In situ $^{40}Ar/^{39}Ar$ UV laser dating of mylonitic mica fish: cooling or crystallisation ages?

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High-spatial resolution geochronology of fabric-forming minerals provides a direct means of reconstructing fabric development associated with shear zone activity. However, interpreting the results from any geochronology study requires knowledge of the temperature-deformation history and associated (re)-crystallisation mechanisms of the minerals of interest. Syntectonic muscovite fish from the hanging wall of the Porsgrunn-Kristiansand Shear Zone (PKSZ, Southern Norway) formed during greenschist facies reactivation of thrust-related, Sveconorvegian (~1.1Ga) mylonites. Individual muscovite fish display no excess argon component and record very constant $^{40}Ar^*/^{39}Ar$ ratios on the intra- and inter-grain scale when analysed with the $^{40}Ar/^{39}Ar$ UV laser microprobe. Neocrystallisation of muscovite in the hanging wall was accompanied by infiltration of meteoric fluids during extensional shearing as evidenced by low δ^8O values for quartz and muscovite ($\delta^{18}O_{qtz}$ =0.05-3.35‰, $\delta^{18}O_{ms}$ =0.33‰). Oxygen isotope thermometry of the footwall mylonites yields deformation temperatures within the range commonly assumed as the argon closure temperature for muscovite. Temperatures in the hanging wall were lower and probably affected by percolating meteoric fluids. In contrast, $^{40}Ar/^{39}Ar$ UV laser dating of muscovite with variably-sized segmentation due to first-order lattice discontinuities from the extensional Pogallo Shear Zone (Ivrea Zone, Italy) reveals remarkable intra-grain $^{40}Ar/^{39}Ar$ variations, analogous to staircase spectra obtained by bulk step heating experiments. In situ UV laser and step heating $^{40}Ar/^{39}Ar$ data are consistent with argon diffusing from heterogeneously-sized coherent segments into zones with high defect density (e.g high angle kink bands or microfractures) that acted as fast diffusion pathways. Unlike the highly variable $^{40}Ar/^{39}Ar$ data obtained from the slowly cooled Pogallo Shear Zone, the results of in situ $^{40}Ar/^{39}Ar$ geochronology from the PKSZ hanging wall mylonites exclude significant post-mylonitic, diffusional argon loss but rather date formation of the muscovite fish and hence mylonitisation during shear zone reactivation. The consistency of $^{40}Ar/^{39}Ar$ ages across the PKSZ indicates that meteoric fluid infiltration had negligible effects on the overall $^{40}Ar^*$ budget. Both in situ $^{40}Ar/^{39}Ar$ UV laser studies underscore the fact that the mechanisms controlling loss or retention of $^{40}Ar^*$ in deformed minerals need to be evaluated individually within a microstructural context in any $^{40}Ar/^{39}Ar$ study focussed on reconstructing tectonic histories.

References

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Tropical Atlantic warming during thermohaline circulation slowdown

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Evidence for abrupt climate changes on millennial and shorter timescales is widespread in marine and terrestrial climate records. Rapid reorganization of ocean circulation is considered to exert some control over these changes, as are shifts in the concentrations of atmospheric greenhouse gases. The response of the climate system to these two influences is fundamentally different: slowing of thermohaline overturn in the North Atlantic Ocean is expected to decrease northward heat transport by the ocean and to induce warming of the tropical Atlantic, whereas atmospheric greenhouse forcing should cause roughly synchronous global temperature changes. So these two mechanisms of climate change should be distinguishable by the timing of surface-water temperature variations relative to changes in deep-water circulation. Here we present high-temporal-resolution records of sea surface and intermediate water temperatures from the tropical Atlantic Ocean which span the past 30,000 years, derived from measurements of temperature-sensitive alkenone unsaturation in sedimentary organic matter and the oxygen isotope composition of benthic foraminifera. We find significant warming is documented for Heinrich event H1 (16,900±15,400 calendar years BP) and the Younger Dryas event (12,900±11,600 cal. yr BP), which were periods of intense cooling in the northern North Atlantic. Temperature changes in the tropical and high-latitude North Atlantic are out of phase, suggesting that the thermohaline circulation was an important control for the temperature distribution in the Atlantic Ocean during these rapid climate changes.