Recovering the timing of mylonitization from coupled $^{40}Ar/^{39}Ar$ and hydrogen isotope data

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The time scales and rates of ductile deformation, thermal relaxation and associated syntectonic fluid flow in mylonites provide key elements in reconstructing the tectonic history of orogenic belts. Low-angle normal displacement detachments, delimit core complexes of the North American Cordillera and accommodated most of the exhumation related strain during collapse of the Cordilleran orogen and Basin and Range extension. Recently, quantitative paleoaltimetry techniques have been developed that exploit variations in the isotopic composition of meteoric fluids that circulate within detachment systems. These techniques relate shear zone kinematics to evolution of topography in the orogen and provide unprecedented boundary conditions for tectonic models that predict the long-term topographic evolution of mountain ranges. However, these techniques are applicable only where the timing of detachment faulting can be determined with high precision.

In an effort to reconstruct the long-term topographic history of the Basin and Range province, we have investigated relationships among recrystallization, fluid flow, and isotope exchange in mylonitic quartzite of the Raft River core complex (Utah). Multiple thermochronometer ($^{40}Ar/^{39}Ar$ ms, bt, and Kfsp, ApHe) data constrain the thermal history of footwall rocks in the core complex and are complemented by oxygen isotope thermometry and $^{40}Ar/^{39}Ar$ data of various mylonite generations. Coupled δD and $^{40}Ar/^{39}Ar$ data from three generations of detachment mylonite show distinct syntectonic fluid compositions that decrease from the Eocene (δD ca. -120 permil at ~40 Ma) to the mid and late Miocene (δD ca. -95 permil at 23 Ma and 16-14 Ma). The observed timing of deformation together with the δD data are consistent with tectonic models that invoke Eocene collapse of an Early Cenozoic continental plateau and subsequent regional extension events at 23 Ma and 16-14 Ma that established the Raft River topography. Identifying a meteoric origin of syntectonic fluids eliminates considerations of extraneous argon as a potential obstacle in $^{40}Ar/^{39}Ar$ dating of mylonites. More importantly, the thermal (cooling) effect of surface-derived fluids has considerable impact on the thermal structure of detachment systems and facilitates the distinction between cooling and deformation ages.