Geophysical Research Abstracts
Vol. 13, EGU2011-12771-1, 2011
EGU General Assembly 2011
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Eocene extension and meteoric fluid flow in quartzite mylonite of the Raft River metamorphic core complex (USA)

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Metamorphic core complexes are common structural features in the Basin and Range Province of the western United States and are formed by large detachments that control their geometry, denudation and rock uplift. These low-angle extensional detachment systems contribute to thermal and mechanical re-equilibrium of orogenic crust and record the kinematic boundary conditions during the late stage of orogenic evolution. The interplay among various parameters such as strain localization, fluid-rock interaction and Earth surface processes dominates the evolution of these detachments and their thermomechanical behavior. In order to investigate the interaction between ductile deformation, detachment kinematics and fluid flow we used a multi-disciplinary approach: Our study includes (1) observation of microstructures, (2) electron microprobe measurements of white micas, and (3) measurements of the hydrogen isotopic composition of syntectonic white micas. We combined these data with $^{40}Ar/^{39}Ar$ data to resolve the temporal and kinematical relationship between core complex formation and fluid flow at mid-crustal levels.

Our study focuses on the Raft River Metamorphic Core Complex in northern Utah, USA, with the associated top-to-the-east Miocene Raft River Detachment and an underlying 100 to 300 m thick mylonitic shear zone. A ca. 190 m section of mylonitic mica-bearing quartzite within the footwall of the southwestern Raft River Mountains (Pine Creek Valley) encompasses the entire sequence of Elba Quartzite, the lowermost stratigraphic unit of the Raft River Shear Zone. Syntectonic white mica within the mylonite yields $^{40}Ar/^{39}Ar$ ages of ca. 40-45 Ma.

The sampled quartzites display a well-developed subhorizontal mylonitic foliation. An east-southeast to west-northwest stretching lineation orientation represents the shearing direction and displacement of the hanging wall. The microstructures of recrystallized quartz and white mica reveal plastic deformation of the quartzites by grain boundary migration with a significant amount of pure shear strain. Micro shear sense indicators equally show a top-to-the-east movement of the hanging wall. The chemical composition of syntectonic white mica suggests a muscovitic composition. We found no evidence of different generations of muscovites or of differently recrystallized mica tips. The hydrogen isotopic composition of muscovite ranges from -125 to -150 $\pm$ 5 ‰ without a distinct trend across the section. These very low hydrogen isotopic values require synkinematic interaction with meteoric fluids and further suggest that during Eocene extension brittle faults within the upper plate were pathways for surface-derived fluids that percolated into the detachment system and penetrated down to the brittle-ductile transition.

Our stable (δD) and radiogenic ($^{40}Ar/^{39}Ar$) isotope data support reports of rapid cooling of the Pine Creek location in Middle Eocene time. This exhumation event occurred during the infiltration of meteoric fluids at depths of ductile deformation in the detachment and it is likely that the circulating fluids actively influenced the deformation mechanisms and kinematics of the detachment and ultimately, the exhumation history of the core complex.