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Quartz recrystallization and fluid flow during exhuming footwall rocks of the Northern Snake Range detachment, Nevada

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The Northern Snake Range metamorphic core complex (Nevada) represents a spectacular example of core complex formation developed as a consequence of Tertiary extension of the Basin and Range Province. With a top to the east sense of shearing, the N-S striking Northern Snake Range detachment (NSRD) accommodated exhumation of Precambrian and Cambrian quartzites relative to upper plate Paleozoic units and exposed over more than 100 km an almost complete footwall-hanging wall cross section of muscovite-bearing quartzite mylonites and schists.

Samples collected across the NSRD indicate a systematic pattern of 40Ar/39Ar ages, δDmuscovite values and quartz microstructures. Despite complex, yet systematic 40Ar release spectra 40Ar/39Ar ages become increasingly younger from the top (26.9 Ma) to the bottom (21.3 Ma) of the exposed section of the detachment. δD values of muscovite as low as -150 ‰ (VSMOW) at the top of the detachment zone attain progressively less negative values over the 300 m thick section, reaching up to -72 ‰ (VSMOW) at the base of the section. These results suggest that meteoric water percolated several 10s to 100s of meters into the detachment zone during normal faulting. This hydrogen isotope trend can be correlated with quartz microstructures that are characterized at the top of the detachment by very fine grained neoblasts that recrystallized by subgrain rotation from large elongate quartz grains and a coarser quartz fabric showing grain boundary migration towards the bottom. The quartz c-axis fabric is defined by a strong maximum parallel to Y and a single girdle shape that stretches into an inclined girdle, whose pole is the largest concentration of a-axes, consistent with top-E shearing. Quartz c-axis and a-axes fabrics are constant from the top to the base of the section. These data compatible with plastic deformation dominated by prism-a glide that typically occurs between 400°C and 700°C are consistent with our results of oxygen isotope thermometry.

Collectively, these data indicate that the fossil hydrothermal system of the Northern Snake Range metamorphic core complex has been exhumed over at least the past 27 Ma by the combined effects of extensional detachment faulting and erosion. Meteoric fluids that penetrated the brittle upper crust became involved in large-scale convective flow to several (5-15) km depth over the time scales of mylonite formation (ca. 27 to 23 Ma). Based on the absence or decreased importance of meteoric fluids in the lower part of the exposed NSRD and changes in 40Ar retention behavior of white mica, we suggest that ductile deformation and meteoric hydrothermal activity in the footwall of the NSRD shut down after 23 Ma when isotherms that were previously compressed by rapid footwall uplift and associated heat advection started to relax. 40Ar/39Ar data and oxygen isotope thermometry indicate that the base of the detachment remained hot until the mylonitic quartzite cooled through the closure temperature of argon in muscovite between ca. 23 and 21 Ma. Collectively, the stable and radiogenic isotope and microstructural data allow us to relate 40Ar/39Ar data to individual time intervals of detachment activity, the latter being influenced by the presence of meteoric fluids at or close to the brittle-ductile transition in the actively deforming core complex.