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Miocene latitudinal climatic and topographic variability within the central North American Cordillera

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The long-term climatic evolution and atmospheric circulation patterns of the Earth are influenced by the topography of large mountain chains whose topography is in turn controlled by links and feedbacks of surface processes and those acting within the Earth´s interior. Stable isotopes in precipitation change systematically with elevation in many modern mountain ranges and have become an increasingly important tool in reconstructing the long-term topographic and climatic evolution of the world's largest mountain ranges. Here, we present stable isotope data from meteoric fluids trapped in orogen-scale deformation zones and associated fault-bounded basin sediments that record paleoelevation and also link the geodynamics of orogens with the overall long-term landscape and climate histories.

To reconstruct the Cenozoic paleoelevation history of the central part of the North American Cordillera, we focus on the metamorphic core complexes of the Snake Range (Nevada) and Buckskin Mountains (Arizona). The Snake Range and Buckskin Mountains represent both classic examples of normal fault-bounded metamorphic core complexes that developed as a consequence of Oligocene Miocene extension of the Basin and Range Province. Synkinematic muscovites collected systematically over the top-300 m of section within the Snake Range detachment reveal a pattern of increasingly younger 40Ar/39Ar ages (26.9 Ma to 21.3 Ma) from the top to the bottom of the detachment. Across the same section dD muscovite values as low as -150 per mil occur at the top of the detachment zone and attain progressively higher values of up to -72 per mil towards the bottom of the section. This hydrogen stable isotope trend suggests that meteoric fluids percolated 10s to 100s of meters into the ductile segment of the detachment over the time scale of mylonitic deformation (ca. 27 to 23 Ma). In contrast, dDmuscovite values of similarly aged mylonitic quartzites from the Buckskin Mountains are much higher and range between -87 per mil and -66 per mil.

Even though detachments in both metamorphic core complexes are similar in age and geodynamic role in shaping and transforming the extending Cordilleran orogen during the Miocene, stable isotope data from both core complexes suggest that meteoric fluids that entered the two detachments had vastly different hydrogen isotope compositions. Therefore, the stable isotopic composition of precipitation (as the ultimate source for the meteoric water) in central Nevada must have been affected by different atmospheric circulation conditions including, but not limited to, higher surface elevations and increased continentality. We postulate that during the Miocene the southern segment of the Cordilleran orogen (Arizona) never attained elevations as high as the central segment currently occupied by the Snake Range in Nevada; a situation similar to the modern topography of the region. This would imply that fundamentally different conditions prevailed in the subsurface beneath these parts of the orogen leading to very different topography, which has far reaching implications for mountain building in general and for moisture transport in global climate models.