Temperatures and fluids on faults based on carbonate clumped-isotope thermometry

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Abstract

We present results from a carbonate clumped-isotope thermometric study of 41 carbonate samples collected within ~1 m or less of the Mormon Peak detachment, a large-slip Miocene normal fault in the Basin and Range of southern Nevada. Samples include cataclastic rocks, narrow vein fillings and larger void-filling carbonates. Our results are consistent with earlier measurements of O and C isotopic ratios and fluid inclusion temperatures, and provide independent constraints on the isotopic composition and temperature of syntectonic pore waters. The results reveal a wide range of precipitation temperatures (10 to 139 °C) associated with deformation, and indicate that the pore waters were meteoric, with $\delta^{18}O$ as low as –11‰ (SMOW) and $\delta^{13}C$ as low as –8‰ (VPDB). The results do not provide any direct evidence for high-temperature thermal decomposition reactions (ca. 500 to 800°C) that are widely expected to result from flash heating along upper crustal faults, although they do not rule them out so long as recarbonation occurs at very low temperature, or the products of these reactions are volumetrically minor. The results are difficult to reconcile with recent suggestions that the detachment is the base of one or more catastrophically emplaced, surficial landslides. In concert with other lines of evidence, the data are most simply interpreted as recording deformation and precipitation events through a long history of slip, accompanied by relatively deep (>3 km) circulation of meteoric pore waters along the detachment plane.

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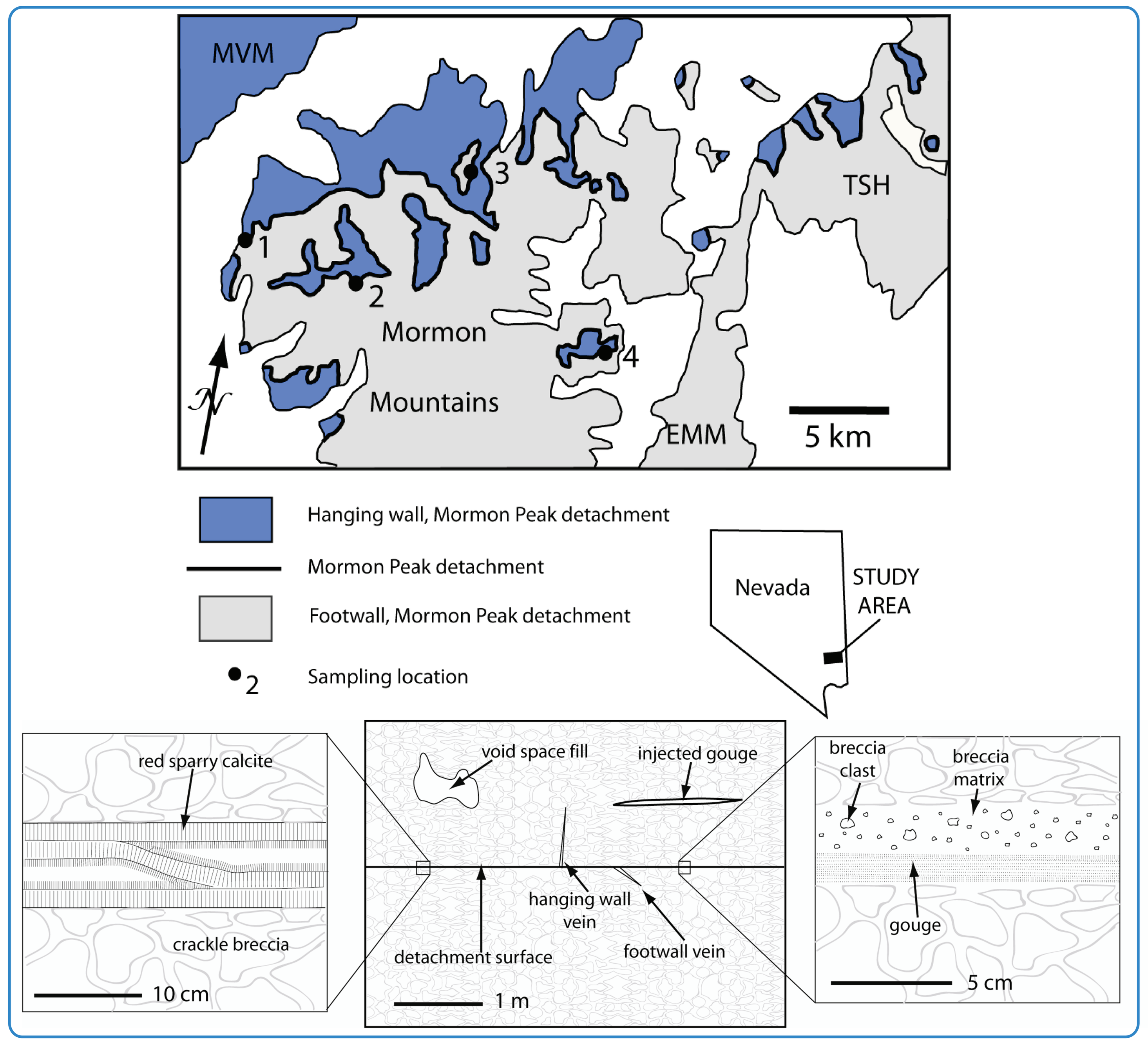
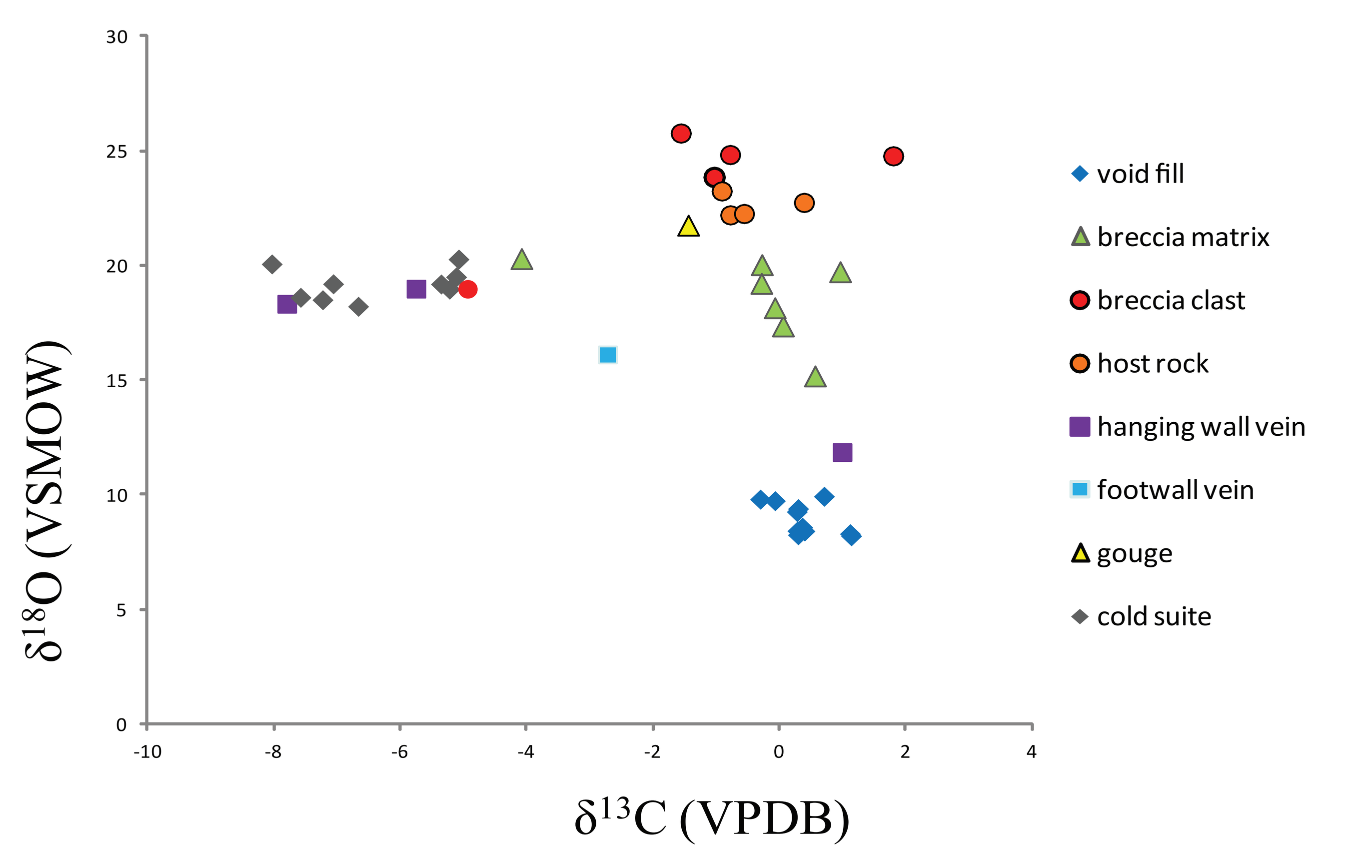
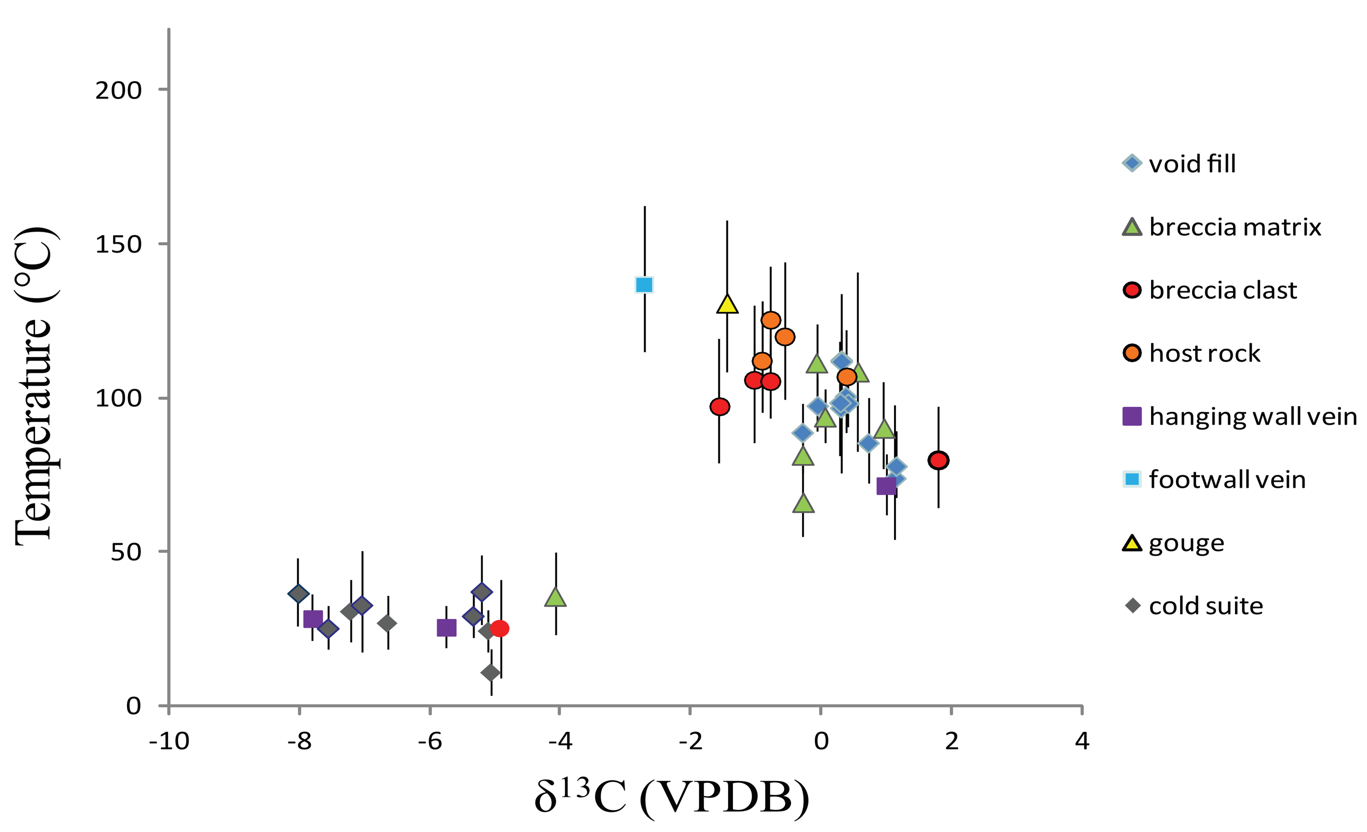
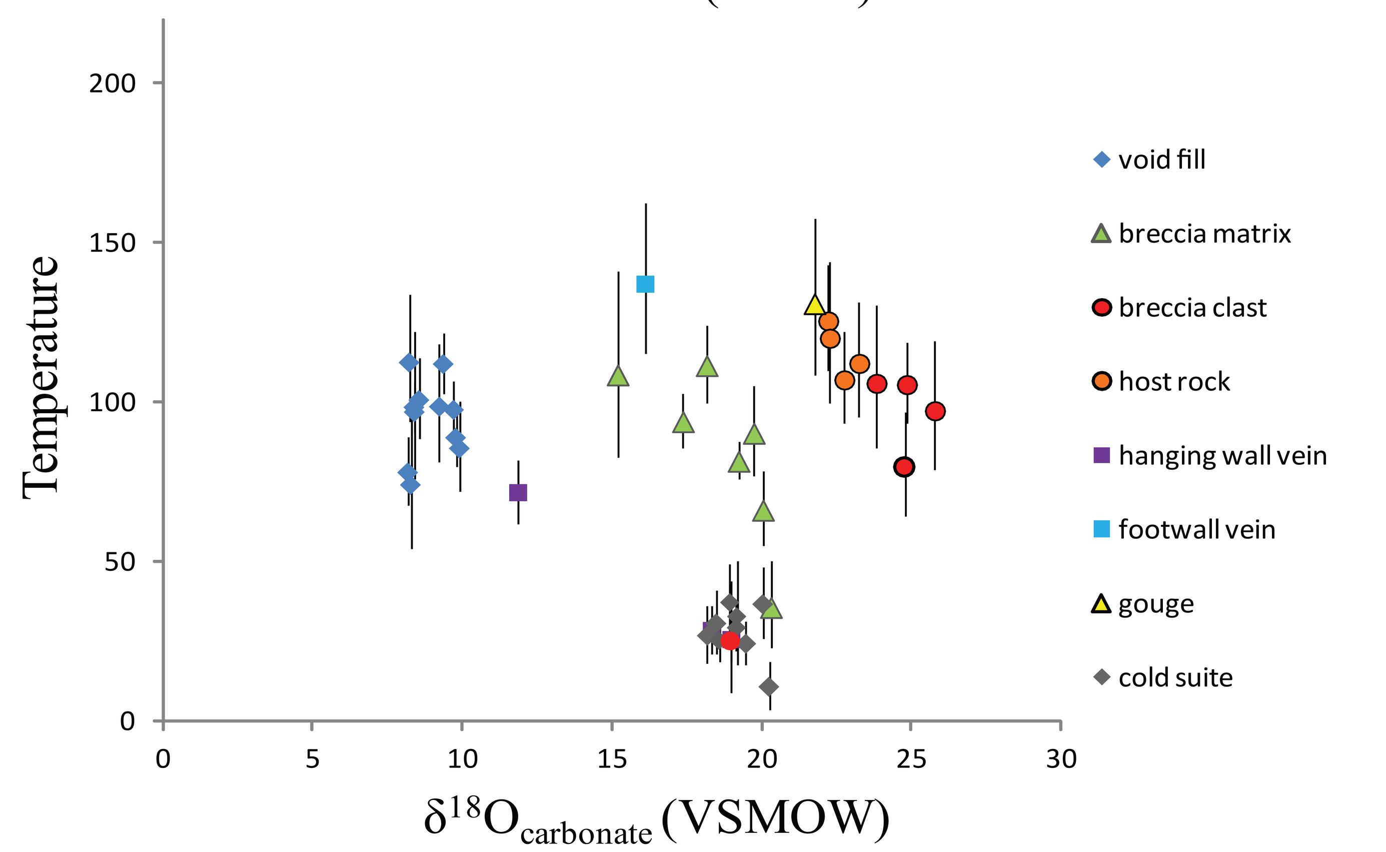
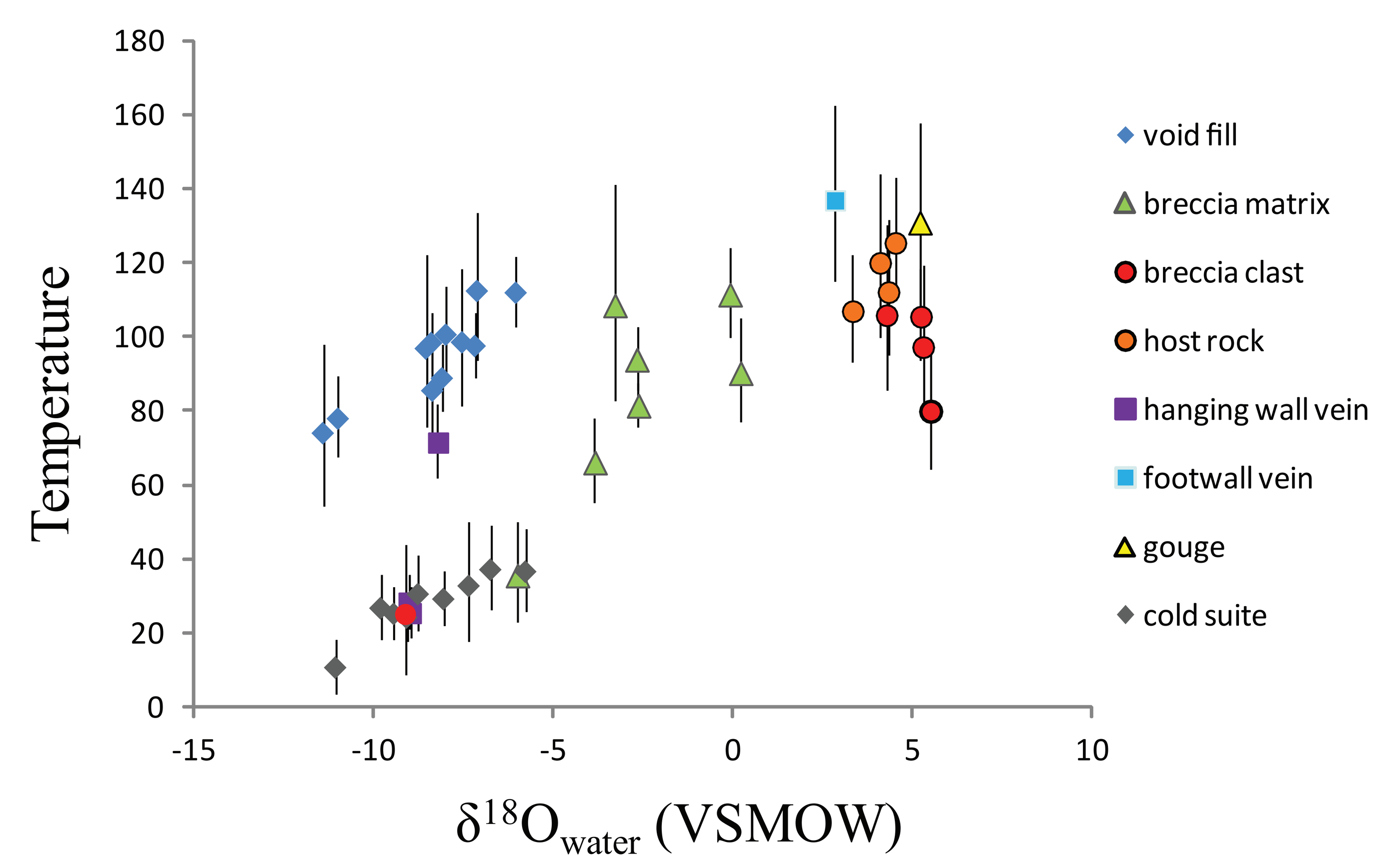


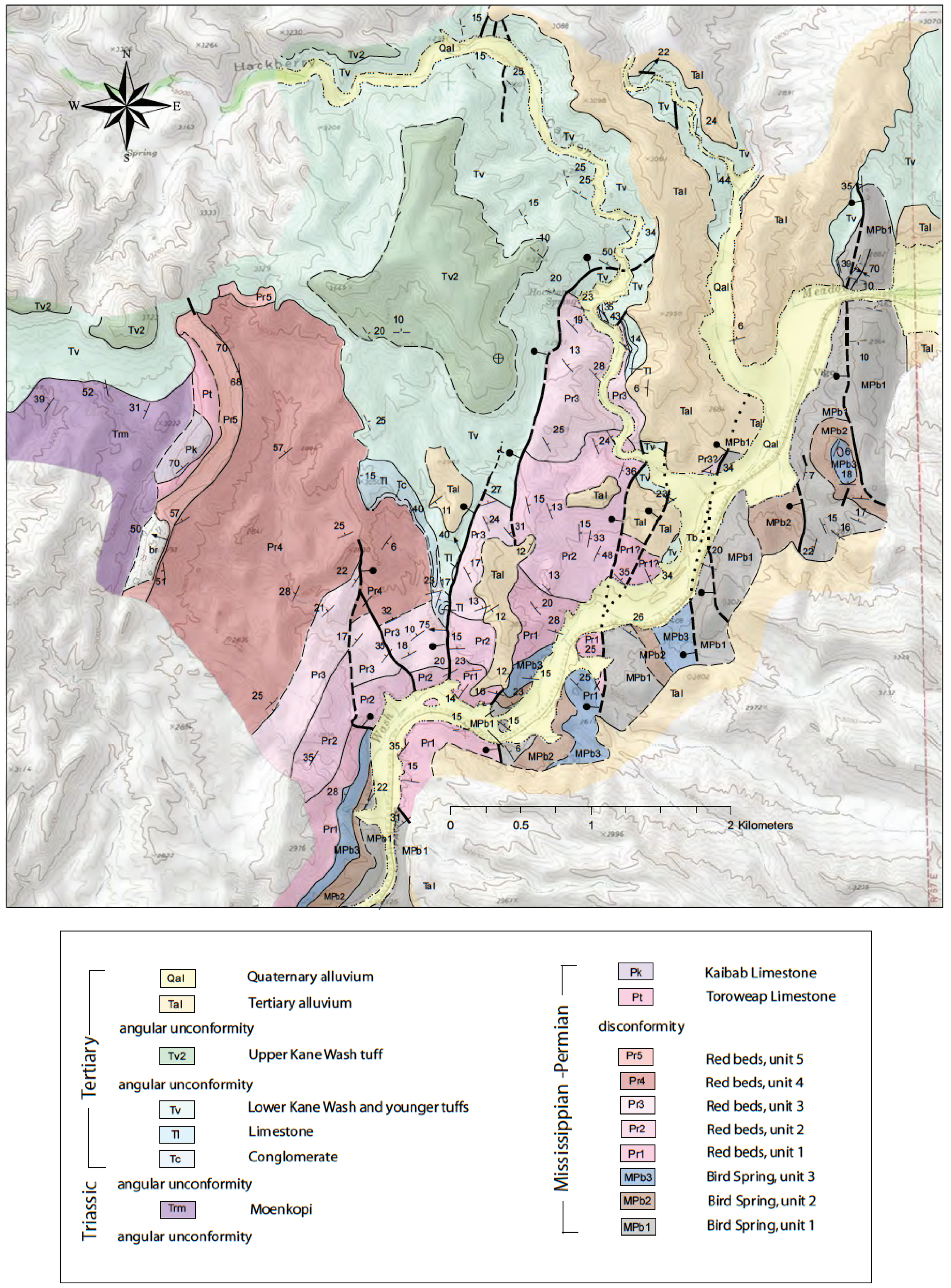








Temperatures of fault rocks indicate two distinct phases of calcite precipitation from meteoric water infiltration. The warmer phase is unexpectedly warm for depths of 2 kilometers, the thickness of the hanging wall, suggesting potential warm fluid migration up the fault. The cooler phase displays a variety of textures, mostly undeformed, suggesting it formed late in the slip evolution. Also, the clasts within the breccias preserve the chemical signature of the host rock, indicating that brecciation does not reset the clumped isotopic values for 1 cm clasts.



Mapping Discussion

The Meadow Valley Mountains are expected to be consistent with features in the hanging wall of the Mormon Mountains, where the clumped isotope samples were collected. Here, mapping in the Meadow Valley Mountains indicates a pattern of anticlinal flexure that has been disrupted by faulting. This pattern is similar to that observed in the Mormon Mountains. This suggests that the Mormon Peak Detachment is likely a rooted fault, with a continuous hanging wall across Meadow Valley Wash. It is less likely that the detachment represents a plane of slip for a landslide which toes in Meadow Valley Wash. The Tertiary volcanics also preserve a record of faulting and tilting, with the older units showing deformation, while the younger units are mostly subhorizontal.

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