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The Black Belt Shear Zone records the earthquake cycle at the brittle-ductile transition: implications for the SCEC Community Rheology Model

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Abstract. The inception of the Laramide Orogeny in Southern California is marked by a Late Cretaceous arc flare-up in the Southern California Batholith (SCB) that was temporally and spatially associated with syn-plutonic development of a regionally extensive, transpressional shear zone system. This ~200 km-long system is the best analog for the shear zones that extend into the middle crust beneath the major lithotectonic block-bounding faults of the San Andreas Fault system. We focus on the Black Belt Shear Zone, which preserves an ancient brittle-ductile transition (BDT), and is exposed in the SE corner of the San Gabriel lithotectonic block. The mid-crustal Black Belt Shear Zone forms a ~1.5-2 km thick zone of mylonites developed within hornblende and biotite tonalites and diorites. Mylonitic fabrics strike SW and dip moderately to the NW, and kinematic indicators from the Black Belt Shear Zone generally give oblique top-to-SW, sinistral thrust-sense motion (present-day geometry). U-Pb zircon ages of host rock to the Black Belt mylonites demonstrate crystallization at ~86 Ma and metamorphism at ~79 Ma at temperatures ~753 °C. Syn-kinematic, metamorphic titanite grains aligned with mylonitic foliation in the Black Belt Shear Zone give an age of ~83 Ma. These data indicate syn-magmatic sinistral-reverse, transpressional deformation. The BDT rocks in the Black Belt Shear Zone are characterized by a ~10 m-thick section of high strain mylonites interlayered with co-planar cataclasite and pseudotachylite (pst) seams. Microstructural and electron backscatter diffraction (EBSD) analysis shows that the mylonites and cataclasites are mutually overprinted, and pst seams are overprinted by mylonitic fabric development. Pst survivor clasts show the same shear sense as the host mylonite, and this kinematic compatibility demonstrates a continuum between brittle and ductile deformation that is punctuated by high strain rate events resulting in the production of frictional melt. EBSD analysis reveals a decreasing content of hydrous mafic mineral phases in host mylonite with increasing proximity to pst seams. This suggests that pst was generated by melting of hornblende and/or biotite, implying that coeval development of mid-crustal mylonites and pst does not require anhydrous melting conditions. Rather, the production of pst may liberate water, implying that BDT rock rheology is affected by transient pulses of water influx and strain rate increases.

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