Mechanisms of Extensional Strain Localization: An Example from Cordilleran Metamorphic Core Complexes

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Crustal extension is a fundamental process in plate tectonics, and understanding its driving mechanisms is critical to our understanding the role of extensional deformation in the evolution of the Earth's continents. How and why extension localizes into narrow belts versus being distributed across wide orogens remains enigmatic. Here we investigate extensional strain localization in the North American Cordillera (NAC) and Basin and Range province, where early phases of high magnitude strain (>100%) were fairly localized along a ~2500-km long belt of metamorphic core complexes, and subsequent late-stage low-magnitude strain appears to be fairly distributed across the 500-600-km width of the Great Basin. Various forces compete to drive intracontinental extension in the western United States, and we present field-based case studies of the Central NAC core complexes—the Ruby-East Humboldt, Snake Range, and Albion-Raft River-Grouse Creek—to explore strain localization due to plate-boundary stresses, internal body forces (GPE), and/or crustal rheology including thermal weakening from pervasive magmatism. The studied core complexes consist of significant syn-kinematic intrusions, and we demonstrate how the composition, volume and age (i.e., duration and relative timing) of these intrusions affected strain rates. Through a combination of new and synthesized U-Pb geochronology, $^{40}\text{Ar}/^{39}\text{Ar}$ thermochronology and electron backscatter diffraction (EBSD) analysis we link transient thermal and rheological evolution of the crust with deformation mechanisms from grain to outcrop to regional scales. More broadly, we discuss the mechanisms and modes of crustal extension during orogenesis, and whether extension in active orogens is a transient response to modulate GPE gradients, or a precursor to orogenic collapse.