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Three dimensional mechanical analysis of a gravity driven salt system using InSAR and numerical modeling

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The Grabens of Canyonlands National Park is a well-exposed gravity driven system of salt structures driven by the incision of the Colorado River canyon toward a ∼300 m thick evaporite layer. The region contains an array of normal faults with displacement accommodated by a combination of salt flow and overburden gliding toward the canyon and provides the opportunity to explore salt deformation mechanics in three dimensions. Maybe describe other structures besides faults? Meander anticline, diapirs. Using a combination of interferometric synthetic aperture radar (InSAR) and three-dimensional numerical modeling, we: 1) quantify displacement rates and kinematics of the region, 2) explore how various parameters driving deformation interact and control deformation, and 3) use these results to understand the mechanics of a gravity driven salt system. Initial InSAR results show average line-of-sight (LOS) displacement of 1-3 mm/yr throughout the deforming region. The data set can additionally provide a time series from 1992-2011 and multiple components of deformation using both ascending and descending scenes. Three-dimensional numerical models were created to explore the roles of overburden rheology, salt geometry, and topography on salt deformation. We converted the model displacement into LOS displacement rates for direct comparison to InSAR rates. Within the Grabens, overburden rheology plays an important role on deformation patterns. Not only do preexisting weaknesses allow propagation of deformation away from the river canyon and an increase in overburden displacement rates, the mechanics in the region are spatially complex. The models indicate a transition from gravity spreading to gliding dependent on topography, where spreading is dominant below horsts and transitions to gliding toward the grabens. Additionally, salt flow is more sensitive to smaller scale topographic features and is diverted toward individual side tributaries and grabens on spatial scales of hundreds to tens of meters. To the south of the Grabens, the structural expression as well as the mechanics differ though surface displacement rates are similar to the Grabens. We attribute this difference in structural expression—where deformation is accommodated along a southern bounding fault—to breaching of the evaporite layer within the Colorado River canyon. When unconfined salt is modeled, displacement patterns in the region are similar to that observed via InSAR. The mechanics in the region shift to gliding dominant, and salt flow patterns are controlled by overburden movement toward the canyon.