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Kinematics and strain in an evaporite décollement:
Insights from the Minas Viejas basal shear zone, Sierra Madre Oriental, Mexico

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Our project has focused on deformation within an evaporite décollement in the Sierra Madre Oriental near Galeana, Mexico. The Upper Jurassic Minas Viejas Formation comprises the décollement, which accommodated detachment folding of overburden strata during Late Cretaceous to Paleogene thin-skinned shortening. Originally our research focused on penetrative strain within the décollement, but over the course of our fieldwork it became increasingly clear that a younger, thick-skinned uplift event had dramatically modified the décollement deformation zone. During year 2 of this project we focused on understanding the geometry, kinematics, and timing of this cryptic younger deformation event. Our field area has expanded to encompass the entire Potosí uplift, which includes outstanding exposures of sub-décollement rocks that have allowed us to investigate the thick-skinned deformation.

Thick-skinned deformation in the Potosí uplift involved folding of sub-décollement Triassic to Jurassic red-beds with development of a NNW-trending anticlinorium and NNW-striking disjunctive cleavage, ENE-directed thrust faulting (Fig. 1), and formation of ENE-striking extension fractures and strike-slip faults associated with barite mineralization. Folded Cretaceous strata above the décollement record an average shortening direction of N44E associated with thin-skinned deformation, whereas structures below the décollement record a shortening direction of N59E associated with thick-skinned deformation. Thrust faulting and folding associated with the Potosí uplift locally modified folds within the Cretaceous overburden by decreasing the tightness of a map-scale syncline and refolding a regional anticline limb into recumbent chevron folds (Fig. 2). Evaporites within the Minas Viejas Formation were mostly evacuated beneath the uplifted core of the anticlinorium and extruded eastward into a part of the section that is structurally ~2.5 km thick. Normal faults and steeply-dipping dip-slip faults that juxtapose the Minas Viejas Formation against sub-décollement strata are likely outer-arc extensional features along the crest of the thick-skinned uplift (Fig. 2). Evaporite structures are detached from the overburden strata ~0.5 km below the top of the Minas Viejas Formation, which defines the top of the décollement.

To establish the timing of the transition from thin-skinned to thick-skinned shortening we determined four (U-Th)/He cooling ages from detrital zircons in sandstone bellow the décollement and from in the lowermost part of the décollement. All of the cooling ages range from ~44 Ma to 60 Ma (43.8 ± 3.2 Ma, 48.6 ± 3.9 Ma, 49.4 ± 9.1 Ma, and 59.7 ± 9.1 Ma). An organic-rich shale bed in the upper-middle part of the Minas Viejas Formation yielded an indigenous %Ro vitrinite reflectance value of 1.92 ± 0.10, indicative of a maximum burial temperature of ~180-200 °C, which is consistent with complete resetting of zircon (U-Th)/He ages near the base of the décollement. We interpret the cooling ages to directly record the timing of thick-skinned uplift as the base of the décollement was exhumed to <7 km. These data indicate that thick-skinned exhumation in the Potosí uplift initiated by the early Eocene and was coeval with thin-skinned shortening farther north in the Sierra Madre Oriental. We attribute this along-strike change in deformation style to the presence of a higher carbonate to evaporite ratio in the Minas Viejas Formation across the Potosí uplift compared to the Minas Viejas farther north. The shift from thin-skinned deformation involving the evaporite décollement to thick-skinned deformation involving sub-décollement rocks thus represents a progressive transition during the late stages of Sierra Madre Oriental shortening rather than a boundary between unrelated deformation events.

This project has provided outstanding field research experiences for 4 students and one postdoctoral fellow in our department. MS student Stewart Williams has led the field mapping effort, and a 1-year no-cost extension for this project is allowing Williams to complete the project while being supported by a GRA for the 2018-2019 academic year. MS student Skyler Mavor has also played an important role assisting with fieldwork in this project, and undergraduate students Blake Franklin and Omar Gomez have participated in fieldwork. Postdoctoral fellow Michael Prior has led the thermochronology component of this project, providing a new direction for his research program. This project has also provided a major new research direction for PI Singleton, who will likely continue research in the Sierra Madre Orientation long past the completion of this project. To date we have published two abstracts that will be presented at the fall 2018 GSA and AGU meetings (Prior et al., 2018; Williams et al., 2018).

Figure 1. A fault-bend fold developed within the Triassic-Jurassic red beds below the evaporite décollement. The red line shows the trace of the ENE-vergent thrust fault, and the yellow lines show the trace of bedding.

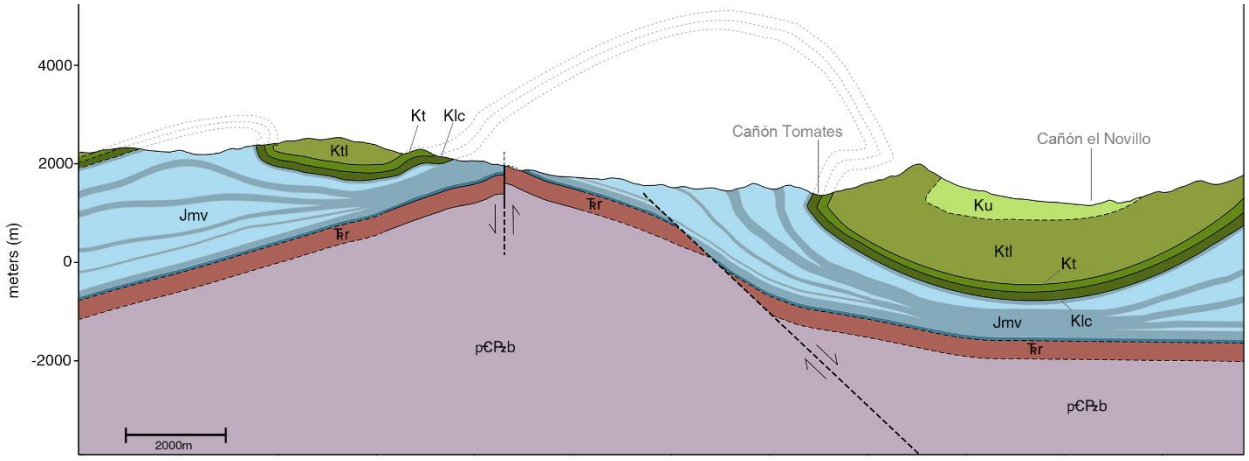

Figure 2. E-W cross section across the southern end of the Potosí uplift illustrating how broad folding of units below the Minas Viejas Formation décollement (Jmv) has affected overburden folds and the thickness of the Minas Viejas.