An evaluation of competing models for extension across the Death Valley region, California-Nevada

Byrdie Renik
Department of Earth and Environmental Sciences and Lamont-Doherty Earth Observatory,
Columbia University
(415) 225-9692
renik@LDEO.columbia.edu

My dissertation is motivated by the question of how the continental crust extends, in particular the low-angle normal fault paradox. Numerous normal faults dip at low angles, yet the general interpretation of active faulting at such dips conflicts with rock mechanical theory. A type locality for this puzzle and for one possible solution – the rolling hinge model – is Death Valley, California, which underwent peak extension in Miocene time. With sequentially active splays that rotate through a migrating "hinge" and root in a single surface, the rolling hinge model both explains the observed low dips and enables planes to have dipped more steeply while active. The applicability to Death Valley, however, is contested. Thus, three potentially viable models remain: active low-angle faulting, traditional high-angle faulting, and the rolling hinge. The models differ fundamentally in their predictions of extensional magnitude and timing. My dissertation aims to evaluate these predictions using palinspastic reconstruction and thermochronology.

The magnitude of Miocene extension across Death Valley is best constrained by displacement on bounding strike-slip structures: the Furnace Creek and Sheephead fault zones. Reinterpretation of the middle Miocene Eagle Mountain Formation as fluvial-lacustrine challenges a piercing point on the Furnace Creek fault zone critical to the extreme, fast-paced extension posited by the low-angle and rolling hinge models. An emerging synthesis of remaining piercing points indicates that displacement was significant, but more compatible with the high-angle than the low-angle or rolling hinge models. New mapping of the Sheephead fault zone suggests a relatively immature, right-lateral shear zone. This is at odds with the rolling hinge prediction of a single, mature, throughgoing fault system.

The timing of extension is best constrained by the ages of strike-slip faults and the chronology of exhumation in the metamorphic core of the Black Mountains, adjacent to Death Valley. Although the age of the Furnace Creek fault zone is difficult to determine, I am in the process of dating volcanic rocks associated with the Sheephead fault zone. To address uncertainty in published exhumation data from the Black Mountains, I am collecting cooling ages on gneiss there. Sampling localities are positioned to elucidate whether exhumation migrated consistently northwestward (rolling hinge model), and whether it was accomplished chiefly via Neogene extension (rolling hinge and low-angle models) or in significant part by earlier erosion (high-angle model).