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Testing fault growth models with low-temperature thermochronology

Magdalena Curry (1,3), Jason Barnes (2,3), and Joseph Colgan (4)

(1) Institut des Sciences de la Terre, Universite Grenoble Alpes, Grenoble, France (maggellis@gmail.com), (2) Landscape Analytics LLC, Seattle, Washington, USA (barnesjasonb@gmail.com), (3) Department of Geosciences, University of North Carolina, Chapel Hill, North Carolina, USA, (4) U.S. Geological Survey, Lakewood, Colorado, USA (jcolgan@usgs.gov)

Common fault-growth models diverge in predicting how faults accumulate displacement and lengthen through time. A paucity of field-based data documenting the lateral component of fault growth hinders our ability to test these models and fully understand how natural fault systems evolve. We outline a framework for using apatite (U-Th)/He thermochronology (AHe) to quantify the along-strike growth of faults. We test our framework in the normal-fault bounded Pine Forest Range from the U.S. Basin and Range Province. We combine new and existing cross-sections with 18 new and 16 existing AHe cooling ages to determine the spatiotemporal variability in footwall exhumation and evaluate models for fault growth. Three age-elevation transects in the Pine Forest Range show rapid exhumation began along the range-front fault between ca. 15–11 Ma at rates of 0.2–0.4 km/m.y., ultimately exhuming ca. 1.5–5 km. The ages of onset of rapid exhumation identified at each sample transect lie within data uncertainty, indicating concomitant onset of faulting along strike. We show that even in the case of growth by fault-segment linkage, the fault would achieve its modern >40 km length within 3–4 m.y. of onset. A constant fault-length growth model is the best explanation for our thermochronology results. We advocate that low-temperature thermochronology can be further utilized to better understand and quantify fault growth with broader implications for seismic hazard assessments and the coevolution of faulting and topography.