U-Th Dating of Syntectonic Calcite Veins Reveals the Dynamic Nature of Fracture Cemenetion and Healing in Faults

Randolph Williams¹, Peter Mozley², Warren Sharp³, and Laurel Goodwin¹

¹University of Wisconsin-Madison, Geoscience, Madison, United States of America (rwilliams@wisc.edu)
²New Mexico Tech, Earth and Environmental Science, Socorro, United States of America
³Berkeley Geochronology Center, Berkeley, United States of America

Fracture cementation is an important control on the recovery of prefailure levels of permeability and strength in faults and reservoir rock. The timescales of this process, however, are almost entirely unknown from direct analysis of the rock record. We report U-Th dating results that quantify rates of fracture cementation in syntectonic calcite veins from the Loma Blanca fault, New Mexico, USA. Measured cementation rates vary from ~0.05 to 0.80 mm/ka and exhibit a power function correlation with minimum fracture apertures. We argue that this correlation is the result of crystal growth in a transport-limited system, where cementation rates were proportional to rates of fluid flow in individual fractures. We argue that such transport-limited growth necessarily leads to a heterogeneous distribution of cementation rates as fluids migrate through fracture networks of variable and changing aperture. For this reason, individual fractures are not expected to seal at monotonic rates through time but could instead experience order-of-magnitude increases or decreases in sealing rate depending on their geometric properties (e.g., aperture, length/width, and orientation) and position within a continually evolving fracture network. We further argue that such transport-limited, flux-dependent cementation necessarily leads to a heterogeneous distribution of permeability and strength recovery as fluids migrate through fault-zone fracture networks. These heterogeneities may influence rupture propagations pathways and the continual development of fault-zone architecture/complexity.