Strength and evolution of fault rocks in low-angle normal fault zones

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Current research shows that laboratory data and classic Andersonian fault mechanic theory *(Anderson, E. M., 1942, 191 pp., Oliver and Boyd, Edinburgh)* cannot explain slip along several 'misoriented' large displacement faults. Current research groups (SAFOD) are focused on the San Andreas Fault zone which slips at almost 90° to the regional compressive stress direction *(e.g. Zoback, M. D. et al., 1987, Science, 238, p. 1105-1111).* Low-angle normal faults (LANF's) are also a mechanical paradox and record large displacements at dip angles interpreted as misoriented for slip. The goal of our project is to study the evolution of fault rocks from LANF's to determine if these zones are strong or weak, and what controls motion along these faults.

To understand low-angle normal faults, two major fault zones in Southern California will be studied: the West Salton detachment (WSD) fault and the Whipple Mountains detachment (WMD). These LANF's are both well-studied by several workers (including the PI's of this project), have quartzo-feldspathic footwalls, and have differing amounts of slip ranging from several meters to several kilometers. The WSD zone has evolved in the brittle-upper crust, whereas the WMD has brittle-ductile slip allowing us to characterize variability depending on the nature of the displacement. The simple footwall rock type reduces rheologic and mechanical differences based solely on mineralogy.

We have three hypotheses for why slip occurs on LANF's: 1. The stress field rotates into a more favorable orientation approaching the fault. 2. Slip occurs due to a weak material localized in the fault zone. 3. Slip is facilitated by high pore-fluid pressure. These hypotheses can be tested using integrated structural, chemical and thermochronologic analyses of the fault rocks and may not be independent of one another. Rotation from the regional stress direction to a local, more favorable orientation on the displacement surface is an easily testable hypothesis. Several outcrop and microstructures will be measured (e.g. tensile cracks, conjugate faults and fractures, reidel shears) inside and outside the fault zone. A bootstrap stress inversion will allow these structures to be a proxy for paleo-stress directions. Microstructural data will be analyzed for weak materials in the fault zone. A weak material is anything that will reduce friction along the fault, thus allowing for slip at greater than typical angles. Prior studies show that certain clays (e.g. montmorillonite), pseudotachylite and amorphous gels can reduce friction during slip. An increase in pore fluid pressure is the most difficult hypothesis to test. There is clear evidence that fluids are present during faulting, but variability of the presence of fluids inside and outside the fault zone may provide some insight about this hypothesis. Additionally, the source and temperature of fluid flux during faulting may be important.