FINAL TECHNICAL REPORT

USGS Award No: 1434-HQ-98-GR-00003 (TAMU)
USGS Award No: 1434-HQ-98-GR-00036 (SLU)

GEOCHEMICAL INVESTIGATION OF FLUID INVOLVEMENT IN EXHUMED FAULTS OF THE SAN ANDREAS SYSTEM: COLLABORATIVE RESEARCH WITH TEXAS A&M UNIVERSITY AND SAINT LOUIS UNIVERSITY

Program Element: III (Understanding Earthquake Processes)

Key Words: Fault dynamics, Thermophysical modeling, Laboratory studies, Tectonic structures

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Technical Summary

Many models have been proposed to account for the weak-fault behavior of large strike-slip faults in the San Andreas system. The physical and chemical role(s) of fluids are fundamental to several of these models. In addition, several models invoke chemical and mechanical effects of fluids in the nucleation, propagation, and arrest of seismic ruptures. The goal of this study is to determine the role of fluids in the seismogenic cycle through an integrated structural-geochemical study of fault rocks exposed in and along the Punchbowl fault. The Punchbowl fault accommodates more than 40 km of right-lateral strike-slip displacement and is an ancient fault of the San Andreas system. Microstructures and mineral assemblages of the fault rocks are consistent with faulting at 2 to 4 km depth. By analogy with nearby active faults, we assume that the Punchbowl fault was seismogenic and that the structure of the fault records the passage of numerous earthquake ruptures. We have mapped in detail (at scales of 1:10 and 1:1) the core of the Punchbowl fault at four different localities in the Devil's Punchbowl area. Approximately one hundred samples have been collected from within and adjacent to the mapped regions in order to characterize both the fault rocks and the host rocks. Major and trace element geochemistry of seventy samples have been determined by XRF, mineralogy has been determined for approximately forty samples using XRD, and oxygen isotope data has been collected from twenty samples. Structures at all scales record the localization of fault displacement not only to the ultracataclasite layer, but to discrete slip surfaces within the layer as well. Petrology of fault rocks and host rocks document hydration reactions occurred in the fault rocks during fault movement. Geochemical data indicates that the ultracataclasite composition reflects mechanical mixing of host rocks, chemical exchange with pore fluids, and mass transfer and volume loss. Oxygen isotope data suggests that the fault zone system was not fluid starved and that some isotopic exchange with the fluid occurred during deformation of the ultracataclasite. Of the various mechanisms proposed to explain the low strength of the San Andreas system and to produce dynamic weakening of faults, those that assume extreme localization of slip and restricted fluid flow appear most compatible with our observations.

Non-Technical Summary

Knowledge of how and why earthquakes occur is critical in our effort to reduce the loss of life and property as a result of natural hazards. The physical processes operating in fault zones leading to earthquake slip nucleation, propagation and arrest occur deep within the Earth's crust and can not be studied directly. One of the primary means of investigating earthquake faulting processes is through careful study of ancient faults that are presently exposed on the Earth's surface due to erosion of overlying material. We are using a variety of analytic techniques to study the earthquake process, with special attention being given to the mechanical and chemical interaction of pore fluid and rock during faulting. This field study provides information to guide future experimental and theoretical modeling efforts and to test current hypotheses of the faulting process. This and related work will ultimately provide a sound mechanistic understanding of the earthquake faulting process that will help us understand how and why earthquakes occur.