Stony Brook University
The Graduate School

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Abstract

Experimental Constraints on the Frictional Properties of Fault Zones Through the San Andreas Fault Observatory at Depth Scientific Drilling Project

By

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The mechanical behavior of a fault depends on the complex interaction between numerous parameters including composition, hydraulic properties, state of stress and the partitioning of strain between the country rock and gouge layer. One of the most important properties of the gouge is the coefficient of friction μ, defined as the ratio of shear stress to normal stress acting on the fault. In recent years a number of drilling projects have been conducted to retrieve core samples from seismogenic systems and systematic mineralogical characterization of core samples have underscored the pervasive occurrence of weak minerals in shear zones. I constrain the level of stress supported by a fault system based on laboratory measurements of the intrinsic strength of the fault materials and through modeling of fault zone pore fluid pressures. Friction experiments were conducted on materials derived at depth in the San Andreas Fault Observatory at Depth (SAFOD) borehole. A technique was developed to obtain meaningful mechanical data from drill cuttings and the data were used to construct a rheological profile of the country rock and faults penetrated by the SAFOD hole. It was observed that material strength was sensitive to mineralogical composition and the majority of the shear zones in the SAF system contained clay and hydrated phases. A systematic investigation into the frictional sliding behavior of quartz-montmorillonite-illite gouge mixtures was undertaken to elucidate the role of mineralogy on strength. As clay content was increased, the strength of the gouge decreased nonlinearly in two stages, which were manifested as the development of Riedel shear fractures and clay foliation. To constrain the pore pressures involved, I modified Rice's (1992) theoretical model for fault zone overpressure to allow for variable μ in the gouge and incorporate recent findings at SAFOD. Experimental data obtained at hydrothermal conditions on illitic fault gouge from a minor strand of the SAF, chrysotile and talc were used to set the μ of the gouge. On this basis, the pore pressures required to weaken the SAF would have to be sub-hydrostatic to 3 times the lithostatic stress.

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