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Review of evidence for a weak San Andreas Fault

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The hypothesis that the San Andreas Fault (SAF) is a weak plate-boundary fault is largely based on modelling of regional stress orientations and measurements of heat flow along the fault. Significant frictional heating should accompany slip on a fault with a coefficient of friction in the range 0.6-0.8 that is predicted from laboratory studies, and over time a band of high heat flow should develop over the fault trace. The absence of a detectable heat flow anomaly centered over the SAF in the heat flow data obtained from shallow boreholes provided the first evidence that the fault is weak. The original calculations of expected frictional heating assumed that heat flow in the crust is dominated by conduction. Heat flow measurements obtained to 3.5 km depth in the Cajon Pass scientific drillhole and to 2.2 km depth in the SAFOD (San Andreas Fault Observatory at Depth) pilot hole near Parkfield are consistent with a conductive thermal regime and show no evidence of frictional heating along the fault. Heat flow is not affected by faults and fracture zones that cross either the Cajon Pass hole or the SAFOD pilot hole at depth. Recent modelling studies conducted over a range of assumed permeabilities indicate that topographically driven groundwater flow would not obscure a heat flow anomaly generated along a strong fault in the Mojave Desert of southern California or the Parkfield area of central California. Model scenarios of frictional heating along a weak fault provide the best fit to the heat flow data in both areas.

The other main line of evidence for a weak SAF is that the regional maximum horizontal compressional stress (S_{Hmax}) is oriented nearly perpendicular to the strike of the fault, with relatively low shear stresses resolved on the fault plane. Stress orientations cited in support of a weak SAF in a strong crust include those obtained from hydraulic fractures, borehole breakouts in wells drilled to depths of 1-5 km, geologic structures such as the axes of young folds, and earthquake focal mechanisms. Considerable controversy does exist over the interpretation of many of the stress orientations obtained from inversion of earthquake focal mechanisms, especially in close proximity to the SAF where S_{Hmax} may – in some locations – rotate to make a more acute angle with the fault. Perhaps the most persuasive case for a weak SAF in a strong crust can be made from the stress orientation data for the roughly 300 km-long straight section of the fault in central California where there is no evidence for rotation in S_{Hmax} as the fault is approached, and it is supported by modelling of the stress measurements recently obtained from the SAFOD pilot hole.