Slip Partitioning and Regional Stress Fields from Geometrically Irregular Faults

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Oblique motion along bends in strike-slip faults typically results in a complex partitioning of slip onto a variety of faults with different senses of motion. Partitioning can be explained by the upward elastoplastic propagation of oblique slip from a fault or shear zone at depth. The strain field ahead of the propagating fault separates into zones of predominantly normal, reverse, and strike-slip faulting. We use an elastic approximation to plastic behavior to explain the distribution of faults observed along the San Andreas fault in California. This process has important implications for regional stress fields in areas where the strain is partitioned onto structures with different senses of motion. In particular, the notion of a partitioned stress field driven by slip at depth can be used to generate a realistic background stress field for models of Coulomb stress interactions.

Slip partitioning has also been observed in individual earthquake ruptures, most notably in the 2001 M=7.8 Kokoxili, China earthquake. The surface faulting in this event has been modeled using the static stress field from motion on a buried oblique slip fault. The static model successfully predicts the observed orientation of partitioned coseismic dip-slip and strike-slip faulting. The model also predicts the observed regions of surface fracturing where there are no coherent, colinear structures.

To further test the development of coseismic slip partitioning we use a dynamic 3-D finite element analysis to investigate rupture propagation on a branched fault system. The fault geometry is that of an oblique fault at depth that branches into vertical and dipping segments near the surface. We find that oblique slip on the basal fault results in partitioned slip on the near-surface faults, with more strike-slip motion at the surface trace of the vertical fault, and more dip-slip motion at the surface trace of the dipping fault. This result is in qualitative agreement with the static models. When slip on the basal fault includes a normal component, the preferred rupture propagation is upward to the vertical surface fault. Conversely, a thrust component of slip on the base fault results in preferred propagation upward to the dipping surface fault. Stress interactions within geometrically complex fault systems can lead to complexity in rupture propagation, including a crucial dependence on the direction of slip.