The Weak-Fault Problem and the Strength of the Crust

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ABSTRACT

The strengths of mountain belts and major faults have been notoriously difficult to constrain and there is ongoing debate over the controlling mechanisms and stress magnitudes. Here we show that the strengths of active thrust-belt wedges and their basal detachments can be directly determined from the co-variation of surface slope α with detachment dip β, without strong assumptions about the specific strength-controlling mechanisms. Even a single taper measurement (α, β) can strongly constrain the set of possible wedge and detachment strengths. This theory is tested with dry sand wedges and then applied to the Niger delta thrust belt, the active Taiwan mountain belt, the thrust that slipped in the M = 7.6 Chi-Chi earthquake and a number of submarine accretionary wedges. Their basal detachments are shown to be exceedingly weak, with effective coefficients of friction (0.04–0.1) that are an order of magnitude less than most laboratory friction coefficients (0.6–0.85). In contrast, these wedges are moderately strong internally, within the range of pressure-dependent strengths in deep boreholes. These results confirm the existence of exceedingly weak faults and strong crust, which raises important causal questions that are explored