Brittle faults are weak but the ductile middle crust is strong: implications for lithospheric mechanics

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A global compilation of shear stress magnitudes, determined using dynamically recrystallized grain-size paleopiezometry from mylonites along major fault zones, suggests that maximum shear stresses between 80 and 120 MPa are reached at temperatures between 300 and 350°C on normal, thrust, and strike-slip faults. These stresses are consistent with estimates of brittle rock strength based on Coulomb friction (e.g., Byerlee's law), and with in-situ measurements of crustal stress measured in boreholes. Many brittle faults in all tectonic regimes are considered to be relatively weak, however; peak shear stresses for active faults estimated by a variety of techniques lie in the range 1-50 MPa. The sharp contrast between shear stresses estimated on the seismogenic parts of major faults and those estimated from ductile shear zones immediately below the seismogenic layer has important implications.

1. The lower limit of seismicity in major fault zones is not controlled by the intersection of frictional slip laws on faults with ductile creep laws. Rather, it represents an abrupt downward termination, probably controlled by temperature, of the weakening processes that govern fault behavior in the upper crust.
2. In areas of active faulting, the upper crust contributes little to lithospheric strength. Conversely, ductile middle crust below the brittle-ductile transition deforms at high stresses, and forms a significant load-bearing element within the lithosphere. This zone loads the seismogenic layer, and exerts a strong control on both the location and slip rate of faults.