How Faulting Keeps the Crust Strong

Townend & Zoback

Prithvi Thakur

Paper discussion

Key Points

- Intraplate crust: critically stressed, hydrostatic pore pressure, high permeability.
- Observed friction coefficient = 0.6-1.0. The theoretical friction coefficient for brittle rocks is 0.6.
- Laboratory measurements show upto four orders of magnitude lower permeability than in-site borehole measurements.
- Critically stressed rocks are hydraulically conductive.

Key Points

- Characteristic diffusion rate for fluid transport in the upper 1-10km is 10-1000 yr.
- Intraplate crust is able to sustain higher differential stresses than would be possible if bulk permeability were sufficiently low to sustain fluid pressures higher than hydrostatic.

Discussion

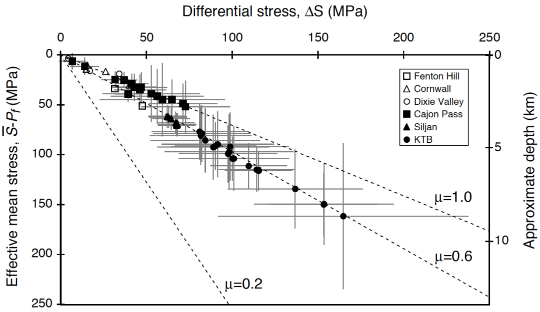


Figure 1. Dependence of differential stress, ΔS, on effective mean stress, $\overline{S} - P_f$, at six locations where deep stress measurements have been made. Dashed lines illustrate relationships predicted using Coulomb frictional-failure theory for various coefficients of friction, μ. References: Fenton Hill—Barton et al. (1988); Cornwall—Pine et al. (1983), Batchelor and Pine (1986); Dixie Valley—Hickman et al. (1997); Cajon Pass—Zoback and Healy (1992); Siljan—Lund and Zoback (1999); KTB (German Continental Deep Drilling Program)—Brudy et al. (1997).

Discussion

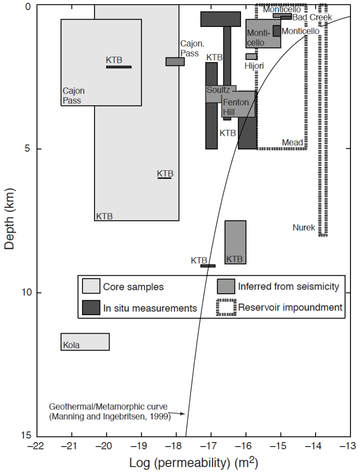
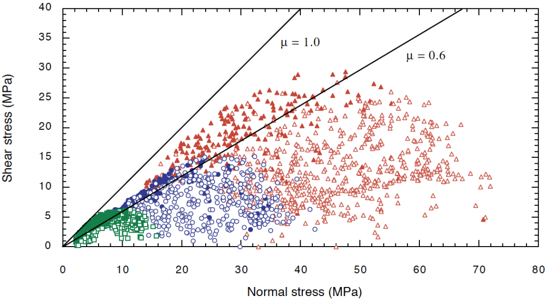


Figure 2. Deep crustal permeability data acquired from core samples, in situ hydraulic tests, and induced seismicity. References: core samples—Huenges et al. (1997), Lockner et al. (1991), Morrow and Byerlee (1988, 1992), Morrow et al. (1994); in situ measurements—Coyle and Zoback (1988), Huenges et al. (1997); seismicity data—Sasaki (1998), Shapiro et al. (1997, 1999), Zoback and Hickman (1982); reservoir impoundment data—Roeloffs (1988), Talwani et al. (1999); geothermal/metamorphic curve—Manning and Ingebritsen (1999). KTB—German Continental Deep Drilling Program.

Discussion

Figure 3. Shear and normal stresses on fractures identified with borehole imaging techniques in Cajon Pass (triangles), Long Valley (circles), and Nevada Test Site (squares) boreholes. Filled symbols represent hydraulically conductive fractures and faults, and open symbols represent nonconductive fractures. Original data are from Barton et al. (1995).



Discussion

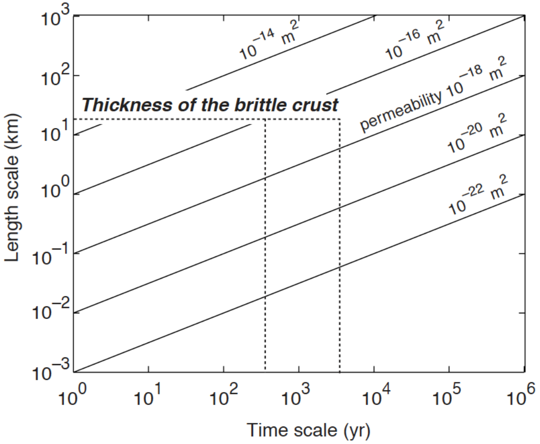


Figure 4. Length and time scales for diffusive fluid flow in rock masses of different permeabilities.

Questions and Discussions

- The depth measurements are shallow, we can talk about induced seismicity but not about most faults?
- High permeability would imply what in terms of pore pressure?
- What is the relation between differential stress and fluid pressure?
- Characteristic length scale of faulting?