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On the maintenance of high fluid pressures in large fault zones.

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In order to appeal to high fluid pressures to explain the inferred weakness of large fault zones such as the San Andreas fault, whilst the surrounding crust is strong and not overpressured by pore fluid, a low permeability fault rock seal required to inhibit leakage into the country rock. At the same time, a higher along-fault permeability is required to keep pore pressure replenished by input from depth. Typically this implies a fault zone permeability anisotropy of at least 3 orders of magnitude. Pure clay fault gouge cannot produce this degree of anisotropy from mechanical orientation of platelets alone.

We have undertaken geological mapping in the Carboneras Fault Zone (CFZ) of S.E. Spain as a potential analog for some large fault zones. It has several tens of km of left lateral offset, and comprises a series of anastomosing bands of clay-rich fault gouge, tens of metres wide, enclosing elongate lenses of fractured country rock. We measured the permeability (and its anisotropy) of intact samples of clay-rich gouge using both water and argon as pore fluids, at a constant pore pressure of 40 MPa and with total confining pressures ranging up to 200 MPa. We also evaluated the influence of temperatures up to 180^{o}C and of sub-yield differential stresses. For flow nomal to foliation, permeabilities were as low as 10^{-21}m^{2}, and typically 3 orders of magnitude higher parallel to foliation. SEM microstructural study showed that the high anisotropy is due to the fact that the gouge is banded on a fine scale, with clay-rich layers containing well-oriented and compact phyllosilicate grains, alternating with granular cataclasite layers that provide the high hydraulic conductivity parallel to the foliation. The experimental data allow extrapolation of the effects of effective pressure and temperature

over the depth range of upper crustal faulting.

The permeability normal to the foliation is sufficiently low to inhibit leakage over geologically significant time periods provided there is some replenishing fluid input from depth. This means it is in principle possible to appeal to high pore fluid pressures as a weakening agent for fault zones that have the type of banded structure and fault gouge band thicknesses seen in the CFZ, but not with simpler fault zones comprising a single, central gouge zone bounded on each side by wider zones of cataclasite.

Unlike intraplate fault zones, large plate-boundary faults must transect the crust and extend into the upper mantle, and are able to tap fluids from mantle sources. This is probably necessary to maintain the small, but continuous, fluid flux needed to maintain high intra-fault fluid pressures.