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Comparison of the mechanical properties of seismogenic fault gouge from extensional, strike-slip, and compressional fault zone drilling

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Fault gouge recovered in the deeper section of plate boundary faults and other major extensional and strike-slip tectonic lineaments has undergone ring shear testing under water-saturated conditions (up to 25 MPa effective normal stress). Experiments served to solve the longstanding question whether low sediment friction is sufficient to explain movement along these sutures, or whether high transient pore-pressure is required to make the fault slip. Materials tested included (apart from mineral standards) marine sediments and gouge material from deep-sea drilling off Costa Rica, Japan, Barbados (all thrust faults), and off Papua New Guinea (Woodlark Basin), as well as continental drilling such as SAFOD/California (strike-slip), Chelungpu/Taiwan (compressional), or the Corinth rift/Greece (extensional). Data are complemented by gouge from onshore outcrops which were exhumed from seismogeneic depth (e.g. Nobeoka thrust fault/Japan). Results suggest that friction coefficients along major low-angle faults (decollements off Costa Rica, Nankai, Barbados; normal detachment in the Woodlark Basin) are sufficiently low (between 0.1 and 0.2) to explain movement along these faults, even at near-hydrostatic pore fluid pressures. Higher friction coefficients around 0.25-0.3 were encountered during shear tests of gouge from the San Andreas Fault, the Chelungpu fault zone in Taiwan, or Nobeoka FZ/Japan, where alteration by fluids appears to have been less effective. In these latter scenarios, excess pore pressures - e.g. due to pre-seismic stress variations at depth - may be required to overcome frictional strength and cause earthquake rupture.