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Mechanical properties of the shallow Nankai Trough accretionary sediments

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We report the results of triaxial compression and friction experiments of clayey mudstone, silty mudstone, sandstone and tuff samples, which are cored from the shallow (1000-1500 mbsf) Nankai Trough accretionary prism at IODP Sites C0002 and C0009, at room temperature, and confining pressures and pore water pressures close to their in situ conditions.

Triaxial compression experiments at these conditions and an axial displacement rate of 10 μm/s reveal that the failure strength is ≈300 MPa for a sandstone sample, ≈48 MPa for a tuff sample, ≈20 MPa for a silty mudstone sample, and ≈14 MPa for a clayey mudstone sample. The sandtone, tuff and silty mudstone samples failed relatively rapidly within 20 s, while the clayey mudstone sample failed slowly for ≈40 s. Another silty mudstone sample did not fail, and deformed ductilely at a strength of ≈15 MPa. The sandstone sample is strongly lithified by being cemented by calcite, which makes this sample's failure strength very high. The ductilely deformed silty mudstone sample seems not lithified enough to fail. A probable increase in pore pressure during compression of the clayey mudstone sample due to its low porosity (≈11 %) and permeability (≈10^{-19} m^2) in addition to its intrinsic weakness due to the abundance of clay minerals (≈42 wt%) likely makes this sample weak and promotes its slow failure. Such failure in clayey mudstone is a possible source for slow slip events observed in the shallow Nankai Trough accretionary prism.

Friction experiments at these conditions and axial displacement rates changed stepwise among 0.1, 1 and 10 μm/s reveal that frictional properties of these samples change systematically according to the content of clay minerals. The content of clay minerals is ≈6 wt% in the sandstone sample, ≈17 wt% in the tuff sample, 29-34 wt% in the silty mudstone samples, and ≈42 wt% in the clayey mudstone sample. Steady-state friction coefficient at the axial displacement rate of 1 μm/s decreases with increasing content of clay minerals, from 0.87 of the sandstone sample, through 0.71 of the tuff sample and 0.53-0.56 of the silty mudstone samples, to 0.25 of the clayey mudstone sample. Slip-dependent frictional behavior also changes from slip hardening to slip weakening with increasing content of clay minerals. Although all samples exhibit velocity-strengthening behavior upon stepwise changes in sliding velocity, the ratio of $(a - b)$ value to the velocity dependence of steady-state friction decreases with increasing content of clay minerals, which implies that the friction component decreases while the flow component increases accordingly. Thus, faulting in the shallow Nankai Trough accretionary prism is likely controlled by the content of clay minerals in sediments as well as in fault zones.

Keywords: Nankai Trough, accretionary sediments, failure properties, frictional properties