Frictional properties of accretionary sediments/rocks and their implications for the transition of aseismic to seismic faulting at the Nankai Trough Subduction Zone

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In order to examine the shallow transition of stable aseismic to unstable seismic faulting along the megathrust at the Nankai Trough subduction zone, which is estimated to occur at temperatures of 100–150°C, we conducted triaxial friction experiments on the following samples at effective confining pressures of 12–120 MPa and temperatures (*T*) of 50–200°C, and at displacement rates (*V*) changed stepwise among 0.1155, 1.155 and 11.55 μm/s. We used accretionary mud, incoming basalt and sand, and subducting chert samples collected from the Nankai Trough and the Japan Trench for experiments at *T* ≦100°C, while mélange mudstone, sandstone, basalt and chert samples collected from the Shimanto belt in Eastern Shikoku for experiments at *T* ≧150°C. We then fitted the friction data for each step change in *V* by the rate- and state-dependent friction constitutive law, and obtained the optimized (*a* − *b*) value, i.e., an indicator of frictional stability, at each *V*.

The results show that steady-state friction coefficient μ_{ss} decreases with increasing content of clay minerals at *T* ≦100°C, while such tendency becomes weak at *T* ≧150°C. For a given sample, μ_{ss} decreases with increasing *T* from 50°C to 100°C, while it increases with increasing *T* from 150°C to 200°C, the amount of which tends to be greater for samples with larger amounts of clay minerals.

Our results also show that (*a* − *b*) value tends to increase with increasing content of clay minerals at *T* ≦100°C, whereas (*a* − *b*) value tends to decrease with increasing content of clay minerals at *T* ≧150°C. The former is attributable to the stabilizing effect of clay minerals, while the latter is possibly due to the effects of dissolution–precipitation creep favored at lower *V*s and in the presence of clay minerals. For a given sample, (*a* − *b*) value tends to decrease with increasing *T*, which is also likely due to the effects of dissolution–precipitation creep favored at higher *T*s or lower *V*s.

(*a* − *b*) value is positive for all samples at 50°C. At 100°C, (*a* − *b*) value is still positive for mud, while it is ≈0 for basalt and negative for chert. Then (*a* − *b*) value is negative for most samples at ≧150°C, and all samples exhibited stick-slip at 200°C. Thus in all types of sediments/rocks faulting is stable and aseismic at 50°C, while unstable and seismic at 200°C, demonstrating the shallow transition of aseismic to seismic faulting along the megathrust with increasing *T*. Our results also show that the transition *T* is different among different types of sediments/rocks. The transition *T* increases with increasing content of clay minerals from <100°C for chert with a trace amount of clay minerals, through ≈100°C for basalt with a moderate amount of clay minerals, to >100°C for mudstone with a significant amount of clay minerals.

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