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Frictional healing of the Nankai frontal thrust and megasplay fault - Bridging the gap between laboratory and in-situ data

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The Nankai Trough subduction zone hosts a wide spectrum of slip behavior, from slow slip events to megathrust earthquakes. Recent studies documented shallow recurring slow slip events at the Nankai Trough subduction megathrust fault; these events occur every 8 to 15 months, releasing accumulated elastic strain energy.

This study used slide-hold-slide (SHS) experiments in a ring shear device to investigate fault restrengthening (or "healing") for the megasplay and the frontal thrust faults (IODP Sites C0004 and C0007) along the Kumano transect. For both fault zones, saturated samples were tested under 4 MPa effective normal stress at room temperature and humidity. We employed hold times from 10 – 10e6 seconds and two different shearing velocities (10 and 0.01 μm/s). These loading velocities are chosen to represent the slip velocities of previously documented very low-frequency earthquakes and slow slip events in the subduction zone. To study the time-dependent restrengthening of faults in a laboratory setup, the SHS experiments are commonly employed as an analogue for the seismic cycle. Our study is designed to bridge the gap between laboratory and in-situ derived healing rates between repeated slow slip events.

Our data show that the megasplay fault heals faster than the frontal thrust fault. When a log-linear fit is applied to our data, we see that the healing rates in the megasplay fault are $\sim$2.5 times larger than in the frontal thrust fault at the higher velocity, and 5 times larger at the lower velocity. We observe that higher shearing velocity correlates with increased frictional healing and creep. The megasplay fault exhibits log-linear healing rates 25 times higher at 10 μm/s than at 0.01 μm/s. In contrast, the frontal thrust fault shows a log-linear healing rate 2 times greater at the higher shearing velocity. In addition to the standard log-linear law we also applied an alternative power-law fit to our data that accounts for accelerated healing. Both healing laws produce good fits with R2 of 0.9 – 0.97. The 10 μm/s SHS experiments are well-described by both laws, whereas the 0.01 μm/s experiments are significantly better described by the power-law fit. Therefore, at the slower velocity advanced fault healing is expected at larger hold times. Moreover, we speculate that slow slip events on the megasplay fault would recur more frequently than on the frontal thrust fault due to higher healing rates.

Ongoing work includes derivation of in-situ healing rates in between consecutive slow slip events from geodetic and long-term borehole measurements, which we will compare with our experimental data set.