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Monitoring Frictional Strength with Acoustic Wave Transmission

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In order to examine the relationships between frictional strength and amplitudes of elastic waves transmitted across frictional interfaces, the amplitudes of longitudinal and shear waves transmitted across interfaces between granite samples during frictional experiments were measured. The amplitude increases proportionally to the logarithm of quasi-stationary contact time and decreases with slip displacement during reloading after quasi-stationary contact. These changes of amplitudes are similar to healing and slip weakening of the frictional strength generally observed in frictional experiments. During steady-state sliding of the frictional interfaces, the amplitude is proportional to the logarithm of reciprocal of the sliding velocity. This behavior is consistent with the change of the frictional strength expected in rate- and state-dependent friction law. These changes of amplitudes are observed with both longitudinal and shear waves, and there is no qualitative difference between them. We inferred the frictional strength with rate- and state-dependent friction law and compared it with amplitudes of elastic waves. The relationships between inferred frictional strength and amplitudes of elastic waves are quantitatively same for changes of frictional strength by different causes under constant normal stress, although the relationships are different between normal stress change and the other changes under constant normal stress. This result is consistent with the concept of rate- and state-dependent friction law that the change of contact state under constant normal stress depends on time-dependent healing. It is known that frictional strength depends on real contact area and amplitude of elastic wave depends on not only real contact area but also size distribution of real contacts. The difference between relationships between inferred frictional strength and amplitudes of elastic waves suggests that the ways real contact area increase are different between normal stress change and the other changes under constant normal stress.