

Temporal variations of reflected and transmitted wave during a slide-hold-slide experiment on a biaxial friction testing machine

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Slow slip events (SSEs), which is one of the slow earthquakes differing from regular earthquakes, have been detected at both shallower and deeper portions of the seismogenic zones, such as Japan and New Zealand. We carried slide-hold-slide experiments with gouge layer under a slip velocity of an SSE using a biaxial friction testing machine under the condition with the temperature and the humidity of room. We measured temporal changes of acoustic impedance in the gouge layer with reflected and transmitted wave during slides and holds. As a result, we detected variations in travel time, amplitude, and cross-correlation coefficient on first arrival of reflected and transmitted wave.

The features of observed waveforms were classified clearly by a slide-hold-slide conditions into two categories: sliding and holing. We chose two materials as gouge powder, which were clay mineral (Ca⁺ montmorillonite) and quartz. Regardless of the kinds of the gouge powder, the amplitude both of reflected and transmitted waves showed opposite temporal variation during the slide-hold-slide sequences; the amplitude of transmitted wave decreased during slides and increased during holds, respectively. This suggests that the amplitudes of reflected and transmitted waves indicate a change of an elastic-wave speed in the gouge layer.

The travel times of transmitted waves increased during slides and decrease during holds. According to Birch (1961), a propagation speed of elastic waves normally decreases as the density of media decreases, or as the porosity increases. Increasing travel times of transmitted waves in our experiments may indicate the change of the density, or porosity in the gouge layer. Although the travel times of reflected waves decreased during slides and increased during holds in the case of clay mineral, the travel time on quartz powder did not change through our experiment.

The temporal change on correlation of observed transmitted wave also shows significant changes from a slide to a hold. The change of travel time, the amplitude, and the cross-correlation coefficient of transmitted waves were more sensitive to a slide-hold-slide condition, such as slip rate on the gouge later than those of reflected wave. Those result suggests that a transmitted wave is more suitable for monitoring SSE although a reflected wave is also useful for monitoring, and that a beginning and an end of an SSE can be detected by reflected and transmitted waves.

Keywords: slow slip event, biaxial friction experiment, gouge