Characteristics of Foreshock Activities Preceding the Main Rupture Observed on a 4m-long Laboratory Fault

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We report some experimental results of foreshock activities associated with evolving local slow slip events preceding the main rupture on a laboratory fault. To investigate the preparation process of laboratory earthquake with enough spatial resolution, we used a large-scale friction apparatus newly developed and installed at NIED as shown in Figure 1. As experimental specimens, we used two rectangular metagabbro blocks, whose nominal contacting area was 4.0 m long and 0.1 m wide. Normal load was applied by eight flat jacks on the top surface of the upper specimen, and the associated pressures were kept at around 6 MPa during the experiments by closing each oil circuit. After applying normal load, we applied shear load by manually pumping up a hydraulic jack, which was fixed at the western end of the apparatus. To monitor local phenomena on the fault, we installed 16 AE sensors (Olympus V103-RM), 40 triaxial rosette strain gauges (Kyowa SKS-30282), and 10 eddy current displacement sensors (Shinkawa FK-202F) along the fault. Because of the effective range of eddy current displacement sensor, the total amount of displacement during one experimental run was limited within 2 mm.

Here we investigate two experiments FB02-006 and -008 with relatively high shear loading rate (67-185 kPa/s) as well as two other experiments FB02-007 and -010 with relatively low loading rate (2-7 kPa/s). In each experiment, we focus on the last seven stick-slip events just before the total amount of displacement reached 2 mm. The displacement data showed that both the eastern and western edges of the fault kept slipping during the shear loading, though the slip rate was very low ($< \sim 20$ μm/s). It is consistent with FEM calculation that fault should start to slip at both edges in this configuration. This steady slip was significant during the experiments with low loading rates, in both quantity and area. However, the steady slip did not immediately induce foreshocks; most of the foreshocks were observed just before the main rupture. With approaching the main rupture, we could observe foreshocks even within the steady slip area, which suggests that foreshocks need some amount of slow slip and/or slip rate to occur. Such foreshocks occurred in isolated patches and the onset of AE waveforms looked evident. In the next stage, nucleation started at the locked area, precursory slow slip propagation accelerated, and then many foreshocks started to occur continuously and simultaneously within the nucleated slipping area, which caused an overlap of AE waveforms. These observations suggest that spatiotemporal evolution of slow slip and background loading rate strongly control the style of foreshock activities.

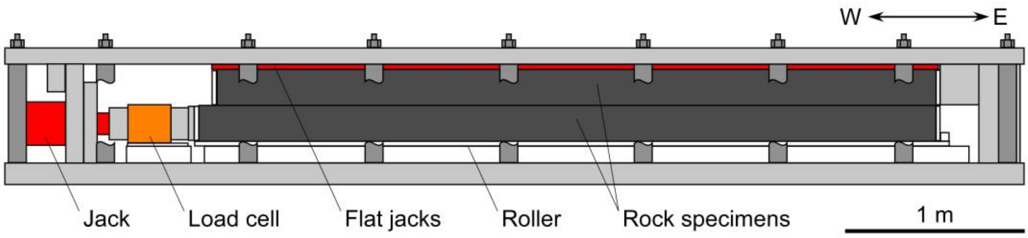

Figure 1. Schematic diagram of newly developed apparatus at NIED