Effect of fault surface evolution on slow slip behaviors in large-scale biaxial experiments

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To investigate the preparation process preceding the main fast rupture under more realistic condition, we conducted stick-slip experiments using large-scale biaxial friction apparatus at NIED in Tsukuba, Japan. We used two rectangular metagabbro blocks as specimen, whose contacting area was 1.5 m long and 0.1 m wide. The experiments were repeatedly conducted with same pair of specimens, which means the fault surface evolved with the frictional slip. We successively conducted a set of three experiments under the condition of constant normal stress of 6.7 MPa and loading rate of 0.01 mm/s. All wear materials were collected after each experiment. To artificially accelerate fault evolution from one stage to the next, we applied fast loading with long slip displacement between a set of three experiments. As a result, we obtained three sets of the experimental result in different evolutional stages I, II and III; one and two fast-loading processes mentioned above were performed before the experimental sets in Stage II and III, respectively. In all experiments, we observed many stick-slip events, the number of which tended to increase with the maturity of the fault. Local strain array also showed slow propagation of shear stress drop, which was derived from slow slip before the main rupture. We found that the occurrence location of slow slip and its occurrence time relative to the main rupture, depend on the stage of fault evolution. In Stage I, both the temporal and spatial distributions of the slow slip occurrence were mono-modal, whereas a variety of occurrence times were observed in Stage II and III. The occurrence locations in Stage I and II look consistent with the initial normal pressure distribution on the fault, which was estimated from pressure sheet measurements (Fujifilm PRESCALE LW) just before each experiment; slow slips started to propagate from the location where the initial normal pressure is at a local minimum. On the contrary, we cannot find such clear relationship in Stage III, though some of the occurrence locations look related to the distribution of wear material generated with the frictional slip. These results suggest that the fault surface evolution may increase the complexity of slow slip behaviors.

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