Strength recovery of fault gouge gauge under fluid flow condition

*Yohei Hamada[1], Takehiro Hirose[1], Wataru Tanikawa[1]

1. Japan Agency for Marine-Earth Science and Technology Kochi Institute for Core Sample Research

The geofluid is considered to play a major role in the occurrence of earthquake including slow slips. Water is abundant inside the crust and flows universally along cracks, pore, and faults. Due to the physical-chemical interaction between fluid and rock, the strength of the fault changes with time. Here, we conduct laboratory friction experiments in order to verify the hypothesis that the flow of water suppresses the increase of fault strength (strength recovery).

The strength of the fault decreased sharply during an earthquake. It recovers during inter seismic period after the earthquake and becomes possible to store energy for the next earthquake. The mechanism of the strength recovery the fault during the “hold” period is that the microscopic contact area (asperity) on the fault surface adheres due to water-rock interaction such as pressure solution and increase of the real contact area. Does the asperity growth occur in a fluid-flow environment as well? To answer this question, we performed slide-hold-slide test under condition of water flow (flow SHS test) using a fluid pressure controlled rotary shear apparatus installed in JAMSTEC Kochi.

Indian sandstone crushed to 125-250 μm was used as a simulated fault gouge, and the flow SHS test was performed under the condition of flowing water at a flow rate of 0.0cc/min and 0.6 cc/min to compare the strength recovery rate. The experiment was conducted under the conditions of a slip velocity of 5 μm/s, a normal stress of 3 MPa, a water pressure of 0.3 MPa, and a hold time of 2 seconds to 12 hours.

In case of without the flow, the frictional strength recovered in proportion to the logarithm of time, as in previous studies (e.g. Dietrich, 1972). On the other hand, the frictional strength did not almost recover in the presence of flow. The water pressure tended to gradually increase with the hold time. When the strength recovery is expressed by the effective friction coefficient, the increase rate of the friction coefficient was almost the same as that when there was no flow.
As comparison experiments, we also conducted the same experiments using ceramic ball (300 micron) that does not easily react with water, and the same result was obtained. The fact that the fault strength does not recover in flow SHS experiments is thought to be since the flow suppresses the growth of asperity inhibiting water-rock reaction in the contact area, or because the increasing contact area induced buildup of fluid pressure, which may prevent the strength recovery.

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