Frictional property of rocks in the Izu forearc: implications for the Boso slow slip events

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As different from the Nankai and Tohoku subduction zones, island-arc components composing the Izu arc subducts beneath the Kanto region. The collision and subduction of the Izu arc into the Kanto region could result in occurring the different type of earthquakes, including seismic slip (e.g., the 1923 great Kanto earthquake) and aseismic creep (i.e., the Boso slow slip events). Based on a source location map of the Kanto earthquake and the Boso SSEs (e.g., Hirose et al., 2014), the seismic and aseismic slip at the Kanto region seems to generate side by side at almost same depth, probably nearly same P-T conditions. We thus hypothsis that the different types of slips arise from different materials of the Izu arc.

To address this hypothesis, we have performed friction experiments on five types of rocks from the Izu forearc at temperature of 300oC (nearly seismogenic condition), confinig pressure of 156 MPa and fluid pressure of 60 MPa using a high P-T gas medium apparatus at AIST. Rock types used in this study were marl, boninite, andesite, antigorite and chirysotile serpentinites that were recoverd by Leg 125, Ocean Drilling Program from the Izu forearc. Considering the direction of plate motion, igneous rocks composing the arc is expected to be subducted into the hypocentral area of the Kanto earthquake, while serpentinite appeared as a diaper in the forearc is to be subducted into the area where the Boss SSEs occur. In the experiments, we fixed the temperature and pressure conditions to investigate the difference in slip behavior between the rock types.

In the experiments we conducted velocity-stepping tests at slip rates of 0.1-1 μm/s. At the experimental condition, serpentinites exhibited velocity strengthening behavior. In contrast, marl, boninite and andesite characteristically showed a periodic stick-slip behavior. Slip duration of the stick-slip events was an order of seconds, three orders of magnitude longer than the ideal slip duration of stick-slip event as expected from the stiffness and mass of the apparatus. We thus called such slip behavior as “slow stick-slip”. Linear relationship between the slip duration and the stress drop of slow stick-slip hold for the observed slow stick-slip events, except for the event of marl sample of which the relationship shifted from linear to cubic with displacement. The linear relationship between the duration and the stress drop is consistent with that between the duration and the seismic moment of slow earthquakes in nature (Ide et al., 2007), as the stress drop is proportional to the seismic moment. The result implies that the Boso SSEs may be hosted by igneous rocks (e.g., boninite or andesite) composing the Izu arc, rather than serpentinite which is often considered as a source material for slow earthquakes. However the result should be taken carefully, because whether slow sticks-slip occurs or not depends on the balance between the stiffness of fault surrounding mdedium and the critical stiffness which is defined by effective normal stress and friction parameters of fault materials. To connect the slow stick-slip observed in laboratory with slow earthquake in nature, it is necessary to consider the coupling between the stiffness components.

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