Deep slow earthquakes along the subducting plate and fluid

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In southwest Japan and Cascadia, deep slow earthquakes including the slow slip event frequently occur at the interface between the subducting oceanic plate and overlying plate. These deep slow earthquake phenomena occur periodically in the transition zone between the seismogenic zone and deep stable sliding zone. The occurrence of slow earthquakes might be related to the existence of fluid, cycle of fluid in the subduction zone and subduction process. In this paper, we discuss the characteristics of deep slow earthquakes and relation to fluid.

At present, there are three types of deep slow earthquakes which occur in the transition zone on the subducting plate boundary; low-frequency tremor predominant in a frequency of around 2 Hz, very-low-frequency earthquake predominant in a period of 20 seconds, and the short-term slow slip event with duration of a several days. These slow earthquakes are characterized as a spatiotemporal cluster activity. In each segment region, these occur periodically at a regular interval. The episodic slow slip event is always accompanied by very active tremor with clear migration and occurrence of very-low-frequency earthquake. On the other hand, the episode of minor tremor activity is not associated with detection of the slow slip event because the crustal deformation caused by the minor slow slip event does not exceed the noise level. Basically, these three types of slow earthquakes always occur simultaneously. The focal mechanisms of these slow earthquakes are all thrust type according to the geometry and motion of the subducting plate. Therefore, these are a kind of stick slip process like as the megathrust earthquake.

These slow earthquakes occur at the depth of 30 km, where the metamorphism is processed within the oceanic crust and accretionary sediment material dragged with the subducting plate. The metamorphism needs fluid. Inside the oceanic slab, dehydration process can release fluid, which is transported to the plate interface and brings the mechanical instability to the interplate coupling, then trigger the slow earthquakes and metamorphism. Shelly et al.(2006) estimated the high Vp/Vs oceanic crust just beneath the tremor source in western Shikoku. Matsubara et al.(2008) obtained the low-velocity and high Vp/Vs mantle wedge just above the tremor source. Both tomography results indicate that the rich fluid exist around the tremor source. The belt-like tremor source zone is not homogeneous and there are some gaps like as Ise bay and Kii Channel. This gap might be related to the configuration of the subducting Philippine Sea plate (Shiomi et al., 2008) and/or fluid amount due to the difference in dehydration process in the slab.

Based on the comparison in magnitude of these slow earthquakes, the short-term slow slip event as the interplate stick slip process, which periodically releases the stress accumulated by constant plate convergence, should be the primary phenomenon. Deep low-frequency tremor and very-low-frequency earthquake are considered as failure of the micro crack or small patch on the fault plane triggered by the transient slow slip. Once the slow slip event occurs, the dehydration process is reactivated due to the generation of pore by slip failure. Then, increase of the pore fluid pressure due to increase of the super critical fluid makes weakening of the fracture strength. Moreover, highly pore fluid pressure liberated in the slab by dehydration process makes weakening the strength in the oceanic crust. This might cause the underplating process, which is one candidate of the occurrence mechanism of the slow earthquake.