Low-frequency seismic phenomena relating to the subduction process in southwest Japan

Kazushige Obara[1]

[1] NIED

Densely distributed seismograph networks operated by NIED contribute to improvement in the detection capability for seismic phenomena and discovery of new observational facts. Especially, in southwest Japan, some low-frequency seismic phenomena relating to the subduction process of the descending Philippine Sea plate have been discovered. One is the non-volcanic deep tremor which occurs at the deeper extension of the asperity (Obara, 2002). The active tremor is usually associated with short-term slow slip event. On the other hand, very low-frequency (VLF) earthquakes in the accretionary prism on the land side of the Nankai trough have been detected by broadband seismograph network. In this paper, characteristics of these low-frequency seismic phenomena are reviewed.

Non-volcanic deep tremors are distributed in a narrow belt along the depth contour line of 30km of the subducting plate boundary with a length of 600km from southern Nagano prefecture to the Bungo channel. Similar seismic event, which is deep low-frequency (DLF) earthquake, is often observed at the depth of Moho beneath volcanoes and active fault systems. They have relatively clear P and S wave and long duration coda wave with a predominant frequency of 2 Hz. On the other hand, the signal of the tremor is random wave train with wide frequency range from 1.5 to 5 Hz. The non-volcanic tremor lasts for many days with the amplitude smoothly changing. The belt-like tremor activity is separated into some groups. The active tremor occurs with a recurrence interval of 6 months associated with the short-term slow slip event. The slow slip event has time duration of 2-5 days, which is much shorter than that of the Tokai slow slip detected by GPS. The source of the tremor and short-term slow slip event usually migrates with a speed of 10km/day along the strike of the slab. During the migration, the tremor energy release has a periodicity of 12 hours which might be affected by the earth tide. Minor tremor activities frequently occur without any crustal movement. Sometimes, minor tremor is triggered by local earthquakes or teleseismic waves. These triggering phenomena are important in order to resolve the mechanism of the tremor.

The relationship between the tremor and slow slip is still unresolved. The DLF earthquake and tremor might have a similar mechanism because of common features in the source depth and frequency content of seismograms. For example, the low-frequency seismic wave is generated by the crack failure with low stress drop due to the existence of fluid under a certain temperature condition. The difference in the volume of available fluid and the crack density may be responsible for the different durations and activity for tremors and DLF earthquakes. In the tremor source area, it is expected that cracks will be well developed due to the underplating along the subducting plate interface and the metamorphism. Dehydration of the subducting oceanic plate also will release large volumes of fluid.

VLF earthquakes along the Nankai trough excite only the surface wave with a predominant period of 10 seconds. In some cases, small amplitude body wave is detected and the spectral analysis estimates the stress drop of 1 % compared to the ordinary earthquakes. The focal mechanism of these earthquakes is the reverse fault type, which corresponds to the result from reflection survey. These reverse fault system is considered as the fluid path route. Therefore VLF earthquakes occur by the fault dislocation with a low speed of slip velocity due to the existence of unconsolidated materials with fluid on the fault plane. Just after the southeastern off Kii-Peninsula Earthquakes on September 5, 2004, active swarm of the VLF earthquake occurred on the aftershock area. This swarm activity might occur by chain-like deformation at the reverse fault system due to the instability inside the accretionary prism caused by the strong motion or fluid circulation.