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南海トラフプレート境界域のダイナミクスと応力状態の海底観測・監視を目指して
Seafloor monitoring for dynamics and stress state of the seismogenic plate interface in the Nankai Trough

荒木 英一郎 [1*] ; 木村 俊則 [1] ; 町田 祐弥 [1] ; 高江洲 盛史 [1] ; 三浦 誠一 [1] ; 高橋 成実 [1] ; 中野 優 [1] ;
小平 秀一 [1]
ARAKI, Eiichiro[1*] ; KIMURA, Toshinori[1] ; MACHIDA, Yuya[1] ; TAKAESU, Morifumi[1] ; MIURA, Seiichi[1] ;
TAKAHASHI, Narumi[1] ; NAKANO, Masaru[1] ; KODAIRA, Shuichi[1]

[1] 海洋研究開発機構　地震津波海域観測研究開発センター
[1]CEAT, Japan Agency for Marine-Earth Science and Technology

Stress and pore-fluid pressure are considered to be key parameters governing behavior of seismogenic plate interface. Direct observation of these parameters is difficult, but we are trying to establish seafloor observation techniques that let us infer these parameters at the seismogenic plate interface in the Nankai Trough, south of Japan.

In the Nankai Trough, we started development of real-time seafloor observation network (called DONET) since 2010. The network aims monitoring of seismic activity in the seismogenic subducting plate boundary in the Nankai Trough where repeated occurrence of large earthquakes in the history. The DONET will distribute more than 50 observatories in the rupture area of Tonankai and Nankai earthquakes. Currently, the network is continuously monitoring micro earthquakes and very low frequency earthquakes in the vicinity of them with 20+ sites. This enables us to look into stress state and its temporal change in the crust through their mechanisms. Very low frequency events were observed below the DONET network after off Tohoku events in March, 11, 2011 (Toh et al, 2011). We consider monitoring of such events is very important to know current status of the interface in preparation for the next earthquake.

The DONET observatories are also monitoring seafloor water pressure using Quartz pressure gauges, which are able to detect seafloor level change as small as 1 cm. We plan to use the networked seafloor pressure observation to detect crustal deformation due to slip in the plate interface. As the pressure gauge has instrumental offset drift in long-term, it is currently difficult to evaluate small ground deformation using pressure data over month period, but we are developing techniques to calibrate seafloor pressure gauge to compensate effects of the instrumental drift so that we can identify long-term change of the seafloor level as small as 1 cm also in such long-term. When such techniques are developed, we expect to identify where in the subducting seismogenic plate interface accumulate slip deficit for the next large earthquake.

We consider pore-fluid pressure near the plate interface may control slip in the plate interface. Observation of pore-fluid pressure in the crust is already in practice using seafloor boreholes drilled in scientific drilling programs (ODP Leg 196, and IODP expeditions 332) here in the Nankai Trough. Existing borehole pore-fluid pressure observations in the Nankai Trough, are reaching up to 1 km below the seafloor. Therefore, it is very effective way to observe pore-fluid pressure in seaward end of the plate interface, but in deeper interface where seismogenic slip occurred in the last large earthquake in the Nankai Trough, existing technology is still out of reach to the interface itself and we need to develop deep borehole observatory penetrating it in the future.

Monitoring characteristics of seismic waves traveling near the target seismogenic plate interface may provide another way to estimate stress state and pore-fluid pressure. Brenguier et al., (2014) suggested that the crustal seismic wave velocity would have strong relationship with status of pore-fluid in crust. Seismic anisotropy is also known to indicate background stress state. We were encouraged from these facts to conduct a series of experiments to observe characteristics of seismic wave velocity in the Nankai Trough seismogenic plate boundary and its temporal change using the DONET and borehole observatory. Using airgun seismic source and the network of seismometers, seismic velocity of the crust is measured precisely. By repeating, we expect to identify its change. To begin with, we conducted an airgun shooting cruise in March, 2013 to survey anisotropic structure of the area, confirming observed seismic anisotropy around IODP site C0002 in accordance with known stress from borehole breakout. Next experiment is planned in March, 2014 to evaluate our ability to identify change in seismic velocity.

Keywords: seafloor observation, seismogenic zone, stress, seismic anisotropy, temporal change, borehole