Active and passive seafloor electromagnetic monitoring using off-Toyohashi submarine cables

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Existence of fluid on seismogenic faults has a key role on occurrence of great earthquakes because high pore pressure in a fault zone allows sliding at low shear stress. Electromagnetic (EM) surveys have revealed electrical conductivity structure around seismogenic zones with great earthquakes because enhanced electrical conductivity at subsolidus temperatures is principally controlled by the presence of water. Kasaya et al. (2005) suggest less fluid condition in the asperity of the 1944 Tonankai Earthquake along the Nankai trough. However, there is no information how fluid can act on occurrence of great earthquakes: for example, whether highly-pressurized deep fluid moves into seismically locked zones and reduces strength of locked zones rapidly or not.

One of the best ways to test such hypothesis is electromagnetic monitoring around seismically locked zones. Here, we introduce an observation project named Tokai-SCANNER: Tokai Submarine Cabled Network observatories for Nowcast of Earthquake Recurrences. The system just has been constructed on April, 2007 on the Tokai region, Japan, where a locked plate boundary on the subducting Philippine Sea plate is clearly recognized (Sagiya, 1999). In addition, a slow slip on the plate boundary is recently found (Ohta et al., 2004). Such a slip makes a stress concentration near the boundary between the locked and slipping zones, so that the boundary region has a potential of an initial rupture of the next Tokai earthquake. The Toyohashi cables, originally installed and maintained by KDDI, are located on both the locked and slipping zones of the Tokai region. This cable was transferred to JAMSTEC in 2006, and can be used for a best facility to monitor physical properties of the plate boundary.

The details of the scientific observation at the Tokai-SCANNER is introduced here. As an active monitoring, a controlled-source electromagnetic monitoring is conducted to detect conductivity variation (indication of fluid migration) on the plate boundary. The Toyohashi W-cable is used as a transmitting dipole source with two electrodes located at 0km (coast line) and 60 km (off shore), respectively. The OBEMs and the Toyohasi E-cable are used for receivers. Numerical calculations show us that apparent resistivity values daily obtained can be changed if the high conductive zone on the plate boundary is revealed. Therefore, the submarine cables are useful tools for monitoring fluid around the plate interface. As a passive monitoring, we connected various sensors to the tip of the Toyohashi W-cable; seismometers, pressure gauges, thermometers, proton magnetometer and voltmeters. These sensors is sensitive to off-shore micro earthquakes and slow-slip events, seafloor upward/downward movements, heat transportation with fluid flow, geomagnetic variation associated with stress changes and self-potential variation with fluid pressure changes. Such a multidisciplinary sensor package will help us to discuss on the detailed process before/at/after the earthquakes

One problem using long cables for monitoring is low spatial resolution. Before the monitoring, we suggest a conventional electromagnetic survey with ocean-bottom electromagntometers (OBEMs) such as reported in Kasaya et al. (2005). A combination of OBEM surveys and electromagnetic monitoring with long cables allow us to detect locations of anomalous conductivity variation related to fluid migration below the seafloor.