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Toward seafloor geodetic monitoring of spatial and temporal variation of the seismic coupling in an offshore seismogenic

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The Hi-net operated by NIED, Japan, and the GEONET operated by Geographical Survey of Japan have demonstrated that dense and high precision seismic/geodetic networks are crucial for the monitoring of seismic activities and spatial/temporal change in strain distribution. Big earthquakes will occur in the subduction zones under the sea, however, and the seismic/geodetic networks on land are not efficient in monitoring the crustal activities in the offshore seismogenic zone. That is why the cabled seafloor observation systems DONET and DONET2 are being constructed, and geodetic methods such as GPS/Acoustic (GPS/A) seafloor positioning, ocean bottom pressure monitoring, and downhole tilt/strain monitoring have been developed.

GPS/A seafloor positioning has become a principal geodetic system for observation of seafloor crustal movement near plate boundaries. There remain, however, substantial differences from GPS observation on land as is mentioned below. Our groups in Tohoku and Nagoya Universities have been working to reduce the differences under the programs supported by the MEXT, Japan, for improvement of the observation system for seafloor crustal movement.

Precision of seafloor positioning by GPS/A is one of key problems. Considering that plate motions are several centimeters per year in most cases, repeatability of a few centimeters by GPS/A is a big difference from a few millimeters by GPS on land. We have estimated that lateral variations in the sound velocity in the ocean can be a key to improve the precision in the positioning and to reduce the required time for the measurement (Kido et al., 2008). GPS/A positioning has coped with the problem by averaging the effects of the lateral velocity variations for one or two days at one site. Therefore, this is a key problem in the way to GPS/A networks, for example, above the seismogenic zones in the Nankai Trough. We have partly succeeded in estimating the lateral variations in the acoustic velocity by using 4-5 precision acoustic transponders (PXPs) (Kido 2007; Kido et al., 2010). We are also trying to estimate later velocity gradient by using a few units of sea surface system (Tadokoro et al., 2010).

Another critical problem of the present GPS/A positioning lies in the campaign style observation to measure the position of an array of acoustic transponders spending one or two days once or twice a year. It is similar to the triangulation observation on land before the age of the GPS, quite different from the semi-realtime continuous observation on land. Chadwell et al. (2009, AGU Fall Meeting) made a step forward for this problem by carrying out a continuous GPS/A observation with a moored buoy on a shallow seafloor. We are also developing a system for continuous observation using a moored small buoy (Fujimoto et al., 2008).

Long-term attitude stability of a PXP deployed on thick sediment has been a basic problem in the GPS/A observation; a tilt of the PXP causes a shift of the acoustic transducer on the top, which is analyzed as a position change of the PXP. While a pillar of a GPS antenna on land is set up firmly on the ground, a PXP is deployed on the seafloor after a free fall from the sea surface. It is a serious problem to detect coseismic crustal movements on the seafloor. M7-class earthquakes occurred in 2004 off Kii Peninsula, Central Japan, gave us a good opportunity to study the problem. By using a JAMSTEC ROV (remotely operated vehicle), we visually observed ten PXPs in 2006, seven of which had been used to detect coseismic seafloor crustal movements of 20 cm or more as was reported by Kido et al. (2006) and by Tadokoro et al. (2006). The diving survey confirmed that all of the seven PXPs stood vertically on the flat sediment, no effects of the earthquakes being recognized (Fujimoto et al., in press).

Keywords: GSP/Acoustic, seafloor crustal movement, seafloor geodesy, seismic coupling, seismogenic zone