Development of seafloor positioning system using a moored buoy

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Recent development of GPS/Acoustic technology for seafloor geodesy enable us to detect inter- and co-seismic seafloor displacements with practically acceptable accuracy. To utilize such observations for earthquake prediction along the Nankai trough, GPS/Acoustic survey is incorporated with the DONET project, which is promoted by the MEXT and plans to construct a seafloor cable network in Kumano-nada Current GPS/Acoustic survey employs a periodically repeated campaign style by way of individual research cruises, although some group have started developing an on-demand autonomous survey system using an AUV. In the DONET project, our Tohoku University group is working along the following two systems: (1) monitoring long-baseline seafloor displacement; (2) detecting short-baseline seafloor strain across a possible splay fault.

(1) A semi-realtime monitoring system for seafloor displacement using a moored buoy.

There are two aspects in the system: one is on the hardware to be as small as possible in size and power consumption for safe mooring and the limit of the cable spec; the other is on the software with new survey and analytic styles to realize high accuracy measurement even within a short time or in semi-realtime. For the hardware, we have developed a tubular-shaped buoy, which is much stable in attitude compared to the traditional cubic-shaped one. We also introduced a new battery-driven acoustic assembly confined in the buoy. In this year, we will develop a further small buoy with a single GPS antenna equipped. The attitude of the buoy is monitored through the INS/GPS technique with an aid of a low-cost gyro-triad using the MEMS technology. For the software aspect, we have theoretically demonstrated that gradient of stratified sound speed in ocean, which degrade the accuracy in positioning, can be effectively corrected by using two additional seafloor transponders (i.e., five in total). This enable us to make reliable positioning without taking a long-time temporal average and hence suited for the semi-realtime monitoring. We have started observation along this new strategy. Furthermore, introducing a high sampling-rate GPS receiver for accurate monitoring of the buoy attitude, we found that the cycle-slips in traveltime detection in acoustic signals can be properly corrected. This advantage will be also applicable in the new system of a single antenna.

(2) A short-baseline seafloor strain monitoring system across a splay fault.

We have developed the system and already conducted a 24-hour experiment at a flat region of Kumano-nada. Because of the nature of less noise near the deep seafloor and static condition of acoustic measurements, traveltime detection in an acoustic signal is in the optimal condition. The largest problem in this method is solely sound speed variation associated with temperature change with time, which results in apparent change in distance and hence strain. In the experiment, we found that linear interpolation of *in-situ* measured temperatures between both the ends of the baseline is sufficient to measure the change in distance within 5-mm of accuracy. Currently, we still continue to long-term survey for a year in Kumano-nada. In this year we will retrieve the instruments and recover the new data, then install them again on the seafloor across a selected splay fault by way of a diving survey planed to have on September. The validity of the linear interpolation is degraded as proportional to the square of the absolute distance. Therefore it is important to make detailed survey of splay fault structure to minimize the length of the baseline to be measured.

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