Development of a precision system for observing crustal deformation at the seafloor with an accuracy of 1cm

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Crustal deformation (static displacement and strain) decades rapidly with the distance from a deformation source. Therefore, the observation of crustal deformation near the source is very basics to understanding its mechanism. In particular, near subduction plate boundaries large deformation takes place particularly under the sea. For this reason, crustal deformation observation at the seafloor is extremely desired.

Major techniques of seafloor crustal deformation observation are: 1) Monitoring at single points for measurements of tilts, strains, gravities at the seafloor or within ocean-bottom boreholes, 2) Acoustic ranging between two seafloor benchmarks (transponders), and 3) Geodetic positioning of seafloor benchmarks. In order to detect changes in crustal deformation over a wide area, the technique 3) using kinematic GPS and acoustic ranging is the optimal. At this moment it has come to obtain measurement results in high accuracy. Although a short-term observation (1 to 2 days) its measurement error amounts to about 5 to 10cm, the error of repetition observations may reach several times larger than that. It is thought that the main factors of these systematic errors are possibly originated from positioning by Kinematic GPS, estimations of seawater acoustic velocities, and detection of acoustic signals.

For the purpose of obtaining the accuracy of 1 cm in positioning seafloor benchmarks, the following problems must be carried out: 1) Developing a new software of kinematic GPS; 2) Development of a new observation techniques. A GPS marine network with several vessels is a possible way to realize this; 3) Real-time monitoring of the temporal and spatial changes of acoustic velocity structures. For this purpose, using a unit of 3 to 4 seafloor benchmarks and onboard acoustic transducers, acoustic velocities are measured simultaneously together with acoustic rages.

With the present system, we postprocess acoustic and GPS data after obtaining the ephemeris data. However, it is important to know an accuracy of measurements onboard during the observation in order to design measurement tracks. In addition, in the present system, a signal transmitting interval is as long as 20 seconds, and the number of measurement is extremely restricted. This will be shortened less than 1s, and the number of measurements is raised as much as 10,000 or more for a single observation. By developing a new system, highly precise observation will be realized.

We will also make observations offshore Kumano-Nada and Tokaido will be carried out simultaneously. A five-year plan for a comprehensive system and the observation technique for high precision (1cm) will be discussed in detail.