Ocean Bottom Crustal Deformation -Repetitive measurement in Suruga Bay and Evaluation of the Error-

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1. Introduction

We are developing a system for measure the ocean bottom crustal deformation using a vessel and benchmarks transponders on sea floor. In the system, we determine the position of the vessel by Kinematic GPS method and measure distances between the vessel and the benchmarks by acoustic ranging. Then we can determine the position of the transponder. We have installed several benchmark units to carry out a continuous monitoring in two regions, Suruga Bay and Kumano basin. Each benchmark unit consists of three transponders. In this study, we report the results of the observation using the benchmark units at two sites situated in the northwestern and northeastern part of the Suruga Bay on October and November 2002, respectively. Then we estimate the positioning error of benchmark from the viewpoint of observation design.

2. Observation in Suruga Bay and Analysis method

In Suruga Bay, two sites are located on the ocean floor of 800m depth. Each site is composed of three units within radius of about 500m. We used a Kinematic GPS software GraphNav to determine position of the ship every second. The reference point for the GPS was located in Yaizu, west of the bay. The baseline length is about 30 km. The accuracy of the positioning is as good as 10 cm in horizontal direction with such short baseline.

The acoustic ranging for each unit was repeatedly done from 500 to 1000 times during each measurement in a one-day observation period. Throughout the observation period, we let the vessel moved to a certain distance adrift with the wind and current for a several hours while sending and receiving acoustic signals. Each drift made an observation line and was repeated which covered suitable area. In parallel with the acoustic ranging measurement, we also measured the acoustic velocity of ocean water using a CTD profiler several times. We assume that the sound velocity is constant for a given length of time and changes between them. We estimated velocity correction coefficient a for each time and the position of the three benchmarks simultaneously. To give a certain time length, it is better to adjust the length longer for the measurement when the velocity changes modestly and shorter for the steeper change. We can determine the length on the basis of AIC.

3. Result of repetitive measurement

The estimated positions of each benchmark unit measured repetitively were distributed in a circle with radius of 20 cm. This radius is much larger than the relative moving rate between Philippine Sea plate and Eurasian Plate under Suruga Bay, which is about 2 cm per year. So the value 20 cm must be an estimation error.

4. To evaluate the accuracy of the positioning on the basis of measurement design and the effect of temporal variations in sound velocity, we carried out a synthetic experiment. We made synthetic travel-time data using certain velocity change models with actual vessel position. We resolved the benchmark unit locations. As a result, we found that the error of 20 cm should be due to the shortage of both data number and badness of geometrical distribution of the ray paths.

In addition, we found that the measurement design, in which the vessel moves dependent on the currents and the winds, was very sensitive to both the measurement error in the position of the instruments on the vessel and the bad repeatability of the deploying. We can choose optimum arrangement of the ray paths which make us to acquire robust dataset to such a problem if we have a suitable vessel. Though we do not have such a vessel at Suruga Bay, we can achieve a few cm accuracy with precise positioning of the instruments and with acoustic ranging data 2 times as large as now.