Detecting localized seafloor deformation using traveltime difference of acoustic signals of transponders nearby --Observation in the Japan Trench--

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There often found fault-like feature near axis seafloor in the subduction zones, which may be formed through repeating occurrence of earthquake cycle. It is almost unrevealed when these faults are activated in the cycle because of the lack of in-situ geodetic measurement. Direct-path seafloor ranging technique is known to be suitable for monitoring the activity of such a fault. However, this technique sometimes has a difficulty to keep clearance along the acoustic path due to topographic obstacle. Here we proposed a modified GPS/Acoustic technique that intrinsically needs no direct-path and can precisely measure relative motion of two seafloor transponders lied along a short baseline. We applied this new technique at a cliff in the Japan Trench, which is interpreted as a backthrust.

Accuracy of direct-path seafloor ranging tends to be proportional to the baseline length, say 1 cm/km, for instance. While the accuracy of individual positioning of transponder in GPS/A measurement is a few to several tens of cm. This is mainly due to spatio-temporal variation of sound speed, kinematic GPS analysis, traveltime detection in acoustic waveforms. If a pair of seafloor transponders is installed across a fault, traveltime difference can be precisely determined because of similarity of the waveform. In addition, effect of the sound speed variation is almost cancelled except for un-common acoustic path within the deep thin layer. Furthermore, quantity of traveltime difference itself is free from error in absolute positioning of kGPS. Only relative positioning error within a time of traveltime difference, e.g., 100 msec, has take effect. Taken all of these natures together, we expect the total accuracy of the proposed new technique is about 1 cm for 100-300 m of baseline length. The advantages of this new technique are facility of installation due to uncecessity in clearance of direct-path and a pair of transponders alone can describes full-3D relative motion. On the other hand the disadvantages are only campaign data like GPS/A is available (not a continuous data) and baseline length must be confined within 100-300 m to achieve practical accuracy.

In the KH15-02 cruise, September 2015, we installed three seafloor transponders at the top and bottom of a cliff at 38.171N, 143.550E, 3500 m in depth along the Japan Trench. Although the transponder does not need to be locate on a steep sloop like the direct-path technique, we kept the baseline as short as possible. To perform this, we employed the Navigable Sampling System (NSS), which can remotely control the wire-end vehicle with realtime video monitor. We have carried out GPS/A measurements to thus installed transponders just after the installation and two months later to obtain the data to evaluate the accuracy. In order to monitor the activity of this target fault, further GPS/A measurement must be repeatedly required for years.

In the presentation, we introduce the detail of how most of the error sources can be cancelled and quantitatively discuss the remaining error, which are compared with the initial survey data mentioned above.

Keywords: Acoustic Ranging, GPS/A, Back Thrust, Seafloor Geodesy

