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Characteristic evaluation of the most suitable seismic exploration array to detect a seafloor topography change

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Generally typical large-scale seismic exploration is not so suitable for isolated, small-scale areas. We expect that a marine exploration with AUV (Autonomous Underwater Vehicles) can solve this problem because of its portability. In order to obtain the dense and high-quality data, various exploration sources may require new type receivers array design.

In this study we therefore assessed the characteristics of survey design for optimum seismic exploration for a target near/under a sea-bottom by using an elastic wave simulation with an elastic finite-difference method (Larsen, 2000). We assumed that a survey target was a stair-casing transformation at the sea bottom as long as 6 m. The model space was 1000m long and, 300m long in horizontal and vertical directions, respectively, and water depth was 150m. The model space was divided into 0.2m-0.2m staggered grids. We gave the parameter of P and S wave velocities (Vp, Vs), attenuation factor (Qp, Qs), and density (ρ). We used a Ricker wavelet as a source time function with a central frequency of 100Hz and 50 receivers installed on the single receiver cable. We calculated 54 cases of seismic records using 6 fixed sources and 9 receivers arrays. We found two important seismic phases, that is, secondary P-waves (called X-phase) and S-waves (Y-phase) that were excited by the target as a secondary source in order to detect the changes of bathometry and understructure. The X-phases were observed in all cases of receiver arrays, but the amplitudes were small and they may be lost in background noises. The Y-phases had larger amplitudes than X-phase but could not be observed by the undersea receiver. In a case of X-phase, the amplitudes became larger when the source was located at a lower area of the bathometry than that at a high area. In the case of X-phase, the largest amplitude was excited by the sea bottom receivers array which was 4~20 times as large as the other X-phases. In the case of Y-phase, the largest amplitude was observed at the receivers array at the sea bottom. We found that since the source on the sea bottom had the largest amplitude, it was good to obtained high-quality data. It however noticed that an interval between the target and the source is required to be a appropriate distance not to overlap the secondary waves and the primary waves each other.

The location of bathometry change point in horizontal can be detected easily by using the seismic records of the X and the Y phases. But S/N ratio might be smaller because the amplitude of the X-phase and the Y-phase are small. Vertical array is divided into the marine part and the underground part, so it can observe larger amplitude of those phases simultaneously. A vertical array is good to detect the bathometry change in the vertical direction and to obtain a high S/N ratio when the secondary waves and boundary waves with large amplitude can be observed. It however notices that this type of vertical array needs a high cost of the installing and the difficulty of the transport.

In summary, I suggest a seismic exploration array that has both a horizontal array and a vertical array. First, by using a towing horizontal receivers array, the target location can be identified in a horizontal direction in a large area and then by using the vertical array to explore in detail. Before installing the vertical array, we suggest the use of AUV shoots near the sea bottom because it can excite the large amplitude by boundary waves that can record X-phase more correctly. The vertical array is expected to be installed at the upper side of the staircase at 100m away from the target. To observe the records with a higher S/N ratio and to identify the location of the bathometry change in vertical direction. In future, there is an issue to calculate the geometry and size of bathometry change by using the characteristics of frequency dependency.

Keywords: geophysical exploration, seafloor topography change, exploration array evaluation