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Development of Vertical Cable Seismic System for Hydrothermal Deposit Survey

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Hydrothermal vents are commonly found near volcanically active places, areas where tectonic plates are moving apart, ocean basins, and hotspots. Potential new deposits of lead-zinc-copper sulfide are generated by cooling hot water around the vents. There are about ten hydrothermal deposits founded around the water depth of 1000m along Izu-Ogasawara Trench and Okinawa-Trough in Japan. The deposits often exists in very thin layer and spatially limited area surrounded by complex seabottom feature like volcanic caldera. Some hydrothermal vents form roughly cylindrical chimney structures. In order to evaluate hydrothermal deposit, we have proposed the reflection seismic survey with vertical cable recording geometry, which is named as VCS (Vertical Cable Seismic).
VCS has great advantages over conventional seismic method as follows:
1. It achieves 3D image within limited area. The target of hydrothermal deposit is within 1km x 1km around the depth of 1000m. The conventional 3D seismic is not effective. 3D image is necessary for the estimate the complex hydrothermal area.
2. Seabottom condition is too rough to deploy ocean bottom sensors, such as OBC or OBS. Vertical cables are located on the seabottom, but the sensors are in the marine water. It avoids the coupling problems. The vertical hydrophone array can separate the wavefield. It can separate upgoing (reflection) and downgoing wave (direct wave and ghost) and distinguish the scattered waves in complex feature in hydrothermal area.
3. Various types of marine source are applicable with VCS such as sea-surface source (air gun, water gun etc.), marine vibrator or ocean bottom source.
These features imply that VCS is suitable for the hydrothermal deposit exploration.

Our first experiment has been carried out in November in Lake Biwa, JAPAN. At first we are interested in geometry of source and receiver distribution and the resultant target coverage, then we did survey planning (2D and 3D) and data simulation. We used the several types of sources (GI gun, water gun and piezotranceducer) and receivers (hydrophone and 3C accelerometer) as well as different types of positioning system. We will be able to plan a suitable survey for hydrothermal deposit using these results. The 2D VCS data is processed. It follows the walk-away VSP processing, including wave field separation and depth migration. The result gives clearer image than the conventional seismic section. Prestack depth migration is applied to 3D data to obtain good quality of the 3D depth volume. Through the survey in Lake Biwa, we have established the total VCS procedure, that is, pre-survey study, data acquisition system, field operation, data processing. We have concluded that VCS is one of the promising seismic surveys for hydrothermal deposit.