Multi-stage Seismic Survey for Seafloor Massive Sulphide (SMS) exploration

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“Cross-ministerial Strategic Innovation Promotion programs (SIP)” was launched by the Council for Science, Technology and Innovation (CSTI) in 2014. It addresses eleven issues selected considering the critical social needs. “Next-generation technology for ocean resources exploration (Zipangu in the Ocean program) “is one of the SIP issues. In this project, we aim to establish the survey protocol for seafloor massive sulphide (SMS), especially buried deposits. In this protocol, very high-resolution images are required for seismic survey technologies. We introduce the new concept of seismic data acquisition in the vicinity of ocean bottom using autonomous recording systems, in order to preserve high frequencies and achieve higher vertical and horizontal resolution. We have developed three types of surveys, and the deep-towed autonomous cable seismic (DT-ACS), the Zero-offset Vertical Cable Seismic (ZVCS) and the 3D Vertical Cable Seismic (3DVCS). In this paper, we proposed "Multi-stage seismic survey” using DT-ACS, ZVCS and 3DVCS in Izena Hole, Okinawa Trough. The results demonstrated the effectiveness of this approach for SMS exploration.

DT-ACS (Deep-tow Autonomous Cable Seismic)

DT-ACS is a deep-tow reflection seismic using the autonomous logger system. Deep-tow seismic enables us the data acquisition close to the target and it is efficient. SBP system was attached to the towing body, and simultaneous shooting with the sea surface source. We can apply standard marine seismic data processing technique to ACS data. We aimed to acquire a two-dimensional cross section of the whole submarine volcano including the hydrothermal activity area and to classify between the hydrothermal active and inactive area by the seismic facies.

ZVCS (Zero-offset Vertical Cable Seismic)

ZVCS is a deep-tow exploration system using a upstanding cable. SBP system was attached to the towing body, and simultaneous shooting with the sea surface source. the shooting position was keeping zero-offset between source and reciever. The towing depth was about zero to ten meter altitude from the seafloor. We aimed to acquire a high-density two-dimensional cross section of the hydrothermal activity area than DT-ACS data and to detect characteristics of the SMS deposits by the seismic facies. In the ZVCS, it is possible to easily separate and extract only the reflection from just below the ZVCS by vertically arranged hydrophones. Therefore, side reflection noise such as chimney and mound in hydrothermal activity area can be removed.

3D VCS (3D Vertical Cable Seismic)

3D VCS uses hydrophone arrays vertically moored from the seafloor to record acoustic waves generated by seismic source. It is a fixed observation system, but by areal shooting it gives us a 3D image of subsurface structure. Because of the observation close to the target, high quality data could be acquired. To acquire enough reflected energy from unknown sub-seafloor structure, we conducted circle shooting

that it is possible to various azimuths and offsets shooting. We applied Three-dimensional Pre-Stack Depth Migration (3D-PSDM) to sub-seafloor imaging. For velocity analysis of the imaging area, Common Scattering Point (CSP) gathers obtained by Equivalent Offset Migration (EOM) were used.

This work was supported by Council for Science, Technology and Innovation(CSTI),Cross-ministerial Strategic Innovation Promotion Program(SIP), “Next-generation technology for ocean resources exploration” (Lead agency: JAMSTEC).

Keywords: SIP "Next-generation technology for ocean resources exploration", High resolution seismic, Seafloor Massive Sulfides (SMS), VCS

