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Various applications of acoustic data to deep-seabed mineral deposits

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1. Introduction

For several decades, marine scientists have used highly elaborate sonar techniques to record bathymetric and acoustic backscatter images in a wide variety of seafloor environments [1]. These sonar systems are vital to our understanding of volcanism and tectonics and are also invaluable tools for locating mineral deposits in the deep oceans. Regarding the latter, it is required that marine mineral deposits (e.g., Fe-Mn crust, manganese nodules and hydrothermal vents) are evaluated for spatial distribution and resource potential (Fig 1(a)) [2]. In exploring the vast seafloor, it is common to link high resolution geophysical methods such as deep-tow side-scan sonar (DTSSS) and remotely operated vehicles (ROV), with lower resolution systems such as multibeam echo sounders (MBES) (Fig 1(b)).

Here we present the measurement results of our multi-scale investigations of the deep-sea floor using MBES, DTSSS and ROV.

2. Field Measurements

Regional bathymetry and DTSSS surveys were conducted in the Korea-licensed manganese nodule fields of the northeast equatorial Pacific each June-July from 2011 to 2014. Deployed sonars included R/V Onnuri's hull-mounted EM120 multibeam/backscatter system as well as the DSL-120A and IMI-30 DTSSS systems. These surveys ensonified ~1,000 km2 of the nodule field and yielded bathymetry and backscatter grids at resolutions of 5 to 10 m and ~5 and ~1 m, respectively.

At each of the five seamounts we targeted in 2013 and 2014, bathymetric and backscatter data were acquired using the Simard EM120 multibeam system and the IMI-30 DTSSS. Eleven camera tow operations were also performed to observe the summits and slopes of the targeted seamounts.

Ultrahigh-resolution bathymetry and backscatter data were acquired at active deep sea hydrothermal vent fields within zone "V-18s-HR". A RESON SeaBat 7125 multibeam echo sounder, operating at a frequency of 400 kHz to maximum altitude (H) of 200 m above seafloor, was deployed on the ROPOS ROV for the survey. The RESON system has a horizontal resolution of 5% of H, and a bathymetric accuracy of 0.2% of H. We conducted surveys at an altitude of 50 m above seafloor, covering about 2 km^2.

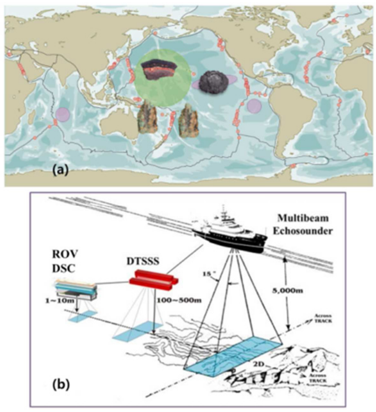

Fig. 1 (a) Global distribution of deep-ocean minerals (Manganese nodules (lavender), cobalt-rich crust (green), and hydrothermal vents (orange circles)), (b) imaging the deep seabed at multiple resolutions simultaneously using hull-mounted multibeam, DTSSS, and ROV sonar systems.

3. Results

Hydrothermal vents fields were observed on the eastern wall of the TA25 subsea caldera volcano (cruise SO-167 sector V-18s-HR) within the southern Tonga arc.

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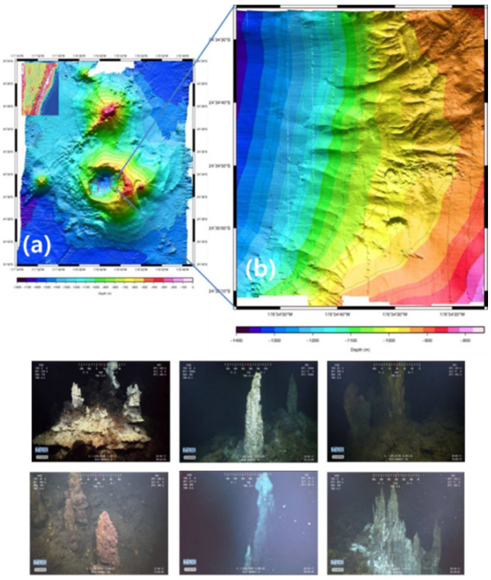

(c)

Fig. 2 (a) EM1209 bathymetry map (50 m grid) obtained over TA25 subsea caldera volcano, (b) RESON ultrahigh resolution (50 cm grid) bathymetry from the eastern wall of the TA25 subsea caldera volcano, (c) photographs of hydrothermal chimneys in the TA25 region imaged by ROV.

Ultrahigh-resolution ROV bathymetry, acquired near the seafloor (1 m grid), revealed the more detailed structure of the hydrothermal field lacking in the lower-resolution MBES and DTSSS. ROV observations revealed hundreds of hydrothermal chimneys in this vicinity, most of which are less than about 2-4 m high.

The surveyed seamounts could be categorized into two types based on the sizes of the summits and on the acoustic backscattering intensity (ABS) over the area. Type 1 is characterized by summit size > 300 km^2 with a bimodal distribution of ABS mode. Type 2 is characterized by summit sizes < 300 km^2 with a normal distribution of ABS mode. Guyots of type 1 typically show a relatively low ABS in the center but high ABS along the outer rim. Deep Sea Camera (DSC) observations over Type 1 guyots show carbonate-bearing unsolidified sediments cover in the center and Mn-crust exposure along the periphery.

For the Korea-licensed manganese nodule field in the Clarion-Clipperton fracture zone vicinity, acoustic backscatter obtained both by 30 kHz and 120 kHz DTSSS show a roughly reverse correlation with bathymetry. However, the 120 kHz data show unexpectedly high backscatter intensity in some flat areas of the flat (i.e., <3° slope gradient) and deep seafloor. Because backscatter intensities are also affected by reflecting material properties such as hardness, size, and shape, the anomalous high intensities may be caused by a massive aggregation of nodules.

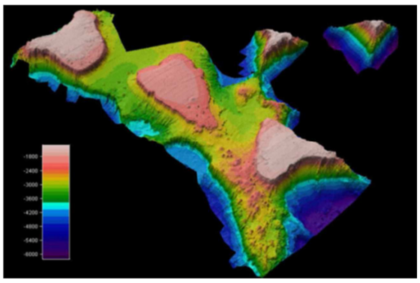

Fig. 3 Multi-beam sonar map of OSM14-16 in the Western Pacific. The flat-topped summit of OSM14 seamount is 1,400-2,500 m deep depths while the narrow flat tops of OSM15 and 16 are between 1,300-1,500 m deep.

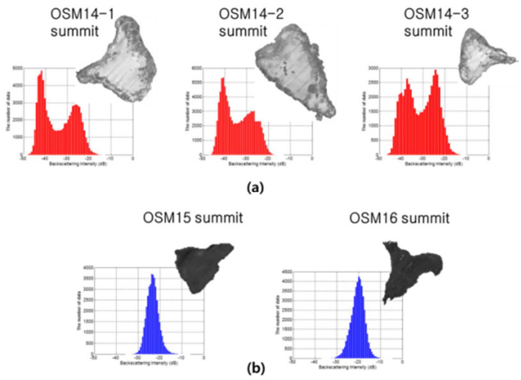

Fig. 4 Backscatter maps and histograms of OSM14 summits of Fig.3. The surveyed seamounts could be categorized into two types based on the sizes of the summits and on the acoustic backscattering intensity (ABS) over the area. Type 1 is characterized by summit size > 300 km2 with a bimodal distribution of ABS mode (a). Type 2 is characterized by summit sizes < 300 km2 with a normal distribution of ABS mode (b).

Acknowledgment

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