Magnetic survey using ROV in the Hakurei site in Izena Hole, Okinawa Trough

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Near-bottom magnetic surveys using the remotely operated vehicle (ROV) “Hakuyo 3000” (Fukada Salvage) were conducted in the Hakurei hydrothermal site in Izena Hole, Okinawa Trough, in FY2015 and FY2016 by Research and Development Partnership for Next Generation Technology of Marine Resources Survey (J-MARES). The magnetic vector fields were measured using 3-axis fluxgate magnetometers ~3-4 m above the seafloor along the 7 survey lines in NW-SE and W-E directions in an area ~500 ×800 m (in the N-S and W-E directions, respectively) centered on one of the largest sulfide mounds in the northern part of the Hakurei site. The magnetometers were installed on an underwater towed body suspended from the ROV by a cable ~6 m long. The attitude of the towed body was measured by a fiber-optic gyroscope (PHINS6000, iXblue). A figure-eight maneuver was carried out during each survey to collect data for magnetic data calibration.

In the FY2015 survey, two magnetometers were installed on the towed body. The correction for the magnetic field produced by the towed body was successful for both the magnetometers; the geomagnetic fields obtained after correction were nearly the same between the two magnetometers (<~10 nT differences). In the FY2016 survey, a single magnetometer was installed. The calibration was successful, and the magnetic fields obtained after correction seemed true except for the duration of ~15 minutes immediately after the start of measurements, where unusually high values were measured only in the vertical component. An electromagnetic survey had been conducted before the magnetic survey on the same day, and a large electric current had been sent through a horizontal loop around the towed body during the electromagnetic survey. It is suspected that a small current still remained and produced magnetic fields for a certain time after switching off the instrument. The magnetic field became normal values after the 15-minute duration, and we successfully obtained the geomagnetic vector fields which were consistent with the results of the 2015 survey.

The resulting geomagnetic vector anomalies were utilized for an inversion to obtain a magnetization intensity distribution on the seafloor. The seafloor magnetization had little variation in the northwestern part of the survey area but showed a complex pattern in the eastern and southern parts which did not necessarily agree to the distribution of sulfide mounds on the seafloor. The most remarkable feature was a high-magnetization zone elongated from the large mound to a SE direction. The high-magnetization zone has been found by a deep-sea magnetic survey using autonomous underwater vehicle (AUV) in 2014. But the distribution we obtained has higher resolution because our ROV observations were conducted much closer to the seafloor than the AUV survey (at an altitude of ~70 m). The highest magnetization was found in the easternmost of the high-magnetization zone, near the foot of the caldera wall. It has been reported that the high magnetizations in the Hakurei site are carried by pyrrhotite in sulfide ores. We then speculate that ore deposits might have been buried by a large amount of debris from the caldera wall; it is likely that oxidation of pyrrhotite is prevented by isolating it from seawater.

J-MARES has conducted seismic reflection surveys in the Hakurei site. We also discuss sub-seafloor structures and compare them with the results from the magnetic study.

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