Near-seafloor magnetics reveal hydrothermal alteration and strongly magnetized lava flow at the Irabu knolls, Okinawa Trough

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Magnetic mapping is of increasing interest in studies of seafloor hydrothermal systems because such data can promote the understanding of the location and spatial extent of hydrothermal alteration zones. Previous studies reported both reduced and enhanced magnetization at hydrothermal fields of different tectonic settings, suggesting that the destruction and production of magnetic minerals are controlled by geological and tectonic background. In order to characterize magnetic response of arc-backarc hydrothermal systems, we investigated the Irabu hydrothermal field (IHF) at the southern Okinawa Trough. The Irabu knolls are located on the axial area of backarc rift and consist of basalt to andesite. Near-seafloor vector magnetic measurements were performed using the AUV URASHIMA during the R/V Yokosuka cruise YK14-16. The seafloor rock samples from the same region were used for rock magnetic measurements and petrological observations. The integrated analysis of the magnetic anomaly and rock magnetic properties led to the following conclusions:

(i) The IHFs are associated with reduced magnetization reflecting the hydrothermal alteration of magnetic minerals present in the extrusive lavas and the deposits of non-magnetic hydrothermal material.

(ii) The basaltic lavas show high natural remanent magnetization (NRM) intensity ranging from 7 A/m to 214 A/m. These extremely strong NRM were caused by less oxidation, abundant single-domain-titanomagnetite grains formed under proper crystal growth rates, and low Ti content for titanomagnetites. These strongly magnetized host rocks produce large variations of magnetic anomalies in the Irabu knoll, resulting in a clear magnetic contrast between the IHFs and their surroundings areas.

(iii) The low magnetization zones (LMZs) related to the IHFs are located at the rim of the caldera floor in an elongated direction parallel to the local strike of the caldera, and extend into the caldera wall. These observations suggest that the hydrothermal fluids ascended through the caldera fault and caused accumulation of hydrothermal deposits and the occurrence of hydrothermally altered zones in both the caldera floor rim and wall.

(iv) The LMZ extends across several hundred meters along the caldera rim. Compared with similar hydrothermal fields of the Hakurei and Brothers situated in other arc-backarc volcanoes with summit calderas, it is clarified that hydrothermal systems controlled by caldera faults have horizontal spatial scale equal to or larger than those of detachment-controlled large hydrothermal fields at slow-spreading ridges such as the TAG. It is implied that the permeability structure and style of hydrothermal circulation may play important roles in the formation of the larger demagnetized hydrothermal fluid pathways at caldera-controlled systems.