Contribution of diffuse fluid output to the neutrally buoyant plume at the TAG hydrothermal mound, Mid-Atlantic Ridge

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Introduction

The fluid discharged from black smoker vents rises by buoyancy force resulting from differences in density relative to a similar water column of ambient seawater. As this fluid rises, it produces a buoyant plume. The buoyant plume rises to a height where the fluid density is equilibrium with ambient seawater, becoming a neutrally buoyant plume. A rise height of neutrally buoyant plume depends on ambient temperature and salinity gradients, crossflow current velocity, and the heat flux at the seafloor. Previous studies show that heat fluxes estimated from rise heights of neutrally buoyant plume are larger than those measured from black smokers directly [e.g., Baker and Massoth, 1987; Bemis et al., 1993]. This discrepancy indicates that heat flux from diffuse flow contributes to make neutrally buoyant plume. However, it remains unclear how much of the heat released from the diffuse sources contributes to the neutrally buoyant plume. In this presentation, we present contribution of the heat flux released from the diffuse sources to form the neutrally buoyant plume above the TAG hydrothermal mound.

TAG hydrothermal mound

The TAG hydrothermal mound is an active hydrothermal system that has been studied well [e.g., Rona et al., 1986; Humphris et al., 1995; Tivey et al., 1995]. This mound is isolated from other high-temperature hydrothermally active sites and a neutrally buoyant plume lies above the mound. Active, high- and low-temperature hydrothermal sources have been identified in this well-mapped area. Heat fluxes from these high-temperature fluid vents and diffuse flow at the mound have been estimated [Schultz and Elderfield, 1997; Goto et al., 2003].

Measurements

In August 1994, fifteen Shinkai 6500 dives were carried out at the TAG hydrothermal mound as a part of surveys of the MODE'94 Leg 2 cruise [Fujioka et al., 1995]. During these dives, oceanographic measurements with CTD system mounted on the submersible were performed. Heights of the neutrally buoyant plume above the mound were observed from temperature and salinity anomalies in water column.

During the MODE'94 Leg 2 cruise, current velocity was measured with long-term deep seafloor observatory platform deployed on the mound for 16 days [Fujioka et al., 1997].

Result and discussion

To estimate contribution of heat released from diffuse sources for the formation of the neutrally buoyant plume, we first estimated the heat flux from the TAG hydrothermal mound from the heights of the neutrally buoyant plume above the mound and ambient current flow velocities using a plume model in a density-stratified environment with crossflow current [Middleton, 1986]. Heights of the neutrally buoyant plume show a negative correlation to the ambient current flow velocities. Our estimated heat flux from TAG neutrally buoyant plume is 452 +/- 89 MW. Concurrently, heat fluxes estimated from high-temperature fluid discharge and low-temperature diffuse flow are 86 +/- 22 MW [Goto et al., 2003] and at least 780-2513 MW [Schultz and Elderfield, 1997], respectively. Thus, we concluded that low-temperature diffuse flow contributes a heat flux of 366 +/- 111 MW to the TAG neutrally buoyant plume. This contribution is only 10-61% of heat flux due to low-temperature diffuse flow. Therefore, much amount of fluid from diffuse sources and associated heat did not rise but drifted horizontally with ambient deep-sea currents.