

Characteristics of 3D structures of ADCP echo intensity anomaly observed over hydrothermal vent fields of the Snail, Archean and Pika in the South Mariana Trough

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We conducted 4 dives of the AUV 'Urashima', owned by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), over three hydrothermal vent fields (called as the Snail, Archean and Pika Sites; Fig.1) within the South Mariana Trough in the *R/V Yokosuka* cruise of July 2009 (YK09-8; JAMSTEC, 2009). The AUV mounted upward a 600-kHz acoustic Doppler current profiler (ADCP) and observed both of current velocity and echo intensity measured by reflected sound pulses from multiple layers over the AUV. The present study shows 3D images of the echo intensity maxima obtained with the ADCP, which indicates expansion and advection of hydrothermal plumes from the vent sites, and is the first study to examine the characteristics of hydrothermal plumes with current velocity and echo intensity measured with an ADCP mounted on an AUV.

The Snail (or called as Fryer) Site exists at 2880 m depth at 12.9533°N, 143.6200°E on a part of a spreading ridge (Wheat et al., 2003), and Baker et al. (2005) observed its large scale

extension by tow-yos of chemical sensors such as turbidity and Eh (oxidized rate) sensors. The Archean Site is located on the Snail's south-eastward valley of 2990 m depth at 12.9400°N, 143.6317°E (JAMSTEC, 2009). The Pika Site is over the far south-eastward mound at 2830 m depth of 12.9183°N, 143.6483°E (Ishibashi et al., 2004). These sites show high hydrothermal activity in the southernmost area of the Mariana Trough, and research of the characteristics of them should be really

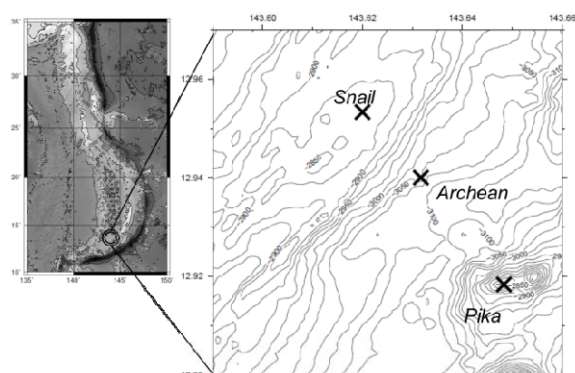


Figure 1: Topographic maps of the observation area. Solid contours in the enlarged map of the South Mariana Trough show 25m-depth intervals. Crosses show vent sites of the Snail, Archean and Pika.

important for biological and geological themes.

This was the first survey for the AUV *Urashima* in hydrothermal field. The survey was conducted by different dive plan to determine the extent of hydrothermal plume. The 100m-altitude cruising plan was applied to survey for each mound: Snail (Dive 1 the same as “Dive#91” in the cruise report; JAMSTEC, 2009), Archaean (Dive 2 as “Dive#92”), and Pika (Dive 3 as “Dive#93”). The 150m-altitude cruising plan was applied for broad area survey over three mounds (Dive as “Dive#94”). Specifications and equipment of the AUV are indicated in Table 1. Dataset from a CTD-DO sensor (SEB19⁺, Seabird), a turbidity sensor (JFE Advantech Co., Ltd) and an ADCP (Workhorse Sentinel 600-kHz, Teledyne RDI) were used to estimate images of plumes. The CTD-DO and turbidity sensors set within the AUV payload. The ADCP installed onto the AUV's upper side obtained echo intensity data from the upward layers at every 3 seconds. The maximum number of the vertical layers was set to 23 between the 1st layer at 1 m above the AUV and the last bin at 47 m above with 2 m intervals.

Table 1: Specifications and equipment of the AUV
Urashima.

AUV		
Specifications	Maximum operation depth	3500 m
	Maximum cruising distance	130 km
	Speed	0–2.7 knot
	Length	10 m
	Width	1.3 m
	Height	1.5 m
	Weight in the air	6.5 tonnes
	Power system	Rechargeable Li ion cell
AUV equipments		
Multibeam sonar	Product name	SeaBat 7125
	Frequency	400 kHz
	Sector coverage	128 deg
	Number of beams	256
	Resolution	6 mm
Side scan sonar	Product name	Edgetech 2200M
	Frequency	120 kHz (chirp)
	Slant range	300 m
Subbottom profile	Product name	Edgetech 2200M
	Frequency	1–6 kHz (chirp)
	Resolution	15–25 cm
ADCP	Product name	Workhorse ADCP
	Frequency	600kHz
Turbidity sensor	Product name	ATU6-CMP
	Resolution	0.0002FTU

Anomalies of the higher echo intensity relatively well-correspond to the higher turbidity in the most observed area, highly suggesting plumes' distribution.

Moreover, the ADCP's multiple-range system is rather effective for obtaining plumes' layer thickness than using only a single point chemical sensor. Over the vents, anomalies of the higher echo intensity shows that a spouted plume has at least 120 m in thickness at the Pika Site, 200 m at the Archaean Site and 100 m at the Snail Site. Moreover, the echo intensity anomaly in the Snail Site is able to suggest the plume's lower rim that the turbidity cannot detect. This observation way using ADCPs is the most valid

when an AUV is available to move laterally over vent sites.

It is also confirmed that the higher anomalies mentioned above are suggested to be advected south-westward by the local mean current using velocity data.

The other interesting characteristics we found are an existence of the anomalies of higher echo intensity and the lower turbidity area. For example, these are found in the northern area of the Archaean Site, the downslope from the Pika site and the south-western downslope from the Snail Site. The reason of this is still unknown from data of only the present study, however, one reasonable cause might be due to density differences by microstructures and babbles that are not usually able to be detected by a turbidity sensor.