Two possible hydrothermal vents in the northern Okinawa Trough

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Abstract **As the Okinawa Trough is a back-arc basin in early spreading, modern submarine hydrothermal activity and mineralization have many characteristics which have aroused wide attention. Up to now, three well-known hydrothermal venting areas are all located in the middle part of the trough. During two cruise investigations to map and sample the seafloor, numbers of *Calyptogena* sp. shells were dredged at two sites in the northern trough with comparatively thicker crust and numerous submarine volcanoes. Based on the fact that *Calyptogena* sp. is only observed around the hydrothermal vents and lives on hydrothermal activities, it is predicted that there is the possibility of modern hydrothermal activities in the northern part of the trough. In this note, the shell is carefully characterized and the sample locations with possible hydrothermal activity are given. It is pointed out that the research of biogenic fossils to trace hydrothermal activity changes in venting time, strength fluctuations, evolution in chemical compositions and so on should be stressed in the future in addition to the study of the ecological characteristics of hydrothermal organisms.**

Keywords: shells of *Calyptogena* sp., possible hydrothermal vents, northern Okinawa Trough.

Up to now, several active hydrothermal vents and deposit areas have been found in the Okinawa Trough, of which three well-known hydrothermal vents are Minami-Ensei knoll (28°23′N, 127°38′E) with the water depth of about 770 m and maximum hydrothermal fluid temperature of 270℃[1], Izena cauldron (JADE Site, 27°16′N, 127°05′E) with 1300—1600 m water depth and maximum temperature of about 320 ℃[2], Iheya ridge (CLAM Site, 27°33′N, 126°58′E) with about 1400 m water depth and the maximum of 220℃[2]. All of these hydrothermal vents are located in the middle part of the trough (fig. 1).

In September 1984, Japan Marine Science and Technology Center first discovered hydrothermal deposits and vent system of chimney in middle part of the Okinawa Trough and observed a large amount of benthons[3]. As known to all, *Calyptogena* sp. and *Bathymodiolus* are the dominant clam species in the hydrothermal community and the former is specially aboundant[4—6]. Up to now, two species of *Calyptogena* sp. living in the hydrothermal venting area have been observed in the trough. Two cruise investigations were carried out to map and sample the seafloor on the scale of 1:1000000 by the Institute of Oceanology, the Chinese Academy of Sciences in 1992 and 1994 respectively. During the investigation cruises, numbers of *Calyptogena* sp. cells were dredged at two sites (ES1 and ES2 in fig. 1) in the north of the trough. Based on the fact that *Calyptogena* sp. is only observed around the hydrothermal vents and lives on hydrothermal activities, it is predicted that there is the possibility of modern hydrothermal activities in the northern part of the trough.

1 *Calyptogena* sp. shells and sample locations

Calyptogena sp. shells were collected at two sites in the north of the Okinawa Trough (fig. 1). Site ES1 is located at 129°04.96′E, 30°19.82′N, with 521 m water depth, the south side of a submarine volcano on the south of Kusagaki. The water depth of the volcano summit is only 118 m. Site ES2 is located at 128°06.17′E, 28°48.82′N, with 779.2 m water depth, the south side of a small crater between two relatively large submarine volcanoes. The water depth around the crater is about 1000 m. The seafloor around site ES1 is covered by loose and sandy sediments (sand: 93.1%, fine sand: 6.9%), with abundant volcanic fragments and foraminiferal shells. Sediments on site ES2 are poorly graded and sandy (sand: 65.9%; fine sand: 10.2%; clay: 23.9%), mainly composed of volcanic glass and foraminiferal shells, with some pumice fragments.

Calyptogena sp. shells collected from site ES1 are about 11×6 cm in size, grey, with a few tawny spots on the surface. The growth striations are very clear on the outer surface of shells, while the muscle scars on the inner surface are not clear. This kind of *Calyptogena* sp. was identified as *Calyptogena soyoae* (or *Lucinoma spectabilis*) (Plate Ⅰ-1, 2). *Calyptogena* sp. shells collected from site ES2 are similar to those from ES1 in size and color, with more evident tawny spots. The muscle scars on the inner surface and the growth striations of the outer surface are both clear. This kind of clam shells was identified as *Calyptogena* sp. (Plate Ⅰ-3, 4). Xu Fengshan, the conchologist and professor in the Institute of Oceanology, the Chinese Academy of Sciences, did all of the identification work on the clam species.

2 Ecological habits of *Calyptogena* sp. in the Okinawa Trough

The *Calyptogena* sp. in the Okinawa Trough mainly lives in the seafloor covered by sediments, which is different from that in Galapagos, living in the fissures of basalt[7]. On the sandy sediment-covered seafloor where organisms cluster densely, the *Calyptogena* sp. is distributed as dense as up to 10 kg/m^2, of which some large ones are as long as 15 cm. They are half buried in sediments. From the opening of the shells, pink mantle can be seen venting gas with a poorly matured-siphon. The thickness of sediments in the most areas where *Calyptogena* sp. is distributed densely is about 10—15 cm, while that of am-

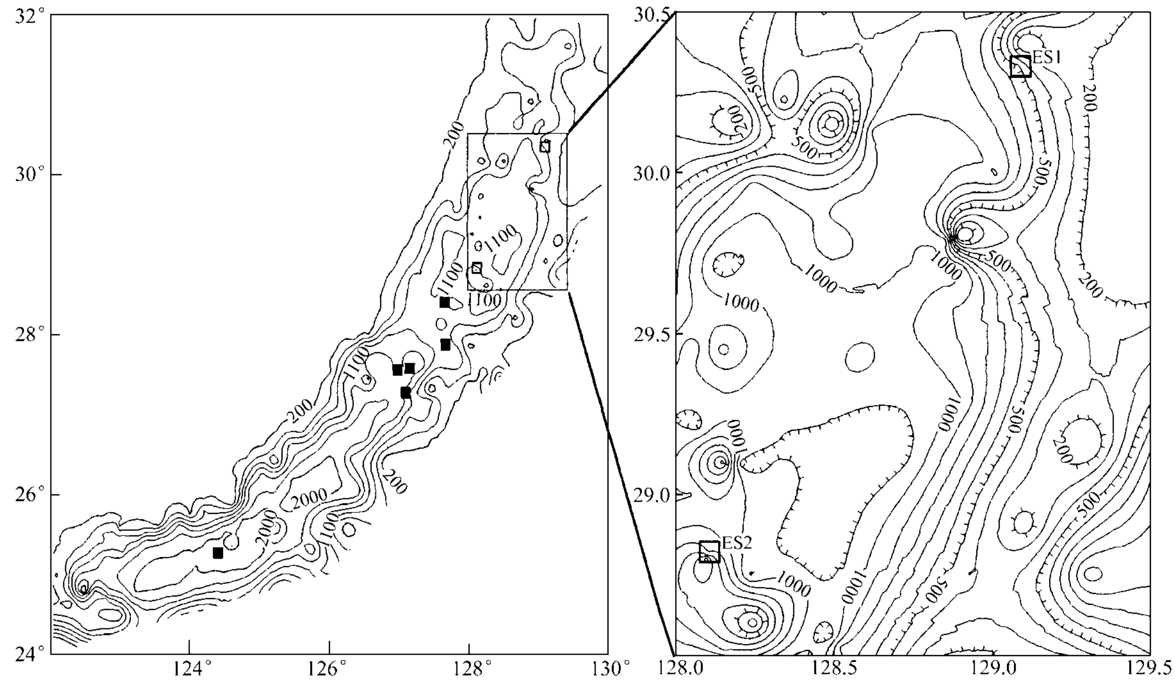

Fig. 1. Distribution of active hydrothermal vents and deposit areas in the Okinawa Trough. ■, Confirmed hydrothermal vents and deposit areas; □, possible hydrothermal vents.

bient sediments is only 5 cm. In addition, all of the *Calyptogena* sp. in the trough have plenty of blood, retrogressive digestive tubes and mast gills, which are similar to *Calyptogena magnifica* living on the base rocks in the East Pacific Rise hydrothermal field[8,9].

3 Significance of further investigation and research

In 1977, macroorganism communities around the hydrothermal vents were first discovered in Galapagos Rift at water depth of 2500 m[5,10]. Till 1986, the hydrothermal communities had also been found in the Mid-Atlantic Ridge and East Pacific Rise hydrothermal fields by American famous submersible "ALVIN"[7,11]. The whole scientific circles, especially the life science and environmental science realms, were shocked by all of these discoveries because these creatures can survive in the deep-sea environment, even on the new-formed mid-ocean ridge crust, far away from the land and without photosynthesis. In a word, these organisms survive depending on the hydrothermal activity and play an important role in the hydrothermal mineralization process at the same time. Up to now, the research on modern submarine hydrothermal biology has made great progress. It has been found that most of hydrothermal organisms around the vents are new species. They can survive healthily in a comparatively high temperature environment near the vents[7] and rely on the chemosynthesis to sustain the ecosystem development and basic reproduction, having nothing to do with photosynthesis necessary for the creature on land. Macroorganism communities thrive surrounding hydrothermal vents, strongly depending on the venting of hydrothermal fluid. Therefore, the study of the origin, distribution, ecological characters and the relations with hydrothermal activities of these creatures will be of great benefit not only to the study of the regularities in the submarine hydrothermal activity and the mechanism of hydrothermal mineralizations but also to the research of the origin and evolution of species on the Earth.

At present, the study of submarine hydrothermal activities and mineralizations has been the international multi-interdisciplinary frontier field. The study on the hydrothermal biology, one of hot research points, mainly includes two aspects. One is the study of origin, growth process, ecological characters, feeding habit and reliance on hydrothermal activities of hydrothermal organisms; the other is the research of biogenic fossils to trace hydrothermal activities. Information recorded in the fossils can be used to seek for the regularity of hydrothermal activities in venting time, strength fluctuations, evolution in chemical compositions of the venting fluid, etc. Organisms are generally sensitive to the environment. A little change of hydrothermal activities in venting strength, dormant period, and other physical-chemical indexes can affect the ambient seawater. Then, the change can be precisely impressed on the texture, chemical compositions (especially the trace element compositions) and the isotopic compositions of shells. Based on this fact, the regularities of hydrothermal activities especially in short time scale can be systematically studied with fossils of hydrothermal creatures.

It is well known that modern submarine hydrothermal activities are generally associated with submarine volcano eruptions or magmatic activities. In the Okinawa Trough, the magmatic activities and volcanic rocks are mainly distributed in the middle and north part, especially in the northern trough[12]. A lot of hydrothermal vents have been found in the middle of the trough and a few also in the south of the trough[2]. Modern hot springs are also found in the Wakamiko caldera at the north end of the trough and on the Taiwan and Iriomotejima islands at the south end[13]. However, no report on hydrothermal vent in the northern trough has been published, which needs to be in detail investigated in the future.

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