# Report on RN97 Cruise by T/S Nagasaki Maru in the Southern Okinawa Trough

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## Abstract

As a part of the educational cruise (RN97 Cruise) for students of College of Science, University of the Ryukyus, by T/S *Nagasaki Maru*, the scientific survey is carried out during November 15 to 24, 1997. We dredge seafloor samples at several seaknolls which locate in the southern Okinawa Trough. Pumices and dacitic lava fragments are dredged. The rocks are quite fresh, and thus appear to be Quaternary eruptives, confirming the presence of continuous volcanic front from the northern Ryukyu Arc to the southern Ryukyu Arc. Surface sediment type varies depending on depositional settings. Sediments recovered by a grab sampler are composed of quartz sand in the continental shelf, biogenic calcareous sand in the Hokuto-Sekibi Bank and the Ryukyu Ridge, and mud in the Okinawa Trough. The radiolarian assemblage from the surface sediment sample in the Okinawa Trough is characterized by warm water species in accord with the oceanographic setting.

## Introduction

The educational RN (Ryukyu-Nagasaki) 97 cruise by T/S *Nagasaki Maru* was undertaken for students of College of Science, University of the Ryukyus, during November 15 to 24, 1997. As a part of this cruise, we carried out some scientific operations involving dredging and grabbing seafloor. In addition, we trawled twice at the East China Sea Shelf during the cruise. In this paper, we present the preliminary result of the cruise.

The Ryukyu Arc extends for ~1200 km from Kyushu to Taiwan, and has been related to W-dipping subduction of the Philippine Sea Plate under the Eurasian Plate at the Ryukyu Trench (Fig. 1). In the northern Ryukyu Arc, volcano islands (Tokara Islands) broadly define the present-day active volcanic front. However, the volcanic front becomes indistinct toward the south at the central to southern Okinawa Trough-Ryukyu Arc system. In the southern Ryukyu Arc, several seaknolls have been found between non-volcanic Ryukyu ridge and the central graben of the trough (Fig. 1). Trace of these seaknolls has been considered to represent the present-day volcanic front in the southern Ryukyu Arc, based on the topographic characteristics (Watanabe

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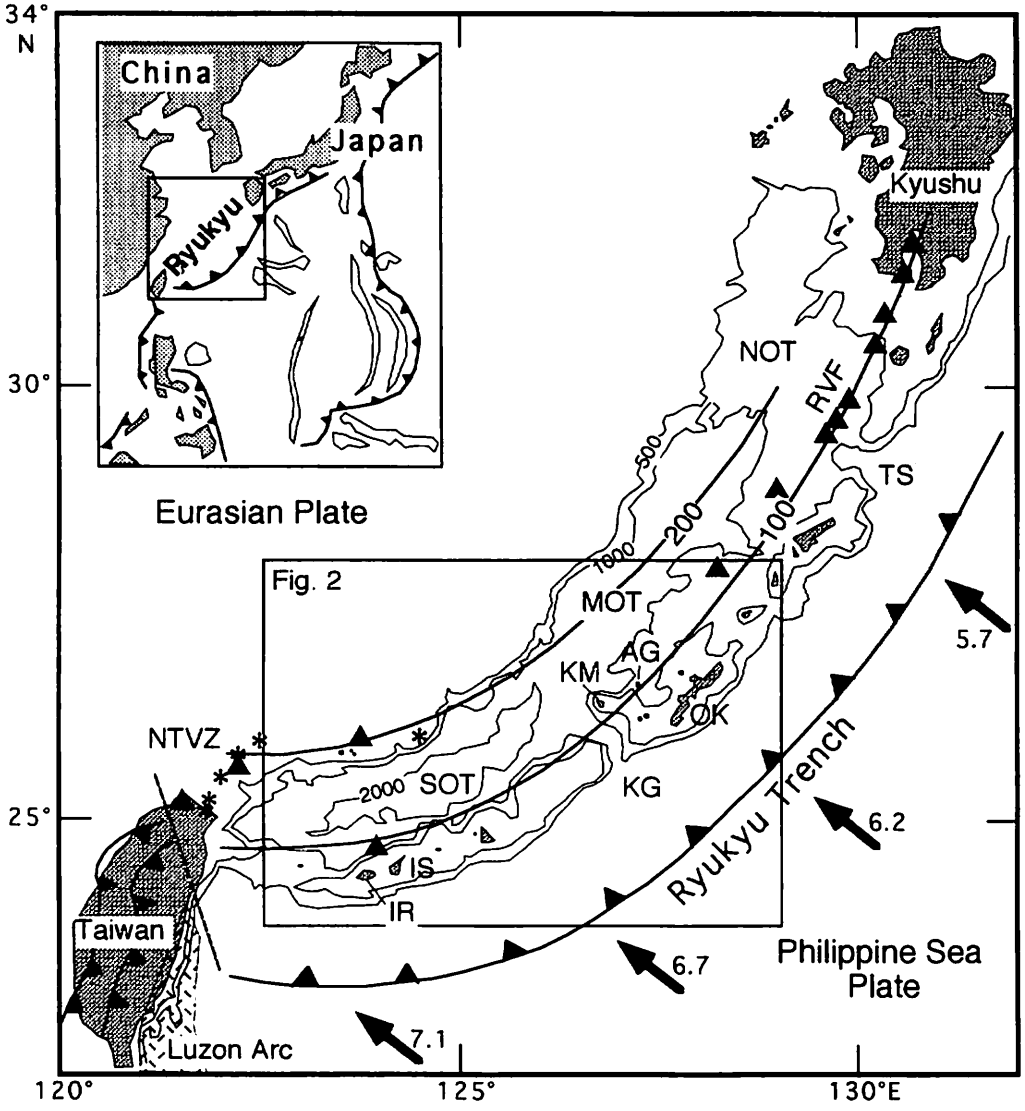


Fig. 1. A bathymetric and plate tectonic map of the Okinawa Trough-Ryukyu Arc system. Solid triangles and asterisks indicate the Quaternary and late Pliocene volcanoes, respectively. Bathymetric contours (500, 1000, and 2000 m) are indicated. Thick lines represent the depth contours (100 and 200 km) of the Wadati-Benioff zone. RVF, Ryukyu Volcanic Front; NOT, northern Okinawa Trough; MOT, middle Okinawa Trough; SOT, southern Okinawa Trough; TS, Tokara Strait; KG, Kerama Gap; OK, Okinawa-jima; AG, Aguni-jima; KM, Kume-jima; IS, Ishigaki-jima; IR, Iriomote-jima; NTVZ, Northern Taiwan Volcanic Zone. Solid arrows indicate plate motion vectors (numbers indicate rate in centimeters per year) of the Philippine Sea Plate relative to Eurasian Plate (Seno et al., 1993).

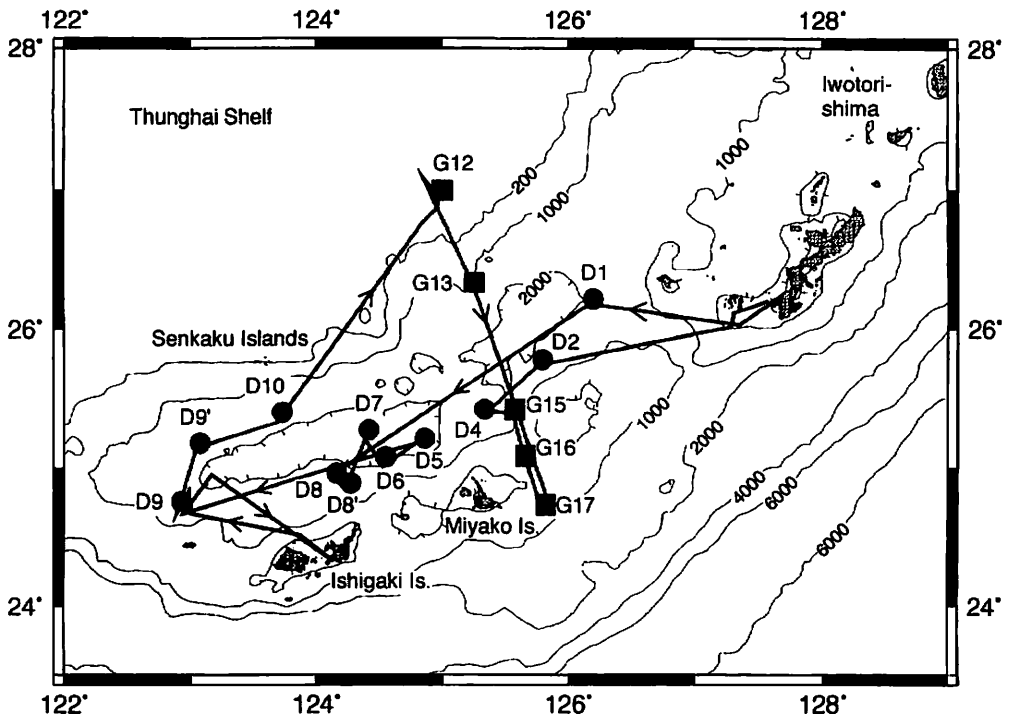


Fig. 2. Chart showing sampling sites. Tracklines of the RN97 Cruise by the T/S *Nagasaki Maru* (November 15-24, 1997) are also indicated. ●= dredged site, ■= grabbed site.

et al., 1995), seismic reflections (Furukawa et al., 1991), magnetic anomalies (Ueda, 1986; Furukawa, 1991; Oshida et al., 1992; Sibuet et al., 1998), and depths of the Benioff zone (Sibuet et al., 1998). However, only two samples from the estimated volcanic front (Watanabe et al., 1995; Ishikawa et al., 1991) have poorly supported the presence of the volcanic front. To ensure the presence of the volcanic front in the southern Ryukyu Arc, it is essential to take samples from these seaknolls estimated to be volcanic.

The Ryukyu Arc borders the East China Sea from the Pacific Ocean. Southern part of the East China Sea is influenced by Kuroshio Current, whereas the offshore Pacific is dominated by warm water masses influenced by Kuroshio Counter Current. The grab sampling sites were designed to investigate radiolarian assemblages in surface sediments in the marginal sea (Kuroshio Current) to the open ocean. Surface sediments on the outer half of the continental shelf of the East China Sea consist of coarse sands (Niino and Emery, 1961; Saito and Yang, 1993). Various surface sediments, clay, calcareous ooze, foraminiferal sand and pumiceous gravel, have been reported from sporadically distributed dredge, grab, and piston core sites in the Ryukyu Arc-Okinawa Trough region (Honza, 1976 ed.; Yamamoto et al., 1984; Ono et al., 1989; Ono and

Takagi, 1991)). The grab sites provide additional information of surface sediment types in various depositional settings from continental shelves to fore-arc slopes in this region.

The scientific objectives of RN97 Cruise are: (1) to confirm the presence of volcanic front in the southern Ryukyu Arc by dredging the samples from the region and (2) to recover surface sediments of the seafloor across the Okinawa Trough-Ryukyu Arc system.

## Dredged samples

The ship track and sampled sites during the RN97 Cruise are shown in Fig. 2. Dredged sites were chosen to locate on the seaknolls which are inferred to be volcanic; most samples were taken from the slopes of seaknolls. Most sites locate between the axis of the Okinawa Trough and non-volcanic Ryukyu arc, while two sites (D 9', 10) locate behind the central graben of the southern Okinawa Trough. A Niino-type dredger was used.

Volcanic rocks were recovered from seven sites (Figs. 2, 3 and Table 1). On the other hand, we recovered sedimentary rocks (Fig. 3 H) at site D 10 (Uotsuri Knoll) which locate behind the graben of the southern Okinawa Trough. Most dredged samples are rhyolitic pumices, but andesitic to dacitic lava blocks have also been recovered (Sites D 6, D 8' and D 9). Pumices and dacitic lavas are quite fresh, and thus appear to be the Quaternary eruptives. Therefore, it is definite that the volcanic front is present in the southern Ryukyu Arc. The Benioff zone of the Philippine Sea Plate lies ~100 km beneath the proposed volcanic front in the southern Ryukyu Arc (Fig. 1); this value is conformable to a constant depth of 108±18 km compiled from many subduction zones (Tatsumi and Eggins, 1995). Dredged samples seem to have higher silica contents than rocks from the northern Ryukyu volcanic front, where andesite is abundant (e.g., Nakada, 1986; Daishi, 1992). It is interesting to note that the rift-related volcanism in the southern Okinawa Trough marges the volcanic front at two area, i.e. the eastern tip of the Yaeyama central graben (D 5) and western tip of the Yonaguni central graben (D 9) (Fig. 2). The K/Ar dating of samples collected during the cruise will further constraint on the volcanic activities. Additionally, geochemical analyses on dredged samples will contribute to the petrogenesis.

## Seafloor sediments recovered by a grab sampler

Five grab sites were chosen to investigate the composition of surface sediments and microfossil thanatocoenosis on the continental shelf, the Okinawa Trough, and the Ryukyu Ridge (Fig. 2, Table 2). An Okean-type grab sampler was used. Sufficient amount of sediments were recovered from four sites (G12, G13, G15 and G17) but only a small rock fragment from the G16 site.

Sample G 12 is recovered from the continental shelf in the East China Sea. It is

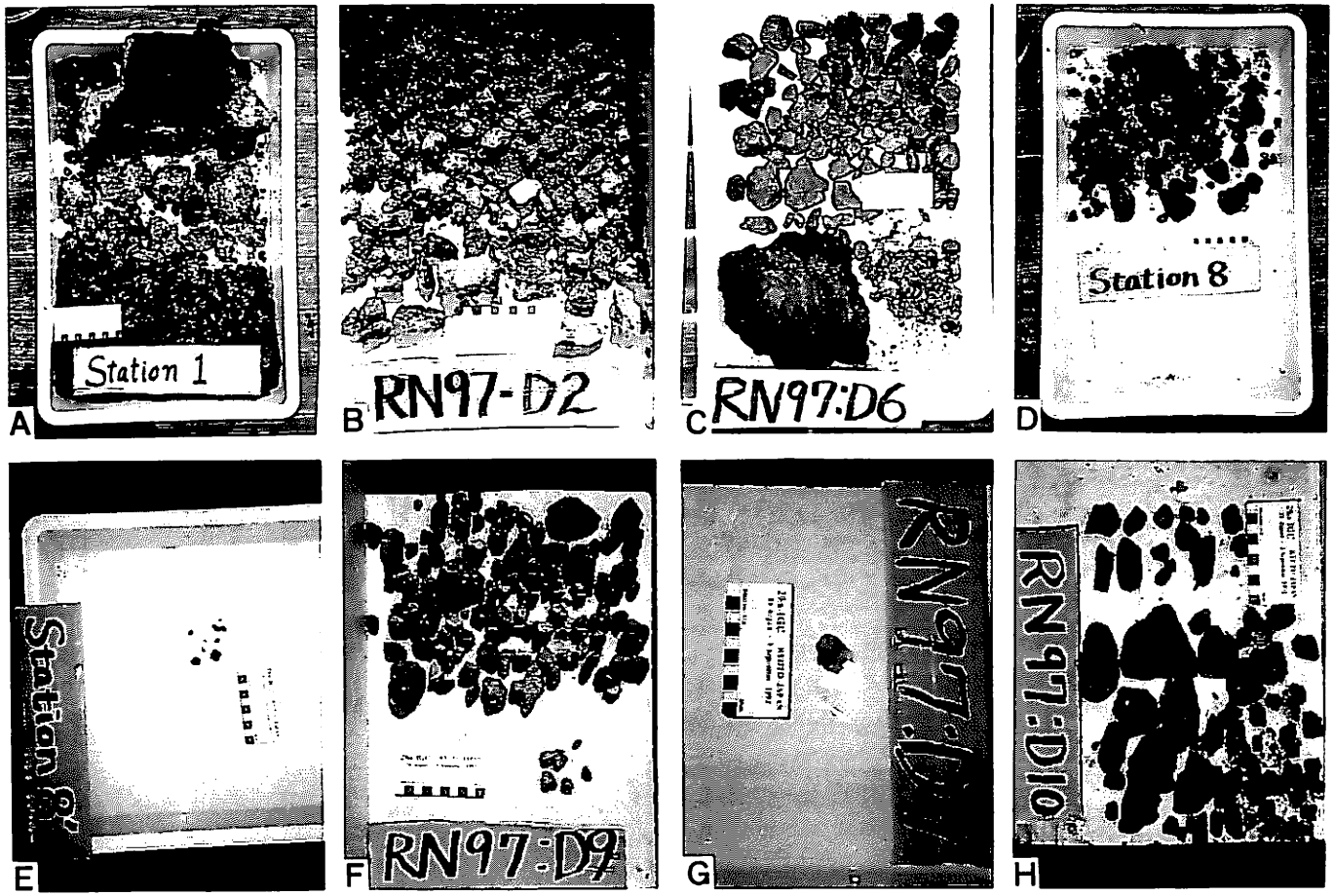


Fig. 3. Photographs of dredged rock samples.
A, pumice blocks of RN97-D1; B, pumice blocks of RN97-D2; C, pumice (lower right) and andesitic lava blocks (upper and large one) ofRN97-D 6; D, pumice and scoria blocks of RN97-D 8; E, small amount of scoria and andesitic blocks of RN97-D 8'; F, dacitic (upper) and pumice blocks (lower) of RN97-D 9; G, scoriaceous rock of RN97-D 9'; H, sandstone and mudstone of RN97-D10. Scale card is 10 cm long.

Table 1. Locations and principal rock types of dredged samples during the RN-97 Cruise.

| Site No. | Date (1997) | Time (on & off) | Position Latitude (N) | Position Longitude (E) | Depth (m) | Samples and Remarks |
|---|---|---|---|---|---|---|
| D1 | Nov. 15 | 17:44 | 26°13.00' | 126°12.24' | 1091 | Pumice blocks (Max.size: 32x19x15 cm) |
| | | 18:19 | 26°13.11' | 126°12.68' | 697 | Soft sediment |
| D2 | Nov. 22 | 17:28 | 25°46.91' | 125°47.87' | 1650 | Pumice blocks with dark inclusion |
| | | 17:49 | 25°47.17' | 125°47.83' | 1500 | (Max. size: 7x4x4 cm) |
| | | | | | | Soft sediment |
| D4 | Nov. 22 | 13:27 | 25°25.30' | 125°20.30' | 1650 | Soft sediment |
| | | 14:06 | 25°25.81' | 125°20.95' | 1450 | |
| D5 | Nov. 16 | 17:37 | 25°12.81' | 124°51.74' | 2075 | No recovery |
| | | 18:01 | 25°12.97' | 124°52.03' | 1945 | Dredger was lost during jerk up |
| D6 | Nov. 16 | 14:46 | 25°05.31' | 124°33.20' | 1860 | Pumice blocks (Max. size: 4x3x3 cm) |
| | | 15:20 | 25°05.82' | 124°33.37' | 1930 | Two types of andesitic lava blocks |
| | | | | | | (Max. size: 23x19x12 cm) |
| | | | | | | Soft sediment |
| D7 | Nov. 16 | 12:41 | 25°16.38' | 124°25.25' | 2200 | No recovery |
| | | 12:50 | 25°16.37' | 124°25.21' | 2210 | |
| D8 | Nov. 16 | 07:05 | 24°57.85' | 124°09.99' | 1413 | Scoria blocks (Max. size: 3x2x1 cm) |
| | | 07:16 | 24°57.85' | 124°10.14' | 1352 | Pumice blocks (Max. size: 7x4x5 cm) |
| | | | | | | Soft sediment |
| D8' | Nov. 16 | 08:35 | 24°53.57' | 124°16.53' | 1825 | Scoria blocks (Max. size: 1x1x1 cm). |
| | | 09:08 | 24°53.87' | 124°16.24' | 1712 | Andesitic blocks (Max. size: 1x1x1 cm) |
| | | | | | | Soft sediment |
| D9 | Nov. 20 | 07:16 | 24°45.67' | 122°55.55' | 1520 | Pumice blocks (Max. size: 3x2x1 cm) |
| | | 07:57 | 24°46.48' | 122°55.86' | 1470 | Dacitic lava blocks (Max. size: 6x4x4 cm) |
| | | | | | | Lappili tuff fragments (Max. size: 5x4x3 cm) |
| | | | | | | Soft sediment |
| D9' | Nov. 20 | 10:42 | 25°10.80' | 123°04.63' | 1480 | One piece of scoriaceous rock (3x2x2 cm) |
| | | 11:21 | 25°11.69 | 123°04.81' | 1370 | Soft sediment |
| D10 | Nov. 20 | 18:51 | 25°24.03' | 123°44.03' | 1380 | Sandstone (Max. size: 8x6x3 cm) |
| | | 19:18 | 25°24.15' | 123°44.66' | 1250 | Mudstone (Max. size: 5x3x2 cm) |
| | | | | | | Scoria blocks (Max. size: 3x2x2 cm) |
| | | | | | | Pumice blocks (Max. size: 5x4x3 cm) |
| | | | | | | Soft sediment |

Table 2. Locations and sediment types of samples recovered by an Okean-type grab sampler.

| Site No. | Date (1997) | Time (touch) | Position | | Depth (m) | Samples and Remarks |
|---|---|---|---|---|---|---|
| | | | Latitude (N) | Longitude (E) | | |
| G12 | Nov. 21 | 06:34 | 26°59.8' | 125°00.1' | 115 | Grey fine sand, molluscan shell |
| G13 | Nov. 21 | 16:20 | 26°20.1' | 125°15.4' | 258 | Foraminiferal sand |
| G15 | Nov. 22 | 11:58 | 25°25.2' | 125°34.9' | 1542 | Brown mud (0-2 cm) on grey mud (2-12 cm) |
| G16 | Nov. 22 | 09:43 | 25°05.3' | 125°39.9' | 685 | Limestone fragment |
| G17 | Nov. 22 | 07:05 | 24°44.3' | 125°49.5' | 720 | Foraminiferal calcareous sand, pteropods |

composed of fine grained sand with rare planktic and benthic foraminifers, and very rare radiolarians, pteropods and molluscan shells. This sandy sediment consists mainly of quartz and contains extremely rare finer grains, agreeing with the type of sediments on the outer half of the shelf discovered by Niino and Emery (1961).

Sample G 13 obtained from the top of the Hokuto-Sekibi Bank comprises of foraminiferal sand dominated by planktic forms with rare pteropods and very rare siliceous sponge spicules.

Sample G 15 is recovered from the saddle on the east of Daiichi-Miyako Sea Knoll. It consists of brown mud (sub-sediment surface 0-2 cm) and grey mud (2-12 cm). These muds contain abundant planktic foraminifers, rare benthic foraminifers, radiolarians and siliceous sponge spicules, and very rare pteropods and ostracods.

The rock fragment of Sample G 16 from the Miyako Saddle is yellowish brown limestone. It is thinly coated by manganese except a fresh broken-out section probably truncated by the grab action. A deep-sea periphytonic coral attaches the black-coated rock surface. These indicates that the grab-sampled site is an outcrop of limestone or large rock masses uncovered by soft sediments. Sample G 17 from the fore-arc slope is composed of medium grained foraminiferal calcareous sand with common pteropods and coral fragments. A similar sediment characterized by coarse sand and pteropods has been taken from an adjacent site, RN 88-OK 10, at a similar depth (Ono and Takagi, 1991).

## Radiolarians

The grab-sampled surface sediments were investigated to assess presence of radiolarians with a binocular microscope. Radiolarians have been recognized in Samples G 12, G 13 and G 15, but they are abundant only in Sample G 15. The surface sediment (brown mud) of Sample G 15 was treated to observe the radiolarian assemblage. Small amount of the wet sample was disaggregated with a hydrogen peroxide, and then

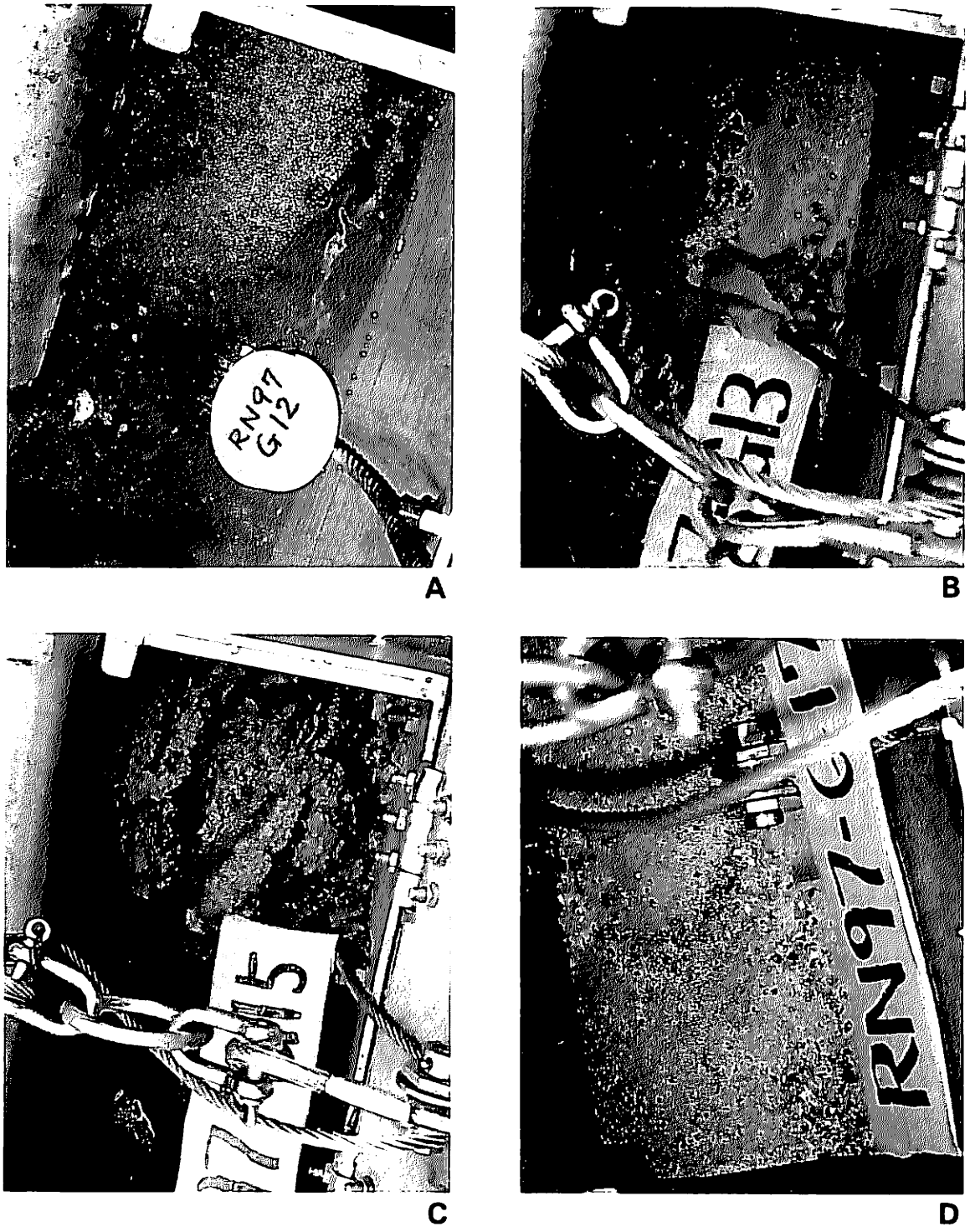


Fig. 4. Photographs of sediments recovered by a grab sampler.
A, RN97-G12; B, RN97-G13; C, RN97-G15; D, RN97-G17.

Table 3. Radiolarians from Sample RN97-G15 (0-1 cm).

| Radiolarian taxa | G15, 0-1 cm |
|---|---|
| *Acrosphaera lappacea* (Haeckel) | 2 |
| *Acrosphaera murrayana* (Haeckel) | 3 |
| *Acrosphaera spinosa* (Haeckel) | 10 |
| *Buccinosphaera invaginata* Haeckel | 3 |
| *Collosphaera tuberosa* Haeckel | 1 |
| *Collosphaera* sp. | 1 |
| *Disolenia zanguebarica* (Ehrenberg) | 3 |
| *Otosphaera* spp. | 2 |
| *Siphonosphaera* spp. | 4 |
| Collosphaeridae gen. et sp. indet. | 1 |
| *Actionomma arcadophorum* Haeckel | 4 |
| *Axoprunum stauraxonium* Haeckel | 1 |
| *Hexacontium* spp. | 3 |
| *Hexalonche* spp. | 4 |
| *Hexastylus* spp. | 2 |
| Actinommidae genn. et spp. indet. | 14 |
| *Heliodiscus* spp. | 5 |
| *Didymocyrtis tetrathalamus* (Haeckel) | 33 |
| *Stylochlamydium asteriscus* Haeckel | 1 |
| *Stylodictya multispina* Haeckel | 4 |
| *Stylodictya camerina* Campbell and Clark | 1 |
| Porodiscidae gen. et sp. indet. | 1 |
| *Dictyocoryne truncatum* (Ehrenberg) | 3 |
| *Dictyocoryne* spp. | 10 |
| *Euchitonia elegans* (Ehrenberg) | 1 |
| *Euchitonia furcata* Ehrenberg | 11 |
| *Spongaster tetras tetras* Ehrenberg | 4 |
| Spongodiscidae genn. et spp. indet. | 5 |
| *Octopyle stenozona* Haeckel | 15 |
| *Tetrapyle octacantha* Muller | 41 |
| Pyloniidae genn. et spp. indet. | 13 |
| *Larcopyle butschlii* Dreyer | 6 |
| *Larcospira quadrangula* Haeckel | 1 |
| *Lithelius minor* Jorgensen | 2 |
| *Spongurus elliptica* Ehrenberg | 1 |
| Litheliidae genn. et spp. indet. | 28 |
| *Giraffospyris angulata* (Haeckel) | 11 |
| *Liriospyris reticulata* (Ehrenberg) | 2 |
| *Liriospyris* sp. | 5 |
| Spyrida genn. et spp. indet. | 5 |
| Lophophaeninae gen. et sp. indet. | 1 |
| Sethoperinae genn. et spp. indet. | 2 |
| Sethophormididae enn. et spp. indet. | 3 |
| *Cycladophora bicornis* Popofsky | 3 |
| *Eucyrtidium acuminatum* (Ehrenberg) | 1 |
| *Eucyrtidium hexagonatum* Haeckel | 2 |
| *Lithopera bacca* Ehrenberg | 1 |
| *Pterocanium praetextum* (Ehrenberg) | 8 |
| *Pterocanium trilobum* (Haeckel) | 2 |
| *Anthocyrtidium ophirense* (Ehrenberg) | 3 |
| *Pterocorys sabae* (Ehrenberg) | 10 |
| *Pterocorys clausus* (Popofsky) | 1 |
| Total radiolarians counted | 304 |

Table 4. Locations of trawlnet sampling.

| | Date (1997) | Time (set & up) | Position Latitude (N) | Position Longitude (E) |
|---|---|---|---|---|
| 1st try | Nov. 21 | 08:40 | 27°04.9' | 124°53.4' |
| | | 10:07 | 27°01.8' | 124°57.7' |
| 2nd try | Nov. 21 | 10:50 | 27°01.3' | 124°55.7' |
| | | 12:16 | 26°57.5' | 124°58.0' |

Table 5. Fish catch of trowel.

| Variety | 1st try (kg) | 2nd try (kg) |
|---|---|---|
| Swordtip squid | 2.2 | 2.0 |
| Japanese flying squid | 1.2 | 0.6 |
| Cuttlefishes | 3.3 | 2.4 |
| Golden tai | 6.1 | 1.2 |
| Gurnards | 4.0 | 9.2 |
| Goatfishes | 2.5 | 3.3 |
| Lizardfishes | 2.6 | - |
| Bluespotted stargazer | 1.3 | - |
| Yellow goosefish | 5.6 | 3.0 |
| Cornet fish | 1.3 | 2.0 |
| Flounders | 0.3 | 2.2 |
| Whitefin kingfish | 11.9 | 3.6 |
| Skate | 7.5 | 6.3 |
| Sharks | 12.0 | 26.5 |
| Japanese fan lobster | 1.0 | - |
| Matron flathead | 2.0 | - |
| Black scraper | ~550 | ~50 |
| Octopuses | - | 1.1 |
| Smoothback puffer | - | 0.6 |

sieved through a mesh with 63 $\mu m$ openings. The remaining coarse particles were pipetted onto a glass slide. After dried, it was mounted with a resin Entellan-new.

The radiolarian assemblage is well diversified and dominated by warm water species (Table 3). Most of the species listed in Table 3 are common to those reported

from the surface sediments in South and East China Seas by Ling (1972). *Octopyle stenozona* and *Tetrapyle octacantha* occupy 18 % of the assemblage. The relative abundance of *Didymocyrtis tetrathalamus* reaches 10 %. Other characteristic species includes *Acrosphaera spinosa, Euchitonia furcata, Giraffospyris angulata,* and *Pterocorys sabae.* The radiolarian assemblage accords with the oceanographic condition around the sample site which influenced by the warm Kuroshio-Kuroshio Counter Current system around the Ryukyu Arc.

## Trawling

We trawled twice at the eastern continental shelf of the East China Sea (Fig. 2, Table 4), using a otter board-type trawlnet (~50 m long and ~30 m wide). Fish catch is given in Table 5.

## Acknowledgments

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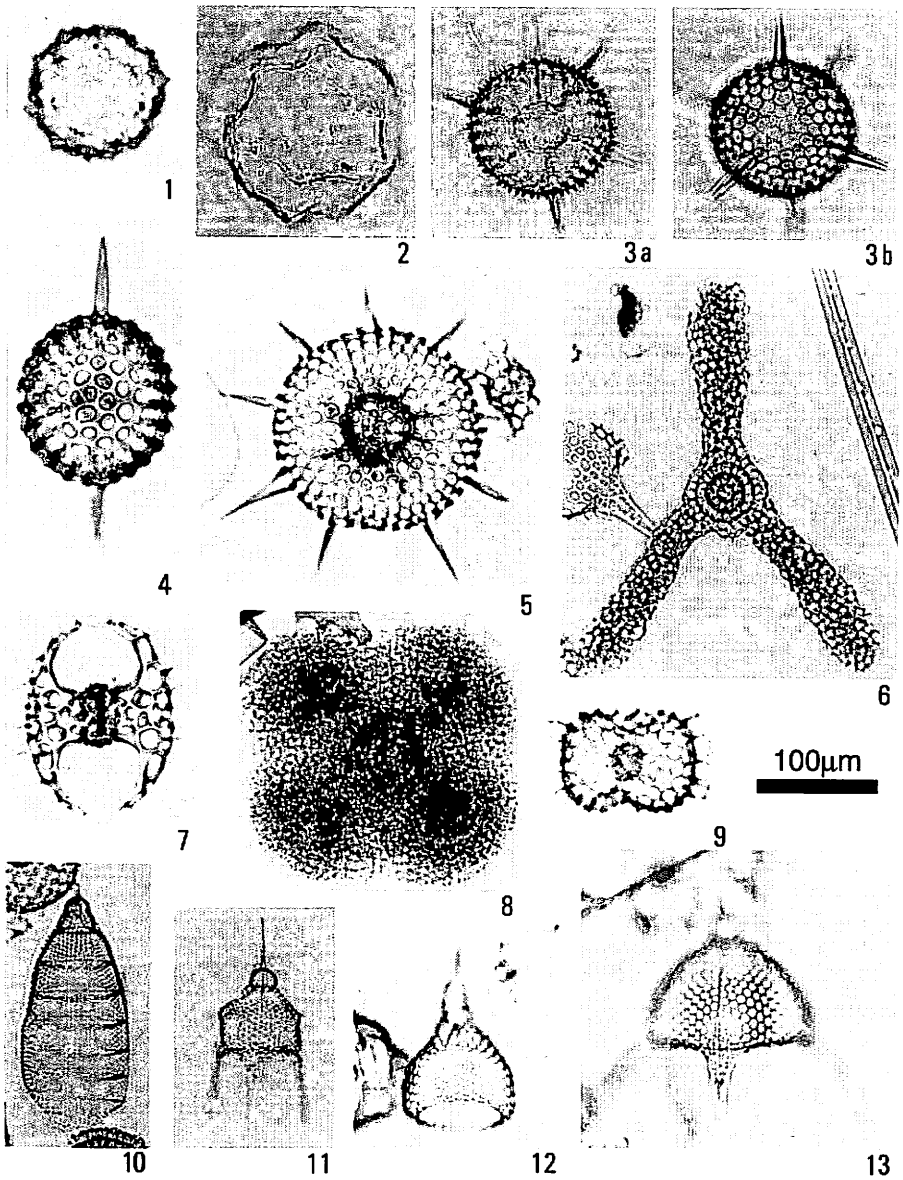


**Plate 1 Photographs of radiolarians**

1 *Acrosphaera spinosa* (Haeckel). RN97-G15 (0-1cm), sl. 1, C23/4
2 *Collosphaera tuberosa* Haeckel. RN97-G15 (0-1cm), sl.1, H24/4
3 *Hexalonche sp.* RN97-G15 (0-1cm), sl.1, C34/3
4 *Axoprunum stauraxonium* Haeckel. RN97-G15 (0-1cm), sl.1, F21/1
5 *Heliodiscus* sp. RN97-G15 (0-1cm), sl.1, G44/1
6 *Euchitonia furcata* Ehrenberg. RN97-G15 (0-1cm), sl.1, S21/1
7 *Tetrapyle octacantha* Muller. RN97-G15 (0-1cm), sl.1, R28/1
8 *Spongaster tetras tetras* Ehrenberg. RN97-G15 (0-1cm), sl.1, N39/1
9 *Didymocyrtis tetrathalamus* (Haeckel). RN97-G15 (0-1cm), sl.1, C28/2
10 *Eucyrtidium acuminatum* (Ehrenberg). RN97-G15 (0-1cm), sl.1, M28/1
11 *Pterocanium praetextum* (Ehrenberg). RN97-G15 (0-1cm), sl.1, V19/2
12 *Anthocyrtidium ophirense* (Ehrenberg). RN97-G15 (0-1cm), sl.1, W23/4
13 *Pterocanium trilobum* (Haeckel). RN97-G15 (0-1cm), sl.1, C36/2