VIII. SEDIMENTS, ROCKS AND FERROMANGANESE OXIDE

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1. Introduction

The area surveyed was the northern part of the Ogasawara-Mariana Arcs, one of the main arc-trench systems of the western Pacific Ocean. The major structures of the area are the N-S trending ridges and trench, called the Ogasawara (Bonin) Ridge, the Shichito Ridge, and the Ogasawara (Bonin) Trench which runs parallel to the ridges. A part of the Mariana Arc located to the south of the Ogasawara Arc was also surveyed during cruise GH79-2.

The length and width of the Shichito and the Ogasawara Ridges are similar to the dimensions of Honshu, Japan. There are small islands in the area, such as the Izu-shichito Islands, the Ogasawara Islands including the Kazan Retto (Volcano Islands), and many other smaller islands. However, as these islands are too small to be representative of the regional geology, a marine geological survey was essential to determine the regional geology and mineral resources of the area.

Sampling was carried out at 127 sites throughout cruises GH79-2~-4(Figs. I-1 and 2). Descriptions of samples taken by piston coring and drilling can be found in other chapters. Rocks, sediments and ferromanganese oxides taken by dredge and rock-coring are described in this chapter. Bottom photographs by a one-shot camera attached to a free-fall-grab are discussed at the end of the chapter.

2. Sediments

During the cruises, soft sediments were taken by a small, cylinder-type dredge which was attached to a main chain-bag-type dredge. These soft sediments may be regarded as surficial sediments. Surficial sedimentary environments were also suggested by the soft sediments taken by piston corer, rock corer and sampling tube attached to a free-fall grab. Microscopic observations were made of their coarse fraction ($> 63\ \mu m$) with binocular microscope. The compositions of the coarse fractions are classified into biogenic, volcanogenic, terrigenic (rock fragments), and authigenic (micro-manganese nodules) components.

The distribution of biogenic components, planktonic foraminifera (calcareous tests), radiolarians and diatoms (siliceous tests), projected on an E-W sections, is shown in Fig. VIII-1. A remarkable zonation which can be related to water depth is described below.

a) Planktonic foraminifera occur predominantly at depths shallower than 3,500 m.

b) Planktonic foraminifera occur with radiolarians at depths between 3,500 and 4,200 m.

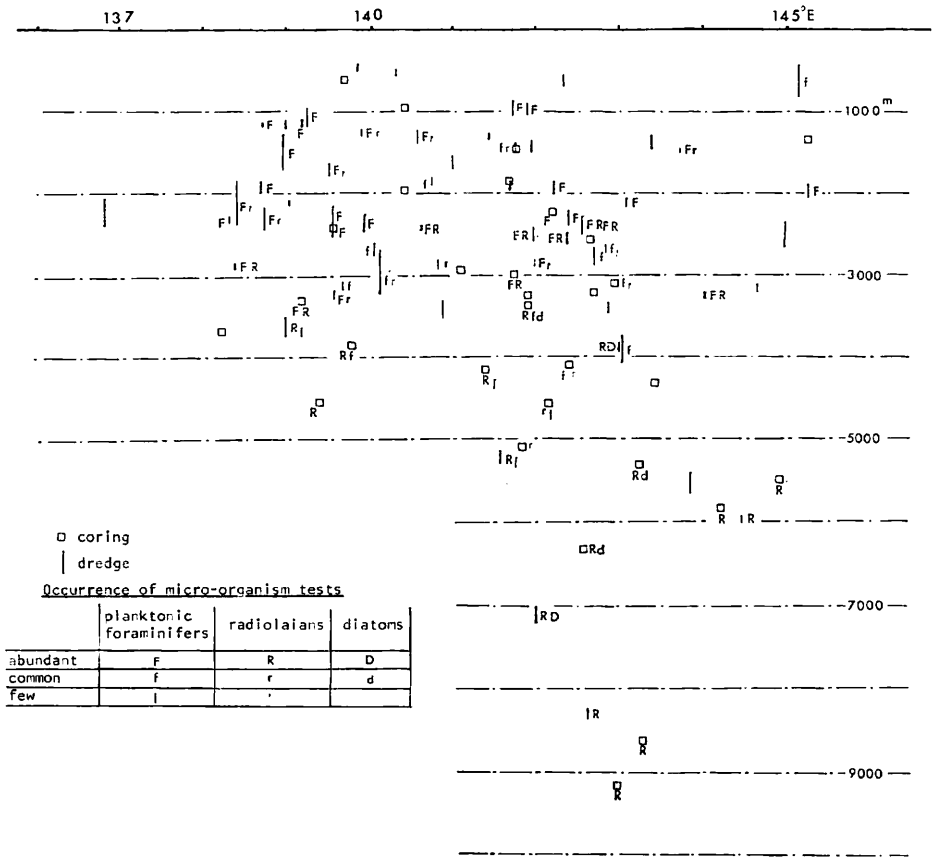


Fig. VIII-1 Occurrence of micro-organism tests in surficial sediments of cruises GH79-2, -3 and -4, projected on the latitudinal section with water depth.

c) Radiolarians occur without planktonic foraminifera at depths greater than 4,200 m.

This zonation is mainly the result of dissolution of the calcareous tests of planktonic foraminifera at the calcium carbonate compensation depth (CCD) which seems to be at approximately 3,500 m here. Some high contents of radiolarians were found at a few sites at 2,000 to 3,500 m on the eastern continental slope of the Ogasawara Trench. This is possibly owing to the influence of an upwelling current at the trench slope.

Volcanic, glassy particles are commonly found in these surficial sediments. They are divided into two types; colored (olive to brown) and colorless. Distribution of the glassy particles is shown in Fig. VIII-2. Colored glassy particles occur in the surficial sediments of the southern part of surveyed area. The large quantity and large size of the colored glassy particles imply that the volcanic source of these colored glassy particles is located on the ridge area in the southern part of the surveyed area.

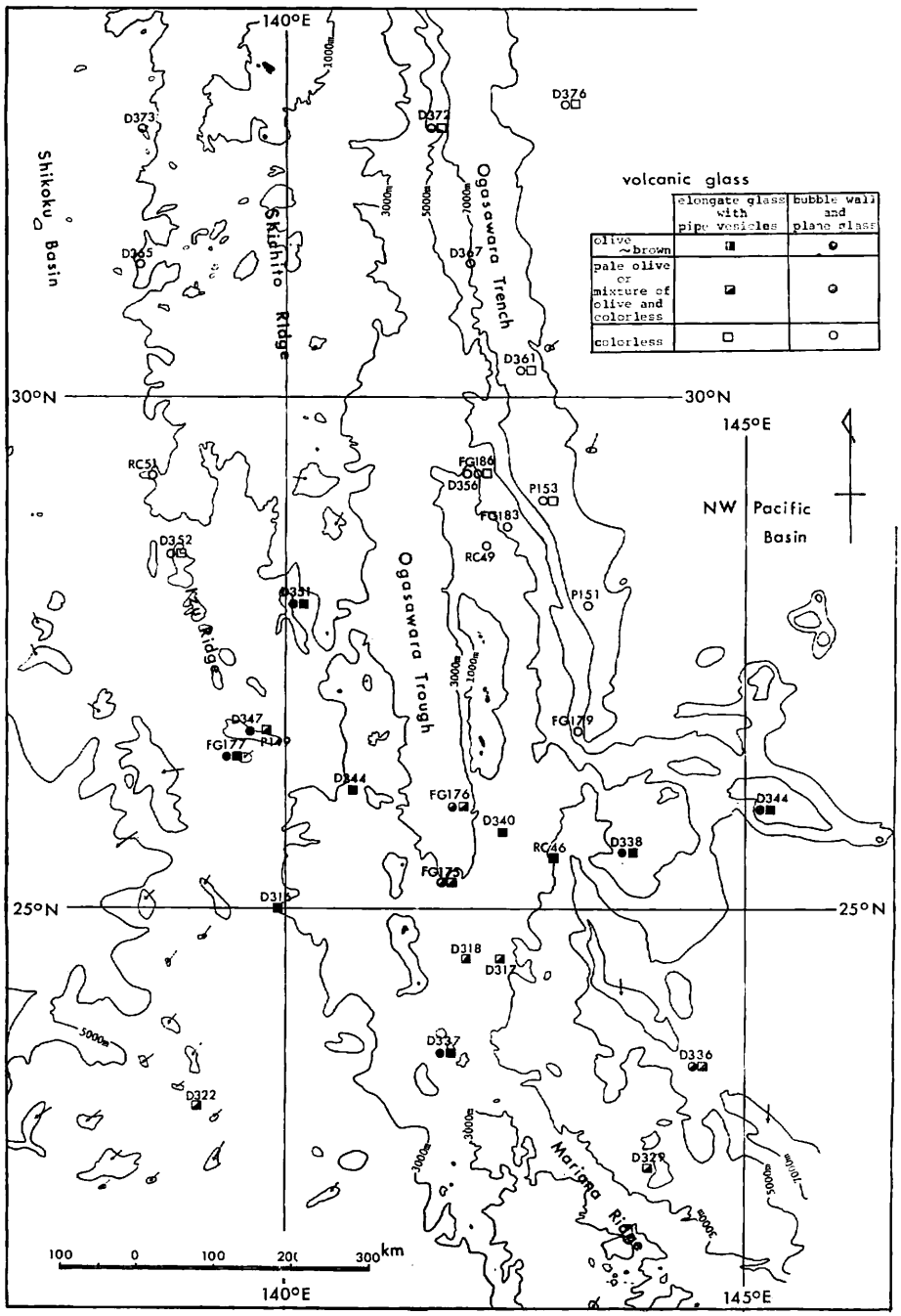


Fig. VIII-2 Distribution of volcanic glass in surficial sediments of GH79-2, -3 and -4 cruises.

3. Rocks

Sampling sites of rocks in the area are shown in Fig. VIII-3. In this figure, in situ pumice (i.e. no suggestion of emplacement by floating) is shown along with sedimentary, volcanic and metamorphic rocks. It is not thought that the rocks were carried from a distant source by ice-rafting, as were some in the Japan Sea and the North Pacific Ocean, or like rounded pebbles on the continental shelves around the Japanese Islands, because the latitudes of the surveyed area are far beyond the southern limit of ice-rafting in the northern hemisphere. These rocks are thought to be one of the constituents of the seamounts or highs where the sampling was carried out, even if the rocks were not sampled directly from outcrop.

The sampled rocks are described below within their topographical divisions.

1) The Ogasawara Plateau

The Ogasawara Plateau is a large-scale seamount with flat top, located at the junction between the Ogasawara Trench and the Mariana Trench. Sampling works were attempted on the Plateau during cruise GH74-3 (INOUE *ed.*, 1976), but rocks constituting the Plateau were not obtained. During the recent cruises, sedimentary rocks were taken from two sites (D343, and D345). Both are siltstones. The sample from D343 is a hard rock covered by a thin layer of ferromanganese oxide, while the sample from D345 is rather soft and contains foraminifera.

2) The Ogasawara Trench and its slope

A claystone core, 22 cm in length, was taken from a high on the inner trench slope of the southern edge of the Trench. The upper surface is covered by a thin coat of ferromanganese oxide.

D361 was located on the outer trench slope off Torishima Island. Chert, radiolarian mudstone and platy ferromanganese oxide were dredged from the site. Cretaceous radiolaria were identified in the mudstone and chert.

FG188 and RC53 were both taken at station 1564 on the inner trench slope. A few, very small fragments of claystone were obtained.

3) The northern part of the Mariana Trench

In situ rocks were dredged from D323, D324, D329 and D336. D323 was located on the slope of a high on the inner trench slope. Volcanic breccia covered by a thick ferromanganese crust, and greyish and yellowish-white volcanic rock coated by a thin ferromanganese film were obtained. The coarse fragments of the breccia are orthopyroxene-clinopyroxene andesite, while the groundmass is composed of plagioclase, clinopyroxene, orthopyroxene and brown glass. The greyish and yellowish-white volcanic rock is a hornblende-hypersthene andesite containing small amounts of augite. The hornblende phenocrysts are green-colored and the groundmass of the rock is composed of plagioclase, hypersthene, clinopyroxene and glass.

The D324 samples were dredged from the lower part of the same slope as

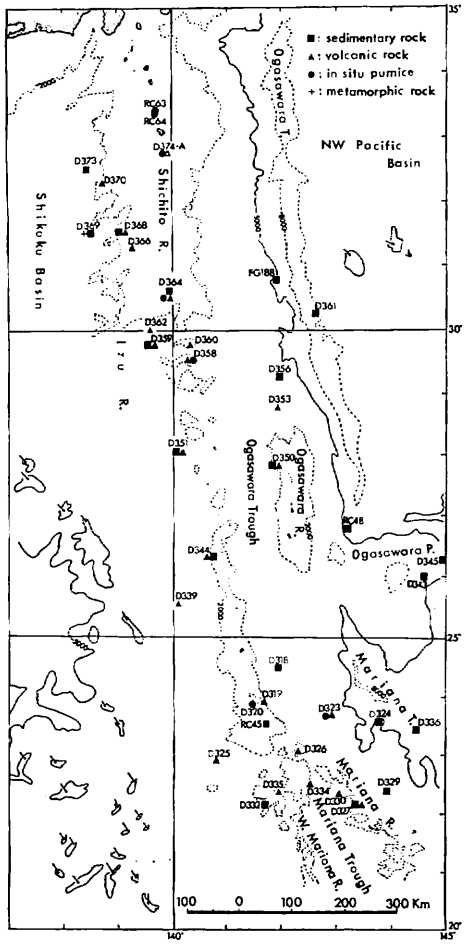


Fig. VIII-3 Localities of sedimentary, volcanic, metamorphic rocks and in situ pumice obtained during GH79-2, -3 and -4 cruises.

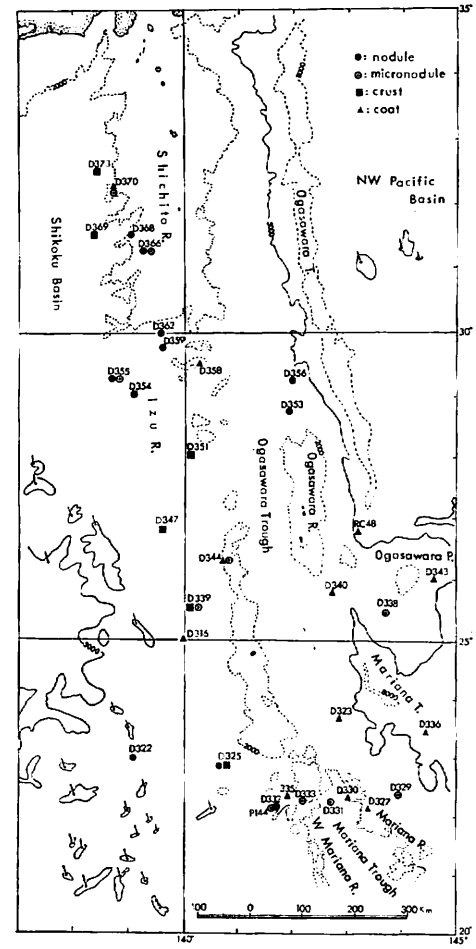


Fig. VIII-4 Localities of ferromanganese oxide.

D323. The siltstone from this site, when observed under a microscope was found to be a crystalline tuff containing a lot of clinopyroxene and orthopyroxene. Volcanic rock fragments were also found at D324 and the quartz crystals in these fragments show wavy extinction.

Tuffaceous sandstone consisting mainly of volcanic material was dredged from site D329. It is composed of plagioclase, augite, hypersthene and green hornblende grains, foraminifera, brown glass and fragments of dolerite and andesite. White mica is present in the fine-grained matrix.

Siltstone was taken from a high on the lower part of the inner trench slope (D336), and was found to be partly coated by ferromanganese oxide.

4) The northern part of the Mariana Ridge

This area corresponds to the place where the Mariana Ridge (outer ridge) and the West Mariana Ridge (inner ridge) join. The Mariana trough disappears in this region. Observation of the seismic profiles, however, indicate that rifting of the Trough extends slightly north-northwest as a narrow depression (cf. Chapter VI). Sampling sites were selected with these points in mind.

Mariana Ridge(outer ridge)

Rock samples were taken from two sites, D326 and D327. D326 was sited on the slope near the top of a seamount called the Nikko Seamount. The Nikko Seamount was not listed on the table of active volcanoes used during our survey. However, pale green-colored water was observed to fan out to a distance of about 500 m around the seamount on 12 July, 1979 (Hydrographic Department of Maritime Safety Agency, 1979). A lot of glassy andesite was dredged from the site. The rocks are black-colored and have elongated pores which indicate a flow structure. Phenocrysts in the rock are plagioclase, augite, hypersthene and an opaque mineral (iron ore) and the groundmass consists of plagioclase, clinopyroxene and light-brown colored fresh glass.

Samples from site D327 were also mainly volcanic rocks. Two types were distinguished. A coarse-grained augite andesite which contains plagioclase and augite as phenocrysts, and plagioclase, clinopyroxene, quartz and potassium feldspar in the groundmass. Some of the mafic minerals have been completely altered to an assemblage of actinolite, quartz and an opaque mineral. A micrographic texture can often be observed between the quartz and potassium feldspar in the groundmass. The other type is orthopyroxene-augite andesite, which contains plagioclase (partly cericitized), orthopyroxene (completely altered to chlorite), augite and an opaque mineral as phenocrysts, and plagioclase, quartz, an opaque mineral and some clinopyroxene in the groundmass.

A sand sample from D330, between the above two sites, was observed under a microscope. The sand is composed of foraminifera and stained grains of hypersthene-augite andesite (glassy), light-brown glass fragments, crystal fragments (hypersthene, augite and plagioclase), sandstone fragments (grains: plagioclase, clinopyroxene and foraminifera), and damaged foraminiferal test.

The West Mariana Ridge(inner ridge)

Rock samples were taken from two sites, D332 and D335. Samples from site D332 were found to be calcareous sandstone with a thin ferromanganese coat and lithic tuff. Many fossil foraminifera are present in the sandstone. Other grains in the sandstone are plagioclase, oxidized olivine (red-colored), light-green hornblende, clinopyroxene, orthopyroxene and andesitic rock fragments. These grains are cemented by a fine-grained calcite matrix. The lithic tuff consists of volcanic rock fragments altered to various degrees (olivine-clinopyroxene andesite, clinopyroxene andesite, glassy volcanic rock and volcanic rock with a groundmass consisting of plagioclase lath, quartz and other minor constituents), crystal fragments (plagioclase, olivine, augite and green hornblende), glass fragments and

foraminifera.

The rock sample from D335 has a 3 cm thick crust of ferromanganese oxide and no texture is observed under the microscope. Plagioclase, brown hornblende and clinopyroxene are present as euhedral crystals, but the other minerals are all altered to clay minerals.

The Mariana Trough

A rock penetrated by a large amount of ferromanganese oxide was collected from site D331. Under microscopic observation, rock fragments and crystal fragments can be distinguished, but the matrix of the rock is altered to clay minerals. In some cases ferromanganese oxide exists as a matrix. The rock fragments are volcanics, and dolerite and glassy andesite are present. Plagioclase, calcite, augite and hypersthene are identified as the crystal fragments. In rare cases, an aggregate of quartz grains with sutured contacts is found in association with chlorite. The rocks at site D331 are thought to be sandstone or lithic tuff consisting mainly of volcanic rock fragments.

Rock from site D334 are hypersthene-augite andesite (glassy), similar to the rocks from the Nikko Seamount, and a small fragment of pyroxene-quartz dacite. The latter consists of plagioclase, quartz and completely altered pyroxene as phenocrysts and plagioclase and quartz as the groundmass.

Core RC45 was taken from a depression on the northern edge of the Mariana Trough. The lowermost part of the core is a crystalline lithic tuff, containing plagioclase, olivine, clinopyroxene and, rarely, brown mica as crystal fragments, and glassy andesite (clinopyroxene andesite containing a little brown mica) as rock fragments. Pale brown glass fragments are also found. Black sand grains, in the layer above the tuff, consist of the crystals of plagioclase, olivine, clinopyroxene and pale brownish-green hornblende, and glassy andesite (olivine-clinopyroxene andesite) fragments.

5) The Shichito Ridge

The Shichito Ridge occupies the central part of the area. All the islands of the Ogasawara Arc, except the Ogasawara Islands, lie on this Ridge. These islands are made up of volcanic rocks—in other wards, the ridge is a large volcanic chain. The length of the ridge, from Izu-Oshima Island to Minami-Iwojima Island, corresponds to that of Honshu.

The samples from site D319 and D320 were dredged from the slope of a high of Minami-Iwojima Island. The samples from D319 compose pebbles of olivine-augite andesite surrounded by glass. Most of the pebbles are about 3 cm in diameter. It is thought that these pebbles were not formed by weathering and erosion of a source rock, but formed hyaloclastically at their present size and shape. Some devitrification has taken place in the glassy part. Skeltal crystals of olivine are also present.

A chain-bag dredge was lost because of the strength of the basement rock during sampling at site D320. Judging from the sample in the other small cylinder-type dredge, the basement rock is a thick pumice layer. The pumice sampled had a

black coating on the surface which is supposed to be the exposed surface. Rounding, which would be formed during transport, was not present, and all of the pumice fragments were in contact with each other. From these facts, it can be deduced that the pumice layer was not formed as a deposit of a large amount of floating pumice but as an in situ pumice flow.

Sandstone, volcanic breccia and olivine basalt were dredged from site D344 between Kita-Iwojima and Nishinoshima Islands. The phenocrysts of the basalt are plagioclase and olivine, while the groundmass consists of plagioclase, clinopyroxene, olivine and a small amount of pale-brown to colorless glass. The rock is fresh except that the rim of the phenocrysts of olivine show a slightly reddish brown-color.

Samples from site D351, north of Nishinoshima Island, are siltstone with a thin (5 mm) ferromanganese crust, sandstone and clinopyroxene basalt. The phenocrysts of the basalt are plagioclase and clinopyroxene (pigeonite?). The groundmass is composed of plagioclase, clinopyroxene, opaque minerals and brown glass. The basalt has a sub-ophitic texture, and the clinopyroxene and plagioclase in the groundmass show dendritic and swallow-tail textures respectively.

The two site, D358 and D360 were both located south of the Sofu-gan Rocks. Samples from D358 are pumice (may be in situ) and acid igneous rocks with a thin ferromanganese coat. The latter are all small fragments of dacite (phenocrysts: plagioclase, quartz and hornblende), an acid coarse holocrystalline rock containing biotite, and tuff. Site D360 was located on the slope of the Sofu-gan Rocks. Coarse volcanogenic sandstone and basaltic fragments were obtained there.

Site D374-A was located between Hachijojima and Aogashima Islands. Presumably in situ pumice (phenocrysts: plagioclase and clinopyroxene) and volcanic breccia were dredged up. The coarse fragments in the breccia are basalt. Although all the mafic phenocrysts are altered to serpentinite, it is thought that they were originally olivine phenocrysts. The groundmass of the rock is composed of plagioclase and clinopyroxene.

6) The Izu Ridge (The Nishi-shichito Ridge)

Geological data for the Izu Ridge are less than for all the other Izu-Ogasawara Ridges, because no islands exist on the ridge, and it has remained unsurveyed except for the Zenisu Rocks and their neighborhood around Izu Peninsula. During these cruises, too, sampling sites on the ridge were few, and the success rate was also low.

The Izu Ridge is smaller than the Shichito and Ogasawara Ridges in its topographic height. The southern part of the ridge off Iwojima Island in a row of discontinuous knolls while the northern part of the Ridge, from west of the Sofu-gan Rocks to the Zenisu Rocks and their neighborhood, is a N-S trending series of small en echelon ridges which lie at high angles to the trend of the main Shichito Ridge. The depressions between the Izu and the Shichito Ridges are not distinct in the north. The Izu Ridge is only well-developed along the central part of the Ogasawara Trough on its west side.

The southmost site on the ridge was site D325. It is possible that the seamount

at this site is not a part of the Izu Ridge at all. The seamount is, however, independent of the Kazan-retto and of the inner and the outer Mariana Ridges, and so is considered to be on a southern extension of the Izu Ridge. At D325 we obtained a pumice breccia. Its surface is covered by a thin ferromanganese coat. In some cases, the surface of the pumice pebbles within the breccia are also coated. Plagioclase, hypersthene, clinopyroxene and olivine were identified as the phenocrysts of the pumice.

Site D339 was to the west of Kita-Iwojima Island. Andesite with a ferromanganese coat was obtained.

Site D359 was west of the Sofu-gan Rocks and between the Shichito and Izu Ridges. Judging by the distribution of manganese nodules as mentioned later the seamount here is thought to be a member of the Izu Ridge. Siltstone fragments with a ferromanganese coat and slightly altered basaltic rocks were obtained at this site.

The three sites D366, D368 and D369 are all located west of Smith Island. Of these sites, site D366 lies east of the Ridge, site D368 on the central part, and site D369 on the west part of the Ridge which corresponds to the eastern edge of Shikoku Basin.

Andesite with a thin ferromanganese coat was dredged from site D366. The phenocrysts of the rock are plagioclase, augite, quartz, pale greenish-brown hornblende and orthopyroxene (altered). The quartz phenocrysts are always surrounded by a reaction rim of fine-grained quartz. The groundmass is composed of plagioclase, quartz, clinopyroxene, opaque minerals and a large amount of very fine-grained material.

The rocks from site D368 are also ferromanganese oxide coated. They are augite-olivine basalt, sandstone and siltstone. The basalt has plagioclase, augite and olivine with a reddish-brown surface as phenocrysts, and a groundmass of plagioclase, clinopyroxene and opaque minerals.

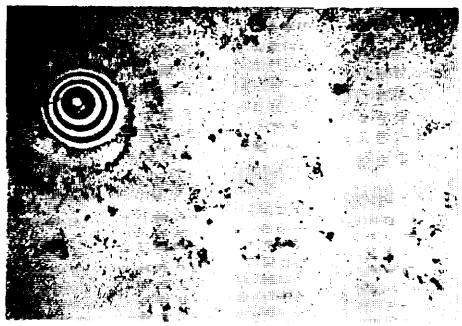
The sample from D369 are also coated rocks. Siltstone, schist, and a metalliferous(?) material with a resinous luster were obtained. The schist is composed of chlorite, white mica, quartz and albite.

Hypersthene bearing augite-olivine basalt with a ferromanganese coat was sampled at site D370 west of Aogashima Island. The phenocrysts of the rock are olivine, clinopyroxene and a little orthopyroxene. Plagioclase is not present. The groundmass consists of clinopyroxene, olivine, orthopyroxene and glass. The proportion of glass is high in one part, but a gradual evolution to variole can be observed. The clinopyroxene of the groundmass in the crystalline part sometimes shows dendritic texture. It is thought, therefore, that the fragments were a part of a pillow lava or originally hyaloclastic rubble.

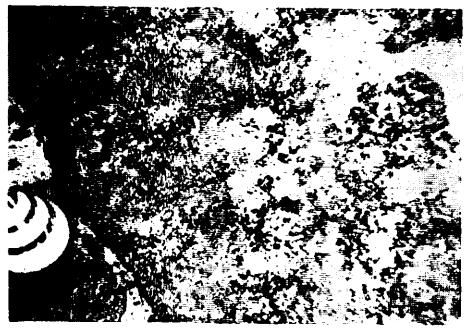
A sample from site D373 was obtained on the slope of the seamount northwest of site D370. It was siltstone with a ferromanganese oxide coat.

4. Ferromanganese Oxide

The sites ferromanganese oxide obtained during cruise GH79-2, 3 and 4 are shown in Fig. VIII-4. The oxide materials are distinguished into three types of



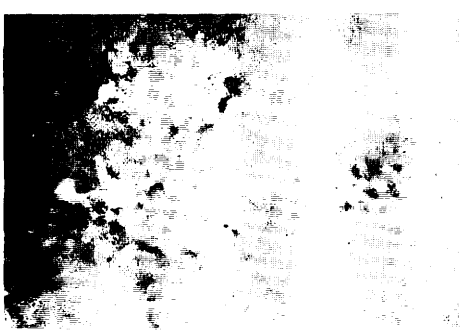
St.1494
FG165-C
2,580 m



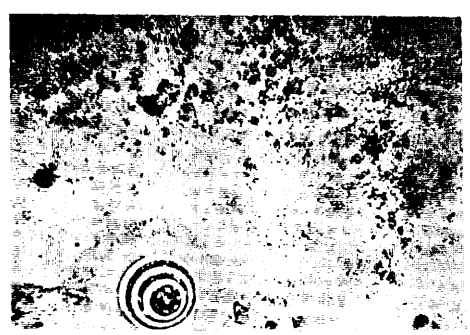
St.1499
FG166-C
2,458 m

St.1500
FG167-C
3,945 m

St.1501
FG168-C
3,185 m

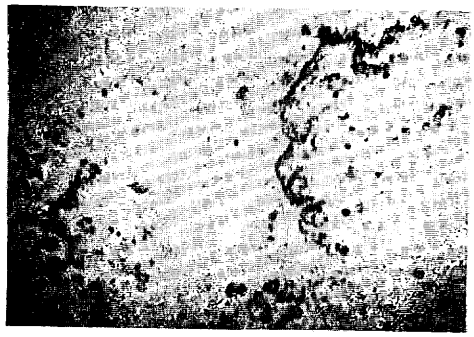


St.1503
FG169-C (out of focus)
5,660 m



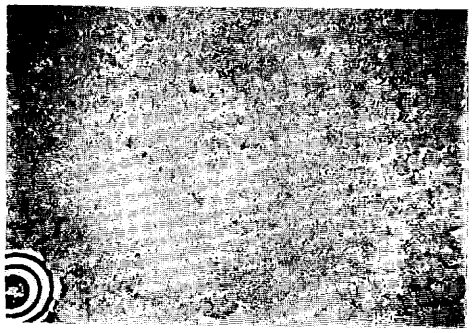
St.1504
FG170-C
3,135 m

Plate VIII-1a Subsea photographs taken by a one-shot camera attached to a freefall grab sampler and marine drill. Station number, sample number (freefall grab number) and water depth are shown below each photograph. Diameter of the weight in the photographs is approximately 8 cm.

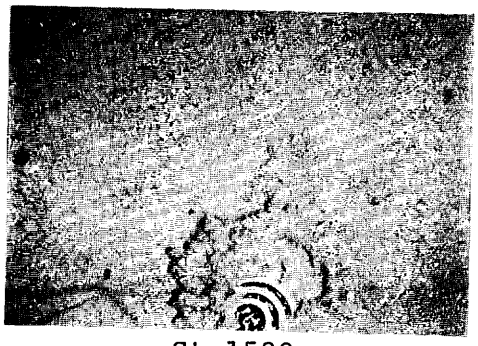


St.1512
FG171-C
2,000 m

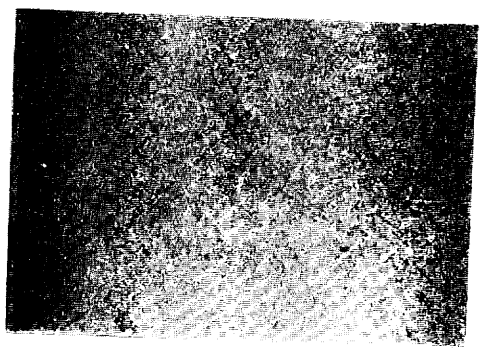
St.1516 *
FG172-C
4,280 m



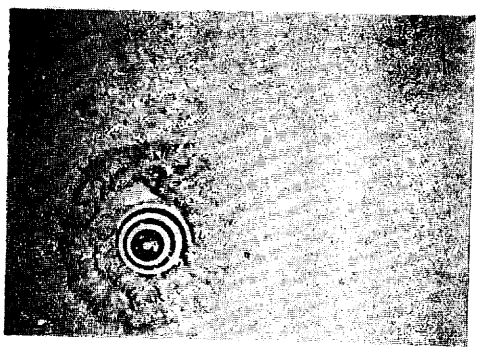
St.1517
FG173-C
6,000 m



St.1528
FG176-C
3,340 m

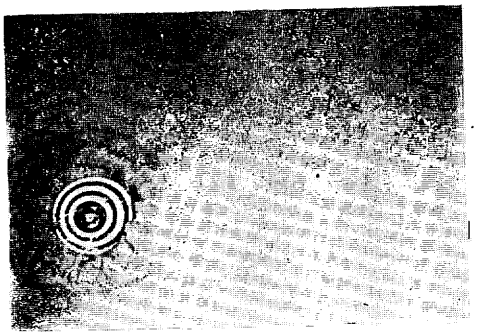


St.1532
FG177-C
4,530 m

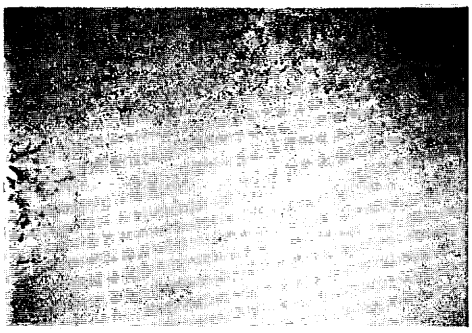


St.1534
FG178-C
3,832 m

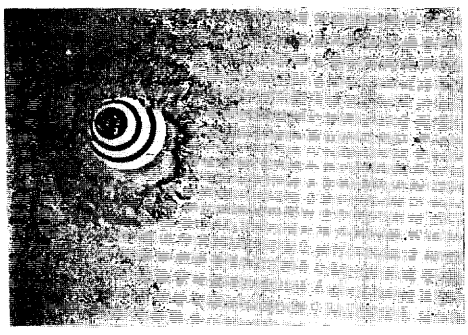
Plate VIII-1b



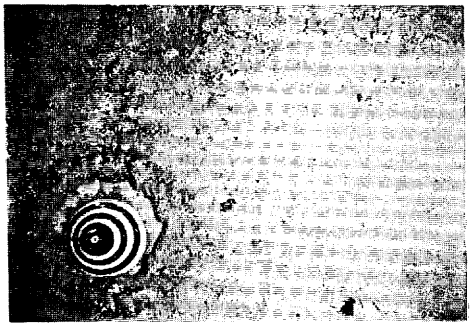
St.1536
FG179-C
5,310 m



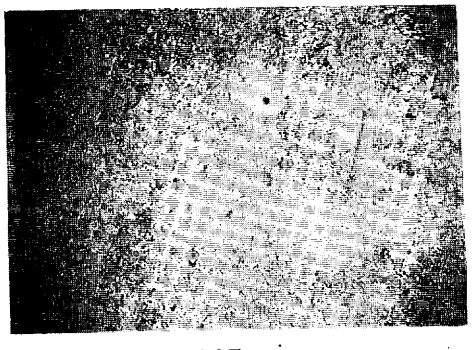
St.1538
FG180-C
5,473 m



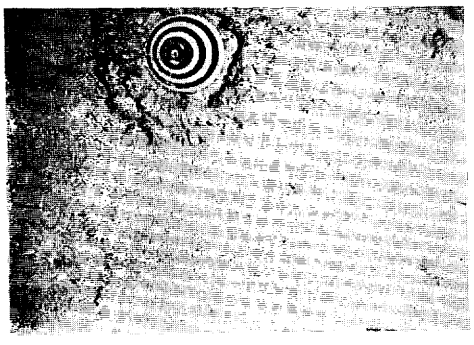
St.1542
FG181-C
4,150 m



St.1546
FG182-C
2,150 m

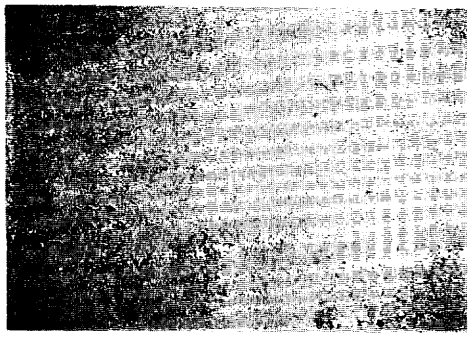


St.1547
FG183-C
4,150 m

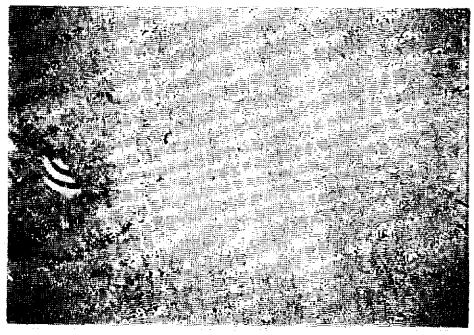


St.1549
FG184-C
3,280 m

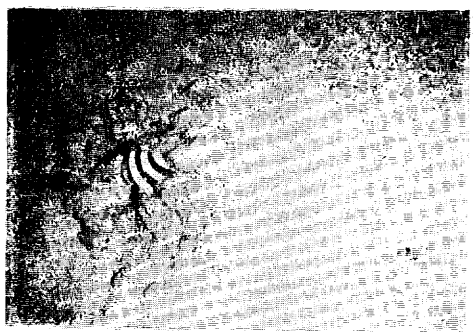
Plate VIII-1c



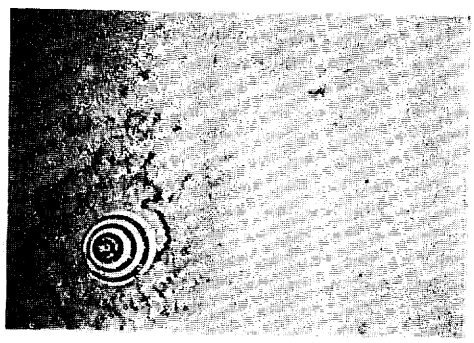
St.1554
FG186-C
4,550 m



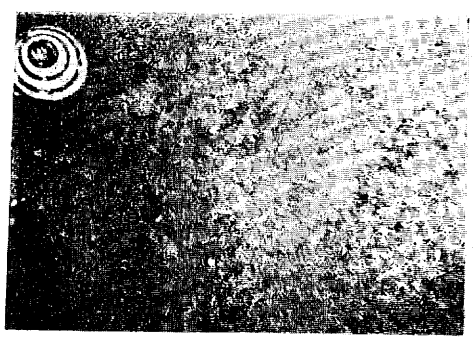
St.1559
FG187-C
5,796 m



St.1564
FG188-C
5,230 m



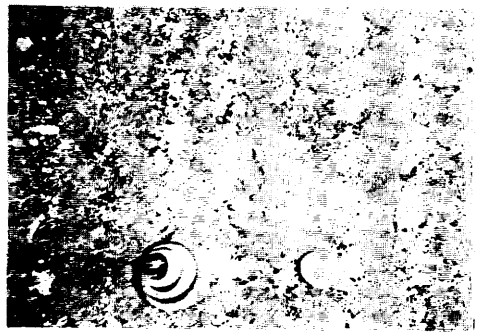
St.1565
FG189-C
2,915 m



St.1586
FG190-C
950 m

St.1570
H11
168 m

Plate VIII-1d



St.1571
H12
245 m

St.1572
H13
180 m

*Two parallel horizontal lines in the central part are stains on film through the developing.

Plate VIII-1e

nodule, crust and coat. Here, we call "coat" when ferromanganese oxide is thinner than about 1 mm thick coated all or a part of the rock, and "crust" when ferromanganese shell is thicker than the "coat" and is not covered all surface of the rock. Nodule shaped ferromanganese oxides were sampled only from the Izu and the Ogasawara Ridges. Thin coat or crust, and micronodule ferromanganese oxides were obtained from the Shichito Ridge and northern Mariana Ridge.

The difference of the oxide thickness is considered to be a result in that of age when the ridge was formed. Modern volcanoes are the main constituent of the Shichito Ridge and of the northern Mariana Ridge. On the other hand, the Ogasawara Ridge is consisted of the Paleogene formations, and has no modern volcanism. No data for the age of the Izu Ridge is available, except that of the Zenisu Rocks on the northern end of the Ridge where the presumable Miocene rocks were reported (ISSHIKI, 1980). No evidence of the volcanic activity such as a submarine eruption or colored water has been reported in the Izu Ridge area.

5. Bottom Photography

Bottom photography was carried out by one-shot camera attached to a freefall grab at 26 stations of coring and dredge, and to a foot frame of marine drill at 4 stations. Its purpose was observation of bottom condition of the sampling station, such as manganese nodule and benthonic organism activity. Distinct manganese nodule was not found in these photographs, because the photography was carried out when the piston core was sampled mainly on flat plains. Faecal ridges as like a twisted rope are observed in the photographs FG 179C and 184C. Small deep holes (burrow) are observed in the photographs FG 172C, 183C and 184C. Many sessil animals are observed in the photograph H 12 (Plate VIII-1a ~ 1e).

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