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CRUISE REPORT

R/V TANGAROA

Mn-NODULE INVESTIGATIONS IN THE SOUTHWESTERN PACIFIC BASIN

CRUISE LEADER - G. P. GLASBY (NZOI)

4 MAY - 2 JUNE, 1974

Submitted by:

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ABSTRACT

(Submitted to Geol. Soc. of Amer. for presentation at the November 1974 Annual Meeting, under the title "Distribution and Morphology of Manganese Nodules from the Southwestern Pacific Basin", by G. P. Glasby, M. A. Meylan, and H. Bäcker).

A reconnaissance cruise by the NZOI research vessel TANGAROA has defined limits of manganese nodule occurrence in portions of the Southwestern Pacific Basin. Bottom samples were collected at 46 stations between New Zealand and Rarotonga (in the Cook Islands), using pipe dredges, gravity corers and free fall grabs. Manganese nodules were recovered at 9 stations southwest of Rarotonga, at distances of 130 to 1000 km from the island, and in depths of 4700 to 5700 meters. Dense concentrations, up to 100% (as seen in bottom photographs), occur in a more restricted area, 220 to 745 km southwest of Rarotonga. A free fall grab yielded 20 kg/m^2 of nodules at one station in this area. Most of the nodules are spheroidal, and range in size from 1-9 cm.

Nodules were recovered at 15 stations in two areas south of Rarotonga, 45 to 1270 km and 1580 to 2090 km south of the island, and in depths of 3970 to 5590 meters. Compared to the nodules collected southwest of Rarotonga, nodules from the areas south of Rarotonga show a wider range of sizes (0.5-11 cm) and shapes (discoidal, botryoidal, spheroidal with equatorial "skirts", and more irregular forms in addition to many spheroidal nodules).

Considering the entire study area, where different nodule morphologies occur at a single station, the smaller nodules tend to be more spheroidal. Surface textures of the nodules are generally uniformly granular. Nodules from all areas in the basin occur on light brown to dark brown silty clay; the coarse fraction of the sediment invariably includes volcanic fragments (pumice, tuff, and basalt), and often sharks' teeth. Areas devoid of nodules have little coarse fraction in the sediment. Sedimentation rates and availability of nuclei are presumed to govern nodule distribution.

ACKNOWLEDGMENTS

The success of any cruise depends upon several factors such as good weather, a good ship, and good luck. The TANGAROA is admirably suited for oceanographic research, and she found enough good weather so that we were in the right place at the right time. But nothing is more important than the assistance and interest of the ship's officers and crew. Captain Neil Gillstrom and the men of the TANGAROA are to be complimented for so willingly providing such support. Teamwork within the scientific party is another key to success, and Cruise Leader Geoff Glasby ably sorted out varying interests to provide continuity to the program. We are indebted to Dr. Glasby (and the New Zealand Department of Scientific and Industrial Research) for cruise planning and for inviting us to share an opportunity to explore for manganese nodules. My own participation was funded by the NSF-IDOE Ferromanganese Research Program, and this support is gratefully acknowledged.

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I. INTRODUCTION

The R/V TANGOROA departed from Wellington on May 4, 1974 to explore for manganese nodules in the Southwestern Pacific Basin. As stated in the cruise prospectus, the objectives of the cruise were to establish the distribution, density and metal contents of manganese nodules, and their relationship to sediment type, in order to assess nodule genesis and their potential for commercial exploitation. The cruise objectives were achieved during a month-long survey between New Zealand and Rarotonga, when bottom samples were collected at 46 stations, with nodules recovered at 24 of these stations. The TANGAROA returned to Wellington on June 2, 1974. A chronological list of cruise highlights is presented in Table 1. Cruise personnel are listed in Table 2.

II. CRUISE TRACK AND BATHYMETRY

As originally planned, the TANGAROA was to leave Wellington and proceed ENE to 40° S. Lat., 172° W. Long., then NE to 32° S. Lat., 160° W. Long., then directly north to Rarotonga (21° 15' S. Lat., 159° 50' W. Long.), and return to Wellington on a southwesterly course. A storm encountered during the first few days out of port forced a change of plans, and the original cruise track was followed approximately in reverse. The principal alteration was the run south from Rarotonga to about 40° S. Lat., instead of 32° S. Lat. (see Fig. 1).

The cruise track was based in part on data published by Skornyakova and Andryushchenko (1970), including a map showing extensive nodule deposits in the Southwestern Pacific Basin. The TANGAROA cruise has demonstrated that the deposits are not as widespread as believed by Skornyakova and Andrushchenko (see Section IV, Nodule Distribution and Density).

A variety of bathymetric features was crossed during the cruise. From prior to station G972 to station G982, the bottom was mostly a flat or gentlely undulating abyssal plain, with a few scattered seamounts. Relief was generally less than 100 meters, apparently due to burial of original features. As the manganese nodule deposits southwest of Rarotonga were approached (stations G983 to G988), general relief of the abyssal hills increased to about 200 meters, and seamounts became more numerous. Manganese nodules were recovered from relatively flat abyssal plains or basins between the seamounts (stations G989 to G996).

The bottom rose gradually toward Rarotonga (G997) and then less than 20 miles from the island, the steep slopes of the volcanic edifice of Rarotonga were encountered (G998 to G1000).

South of Rarotonga (G1001 to G1005), general relief of the rolling abyssal hills (up to about 300 meters) was greater than for similar features to the west. As the TANGAROA continued south, the bottom became even more rugged, with numerous seapeaks and seamounts (stations G1006 to G1018). A variety of manganese nodules and volcanic fragments were recovered from most of the stations in the hilly and mountainous areas south of Rarotonga.

Subsequent stations on the return to Wellington sampled nearly flat abyssal plains, often sloping up or down to a few seamounts that abruptly pierced sediment cover. The echo sounding program ended as the TANGAROA obliquely crossed the northern flank of the Chatham Rise.

III. OPERATIONS AND EQUIPMENT PERFORMANCE

Initial plans called for stations to be occupied every 50 nautical miles.

TABLE 1 -- CRUISE HIGHLIGHTS

4 MAY	--	Depart from Overseas Terminal, Wellington, New Zealand, and proceed ENE after rounding Cape Palliser.
6 MAY	--	Planned first station is abandoned, and course altered to NNE, after encountering gale force winds and heavy seas.
7 MAY	--	Occupy first station of cruise (G972).
12 MAY	--	First nodules of cruise recovered.
13 MAY	--	Nodules recovered from depth of 5400 meters at site of reported reef. First bottom photos obtained, showing dense nodule coverage.
16 MAY	--	Arrive at Avatiu harbor, Rarotonga. Preliminary cruise results presented at meeting of Rarotonga Scientific Society.
17 MAY	--	TANGAROA scientists entertained at morning tea by the Hon. Sir Albert Henry, Premier of the Cook Islands.
19 MAY	--	Depart from Rarotonga, and proceed due south.
22 MAY	--	Storm forces ship to reduce speed.
26-27 MAY	--	Ship slowed or stopped as result of high winds and heavy seas. Change course to SW.
28 MAY	--	Change course to head directly for Wellington.
30 MAY	--	Storm forces ship to reduce speed.
31 MAY	--	Last station of cruise (G1024).
2 JUNE	--	Arrive at Queen's Wharf, Wellington.

TABLE 2 -- SCIENTIFIC PARTY

	POSITION	AFFILIATION	FIELD OF INTEREST
Geoffrey P. Glasby	Cruise Leader	NZOI	Mn-Nodules
John C. McDougall	Asst. Cruise Leader	NZOI	Sedimentology
Harald Bäcker	Scientist	Preussag	Mn-Nodules
Maurice A. Meylan	Scientist	U. of Hawaii	Mn-Nodules
Richard J. Singleton	Scientist	NZOI	Biology and Bottom Photography
William E. Whitley	Scientist	NZOI	Electronics

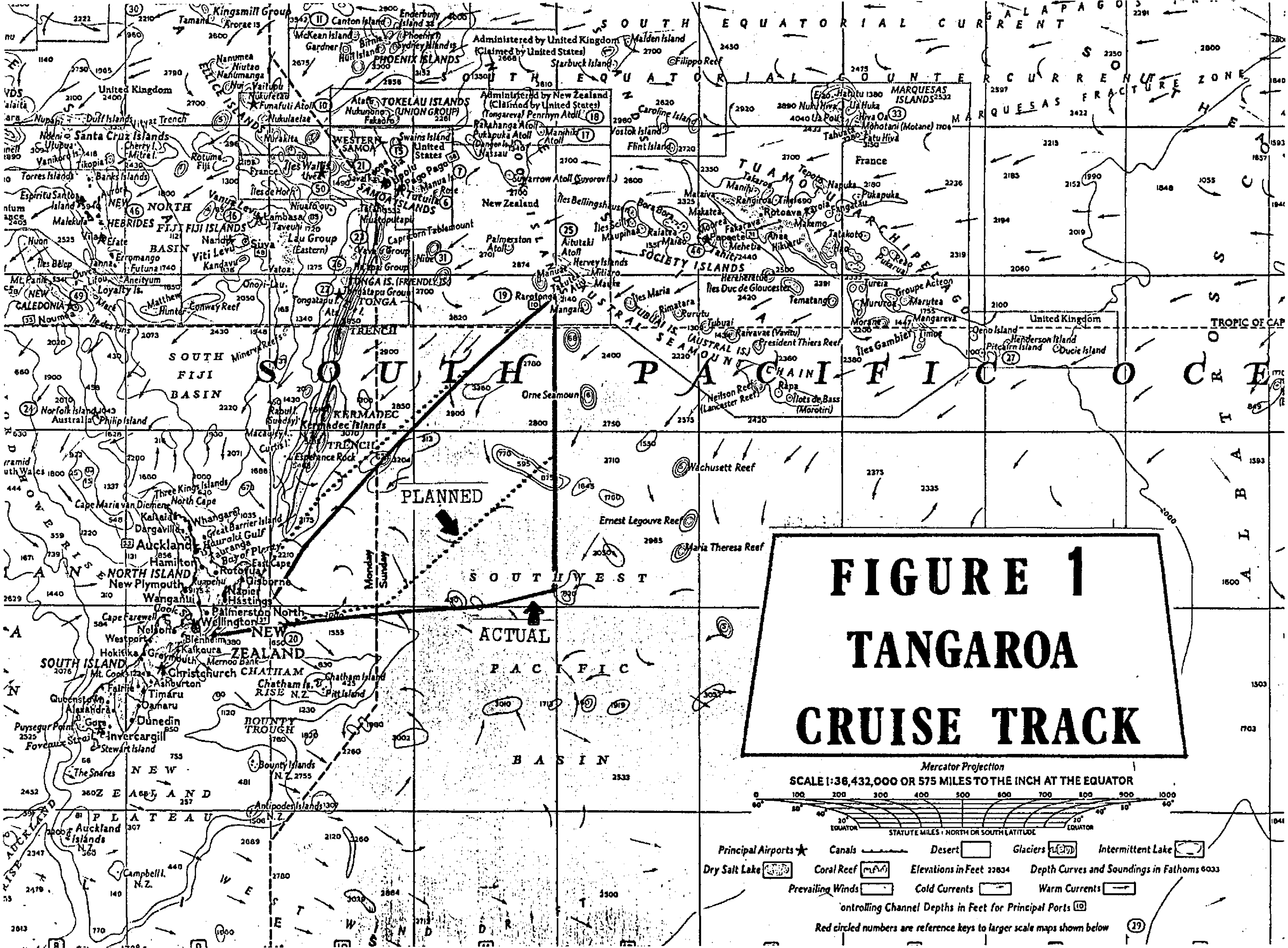

FIGURE 1
TANGAROA
CRUISE TRACK

Weather and logistical considerations caused some variance, resulting in station spacings of about 40 to 100 nm. A total of 53 stations was occupied, and 46 of these produced bottom samples. Most stations (except G992, G993, G996, G1004, G1006, G1010, G1013, G1014, and G1015) consisted of a single operation. Seventy pieces of equipment were sent to the bottom, and 55 returned with samples or data, for a success ratio of 79%. A station summary is presented in the Appendix (Table A).

The most frequently used piece of equipment was a closed-end pipe dredge approximately 1 ft. in diameter and 3 1/2 ft. long. It was surprisingly successful in collecting nodules and/or sediment from the great depths (mostly greater than 5000 meters) common in the Southwestern Pacific Basin. Other pieces of gear utilized include a short gravity corer, capable of collecting cores up to about 3 ft. long; an Edgerton-type deep-sea camera triggered by a lead weight and used without a pinger (a couple of attempts to use a pinger attached to the wire above the camera failed); VALDIVIA and Kennecott free fall grabs; and an orange peel grab. The NZOI rock dredges (see McDougall, 1973) were not used on this cruise. Table 3 summarizes the operational success, i.e., success in collecting data or samples, of the various pieces of gear.

TABLE 3 — OPERATIONAL SUCCESS

Orange-peel grab:	0 for 2	
Pipe dredge:	35 for 38	
Short corer:	10 for 14	
Free fall grab:	7 for 8	
Bottom camera:	3 for 8	
	55 for 70	TOTAL

All bottom equipment (except the free fall grabs) was attached to 8 mm (5/16") wire and raised and lowered by a hydraulic winch. The winch is mounted amidships on the foredeck of the TANGAROA, and for this cruise the wire was passed through a sheave hung on the port "A"-frame.

No attempt was made to collect geophysical data other than 12 kHz echo sounder profiles. These profiles are essentially continuous for the entire cruise track, and are of variable quality, the poorest records being obtained during the rough weather encoutered south of Rarotonga. The records were made on the 0-8000 m scale, and depths can be read to approximately ±25 m.

Positions were obtained with an I.T.T. satellite navigation system that provided instantaneous read-outs based on most-recent fixes and continually-updated dead reckoning information. Most station positions are probably accurate to ± 1 km or better.

IV. NODULE DISTRIBUTION AND DENSITY

Manganese nodules were recovered at 15 stations in three areas of the northwestern quadrant of the Southwestern Pacific Basin (see Fig. 2). One of the areas is 130 to 1000 km (70-540 miles) southwest of Rarotonga (stations G987-G989 and G991-G996). The other two areas are due south of Rarotonga, at distances of 45 to 1270 km (25-685 miles) and 1580-2090 km (855-1130 miles) from the island. Nodules from the more northerly areas were sampled at stations G1001-G1009, G1011, and G1012, while the more southerly area includes G1016, G1017, G1019, and G1020.

The limits of manganese nodule occurrence defined during this cruise are more restricted than the limits extrapolated by Skornyakova and Andryushchenko (1970). Instead of nearly the entire basin floor being covered with ore-grade nodule deposits, only certain areas have dense concentrations of nodules. Goodell et al (1971) report one such area in the southeastern quadrant of the Southwestern Pacific Basin, based primarily on data collected during ELTANIN cruise 24. Another dense concentration was discovered in the area southwest of Rarotonga during the present cruise. Parts of the nodule fields south of Rarotonga may contain dense deposits, but no bottom photographs or grab samples were obtained to support dredge collections.

Southwest of Rarotonga, nodules occur at depths of 4715 to 5685 m. The densest concentrations of nodules are found from 220 to 745 km (120 to 400 nautical miles) from the island, in water depths of 4715 to 5565 m. Bottom photographs at station G992 show nodules nearly completely covering the bottom. At station G993, nodule coverage is seen to be about 30-50%, and a free fall grab sample contained about 20 kg/m^2 of nodules. By the time station G996 was reached (70 miles southwest of Rarotonga), nodule density had dropped to about 10%, and none were recovered at a distance of 35 miles from the island (station G997).

In the first nodule field encountered on the run south from Rarotonga, nodules occur at depths of 3970 to 5400 m (only one station was more shallow than 4820 m, and at this station, G1001, the ferromanganese accumulations are more properly termed crusts, rather than nodules). The variation in nodule morphology in this field is probably as great as for any area of similar size in the oceans (see Section V, Nodule Morphology and Size).

In the more southerly nodule field, nodules occur at depths of 5020 to 5590 m, As in the field just to the north, most samples were collected by pipe dredge, so that an estimate of nodule density cannot be made. Some dredges did contain nodules in abundances similar to collections made in the dense deposits southwest of Rarotonga.

V. NODULE MORPHOLOGY, SIZE AND SURFACE TEXTURE

The predominate nodule shape in the cruise area is spheroidal. But a surprising variety of shapes were recovered, particularly in the nodule field immediately south of Rarotonga. Nodule size also varies over a wide range, from about 1/2 cm to 11 cm. Even at individual stations, the largest and smallest nodules are often an order of magnitude different in size. Such a range has not been noted commonly in the past because smaller nodules tend to filter through the open mesh of dredge bags. The closed-end pipe dredge used on the TANGAROA is ideal for quickly sampling sediments and all nodule sizes up to about 30 cm in diameter.

The nodule field southwest of Rarotonga typically yielded spheroidal nodules; this shape predominates at 7 of the 9 stations where nodules were recovered. At one station (G988) the only nodule retrieved has an ellipsoidal

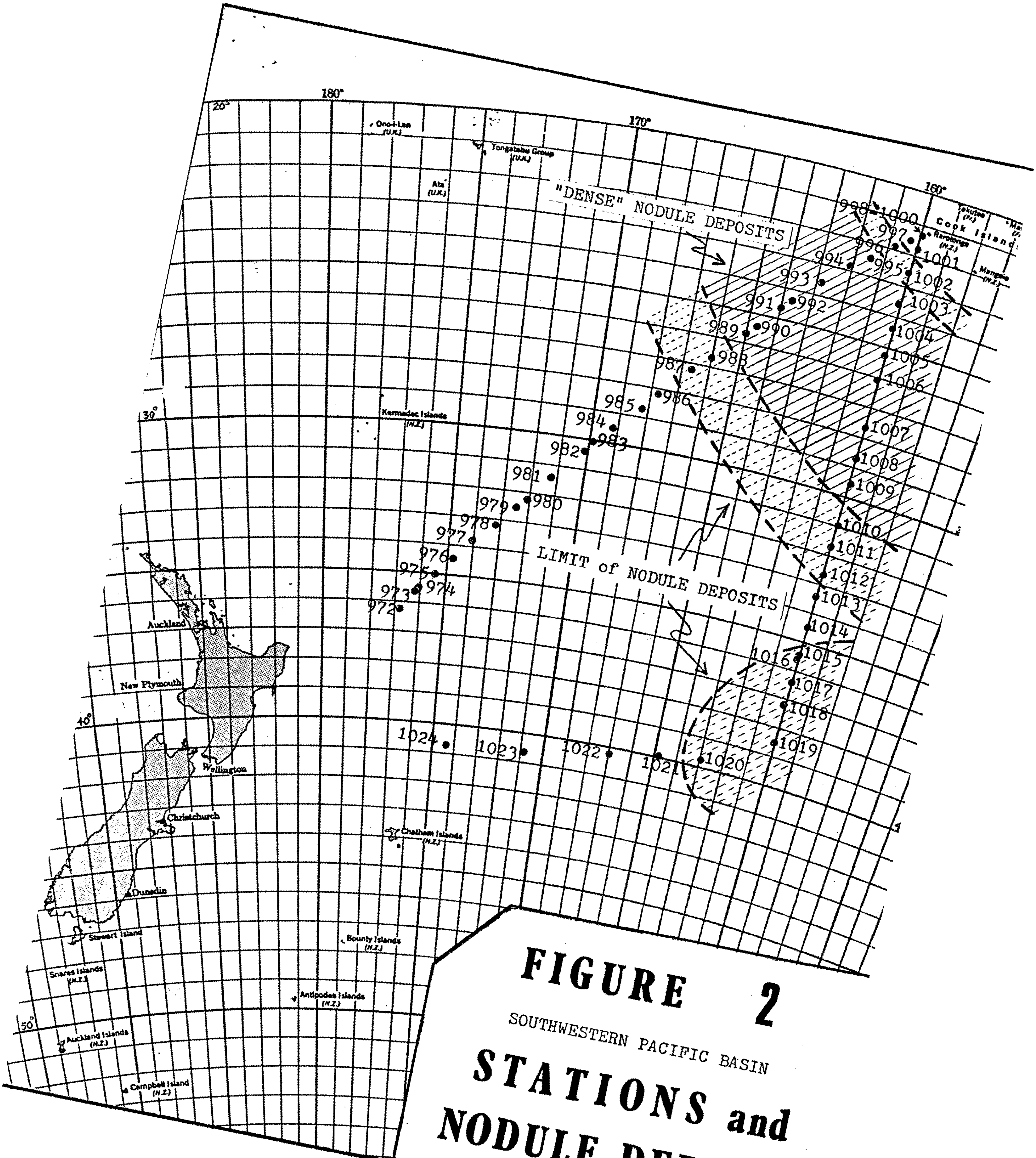

FIGURE 2

SOUTHWESTERN PACIFIC BASIN

STATIONS and NODULE DEPOSITS

morphology. At station G995, the larger nodules are tabular-discoidal or discoidal, while smaller ones often display modified spheroidal or ellipsoidal forms. Most nodules in this field that are not spheroidal have an ellipsoidal shape; a few are cylindrical or prolate. Nodule size ranges from 0.7 to 8.9 cm.

The greatest variety of nodule forms is found in the field just south of Rarotonga. The primary morphology at 7 stations is tabular-discoidal or discoidal. At 3 stations (G1005, G1006, and G1011) spheroidal shapes predominate, and at station G1004 almost all the nodules are ellipsoidal. At those stations where tabular-discoidal or discoidal nodules are most conspicuous, the smaller nodules tend to be spheroidal. At stations G1005 and G1006, the larger spheroidal nodules have equatorial "skirts", and at station G1003, both the larger discoidal and spheroidal nodules have equatorial "lips" that curl toward the lower surface. The skirt on G1006 nodules appears to be a pavement of ferromanganese-cemented volcanic fragments. The larger nodules found at G1005 have two skirts, one resembling that on G1006 nodules, and the other somewhat similar to the "lips" on G1003 nodules. The most irregular nodules in this field are those recovered at station G1001; they have an over-all tabular-discoidal morphology with a cindery or pahoehoe aspect, and frequently have holes through their thinner parts. Nodules from this field range in size from 0.6 to 10.6 cm.

The most southerly nodule field defined by this cruise was sampled at 4 stations, and "botryoidal" nodules (resembling a bunch of grapes) were found at all four. Some of the smaller nodules at these stations are spheroidal or intergrown spheroids ("polys"). Very few polys were found in the other two nodule fields. Nodules from this field of "botryoidals" range in size from 0.6 to 10.9 cm.

Table 4 summarizes the primary morphology and size of nodules at individual stations. More details regarding shape (and surface texture) are found in the Appendix. (Table C).

The largest proportion of nodules tend to have uniformly granular surface textures. This is particularly true of smaller nodules, as many larger nodules display two (or more) varieties of surface texture. Many of the larger nodules from the field southwest of Rarotonga possess a cavernous microbotryoidal surface on one side, and a granular texture on the other side. (It was usually difficult, if not impossible , to judge which surface was imbedded in sediment, and which was exposed above the sediment-water interface.) Only two stations (G1003 and G1007) from the fields south of Rarotonga yielded nodules with a cavernous microbotryoidal surface. Nodules from these fields tend to display granular textures, often superimposed upon or associated with botryoidal or microbotryoidal surfaces.

VI. SEDIMENTS

Brown silty clay is the principal sediment of the Southwestern Pacific Basin. Only on the crests and upper flanks of seamounts, and on the submarine slopes of islands such as Rarotonga, are calcareous sediments abundant. In the parts of the basin traversed during this cruise, sediment color varies from light brown near New Zealand to dark brown near Rarotonga. The lighter colored silty clays probably contain larger amounts of terrestrially-derived silicates and volcanic ash from New Zealand. Manganese nodules occur primarily on the brown or dark brown silty clays, but some lighter colored clays, e.g., at stations G1019 and G1020, occur in nodule fields. The sediments appear to be essentially devoid of micronodules.

TABLE 4 — NODULE MORPHOLOGY AND SIZE

STATION	RANGE (CM) of MAX. DIAM.	MORPHOLOGY (LARGER ---> SMALLER)
G987	1.6-2.9	Spheroidal.
G988	1.7	Ellipsoidal.
G989	1.1-7.2	Spheroidal.
G991	1.1-5.0	Spheroidal.
G992	1.3-4.1	Spheroidal.
G993	1.0-6.0	Spheroidal.
G994	0.7-8.0	Spheroidal.
G995	0.8-8.9	Tabular-discoidal ---> spheroidal or ellipsoidal.
G996	1.8-3.5	Spheroidal or ellipsoidal.
G1001	Up to 10.1	Type 1 Tabular-discoidal. Type 2 spheroidal → spheroidal or discoidal-ellipsoidal
G1002	0.6-4.8	Discoidal ---> spheroidal or discoidal.
G1003	0.8-6.5	Spheroidal or discoidal ---> discoidal.
G1004	1.0-6.4	Ellipsoidal.
G1005	0.9-10.1	Spheroidal.
G1006	0.9-10.6	Spheroidal.
G1007	0.6-7.6	Tabular-discoidal ---> spheroidal.
G1008	0.7-3.6	Discoidal ---> spheroidal.
G1009	0.8-8.2	Tabular-discoidal ---> spheroidal.
G1011	2.9, 3.0	Spheroidal.
G1012	1.4-9.5	Tabular-discoidal, discoidal, ellipsoidal and polygonal.
G1016	0.6-8.2	Botryoidal ---> spheroidal or poly.
G1017	1.8-5.8	Spheroidal ---> botryoidal.
G1019	1.6-7.2	Botryoidal ---> spheroidal or poly.
G1020	2.5-10.9	Botryoidal.

A coarse fraction was separated from most sediments collected with the pipe dredge. This was accomplished by straining the sediment through cheesecloth (after a sample split was removed and placed in a container). The coarse fraction in the study area generally consists of granule and small pebble-size volcanic fragments, especially pumice, tuff, and basalt. Most of the pumice and tuff fragments are round or subround. Sharks' teeth were found in the coarse fraction at 13 stations (and at 12 of these, nodules were recovered). The character of the surface of the teeth varies from fresh to Mn-stained or encrusted. The coarse fraction appears to be most abundant in the darker brown clays, probably reflecting an association with slower rates of sedimentation. Coarse fractions have generally been ignored in studies of marine sediments, but they may be relevant to nodule genesis.

Sediment samples were retrieved at a total of 45 stations, including all but one station (G996) that also yielded nodules. At 34 stations, a coarse fraction was separated from the sediment, and at two stations, the only sediment recovered consisted solely of coarse material. Eight of the sediment samples are short cores contained in plastic liners, while the remainder are stored in glass jars or plastic bags. More complete descriptions of the coarse fractions collected during this cruise may be found in the Appendix (Table B).

VII. SUMMARY OF SCIENTIFIC RESULTS AND CONCLUSIONS

Extensive fields of manganese nodules exist in a belt at least 300 miles wide southwest and south of Rarotonga, a width comparable to that of the nodule deposits of the siliceous ooze province southeast of Hawaii. Nodule density varies from widely scattered (especially near the edges of the belt) to an essentially complete coverage at places within the belt. Nodules range in size from about 1/2 cm to 11 cm, and nodules from certain stations vary in size by an order of magnitude. Nodules from southwest of Rarotonga are spheroidal, while nodules from the field just south of the island are generally either tabular-discoidal (especially larger nodules) or spheroidal (especially the smaller nodules). Nodules from the most southerly field are either "botryoidal" (shaped like a bunch of grapes) or "polys" (intergrown spheroids). The predominate surface texture of nodules from the cruise area is granular, but many larger nodules from the field southwest of Rarotonga display a cavernous microbotryoidal surface on one side.

Silty clays are the most important sediment type in the Southwestern Pacific Basin. In the cruise area they vary in color from light brown (near New Zealand) to dark brown (near Rarotonga). This probably reflects a higher input of terrigenous silicates and volcanic ash near New Zealand, as opposed to the slower pelagic sedimentation that occurs near Rarotonga. Higher rates of sedimentation near New Zealand are probably also responsible for the smooth bottom topography, whereas south of Rarotonga a rugged volcanic terrane exists. Nodules appear to be restricted mostly to the brown and dark brown clays, which are characterized additionally by an important coarse fraction of small volcanic fragments, as well as shark's teeth. Sedimentation rates and availability of nuclei are probably the most important factors that govern nodule distribution.

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A P P E N D I X

TABLE A - STATION SUMMARY

Sta. No.	Date	On Bottom Time	Lat. S.	Long. W.	Depth(m)	Bottom Topography	Gear	Results
G972	7 MAY	0955	36°15.5'	176°53.9'	5540	Flat	Short (4 ft.) Corer	Core 27.5 cm. Brown clay.
G973	7 MAY	1630	35°39.0'	176°14.0'	5437	Abyssal hill slope	Short corer	Mn frags. on core cutter.
G974	7 MAY	1955	35°35.1'	176°08.8'	4715	Flank of small seamount	Orange-peel grab	Grab empty; Mn streaks.
G975	8 MAY	0257	35°02.8'	175°29.9'	5643	Flat	Orange-peel grab	Grab empty.
G976	8 MAY	1010	34°26.5'	174°48.6'	5643	Small abyssal hills	Short corer	Core 51 cm. Brown clay.
G977	8 MAY	1725	33°51.6'	174°04.0'	5748	Rolling abyssal hills	Short corer	Core 35 cm. Lt. brn. silty clay.
G978	9 MAY	0203	33°11.8'	173°14.3'	5883	Flat, 100m abyssal hills	Short corer	Core 25 cm. Brn. gray silty clay.
G979	9 MAY	0908	32°32.1'	172°29.7'	5852	Smooth	Short corer	Core 26.5 cm. Brown clay.
G980	9 MAY	1350	32°12.4'	172°07.2'	4613	Near top of 1100m seamount	Pipe dredge	Microfossiliferous lt. brown clay with micro-nodules, Mn coated tuff frags.
G981	9 MAY	2240	31°22.6'	171°13.8'	5826	Flat	Short corer	Core 48.5 cm. Brn. silty clay.
G982	10 MAY	1101	30°19.7	170°09.2'	5536	Small abyssal hills	Short corer	Core 19 cm. Brown clay, weathered Mn-coated pumice frag. at top.
G983	10 MAY	1600-1638	30°04.4'	169°51.6'	5612	Valley between 200m abyssal hills	Bottom cameras	No photos.

Sta. No.	Date	On Bottom Time	Lat. S.	Long. W.	Depth(m)	Bottom Topography	Gear	Results
G984	10 MAY	2239	29°32.9'	169°16.2'	5407	Lower slopes of seamount	Short corer	Core 11.5 cm. Brn. silty clay, coated pumice frag. near core top.
G985	11 MAY	0640-0650	28°45.3'	168°19.0'	5333	Base of seamount	Pipe dredge	Brn. silty clay with tuff, pumice frag., some Mn-coated.
G986	11 MAY	1455-1545	28°12.8'	167°43.9'	5592	Abyssal hills NE of seamount	Bottom camera	No photos.
G987	12 MAY	0200-0232	27°10.5'	166°38.9'	5685	Abyssal hills 200m relief	Pipe dredge	Brn. clay with volcanic frags. (pumice et al), plus small nodules.
G988	12 MAY	1117-1124	26°38.6'	166°02.9'	5643	Abyssal hills, < 200m relief	Pipe dredge	Brn. silty clay with volcanic frags., some Mn-coated, shark tooth, one Mn-nodule.
TANGO 1 02 03 X G989	12 MAY	2134-2139	25°41.7'	165°02.2'	5565	Nearly flat	Pipe dredge	Brn. clay with abundant nodules.
G990	13 MAY	0300-0303	25°22.3'	164°43.0'	5300	Slope of seamount	Pipe dredge	Weathered volcanic frags., Mn-coated.
04 05 06 X G991	13 MAY	1107-1112	24°38.5'	164°02.4'	5416	Basin between small seamounts	Pipe dredge	Brn. clay with pumice frags; shark teeth, abundant nodules.
07 X 08 G992A	13 MAY	1643-1650	24°21.3'	163°41.0'	5440	Abyssal plain, 20m relief	Pipe dredge	Brn. clay with shark's teeth, volcanic frags., abundant nodules.
G992B	13 MAY	1930-2020	24°22.3'	163°40.6'	5270-5426	Abyssal plain, 20m relief	Bottom camera	7 photos.

	Sta. No.	Date	On Bottom Time	Lat. S.	Long. W.	Depth(m)	Bottom Topography	Gear	Results
	G992C	13 MAY	2223	24°21.6'	163°42.3'	5437	Ditto	Short Corer	Core 32.5 cm. Brn. clay, 4 nodules at top.
	G993A	14 MAY	0705-0710	23°34.1'	162°50.9'	5126	Irregular, up to 200m relief	pipe dredge	No sample.
	G993B	14 MAY	0958-1100	23°32.6'	162°52.8'	4983-5076	Ditto	Bottom camera	2 photos.
09 10 11 12	G993C	14 MAY	1256	23°32.1'	162°54.1'	4962	Ditto	Short corer	Core 42. cm. 4 nodules at top.
14	G993D	14 MAY	Launch 1316	Ditto	Ditto	4983	Ditto	VALDIVIA free fall grab	1 small, 1 large nodule.
	G993E	14 MAY	Launch 1350	Ditto	Ditto	4993	Ditto	Kennecott free fall grab	Abundant nodules.
13 14	G994	14 MAY	2346-2350	22°56.2'	162°04.8'	4848	Abyssal plain, 10 miles from seamount	Pipe dredge	Abundant large nodules with brown clay.
15 16 17 18	G995	15 MAY	0633-0640	22°25.1'	161°29.0'	4715	Slightly rolling abyssal plain	Pipe dredge	Brown clay with volcanic frags., abundant nodules.
	G996A	15 MAY	~1435-(?)	21°53.7'	160°52.4'	4817	Abyssal plain, 150m relief	Bottom camera	2 color photos.
19	G996B	15 MAY	Launch 1328	21°53.8'	160°54.8'	4817	Ditto	VALDIVIA free fall grab	Several small nodules, traces of brn. clay.
	G997	15 MAY	2228-2235	21°31.3'	160°19.9'	4674	Rolling abyssal hills, 100m relief	pipe dredge	Dark brown clay with few volcanic frags.

	Sta. NO.	Date	On Bottom Time	Lat. S.	Long. W.	Depth (m)	Bottom Topography	Gear	Results
	G998	16 MAY	0258-0302	21°19.9'	159°59.4'	3850	Abyssal hills NE of seamount	Pipe dredge	Lt. brn. very fine sandy calcareous clay, shell frags. volcanic frags.
	G999	16 MAY	0620	21°17.4'	159°59.8'	3750	Base of Raro-tonga edifice	Short corer	Traces of sand grains.
	G1000	16 MAY	0830-0836	21°17.6'	159°54.8'	2721	Steep submarine slope of Raro-tonga Island	Pipe dredge	Shell hash sand.
20 / 15	G1001	19 MAY	1426-1434	21°41.2'	159°57.1'	3970	300m rise just south of Raro-tonga edifice base	Pipe dredge	Lt. brn. calcarenite, slightly marly, with pumice, cindery Mn crusts.
21 22 Y	G1002	19 MAY	2212-2216	22°32.6'	160°07.0'	4817	Rolling abyssal plain, 100m relief	Pipe dredge	Stiff dk. brn clay with assorted volcanic frags., some Mn-coated; also nodules.
23 /	G1003	20 MAY	0624-0630	23°29.1'	160°08.4'	4817	Rolling abyssal hills, 200m relief	Pipe dredge	Brn. silty clay with small to large nodules, shark teeth, whale ear bones,
	G1004A	20 MAY	1525-1615	24°18.4'	160°04.5'	5127	Rolling abyssal hills, 300m relief	Bottom camera	No photos.
	G1104B	20 MAY	Launch 1418	Ditto	Ditto	5070	Ditto	VALDIVIA free fall grab	Grab lost.
24 Y	G1004C	20 MAY	Launch 1436	Ditto	Ditto	5080	Ditto	VALDIVIA free fall grab	Nodules with dk. brn. clay.
25	G1005	21 MAY	0030-0036	25°13.0'	160°04.2'	5126	Rolling abyssal hills, up to 200-300m relief	Pipe dredge	Large nodules, pumice frags., in brown clay.

	Sta. No.	Date	On Bottom Time	Lat. S.	Long. W.	Depth(m)	Bottom Topography	Gear	Results
	G1006A	21 MAY	0735-0745	26°03.7'	160°03.5'	5075	Just south of 500m seapeak	Pipe dredge	Traces of brown clay.
26 X	G1006B	21 MAY	1001-1007	26°04.6'	160°03.9'	5116	Ditto	Pipe dredge	Brown clay with spheroidal nodules with pavement skirt.
27 28	G1007	21 MAY	2157-2202	27°39.1'	160°00.9'	4982	Rugged abyssal hills, 200m relief	Pipe dredge	Brn. clay with many small nodules, a few larger flattened nodules.
29	G1008	22 MAY	0614-0622	28°41.7'	159°57.2'	5438	Rugged abyssal hills, 200m relief	Pipe dredge	Brown clay with many small nodules.
30	G1009	22 MAY	1327-1342	29°29.5'	159°56.0'	~5300	Upper slope of 300m abyssal hill, area of deep-sea ridges	Pipe dredge	Brown clay with many small nodules, some pumice frags.
	G1010A	23 MAY	0927-0932	31°01.2'	159°56.5'	5437	Rolling abyssal hills, 200m relief	Pipe dredge	Brn. clay with a few volcanic frags, some Mn-stained, also shark's teeth.
	G1010B	23 MAY	1214-1256	30°59.3'	159°57.8'	5427	Ditto	Bottom camera	No photos.
	G1011	23 MAY	2006-2016	31°44.6'	160°01.3'	5385	At base of seamount in area of rolling abyssal hills, 200m relief	Pipe dredge	Brown clay with two small nodules.

Sta. No.	Date	On Bottom Time	Lat. S.	Long. W.	Depth(m)	Bottom Topography	Gear	Results
32 X G1012	24 MAY	0429-0435	32°40.5'	160°00.8'	~5300	At base of 1400m seamount in area of hills up to 400m relief	Pipe dredge	Angular basalt frags. with thin Mn-coating, in brown clay.
G1013A	24 MAY	1203-1210	33°27.9'	160°00.6'	5249	Rolling abyssal hills, 200m relief	Pipe dredge	Traces of brown clay.
G1013B	24 MAY	1420-1425	33°25.7'	160°02.0'	5312	Ditto	Pipe dredge	Brown clay with pumice frags.
G1013C	24 MAY	Launch 1404	Ditto	Ditto	5333	Ditto	Kennecott free fall grab	Empty.
G1013D	24 MAY	Launch 1412	Ditto	Ditto	5333	Ditto	Kennecott free fall grab	Traces of brown clay.
G1013E	24 MAY	Launch 1438	33°25.1'	160°02.4'	5350	Ditto	VALDIVIA free fall grab	Traces of brown clay with Mn-coated pumice.
G1014A	25 MAY	0225	34°27.9'	160°04.5'	5229	Abyssal hills up to 250m	Bottom camera	No photos.
G1014B	25 MAY	0427-0435	34°28.0'	160°06.5'	5146	Ditto	Pipe dredge	Brown clay with few pumice granules.
G1015A	24 MAY	1218	35°21.0'	160°03.2'	5333 ±200	Rolling abyssal hills, 200m relief	Short corer	Traces of light brown clay.
G1015B	25 MAY	1412	Ditto	Ditto	~5333	Ditto	Short corer	Corer lost.

	Sta. No.	Date	On Bottom Time	Lat. S.	Long. W.	Depth(m)	Bottom Topography	Gear	Results
32 X	G1016	25 MAY	1700-1710	35°27.3'	160°04.0'	~5591	Valley in area of abyssal hills up to 400m relief	Pipe dredge	Brown clay with spherical nodules, Mn-encrusted shark's teeth, vertebrae.
33 34 X 35 36 37	G1017	26 MAY	0024-0030	36°22.6'	160°04.8'	5450 ±100	Depression in area of rolling abyssal hills, up to 200m relief	Pipe dredge	Brown clay with medium-sized spherical nodules.
	G1018	26 MAY	0750-0800	37°13.1'	160°05.5	5126	Rugged abyssal hills 10nm south of 900m seapeak	Pipe dredge	Brown clay with few volcanic granules, some weathered.
18 38 X	G1019	26 MAY	1740-1745	38°31.2'	160°04.2'	5021	Relatively smooth	Pipe dredge	Brown clay with Mn-nodules.
39 X	G1020	28 MAY	0937-0942	39°52.1'	162°59.0'	5021	Relatively flat	Pipe dredge	Brown clay with Mn-nodules.
	G1021	28 MAY	2113-2118	40°01.5'	164°52.3'	5125	Flat abyssal plain, sloping upward 200m in 15nm prior to station	Pipe dredge	Lt. brown silty clay.
	G1022	29 MAY	1019-1024	40°12.8'	167°00.6'	4919	Flat abyssal plain	Pipe dredge	Lt. brown silty clay.
	G1023	30 MAY	0922-0927	40°39.0'	170°55.1'	4224	Flat abyssal plain	Pipe dredge	Lt. brn. silty clay with shell fragments, worm tubes.
	G1024	31 MAY	0929-0934	40°40.2'	174°23.1'	3999	Depression at base of 250m high, 20nm wide flat-topped mound.	Pipe dredge	Light tan calcareous clay, with worm tubes and glacial erratics(?)

Sta. No.	Date	On Bottom Time	Lat. S.	Long. W.	Depth(m)	Bottom Topography	Gear	Results
G1016	25 MAY	1700-1710	35°27.3'	160°04.0'	~5591	Valley in area of abyssal hills up to 400m relief	Pipe dredge	Brown clay with spherical nodules, Mn-encrusted shark's teeth, vertebrae.
G1017	26 MAY	0024-0030	36°22.6'	160°04.8'	5450 ±100	Depression in area of rolling abyssal hills, up to 200m relief	Pipe dredge	Brown clay with medium-sized spherical nodules.
G1018	26 MAY	0750-0800	37°13.1'	160°05.5	5126	Rugged abyssal hills 10nm south of 900m seapeak	Pipe dredge	Brown clay with few volcanic granules, some weathered.
G1019	26 MAY	1740-1745	38°31.2'	160°04.2'	5021	Relatively smooth	Pipe dredge	Brown clay with Mn-nodules.
G1020	28 MAY	0937-0942	39°52.1'	162°59.0'	5021	Relatively flat	Pipe dredge	Brown clay with Mn-nodules.
G1021	28 MAY	2113-2118	40°01.5'	164°52.3'	5125	Flat abyssal plain, sloping upward 200m in 15nm prior to station	Pipe dredge	Lt. brown silty clay.
G1022	29 MAY	1019-1024	40°12.8'	167°00.6'	4919	Flat abyssal plain	Pipe dredge	Lt. brown silty clay.
G1023	30 MAY	0922-0927	40°39.0'	170°55.1'	4224	Flat abyssal plain	Pipe dredge	Lt. brn. silty clay with shell fragments, worm tubes.
G1024	31 MAY	0929-0934	40°40.2'	174°23.1'	3999	Depression at base of 250m high,20nm wide flat-topped mound.	Pipe dredge	Light tan calcareous clay, with worm tubes and glacial erratics(?)

NOTE: Dates and times are local, not GMT. Depths have been corrected with Matthew's Tables and also for ship's draft.

TABLE B -- SAMPLE INVENTORY AND BRIEF DESCRIPTIONS

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G972	Core 27.5 cms. Light brown silty clay.	None.	None.
G973	None.	None.	1 x 4 oz. jar. Ferromanganese flakes from cutter edge.
G974	None.	None.	Ferromanganese streaks on grab surface.
G975	None.	None.	None.
G976	Core 51 cms.; 1 x 4 oz. jar. Light gray brown silty clay.	None.	None.
G977	Core 35 cms. Light brown silty clay.	None.	None.
G978	Core 25 cms. Light brown silty clay.	None.	None.
G979	Core 26.5 cms. Light brown silty clay.	None.	None.
G980	1 x qt. jar. Cream to light brown foraminiferal ooze with micronodules or black volcanic sand gains.	1 x 12 oz. jar. Volcanic rock frags. up to 15mm max. diam., most 1-5mm, tuff, basalt and pumice (?). Many tuff frags. subround to round. A few frags. display Mn-staining.	See coarse fraction. No nodules.

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G981	Core 48.5 cms. Brown silty clay.	None.	None.
G982	Core 19 cms. Brown silty clay, with Mn-coated pumice fragment at core top.	1 x 4 oz. jar (sample removed from core top). One pumice frag. (22 x 19 x 10 mm, wt. 4 gms.), weathered, with thin Mn-coating.	See coarse fraction. No nodules.
G983	---Unsuccessful bottom camera station---		
G984	Core 11.5 cms. Brown silty clay, with Mn-coated pumice frag. near core top.	1 x 4 oz. jar (sample removed from near core top). Subangular pumice frag. (20 mm max. diam.) with very thin coating of Mn over most of surface.	See coarse fraction. No nodules.
G985	1 x qt. jar. Brown silty clay.	1 x 12 oz. jar. Assorted volcanic frags. (tuff, basalt, pumice) up to 12 mm max. diam, but mostly 1-5 mm. Many tuff/pumice frags. subround to round. A few frags. are Mn-stained.	See coarse fraction. No nodules.
G986	---Unsuccessful bottom camera station---		
G987	1 x qt. jar. Brown silty clay.	1 x 4 oz. jar. Assorted volcanic frags. (pumice, tuff, basalt) up to 14 mm max. diam., but mostly 1-5 mm. Some pumice very light colored. Many frags. subround to round. One cindery volcanic frag. (13 mm max. diam.) with thin coating of Mn, partly micro-botryoidal; a 1 mm hole thru frag.	In coarse fraction jar. Four small (16-29 mm max. diam.) Mn-nodules, spheroidal, ellipsoidal and prolate; one intergrowth. See separate description for more details. See also course fraction.

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G988	1 x qt. jar. Brown silty clay.	1 x 12 oz. jar. One subangular pumice frag., 26 mm max. diam. Other assorted volcanic frags. (tuff, basalt, pumice) up to 15 mm max. diam., but mostly 1-5 mm. Most tuff/pumice round to subround. One partly Mn-stained basalt frag. One fresh shark's tooth.	In coarse fraction jar. One small Mn-nodule (17 mm max. diam.), ellipsoidal. Described separately.
G989	1 x qt. jar. Brown silty clay.	1 x 4 oz. jar (transferred from plastic bag). One subangular pumice frag., 18 mm max. diam. Smaller volcanic frags., mostly 1-5 mm round to subround pumice/tuff. A few cindery basalt frags., partly Mn-stained. One corroded shark's tooth. Also some Mn-nodule frags.	1 x plastic bag (in plastic box). Spheroidal nodules 1-6 mm max. diam. Described separately. See also coarse fraction.
G990	Traces of brown silty clay (no sample?).	1 x 12 oz. jar. Frags., up to 50 mm max. diam., of Mn-encrusted weathered basalt. Surface of Mn-crust is microgranular to cavernous macrogranular or microbotryoidal. Substrate beneath crust is yellow-orange and penetrated with Mn-dendritic tubes.	See coarse fraction. No nodules.
G991	1 x qt. jar. Brown silty clay.	1 x 12 oz. jar. Two Mn-stained sharks' teeth, 32 and 20 mm long. Volcanic frags., including one 27 mm max. diam. tuff/pumice frag. weathered to a yellow color. Other frags. are 1-13 mm tuff and pumice.	4 x plastic bags (contained in two plastic boxes). Spheroidal nodules 1-5 cm. max. diam. Contained in coarse fraction jar: Frags. of reddish-black Mn-crust up to 25 mm max. diam., but most ~1 mm size. Surface has a cindery aspect, with a microbotryoidal to cavernous granular texture. Also one Mn-filled and replaced tube or Mn-coated object 28 mm long and 2-3 mm diameter; --cont.--

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G991 cont.			surface is microgranular to granular. Nodules described separately.
G992A	1 x 12 oz. jar. Brown silty clay.	1 x 4 oz. jar. Three corroded sharks' teeth, 23, 17, & 15 mm long. Several frags. round-subround pumice, 6-15 mm.	3 x plastic bags (in 2 plastic boxes). Spheroidal Mn-nodules 1-4 cm max. diam. Described separately.
G992B	7 bottom photos -- dense nodule concentration.		
G992C	Core 32.5 cm. Brown silty clay.	None.	Four Mn-nodules at core top. Retained in core.
G993A	--Unsuccessful pipe dredge attempt--		
G993B	2 bottom photos -- 30 to 50% nodule coverage.		
G993C	Core 42 cm. and 1 x 4 oz. jar. Brown to dark brown silty clay.	None.	Four Mn-nodules at core top. Retained in core.
G993D	None.	None.	1 x plastic bag, in plastic box. Two Mn-nodules, 2 and 4 1/2 cm. max. diam., spheroidal. Described separately.
G993E	None.	1 x 4 oz. jar. Three subround-subangular pumice frags., 8-10 mm max. diam., weathered.	3 x plastic bags, in 2 plastic boxes. Spheroidal Mn-nodules, 1-6 cm. max. diam. Described separately.

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G994	1 x qt. jar. Brown silty clay.	In plastic bag with smallest nodules. One 27 mm max. diam. subround to subangular pumice frag. One 13 mm round pumice frag.	5 x plastic bags. Spheroidal and ellipsoidal nodules, 1/2-8 cm. max. diam. Described separately.
G995	1 x 12 oz. jar. Brown silty clay.	1 x 4 oz. jar. Assorted volcanic frags. up to 21 mm max. diam., but mostly 1-5 mm. Most are round-subround weathered pumice frags., a few are cindery partly Mn-coated basalt frags. One fresh shark tooth frag. Five white benthic foram tests. A few Mn-nodule frags.	4 x plastic bags. Spheroidal, ellipsoidal, and discoidal Mn-nodules, about 1-8 cm. max. diam. Described separately. See also coarse fraction.
G996A	2 bottom photos -- 10% nodule coverage.		
G996B	None.	None.	1 x plastic bag. Spheroidal and ellipsoidal nodules, 1 1/2 - 3 1/2 cm. max. diam. Described separately.
G997	1 x 12 oz. jar. Dark brown silty clay.	1 x small plastic vial. Subangular-subround pumice frags. to 6 mm max. diam.	None.
G998	1 x 12 oz. jar. Light brown foram silty clay with dark mineral grains (several sizes, but probably not Mn-micronodules).	1 x 4 oz. jar. Forams. A few small volcanic frags. (basalt and tuff/pumice) with minor Mn-staining. Also rubbery objects of irregular shape that may be collections of ash particles with an organic matrix.	See coarse fraction. No nodules.
G999	Traces of shell hash sand.	None.	None.

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G1000	1 x 12 oz. jar. Shell hash/ volcanic sand.	None.	None.
G1001	1 x 12 oz. jar. Light brown foram silty clay.	In two plastic bags with nodules. In plastic bag compartment: Three round-subround pumice frags.; one is a 30 mm max. diam. prolate ellipsoid with half of surface gray-brown and other gray; second is 36 mm flattened ellipsoid, also with the two different surface colors; third is a 36 mm ellipsoid, buff-white in color. All have open vesicles at surface. In plastic bag with nodule frags.: Brown subangular frags. up to 25 mm. max. diam. (lithified ash or altered volcanic?).	5 x plastic bags. Discoidal, (with irregular outline in plan view) and ellipsoidal nodules (and/or thinly encrusted weathered volcanics), 1 to 9 1/2 cm. max. diam., with larger crusts having central hole. Described separately.
G1002	1 x 12 oz. jar. Stiff dark brown silty clay.	2 x plastic bags. Angular basalt frags. up to 7 cm max. diam., weathered to a red color, and with a thin Mn-coating on one surface. Cindery aspect to some frag. surfaces, just below Mn-coating. Other small undifferentiated volcanic frags. mostly 1-5 mm, many subround-round. At least one small shark's tooth.	1 x plastic bag. Ellipsoidal, spheroidal, and discoidal nodules 1/2 to cm. max. diam., and nodule segments. Described separately. See also coarse fraction.
G1003	1 x 12 oz. jar. Dark brown silty clay.	1 x 4 oz. jar (transferred from plastic bag). Two partly Mn-stained whale ear bones, both about 28 mm max. diam. Several corroded sharks' teeth, several small fresh ones. Assorted volcanic frags., up to 12 mm max. diam., but mostly 1-5 mm (basalt; buff-white, gray and gray-brown tuff/pumice, many round-subround).	2 x plastic bags. Discoidal and spheroidal nodules 1/2 - 7 cm. max. diam. Some of larger ones have equatorial "lips". Described separately. See also coarse fraction.

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G1004A	--Unsuccessful bottom camera station--		
G1004B	--Unsuccessful free fall grab; grab lost--		
G1004C	1 x 4 oz. jar. Dark brown silty clay.	Possibly in compartment with nodule frags.	Ellipsoidal and spheroidal nodules 1 to 6 1/2 cm. max. diam. Also nodule frags. Described separately.
G1005	1 x 12 oz. jar. Dark brown silty clay.	Compartment in one bag with nodules. One subangular pumice frag., 25 mm max. diam. Five smaller frags. (three angular basalt [?] and two subround pumice), 6-10 mm max. diam.	3 x plastic bags. Spheroidal and flattened spheroidal nodules 1-9 cm max. diam. Some larger ones with skirts. Described separately.
G1006A	--Unsuccessful pipe dredge; traces of brown silty clay--		
G1006B	1 x 12 oz. jar. Dark brown silty clay.	Compartment in one bag with nodules. One 3 cm. corroded shark tooth. Angular to subangular reddish basalt frags., up to 16 mm max. diam., some partly Mn-stained. Some smaller (up to 13 mm, mostly < 5 mm) round to subround pumice/tuff frags.	3 x plastic bags. Spheroidal and irregularly shaped nodules 1-10 1/2 cm. max. diam. Larger ones with irregular pavement skirts. Described separately. See also coarse fraction.
G1007	1 x qt. jar. 1 x 12 oz. jar. Dark brown silty clay.	Compartment in one bag with nodules. Several corroded shark's teeth, some with Mn-crusts. Round to subround pumice frags. to 29 mm max. diam. Also smaller cindery basalt frags.	3 x plastic bags. Spheroidal, ellipsoidal, prolate, and tabular discoidal nodules, 1/2 to 7 1/2 cm. max. diam. Described separately. See also coarse fraction.
G1008	1 x 12 oz. jar. Brown silty clay.	Compartment in one bag with nodules, in vial. Assorted volcanic frags. to --cont.--	2 x plastic bags. Spheroidal, ellipsoidal-discoidal and discoidal nod- --cont.--

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G1008 cont.		11 mm max. diam., mostly round to subround pumice. One small fresh shark's tooth.	ules 1/2 - 3 1/2 cm. max. diam. Most larger ones with satellite growth on one surface.
G1009	1 x 12 oz. jar. Brown to dark brown silty clay.	Compartment in one bag with nodules. One Mn-encrusted shark's tooth. Round to subround gray-brown pumice frags. up to 21 mm. max. diam.	4 x plastic bags. Spheroidal, tabular-discoidal and ellipsoidal nodules 1-8 cm. max. diam. Also nodule frags. Described separately.
G1010A	1 x 12 oz. jar. Brown silty clay.	1 x 4 oz. jar. Several small fresh shark's teeth. Assorted volcanic frags. up to 11 mm max. diam., but mostly 1-5 mm; mostly subround to round dark gray pumice/tuff; a few angular basalt frags. Only minor Mn-staining.	See coarse fraction. No nodules.
G1010B	--Unsuccessful bottom camera station--		
G1011	1 x 12 oz. jar. Brown to dark brown silty clay.	1 x 12 oz. jar. Many round-subround lumps of partly lithified mud, brown in color; two are prolate, 24 and 23 mm long; very light weight. Also assorted volcanic frags. up to 14 mm max. diam.; subangular basalt, reddish and partly Mn-stained; round to subround pumice, some buff-white in color.	In coarse fraction jar. Two spheroidal nodules, both 3 cm. max. diam. Described separately. See also coarse fraction.
G1012	1 x 12 oz. jar. Brown to dark brown silty clay.	1 x small plastic bag. Angular reddish basalt frags. up to 9 mm max. diam.	1 x plastic bag. Polygonal nodules consisting of a thin Mn-crust over angular basalt, 3-6 cm. max. diam. Also smaller nodules or nodule frags. Described separately.

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G1013A	1 x 4 oz. jar. Traces of brown silty clay.	None.	None.
G1013B	1 x 12 oz. jar. Brown to dark brown silty clay.	1 x 4 oz. jar. Assorted volcanic frags. up to 11 mm max. diam., mostly 1-5 mm.; round-subround tuff and pumice (some of latter buff-white color).	None.
G1013C	None.	None.	None.
G1013D	Traces brown silty clay.	None.	None.
G1013E	Traces brown silty clay.	1 x 4 oz. jar. One subround pumice frag., 29 mm max. diam. Surface has small black spots that may be Mn.	See coarse fraction. No nodules.
G1014A	--Unsuccessful bottom camera station.--		
G1014B	1 x 12 oz. jar. Brown to dark brown silty clay.	1 x 4 oz. jar. Assorted volcanic frags. up to 9 mm max. diam. Most round-subround tuff and pumice, most gray-brown or buff-white. Some gray, fine-grained vesicular frags. (basalt?).	None.
G1015A	1 x 4 oz. jar. Brown silty clay.	None.	None.
G1015B	--Short corer lost by two-blocking--		

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G1016	1 x 12 oz. jar. Brown silty clay.	In plastic bag with nodules. One large corroded shark's tooth. Assorted volcanic frags., apparently mostly pumice 1-5 mm max. diam., round to subround and some white-buff in color; angular to sub-angular basalt common.	1 x plastic bag. Botryodial and spheroidal nodules up to 8 cm. max. diam. Described separately.
G1017	No sample? Notes report brown clay.	1 x 4 oz. jar. One round yellow-green tuff frag. (olivine sand?), 7 mm max. diam. One subangular pumice frag., mottled gray-brown with weathered ap-pearance.	2 x plastic bags. Botryoidal to spheroidal nodules, 2-5 cm. max. diam. Described separately.
G1018	1 x 12 oz. jar. Brown to light brown silty clay.	1 x 4 oz. jar. Assorted volcanic frags. up to 10 mm max. diam.; tuff/pumice, some apparently weathered. One 5 mm frag. crustal material, apparently either Mn-cemented sediment or Mn-replaced highly-altered volcanic.	See coarse fraction. No nodules.
G1019	1 x 12 oz. jar. Brown to light brown silty clay.	In compartment of plastic bag with smallest nodules. Two (?) small round pumice granules.	1 x plastic bag. Spheroidal and botryoidal nodules, 1 1/2 - 6 1/2 cm. max. diam. Described separately.
G1020	1 x 12 oz. jar. Brown to light brown silty clay.	None.	2 x plastic bags. Botryoidal nodules, 2 1/2 - 11 cm. max. diam. Described separately.
G1021	1 x 12 oz. jar. Brown to light brown silty clay.	1 x 4 oz. jar. Two small round to sub-round tuff/pumice frags., 3 and 4 mm max. diam. One flattened 12 mm-long object that may be organically-cement-ed sediment.	None.

STATION	SEDIMENT	NON-FERROMANGANESE COARSE FRACTION	FERROMANGANESE
G1022	1 x 12 oz. jar. Brown to light brown silty clay.	1 x 4 oz. jar. Assorted volcanic frags. up to 12 mm max. diam., including a couple of fine-grained gray pumice frags. Largest volcanic is partly Mn-coated pumice. Worm tubes, egg cases, and shells.	See coarse fraction. No nodules.
G1023	1 x 12 oz. jar. Light brown silty clay.	1 x 4 oz. jar. A few round-subround pumice frags. up to 5 mm max. diam. Also shells, worm tubes.	None.
G1024	1 x 12 oz. jar. Light brown calcareous silty clay.	1 x 4 oz. jar. One angular, dark gray fine-grained rock frag., 32 mm max. diam.; may be either basalt or a Mn-stained glacial erratic. Also smaller angular basalt (?) and subround pumice frags. Also worm tubes.	See coarse fraction. No nodules.

TABLE C--Mn-NODULE DESCRIPTIONS

STATION	NODULE TYPE	SIZE RANGE(CM)	PRIMARY MORPHOLOGY	SECONDARY MORPHOLOGY	SURFACE TEXTURE	COMMENTS
G987	#1	1.6-2.9	Spheroidal to ellipsoidal.	Incipient lobes on one side. One is 2-poly.	Microgranular.	3 nodules.
	#2	2.3	Prolate.	Irregular.	Microbotryoidal with scattered macrobotryoids.	1 nodule. Some surface protrusions may be agglutinated volcanic frags.
G988	#1	1.7	Ellipsoidal.	One partly developed lobe.	Microgranular.	1 nodule.
G989	#1	1.1-7.2	Spheroidal, some ellipsoidal, a few prolate, one tabular.	Some smaller ones faceted to near-polygonal. Incipient to well developed lobes on smaller ones.	Smaller ones uniformly granular. This is replaced on one side (lower?) of many larger ones by cavernous microbotryoidal surface.	A few are re-encrusted fractured nodules. Two large, some small polys.
G990	Crust	0.1-5.0	Frags.	-------------	See coarse fraction.	Mn-encrusted weathered angular basalt. See coarse fraction.
G991	#1	1.1-5.0	Predominantly spheroidal; some ellipsoidal to cylindrical; a few prolate.	Many spheroidals faceted to near-polygonal shape. Some nodules, especially smaller ones, with incipient to well-developed lobes.	Most larger ones have one cavernous microbotryoidal surface and one microgranular surface. Proportion of surface that is microgranular increases with decreasing size; essentially no cavernous aspect on nodules <2cm.	See also coarse fraction. No polys. Cannot distinguish upper and lower surfaces.

STATION	NODULE TYPE	SIZE RANGE (CM)	PRIMARY MORPHOLOGY	SECONDARY MORPHOLOGY	SURFACE TEXTURE	COMMENTS
G992A	#1	1.3-4.1	Predominantly spheroidal, some cylindrical, a few ellipsoidal.	Many shperoidals faceted to near-polygonal shape. A few smaller nodules with incipient lobes.	Most larger ones have granular surfaces grading to cavernous microbotryoidal. Some have microgranular surfaces grading or changing abruptly to cavernous surface (where latter has broken or been abraded off). Many smaller nodules retain cavernous aspect, although most surfaces granular.	No polys. Upper and lower surfaces cannot be distinguished on most nodules, and when interface seems apparent, there is no relation to texture, although often the smoother microbotryoidal surface seems to have been in the sediment. Thickness of cavernous surficial layer is variable--genetic implications?
G993D	#1	2.0&4.4	Spheroidal.	Larger one tending toward ellipsoidal, smaller is near-polygonal due to faceting.	Both have granular surfaces grading to cavernous microbotryoidal. Larger one has smoothly microgranular surface beneath fracture-removed outer layer.	2 nodules. Neither poly.
G993E	#1	1.0-6.0	Predominantely spheroidal. Some larger ones ellipsoidal. Some intermediate size cylindrical, one prolate. A few smaller ones tabular or discoidal.	Many, especially smaller nodules, are near-polygonal due to faceting. A few smaller nodules with incipient lobes.	Larger and intermediate size nodules have granular lower surface, cavernous microbotryoidal upper surface. Many smaller ones retain cavernous aspect to part of surface, but most granular.	No polys. Upper and lower surfaces <u>can</u> be distinguished here.
G994	#1	0.7-8.0	Spheroidal. A few ellipsoidal. A few small prolate.	Largest nodule has "hump" on one side. Some small nodules with incipient lobes.	Granular to microbotryoidal upper surface (with some areas cavernous), lower surfaces granular to --cont.--	No polys, but one small nodule has satellite. Few interme- --cont.--

STATION	NODULE TYPE	SIZE RANGE (CM)	PRIMARY MORPHOLOGY	SECONDARY MORPHOLOGY	SURFACE TEXTURE	COMMENTS
G994 cont.					flattened microbotryoidal cavernous. Smaller nodules uniformly granular.	diate or small size nodules.
G995	#1	0.8-8.9	Tabular-discoidal and discoidal for all larger than ~3 cm. Modified spheroidal or flattened ellipsoidal for smaller ones.	Incipient to well-developed lobes, development increasing with decreasing size. Largest have brown sediment knob (or raised area) on lower surface; sediment is lithified. Some knobs in depression.	Smallest are granular to microgranular. With increasing size, bottom surface becomes more cavernous microbotryoidal, while upper surface remains granular or becomes suppressed microbotryoidal.	Two small polys. Poorly developed septarian fracturing on some. One large nodule was fractured and re-encrusted. At least one shark tooth nucleus.
G996B	#1	1.8-3.5	Spheroidal or ellipsoidal.	Incipient lobes on smaller ones.	Granular.	One poly.
G1001	#1	Up to 10.1	Largest are tabular; smaller are tabular or polylobate. A few small prolate. Most of smallest ones obviously frags. Many tabular nodules have discoidal aspect.	Tabular ones are irregular in outline. Polylobate forms also irregular. All have general cindery aspect. Some, especially larger ones, have small central or subcentral depression or hole through nodule.	Most have one pahoehoe-like surface, with superimposed botryoidal to granular texture; other surface less relief and less ropy. Smaller ones have botryoidal with superimposed granular texture.	Must have comprised a near-pavement of flattened nodules, some possibly loosely connected to adjacent nodules. Some are incompletely covered by Mn; substrate is brown sediment (ash?).
	#2	2.0-4.9	Largest is spheroidal. Three are prolate. Other 3 discoidal to ellipsoidal.	Incipient lobes on ellipsoidal forms.	Large spheroid has one granular surface, one smooth botryoidal surface. Others have granular and/or botryoidal with superimposed granular.	Differentiated from Type #1 on basis of surface texture having less relief. Largest is only regular spheroid in sample.

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STATION	NODULE TYPE	SIZE RANGE (CM)	PRIMARY MORPHOLOGY	SECONDARY MORPHOLOGY	SURFACE TEXTURE	COMMENTS
G1001 cont.	#3	Up to 5.6	Frags.	Segments of large botryoids?	Smooth microgranular to granular.	Appear related to large spheroid (type #2). Mn-crust up to 1 cm.+ thick.
G1002	#1	0.6-4.8	Larger ones discoidal, smaller are spheroidal or flattened discoidal. A few small prolate. Many frags.	Segmented aspect to a few.	Smaller ones microgranular. Larger are microgranular (black) to cavernous granular (reddish).	Larger ones appear to have been dislodged from accompanying rock frags. No polys.
G1003	#1	0.8-6.5	Largest are spheroidal or discoidal, smaller are mostly flattened discs.	Some larger discs have equatorial "lip" curling toward lower surface. This same type of growth has appearance of skirt on large spheroidal nodules. Larger discoidal nodules have convex upper surface, flattened lower surface.	Large spheroids have granular to cavernous microbotryoidal surfaces. Most smaller nodules uniformly microgranular. Larger discs have one microgranular or granular surface, other is cavernous microbotryoidal to suppressed botryoidal.	Many discoidals fractured and re-encrusted. Some smaller nodules have agglutinated basalt frags.
G1004C	#1	1.0-6.4	Ellipsoidal. Many frags.	Incipient lobes on largest ones. One has 5 mm - high knob. Many have spheroidal (or reniform) aspect.	On larger, one surface is granular, other smooth. On smaller ones, surface more uniformly microgranular.	At least one of larger has been fractured and re-encrusted.
G1005	#1	7.6-10.1	Spheroidal.	Two equatorial skirts on each, one regular, one irregular and incomplete.	Surface above regular skirt is granular to microbotryoidal, equatorial band is botryoidal with superimposed granular, surface below irregular skirt is higher-relief botryoidal.	Five nodules. Irregular skirt appears to be encrusted cindery volcanic.

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STATION	NODULE TYPE	SIZE RANGE(CM)	PRIMARY MORPHOLOGY	SECONDARY MORPHOLOGY	SURFACE TEXTURE	COMMENTS
G1005 cont.	#2	5.3-6.4	Spheroidal.	Lack equatorial skirts. Largest has flattened equatorial band.	Granular on one surface, suppressed botryoidal or botryoidal with granular on other.	Three nodules.
	#3	0.9	Spheroidal.	-------	Granular.	One nodule.
G1006B	#1	3.9-10.6	Spheroidal.	Pavement skirt. Skirt "curls" toward upper or lower surface. Skirt only partly developed on smallest one. Skirt outline is irregular.	Microbotryoidal on side toward which skirt curls, granular on other side. Concave portion of skirt is botryoidal with superimposed poorly developed microbotryoids. Convex part of skirt is channelled botryoidal, with superimposed granular texture.	Pavement similar to G1001, type #1; occurs as either basal or upper skirt. Total 8 nodules.
	#2	1.2-6.8	Tabular or polygonal.	Irregular in outline.	One side channelled botryoidal, other microbotryoidal or smooth with scattered protrusions.	Consist of the material that makes up the skirts of type #1.
	#3	0.9-2.9	Spheroidal; also ellipsoidal, prolate, discoidal.	Many with protrusions or bumps on one side. A few faceted.	Granular. Protrusions are smoothly encrusted agglutinated volcanic frags.	Protrusions may consist of same material that makes up the skirts of type #1.
G1007	#1	0.6-7.6	Larger ones are tabular-discoidal. With decreasing size, shape becomes discoidal, then ellipsoidal; smallest generally spheroidal. Some prolate of all sizes.	Tabular-discoidals have slightly irregular outline. Some intermediate sizes appear to be fractured and re-encrusted discoidals. Some of smaller nodules have well developed lobes; a few even have a "botryoidal" shape.	Larger ones have two distinct surfaces, one cavernous botryoidal with superimposed microbotryoids, other granular or microgranular. On intermediate sizes, differences less distinct, with one side macrogranular to microbotryoidal, and other side with more clustered microbotry- -- cont. --	Cannot readily distinguish upper and lower surfaces. Polys small and few. Although largest nodules are distinctly different from smallest ones, there ia a gradation between -- cont. --

STATION	NODULE TYPE	SIZE RANGE(CM)	PRIMARY MORPHOLOGY	SECONDARY MORPHOLOGY	SURFACE TEXTURE	COMMENTS
G1007 cont.					oids. Smaller nodules uniformly granular.	the sizes when shape and surface texture are considered.
G1008	#1	0.7-3.6	Larger ones discoidal or ellipsoidal-discoidal, smaller ones spheroidal.	Larger ones have one side slightly flattened in comparison to other side; flattened side has central cluster of satellite protrusions. Some have additional equatorial satellite intergrowths. Many smaller ones have satellite protrusions or "bumps".	Satellite protrusions on all sizes tend to be smooth. Flattened surface of larger nodules made up of poorly defined microbotryoids; other surface granular. Smaller nodules tend to be uniformly granular.	Several 2-polys (inter-growths of smaller spheroidals). Central satellite protrusions on larger ones probably on upper surfaces.
G1009	#1	0.8-8.2	Largest are tabular-discoidal, and some intermediate sizes are ellipsoidal, but most intermediate and small nodules are spheroidal. A few prolate, one "curled plate."	Tabular-discoidals have slightly irregular outline. Some of ellipsoidals are faceted, as are many smaller spheroidal nodules.	Surfaces mostly uniformly granular to microbotryoidal.	No polys. Cannot distinguish upper and lower surfaces.
G1011	#1	2.9&3.0	Spheroidal.	One has 3 satellite protrusions. Both slightly flattened on two sides.	Granular.	Two nodules. Cannot distinguish upper and lower surfaces.
G1012	#1	1.4-9.5	Tabular-discoidal, discoidal, ellipsoidal and polygonal. Also many small frags.	Many irregular, as if section had been broken off prior to growth of Mn-coating.	Each has fairly uniform microbotryoidal (or granular) surface. One side occasionally has slightly higher relief than other side.	No polys. Cannot distinguish upper and lower surfaces. Most polygonal nodules may be angular basalt frags. with thin Mn-coating.

STATION	NODULE TYPE	SIZE RANGE (CM)	PRIMARY MORPHOLOGY	SECONDARY MORPHOLOGY	SURFACE TEXTURE	COMMENTS
G1016	#1	4.4	Double cylinder.	Groove on one side.	Granular.	Mn-encrusted vertebra.
	#2	0.6-8.2	Largest are "botryoidal" (grape bunches), smaller are spheroidal or intergrown spheroids (polys).	Some smaller ones have angular satellite protrusions.	Mostly uniformly granular. On some larger ones this is superimposed on poorly developed botryoids.	Polys mostly double and triple, some higher multiples. Cannot distinguish upper and lower surfaces.
G1017	#1	2.3&1.8	Prolate.	Both have one end flattened.	Microgranular.	Broken off of larger accumulation?
	#2	1.8-5.8	Mostly spheroidal. Some of smaller are "botryoidal".	Some spheroidals vaguely faceted.	Spheroidals have botryoidal with superimposed granular or microbotryoidal surfaces. Botryoidal development decreases as spheroidal size decreases. "Botryoidal" nodules have granular surfaces.	Well developed worm tubes in some crevasses. Cannot distinguish upper and lower surfaces.
G1019	#1	1.6-7.2	Largest are "botryoidal", smaller are spheroidal or intergrown spheroids.	A few spheroidals have incipient lobes.	Largest has granular surface superimposed on poorly developed botryoids. All others have uniformly granular surfaces.	Polys mostly double and triple; higher order intergrowths assume "botryoidal" form. Many have well developed worm tubes on surfaces. Cannot distinguish upper and lower surfaces.

STATION	NODULE TYPE	SIZE RANGE (CM)	PRIMARY MORPHOLOGY	SECONDARY MORPHOLOGY	SURFACE TEXTURE	COMMENTS
G1020	#1	2.5-10.9	Most are "botryoidal". Some smaller ones are more obviously intergrown spheroids.	Depth of crevasse between intergrowths is variable.	Largest have granular texture superimposed on botryoids or microbotryoids. Smaller nodules have uniformly granular surfaces.	Two smallest nodules are 2- and 3-poly, all others higher order multiple intergrowths. Largest appear to have higher relief botryoids on lower surface. Several with well developed worm tubes.