HIG-75-17

FERROMANGANESE DEPOSITS OF THE OCEAN FLOOR

Cruise Report Mn-74-02
R/V MOANA WAVE

San Diego to Honolulu
11 September to 10 October, 1974

PARTICIPATING SCIENTISTS

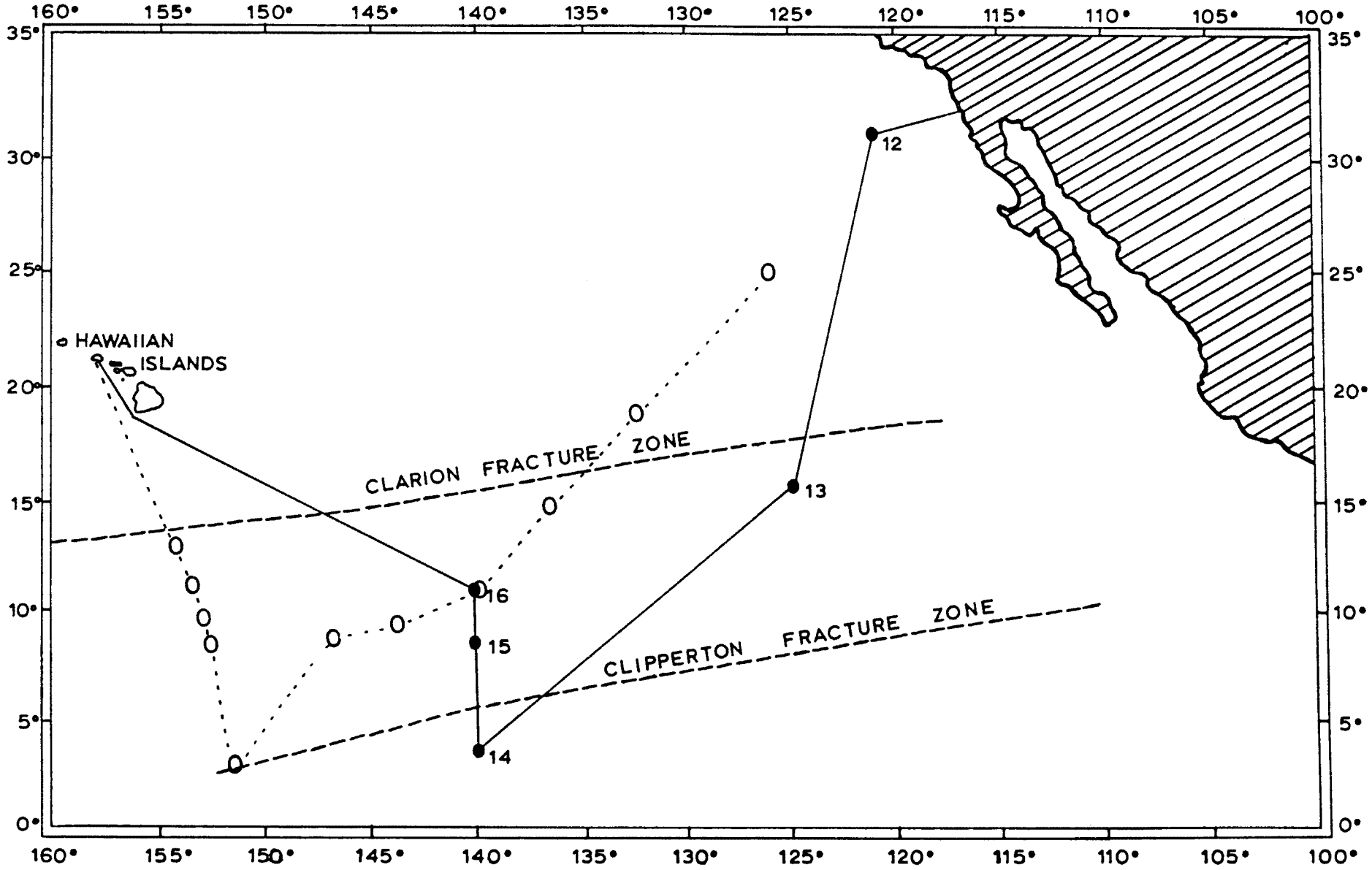
S. V. Margolis, C. J. Bowser *(Co-Chief Scientists)*,
J. Murray, J. L. Mero, W. Hardy, W. C. Dudley,
B. K. Dugolinsky, K. Binder, R. Hall, and C. Boatman

INTER-UNIVERSITY PROGRAM OF RESEARCH

Sponsored by
Seabed Assessment Program
International Decade of Ocean Exploration
National Science Foundation

SEPTEMBER 1975

HAWAII INSTITUTE OF GEOPHYSICS
UNIVERSITY OF HAWAII



Frontispiece. Mn-74-02 cruise track (solid line). Dashed line with open circles is Mn-74-01 cruise track.

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Approved by Director

George P. Woollard

Date: 29 September 1975

Technical Report number 10, NSF GX-34659, Inter-University
Program of Research on Ferromanganese Deposits on the Ocean Floor

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SECTION I

INTRODUCTION

Cruise Mn-74-02 of the R/V MOANA WAVE was the second part of the field work of the NSF/IDOE Inter-University Ferromanganese Research Program in 1974, and we gratefully acknowledge the support of the office for the International Decade of Ocean Exploration and the Office of Oceanographic Facilities and Support. This program was designed to investigate the origin, growth, and distribution of copper/nickel-rich manganese nodules in the Pacific Ocean. The field effort was designed to satisfy sample requirements of the fifteen principal investigators, while increasing general knowledge of the copper/nickel-rich nodule deposits of the equatorial Pacific. This report is the second of a series of cruise reports designed to assist sample requests for documented nodules, sediment, and water samples so that laboratory results can be realistically compared and related to the environment of nodule growth.

Nodule samples and bathymetric and navigational data are archived at the Hawaii Institute of Geophysics, University of Hawaii. Bulk chemical analyses of nodules and reduction of survey data will be carried out at Hawaii. Sediment cores will be stored at the University of Hawaii and at Scripps Institution of Oceanography. The SIO analytical facility will provide stratigraphic data on sediment chemistry.

Samples may be requested from:

Dr. James E. Andrews or Dr. Stanley V. Margolis
Department of Oceanography
University of Hawaii
2525 Correa Road
Honolulu, Hawaii 96822

The first part of the field work of this program is reported in Andrews, J. E. et al., 1974, Ferromanganese Deposits of the Ocean Floor; Cruise Report MN-74-01, R/V MOANA WAVE, Honolulu to San Diego, 17 July to 10 August, 1974, Hawaii Institute of Geophysics report HIG-74-9, Honolulu.

PROGRAM AND CRUISE OBJECTIVES

The Ferromanganese Research Program of the United States National Science Foundation's International Decade of Ocean Exploration (NSF/IDOE) has a general goal: to elucidate and define the factors which initiate, influence, and alter the formation, growth, and distribution of manganese nodules. Why do nodules form, why are some nodules trace metal enriched, and what controls these occurrences in both local and regional patterns?

To examine these problems on the more specific level requires a variety of approaches. Several considerations must be established: a) the relationship of mineralogy to density and growth; b) the relationship of chemical variations (especially trace metal enrichment) to the environment, which in turn involves the immediately superjacent water mass and the underlying sediment and its pore water; c) the role of biological factors in, on, and around the nodules as influences; d) nodule structure--both internal and external and its relationship to mineralogy, chemical content, and locale; e) the geologic setting of nodule deposits--local and regional sea-floor structure, sea-floor history (e.g., sea-floor spreading), and the effect of these on oceanographic conditions.

Investigators representing several of the major U.S. oceanographic institutions involved in the IDOE Ferromanganese Program are pursuing studies in each of these problem areas.

In viewing these objectives for cruise Mn-74-02 and subsequent field work in the NSF/IDOE Program, it is perhaps most direct to consider the various active hypotheses concerning the origin and growth with which the investigators have to deal in order to define the field goals and sample requirements.

1. Terrigenous Origin: Material provided for growth from the continents via the overlying water mass.

> Requirements: Well-documented nodule samples covering large areas of the sea floor, and corresponding water samples (particularly near bottom) for dissolved and particulate trace metals and water mass parameters.

2. Hydrothermal-Volcanogenic: Main contributions from hydrothermal sources related to submarine volcanism, both local (sea mountains and hills) and regional (sea-floor spreading--mid-ocean ridges and fracture zones.)

> Requirements: Well-documented nodules sampled in detail especially towards regional and local sea-floor structures--concentrating on samples patterned at various distances from major and minor potential volcanic sources. Well-documented bathymetry and profiles to establish small-scale volcanic sources, or absence thereof.

3. Halmyrolysis-Volcanogenic: Major elemental contribution derived from interaction of volcanogenic materials and sea water.

Requirements: Well-documented nodule and sediment samples appropriately located with respect to sea-floor structure (as for 2 above), sediment and pore water chemistry. Of prime importance is availability of box cores and free fall cores most appropriate for this work.

4. Diagenetic: Major contributions from the sediment column related to sedimentation rate, oxidation state, pore water migration during sedimentation, and diffusion.

Requirements: Essentially, as for 3 above, box cores and free fall cores are most important. Preferred sample sites would contrast deposits adjacent to or overlying volcanic sources with deposits from 'undisturbed' sea floor, and a variety of sediment types.

5. Biogenic: Major contributions via element-fixing microorganisms, tube-building foraminifera, and major environmental adjustments by local benthic populations.

Requirements: Nodules should be collected with an absolute minimum of handling, special preservation (freezing, formalin), plus box cores and photos to document in situ relations.

The phrase 'well-documented samples' is used here to indicate samples whose point of origin is well known, principally in terms of local and regional bathymetry, structure, sediment type and age, and for which reasonable documentation of in situ patterns is known (via TV or photographic examination), and for which bulk chemical data is known. Minimal handling and cold or freezing storage temperature are desired to prevent mineralogical and chemical changes. These samples may be obtained by: a) free fall grab, b) box cores, c) or dredge -- each having its own special advantages and disadvantages.

a). Free fall grabs are precisely located (within limits of satellite navigation) and provide evidence of nodule density (kg/m^2), but yield only very small sediment samples and small quantities of nodules. (Sea-floor area sampled by the grab is 0.08 m^2).

b). Box cores give oriented and undisturbed samples of nodules and sediment in original relationships, and also permit density evaluation. Sample location is not easily controlled, and volume is low (except in dense deposits).

c). Dredging provides large volumes, but is also poorly controlled for precise sample location, and probably adversely affects samples desired for study of surface characteristics.

The five stations occupied during Mn-74-02 were designed to increase regional knowledge and to sample, in detail, the smaller areas while documenting the bathymetry of each site.

The prime objectives in Mn-74-02 were:

1. To occupy a hemipelagic station (12) for the purpose of pore water chemistry intercalibration.

2. To sample a carbonate ooze station near the equator in order to compare pore water chemistry with the siliceous ooze belt.

3. To obtain box cores from all stations in order to recover nodules in in situ position and to sub-sample for pore water chemistry.

4. To reoccupy stations visited during Mn-74-01 in order to obtain more detailed sampling and bathymetry, and to perform operations (e.g. bottom photography, box-coring, harpoon sampling) that were not done during the first visit.

CRUISE SCHEDULE - Mn-74-02

Depart San Diego 1800Z 11 September 1974
Nimitz Marine Facility
Scripps Institution of Oceanography

Station No.	Time on Station	Coordinates
Shakedown Cruise	0940Z 12 September-0554Z 13 September	32°14'N 118°38'W
12	1826Z 17 September-1214Z 18 September	30°43'N 119°51'W
13	0638Z 22 September-0400Z 25 September	16°06'N to 15°00'N 125°00'W
14	1819Z 29 September-1548Z 30 September	04°25'N 140°03'W
15	1410Z 01 October-0222Z 03 October	09°00'N 140°00'W
16	1409Z 03 October-0830Z 05 October	11°03'N 140°00'W

Arrive Honolulu 2130Z 10 October 1974
Pier 18
University of Hawaii

PERSONNEL - Mn-74-02

Name	Organization	Duties
Dr. Stanley V. Margolis	University of Hawaii	Co-chief Scientist, Geology
Dr. Carl J. Bowser	University of Wisconsin	Co-chief Scientist, Water Chemistry
Dr. James Murray	University of Washington	Pore Waters, Harpoon
Dr. Wilton Hardy	University of Hawaii	Navigation, Computers, Double Chirp
Dr. John L. Mero	Ocean Resources, Inc.	TV System
Mr. Walter C. Dudley	University of Hawaii	Surveys, Geology
Mr. Brent K. Dugolinsky	University of Hawaii	Nodules, Photography
Mr. Kenneth Binder	University of Hawaii	Water Sampling
Mr. Charles Boatman	University of Hawaii	Pore Water Squeezing
Mr. Roger Hall	University of Hawaii	Chemistry Technician
Mr. Bruce Gottesburen	University of Hawaii	Electronics Technician
Mr. Michael Christie	University of Hawaii	Deck Technician
Mr. David Schlabach	University of Hawaii	Electronics Technician

EQUIPMENT AND LABS - Mn-74-02

2 Box Cores

8 Free Fall Grabs (CNEXO)

50 Free Fall Grab Weights

3 Free Fall Core Floats (Benthos)

16 Free Fall Core Bonnets

30 Free Fall Core Collar Weights

30 Free Fall Core Disc Weights

3 Cameras - EG and G

3 Strobes - EG and G

1 Pinger - Benthos

1 Pinger - EG and G

2 Dredges - Large Box

2 Dredges - Box Type

3 Dredges - Barrel Type

TV System - Hydroproducts (with Markey Winch)

Rosette (NOAA) with 12-liter Niskin Bottles

Magnetometer

Echo Sounding System 3.5 and 12 kHz

CESP - Correlation Processor

PTR - Transceiver

PDD - Digitizer

UGR - Recorder

Wang Computer/Disc Storage and Hewlett Packard Plotter

Double Chirp System (Experimental)

Satellite Navigation - Magnavox

EQUIPMENT AND LABS - Mn-74-02 (continued)

Liquid Nitrogen - 3 Dewars

Winches:

Markey - TV 3/4" Conductor Cable

Northern Lines - Dredging

Coring

9/16" 3 X 19 Wire

Hydro Remote Control - 3/16" Wire

Hydro-Markey - 1/4" Conductor Wire

Lab Vans:

General Lab Van - Water Analysis

Alkalinity

Salinity

Dissolved O_2

Chemistry Lab Van - Water Analysis

Alkalinity

Salinity

Dissolved O_2

Manganese Lab Van - Darkroom

TV and Camera Staging

Sample Description and Sorting

Cold Van - Core Squeezing

Sample Storage

Frozen Samples in Ship's Freezer, Temperature at 4°C

CRUISE NARRATIVE Mn-74-02

Cruise Mn-74-02 of the R/V Moana Wave for the Inter-University Ferromanganese Program (NSF-IDOE) departed San Diego at 1800Z 11 September 1974, and arrived at Honolulu 1230Z 10 October 1974 after a voyage of 3,740 nautical miles (nm) and the occupation of five stations.

Stations 12 and 14 turned out to be primarily of interest in terms of pore water chemistry and sedimentology, as no nodules were recovered at those stations. At stations 13, 15, and 16 abundant manganese nodules were recovered, as well as box cores of nodules and sediment, while water chemistry sampling was also carried out.

This cruise (frontispiece) was planned as the second of a series of two cruises to the northeast equatorial Pacific to collect manganese nodules, and to study their environment of formation in terms of structural and bathymetric setting, bottom sediments, and water chemistry. The first cruise, Mn-74-01, had problems with the Northern Lines winch, which resulted in the loss of the box corer, a necessary piece of equipment for recovering undisturbed samples of nodules and sediment for study of in situ relationships. The purpose of Mn-74-02 was to obtain successful box cores from several stations, to perform water chemistry of sea water and pore waters at these stations, to collect free fall grab samples of nodules, free fall cores of sediments, and dredges of nodules, and to investigate the sea floor by means of TV camera and 35-mm bottom camera work.

The cruise was successful in that the original goals were accomplished, but operations were seriously hampered by winch inadequacies and failures. In order to minimize anticipated problems, a shakedown cruise was undertaken before the main cruise. Several mechanical problems were identified and an attempt was made to repair them before leaving for Honolulu. It was determined that the Northern Lines winch was useless with the cable available because it did not have the necessary pulling power to lift the weight of cable and attached equipment in the depths of water in which operations were to be carried out (4,800-5,300 meters). An attempt was made to obtain a smaller-diameter cable at Scripps but none was available. This meant that the Markey winch had to be relied upon for all heavy work off the fantail. The problem with the Markey winch, however, was that it had a leaky torque converter, and it only had 5,400 meters of cable on it when the Moana Wave left San Diego. Since this winch was to be of primary importance for box coring and dredging, the decision was made to stay in port and repair the oil seal on the Markey winch before departing. While in port an attempt was also made to get the bottom TV system working, but it never became operational because of suspected breaks in the conducting cable. Of the two hydrographic winches, only the old Teritu winch was operational, but its meter-reading meter did not function and it had problems with the cable level winding mechanism.

The box coring was limited in terms of depth because of insufficient

cable. Topographic highs were the only areas within reach, and these areas did not always contain nodules. On several attempts, problems with the fit of the spade and bottom plate caused sediment loss. Both the borrowed Scripps and Kennecott box cores worked well.

The CNEXO free fall grabs worked very well on all occasions and none were lost on this cruise.

Dredging was done at station 13 with the five-ton box buckets. Subsequent use of these large dredges was restricted by insufficient cable.

Three runs were tried with the E.G. and G. 35-mm camera and one was successful at station 15. Failures were caused by broken shutters and film advance mechanisms.

The water-sampling rosette, satellite navigation, and pingers all performed satisfactorily on the cruise. Standard Hawaii Institute of Geophysics laboratory and station logs were maintained for the cruise.

For a review of shipboard navigational and survey facilities, as well as discussion of equipment operations, see the cruise report for Mn-74-01 (HIG-74-9).

SECTION II

DISCUSSION OF STATION DATA - SECTION II

This section presents station operations, sample descriptions, and summary tables. Bathymetric surveys, with sample locations noted, are included for the major stations (13, 14, 15, and 16). Bathymetric contours are in meters. Track charts are included to show control on bathymetry. Dashed contours on bathymetry are extrapolated between widely spaced tracks. Photographs documenting free fall grab samples show nodule coverage as sampled by the dimensions of the grabs (0.08 m^2 outlined area in photographs). Nodule cover densities(kg/m^2) are derived from weights of nodules recovered in the grabs ($kg/0.08\ m^2$). These are weights taken on board ship shortly after retrieving the grabs. Water chemistry (water column and pore water) results in the tables accompanying the station summaries were derived on board ship.

STATION SUMMARY

STATION: 12

TIME ON STATION: 17/9/74 1126Z

LATITUDE: 30° 43' N

TIME DEPART STATION: 18/9/74 0514Z

LONGITUDE: 119° 52' W

SEDIMENT TYPE: Brown clay

OPERATIONS: Box core #1 17/9/74 2339Z - 18/9/74 0157Z

Harpoon #1 18/9/74 0312Z - 0525Z

Water cast #1 18/9/74 0900Z - 1300Z

DISCUSSION:

This station was conducted primarily for water chemistry and pore water calibration. No detailed bathymetric survey was conducted, and no grab samples were taken. The results are discussed in Section III of this report.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Box core

LAT. N.: 30°43'

LONG. W.: 119°52'

WATER DEPTH: 4100 m

STATION: 12

SAMPLE NO.: BC #1

DATE: 17 Sept 74 - 18 Sept 74

TIME: LAUNCH: 2339 Z

ON BOTTOM _____

RECOVER 0157 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Rugged

SPECIFIC BATHYMETRIC LOCATION:

Continental slope

ASSOCIATED SEDIMENT -- Brown clay

Sample No:

Type:

NODULE TYPES AT THIS STATION:

None

STATION SUMMARY

STATION: 13A

TIME ON STATION: 22/9/74 0530Z

LATITUDE: 16°N

TIME DEPART STATION: 22/9/74 1129Z

LONGITUDE: 125°W

SEDIMENT TYPE: Red Clay

OPERATIONS: FFG #1, 2, 3, 4, 22/9/74 0638Z - 22/9/74 1111Z

DISCUSSION:

This station was conducted in order to find an area close to the U.S. Mainland that had abundant nodules and relatively flat bathymetry that was suitable for dredging and mining. After a preliminary survey and recovery of grabs, this area was deemed not satisfactory, and the Moana Wave proceeded to 15°N-125°W, which was designated Station 13B. No detailed survey is given for Station 13A.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

STATION: 13-A

COLLECTION DEVICE: CNEXO - FFG's

SAMPLE NO.: FFG -001, -002, -003, -004

LAT. N.: 16°01.0' - 16°06.8'N

DATE: 22 Sept 74

LONG. W.: 124°58.9' - 125°59.0'W

TIME: LAUNCH: 0548, 0607, 0621, 0635 Z

WATER DEPTH: 4210 - 4430 m

ON BOTTOM _____

RECOVER 1019, 1039, 1058, 1111 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

South of Clarion Fracture Zone; rolling abyssal hills with occasional sharp-peaked hills of up to 350-m relief.

SPECIFIC BATHYMETRIC LOCATION:

FFG-001: Top of 240-m hill

FFG-002: Flat valley floor between sharp-peaked 240-m hill and very broad-peaked 85-m hill

FFG-003: Lower flank of broad-peaked 85-m hill

FFG-004: Top edge of broad-peaked 85-m hill

ASSOCIATED SEDIMENT --

Sample No: FFG-002 and FFG-004

Type: Red Clay (adhering to several of the nodules)

NODULE TYPES AT THIS STATION:

FFG-001: empty

FFG-002: (2)m[p]$^{S}_{r}$-b, (1)m[S]$^{S}_{r}$, (2)m[E]$^{S}_{r}$, (3)m[T]$^{S}_{r}$, (2)s[T]$^{S}_{r}$, (3)s[D]$^{S}_{r}$, (1)s[P]s, (1)s[D-S]$^{S}_{r}$, (2)s[D-E]s, (3)s[E]s

FFG-003: (1)1[E]$^{S}_{r}$, (1)m[E]$^{S}_{r}$, (1)m[E]s, (1)m[E]$^{S}_{r}$, (6)s[D]$^{S}_{r}$, (1)s[D-F]$^{S}_{r}$, (4)s[P]$^{S}_{r}$, (17)s[F]s, (10)s[S]r, (1)s[E]$^{S}_{r}$,

FFG-004: (1)m[D-F]$^{S}_{r}$, (1)m[E-F]$^{S}_{r}$, (6)s[E]r, (4)s[S]r

STATION: 13-A SAMPLE NO.: FFG-002

NODULE TYPES: $m[P]^{s}_{r}$-b, $m[S]^{s}_{r}$, $m[E]^{s}_{r}$, $m[T]^{s}_{r}$, $s[D]^{s}_{r}$, s[P]s, $s[D\text{-}S]^{s}_{r}$, s[D-E]s, s[E]s

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	6	13	1			20	3
Weight (Kg)	.01	.20	.11			.32	.02

SIZE RANGE OF MAX. DIAM.: 10-50 mm

PRIMARY MORPHOLOGY: Variable; many appear to be partially healed fragments. Many smaller nodules generally more angular; one shark's tooth covered with thin coating of manganese.

SECONDARY MORPHOLOGY: Slight equatorial rim on some.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Two 2-poly

SURFACE TEXTURE:

Upper Surface: Smooth

Lower Surface: Rough on all medium-size nodules and some smaller nodules; smooth on others

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
			<----------	----------	---------->
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
			<----------	----------	---------->

ABSOLUTE DIAM. OF MAMMILLAE: ≤ 1 mm for granules; 3-20 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes common.

STATION: 13-A SAMPLE NO.: FFG-003

NODULE TYPES: 1[E]$^{s}_{r}$, m[E]$^{s}_{r}$, m[E]s, m[E]$^{s}_{r}$,s[D]$^{s}_{r}$, s[D-F]$^{s}_{r}$, s[P]$^{s}_{r}$,, s[F]s, s[S]r, s[E]$^{s}_{r}$

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	27	12	1	1		41	
Weight (Kg)	.02	.10	.05	.11		.28	

SIZE RANGE OF MAX. DIAM.: 10-80 mm

PRIMARY MORPHOLOGY: Large nodule ellipsoidal; medium-size nodules ellipsoidal; smaller ones variable.

SECONDARY MORPHOLOGY: Many small, agglutinated angular rock fragments projecting from surface of many nodules.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Two 2-poly, one 3-poly

SURFACE TEXTURE:

Upper Surface: Smooth on all except small, spheroidal types

Lower Surface: Rough to gritty on all except small fragmental and medium ellipsoidal types

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<----------	----------	---------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<----------	----------	---------->		

ABSOLUTE DIAM. OF MAMMILLAE: ≤ 1 mm for granules; 2-15 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes common.

STATION: 13-A SAMPLE NO.: FFG-004

NODULE TYPES: $m[D\text{-}F]^{S}_{r}$, $m[E\text{-}F]^{S}_{r}$, s[E]r, s[S]r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	4	8				12	4
Weight (Kg)	.01	.09				.10	.05

SIZE RANGE OF MAX. DIAM.: 10-40 mm

PRIMARY MORPHOLOGY: Medium-size nodules discoidal- to ellipsoidal-fragmental; smaller ones ellipsoidal or spherical.

SECONDARY MORPHOLOGY: Distinct angularity on some due to fragmentation and subsequent partial healing.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: One 2-poly

SURFACE TEXTURE:

Upper Surface: Smooth on larger nodules; gritty on smaller ones

Lower Surface: Gritty

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<----------	----->			
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<----------	----->			

ABSOLUTE DIAM. OF MAMMILLAE: $\simeq$ 1 mm

COLOR OF NODULE STREAK: Light brown

COMMENTS: Some nodules covered with red clay.

STATION SUMMARY

STATION: 13B

LATITUDE: 15°N

LONGITUDE: 115°02'W

TIME ON STATION: 22/9/74 0844Z

TIME DEPART STATION: 24/9/74 2000Z

SEDIMENT TYPE: Red Clay

OPERATIONS: FFG #5, 6, 7, 8, 9, 10, 11, 12 22/9/74 1645Z - 23/9/74 0200Z

Dredges #1, 2, 3, 4 23/9/74 0240Z - 24/9/74 0024Z

FFcore #1 24/9/74 0103Z - 0311Z

Hydrocast #2 24/9/74 0416Z - 0757Z

Boxcore #2 24/9/74 0840Z - 1200Z

Harpoon #2 24/9/74 1250Z - 1605Z

Harpoon #3 25/9/74 0047 - 0350

DISCUSSION:

This is the best-documented station of cruise Mn 74-02. Sampling operations were oriented to the geologic setting defined by a bathymetric chart covering over 80 n. mile^2 of sea floor. Good survey control was accomplished by evenly spaced control tracks (1-mile separation) run over distances of 9 miles. The bathymetry revealed by survey operations shows a North-South trending abyssal hill fabric of 100-meters maximum relief. Seismic reflection profiling (3-5 Khz) approaching the station site indicated a somewhat greater relief (350 m), and sharp-topped abyssal hills. A broad, flat-floored valley separates two prominent hills in this area, with slopes commonly of 2°. The steeper slope and sharp-topped hill in the SE portion of the area are probably of structural (fault) origin. A total of eight freefall grabs were launched. All of which returned an assortment of small nodule types. Coverage densities are generally low (typical of the Red Clay region), and average >10Kg/FFG. There appears to be no correlation of nodule coverage density to bathymetric setting.

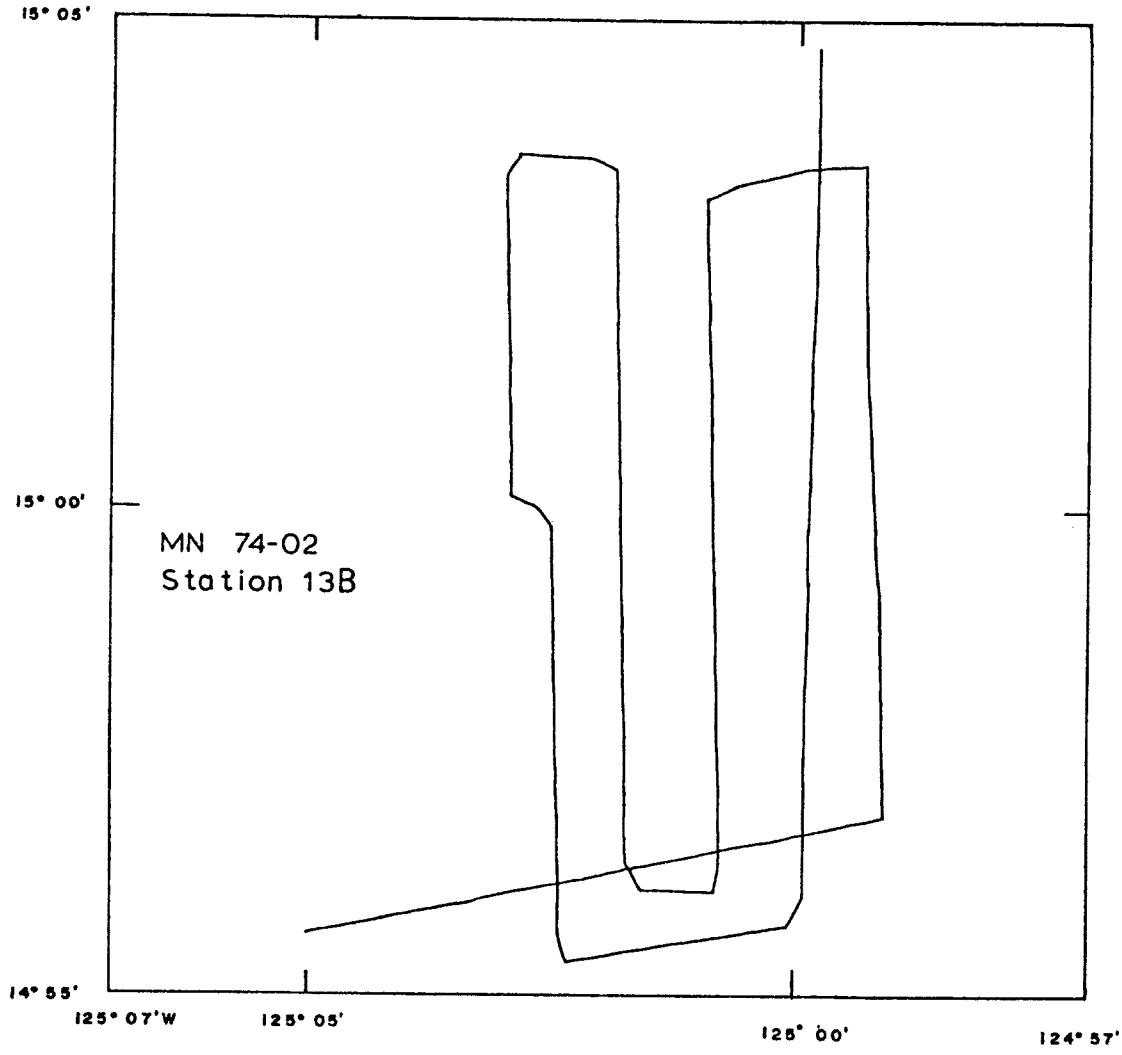

Fig. 1. Track chart, station 13B.

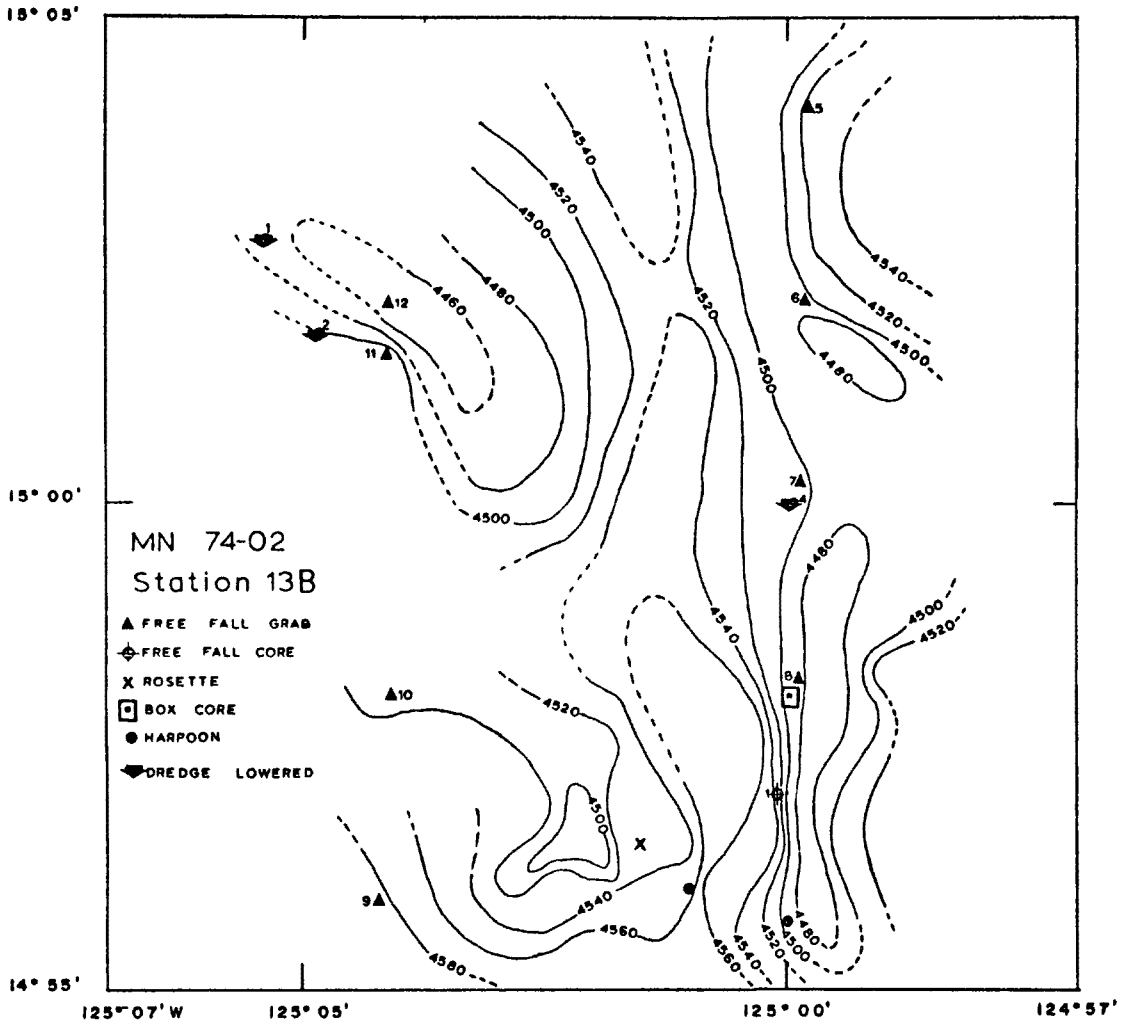

Fig. 2. Bathymetry, station 13B.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Dredge

LAT. N.: 15°02.7' N

LONG. W.: 125°05.5' W

WATER DEPTH: 4465 m

STATION: 13B

SAMPLE NO.: D-001

DATE: 23 Sept 74

TIME: LAUNCH: 0240 Z

ON BOTTOM 0400 Z

RECOVER 0750 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

South of Clarion Fracture Zone; rolling abyssal hills with occasional sharp-peaked hills of up to 350-m relief.

SPECIFIC BATHYMETRIC LOCATION:

Rolling abyssal hills

ASSOCIATED SEDIMENT --

Sample No: D-001

Type: Siliceous clay (adhering to dredge bucket)

NODULE TYPES AT THIS STATION: Wide variety

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Kennecott Box Corer

LAT. N.: 14°58' N

LONG. W.: 125°01' W

WATER DEPTH: 4840 m

STATION: 13B

SAMPLE NO.: BC-002

DATE: 24 Sept 74

TIME: LAUNCH: 0840 Z

ON BOTTOM 1038 Z

RECOVER 1200 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Low, rolling abyssal hills

SPECIFIC BATHYMETRIC LOCATION:

Valley floor

ASSOCIATED SEDIMENT --

Sample No: BC-002

Type: Siliceous clay

NODULE TYPES AT THIS STATION:

(1)1[F]$^{S}_{b}$-r, (1)m[F]s

STATION: 13B SAMPLE NO.: BC-002

NODULE TYPES: $l[F]^{s}b$-r, m[F]s

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules			1		1	2	
Weight (Kg)			.1		.2	.3	

SIZE RANGE OF MAX. DIAM.: 50-80 mm

PRIMARY MORPHOLOGY: Faceted

SECONDARY MORPHOLOGY: Botryoidal rim on larger nodule; appears like a fractured "mushroom" nodule.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Smooth

Lower Surface: Botryoidal, rough on large nodule; smooth on medium

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<------	------->		
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<------	------->		

ABSOLUTE DIAM. OF MAMMILLAE: 1 mm for granules; 3-20 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: CNEXO-FFGs

LAT. N.: 14°58.0' - 15°03.8' N

LONG. W.: 125°00.1' - 125°00.2' W

WATER DEPTH: 4460 - 4525 m

STATION: 13B

SAMPLE NO.: FFG-005, -006, -007, -008

DATE: 22 Sept 74

TIME: LAUNCH: 1645, 1659, 1712, 1724 Z

ON BOTTOM _____

RECOVER 2025, 2040, 2057, 2100 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Rolling abyssal hills from 25- to 100-m relief.

SPECIFIC BATHYMETRIC LOCATION:

FFG-005: Valley floor between 80-m hill and 15-m hill

FFG-006: Top of flat-topped 50-m hill

FFG-007: Valley floor between 50-m flat-topped hill and hill with multiple peaks ranging from 25 m above valley floor on one side to 100 m on other

FFG-008: In 10-15-m depression on top of multiple-peaked hill

ASSOCIATED SEDIMENT --

Sample No: FFG-005, -007, -008

Type: Red clay (adhering to some of the nodules)

NODULE TYPES AT THIS STATION:

FFG-005: (3)1[D]$^{S}_{r}$, (2)1[F]$^{S}_{r}$, (33)m[F]$^{S}_{r}$, (3)s[F]r

FFG-006: (2)s[P]r

FFG-007: (4)1[D]$^{S}_{r}$, (2)1[F]$^{S}_{r}$, (8)[F]$^{S}_{r}$, (2)m[S]$^{S}_{r}$, (2)s[D]r

FFG-008: (1)1[D]$^{S}_{r}$, (1)m[D]$^{S}_{r}$, (1)m[E]r, (1)m[S]$^{S}_{r}$, (2)s[P]r, (6)s[S]r, (2)s[D]r, (26)m[F]$^{S}_{r}$, (8)s[F]r

STATION: 13B SAMPLE NO.: FFG-005

NODULE TYPES: $1[D]^{s}_{r}$, $1[F]^{s}_{r}$, $m[F]^{s}_{r}$, $s[F]r$

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	2	13	21	5		41	
Weight (Kg)	.01	.25	.72	.63		1.6	

SIZE RANGE OF MAX. DIAM.: 10-80 mm

PRIMARY MORPHOLOGY: Most nodules are faceted due to fragmentation and subsequent partial healing. Nodules that are not faceted are discoidal.

SECONDARY MORPHOLOGY: Smaller nodules generally rounded whereas larger ones are more botryoidal. Well-developed botryoidal, equatorial rim on large discoidal and some large faceted nodules.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: One 2-poly

SURFACE TEXTURE:

Upper Surface: Smooth

Lower Surface: Rough, gritty

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<---	---	---	--->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<---	---	--->	

ABSOLUTE DIAM. OF MAMMILLAE: ≤ 1 mm for granules; 2-10 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes common on underside of equatorial rim.

STATION: 13B SAMPLE NO.: FFG-006

NODULE TYPES: s[P]r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm.	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	2					2	
Weight (Kg)	<0.1					<.01	

SIZE RANGE OF MAX. DIAM.: 20 mm

PRIMARY MORPHOLOGY: Both 2-polylobate nodules with elongated shape

SECONDARY MORPHOLOGY:

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Two 2-poly

SURFACE TEXTURE:

Upper Surface: Rough and gritty

Lower Surface: Rough and gritty

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
				<----------	---------->
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<----------	---------->		

ABSOLUTE DIAM. OF MAMMILLAE: 1 mm for granules; 2-10 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes on both nodules.

STATION: 13B SAMPLE NO.: FFG-007

NODULE TYPES: $1[D]^{s}_{r}$, $1[F]^{s}_{r}$, $m[F]^{s}_{r}$, $m[S]^{s}_{r}$, s[D]r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	5	3	3	5	2	18	2
Weight (Kg)	.01	.04	.13	.48	.45	1.11	.09

SIZE RANGE OF MAX. DIAM.: 10-85 mm

PRIMARY MORPHOLOGY: Discoidal to elongate spheroidal for most of larger nodules. Many are faceted due to fracturing and re-healing.

SECONDARY MORPHOLOGY: Well-developed equatorial rim on many of the larger nodules. Large, deep crack on one large discoidal nodule.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: 0

SURFACE TEXTURE:

Upper Surface: Smooth on all except small discoidal nodules

Lower Surface: Rough, gritty

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<----------	----------	--------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<----------	----------	--------->	

ABSOLUTE DIAM. OF MAMMILLAE: ≤ 1 mm for granules; 5-20 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Large discoidal nodules are 'mushroom'-shaped with well-developed equatorial rim of gritty botryoids.

STATION: 13B SAMPLE NO.: FFG-008

NODULE TYPES: $1[D]^{S}_{r}$, $m[D]^{S}_{r}$, m[E]r, $m[S]^{S}_{r}$, $m[F]^{S}_{r}$, s[P]r, s[S]r, s[D]r, s[F]r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	15	20	12		1	48	9
Weight (Kg)	.01	.25	.39		.18	.80	.15

SIZE RANGE OF MAX. DIAM.: 5-85 mm

PRIMARY MORPHOLOGY: Larger nodules flattened discoids or elongate spheroids, whereas many medium and small nodules are faceted due to fracturing.

SECONDARY MORPHOLOGY: Well-developed equatorial, botryoidal rim on many of the larger nodules.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: 0

SURFACE TEXTURE:

Upper Surface: Smooth on large discoidal and medium discoidal, spheroidal, and faceted nodules; rough on others

Lower Surface: Rough, gritty on all nodules

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<--------	----------	-------->		
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<--------	------->			

ABSOLUTE DIAM. OF MAMMILLAE: $\leq$ 1 mm for granules; 3-10 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes on bottom of equatorial rim,

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: CNEXO-FFGs

LAT. N.: 14°56.0' - 15°02.2' N

LONG. W.: 125°04.0' - 125°04.2' W

WATER DEPTH: 4455 - 4590 m

STATION: 13B

SAMPLE NO.: FFG-009, -010, -011, -012

DATE: 22-23 Sept 74

TIME: LAUNCH: 2152, 2208, 2225, 2239Z 22 Sept 74

ON BOTTOM _____

RECOVER 0108, 0125, 0146, 0203 Z 23 Sept 74

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Abyssal hills ranging from 25-m to 140-m relief.

SPECIFIC BATHYMETRIC LOCATION:

FFG-009: Broad valley between sharp-peaked 140-m hill and broad, multiple-peaked 85-m hill.

FFG-010: Lower flank of 10-m peak of multiple-peaked 85-m hill.

FFG-011: Lower flank of broad-peaked 80-m hill.

FFG-012: Top of broad-peaked 80-m hill.

ASSOCIATED SEDIMENT --

Sample No: FFG-012

Type: Red clay (adhering to some nodules)

NODULE TYPES AT THIS STATION:

FFG-009: (2)m[E-D]$^{S}_{r}$, (1)m[E]$^{S}_{r}$, (1)m[S]s, (2)s[E]s, (1)s[S]$^{S}_{r}$, (2)s[P]s, (4)s[D]$^{S}_{r}$, (1)l[F]$^{S}_{r}$, (27)m[F]$^{S}_{r}$, (10)s[f]$^{S}_{r}$

FFG-010: (1)m[E]r, (1)s[F]r

FFG-011: (1)l[E-D]$^{S}_{r}$, (1)l[S]$^{S}_{r}$, (1)l[E-D]$^{S}_{r}$, (2)m[D]$^{S}_{r}$, (6)m[E]$^{S}_{r}$, (3)m[S]$^{S}_{r}$, (1)s[P]$^{S}_{r}$, (1)s[E]$^{S}_{r}$, (40)m[F]$^{S}_{r}$, (12)s[F]$^{S}_{r}$

FFG-012: (1)m[e]$^{S}_{r}$, (3)s[E]$^{S}_{r}$, (4)s[S-D]$^{S}_{r}$, (65)m[F]$^{S}_{r}$, (25)s[F]$^{S}_{r}$

STATION: 13B SAMPLE NO.: FFG-009

NODULE TYPES: $m[E\text{-}D]^{s}_{r}$, $m[E]^{s}_{r}$, m[S]s, s[E]s, $s[S]^{s}_{r}$, s[P]s, $s[D]^{s}_{r}$, $1[F]^{s}_{r}$, $m[F]^{s}_{r}$, $s[F]^{s}_{r}$

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	4	28	17	2		51	21
Weight (Kg)	.01	.34	.46	.20		1.0	.2

SIZE RANGE OF MAX. DIAM.: 15-65 mm

PRIMARY MORPHOLOGY: Variable. Most larger nodules are spheroidal to ellipsoidal and discoidal. Most smaller ones faceted due to fracturing.

SECONDARY MORPHOLOGY: Deviations from ideal spheroids, ellipsoids, and discoids are a result of faceting. Septarian cracks are common, especially on larger nodules. Coarse equatorial rim on many. Some agglutinated, angular particles, generally on top surface.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Two 2-poly

SURFACE TEXTURE:

Upper Surface: Smooth on all nodules

Lower Surface: Smooth on medium-sized spheroidal, small elongate and small polylobate nodules. Rough to gritty on rest.

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<--------	----------	-------->		
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<----------	------>			

ABSOLUTE DIAM. OF MAMMILLAE: ≤ 1 mm for granules; 3-5 mm for botryoids.

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes conspicuous by their absence.

STATION: 13B SAMPLE NO.: FFG-010

NODULE TYPES: m[E]r, s[F]r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules		2				2	
Weight (Kg)		.05				.05	

SIZE RANGE OF MAX. DIAM.: 25-35 mm

PRIMARY MORPHOLOGY: One medium-size ellipsoidal nodule and one small faceted nodule (35 mm and 25 mm max. diameter, respectively).

SECONDARY MORPHOLOGY:

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: 0

SURFACE TEXTURE:

Upper Surface: Finely gritty

Lower Surface: Finely gritty

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<----------	---->			
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<----------	---->			

ABSOLUTE DIAM. OF MAMMILLAE: 1 mm

COLOR OF NODULE STREAK: Dark brown

COMMENTS:

STATION: 13B SAMPLE NO.: FFG-011

NODULE TYPES: $1[E\text{-}D]^{S}_{r}$, $1[S]^{S}_{r}$, $1[E\text{-}D]^{S}_{r}$, $m[D]^{S}_{r}$, $m[E]^{S}_{r}$, $m[S]^{S}_{r}$, $s[P]^{S}_{r}$, $s[E]^{S}_{r}$, $m[F]^{S}_{r}$, $s[F]^{S}_{r}$

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	5	28	32	2	1	68	44
Weight (Kg)	.01	.38	1.39	.22	.18	2.18	.22

SIZE RANGE OF MAX. DIAM.: 10-85 mm

PRIMARY MORPHOLOGY: Variable. Most larger nodules spheroidal, ellipsoidal-discoidal; medium-size ones are discoidal, spheroidal, or ellipsoidal; smaller ones are faceted, ellipsoidal or polylobate.

SECONDARY MORPHOLOGY: Faceting common on many nodules of all sizes. Larger nodules have equatorial rims of slight development. Most faceted types appear to have been either discoidal or ellipsoidal. Some nodules have well-developed botryoids.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: One 2-poly

SURFACE TEXTURE:

Upper Surface: Smooth on all nodules

Lower Surface: Rough on all nodules

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<----------	---------->			
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<----------	---------->			

ABSOLUTE DIAM. OF MAMMILLAE: ≤1 mm for granules; 3-10 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: NO foram tubes noticed on any surface. Partially healed cracks common on some larger nodules.

STATION: 13B SAMPLE NO.: FFG-012

NODULE TYPES: $m[E]^{s}_{r}$, $s[E]^{s}_{r}$, $s[S\text{-}D]^{s}_{r}$, $m[F]^{s}_{r}$, $s[F]^{s}_{r}$, $m[P]^{s}_{r}$

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	16	75	7			98	12
Weight (Kg)	.05	.88	.32			1.25	.15

SIZE RANGE OF MAX. DIAM.: 10-55 mm

PRIMARY MORPHOLOGY: Medium-size nodules are generally ellipsoidal or faceted; smaller nodules are variable, ranging from ellipsoidal to spheroidal-discoidal and faceted. One medium-size 2-polylobate nodule.

SECONDARY MORPHOLOGY: Generally smooth on top surfaces with gritty rims on some. Most faceted types appear to have originally been discoidal prior to fracturing and subsequent healing. Septarian cracks on medium-size ellipsoidal nodule.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: One 2-poly

SURFACE TEXTURE:

Upper Surface: Smooth

Lower Surface: Finely gritty

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<----------	------>			
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<----------	----------	------>		

ABSOLUTE DIAM. OF MAMMILLAE: 1 mm for granules; 3-5 mm botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS:

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Dredge

LAT. N.: 15 03' N

LONG. W.: 125 05' W

WATER DEPTH: 4465 m

STATION: 13B

SAMPLE NO: D-002

DATE: 23 Sept 74

TIME: LAUNCH: 0240 Z

ON BOTTOM 0400Z

RECOVER 0750Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

South of Clarion Fracture Zone; rolling abyssal hills with occasional hill of up to 350 m relief.

SPECIFIC BATHYMETRIC LOCATION:

ASSOCIATED SEDIMENT --

Sample No:

Type: Red siliceous clay

NODULE TYPES AT THIS STATION: Wide variety

STATION: 13B SAMPLE NO.: D-001

NODULE TYPES: wide variety (see comments)

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	Wide variety of sizes (see comments)						
Weight (Kg)							

SIZE RANGE OF MAX. DIAM.: Wide range from less than 10 mm to over 100 mm

PRIMARY MORPHOLOGY: Wide range

SECONDARY MORPHOLOGY:

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Several of various number of coalespheroids.

SURFACE TEXTURE:

Upper Surface: Variable

Bottom Surface: Variable

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<--------	---------	----------	-------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<--------	---------	----------	-------->	

ABSOLUTE DIAM. OF MAMMILLAE: Wide range for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Nodules in photograph represent only a small portion of whole dredge. Samples chosen for photograph may have been biased. Immediate storage and great number of nodules prohibited detailed study of significant portion.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

STATION: 13B

COLLECTION DEVICE: Dredge

SAMPLE NO.: D-002

LAT. N.: 15°01.7' N

DATE: 23 Sept 74

LONG. W.: 125°04.8' W

TIME: LAUNCH: 0900 Z

WATER DEPTH: 4500 m

ON BOTTOM 1015 Z

RECOVER 1400 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

South of Clarion Fracture Zone; rolling abyssal hills with occasional sharp-peaked hills of up to 350-m relief.

SPECIFIC BATHYMETRIC LOCATION:

ASSOCIATED SEDIMENT --

Sample No:

Type: Red siliceous clay (adhering to dredge bucket)

NODULE TYPES AT THIS STATION: Wide variety

STATION: 13 B SAMPLE NO.: D-002

NODULE TYPES: Wide variety (see comments)

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules		Wide range in sizes (see comments)					
Weight (Kg)							

SIZE RANGE OF MAX. DIAM.: Wide range

PRIMARY MORPHOLOGY: Variable

SECONDARY MORPHOLOGY:

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Several of various numbers of coalespheroids.

SURFACE TEXTURE:

Upper Surface: Variable

Lower Surface: Variable

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<----------	----------	----------	---------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<----------	----------	----------	---------->	

ABSOLUTE DIAM. OF MAMMILLAE: Wide range for botryoids

COLOR OF NODULE STREAK: Brown

COMMENTS: Samples chosen for photograph represent only a very small portion of whole dredge; samples chosen may have been biased. Immediate storage and great number of nodules prohibited detailed study of significant portion of whole dredge.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Dredge

LAT. N.: 15°00.0' N

LONG. W.: 125°00.0' W

WATER DEPTH: 4515 m

STATION: 13B

SAMPLE NO.: D-004

DATE: 23-24 Sept 74

TIME: LAUNCH: 2020 Z 23 Sept 74

ON BOTTOM 2150 Z

RECOVER 0020 Z 24 Sept 74

BATHYMETRIC PROVINCE, GENERAL RELIEF:

South of Clarion Fracture Zone; rolling abyssal hills with occasional sharp-peaked hills of up to 350-m relief.

SPECIFIC BATHYMETRIC LOCATION:

ASSOCIATED SEDIMENT --

Sample No:

Type: Red siliceous clay

NODULE TYPES AT THIS STATION: Wide variety

STATION: 13B SAMPLE NO.: D-004

NODULE TYPES: Wide variety (see comments)

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules		Wide variety of sizes (see comments)					
Weight (Kg)							

SIZE RANGE OF MAX. DIAM.: Wide range

PRIMARY MORPHOLOGY: Variable

SECONDARY MORPHOLOGY:

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Several of various numbers of coalespheroids.

SURFACE TEXTURE:

Upper Surface: Variable

Lower Surface: Varible

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<--------	----------	----------	-------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<--------	----------	----------	-------->	

ABSOLUTE DIAM. OF MAMMILLAE: Wide range for botryoids

COLOR OF NODULE STREAK: Brown

COMMENTS: Samples chosen for photograph represent only small portion of whole dredge; sample may have been biased. Immediate storage and great number of nodules prohibited detailed study of complete dredge.

TABLE 1: STATION 13 A and B SAMPLING SUMMARY

SAMPLE	(N) LAT.	(W) LONG.	DEPTH	NODULES	TOTAL WEIGHT	RANGE OF MAX. DIAM.	ASSOCIATED SEDIMENT	TOPOGRAPHY
FFG001	16°07'	124°59'	4210	0	--	--	--	Crest of 240-m hill
FFG002	16°05'	124°58'	4390	23	.34 Kg	10-50 mm	red clay	Valley between hills
FFG003	16°03'	124°59'	4411	41	.28 Kg	10-80 mm	red clay	Lower flank of 85-m hill
FFG004	16°01'	124°59'	4430	16	.15 Kg	10-40 mm	red clay	Crest of 85-m hill
FFG005	15°04'	125°00'	4525	41	1.60 Kg	10-80 mm	red clay	Top flank of low, broad hill
FFG006	15°02'	125°00'	4500	2	.01 Kg	10-20 mm	red clay	Near top of low, broad hill
FFG007	14°59'	125°00'	4505	20	1.20 Kg	10-85 mm	red clay	Top flank of low, broad hill
FFG008	14°58'	125°00'	4480	57	.95 Kg	5-85 mm	red clay	Near top of low, broad hill
FFG009	14°56'	125°04'	4590	72	1.20 Kg	15-65 mm	red clay	Lower flank of broad hill
FFG010	14°58'	125°04'	4515	2	.05 Kg	25-35 mm	red clay	Top of broad hill
FFG011	15°00'	125°04'	4510	112	2.40 Kg	10-85 mm	red clay	Mid-flank of 80-m hill
FFG012	15°02'	125°04'	4455	110	1.40 Kg	10-55 mm	red clay	Top of 80-m hill
FFC001	14°57'	125°00'	4535	--	--	--	red clay	Lower flank of 80-m hill
Rosette 001	14°56'	125°02'	4530	--	--	--	red clay	Mid-flank of 60-m hill
BOX CORE 001	14°58'	125°00'	4495	--	--	--	red clay	Upper flank of 80-m hill
HARPOON 001	14°56'	125°00'	4495	--	--	--	red clay	Upper flank of 80-m hill
HARPOON 002	14°56'	125°01'	4555	--	--	--	red clay	Valley between 60-m hill and 80-m hill
DREDGE #1	15°03' 15°00	125°05' 125°08'	4465 (start) 4550 (end)		334.0 Kg	--	red clay	Low, rolling hills

TABLE 1: (continued)

SAMPLE	(N) LAT.	(W) LONG.	DEPTH	NODULES	TOTAL WEIGHT	RANGE OF MAX. DIAM.	ASSOCIATED SEDIMENT	TOPOGRAPHY
DREDGE #2	15°01' 14°55'	125°05' 125°06'	4500 (start) 4570 (end)		215.0Kg	--	red clay	Low, rolling hills
DREDGE #3	14°55' 14°54	125°06' 125°06'	4570 (start) 4500 (end)		empty	--	red clay	(Never hit bottom, excessive wire angle)
DREDGE #4	15°00' 14°57'	125°00' 125°00'	4495 (start) 4525 (end)		92.0Kg	--	red clay	Low, rolling hills

STATION SUMMARY

STATION: 14A

TIME ON STATION: 29/9/74 1820Z

LATITUDE: 4° 32' N

TIME DEPART STATION: 29/9/74 2300Z

LONGITUDE: 140° 05' W

SEDIMENT TYPE: Carbonate ooze

OPERATIONS: FFG #13, 14, 15, 16 29/9/74 1820Z - 2300Z

DISCUSSION:

The limited number and unequal spacing of the survey track grid resulted in relatively poor control for the bathymetry chart produced for this area. The general structural trend seems to be NE/SW, indicating a possible influence of the Clipperton fracture zone. Bathymetric relief is quite subdued (60-m maximum relief), suggesting a rather thick sedimentary section. A total of eight freefall grabs were launched in the area at 2-3 mile intervals, and all returned empty.

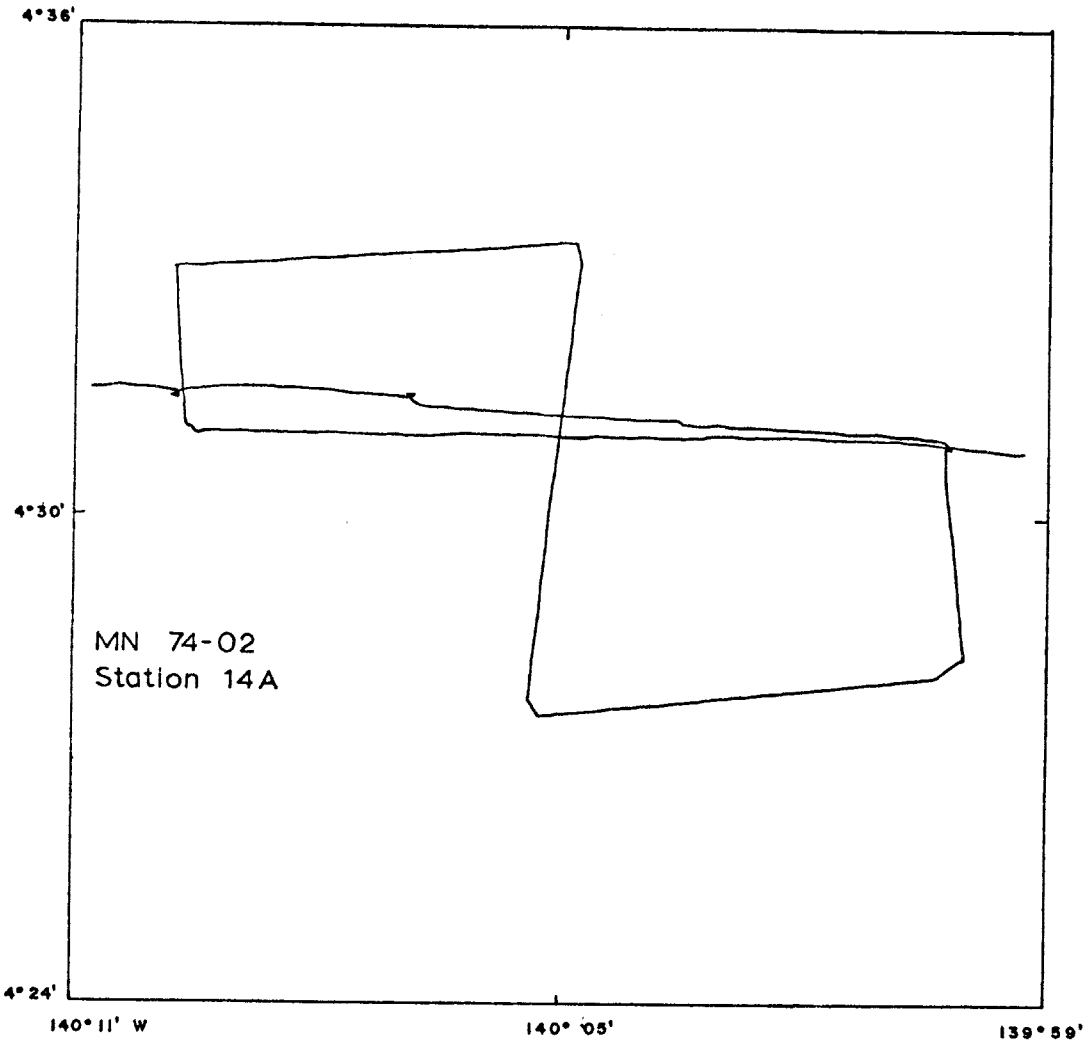

Fig. 3. Track chart, station 14A.

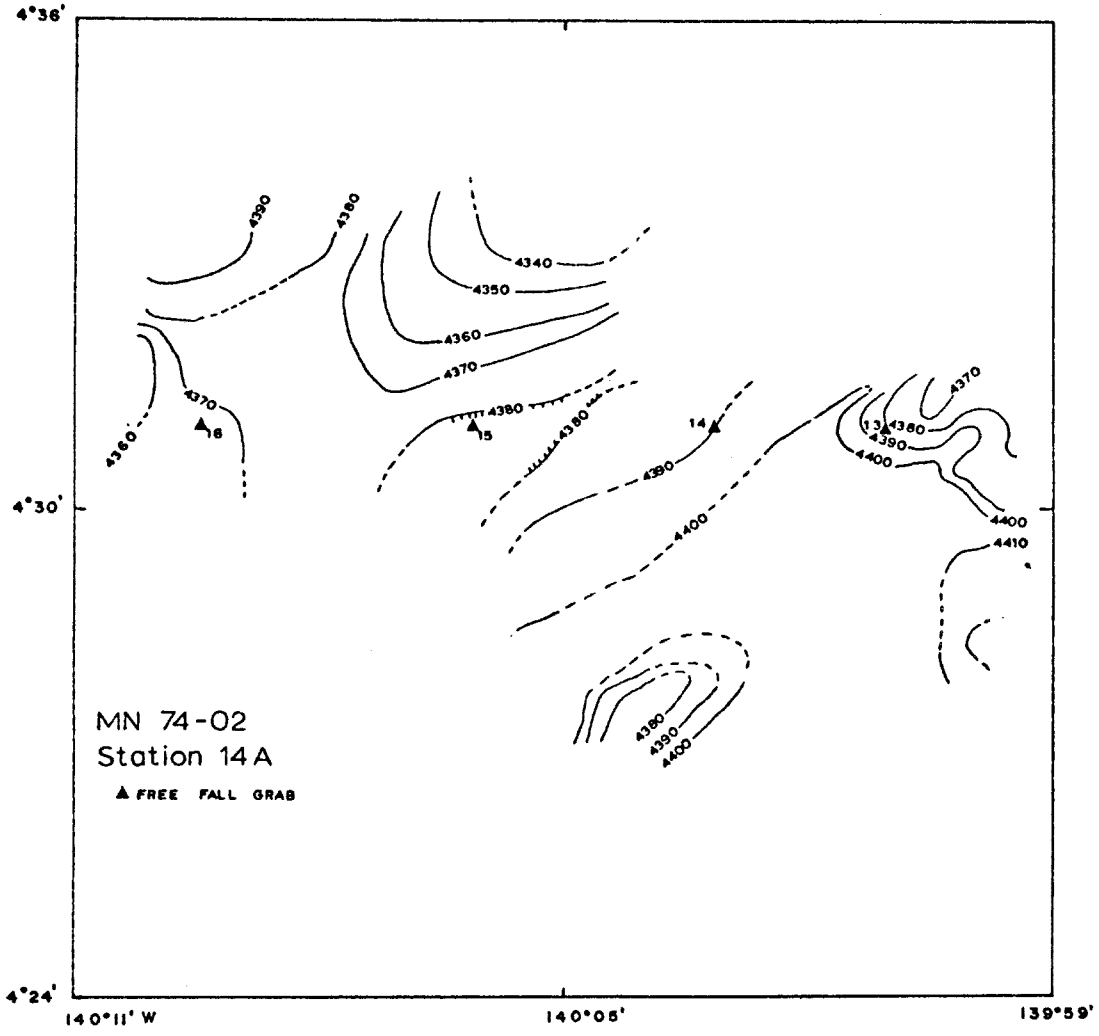

Fig. 4. Bathymetry, station 14A.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

STATION: 14A

COLLECTION DEVICE: CNEXO FFGs

SAMPLE NO.: FFG-013, -014, -015, -016

LAT. N.: 4°30.1' N

DATE: 29 Sept 74

LONG. W.: 140°00.1' - 140°10.1' W

TIME: LAUNCH: 1820, 1840, 1859, 1922 Z

WATER DEPTH: 4365 m - 4390 m

ON BOTTOM _____

RECOVER 2140, 2212, 2236, 2300 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Low, rolling abyssal hills with up to 75-m relief.

SPECIFIC BATHYMETRIC LOCATION:

FFG-013: Mid-flank of 25-m hill.

FFG-014: Flat terrace between 10-m hill and 10-m depression.

FFG-015: Upper flanks of 10-m depression.

FFG-016: Lower flank of abyssal hill of unknown relief.

ASSOCIATED SEDIMENT --

Sample No: None

Type: Unknown

NODULE TYPES AT THIS STATION:

FFG-013: Empty

FFG-014: Empty

FFG-015: Empty

FFG-016: Empty

STATION SUMMARY

STATION: 14B

LATITUDE: 4° 32' N

LONGITUDE: 140° 25' W

TIME ON STATION: 30/9/74 0005Z

TIME DEPART STATION: 30/9/74 1548Z

SEDIMENT TYPE:

OPERATIONS: FFG #17, 18, 19, 20 30/9/74 0005Z - 0449Z

FF core #2 30/9/74 0211Z - 0402Z

Hydro cast #3 30/9/74 0630Z - 0900Z

Box core #3 30/9/74 0918Z - 1130Z

Harpoon #4 30/9/74 1220Z - 1534Z

DISCUSSION:

See discussion, Station 14A.

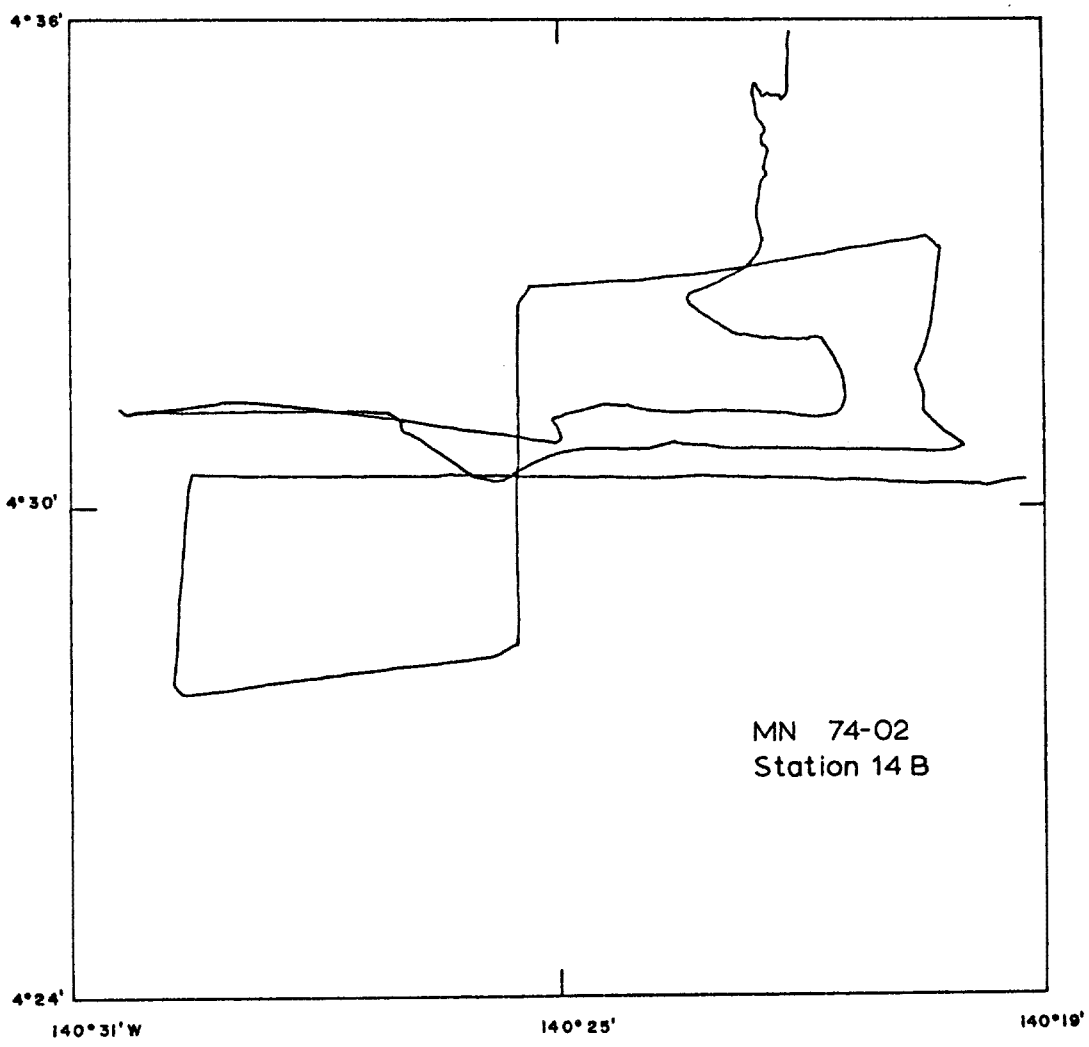

Fig. 5. Track chart, station 14B.

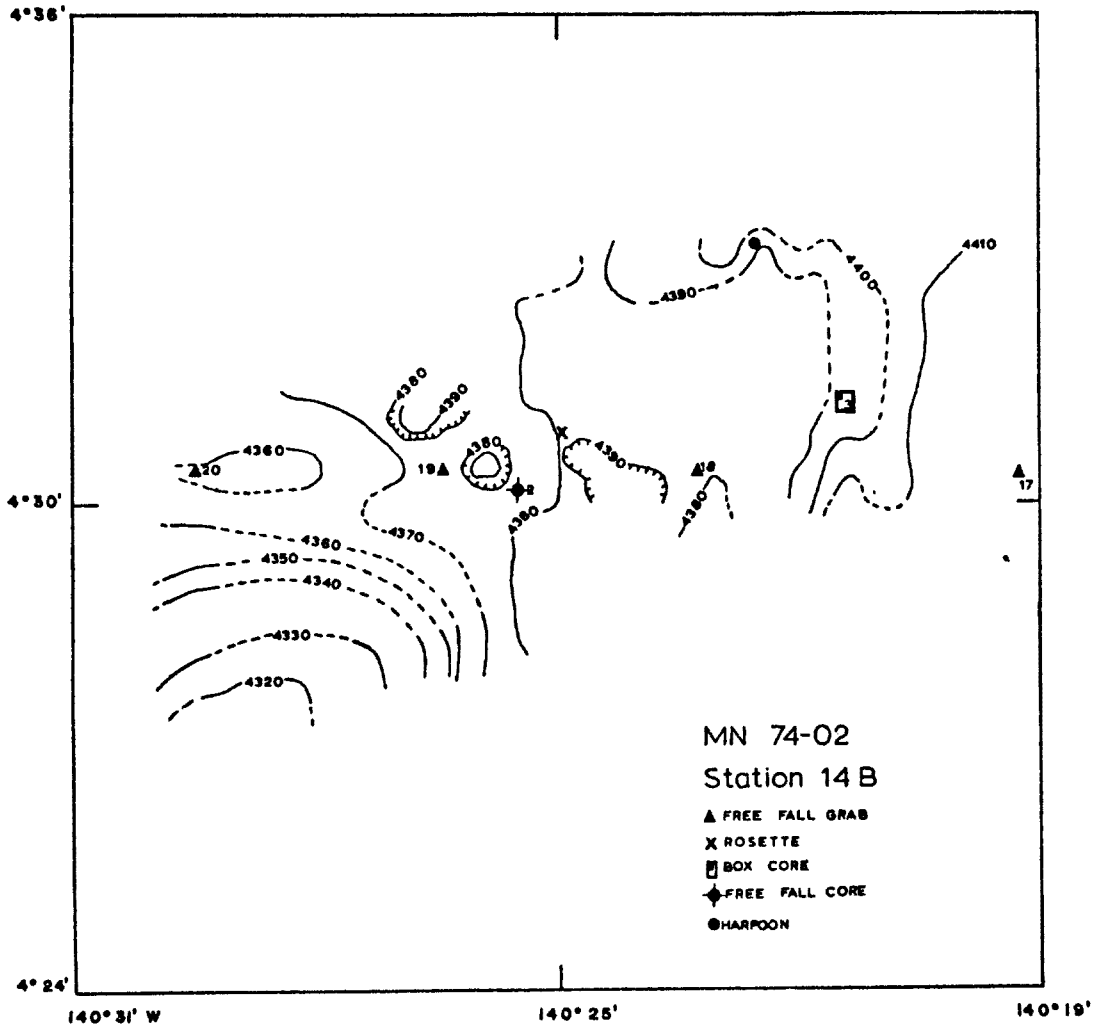

Fig. 6. Bathymetry, station 14B.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

STATION: 14B

COLLECTION DEVICE: CNEXO-FFGs

SAMPLE NO.: FFG-017, -018, -019, -020

LAT. N.: 4°30.1' - 4°30.3' N

DATE: 30 Sept 74

LONG. W.: 140°19.6' - 140°30.1'W

TIME: LAUNCH: 0005, 0030, 0052, 0113 Z

WATER DEPTH: 4355 m - 4415 m

ON BOTTOM _____

RECOVER 0317, 0347, 0418, 0449 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Low-relief abyssal hills with maximum relief of 50 m on plateau.

SPECIFIC BATHYMETRIC LOCATION:

FFG-017: Very flat area of general plateau.

FFG-018: Edge of plateau about 25 m above valley.

FFG-019: Plateau between 50-m hill and 20-m depression.

FFG-020: Top of 15-m peak on 50-m hill.

ASSOCIATED SEDIMENT --

Sample No: FFC-002: Foraminiferal bearing Nanno ooze

Type:

NODULE TYPES AT THIS STATION:

FFG-017: No nodules recovered

FFG-018: Empty

FFG-019: Empty

FFG-020: No nodules recovered

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Box core

LAT. N.: 4°32'

LONG. W.: 140°21'

WATER DEPTH: 4392 m

STATION: 14B

SAMPLE NO.: BC#3

DATE: 30 Sept 74

TIME: LAUNCH: 0918 Z

ON BOTTOM _____

RECOVER 1130 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Abyssal hills

SPECIFIC BATHYMETRIC LOCATION:

Gentle slope

ASSOCIATED SEDIMENT -- Calcareous ooze

Sample No:

Type:

NODULE TYPES AT THIS STATION:

None

TABLE 2: STATION 14A and B SAMPLING SUMMARY

SAMPLE	(N) LAT.	(W) LONG.	DEPTH	NODULES	TOTAL WEIGHT	RANGE OF MAX. DIAM.	ASSOCIATED SEDIMENT	TOPOGRAPHY
FFG013	4°30'	140°00'	4468	0	---	---	calcareous ooze	Mid-flank of 40-m hill
FFG014	4°30'	140°03'	4394	0	---	---	calcareous ooze	Wide valley
FFG015	4°30'	140°06'	4385	0	---	---	calcareous ooze	Depression on valley floor
FFG016	4°30'	140°10'	4365	0	---	---	calcareous ooze	Valley
FFG017	4°30'	140°20'	4415	0	---	---	calcareous ooze	Mid-flank of low hill
FFG018	4°30'	140°23'	4385	0	---	---	calcareous ooze	Valley
FFG019	4°30'	140°27'	4380	0	---	---	calcareous ooze	Valley
FFG020	4°30'	140°30'	4370	0	---	---	calcareous ooze	Top of low hill
Rossette #2	4°31'	140°25'	4385	-	---	---	calcareous ooze	Valley
BOX CORE #3	4°32'	140°21'	4392	-	---	---	calcareous ooze	Gentle slope
FFC002	4°30'	140°25'	4380	-	---	---	calcareous ooze	Valley
HARPOON #3	4°34'	140°22'	4395	-	---	---	calcareous ooze	Gentle slope

STATION SUMMARY

STATION: 15

LATITUDE: 9° N

LONGITUDE: 139° 50' W

TIME ON STATION: 1/10/74 1410Z

TIME DEPART STATION: 2/10/74 0222Z

SEDIMENT TYPE: Micro-nodule bearing radiolarian clay-silt.

OPERATIONS: FFG #021, 022, 023, 024 1/10/74 1410Z - 0203Z 2/10/74
Box core #4 2/10/74 0503Z - 0724Z
Hydrocast #3 2/10/74 0806Z - 1140Z
FFG #025 2/10/74 0830Z - 1218Z
Box core #5 2/10/74 1328Z - 1715Z
Harpoon #4 2/10/74 1750Z - 2115Z
Camera #1 2/10/74 2142Z - 0201Z 3/10/74
FFG #26 2/10/74 2149Z - 0203Z 3/10/74

DISCUSSION:

The unequal spacing of survey control tracks greatly inhibited the evaluation of bathymetry at this site. Often tracks crossing the same geographic position would reveal depths varying by 50 m or more, suggesting the 'averaging' problem created by wide beam echo sounding sytems (3.5 Khz). The resulting bathymetry chart, covering about 30 n. miles^2, displays this complexity, and consequently no bathymetric trends are evident. The area appears to be dominated by low, rounded abyssal hills and intervening valleys of 75-m maximum relief. Slopes are gentle, averaging 1-2°. Six free fall grabs were recovered containing a wide variety of nodules from all bathymetric settings. Highest nodule coverages (Kg) were recovered from hill tops and slopes.

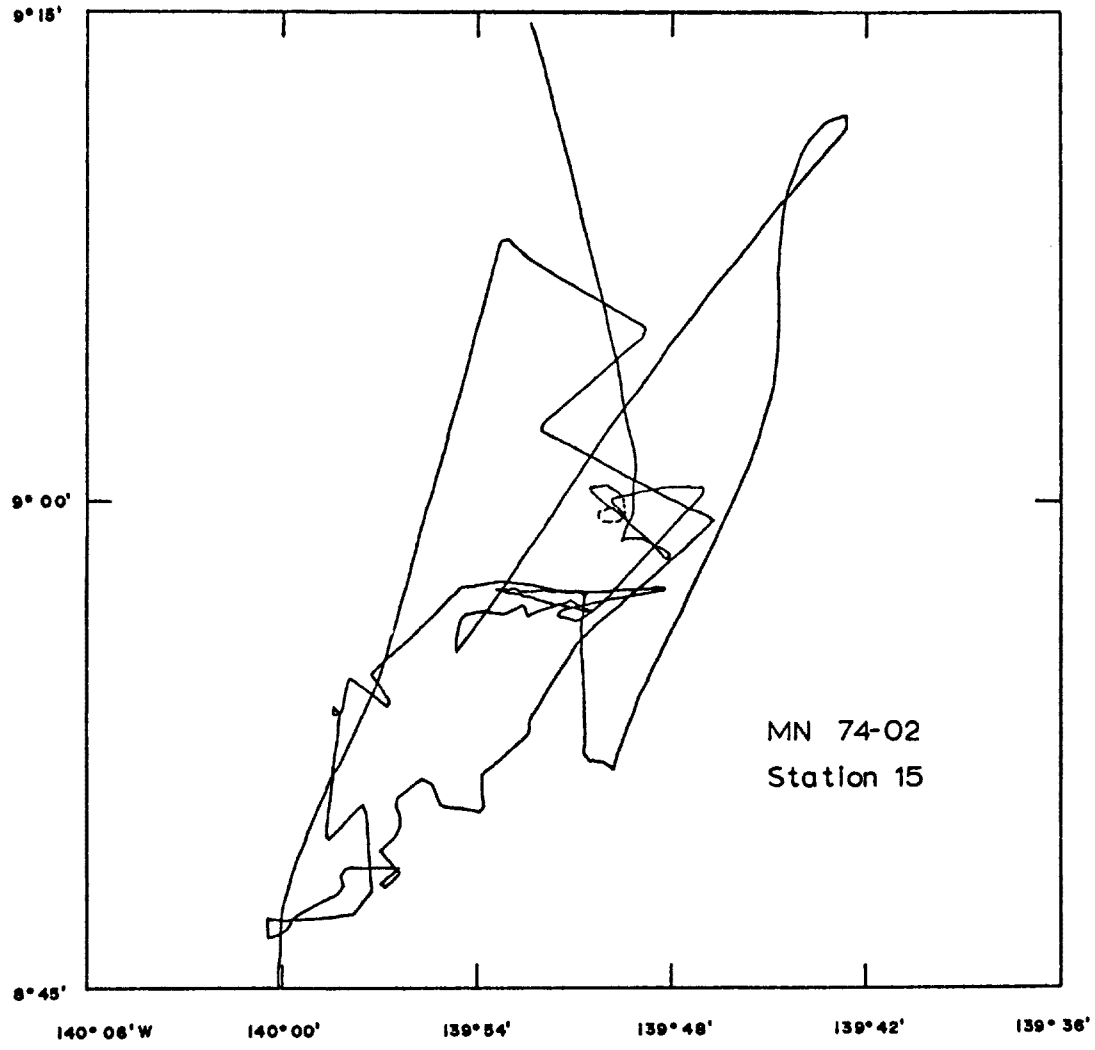

Fig. 7. Track chart, station 15.

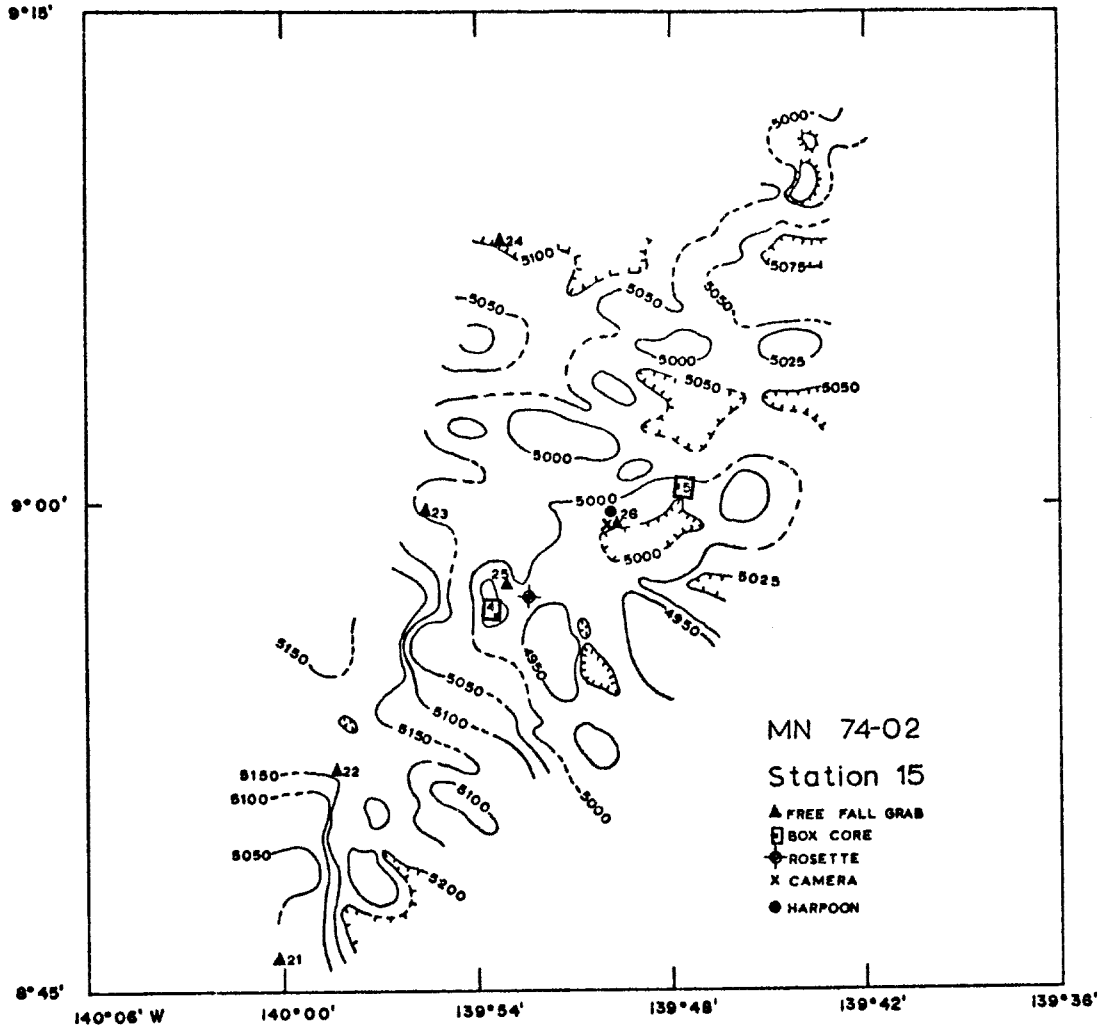

Fig. 8. Bathymetry, station 15.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Box core

LAT. N.: 8°56'

LONG. W.: 139°54'

WATER DEPTH: 4940 m

STATION: 15

SAMPLE NO.: BC#4

DATE: 2 Oct 74

TIME: LAUNCH: 0503 Z

ON BOTTOM _____

RECOVER 0724 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Abyssal hills

SPECIFIC BATHYMETRIC LOCATION:

Top of multipeaked hill

ASSOCIATED SEDIMENT -- Micronodule bearing radiolarian ooze

Sample No:

Type:

NODULE TYPES AT THIS STATION:

None recovered

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

STATION: 15

COLLECTION DEVICE: Box core

SAMPLE NO.: BC#5

LAT. N.: 9°00'

DATE: 2 Oct 74

LONG. W.: 139°48'

TIME: LAUNCH: 1328 Z

WATER DEPTH: 5010 m

ON BOTTOM _____

RECOVER 1715 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Abyssal hills

SPECIFIC BATHYMETRIC LOCATION:

Plateau on multipeaked hill

ASSOCIATED SEDIMENT -- Micronodule bearing radiolarian ooze

Sample No:

Type:

NODULE TYPES AT THIS STATION:

None recovered

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Camera

LAT. N.:

LONG. W.:

WATER DEPTH:

STATION: 15

SAMPLE NO.: Camera #1

DATE: 2 Oct 74 - 3 Oct 74

TIME: LAUNCH: 2142 Z

ON BOTTOM _____

RECOVER 0201 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Abyssal hills

SPECIFIC BATHYMETRIC LOCATION:

Plateau on multipeaked hill

ASSOCIATED SEDIMENT -- Siliceous ooze

Sample No:

Type:

NODULE TYPES AT THIS STATION:

None

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

STATION: 15

COLLECTION DEVICE: CNEXO-FFGs

SAMPLE NO.: FFG-021, -022, -023, -024, -025, -026

LAT. N.: 8°46.0' - 9°10.0' N

DATE: 1-3 Oct 74

LONG. W.: 139°50.6' - 140°00.02' W

TIME: LAUNCH: 1410, 1444, 1530, 1613

WATER DEPTH: 4975 m - 5175 m

ON BOTTOM 0830, 2149 Z

RECOVER 2356, 2314, 0121, 0210, 1218, 0203

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Abyssal hills and depressions with 250-m maximum relief.

SPECIFIC BATHYMETRIC LOCATION:

FFG-021: Near top of 100-m hill.

FFG-022: Lower flank of 100-m hill.

FFG-023: Edge of plateau.

FFG-024: Lower flank of 100-m hill.

FFG-025: Lower flank of 50-m hill.

FFG-026: Plateau, near edge of depression

ASSOCIATED SEDIMENT --

Sample No: FFG-021, -023, -024, -025, -026

Type: Micro-nodule bearing radiolarian clay.

NODULE TYPES AT THIS STATION:

FFG-021: (1)1[B]$^{b}_{r}$, (3)1[E-S]$^{b}_{r}$, (1)1[F]b, (1)m[F]$^{b}_{r}$, (2)m[S-D]$^{b}_{r}$, (1)m[E]$^{b}_{r}$, (1)m[T]$^{b}_{r}$, (3)s[S]s, (2)s[D]$_{r}$, (2)s[P]$_{r}$, (2)s[S]$^{b}_{r}$, (1)s[B]b

FFG-022: (1)s[B]$_{r}$

FFG-023: (1)1[T-P]$_{r}$, (2)1[E]$_{r}$, (2)1[E-P]$_{r}$, (1)m[S-P]$_{r}$, (1)s[D]s, (3)s[E]s, (2)s[B]s, (12)s[P]s, (7)s[S]s

FFG-024: (1)1[E]$^{b}_{r}$, (1)1[D]$^{b}_{r}$

FFG-025: (1)1[E]$^{b}_{r}$ (1)1[T]$^{b}_{r}$ (3)m[D]$^{b}_{r}$, (2)m[P]$^{b}_{r}$, (8)s[S]$^{b}_{r}$ (2)s[P]$_{r}$

FFG-026: (4)1[S]$^{b}_{r}$, (1)m[S]$^{b}_{r}$, (1)m[E]$^{b}_{r}$, (3)s[S]r

STATION: 15 SAMPLE NO.: FFG-021

NODULE TYPES: 1[B]$^{s}_{b}$-r, 1[E-S]$^{s}_{b}$-r, 1[F]b, m[F]$^{s}_{b}$-r, m[S-D]$^{s}_{b}$-r, m[E]$^{s}_{b}$-r, m[T]$^{s}_{b}$-r, s[S]s, s[D]$^{s}_{r}$, s[P]$^{s}_{r}$, s[S]$^{s}_{b}$-r, s[B]b

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	5	5	5	2	3	20	
Weight (Kg)	.01	.05	.24	.18	.68	1.16	

SIZE RANGE OF MAX. DIAM.: 5-90 mm

PRIMARY MORPHOLOGY: Variable, ranging from ellipsoidal to spheroidal and faceted for larger nodules; even more variable for smaller nodules.

SECONDARY MORPHOLOGY: Most nodules have well-developed botryoids on all surfaces. Those of biological origin have shark's teeth nuclei.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Two 2-poly.

SURFACE TEXTURE:

Upper Surface: Botryoidal, smooth
Lower Surface: Botryoidal,-gritty
} Equatorial rim very gritty, botryoidal

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<------	----------	------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<--------	----------	----------	------->	

ABSOLUTE DIAM. OF MAMMILLAE: ≤1 mm for granules; 5-20 mm for botryoids

COLOR OF NODULE STREAK: Light brown

COMMENTS: Benthic foram tubes on bottom side and on equatorial rim, red clay adhering to many.

STATION: 15 SAMPLE NO.: FFG-022

NODULE TYPES:

NUMBER AND WEIGHT OF NODULES: $s[B]_r^s$

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	1					1	
Weight (Kg)	<.01					<.01	

SIZE RANGE OF MAX. DIAM.: 20 mm

PRIMARY MORPHOLOGY: Small nodule with shape resulting from shark's tooth nucleus.

SECONDARY MORPHOLOGY:

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Smooth

Lower Surface: Gritty

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<----------	---------->			
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<----------	---------->			

ABSOLUTE DIAM. OF MAMMILLAE: ≤ 1 mm

COLOR OF NODULE STREAK: Very light brown

COMMENTS: Calcified tube worm also found in grab sampler.

STATION: 15 SAMPLE NO.: FPG-023

NODULE TYPES: $1[T\text{-}P]^{S}_{r}$, $1[E]^{S}_{r}$, $1[E\text{-}P]^{S}_{r}$, $m[S\text{-}P]^{S}_{r}$, s[D]s, s[E]s, s[B]s, s[P]s, s[S]s

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	13	12	1	4	1	31	
Weight (Kg)	.04	.06	.07	.25	.08	.50	

SIZE RANGE OF MAX. DIAM.: 8-85 mm

PRIMARY MORPHOLOGY: Variable; larger ones elongate-poly-lobate, tabular-poly-lobate, or ellipsoidal; smaller ones discoidal, ellipsoidal, spheroidal, or poly-lobate. Two small shark's tooth nucleated nodules.

SECONDARY MORPHOLOGY: Many larger nodules have botryoidal rim.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Thirteen 2-poly, two 3-poly, one 5-poly

SURFACE TEXTURE:

Upper Surface: Smooth on all nodules

Lower Surface: Rough on all large and medium-sized nodules; smooth on all small nodules

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<----------	----------	----------	---------->
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<----------	----------	----------	---------->

ABSOLUTE DIAM. OF MAMMILLAE: 1 mm for granules; 5-25 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes common.

STATION: 15 SAMPLE NO.: FFG-024

NODULE TYPES: $1[E]^{b^S_r}$, $1\ [D]^{b^S_r}$

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules				1	1	2	
Weight (Kg)				.07	.1	.17	

SIZE RANGE OF MAX. DIAM.: 60-110 mm

PRIMARY MORPHOLOGY: One large ellipsoidal nodule with botryoidal surfaces; one large discoidal nodule with botryoidal surfaces.

SECONDARY MORPHOLOGY: Well-developed equatorial rim on both.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Botryoidal, smooth

Lower Surface: Botryoidal, rough

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
				<----------	---------->
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
				<----------	---------->

ABSOLUTE DIAM. OF MAMMILLAE: 5-20 mm for botryoids

COLOR OF NODULE STREAK: Brown

COMMENTS:

STATION: 15 SAMPLE NO.: FFG-025

NODULE TYPES: $1[E]^{b}_{r}$, $1[T]^{b}_{r}$, $m[D]^{b}_{r}$, $m[P]^{b}_{r}$, $s[S]^{s}_{r}$, $s[P]^{s}_{r}$

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	7	7	1	1	1	17	
Weight (Kg)	.02	.10	.04	.06	.08	.30	

SIZE RANGE OF MAX. DIAM.: 5-85 mm

PRIMARY MORPHOLOGY: Larger nodules ellipsoidal or tabular; medium-size nodules discoidal or poly-lobate; smaller nodules spheroidal or poly-lobate.

SECONDARY MORPHOLOGY: Well-developed botryoidal surfaces on medium and large nodules.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Four 2-poly

SURFACE TEXTURE:

Upper Surface: Botryoidal, smooth on large and medium nodules; smooth on smaller nodules

Lower Surface: Botryoidal, rough on large and medium nodules; rough on smaller nodules

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<------	------	------	------	------>
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<------	------	------	------	------>

ABSOLUTE DIAM. OF MAMMILLAE: ≤1 mm for granules; 5-15 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Some benthic foram tubes on lower surfaces.

STATION: 15 SAMPLE NO.: FFG-026

NODULE TYPES: $1[S]^{bs}_{r}$, $m[S]^{bs}_{r}$, $m[E]^{bs}_{r}$, $s[S]r$

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	3		2	2	2	9	
Weight (Kg)	.01		.15	.35	.72	1.22	

SIZE RANGE OF MAX. DIAM.: 9-90 mm

PRIMARY MORPHOLOGY: Large and small nodules are spheroidal; medium-size nodules are spheroidal or ellipsoidal.

SECONDARY MORPHOLOGY: Equatorial rim on some nodules.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Botryoidal, smooth on large and medium nodules; rough on small nodules

Lower Surface: Botryoidal, rough on large and medium nodules; rough on small nodules

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<------	----------	------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<------	------>		

ABSOLUTE DIAM. OF MAMMILLAE: $\leq$ 1 mm for granules; 5-15 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes common on equatorial rim and bottom surfaces, siliceous sponge.

TABLE 3: STATION 15 SAMPLING SUMMARY

SAMPLE	(N) LAT.	(W) LONG.	DEPTH	NODULES	TOTAL WEIGHT	RANGE OF MAX. DIAM.	ASSOCIATED SEDIMENT	TOPOGRAPHY
FFG021	8°47'	140°00'	5085	20	1.16 Kg	5-90 mm	micronodule bearing rad. ooze	Top flank of 150-m hill
FFG022	8°53'	139°58'	5170	1	.01 Kg	10 mm	micronodule bearing rad. ooze	Valley floor
FFG023	9°00'	139°55'	5040	31	.50 Kg	8-85 mm	micronodule bearing rad. ooze	Top of hill
FFG024	9°09'	139°53'	5105	2	.17 Kg	65-90 mm	micronodule bearing rad. ooze	Top edge of valley floor depression
FFG025	8°55'	139°55'	4975	17	.30 Kg	5-85 mm	micronodule bearing rad. ooze	Plateau on multipeaked hill
FFG026	8°59'	139°50'	5031	10	1.22 Kg	9-90 mm	micronodule bearing rad. ooze	Plateau on multipeaked hill
BOX CORE #4	8°56'	139°54'	4940	--	--	--	micronodule bearing rad. ooze	Top of multipeaked hill
BOX CORE #5	9°00'	139°48'	5010	--	--	--	micronodule bearing rad. ooze	Plateau on multipeaked hill
Rosette #3	8°55'	139°52'	4975	--	--	--	micronodule bearing rad. ooze	Plateau on multipeaked hill
HARPOON #4	9°00'	139°50'	5010	--	--	--	micronodule bearing rad. ooze	Plateau on multipeaked hill
CAMERA	8°59 '	139°50'	5005	--	--	--	micronodule bearing rad. ooze	Plateau on multipeaked hill

STATION SUMMARY

STATION: 16 TIME ON STATION: 3/10/74 1409Z

LATITUDE: 11° 05' N TIME DEPART STATION: 4/10/74 0930Z

LONGITUDE: 140° W

SEDIMENT TYPE: Micronodule bearing siliceous silt-clay.

OPERATIONS:
FFG #27, 28, 29, 30 3/10/74 1409Z - 2224Z
Box core #6 3/10/74 2336Z - 0218Z 4/10/74
Plankton tow #1 4/10/74 0303Z - 0322Z
FFG #31, 32, 33, 34 4/10/74 0001Z - 1129Z
Box core #7 4/10/74 0412Z - 0647Z
Harpoon #5 4/10/74 0724Z - 1011Z
Box core #8 4/10/74 1258Z - 1446Z
Harpoon #6 4/10/74 1522Z - 1823Z
Hydrocast #4 4/10/74 2147Z - 0136Z 5/10/74
Plankton tow #2 5/10/74 0204Z - 0251Z
FFG #35, 36, 37 4/10/74 2338Z - 0308Z 5/10/74
Camera-002 5/10/74 0357Z - 0820Z

DISCUSSION:

Survey control track spacing is slightly improved at this station. General bathymetric trend appears to be north-south. The bathymetric chart constructed for this area (about .80 n. miles^2) reveals a complex series of closed depressions which complicate the gently undulating east-facing flank of a prominent abyssal hill. Maximum relief in this area is 150 m. Eleven freefall grabs were launched at variable intervals of .25 to 2 µmiles and recovered nodules from most bathymetric settings. Highest nodule concentrations seemed to be from the top or upper flanks of small (25-50 m) hills. A variety of siliceous mud fragments and 'worm tubes' were collected from all settings, suggesting a widespread and uniform distribution.

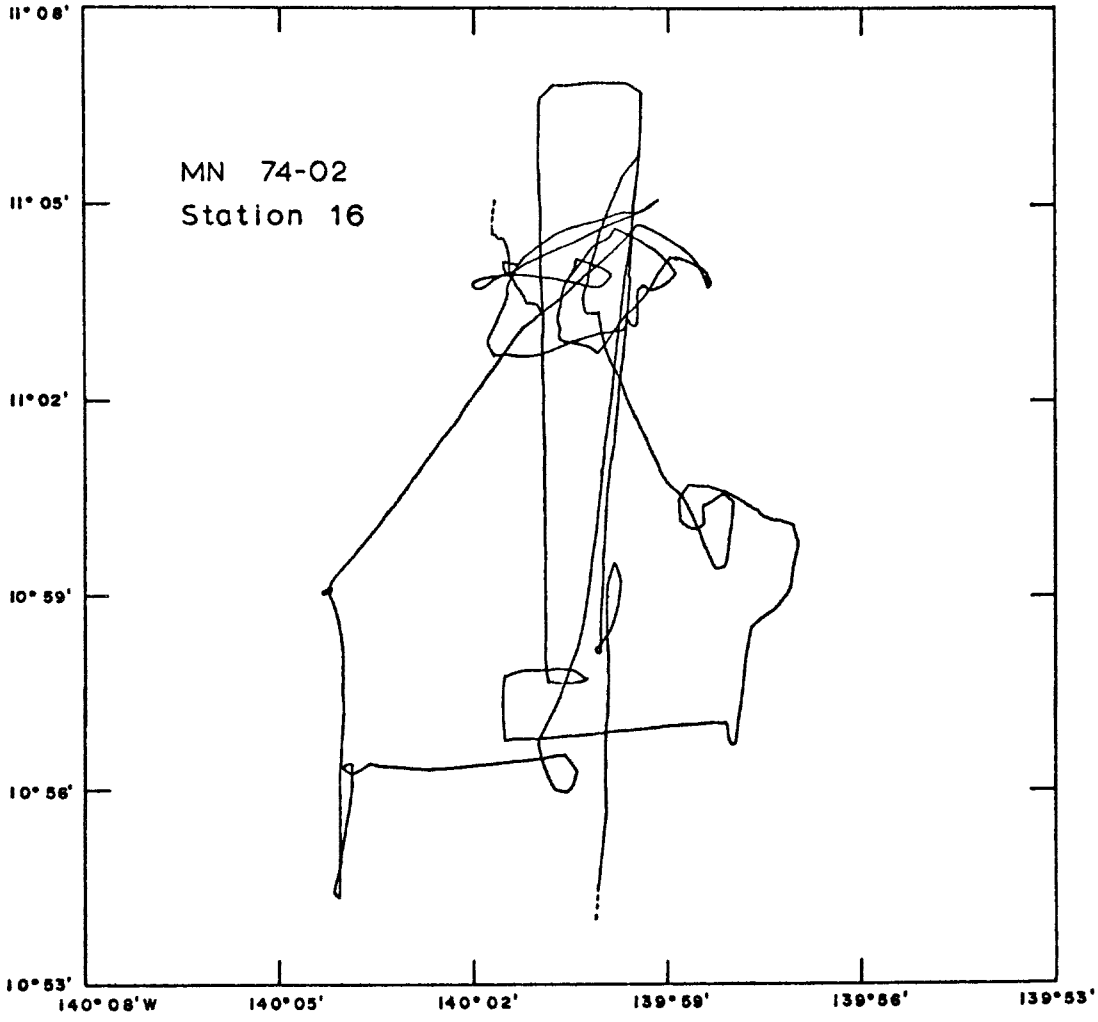

Fig. 9. Track chart, station 16.

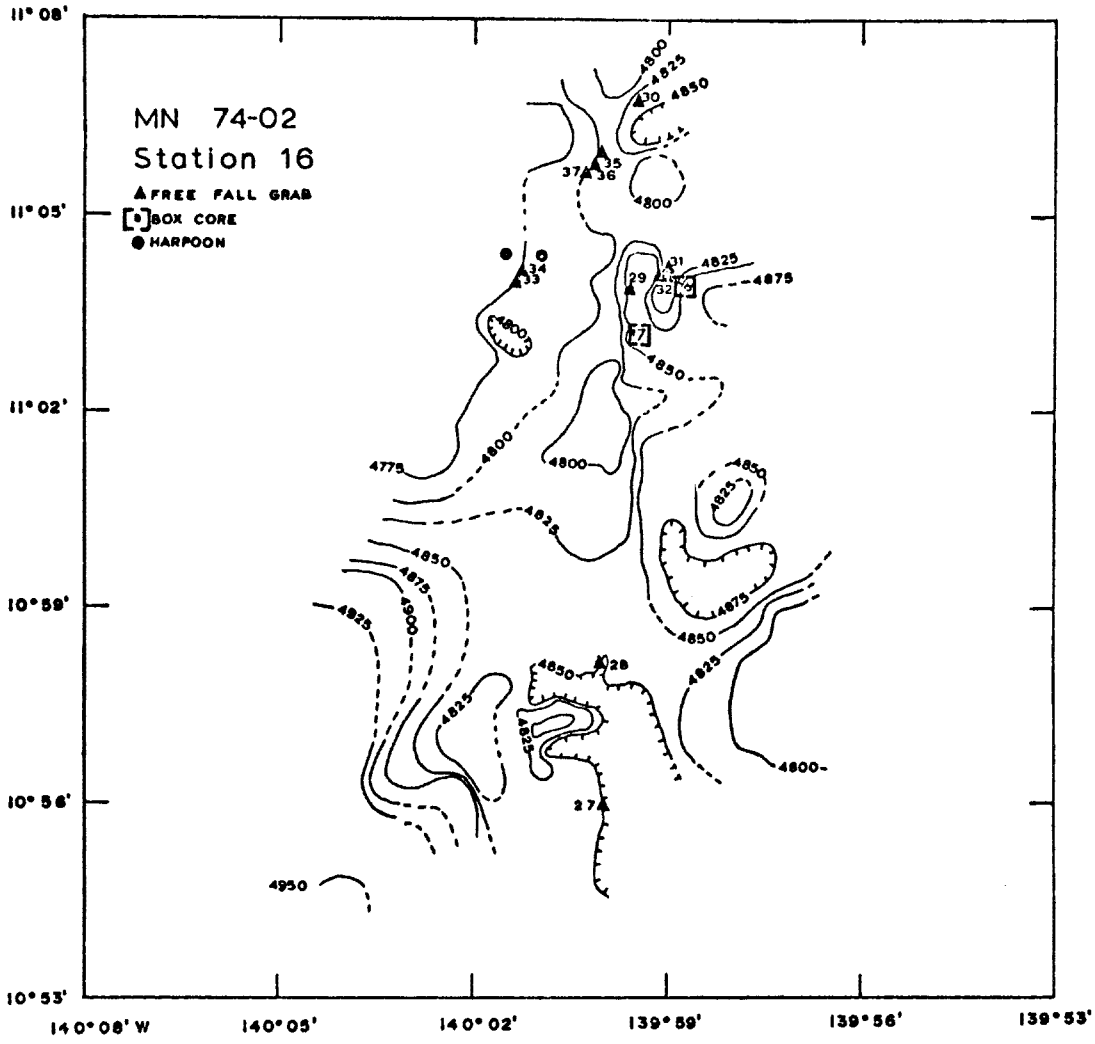

Fig. 10. Bathymetry, station 16.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: CNEXO-FFGs

LAT. N.: 10°56.0' - 11°06.7' N

LONG. W.: 139°59.5' - 140°00.0' W

WATER DEPTH: 4825 - 4850 m

STATION: 16

SAMPLE NO.: FFG-027, -028, -029, -030

DATE: 3 Oct 74

TIME: LAUNCH: 1409, 1454, 1533, 1600 Z

ON BOTTOM _____

RECOVER 2128, 2224, 1928, 1950 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Low rolling abyssal hills of 75-m maximum height, adjacent to steep hills of up to 350-m height.

SPECIFIC BATHYMETRIC LOCATION:

FFG-027: Flat plain off 125 m hill

FFG-028: Near edge of depression of unknown depth

FFG-029: Valley between two 50-m hills

FFG-030: Mid-flank terrace of 70-m hill

ASSOCIATED SEDIMENT --

Sample No: FFG-028, -029, -030

Type: Micro-nodule-bearing siliceous clay

NODULE TYPES AT THIS STATION:

FFG-027: (1)s[S]r

FFG-028: (1)l[E]b-r, (1)l[D]$^{bs}_{r}$, (1)m[E]b-r

FFG-029: (2)l[s]$^{bs}_{r}$, (1)m[P]b-r, (1)m[D] b-r, (1)m[E]b-r, (1)s[D]b-r, (2)s[E]b-r

FFG-030: (1)l[E]$^{bs}_{r}$, (3)m[S]b-r, (11)s[S]b-r, (3)s[P]b-r, (1)s[t]s

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: CNEXO-FFGs

LAT. N.: 11°03.0' - 11°04.5'N

LONG. W.: 139°59.0' - 140°01.6' W

WATER DEPTH: 4775 m - 4805 m

STATION: 16 (continued)

SAMPLE NO.: FFG-031, -032, -033, -034

DATE: 4 Oct 74

TIME: LAUNCH: 0001, 0005, 0721, 0724 Z

ON BOTTOM _____

RECOVER 0333, 0339, 1123, 1129 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Low rolling abyssal hills of about 100-m maximum relief.

SPECIFIC BATHYMETRIC LOCATION:

FFG-031: Mid-flank of 50-m hill

FFG-032: Mid-flank of 50-m hill

FFG-033: Flat plain

FFG-034: Flat plain

ASSOCIATED SEDIMENT --

Sample No: FFG-031, -032, -033, -034

Type: Micronodule-bearing red siliceous clay

NODULE TYPES AT THIS STATION:

FFG-031: (1)l[E]b-r, (2)m[D]b-r, (2)s[D]b-r

FFG-032: no nodules recovered

FFG-033: (1)l[T]b-r, (1)m[T]b-r, (1)s[T]b-r

FFG-034: (2)l[S]$^{b}_{r}$, (2)l[S]$^{b}_{r}$, (1)l[T]$^{b}_{r}$, (1)l[B]s, (1)m[F]$^{b}_{r}$, (7)s[S]r, (1)s[P]r, (2)s[T]s

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: CNEXO-FFGs

LAT. N.: 11°06.1' N

LONG. W.: 140°00.8' W

WATER DEPTH: 4800 m

STATION: 16 (continued)

SAMPLE NO.: FFG-035, -036, -037

DATE: 4-5 Oct 74

TIME: LAUNCH: 2338, 2341, 2343 Z

ON BOTTOM _____

RECOVER 0313, 0318, 0308 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Flat plain between low, rolling abyssal hills.

SPECIFIC BATHYMETRIC LOCATION:

FFG-035: Flat plain

FFG-036: Flat plain

FFG-037: Flat plain

ASSOCIATED SEDIMENT --

Sample No: FFG-035, -036, -037

Type: Micronodule-bearing red siliceous clay

NODULE TYPES AT THIS STATION:

FFG-035: (1)l[T]$^{bs}_{r}$, (1)m[T]b-s, (1)s[E]s

FFG-036: (2)s[S]b-r, (3)s[S]s, (1)s[P]s, (2)s[P]b-r

FFG-037: (1)m[F]$^{s}_{b}$-r, (1)m[T]$^{bs}_{r}$, (1)s[F]$^{s}_{r}$, (1)s[S]$^{s}_{r}$, (1)s[E]r

STATION: 16 SAMPLE NO.: FFG-027

NODULE TYPES: s[S]r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm.	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	1					1	
Weight (Kg)	.01					.01	

SIZE RANGE OF MAX. DIAM.: 8 mm

PRIMARY MORPHOLOGY: Spheroidal

SECONDARY MORPHOLOGY:

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Rough, gritty

Lower Surface: Rough, gritty

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<------	------>		
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<------	------>		

ABSOLUTE DIAM. OF MAMMILLAE: ≤ 1 mm for granules

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes.

STATION: 16 SAMPLE NO.: FFG-028

NODULE TYPES: 1[E]b-r, 1 $[D]^{bs}_{r}$, m [E]b-r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules			1	1	1	3	
Weight (Kg)			.06	.20	.25	.51	

SIZE RANGE OF MAX. DIAM.: 55-90 mm

PRIMARY MORPHOLOGY: Ellipsoidal to discoidal

SECONDARY MORPHOLOGY: Large botryoids on all surfaces; very well-developed equatorial rim with large botryoids.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Botryoidal, rough on ellipsoidal nodules; botryoidal, smooth on discoidal nodule

Lower Surface: Botryoidal, rough

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
			<----------	----------	---------->
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
			<----------	----------	---------->

ABSOLUTE DIAM. OF MAMMILLAE: 1-2 mm for granules; 5-20 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Benthic foram tubes common to all nodules.

STATION: 16 SAMPLE NO.: FFG-029

NODULE TYPES: 1[S]b^r_s, m[P]b-r, m[D]b-r, m[E]b-r, s[D]b-r, s[E]b-r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules		5	1		2	8	
Weight (Kg)		.09	.05		.83	.97	

SIZE RANGE OF MAX. DIAM.: 25-90 mm

PRIMARY MORPHOLOGY: Large nodules are spheroidal, medium-size nodules are poly-lobate, discoidal, or ellipsoidal; small ones are discoidal or ellipsoidal.

SECONDARY MORPHOLOGY: Well-developed botryoidal, equatorial rims common

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: One 4-poly

SURFACE TEXTURE:

Upper Surface: Botryoidal, rough

Lower Surface: Botryoidal, smooth on large spheroidal nodules; botryoidal, rough on others

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
			<------	----------	-------->
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
			<------	----------	-------->

ABSOLUTE DIAM. OF MAMMILLAE: ≤ 1 mm for granules; 5-25 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Well-developed mud lines marking sediment-water interface benthic foram tubes.

STATION: 16 SAMPLE NO.: FFG-030

NODULE TYPES: $1[E]b^{s}_{r}$, m[S]b-r, s[S]b-r, s[P]b-r, s[T]s

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	8	8	2		1	19	
Weight (Kg)	.02	.1	.12		.30	.45	

SIZE RANGE OF MAX. DIAM.: 5-90 mm

PRIMARY MORPHOLOGY: Large nodule is ellipsoidal; medium nodules are spheroidal; small nodules vary from spheroidal to tabular and poly-lobate.

SECONDARY MORPHOLOGY: Well-developed equatorial rim on many nodules

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: One 2 poly, two 3-poly

SURFACE TEXTURE:

Upper Surface: Botryoidal, smooth on large; smooth on tabular small nodule; botryoidal, rough on others

Lower Surface: Smooth on small, tabular nodule; botryoidal, rough on others

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<-----	----------	------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<-----	----------	------->	

ABSOLUTE DIAM. OF MAMMILLAE: $\leq$ 1 mm for granules; 5-15 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Well-developed mud lines; benthic foram tubes; siliceous sponges.

STATION: 16 SAMPLE NO.: FFG-031

NODULE TYPES: 1[E]b-r, m[D]b-r, s[D]b-r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules		2	2		1	5	
Weight (Kg)		.10	.20		.25	.55	

SIZE RANGE OF MAX. DIAM.: 25-100 mm

PRIMARY MORPHOLOGY: Large nodule is ellipsoidal; medium nodules are discoidal; small ones are discoidal.

SECONDARY MORPHOLOGY: Detailed study of sample not possible due to immediate retrieval from sampler and direct preservation/cold storage.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Botryoidal, rough

Lower Surface: Botryoidal, rough

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE

ABSOLUTE DIAM. OF MAMMILLAE:

COLOR OF NODULE STREAK:

COMMENTS: Detailed study of sample not possible due to immediate retrieval from sampler and direct preservation/cold storage.

STATION: 16 SAMPLE NO.: FFG-033

NODULE TYPES: l[T]b-r, m[T]b-r, s[T]b-r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules		1	1	1		3	
Weight (Kg)		.04	.12	.18		.34	

SIZE RANGE OF MAX. DIAM.: 25-75 mm

PRIMARY MORPHOLOGY: Tabular nodules of irregular shape

SECONDARY MORPHOLOGY: Edges rough, botryoidal

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Botryoidal, rough

Lower Surface: Botryoidal, rough

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<----------	----------	---------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<----------	----------	---------->	

ABSOLUTE DIAM. OF MAMMILLAE: $\leq$ 1 mm for granules; 5-12 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Six hardened clay balls of irregular shape (reddish, siliceous clay); nodules have mottled brown patches of hardened benthic foram tubes.

STATION: 16 SAMPLE NO.: PPG-034

NODULE TYPES: $1[S]^{b^r_s}$, $1[S]^{b^s_r}$, $1[T]^{b^s_r}$, 1[B]s, $m[F]^{b^s_r}$, s[S]r, s[P]r, s[T]s

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	7	4		4	2	17	
Weight (Kg)	.01	.04		.42	.55	1.02	

SIZE RANGE OF MAX. DIAM.: 5-85 mm

PRIMARY MORPHOLOGY: Larger nodules generally spherical, botryoidal; one large tubular ([B]) nodule and one large tabular;medium nodules are tabular; smaller ones range from spheroidal to tabular and poly-lobate.

SECONDARY MORPHOLOGY: Well-developed botryoidal surfaces on large and medium nodules. 1[B]s nodule is hollow tube, 70 mm long and 15 mm diameter.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: One 2-poly

SURFACE TEXTURE:

Upper Surface: Variable

Lower Surface: Variable

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<------	----------	------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<------	----------	------->	

ABSOLUTE DIAM. OF MAMMILLAE: 3-25 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Bottom determined by presence of clay (bottom of nodule) on nodules with rough top surfaces and smooth bottom surfaces. Benthic foram tubes.

STATION: 16 SAMPLE NO.: FFG-035

NODULE TYPES: $l[T]b^{s}_{r}$, m[T]b-s, s[E]s

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	1	1			1	3	
Weight (Kg)	<.01	<.01			.15	∿.16	

SIZE RANGE OF MAX. DIAM.: 10-120 mm

PRIMARY MORPHOLOGY: Tabular and ellipsoidal

SECONDARY MORPHOLOGY: Tabular nodules very irregular

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Botryoidal, smooth for large tabular and medium tabular; smooth for small ellipsoidal

Lower Surface: Botryoidal, rough for large tabular; botryoidal, smooth for medium tabular; smooth for small ellipsoidal

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		<------	----------	------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		<------	----------	----------	---------->

ABSOLUTE DIAM. OF MAMMILLAE: 1 mm for granules; 3-25 mm for botryoids.

COLOR OF NODULE STREAK: Brown

COMMENTS: One small (10-mm) hardened clay ball (siliceous); benthic foram tubes; 'rusty' encrustations (appear to be hardened foram tubes).

STATION: 16 SAMPLE NO.: FFG-036

NODULE TYPES: s[S]b-r, s[S]s, s[P]s, s[P]b-r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules	4	4				8	
Weight (Kg)	<.01	.05				~.05	

SIZE RANGE OF MAX. DIAM.: 5-40 mm

PRIMARY MORPHOLOGY: Spheroidal and poly-lobate (2-poly)

SECONDARY MORPHOLOGY: Botryoidal rim on some nodules

NUMBER AND MULTIPLICITY OF COALESPHEROIDS: Three 2-poly

SURFACE TEXTURE:

Upper Surface: Botryoidal, rough on some, smooth on others

Lower Surface: Botryoidal, rough on some, smooth on others

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
	<----------	----------	----------	---------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
	<----------	----------	----------	---------->	

ABSOLUTE DIAM. OF MAMMILLAE:

COLOR OF NODULE STREAK: 1 mm for granules; 2-5 mm for botryoids

COMMENTS: One small (20-mm), flat clay ball (siliceous); benthic foram tubes.

STATION: 16 SAMPLE NO.: FFG-037

NODULE TYPES: $m[F]^{s}_{b}$-r, $m[T]^{bs}_{r}$, $s[S]^{s}_{r}$, s[E]r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE (mm)	20	20-40	40-60	60-80	80	TOTAL	FRAGS.
Number of nodules	2	1	2			5	
Weight (Kg)	.01	.01	.07			.09	

SIZE RANGE OF MAX. DIAM.: 11-55 mm

PRIMARY MORPHOLOGY: Faceted, tabular, spheroidal, and ellipsoidal

SECONDARY MORPHOLOGY: Faceted nodules angular due to fracturing and incomplete healing.

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Smooth on medium, faceted, botryoidal, smooth on medium tabular; smooth on small faceted and spheroidal rough on small ellipsoidal

_____ Surface: Botryoidal; rough on medium tabular and faceted; rough on others

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
		←--------	--------→		
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
		←--------	--------→		

ABSOLUTE DIAM. OF MAMMILLAE: 1 mm for granules; 3-20 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Two rust-colored platy crusts of 35-mm and 40-mm max. diameter benthic foram tubes.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Bottom camera

LAT. N.: 11°04.6' N

LONG. W.: 140°02.0' W

WATER DEPTH: 4775 m

STATION: 16

SAMPLE NO.: C-002

DATE: 5 Oct 74

TIME: LAUNCH: 0357 Z

ON BOTTOM _____

RECOVER 0820 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Abyssal hills

SPECIFIC BATHYMETRIC LOCATION:

Drifting over broad 25-50-m hill

ASSOCIATED SEDIMENT --

Sample No:

Type: Tan siliceous ooze, adhering to camera frame

NODULE TYPES AT THIS STATION:

(1)1[D-E]$^{S}_{D}$-r

STATION: 16 SAMPLE NO.: C-002

NODULE TYPES: $1[D\text{-}E]^{S}_{b}\text{-}r$

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules					1	1	
Weight (Kg)					.15	.15	

SIZE RANGE OF MAX. DIAM.: 80 mm

PRIMARY MORPHOLOGY: Ellipsoidal-discoidal

SECONDARY MORPHOLOGY: Botryoidal bottom and rim

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Smooth

Lower Surface: Botryoidal, rough

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
			<---------	--------->	
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
			<------	-------->	

ABSOLUTE DIAM. OF MAMMILLAE: 1 mm for granules; 3-25 mm for botryoids

COLOR OF NODULE STREAK: Dark brown

COMMENTS: Found on strobe light housing of bottom camera.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Box core

LAT. N.: 11°04'

LONG. W.: 140°00'

WATER DEPTH: 4820 m

STATION: 16

SAMPLE NO.: BC#6

DATE: 3 Oct 74 - 4 Oct 74

TIME: LAUNCH: 2336 Z

ON BOTTOM _____

RECOVER 0218 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Gentle abyssal hills

SPECIFIC BATHYMETRIC LOCATION:

Flank of small hill

ASSOCIATED SEDIMENT -- Siliceous clay

Sample No:

Type:

NODULE TYPES AT THIS STATION:

None

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

COLLECTION DEVICE: Kennecott box corer

LAT. N.: 11°04.0' N

LONG. W.: 139°59.0' W

WATER DEPTH: 4812 m

STATION: 16

SAMPLE NO.: BC-007

DATE: 4 Oct 74

TIME: LAUNCH: _____

ON BOTTOM 1258 Z

RECOVER _____

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Low, rolling abyssal hills

SPECIFIC BATHYMETRIC LOCATION:

Mid-flank of 75-m hill

ASSOCIATED SEDIMENT --

Sample No: BC-008

Type: Siliceous clay

NODULE TYPES AT THIS STATION:

(1)m[D]b-r

STATION: 16 SAMPLE NO.: BC-007

NODULE TYPES: m[D]b-r

NUMBER AND WEIGHT OF NODULES:

TEMPLATE SIZE, mm	<20	20-40	40-60	60-80	>80	TOTAL	FRAGS.
Number of nodules			1			1	
Weight (Kg)			.1			.1	

SIZE RANGE OF MAX. DIAM.: 40 mm

PRIMARY MORPHOLOGY: Discoidal

SECONDARY MORPHOLOGY: Well-developed botryoidal, equatorial rim

NUMBER AND MULTIPLICITY OF COALESPHEROIDS:

SURFACE TEXTURE:

Upper Surface: Botryoidal, rough

Lower Surface: Botryoidal, rough

CHARACTER OF SURFACE MAMMILLAE:

RELIEF	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
			<------>		
RELATIVE SIZE	VERY FINE	FINE	MEDIUM	COARSE	VERY COARSE
			<------->		

ABSOLUTE DIAM. OF MAMMILLAE: 1 mm for granules; 3-10 mm for botryoids.

COLOR OF NODULE STREAK: Dark brown

COMMENTS: One large mud lump (110 X 90 X 40 mm, .45 Kg) - siliceous.

Mn-NODULE SAMPLE LOG

CRUISE: Mn-74-02

STATION: 16

COLLECTION DEVICE: Box core

SAMPLE NO.: BC#8

LAT. N.: 11°03'

DATE: 4 Oct 74

LONG. W.: 140°01'

TIME: LAUNCH: 0412 Z

WATER DEPTH: 4885 m

ON BOTTOM _____

RECOVER 0647 Z

BATHYMETRIC PROVINCE, GENERAL RELIEF:

Gentle abyssal hills

SPECIFIC BATHYMETRIC LOCATION:

Flank of small hill

ASSOCIATED SEDIMENT -- Siliceous clay

Sample No:

Type:

NODULE TYPES AT THIS STATION:

None

TABLE 4: STATION 16 SAMPLING SUMMARY

SAMPLE	(N) LAT.	(W) LONG.	DEPTH	NODULES	TOTAL WEIGHT	RANGE OF MAX. DIAM.	ASSOCIATED SEDIMENT	TOPOGRAPHY
FFG027	10°55'	140°00'	4850	1	.01 Kg	8 mm	micronodule bearing rad. ooze	Top edge of depression
FFG028	10°58'	140°00'	4835	3	.51 Kg	55-90 mm	micronodule bearing rad. ooze	Top edge of depression
FFG029	11°04'	140°00'	4855	8	.97 Kg	25-90 mm	micronodule bearing rad. ooze	Lower flank of 100-m hill
FFG030	11°07'	140°00'	4840	19	.45 Kg	5-90 mm	micronodule bearing rad. ooze	Lower flank of hill
FFG031	11°04'	139°59'	4805	5	.55 Kg	25-90 mm	micronodule bearing rad. ooze	Mid-flank of 75-m hill
FFG032	11°04'	139°59'	4805	0	---	---	micronodule bearing rad. ooze	Mid-flank of 75-m hill
FFG033	11°04'	140°01'	4780	2	.30 Kg	55-75 mm	micronodule bearing rad. ooze	Flank of hill
FFG034	11°04'	140°01'	4780	17	1.02 Kg	5-85 mm	micronodule bearing rad. ooze	Flank of hill
FFG035	11°06'	140°00'	4800	3	.16 Kg	10-120 mm	micronodule bearing rad. ooze	Flank of hill
FFG036	11°06'	140°00'	4800	8	.05 Kg	5-40 mm	micronodule bearing rad. ooze	Flank of hill
FFG037	11°06'	140°01'	4800	5	.09 Kg	11-55 mm	micronodule bearing rad. ooze	Flank of hill
CAMERA #2	11°05'	140°02'	4775	1	.15 Kg	75 mm	micronodule bearing rad. ooze	Flank of hill
BOX CORE #6	11°05'	140°00'	4800	---	---	---	micronodule bearing rad. ooze	Flank of hill
BOX CORE #7	11°04'	139°59'	4820	1	.1 Kg	50 mm	micronodule bearing rad. ooze	Mid-flank of 75-m hill
BOX CORE #8	11°04'	140°00'	4855	---	---	---	micronodule bearing rad. ooze	Mid-flank of 75-m hill
Harpoon #5	11°04'	140°01'	4780	---	---	---	micronodule bearing rad. ooze	Flank of hill
Harpoon #6	11°04'	140°02'	4770	---	---	---	micronodule bearing rad. ooze	Flank of hill

SECTION III

SECTION III

This section discusses shipboard and land-based analysis of pore waters and nodules, as well as water column chemistry. See Section III of the Mn-74-01 cruise report for nodule classification system, glossary of terms, and shipboard sampling of nodules and water samples.

Mn-74-02 XRF BULK CHEMICAL ANALYSES

Brent K. Dugolinsky

Bulk chemical analyses of over 50 similar-size (2-3 cm) nodules (minus nucleus) were obtained by X-ray fluorescence techniques. Results of the elemental compositions of the nodules were plotted graphically in order to determine any chemical trends between the major and minor elements present.

Sample Preparation and Technique

Whole nodules were partially embedded in plastic resin and cut in half. The embedded halves were set aside for future SEM-microprobe analyses. The remaining halves were crushed and sieved, after removing any foreign nuclear material present. The sieved powders were placed in SPEX caps and compressed under 10,000-lb pressure to form a compacted, flattened pellet. The pellets were stored in a dessicator until such time as they were to be analyzed by X-ray fluorescence.

Samples were analyzed at 19 KV and 16 microamps by an EDAX (Energy Dispersive Analysis of X-Rays) X-ray fluorescence spectrometer. The spectra generated were manipulated by an EDIT/7/XRF computer program. This program removes spectral background leaving net peaks with a statistical confidence limit of 95%, allows for the integration of counts for elemental peaks in the spectrum, and provides for the application of previously established linear calibration curves to those intensities to obtain concentration values. Calibration curves were based on South Pacific nodules which were analyzed by commercial laboratories.

Discussion

Results demonstrated a relatively consistent major and minor element composition over wide areas of the survey region (Table 5). Very little variation was noted (1) within any given free fall grab sample; (2) between different free fall grab samples at the same station; or (3) between stations. The apparent greater variation in values within a single grab sample as contrasted with the variation between different grab samples at the same station (Table 6) may be due to the difference in the respective number of samples analyzed (i.e., FFG-002 which is based on four samples versus station 13-A which is based on nine samples).

Chemical analyses of nodules collected from Cruise Mn-74-02 were similar to those nodules collected from the same general area of the Pacific during Cruise Mn-74-01 (Table 7).

It has often observed that Cu+Ni content increases as Mn/Fe increases over the entire range of nodule composition. This general correlation hold true for nodules analyzed from Mn-74-02 (Fig. 11). However, within the range of composition of the nodules analyzed, as the Mn/Fe increases, the Ni/Cu ratio decreased (Fig. 12). Less obvious was the trend of decreasing Ni/Cu with increasing Ni+Cu (Fig. 13), suggesting an increase of Cu relative to Ni as Mn/Fe increases. The question that presents itself is whether the Cu enrichment prevails due to higher percentages of Mn, or to lower values of Fe.

No significant increase of Ni with increasing Mn content was found (Fig. 14). On the other hand, slight general increase of Cu, especially at higher values of Mn, was apparent.

More significant was the relationship between Ni and Cu with Fe (Fig. 15). Again, Ni remains relatively constant over the whole range of Fe covered by the analyses. However, Cu demonstrates a more noticeable increase with decreasing Fe content.

It should be noted that these preliminary analyses include fewer than 60 samples and statistical measurements may not be strictly applicable to general inter-element patterns over wide areas of the nodule sampling sites. More analyses, especially on nodules of a wider range of sizes, will undoubtedly clarify patterns. However, the apparent chemical trends in the samples thus far analyzed suggest that the lack of Fe rather than the abundance of Mn may control the minor element enrichment, especially of Cu, in manganese nodules.

TABLE 5 : Mn-74-02 XRF BULK CHEMICAL ANALYSES (minus nucleus)

STATION	SAMPLE	MN	FE	NI	CU	TI	MN/FE	NI/CU	NI+CU
13-A	FFG-002	30.30	6.76	1.49	1.10	.29	4.48	1.35	2.59
		27.85	8.54	1.59	.76	.33	3.26	2.09	2.35
		27.42	7.96	1.75	.93	.34	3.44	1.88	2.68
		31.36	7.86	2.09	1.01	.30	3.99	2.07	3.10
	FFG-004	27.74	8.14	1.83	1.08	.34	3.41	1.69	2.91
		29.03	7.70	1.82	1.05	.26	3.77	1.73	2.87
		28.46	8.51	1.77	1.01	.31	3.34	1.75	2.78
		27.95	7.89	1.77	.97	.28	3.54	1.82	2.74
		27.27	8.73	1.79	1.04	.31	3.12	1.72	2.83
13-B	FFG-005	30.11	8.43	1.79	1.07	.32	3.57	1.67	2.86
		29.15	8.56	1.66	.97	.30	3.41	1.71	2.63
		28.25	8.59	1.70	.98	.31	3.29	1.73	2.68
		30.36	8.50	1.77	1.03	.34	3.57	1.72	2.80
	FFG-007	23.75	9.13	1.69	.91	.32	2.60	1.85	2.60
	FFG-008	28.99	7.70	1.66	1.14	.33	3.76	1.46	2.80
		29.68	7.99	1.58	1.09	.31	3.71	1.45	2.67
		29.38	7.65	1.65	1.11	.30	3.84	1.49	2.76
		29.87	8.16	1.71	1.10	.29	3.66	1.55	2.81
		32.56	6.77	1.68	1.18	.25	4.81	1.42	2.86
		29.89	7.50	1.65	1.15	.26	3.99	1.43	2.80
13-C	FFG-009	29.50	8.17	1.78	1.06	.38	3.61	1.68	2.84
		27.73	9.15	1.52	.80	.41	3.03	1.90	2.32
		27.99	8.58	1.56	.83	.33	3.26	1.88	2.39
		27.00	10.16	1.51	.83	.47	2.66	1.82	2.34
		27.82	9.16	1.59	.84	.38	3.04	1.89	2.43
		29.89	8.42	1.72	.96	.36	3.55	1.79	2.68
	FFG-011	30.04	8.48	1.68	1.11	.33	3.54	1.51	2.79
		27.66	8.15	1.52	.92	.30	3.39	1.65	2.44
		30.05	8.27	1.75	1.01	.32	3.63	1.73	2.76

TABLE 5: (continued)

STATION	SAMPLE	MN	FE	NI	CU	TI	MN/FE	NI/CU	NI+CU
		25.81	9.02	1.75	.92	.35	2.86	1.90	2.67
		24.09	9.34	1.35	.77	.54	2.58	1.75	2.12
13-C	FFG-012	30.49	6.98	1.98	1.34	.32	4.37	1.48	3.32
		28.34	8.92	1.72	.91	.39	3.18	1.89	2.63
		26.86	8.97	1.74	.97	.34	2.99	1.79	2.71
		27.85	8.84	1.78	1.02	.34	3.15	1.75	2.80
		26.72	8.82	1.59	.95	.37	3.02	1.67	2.54
		26.12	10.02	1.72	1.01	.38	2.61	1.70	2.73
		29.46	8.86	1.90	1.00	.35	3.33	1.90	2.90
15	FFG-021	30.06	6.65	1.72	1.28	.23	4.52	1.34	3.00
		31.94	6.37	1.64	1.19	.22	5.01	1.38	2.83
		27.47	8.51	1.59	1.14	.28	3.22	1.39	2.73
		32.02	7.26	1.73	1.17	.24	4.41	1.48	2.90
	FFG-023	25.49	7.66	1.55	.98	.28	3.33	1.58	2.53
		26.54	8.54	1.80	1.03	.31	3.11	1.75	2.83
		26.81	7.53	1.82	1.00	.33	3.56	1.82	2.82
		28.72	8.35	1.87	1.07	.38	3.44	1.75	2.94
	FFG-024	24.68	7.67	1.70	.87	.36	3.22	1.95	2.57
	FFG-026	32.47	5.94	1.85	1.20	.27	5.47	1.54	3.05
16	FFG-029	31.03	6.95	1.72	.93	.35	4.46	1.85	2.65
	FFG-030	30.49	6.98	1.98	1.34	.32	4.37	1.48	3.32
		31.65	5.41	1.79	1.26	.20	5.85	1.42	3.05
		29.63	6.21	1.70	1.14	.24	4.77	1.49	2.84
	FFG-036	26.25	6.75	1.75	1.21	.28	3.89	1.45	2.96
13-C	DREDGE-1	27.83	8.02	1.68	1.10	.34	3.47	1.53	2.78
		29.64	8.51	1.72	1.05	.27	3.48	1.64	2.77
		29.60	8.70	1.64	1.07	.30	3.40	1.53	2.71
	DREDGE-2	30.03	9.24	1.65	1.04	.39	3.25	1.59	2.69
	DREDGE-4	29.08	8.26	1.60	1.07	.33	3.52	1.50	2.67

TABLE 6 : Mn-74-02 XRF BULK CHEMICAL ANALYSES ARITHMETIC MEANS AND STANDARD DEVIATIONS

SAMPLE	MN	FE	NI	CU	MN/FE	NI+CU
FFG-002 (4)	29.23	7.78	1.73	.95	3.79	2.68
	1.90	.74	.26	.14	.55	.31
FFG-004 (5)	28.09	8.19	1.80	1.03	3.44	2.83
	.68	.43	.03	.04	.24	.07
STA. 13A (9)	28.60	8.01	1.77	.99	3.59	2.76
	1.40	.59	.17	.10	.42	.21
FFG-005 (4)	29.47	8.52	1.73	1.01	3.46	2.74
	.96	.07	.06	.05	.14	.11
FFG-008 (6)	30.06	7.63	1.66	1.13	3.96	2.78
	1.27	.48	.04	.03	.43	.06
STA. 13B (11)	29.27	8.09	1.69	1.07	3.66	2.75
	2.13	.65	.06	.08	.53	.09
FFG-009 (6)	28.32	8.94	1.61	.89	3.19	2.50
	1.12	.72	.11	.10	.36	.21
FFG-011 (5)	27.53	8.65	1.61	.95	3.20	2.56
	2.62	.51	.17	.13	.46	.28
FFG-012 (7)	27.98	8.77	1.78	1.03	3.24	2.80
	1.58	.90	.13	.14	.55	.25
DREDGE-1 (3)	29.02	8.41	1.68	1.07	3.45	2.75
	1.03	.35	.04	.03	.04	.04
ALL DREDGES (5)	29.24	8.55	1.66	1.07	3.42	2.72
	.86	.47	.04	.02	.11	.05
STA. 13-C (23)	27.97	8.80	1.68	.96	3.21	2.63
	1.72	.71	.15	.13	.44	.27
FFG-021 (4)	30.37	7.20	1.67	1.20	4.29	2.87
	2.14	.95	.07	.06	.76	.11
FFG-023 (4)	26.89	8.02	1.76	1.02	3.36	2.78
	1.35	.50	.14	.04	.19	.18

TABLE 6 : (continued)

SAMPLE	MN	FE	NI	CU	MN/FE	NI+CU
STA. 15 (10)	28.62	7.45	1.73	1.09	3.93	2.82
	2.86	.90	.11	.12	.85	.17
FFG-030 (3)	30.59	6.20	1.82	1.25	5.00	3.07
	1.01	.79	.14	.10	.77	.24
STA. 16 (5)	29.81	6.46	1.79	1.18	4.67	2.96
	2.12	.66	.11	.16	.73	.25
TOTAL (58)	28.69	8.08	1.71	1.04	3.62	2.74
	2.00	.97	.13	.13	.67	.22

(Numbers in parentheses represent number of nodules analyzed)

TABLE 7 : Mn-74-01 XRF BULK CHEMICAL ANALYSES

SAMPLE	MN	FE	NI	CU	TI
FFG-001	30.4	5.92	1.37	1.34	.46
FFG-002	31.1	5.97	1.28	1.31	.48
FFG-003	29.8	6.42	1.31	1.18	.55
FFG-004	25.8	5.64	1.60	1.40	.45
FFG-006	27.7	4.65	1.59	1.44	.35
FFG-007	28.9	6.75	1.42	1.12	.68
FFG-007	26.6	7.82	1.71	1.03	.39
FFG-009	29.4	6.52	1.53	1.11	.63
FFG-015	29.7	7.40	1.15	1.31	.41
FFG-015	27.1	8.97	1.30	.99	.31
FFG-016	32.0	3.65	1.89	1.52	.37
FFG-017	31.0	5.66	1.52	1.06	.57
FFG-017	23.5	6.68	1.79	.91	.27
FFG-018	30.4	4.02	1.91	1.60	.34
FFG-019	26.5	4.57	1.44	1.12	.44
FFG-020	30.7	5.04	1.78	1.43	.52
FFG-021	30.0	4.79	1.61	1.25	.47
FFG-022	26.3	5.53	1.71	1.23	.45
FFG-023	23.2	7.77	1.31	.74	.56
FFG-025	27.4	6.87	1.48	1.10	.65
FFG-025	28.1	8.07	2.27	1.17	.34
FFG-026	29.5	5.44	1.56	1.18	.54

TABLE 7 : (continued)

SAMPLE	MN	FE	NI	CU	TI
FFG-026	29.9	8.40	1.93	1.02	.39
FFG-028	29.2	4.53	1.51	1.34	.34
FFG-029	33.1	3.85	1.65	1.15	.41
FFG-032	32.1	3.31	1.74	1.25	.4
FFG-036	30.0	5.75	1.37	1.43	.40
FFG-036	26.9	8.89	1.47	1.09	.34
FFG-037	26.8	8.31	1.37	1.12	.67
FFG-038	23.8	10.35	1.11	.86	.77
FFG-038	22.5	11.15	1.07	.73	.49
FFG-039	27.0	8.15	1.32	1.13	.51
FFG-042	26.0	7.95	1.18	1.28	.54
FFG-043	25.8	9.31	1.28	1.11	.64

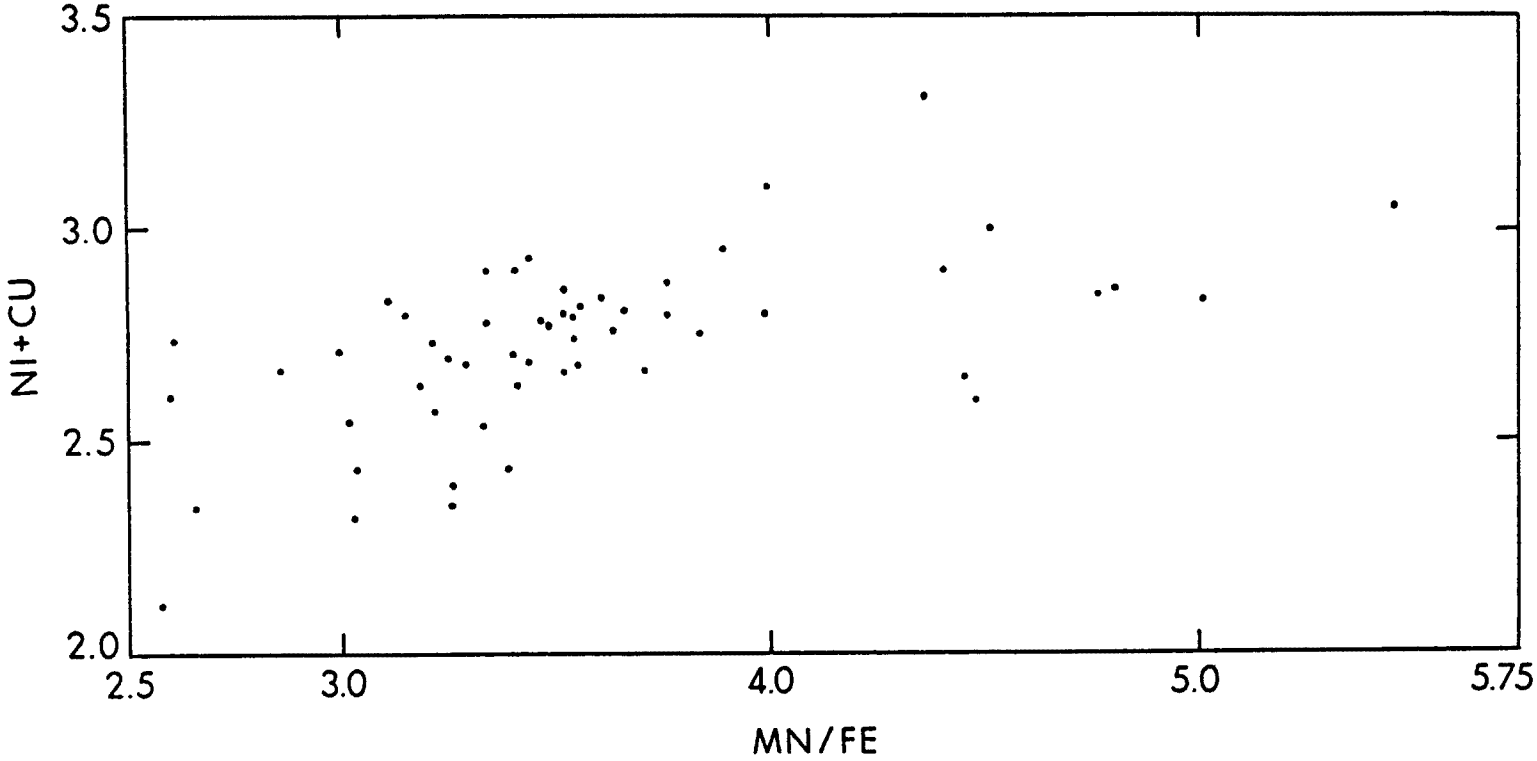

Fig. 11. Ni+Cu versus Mn/Fe; Mn-74-02 bulk analyses.

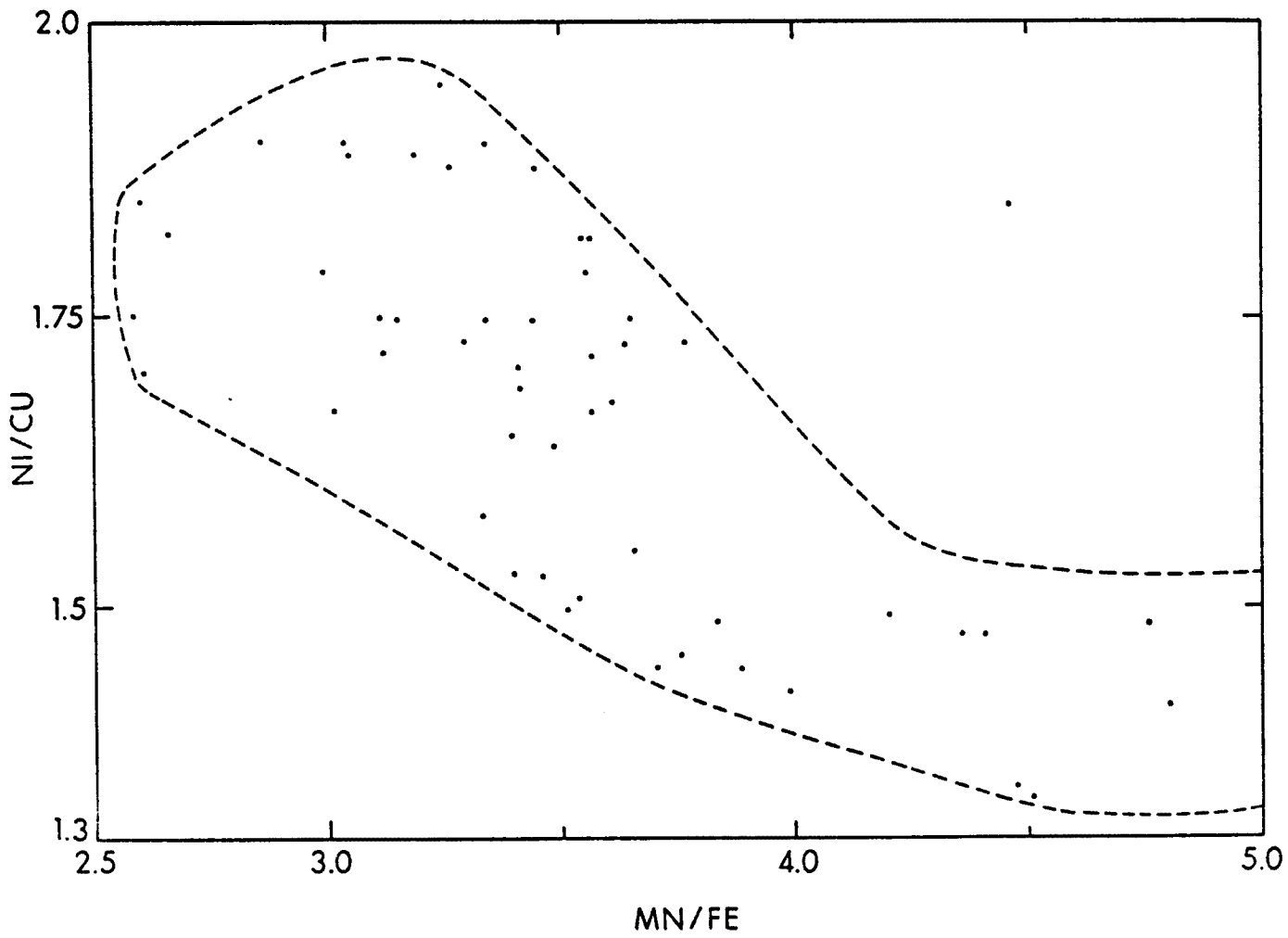

Fig. 12. Ni/Cu versus Mn/Fe; Mn-74-02 bulk analyses.

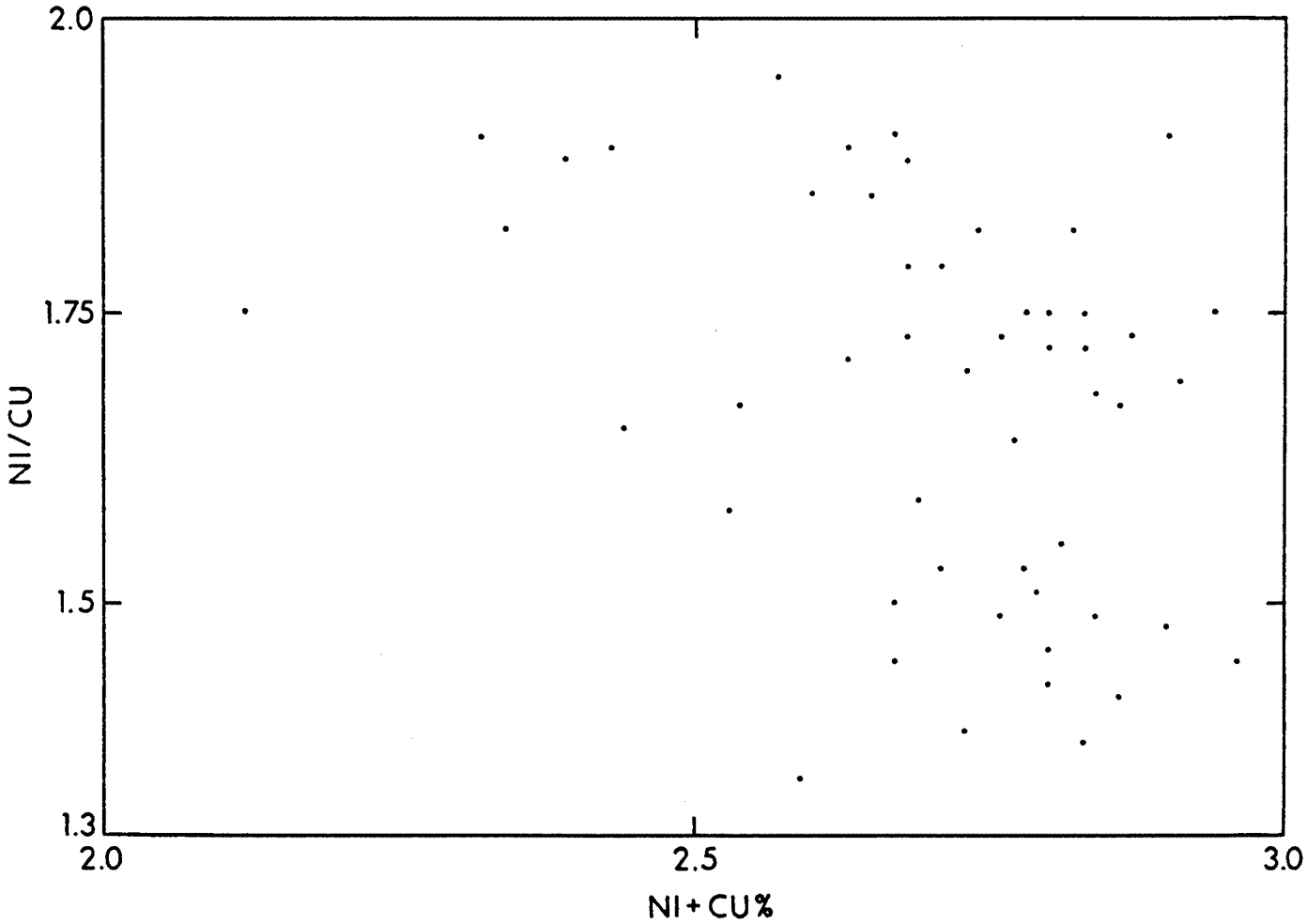

Fig. 13. Ni/Cu versus Ni+Cu; Mn-74-02 bulk analyses.

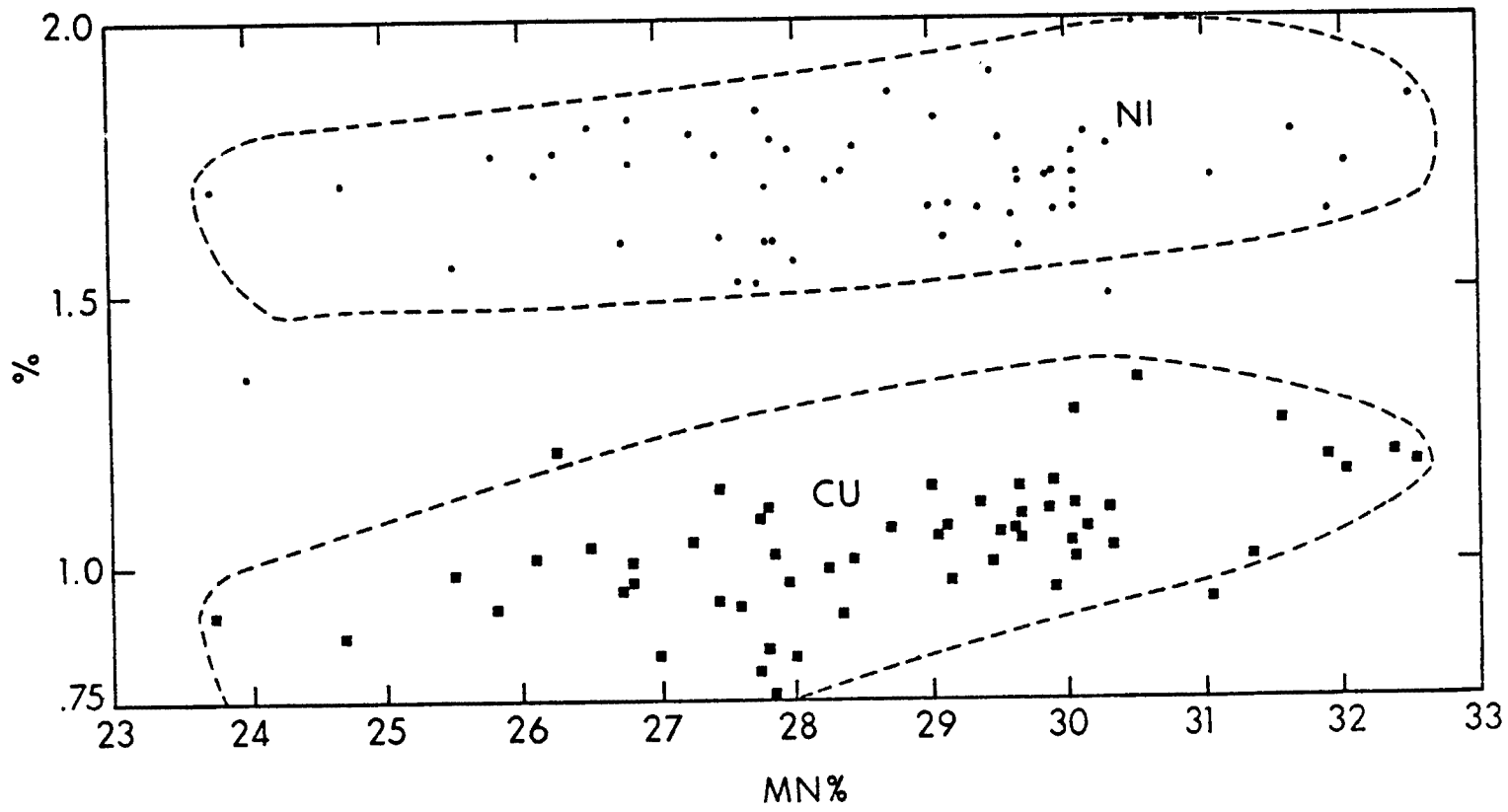

Fig. 14. Cu versus Mn; Ni versus Mn; Mn-74-02 bulk analyses.

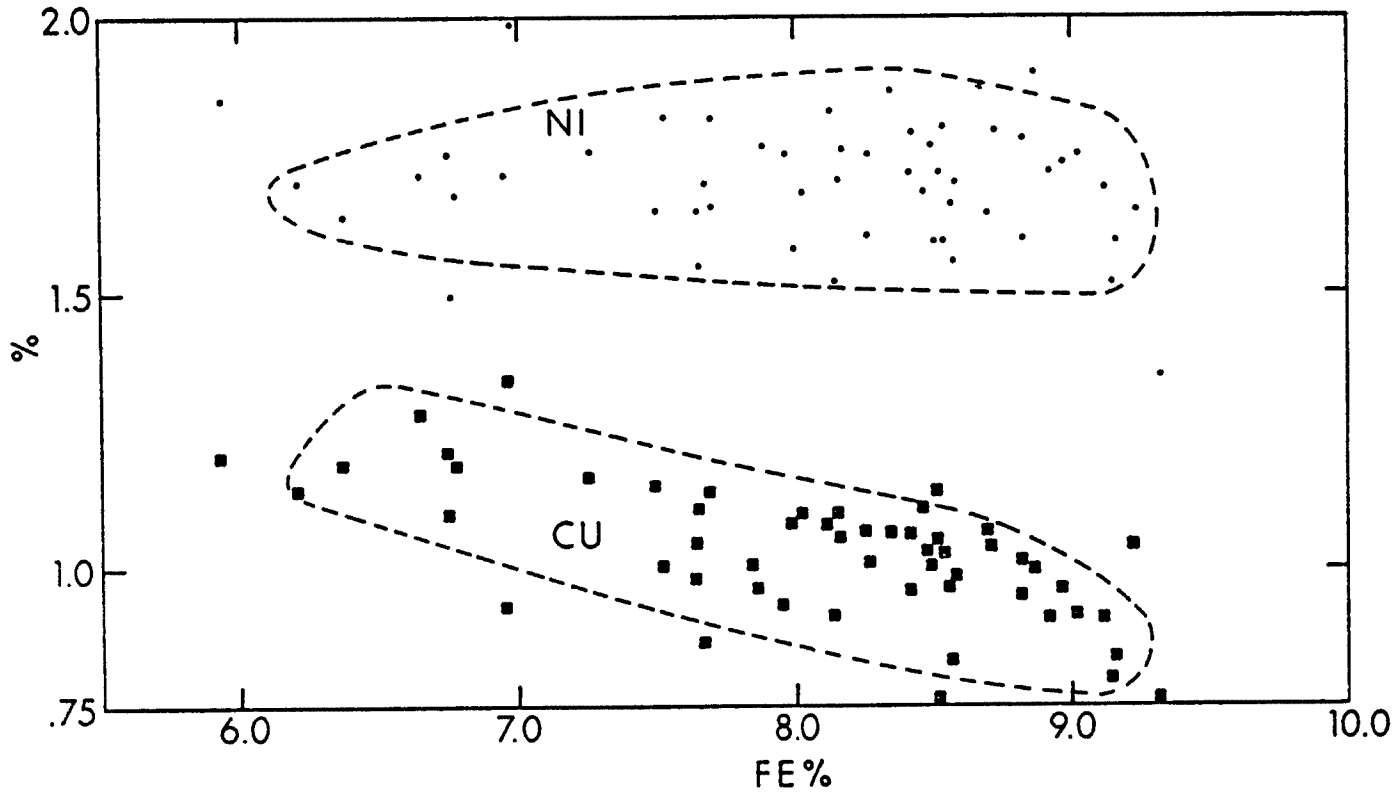

Fig. 15. Ni versus Fe; Cu versus Fe; Mn-74-02 bulk analyses.

SHIPBOARD PORE WATER ANALYSES

Carl J. Bowser

Pore fluids were extracted on shipboard from box core sub-cores. Sampling and analytical procedures were identical to those described in the cruise report from R/V Moana Wave Cruise Mn-74-01 (Hawaii Institute of Geophysics Report HIG-74-9). For details of procedures for sampling and analysis, reference should be made to the earlier report.

Box cores were used exclusively for sampling on this cruise, whereas free fall cores had to be used on the earlier cruise. Box cores adequate for interstitial water studies were obtained from four stations: 12-hemipelagic sediment; 13A-red clay; 14-carbonate ooze; and 16-siliceous ooze. Where box cores were sampled for pore fluid analyses, additional sub-cores were obtained for freezing in liquid nitrogen for mineralogic studies and biostratigraphic analysis.

Nodules were not present on the box core surface at stations 12 and 14. One nodule was collected from box cores at station 13A, and six nodules were collected from cores at station 16. Diagrams showing each box core and sampling areas are shown in Figs. 16 and 17.

Following the same procedure employed on the previous cruise, cores were generally sampled at 2-cm intervals for squeezing of pore fluids. The top 20-30 cm were used for the total studied interval. Pore fluid sample recoveries were generally similar to those obtained on Mn-74-01.

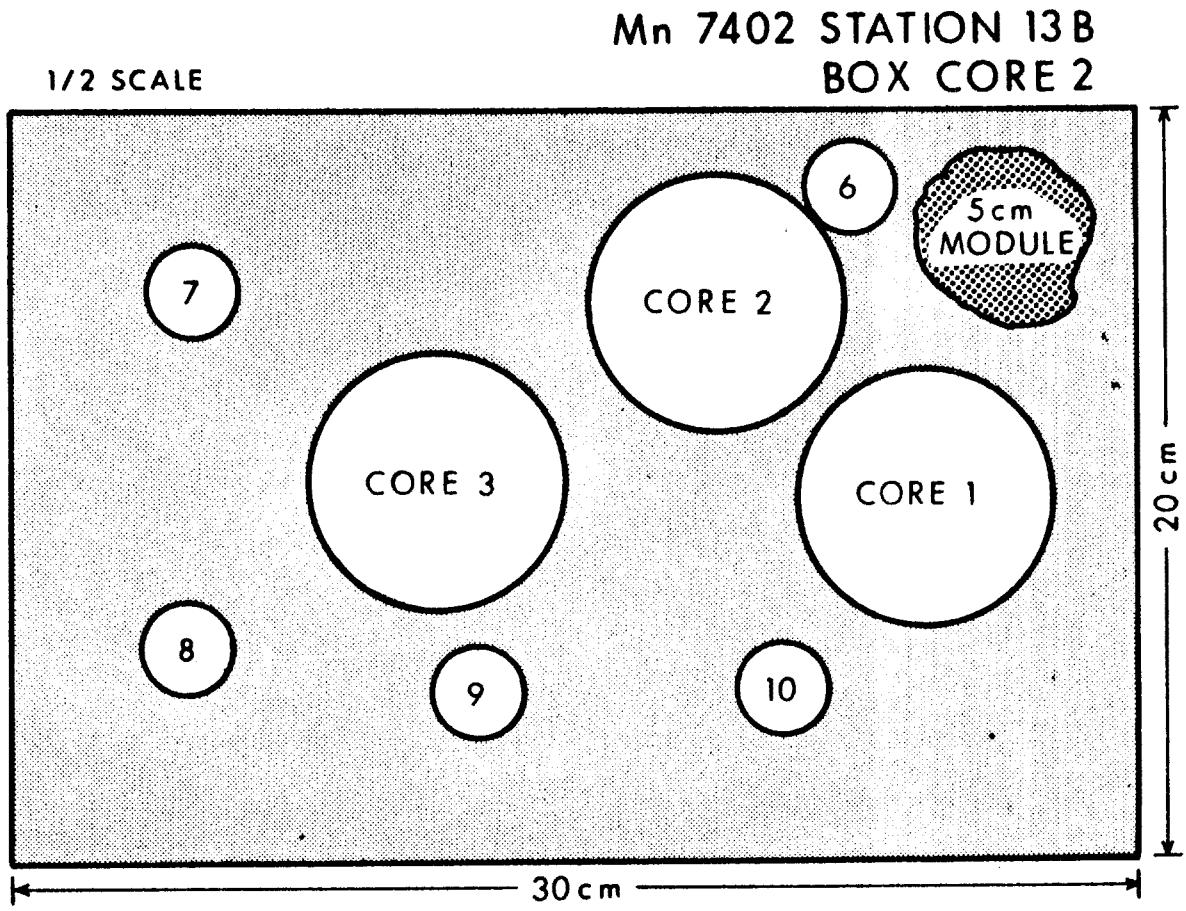

Fig. 16. Station 13B, box core 2.

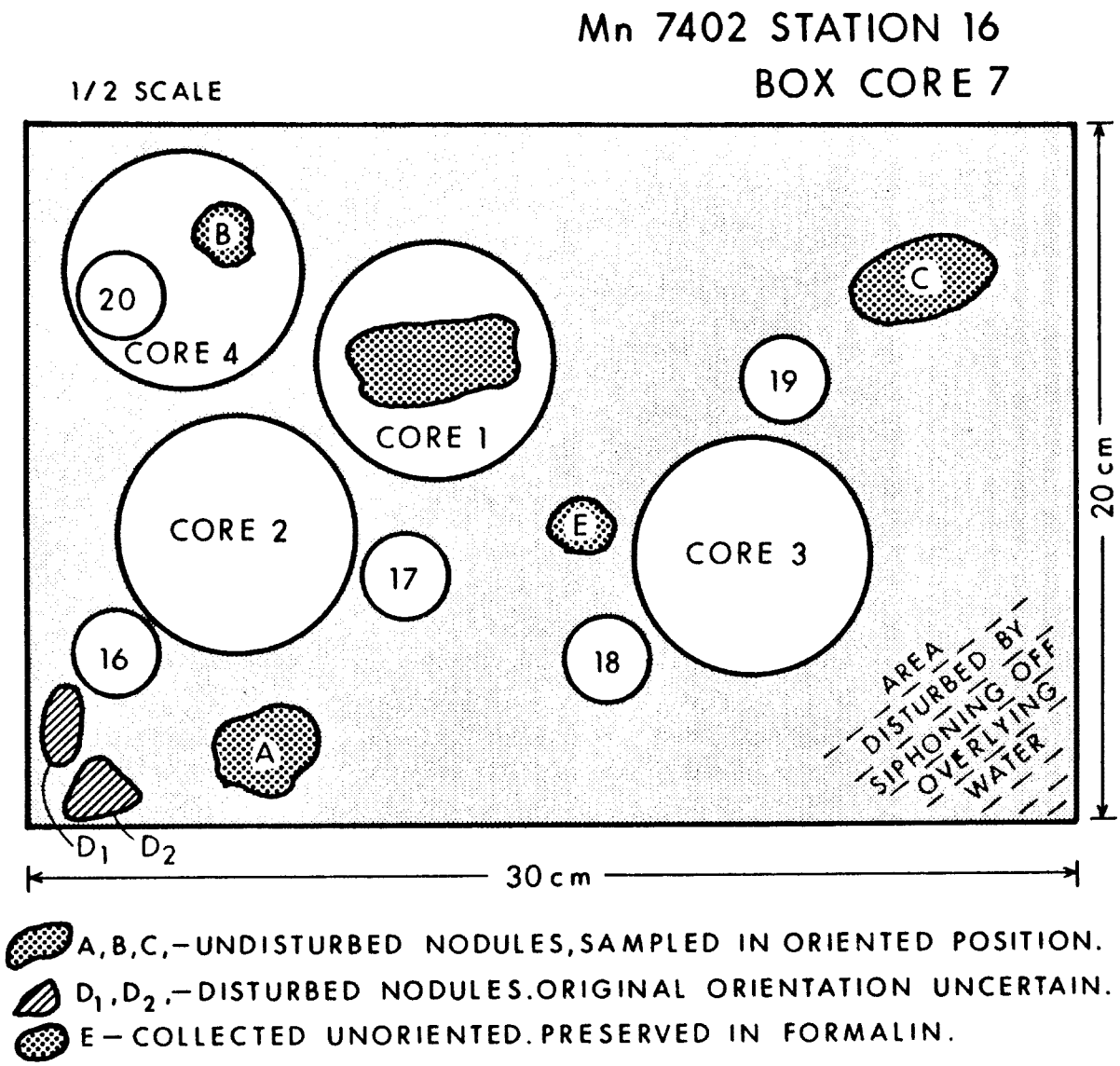

Fig. 17. Station 16, box core 7.

IN SITU PORE WATER SAMPLING PROGRAM

James W. Murray

The design and operation of the in situ pore water sampler was by Oceanics Industries (Osterville, Mass.) and is similar to that described by Sayles et al. (1973)*. The instrument penetrates into the sediment and through the action of a hydraulically compressed piston draws the sample, storing it in thin-walled Teflon capillary tubing. There are sampling ports in the harpoon to sample at depths of 5, 15, 30, 60, 100, and 140 cm in the sediment given normal penetration. One additional port collects sea water from 1/2 meter above the sediment water interface. A maximum sample of 21 ml can be collected from each port; of this volume 17 or 18 ml are usable samples while the remainder acts as a rinse. The principal advantage of using an in situ sampler as opposed to squeezing the pore water out of sediment cores is that when samples are collected in situ, there are no problems of temperature and pressure changes that commonly occur when a core is brought to the surface. The instrument has its own problems, however, as there is some uncertainty as to the exact depth of the sampling ports below the sediment water interface (i.e. actual penetration of the harpoon), and the sampling ports are potential sources of contamination. The sampler is lowered slowly onto the bottom. The sampler's large-diameter, flat-bottom plate is intended to keep the sampler positioned at the sediment water interface. There is no evidence at present to indicate that the depth of sampling ports is inaccurate by more than a cm or so. The subject of trace metal contamination by the ports is currently being tested in the laboratory. PO_4 and NH_3 contamination was thoroughly tested during this cruise by pumping distilled deionized water into one of the ports and letting it remain within the system for two days. The water was then extracted and analyzed for PO_4 and NH_3. The absorbance values were found to be no different from the blank.

The in situ sampler arrived at the University of Washington only ten days before the scheduled cruise departure. Assembly and pressure testing was carried out, but no opportunity was left to operationally test the sampler before the cruise. The first half of the Mn-74-02 cruise was dedicated to solving remaining problems. To this end, the assistance of Roger Hall and Charles Boatman is gratefully acknowledged.

Insufficient volume was collected at stations 12 (Hemipelagic site) and 13, primarily due to some mechanical problems with the sampler. These problems were corrected and good samples were collected at stations 14 (carbonate ooze) and 15 (siliceous ooze). At station 16, the sampler did not

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*Sayles, F.L., Wilson, T.R.S., and Mangelsdorf, P.C. (1973) In situ sampler for marine sedimentary pore waters: Evidence for potassium depletion and calcium enrichment. Science, 181, p. 156-164.

penetrate completely in spite of an additional 120 pounds of lead weight and two penetration attempts. The sediments at this station were composed of a thin veneer of recent siliceous ooze underlain by a more compact tertiary siliceous ooze.

At station 14, an intercalibration was conducted between the in situ sampler and samples squeezed from sediments recovered with a box core. Alkalinity, pH, NH_3, and PO_4 were analyzed at sea and samples were acidified for later trace metal analyses in the lab. All alkalinities were measured by J. Murray on 1-ml samples using the method described by E. Callender in the Mn-74-01 report. Precision of replicate determinations varied from 1 to 2%. The pH measurements were made by C. Bowser and J. Murray, while the NH_3 and PO_4 determinations were made by C. Boatman.

The results are shown in figures 18 and 19. The box core samples were squeezed approximately every 2 cm from the surface to 25 cm, so the only points for possible direct comparison with the in situ sampler are at 5 and 15 cm. Unfortunately, no samples were collected in situ at 5 cm because of a pinch in the capillary tubing. A preliminary evaluation of the data indicates that the results of pH, alkalinity, and PO_4 on squeezed samples are lower than those on in situ samples. The NH_3 values of the squeezed samples may be slightly higher than those of the in situ samples; however, this is difficult to state positively because of the large amount of scatter in the analyses. A total comparison for this station will be possible when the trace metal analyses are completed. On future cruises a more thorough intercalibration between the in situ sampler and squeezed samples is anticipated.

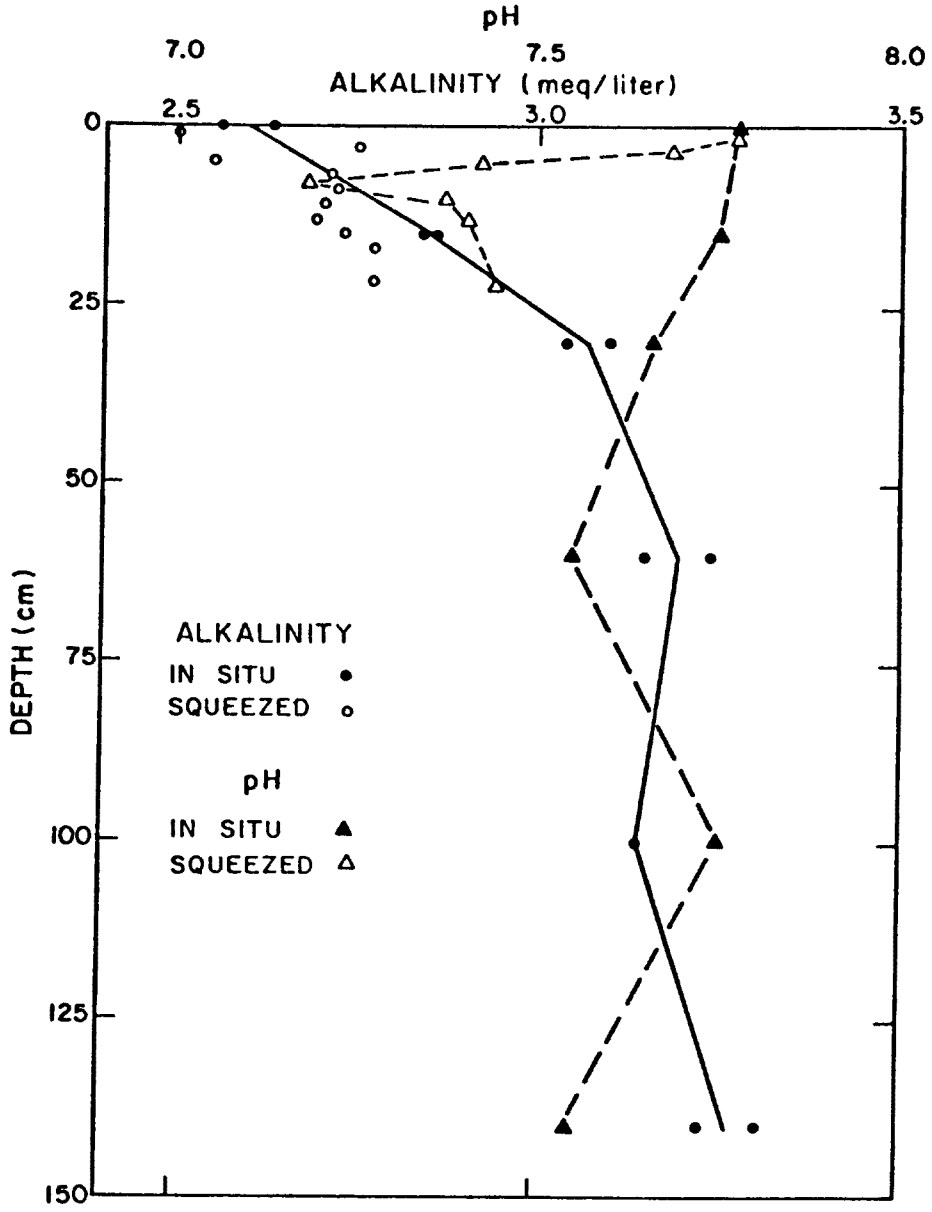

Fig. 18. In situ versus squeezed alkalinity values with respect to depth in sediments.

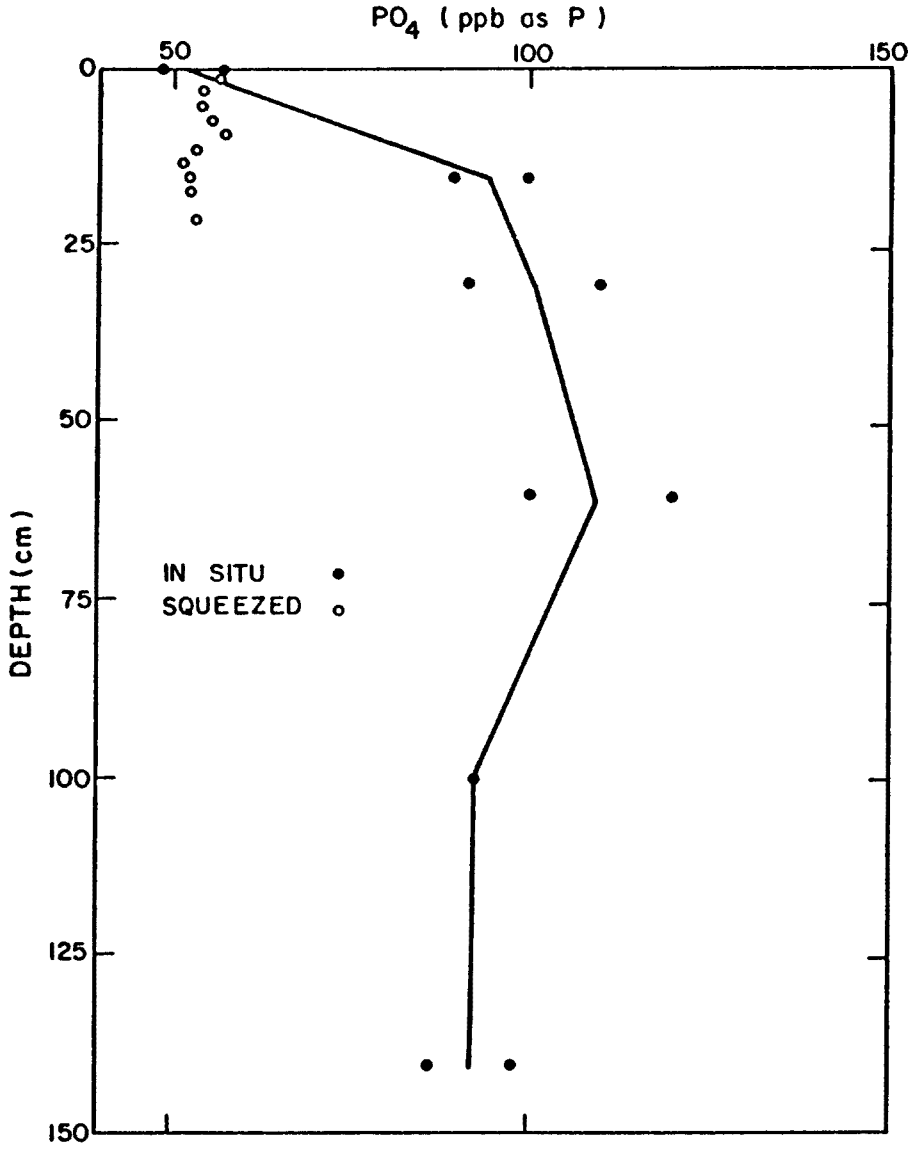

Fig. 19. In situ versus squeezed PO_4 values with respect to depth in sediments.

WATER CAST REPORT

Kenneth F. Binder

Water casts were made at stations 12, 13, 14, and 15 using the General Oceanics rosette sampler with eleven 12-liter Nisken bottles attached. For a more detailed description of this apparatus, see the preliminary cruise report for Mn-74-01. On station 16, a wire cast was substituted for the rosette sampler.

Of the four winch systems on board the R/V Moana Wave, only the rosette winch fitted with 1/4" conductor cable was capable of extended bottom time at 5,000-meter depth. The bottom camera and pore water sampler (see Murray, this report) also required the use of the rosette conductor cable, putting extreme stress on the cable. Because of the increased work load on the rosette conductor cable and winch, time-consuming mechanical and electrical failures occured. On station 12, the pore water sampler was attached to the conductor cable by crimping a loop in the end of the cable. This procedure caused the cable to short and required a new water-tight splice before the rosette could be used. On station 13, this problem was overcome by using the specially designed large surface area clamp which had been made for the rosette sampler. The bottom camera was later attached to the conductor with the same clamp. At station 15, the rosette winch began to have mechanical failures which directly affected the quality of the water casts. Of primary importance was the fact that the wire-out meter was destroyed and therefore had to be removed. Consequently, stopping the rosette at the desired wire-out readings was reduced to educated guesswork since the bottom pinger trace was often of poor quality. It also became increasingly difficult to fly the rosette near the bottom because the winch brake was not operating properly. At station 16, the conductor cable was no longer functional as a conductor cable, so the rosette was disassembled and a wire cast was run.

To accomplish the wire cast on station 16, all the bottles had to be removed from the rosette and new lanyards had to be made for each bottle. Wire bolts also had to be placed on the bottles. A 250-pound weight was made up of three free fall core weights and this weight was attached to the bottom of the wire with the rosette clamp. The benthos pinger was attached approximately 10 meters above the weight and the first Nisken bottle was attached approximately 10 meters above the pinger. Four bottles were placed near the bottom allowing about 5 meters between bottles for messenger acceleration. It appears that bottle number one must have pre-tripped on the way down, but not before it was at least 2,000 meters deep. This pre-tripping was probably caused by rolling of the ship. Bottle two may also have pre-tripped, but it is not presently known whether this actually occurred. Bottle three tripped at depth and thus along with thermal depths assured that the remainder of the cast was secure. It is important to keep in mind that the large trace-metal sample from bottles one to four is a mixed sample and not entirely composed of bottom water. As with all water casts, the sampler was checked and rechecked to make sure that all the sampling equipment was as clean as possible as it went over the side.

CHEMICAL ANALYSIS

Included with this report are data forms for each water cast (Tables 8-12). These forms are self-explanatory. Any questions concerning chemical methods of analysis or equipment used may be answered by referral to the preliminary cruise report for Mn-74-01. A description of each analysis or reference is given there.

Salinity samples were not run onboard ship as on the first Mn cruise, but were stored in tightly capped bottles and kept refrigerated for later analysis. These samples were run on October 14, 1974 at the Coconut Island Marine Facility on a similar Bisset-Berman type salinometer.

Station 13 data (lat. 14°55'N, long. 125°01'W) was compared with data from GEOSECS Station 342 (lat. 14°29'N, long. 123°8.9'W) 125 miles distant. The results of this comparison show that some reasonable data has been obtained in the present work.

TABLE 8: STATION 12 - ROSETTE CAST 1

Sept. 18, 1974 Lat. 30°43'N Long. 119°50'W

Bottle No.	Thermal Depth, m	PDR Distance Off Bottom	Corrected Temp, °C	O_2 ml/ liter	PO_4 Mg-At/ liter	Silicate Mg-At/ liter	Salinity, ‰	Trace Metals
1	3784	4	1.54	3.05			34.680	38 liters from bottles 1, 2, 3, 4, 5, for particulate trace metals
2	3784	4						
3	3784	4	1.54	3.07			34.678	
4	3784	4						
5	3784	4						
6	3680	100	1.56					2 liters from bottles 6, 7, 8 for soluble trace metals
7	3680	100						
8	3680	100						
9	2779	1000	1.675					2 liters from bottles 9, 10 11 for soluble trace metals
10	2780	1000						
11	2780	1000	1.675					

TABLE 9: STATION 13 - ROSETTE CAST 2

Sept. 23, 1974 Lat. 14°55.0'N Long. 125°01.4'W

Bottle No.	Thermal Depth, m	PDR Distance Off Bottom	Corrected Temp., °C	O_2 ml/ liter	PO_4 Mg-At/ liter	Silicate Mg-At/ liter	Salinity, ‰	Trace Metals
1	4533	2-3		3.73	2.52	159.9	34.688	30 liters from bottles 1, 2, 3 for particulate trace metal analysis
2	4533	2-3		3.83	2.53	160.7	34.688	
3	4533	2-3	1.445		2.55	161.0	34.689	
4	4433	100		3.79	2.54	158.1	34.695	
5	4000	500		3.35	2.57	160.3	34.694	
6	3475	1060	1.545	3.13	2.69	100.6	34.677	
7	2980	1550		2.91	2.78	167.3	34.670	
8	1390			1.32	3.29	144.1	34.595	
9	893		4.755	0.49	3.42	95.9	34.541	
10	420			0.10	2.98	47.4	34.581	
11	100			3.79	0.99	8.1	34.260	

TABLE 10: STATION 14 - ROSETTE CAST 3

Sept. 30, 1974 Lat. 4°31.20'N Long. 140°24.10'W

Bottle No.	Thermal Depth, m	PDR Distance Off Bottom	Corrected Temp., °C	O_2 ml/ liter	PO_4 Mg-At/ liter	Silicate Mg-At/ liter	Salinity, ‰	Trace Metals
1	4407	∿2m	1.41	3.90	2.56	161.8	34.711	32 liters from bottles 1, 2, 3 for particulate trace metal analysis
2	4407	∿2m		3.96	2.53	160.3	34.703	
3	4407	∿2m	1.40	4.13	2.55	161.4	34.708	
4	4297	112m		3.94	2.52	181.8	34.731	
5	3897	510m		3.74	2.61	147.1	34.709	
6	3387	1020m	1.57	3.29	2.67	143.4	34.717	
7	1149			1.31	2.96	143.4	34.615	
8	949			1.07	3.18	127.20	34.546	
9	699		6.27	0.92	3.08	115.8	34.959	
10	460			1.28	2.68	58.1	34.625	
11	70			4.70	0.66	7.35	34.968	

TABLE 11: STATION 15 - ROSETTE CAST 4

Oct. 2, 1974 Lat. 8°57.45'N Long. 139°50.8'W

Bottle No.	Thermal Depth, m	PDR Distance O Off Bottom	Corrected Temp., ° C	O_2 ml/ liter	PO_4 Mg-At/ liter	Silicate Mg-At/ liter	Salinity, ‰	Trace Metals
1	4702	∿200	1.40		2.60	123.6	34.693	29 liters from bottles 1, 2, 3 for particulate trace metal analysis
2	4702	∿200		4.02	2.58	124.3	34.695	
3	4702	∿200	1.39	4.13	2.56	123.6	34.692	
4	4575	∿250		4.05	2.57	124.7	34.699	
5	4450			4.00	2.56	127.3	34.716	
6	4317		1.39	3.97	2.55	132.7	34.698	
7	4240			3.65	2.61	129.1	34.683	
8	4168			3.91	2.55	136.2	34.694	
9	4068		1.39	3.44	2.57	129.1	34.697	
10	3980			3.95	2.55	132.7	34.691	
11	3890			3.75	2.61	136.2	34.682	

TABLE 12: STATION 16 - WIRE CAST 1

Oct. 4, 1974 Lat. 11°05'N Long. 140°00'W

Bottle No.	Thermal Depth, m	PDR Distance Off Bottom	Corrected Temp., °C	O_2 ml/ liter	PO_4 Mg-At/ liter	Silicate Mg-At/ liter	Salinity, ‰	Trace Metals
1	1989			2.41			34.641	'Boylan' Cast 76 liters sol. and particu-late trace metals
2	?							
3	4751	~30		4.05			34.699	
4	4751	~30		4.02				
5	1618							
6	1612			1.94			34.607	8 liters acidified with 6 m HCl
7	1603							
8	1594			1.95			34.603	
9	20							
10	15							
11	10							