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RESULTS OF R/V YAQUINA CRUISE YALOC-74, LEG 3:
SEABED DISPOSAL PROGRAM, NORTH PACIFIC STUDY AREA MPG-2,
33°20'N, 151°00'W, NOV. 30 - DEC. 21, 1974

Ref. No. 75-4

by

G. Ross Heath

Approved for distribution

John A. Brown

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ABSTRACT

During 10 days in the vicinity of 33°20'N, 151°00'W (MPG-2 area), three near-bottom current meters were deployed, the bathymetry and sub-bottom acoustic structure of the surrounding seafloor were determined, and sediment cores were collected for studies of artificial radionuclide distribution, geotechnical properties, geochemical properties, and to identify the character of shallow acoustic reflectors. Large volume water samples for artificial radionuclide studies and suspended sediment were also collected. These samples and data will supplement earlier material to be used in the evaluation of the central North Pacific as a potential site for the ultimate disposal of high-level reactor wastes.

INTRODUCTION

R/V Yaquina left Honolulu, Hawaii at 0800 on November 30, 1974, to start Leg 3 of her cruise YALOC-74. Most of the scientific work — deep-current measurements, bottom photography, large-volume water sampling, and various types of sediment coring— was concentrated within about 37 km (20 n.m.) of 33°20'N, 151°00'W, an area designated as MPG-2 (second mid-plate gyre area). The leg ended in Newport, Oregon at 0830 on December 21, 1974.

MPG-2 is the second area beneath the central North Pacific gyre selected for detailed study under the Seabed Disposal Program, an ERDA program under the direction of Sandia Laboratories, Albuquerque, New Mexico. The general setting of the area within the North Pacific basin is shown in Figure 1. The locations of the current meters relative to those in MPG-1 are shown in Figure 2.

The area was chosen for detailed study for the following reasons:

1. It lies in a region of typical North Pacific abyssal hills, with no seamounts closer than 100 km, and the nearest area of major structural disturbance, the Murray Fracture Zone, some 300 km to the south.
2. It lies within an area surveyed magnetically and bathymetrically by the NOAA ship OCEANOGRAPHER (Stevens, 1972). The magnetic profiles (Figures 3 and 4) indicate an absence of major structural disturbance, and by correlation with Heirtzler et al's. (1968) time scale, suggest that the basaltic crust was formed 80-85 million years ago at the crest of the East Pacific Rise.

Figure 1: Location of study area MPG-2 (shown by star) relative to gross morphology of the North Pacific. Dashed square outlines area covered by Figure 2. Contour interval 1 km.

Figure 2: Bathymetry of the Hawaii-MPG-1 - MPG-2 region. Contour interval 200 fm. Stars in MPG-1 and MPG-2 areas are near-bottom current-meter locations.

Figure 3: Magnetic profiles plotted along R/V OCEANOGRAPHER tracklines in MPG-2 region. Vertical scale (normal to tracklines) is 400γ/inch; baseline value corresponding to trackline is -130γ. Dashed line marks approximate western edge of anomaly 33 (crust about 82 million years old). M1, M2 and M3 are current-meter locations.

Figure 4: Magnetic anomalies in MPG-2 area based on R/V OCEANOGRAPHER tracklines (Stevens, 1972). Contour interval 25 gammas. Solid circles show locations of near-bottom current meters.

3. It is close to GEOSECS station 204, where the vertical distribution of hydrographic and geochemical properties in the water column have been determined in detail.
4. It lies in the same depositional province as MPG-1. Comparison of results from the two areas gives some indication of the variation in physical and chemical properties over a distance of 700 kilometers. MPG-2 data can also be used to infer whether the Musician Seamounts to the west of MPG-1 influence sedimentation in that area.

The cruise was very successful. Work in the MPG-2 area included 28 stations and detailed bathymetric surveys around three deep current meters. Only about 6 hours were lost due to bad weather.

SCIENTIFIC STAFF

The following people from Oregon State University (OSU), Scripps Institution of Oceanography (SIO), Woods Hole Oceanographic Institution (WHOI) and Worcester Polytechnic Institute (WPI) took part in YALOC-74, Leg 3. Areas of prime responsibility are indicated:

G. Ross Heath	OSU	Chief scientist (now at URI)
Peter Kalk	OSU	Party chief
Terry Chriss	OSU	
Tom Flaherty	OSU	
Shelly Goldberg	OSU	
Jery Graham	SIO	Current meters, camera
Pat Johnson	OSU	
Charlotte Lawson	WHOI	Water sampling, 8" corer

Cyndi Millet	OSU	
Charles Nickerson	WPI	Geotechnical studies
Bob Peterson	OSU	<u>In situ</u> water filtration
John Toth	OSU	Acoustic experiments
Barbara VanDyk	WHOI	Camera, bathymetry
Chiye Yamashiro	OSU	

SCIENTIFIC PROGRAMS

1) Bathymetry

The profiles run by R/V OCEANOGRAPHER in 1971 (Stevens, 1972) define a series of irregular, elongate abyssal hills and valleys trending at about 350° in the MPG-2 area. Total relief in the area $32^{\circ}50' - 33^{\circ}50'N$, $150^{\circ}20' - 151^{\circ}30'W$ is 340 meters (190 fathoms), but adjacent hills and valleys usually differ in elevation by about 150 m (80 fm.). Figure 5, based on OCEANOGRAPHER and YAQUINA data, shows that the abyssal topography, although irregular, has a wavelength of about 12-14 km.

To define the bathymetric setting of the current meters, more detailed surveys were made of the sea floor within about 10 km of each meter. These surveys (Figs. 6-8) confirm the general conclusions based on the regional survey, but show that, on a scale of a few kilometers, the north-northwest topographic grain is modified by numerous small irregularities.

By analogy with earlier surveys of abyssal hills using both surface and near-bottom profiling equipment, it is probable that the slopes bounding the abyssal hills and valleys are considerably steeper than indicated in Figures 6-8. Some support for this view is provided by two

Figure 5: Generalized bathymetry of MPG-2 area based on R/V OCEANOGRAPHER tracklines (Stevens, 1972) and R/V YAQUINA tracklines during YALOC-74. Contour interval 20 fm (uncorrected). Dashed squares outline detailed bathymetric surveys (Figs. 6-8) around near-bottom current meters (solid circles).

Figure 6: Tracklines and bathymetry around current meter I (solid circle), MPG-2 area. Contour interval 20 m (values corrected for sound velocity in seawater using Matthews tables).

Figure 7: Tracklines and bathymetry around current meter 2 (solid circle), MPG-2 area. Contour interval 20 m (values corrected for sound velocity in seawater using Matthews tables).

Figure 8: Tracklines and bathymetry around current meter 3 (solid circle), MPG-2 area. Contour interval 20m (values corrected for sound velocity in seawater using Matthews tables).

pinger profiles made by towing a 12 kHz pinger 20-50 m above the sea floor. The profiles (Figs. 9, 10) indicate that the abyssal hills and valleys are separated by a number of steps with steep bounding slopes, probably small normal faults. Because the depth of the pinger is not known absolutely, the profiles of Figures 9 and 10 cannot be compared directly with the profiles made by the ship. Nevertheless, the small steps are probably real, and illustrate the smoothing effect of the 30° sound cone generated by the ship's 12 kHz transducers.

2) Navigation

Positioning throughout the MPG-2 survey was by dead-reckoning between satellite fixes. Two satellite navigators were used, a Magnavox 706CA and a new Magnavox MX750. The fix positions for the two instruments agreed to within .01 degrees of latitude and longitude, but the 706CA accepted more low and high angle passes. For the ten days in the MPG-2 area, we received 22-25 (average, 24) usable fixes per day.

3) Magnetics

A proton-precession magnetometer was towed during entry to the MPG-2 area and throughout the detailed surveys around the current meters. The magnetic data have been digitized but have not yet been reduced to anomaly form.

4) 3.5 kHz Profiling

3.5 kHz reflection records were made throughout the MPG-2 survey, both on station and underway. The acoustic stratigraphy is relatively uniform over the area, (Fig. 11), consisting of a transparent layer 5-10 m sec thick over a strong and persistent reflector (also visible in the 12 kHz and pinger profiles), over a second, slightly less transparent layer generally 20-30 m sec thick, which in turn overlies an opaque

Figure 9: 12 kHz acoustic reflections from sea floor and a shallow sub-bottom reflector as recorded by the ship's transducer (lower) and a Benthos pinger towed close to the sea floor (upper trace). The marked variations in thickness of the surface layer evident in the pinger record are largely concealed in the surface trace.

Figure 10: Surface and near-bottom generated 12 kHz reflection profiles (as Fig. 9). Both topography and thickness of the surface layer have been smoothed on the surface trace.

Figure 11: Typical 3.5 kHz acoustic profile from the MPG-2 area. The upper two layers (buff and dark brown pelagic clay) have been sampled by piston cores.

acoustic basement 40-60 m sec thick. The opaque layer is usually structureless, but occasionally shows faint layering (Fig. 12).

Sediments recovered in a series of piston cores grade from a surface, buff illite-rich clay of Quaternary age to very dark brown, more indurated smectite-rich clay of probably Tertiary age. Shipboard torvane measurements by C. Nickerson gave about 70 g/cm² for the buff clay versus about 110 g/cm² for the dark brown material. The shallow, somewhat diffuse reflector present throughout the area (Fig. 11) is produced by a sequence of thin (less than 15 cm) ash beds. The number of ash beds in a core ranges from 7 to 10. With one exception, these beds are confined to a 3-meter interval starting 4 to 5 m below the sea floor. The ashes were probably basaltic originally, but have been severely altered to phillipsite. The clay in contact with the ash is locally indurated to a weak porcellanite over a 5-20mm interval.

The thickness of all the acoustic units varies by about a factor of 2 over the area. The transparent layers seem to be thickest in narrow valleys, implying some downslope movement of sediments, but there are many exceptions and, as evident from Figure 9, variations in the thickness of the surface layer over a distance of 100 m can be as great as variations over tens of kilometers.

The distribution patterns may become clearer when isopach maps are prepared for the detailed survey areas. At present, however, the process or processes producing the variations in thickness of the acoustic layers are not understood.

5) Free-vehicle deep-current meters.

Three S10 free-vehicle current meters were dropped at the locations

Figure 12: Acoustic profile (3.5 kHz) showing unusually well-developed layering in the opaque zone (probably early Tertiary chert) that forms acoustic basement in the MPG-2 area.

shown on Figure 5 and subsequent figures. The Savonius-type meters were anchored 100 m off the sea floor. About 230 hours of records were obtained from each meter.

The northwest meter (#1) recorded only direction, but the other two gave good direction and velocity records for the full 230 hours.

Records from meters 2 and 3, reduced by B. Taft, University of Washington, are dominated by semi-diurnal components with maximum velocities of 5-6 cm/sec (Fig. 13). In addition, though, both records have advective components of about 2 cm/sec to the south or southwest (Fig. 14). There is little coherence between the advective patterns from the two meters (Fig. 14), and even the higher frequency components show surprising differences (Fig. 13). The latter differences may reflect threshold problems, but the lower frequency incoherence is shared by other arrays of comparable scale, and probably results from transient mesoscale disturbances passing through the area.

The bathymetric surveys around meters 2 and 3 (Figs. 7 and 8) show that the nearest topographic highs reaching the depths of the meters are 3-6 km away from the moorings. Thus, the directions and velocities recorded should reflect regional flow, rather than topographically channeled near-bottom currents.

6) Bottom photography

The problems that have plagued the 70 mm camera persisted on this cruise. Prior to reaching the MPG-2 area, the camera operated intermittently on the bench due to bad connections between modules. These problems were tracked down and apparently repaired.

Figure 13: North-south (V) components of currents re-recorded 100m off bottom by meters 2 and 3. Negative values indicate southward flow.

Figure 14: Progressive vector diagrams of current records from meters 2 and 3.

Two lowerings were made in the MPG-2 area, both using the pogo-switch made of operation. The first lowering consumed a 100 ft roll of film - surprising in view of the time at the bottom. In this case, the camera returned with the pogo weight wrapped around the camera frame. During the second lowering, the pogo-weight was lost, but about half a roll of film was exposed. Prior to the third planned lowering, the film was found to be fully advanced, and the shutter motor burned out, thereby terminating this facet of the program.

7) Suspended matter in deep-water

Two sets of samples of suspended matter were filtered from water near the sea floor and at 3500 m. The first set was collected in situ using a submersible pump connected to two 14.2 cm Nuclipore filters. The second set was collected by filtering water brought to the surface in Dr. V. Bowen's large volume sampler. This set was designed to calibrate the flow-meter used with the submersible system, and to evaluate the relative efficiencies of the two techniques. The samples will be worked up by R.E. Peterson of O.S.U.

8) Large-volume water samples.

A profile of 13 large-volume water samples was collected for Dr. V. Bowen near current meter 3. The only problem encountered was a lack of reversing thermometers to determine the exact depth of each sample. This problem was alleviated by using a pinger for depth control and collecting salinity samples so that the MPG-2 profile can be correlated with the nearby GEOSSECS station 204.

9) 8" Spinctor cores.

Five 8" cores were taken in the MPG-2 area. Three are for radio-nuclide studies (Dr. V. Bowen), and two provide large quantities of sediment for other geochemical work. Most of the cores showed a decrease in diameter upwards, but the core tops appeared relatively undisturbed. The lengths of the cores range from 49-69 cm. Problems encountered previously with this type of corer in the North Pacific appear to have been avoided by raising the core as gently as possible from the bottom (essentially maintaining tension of 2200-2400 lb on the wire and allowing the movement of the ship to work the core out of the bottom).

10) 5" hydroplastic cores

Cores for geotechnical studies of the near-surface sediments were taken with a simple gravity corer. The first two overpenetrated, but the last three (with half the weight) provided excellent material. These samples will be worked up by C.R. Nickerson of W.P.I.

11) Piston cores

Five piston cores were attempted in the MPG-2 area. The first pretripped (because of wire surge due to swells approaching 30 ft in height), the other four penetrated 10-13 meters into the upper transparent layers. In three cases, 60 ft cores were attempted. Each time, one to two barrels were bent with no significant increase in penetration.

The four longest cores all penetrated into the second transparent layer, but none reached the opaque layer. Core-nose samples (the least disturbed sediment in a piston core) from 65P and 73P were taken for consolidation tests (C. Nickerson). 10 cm sections every 1.5 m were also

taken from 65P and sealed for later geochemical work by the author.

12) Kasten cores

Two kasten cores were taken in the MPG-2 area. The first, 3 m long, overpenetrated. The second, 6 m long, penetrated a little over 4 m. This core appears to have reached the second transparent layer, thereby recovering a large volume of the dark brown sediment. Triaxial and consolidation samples (C. Nickerson) were taken from the core nose which should contain relatively undisturbed sediment.

13) General sedimentology

The sediments sampled fall into two clear groups. Those near the sea floor are buff, uniform clays, sometimes slightly mottled. They contain a few radiolarians (Quaternary) and fragments of phosphatic fish debris, but are essentially non-fossiliferous. By analogy with other cores from the central North Pacific, this buff sediment is quartz- and illite-rich, and is derived largely from periglacial debris formed by the glacial advances across North America and Europe during the Pleistocene.

The second group of sediments, the dark brown clays of the second transparent layer, are probably rich in smectite and ferromanganese hydroxyoxides. Such sediments, which are forming today in the South Pacific, are largely authigenic or formed from altered tholeiitic volcanic debris. They typically have high surface activities and cation exchange coefficients.

The maximum thickness of sediment positively identified in the MPG-2 area is about 70 m sec (about 50 m). The portion of the opaque layer beyond the penetration of the 3.5 kHz system and the carbonate

sequence that probably underlies it may be another 30-50 m thick.

One aspect that distinguishes the MPG-2 area from most of the central North Pacific is the lack of ferromanganese nodules. Nodules were recovered in several cores near current meter 3, but are rare at other stations. Hopefully, the bottom photographs at meters 2 and 3 will give some indication of the coverage at these two topographically distinct locations.

CONCLUSIONS

The MPG-2 area studies carried out during YALOC-74, Leg 3 have yielded the data and samples needed to critically compare this area with MPG-1. In addition, enough sediments samples are now available to begin in-depth laboratory studies of the geotechnical and geochemical properties of central North Pacific sediments.

ACKNOWLEDGMENTS

The successful completion of a study of this complexity would have been impossible without the full cooperation of all members of the ship-board scientific party, as well as the ship's officers and crew. Special thanks are due to Mr. Frisbee Campbell of Hawaii Institute of Geophysics, who took care of equipment shipped to Honolulu, and coordinated the transfer of instruments from R/V MOANA WAVE to R/V YAQUINA on November 29.

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APPENDIX I Station List

station	operation	date	time (GMT)	water depth (m)	core leng. (cm)	Lat (N)	Long (W)	Comments
Y74-3-44	In situ filter system	12/1/74	1215- 1515	4499- 4515		22° 19.5'	155° 42.3'	30 l Niskin sample also filtered
-45	" " " "	12/1/74	2030- 2330	4539- 4515		22° 19.5'	155° 44.4'	30 l Niskin sample also filtered
-46	Current meter #1.	12/5/74 12/15/74	0704 0035	5534		33° 26.90'	151° 00.00'	Foam pad left above rotor
-47	" " #2	12/5/74 12/15/74	0936 0427	5505		33° 10.98'	151° 00.23'	
-48	" " #3	12/5/74 12/15/74	1318 0820	5538		33° 26.4'	150° 42.4'	
-49	Large volume water cast					33° 26.85'	150° 42.62'	Median position of cast
	100 m	12/5/74	1520			33° 26.85'	150° 42.62'	
	1000 m	12/5/74	1708			33° 27.35'	150° 42.93'	
	5520 m	12/5/74	2017	5536		33° 27.30'	150° 42.05'	
	0 m	12/5/74	2210			33° 26.96'	150° 41.50'	
	5290 m	12/5/74	2310	5490		33° 26.83'	150° 41.10'	
	2500 m	12/6/74	0308			33° 26.70'	150° 42.30'	First attempt did not trip
	4500 m	12/6/74	0530			33° 26.80'	150° 43.33'	
	3500 m	12/6/74	0635			33° 26.69'	150° 43.45'	
	1250 m	12/6/74	0810			33° 26.59'	150° 43.26'	
	700 m	12/6/74	0905			33° 26.80'	150° 43.05'	
	500 m	12/6/74	0904			33° 26.94'	150° 42.88'	
	350 m	12/6/74	1010			33° 27.06'	150° 42.59'	
	200 m	12/6/74	1035			33° 27.15'	150° 42.40'	
-50	Hydroplastic core	12/7/74	0907	5466	292	33° 26.35'	150° 43.65'	Core at WPI(Nickerson)=HPC-1. Slight overpenetration.
-51	Camera	12/7/74	1351- 1457	5478- 5480		33° 27.15' 33° 27.10'	150° 43.54' 150° 43.53'	Run appeared normal.

APPENDIX Station List

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station	operation	date	time (GMT)	water depth (m)	core leng. (N) (cm)	Lat (N)	Long (W)	Comments
-52	8" sphincter core	12/7/74	2039	5508	59	33° 25.75'	150° 41.8'	Core at WHOI(Bowen). Top slightly washed.
-53	Piston core	12/8/74	0028	5565	81	33° 24.36'	150° 42.9'	Pretrip. Core at OSU
-54	Hydroplastic core	12/8/74	1245	5567	244	33° 10.95'	150° 54.93'	Core at WPI(Nickerson)≡HPC-2
-55	Camera	12/8/74	1736- 1846	5582- 5582		33° 10.56' 33° 10.23'	150° 52.08' 150° 52.29'	Slight overpenetration. Roll 1/2-exposed. Pogo weight missing.
-56	8" sphincter core	12/8/74	2241	5595	0	33° 10.73'	150° 55.58'	Wires to both valves broken.
-57	<u>In situ</u> filter system	12/9/74	0217- 0528	5596- 5598		33° 10.29' 33° 10.66'	150° 56.39' 150° 56.28'	
-58	Piston core	12/9/74	0910	5600	1118	33° 10.05'	150° 54.10'	Reflector is phillipsite/ chert layer. Core at OSU.
-59	8" sphincter core	12/9/74	1508	5589	49	33° 10.65'	150° 54.44'	Core at WHOI (Bowen)
-60	<u>In situ</u> filter system	12/9/74	1830- 2130	5585- 5596				
-61	Hydroplastic core	12/10/74	0305	5325	216	33° 08.63'	151° 15.77'	Core at WPI (Nickerson)≡ HPC-3.
-62	Piston core	12/10/74	0651	5329	998	33° 08.69'	151° 15.75'	Core at OSU
-63	8" sphincter core	12/10/74	1607	5328	52	33° 09.23'	151° 15.82'	Core at WHOI (Bowen)
-64	Hydroplastic core	12/10/74	2127	5510	227	33° 12.50'	151° 00.12'	Core at WPI (Nickerson) ≡HPC-4
-65	Piston core	12/11/74	0115	5512	1146	33° 13.17'	150° 59.61'	Core At OSU; 10 cm segs at 1.5m intervals at URI(Heath); catcher at WPI (Nickerson)

APPENDIX I Station List

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station	operation	date	time (GMT)	water depth (m)	core leng. (cm)	Lat (N)	Long (W)	Comments
-66	8" sphincter core	12/11/74	0459	5480	69	33° 12.78'	150° 58.77'	Core at URI (Heath)
-67	Kasten core	12/11/74	2336	5507	305	33° 11.75'	150° 59.86'	Core at OSU. Samples from top and bottom at WPI (Nickerson). Overpenetrated
-68	Hydroplastic core	12/12/74	0558	5535	187	33° 26.43'	151° 00.21'	Core at WPI (Nickerson)≡ HPC-5
-69	Multiple gravity core	12/12/74	0926	5524	49	33° 26.28'	151° 00.88'	Cores at OSU (3) and URI (1-Heath)
-70	8" sphincter core	12/12/74	1315	5501	68	33° 27.16'	151° 00.87'	Core at URI (Heath)
-71	Kasten core	12/13/74	0515	5506	413	33° 27.25'	150° 59.13'	Core at URI ; catcher samples at WPI (Nickerson).
-72	Large volume water bottle							Calibration of <u>in situ</u> filter system
	I	12/13/74	1035	5514		33° 27.69'	150° 58.97'	
	II	12/13/74	1418	5526		33° 28.71'	151° 00.48'	
	III	12/13/74	1642	5516		33° 27.32'	151° 00.46'	
-73	Piston core	12/13/74	2210	5540	1289	33° 26.57'	150° 54.72'	Core at OSU; catcher sample at WPI (Nickerson)
-74	Pinger profile	12/13/74	0550- 1020			33° 23.38' 33° 23.52'	151° 05.21' 151° 03.21'	
-75	Large volume water bottle							Filtered for suspended matter
	I	12/20/74	0820	3416		43° 48.30'	128° 40.94'	
	II	12/20/74	1130	3392		43° 49.18'	128° 40.80'	
	III	12/20/74	1345	3363		43° 49.34'	128° 40.50'	
	IV	12/20/74	1633	3374		43° 49.08'	128° 39.41'	

APPENDIX II Physical Properties samples from MPG-2 area taken by C. Nickerson for study
at WPI (Dr. A. Silva).

	WATER CONTENT and CARBONATE	GRAIN SIZE CLASSIFICATION	CONSOLIDATION (size)	TRIAxIAL (All 2")	TORVANE (No.)
Y 74-3-50 H G	22	18	8	5 (2.5")	-- 18
Y 74-3-54 H G	33	26	4	9 (2.5")	-- 26
Y 74-3-61 H G*	2	--	1	2 (2.0")	-- --
Y 74-3-62 H G	3	--	1	-	-- 3
Y 74-3-64 H G*	1	1	1	1 (2.0")	-- --
Y 74-3-65 P C	1	--	1	3 (2.0")	-- --
Y 74-3-67 K	11	11	5	8+4=12 (2.0")(2.5")	-- --
Y 74-3-68 H G*	--	--	--	-	-- --
Y 74-3-71 K	5	--	9	4 (2.0")	4 --
Y 74-3-73 P C	2	--	2	1 (2.0")	-- --
TOTAL	80	56	32	37	4 47

*CORES

Y 74-3-61 H G

Y 74-3-64 H G

Y 74-3-68 H G

All saved for shipment to
Armand J. Silva
Worcester Polytechnic Institute
Worcester, Mass. 01609
for further sampling.