ANALYSIS OF "ECHO SOUNDING" DATA NORTH-CENTRAL PACIFIC

Progress Report

Dennis E. Hayes

MASTER

Lamont-Doherty Geological Observatory of
Columbia University
Palisades, New York 10964

February 1, 1974 - October 15, 1974
(January 31, 1975 - Contract Expiration Date)

PREPARED FOR THE U. S. ATOMIC ENERGY COMMISSION
UNDER CONTRACT NO. AT(11-1)-2430

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Progress Report

CONTRACT AT(11-1) 2430

Analysis of "Echo Sounding" Data North-Central Pacific

Principal Investigator: Dennis E. Hayes

ABSTRACT

Echograms and seismic profiler records have been examined in the area bounded by 29°N and 31°N; 156°W and 160°W. Total sediment thicknesses are thin and uniform north of the Murray fracture zone but both bottom relief and sediment disposition are variable within the fracture zone province. A bottom pinger operating a 3.5 kHz has been built and tested preliminarily. The instrument promises to be most useful in delineating the nature of micro-relief and the acoustic properties of the uppermost sediments (~100m) in areas of deep water. Three-dimensional perspective views of the seafloor relief have been generated using computers and provides a graphic illustration of the physiography in the study area.

This report was prepared as an account of Government-sponsored work. Neither the United States, nor the Atomic Energy Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liability with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

As used in the above, 'person acting on behalf of the Commission' includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

Progress Report
Contract AT(11-1) 2430

This progress report summarizes the first nine months of work in this contract. The principal investigator has devoted 100% of time for approximately one calendar month and will devote about 50% for one additional month during the remainder of the current contract.

Review of tasks to be performed:

- 1) Examine existing Lamont-Doherty 3.5 kHz, 12 kHz, 17 kHz sounding/reflectivity data and similar 3.5 kHz data anticipated from Taft cruise to evaluate:
 - a) Nature and extent of small scale topography
 - b) Coherence and distribution of subbottom reflectors and correlation with existing sediment cores.
 - c) Feasibility of "pinger probe" studies to define micro-topography and detailed subbottom reflector disposition, L-DGO vessels.
- 2) Formulate long-range experiment to determine compressional wave velocity profile using 3.5 kHz source and expendable radio sonobuoys.
- 3) Digitize bottom contours in primary study area.
- 4) Archival search of bathymetric data.

Progress Report:

Item 1. (a and b) Nature and extent of small scale topography, sediment thickness and subbottom reflectors.

The primary area of interest, located between 29°N to 31°N and 156°W to 160°W, is north of Hawaii and east of the Musician Seamount Chain, Figure 1A. The southern section of the survey area is dominated by the troughs and escarpments of the Murray Fracture Zone. Relief there is rugged basement outcrops are frequent, and the sediment thickness and character are variable.

The remaining two-thirds of the study area north of the Murray Fracture Zone has considerably lower relief, outcrops are infrequent, and sediment thickness and character are more uniform, Figure 1b.

The sediment is very thin throughout the area especially in view of the presumed age of the underlying oceanic basement (< 80 m.y.). Analyzing paleomagnetic data from piston cores, Opdyke and Foster (1970) have established a sedimentation rate of less than 3 mm/1000 yrs. for much of the Central Pacific Basin during the past 5 m.y. At that rate sediment accumulation for 80 m.y. would be less than 240 m. Since the thickness is actually less than 80 m in the study area, the average rate of accumulation is considerably less than 3 mm/1000 yrs., perhaps as low as 0.5-1 mm/1000 yrs. and suggests the strong possibility of major sedimentary hiatuses here. The occurrence of manganese stains, micromodules, or nodules in all the cores from this area supports the inference of a very slow sedimentation rate.

The sediment type in the area is predominantly yellowish-brown clay with varying amounts of manganese and pelagic components, e.g. fish teeth, palagonite, sponge spicules, quartz, etc. The coarse fraction constitutes only a small percentage of the cores with yellowish-brown clays making up the rest. The clays cored in the area probably are the major components of the upper part of the sediment column. The upper part, a transparent layer 0-40 m thick, overlies an opaque layer of at least comparable thickness. The precise boundary of the sediment/basement contact is obscured by the presence of a very strong reflector, the lower opaque layer, which may represent a zone of alternating chert and zeolite rich clay (Winterer, Ewing et al., 1973, Initial Reports of the Deep Sea Drilling Project, Vol. 17).

The combination of thin sediment cover and deep water (5500-6000m in the northern part, 5500-6700 m in the south) means that standard sonobuoy studies do not yield detailed information about sediment thickness or velocities (as discussed later).

From examination of 3.5 kHz echograms from all the available crossings (there was no 3.5 kHz data obtained during the Taft cruise), a regional sub-bottom reflector can be traced in the area and also several degrees north. This reflector varies in depth from 0-20 m, closely parallels topography, and is shown in Fig. 2. profile a. Also seen in Fig. 2 is a weak second reflector and regular hyperbolae tangent to the deepest subsurface reflector.

Figure 2 profile c shows an outcrop and the manner in which it affects the echo character in the abyssal hill region. The major internal reflector disappears or appears only irregularly; resolution on the 3.5 kHz echograms become poorer, and the reflection hyperbolae become large and irregular. The effect of the outcrop is localized, and it can be seen sediment laps up to the outcrop.

Fig. 2 profile b is taken from a transition zone travelling north from the fracture zone province into the abyssal hill region. The features described in the preceding paragraph are evident here; that is, resolution is good in the flat areas but is progressively poorer in hills of even modest size, 160 m. Fig. 2 profile d is from the fracture zone province. The sediment here is more opaque (at 3.5 kHz), hyperbolae are more irregular than those of the abyssal hill region, and the internal reflector is absent. Seismic reflection profiler records show that sediment thickness in the fracture zone is variable and, where ponding occurs, thicknesses exceed 160 m (see Fig. 3, profiles A and B near right side).

The deepest reflector observed on the profiler records appears as a gray/black region below the transparent layer. This gray region is probably about the same thickness as the transparent layer.

Item 1. (c) A 3.5 kHz pinger probe has been designed and built by ORE (Ocean Research Equipment, Inc.).

The prototype instrument was recently tested on board R/V Vema en route from Bermuda to New York. The value of general pinger probe studies has been summarized in a report by Ewing et al. (1973) using a 12 kHz energy source. A much greater penetration is anticipated with the low frequency (3.5 kHz) energy source. The tests were conducted in an area of abyssal depths between Bermuda and New York. Sub-bottom penetration of ~50 meters and several coherent sub-bottom reflectors were recorded with the bottom pinger while no coherent sub-bottom reflections could be recognized using a hull-mounted 3.5 kHz transducer. A 12 kHz bottom-pinger was also used simultaneously as part of the sediment coring operation, but no sub-bottom penetration was recorded at this frequency. Although more tests are needed to include a wider variety of bottom and sediment characteristics, our preliminary results indicate the 3.5 kHz pinger probe will be extremely useful in mapping the detailed acoustic properties of the upper 100m of the seafloor. Two additional instruments have also been fabricated, delivered to Lamont-Doherty and bench checked. One unit was partially defective and has been returned to O. R. E. for repair.

Item 2 Advances have been made using surface sonobuoy measurements for the determination of velocity and thicknesses of thin layers (Bryan, 1974). In the primary area of interest, the water depth to sediment thickness ratio is so large that even this revised technique offers marginal promise. We are now in the early stages of formulating experiments which will incorporate the 3.5 kHz bottom energy source and a deep hydrophone system to conduct a near bottom seismic refraction experiment. This should provide reliable information regarding the thickness and velocity characteristics of very thin sediment layers in deep water. The hydrophone signals would either be telemetered back to the ship using the standard conducting cables and recorded both on analog recorders and magnetic tape or alternatively be self-recording on the bottom. Sea tests are planned for early November, again in the North Atlantic and utilizing R/V Vema.

Item 3 Bottom contours within the study are still being evaluated and are likely to change; hence, these have not yet been digitized. However, using the bathymetric map of the Pacific Oceanographic Laboratory, we have digitized over two minute by two minute grid areas with a resolution of about 50 m throughout the area. Three dimensional prospective views of the bottom relief in the area are shown with various vertical exaggerations in Figures 4, 5, and 6.

Item 4 We have made progress on an archival search of that bathymetric data and have gathered together all the data from the NOO which includes the survey lines that were used in compiling the POLS map as well as other

Navy lines. We received some proprietary information about additional classified bathymetric data within the area (about 5 cruises) which may be made available if the need to know can be demonstrated.

REFERENCES

- Bryan, G. M., 1974, Sonobuoy Measurements in Thin Layers, in Physics of Sound in Marine Sediments, Loyd Hampton, Editor, p. 119-130: Plenum Press.
- Ewing, M., Embley, R. W., and Shipley, T. H., 1973, Observations of shallow layering utilizing the Pinger-probe echo-sounding system: Marine Geology, v. 14, M55-M63.
- Opdyke, N. D. and Foster, J. H., Paleomagnetism of cores from the North Pacific, 1970, in Geological Investigations of the North Pacific, James D. Hays, Editor, G.S.A. Memoir No. 126: Geological Soc. of America.
- Winterer, E. L., Ewing, J. I., et al., 1973, Initial Reports of the Deep Sea Drilling Project, Volume 17, Washington, D.C. (U.S. Government Printing Office).

Figure 1

RC 1303

20 KILOMETERS

10 NAUTICAL MILES

Figure 2

C

12-11 0600

- 0630 -

5625M -
3000FM

6000M -
3200FM 3.5 KHZ

RC 1303

d

12-08 2030

5250 M
2800FM

3.5 KHZ

20 KILOMETERS

10 NAUTICAL MILES

Figure 2

A 02-08 2130

04-08 0030

2800 M

3200 M

^
a

^
b

^
d

RC 1208

RC 1210

B 19-09 0930

21-09 1030

SECONDS

2 S209

R104

4

6

5250 M

6000 M

200 KILOMETERS

100 NAUTICAL MILES

Figure 3

Figure 4

Figure 5

Figure 6