Cruise Report for RC26-06

A Multichannel Seismic Investigation of DSDP Site 504B

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Prepared for: Ocean Drilling Program

National Science Foundation

6/26/85

Introduction

The multichannel seismic (MCS) reflection survey conducted during R/V CONRAD leg RC26-06 was intended to determine the oceanic crustal structure and the lateral variability of this structure and the oceanic Moho at DSDP Site 504B. Conducted between May 7-18, 1985, the MCS site survey investigated the crustal structure at Site 504B in terms of its setting relative to the Costa Rica ridge crest to the north, to the Panama and Ecuador fracture zones to the east and west, and to previously mapped east-west trending isochrons. Multichannel reflection data were also acquired along tracks which will permit an investigation of the variability of the crustal structure immediately adjacent to Site 504B. These data should allow the more accurate characterization of whether the drillsite is typical of the surrounding oceanic crust. Both high-resolution MCS images of the upper oceanic crust as well as laterally continuous MCS images of the oceanic Moho near Site 504B were obtained by using more than one type of large (~2000 cu. in.) airgun array on critical survey lines.

Wide-angle seismic refraction data (50 m shot spacing) were routinely collected using over 40 expendable fixed-gain military sonobuoys. At least 10 of these sonobuoys should provide valuable constraints on the total crustal velocity structure near Site 504B. An additional 10 sonobuoys will provide information concerning the lateral and vertical variability of the upper crust. Several sonobuoy records were acquired for which the seismic energy propagated through that portion of the crust already sampled at Site 504B. It is hoped that analysis of these refraction data relative to known drilling results from Site 504B will place additional constraints on marine refraction data elsewhere. Several of these refraction profiles show prominent shear-wave arrivals which will impose additional constraints on the velocity-depth structure near the drill site.

Cruise Narrative

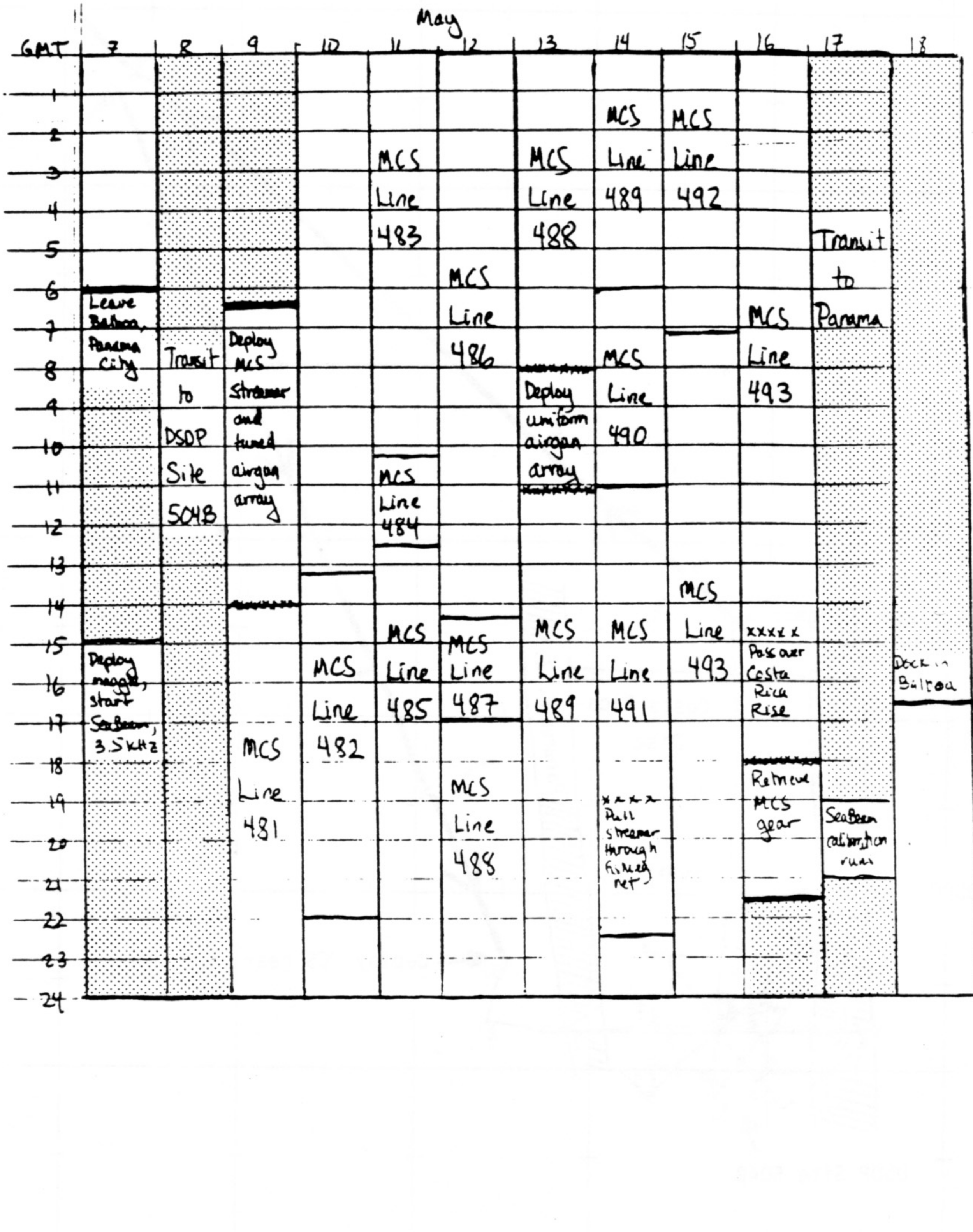
MCS reflection data were acquired during RC26-06 over a 7-day period beginning at 1400 Z on 9 May and ending at 1800 Z on 16 May. During this time the seas were calm and we experienced neither serious nor unexpected equipment downtime. Both the launching and recovery of the MCS gear were routine and were performed in less than the allocated time. These favorable working conditions allowed the acquisition of more seismic reflection profiles than previously anticipated. Multichannel seismic acquisition time was nearly equally divided between two different airgun arrays; the 4 x 466 cu. in. (uniform) array conventionally used on the CONRAD and the new tuned 4-element airgun array. The following section (and Table 1) presents a more detailed outline of the investigation completed during RC26-06. Figure 1 shows the entire trackline for the cruise.

0553Z	7 May	- Leave Balboa Pier, Panama and turn on gravimeter
1450Z	7 May	- Deploy magnetometer, turn on SeaBeam, 3.5 kHz - Transit to a point east of Panama Fracture Zone at latitude of DSDP Site 504B
0620-1400Z	9 May	- Deploy MCS streamer and tapered airgun array
1400Z 0802Z	9 May to 13 May	- Acquire MCS Lines 481-488 and sonobuoys #1-26
1108Z	13 May	- Deploy 4 x 466 cu. in. airgun array
1108Z 2128Z	13 May to 16 May	- Acquire MCS Lines 489-493 and sonobuoys #27-47
1900Z(approx)	14 May	- Pull MCS streamer through fishing net
2150Z(approx)	16 May	- Pass over DSDP Site 505
1440Z	16 May	- Pass over Costa Rica ridge crest
1800-2128Z	16 May	- Retrieve MCS streamer and airgun array at 3°30'N, 83° 47'W
2144Z	16 May	- Steam for Balboa Harbor, Panama with 3.5 kHz, SeaBeam magnetometer and gravity running
1900-2100Z	17 May	- Calibrate SeaBeam

TABLE 1.

RC26-06

A Multichannel Seismic Investigation of DSDP Site 504B



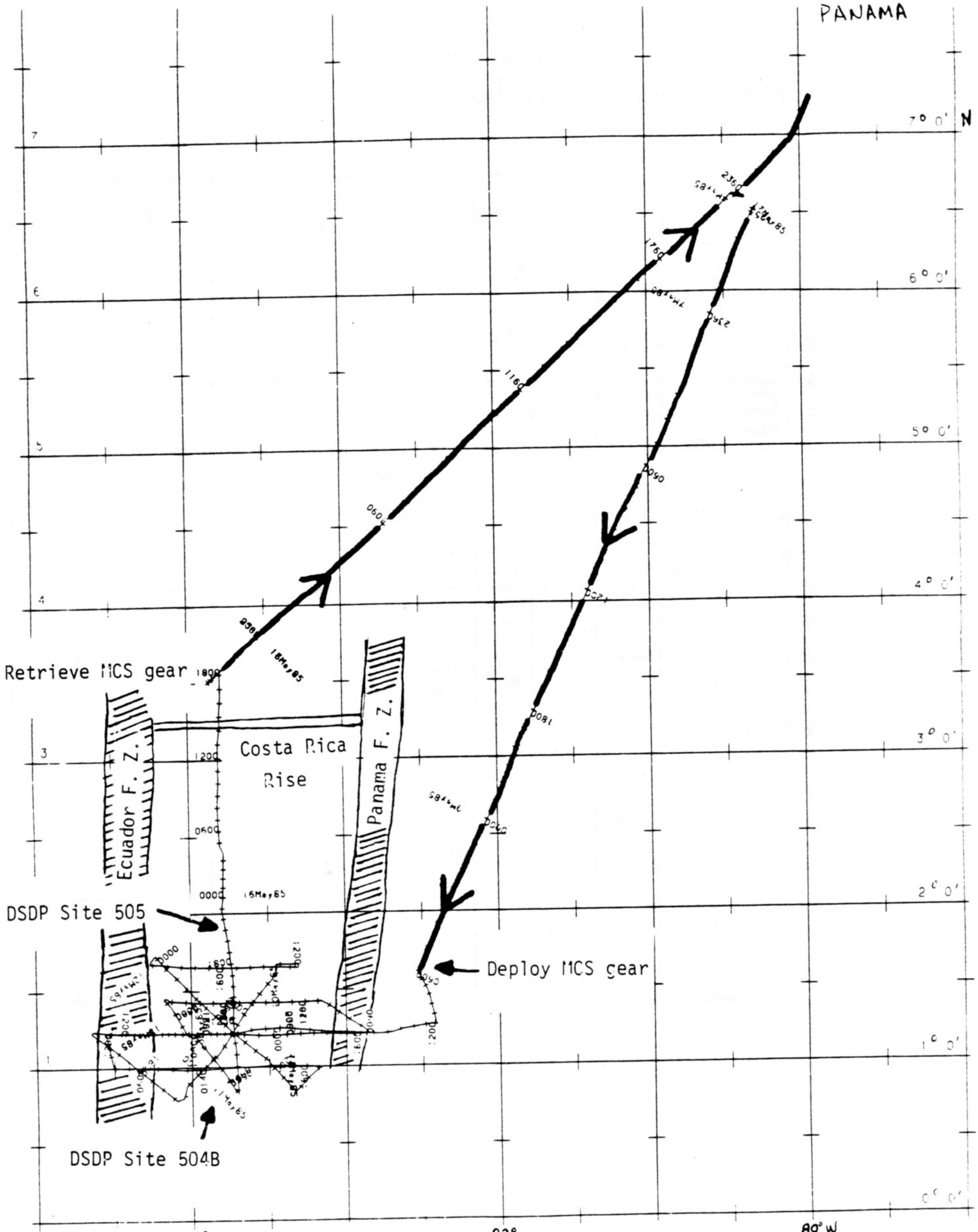


Figure 1. The trackline for RC2606 based upon the preliminary navigation. Segments of the trackline in which the R/V CONRAD was in transit only are marked as heavy solid lines. The trackline has tickmarks at hourly intervals and is annotated every 6 hours.

1500Z(approx) 18 May - Arrive Balboa Anchorage

1630Z(approx) 18 May - Arrive Balboa Pier, Panama

Collected Data

MCS Data

Nearly 1700 km of multichannel seismic (MCS) reflection profiles were surveyed in 7 1/6 days. Of these profiles one-half were acquired using the new tuned airgun array known to provide a broader-band source signature than the conventional uniform (4 x 466 cu. in.) airgun array. These MCS lines were primarily intended to provide higher-resolution images of the upper crust than is attainable from the uniform airgun array. The other half of the MCS profiles were collected with the uniform airgun array because this array routinely provides continuous reflections from the oceanic MOHO.

During the experiment the 48-channel streamer was configured at 2.4 km length, with a group interval of 50 m. The repetition rate of the source array of 20 seconds, coupled at the average towing speed of 5 kts, led to a nominal 50 m shot spacing and 24-fold coverage. Although the streamer was not quite properly balanced, it was towed deeper at the head of the streamer than at the tail (40 ft. versus 25 ft.), the galvanometer camera records show that the S/N levels were high, and quite acceptable for the entire investigation. Data were ditally recorded on a DFS-IV at 4 msec after being anti-aliased filtered at 62.5 Hz. Monitor records of a single-channel of the digitally recorded MCS data were made throughout the investigation on an EPC-type recorder as a realtime quality control check. Over 320 9--track tapes recorded at 1600 BPI were acquired. Galvanometer camera records were made periodically as needed to examine the recorded waveforms and noise characteristics in detail.

Figure 2 shows the location of the collected MCS lines relative to the DSDP Site 504B. One 220 km long E-W line running through DSDP Site 504B was collected twice, once with each airgun array (Lines 481 and 489), in order to provide a direct comparison of the vertical resolution of the two different airgun arrays. Preliminary visual comparison of the single-channel monitor records suggests that the signature of the tuned array is significantly less reverberant than that of the uniform array, although the exact character of the tuned array wavelet was difficult to ascertain with confidence. Thus, the monitor records for the tuned airgun array show significantly more detail in the upper crust. Until the MCS lines are processed, however, it is unknown whether the reflection amplitude of the Moho produced by the tuned airgun array is as large as that produced by the uniform airgun array.

These 220 km long E-W MCS lines also provide a critical test of a model for the segmentation of oceanic crust between fracture zones recently proposed by Mutter et al. (1985). The MCS lines cross the Ecuador Fracture Zone where the age offset is nearly 5 Ma and the Panama Fracture Zone where the age offset is currently unknown (Figure 3). At both fracture zones a thinner than normal crust is expected based on seismic refraction and reflection experiments performed at other fracture zones. If the segmentation model is correct the crust should systematically thicken away from the fracture zones and towards DSDP Site 504B. This thickening, according to the Mutter et al. (1985) model, is accomplished by thickening primarily in the lower crust, under a reflector they name "R". These E-W profiles between two fracture zones, thus provide a direct test of the Mutter et al. (1985) model.

The 330 km long N-S line through the DSDP Sites 504B and 505 and over the Costa Rica ridge crest (line 493) was conducted along a flow line to examine the age dependence of the crustal structure (Figure 3). The monitor records

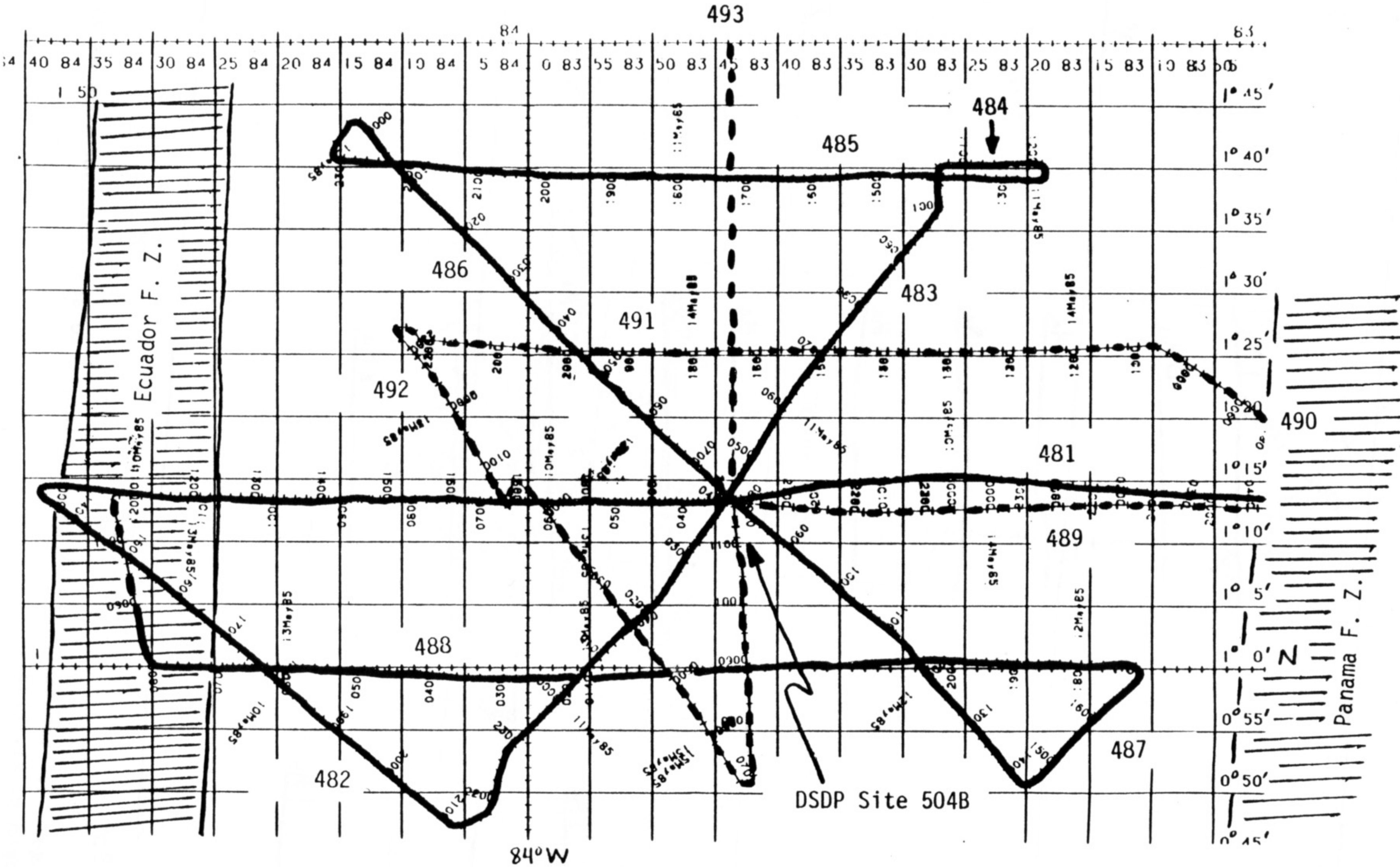


Figure 2. Location map showing the numbering scheme of MCS lines acquired during RC26-06 as well as their position relative to DSDP Sites and known tectonic elements. MCS lines collected using the tuned airgun array are shown as bold solid lines, MCS lines acquired using the uniform airgun array are shown as bold dotted lines.

line #5 wrong

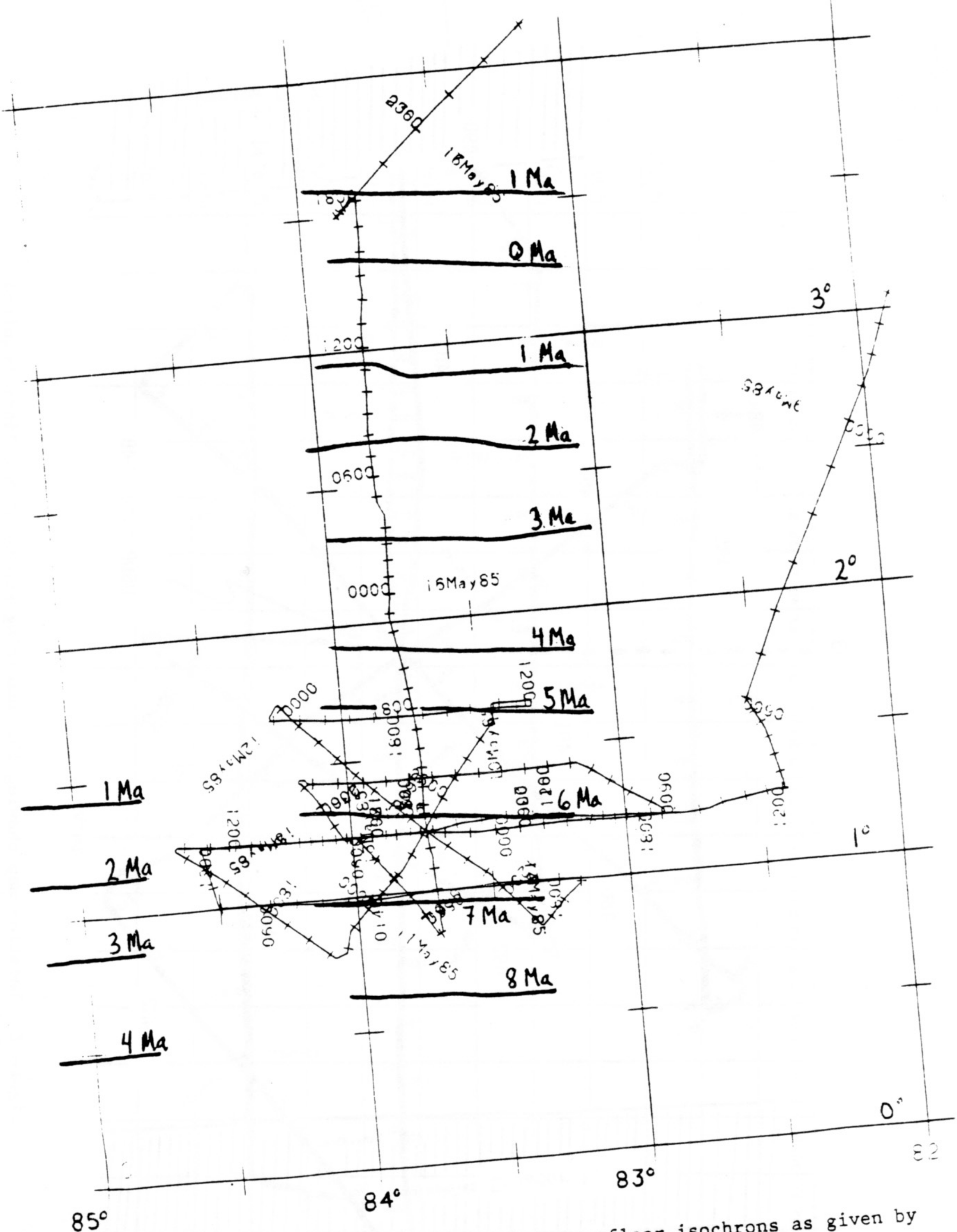


Figure 3. Locations of MCS lines relative to seafloor isochrons as given by Rogan et al. (1985).

collected during this profile show pervasive scattering from the rough seafloor. A subsidiary goal of this line was to obtain a crossing of the ridge crest in order to test for the presence of an axial magma at this moderately-fast spreading ridge.

Five crossings of DSDP Site 504B were made at four different azimuths (Figure 4). Four of these five MCS lines were navigated using GPS coverage; the SeaBeam coverage should allow the fifth MCS line to be navigated accurately relative to the other crossings.

Three additional, but shorter E-W MCS profiles, were collected. The E-W orientation was favored because it was noted early in the cruise that the sonobuoy records better satisfied the 1-D structural assumptions used to invert the data. These E-W oriented MCS lines nearly paralleled the seafloor isochrons (Figure 3). MCS line 485 was sited on seafloor approximately 5 Ma old, line 491 on seafloor 5.5-5.7 Ma old, lines 481 and 489 on seafloor 6.0-6.3 Ma old, and line 488 on seafloor 6.8-7.0 Ma old.

Sonobuoy Refraction Data

Over 40 expendable, military (SSQ-57A) sonobuoys having a fixed gain were collected during the experient. Mantle refractions were observed on at least 10 of these sonobuoys beyond 30 km range and thus will provide useful constraints on total crustal structure and thickness. Upper crustal refractions were observed on over half of the 47 sonobuoy refraction profiles collected which will be helpful in determining the lateral variability in the upper crustal structure near DSDP Site 504B. Several records show prominent shear wave arrivals which provide additional constraints on the interpretation of the crustal structure.

An attempt was made to deploy several sonobuoys at close range to DSDP 504B so that the seismic refraction energy would insonify the crust already sampled by the drillbit (Figure 4). Three sonobuoys were deployed at ranges designed to

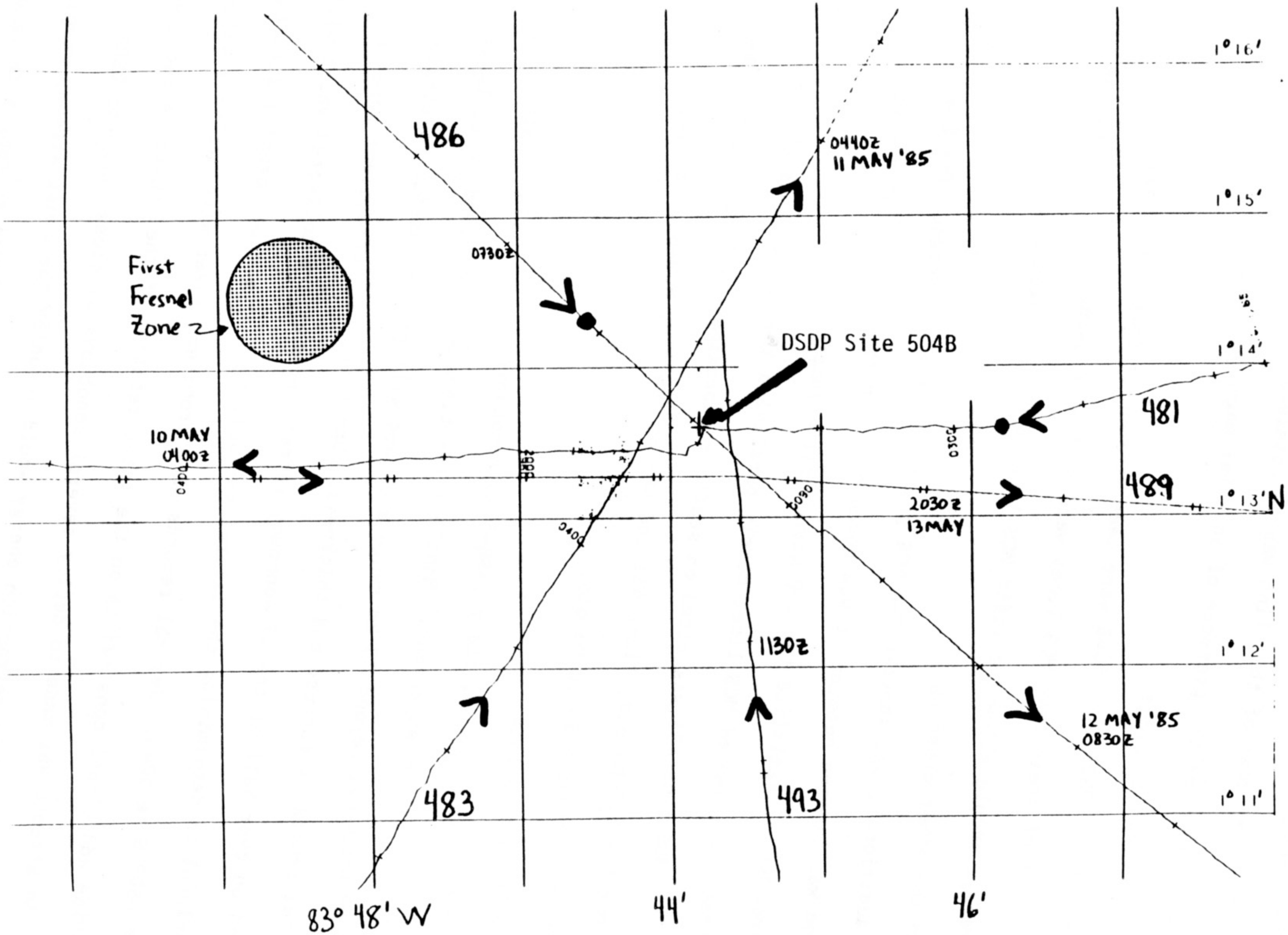


Figure 4. Expanded view of the location of the MCS lines (arrows show ship heading) and sonobuoys (solid dots show launch positions) acquired near DSDP Site 504B. Four of the five MCS lines shown here were acquired when GPS coverage was available. The shaded circle shows the size of the footprint (first Fresnel zone) of 10Hz seismic energy on the seafloor, showing that these lines insonified the DSDP Site.

sample the transition between layers 2 and 3, the other 2 were deployed at ranges designed to sample the base of the crust under the Site 504B. The wide-angle reflection data from these sonobuoys will provide a valuable comparison to the sonic well logging and oblique seismic experiments already performed at the drillsite.

SeaBeam Data

SeaBeam data were routinely collected during the entire cruise, although the line spacing is generally inadequate to construct bathymetric maps. These data were used to help provide a realtime estimate of the navigation, to confirm the tectonic location of the MCS lines, and to insure the reoccupation of key MCS lines.

These data document that the low bathymetric relief at DSDP Site 504B has a predominately E-W grain. Conversely, the SeaBeam data collected at the fracture zones show a complicated nonlinear ridge and valley morphology.

Equipment Performance

Multichannel Streamer

The depth-controlling birds were damaged on May 14 but functioned well throughout the cruise. The depth transducers #3 and #4 did not work throughout the cruise. The streamer was quiet even though head was ~20 ft. deeper than most of streamer. Channel 41 did not function for the entire cruise.

DFS IV

The DFS IV digital recorder functioned well throughout the cruise. One mino problem with one tape drive on Line 493 was quickly fixed.

A/G and air compressors

Tuned airgun array A/G #1 had firing line problems which caused some minor down time. In the 4x466 cu. in. airgun array A/G #2 had firing line problems causing some minor down time.

Sonobuoy receiver

During 13-15 May we experienced considerable difficulty in recording sonobuoys beyond the range at which first-arriving compressional waves break-out of the water wave (5-6 km). Because a number of different sonobuoy types were used (both fresh out of canisters and previously opened SSQ-41Bs and 57As) and because the sonobuoy antennas were checked and found to be in proper order two hypotheses are reasonable:

1) the sonobuoy receiver malfunctioned

2) poor atmospherics caused the loss of reception of the radio carrier frequency.

Regarding hypothesis 1 there were two independent sonobuoy recervers which both apparently showed the same problem so this hypothesis seems unlikely.

Regarding hypothesis 2 there was apparently some improvement in reception when the weather became overcast - the period of poor reception apparently coincided with a period of clear skies.

SeaBeam

The SeaBeam system functioned well and real-time maps were available throughout the cruise. A calibration of the SeaBeam system in an area of "flat" topography was made between 1900-2100Z on 17 May.

GPS

GPS coverage was available for approximately 9 hrs. daily - between 0200 and 1200 Z. GPS coverage was available for 4 of the 5 crossings of DSDP Site 504B (Figure 5).

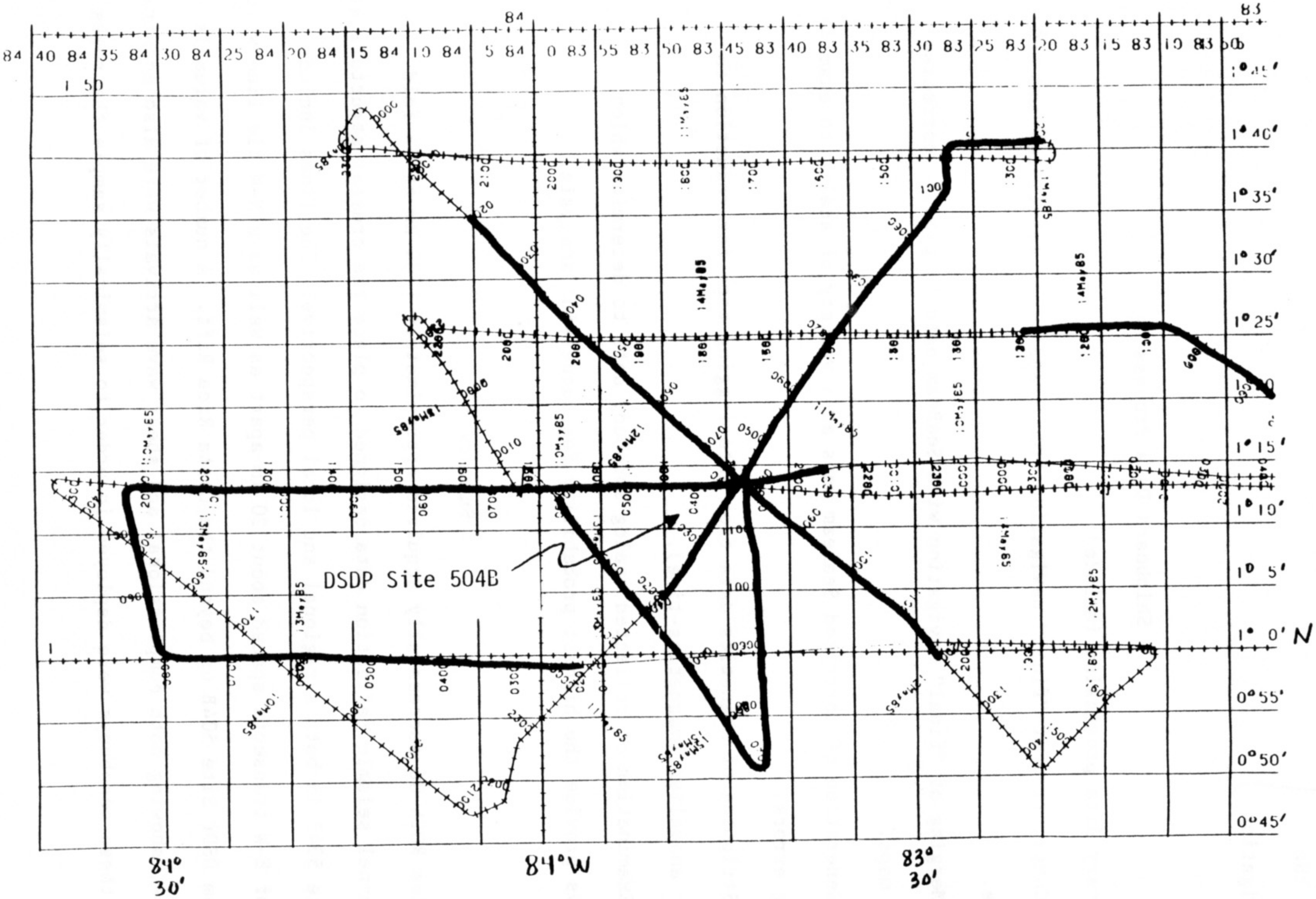


Figure 5. Trackline for RC26-06 showing the locations of GPS coverage (bold solid lines).

Data Logger and Underway Geophysics

Magnetics Gravity 3.5 kHz Navigation	All systems performed well.

Shipboard Data Processing

Preliminary data processing included:

1) Compilation of "final" navigation from Transit NAV satellites and GPS coverage.

2) Merging of "final" navigation with SeaBeam data to produce corrected SeaBeam maps.

3) Generation of corrected SeaBeam maps at a variety of scales to examine crossing errors.

4) Stripping of magnetics data from data logging tape for reduction to magnetic anomalies (magnetics-time).

5) Examination of collected analog sonobuoy data to determine which sonobuoys provide the highest probability for successful analysis.

Summary

Cruise RC26-06 successfully acquired approximately 1700 km of 24-fold multichannel seismic reflection data designed to place the crustal structure at DSDP Site 504B in both a regional and local perspective. The lines include a series of E-W transects spaced about 20 km apart as well as a N-W tie line which runs from DSDP Site 504B up beyond the Costa Rica Rift. A number of valuable sonobuoys, showing both compressional and shear wave arrivals were also acquired. Five of these sonobuoys were deployed in order to seismically sample the rocks already drilled at Site 504B. All equipment functioned well throughout the investigation and no time was lost due to equipment failure or poor weather.

References

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Acknowledgements

P. Lonsdale provided SeaBeam data from the Costa Rica rift. Karl Brenner prepared compilations of geophysical data from the DSDP Site Survey Data Bank at Lamont-Doherty Geological Observatory. M. Langseth provided unpublished watergun records from DSDP Site 504B. The able seamanship of the officers and crew of the R/V CONRAD made possible the timely acquisition of the MCS data. The technical competence of the science party was a pleasure to supervise and made the cruise a success. Funding for this work was provided by the Ocean Drilling Program at the National Science Foundation under contracts OCE84-10658 (WHOI) and OCE84-11980 (LDGO).

Appendix 1. Scientific Personnel

T.M. Brocher (WHOI)	-	Chief Scientist
J.C. Mutter (LDGO)	-	Co-Chief Scientist

G. Barth (LDGO) J. Collins (WHOI) V. Fry (WHOI) J. Lorenzo (LDGO) E. Vera (LDGO) C. Zehnder (LDGO)	Main Lab Watchstanders

J. Freitag (URI)	-	SeaBeam Technician
M. Iltzsche (LDGO)	-	A/G and air compressor mechanic
P. Lemmond (URI)	-	SeaBeam Technician
R. Mawiriwiri (LDGO)	-	A/G Technician
M. Rawson (LDGO)	-	Observer
F. Robinson (LDGO)	-	A/G Technician
J. Smith (LDGO)	-	Marine Science Co-ordinator
J. Stennent (LDGO)	-	MCS Technician

Appendix 2. MCS Lines

Line No.	Date (May)	Start time of line (GMT)	End time of line (GMT)
481	9-10	1406	1315
482	10	1315	2158
483	10-11	2158	1018
484	11	1018	1234
485	11-12	1234	0007
486	12	0007	1422
487	12	1430	1655
488	12-13	1710	0802
489	13-14	1109	0602
490	14	0602	1105
491	14	1105	2225
492	14	2243	0708
493	15-16	0708	1800