Kroenke, L. W., Berger, W. H., Janecek, T. R., et al., 1991
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4. UNDERWAY GEOPHYSICS[1]

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INTRODUCTION

Geophysical data were collected during Ocean Drilling Program (ODP) Leg 130. Of the 2767 nmi traveled during the round trip from and to Guam, we collected bathymetric data for 2753 nmi, magnetic data for 2741 nmi; and seismic reflection data for 863 nmi. Of the 62.7 total days spent at sea, 11.5 days were spent in transit.

Shipboard geophysical instruments included two precision echo-sounders (3.5 and 12 kHz), a proton precession magnetometer, single-channel seismic profilers, and a satellite navigation system. These instruments were maintained and operated by ODP marine technicians, in cooperation with the scientific party and the officers and crew of the *JOIDES Resolution.*

NAVIGATION DATA

Navigation data were collected in the underway geophysics lab by a Magnavox 1107 satellite navigation system (SATNAV). We obtained the ship's positions with this system during the entire 62.7 days at sea and received 1702 satellite fixes during the cruise (Table 1, back pocket microfiche).

A plot of the general navigation for Leg 130 is shown in Figure 1. This plot was generated from satellite navigation and course- and speed-change information. These data were compiled from the shipboard bridge log, the underway geophysical log, and the satellite navigation sheets. Course and speed information came from the digital-seismic tape headers. The Geological Data Center at Scripps Institution of Oceanography produced this navigation compilation.

BATHYMETRIC DATA

Bathymetric data were obtained with 3.5-kHz (EDO-248C recorder system) and 12-kHz (Raytheon recorder system) echo-sounders. We operated both systems with a CESP-III correlator system to improve signal strength. The quality of the recorded data was poor when the ship traveled at speeds greater than about 8 kt. A summary of the bathymetric data collected during Leg 130 is displayed in Figure 2.

MAGNETIC DATA

A Geometrics 801 proton-precession magnetometer was towed approximately 300 m astern during transits between sites and during the transits from and to Guam. The data were recorded in analog format on a graphics recorder, digitally in the header of the seismic tapes and manually every 5 min in the underway geophysics log. The magnetic field values were reduced to anomaly values by subtracting the 1985 IGRF value. A summary of the results is shown in Figure 2.

SEISMIC REFLECTION DATA

At least one single-channel seismic line was run across each site before it was occupied. Single-channel seismic lines also were run during several of the transits between sites to provide seismic stratigraphic continuity across the Ontong Java Plateau.

The seismic sources used aboard the *JOIDES Resolution* during Leg 130 usually consisted of two synchronized 80-in.[3] Seismic Systems Inc. water guns firing at a 10-5 rep rate. The seismic receiver, deployed from the fantail and towed approximately 300 m behind the vessel, consisted of a 100-m-long Teledyne model 178 streamer, containing 60 active sections. Towing depth was usually 10 m and was set by weighting the streamer and by adjusting the ship's speed. Hydrophone elements were combined to produce a single signal, which was recorded on both analog and digital records.

Seismic data were displayed in real time in analog format on two EDO-550, dry-paper recorders, using only the streamer, amplifiers, and two band-pass filters (Table 2). These data also were recorded digitally using a supermicro 561 Masscomp computer, which functioned as the central unit for recording, processing, and displaying the data. Raw data were recorded on nine-track tapes with a Cipher drive, using SEG-Y format and a density of 1600 bpi. The header for each shot contains the following information: shot number, date, time, wind speed, wind direction, ship's speed, ship's gyro heading, cumulative distance traveled, streamer and gun depth, and information on the timing of the guns.

Digital data were processed and displayed in real time on a 15-in.-wide Printronix, high-resolution graphic printer (160 dots/in.). The digital profiles were reprocessed on site using the Masscomp computer and the SIOSEIS processing system. The reprocessed lines were displayed on a 22-in. Versatec electrostatic plotter (200 dots/in.).

SINGLE-CHANNEL SEISMIC REFLECTION PROFILES

A map view of the bathymetry of the Ontong Java Plateau traversed on Leg 130 is shown together with the ship's track in Figure 3. The single-channel seismic reflection profiles with their corresponding track segments are shown in Figures 4 through 31. The digital data were analog, band-pass filtered (25–250 Hz) and collected at a 1-ms digitization rate. The quality of the data is somewhat variable as it depended on the ship's speed and sea conditions. Further filtering did not improve the quality of the digital data, so additional filtering was not applied to the reprocessed data. A three-trace, center-weighted running mix and automatic gain control were applied to all traces. Bad traces were deleted. The signal was muted to the seafloor on all of the profiles. The parameters used in collecting and reprocessing the seismic data are listed in Table 2. We collected 10 seismic lines during the cruise, as follows.

Seismic Line 1

Seismic Line 1 was collected across Site 807 en route to Site 803 (Julian Day [JD] 026/1117 Universal Time Coordinated

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[1] Kroenke, L. W., Berger, W. H., Janecek, T. R., et al., 1991. *Proc. ODP, Init. Repts.,* 130: College Station, TX (Ocean Drilling Program).

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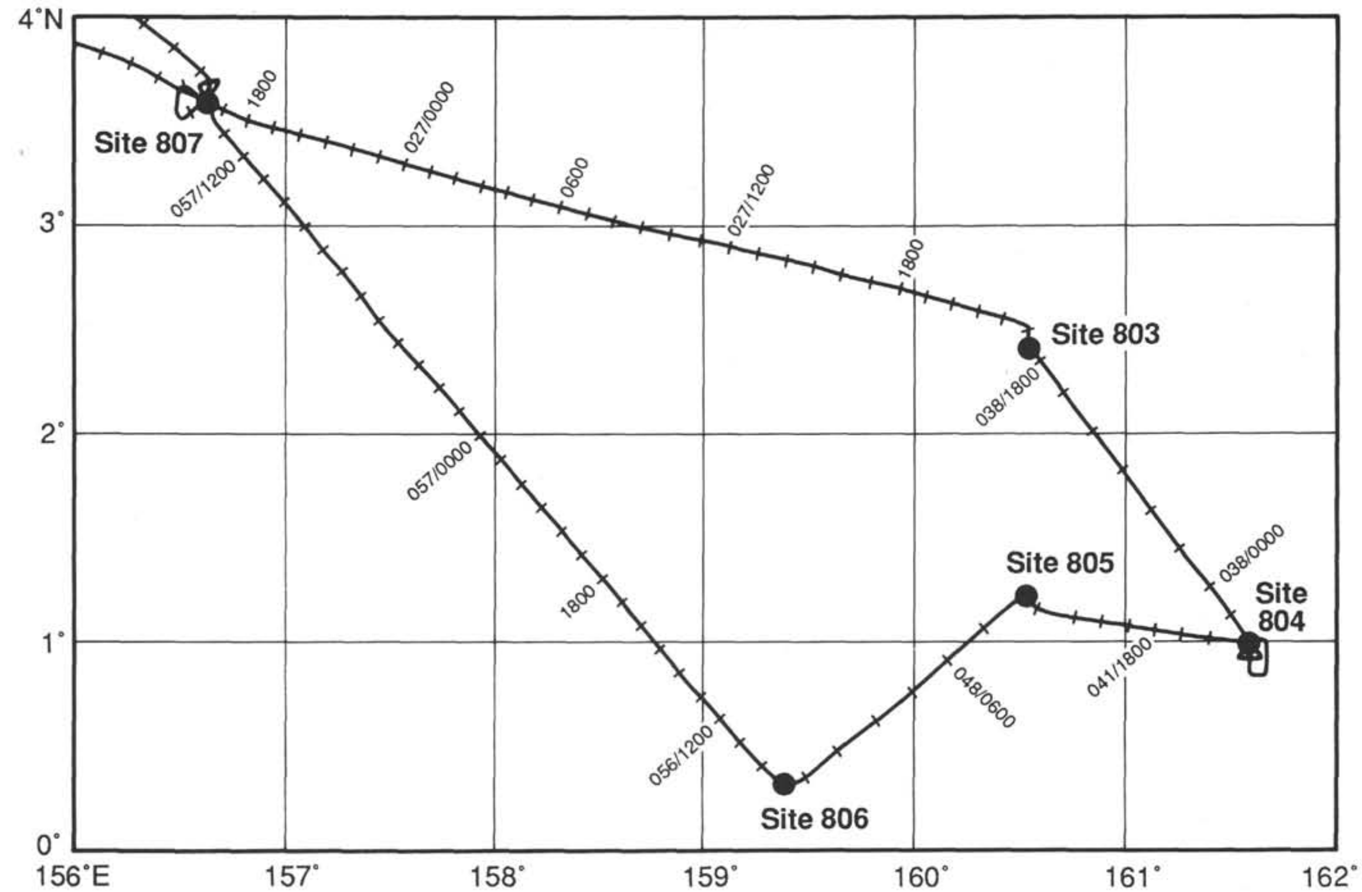

Figure 1. Leg 130 track line on the Ontong Java Plateau. The locations of Sites 803 through 807 are also shown.

[UTC] to JD 026/1737 UTC). A short survey (Fig. 4) was conducted at this site, which had not been covered by the ROUNDABOUT site survey (see Mayer et al., this volume). Water depth ranges from 2700 to 2775 m and the thickness of the sedimentary section ranges from 0.9 to 1.3 s (two-way traveltime [twt]) on this profile. The processed digital seismic profiles (Figs. 5 and 6) clearly show the drilling target, a small basement depression that had been identified on a 1975 analog seismic profile (*Thomas Washington,* EURYDICE 9 Cruise). Thickening of the sedimentary section occurs mid-section (about 4.2 s) at the site and at the base of the section in the basement depression. The data do not resolve the sedimentary section very well, however, because the eel was towed too deep (15–18 m) and at a slow speed (about 7 kt), resulting in a low-frequency-dominated record.

Seismic Line 2

Seismic Line 2 was collected during the transit from Site 807 to Site 803 (JD 026/1737 UTC to JD 027/1900 UTC). The ship's speed was greater during this transit (about 8.5 kt) than during the survey of Site 807; thus, the eel rode at a shallower depth, increasing the frequency content and the resolution of the data. The ship's track for Seismic Line 2 is shown in Figure 7, and the processed digital-seismic profiles are presented in Figures 8, 9, 10, 11, and 12. This long seismic profile was collected to tie the seismic stratigraphy of Site 807 to that of the other sites, which had been more thoroughly surveyed. Water depth on this profile ranges from 1875 to 3340 m, and the thickness of the sedimentary section from 0 to 1.05 s.

Most of the sedimentary section revealed by Seismic Line 2 was undisturbed, with uniform, flat-lying reflectors. However, several areas were highly disturbed, characterized by pinch and swell of layers, surface erosion, and internal deformation. Some portions of the line have numerous mid-section reverberant layers (MSRs), which are especially common near the east flank of a small rugged seamount (approximately 30 km across and 1100 m high) located near JD 027/1630 UTC (Fig. 12). The MSRs occur at a common depth in the section (0.25–0.3 s below sea floor [sbsf]) and appear to extend out from the flank of the seamount. Their acoustic character is also quite similar to that of the basement, leading us to infer that they might be sills or extrusive lava flows.

Alternatively, the MSRs may be diagenetically altered layers ("hardgrounds") created by fluid circulation. The MSRs also occur near three small acoustically transparent, diapirlike structures that are located between JD 027/0130 UTC and JD 027/0400 UTC (Figs. 8 and 9). The largest of these features, which we tentatively interpret as mud volcanoes, is about 3.5 km across and 375 m high. If the MSRs are recently intruded sills, the mud volcanoes may have been created by hydrothermal remobilization of sediment.

Seismic Line 3

Seismic Line 3 was collected on the approach and survey of Site 803 (JD 027/1900 UTC to JD 028/0133 UTC). The ship's track for Seismic Line 3 is shown in Figure 13, and the processed digital-seismic profiles are presented in Figures 14 and 15. The survey crossed the site from north to south and then

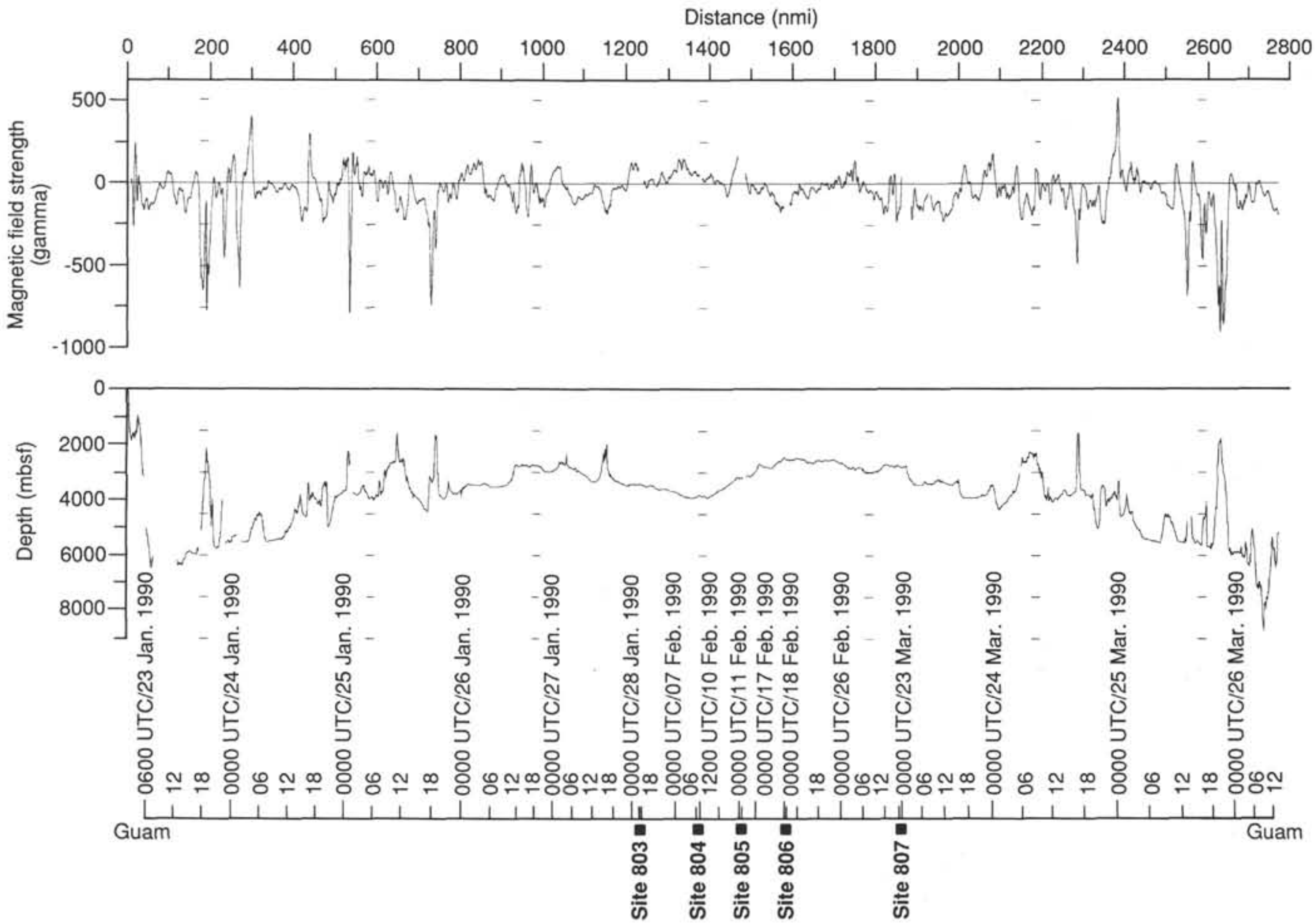

Figure 2. Summary of magnetic anomaly and bathymetry data for Leg 130.

approached the site from the east along one of the ROUNDABOUT site survey profiles. Water depth on this profile ranges from 3340 to 3490 m and sediment thickness from 0.65 to 0.75 s. The section is undisturbed near the site but very disturbed elsewhere with pinching and thinning of layers, MSRs, and deformation. The beacon was dropped at JD 028/0128 UTC, as the ship came off a prominent MSR layer and passed over an undisturbed section.

The depth of the eel was greater than normal because the ship reduced speed during the survey. This resulted in a low-resolution, low-frequency-dominated record.

Seismic Line 4

Seismic Line 4 was collected on the approach and survey of Site 804 (JD 038/0103 UTC to JD 038/0606 UTC). The ship's track for Seismic Line 4 is shown in Figure 16, and the processed digital-seismic profiles are presented in Figures 17 and 18. The survey was designed to cross two pre-existing profiles from the ROUNDABOUT site survey. The ship crossed the site from north to south and then approached the site from the east. Water depth on this profile varies from 3825 to 3925 m, and the thickness of the sedimentary section ranges from 0.25 to 0.65 s. The main structural feature of the site is a narrow northwest-striking basement depression that has a basement relief of about 0.3 s. The section is very disturbed, consisting of rough basement topography, faults and folds of the graben flanks, and evidence of sliding and slumping in the graben. These slump deposits can be identified in the record by their semitransparent, "chaotic" acoustic character. The site was located in the center of this small graben structure where the section appeared to be the least disturbed.

After our experience with the earlier surveys, the eel towing depth was reduced and the survey speed increased slightly, resulting in a higher frequency record and improved resolution.

Seismic Line 5

Seismic Line 5 was a post-site survey of Site 804 (JD 041/1205 UTC to JD 041/1833 UTC) (Fig. 16). The line was run to provide more information on the area around Site 804, an alternate site that had not been surveyed extensively by the ROUNDABOUT site survey. The ship left the site heading southwest, turned to the east, passed along the axis of the narrow graben drilled at Site 804, and headed northwest on the way to Site 805.

Water depth along this profile ranges from 3600 to 3915 m, and sediment thickness ranges from 0.35 to 0.65 s. This profile looks very similar to Seismic Line 4 in the area near the site. The section becomes significantly more compressed out of the graben and away from the site to the northwest (Fig. 19). The section gradually thickens again with decreasing water depth on the transit to Site 805 (Fig. 20). This thickening occurs throughout the section, but it appears to be greatest at the top of the section (Fig. 21).

Table 2. Seismic data, real-time recording, and reprocessing parameters.

Line Number	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10
Location	Site 807	Transit	Site 803	Site 804	Transit	Site 805	Site 806	Transit	Site 807	Transit
Time (UTC)										
Start	026/1117	026/1737	027/1900	038/0103	041/1205	041/1833	048/0950	056/0915	057/1045	082/0030
End	026/1737	027/1900	028/0133	038/0606	041/1833	042/0134	048/1100	057/1045	057/1630	082/2202
Shotpoints										
Start	5050	6951	14559	541	59	1972	414	1	7657	9381
End	6950	14558	16509	2055	1971	3609	770	7656	9380	17013
Distance (nmi)	45	205	48	87	45	42	9	191	40	151
Source	2 80 in.^{3}	2 80 in.^{3}	2 80 in.^{3}	2 80 in.^{3}	2 80 in.^{3}	2 80 in.^{3}	2 80 in.^{3}	1 80 in.^{3}	1 80 in.^{3}	1 80 in.^{3}
(water guns)								1 200 in.^{3}	1 200 in.^{3}	1 200 in.^{3}
Streamer	Port	Port	Port	Port	Port	Port	Port	Port	Port	Port
Analog 1:										
Range (s)	0–10	0–10	0–10	0–10	4–7	4–7	3–6	3–6	3–6	3–6
High cut (Hz)	150	150	150	150	150	150	150	150	150	150
Low cut (Hz)	30	30	30	30	30	30	30	30	30	30
Gain (dB)	40	40	40	40	40	40	40	40	40	40
Analog 2:										
Range (s)	2–8	2–8	2–8	2–8	0–10	0–10	0–10	0–10	0–10	0–10
High cut (Hz)	150	150	150	150	150	150	150	150	150	150
Low cut (Hz)	30	30	30	30	30	30	30	30	30	30
Gain (dB)	40	40	40	40	40	40	40	40	40	40
Digital:										
Data window (ms)										
Length	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
From	3000	Varied	4000	4000	4000	4000	3000	3000	3000	3000
To	8000	Varied	9000	9000	9000	9000	8000	8000	8000	8000
Filter										
High cut (Hz)	250	250	250	250	250	250	250	250	250	250
Low cut (Hz)	25	25	25	25	25	25	25	25	25	25
Mix										
Traces	3	3	3	3	3	3	3	3	3	3
Weights	131	131	131	131	131	131	131	131	131	131
AGC										
Window (ms)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

Seismic Line 6

Seismic Line 6 (JD 041/1833 UTC to JD 042/0134 UTC) was collected on the transit to, as well as on, the survey of Site 805 (Fig. 22). Only a single crossing of the site was planned, as it had been well surveyed previously. A beacon failure on the first pass, however, led to a second crossing of the site.

Water depth along this profile ranges from 3170 to 3600 m, and the thickness of the sedimentary section ranges from 0.65 to 0.8 s. The section is moderately disturbed, with pinching of layers throughout the section, deformation, and surface erosion channels (Fig. 23). Site 805 was located west of a zone of surface erosion in an area of slightly thicker sediments.

The change in character of the seismic record at about 2217 UTC (Fig. 23) is the result of a decrease in ship speed.

Seismic Line 7

Seismic Line 7 (JD 48/0950 UTC to JD 48/1100 UTC) was collected during the site survey of Site 806 (Fig. 24). Water depth on this profile ranges from 2475 to 2620 m, and the thickness of the sedimentary section is 1.00–1.03 s. The section is uniform with no indication of significant thickening or thinning of layers (Fig. 25). A small surface erosion channel occurs about 7 km east-northeast of the site (about 1006 UTC; Fig. 25). Although there is a distinct slope to the bottom (and the seismic section) and the seismic layering is undulating, there is no obvious seismic evidence of slumping or internal deformation of the section at the site.

Seismic Line 8

Seismic Line 8 (JD 056/0915 UTC to JD 057/1045 UTC) was collected on the transit from Site 806 to Site 807 (Fig. 26). This long profile was collected to help tie together the seismic stratigraphy of the individual sites. This line also was used to test one of the new 200-in.^{3} HAMCO water guns, which was towed in conjunction with one of the 80-in.^{3} guns. The increased power of the larger gun, particularly in the low frequencies, made a definite improvement in our ability to separate the basement reflector from the heavy reverberations that occur just above it. At the same time, the 80-in.^{3} gun provided the higher frequency energy that resolves the sedimentary layering.

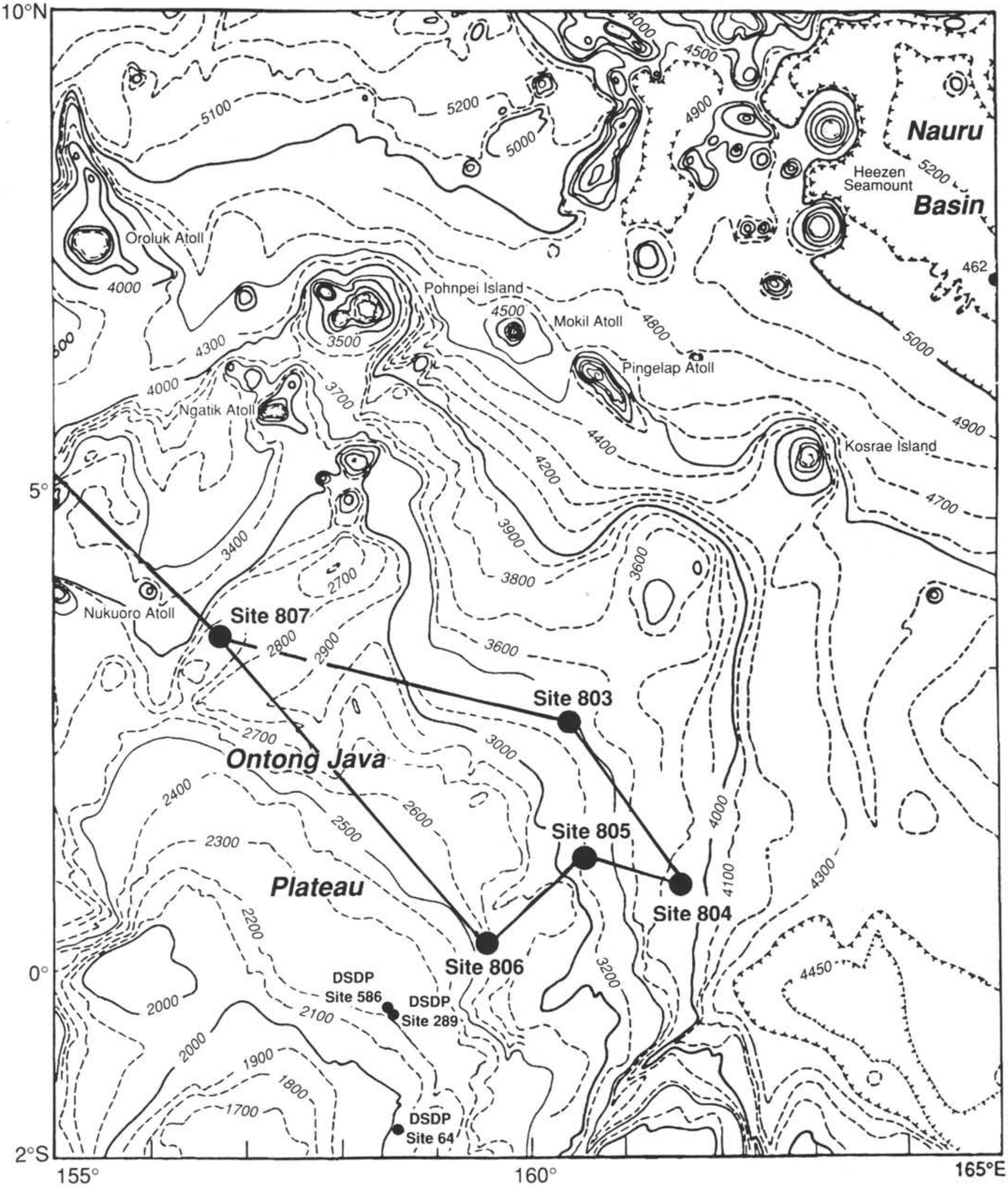

Figure 3. Bathymetric map of the Ontong Java Plateau (Mammerickx and Smith, 1985) with Leg 130 ship track and drill sites.

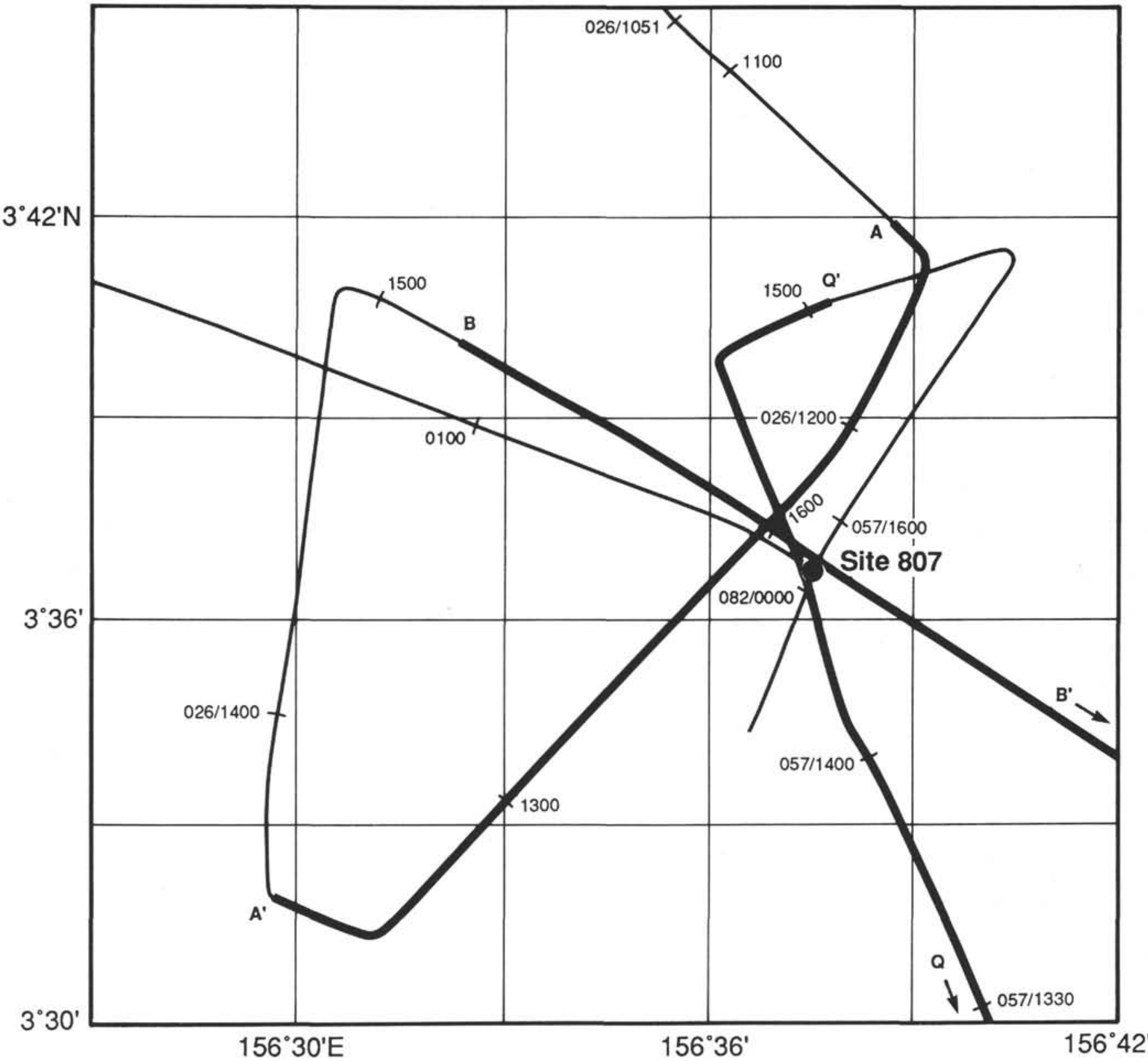

Figure 4. Ship track for single-channel Seismic Lines 1 (JD 026) and 9 (JD 057), including the locations of profiles A-A′, B-B′, and Q-Q′.

Water depth on this profile ranges from 2475 to 3008 m, and the thickness of the sedimentary section ranges from 0.9 to 1.16 s. Figure 27 shows a portion of this seismic line (P-P′; Fig. 26). The undisturbed stratigraphy shown in Figure 27 is typical of the line as a whole. The increased power of the larger water gun is evident at depth where the heavy reverberations that typically occur just above basement (see earlier seismic profiles) have been resolved into a crisp upper horizon and a heavy, sharp basement reflection.

Seismic Line 9

Seismic Line 9 (JD 057/1045 UTC to JD 057/1630 UTC) was collected on the site survey of Site 807 (Fig. 4). The 200-in.^{3} water gun also was used with one of the 80-in.^{3} guns on this line. Water depth on this profile ranges from 2700 to 2830 m, and the thickness of the sedimentary section ranges from 0.92 to 1.2 s. The small basement depression drilled at Site 807 is shown near the center of Figure 28. Although the deep reflectors in the depression are less reverberant and are more clearly defined, the overall quality of the section and the resolution of the upper stratigraphy is much poorer with this water gun combination (Figs. 5, 6, and 28).

Seismic Line 10

Seismic Line 10 (JD 082/0030 UTC to JD 082/2202 UTC) was collected during the early part of the transit to Guam following drilling at Site 807 (Fig. 29). Water depth on this profile ranges from 2775 to 3750 m, and the thickness of the sedimentary section is 0.0–1.2 s. The water depth increases sharply by

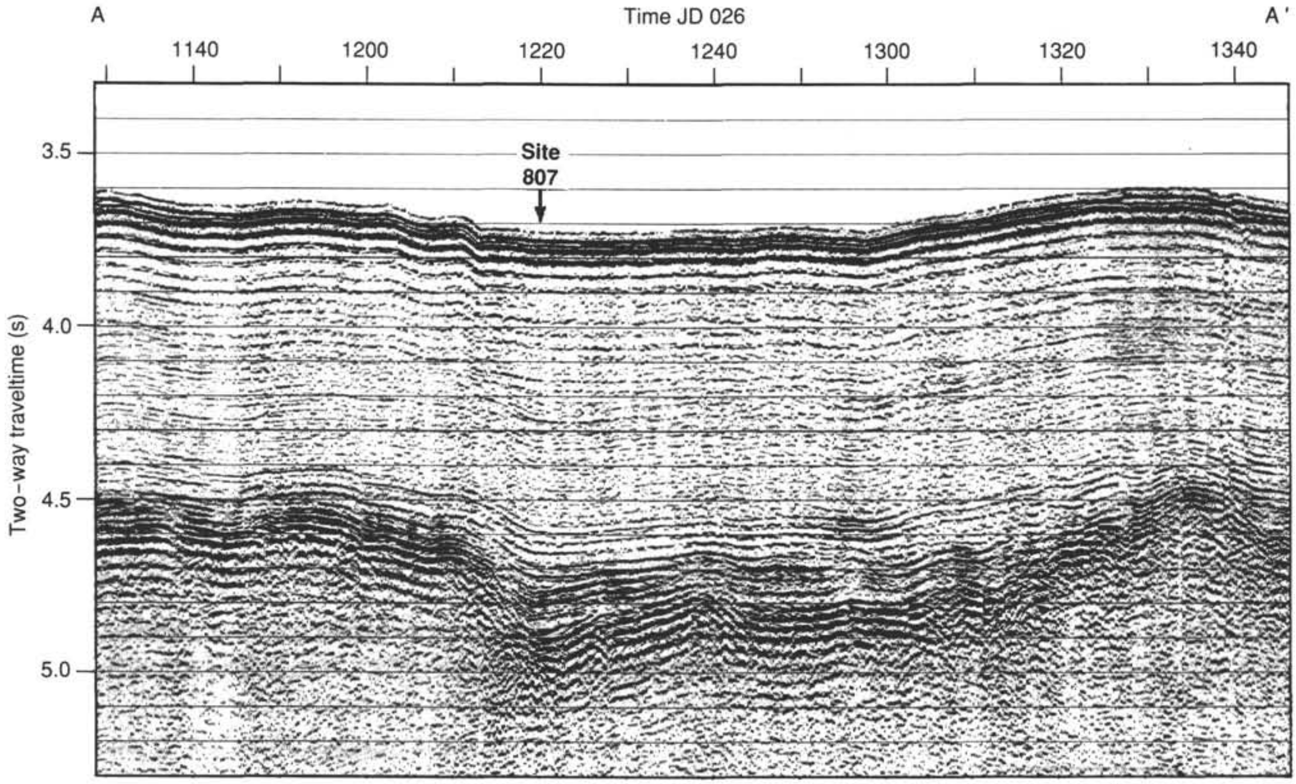

Figure 5. Profile A-A′ of processed digital single-channel seismic reflection Line 1 showing a north-south crossing of the small basement depression drilled by Site 807. The section thickens in the middle (about 4.2 s) and in the basement depression (about 4.8 s). JD = Julian Day throughout.

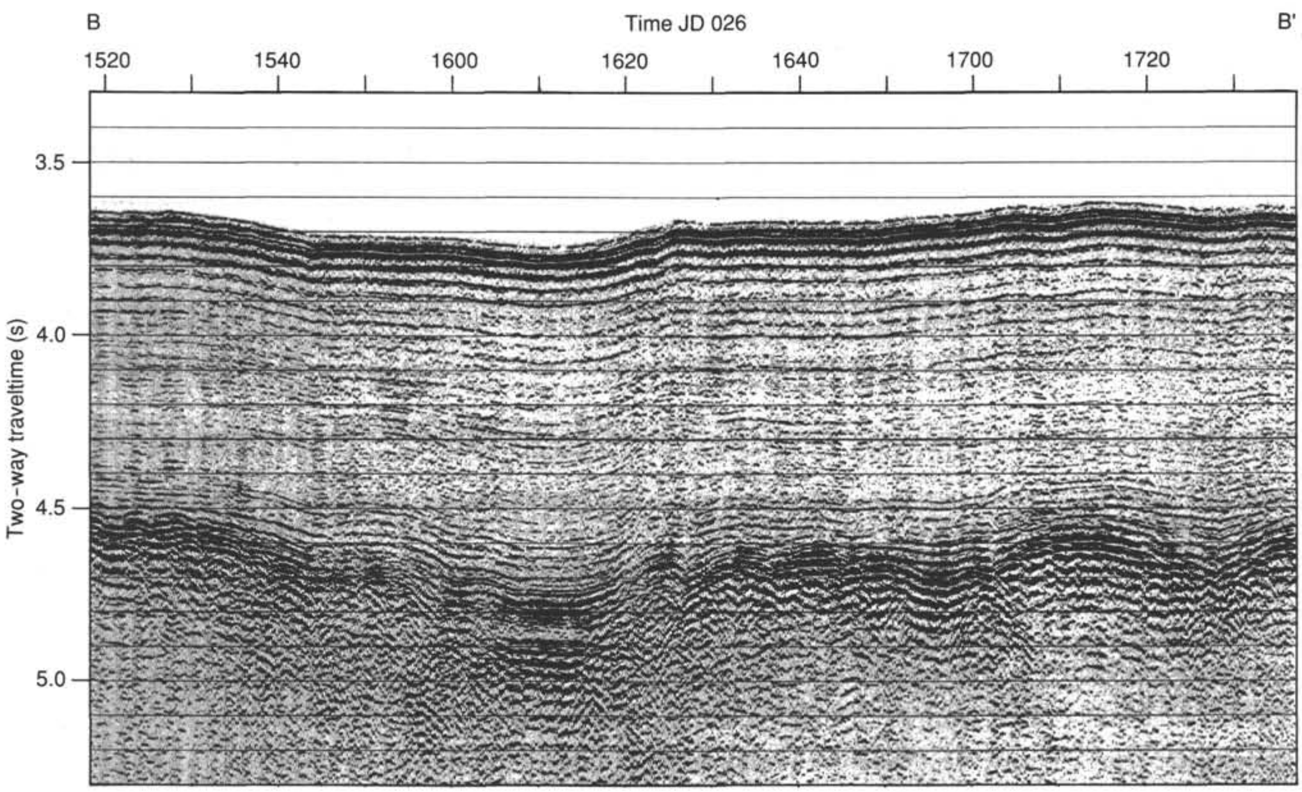

Figure 6. Profile B-B′ of processed digital single-channel Seismic Line 1 showing a northwest-southeast crossing of Site 807. The small basement depression at about JD 026/1615 UTC is much narrower on this crossing than on the north-south crossing (A-A′).

about 700 m just to the north of Site 807. Much of this change results from the thinning of the upper part of the section. The sedimentary section increases again farther north because of thickening in the lower part of the section (Fig. 30). Horst and graben structures appear in the basement as the profile approaches the northern edge of the Ontong Java Plateau (Fig. 31). A sharp increase in water depth of about 550 m at JD 082/1515 UTC marks the northern edge of the Ontong Java Plateau. To the north of this drop-off, the section thickens to more than 1.2 s and internal reflectors become highly distorted.

REFERENCES

Mammerickx, J., and Smith, S. M., 1985. *Bathymetry of the North Central Pacific*: Boulder, CO (Geological Society of America), Map and Chart Ser., No. MC-52.

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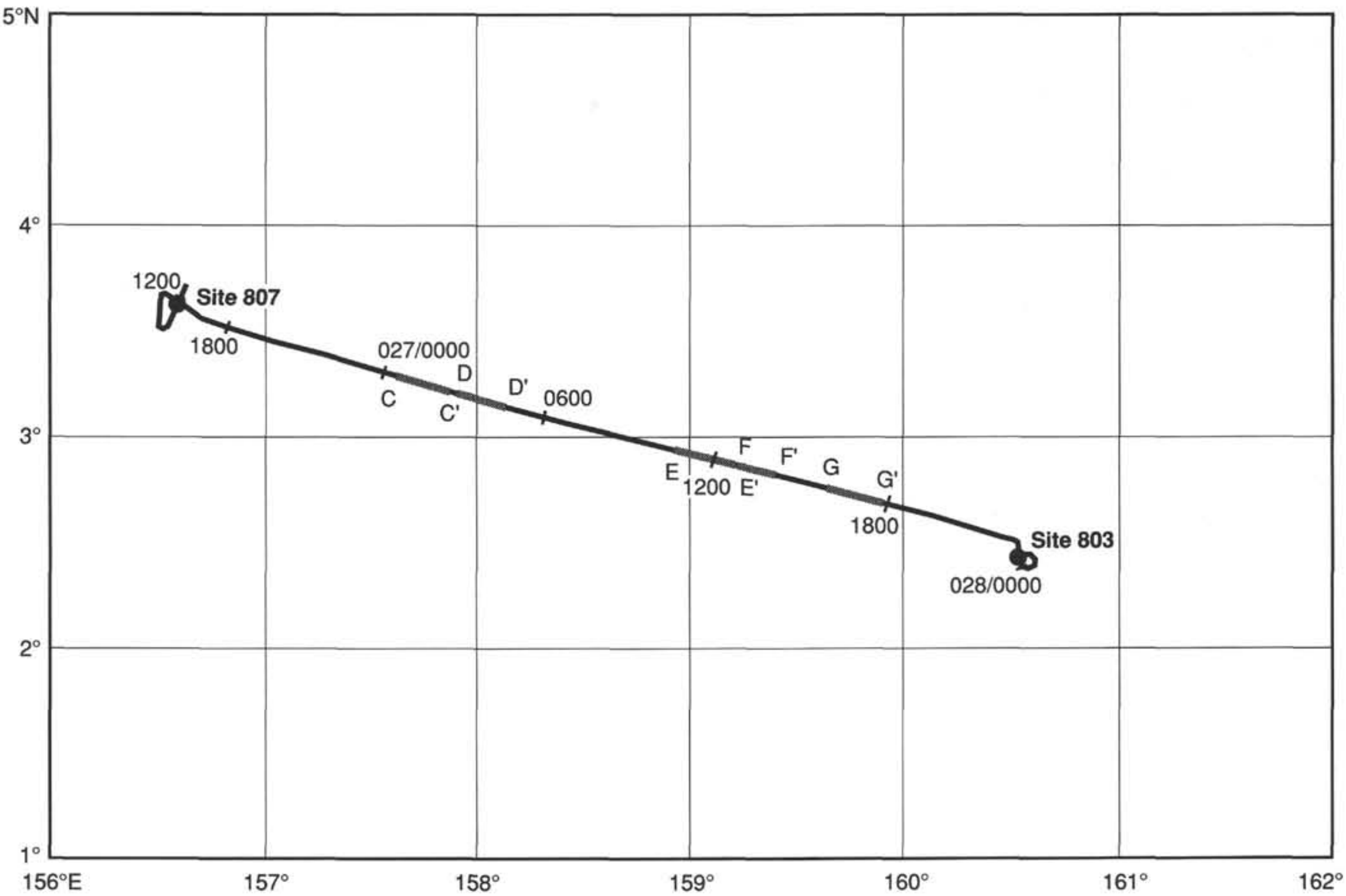

Figure 7. Ship track for single-channel Seismic Line 2, showing the locations of profiles C-C′, D-D′, E-E′, F-F′, and G-G′.

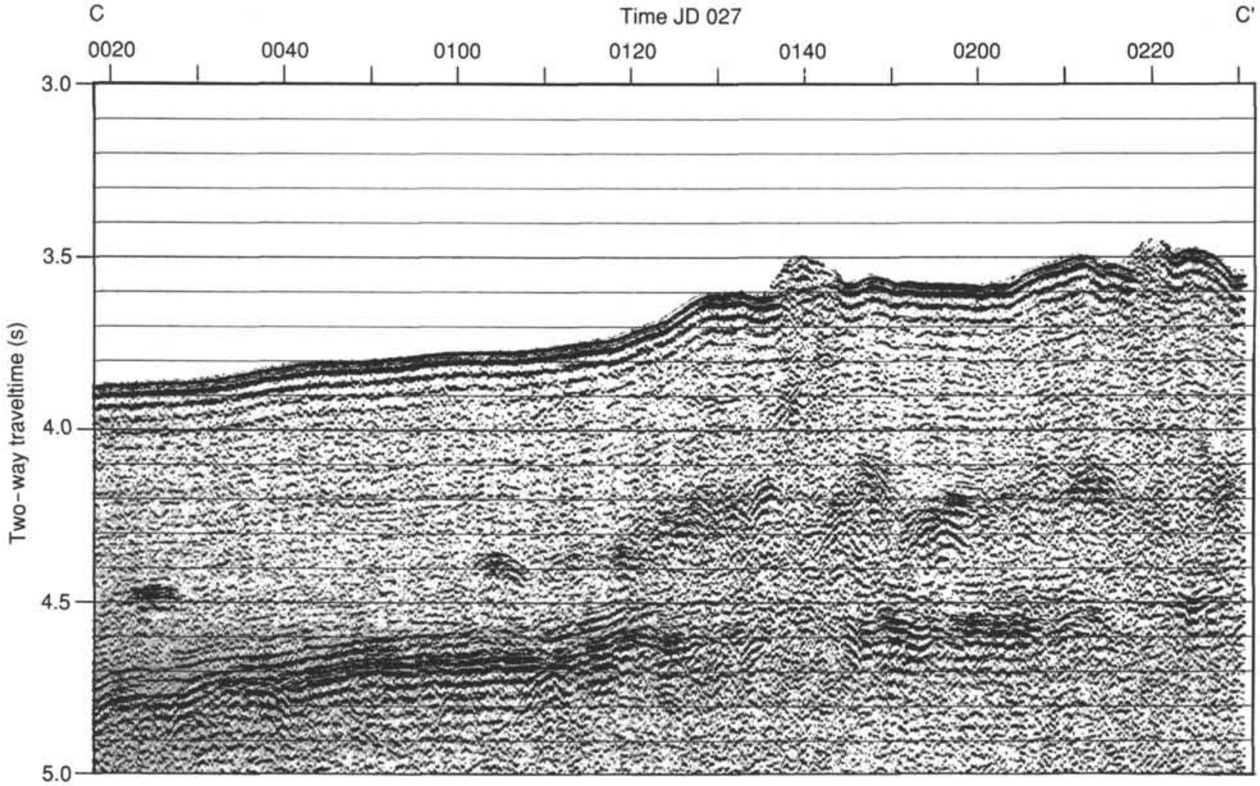

Figure 8. Profile C-C′ of processed digital single-channel Seismic Line 2 showing two of the small diapirlike structures associated with mid-section reverberant layers (MSRs). The transparent seismic character of these features leads us to interpret them as mud volcanoes.

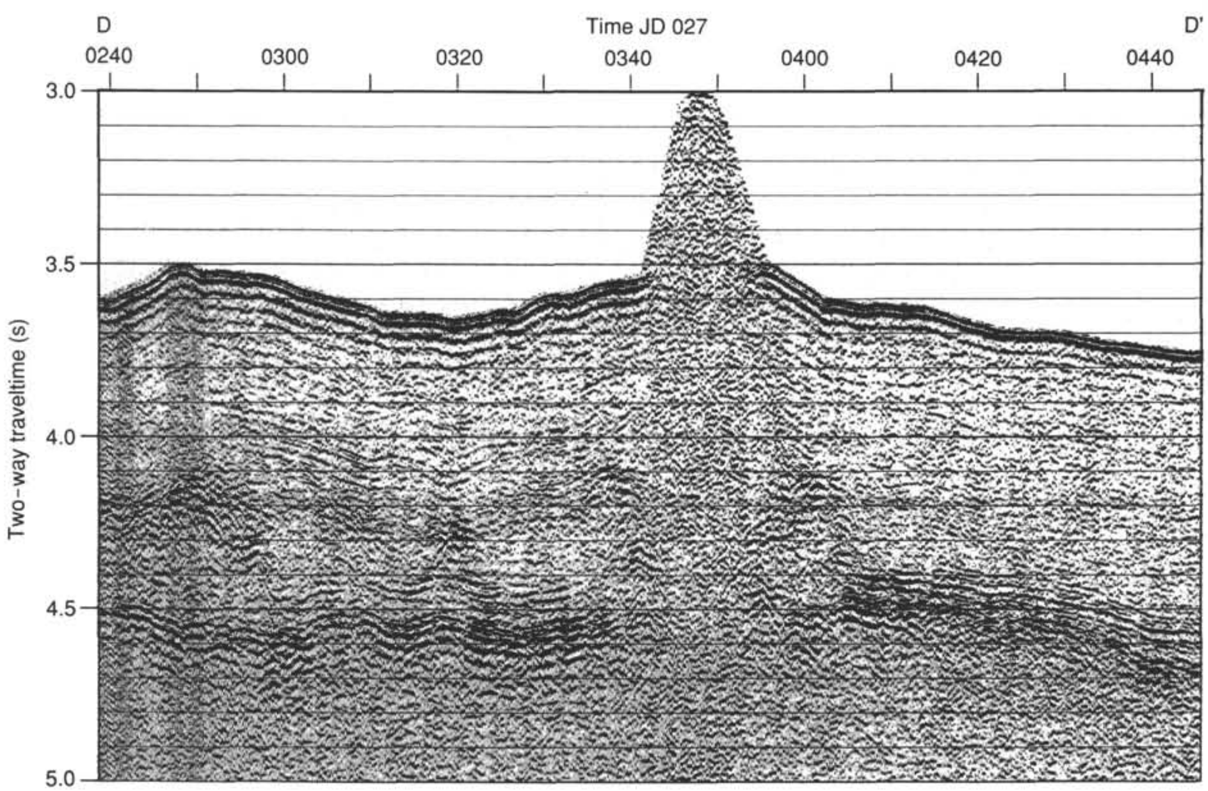

Figure 9. Profile D-D′ of processed digital single-channel Seismic Line 2 showing the largest of the diapirlike features that we interpret as mud volcanoes.

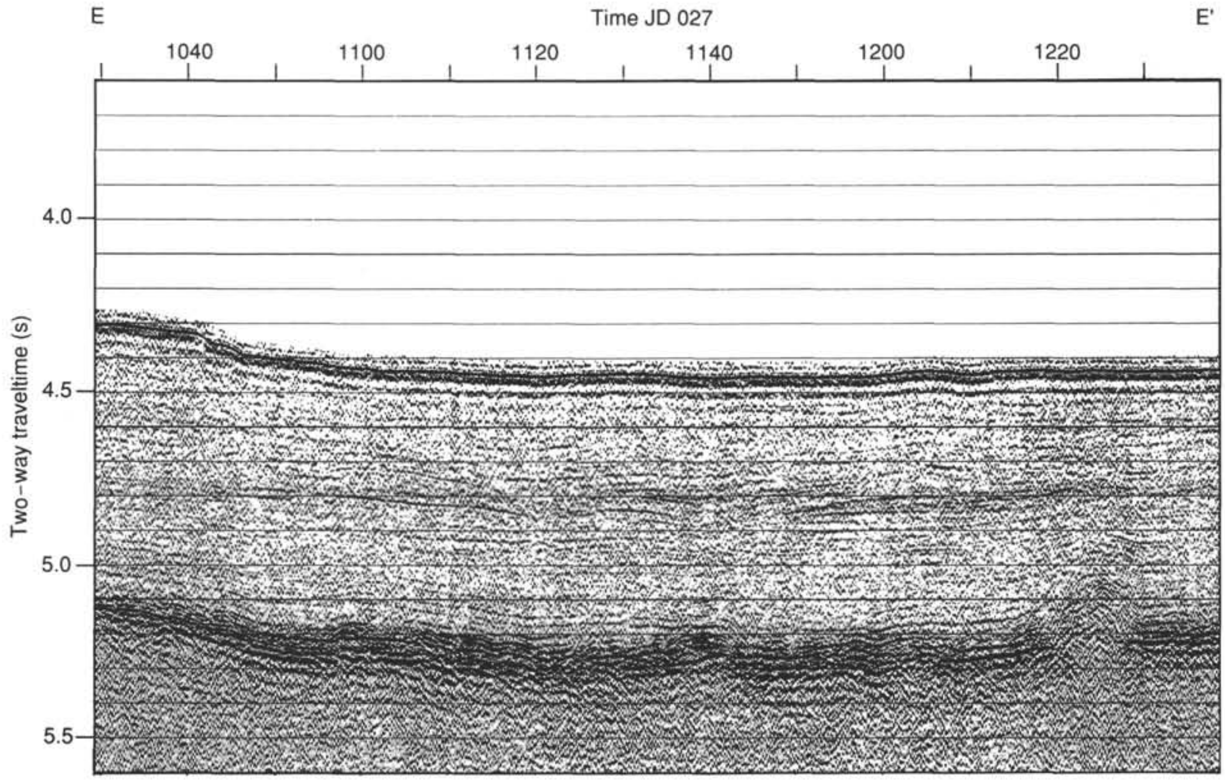

Figure 10. Profile E-E′ of processed digital single-channel Seismic Line 2 showing pinching and swelling of seismic layers mid-section (4.7–5.0 s).

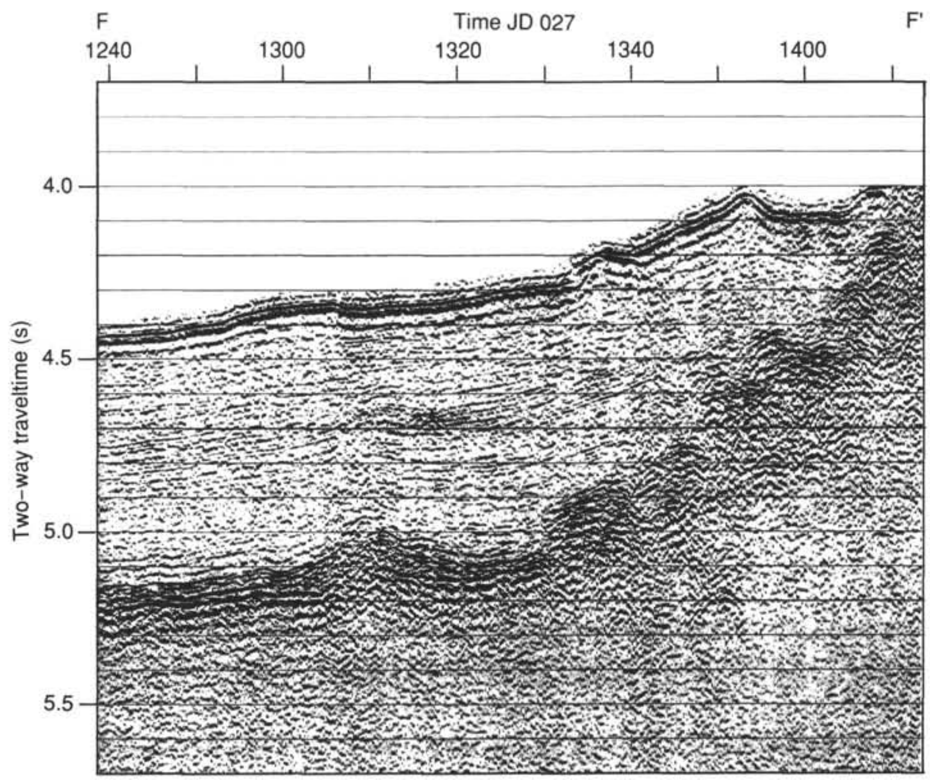

Figure 11. Profile F-F′ of processed digital single-channel Seismic Line 2 showing the sedimentary section on the western flank of a small uncharted seamount. The sediment appears to drape over the seamount with only minor surface disruption.

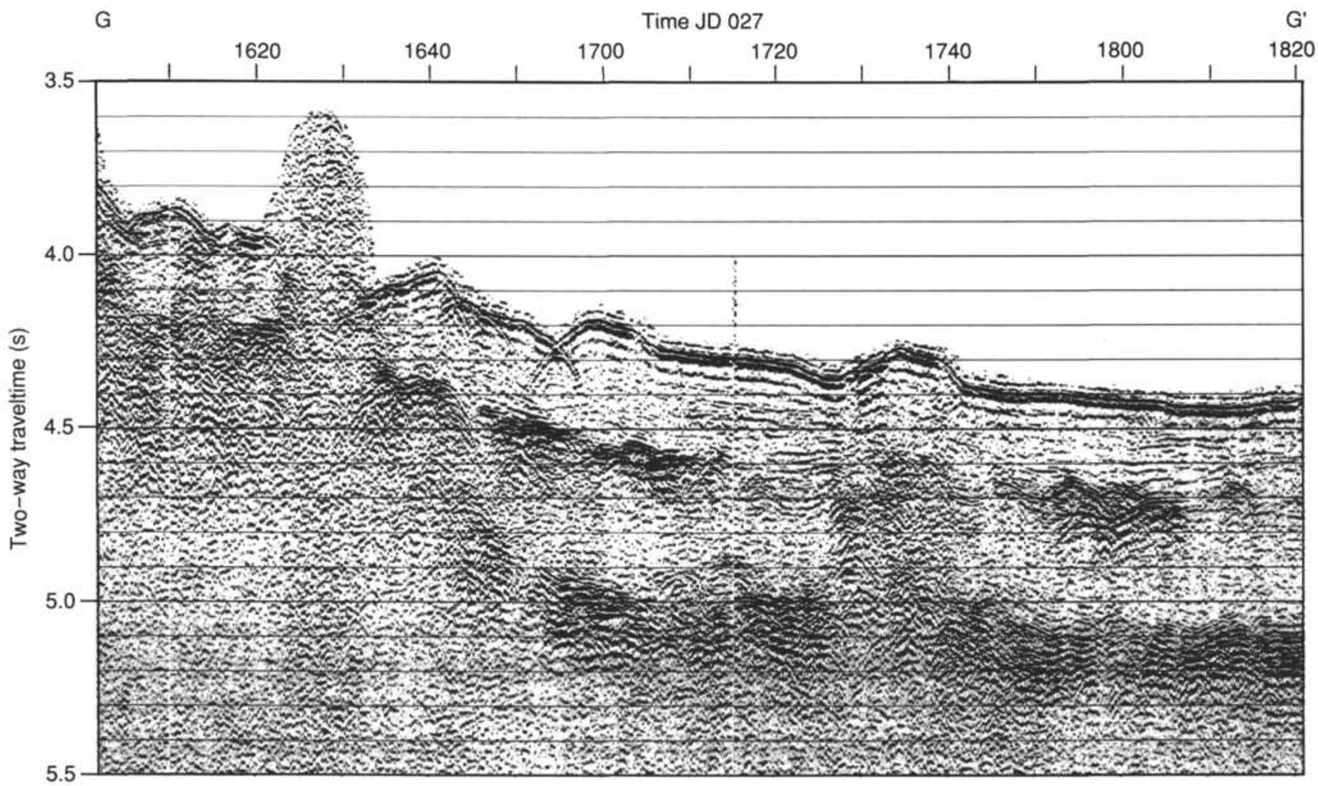

Figure 12. Profile G-G′ of processed digital single-channel Seismic Line 2 showing the east flank of the small uncharted seamount. More surface disturbance occurs on this flank of the seamount than the western flank, which may be associated with the occurrence of MSRs. The MSRs occur at a common level in the section (about 0.3 sbsf).

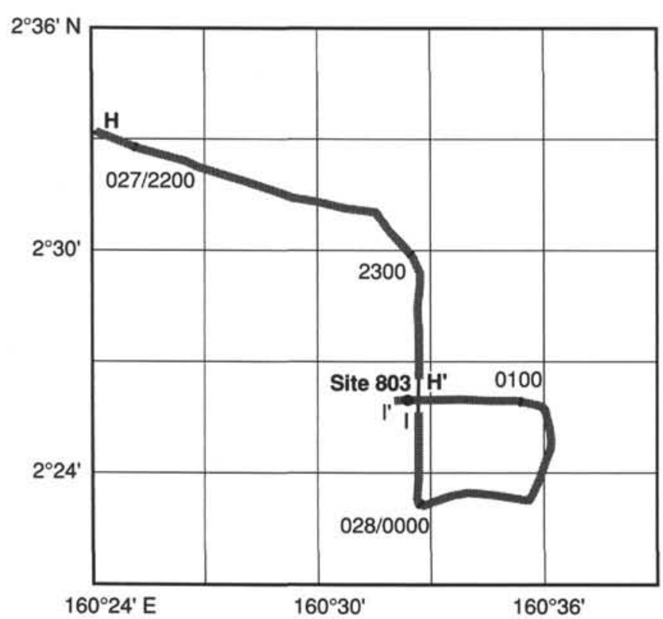

Figure 13. Ship track for single-channel Seismic Line 3 showing the locations of profiles H-H′ and I-I′.

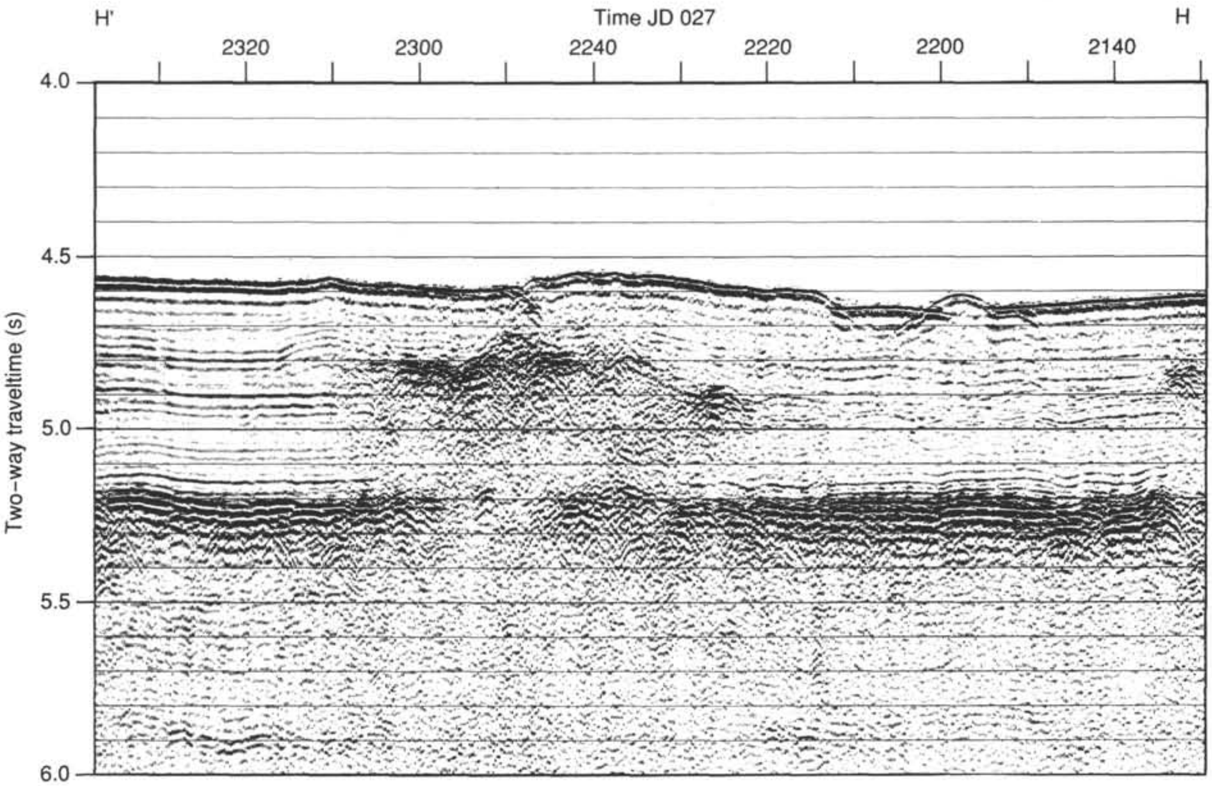

Figure 14. Profile H-H′ of processed digital single-channel Seismic Line 3 showing an MSR associated with surface disruption. The MSR has a rough seismic character, similar to basement, and clearly deforms the overlying sediment. This implies that it may be a volcanic sill.

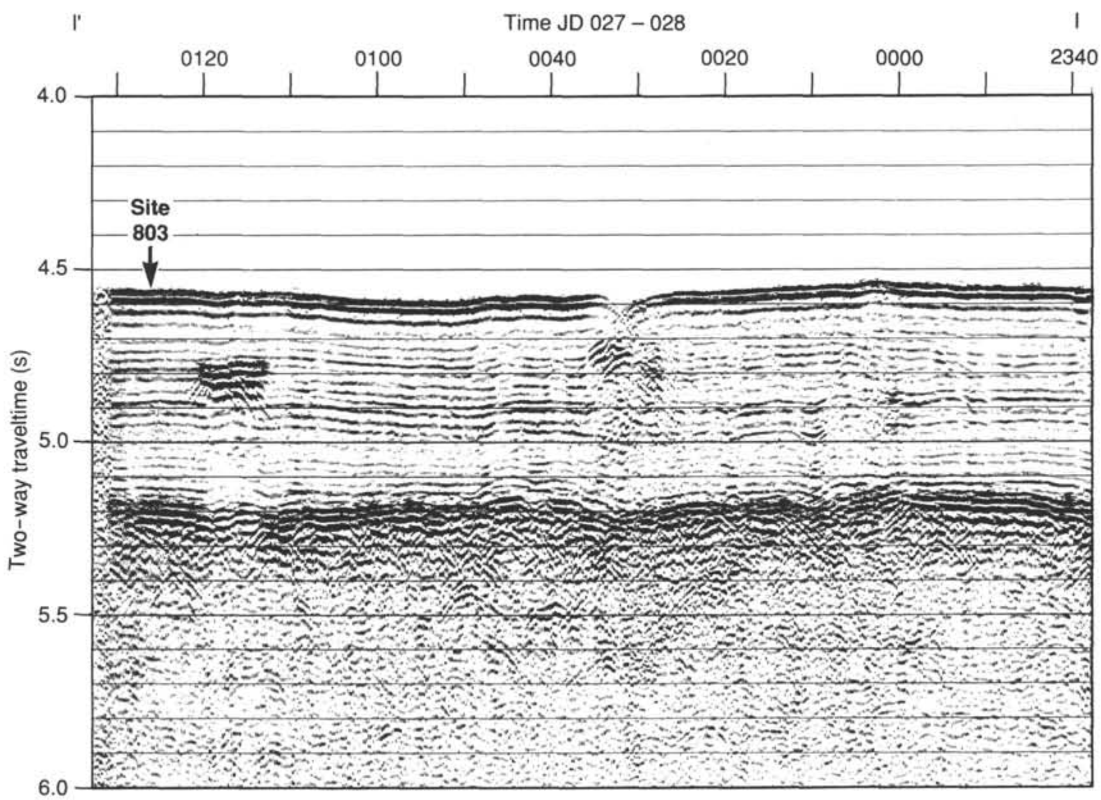

Figure 15. Profile I-I′ of processed digital single-channel Seismic Line 3. A small surface erosional channel is located at about 0033 UTC. Site 803 is located just to the left (west) of a small MSR.

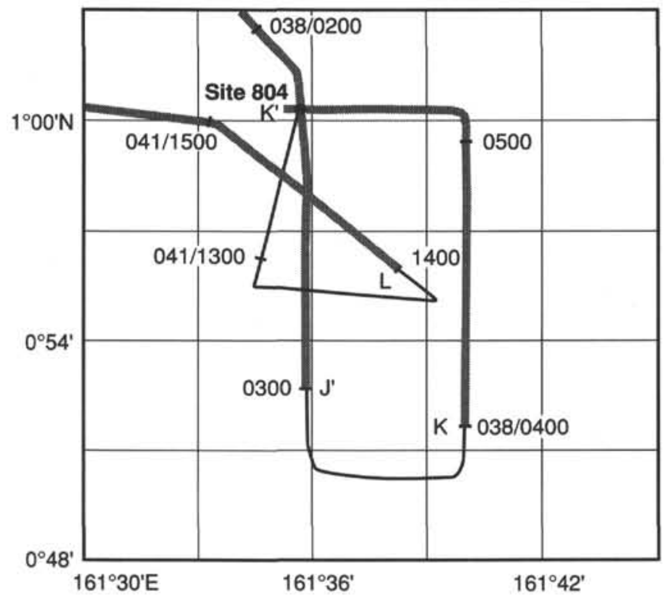

Figure 16. Ship track for single-channel Seismic Lines 4 (JD 038) and 5 (JD 041) showing the locations of profiles J-J', K-K', and L-L'.

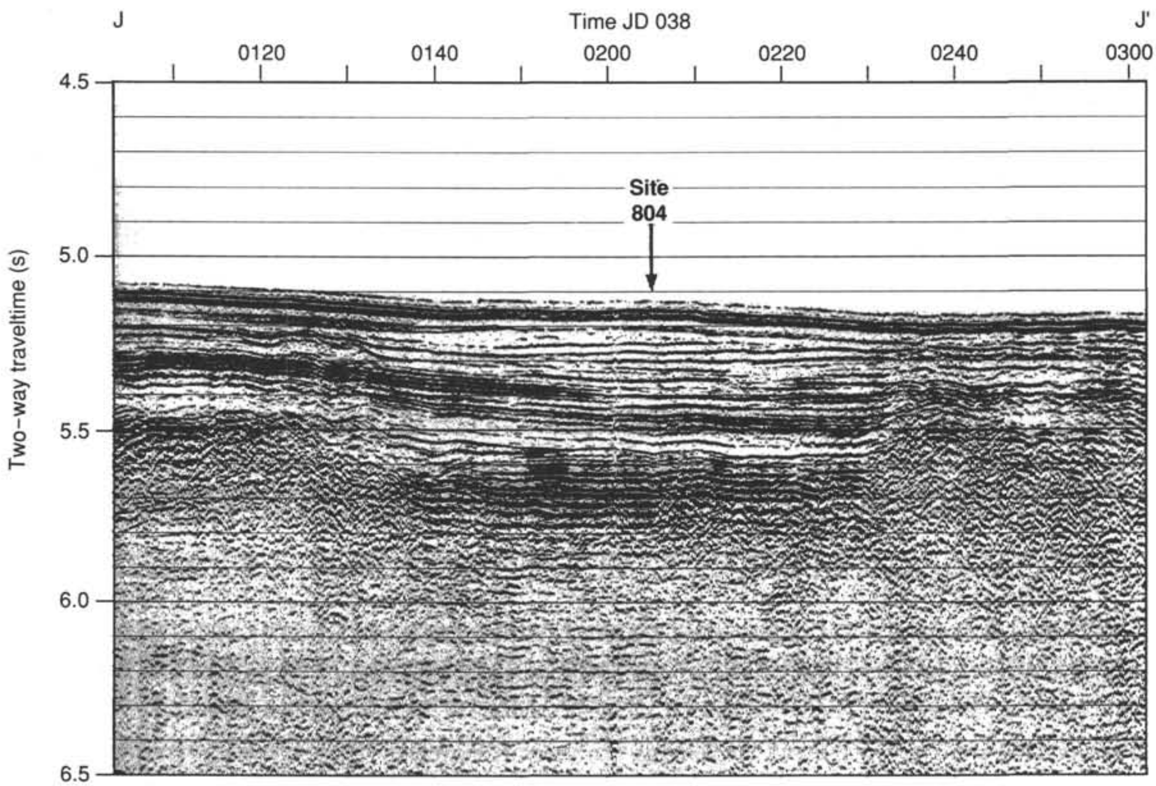

Figure 17. Profile J-J' of processed digital single-channel Seismic Line 4 showing a north-south crossing of the small northwest-trending graben drilled by Site 804. Minimal disruption of the sediment on the flanks of the graben implies that it is an original basement feature that has been infilled by sediment. The sediment fill includes several disturbed zones and lens-shaped layers indicative of slumping. Small faults and disruption on the edges of the feature probably result from differential sediment compaction.

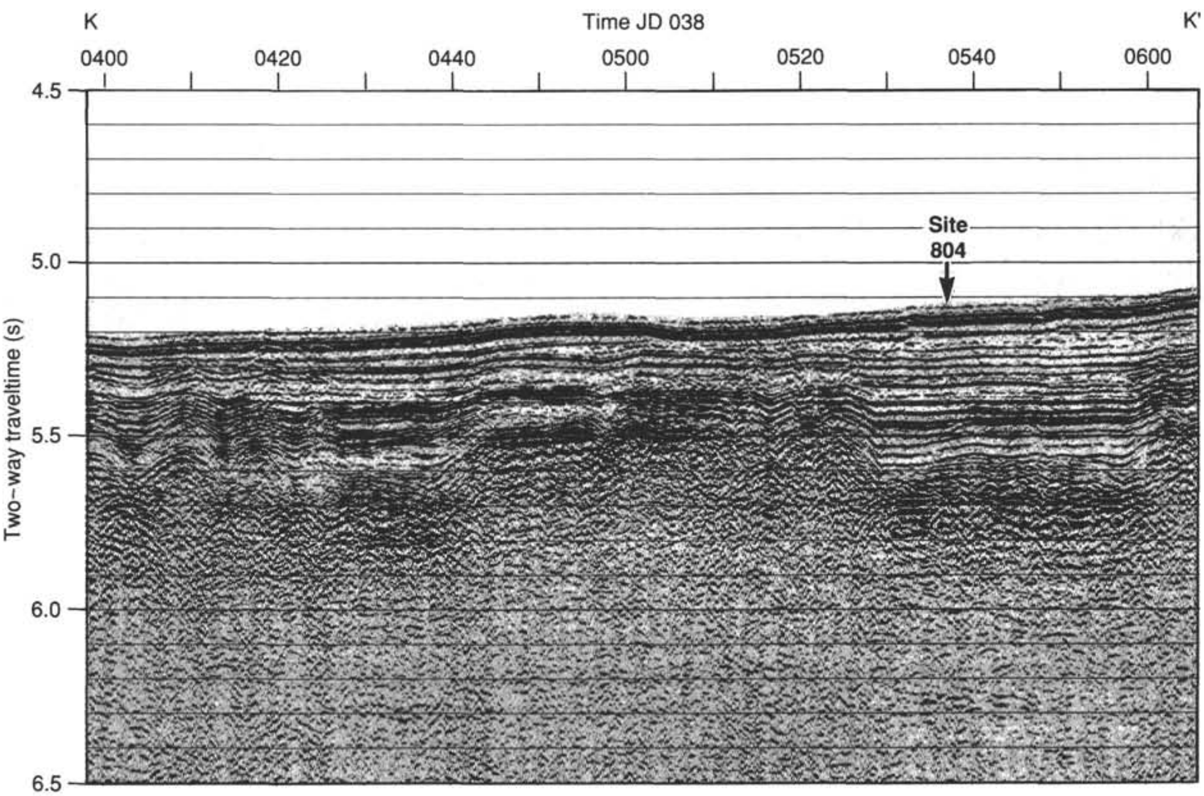

Figure 18. Profile K-K′ of processed digital single-channel Seismic Line 4 showing an east-west crossing of the small graben (right edge of figure). The sediment filling the graben appears to be much less disturbed in this crossing. Faulting is clearly evident on the left (east) edge of the graben. A south-north crossing of the same graben to the south (left portion of figure) shows much more deformation of the sediment filling the graben.

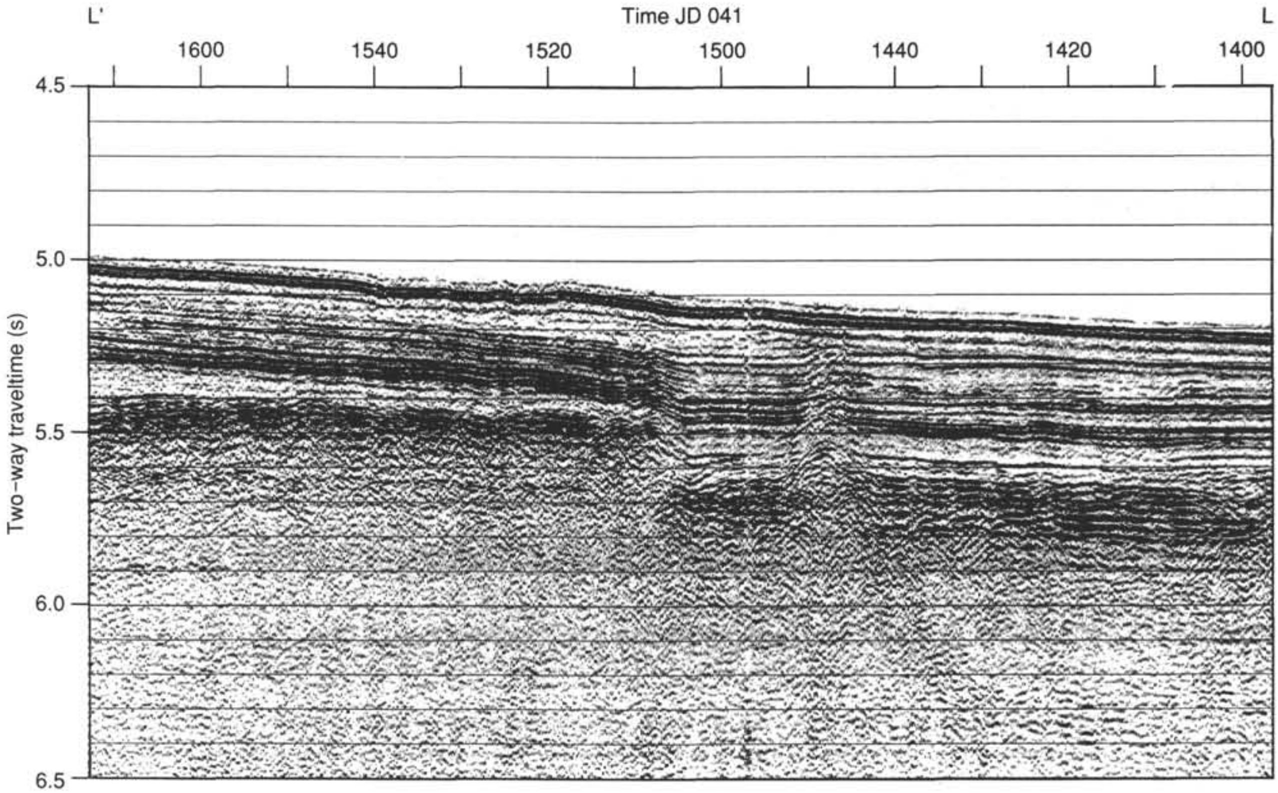

Figure 19. Profile L-L′ of processed digital single-channel Seismic Line 5. This is a northwest-southeast profile along the axis of the small graben showing the transition to the more compressed section on the northwest flank of the feature.

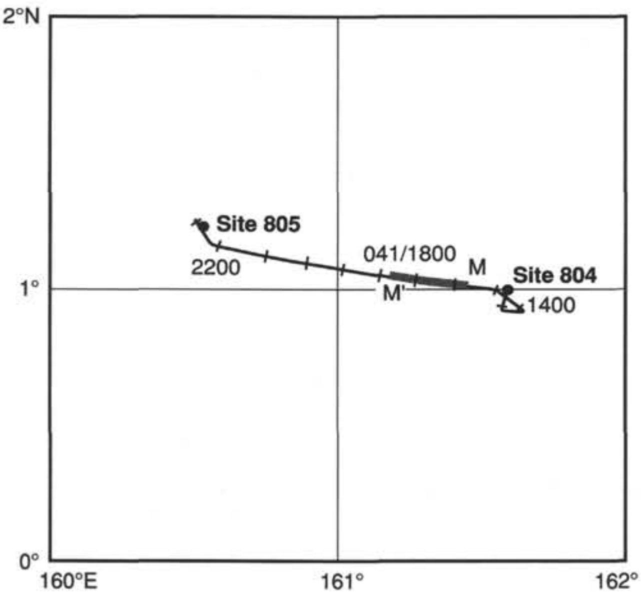

Figure 20. Ship track for single-channel Seismic Lines 5 and 6 on the transit between Sites 804 and 805. The location of profile M-M′ is shown.

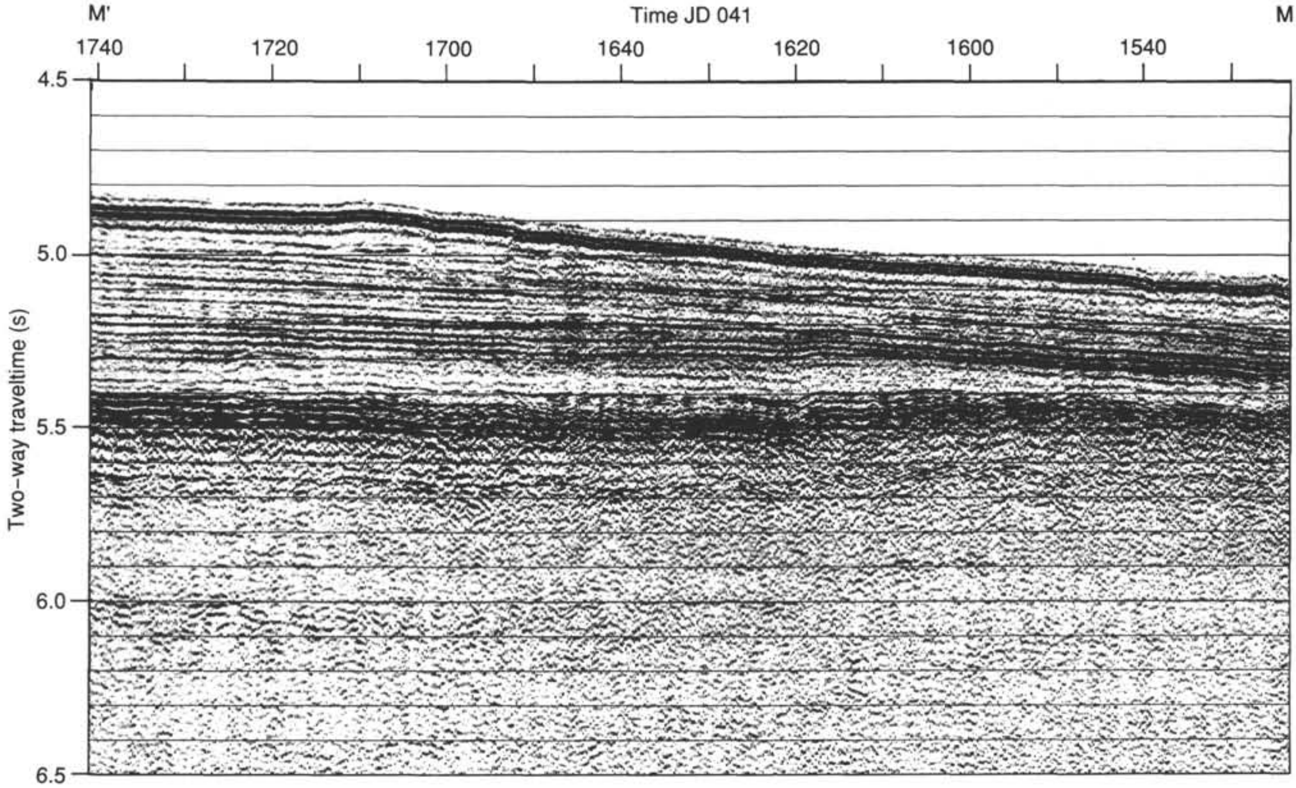

Figure 21. Profile M-M′ of processed digital single-channel Seismic Line 5 showing the thickening of the sedimentary section with decreasing water depth. Thickening occurs at all levels in the section but is most pronounced at the top.

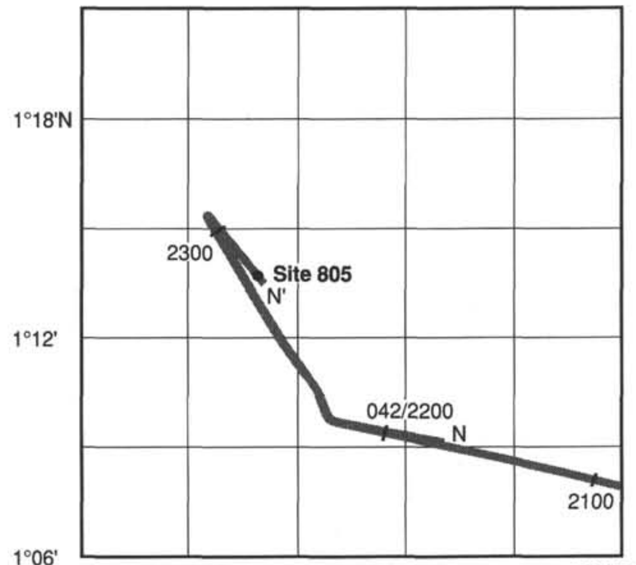

Figure 22. Ship track for single-channel Seismic Line 6 showing the location of profile N-N′.

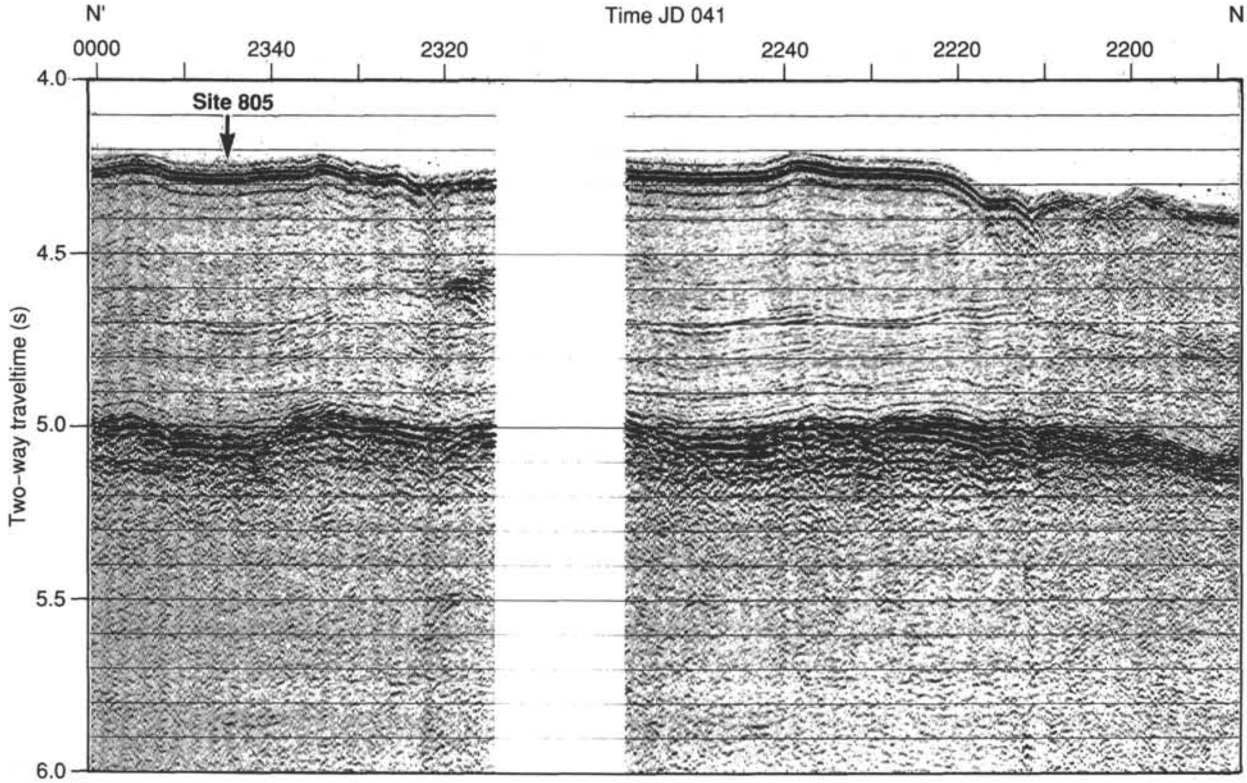

Figure 23. Profile N-N′ of processed digital single-channel Seismic Line 6. Site 805 is located to the west of a zone of surface erosion in an area of slightly thicker sediments.

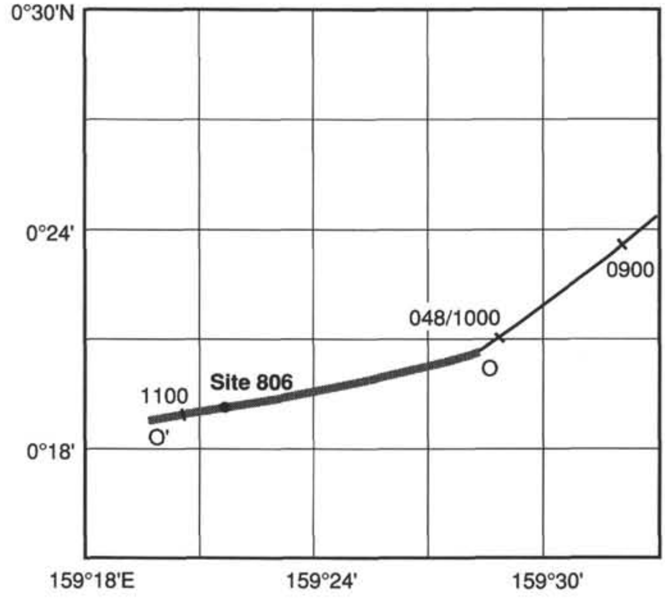

Figure 24. Ship track for single-channel Seismic Line 7 showing the location of profile O-O′.

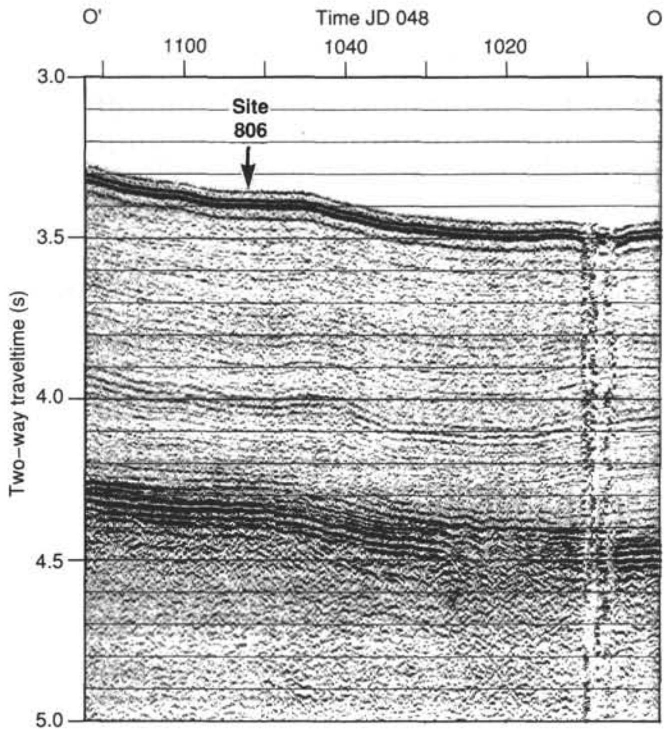

Figure 25. Profile O-O′ of processed digital single-channel Seismic Line 7. The sedimentary section is undulating but fairly undisturbed near Site 806.

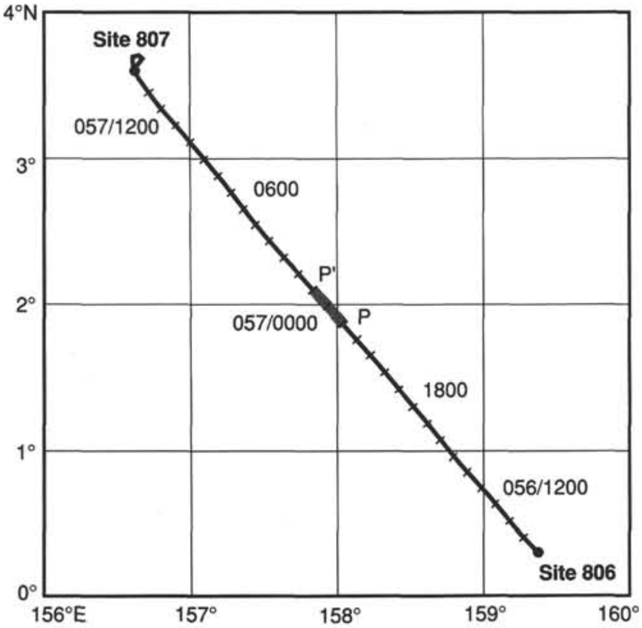

Figure 26. Ship track for single-channel Seismic Line 8 showing the location of profile P-P′.

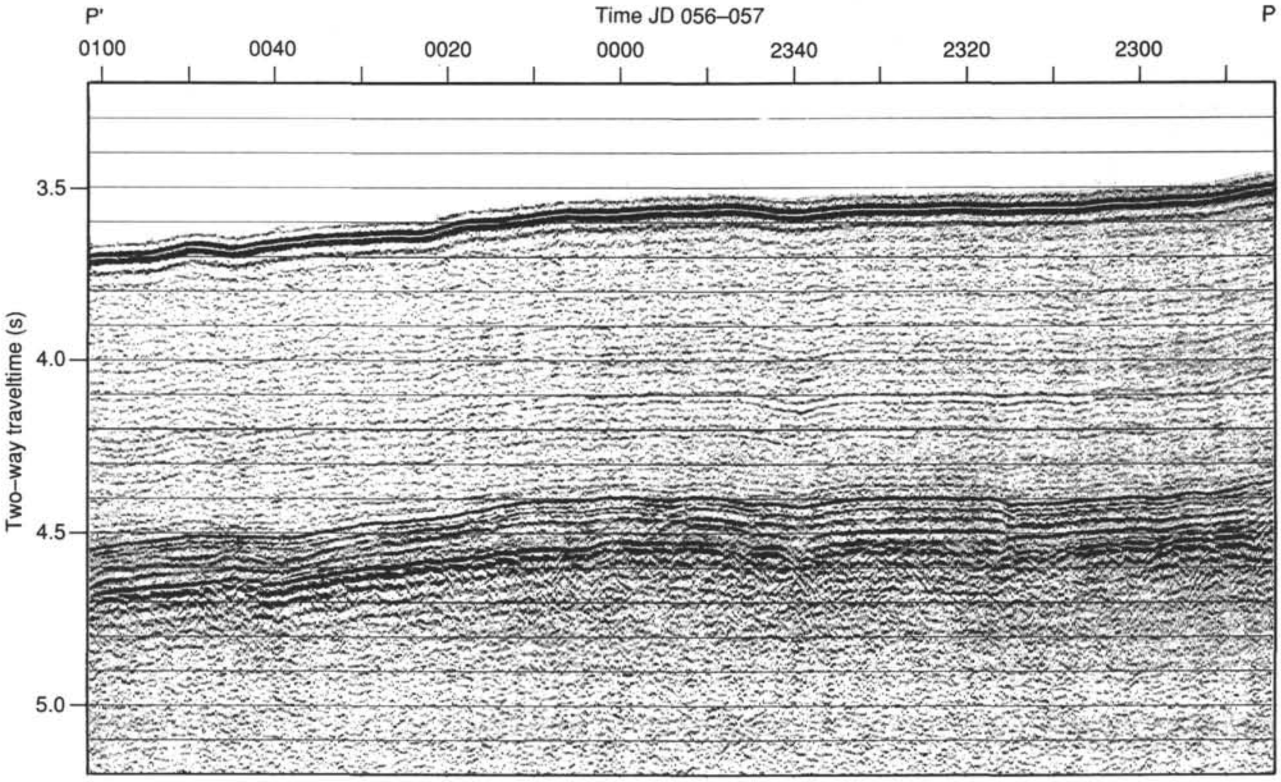

Figure 27. Profile P-P′ of processed digital single-channel Seismic Line 8.

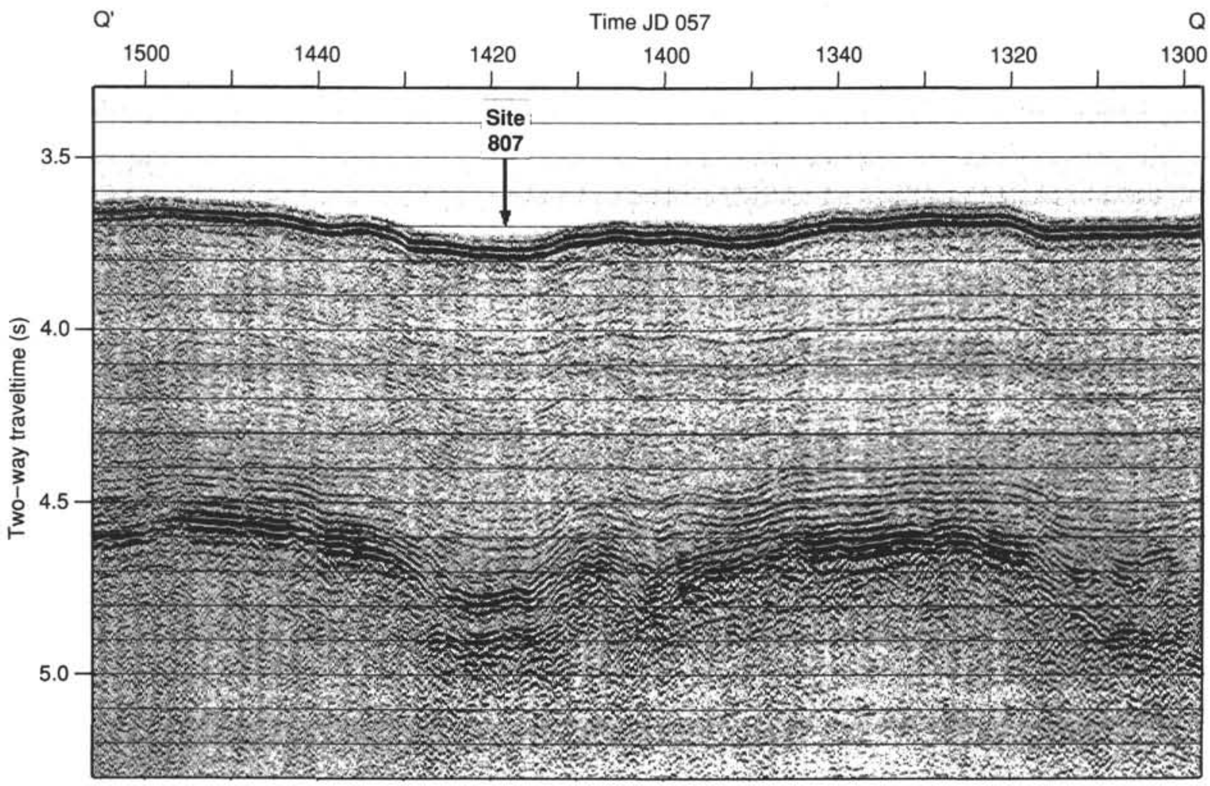

Figure 28. Profile Q-Q′ of processed digital single-channel Seismic Line 9 across the basement depression, at about JD 057/1420 UTC, drilled at Site 807.

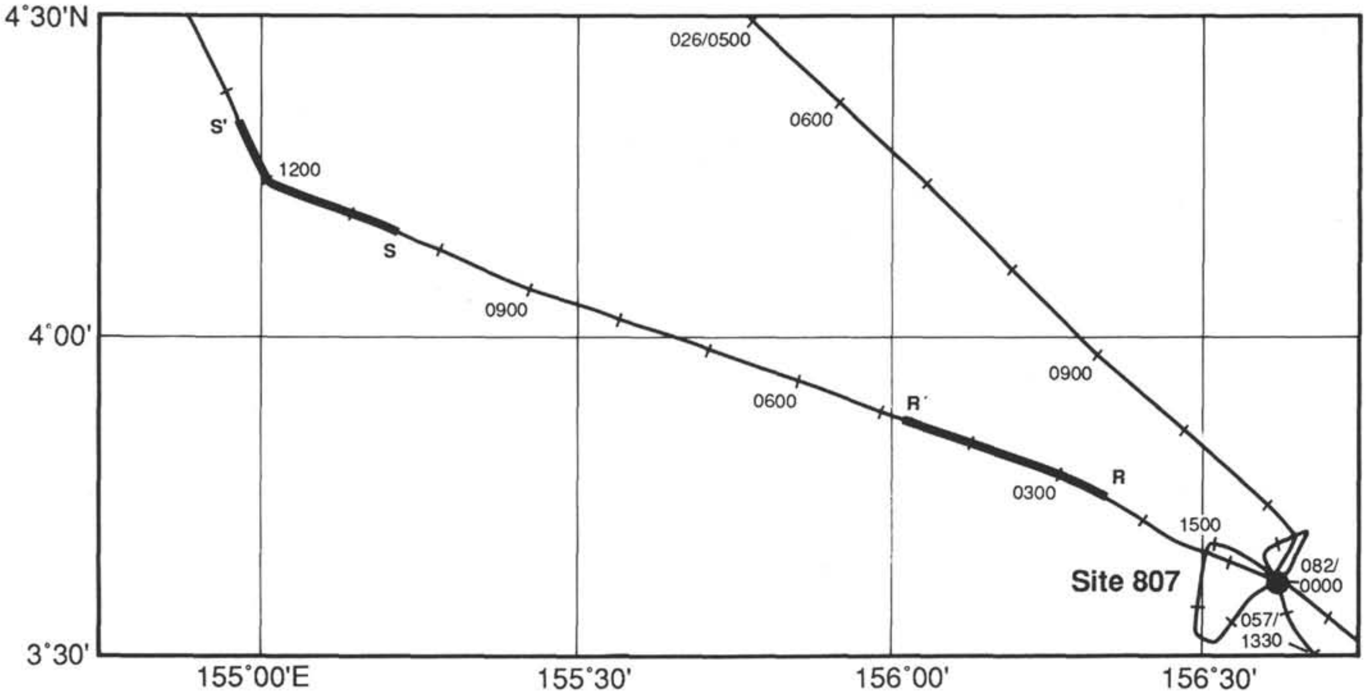

Figure 29. Ship track for single-channel Seismic Line 10 showing the locations of profiles R-R′ and S-S′.

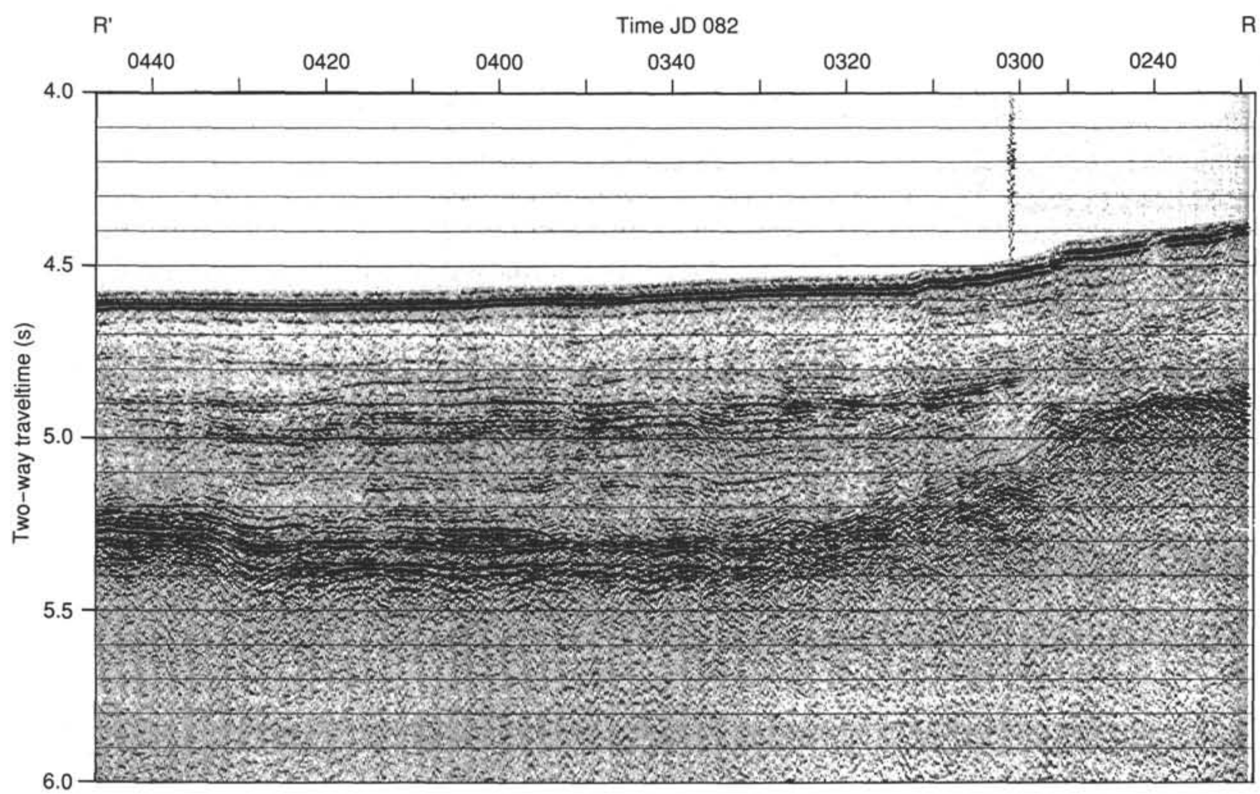

Figure 30. Profile R-R′ of processed single-channel Seismic Line 10. The lower portion of the section thickens as the plateau slowly increases in depth to the north.

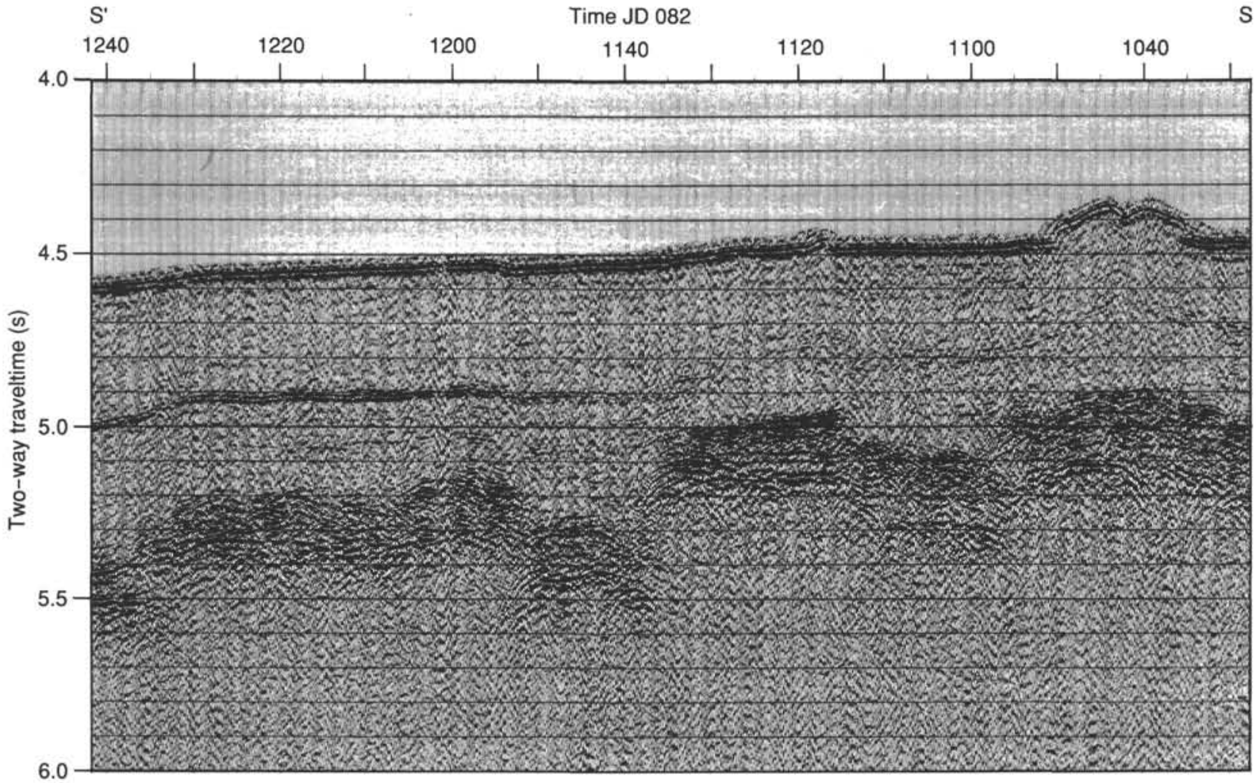

Figure 31. Profile S-S′ of processed single-channel Seismic Line 10. The basement of the plateau is extensively faulted in this area.