Fryer, P., Pearce, J. A., Stokking, L. B., et al., 1990
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3. UNDERWAY GEOPHYSICS[1]

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INTRODUCTION

Underway geophysical data are an important part of the Ocean Drilling Program (ODP) because these data provide the basis for (1) defining the scientific problems to be addressed by drilling, (2) selecting sites, and (3) interpreting the drilling results within a regional structural and stratigraphic context. This chapter describes the acquisition and display of the underway geophysical data collected aboard *JOIDES Resolution* during Leg 125.

SHIPBOARD UNDERWAY GEOPHYSICS

JOIDES Resolution is equipped to acquire, display, and process a variety of geophysical data, including underway navigation, bathymetric, magnetic, single-channel seismic-reflection, and sonobuoy refraction/wide-angle reflection data. Digital logging of most of these data facilitates post-cruise processing. Navigation data, bathymetry, and magnetics data are routinely edited and corrected by the Geological Data Center (GDC) at Scripps Institution of Oceanography under contract to ODP. Merged digital data are produced in MGD77 Exchange Format and, along with microfilm copies of all original analog records, are available from the Data Librarian at ODP headquarters, College Station, Texas, the Site Survey Data Bank at Lamont-Doherty Geological Observatory, and the National Geophysical Data Center, Boulder, Colorado.

The equipment and methods used for the acquisition of underway geophysical data aboard *JOIDES Resolution* are briefly described in the following sections. We then describe and discuss the data collected at each site on Leg 125.

Navigation

Equipment and Methods

Primary navigation data were acquired during Leg 125 by a Magnavox model MX 1107 Transit/Global Positioning System (GPS) satellite navigator, located in the underway geophysics laboratory. Additional navigational equipment is located on the bridge of the vessel, including a Magnavox MX 4400 GPS receiver and a Magnavox MX 702A Transit satellite receiver, as well as Decca and Loran C radio-positioning systems. GPS position fixes were available during two intermittent windows totalling about 10–11 hr each day. Transit satellite fixes were available at various times throughout the day. The satellite receiver automatically calculated dead reckoning (DR) positions between satellite fixes while operating in the Transit mode. All fixes, together with course and speed information, were digitally recorded in a computer file at selected time intervals (typically every 15–30 min during nonseismic transit segments and every 2 min while acquiring seismic data) using a Masscomp 561 super-microcomputer system. These data were used to produce plots of the ship's position as a function of time. A printout of all of the Transit satellite fixes and GPS and DR fixes at 30-min intervals was also obtained. Fixes collected while on site were averaged to produce the location for that site. Navigation data were compiled by the GDC and used for trackline displays. The navigation data are presented in Table 1 (microfiche, back pocket), and a trackline of the entire cruise is displayed in Figure 1.

Transits between Sites

Underway geophysical data were collected on Leg 125 during transits to and between drill sites. The data collected include (1) 3.5- and 12-kHz precision echo-sounder profiles, (2) total intensity measurements of the Earth's magnetic field, (3) single-channel seismic-reflection profiles (collected through each site), and (4) underway navigation data. The instruments were maintained and operated by ODP marine technicians, in cooperation with the shipboard scientific party and the officers and crew of SEDCO-FOREX, Inc.

Bathymetry: Equipment and Methods

Bathymetric data were acquired using both the 3.5- and 12-kHz systems and displayed using Raytheon model 1807M LSR Line Scan recorders, which were operated generally at a 1-s sweep rate. The 3.5-kHz system used a Raytheon PTR105B transceiver and 12 Raytheon transducers, whereas the 12-kHz system used a Raytheon PTR105B transceiver driving an EDO 323B transducer. Both systems normally operate with CESP-III correlators. Transducers for both systems are mounted in a sonar dome that was recently installed to improve noise conditions at high ship speeds and in rough weather conditions. The 3.5-kHz system provided some information regarding sub-bottom acoustic stratigraphy, generally with penetration of up to 5034, 4100 m. Bathymetric data encompassing the entire cruise are displayed in Figure 2.

Magnetics: Equipment and Methods

Measurements of the total intensity of the Earth's magnetic field were collected along the ship's track by a Geometrics 801 proton-precession magnetometer. The sensor was towed approximately 400 m behind the ship. Measurements were made at 3-s intervals with a sensitivity of about 1 nT. Values were digitally recorded in the header of the seismic-reflection data on the Masscomp computer every 99 s during nonseismic transit periods and once per shot (12-s interval) while acquiring seismic-reflection data. The magnetics data were also displayed in analog form on a strip-chart recorder in real time, with manual entries of the magnetic field intensity logged every 5 min. The magnetics data were processed later by the GDC to remove the regional International Geomagnetic Reference Field and to correct time variations (Fig. 2).

[1] Fryer, P., Pearce, J. A., Stokking, L. B., et al., 1990. *Proc. ODP, Init. Repts.*, 125: College Station, TX (Ocean Drilling Program).

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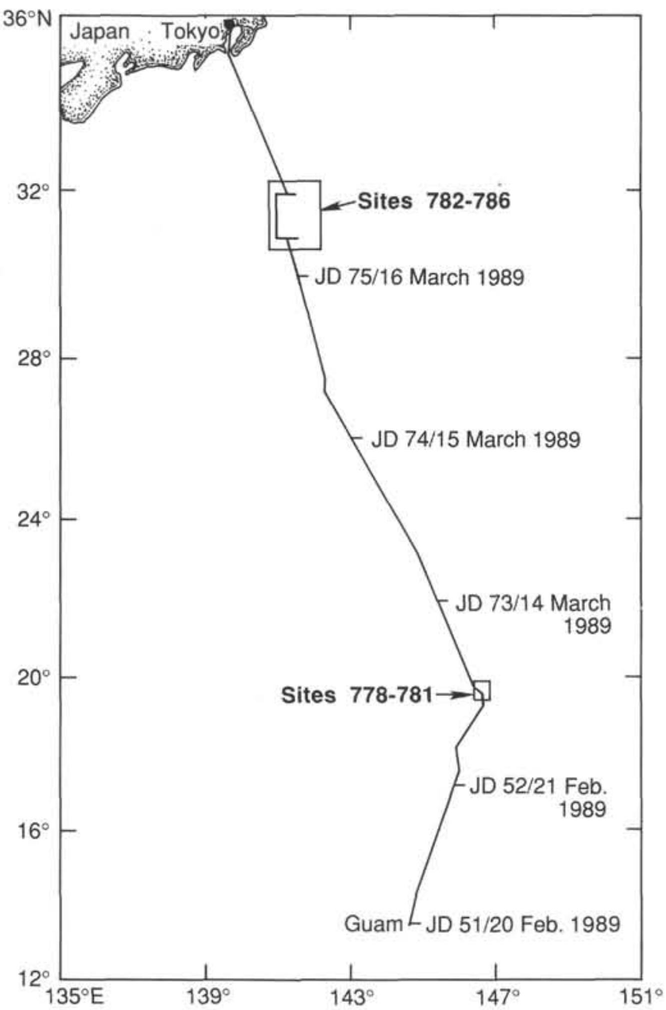

Figure 1. General trackline map of ODP Leg 125, showing site locations generated from GPS and Transit satellite navigation and the course- and speed-change data given in Table 1. Enlarged trackline maps are shown for Sites 778–781 in Figure 3 and for Sites 782–786 in Figure 18.

Seismic-Reflection Profiling: Equipment and Methods

The seismic-reflection data collected across drilling sites during Leg 125 are described in the following site sections. The ship's track along which seismic-reflection data were collected is shown in Figure 1.

Seismic Source

The seismic sources used for underway reflection profiling during Leg 125 consisted of two 80-in.^{3} water guns (Seismic Systems, Inc.) fired at approximately 2000-lb pressure. The guns were towed approximately 14 m apart roughly 25 m behind the ship in special towing frames engineered by ODP. The guns were fired every 12 s and were towed at depths between 6 and 13 m, depending on the ship's speed.

Hydrophone Streamer

One 100-m Teledyne hydrophone streamer was towed from the fantail during Leg 125. The streamer was towed approximately 500 m behind the vessel at a depth ranging from 15 to 20 m. The output signals of the 60 active hydrophone elements of the streamer were summed to produce a single seismic signal.

Seismic Data Recording

Real-time analog seismic-reflection data were displayed on the two Raytheon recorders. The seismic signal from the hydrophone streamer was amplified and band pass-filtered at 40 to 150 Hz prior to display.

The seismic-reflection data were also simultaneously recorded in digital format by a Masscomp 561-based acquisition system using the HIGHRES software package. Data were filtered and displayed in real time on a 15-in. Printronix high-resolution graphics printer capable of a resolution of 160 dots per inch. Filtered seismic data were recorded on Cipher tape drives in SEG Y format at a density of 1600 bits per inch.

MARIANA SITES

Sites 778–781 were drilled to investigate Conical Seamount and a prominent reflector within a nearby horst structure. The trackline for these sites is shown in Figure 3.

Sites 778 and 779

Only one geophysical survey (Figs. 4 and 5) of Conical Seamount was run for Sites 778 and 779 because of the extensive SeaMARC II side-scan sonar images of the seamount and the six-channel seismic-reflection data collected during a 1987 site survey. The location for Site 778 was selected on the basis of the Leg 125 shipboard survey and geophysical surveys run during the 1987 survey (see Fryer et al., this volume). Site 778 was located on the flank of the seamount in the middle of a major serpentine flow that was outlined on the side-scan data. Site 779 was located about 3.5 km northeast of Site 778, where the side-scan sonar backscatter was lower and where we hoped there might be greater sediment cover.

Sites 778 and 779 are situated about halfway up the southern flank of Conical Seamount in water depths of 3913.7 and 3947.2 m, respectively (Fig. 6). The geophysical survey of Conical Seamount involved two crossings of the seamount before the beacon was dropped. The seismic-reflection record from the seamount revealed little of the internal structure of the seamount. Only short, discontinuous reflectors are evident in the record, indicating that perhaps thin sediment layers or serpentine flows flank the seamount. Continuous reflectors are absent from the profile of the seamount probably because of its chaotic internal structure related to diapirism and extrusion of flows onto its flanks or because of the lack of power in the seismic system.

Site 780

Site 780 was drilled on the west-southwest side of the summit of Conical Seamount, following a geophysical survey that was started close to Site 779 (Fig. 7). A single-channel seismic-reflection profile across Site 780 (Figs. 8 and 9) shows up to 400 ms (about 400 m at 2 km/s) of stratified layers at the base of the seamount. This stratified section is probably composed of debris flows derived from the seamount. At Site 780, near the crest of the seamount, the reflection record shows a reflector about 100 ms below seafloor (bsf). The reflector may correspond to the sediment and serpentinite layers encountered during drilling. The seamount shows little internal reflectivity, as noted on a previous reflection profile across the seamount (Fig. 6). This lack of reflectivity in the profile probably results from the chaotic internal structure of the seamount or from the lack of power of the seismic system.

Site 781

Two single-channel seismic-reflection profiles were shot across Site 781. The tracklines of the surveys are shown in Figure 10. The surveys outlined a prominent reflector of high relative amplitude about 85 ms bsf of the horst drilled at Site

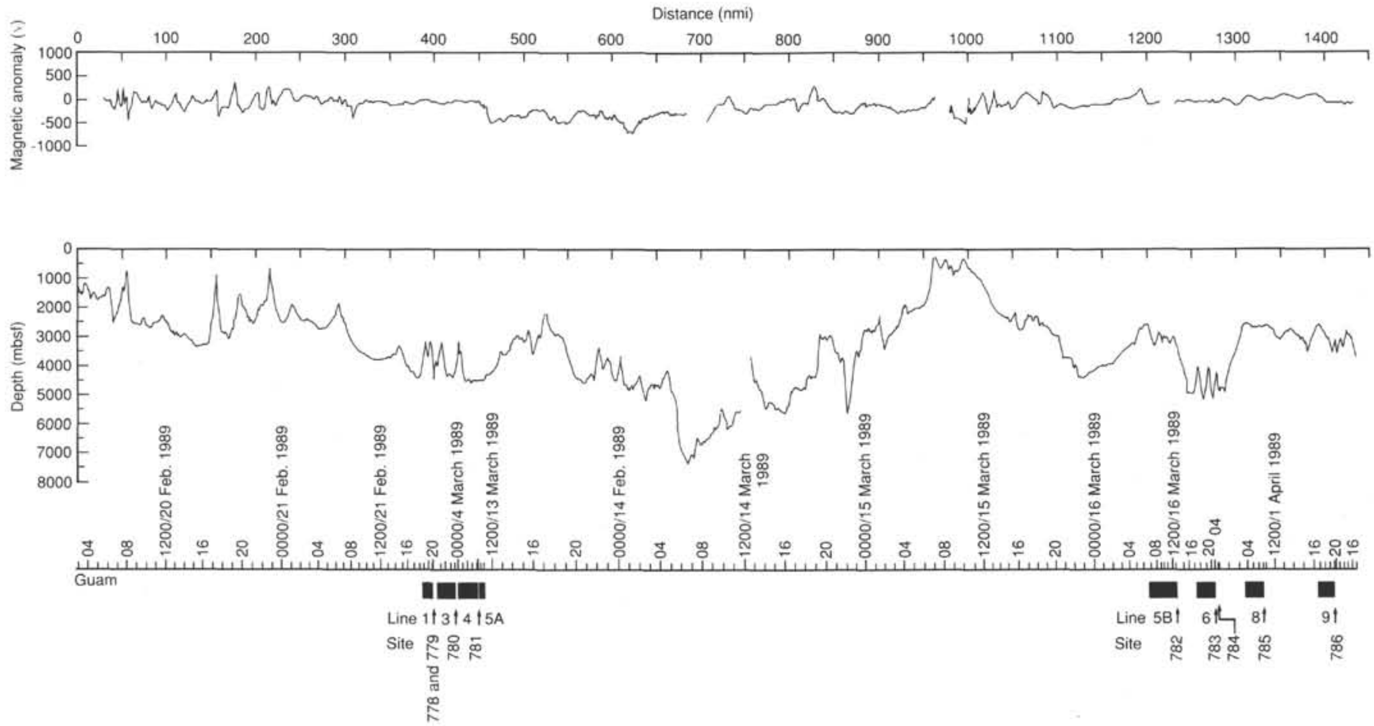

Figure 2. Records of magnetic anomaly and bathymetric profiles obtained during Leg 125. Solid bars indicate the seismic-reflection coverage.

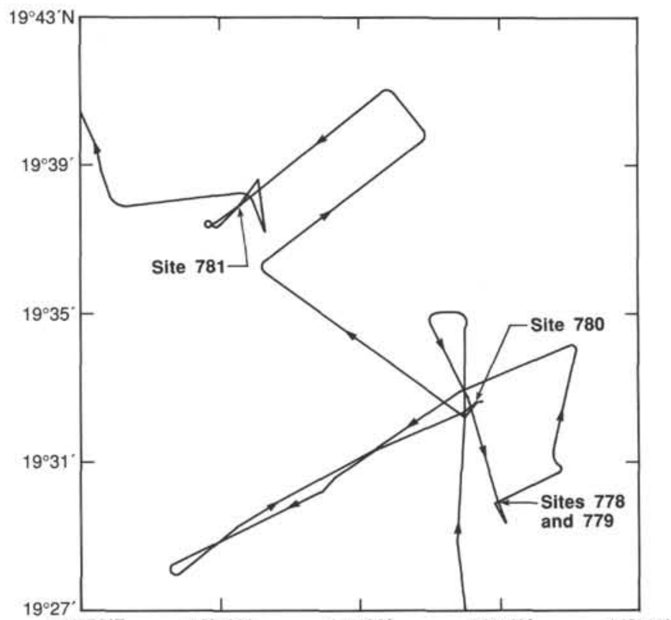

Figure 3. Enlarged trackline map near Sites 778–781. Trackline maps of individual sites, with locations of seismic-reflection profiles, are shown in Figures 4, 7, and 10.

781. The reflector was thought to be a possible basement horizon (Figs. 11–13), but subsequent drilling showed the reflector to be a basalt layer about 30 m thick. The reflector lies within a horst structure adjacent to a small graben (Fig. 12). The 72-m-thick sedimentary sequence overlying the basalt has an average velocity of 1505 m/s. The layered reflectors beneath the basalt layer are presumably from sedimentary sequences underlying the volcanic section.

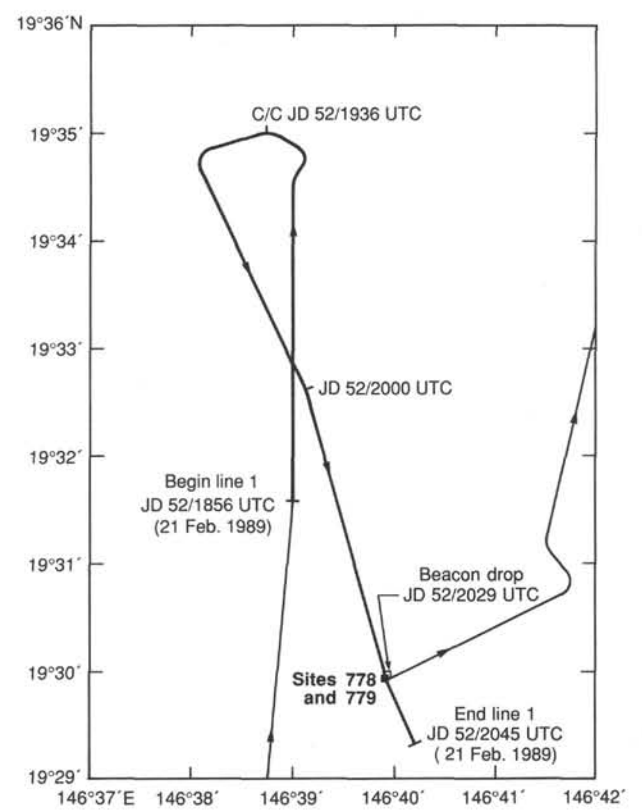

Figure 4. Trackline map of Sites 778 and 779, in the southern part of the area investigated during Leg 125, showing the location of the drill sites and geophysical tracklines. Digital seismic-reflection line 125-01 is displayed in Figure 5.

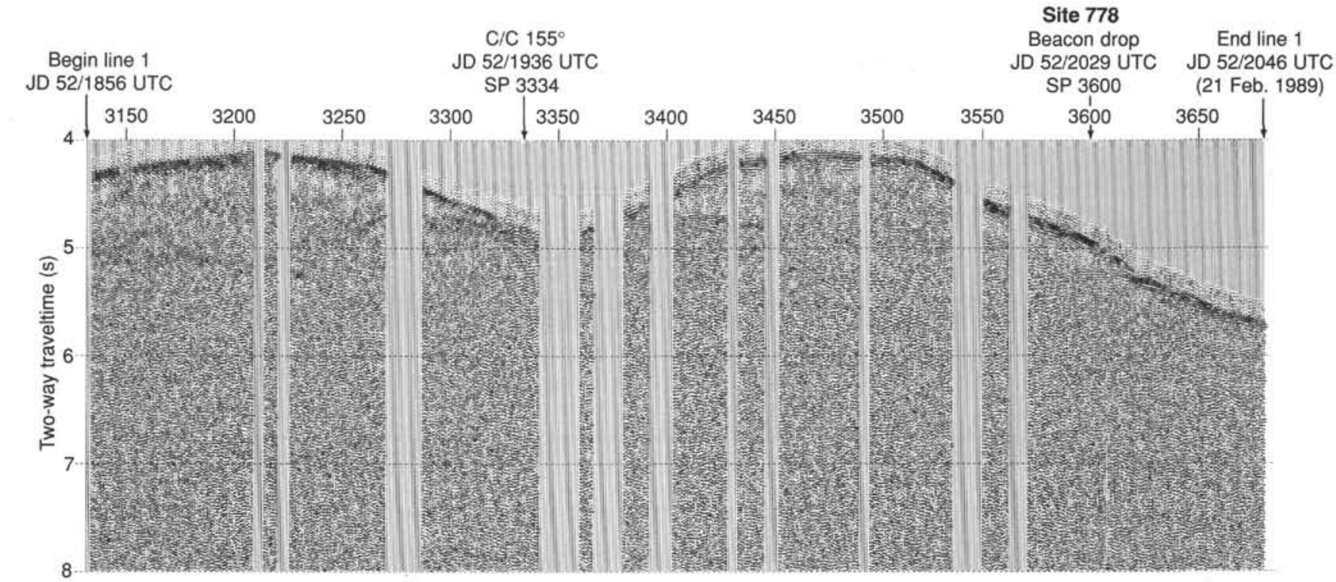

Figure 5. Processed digital seismic data collected from survey line 125-01, en route to Site 778. Automatic gain control (AGC) was applied, and the processing filter parameters were 25-30-70-90 Hz. The trackline navigation is shown in Figure 4.

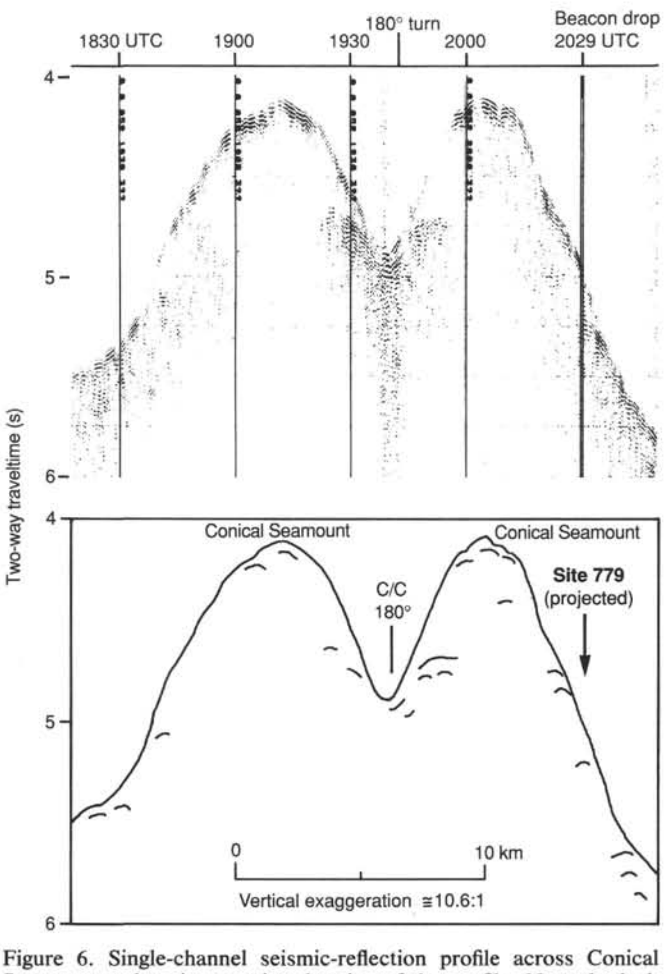

Figure 6. Single-channel seismic-reflection profile across Conical Seamount and an interpretive drawing of the profile. Note the lack of internal reflectors within the seamount. Site 778 is at the arrow marking the projected location for Site 779.

A second prominent reflector of equally high amplitude was recorded beneath a layered sequence that fills a small graben adjacent to the horst block at Site 781 (Figs. 12–14). On these profiles, this second reflector is offset from the basalt layer within the horst at Site 781 by about 100 to 150 ms. One interpretation of the reflector geometry is shown in Figures 12 and 13, where the offset between the reflectors is interpreted as a normal fault separating the graben from the horst.

A different interpretation, however, can be made using the reflection data collected after Site 781 was drilled. The seismic-reflection profile, shown in Figures 15 and 16, reveals irregular and "rubbly-looking" reflectors beneath well-layered, horizontal reflectors from the overlying sedimentary sequences. The irregular reflectors are from the basalt layer drilled at Site 781, and these reflectors can be traced laterally at the same sub-bottom depth to beneath the adjacent graben. Thus, the basalt layer can be interpreted on this profile as extending laterally from the horst into the graben, perhaps originally as a flow or intrusive (sill) structure. The flow or intrusion could have continued horizontally within the horst, but dropped to a deeper level within the graben, as shown in Figures 12 and 13, giving the apparent offset between the two "flow" reflectors on this profile. This interpretation does not require that the two prominent reflectors be separated by a normal fault, as discussed previously.

With the limited seismic-reflection data around Site 781, we cannot determine whether the basalt layers are offset by faulting or if they occupy different levels in the stratigraphy. However, the volcanic layers may be intimately associated with the fault bounding the graben because the volcanic units are limited in lateral extent away from the graben and horst. The 3.5-kHz depth record collected during the post-drilling survey shows several tilted fault blocks within the graben (Fig. 17). An acoustically opaque zone evident at the faulted(?) boundary between the graben and horst could be basaltic material. Thus, the basalt emplacement could be related to activity on the fault separating the horst and graben, and magmas could have used this fault in the forearc to gain access to the surface or near surface at Site 781. Further analysis of magnetic data from the site surveys may help to determine if the sources of the basaltic rocks lie vertically beneath Site 781.

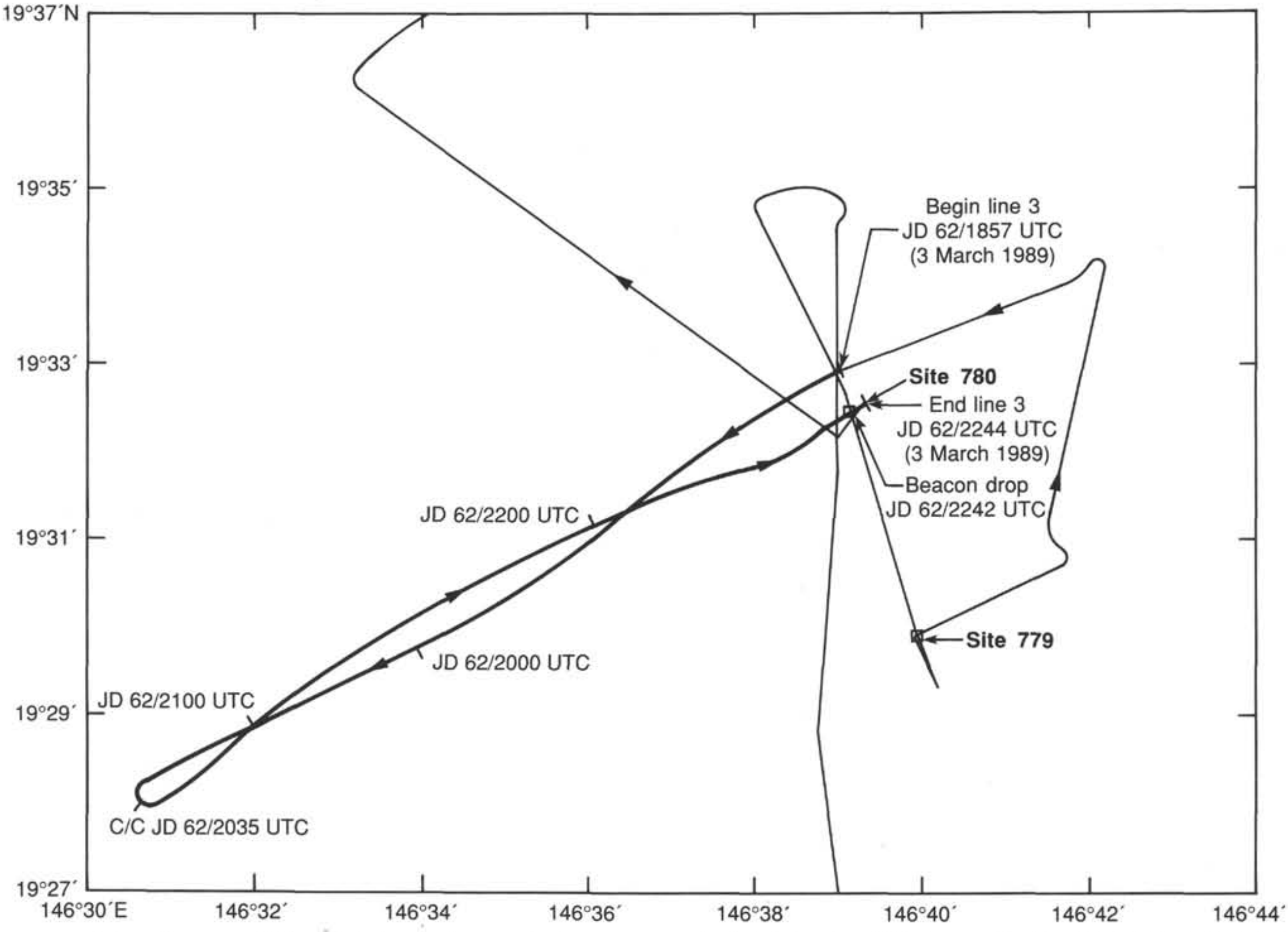

Figure 7. Trackline map of Site 780, in the southern part of the area investigated during Leg 125, showing the location of the drill site and geophysical trackline. Digital seismic-reflection line 125-03 is displayed in Figure 8.

IZU-BONIN SITES

Sites 782–786 were drilled in the Izu-Bonin forearc. A detailed trackline of these sites is shown in Figure 18.

Site 782

Site 782 was drilled in the Izu-Bonin forearc after a geophysical survey was made following the transit from Site 781 (Fig. 19). The single-channel seismic-reflection profile across Site 782 (Fig. 20) shows up to 450 ms (about 400 to 430 m at 1.8 to 1.9 km/s, respectively) of stratified layers overlying a basement reflector labeled *B* on Figure 21. This stratified section is composed mainly of pelagic and hemipelagic sediment and ash layers derived from the ancestral Izu-Bonin Island arc. The oldest sediment overlying the basement reflector is Eocene in age. The basement reflector is basalt, perhaps from the earliest phase of volcanism in the formation of the arc.

Site 783

Site 783 was drilled on the northern flank of Torishima Forearc Seamount on the inner wall of Izu-Bonin Trench in a water depth of 4648.8 m. The geophysical survey of the site involved two crossings of the seamount before the beacon was dropped (Figs. 22 and 23).The seismic-reflection record revealed that the seamount has little internal structure. Only short, discontinuous reflectors are evident in the record, indicating a thin sediment cover over the flanks of the seamount. A break in slope halfway down the eastern flank can be interpreted on the reflection profile as a slump feature (Fig. 24). Continuous reflectors are absent from the seamount probably because of its chaotic internal structure related to faulting and to the possible diapiric intrusion of serpentinite or because of the limited power of the seismic system. The reflection and drilling data also show that the crest of the seamount is not underlain by active serpentinite material, unlike the crest of Conical Seamount.

Site 785

Site 785 was drilled in the Izu-Bonin forearc in a water depth of 2660.8 m. The geophysical survey of the site involved two crossings of the site before drilling commenced (Figs. 25 and 26). The seismic-reflection record from the forearc shows a thick sedimentary sequence more than 1 s (1 km) thick in the east. To the west, basement appears to be truncated by a reverse fault that offsets most of the sedimentary strata and may reach the seafloor along a small swale. Basement was not observed on the west side of this fault, where the forearc is underlain by a thick sedimentary sequence. The reflectors from this sequence are curvilinear and this fact may suggest that channel-filling processes are active adjacent to the fault. Alternatively, the fault structure interpreted in Figure 27 may be the edge of a filled channel. Further processing of the seismic-reflection data may allow better resolution of the fault/channel-fill structures.

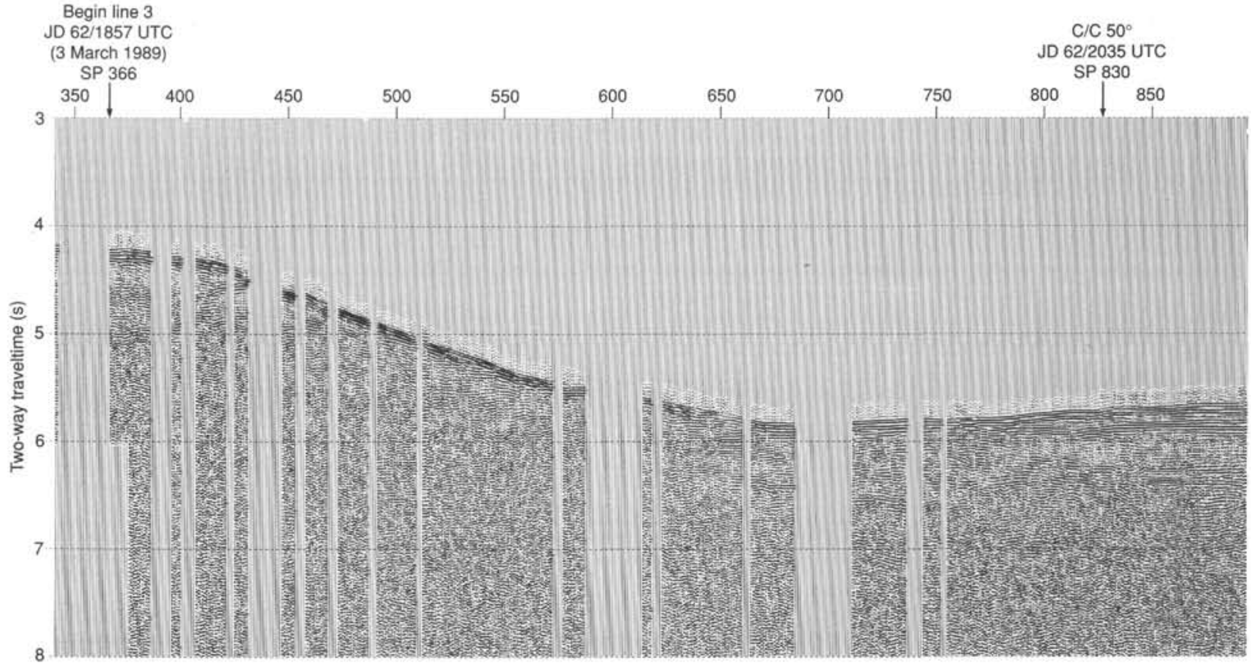

Figure 8. Processed digital seismic data collected from survey line 125-03, en route to Site 780. AGC was applied, and the processing filter parameters were 25-30-70-90 Hz. The trackline navigation is shown in Figure 7.

Site 786

Site 786 was drilled in the Izu-Bonin forearc in a water depth of 3058.1 m. The geophysical survey of the site involved two crossings of the site prior to drilling (Figs. 28–30).The seismic-reflection record shows a thick sedimentary sequence draping volcanic basement. To the west, the section is cut by two high-angle normal faults, which rupture the seafloor and form a series of stepped-down terraces. The faulting and morphology of the area suggest that the forearc is being extensionally deformed.

Site 786 is situated over a basement high that is draped with about 115 m of sediment, as revealed by drilling (Fig. 30). The reflection data suggest that the stratigraphic section recovered at Site 786 is thinner than the adjacent sequences in the surrounding valleys. This relationship indicates that since the beginning of sedimentation the basement knoll at Site 786 may have always been higher than the surrounding country rock.

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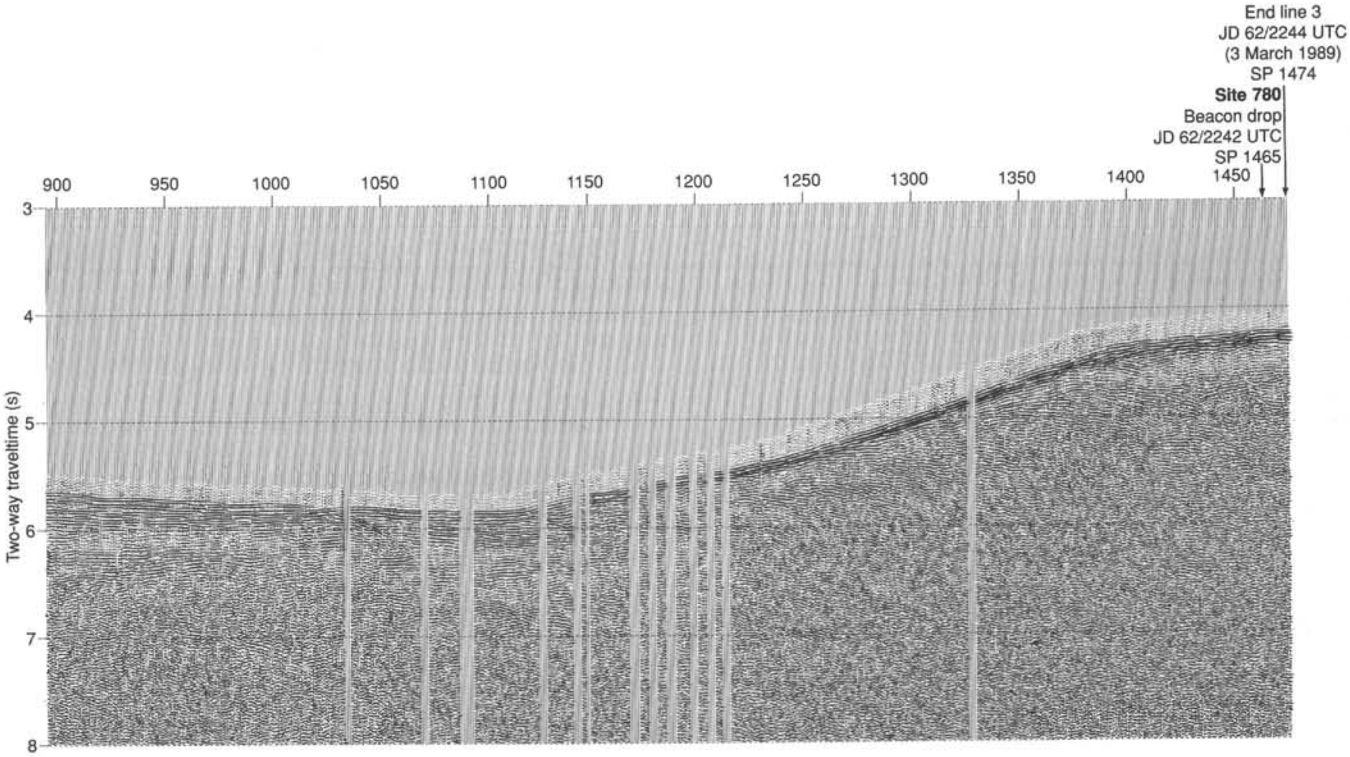

Figure 8 (continued).

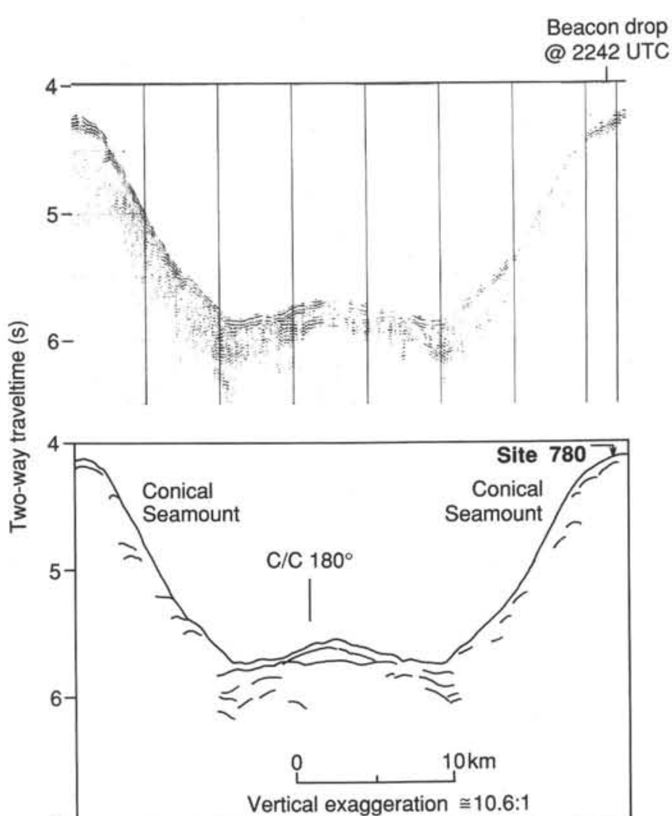

Figure 9. Single-channel seismic-reflection profile across Conical Seamount and the sediment section at the base of the seamount and an interpretive drawing of the profile.

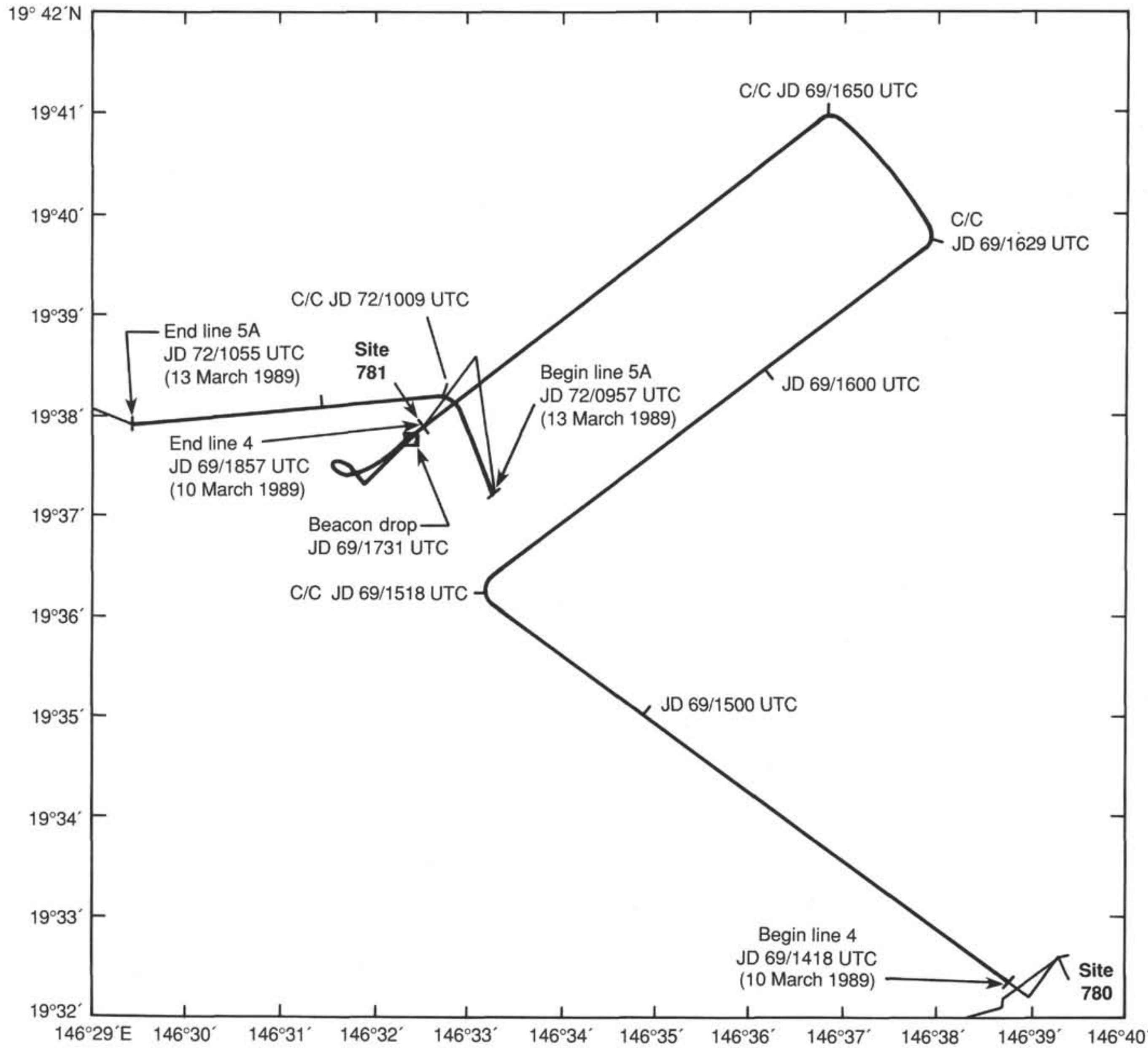

Figure 10. Trackline map of Site 781, in the southern part of the area investigated during Leg 125, showing the location of the drill site and geophysical trackline. Digital seismic-reflection lines 125-04 and 125-05A are displayed in Figures 11 and 15, respectively.

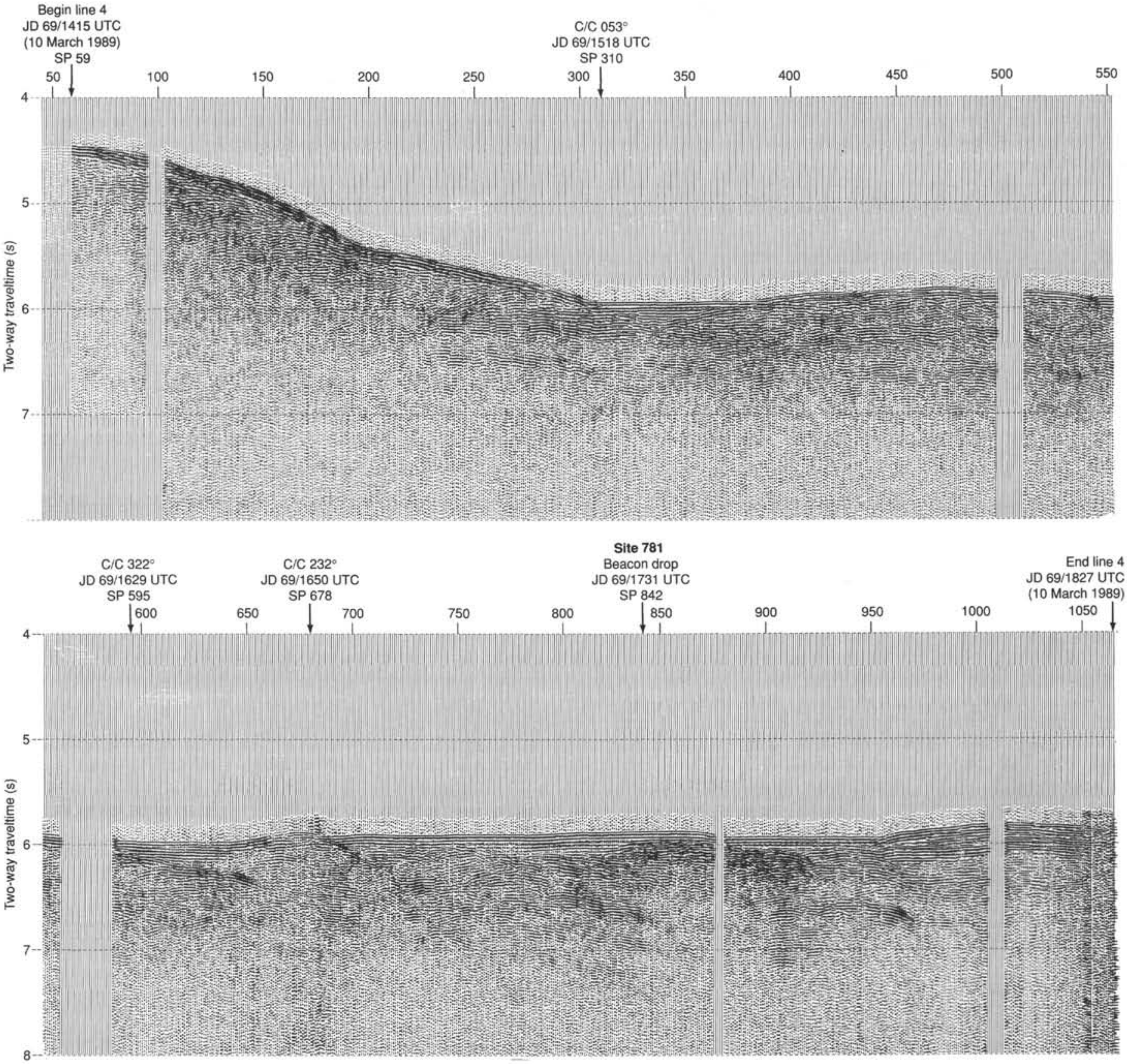

Figure 11. Processed digital seismic data collected from survey line 125-04, en route to Site 781. No AGC was applied, and the processing filter parameters were 25-30-70-90 Hz. The trackline navigation is shown in Figure 10.

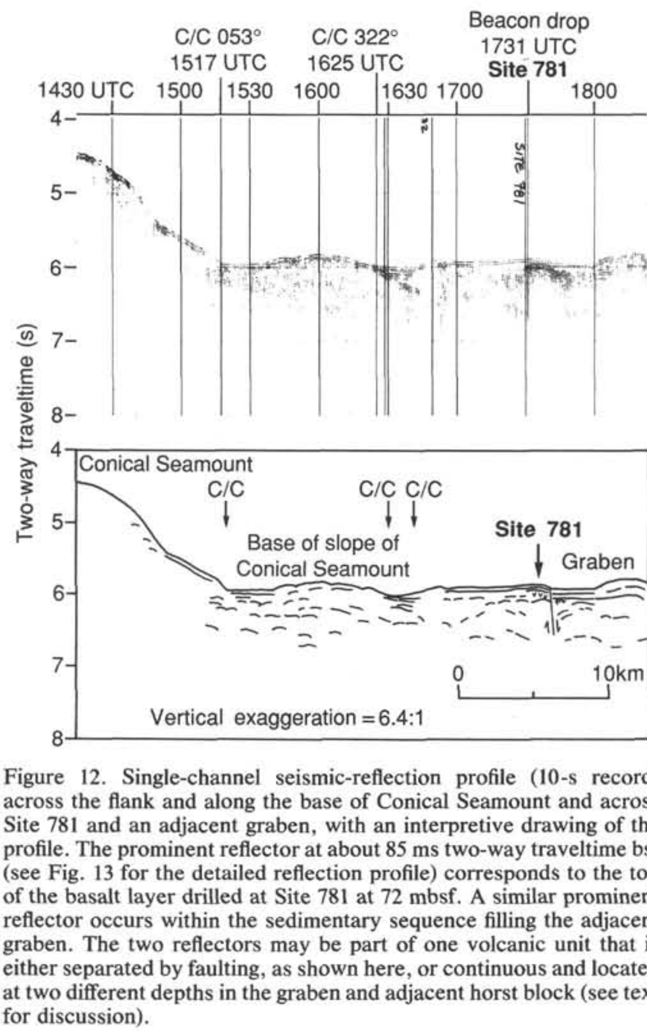

Figure 12. Single-channel seismic-reflection profile (10-s record) across the flank and along the base of Conical Seamount and across Site 781 and an adjacent graben, with an interpretive drawing of the profile. The prominent reflector at about 85 ms two-way traveltime bsf (see Fig. 13 for the detailed reflection profile) corresponds to the top of the basalt layer drilled at Site 781 at 72 mbsf. A similar prominent reflector occurs within the sedimentary sequence filling the adjacent graben. The two reflectors may be part of one volcanic unit that is either separated by faulting, as shown here, or continuous and located at two different depths in the graben and adjacent horst block (see text for discussion).

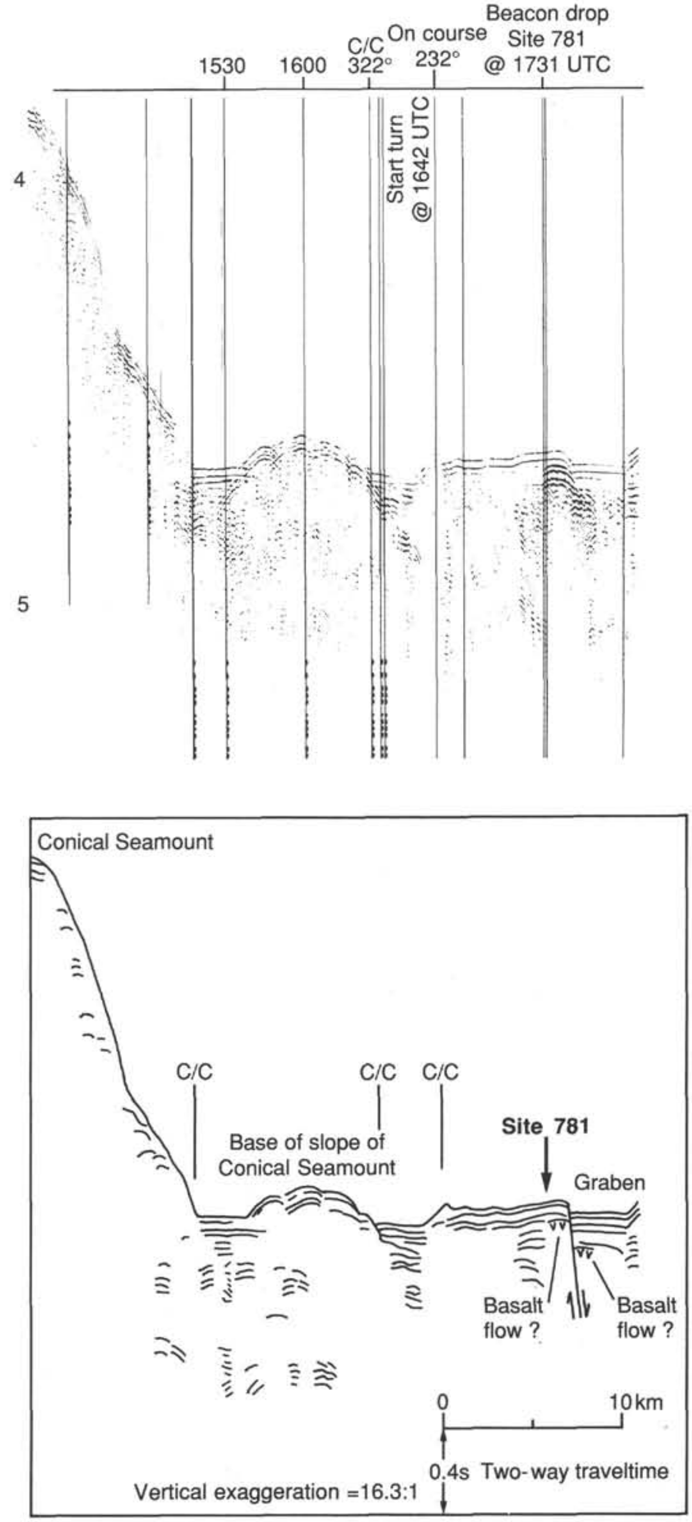

Figure 13. Detailed 4-s record duplicating the seismic-reflection profile shown in Figure 12 and an interpretive drawing of the profile. Note the prominent basaltic reflector at Site 781 and the adjacent reflector in the graben, which is also interpreted as a volcanic layer.

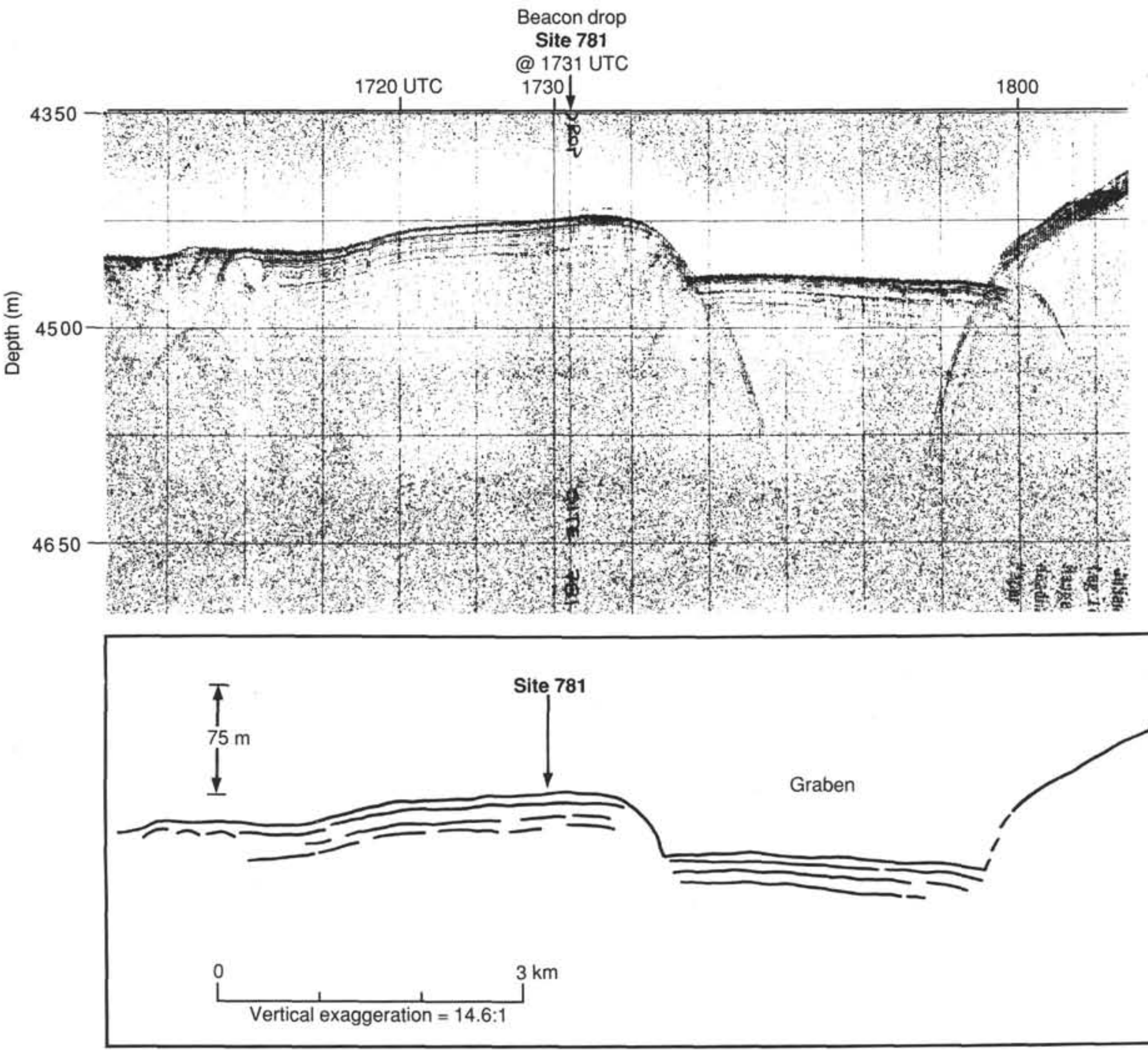

Figure 14. The 3.5-kHz depth record across Site 781 and the adjacent graben and an interpretive drawing of the profile. The graben and adjacent horst are underlain by gently dipping reflectors from sedimentary layers. The strata in the graben are uplifted and thin toward the horst block penetrated at Site 781, suggesting recent tectonic activity.

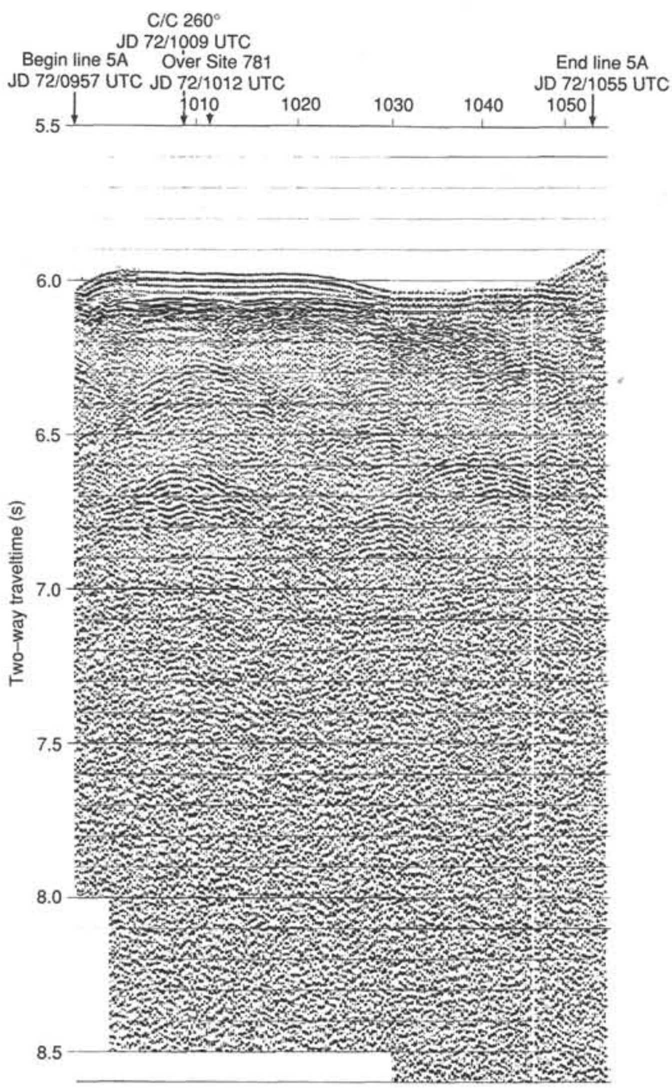

Figure 15. Processed digital seismic data collected from survey line 125-05A, run immediately after leaving Site 781. AGC was applied, and the processing filter parameters were 25–140 Hz with a filter length of 37 Hz. The trackline navigation is shown in Figure 10.

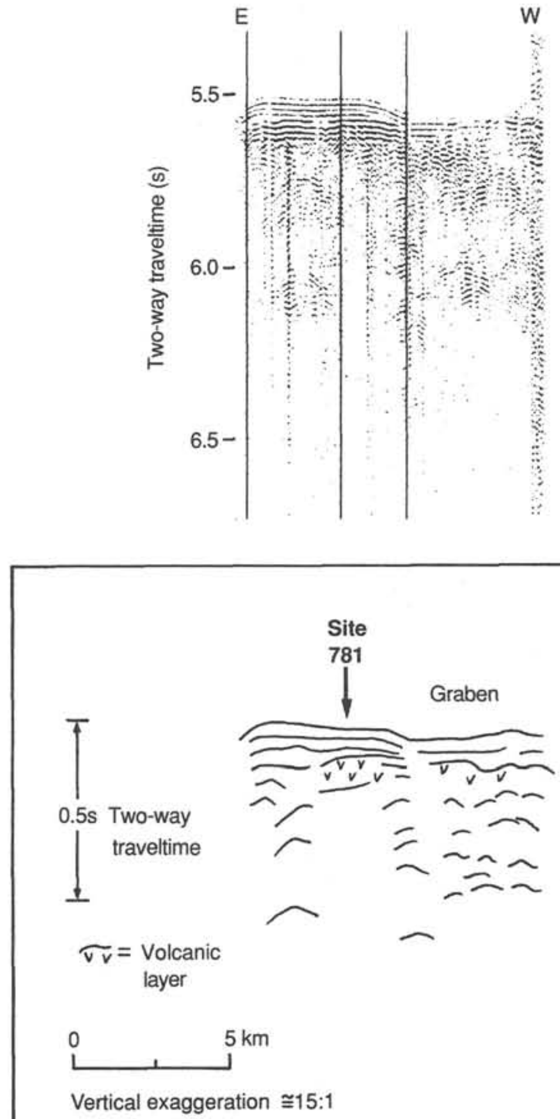

Figure 16. Single-channel seismic-reflection profile run east-west across Site 781 after it was drilled and an interpretive drawing of the profile. The profile location is shown in Figure 10. The well-layered, horizontal reflectors are from sedimentary sequences and the irregular, "rubbly-looking" reflectors are from basaltic layers beneath the sedimentary sequences (at least at Site 781). These layers extend laterally and horizontally beneath the graben fill adjacent to Site 781, unlike the basaltic layers shown on the other crossings, which appear to be offset by a normal fault along the graben flank (Figs. 12 and 13; see text for discussion).

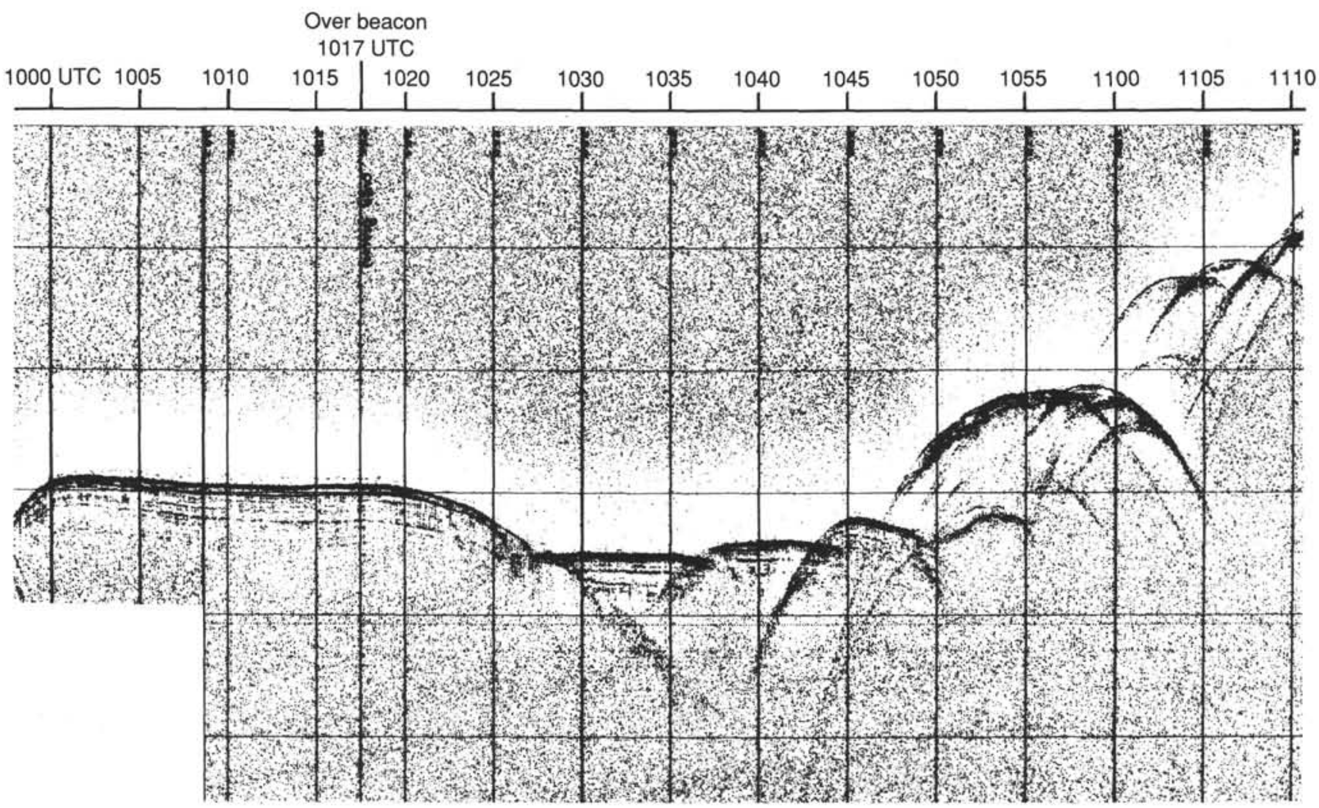

Figure 17. The 3.5-kHz depth record run across Site 781 after drilling and concurrent with the profile shown in Figure 16. The graben adjacent to Site 781 is underlain by a series of stepped blocks, probably offset by faults. The layered reflectors within each block are probably sedimentary layers, and the opaque zone along the east edge of the graben near Site 781 may be volcanic rocks that were not penetrated by the 3.5-kHz sound source. If the opaque zone is underlain by basaltic rocks, then these rocks may be associated with a fault zone flanking the graben.

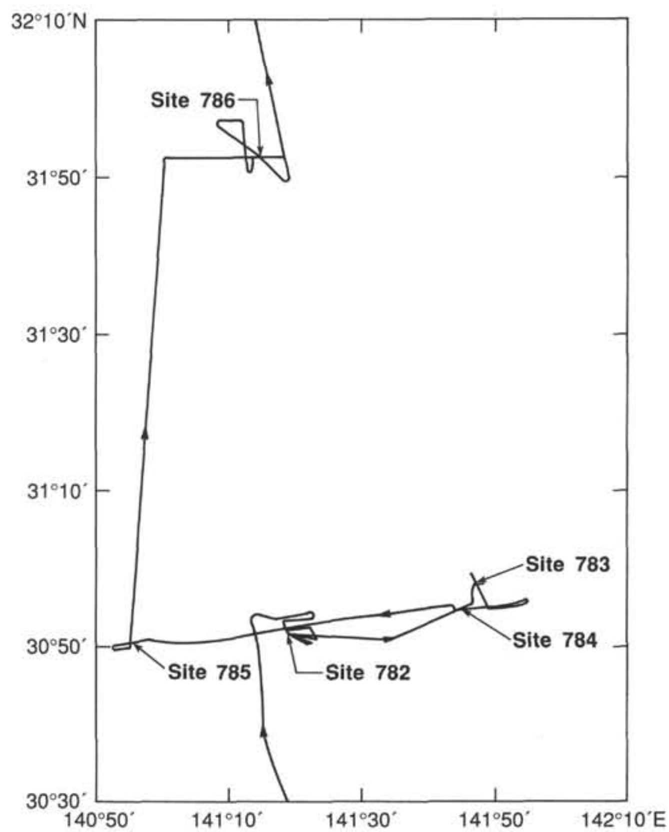

Figure 18. Enlarged trackline map near Sites 782–786. Trackline maps of individual sites, with locations of seismic-reflection profiles, are shown in Figures 19, 22, 25, and 28.

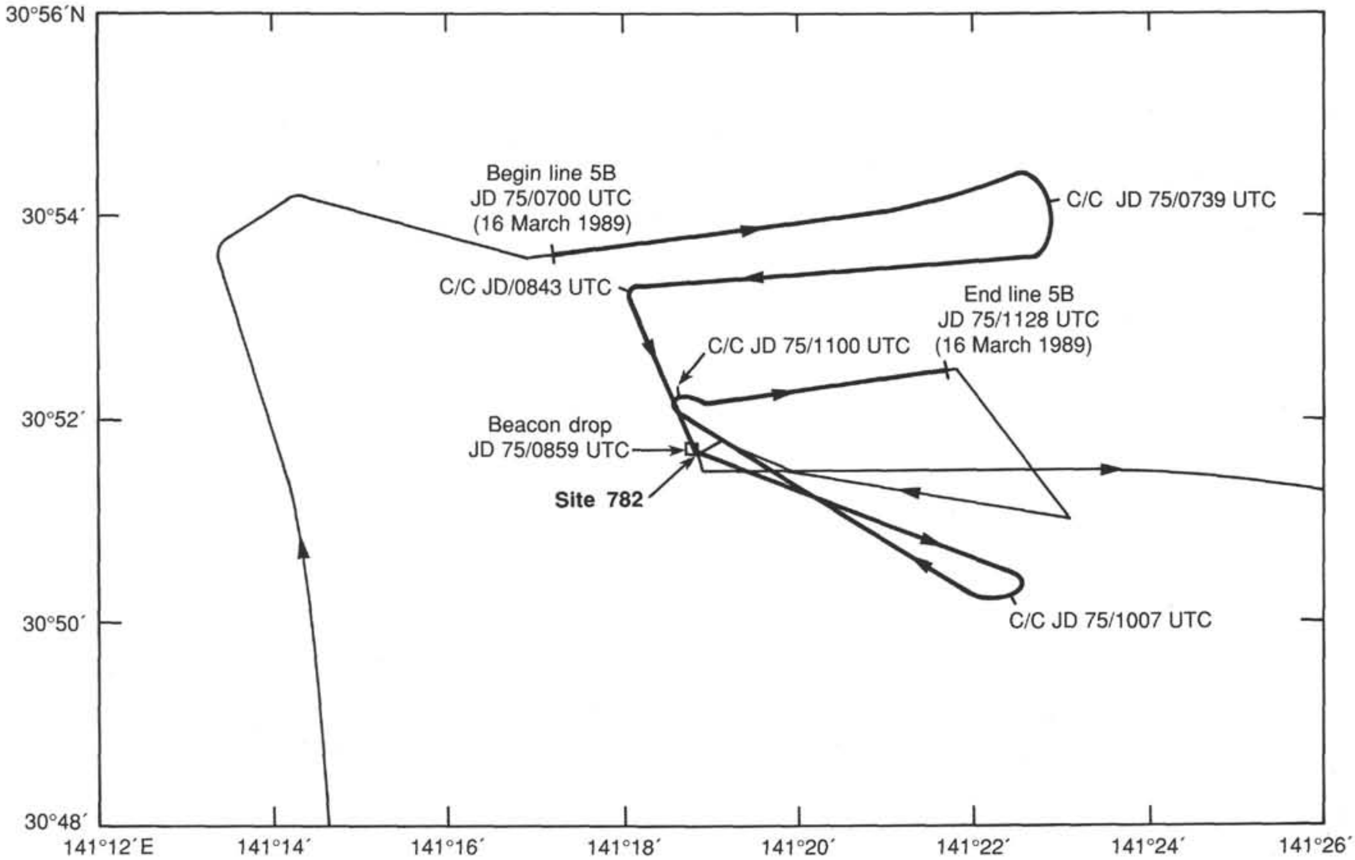

Figure 19. Trackline map of Site 782, in the northern part of the area investigated during Leg 125, showing the location of the drill site and geophysical trackline. Analog seismic-reflection line 125-05B is displayed in Figure 20.

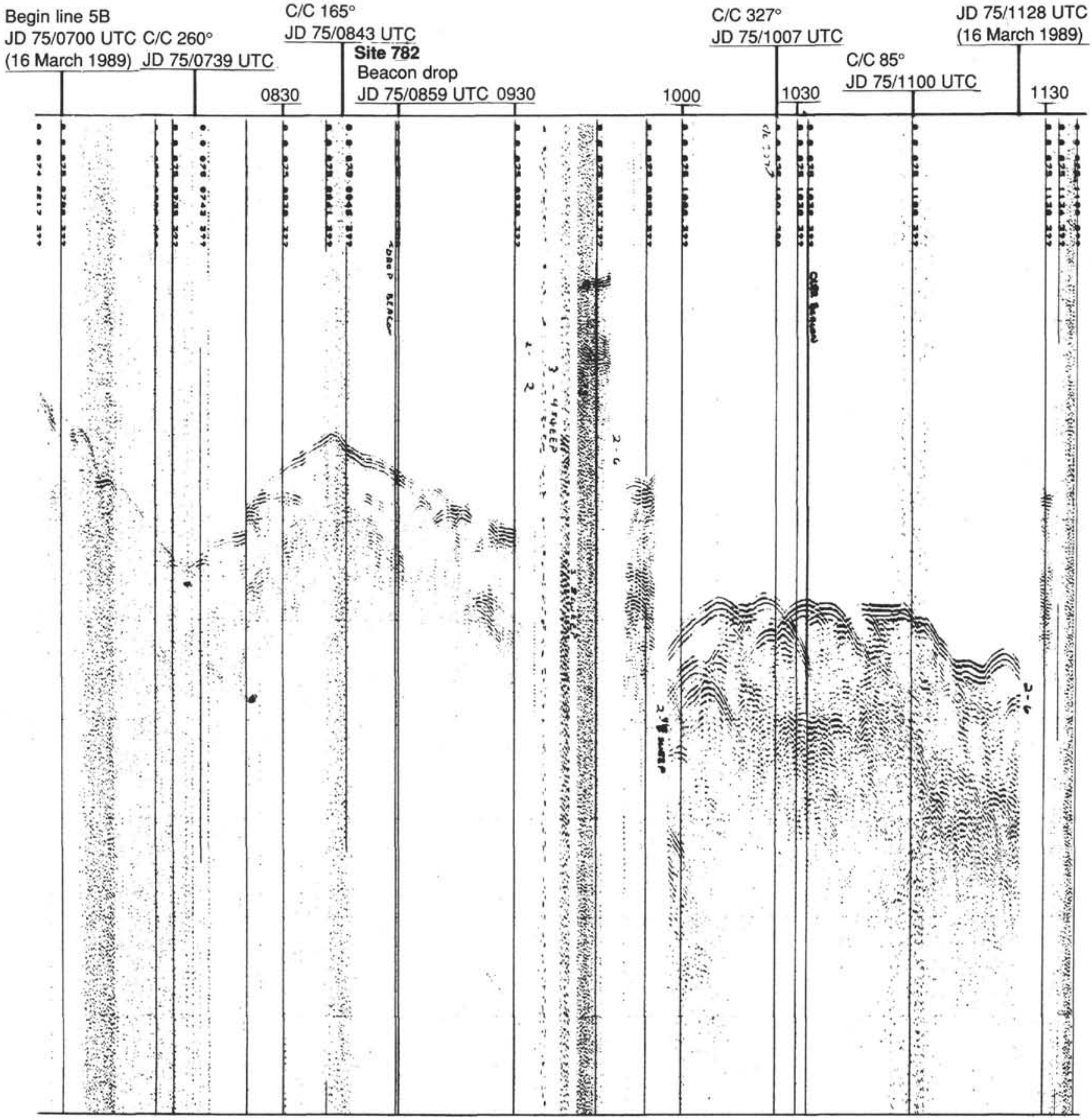

Figure 20. Analog single-channel seismic data collected from survey line 125-05B, en route to Site 782. The trackline navigation is shown in Figure 19.

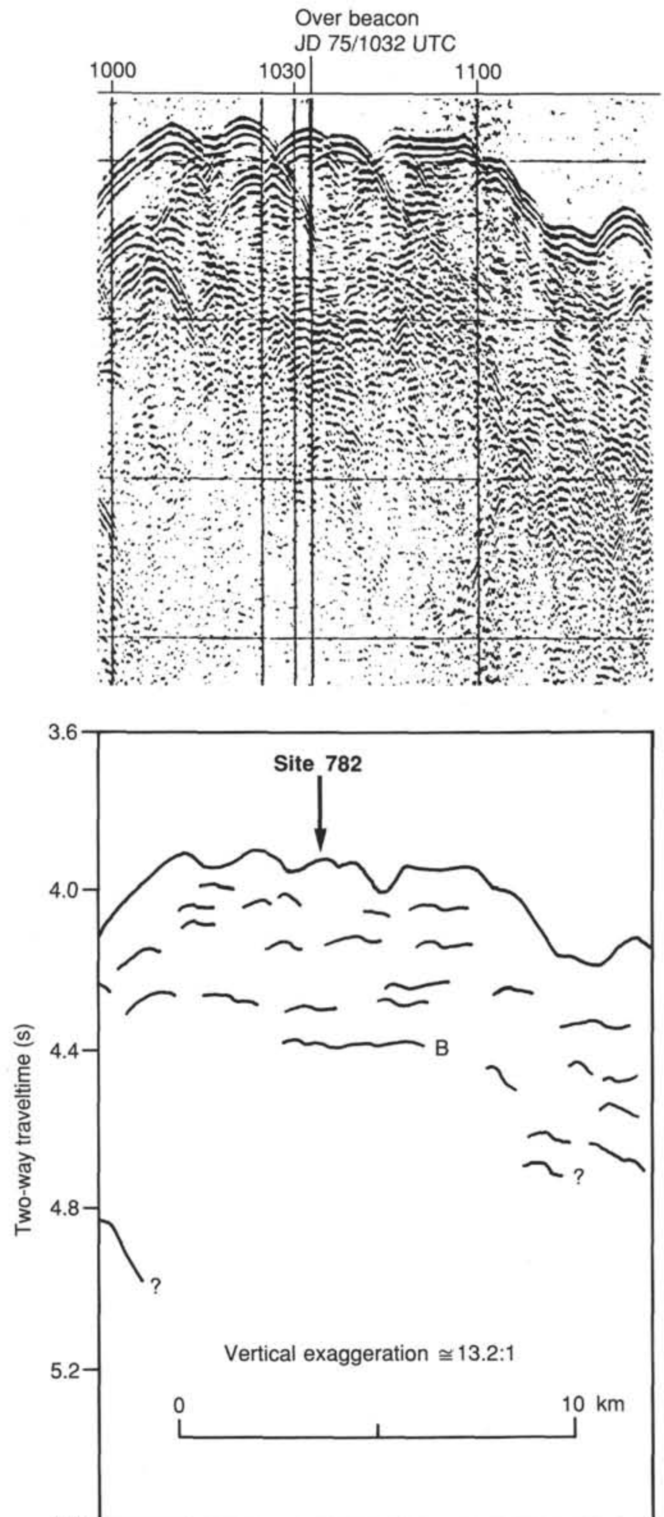

Figure 21. Single-channel seismic-reflection profile across Site 782 in the Izu-Bonin forearc and an interpretive drawing of the profile. The prominent basement reflector is labeled *B*.

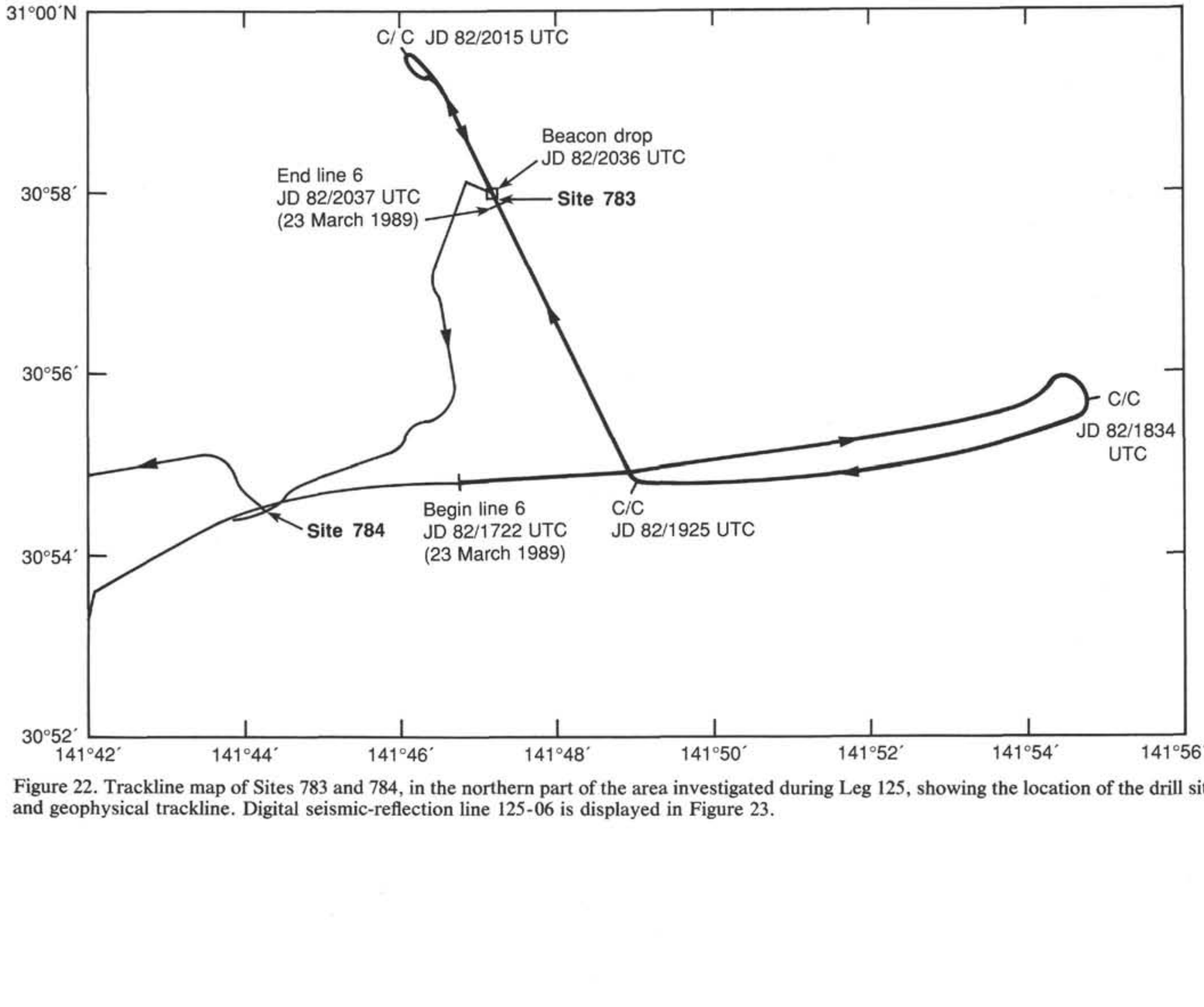

Figure 22. Trackline map of Sites 783 and 784, in the northern part of the area investigated during Leg 125, showing the location of the drill sites and geophysical trackline. Digital seismic-reflection line 125-06 is displayed in Figure 23.

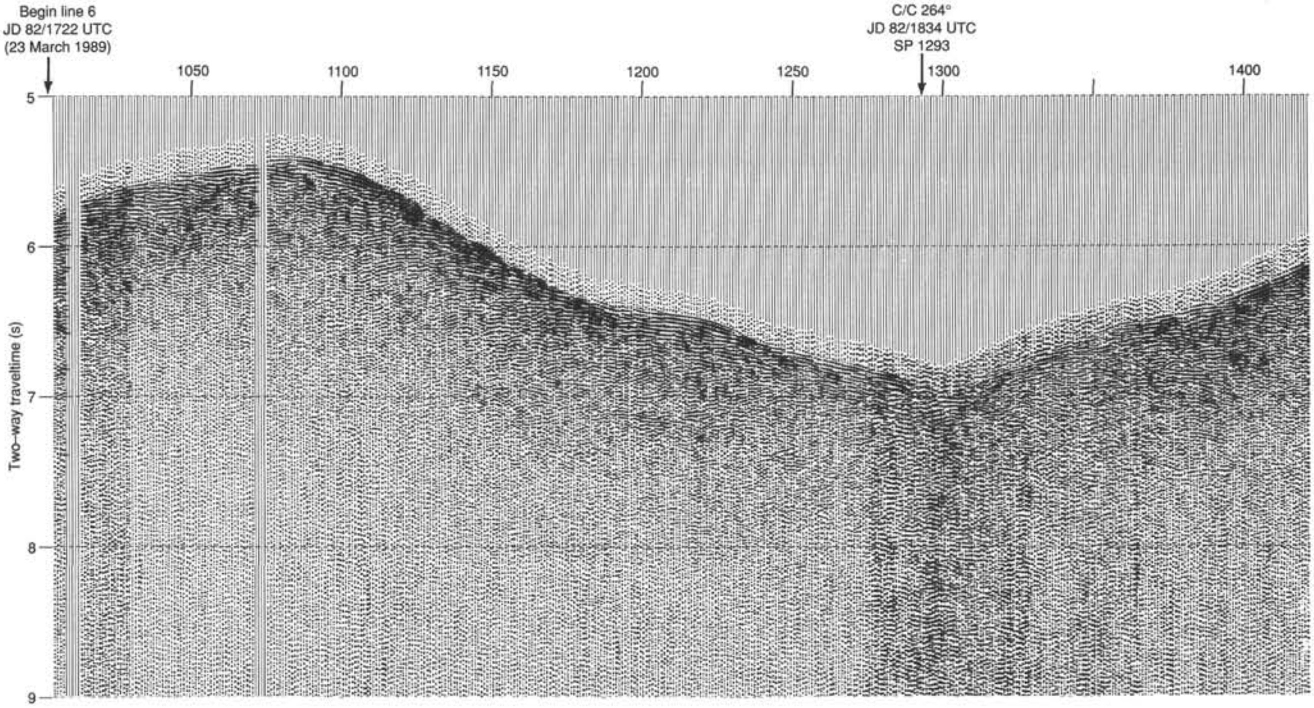

Figure 23. Processed digital seismic data collected from survey line 125-06, en route to Site 783. AGC was applied, and the processing filter parameters were 25-30-70-90 Hz. The trackline navigation is shown in Figure 22.

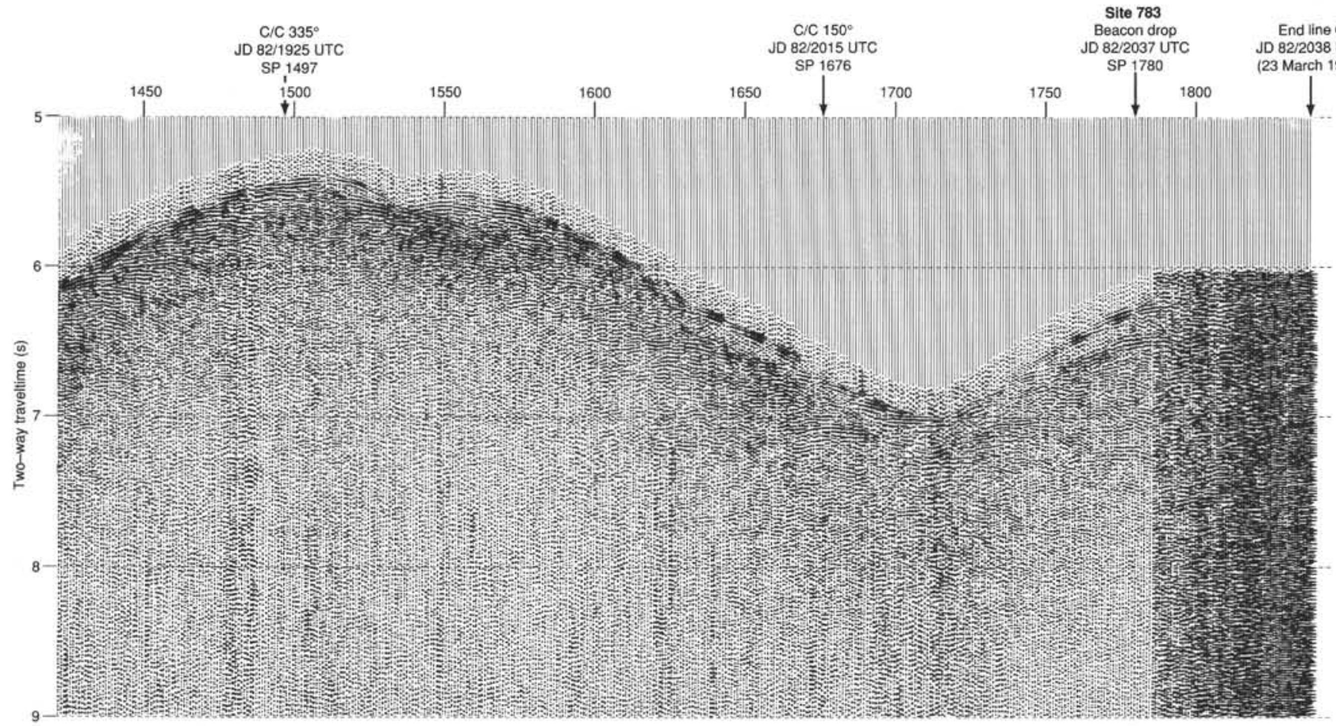

Figure 23 (continued).

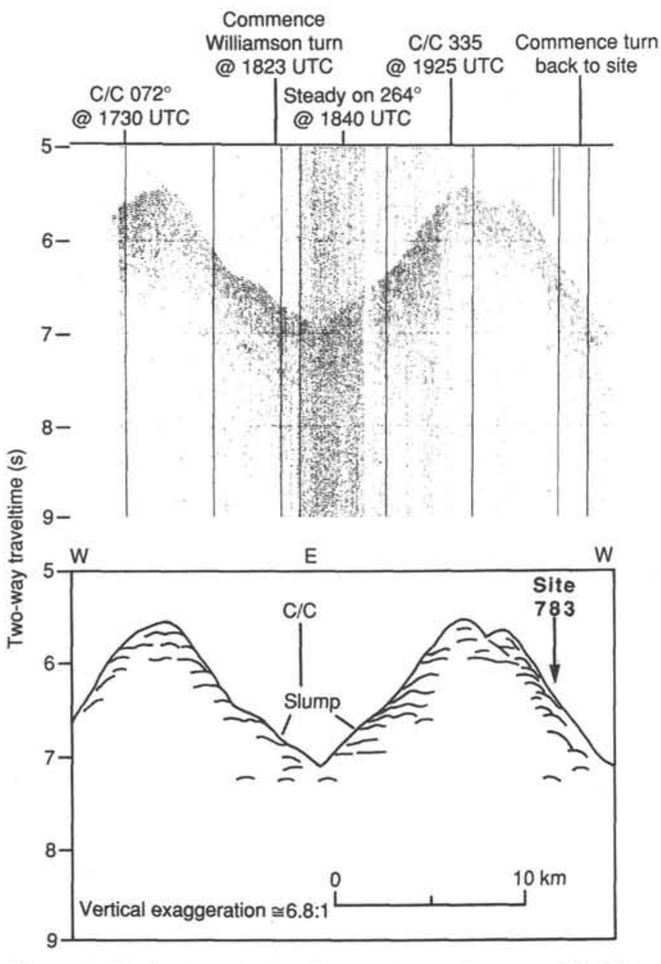

Figure 24. Single-channel seismic-reflection profile across Site 783 of an unnamed seamount in the Izu-Bonin forearc and an interpretive drawing of the profile. The internal structure of the seamount is poorly reflective, and only short, discontinuous reflectors were recorded.

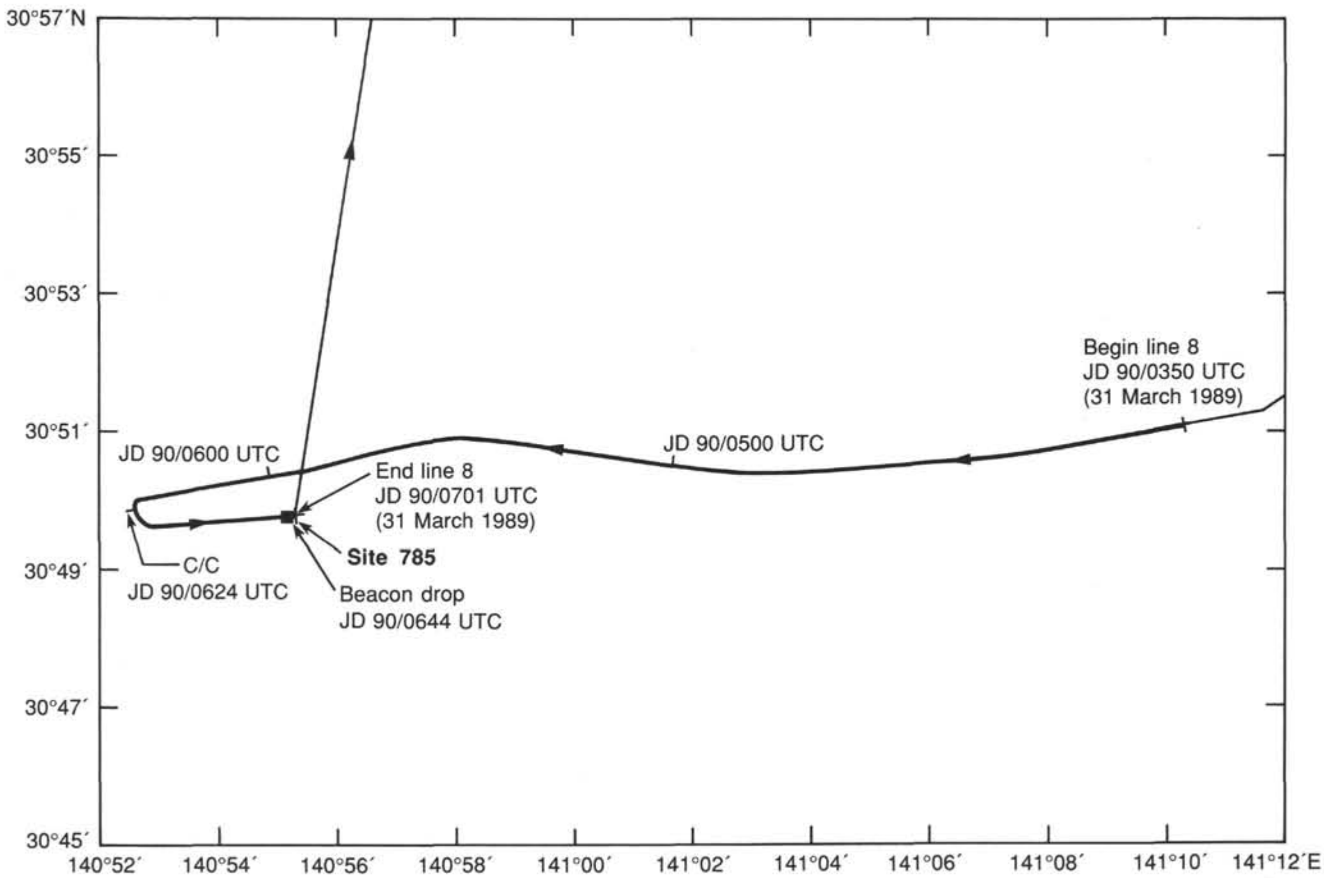

Figure 25. Trackline map of Site 785, in the northern part of the area investigated during Leg 125, showing the location of the drill site and geophysical trackline. Digital seismic-reflection line 125-08 is displayed in Figure 26.

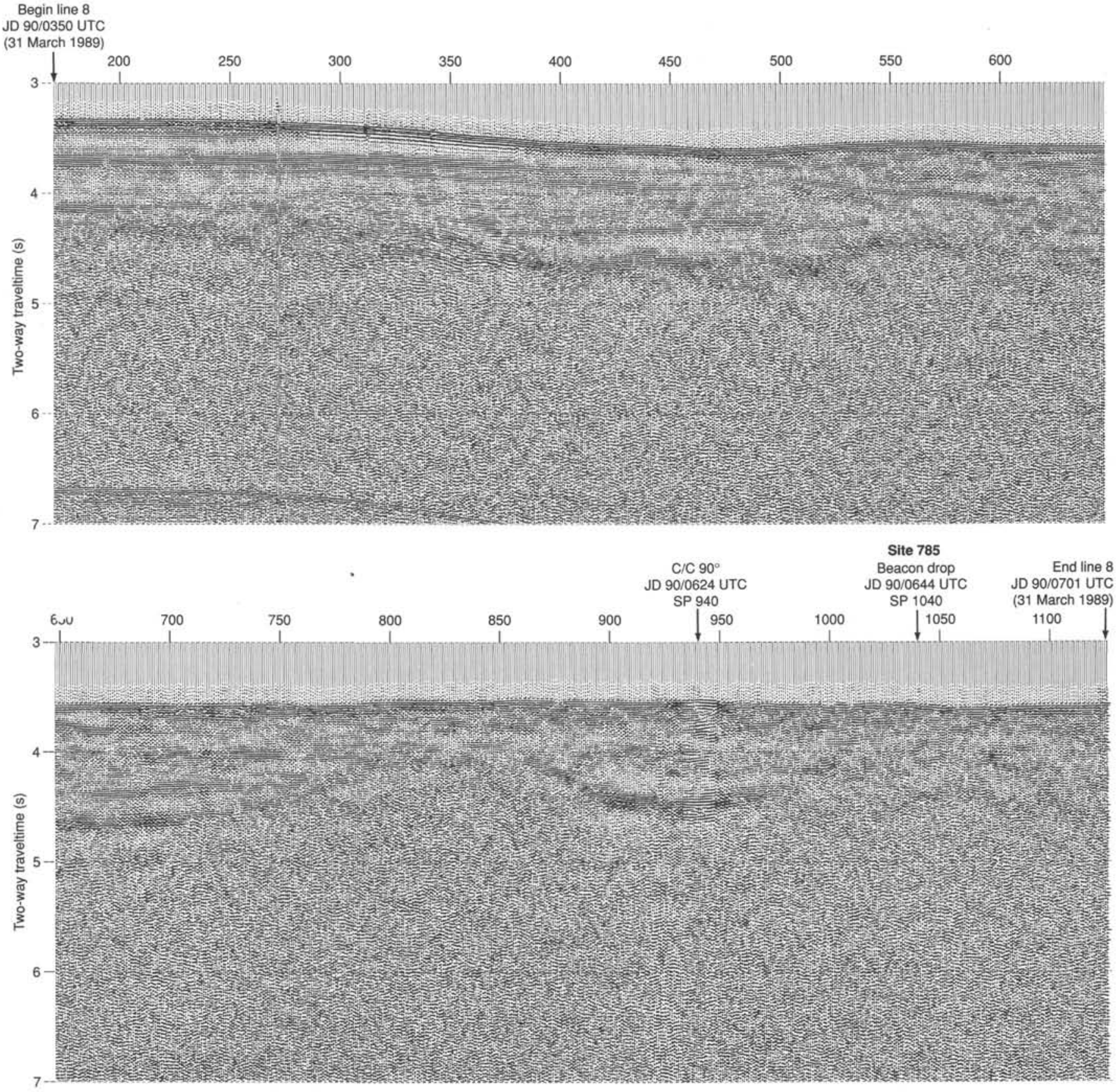

Figure 26. Processed digital seismic data collected from survey line 125-08, en route to Site 785. AGC was applied, and the processing filter parameters were 25-30-70-90 Hz. The trackline navigation is shown in Figure 25.

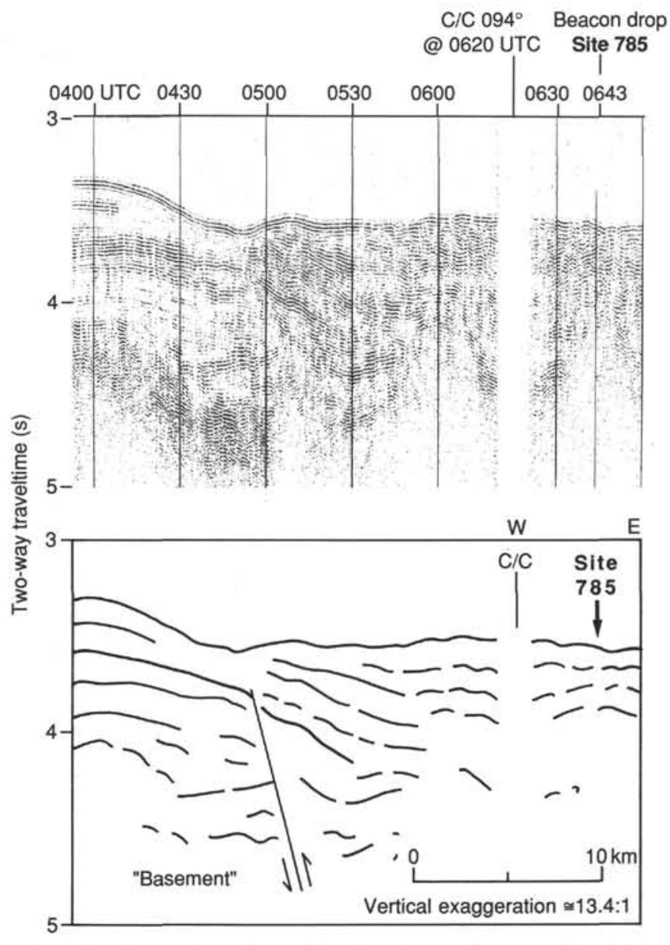

Figure 27. Single-channel seismic-reflection profile across Site 785 in the Izu-Bonin forearc and an interpretive drawing of the profile. The fault structure shown can be interpreted alternatively as an edge of a channel-fill structure.

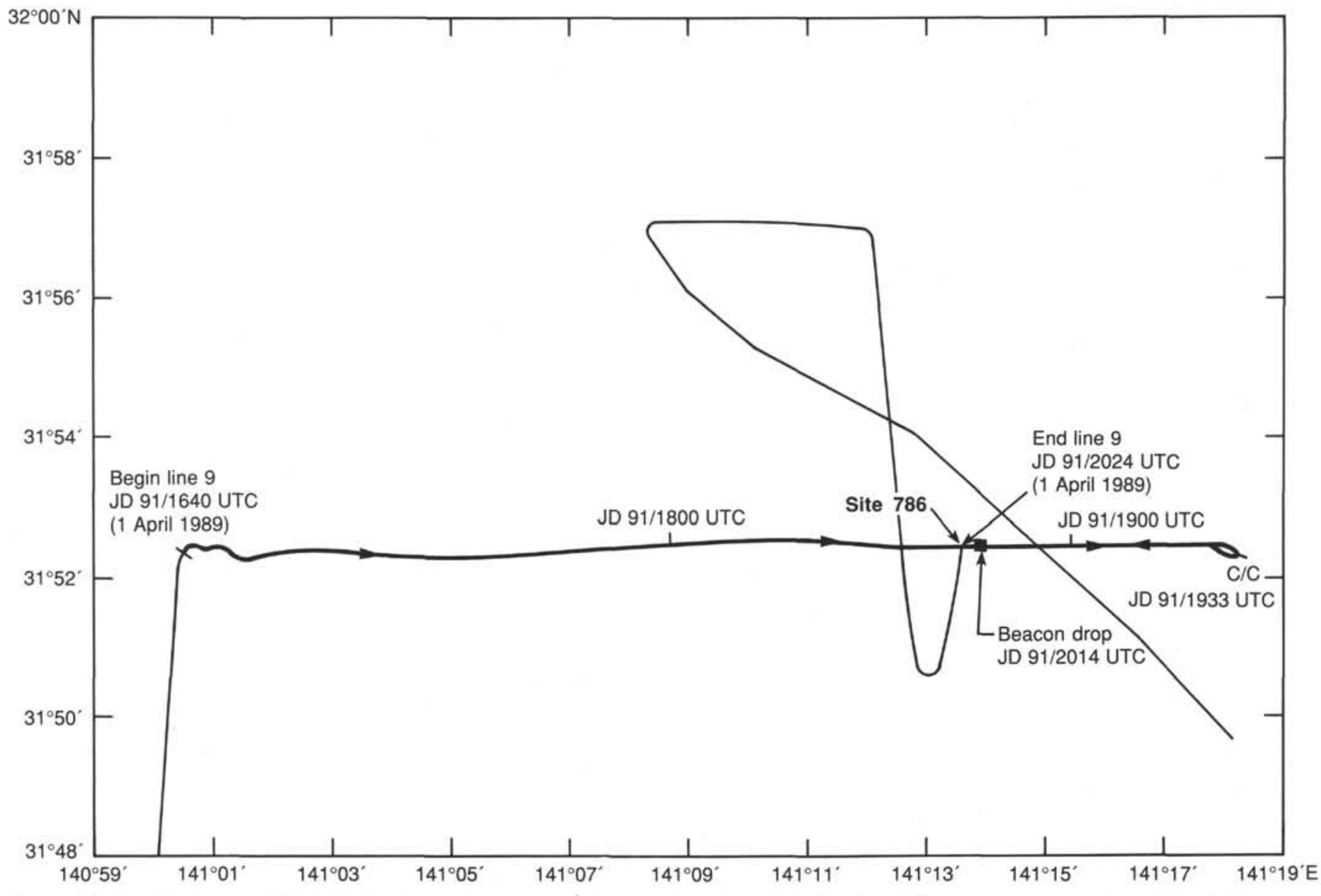

Figure 28. Trackline map of Site 786, in the northern part of the area investigated during Leg 125, showing the location of the drill site and geophysical trackline. Digital seismic-reflection line 125-09 is displayed in Figure 29.

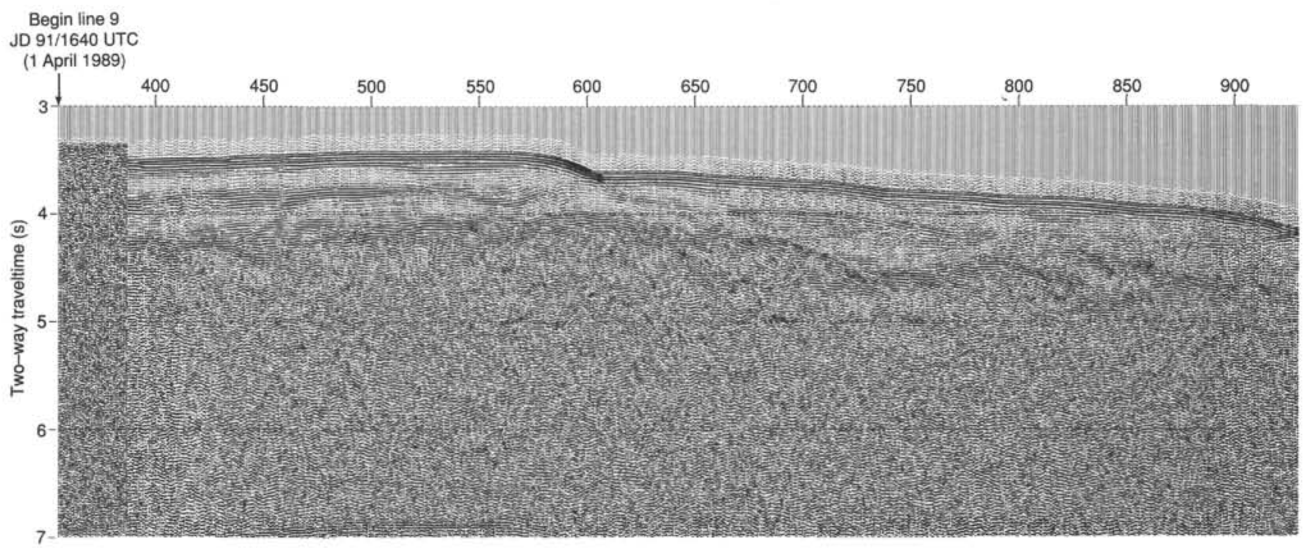

Figure 29. Processed digital seismic data collected from survey line 125-09, en route to Site 786. AGC was applied, and the processing filter parameters were 25-30-70-90 Hz. The trackline navigation is shown in Figure 28.

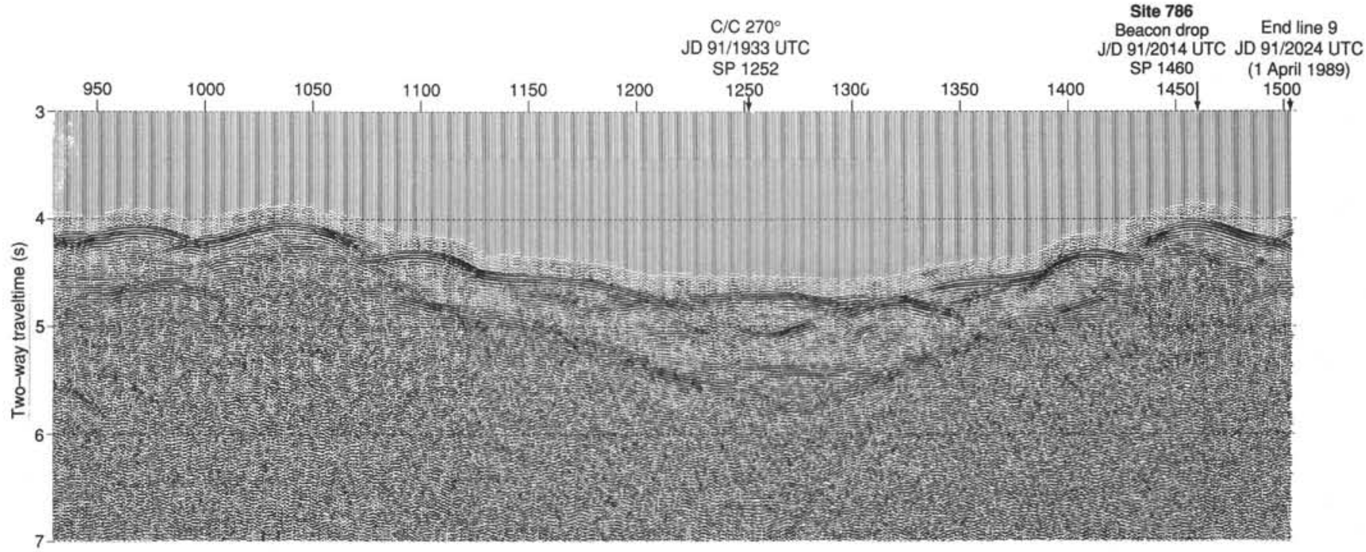

Figure 29 (continued).

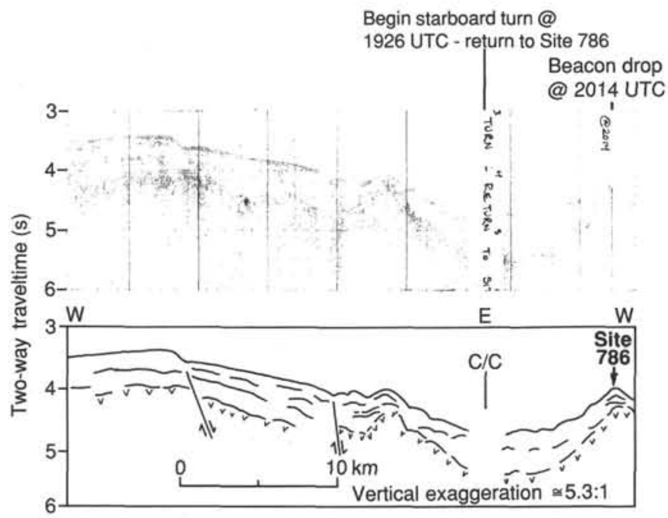

Figure 30. Single-channel seismic-reflection profile across Site 786 in the Izu-Bonin forearc and an interpretive drawing of the profile.