OCEAN DRILLING PROGRAM

LEG 138 PRELIMINARY REPORT

EASTERN EQUATORIAL PACIFIC

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ABSTRACT

The primary objective of ODP Leg 138 was to define the paleoceanographic evolution of the eastern equatorial Pacific during the last 12 million years. To address this objective, over 5500 m of core were recovered from 11 sites drilled along two north-south transects (95°W and 110°W) that crossed the complex oceanographic circulation system of the equatorial Pacific. By combining real-time laboratory core logging of sediment density, magnetic susceptibility, and color spectral reflectance with double and triple coring, we were able to construct composite sections and assure complete recovery at 8 of the 11 sites.

The broad pattern of temporal variation in sediment accumulation is dominated by basin-wide events, typically reflected by changes in calcium carbonate content (probably related to dissolution) or as biogenic opal-rich intervals. The sediment accumulation patterns over the last 12 million years are consistent with those found in the central equatorial Pacific (DSDP Leg 85), the western equatorial Pacific (ODP Leg 130), and the equatorial Indian Ocean (ODP Leg 115). Superimposed on the long-term fluctuations are high frequency variations in the ratio of sedimentary components (reflected in the continuous core logs of density, susceptibility, and color) that are consistent with Milankovitch climate forcing induced by variations in the earth's orbit.

The excellent bio- and magnetostratigraphy, along with the high-resolution core logs, have allowed us to produce detailed sedimentation and accumulation rate curves that will set the stage for the development of a high-resolution stratigraphy.

INTRODUCTION

Leg 138 represents the fifth expedition of the Ocean Drilling Program to examine the evolution of global climate change during the late Cenozoic through high-resolution studies of tropical ocean sediments. Previous legs have sampled the equatorial Atlantic (Leg 108), the Peru Current (Leg 112), the western tropical Indian Ocean (Leg 117), and the western equatorial Pacific (Leg 130).

The data produced from the cores will address the evolution of climate during the period when the earth changed to a world dominated by extensive northern high-latitude glaciation. The focus of this leg was the eastern Pacific equatorial circulation system, a region responsible for over half of the world's primary productivity and a sensitive recorder of global climate change.

SCIENTIFIC OBJECTIVES

From complete, undisturbed cores, answers to the following questions can be expected:

1. How did Pacific equatorial circulation evolve through the late Cenozoic as a response to increased global glaciation?

2. Are oceanographic changes hemispherically symmetrical or asymmetrical?

3. What was the nature of the circulation system during the late Miocene when open communication with the Atlantic occurred through the Panamanian seaway?

4. What was the nature of oceanographic variability during the late Miocene and Pliocene, and how does this compare to the Pleistocene (i.e., do the changing boundary conditions modify the sensitivity of the system)?

5. What was the nature of circulation during the Pliocene after the closure of Panama but before the onset of Pleistocene glaciation in the Northern Hemisphere?

6. How do oceanographic changes affect productivity in the equatorial Pacific surface waters?

The answers to these questions will provide important clues needed to understand the cause and nature of oceanographic and climatic variability.

Two complementary north-south transects were drilled across the complex equatorial current system (Fig. 1; Table 1). The western transect (seven sites centered around 110°W) crossed the equatorial Pacific current system where it is fully developed and removed from influences of eastern boundary currents. As such it represents the easternmost (and highest productivity) end-member of an oceanwide study of equatorial sedimentation (Legs 85 and 130). The north-south transect adds a new dimension to the study of this current system and allows a detailed look at the development of the equatorial current system in response to global climatic change. The eastern transect (four sites centered around 95°W) was designed to look at the interaction of the equatorial current system with the Peru Current and the eastern boundary of the Pacific. This transect will provide insight into changes in coastal upwelling as well as the eastern boundary current system.

COMPOSITE SECTIONS

The recovery of complete, high-resolution paleoclimatic records was of primary importance to understand the paleoceanographic history of the eastern equatorial Pacific. On Leg 138 we used real-time laboratory core logging of sediment density (GRAPE), magnetic susceptibility, and color spectral reflectance (a new instrument) to continuously monitor recovered core and ensure that cores from adjacent holes overlapped at core breaks. By combining real-time monitoring of these high-resolution profiles (2-5 cm) with double and triple coring, we were able to construct composite sections and assure nearly complete recovery of the sedimentary section. Construction of these composite sections revealed that a single APC-cored hole recovers approximately 90% of the section and a single XCB-cored hole recovers about 75% of the section.

DRILLING RESULTS

EASTERN TRANSECT

Site 844 (proposed Site EEQ-2)

The sedimentary section recovered at this site records the complex interplay amongst the divergence-driven equatorial current system, the shoaling of the thermocline associated with the Costa Rica Dome, terrigenous input, plate movements, and ocean chemistry. While a detailed reconstruction of these complex interactions must await shore-based studies, we present here a brief preliminary geologic history of Site 844 based on our initial shipboard results.

Site 844 (proposed site EEQ-2) is located on the Cocos Plate on crust formed about 17.5 Ma at the East Pacific Rise. Backtracking the site using the absolute plate motion for the Cocos Plate shows that the site formed at about 2° north of the equator (Fig. 2). Based on present-day oceanographic boundaries, this would place the nascent Site 844 beneath the South Equatorial Current (SEC). Double (and where necessary, triple) APC coring, in conjunction with the real-time analyses of continuous core logs (GRAPE, susceptibility and color), has assured the recovery of a continuous record of sedimentation at Site 844 spanning the last 17.3 m.y. (Figs. 3 and 4).

The first sediment to accumulate at the site was a metalliferous diatom nannofossil ooze, generated in the relatively productive waters of the SEC and by hydrothermal emanations associated with rifting. Following this initial phase of sedimentation, calcareous sediments, mostly foraminifer nannofossil oozes, accumulated at rates as high as 38 m/m.y. in the early to middle Miocene (Fig. 5). Siliceous sedimentation also was important during this interval, with radiolarians and especially diatoms increasing in abundance through the middle Miocene. Sedimentation rates of 30-35 m/m.y. are typical of those of the divergence-driven system of today's eastern equatorial Pacific.

At about 10.4 Ma, sedimentation rates rapidly decreased to about 10 m/m.y., with the lithology characterized by alternating carbonate and siliceous clay-rich oozes. The paleolatitude of the site at this time is about 4°N; assuming present current circulation patterns, this would put the site near the northern edge of the present South Equatorial Current and into a region presently characterized by relatively low sedimentation rates. While the reduction of sediment accumulation at this time may be, in part, due to the location of the site relative to surface circulation patterns, there is evidence that this reduction may be related to a major reorganization of oceanic circulation.

Large changes in carbonate sedimentation have been observed near the middle/upper Miocene boundary at a number of sites around the Pacific: in the central equatorial Pacific (Mayer, Theyer, et al., 1985); on Hess Rise—the mid-Chron 10 event (Vincent, 1981); and in the Southern Ocean (Barker, Kennett, et al., 1990). Widespread hiatuses (Barron and Keller, 1982), an increase in provincialism between high- and low-latitude microfossil assemblages (Bukry, 1985), and a rapid change in the "eustatic sea level" curve of Haq et al. (1987) also characterized this time period. These events, expressed as a widespread, synchronous seismic event first mapped in the central equatorial Pacific (Mayer et al., 1986) and subsequently found in the western equatorial Pacific (Berger et al., 1991) and now at Site 844, are evidence of a significant change in the characteristics of Pacific bottom waters. Coincident with this restructuring of Pacific bottom water is the occurrence of major erosional events in the deep North Atlantic (Mountain and Tucholke, 1983; Tucholke and Laine, 1982). The intensification of North Atlantic Deep Water associated with these erosional events may have resulted in increased partitioning of silica and carbonate between the Atlantic and Pacific and may account for the major changes in the Pacific carbonate record at this time (Mayer et al., 1986). Detailed shore-based work should help resolve the causes and effects of this far-reaching oceanographic event.

Sedimentation at Site 844 during the late Miocene and Pliocene was characterized by a continuation of alternating calcareous and siliceous lithologies, with sedimentation rates relatively low (less than 10 m/m.y.) as compared to the early to middle Miocene. The presence of siliceous microfossils, especially diatoms, suggests that surface productivity during this interval was elevated as compared to the open tropical Pacific. Radiolarian assemblages show significant differences from assemblages at tropical sites of the same age, which also suggests an oceanographic environment at Site 844 different from that of the open tropical Pacific.

During the late Pliocene, sedimentation rates increased, probably as a result of an increase in noncarbonate biogenic accumulation. The paleolatitude of the site at this time is within 1° of its present position within the high-productivity zone associated with the Costa Rica Dome. While increased sedimentation resulting from enhanced ocean production associated with the Costa Rica

Dome was expected in the Pleistocene, the depth of the site precludes accumulation of calcium carbonate. Thus sedimentation rates in the youngest part of the section did not reach the levels found in the Miocene or found presently in areas of the eastern equatorial Pacific where carbonate is accumulating.

Superimposed on these long-term trends in sedimentation is a high degree of variability as demonstrated in the continuous sediment parameters collected by color reflectance, GRAPE density, and magnetic susceptibility (Fig. 3). This variability occurs on scales from centimeters to meters; further high-resolution studies will be necessary to determine the processes responsible for this variability. For example, it is not yet known if the high-frequency variability in carbonate sedimentation during the Miocene reflects changes in production and/or changes in preservation (processes that are not necessarily uncoupled in pelagic sediments) or whether the variability is related to external climate forcing such as that observed in the Pleistocene climate's response to orbital variations.

Site 845 (proposed Site EEQ-1)

While the local tectonic history of this area of the Pacific was not an important objective of Leg 138, the results provide an age for the previously undated magnetic anomalies of the region and, more importantly, provide important constraints on the backtrack history of Site 845. An accurate backtrack path is required for understanding the paleoceanographic record of the site.

Site 845 is located within a region where the magnetic anomaly pattern has been mapped but has not been correlated with the known magnetic time scale (Klitgord and Mammerickx, 1982). Based on estimated East Pacific Rise spreading rates for the Cocos Plate (71 mm/yr; Hey et al., 1977) and crustal subsidence models, the age of basement was expected to be about 15 Ma (see Fig. 2). Initial biostratigraphic analyses of Site 845 samples place basement in the lower Miocene (CN3, NN4) at about 17 Ma. While the 2-million-year discrepancy may be dismissed as the result of inaccuracies in spreading rate, subsidence rate, and biostratigraphic determinations, it is also possible that this discrepancy requires rethinking of existing plate reconstruction models for the region. For example, the spreading rate for the East Pacific Rise may not represent the true long-term average spreading rate for this part of the Pacific, or the Berlanga Rise to the west of Site 845 may be a fossil spreading center as suggested by Klitgord and Mammerickx (1982), and thus basement at Site 845 was not formed at the East Pacific Rise.

The basement age at Deep Sea Drilling Project Site 495, which appears to have formed along the same spreading segment of the Cocos Plate, provides a means of estimating early Miocene spreading rates. Basement at Site 495 was biostratigraphically dated as early Miocene (Auboin, von Huene, et al., 1982). Taking 22 Ma as the oldest possible age for the basement at Site 495 and 17 Ma as the age at Site 845, we estimate a minimum spreading rate of about 65 mm/yr during the early Miocene. If this estimate represents the average rate for East Pacific Rise spreading, then the estimated age of basement at Site 845 is about 16.5 Ma--not too different from the age based on micropaleontological results from Site 845. If the Berlanga Rise is indeed a fossil spreading center, then this minimum spreading rate estimate suggests that the ridge became inactive about 2 million years after the formation of the crust at Site 845. These estimated spreading rates would not require a large change in spreading rate from the Berlanga Rise to the new East Pacific Rise.

Klitgord and Mammerickx (1982) suggest that the spreading history of the Cocos Plate has been uniform since the major reorganization of the eastern Pacific spreading centers at about 12.5 Ma. Taking 15 Ma as the end of spreading on the Berlanga Rise, we assume that the absolute pole for the Cocos Plate is a reasonable representation of the backtrack path for Site 845 over at least the last 15 million years (Fig. 2). Thus, we have a higher degree of confidence in the paleolatitudes for Site 845 during the last 12 million years, a lesser degree of confidence for the period of 12 to 15 Ma, and the least confidence for the oldest 3 million years. The initial paleolatitude of the site was between 4° and 5° north of the equator. Within the present oceanographic setting this would place the site at the northern limit of the South Equatorial Current (SEC) at the time of its creation.

Double (and where necessary, triple) APC coring, in conjunction with the real-time analyses of continuous core logs (GRAPE, susceptibility, and color), has assured the recovery of a continuous record of sedimentation at Site 845 spanning the last 17 m.y. (Figs. 6 and 7). Sedimentation at Site 845 began with accumulation of metalliferous nannofossil ooze followed by an interval of high carbonate accumulation. Initially, sedimentation rates may have been as high as 50 m/m.y., but over the interval of high carbonate accumulation, 17 Ma to 11.5 Ma, sedimentation rates dropped to an average of about 26 m/m.y. (Fig. 8). The average sedimentation rate was about 35% less than the rate observed during the same interval at Site 844, whose latitudinal position was about 2° farther south. This difference may reflect a gradient in surface production across the 2° of latitude, a gradient even less than that observed today, and/or dissolution differences associated with changes in water depth.

While the sharp decrease in sedimentation rate at about 16 Ma is most probably an artifact of the limited number of datums used in constructing the sedimentation-rate curve, it is likely that this interval did see a reduction in sedimentation rate as the site traveled out from under the influence of the equatorial divergence. This conclusion is supported by examination of the GRAPE record (often a proxy for carbonate content; Mayer, 1991), which shows a trend of decreasing density in the interval from 16.5 to 14 Ma. A decrease in wet bulk density in the deepest part of the section (where compaction should be greatest) can only be explained by the presence of siliceous microfossils, which have low grain densities and maintain an open structure even under substantial overburden. As the site moved out from under the very productive waters associated with the equator (from 16.5 to 14 Ma), the proportion of siliceous microfossils decreased, resulting in lower overall sedimentation rates. Sedimentation after this time (14 to 11.5 Ma) was dominated by the deposition of carbonate, indicative of a moderately productive environment coupled with a relatively deep CCD.

The interval from 10.5 to 9.5 Ma is marked by a significant transition in sedimentation. Sedimentation rates decreased to about 15 m/m.y. over this interval, and the sediment section is characterized by a transition between high carbonate sediments of the middle Miocene to more siliceous clay sediments of the late Miocene (Fig. 8). The transition in sediment type is well characterized by the color reflectance data (Fig. 6) in which the red and near-infrared bands show a marked increase associated with the more reddish appearance of the sediment. The sediment over this interval is a clay and radiolarian clay sediment with manganese oxides. These sediments are consistent with reduced sedimentation rates between 10.5 and 8.5 Ma and with oxidized conditions as opposed to the previous sedimentary environment. The timing of the carbonate decrease appears to be coincident with similar decreases in sediment carbonate content noted in many areas of the Pacific and may be a manifestation of a major oceanographic event that affected the position of the CCD (see discussion in Site 844 section; or in Theyer et al., 1989). In addition, chemical analyses indicate elevated Fe/Al ratios in this interval, which suggest a possible hydrothermal component in this part of the section at Site 845.

The oxidized character of the sediment section in this interval is paralleled by a marked increase in magnetic susceptibility (Fig. 6) and also coincides with the beginning of the interval in which paleomagnetic stratigraphy could be established for the site. Throughout this entire interval the paleolatitude of the site was about 6°N, and thus the site was well away from the influence of equatorial divergence. Detailed sedimentological, geochemical, and paleoceanographic studies of this and other sites of the eastern transect should help resolve the nature of this transition.

Sedimentation during the late Miocene to late Pliocene is characterized by mixtures of radiolarians, diatoms and clays. Sedimentation rates vary between about 10 and 20 m/m.y., with the average for the interval (1.6 to 8.5 Ma) being 15 m/m.y. Color reflectance and sediment density (Fig. 6) show the relatively uniform nature of the sediments, but the carbonate data do demonstrate short intervals of increased carbonate content in this otherwise biogenic silica-dominated sequence (Fig. 8).

The interval of the late Miocene to late Pliocene sedimentation is terminated by a marked increase in sedimentation rates during the Pleistocene. This increase in sedimentation rate is associated with a marked increase in organic carbon accumulation but not with an increase in the carbonate content of the sediment (Fig. 8). The late Pliocene and Pleistocene is also an interval in which magnetic susceptibility is much reduced (Fig. 6), and a paleomagnetic stratigraphy could not be defined. The decrease in susceptibility seems to precede the increase in sedimentation. Comparison with Site 844 shows that this interval is marked by a correlatable decrease in susceptibility. Thus, the susceptibility signal at Site 845 during this interval may contain both a primary signal of magnetic mineral accumulation as well as a diagenetic signal associated with increased organic carbon degradation and reducing conditions in the youngest part of the sediment section.

The marked increase in sedimentation during the Pleistocene may be associated with the movement of the site to near its present latitudinal position at the boundary between the North Equatorial Current and North Equatorial Countercurrent. This is where off-equator divergence takes place, which would help enhance surface production and help contribute to the increased accumulation of organic carbon and biogenic siliceous sediments. Additionally, we may be seeing the influence of the eastern boundary current. Again, detailed shore-based studies will be needed to resolve these questions.

Of critical importance to paleoceanographic and sedimentologic studies of the eastern equatorial Pacific are the paleomagnetic results of Site 845. Excellent paleomagnetic stratigraphy was determined, spanning the middle Miocene to middle Pliocene (about 13.4 to 2.7 Ma). This high-resolution record represents a unique sequence that should prove of great value in calibrating biostratigraphic datums to an absolute age scale. Also this high-resolution sequence contains three short normal polarity features not recognized in accepted polarity time scales. If these features can be further verified, they will provide important new information for paleomagnetic stratigraphy and about the behavior of the Earth's field.

Site 846 (proposed Site EEQ-4)

Site 846, the southernmost site of Leg 138's eastern transect, is located approximately 300 km due south of the Galapagos Islands within the region of interaction between the South Equatorial Current (SEC) and the Peru Current (Fig.1). The relatively high sedimentation rates associated with this region have resulted in the accumulation of more than 400 m of sediment representing approximately 16.5 Ma of continuous deposition (Figs. 9 and 10). Four holes were drilled at Site 846, and the combination of real-time analyses of continuous core logs (GRAPE, susceptibility, and color) with overlapping APC's has assured the complete recovery of the upper 200 m of the section (approximately the last 4 m.y.); the rest of the section was recovered (with only minor gaps) with XCB coring. During drilling at Site 846 we also used the XCB to sample part of the section we had already recovered with the APC. This experiment showed that while the XCB causes slightly more disturbance than the APC, the quality of XCB material is excellent and well suited for high-resolution paleoceanographic studies.

Site 846, located at approximately 3°S, is on the southern limb of the Carnegie Ridge near the boundary between crust generated at the Galapagos Spreading Center and crust generated at the East Pacific Rise. While it is impossible, given the information at hand, to determine at which spreading center the site was formed, from a paleoceanographic point of view this is of little concern. In either case, the site formed approximately 16.5 Ma, and its absolute motion has been constrained by the Pacific-Nazca pole of rotation (as determined from the Hawaiian and Galapagos hotspot trends). The resulting backtrack path (Fig. 2) shows that for most of its history the site has traveled in a generally east-west direction and has thus remained at its present latitude. Paleoceanographically, this makes the site well suited for studies of the history of equatorial circulation. While there is little conclusive evidence for which spreading center generated the crust that Site 846 sits on, the presence of a north-south-oriented bathymetric offset to the west of the site (which may be related to the Galapagos Island Fracture Zone--Hey, et al., 1977) leads us to believe that the site originated at the Galapagos Spreading Center.

The first sediment to accumulate on the newly formed basalt at Site 846 was a very dark-reddish-brown metalliferous foraminifer nannofossil ooze. Overlying the metalliferous sediments is approximately 40 m of clayey foraminifer nannofossil chalk with virtually no biogenic silica but with a number of chert layers (small amounts were recovered by drilling, but the presence of significant amounts is clear in the logging data). The chemistry of the interstitial waters also reflects the uptake of silica in the region of chert formation as well as the effects of alteration of basalt. During the time interval represented by these deposits, sedimentation rates are lowest of the entire section (approx. 10 m/m.y.--Fig. 11), as are non-carbonate mass-accumulation rates (these must be interpreted cautiously because of the presence of chert and chalk in this interval).

In the interval from 14.1 to 10.6 Ma, sedimentation rates picked up to a level of approximately 17 m/m.y. Mass-accumulation rates of all components also remain rather moderate. Carbonate contents are quite high in the section that consists predominantly of nannofossil ooze. It is interesting to note that although this interval is dominated by pelagic carbonate, its magnetic-susceptibility signal is stronger than elsewhere in the section (Fig. 9). We attribute this to the reduced levels of organic carbon in this interval relative to the rest of the section (elsewhere in the section the susceptibility signal is lost due to dissolution of magnetic components in the presence of organic carbon and sulfate reduction). The carbonate content slowly decreases upsection as biogenic carbonate is replaced by biogenic silica (though biogenic silica is still only a minor component). This slow decrease in carbonate content is probably related to the gradual deepening of the site as it moves away from the ridge crest.

At approximately 10.6 Ma there was a major change in the sedimentary deposits. The period from 10.6 to about 7 Ma was characterized by a slight reduction in sedimentation and non-carbonate accumulation rates (Fig. 11) but a large decrease in the carbonate accumulation rate and the percentage of carbonate. The sediment that accumulated at this time is predominantly clayey radiolarian diatom ooze. The effect of the increase in silica is clearly seen in the large drop in reflectance and saturated bulk density (Fig. 9) and sonic velocity. Also associated with this interval is a small increase in clay content as seen in the smear slides, gamma-ray logs, and susceptibility. Given the large decrease in carbonate mass-accumulation rate coincident with very little change in the non-carbonate accumulation rate, we interpret this major change in sedimentation to be the result of a dissolution event (or events) related to a major reorganization of Pacific circulation. A similar feature has been noted at all of the previous Leg 138 sites and at a number of other locations throughout the Pacific (Mayer et al., 1986). The detailed nature of this event, including determination of its synchroneity, will be the subject of shore-based studies.

At approximately 7 Ma, sedimentation and accumulation rates (particularly carbonate accumulation rates) increased greatly (Fig. 11). This is in contrast to Sites 844 and 845, whose carbonate sedimentation never recovered from the middle/late Miocene boundary "dissolution event" and may be the result of the shallower depth of Site 846. If this is the case, it implies the establishment of a rather steep gradient to the CCD after the middle Miocene--a feature that is still found today (Mitchell Lyle, unpublished data).

The late Miocene to the Pleistocene was a time of generally high sedimentation (40-60 m/m.y.) and carbonate accumulation rates with a large degree of variability in the sedimentary components, which range from nannofossil ooze to diatom ooze (though nannofossil ooze with foraminfers and diatoms is the most abundant). Carbonate contents vary widely (from 15% to 90%), reflecting relatively high-frequency changes in productivity and dissolution. Organic carbon content increased steadily throughout this interval with C_{org} accumulation rates reaching a peak during the interval from 2 to 1 Ma. The presence of significant organic material at Site 846 is confirmed by evidence for sulfate reduction and the distinct odor of H_2S in the upper part of the section, as well as the presence of biogenic methane. The presence of methane in the midst of the sulfate-reduction zone calls into question the general belief that methane forms only after the depletion of sulfate. Additionally, the absence of a susceptibility signal in the entire interval from the late Miocene to the Pleistocene can be attributed to the relatively high C_{org} concentrations and the associated reduction of magnetic minerals.

During the interval from 2 to approximately 1.5 Ma, sedimentation was once again dominated by biogenic silica components. In contrast to the earlier interval of silica dominance (10.5 to 7 Ma), the younger time period shows a large increase in the non-carbonate accumulation rate and a decrease in the carbonate accumulation rate. The combination of increased non-carbonate accumulation with decreased carbonate accumulation may indicate that productivity has increased to the point where the increase in alkalinity (associated with the organic matter) overcomes the increased production of carbonate material, resulting in a net loss of carbonate. Clearly, since the late Miocene, Site 846 has been subjected to large, high-frequency changes in sediment flux. The relationship of these changes to variations in the Peru Current, to changes in climatic forcing, and to fluctuations in deep ocean chemistry will be the subject of shore-based research.

Site 847 (proposed Site EEQ-3)

Site 847 is located within the equatorial divergence approximately 380 km west of the Galapagos Islands (Fig. 1). The surface oceanographic conditions of this region of the equatorial Pacific reflect the interaction of three major oceanic elements: (1) the eastern end of the westward-flowing South Equatorial Current (SEC) (which is also influenced by the cold northward-flowing Peru Current); (2) divergence and upwelling caused by the change in the direction of the Coriolis force at the equator; and (3) the seasonal shoaling of the eastward-flowing subsurface Equatorial Undercurrent. The site was selected in an effort to extract the late Neogene record of changes in this circulation--changes which may reflect variations in global atmospheric conditions and climate.

In addition to being influenced by a complex surface oceanographic regime, the sediment at Site 847 also reflects the interaction of tectonism and deep ocean chemistry. Estimates of basement age for the site can be made based on tectonic reconstructions of the eastern Pacific (Hey, 1977; Hey et al., 1977). The site is located near the boundary between crust formed at the Galapagos Spreading Center to the north and the East Pacific Rise to the west of the site. While it is difficult to determine from which of the two spreading centers the site originated, it is not critical to paleoceanographic reconstructions because the absolute motion of all crust in the region is dominated by the Pacific-Nazca pole of rotation, and thus the site has remained in its present equatorial (and thus oceanographic) setting for most of its history (Fig. 2). Of greater concern is the age of the crust. While Site 847 sits in a region whose tectonics are not well determined, the reconstruction of Hey (1977) calls for crust generated at either of these ridge crests to be approximately 9 Ma. The deepest samples recovered at Site 847 were, however, cherts with a calcareous veneer that contained abundant nannofossils of early Miocene (approx. 22 Ma) age. The sediments immediately above the chert were approximately 6.5 Ma in age. The presence of approximately 22-Ma microfossils immediately below 6.5-Ma material on crust thought to be about 9 Ma raises a number of questions about the tectonic history of this poorly known region. These questions are beyond the scope of shipboard analyses and will be the subject of future study. The presence of chert at a relatively shallow depth also implies higher than normal geothermal gradients. The proximity of the spreading centers and the Galapagos hotspot must thus be taken into account in reconstructing the geologic history of the sediments at Site 847. Given our uncertainty about the nature of the earliest history of the site, we will restrict our discussion of its geologic history to that period represented by the sediment overlying the chert--the last 6.5 m.y.

Four holes were drilled at the site. Holes B and C were both APC cored to approximately 135 mbsf and then continued with the XCB coring system to 247 and 232 mbsf respectively. Both holes were terminated when chert, an indication of increased temperature gradients, stopped penetration of the XCB. APC coring in conjunction with real-time monitoring of laboratory core logs (GRAPE, color, and susceptibility) assured that in the upper 135 m a continuous section was recovered (Figs. 12 and 13). Double XCB coring of the lower part of the section allowed further assessment of the potential of XCB-cored material for high-resolution paleoceanographic studies and helped extend the section over which continuous recovery could be assured.

The drilled section represents what appears to be continuous sedimentation over the last 6.5 m.y. Sedimentation rates were, in general, high, being consistently over 30 m/m.y. and during the early Pliocene may have been as high as 85 m/m.y. (Fig. 14). The sediments are predominantly nannofossil oozes with varying amounts of biogenic silica. A few intervals are dominantly calcareous nannofossil diatom ooze with higher proportions of clay.

To a first order, the properties of the sediments reflect the interplay between calcareous and biogenic silica deposition, while to a second order diagenesis also influences the section. Trends in sediment density and color reflection are very similar (Fig. 12); both of these properties reflect changes in calcium carbonate content. The interval from 6.5 to 5 Ma is characterized by high sedimentation rates (approx. 30 m/m.y.--Fig. 14) and high frequency fluctuations in the proportions of nannofossils relative to diatoms. Clay content is low and remains fairly constant throughout the interval. The relationship of these carbonate/silica cycles to variations in ocean chemistry (dissolution), changes in surface-water conditions (productivity), and climatic forcing will be the subject of detailed shore-based study.

Based on long-term sedimentation and accumulation-rate changes, it is possible to make a few general inferences. There are two prominent intervals of high diatom abundances within the section. The youngest, at about 1.9 to 1.5 Ma, shows a small increase in sedimentation rates and a marked decrease in color reflectance, sediment density, and calcium carbonate content (Figs. 12 and 14). Mass-accumulation rates show that the interval is a time of increased non-carbonate (assumed to be predominantly biogenic silica) and organic carbon accumulation and decreased carbonate flux. We infer that this interval represents a time of increased productivity and that the decrease in calcium carbonate may reflect enhanced dissolution due to increased organic carbon regeneration within the sediments.

The older interval of high diatom abundances occurred around 4.5 Ma and is most clearly distinguished by the marked negative magnetic susceptibility. This older interval, however, shows an increased flux of all sedimentary components. This difference between these two intervals may reflect a number of different processes that need further evaluation. For example, the younger interval may reflect increased production of opal and carbon, which resulted in increased dissolution of calcium carbonate. If so, then during the older interval the ratio of carbonate to organic carbon flux must have been sufficiently higher so that the increased production of organic carbon did not reduce an overall decrease in carbonate burial. Thus the differences between these events may reflect changes in the biological communities producing the carbonate, opal, and organic carbon, as well as processes associated with dissolution of these components. Finally, the timing of this event seems to coincide with similar increases in sedimentation rates at other sites in the Pacific.

There is geochemical evidence for fluid advection, particularly in the deeper part of the section at Site 847. Interstitial-water profiles of alkalinity, sulfate, and ammonia appear to be affected by upward advection as do the convex upward profiles of sodium and chloride. The presence of fluid advection as well as the relatively high temperature gradients found at Site 847 (approx. 0.076 °C/m) provides an explanation for the presence of chert at relatively shallow depths.

One of the primary objectives of Leg 138 was the study of high-resolution climate change (time scales within the Milankovitch frequency bands requiring sampling intervals of at most 5 k.y.) during the late Neogene. While much of this effort will require significant shore-based laboratory work, one of the essential elements of these studies is a high-resolution chronostratigraphic framework. In the Pleistocene such a framework has been established by using the presence of orbitally related frequency components within the climate record (e.g., Imbrie et al., 1984; Martinson et al., 1987). Mayer (1991) has shown that in the equatorial Pacific, the GRAPE density record is a proxy for carbonate content and that, if carefully spliced, the GRAPE record can be used to provide an extremely detailed paleoceanographic record suitable for orbital tuning. We have extended this approach to all of the high-resolution real-time data-acquisition systems used during Leg 138 (GRAPE, color reflectance, and magnetic susceptibility) and have begun to evaluate the possibility of orbitally tuning through the late Neogene. The quality of the GRAPE density data in Site 847, and their high degree of correlation with Site 846, suggested that both very high-resolution stratigraphic correlations could be achieved with these data. Our evaluation was greatly aided by the composite sections that could be constructed from the overlapping cores. The series used in these analyses were assembled by selecting the best data set from specific cores. By splicing these cores together a continuous GRAPE density record was constructed, and the data, plotted on initial time scales, seemed to reflect orbital forcing.

Initial orbital tuning was started for the time interval 5 to 2 Ma . Of particular interest is the change in the frequency bands associated with orbital tilt and precession. Between 3 to 2 Ma there is concentration of variance in the 41,000-year tilt band without a significant concentration in the precession band. The end of an interval where precessional frequencies are important in these records occurred 3 m.y. Between 5 and 3 Ma there is a concentration of variance at both the 23,000 and 19,000 frequency bands of precession as well as increased variance in the low frequencies. Thus there is strong evidence for orbital response in these sediment records and this response having evolved through the late Neogene. More importantly, this strongly suggests that the continuous section at Site 847 will provide an excellent paleoceanographic record of the equatorial Pacific.

WESTERN TRANSECT

Site 848 (proposed Site WEQ-5)

Site 848 is the southernmost site of Leg 138's western transect. The proximity of the site to the East Pacific Rise, as well as its position south of the equator (it has not yet crossed through the zone of highest equatorial productivity), has resulted in a relatively thin (94 m) sedimentary section. Nonetheless, continuous core logs (GRAPE, susceptibility, and color) and overlapping APC's have resulted in the complete recovery of an approximately 10.5-m.y. depositional record.

Site 848 is located about 650 km west of the East Pacific Rise on crust generated at about 10-11 Ma. The backtrack path of the site is quite straightforward. It is constrained by the movement of the Pacific Plate, which can be reconstructed from the numerous hotspot traces of the Pacific and from sediment distribution in the equatorial region (van Andel et al., 1975; Fig. 15). From an original ridge-crest depth of approximately 2700 m, the site has subsided to its present depth of 3866 m, and in doing so has intercepted a regionally and temporally variable CCD and lysocline.

The paleomagnetic results of Site 848 represent a significant addition to the stratigraphic framework required for the high-resolution paleoceanographic studies planned for Leg 138 cores. Though the paleomagnetic signal at Site 848 was variable, polarity reversals are resolvable in the upper 47 mbsf (0-4.7 Ma) and in the interval from 72 mbsf to basement (6.8-10.5 Ma). The upper zone contains every major polarity chronozone and subchronozone between the Bruhnes and the Thvera (Fig. 16). At these low latitudes, polarity reversals are primarily identified by the declination pattern. The success of the Multishot tool in providing core orientation is directly responsible for providing this extremely rare, deep-ocean, equatorial Pacific magnetic-reversal record. The magnetic-susceptibility record once again proved to be valuable as an interhole correlation tool. The strength of both the magnetic susceptibility and remanence intensity appears to be inversely correlated to both sedimentation rate and carbonate content, suggesting that the recovery of the paleomagnetic record may be the result of increased carbonate dissolution that has concentrated clay minerals.

The high-quality magnetic data provide excellent resolution of sedimentation-rate changes at this site, which will greatly help in resolving the sedimentation history of this region. We use these data to present a summary of the long-term changes in sediments recorded at Site 848.

The first sediment to accumulate above the newly formed Site 848 was a nannofossil ooze containing a substantial component of iron oxides and clays (Figs. 16 and 17). Sedimentation rates during this time (10.6-8.9 Ma) were very low (4-6 m/m.y., Fig. 18), and, in general, both susceptibility and density are high (Fig. 16). The presence of oxides is clearly and quantitatively indicated by the distinctive peaks in the percentage of red reflectance curves produced by the color scanner. While the presence of metalliferous sediments is related to ridge-crest hydrothermal activity, the relative percentage of the metalliferous component is variable; the sediment immediately overlying basement has a smaller percentage of metalliferous sediment than that above it. These variations appear to be related to dilution by carbonate, and thus the section in the interval from 10.6 Ma to approximately 8.8 Ma presents a record of increasing dissolution that is probably related to both the deepening of the site as it moves away from the ridge crest and the regional behavior of the CCD. At each of the Leg 138 sites, as well as at numerous other sites in the Pacific, this period of time appears to have been one of enhanced dissolution (Theyer et al., 1989). Carbonate deposition and sedimentation rates (Fig. 18) reached a minimum at about 8.8 Ma, as did the accumulation rates of the non-carbonate components. This point is represented in the sediment column as a small (less than 2-m thick) layer of hydrous clays. Interstitial-water profiles of sodium, chloride, alkalinity, magnesium, potassium, and silica in the oxide-rich interval show evidence for the effects of alteration of basalt.

The carbonate minimum at about 8.8 Ma was followed by a short (approx. 500-k.y.) interval of higher (10-12 m/m.y.) sedimentation and accumulation rates which produced a high percentage of carbonate nannofossil oozes (Fig. 18). Following this brief increase was an extended period (8.3-6.8 Ma) of low sedimentation rates (4-6 m/m.y.) with reduced but still quite high carbonate contents. From 6.8 to 4 Ma, sedimentation rates increased (>15 m/m.y.) as did carbonate and non-carbonate accumulation rates. High-frequency variations in carbonate content dominate the record as the relative proportions of carbonate and silica varied in response to changes in both deep and surface oceanographic conditions. Sedimentation and accumulation rates once again dropped during the interval from 4 to 1.7 Ma; this drop in accumulation rate is expressed as a slight decrease in carbonate content. The Pleistocene is characterized by the highest sedimentation rates of the section (as high as 20 m/m.y.) and a concomitant increase in carbonate content.

<u>Site 849 (proposed Site WEQ-6)</u>

Site 849 is the second site drilled along Leg 138's western transect. The present location of Site 849 is within the equatorial divergence zone, and thus the site was selected to provide the latest Neogene history of the oceanic conditions within this highly productive region (Fig. 1).

Site 849 is located about 860 km west of the East Pacific Rise on crust generated at about 11-12 Ma. The backtrack path of the site is quite straightforward, constrained by the movement of the Pacific Plate, which can be reconstructed from the numerous hotspot traces of the Pacific and from sediment distribution in the equatorial region (van Andel et al., 1975; Fig. 15). From an original ridge-crest depth of approximately 2700 m, the site has subsided to its present depth of 3850 m, and in doing so it has intercepted a regionally and temporally variable lysocline. Throughout its history Site 849 has been above the CCD.

The pattern of sedimentation at Site 849 is now a familiar one for pelagic sediments within this region of the equatorial Pacific. The first sediment to accumulate above the newly formed Site 849 was a nannofossil ooze containing a substantial component of iron oxides and clays (Figs. 19 and 20). Initial sedimentation rates at the site are around 50 m/m.y. As with many sites in the equatorial region, sedimentation rates dropped after 10 Ma. Sedimentation rates during the time interval 10 to 8 Ma were the lowest in the section, estimated at 15 m/m.y. (Fig. 21). During this period the estimated backtrack path places the site at about 2° to 2.5° south of the equator. These reduced sedimentation rates are not too different from the present-day sedimentation rates of Site 848 (now at 2°59'S). This interval of reduced sedimentation rate is characterized by increased dissolution of calcium carbonate. It coincides with a similar event seen at all Leg 138 sites and seems to represent a major dissolution event within the Pacific.

At about 8 Ma there was an overall increase in sedimentation rates to around 40 m/m.y., which is reflected in an increase in mass-accumulation rates of calcium carbonate, organic carbon, and non-carbon material (Fig. 21). As at other sites drilled during Leg 138, the latest Miocene and early Pliocene were marked by extremely high sedimentation rates. At Site 849 rates of over 100 m/m.y. are estimated for the time interval from 4.0 to 5 Ma. By this time the site had moved well into the equatorial divergence zone. Though still within the equatorial divergence zone in the Pliocene and Pleistocene, sedimentation rates decreased to a relatively constant 30 m/m.y., indicating a temporal change in oceanic conditions. Ultimately, comparisons with other sites along the 110°W transect will allow us to evaluate whether this decrease in sedimentation rates reflects a change in the north-south gradients across the equator.

Mass-accumulation rates of organic carbon and calcium carbonate during the latest Miocene are also a factor of three greater than they were during the Pliocene and Pleistocene (Fig. 21). It is not possible to evaluate the effect of changing dissolution in controlling this marked decrease in sediment accumulation. However, sediment-trap studies from the equatorial divergence at 140°W suggest that even if the entire present-day flux of carbonate were preserved in the geologic record, about a two- to threefold increase in carbonate-accumulation rates could be explained in terms of only carbonate preservation (Murray, 1987). Assuming that these present-day fluxes at 140°W are representative of those at 110°W, and given the evidence of carbonate dissolution at Site 849, we infer that the high accumulation during the latest Miocene must reflect increased production.

One indication of increased production at this site is the presence of very diatom-rich layers. Structurally, these layers are laminated and contain a very high percentage of diatoms tests of, usually, a single species, Thalassiothrix longissima. These intervals are most prominent at 3.5 to 4.6 Ma, 4.9 to 5.3 Ma, and 6 to 6.7 Ma. While it is not yet possible to determine the mode of formation of these laminated intervals, they have been found in a number of sites and seem to occur within similar time intervals.

The interstitial-water chemistry at Site 849 is unusual in that the diffusive transport of many constituents appears to have been disrupted by a layer of diagenetically silicified calcite at 237 mbsf (approx. 6.2 Ma). The layer (represented by a calcite nodule in the core and clearly discernible on the downhole logs) appears to have sealed off the bottom 100 m of the sediment column, disrupting diffusive transport between the material above and below. The effect of this layer is seen in the profiles of alkalinity, sulfate, ammonia, calcium, and strontium; above the layer these profiles are controlled by diagenesis, below they are controlled by diffusion. The position of this layer is associated with a very rapid shift in the carbonate curve and with a regional seismic reflector. This same carbonate shift has been noted at a number of Leg 138 sites, implying that it represents a regional oceanographic event; the diagenetic layer may be a local response to this event.

Site 850 (new site)

Contingency time to allow for bad weather and equipment failure must be built into any drilling plan. We were fortunate on Leg 138 to have neither equipment nor weather problems, and this fact, combined with the skill and hard work of the SEDCO and ODP crews, enabled us to drill a complete extra site. Site 850 was chosen as the extra site because of its location just north of the equator and its position halfway between Sites 849 and Site 851. Recent physical and biological oceanographic studies have demonstrated that the equatorial divergence zone has very steep and strong gradients, particularly in surface productivity. Given the success we have had at previous sites in correlating the high-resolution continuous core logs collected on board the ship (GRAPE, susceptibility, and color reflectance), we felt that it would be possible to evaluate, with sufficient resolution, the spatial and temporal history of these steep equatorial gradients.

Site 850 is located about 900 km west of the East Pacific Rise on crust generated at about 11-12 Ma. The backtrack path of the site is quite straightforward, constrained by the movement of the Pacific Plate as reconstructed from hotspot traces and sediment distribution (van Andel et al., 1975; Fig. 15), though there is some controversy over the appropriate pole of rotation. From an original ridge-crest depth of approximately 2800 m, the site has subsided to its present depth of 3800 m. The backtrack path of van Andel et al. (1975) would suggest that Site 850 crossed under the narrow equatorial divergence zone at approximately 4 Ma, while that of Duncan and Clague (1985) suggests an equatorial crossing at about 6 Ma.

The time available to drill Site 850 permitted only double APC coring to 74 mbsf; the rest of the section (74-399.9 m) was single APC and XCB cored. The section is predominantly diatom nannofossil ooze with varying proportions of other microfossil constituents (Figs. 22 and 23). Because much of the section was sampled with only single APC or XCB, it was inevitable that there be minor gaps in section recovered. A full suite of downhole logs was collected, however, and between the logs and the laboratory core measurements (GRAPE, color, and susceptibility) collected at at Site 850 and nearby sites, we hope to be able to estimate the extent of the missing intervals and, if possible, fill the gaps (with downhole logging data).

Site 850 is only 100 km north of Site 849, and thus its sedimentation history is, in general, similar to that of Site 849. The temporal and spatial differences, however, are what provide information on the history of the divergence-driven gradients. The first sediment to accumulate above the newly formed basement at Site 850 was a nannofossil ooze containing a substantial component of iron oxides and clays. Initial sedimentation rates at the site were around 50 m/m.y. As with many sites in the equatorial region, sedimentation rates dropped after 10 Ma, in part reflecting the subsidence of the site away from the ridge crest (Fig. 24). Between 10.5 and 9.5 Ma, sedimentation is characterized by generally high carbonate, non-carbonate, and organic carbon accumulation rates and sedimentation rates of approximately 40 m/m.y. The sediment in this interval is radiolarian and diatom nannofossil ooze with several distinctive layers of laminated diatom ooze and thinly bedded chert. Four very thin (cm scale) chert horizons were clearly imaged on the formation microscanner (FMS) log. We could confirm that three of these layers were recovered in place in the XCB, a credit to both the FMS's ability to image thin layers and the XCB's ability to recover them.

The chert layers appear to have a dramatic effect on the interstitial-water chemistry, dividing the section into two distinct zones. Above the chert microbial degradation of organic matter consumes sulfate, generating concave-downward and concave-upward profiles of sulfate and alkalinity, respectively. Below the chert, both sulfate and alkalinity return to seawater values. Ammonia decreases 22-fold across this boundary, while potassium is invariant. Magnesium and calcium decrease downhole, and silica increases with depth, consistent with the possibility of reaction with biogenic silica. The silica trend reverses below the chert boundary, decreasing into basement (but without a dramatic shift within the chert zone). The lack of a silica pore-water signal associated with the chert suggests that the chert layers are relict.

Between about 9.5 and 8.5 Ma, an interval of relatively constant sedimentation rate, carbonate and organic carbon accumulation rates were relatively low. Non-carbonate accumulation rates, however, were relatively high, suggesting increased input of clay. Elevated susceptibility values and decreased carbonate content support the suggestion of increased clay flux. Sedimentation rates slowly decreased between about 9 and 7 Ma, after which there was a large increase in sedimentation (to more than 90 m/m.y.) and accumulation rates (Fig. 24). During this time interval, the non-carbonate accumulation rate, which is dominated by biogenic silica, increased proportionally more than the carbonate accumulation rate, and the carbonate content dropped sharply. This implies a productivity event with the associated dilution and enhanced dissolution of carbonate. Each of the previous western transect sites (848 and 849) shows a similar increase in sedimentation and accumulation rates for this time.

There was a sharp drop in sedimentation and accumulation rates between 6 and 5 Ma (a feature shared with Site 849 but not Site 848), and then another increase to sedimentation rates as high as 100 m/m.y. between 5 and 4.5 Ma. Non-carbonate accumulation rates, again presumably reflecting accumulation rates of biogenic silica, also increased during this interval, but not to the levels observed at 7 Ma. Carbonate-accumulation rates over the interval are very high, but when viewed at extremely high resolution, the carbonate curve can be seen to fluctuate rapidly between about 50% and 90% carbonate. Sedimentation rates drop to about 30 m/m.y. at 4 Ma, the time at which Site 850 is estimated to have been directly under the equatorial divergence. While a drop in sedimentation rate coincident with the equatorial crossing may seem surprising, when viewed in a larger context it is clear that regional and temporal fluctuations in eastern equatorial Pacific sediment accumulation far outweighed the influence of the equator on sediment accumulation. In addition, the evaluation of how the equatorial divergence impacts sedimentation along this transect is complicated by two factors: (1) the resolution of the sedimentation-rate curves, based on initial biostratigraphy, is much lower than can be achieved using stratigraphies based on the high resolution data sets (e.g. GRAPE sediment densities) collected during the leg. A more detailed pattern of spatial and temporal sedimentation will emerge as part of post-cruise studies; and (2) there is still uncertainty as to the appropriate pole of rotation to use for the Pacific Plate. The van Andel et al. (1975) rotation pole is based on low-resolution stratigraphic determination of the zone of maximum sediment accumulation. More recent poles, such as that of Duncan and Clague (1985) are based on hotspot reference frames. Use of these poles results in differences of as much as 2 m.y. as to the time when the sites along the 110°W transect crossed the equatorial zone. More importantly, however, the gradient between Sites 850 and 849 is apparent in the available data, suggesting that the geologic record indeed shows the high gradients of the equatorial Pacific.

As at most high-sedimentation-rate, pelagic, equatorial sites, the paleomagnetic signal at Site 850 was, for the most part, too weak to produce a measurable stratigraphy. Surprisingly, a brief interval (3.4 to 2.9 Ma) showed a strong and coherent pattern with five reversals spanning the Keana subchron to the Gauss/Gilbert boundary. The origin of this strong magnetic signal is, at present, not understood. Unlike other sites with strong magnetic signals, there are neither anomalous sedimentation rates nor a change in redox conditions associated with this interval at Site 850.

Site 850 was an "extra" site drilled in an attempt to delineate the spatial and temporal variations in the narrow high-productivity zone associated with divergence on the equator. The ultimate success of this experiment must await both high-resolution stratigraphic studies and studies of the biologic response to these gradients as recorded in the planktonic fossils preserved in the pelagic sediments of the equatorial region.

Site 851 (proposed Site WEQ-4)

Site 851 is the fourth site drilled along Leg 138's western transect. The present location of Site 851 is on the northern edge of the westward-flowing South Equatorial Current. Thus the site was selected to provide the latest Neogene history of the oceanic conditions within this highly productive region.

Site 851 is located about 860 km west of the East Pacific Rise on crust generated at about 11-12 Ma. The backtrack path of the site is quite straightforward, constrained only by the movement of the Pacific Plate. Poles of rotation of the Pacific Plate have been estimated based on hotspot traces (Duncan and Clague, 1985) and also using the age distribution of sediments from DSDP sites along the equatorial sediment bulge (van Andel et al., 1975). Depending on which of these rotation schemes is used, the time of the equatorial crossing of Site 851 can differ by as much as 2 m.y. We present the results of the van Andel et al. (1975) rotation in Figure 15; however, a more detailed analysis of the coring and paleomagnetic results from all Leg 138 sites may provide a refinement to these rotation schemes.

From an original ridge-crest depth of approximately 2800 m, the site has subsided to its present depth of 3772 m and, in doing so, has intercepted a regionally and temporally variable lysocline. Throughout its history Site 851 has been above the CCD. The combination of triple APC and double XCB coring in conjunction with the real-time monitoring of continuous core logs (GRAPE, susceptibility, and color reflectance), resulted in the almost continuous recovery of the 320-m-thick section. The sedimentary sequence spans the interval from the uppermost middle Miocene to the Pleistocene and can be described as a single lithological unit composed of varying mixtures of foraminifer nannofossil ooze and diatom nannofossil ooze (Figs. 25 and 26).

The pattern of sedimentation at Site 851 is typical of pelagic sedimentation within this region of the equatorial Pacific. The first sediment to accumulate above the newly formed Site 851 was a nannofossil ooze containing a substantial component of iron oxides and clays. Initial sedimentation rates at the site were around 50 m/m.y. As with many sites in the equatorial region, sedimentation rates dropped after 10 Ma (Fig. 27). Sedimentation rates during the time interval 10 to 8 Ma were about 35 m/m.y. This rate is higher than that of Site 849, which should have been south of the equatorial divergence region at this time, but it is about the same or possibly lower than the rate at the nearest southerly site, Site 850. Based on the van Andel et al. (1975) pole rotation for the Pacific Plate, Site 850 would be a little more than 1° equator during this time period (Fig. 15). This interval of reduced sedimentation rate is characterized by increased dissolution of calcium carbonate and coincides with a similar event seen at all Leg 138 sites and seems to represent a major dissolution event within the Pacific. The record we see is thus a complicated interplay of large-scale temporal changes in ocean chemistry superimposed on more local responses to surface current regimes.

At about 7 Ma there was an increase in the sedimentation rates to around 65 m/m.y., which is reflected in an increase in mass-accumulation rates of calcium carbonate, organic carbon, and non-carbon material (Fig. 27). As at other sites drilled during Leg 138, the latest Miocene and early Pliocene were marked by high sedimentation rates, though not as high as those at previous sites drilled along the 110° W transect. While these rates are relatively high, they are about 40% less than at Sites 849 and 850. During the Pliocene and Pleistocene, sedimentation rates decreased to a relatively constant 20 m/m.y. Again, this decrease is paralleled by decreases at more southerly sites, but as expected from productivity gradients in the present Pacific, recent sedimentation rates at Site 851 are less than the rates estimated for Sites 850 and 849.

In many aspects, Site 851 continues the trends in sediment, pore-water, and physical gradients defined at previous sites along the 110° W transect. Sedimentation rates were relatively high, but the lower accumulation rates of organic carbon are reflected in less reducing pore waters, better preservation of calcium carbonate, and the presence of a stable magnetic signal for at least the last 4 m.y. This combination is unique and should make Site 851 a key record for high-resolution paleoceanographic studies along the 110° W transect.

Site 852 (proposed Site WEQ-3)

Site 852 is the fifth site drilled along Leg 138's western transect. The present location of Site 852 is near the boundary between the westward-flowing South Equatorial Current and the eastward-flowing North Equatorial Countercurrent. The site was selected to provide a late Neogene history of the interaction between these currents.

Site 852 is located about 900 km west of the East Pacific Rise on crust generated at about 11-12 Ma. The backtrack path of the site is quite straightforward, constrained only by the movement of the Pacific Plate. Poles of rotation of the Pacific Plate have been estimated based on hotspot traces (Duncan and Clague, 1985) and also using the age distribution of sediments from DSDP sites along the equatorial sediment bulge (van Andel et al., 1975; Fig. 15). While the backtrack paths for Site 852 differ depending on which of these poles of rotation is used, neither reconstruction suggests that Site 852 crossed the equator. Thus Site 852 is the first of the western transect sites presently north of the equator not to have passed under the equatorial divergence.

From an original ridge-crest depth of approximately 2800 m, Site 852 has subsided to its present depth of 3872 m and, in doing so, has intercepted a regionally and temporally variable lysocline. The combination of triple APC and double XCB coring, in conjunction with the real-time monitoring of continuous core logs (GRAPE, susceptibility, and color reflectance), permitted the continuous recovery of the 117-m-thick section (Figs. 28 and 29). While no basement was recovered in the deepest XCB's, these cores encountered hard material at the seismically predicted depth of basement, and thus we assume that the hole reached basement. The sedimentary sequence spans the interval from the uppermost middle Miocene to the Pleistocene and can be described as a single lithological unit composed of varying mixtures of foraminifer nannofossil ooze, nannofossil foraminifer ooze with oxide-rich beds, and radiolarian nannofossil ooze (Fig 28).

Stratigraphic control at Site 852 was provided by all four of the chief planktonic microfossil groups and an excellent magnetostratigraphy. In the upper 80 m all reversals from the Bruhnes Chron to the top of Chron C3A were recognized, while in the lower part of the section reversals from the upper part of Chron C4A to the top of Chron 5 were identified. Only the interval from about 8 to 6 Ma (80-110 mbsf) had magnetic intensities too low to provide a recognizable stratigraphy from the shipboard analyses. This same interval also has an extremely low susceptibility signal (Fig. 28), probably the result of dilution by calcium carbonate.

While the general shape of the sedimentation-rate curve at Site 852 (Fig. 30) is similar to that of the previous western transect sites, rates are much lower in magnitude. Also, the distribution of microfossil constituents is quite different. These characteristics reflect the position of the site north of the equatorial high-productivity zone.

The first sediment to accumulate above the newly formed Site 852 was a radiolarian-rich nannofossil ooze containing a substantial component of iron oxides and clays. Initial sedimentation rates at the site were around 8 m/m.y (Fig. 30), substantially lower than the 50 m/m.y. seen at Site 851, 380 km to the south. As with many sites in the equatorial region, sedimentation and mass accumulation rates drop after 10 Ma. Between 10 and 8 Ma, sedimentation rates are as low as 3 m/m.y., the lowest rate recorded on Leg 138. The low carbonate content and relatively high percentage of radiolarians in this interval suggest that this was a time of increased dissolution of calcium carbonate. Again, this event appears to coincide with similar events seen at all Leg 138 sites and seems to represent a major carbonate-dissolution event within the Pacific.

At about 8 Ma there is an increase in sedimentation rates to around 21 m/m.y., which is reflected in a large increase in the mass-accumulation rates of calcium carbonate but only a small increase in the accumulation rate of non-carbonate (Fig 30). Sedimentation and accumulation rates dropped in the interval between 7.5 and 6.5 Ma, but carbonate content remained quite high through this interval, with the dominant sedimentary component being nannofossil ooze.

At about 6 Ma, radiolarian abundance dropped sharply. This drop in biogenic silica abundance is coincident with the movement of Site 852 out from under the North Equatorial Countercurrent and into the North Equatorial Current, assuming that present-day oceanographic boundaries apply to the late Miocene. From this point on in the history of Site 852, biogenic opal abundances remained relatively low.

During the Pliocene and Pleistocene, sedimentation rates decreased to about 12 m/m.y. The sediment in this interval has a relatively high abundance of foraminifers, greater than that seen at any other Leg 138 site. We attribute this to a relatively low flux of biogenic opal and organic carbon in the region that limited both the dilution and dissolution of carbonate.

The low organic carbon input at Site 852 is clearly reflected in the interstitial-water chemistry, which suggests that on a macroscale, the sediment column at Site 852 has been oxidizing throughout. Alkalinity does not change in this interval, suggesting that dissolution is confined to the sediment/water, interface where oxygen and nitrate are consumed to oxidize organic matter. With the relatively low sedimentation and organic carbon accumulation rates present at Site 852, all of the labile organic matter is consumed before burial.

Superimposed on these general long-term trends in sedimentation are high-frequency fluctuations in the ratios of carbonate, silica, and clay abundances. Whether these fluctuations are the response to changes in the surface current regime (and thus local) or the result of more regional changes in bottom-water chemistry will be the subject of shore-based studies. The similarity of these high-frequency variations (as expressed in the near-continuous GRAPE records) between Site 852 and Site 848 (which also has never entered the high-productivity equatorial divergence zone), however, implies that the signal we are seeing represents regional carbonate dissolution-events.

Site 853 (proposed Site WEQ-7)

Site 853 is the sixth site drilled along Leg 138's western transect. The present location of Site 853 is well within the eastward-flowing North Equatorial Countercurrent. The site also seasonally underlies the northern hemisphere trade winds. The site was selected in a region where it was thought that the sediment rates were high enough that we might see a record of both NECC fluctuations and the trade winds.

Site 853 is located about 900 km west of the East Pacific Rise on crust generated at about

10 Ma. The backtrack path of the site is quite straightforward, constrained only by the movement of the Pacific Plate. Poles of rotation of the Pacific Plate have been estimated based on hotspot traces (Duncan and Clague, 1985) and also using the age distribution of sediments from DSDP sites along the equatorial sediment bulge (van Andel et al., 1975; Fig. 15). Neither of these reconstructions suggests that Site 853 passed under the equatorial divergence.

From an original ridge-crest depth of approximately 2800 m, Site 853 has subsided to its present depth of 3726 m and, in doing so, has intercepted a regionally and temporally variable lysocline. While five holes were drilled at Site 853 and the section is only about 73 m thick, severe heave due to bad weather resulted in several small gaps and a re-cored interval in the recovered section. As at other Leg 138 sites, we used real-time analyses of continuous core logs (GRAPE, susceptibility, and color reflectance) to monitor the offset between cores, but unfortunately the unpredictability of where the APC will shoot in a heave cycle, combined with the limits of time, prevented us from recovering 100% of the section.

Basalt was recovered in Hole B when the APC bounced off basement at about 73 mbsf. Above basaltic basement is a continuous upper Miocene to Pleistocene sequence of clayey nannofossil oozes and nannofossil oozes with more abundant foraminifers and iron and manganese oxides in the upper 28 m (Figs. 31 and 32). Reflecting the relatively low productivity due to the northern location of the site, siliceous microfossils are virtually absent, being present only in the upper few meters (last 500-600 k.y.). The last few hundred thousand years have been the time of the lowest sedimentation and accumulation rates at site 853 (Fig. 33) and the time at which the site has been farthest from the equator. Within the section there are several intervals of almost pure nannofossil ooze, marked by high carbonate-content intervals (Fig. 33), probably representative of times of enhanced carbonate preservation. The presence of siliceous microfossils only in the upper few meters may be the result of post-sedimentation processes, but this does not appear to be supported by the pore-water chemistry.

Stratigraphic control at Site 853 was provided mainly by nannofossils and an excellent magnetostratigraphy. All reversals from the Brunhes Chron to the top of Chron C4A were recognized, and several small reversals not yet part of the Magnetic Polarity Time Scale have been identified. Susceptibility levels were relatively high throughout the section and played an important role in interhole correlations.

Sedimentation rates are low at Site 853 and the general shape of the sedimentation-rate curve (Fig. 33) differs from that of the previous western transect sites in that it shows a general decrease from the late Miocene to the Pleistocene, reflecting the northward movement of the site away from any influence of the equatorial current system. Superimposed on this general trend, however, are short intervals of higher and lower sedimentation and accumulation rates that follow a pattern similar to that at the other Leg 138 sites.

The first sediment to accumulate above the newly formed Site 853 was a nannofossil ooze containing a substantial component of hydrothermally derived iron oxides and clays. Initial sedimentation rates at the site were probably around 6-8 m/m.y (Fig. 33) but are poorly constrained because of the lack of stratigraphic markers in this interval. Sedimentation rates increased to about 15 m.y. at about 7.5 Ma and stayed at this level until about 4.8 Ma. During the Pliocene and Pleistocene, sedimentation rates decreased to about 4-5 m/m.y. The sediment in this interval has a relatively high abundance of foraminifers.

The low organic carbon input at Site 853 is clearly reflected in the interstitial-water chemistry, which suggests that, on a macroscale, the sediment column at Site 853 has been oxidizing throughout. Alkalinity profiles suggest that dissolution is confined to the sediment/water interface, where oxygen and nitrate are consumed to oxidize organic matter. With the relatively low sedimentation and organic carbon accumulation rates present at Site 853, all of the labile organic matter is consumed before burial.

Superimposed on these general long-term trends in sedimentation are high-frequency fluctuations in the ratios of carbonate and clay abundances. Sorting out the significance of these changes in terms of atmospheric circulation, surface circulation, and deep-water chemistry will be attempted in shore-based studies.

Site 854 (proposed Site WEQ-2)

Site 854 is the northernmost site drilled along Leg 138's western transect. The primary objective of the site was to sample the region well north of the present position of the Intertropical Convergence Zone (ITCZ). This atmospheric boundary marks the dividing line between the Northern and Southern Hemisphere trade winds. Most sites drilled during Leg 138 are either within the southeast trades (Sites 846-851) or near the extreme positions of the ITCZ (Sites 852-853) and thus give either a Southern Hemisphere signal or a mixed Northern and Southern Hemisphere signal recording the ITCZ's movement in response to climate change. The only other sites drilled during Leg 138 in a more northerly position (Site 844 and 845) are close to Central America and may contain terrigenous sediment transported by processes other than eolian. Thus, Site 854 provides a unique record of eolian sediments transported by the Northern Hemisphere wind.

Site 854, like all other sites along the 110°W transect, is located about 900 km west of the East Pacific Rise on crust generated at about 10 Ma. The backtrack path of the site is quite straightforward, constrained only by the movement of the Pacific Plate. Poles of rotation of the Pacific Plate have been estimated based on hotspot traces (Duncan and Clague, 1985) and also using the age distribution of sediments from DSDP sites along the equatorial sediment bulge (van Andel et al., 1975; Fig. 15). While the backtrack paths for Site 854 differ depending on which of these poles of rotation is used, neither of the reconstructions has Site 854 crossing the equator.

The sediments at Site 854 reflect its more northerly position relative to other sites along the 110°W transect. The site is north of the dominant regions of divergence (at the equator and at the boundary between the North Equatorial Current and the North Equatorial Countercurrent) and thus is not in a region of elevated surface productivity. This is reflected in the overall low sedimentation rates, which resulted in a section less than 50 m thick on crust equivalent in age to other sites along the transect (Figs. 34 and 35).

The sediments in the younger part of the section are dominated by clay, nannofossils, and foraminifers. Siliceous microfossils are present but in much lower abundances than nannofossils and foraminifers. Other indications of decreased productivity in the region are seen in the interstitial-water chemistry, which suggests that the sediment section has been oxic and that little diagenesis driven by the decay of organic matter has taken place within the sediment column. The high clay content combined with little or no diagenesis resulted in higher magnetic susceptibilities than have been seen at most sites along the western transect (Fig. 34) and a stable magnetic remanence. The excellent magnetic stratigraphy obtained at the site allows a rather detailed picture of sedimentation history of this area over the past 9 m.y.

The first sediment to accumulate above the newly formed Site 854 was a black manganese and iron-rich metalliferous clay. Accumulation was relatively low starting at about 2.5 m/m.y. This metalliferous clay was unlike the sediment seen above basement at other Leg 138 sites and reflects the general reduced surface production that existed at this site even during the Miocene. The backtrack position of this site, based on the van Andel et al. (1975) rotation, is still at about 10°N at this time, which places it well north of the present-day region of high sedimentation. This unusual metalliferous sediment may reflect sedimentary inputs dominated both by ridge-crest processes and processes of authigenic accumulation of manganese oxides, making the section a unique end-member of metal oxide accumulation.

For the most part, sedimentation rates remained low at Site 854 from 7.5 to 8 Ma (Fig. 36). After this time, rates increased by a factor of 3 to about 15 m/m.y. The early part of this interval of increased sedimentation rates has much higher abundances of calcium carbonate. Nannofossils make up about 60% of the sediment, and sometimes as much as 80%. While this increase in carbonate accumulation may reflect a decrease in carbonate dissolution, the increase in sedimentation rate at 7.5 Ma occurs at a somewhat younger time than seen at some of the other sites along the transect. Sites with magnetic stratigraphy seem to show some increases at this time, while sites with only biostratigraphic control do not resolve sedimentation rates during this interval sufficiently to determine if these differences are real. Future stratigraphic analysis is critical for resolving such differences.

During the interval of high sedimentation, the sediments change from a clayey nannofossil ooze to an oxide-rich clay between about 22 and 32 mbsf. Even with the lithologic change to reduced carbonate contents, sedimentation rates remained at the 15 m/m.y. level. Non-carbonate mass-accumulation rates show a maximum between about 7.5 and 6 Ma (Fig. 36), while carbonate-accumulation rates are high only in the interval of 7.5 to about 7 Ma. The lack of siliceous microfossils in these sediments suggests that non-biogenic accumulation must have been significantly higher at this site during this time.

At about 6.3 Ma, sedimentation rates dropped to about 5 m/m.y. Biostratigraphic and lithostratigraphic evidence suggest a hiatus between 5.5 and 3.5 Ma. Above this interval sedimentation rates are relatively low, averaging about 5 m/m.y. In this upper interval siliceous microfossils and foraminifers are present, but only as minor components of the sediments.

The hiatus at Site 854 occurred at a time when elevated sedimentation rates are observed at essentially all other sites along the 110°W transect. If this increase in general accumulation solely reflects a decrease in carbonate dissolution, we might expect an increase in carbonate accumulation at Site 854 as well. Pisias and Prell (1985) suggest, based on carbonate budget calculations from the equatorial Pacific, that the marked increase in rates, observed mostly at near equator site, reflected a narrowing of the productivity belt without a significant change in total carbonate being accumulated in the region. Pisias and Prell (1985) used the data of of van Andel et al. (1975), augmented by results from DSDP Leg 85. The more detailed stratigraphic framework possible for the Leg 138 transect would hopefully provide a more rigorous test of this hypothesis.

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Table 1. Summary of coring operations on Leg 138.

Hole	Latitude	Longitude	Water Depth (m)	Cores	Interval drilled (m)	Interval cored (m)	Core rec. (m)	Core rec. (%)	Cored with APC (m)	Recovered with APC (m)	APC rec. (%)	Cored with XCB (m)	Recovered with XCB (m)	XCB rec. (%)	Time on Hole (hours)	Time on Site (days)
844A	7° 55.28N	90° 28.85W	3425.0	1	9.5	9.5	9.94	104.6	9.5	9.94	104.6				15.6	
844B	7° 55.28N	90° 28.85W	3425.0	31	290.9	290.9	289.92	99.7	185.0	193.78	104.7	105.9	96.14	90.8	52.2	
844C	7° 55.28N	90° 28.85W	3425.0	19	180.1	180.1	189.34	105.1	180.1	189.34	105.1				21.7	
844D	7° 55.28N	90° 28.85W	3425.0	1	33.5	9.5	10.12	106.5	9.5	10.12	106.5				8.9	
		Site Totals:		52	514.0	490.0	499.32	101.9	384.1	403.18	105.0	105.9	96.14	90.8	98.4	4.1
845A	9° 34.95N	94° 35.45W	3715.9	31	291.6	291.6	292.63	100.4	207.1	216.95	104.8	84.5	75.68	89.6	60.0	
845B	9° 34.93N	94° 35.38W	3715.9	21	202.6	199.5	195.23	97.9	199.5	195.23	97.9				22.9	
845C	9° 34.94N	94° 35.38W	3715.9	3	48.5	28.5	29.49	103.5	28.5	29.49	103.5				10.1	
		Site Totals:		55	542.7	519.6	517.35	99.6	435.1	441.67	101.5	84.5	75.68	89.6	93.0	3.9
846A	3° 5.70S	90° 49.08W	3307.3	1	7.2	7.2	7.22	100.3	7.2	7.22	100.3				7.2	
846B	3° 5.70S	90° 49.08W	3307.5	45	422.4	422.4	373.44	88.4	206.5	215.20	104.2	215.9	158.24	73.3	61.1	
846C	3° 5.80S	90° 49.09W	3307.5	20	192.5	190.0	193.10	101.6	190.0	193.10	101.6				20.3	
846D	3° 5.80S	90° 49.07W	3307.5	26	249.4	245.4	247.85	101.0	159.3	165.79	104.1	86.1	82.06	95.3	27.3	
		Site Totals:		92	871.5	865.0	821.61	95.0	563.0	581.31	103.3	302.0	240.30	79.6	115.9	4.8
847A	0° 11.59N	95° 19.23W	3346.0	1	9.5	9.5	9.52	100.2	9.5	9.52	100.2				8.5	
847B	0° 11.59N	95° 19.23W	3346.0	27	247.0	247.0	242.19	98.1	139.5	145.52	104.3	107.5	96.67	89.9	41.7	
847C	0° 11.58N	95° 19.19W	3346.0	25	232.3	230.3	225.71	98.0	123.5	128.84	104.3	106.8	96.87	90.7	21.2	
847D	0° 11.58N	95° 19.20W	3346.9	14	130.1	130.1	133.57	102.7	130.1	133.57	102.7				18.7	
		Site Totals:		67	618.9	616.9	610.99	99.0	402.6	417.45	103.7	214.3	193.54	90.3	90.1	3.8
848A	2° 59.63S	110° 28.79W	3865.1	1	9.4	9.4	9.54	101.5	9.4	9.54	101.5				8.2	
848B	2° 59.63S	110° 28.79W	3867.3	12	93.8	93.8	97.75	104.2	93.3	97.75	104.8	0.5	0.00	0.0	20.2	
848C	2° 59.65S	110° 28.81W	3867.0	11	94.2	94.2	97.74	103.8	91.0	94.72	104.1	3.2	3.02	94.4	14.0	
848D	2° 59.66S	110° 28.81W	3866.1	10	93.9	93.9	96.88	103.2	93.9	96.88	103.2				20.3	
		Site Totals:		34	291.3	291.3	301.91	103.6	287.6	298.89	103.9	3.7	3.02	81.6	62.7	2.6
849A	0° 10.98N	110° 31.18W	3848.8	1	8.7	8.7	8.69	99.9	8.7	8.69	99.9				7.7	
849B	0° 10.98N	110° 31.18W	3850.8	37	350.5	350.5	343.78	98.1	120.7	124.07	102.8	229.8	219.71	95.6	60.7	

Table 1 (cont.). Summary of coring operations on Leg 138.

Hole	Latitude	Longitude	Water Depth (m)	Cores	Interval drilled (m)	Interval cored (m)	Core rec. (m)	Core rec. (%)	Cored with APC (m)	Recovered with APC (m)	APC rec. (%)	Cored with XCB (m)	Recovered with XCB (m)	XCB rec. (%)	Time on Hole (hours)	Time on Site (days)
849C	0° 10.99N	110° 31.18W	3850.8	11	105.5	104.5	105.70	101.1	104.5	105.70	101.1				14.1	
849D	0° 10.99N	110° 31.17W	3850.8	34	326.7	322.7	319.45	99.0	108.5	99.76	91.9	214.2	219.69	102.3	37.4	
		Site Totals:		83	791.4	786.4	777.62	98.9	342.4	338.22	98.8	444.0	439.40	99.0	119.9	5.0
850A	1° 17.84N	110° 31.28W	3797.8	8	74.2	74.2	77.12	103.9	74.2	77.12	103.9				14.9	
850B	1° 17.83N	110° 31.29W	3797.8	42	399.8	396.8	393.58	99.2	95.0	99.69	104.9	301.8	293.89	97.4	65.3	
		Site Totals:		50	474.0	471.0	470.70	99.9	169.2	176.81	104.5	301.8	293.89	97.4	80.2	3.3
851A	2° 46.22N	110°34.31W	3773.0	1	6.5	6.5	6.45	99.2	6.5	6.45	99.2				7.8	
851B	2° 46.22N	110°34.31W	3772.0	34	320.5	320.5	318.05	99.2	140.5	147.46	105.0	180.0	170.59	94.8	52.1	
851C	2° 46.21N	110°34.29W	3772.0	14	135.5	133.0	136.65	102.7	133.0	136.65	102.7				14.8	
851D	2° 46.21N	110°34.29W	3772.0	2	19.0	19.0	20.10	105.8	19.0	20.10	105.8				2.0	
851E	2° 46.21N	110°34.29W	3772.0	35	318.4	318.4	316.69	99.5	133.0	140.59	105.7	185.4	176.10	95.0	41.1	
		Site Totals:		86	799.9	797.4	797.94	100.1	432.0	451.25	104.5	365.4	346.69	94.9	117.8	4.9
852A	5° 17.57N	110° 4.58W	3872.7	1	5.8	5.8	5.86	101.0	5.8	5.86	101.0				8.4	
852B	5° 17.57N	110° 4.58W	3871.6	13	113.4	113.4	119.68	105.5	113.4	119.68	105.5				14.7	
852C	5° 17.55N	110° 4.56W	3871.5	13	117.3	117.3	125.59	107.1	110.5	116.75	105.7	6.8	8.84	130.0	14.1	
852D	5° 17.55N	110° 4.54W	3871.5	12	116.0	114.0	120.56	105.8	114.0	120.56	105.8				25.2	
		Site Totals:		39	352.5	350.5	371.69	106.0	343.7	362.85	105.6	6.8	8.84	130.0	62.4	2.6
853A	7° 12.66N	109°45.08W	3726.0	1	9.5	9.5	10.15	106.8	9.5	10.15	106.8				8.1	
853B	7° 12.66N	109°45.08W	3727.2	9	72.4	72.4	77.68	107.3	72.4	77.68	107.3				10.0	
853C	7° 12.65N	109°45.08W	3726.5	8	68.2	68.2	69.57	102.0	66.0	68.30	103.5	2.2	1.27	57.7	8.8	
853D	7° 12.65N	109°45.07W	3724.2	7	65.8	65.8	68.81	104.6	65.8	68.81	104.6				7.3	
853E	7° 12.65N	109°45.07W	3725.2	2	18.0	18.0	18.51	102.8	18.0	18.51	102.8				8.5	
		Site Totals:		27	233.9	233.9	244.72	104.6	231.7	243.45	105.1	2.2	1.27	57.7	42.7	1.8
854A	11° 13.43N	109° 35.65W	3579.6	3	46.8	28.7	20.89	72.8	28.7	20.89	72.8				9.7	
854B	11° 13.43N	109° 35.65W	3579.1	5	45.4	45.4	48.01	105.7	45.4	48.01	105.7				4.8	
854C	11° 13.43N	109° 35.65W	3579.9	6	46.0	46.0	54.03	117.5	46.0	54.03	117.5				18.9	
		Site Totals:		14	138.2	120.1	122.93	102.4	120.1	122.93	102.3	0.0	0.00	0.0	33.4	1.4
		Leg Totals:		599	5628.3	5542.1	5536.8	99.90	3711.5	3838.01	103.41	1830.6	1698.77	92.80	916.5	38.2

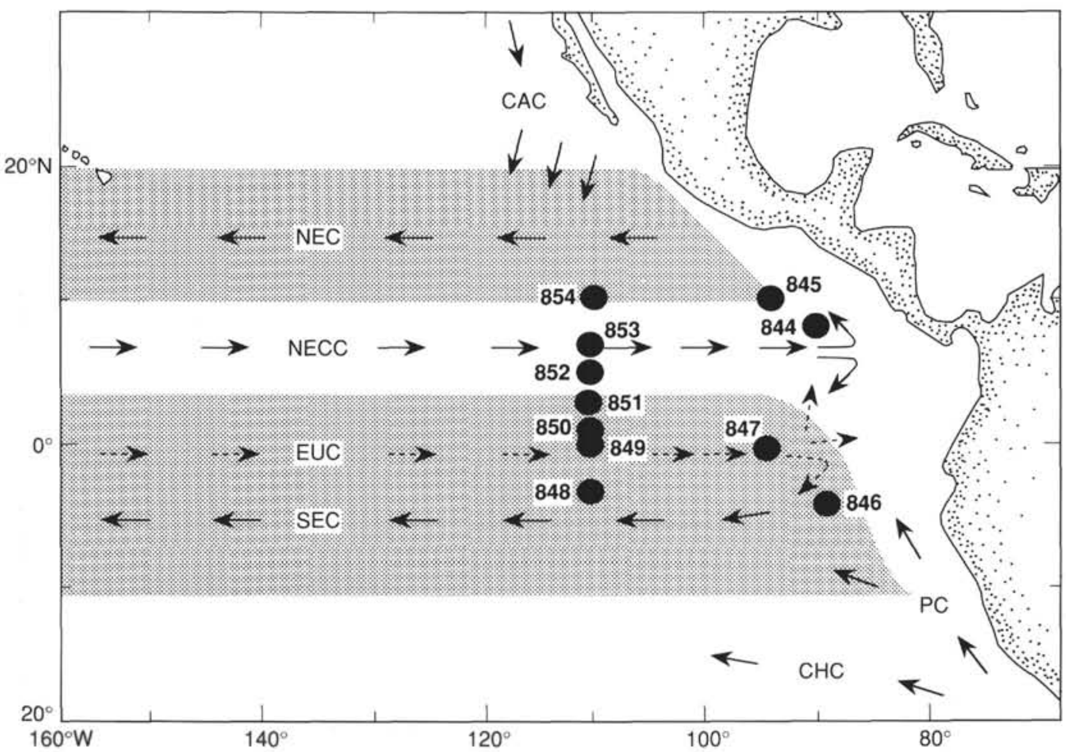


Figure 1. Generalized circulation system of the eastern equatorial Pacific. Surface current shown as solid arrows, subsurface current as dashed arrows: CAC - California Current; NEC - North Equatorial Current; NECC - North Equatorial Countercurrent; EUC - Equatorial Undercurrent; SEC - South Equatorial Current; PC - Peru Current; and CHC - Chile Current. Shaded areas illustrate general latitudinal extent of the SEC and NEC.

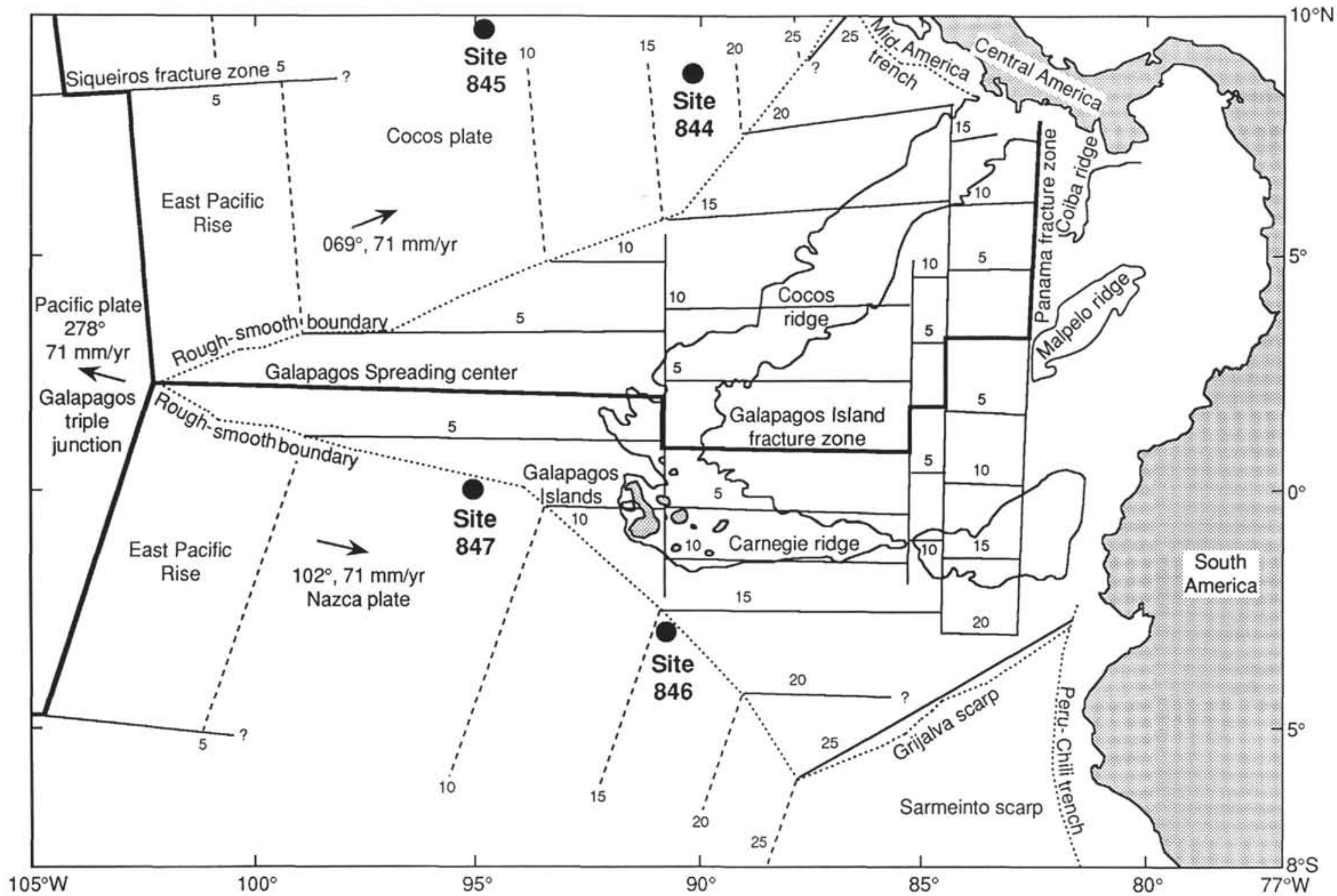


Figure 2. Backtrack paths of eastern transect sites 844-847. Ages of magnetic lineations in millions of years.

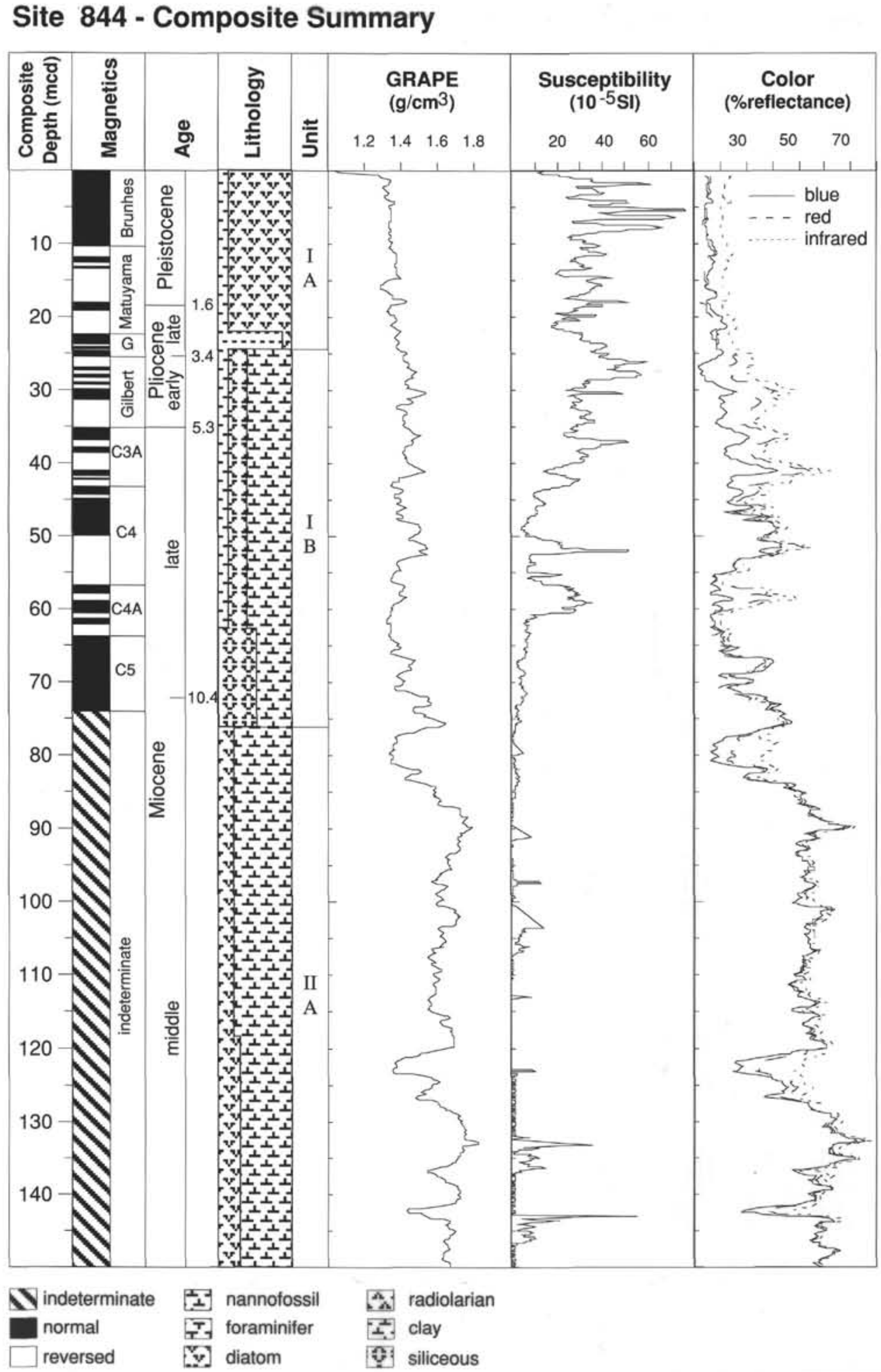
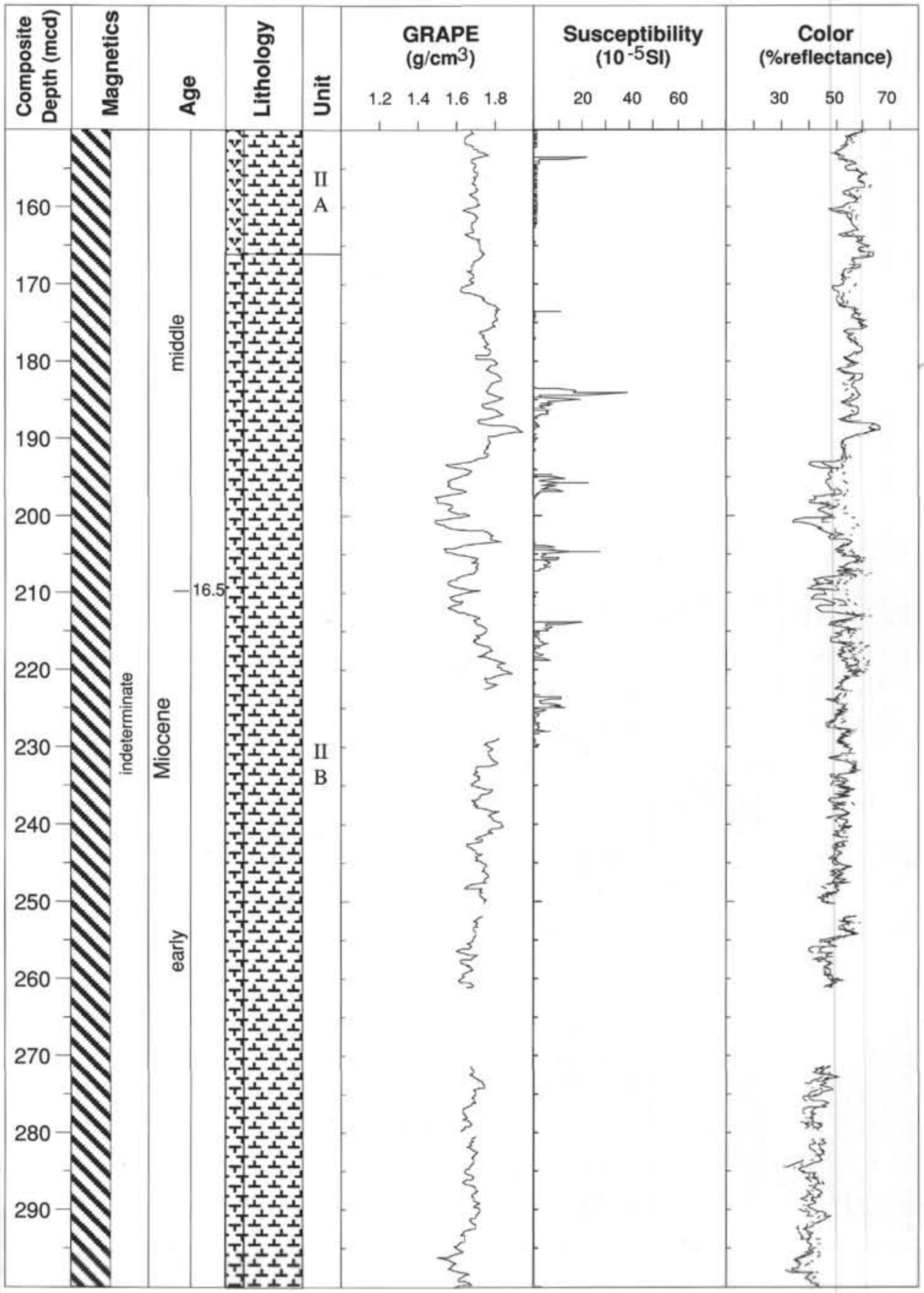


Figure 3. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility and color reflectance for Site 844. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

Site 844 - Composite Summary (cont.)



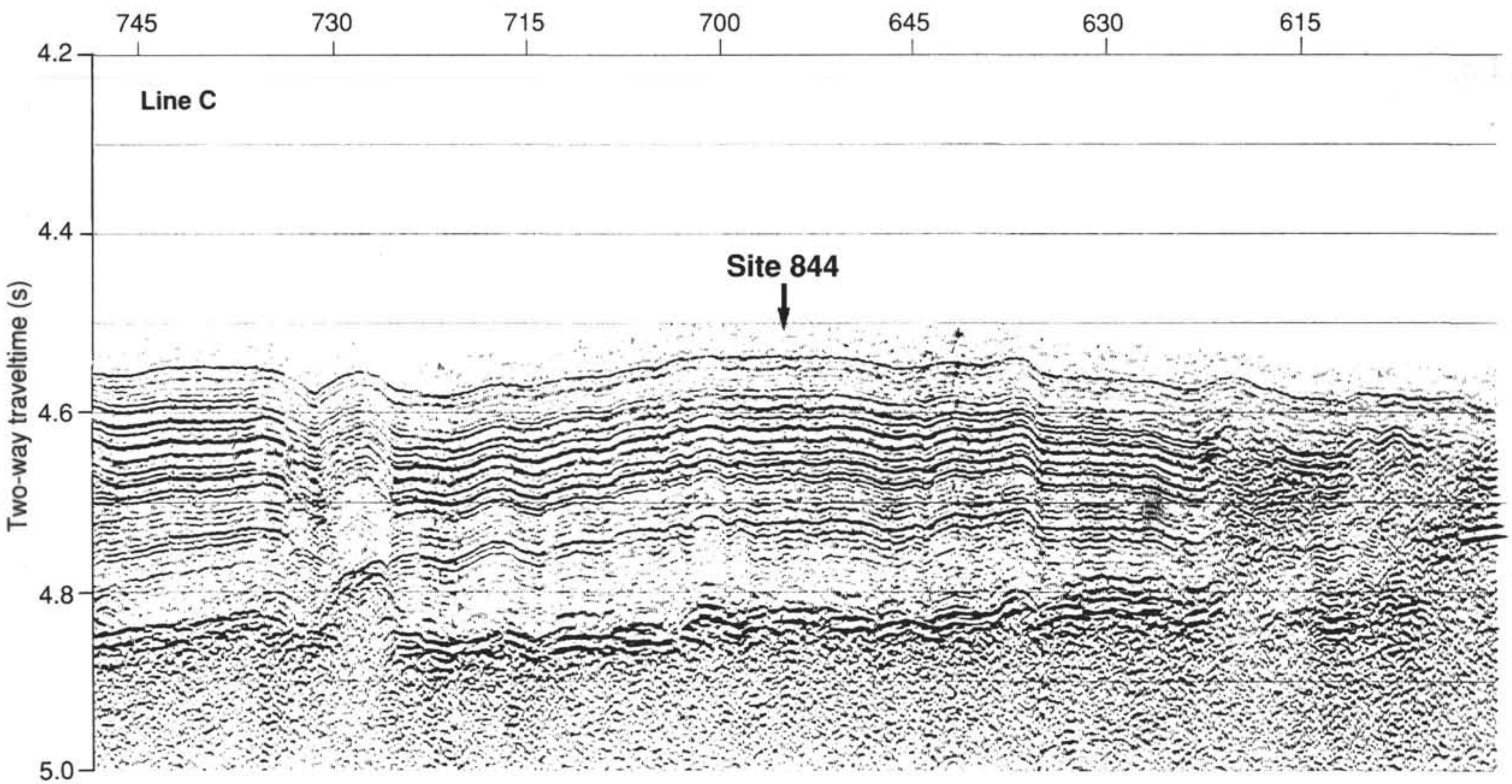


Figure 4. Single-channel seismic profile over Site 844. Profile collected during VENTURE 01 cruise of the R/V *Thomas Washington*.

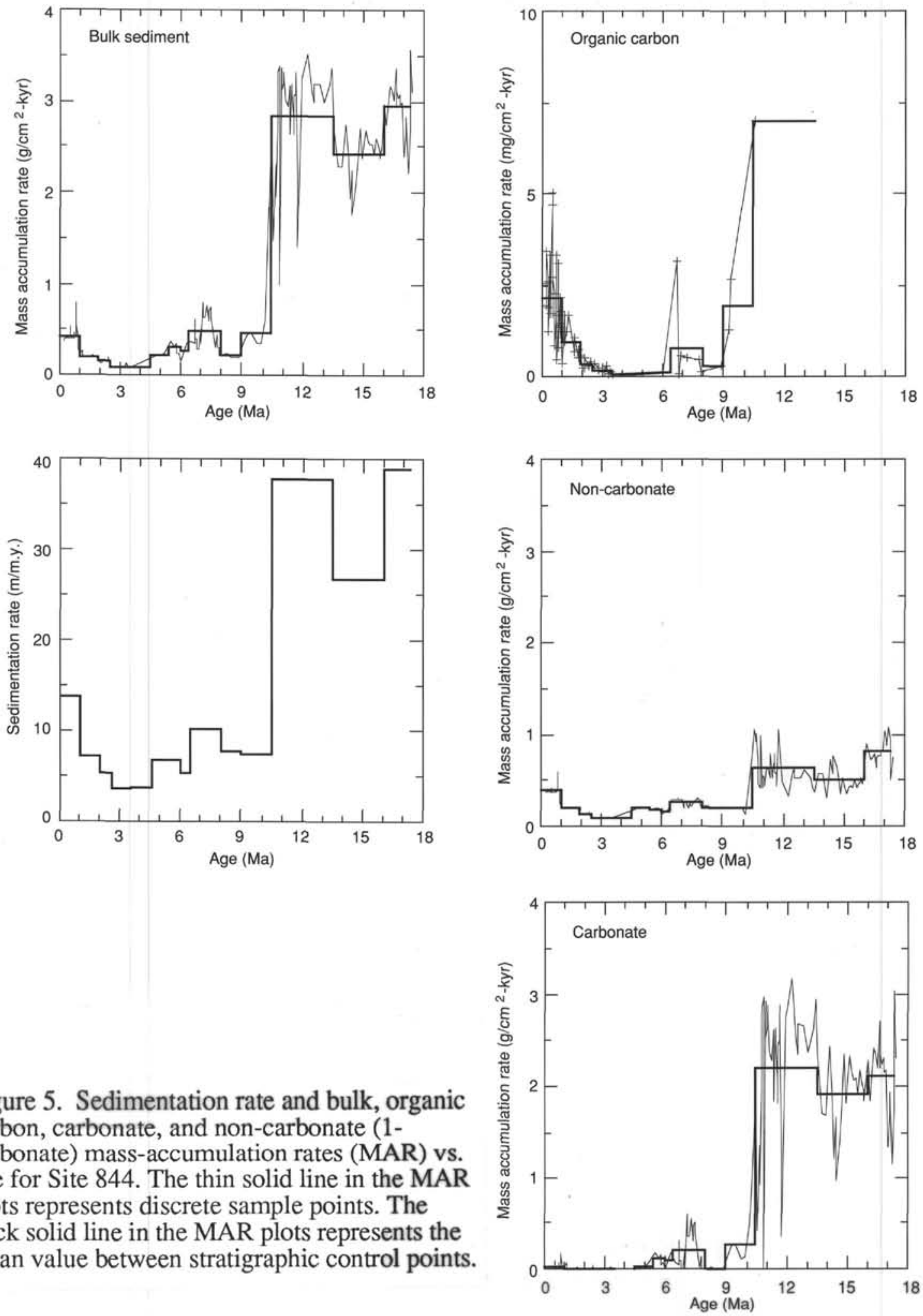


Figure 5. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 844. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

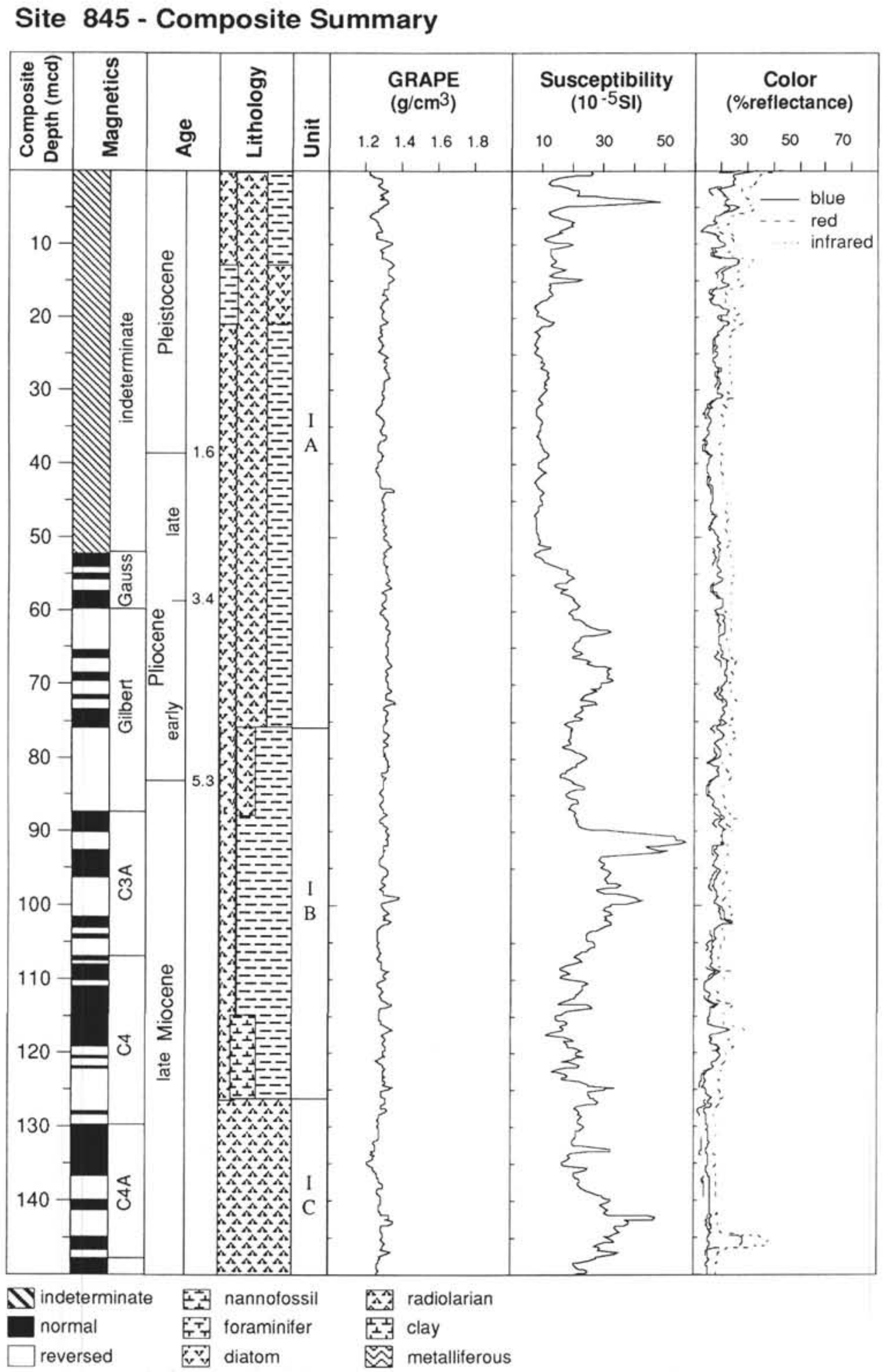
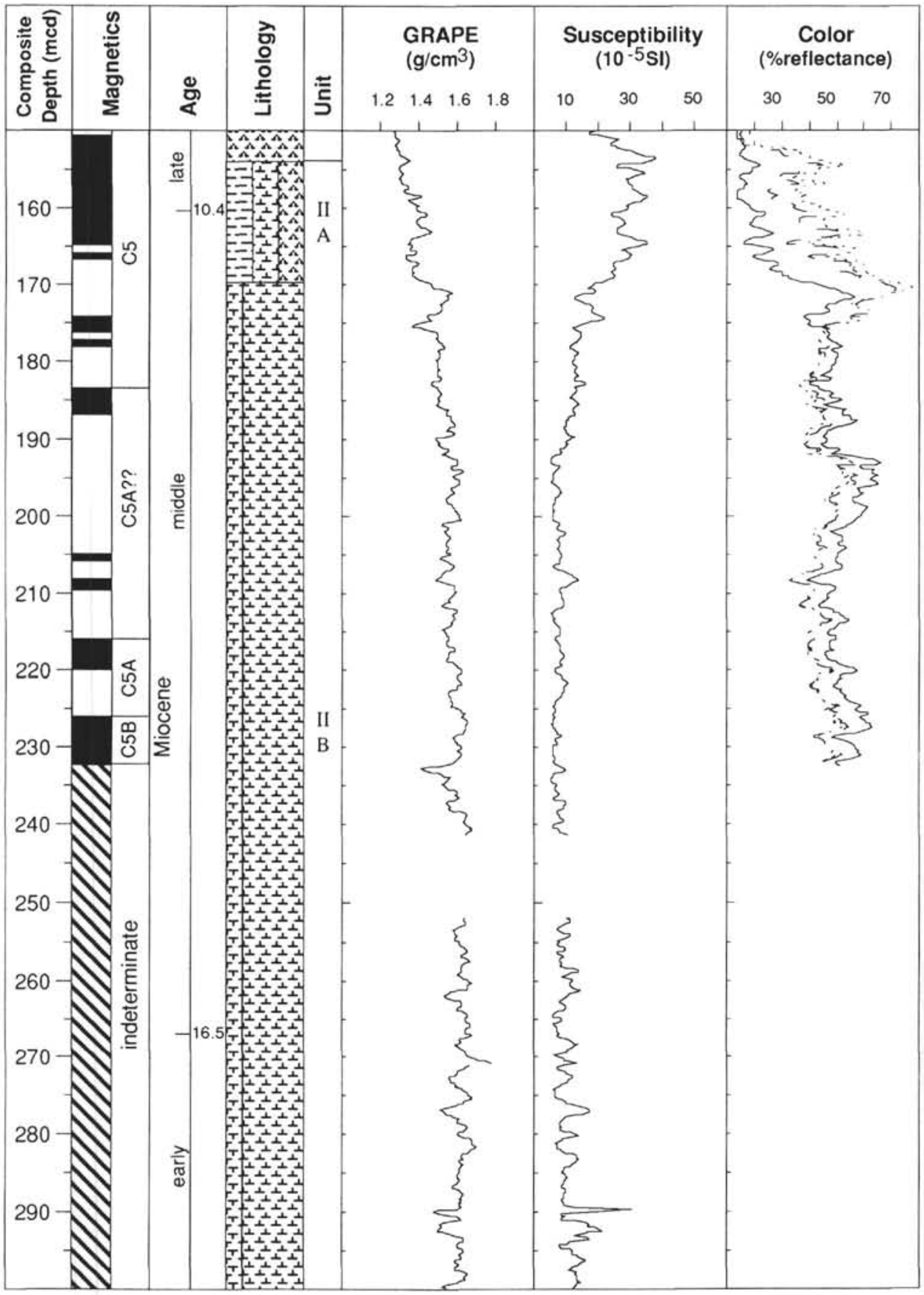


Figure 6. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 845. The composite data consist of sections spliced together from multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point Gaussian filter.

Site 845 - Composite Summary (cont.)



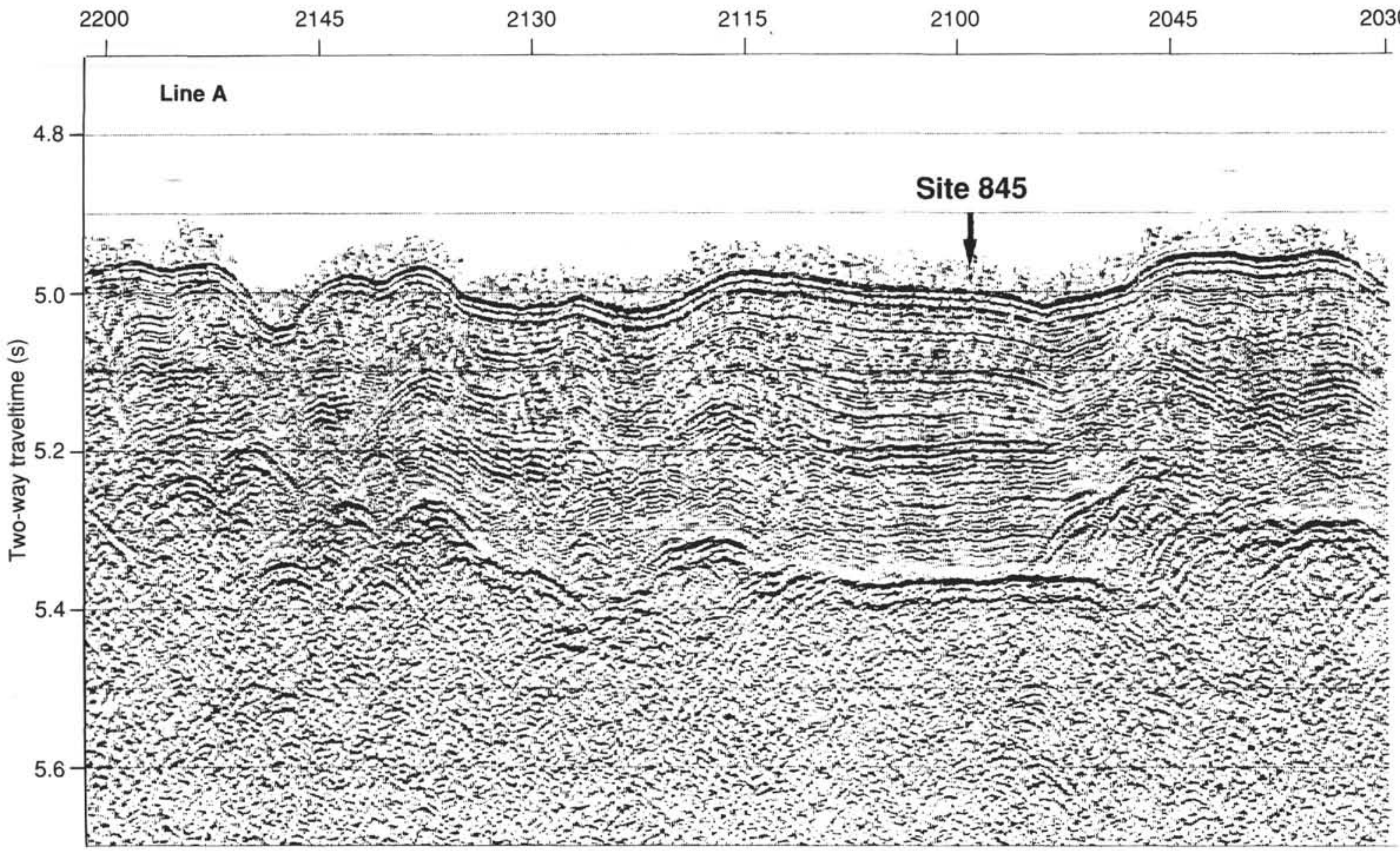
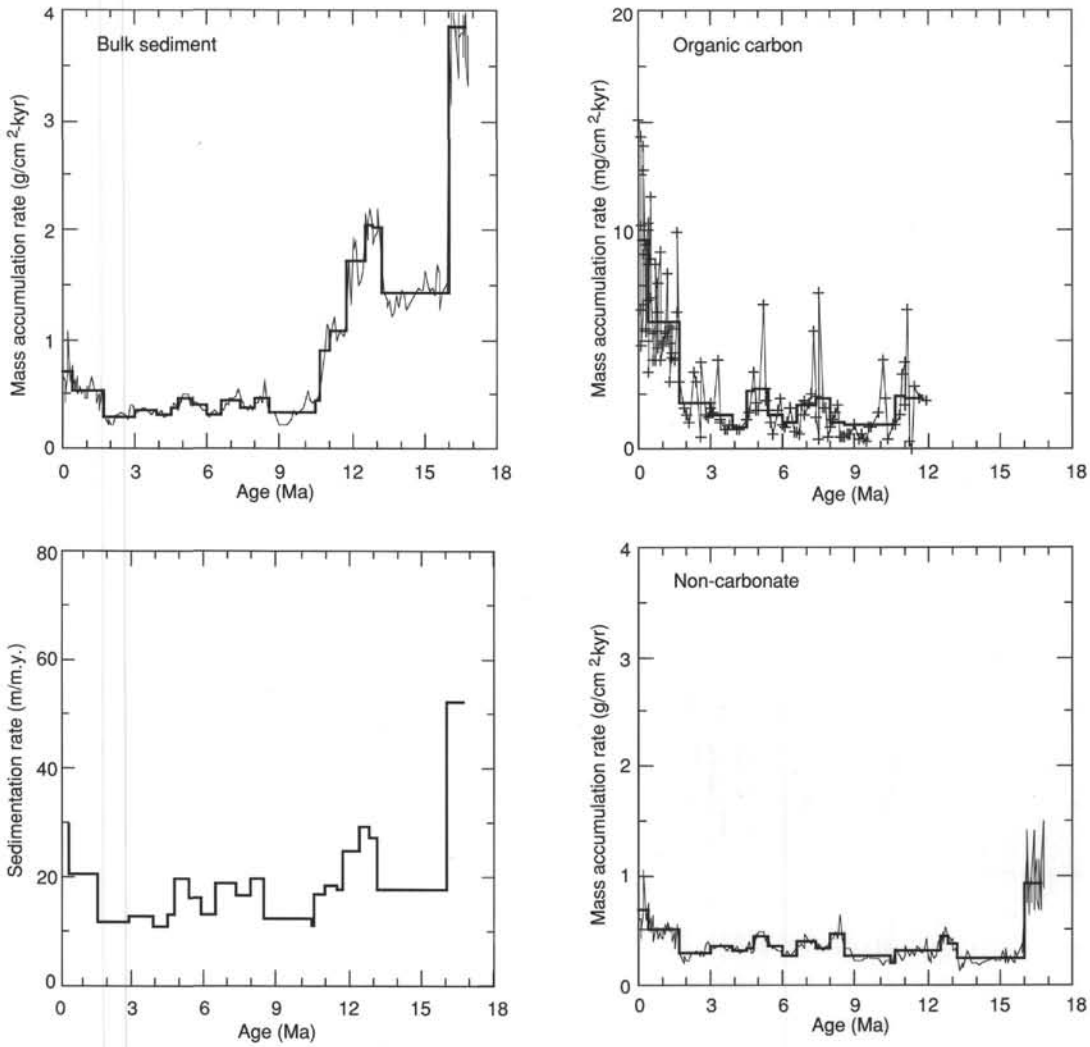


Figure 7. Single-channel seismic profile over Site 845. Profile collected during VENTURE 01 cruise of the R/V *Thomas Washington*.



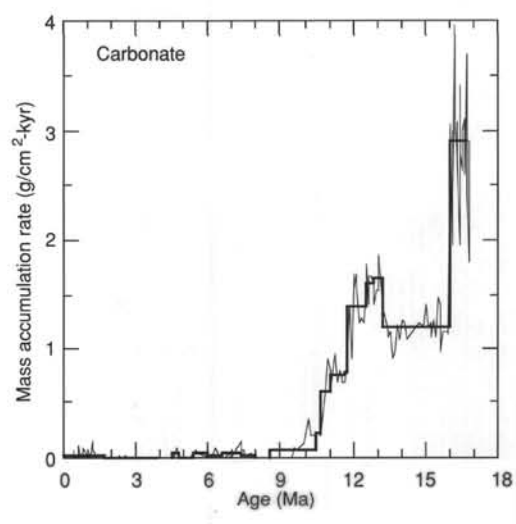


Figure 8. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 845. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

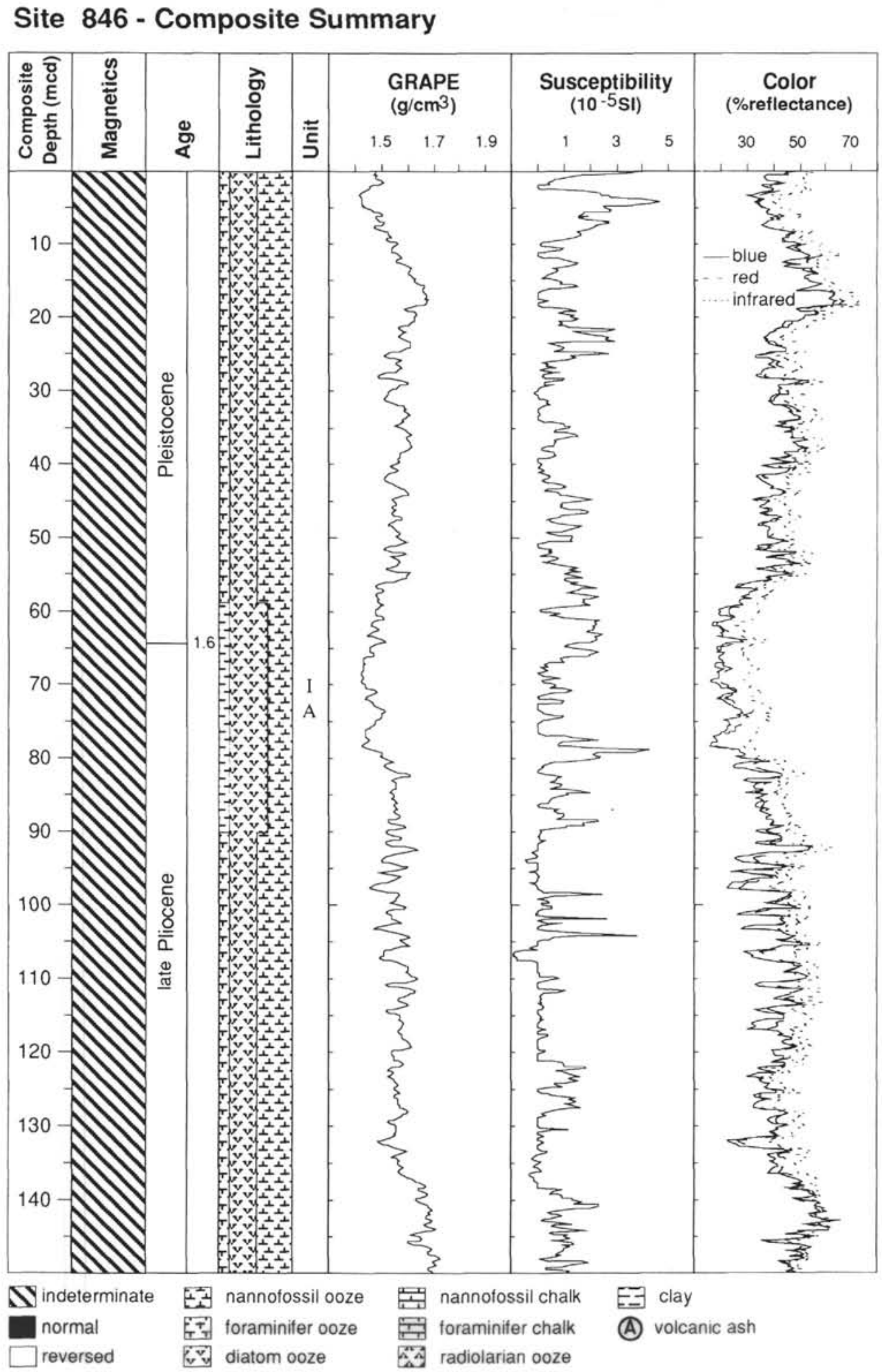


Figure 9. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 846. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

Site 846 - Composite Summary (cont.)

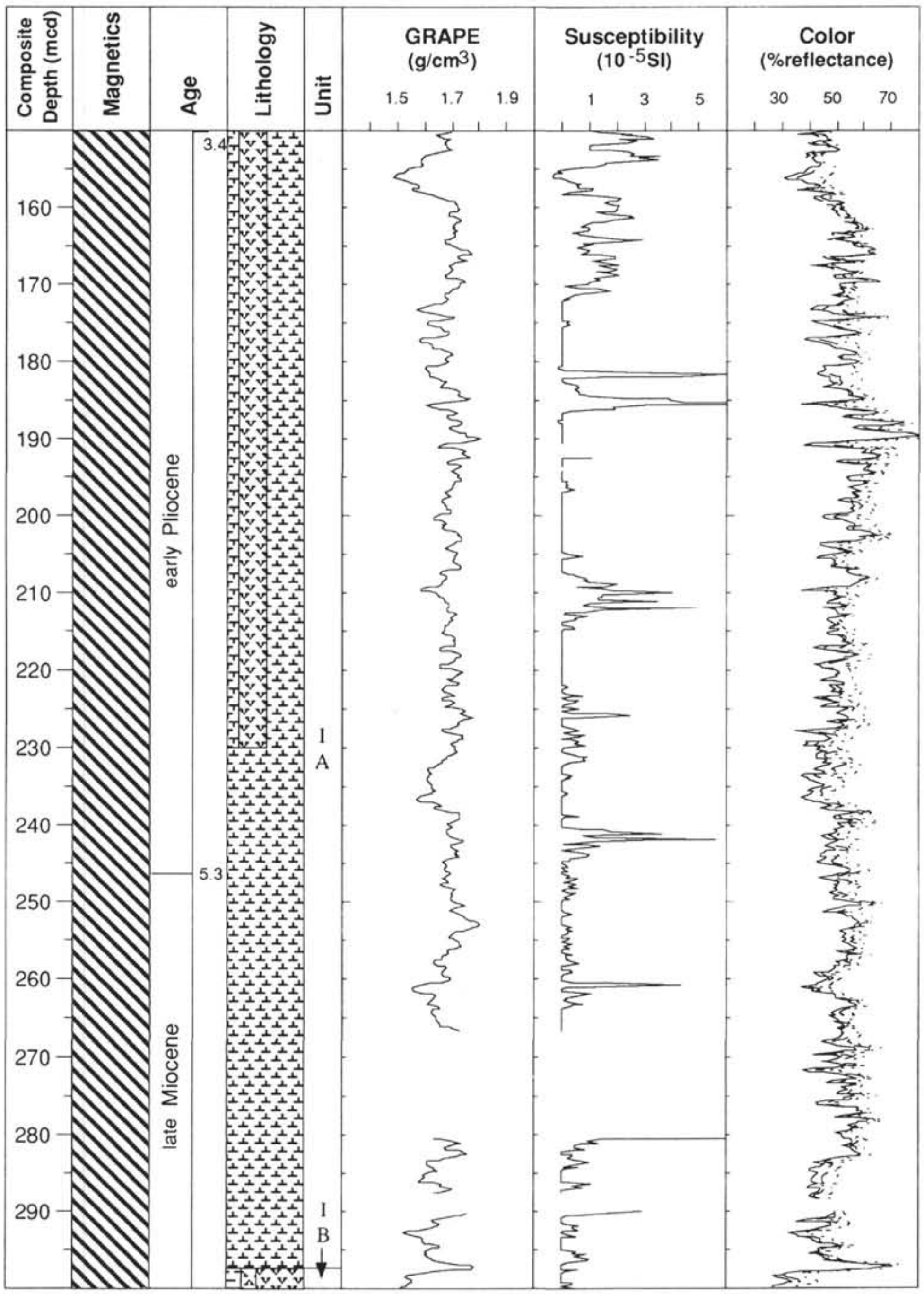
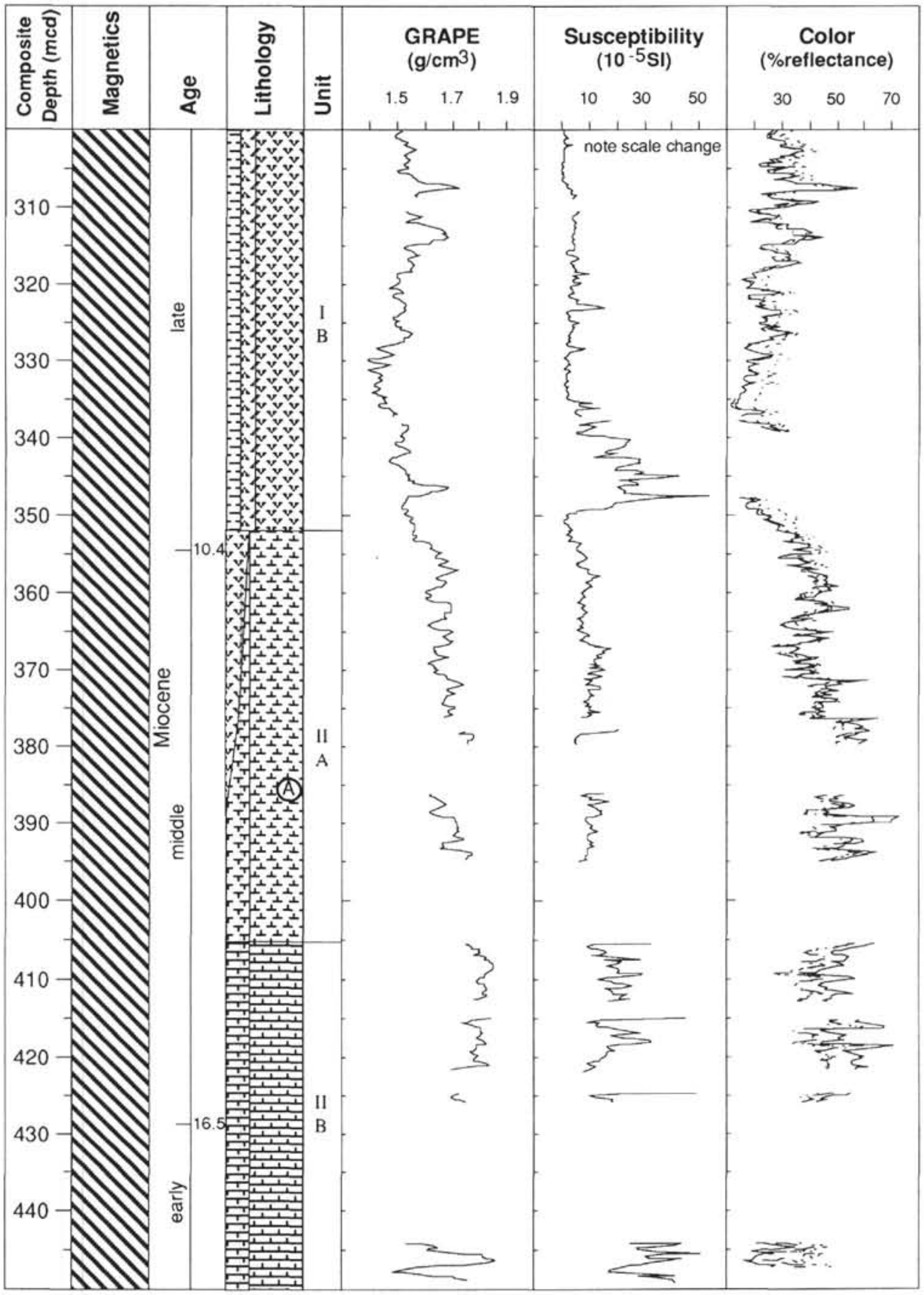


Figure 9 (cont.). Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 846. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

Site 846 - Composite Summary (cont.)



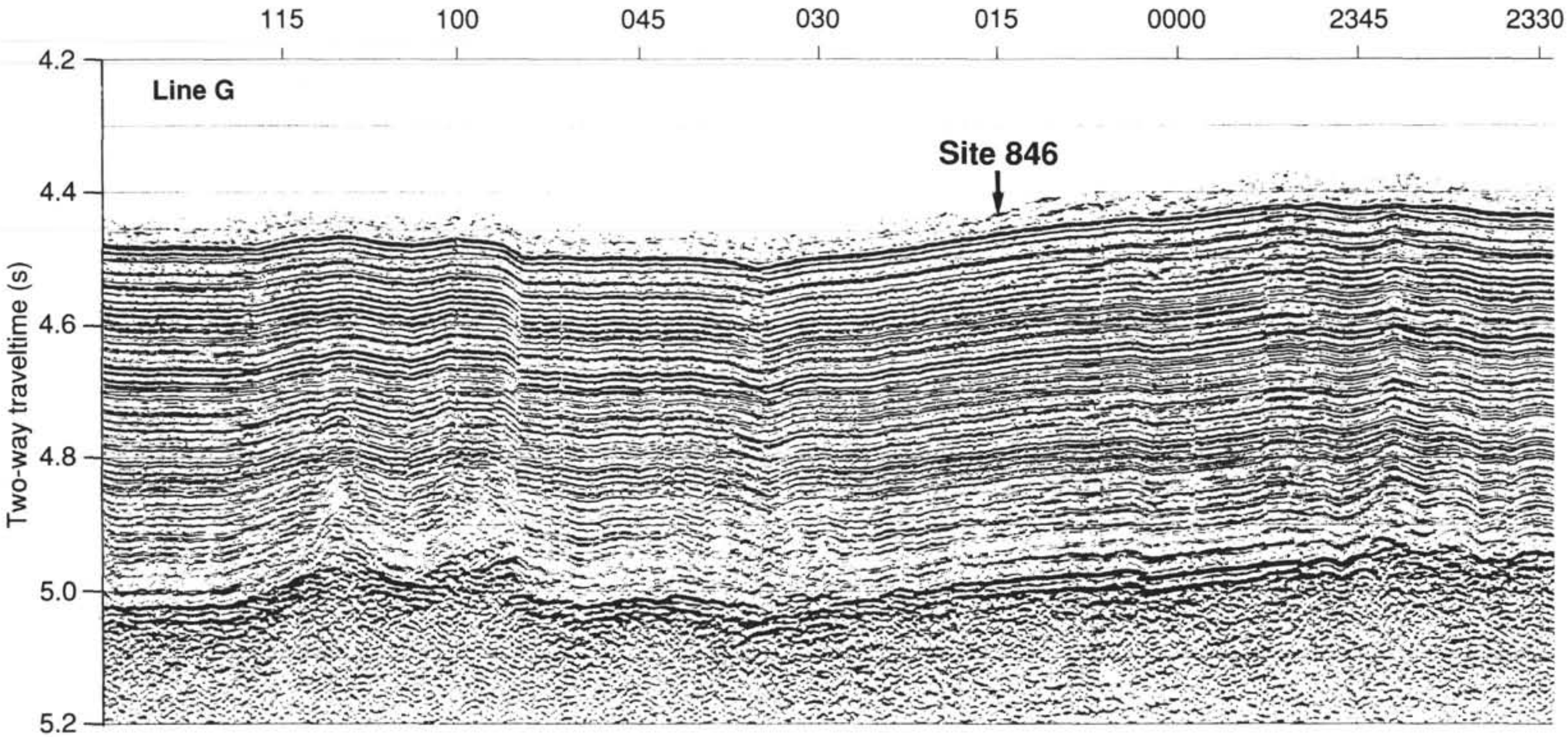


Figure 10. Single-channel seismic profile over Site 846. Profile collected during VENTURE 01 cruise of the R/V *Thomas Washington*.

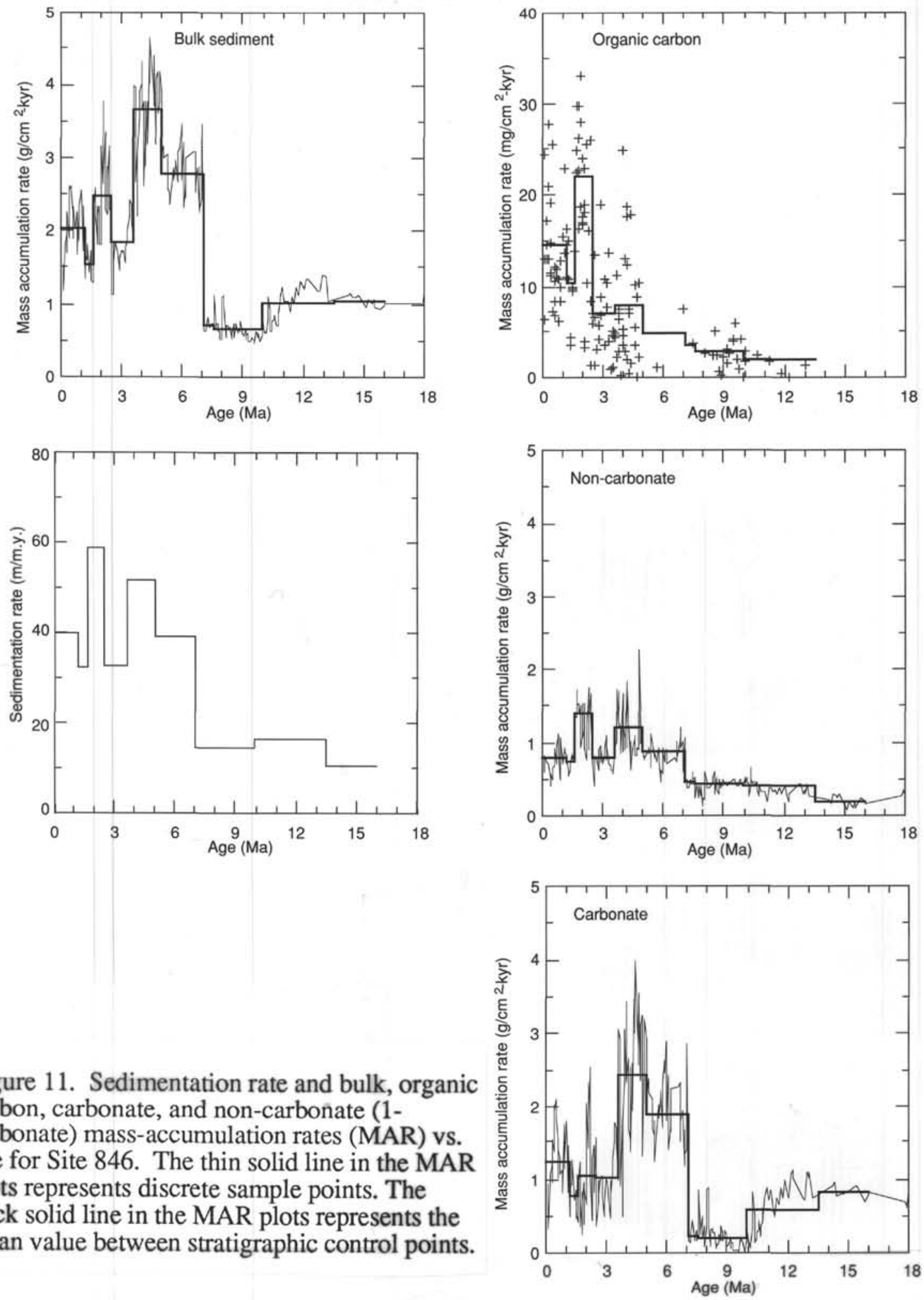


Figure 11. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 846. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

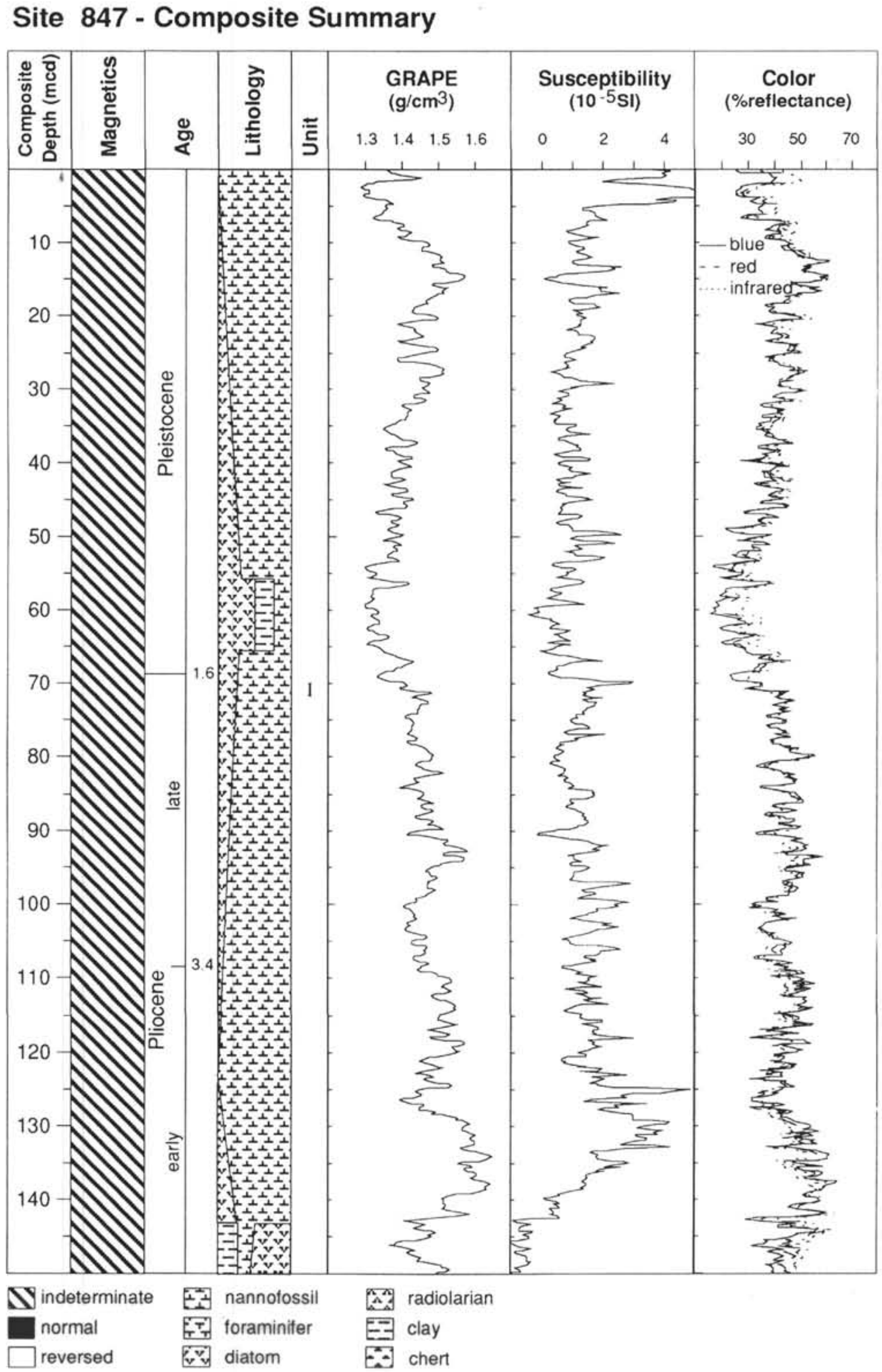
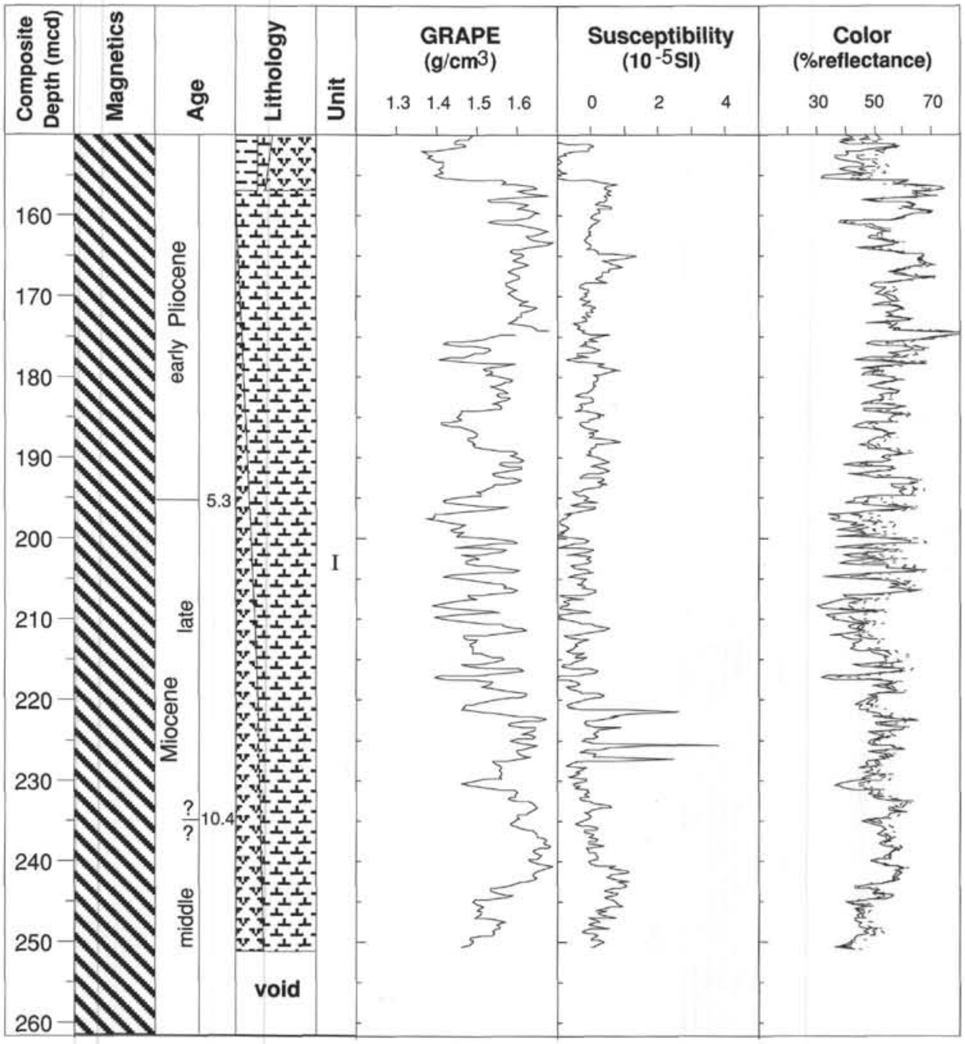


Figure 12. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 847. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

Site 847 - Composite Summary (cont.)



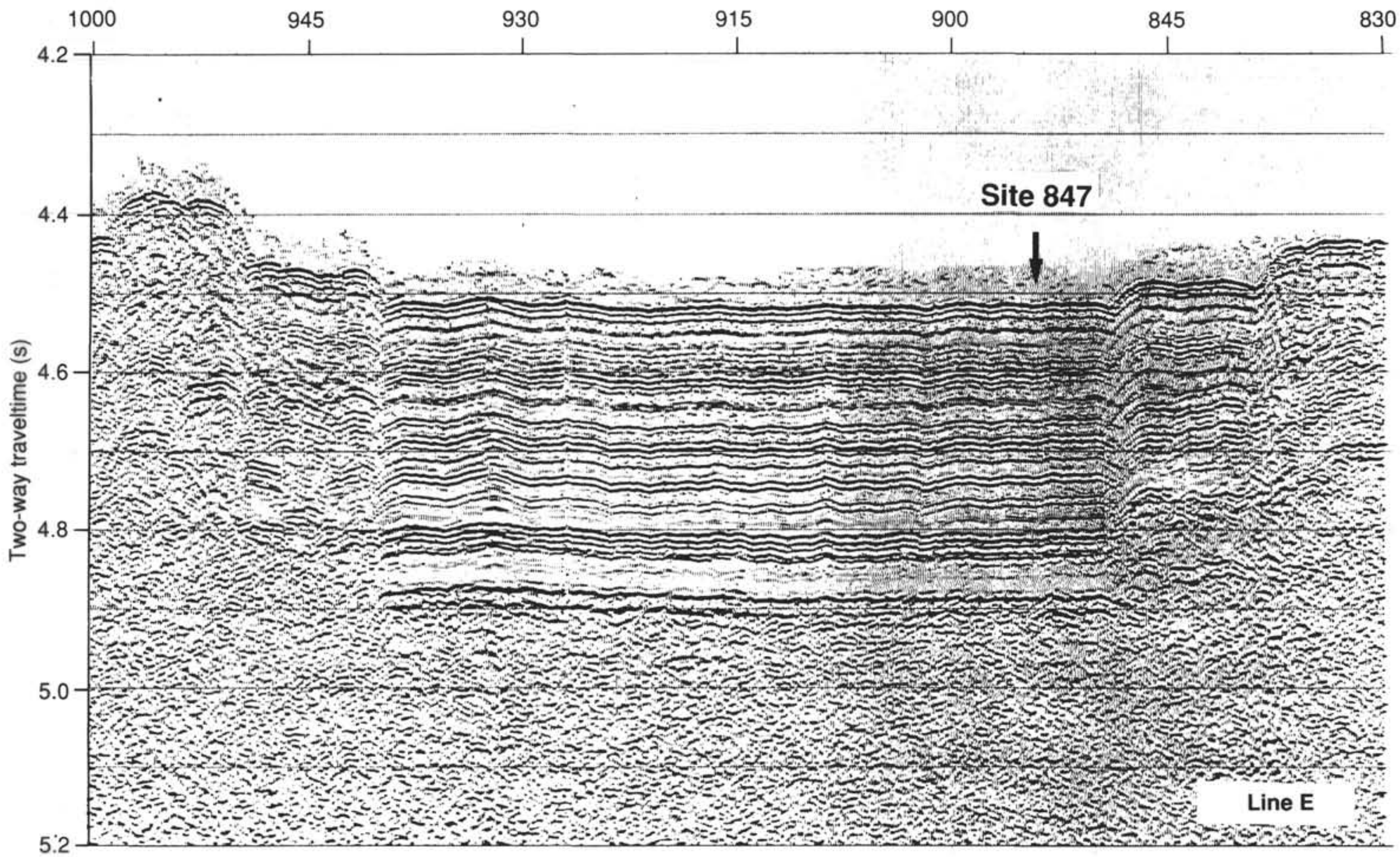
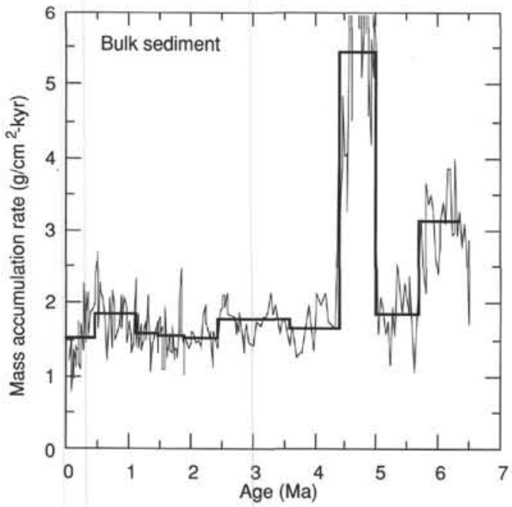
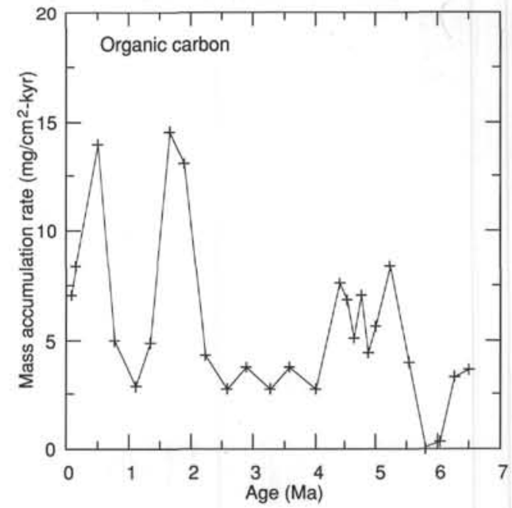
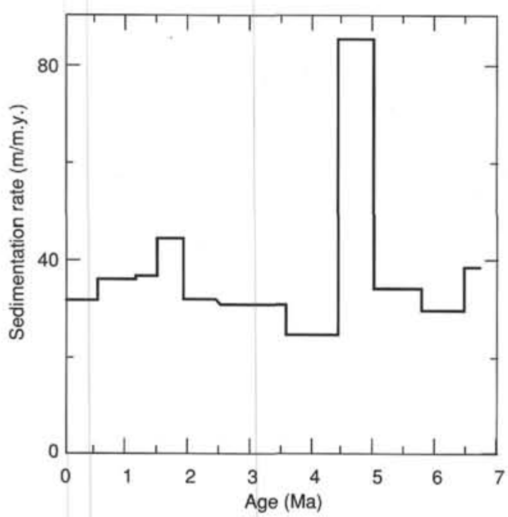
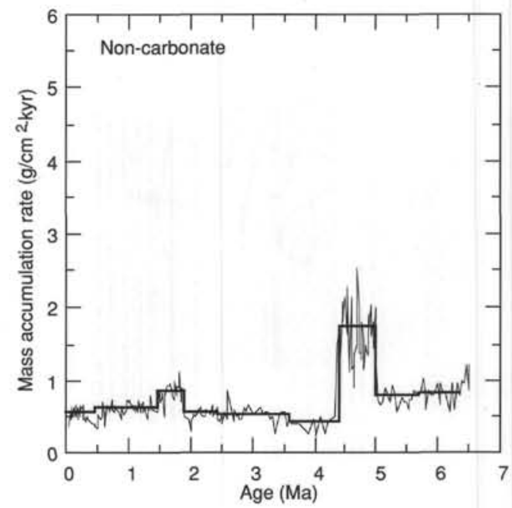


Figure 13. Single-channel seismic profile over Site 847. Profile collected during VENTURE 01 cruise of the R/V *Thomas Washington*.









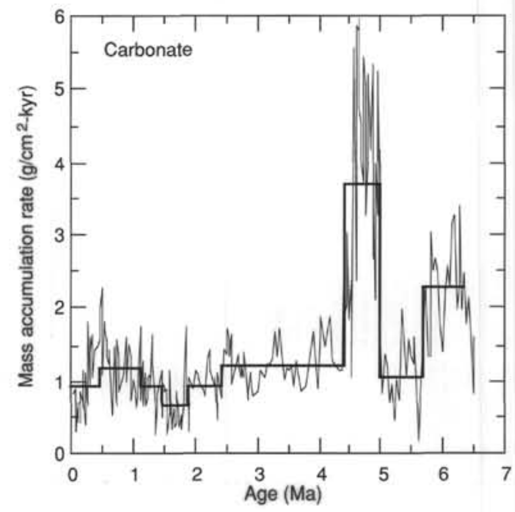


Figure 14. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 847. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

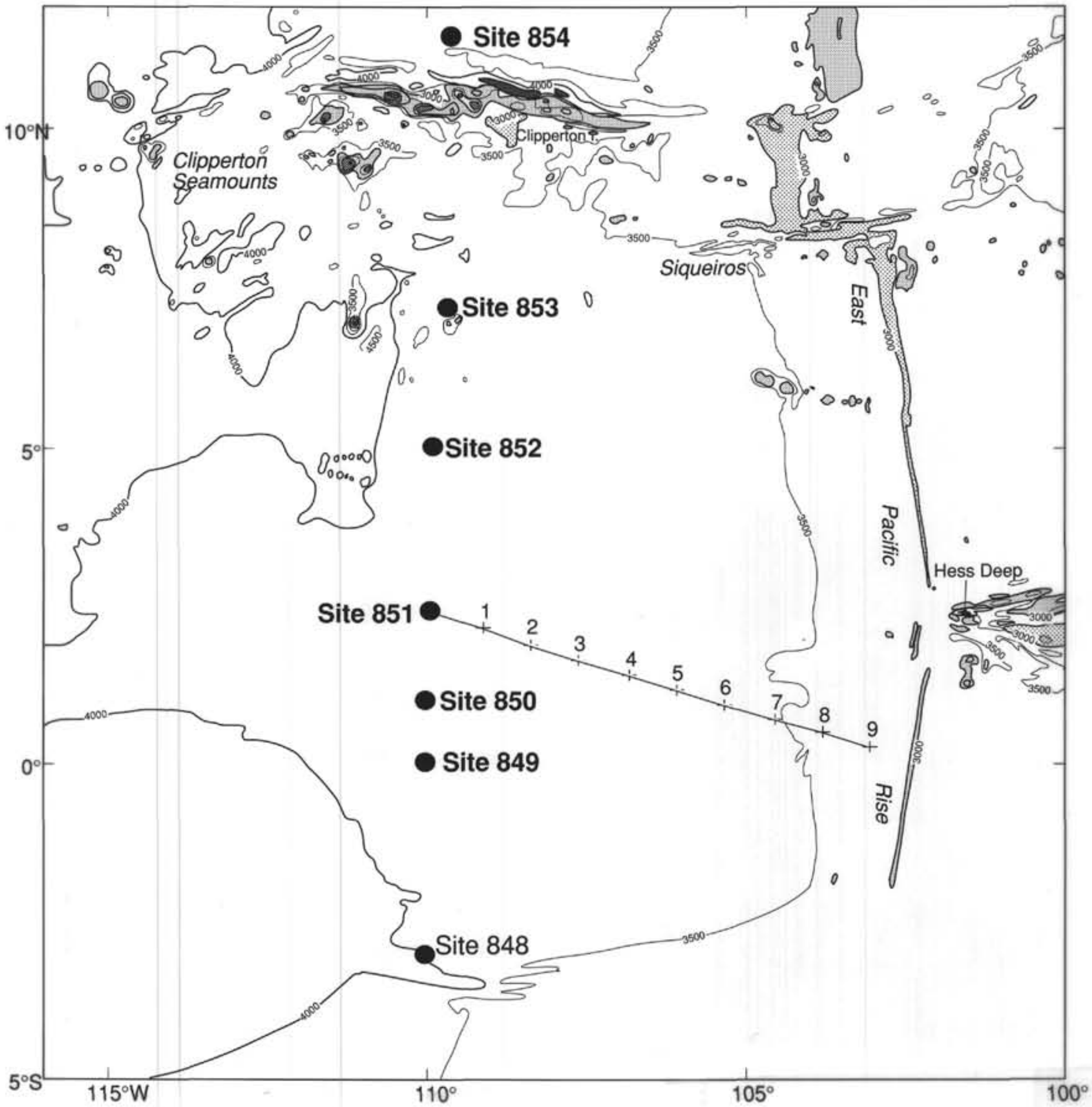


Figure 15. Backtrack path in million-year increments of Sites 881 on the western transect of Leg 138. The backtrack paths of the other sites are similar to that of Site 851.

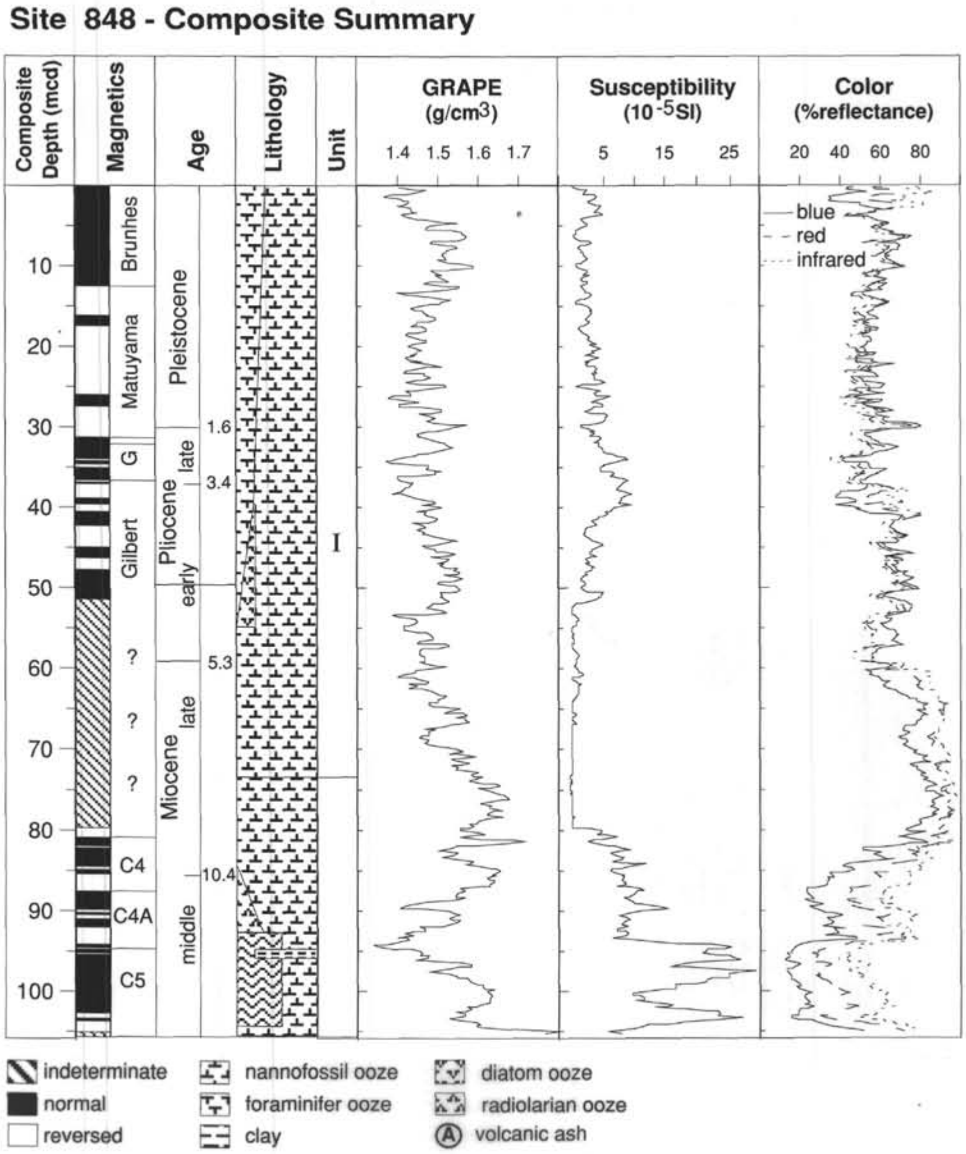


Figure 16. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 848. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

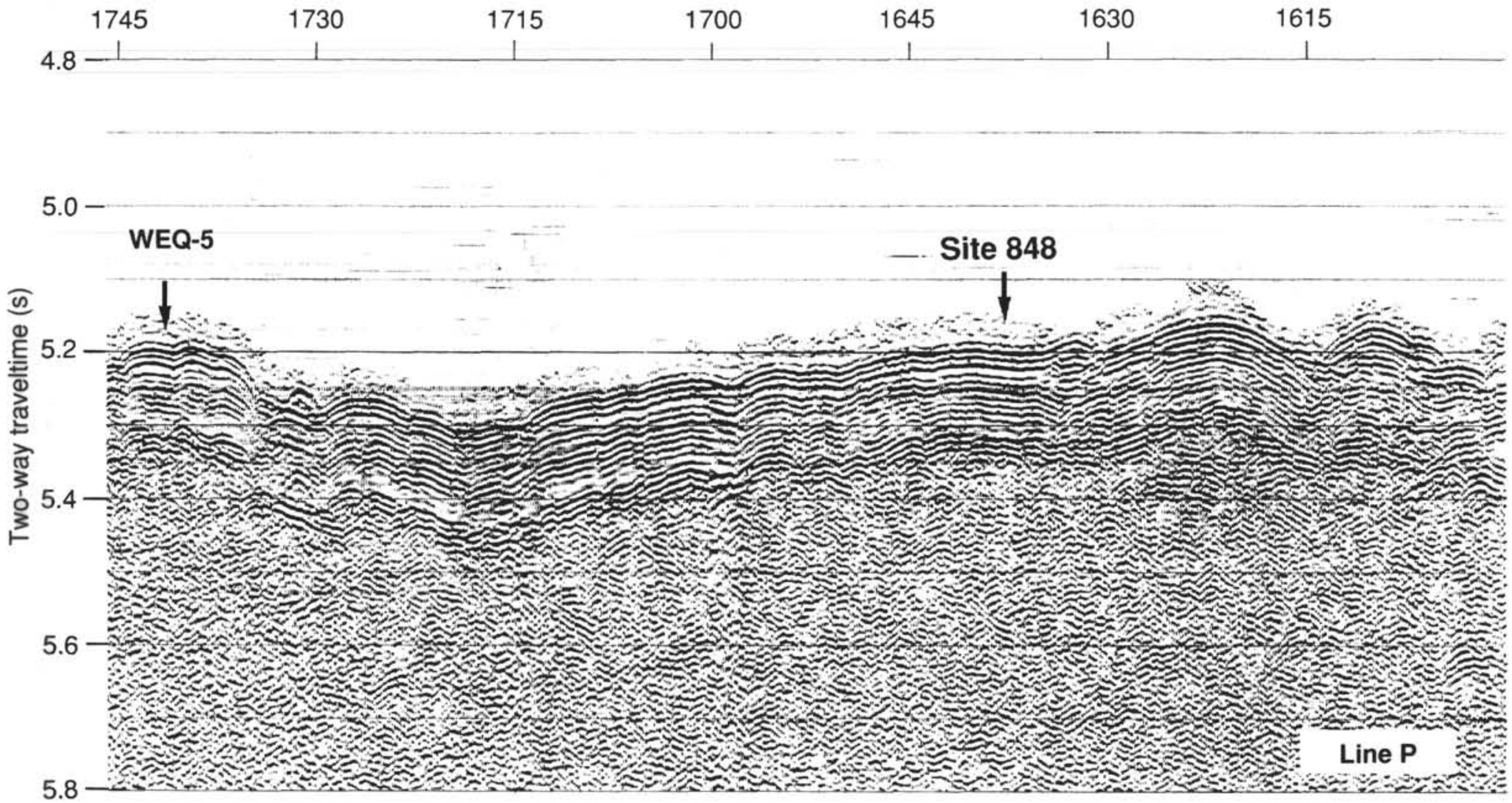
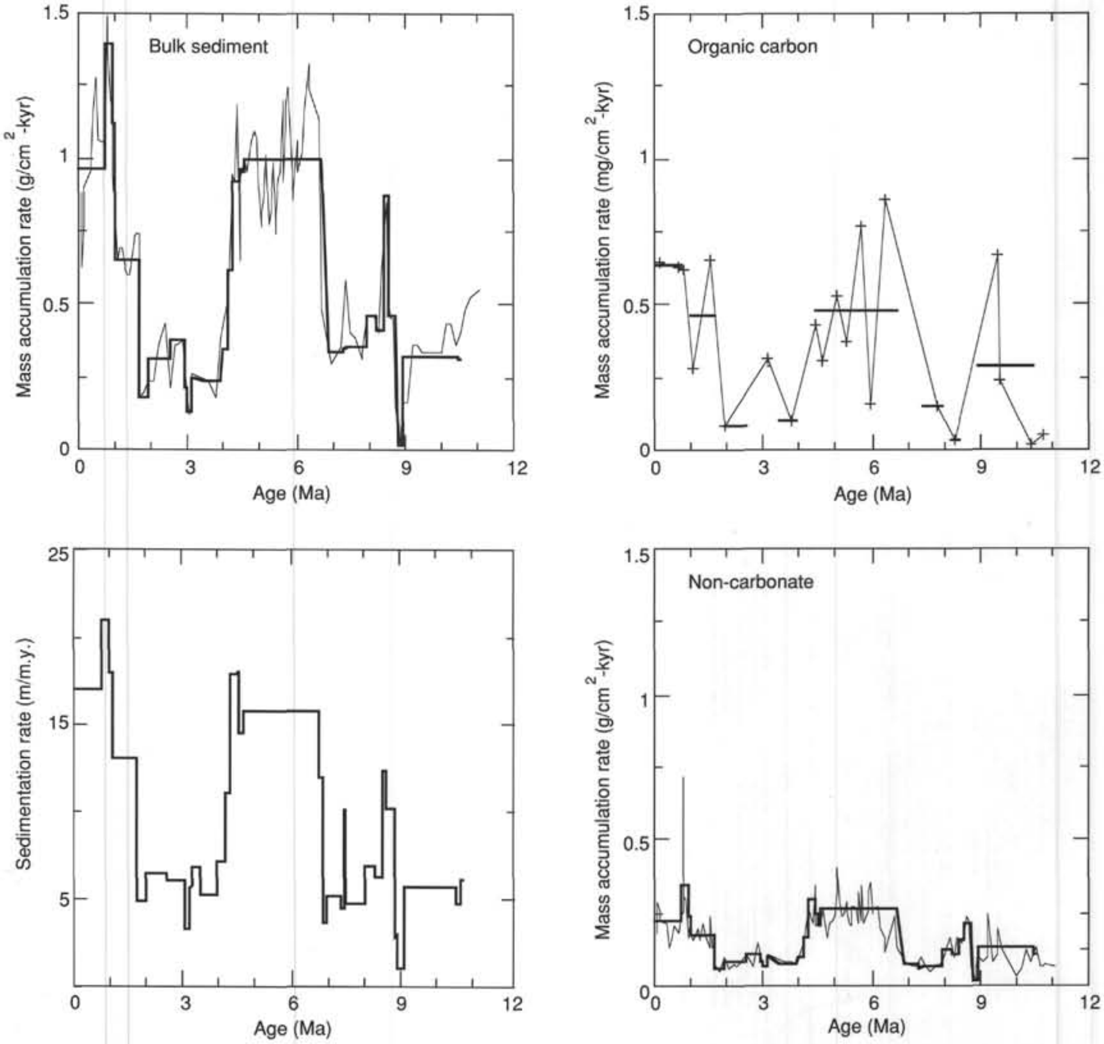


Figure 17. Single-channel seismic profile over Site 848. Profile collected during VENTURE 01 cruise of the R/V *Thomas Washington*. Figure shows proposed site WEQ-5 and approximate location of Site 848.



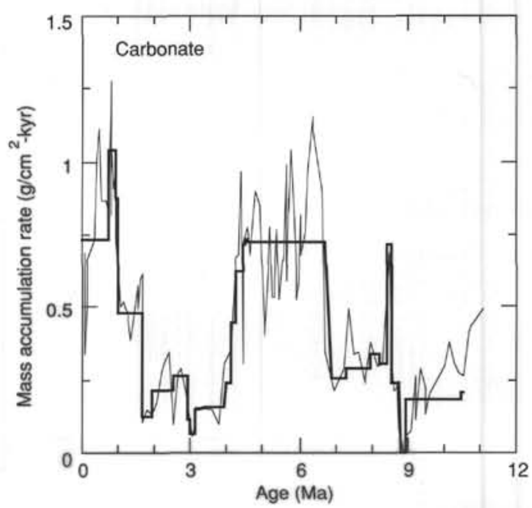


Figure 18. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 848. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

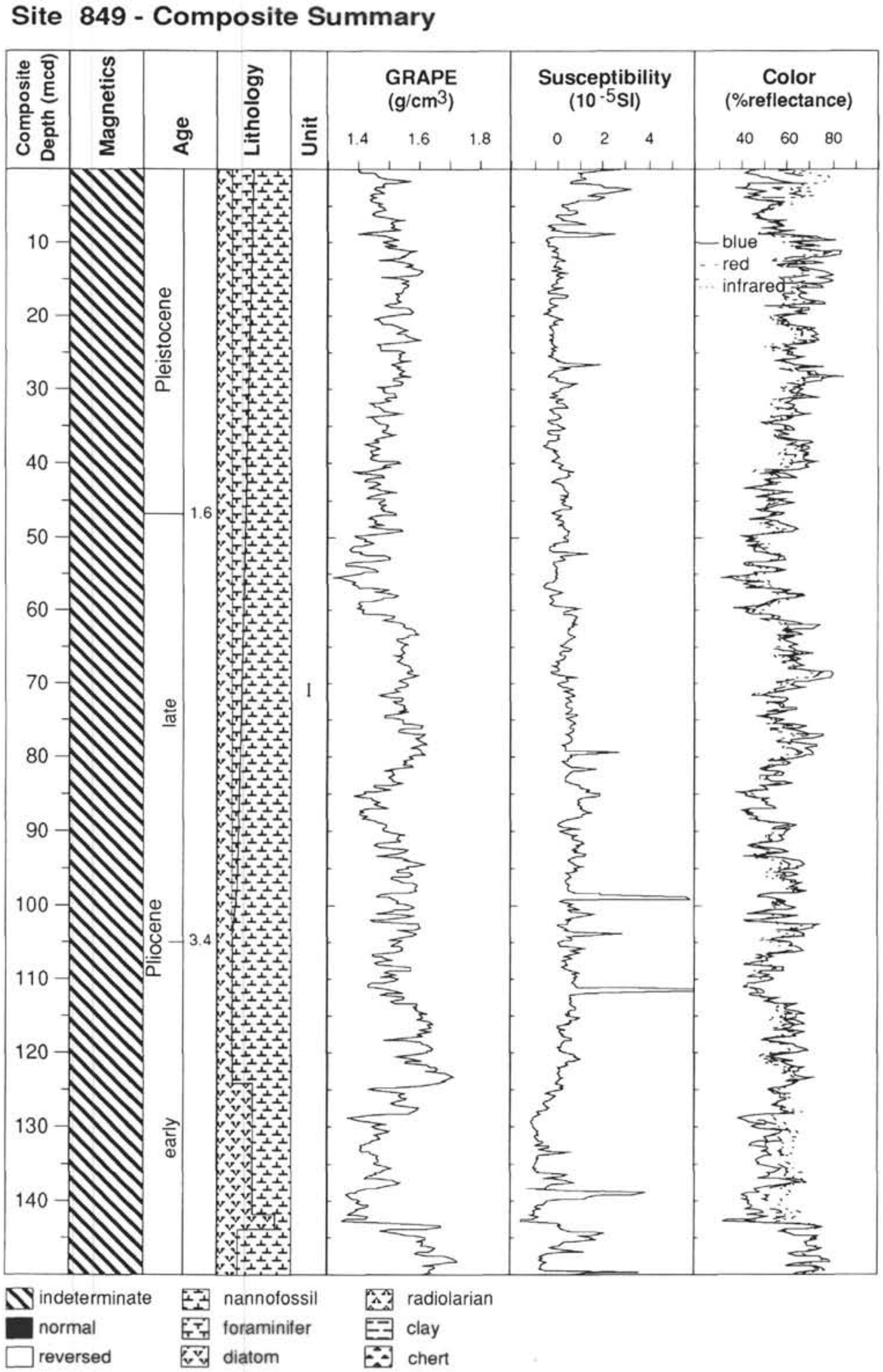
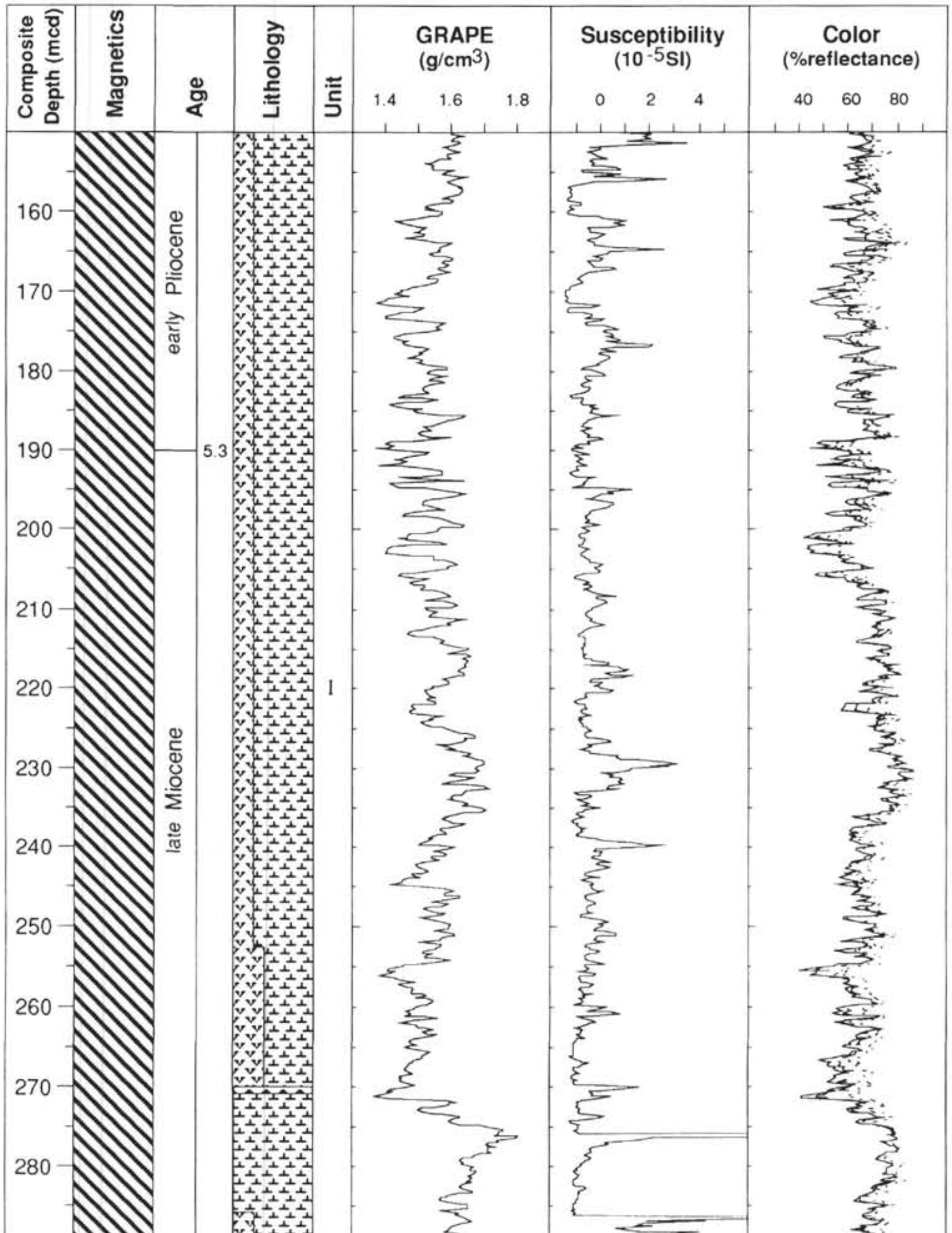


Figure 19. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 849. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

Site 849 - Composite Summary (cont.)



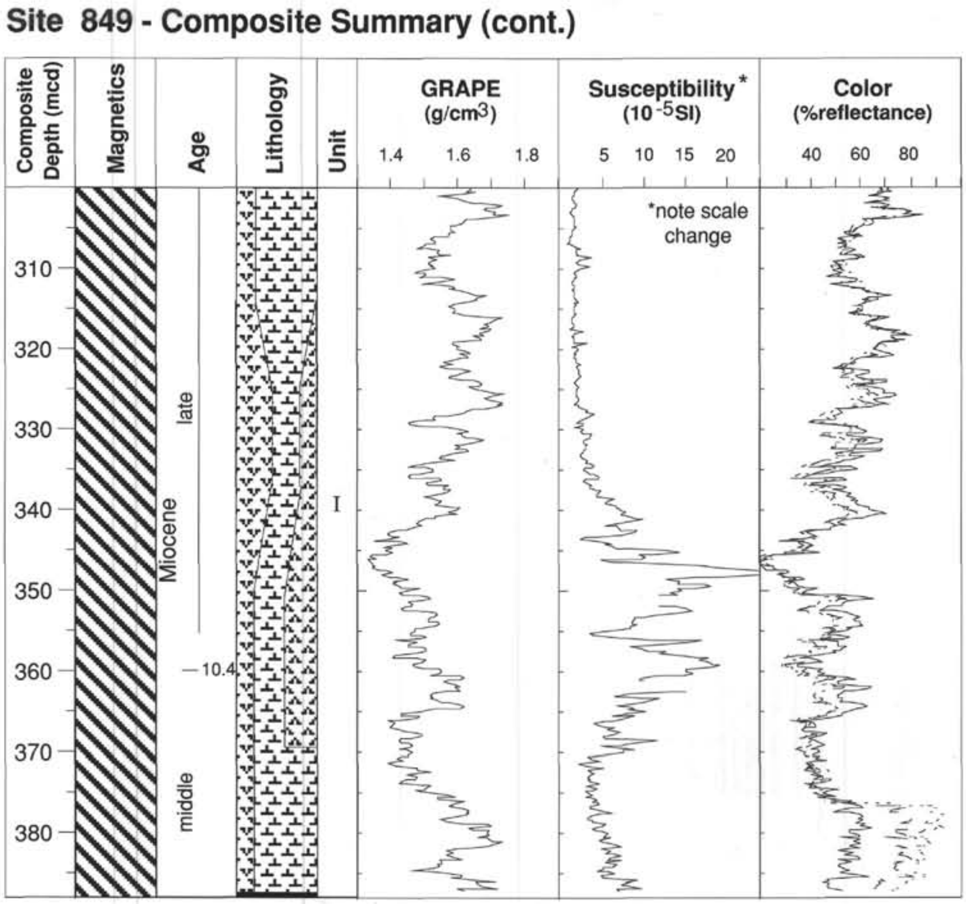


Figure 19, cont. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 849. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

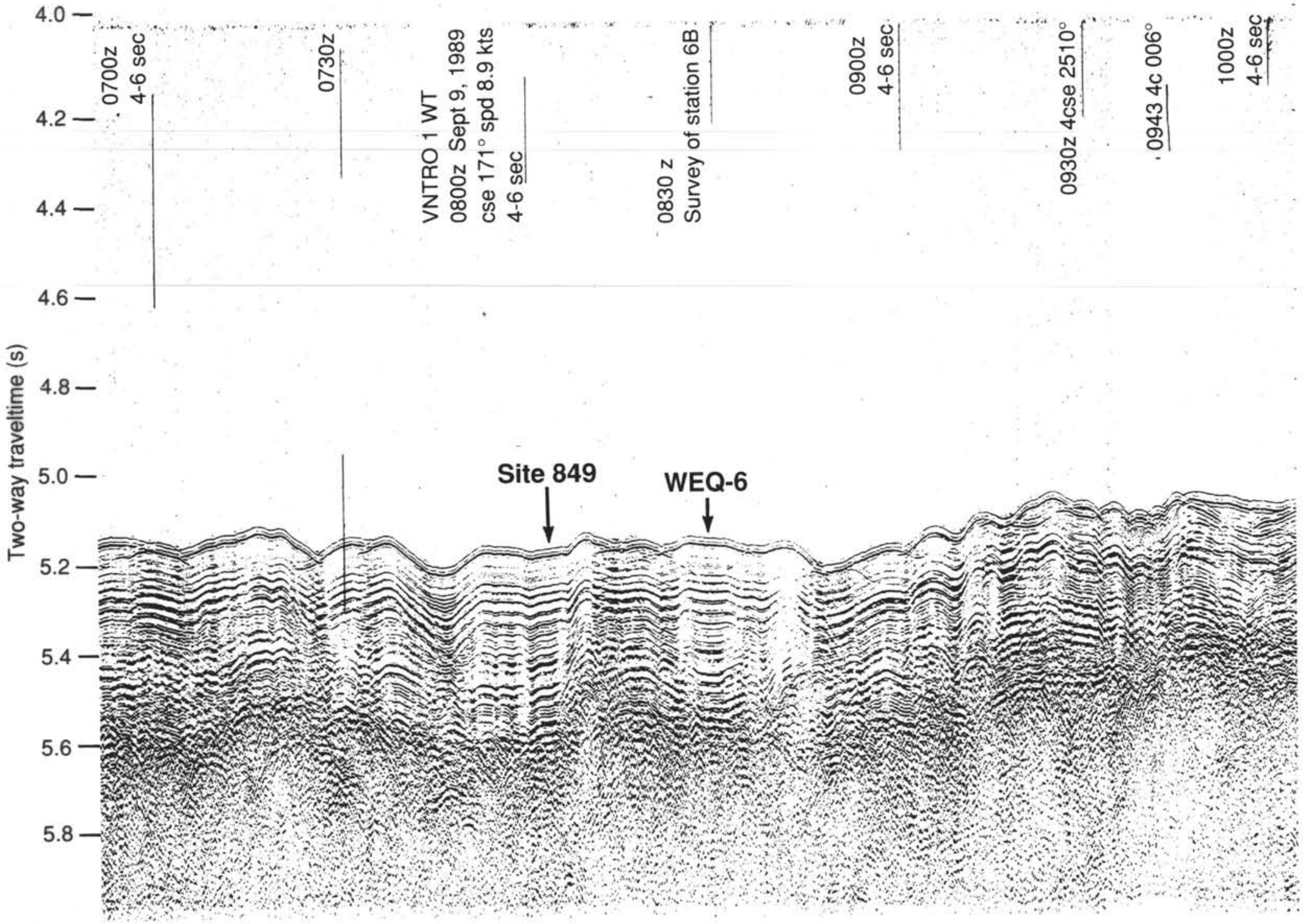
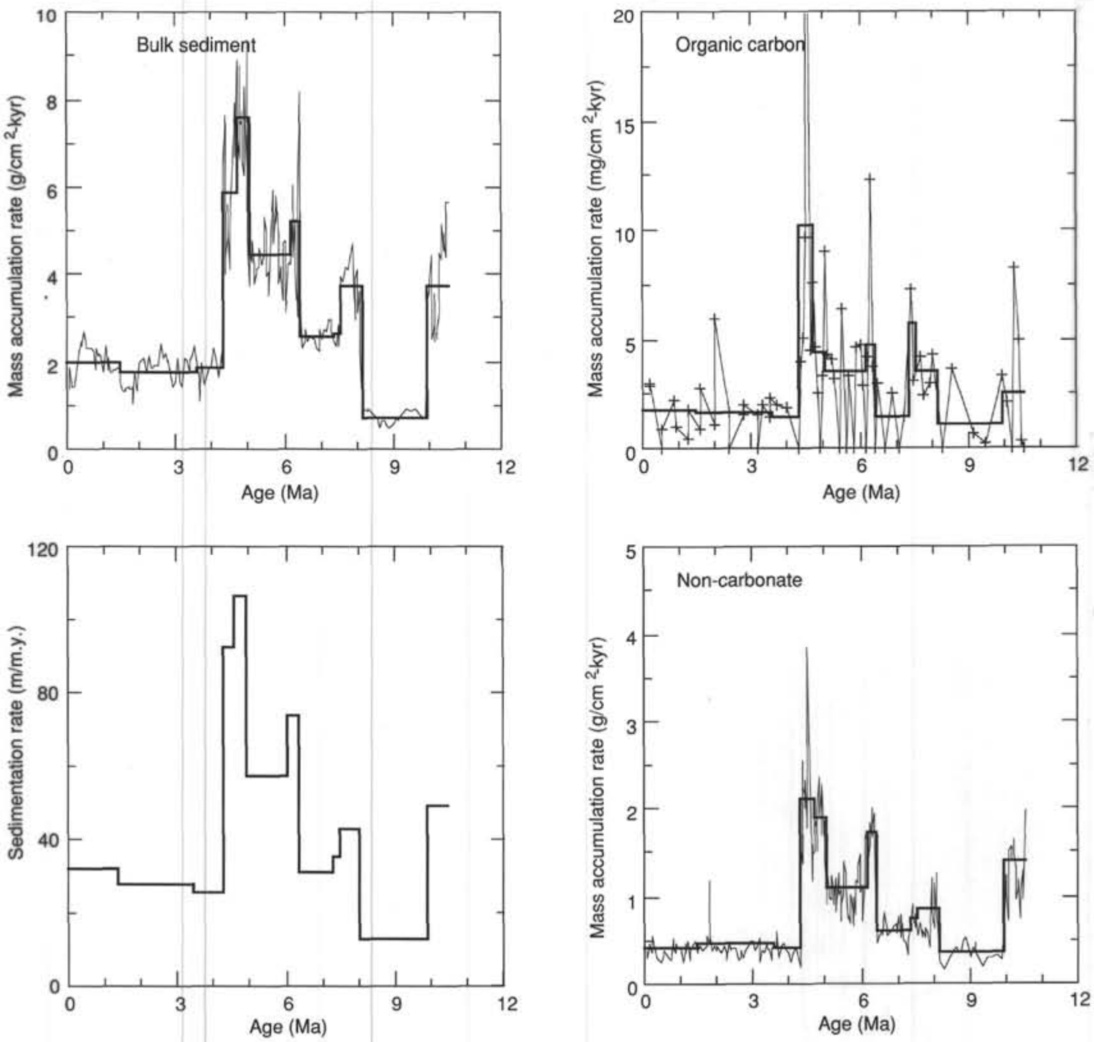


Figure 20. Single-channel seismic profile over Site 849. Profile collected during VENTURE 01 cruise of the R/V *Thomas Washington*. Figure show proposed site and actual drilling location of Site 849.



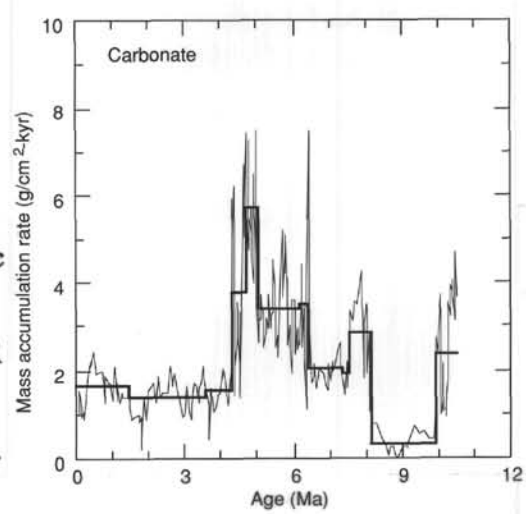


Figure 21. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 849. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

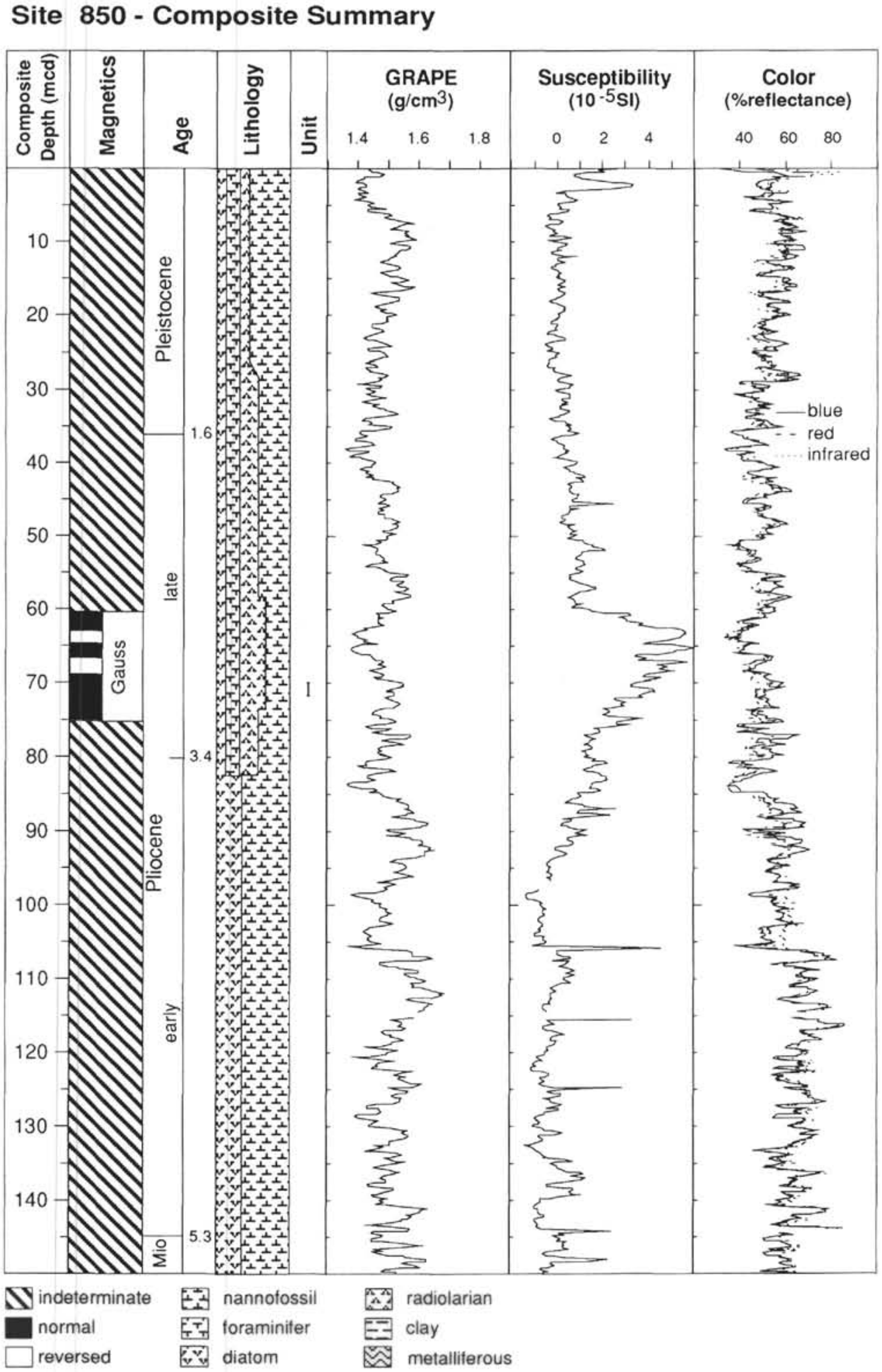


Figure 22. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 850. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

Site 850 - Composite Summary (cont.)

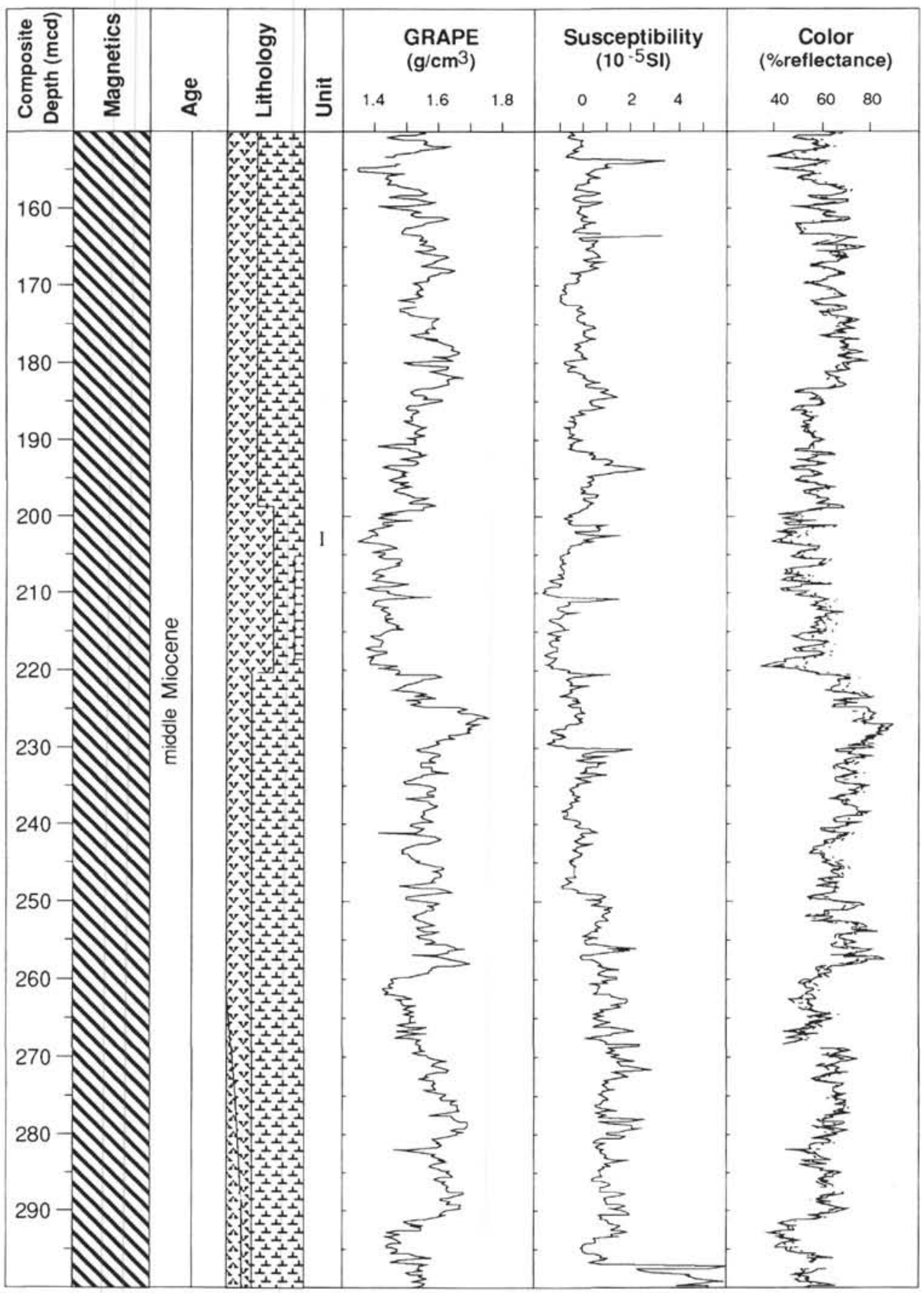
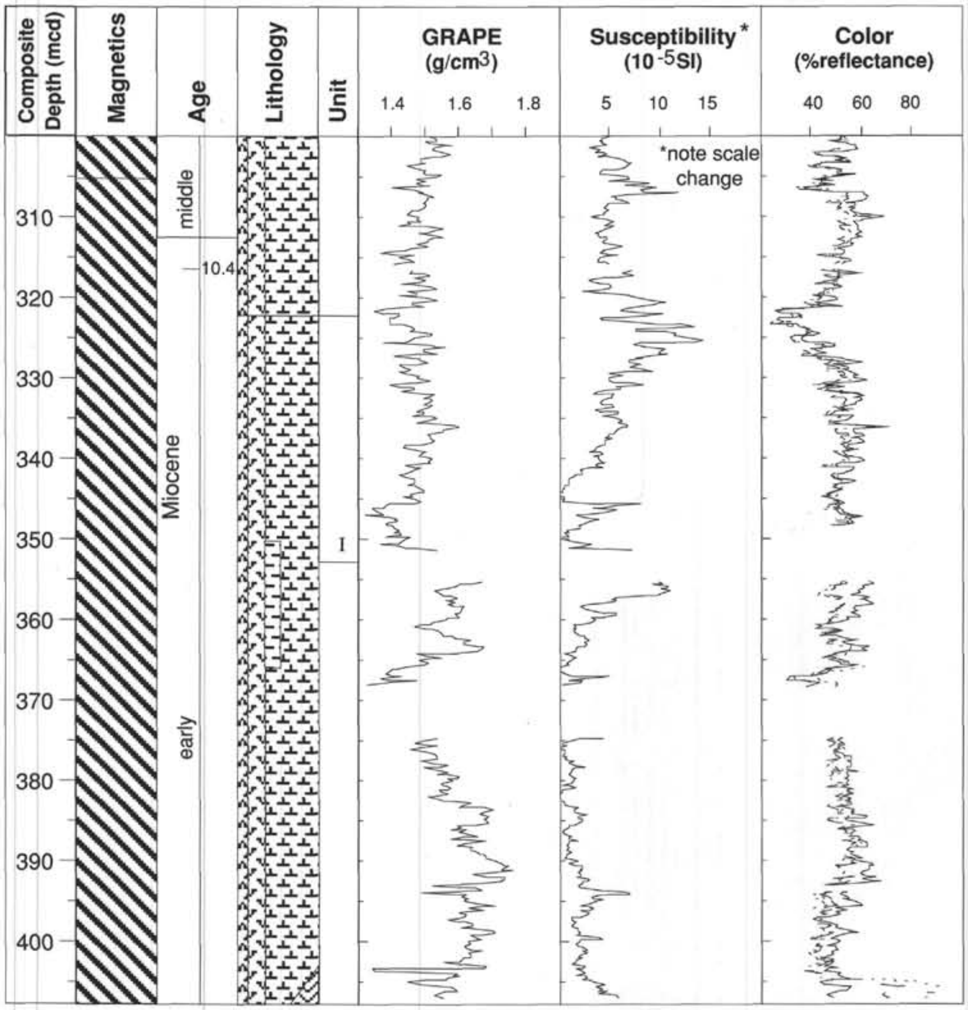


Figure 22, cont. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 850. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

Site 850 - Composite Summary (cont.)



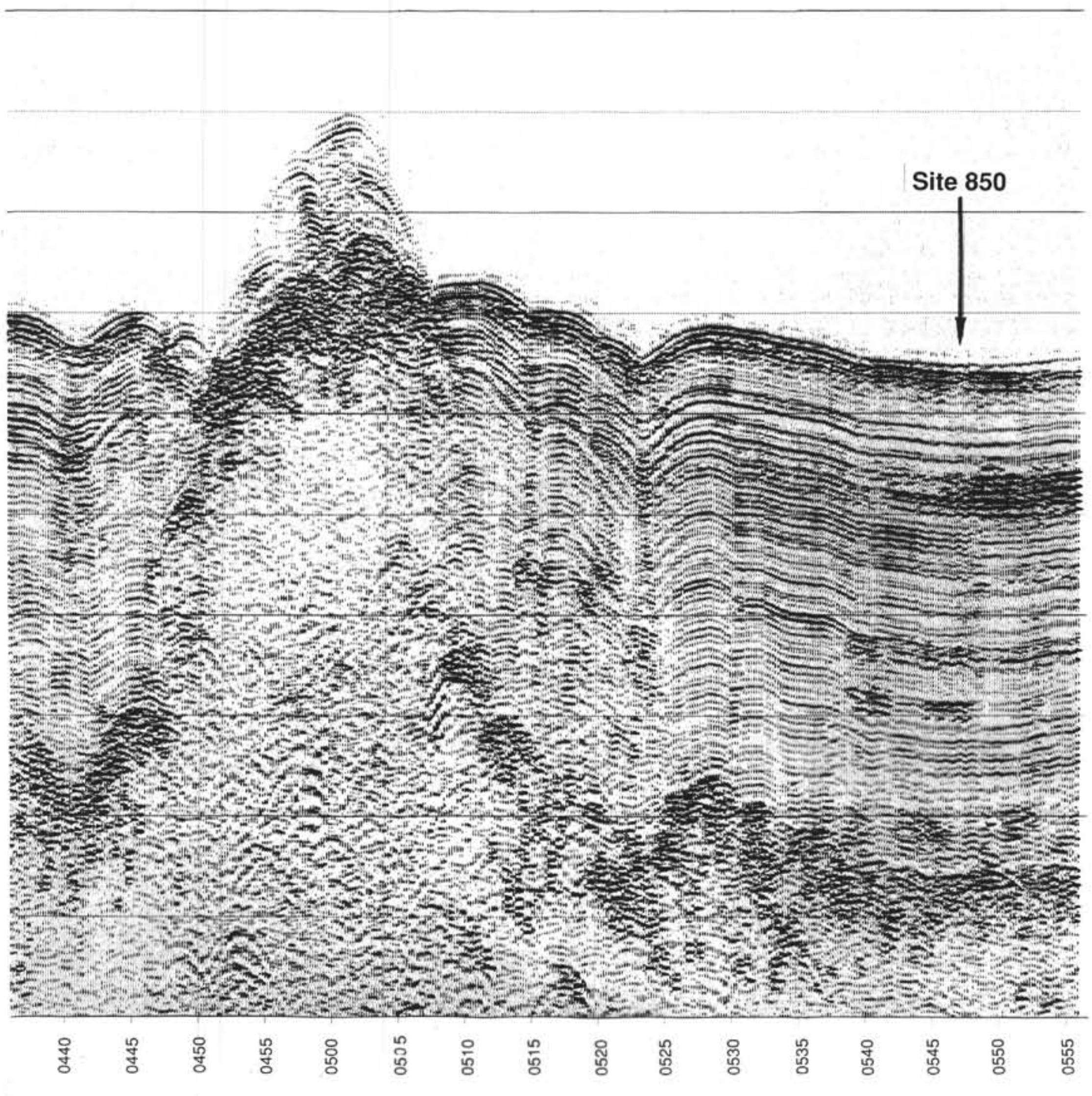
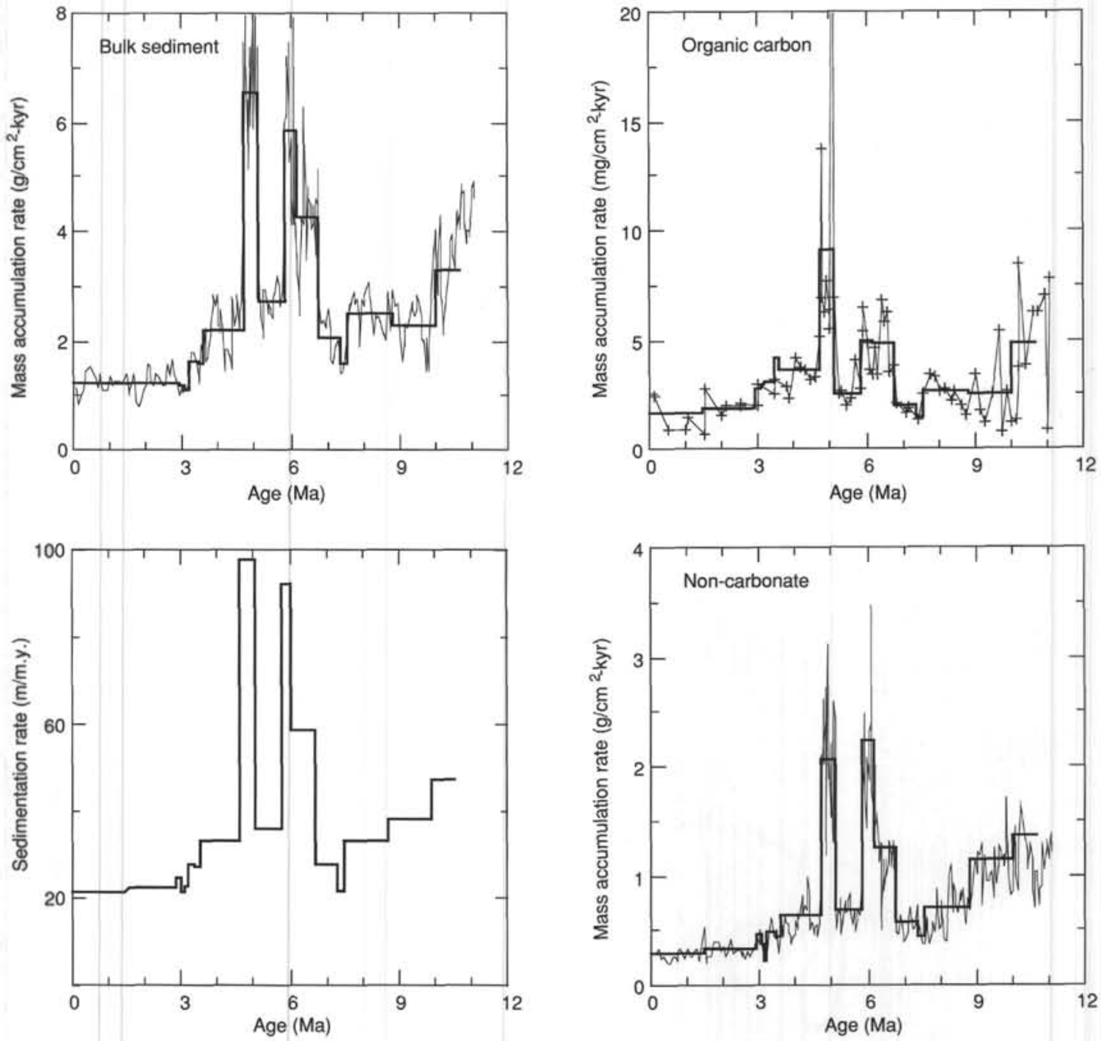


Figure 23. Single-channel seismic profile over Site 850. Profile collected during site survey by *JOIDES Resolution*.



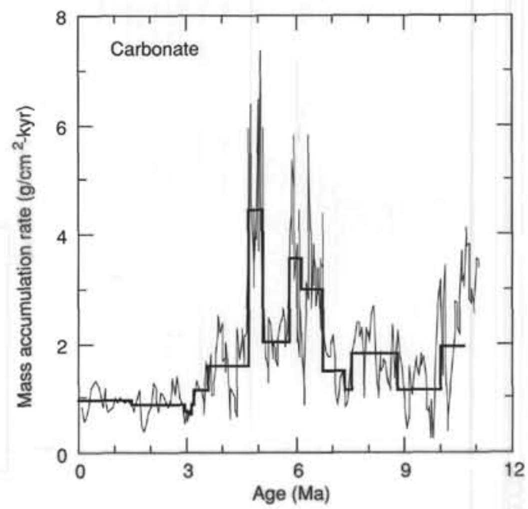


Figure 24. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 850. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

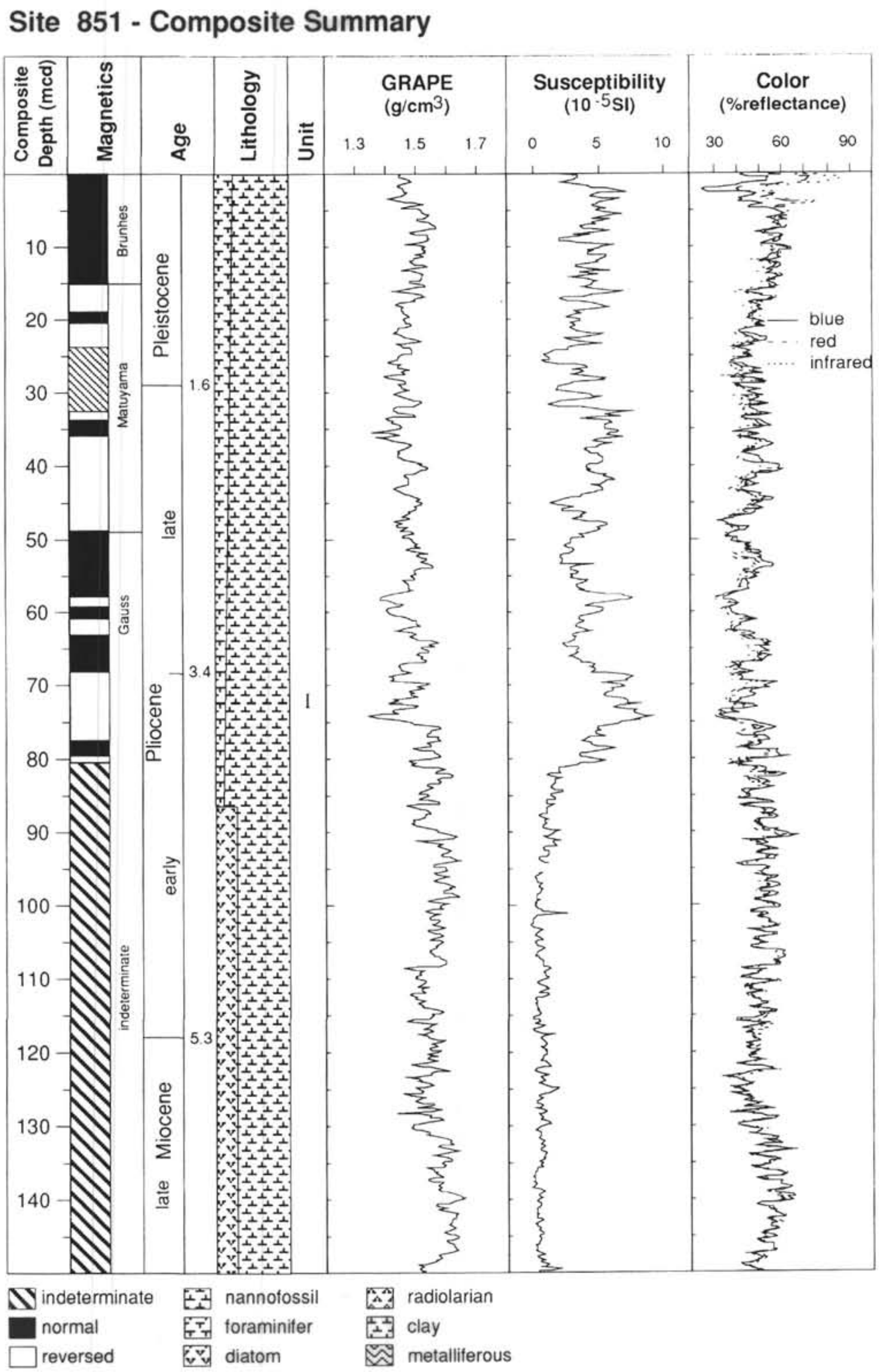
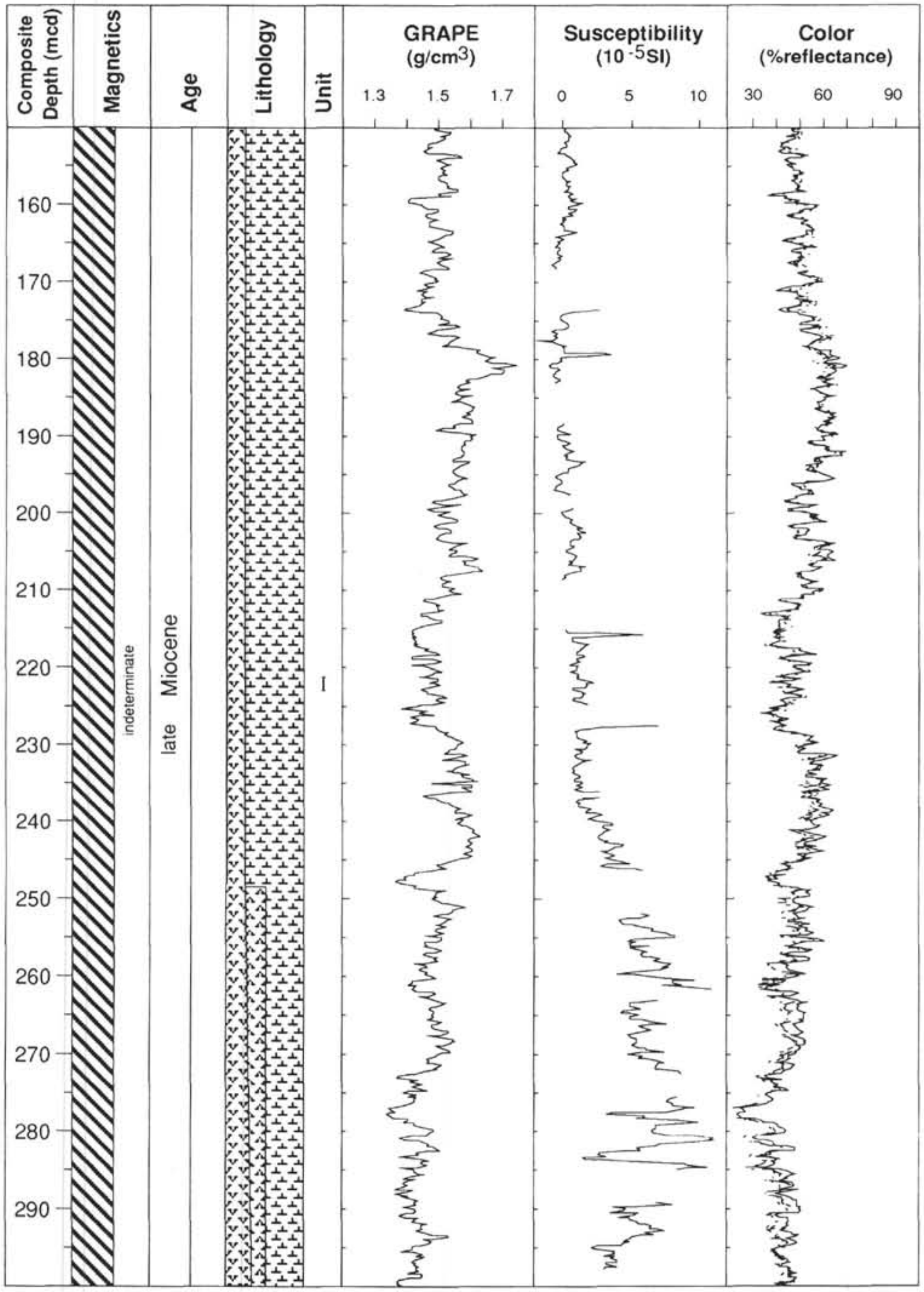


Figure 25. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 851. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

Site 851 - Composite Summary (cont.)



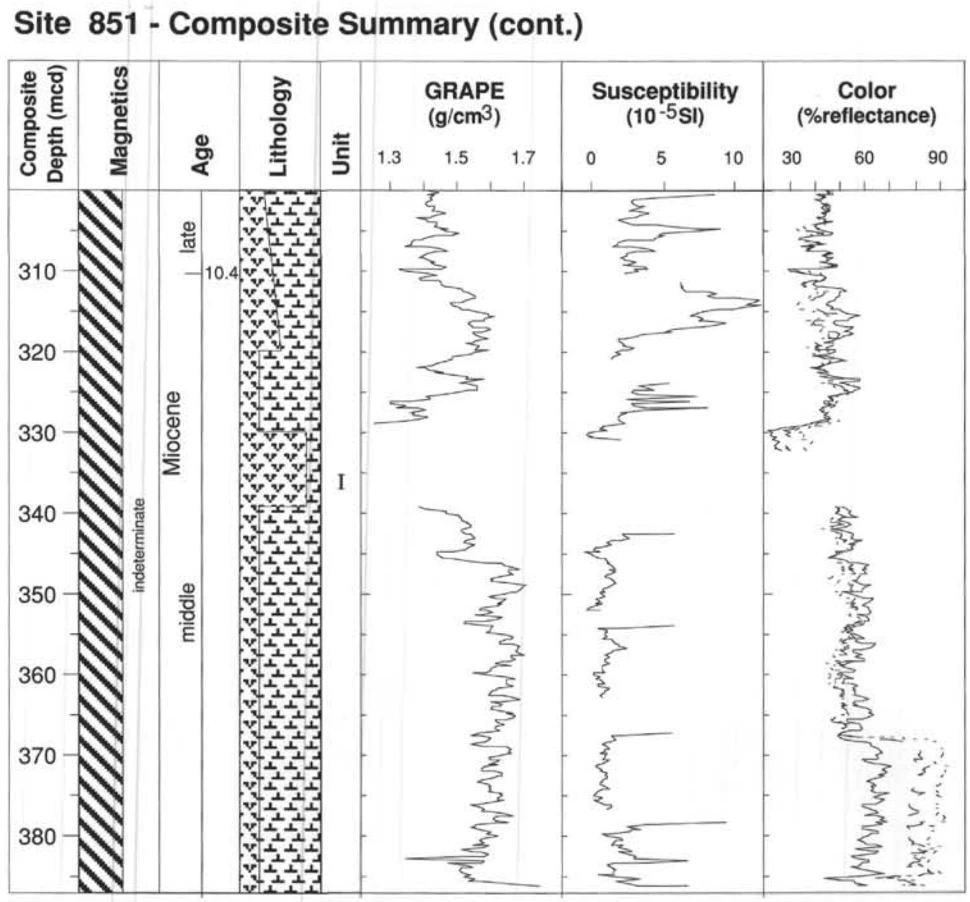


Figure 25, cont. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 851. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

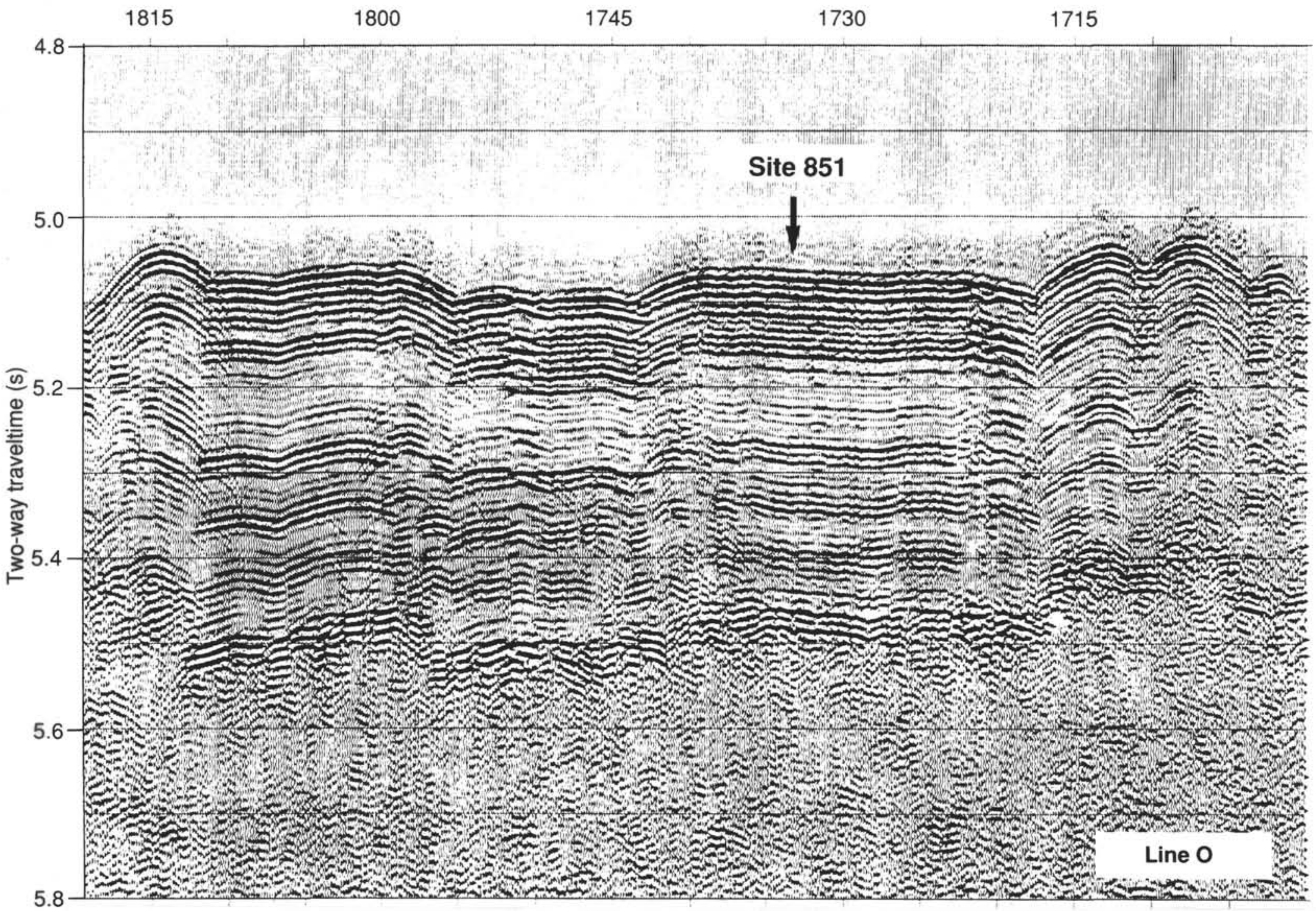


Figure 26. Single-channel seismic profile over Site 851. Profile collected during VENTURE 01 cruise of the R/V *Thomas Washington*.

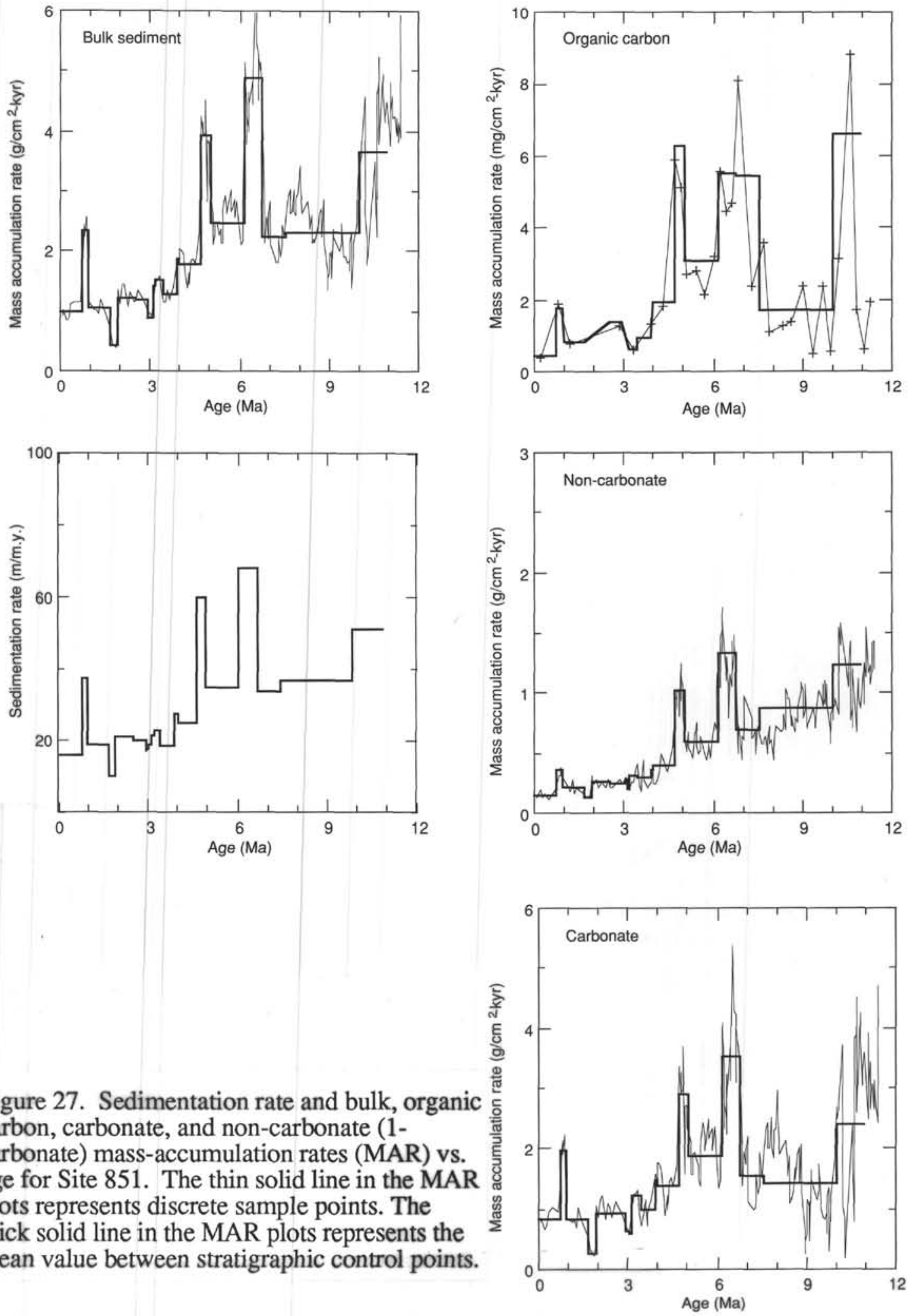


Figure 27. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 851. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

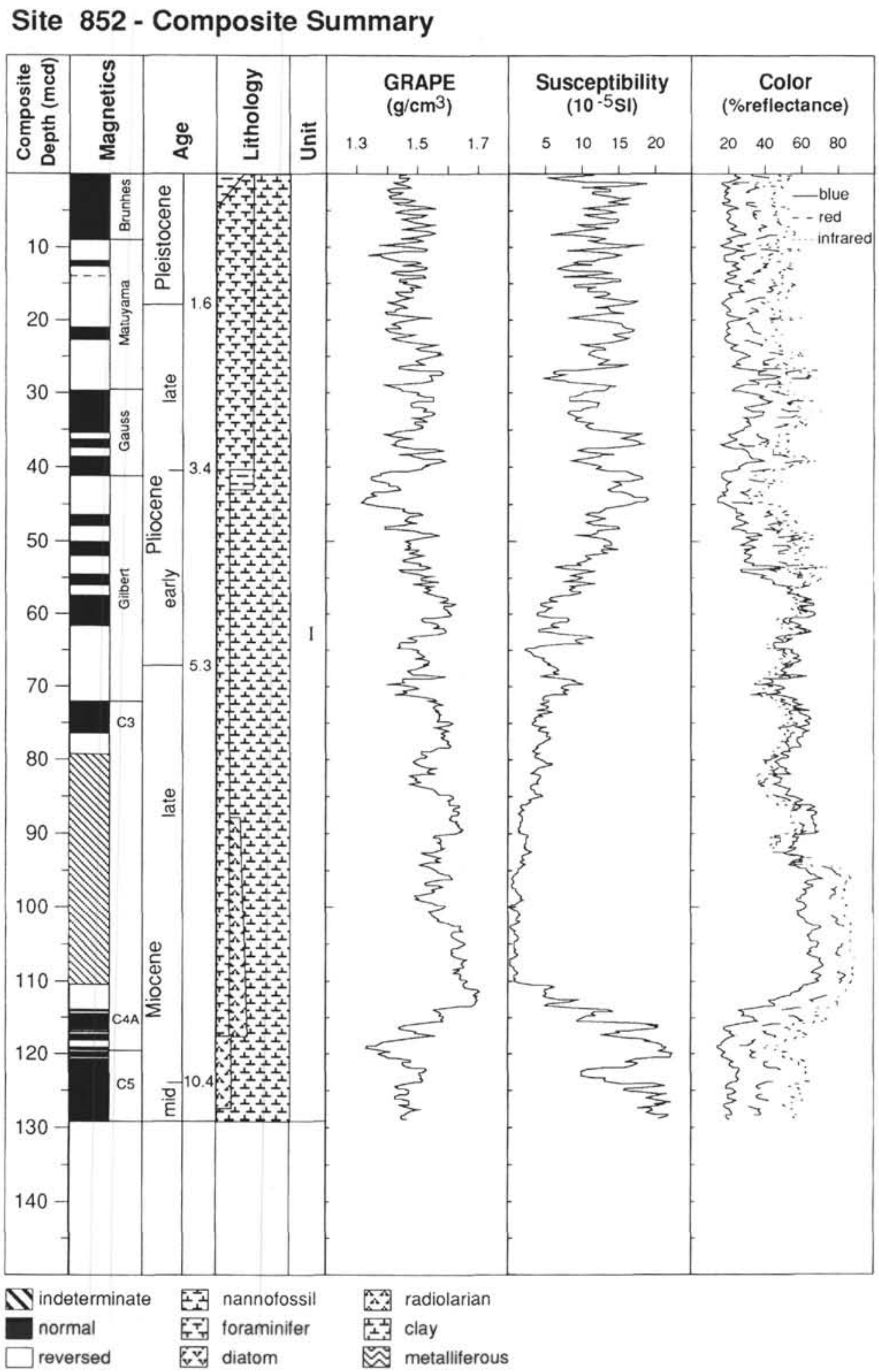


Figure 28. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 852. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

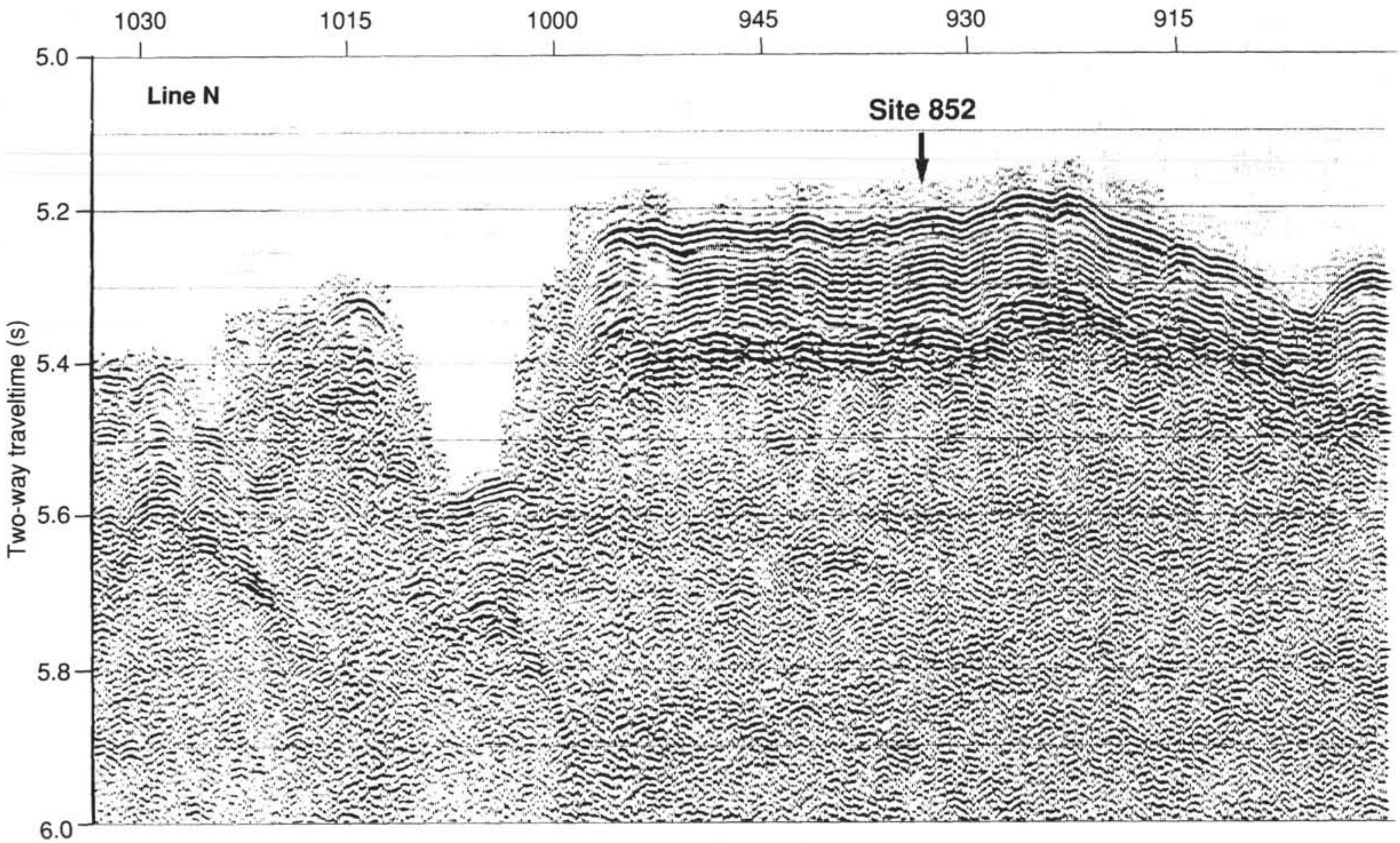
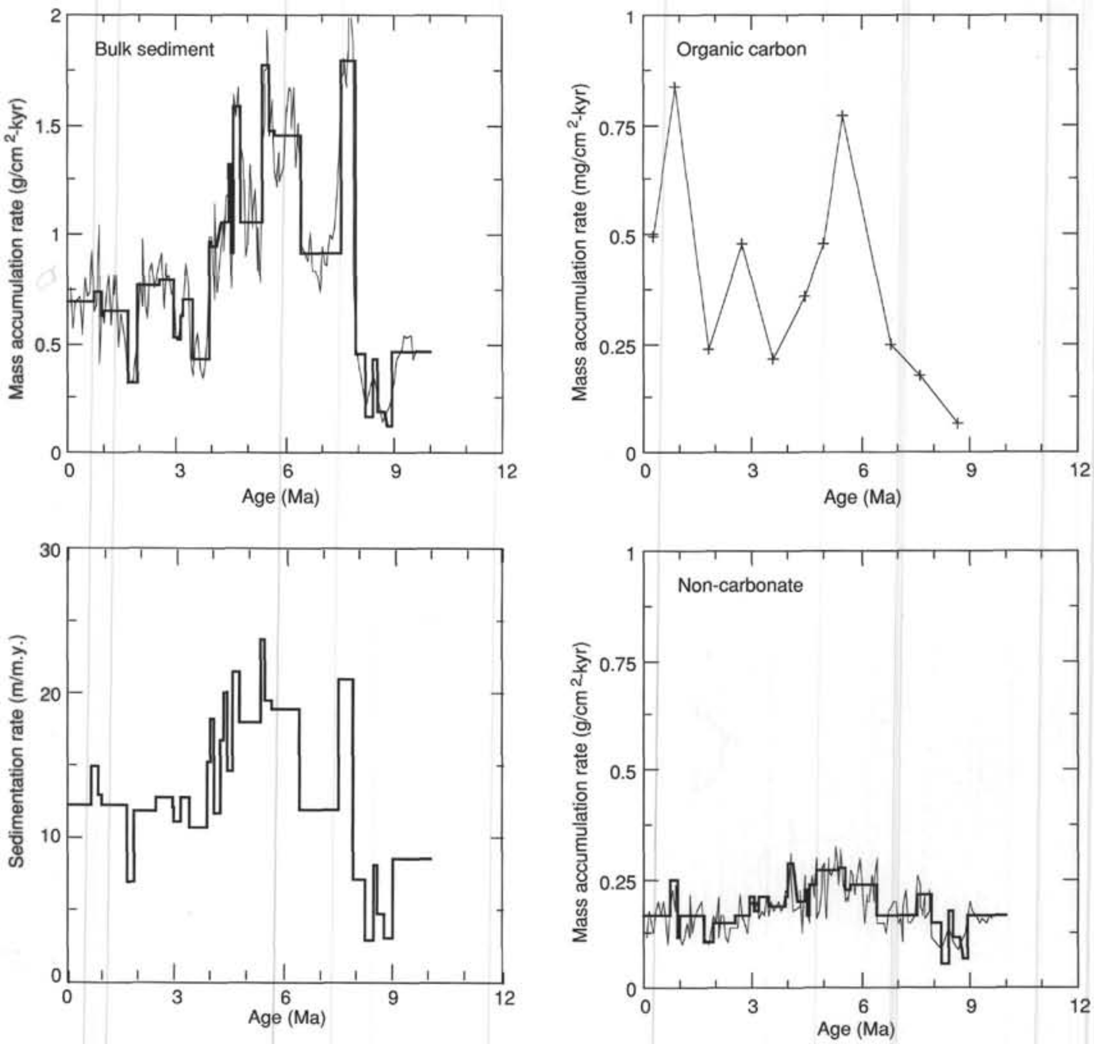


Figure 29. Single-channel seismic profile over Site 852. Profile collected during VENTURE 01 cruise of the R/V *Thomas Washington*.



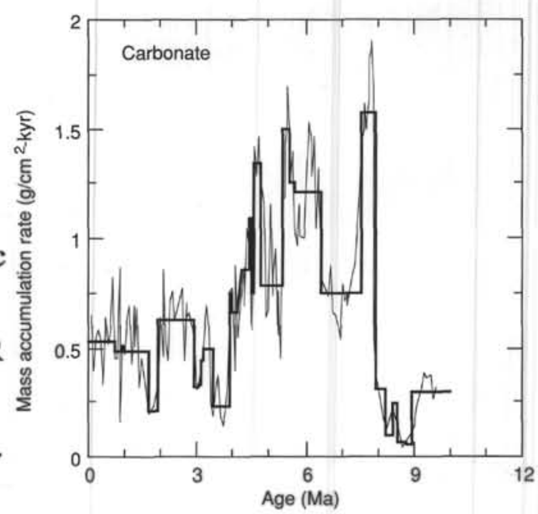


Figure 30. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 852. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

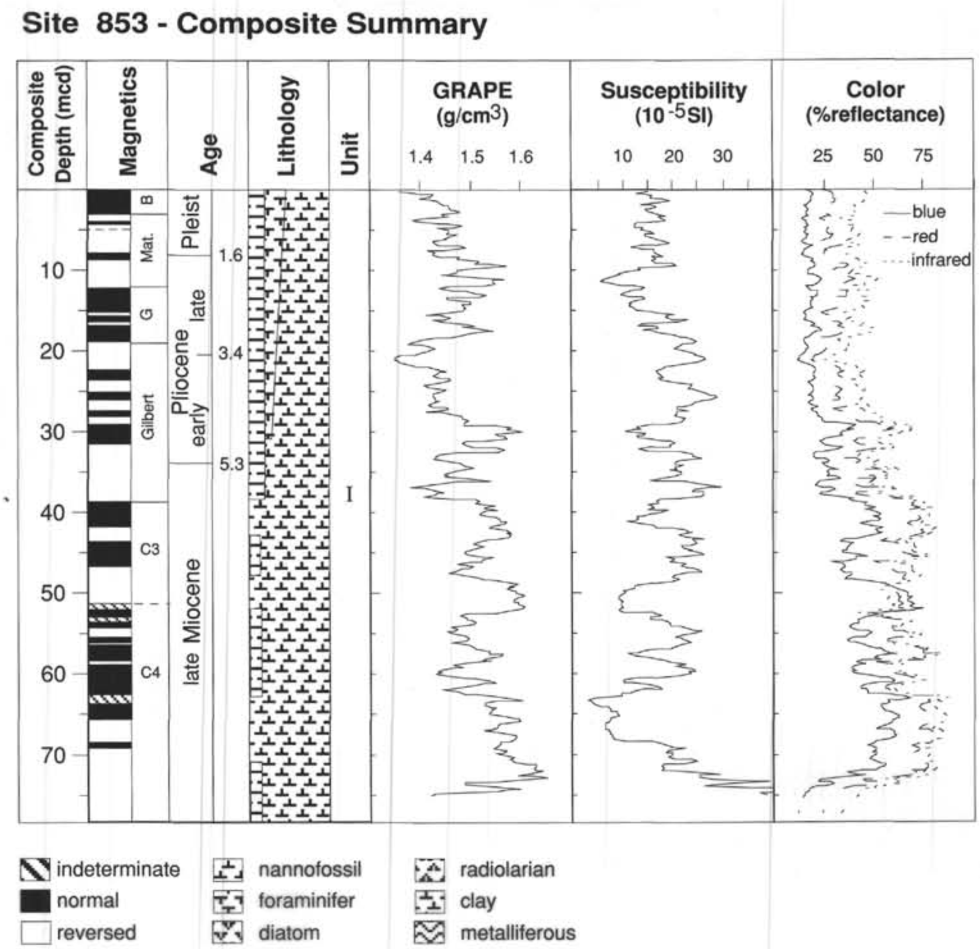


Figure 31. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 853. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

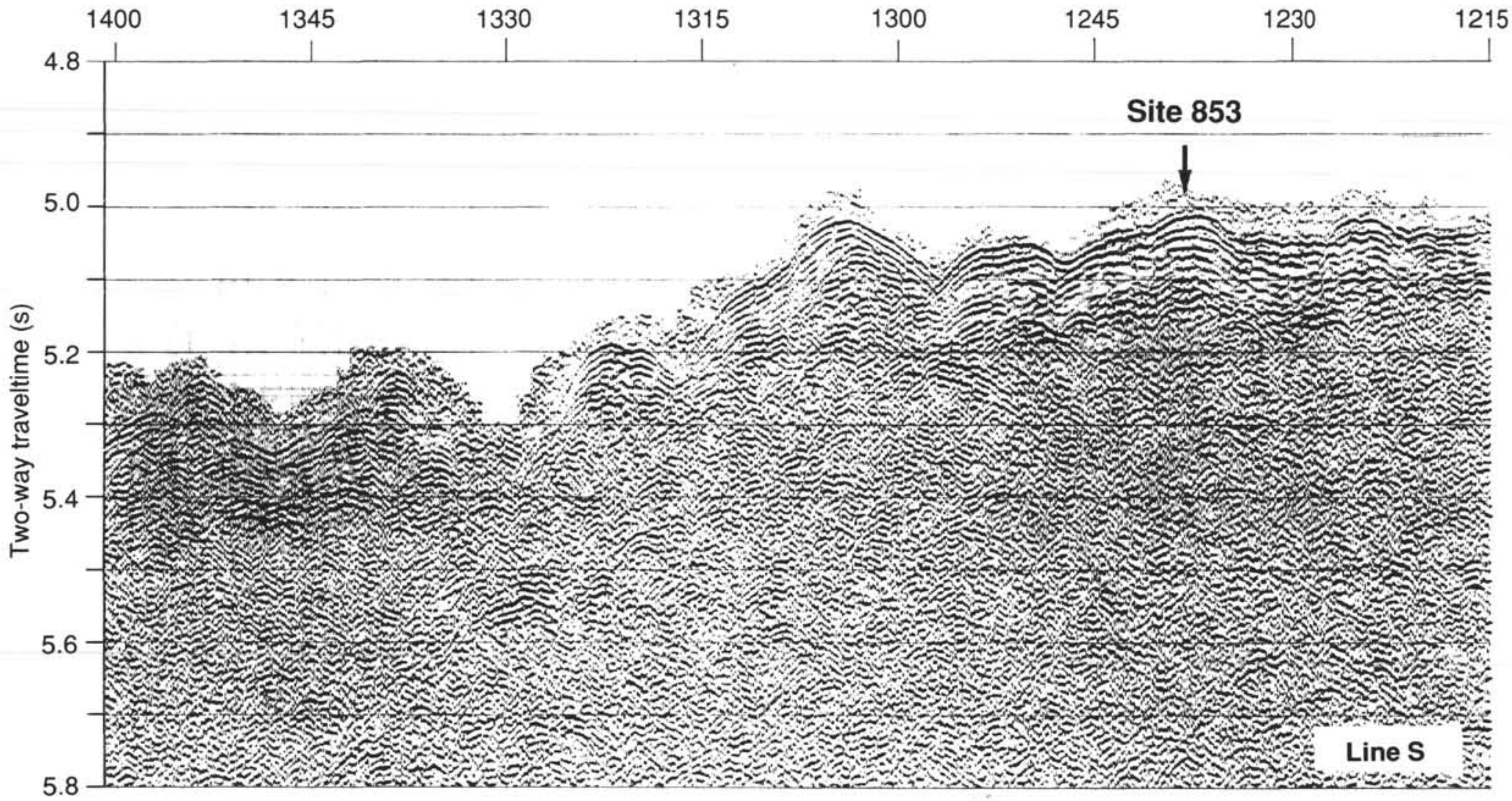


Figure 32. Single-channel seismic profile over Site 853. Profile collected during VENTURE 01 cruise of the R/V *Thomas Washington*.

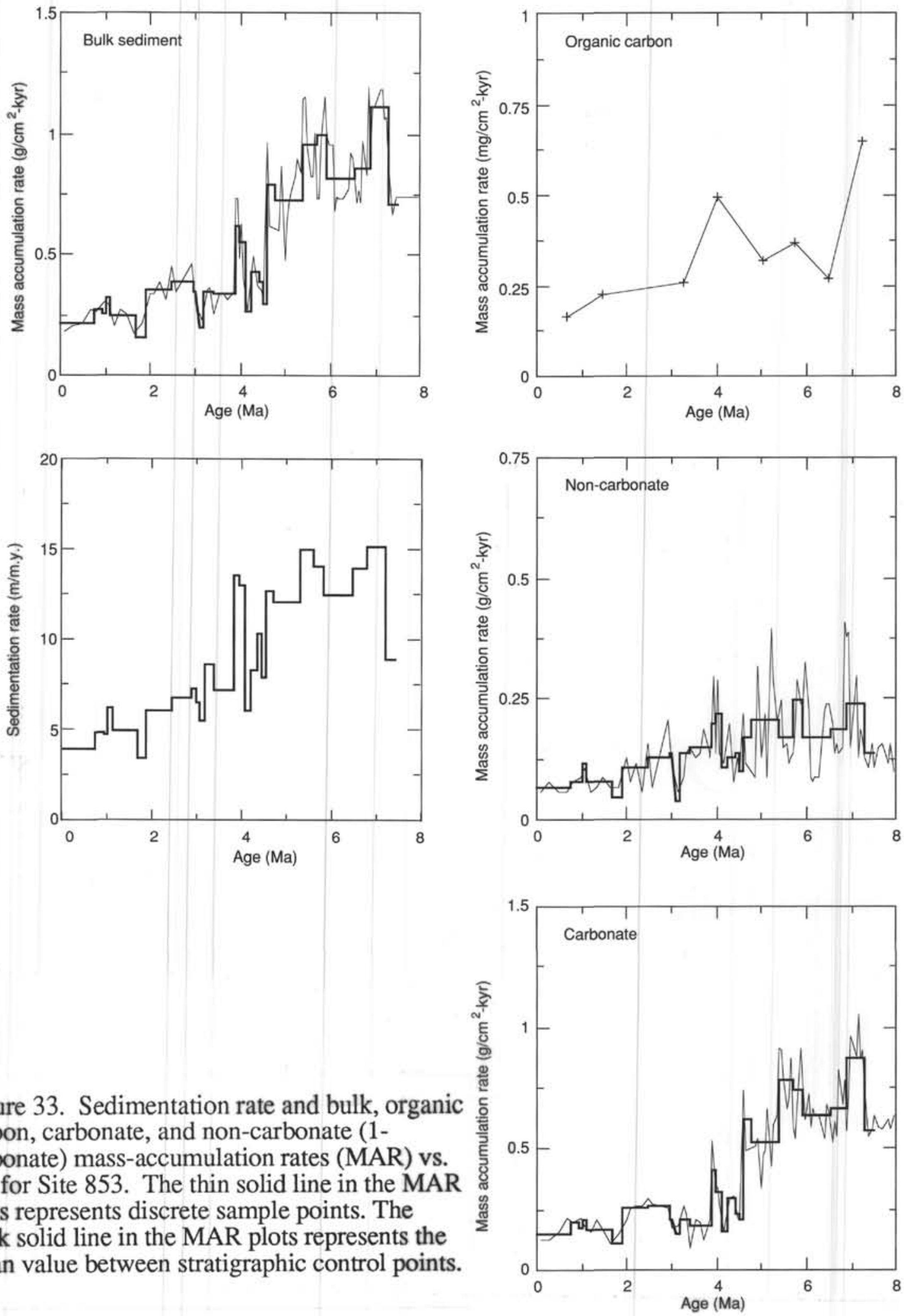


Figure 33. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 853. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

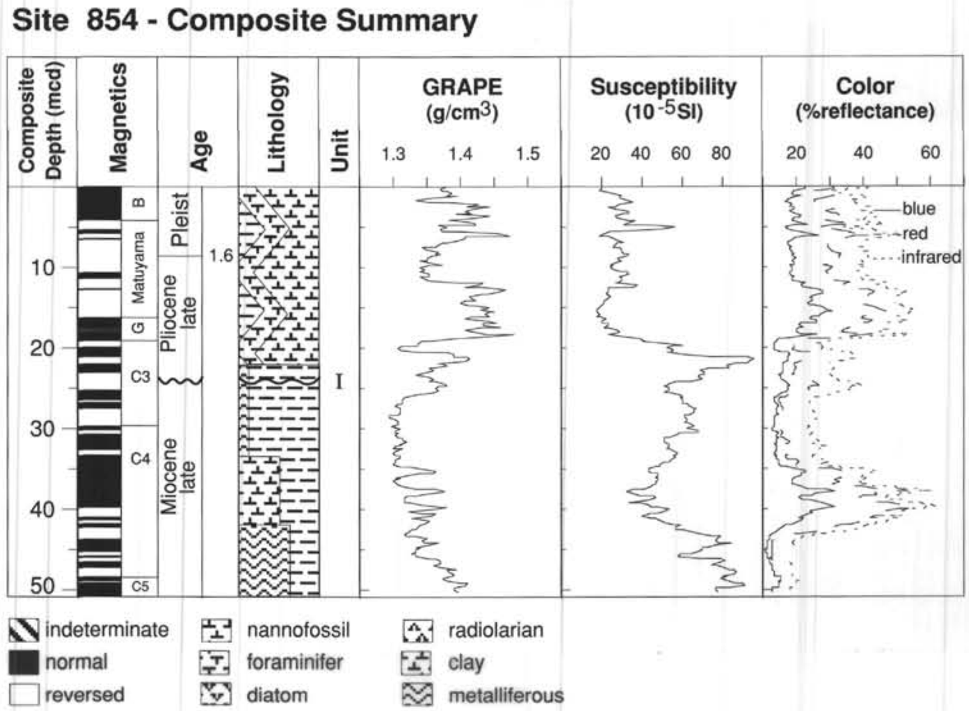


Figure 34. Composite summary of magnetics, age, graphic lithology, GRAPE, magnetic susceptibility, and color reflectance for Site 854. The composite data consist of sections spliced together from the multiple holes drilled at the site. The data are shown plotted against meters composite depth (mcd), the new depth scale used when composite sections are constructed. The GRAPE, susceptibility, and color data are smoothed using a 20-point gaussian filter.

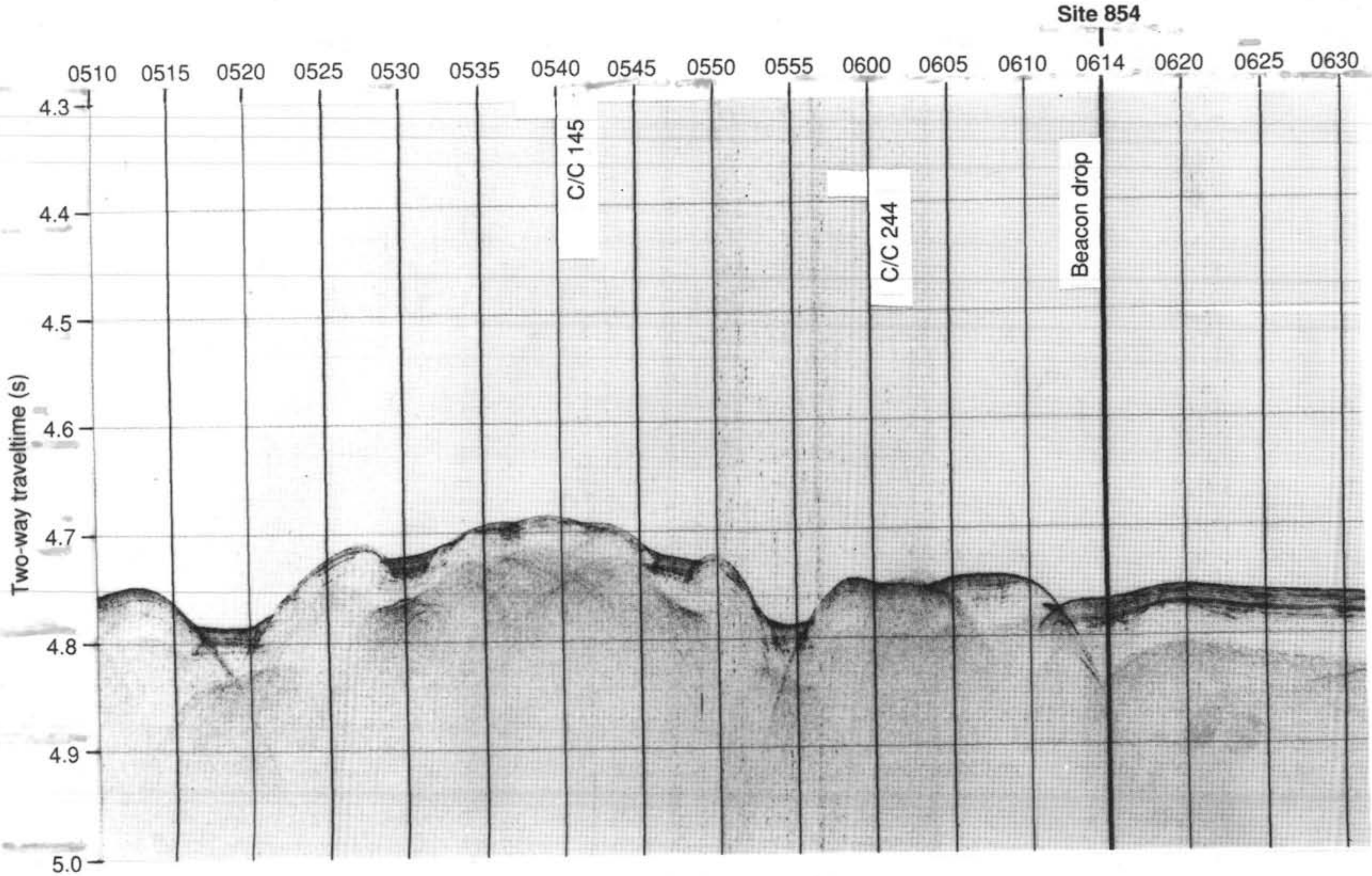


Figure 35. 3.5 kHz profile over Site 854. Profile collected during site survey by *JOIDES Resolution*.

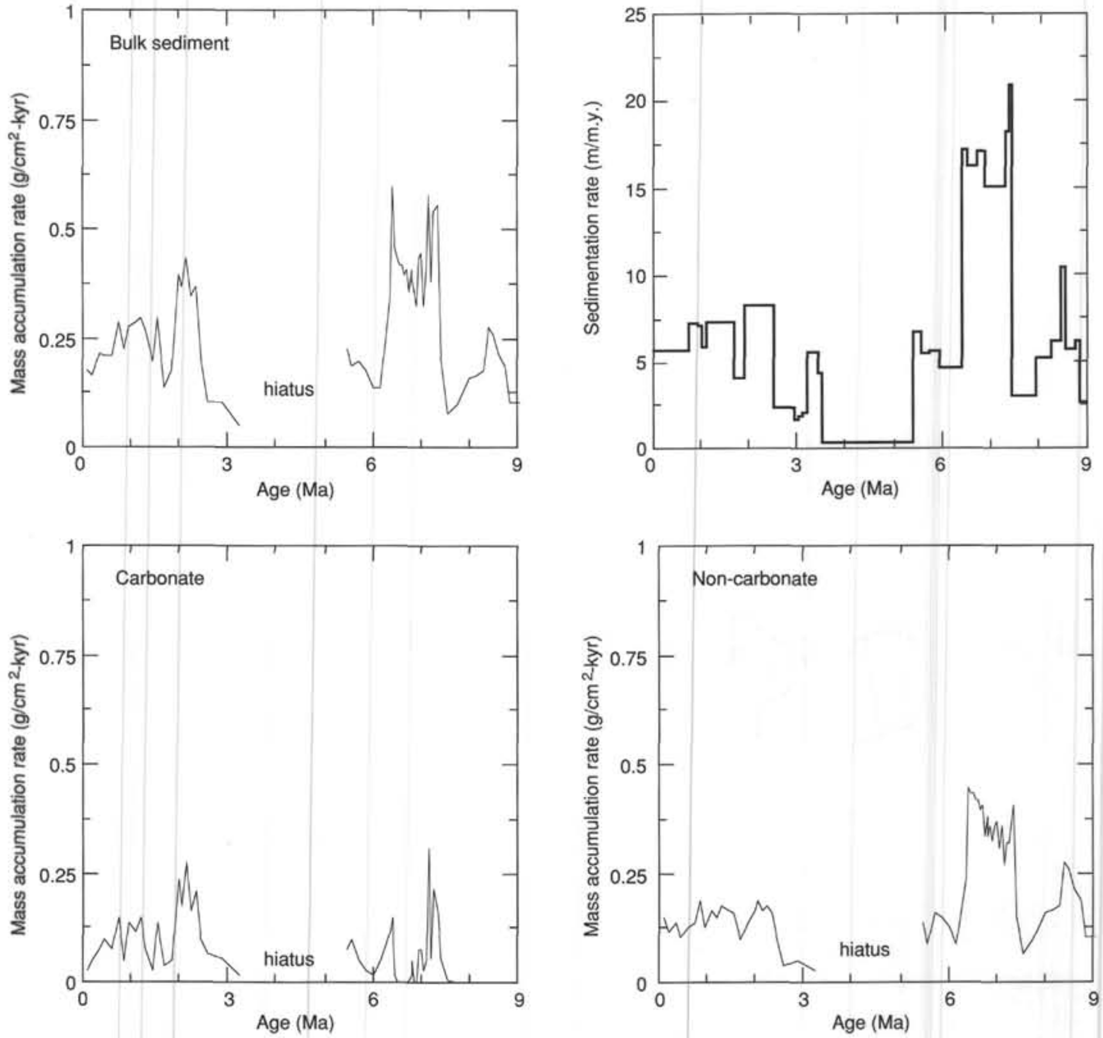


Figure 36. Sedimentation rate and bulk, organic carbon, carbonate, and non-carbonate (1-carbonate) mass-accumulation rates (MAR) vs. age for Site 854. The thin solid line in the MAR plots represents discrete sample points. The thick solid line in the MAR plots represents the mean value between stratigraphic control points.

OPERATIONS REPORT

The ODP Operations and Engineering personnel aboard JOIDES Resolution for Leg 138 of the Ocean Drilling Program were:

Operations Superintendent:	Ron Gout
Schlumberger Engineer:	Brian Davis

TRANSIT FROM PANAMA TO SITE 844

The JOIDES Resolution cast off the last line at 1348 hr (local time), 5 May 1991, and sailed west toward Site 844 (proposed site EEQ-2). We covered the 727 nmi to the first survey way point at an average speed of 10.6 kts.

At 1000 hr, 8 May, the site survey for Site 844 began. The beacon was deployed at 1437 hr, 8 May, and the survey was concluded at 1524 hr, 8 May. The depth to the seafloor, based upon the precision depth recorder (PDR), was 3430 mbrf.

SITE 844

HOLES 844A/844B

Core 138-844A-1H was taken at a depth of 3425 mbrf at 0508 hr, 9 May. The core recovered 9.94 m of sediment and consequently could not be used to establish the mud line. In order to establish the mud line, the pipe was pulled above the seafloor to start a second hole. Hole 844A concluded at 0600 hr, 9 May, when the bit cleared the mud line. The ship was offset 20 m, and Hole 844B was started successfully when Core 844B-1H was taken at 0608 hr, 9 May.

Cores 844B-1H through -3H were taken successfully from 0 to 23.5 mbsf. Orientation began with Core 844B-4H. However, the drill pipe was not advanced after Core 844B-3H was taken. As a result, the same sedimentary interval was cored again with Core 844B-4H. The pipe then was advanced 19 m before Core 844B-5H (33.0-42.5 mbsf) was taken. Cores 844B-6H through -19H (42.5-175.5 mbsf) were taken without incident. Approximately 150,000 lb of overpull was required to retrieve Core 844B-20H, thus forcing the termination of the APC coring program for this hole. The average sediment recovery for the APC section at Hole 844B was 104.7%.

Coring resumed with the XCB system at Core 844B-21X and advanced without incident to 290.9 mbsf (Core 844B-31X), where contact with basaltic basement was confirmed by the recovery of 10 cm of basalt. The depth objective for the hole was reached at this point, and preparations for logging were begun. The average recovery for the XCB section of Hole 844B was 90.8%. The recovery for the entire hole was 99.7%.

Hole 844B Logging Operations

After sweeping the hole with mud, the pipe was pulled back to the logging depth of 71.9 mbsf, and the downhole measurements began. Hole 844B was logged with the three standard ODP tool strings. All logging tools performed well, but getting in or out of pipe proved to be problematic on two of the logging runs.

On the first run, with the geophysical string, the tool had problems getting out of the base of the drill string on both the main and the repeat logging passes. On the main pass, the logging string jammed about 15 m above the bit, within the BHA. After careful pumping, the tool string was freed and the hole was logged to 285.9 mbsf, 5 m above the total depth drilled. At the base of the hole, the wireline heave compensator broke down and couldn't be restarted. Since the seas were very calm, the lack of the heave compensator did not significantly affect the logging. Logging up the hole was successful. On the repeat pass, as the tool string was lowered through the drill pipe, it would not pass the bit. In addition, there seemed to be an obstruction below. The pipe was lowered one stand and broke through the obstruction, allowing the logging string to reenter the open hole.

The geochemical log was run from 289.6 mbsf to the mud line, with measurements taken through the pipe. No operational problems were encountered with this logging run.

The FMS tool was used to log the section from 290.5 to 65 mbsf and again from 156.5 to 65 mbsf. No problems were encountered until the tool was brought into the drill pipe. Apparently the lockable flapper valve on the XCB bit had unlatched and blocked the tool string from reentering. Again, with gentle pumping, the tool string could be run into pipe.

At the conclusion of the logging program, all tools were recovered, and the derrick was rigged down from logging. The pipe was then pulled out of the hole and cleared the mud line at 1024 hr, 11 May, ending Hole 844B.

HOLE 844C

The vessel was offset 20 m south, and Hole 844C began when Core 844C-1H was taken at 1128 hr, 11 May. Eighteen APC cores (0-170.6 mbsf) were taken successfully with orientation beginning on Core 844C-4H. The core barrel became stuck in the hole after Core 844C-19H (170.6 to 180.1 mbsf) was taken. After washing 6 m over the barrel and applying 130,000 lb of overpull, the core barrel was retrieved. Coring operations were concluded in Hole 844C after Core 844C-19H. At this point, the pipe was pulled out of the hole, and the bit cleared the mud line at 0804 hr, 12 May, thereby ending Hole 844C. The recovery for Hole 844C was 105%.

HOLE 844D

In order to recover the sedimentary interval missed during coring operations at Hole 844B, the vessel was offset 20 m west, and Hole 844D was washed down to 24 mbsf. A single core, 844D-1H, was taken over the the interval from 24.0 to 33.5 mbsf and recovered 10.12 m of sediment (106.5% recovery). After Core 844A-1H was retrieved, the pipe was pulled to the surface, and the bit reached the drill floor at 1622, 9 May, thereby ending Hole 844D.

The Datasonics beacon was successfully retrieved at 1345 hr, 12 May, after a leisurely ascent from the seafloor at a rate of 40 m/min. At 1700 hr, 9 May, the vessel began the transit to the next site, officially ending Site 844.

TRANSIT FROM SITE 844 TO SITE 845

The transit from Site 844 to Site 845 covered 257 nmi to the first survey waypoint at an average speed of 10.6 kt. The site survey for Site 845 began at 1648 hr (local time), 13 May. At 1830 hr, 13 May, the beacon was deployed successfully, and the survey was concluded at 1918 hr, 13 May. The depth to seafloor, based upon the precision depth recorder (PDR), was 3720.4 mbrf.

SITE 845

HOLE 845A

Core 845A-1H was taken at 0254 hr, 14 May, at a depth of 3715.9 mbrf and recovered 7.6 m of sediments. Cores 845A-2H through -21H were taken successfully from 7.6 to 197.6 mbsf with orientation of the APC cores beginning with Core 845A-4H. An overpull of 60,000 lb was required to retrieve the core barrel on Core 845A-22H (197.6-207.1 mbsf), thus forcing the termination of the APC-coring program for this hole. The average sediment recovery for the APC section at Hole 845A was 104.8%.

Coring resumed with the XCB-coring system at Core 845A-23X and advanced without any problems to Core 845A-31X (207.1-291.6 mbsf), where contact with the basement was confirmed by the recovery of 1.49 m of basalt. The depth objective of the hole was reached at this point, and preparations for logging were begun. The average sediment recovery for the XCB section of Hole 845A was 89.6%.

Hole 845A Logging Operations

After sweeping the hole with mud, the pipe was pulled back to 62.1 mbsf, and the three standard ODP tool strings were run.

The geophysical tool string was run first, and the heave compensator was on for both the main and repeat logging passes. The main logging run was from 292 to 100 mbsf with a repeat from 170.4 and 99.1 mbsf. No problems were encountered during either run.

The geochemical tool was run second, and minor problems occurred during the calibration of the string. One of the high-voltage circuits was too far out of range for the feedback circuitry to correct the problem. The voltage on this circuit was reset manually, after which the tool worked properly. During the time that the problem was being traced, the tool string was moved upward at a rate of 300 ft/hr (to 137.5 mbsf) to minimize neutron-activation hotspots in the borehole. Nevertheless, care should be taken when examining the natural gamma-ray logs over the interval from the base of the hole to 137.5 mbsf, as the formation may have been activated. Once the system was calibrated and lowered to total depth (291.3 mbsf), the log was run without further problems from the base of the hole up to the mud line.

The third logging run, the formation microscanner, went smoothly. Two runs were made, one from 291.3 to 155.1 mbsf, and a second from 291.5 to 69.8 mbsf. No problems were encountered during either pass.

At the conclusion of the logging program, the drill string was pulled out of the hole. The bit cleared the mud line at 0629 hr, 16 May, officially ending Hole 845A.

HOLE 845B

The vessel was offset 20 m south, and Hole 845B was begun by washing down to 3.1 mbsf. This starting depth for coring operations in Hole 845B corresponds to a 5-m vertical offset relative to Hole 845A. Core 845B-1H (3.1-12.6 mbsf) was taken at 0700 hr, 16 May, and coring operations continued until the depth objective was reached at Core 845B-21H (202.6 mbsf). Every APC core was oriented starting with Core 845B-4H. During operations at this hole, the wave height varied between 6 and 9 ft with a vessel heave of 4 to 7 ft. These conditions were probably responsible for the lower than expected recovery in the upper portion of the hole. After Core 845B-21H was retrieved, the pipe was pulled above the mud line to begin Hole 845C. The average sediment recovery for the APC section of Hole 845B was 97.9%.

HOLE 845C

The vessel was offset 20 m west, and Hole 845C was begun at 0600 hr, 17 May, by washing down to 20 mbsf. Three APC cores were taken over the interval from 20.0 to 48.5 mbsf to ensure recovery overlap with the other holes in the upper 50 m of the sedimentary section. After Core 845C-3H was retrieved, the drill string was pulled out of the hole and the bit brought on deck at 1450 hr, 17 May (Larry Mayer's birthday).

Concurrent with pulling out of the hole, the beacon was remotely released, and it reached the surface in 45 min. The crane operator easily plucked the unit out of the water despite 6-ft. seas. The hydrophones and thrusters were retracted, and the vessel was under way to Baltra in the Galapagos Islands at 1530 hr, 17 May.

TRANSIT TO SITE 846

The original operations plan upon leaving Site 845 was to drill proposed Site EEQ-3. In order to pick up two multishot cameras and batteries for the cameras, the operations plan was changed to drill proposed site EEQ-4 first. This change would allow the ship to pass directly by Baltra, in the Galapagos Islands while on its way to EEQ-4 and rendezvous with a small boat carrying the necessary supplies. The JOIDES Resolution arrived at the rendezvous point near Baltra at 1320 hr, 20 May, after sailing 650 nmi from Site 845 at an average speed of 10.3 kt. Two multishot cameras, AA batteries for the multishots, mail, and an electronic thermometer were off-loaded from the Moby Dick, and the JOIDES Resolution continued on its transit to EEQ-4.

The transit from Baltra to Site EEQ-4 traversed 177 nmi at an average speed of 10.1 kt. Upon arrival at the initial survey waypoint at 0700 hr, 21 May, a short seismic survey was conducted over the site. At 0948 hr, 21 May, the beacon was released, and the vessel returned to the site location. By 1030 hr, 21 May, the thrusters and hydrophones were lowered, and the ship was on location. The depth to seafloor, based upon the precision depth recorder, was 3310.4 mbrf.

SITE 846

HOLE 846A

Core 846A-1H was taken at 1658 hr, 21May and recovered 7.22 m of sediment to establish the mud line depth at 3307.3 mbrf. This core was taken for whole-round samples and constituted the entire coring at Hole 846A.

HOLE 846B

The second mud-line core at this site (Core 846B-1H) was taken at 1745 hr, 21 May, and recovered 7.05 m of sediment. The drill-pipe measurement of the mud-line depth was 3307.5 mbrf. Cores 846B-1H through -21H were taken successfully from over the interval from 0 to 197.0 mbsf, and all APC cores beginning with Core 846B-4H were oriented. The core barrel became stuck upon retrieval of Core 846B-22H (197.0-206.5) but was successfully retrieved after washing 2 m over the barrel and applying 140,000 lb of overpull. The average recovery for this APC-cored interval was 104%.

At 1300, 22 May, coring resumed with the XCB coring system, and Cores 846B-23X through -44X (206.5-418.6 mbsf) were taken successfully as coring continued toward basement. Basement was reached at 420 mbsf, and total depth was reached at 422.4 mbsf (Core 846B-45X). This last core advanced 3.8 m and recovered 1.5 m of basalt. The average recovery for the entire XCB sequence was 73.3%. Below 341.3 mbsf (Core 846B-36X) core recovery was poor (44%), most likely the result of chert stringers interbedded with nannofossil chalk and metalliferous sediments. As the depth objectives for this hole were reached after Core 846B-45X, coring ceased and preparations for logging began.

Hole 846B Logging Operations

After sweeping the hole with mud, the pipe was pulled back to the logging depth of 76 mbsf, and the hole was logged using the three standard ODP tool strings.

The geophysical string was the first logging run, and the main and repeat passes were made with the heave compensator turned on. The main logging run was from 420.9 to 85 mbsf. The section between 420.9 and 335 mbsf was logged again in order to remove a bad wire wrap on the winch near the bottom of the hole.

The geochemical tool string was run next, and no problems were encountered while calibrating the GST. The geochemical string also was run with the heave compensator turned on. Data were collected from 419.7 to 75.9 mbsf, and some difficulty was encountered in getting the tool back into the pipe. Thus there is the possibility that activated hotspots occur just above 76 mbsf, where the GST passed the same interval several times. Once the tool was in the pipe, logging continued up to the mud line, after which the tool string was brought on deck.

The FMS logging run went smoothly. On the first pass the hole was logged from 419.1 to 197.8 mbsf and from 421.5 to 66.4 mbsf on the second pass. The lower portion of the hole was logged twice to ensure good coverage where the hole conditions were optimal for FMS measurements. This interval also had the poorest sediment recovery. No problems were encountered during either pass.

At the conclusion of the logging program, the drill string was pulled out of the hole, and the bit cleared the mud line at 0608 hr, 24 May, thereby ending Hole 846B.

HOLE 846C

The vessel was offset 20 m south and at 0832 hr, 24 May, Hole 846C was spudded and washed down to 2.5 mbsf, where Core 846C-1H was taken. The first three core barrels (Core 846C-1H through -3H; 2.5 to 31.0 mbsf) required significant overpull and jarring before the inner barrel could be released from the outer core barrel. The inner shear pin/landing shoulder sub was replaced after the third core, and mud was circulated to flush any debris that may have fouled the landing saver sub. There were no more problems with the core barrels getting stuck.

Cores 846H-4H through -20H were taken successfully over the interval from 31.0 to 192.5 mbsf. All cores after Core 846C-3H were oriented. To ensure that overpull was not encountered during Hole C drilling operations, APC coring was terminated at Core 846C-20H. The average recovery for the hole was 101.6%.

HOLE 846D

The pipe was pulled just above the mud line at 0227 hr, 25 May, and the ship was offset 20 m west. The bit was washed down 4 m, and APC coring was resumed at 0317 hr with Core 846D-1H (4.0-13.5 mbsf) and continued without incident to Core 846D-17H (163.3 mbsf). Core 846-6H was advanced only 7.3 m to get a better overlap of the sedimentary record with the previous holes at this site. All piston cores after Core 846D-3H were oriented. The APC coring program ended after Core 1846D-17H, well before refusal depth. Drilling operations were switched over to the XCB system at this point to obtain several XCB cores over the same depth interval as APC cores in the previous hole. We hope this comparison will provide insight into coring disturbances associated with each coring system.

Cores 846B-18 through -26X were taken successfully, and drilling operations ended when the depth objective for this hole was reached after Core 846C-26X. The average recovery for the XCB portion of the hole was 95.3%.

The pipe tripped out of the hole after Core 846D-26X was retrieved, and the bit was on deck at 0528 hr, 26 May, ending Hole 846D. After the hydrophones and thrusters were retracted and the rig floor secured, the JOIDES Resolution was under way toward proposed site EEQ-3 at 0545 hr, 26 May.

TRANSIT TO SITE 847

The transit from Site 846 to Site 847 (proposed site EEQ-3) covered 322 nmi in 32.3 hr at an average speed of 10.0 kt. At 1400 hr, 27 May, the vessel reached the first survey waypoint, and the seismic gear was deployed as the ship slowed to 6 kt to begin the survey. After a 21-nmi survey, the beacon was deployed at 1630 hr, 27 May, at the proposed site location. The seismic gear was then retrieved as the ship returned to the site, and, once on site, the hydrophones and thrusters were deployed. The depth to the seafloor, based upon the precision depth recorder (PDR), was 3354.4 mbrf.

SITE 847

HOLE 847A

This hole consisted of a single mud-line core dedicated to whole-round geochemical and physical-property measurements. The drill string was lowered to 3348 mbrf, where the first piston core (847A-1H) was taken at 0045 hr, 28 May. A full core barrel was retrieved (9.52 m) and thus could not be used to establish the mud-line depth.

HOLE 847B

The second mud-line core (847B-1H) was taken at 3343 mbrf and recovered 6.5 m of sediment, establishing the mud-line depth at 3346 mbrf. Cores 847A-1H through -14H (0-130.0 mbsf) were taken in rapid succession with orientation beginning on Core 847A-4H. The core barrel became stuck after Core 847B-15H was taken and could not be retrieved, even with an overpull of 80,000 lb. The core barrel was then drilled over approximately 3 m, at which point the core barrel came free without any overpull. The APC coring program in this hole was terminated after Core 847C-15H. The average recovery for the APC-cored interval was 104%.

Coring resumed with the XCB coring system, and Cores 846B-16X through 25X were taken over the interval from 139.5 to 231.9 mbsf. While cutting Core 846B-26X (231.9-241.5 mbsf), the rate of penetration decreased sharply, and the core barrel was retrieved with only 0.14 m of chert fragments. The soft-formation cutting shoe was completely destroyed and was replaced with the tungsten-enhanced cutting shoe that was used with success to cut basalt at the previous three sites. After 60 min of coring and only 5.5 m of penetration, the next core (846B-27X, 241.5-247.0 mbsf) recovered only 0.04 m of chert fragments. The cutting shoe was missing three inserts, and the cutting structure was completely worn down.

A review of the seismic records indicated that the chert layer could be over 40 m thick. The time required for pulling the pipe, switching to the RCB coring system, and drilling to basement was not warranted, so drilling was stopped and preparations for logging begun. Recovery in the XCB portion of the hole was 89.9%.

Hole 847B Logging Operations

After sweeping the hole with mud, the pipe was pulled back to the logging depth of 65.7 mbsf, and the three standard ODP tool strings (geophysical, geochemical, and FMS) were run. All logging, except the downward pass of the geophysical tool string, was done with the heave compensator on.

The downward pass with the geophysical string logged the section to total depth (246.3 mbsf). On the first upward logging pass, the resistivity log was recalibrated while the tool was in motion. Thus, good data were collected only from 201.2 mbsf (the depth at which the calibrations were completed) to 128.3 mbsf. The second geophysical logging run collected data over the interval from 246.0 to 73.8 mbsf, at which point the run was stopped, the heave compensator turned off, and the tool brought into the drill string.

The geochemical string was lowered to total depth (247.2 mbsf), the heave compensator turned on, and the GST calibrated while the tool was pulled up the hole (to avoid activating the section). Once the GST was calibrated, the tool was lowered to total depth (248.4 mbsf), and the hole was logged up to 75.9 mbsf, at which point the heave compensator was turned off and the tool pulled into the pipe. Once in the pipe, geochemical logging continued up to the mud line. The logging run was stopped for a short interval at about 155 mbsf, when the winch was switched to the backup motor. Thus, there may be activated sections of borehole near this depth interval and unreliable recordings on the ACT or natural gamma-ray logs.

Some difficulties were encountered during the FMS logging, but one good pass was recorded from total depth (247.2 mbsf) to the base of pipe. During the first upward pass the circuit used to close the calipers developed an intermittent short. The calipers did close upon reaching the pipe, but the process took much longer than normal. The second FMS run was canceled instead of risking a second pass in which the calipers might not close.

At the conclusion of the logging program, the drill string was pulled out of the hole, and the bit cleared the mud line at 1840 hr, 29 May, ending Hole 847B.

HOLE 847C

The vessel was then offset 20 m south and the bit was washed down to 2 mbsf, where APC coring was initiated. Cores 847C-1H through -13H were taken over the interval from 2.0 to 125.5 mbsf. The sub-bottom depth of 125.5 mbsf was approximately 5 m short of the overpull zone in Hole 847B, and the APC coring program at this hole was ended at this depth to avoid getting the core barrel stuck. The recovery in the APC section of Hole 847C was 104%.

Coring resumed with the XCB coring system, and Cores 847C-14X through 847C-24X recovered sediment from 125.5 to 230.9 mbsf. During the cutting of Core 847B-25X (230.9-232.3 mbsf) a hard chert layer was encounterd. Although care was taken to detect the change in rate of penetration corresponding to contact with the chert layer, the soft-formation cutting shoe had severely worn cutting structures after only 5 min of rotation. The XCB coring was terminated at this point. Average recovery in the XCB section of Hole 847C was 90.7%.

After coring operations ceased, the pipe was pulled out of the hole, and the mud line was cleared at 1550, 30 May, ending Hole 847C.

HOLE 847D

The vessel was offset 20 m west and the bit lowered to 3344.2 m (approximately 2 m above the seafloor). The first piston core for this hole was taken at 1755, 30 May, and recovered 6.61 m of sediment, establishing the mud line at 3346.9 mbrf for Hole 847D.

Piston coring continued to 130.1 mbsf (Core 847D-14H) with orientation beginning on Core 847D-4H. The depth objective for the hole was reached at Core 847D-14H, and the coring program for Site 847 was concluded. While the pipe was being pulled, the beacon was retrieved after a 34-min ascent to the surface. The bit reached the drill floor at 1014, 31 May. At this point, the rig floor was quickly secured, the hydrophones and thrusters raised, and by 1030 hr, 31 May, the vessel was under way to proposed site WEQ-5.

TRANSIT FROM SITE 847 TO SITE 848 (WEQ-5)

The transit from Site 847 to proposed site WEQ-5 covered 932 nmi at an average speed of 10.0 kt. At 0645 hr, 4 June, the vessel slowed to 6 kt to deploy the seismic gear in preparation for the site survey. The survey covered 14 nmi at an average speed of 6.0 kt and at 0820 hr, 4 June, the beacon was deployed at the proposed location. The vessel returned to location after a 10-min survey past the site, and the hydrophones and thrusters were lowered by 0915 hr, 4 June. The depth to the seafloor, based upon the precision depth recorder (PDR), was 3871.5 mbrf. As the drill string was being lowered to the seafloor, the beacon pulse rate switched to half rate. A backup beacon was quickly deployed, and the first beacon was successfully retrieved.

SITE 848

HOLE 848A

This hole consisted of a single mud-line core dedicated to whole-round geochemical and physical-property measurements. The pipe was lowered to 3865 mbrf, and the first (and only) piston core was taken at 1630 hr, 4 June. The core contained 9.54 m of sediment.

HOLE 848B

The pipe was raised to 3860 mbrf to provide a vertical offset from the previous hole. At 1736 hr, 4 June, Core 848B-1H was taken, and 2.23 m of sediment was recovered, establishing the mud line at 3867.3 mbrf.

APC coring continued through Core 848B-10H (87.7 mbsf) with orientation beginning at Core 848B-4H. As Core 848B-11H was taken, the barrel hit a hard surface that prevented full stroke. The core was retrieved with 5.6 m of sediment in the liner. Assuming that the barrel advanced by the amount of recovery, the basement contact was estimated at 93.2 mbsf.

In the hope of retrieving basement material, the XCB was used to cut Core 848B-12X. After penetrating approximately 0.5 m, the barrel was retrieved, but no sediment or basement material was recovered. The coring program was terminated at this point, and the hole was prepared for logging. Recovery in the APC section was 101.5%.

Hole 848B Logging Operations

The hole was swept with mud and the pipe pulled to 88 mbsf (6.3 m off bottom) in preparation for logging. Only the geochemical tool string was run because there was only 6 m of open hole at the base of the pipe. After rig-up and calibration, the geochemical tool string was lowered down the pipe. At total depth (94.5 mbsf), the tool string was raised slowly while the GST (Geochemical Spectral Tool) was calibrated. This calibration pass activated the bottom of the borehole, as is evident from the high natural gamma counts recorded at the base of the hole during the main logging pass. In addition, a spike in the aluminum log was recorded at 63.3 mbsf in the borehole section opposite where the californium source in the ACT (aluminum clay tool) stopped. After calibration, the tool string was lowered back to total depth (93.9 mbsf) for the main logging pass.

The log was run with the heave compensator off to avoid differential motion between the logging tool string and the pipe. If the heave compensator were on, heave in the pipe could have caught and broken the logging tool when it extended beyond the bit. The main logging pass was run from 93.9 mbsf to the mud line, and the tool string was pulled from the hole. After rigging down from logging, the top drive was set back and the pipe pulled out of the hole. At 1241 hr, June 5, the mud line was cleared, ending Hole 848B.

HOLE 848C

After the vessel was offset 20 m south, the pipe was lowered to 3863 mbrf. The first piston core was taken at 1405 hr, June 5, and retrieved 5.57 m of sediment, establishing the mud line at 3867.0 mbrf. APC coring continued through Core 848C-10H (91.0 mbsf) with orientation beginning at Core 848C-4H.

The XCB coring system was used to cut Core 848C-11X, as basement was approximately 3 m below the the base of Core 848C-10H. After rotating approximately 45 min with a carbide enhanced bit and advancing only 3.2 m, the barrel was retrieved. The barrel contained 3.02 m of sediment, but the contact with basement was not recovered. Four of the five tungsten-carbide inserts on the bit were missing, and the cutting-shoe surface was severely worn.

The coring program in this hole was stopped at this point, and the pipe was pulled up to the mud line. The bit cleared the mud line at 0240 hr, June 6, ending Hole 848C.

HOLE 848D

The vessel was offset 20 m east, and the bit was lowered to 3865 m. Core 848D-1H was taken at 0355 hr, June 6, and recovered 8.44 m of sediment, establishing the mud line at 3866.1 mbrf. APC coring continued routinely through Core 848D-7H (65.4 mbsf) with orientation beginning at Core 848D-4H. Upon retrieval of Core 848D-7H, the forward core line parted at the rope socket. The aft core line was connected to the R/S overshot and run in the hole. The core barrel was successfully retrieved on the first fishing attempt.

The remaining three APC cores were routinely obtained to a depth of 93.9 mbsf. As the depth objective of the hole was reached at this point, the pipe was then pulled out of the hole, and the bit was on deck by 2217 hr, 6 June. The rig floor was secured for the transit, the hydrophones and thrusters retracted, and the vessel was under way to the next location by 2300 hr, June 6.

TRANSIT TO SITE 849

The transit to Site 849 (prospectus site WEQ-6) covered 171 nmi in 13.8 hr at an average speed of 11.6 kt. At 1245 hr, 7 June, the vessel slowed to 6 kt for the deployment of the seismic gear and began a short seismic survey that covered 22 nmi at an average speed of 6.1 kt. The beacon was deployed at 1639 hr, 7 June, approximately 7.5 km north of the proposed location. The site survey continued for 10 min after the beacon deployment, then the ship returned to the site location and lowered the thrusters and hydrophones by 1730 hr, 7 June. The depth to the seafloor at Site 849, based upon the precision depth recorder (PDR), was 3855.0 mbrf.

SITE 849

HOLE 849A

This hole was a single mud-line core dedicated to whole-round geochemical and physical-property measurements. The pipe was lowered to a depth of 3848 mbrf, and the first (and only) piston core was taken at 0020 hr, 8 June. The core was retrieved with a full barrel, thus allowing only an estimate of mud-line depth (3848.8 mbrf).

HOLE 849B

At 0115 hr, 8 June, Core 849B-1H was taken in a water depth of 3848 mbrf and retrieved 6.79 m of sediment, establishing the mud-line depth at 3850.8 mbrf. APC Cores 849B-1H through 1-13H were taken from 0 to 120.7 mbsf with orientation beginning at Core 849B-4H. An overpull of 100,000 lb was required to pull Core 849B-13H from the sediment, and thus the APC coring program in Hole B was terminated at this point. Recovery in the APC interval was 102.8%.

Drilling continued with the XCB coring system, and Cores 849-14X through-37X were taken over the interval from 120.7 to 350.5 mbsf. Core 849B-37X was drilled about 1.5 m into basement, but only 13 cm of basalt fragments was recovered. XCB coring concluded at this point, and the hole was prepared for logging.

Recovery in the XCB section of the hole was 95.6%.

Hole 849B Logging Operations

The hole was swept with mud, and the pipe was pulled to the logging depth of 61.0 mbsf. All three standard ODP tool strings were run, with only a few operational problems. The heave compensator did not function properly, and thus the hole was logged without it. The lack of heave compensation did not affect log quality significantly, as wave height was only 2-3 feet, and only a few uncompensated accelerations were noted in the initial processing of the FMS data.

The first logging run was with the geophysical tool string. The downward pass logged the hole from 61.0 to 350.2 mbsf, and the main upward pass logged the hole from 350.2 to 71.9 mbsf. During the upward pass, the base of the tool string stuck in the open hole at 149.7 mbsf. The tool was twice lowered and raised to break it free but without success. The third attempt freed the tool string. Tool sticking on the upward pass resulted in step-like structures around 135-116 mbsf in velocity and density logs. Further up the hole, the tool again experienced minor sticking problems, as evidenced by large variations in cable tension. On the repeat geophysical run, from 172.5 to 71.0 mbsf, the tool experienced minor sticking problems above 114 mbsf.

Next, the geochemical tool was lowered into the hole. At a depth of a few hundred meters below the rig floor, the ACT sonde appeared nearly ready to fail and was brought to the surface for repairs. The tool was then lowered to total depth (351.1 mbsf), the GST calibrated, and the main log run from 351.1 mbsf to the mud line. No sticking problems occurred during the geochemical run.

The FMS tool was rigged up and lowered to total depth (350.5 mbsf). During the first pass, the hole was logged over the interval from 350.5 to 233.5 mbsf. The tool string was lowered back to total depth, and a second pass was made from 350.5 to 111.6 mbsf. The log was stopped at 111.6 mbsf during the second pass because the hole was washed out well beyond the maximum FMS caliper extension. After the calipers were closed, the FMS tool string was brought to the surface and logging operations concluded. The drill string was then pulled out of the hole, and the bit cleared the mud line at 1304 hr, 10 June, ending Hole 849B.

HOLE 849C

Hole 849C was drilled to ensure that a continuous APC section was recovered and enough material was available for the high-resolution paleoceanographic studies. The vessel was offset 20 m south, and the bit was washed down 1 m below the mud line to 3851.8 mbrf. The first piston core barrel landed too hard, and the shear pin parted, prefiring the core. During the next APC attempt the overshot shear pin parted (damaged in the initial landing), necessitating another wireline round trip.

The first piston core was successfully taken at 1430 hr, 10 June. Continuous APC coring continued to total depth (Core 849C-11H; 105.5 mbsf) with orientation beginning at Core 839C-4H. The recovery for Hole 849C was 101%. The pipe was then pulled above the mud line to begin another hole. The bit cleared the mud line at 0310 hr, 11 June, ending Hole 849C.

HOLE 849D

Hole 849 was drilled to ensure that a continuous APC section was recovered and to try to recover a completed XCB section. The vessel was offset 20 m east, and the bit was washed down 4 m below the mud line to 3854.8 m, and Core 849D-1H was taken at 0350 hr, 11 June. APC coring advanced to 108.5 mbsf (Core 11H) with orientation beginning with Core 849D-4H. XCB coring began after Core 11H and continued through Core 849D-34X (326.7 mbsf), at which point time constraints forced the termination of the hole. Recovery was 91.9% in the APC interval and 102.3% in the XCB interval.

The last core (849D-34X) was retrieved slowly in order to coat the aft sand line. The forward core line would be used for the rest of the leg. At 0930 hr, 12 June, the last core was brought on deck, and the pipe was pulled out of the hole. After the bit came on deck at 1610 hr, the rig floor was quickly secured, the hydrophones and thrusters were retracted, and the vessel began the transit to Site 850 at 1630 hr, 12 June.

TRANSIT TO SITE 850

The transit from Site 849 to Site 850 traversed the 54 nmi at an average speed of 12.6 kt. Upon reaching the general area of the new site, the vessel slowed to 6 kt and the seismic equipment was deployed. The vessel began the site survey at 2100 hr, 12 June, and at 2248 hr, the beacon was deployed. The survey continued for 10 min past the site. The ship then returned to the site, and the hydrophones and thrusters were lowered by 2330 hr, 12 June. The depth to seafloor, based upon the precision depth recorder (PDR), was 3803.4 mbrf.

SITE 850

Site 850 was not in the original Leg 138 drilling prospectus. As a result of additional time acquired during the course of the leg, this location was added to supplement the proposed sites.

HOLE 850A

Core 850A-1H was taken at a depth of 3796 mbrf at 0620 hr, 13 June, and 7.68 m of sediment was recovered, establishing the mud line at 3797.8 mbrf. Piston coring advanced to 74.0 mbsf with multishot orientation beginning on the fourth core. After Core 850A-8H was recovered , the time allotted for this hole expired. The pipe was then pulled out of the hole, and the bit cleared the mud line at 1344 hr, 13 June, terminating Hole 850A. Core recovery for Hole 850A was 103.9%.

HOLE 850B

The vessel was offset 20 m south from Hole 850A. The bit was washed down 3 mbsf, and Cores 850B-1H through -10H were taken over the interval from 3.0 to 98.0 mbsf with orientation beginning at the fourth core. An overpull of 75,000 lb was needed to pull Core 850B-10H free, forcing the termination of the APC coring program at this point. The recovery in the APC section of the hole was 104.9%.

Coring resumed with the XCB system at Core 850B-11H and continued to a depth of 399.8 mbsf (Core 42X), where basement was reached. As the depth objective for the hole was reached, the coring program was terminated, and preparations for logging were begun. Recovery in the XCB section was 97.4%.

Hole 850B Logging Operations

In preparation for logging, mud was pumped into the hole and the pipe was pulled to 65.3 mbsf. All three standard ODP tool strings were run, with only a few operational problems. The heave compensator did not function properly, and logging was conducted without it. Wave height, however, remained below 2-3 ft.

Hole 850B was first logged with the geophysical tool string. In order to save time and to fit FMS logging into the limited schedule, the downlog or repeat section was not run. The main log was run from total depth to 79.2 mbsf. The Lamont temperature tool failed during this logging pass due to a short circuit in the tool that drained the battery.

The hole was next logged with the geochemical tool string from 399.3 mbsf to the mud line. In order to minimize activation of the borehole, the GST calibration procedure was changed. The tool string was lowered to total depth, and several meters of extra cable were lowered out. The GST was then calibrated as the slack was pulled out of the cable. The calibration was finished before the tool had moved more than a meter in the borehole. There should be no spikes in the record due to hole activation during calibration, although there is one section of bad GST data, between 255 and 262 mbsf, where the high voltage to the tool was unstable.

The first FMS pass was run from total depth to 305 mbsf. The tool string then was lowered back to total depth, and the main logging pass covered the interval from total depth to 88 mbsf. The log was stopped at 88 mbsf because the hole was washed out above this depth. There was a problem getting the top of the tool string and then the base of the tool string into the pipe because the FMS caliper did not fully close at the end of the run. Eventually, the tool was worked back into pipe, however, at the expense of minor damage to one of the FMS pad assemblies.

At the conclusion of the logging program, the drill string was pulled out of the hole. The bit cleared the mud line at 1304 hr, 16 June, terminating Hole 850B. The rig floor was quickly secured, the thrusters and hydrophones retracted, and the ship was under way toward Site 851 by 0700 hr, 16 June.

TRANSIT TO SITE 851

The transit to Site 851 covered 81 nmi in 7 hr at an average speed of 11.6 kt. Upon reaching the first survey waypoint at 1400 hr, 16 June, the seismic equipment was deployed, and a 1-hr survey begun. After the beacon was deployed at 1500 hr the survey continued for 10 min past the site. Upon completion of the survey, the ship returned to the site, and the thrusters and hydrophones were lowered by 1600 hr. The depth to seafloor, based upon the precision depth recorder (PDR), was 3775.9 mbrf.

SITE 851

HOLE 851A

This hole was dedicated to whole-round and physical-property sampling. The first (and only) core for this hole was taken at 2247 hr, June 16, and recovered 6.45 m of sediment, establishing the mud line at 3773.0 mbrf. After retrieval of Core 851A-1H, the bit was pulled above the mud line to begin the next hole.

HOLE 851B

Core 851B-1H was taken at 2335 hr, 16 June, and recovered 7.58 m of sediment. Piston coring continued through Core 851B-13H (121.5 mbsf) with orientation beginning on the fourth core. An overpull of 100,000 lb was encountered during the retrieval of Core 851B-13H, necessitating the switch to XCB coring at this point. Average sediment recovery for the APC section was 105%.

Coring proceeded with the XCB system until 318 mbsf (Core 851B-34X), where contact with basement was indicated by a marked decrease in the rate of penetration. After coring for an additional 20 min, the hole was deepened to only 320.5 mbsf. The bottom of the core (34X) contained basaltic fragments and confirmed contact with basement. As the depth objectives for the hole were reached at this point, preparations for logging were begun. Recovery in the XCB section was 94.8%.

Hole 851B Logging Operations

The hole was swept with mud, and the pipe was set to the logging depth of 62.0 mbsf. All three standard ODP tool strings were run, with only a few operational problems. The heave compensator did not function properly, and therefore the hole was logged without it. Seas were calm, however, and remained below 2-3 ft in height.

Hole 851B was first logged with the geophysical tool string. The downlog was stopped at 178.0 mbsf because of a software problem. The main logging pass (total depth to 83.8 mbsf) and the repeat pass (175.3 to 89.9 mbsf) went smoothly.

The next logging run was with the geochemical tool string. In order to minimize activation of the borehole, the same GST calibration procedure was used as in Hole 850B. The tool string was lowered to total depth, and several meters of extra cable was payed out. The GST was then calibrated as the slack was pulled out of the cable. The calibration was finished before the tool had moved more than a meter in the borehole. There should be no spikes in the records due to hole activation during calibration. The geochemical log was run from total depth to the mudline. When the GST entered pipe, however, it lost its calibration and did not respond properly during the remaining pass up to the mud line.

The formation microscanner was run from 323.1 to 219.5 mbsf and again from 323.1 to 68.6 mbsf. Logging with the FMS proceeded uneventfully, and at the end of the second run the tool string was brought into the pipe without any of the caliper-closing problems encountered in the previous holes.

At the conclusion of logging, the drill string was pulled out of the hole, and the bit cleared the mud line at 0254 hr, 19 June, thereby ending Hole 851B.

HOLE 851C

This hole was drilled to ensure overlap in the APC-cored section and to provide enough material for high-resolution sampling. The ship was offset 20 m south and the bit washed down to 2.5 mbsf, where the first piston core was taken at 0350 hr, 19 June. Piston coring advanced without incident to 135.5 mbsf (Core 851C-14H) with orientation beginning at Core 851C-4H (31.0-40.5 mbsf). Piston coring concluded after Core 851C-14H was retrieved and the pipe was pulled out of the hole. The bit cleared the mud line at 1744 hr, 19 June, ending Hole 851C. Recovery for Hole 851C was 102.7%.

HOLE 851D

This hole was drilled to provide two cores for paleomagnetic studies. After the vessel was offset 20 m east, the first APC core was taken at 1830 hr, 19 June, in a water depth of 3772.0 m. After the second core was retrieved, the pipe was pulled out of the hole, and the bit cleared the mud line at 1942 hr, June 19, thereby ending Hole 851D.

HOLE 851E

The first APC core in Hole 851E was taken at 2035 hr, 19 June, in a water depth of 3772 m. Piston coring continued until 133.0 mbsf (Core 851E-14H) with orientation beginning at Core 851E-4H (28.5-38.0 mbsf). Recovery for the APC section was 105.7%.

Coring continued with the XCB system to 317.4 mbsf (Core 851E-34X), where contact with basement was made. Another XCB core (35X) was cut in an attempt to recover basement. After penetrating 1 m in 30 min, the barrel was retrieved with 0.74 m of sediment and no indication of basalt. Recovery for the XCB portion of the hole was 95.0%.

After Core 851E-34X was retrieved, the drill string was pulled out of the hole, and the bit was on deck by 0835 hr. The acoustic beacon also was successfully retrieved at 0835 hr.

By 1245 hr, 21 June, the rig floor was secured, the thrusters and hydrophones retracted, and the vessel under way to the next site.

TRANSIT TO SITE 852

The transit from Site 851 to Site 852 covered 142 nmi over 12.5 hr at an average speed of 11.4 kt. At 0015 hr, 22 June, the ship slowed to 6.6 kt and the seismic gear was deployed for the site survey. The beacon was dropped on location at 0235 hr, 22 June, and the survey was continued for 10 min past the site. The survey covered 17 nmi at an average speed of 5.9 kt. Once the survey was completed, the seismic equipment was retrieved, the vessel returned to the site, and the thrusters and hydrophones were lowered by 0315 hr, 22 June. The depth to seafloor, based upon the precision depth recorder (PDR), was 3875.4 mbrf.

SITE 852

HOLE 852A

This first hole at this site consisted of a single mud-line core dedicated to whole-round geochemical and physical-property measurements. As the drill string was being lowered, a hose supplying low-pressure air to the drawworks clutch parted, and operations were stopped for 1 hr while repairs were made. By 0915 hr, 22 June, the hose was replaced, and the pipe was lowered to the seafloor. After positioning the bit at 3869 mbrf, a single piston core was taken at 1100 hr, 22 June. The core contained 5.86 m of sediment and established the mud line at 3872.7 mbrf.

HOLE 852B

Core 852B-1H was taken in a water depth of 3871 m and retrieved 8.87 m of sediment, establishing the mud line at 3871.6 mbrf. APC coring advanced to 113.4 mbsf (Core 852B-13H) with orientation beginning on the fourth core. The piston did not fully extend on Core 852B-13H, presumably because of contact with basement. The core barrel was empty upon retrieval and thus could not be used to establish the depth of the sediment/basement interface. The coring program was terminated in Hole 852B at this point, and the pipe was pulled out of the hole, with the bit clearing the mud line at 0140 hr, 23 June (end of hole). The recovery for the hole was 105.5%.

HOLE 852C

Hole 852C was drilled to ensure that a continuous section was recovered and to provide enough material for high-resolution sampling. The vessel was offset 20 m south and the bit lowered to 3868 mbrf. Core 852C-1H was taken at 0210 hr, 23 June, and recovered 6.08 m of sediment, establishing the mud line at 3871.5 mbrf for this hole. Piston coring advanced to 110.5 mbsf (Core 852B-12H) with orientation beginning at the fourth core. At this point the XCB was run in the hole, as basement was less than 9 m from the base of the previous core.

The first 6 m of Core 852-13X was cut in 10 min, whereas the next 0.8 m took 30 min to advance. Upon retrieval, the core barrel had 8.84 m of sediment but no basement material. The coring program in Hole 852C was terminated at this point, and the drill pipe pulled out of the hole. The bit cleared the mud line at 1545 hr, 23 June, ending Hole 852C. Recovery was 105.7% in the APC portion of the hole and 130% in the XCB section.

HOLE 852D

Hole 852D was also drilled to ensure that a continuous section was recovered and to provide enough material for high-resolution sampling. The ship was offset 20 m east, the bit lowered to 3862 mbrf (2 mbsf), and Core 852D-1H was taken at 1630 hr, 23 June. APC coring advanced to 116.0 mbsf (Core 852D-12H) with orientation beginning at the fourth core. The depth objectives of the hole were reached after Core 852D-12H, and preparations were then made for logging.

Hole 852D Logging Operations

The pipe was pulled to 77.7 mbsf for logging, and the hole was flushed with mud. Only the geochemical tool string was run, as the hole was too short for the other tools (116.0 m total depth). After rig-up, the geochemical tool string was lowered down the pipe, and, to avoid irradiating the section, the same GST calibration procedures were used as at Sites 850 and 851.

The geochemical log was run with the heave compensator off, as it was not functioning properly. The hole was logged from 115.2 mbsf to the mud line. As at Site 851, the tool lost its calibration upon entering the pipe (49.4 mbsf). Apparently, when the GST enters pipe, the count rate drops, and feedback circuits raise the voltage of the accelerator for the neutron generator above its tolerance. Only a few meters of bad data were recorded before the problem was corrected, and logging continued from the base of the hole to the mud line. The tool was then brought on deck and the logging operations were concluded by 1045 hr, 24 June.

After rigging down from logging, the pipe was pulled out of the hole. The ship was offset while the pipe was being pulled, and the commandable beacon was retrieved. The bit was brought on deck at 1615 hr, the rig floor secured for transit, the hydrophones and thrusters raised, and the ship was under way toward the next site by 1645 hr, 24 June.

TRANSIT TO SITE 853

The transit from Site 852 to Site 853 (proposed site WEQ-7) covered 104 nmi at an average speed of 11.4 kt. At 0245 hr, 25 June, the vessel slowed to 6 kt as the seismic equipment was deployed for a short survey. At 0419 hr, an acoustic beacon was launched successfully on location, and the survey continued for 10 min past the site. The survey covered 13.5 nmi at an average speed of 5.9 kt. At the end of the survey, the water guns were retrieved, and the ship returned to the site location. The hydrophones and thrusters were lowered and in place by 0530 hr, 25 June. The depth to seafloor, based upon the precision depth recorder, was 3726.4 mbrf.

SITE 853

HOLE 853A

This hole was dedicated to whole-round samples for geochemical and physical-property studies. The drill pipe was lowered to 3720 mbrf, where the first piston core was taken at 1130 hr, 25 June. The core barrel was retrieved empty (water core), but mud was found on the cutting shoe, indicating contact with the seafloor.

The next piston core was taken 6 m lower. A full core barrel was retrieved (10.15 m), and the mud line was inferred to be 3726 mbrf.

HOLE 853B

The mud-line core for this hole was taken in a water depth of 3722 m at 1320 hr, 25 June. The advance intervals for Cores 853B-2H, -3H, and -4H were reduced to 8 m in an attempt to study the effects of core expansion. The normal piston coring interval of 9.5 m was resumed with Core 853B-5H when the results of the core-expansion exercise were inconclusive. Multishot orientation began with Core 853B-5H on this hole. Coring ended in this hole when Core 853B-9H hit basement at 72.4 mbsf.

The recovery was 107.3% in this hole. The inflated recovery figure for this hole resulted from the recovery of full core barrels (over 9.5 m) on Cores 853B-2H to 4H, which were only advanced 8.0 m.

After Core 853B-9H was retrieved, the pipe was pulled out of the hole, and the bit cleared the seafloor at 2225 hr, 25 June, ending Hole 853B.

HOLE 853C

The ship was offset 20 m south, the bit lowered to 3726 mbrf, and the mud-line core taken at 2307 hr, 25 June. Piston coring advanced to a depth of 66.0 mbsf (Core 853C-7H) with multishot orientation starting with Core 853C-4H. The XCB coring system was used with the eighth core in an attempt to retrieve the sediment/basement contact. The core barrel effortlessly advanced 2.2 m, when a sudden decrease in rate of penetration and an increase in torque indicated basement contact. Time constraints did not allow for coring into basement, and the core barrel (Core 853C-8H) was retrieved with 1.27 m of sediment. The recovery was 103.5% for the APC section and 57.7% for the XCB section.

Once the last core was on deck, the pipe was pulled out of the hole, with the bit clearing the seafloor at 0710 hr, 26 June, ending Hole 853C.

HOLE 853D

This hole was drilled to ensure that a continuous sequence was recovered and enough material was available for high-resolution sampling. The vessel was offset 20 m east and the pipe lowered to 3723 mbrf. Core 853D-1H was taken at 0820 hr, June 26, and recovered 8.81 m of sediment. Piston coring advanced through Core 853D-7H, which stopped just short of basement (65.8 mbsf). The cores were oriented starting with Core 853D-4H. Recovery in this hole was 104.6%.

After recovering the last core barrel, the pipe was pulled out of the hole, and the bit cleared the sea floor at 1430 hr, 26 June, ending Hole 853D.

HOLE 853E

The vessel was offset 20 m south, and Core 853D-1H was taken at 1510 hr, 26 June. Due to time constraints only one more core was taken. Recovery was 102.8% in the hole.

After the last core was retrieved, the pipe was pulled out of the hole. As the pipe was being pulled out of the hole, the beacon was released by remote command and was on deck at 1827 hr, 26 June.

The bit was on deck by 2235 hr, 26 June, after which the rig floor was secured and the thrusters and hydrophones raised. The ship began the transit to Site 854 at 2300 hr, 26 June.

TRANSIT TO SITE 854

The transit to Site 854 covered 236 nmi and averaged 10.5 kt. Upon reaching the proximity of the site at 2115 hr, 27 June, the vessel slowed to 6 kt to conduct a site survey with the 3.5-kHz echo sounder. At 2315 hr, the beacon was deployed, after which the ship came about and returned to the site location by 2330 hr. The survey covered 13 nmi at an average speed of 5.9 kt. The depth to seafloor, based upon the precision depth recorder (PDR), was 3584.0 mbrf.

SITE 854

HOLE 854A

The drill pipe was lowered to 3580 mbrf, and the first piston core was taken at 0523 hr, 28 June, recovering 9.9 m of sediment. The first core established the mud line at 3579.1 mbrf. Only one more APC core was taken in this hole (854A-2H, 9.9-19.4 mbsf). With such a thin sedimentary section providing little lateral stability to the BHA, there was concern that if the piston core were to impact the basalt in such conditions the piston rod could get bent. If that were to happen, the core barrel would have to be retrieved with a pipe trip. Because of the time constraints on this last site, an extra pipe trip could not be accommodated and still attain the site objectives. Thus the XCB system was used to take the next core. When Core 854A-3X was retrieved with only 0.96 m of sediment (the sediment was too soft for the XCB), the decision was made to advance ahead by drilling and define basement depth. Basement was reached at 46.8 mbsf by 0800 hr. The pipe was then pulled out of the hole, and the bit cleared the mud line by 0855 hr, ending Hole 854A.

HOLE 854B

Without offsetting the ship, Core 854B-1H was taken at 0930 hr, 28 June, in a water depth of 3578 mbrf and recovered 8.4 m of sediment, establishing the mud-line depth at 3579.6 mbrf. Piston coring advanced quickly to 45.4 mbsf (Core 854B-5H) and recovered 48.01 m of sediment (105.7% recovery). After Core 854B-5H was brought on deck, the pipe was pulled out of the hole, and the bit cleared the mud line at 1341 hr, 28 June, thereby ending the hole.

HOLE 854C

This was the 42nd hole and the last one of Leg 138. The last mud-line core was taken in a water depth of 3574 mbrf at 1428 hr, 28 June, and recovered 3.6 m of sediment, establishing the mud line at 3579.9 mbrf. Piston coring advanced to 46.0 mbsf and recovered 54.03 m (117.5% recovery). (With the recovery of Core 854C-3H, the old core recovery record of 5502 m, set on Leg 133, was broken.) The last core of the hole (Core 854C-6H) was advanced only 4.4 m to avoid hitting basement and to attempt to recover as much of the section above basement as possible. The retrieved core barrel contained 9.99 m of sediment. Most likely the sidewall was cored, and sediment recovered in the previous APC core was cored again. After Core 854C-6H was recovered the pipe was pulled out of the hole, and the bit was on deck at 0410 hr, 29 June.

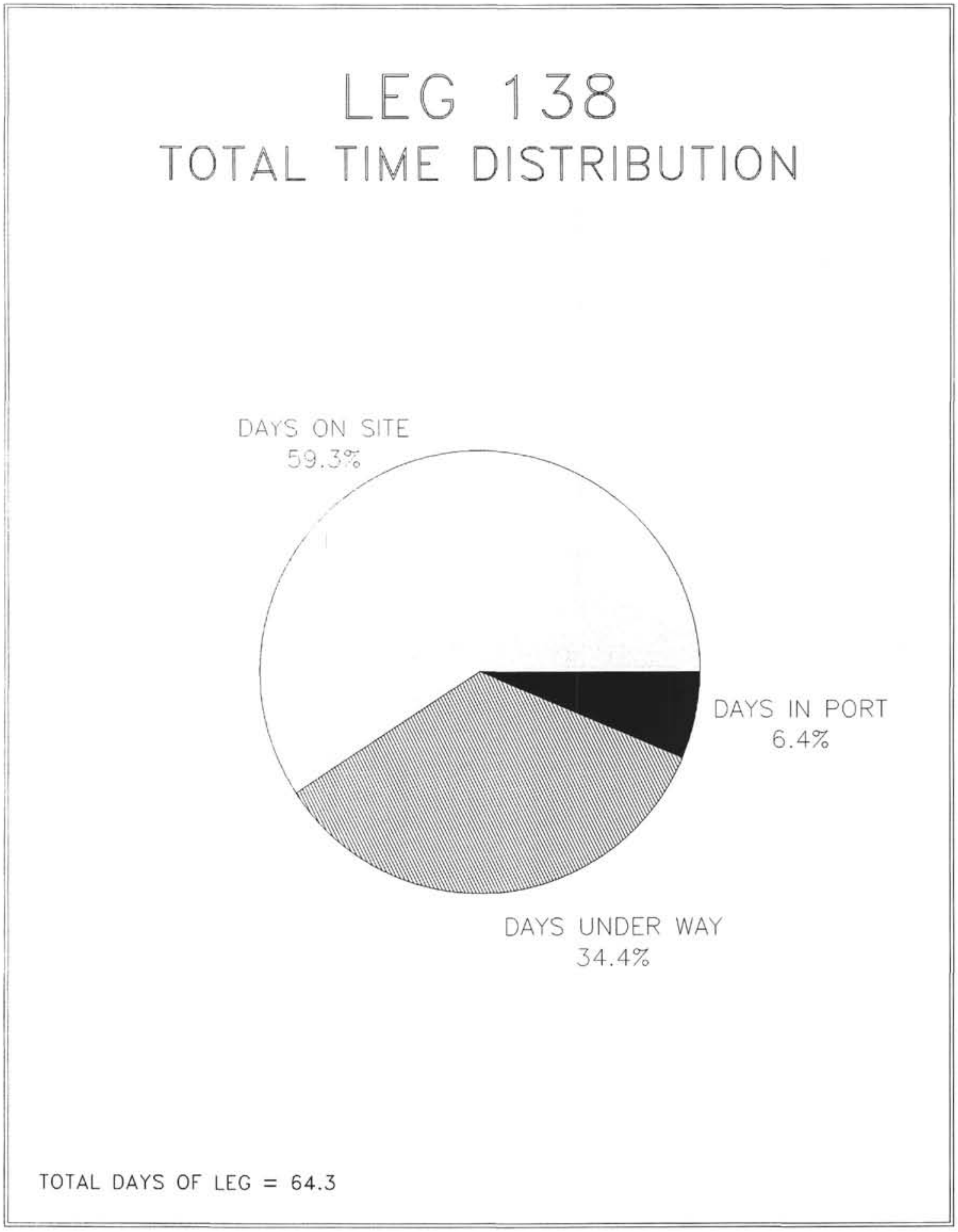
TRANSIT TO SAN DIEGO

The vessel was under way at full speed toward San Diego at 0800 hr, 29 June. The JOIDES Resolution arrived at the dock in San Diego at 1530 on 4 July 1991.

Operations Resume
Leg 138

Total days (May 1, 1991 - July 4, 1991	64.3
Total days in port	4.1
Total days under way	22.1
Total days on site	38.2
Trip time	6.8
Coring time	23.8
Drilling time	0.1
Logging/downhole science time	6.3
Repair time (contractor)	0.2
Repair time (ODP)	0.1
Other	0.8

Total distance traveled (nautical miles)	5421
Average speed (knots)	10.4
Number of sites	11
Number of holes	42
Number of reentries	0
Total interval cored (m)	5542.1
Total core recovery (m)	5536.8
Percent core recovery	99.9
Total interval drilled (m)	86.2
Total penetration (m)	5628.3
Maximum penetration (m)	393.6
Maximum water depth (m from drilling datum)	3872.7
Minimum water depth (m from drilling datum)	3307.3


LEG 138
TOTAL TIME DISTRIBUTION
DAYS ON SITE
59.3%
DAYS IN PORT
6.4%
DAYS UNDER WAY
34.4%
TOTAL DAYS OF LEG = 64.3

TECHNICAL REPORT

The ODP Technical and Logistics personnel aboard the JOIDES Resolution for Leg 138 of the Ocean Drilling Program were:

Laboratory Officer:	Burney Hamlin
Assistant Laboratory Officer:	Bill Meyer
Yeoperson:	Jo Claesgens
Curatorial Representative:	John Miller
Computer System Manager:	John Eastlund
Electronics Technicians:	Jim Briggs Eric Meissner
Photographer:	Mark Gilmore
Chemistry Technicians:	Valerie Clark Gretchen Hampt
X-ray Technician:	Wendy Autio
Marine Technicians:	John Beck Daniel Bontempo Tim Bronk Brad Cook Sung-Ho Kang Jon Lloyd Cynthia Mullican

PORT CALL

Most of the technical staff left College Station, Texas, 30 May 1991 for Panama via Dallas and Miami. Few problems were experienced on the short flights; we and the SEDCO personnel were met and accompanied through Panamanian immigration and customs. Our baggage was picked up, and the agent provided transportation to the Riande Continental Hotel for the night. The ship's normal early morning arrival was delayed until the tides permitted safe passage under the Bridge of the Americas. We met the ship late in the morning for technician crossovers.

Shipments on and off the ship moved well throughout the port call. A service call with DEC was arranged to investigate some VAX irregularities the previous crew experienced, but troubleshooting diagnostics were normal. Welding was done to repair cracks in the derrick guide rail and around the guide horn in the moon pool.

Earl and Wright of San Francisco, naval architects, sent representative Jim Duhnam to continue his chill-water survey. This was to prepare for the installation of additional air conditioning and air-handling machinery on the top of the lab stack during the San Diego port call. A sheet-metal fabricator working with Jim was consulted on needed work for the partially finished subsea shop. The 4 day port call was a treat for a change, allowing extended crossovers for some, lab familiarization and equipment calibration for others.

UNDERWAY/SITE SURVEYS

Last lines were away at 13:48 5 May for Site 844 (EEQ-2), 3 days away. Underway watches were started as soon as traffic cleared and we had moved out into the Gulf of Panama.

Site surveys were short, usually lasting 1 to 4 hours. Two S-80 water guns were used, and the hydrophone array was kept shallow by partial deployment. Site-survey quality was good, and the quick surveys verified the previously selected sites. GPS navigation was available nearly full time the entire cruise. The last site, Site 854, had little sediment cover and was surveyed using the 3.5 kHz depth recorder only. Site-survey seismic tapes were processed by the staff geophysicist, providing good profiles to compare with the reference records.

On three occasions during transits between sites, the NAVLOG navigation recording software began logging data on irregular half hours. The MASSCOMP computer and a new software version were suspect, but the actual cause is undetermined. GPS hard copy was available, and the missed half-hour positions were hand entered into the GEOPLOT plotting files to close the track gaps. SMOOTH accommodated the reduced number of positions recorded. Gaps in the GPS NAVLOG files also were noted while collecting positions for site averages. It was discovered that the MASSCOMP computer was rebooting when the regulated power shifted from the Cyberex to the motor-generator set.

The magnetometer and depth recorders were secured 2 days before port call as we traveled up Scripps Institution of Oceanography's well-traveled path.

OPERATIONS

The purpose of the leg was to define the paleoceanographic evolution of the Eastern Pacific during the last 12 million years. This is the fifth expedition in a series to study global climatic change through high-resolution studies of tropical ocean sediments. Two north-south transects were sampled with the advanced piston coring (APC) system with multiple holes at the sites to ensure complete recovery and to allow special sampling programs. The extended core barrel

(XCB) system was used to deepen several of the holes to basement. The scientists were pleased that the XCB could deliver high-quality continuous sections.

The planned drilling order of the sites was changed after the second site to permit a rendezvous off Ecuador's Baltra Naval Station in the Galapagos Islands. We had sailed with only one multishot core orientation camera; our other two were broken. These cameras were repaired and hand carried to the ship with welcome newspapers, magazines, and mail. Additional batteries were also delivered to ensure that all multiple holes could be oriented if necessary. The camera pictures were also used to obtain drift values for the holes drilled.

Transit speeds and drilling conditions were better than planned, making time to include an additional site, midway between proposed sites WEQ-6 and WEQ-4 and alternate site WEQ-2. The new site offered approximately 400 m of sediment to be double piston cored, almost ensuring that total recovery for the leg would approach Leg 133's record. Site 854, our last and 11th site (WEQ-2), had only a thin 50-m veneer of sediments, but it was enough to let the Leg 138 staff assume ODP's record recovery title with 5536.8 m and 99.9% recovery. Nine of the sites drilled were logged using geophysical and geochemical tool strings. Results were exceptional, contributing 7155 m of records. FMS data were collected and processed at seven of the sites. Drilling for the leg was finished at 2000 hr on the 28th. Pipe was pulled, then old pipe was made up for the following leg until 0800 on the 29th when the ship got under way. The 1356-nmi transit to San Diego, California, was made in 5.5 days, with the first line at 1500 on 4 July. A record 5400 nmi was traveled since leaving Panama.

CURATION

A leg resulting in heavy recovery is always a challenge for the curatorial representative to organize, guide, and document. In spite of the fact that much of the sampling was deferred to the shore labs, 21,227 samples were taken during the leg. Special sampling programs resulted in dedicated holes, and mud-line cores were used for whole- round samples for physical-properties and geochemical determinations. Because of the need to ensure recovery overlap between holes, many cores were run through the MST, split, and boxed out of order. A scheme to guide those racking the cores at the Gulf Coast Repository was prepared.

Biological sampling for a British investigator, using sterilized scalpels, syringes, and other medical media, was done at Site 851. Sample intensity diminished with depth but continued to basement. Half of the sample was stabilized with formalin solutions. The scientific staff took responsibility for the program.

Fourteen boxes of cores were selected to be taken to the Scripps Institution of Oceanography's magnetics lab for high-resolution studies. The cores were to be returned to the GCR.

CORE LAB

The collection of crates and boxes that arrived in the core lab from Oregon State University was considerable. The instruments and SUN computer workstations were soon in place on the full length of the core-lab description table and on the end of the sampling table for good measure. A color scanner, based on reflectance spectroscopy, was mounted over a split-core automated track similar to the multisensor track (MST). The instrument was controlled by a PC, but the very large data files generated were manipulated by two SUN workstations and stored on an 800-mb hard disk. Multichannel spectral signatures of the cores were recorded, processed and displayed; then they were correlated with carbonate-content values, GRAPE density measurements, and other lab-derived physical properties of the sediment. Concatenated lab data with depth assignments were then compared to the downhole logs made at most sites. The real-time analysis of the data collected by the MST and color scanner guided the offset of coring on subsequent holes, ensuring full recovery of the sediment column. Further processing of the data will guide shore sampling. The overall high success of the system and the value of its data support the belief that the split-core color scanner will one day join ODP's shipboard instrumentation.

The ODP digital imaging system was set up, and some image and data records were made for comparison later with the color-scanner data. The digital image system was returned to ODP at the end of Leg 138.

A new digital sonic velocimeter (DSV), developed by the Bedford Institute of Oceanography and Dalhousie University, was installed with software by Larry Mayer, a co-chief scientist on this leg. Transducer crystals are mounted into blade pairs that are inserted into cut cores. A digital storage and processing oscilloscope calculates the velocity of sound in the sediment and creates data files. The instrument may eventually be modified to measure discrete samples, retiring the venerable Hamilton Frame device, inherited from DSDP. Thinner transducer blades will be investigated to reduce cracking drier types of sediments.

The MST was used continuously on the APC cores, giving satisfactory results. Data from the GRAPE, magnetic susceptibility, and sound velocity (P-wave) were scrutinized and incorporated into the database describing the sediment characteristics. Needed software features were written to assist the physical-properties technician edit/clean and verify the results.

The paleomagnetics lab scientists experienced few problems with the cryogenic magnetometer and made over 3300 pass-through runs on 1358 sections. Almost all runs were made at several demagnetization levels. Core quality was good to excellent for their purposes and may be the basis for rewriting the paleomagnetic history of the region. Elusive electrical noise observed primarily in one magnetometer's axis squid boxes has been collected for analysis ashore, and a spare box was installed. A MAC was used for the spinner magnetometer for a few discrete samples and for data verification. One of the scientists provided and modified the software to conform to ODP conventions. A point was made that the lab software is in need of maintenance as equipment and needs are changing.

The auxiliary core rack was installed prior to our arrival at the first site in anticipation of the high APC recovery and was in use during the entire leg. The record recovery moved smoothly through the lab with few new problems. Enhancements were made to MST software to speed data-file corrections (Autofix), and a physical-properties spreadsheet was developed to ease and standardize the collection and filing of data. Both were successfully implemented. The core splitter performed well and was serviced after we departed the sites. A masonry blade was used on the saw with no failures to cut harder material instead of the usual lapidary blade.

Training of new technicians in physical properties continued to a level that allowed them to begin writing instructions for new equipment (DSV) and software (Autofix) and to develop end-of-site checklists to help ensure data completeness and integrity.

CHEMISTRY LAB

"We ran carbonates," the chemistry technicians said when asked of their achievements this leg. The Coulometer was indeed heavily used, giving values for over 2000 samples. These values were plotted and compared to the spectral traces for distinctive signatures that could be used to characterize the carbonates for an entire hole.

A method to analyze biogenic opal for its silica contents was used for the first time. This procedure is time consuming, so only a few samples were analyzed. The numbers obtained, however, corresponded well to trends seen on the spectral traces recorded by the Oregon State University system, so the technique will likely be used on selected future legs.

Pore-water chemistry was routinely done. The atomic absorbtion spectrophotometer was used for lithium ion determinations, which were compared with trends seen in the strontium ion curves. Both ions are affected by the recrystallization of calcite.

Although many gas samples were taken, little gas - methane or H_2S - was detected over the background levels.

The HP LAS computer system was troublesome to work with early in the cruise, before it was discovered that the hard disk was crowded with the previous leg's data and tests.

X-RAY LAB

During port call a repaired sample changer was installed in the Philips XRD, and it worked well in spite of a couple of quirks. The instrument was well-aligned and had good tube intensity. The system shut itself down safely twice because of a main power failure and inadequate chill water. With these conditions corrected, 47 oriented smear slides or acid-treated samples were run. A primary transformer failed in mid-cruise, terminating the shipboard X-ray-diffraction program.

A pilot study of geochemical trends reflecting XRF results was made. Aluminum/iron ratios were made which can be tied to source rocks. It was noted that aluminum trends in the sediments followed magnetic-susceptibility measurements, though that element itself is not sensed by that instrument. Another interesting study used CaO numbers, which were recalculated to include the CO_2 burned off during sample preparation. The resulting artificial carbonate values corresponded well to Coulometer values. The primary restriction in using the XRF for more determinations of this type is the 3 days of sample preparation.

The ARL XRF unit worked well this leg, though it too was subjected to two power failures, both attributed to loose electrical panel lugs. The initial emphasis was for major-element analysis of samples from near basement but was later expanded to include archive smears from each section at four sites. There were 154 of the major-element analyses made, mostly of the sediments. Ten minor-element analyses were also made of near-basement samples.

Plumbing larger chill-water pipes to the HASKRIS heat exchanger, which cools both X-ray instruments, seems to have solved the problem of marginal cooling capacity and allowed the units' temperature-control system to operate, perhaps for the first time.

COMPUTER SERVICES

This was a challenging leg for Computer Services. New instruments in the lab and the large data files generated led to problems that were handled ably by the specialized technical staff sailing to support the leg. With three technicians with system manager-level computer and software skills and an apprentice to help, few problems were left unsolved.

A persistent problem with a DEC microvax was not repaired; therefore, a DEC service call was scheduled for San Diego.

Both of the QMS laser printers were removed from the ship after the VAX software was modified to use the Apple laserwriters.

LAB SOFTWARE

With the software skills available, it is not surprising that so many of the labs' programs received attention this leg. Problems associated with the VAX VMS upgrade last leg were addressed. PCs were upgraded and WINDOWS software installed, and conflicts with screensavers noted. Updated WordPerfect programs for the PCs and MACs were evaluated and installed as software licenses permitted. Some fixes in the SMOOTH navigation program were made to ease plotting tracks crossing the equator. The underway technician received instruction in the features the program offers.

Considerable time was spent making the new Digital Sediment Velocimeter instrument software perform and conform to ODP formats and standards. The software would not initially run on our IBM clones in any configuration, initially making it necessary to use the Co-chief's portable. A pared-down version of the original C program was rewritten in Fortran for our use. Support software was ordered to continue and finish the job.

A utility was written to make SLIDES information in the database accessible to scientists. Instructions were written on the procedures to obtain sub-bottom depths for data files collected.

PHOTO LAB

A new photographer assisted in the photo processing of the record amount of core material. Routine maintenance and PM kept the equipment smoothly working. The lab's water quality suffered when some of the ship's hot-water valves were serviced and water heaters flushed, resulting in numerous blocked filters. Water temperatures were adjusted cooler after this incident.

Some X-ray photographs of cut core sections were made for study of sediment laminar features.

The laboratory microscopes were cleaned and problems corrected as necessary. Common problems were optics misalignment, "out of range" focusing adjustments, and source lamp changes. Professional service was scheduled for the San Diego port call.

ELECTRONICS SHOP

Broad technical support was provided this leg. This help ranged from operations drilling sensors and the lab's instrumentation and computers, to instrument development and installation, to copier maintenance and other mechanical problems, and finally, to core receiving.

Focal points of these efforts included rewiring hydrophone cables in the underway lab to reduce noise, troubleshooting the chemistry lab's Rock-Eval organic carbon chromatograph until it now is achieving excellent results , and continuing with the development of the ADARA temperature recorder.

The Electronic Technicians assumed the responsibility for launching the expendable bathythermographs (XBT) for NOAA and prepared the data for satellite transmission.

DOWNHOLE TOOLS

The Eastman Whipstock multishot camera was used extensively, though not on all holes, as the sediment magnetic signatures became too weak to follow. Camera runs were extended progressively until we were successfully getting 5 hr of service from a battery set, permitting the maximum amount of film to be loaded into the camera. Sixty-eight camera deployments were made. The batteries began sticking in one case, which was disassembled, cleaned, and returned to service.

Formation microscanner (FMS) data were collected and processed for seven sites. Data were distributed in several different plotted formats, including selected images for the staff to inspect. Plotter service was scheduled for port call.

STOREKEEPING

The shipments on and off the ship were relatively small and routine. The new storekeeper continued developing his computer skills to efficiently generate the necessary search, status, and reorder reports requested. A GFE inventory of the computer equipment was made and identification tags placed on new items received. Physical counts were made as necessary.

SPECIAL PROJECTS

Several requests were made to support the San Diego port-call modification. The flammable gas bottle corral and cover were cut away from their location forward of the elevator shaft and re-installed on the opposite side. This was to clear the area over the lab-stack stairwell for the installation of the additional air-conditioning equipment. Scaffolding was assembled on the last day of the transit to gain access to the lab stairwell overhead. Insulation was stripped back and ducting removed to give the port-call welders easy access. Two stuffing-tube penetrations were made for a breathing air line and a H_2S sensor cable.

Shipboard welders installed the watertight doors and hatch in the under-construction subsea shop. Interior white paint was requested.

The stainless-steel replacement stem for the doppler sonar speed log arrived in the Panama Operations shipment. As the company that made the transducer is close to San Diego and the port call was longer than usual, we felt it would be a good idea to assemble the parts and proceed toward installation. We found a critical threaded plate in the extended transducer housing to be off axis, so the transducer could not be screwed into it. The engineers were informed and instructions requested.

Finishing the conversion of the X-ray lab chill-water supply from 1/2 in. copper tubing to 7/8 in. was a larger job than expected, taking two men 2-3 days. The HASKRIS now maintains a bath temperatures 5°-6° colder than previously, to everyone's relief.

Other projects of smaller scope were accomplished. The safety net on the perimeter of the helideck was being serviced, making it an opportune time to request that two pad eyes be welded below the deck, outer aft. This will be a convenient place to tow the streamers farther out of the wake.

A Barnstead water de-ionizing filter column was plumbed at the forward sink in the paleontology lab, allowing samples to be washed or water containers filled.

Ideas were solicited from the ship's party to explore variations of the core-lab layout to accommodate two more MSTs. The success of the spectral imaging system during this leg and developing plans for other sensors propelled the effort. The composite drawing was sent to shore.

Technicians spent considerable time in front of the MST this leg to insure prompt core processing and cutting. A spare Mac SE was installed across the aisle with tutorials for the various programs available. The station was also used to make notes and write reports and documentation.

SAFETY

The METS participated to a fuller degree in the weekly fire drills than on many other legs. Each member of the team was assigned gear to bring to the staging area for each drill. METS members suited up in the fire gear and breathing apparatus on four occasions, one time under blackout conditions as a rescue squad. Proficiency improved noticeably.

LAB STATISTICS: LEG 138

GENERAL STATISTICS:		
	SITES	11
	HOLES	42
	INTERVAL CORED (M)	5542.1
	CORE RECOVERED (M)	5536.6
	NUMBER OF CORES	599
	NUMBER OF SAMPLES	21227
SAMPLES ANALYZED:		
	INORGANIC CARBON (CACO3)	2657
	TOTAL CARBON - CNS	1150
	WATER CHEMISTRY	151
	THIN SECTIONS	3
	XRD	47
	XRF (MAJORS)	154
	XRF (MINORS)	10
	MST RUNS	>4200
	CRYOMAG RUNS	3319
	PHYS PROPS VELOCITY	4851
	INDEX PROPERTIES	4012
	THERMAL CONDUCTIVITY	267
	VANE SHEAR	2523
UNDERWAY GEOPHYSICS:		
	TOTAL MILES TRAVELED (APX)	5421
	BATHYMETRY, MAGNETIC (APX)	4900
	SEISMIC (APX)	138
DOWNHOLE TOOLS:		
	CORE ORIENTATION RUNS	68