OCEAN DRILLING PROGRAM

LEG 122 PRELIMINARY REPORT

EXMOUTH PLATEAU

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October 1988

Preliminary Report No. 122
First Printing 1988

Distribution

Copies of this publication may be obtained from the Director, Ocean Drilling Program, Texas A&M University Research Park, 1000 Discovery Drive, College Station, Texas 77840. In some cases, orders for copies may require a payment for postage and handling.

D I S C L A I M E R

This publication was prepared by the Ocean Drilling Program, Texas A&M University, as an account of work performed under the international Ocean Drilling Program, which is managed by Joint Oceanographic Institutions, Inc., under contract with the National Science Foundation. Funding for the program is provided by the following agencies:

Department of Energy, Mines and Resources (Canada)
Deutsche Forschungsgemeinschaft (Federal Republic of Germany)
Institut Français de Recherche pour l'Exploitation de la Mer (France)
Ocean Research Institute of the University of Tokyo (Japan)
National Science Foundation (United States)
Natural Environment Research Council (United Kingdom)
European Science Foundation Consortium for the Ocean Drilling Program
(Belgium, Denmark, Finland, Iceland, Italy, Greece, the Netherlands, Norway, Spain, Sweden, Switzerland, and Turkey)

SCIENTIFIC REPORT

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ABSTRACT

Four sites (759, 760, 761, 764) on the Wombat Plateau and two sites (762, 763) on the western part of the central Exmouth Plateau were drilled during Leg 122. These sites, together with sites scheduled for drilling during Leg 123 on the Exmouth Plateau and adjacent Argo Abyssal Plain, will help to provide a complete Late Triassic through Quaternary history of the Exmouth Plateau.

The composite section recovered at the four sites drilled on the Wombat Plateau comprises: a paralic to marginal-marine lower Carnian-Norian section of an early rift environment with the oldest nannoflora yet discovered; an almost complete marine Rhaetian carbonate platform sequence; a condensed hemipelagic mid-Cretaceous section and possibly complete Cretaceous/Tertiary boundary; an expanded Paleocene eupelagic marine sequence; and a middle Eocene-Quaternary eupelagic marine sequence. Liassic to earliest Cretaceous sediments are missing. New constraints on the ages of seismic reflectors on the Wombat Plateau from these drilling results indicate that major rifting and block-faulting in the region occurred in the Early-Middle Jurassic (pre-Callovian). This corresponds with the timing of the block-faulting event on the central Exmouth Plateau, marked by an unconformity between the Triassic Mungaroo Sandstone equivalent strata and the overlying Oxfordian-Kimmeridgian Dingo Sandstone equivalent strata.

The composite section recovered at the two sites drilled on the Exmouth Plateau includes a thick, prograding distal-shelf margin sequence of Berriasian-Valanginian age (Barrow Group equivalent) that will be important for understanding depositional processes of clastic wedges for comparison with modern clastic depositional systems. Dating of the unconformity overlying this sequence narrows the age of break-up of the western and southern margins of the Exmouth Plateau to Hauterivian-Barremian. Overlying this unconformity, hemipelagic sediment of the Albian-Cenomanian characterizes the "juvenile ocean" stage in the evolution of this margin, and the change to purely pelagic sedimentation in the Turonian represents the beginning of the "mature ocean" margin stage. Sea-level fluctuations deciphered at Exmouth Plateau and Wombat Plateau sites from sequence stratigraphic analyses correspond well with the global eustatic cycle chart.

INTRODUCTION

Leg 122 was one of the few Ocean Drilling Program legs devoted entirely to drilling on passive continental margins. The northwestern margin of Australia, from the Exmouth Plateau to the Scott Plateau, is one of the oldest oceanic passive margins in the world, and forms part of the Permian to Cretaceous Westralian Superbasin, extending from the Arafura Sea to southwesternmost Australia (Yeates et al., 1986). The Exmouth Plateau is a rifted and deeply subsided piece of continental crust, covered by more than 8 km of Phanerozoic sediments. To the east, the plateau is separated from the Australian shelf by the down-warped Kangaroo Trough and it is bounded to the north, west, and south by oceanic crust of the Argo, Gascoyne, and Cuvier Abyssal Plains, respectively (Exon and Willcox, 1978). The present structural configuration of the Exmouth Plateau region was initiated by rifting and drifting between eastern Gondwana and Eurasia in Late Triassic to Middle Jurassic time, followed by Late Jurassic to Neocomian rifting and drifting between northwest Australia and, to the south and west, "Greater India," and to the north, other Gondwanan fragments.

The northern margin of the Exmouth Plateau (Fig. 1) formed around 145-150 Ma by seafloor spreading in the Argo Abyssal Plain at magnetic anomaly M25 time (Veevers, Heirtzler, et al., 1974; Larson, 1975; Heirtzler et al., 1978). The breakup of the western margin occurred around 120 Ma in the Neocomian when seafloor spreading was initiated in the Gascoyne Abyssal Plain and the Indian Plate began moving to the northwest. The southern margin of the plateau formed along an incipient transform fault at the same time as the western margin (Larson et al., 1979). The dominant fault trend on the plateau, northeast-southwest, is probably coeval with the Gondwanan dispersal in Late Triassic to Middle Jurassic time, as it was in the Dampier sub-basin to the east (Veenstra, 1985); it culminated in the Callovian breakup of the northern margin. A second, east-west, direction of faulting evident on the northern part of the plateau produced the "North Exmouth hinge zone" (Exon et al., 1982; Exon and Williamson, 1988) that separates the northern part from the rest of the plateau. This fault direction developed at the same time as the dominant northeastern trend, but was rejuvenated later, either in the Callovian or at the close of the Neocomian. The northern margin was itself cut into a series of uplifted and tilted horsts, separated by northeast-trending faults, which were often deeply incised by submarine canyons. One of these high blocks or horsts, a subplateau of the Exmouth, is the Wombat Plateau (Fig. 1). The Wombat Plateau is separated from the Exmouth Plateau by the Wombat half-graben that formed during the Callovian or late Neocomian rejuvenation of the hinge zone, which Exon et al. (1982) suggested was late Neocomian, but our present results suggest was earlier.

The availability of data, under Australian petroleum legislation, from extensive exploratory seismic work (Exon and Willcox, 1978; Wright and Wheatley, 1979) and commercial wells on the Exmouth Plateau (Barber, 1982; Cook et al., 1985; Exon and Wiliamson, 1988), dredge surveys (von Stackelberg et al., 1980; von Rad and Exon, 1983; von Rad et al., in press), as well as DSDP sites on the adjacent abyssal plains (Veevers, Heirtzler, et al., 1974), provided important precursory data for the Leg 122 study of the evolution of passive continental margins. Existing evolutionary models of margin development envision the rifting mechanism in terms of uplift and subsidence cycles, or varying thermal response of continental and oceanic lithosphere. A recent two-ship seismic reflection-refraction experiment on the Exmouth Plateau identified large rotated fault blocks and a set of prominent, subhorizontal, mid-crustal detachment faults under the central Plateau (Mutter et al., 1988; Williamson and Falvey, 1988). Unfortunately, the deeper crustal structure of the central and outer Exmouth Plateau, which lies beneath gas-rich sediments, cannot be drilled using current ODP riserless technology. Hence, it is not possible to test these new continental-margin development models, which postulate the deformation on the outer plateau by lithospheric thinning and "pure shear" that postdates the "thin-skinned" deformation with "simple-shear" detachment systems under the central plateau.

The central Exmouth Plateau sediments were deposited in an extension of the Carnarvon Basin, a north-facing Tethyan embayment in Gondwana which received detrital sediments from the south until Neocomian time. On the central plateau some 3000 m of paralic and shallow-marine detrital sediments were deposited during Permian through Middle Jurassic time. After Late Jurassic rifting, about 1000 m of deltaic sediments derived from the south and east covered the Late Jurassic and Early Cretaceous block-faulted surface.

We investigated the sediment deposition on the Exmouth Plateau that occurred in four major phases: (1) A Late Triassic to Middle Jurassic rift phase, in which a large volume of terrigenous sediments was shed from the hinterland areas to the south and east, and was deposited over thick Permian to Lower Triassic continental, and marginal marine facies. On the northern Exmouth Plateau these facies alternate with shallow-water carbonates deposited in a southeasterly embayment of the Tethys; (2) A latest Jurassic to Neocomian deltaic phase on the central plateau during which a large clastic wedge prograded from the southeast to the northwest; (3) A post-breakup sediment-starved late Neocomian to early Late Cretaceous phase; followed by (4) A Late Cretaceous to Cenozoic phase of eupelagic sedimentation over the slowly subsiding plateau with little terrigenous influence. The sedimentary patterns of the northern part of the plateau, including the Wombat Plateau, have differed considerably from those of the Exmouth Plateau proper between latest Triassic and mid-Cretaceous times.

The elevated position of the Exmouth Plateau makes it more favorable than the deep basins for preservation of the stratigraphic record because it lies above the extensive erosive and corrosive actions of bottom waters. The relatively unimpaired integrity of the stratigraphic record makes the plateau an ideal place to study the effects and timing of sea-level fluctuations and to date prominent unconformities. Drilling and well-log data, along with the existing seismic grid on the plateau, provide an opportunity to document depositional sequences of the Mesozoic and Tertiary and to test the eustatic sea-level model (Haq et al., 1987, 1988).

The unique opportunity of continental margin drilling in the relatively protected setting of an elevated plateau promises to provide answers to several interrelated questions common to very old passive margins, as well as to specific questions about the wide marginal plateau setting of the Exmouth Plateau area. Leg 122 was designed with the following major objectives in mind:

1. To unravel the rift, rift-drift transition, and post-breakup history of a sediment-starved continental margin, and to understand its sedimentary and paleoenvironmental development from juvenile to mature oceanic margin.
2. To document the temporal and spatial distribution of the Mesozoic and Cenozoic depositional sequences in order to separate the effects of basin subsidence, sediment supply, and sea-level changes, thus leading to testing sequence-stratigraphic and eustatic models and other theories of rhythmic sedimentation.
3. To improve the Late Triassic to Cretaceous chronostratigraphy (magneto-,

bio-, and chemostratigraphies) and to establish a framework for the correlation of Mesozoic and Tertiary strata off Australia with those of the stratotypes and classical sections in Europe and North America.
4. To recover and investigate Jurassic and Cretaceous anoxic sediments, in order to understand their genesis in shallow-marine and open-marine settings.
5. To retrieve and examine the section across the Cretaceous/Tertiary boundary in order to test various competing hypotheses about the massive extinction event at the end of the Mesozoic.

To achieve these objectives, four Leg 122 sites (759, 760, 761, 764) were drilled to recover a composite Late Triassic syn-rift to Cenozoic record of sediments in a complete transect of the Wombat Plateau (Figs. 2 and 3). Two additional sites (762, 763) were located on the western part of the central Exmouth Plateau to recover the late-rift Lower Cretaceous succession of terrigenous shelf margin pro-delta sediments, overlain by a pelagic sequence of late Cretaceous through Quaternary age representative of a mature continental margin (Figs. 4 and 5). It was envisaged that together these two transects of sites would furnish a complete Late Triassic through Quaternary history of the Exmouth Plateau. In addition, Leg 122 is closely integrated with Leg 123, with several major objectives common to both legs. During Leg 123 two sites are planned, one to be drilled on the western, deep-water flank of the Exmouth Plateau (proposed site EP-2A) and another in the Argo Abyssal Plain (proposed site AAP-1B). The combined results of these two legs will help unravel the mysteries of the western Australian continental margin.

THE WOMBAT PLATEAU TRANSECT

SITE 759 (SOUTHEASTERN EDGE OF THE WOMBAT PLATEAU)

Site 759 (proposed site EP10A') is located near the top of the southeast slope of Wombat Plateau, at 16°57.24'S, 115°33.63'E and in a water depth of 2092 m (Fig. 1 and Table 1). Hole 759B was continuously cored by rotary coring (RCB) to a depth of 308 mbsf with a total recovery of 129.6 m (42%). The hole was logged with a combination string of seismic-stratigraphic tools.

The major objectives at Site 759, in conjunction with the three other Wombat Plateau sites (760, 761, and 764) were: reconstruction of the Mesozoic paleoenvironment; establishment of the early-rift, drift, uplift and subsidence histories of this continental margin; and testing eustatic sea-level fluctuation models in relation to tectonics and sediment supply. These four sites on the Wombat Plateau form a north-south transect with successively younger Mesozoic sections being truncated by a major angular unconformity (Fig. 2). They provide a fairly complete record of the late Triassic to Holocene evolution of this margin.

The section penetrated at Site 759 encountered Triassic (Carnian to Norian) rocks directly underlying the angular unconformity at 40.5 mbsf. The section drilled at this site was older than expected and extended the record of the oldest sediments drilled during DSDP/ODP activities to Late Triassic (Carnian/Norian, 231-215 Ma).

The lithologic units (Fig. 6) are summarized below in stratigraphic order from Carnian to the Quaternary. The lithofacies are diversified, with widely varying textures and sedimentary structures and minimal core disturbance.

Unit V: (308-205 mbsf; Carnian; the oldest marine rocks drilled by DSDP/ODP). This prodeltaic sequence is assumed to be upward-shallowing. This 103-m-thick sequence consists of silty claystone alternating with clayey siltstone and sand, dated on the basis of terrestrial palynomorphs (spores and pollen). The silty claystone is dark-gray to black, mostly laminated, and contains pyrite concretions (becoming abundant upward), thin siderite layers, lenses, or nodules, (decreasing upward), and rare sandstone. The presence of calcareous nannofossils in this unit indicates it to be marine. However, the lack of a normal shallow-marine mollusk fauna, the black color and high organic-carbon content, and the excellent preservation of laminations (= lack of bioturbation) all indicate that these sediments were deposited under restricted-marine, but low-energy conditions. The abundance of pyrite and siderite points to diagenesis under reducing conditions. Overall, these data suggest a distal prodelta setting, in a water depth between a few tens of meters to about 100 m (i.e., below wave base).

Unit IV: (205-135.9 mbsf; Carnian). A lithologically transitional unit between the unconformably overlying neritic carbonates of Unit III and the underlying siliciclastic sediments of Unit V. Parallel-laminated, massive, or bioturbated silty claystone and clayey siltstone are dominant in Unit IV. Coarser-grained clastic and carbonate interbeds are also present. Occasional coal seams are associated with silty horizons.

Unit III: (135.9-40.5 mbsf; Carnian). This sequence consists of an alternation of neritic carbonates and dark-gray, paralic, silty claystones, with a general upward increase in the proportion of carbonates. Palynologic evidence suggests that this unit unconformably overlies Unit IV, although the lower two cores in this unit are barren. Medium-grained quartz sandstone is common at some intervals. The succession represents nearshore fluviodeltaic to carbonate shelf environments. Several upward-fining transgressive sequences (sandstone or mudstone overlain by restricted-marine to open-marine carbonates) were identified in wireline logs between 200 and 130 mbsf. The best example is near the boundary between Units IV and III where a thick calcareous sandstone is overlain by a calcareous packstone containing oyster shells and coal fragments. A very high gamma ray (thorium) peak at this boundary indicates that a condensed section and a possible hardground formed during a landward migration of the strandline.

Unit II: (40.5-31 mbsf; undated). This unit consists of hemipelagic sand composed of foraminifer and quartz grains, along with downhole contaminants consisting of mixed microplankton of Quaternary to early Miocene age. It overlies the major unconformity above the Norian. The sand is inferred to be a lag deposit that was deposited during a long period of winnowing, non-deposition, and erosion possibly in the Cretaceous to Paleogene.

Unit I: (31-0 mbsf; lower Miocene to Quaternary). Pelagic foraminifer and nannofossil ooze. This unit consists of a 4.3-m-thick light-bluish gray to greenish-gray nannofossil ooze of early Miocene age, unconformably overlain by a 26.7-m-thick light reddish-brown to pink foraminifer nannofossil ooze of Quaternary age.

Discussion

The lithofacies of lower and middle Carnian Units V and IV represent a major upward-shallowing (regressive) sequence that grades from a marine, low-energy, nannofossil-bearing, distal prodelta facies at the base to a deltaic marginal-marine facies, and then to a swampy somewhat higher-energy muddy sandstone facies at the top of this unit. A seaward migration of the strandline is indicated by this facies change, which could have been produced by a drop in eustatic sea level and/or by the delta prograding northward from the Eastern Gondwanan continent toward the Neo-Tethys Sea. The presence of abundant siderite layers indicates early diagenesis under reducing conditions. A restricted distal prodelta setting seems most likely for the site in the Carnian, either facing the open ocean, like the present Niger Delta, or with adjacent carbonate banks which formed a partial barrier against the open marine Neo-Tethys Sea, like the present-day setting of the Mississippi Delta. Fluctuations in the spore:pollen ratio from 1:1 to 1:10 might indicate periodic alternations of relatively arid to relatively humid climate.

Preliminary results from carbonate lithofacies of Units III and IV suggest a marginal-marine, predominantly low-energy intertidal or subtidal setting (indicated by wackestone and perhaps by dolomite), with tempestite (indicated by grainstone) and higher-energy deposits (rudstone, oolites) on local carbonate shoals, bars, or in tidal channels. In general, however, the carbonate facies are mud-dominated, suggesting a low-energy, shallow environment. Fluviodeltaic progradation appears to decrease upward between Units IV and III. There is some indication of a few upward-shallowing cycles between 200 and 46 mbsf, with coal seams and sandstones around 190, 90, and 50 mbsf representing end points of the regressive cycles.

The Carnian rocks at Site 759 are unconformably overlain by a yellowish foraminifer quartz sand. Paleontological data suggest a hiatus of about 200 m.y. at this site, which was caused by the strong continuous denudation of the uplifted southern flank of the northward tilted Wombat Plateau horst. Because the site was drilled above the strongly truncated southern edge of the Wombat Plateau, it provided a "window" to sample the record of pre- and syn-rift margin history of the Exmouth Plateau and the oldest sediments yet recovered by DSDP/ODP.

SITE 760 (SOUTHEASTERN EDGE OF THE WOMBAT PLATEAU)

Site 760 (proposed site EP10A") is located at the top of Wombat Plateau near its southeast edge (Fig. 1). It lies about 5 km north-northwest (and downdip) of Site 759, at 16°55.32'S, 115°32.48'E, and at a water depth of 1969.7 m. Hole 760A was continuously cored by advanced hydraulic piston corer (APC) to a depth of 83.9 mbsf and by extended core barrel (XCB) to a depth of 284.9 mbsf. Hole 760B was RCB-cored between 89.9 m and 118.4 mbsf, drilled between 118.4 and 283.0 mbsf, and cored from 283.0 mbsf to a total depth (TD) of 506.0 mbsf. The total recovery of both holes was about 320 m. The relatively low recovery (59%) was due mainly to alternating hard (limestone) and soft (sandstone, mudstone) lithologies. Attempts to log failed below 150 mbsf because of severe bridging at sandy horizons.

Site 760 was drilled to retrieve the post-Norian Triassic, and possibly Jurassic, section which was missed at Site 759 due to the deep truncation of the uplifted, tilted, southeastern part of the Wombat Plateau horst (Fig. 2). However, drilling at Site 760 revealed that the main unconformity at Site 760 was still underlain by Upper Triassic and not by Jurassic sediments. Nevertheless, the site provided a valuable upper Carnian to Quaternary record which was subdivided into seven lithologic units (Fig. 7).

Unit VII: (506-464.05 mbsf; Carnian). The oldest sediments recovered at Site 760 consist of black to dark-gray, mostly parallel-laminated silty claystone with minor silty sandstone intercalations; siderite beds, lenses and nodules; pyrite; and a few mollusk-rich layers. The presence of nannofossils suggests an open-marine environment, and fine laminations (i.e., the absence of bioturbation and benthic life) indicate oxygen-depleted conditions in rapidly deposited, organic-rich, near-surface sediments. The environment of deposition of this unit could be a protected, low-energy tidal flat or lagoon, or an open-marine, deeper (>50-100 m) prodelta setting. Soft-sediment deformation, slump structures, and siderite beds in this unit resemble the same features observed in Unit V at Site 759, which was interpreted as deposited in a distal prodelta mud environment. However, the mollusk horizons and the sandier character at the base of Unit VII at this site are differences from Site 759.

Unit VI: (464.05-284.9 mbsf; Carnian to Norian-Rhaetian). The entirely siliciclastic Unit VII is succeeded by a variable sequence of alternating shallow-water carbonates and paralic clayey, silty, and sandy sediments. In general, a shallowing-upward trend can be observed between 506 mbsf (distal prodelta muds?) to 409 mbsf (lowermost coal occurrence). The lower part of this unit (460 to about 409 mbsf) contains calcite-cemented quartz sandstone; redeposited mollusk coquina; algal limestone rich in red algae and dasycladaceans; and oncolitic/oolitic pelsparite rich in mollusks, corals, and other bioclasts. These limestones include mud-dominated packstone, wackestone, and carbonate mudstone, and only minor grainstone. A fluctuating shallow-marine, quiet, intertidal (lagoonal) carbonate bank environment is inferred for these limestones. Of special significance, as marking the presence of an unconformity, might be a conglomeratic limestone (rudstone) found at 407 mbsf near the Carnian/Norian boundary.

The sequence between 405 and 284.9 mbsf is characterized by fluctuations from shallow-water (subtidal) carbonate environments (e.g., grainstone and wackestone with corals, ooids, peloids), to subtidal (lagoonal to back-bay) and intertidal settings, characterized by dolomite, algal mats, and mudstone containing mollusks and solitary corals. The carbonate facies is dominated by oyster-type mollusks and foraminifers, but also contains a few red algae and solitary corals characteristic of more temperate Tethyan associations. This shallow-water carbonate facies is randomly interbedded with dark-gray to black silty claystone with minor cross- to parallel-laminated siltstone and sandstone, documenting a fluviodeltaic (delta front to alluvial plain) setting. Commonly, an intertidal to supratidal environment is indicated by algal mats, claystone with rootlets, and local coal seams.

Units V and IV: (284.9-210.9 and 210.9-86.5 mbsf; Norian-Rhaetian). These units are characterized by siliciclastic sediments. In general, Units V and IV show an upward-shallowing (regressive) trend from marine, glauconite-bearing mudstone (inner shelf to lagoon) to marginal-marine, more sandy and silty deltaic sediments. The sediments of the lower siliciclastic Unit V were deposited in a shallow- to marginal-marine environment, probably in an estuarine, distributary bay, or tidal flat/channel setting, with a few excursions into subaerial delta plain to coal swamp conditions. However, fish debris, glauconite, and mollusks generally indicate a marine setting, whereas the upper siliciclastic interval (Unit IV) is predominantly nonmarine. This nonmarine unit is characterized by black silty claystone interbedded with clayey siltstone to silty sandstone. Several horizons with coal seams, root mottling, caliche, and soil profiles all indicate subaerial marsh, flood plain, delta channel, and coal swamp environments.

Unit III. (86.5-80.1 mbsf; post-Cretaceous to Eocene). This unit is a manganese hardground. The major angular unconformity between Norian and the overlying upper Eocene sediments spans a period of at least 110 m.y. The top of the late Norian sequence below the unconformity is a soil horizon with rootlets. Therefore, we infer that the post-Norian erosion of the Wombat Plateau started under subaerial conditions.

Units II and I: (80.1-21.7 and 21.7-0 mbsf; Eocene to Quaternary). This is eupelagic nannofossil ooze, which became more foraminifer-rich between late Pliocene and Quaternary times. Several hiatuses were noted, including a hiatus between upper Eocene and upper Oligocene sediments, a 3-m.y. hiatus separating the upper Miocene from the upper Pliocene, and a shorter hiatus separating the upper Pliocene from the Quaternary.

Discussion

If the conglomerate at 407 mbsf in Unit VI is in place, its composition of <5-mm-long pebbles of altered intermediate volcanics and volcanic glass, as well as mollusks and algal limestone fragments, suggests the erosion of pre-existing volcanic and carbonate rocks, perhaps during a transgressive event, and their deposition in a high-energy shallow carbonate bank environment. Rhaetian early-rift volcanics of trachytic to rhyolitic composition have been dredged from the northern Wombat Plateau (von Rad and Exon, 1983; von Rad et al., in press), and the described volcanic fragments might indicate an earlier (Norian) phase of early-rift volcanism in the Wombat Plateau area.

The alternation of shallow-water carbonate with deltaic, siliciclastic facies in the upper part of Unit VI can be explained by the lateral migration of delta lobes over a carbonate shelf. A delta lobe would have been covered later by another carbonate bank, after the deltaic depocenter switched laterally from a "delta abandonment facies" to a new position. This "Mississippi-type," migrating delta lobe model does not require necessarily a fluctuating sea level to explain the frequent alternation of both facies. However, sea-level rises and falls could have played an important role.

During the first 60 m.y. of post-Triassic subsidence in paralic to neritic environments, only a few meters of variegated claystone to silty sandstone was deposited in a setting where erosion and reworking prevailed. Later, the Wombat Plateau sank to bathyal water depths but continued to remain in a predominantly nondepositional realm (like the present-day Blake Plateau), as evidenced by several layers of manganese nodules with nuclei of yellowish carbonate to siliciclastic material. The uppermost layer of soft manganese nodules is 40 cm thick, and shore-based work on the age of the nucleus and subsequent laminae of these nodules may document important events in the history of this subsiding plateau between 90 and 50 Ma.

During the last 50 m.y. the Wombat Plateau subsided slowly to the present water depth. Color bands (15-30 cm thick) in the upper Oligocene to upper Miocene section, and equivalent 5-50-cm-thick color bands in the upper Pliocene to Quaternary section, may document Milankovich-type cycles on the order of 10^3-10^5 yr.

SITE 761 (CENTRAL PART OF EASTERN WOMBAT PLATEAU)

Site 761 (proposed site EP9E) is located on the central Wombat Plateau about 20 km north of Site 760 at 16°44.22'S, 115°32.10'E and in a water depth of 2167.9 m (Figs. 1 and 2). Hole 761B was continuously cored by APC to a depth of 89.7 mbsf and by XCB to a total depth of 286.7 mbsf. Recovery in this hole was excellent in the uppermost 96 m, but varied widely between 96 and 286.7 mbsf due to the presence of porcellanite layers. The overall recovery rate was 69.4%. Hole 761C was drilled down to 160.2 mbsf, recored the Cretaceous/Tertiary (K/T) boundary (between 160.2-179.2 mbsf), and then was drilled down to 230 mbsf to recore the interval of poor recovery in Hole 761B between 230 and 286.7 mbsf. Below this depth the hole penetrated Upper Triassic rocks (dated by palynomorphs) to a total depth of 436.7 mbsf. Recovery in the hard Triassic lithologies was very poor, with an overall rate of 32%. Bridging in sandy formations prevented our logging the open hole below 268 mbsf. However, a suite of geochemical logs was obtained by logging through the pipe. The objectives of Site 761 were similar to those of Site 760, with the additional objectives of retrieving a more complete Tertiary to mid-Cretaceous section to date the late Mesozoic-Cenozoic reflectors, and retrieving a younger, pre-angular unconformity Mesozoic (possibly Rhaetian to Liassic) stratigraphic section.

Drilling at Site 761 (Fig. 8) provided us with several important findings, including a nearly complete K/T boundary, a condensed Lower and middle Cretaceous and post-rift and post-breakup sequence, and a nearly complete marine Rhaetian sequence. The following lithologic units were identified in the cored section:

Unit VI: (436.7-427.1 mbsf; Norian). The Norian at the base of Hole 761C is characterized by black, more or less laminated, carbonaceous claystone with pyrite nodules and coal seams, which resemble the coeval paralic sediments described from Site 760. A paralic (marginal-marine to deltaic/coal swamp) environment with limited bottom-water circulation is inferred for this sequence. A sequence boundary lies above this unit.

Unit V: (427.1-338.3 mbsf; Rhaetian). The abrupt contact of the paralic claystone (Unit VI) with the overlying dark laminated marine claystone and crinoidal limestone of Subunit VB of Rhaetian age is marked by an intraclast floatstone at the base. This contact appears to be a sequence boundary, documenting a sea-level lowstand followed by a slow sea-level rise (transgression) which initiated the Rhaetian eustatic cycle (Haq et al., 1987). The overlying black claystone is rich in coccoliths and hence fully marine, and the interbedded crinoidal limestone indicates an open-marine, comparatively deep-water (i.e., deeper than 100 m) environment. In general, sedimentation in the lower Rhaetian Subunit VB is characterized by considerable terrigenous influx and probably greater water depths than the overlying upper Rhaetian Subunit VA. Based on logging results, the siliciclastic portion of Subunit VB contains fining-upward cycles which could indicate transgressions. During the late stages of the deposition of this subunit, open-marine shelf margin conditions prevailed when the strandline migrated landward during a sea-level rise.

The overlying lithologic Subunit VA (Rhaetian) is characterized by less siliciclastic material and slightly shallower water depths, probably 30-100 m (within the photic zone), judging from the presence of red algae and hermatypic corals. In general, the limestone of Unit VA contains a mollusk-coralline algal association, while the crinoids and ostracodes are mostly associated with the deeper-water, black claystone facies. Carbonate grainstone to packstone contains a microreefal association of red coralline algae and corals. Especially noteworthy are thalli of red algae ("rhodoliths") in life position within the mudstone. Some limestone types are dolomitized.

Unit IV: (338.3-259.5 mbsf; Rhaetian). This unit consists of white to very pale brown neritic limestone that was deposited in very shallow-subtidal, intertidal to littoral, or even supratidal settings. Within Unit IV, an upward-shallowing (regressive) trend can be recognized from the following observations: the lower part of the unit is dominated by wackestone and packstone with hermatypic, branching corals, indicating a protected low-energy lagoonal setting, whereas in the upper part well sorted, ooid-foraminiferal, peloidal grainstone, algal mats, and megalodonts prevail, indicating a perireefal, intertidal setting with sporadic supratidal exposure.

A hiatus of at least 80 m.y. above Unit IV marks the major pre-middle Cretaceous unconformity at Site 761. The conditions under which this erosional event above the upper Rhaetian have occurred may be ascertained by detailed isotopic studies of the cements filling dissolution cracks and vugs in the topmost Rhaetian limestones. The unconformity could be due to the post-Rhaetian (or post-Liassic) uplift of the plateau, followed by erosion, faulting, brecciation and cementation, and later submergence in the early Cretaceous, or it may be due to post-Rhaetian (Cretaceous?) drowning of the carbonate platform, followed by submarine dissolution and cementation.

Unit III: (259.5-255.4 mbsf; early Cretaceous [Neocomian]). A thin sequence of brown, unconsolidated, lithic quartzose sandstone grading upward into dark yellowish-brown, poorly sorted, quartzose, lithic, clayey sandstone rich in mollusks and belemnites, is overlain by a light yellowish-brown calcisphere-nannofossil clay to silty claystone (which belongs to Subunit IIC). We tentatively interpret these lithologies as representing a deepening (and fining?) upward sequence from (1) littoral to nearshore sandstone (heavy minerals, glauconite, and mollusks indicate reworking during a marine transgression) to (2) a moderately deep (midshelf?) environment for the belemnite-mollusc sandstone, overlain by (3) an outer shelf/upper slope, open-marine, hemipelagic setting for the nannofossil claystone (lithologic Subunit IIC). Alternatively, the presence of Mn micronodules throughout Unit III might indicate that most or all of this unit was laid down in a fairly deep environment with long intervals of nondeposition.

Unit II: (255.4-176.9 mbsf; Cretaceous [Neocomian-Maestrichtian]). A 20.4-m-thick section of slowly deposited, possibly Neocomian, sediment (Subunit IIC) overlies Unit III. It consists of light to dark yellowish-brown calcisphere-nannofossil chalk interbedded with four sepiolite/smectite beds which, according to the gamma-ray logs, might be several meters thick. This suggests a hemipelagic environment for the subunit, which originated during the subsidence of the Wombat Plateau to bathyal depths. Changes in the clay input caused rhythmic color banding over 20-30-cm intervals. The presence of thoracosphaerids (calcareous dinoflagellates) in large numbers points to "stressed" conditions, possibly in a hypersaline, restricted environment during the "juvenile" stage of Indian Ocean formation. Zeolite is present, as are a few porcellanite/chert nodules.

Subunits IIB and IIA represent Late Cretaceous pelagic deposition on the subsiding Wombat Plateau and consist of very pale-brown nannofossil chalk of Albian to Maestrichtian age. The chalk contains foraminifers and *Inoceramus* fragments. Local layers or nodules of porcellanitic chert, replacing radiolarian-rich foraminiferal chalk, and the presence of authigenic zeolite (clinoptilolite) suggest dissolution of skeletal opal, diagenetic silica mobilization, and reprecipitation as authigenic silicate (zeolite) or opal-CT.

An almost complete (but disturbed) K/T boundary was recovered in Hole 761B and an apparently complete, although slightly disturbed, one in Hole 761C. The boundary is marked by (?displaced) porcellanite fragments and by a sharp color contrast between the youngest Maestrichtian white chalk and the overlying bioturbated, very pale brown clayey nannofossil chalk of oldest Paleocene age. A broad peak of the gamma-ray and resistivity logs may have been produced by increased clay content and/or by the presence of porcellanite layers.

Unit I: (176.9-0 mbsf; Cenozoic). The K/T boundary is overlain by an expanded (53.2 m) Paleocene chalk sequence (Subunit ID). This comprises a rare complete Paleocene section with no detectable gaps in sedimentation (Fig. 9). The chalk contains several intervals with porcellanite nodules. The basal Paleocene is rich in clay and authigenic clinoptilolite. The Paleocene is overlain by lower to middle Eocene white nannofossil ooze with several layers of porcellanite (Subunit IC). The section above (Subunits IB and IA) consists of late Oligocene to Quaternary eupelagic, white bioturbated nannofossil ooze with faint color banding that is better developed upsection. The preservation of nannofossils and foraminifers (which increase in abundance toward the Quaternary) is excellent. Several hiatuses were noted, especially between the middle Eocene and upper Oligocene, the upper Miocene and upper Pliocene, and Pliocene and Quaternary sections.

Discussion

A puzzling feature of the sequence recovered at Site 761 is the pebbly mudstone containing coarse quartz and fragments of reworked crinoidal limestone at the base of Subunit VB. Two working hypotheses were developed by the shipboard sedimentologists to explain its origin: (1) A deeper-water origin by mass wasting: the sequence boundary between Units VI and V is a hiatus, during which the Wombat Plateau experienced block faulting followed by rapid subsidence and syndepositional erosion of the higher blocks, with mass flows or slumps of the lower blocks into moderately deep (>100 m) shelf depths. (2) The sequence boundary between Units VI and V is an unconformity. The sediments immediately overlying the unconformity (Subunit VC) contain abundant quartz similar to that frequently observed just above a coastal onlap. They are not the very first shallow shelf wedge deposits of the lowstand system tract. These are probably represented by the pebble of reworked ooid grainstone just above the sequence boundary, which does not belong to the Norian underlying sequence. Also the presence of crinoids indicates that the very first deposits above the sequence boundary were laid down in rather deep water. The time gap at the sequence boundary may have been caused by tectonic subsidence and/or by eustatic sea-level fluctuations.

Detailed work is needed to decide whether the upward-shallowing between Units V and IV was due to continued carbonate buildup (equaling or exceeding subsidence), sea-level drop, tectonic uplift, or a combination of these causes. The carbonate microfacies types of Unit IV (algal mats, skeletal wackestone and packstone, skeletal peloidal packstone and grainstone, and ooid grainstone) suggest a shallow-water (lagoonal) setting for most of the upper Rhaetian succession, rather than a bank edge (patch-reef) environment.

Although it is likely that the Rhaetian section at Site 761 is not entirely complete (truncated at its top and base, with a possible hiatus between Units VA and VB), there are striking similarities of these facies with those of the western Tethys in the Alps. In the western Alps the lower Rhaetian is mainly terrigenous, and dark-colored with bone beds and coquinas of the bivalve Rhaetavicula contorta, documenting a restricted-marine facies with condensed sediment intervals. There, the upper Rhaetian consists of carbonate rocks formed on patch reefs, associated with megalodonts and layers rich in the benthic foraminifer, Triasina.

The Rhaetian facies of the Northern (Austroalpine) Calcareous Alps of southern Bavaria can be directly correlated with the equivalent carbonate sequence in Units V and IV of Site 761, leading to the conclusion that it was deposited in the same major paleobiogeographic province of the Tethys. A major global cause, most probably paleoenvironment changes driven by eustatic sea-level cycles, must be the reason for this conspicuous similarity of facies. The Rhaetian at Site 761, as in the Alps and elsewhere (Haq et al., 1987), is represented by one major third-order sea-level cycle, with at least two fourth-order fluctuations occurring in the highstand systems tracts.

It is clear that at the end of the deposition of Unit III, the Wombat Plateau had subsided into moderately deep (outer shelf/upper slope) waters with terrigenous components (clay minerals, quartz, etc.) becoming successively more mixed with pelagic (nannofossil carbonate) constituents. Concentrated occurrences of belemnites (with glauconite and phosphorite) of mid-Cretaceous (especially late Aptian/Albian) age have been reported worldwide from many condensed sections representing major sea-level rise events; those on the Wombat Plateau are Neocomian.

Also of interest are several distinct layers of white, pale-brown to pink, massive, waxy "clay" in Subunit IIC, which were determined to be a sepiolite/smectite mixture by shipboard XRD analysis. Some sepiolite layers have sharp basal and gradational upper contacts, suggesting deposition by downslope movements. Two alternative hypotheses about the origin of sepiolites were discussed on board: (1) Altered volcanic ash or ash turbidites. The age of the deposit (Early Cretaceous) would favor this model as it precedes the Neocomian onset of drifting of the Gascoyne Abyssal Plain. During this time both the Joey Rise volcanic epilith west of the Wombat Plateau (Cook et al., 1978) and the large volcanic structure of the Wallaby Plateau (south of Exmouth Plateau) originated (von Rad and Exon, 1983). (2) Evaporitic precipitation of sepiolite in restricted lagoonal or sabkha settings during arid climatic conditions, and redeposition of the evaporitic clays into the adjacent margin sediments. One possible scenario is that the sepiolite clays formed in wide supratidal sabkhas during sea-level lows and were redeposited by turbidity currents downslope into the newly available deeper shelf/upper slope environment, whereas the transgressive periods are documented by calcisphere-nannofossil chalks. A major problem with this model is the lack of evidence for mixing of the sepiolite with clay and coarser terrigenous deposits. Another scenario is that the sepiolite clays are in-situ evaporites formed during desiccation periods of sea-level lowstands (or perhaps as deep-water evaporites), and that the calcisphere oozes below and above represent normal pelagic sedimentation during sea-level highstands. The presence of calcispheres indicates a pelagic environment far from the shoreline. Four such sepiolite mudstone/calcisphere cycles can be deciphered on the gamma-ray logs.

SITE 764 (NORTHERN FLANK OF THE WOMBAT PLATEAU)

Site 764 (proposed Site EP9F) is located very close to the northeastern edge of Wombat Plateau at 16°33.96'S, 115°27.43'E in a water depth of 2698.6 m (Figs. 1 and 2). The site is about 34 km north-northeast of Site 761. Hole 764A was continuously cored by RCB to a depth of 69.0 mbsf. Hole 764B was drilled in order to recover more material of the critical section over- and underlying the main Mesozoic unconformity. It was drilled to 40 mbsf and continuously cored by RCB to a total depth of 294.5 mbsf (Fig. 10). Recovery in the Upper Cretaceous to Neogene oozes was 40%-100%, but dropped dramatically to 10%-15% in the shallow-water Rhaetian carbonates. Only in the basal marlstone unit did the recovery rate increase again to about 66%. Logging was performed through the drill pipe because the bit could not be released after the completion of drilling. A suite of geochemical logs and gamma-ray/neutron porosity/density logs was obtained, which are helpful in reconstructing the lithologies in the poorly recovered units below 50 mbsf.

Seismic stratigraphic data had indicated that the Lower Mesozoic section underlying the main Mesozoic unconformity was expanded upward into a younger (uppermost Rhaetian to possibly Liassic) section northward from the location of Site 761. Although no Liassic section was recovered, drilling Site 764 was successful in recovering a considerably younger and more complete marine Rhaetian section than at Site 761.

Unit VII: (294.5-280.1 mbsf; Rhaetian). The oldest sediments recovered at Site 764 consist of very dark, clayey, partly recrystallized carbonate mudstone to wackestone with $CaCO_3$ contents of 57%-65% ("marlstone") and organic carbon contents of 0.2%-0.5%. These rocks are interbedded with light-gray carbonate mudstone with clay. Palynomorphs indicate a Rhaetian age. Crinoid fragments are common in the clayey carbonate mudstone. At Site 761, in-situ occurrences of crinoids were explained as indicating an open-marine, deeper-water (lower photic zone) environment. However, another explanation of this facies is that the crinoid fragments suggest the formation of coral reef barriers. The extensive bioturbation with a distinct ichnofacies of burrow types (worms and crustaceans?) suggests a nutrient-rich substratum and/or slow sedimentation rates, and possibly a lagoonal to back-reef mud-flat environment. The environment was certainly open-marine and low-energy: lagoonal (back-reef) or deeper-marine (deeper fore-reef slope, indicated by the presence of crinoids).

Unit VI: (280.1-72.5 mbsf; Rhaetian). This unit is a white to pale brown, reefal to perireefal sequence, of which less than 10% was recovered. It consists of a great variety of shallow-water platform limestones and related lithologies with well-preserved reefal structures and many macrofossils. Detailed microfacies work is necessary before the vertical and lateral evolution of carbonate paleoenvironments of this unit can be fully understood. Major lithologies include wackestone, packstone, grainstone, rudstone, and boundstone. In-situ sessile benthic fossils, such as colonial corals and green algae, are prevalent. Bryozoans, brachiopods, echinoderms, gastropods, and bivalves are also present. Coralgal limestone indicates that deposition was in the zone of the chlorozoan association (low-latitude, tropical belt) of the Tethys ocean. Oolitic and oncolitic grainstone points to a Bahaman-type, high-energy environment. Most limestones are highly porous with vugs filled partly by dogtooth calcite and partly by several generations of micrite and hematite-goethite. Coquinas were also observed.

These microfacies types signify either a highly agitated, well-oxidized carbonate bank environment or a reefal (backreef/forereef/reef platform) environment. The lower part of Unit VI consists of bioclastic rudstone and floatstone interbedded with wackestone and mudstone. This is interpreted as talus material on a forereef or back-reef slope or a ramp (the slightly inclined seaward slope of a carbonate bank). At least five cycles with the following upward sequence can be deciphered: packstone/wackestone (in-situ deeper marine fore-reef or ramp environment); rudstone/carbonate breccia (gravity mass-flow deposits, possible fore-reef talus); white oolite grainstones (Bahaman bank deposit, highly agitated); reefal boundstone/ bafflestone (central coral-reef buildup); grainstone, packstone, wackestone (possibly back-reef, intertidal); and carbonate mudstone (intertidal, lagoonal, quiet water).

Units V and IV: (72.5-49.3 mbsf; Rhaetian). Unit V represents a transgressive facies and consists of gray to dark gray alternating recrystallized clayey limestone and calcareous claystone. The depositional environment was probably open-marine and below wave base, possibly a protected lagoonal to intermediate shelfal position. The overlying Unit IV consists of lighter colored fossiliferous wackestone, packstone, and grainstone with *Triasina hantkeni*. The wackestone and packstone are partly dolomitized. Grainstone fines upward into wackestone and carbonate mudstone. These sediments were probably deposited in a well-oxygenated, quiet to moderate-energy environment with periodic current redeposition. Crinoids found in the wackestone and carbonate mudstone might indicate a deeper-marine (lower photic zone below 100 m water depth) environment.

A major unconformity with a 120-m.y. hiatus overlies the upper Rhaetian shallow-water limestone of Unit IV that is covered by Coniacian to Maestrichtian chalk.

Unit III: (49.3-41.5 mbsf; late Cretaceous [Santonian-Maestrichtian]). Much of the Cretaceous sequence at Site 764 has been eroded, and even the preserved part of the Upper Cretaceous is extremely condensed. Only 8.04 m of fossiliferous nannofossil chalk was deposited during Campanian to early Maestrichtian times, as compared to an 80-m-thick Coniacian/Santonian to Maestrichtian equivalent section at nearby Site 761. This may indicate strong winnowing by bottom currents at the outer edge of the Wombat horst during most of Late Cretaceous time. *Inoceramus* and other shell fragments are abundant in this unit, as is plant debris.

Units II and I: (41.5-0 mbsf; late Eocene to middle Miocene and Quaternary). During the Cenozoic, foraminifer nannofossil ooze was deposited, punctuated by at least one erosional hiatus, between Miocene and Quaternary sediments. The Cenozoic section is 175 m thick at Site 761, but thins out in a northerly direction, until at Site 764 the unconformity has cut into the

Maestrichtian. On the late Eocene unconformity a chalky gravel with Mn oxides was observed. Apparently a thin Mn crust was formed during an extended nondepositional period and later broken up by currents. Slumping and soft-sediment deformation was also noticed in this unit.

Discussion

Sites 761 and 764 together recovered a nearly complete marine Rhaetian section, including a thick unit of a reef complex and other shelfal carbonate environments. This expanded marine Rhaetian section is unique in the southern hemisphere, and represents two well-documented cycles of sea-level change corresponding to the global cycle chart (Haq et al., 1987). The lower sequence boundary was identified at Site 761 near the Norian/Rhaetian boundary, whereas the upper sequence boundary exists between Units V and VI above the reefal complex. The reef complex itself (Unit VI) represents the highstand systems track. The boundary between Units VI and VII within the last recovered core represents the maximum flooding surface (downlap surface), that is preceded by the transgressive systems track of Unit VII.

The reefal complex (Unit VI) was deposited during sea-level highstand. The cause of termination of carbonate buildup at the end of Unit VI time might be a sharp sea-level drop near the end of the Rhaetian, followed by a transgression (Unit V). Alternatively it could be due to accelerated tectonic subsidence which may have drowned the reef rather than exposed it. However, it is most likely that the boundary between reefal Unit VI and the overlying shallow-open marine Unit V is a sequence boundary. Unit V is only 16.6 m thick and probably characterizes a condensed transgressive facies.

CENTRAL EXMOUTH PLATEAU TRANSECT

SITE 762 (WESTERN PART OF CENTRAL EXMOUTH PLATEAU)

The main objectives of Sites 762 and 763 were to provide a transect of sites on the central Exmouth Plateau, where Site 762 is located distally and Site 763 more proximally to the terrigenous source of sediments being shed from the southern hinterland during latest Jurassic through Early Cretaceous times. Extensive seismic data in the area show a thinner Cenozoic section but a considerably expanded and hence stratigraphically important Lower to mid-Cretaceous section at Site 763, than that cored at Site 762 (Fig. 4).

Site 762 (proposed site EP12P) is on the central Exmouth Plateau at 19°53.24'S, 112°15.24'E, in 1360 m of water (Figs. 1 and 4). The site is about 2.5 km northeast of the Eendracht-1 industrial well site. Site 762 was designed to "twin" the almost unsampled upper part of Eendracht-1 to a depth of 940 mbsf. Hole 762B was continuously cored by APC to a depth of 175.4 mbsf with an excellent recovery rate of 99.77%. Hole 762C was drilled to 170.0 mbsf and continuously cored with XCB from 170.0 mbsf to 940.0 mbsf, an ODP depth record for XCB coring. Core recovery at Hole 762C was moderate to fair with 534.64 m recovered (69.4%). A significant proportion of this recovery is, however, in the form of sediment slurry between "biscuits" of relatively intact sediment. During Leg 122 this form of core disturbance was more common when coring with the XCB than with the RCB. Altogether, three runs of downhole logging (seismic-stratigraphic combination, geochemical tool, and lithoporosity combination) were successfully performed using the side-wall entry sub and the free-fall minicone. Unfortunately, the neutron density tool was lost and could not be recovered.

The main objectives of drilling Site 762 were (1) to provide documentation of Lower Cretaceous to Quaternary depositional sequences and cycles of sea-level change in an area with excellent seismic-stratigraphic and commercial well control, and (2) to study the Cretaceous and Tertiary paleoenvironments during the late rift, juvenile ocean and mature ocean stages of a sediment-starved passive continental margin. This site, together with central Exmouth Plateau Site 763, will furnish data that will help isolate tectonic, sedimentary, and eustatic signals in testing sequence-stratigraphic models, and enhance our knowledge about the Cretaceous paleoenvironmental evolution of the area. Pre-site information from the Eendracht-1 well (including seismic surveys and downhole logging) was very helpful in planning Site 762. This was not only advantageous for predictions of stratigraphy, but it was also a prerequisite of the JOIDES Pollution Prevention and Safety Panel (PPSP) to safeguard against the hazards of drilling in an area of known substantial gas occurrence. A seismic profile is shown in Figure 11.

The following lithologic units were identified at Site 762 (Fig. 12):

Unit VI: (940.0-848.5 mbsf; Berriasian-Valanginian). This unit is a restricted, shelf prodelta, black, organic-rich silty claystone and clayey siltstone of early to middle Berriasian age (based on dinoflagellate and nannofossil evidence). These rocks come from just above the base of the Barrow Group equivalent sequence which, according to Eendracht-1 data, has a total thickness of about 140 m in this distal setting. The Berriasian to Valanginian clastic wedge prograded from southeast to northwest across the Exmouth Plateau, and reaches a maximum thickness of 1500 m on the central plateau far to the east of Site 762 (Erskine, in press). This clastic wedge, which was deposited in less than 7 m.y., is part of a system of prograded siliciclastic continental margin sediments deposited in a variety of settings including alluvial plain, deltaic, submarine canyon/fan, and deeper basin plain. A sequence-stratigraphic interpretation of this expanded, high-sedimentation rate progradational wedge, which was deposited in three cycles between the basal Berriasian (128.5 Ma) erosional unconformity and the top-Valanginian (121 Ma) unconformity, is given in Erskine (in press).

Unit V: (848.5-838.5 mbsf; lower Aptian). The Berriasian to Valanginian clastic wedge is truncated by an erosional unconformity, probably documenting an earliest Aptian sea-level drop. The overlying black calcareous claystone of Unit V (Muderong Shale equivalent) is only 10 m thick, suggesting low input of terrigenous material to this transgressive marine unit deposited during rising sea-level (Erskine, in press). The lower part of the unit is still black, pyritic, moderately organic-rich claystone (1%-4% $CaCO_3$, 0.8% organic carbon). The unit grades upward into lighter-colored, more calcareous material.

Unit IV: (838.5-554.3 mbsf; lower Aptian to upper Maestrichtian). This unit (Gearle Siltstone equivalent) is characterized by hemipelagic chalk/marl (clayey chalk and calcareous claystone) sedimentation in the lower part (838.5-780 mbsf) and by pelagic chalk sedimentation in the upper part (780-554 mbsf). During the Aptian, hemipelagic nannofossil clayey chalk (marl) (56%-83% $CaCO_3$) was first deposited on the Exmouth Plateau (Subunit IVE). A sharp downward velocity decrease is seen between the marl/chalk and the underlying mudstone, which is ascribed to changes in the degree of induration. The clayey chalk is overlain by marked, 10-30-cm-thick cycles of alternating light-colored chalk and dark-colored clayey chalk (marlstone) (Subunit IVD). These cycles correspond to about 35-100 k.y. The minimum $CaCO_3$ values of the clayey chalk increase from about 54% at the base of the unit to 78% at its top. Anastomosing pressure-suture seams or "microstylolites" in the chalk document pressure solution under deep-burial conditions. Microstylolites occur between 660 and 840 mbsf and increase in frequency downward.

The section between 780.0 and 697.0 mbsf (Subunit IVC) is characterized by light greenish to white, more or less homogeneous chalk (88%-92% $CaCO_3$)

without chalk/marl cycles, interbedded with very thin (1-4 cm), green, calcareous claystone layers which might represent rare events of terrigenous input into a predominantly chalk environment, or layers compacted by stylolitic development. The interval between 697.0 and 554.3 mbsf (Subunits IVB and IVA) is typified by upper Santonian to upper Maestrichtian eupelagic chalk. The upper Campanian to lower Maestrichtian (Subunit IVB) is characterized by reddish-brown chalk which contrasts with the over- and underlying (light) greenish gray chalks, not only in color and composition (somewhat higher $CaCO_3$ contents), but also in the gamma-ray log response (higher values). Pressure solution (microstylolites) is as common in this subunit as in the underlying ones. Inoceramus prisms are abundant. This subunit was probably deposited in bathyal water depths (around 1000 m), with more oxidizing bottom waters than either before or after this period. The overlying section (Subunit IVA) is upper Maestrichtian chalk characterized by high carbonate contents and light greenish colors with alternations of chalk (82%-95% $CaCO_3$) and clayey nannofossil chalk (56%-70% $CaCO_3$) in 20-50-cm cycles. The chalks are highly bioturbated, showing well-preserved Planolites- and Zoophycos-type burrows. Thin claystone interbeds spaced about 40-150 cm apart indicate periodic input of terrestrial clay into this carbonate-dominated eupelagic environment.

An incomplete K/T boundary was recovered at 554.3 mbsf between nannofossil zones NP1 and NK20, and a nearly 3-m.y. record might be missing. The boundary is marked by color and compositional changes, as well as a distinct upward increase in gamma-ray values.

Unit III: (554.3-265.0 mbsf; lower Paleocene to middle Eocene). This unit documents eupelagic carbonate deposition in bathyal water depths (>1000 m) and a high degree of bioturbation. Individual large Zoophycos-, Planolites-, and Teichichnus-type burrows, as well as small Chondrites, Helminthoidea, and a great variety of as-yet-undetermined trace fossils are present. Terrigenous clay input peaked during the early Paleocene, just above the K/T boundary, with claystones and chalks (marls) containing only 43%-63% $CaCO_3$. The paleoenvironmental significance of this comparatively high clay influx in the early Paleocene might be explained by a global sea-level lowstand during which the site was receiving resuspended sediments from a nearby shoreline. Upsection, the clay content decreases rapidly. A well-developed rhythmicity in color alternations of chalk/marl cycles is observed in Unit III. It is not clear whether these cycles are due to changes in surface productivity (nannofossil input) or terrigenous clay input, or a combination of both factors.

Units II and I: (265.0-0 mbsf; middle Eocene to Quaternary). These units are characterized by eupelagic deposition of foraminifer nannofossil ooze in a bathyal environment, similar to the modern analog where almost no terrigenous material reaches the isolated central Exmouth Plateau. Sedimentation rates vary, but are generally lower in the Miocene-Oligocene than in the early

Paleogene, and sedimentation is interrupted by several hiatuses (e.g., between the lower and middle Miocene), which document erosive bottom currents. A similar depositional regime can be observed presently on the top of the plateau with very low deposition rates, winnowing, or even periodic erosion. Porcellanite nodules are present in the lower upper Eocene, documenting the well-known global peak of silicoplankton fertility (and silica preservation). Blooms of Braarudosphaera bigelowii in the upper lower Oligocene to lowermost Miocene might indicate a "stressed" environment. In general, foraminiferal content increases upsection to the Quaternary, which contains 20%-50% planktonic foraminifers. It is not clear whether this increase is due to changes in the productivity of foraminifers against a background of nannofossils, to solution effects, or to winnowing by bottom currents.

Discussion

Site 762 was, in the early Cretaceous, located at the most distal, basinward part of the prograding clastic wedge (Unit VI) in a relatively deeper water (150-300 m) basinal, "shelf-margin prodelta" setting (Fig. 4). At the time of continental rifting, the central Exmouth Plateau was an epicontinental, restricted marginal sea with a maximum depth of about 300 m (based on seismic profiles with delta clinoforms), which might be compared to the present-day Yellow Sea in front of the Hoangho delta, or the northwestern Black Sea in front of the Dnepr delta. The shelf break was almost at the site of commercial well-site Investigator-1, 90 km to the southeast, with canyons and submarine fans north of this site, and a basin plain with silty claystone deposition further seaward including the location of Site 762. The silty claystone contains only 1%-5% carbonate, but appreciable percentages of terrigenous quartz, mica, feldspar, glauconite, and pyrite. Clay minerals are dominant, and include mainly kaolinite and illite (with traces of smectite), a typical association of weathering products transported by rivers from continents during periods of humid climate. Large dolomite concentrations are most likely indicative of a restricted environment. Mollusk shells are common. Nannofossils are very rare, whereas glauconite increases downhole. A number of thin limestone beds occur near the top of Unit VI. These may indicate a sea-level highstand (with cementation during sediment-starvation) preceded by transgressive sediments and followed by a brief highstand systems tract. According to this interpretation, a complete Valanginian sea-level cycle might be present at the top of Unit VI. Many belemnites were found within the highstand systems tracts, as at Site 761.

The black organic-rich sediments of Unit V mark the onset of open-marine, "juvenile-ocean" sedimentation (Veevers and Johnstone, 1974) in a shelf or upper slope setting. The presence of the benthic foraminifer, Epistomina, may indicate shelf depths below 200 m. The base of the unit was deposited under poorly oxygenated conditions (perhaps corresponding to the postulated global Aptian anoxic event) which gradually improved upsection.

The presence of dinoflagellates and coccoliths indicates the gradual transition to fully marine conditions, also documented by the transition from a siliciclastic to a carbonate-dominated environment.

During the early Aptian, sea-floor spreading commenced at the western and southern margins of the Exmouth Plateau, forming the Gascoyne and Cuvier Abyssal Plains and marking the final separation of "Greater India" from Australia. In this sense, the Aptian transgression of the central Exmouth Plateau coincides with continental breakup, and the unconformity underlying this unit could be called a "breakup unconformity."

The deposition of chalk of Unit IV marks the onset of carbonate sedimentation under open-marine conditions, representing the continuation of the "juvenile-ocean stage" (Veevers and Johnstone, 1974). This development is indicated by the increasing abundance of planktonic foraminifers and coccoliths, suggesting an epicontinental pelagic environment similar to that under which the northwestern European Upper Cretaceous chalks were deposited. Sluggish circulation with oxygen-depleted (to anoxic?) conditions, like those probably in effect during deposition of the lower Aptian Unit V, recurred at the Cenomanian/Turonian boundary. The Cenomanian/Turonian boundary event, a global sea-level highstand and "stagnation" event, is marked at Site 762 by a 20-cm-thick organic-rich shale layer and a thin (3 cm) "black shale" layer.

Slow, ongoing subsidence of the Exmouth Plateau during late Cretaceous time gradually changed the environment from siliciclastic-dominated (Units VI and V) to transitional hemipelagic (Subunits IVC and IVD), and finally, to an eupelagic carbonate-dominated facies (Subunits IVB and IVA). An unusual finding was a downhole increase in porosity and decrease in sonic velocity within Subunit IVB, which indicates a slightly overpressured interval. High values of thermogenic methane were recorded in headspace gas from 970.0 to 510.0 mbsf, in Units VI to III. This methane is believed to have traveled up faults from Triassic source beds, and to have been partially trapped beneath Paleocene clayey chalk.

Post-cruise correlation of the results of Sites 762 and 763 to well-established seismic stratigraphy and biostratigraphic determinations, both from this leg and from numerous commercial wells, will provide a three-dimensional view of this clastic continental margin wedge and a better understanding of its evolution during Berriasian to Valanginian times.

SITE 763 (CENTRAL EXMOUTH PLATEAU)

Site 763 (proposed site EP7V) is located about 84 km south of Site 762 on the western part of central Exmouth Plateau at 20°35.19'S, 112°12.52'E in a water depth of 1367.5 m (Figs. 1 and 4). The site is about 1.2 km east of the Vinck-1 commercial well site. The site was designed to "twin" the virtually unsampled upper part of this well to a maximum depth of 1125 mbsf.

Hole 763A was continuously cored using APC to a depth of 194.9 mbsf with 103.6% recovery. A reentry cone was set at Hole 763B, and the hole was drilled to 190 mbsf, then continuously cored by XCB to 653.5 mbsf. When the coring reached 590 mbsf an intermediate logging run was made and the interval 570-375 mbsf was logged. The purpose was to compare precisely the level of stratigraphic boundaries at Site 763 with the Vinck-1 well, as requested by the JOIDES Pollution Prevention and Safety Panel. This was mandated to ascertain whether these boundaries were at the same level or lower in Hole 763B than in Vinck-1.

Coring resumed in Hole 763B, but the core barrel became stuck at 653.5 mbsf, and the hole had to be abandoned. Hole 763C was drilled to a depth of 385 mbsf, an RCB-core was taken between 385.0 and 394.5 mbsf to recore the Cenomanian/Turonian boundary, drilling continued to 645 mbsf, and continuous RCB-coring resumed to the TD of 1036.6 mbsf. The recovery rate of the rotary-cored Hole 763C was approximately 83%, a better recovery rate with less disturbed material than in the equivalent XCB-drilled section at Site 762. Coring at Hole 763C was stopped at 1036.6 mbsf (about 81 m shallower than the originally planned TD), due to a sudden increase in hydrocarbon gas content which had not been predicted. Logging with the NGT and Dual Induction-LSS-NGT tools was possible only between 690 and 200 mbsf because of bridging and rapidly deteriorating hole conditions due to caving of Lower Cretaceous claystone.

The major objectives in drilling Site 763 were documentation of Cretaceous depositional sequences, including dating hiatuses and sequence boundaries, and the testing of sequence-stratigraphic and eustatic models. A seismic profile across the site is shown in Figure 13. The following lithologic units were identified at Site 763 (Fig. 14):

Units VII and VI: (1036.6-622.5 mbsf; Berriasian to Valanginian). A shelf margin prodeltaic environment (Barrow Formation equivalent). This progradational clastic wedge has already been described at Site 762. Because Site 763 is considerably more proximal to the terrigenous source area than Site 762, the Barrow Formation equivalent is nearly three times thicker at Site 763 than at Site 762.

The oldest sediments recovered at Site 763 are homogeneous, very dark gray, silty prodelta claystone, which were deposited rapidly (60 to >100 m/m.y.) on a prodelta slope in a few hundred meters of water. Upsection, the occurrence of siderite beds, siderite concretions, and/or sideritized burrows increases, as does the content of glauconite and pyrite. The overlying sediments are characterized by alternation of black, silty claystone with a few calcite-cemented sandstone interbeds. The unit was deposited on a possibly restricted delta slope with water depths of less than a few hundreds of meters. Whether the high organic content is due to anoxic bottom water, rapid sedimentation rates, or reducing conditions in the sediment cannot yet be determined.

The overlying Subunit VIB consists of 17.1 m of well-sorted medium-grained sandstone that was recovered only in trace amounts, but whose presence is clearly demonstrated by the logging results. The sandstone is interbedded with structureless to weakly laminated silty claystone with pyrite nodules, plant debris, and pelecypods, but little glauconite. Subunit VIA is black, organic-rich, sandy/silty claystone to clayey siltstone with a few glauconitic limestone interbeds. This 21-m-thick condensed section is marked by an abundance of belemnites in its upper part (middle Valanginian).

Unit V: (622.5-570 mbsf; early Aptian). This unit consists of a 52.5-m-thick section of dark gray to black, organic-rich claystone to clayey sandy siltstone with minor limestone nodules and interbeds (Muderong Shale equivalent). This is a considerably expanded lower Aptian transgressive section, as compared to the 10-m-thick equivalent Unit V of Site 762. Glauconite pellets are especially abundant, as are terrigenous grains such as silt- to sand-sized quartz and altered feldspar. Secondary minerals include pyrite, a typical early diagenetic mineral in oxygen-depleted environments, and zeolites (probably clinoptilolite), which commonly occur in carbonaceous mid-Cretaceous claystone. The claystone shows strong signs of compaction. Organic carbon contents range from 0.3% to 1.8%. Thin-shelled ammonites also occur in this unit. The foraminiferal record is poor, but the few gavelinellid and epistominid benthic foraminifers suggest a restricted-marine environment, most probably a poorly oxygenated, middle to inner(?) shelf environment with strong terrigenous influx. The absence of planktonic foraminifers and the rare occurrence of calcareous nannoplankton may point to a semienclosed marginal sea environment, possibly with reduced salinity.

Unit IV: (570-389.5 mbsf; middle Aptian-early Albian to late Cenomanian). This is hemipelagic chalky claystone (Gearle Siltstone equivalent), similar to that at Site 762. The first hemipelagic sediments were deposited in the middle to late Aptian, and consist of greenish-gray, zeolitic nannofossil calcareous claystone (marlstone). This 184.3-m-thick unit is about 10 times thicker at Site 763 than the equivalent section at Site 762, and was deposited in an open-marine environment at bathyal water depths. Terrigenous supply was reduced, and the heavy mineral assemblage suggests that it was possibly derived from a source dominated by metamorphic rocks. According to foraminiferal faunas, however, most of the Cenomanian section is not a normal pelagic facies.

The hemipelagic nature of the calcareous claystone is characterized by biogenic contents of about 20%-40% nannofossils and less than 15% foraminifers, the presence of quartz, feldspar, mica, heavy minerals, and glauconite (<10%), and a downhole increase in clay content. Bioclasts include Inoceramus prisms, other pelecypods, and belemnites. Bioturbation is extensive, with distinct individual trace fossils (Zoophycos, Planolites, Teichichnus, Chondrites) present. Authigenic zeolites are very common (10%-15%) in this calcareous claystone, as are hard interbeds of recrystallized carbonate (dolomite or siderite?) that occur in the lower part of the unit (Subunit IVB). Color cycles (40% $CaCO_3$ in dark, 70% $CaCO_3$ in light layers) are common, with a maximum of 4-5 cycles per section, corresponding to about 20-40 k.y./cycle. This unit has the highest contents of thermogenic methane (and ethane) experienced at Site 763 (with the exception of the basal two cores of Unit VII).

Unit III: (389.5-247.0 mbsf; Turonian to upper Campanian). Eupelagic chalk equivalent to Toolonga Calcilulite on land. Lithologic Unit III is represented by a 138.7-m-thick sequence of Turonian to upper Campanian light greenish-gray nannofossil chalk with foraminifers, with alternating color bands or cycles. Like Unit IV, this unit is extensively bioturbated. At the base of the unit two thin black layers mark the global Cenomanian/Turonian boundary anoxic event. They separate upper Cenomanian clayey nannofossil chalk and chalky claystone from lower to middle Turonian nannofossil chalky claystone. The contact with overlying Turonian chalk was not recovered. The zeolitic black claystone of these layers is structureless to laminated or bioturbated, contains 9%-15% organic carbon, and was probably deposited during conditions of complete to partial bottom water stagnation. The $CaCO_3$ content in Unit III gradually decreases downsection. As at Site 762, rhythmic alternations between light-colored (85%-90% $CaCO_3$) and darker-colored beds (70%-75% $CaCO_3$) are very common. They correspond to cycles with a duration of 20-60 k.y. The upper part of the thin Subunit IIIA shows an upward-coarsening trend with increasing proportions of rounded quartz, glauconite, pyrite, and Inoceramus prisms (especially in the upper 25 cm). The major ooze/chalk boundary at Site 763 coincides with the boundary between Units III and II.

Unit II: (247.0-141.7 mbsf; middle Eocene to lower Miocene). The 348-m-thick upper Campanian to middle Eocene sediments recovered at Site 762, including the K/T boundary, were missing at Site 763. Middle Eocene white chalk directly overlies upper Campanian chalk at this site. Foraminiferal assemblages just above the unconformity contain up to 60% reworked Campanian, Paleocene, and lower Eocene foraminifers and nannofossils. Deposition of the middle Eocene chalk took place in an open-marine, pelagic environment. The lower part of this unit (Subunit IIB) is composed of white nannofossil ooze which is less indurated than the overlying sequence of white, semi-lithified foraminifer-nannofossil chalk to ooze (Subunit IIA). This inversion of the normal induration trend might be due to the comparatively high content of H_2S in Subunit IIB, which might have inhibited the ooze to chalk transformation. Subunit IIB shows only minor contents of finely disseminated pyrite, whereas the underlying Unit III contains abundant pyrite, indicating the presence of Fe^{2+} in the pore waters, necessary for the formation of pyrite.

Unit I: (141.7-0 mbsf; lower Miocene to Quaternary). Lithologic Unit I is characterized by a comparatively high (15 m/m.y.) rate of sedimentation (Fig. 9) of eupelagic nannofossil ooze with abundant foraminifers and very small contents of terrigenous quartz and clay minerals. The color grades from white at the base of the unit to gray at its top, which correlates with an upward increase of clay content to about 15%. Nannofossils and foraminifers (the latter increasing in abundance upward) are well preserved.

Discussion

The quartz sandstone of Subunit VIB may represent the rare discovery of a basin-floor fan deposit, documenting the major early Valanginian sea-level lowstand with an underlying Type I sequence boundary corresponding to the 126-Ma sequence boundary on the global cycle chart (Haq et al., 1987, 1988). Alternatively, the sand may represent channel fill within the lowstand systems tracts above this boundary. The glauconite, pyrite, shell fragments, belemnites, quartz, and calcareous concretions in Subunit VIA indicate that it was most likely deposited during a sea-level rise (transgressive systems tract). Hauterivian to Barremian time is represented by a major hiatus at Site 763 which probably marks the post-Neocomian and pre-Aptian erosional event following initiation of the breakup of the western margin of the plateau ("breakup unconformity").

Palynomorphs of Unit V suggest normal marine conditions in the lower part of the unit (transgressive or highstand), and a possible sea-level lowstand in the earliest Aptian, indicated by large terrigenous content, spores, and wood in the upper part. The hemipelagic marls of Unit IV may represent normal "juvenile ocean" sediments following the earlier breakup of the central Exmouth Plateau area.

Slow ongoing subsidence of the Exmouth Plateau during the middle Late Cretaceous and the removal of a sediment-shedding southern source area (in the area of the present Cuvier Abyssal Plain) due to northwestward drift of this continental fragment gradually changed the environment from hemipelagic with considerable terrigenous supply (Unit IV) to a eupelagic, carbonate-dominated setting in Unit III (mature ocean stage). A condensed sequence or a hiatus (covering most of the Coniacian to Santonian) marks the boundary between Subunits IIIB and IIIC (353 mbsf).

The dramatic 30-m.y. hiatus between Units II and III at Site 763, which does not occur at Site 762, might be explained by increased bottom-water circulation in the area, in the latest Cretaceous to early Tertiary. Alternatively, it may have been caused by tectonic uplift in the Paleogene of the southern hinterland and its immediate foreland, which caused widespread erosion of pelagic sediments at Site 763, but not at Site 762 where deposition in a deeper margin environment continued. This unexpected finding suggests vertical tectonics and/or enhanced bottom current circulation for extended periods during the Late Cretaceous to early Paleogene. Sedimentation rates decreased dramatically during deposition of the carbonate sediments of Unit II: from 10 m/m.y. during middle Eocene to late Oligocene time (Subunit IIB), to about 2 m/m.y. from late Oligocene to middle Miocene time (Subunit IIA). Higher sedimentation rates might also have been the reason for the somewhat higher degree of induration of Subunit IIA (oozes exposed longer at the sediment/seawater interface).

Paleontological data show several dramatic hiatuses that have been accurately dated. The major ones occur in the middle Miocene, between the Campanian and middle Eocene, and in the Hauterivian, Barremian, and late Berriasian. Possible breaks in the early Santonian and middle Aptian have also been noted. Interesting differences in sedimentation history between Sites 762 and 763 will be investigated in detail during post-cruise studies. Precise biostratigraphic control will enhance sequence stratigraphic analyses of the two sections.

Headspace gas values of up to 85,000 ppm methane occur between 600 mbsf and 300 mbsf in Units V-III. The methane appears to be thermogenic and to have moved up faults from the Triassic, and to be partially trapped beneath late Cretaceous chalk.

CRUISE HIGHLIGHTS

Leg 122 results contribute new data that bear on the tectonic, sedimentary, and paleoenvironmental evolution of passive continental margins typified by the Exmouth Plateau. Highlights of these results at the time of the conclusion of the cruise were as follows:

1. On the Wombat Plateau we documented an unconformity between late Carnian and Norian which marks an earlier episode of block-faulting and constrains the timing of the reactivation of the northern Exmouth Plateau Hinge Zone.

2. Validating seismic horizons on the Wombat Plateau by constraining the ages of prominent reflectors demonstrates that the major rifting and block-faulting in the region occurred in the Early to Middle Jurassic (pre-Callovian). The steep north and south escarpments of the plateau developed at this time, culminating in the formation of the Wombat half-graben to the south, rift-flank tilting of the Wombat horst and initiation of the formation of Argo Abyssal Plain to the north. Pre-rift strata were tilted gently to the north and may have been subaerially exposed and eroded by wave action. Further tilting at a later time slowly developed a more accentuated northward slope as the now-coupled Argo Abyssal Plain sank. The unexpected complete absence of Jurassic sediments on the Wombat Plateau is also a testament to this major rift stage and its aftermath. Seismic and industry well site data suggest that on the central Exmouth Plateau the block-faulting event can also be dated as Early to Middle Jurassic, and is marked by an unconformity between the Triassic Mungaroo Sandstone equivalent strata and the thin Oxfordian-Kimmeridgian Dingo Claystone equivalent sediments.

3. Biostratigraphically constrained dating of the unconformities on the central Plateau has considerably narrowed the age of the breakup of the western and southern margins of the Exmouth to Hauterivian-Barremian. The breakup is constrained by the major erosional unconformity between Valanginian and early Aptian time.

4. The middle Eocene unconformity at Site 763 that eroded down into the Maestrichtian sediments most likely occurred because the site was on a relative structural high, and was therefore eroded and preferentially planated as compared to the section at Site 762.

5. The first known occurrence of carbonate on the Exmouth Plateau derived from the Tethys Ocean in the early to middle Carnian, when purely marginal marine clastics graded into interbedded carbonates and deltaic facies. We recovered an over 900-m-thick sequence of Triassic sediments of which 30% are carbonates and the remainder are low-energy paralic to fluvio-deltaic facies. Active delta-lobe migrations modify the stacking patterns in the latter facies. In the Rhaetian, the Wombat Plateau developed a carbonate platform type setting. The recovery of an almost complete marine Rhaetian

succession is the exception outside western Europe, with which it shows remarkable similarities.

6. Recovery of the thick prograding distal-shelf margin sequence of the Berriasian-Valanginian (Barrow Group equivalent) will be important in the understanding of depositional processes in clastic wedges by comparison with modern clastic depositional systems, such as the Gulf Coast sequences. Dinoflagellate assemblages in these sediments, which otherwise lack microfossils, will be extremely helpful in narrowing down the age of various prograding subunits.

7. The hemipelagic sediments of the Albian-Cenomanian characterize the "juvenile ocean" stage in the evolution of this margin, and the change to purely pelagic sedimentation in the Turonian represents the beginning of the "mature ocean" margin stage.

8. In the recovered stratigraphic record, where tectonic events can be isolated, sea-level fluctuations can be deciphered from sequence stratigraphic analysis of seismic, litho- and biofacies, and well-log data. These considerations document important sequence boundaries on the Wombat Plateau between the middle and late Carnian, at the Norian/Rhaetian boundary, and in the latest Rhaetian, whose timing and relative magnitude conform well with the eustatic cycle chart (Haq et al., 1987). In addition, the sequence boundary and systems tracts recognized in the central Exmouth Plateau Barrow Group equivalent strata also correspond well to the global cycle chart. These preliminary results are of considerable importance in providing a test of the validity of the eustatic model.

9. Discovery of diverse Carnian-Rhaetian calcareous nannofossils on the Wombat Plateau represents the oldest known occurrence of this fossil group, which will help elucidate their early evolutionary history and may help biostratigraphic subdivision of the late Triassic. The recovery of an expanded Paleocene sequence at Site 761 with well-preserved foraminifers, nannofossils, and radiolarians with be very helpful in resolving magnetobiochronologic issues for this rarely cored interval. It also offers the opportunity to establish a Paleocene zonation for the Radiolaria for the first time. Stable-isotopic analyses of the Paleocene section and across the apparently complete K/T boundary interval will also provide previously scarce data for this important interval.

10. Rock-Eval pyrolysis of the sediments on central Exmouth Plateau indicates the organic matter to be land-derived. Organic-carbon values are generally low (1% or less) in the cored intervals, but increase to 15% in the thin black shale layers at the Cenomanian/Turonian boundary. Hydrocarbon gases show peak concentrations in the Upper Cretaceous chalk. The deep-sourced gases bypass the Lower Cretaceous clastic sequence of the Barrow equivalent strata through faults, into the Upper Cretaceous chalk which acts as a

barrier to further upward migration of gases so that their pore waters become charged with dissolved methane.

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FIGURE CAPTIONS

Fig. 1: Location of ODP Leg 122 drill sites (large dots) on the Exmouth Plateau, off Northwestern Australia. Commercial well sites are also indicated (small dots). Bathymetry given in corrected meters. Modified from von Stackelberg et al., 1980.

Figure 2. A. South-to-north multichannel seismic line across the eastern Wombat Plateau. Line was collected by the Australian Bureau of Mineral Resources (BMR) vessel, Rig Seismic, using a 48-channel seismic cable and two 500-in.^{3} air guns. Data were processed at BMR. Vertical exaggeration = 20X. TD = total depth.
B. Interpreted multi-channel seismic section of the Wombat Plateau showing the location and depth of penetration of Sites 759, 760, 761, and 764. Letters within the seismic profile refer to ages as follows: N=Neogene, P=Paleogene, K=Cretaceous, Rh=Rhaetian, Nr=Norian, and C=Carnian.

Figure 3. Composite lithologic and age column for the four Leg 122 sites on the eastern Wombat Plateau. The lithologic legend applies to all Leg 122 sites. Wavy lines between chronostratigraphic boundaries indicate a hiatus. Depth is given in meters below seafloor (mbsf).

Figure 4. A. South-to-north single-channel water-gun seismic line from the south-central Exmouth Plateau. Unprocessed line was collected by JOIDES Resolution. Vertical exaggeration = 10X.
B. Interpreted single-channel seismic line through Sites 762 and 763 on the central Exmouth Plateau. Notice the thinning of the clastic wedge (Units VI and VII) and the thickening of the lower Tertiary sequence (Unit II) from south to north.

Figure 5. Comparison of the lithologies and ages recovered at Sites 762 and 763 on the Exmouth Plateau. The lithologic legend is given in Figure 3.

Figure 6. Lithostratigraphy, lithologic units, age, and core recovery (black = recovered interval) of Site 759 holes. The lithologic legend is given in Figure 3.

Figure 7. Lithostratigraphy, lithologic units, age, and core recovery (black = recovered interval) of Site 760 holes. The lithologic legend is given in Figure 3. Wavy lines between chronostratigraphic boundaries indicate a hiatus. Depth is given in meters below seafloor (mbsf).

Figure 8. Lithostratigraphy, lithologic units, age, and core recovery (black = recovered interval) of Site 761 holes. The lithologic legend is given in Figure 3. Wavy lines between chronostratigraphic boundaries indicate a hiatus. Depth is given in meters below seafloor (mbsf).

Figure 9. A. Cretaceous and Cenozoic sedimentation rates for Sites 760, 761, and 764 on the Wombat Plateau. For all figures, Cenozoic ages and depths are based on nannofossil zones from the zonation of Martini (1971). Cretaceous ages and depths are those of stage boundaries. In both cases ages are taken from the Haq et al. (1987) timescale. Average errors for age and depth are ±2 m.y. and ±4 m respectively for the Cenozoic and ±4 m.y. and ±9.5 m for the Cretaceous.
B. Cretaceous sedimentation rates for Sites 762 and 763 on the Exmouth Plateau.
C. Uppermost Cretaceous and Cenozoic sedimentation rates for Leg 122 sites 760-764.

Figure 10. Lithostratigraphy, lithologic units, age, and core recovery (black = recovered interval) of Site 764 holes. The lithologic legend is given in Figure 3. Wavy lines between chronostratigraphic boundaries indicate a hiatus. Depth is given in meters below seafloor (mbsf).

Figure 11. North-to-south multichannel seismic line X79B-1425 showing location and penetration of Site 762, and lithologic units encountered. Lithologic information below Site 762 total depth is from the Eendracht 1 industry well, located 2 km to the southwest. Line was collected and processed by Geophysical Services International (GSI) in 1979.

Figure 12. Lithostratigraphy, lithologic units, age, and core recovery (black = recovered interval) of Site 762 holes. The lithologic legend is given in Figure 3. Wavy lines between chronostratigraphic boundaries indicate a hiatus. Depth is given in meters below seafloor (mbsf).

Figure 13. West-to-east multichannel seismic line X78-272, showing location and penetration of Site 763, and lithologic units encountered. Lithologic information below Site 763 total penetration is from the Vinck 1 industry well, located 2 km to the northwest. Line was collected and processed by GSI in 1978.

Figure 14. Lithostratigraphy, lithologic units, age, and core recovery (black = recovered interval) of Site 763 holes. The lithologic legend is given in Figure 3. Wavy lines between chronostratigraphic boundaries indicate a hiatus. Depth is given in meters below seafloor (mbsf).

Table 1. Leg 122 Site Summary

Hole	Latitude (°S)	Longitude (°E)	Water depth (m)	Number of Cores	Meters Cored	Meters Recov'd	Percent Recov'd	Meters total Penet.
759A	16°57.25'	115°33.61'	2091.9	1	0.0	0.00	0.0	28.0
759B	16°57.24'	115°33.63'	2091.9	39	308.0	129.60	42.1	308.0
760A	16°55.32'	115°32.48'	1969.7	38	284.9	196.58	69.7	284.9
760B	16°55.32'	115°32.47'	1969.7	29	251.5	123.02	48.9	506.0
761A	16°44.26'	115°32.09'	--	1	9.5	9.92	104.4	9.5
761B	16°44.23'	115°32.10'	2167.9	33	286.7	199.08	69.4	286.7
761C	16°44.22'	115°32.10'	2167.9	33	225.7	72.14	32.0	436.7
762A	19°53.23'	112°15.26'	--	1	9.5	10.04	105.7	9.5
762B	19°53.24'	112°15.24'	1360.0	19	175.4	174.90	99.7	175.4
762C	19°53.23'	112°15.24'	1360.0	91	770.0	534.64	69.4	940.0
763A	20°35.20'	112°12.50'	1367.5	21	194.9	201.88	103.6	194.9
763B	20°35.19'	112°12.52'	1367.5	54	463.5	376.35	81.2	653.5
763C	20°35.21'	112°12.51'	1367.5	46	401.0	332.83	83.0	1036.6
764A	16°33.96'	115°27.43'	2698.6	8	69.0	40.56	58.8	69.0
764B	16°33.96'	115°27.43'	2698.6	31	254.5	44.33	17.4	294.5

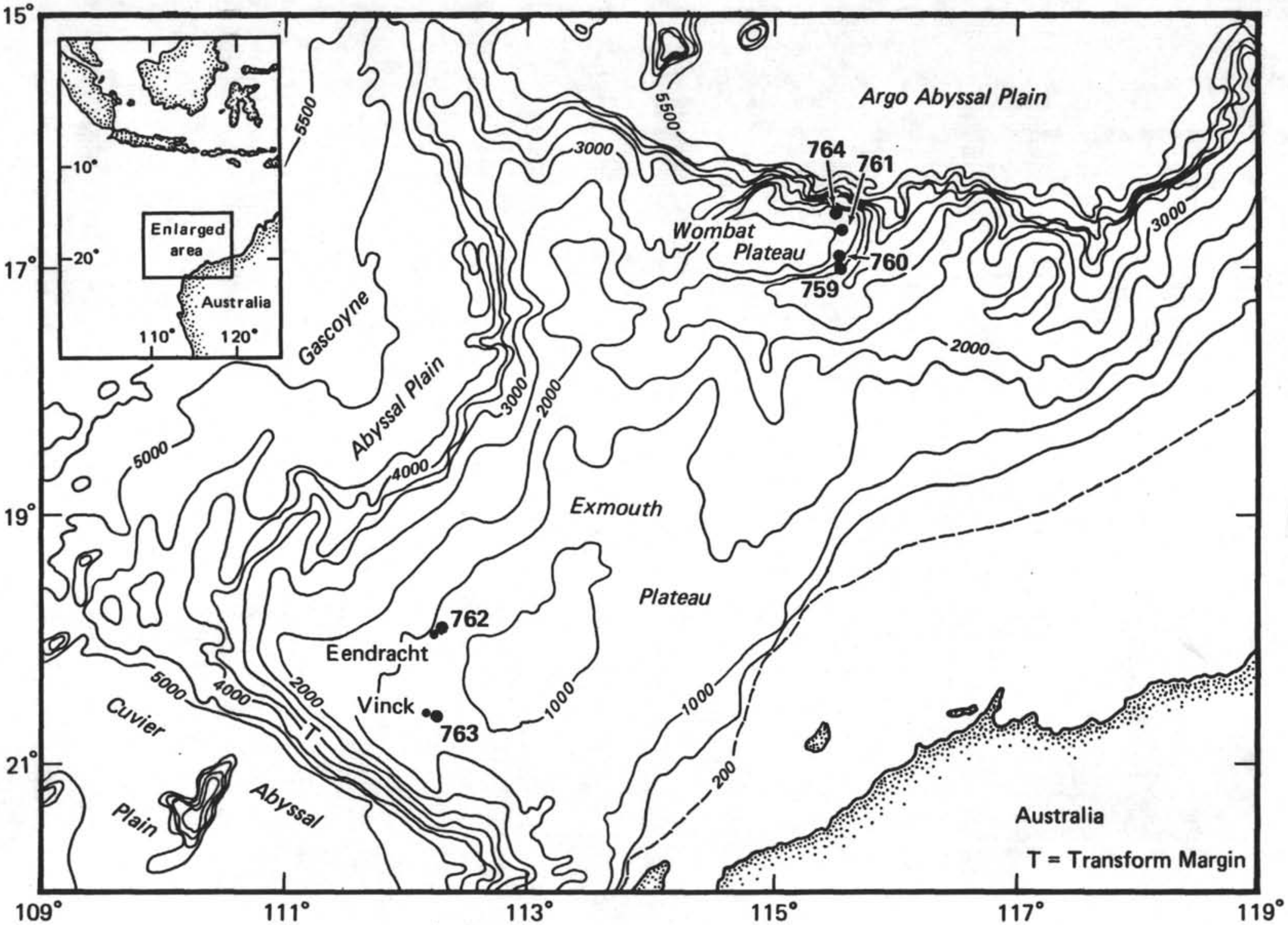

15°
17°
19°
21°
109°
111°
113°
115°
117°
119°
10°
20°
Enlarged area
Australia
110°
120°
Argo Abyssal Plain
764
761
760
759
Wombat Plateau
Gascoyne
Abyssal Plain
Exmouth
Plateau
762
Eendracht
Vinck
763
Cuvier
Abyssal
Plain
T
Australia
T = Transform Margin
5500
3000
2000
4000
5000
1000
200

Figure 1

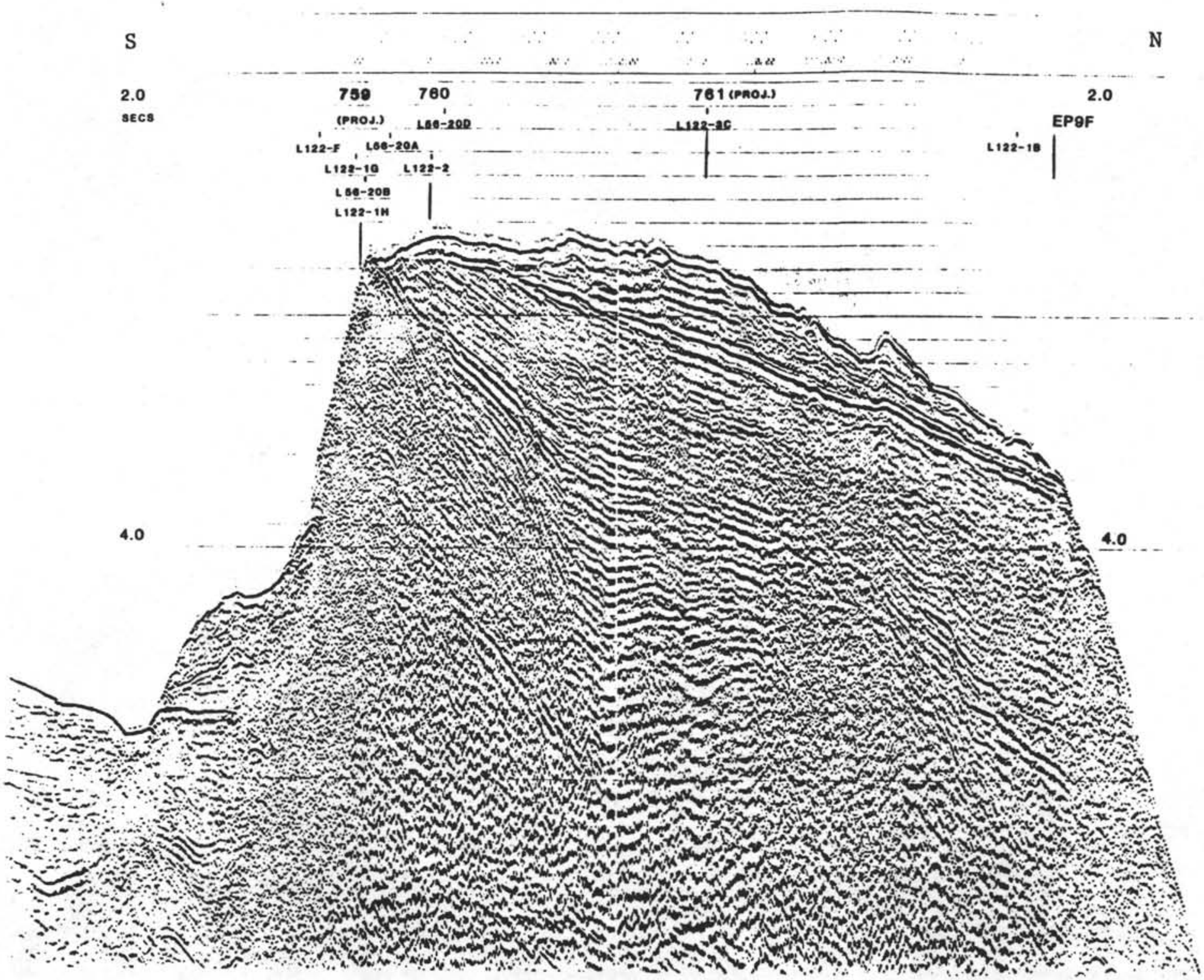

S
N
2.0
SECS
759
(PROJ.)
760
L56-20D
761 (PROJ.)
L122-8C
2.0
EP9F
L122-F
L56-20A
L122-1G
L122-2
L56-20B
L122-1H
L122-1B
4.0
4.0

Figure 2A.

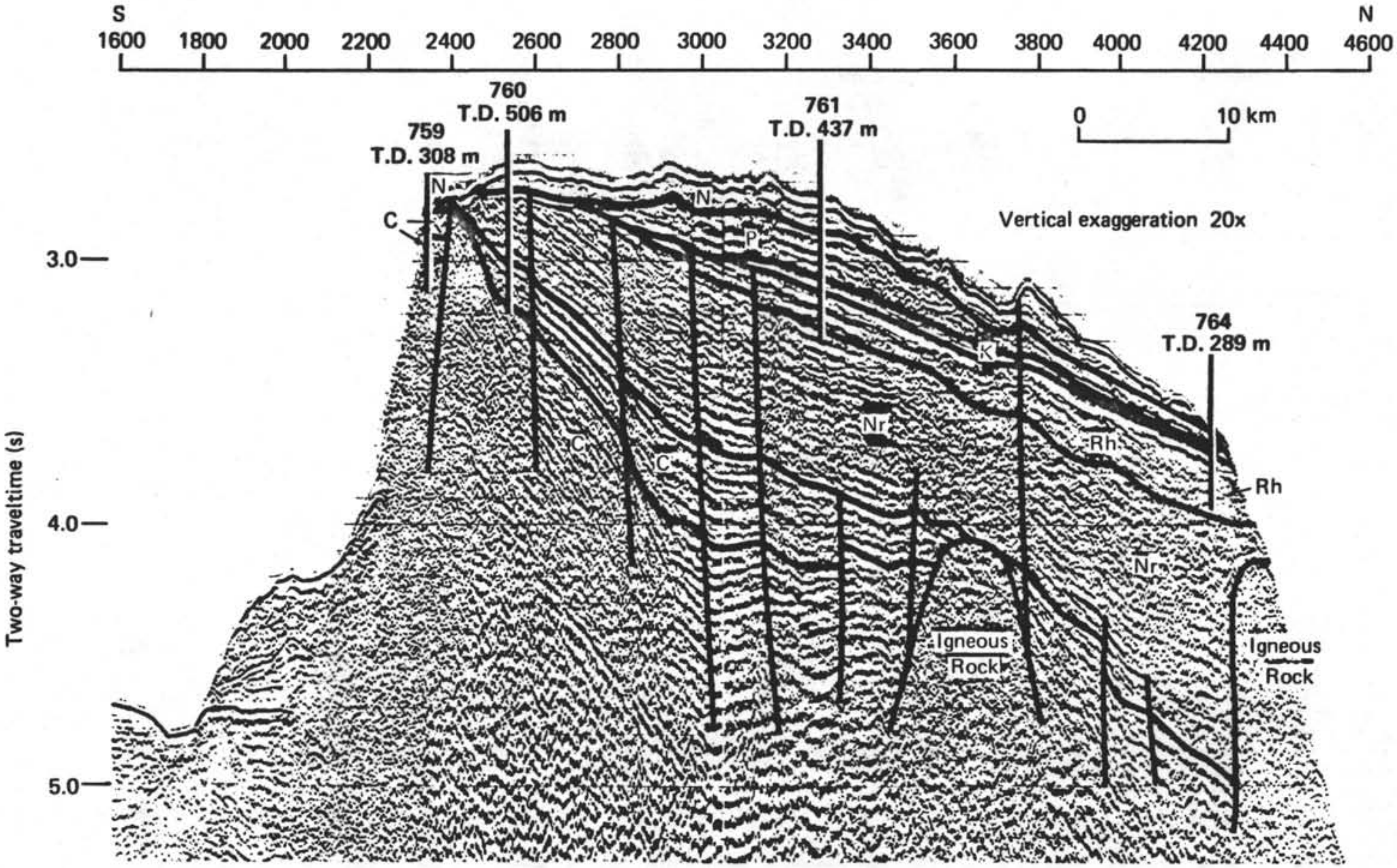

S
N
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
760
T.D. 506 m
759
T.D. 308 m
761
T.D. 437 m
764
T.D. 289 m
0
10 km
Vertical exaggeration 20x
Two-way traveltime (s)
3.0
4.0
5.0
N
C
P
K
Nr
Rh
Igneous
Rock

Figure 2B.

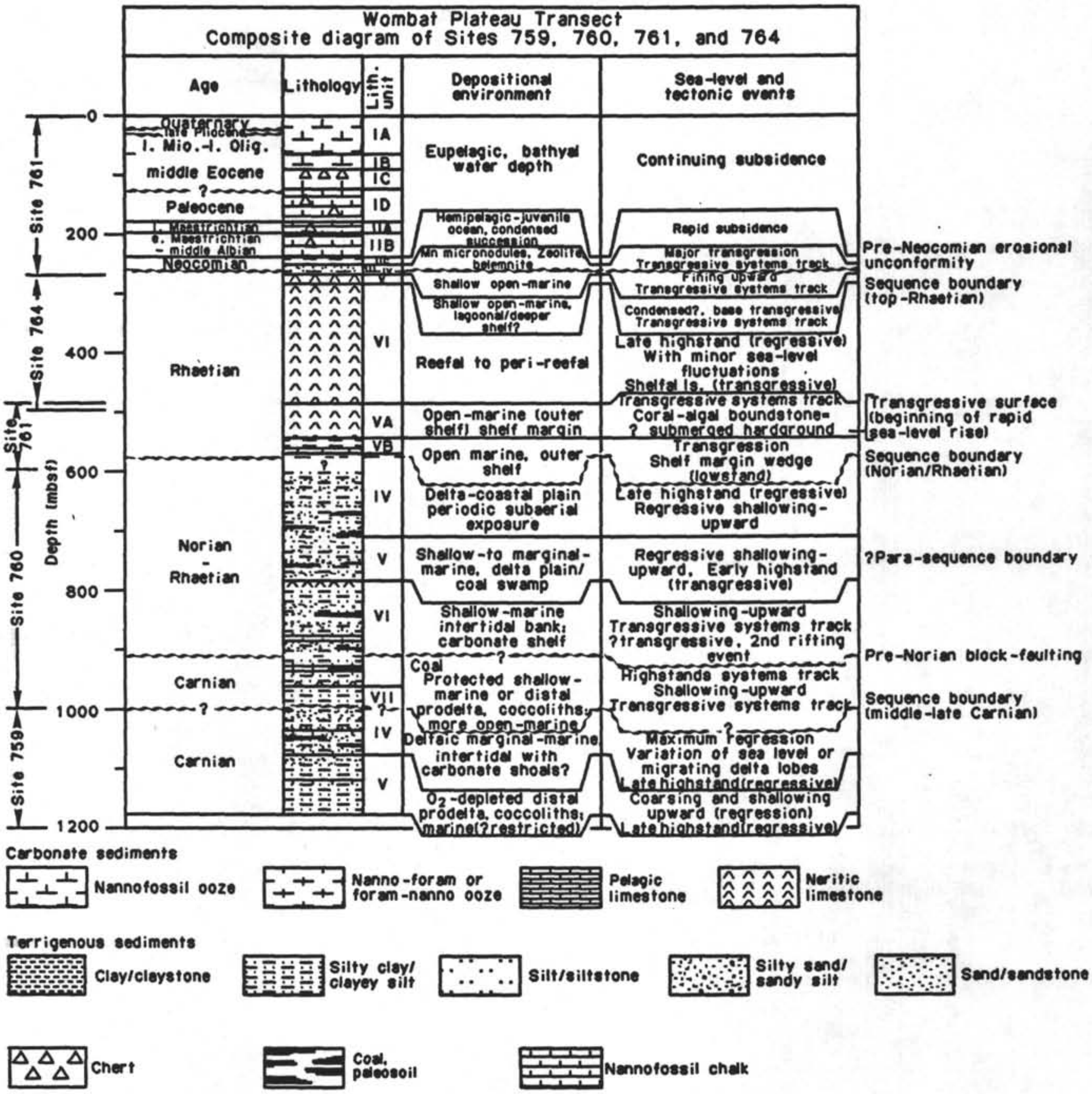

Wombat Plateau Transect
Composite diagram of Sites 759, 760, 761, and 764
Age
Lithology
Lith. unit
Depositional environment
Sea-level and tectonic events
Depth (mbsf)
0
200
400
600
800
1000
1200
Site 761
Site 764
Site 761
Site 760
Site 759
Quaternary
late Pliocene
l. Mio.-l. Olig.
middle Eocene
Paleocene
l. Maestrichtian
e. Maestrichtian
- middle Albian
Neocomian
Rhaetian
Norian
-
Rhaetian
Carnian
Carnian
IA
IB
IC
ID
IIA
IIB
V
VI
VA
VB
IV
V
VI
VII
IV
V
Eupelagic, bathyal water depth
Hemipelagic-juvenile ocean, condensed succession
Mn micronodules, Zeolite, belemnite
Shallow open-marine
Shallow open-marine, lagoonal/deeper shelf?
Reefal to peri-reefal
Open-marine (outer shelf) shelf margin
Open marine, outer shelf
Delta-coastal plain periodic subaerial exposure
Shallow-to marginal-marine, delta plain/ coal swamp
Shallow-marine intertidal bank; carbonate shelf
Coal
Protected shallow-marine or distal prodelta, coccoliths; more open-marine
Deltaic marginal-marine intertidal with carbonate shoals?
O2-depleted distal prodelta, coccoliths; marine(?restricted)
Continuing subsidence
Rapid subsidence
Major transgression
Transgressive systems track
Fining upward
Transgressive systems track
Condensed?, base transgressive
Transgressive systems track
Late highstand (regressive)
With minor sea-level fluctuations
Shelfal ls. (transgressive)
Transgressive systems track
Coral-algal boundstone-
? submerged hardground
Transgression
Shelf margin wedge (lowstand)
Late highstand (regressive)
Regressive shallowing-upward
Regressive shallowing-upward, Early highstand (transgressive)
Shallowing-upward
Transgressive systems track
?transgressive, 2nd rifting event
Highstands systems track
Shallowing-upward
Transgressive systems track
Maximum regression
Variation of sea level or migrating delta lobes
Late highstand(regressive)
Coarsing and shallowing upward (regression)
Late highstand(regressive)
Pre-Neocomian erosional unconformity
Sequence boundary (top-Rhaetian)
Transgressive surface (beginning of rapid sea-level rise)
Sequence boundary (Norian/Rhaetian)
?Para-sequence boundary
Pre-Norian block-faulting
Sequence boundary (middle-late Carnian)
Carbonate sediments
Nannofossil ooze
Nanno-foram or foram-nanno ooze
Pelagic limestone
Neritic limestone
Terrigenous sediments
Clay/claystone
Silty clay/ clayey silt
Silt/siltstone
Silty sand/ sandy silt
Sand/sandstone
Chert
Coal, paleosoil
Nannofossil chalk

Figure 3.

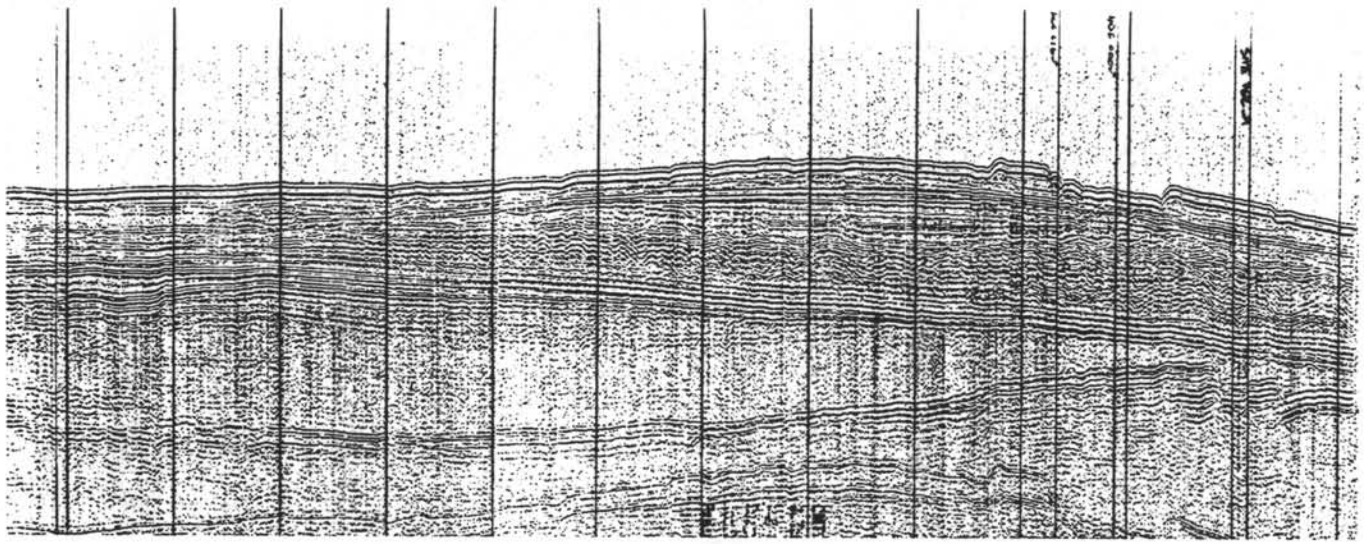


Figure 4A.

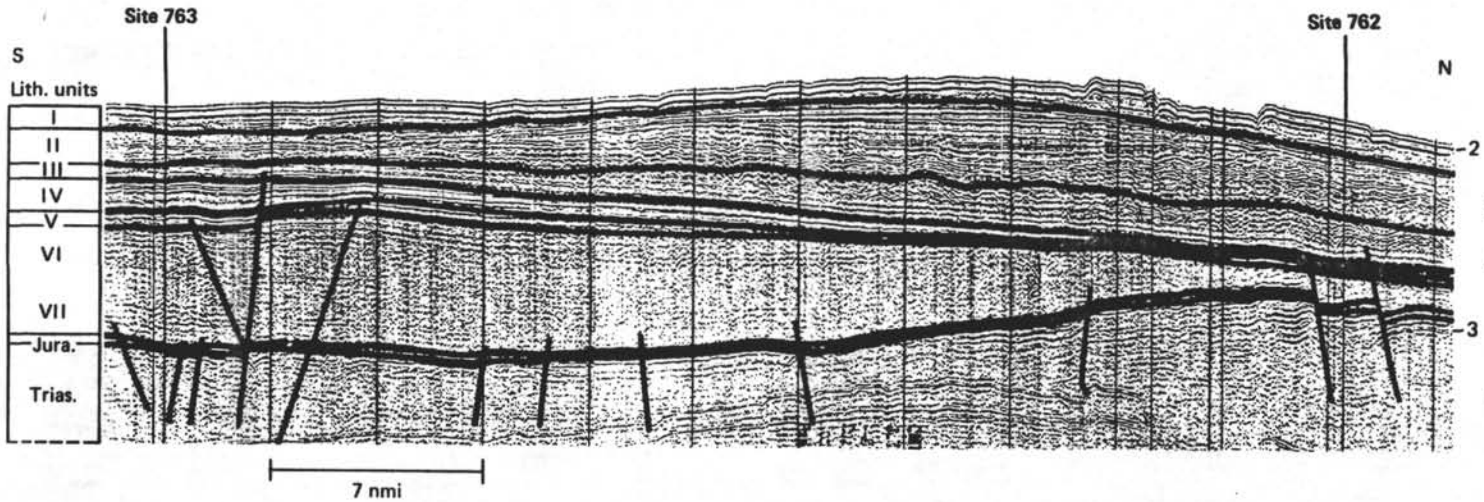
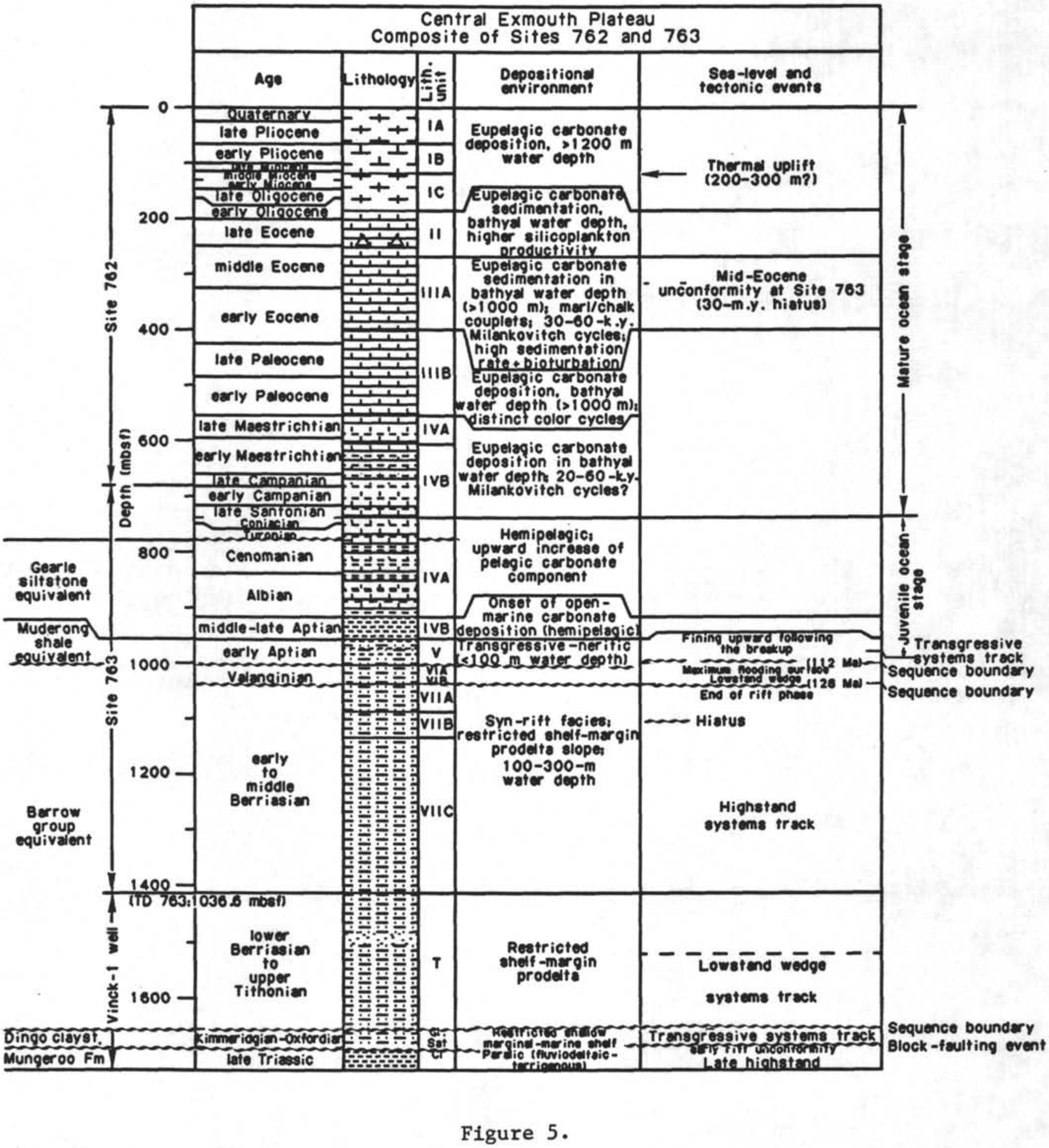

Site 763
Site 762
S
N
Lith. units
I
II
III
IV
V
VI
VII
Jura.
Trias.
-2
-3
Two-way traveltime (s)
7 nmi

Figure 4B.



Central Exmouth Plateau
Composite of Sites 762 and 763
Age
Lithology
Lith. unit
Depositional environment
Sea-level and tectonic events
Depth (mbsf)
Site 762
Site 763
Vinck-1 well
0
200
400
600
800
1000
1200
1400
1600
Quaternary
late Pliocene
early Pliocene
late Oligocene
early Oligocene
late Eocene
middle Eocene
early Eocene
late Paleocene
early Paleocene
late Maestrichtian
early Maestrichtian
late Campanian
early Campanian
late Santonian
Coniacian
Turonian
Cenomanian
Albian
middle-late Aptian
early Aptian
Valanginian
early to middle Berriasian
(TD 763: 1036.6 mbsf)
lower Berriasian to upper Tithonian
Kimmeridgian-Oxfordian
late Triassic
IA
IB
IC
II
IIIA
IIIB
IVA
IVB
IVA
IVB
V
VIIA
VIIB
VIIC
T
Eupelagic carbonate deposition, >1200 m water depth
Eupelagic carbonate sedimentation, bathyal water depth, higher silicoplankton productivity
Eupelagic carbonate sedimentation in bathyal water depth (>1000 m); marl/chalk couplets; 30-60-k.y. Milankovitch cycles; high sedimentation rate+bioturbation
Eupelagic carbonate deposition, bathyal water depth (>1000 m); distinct color cycles
Eupelagic carbonate deposition in bathyal water depth; 20-60-k.y. Milankovitch cycles?
Hemipelagic; upward increase of pelagic carbonate component
Onset of open-marine carbonate deposition (hemipelagic)
Transgressive-neritic (<100 m water depth)
Syn-rift facies; restricted shelf-margin prodelta slope; 100-300-m water depth
Restricted shelf-margin prodelta
Restricted shallow marginal-marine shelf
Paralic (fluviodeltaic-terrigenous)
Thermal uplift (200-300 m?)
Mid-Eocene unconformity at Site 763 (30-m.y. hiatus)
Fining upward following the breakup
Maximum flooding surface (112 Ma)
Lowstand wedge (128 Ma)
End of rift phase
Hiatus
Highstand systems track
Lowstand wedge systems track
Transgressive systems track
early rift unconformity
Late highstand
Mature ocean stage
Juvenile ocean stage
Transgressive systems track
Sequence boundary
Sequence boundary
Sequence boundary
Block-faulting event
Gearle siltstone equivalent
Muderong shale equivalent
Barrow group equivalent
Dingo clayst.
Mungeroo Fm

Figure 5.

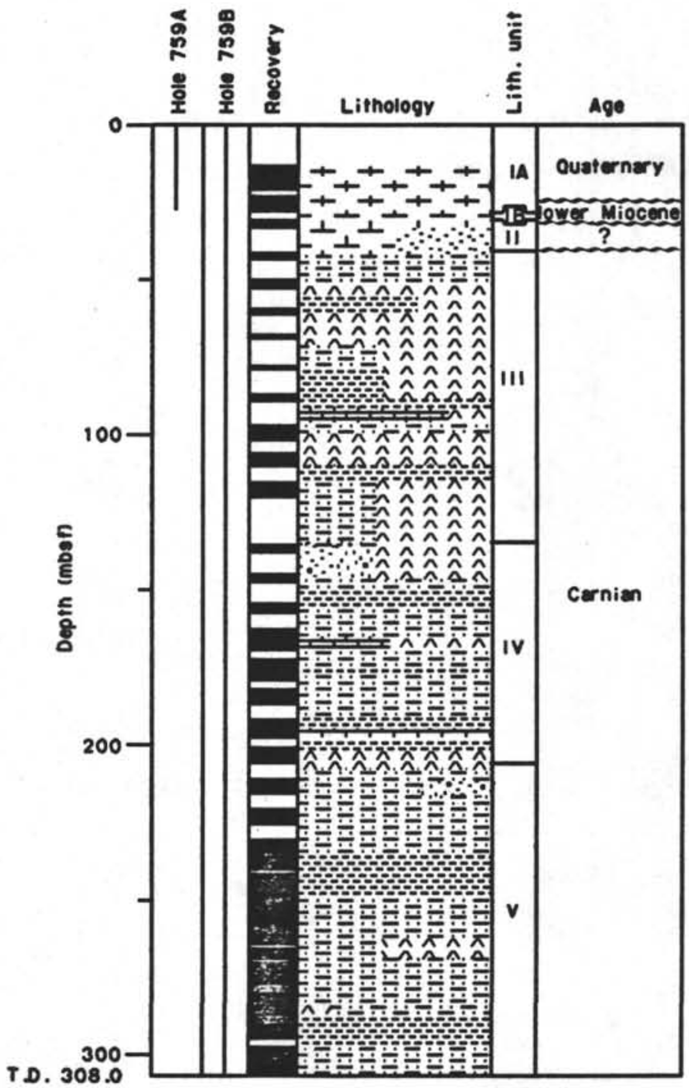
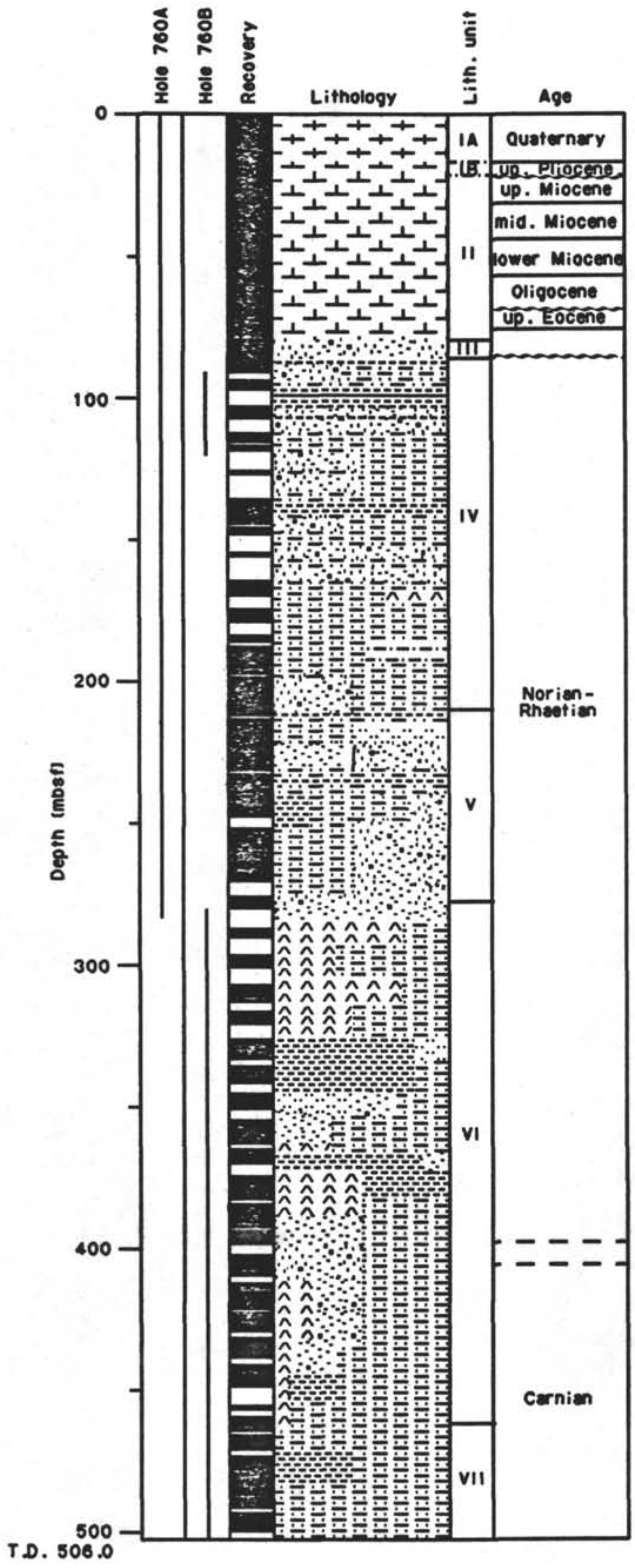

Hole 759A
Hole 759B
Recovery
Lithology
Lith. unit
Age
0
100
200
300
T.D. 308.0
Depth (mbsf)
IA
IB
II
III
IV
V
Quaternary
lower Miocene
?
Carnian

Figure 6.



Hole 760A
Hole 760B
Recovery
Lithology
Lith. unit
Age
0
100
200
300
400
500
Depth (mbsf)
T.D. 506.0
IA
IB
II
III
IV
V
VI
VII
Quaternary
up. Pliocene
up. Miocene
mid. Miocene
lower Miocene
Oligocene
up. Eocene
Norian-
Rhaetian
Carnian

Figure 7.

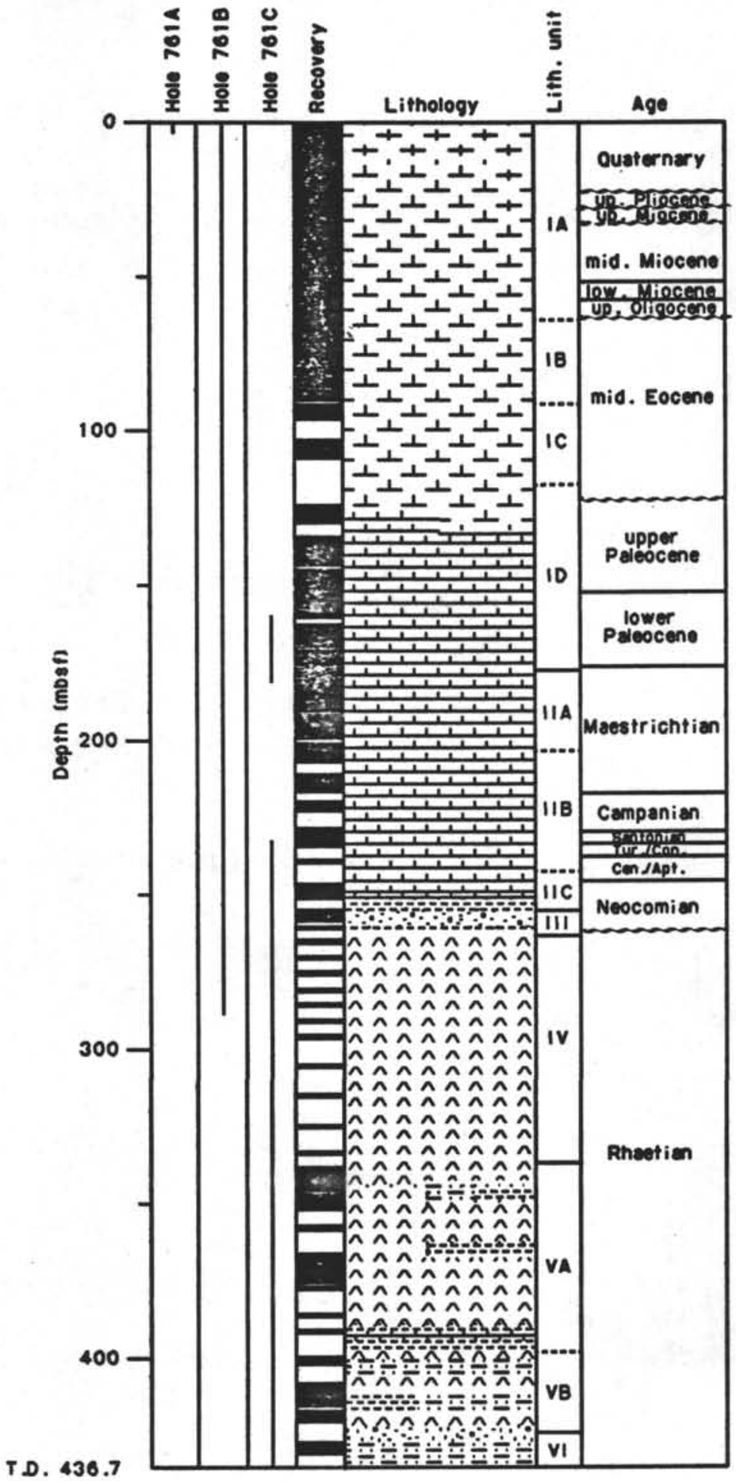

Hole 761A
Hole 761B
Hole 761C
Recovery
Lithology
Lith. unit
Age
0
100
200
300
400
Depth (mbsf)
T.D. 436.7
IA
IB
IC
ID
IIA
IIB
IIC
III
IV
VA
VB
VI
Quaternary
up. Pliocene
mid. Miocene
low. Miocene
up. Oligocene
mid. Eocene
upper Paleocene
lower Paleocene
Maestrichtian
Campanian
Cen./Apt.
Neocomian
Rhaetian

Figure 8.

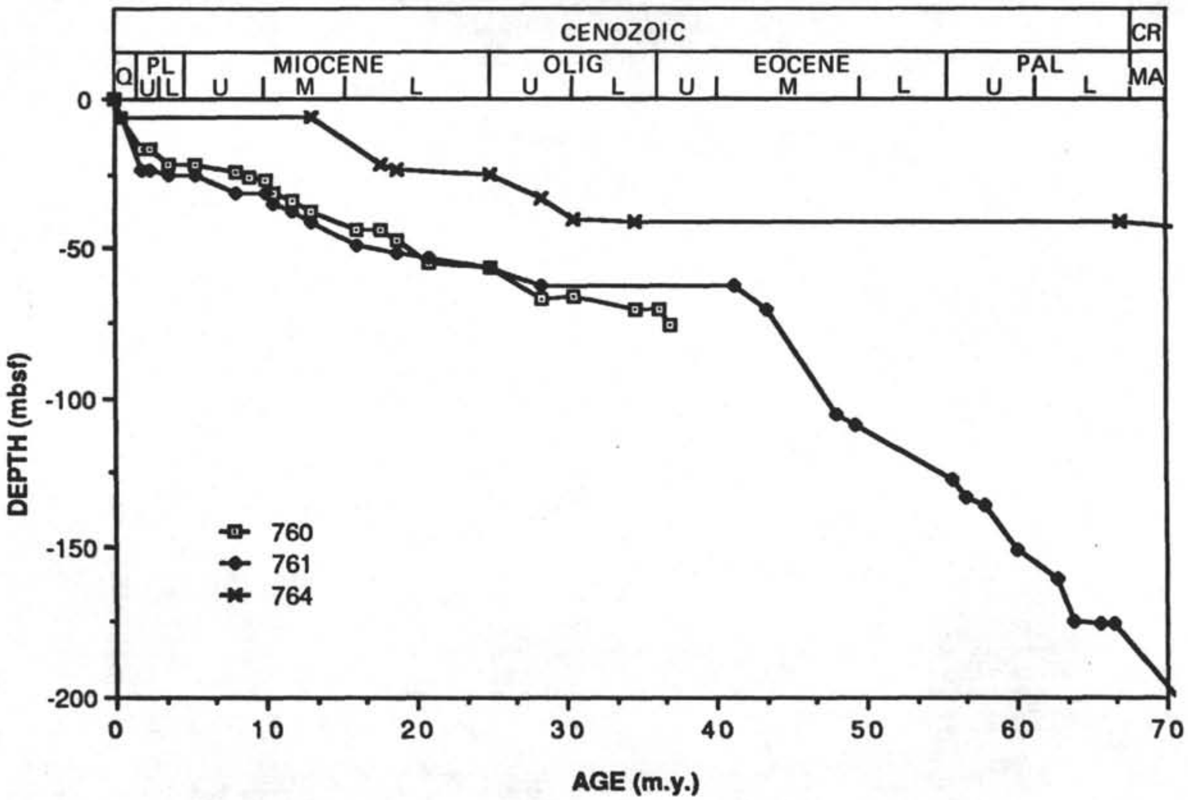

CENOZOIC
CR
Q
PL
U
L
MIOCENE
U
M
L
OLIG
U
L
EOCENE
U
M
L
PAL
U
L
MA
DEPTH (mbsf)
0
-50
-100
-150
-200
760
761
764
0
10
20
30
40
50
60
70
AGE (m.y.)

Figure 9A.

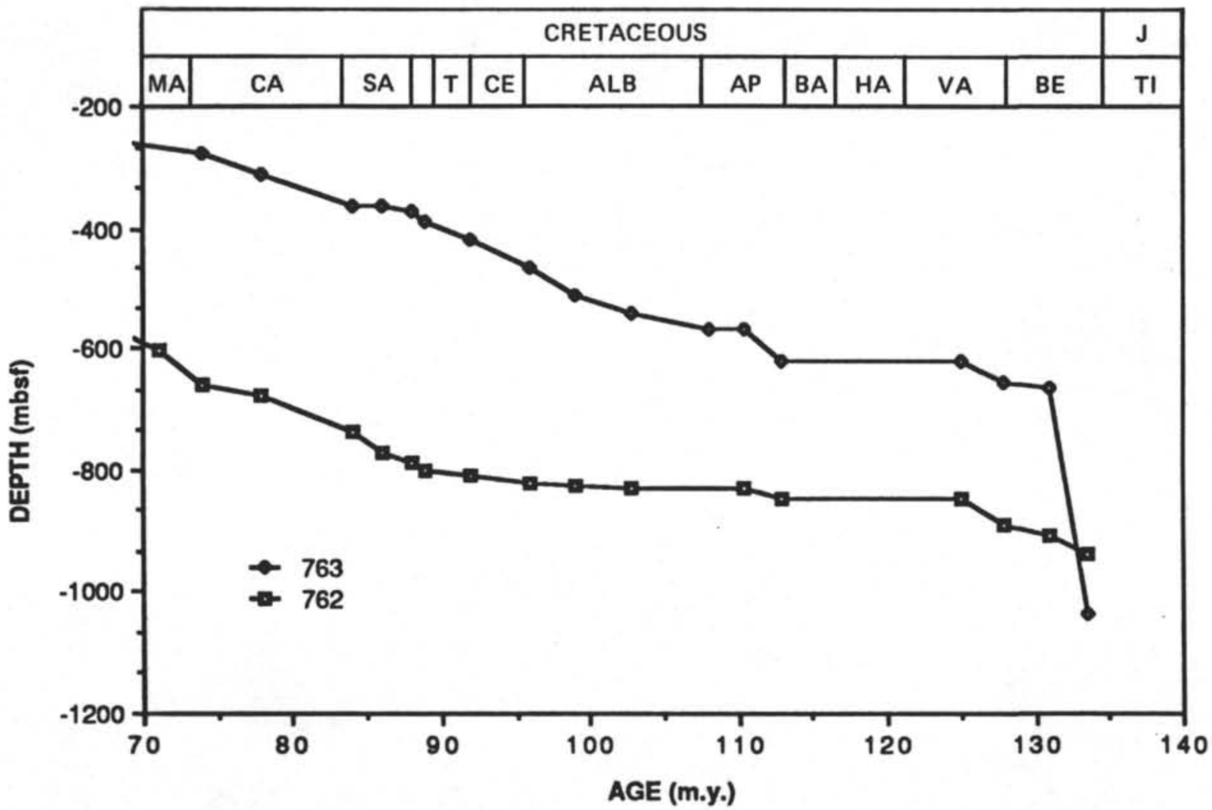

CRETACEOUS
J
MA
CA
SA
T
CE
ALB
AP
BA
HA
VA
BE
TI
-200
-400
-600
-800
-1000
-1200
DEPTH (mbsf)
763
762
70
80
90
100
110
120
130
140
AGE (m.y.)

Figure 9B.

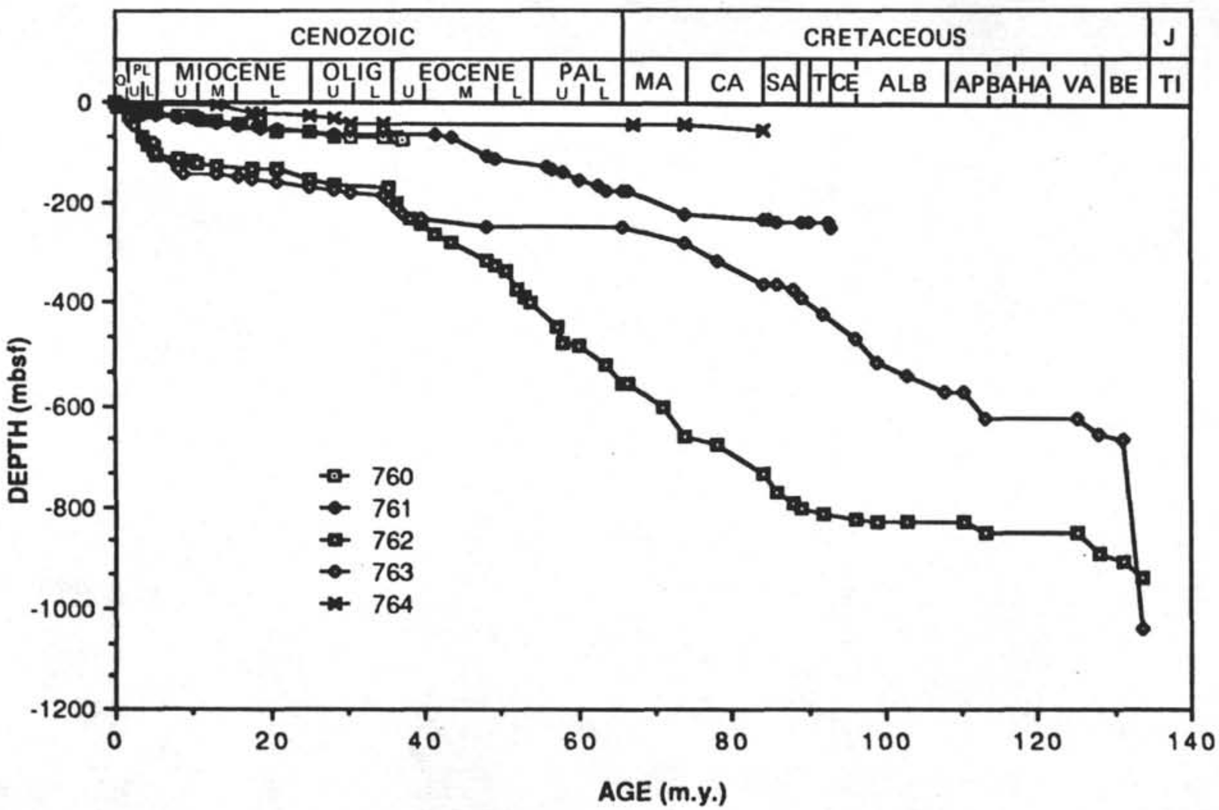

CENOZOIC
CRETACEOUS
J
Q
PL
U
L
MIOCENE
U M L
OLIG
U L
EOCENE
U M L
PAL
U L
MA
CA
SA
T
CE
ALB
AP
BA
HA
VA
BE
TI
0
-200
-400
-600
-800
-1000
-1200
DEPTH (mbsf)
0
20
40
60
80
100
120
140
AGE (m.y.)
760
761
762
763
764

Figure 9C.

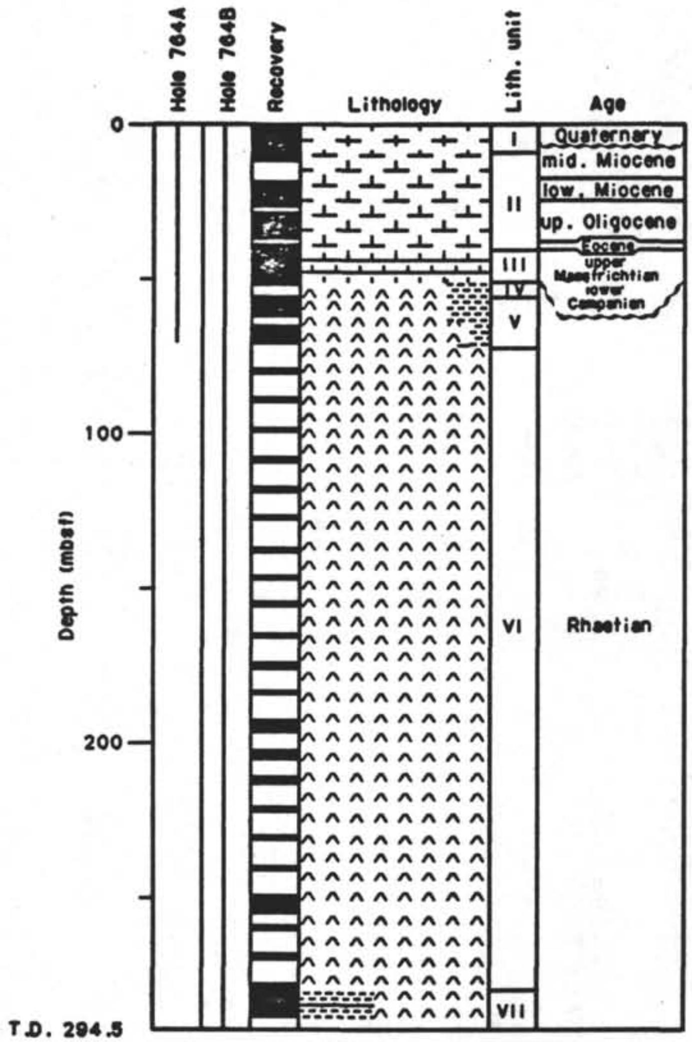

Hole 764A
Hole 764B
Recovery
Lithology
Lith. unit
Age
0
100
200
Depth (mbsf)
T.D. 294.5
I
II
III
IV
V
VI
VII
Quaternary
mid. Miocene
low. Miocene
up. Oligocene
Eocene
upper Maastrichtian
lower Campanian
Rhaetian

Figure 10.

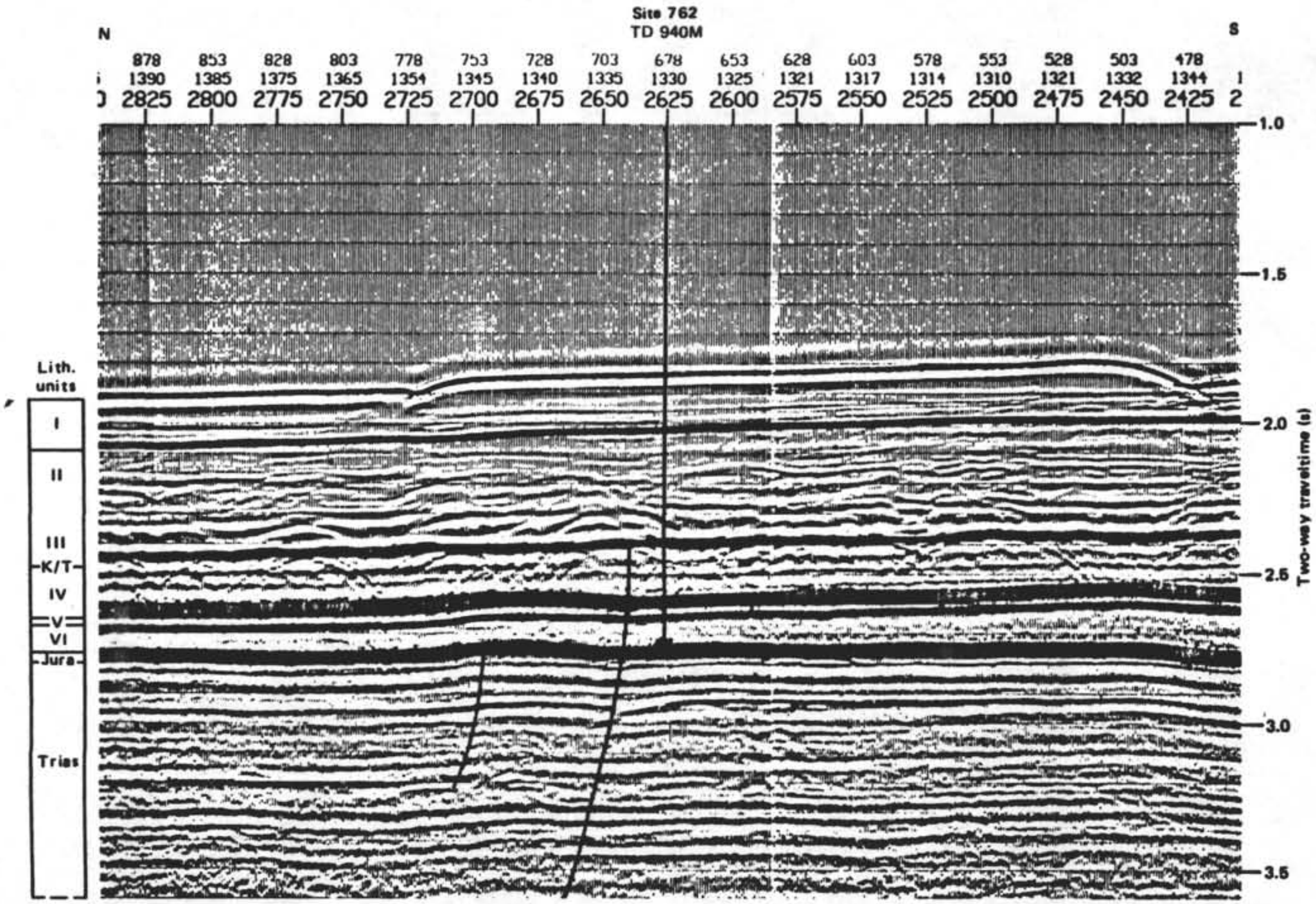

Site 762
TD 940M
N
S
878 853 828 803 778 753 728 703 678 653 628 603 578 553 528 503 478
1390 1385 1375 1365 1354 1345 1340 1335 1330 1325 1321 1317 1314 1310 1321 1332 1344
2825 2800 2775 2750 2725 2700 2675 2650 2625 2600 2575 2550 2525 2500 2475 2450 2425
Lith. units
I
II
III
K/T
IV
V
VI
Jura
Trias
1.0
1.5
2.0
2.5
3.0
3.5
Two-way traveltime (s)

Figure 11.

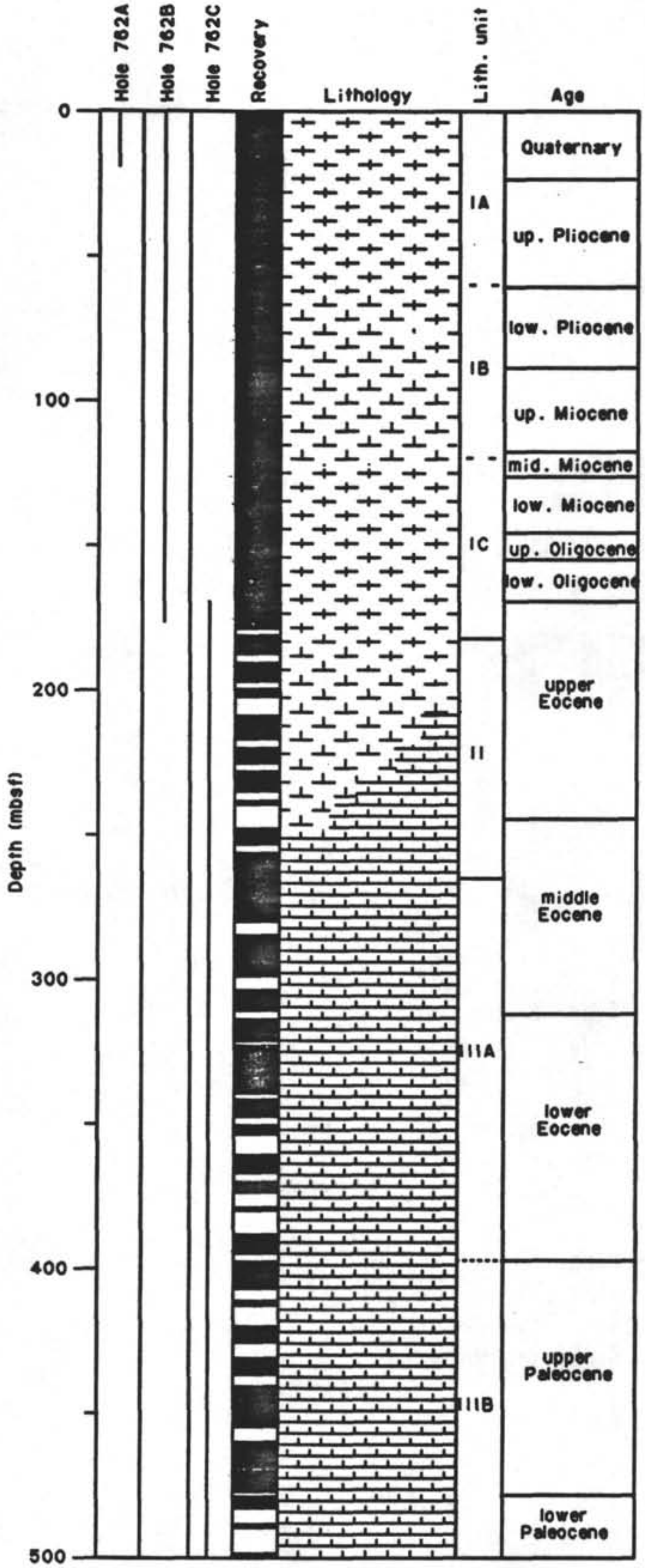

Hole 762A
Hole 762B
Hole 762C
Recovery
Lithology
Lith. unit
Age
Depth (mbsf)
0
100
200
300
400
500
IA
IB
IC
II
IIIA
IIIB
Quaternary
up. Pliocene
low. Pliocene
up. Miocene
mid. Miocene
low. Miocene
up. Oligocene
low. Oligocene
upper Eocene
middle Eocene
lower Eocene
upper Paleocene
lower Paleocene

Figure 12.

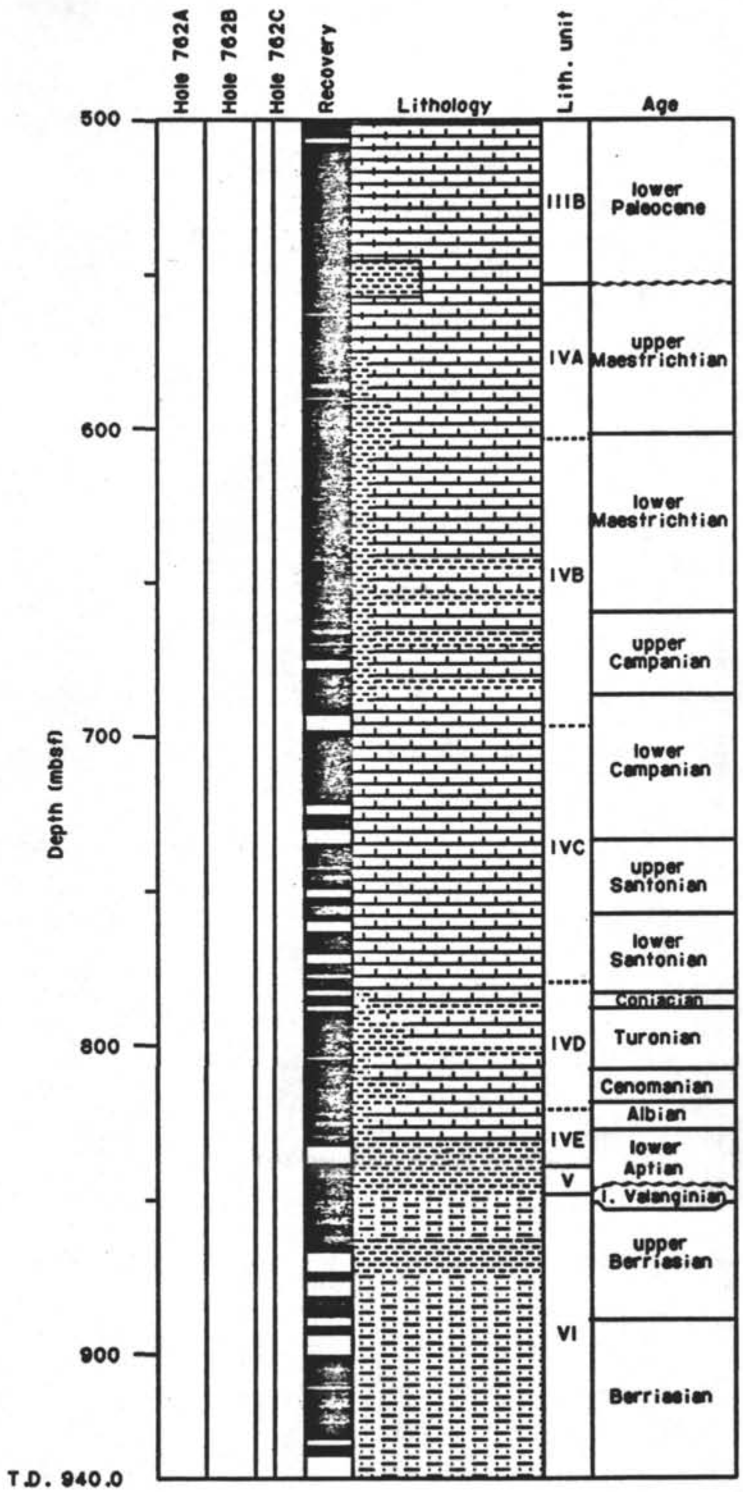


Figure 12 cont.

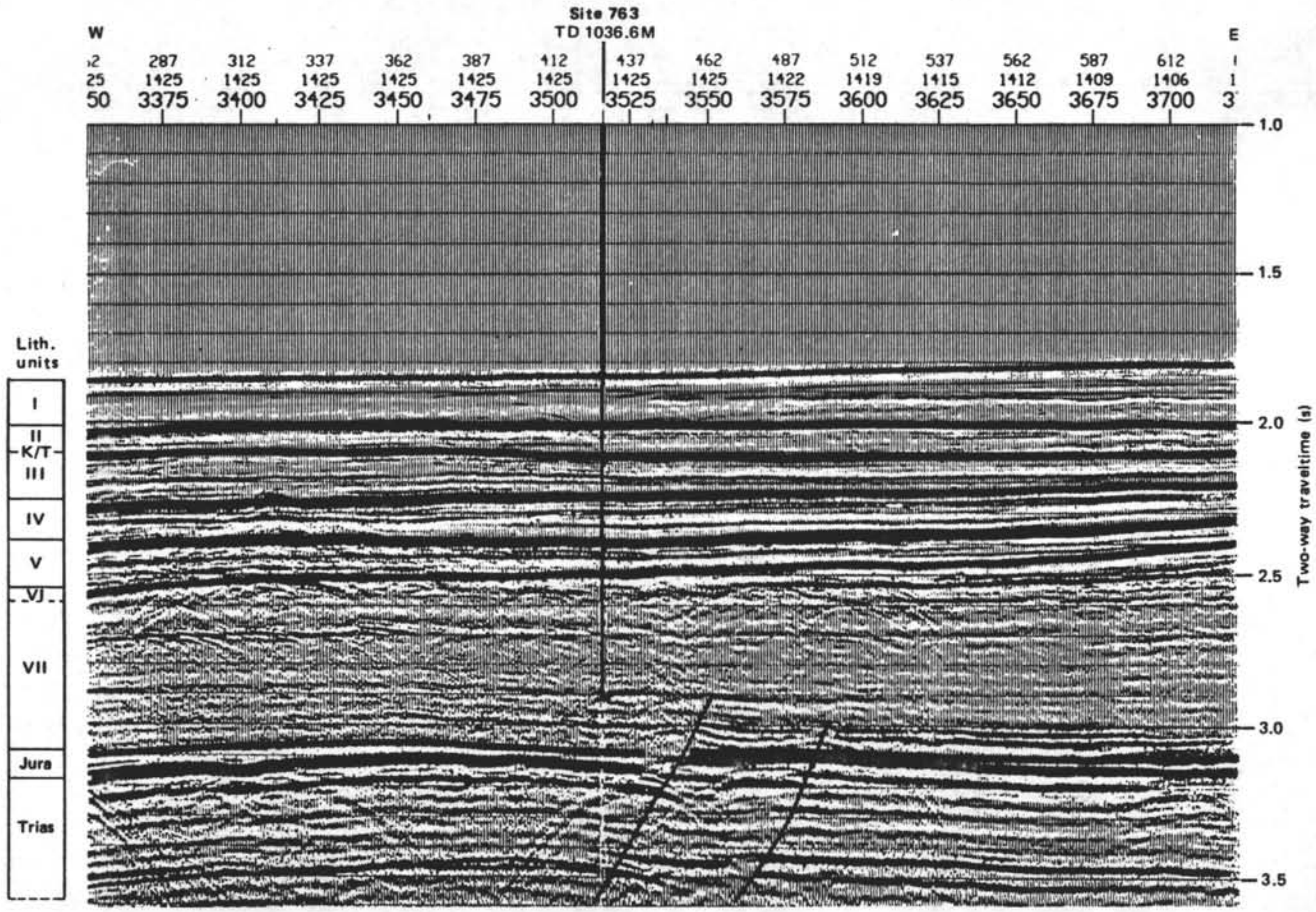

Site 763
TD 1036.6M
W
E
287 312 337 362 387 412 437 462 487 512 537 562 587 612
1425 1425 1425 1425 1425 1425 1425 1425 1422 1419 1415 1412 1409 1406
3375 3400 3425 3450 3475 3500 3525 3550 3575 3600 3625 3650 3675 3700
1.0
1.5
2.0
2.5
3.0
3.5
Two-way traveltime (s)
Lith. units
I
II
K/T
III
IV
V
VI
VII
Jura
Trias

Figure 13.

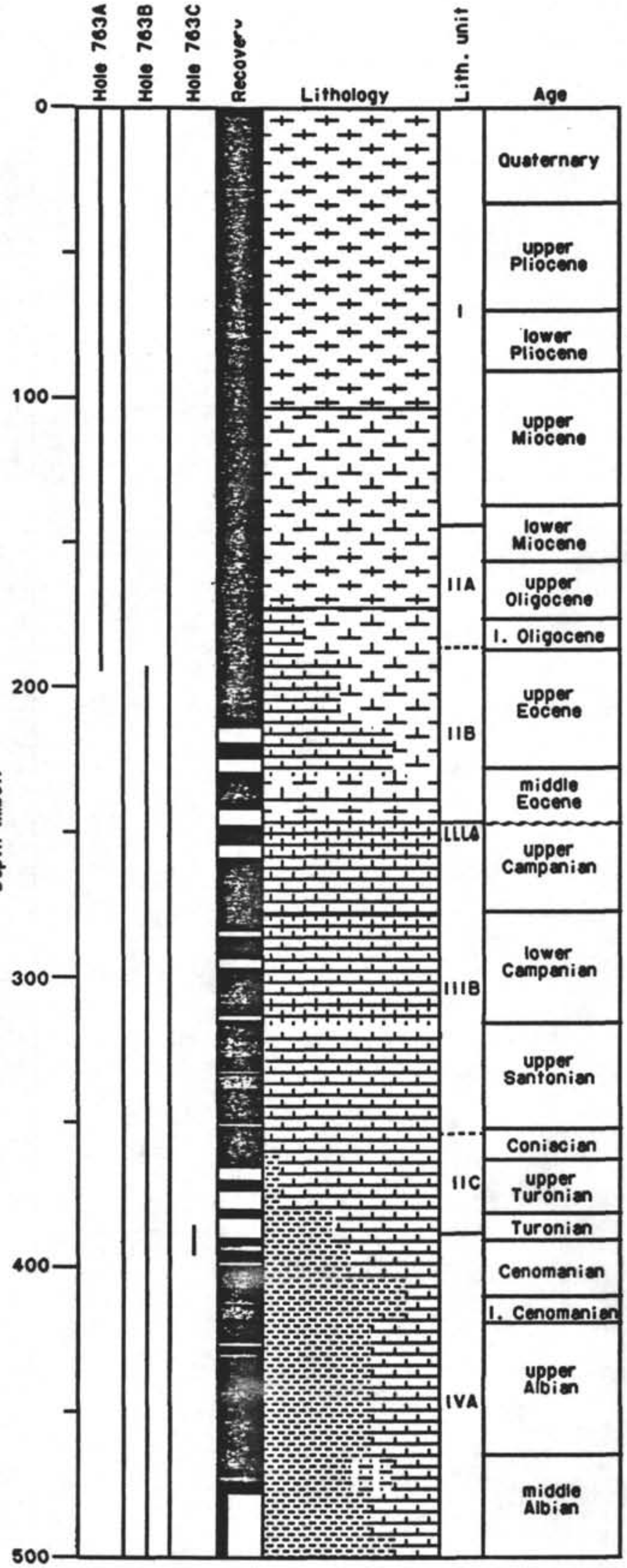

Hole 763A
Hole 763B
Hole 763C
Recovery
Lithology
Lith. unit
Age
Depth (mbsf)
0
100
200
300
400
500
I
IIA
IIB
LLLA
IIIB
IIC
IVA
Quaternary
upper Pliocene
lower Pliocene
upper Miocene
lower Miocene
upper Oligocene
l. Oligocene
upper Eocene
middle Eocene
upper Campanian
lower Campanian
upper Santonian
Coniacian
upper Turonian
Turonian
Cenomanian
l. Cenomanian
upper Albian
middle Albian

Figure 14.

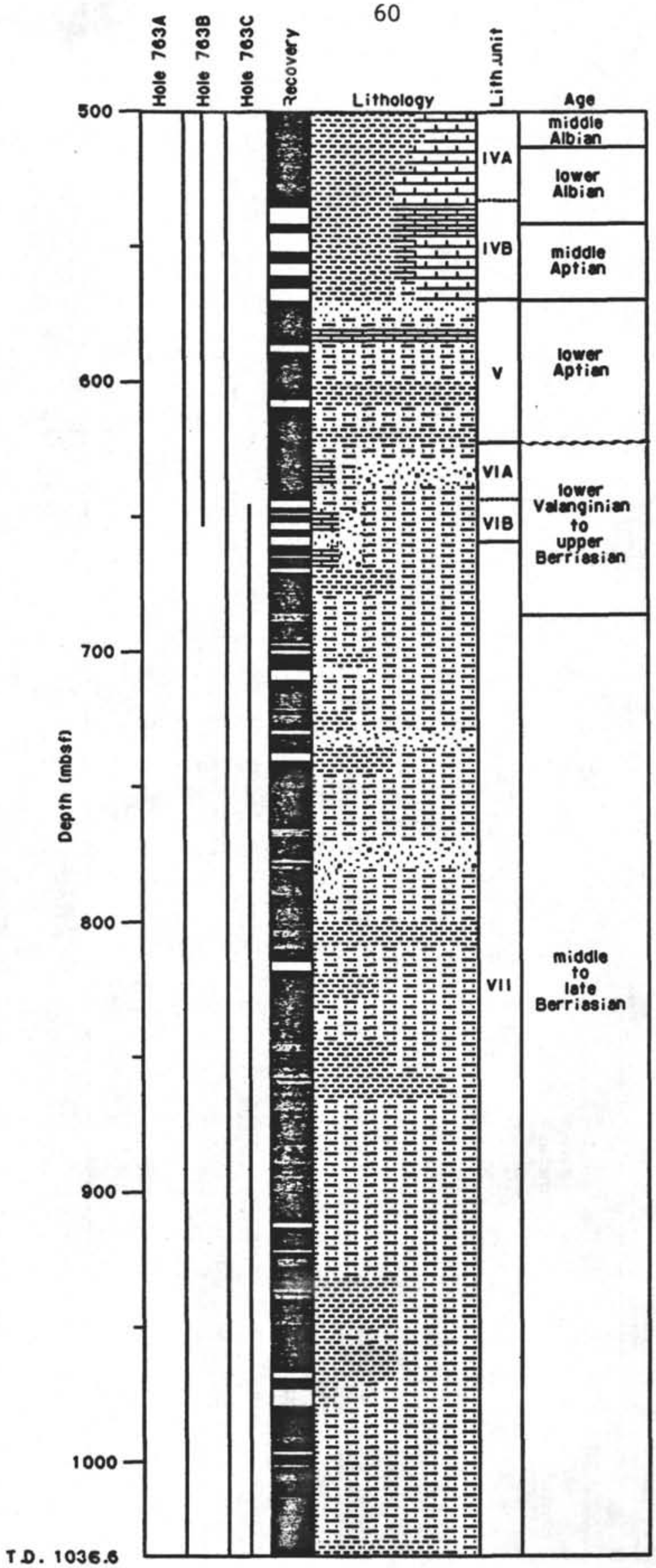


Figure 14 cont.

OPERATIONS SYNOPSIS

The ODP Operations personnel aboard JOIDES Resolution for Leg 122 of the Ocean Drilling Program were:

Operations Superintendent: Charles Hanson

Drilling Engineer: Dan Reudelhuber

OCEAN DRILLING PROGRAM
OPERATIONS REPORT
LEG 122

SINGAPORE PORT CALL

Leg 122 began officially in Singapore harbor, Republic of Singapore, at 0230 hr, 28 June 1988, when JOIDES Resolution dropped anchor in Johor Anchorage to await the pilot. At daylight the ship proceeded through Serangoon Harbor to the Loyang Offshore Supply Base, and the first line was on the dock at 0905 hr. Airfreight was offloaded and incoming freight was onloaded, cores were offloaded, 2017 sacks of barite was taken aboard, and drill pipe was offloaded from the riser hold. Cleaning of two fuel tanks to allow installation of the new sonar dome was started, and drill-pipe inspection was begun. A new Schlumberger logging cable was installed on the winch and the old one was offloaded. A total of 407,447 gallons of fuel was taken aboard. Drill-pipe inspection continued, but intermittent rain hampered the inspection operation. By the afternoon of 2 July 1988 all of the 5-in. (444 joints) and 54 joints of the 5-1/2 in. drill pipe had been inspected; there was not time to finish the inspection. JOIDES Resolution departed Singapore at 1645 hr.

The course was southeast across the Java Sea to the island of Bali, through the Strait of Lombok to the Indian Ocean and then south to the first site. During the second day at sea the Cyberex system, which supplies regulated power to the lab stack, suffered a catastrophic failure. Many surge protectors and some laboratory equipment were damaged. A temporary partial solution to the Cyberex problem was to equip critical equipment with the limited number of small undamaged surge protectors while parts were being obtained for the Cyberex from the USA. No attempt was made to power up the VAX computer. At 1830 hr, 7 July 1988, the beacon was dropped at 16°57.25'S, 115°33.61'E. The voyage of 1483 nmi had been made in 123.25 hours at an average speed of 12 kt.

SITE 759 (PROPOSED SITE EP-10A)

Hole 759A

Planned penetration for the first hole was 1300 mbsf. It was anticipated that more than one bit would be required to drill the hole and that a reentry cone would be needed. Since deep objectives were of primary importance, a rotary coring (RCB) assembly was used. The precision depth recorder (PDR) indicated a water depth of 2107.3 m DES (in this report, drilling and water depths are measured from the dual elevator stool, m DES, or in meters below sea floor, mbsf). At 2103 m DES the bit appeared to take weight in very soft sediment and it easily penetrated 9.5 m. The core barrel was pulled, but there was no recovery. The bit was raised above the mud line and a jet-in test was performed to determine the feasibility of washing in 16-in. casing. The bit was jetted in 28 mbsf, where firm sediments were encountered.

After 7.5 hr on site, the beacon began transmitting intermittently and a second beacon was launched.

Hole 759B

The bit was pulled clear of the sea floor and the ship was moved 20 m north. The first 12.5 m was cored with no bit rotation through very soft material; there was no recovery. Cores 122-759B-3R and 122-759B-4R recovered a total of 12.7 m of sediment, but the next 199.5 m of coring recovered only 50.3 m of core. In a effort to increase recovery, cutting half cores was tried. Although the overall penetration rate decreased, the recovery percentage doubled, and in the last 77.5 m cored the recovery was 87%. Recovery for the hole averaged 42.1%.

The scientific party had determined that the upper section of the desired stratigraphic sequence was missing, and the proposed 1300 m hole was terminated at 308.0 mbsf.

Two logging runs were planned. The hole was conditioned and the bottom of the drill string was pulled to 40 mbsf. After a tool failure, the seismic stratigraphy combination (DITE/SDT/NGT/MCD) was run successfully from 308 through 69 mbsf. The second log was not run because the time taken by the tool failure had used the allotted logging time.

Constant monitoring of the cores for gas produced only sporadic traces of hydrocarbons. The hole was plugged with a 150 sack cement plug and terminated.

SITE 760 (PROPOSED SITE EP10A")

Hole 760A

Site EP10A" lies 2.2 nmi northwest of Site 759. JOIDES Resolution was under way to it at 2115 hr, 11 July. After a short survey, the beacon was dropped at 2315 hr at 16°55.32'S 115°32.48'E. The hole was to be cored by advanced hydraulic piston coring and extended core barrel assemblies (APC/XCB). A mud-line core was shot and the mud line determined at 1981.1 m DES. Nine piston cores were taken to a penetration of 83.7 mbsf before a pullout force of 70,000 lb required the termination of piston coring; the recovery was 103%.

Coring continued with the XCB system. From 93.2 mbsf through 182.7 mbsf recovery was only 33%. The cored interval was reduced to 5 m ("half cores") at 187.9 mbsf in an effort to improve the recovery percentage. This procedure was successful as the recovery increased to 78% for the next 40 m. At 251.4 mbsf the XCB cutter shoe and 3 in. of the barrel broke off and remained in the hole. An Atride center bit was run in place of the XCB cutter in an attempt to push aside or break up the junk, and 3 m of hole was made. Coring continued to 284.9 mbsf where the bit torque increased and the drilling rate decreased to near zero. This was interpreted as evidence that the bit had failed from wear and/or junk damage. No further coring was possible.

Recovery for the hole was 69.7%. Although no significant amount of gas had been detected, the bit was raised to 105 mbsf where a 200 sack cement plug was placed. Hole 760A was concluded at 1300 hr, 14 July.

Hole 760B

Deeper penetration coring was needed to reach the scientific objectives of the site. The coring strategy was to drill a second hole with the rotary system and a standard 9-7/8-in. bit to the total depth of Hole 760A (284.9 mbsf), and then begin RCB coring. The ship was moved 20 m north to avoid the previous hole.

The Atride center bit was installed in the core bit, and the hole was drilled to 283.0 mbsf; three cores were taken between 89.9 and 118.4 mbsf. From this depth, RCB coring was resumed to 506 mbsf, and at that depth a geological overlap with Hole 760A was obtained. At Site 760, as at Site 759, the recovered material was older than expected and the scientific party judged that their scientific objectives could be better achieved at another location. Recovery was 49% for Hole 760B.

The hole was conditioned for logging. After repairing a faulty cable head on the logging line, the seismic stratigraphic tool string (DITE/SDT/NGT/MCD/GNGT) was lowered to 175 mbsf where an obstacle was encountered. The hole was logged up to the end of the pipe at 64 mbsf. Two more logging attempts also were hampered by hole bridges. The Schlumberger equipment was rigged down, and a 100 sack cement plug was placed with the end of the pipe at 208 mbsf.

The thrusters and hydrophones were raised and secured, and JOIDES Resolution departed for proposed site EP9E at 0045 hr, 19 July 1988.

SITE 761 (PROSPECTUS SITE EP9E)

Hole 761A

Hole 761A is located 11.2 nmi north of Site 760. The transit was made in 4 hr, which included a brief site survey. The beacon was dropped at 0315 hr, 19 July at 16°44.23'S, 115°32.12'E. The ship was positioned, and a 9-7/8-in. polycrystalline-synthetic-diamond-compact (PDC) APC/XCB bit was selected.

The PDR water depth was 2184 m DES and the bit was positioned at 2179 m DES. A full core barrel was obtained, indicating that the bit had been below the mud line when the core was shot.

Hole 761B

The bit was raised to 2174 m DES for the second attempt, and a 4.2-m core was acquired, establishing the mud line at 2179.3 m DES. Ten APC cores were obtained with over 100% recovery before a pullout of 95,000 lb was reached, and piston coring was concluded.

Coring continued with the XCB system. Several chert layers were encountered, which hampered coring and required some drilling with a center bit in place. In softer material, for example from 122.7 through 217.7 mbsf, 78.7 m of core were recovered (83% recovery), and the average rate of penetration was just 14 minutes/core.

At 286.7 mbsf collective evidence suggested a worn out bit and possible down-hole equipment problems. The hole was filled with 10 ppg mud, and the drill string and BHA were pulled to the rig floor.

Hole 761C

Deeper-penetration coring was necessary to complete the scientific objectives at the site. The ship was offset 20 m north. Hole 761C was drilled to 160.2 mbsf with the Atride center bit. Two APC-cores were then taken in an attempt to capture the Cretaceous/Tertiary (K/T) boundary. Recovery was 70% over the K/T interval. The hole then was drilled to 230 mbsf where coring commenced.

With the exception of 5 cores, the recovery rate for the remainder of the hole was low. The only apparent reason for the poor recovery was that the formation was alternating hard and soft. Overall recovery was only 32%. At 436.7 mbsf the scientific objective of the hole had been achieved, and coring was terminated to run logs.

Great effort was made to ensure successful logging. These efforts consisted of using mud while coring, bit wiper trips, and loading the hole with mud before logging. The bottom of the BHA was pulled to 126 mbsf, and the first logging tool DITE/SDT/NGT/MCD (seismic stratigraphy), was started down the drill pipe. A short in the cable head required repair. The repaired tools were lowered down the hole, but encountered an obstruction at 276 mbsf. A log was obtained back to the drill pipe at 126 mbsf.

The geochemical tool (GST/ACT/NGT) was successfully run through the drill pipe with the pipe at 416 mbsf. While the logging tools were being rigged down, the hole was filled with 10.2 ppg mud. JOIDES Resolution was under way to the next site at 0200 hr, 25 July 1988.

SITE 762 (PROSPECTUS SITE EP12P)

Hole 762A

Proposed site EP12P is located 227 nmi south-southwest of Hole 761C, and the steaming time was 24-1/4 hours, which included a brief geophysical survey as the site was approached. The beacon was dropped at 19°53.23'S, 112°15.26'E at 0215 hr, 26 July 1988. The bit selected was a 11-7/16 in. APC/XCB type.

The PDR water depth was 1376.3 m DES. It was anticipated that several reentries might be required to reach total depth, and a wash-in test was conducted to determine the amount of 16-in. casing that could be jetted in. The bit was washed to 74 mbsf through soft sediments with no difficulty, and then raised to 1371.3 m DES, where a mud-line core was shot. The barrel was full, signifying that the bit had been below the sea floor.

Hole 762B

The second hole was begun with the bit at 1366.3 m DES, and the mud line was established at 1371.4 m. Twenty APC cores were taken to 175.4 mbsf. Recovery was 99.7%. Operations were trouble free until the last core, when the core barrel could not be pulled free and the piston rod finally parted at 160,000 lb overpull. The bottom of the core barrel was left behind, terminating the hole.

Hole 762C

The drill pipe was pulled clear of the seafloor, and the ship was moved 20 m north.

The planned depth of this hole was 940 mbsf. We believed that the hole could be drilled with 2 bits. Our operational plan was to drill as deep possible with the XCB, launch a free-fall funnel (mini-cone), and reenter with the RCB assembly to finish the hole. An alternative was to core as deep as possible with the XCB, make a pipe trip for an RCB bit, drill a new hole to the depth where the XCB hole had been terminated, and then core to the planned total depth.

Hole 762C was drilled to 170.0 mbsf with the Atride center bit in a rotating time of 89 min. Coring conditions from 170.0 through 360.0 mbsf were excellent. At 360.0 mbsf the rate of penetration suddenly decreased, remained slow to 554 mbsf, and increased to 716 mbsf, where it again began to decrease. From 765 mbsf through 863.5 mbsf, half-cores were taken in a effort to improve recovery; the results were unimpressive.

At 478 mbsf a set screw in the "GS" overshot backed off, and five fishing runs with the wire line were made, finally recovering the core barrel.

At 838.5 mbsf, what had been white chalk for hundreds of meters became black claystone; the hole began to fill with debris during connections. Total depth was reached at 940 mbsf, the deepest XCB penetration in ODP history. Total recovery for the hole was 69.4%.

Before logging the hole it was necessary to make a drill-pipe round trip to remove the flapper valve from the BHA. A mini-cone with a mud skirt was launched. The drill pipe was round tripped and the flapper valve was removed. The hole was circulated clean with sea water and filled with mud. The SES (side-entry sub) was used to log. Run #1 was the seismic-stratigraphy tool (DITE/SDT/NGT/MCD). Run #2 was the geochemical tool (GST/ACT/NCT). Run #3 was the lithodensity tool (NGT/CNL/LDT).

When the last suite of logging tools reached the drill pipe it was impossible to work them back into the pipe. The logging cable was cut and the drill pipe and cable were withdrawn simultaneously. When the bit reached the surface we found that the weak point in the cable head had broken, and the tools were lost either downhole or onto the seafloor. Several feet of buoy tether wire was balled in the throat of the bit, and it was obviously the reason for not being able to pull the tool back into the BHA. The logging tool contained 2 nuclear sources, and a major effort was made to recover them. An overshot with a 3-3/8 in. grapple was attached to the end of the drill pipe. The drill pipe and TV camera were lowered to a few meters above the cone, and a systematic search of the area around the cone was made by moving the ship and observing the seafloor with the TV. No indication of the tool was visible on the soft seafloor. The hole was reentered and the drill pipe was run to the bottom of the hole, then pulled above the seafloor. The overshot was observed with the TV; the fish was not in the overshot. Experience suggested that additional fishing was unlikely to succeed, and we decided to plug and abandon the hole.

The drill pipe was lowered into Hole 762C to 800 mbsf, and 10.2 ppg mud was circulated to 300 mbsf. With the drill pipe at 359 mbsf, a 150 sack cement plug was placed on top of the heavy mud. Hole 762C was abandoned at 0830 hr, 5 August 1988.

SITE 763 (PROPOSED SITE EP7V)

Hole 763A

Site 763 is located 42 nmi south of Hole 762C. The voyage was made in 6.5 hr, which included a brief site survey. The beacon was dropped at 1505 hr 5 August at 20°35.20'S, 112°12.50'E. A jet-in test was made in expectation of setting a reentry cone; results were interpreted to mean that four joints of casing could be jetted in without difficulty.

An 11-7/16-in. APC/XCB bit was chosen. The first APC core established the mud line at 1378.9 m. Twenty-one piston cores were taken to 194.9 mbsf. Core 122-763A-21H could not be extracted with 140,000 lb overpull. Washing the bit over the barrel failed to budge it. Tension was taken on the wire line, the bit was rotated 7 m over the barrel, and the barrel was rescued without damage. Core recovery for the hole was 201.88 m (103.6%). The hole was terminated at 1930 hr, 6 August.

Hole 763B

The ship was moved 50 m north. In anticipation of multiple reentries, a full size reentry cone was deployed. The 16-in. casing was jetted-in with only minor difficulty from 1378.9-1429.41 m DES (mud line to 50.5 mbsf). Total deployment time, including two drill pipe round trips, was 29 hr.

The scientists forecast that the formations to be cored would be alternating hard and soft for several hundred meters. The operational plan was to XCB as far as possible to take advantage of the anticipated better recovery of the XCB, make a drill pipe round trip to change to an RCB coring assembly, and then core to total depth. The 11-7/16-in. XCB bit was drilled with a center bit in place to 190.0 mbsf, near the total depth of Hole 763A.

Core 122-763B-9X (266.0 mbsf) caused some concern. THe rotten-egg smell of hydrogen sulfide (H_2S) gas was noticed in the lab, but the highest concentration measured by headspace analysis was 22 ppm, within the safe working level. Core 122-763B-41X (570 mbsf) was the last core to contain a noticeable smell.

Coring results and conditions were excellent as the rate of penetration was typically 30 minutes per core and recovery was usually in excess of 100%. At 598.5 mbsf the coring operation was interrupted to run a correlation log on the recommendation of the JOIDES Pollution and Safety Panel. Logs from the offset Vinck-1 well indicated that it contained no porous reservoir sand above 600 mbsf, but below 600 mbsf there were water-filled sands that contained no hydrocarbons. Orders were that if Hole 763B was more than 10 m structurally higher than the Vinck-1 well at the 600 mbsf level, we would have to plug and abandon it. After a tool malfunction was repaired, the seismic-stratigraphy tool (DITE/SDT/NGT/MCD) was run from 557.9 to 365.4 mbsf. The logs were correlated and the conclusion was that Hole 763B was structurally 12 m low compared to the Vinck-1 well.

At Core 122-763B-55X (653.5 mbsf) disaster struck. Hard drilling was encountered abruptly, and when the core barrel was retrieved we found that the spring stop quick release in the coring assembly had parted, leaving the bottom portion of the barrel in the hole. Experience suggested that we were faced with a hopeless fishing job.

The drill pipe was positioned at the bottom of the hole, and 200 barrels of 10.2 ppg mud was circulated into the hole. The drill pipe was then raised to 220 mbsf, near the shallowest depth of high gas readings, and a 200 sack cement plug was placed. The drill pipe and BHA were recovered, and Hole 763B was abandoned at 2100 hr, 11 August 1988.

Hole 763C

The ship was moved 30 m south to avoid the reentry cone. The core barrel was run with a Smith center bit. The previous depth of Hole 763B, 645.1 mbsf, was reached in a total rotating time of 11.84 hr (19.5 total operational hr), and included one core between 385.0 and 394.5 mbsf. Coring continued with no hole problems for 2 days with nearly 100% recovery.

Headspace methane analyses from 700 mbsf to 1000 mbsf had shown a gradual increase to 10,000 ppm. While cutting Core 122-763C-46R (1036.6 mbsf), the headspace gas in core 122-763C-45R was being analyzed; the methane reading soared to over 80,000 ppm in this sample. Core 122-763C-46R was recovered and its gas content was slightly less than 60,000 ppm, confirming that the gas increase in the previous core was not unique. Because of the gas concentrations and essential completion of scientific objectives, the hole was terminated at 1036.6 mbsf.

A short trip was made to condition the hole for logging. Drag on the drill pipe was high, and several bridges had to be drilled out. A second short trip was made; conditions improved but they were far from conducive to logging.

The seismic stratigraphy tool (LSS,SDT,NGT,MCD) was picked up, and the SES was installed. The drill pipe was lowered to 698 mbsf, where it struck a hole bridge (probably a sand interval) that had been encountered every pipe trip. The Schlumberger logger set the logging tool onto the same obstacle, and 3,000 lb overpull was required to extract the tool. The hole was logged up to the drill pipe at 200 mbsf.

The prospect of permanently removing the bridge at 698 mbsf and then lowering the logging tools through the sand interval were meager, and the probability of sticking both the drill pipe and logging tools in the Barrow formation below the sand interval was substantial. Logging efforts in this hole were abandoned.

Due to the high concentration of gas in the hole it was necessary to thoroughly plug the hole. The drill pipe was run to the bridge at 698 mbsf and 110 barrels of 12.5 ppg mud was circulated into the hole. This mud would cover the gassy formation. The drill pipe was pulled to the top of the gassy formation at 350 mbsf, where a 200 sack cement plug was placed on top of the mud. JOIDES Resolution was under way to proposed site EP9F at 1200 hr, 17 August 1988.

SITE 764 (PROPOSED SITE EP9F)

Hole 764A

Site 764 is located 304 nmi north-northwest of Hole 763C. The voyage of 333 nmi, including a site survey, was made at an average speed of 12.2 kt. The beacon was dropped at 1615 hr, 18 August at 16°33.96'S, 115°27.43'E.

The scientific interest at this site was primarily in deep, hard sediments rather than shallower material; therefore the RCB coring assembly was used. The bit took weight at 2710.0 m DES, and this depth was used as the top of the first core. Eight RCB cores were taken to 69.0 mbsf, but the core recovery was only 59%, owing to the unconsolidated consistency of the sediment. Because of the unexpected scientific importance of the geologic section, the Co-Chief Scientists chose to recore the interval to increase total recovery.

Hole 764B

The bit was pulled above the sea floor and the ship was offset a few meters. The first core was drilled to 40 mbsf, where coring commenced. A transition to much slower drilling (ooze to shallow-water limestone) was encountered at 50 mbsf. Core recovery in the limestone was low, averaging only 12.5% from 50 to 279.5 mbsf.

Core 122-764A-31R (294.5 mbsf) was the last core of the leg because of time limitation. The core barrel was advanced 15 m, instead of the normal 9.5 m, and a spectacular 9.94-m-long core was recovered, containing a transition from pale brown carbonate mudstone to intensely bioturbated carbonate mudstone.

Successful logging was crucial because of the poor core recovery in the limestone interval. However, the hydraulic bit release failed to function and efforts to release the bit clogged the BHA just above the bit. This made it impossible to lower the logging tool below the BHA. Two successful log runs were made inside the drill pipe with the geochemical (NGT/ACT/GST) and seismic stratigraphic (NGT/CNL/LDT) suites. At the conclusion of logging operations, the drill pipe was raised to 100 mbsf and a 125 sack cement plug was placed.

JOIDES Resolution departed for Singapore at 1945 hr, 22 August 1988. The anchor was dropped at Johor Shoal Buoy near Singapore at 0700 hr, 28 August 1988, ending Leg 122.

OCEAN DRILLING PROGRAM
OPERATIONS RESUME
LEG 122

Total Days (28 June-28 August 1988)		60.98
Total Days in Port		4.39
Total Days Underway		13.19
Total days on Site		43.40
Drill	1.72	
Coring including wireline	24.54	
Logging	8.93	
Trips	4.36	
Reentry	1.40	
Other	2.45	

	43.40	

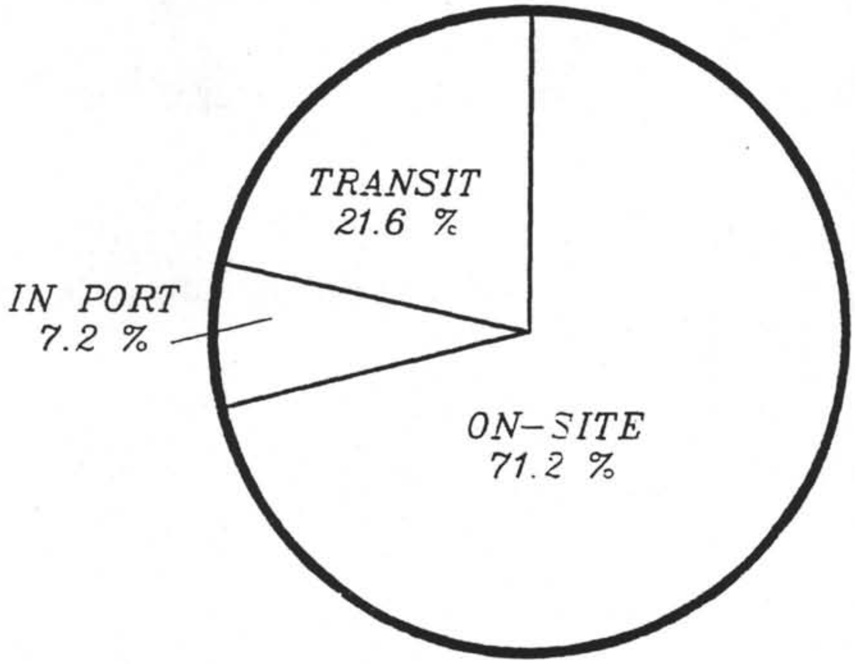
Total Distance Traveled	3756.0 nmi
Average Speed	11.9 kt
Number of Sites	6
Number of Holes	15
Total Interval Cored	3704.1 m
Total Core Recovery	2445.8 m
Average Core Recovery	66.0 %
Total Interval Drilled	1532.1 m
Total Penetration	5236.2 m
Maximum Water Depth	2710.0 m
Minimum Water Depth	1371.4 m

ODP OPERATIONS
SITE SUMMARY REPORT
LEG 122

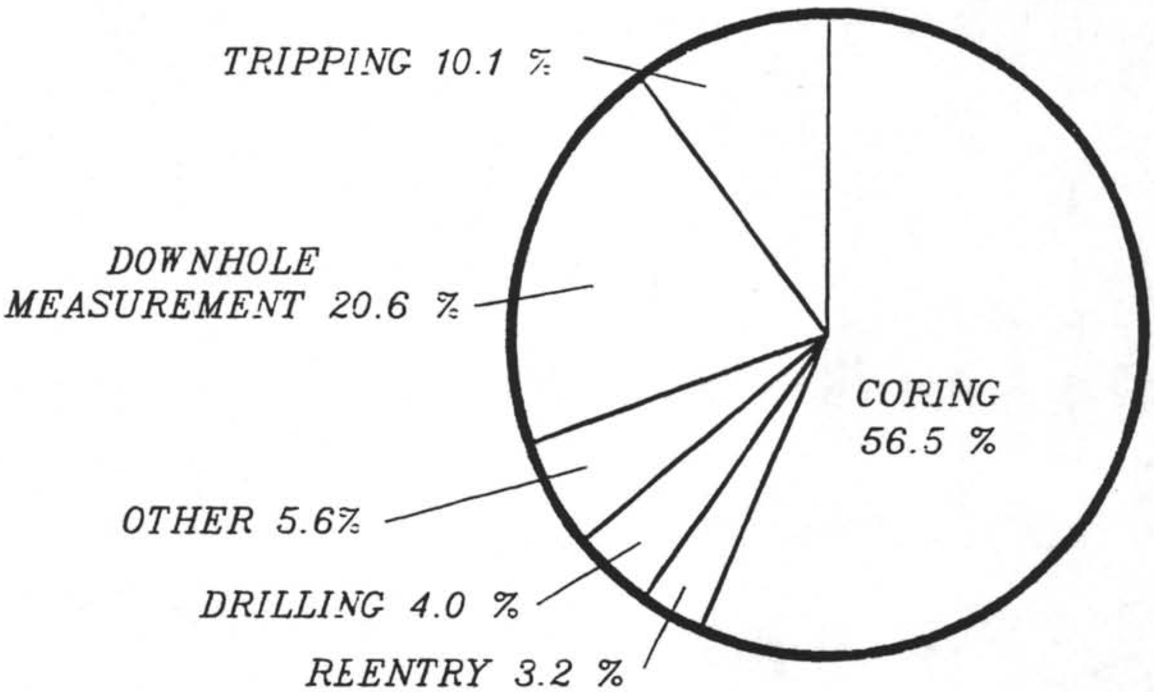
HOLE	LATITUDE	LONGITUDE	DEPTH METERS	NUMBER OF CORES	METERS CORED	METERS RECOVERED	PERCENT RECOVERED	METERS DRILLED	TOTAL PENETRATION
759A	16-57.25S	115-33.61E	2103.0	1	0.0	0.0	100.0%	28.0	28.0
759B	16-57.24S	115-33.63E	2103.0	39	308.0	129.6	42.1%	0.0	308.0
760A	16-55.32S	115-32.48E	1981.1	38	281.9	196.6	69.7%	3.0	284.9
760B	16-55.32S	115-32.47E	1981.1	29	251.5	123.0	48.9%	254.5	506.0
761A	16-44.26S	115-32.09E	-	1	9.5	9.9	104.2%	0.0	9.5
761B	16-44.23S	115-32.10E	2179.3	33	286.7	199.1	69.4%	0.0	286.7
761C	16-44.22S	115-32.10E	2179.3	33	225.7	72.1	31.9%	211.0	436.7
762A	19-53.23S	112-15.26E	-	1	9.5	10.0	105.3%	0.0	9.5
762B	19-53.24S	112-15.24E	1371.4	19	175.4	174.9	99.7%	0.0	175.4
762C	19-53.23S	112-15.24E	1371.4	91	770.0	534.6	69.4%	170.0	940.0
763A	20-35.20S	112-12.50E	1378.9	21	194.9	201.9	103.6%	0.0	194.9
763B	20-35.19S	112-12.52E	1378.9	54	463.5	376.4	80.7%	190.0	653.5
763C	20-35.21S	112-12.51E	1378.9	46	401.0	332.8	83.0%	635.6	1036.6
764A	16-33.96S	115-27.43E	2710.0	8	69.0	40.6	58.8%	0.0	69.0
764B	16-33.96S	115-27.43E	2710.0	31	254.5	44.3	17.4%	40.0	294.5
	Totals :			445	3701.1	2445.8	66.0%	1532.1	5233.2

LEG 122

TIME DISTRIBUTION



ON-SITE TIME BREAKDOWN



TECHNICAL REPORT

The ODP Technical and Logistics personnel aboard JOIDES Resolution for Leg 122 of the Ocean Drilling Program were:

Laboratory Officer:	Brad Julson
Computer System Manager:	Lawrence Bernstein
Curatorial Representative:	Steve Prinz
Yeoperson:	Michiko Hitchcox
Electronics Technician:	Michael Reitmeyer
Electronics Technician:	Barry Weber
Photographer:	Christine Galida
Chemistry Technician:	Matt Mefferd
Chemistry Technician:	Joseph Powers
X-ray Technician:	Donald Sims
Marine Technician:	Wendy Autio
Marine Technician:	Jenny Glasser
Marine Technician:	Grant Macrae
Marine Technician:	Janice Mills
Marine Technician:	Kevin Rogers
Marine Technician:	Amy Russell
Marine Technician:	Christian Segade

INTRODUCTION

Leg 122 commenced at 0905 hr, 28 June 1988, at the Loyang Offshore Dock facilities located on the eastern side of Singapore and ended 62 days later on 28 August 1988, at the same dock. Over 3700 m were drilled resulting in over 15,000 samples for shipboard and shore-based analysis.

PORT CALL, SINGAPORE

Three local pipe fitters were employed during the portcall to install the new auxiliary air conditioning (a/c) unit on the foc'sle deck. An ARL representative from Sydney performed general maintenance and upgraded circuit boards on the XRF 8400. After being repaired in the United States, the MX4400 GPS receiver was re-installed on the bridge.

Air freight and surface shipments were onloaded and offloaded. All the core boxes were offloaded into a 40-ft refrigerated container. Frozen cores were offloaded into a freezer container.

A drill pipe inspection was performed. Two of the ship's tanks were cleaned in preparation for the welding requirements of the sonar dome installation. A Schlumberger logging cable was installed on the logging winch and the old cable was offloaded.

The local Singapore Aggie club was given a tour of the ship by the on-board Aggies.

CRUISE ACTIVITIES

The ship departed 2 July 1988 for Site 759. Lab Officer Bill Mills was evacuated by helicopter to Surabayu, Indonesia, during the initial transit to the first site. Mills was then flown to Singapore for medical treatment. Matt Mefferd assumed Lab Officer duties until Brad Julson arrived by launch from Singapore later in the cruise.

Power Problems

One day out of port, the Cyberex power conditioner failed. The Cyberex provides regulated power for the lab stack. Scientific equipment operating on regulated power was secured. Less power sensitive equipment was switched to ship's power, protected by surge protectors. The power to the underway (U/W) lab was regulated by using a Sola power conditioner. It was decided not to run the shipboard VAX computer on non-regulated power; therefore, scientific computing switched from the VAX to the personal computer (PC) level. A telex was sent to ODP Headquarters requesting spare parts for the Cyberex. Julson brought out the requested parts.

The initial Cyberex failure was attributed to a reference oscillator printed circuit board that went off-frequency causing an invertor to operate at 75+ Hz, taking out the harmonic filter on the output. The spikes sent down the line damaged power supplies and other electronic components.

After 4 days of round-the-clock repairs, the Cyberex was tested. The lab's electricity load was simulated with high current load items such as hot plates, ovens, and heat guns. After sufficient testing with non-critical equipment, the critical lab equipment systems were one by one switched over to regulated power. The three power phases were closely monitored and the electric load was balanced on each phase. The VAX computer was the last system put on line.

Everything ran well for 2 weeks until a second Cyberex failure interrupted the lab stack regulated power. This time the Cyberex went down cleanly and there were no large frequency fluctuations. Again all equipment was secured and lab equipment was plugged into the ship's unregulated power with surge protection. The electricians went back to work on the Cyberex, but efforts to find the cause of the second failure were unsuccessful and the Cyberex was secured for the remainder of the leg.

Other options to get clean power to the lab stack were reviewed. The most viable option entailed splitting the 4160 V buss from the 480 V buss. Unregulated lab stack power is on the same 480 V buss as is the drill floor's electric draw-works brake, which puts electronic noise in the buss when the brake is applied.

During the transit to Singapore after the final site of Leg 122, the 4160 and 480 V busses were separated and the 480 V buss monitored. During the 6-hr test, large motors like pumps and generators were cycled on and off the 480 V buss. Impulses, frequencies, and voltages on all three phases were within the VAX's electrical specifications. The VAX was turned on to allow end of leg data uploading and final backups, without further incident.

LABORATORY ACTIVITIES

Physical Properties Lab

The GRAPE worked well after greasing an upper bearing. New transducers arrived with more solid standoffs for the P-wave logger, but even these broke during use. Because of gas expansion, many core liners were punctured to alleviate pressure. Mud oozed out of these holes and made it necessary to clean the transducers frequently. Stronger springs are needed in order to keep the transducers in better contact with the core liner.

Long drill bits were used to drill holes in indurated sediment to allow thermal conductivity measurements with needle probes.

The Hamilton frame was cleaned and greased. A variable resistor was hooked up to accurately measure the thickness of each sample using a digital multimeter.

The vane shear had problems when a transducer failed. Replacement transducers had too small an inner diameter to attach to the motor shaft. Two were machined out on a lathe in order to make them fit and spares are on order.

Paleomagnetics Lab

The equipment in this lab functioned well. Efforts to connect the Molspin magnetometer to the IBM compatible microcomputer were stalled by interface timing. The project will be completed on Leg 123.

Core Lab

Gas was common in the cores and most of the liners had to be punctured before they could be capped and sealed. The core extruder was used extensively this leg. It has proven once again to be a valuable tool in removing core catcher material. It cannot be used with APC cores because the core catcher contains a flapper; however, these cores are usually composed of soft material that does not need to be extruded. In indurated sediments, where XCB drilling is effective, the disturbance to the core while using the extruder is minimal. There is much less disturbance using the core extruder than pounding the core out with a hammer.

For space reasons, one of the Felker saws was removed from the core lab.

Chemistry Lab

The chemistry lab was busier than usual due to gas monitoring. Drilling in a known gas field required extremely close monitoring of core gas concentrations using head space vials, and the Booker Natural Gas and Carle gas chromatographs (with custom-packed and off-the-shelf columns.) The gas concentrations closely matched the industry mud gas analyses. Fairly rich organic zones were cored and a number of extraction methods were used. A modified condenser with a rotary evaporator was used on sediments that had been broken up using the sonicator. The Rock Eval was used to determine both the type and source of recovered organic materials.

Carbonate contents were measured continuously with the coulometer. Interstitial water (IW) samples were taken every core from the top ten cores at a number of sites, which tripled the number of IW samples analyzed. The scientists used spreadsheets extensively for data analysis and plotting.

The auxiliary a/c unit, installed at the beginning of the leg, has three speeds and cools the chemistry lab to below 75°F even in the tropics. Apparently, the problem of high foc'sle deck temperatures has been solved.

X-Ray Lab

The X-ray lab was used sparingly due to the lack of regulated power. When there was power, the XRD was in constant use. During this time, 96 samples were analyzed. Fortunately, the XRD did not suffer any damage from the power losses.

The XRF was one of the few instruments damaged by the power spikes. The XRF was scheduled to be recalibrated the day the power went down. When power was resumed three weeks later, it was discovered that the XRF tube was blown. Also, one of the programs was damaged and a backup from Leg 111 was used to find an intact copy. Diagnostic testing continued until the power was lost again.

Thin Section Lab and Scanning Electron Microscope (SEM) Lab

The thin section lab was used frequently. A large number of thin sections were requested from the rubble of a poorly recovered section of Hole 764B suspected of being Jurassic in age. The SEM was only used for several hours of scanning, and appears to have survived the power crash.

Computers

The scope of computer use aboard ship changed completely due to the power crashes. Previously, the VAX had been used both to archive data and to do the actual processing. Despite the loss of the VAX, both scientists and techs regrouped and switched to spreadsheets to enter data for a number of reasons--most scientists are familiar with them and they are easy and speedy for data entry. The emphasis for graphics switched from the laser printers to individual plotters hooked to the PCs for the spreadsheet data.

Without the VAX to act as junction, micros were hardwired together to transfer data from applications. IBM/clones, PRO350s, HP150s, and Macintoshes were all used. The common denominator among all the PCs and systems now is the program "Kermit." Due to the power crash, a number of printers were damaged, as well as the power supply to the TU-80 tape drive.

Photo Lab

A large number of core closeup photographs were requested. The loss of the densitometer bulb and film damage may have been linked to the power problems. There were problems with the Kreonite water chillers; they could not produce the flow of chilled water available in the past. The fact that the Kreonite coolers were not turned off in port when the ship's chill water system was turned off may mean excessive pressure built up in the compressors and caused a loss of refrigerant. The problem of rust in the water has improved since the Delrin spacers were put in on Leg 121.

Electronics and Downhole Tools Labs

Blown power supplies and surge suppressors kept the E.T.s busy. The TV reentry system was switched to unregulated power without problem. The regulator boards on both copiers were blown when regulated power was lost. A second laser printer was received this leg and an overhaul was necessary to get it working. It was installed in the computer user room. The GPS external standard interface card was connected to the bridge receiver but, no GPS/transit satellites could be acquired. The card is being sent back for repairs. The underway lab's GPS (global positioning system) functioned well all during the leg.

Nine heatflow/porewater runs were made by lowering the tool downhole on the sand line. The first four runs were heatflow only and the rest were heatflow and porewater. All except the first run were successful.

Fantail and Underway Geophysics Lab

The underway geophysicist used predictive deconvolution processing to help identify horizon depths. The deconvolution program, also used on Leg 119, was strongly endorsed by the geophysicist as a routine processing procedure for each site survey.

A batch of Navy-issue sonobuoys was received. They are extremely easy to use and reliable.

Storekeeping

Our VAX-based inventory program was down most of the cruise. When the VAX was brought up, there were periods of intense updating of item usages.

A new method of attaching velcro labels to storage bins worked well. Previously, when items were moved and consolidated to make way for large quantities of a single item, it was difficult to move the labels from shelf to shelf. Velcro backing resolved this problem.

Safety

The Marine Emergency Technical Squad (METS) practiced with SEDCO each week and staged one emergency drill in the casing hold. Hydrofluoric acid was used during the cruise by paleontologists, and safety procedures were reviewed and followed. Solvents stored under the sink in the paleontology lab were moved into the chemistry lab or the solvent storage area. Mandatory use of goggles while using acetone on the catwalk was initiated.

General

The Totco System, used to measure 20 different drilling parameters and display them on a screen, was installed. The display is updated twice a second. Eventually, the display will be viewed over the ship's television system on channel 11.

Final preparations were made for the sonar dome installation scheduled for the Singapore II portcall. Welding of additional structural reinforcement was finished and the cables have been connected to the J-box. The new forward position should improve 3.5 kHz and 12 kHz records by reducing noise from moonpool turbulence and machinery.