17. SITE 729[1]

Shipboard Scientific Party[2]

HOLE 729A

Date occupied: 28 September 1987

Date departed: 28 September 1987

Time on hole: 16 hr, 30 min

Position: 17°38.715'N, 57°57.221'E

Water depth (sea level; corrected m, echo-sounding): 1398.5

Water depth (rig floor; corrected m, echo-sounding): 1409.0

Bottom felt (m, drill pipe): 1403.8

Penetration (m): 109.1

Number of cores: 13

Total length of cored section (m): 109.1

Total core recovered (m): 31.72

Core recovery (%): 29.1

Oldest sediment cored:
Depth sub-bottom (m): 109.1
Nature: nummulitic, shallow-water limestone
Age: Undetermined
Measured velocity (km/s): -

Principal results: Site 729 is situated in water depths of 1400 m off Oman's shore on a basement block of presumed ophiolitic origin. Our objectives in drilling Site 729 were to recover the oldest sediments on one of the blocks, to penetrate to underlying strata, and possibly to recover igneous rock.

We obtained the following results in drilling Site 729:

1. shallow-water carbonates underlie a condensed Quaternary hemipelagic sequence;
2. shallow-water limestones at Site 729 are similar in character and facies to those recovered at Site 726, 60 km to the west on a second basement ridge; and
3. the limestone sequence apparently is not cemented and dolomitized.

The results of drilling at Site 729 show that pre-Neogene basement, which today is characterized by the mosaic of tectonic structures in the Neogene, may have been a starved carbonate platform in the Paleogene. It may have been uplifted and eroded in the Oligocene and broken into slope basins and ridges in the Neogene.

BACKGROUND AND OBJECTIVES

Site 729 is located in water depths of about 1400 m at 17°38.715'N and 57°57.221'E on the continental margin of Oman (Fig. 1). This area of the slope and margin may be composed, in part, of the upthrust ophiolite complex that is observed on the island of Masirah to the north of Site 726 (Moseley and Abbotts, 1979). Slope basins between ophiolite blocks lie at water depths ranging from 1500 m to 500 m and thus accumulate sediments coincident in water depth with the intermediate-water masses of the Arabian Sea. Site 729 is located on the deepest and most distal basement block that forms the seaward boundary of the lower slope basin (Fig. 1). The location of Site 729 is shown in Figure 2, and its structural and depositional setting is shown in Figure 3. Site 729 is located on the brow of the east-facing scarp of a basement peak that is thought to be an ophiolite complex (Fig. 3). This block forms the eastern boundary of the lower slope basin and is faulted just west (landward) of Site 729.

Seismic reflection profiles (Fig. 3) show a pelagic cap in the uppermost 0.05 s (about 40 mbsf) that is underlain by a relatively transparent zone to 0.2 s (about 170 mbsf). Diffuse reflections, which are thought to be the ophiolitic basement, occur at about 0.35 s or about 310 mbsf (Fig. 3B). In general, this location reveals older conformable reflectors that have an unknown relationship to basement and that are truncated and draped by pelagic sediments. We selected Site 729 to obtain samples of older, truncated sediments and possible underlying basement.

Our specific objective for drilling at Site 729 was to obtain samples of the basement complex and its overlying sediments in order to help constrain the tectonic and depositional history of the margin and the slope basins.

OPERATIONS

The *JOIDES Resolution* reached Site 729 in dynamic positioning mode after a transit of 1.5 hr from Site 728. Since Site 729 had been surveyed previously and marked with a beacon, no additional survey was performed. At 0600 hr on 28 September 1987, the ship was positioned over the beacon in 1398.8 m water depth. The position of Site 729 as obtained by global positioning system (GPS) is 17°38.715'N and 57°57.221'E.

Because the goal of our drilling at Site 729 was to retrieve ophiolitic basement overlain by limestone, we used the rotary core barrel (RCB) system to cut the first core at 1030 hr on 28 September. After first satisfying recoveries in nannofossil oozes to Core 117-729A-4R (26.3 mbsf), recovery dropped sharply in brittle limestones, of which only pebble-sized fragments were recovered from Cores 117-729A-5R to -13R (109.1 mbsf total depth). Hole conditions deteriorated rapidly, and we abandoned drilling in Hole 729A after Core 117-729A-13R. The overall recovery rate for Hole 729A was 29.1% (Table 1). By 2230 hours on 28 September 1987, the ship was underway to Site 730 with no further delays.

LITHOSTRATIGRAPHY

Lithologic Units

We subdivided sediments and rocks recovered at Site 729 into two lithologic units. Lithologic Unit I is composed of foraminifer muds of Quaternary age, while Unit II is a fossiliferous, shallow-water limestone (Fig. 4).

Unit I (Depth: 0–28.35 mbsf; Age: Holocene-Pleistocene)

Core 117-729A-1R through Section 117-729A-4R-5, 5 cm.

Unit I is composed of nannofossil-foraminifer-rich mud to marly nannofossil ooze. The grain sizes include clay- (30%–80%), silt- (15%–40%), and sand-sized particles (5%–30%).

[1] Prell, W. L., Niitsuma, N., et al., 1989. *Proc. ODP, Init. Repts.*, 117: College Station, TX (Ocean Drilling Program).

[2] Shipboard Scientific Party is as given in the list of Participants preceding the contents.

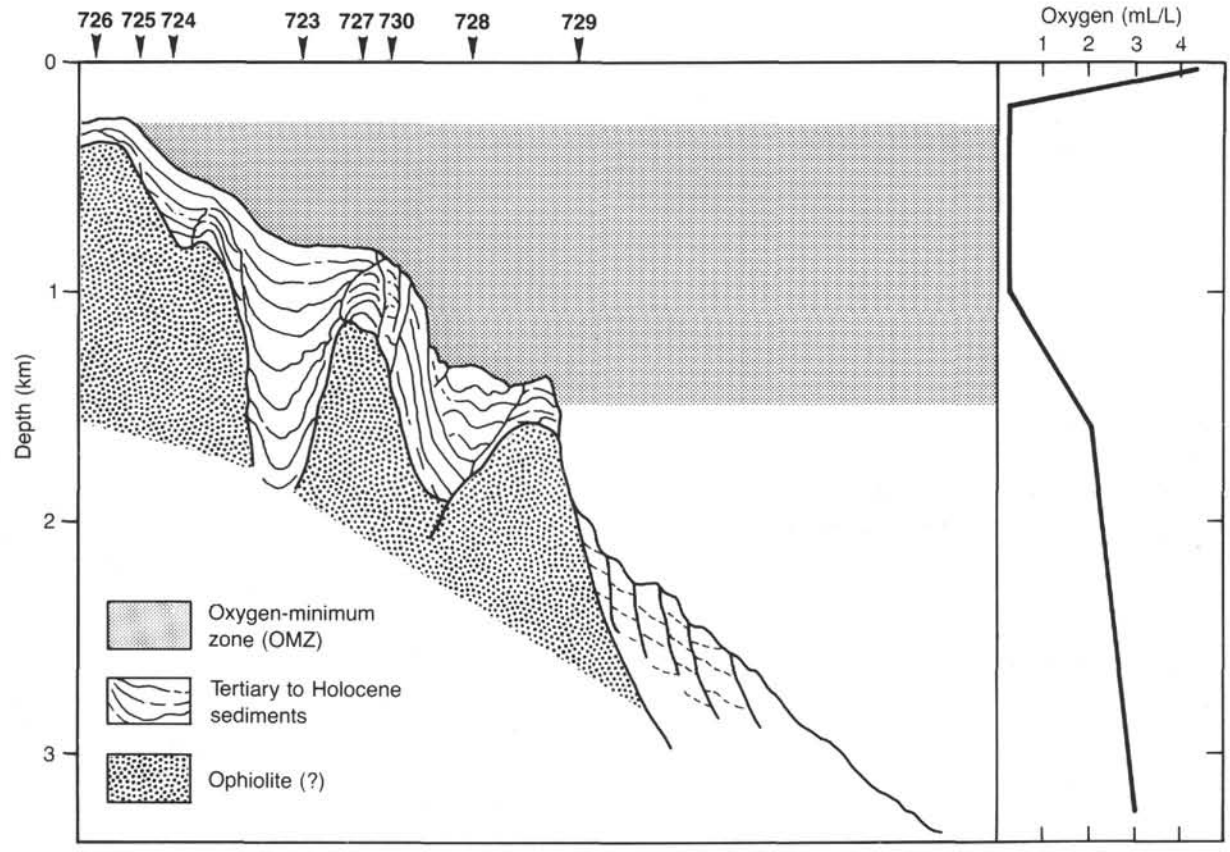


Figure 1. Structure of the Oman margin and the oxygen-minimum zone (OMZ). The schematic profile shows the series of basement ophiolite blocks and the sedimentary basins between them. The concentration of oxygen in the water column (RC-2704, unpubl. date) defines the depth range of the OMZ and where it impinges on the margin. The schematic location of Site 729 is indicated.

The sand fraction is composed mainly of foraminifer tests, which exhibit their highest occurrence toward the top of Unit I. This foraminifer-rich facies is replaced downhole by a nannofossil-dominated facies. The sediments are olive in color (5Y 4/3 to 5/3) and display burrow mottling in Cores 117-729A-3R and -4R. The upper two cores do not show burrow mottling because of drilling disturbance.

Unit I exhibits slight differences in lithology, which are expressed as indistinct alternations of light and dark layers between 0.2 and 1.5 m thick. The light layers are more coarse grained and foraminifer rich, while some of the dark layers seem, from smear slide analyses, to have a higher content of organic carbon. Organic carbon values range from 0.5% to 1.7% (Table 2). Trace amounts of authigenic dolomite rhombs occur in Cores 117-729A-3R and -4R, while phosphorite concretions are found 5 cm above the transition from Unit I to Unit II. That transition appears in Core 117-729A-4R as a relatively sharp boundary.

Unit II (Depth: 28.35–109.1 mbsf; Age: undetermined)

Sections 117-729A-4R-5, 5 cm, through 117-729A-13R.

Unit II is a large foraminifer- to algae-bearing carbonate sequence which is relatively weakly cemented and highly porous. The recovery within Unit II was so low (0%–2.5%) that we could not establish a detailed stratigraphy of the carbonate sequence. The uppermost part of Unit II (Core 117-729A-4R, 28.3–32.0 mbsf) contains a white, highly calcareous, weakly cemented, and friable foraminifer-wackestone with a fine-grained micritic matrix. The facies contains whole and fragmented specimens of large, benthic foraminifers which reach a diameter of 0.5–1 cm. Further downhole, carbonates were only recovered in Core 117-729A-10R (70–80 mbsf) with 24 cm of algae-dominated wackestone. Thin-section examination of this facies reveals an encrusting, oncolithic type of algae and branches of red algae. Foraminifer tests are filled with two generations of cement: early fibrous rim cement and a later blocky spar. The matrix of the rock is dolomitized.

Discussion

The weakly cemented to partly dolomitized rocks of Unit II are shallow-water carbonates. The presence of red algae indicates shallow water (tens of meters deep) with normal salinities (Flügel, 1982). Facies and diagenetic patterns appear to be similar to those observed in the Eocene carbonates recovered at Site 726 approximately 50 km west of Site 729. These similarities include (1) the occurrence of foraminifer-rich and algae-dominated facies in the upper and lower parts of the recovered sequences, respectively; (2) the low degree of cementation in the upper facies, and (3) initiation of matrix dolomitization in the lower facies. However, a dolomitized zone which we found at the transition from Unit I to Unit II at Site 726 was not encountered at Site 729. Implications regarding the time gap between Unit I and II are discussed for Site 726 (see "Lithostratigraphy" section, "Site 726" chapter, this volume) and are not repeated here.

Unit I is composed of a condensed Quaternary sequence. The relatively large grain size of the sediment and the occurrence of clayey to silty sand layers are due mainly to the high foraminifer content (10%–40%). Site 729 is located on a somewhat isolated promontory off the Oman margin in a water depth of 1400 m (see "Background and Objectives" section, this chapter) and the silty sand layers may represent winnowed

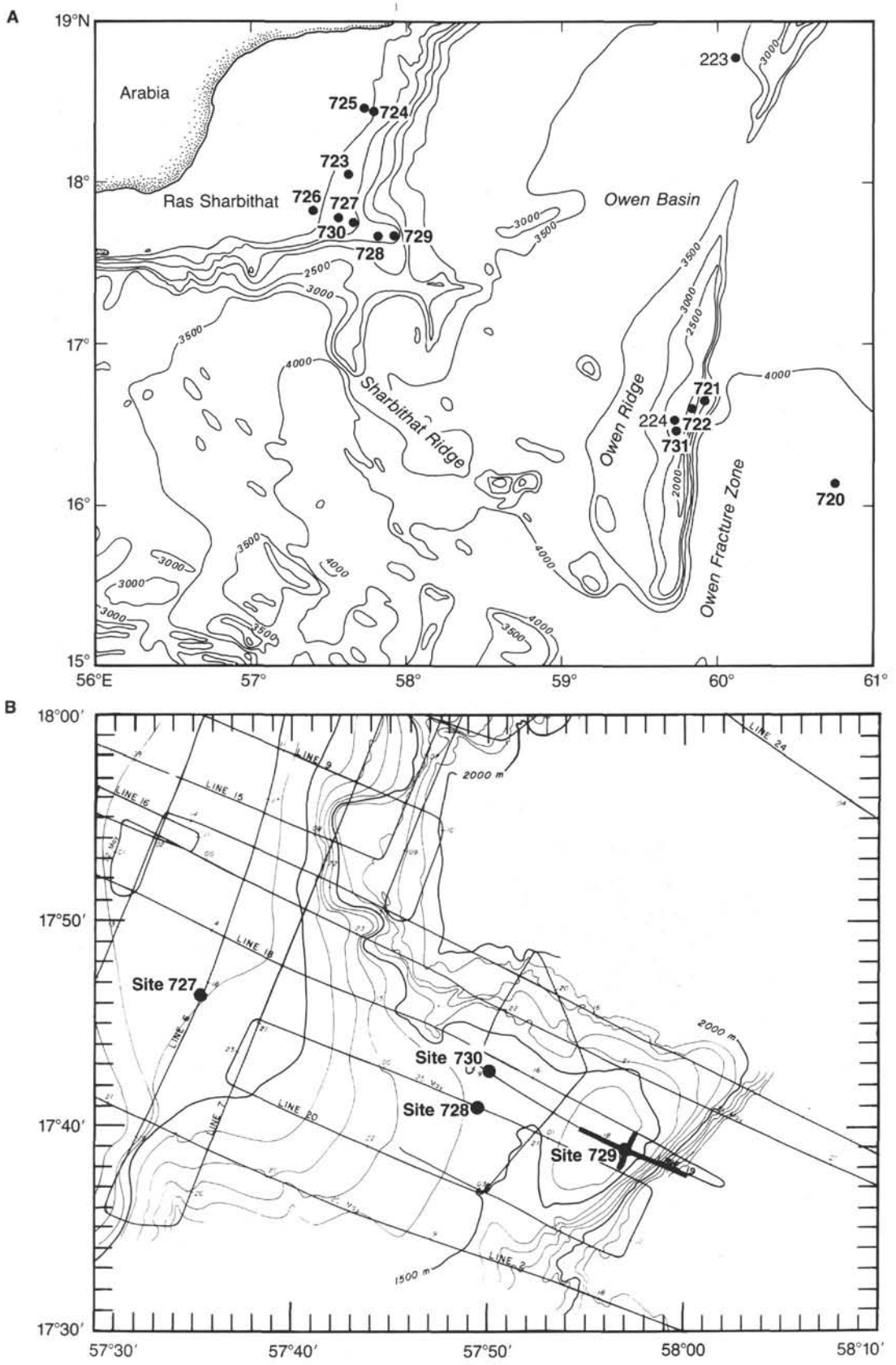
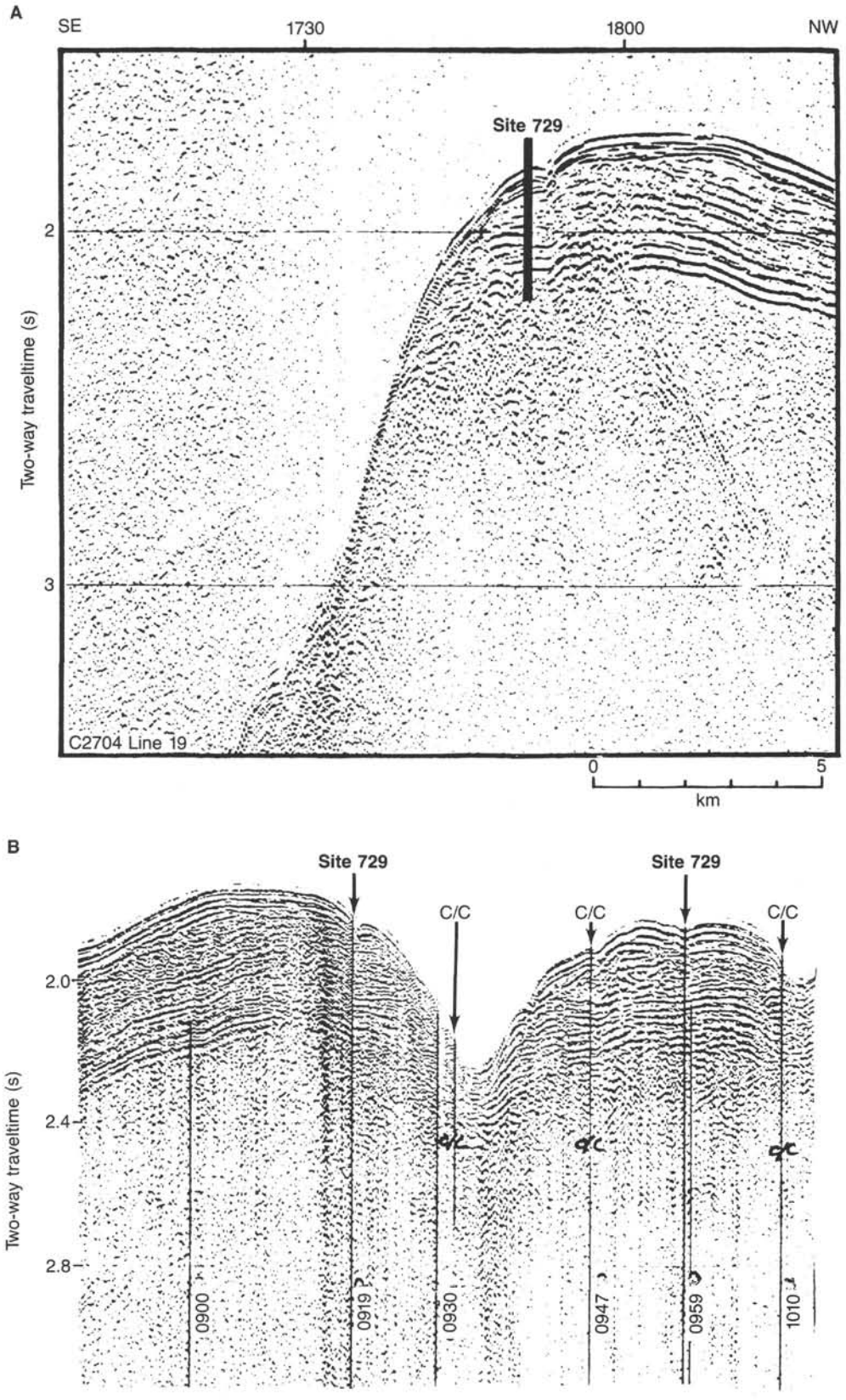


Figure 2. A. Bathymetry of the Oman margin and the location of Site 729. B. The detailed location of Site 729 and the seismic profiles shown in Figure 3. Bathymetric data are from the site survey (RC2704, 1986).



JOIDES Resolution Line 7

Figure 3. Single-channel seismic (SCS) reflection profiles showing the structural and depositional setting of Site 726. A. RC-2704 Line 19 is perpendicular to the strike of the basement block and shows the faulting near the crest. B. *JOIDES Resolution* Line 7 shows both dip and strike sections of the basement peak. The profile indicates two passes made by the *JOIDES Resolution*. C/C = course change.

Table 1. Coring summary, Site 729.

Core no.	Date (Sept. 1987)	Time (local)	Depth (mbsf)	Cored (m)	Recovered (m)	Recovery (%)
117-729A-						
1R	28	1105	0–3.2	3.2	3.26	102.0
2R	28	1135	3.2–12.7	9.5	8.81	92.7
3R	28	1210	12.7–22.3	9.6	9.68	101.0
4R	28	1300	22.3–26.3	4.0	9.67	242.0
5R	28	1325	26.3–31.9	5.6	0	0
6R	28	1350	31.9–41.4	9.5	0.01	0.1
7R	28	1430	41.4–51.0	9.6	0	0
8R	28	1505	51.0–60.6	9.6	0.01	0.1
9R	28	1530	60.6–70.3	9.7	0.02	0.2
10R	28	1600	70.3–80.0	9.7	0.24	2.5
11R	28	1750	80.0–89.7	9.7	0.02	0.2
12R	28	1715	89.7–99.4	9.7	0	0
13R	28	1745	99.4–109.1	9.7	0	0
				109.1	31.72	

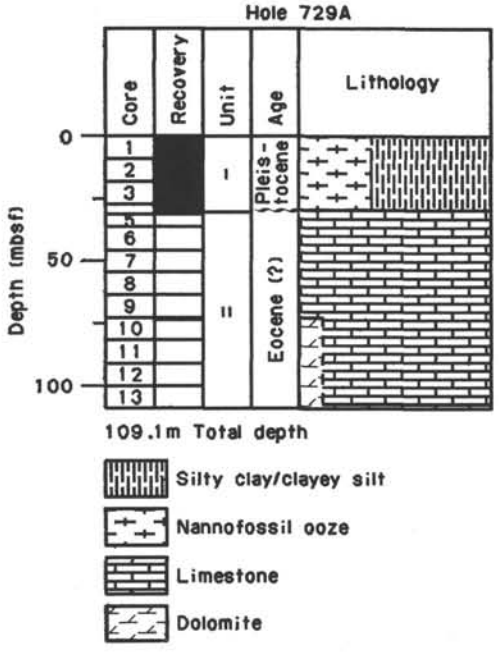


Figure 4. Lithologic summary, Site 729.

deposits. We have listed in Table 2 a few of the carbonate and organic carbon measurements which characterize this unit.

BIOSTRATIGRAPHY

Introduction

The uppermost sediments recovered at Site 729 are marly foraminifer nannofossil oozes of Pleistocene to Holocene age. However, below 26 m, we recovered a lithified limestone.

Only the uppermost lithologic unit contains planktonic foraminifers and calcareous nannofossils, which are abundant and have moderate to good preservation. Benthic foraminifers are common and have moderate to good preservation in Unit I. Benthic foraminifers are also present in the limestone, but the preservation deteriorated dramatically. No siliceous microfossils were found at this site (Fig. 5). For a detailed listing of faunap events see Table 3.

Table 2. Carbonate and organic carbon data, Site 729.

Core, section, interval (cm)	Depth (mbsf)	Total carbon (%)	Inorganic carbon (%)	Organic carbon (%)	$CaCO_3$ (wt%)
117-729A-					
1R-3, 10–12	3.10	9.30	8.29	1.01	69.1
2R-3, 39–41	6.59	8.73	7.03	1.70	58.6
2R-6, 39–41	11.09	9.32	8.82	0.50	73.5
3R-1, 70–72	13.40	8.92	8.25	0.67	68.7
3R-3, 70–72	16.40	9.43	8.60	0.83	71.6
3R-6, 60–62	20.80	8.44	7.37	1.07	61.4
4R-1, 60–62	22.90	9.08	7.74	1.34	64.5
4R-3, 41–43	25.71	7.27	6.72	0.55	56.0

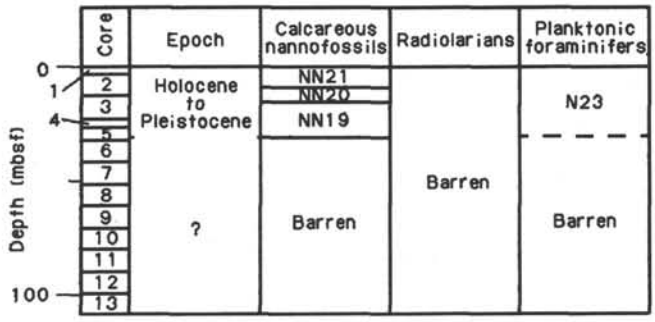


Figure 5. Correlation of planktonic microfossil zones in Hole 729A.

Table 3. Stratigraphic listing of faunal events for Hole 729A.

Event	Sample or section, interval (cm)	Depth (mbsf)	Age (Ma)	Source of age
B *Emiliania huxley*	117-729A-2R-3, 105–106	7.25	0.19	1
	117-729A-2R-5, 105–106	10.25		
T *Pseudoemiliana lacunosa*	117-729A-3R-1, 105–106	13.75	0.49	1
	117-729A-3R-3, 105–106	16.75		
B *Gephyrocapsa parallela*	117-729A-3R, CC	22.30	[a]0.89	3
	117-729A-4R-1, 105–106	23.35		
T [b]*Geophyrocapsa* large	117-729A-4R-1, 105–106	23.35	[a]1.10	3
	117-729A-4R-3, 105–106	26.35		

Note: T = upper limit and B = lower limit. Sources of ages are: 1 = oxygen isotope data for Site 723 (N. Niitsuma, unpubl. data) and 3 = Takayama and Sato, 1987.
[a] North Atlantic data.
[b] Long axis greater than 6 μm.

Planktonic Foraminifers

The first three core-catcher samples (3.2–22.3 mbsf) in Hole 729A contained abundant and well-preserved planktonic foraminifer assemblages. *Globigerinella calida calida* and *Globorotalia truncatulinoides* indicate a Pleistocene age. The lower part of the section, which is composed of shallow-water carbonates, is barren.

Benthic Foraminifers

The benthic foraminiferal fauna was studied in the core catchers of Hole 729A. Preservation in the upper three samples (117-729A-1R, CC, through -3R, CC; 3.2–22.3 mbsf) is good to moderate, whereas the remainder of the sequence consists of lithified or semilithified limestone with sharply deteriorating states of preservation. In order to investigate the foraminiferal

fauna in the limestone, shore-based studies of thin sections will have to be conducted.

The planktonic/benthic (P/B) ratio is about 99% in the upper three samples where benthic foraminifers are rare and have moderate diversity.

Common benthic foraminiferal species in the unconsolidated uppermost Pleistocene interval of Hole 729A are *Bolivina ordinaria*, *Cibicidoides wuellerstorfi*, *Hoeglundina elegans*, *Melonis barleeanum*, *Osangularia culter*, *Pullenia subcarinata*, *Sigmoilinopsis schlumbergeri*, and *Uvigerina hispida*. The faunal composition and the high P/B ratio indicates that Site 729 was located in the upper middle bathyal zone during the Pleistocene.

The benthic foraminiferal fauna in the underlying limestone was not investigated. However, the presence of larger foraminifers of nummulitid and amphistegid types indicates that this part of the sequence was deposited in a shallow-water environment.

Calcareous Nannofossils

Calcareous nannofossils are abundant with moderate to good preservation in the uppermost three core catchers at this site. Sediments down to 7.25 mbsf contain *Emiliania huxleyi* and are assigned to Zone NN21 (upper Pleistocene to Holocene). Sediments in Samples 117-729A-2R-5, 105–106 cm, down to 117-729A-3R-1, 105–106 cm (10.25–13.75 mbsf), contain neither *E. huxleyi* nor *Pseudoemiliania lacunosa* and are assigned to Pleistocene Zone NN20. Sediments in Sample 117-729A-3R-3, 105–106 cm, down to 117-729A-4R-5, 4 cm (16.75–28.3 mbsf), contain *P. lacunosa* and belong to Zone NN19 (lower Pleistocene to uppermost Pliocene). Below this, the lithology changes from a marly nannofossil ooze to a partially lithified limestone which does not contain any calcareous nannofossils (Fig. 5 and Table 3).

Radiolarians

This site is barren of siliceous microfossils.

Paleoenvironmental Implications

The presence of limestone which contains larger foraminifers in the lower part of the sequence indicates a very shallow-water (<200 m) environment during the depositional period.

ACCUMULATION RATES

Sedimentation rates at Site 729 are based on four nannofossil datums identified in the top 26 m (Fig. 6). The mean rate increases upsection from 18 to 46 m/m.y. The higher rate is associated with the foraminifer-rich interval at the top of the site (see "Lithostratigraphy" section, this chapter). The low rate of sedimentation for the hemipelagic deposits at Site 729 may be attributed to postdepositional winnowing, which is thought to be responsible for the silty foraminiferal sand layers found at this site (see "Lithostratigraphy" section, this chapter).

We calculated the mass accumulation rates of calcium carbonate, organic carbon, and noncarbonate sediment components from average values between the datum levels (Table 4). Total accumulation averages 2.6 g/cm^2/k.y. over the past 1.1 m.y., with more than half of this value attributed to calcium carbonate. Organic carbon accumulations are comparable to the calculated rates for the pelagic deposits at Owen Ridge sites (see Owen Ridge site chapters, this volume).

PHYSICAL PROPERTIES

The measurement and analysis of physical properties at Site 729 were restricted by a very low recovery rate in Cores 117-729A-5R through -13R. Physical properties measurements were limited to index properties (wet-bulk density, porosity, water content, and grain density) determined for sediments from Cores 117-729A-1R to -4R.

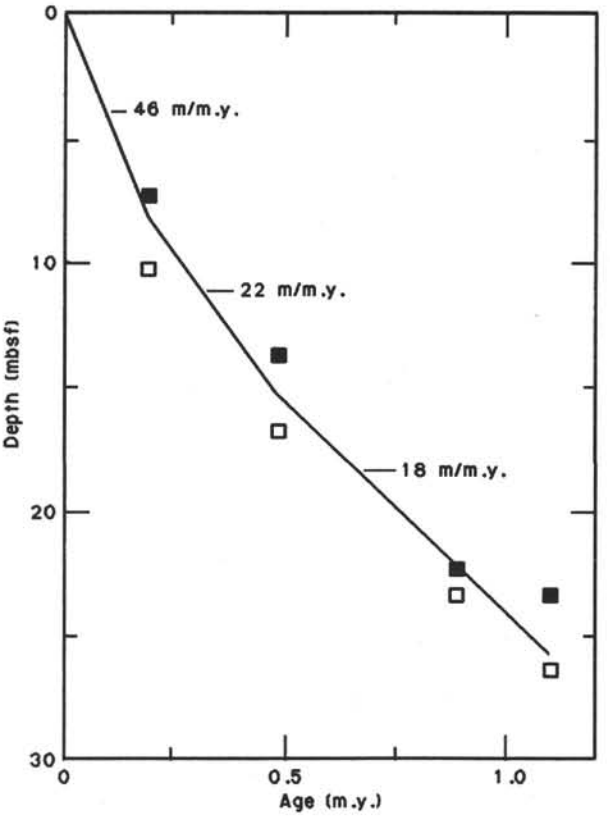


Figure 6. Age-depth plot of stratigraphic datums listed in Table 3. The filled and open dots are the upper and lower depths of each datum level, respectively. Indicated sedimentation rates are calculated between nannofossil datum levels.

Two lithologic units were identified at Site 729. Unit I is a nannofossil-foraminifer-rich mud to a marly nannofossil ooze (see "Lithostratigraphy" section, this chapter) extending from the sea floor to approximately 24 mbsf. The interval from 0 to 13 mbsf shows a slight increase in porosity from 64% to 67% and in water content from 41% to 43%; grain density remains roughly constant at 1.61 g/cm^3. The interval from 13 to 24 mbsf shows an abrupt decrease in porosity from 67% to 56% and in water content from 43% to 32%; wet-bulk density, on the other hand, increases from 1.61 to 1.80 g/cm^3 (Table 5). These data are presented with the cautionary note that drilling disturbances occurred throughout these sediments.

Unit II (24–109 mbsf) is characterized by a very friable and highly disturbed nummulitic limestone. Because of the high degree of drilling disturbance, index properties were not determined for these sediments.

INORGANIC GEOCHEMISTRY

Recovery was poor at Site 729, and only two interstitial water samples were collected, both by squeezing. The standard suite of analytical measurements was performed on the samples; the results are listed in Table 6.

The data indicate that diagenetic activity is not pronounced in the sediments at this site. Little difference from expected bottom-water concentrations of most constituents is seen in the top 30 m. Sulfate reduction over the top ~30 m is hardly evident.

Table 4. Sedimentation and accumulation rate data for Site 724.

Depth interval (mbsf)	Age range (m.y.)	$CaCO_3$ ($\bar{x}$ %)	C_{org} ($\bar{x}$ %)	Dry-bulk density ($\bar{x}$ g/cm^3)	Sed. rate ($\bar{x}$ m/m.y.)	$CaCO_3$ acc. rate (g/cm^2/k.y.)	Non-$CaCO_3$ acc. rate (g/cm^2/k.y.)	C_{org} acc. rate (mg/cm^2/k.y.)
0–8.75	0–0.19	63.9	1.36	0.948	46.0	2.79	1.57	59.3
8.75–15.25	0.19–0.49	71.1	0.59	1.004	21.7	1.55	0.63	12.9
15.25–22.30	0.49–0.89	65.8	1.08	1.122	17.6	1.30	0.68	21.3
22.30–26.00	0.89–1.10	56.0	0.55	1.224	17.6	1.21	0.95	11.8

Table 5. Physical properties summary, Hole 729A.

Core, section, interval (cm)	Depth (mbsf)	Wet-bulk density (g/cm^3)	Porosity (%)	Water content (%)	Grain density (g/cm^3)	Dry-bulk density (g/cm^3)
117-729A-						
1R-3, 10–12	3.10	1.621	64.3	40.7	2.650	0.962
2R-3, 40–42	6.60	1.611	66.1	42.0	2.664	0.934
2R-6, 40–42	11.10	1.605	67.1	42.8	2.705	0.918
3R-1, 70–72	13.40	1.706	60.1	36.1	2.624	1.090
3R-3, 70–72	16.40	1.700	61.1	36.8	2.696	1.074
3R-6, 60–62	20.80	1.770	56.2	32.5	2.636	1.194
4R-1, 60–62	22.90	1.725	61.1	36.3	2.574	1.099
4R-3, 41–43	25.71	1.796	55.8	31.8	2.711	1.224

Table 6. Summary of interstitial water geochemical data, Site 729.

Sample, interval (cm)	Depth (mbsf)	Vol. (mL)	pH	Alk. (mmol/L)	Sal. (g/kg)	Mg (mmol/L)	Ca (mmol/L)	Cl (mmol/L)	SO_4 (mmol/L)	PO_4 (μmol/L)	NH_4 (mmol/L)	SiO_2 (μmol/L)	Mg/Ca
117-729A-													
1R-2, 145–150	2.95	44	7.50	3.74	35.8	52.63	10.02	562	24.6	3.0	0.13	198	5.25
3R-4, 145–150	18.65	36	7.50	2.34	35.9	57.84	10.27	562	24.3	1.5	0.14	350	6.63

The shallow gradient of dissolved silica (~15 μmol/L/m) is among the lowest observed on the margin and indicates that the sediments at Site 729 are opal depleted.

ORGANIC GEOCHEMISTRY

The sediments recovered at Site 729 on the Oman margin were divided into two lithologic units. Eight physical property samples from Unit I, which consists of marly foraminifer-nannofossil oozes of Pleistocene age, were analyzed for their inorganic and organic carbon contents. The results are listed in Table 2. No gas pockets were observed.

SUMMARY AND CONCLUSIONS

Site 729 is situated in water depths of 1400 m on the Oman continental margin in the northwestern Indian Ocean. One of eight sites on the Arabian margin, Site 729 is located on a basement block of presumed ophiolitic origin. Adjacent ridges of ophiolite blocks confine a series of deep slope basins at various depth ranges on the Oman margin. Neogene sections in these basins have been the prime target of drilling on the margin during Leg 117. The objective of Site 729 was to recover the oldest sediments on one of the blocks, to penetrate to underlying strata, and possibly to recover igneous rock. Once the nature and age of the underlying rocks are established, we hoped to use our findings to delineate the tectonic history of the basement ridges and basins.

The main results obtained by drilling at Site 729 are:

1. Shallow-water carbonates underlie a condensed Quaternary hemipelagic sequence.

2. The shallow-water limestones at Site 729 are similar in character and facies to those recovered at Site 726, 60 km to the west on a second basement ridge.

3. The limestone sequence apparently is not cemented and/or dolomitized.

The sediments recovered at Site 729 were sudivided into two lithologic units. Unit I (0–26.3 mbsf) consists of marly, foraminifer-nannofossil oozes of Pleistocene age. Unit II, although very sparsely recovered, is believed to be composed of nummulitic shallow-water limestones with oncoliths, uncemented and very brittle. Our failure to recover any coherent portion of this unit down to a total depth of 109.1 mbsf led to the decision to abandon Site 729 without reaching basement for fear of drilling complications.

This site confirmed that the basement structures are overlain (probably unconformably) by shallow-water limestones of Paleogene(?) age. A similar sequence is observed on the island of Masirah to the north, where shallow-water limestones of Eocene age unconformably overlie the allochthonous ophiolite series.

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