3. BACKGROUND AND SUMMARY OF DRILLING RESULTS—OWEN RIDGE[1]

Shipboard Scientific Party[2]

The Owen Ridge is an asymmetric, northeast-trending ridge that originates at about 15°30′N, 59°50′E, where the Sharbithat Ridge intersects the Owen Fracture Zone, and extends to about 20°N, 61°E, where it merges with the Murray Ridge (Figs. 1 and 2). The trend of the Owen Ridge is somewhat oblique to the Arabian continental margin and its distance from land is about 320 km in the south and about 200 km in the north. The Owen Basin, which lies between the Arabian margin and the Owen Ridge, is sediment filled and has depths of 3200–3500 m (Fig. 1).

The crest of the ridge varies from about 1900 m to 2100 m below sea level and has two distinct sediment caps that are formed of thick, smooth, subhorizontal pelagic sediments (Fig. 2). The eastern scarp of the ridge dips steeply (about 15°) to the east, where it abuts the Indus Fan at about 4000 m (Figs. 2 and 3). The Owen Fracture Zone bounds the base of the scarp and is observed as a deformation front in the Indus Fan sediments (Fig. 3, see also "Seismic Stratigraphy" section, "Site 720" chapter, this volume). The orientation of the eastern scarp and the character of deformation in the fan sediments changes at about 16°30′N (Fig. 2), where the ridge trends more northeastward and is associated with uplift and deformation of the adjacent fan sediments, as indicated by the eastward displacement of the 4000-m isobath. The western flank of the ridge dips more gently (about 4°) and merges into the Owen Basin at about 3500 m. The physiography of the western flank is extremely complex and is characterized by eastward-trending slump valleys and sediment ridges (Fig. 2). Much of the sediment in the valleys appears to be displaced and reworked, so that drill sites for Leg 117 were targeted only on the sediment ridges and caps near the crest of the ridge.

The origin of the Owen Ridge and the age of the underlying basement rock are connected to both the early separation of Madagascar and India and to the middle Tertiary reorganization of seafloor spreading in the Indian Ocean. Several authors (McKenzie and Sclater, 1971; Whitmarsh, 1974; Norton and Sclater, 1979; Whitmarsh, 1979; Stein and Cochran, 1985) postulate that the Owen Fracture Zone was the major transform between spreading centers to the north and south of the Arabian margin. This plate geometry places the Owen Ridge and Owen Basin on the passive Arabian margin and assigns them a Jurassic age. However, DSDP drilling in the easternmost Owen Basin (Site 223 is 30 km west of the Owen Fracture Zone) found a basal igneous unit (717–740 mbsf) of trachybasalt and hyaloclastic breccia overlain by late Paleocene tuffaceous claystone (Whitmarsh et al., 1974). DSDP drilling on the Owen Ridge (Site 224) recovered middle to lower Eocene sediments above lamprophyric igneous rocks (Site 224; Whitmarsh et al., 1974). Supporters of the Jurassic-Triassic age for the Owen Basin generally discount the Sites 223 and 224 igneous rocks as not representing true oceanic basement. Thus, questions still remain concerning the age and nature of igneous basement underlying the Owen Ridge and Basin.

The uplift history of the Owen Ridge has been interpreted on the basis of drilling results at DSDP Site 224 (Whitmarsh et al., 1974) and seismic reflection profiles (Whitmarsh et al., 1974; Whitmarsh, 1979) and Leg 117 site survey data (Mountain and Prell, this volume). The timing and amount of uplift is based on the presumption that the upper Oligocene to lower Miocene turbidite beds deposited at the site were originally flat lying and that they have been uplifted along the Owen Fracture Zone and tilted westward. The stratigraphy at Site 224 (Whitmarsh et al., 1974) indicates that the transition from turbidites to pelagic sediments occurred in late Oligocene to early Miocene time, but poor recovery precludes a more exact reconstruction of the uplift history. The cause of the uplift is attributed to compression along the Owen Fracture Zone caused by changes in spreading direction associated with the continued collision of India and Asia and the opening of the Gulf of Aden (Whitmarsh, 1979).

Following its uplift above the reach of turbidite deposition, the ridge crest has accumulated predominantly pelagic, carbonate-rich sediments during the late Neogene (Whitmarsh et al., 1974; Prell, 1984a; 1984b; Mountain and Prell, unpubl. site survey data). The crest of Owen Ridge lies more than 2000 m above the surface of the Indus Fan and about 1500 m above the Owen Basin, and thus acts as a platform for the accumulation of pelagic sediments. Most of the Owen Ridge and all of Leg 117 drilling sites except Site 720 are shallower than the Holocene carbonate lysocline at 3900–4000 m (Kolla et al., 1976) and the foraminiferal lysocline, which lies at about 3300 m (Cullen and Prell, 1984). Hence, the late Neogene sediments were expected to have good carbonate preservation, so that paleoenvironmental interpretations based on foraminifers and calcareous nannofossils would not be biased by dissolution.

The sediments typically range from 50% to 80% in carbonate content and have accumulation rates of 30–40 m/m.y. in the late Neogene. The pelagic carbonates of the ridge are diluted by terrigenous sediments that are transported to the ridge primarily by winds. Recent studies have shown that the concentrations of mineral aerosols over the Arabian Sea are among the highest recorded in the global marine environment (Savoie et al., 1987; Chester et al., 1985; Prodi et al., 1983). Other studies have documented agreement between the distribution of seafloor clay minerals and aerosol mineral concentrations (Chester et al., 1985) and between estimates of their flux based on mean aerosol concentrations and sediment data (Savoie et al., 1987). Mineralogical studies of modern seafloor sediments suggest that eolian components comprise a significant proportion of Arabian Sea sediments as a whole and are the dominant terrigenous component in the northwestern Arabian Sea (Goldberg and Griffin, 1970; Kolla and Biscaye, 1976; Kolla et al., 1981). These mineralogical studies also indicate that the Arabian and Somali peninsulas are major source areas for eolian palygorskite while the Iran-Pakistan region is a major source for eolian illite and chlorite. Mineral-specific source areas such as these offer the possibility of studying the relative influence of the winter and summer monsoon regimes in the geologic past. The record of eolian transport and deposition on the Owen Ridge should provide in-

[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.

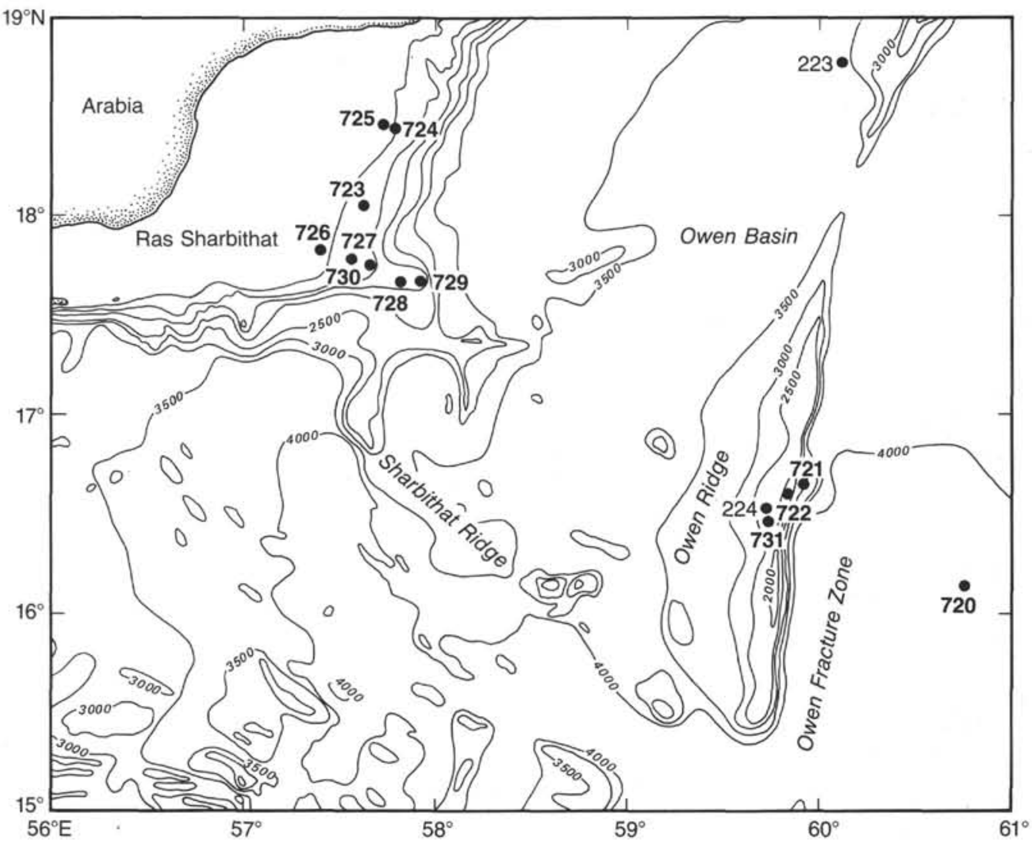

Figure 1. General bathymetry of the northwestern Indian Ocean and ODP Leg 117 study area with locations of ODP and DSDP drill sites.

formation about past monsoonal variability both in terms of the aridity of surrounding landmasses and the monsoon wind strength.

Opal is relatively sparse in the ridgecrest sediments, but does occur in the more interglacial intervals of the upper Quaternary sediments. The appearance of siliceous microfossils in the early to late Miocene of Sites 223 and 224 (Whitmarsh et al., 1974) has been interpreted to signify the onset of higher productivity associated with upwelling in the western Arabian Sea. The biotic signature of monsoonal upwelling is also recorded by other plankton groups. For example, the abundance of certain indicator species of planktonic foraminifers (such as *Globigerina bulloides*) has been used in modern plankton samples (Kroon, pers. comm., 1987) and in surface and Quaternary sediments (Prell, 1984a) as an index of monsoonal upwelling. Planktonic foraminiferal data indicate that in the late Quaternary, the intensity of the monsoonal upwelling underwent cyclic variations related to the orbitally induced changes in summer radiation in the northern hemisphere (see "Introduction" chapter, this volume).

In summary, the Owen Ridge is known to contain well-preserved late Neogene pelagic and eolian sediments that should record the past variations of monsoonal upwelling and climates.

DRILLING OBJECTIVES

Given this observational and theoretical background, which is further outlined in the "Introduction, Background, and Major Objectives for ODP Leg 117 (Western Arabian Sea) in Search of Ancient Monsoons" chapter (this volume), the specific objectives for drilling on the Owen Ridge were:

1. To recover a continuous upper Neogene section of pelagic sediments from the crest of the Owen Ridge that would contain both long-term (10^5–10^6 yr) variations, possibly related to Himalayan tectonics, and short-term (10^4–10^5 yr) variations in the biotic, sedimentologic, and chemical response to monsoonal circulation that are related to the Milankovitch mechanism of climate change (i.e., orbitally-induced changes in seasonal radiation).
2. To use these biotic and geologic records (time series) to test the hypotheses of orbital (by changes in solar radiation) and orographic (by uplift of mountains) forcing of monsoon intensity and to identify other nonorbital processes that affect the record of monsoonal variation.
3. To use the pelagic and eolian sediment record to identify the initiation and history of monsoonal upwelling and of pelagic carbonate deposition in the Arabian Sea.
4. To use the age and character of the terrigenous and pelagic sediments and the transition between them, and the preservation state of the pelagic carbonates to reconstruct the uplift history of the Owen Ridge.

SUMMARY OF DRILLING RESULTS

Leg 117 cored three sites (Sites 721, 722, and 731) on the Owen Ridge (Figs. 1 and 2). The major themes in the interpretation of the depositional history of these sites emphasize the lithologic facies and uplift of the Owen Ridge, the first occurrence and preservation of siliceous plankton microfossils and the appearance of distinct upwelling faunas, and the pattern of high-frequency variability in the abundance of various sedimentary

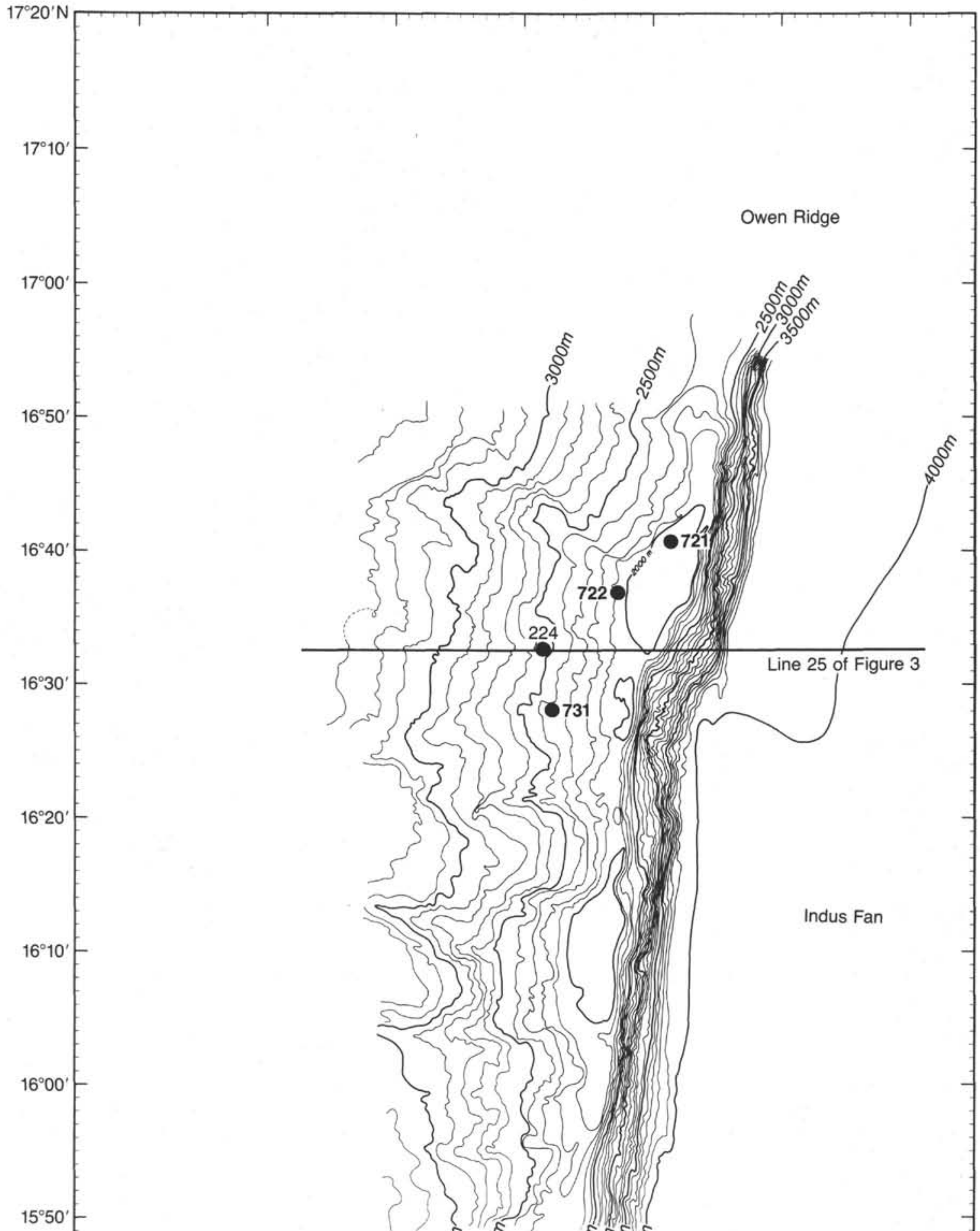

Figure 2. Bathymetry of the Owen Ridge according to results of site survey cruise RC2704 (Mountain and Prell, this volume). Locations of DSDP Sites 224, and Sites 721, 722, and 731 drilled during ODP Leg 117 are noted, as well as the location of RC2704 seismic Line 25 (see Fig. 3).

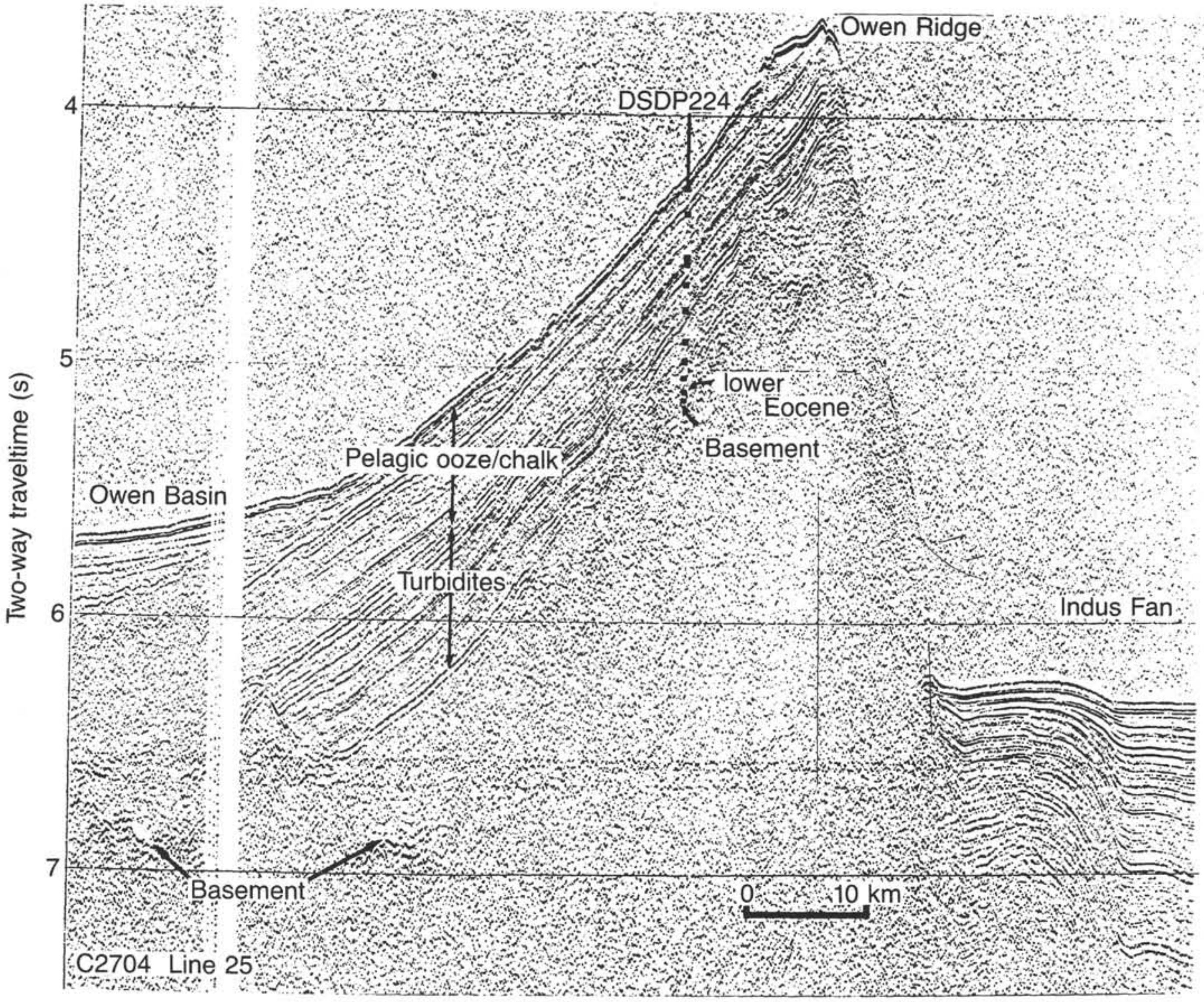

Figure 3. Seismic image and interpretation of Line 25 taken during site survey cruise RC2704 (Mountain and Prell, this volume) across the Owen Ridge in the Leg 117 study area (see text for discussion).

components. Below, we summarize our shipboard findings that are relevant to these themes. Specific observations and results are found in the respective site chapters.

Lithologic Sequence

The section penetrated on the Owen Ridge ranges from late Oligocene to Holocene in age and has been divided into four major lithologic units (Fig. 4).

The oldest lithologic unit, Unit IV with the thickest drilled section reaching from 320 to 994 mbsf in Hole 731C, is characterized by alternating coarse-grained sand and silt turbidites and mud turbidites with no overall large-scale fining-upward trend that were deposited from the late Oligocene(?) to the late early Miocene. The uppermost 70–80 m of Unit IV (lower Miocene) consist of interbedded fine-grained turbidites which fine upward and are interbedded with nannofossil chalks toward the top of this unit. The increase of pelagic deposits upsection is probably related to the uplift of the Owen Ridge out of the regime of turbidite deposition rather than to a decrease in turbidite deposition in the area. Preservation of planktonic calcareous and opaline tests is poor, and benthic foraminifers from upper and middle bathyal depths are absent.

Unit III (the thickest undisturbed section, 241–320 mbsf in Hole 731A) is composed of nannofossil chalk of early to middle Miocene age. The unit is characterized by low porosity, high density, and high seismic velocity. Silica preservation is poor in the carbonate-rich chalks (80%–90% $CaCO_3$). A hiatus, equivalent to about 45 m sediment (compared to Sites 731 and 722), occurs at the top of this unit at Site 721.

Unit II (the thickest undisturbed section, 221–343 mbsf in Hole 722B) comprises siliceous nannofossil chalk and ooze that grade upsection to foraminifer-nannofossil chalk and ooze of late Miocene age. Biogenic opal is an abundant component, and both diatoms and radiolarians are preserved in the sediments. These silica components are reflected by the low bulk and grain densities and the high porosity of Unit II. The gradients in physical properties give the chalk and siliceous units a distinctive seismic reflection signature that can be mapped over much of the Owen Ridge. At Site 721, the upper boundary of Unit II is marked by a compressed section, and sediments of the

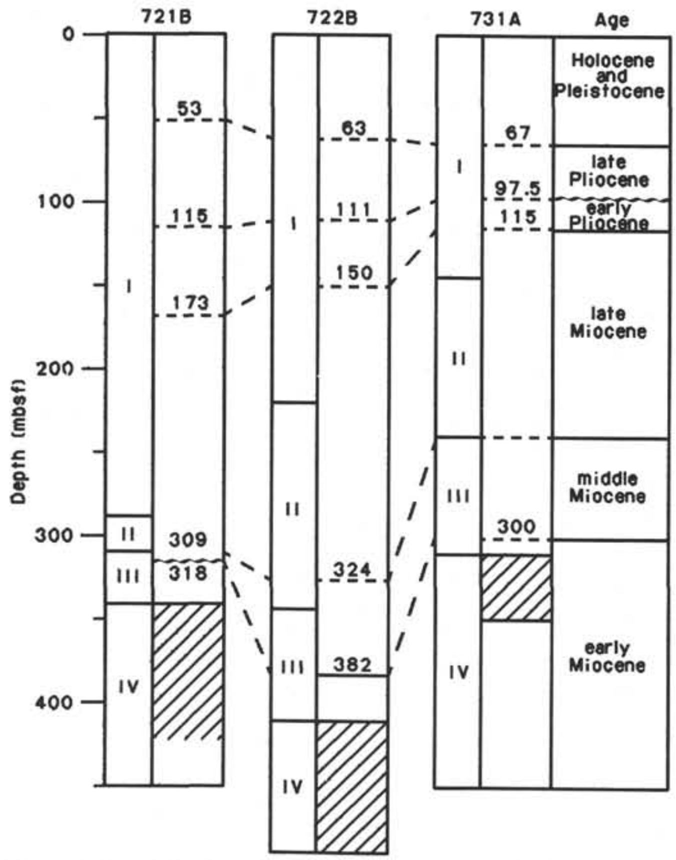

Figure 4. Synthesis diagram of lithologic boundaries (solid lines) and age boundaries (dashed lines) for Sites 721, 722, and 731 on the Owen Ridge. Hiatuses are shown as wavy lines. Patterned areas denote the transitional turbidite-pelagic facies discussed in the text.

lower half of the unit show evidence of soft-sediment deformation throughout, corresponding to a loss of about 100 m of section relative to Site 722. At Sites 722 and 731, the interval of siliceous sediments with the highest porosity and lowest density also displays distinctive sigmoidal vein structures that are perpendicular to bedding and occur preferentially in the darker opaline, organic carbon-rich bands. Similar structures have been observed in accretionary prisms (Lundberg and Leggett, 1986, and references therein) and have been ascribed both to hydrofracturing by dewatering mechanisms and to dilation as a result of applied deviatoric stresses. The significance of these structures is not clear, but we note their association with the low-density sediments that failed by slumping at Site 721. Possibly the slump event caused a decrease of lateral stress. However, the vein structures have only about 300 m of overburden at present and had less at the time of vein formation. These structural features may reflect tectonic processes that caused the uplift of Owen Ridge, but the specific relationship cannot be determined with our scant evidence. Microfossil assemblages in Unit II are characterized by the lack of typical tropical species and the dominance of cool-water assemblages. Sedimentation rates range from 20 to 50 m/m.y. over much of the interval of Units II but decrease near its upper boundary.

Unit I (the thickest undisturbed section, 0–221 mbsf in holes at Site 722) consists exclusively of alternating light and dark layers of foraminifer-bearing to foraminifer-nannofossil ooze, and nannofossil ooze of Holocene to late Miocene age. In contrast to Unit II, biogenic silica is sparse and poorly preserved in Unit I. The sediments of this unit reveal strong cyclicity that is indicated by changes in color, bulk density, carbonate content, and magnetic susceptibility on whole-round cores (see discussion below).

Uplift of Owen Ridge and Comparison of Sedimentary Sections

The uplift history of Owen Ridge is indicated by the gradational transition within lithologic Unit IV from turbiditic to pelagic facies in the late early Miocene and by phases of nondeposition and erosion. On the basis of mineralogy, we infer that the provenance of the turbiditic sediments on the Owen Ridge was probably the same source as for the Indus Fan. This inference is based on the presence of well-crystallized chlorite and the absence of kaolinite in turbiditic sediments from Site 722; this association is identical to the mineralogy of the Indus Fan deposits recovered at Site 720. The upper boundary of the turbiditic sequence is marked by a prominent seismic reflector (C) that onlaps onto a basement peak near Site 722 and can be mapped over much of the Owen Ridge and Basin (Fig. 3 and site survey chapter, this volume).

Preliminary examination of the sedimentary sections recovered at Sites 721, 722, and 731 during Leg 117, and at Site 224 during DSDP Leg 23 (Whitmarsh et al., 1974) provides some insights into the tectonic and depositional evolution of the Owen Ridge. Lithostratigraphic summaries of the Owen Ridge Sites (based on preliminary biostratigraphic data at Sites 721, 722, and 731) are compared in Figure 4. Water depths for these sites are 1945 m, 2028 m, and 2365 m, respectively. The oldest sediments recovered at Sites 722 and 731 are terrigenous turbidites of late Oligocene to early Miocene age; at Sites 722 and 731, these are conformably overlain by mixed turbidite-carbonate (i.e., "transitional") lithofacies of late early Miocene age. The oldest sediments recovered at Site 721 consist of this lower Miocene mixed turbidite-carbonate ("transitional") lithofacies.

Age control in the basal portions of these sites is limited by the scarcity of biostratigraphic datums, but ages for the tops of the "transitional" lithofacies have been estimated from available age-depth plots (see "Biostratigraphy" section in "Site 721," "Site 722," and "Site 731" chapters, this volume). These ages are approximately 15–16 Ma at each site, suggesting that all three locations were uplifted above the level of turbidite dominance at approximately the same time. Consistent onlap directions in seismic reflection profiles of the ridge suggest that shallower portions of the Owen Ridge (Site 721) began to be uplifted before deeper locations (Sites 722 and 731; see site survey chapter, this volume); such a pattern is not apparent from the recovered sediments with the age control presently available.

Thicknesses of the mixed turbidite-carbonate lithofacies do show a consistent variation across the study area, however, and may provide information about early rates of uplift at Sites 721, 722, and 731. As described above, the change from entirely terrigenous turbidites to a lithofacies of mixed turbidites and carbonate caps is interpreted as a record of uplift for the site above the level of turbidite-dominated sedimentation. In a similar manner, the change from the mixed turbidite-carbonate lithofacies to entirely pelagic carbonates can be interpreted as a record of uplift above the shallowest level of turbidite sedimentation. By assuming that the flux of turbidites to this area remained relatively constant through the early to middle Miocene, the thickness of the mixed turbidite-carbonate interval at each site can be used as rough indicator of the time required for that site to be uplifted through the zone of transitional deposition. Under those conditions, thicker mixed turbidite-carbonate intervals imply a longer residence time in the transition zone and slower rates of uplift. Of course, changes in the turbidite flux to the area and between sites cannot be ruled out at this time. The mixed turbidite-carbonate lithofacies at Site 721 is at least 80 m thick (its base was not recovered), and the same lithofacies at Sites 722 and 731 is 86 m and 40 m thick, respectively. The general pattern is that sites presently in shallower water have thicker transitional intervals. This pattern may indicate either that uplift of Owen Ridge accelerated after its initiation in the early Miocene, or that the Owen Ridge was not uplifted as a single coherent block. Although the general pattern and time of uplift of the Owen Ridge region is clear from the stratigraphic section, detailed biostratigraphic, sedimentologic, and seismic stratigraphic analyses must be integrated to adequately define the rates of uplift of the Owen Ridge.

The Onset of Upwelling Faunas and Opal Deposition

As summarized in the introduction, the western Arabian Sea experiences large seasonal or monsoonal variations in atmospheric and oceanic circulation that affect the upwelling, productivity, and species composition of the western Arabian Sea off the continental margin of Oman. Monsoonal variability also affects the climates of the surrounding lands and, thus, the composition and transport of eolian dust and pollen species to the marine environment. All of these environmental responses to past monsoonal variations must be recorded in the sediments of the Owen Ridge. Here, we summarize our preliminary observations on silica deposition, fossil plankton composition, and accumulation rates as they relate to the interpretation of monsoonal evolution and variability.

Middle Miocene

The first indication of enhanced productivity over the Owen Ridge, possibly associated with monsoonal upwelling, is a dramatic change in the sediment facies. Prior to the upper middle Miocene, biogenic opal was absent from the Unit III chalks, and carbonate was abundant but poorly preserved. The opaline microfossil abundances increase suddenly (between Cores 722A-36A and -37X) at the base of Unit II in the upper middle Miocene and remain abundant throughout Unit II (late Miocene). The siliceous microfossil assemblage is composed of radiolarians and diatoms that are tropical in nature according to our preliminary investigation. The associated planktonic foraminifer fauna also contains some species (rare, but well-preserved) that are indicative of higher productivity. Preliminary analyses indicate that this early phase of opal accumulation is associated with increasing accumulation rates relative to the chalk Unit III, but that the highest rates occur in the late Miocene. The upper middle and lower upper Miocene interval has average carbonate and noncarbonate (including opal) accumulation rates of 1–2 $g/cm^2/k.y.$ (Fig. 5). Over this interval, organic carbon increases from les than 0.1% in Units III and IV to greater than 1.0% at the base of the opal-rich Unit II. Hence, the sediments of the upper middle Miocene exhibit the first evidence of higher surface water productivity, which may be associated with monsoon-induced upwelling in the western Arabian sea.

Late Miocene

The siliceous facies (Unit II) grades upward to foraminifer-nannofossil ooze and chalk (Unit I) within the late Miocene. During this interval, the different plankton groups undergo dramatic, but not simultaneous, changes. The first clear faunal indication of upwelling is the appearance of radiolarian assemblages that contain more robust, cool-water forms and lack many tropical forms. A distinctive upwelling planktonic foraminifer fauna appears in the early late Miocene near the boundary between lithologic Units II and I with the simultaneous appearance of *Globigerina bulloides, Globorotalia menardii*, and *G. tumida*, and the *Neogloboquadrina* lineage of *N. acostaensis* and *N. dutertrei*. The nannofossil floras of this interval are characterized by low diversity. Although not all of the biotic and sedimentologic indicators of high productivity are in accord, the latter half of the late Miocene was clearly an interval of higher pelagic influx to the sediments of the Owen Ridge. This pattern does not seem to be caused merely by better preservation, because changes in the preservation of foraminifers and nannofossils do not coincide with changes in accumulation rates. The remainder of the upper Miocene is characterized by high rates of carbonate (2–4 $g/cm^2/k.y.$) and noncarbonate (about 1–2 $g/cm^2/k.y.$) accumulation. Accumulation rates of organic carbon reach 70 $mg/cm^2/k.y.$ in the uppermost Miocene, where the high accumulation rates are associated with abundant, well-preserved planktonic foraminifers and nannofossils (Fig. 5). The late Miocene sediments of Owen Ridge display clear sedimentary signatures, such as high accumulation rates and distinctive plankton assemblages, that are indicative of high productivity and upwelling.

Pliocene-Pleistocene

The Pliocene-Pleistocene sediments of the ridge are composed of foraminifer-bearing and foraminifer-nannofossil ooze with alternating light and dark bands (Unit I). This cyclic pattern of sedimentation is also a possible reflection of monsoonal influence on climate and is discussed below. In the lower Pliocene, cold-water forms of calcareous nannoplankton appear, but biogenic silica abundance decreases. Both tropical and upwelling assemblages of planktonic forams remain abundant throughout the Pliocene-Pleistocene. This sequence of assemblages may indicate an ecologic response to the evolution of monsoonal upwelling. However, detailed study of the faunal and floral variations will be needed to establish the oceanographic significance of biotic changes.

The high rates of carbonate accumulation in the late Miocene decrease to about 1–2 $g/cm^2/k.y.$ in the Pliocene and the decrease appears independent of any change in carbonate preservation (Fig. 5). From the lower Pliocene toward the Holocene, both carbonate and noncarbonate accumulation rates appear to increase; the details of the trend vary from site to site. Two sites show a decrease in accumulation rates in the latest Pleistocene. In summary, the Pliocene to Holocene sediments on Owen Ridge indicate that upwelling has continued throughout this period, but that the ecologic response (carbonate rather than siliceous primary production) to the upwelling and the relative preservation of fossil groups has changed. We speculate that this change may reflect the evolution of the monsoon or of the circulation patterns of the western Arabian Sea during this time.

Although the broad pattern of increased productivity and composition of plankton assemblages is in accord with our premises of the monsoon-induced sedimentation, the verification of the causal relationship between different modes of monsoonal upwelling and sediment facies must be confirmed by establishing the exact relationship between the biotic assemblages, accumulation rates, and sedimentary responses to monsoonal upwelling and global climate.

Leg 117 results have shown that the onset of silica deposition, a possible indicator of monsoonal upwelling, occurred in the late middle Miocene. In the late Miocene, the high carbonate and carbon accumulation rates associated with the appearance of upwelling faunas clearly indicate that the monsoonal upwelling system was active. However, other areas of the world ocean also have high accumulation rates in the upper Miocene (Prell et al., 1982; Theyer et al., 1984). Thus, the question of global causes vs. regional causes of high productivity in the western Arabian Sea must be considered before the apparent upwelling phase of the late Miocene can be solely attributed to the relatively local monsoonal mechanism. The long-term increase in carbonate accumulation rates in the Pliocene and Pleis-

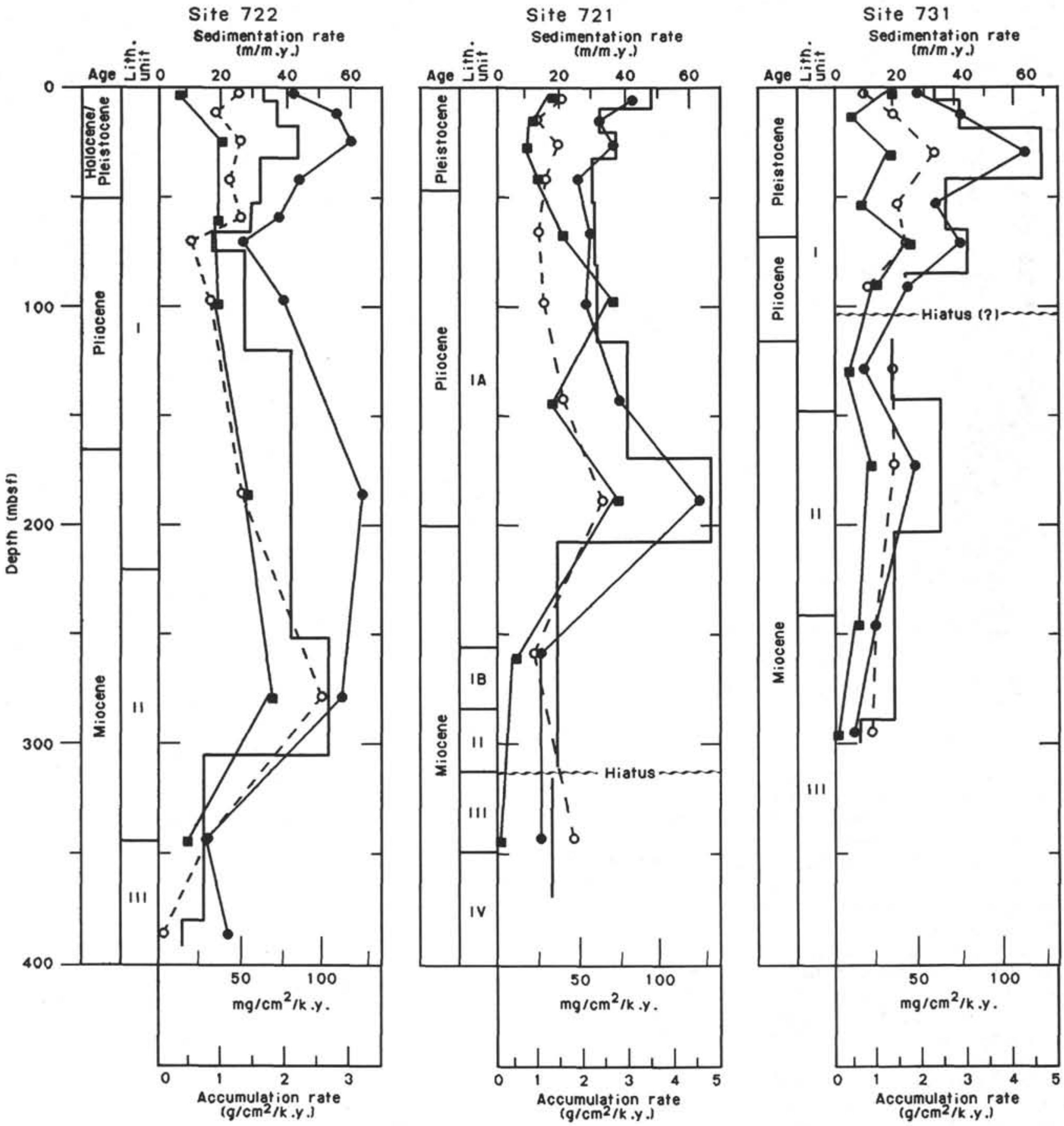

Figure 5. Summary of age, lithologic units, sedimentation (step-pattern) and accumulation rates of noncarbonate (circles), carbonate (dots), and organic carbon (squares) from Owen Ridge Sites 722, 721, and 731. Note the different scale for organic carbon inside the bottom line.

tocene may also reflect an increase in the intensity of monsoonal upwelling and eolian transport brought about by continued uplift of the Himalaya. This long-term trend would be consistent with the gradual modification of climatic boundary conditions due to tectonic mechanisms rather than with the short-term orbital insolation changes. The persistent abundance of upwelling faunas in the Pleistocene/Holocene support this speculation, but the lower rates of organic carbon accumulation raise questions about the association of upwelling with productivity. Alternatively, some of the intervals of low accumulation rate on the Owen Ridge may reflect changes in the depositional environment due to phases of local uplift.

In summary, the sediments of Owen Ridge give ample evidence of large changes in productivity and composition and abundance of upwelling-related faunas. The discrimination between regional vs. global causes, and the specific relationship between productivity and upwelling remain one aspect to be clarified during post-cruise research.

Short-term Variability and Sedimentary Cycles

The major characteristic of the Pliocene and Pleistocene sediments of the Owen Ridge is the continuous alternation of foraminifer-bearing, foraminifer-nannofossil, and nannofossil ooze, (Unit I). This alternation is revealed as a cyclicity in sediment

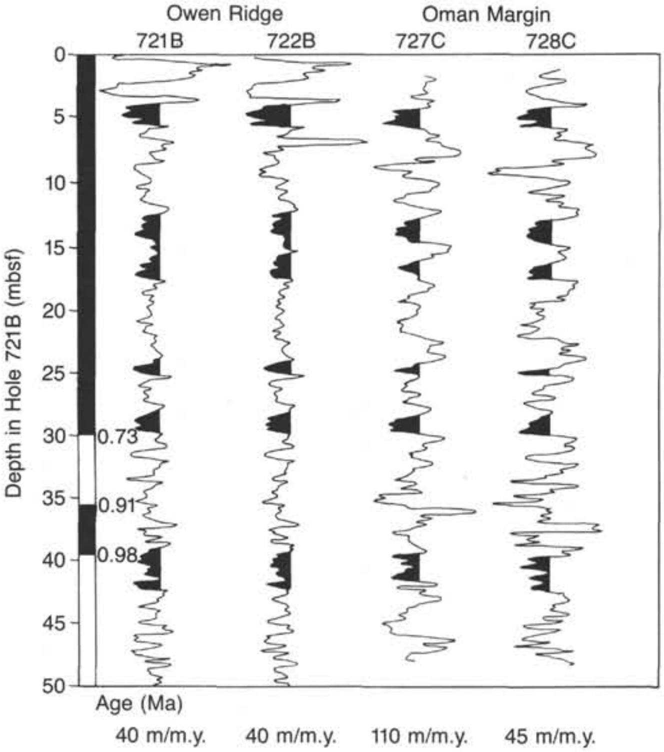

Figure 6. Examples of high-resolution records of magnetic susceptibility in cores from the Owen Ridge (Holes 721B and 722B) and the Oman margin (Holes 727C and 728C). Correlative intervals are shaded; magnetic polarity and reversal ages are on the left. Depth scale is normalized to depth of correlative interval in Hole 721B; note the different sedimentation rate for each site (bottom).

color, magnetic susceptibility, wet-bulk density, and carbonate content. The sediment cycles are thought to reflect both changes in oceanic productivity/preservation and changes in the input of eolian material. Preliminary analysis of the mineralogy of the clastic fraction reveals that the concentrations of quartz and dolomite covary in phase with the susceptibility data. This association of minerals is consistent with an eolian source. If the intensity of monsoonal upwelling and eolian transport is controlled largely by variations of solar radiation, a strong cyclicity is expected in the sediments of the Owen Ridge. Preliminary analysis of detailed (5-cm intervals) magnetic susceptibility measurements reveal a dominant periodicity of about 1 m in length and other periodicities of about 1-2 m, 3-4 m, and 12-14 m (Fig. 6). Power spectra of the magnetic susceptibility time series for Holes 721B (0-2.7 Ma) and 722A (0-2.6 Ma) gave periodicities near 19, 23, 41, and 400 k.y. Some intervals show power near 100 k.y. These periodicities match those expected for the Milankovitch mechanism, which is suspected to be a major cause of variations in monsoon intensity. A similar conclusion was reached at Site 721 by calculating the Walsh spectrum of sediment color changes that were classified as dark, medium, and light. Using a linear sedimentation rate over the past 2.95 m.y., we found the same periodicities that were observed in the magnetic susceptibility data. Here, we should note that these periodicities are not unique to the monsoon mechanism and that post-cruise research will focus on the distinction between global and monsoonal variability over these intervals.

SUMMARY

In summary, the sediments of the Owen Ridge exhibit many characteristics that reflect the tectonic uplift history of the ridge and the evolution of upwelling and pelagic ecosystems in the late Neogene. Understanding how these sedimentary responses are related to the evolution of monsoonal circulation and to changes in global climate was and is a major goal of Leg 117.

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