8. MESOZOIC CALCAREOUS NANNOFOSSILS, DEEP SEA DRILLING PROJECT SITES 415 AND 416, MOROCCAN BASIN

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INTRODUCTION

Cretaceous sediments were recovered at Sites 415 and 416, drilled during DSDP Leg 50. Jurassic sediments were only found in Hole 416A. Figure 1 shows the site locations and Figure 2 shows the calcareous-nannofossil zonation of the cored interval.

Calcareous nannofossils from 24 samples of Hole 415A and 194 samples of Hole 416A were studied on smear slides and identified with a light microscope. Species discussed are listed in Table 1. Abundance and preservation of the calcareous nannofossil species were determined for all samples. Estimates of abundance were made with the light microscope at a magnification of ×1560. Species are recorded as: abundant (A), more than 25 specimens per traverse; common (C), 6-25 specimens per traverse; few (F), 3-5 specimens per traverse; and rare (R), 1-2 specimens per traverse.

Distribution of nannofossils of Holes 416A and 415A is shown in Figures 3 (back pocket, this volume) and 4, respectively.

CALCAREOUS-NANNOFOSSIL BIOSTRATIGRAPHY AND ZONATION

Jurassic

Many papers have been published about Jurassic calcareous nannofossils and several zonations—Stradner (1963), Prins (1969), Worsley (1971), and Rood et al. (1973)—have been proposed. We used the zonation of Barnard and Hay (1974) for this paper.

Jurassic (Tithonian) sediments were penetrated only in Hole 416A of the Leg 50 drilling. Occurrence and abundance of the Jurassic nannofossil species are shown on Figure 3 (back pocket).

Parhabdolithus embergeri Zone

Authors: Barnard and Hay (1974).

Definition: Interval from the first occurrence of *Parhabdolithus embergeri* (Noel) to the first occurrence of *Nannoconus colomii* (de Lapparent).

Important common species: *Parhabdolithus embergeri* (Noel), *Conusphaera mexicana* Trejo, and *Polycostella beckmanii* Thierstein.

Stage: Tithonian (upper Kimmeridgian to Portlandian).

Remarks: The boundary between this zone and the *Nannoconus colomii* Zone is in this paper recognized by the first occurrence of *Parhabdolithus asper* (Stradner) and by the first common occurrence of *Polycostella senaria* Thierstein. The latter species was also a rare constituent in two samples below the Jurassic/Cretaceous boundary. *Nannoconus colomii* (de Lapparent) is rare at Hole 416A and first occurs in the middle part of the Berriasian. *Stephanolithion laffittei* Noel, *Rucinolithus wisei* Thierstein, and *Lithraphidites carniolensis* Deflandre, which, according to Thierstein (1976), first occur at the base of the Berriasian, were recorded at Hole 416A in the upper part of the Berriasian interval or within the lower Valanginian to upper Hauterivian. This zone is present only in the interval between Samples 416A-57, CC to 416A-53-2, 45-46 cm.

Cretaceous

We used the Cretaceous zonation of van Hinte (1976) for this study, as given in Figure 2. It incorporates the zonations of Bukry (1974), Roth (1973), Thierstein (1973), and others.

Nannoconus colomii Zone

Authors: Worsley (1971), modified by Thierstein (1971).

Definition: Interval from the first occurrence of *Nannoconus colomii* (de Lapparent) to the first occurrence of *Cretarhabdus angustiforatus* (Black).

Stage: Berriasian.

Remarks: It was difficult to recognize both zonal boundaries in accordance with the definition of this zone. A small number of *Nannoconus colomii* (de Lapparent) first occur 6 meters above the lower limit of this zone and the species is missing in much of the Berriasian interval. The first occurrence of *Cretarhabdus angustiforatus* (Black) does not coincide with the upper boundary of this zone, but is about 10 meters above the Berriasian/Valanginian boundary.

In this paper we used the first occurrence of *Parhabdolithus asper* (Stradner) and the first common occurrence of *Polycostella senaria* Thierstein to define the lower boundary of this zone. The top of this zone is marked by the first occurrence of *Bipodorhabdus colligatus* (Black), *Calcicalathina oblongata* (Worsley), *Diadorhombus rectus* (Worsley), and *Tubodiscus verenae* Thierstein. The zone was recognized only in Hole 416A (Samples 53-2, 26 cm to 48-1, 86-87 cm).

Cretarhabdus angustiforatus Zone to *Lithraphidites bollii* Zone

This zone is defined as the interval from the first occurrence of *Bipodorhabdus colligatus* (Black), *Calci-*

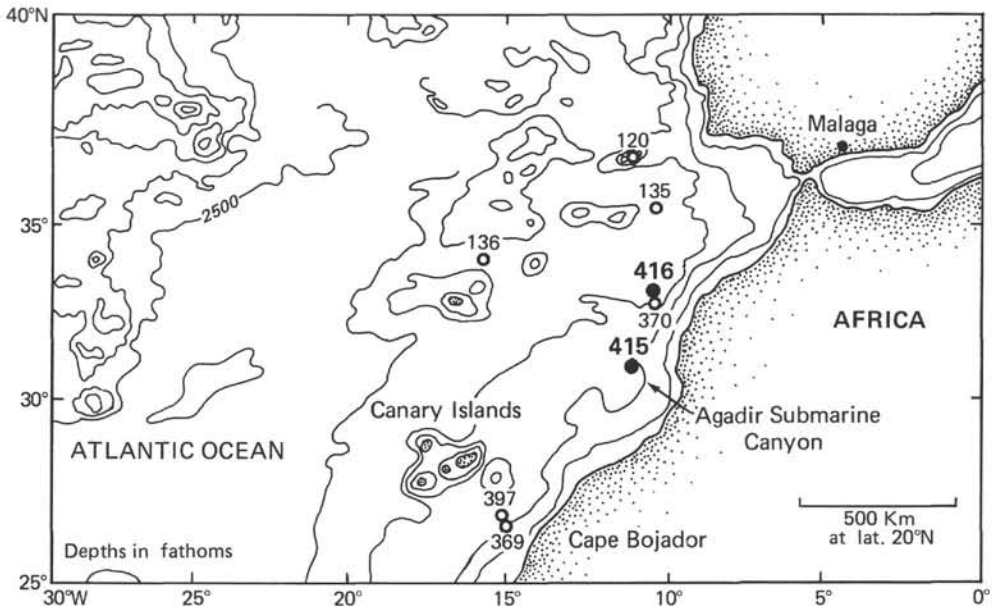

Figure 1. *Location of DSDP Sites 415 and 416.*

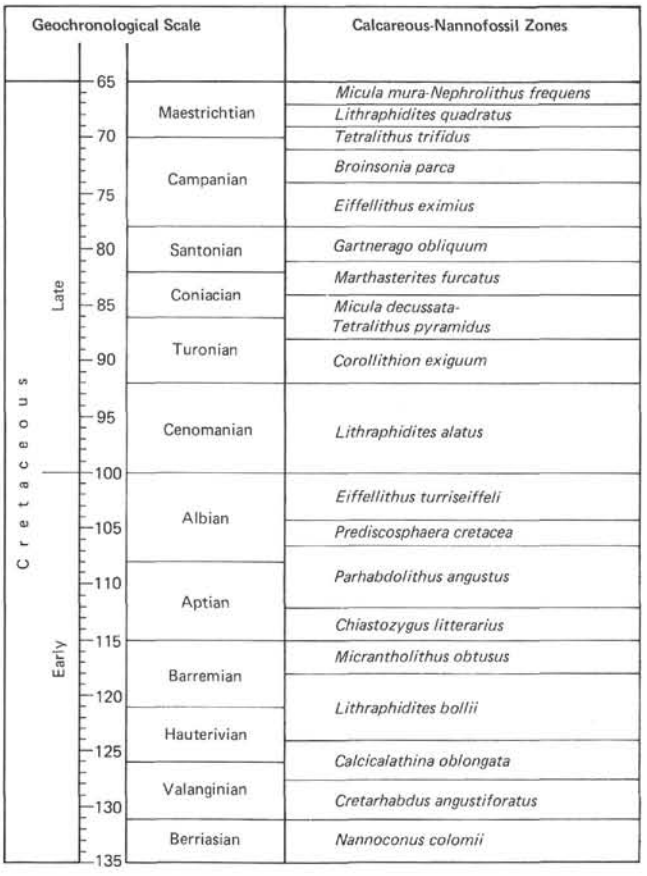

Figure 2. *Cretaceous nannofossil zonation used in this report correlated with the geochronological scale of van Hinte (1976).*

TABLE 1
Nannofossil Species Considered in This Report, Listed Alphabetically by Specific Name

Corollithion achylosum (Stover)
Lithraphidites alatus Thierstein
Podorhabdus albianus Black
Cretarhabdus angustiforatus (Black)
Parhabdolithus angustus (Stradner)
Parhabdolithus asper (Stradner)
Watznaueria barnesae (Black)
Polycostella beckmannii Thierstein
Broinsonia bevieri Bukry
Flabellites biforaminis Thierstein
Watznaueria biporta Bukry
Watznaueria britanica (Stradner)
Lithraphidites carniolensis Deflandre
Cruciellipsis chiastia (Worsley)
Markalius circumradiatus (Stover)
Bipodorhabdus colligatus (Black)
Nannoconus colomii (de Lapparent)
Watznaueria communis Reinhardt
Cretarhabdus conicus Bramlette and Martini
Biscutum constans (Gorka)
Cretarhabdus coronadventis Reinhardt
Prediscosphaera cretacea (Arkhangelsky)
Chiastozygus cuneatus Lyul'eva
Cruciellipsis cuvillieri (Manivit)
Watznaueria deflandrei
Podorhabdus dietzmanni (Reinhardt)
Zygodiscus diplogrammus (Deflandre and Fert)
Cribrospherella ehrenbergi (Arkhangelsky)
Zygodiscus elegans Gartner
Parhabdolithus embergeri (Noel)
Broinsonia enormis (Shumenko)
Zygodiscus erectus (Deflandre)
Reinhardtites fenestratus (Worsley)
Lithastrinus floralis Stradner
Scapholithus fossilis Deflandre and Fert
Tranolithus gabalus Stover
Sollasites horticus (Stradner, Adamiker and Maresch)

TABLE 1 — *Continued*

Mitosia infinitae Worsley
Stephanolithion laffittei Noel
Diazomatholithus lehmani Noel
Chiastozygus litterarius (Gorka)
Cretarhabdus loriei Gartner
Tetralithus malticus Worsley
Cyclagelosphaera margereli Noel
Watznaueria martelae (Noel)
Vagalapilla matalosa (Stover)
Conusphaera mexicana Trejo
Calcicalathina oblongata (Worsley)
Micrantholithus obtusus Stradner
Tranolithus orionatus (Reinhardt)
Manivitella pemmatoidea (Deflandre and Manivit)
Diadorhombus rectus Worsley
Polycostella senaria Thierstein
Corollithion signum Stradner
Parhabdolithus splendens Deflandre
Vagalapilla stradneri (Rood, Hay and Barnard)
Cretarhabdus surirellus (Deflandre)
Eiffellithus turriseiffeli (Deflandre and Fert)
Tubodiscus verenae Thierstein
Rucinolithus wisei Thierstein
Biscutum sp.
Braarudosphaera sp.
Broinsonia sp.
Corollithion sp.
Cretarhabdus sp.
Eiffellithalid sp.
Micrantholithus sp.
Nannoconus sp. (small specimens)
Podorhabdus sp.
Vekshinella sp.
Watznaueria sp.
Zeugrhabdotus sp.
Zygodiscus sp.

calathina oblongata (Worsley), and *Diadorhombus rectus* Worsley to the last occurrence of *Cruciellipsis cuvillieri* (Manivit) and *Bipodorhabdus colligatus* (Black).

Stage: Lower Valanginian to upper Hauterivian.

Remarks: We could not divide the interval cored in Hole 416A into two zones. According to Thierstein (1971) the *Cretarhabdus angustiforatus* Zone is defined as the interval from the first occurrence of *Cretarhabdus angustiforatus* (Black) to the first occurrence of *Calcicalathina oblongata* (Worsley). At Hole 416A *Calcicalathina oblongata* (Worsley) is first present in Sample 416A-48-1, 86-87 cm, below the first occurrence of *Cretarhabdus angustiforatus* (Black) in Sample 416A-46, CC. It is not clear whether a hiatus exists between the Berriasian and Valanginian. If that were the case we would expect the first occurrence of *Cretarhabdus angustiforatus* (Black) and of *Calcicalathina oblongata* (Worsley) to be in the same sample. Also, the presence of *Cretarhabdus angustiforatus* (Black) in the lower part of this interval is sporadic and specimens are relatively rare.

The top of this stratigraphic interval was designated as upper Hauterivian. Indeed, it is unlikely that the entire Hauterivian stage is represented. This conclusion is reached on the basis of the persistent occurrence of *Bipodorhabdus colligatus* (Black) and *Cruciellipsis cuvillieri* (Manvit) throughout the interval. Both species became extinct in the late Hauterivian (Thierstein, 1971, 1976). Although reworking by turbidity currents could have extended their occurrences upward beyond their actual range, we doubt that they would have occurred so persistently and in such a well-preserved state had they been redeposited. Moreover, species that would indicate deposition earlier than early Hauterivian are lacking. These include *Lithraphidites bollii* (Thierstein) and particularly *Nannoconus bucheri* Brönnimann. The highest occurrence of *Rucinolithus wisei* Thierstein which we found in Sample 31-5, 8-9 cm corresponds to a mid-Valanginian datum level. However, this datum is no more reliable than other highest occurrences within this interval, and, inasmuch as the species was not found higher in the section, it may be simply that it was so rare among other indigenous and redeposited species that its presence escaped notice.

This stratigraphic interval was recognized only in the interval from Sample 416A-48-1, 86-86 cm through Sample 416A-7-1, 18 cm.

Micrantholithus obtusus Zone

We did not recognize this zone in the samples studied.

Chiastozygus litterarius Zone

Author: Thierstein (1971), modified by Thierstein (1973).

Definition: Interval from the last occurrence of *Nannoconus colomii* (de Lapparent) and (or) the first occurrences of *Chiastozygus litterarius* (Gorka) and (or) *Rucinolithus irregularis* Thierstein to the first occurrence of *Parhabdolithus angustus* (Stradner) and (or) *Lithastrinus floralis* (Stradner).

Important common species: *Chiastozygus litterarius* (Gorka).

Stage: Lower Aptian.

Remarks: This zone was recognized only in Sample 416A-6, CC. The sample contains a moderately well-preserved and relatively diverse assemblage of coccoliths with *Chiastozygus litterarius* (Gorka) but without *Nannoconus colomii* (de Lapparent), *Parhabdolithus angustus* (Stradner) and *Lithastrinus floralis* (Stradner). The rest of Core 416A-6 lacks calcareous nannofossils. The lower and upper limits of the *Chiastozygus litterarius* Zone are difficult to recognize because the cores above Core 416A-7 were taken at widely spaced intervals. The poorly sampled section may also explain the absence of the *Micrantholithus obtusus* Zone and the *Parhabdolithus angustus* Zone.

Parhabdolithus angustus Zone

We did not recognize this zone in the samples studied.

Predicosphaera cretacea Zone

Author: Thierstein (1971), modified by Thierstein (1973).

Definition: Interval from the first occurrence of *Predicosphaera cretacea* (Arkhangelsky) to the first occurrence of *Eiffellithus turriseiffeli* (Deflandre and Fert).

Important common species: *Prediscosphaera cretacea* (Arkhangelsky), *Corollithion achylosum* (Stover),

Abundance
A = Abundant
C = Common
F = Few
R = Rare

Preservation
G = Good
M = Moderate
P = Poor

Sample (Interval in cm)	Sub-bottom Depth (m)	Abundance	Preservation	*Sollasites horticus*	*Cretarhabdus loriei*	*Tranolithus gabalus*	*Corollithion signum*	*Parhabdolithus embergeri*	*Cretarhabdus coronadventis*	*Stephanolithion laffittei*	*Lithraphidites carniolensis*	*Cretarhabdus angustiforatus*	*Vagalapilla stradneri*	*Watznaueria barnesae*	*Eiffellithus turriseiffeli*	*Zygodiscus diplogrammus*	*Parhabdolithus angustus*	*Parhabdolithus asper*	*Watznaueria biporta*	*Biscutum constans*	*Prediscosphaera cretacea*	*Zygodiscus elegans*	*Zygodiscus erectus*	*Chiastozygus litterarius*	*Lithastrinus floralis*	*Podorhabdus albianus*
415A-7-1, 23-24	509.73	Barren																								
8-1, 20-21	576.20	Barren																								
8-2, 91-93	578.41	R	P											C	R	C	R	R	R	R	R	F	R	R	R	R
8, CC	585.5	R–F	P–M										R	F	F	R				F	R	R			R	
9-1, 61-63	643.11	R	P									R		F	R	R										
9-5, 64-65	649.14													R				R								
9, CC	652.0	F	P							F	F		R	A	C	C				F	R	R	R	R	F	
10-1, 19-20	709.19	R	P											R						R						
10-1, 41-42	709.41						R	F	R		F			A	C	R					R					
10-2, 12	710.62	R	P											R	R		R		R		R					
10-2, 13-14	710.63						R							C	F	R										
10, CC	718.5	R	P			R				R			R	F	F	C	R			R	R					
11-1, 30-34	794.80	F	P		R	R	F	F	R	R	C	R	R	A	C	A	R	C	R	A	C	F	C	R	R	F
11-2, 73-74	796.73				R		F	F	F	R	R			A	A	F	R	R	F		R			R	R	C
11, CC	804.0	C	M-G				C			C	C			A	A	A	C	C	F	R	C	C	C	C		
12-1, 126-129	881.26	F-C	M			F	C	F	R	R	F	F		A	A	A	F	R		A	C		F	C	F	F
12-2, 48-49	881.98						R	F	R	F	F			A	A	F	F	R	F		F			F	F	C
12, CC	889.50	A	M							R	F	R	C	A	A	A	C	C		C	C			F		
13-1, 98-99	956.98	Barren																								
13-2, 34-35	957.84				R		R	F	R	R	R			A	C	F	F	R			F			R	F	C
13, CC	965.50	F	P		R	R	R	F		R	F		R	A	C	C	R		R	C	R	R		R	R	F
14-1, 17-18								R	R	R	F	R		A	C	F	F	R	R		R			R	F	F
14, CC	1041.50	R–F	P					R		R			R	R	F	F				F	R	R	F	R		
15, CC	1079.50	F	M	R	R	R	F	R	R	R	R	F	R	C	F	C	R	F	R	C	R	F	R	R	R	R

Sample (Interval in cm)	*Vagalapilla matalosa*	*Corollithion achylosum*	*Cribrosphaerella ehrenbergi*	*Biscutum* sp.	*Nannoconus* sp.	*Cretarhabdus conicus*	*Watznaueria britanica*	*Reinhardtites fenestratus*	*Manivitella pemmatoidea*	*Cruciellipsis chiastia*	*Watznaueria communis*	*Broinsonia bevieri*	*Tranolithus orionatus*	*Cretarhabdus surirellus*	*Chiastozygus cuneatus*	*Parhabdolithus splendens*	*Scapholithus fossilis*	*Podorhabdus dietzmanni*	*Flabellites biforaminis*	*Lithraphidites alatus*	*Broinsonia enormis*	*Broinsonia* sp.	*Vekshinella* sp.	Calcareous-Nannofossil Zones	Stages
415A-7-1, 23-24																								*Eiffellithus turriseiffeli* Zone to *Lithraphidites alatus* Zone	Upper Albian to Cenomanian
8-1, 20-21																									
8-2, 91-93	F			R																					
8, CC	R			R																					
9-1, 61-63	R			R																		R			
9-5, 64-65																									
9, CC	R		R											R											
10-1, 19-20																									
10-1, 41-42										R	F	F	C	R											
10-2, 12	R													R											
10-2, 13-14												F	R	F									R		
10, CC	R													F								R			
11-1, 30-34	R	R		C					F		C		F	R			R	R							
11-2, 73-74								R	F	R	C		C	F											
11, CC	R	R	R	C									C	C		R					R				
12-1, 126-129	F	R	R					R	F		F	F		F				F							
12-2, 48-49							R		R		C	F	F	F				F	R	F	R				
12, CC	C	C	F	R				R	C			R	C	A	R	A	F	R	F						
13-1, 98-99																									
13-2, 34-35							R		R	R	C	R	F	R				R							
13, CC	R			R		F	R		R	R	F		C	F	R	R	R								
14-1, 17-18					R	R	R	R	R	R	F	R	C	R											
14, CC		R	R	R																					
15, CC	R																								

Figure 4. *Distribution of Cretaceous nannofossils, Hole 415A.*

Parhabdolithus angustus (Stradner), *Cretharhabdus coronadventis* Reinhardt, and *Mitosia infinitae* Worsley.

Stage: Middle Albian.

Remarks: Sample 416A-5, CC was designated as middle Albian. The lower limit of this interval is defined by the presence of *Prediscosphaera cretacea* (Arkhangelsky), *Cretharhabdus coronadventis* Reinhardt, and *Corollithion achylosum* (Stover); the upper limit is defined by the first occurrence of *Eiffelithus turriseiffeli* (Deflandre). We cannot establish the thickness of this zone, because no cores were taken for 128 meters below Core 416A-5. The youngest Cretaceous sediments recovered at Hole 416A are middle Albian. Sample 416A-5-1, 34-35 cm contains middle-Eocene calcareous nannofossils which demonstrate the presence of a hiatus from middle Albian to middle Eocene.

Eiffellithus turriseiffeli Zone to *Lithraphidites alatus* Zone

This stratigraphic zone is defined as the interval from the first occurrence of *Eiffellithus turriseiffeli* (Deflandre and Fert) to the first occurrence of *Corollithion exiguum* (Stradner).

Important common species: *Eiffellithus turriseiffeli* (Deflandre), *Lithraphidites alatus* (Thierstein), *Cruciellipsis chiastia* (Worsley), and *Podorhabdus albianus* Black.

Stage: Upper Albian to Cenomanian.

Remarks: We cannot assign a more precise age to this interval on the basis of calcareous nannofossils because we are dealing with a residual assemblage, one in which many forms, including key species, have been removed by dissolution. We base the age assignment for this interval largely on the co-occurrence of *Eiffellithus turriseiffeli* (Deflandre), *Cruciellipsis chiastia* (Worsley), *Lithraphidites alatus* Thierstein, and *Podorhabdus albianus* Black, and on the absence of *Corollithion exiguum* Stradner and *Gartnerago obliquum* (Stradner). (Stradner).

This stratigraphic interval was recognized only at Site 415 between Samples 415A-15, CC through 415A-7-1, 23-24 cm.

The following Cretaceous zones were not recognized at Sites 415 and 416: *Corollithion exiguum* Zone, *Micula decussata-Tetralithus pyramidus* Zone, *Marthasterites furcatus* Zone, *Gartnerago obliquum* Zone, *Eiffellithus eximius* Zone, *Broinsonia parca* Zone, *Tetralithus trifidus* Zone, and *Lithraphidites quadratus* Zone.

Micula mura-Naphrolithus frequens Zone

Authors: Čepek and Hay (1969).

Definition: Interval from the first occurrence of *Nephrolithus frequens* (Gorka) and (or) *Micula mura* (Martini) to the level of extinction of most Upper Cretaceous species ("Cretaceous/Tertiary boundary").

Important common species: *Micula mura* (Martini) and *Lithraphidites quadratus* Bramlette and Martini.

Remarks: We recognized upper Maestrichtian sediments only in Samples 415A-6-2, 32-33 cm and 415A-6-2, 27-23 cm. The nannofossils in these samples are Late Cretaceous species with no admixture of Cenozoic species. The samples above and below these upper-Maestrichtian samples yielded the following results.

Sample (Interval in cm)	Stratigraphic Interval
415A-6-1, 74-75	Tertiary
415A-6-1, 137-138	Tertiary—not older than *Cruciplacolithus tenuis* Zone, NP 2
415A-6-2, 27-28	Upper Maestrichtian
415A-6-2, 32-33	Upper Maestrichtian
415A-6-2, 94-95	Tertiary—not older than *Cruciplacolithus tenuis* Zone, NP 2
415A-6-2, 132-133	Tertiary

These results may indicate that the upper-Maestrichtian sediments are allochthonous in the Tertiary section.

Hiatuses

We detected no hiatuses in the Lower and Middle Cretaceous sequences of Sites 415 and 416. But at Hole 416A, a long hiatus, representing some 70 m.y., is present between the upper Hauterivian and lower Eocene.

DISTRIBUTION OF CALCAREOUS NANNOFOSSILS

Site 415 (latitude 31°01.72°N; longitude 11°39.11°W; water depth 2794 m)

Site 415 is located in Agadir Canyon (Figure 1; Table 2) about 100 miles south from Sites 370 (Leg 41) and 416. The total depth drilled in Hole 415A was 1079.5 meters. The uppermost Cretaceous sediments containing a nannofossil assemblage of the *Micula mura-Nephrolithus frequens* Zone appear in Samples 415A-6-2, 27-28 cm and 415A-6-2, 32-33 cm. They are not older than upper Maestrichtian, but inasmuch as lower-Paleocene sediments (*Cruciplacolithus tenuis* Zone; NN 2) occur above and below this level, the Maestrichtian assemblage may be allochthonous. The upper-Maestrichtian sediments are marlstone. The same type of sediment (partly mudstone), with layers of limestone, shale, fine sandstone, and calcarenite in Samples 415A-7-1, 23-24 cm through 415A-15, CC, composes the upper Albian to Cenomanian. The coccolith assemblages are generally poor with rare to few specimens. In the core-catcher samples from Cores 415A-11 and 415A-12, however, coccoliths are common to abundant and are moderately well-preserved. This stratigraphic level yielded assemblages of 43 species, including *Eiffellithus turriseiffeli* (Deflandre), *Lithraphidites alatus* (Thierstein), *Cruciellipsis chiasta* (Worsley), and *Podorhabdus albianus* (Black), but without *Corollithion exiguum* (Stradner) and *Gartnerago obliquum* (Stradner). This assemblage indicates that the samples fall in the *Eiffellithus turriseiffeli* Zone to *Lithraphidites alatus* Zone. *Lithraphidites alatus* (Thierstein) was recognized in only one sample (415A-12-2, 48-49 cm), and we therefore cannot be certain that this one occurrence of only a few specimens can adequately define the *Lithraphidites alatus* Zone.

Site 416 (latitude 32°50.18'N; longitude 10°48.06'W; water depth 4191 m)

Site 416 was drilled in a deep basin off Morocco (Figure 1) only 2 km from Site 370 (Leg 41). Hole 416A comprises a 1624-meter section. The Mesozoic sediments recovered from Hole 416A, from 762 to 1624 meters, are divided into three lithological units within which five stratigraphic horizons, extending from Tithonian to middle Albian, are recognized. The three youngest stratigraphic levels correlate very well with Site 370 of Leg 41 Čepek , 1978). The combination of results from both sites provides a good basis for a reconstruction of the Tithonian to Lower Cretaceous stratigraphy of the Moroccan Basin.

The sediments at the top of the Cretaceous are claystone, silty claystone with some siltstone, and fine sandstone. A poorly preserved but diverse assemblage of coccoliths occurs in the upper part of this unit. Sample 416A-5, CC contains *Prediscosphaera cretacea* (Arkhangelsky), *Parhabdolithus asper* (Stradner), *Cretarhabdus coronadventis* (Reinhardt), and *Corollithion achylosum* (Stover). The presence of *Prediscosphaera cretacea* (Arkhangelsky) indicates that the assemblage is not older than middle Albian. The absence of *Eiffellithus turriseiffeli* (Deflandre and Fert) indicates that the assemblage is not younger than middle Albian. But the absence of this key species could also result from poor preservation. These middle-Albian sediments correspond to the middle Albian of Core 370.25. The upper boundary of this stratigraphic interval is well defined because Sample 416A-5-1, 34-35 cm contains an assemblage of middle-Eocene nannofossils (Zones NP 13-NP 14), which shows that a hiatus exists from middle Albian to middle Eocene. We cannot designate the lower boundary of this interval because the 128-meter interval between Cores 416A-5 and 416A-6 was not cored.

The lower part of this sedimentological unit is lower Aptian. The lower-Aptian sediments were recovered only in the core-catcher sample of Core 416A-6, and they belong to the *Chiastozygus litterarius* Zone. The rest of this core lacks coccoliths. Nannofossils are sparse to common and are moderately well preserved. The assemblage includes *Chiastozygus litterarius* (Gorka) but lacks *Parhabdolithus angustus* (Stradner) and *Lithastrinus floralis* (Stradner). The sediments of Cores 370-32 and 370-33 of Site 370 (Leg 41) are the same age. About 95 meters were drilled without coring between Cores 416A-6 and 416A-7; thus, we cannot determine the thickness of the lower-Aptian sediments.

The upper-Hauterivian to lower-Valanginian sediments are represented within the unit of turbidites. For the most part this section consists of calcareous and quartzose fine sandstone, siltstone, and mudstone. Only at the base of this stratigraphic interval does the turbidite unit have siltstone and mudstone with hard micrite and calcarenite. Core 416A-7 was taken at a depth between 982 and 1093 meters, and consequently we cannot establish the exact depth of the 4.5-meter core. The age between this core down to Sample 416A-48-1, 86-87 cm is recognized by the presence of *Cruciellipsis cuvillieri* (Manvit) (upper limit), *Bipodorhabdus colligatus* (Black) (upper and lower limit), *Diadorhombus rectus* (Worsley) (lower limit), and *Calcicalathina oblongata* (Worsley) (lower limit). This assemblage identifies the *Lithraphidites bollii* Zone to the *Cretarhabdus angustif oratus* Zone, but the zone species *Lithraphidites bollii* (Thierstein) was not observed in the samples. Coccolith assemblages are rare to sparse within this interval and are poorly to moderately well preserved. The upper part of this stratigraphic interval corresponds to the *Lithraphidites bollii* Zone to the *Calcicalathina oblongata* Zone at Site 370 of Leg 41.

The sediments of Samples 416A-48, CC through 416A-53-2, 26 cm are lithologically similar to those at the base of the upper Hauterivian to lower-Valanginian interval. The nannofossils, however, fall in the Berriasian *Nannoconus colomii* Zone. Coccoliths in this interval are sparse to common and are poorly to moderately well preserved. We recognized the base of the *Nannoconus colomii* Zone by the first occurrence of *Parhabdolithus asper* (Stradner) and the first occurrence of abundant *Polycostella senaria* (Thierstein). The top of this zone is marked by the first occurrence of *Bipodorhabdus colligatus* (Black), *Calcicalathina oblongata* (Worsley), *Diadorhombus rectus* (Worsley), and *Tubodiscus verenae* (Thierstein). The Berriasian was not reached at Site 370 (Leg 41).

The Jurassic sediments of the Tithonian *Parhabdolithus embergeri* Zone are lithologically similar to those of the Berriasian, and were recovered in Samples 416A-53-2, 45-46 cm to 416A-57, CC (base of hole). The assemblages include a few specimens of *Parhabdolithus embergeri* (Noel), *Conusphaera mexicana* (Trejo), and *Polycostella beckmanii* (Thierstein), but lack exclusively Cretaceous species. The specimens are poorly to moderately well preserved.

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