Orbitally induced cycles in benthonic foraminiferal morphogroups and trophic structure distribution patterns from the Late Albian "Amadeus Segment" (Central Italy)

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ABSTRACT

A detailed analysis was made of benthonic foraminiferal distribution patterns and morphogroups in the late Albian "Amadeus Segment" of the Aptian-Albian organic-rich Scisti a Fucoidi Formation outcropping over a widespread area of the Umbria-Marche region, Central Italy. Rhythmic changes in the trophic structures and composition of benthonic foraminiferal assemblages suggest cyclical fluctuations of the sea floor environment which appear to be orbitally induced. Benthonic foraminiferal assemblages varied significantly through the section and appear to contain a strong paleoecological signal. Fluctuations in both bottom water oxygenation and the surface primary productivity as a result of the orbital forcing are interpreted to have been the primary controls on benthonic foraminiferal distribution patterns. *J. Micropalaeontol.* **12** (2): 227-239, December 1993.

INTRODUCTION

Foraminifera have been extensively used for paleoenvironmental interpretation, and the use of various morphological groups in benthonic foraminiferal assemblages is not new. This approach has been used, especially in the Cretaceous, to study the organic rich strata which were a global component of this period in a variety of lithologies and paleoenvironments. Several studies (Jones & Charnock, 1985; Bernhard, 1986; Corliss & Chen, 1988; Coccioni, 1990a and b; Koutsoukos & Hart, 1990; Coccioni & Galeotti, 1991; Kaiho, 1991, among others) have shown the utility of this method and its potential in detecting the paleoceanographic conditions in which the hypoxic/anoxic events took place. Moreover, the influence of orbital forcing on benthonic foraminiferal assemblage pattern distribution has been recently recognized by Cottle (1989), Leary *et al.* (1989), and Coccioni & Galeotti (1991).

The present study aims to document the benthonic foraminiferal distribution patterns from the Late Albian "Amadeus Segment" (Coccioni & Galeotti, 1991) of the Fiume Bosso section (Fig. 1), using a morphological approach.

THE "AMADEUS SEGMENT" [1]

This 193-cm thick stratigraphic interval belongs to the "Whitish Marly Limestone Member" of the Scisti a Fucoidi Formation (Coccioni et al., 1987, 1989 and 1990b) (Fig. 2) which, according to several authors (Fischer et al.,1985; Fischer & Herbert, 1988; Premoli Silva *et al.*, 1989b; Coccioni *et al.*, 1990b; Erba, 1992; Coccioni *et al.*, 1990 b, among
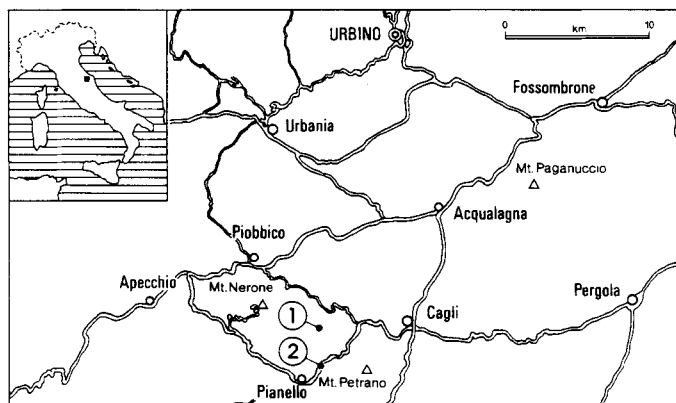
Fig. 1 Location of the Poggio le Guaine (1) and Fiume Bosso (2) sections which following Coccioni *et al.* (1990a and b) are the reference sections for the Scisti a Fucoidi Formation in the Umbria-Marche Apennines Basin. The sections outcrop in Geological Map of Italy, F. 290 "Cagli", 1:50.000.

others), was deposited at a mean sedimentation rate of 5m/Ma. The Amadeus Segment which corresponds litho- and biostratigraphically to the ca. 400 ka-Segment 1 of Premoli Silva *et al.* (1989a and b) consists of a rhythmic alternation of whitish marls and calcareous marls, and black shales characterized by a Corg content > 1% (group 2 of Premoli Silva *et al.*, 1989a); some radiolarian rich layers occur (Figs 3-4). Rhythmic Cretaceous sequences (e.g. the Scisti a Fucoidi) of the Umbria-Marche Basin of the central Italy were studied by several authors (de Boer, 1982; Schwarzacher & Fischer, 1982; de Boer & Wonders, 1984;

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[1] The "Amadeus Segment" was named by Coccioni & Galeotti (1991) to celebrate the second centennial anniversary of the death of Wolfgang Amadeus Mozart (1756-1791). On the other hand isn't the rhythmic alternation of whitish carbonate-rich layers and black shale reminiscent of a piano keyboard?
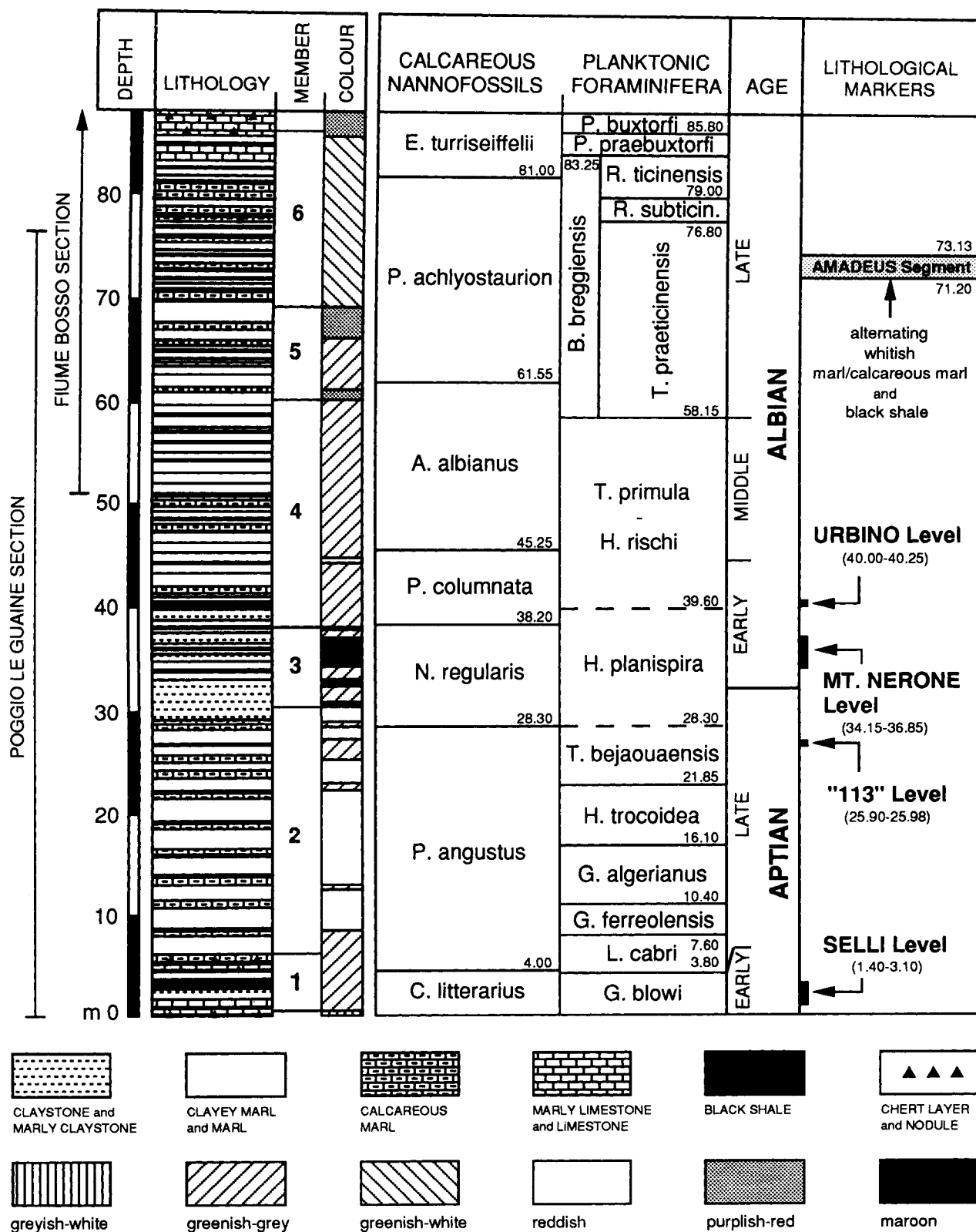
Fig. 2 Lithostratigraphy and biostratigraphy of the Poggio le Guaine-Fiume Bosso composite sequence (after Coccioni *et al.*, 1990a and b, modified). Numbers indicate metres above the base. The right column indicates the positions of the Amadeus Segment and of four distinctive global and regional marker black-shales layers.
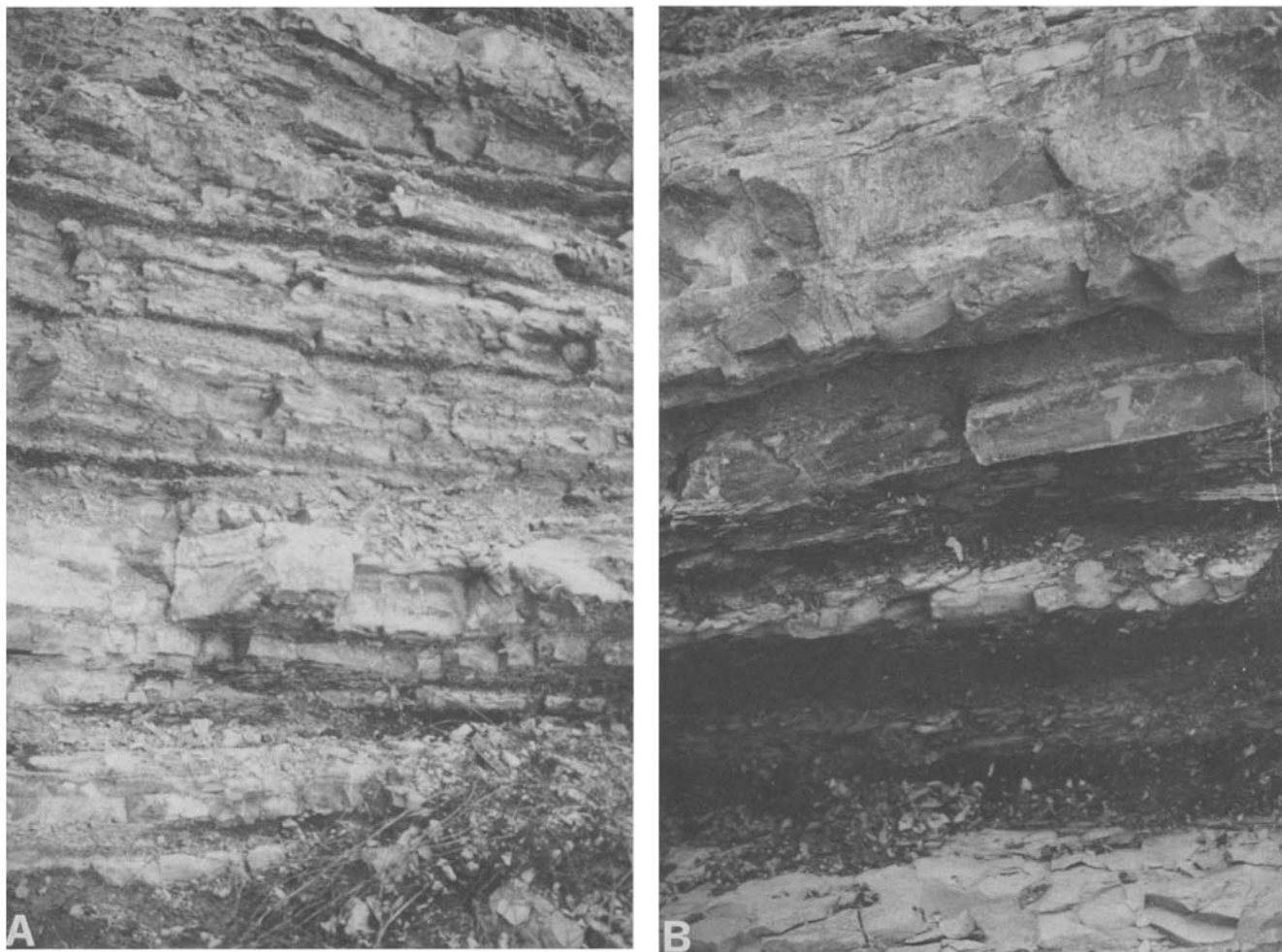
Fig. 3 A: The Amadeus Segment in outcrop. B: Detail of the previous photograph showing the rhythmic alternation of whitish marls and calcareous marls, and black shales.

Fischer & Schwarzacher, 1984; Fischer et al., 1985; Herbert & Fischer, 1986; Herbert *et al.*, 1986; Herbert, 1987 and 1992; Fischer & Herbert, 1988; Fischer *et al.*, 1991; among others) who demonstrated that the bedding rhythms reflect the Earth's orbital variations. According to Herbert & Fischer (1986), Herbert (1987), and Fischer & Herbert (1988) the marl-limestone bedding couplets of the stratigraphic interval including the Amadeus Segment record the precession cycle (19-23 ka) and a grouping of these couplets into bundles records the short cycle of eccentricity (95-125 ka). According to these authors these cycles result from changes in carbonate productivity and sea-floor stagnation. Even changes in abundance of planktonic foraminifera and trace fossils distributions were shown to be orbitally controlled (Premoli Silva *et al.*, 1989a and c; Premoli Silva & Erba, 1991).

MATERIAL AND METHODS

The Amadeus Segment was sampled bed by bed (at approximately 5-cm intervals) from a deep trench to eliminate surface contamination. The samples were marked

as AMS 1 to AMS 38 from bottom to top. The $CaCO_3$ content of each sample was estimated volumetrically. Sample preparation for foraminiferal study involved: crushing of 150 gr of sample; disaggregation by diluted hydrogen peroxide; washing through a 32 µm sieve; and drying. All the benthonic foraminifera were picked from the three coarser fractions (> 420 µm, 420-250 µm, 250-125 µm) into numbered slides for quantitative analysis. The composition of the remaining fraction (<125 µm) was only noted, but in no cases did it contain species not recorded from the other fractions. The classification followed is based on Loeblich & Tappan (1988). Plates 1 and 2 illustrate all identified taxa.

The quantitative analysis was carried out by studying the variations in abundance of the species within the assemblages. On the basis of their shape, chamber arrangement, and inferred mode of life, the recognized species were grouped into 10 morphogroups (see Table 1); then, the variations in relative abundance of these groups within the assemblages were observed. To obtain information on the trophic structure variations a number of
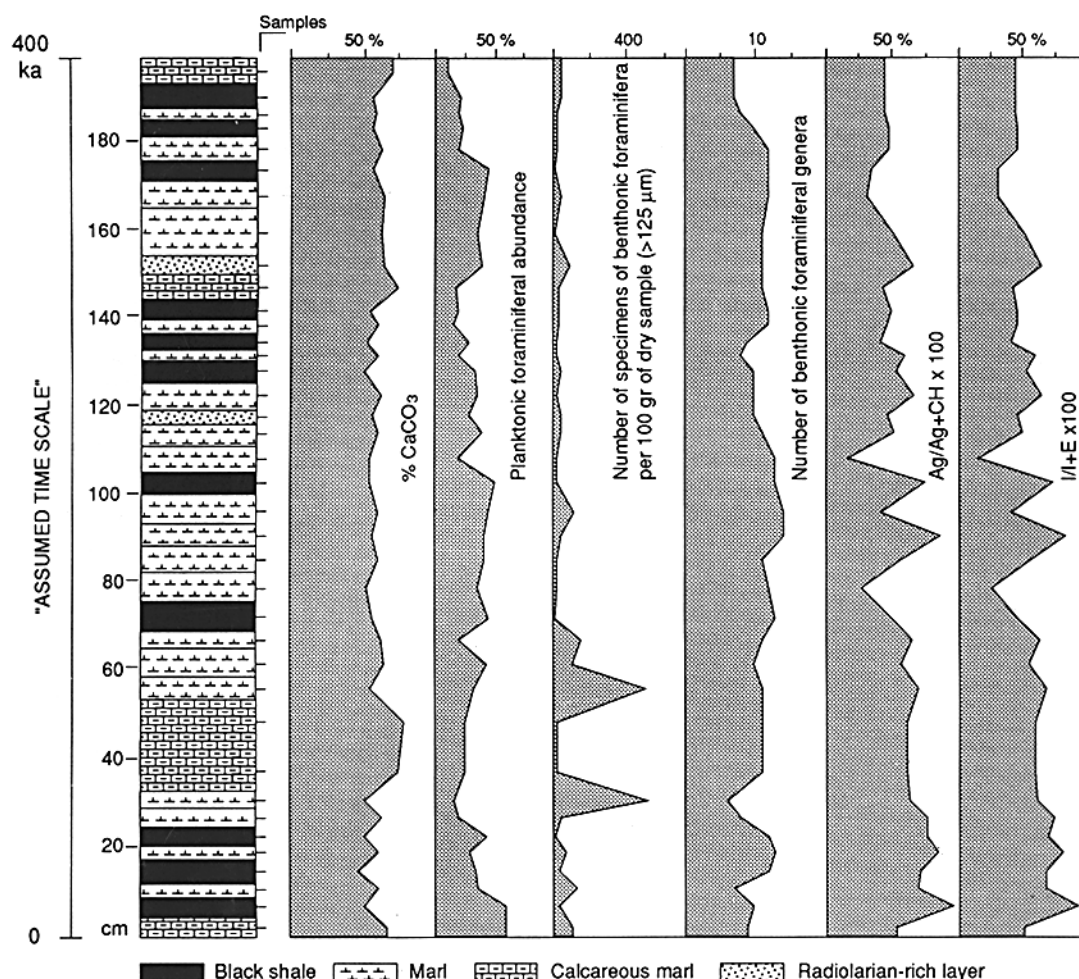
Fig. 4 Generalized lithological log of the Amadeus segment and variations of some peculiar data. Abbreviations as follows: Ag=Agglutinated benthonic foraminifera, CH=Calcareous-hyaline benthonic foraminifera, I=Infaunal forms, E=Epifaunal forms.

indices were calculated including: the number of specimens per 100 g of dried sample; the number of genera per sample; the infaunal (I)/epifaunal (E) forms ratio calculated as I/I+E x 100; and the agglutinating (Ag)/calcareous hyaline (CH) forms ratio calculated as Ag/Ag+CH x 100. The absolute abundance of planktonic foraminifera was estimated by counting on a graduated screen and comparing obtained values with those from grain-size diagrams (Baccelle & Bosellini, 1965).

Finally, to detect periodicity in the foraminiferal data, a fourier function analysis was applied to the abundance records of each species, genus, and morphogroup. This analysis was carried out by using the Strata Base 6.1 program (Ripepe, 1988). The type of sampling might have affected the result of the spectral analysis since it did not take into account the possible variations within a single layer and because it was too wide. However, detailed study of samples taken in several sites along a single layer showed consistency of benthonic foraminiferal assemblages. Furthermore, only spectral analyses that showed cyclicity clearly enough to be retained as primary were considered valid.
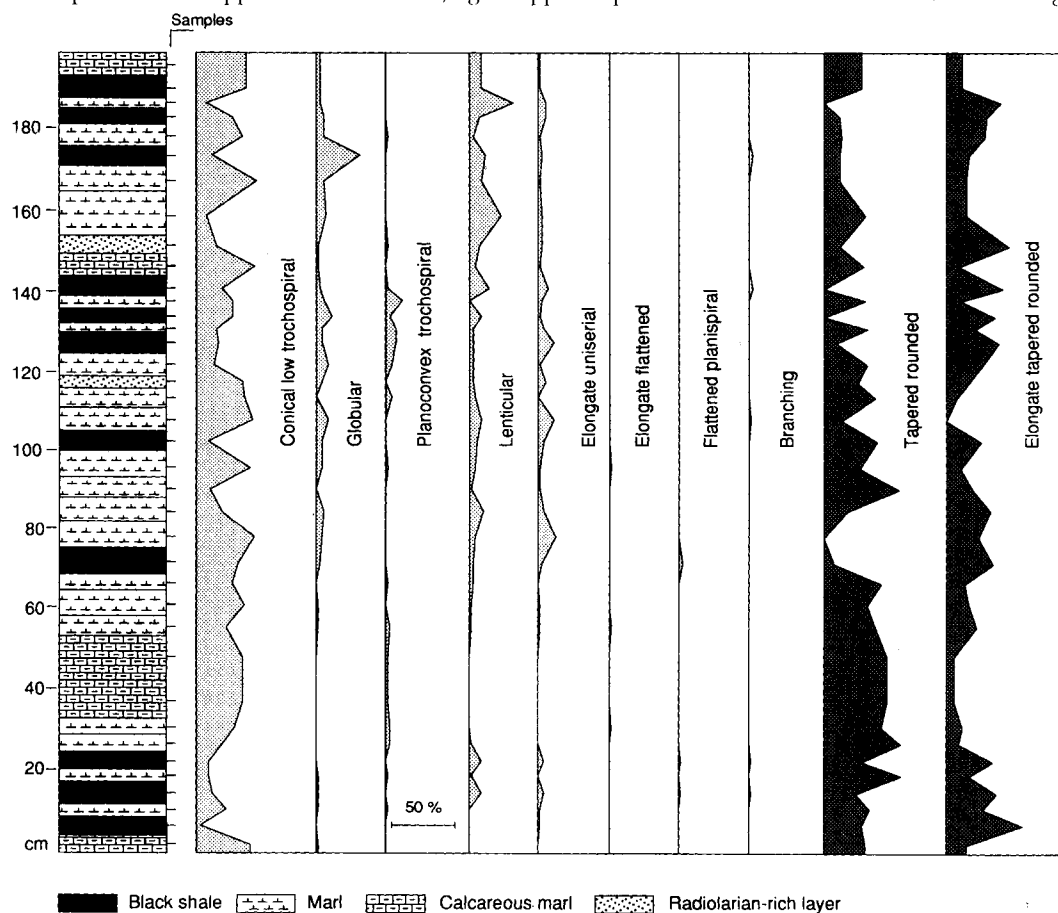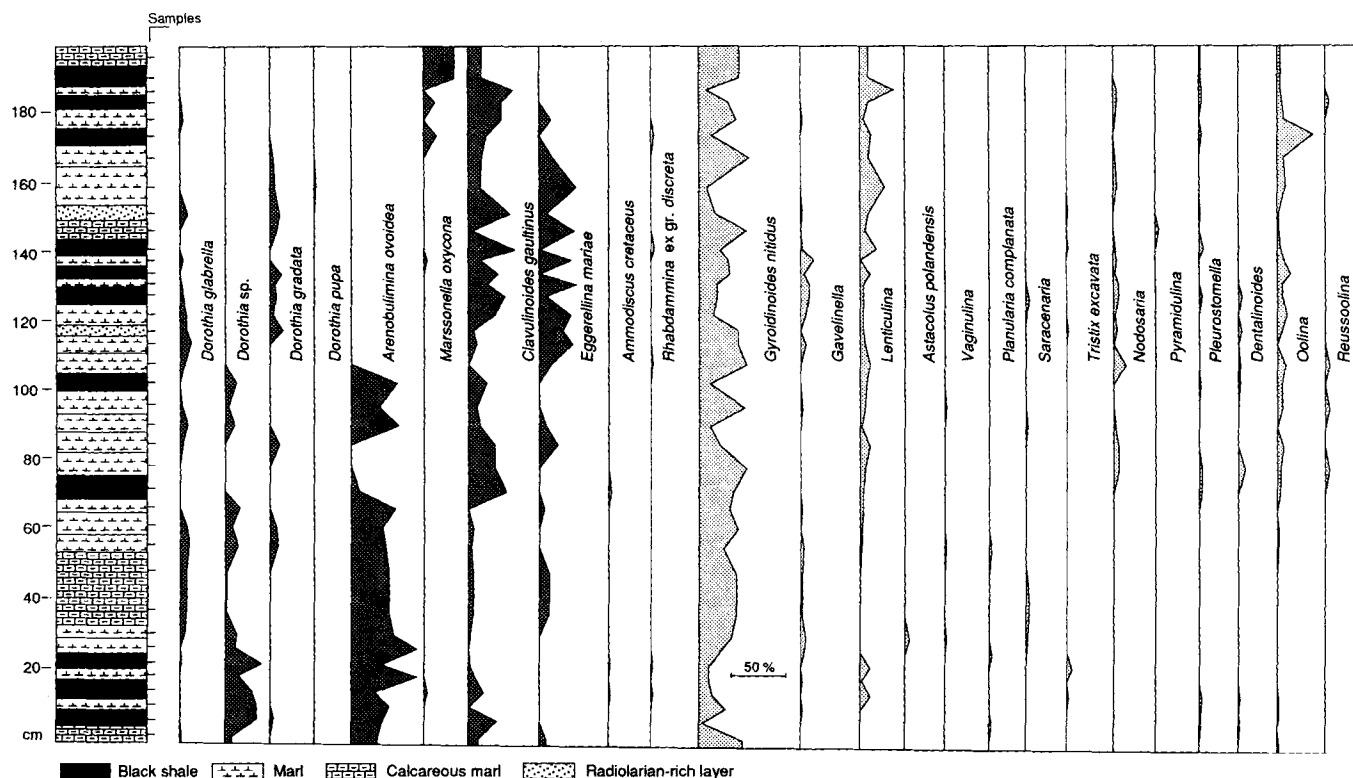
RESULTS

The $CaCO_3$ content of the Amadeus Segment ranges from 50 to 75% (Fig. 4), with minima of 50-55% in the black-shales. Planktonic foraminifera are more abundant in samples with low carbonate content with greatest abundance in the marly layers, whereas they decrease in abundance in samples rich in carbonate (Fig. 4).

The benthonic foraminiferal assemblages of the Amadeus Segment are composed of calcareous hyaline and both calcareous and silicified-walled agglutinating forms. Preservation is moderate to good. Forty-two species were identified belonging to twenty-two genera among which *Gyroidinoides*, *Arenobulimina*, *Dorothia*, and *Clavulinoides* predominate.

The benthonic foraminiferal assemblages change with lithology and three distinct associations can be recognized (Table 3):

(a) Marl Association (MA):
    (i) High abundance;
    (ii) High diversity;
    (iii) Low dominance

Fig. 5 Generalized lithological log of the Amadeus Segment and relative abundance percentages of benthonic foraminiferal genera and species. Dark stippled=infaunal forms, light stippled=epifaunal forms. Assumed Time Scale as in fig. 4.

Fig. 6 Generalized lithological log of the Amadeus Segment and relative abundance percentages of benthonic foraminiferal morphogroups. Light stippled=epifaunal forms, dark stippled=infaunal forms. Assumed Time Scale as in fig. 4.

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(iv) Large size of the specimens (>250 µm);

(v) Predominance of low surface to volume ratio morphotype;

(b) Calcareous Marl Association (CMA):

(i) Low abundance;

(ii) Variable diversity;

(iii) High dominance;

(iv) Small size of the specimens (< 250 µm);

(c) Black-Shale Association (BSA):

(i) Low abundance;

(ii) Low diversity;

(iii) High dominance;

(iv) Small size of the specimens (< 250 µm);

(v) Predominance of high surface to volume ratio morphotypes.

The distribution of many species, genera, and morphogroups through the Amadeus Segment appears to be cyclical (Figs. 5 and 6). However, some of them (e.g. *Marssonella oxycona, Pleurostomella*, and branching morphotypes) exhibit such a discontinuous distribution that it would be very difficult to carry out a significant evaluation. On the basis of an assumption of uniform sedimentation rate, the spectral analyses support the hypothesis that, in some cases, the cyclicities appear to be astronomically driven (Fig. 7). In addition, since other workers (Herbert & Fischer, 1986; Herbert, 1987; Fischer & Herbert, 1988; Premoli Silva *et al.*, 1989a and b; Fischer et al., 1991) have already provided strong evidence of Milankovitch Cyclity influencing sedimentation in this sequence, then it is reasonable to interpret the benthonic foraminiferal patterns in this context.

The following can be recognized: (i) the precession cycle (19-23 ka) followed by *Gyroidinoides nitidus, Clavulinoides gaultinus*, and tapered rounded elongate, tapered rounded, lenticular, and conical low trochospiral morphogroups, (ii) the short eccentricity cycle (95-123 ka) followed by *Clavulinoides gaultinus, Lenticulina*, and elongate tapered rounded, tapered rounded, and lenticular morphogroups (Table 2). Consequently, variations in the trophic structure, assume cyclical aspects. In fact, the paleocommunities mainly consisting of infaunal forms and those mainly consisting of epifaunal forms, alternate with a periodicity correlatable to the obliquity (42 ka) and precession (19-23 ka) cycles (Fig. 7), whereas the benthonic foraminiferal abundance variations record the obliquity cycle. Inverse relationships can be observed between *Gavelinella* and *Lenticulina*, between *G. nitidus* and *C. gaultinus*, and between elongate tapered rounded and tapered rounded morphogroups.

DISCUSSION

Several authors (Corliss, 1985; Bernhard, 1986; Corliss & Chen, 1988; Coccioni, 1990; a and b; Bartolini *et al.*, 1990; Koutsoukos & Hart, 1990; Coccioni & Galeotti, 1991; Kaiho, 1991, among others) have shown that test size and

predominant morphologies of benthonic foraminifera from hypoxic/anoxic deposits differ from those of oxic deposits. Based on these works the benthonic foraminiferal distribution patterns in the Amadeus Segment can be largely explained in terms of oxygen content variations. Both the composition and the abundance of the benthonic foraminiferal assemblages are different in the different lithotypes. The BSA composition suggests a high degree of oxygen depletion on the bottom water. In contrast, both the MA and the CMA compositions are indicative of well oxygenated bottom water. The MA assemblage displays highest abundance of benthonic foraminifera in the fraction greater than 125 µm. This measure of the benthonic foraminiferal assemblages (benthonic foraminiferal flux) has been shown to be directly linked to organic flux rates (Herguera & Berger, 1991) suggesting fluctuation in primary productivity. The low abundance in the CMA is, probably, a reflection of rapid sedimentation, which may dilute the benthos.

On the basis of the distribution of species, genera and morphogroups in the different lithotypes which are assumed to reflect different oxygenation conditions, we have tried to identify aerobic, intermediate, and anaerobic forms (Table 3). According to some authors (Bernhard, 1986; Coccioni, 1990a and b; Kaiho, 1991) infaunal anaerobic forms have higher surface area-to-volume ratios than aerobic ones. Leutenegger & Hansen (1979) suggested that high surface area-to-volume ratios and high porosity tests could provide a greater area for mitochondrial oxygen uptake. Moreover, we suggest that tapered and elongate morphologies could facilitate movement towards the water-sediment interface where the quantity of dissolved oxygen is greater.

The infaunal assemblages are devoid of intermediate forms (Table 3). This suggests, the infaunal forms were highly sensitive to dissolved oxygen content changes. Conversely, the epifaunal assemblages are almost entirely represented by intermediate forms, suggesting less sensitivity of these assemblages to oxygen content variations.

The aerobic assemblages include a good percentage of *Pleurostomella* specimens which, on the contrary, was suggested as an anaerobic index by Bernhard (1986) and Kaiho (1991). Moreover, other forms considered aerobic by these authors (e.g., planoconvex, lenticular, globular/sphaerical morphotypes) or anaerobic (e.g., *Nodosaria* and *Dentalinoides*) are here considered intermediate indices of dissolved oxygen content.

The infaunal anaerobic forms from the Amadeus Segment have a high surface area to volume ratio, while epifaunal forms with a very high surface area to volume ratio represent intermediate or even aerobic indices. This implies that, in certain conditions, a particular morphology can be adaptive for an infaunal strategy but not for an epifaunal strategy. In conditions where oxygenation is low, for example, an infaunal species with a cylindrical and elongate morphology may have had an advantage because it could move more easily towards the water-sediment interface

Table 1 Benthonic foraminiferal morphogroups and trophic strategies in the Amadeus Segment. Genera and species are arranged in taxonomic order.

MORPHOGROUP	GENUS/SPECIES	TROPHIC STRATEGY
Lenticular	Lenticulina Saracenaria Astacolus Planularia	Epifaunal to shallow infaunal deposit feeders
Elongate flattened	Vaginulina	
Globular	Reussolina Oolina	
Elongate uniserial	Dentalinoides Nodosaria Pyramidulina Tristix Pleurostomella Pseudonodosaria	
Conical low trochospiral	Gyroidinoides	
Flattened planispiral	Ammodiscus	
Branching	Rhabdammina	Elevated, erect suspension feeder
Planoconvex trochospiral	Gavelinella	Epifaunal living on elevated substrate?
Elongate tapered rounded	D. gradata D. sp. C. gaultinus	Infaunal deposit feeders
Tapered rounded	A. ovoidea D. glabrella M. oxycona E. mariae D. pupa	

AMADEUS SEGMENT	Short Eccentricity Cycle (95-127 ka)	Obliquity Cycle (ca. 40 ka)	Precession Cycle (19-23 ka)
Genera/Species	D. glabrella Lenticulina C. gaultinus	D. glabrella Lenticulina	Lenticulina C. gaultinus G. nitidus
Morphogroups	Lenticular Tapered rounded Tapered elongate rounded	Lenticular	Lenticular
Trophic structure	—	I/I+E X 100 number of specimens	I/I+E x 100

Table 2 Benthonic foraminifera and cyclicity in the Amadeus Segment. Genera and species are arranged in taxonomic order.

	Aerobic	Intermediate	Dysaerobic	
Infaunal forms	A. ovoidea D. gradata E. mariae	—	D. gradata D. sp. C. gaultinus	
Epifaunal forms	G. flandrini Pleurostomella	Nodosaria Saracenaria Lenticulina Oolina G. nitidus	R. ex gr. discreta A. cretaceus	A
Infaunal forms	Tapered elongate	—	Tapered rounded elongated	
Epifaunal forms	Planoconvex trochospiral	Conical low trochospiral Elongate uniserial Globular Lenticular	Branching Flattened planispiral	B

Table 3 Aerobic, intermediate, and anaerobic forms in the Amadeus Segment based on distribution in different lithologies. A=genera and species, B=morphogroups.
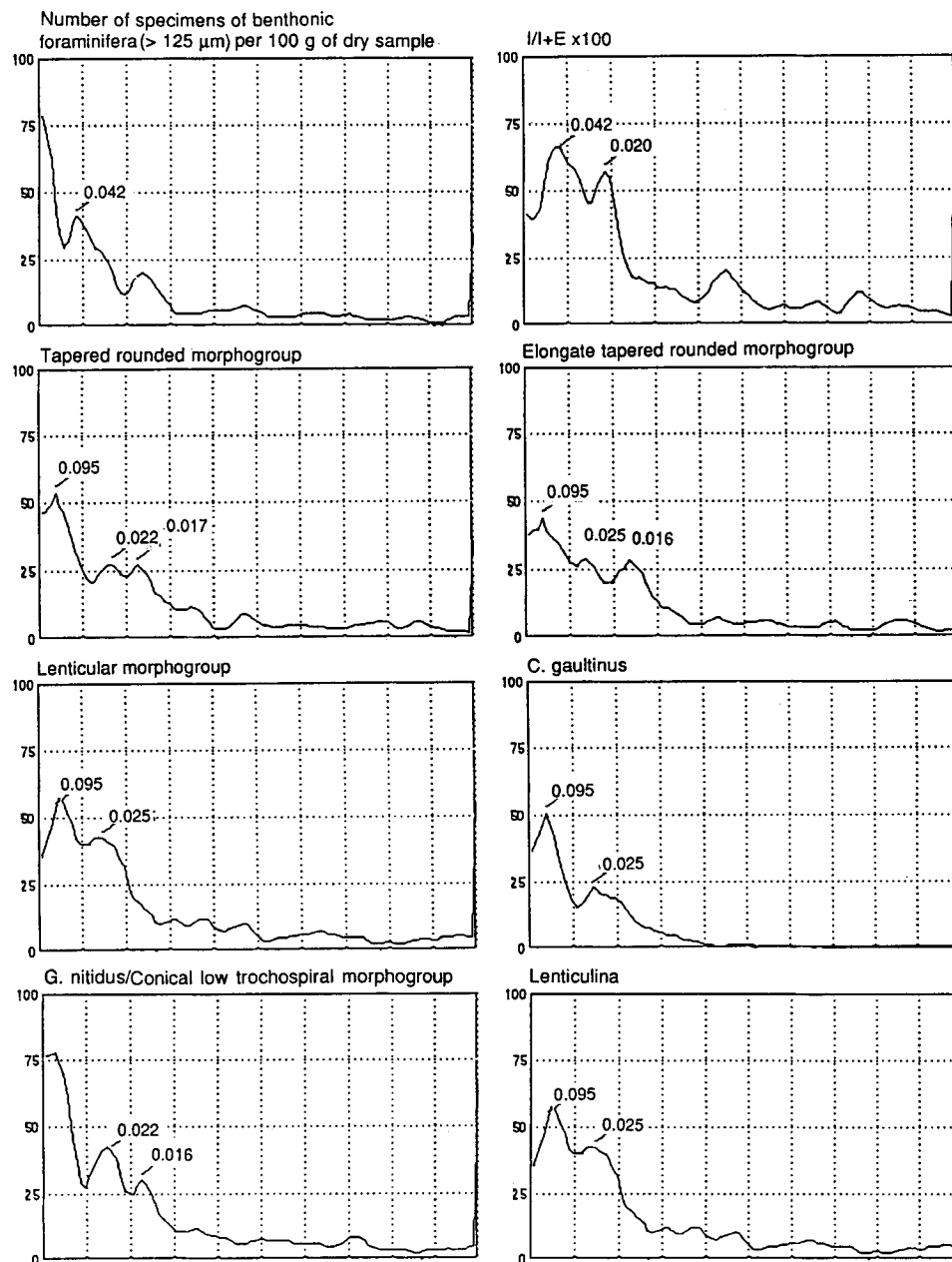
Fig. 7 Spectral analyses of the benthonic foraminiferal assemblages distribution throughout the Amadeus Segment. For each spectrum, the vertical axis represents power, the horizontal axis is harmonic number. Particularly strong peaks are labelled with their periodicity, in Ma.

Explanation of Plate 1

Fig. 1. *Gyroidinoides nitidus* (Reuss), sample AMS 8, x58. **Fig. 2.** *Lenticulina* sp., sample AMS 1, x70. **Fig. 3.** *Lenticulina gaultina* (Berthelin), sample AMS 8, x53. **Fig. 4.** *Lenticulina ovalis* (Reuss), sample AMS 8, x53. **Fig. 5.** *Lenticulina* cf. *acuta* (Reuss), sample AMS 11, x35. **Fig. 6.** *Astacolus polandensis* (Trujillo), sample AMS 8, x53. **Fig. 7.** *Vaginulina* sp., sample AMS 18, x53. **Fig. 8.** *Planularia complanata* (Reuss), sample AMS 2, x106. **Fig. 9.** *Vaginulina kochii* Roemer, sample AMS 8, x94. **Fig. 10.** *Saracenaria* sp., sample AMS 8, x53. **Fig. 11.** *Saracenaria bullata* (Berthelin), sample AMS 30, x35. **Fig. 12.** *Tristix excavata* (Reuss), sample AMS 8, x53. **Fig. 13.** *Nodosaria humilis* Roemer, sample AMS 2, x35. **Fig. 14.** *Pseudonodosaria* sp., sample AMS 16, x53. **Fig. 15.** *Pyramidulina obscura* (Reuss), sample AMS 2, x35. **Fig. 16.** *Pyramidulina paupercola* (Reuss), sample AMS 2, x35. **Fig. 17.** *Nodosaria limbata* d'Orbigny, sample AMS 30, x53. **Fig. 18.** *Nodosaria* sp. 1, sample AMS 26, x70. **Fig. 19.** *Nodosaria* sp. 2, sample AMS 1, x70. **Fig. 20.** *Nodosaria* sp. 3, sample AMS 2, x70.
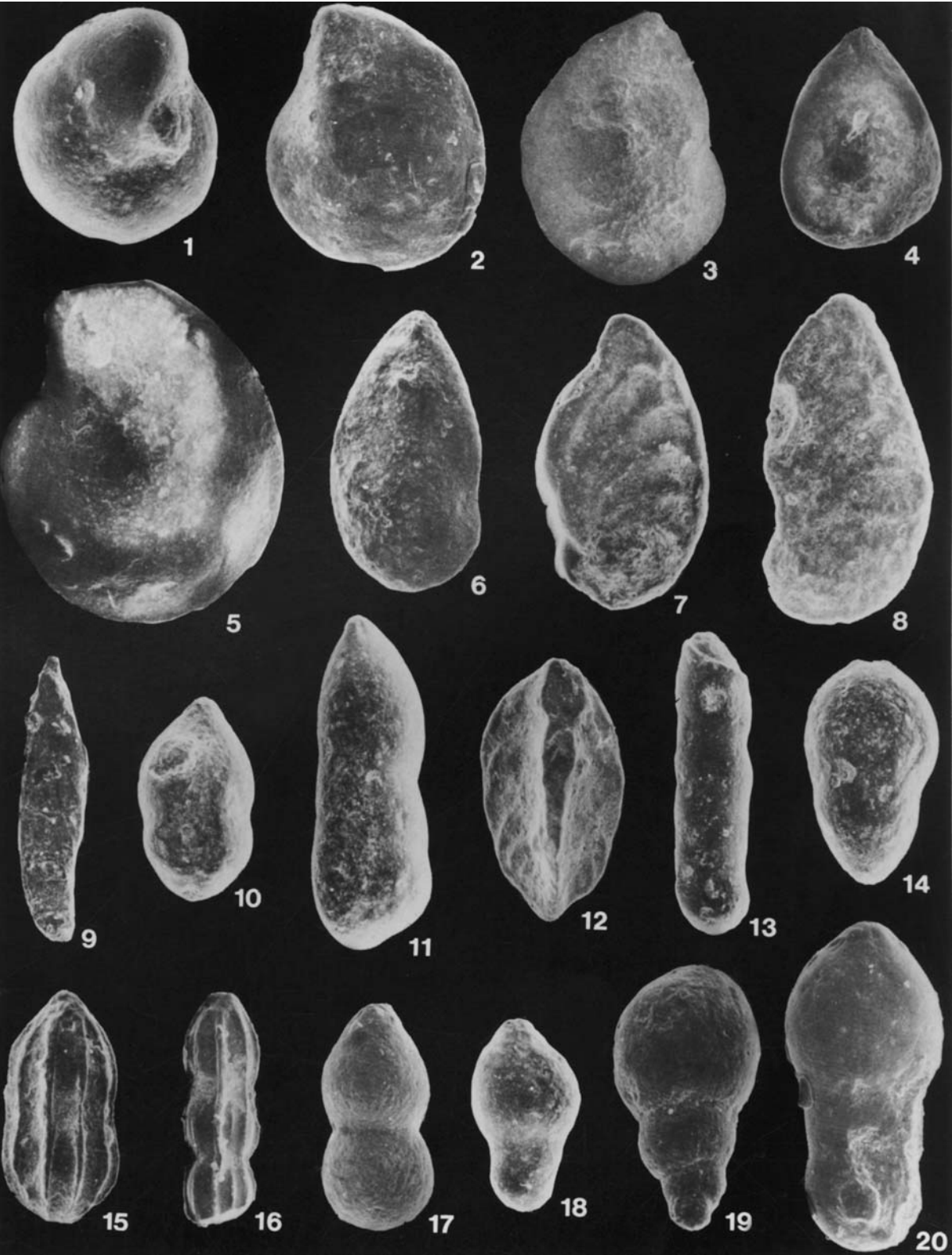
where there is a greater quantity of dissolved oxygen. In the same oxygenation conditions an epifaunal species with the same morphology might have been at a disadvantage because it would tend to sink into the substrate where the dissolved oxygen content is lower. Furthermore, it is possible that similar morphotypes can be characterized by a different feeding strategy. In this case the distribution of the morphogroups would be influenced not only by the dissolved oxygen content but also by the availability of nutrients on the sea floor.

Most of morphological studies on benthonic foraminiferal assemblages in dysaerobic environments have been carried out on sediments deposited under conditions of high epipelagic production. The high primary productivity levels contribute to high nutrient fluxes in the form of particulate organic material inducing oxygen deficiency in bottom waters. Deposited organic matter and bacteria are the primary trophic resource for the microbenthos thriving under such conditions. Contrary to this model, the black shale layers from the Amadeus Segment represent conditions of moderate to low fertility (Premoli Silva et al., 1989a; Erba, 1988 and 1992); this helps to explain the different behaviour of the epifaunal assemblages from the Amadeus segment to those studied by Bernhard (1986) and Kaiho (1991) (see above).

The cyclical assemblage changes recognized in the Amadeus Segment are, probably, a result of cyclical changes in both oxygen content and primary productivity induced by orbital forcing. In fact variations of these two parameters cause considerable changes in the trophic structure of the bottom environment and so in the benthonic communities (Jones & Charnock, 1985; Bernhard, 1986; Coccioni, 1990b; Koutsoukos & Hart, 1990; Premoli Silva & Erba, 1991, among others).

The influence of orbital forcing on benthonic foraminiferal assemblage pattern distribution has been reported previously from the Cenomanian and Turonian of southern England (Leary et al., 1989; Cottle, 1989) and from the Late Albian of Central Italy (Coccioni & Galeotti, 1991). Leary et al. (1989) showed that changes in the abundance of *Lenticulina* and *Gavelinella* were related to changes in amount of introduced carbonate sediment as a consequence of the precessional forcing of the climate. Detailed sampling of two sections of Turonian-aged Chalk from south-east England for foraminifera has revealed that cyclical abundance changes of *Gyroidinoides nitidus* and *Gavelinella*

emscheriana were mediated by orbitally induced climatic cycles (Cottle, 1989). In particular, changes in abundance of *G. nitidus* were driven by the obliquity cycle. Instead, in the Amadeus Segment the cyclical changes in abundance of this species are correlatable to the precessional cycle. Evidently, a single species may show a different sensitivity to orbital forcing through time (probably under different climatic regimes) or at different paleolatitudes.

CONCLUSIONS

Abundance, taxonomic composition, morphology, and test size of benthonic foraminifera fluctuate greatly from layer to layer throughout the Amadeus Segment reflecting dynamic fluctuations of the sea floor environment.

With respect to lithology, three peculiar associations (MA, CMA, and BSA) have been identified which we suggest to be related to different degrees of primary productivity and oxygenation of the bottom water. This paper provides evidence that these changes are the result of orbitally induced productivity and redox cycles .

The influence of orbital forcing has been recognized in the distribution of some species, genera and morphogroups. Moreover, the orbital forcing drives cyclic changes in the trophic strategies. Our data demonstrate that a single species may show different sensitivity to orbital forcing through time (probably under different climatic regimes) or at different paleolatitudes.

The impoverishment of the benthonic foraminifera assemblages within the black shales, which were deposited under a low productivity regime, can be attributed to oxygen depletion under stratified water conditions. It coincides with predominance of the more specialized anaerobic forms within the infaunal assemblages, which are more sensitive indicators of oxygen content variations. In the more calcareous lithotypes, which were deposited under high productivity regimes, the impoverishment of the benthonic foraminiferal assemblages is interpreted as due to the rapid introduction of a large amount of sediment, mainly made up of nannoplankton, which tend to dilute the benthos.

On the basis of the distribution of species, genera, and morphogroups throughout the Amadeus Segment, aerobic, intermediate and anaerobic forms have been identified. In agreement with previous studies, the infaunal anaerobic forms have a high surface area to volume ratio. On the basis of our data, certain epifaunal forms are considered to be

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Explanation of Plate 2

Fig. 1. *Dentalinoides communis* (d'Orbigny), sample AMS 2, x85. Fig. 2. *Dentalinoides cylindroides* (Reuss), sample AMS 2, x68. Fig. 3. *Oolina* sp., sample AMS 27, x51. Fig. 4. *Oolina globosa* (Montagu), sample AMS 16, x68. Fig. 5. *Oolina apiculata* Reuss, sample AMS 4, x68. Fig. 6. *Oolina oxystoma* (Reuss), sample AMS 16, x90. Fig. 7. *Dentalinoides oligostegia* (Reuss), sample AMS 6, x51. Fig. 8. *Pleurostomella subnodosa* Reuss, sample AMS 6, x51. Fig. 9. *Pleurostomella* sp., sample AMS 24, x51. Fig. 10. *Gavelinella intermedia* (Bethelin), sample AMS 8, x90. Fig. 11. *Gavelinella flandrini* Moullade, sample AMS8, x68. Fig. 12. *Reussoolina* sp., sample AMS 16, x68. Fig. 13. *Eggerellina mariae* Ten Dam, sample AMS 13, x51. Fig. 14. *Arenobulimina ovoidea* Marie, sample AMS 8, x51. Fig. 15. *Dorothia pupa* (Reuss), sample AMS 21, x68. Fig. 16. *Dorothia glabrella* Cushman, sample AMS 11, x68. Fig. 17. *Marssonella oxycona* (Reuss), sample AMS 4, x68. Fig. 18. *Ammodiscus cretaceus* (Reuss), sample AMS 4, x68. Fig. 19. *Rhabdammina* ex gr. *discreta* Brady, sample AMS 20, x90. Fig. 20. *Dorothia* sp., sample AMS 8, x51. Fig. 21. *Dorothia gradata* Berthelin, sample AMS 13, x34. Fig. 22. *Clavulinoides gaultinus* (Morozova), sample AMS 13, x68.
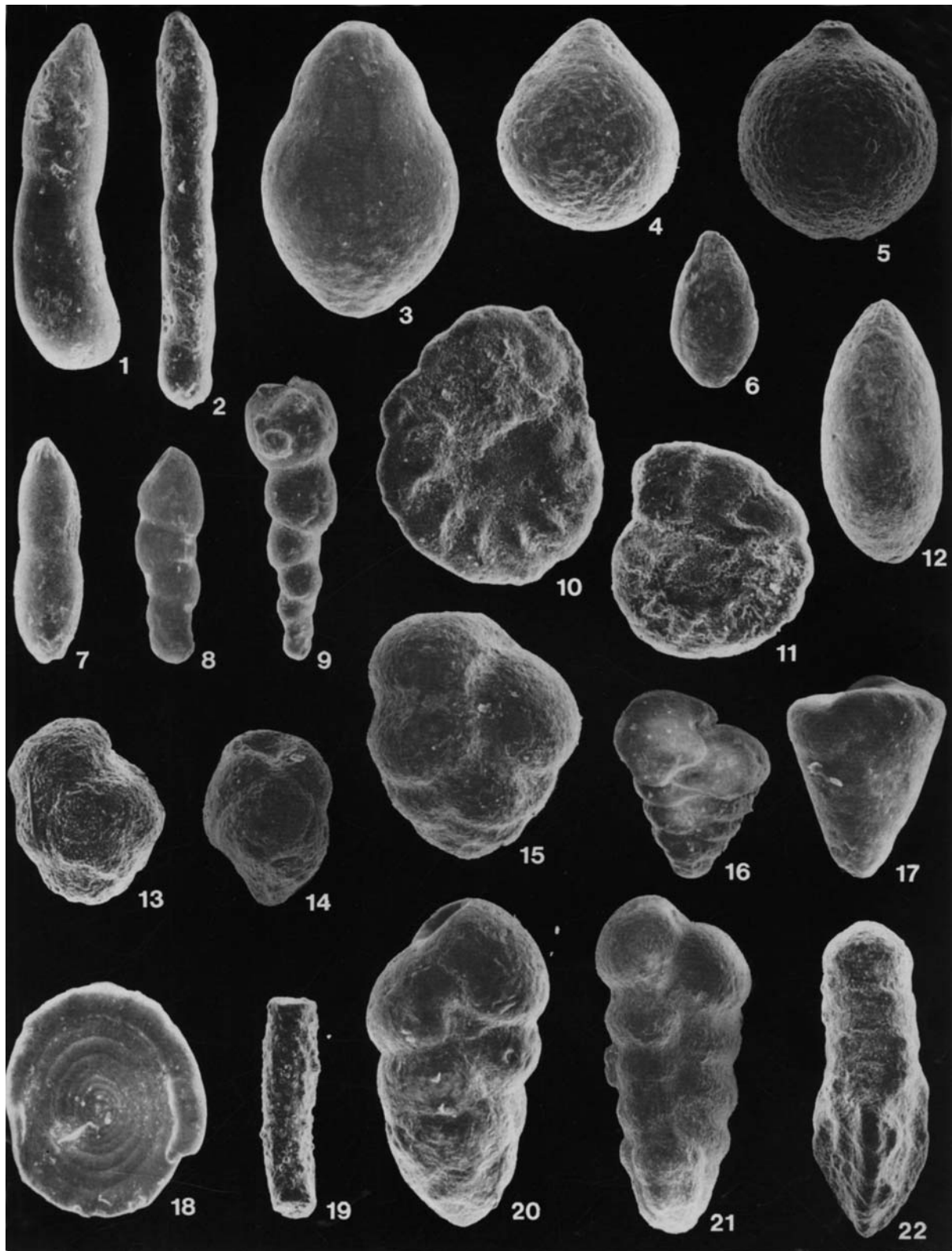
aerobic or intermediate indices. It must be pointed out that, for the same forms, other authors have proposed a different specialization with respect to the oxygen content. The cause of this different behaviour of the epifaunal assemblages can be attributed to the different paleoceanographic regime (that is very high productivity vs low productivity) under which the Amadeus Segment black shales were deposited.

ACKNOWLEDGEMENTS

Species list arranged in taxonomic order following Loeblich & Tappan (1988)

Rhabdammina ex gr. *discreta* Brady, 1881
Ammodiscus cretaceus (Reuss), 1862
Eggerellina mariae Ten Dam, 1950
Arenobulimina ovoidea Marie, 1941
Dorothia glabrella Cushman, 1933
Dorothia gradata Berthelin, 1880
Dorothia pupa (Reuss), 1860
Dorothia sp.
Marssonella oxycona Reuss, 1860
Clavulinoides gaultinus (Morozova), 1948
Dentalinoides communis (d'Orbigny), 1839
Dentalinoides cylindroides (Reuss), 1860
Dentalinoides oligostegia (Reuss), 1846
Nodosaria humilis Roemer, 1841
Nodosaria limbata d'Orbigny, 1840
Nodosaria sp. 1
Nodosaria sp. 2
Nodosaria sp. 3
Pseudonodosaria sp.
Pyramidulina obscura (Reuss), 1845
Pyramidulina paupercola (Reuss), 1846
Tristix excavata (Reuss), 1863
Lenticulina cf. *acuta* (Reuss), 1860
Lenticulina gaultina (Berthelin), 1880
Lenticulina ovalis (Reuss), 1844
Lenticulina sp.
Saracenaria bullata Reuss, 1846
Saracenaria sp.
Astacolus polandensis Trujillo, 1960
Planularia complanata (Reuss), 1845
Vaginulina kochii Roemer, 1841
Vaginulina sp.
Reussoolina sp.
Oolina apiculata (Reuss), 1851
Oolina globosa (Montagu), 1803
Oolina oxystoma (Reuss), 1863
Oolina sp.
Pleurostomella subnodosa Reuss, 1860
Pleurostomella sp.
Gyroidinoides nitidus (Reuss), 1846
Gavelinella flandrini Moullade, 1860
Gavelinella intermedia (Berthelin), 1880

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