# LATEST ALBIAN-EARLIEST TURONIAN DEEP-WATER AGGLUTINATED FORAMINIFERA IN THE BOTTACCIONE SECTION (GUBBIO, ITALY) - BIOSTRATIGRAPHIC AND PALAEOECOLOGIC IMPLICATIONS

*Rodolfo COCCIONI, Simone GALEOTTI and Marco GRAVILI*

Istituto di Geologia dell'Università
Via S. Chiara, 27 - 61029 Urbino (Italia)

## ABSTRACT

Using semi-quantitative methods, the distribution of deep-water agglutinated foraminifera (DWAF) was analyzed within the Latest Albian-earliest Turonian pelagic limestones of the famous Bottaccione standard section. The characteristic bathyal communities include forms of purely agglutinated "flysch-type" assemblages and elements which are typical of Upper Cretaceous abyssal environments of the North Atlantic. Well-established planktonic foraminiferal and calcareous nannofossil zonations allowed to directly gauge the stratigraphic ranges of DWAF, contributing to a better chronostratigraphic calibration of a deep-water agglutinated foraminiferal zonation. Differences in ranges of some biostratigraphic marker species were observed. The distribution of morphogroups enabled us to interpret levels of oxygenation and organic input. The effects of the Cenomanian-Turonian boundary event (here represented by the ichtyolithic-bituminous-radiolaritic Livello Bonarelli) on the DWAF were explored in detail. A major faunal change in agglutinated foraminiferal communities consisting of a marked decrease in faunal density and species richness was recognized in the middle of the *Rotalipora cushmani* Zone coinciding with a marked change in sedimentary regimes and related to extensive oxygen depletion on the sea bottom. The anoxic Livello Bonarelli did not lead to extinction of any species. Instead, some species have their first and last occurrences just above it. After adverse environmental conditions lasting for some hundreds of thousands of years on the sea bottom, a rapid re-establishment of pre-Livello Bonarelli environmental conditions followed.

Keywords: Agglutinated Foraminifera, Biostratigraphy, Palaeoecology, Upper Cretaceous, Cenomanian-Turonian boundary event, Scaglia limestone, Gubbio, Italy.

## RESUMEN

Se analiza, semicuantitativamente, la distribución de los foraminíferos aglutinantes de aguas profundas (DWAF) de las calizas pelágicas (entre el Albiense terminal y el Turoniense basal) de la famosa sección de Bottaccione. Las asociaciones batiales características incluyen tanto formas del "tipo-flysch" como elementos típicos de los ambientes abisales noratlánticos. Las zonaciones de foraminíferos planctónicos y las de nanofósiles permiten calibrar las distribuciones estratigráficas de los DWAF, contribuyendo a una mejor cronoestratigrafía de la biozonación de foraminíferos aglutinantes y observándose algunas diferencias en las distribuciones de ciertos biomarcadores. La distribución de los morfogrupos nos permite conocer los niveles de oxigenación y de sumistro de materia orgánica. Se investiga en detalle el influjo del acontecimiento del límite Cenomaniense/Turoniense sobre los DWAF, que en esta sección está representado por el "nivel Bonarelli". Un cambio importante en las asociaciones de los foraminíferos aglutinantes, menor abundancia y menor riqueza específica, se reconoce hacia la mitad de la Zona de *Rotalipora cushmani*, que coincide con un cambio en el régimen sedimentario relacionado con aguas profundas muy pobres en oxígeno. No obstante, este nivel anóxico no conlleva extinción de especie alguna, aunque algunas especies tienen su último o primer registro sobre el mismo. Después de un período de varios cientos de miles de años en estas adversas condiciones, hubo un reestablecimiento rápido de las condiciones ambientales previas al depósito del "nivel Bonarelli".

Palabras clave: Foraminíferos aglutinantes, Bioestratigrafía, Paleoecología, Cretácico Superior, Acontecimiento del límite Cenomaniense/Turoniense, Calizas Scaglia, Gubbio, Italia.

## INTRODUCTION

The biostratigraphic value of the deep-water agglutinated foraminifera (DWAF) was overlooked for a long time, the distribution of this faunal group in sediments depending strongly upon environmental factors. In the last ten years the Cretaceous DWAF have become an important group in biostratigraphic correlation and paleoenvironmental interpretation of deep oceanic sequences (Geroch and Nowak, 1984; Kuhnt, 1987, 1990, 1992; Kaminsi *et al.*, 1988a; Moullade *et al.*, 1988; Kuhnt *et al.*, 1989, 1992; Kuhnt and Kaminski, 1989, 1990, 1993; Coccioni, 1990; Geroch and Olszewska, 1990; Koutsoukos and Hart, 1990; Koutsoukos *et al.*, 1990; Neagu, 1990; Kuhnt and Moullade, 1991; Kaminski and Geroch, 1992; Kaminski *et al.*, 1992; Wightman and Kuhnt, 1992; Coccioni and Galeotti, 1993; Kaiho *et al.*, 1993; Reicherter *et al.*, 1994; among others). The results of biostratigraphic investigations in the Polish Carpathians during the last three decades have been synthesized by Geroch and Nowak (1984) in a formal zonation which constitutes the only workable biostratigraphic scheme available for Cretaceous sediments and have been applied either directly, or with slight modifications, to diffe-

rent areas of the the North Atlantic and Western Tethys (Moullade *et al.*, 1988; Kaminski *et al.*, 1992; Kuhnt and Kaminski, 1989, 1990; Kuhnt *et al.*, 1992). However, as pointed out by Kaminski and Geroch (1992) and Kuhnt *et al.* (1992) the calibration of the Cretaceous DWAF biozonation to a standard scale is still problematic and new stratigraphic sections, especially of Aptian-Cenomanian age, need to be analyzed in order to improve the biostratigraphic scheme and to attain the level of stratigraphic accuracy required to incorporate a zonation based on DWAF into a general Tethyan Cretaceous correlation scheme. Furthermore, this analysis might also be helpful to explore the potential of DWAF for documenting paleoceanographic changes.

Latest Albian-earliest Turonian deep-water pelagic limestones of the Bottaccione section (Fig. 1), a famous magnetostratigraphic standard section for the Tethyan mid-upper Cretaceous-Paleogene, provided an exceptional opportunity (1) to directly calibrate the stratigraphical ranges of DWAF by means of well-established planktonic foraminiferal and calcareous nannofossil zonations, (2) to evaluate changes of the taxonomic composition and correlate these changes with environmental parameters, and (3) to explore in detail the effects

of the Cenomanian-Turonian (C/T) boundary global palaeoceanographic event on the DWAF.

The results of our detailed investigation are here reported which will further improve our knowledge of the mid-Cretaceous DWAF.

## GEOLOGICAL SETTING, LITHOLOGY, AND STRATIGRAPHY

The Cretaceous pelagic sequences of the Umbria-Marche Apennines were deposited in a complex basin and swell topography along the continental margin of the Apulian block, which moved with Africa relative to northern Europe. The basement of the Umbria-Marche Apennines is continental and the Upper Jurassic through Paleocene pelagic succession overlies a subsiding Triassic to Early Jurassic carbonate platform. The Cretaceous pelagic sequence of the Umbria-Marche Apennines is subdivided into four formations as follows (from bottom to top): Maiolica p.p. (Tithonian-early Aptian), Scisti (or Marne) a Fucoidi (early Aptian-latest Albian), Scaglia Bianca (latest Albian-earliest Turonian), and Scaglia Rossa p.p. (earliest Turonian-early Lutetian).

For this study we sampled the top of the Scisti a Fucoidi, the entire Scaglia Bianca, and the lowermost part of the Scaglia Rossa (Fig. 2).

The Scaglia Bianca belongs to the Scaglia succession which is lithologically subdivided into several discrete formations and members on the basis of color changes and the presence or absence of chert (Arthur and Fischer, 1977; Arthur, 1977, 1979; Alvarez and Montanari, 1988; Coccioni et al., 1992). The Scaglia Bianca consists mostly of yellowish-grey to grey limestones with a few pink to reddish limestone beds, and several greenish-grey to black marlstones and shales interbedded in the lowermost and uppermost portions of the formation. According to Coccioni et al. (1992) the average

thickness of the Umbria-Marche Scaglia Bianca is 67 m and beds are on average 12 cm-thick. The dominant lithotype (overall carbonate content > 70%) is due to lithification of nannofossil-planktonic foraminiferal ooze, deposited above the calcite compensation depth (CCD). Siliceous components are important throughout the formation where they occur mainly as chert nodules and lenses containing radiolarians which, however, are also found within discrete layers. Chert nodules and lenses are generally greenish-grey to pinkish-grey in colour but in some cases reddish-brown or dark-grey to black in proximity to similarly coloured limestone beds. Contact with the underlying Scisti a Fucoidi and the overlying Scaglia Rossa is gradational, with the former characterized by a progressive increase upsection of limy, silicified beds and the latter by alternating yellowish-grey and pink coloured beds. Burrowing is common and especially evident in zones of contrasting lithologies.

The pelagic limestones of the Cretaceous portion of the Scaglia succession were deposited well above the CCD, at a deep bathyal bathymetric position in a water depth between 1500 m and 2500 m (Arthur and Premoli Silva, 1982; Coccioni, 1990; Kuhnt, 1990).

Four discrete members (here codified as W) are distinguished within the Scaglia Bianca (Coccioni et al., 1992). They are (from bottom to top): W1 (Lower Yellowish-Grey Member) comprised of yellowish-grey limestone with common nodules and lenses of greenish-grey chert; greenish-grey to black, marly/shaly layers are interbedded in the lower portion; W2 (Reddish Member) consists of pink to reddish limestone with subordinate yellowish-grey limestone and rare greenish-grey marly layers; pinkish-grey chert nodules and lenses are distributed throughout; W3 (Upper Yellowish-Grey Member) is represented by yellowish-grey limestone with common nodules and lenses of greenish-grey chert; W4 (Greyish Member) is comprised of mostly light-grey to grey limestone with common nodules and lenses of dark-grey to black chert throughout; black marly/shaly layers are interbedded in the upper portion.

A prominent regional, 0.5 to 2 m-thick marker bed, named Livello Bonarelli (Scisti ittiolitici of Bonarelli, 1891) occurs near the top of Member W4, at the base of the *Whiteinella archaeocretacea* Zone according to Premoli Silva and Sliter (in press). It is devoid of calcareous plankton and benthos and consists of olive-green to black mudstones and black, organic carbon-rich (more than 23 percent organic carbon according to Arthur and Premoli Silva, 1982), finely laminated shales, often rich in fish remains, pyrite nodules and/or radiolaria, alternated with radiolarian silty and sandy layers (Coccioni et al., 1991). The ichtyolithic-bituminous-radiolaritic Livello Bonarelli took place under eutrophic and anoxic conditions, the data from the Umbria-Marche Basin supporting the hypothesis of an exceptionally intense upwelling as a major cause of its deposition (Arthur and Premoli Silva, 1982; Coccioni et al., 1991; Premoli Silva and Sliter, 1995). As already known, this short-lived anoxic event constitutes the landward sedimentary expression of the worldwide Oceanic Anoxic Event 2 (OAE 2) of Schlanger and Jenkyns (1976) which took place close to the C/T boundary when the second-largest Cretaceous extinction (Raup and Sepkoski, 1986) coincidentally occurred. According to several authors (Geroch and Nowak, 1984; Kuhnt, 1987; Moullade et al., 1988; Kuhnt et al., 1989, 1992; Kaminski et al., 1992; Kuhnt, 1992) the C-T boundary event (CTBE) is accompanied by an important taxonomic turnover in DWAF.

Mainly as a result of the anoxic environment at the sediment/water interface the Livello Bonarelli and the adjacent, silicified limestone beds lack any signs of benthic life which together constitute the so called "benthic-free interval", 0.60 to 2.4 m thick. The planktonic foraminiferal community underwent significant changes in abundance and diversity clo-
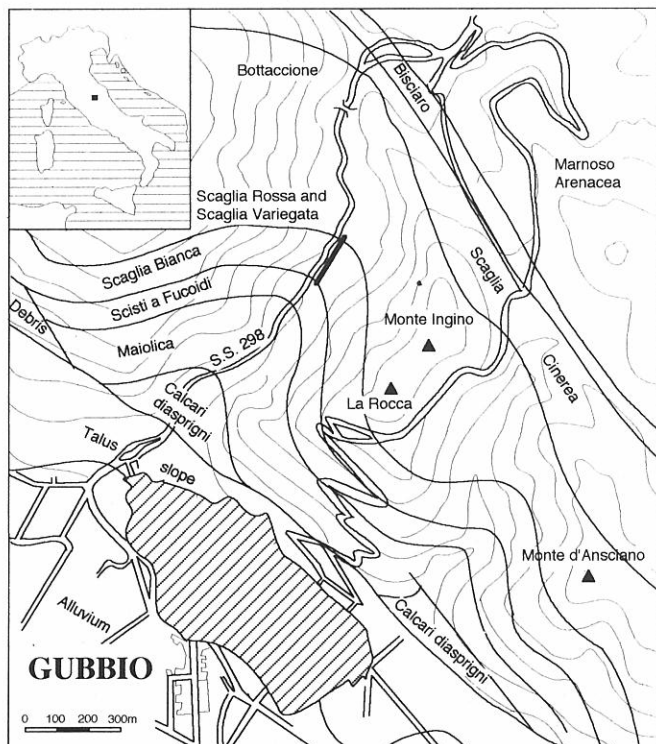


**Figure 1.** Location of the studied section marked with a thick line on a simplified map that gives the boundaries in the Gubbio area (after Orlando, 1983 modified).
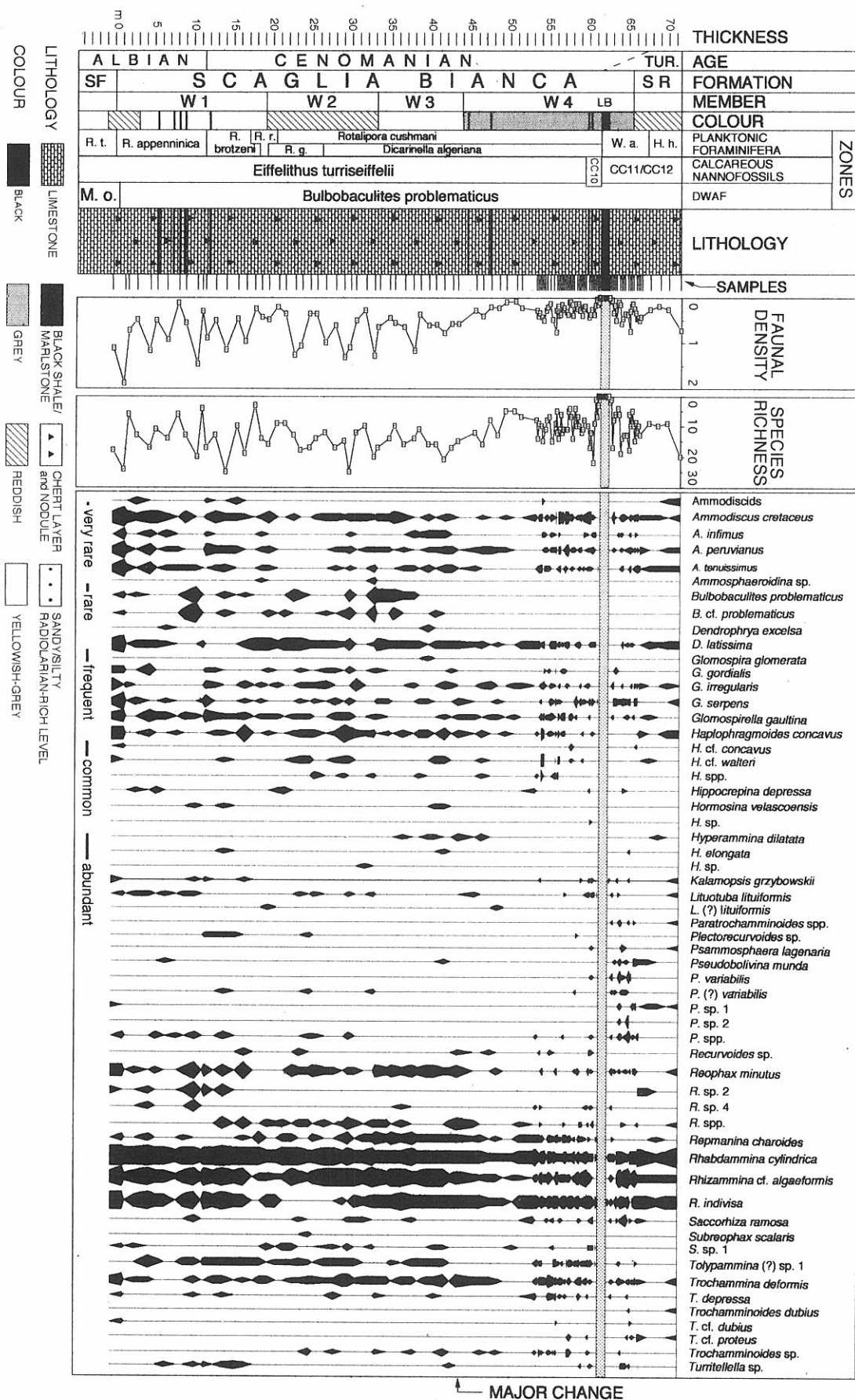
**Figure 2:**

Semi-quantitative distribution of DWAF throughout the studied section plotted against the litho-, bio-, and chronostratigraphy, the sample(s) position, and the estimated faunal parameters. The species are arranged from left to right in alphabetical order. Planktonic foraminiferal zonation after Premoli Silva and Sliter (1995); calcareous nannofossil zonation after Ghisletti and Erba (in prep.); DWAF zonation after Geroch and Nowak (1984) and Coccioni and Galeotti (in prep.). Abbreviations: SF = Scisti a Fucoidi; SR = Scaglia Rossa; LB = Livello Bonarelli; R.t. = *Rotalipora ticinensis*; R.r. = *Rotalipora reicheli*; R.g. = *Rotalipora greenhornensis*; W.a. = *Whiteinella archaeocretacea*; H.h. = *Helvetoglobotruncana helvetica*; M.o. = *Marssonella oxycona*. The dotted band shows the stratigraphic extent of the "benthic-free interval" including the Livello Bonarelli which here corresponds to the CTBE. Note the "Major Change" in the middle part of the *Rotalipora cushmani* Zone (see text for explanation).

se to the Livello Bonarelli (Arthur and Premoli Silva, 1982; Piergiovanni, 1989; Coccioni et al., 1991; Premoli Silva and Sliter 1995). The fauna within some decimeters thick sediments just below the Livello Bonarelli becomes extremely poor, but still contains very rare specimens of rotaliporids. The extinction of the rotaliporids occurs at the bottom of the Livello Bonarelli (Coccioni et al., 1991; Premoli Silva and Sliter 1995). The recovery in abundance and diversity of planktonic foraminifera occurs some decimeters above the top of the Livello Bonarelli. The features of the pre-and post-Livello Bonarelli planktonic foraminiferal community allowed us to recognize a "lower" and an "upper critical interval" respectively, both of them some decimeters thick (Coccioni et al., 1991). The distribution and composition of planktonic foraminifera, calcareous nannoflora and radiolarians lead to interpret the "critical intervals" as period of increased nutrient contents in the surface water and the Livello Bonarelli as a very high fertility event.

Recently, Premoli Silva and Sliter (1995) and Ghisletti and Erba (in prep.) have refined the calcareous plankton biostratigraphy for limestone of the Scaglia Group exposed in Bottaccione section which allows recalibration of biozone boundaries with the previously measured paleomagnetic stratigraphy, the determination of local sedimentation rates, and the broader rate of evolutionary change.

The Bottaccione section (lat. 43° 21' 27"; long. 0° 08' 01"), a classic Tethyan setting, is located a few kilometers from the City of Gubbio, on the northern slope of the Bottaccione Valley, along the road S.S. 298 (Fig. 1). The section has since been the object of detailed sedimentologic (Arthur, 1977, 1979; Coccioni and Battistini, 1989; Coccioni et al., 1992), chemostratigraphic (Renard, 1986; Corfield et al., 1991; Ingram et al., 1994), magnetostratigraphic (Premoli Silva et al., 1974; Arthur and Fisher, 1977; Alvarez et al., 1977; Roggenthen and Napoleone, 1977; Napoleone, 1977, 1981), and biostratigraphic studies (Renz, 1936, 1951; Luterbacherand Premoli Silva, 1962, 1964; Premoli Silva, 1977; Premoli Silva et al., 1977; Monechi and Thierstein, 1985; Coccioni and Battistini, 1989; Micarelli and Potetti, 1989; Piergiovanni, 1989; Kuhnt, 1990; Kuhnt and Kaminski, 1990; Marcucci Passerini et al., 1991; Premoli Silva and Sliter 1995; Coccioni and Galeotti, in prep.; Ghisletti and Erba, in prep.). The Bottaccione section has became famous mainly for the presence, at the Cretaceous-Tertiary boundary, of a thin clay layer enriched in iridium (Alvarez et al., 1980).

In the Bottaccione section the Scaglia Bianca is 65.25 m thick. The thickness of the four members is as follows: W1 = 18.97 m, W2 = 14.08 m, W3 = 10.83 m, and W4, = 21.37 m. The Livello Bonarelli is 0.90 m thick. The thickness of the other lithostratigraphic intervals is as follows: "lower critical interval" = 0.62 m; "upper critical interval" = 1.4 m; "benthic-free interval" = 1.35 m.thick.

According to Premoli Silva and Sliter (1995) the average rate of accumulation for the Scaglia succession is 9.3 m/Ma using the values derived from the Gradstein et al. (1994) scale which seems the most appropriate for the Scaglia deposits. The rock accumulation rate for the Albian part of the Scaglia Bianca is 3.44 m/Ma then increasing to 9.64 m/Ma and 8.14 m/Ma respectively in the Cenomanian and Turonian parts of the formation. The Scaglia Bianca would therefore represent ~ 9 Ma of apparently continuous pelagic sedimentation. The rate of accumulation increased in the upper part of the Cenomanian (i.e., in the Dicarinella algeriana subzone) because of a local redistribution of sediments within the Umbria-Marche Basin due to syndepositional tectonic activity reaching a peak in the middle-late Cenomanian time (see also Coccioni et al., 1992). This tectonic pulse produced the characteristic resedimentation and reworking features recognized at different stratigraphic levels in the upper Cenomanian. However, on the basis of the benthic foraminiferal assembla-

ges, there is no evidence of redeposition from other than bathyal environments.

## MATERIAL AND METHODS

A set of 600 samples from the top of the Scisti a Fucoidi to the lowermost part of the Scaglia Rossa were collected by Coccioni et al. (1992) in the Bottaccione section most of which were used by Premoli Silva and Sliter for their planktonic foraminiferal analysis.

The present study is based on agglutinated foraminifera from 129 samples of this sample set. Samples of 50-200 g were dissolved completely in HCI and washed through a 63-μm sieve. The agglutinated foraminifera from each sample were counted and semi-quantitatively analyzed. The relative abundance has been estimated as follows: very rare = 1-2 specimens; rare = 3-5 specimens; frequent = 6-10 specimens; common = 11-25 specimens; abundant => 25 specimens. Conventionally, also in agreement with Wightman and Kuhnt (1992), for this study any fragment of tubular forms has been counted as one individual. For each sample the faunal density expressed as number of specimens per gram of sediment and the species richness expressed as number of species were determined. The stratigraphic distribution of the recognized species and their relation to major lithologies, faunal density, and species richness are plotted in Figures 2 and 3.

We largely adopted species concepts of Kaminski et al. (1988a), Moullade et al. (1988), Kuhnt (1990), Kuhnt and Kaminski (1990, 1993), Kaminski et al. (1992), and Wightman and Kuhnt (1992) but in some instances we deviated from these and used additional documentation. At suprageneric levels we followed the classification proposed by Loeblich and Tappan (1988). All the identified taxa were allocated into six morphogroups (Fig. 4) largely following Jones and Charnock (1985), Bernhard (1986), Kaminski et al. (1988b), Koutsoukos and Hart (1990), Koutsoukos et al. ( 1990), Nagy (1992), and Tyszka (1994). Plates I to III show photographs of most of the identified taxa.

## RESULTS

### DWAF DISTRIBUTION, FAUNAL DENSITY, AND SPECIES RICHNESS TROUGHOUT THE SECTION

All samples contain agglutinated foraminifera (5 to 289 individuals each) of moderate to good preservation except for the samples from the "benthic-free interval" where only radiolarians and occasionally also silicified planktonic foraminifera were found (Fig. 2). Over sixty species were identified, representing twenty-six genera of twelve families among which Bathysiphonidae, Ammodiscidae, Trochammindae, Telamminidae and Haplophragmoididae dominate.

The faunal parameters vary throughout the section, the widest fluctuations occurring within the interval from the Rotalipora appenninica Zone to the lower half of the Rotalipora cushmani Zone (that is within Members W1 to W3). The faunal density ranges from 0 to 1.87 specimens per gram peaking at the base of the Rotalipora appenninica Zone. The species richness changes almost paralleling the faunal density reaching a maximum value of 25. The values of both the faunal parameters markedly decrease within the upper half of the Rotalipora cushmani Zone (that is within the Member W4) where on the average they are reduced respectively by 65% and 30%, dropping to 0 throughout the "benthic-free interval". Then the values of both the faunal parameters increase again within the overlying zones. It is noteworthy

that the faunal density shows a definite trend towards a gradual decrease throughout the Scaglia Bianca. The species richness does not show the same trend as the faunal density, however it fluctuates more than the other faunal parameter within the upper half of the *Rotalipora cushmani* Zone. The relative abundances of recognized species significantly change throughout the section without, however, important variations within the interval from the *Rotalipora appenninica* Zone to the lower half of the *Rotalipora cushmani* Zone.

Assemblages are mainly characterized by *Rhizammina* cf. *algaeformis*, *Rhizammina indivisa*, *Repmanina charoides*, *Ammodiscus cretaceus* and with less extent by *Dendrophrya latissima*, *Haplophragmoides concavus*, *Rhabdammina cylindrica*, *Reophax minutus* and *Trochammina deformis*. Other species are generally rare throughout the section. *Ammosphaeroidina* sp., *Bulbobaculites problematicus*, *Bulbobaculites* cf. *problematicus*, *Dendrophrya excelsa*, *Hyperammina* sp., *Hormosina velascoensis*, and *Subreophax* ex gr. *scalaris* are found at different stratigraphic levels up to the middle of the *Rotalipora cushmani* Zone, therefore lacking within the Member W4.

All the species occurring within the upper half of the *Rotalipora cushmani* Zone are involved in the faunal change which here takes place. On the whole, however, *Haplophragmoides concavus*, *Reophax minutus*, and *Reophax* spp. appear to support the most important variations of the relative abundance. *Hormosina* sp., *Kalamopsis grzybowskii*, *Paratrochamminoides* spp., *Psammosphaera lagenaria*, *Pseudobolivina variabilis*, *Pseudobolivina* sp. 1, *Pseudobolivina* sp. 2, *Trochamminoides dubius*, *Trochamminoides* cf. *dubius*, and *Trochamminoides* cf. *proteus* are found exclusively close to the Livello Bonarelli. In particular, *Paratrochamminoides* spp., *Pseudobolivina* sp. 2, and

*Trochamminoides dubius* occur only just above the "benthic-free interval", where the genus *Pseudobolivina* flourishes.

## DWAF ACROSS THE CTBE

To explore the effects of the Cenomanian-Turonian boundary event on the DWAF we have taken into consideration their stratigraphic distribution just below and above the "benthic-free interval" (Fig. 3). The stratigraphic interval under consideration which is 5.2 m-thick, would span 0.8 to 1.15 Ma according to the figure of 0.35 to 0.7 Ma for the time of deposition of the Livello Bonarelli given by Arthur and Premoli Silva (1982) and to the mean accumulation rate of 8.14 to 9.64 m/Ma provided by Premoli Silva and Sliter (1995) for the Cenomanian-Turonian Scaglia. The "benthic-free interval" would last 0.4 to 0.75 Ma, the "lower critical interval "and the" upper critical interval "spanning ~ 0.18 Ma and ~ 0.12 Ma respectively.

The faunal parameters vary throughout. Their values fade markedly within the "lower critical interval", then falling to 0 within the "benthic-free interval". Later on, already within the upper half of the "upper critical interval", the values of the faunal parameters increase reaching those prior the "lower critical interval".

Within the stratigraphical interval under consideration over thirty-eight species occur. Assemblages are mainly characterized by *Rhizammina* cf. *algaeformis*, *Rhizammina indivisa*, *Repmanina charoides*, and *Ammodiscus cretaceus*. The other species are generally rare throughout. Within the "lower critical interval" only *Ammodiscus peruvianus*, *Glomospira serpens*, *Lituotuba lituiformis*, *Saccorhiza* sp., *Tolypammina* sp., *Rhabdammi-*
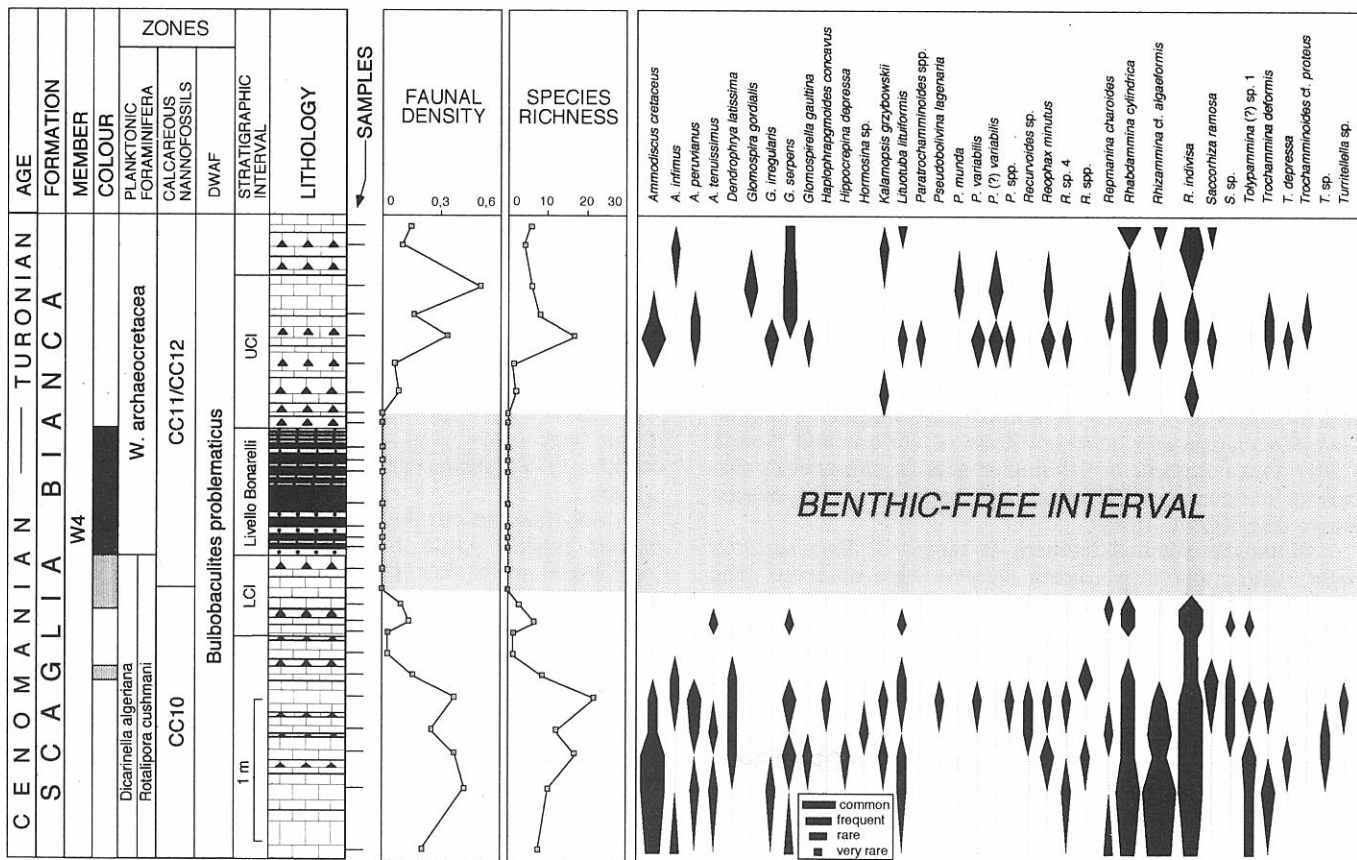


**Figure 3.** Detail of the studied section across the Livello Bonarelli with the semi-quantitative distribution of DWAF plotted against the litho-, bio-, and chronostratigraphy, the sample(s) position, and the estimated faunal parameters. The species are arranged from left to right in alphabetic order. Note the "lower" and "upper critical intervals" (here abbreviated as LCI and UCI, respectively) adjacent to the Livello Bonarelli. The stratigraphical interval reported in this figure would span 0.8 to 1.15 Ma. The dotted band shows the stratigraphic extent of the "benthic-free interval" including the Livello Bonarelli which here corresponds to the CTBE. Legend as in Fig. 2.

*na cylindrica, Rhizammina* cf. *algaeformis,* and *Rhizammina indivisa* are found, the latter three species lasting on the sea floor to the onset of the "benthic-free interval". The following species occur within the upper critical interval: *Ammodiscus cretaceus, Ammodiscus peruvianus, Glomospira gordialis, Glomospira irregularis, Glomospira serpens, Glomospirella gaultina, Kalamopsis grzybowskii, Lituotuba lituiformis, Paratrochamminoides* spp., *Pseudobolivina munda, Pseudobolivina variabilis, Pseudobolivina? variabilis, Pseudobolivina* spp., *Reopax minutus, Reophax* sp. 4, *Repmanina charoides, Rhabdammina cylindrica, Rhizammina* cf. *algaeformis, Rhizammina indivisa, Saccammina ramosa, Trochammina deformis, Trochammina depressa,* and *Trochamminoides* cf. *proteus.*

*Kalamopsis grzybowskii* and *Rhizammina indivisa* are the first forms to reappear after the "benthic-free interval", the reappearance of *Rhabdammina cylindrica* following promptly. In the next sample most of species recognized within the "upper critical interval" reoccur such as *Ammodiscus cretaceus, Ammodiscus peruvianus, Glomospira irregulari., Glomospirella gaultina, Lituotuba lituiformis, Paratrochamminoides* spp., *Pseudobolivina variabilis, Pseudobolivina* (?) *variabilis, Pseudobolivina* spp., *Reophax minutus, Reophax* sp. 4, *Rhizammina* cf. *algaeformis, Saccorhiza ramosa, Trochammina deformis* and *Trochammina depressa. Glomospira serpens, Repmanina charoides, Trochamminoides* cf. *proteus* reappear higher within the "upper critical interval", the occurrence of *Glomospira gordialis* and *Pseudobolivina munda* immediately following. Finally, at the top of the stratigraphical interval under consideration *Ammodiscus infimus* also reappears.

## DISCUSSION

### BIOSTRATIGRAPHIC IMPLICATIONS

Geroch and Nowak (1984) proposed three zones from the middle Albian to the middle Turonian based on the first occurrences of DWAF as follows (from bottom to top): *Plectorecurvoicles alternans* Zone, *Ammobaculites problematicus* Zone, and *Uvigerinammina jankoi* Zone.

Most of the taxa recognized in our material are long-ranging cosmopolitan species but some biostratigraphic indicators occur such as *Ammodiscus infimus, Bulbobaculites problematicus* (reported as *Ammobaculites problematicus* in Geroch and Nowak, 1984), *Hippocrepina depressa,* and *Kalamopsis grzybowskii.*

*Plectorecurvoides alternans,* the first occurrence (FO) of which defines the base of the middle Albian-middle Cenomanian *Plectorecurvoides alternans* Zone of Geroch and Nowak (1984) does not occur in the studied section, this species also lacking in the Upper Cretaceous limestones of the Scaglia Rossa (see Kuhnt, 1990).

Moreover, some differences in ranges of *Bulbobaculites problematicus* and *Hippocrepina depressa* were observed. The total range of *Bulbobaculites problematicus* is given as upper part of the lower Albian to lowermost Campanian (Neagu, 1970, 1990; Kuhnt, 1990; Kaminski and Geroch, 1992; Kuhnt et al., 1992). Its partial range and optimum occurrence characterized the *Bulbobaculites problematicus* Zone which, according to Geroch and Nowak (1984), would span the middle Cenomanian-middle Turonian. In the Bottaccione section, however, *Bulbobaculites problematicus* first appears in the lowermost part of the *Rotalipora appenninica* Zone that is in the latest Albian. This datum is supported by detailed investigations throughout the Aptian-Albian Scisti a Fucoidi where *Bulbobaculites problematicus* has not been found (Coccioni, 1990; Coccioni and Galeotti, in prep.). According to our data this species temporarily disappears in the middle of the *Rotalipora cushmani* Zone (middle Cenomanian), then reported

again as *Haplophragmium problematicum* by Kuhnt (1990) in the middle Turonian-lower Campanian of the Gubbio sections.

The FO of *Bulbobaculites problematicus* allowed us to place the lower boundary of the *Bulbobaculites problematicus* Zone which lies over the *Marssonella oxycona* Zone of Coccioni (1990) and Coccioni and Galeotti (in prep.). *Uvigerinammina jankoi,* the FO of which defines the base of the middle Turonian-early Campanian *Uvigerinammina jankoi* Zone has not been recognized in the studied section.

According to several authors (Geroch and Nowak, 1984; Kuhnt et al., 1989; Kaminski and Geroch, 1992; Kuhnt, 1992; Kuhnt et al., 1992) *Hippocrepina depressa* does not cross the CTBE. Conversely, according to our data this species still occurs just above the Livello Bonarelli therefore becoming extinct within the planktonic foraminiferal *Whiteinella archaeocretacea* Zone, that is within the calcareous nannofossil CC11/CC12 Zones.

Differences in ranges of other species such as *Ammodiscus infimus, Ammodiscus tenuissimus, Hormosina velascoensis,* and *Trochamminoides dubius* were also observed. According to Geroch and Nowak (1984) *Ammodiscus infimus* disappears in the latest Maastrichtian whereas Kuhnt (1992) quoted this species as becoming extinct at the CTBE. In the Bottaccione section *Ammodiscus infimus* last occurs just above the Livello Bonarelli within the planktonic foraminiferal *Whiteinella archaeocretacea* Zone, that is within the calcareous nannofossil CC11/CC12 Zones. According to Kaminski and Geroch (1992) *Ammodiscus tenuissimus* does not extend over the Albian but in our section this species is found throughout. The FO of *Hormosina velascoensis* reported by Kuhnt et al. (1989, 1992) and Wightman and Kuhnt (1992) to take place in the lower-middle Campanian. As mentioned above, however, *Hormosina velascoensis* occurs, although with rare, scattered specimens, at different stratigraphic levels (i.e., in the upper part of the *Rotalipora appenninica* Zone, in the lower part of the *Rotalipora brotzeni* Zone, and in the middle parte of the *Rotalipora cushmani* Zone), the FO of this species therefore displaying a questionable placement. *Trochamminoides dubius* has been previously reported from the Upper Cretaceous to the lower Eocene (Hanzlikova, 1972; Neagu, 1970; Sandulescu, 1973; Samuel, 1977; Kaminski et al., 1988a; Kuhnt, 1990). The appearance of this taxon within the *Whiteinella archaeocretacea* Zone, well above the Livello Bonarelli, has therefore to be considered as a true FO.

In agreement with Kuhnt (1992) *Pseudobolivina* sp. 2, which might have evolved from *Pseudobolivina variabilis,* first appears as a new species during the radiation after the anoxic crisis. Finally, *Pseudobolivina munda* the FO of which has been quoted by Kuhnt (1992) just above the CTBE has been found well below it at different stratigraphic levels, in the middle of *Rotalipora appenninica* and *Rotalipora cushmani* Zones.

According to our data, therefore, the studied section falls almost entirely within the *Bulbobaculites problematicus* Zone of Geroch and Nowak (1984). However, it becomes clear that it is needed to extend downward and/or upward the stratigraphic ranges of some DWAF which were previously reported by different authors.

### PALAEOECOLOGIC IMPLICATIONS

As already known, the distribution of DWAF is controlled by different environmental parameters such as paleobathymetry, availability of carbonate and nutrients, terrigenous detrital input, substrate disturbance by bottom hydrodynamics, and oxygenation of bottom and pore waters. Foraminiferal test morphology plays an important role in determining the response of a single species to variations of environmental parameters by directly influencing its nutrient strategy and

life-position (see review in Tyszka, 1994, *cum bibl.*). Distribution of deep-water agglutinated foraminiferal morphogroups has been shown to be strongly related to environmental conditions (Jones and Charnock, 1985; Bernhard, 1986; Koutsoukos and Hart, 1990; Koutsoukos *et al.*, 1990; Nagy, 1992; Coccioni and Galeotti, 1993; Tyszka, 1994; among others). Morphogroup analysis together with the study of the distribution of species which are regarded as good environmental indicators would therefore applied to fossil assemblages for palaeoenvironmental interpretation.

In the studied section, morphogroups A1 and A3 which include epifaunal, primarily suspension and active deposit feeders (Fig. 4), dominate throughout the latest Albian-earliest Turonian, therefore suggesting low organic-carbon flux and oxygenated conditions at the sea floor except for the "benthic-free interval". A low supply of organic matter coinciding with a low sedimentation rate appears to be a favorable factor for tubular, primarily suspension-feeding forms, such as bathysiphonids and active deposit feeders, discoidal coiled, such as ammodiscids which dominate the assemblages (Tyszka, 1994).

Arthur (1977, 1979) interpreted the colours of the Gubbio limestone sequence as a direct indication for the original oxygenation state of the sea floor, concluding that increasing oxydation caused the reddish colours. According to Kuhnt (1990) the composition of benthic agglutinated foraminiferal assemblages in the Upper Cretaceous limestone at Gubbio would confirm such an interpretation. In fact, in the grey-white, chertified parts of the sequence agglutinated foraminifera are absent or rare, and consist of low-diversity assemblages which are dominated by "primitive" tubular forms. In the reddish, well-oxygenated parts of the sequence the agglutinated assemblages show increased abundance and diversity, and contain species which, according to Kuhnt and Kaminski (1989) and Kuhnt (1990), are characteristic of well-oxygenated deep-sea environment. Conversely, according to our data the taxonomic composition of agglutinated foraminifera does not change remarkably in the first three members of the Scaglia Bianca where a discrete reddish interval is contained between two light ones. The variations of the faunal density and species richness, moreover, are not related to colour changes only suggesting dynamic fluctuations of the sea-floor environment.

Up to the middle of the *Rotalipora cushmani* Zone polytaxic assemblages with complex trophic structure are found. A major change in agglutinated foraminiferal communities occurs in the middle of the *Rotalipora cushmani* Zone leading to low-diversity, poor assemblages on the sea floor for ~ 2.5 Ma, however without remarkable changes in the taxonomic composition. This event coincides with a marked change in sedimentary regime (i.e., dark colour of limestone; occurrence of laminated, dysoxic layers and pyrite nodules) and is readily explained by a general drop in bottom-water oxygen levels. The major change which takes place in the middle of the *Rotalipora cushmani* Zone would be the first signal of the forthcoming Livello Bonarelli which is the product of high fertility combined with poor oxygenation at the bottom.

The taxa most affected by this change are *Haplophragmoides concavus, Reophax minutus,* and *Reophax* spp. which are here regarded as less tolerant of low-oxygen levels. The forms vanishing within the Member W4 are *Ammosphaeroidina* sp., *Bulbobaculites problematicus, Bulbobaculites* cf. *proble-*

| MORPHO-GROUP | TEST FORM | MORPHOLOGY | LIFE POSITION | TROPHIC STRATEGY | TAXA |
|---|---|---|---|---|---|
| A-1 | UNILOCULAR | TUBULAR or BRANCHING | EPIFAUNAL ERECT | PRIMARILY SUSPENSION FEEDERS | *Dendrophrya Rhabdammina Rhizammina Hyperammina Hippocrepina Saccorhiza Kalamopsis* |
| A-2 | UNILOCULAR | MEANDERING | EPIFAUNAL ATTACHED | PASSIVE HERBIVORES | *Tolypammina* |
| A-3 | UNILOCULAR | DISCOIDAL COILED | EPIFAUNAL | ACTIVE DEPOSIT FEEDERS | Ammodiscids *Ammodiscus Glomospira Glomospirella Repmanina Turritellella* |
| A-4 | MULTILOCULAR | LOW TROCHSPIRAL PLANO-CONVEX or CONCAVO-CONVEX | EPIFAUNAL | HERBIVORES DETRITIVORES | *Ammosphaeroidina Trochammina* |
| A-5 | MULTILOCULAR | PLANISPIRAL STREPTOSPIRAL | SHALLOW INFAUNAL | DETRITAL/ BACTERIAL SCAVENGERS | *Paratrochamminoides Trochamminoides Haplophragmoides Lituotuba Bulbobaculites Recurvoides Plectorecurvoides* |
| A-6 | MULTILOCULAR | ELONGATED UNISERIAL/ BISERIAL | SHALLOW TO DEEP INFAUNAL | | *Reophax Subreophax Hormosina Pseudobolivina* |

**Figure 4.** Agglutinated foraminiferal morphogroups in the latest Albian-earliest Turonian (Bottaccione section and their inferred life position and feeding habits.

*maticus, Dendrophrya excelsa, Hyperammina* sp., *Hormosina velascoensis* and *Subreophax scalaris* which appear to be strongly susceptible to decreasing oxygenation and probably aerobes.

Immediately prior to and after the "benthic-free interval" assemblages are characterized by minute specimens (generally less than 250 µm in maximum diameter or length). The small size are interpreted as a reaction to the adverse oxygen-deficient conditions in organic-rich sediments by minimizing the oxygen consumption and increasing the efficiency of oxygen uptake by increasing the surface/volume ratio (see also Bradshaw, 1961). Similar agglutinated foraminiferal assemblages with predominantly minute specimens have been observed by Kuhnt (1992) at the Cenomanian-Turonian boundary in the abyssal environments of the North Atlantic.

Within the "lower critical interval" where the last, rare rotaliporids live on again the impoverished assemblages consist of few, stratigraphically long-ranging taxa with different life position and trophic strategy (*Ammodiscus peruvianus, Glomospira serpens, Lituotuba lituiformis, Saccorhiza* sp., *Tolypammina* sp., *Rhabdammina cylindrica, Rhizammina* cf. *algaeformis,* and *Rhizammina indivisa*) inferred to be opportunistic, able to survive in low-oxygen environments with increasing supply of organic matter. Tubular, primarily suspension-feeding forms, such as *Rhabdammina cylindrica* and *Rhizammina indivisa,* and *Repmanina charoides* (epifaunal, active deposit feeder) last on the sea floor to the onset of the "benthic-free interval", therefore proving to have the highest environmental tolerance to low oxygenation.

According to our data and following the stratigraphic ranges of the DWAF given by previous authors there is no species which becomes extinct at the CTBE in the Bottaccione section. *Hippocrepina depressa* and *Ammodiscus infimus* which appear to be extinct at the CTBE as quoted by Kuhnt (1992) from the benthic deep-sea communities of the North Atlantic have, instead, their last occurrences just above the Livello Bonarelli.

The recolonization fauna after the CTBE displays low to medium specific richness and high dominance. Overall, the biotic recolonization shows a distinct two-step pattern as follows (from bottom to top): 1) re-occurrence of tubular, primarily suspension-feeders just above the CTBE, *Kalamopsis grzybowskii* and *Rhizammina indivisa* firstly appearing; 2) re-occurrence of several epifaunal and infaunal forms with different trophic strategies which are stratigraphically long-ranging and environmental tolerant species such as *Ammodiscus cretaceus, Glomospira gordialis, Glomospira irregularis, Glomospirella gaultina, Repmanina charoides, Rhizammina* cf. *algaeformis,* and different species of *Pseudobolivina*. Based on our data, *Kalamopsis grzybowskii* and *Rhizammina indivisa* appear to have a high capability to recolonize the substrate contrarily to what suggested by Kaminski *et al.* (1988b).

The environmental tolerant species taxa recognized close to the "benthic-free interval" are comparable to those observed in oxygen deficient environments across the C/T boundary in north European shelf seas and bathyal environments (Kemper, 1986; Koutsoukos *et al.*, 1990) and are considered as r-selected, opportunistic taxa. In particular, *Ammodiscus, Glomospirella* and *Glomospira gordialis* are presumably well-adapted to take advantage of an increased supply of food particles derived from the surface layer of the ocean (Gooday, 1988; Gooday and Lambshead, 1989; Graf, 1989; Gooday and Turley, 1990; Thiel *et al.*, 1989).

The taxa occurring in beds immediately overlying the CTBE are here regarded as "Lazarus"-species (see Jablonski, 1986) which very likely recolonized the deep-sea environments soon after the end of the deposition of the Livelli Bonarelli. They are similar to those which compose the assemblages found in several Cretaceous and Paleogene deep-sea sites and described as "Biofacies B" by Kuhnt *et al.* (1989) and Kuhnt (1992). "Biofacies B" is often associated with biosiliceous radiolarian-rich sediments, which probably indicate enhanced surface productivity of siliceous plankton due to the presence of upwelling or nutrient influx. After the CTBE, when definite oxic bottom-water conditions develop again, *Pseudobolivina* sp. 2 and later on *Trochamminoides dubius* occur and are regarded as new species appearing during the radiation after the anoxic crisis. According to Kuhnt (1992) the former species may have evolved in the early Turonian from the Albian/Cenomanian *Pseudobolivina variabilis* following a morphological adaption to oxygen deficient conditions. It is noteworthy that *Pseudobolivina* flourishes with different species just above the Livello Bonarelli within the *Whiteinella archaeocretacea* Zone, possibly occupying available niches soon after the anoxic event.

The biotic recolonization therefore points to a relatively rapid recovery of the benthic foraminiferal assemblages which could have been achieved ∼ 60 ka after the end of the CTBE when polytaxic assemblages with complex trophic structures reappear. The stepped pattern of recolonization is regarded as the response to the return of (1) more oxygenated bottom-water conditions and (2) a greater environmental stability. In fact, above the CTBE, the carbonate content, faunal density, and species richness return to approximately the values they had before the CTBE.

## CONCLUSIONS

Latest Albian-earliest Turonian pelagic limestones of the famous, Bottaccione standard section yield characteristic bathyal assemblages of DWAF of at least sixty species which include forms of purely agglutinated "flysch-type" assemblages and elements which are typical for Upper Cretaceous abyssal environments of the North Atlantic.

By means of well-established planktonic foraminiferal and calcareous nannofossil zonations it was possible to directly gauge the stratigraphical ranges of DWAF, contributing to a better chronostratigraphic calibration of a deep-water agglutinated foraminiferal zonation. Differences in ranges of some biostratigraphic markers were recognized.

This study was also helpful to explore the potential of DWAF for documenting paleoceanographic changes including the CTBE which mainly affected benthic life in the deep-sea and are here represented by the ichtyolithic-bituminous-radiolaritic Livello Bonarelli.

Morphological analysis has once again proved to be an efficient method for discriminating and interpreting fossil environments, the distribution of morphogroups allowing interpretations of level of oxygenation and organic input.

A major faunal change consisting of a marked decrease in faunal density and species richness was recognized in the middle of the *Rotalipora cushmani* Zone coinciding with a marked change in sedimentary regimes and related to declining oxygenation on the sea floor. This change in agglutinated foraminiferal communities well predated the onset of the anoxic Livello Bonarelli which moreover did not lead to extinction of any species. Instead, some species have their first and last occurrences just above the CTBE.

After adverse environmental conditions lasting for some hundreds of thousands of years on the sea floor the recovery of the benthic foraminiferal ecosystem was relatively fast, the reestablishment of pre-CTBE environmental conditions rapidly following.

## TAXONOMIC NOTES

The alphabetic listing of species includes the original and present name of the species. Only the type-reference and a selection of subsequent papers containing well-illustrated, typical specimens are provided. A short diagnosis is given for each species.

### Ammodiscids
(Pl. I, Figs. 9-12)

We placed in this group all the specimens closely resembling the genus *Ammodiscus* when it was not possible to classify them at generic level.

### *Ammodiscus cretaceus* (Reuss)
(Pl. I, Fig. 14)

1845   *Operculina cretacea* Reuss, 35, Pl. 13, Figs. 64-65.
1988   *Ammodiscus cretaceus* (Reuss); Moullade *et al.*, 363, Pl. 1, Fig. 7.
1988a  *Ammodiscus cretaceus* (Reuss); Kaminski *et al.*, 184, Pl. 3, Fig. 7.
1989   *Ammodiscus cretaceus* (Reuss); Kuhnt *et al.*, Pl. A-5, Fig. a.
1990   *Ammodiscus cretaceus* (Reuss); Kuhnt, p. 310, Pl. 1, Figs. 2-3.
1991   *Ammodiscus cretaceus* (Reuss); Kuhnt and Moullade, Pl. 4, Fig. A.
1992   *Ammodiscus cretaceus* (Reuss); Kaminski *et al.*, 252, Pl. 2, Fig. 2.
1992   *Ammodiscus cretaceus* (Reuss), Wightman and Kuhnt, 255, Pl. 1, Fig. 6.
1993   *Ammodiscus cretaceus* (Reuss); Kaiho *et al.*, 27, Pl. 1, Fig. 6.
1993   *Ammodiscus cretaceus* (Reuss); Kuhnt and Kaminski, 72, Pl. 2, Fig. 1.
1994   *Ammodiscus cretaceus* (Reuss); Reicherter *et al.*, Fig. 7A/A.

Test large, circular outline, biconcave, evolute, with 8 to 10 whorls relatively broad and regularly increasing in size. Wall finely agglutinated, smoothly finished. The proloculus is generally visible.

### *Ammodiscus infimus* Franke
(Pl. I, Fig. 15, 16)

1936   *Ammodiscus infimus* Franke, 15, Pl. 1, Fig. 14a-b.
1984   *Ammodiscus infimus* Franke; Geroch and Nowak, Pl. 1, Fig. 11; Pl. 5, Fig. 13.
1994   *Ammodiscus infimus* Franke; Reicherter *et al.*, Figs. 7A/G-H.

Test composed of 7-8 whorls planispirally coiled. Wall coarsely agglutinated with an irregular surface. The proloculus is generally visible and the whorls increase regularly in diameter as added. The last whorl is noticeably larger than former one.

### *Ammodiscus peruvianus* Berry
(Pl. I, Fig. 13)

1928   *Ammodiscus peruvianus* Berry, 403, Fig. 27.
1988a  *Ammodiscus peruvianus* Berry; Kaminski *et al.*, 185, Pl. 37 Figs. 11-12.
1989   *Ammodiscus peruvianus* Berry; Kuhnt *et al.*, Pl. A-3, Fig. d; p. 137, Pl. D1, Fig. 7.
1993   *Ammodiscus peruvianus* Berry; Kuhnt and Kaminski, 72, Pl. 2, Fig. 2.

Test characterized by its elliptical outline. Wall finely agglutinated. The main problem in classifying this form derive from a possible confilsion with deformed specimens of *Ammodiscus cretaceus*.

### *Ammodiscus tenuissimus* (Gümbel)
(Pl. I, Fig. 17)

1862   *Spirillina tenuissima* Gümbel, 214, Pl. 13, Fig. 2.
1992   *Ammodiscus tenuissimus* (Gümbel); Kaminski *et al.*, 252, Pl. 2, Fig. 3.

Test extremely thin with a globular proloculus followed by a single tube planispirally coiled to form 10 or more whorls. The diameter of the tube slowly increasing in the first whorls shows a sharp increment in the last one.

### *Ammosphaeroidina* sp.
(Pl. III, Fig. 4)

Test globose, strepospirally coiled. The chambers are often compressed in our specimens. They are low in number and strongly embracing. Only the four chambers of the last whorl are visible showing a coarsely agglutinated wall. The aperture consists in a low interiomarginal arch.

### *Bulbobaculites problematicus* (Neagu)
(Pl. III, Fig. 6)

1962   *Ammobaculites agglutinans* (d'Orbigny) sp. *problematicus* Neagu, 61, Pl. 2, Figs. 22-24.
1984   *Ammobaculites problematicus* (Neagu); Geroch and Novak, Pl. 1, Figs. 17-18; Pl. 6, Fig. 23.
1988   *Haplophragmium lueckei* (Cushman and Hedberg); Moullade *et al.*, 363, Pl. 3, Figs. 1-6.
1989   *Haplophragmium problematicum* (Neagu); Kuhnt *et al.*, Pl. A-2, Figs. i-k.
1990   *Haplophragmium problematicum* (Neagu); Kuhnt, 312, Pl. 4, Figs. 3-9.

Test small, elongate, early stage with streptospiral arrangement of globose chambers. Later chambers become uncoiled and rectilinearly disposed. Sutures distinct, depressed and horizontal. Wall agglutinated, smoothly finished. Aperture terminal, small and rounded.

### *Bulbobaculites* cf. *problematicus* (Neagu)
(Pl. III, Fig. 5)

1962   *Ammobaculites agglutinans* (d'Orbigny) sp. *problematicus* Neagu, 61, Pl. 2, Figs. 22-24.

It differs from *Bulbobaculites problematicus* in having a lower number of chambers in the uniserial portion.

### *Dendrophrya excelsa* Grzybowski

1988   *Dendrophrya excelsa* Grzybowski, 272, Pl. 10, Figs. 1-4.
1988a  *Dendrophrya* ex gr. *excelsa* Grzybowski; Kaminski *et al.*, 182, Pl. 1, Figs. 4-5.
1989   *Dendrophrya excelsa* Grzybowski; Kuhnt *et al.*, A-3, Fig. b; Pl. C-3, Figs. 1-3; p. 137, Pl. D-1, Fig. 2.
1993   *Dendrophrya excelsa* Grzybowski; Kuhnt and Kaminski, 72, Pl. 1, Fig. 2.

Test tubular, moderately coarse, flattened. Fragments in our samples are mostly straight, rarely branched.

### *Dendrophrya latissima* Grzybowski
(Pl. I, Figs. 1A, B)

1898   *Dendrophrya latissima* Grzybowski, 17, Pl. 10, Fig. 8.
1988a  *Dendrpphrya latissima* Grzybowski; Kaminski *et al.*, 182, Pl. 1, Fig. 6.
1989   *Dendrophrya latissima* Grzybowski; Kuhnt *et al.*, Pl. A-3, Fig. a; Pl. D-1, Fig. 1.
1993   *Dendrophrya latissima* Grzybowski; Kuhnt and Kaminski, 72, Pl. 1, Fig. 3.

A large flattened tube with a thin, finely agglutinated wall. All fragment identified in this study are straight. Specimens os this species have a typical "eight" profile of the tube.

### *Glomospira glomerata* (Grzybowski)
(Pl. II, Fig. 1)

1898   *Ammodiscus glomeratus* Grzybowski, 285, Pl. 11, Fig. 4.
1988a  *Glomospira glomerata* (Grzybowski); Kaminski *et al.*, 185, Pl. 3, Fig. 16.
1989   *Glomospira glomerata* (Grzybowski); Kuhnt *et al.*, Pl. C-3, Fig. 8; Pl. D-1, Fig. 9; Pl. D-3, Fig. 6.

Test finely agglutinated. Proloculus followed by a single, narrow chamber arranged in broad S-shaped coils. It differs from *Glomospira irregularis* in having a more open coiling.

### *Glomospira gordialis* (Jones and Parker)
(Pl. I, Fig. 19)

1860   *Trochammina squamata* Jones and Parker var. *gordialis* Jones and Parker, 304.
1988   *Glomospira gordialis* (Jones and Parker); Moullade *et al.*, 363, Pl. 1, Fig. 4.
1988a  *Glomospira gordialis* (Jones and Parker); Kaminski *et al.*, 185, Pl. 3, Fig. 17
1989   *Glomospira gordialis* (Jones and Parker); Kuhnt *et al.*, Pl. A-2, Fig. C; Pl. C-2, Fig. 2; Pl. C-5, Fig. 11.
1990   *Glomospira gordialis* (Jones and Parker); Kuhnt, 311, Pl. 1, Figs. 9-10.
1992   *Glomospira gordialis* (Jones and Parker); Kaminski *et al.*, 253, Pl. 2, Fig. 4.
1992   *Glomospira gordialis* (Jones and Parker); Wightman and Kuhnt, 255, Fig. 4.
1992   *Glomospira gordialis* (Jones and Parker); Wightman and Kuhnt, 255, Pl. 1, Fig. 10.
1993   *Glomospira gordialis* (Jones and Parker); Kaiho *et al.*, p. 27, Pl. 4, Fig. 5.
1993   *Glomospira gordialis* (Jones and Parker); Kuhnt and Kaminski, 73, Pl. 2, Fig. 4.
1994   *Glomospira gordialis* (Jones and Parker); Reicherter *et al.*, Fig. 7A/C

Irregularly coiled tube, which in the last whorl lies generally in one. Diameter of the tube is small. Glomospira gordialis is distinguished by its smooth, very finely agglutinated wall.

## Glomospira irregularis (Grzybowski)
(Pl. II, Fig. 3)

1898   *Ammodiscus irregularis* Grzybowski, 285, Pl. 2, Figs. 2-3.
1988a  *Glomospira irregularis* (Grzybowski); Kaminski *et al.*, 185, Pl. 3, Figs. 20-21.
1989   *Glomospira irregularis* (Grzybowski); Kuhnt *et al.*, Pl. A-3, Fig. e; Pl. A-4, Fig. b; Pl. C-1, Fig. 8; Pl. C-2, Fig. 4 (A); Pl. C-4, Figs. 1-2; Pl. C-8, Fig. 5.
1992   *Glomospira irregularis* (Grzybowski); Kaminski *et al.*, 253, Pl. 2, Fig. 6.
1993   *Glomospira irregularis* (Grzybowski); Kuhnt and Kaminski, 73, Pl. 2, Fig. 6.
1994   *Glomospira irregularis* (Grzybowski); Reicherter *et al.*, Fig. 7A/D.

Test comprised of a broad, irregularly coiled tube which is often flattened. The wall is moderately coarse. It differs from the other species of the genus in aglutinating coarser grains.

## Glomospira serpens (Grzybowski)
(Pl. II, Fig. 2)

1898   *Ammodiscus serpens* Grzybowski, 285, Pl. 10, Figs. 31-33.
1988   *Glomospira serpens* (Grzybowski); Moullade *et al.*, 363, Pl. 1, Figs. 2-3.
1988a  *Glomospira serpens* (Grzybowski); Kamnski *et al.*, 185-186, Pl. 3, Figs. 22-23.
1989   *Glomospira serpens* (Grzybowski); Kuhnt *et al.*, Pl. C-2, Fig. 3 (A, B).
1990   *Glomospira serpens* (Grzybowski); Kuhnt, 311, Pl. 1, Fig. 4.
1992   *Glomospira serpens* (Grzybowski); Wightman and Kuhnt, 255, Pl. 1, Fig. 12.

Test elongate ellipsoidal. Our specimens show a smoothly-finished wall. In according with Kaminski *et al.* (1988a) we have included this specimens in *Glomospira serpens*.

## Glomospirella gaultina (Berthelin)
(Pl. II, Fig. 4)

1880   *Ammodiscus gaultinus* Berthelin, 19, Pl. 1, Figs. 3a-b.
1988   *Glomospirella gaultina* (Berthelin); Moullade *et al.*, 363, Pl. 1, Fig. 5.
1989   *Glomospirella grzybowski* (Jurkiewicz); Kuhnt *et al.*, Pl. D-3, Figs. 3-4.
1990   *Glomospirella gaultina* (Berthelin); Kuhnt, 311, Pl. 1, Fig. 8.
1992   *Glomospirella gaultina* (Berthelin); Kaminski *et al.*, 253, Pl. 2, Fig. 15
1993   *Glomospirella gaultina* (Berthelin); Kuhnt and Kaminski, 73, Pl. 2, Fig. 5.

Test comprised of a tube irregularly coiled in the initial part which is followed by one or two planispirally arranged whorls. Aperture is simple, rounded at the end of the tube.

## Haplophragmoides concavus (Chapman)
(Pl. II, Fig. 17)

1892   *Trochammina concava* Chapman, 327, Pl. 6, Figs. 14a-b.
1994   *Haplophragmoides concavus* (Chapman); Reicherter *et al.*, Fig. 7B/A, C.

Planispiral, flattened and finely agglutinated test. Only the three to five chambers of the last whorl are visible. It is similar to *Haplophragmoides walteri* because of its narrow compressed rim, but it differ from this form in having less chamber in the final whorl and a lobate outline.

## Haplophragmoides cf. concavus (Chapman)
(Pl. II, Fig. 15)

Test small, slightly evolute, lobate, showing four globular chambers in the final whorl. Sutures depressed; wall medium-grain agglutinating. The studied specimens are very often compressed. It differs from *H. concavus* in having a more labate outline and a coraser agglutinating test.

## Haplophragmoides cf. walteri (Grzybowski)
(Pl. II, Fig. 16)

1898   *Trochammina walteri* Grzybowski, 290, Pl. 11, Fig. 31.
1988   *Haplophragmoides* sp. cf. *walteri* (Grzybowski); Moullade *et al.*, 364, Pl. 8, Fig. 7.
1990   *Haplophragmoides* cf. *walteri* (Grzybowski); Kuhnt, 314, Pl. 4, Figs. 10-12.
1993   *Haplophragmoides* cf. *walteri* (Grzybowski); Kuhnt and Kaminski, 73, Pl. 5, Figs. 2-3.

Test planispirally coiled, involute, strongly compressed with a circular outline. Sutures indstinct; surface smooth. It differs from *Haplophragmoides concavus* in having more than 5 chambers in the last whorl. It differs from typical *Haplophragmoides walteri* in having less chambers in the final whorl and a smaller size.

## Hippocrepina depressa Vasicek
(Pl. I, Fig. 7)

1947   *Hippocrepina depressa* Vasicek, 243, Pl. 1, Figs. 1a-b, 2.
1984   *Hippocrepina depressa* Vasicek; Geroch and Nowak, Pl. 1, Fig. 7; Pl. 5, Figs. 45.
1992   *Hippocrepina depressa* Vasicek; Kaminski *et al.*, 254, Pl. 1, Figs. 7-8.
1994   *Hippocrepina depressa* Vasicek; Reicherter *et al.*, Fig. 7A/E-F.

Test comprised of a small conical tube, laterally compressed which may be arched and have a annular constrictions at irregular interval. Wall finely agglutinated, finely finished. Aperture single at the end of the tube.

## Hormosina velascoensis (Cushman)
(Pl. II, Fig. 8)

1926   *Nodosinella velascoensis* Cushman, 520, Pl. 20, Fig. 9.
1990   *Hormosina velascoensis* (Cushman); Kuhnt 1990; 316, Pl. 2, Figs. 13-14.
1990   *Hormosina velascoensis* (Cushman); Kuhnt and Kaminski, 475, Pl. 12, Figs. k-1.
1993   *Hormosina velascoensis* (Cushman); Kuhnt and Kaminski, 74, Pl. 2, Figs. 8, 10-12.

Test comprised of flattened and linearly disposed chambers which not distinctly overlap. Our specimens are comparable to that figured by Kuhnt (1990, Pl. 2, Fig. 13).

## Hormosina sp.
(Pl. I, Fig. 6)

Chambers arranged in a rectilinear series. Wall thin, medium to coarse agglutinating. Our specimens are usually deformed which makes difficult an identification at specific level.

## Hyperammina dilatata Grzybowski
(Pl. I, Fig. 4)

1896   *Hyperammina dilatata* Grzybowski, 274, Pl. 8, Fig. 17a-b.
1988a  *Hyperammina dilatata* Grzybowski; Kaminski *et al.*, 184, Pl. 2, Figs. 1-2.
1990   *Hyperammina dilatata* Grzybowski; Kuhnt, 318, Pl. 2, Figs. 10-11.
1991   *Hyperammina dilatata* Grzybowski; Kuhnt and Moullade, Pl. 4, Figs. G-H.
1992   *Hyperammina dilatata* Grzybowski; Kaminski *et al.*, 254, Pl. 1, Figs. 12-14.
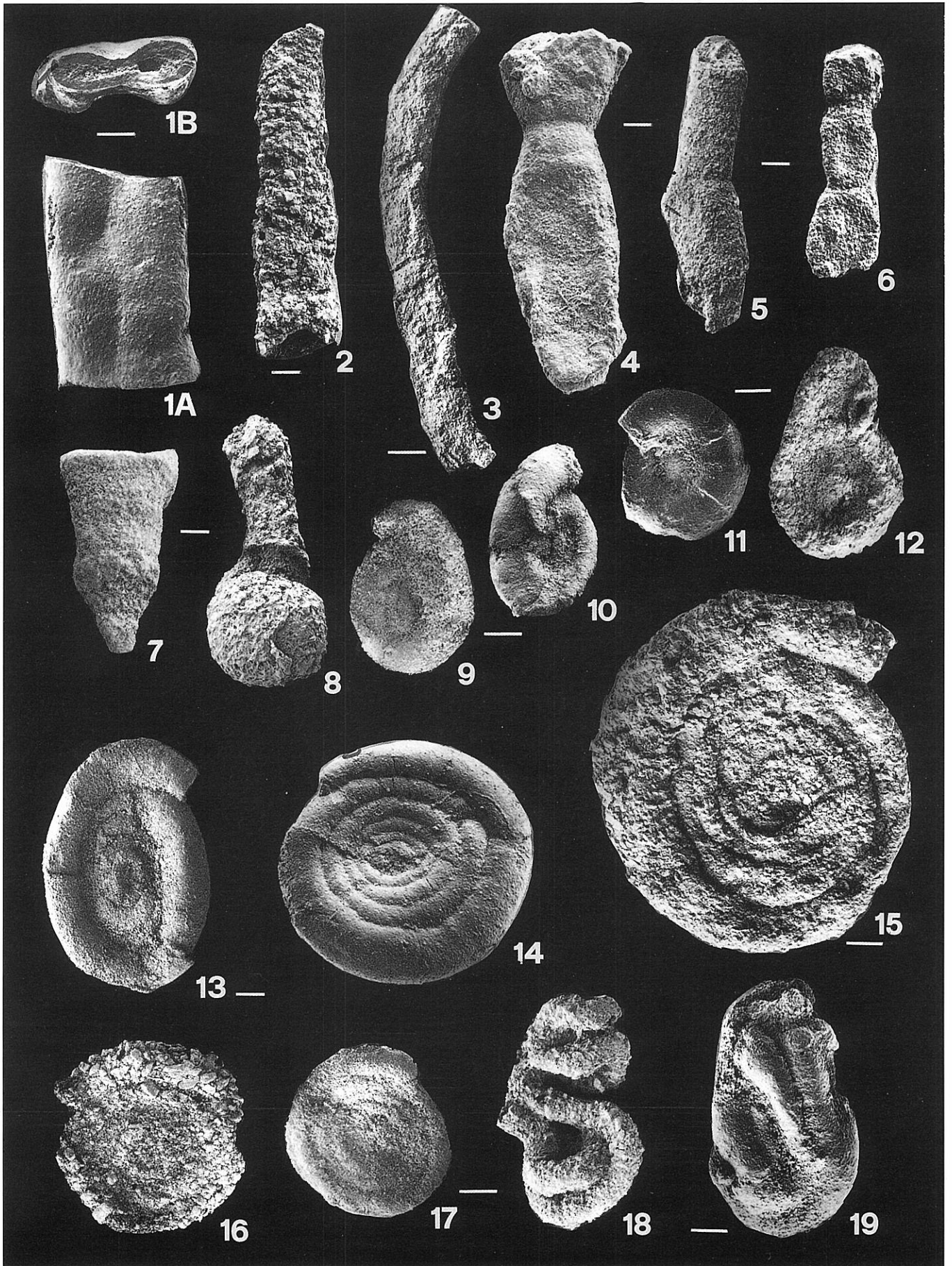1992   *Hyperammina dilalata* Grzybowski; Wightman and Kuhnt, 257, Pl. 1, Fig. 4.

Test comprised of a large single chamber with thick, fine-grained wall. Aperture terminal rounded. It differs from *Hyperammina excelsa* in not having two opening and in its more irregular "sack-like" shape.

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**Plate I**

1A, B  *Dendrophrya latissima* Grzybowski, sample BTT 548. x 170.
2      *Rhabdammina cylindrica* Glaessner, sample BTT 515. x 130.
3      *Rhizammina indivisa* Brady, sample BTT 367. x 45.
4      *Hyperammina dilatata* Grzybowski, sample BTT 367. x 130.
5      *Hyperammina elongata* Brady, sample BTT 297. x 130.
6      *Hormosina* sp. sample BTT 550. x 130.
7      *Hippocrepina depressa* Vasicek, sample BTT 421. x 130.
8      *Saccorhiza ramosa* (Brady), sample BTT 579. x 130.
9      Ammodiscid, sample BTT 509. x 170.
10     Ammodiscid, sample BTT 501. x 170.

11     Ammodiscid, sample BTT 507. x 170.
12     Ammodiscid, sample BTT 501. x 170.
13     *Ammodiscus peruvianus* Berry, sample BTT 438. x 130.
14     *Ammodiscus cretaceus* (Reuss), sample BTT 392. x 130.
15     *Ammodiscus infimus* Franke, sample BTT 392. x 85.
16     *Ammodiscus infimus* (juvenile specimen) Franke, sample BTT 515. x 130.
17     *Ammodiscus tenuissimus* (Gümbel), sample BTT 521. x 170.
18     *Tolypammina* (?) sp. 1, sample BTT 501. x 170.
19     *Glomospira gordialis* (Jones and Parker), sample BTT 195. x 170.

Scale bar = 50 µm (except 3 = 200 µm; 15 = 100 µm).

*Hyperammina elongata* Brady
(Pl. I, Fig. 5)

1884   *Hyperammina elongata* Brady, 257, Pl. 23, Figs. 4,7-10.
1988a  *Hyperammina elongata* Brady; Kaminski *et al.* 1988, 184, Pl. 1, Figs. 13-14.
1990   *Hyperammina elongata* Brady; Kuhnt, 318, Pl. 2, Fig. 12.
1992   *Hyperammina dilatata* Grzybowski; Wightman and Kuhnt, 257, Pl. 1, Fig. 5.
1993   *Hyperammina elongata* Brady; Kuhnt and Kaminski, 74, Pl. 1, Fig. 6.

The test, often compressed, consists of a globular proloculus followed by a cylindrical tube without constrictions. Wall thin, fine-grained agglutinated, glassy.

*Hyperammina* sp.

Straight fragments of tubular chamber. Diameter of the chamber is constant, slightly tapering in the terminal part where aperture is placed. Wall finely agglutinated.

*Kalamopsis grzybowskii* (Dylazanka)
(Pl. II, Fig. 7)

1923   *Hyperammina grzybowskii* Dylazanka, 65-66.
1988a  *Kalamopsis grzybowskii* (Dylazanka); Kaminski *et al.* 1988, 187, Pl. 1, Figs. 18-20.
1989   *Kalamopsis grzybowskii* (Dylazanka); Kuhnt *et al.*, Pl. A-4, Figs. f, g; Pl. D-3, Fig. 7.
1990   *Kalamopsis grzybowskii* (Dylazanka,); Kuhnt, 318, Pl. 2, Fig. 15.
1991   *Kalamopsis grzybowskii* (Dylazanka); Kuhnt and Moullade, Pl. 4, Fig. F.
1992   *Hyperammina grzybowskii* (Dylazanka); Wightman and Kuhnt, 257, Pl. 2, Fig. 3.
1993   *Kalamopsis grzybowskii* (Dylazanka); Kuhnt and Kaminski, 74, Pl. 1, Figs. 7-9.

Mainly single-chambered, flattened fragments, often btocken in correspondence to constrictions. Wall thick, fine-grained agglutinating. It differs from *Kalamopsis dubia* in having smaller size and thinner wall.

*Lituotuba lituiformis* (Brady)
(Pl. II, Fig. 14)

1879   *Trochammina lituiformis* Brady, 59, Pl. 5, Fig. 16.
1988a  *Lituotuba lituiformis* (Brady); Kaminski *et al.*, 90, Pl. 4, Figs. 14-15.
1989   *Lituotuba lituiformis* (Brady); Kuhnt *et al.*, Pl. A-3, Fig. f.
1990   *Lituotuba lituiformis* (Brady); Kuhnt, 318-320, Pl. 1, Figs. 17-18.
1992   *Lituotuba lituiformis* (Brady); Wightman and Kuhnt, 257, Pl. 1, Fig. 14.
1993   *Lituotuba lituiformis* (Brady); Kuhnt and Kaminski, 74, Pl. 2, Fig. 7.

Test comprised of an irregularly coiled initial portion followed by an uncoiled part, often compressed. Wall coarsely agglutinated.

*Lituotuba* (?) *lituiformis* (Brady)
(Pl. II, Fig. 18)

It differs from the typical *Lituotuba lituiformis* in having a more compressed test and a smaller uncoiled portion.

*Paratrochamminoides* spp.

Irregularly coiled tests with flattened ovoid chambers.

*Plectorecurvoides* sp.

Chambers biserially arranged and planispirally enrolled.

*Pseudobolivina lagenaria* Krasheninnikov
(Pl. III, Fig. 10)

1974   *Pseudobolivina lagenaria* Krasheninnikov, 639-640, Pl. 5, Figs. 1a-b, 2a.
1988   *Pseudobolivina lagenaria* Krasheninnikov; Moullade *et al.*, 366, Pl. 9, Figs. 7-8.
1990   *Pseudobolivina lagenaria* Krasheninnikov; Kuhnt, 322, Pl. 6, Figs. 3-4.

A species characterized by the tendency to be uniserially arranged of the last chambers and a distinct apertural neck. Wall finely agglutinated.

*Pseudobolivina munda* Krasheninnikov
(Pl. III, Fig. 9)

1973   *Pseudobolivina munda* Krasheninnikov, 210, Pl. 2, Figs. 10-11.
1988   *Pseudobolivina munda* Krasheninnikov; Moullade *et al.*, 366, Pl. 9, Figs. 9-10.
1990   *Pseudobolivina* cf. *munda* Krasheninnikov; Kuhnt 1990, 324, Pl. 6, Figs. 1-2.
1992   *Pseudobolivina munda* Krasheninnikov; Wightman and Kuhnt, 258, Pl. 4, Fig. 5.

Test narrow, wedge shaped and elongate. The chambers, biserially arranged, are characterized by an oval shape elongate in the direction of the growth, slightly increasing in size as added.

*Pseudobolivina variabilis* Vasicek
(Pl. III, Fig. 8)

1947   *Pseudobolivina variabilis* Vasicek, 243, Pl. 1, Figs. 1a-b, 2.
1984   *Pseudobolivina variabilis* Vasicek; Geroch and Novak, Pl. 1, Fig. 24; Pl. 6, Figs. 19-20.
1994   *Pseudobolivina variabilis* Vasicek; Reicherter *et al.*, Fig. 7A/I.

Elongate test comprised of biserially arranged chambers. Sutures distinct. Wall finely agglutinated.

*Pseudobolivina* (?) *variabilis* Vasicek
(Pl. III, Fig. 7)

1947   *Hippocrepina depressa* Vasicek, 243, Pl. 1, Figs. 1a-b, 2.

If differs from typical *Pseudobolivina variabilis* in having a larger last chamber which obscures the biserially arrangement of the previous ones.

*Pseudobolivina* sp. 1
(Pl. III, Fig. 11)

1988   *Pseudobolivina* sp. 1; Moullade, Kuhnt and Thurow, 366, Pl. 9, Figs. 5-6.

A species of *Pseudobolivina* without apertural neck which makes it different from *Pseudobolivina lagenaria*.
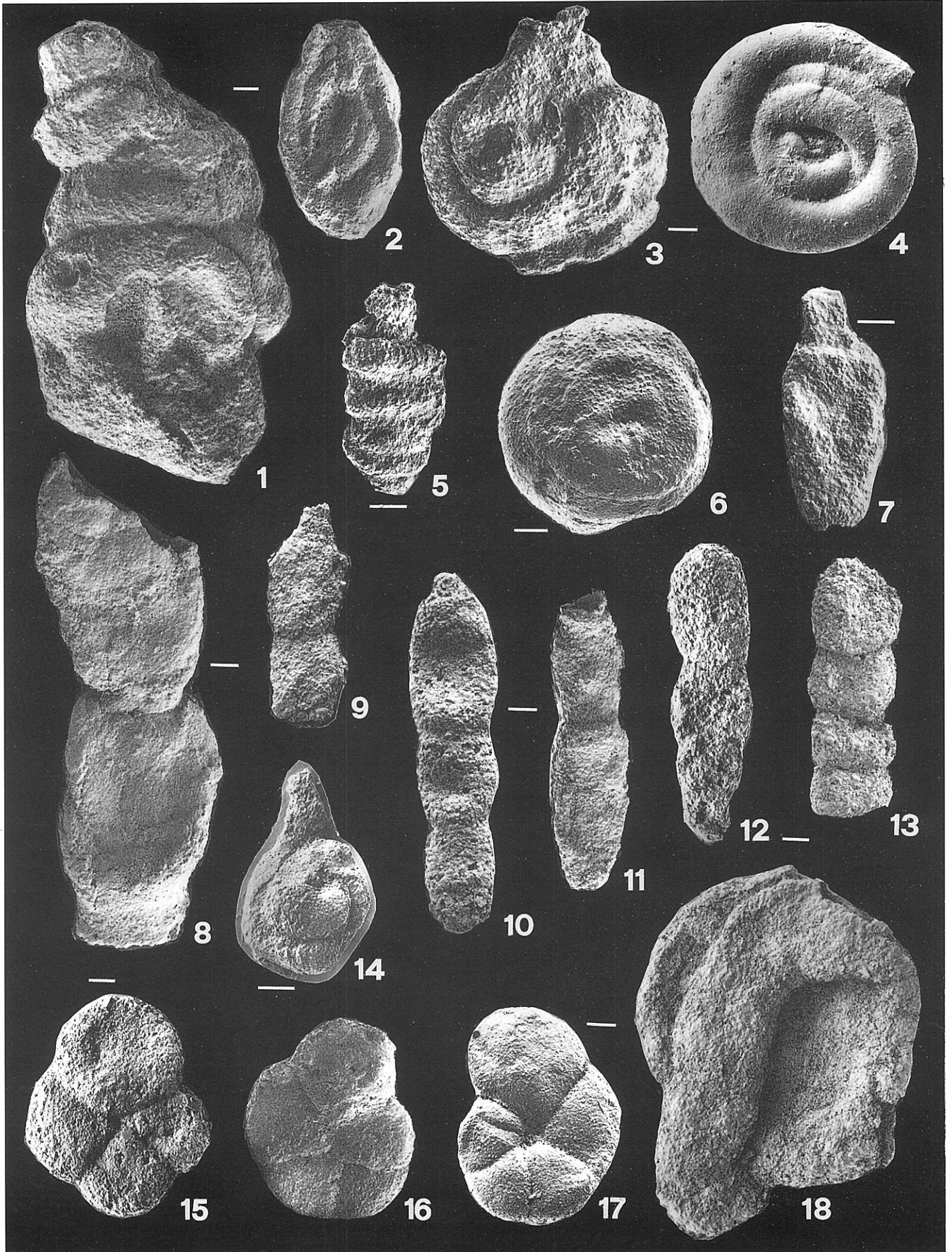
*Pseudobolivina* sp. 2
(Pl. III, Fig. 12)

1988   *Pseudobolivina* (?) sp. 2; Moullade, Kuhnt and Thurow, 366, Pl. 9, Figs. 11-12.

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**Plate II**

1    *Glomospira glomerata* (Grzybowski), sample BTT 392. x 130.
2    *Glomospira serpens* (Grzybowski), sample BTT 22. x 130.
3    *Glomospira irregularis* (Grzybowski), sample BTT 22. x 130.
4    *Glomospirella gaultina* (Berthelin), sample BTT 392. x 130.
5    *Turritellella* sp., sample BTT 416. x 170.
6    *Repmanina charoides* (Jones and Parker), sample BTT 575. x 300.
7    *Kalamopsis grzybowskii* (Dylazanka), sample BTT 541. x 170.
8    *Hormosina velascoensis* (Cushman), sample BTT 408. x 130.
9    *Subreophax scalaris* (Grzybowski), sample BTT 257. x 130.
10   *Reophax minutus* (Tappan), sample BTT 265. x 130.
11   *Subreophax* sp. 1, sample BTT 195. x 130.
12   *Reophax* sp. 2, sample BTT 257. x 130.
13   *Reophax* sp. 4, sample BTT 146. x 130.
14   *Lituotuba lituiformis* (Brady), sample BTT 546. x 170.
15   *Haplophragmoides* cf. *concavus* (Chapman), sample BTT 530. x 130.
16   *Haplophragmoides* cf. *walteri* (Grzybowski), sample BTT 515. x 170.
17   *Haplophragmoides concavus* (Chapman), sample BTT 367. x 130.
18   *Lituotuba* (?) *lituiformis* (Brady), sample BTT 548. x 130.

Scale bar = 50 μm (except 6 = 25 μm).

Plate II

The last chamber is compressed and has a tendency to get uniserial. It seems to have an apertural neck.

### *Pseudobolivina* sp.
(Pl. III, Fig. 13)

Test elongate. Chambers biserially arranged, rapidly increasing in size as added. Sutures indistinct. Wall finely agglutinated.

### *Recurvoides* sp.

Test small, involute, with abrupt change of coiling direction.

### *Reophax minutus* (Tappan)
(Pl. II, Fig. 10)

1940    *Reophax minuta* Tappan, 94, Pl. 14, Figs. 4a-b.
1984    *Reophax minutus* (Tappan); Geroch and Nowak, Pl. 1, Fig. 9; Pl. 5, Figs. 17-19.
1994    *Reophax minutus* (Tappan); Reicherter *et al.*, Fig. 7A/O-P.

. Test composed of 4 to 5 compressed chambers slowly increasing their size as added. Wall finely agglutinated.

### *Reophax* sp. 2
(Pl. II, Fig. 12)

1988a   *Reophax* sp. 2; Kaminski *et al.*, 187, Pl. 3, Figs. 2-3.
1990    *Reophax* sp. 2; Kuhnt, 324, Pl. 3, Figs. 7-9.

Test compressed, elongate, comprised of 4 to 5 chambers, partially embracing, gradually increasing in size as added. Some specimens closely resemble the modern species *Reophax dentaliniformis*.

### *Reophax* sp. 4
(Pl. II, Fig. 13)

1990    *Reophax* sp. 4; Kuhnt 1990, 324, Pl. 3, Fig. 12.

Test flattened, formed of very elongate chambers. Wall thin and finely agglutinated. Sutures clearly distinct.

### *Reophax* spp.

Test often compressed, distinct sutures between uniserially arranged chambers.

### *Repmanina charoides* (Jones and Parker)
(Pl. II, Fig. 6)

1860    *Trochammina squamata* Jones and Parker var. *charoides* Jones and Parker, 304.
1928    *Glomospira charoides* (Jones and Parker) var. *corona* Cushman and Jarvis, 89, Pl. 12, Figs. 9-11.
1988    *Glomospira charoides* (Jones and Parker); Moullade *et al.*, 363, Pl. 1, Fig. 6.
1988a   *Glomospira charoides* (Jones and Parker); Kaminski *et al.*, 185, Pl. 3, Figs. 14-15.
1989    *Glomospira charoides* (Jones and Parker); Kuhnt *et al.*, Pl. A-2, Fig. d; Pl. C-8, Fig. 9; Pl. C-3, Fig. 7; Pl. C-5, Figs. 12-13; Pl. C-8, Fig. 4; Pl. D-1 Fig. 8; Pl. D-3, Fig. 5.
1990    *Glomospira charoides* (Jones and Parker); Kuhnt, 311, Pl. 1, Fig. 11.
1992    *Glomospira charoides* (Jones and Parker); Wightman and Kuhnt, 255, Pl. 1, Fig. 9.
1993    *Glomospira charoides* (Jones and Parker); Kaiho *et al.*, 27, Pl. 1, Figs. 7-8.

1993    *Glomospira charoides* (Jones and Parker); Kuhnt and Kaminski, 73, Pl. 2, Fig. 3.
1994    *Glomospira charoides* (Jones and Parker); Reicherter *et al.*, Figs. 7A/B.

Test subspherical, formed by 6 whorls of a thin tube streptospirally coiled, later trochospiral arranged in a sort of crown. The wall is extremely fine-grained, smoothly finished.

### *Rhabdammina cylindrica* Glaessner
(Pl. I, Fig. 2)

1937    *Rhabdamrnina cylindrica* Glaessner, 354, Pl. 1, Fig. 1.
1989    *Rhabdammina cylindrica* Glaessner; Kuhnt *et al.*, Pl. C-5, Fig. 1.
1993    *Rhabdammina cylindrica* Glaessner; Kuhnt and Kaminski, 75, Pl. 1, Fig. 1.

Rectilinear tubular fragments with a relatively large diameter, characterized by the absence of any constrictions.

### *Rhizammina* cf. *algaeformis* Brady

1879    *Rhizammira algaeformis* Brady, 20, Pl. 4, Figs. 16-17.
1990    *Rhizammina* cf. *algaeformis* Brady; Kuhnt, 324, Pl. 1, Fig. 1.

Irregularly curved tubes of constant diameter, dichotomous branching. It differs from *Rhizammina indivisa* also in having coarser-grained wall.

### *Rhizammina indivisa* Brady
(Pl. I, Fig. 3)

1884    *Rhizammina indivisa* Brady, 277, Pl. 29, Figs. 5-7.
1988a   *Rhizammina indivisa* Brady; Kaminski *et al.*, 183, Pl. 1, Figs. 10-13.
1989    *Rhizammina indivisa* Brady; Kuhnt *et al.*, Pl. A-1, Fig. a; Pl. A-2, Fig. a; pl. C-3, Figs. 4-5; Pl. C-8, Figs. 1-3.
1990    *Rhizammina indivisa* Brady; Kuhnt, 324, Pl. 1, Fig. 13.
1993    *Rhizammina indivisa* Brady; Kaiho *et al.*, 26, Pl. 1, Fig. 3; Pl. 4, Figs. 2-3.
1993    *Rhizammina indivisa* Brady; Kuhnt and Kaminski, 75, Pl. 1, Fig. 4.

Irregularly curved tubes of constant diameter, commonly flattened and bent, finely agglutinated.

### *Saccorhiza ramosa* (Brady)
(Pl. I, Fig. 8)

1879    *Hyperammina ramosa* Brady, 33, Pl. 3, Figs. 14-15.
1991    *Saccorhiza ramosa* (Brady); Kuhnt and Moullade, 314-315, Pl. 1, Figs. I-J.

A round ovoid proloculus followed by a long in some cases branching tube. The diameter of the tubular chamber is considerably smaller than that of the proloculus.
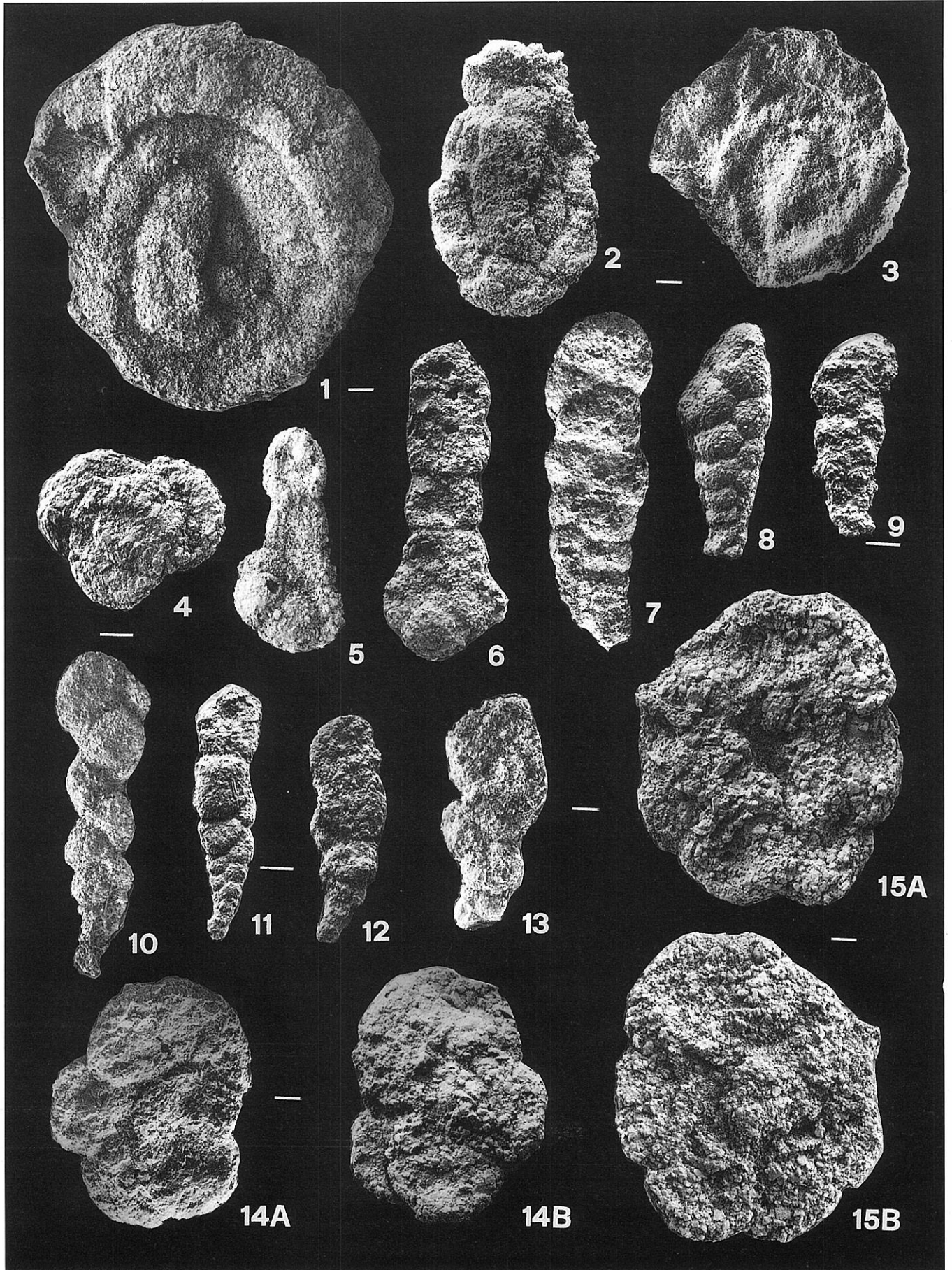
### *Subreophax scalaris* (Grzybowski)
(Pl. II, Fig. 9)

1896    *Reophax guttifera* Brady var. *scalaria* Grzybowski, 277, Pl. 8, Fig. 26.
1988a   *Subreophax scalaria* (Grzybowski); Kaminski *et al.*, 187, Pl. 2, Figs. 16-17.
1989    *Suhreophax scalaris* (Grzybowski); Kuhnt *et al.*, Pl. A-3, Fig. i; Pl. C-1, Fig. 9; Pl. C-3, Figs. 9-10; Pl. C-6, Fig. 9; Pl. C-8, Fig. 7; Pl. D-2, Fig. 4.
1990    *Subrephax scalaris* (Grzybowski); Kuhnt, 326, Pl. 3, Figs. 4-5.
1992    *Subreophax scalaris* (Grzybowski); Wightman and Kuhnt, 258, Pl. 2, Fig. 4.
1993    *Subreophax scalaris* (Grzybowski); Kuhnt and Kaminski, 75, Pl. 3, Figs. 2-3.

**Plate III**

1    *Trochamminoides* cf. *proteus* (Karrer), sample BTT 530. x 120.
2    *Trochamminoides dubius* (Grzybowski), sample BTT 592. x 120.
3    *Trochamminoides* cf. *dubius* (Grzybowski), sample BTT 581. x 120.
4    *Ammosphaeroidina* sp., sample BTT 186. x 160.
5    *Bulbobaculites* cf. *problematicus* (Neagu), sample BTT 195. x 120.
6    *Bulbobaculites problematicus* (Neagu), sample BTT 332. x 120.
7    *Pseudobolivina* (?) *variabilis* Vasicek, sample BTT 568. x 120.
8    *Pseudobolivina variabilis* Vasicek, sample BTT 574. x 120.

9    *Pseudobolivina munda* Krasheninnikov, sample BTT 574. x 160.
10   *Pseudobolivina lagenaria* Krasheninnikov, sample BTT 574. x 160.
11   *Pseudobolivina* sp. 1, sample BTT 574. x 160.
12   *Pseudobolivina* sp. 2, sample BTT 574. x 160.
13   *Pseudobolivina* sp., sample BTT 576. x 120.
14A, B  *Trochammina deformis* Grzybowski, sample BTT 583. x 120.
15A, B  *Trochammina depressa* Lozo, sample BTT 530. x 120.

Scale bar = 50 µm.

Plate III

Test consisting of numerous discoidal partially overlapping chambers, slightly increasing in size as added. The test has a bent or curved profile.

*Suhreophax* sp. 1
(Pl. II, Fig. 11)

1990   *Subreophax* sp. 1; Kuhnt, 326, Pl. 3, Fig. 14.

It differs from *Subreophax scalaris* in having more elongate chambers.

*Tolypammina* (?) sp. 1
(Pl. I, Fig. 18)

1990   *Tolypammina* (?) sp. 1; Kuhnt, 326, Pl. 1, Fig. 15.

An ovoid proloculus followed by a tubular chamber coiled in regular loops. Wall thin, smooth, finely agglutinated characterized by a glassy aspect.

*Trochammina deformis* Grzybowski
(Pl. III, Figs. 14A, B)

1898   *Trochammina deformis* Grzybowski, 288, Pl. 11, Figs. 20-22.
1989   *Trochammina deformis* Grzybowski; Kuhnt *et al.*, Pl. D-3, Fig. 10.
1990   *Trochammina deformis* Grzybowski; Kuhnt, 326, Pl. 5, Fig. 7.

The four to six chambers of the last whorl slightly increase in size as added. Sutures depressed. Periphery lobulate. Wall coarse grained.

*Trochammina depressa* Lozo
(Pl. III, Fig. 15A, B)

1944   *Trochammina depressa* Lozo, 552, Pl. 2, Figs. 4a-5.

Test of small to medium size, compressed. Five to six chambers in the last whorl regularly increasing in size as added. Sutures depressed, gently curved on spiral side. Fine-grained wall, surface smooth.

*Trochamminoides dubius* (Grzybowski)
(Pl. III, Fig. 2)

1901   *Ammodiscus dubius* Grzybowskii, 274, Pl. 8, Figs. 12-14.
1988a  *Trochamminoides dubius* (Grzybowski); Kaminski *et al.*, 191, Pl. 4, Figs. 16-17.
1990   *Trochamminoides dubius* (Grzybowski); Kuhnt, 326, Pl. 5, Fig. 11.
1990   *Trochamminoides dubius* (Grzybowski); Kuhnt and Kaminski, 486-487, Pl. 4, Fig. e.
1993   *Trochamminoides dubius* (Grzybowski); Kuhnt and Kaminski, 78, Pl. 5, Fig. 13.

Test flattened, irregularly planispirally coiled, comprised of 4 whorls. Chambers elongate. Finely agglutinated.

*Trochamminoides* cf. *dubius* (Grzybowski)
(Pl. III, Fig. 3)

1901   *Ammodiscus dubius* Grzybowski, 274, Pl. 8, Figs. 12-14.
1990   *Trochamminoides* cf. *dubius* (Grzybowski); Kuhnt, 326, Pl. 5, Fig. 8.
1990   *Trochamminoides* cf. *dubius* (Grzybowski); Kuhnt and Kaminski, 487, Pl. 4, Fig. f.

It differs from typical *Trochamminoides dubius* in having a rougher surface, and coarser-grained and thicker wall.

*Trochamminoides* cf. *proteus* (Karrer)
(Pl. III, Fig. 1)

1866   *Trochammina proteus* Karrer, 494, Pl. 1, Fig. 8.
1990   *Trochamminoides* cf. *proteus* (Karrer); Kuhnt, 326, Pl. 5, Fig. 9.
1990   *Trochamminoides* cf. *proteus* (Grzybowski); Kuhnt and Kaminski, 487, Pl. 4, Figs. b-c.

Irregularly coiled in the first stages, then low trochospiral. Wall thick and coarse-grained. Chambers elongate. Differs from typical *Trochamminoides proteus* in having fewer, more elongate chambers.

*Trochamminoides* sp.

Proloculus followed by a tubular chamber undivided in the first stage,

then divided in few elongated chambers. Irregularly to planispirally coiled. Sutures indistinct. Wall coarse-grained.

*Turritellella* sp.
(Pl. II, Fig. 5)

1991   *Turritellella* sp.; Kuhnt and Moullade, Pl. 4, Fig. D.

Test small, finely agglutinated. Proloculus followed by a trochospirally arranged tubular chamber which becomes rectilinear at the end.

## ACKNOWLEDGMENTS

## BIBLIOGRAPHY

Alvarez, L. W., Alvarez, W., Asaro, F. and Michel, H. V. 1980. Extraterrestrial cause for the Cretaceous-Tertiary extinction. *Science,* **208,** 1095-1108.

Alvarez, W., Arthur, M. A., Fisher, A. G., Lowrie, W., Napoleone, G., Premoli Silva, I. and Roggenthen, W. M. 1977. Upper Cretaceous-Paleocene magnetic stratigraphy at Gubbio, Italy: V. Type section for the late Cretaceous-Paleocene geomagnetic reversal time scale. *Geological Society America, Bulletin,* **88,** 383-389.

Alvarez, W. and Montanari, A. 1988. The Scaglia limestones (Late Cretaceous-Oligocene) in the northeastern Apennines carbonate sequence: Stratigraphic context and geological significance. *In: The Eocene/Oligocene boundary in the Umbria-Marche Basin (Italy)* (Eds. I. Premoli Silva, R. Coccioni and A. Montanari). Tipografia Aniballi, Ancona, 1-268.

Arthur, M. A. 1977. Sedimentology of Gubbio sequence and its bearing on paleomagnetism. *In: Paleomagnetic Stratigraphy of pelagic carbonate sediments* (Ed. G. P. Pialli), *Memorie Società Geologica Italiana,* **15** (1976), 9-20.

Arthur, M. A. 1979. Sedimentologic and geochemical studies of Cretaceous and Paleogene pelagic sedimentary rocks: the Gubbio sequence, Part I. *Ph. Dissertation* (unpublished), Princeton University, Princeton, 1-173.

Arthur, M. A. and Fisher, A.G. 1977. Upper Cretaceous-Paleocene magnetic stratigraphy at Gubbio, Italy: I. Lithostratigraphy and sedimentology. *Geological Society America, Bulletin,* **88,** 367-371.

Arthur, M. A. and Premoli Silva, I. 1982. Development of widespread organic carbon-rich strata in Mediterranean Tethys. *In: Nature and Origin of Cretaceous Carbon-rich Facies* (Eds. S.O. Schlanger and M.B. Cita). Academic Press, 7-54.

Bernhard, J. M. 1986. Characteristic assemblages and morphologies of benthic foraminifera from anoxic, organic-rich deposits: Jurassic trough Holocene. *Journal of Foraminiferal Research,* **16,** 207-215.

Bonarelli, G. 1891. Il territorio di Gubbio. *Notizie Geologiche,* Roma, 1-38.

Bradshaw, J. S. 1961. Laboratory experiments on the ecology of foraminifera. *Contribution of the Cushman Foundation for Foraminiferal Research,* **12,** 87-106.

Coccioni, R. 1990. Benthonic foraminifera from the Aptian-Albian organic-rich Scisti a Fucoidi of the Poggio le Guaine-Fiume Bosso composite sequence (Umbria-Marche Apennines, Italy). *IGCP 262 Tethyan Cretaceous Correlation, Pelagic and Flysch Facies Meeting,* Krakow, May 28-June 2, 1990, 18-19.

Coccioni, R. and Battistini, F. 1989. Stratigraphy of the Early Aptian-Late Albian Scisti a Fucoidi in the Umbria-Marche area. *In: Volume of Abstracts* (Eds. R. Coccioni, S. Monechi and G. Parisi). 1st Meeting of the Working Group 2-Pelagic Facies (IGCP Project N. 262 "Tethyan Cretaceous Correlation"), Urbino, 14-16 February, 1989. Centrostampa Università Urbino, 11-17.

Coccioni, R., Erba, E. and Premoli Silva, I. 1991. Litho- and biostratigraphy of the Livello Bonarelli close the Cenomanian-Turonian boundary (Umbria-Marche Apennines, Italy) and possible paleoceanographic significance. Colloque International sur les Evenements de la limite Cenomanien-Turonien, Grenoble, 24-26 Mai, 1991. *Geologie Alpine,* Memoire H.S. **17,** 25-26.

Coccioni, R. and Galeotti, S. 1993. Orbitally induced cycles in benthonic foraminiferal morphogroups and trophic structure distribution patterns from the Lafe Albian "Amadeus Segment" (Central Italy). *Journal of Micropaleontology*, **12**, 227-239.

Coccioni, R. and Galeotti, S., in prep. Benthic foraminifera from the Aptian-Albian organic-rich Scisti a Fucoidi of Northeastern Apennines (central Italy) - Biostratigraphic and palaeoecological implications.

Coccioni, R., Galeotti, S. and Ragni, D. 1992. Litho- and biostratigraphy of the Scaglia Bianca Formation (Late Albian-Late Cenomanian) in the Umbria-Marche Apennines (Italy). *6th Annual Mecting of IGCP 262 (Tethyan Cretaceous Correlation) - "Cretaceous Facies in Orogenic Belts"*, Athens, 22-26 May, 1992, 4.

Corfield, R. M., Cartlidge, J. E., Premoli Silva, I. and Housley, R. A. 1991. Oxygen and carbon isotope stratigraphy of the Palaeogene and Cretaceous limestones in the Bottaccione Gorge and the Contessa Highway sections, Umbria, Italy. *Terra Nova*, **3**, 414-422.

Geroch, S. and Nowak, W. 1984. Proposal of zonation for the late Tithonian-late Eocene, based upon arenaceous Foraminifera from the Outer Carpathians, Poland. *In: Benthos'83* (Ed. H.J. Oertli). 2nd International Symposium on Benthic Foraminifera (Pau, April 1983). Elf Aquitaine, Esso REP an Total CFP, Pau and Bordeaux, 225-239.

Geroch, S. and Olszewska, B. 1990. The oldest assemblages of agglutinated foraminifers of the Polish Carpathians. *In: Palaeoecology, biostratigraphy and taxonomy of agglutinated Foraminifera* (Eds. C. Hemleben, M.A. Kaminski, W. Kuhnt and D.B. Scott). NATO-ASI Series C327, Kluwer Academic Press, 225-239.

Ghisletti, L. and Erba, E., in prep. Calcareous nannofossils of the Bottaccione section (Albian through Santonian).

Gooday, A. J. 1988. A response by benthic Foraminifera to the depositon of phytodetritus in the deep-sea. *Nature*, **332**, 70-73.

Gooday, A. J. and Lambshead, P. J. D. 1989. Influence of seasonally deposited phytodetritus on benthic foraminiferal populations in the bathyal northeast Atlantic: the species response. *Marine Ecology Progress Series*, **58**, 53-67.

Gooday, A. J. and Turley, C. M. 1990. Responses by benthic organisms to input of organic material to the ocean floor: a review. *Philosophical Transactions of the Royal Society of London*, **A331**, 119-138.

Gradstein, F. M., Agterberg, F. P., Ogg, J. G., Hardenbol, J. and Huang, Z. 1994. A Mesozoic Time Scale. *Journal of Geophysical Research*, **99**, 24051-24074.

Graf, G. 1989. Benthic-pelagic coupling in a deep-sea benthic community. *Nature*, **341**, 437-439.

Hanzlikova, E. 1972. Carpathian upper Cretaceous foraminifera from Moravia (Turonian-Maestrichtian). *Rozpravy Ustred niho Ustavu Geologického*, **39**, 1-160.

Ingram, B. L., Coccioni, R., Montanari, A. and Richter, F.M. 1994. Strontium Isotopic Composition of Mid-Cretaceous Seawater. *Science*, **264**, 546-550.

Jablonski, D. 1986. Causes and consequences of mass extinctions: a comparative approach. *In: Dynamics of Extinction* (Ed. D.K. Elliot). Wiley, New York, 183-229.

Jones, R. W. and Charnock, M. A. 1985. "Morphogroups" of agglutinated foraminifera. Their life positions and feeding habits and potential applicability in (paleo)ecological studies. *Revue de Paléobiologie*, **4**, 311-320.

Kaiho, K., Fujiwara, O. and Motoyama, I. 1993. Mid-Cretaceous faunal turnover of intermediate-water benthic foraminifera in the northwestern Pacific Ocean margin. *Marine Micropaleontology*, **23**, 13-49.

Kaminski, M. A. and Geroch, S. 1992. The use of deep-water agglutinated Foraminifera in correlating Lower Cretaceous pelagic and flysch sequences: current status and prospects for the future. *Cretaceous Research*, **13**, 453-466.

Kaminski, M. A., Gradstein, F. M., Berggren, W. A., Geroch, S. and Beckmann, J. P. 1988a. Flysch-Type Agglutinated Assemblages from Trinidad: Taxonomy, Stratigraphy and Paleobathymetry. *In: Second Workshop on Agglutinated Foraminifera, Vienna 1986, Proceedings* (Eds. F. Rögl and F.M. Gradstein). Abhandlungen der Geologischen Bundesanstalt, **41**, 155-227.

Kaminski, M. A., Gradstein, F. M. and Geroch, S. 1992. Uppermost Jurassic to Lower Cretaceous deep-water benthic foraminiferal assemblages from ODP Site 765 on the Argo Abyssal Plain. *In: Proceeding of the Ocean Drilling Program, Scientific Results* (Eds. F.M Gradstein and J. Ludden), **123**, 239-269.

Kaminski, M. A., Grassle, F. M. and Whitlatch, R.B. 1988b. Life History and Recolonization among Agglutinated Foraminifera in the Panama Basin. *In: Second Workshop on Agglutinated Foraminifera, Vienna 1986, Proceedings* (Eds. F. Rögl and F.M. Gradstein). Abhandlungen der Geologischen Bundesanstalt, **41**, 229-243.

Kemper E. 1986. Das Klima der Kreide-Zeit. *Geologisches Jahrbuch*, **A96**, 5-185.

Koutsoukos, E. M. and Hart, M. B. 1990. Cretaceous foraminiferal morphogroup distribution patterns, paleocommunities and trophic structures: a case study from the Sergipe Basin, Brazil. *Transactions of the Royal Society of Edinburgh: Earth Sciences*, **81**, 221-246.

Koutsoukos, E. M., Leary, P. and Hart, M. B. 1990. Latest Cenomanian-earliest Turonian low-oxygen tolerant benthonic foraminifera: a case-study from the Sergipe basn (N.E. Brazil) and the western Anglo-Paris basin (southern England). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **77**, 145-177.

Kuhnt, W. 1987. Upper cretaceous foraminiferal assemblages of the external units of the Rif (Northern Morocco) - a paleobathymetric model of the Late Mesozoic North African continental margin. *Géologie Méditerranéenne*, **XIV, 27** (1987), 109-131.

Kuhnt, W. 1990. Agglutinated foraminifera of western Mediterranean Upper Cretaceous pelagic limestones (Umbrian Apennines, Italy, and Betic Cordillera, Southern Spain). *Micropaleontology*, **36**, 297-330).

Kuhnt, W. 1992. Abyssal recolonization by benthic foraminifera after the Cenomanian-Turonian boundary anoxic event in the North Atlantic. *Marine Micropaleontology*, **19**, 257-274.

Kuhnt, W., Geroch, S., Kaminski, M. A., Moullade, M. and Neagu, T. 1992. Upper Cretaceous abyssal claystones in the North Atlantic and the Western Tethys: Current status of biostratigraphical correlation using agglutinated foraminifers and palaeoceanographic events. *Cretaceous Research*, **13**, 467-478.

Kuhnt, W. and Kaminski, M. A. 1989. Upper Cretaceous Deep-Water Agglutinated Benthic Foraminiferal Assemblages from the Western Mediterranean and Adjacent Areas. *In: Cretaceous of the western Tethys* (Ed. J. Wiedmann). Proceedings 3rd International Cretaceous Symposium, Tübingen 1987. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 91-120.

Kuhnt, W. and Kaminski, M. A. 1990. Palaeoecology of Late Cretaceous to Paleocene deep-water agglutinated foraminifera from the North Atlantic and Western Tethys. *In: Palaeoecology, biostratigraphy and taxonomy of agglutinaled Foraminifera* (Eds. C. Hemleben, M.A. Kaminski, W. Kuhnt and D.B. Scott). NATO-ASI Series C327, Kluwer Academic Press, 433-505.

Kuhnt, W. and Kaminski, M. A. 1993. Changes in the community structures of deep water agglutinated foraminifers across the K/T boundary in the Basque Basin (northern Spain). *Revista Española de Micropaleontología*, **25**, 57-92.

Kuhnt, W., Kaminski, M. A. and Moullade, M. 1989. Late Cretaceous deep-water agglutinated foraminiferal assemblages from the North Atlantic and its marginal seas. *Geologische Rundschau*, **78**, 1121-1140.

Kuhnt, W. and Moullade, M. 1991. Quantitative analysis of Upper Cretaceous abyssal agglutinated foraminiferal distribution in the North Atlantic - Paleoceanographic implications. *Revue de Micropaléontologie*, **34**, 313-349.

Loeblich, A. R., Jr. and Tappan, J. H. 1988. *Foraminiferal genera and their classification*. New York, Van Nostrand Reinhold Company, **1** and **2**, 1-970 and 1-212.

Luterbacher, H. P. et Premoli Silva, I. 1962. Note préliminaire sur une révision du profil de Gubbio, Italie. *Rivista Italiana di Paleontologia*, **68**, 253-288.

Luterbacher, H. P. e Premoli Silva, I. 1964. Biostratigrafia del limite Cretacico-Terziario nell'Appennino Centrale. *Rivista Italiana di Paleontologia*, **70**, 67-128.

Marcucci Passerini, M., Bettini, P., Dainelli, J. and Sirugo, A. 1991. The "Bonarelli Horizon" in the central Apennines (Italy): radiolarian biostratigraphy. *Cretaceous Research*, **12**, 321-331.

Micarelli, A. and Potetti, M. 1989. Calpionellids assemblages in the Marche-Umbria area. *In: Volume of Abstracts* (Eds. R. Coccioni, S. Monechi and G. Parisi). 1st Meeting of the Working Group 2-Pelagic Facies (IGCP Project N. 262 "Tethyan Cretaceous Correlation") Urbino, 14-16 February, 1989. Centrostampa Università Urbino, 84-97.

Monechi, S. and Thierstein, H. R. 1985. Late Cretaceous-Eocene nannofossil and magnetostratigraphic correlations near Gubbio, Italy. *Marine Micropaleontology*, **9**, 419-440.

Moullade, M., Kuhnt, W. and Thurow, J. 1988. Agglutinated benthic foraminifers from Upper Cretaceous variegated clays of the North Atlantic Ocean (DSDP Leg 93 and ODP Leg 103) *In: Proceedings of the Ocean Drilling Program, Scientific Results* (Eds. G. Boillot, E. L. Winterer *et al.*), **103**, 349-377.

Nagy, J. 1992. Environmental significance of foraminiferal morphogroups in Jurassic North Sea deltas. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **95**, 111-134.

Napoleone, G. 1977. Paleomagnetic studies of the Paleocene section at Gubbio. *In: Paleomagnetic Stratigraphy of pelagic carbonate sediments* (Ed. G.P. Pialli), *Memorie Società Geologica Italiana*, **15** (1976), 51-60.

Napoleone, G. 1981. Lo sviluppo della stratigrafia magnetica nella sezione tipo di Gubbio e sua incidenza nella ricerca paleomagnetica. *Memorie della Società Geologica Italiana,* **21,** 289-299.

Neagu T. 1970. Micropaleontological and stratigraphical study of the Upper Cretaceous deposits between the upper valleys of the Buzau and Riul rivers (eastern Carpathians). *Memorie Institut Geologica Romaniei,* **12,** pp. 109.

Neagu T. 1990. *Gerochammina* N.G. and related genera from the Upper Cretaceous flysch-type benthic foraminiferal fauna, eastern Carpathians - Romania. *In: Palaeoecology, biostratigraphy and taxonomy of agglutinated Foraminifera* (Eds. C. Hemleben, M.A. Kaminski, W. Kuhnt and D.B. Scott). NATO-ASI Series C327, Kluwer Academic Press 245-265.

Orlando, M. 1983. *Geologia dei Monti di Gubbio e biostratigrafia del limite Eocene-Oligocene.* Università di Milano (unpublished thesis).

Piergiovanni, F. 1989. Eventi lito-stratigrafici nella Scaglia Bianca Umbro-Marchigiana in connessione con l'episodio anossico del "Livello Bonarelli" (Limite Cenomaniano-Turoniano). *Bollettino della Società Geologica Italiana,* **108,** 289-314.

Premoli Silva, I. 1977. Upper Cretaceous-Paleocene magnetic stratigraphy at Gubbio, Italy. II. Type section for the late Cretaceous-Paleocene geomagnetic reversal time scale. *Geological Society America, Bulletin,* **88,** 371-374.

Premoli Silva, I., Napoleone, G. e Fisher, A. G. 1974. Risultati preliminari sulla stratigrafia paleomagnetica della Scaglia cretaceo-paleocenica della sezione di Gubbio (Appennino centrale). *Bollettino della Società Geologica Italiana,* **93,** 647-659.

Premoli Silva, I., Paggi, L. and Monechi, S. 1977. Cretaceous through Paleocene biostratigraphy of the pelagic sequence at Gubbio, Italy. *In: Paleomagnetic Stratigraphy of pelagic carbonate sediments* (Ed. G.P. Pialli), *Memorie Societa Geologica Italiana,* **15** (1976), 21-32.

Premoli Silva, I. and Sliter, W. V. 1995. Cretaceous planktonic foraminiferal biostratigraphy and evolutionary trends from the Bottaccione section, Gubbio, Italy. *Palaeontographia Italica,* **82** (1994), 1-89.

Raup D. M. and Sepkoski J. J., Jr. 1986. Periodic extinctions of families and genera. *Science,* **231,** 833-836.

Reicherter, K., Pletsch, T., Kuhnt, W., Manthey, J., Homeier, G., Wiedmann, J. and Thurow, J. 1994. Mid-Cretaceous paleogeography and paleoceanography of the Betic Seaway (Betic Cordillera, Spain). *Palaeogeography, Palaeoclimatology, Palaeoecology,* **107,** 1-33.

Renard, M. 1986. Pelagic carbonate chemostratigraphy (Sr, Mg, $^{18}$O, $^{13}$C). *Marine Micropaleontology,* **10,** 117-164.

Renz, O. 1936. Stratigraphische und mikropalaeontologische Untersuchung der Scaglia (Obere Kreide-Tertiär) im Zentralen Apennin. *Eclogae Geologicae Helvetiae,* **29,** 1-149.

Renz, O. 1951. Ricerche stratigrafiche e micropaleontologiche sulla Scaglia (Creataceo superiore-Terziario) dell'Appennino centrale. *Memorie Descrittive della Carta Geologica d'Italia,* **29,** 1-173.

Roggenthen, W. M. and Napoleone, G. 1977. Upper Maastrichtian-Paleocene magnetic stratigraphy at Gubbio, Italy. IV. Upper Maastrichtian-Paleocene magnetic stratigraphy. *Geological Society America, Bulletin,* **88,** 378-383.

Samuel, O. 1977. Agglutinated foraminifers from Paleogene flysch formations in West Carpathians of Slovakia. *Západne Karpaty, série palontológie,* **2-3,** 7-70.

Sandulescu, J. 1973. Etude micropaléontologique et stratigraphique du flysch du Crétacé Supérieur, Paléocène de la region de Bretcu, Comandau (secteur interne meridional de la nappe de Tarcau, Carpates orientales). *Institut Géologique Mémoires,* **17,** 1-52.

Schlanger, S. O. and Jenkins, H. C. 1976. Cretaceous anoxic events: causes and consequences. *Geologie en Mijnbouw,* **55,** 179-184.

Thiel, H., Pfannkuche, O., Schriever, G., Lochte, K., Gooday, A. J., Hemleben, C., Mantoura, R. F. G., Turley, C. M., Patching, J. W. and Riemann, F. 1989. Phytodetritus on the deep-sea floor in a central oceanic region of the northeast Atlantic. *Biological Oceanography,* **6,** 203-239.

Tyszka, J. 1994. Response of Middle Jurassic benthic foraminiferal morphogroups to dysoxic/anoxic conditions in the Pieniny Klippen Basin, Polish Carpathians. *Palaeogeography, Palaeoclimatology, Palaeoecology,* **110,** 55-81.

Wightman, W. G. and Kuhnt, W. 1992. Biostratigraphy and palaeoecology of late Cretaceous abyssal agglutinated foraminifers from the Western Pacific Ocean (Deep Sea Drilling Project Holes 196A and 198A and Ocean Drilling Program Holes 800A and 801A). *In: Proceedings of the Ocean Drilling Program, Scientific Results* (Eds. R.L. Larson, Y. Lancelot *et al.*), **129,** 247-264.

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# REVISTA ESPAÑOLA DE PALEONTOLOGÍA