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APTIAN TO CAMPANIAN CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY FROM THE BOTTACCIONE SECTION, GUBBIO, CENTRAL ITALY.

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Riassunto. L'analisi biostratigrafica condotta sui Nannofossili calcarei delle Formazioni degli Scisti a Fucoidi e della Scaglia ha permesso di migliorare la risoluzione stratigrafica della sezione del Bottaccione (Bacino Umbro-Marchigiano, Italia Centrale) nell'intervallo Aptiano superiore-Campaniano. Inoltre, caratteristici bioeventi addizionali quali l'ultima comparsa di *Assipetra infracretacea larsonii* e *Rucinolithus terebrodentarius youngii*, la prima comparsa di *Parhabdolithus achlyostaurion* e di esemplari sovradimensionati di *Biscutum constans* potrebbero essere utilizzati per migliorare la stratigrafia a Nannofossili calcarei alle basse latitudini nell'intervallo Aptiano superiore-Albiano.

Abstract. Late Aptian-Campanian biostratigraphic investigations performed on calcareous nannofossils provided a refined stratigraphic resolution of the Scisti a Fucoidi and Scaglia Formations in the Bottaccione section (Umbria-Marche Basin, Central Italy). Additional bioevents such as the Last Occurrence (LO) of both *Assipetra infracretacea larsonii* and *Rucinolithus terebrodentarius youngii* and the First Occurrences (FOs) of *Parhabdolithus achlyostaurion* and large *Biscutum constans* were detected and might be used to refine the Late Aptian-Albian biostratigraphy at low latitudes.

Introduction

The sediments exposed in the Bottaccione Gorge have been investigated by several authors owing to the continuous exposure from Upper Jurassic to lower Upper Eocene and the only modest tectonic disturbances. Many studies on lithostratigraphy, biostratigraphy and magnetostratigraphy of the Bottaccione succession were performed in the last century. Renz (1936) proposed an Aptian-Eocene biostratigraphy. The planktonic foraminiferal biostratigraphy was carried out by Luterbacher & Premoli Silva (1962), Premoli Silva (1977) and Premoli Silva & Sliter (1994). Mohler (1966) tried to combine the nannofossil and planktonic foraminifer biostratigraphy. Arthur & Fischer (1977) and Arthur (1979) surveyed and measured the section. Alvarez et al. (1977), Lowrie et al. (1982) and Napoleone et al. (1983) provided detailed paleomagnetic analyses. In addition, chemostratigraphic studies based on oxygen, carbon and strontium were performed by Renard (1986), Corfield et al. (1991), Jenkyns et al. (1994) and Stoll & Schrag (2000).

Monechi & Thierstein (1985) established a detailed Early Campanian to Late Eocene nannofossil stratigraphy, recently refined by Gardin et al. (2001), calibrated with the magnetostratigraphy of the Bottaccione section. The nannofossil biostratigraphy previously proposed for the Aptian to Santonian interval by Monechi (1981), Erba (1988) and Ghisletti & Erba in Premoli Silva & Sliter (1994) is here refined based on updated taxonomy and bio-chronostratigraphy.

This study documents a high-resolution biostratigraphy using calcareous nannofossils from the Upper Aptian to the lowermost Campanian of the Bottaccione Gorge. The nannofossil events are directly calibrated to the foraminiferal biostratigraphy reported by Premoli Silva & Sliter (1994), since both studies have been conducted on the same samples.

Geological setting and lithology

The Bottaccione section is located close to the town of Gubbio along the road-cut from Gubbio to Scheggia in the Umbria-Marche Basin, Central Italy (Fig.1). Here a fairly continuous pelagic (lower to upper bathyal) sedimentation characterizes the Jurassic to Paleogene interval. Very condensed or incomplete sequences suggest the occurrence of ancient structural highs.

Above basement and Triassic evaporites, the Jurassic and Cretaceous sedimentary succession is mainly composed by calcareous to marly calcareous lithotypes containing nodules and layers of chert.

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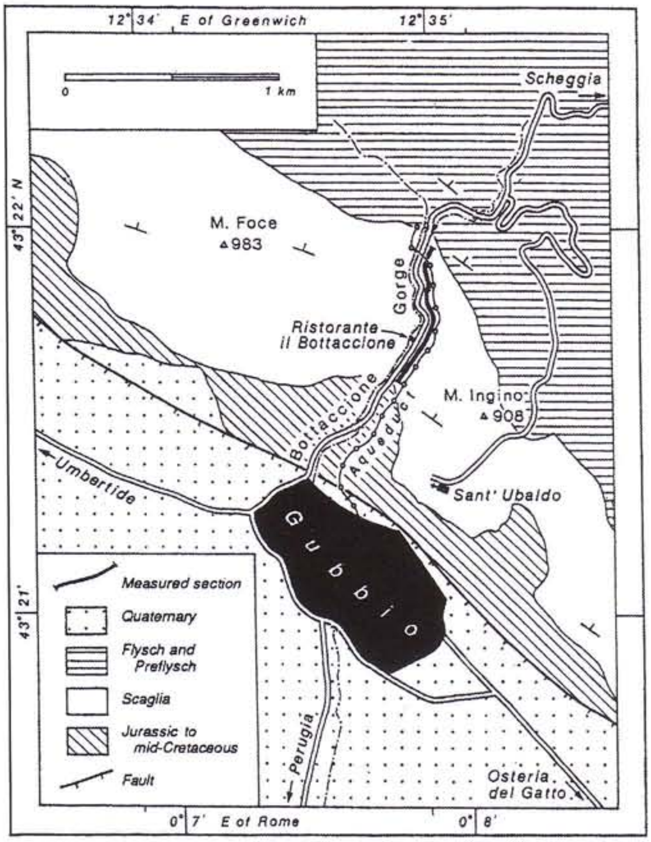


Fig. 1 - Location map of the Bottaccione section (after Premoli Silva & Sliter 1994).

In particular, the succession outcropping at Bottaccione and studied in this paper is referred to Scisti a Fucoidi and Scaglia Formations.

The Scisti a Fucoìdi Formation of Early Aptian-Late Albian age consists of alternating marlstones, marly limestones, limestones and organic-rich black shales. The contact between the Scisti a Fucoidi and the overlying Scaglia Formation is transitional; the marly intervals decrease, whereas the limestones become dominant.

The Scaglia Formation (Late Albian-Oligocene) is composed of limestones and marly limestones with lenses or bands of chert. It is possible to subdivide this formation into four members on the basis of lithological characteristics and color (Cresta et al. 1989): Scaglia Bianca (Late Albian-Early Turonian), Scaglia Rossa (Early Turonian-Middle Eocene), Scaglia Variegata (Middle Eocene-Late Eocene) and Scaglia Cinerea (Late Eocene-Oligocene). The most prominent feature of the Scaglia Bianca is the presence of organic-rich black shales and siliceous sediments (Bonarelli Horizon, Oceanic Anoxic Event 2) in the uppermost Cenomanian.

Material and Methods

Biostratigraphic investigations were performed on samples collected from the Scisti a Fucoidi, Scaglia Bianca and Scaglia Rossa. A total of 354 samples of limestones, marly limestones and marlstones were prepared using standard techniques (Monechi & Thierstein 1985); no ultrasonic cleaning or centrifuge concentration were applied in order to retain the original biogenic composition of the sample. Smear slides, prepared with Norland Optical Adhesive, were analyzed using standard light microscope techniques under cross polarizers and trasmitted light at 1250X magnification.

Due to calcite dissolution and/or overgrowth, preservation and abundance of calcareous nannofossil species may vary significantly. Thus, to characterize preservation a simple code system (Ocean Drilling Program code) has been adopted and is listed below:

VG (very good) = no evidence of dissolution and/or overgrowth is present; there is no alteration of primary morphological characteristics, and specimens appear diaphanous; specimens are identifiable to the species level.

G (good) = little or no evidence of dissolution and/or overgrowth is present; primary morphological characteristics are only slightly altered; specimens are identifiable to the species level.

M (moderate) = specimens exhibit some etching and/or overgrowth; primary morphological characteristics are sometimes altered; however, most specimens are identifiable to the species level.

P (poor) = most specimens exhibit overgrowth or dissolution; primary morphological characteristics are sometimes destroyed; fragmentation has occurred; species identification is often impaired.

Estimates of the total calcareous nannofossil abundance, compared to that of other biogenic particles and inorganic components, were recorded as follows:

C (common) = >51% of all particles,
F (few) = 11%-50% of all particles,
R (rare) = 1%-10% of all particles,
T (trace) = <1% of all particles, and
B (barren) = no nannofossils are present.

Estimates of the relative abundance of calcareous nannofossil species in the studied assemblages, were determined as follows:

D (dominant) = >51% of the total assemblage,
A (abundant) = 11%-50% of the total assemblage,
C (common) = 2%-10% of the total assemblage,
F (few) = 0.1%-1% of the total assemblage, and
R (rare) = <0.1% of the total assemblage.

Biostratigraphy and discussion

The nannofossil biozonation adopted in this study (Figs 2,3) is that of Roth (1978) and is regarded as standard as summarized in Perch-Nielsen (1985). The NC biozonation provided by Roth (1978) and the improvements proposed by Bralower et al. (1995) are largely

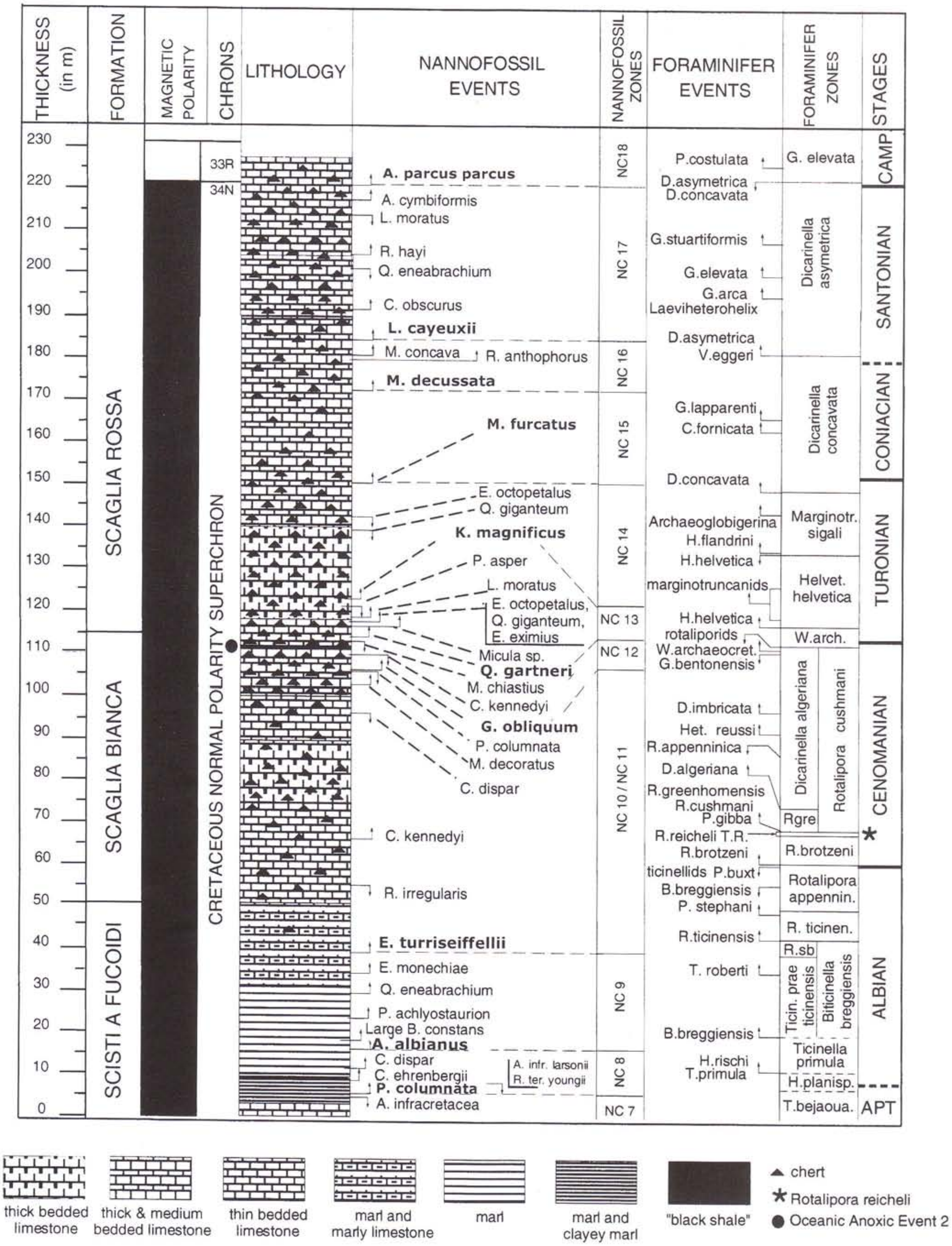


Fig. 2 - Lithostratigraphic log, foraminiferal (after Premoli Silva & Sliter 1994) and nannofossil events recognized at Bottaccione.

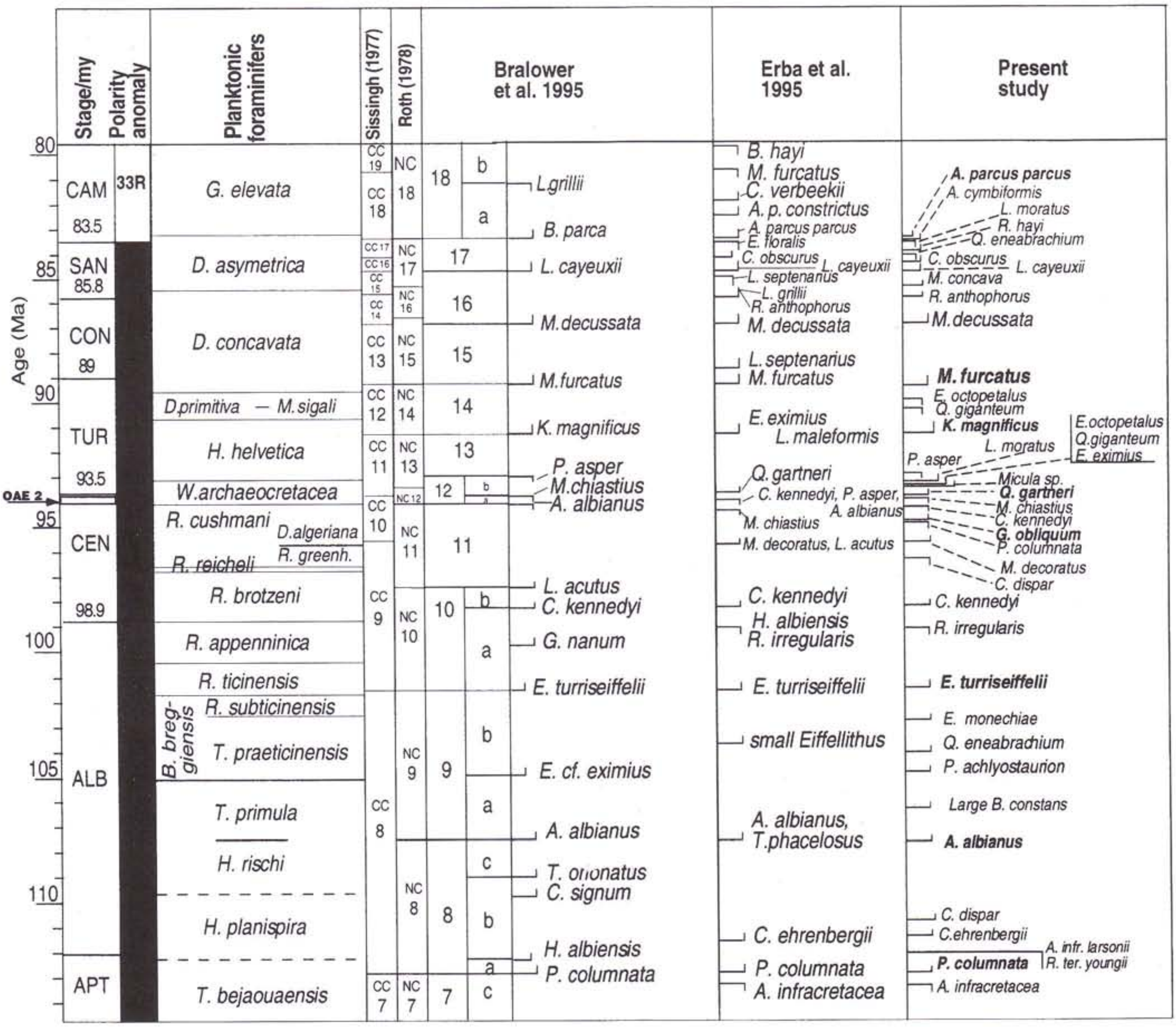


Fig. 3 - Comparison amongst the bioevents detected at Bottaccione and previous biozonations. Planktonic foraminifers from Premoli Silva & Sliter (1999). The gray pattern indicates the time interval investigated.

based on DSDP/ODP results and allow a good correlation between nannofossil and planktonic foraminifer biostratigraphic data.

The Sissingh (1977) scheme was constructed on results from land sections (mostly in Europe), but his planktonic foraminiferal data are often unavailable or different from those observed by Premoli Silva & Sliter (1994) at Bottaccione.

The UC biozonation, recently published by Burnett (1998), does not allow a good calibration with planktonic foraminiferal biozonations and most nannofossil events are recognizable only at higher latitudes or in better preserved material.

Most nannofossil assemblages found are dominated by *Watznaueria barnesae*, a species very resistant to diagenetic modifications (Roth & Krumbach 1986). Indeed, large amounts of *W. barneasae* usually indicate a low degree of nannofossil preservation.

In general, the Scaglia displays a nannofossil preservation ranging from poor to moderate and the overall nannofossil abundance is low. By contrast, calcareous nannofossils in the Scisti a Fucoidi are just slightly altered, thus allowing the identification at species level and their abundance ranges from few to common.

The bottom of the investigated succession is assignable to the Late Aptian NC7 nannofossil zone based on the occurrence of *Eprolithus floralis* in the lowermost sample investigated (sample Apt 4 - 0.60 m). The NC7/NC8 zonal boundary is placed at the FO of *Prediscosphaera columnata* (sample Apt 19 - 5.86 m). This zonal boundary is preceded by the LO of *Assipetra infracretacea* (sample Apt 17 - 5. 48 m), whereas *A. infr. larsonii* disappears at 7.33 m (sample Apt 22) associated with the LO of *Rucinolithus terebrodentarius youngii*. *A. infr. larsonii* and *R. ter. youngii* represent the large-sized morphotypes of *A. infracretacea* and *R. terebrodentarius*, respectively and their stratigraphic range is restricted to the Aptian stage (Tremolada & Erba 2002).

The FO of *Cribrosphaerella ehrenbergii* lies at 8.60 m (sample Apt 28) indicating an earliest Albian age. *Calculites dispar* was first observed in the sample Apt 42 bis (14.75 m) and displays a continuous occurrence although characterized by low abundance. This species was established by Al-Rifaiy et al. (1990) and there are still limited data concerning its distribution. The LO of *C. dispar* was detected in the Bottaccione section at 97.09 m (sample B 458), of Late Cenomanian age, suggesting a slightly later disappearence than reported by Al-Rifaiy et al. (1990).

Axopodorhabdus albianus is extremely rare in the samples investigated and its first occurrence is located at 15.74 m (sample Apt 47). The FO of *A. albianus* marks the NC8/NC9 zonal boundary, within the *Ticinella primula* foraminiferal Zone (Premoli Silva & Sliter 1994, 1999). The top of the NC9 nannofossil zone is defined by the first occurrence of *Eiffellithus turriseiffelii* at 37.80 m (sample Apt 89) preceding the FO of *Rotalipora ticinensis* at 43.10 (Premoli Silva & Sliter 1994). The FO of *E. turriseiffelii* is anticipated by the occurrence of *Eiffellithus monechiae* (Bown et al. 1998) at 35.55 m (sample Apt 84). This taxon may represent the *Eiffellithus* cf. *E. eximius* documented by Bralower et al. (1995) or the small *Eiffellithus* reported in Erba et al. (1995).

Within Zone NC9 other events such as the FOs of large *Biscutum constans* at 16.68 m (sample Apt 48) and *Parhabdolithus achlyostaurion* at 23.61 m (sample Apt 64) were recognized. The FO of large-sized specimens of *B. constans* is a peculiar event of the Tethyan Albian documented as *B. magnum* sensu Erba et al. (1999) at the Cismon drillcore (Northeastern Italy, Venetian alps), Erba (1988) at the Piobbico drillcore (Umbria-Marche Basin, Central Italy) and Bellanca et al. (in press) at the Calabianca section (Nortwestern Sicily, Southern Italy).

Several authors (e.g. Bralower et al. 1995; Bown et al. 1998) report the FO of *P. achlyostaurion* in the Late Aptian, but at the Bottaccione section, the Cismon drillcore (Erba et al. 1999), the Piobbico drillcore (Erba 1988) and the Calabianca section (Bellanca et al. in press) this event is dated as Middle Albian. This discrepancy is probably due to different criteria in the taxonomic identification or a biogeographic control hampering a widespread and simultaneous first occurrence of *P. achlyostaurion*.

The LO of *Rucinolithus irregularis* lies at 54.65 m (sample B 58) in the Late Albian within the *Rotalipora appenninica* foraminiferal Zone (Premoli Silva & Sliter 1994) and the FO of *Corollithion kennedyi* at 68.74 m (sample B 193), within the *Rotalipora reicheli* Zone (Premoli Silva & Sliter 1994) indicating an Early Cenomanian age.

The FO of the foraminifer *Rotalipora brotzeni* was recognized at 61.20 m (Premoli Silva & Sliter 1994).

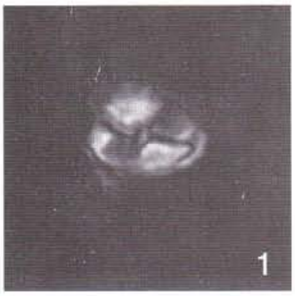
C. kennedyi displays a quite continuos presence through the Cenomanian up to 110.78 m (sample B 561), just prior to the deposition of the Bonarelli Horizon. In several sections such as Novara di Sicilia, Northeastern Sicily (Tremolada unp. data) and Eastbourne, United Kingdom (Paul et al. 1999) the LO of *C.*

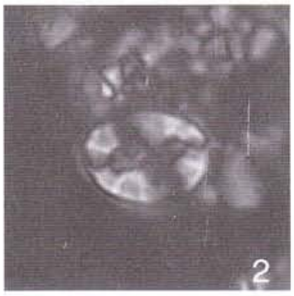
PLATE 1

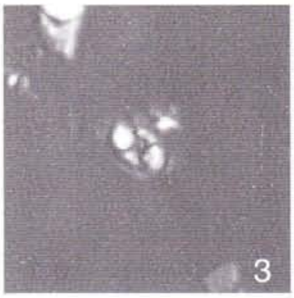
All specimens at x2000 magnification. Fig. 1 - *Eiffellithus eximius*, crossed nicols, sample B 580. Fig. 2 - *Eiffellithus eximius*, crossed nicols, sample 16/164. Figs 3,4 - *Calculithes dispar*, crossed nicols, sample B60, same specimen. Figs 5,6 - *Micula* sp., crossed nicols, sample 16/164, same specimen. Figs 7,8 - *Corollithion kennedyi*, crossed nicols, sample B 558, same specimen. Fig. 9 - *Micula* cf. *decussata*, crossed nicols, sample 16/112. Fig. 10 - *Micula decussata*, crossed nicols, sample 16/114. Fig. 11 - *Rucinolithus irregularis*, crossed nicols, sample B 49. Fig. 12 - *Quadrum eneabrachium*, crossed nicols, sample Apt 73. Fig. 13 - *Rucinolithus hayi*, crossed nicols, sample 16/104R. Fig. 14 - *Biscutum constans*, crossed nicols, sample B 273. Fig. 15 - Large *B. constans*, crossed nicols, sample B 104. Fig. 16 - Large *B. constans*, trasmitted light, sample B 123. Fig. 17 - *Aspidolithus parcus parcus*, crossed nicols, sample 16/100R. Fig. 18 - *Calculithes obscurus*, crossed nicols, sample 16/102. Fig. 19 - *Kamptnerius magnificus*, crossed nicols, sample 16/175. Fig. 20 - *Kamptnerius magnificus*, crossed nicols, sample 16/175.

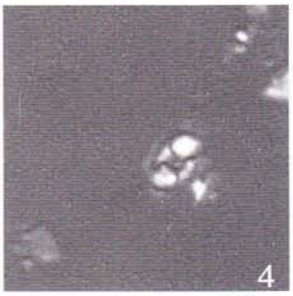
PLATE 2

All specimens at x2000 magnification. Figs 1,2 - *Microstaurus chiastius*, crossed nicols, sample B554, same specimen. Fig. 3 - *Microrhabdulus decoratus*, crossed nicols, sample B 535. Fig. 4 - *Prediscosphaera columnata*, crossed nicols, sample Apt 20. Fig. 5 - *Marthasterites furcatus*, trasmitted light, sample 16/148. Fig. 6 - *Marthasterites furcatus*, trasmitted light, sample 16/145. Fig. 7 - *Marthasterites furcatus*, trasmitted light, sample 16/145. Fig. 8 - *Eiffellithus turriseiffelii*, crossed nicols, sample 16/102R. Fig. 9 - *Parhabdolitus achlyostaurion*, crossed nicols, sample B 53. Fig. 10 - *Parhabdolitus achlyostaurion*, crossed nicols, sample B 58. Fig. 11 - *Parhabdolitus achlyostaurion*, crossed nicols, sample B 19 Fig. 12 - *Parhabdolitus achlyostaurion*, crossed nicols, sample B 24. Fig. 13 - *Quadrum gartneri*, crossed nicols, sample B 570. Fig. 14 - *Reinhardtites* cf. *anthophorus*, crossed nicols, sample 16/101. Fig. 15 - *Cribrosphaerella ehrenbergii*, crossed nicols, sample B 471. Fig. 16 - *Assipetra infracretacea larsonii*, crossed nicols, sample Apt 22. Fig. 17 - *Gartnerago obliquum*, crossed nicols, sample B 546. Fig. 18 - *Eiffellithus trabeculatus*, crossed nicols, sample B 471. Fig. 19 - *Rucinolithus terebrodentarius youngii*, crossed nicols, sample Apt 11. Fig. 20 - *Rucinolithus terebrodentarius youngii*, crossed nicols, sample Apt 12.



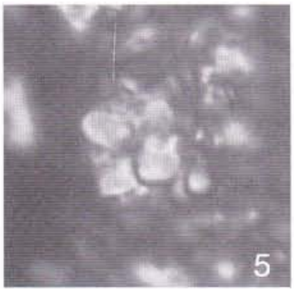


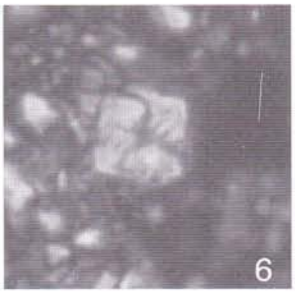


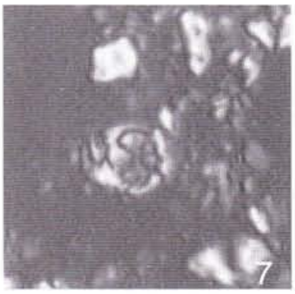


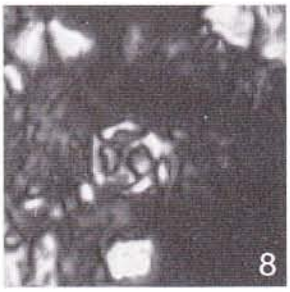
E. eximius

C. dispar



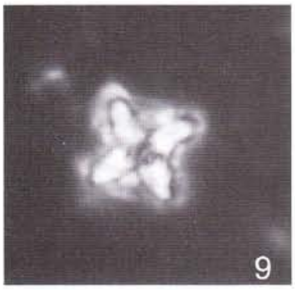


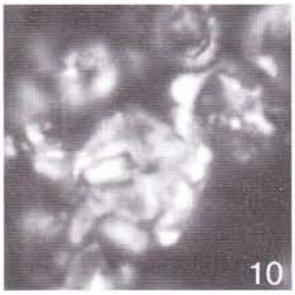


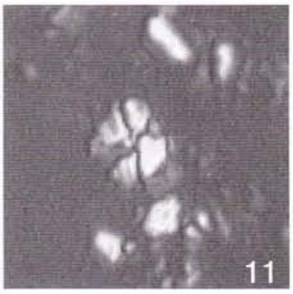


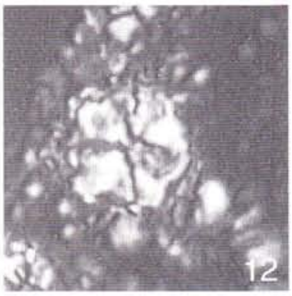
Micula sp.

C. kennedyi







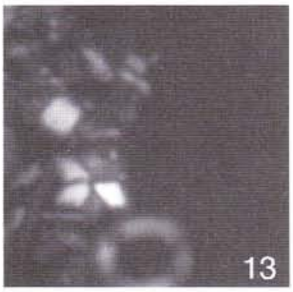


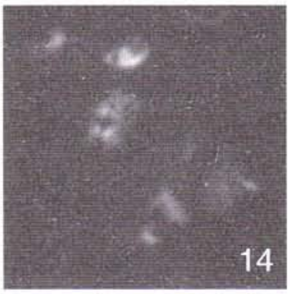
M. cf. *decussata*

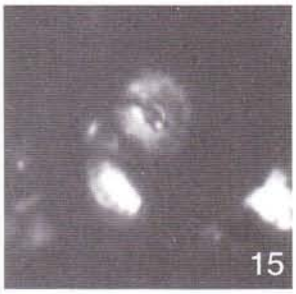
M. decussata

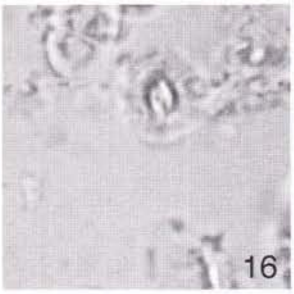
R. irregularis

Q. eneabrachium





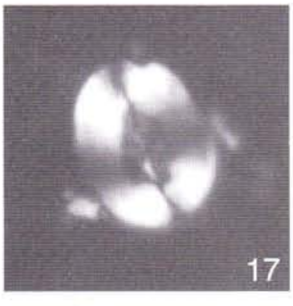


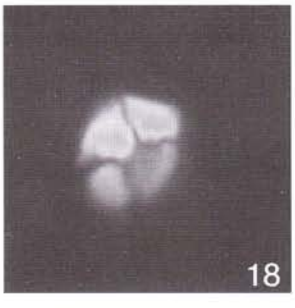


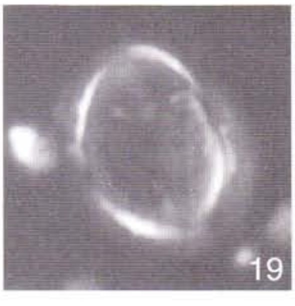
R. hayi

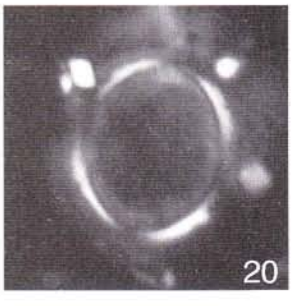
B. constans

large *B. constans*





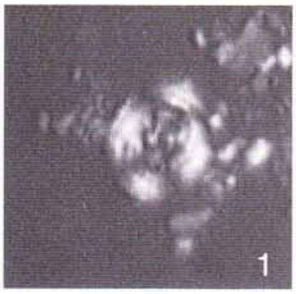




A. parcus parcus

C. obscurus

K. magnificus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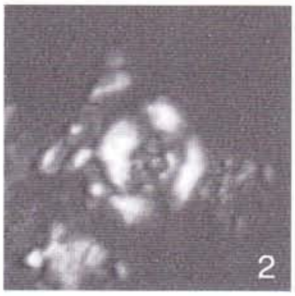
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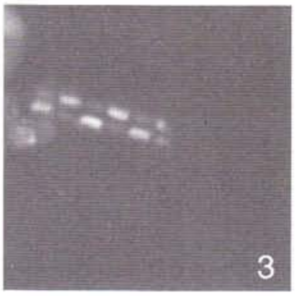
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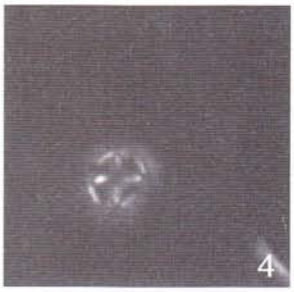
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M. chiastius

M. decoratus

P. columnata


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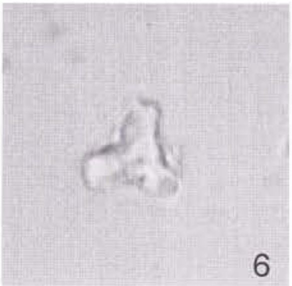
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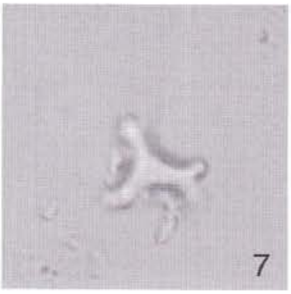
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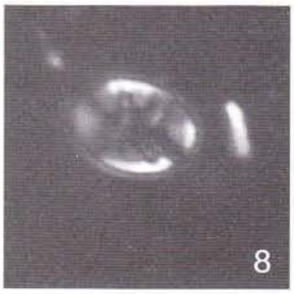
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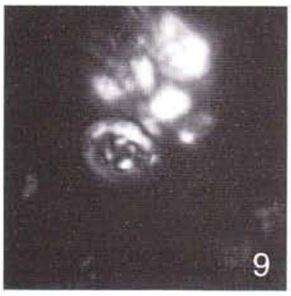
M. furcatus

E. turriseiffelii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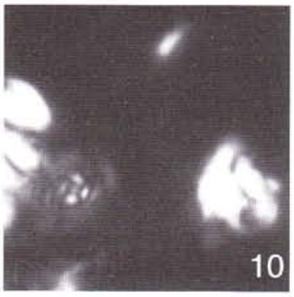
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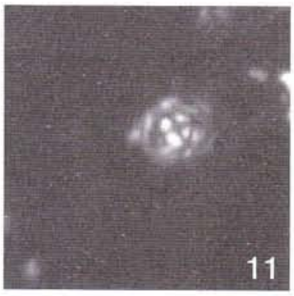
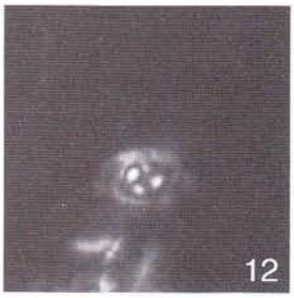
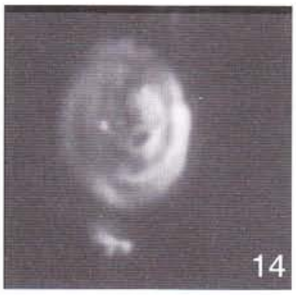

11


12

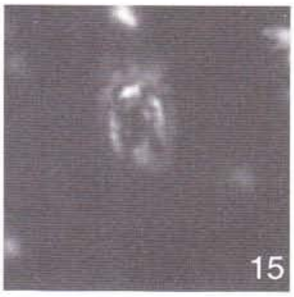
P. achlyostaurion


13

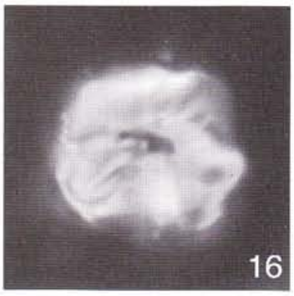
Q. gartneri


14

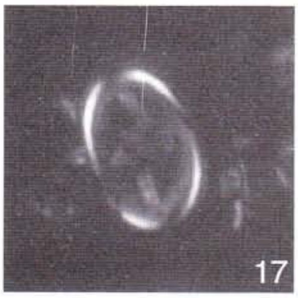
R. cf. *anthophorus*


15

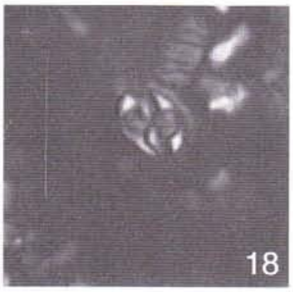
C. ehrenbergii


16

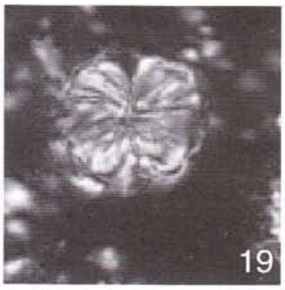
A. infr. larsonii


17

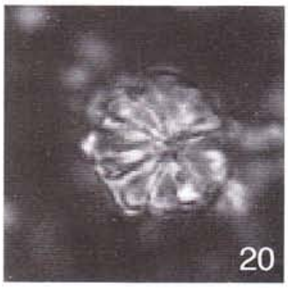
G. obliquum


18

E. trabeculatus


19

R. ter. youngii


20

kennedyi was recognized within the Bonarelli Horizon equivalents. This apparent discrepancy is possibly due to the lack of calcium carbonate in the uppermost Cenomanian black shales at Bottaccione, but Luciani & Cobianchi (1999) detected the LO of *C. kennedyi* just above the Bonarelli Horizon at Antruiles, Northeastern Italy.

The interval immediately preceding the Bonarelli Horizon is marked by several nannofossil events such as the FO of *Microrhabdulus decoratus* at 107.92 m (sample B 533), the LO of *P. columnata* at 108.77 m (sample B 542) and the FO of *Gartnerago obliquum* at 109.35 m (sample B 546), which defines the base of the nannofossil zone NC12. It was not possible to subdivide the zones NC10 and NC11, since the zonal marker *Lithraphidites acutus* shows a too spotty distribution.

The extinction of the foraminiferal genus *Rotalipora* lies at 111 m (Premoli Silva & Sliter 1994) slightly below the Bonarelli Horizon; this event represents the base of the *Whiteinella archaeocretacea* Zone. The top of this zone is placed at the FO of *Helvetoglobotruncana helvetica* (sample 16/177 - 117 m).

The LO of *Microstaurus chiastius* was observed at 112.03 m (sample B 564), whereas the FO of *Quadrum gartneri* (= *Tetralithus pyramidus* of Sissingh 1977 and Roth 1978) lies at 112.59 (sample B 568) and defines the base of the zone NC13. These events are recorded worldwide across the Cenomanian/Turonian boundary. The FO of *Micula* sp., recognized at 112.73 m (sample B 569), preceds the LO of *Parhabdolitus asper* at 114.68 m (sample B 579). *Micula* sp. may be correlatable to *Micula staurophora* as documented by Roth (1978) from the lowermost Turonian.

Kamptnerius magnificus was first observed at 119 m (sample 16/175), although extremely rare, and is used to identify the top of Zone NC13. Within Zone NC13 several bioevents were recognized: the FOs of *Eiffellithus eximius, Quadrum giganteum* and *Eprolithus octopetalus* at 112.94 m (sample B 570), the FO of *Lithastrinus moratus* at 113.07 m (sample B 571) and the FO of *Lucianorhabdus* spp. at 118 m (sample 16/176).

Q. giganteum is usually rare in the Bottaccione section, whereas *E. eximius, L. moratus* and *E. octopetalus* display a continuous stratigraphic distribution, even though the poor preservation can sometimes hamper the identification of *E. octopetalus* and *L. moratus*.

The LOs of *Q. giganteum* (138 m - sample 16/160) and *E. octopetalus* (141 m - sample 16/157) were recognized within Zone NC14. The stratigraphic range of *Q. giganteum* and *E. octopetalus* is slightly different from that reported by Varol (1992) who recorded these events in the Early Turonian.

The FO of *Marthasterites furcatus* defines the base of Zone NC15 and this event was observed at 150 m (sample 16/148) postdating the FO of the foraminifer *Dicarinella concavata* (sample 16/149 - 149 m). *M. furcatus* is always rare at Bottaccione.

The NC15/NC16 zonal boundary is placed at the FO of *Broinsonia lacunosa*, but this taxon was never detected at Bottaccione. In fact, *B. lacunosa* is a delicate coccolith susceptible to diagenetic modifications and its occurrence is conditioned by the degree of preservation of the investigated material. The FO of *Micula decussata* at 173 m (sample 16/125) was used to replace the FO of *B. lacunosa* and to indicate the base of the Zone NC16 (Bralower et al. 1995).

Reinhardtites anthophorus was first observed at 175 m (sample 16/123). This event preceds the FOs of *Micula concava* at 179 m (sample 16/119), *Lucianorhabdus cayeuxii* at 184 m (sample 16/114) and *Calculithes obscurus* at 191 m (sample 16/107). *M. concava, L. cayeuxii* and *C. obscurus* are usually rare and they display a spotty occurrence in the Bottaccione section, whereas *R. anthophorus* shows a rather continuos distribution. *L. cayeuxii* is a cosmopolitan taxon and recorded in low abundances everywhere, but it seems to prefer shallow water environments (Thierstein 1976). In this work I used the FO of *L. cayeuxii* to define the base of Zone NC17 following the modification proposed by Bralower et al. (1995).

The FOs of foraminifers *Dicarinella asymmetrica* and *Ventilabrella eggeri* were detected in the same sample at 181 m (Premoli Silva & Sliter 1994).

Within Zone NC17 several bioevents were recognized: the LOs of *Q. eneabrachium* (196 m - sample 16/102)) and *L. moratus* (216 m - sample 16/108R) and the FOs of *Rucinolithus hayii* (205 m - sample 149GA) and *Arkhangeskiella cymbiformis* (217 m - sample 16/106R).

The FO of *Aspidolithus parcus parcus* lies at 220 m (sample 16/104R) and defines the NC17/NC18 zonal boundary and the Santonian/Campanian stage boundary. The FO of *A. parcus parcus* is a well established event recognizable at both low- and high-latitudes (Bralower et al. 1995) and correlatable to the end of the normal superchron C34N.

The LO of *D. asymmetrica* is recorded at 221.5 m in the Early Campanian (Premoli Silva & Sliter 1994).

Chronostratigraphy

The integrated stratigraphy proposed in Fig. 2 summarizes the foraminiferal and nannofloral biozonations at Bottaccione. Nannofossil and foraminifer events detected in the samples investigated may be used to approximate the stage boundaries at low latitudes when detailed ammonite investigations are not available. The geomagnetic polarity time scales cannot be integrated with microfossil events over the time interval investigated since the Long Normal Superchron spans from the Early Aptian to the Campanian (e.g. Alvarez et al. 1977).

The Aptian/Albian stage boundary is not easily recognizable and there are still uncertainties on the ammonite datum to be used (e.g. Bréhéret et al. 1986; Hart et al. 1996). Kennedy et al. (2000) proposed to use the FO of the ammonite *Leymeriella tardefurcata* to indicate this boundary. Bown (in Kennedy et al. 2000) suggested the FO of the small, circular specimens of *P. columnata* or the LO of *Broinsonia viriosa* to approximate the ammonite-defined Aptian/Albian boundary. Bown (in Kennedy et al. 2000) studied the morphological characteristics of *P. columnata* differentiating three evolutionary stages: elliptical shape (*Prediscosphaera spinosa* of many authors), near-circular shape and circular shape.

However, *B. viriosa* was not found at Bottaccione and it was not possible to differentiate between near-circular and circular morphotypes of *P. columnata*. In fact, the specimens of *P. columnata* recorded in the samples analyzed are affected by overgrowth or etching hampering the study of size/shape variations. The Aptian/Albian stage boundary is usually placed in the lower part of the *Hedbergella planispira* foraminiferal Zone (Premoli Silva & Sliter 1994, 1999; Bralower et al. 1995), between the FOs of *P. columnata* and *C. ehrenbergii*.

A. infr. larsonii and *R. ter. youngii* have their last occurrence within the lower part of the foraminiferal Zone *Hedbergella planispira* and they may be used to approximate the boundary, since these subspecies were only recently established (Tremolada & Erba 2002) and perhaps they need a further documentation of their stratigraphic range, ecologic significance and biogeographic occurrence.

The FO of the planktonic foraminifer *Rotalipora globotruncanoides* (= *R. brotzeni*) best approximates the Albian/Cenomanian boundary (Bralower et al. 1995; Gale et al. 1996; Tröger & Kennedy 1996; Premoli Silva & Sliter 1999). The FO of *R. globotruncanoides* lies at 61 m between the LO of *R. irregularis* at 54.65 m and the FO of *C. kennedyi* at 68.74 m in the Bottaccione section.

The Cenomanian/Turonian boundary is defined by the FO of the ammonite *Watinoceras devonense* (Wright & Kennedy 1991; Bengtson 1996). Several studies performed on planktonic foraminifers (Eicher & Diner 1985; Premoli Silva & Sliter 1994, 1999; Bralower et al. 1995; Bengtson 1996) pointed out that the Cenomanian/Turonian boundary lies between the LO of the genus *Rotalipora* and the FO of *Helvetoglobotruncana helvetica*. The FO of the nannofossil *Q. gartneri* is recorded everywhere in the interval between the extinction of the rotaliporids and the FO of *H. helvetica* (e.g. Perch-Nielsen 1983; Watkins 1986; Watkins et al. 1996; Bengtson et al. 1996). Indeed, the FO of *Q. gartneri* may be used to approximate the Cenomanian/Turonian boundary since it slightly preceds the FO of *W. devonense* at low latitudes, whereas Burnett (1998) reported the first occurrence of *Q. gartneri* from the Lower Turonian (*Mammites nodosoides* ammonite Zone) at high latitudes.

The Turonian/Coniacian boundary can be approximated using the FO of *M. furcatus* (Sissingh 1977; Perch-Nielsen 1983, 1985; Bralower et al. 1995; Watkins et al. 1996), whereas it is not possible to define the Coniacian/Santonian boundary since there are not bio-events directly correlatable to this boundary. The entry of the foraminiferal group of the ventilabrellids may be used to best approximate the Coniacian/Santonian boundary as reported by Salaj (1980, 1984) in Tunisian sections, but this event was detected at the same level as the FO of *Dicarinella asymmetrica* at Bottaccione, thus indicating an Early Santonian age (Premoli & Sliter, 1994).

The Santonian/Campanian boundary is equated to the magnetic chron 34N/33R boundary (e.g. Lommerzheim & Hambach 1992; Bralower et al. 1995; Gradstein et al. 1995) and correlates with the FO of *A. parcus parcus*.

Conclusions

Several important nannofossil events were recognized in the Bottaccione section, even though the nannofloral preservation is poor. A few zonal markers (e.g. *L. acutus*, *B. viriosa* and *B. lacunosa*) are missing or show a spotty occurrence in the samples analyzed.

The nannofossil and foraminifer events found at Bottaccione are correlated in Fig. 2; this scheme may represent a good integrated stratigraphy for Italian sections and the Tethys area in general. Additional nannofossil events proposed herein such as the FOs of large *B. constans*, *P. achlyostaurion* and the LOs of *R. terebrodentarius youngii* and *A. infracretacea larsonii* may be used also in other regions in order to enhance the resolution of the currently available biozonations.

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STAGE	SAMPLE	METER	Total abundance	Preservation	B.constans	Large B. constans	C. litterarius	C. surirellus	M. chiastius	C. margerelii	E. turriseiffelii	L. carniolensis	M. pemmatoidea	P. achlyostaurion	P. angustus	R. fenestratus	R. irregularis	W. britannica	W. barnesae	W. communis	W. manivitae	Z. diplogrammus	B. regularis	C. conicus	P. embergeri	D. rotatorius	F. oblongus	P. asper	T. stradneri	D. lehmanii	C. coronadventis	L. floralis	Z. xenotus	C. ehrenbergii	P. splendens	C. angustiforatus	T. orionatus	B. africana	Z. elegans	C. dispar	V. stradneri	P. spinosa	Nannoconus cf. truittii	V. matalosa	B. lata	N. truittii	A. albianus	C. exiguum	P. columnata	A. infracretacea	A. infr. larsonii	R. ter. youngii	R. terebrodentarius	C. achylosum	Q. eneabrachium	E. monechiae	
ALBIAN	B 66	55.61	C	M	R	R	R				R	R		R	R				A	A	R	R		R	R	R		R					R	R																					R		
	B 64	55.42	F	P	R			R			R	R							A	A	R				R	R		R						R			R						R			R			R					R			
	B 60	54.84	C	P	R				R		R	R						R	A	A	R	F		R	R	R		R						R		R			R	R		R				R	R		R								
	B 59	54.76	F	P	R	R			R	R	R	R		R	R				A	C	R					R		F				R	R	R					R																R		
	B 58	54.65	C	M	R			R	R		R	R	R	R		R	R		A	C	F			R	R	R		R						R	R				R					R													LO R. irregularis
	B 53	53.93	F	M	R	R		R			R			R					A	C	R	R		R	R	R		R			R			R					R							R			R				R				
	B 50	53.7	C	M	R	R		R			R					R		R	A	A	R			R	R	R		R	R					R	R		R									R			R				R				
	B 49	53.63	F	M	R	R	R	R	R	R	R	R		R			R		A	A	R	R			R	R		R					R							R						R			R				R		R		
	B 45	53.28	F	M	R	R		R			R	R	R	R	R		R		A	C	R	R										R							R									R	R				R	R			
	B 42	52.98	F	M	R	R		R			R	R				R	R		A	C	R	R		R	R	R		R													R	R				R			R				R				
	B 40	52.87	F	M	R	R		R				R		R		R	R		A	A	R	R												R												F			R				R				
	B 38	52.61	F	M	R	R			R	R		R	R				R		A	A	R	R			R			R			R								R	R						F			R				R		R	R	
	B 37	52.51	F	P	R			R			R			R		R	R		A	C	R	R			R	R		F	R			R		R							R					R			R								
	B 35	52.45	F	P	R						R	R					R		A	A	R			R	R	R		R											R										R					R			
	B 28	51.66	C	M	R			R			R	R	R	R		R	R		A	C	R	F		R	R	R		R				R														R			R								
	B 26	51.48	F	P	R	R			R	R	R	R			R		R		A	C	R	C			R	R		R		R							R		R			R		R			R		R						R		
	B 24	51.34	F	M	R				R		R			R			R	R	A	C	F	F		R	R	R		R						R						R						R			R				R				
	B 19	51.01	F	M	R	R		R			R	R	R	R			R		A	A	F	F		R	R	R		R								R			R		R								R						R	R	
	B 16	50.65	F	M	R	R				R	R	R			R				A	A	F					R	R	R	R			R			R				R									R						R	R		
	B 08	49.77	F	M	R		R				R	R		R			R		A	A		R		R	R																					R			R					R			
	B 01	48.98	F	P	R	R	R			R	R	R		R		R	R		A	C	R	R				R					R			R					R	R	R	R				R			R				R				
	16/246	48.06	C	M	R	R		R	R		R						R		A	A	F	R				F	R	R	R			R							R		R		R		R	R			R					R			
	16/247	47.18	C	M	R	R					R			R			R		A	A	F				R	F	R	R				R			R						R					R			R								
	16/248	46.46	F	M	R	R			R		R				R			R	A	C	F			R			R	R				R		R			R									R							R				
	16/249	45.70	F	M	R	R	R				R						R		A	C	R				R	F	R	R				R									R					R			R						R		
	16/251	44.98	F	M	R			R	R		R						R		A	A	F	R		R			R	R			R	R			R											R											
	16/252	43.10	C	M	R	R		R	R		F						R		A	C	F						R	R											R															R			
	16/253	42.03	C	M	R	R		R	R		R			R		R	R		A	A	F	R		R	R		R	R	R			R			R						R					R										R	
	16/254	41.05	C	M	R	R					R						R	R	A	A	R	R		R			R	R						R					R					R					R				R				
	16/255	40.15	C	M	R	R		R	R	R	F						R		A	C	R						R	R				R																									
	apt 90	38.82	F	M	R				R		R			R			R		A	A	F	R		R		F	R	R	R		R								R							R								R			
	apt 89	37.80	F	M	R	R					R						R		A	A	R	R			R		R	R				R		R												R											FO E. turriseiffellii
	apt 87	36.71	F	M	R			R	R								R		A	C	R	R		R			R	R	R			R			R											R									R	R	
	apt 86	35.82	C	M	R	R		R						R	R		R	R	A	A	F	R		R			R	R				R							R			R				R	R		R								
	apt 85	35.65	C	M	R				R	R							R		A	A	R	R			R	F	R	R				R		R		R				R	R					R										R	
	apt 84	35.55	C	M	R	R	R							R					A	C	F	R		R			R	R			R	R			R																		R			R	FO E. monechiae
	apt 83	34.84	C	M	R			R	R								R		A	C	R			R	R		R	R		R																R									R		
	apt 82	34.78	F	M	R	R				R		R						R	A	A	F	R		R		F	R	R	R			R			R		R									R	R		R					R			
	apt 81	33.72	C	G	R		R		R	R		R					R		A	A	F	R		R	R		R	R			R								R							R											
	apt 80	33.04	F	M	R	R						R		R			R		A	C	R					F	R	R				R							R	R													R		R		
	apt 79	32.04	F	M	R				R	R						R	R		A	A	F	R		R			R	R	R						R	R										R	R		R								
	apt 77	31.26	F	M	R	R	R	R				R					R		A	A	F						R	R			R			R												R											
	apt 76	30.72	F	M	R	R		R	R			R					R	R	A	A	R			R		F	R	R				R															R							R			
	apt 75	29.88	F	M	R		R			R		R		R			R		A	A	F	R			R		R	R							R	R										R			R								
	apt 73	29.25	F	M	R	R		R	R			R		R					A	A	R			R		F	R	R				R							R							R	R								R		
	apt 71	27.58	C	G	R			R	R								R		A	A	F			R			R	R	R			R		R																					R		FO Q. eneabrachium
	apt 70	26.73	C	G	R	R								R			R		A	C	F	R		R	R		R	R				R																						R			
	apt 68	26.28	C	G	R	R			R	R							R		A	A	F	R				F	R	R			R				R							R				R	R		R				R				
	apt 64	23.61	C	M	R				R					R					A	C	F			R			R	R				R		R																							FO P. achlyostaurion
	apt 63	22.86	C	M	F				R								R		A	C	F	R			R	F	R	R	R											R						R							R				
	apt 62	22.44	C	M	R	R		R							R	R	R		A	A	F			R			R	R				R														R			R					R			
	apt 61	22.30	F	M	R		R					R					R		A	C	R	R					R	R																		R	R		R								
	apt 58	22.02	F	M	R	R		R	R			R				R	R	R	A	C	F	R		R	R	F	R	R			R	R			R				R							R							R				
	apt 57	21.92	C	M	R							R					R		A	A	R	R					R	R	R			R		R		R										R			R								
	apt 56	21.80	C	M	R	R	R		R								R		A	A	F						R	R											R	R						R											
	apt 55	20.19	F	M	R	R			R			R			R			R	A	C	F	R			R		R	R				R			R											R							R				
	apt 53	19.79	C	M	R	R						R							A	A	R			R	R		R	R						R					R							R	R		R								
	apt 52	18.93	C	M	R	R	R	R				R					R		A	C	R	R					R	R	R			R		R		R					R					R							R	R			
	apt 50	17.83	F	M	F				R			R							A	A	F			R	R		R	R		R		R							R				R			F							R				
	apt 49	17.30	F	M	R	R											R		A	C	R	R		R			R	R				R			R					R						F			R				R				
	apt 48	16.68	F	M	R	R	R								R		R		A	C	F						R	R						R	R	R			R							R											FO Large B. constans
	apt 47	15.74	F	M	R			R	R	R									A	C	F	R		R	R		R	R		R	R	R							R		R					R	R						R				FO A. albianus
	apt 46	15.24	C	M	R			R									R		A	A	R						R	R	R											R						C											
	apt 45	15.04	C	G	R				R			R					R		A	A	R	R			R		R	R				R							R							C			R				R	R			
	apt 44	14.94	F	M	R			R				R			R		R		A	A	F	R		R			R	R						R	R							R											R				
	apt 43	14.83	F	M	R			R	R	R							R		A	A	F						R	R	R	R									R	R	R					C			R				R				
	apt 42b	14.75	C	G	F			R	R							R	R		A	C	F			R	R		R	R				R							R	R						C							R				FO C. dispar
	apt 42	14.55	C	G	R		R		R	R					R				A	C	R	R					R	R						R					R							C							R				
	apt 41	14.20	C	G	R			R				R					R		A	A	F	R		R			R	R	R			R			R				R			R				C											
	apt 40	14.00	C	G	R				R			R					R		A	A	F	R		R	R		R	R											R										R				R				
	apt 39	13.87	C	G	F			R	R			R					R	R	A	A	R	R		R	R		R	R	R			R							R		R					R								R			
	apt 38	13.65	C	G	R				R	R		R						R	A	C	F	R			R		R	R						R					R							F							R				
	apt 37	13.05	F	M	R				R			R			R		R	R	A	A	R			R	R		R	R				R			R											F							R				
	apt 36	10.90	F	M	R			R	R			R					R	R	A	A	R	R			R		R	R	R		R	R		R							R					C											
	apt 35	9.90	F	M	R					R							R	R	A	A	F	R		R	R		R	R																		C							R				
	apt 34	9.65	F	M	R		R		R			R					R	R	A	A	F						R	R	R						R	R		R								C			R				R	R			
	apt 33	9.55	F	M	R				R			R					R	R	A	A	F			R			R	R			R	R							R			R				C							R				
	apt 30	9.10	C	M	R		R					R			R				A	C	R					R	R	R	R																	C							R				
	apt 29	8.80	C	M	R				R			R					R		A	A	R	R		R	R	R	R	R				R		R	R	R		R			R	R				C			R				R	R			
	apt 28	8.60	F	M	R				R	R							R		A	A	R	R			R	R	R	R	R			R		R					R							R							R				FO C. ehrenbergii
	apt 25	8.18	C	M	R		R	R									R		A	A	R	F				R	R	R		R		R														F											
	apt 24	7.53	F	M	R			R	R						R	R	R		A	C	R	F		R		R	R	R			R	R			R				R							F							R				
APTIAN	apt 22	7.33	C	M	R		R			R							R		A	A	R	R		R		R	R	R	R																	R					R	R	R				LO A. infr. larsonii
	apt 21	6.93	F	M	R				R			R					R	R	A	C	R					R	R	R								R					R	R				C			R			R					LO R. ter. youngii
	apt 20	6.76	F	P	R		R		R			R					R	R	A	C	R	R		R		R	R	R				R														R			R		R		R				
	apt 19	5.86	C	M	R		R	R	R								R		A	A	R		R			R	R	R	R	R									R							R			R								FO P. columnata
	apt 18	5.61	C	M	R			R									R		A	A	R	R		R		R	R	R				R			R	R										C											
	apt 17	5.48	C	M	R		R		R								R		A	A	R	R					R	R	R												R					R				R			R				LO A. infracretacea
	apt 15	4.88	C	M	F			R	R			R			R		R		A	A	R	R		R		R	R	R				R							R							C					R	R	R				
	apt 14	4.48	C	M	R		R	R	R			R					R	R	A	C	R					R	R	R	R			R				R										R							R				
	apt 13	3.73	C	M	R					R		R			R		R	R	A	A	R		R	R			R	R	R						R				R		R					R						R	R				
	apt 12	3.23	C	M			R	R	R								R		A	C	R	R				R	R	R				R														C					R	R	R				
	apt 11	2.73	C	M				R	R			R			R		R		A	A	R					R	R	R	R							R			R							C				R		R	R				
	apt 10	2.66	C	M	R		R			R		R					R	R	A	A	R	F		R			R	R				R														R							R				
	apt 9	2.59	C	M					R			R					R	R	A	A	R					R	R	R	R		R								R				R			F					R	R					
	apt 8	2.09	C	M				R	R			R					R	R	A	C	R	F		R		R	R	R				R							R		R					R				R		R	R				
	apt 6	1.32	C	M			R	R	R	R					R			R	A	A	R	R	R			R	R	R	R						R	R			R							C					R		R				
	apt 5	1.05	C	M													R		A	A	F	R		R		R	R	R			R	R														C					R						
	apt 4	0.60	C	M	R		R	R	R								R		A	A	F					R	R	R	R			R							R		R					R				R			R				

Appendix 1. Distribution chart of calcareous nannofossils detected at Bottaccione from the Upper Aptian to the Upper Albian.

STAGE	SAMPLE	METER	Total abundance	Preservation	B.constans	Large B. constans	C. litterarius	C. surirellus	M. chiastus	C. margerelii	E. turriseiffelii	E. trabeculatus	L. carniolensis	M. pemmatoidea	P. achlyostaurion	P. angustus	R. fenestratus	W. barnesae	W. communis	W. manivitae	Z. diplogrammus	B. regularis	C. conicus	P. embergeri	D. rotatorius	F. oblongus	P. asper	T. stradneri	D. lehmanii	C. coronadventis	P. varius	L. floralis	Z. xenotus	C. ehrenbergii	P. splendens	C. angustiforatus	T. orionatus	B. africana	G. nanum	Z. elegans	C. dispar	B. gammation	V. stradneri	Broinsonia sp.	B. signata	L. acutus	P. spinosa	Nannoconus cf. truittii	V. matalosa	B. lata	N. truittii	P. cretacea	C. kennedyi	Praediscosphaera sp.	A. albianus	E. trabeculatus	C. exiguum	P. columnata	R. terebrodentarius	C. achylosum	Braarudosphaera sp.	Q. eneabrachium	E. monechiae	Corollithion sp.	
CENOMANIAN	B 482	100.7	F	P	R			R			R			R				A	A	R	R		R		R		R																																R						
	B 478	100.1	F	P		R					R				R			A	A	R	R			R			R																										R	R	R											
	B 474	99.61	C	P	R	R		R	R		R							A	C	R	F			R	R														R										R		R		R	R								R			
	B 471	98.95	C	P		R		R	R		R	R						A	C	R	R			R	R		R							R			R																R					R			R					
	B 469	98.66	F	P				R	R				R					A	C	R	R				R																	R																														
	B 465	98.06	C	P		R	R	R			R		R	R	R			A	F	R	R		R	R			R							R																								R	R											
	B 463	97.71	C	P						R	R		R					A	C	R	R																																						R	R		R										
	B 458	97.09	C	P		R			R	R	R			R	R			A	C	R	R		R	R	R																				R								R											
	B 455	96.64	F	P	R		R	R			R		R				A	F	R	R		R	R	R							R									R												R													R			
	B 451	96.39	F	P	R			R	R				R			R		A	C	R	R						R																																R	R	R										
	B 447	96.03	F	P			R				R		R		R			A	A	R	R			R			R																									R				R	R	R										
	B 445	95.63	C	P	R						F		R					A	A	R	R			R	R		R					R																																			R					
	B 439	95.16	F	P			R		R		R		R	R		R		A	A	R	R		R	R			R					R							R			R		R		R		R				R		R	R					R					
	B 435	94.62	F	P	R			R	R	R	R				R	R		A	A	R	R		R	R								R																				R							R		R				
	B 431	94.18	F	P		R	R	R	R		R							A	A	R	R			R									R	R											R								R						R					
	B 428	93.65	F	P				R			R		R	R	R	R		A	A		R						R					R		R									R									R	R	R	R				R		R					
	B 422	93.16	F	P	R	R		R	R		R	R		R		R		A	C	R	R					R		R																R	R				R						R						R					
	B 419	92.64	F	P		R		R			R		R			R	R		A	C	R	R		R	R								R										R	R									R			R											
	B 416	92.19	F	M		R		F		R	R		R						A	C	R	R		R		R						R																									R	R				R						
	B 412	91.66	F	P	R			R	R	R	R		R			R		A	R	R	F		R	R			R					R		R					R	R													R	R	R					R						
	B 409	91.14	F	P		R	R	R	R	R	R			R				A	F	R	F				R			R				R					R																			R		R								R			
	B 404	90.72	F	P	R	R		R	R	R	R		R				A	C	R	F			R			R					R		R			R				R		R									R													
	B 400	90.27	F	P	R	R	R	R			R					R	R		A	C	R	F		R	R			R																					R	R				R	R			R									
	B 396	89.8	F	P		R		R	R		R		R	R				A	C	R	R		R	R	R		R					R																R								R	R												
	B 393	89.4	F	P		R		R	R		R		R					A	C	R	R			R	R		R					R		R			R																		R	R	R										
	B 388	88.58	F	P		R	R	R	R		R			R				A	C	R	R					R		R					R		R							R	R		R											R											
	B 385	88.09	F	P	R	R	R	R	R		R	R	R						A	A	R	R			R			R					R						R																	R	R									R			
	B 382	87.74	F	P	R	R		R	R		R		R	R				A	C	R	R		R		R																							R				R																				
	B 376	87.14	F	P		R		R	R							R		A	F	R	R			R			R	R				R		R			R																				R		R		R			R	R						
	B 371	86.64	C	P	R	R		R	R				R	R	R			A	C	R	F		R		R		R					R										R															R		R	R										
	B 364	85.65	C	P	R	R		R	R		R				R			A	C	R	R			R			R					R		R			R			R			R							R													R				
	B 354	84.64	R	P		R		R	R						R	R		A	C	R	R																								R									R			R										
	B 348	83.8	R	P	R						R							A	C	R	F				R		R																																																
	B 344	83.57	F	P	R	R		R	R		R			R		R		A	C	R	R			R	R								R													R																R			
	B 336	82.65	C	P		R	R	R	R		R		R				A	C	R	R		R	R	R		R	R						R		R														R		R					R								
	B 326	81.64	F	P	R	R	R		R								A	A	R	R			R	R																											R			R	R												
	B 317	80.68	C	P	R			R	R					R	R			A	A	R	R		R		R		R															R															R													
	B 307	79.7	F	P	R		R		R		R		R			R		A	R	R	F		R	R	R		R							R							R			R	R						R																
	B 299	78.74	F	P				R	R		R							A	F	R	C			R	R		R					R		R						R	R							R				R	R	R												
	B 298	78.65	F	P		R	R	R			R							A	C	R	R		R		R		R							R			R					R		R									R									R			
	B 287	77.62	F	P	R	R		R	R		R		R			R	R		A	A	R	R		R	R			R												R			R	R		R									R	R												
	B 278	76.61	F	P	R		R		R		R				R			A	A	R	R		R	R			R							R																			R	R												
	B 273	75.86	C	M	R	R		R	R		R			R		R		A	C	F	R			R			R	R				R				R												R				R	R	R	R											
	B 272	75.7	F	P	R		R	R		R	R		R					A	C	R	R			R			R																									R														
	B 264	74.75	F	P	R		R	R	R		R			R	R			A	C	R	F			R			R										R				R			R							R													
	B 263	74.68	R	P	R	R		R	R		R		R						A	F	R	R																					R	R			R							R		R											
	B 252	73.75	R	P	R	R		R			R			R				A	R	R	C		R	R			R																	R						R				R										R			
	B 241	72.72	F	P	R	R	R	R			R							A	R	R	F			R	R		R					R		R						R	R		R												R												
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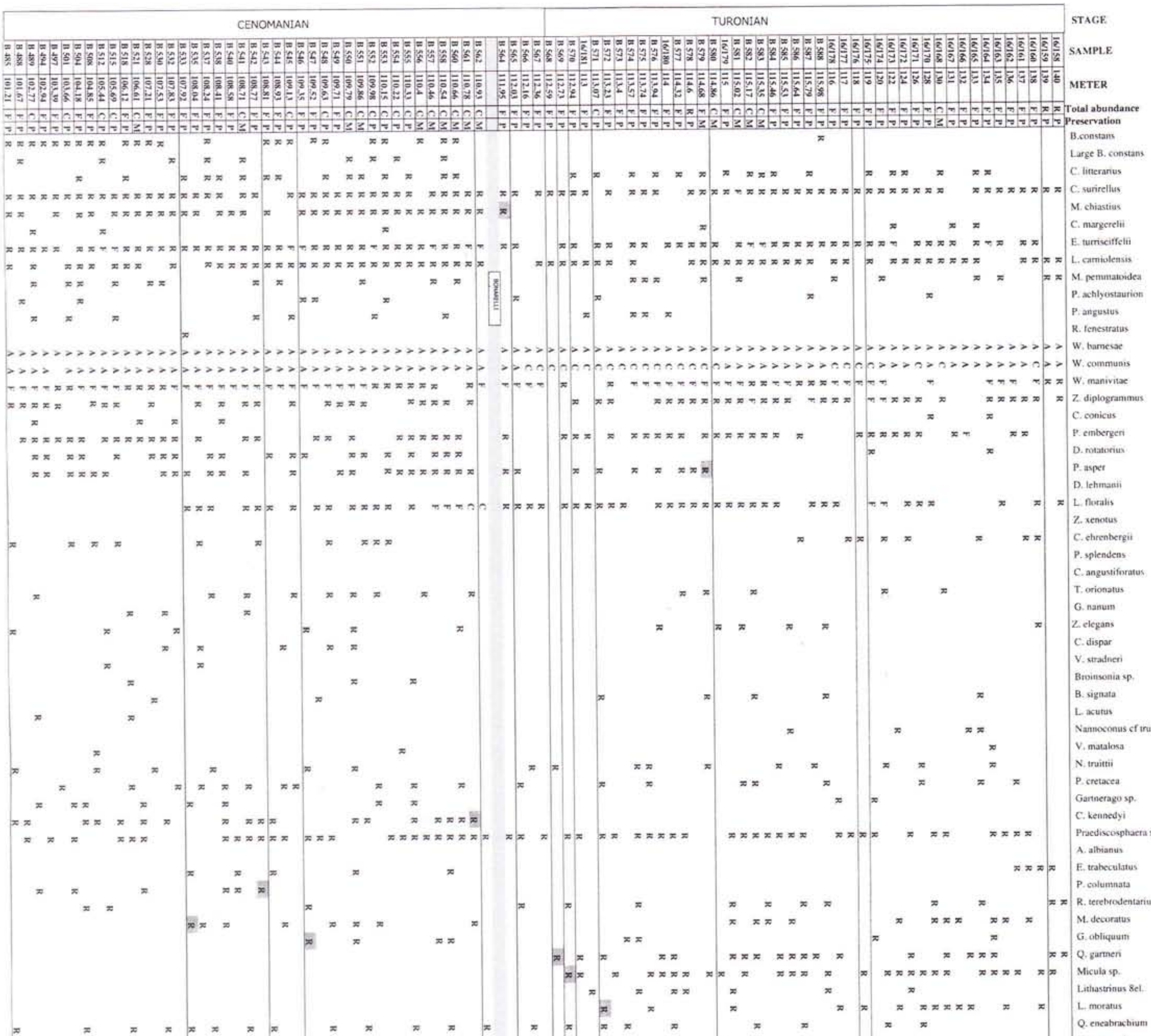
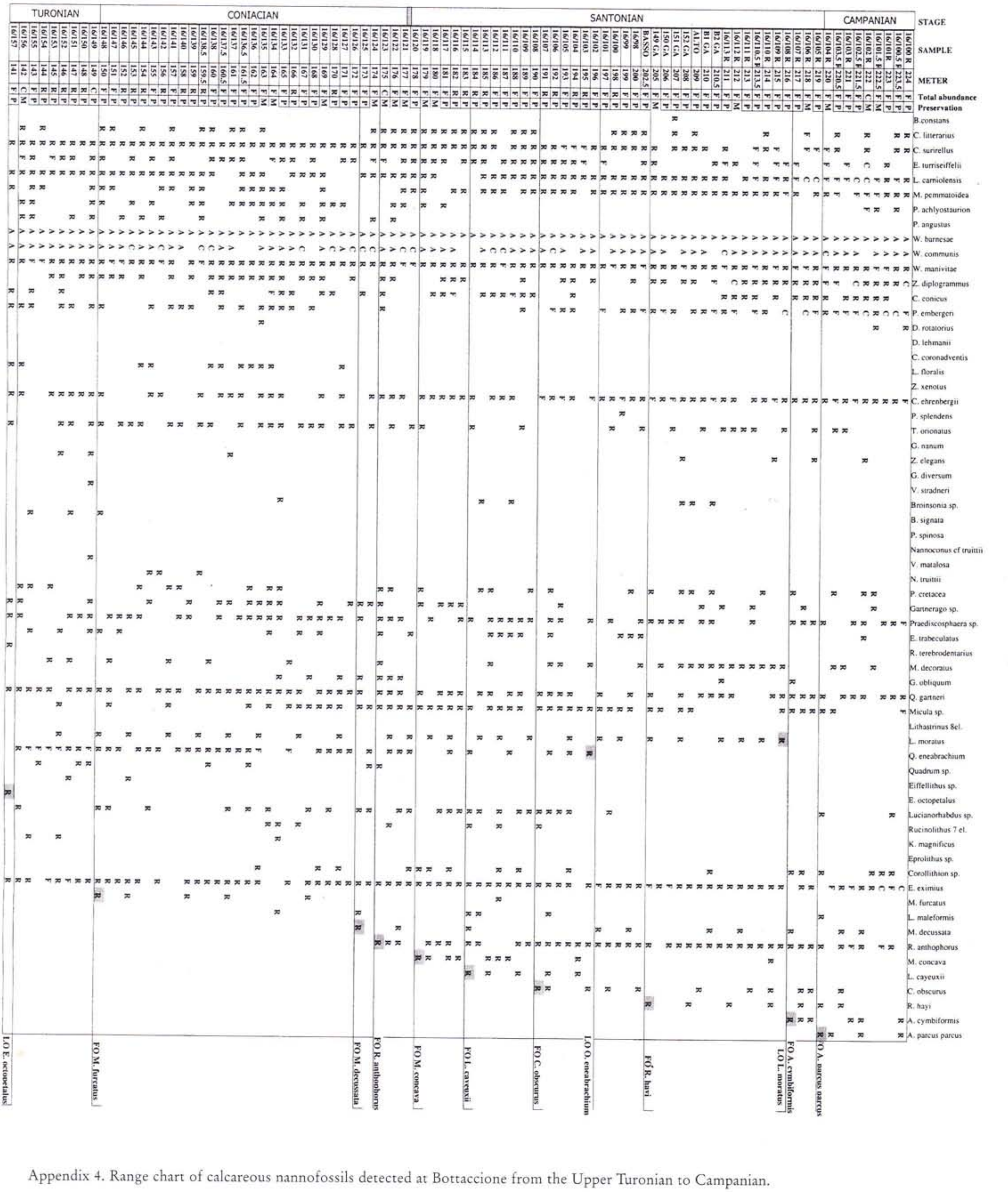
	B 216	70.63	F	P	R			R			R			R				A		R	F			R	R	R								R			R			R												R		R												
	B 215	70.5	F	P	R			R								R		A	A	F	F			R			R							R			R																	R	R	R		R									
	B 212	70.23	F	P	R	R		R	R		R		R		R			A	A	R	F			R				R				R																							R			R										
	B 204	69.65	F	P	R			R			R			R		R		A	A	R	C		R		R		R					R		R			R			R																R														
	B 197	69.15	F	P	R			R			R				R			A	A	R	C			R			R							R							R													R														
	B 193	68.74	C	P	R	R	R				R							A	C	R	F				R		R					R				R	R			R																R												FO C. kennedyi
	B 184	67.8	F	P	R	R					R		R					A	C	R	R		R									R																																									
	B 177	66.55	F	P	R	R		R	R		R		R	R		R		A	C	R	R		R	R	R							R		R			R						R												R												
	B 169	66.45	F	M	R			R	R	R	R		R		R			A	C	R	R			R	R		R			R		R		R									R														R							R			
	B 162	65.89	R	P						R	R			R	R			A	A	R	F		R	R								R														R						R															
	B 161	65.8	F	P	R	R	R	R	R		R								A	A	R	F		R											R						R																R													
	B 154	64.71	F	P					R		R				R			A	C	R	F			R			R																											R																					
	B 150	64.34	F	P			R		R		R		R	R				A	F	R	C		R	R	R		R					R		R	R		R						R																							
	B 145	63.79	F	P	R			R			R		R						A	F	R	R		R											R						R	R											R	R														
	B 144	63.68	R	P			R	R					R			R		A	F	R	C				R							R																																											
	B 142	63.55	F	P				R		R				R	R			A	C	R	C		R	R			R	R				R						R																		R	R												
	B 136	63.05	F	P	R			R					R					A	C	R	C				R									R	R						R															R	R									R			
	B 134	62.75	F	P			R	R	R		R		R			R	R	A	C	R	F		R		R		R												R																R	R												
	B 133	62.58	F	P			R		R		R							A	C	F	C			R			R							R						R	R														R	R												
	B 129	62.02	F	P		R	R	R					R						A	A	R	C		R	R		R	R							R							R		R					R		R	R		R						R				
	B 126	61.7	F	P		R		R	R				R						A	C	R	F											R									R									R																								
	B 125	61.49	F	P		R	R	R			R		R	R	R		R	A	A	R	F					R	R		R												R				R		R											R													R
	B 123	61.36	F	P		R		R			R		R						A	C	R	C		R	R	R		R							R								R							R			R			R											
ALBIAN	B 117	61.12	C	M		R		R			R		R						A	C	R	C				R									R		R			R	R											R	R		R										
	B 113	60.61	C	M	R	R	R	R		R	R		R						A	C	R	F												R		R								R																									
	B 104	59.91	C	B	R	R	R	R	R		R		R		R			A	C	R	C			R			R			R		R		R		R			R			R			R						R				R				R										
	B 103	59.72	F	P	R	R		R			R		R	R				A	C	R	C		R				R					R		R						R											R																	
	B 95	58.64	F	P							R		R					A	C	F	R				R		R					R		R						R											R			R												
	B 93	58.36	C	M		R		R			R		R		R			A	C	R	C			R			R							R	R								R											R											R			
	B 90	57.9	C	M	R	R	R	R		R	F		R				R		A	C	R	C		R				R		R			R		R						R																												
	B 88	57.77	F	P	R	R		R	R		R		R		R			A	C	R	C			R								R		R																																			R
	B 87	57.72	F	P	R	R		R			R		R					A	C	R	C						R							R																								R										
	B 86	57.68	C	M		R	R	R	R		R		R			R		A	A	F	R			R	R	R		R		R				R						R	R											R															
	B 84	57.53	C	P	R			R			R		R	R	R			A	A	R	F		R	R			R							R							R												R								R			
	B 82	57.21	C	M	R			R			R		R						A	C	R	C			R	R	R			R																	R										R																
	B 79	56.87	F	P	R			R	R		R		R	R	R			A	C	R	R		R	R			R		R														R										R																
	B 78	56.75	F	P	R	R		R			R		R	R		R		A	A	F	C			R	R		R																R										R				R										
	B 77	56.66	C	M	R		R	R			R		R				R	A	A	R	C		R	R	R		R	R						R	R																		R											R	R		
	B 74	56.35	F	P	R			R			R		R		R		R	A	A	R	C				R	R				R						R						R											R														
	B 68	55.74	R	P	R			R	R		R		R	R				A	A	R	C			R	R															R																														

Appendix 2. Range chart of calcareous nannofossils detected at Bottaccione from the Upper Albian to the Upper Cenomanian.



Appendix 3. Range chart of calcareous nannofossils detected at Bottaccione from the Upper Cenomanian to the Upper Turonian.



Appendix 4. Range chart of calcareous nannofossils detected at Bottaccione from the Upper Turonian to Campanian.