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APTIAN - ALBIAN CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE SCISTI A FUCOIDI CORED AT PIOBBICO (CENTRAL ITALY)

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Riassunto. La formazione degli Scisti a Fucoidi, estesamente affiorante nel Bacino Umbro-Marchigiano (Italia centrale), è una successione pelagica ciclica depositatasi durante l'intervallo Aptiano-Albiano. I litotipi dominanti sono marne e marne calcaree cui si intercalano calcari marnosi, argille marnose ed argille. Spettacolari sono le variazioni cromatiche, con colori dal grigio, al verde oliva, al rosso, al marrone, al nero. Frequenti sono i livelli di "black shales", spesso modulati ciclicamente.

Uno studio biostratigrafico di dettaglio basato sui Nannofossili calcarei è stato intrapreso sugli Scisti a Fucoidi carotati a Piobbico (Marche). L'abbondanza totale delle nannoflore mostra fluttuazioni correlabili con le variazioni litologiche, così pure il grado di conservazione oscillante da moderato a scarso. I Nannofossili calcarei hanno permesso di ottenere per il Pozzo Piobbico una risoluzione biostratigrafica più dettagliata. Sono stati riconosciuti dieci bio-orizzonti basati su: la prima comparsa (PC) di *Lithastrinus floralis*, la PC di *Parhabdolithus angustus*, l'ultima comparsa (UC) di *Assipetra infracretacea*, la PC di *Nannoconus regularis*, la PC di *Prediscosphaera columnata*, la PC di *Cribrosphaerella ehrenbergii*, la PC di *Axopodorhabdus albianus*, la PC di *Biscutum magnum*, la PC di *Parhabdolithus achlyostaurion*, e la PC di *Eiffellithus turriseiffelii*. In base a prime comparse sono state determinate cinque zone di intervallo, di cui due sono di nuova istituzione e due di nuova definizione. La parte basale della carota è stata attribuita alla porzione superiore dell'intervallo stratigrafico corrispondente alla Zona a *Chiastozygus litterarius*, mentre la parte sommitale della carota è stata attribuita alla porzione inferiore dell'intervallo stratigrafico corrispondente alla Zona a *Eiffellithus turriseiffellii*.

L'integrazione della nannobiostratigrafia con lo schema biostratigrafico basato sui Foraminiferi planctonici ha dato come risultato una migliore calibratura degli orizzonti bio- e cronostratigrafici. La nannobiostratigrafia è stata inoltre verificata in un contesto più regionale, nell'ambito del Bacino Umbro-Marchigiano, ottenendo correlazioni più accurate e una più precisa valutazione delle lacune.

Abstract. The Aptian-Albian Scisti a Fucoidi, widespread in the Umbrian-Marchean Basin (Central Italy), consist of a pelagic cyclic varicolored sequence of marls, marly limestones and «black shales». A core was drilled through this formation at Piobbico (Marche) and a detailed biostratigraphic investigation based on calcareous nannofossils was undertaken.

The total abundance of the nannofloras shows relatively high fluctuations depending on the lithology. The preservation is moderate to poor. In the Piobbico core calcareous nannofossils yielded an improved biostratigraphic resolution. Ten biohorizons were recognized: the first occurrence (FO) of *Lithastrinus floralis*, the FO of *Parhabdolithus angustus*, the last occurrence (LO) of *Assipetra infracretacea*, the FO of *Nannoconus regula-*

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ris, the FO of *Prediscosphaera columnata*, the FO of *Cribrosphaerella ehrenbergii*, the FO of *Axopodorhabdus albianus*, the FO of *Biscutum magnum*, the FO of *Parhabdolithus achlyostaurion*, and the FO of *Eiffellithus turriseiffelii. On the basis of first occurrences five interval zones were recognized, of which two are new and two are redefined. The base of the core was attributed to the upper portion of the stratigraphical interval corresponding to the Chiastozygus litterarius* Zone, whereas the top of the core was attributed to the lower portion of the stratigraphical interval corresponding to the *Eiffellithus turriseiffelii* Zone.

The nannobiostratigraphy was integrated with the planktonic foraminiferal scheme. An improved calibration of bio- and chronostratigraphic horizons was achieved. The proposed nannobiostratigraphic framework was also verified in other sections, within the Umbrian-Marchean Basin. More precise correlations and better estimates of hiatuses were obtained.

Introduction.

The Umbrian-Marchean sequence of the central Italian Apennines represents an essentially continuous record of pelagic- hemipelagic deposition extending from Jurassic through the Paleogene. This sequence is a classical reference section for several regional studies including detailed descriptions of lithostratigraphy, biostratigraphy, and magnetostratigraphy (e.g. Alvarez et al., 1977; Arthur & Fischer, 1977; Premoli Silva, 1977; Wonders, 1979; Lowrie et al., 1980; Monechi, 1981; Arthur & Premoli Silva, 1982; Cirilli et al., 1984; Lowrie & Alvarez, 1984; Lowrie & Channel, 1984; Coccioni et al., 1987; Bralower, 1987).

The Aptian-Albian Scisti a Fucoidi formation represents, within the Umbrian-Marchean sequence, a shaly interval consisting of thinly interbedded red and green marlstones and calcareous mudstones, dark gray to black calcareous shales, and light greenish-gray limestones. The formation is strickingly cyclic.

In order to investigate the characteristics and the origin of these rhythmically deposited pelagic sediments, a continuous 84 meter section of core was drilled through the Scisti a Fucoidi at Piobbico (prov. Pesaro-Urbino, Central Italy). Lithostratigraphy, sedimentary structures, biostratigraphy, paleontology,organic and inorganic geochemistry and remanent magnetism of the core are being studied by a consortium of Italian and American scientists (Premoli Silva et al., 1983; Fischer et al., 1985; Erba, 1986; Herbert & Fischer, 1986; Herbert et al., 1986; Pratt & King, 1986; Herbert, 1987; Premoli Silva et al., 1987).

The chronology is a crucial starting-point for any speculation regarding accumulation rates and rhythmicity patterns. For this purpose calcareous planktonic biostratigraphy was applied to the Piobbico core. The present paper deals with the calcareous nannofossil biostratigraphy, its integration with the planktonic foraminiferal zonal scheme and its validity and applicability in a more regional framework.

Location of the drilling site and lithostratigraphy.

The Piobbico core was drilled at "Le Brecce", located 3 km West of the town of Piobbico (Marche, Italy), at km 33 of the Apecchiese road (Fig. 1). The core penetrated

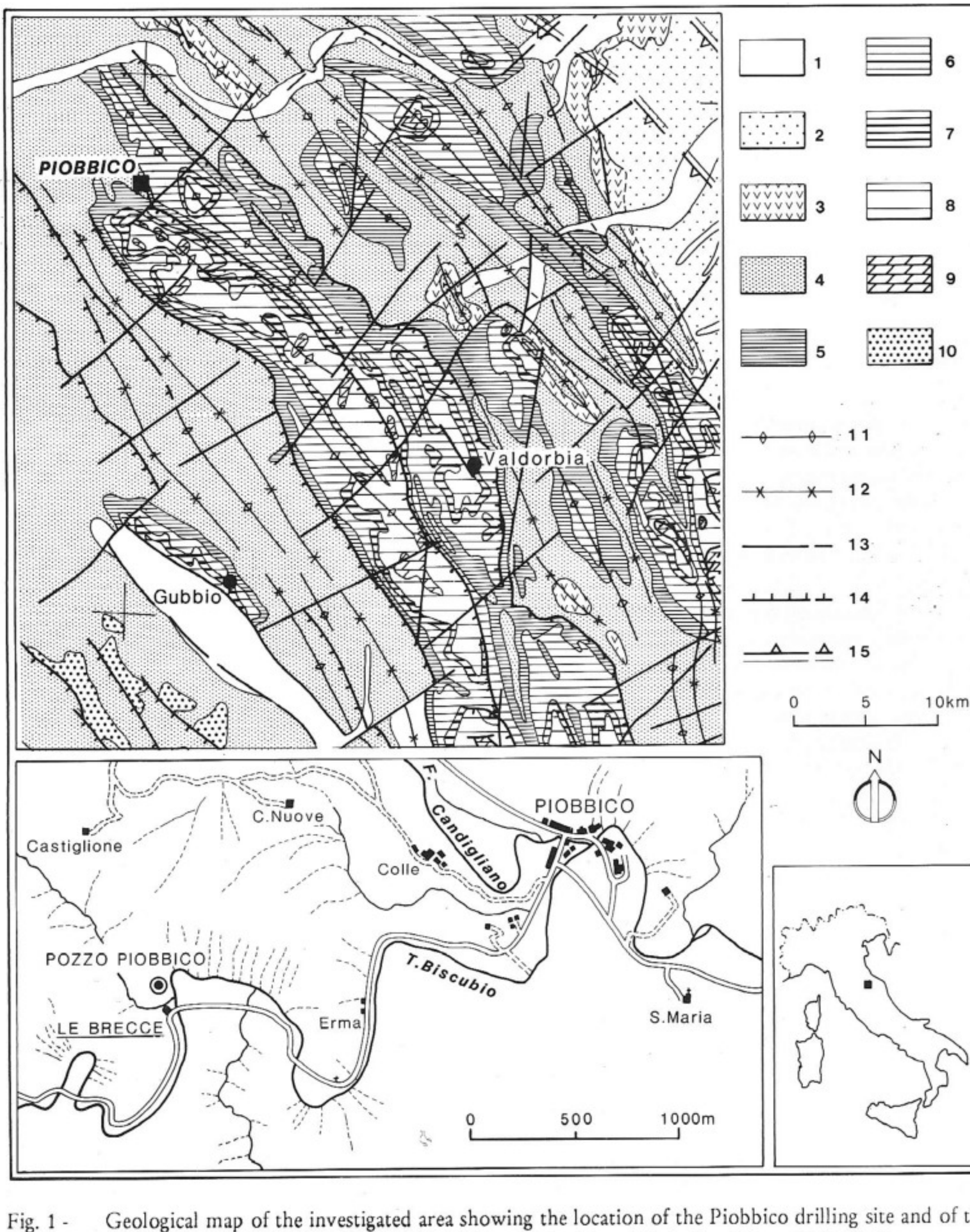

Fig. 1 - Geological map of the investigated area showing the location of the Piobbico drilling site and of the sections studied by Monechi (1981) and here revised (modified after Erba, 1986). 1) Quaternary - Pliocene continental facies; 2) Quaternary - Pliocene marine terrigenous facies; 3) Messinian evaporitic facies; 4) Miocene marine terrigenous facies; 5) Oligocene - Paleocene pelagic facies; 6) Upper Cretaceous pelagic facies; 7) mid-Cretaceous pelagic facies (= Scisti a Fucoidi formation); 8) Lower Cretaceous - Lower Jurassic pp. pelagic facies; 9) Lower Jurassic pp. - Upper Triassic carbonate platform facies; 10) allochthonous units; 11) anticline; 12) syncline; 13) fault; 14) thrust; 15) buried inverse fault.

the entire Scisti a Fucoidi including the upper transition to the Scaglia Bianca and the lower passage to the Maiolica. The total length of the core is 84 meters, with 98% recovery. Taking into account the mean bedding dip of 23°, the corrected thickness of the drilled section is 77.28 meters. Of these 77.28 meters, 70.65 meters correspond to the Scisti a Fucoidi, 5.18 meters correspond to the transition with the underlying Maiolica, and 1.45 meters correspond to the Maiolica.

Detailed lithostratigraphic and sedimentological analyses (Erba, 1986; Tornaghi et al., in prep.), including dominant colors and how they alternate, carbonate contents, and occurrence or absence of «black shales», allowed us to distinguish 19 units within the cored sequence (Fig. 2). The description of these units is here reported from top to bottom.

1) Marls, predominantly grey-green in color, 1 - 5 cm thick, with interbedded 5 cm thick varicolored grey and pink marls and 3 cm thick subordinate white-grey limestones. A single 2 cm thick very dark grey, marly clayey layer ("black shale") is present. Abundant 1 - 2 cm thick white-grey chert lenses. Rare radiolarian calcarenitic horizons (>50% radiolarians/ cm^2). Abundant dark grey wispy burrows.
$CaCO_3$: 62% to 75% (mean 70%).
Thickness: 2.18 m (0 m to 2.18 m);

2) marly limestones, grey-green to white-grey in color, 3 - 18 cm thick, with rare 2 - 3 cm thick white limestones. Frequently interbedded, 1 - 9 cm thick, dark grey-black clayey marls ("black shales") (n. = 40). Frequent radiolarian calcarenitic horizons, approximately equispaced from the top of this unit to 13.43 m. From 13.52 m to the base of this unit, both the "black shales" and the radiolarian horizons decrease in frequency and in interval spacing. Frequent dark grey wispy burrows. Fucoids juxtaposed below and above the "black shales".
$CaCO_3$: 42% to 85% (mean = 65%).
Thickness: 13.53 m (2.18 m to 15.71 m);

3) marls, brown-red in color and 2 - 20 cm thick, alternating with marly limestones, grey-green in color and 1 - 5 cm thick. Two, 3 cm thick, clayey marls ("black shales"). Radiolarian calcarenitic horizons absent. Fucoids present directly below the "black shales".
$CaCO_3$: 52% to 71.5% (mean = 59%).
Thickness: 2.35 m (15.71 m to 18.06 m);

4) marls, grey-green to light grey in color and 3 - 25 cm thick, alternating with subordinate limestones, light grey in color and 2 - 10 cm thick. Frequent, 1 - 6 cm thick, very dark grey-black marls ("black shales") (n. = 8). Rare radiolarian calcarenitic horizons. Abundant dark grey wispy burrows. Fucoids concentrated below and above the "black shales".
$CaCO_3$: 28.6% to 71.5% (mean = 58%).
Thickness: 3.76 m (18.06 m to 21.82 m);

5) marls, brown-red in color and 5 - 25 cm thick, with subordinate interbedded marly limestones, white-grey in color and 1 - 5 cm thick. "Black shales" absent. Rare radiolarian calcarenitic horizons. Rare dark grey wispy burrows.
$CaCO_3$: 52% to 71.5% (mean = 62%).
Thickness: 1.39 m (21.82 m to 23.21 m);

6) marly limestones and marls, grey-green to white-grey in color and 10 - 30 cm thick, in the upper portion grading to predominately marls, grey-green in color and 5 - 30 cm thick, in the lower portion. Frequent, 4 - 12 cm thick, very dark grey- black clayey marls ("black shales") (n. = 11). Frequent, approximately equi-

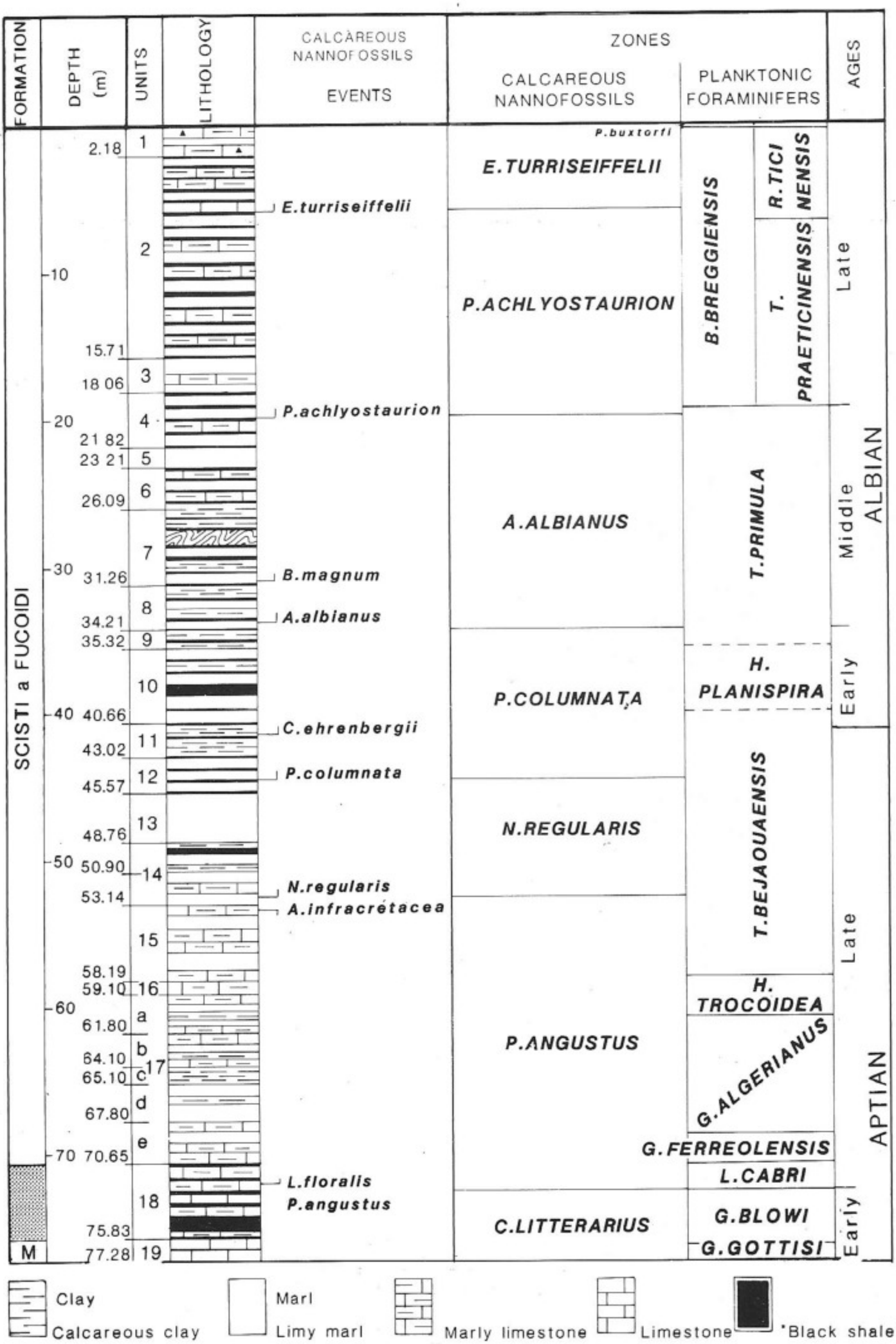

Fig. 2 - Lithostratigraphy and integrated calcareous nannofossil - planktonic foraminiferal biostratigraphy of the Piobbico core. Unit 18 is the transition between the Scisti a Fucoidi and the Maiolica formations. The lower portion of this unit corresponds to the regional spread Livello Selli (Wezel, 1985; Coccioni et al., 1987).

spaced, radiolarian calcarenitic horizons, solely in the upper part of the unit down to 24.60 m. Frequent dark grey wispy burrows. Fucoids juxtaposed above and below the "black shales".
$CaCO_3$: 8.9% to 62% (mean = 50%).
Thickness: 2.88 m (23.21 m to 26.09 m);

7) marls, grey-green in color and 5 - 30 cm thick, and frequently interbedded marly clays and clays, olive-green to dark grey in color and 2 - 10 cm thick. Abundant, 1 - 8 cm thick, very dark grey-black clays ("black shales") (n. = 19). Radiolarian calcarenitic horizons absent. Abundant very dark grey wispy burrows. Fucoids juxtaposed above and below the "black shales".
Between 27.42 m and 27.74 m folded laminae, of probably tectonic origin, associated with calcitic lenses.
$CaCO_3$: 8.9% to 62% (mean = 40%).
Thickness: 5.17 m (26.09 m to 31.26 m);

8) marly clays, grey-green in color and 3 - 20 cm thick, with subordinate marls and limy marls, light grey in color and 2 - 10 cm thick. Frequent, 1 - 9 cm thick, very dark grey-black clays and clayey marls ("black shales") (n. = 7). Radiolarian calcarenitic horizons absent. Rare dark grey wispy burrows. Abundant fucoids concentrated adjacent to the "black shales".
$CaCO_3$: 8.9% to 62% (mean = 35%).
Thickness: 2.95 m (31.26 m to 34.21 m);

9) clayey marls and marls, grey-green in color or occasionally variegated grey-brown and 5 - 20 cm thick, alternating with clays, brown or rarely brown-green varicolored and 5 - 20 cm thick. A single homogeneous millimeter thick green-turquoise lamina (at 37.77 m). Three, 3 - 5 cm thick, very dark grey-black marly clays ("black shales"). A single radiolarian calcarenitic horizon. Rare dark grey wispy burrows. Frequent fucoids juxtaposed above and below the "black shales".
$CaCO_3$: 8.9% to 51.2% (mean = 25%).
Thickness: 1.11 m (34.21 m to 35.32 m);

10) marls, grey-green to light grey in color and 3 - 25 cm thick, and rare limy marls, light grey in color and 2 - 10 cm thick. Frequent, 1 - 24 cm thick, very dark grey-black clays and clayey marls ("black shales") (n. = 13). Rare radiolarian calcarenitic horizons. A single homogeneous millimeter thick green-turquoise lamina (at 35.93 m). Few pyrite nodules at 39.13 m. Abundant dark grey wispy burrows. Abundant fucoids adjacent to the "black shales".
$CaCO_3$: 8.9% to 51.2% (mean = 30%).
Thickness: 5.34 m (35.32 m to 40.66 m);

11) marly clays and clays, predominantly dark brown in color or occasionally brown-green varicolored and 2 - 20 cm thick, and rare marls, dark brown in color and 1 - 5 cm thick. Frequent, 1 - 6 cm thick, very dark grey-black clays ("black shales") (n. = 14). Rare radiolarian calcarenitic horizons. Frequent dark grey wispy burrows. Abundant fucoids, clustered adjacent to the "black shales".
$CaCO_3$: 2.8% to 50% (mean = 17%).
Thickness: 2.36 m (40.66 m to 43.02 m);

12) marls, predominantly grey-green in color or rarely green-brown varicolored and 3 - 10 cm thick. A single, 5 cm thick, light grey limy layer (45.35 - 45.40 m). Rare, 1 - 8 cm thick, very dark grey-black marly clays ("black shales") (n. = 4). Abundant radiolarian calcarenitic horizons. Abundant dark grey wispy burrows. Abundant fucoids, expecially concentrated adjacent to the "black shales".
$CaCO_3$: 8.9% to 62% (mean = 40%).
Thickness: 2.55 (43.02 m to 45.57 m);

13) marls, dark red to grey-red in color and 2 - 20 cm thick, and subordinate limy marls, grey-green in color and 3 - 20 cm thick. Rare, 3 - 5 cm thick, dark red clays. "Black shales" absent. Rare radiolarian calcarenitic horizons. Rare dark grey wispy burrows and fucoids.

$CaCO_3$: 8.9% to 62% (mean = 48%).
Thickness: 3.19 m (45.57 m to 48.76 m);

14) this unit is divided into two subunit.
Subunit 14a: marls, grey-green to light grey in color and 3 - 20 cm thick, with interbedded marly clays, and clays, dark olive-grey in color and 2 - 10 cm thick. A single, 16 cm thick, black marly layer ("black shale"). Rare radiolarian calcarenitic horizons. Frequent dark grey wipsy burrows. Frequent fucoids.
Subunit 14b: ;arls, grey-green in color and 2 - 30 cm thick, alternating with marly limestones, light grey in color and 3 - 10 cm thick. Rare marly clays, dark olive-grey in color and 2 - 5 cm thick. "Black shales" absent. Rare radiolarian calcarenitic horizons, Frequent dark grey wispy burrows. Frequent fucoids.
$CaCO_3$. Subunit 14a: 8,9% to 71.5% (mean = 48%); Subunit 14b: 28.6% to 71.5% (mean = 60%).
Thickness. Subunit 14a: 2.14 m (48.76 m to 50.90 m); Subunit 14b: 2.24 m (50.90 m to 53.14 m); total thickness: 4.38 m (48.76 m to 53.14 m);

15) marly limestones, dark red to brown-red in color or occasionally red-green varicolored and 3 - 20 cm thick, and subordinate marls, grey-green in color and 2 - 10 cm thick. Rare marly clays, dark red in color and 2 - 10 cm thick. "Black shales" absent. Frequent radiolarian calcarenitic horizons, evenly spaced. Frequent dark grey wipsy burrows. Rare fucoids.
$CaCO_3$: 8.9% to 71.5% (mean = 58%).
Thickness: 5.05 m (53.14 m to 58.19 m);

16) marly limestones, predominantly grey-green in color or green- red varicolored and 5 - 40 cm thick, alternating with limy marls, red-brown or grey-green in color and 2 - 10 cm thick. "Black shales" absent. Frequent radiolarian calcarenitic horizons, evenly spaced. Frequent dark grey wipsy burrows. Rare fucoids.
$CaCO_3$: 51.2% to 71.5% (mean = 65%).
Thickness: 0.91 m (58.19 m to 59.1 m);

17) this unit is divided into 5 subunits.
Subunit 17a: marly limestones, dark red and occasionally green in color and 3 - 20 cm thick, and subordinate marls, dark red in color and 5 - 15 cm thick. Rare marly clays, dark red to brown- red in color and 5 - 10 cm thick. "Black shales" absent. Frequent radiolarian calcarenitic horizons. A single pyrite lense (at 60.72 m). Frequent dark grey wispy burrows.
Subunit 17b: closely spaced alternating marly limestones, marls and clayey marls. All lithology are dark red in color and 2 - 15 cm thick. Rare clays, dark brown-red in color and 5 cm thick. "Black shales" absent. Frequent radiolarian calcarenitic horizons. Frequent dark grey wispy burrows.
Subunit 17c: marly clays, dark red-brown in color and 5 - 40 cm thick, and subordinate marls, dark red in color and 3 - 15 cm thick. "Black shales" absent. Frequent radiolarian calcarenitic horizons. Frequent dark grey wispy burrows.
Subunit 17d: marls, dark red in color and 3 - 35 cm thick, and subordinate marly limestones, dark red in color and 5 - 10 cm thick. Rare clays, dark red-brown in color and 2 - 10 cm thick. "Black shales" absent. Frequent radiolarian calcarenitic horizons. Frequent dark grey wispy burrows.
Subunit 17e: limy marls, dark red in color and 3 - 25 cm thick, with subordinate marls and marly limestones, dark red in color and 2 - 10 c m thick. "Black shales" absent. Frequent radiolarian calcarenitic horizons. Frequent dark grey wispy burrows.
$CaCO_3$. 17a: 8.9% to 71.5% (mean = 55%); 17b: 8.9% to 71.5% (mean = 48%); 17c: 28.6% to 51.2% (mean = 30%); 17d: 8.9% to 71.5% (mean = 40%); 17e: 51.2% to 71.5% (mean = 63%).
Thickness. 17a: 2.70 m (59.10 m to 61.80 m); 17b: 2.30 m (61.80 m to 64.10 m); 17c: 1 m (64.10 m to 65.10 m); 17d: 2.70 m (65.10 m to 67.80 m); 17e: 2.85 m (67.80 m to 70.65 m). Total thickness: 11.55 m (59.10 m to 70.65 m);

18) marly limestones and limy marls, grey-green in color and 2 - 20 cm thick, and interbedded marly clays, dark olive-grey in color and 2 - 10 cm thick. Abundant, 1 - 61 cm thick, very dark grey-black marly clays ("black shales") (n. = 19). Frequent radiolarian calcarenitic horizons, evenly spaced. Light green- grey

chert nodules between 71.62 m and 72.45 m. Pyrite nodules at 71.89 m and 73.86 m. Abundant very dark grey wispy burrows. Abundant fucoids juxtaposed above and below the "black shales". Abundant fish remains from 73.47 m to 73.68 m.
$CaCO_3$: 28.6% to 85% (mean = 60%).
Thickness: 5.18 m (70.65 m to 75.83 m);

19) limestones, light grey-green to whitish in color and 5 - 20 cm thick. Abundant 1 - 10 cm thick black clayey marls ("black shales") (n. = 12). Radiolarian calcarenitic horizons absent. Black chert nodules at 75.83 m. Very abundant dark grey wispy burrows. Rare fucoids.
$CaCO_3$: 50% to 90% (mean = 75%).
Thickness: 1.45 m (75.83 m to 77.28 m).

Units 1 to 17 correspond to the Scisti a Fucoidi formation. Unit 18 is the transition to the underlying Maiolica formation. The lower portion of this unit is correlatable with the Livello Selli established for the Umbrian-Marchean Basin by Wezel (1985) and described by Coccioni et al. (1987). This radiolaritic bituminous ichthyolithic marker-horizon represents an older analogue of the Livello Bonarelli (Cenomanian-Turonian boundary). The Livello Selli was recognized throughout all the Umbrian-Marchean Basin and it was demonstrated to be a synchronous event dated to the Early Aptian (*Chiastozygus litterarius* nannofossil Zone) (Coccioni et al., 1987). Coeval analogous horizons were reported also from the Southern Alps (Erba & Quadrio, 1987; transition from the Maiolica to the Scaglia Variegata).

Unit 19 corresponds to the Maiolica formation; the boundary is placed at the lowermost occurrence of black chert (75.83 m).

Biostratigraphy

Materials and methods.

A total of 77 samples from different lithologies were investigated. Preparation was kept simple: for each sample 5 grams of sediment was pulverized in distilled water in order to minimize mechanical breakage. A size-fractionation aiming to concentrate calcareous nannofossils was applied: five successive decantions in distilled water were carried out according to the methodology previously adopted by Monechi & Thierstein (1985) and Erba & Quadrio (1987).

The suspensions were permanently mounted with Canada Balsam and smear slides were analyzed with an optical polarizing microscope. Semiquantitative estimates of total and species abundances were performed at 1250 X. For each smear slide at least 500 fields of view were analyzed in random traverses.

Calcareous nannofossil biostratigraphy.

The Piobbico core corresponds to a time interval spanning the Aptian - Albian (Premoli Silva et al., 1983, 1987; Tacchino, 1985; Tornaghi et al., in prep.). Calcareous nannofossils are extensively used in mid- Cretaceous sequences and a few biozonations have been established so far in different provinces (Thierstein, 1971, 1973, 1976; Roth, 1973, 1978; Manivit, 1971; Manivit et al., 1977; Sissingh, 1977, 1978; Perch-Nielsen, 1979, 1985; Taylor, 1982; Wise, 1983; Jakubowski, 1987). The present biostratigraphy is mainly based on these schemes with minor integrations from Stradner (1963), Stover (1966), Cepek & Hay (1969, 1970), Worsley (1971), Bukry (1974), and Hill (1976).

Mid - Cretaceous Italian sequences from different sedimentary basins have previously been investigated for their calcareous nannofossil contents by Medizza (in Channell et al., 1979), Monechi (1981), Erba (in Erba & Quadrio, 1987).

In the Piobbico core, calcareous nannofossils show relatively high fluctuations in their total abundance depending on the lithology. Marlstones contain the most abundant and the best preserved nannofloras, lower frequencies and poorer preservation are verified both in limestones and in calcareous shales. Limy beds are mostly affected by recrystallization and calcite overgrowth, whereas dissolution is developped in shaly lithotypes. Only one sample (73.82 m) is devoid of calcareous nannofossils.

Tab. 1 summarizes th e tot al abundance of the nannofloras and the species distribution in the core. Samples are labelled in meters from top to bottom.

Ten biohorizons were recognized. From the oldest to the youngest they are: the first occurrence (= FO) of *Lithastrinus floralis* (m 71.61), the FO of *Parhabdolithus angustus* (m 71.61), the last occurrence (= LO) of *Assipetra infracretacea* (m 53.63), the FO of *Nannoconus regularis* (m 52.15), the FO of *Prediscosphaera columnata* (m 44.37), the FO of *Cribrosphaerella ehrenbergii* (m 41.07), the FO of *Axopodorhabdus albianus* (m 33.76), the FO of *Biscutum magnum* (m 30.75), the FO of *Parhabdolithus achlyostaurion* (m 19.56), and the FO of *Eiffellithus turriseiffelii* (m 5.50). Five interval zones were identified two of which are new (*Nannoconus regularis* and *Parhabdolithus achlyostaurion* Zones), and two are redefined (*Parhabdolithus angustus* and *Axopodorhabdus albianus* Zones). The zonal name derives from the entering taxon.

In Fig. 3 the nannostratigraphy established for the Piobbico core is compared with zonations previously proposed for the Tethyan region. The discrepancies among the various zonations are only apparent, because 1) all the Authors were using the same biohorizons for placing the zonal boundaries, and 2) the integration between the ammonite and the nannofossil biostratigraphy was recently modified according to new findings in the Vocotian Trough by Bréhéret et al. (1986) and Delamette et al. (1986) (see discussion below).

The lower portion of the core (from 71.61 m to 77.28 m), for the continuous common occurrence of *Rucinolithus irregularis* and the absence of both *Lithastrinus floralis* and *Parhabdolithus angustus* is correlatable with the upper portion of the stratigraphical interval corresponding to the *Chiastozygus litterarius* Zone of Thierstein (1973). The nannofossil assemblage is not very diversified. It comprises: common *Watznaueria barnesae*, rare/few *Parhabdolithus* sp., *P. embergeri*, *Rucinolithus* sp., *Nannoconus* sp., rare *Watznaueria communis*, *W. britannica*, *W. supracretacea*, *Lithraphidites carniolensis*, *Cretarhabdus* sp., *C. conicus*, *C. angustiforatus*, *C. surirellus*, *Parhabdolithus asper*, *Cyclagelosphaera margerelii*, *C. deflandrei*, *Discorhabdus rotatorius*, *Tegumentum stradneri*, *Rucinolithus irregularis* - 6 elements, *Vagalapilla stradneri*. *Chiastozygus litterarius* is extremely rare and *Nannoconus colomii* was never observed. *Braarudosphaera africana* was first observed near the top of this stratigraphical interval.

On the basis of these data this portion of the core is Early Aptian p.p. in age.

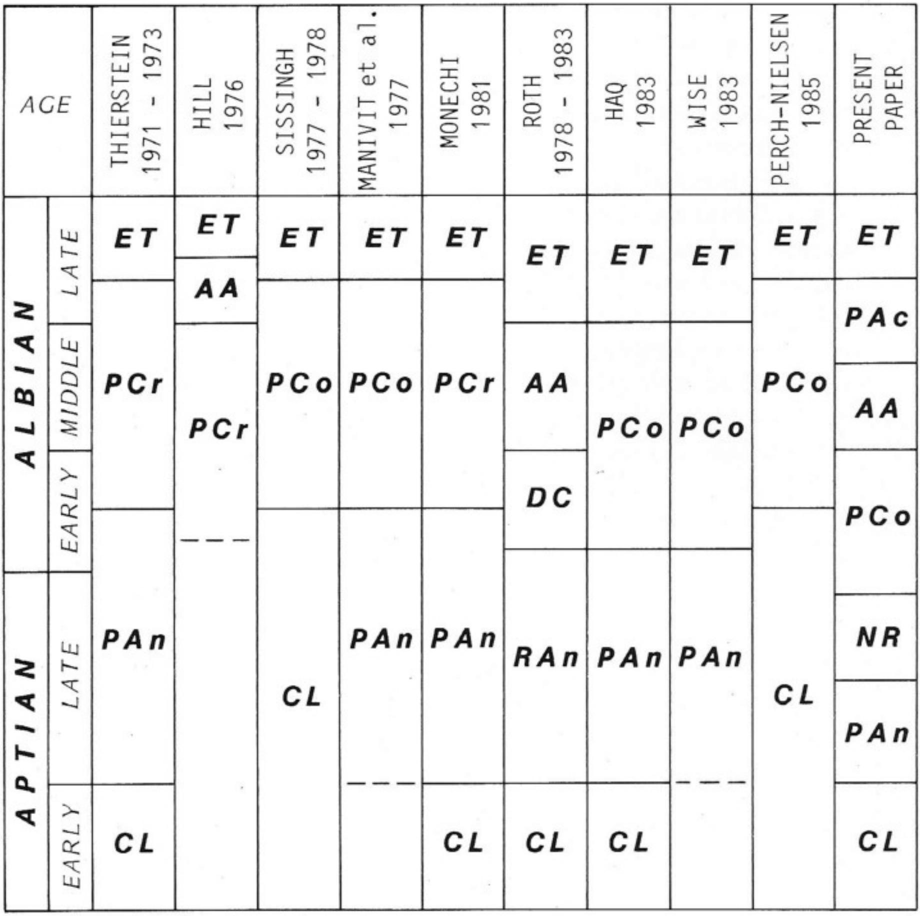

Fig. 3 - Comparison between the nannobiostratigraphy established in this paper and the previous zonations proposed for the Aptian- Albian time interval in the Tethyan region. CL) *Chiastozygus litterarius* Zone; PAn) *Parhabdolithus angustus* Zone; RAn) *Rhagodiscus angustus* Zone; NR) *Nannoconus regularis* Zone; PCo) *Prediscosphaera columnata* Zone; PCr) *Prediscosphaera cretacea* Zone; DC) *Deflandrius cretaceus* Zone; AA) *Axopodorhabdus albianus* Zone; PAc) *Parhabdolithus achlyostaurthon* Zone; ET) *Eiffellithus turriseiffelii* Zone.

Parhabdolithus angustus Zone emend.

Definition. Stratigraphical interval from the first occurrence of *Parhabdolithus angustus* (Stradner) and / or of *Lithastrinus floralis* Stradner to the first occurrence of *Nannoconus regularis* Deres & Achéritéguy (Thierstein, 1973, emended in this paper).

Remarks. According to Thierstein (1973) the lower limit of this zone coincides with the FO of both *Lithastrinus floralis* and *Parhabdolithus angustus*. The upper limit is here newly defined on the basis of the recognition of the FO of *Nannoconus regularis* which is a biohorizon already pointed out by Deres & Achéritéguy (1980). Therefore this zone is correlatable with the lower portion of the stratigraphical interval corresponding to the *Parhabdolithus angustus* Zone of Thierstein (1973).

The lowermost occurrences of both *Lithastrinus floralis* and *Parhabdolithus angustus* were recognized at 71.61 m. Within this zone other species have their first appearance; following the stratigraphical order they are: *Zygodiscus elegans, Flabellites oblonga, Cretarhabdus striatus, Radiolithus planus, Parhabdolithus infinitus, Nannoconus incospicuus, N. truittii rectangularis, Zygodiscus xenotus.* The last occurrences of both *Nannoconus bucheri* and *Assipetra infracretacea* were observed. The assemblage is more diversified than in the underlying zone. Along with previously recorded forms it comprises: frequent / common nannoconids, rare / frequent *Parhabdolithus splendens, Markalius circumradiatus, Reinhardtites fenestratus,* rare *Cruciellipsis chiastia, Zygodiscus elegans, Z. diplogrammus, Watznaueria ovata, W. biporta, Diazomatolithus lehmanii, Cretarhabdus striatus, Assipetra infracretacea, Biscutum constans, Micrantholithus hoschulzii, Manivitella pemmatoidea, Stephanolithion laffittei, Braarudosphaera* spp., and *Corollithion* spp.

Parhabdolithus embergeri, P. asper, Lithraphidites carniolensis, Discorhabdus rotatorius, Cyclagelosphaera deflandrei, Watznaueria supracretacea, Rucinolithus irregularis - 6 elements, *Vagalapilla stradneri* show an increase in their relative abundance.

Reference section. Piobbico core, from 71.61 m to 52.15 m.

Age. Late Aptian pp.

Nannoconus regularis new Zone.

Definition. Stratigraphical interval from the first occurrence of *Nannoconus regularis* Deres & Achéritéguy to the first occurrence of *Prediscosphaera columnata* (Stover). (New zone).

Remarks. On the basis of the FO of *Nannoconus regularis,* which is a biohorizon pointed out by Deres & Achéritéguy (1980), this new interval zone is proposed. This paleontological event is used to define the lower limit of the zone whereas the upper limit coincides with the FO of *Prediscosphaera columnata.* Therefore this zone is correlatable with the upper portion of the stratigraphical interval corresponding to the *Parhabdolithus angustus* Zone of Thierstein (1973).

Nannoconus regularis has its first occurrence at 52.15 m, whereas *Prediscosphaera columnata* is absent in this interval. The first occurrence of *Corollithion achylosum* is recorded in this zone. The assemblage records an increase in abundance of *Vagalapilla stradneri* and *Flabellites oblonga*, and a decrease in abundance of *Lithraphidites carniolensis*, *Rucinolithus* spp., *R. irregularis*.

Reference section. Piobbico core, from 52.15 m to 44.37 m.

Age. Late Aptian pp.

Prediscosphaera columnata Zone.

Definition. Stratigraphical interval from the first occurrence of *Prediscosphaera columnata* (Stover) to the first occurrence of *Axopodorhabdus albianus* (Black) (Hill, 1976).

Remarks. The first appearance of *Prediscosphaera columnata* occurs at 44.37 m. In this zone *Cribrosphaerella ehrenbergii* and *Cretarhabdus coronadventis* have their first occurrence. The assemblage records an increase in abundance of *Cretarhabdus surirellus* and *Biscutum constans*, and a decrease in abundance of *Vagalapilla stradneri* and *Nannoconus truittii*.

Reference section. Piobbico core, from 44.37 m to 33.76 m.

Age. Latest Aptian - Early Albian.

Axopodorhabdus albianus Zone emend.

Definition. Stratigraphical interval from the first occurrence of *Axopodorhabdus albianus* (Black) to the first occurrence of *Parhabdolithus achlyostaurion* Hill (Hill, 1976 emended in this paper).

Remarks. According to Hill (1976) the lower limit of this zone coincides with the FO of *Axopodorhabdus albianus*, whereas the upper limit is here modified on the basis of a new easily detectable biohorizon, the FO of *Parhabdolithus achlyostaurion*. Therefore this zone is correlatable with the lower portion of the stratigraphical interval corresponding to the *Axopodorhabdus albianus* Zone of Hill (1976).

The first occurrence of *Axopodorhabdus albianus* was recorded at 33.76 m. The first appearances of *Biscutum magnum* and *Prediscosphaera cretacea* occur within this zone.

The assemblage records an increase in abundance of *Discorhabdus rotatorius*, *Cyclagelosphaera deflandrei*, *Rucinolithus irregularis* - 6 elements, *Zygodiscus* spp., *Z. elegans*, *Z. diplogrammus*, *Flabellites oblonga*, *Biscutum constans*, and *Manivitella pemmatoidea*. Nannoconids record a sharp decrease in abundance.

Reference section. Piobbico core, from 33.76 m to 19.56 m.

Age. Middle Albian.

Parhabdolithus achlyostaurion new Zone.

Definition. Stratigraphical interval from the first occurrence of *Parhabdolithus achlyostaurion* Hill to the first occurrence of *Eiffellithus turriseiffelii* (Deflandre) (New zone).

Remarks. This new zone is here proposed on the basis of the new easily detectable biohorizon corresponding to the FO of *Parhabdolithus achlyostaurion* and here used as lower limit of this zone. The upper limit coincides with the FO of *Eiffellithus turriseiffelii.* Therefore this new zone is correlatable with the upper part of the stratigraphical interval corresponding to the *Axopodorhabdus albianus* Zone of Hill (1976), and to the uppermost portion of the stratigraphical interval corresponding to the *Prediscosphaera columnata* Zone of Thierstein (1973).

Parhabdolithusa chlyostaurion has its first occurrence at 19.56 m and is continuously recorded in the zone. Extremely rare specimens of *Pervilithus varius* and *Hayesites albiensis* were observed. The assemblage records an increase in abundance of *Parhabdolithus asper, Zygodiscus xenotus, Rucinolithus irregularis, Rucinolithus irregularis* - 6 elements, *Cretarhabdus angustiforatus.* Nannoconids are extremely rare.

Reference section. Piobbico core, from 19.56 m to 5.50 m.

Age. Late Albian pp.

At 5.50 m the FO of *Eiffellithus turriseiffelii* was observed, therefore the uppermost part of the core (from 5.50 m to 0 m), also for the absence of *Lithraphidites acutum*, is correlatable with the lower portion of the stratigraphical interval corresponding to the *Eiffellithus turriseiffelii* Zone of Manivit et al. (1977). With respect to the underlying *Parhabdolithus achlyostaurion* Zone, the nannofossil assemblage of this stratigraphical interval records an increase in abundance of *Biscutum constans* and *B. magnum,* and a decrease in abundance of *Cretarhabdus angustiforatus.* Nannoconids are absent. Rare *Eiffellithus eximius* and *Tranolithus* sp. are present. A Late Albian pp. age is attributed to this stratigraphical interval also according to planktonic foraminiferal data (*Planomalina buxtorfi* Zone).

Calcareous nannofossil - planktonic foraminiferal integrated biostratigraphy and chronostratigraphy.

Middle - Cretaceous (Aptian - Turonian) integrated biostratigraphy was established in the Tethyan region by different Authors. Thierstein (1973) correlated the calcareous nannofossil biozonation with the planktonic foraminiferal scheme elaborated by Moullade (1966) on the Lower Cretaceous stratotypes and parastratotypes from southeastern France. Verbeek (1976, 1977), Verbeek & Wonders (1977), Wonders & Verbeek (1977) and Wonders (1979, 1980) reported correlations between the two microfossil group biostratigraphy for the Middle - Upper Cretaceous European stratotypes. In 1977, Manivit et al., during a IGCP Meeting, elaborated a world-wide revised integrated biostratigraphy of the Aptian - Turonian time interval. Independently Sissingh (1977, 1978) proposed a microfossil biostratigraphy of the Cretaceous stratotypes. A revision of the calcareous nannofossil-planktonic foraminiferal integrated biostratigraphy and the Cretaceous chronostratigraphy was reported for the stratotypes and several tethyan and boreal sections by Perch-Nielsen (1979). Marks (1984) summarized the Cretaceous biostratigraphic frameworks in Europe, whereas Perch- Nielsen (1985) reviewed several Cretaceous zonal schemes.

As regards mid-Cretaceous Italian sequences, integrated schemes between calcareous nannofossils and planktonic foraminifers are reported by Medizza (in Channell et al., 1979) from the Venetian Alps, Monechi (1981) from the Umbrian-Marchean Basin, Erba & Quadrio (1987) from the Lombardian Basin.

The integrated biostratigraphy of the Piobbico core is plotted in Fig. 2. The foraminiferal content was investigated by Tacchino (1985), Premoli Silva et al. (1987), and Tornaghi et al. (in prep.). During the Aptian planktonic foraminiferal biostratigraphy is more detailed whereas during the Albian the two microfossil groups provide comparable subdivisions. In fact in the Piobbico core the use of new nannofossil events allowed to obtain an improved biostratigraphic resolution. Two new interval zones were proposed (*Nannoconus regularis* and *Parhabdolithus achlyostaurion* Zones), whereas two interval biozones were redefined (*Parhabdolithus angustus* and *Axopodorhabdus albianus* Zones). Moreover, the lowermost part of the core was attributed to the upper portion of the stratigraphical interval corresponding to the *Chiastozygus litterarius* Zone of Thierstein (1973), whereas the top of the core was considered as correlatable to the lower portion of the stratigraphical interval corresponding to the *Eiffellithus turriseiffelii* Zone of Manivit et al. (1977).

Major and minor biohorizons and chronostratigraphy are discussed in stratigraphic order, from bottom to top.

The lowest portion of the Piobbico core is attributed to the foraminiferal *Globigerinelloides gottisi* Zone of Early Aptian age. The Barremian/Aptian boundary was not reached with the cored sequence.

The first occurrence (FO) of *Lithastrinus floralis* and *Parhabdolithus angustus* coincide with the first appearance of *Leupoldina cabri* in agreement with Thierstein (1973, 1976), Van Hinte (1976), Medizza (in Channell et al., 1979), Monechi (1981), and Marks (1984). These world-wide events are dated to the Early/Late Aptian boundary (Thierstein, 1971, 1973, 1976, 1977; Roth & Thierstein, 1972; Bukry, 1974; Wise & Wind, 1976; Manivit et al., 1977; Roth, 1978, 1983; Gartner, 1979; Perch-Nielsen, 1979, 1985; Okada & Thierstein, 1979; Monechi, 1981; Taylor, 1982; Wise, 1983; Erba & Quadrio, 1987; Jakubowski, 1987).

Additional minor biohorizons, recognized in the Piobbico core as well as in other European sequences, and useful to identify the Late Aptian, are: the FO of *Flabellites oblonga* (Thierstein, 1973; Perch-Nielsen, 1985), the FO of *Braarudosphaera africana* (Thierstein, 1971, 1973; Perch - Nielsen, 1979, 1985; Monechi, 1981), the FO of *Cretarhabdus striatus* (Thierstein, 1971, 1973), and FO of *Corollithion achylosum* (Thierstein, 1973, 1976; Monechi, 1981). An analogous FO for *Corollithion achylosum* is reported from the Falkland Plateau (Wise & Wind, 1976). In England this datum occurs during the Late Hauterivian according to Taylor (1982). The FO of *Corollithion achylosum* in the Central Atlantic is quite controversial: Roth & Thierstein (1972) observe it in the

Late Aptian, Roth (1983) in the Early Albian, and Covington & Wise (1987) in the Barremian.

According to previous data from Europe (Thierstein, 1976; Perch- Nielsen, 1979, 1985; Deres & Achéritéguy, 1980), and from Central Atlantic (Roth & Thierstein, 1972), the last occurrence of *Nannoconus bucheri* was dated to the Late Aptian.

During the Latest Aptian or approximately at the Aptian/Albian boundary, several Authors record the last occurrence of *Assipetra infracretacea* from European sequences (Thierstein, 1973; Perch-Nielsen, 1979; Monechi, 1981), from Central Atlantic (Siesser, 1979; Gartner, 1979; Roth, 1983), and from Central Pacific (Roth, 1973). This event was observed in the Piobbico core during the Late Aptian.

Deres & Achéritéguy (1980) propose the FO of *Nannoconus regularis* to identify the Aptian/Albian boundary. In the Piobbico core this biohorizon occurs within the *Ticinella bejaouensis* Zone.

The FO of *Prediscosphaera columnata* occurs in the upper portion of the stratigraphical interval corresponding to the *Ticinella bejaouensis* Zone but the poor preservation of the planktonic foraminifers in this part of the core does not allow to uncontroversially place the boundary with the overlying *Hedbergella planispira* Zone. This record is in agreement with the biostratigraphy reported by Van Hinte (1976), Sissingh (1977, 1978), Bréhéret et al. (1986), and Delamette et al. (1986). Medizza (in Channell et al., 1979), Monechi (1981), and Marks (1984) report the FO of *Prediscosphaera columnata* in younger levels, within the *Hedbergella planispira* Zone. Nevertheless it should be noticed that the sequences studied by Medizza are characterized by hiatuses and/or faults in the Late Aptian-Early Albian interval. The integrated biostratigraphy proposed by Monechi was based on the planktonic foraminiferal scheme elaborated by Premoli Silva (in Lowrie et al., 1980). However the foraminiferal biozones were established on poorly preserved samples, containing a depauperated planktonic foraminiferal assemblage of Early Albian age and therefore the foraminiferal biohorizons are not completely reliable (Premoli Silva, 1986 pers. comm.).

Usually the FO of *Prediscosphaera columnata* is dated world-wide to the Early Albian (Thierstein, 1971, 1973, 1974, 1976, 1977; Roth & Thierstein, 1972; Roth, 1973, 1978, 1983; Bukry, 1974; Proto Decima, 1974; Romein, 1975; Hill, 1976; Wise & Wind, 1976; Sissingh, 1977, 1978; Manivit et al., 1977; Verbeek, 1977; Medizza in Channell et al., 1979; Perch-Nielsen, 1979, 1985; Okada & Thierstein, 1979; Cepek, 1981; Monechi, 1981; Taylor, 1982; Wise, 1983; Jakubowski, 1987). Investigations by Bréhéret et al. (1986) and Delamette et al. (1986) on sections from the Vocontian Trough, containing ammonites along with calcareous nannofossils and planktonic foraminifers, changed the position of the Aptian/Albian boundary in respect to the planktonic biohorizons. In fact in the Col de Pre' Guittard section, *Prediscosphaera columnata* was first observed in sediments belonging to the *H. jacobi* Zone and dated to the Clanseiesian (Latest Aptian). It should be noticed that the Col de Pre' Guittard section seems to be the only complete lithologic record spanning the Aptian/Albian boundary. Other coeval sequences from the literature are affected by hiatuses or are siliciclastic. According to these data, the Aptian/Albian boundary should be placed within the lower portion of the stratigraphical interval corresponding to the *Prediscosphaera columnata* Zone and in the upper portion of the stratigraphical interval corresponding to the *Ticinella bejaouanensis* Zone. Therefore the FO of *Prediscosphaera columnata* is dated to the Latest Aptian and the FO of *Nannoconus regularis* is older than the Aptian/Albian boundary (Albian starts with the *L. tardefurcata* Zone).

In the Piobbico core two biohorizons, the FO of *Cribrosphaerella ehrenbergii* and the FO of *Cretarhabdus coronadventis,* occur in the Early Albian. The first datum is in agreement with previous records by Roth & Thierstein (1972) from Central Atlantic, and Perch-Nielsen (1979, 1985) from Europe. A younger record, Late Albian in age, is reported by Thierstein (1973, 1976) from Europe, Hill (1976) from Texas and Oklahoma, Roth (1973, 1981) and Cepek (1981) from Pacific, Okada & Thierstein (1979) from North Atlantic. Thierstein (1974) records the FO of *Cribrosphaerella ehrenbergii* in Coniacian sediments from the Indian Ocean.

The FO of *Cretarhabdus coronadventis* occurs during the Early Albian in Europe according to Thierstein (1973), in the Indian Ocean according to Thierstein (1974), and in Central Atlantic according to Roth (1983). This datum is reported from the Hauterivian of England (Taylor, 1982), from the Early Aptian of Central Atlantic (Roth & Thierstein, 1972; Covington & Wise, 1987) and of the Pacific (Cepek, 1981), and from the Late Aptian of the Falkland Plateau (Wise & Wind, 1976). Hill (1976) records the FO of *Cretarhabdus coronadventis* in sediments of Late Albian age from Texas and Oklahoma.

The Early/Middle Albian boundary can be placed world-wide on the basis of the FO of *Axopodorhabdus albianus* (Thierstein, 1973, 1974, 1976; Roth, 1978, 1981, 1983; Gartner, 1979; Okada & Thierstein, 1979; Cepek, 1981; Taylor, 1982). In the Piobbico core this biohorizon is slightly younger than the first appearance of *Ticinella primula* considered coincident with the beginning of the Middle Albian (Van Hinte, 1976).

In the Piobbico core also the FO of *Biscutum magnum* is recorded at the beginning of the Middle Albian and this biohorizon is slightly younger than the FO of *Axopodorhabdus albianus.* Cepek (1981) observes the FO of *Biscutum magnum* in the Early Albian from the Pacific, whereas Wise & Wind (1976) report this taxon only from Campanian to Maastrichtian sediments from the Falkland Plateau.

Several Authors report the total world-wide range of the marker- species *Hayesites albiensis* during the Albian (Manivit, 1971; Thierstein, 1973, 1976; Verbeek, 1977; Manivit et al., 1977; Perch-Nielsen, 1979, 1985; Taylor, 1982). In the Piobbico core only one *Hayesites* cf. *H. albiensis* was observed in the Late Albian and therefore in the present study this taxon is not considered biostratigraphically useful. Also Monechi (1981) does not report *Hayesites albiensis* in other sections from the Umbrian-Marchean Basin.

In the Piobbico core a useful and easily detectable datum was observed approximately at the Middle/Late Albian boundary. It is the FO of *Parhabdolithus achlyostaurion,* barely coincident with the FO of *Biticinella breggiensis.* This latter event is usually used to determine the beginning of the Late Albian (Van Hinte, 1976; Sigal, 1977). Older records of the FO of *Parhabdolithus achlyostaurion* are reported by Roth (1983) from Valanginian sediments from Central Atlantic, by Taylor (1982) from the Late Aptian of England, and by Hill (1976) from the Middle Albian of Texas and Oklahoma.

The FO of *Eiffellithus turriseiffelii* is a world-wide biohorizon occurring during the Late Albian (Thierstein, 1971, 1973, 1974, 1976, 1977; Roth & Thierstein, 1972; Roth, 1973, 1978, 1981, 1983; Bukry, 1974; Proto Decima, 1974; Romein, 1975; Hill, 1976; Wise & Wind, 1976; Sissingh, 1977, 1978; Verbeek, 1977; Manivit et al., 1977; Gartner, 1979; Medizza in Channell et al., 1979; Okada & Thierstein, 1979; Perch-Nielsen, 1979, 1985; Cepek, 1981; Monechi, 1981; Taylor, 1982; Jakubowski, 1987). In the Piobbico core it approximates the FO of *Rotalipora ticinensis* according to Van Hinte (1976), Medizza (in Channell et al., 1979), Monechi (1981) and Marks (1984). Thierstein (1973) reports the FO of *Eiffellithus turriseiffelii* in older levels where it corresponds to the first appearance of *Biticinella breggiensis.*

The youngest 10 cm of the Piobbico core contain *Planomalina buxtorfi*, therefore the top of the section is attributed to the Latest Albian (Vraconian).

Applicability of the proposed Aptian - Albian nannostratigraphy.

In order to verify the regional extension of the proposed biostratigraphic scheme, the nannostratigraphy established for the Piobbico core was applied to the Bottaccione and Valdorbia sections from the Umbrian-Marchean Basin, previously studied for their calcareous nannofossil contents by Monechi (1981).

The Bottaccione section, located close to the town of Gubbio, has been the object of detailed lithologic, facies, biostratigraphic and paleomagnetic studies (Arthur & Fischer, 1977; Premoli Silva, 1977; Monechi, 1981; Arthur & Premoli Silva, 1982; Monechi & Thierstein, 1985) and was proposed as an Upper Cretaceous - Paleocene standard land section for magnetostratigraphy (Alvarez et al., 1977). The sequence encompasses the entire Scisti a Fucoidi formation but is slightly tectonically disturbed at its contact with the Maiolica formation.

The Valdorbia section outcrops along the road from Scheggia to Sassoferrato, 5 km NE of the town of Scheggia, and 10 km NE of the town of Gubbio. The magnetostratigraphy and biostratigraphy were studied by Lowrie et al. (1980). The section spans the lower portion of the Scisti a Fucoidi, however, in the central part it is intersected by faults.

Fig. 4 summarizes the calcareous nannofossil zonation recognized in the Bottaccione and Valdorbia sections and reports the correlation with the Piobbico core.

The lowermost part of the Bottaccione section is attributed to the stratigraphical interval corresponding to the *Chiastozygus litterarius* Zone (Early Aptian in age), whereas the uppermost portion is considered as correlatable to the stratigraphical interval corresponding to the *Eiffellithus turriseiffelii* Zone (Late Albian in age). Nine biohorizons out of ten identified in the Piobbico core were recognized in this section. They occur in the same stratigraphic order and delimit intervals of consistent relative thickness. The

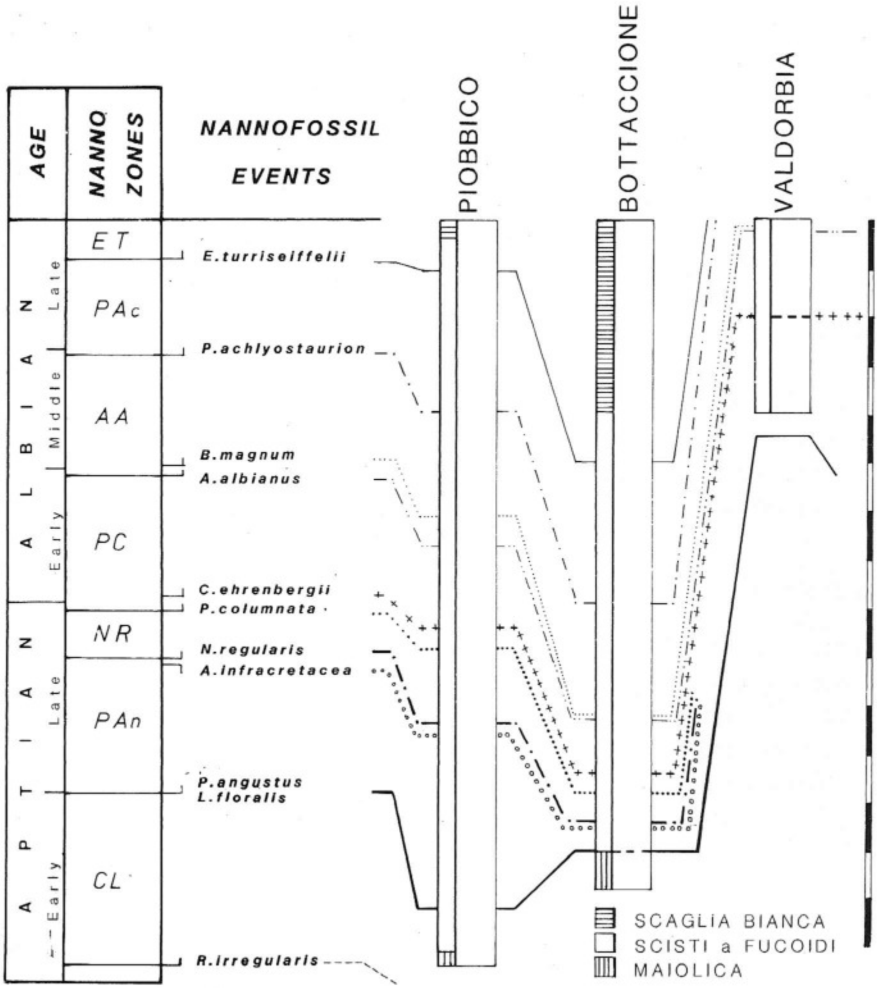

Fig. 4 - Aptian-Albian nannostratigraphic correlation of the Piobbico, Bottaccione and Valdorbia sections (Umbrian-Marchean Basin, Central Italy). Lithostratigraphy of the Bottaccione and Valdorbia sections after Monechi (1981). CL) *Chiastozygus litterarius* Zone; PAn) *Parhabdolithus angustus* Zone; NR) *Nannoconus regularis* Zone; PC) *Prediscosphaera columnata* Zone; AA) *Axopodorhabdus albianus* Zone; PAc) *Parhabdolithus achlyostaurion* Zone; ET) *Eiffellithus turriseiffelii* Zone. - - - - - FO of *Rucinolithus irregularis*; ——— FO of *Lithastrinus floralis* and *Parhabdolithus angustus*; ° ° ° ° ° LO of *Assipetra infracretacea*; · — · — · FO of *Nannoconus regularis*; · · · · · FO of *Prediscosphaera columnata*; + + + + + FO of *Cribrosphaerella ehrenbergii*; — ·· — ·· — FO of *Axopodorhabdus albianus*; ····· FO of *Biscutum magnum*; — · — · — FO of *Parhabdolithus achlyostaurion*; ——— FO of *Eiffellithus turriseiffelii*.

fault occurring at the Scisti a Fucoidi/Maiolica boundary elided the upper portion of the stratigraphical interval corresponding to the *Chiastozygus litterarius* Zone and the lower portion of the stratigraphical interval corresponding to the *Parhabdolithus angustus* Zone.

In the Valdorbia section, the oldest sample already belongs to the *Parhabdolithus angustus* Zone (Late Aptian in age) and the youngest one was dated as Middle Albian (*Axopodorhabdus albianus* Zone). This section has longer intervals missing. Only three biohorizons were recognized: the FO of *Cribrosphaerella ehrenbergii*, the FO of *Axopodorhabdus albianus*, and the FO of *Biscutum magnum*. The fault detected in the central portion of the section eliminated a considerable thickness of the formation. Applying the present nannostratigraphy a much better estimate of the hiatus can be identified than was previously possible. Three calcareous nannofossil biohorizons are absent: the LO of *Assipetra infracretacea*, the FO of *Nannoconus regularis*, and the FO of *Prediscosphaera columnata*. Therefore the upper portion of the stratigraphical interval corresponding to the *Parhabdolithus angustus* Zone, the entire stratigraphical interval corresponding to the *Nannoconus regularis* Zone and the lower portion of the stratigraphical interval corresponding to the *Prediscosphaera columnata* Zone are missing.

Conclusions.

A detailed calcareous nannofossil biostratigraphic investigation was carried out on the Scisti a Fucoidi formation (Aptian - Albian) cored at Piobbico. The nannostratigraphy presented in this paper supports previous zonations and provides a much more precise resolution. Five previously adopted nannofossil events (the FO of *Lithastrinus floralis*, the FO of *Parhabdolithus angustus*, the FO of *Prediscosphaera columnata*, the FO of *Axopodorhabdus albianus*, and the FO *Eiffellithus turriseiffelii*) were recognized, and five new biohorizons (the LO of *Assipetra infracretacea*, the FO of *Nannoconus regularis*, the FO of *Cribrosphaerella erhenbergii*, the FO of *Biscutum magnum*, and the FO of *Parhabdolithus achlyostaurion)* are here proposed for the Aptian - Albian interval. On the basis of first occurrences five interval zones were identified. Of these two are new (*Nannoconus regularis* and *Parhabdolithus achlyostaurion* Zones), and two are here emended (*Parhabdolithus angustus* and *Axopodorhabdus albianus* Zones). The base of the Piobbico core is correlatable with the upper portion of the stratigraphical interval corresponding to the *Chiastozygus litterarius* Zone, whereas the top of the core is attributable to the lower portion of the stratigraphical interval corresponding to the *Eiffellithus turriseiffelii* Zone.

The nannobiostratigraphy was integrated with the planktonic foraminiferal zonation and an improved calibration of bio- and chronostratigraphic horizons was achieved. In particular, according to previous data from the Vocontian Trough, the Aptian/Albian boundary was placed within the lower portion of the stratigraphical interval corresponding to the *Prediscosphaera columnata* nannofossil Zone and in the upper portion of the stratigraphical interval corresponding to the *Ticinella bejaouaensis* foraminiferal Zone.

Moreover the investigation was extended to the Bottaccione and the Valdorbia sections outcropping in the Umbrian-Marchean Basin, in order to verify the applicability of the biostratigraphy established for the Piobbico core in a more regional context.

The consistent ordering of nannofossil events and their relative spacing indicate a good reliability of the proposed biostratigraphic pattern. The improved nannostratigraphy provides more precise correlations and better estimates of hiatuses.

Taxonomy

Calcareous nannofossil species identified and quoted in the distribution chart (Tab. 1) , are here reported following genera and species alphabetical order. References to original descriptions and illustrations, and subsequent changes of the taxonomic position are given. Remarks on characters detected by light microscope (LM) and on stratigraphic ranges are included. Additional references may be found in Loeblich and Tappan (1966 - 1973), Van Heck (1979 - 1983), and Steinmetz (1983 - 1987).

Genus *Assipetra* Roth, 1973.
Assipetra infracretacea (Thierstein, 1973) Roth, 1973 (Pl. 42, fig. 17, 18).
Micula infracretacea Thierstein, 1973, p. 46, pl. 1, fig. 1 - 19. *Assipetra infracretacea* - Roth, 1973, p. 729, pl. 25, fig. 5, 7, 9.

Remarks. In the Piobbico core specimens of this species are characterized by large sizes (8 - 9 μm), within the range size of the holotype (5 - 10 μm). Moreover the structure consists of numerous crystal plates tightly interlocking. The shape is always subrectangular.

Genus *Axopodorhabdus* Wind & Wise in Wise & Wind, 1976.
Axopodorhabdus albianus (Black, 1967) Wind & Wise in Wise & Wind, 1976 (Pl. 42, fig. 7).
Podorhabdus albianus Black, 1967, p. 143. *Axopodorhabdus albianus* - Wind & Wise in Wise & Wind, 1976, p. 297. *Podorhabdus albianus* - Thierstein, 1976, pl. 4, fig. 13, 14.

Genus *Braarudosphaera* Deflandre, 1947.
Braarudosphaera africana Stradner, 1961.
Braadurosphaera africana Stradner, 1961, p. 82, text-fig. 44.

Remarks. In the present paper *B. africana* Stradner and *B. hockwaldensis* Black, 1973 are considered synonym because the differentiating character is the outline of the segments and it can be masked by dissolution and/or overgrowth.

Braarudosphaera regularis Black, 1973.
Braarudosphaera regularis Black, 1973, p. 91, pl. 28, fig. 10.

Genus *Biscutum* Black & Barnes, 1959.
Biscutum constans (Górka, 1957) Black, 1967.

Biscutum magnum Wind & Wise in Wise & Wind, 1976 (Pl. 42, fig. 10, 11).
Biscutum magnum Wind & Wise in Wise & Wind, 1976, p. 298, pl. 20, fig. 4 - 6; pl. 21, fig. 2; pl. 24, fig. 1, 2; pl. 30, fig. 1.

Genus *Chiastozygus* Gartner, 1968.
Chiastozygus litterarius (Górka, 1957) Manivit, 1971.
Discolithus litterarius Górka, 1957, p. 274, pl. 3, fig. 3. *Chiastozygus litterarius* - Manivit, 1971, p. 92, pl. 4, fig. 1 - 5.

Genus *Corollithion* Stradner, 1961.
Corollithion achylosum (Stover, 1966) Thierstein, 1971.
Chiphragmalithus achylosus Stover, 1966, p. 137, pl. 6, fig. 26; pl. 7, fig. 1 - 3; pl. 9, fig. 20. *Corollithion achylosum* - Thierstein, 1971, p. 480, pl. 7, fig. 12 - 16.

Genus *Cretarhabdus* Bramlette & Martini, 1964.
Cretarhabdus angustiforatus (Black, 1971) Bukry, 1973.
Retecapsa angustiforata Black, 1971, p. 409, pl. 33, fig. 4. *Cretarhabdus angustiforatus* - Bukry, 1973, p. 667, pl. 2, fig. 4 - 7.

Remarks. According to Thierstein (1971, 1976) and Erba & Quadrio (1987), *C. angustiforatus* includes forms with 8 struts in the central area lying parallel and diagonal to the axes of the ellipse. Forms with more than 8 struts are here attributed to *C. surirellus*.

Cretarhabdus conicus Bramlette & Martini, 1964.
Cretarhabdus conicus Bramlette & Martini, 1964, p. 299, pl. 3, fig. 5 - 8.

Cretarhabdus coronadventis Reinhardt, 1966.
Cretarhabdus coronadventis Reinhardt, 1966, p. 26, pl. 23, fig. 29, 30.

Cretarhabdus striatus (Stradner, 1963) Black, 1973.
Arkhangelskiella striata Stradner, 1963, p. 176, pl. 1, fig. 1. *Cretarhabdus striatus* - Black, 1973, p. 53, pl. 17, fig. 3 - 6, 10, 11.

Cretarhabdus surirellus (Deflandre in Deflandre & Fert, 1954) Reinhardt, 1970.
Discolithus surirella Deflandre in Deflandre & Fert, 1954, p. 144, text-fig. 30, 31. *Cretarhabdus surirellus* - Reinhardt, 1970, p. 50, pl. 1, fig. 8; pl. 2, fig. 1 - 6; text-fig. 22.

Remarks. In the present paper, *C. surirellus* includes forms with more than 8 struts in the central area.

Genus *Cribrosphaerella* Deflandre in Piveteau, 1952.
Cribrosphaerella ehrenbergii (Arkhangelsky, 1912) Deflandre in Piveteau, 1952 (Pl. 42, fig. 9).
Cribrosphaera ehrenbergi Arkhangelsky, 1912, p. 412, pl. 6, fig. 19, 20. *Cribrosphaerella ehrenbergii* - Deflandre in Piveteau, 1952, p. 111, text-fig. 54a, 54b.

Genus *Cruciellipsis* Thierstein, 1971.
Cruciellipsis chiastia (Worsely, 1971) Thierstein in Roth & Thierstein, 1972.
Helenea chiastia Worsley, 1971, p. 1310, pl. 1, fig. 42 - 44. *Cruciellipsis chiasta* - Thierstein in Roth & Thierstein, 1972, pl. 6, fig. 8 - 13.

Genus *Cyclagelosphaera* Noël, 1965.
Cyclagelosphaera deflandrei (Manivit, 1966) Roth, 1973.
Coccolithus deflandrei Manivit, 1966, p. 268, text-fig. 1a - 1c.*Cyclagelosphaera deflandrei* - Roth, 1973, p. 723, pl. 25, fig. 3; pl. 26, fig. 7; pl. 27, fig. 6.

Cyclagelosphaera margerelii Noël, 1965.
Cyclagelosphaera margereli Noël, 1965, p. 12, text-fig. 45 - 48.

Genus *Diazomatolithus* Noël, 1965.
Diazomatolithus lehmanii Noël, 1965.
Diazomatolithus lehmani Noël, 1965, p. 95, pl. 6, fig. 6 - 10; text-fig. 25 - 27.

Genus *Discorhabdus* Noël, 1965.
Discorhabdus rotatorius (Bukry, 1969) Thierstein, 1973.
Bidiscus rotatorius Bukry, 1969, p. 27, pl. 27, fig. 5 - 9. *Discorhabdus rotatorius* - Thierstein, 1973, p. 42, pl. 5, fig. 13 - 16.

Genus *Eiffellithus* Reinhardt, 1965 emend. Reinhardt, 1966.
Eiffellithus eximius (Stover, 1966) Perch-Nielsen, 1968.
Clinorhabdus eximius Stover, 1966, p. 138, pl. 2, fig. 15, 16; pl. 8, fig. 15. *Eiffellithus eximius* - Perch-Nielsen, 1968, p. 30, pl. 3, fig. 8 - 10.

Remarks. According to Verbeek (1977), *E. eximius* includes forms characterized by a central process approximately aligned with the axes of the ellipse, with which it forms an angle less than 20°.

According to Hill & Bralower (1987), the stratigraphic range of *E. eximius* is extended to the Upper Albian. Therefore the distribution is Upper Albian-Maastrichtian.

Eiffellithus turriseiffelii (Deflandre in Deflandre & Fert, 1954) Reinhardt, 1965 (Pl. 42, fig. 13 - 15).
Zygolithus turriseiffeli Deflandre in Deflandre & Fert, 1954, p. 149, pl. 13, fig. 15, 16; text-fig. 65. *Eiffellithus turriseiffeli* - Reinhardt, 1965, p. 32.

Genus *Flabellites* Thierstein, 1973.
Flabellites oblonga (Bukry, 1969) Crux, 1982.
Watznaueria oblonga Bukry, 1969, p. 33, pl. 11, fig. 8 - 10. *Flabellites oblonga* - Crux, 1982, p. 110, pl. 5.1, fig. 11; pl. 5.8, fig. 1.

Genus *Hayesites* Manivit, 1971.
Hayesites cf. **H. albiensis** Manivit, 1971.

Hayesites albiensis Manivit, 1971, p. 138, pl. 14, fig. 1 - 7.

Remarks. In the Piobbico core only one specimen classified as *Hayesites* cf. H. *albiensis* was observed. The taxonomic attribution is tentative because the specimen is constituted by 5 radially arranged rays although the general structure corresponds to that of *H. albiensis*. Following the original description, this species is characterized by 7 or 8 radial elements but the specimens illustrated as holotype and paratype show 6 - 8 rays. In the literature *H. albiensis* is illustrated by specimens bearing 6 - 7 radial elements.

In other sections from the Umbrian-Marchean Basin this taxon has been never observed (Monechi, 1981; Erba, present paper).

Genus *Lithastrinus* Stradner, 1962.
Lithastrinus floralis Stradner, 1962 (Pl. 42, fig. 4,8).
Lithastrinus floralis Stradner, 1962, p. 370, pl. 2, fig. 6 - 11.

Genus *Lithraphidites* Deflandre, 1963.
Lithraphidites carniolensis Deflandre, 1963.
Lithraphidites carniolensis Deflandre, 1963, p. 3486, text- fig. 1 - 10.

Genus *Manivitella* Thierstein, 1971.
Manivitella pemmatoidea (Deflandre in Manivit, 1965) Thierstein, 1971.
Cricolithus pemmatoideus Deflandre in Manivit, 1965, p. 192, pl. 2, fig. 8. *Manivitella pemmatoidea* - Thierstein, 1971, p. 480, pl. 5, fig. 1 - 3.

Genus *Markalius* Bramlette & Martini, 1964 emend. Perch- Nielsen, 1968.
Markalius circumradiatus (Stover, 1966) Perch-Nielsen, 1968.
Coccolithites circumradiatus Stover, 1966, p. 138, pl. 5, fig. 2, 4; pl. 9, fig. 10. *Markalius circumradiatus* - Perch-Nielsen, 1968, p. 73, pl. 25, fig. 2 - 7; pl. 26, fig. 1 - 7; text-fig. 36, 37.

Genus *Micrantholithus* Deflandre, 1950.
Micrantholithus hoschulzii (Reinhardt, 1966) Thierstein, 1971.
Braarudosphaera hoschulzi Reinhardt, 1966, p. 42, pl. 21, fig. 3. *Micrantholithus hoschulzi* - Thierstein, 1971, p. 482, pl. 1, fig. 12 - 15.

Genus *Nannoconus* Kamptner, 1931 emend. Farinacci, 1964.
Nannoconus bucheri Brönnimann, 1955.
Nannoconus bucheri Brönnimann, 1955, p. 39, pl. 1, fig. 1 - 3, 5 - 7; text-fig. 2k - 2n.

Nannoconus incospicuus Deflandre & Deflandre, 1962.
Nannoconus incospicuus Deflandre & Deflandre, 1962, p. 2639, text-fig. 10.

Nannoconus kamptneri Brönnimann, 1955.
Nannoconus kamptneri Brönnimann, 1955, p. 33, pl. 2, fig. 14, 16, 20; text-fig. 8i - 8m.

Nannoconus regularis Deres & Achéritéguy, 1980 (Pl. 42, fig. 19).
Nannoconus regularis Deres & Achéritéguy, 1980, p. 31, pl. 1, fig. 13.

Nannoconus truittii Brönnimann, 1955.
Nannoconus truitti Brönnimann, 1955, p. 38, pl. 2, fig. 2 - 5, 7; text-fig. 2f-2j.

Nannoconus truittii rectangularis Deres & Achéritéguy, 1980.
Nannoconus truittii rectangularis Deres & Achéritéguy, 1980, p. 25, pl. 1, fig. 11.

Genus *Parhabdolithus* Deflandre, 1952.
Parhabdolithus achlyostaurion Hill, 1976 (Pl. 42, fig. 12, 16).
Parhabdolithus achlyostaurion Hill, 1976, p. 145, pl. 9, fig. 24 - 29.

Remarks. In LM, under crossed nicols, this species shows weak interference colors. Only the central process is bright with a sharp extinction cross.

The stratigraphic range of *P. achlyostaurion* is not well established so far. According to Hill (1976), it appears in the Middle Albian in Texas. Taylor (1982) reports this taxon from Upper Aptian sediments of the Boreal region, and Roth (1983) from the Valanginian of Central Atlantic. The youngest occurrence is Santonian in age.

Parhabdolithus angustus (Stradner, 1963) Stradner, Adamiker & Maresch, 1968 (Pl. 42, fig. 2, 3).
Rhabdolithus angustus Stradner, 1963, p. 178, pl. 5, fig. 6. *Parhabdolithus angustus* - Stradner, Adamiker & Maresch, 1968, p. 32, pl. 20.

Parhabdolithus asper (Stradner, 1963) Manivit, 1971.
Discolithus asper Stradner, 1963, p. 11, pl. 2, fig. 4, 5. *Parhabdolithus asper* - Manivit, 1971, p. 87, pl. 23, fig. 4 - 7.

Parhabdolithus embergeri (Noël, 1958) Stradner, 1963.
Discolithus embergeri Noël, 1958, p. 164, pl. 1, fig. 1, 7, 8. *Parhabdolithus embergeri* - Stradner, 1963, p. 8, pl. 4, fig. 1.

Parhabdolithus infinitus (Worsley, 1971) Thierstein in Roth & Thierstein, 1972.
Mitosia infinitae Worsley, 1971, p. 1311, pl. 1, fig. 48 - 50. *Parhabdolithus infinitus* - Thierstein in Roth & Thierstein, 1972, p. 437, pl. 9, fig. 7 - 16.

Parhabdolithus splendens (Deflandre, 1953) Noël, 1969.
Rhabdolithus splendens Deflandre, 1953, p. 1785, text-fig. 4 - 6. *Parhabdolithus splendens* - Noël, 1969, p. 476, pl. 1, fig. 1 - 4, 7; text-fig. 1, 2.

Genus *Pervilithus* Crux, 1981.
Pervilithus varius Crux, 1981.

Pervilithus varius Crux, 1981, p. 639, text-fig. 1, n. 6 - 9; text-fig. 2, n. 9.

Remarks. Crux (1982) reported a Cenomanian - Campanian distribution. The stratigraphic range of *P. varius* is here extended to the Albian.

Genus *Prediscosphaera* Vekshina, 1959.

Prediscosphaera columnata (Stover, 1966) Manivit, 1971 (Pl. 42, fig. 5, 6).

Deflandrius columnatus Stover, 1966, p. 141, pl. 6, fig. 6 - 10; pl. 9, fig. 16. *Prediscosphaera columnata* - Manivit, 1971, p. 100, pl. 21, fig. 13 - 15.

Prediscosphaera cretacea (Arkhangelsky, 1912) Gartner, 1968.

Coccolithophora cretacea Arkhangelsky, 1912, p. 410, pl. 6, fig. 12, 13. *Prediscosphaera cretacea* - Gartner, 1968, p. 19.

Genus *Radiolithus* Stover, 1966.

Radiolithus planus Stover, 1966.

Radiolithus planus Stover, 1966, p. 160, pl. 7, fig. 22, 24; pl. 9, fig. 23.

Genus *Reinhardtites* Perch-Nielsen, 1968.

Reinhardtites fenestratus (Worsley, 1971) Thierstein in Roth & Thierstein, 1972.

Arkhangelskiella ? fenestrata Worsley, 1971, p. 1305, pl. 1, fig. 33 - 35. *Reinhardtites fenestratus* - Thierstein in Roth & Thierstein, 1972, p. 437, pl. 8, fig. 1, 2.

Genus *Rucinolithus* Stover, 1966.

Rucinolithus irregularis Thierstein in Roth & Thierstein, 1972 (Pl. 42, fig. 1).

Rucinolithus irregularis Thierstein in Roth & Thierstein, 1972, p. 438, pl. 2, fig. 10 - 19. *Rucinolithus irregularis* - Thierstein, 1973, p. 45, pl. 3, fig. 1 - 14.

Remarks. In the Piobbico core, along with typical *R. irregularis,* some specimens consisting of 6 elements and characterized by an extremely regular structure were observed. Similar specimens from Aptian - Albian sequences from Texas and Oklahoma were attributed to *R. wisei* by Hill (1976) and Gartner (1979) reports *R.* cf. *R. wisei* from the Lower Albian of Central Atlantic. The attribution to *R. wisei* is here not accepted both because, under crossed nicols, the extinction pattern of the two forms is different, and because there is a long gap between the stratigraphic range of the two species (Hauterivian - Barremian). In the present paper these non typical forms are named *R. irregularis* - 6 elements.

Genus *Stephanolithion* Deflandre, 1939.

Stephanolithion laffittei Noël, 1957.

Stephanolithion laffittei Noël, 1957, p. 318, pl. 2, fig. 5.

Genus *Vagalapilla* Bukry, 1969.

Vagalapilla stradneri (Rood, Hay & Barnard, 1971) Thierstein, 1973.

Vekshinella stradneri Rood, Hay & Barnard, 1971, p. 249, pl. 1, fig. 2. *Vagalapilla stradneri* - Thierstein, 1973, p. 38.

Genus *Tegumentum* Thierstein, in Roth & Thierstein, 1972.

Tegumentum stradneri Thierstein in Roth & Thierstein, 1972.

Tegumentum stradneri Thierstein in Roth & Thierstein, 1972, p. 437, pl. 1, fig. 7 - 15.

Genus *Zygodiscus* Bramlette & Sullivan, 1961 emend. Gartner, 1968.

Zygodiscus diplogrammus (Deflandre in Deflandre & Fert, 1954) Gartner, 1968.

Zygolithus diplogrammus Deflandre in Deflandre & Fert, 1954, p. 148, pl. 10, fig. 7; text-fig. 57. *Zygodiscus diplogrammus* - Gartner, 1968, p. 32, pl. 21, fig. 2; pl. 22, fig. 7.

Zygodiscus elegans Gartner, 1968.

Zygodiscus elegans Gartner, 1968, p. 32, pl. 10, fig. 3 - 6; pl. 12, fig. 3a - c, 4a - c; pl. 27, fig. 1.

Zygodiscus xenotus (Stover, 1966) Hill, 1976.

Zygolithus xenotus Stover, 1966, p. 149, pl. 4, fig. 16 - 18; pl. 9, fig. 2. *Zygodiscus xenotus* - Hill, 1976, p. 163, pl. 12, fig. 38 - 46; pl. 15, fig. 29.

Genus *Watznaueria* Reinhardt, 1964.

Watznaueria barnesae (Black in Black & Barnes, 1959) Perch - Nielsen, 1968.

Tremalithus barnesae Black in Black & Barnes, 1959, p. 325, pl. 9, fig. 1, 2. *Watznaueria barnesae* - Perch-Nielsen, 1968, p. 69, pl. 22, fig. 1 - 7; pl. 23, fig. 1, 4, 5, 16; text-fig. 32.

Watznaueria biporta Bukry, 1969.

Watznaueria biporta Bukry, 1969, p. 32, pl. 10, fig. 8 - 10.

Watznaueria britannica (Stradner, 1963) Reinhardt, 1964.

Coccolithus britannicus Stradner, 1963, p. 10, pl. 1, fig. 7, 7a. *Watznaueria britannica* - Reinhardt, 1964, p. 753, pl. 2, fig. 3; text-fig. 5.

Watznaueria communis Reinhardt, 1964.

Watznaueria communis Reinhardt, 1964, p. 756, pl. 2, fig. 5; text-fig. 6.

Watznaueria ovata Bukry, 1969.

Watznaueria ovata Bukry, 1969, p. 33, pl. 11, fig. 11, 12.

Watznaueria supracretacea (Reinhardt, 1965) Wind & Wise in Wise & Wind, 1976.

Coccolithites supracretaceus Reinhardt, 1965, p. 40, pl. 2, fig. 7, 8. *Watznaueria supracretacea* - Wind & Wise in Wise & Wind, 1976, p. 308, pl. 50, fig. 8.

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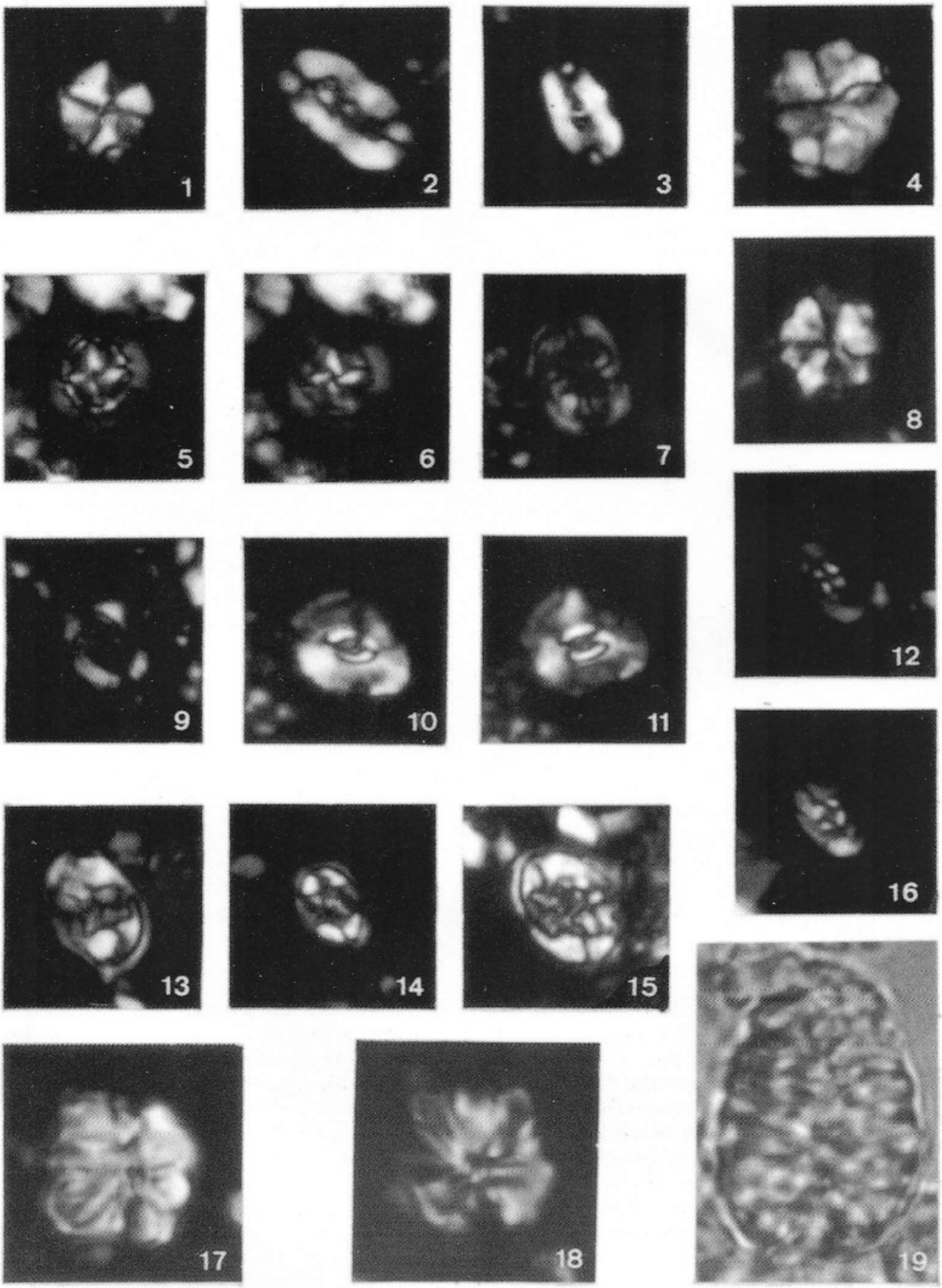
PLATE 42

Light microscope photographs, under cross-polarized light except fig. 19 which is trasmitted light. All specimens from the Piobbico core. Magnification ca. 2400 X except fig. 19 which is ca. 4000 X.

Fig. 1 - *Rucinolithus irregularis* Thierstein. Sample 73.01 m.
Fig. 2 - *Parhabdolithus angustus* (Stradner). Sample 14.80 m.
Fig. 3 - *Parhabdolithus angustus* (Stradner). Sample 44.37 m.
Fig. 4 - *Lithastrinus floralis* Stradner. Sample 44.37 m.
Fig. 5,6 - *Prediscosphaera columnata* (Stover). Sample 44.37 m. Same specimen.
Fig. 7 - *Axopodorhabdus albianus* (Black). Sample 33.76 m.
Fig. 8 - *Lithastrinus floralis* Stradner. Sample 71.61 m.
Fig. 9 - *Cribrosphaerella ehrenbergii* (Arkhangelsky). Sample 16.08 m.
Fig. 10,11 - *Biscutum magnum* Wind & Wise. Sample 24.65 m. Same specimen.
Fig. 12 - *Parhabdolithus achlyostaurion* Hill. Sample 16.08 m.
Fig. 13 - *Eiffellithus turriseiffelii* (Deflandre). Sample 1.80 m.
Fig. 14 - *Eiffellithus turriseiffelii* (Deflandre). Sample 5.50 m.
Fig. 15 - *Eiffellithus turriseiffelii* (Deflandre). Sample 4.90 m.
Fig. 16 - *Parhabdolithus achlyostaurion* Hill. Sample 19.56 m.
Fig. 17 - *Assipetra infracretacea* (Thierstein). Sample 58.03 m.
Fig. 18 - *Assipetra infracretacea* (Thierstein). Sample 53.63 m.
Fig. 19 - *Nannoconus regularis* Deres & Achéritéguy. Sample 44.37 m.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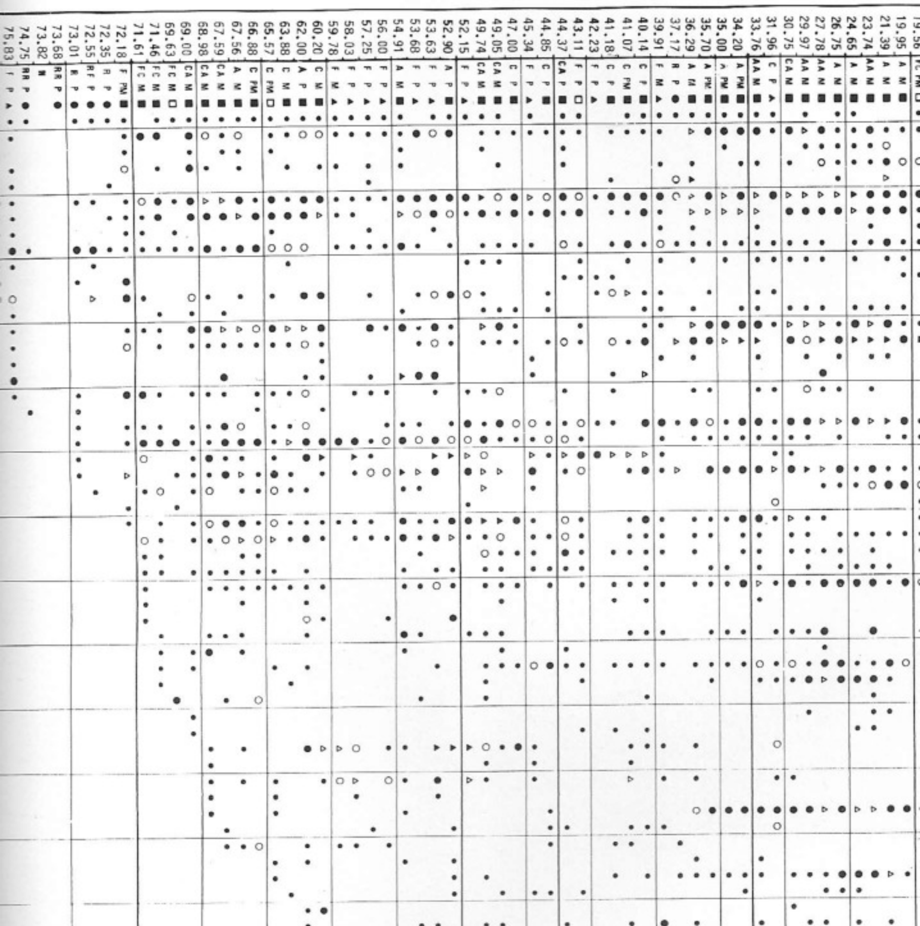
Tab. 1 - Calcareous nannofossil species distribution in the Piobbico core. The semiquantitative analysis was performed at 1250 X as follows. *Total Abundance* (referred to fields of view containing approximately 40 micron-sized particles): AA) extremely abundant: >30 specimens in each field of view; A) abundant: 20-30 specimens in each field; CA) common-abundant: about 20 specimens in each field; C) common: 10-20 specimens in each field; FC) few/common: about 10 specimens in each field; F) few: 5-10 specimens in each field; RF) rare/few: about 5 specimens in each field; R) rare: 1-5 specimens in each field; RR) very rare: 1-2 specimens in each field; N) none: nannofossils absent. *Preservation*: M) moderate; P) poor. *Species Abundance*: ■) abundant: >1 specimen in each field of view; □) common/abundant: 1 specimen in each field; ▼) common: 1 specimen in 2-10 fields; ▽) common/ few: 1 specimen every 10 fields; ●) few: 1 specimen in 11-30 fields; ○) rare/few: 1 specimen every 30 fields; •) rare: 1 specimen in >30 fields.


C.LITTERARIUS
P.ANGUSTUS
N.REGULARIS
P.COLUMNATA
A. ALBIANUS
EARLY
LATE
APTIAN
EARLY
MIDDLE