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Uppermost Jurassic-Lower Cretaceous carbonate deposits from Fara San Martino (Maiella, Italy): biostratigraphic remarks

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ABSTRACT. The Uppermost Jurassic-Lower Cretaceous limestone succession in the Maiella region of Italy has been investigated in a profile covering more than 400 m stratigraphical thickness at Fara San Martino. The succession mainly consists of peritidal limestones, intertidal and supratidal sequences being dominant, together with subtidal lagoonal facies. As a consequence, the microfossil assemblages are generally poorly developed, Microfossils occur within the subtidal lagoonal facies of this suite of restricted sediments. This feature led us to recognise five informal biostratigraphic intervals, which are facies related – instead of biozones, each of the intervals being characterized by specific micropaleontological associations. The occurrence and/or disappearance of some marker microfossils were used as references for separating these intervals. Based on these markers, the Uppermost Jurassic-Lower Cretaceous carbonate deposits from Maiella region may be correlated with similar deposits from the Apennines and from other regions in the perimediterranean area.

Key words: Calcareous algae, Foraminifers, Biostratigraphy, Lower Cretaceous, Maiella, Italy.

INTRODUCTION

The data presented in this paper are part of a larger multidisciplinary stratigraphic study (sedimentology, sequence stratigraphy, and isotopic geochemistry) presented by one of the authors (R.B.) as part of a PhD thesis at the Université Libre de Bruxelles. Two Lower Cretaceous sections from Italy, one located in Frioul (Val Celina section), and another one, included in this paper, in Maiella were investigated as part of this PhD study.

The Fara San Martino section in Maiella allows a very good access to an internal platform carbonate succession covering the Upper Jurassic (Tithonian) – Aptian interval. The Maiella massif was the object of numerous stratigraphic studies (Accarie et al., 1986; Accarie, 1988; Anselmetti et al., 1997; Bernoulli et al., 1996; Eberli et al., 1993; Lampert et al., 1997 and Vecsei, 1991) that focused on the Upper Cretaceous slope deposits but were less specific concerning the Lower Cretaceous platform. As a result, this carbonate platform was very poorly investigated.

This paper illustrates the organisms identified during a detailed biostratigraphic study that allowed the separation of various intervals in spite of the scarcity of the microfossils. This microfaunal depletion is related to the sedimentary system, which is an internal platform that was well-protected from the open sea, where intertidal and supratidal facies interlayered with frequent levels of calcretes and dolocretes (paleosoils) dominated. The identified organisms were most typically present in subtidal lagoon-type environments located between a distal barrier and the often emersed littoral domain (Bruni, 2003).

The Fara San Martino section shows an exceptional stratigraphic continuity over more than 400 m thickness, the beds being displayed subvertical or slightly inclined, allowing systematic sampling. The section has been investigated individually for each bank, a number of 360 oriented samples being collected with an average frequency of one sample per one meter stratigraphic thickness.

LOCATION AND STRATIGRAPHIC FRAMEWORK

The Fara San Martino section is located close to the Fara San Martino village, in the proximity of the San-Martino river gorges (Fig.1). This section, also studied by Crescenti (1969) and Acarie (1980) covers the Upper Jurassic pro parte - Aptian pro parte interval.

From a lithostratigraphic point of view, the internal platform limestones of Liassic to Lower Cretaceous ages are assigned to a single formation, *i.e.* the Morrone di Pacentro Limestone Formation (Crescenti, 1969; Crescenti et al., 1969). This formation is about 600 m thick, of which the first 100 m crop out only partially at regional scale. At Fara San Martino, the Cretaceous succession is 400 m thick.

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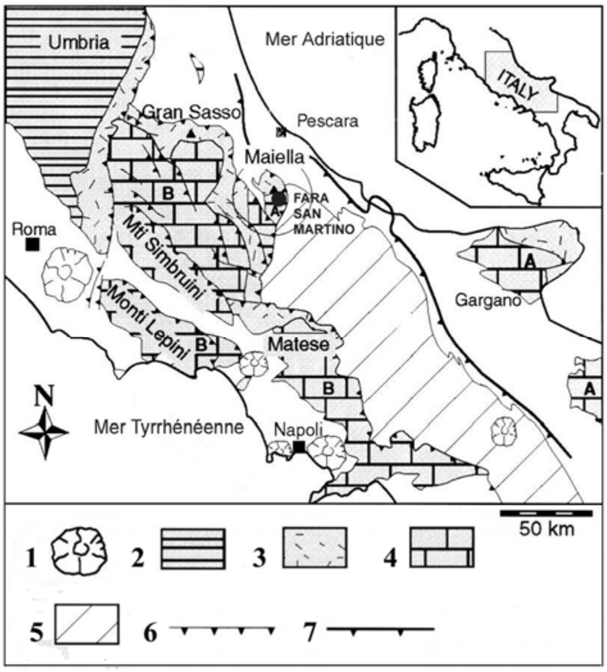


Fig. 1. *Geographic location of the Maiella massif and occurrence of the main geologic formations. 1- Quaternary; 2-pelagic sediments; 3-carbonate turbidites; slope and toe-of-slope; 4-carbonate platforms: A-Apulia, B-Latium-Abruzzo; 5-internal allochtonous units; 6-overthrust; 7-front of allochtonous units (subsurface).*

The lower limit of the formation cannot be observed at Fara San Martino, while the upper limit is represented by a bauxitic episode, rich in pisolites associated with micritic limestones and calcareous breccias. The stratigraphic hiatus connected to the bauxites extends from the Middle-Upper Albian to the Middle Cenomanian (Acarie and Delamette, 1991). The Morrone di Pacentro Formation consists of a typical, low energy internal platform succession (peritidal environment) located behind a platform edge constructed by rudists, where the energy was higher (Bruni, 2003).

Crescenti et al. (1969) separated the following three biozones within the Upper Jurassic -Aptian succession from Fara san Martino: a biozone with *Clypeina jurassica* and *Vaginella striata,* a biozone with *Salpingoporella appeninica*, and a biozone with *Cuneolina camposaurii*. Acarie (1988) reconsidered the above mentioned subdivisions and the general interpretation of the internal platform. He was the first author who insisted on the “indistinctive” feature of the stratification, which he however presented as organised into units about 20 m thick. This author considered a cyclic development for these deposits, the cycles or “sequences” being asymmetrical and showing a general “shallowing upward” evolutionary trend.

BIOSTRATIGRAPHIC ANALYSIS

The taxa considered as references for the biostratigraphic separation were selected among the most frequent (but never abundant!) forms that are, at the same time, easy to be identified. In this study we preferred to defined biostratigraphic intervals rather than biozones that might have shown a more restrained vertical development, but that could have been problematic in their identification.

Thus, five informal intervals (presented below as A, B, C, D, and E) have been defined for this study (Fig. 2). The limits of the intervals are marked by the occurrence and disappearance of the marker microfossils (Fig. 3).

In a normal stratigraphical succession, these intervals are:

Interval A

This interval is delimited by the base of the section and respectively by the occurrence of *Protopeneroplis ultragranulata*, the oldest foraminifer identified in the section. Interval A is dominated, especially in its lower and medium part, by levels with coprolites assignable to genus *Favreina*, and by ostracod levels. Two coprolite species are present: *Favreina salevensis* (PAREJAS) and *Favreina njegosensis* BRONNIMANN. Numerous dasycladalean fragments and rivulariacean-type cyanobacteria (*Cayeuxia* sp.), large fragments of gastropods, ostracods and rare small biseriate foraminifers are sometimes associated with the coprolites.

Association: *Favreina salevensis* PAREJAS, *Favreina njegosensis* BROENNIMANN, *Clypeina sulcata* (ALTH) (Pl. 1, Figs. 1, 2, 4), *Campbelliella striata* (CAROZZI), *Salpingoporella* cf. *annulata* CAROZZI (Pl. 1, Fig. 3), *Salpingoporella* sp. (Pl. 1, Fig. 6), *Clypeina parasolkani* FARINACCI & RADOIČIĆ (Pl. 1, Figs. 5, 14), *Humiella* sp. (Pl. 1, Fig. 7), *Marinella* cf. *lugeoni*, *Bolivinopsis* sp., ?*Andersenolina* sp., miliolids, ostracods, fragments of gastropods and bivalves, and stromatolites.

Location: from m 0 to m 145.

Age: Uppermost Jurassic -Berriasian. The association mainly contains calcareous algae known from the Upper Jurassic –Berriasian interval (Granier and Deloffre, 1993; Bucur, 1999). The presence of Berriasian within the interval A is confirmed by the common presence of *Clypeina parasolkani* FARINACCI & RADOIČIĆ.

Interval B

This interval is defined by the occurrence of *Protopeneroplis ultragranulata* (GORBACHIK). The species occurs a few meters below the first *Vercorsella*. It is followed by the occurrence of *Montsalevia salevensis* CHAROLLAIS, BROENNIMANN & ZANINETTI. The top of the interval is marked by the occurrence of *Campanellula capuensis* DE CASTRO. The interval is about 120 m thick and the deposits are scarce in for a-minifers (small biseriate foraminifers and miliolids). Some levels rich in foraminifers and dasycladalean algae occur in its lower beds. *Salpingoporella annulata* has been identified associated with levels rich in Favreines in the lower part of the interval, below the *Protopeneroplis ultragranulata* level.

Association: *Protopeneroplis ultragranulata* (GORBACHIK) (Pl. 3, Figs. 5, 6), *Vercorsella camposaurii* (SARTONI and CRESCENTI) (Pl. 3, Figs. 10, 11), *Montsalevia salevensis* (CHAROLLAIS, BROENNIMANN & ZANINETTI), (Pl. 3, Figs. 1, 2) *Haplophragmoides joukowskyi* (CHAROLLAIS, BROENNIMANN & ZANINETTI) (Pl. 3, Figs. 3, 4), *Giraliarella*? *prismatica* ARNAUD VANNEAU, *Earlandia*? *conradi* ARNAUD-VANNEAU, *Praechrysalidina infracretacea* LUPERTO SINNI (Pl. 3, Figs. 21, 22), *Rumanoloculina multicostata* NEAGU, *Andersenolina* sp., *Belorusiella* sp., *Vercorsella* sp., *Salpingoporella annulata* CAROZZI, *Favreina salevensis* (PAREJAS), miliolids, ostracods, crinoids, fragments of gastropods and bivalves.

Location: from m 145 to m 264.

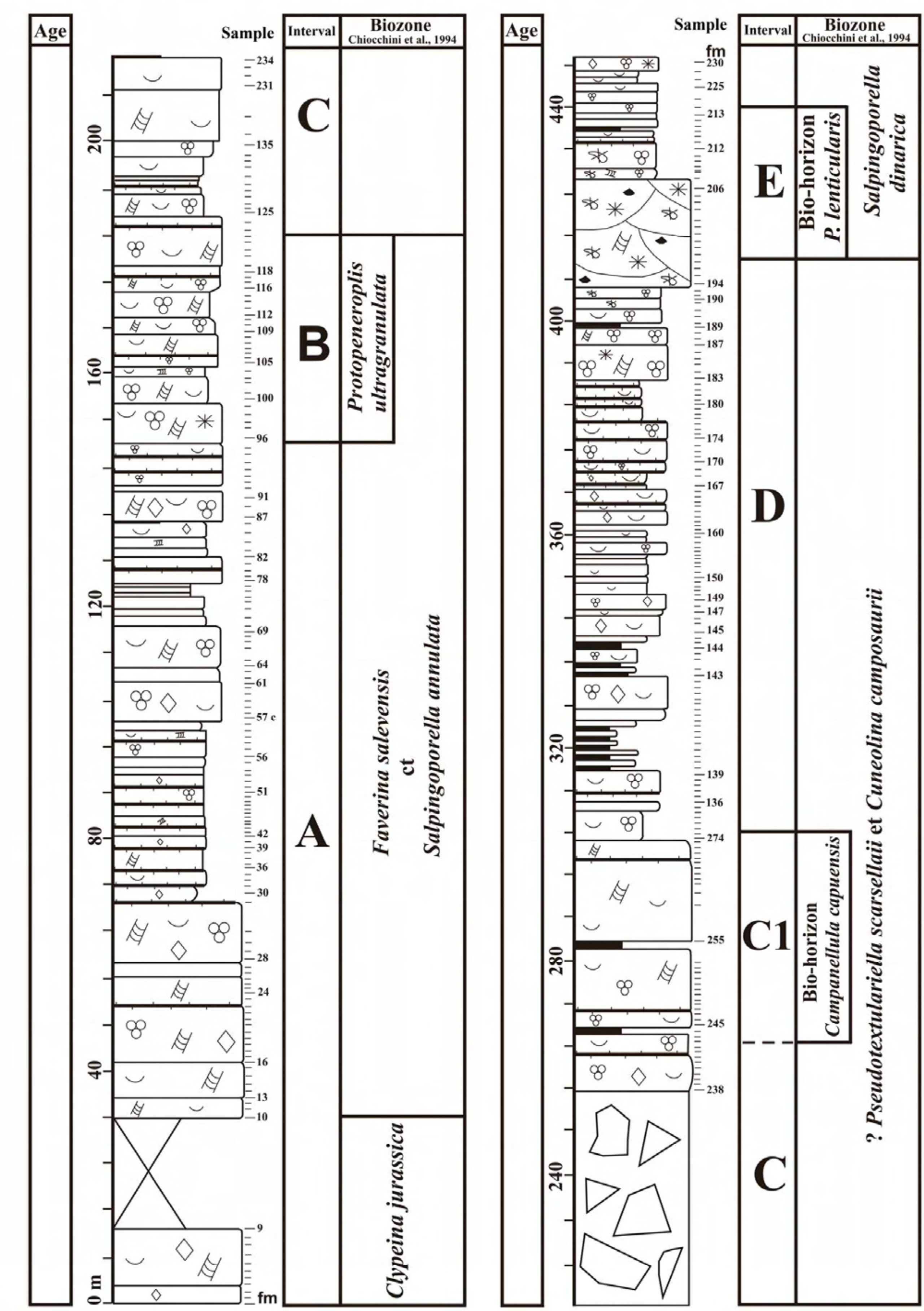


Fig. 2. *Succession of carbonate deposits from Fara San Martino, and delimitation of the five biostratigraphic intervals (A – E).*
(for legend, see page 49).

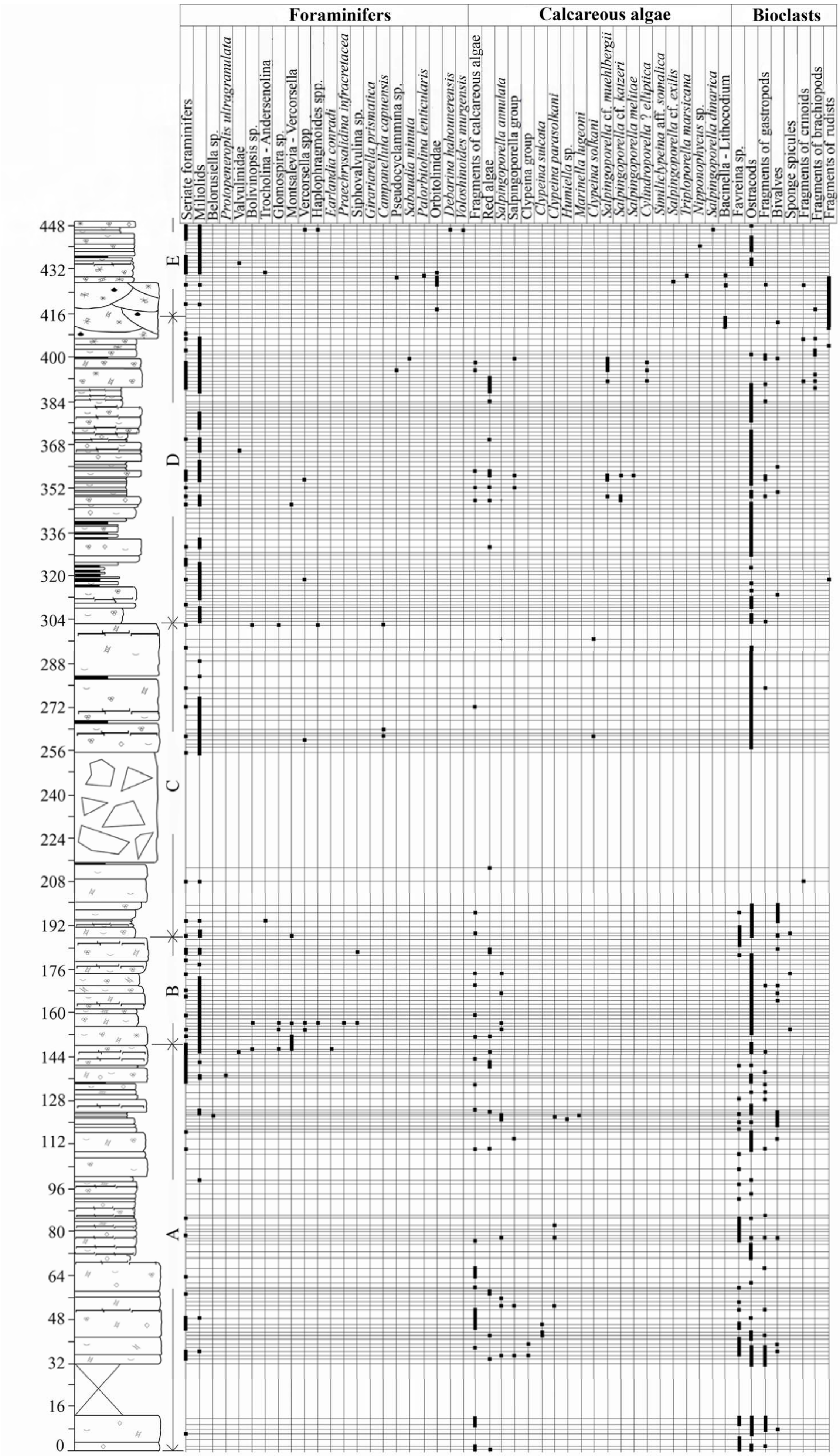
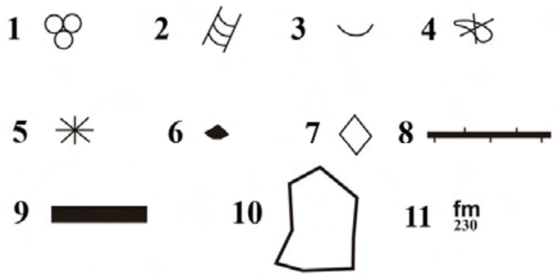

Foraminifers
Calcareous algae
Bioclasts
Seriate foraminifers
Miliolids
Belorusiella sp.
Protopeneroplis ultragranulata
Valvulinidae
Bolivinopsis sp.
Trocholina - Andersenolina
Glomospira sp.
Montsalevia - Vercorsella
Vercorsella spp.
Haplophragmoides spp.
Earlandia conradi
Praechrysalidina infracretacea
Siphovalvulina sp.
Giraliarella prismatica
Campanellula capuensis
Pseudocyclammina sp.
Sabaudia minuta
Palorbitolina lenticularis
Orbitolinidae
Debarina hahounerensis
Voloshinoides murgensis
Fragments of calcareous algae
Red algae
Salpingoporella annulata
Salpingoporella group
Clypeina group
Clypeina sulcata
Clypeina parasolkani
Humiella sp.
Marinella lugeoni
Clypeina solkani
Salpingoporella cf. muehlbergii
Salpingoporella cf. katzeri
Salpingoporella melitae
Cylindroporella ? elliptica
Similiclypeina aff. somalica
Salpingoporella cf. exilis
Triploporella marsicana
Nipponophycus sp.
Salpingoporella dinarica
Bacinella - Lithocodium
Favreina sp.
Ostracods
Fragments of gastropods
Bivalves
Sponge spicules
Fragments of crinoids
Fragments of brachiopods
Fragments of rudists
448
432
416
400
384
368
352
336
320
304
288
272
256
240
224
208
192
176
160
144
128
112
96
80
64
48
32
16
0
E
D
C
B
A

Fig. 3. *(opposite page) Vertical distribution of the main microfossils identified in the limestones from Fara San Martino and their relationship with the five biostratigraphic intervals. For explanation of symbols, see bellow.*



Explanation of the symbols used in Figs. 2 and 3. 1-foraminifers; 2-dasycladalean algae; 3-ostracods; 4-rudists; 5-crinoids; 6-orbitolinids; 7-dolomite; 8-paleosols; 9-mm to cm-size joints; 10-breccia; 11-sample number.

Age: Berriasian-Valanginian. This interval contains a typical association of foraminifers. Even if the typical stratigraphic distribution for *Protopeneroplis ultragranulata* is the Middle Tithonian-Barremian interval (Heinz and Isenschmid, 1988; Bucur, 1993, 1997), the most frequent occurrence for this species is however represented by the Berriasian-Lower Valanginian interval (Azema et al., 1977; Azema et al., 1979; Salvini-Bonnard et al., 1984; Boisseau, 1987; Granier, 1987; Zaninetti et al., 1988; Bucur, 1988; Chiochinni et al., 1988; Velic, 1988; Bucur et al., 1995). In southern Italy, *P. ultragranulata* was assigned to the Berriasian (Luperto Sinni and Masse, 1986).

H. joukowskyi has been described from Valanginian (Charollais et al., 1966) and it was refound in Berriasian-Valanginian deposits by Darsac (1983), Boisseau (1987), Bucur et al. (1995), Ivanova (2000). The species was also reported from Hauterivian limestones (Bucur, 1988; Altiner, 1991).

M. salevensis, described from the same interval as *H. joukowskyi* (Charollais et al., 1966 as *Pseudotextulariella salevensis*) is more frequent in Valanginian deposits (Azema et al., 1977; Darsac, 1983; Chiocchini et al., 1988: Altiner, 1991; Bucur et al., 1995; Ivanova, 2000). The transfer of the species to genus *Montsalevia* (suggested by Zaninetti et al., 1987) was reinforced by Altiner (1991), Bucur et al. (1995), and Schroeder et al. (2000).

Interval C

This interval is defined by the occurrence and respectively the disappearance of species *Campanellula capuensis* DE CASTRO. In general, the interval is scarce in foraminifers and dasycladalean algae but very rich in ostracods.

Association: *Campanellula capuensis* DE CASTRO (Pl. 3, Figs. 7, 8, 9), *Haplophragmoides joukowskyi* (CHAROLLAIS, BRONNIMANN & ZANNINETTI), *Salpingoporella annulata* CAROZZI, *Clypeina solkani* (CONRAD & RADOIČIĆ) (Pl. 2, Fig. 1), *Glomospira* sp., miliolids and ostracods.

Location: from m 265 to m 305.

Age: Hauterivian. According to De Castro (1964), the levels with *Campanellula capuensis* are located between Valanginian and Barremian. Macoin et al. (1970) considered this species as belonging to the Barremian, while Schroeder et al. (1978) to the Lower Barremian. Finally, Bodrogi et al. (1994) reported this species from Upper Hauterivian-Lower Barremian deposits.

In southern Italy, Luperto Sinni and Masse (1984, 1986) have separated a biozone with *Orbitolinopsis*? *capuensis* that they have assigned to the Hauterivian. Claps et al. (1996) have made the same assignment for the species from deposits in Gargano (Pulia, southern Italy). The association accompanying *C. capuensis* in the Fara San Martino section (*H. joukowskyi, S. annulata,* and *C. solkan*) seems to confirm a Hauterivian age for this interval.

Interval D

This interval is defined by the disappearance of *Campanellula capuensis* to the occurrence of the orbitolinid level. Interval D is scarce in microfauna, especially in its basal part, where some miliolids and numerous ostracods are present. Sporadically also levels rich in dasycladaleans and foraminifers were noticed.

Association: *Salpingoporella muhelbergii* (LORENZ) (Pl. 2, Figs. 7, 8), *Salpingoporella* cf. *muhelbergii* (LORENZ), *Salpingoporella* cf. *katzeri* CONRAD & RADOIČIĆ (Pl. 1, Figs. 15-18), *Clypeina solkani* CONRAD & RADOIČIĆ, *Salpingoporella melitae* (RADOIČIĆ) (Pl. 2, Fig. 2), *Cylindroporella*? *elliptica* BAKALOVA sp. (Pl. 2, Fig. 4), *Similclypeina* aff. *somalica* (CONRAD, PEYBERNES & MASSE) (Pl. 2, Fig. 14), *Sabaudia minuta* (HOFKER) (Pl. 3, Figs. 12-15), *Pseudocyclammina* sp., *Bolivinopsis* sp., *Pseudolituonella* sp., *Comaliammina* sp., miliolids, ostracods, fragments of gastropods and bivalves, crinoids, sponge spicules and stromatolites.

Location: from m 305 to m 405.

Age: Barremian. Even if numerous dasycladaleans in this association are typical for the whole Barremian-Aptian interval, the location of interval D between the levels with *Campanellula capuensis* and those with *Palorbitolina lenticularis* constitutes an argument for its Barremian age.

Interval E

This interval, defined based on the occurrence of *Palorbitolina lenticularis,* is characterized by the abundance of benthonic foraminifers, of rivulariacean-type cyanobacteria and especially by the large fragments of rudists belonging to genus *Offrenia*. The microfauna becomes scarcer towards the top of the interval, where only rare miliolids and ostracods are present. The upper limit corresponds to the top of the section.

Association: *Palorbitolina lenticularis* (BLUMENBACH) (Pl. 3, Fig. 19), *Sabaudia minuta* (HOFKER), *"Trocholina" odukpaniensis* (DESAUVAGIE), *Pseudocyclammina* sp. (Pl. 3, Fig. 23), *Salpingoporella pygmaea* (GUEMBEL) (Pl. 2, Fig. 13), *Triploporella marsicana* PRATURLON (Pl. 2, Fig. 12), *Bacinella irregularis* RADOIČIĆ (Pl. 2, Fig. 16), *Lithocodium aggregatum* ELLIOTT, ?*Nypponophicus* sp. (Pl. 2, Fig. 17), sponge spicules, large fragments of gastropods and bivalves including rudists (*Offneria italica*), crinoids and ostracods. At the upper part of this interval, a thin level is very rich in foraminifers and calcareous algae: *Debarina hahounerensis* FOURCADE, RAOULT & VILA (Pl. 3, Fig. 18), *Vercorsella camposaurii* (SARTONI & CRESCENTI), *Vercorsella laurentii* (SARTONI & CRESCENTI) (Pl. 3, Fig. 20), *Voloshinoides murgensis* LUPERTO SINNI & MASSE (Pl. 3, Fig. 17), *Salpingoporella dinarica* RADOIČIĆ (Pl. 2, Figs. 9, 10), *Thaumatoporella parvovesiculifera* (RAINERI).

Location: from m 413 to m 440.

Age: Aptian. *Palorbitolina lenticularis* covers the Upper Barremian-Lower Aptian interval (Schroeder et al., 1978). In southern Italy, this species is typical for the Lower Aptian only (Cherchi et al., 1978; Luperto Sinni and Mase, 1986, 1992; Chiocchini et al., 1994), where it is associated with *Sabaudia minuta, Debarina hahounerensis, Voloshinoides murgensis* and *Salpingoporella dinarica*.

CONCLUSIONS

The micropaleontological analysis of the Upper Jurassic-Lower Cretaceous carbonate succession from the Fara San Martino section (Maiella) led us to the identification of several micropaleontological associations that allowed the separation of five informal stratigraphic intervals. Each of these intervals is characterized by the occurrence and/or disappearance of marker microfossils and each contains a micropaleontological association that is characteristic for a certain age: Uppermost Jurassic –Berriasian - in the case of interval A; Berriasian-Valanginian - for interval B; Hauterivian - for interval C; Barremian - for interval D, and Lower Aptian - for interval E. The micropaleontological associations are scarce and poorly diversified; they are similar to those of other Mediterranean areas and show an equivalent vertical distribution. These associations may be used for regional scale correlations, but also for general correlations in the whole perimediterranean area.

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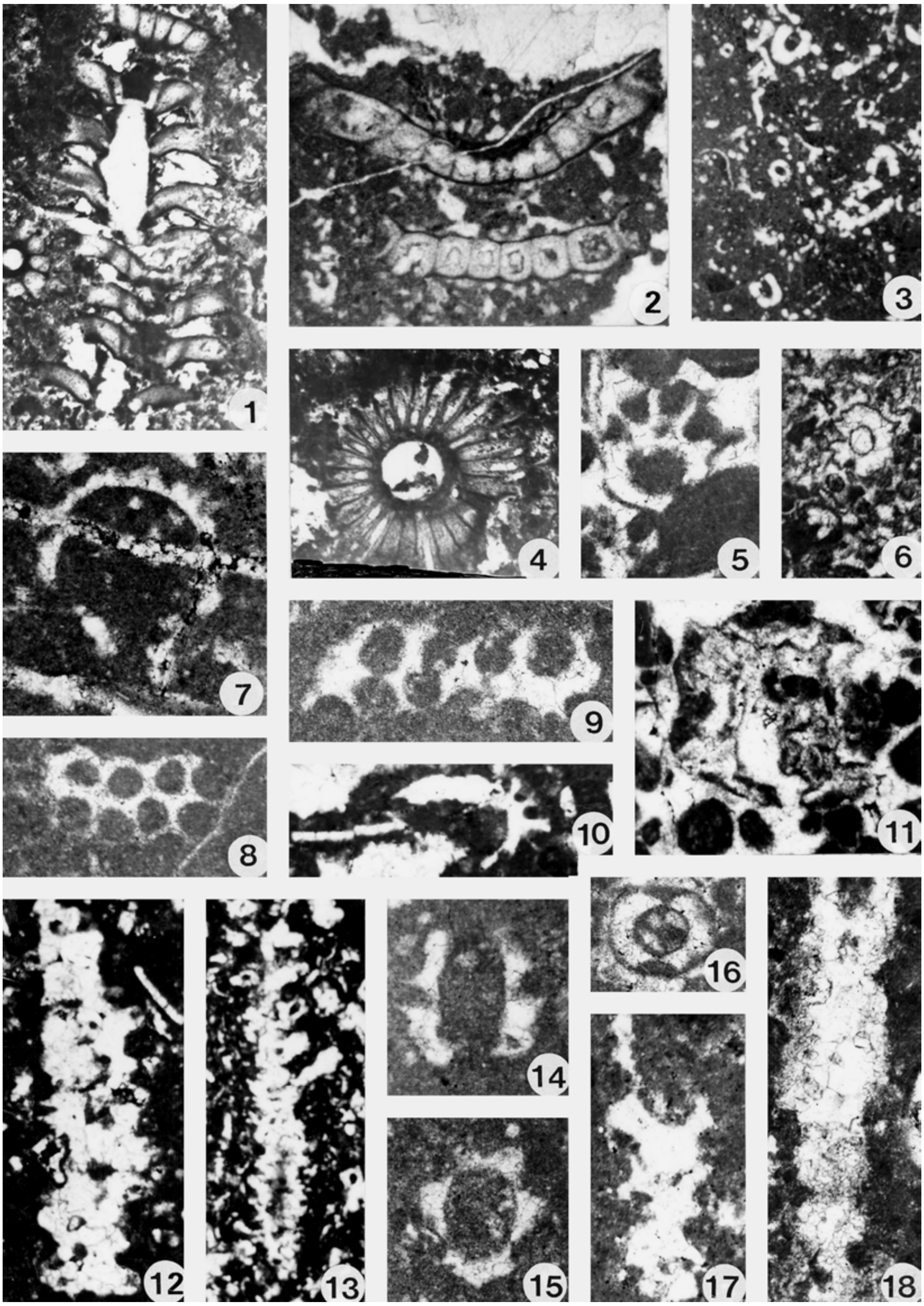
PLATE I



Figs. 1, 2, 4. Clypeina sulcata *ALTH. 1, longitudinal-oblique section; sample N17, X 17. 2, tangential section cutting two successive verticils; sample FSM 16B, X 35. 4, transverse section; sample N17, X 17.*
Fig. 3. Salpingoporella annulata *CAROZZI. Several specimens in oblique and transverse section; sample FSM 72, X 17.*
Figs. 5, 14. Clypeina parasolkani *FARINACCI & RADOIČIĆ. 5, transverse-oblique section; sample FSM 48, X 70. 14, longitudinal-oblique section; sample FSM 38, X 70.*
Fig. 6. Salpingoporella *sp. Transverse section; sample FSM 273, X 35.*
Fig. 7. *?*Humiella *sp. Longitudinal section cuting a lateral; sample FSM 72, X 70.*
Figs. 8, 9. *?*Ioanella *sp. Section through pluricyste aggregates; sample N29, X 70.*
Fig. 10. *?*Clypeina *sp. Oblique section; sample N 24, X 70.*
Figs. 11-13. Clypeina *sp. 11, oblique section; sample N15, X 30. 12, longitudinal-tangential section; sample N 12, X 35.13, longitudinal-tangential section N 14, X 17.*
Figs. 15-18. Salpingoporella *cf.* katzeri *CONRAD & RADOIČIĆ. 15, transverse-oblique section; sample FSM 155, X 70. 16, transverse section; sample FSM 149A, X 70. 17, longitudinal-oblique section; sample FSM 150, X 70. 18, longitudinal-tangential section; sample FSM 150, X 70.*
For all explanations in the plates 1-3, FSM = Fara San Martino

PLATE II

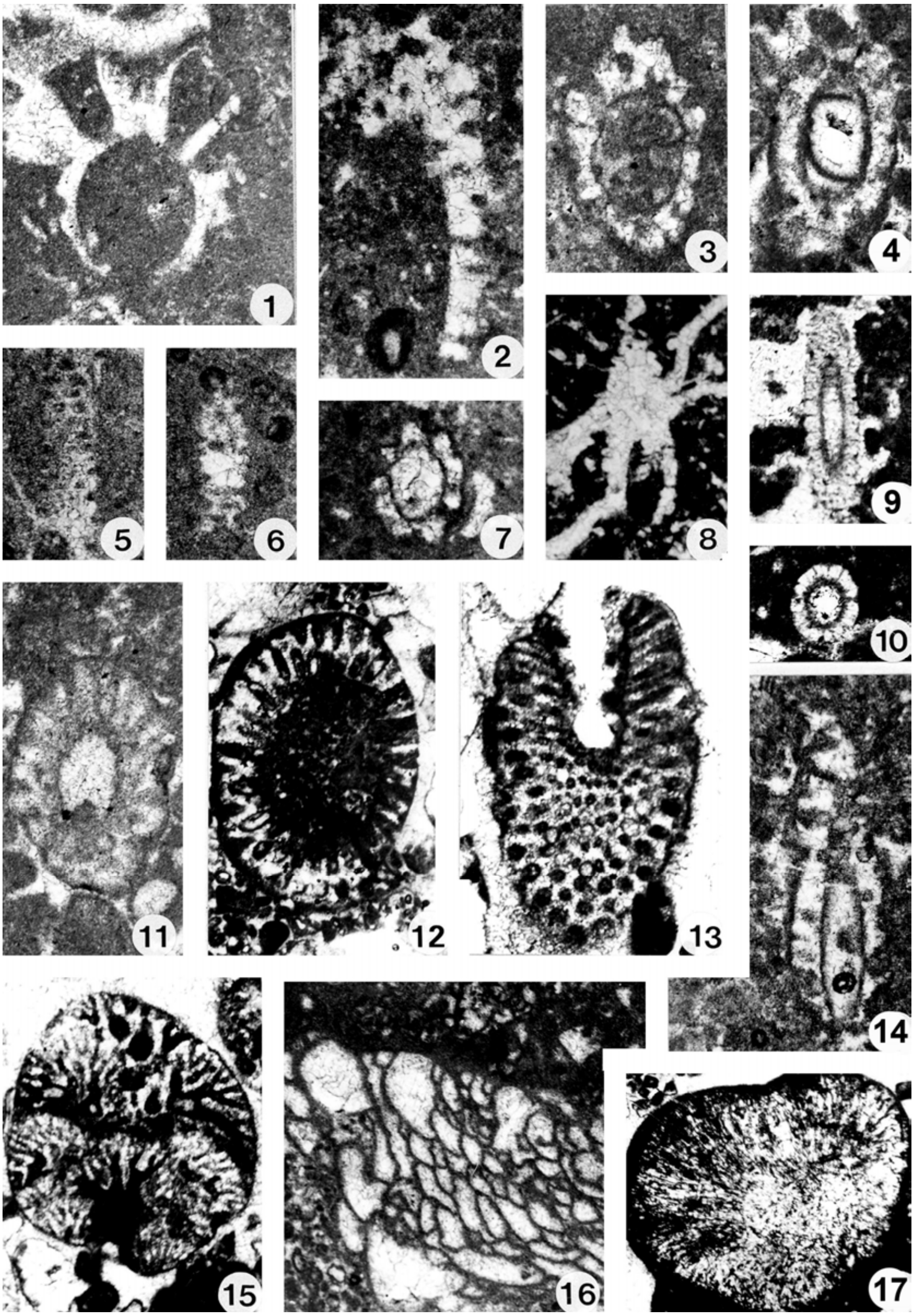


Fig. 1. Clypeina solkani *CONRAD & RADOIČIĆ. Transverse-oblique section; sample FSM 242, X 70.*
Fig. 2. Salpingoporella melitae *RADOIČIĆ. Longitudinal-oblique section; sample FSM 155, X 70.*
Fig. 3. Salpingoporella *sp. Oblique section; sample FSM 155, X 70.*
Fig. 4. Cylindroporella *?* elliptica *BAKALOVA. Oblique section; sample FSM 188, X 70.*
Figs. 5, 6. Salpingoporella *sp. Tangential section (5) and oblique section (6); sample FSM 155, X 70.*
Figs. 7, 8. Salpingoporella muehlbergii *LORENZ. Oblique sections; sample FSM 155, 7 X 70; 8 X 35.*
Figs. 9, 10. Salpingoporella dinarica *RADOIČIĆ. Oblique section (9) and transverse section (10); sample 227, X 70.*
Fig. 11. Salpingoporella *sp. Oblique section; sample FSM 96B, X 70.*
Fig. 12. Triploporella marsicana *PRATURLON. Transverse-oblique section; sample 208, X 17.*
Fig. 13. Salpingoporella pygmaea *GUEMBEL. Oblique section; sample 207, X 35.*
Fig. 14. Similiclypeina *aff.* somalica *CONRAD, PEYBERNES & MASSE. Oblique section; sample FSM 189, X 50.*
Fig. 15. Margueritiella densa *DRAGASTAN. Sample FSM 209, X 35.*
Fig. 16. Bacinella irregularis *RADOIČIĆ. Sample FSM 207, X 35.*
Fig. 17. *?*Nipponophycus *sp.. Sample FSM 209, X 17.*

PLATE III

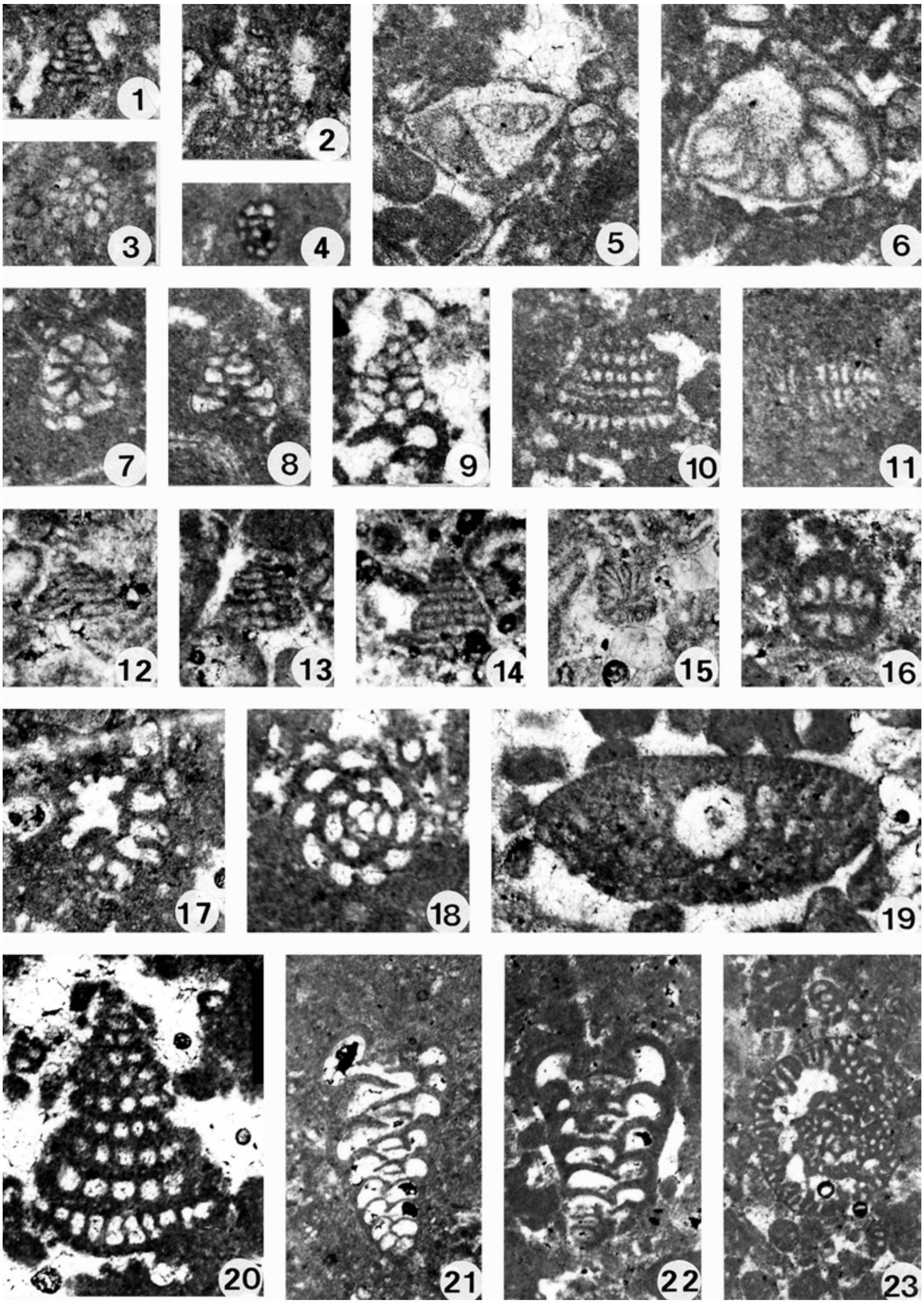


Fig. 1, 2. Montsalevia salevensis *CHAROLLAIS, BROENNIMANN & ZANINETTI. 1, axial section; sample FSM 105, X 70. 2, longitudinal-tangential section; sample FSM 105, X 70.*
Figs. 3, 4. Haplophragmoides joukowskyi *CHAROLLAIS, ROENNIMANN & ZANINETTI. Equatorial section; 3, sample FSM 105; 4, sample FSM 103, X 70.*
Fig. 5, 6. Protopeneroplis ultragranulata *GORBACHIK. 5 axial section; 6, equatorial-oblique section; sample FSM 96B, X 70.*
Figs. 7-9. Campanelulla capuensi*s DE CASTRO. Oblique sections. 7, 8, sample FSM 242; 9, sample FSM 275, X 70.*
Figs. 10, 11. Vercorsella camposaurii *SARTONI & CRESCENTI. 10, longitudinal-tangential section; sample FSM 98, X 70. 11, transverse section; sample FSM 97, X 70.*
Figs. 12-15. Sabaudia minuta *HOFKER. 12, Axial section; 13, 14, longitudinal-tangential sections; 15, transverse-oblique section; sample FSM 190, X 70.*
Fig. 16. Vercorsella *cf.* scarsellai *DE CASTRO. Transverse section; sample FSM 149, X 70.*
Fig. 17. Voloshinoides murgensis *LUPERTO SINNI & MASSE. Transverse-oblique section; sample FSM 227, X 70.*
Fig. 18. Debarina hahounerensis *FOURCADE, RAOULT & VILA. Median-transverse section; sample FSM 227, X 70.*
Fig. 19. Palorbitolina lenticularis *BLUMENBACH. Section cutting the embryonal apparatus; sample FSM 208, X 70.*
Fig. 20. Vercorsella laurentii *SARTONI & CRESCENTI. Longitudinal-tangential section; sample FSM 227, X 70.*
Figs. 21, 22. Praechrysalidina infracretacea *LUPERTO SINNI. Sub-axial sections; 21, sample FSM 97; 22, sample FSM 96, X 35.*
Fig. 23. Pseudocyclammina *sp. Sub-equatorial section; sample FSM 209, X 17.*