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Early Cretaceous benthic associations (foraminifera and calcareous algae) of a shallow tropical-water platform environment (Mljet Island, southern Croatia)

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Abstract

The Lower Cretaceous shallow-marine succession of Mljet Island in Croatia records the geological history of the southern part of the Adriatic Platform during its last tectonically quiet period, prior to the Late Cretaceous collision processes between the Adria Microplate and the Eurasian Plate. We studied the Early Cretaceous biostratigraphy of benthic foraminifera and calcareous algae in order to establish a precise, combined benthic biozonation for the Adriatic, which in turn facilitates a better understanding of the global distribution of these microorganisms during the Early Cretaceous. Thirty-four species from 26 genera of benthic foraminifera and 32 species of calcareous algae, distributed among 11 genera, were recovered from the Lower Cretaceous shallow-water carbonate rocks of Mljet Island in southern Croatia. Nine biostratigraphical units, eight of which are based upon the benthic foraminifera and calcareous algae, and one upon the microencruster *Bacinella irregularis*, have been distinguished within this interval: the *Clypeina parasolkani-Humiella catenaeformis* Interval Zone (Berriasian–earliest Valanginian), *Epimastopora cekici-Pseudoclypeina*? *neocomiensis* Interval Zone (Late Valanginian), *Montsalevia salevensis* Taxon-range Subzone (Late Valanginian), *Clypeina*? *solkani* Abundance Zone (late Early and Late Hauterivian), *Salpingoporella melitae-Salpingoporella muehlbergii* Interval Zone (Barremian), *Bacinella irregularis* Assemblage Zone (Early Aptian), *Salpingoporella dinarica* Abundance Zone (Late Aptian), *Orbitolina* (*Mesorbitolina*) *texana*-"*Valdanchella*" *dercourti* Interval Zone (Early Albian) and "*Valdanchella*" *dercourti* Taxon-range Zone (Late Albian).

The stratigraphical position of the main genera and species of benthic foraminifera and calcareous algae within the Berriasian–Albian interval is discussed, and the established biozones are correlated within the Adriatic Platform domain.

The Early Cretaceous diversification of benthic foraminifera in the area investigated can be shown to follow the sea-level curves for that period, and the major foraminiferal turnovers coincide with global sea-level rise and fall. During relative sea-level rises, coupled with reduced oceanic circulation and expansion of nutrient-poor, shallow tropical waters, these organisms were able to diversify into various euphotic habitats, particularly within shallow subtidal environments of the platform interior. Regressive episodes resulted in the reduction of oligotrophic habitats and a decrease in species richness.

Keywords: Early Cretaceous; Biostratigraphy; Benthic foraminifera; Calcareous algae; Adriatic Platform; Dinarides; Croatia

1. Introduction

In most localities throughout the Adriatic Platform of Croatia, the Lower Cretaceous sedimentary succession is rather monotonous and consists of exclusively shallow-water carbonate rocks, i.e., limestones and dolomites and, sporadically, intraformational breccias. These sediments accumulated in shallow-marine, tropical-water platform environments, similar to those we see today in southern Florida or the Bahamas. The character of inner-platform, shallow coastal waters of the aforementioned Florida Bay restricts the occurrence of fully-marine organisms, and carbonate producers are restricted to seagrasses (e.g., *Thalassia*), molluscs, benthic foraminifera and calcareous green algae (Bosence and Wilson, 2003).

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Such environments correspond to those of the Early Cretaceous in the area investigated, which were extensively colonised by almost exclusively benthic associations (predominantly foraminifera and calcareous algae). Therefore, in the absence of open-marine organisms (e.g., ammonites, planktonic foraminifera, etc.), which are commonly used in high-resolution biostratigraphy, benthic foraminifera and calcareous algae play a key-role in chronological dating of the evolution of the area studied.

The objective of this paper is to describe the characteristic associations of the benthic foraminifera and calcareous algae of southern Croatia (Mljet Island) as a contribution towards a better understanding of the global distribution of these microorganisms during the Early Cretaceous. The subsequent linking of specific Adriatic Platform sections with well-defined stratigraphical ranges of benthic index taxa to specific points within the Tethyan pelagic section could provide chronological resolution much greater than currently available.

This paper omits the systematic description of the entire microfossil assemblage, as it is not intended to be comprehensive, but deals only with the main genera and species of benthic foraminifera and calcareous algae within the Berriasian–Albian interval. Since the morphological characteristics of these species are already well-known, we restrict the remarks to clarifying their stratigraphical position, and the discussion focuses on the data from the Adriatic Platform.

Mljet Island is one of the most important areas for studying the biostratigraphy of the southern part of the Adriatic Platform. This is due to the well-exposed, continuous sections of carbonate platform sediments, with abundant, well-preserved and diverse associations of benthic foraminifera and calcareous algae. However, the study area, due to its rather isolated geographical location and poor connections with mainland Croatia, has not attracted the attention of geologists since the first investigations for economic oil and gas potential. Most of these works were focused on lithostratigraphy and geological mapping (Korolija et al., 1977; Tišljar, 1986; Sokač and Tišljar, 1986), but a few studies have been dedicated to the role of benthic foraminifera and calcareous algae as biostratigraphical tools (Gušić et al., 1995; Velić et al., 2000). Recently, Husinec (2002) lithostratigraphically classified the rock units and gave a regional correlation within the geodynamic evolution of the Adriatic Platform.

2. Geological setting

During the Early Cretaceous, carbonate platforms formed on the huge intraoceanic Adria Microplate, which was drifting eastwards as an Africa-detached element. This continued until the Late Cretaceous, when collision processes with Eurasia began (e.g., Dercourt et al., 1993; Stampfli and Mosar, 1999), resulting in the uplift of the peri-Adriatic mountain chains (Dinarides, Hellenides, Apennines, Southern Alps). Mljet Island represents an inner part of the Adriatic Platform, with unattached, isolated platform morphology. Since its intraoceanic position prevented any terrestrial contamination, and owing to tectonic quiescence during the Early Cretaceous, relative sea-level changes were the key-factor that governed facies dynamics in the area (Husinec, 2002). According to Husinec (2002), transgressive periods favoured intensified carbonate production, resulting in generally thicker beds deposited in subtidal environments of protected shoals and/or lagoons. In the study area, regressive periods are characterised by tidal flat progradation and subsequent peritidal shallowing-upward cycles, commonly ending with emersion breccia horizons at their tops.

The Berriasian–Albian interval of Mljet Island has been subdivided into seven lithostratigraphical units (Husinec, 2002), four of which are shallow-water limestones, and the other three limestone/dolomite alternations or exclusively dolomites. All of these rocks have a prominent inner-platform character and suggest palaeoenvironments ranging from the shallow subtidal of protected shoals and lagoons to the intertidal and supratidal. The underlying strata of the Early Cretaceous succession consist of Tithonian subtidal limestones and dolomites. The studied succession is conformably overlain by a Lower and Middle Cenomanian alternation of dolomites and limestones, followed by Middle and Upper Cenomanian shallow subtidal limestones.

3. Material and methods

The sections sampled for biostratigraphical (benthic foraminifera and calcareous algae) analyses are exposed in Dubrovnik-Neretva County, southern Croatia. One hundred and twenty-two samples were collected from six sections on Mljet Island (Fig. 1): Križ (MK), Mala vrata (MV), Kozarica (MKO), Sobra (MLJ and MS), Konštar (MKR) and Sparožni rat (MSR). The stratigraphical distribution of microfossils for each section is provided in the Appendix (A–E). These six sections were compiled to yield one composite section, representing the Berriasian–Albian. Additional data were obtained from several other isolated exposures during geological mapping of the island (2001–2002). In the laboratory, thin-sections were made of all of the collected samples. As a result, approximately 500 thin-sections, containing benthic foraminifera and calcareous algae, form the basis of this study.

Photographed foraminiferal and algal specimens are deposited at the Institute of Geology at Zagreb. The precise location of all the studied profiles and outcrops has been given by Husinec (2002).

4. Biostratigraphy

Benthic distribution, in particular that of foraminifera and calcareous algae, is strongly controlled by local ecological conditions. Foraminifera in particular are important biostratigraphical tools because they typically evolve rapidly, are abundant and widespread, and species or groups of species often became extinct quite suddenly (Hallock, 1982). Many species can therefore be used for local or even regional correlations. This is typically the case with the shallow, inner-platform domain of the present-day eastern Adriatic coast. These environments, with no open-oceanic influences, commonly lasted

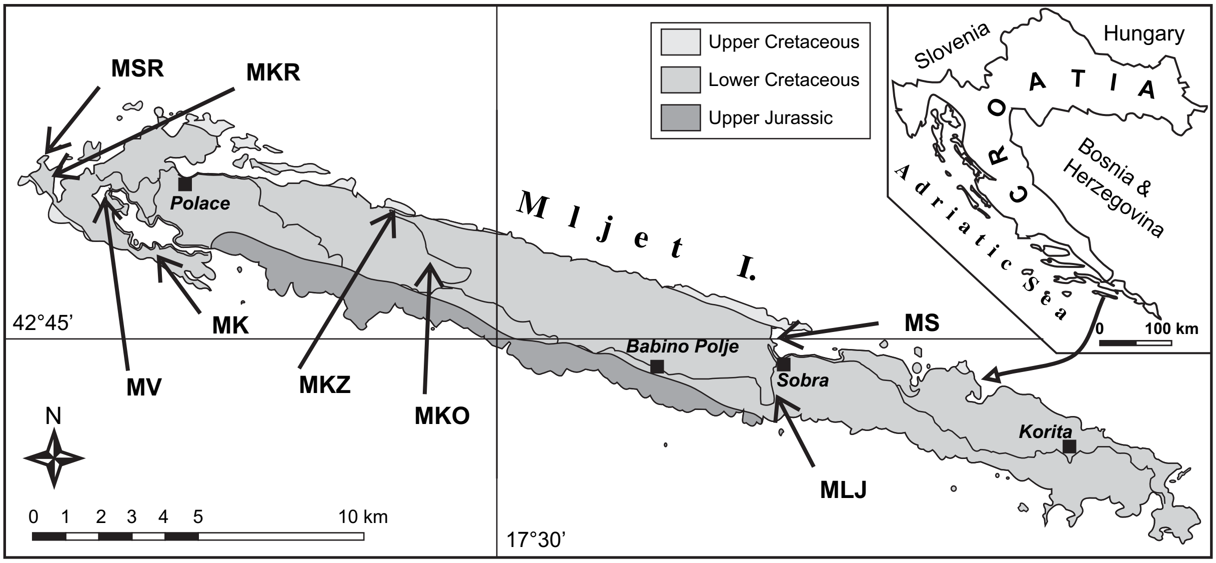


Fig. 1. Simplified geological map of Mljet Island, modified after Husinec (2002), showing locations of studied sections. For explanation of abbreviations, see Section 3.

for tens of millions of years during the Mesozoic. Numerous references on Early Cretaceous biostratigraphy of both benthic foraminifera and calcareous algae from this region (e.g., Velić, 1977, 1988; Velić and Sokač, 1978, 1983; Velić et al., 1995; Husinec et al., 2000; Cvetko Tešović, 2000) show that there is a reasonable correlation with other Mediterranean localities where benthic biozones are calibrated with the established ammonite and planktonic foraminiferal schemes (Hardenbol et al., 1998, and references therein).

Thirty-four species from 26 genera of benthic foraminifera and 32 species of calcareous algae from 11 genera were recovered from the studied sections. In addition, numerous taxa could not be assigned to species level, and are identified only to genus (e.g., *Rectocyclammina*?, *Belorusiella*, *Bolivinopsis*, *Everticyclammina*, *Nubecularia*?, *Pseudocyclammina*, *Pseudolituonella*, *Scandonea*, *Valvulineria*?). Our data show that calcareous algae are the dominant group from the Berriasian through Barremian, while the foraminiferal presence increases from the Barremian through the rest of the Lower Cretaceous (Fig. 2). The Berriasian–Hauterivian assemblage of benthic foraminifera is particularly poorly diversified, which stresses the disparity between contemporaneous benthic foraminifera associations of the southern and northern Tethyan margins, the latter having a more abundant and diverse microfauna, as suggested by Arnaud-Vanneau (1986). The Berriasian–Hauterivian calcareous algae in the study area are characterised by several index taxa, which are well documented along the coastal and insular part of the Adriatic Platform (Sokač and Velić, 1978, 1981a,b; Grgasović and Sokač, 2003).

Nine biozones, based on benthic foraminifera, calcareous algae and problematic microencruster *Bacinella irregularis*, and two unfossiliferous intervals are described from the Lower Cretaceous of the area investigated and their characteristics are presented below, from oldest to youngest. The most important species are illustrated from the Mljet material (Figs. 3–11).

4.1. Clypeina parasolkani-Humiella catenaeformis *Interval Zone: Berriasian–earliest Valanginian (Figs. 3A–F, 4B, C)*

This zone is defined from the first occurrence (FO) of the alga *Clypeina parasolkani* to the last occurrence (LO) of the alga *Humiella catenaeformis* determined within the Mljet succession. Discrepancies in the local duration of this zone are likely, due to the nature of irregular late-diagenetic dolomitisation of underlying and overlying strata. Following a thick dolomitised succession without fossils, the lower boundary of this zone is associated with the first Lower Cretaceous fossiliferous limestone lenses and intercalations within dolomites. This boundary marks the appearance of several Berriasian index species of calcareous algae: *Clypeina isabelae*, *C. parasolkani*, *C. catinula*, *Humiella sardiniensis*, *H. catenaeformis* and *Salpingoporella katzeri*?.

4.2. Humiella catenaeformis *to* Epimastopora cekici *unfossiliferous interval: Early Valanginian*

This interval is characterised by late-diagenetic dolomites and dolomitised limestones, with exceptionally scarce fossil content. It is identified with reference to the under- and overlying biozones. Fossils include *Salpingoporella annulata* (alga) and extremely rare benthic foraminifera (*Trocholina* sp., small indeterminable ataxophragmiids and lituolids), ostracods and faecal pellets (*Favreina* sp.).

4.3. Epimastopora cekici-Pseudoclypeina*?* neocomiensis *Interval Zone: Late Valanginian (Figs. 3G, 4A)*

This zone is defined from the FO of the alga *Epimastopora cekici* to the LO of the alga *Pseudoclypeina*? *neocomiensis*. In the wider southern Adriatic region, these species have

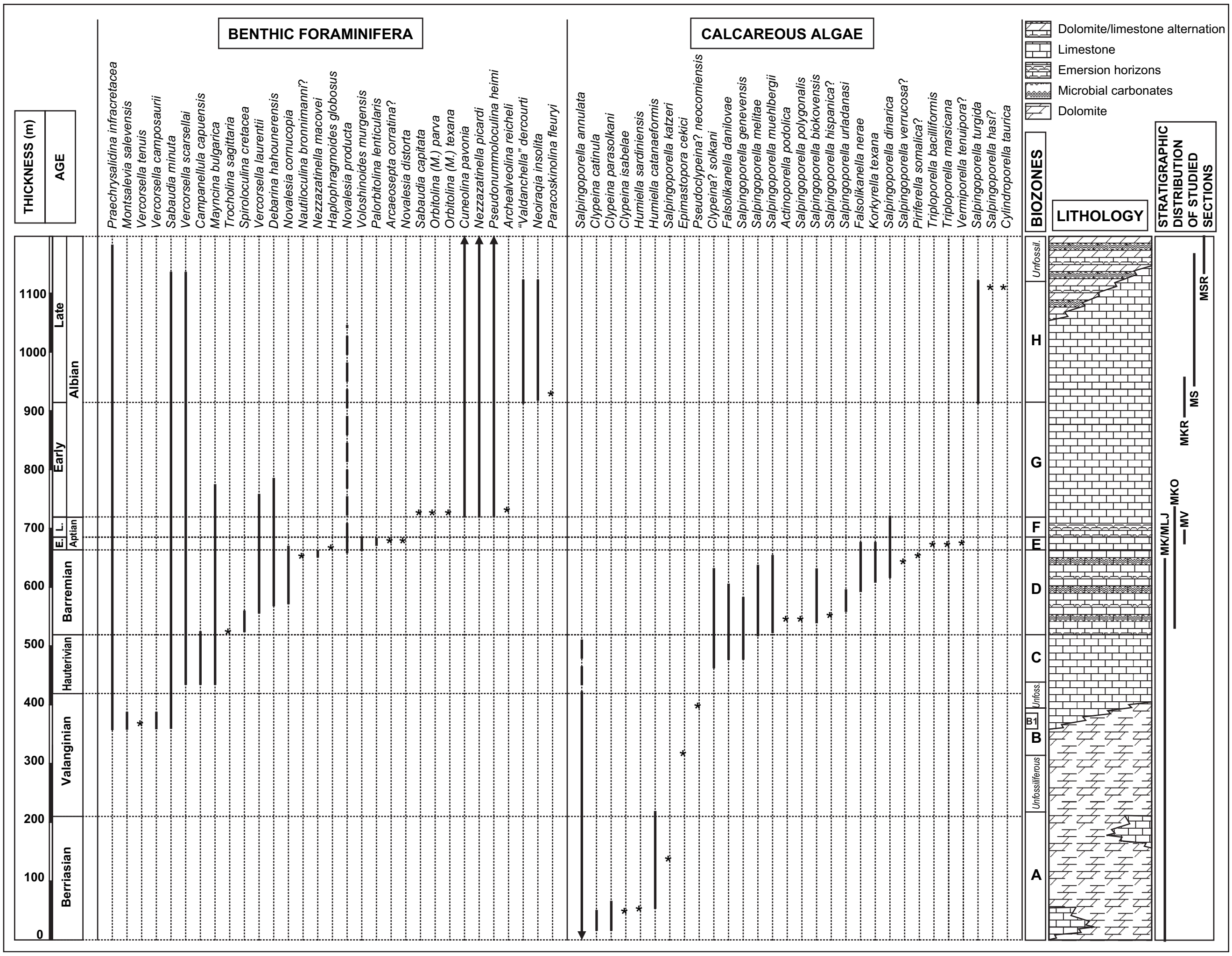


Fig. 2. Stratigraphic distribution of important Early Cretaceous benthic foraminifera and calcareous algae from the Mljet Island succession of southern Croatia, originally situated on the southern margin of the Tethyan Ocean. Biozonation proposed in this study: A, *Clypeina parasolkani-Humiella catenaeformis* Interval Zone; B, *Epimastopora cekici-Pseudoclypeina*? *neocomiensis* Interval Zone; B1, *Montsalevia salevensis* Taxon-range Subzone; C, *Clypeina*? *solkani* Abundance Zone; D, *Salpingoporella melitae-Salpingoporella muehlbergii* Interval Zone; E, *Bacinella irregularis* Assemblage Zone; F, *Salpingoporella dinarica* Abundance Zone; G. *Orbitolina* (*Mesorbitolina*) *texana*-"*Valdanchella*" *dercourti* Interval Zone; H, "*Valdanchella*" *dercourti* Taxon-range Zone. The schematic lithology and stratigraphic distribution of the studied sections are also shown.

Valanginian stratigraphical ranges. However, due to the aforementioned dolomitisation of the Lower Valanginian limestones, the age of this biozone here is Late Valanginian.

The occurrence of several index foraminifera in the central, most fossiliferous part of this biozone, allowed us to establish the *Montsalevia salevensis* Taxon-range Subzone.

4.3.1. Montsalevia salevensis *Taxon-range Subzone: Late Valanginian (Fig. 7A–D, F–H)*

This subzone is determined from the FO to the LO of the foraminifera *Montsalevia salevensis*.

4.4. Pseudoclypeina*?* neocomiensis *to* Campanellula capuensis *unfossiliferous interval: Early Hauterivian*

No stratigraphically useful taxa occur between the LO of the alga *Pseudoclypeina*? *neocomiensis* and the FO of the foraminifera *Campanellula capuensis*, so we designate this part of the section as the *Pseudoclypeina*? *neocomiensis* to *Campanellula capuensis* unfossiliferous interval. The age was determined with reference to the under- and overlying biozones.

4.5. Clypeina*?* solkani *Abundance Zone: late Early–Late Hauterivian (Figs. 4D, E, 7E, I–M)*

This zone is determined by an increased abundance of the alga *Clypeina*? *solkani*. The stratigraphical range of the foraminifera *Campanellula capuensis* is confined to this biozone in the area investigated. The LO of the alga *Salpingoporella annulata* also falls within this zone (in the wider area, its LO marks the end of the Hauterivian), as well as the FOs of the algae *Falsolikanella danilovae* and *Salpingoporella genevensis*.

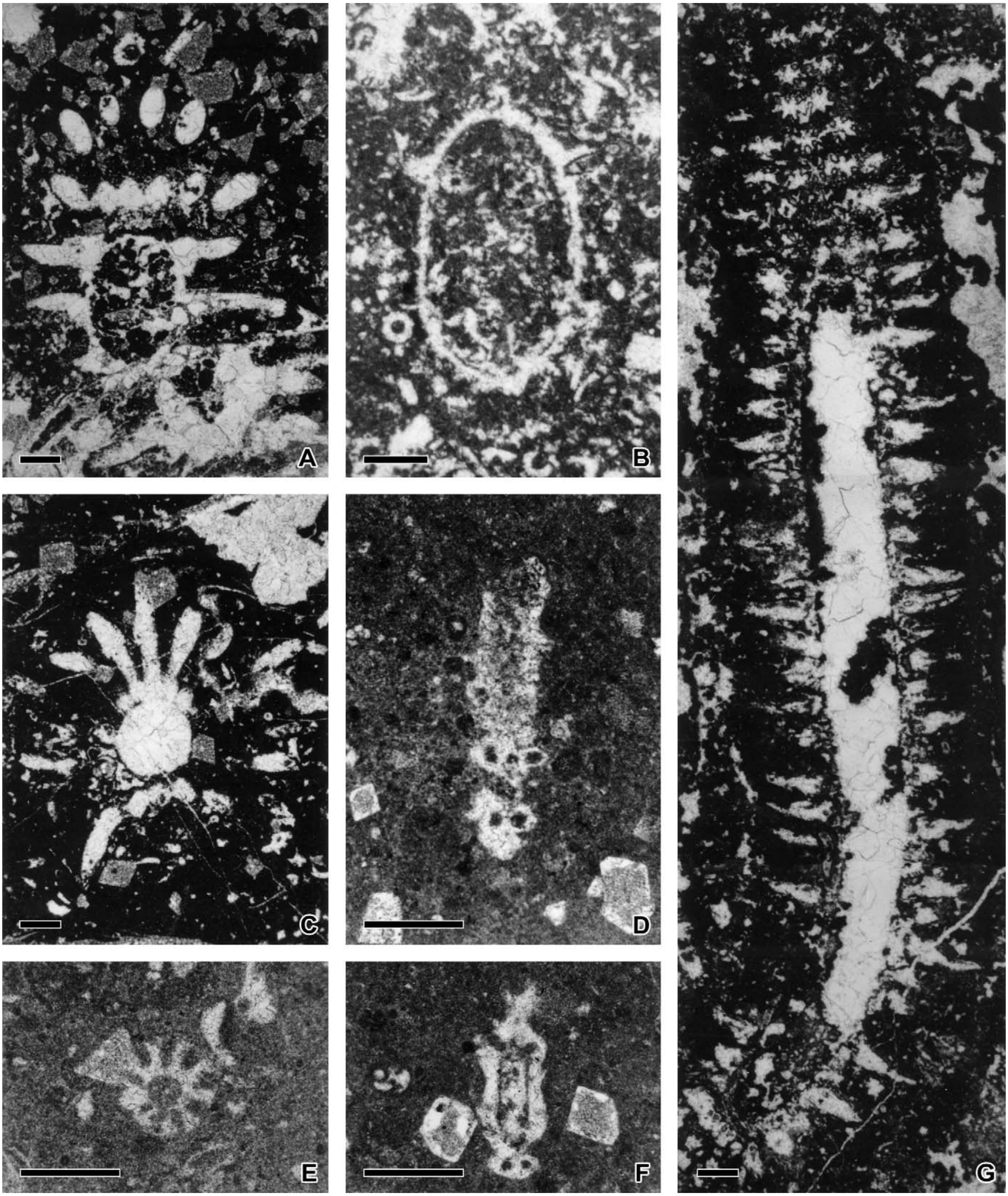


Fig. 3. A, C, *Clypeina catinula*, Berriasian; oblique section, Sobra (MLJ). B, *Humiella sardiniensis*, Berriasian; oblique section, Sobra (MLJ). D–F, *Clypeina parasolkani*, Berriasian; oblique (D, F) and transverse (E) section, Sobra (MLJ). G, *Pseudoclypeina*? *neocomiensis*, Valanginian; tangential oblique section, Sobra (MLJ). Scale bars represent 0.5 mm.

4.6. Salpingoporella melitae-Salpingoporella muehlbergii *Interval Zone: Barremian (Figs. 4F–I, 5A–I, 6A, 7N–R)*

This zone is defined by the FO of the alga *Salpingoporella melitae* and the LO of the alga *S. muehlbergii*. The benthic foraminiferal association lacks index taxa and is characterised by predominantly ataxophragmiids of a wider stratigraphical range. The very rich microfossil assemblage associated with this zone indicates that benthic ecological conditions during the Barremian were particularly favourable for algal growth and as a habitat for small foraminifera.

4.7. Bacinella irregularis *Assemblage Zone: Early Aptian (Figs. 5J, 6E, F, 8)*

The *Bacinella irregularis* Assemblage Zone comprises strata that contain a distinctive assemblage of the following taxa: *Bacinella irregularis* (an enigmatic microencruster interpreted as cyanobacteria: e.g., Camoin and Maurin, 1988; Schmid, 1996), the foraminifera *Voloshinoides murgensis* and *Praechrysalidina infracretacea*, and the algae *Triploporella bacilliformis* and *T. marsicana*. The first and the last mass occurrences of the association delineate the boundaries of the zone.

The Early Aptian fossil association of the wider region is typified by an abundance of orbitolinids, which form the basis of a detailed biostratigraphy. In contrast, the orbitolinid assemblage in the studied area is extremely poor, with scarce occurrences of *Palorbitolina lenticularis* (see Section 5, below).

4.8. Salpingoporella dinarica *Abundance Zone: Late Aptian (Fig. 6B–D)*

This zone is defined by a significant increase in abundance of the nominate algal species and its upper boundary is also coincident with the LO of this alga. This unusual abundance of *Salpingoporella dinarica* within Upper Albian strata can be traced laterally across the Adriatic Platform.

4.9. Orbitolina (Mesorbitolina) texana-"Valdanchella" dercourti *Interval Zone: Early Albian (Figs. 9, 10)*

This zone is defined from the FO of *Orbitolina* (*Mesorbitolina*) *texana* to the FO of "*Valdanchella*" *dercourti*. The Early Albian age (see Section 5, below) is confirmed by the following microfossil association: *Orbitolina* (*Mesorbitolina*) *parva*, *O.* (*M.*) *texana*, *Pseudonummoloculina heimi* and *Archaealveolina reicheli*.

4.10. "Valdanchella" dercourti *Taxon-range Zone: Late Albian (Figs. 6G–L, 11)*

This zone is defined by the FO to LO of "*Valdanchella*" *dercourti*. Numerous occurrences of "primitive" orbitolinids support a Late Albian age for this zone.

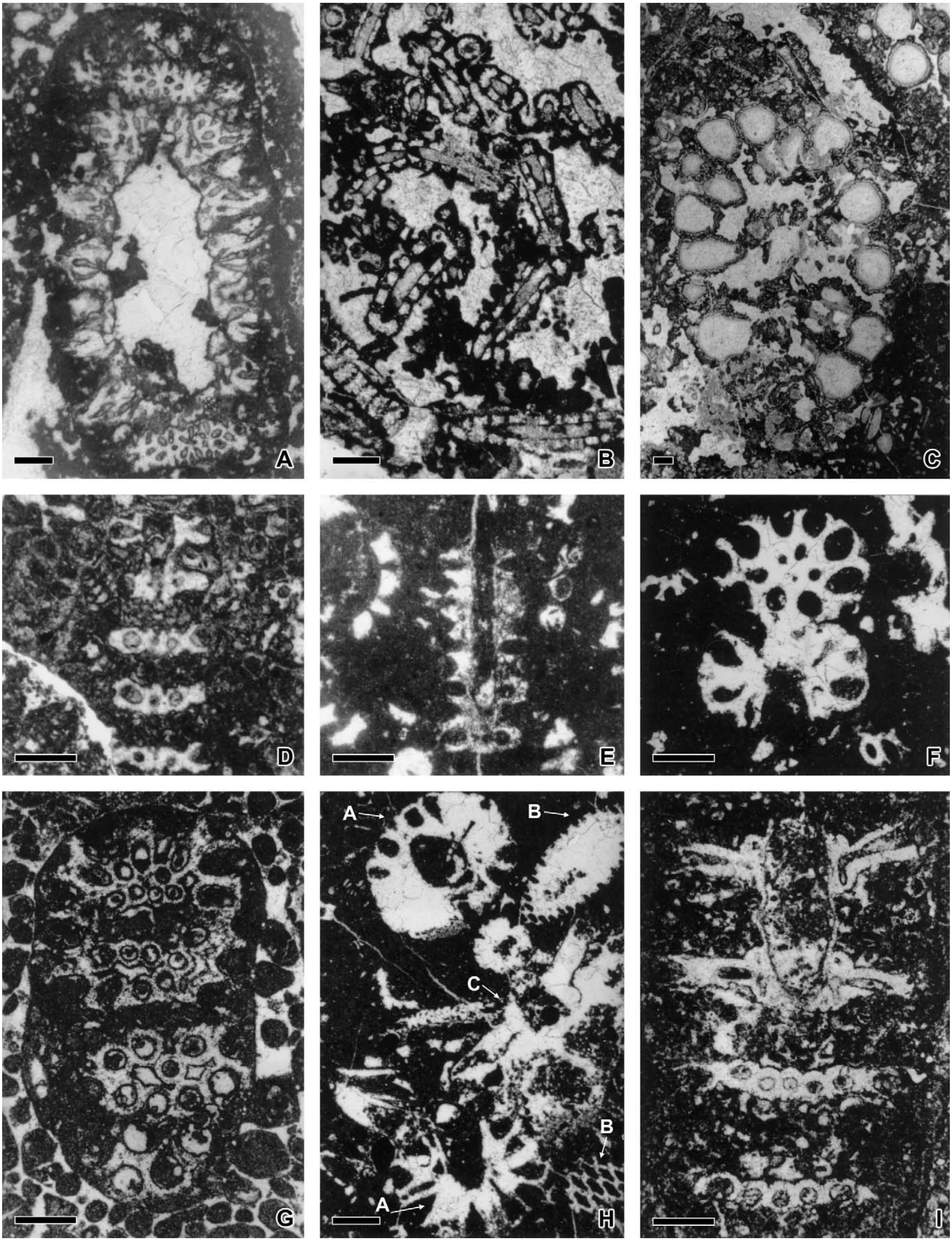
Conformably overlying deposits consist of transitional Albian/Cenomanian dolomitised beds that are devoid of fossils.

5. Discussion

5.1. Benthic foraminifera and calcareous algae abundance and species richness

The distribution of benthic foraminifera is strongly influenced by a variety of physical, chemical and biotic variables, the predominant driving force of which is the differential influence of depth-related factors. Benthic foraminiferal distribution, however, cannot be simply related to depth niches, but to the complex interplay of abiotic and biotic components – the nature of the microbenthos (Koutsoukos and Hart, 1990). Due to the dependence of larger foraminifera on their algal symbionts (see Leutenegger, 1984), we commonly find the fossil remains of these two groups of microorganisms together. Their diversity increases during episodes of reduced oceanic circulation and expansion of nutrient-poor, shallow tropical waters in particular (Hallock, 1981; Hottinger, 1982; Lee and Hallock, 1987; Murray, 1991). According to Wood (1993) and Elias and Young (1998), high nutrient levels are reached during regressive events, and Fischer and Arthur (1977) argued that relative sea-level highs promote reduction in nutrient concentration. This mutualistic relationship, between nutrient availability and euphotic habitat diversity, is therefore a powerful tool for interpreting alternating episodes of high and low foraminiferal diversity (see Hallock, 1988). In addition, due to the isolation of the Adriatic Platform from the main land-masses during the Early Cretaceous, an increased runoff, which could increase the supply of nutrients and eliminate more oligotrophic habitats, may be excluded for the area investigated.

Eustatic sea-level changes, along with synsedimentary tectonics, are major mechanisms influencing the growth and demise of shallow, isolated platforms. Although the studied sedimentary succession appears monotonous, episodes of sea-level change may be identified by the analysis of foraminiferal diversity, which is a valuable indicator of the nature and hostility of an environment, and thus an important palaeoecological tool (Fig. 12). The Berriasian–Early Valanginian foraminiferal association, as a continuation of the Late Jurassic association (Husinec, 2002), is characterised by relatively very low diversity. The hostile nature of this very shallow environment has result in an impoverished foraminiferal association, represented by only a few genera (*Verneuilina*, *Arenobulimina*?, *Pseudocyclammina*, *Rectocyclammina*? and *Trocholina*), leaving calcareous algae as the main carbonate contributors. Such a decimated foraminiferal association can be explained as a consequence of a local extinction event associated with regional sea-level fall. There was little change until the Late Valanginian, when diversity began to increase slightly. This phenomenon may have been connected to the Valanginian drowning unconformity, also known as the Weissert Oceanic Anoxic Event (OAE) (Erba et al., 2004), that is well documented from the Caribbean to eastern Arabia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(Bosellini and Morsilli, 1997, and references therein). Biotic changes, associated with the δ^{13}C anomaly from widespread locations pointing to truly global, rather than local, fertilisation, are interpreted as a consequence of a global change in marine ecosystems, enhanced primary productivity, and accelerated carbon burial under greenhouse climatic conditions, possibly triggered by major igneous and tectonic events (Erba et al., 2004; Weissert and Erba, 2004). During that transgressive phase, organisms were able to diversify into various euphotic habitats, particularly within shallow, subtidal environments of the platform interior. Diversity continued to increase until the mid-Aptian, when it reached its maximum value, presumably influenced by OAE-1a ("Livello Selli": Menegatti et al., 1998). This episode is interpreted in a similar way to the Valanginian Weissert OAE (enhanced primary productivity, accelerated carbon burial under greenhouse conditions, major igneous and tectonic events: e.g., Weissert, 1989; Erba, 1994; Weissert et al., 1998; Larson and Erba, 1999; Erba et al., 2004). This event involved mass extinctions among the benthic platform biota at numerous Tethyan localities (e.g., Masse, 1989; Erba, 1994; Luperto Sinni and Masse, 1993; Skelton, 2003). Subsequently, possibly influenced by increased nutrient availability in surface-waters, oligotrophic habitats were severely reduced and, while the shallow seafloor was covered by algal colonies of *Salpingoporella dinarica*, the Late Aptian foraminiferal species richness decreased. A transgressive episode in the Early Albian, coupled with reduced oceanic circulation and expansion of nutrient-poor, shallow tropical waters, resulted in the appearance of several important foraminiferal species, including *Orbitolina* (*Mesorbitolina*) *parva*, *O.* (*M.*) *texana*, *Pseudonummoloculina heimi*, *Archaealveolina reicheli* and *Cuneolina pavonia*. Throughout the rest of the Albian, foraminiferal abundance and diversity decreased slightly, until a number of disappearances in the latest Albian. This coincides with one of the major regional unconformities within the rather monotonous sequence of Lower Cretaceous carbonates, which in many carbonate platforms of the world resulted in karstification (e.g., Grötsch et al., 1993; Fernández-Mendiola and Gárcia-Mondéjar, 1997).

To conclude, carbonate systems are essentially biogenic and may accordingly respond differently to relative sea-level variations. However, the Early Cretaceous diversification of benthic foraminifera in the area investigated, can be shown to follow the relative sea-level curve for that period and the major foraminiferal turnovers coincide with global sea-level rise and fall. Moreover, unlike numerous Tethyan carbonate platforms, which suffered intensive growth crises or even collapsed during major sea-level rises, e.g., in the Early Aptian (Wissler et al., 2003, and references therein), the Adriatic Platform, and in particular its interior, was much less affected. Instead of biological crisis, we record increased benthic species richness during these periods of marked global sea-level rises during the Early Cretaceous. It is logical, therefore, to assume that shallow-water, carbonate-secreting communities of the Adriatic Platform were able to keep pace with the rate of increase in accommodation space during Early Cretaceous relative sea-level rises.

5.2. A problem of stage delimitation within the inner-platform domain: benthic foraminifera and calcareous algae as biostratigraphical tools

In the absence of ammonites and planktonic foraminifera, i.e., organisms known for their high-resolution stratigraphical value, the age determinations for the Adriatic Platform are typically based on benthic organisms: foraminifera and calcareous algae. The stratigraphical ranges of these organisms are usually calibrated to those Tethyan localities where similar benthic associations are found in association with ammonites or planktonic foraminifera. A problem suffered in this study is that due to unfavourable conditions in some intervals of the Adriatic Platform succession, such as the Berriasian–Barremian, only a very poor foraminiferal assemblage was found (Velić, 1988).

Below, we remark on the main species of benthic foraminifera and calcareous algae within the Berriasian–Albian interval of the area investigated, in order to clarify their stratigraphical positions, and summarise the main results of the discussion with an emphasis on the data from the Adriatic Platform.

5.2.1. Benthic foraminifera

The association of *Vercorsella tenuis* (Fig. 7C) and *Montsalevia salevensis* (Fig. 7D, F–H) is typical for the Valanginian (Velić and Sokač, 1983; Velić, 1988). The stratigraphical range of *Campanellula capuensis* (Fig. 7E, I–M) is, according to Velić (1988), rather short, and is considered as the index species for the latest Hauterivian–earliest Barremian. However, our data show that the stratigraphical range of the species may be expanded to include the late Early Hauterivian.

Palorbitolina lenticularis (Fig. 8A–E), the most common and stratigraphically important orbitolinid foraminifera, is known from numerous Lower Aptian localities in the Croatian area of the Adriatic Platform (e.g., Velić, 1988; Husinec, 2001, and references therein), while in the Bosnian area, the species is found stratigraphically earlier, in the Upper Barremian (Gušić, 1981; Dragičević and Velić, 2002). *Voloshinoides murgensis* (Fig. 8F) is commonly found in association with *Palorbitolina lenticularis* and praeorbitolinids. It is known from the Lower Aptian of Istria (e.g., Velić et al., 1995; Cvetko Tešović, 2000) and the Cres-Lošinj archipelago (e.g., Fuček et al.,

Fig. 4. A, *Pseudoclypeina*? *neocomiensis*, Valanginian; oblique section, Sobra (MLJ). B, *Salpingoporella annulata*, Berriasian; diverse predominantly oblique sections, Sobra (MLJ). C, *Humiella catenaeformis*, Berriasian; oblique section, Sobra (MLJ). D, E, *Clypeina*? *solkani*, Barremian; tangential oblique (D) and longitudinal (E) section, Mala vrata (MV) and Sobra (MLJ). F, G, *Falsolikanella danilovae*, Barremian; tangential oblique (F) and tangential (G) section, Sobra (MLJ). H, Barremian microfossil association: A, *Falsolikanella danilovae*, oblique sections; B, *Salpingoporella melitae*, oblique and tangential sections; C, *Actinoporella podolica*, longitudinal section through whorl, Sobra (MLJ). I, *Actinoporella podolica*, Barremian; tangential oblique section, Sobra (MLJ). Scale bars represent 0.5 mm.

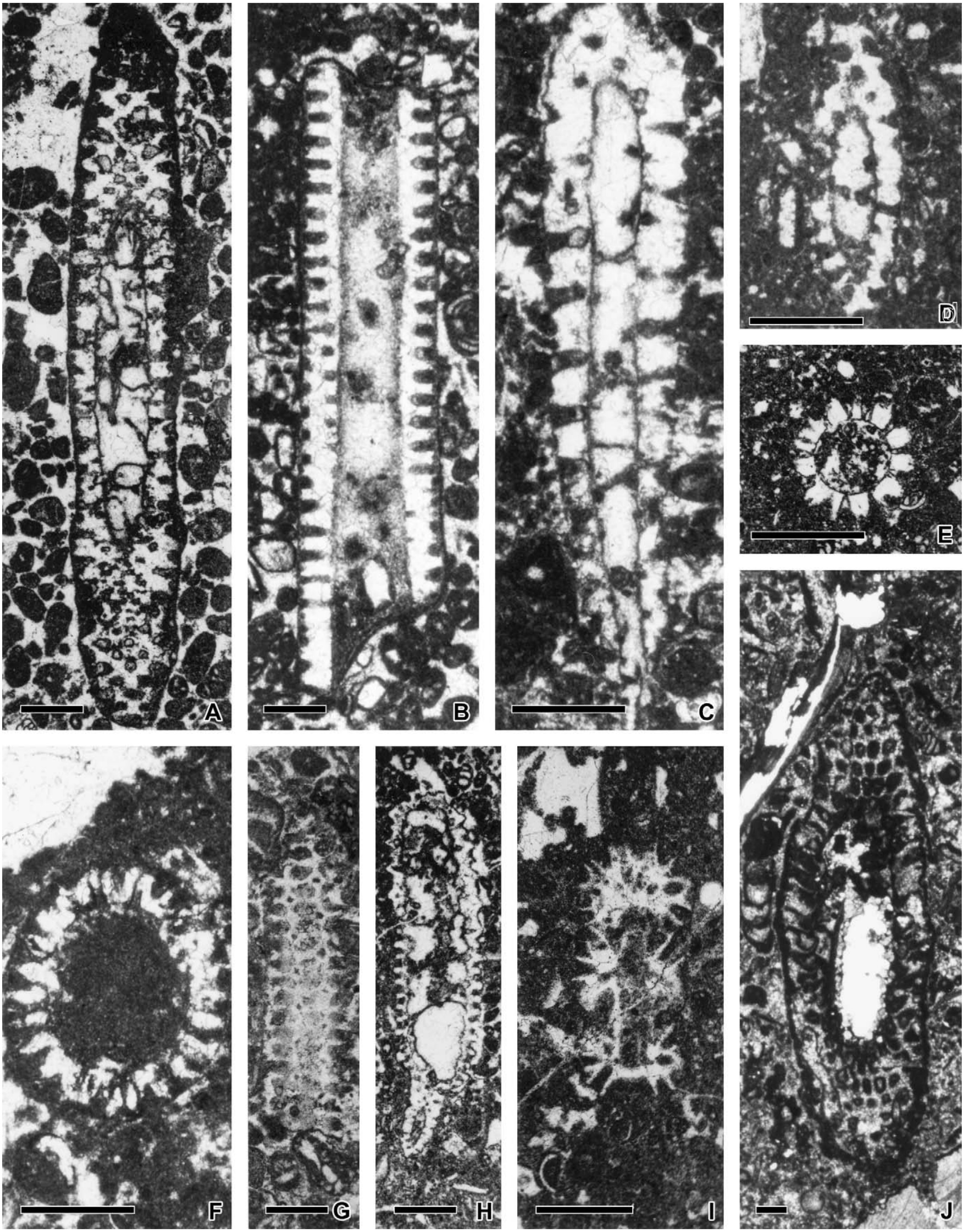

Fig. 5. A, *Salpingoporella genevensis*, Late Hauterivian; oblique tangential section, Sobra (MLJ). B, E, *Salpingoporella melitae*, Barremian; longitudinal (B) and transverse (E) section, Kriz (MK) and Sobra (MLJ). C, D, *Salpingoporella muehlbergii*, Barremian; longitudinal oblique (C) and oblique (D) sections, Kriz (MK). F, *Salpingoporella* sp., Barremian; transverse section, Kriz (MK). G, H, *Korkyrella texana*, Barremian; tangential (G) and oblique (H; head passing into handle) sections, Sobra (MLJ). I, *Falsolikanella nerae*, Barremian; longitudinal tangential section, Sobra (MLJ). J, *Triploporella* sp., Early Aptian; oblique section, Kozarica (MKO). Scale bars represent 0.5 mm.

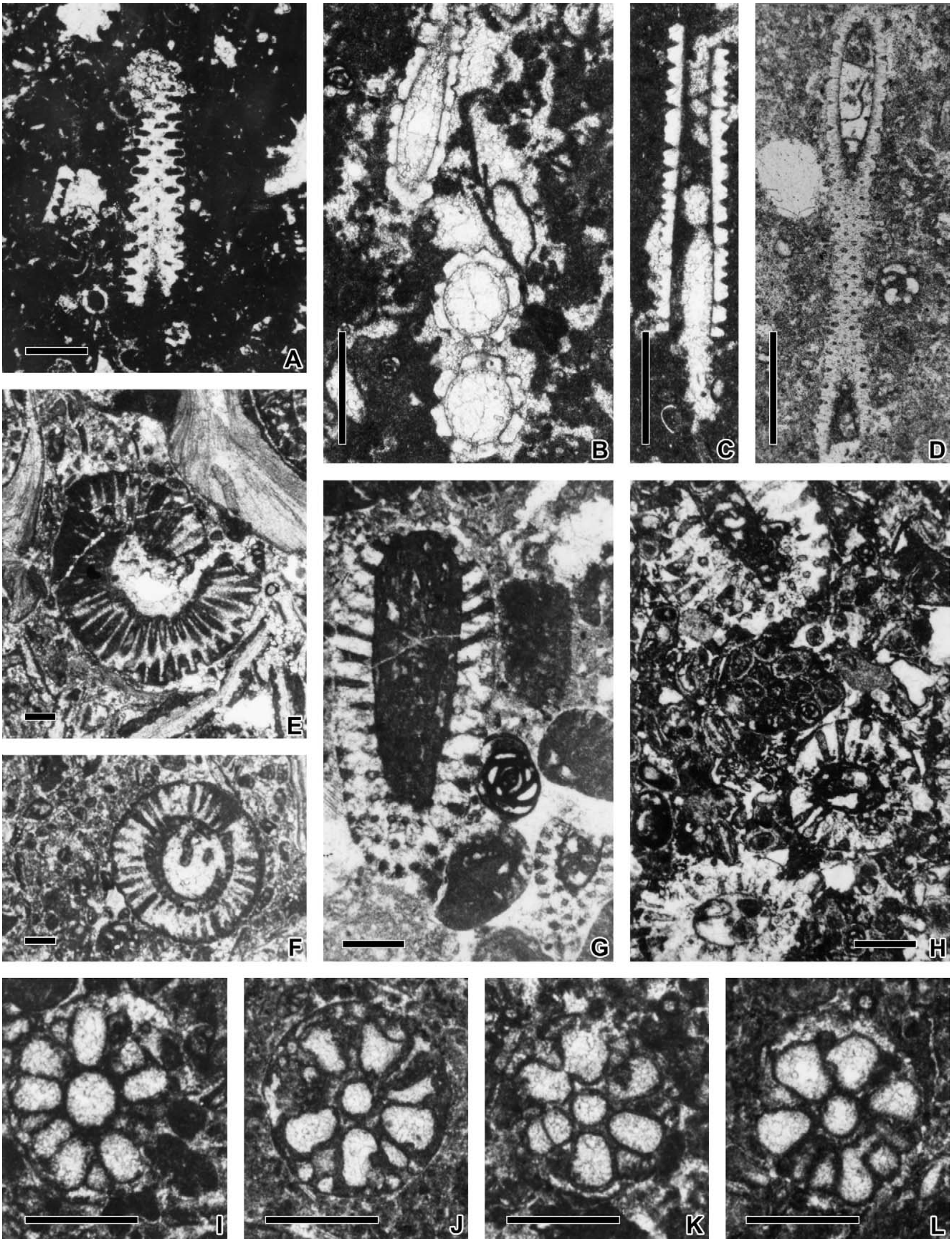

Fig. 6. A, *Salpingoporella urladanasi*, Barremian; tangential section, Sobra (MLJ). B–D, *Salpingoporella dinarica*, Late Aptian; transverse and oblique (B), longitudinal (C) and tangential oblique (D) sections, Kozarica (MKO) and Sobra (MLJ). E, F, *Triploporella bacilliformis*, Early Aptian; transverse section, Kozarica (MKO). G, H, *Salpingoporella turgida*, Late Albian; oblique sections, Sobra (CVB). I–L, *Cylindroporella taurica*, Late Albian; transverse section, Konštar (MKR). Scale bars represent 0.5 mm.

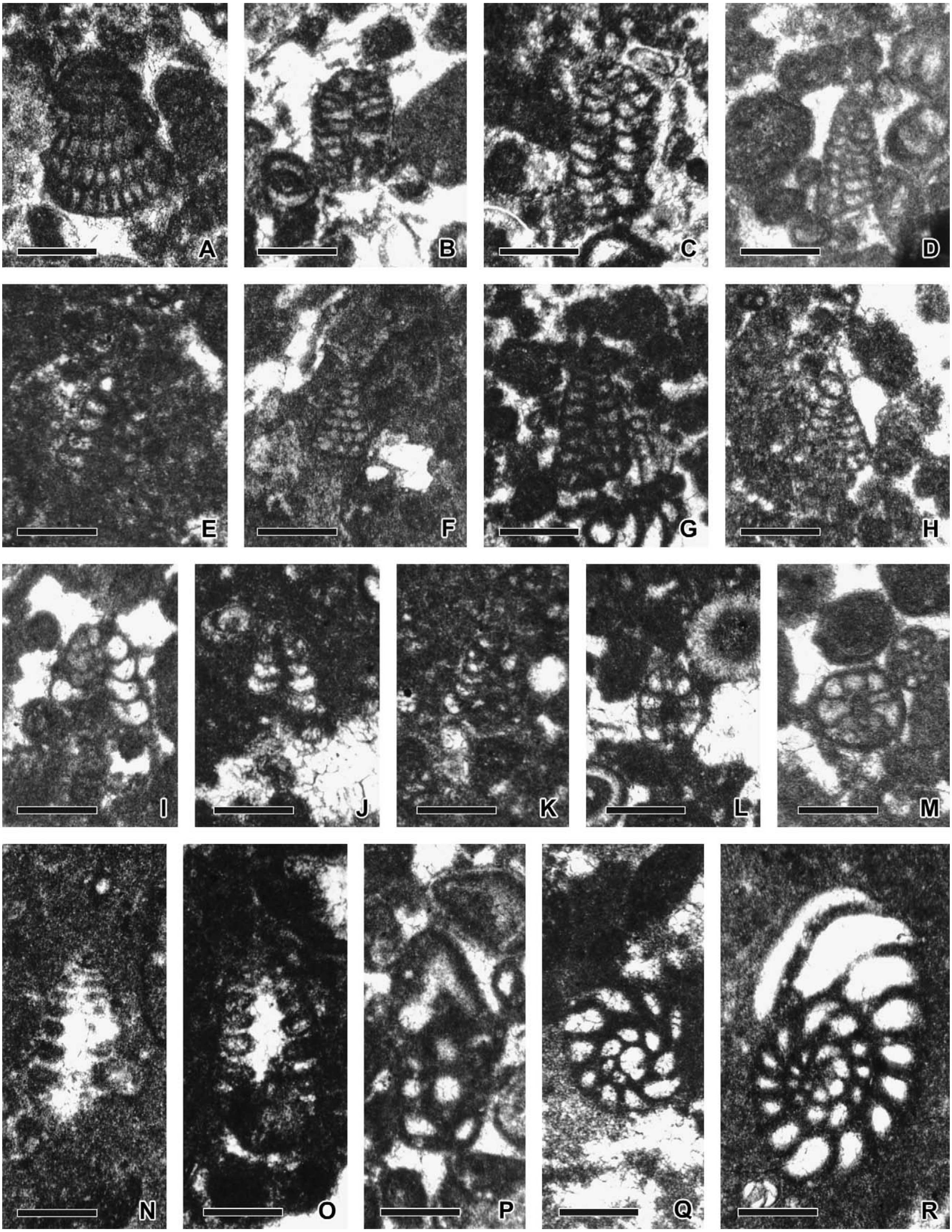

Fig. 7. A, B, *Vercorsella camposaurii*, Late Valanginian; tangential (A) and oblique (B) sections, Križ (MK). C, *Vercorsella tenuis*, Late Valanginian; approximately longitudinal section, Križ (MK). D, F–H, *Montsalevia salevensis*, Late Valanginian; longitudinal section, Križ (MK). E, I–M, *Campanellula capuensis*, Late Hauterivian–Early Barremian; longitudinal (E, I–K) and oblique (L, M) sections, Križ (MK). N, O, *Trocholina sagittaria*, Early Barremian; approximately longitudinal section, Križ (MK). P–R, *Mayncina bulgarica*, Late Hauterivian–Early Barremian; approximately axial (P) and equatorial (Q, R) section, Križ (MK). Scale bars represent 0.2 mm.

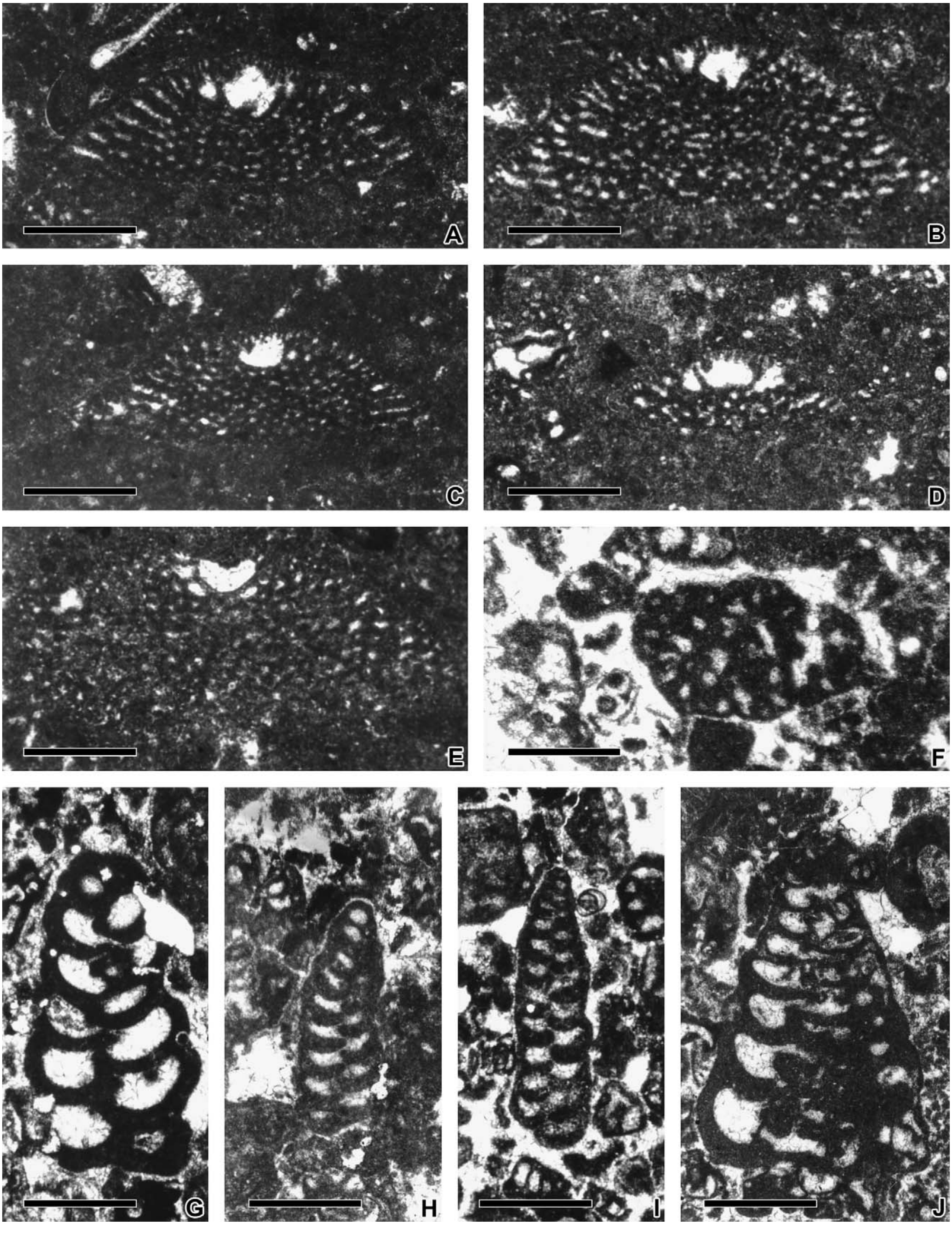

Fig. 8. A–E, *Palorbitolina lenticularis*, Early Aptian; longitudinal/vertical section through megalospheric embryonic apparatus, Uvala Rogač (MN-151). F, *Voloshinoides murgensis*, Early Aptian; oblique section, Mala vrata (MV). G, *Novalesia* cf. *distorta*, Early Aptian; approximately longitudinal section, Mala vrata (MV). H, I, *Novalesia cornucopia*, Early Aptian; longitudinal section, Mala vrata (MV). J, *Praechrysalidina infracretacea*, Early Aptian; approximately longitudinal section, Mala vrata (MV). Scale bars represent 0.5 mm.

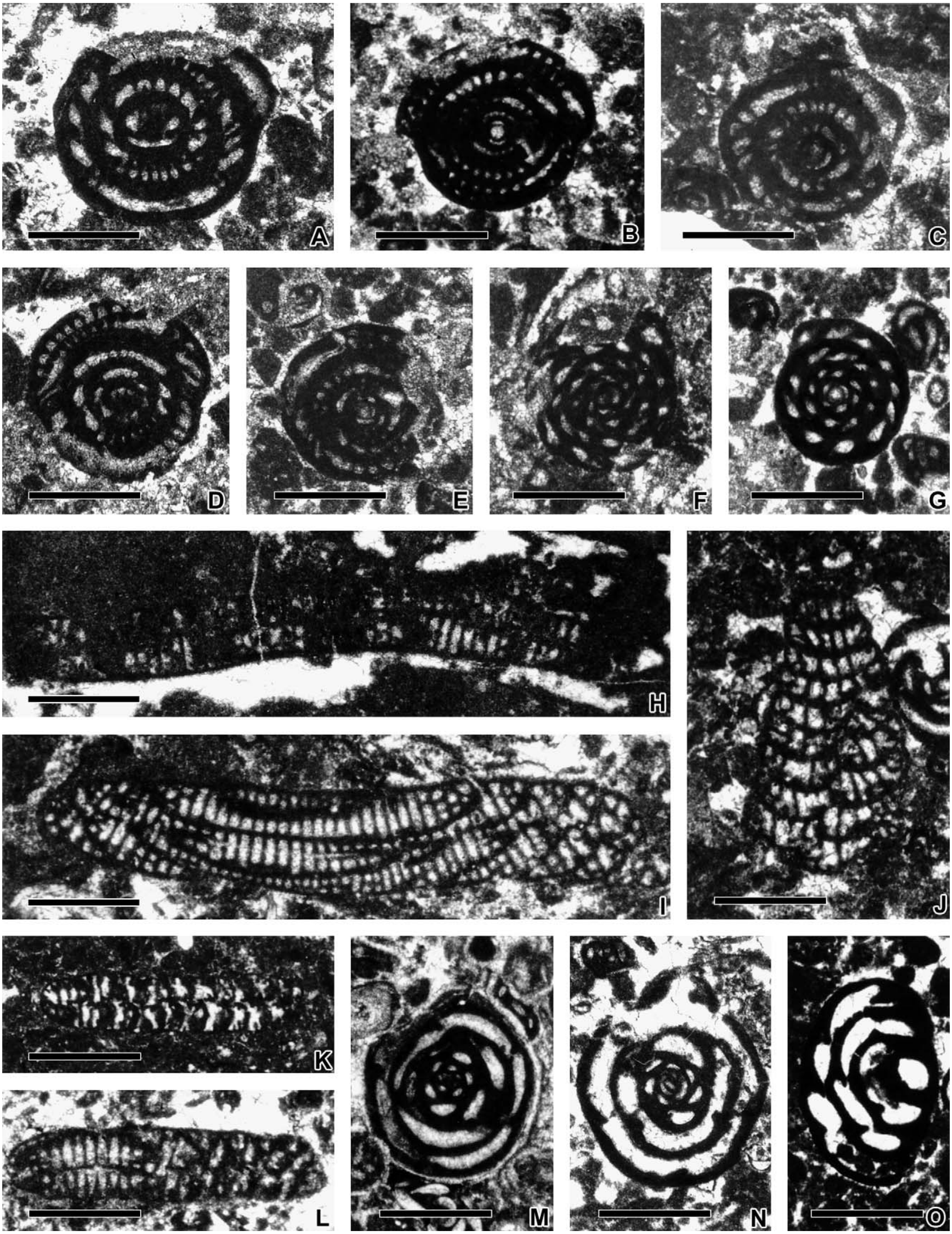

Fig. 9. A–G, *Archaealveolina reicheli*, earliest Albian; axial and approximately axial (A–E) and equatorial (F, G) sections, Kozarica (MKO). H–L, *Cuneolina pavonia*, Albian; transverse (H), oblique (I), approximately longitudinal (J) and transverse to axial-radial (K, L) sections, Sobra (RM), Sparožni rat (MSR) and Konštar (MKR). M–O, *Pseudonummoloculina* sp., Albian; approximately transverse (M, N) and oblique (O) sections, Sobra (MS), Kozarica (MKO) and Konštar (MKR). Scale bars represent 0.5 mm.

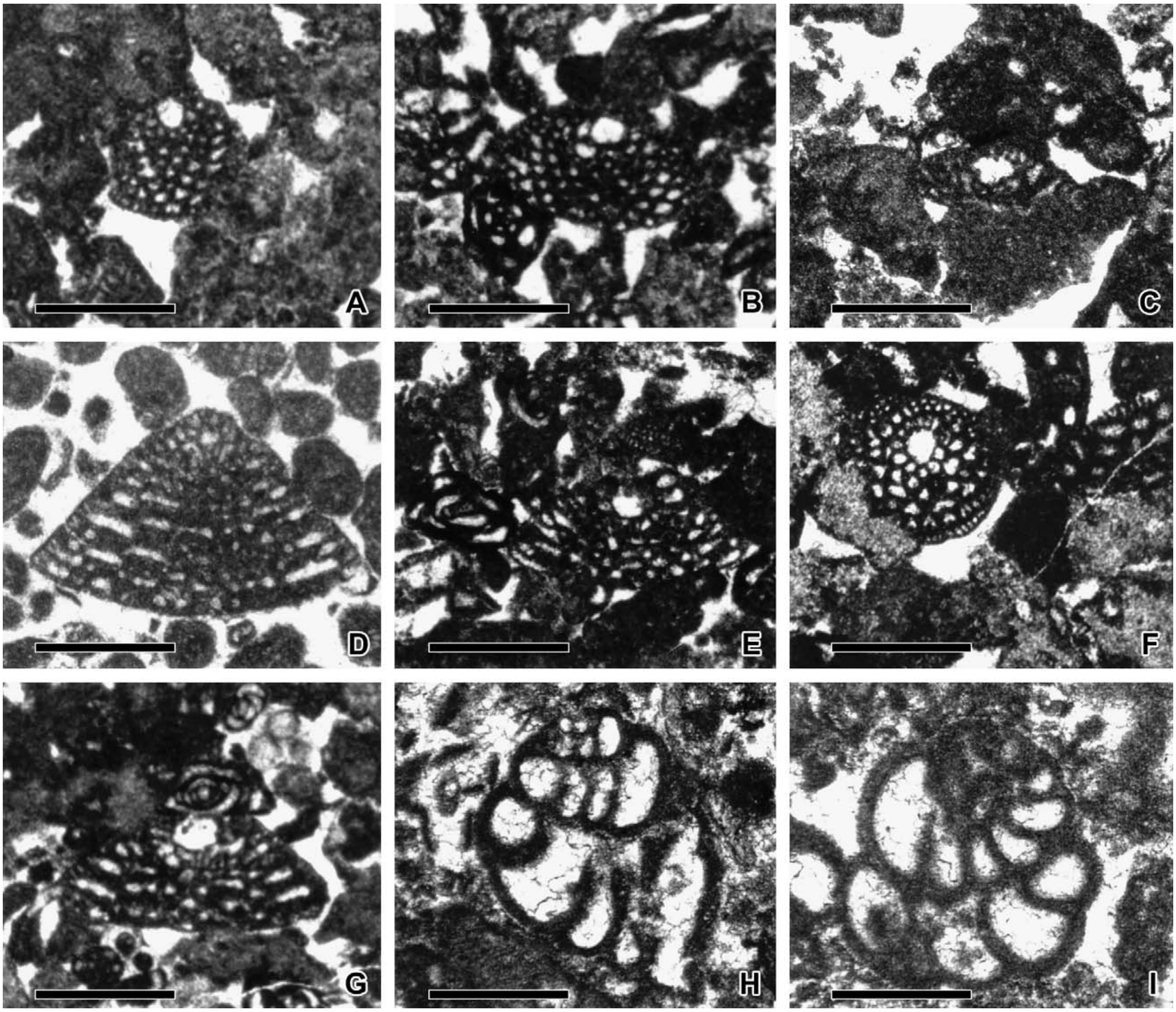

Fig. 10. A–F, *Orbitolina* (*Mesorbitolina*) *parva*, Early Albian; Oblique (A, B, F) and longitudinal/vertical (C–E) sections through megalospheric embryonic apparatus, Rt Lenga (MN-175). G, *Orbitolina* (*Mesorbitolina*) *texana*, Early Albian; longitudinal/vertical section through megalospheric embryonic apparatus, Rt Lenga (MN-175). H, I, *Nezzazatinella picardi*, Early Albian; approximately axial section, Kozarica (MKO). Scale bars represent 0.5 mm (A–G), and 0.25 mm (H, I).

1995; Husinec et al., 2000; Husinec, 2001). In several other localities, it was previously determined as *Preakurnubia* sp., for example, in central (Velić and Sokač, 1978) and southern Croatia (Sokač et al., 1978; Sokač and Tišljar, 1986).

Archaealveolina reicheli (Fig. 9A–G) was previously known from Aptian deposits (Velić and Sokač, 1983). In the northern Adriatic (Fuček et al., 1995; Husinec et al., 2000), as in the study area, the species occurs for the first time in association with *Pseudonummoloculina heimi* and *Cuneolina pavonia* (Fig. 9H–L), that is, in the lowermost Albian. Other Croatian localities (Gorski Kotar and Dalmatia) document the species from Lower Aptian deposits (Velić, 1977; Velić and Sokač, 1978; Sokač and Tišljar, 1986).

Orbitolina (*Mesorbitolina*) *parva* (Fig. 10A–F) and *O.* (*M.*) *texana* (Fig. 10G) are commonly restricted to the Upper Aptian–Lower Albian (Velić, 1988; Husinec et al., 2000; Cvetko Tešović, 2000, and references therein). The association of orbitolinid species *Neoiraqia insolita* (Fig. 11C, E–H) and "*Valdanchella*" *dercourti* (Fig. 11A, B, D), and less frequently *Paracoskinolina fleuryi* (Fig. 11I, J), is typical of Upper Albian limestones of the Adriatic Platform (e.g., Velić, 1988; Husinec et al., 2000).

5.2.2. Calcareous algae

The determined stratigraphical ranges of the insular and coastal belt of southern Croatia are commonly limited by both the lateral and vertical distribution of particular algae-favourable lithofacies. Consequently, the apparent differences in local stratigraphical ranges of some taxa may be enhanced by other factors (e.g., scarce, fragmentary or poorly preserved material, problematical identifications). In our opinion, however, the determined local stratigraphical ranges of algal species, if studied in context with the stratigraphical ranges of the entire microfossil association, seem to remain constant, at least on a local to regional scale. Moreover, the only way to discard the sometimes sweeping assumptions of the dubious

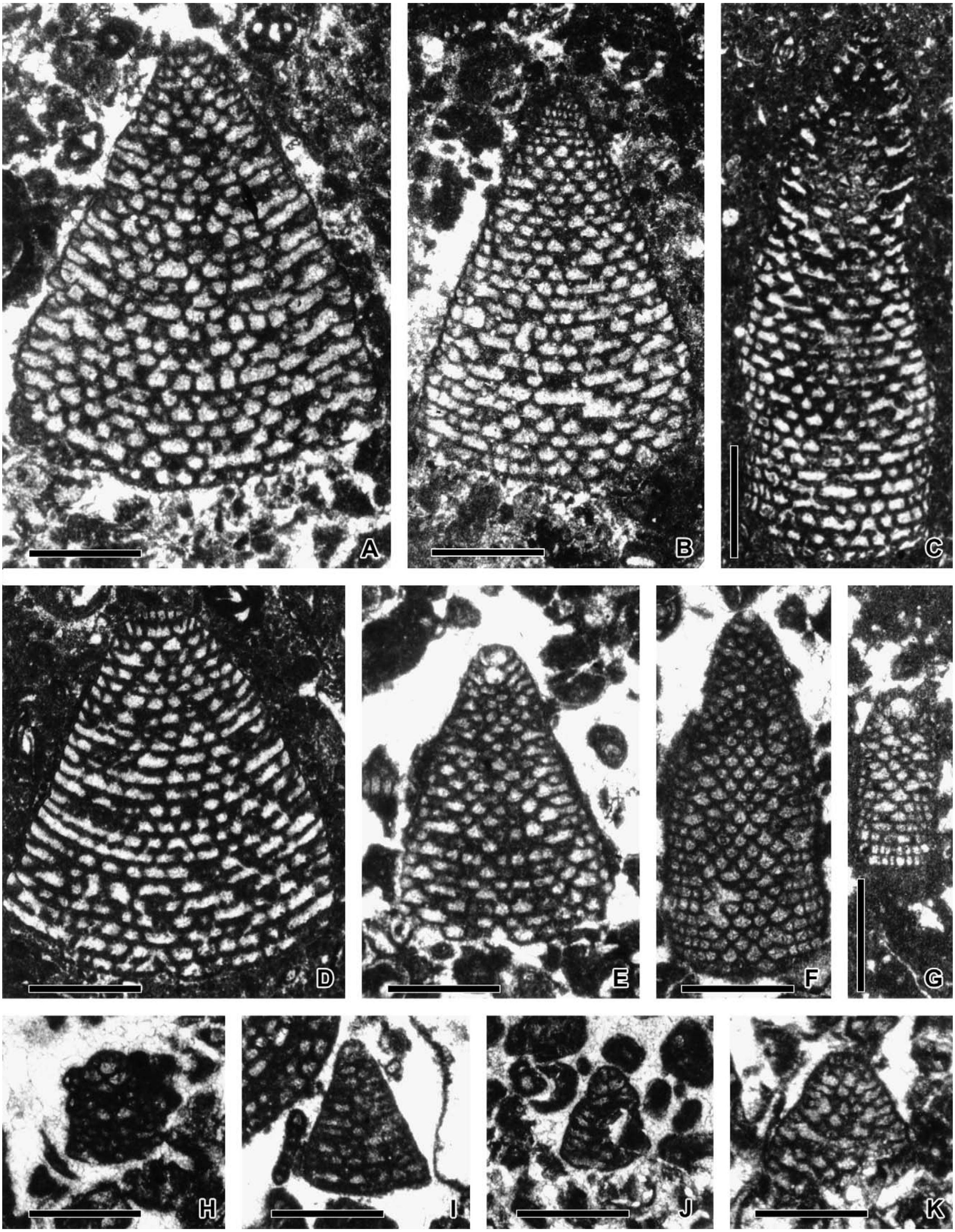

Fig. 11. A, B, D, "*Valdanchella*" *dercourti*, Late Albian; oblique longitudinal section, Sobra (MS) and Konštar (MKR). C, E–H, *Neoiraqia insolita*, Late Albian; oblique longitudinal (C, F–H) and longitudinal (E) sections, Sobra (MS). I, J, *Paracoskinolina fleuryi*, Late Albian; longitudinal (I) and oblique longitudinal (J) sections, Sobra (MS). K, unknown orbitolinid foraminifera, Late Albian; oblique longitudinal section, Sobra (MS). Scale bars represent 0.5 mm.

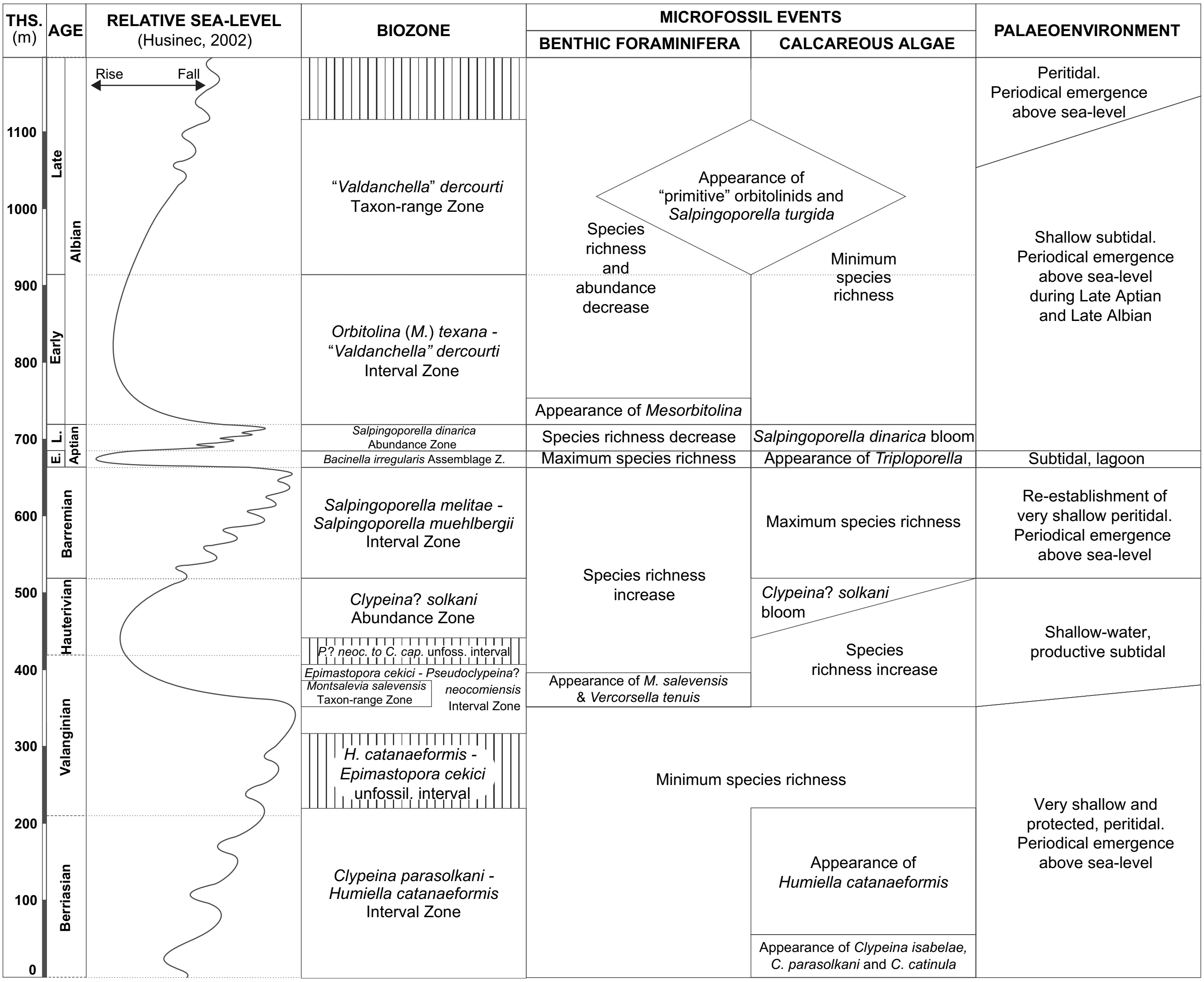

Fig. 12. Relative sea-level oscillations, important benthic (foraminifera and calcareous algae) events, and summary of the palaeoenvironmental interpretation of the Lower Cretaceous succession of Mljet Island, southern Croatia. Relative sea-level curve for the study area was constructed by Husinec (2002), based on analysis of vertical and lateral facies distribution and variability.

biostratigraphical value of calcareous algae is through extensive correlation and, where necessary, reinterpretation of problematical identifications of a particular taxon and its stratigraphical range.

Clypeina parasolkani (Fig. 3D–F) is considered to be an index species for the Berriasian, both in the area investigated and at its type-locality (Farinacci and Radoičić, 1991). The Berriasian age is further indicated by the FO of *Humiella catenaeformis* (Fig. 4C), a species originally described as *Humiella teutae* (Sokač and Velić, 1981a), which is known from numerous localities on the Adriatic Platform (Radoičić, 1967; Sokač and Velić, 1981b; Sokač, 1987), where its LO is coincident with the end of the Hauterivian.

Epimastopora cekici and *Pseudoclypeina*? *neocomiensis* (Figs. 3G and 4A respectively) are two important species for the Valanginian–Hauterivian of the Dinarides. The former was originally described by Radoičić (1970) as a Late Hauterivian or Early Barremian species, while the stratigraphical range of the latter is considered to be Late Valanginian to Early Hauterivian (Radoičić, 1965a). In the Croatian coastal area, both of the species are documented only from the Valanginian (Sokač and Velić, 1978).

The FO of *Pseudoclypeina*? *neocomiensis* occurs just above the LO of the index foraminifera *Montsalevia salevensis* (Fig. 7D, F–H), while its LO in the continuous shallow-water carbonate succession is recorded at a few tens of metres below the FO of the foraminifera *Campanellula capuensis* (Fig. 7E, I–M).

Clypeina? *solkani* (Fig. 4D, E) is a very common species within the Hauterivian–Aptian interval. Sokač (1996) summarised its stratigraphical range by defining its FO below the FO of *Campanellula capuensis* and its LO below the FO of *Palorbitolina lenticularis* (Fig. 8A–E). *Clypeina*? *solkani* is characteristically locally abundant and found in association with *Salpingoporella annulata* (Fig. 4B) and, sporadically, *Humiella catenaeformis* (Fig. 4C), the latter's LO marking the end of the Hauterivian.

The morphologically characteristic, and consequently commonly unambiguously determined algae *Salpingoporella melitae* (Fig. 5B–E), a species originally described from Mljet Island (Radoičić, 1967), and *Salpingoporella muehlbergii* (Fig. 5C, D), are known from numerous localities in the Mediterranean, marking the mid-Early Cretaceous. Their stratigraphical ranges are delimited by the LOs of *Salpingoporella annulata* and *Humiella catenaeformis*, and by the FO of the foraminifera *Palorbitolina lenticularis*. On the island of Mljet, these species are very abundant in a particularly rich Barremian algal association (Sokač, 1996).

Salpingoporella dinarica (Fig. 6B–D) is a well-known species that occurs frequently and abundantly throughout the Mediterranean. Although it is known from somewhat older deposits (Radoičić, 1967; Sokač, 1996), it is more common from the Upper Barremian to the top of the Aptian. Its particular abundance characterises deposits above the *Palorbitolina*- and *Bacinella*-bearing strata.

Following the LO of *Salpingoporella dinarica*, the Lower Albian lacks index calcareous algae. The beginning of the Upper Albian is marked by the FO of *Salpingoporella turgida* (Fig. 6G, H), the species known from numerous Upper Albian localities of the Adriatic Platform (Radoičić, 1965b; Velić and Sokač, 1980; Grgasović and Sokač, 2003). In the later levels of the Late Albian, *S. turgida* is accompanied by sporadic *Cylindroporella taurica* (Fig. 6I–L) and *Salpingoporella hasi*?.

5.3. Regional correlation

A biostratigraphical zonation scheme for the Berriasian–Valanginian strata of the Adriatic Platform does not exist. The establishment here of the Berriasian *Clypeina parasolkani-Humiella catenaeformis* and Late Valanginian *Epimastopora cekici-Pseudoclypeina*? *neocomiensis* Interval Zones helps to improve the biostratigraphical resolution of the area studied. Here, we also suggest that the entire Berriasian–Hauterivian interval of the Adriatic Platform, in cases where other index fossils are absent, may be biostratigraphically referred to as the *Humiella catenaeformis* Taxon-range Zone.

Velić and Sokač (1978) and Velić (1988) defined the *Pseudotextulariella* (= *Montsalevia*) *salevensis* Zone within the Valanginian and Lower Hauterivian alternating fossiliferous grainstone-packstones and wackestones of the Adriatic Platform. It correlates with the *Montsalevia salevensis* Taxon-range Subzone in the study area. It should be noted, however, that the total range of the nominate species in the area investigated is more restricted than is usual for the Adriatic Platform, because it was found only within the Upper Valanginian deposits.

Clypeina? *solkani*, which is one of the most common of the Early Cretaceous calcareous algae of the entire Adriatic Platform and is found at almost every Lower Cretaceous locality (Sokač, 1996), has not been previously used to define its acme zone. The species has been used to define the homonymous Cenozone, covering the entire Berriasian–Hauterivian of the Dinarides (e.g., Velić, 1977) or as the *C.*? *solkani* and *Campanellula capuensis* Zone, proposed for the Hauterivian–Barremian deposits of Cres Island in the northern Adriatic (Fuček et al., 1995).

The interval between the LO of *Campanellula capuensis* and the FO of *Palorbitolina lenticularis* in western Croatia (Cres Island) is recognised as the *Salpingoporella melitae-S. muehlbergii* Interval Zone of Barremian age (Fuček et al., 1995). It correlates well with the homonymous interval biozone of the study area. Similar associations and biozones, which correlate with those established for Mljet Island, are known from numerous localities in Croatia (e.g., Velić et al., 1995; Cvetko Tešović, 2000).

The main feature of the Dinaric Lower Aptian is the abundance of orbitolinids, particularly *Palorbitolina lenticularis.* The total range of this species is commonly used to recognise the homonymous biozone throughout the Adriatic Platform (Husinec et al., 2000, and references therein). Due to the occurence of *P. lenticularis*, the *Bacinella irregularis* Assemblage Zone of Mljet Island correlates with the aforementioned orbitolinid biozone of the wider area.

The *Salpingoporella dinarica* Abundance Zone correlates to the biozones already established in the wider area of the Adriatic Platform (e.g., Velić, 1977; Sokač et al., 1978; Velić et al., 1995; Cvetko Tešović, 2000). The common characteristic of all Croatian localities is that this alga reaches its acme in the Upper Aptian.

The Lower Albian succession of the Adriatic Platform is characterised by frequent, and in places abundant, occurrences of the orbitolinid subgenus *Mesorbitolina*, which serves as a basis for establishing local zonations (e.g., Velić, 1977, 1988; Velić and Sokač, 1978; Sokač et al., 1978; Velić et al., 1995; Cvetko Tešović, 2000; Husinec et al., 2000). Since the occurence of *Mesorbitolina* in the area investigated is extremely rare and is limited to the basal Albian, we proposed the *Orbitolina* (*Mesorbitolina*) *texana*-"*Valdanchella*" *dercourti* Interval Zone, to span the entire Early Albian. This corresponds to the aforementioned *Mesorbitolina*-association-based biozones.

The stratigraphical range of "primitive" orbitolinids on adjacent peri-Adriatic platforms is Upper Albian–basal Cenomanian (e.g., Decrouez and Moullade, 1974; Chiocchini et al., 1984; Mancinelli and Coccia, 2002). However, since within Adriatic Platform deposits these "primitive" orbitolinid forms have never been documented in association with "true" orbitolinids and/or other Cenomanian index taxa, only a Late Albian age is inferred in this region. Therefore, the "*Valdanchella*" *dercourti* Taxon-range Zone of Mljet Island correlates with the homonymous zone established for coeval deposits in Croatian regions of Istria (Velić et al., 1995), Velika Kapela (Velić, 1977; Velić and Sokač, 1978), and Cres and Lošinj (Husinec et al., 2000).

6. Conclusions

In this study, we investigated Early Cretaceous benthic associations (foraminifera and calcareous algae) of shallow, tropical-water platform environments. As an area of study, we chose a segment of the southern part of the Adriatic Platform, cropping out on Mljet Island in southern Croatia, which represents a typical, unattached, isolated (Upper Mesozoic) carbonate platform succession.

Our analyses of the microfossil associations have allowed us to establish a detailed biostratigraphical zonation scheme for the region investigated, exclusively based on the stratigraphical distributions of either benthic foraminifera or calcareous algae. From oldest to youngest, the following nine biozones are recognised: *Clypeina parasolkani-Humiella catenaeformis* Interval Zone (Berriasian–earliest Valanginian), *Epimastopora cekici-Pseudoclypeina*? *neocomiensis* Interval Zone (Late Valanginian), *Montsalevia salevensis* Taxon-range Subzone (Late Valanginian), *Clypeina*? *solkani* Abundance Zone (late Early–Late Hauterivian), *Salpingoporella melitae-Salpingoporella muehlbergii* Interval Zone (Barremian), *Bacinella irregularis* Assemblage Zone (Early Aptian), *Salpingoporella dinarica* Abundance Zone (Late Aptian), *Orbitolina* (*Mesorbitolina*) *texana*-"*Valdanchella*" *dercourti* Interval Zone (Early Albian) and "*Valdanchella*" *dercourti* Taxon-range Zone (Late Albian). We found a good correlation of some of these biozones with those previously published for the same interval of the Adriatic Platform.

Several species of benthic foraminifera and calcareous algae are of great value to the Lower Cretaceous biostratigraphy of the Adriatic Platform. These species have restricted stratigraphical ranges, evolving rapidly and becoming extinct suddenly. They are also abundant and have a widespread distribution. These include: (1) the foraminifera *Vercorsella camposaurii* and *V. tenuis* (Valanginian), *Montsalevia salevensis* (Hauterivian), *Campanellula capuensis* (Hauterivian–basal Barremian), *Palorbitolina lenticularis* and *Voloshinoides murgensis* (Lower Aptian), *Archaealveolina reicheli* (Aptian-lowermost Albian), *Orbitolina* (*Mesorbitolina*) *parva* and *O.* (*M.*) *texana* (Upper Aptian–Lower Albian), "*Valdanchella*" *dercourti* and *Neoiraqia insolita* (Upper Albian); and (2) the calcareous algae *Clypeina parasolkani*, *C. catinula* and *C. isabelae* (Berriasian), *Epimastopora cekici* and *Pseudoclypeina*? *neocomiensis* (Valanginian), *Salpingoporella melitae* and *S. muehlbergii* (Barremian), and *Salpingoporella turgida* and *Cylindroporella taurica* (Upper Albian).

Because of its isolated position within the Late Mesozoic Tethyan Ocean, the Adriatic Platform was free of terrigenous influences. Consequently, benthic distribution within oligotrophic habitats of the study area was primarily controlled by sea-level oscillations, associated changes in oceanic circulation rates, and nutrient availability in surface-waters. We have shown that the Early Cretaceous diversification of benthic foraminifera in the area investigated follows the sea-level curve for that interval, and that the major foraminiferal turnovers, i.e., radiation and extinction events, coincide with global sea-level rise and fall. During relative sea-level rises, which are associated with reduced oceanic circulation and the expansion of nutrient-poor, shallow tropical waters, organisms were able to diversify into various euphotic habitats, particularly within the shallow subtidal environments of the platform interior. Regressive episodes resulted in reduction of oligotrophic habitats and decreased species richness.

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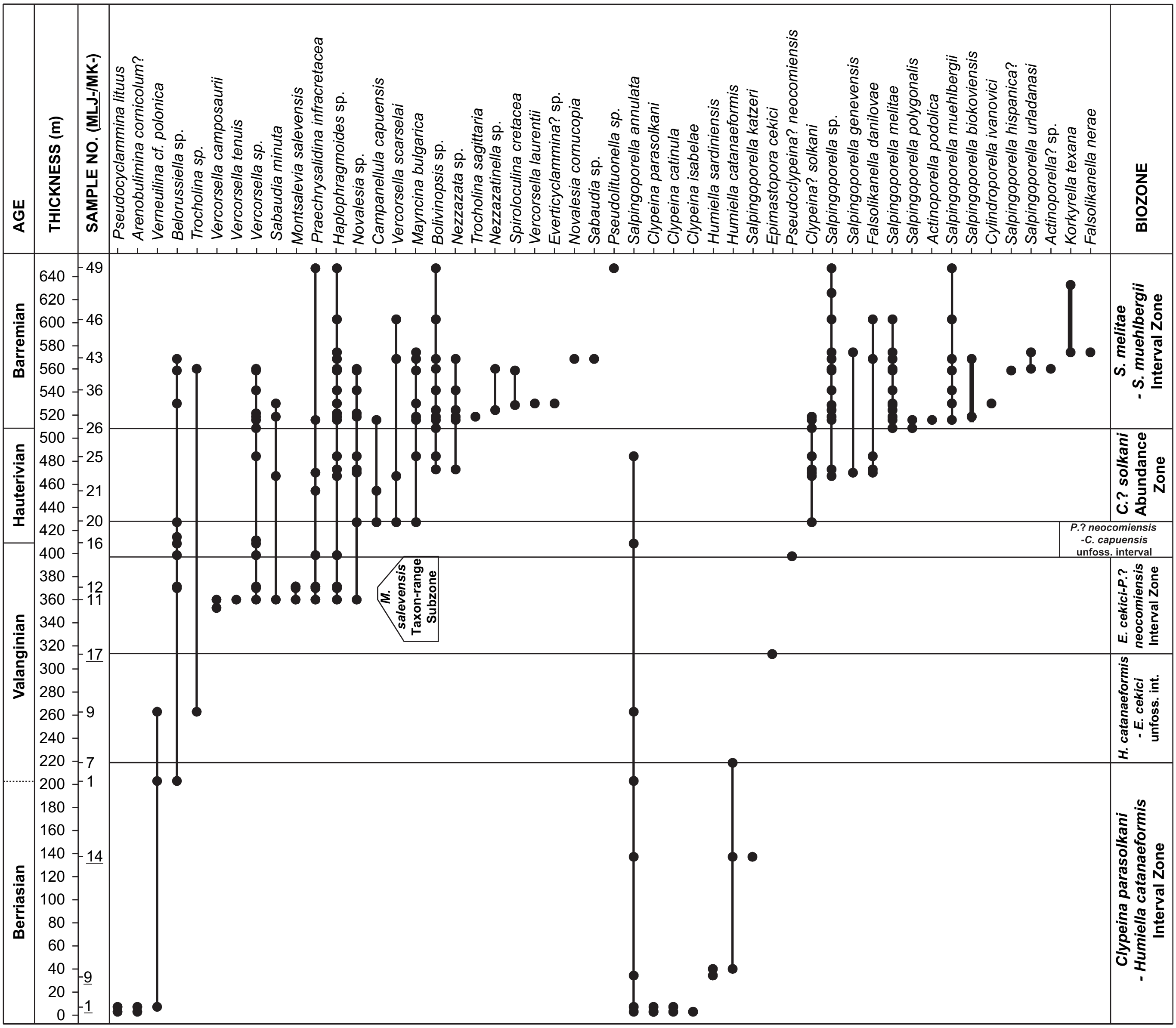
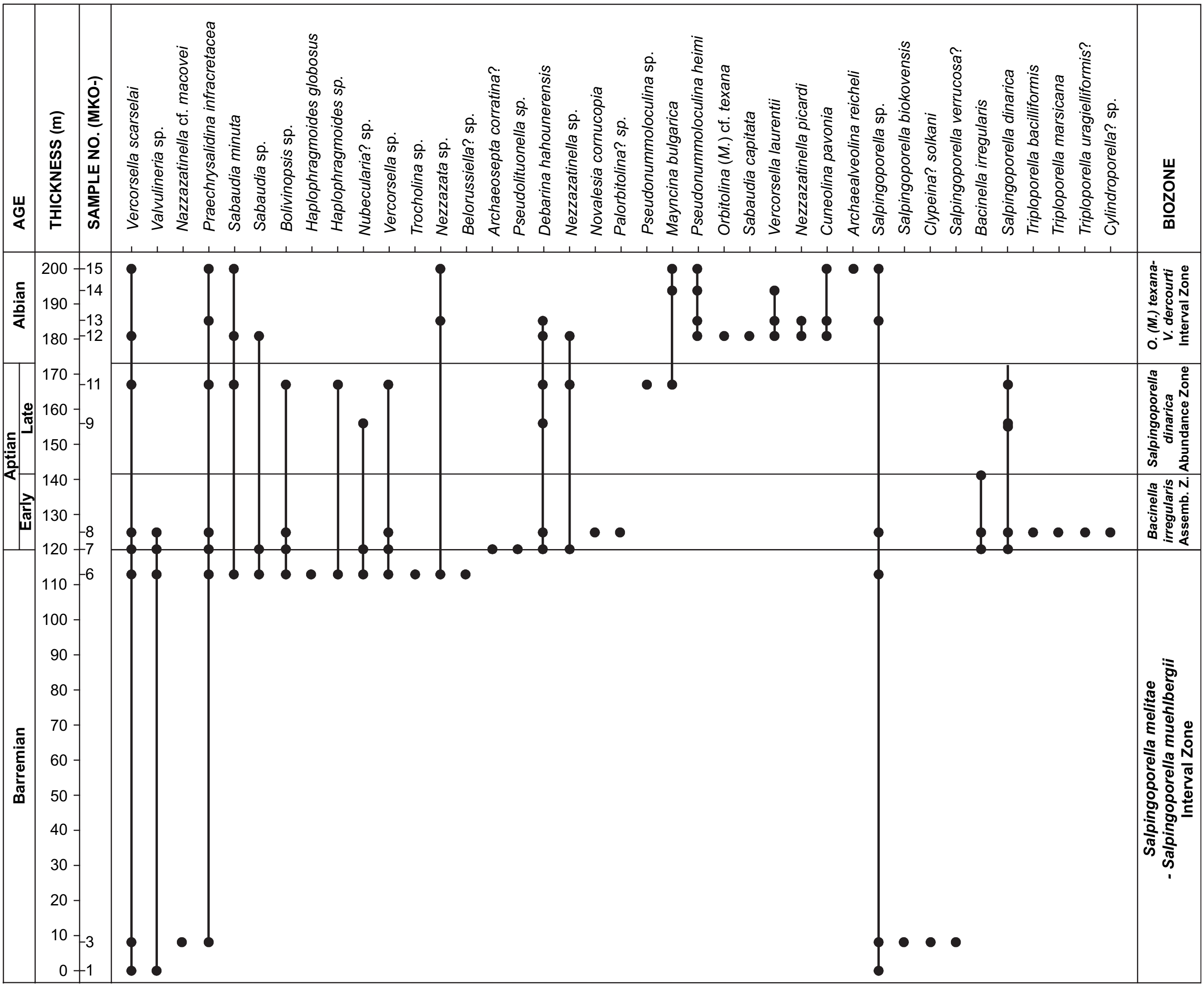
Appendix

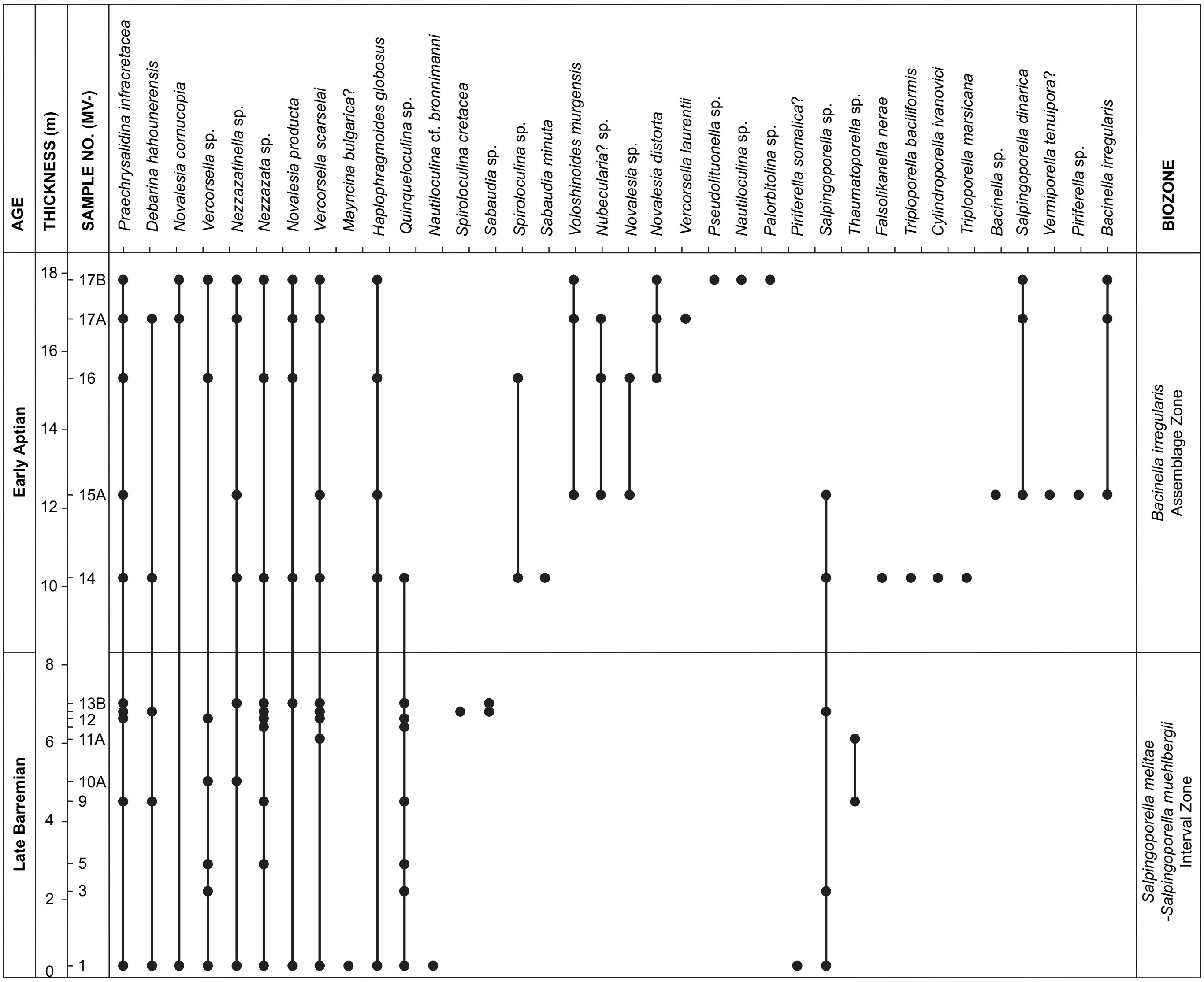
A, Križ/Sobra (MK/MLJ): stratigraphic distribution of microfossils.



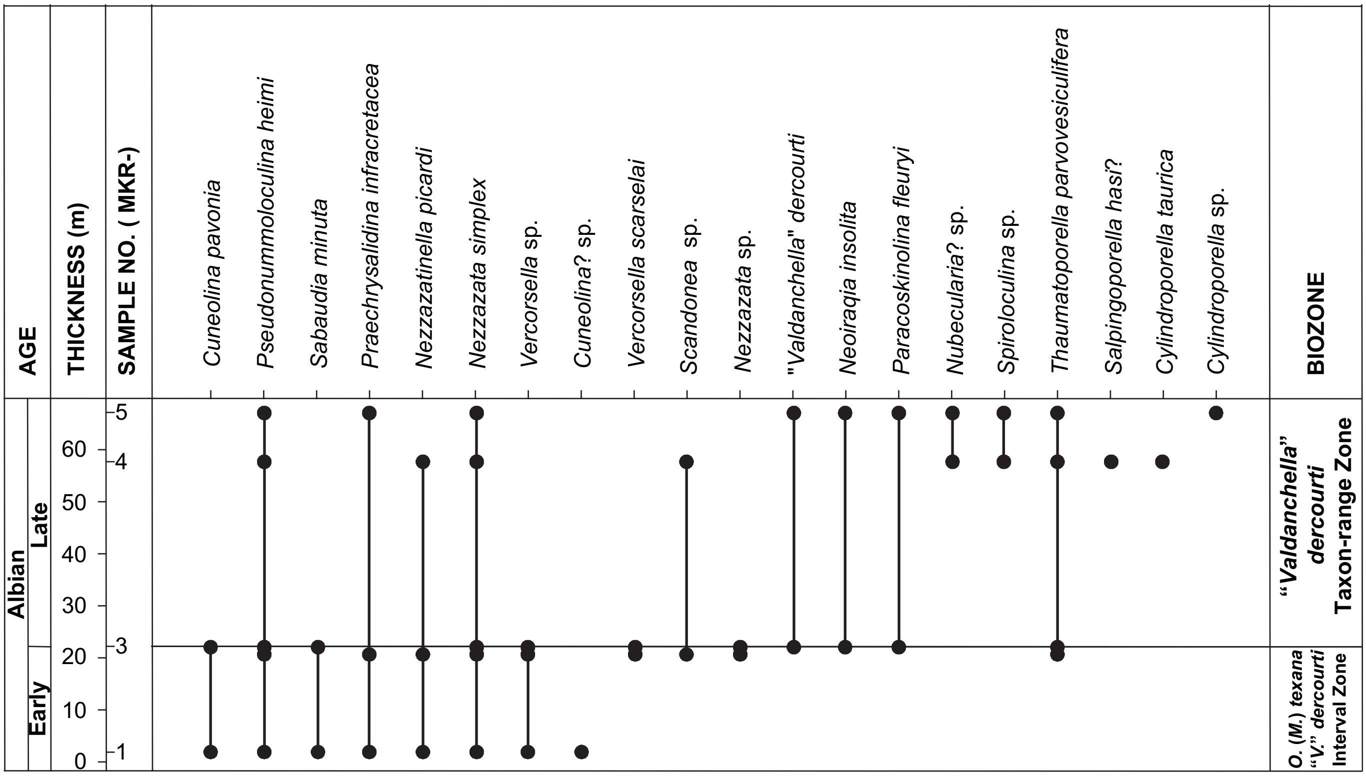
B, Kozarica (MKO): stratigraphic distribution of microfossils.



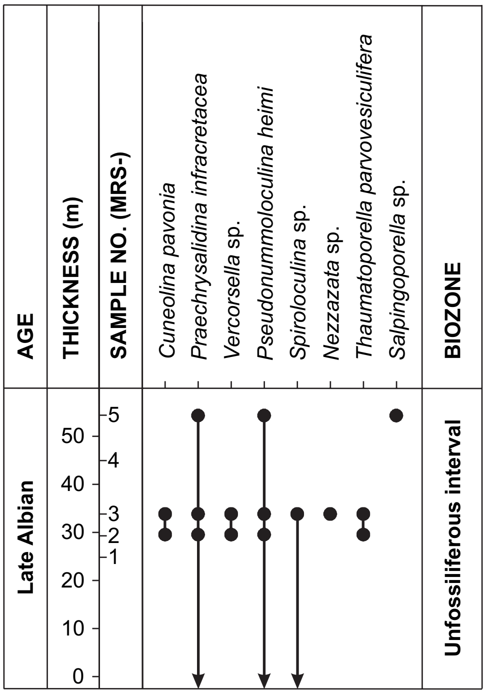
C, Mala vrata (MV): stratigraphic distribution of microfossils.



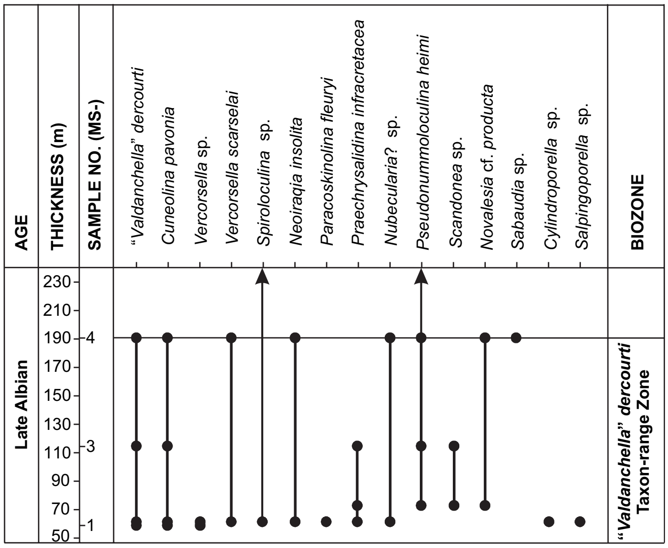
D, Konštar (MKR): stratigraphic distribution of microfossils.



F, Sparozni rat (MRS): stratigraphic distribution of microfossils.



E, Sobra (MS): stratigraphic distribution of microfossils.



List of foraminifera and algae mentioned in the text, with author attributions and dates

Benthic foraminifera

Archaealveolina reicheli (De Castro, 1966)
Archaeosepta coratina Luperto Sinni and Masse, 1993
Arenobulimina cornicolum Arnaud-Vanneau, 1980
Belorussiella sp.
Bolivinopsis sp.
Campanellula capuensis De Castro, 1964
Cuneolina pavonia d'Orbigny, 1846
Debarina hahounerensis Fourcade, Raoult and Vila, 1972
Everticyclammina sp.
Haplophragmoides globosus Lozo, 1944
Mayncina bulgarica Laug, Peybernès and Rey, 1980
Montsalevia salevensis (Charollais, Bronnimann and Zaninetti, 1966)
Nautiloculina cf. *bronnimanni* Arnaud-Vanneau and Peybernès, 1978
Neoiraqia insolita (Decrouez and Moullade, 1974)
Nezzazata simplex Omara, 1956
Nezzazatinella cf. *macovei* Neagu, 1979
Nezzazatinella picardi (Henson, 1948)
Novalesia cornucopia Arnaud-Vanneau, 1980
Novalesia distorta Arnaud-Vanneau, 1980
Novalesia producta (Magniez, 1972)
Nubecularia sp.
Orbitolina (*Mesorbitolina*) *parva* Douglass, 1960
Orbitolina (*Mesorbitolina*) *texana* (Roemer, 1849)
Palorbitolina lenticularis (Blumenbach, 1805)
Paracoskinolina fleuryi Decrouez and Moullade, 1974
Praechrysalidina infracretacea Luperto Sinni, 1979
Pseudocyclammina lituus (Yokoyama, 1890)
Pseudocyclammina sp.
Pseudolituonella sp.
Pseudonummoloculina heimi (Bonet, 1956)
Rectocyclammina sp.
Sabaudia capitata Arnaud-Vanneau, 1980
Sabaudia minuta (Hofker, 1965)
Scandonea sp.
Spiroloculina cretacea Reuss, 1854
Trocholina sagittaria Arnaud-Vanneau, Boisseau and Darsac, 1988
"*Valdanchella*" *dercourti* Decrouez and Moullade, 1974
Valvulineria sp.
Vercorsella camposaurii (Sartoni and Crescenti, 1960)
Vercorsella laurentii (Sartoni and Crescenti, 1960)
Vercorsella scarsellai (De Castro, 1963)
Vercorsella tenuis (Velić and Gušić, 1973)
Verneuilina cf. *polonica* Cushman and Glazewski, 1949
Voloshinoides murgensis Luperto Sinni and Masse, 1993

Calcareous algae

Actinoporella podolica (Alth, 1878)
Clypeina catinula Carozzi, 1956
Clypeina isabelae Masse, Bucur, Virgone and Dalmasso, 1999
Clypeina parasolkani Farinacci and Radoičić, 1991
Clypeina? *solkani* Conrad and Radoičić 1972
Cylindroporella sp.
Cylindroporella taurica Conrad and Varol, 1990
Epimastopora cekici Radoičić, 1970
Falsolikanella danilovae (Radoičić, 1968)
Falsolikanella nerae (Dragastan, Bucur and Demeter, 1978)
Humiella catenaeformis (Radoičić, 1967)
Humiella sardiniensis (Ott and Flaviani, 1983)
Korkyrella texana (Johnson, 1965)
Piriferella somalica (Conrad, Peybernès and Masse, 1983)
Piriferella sp.
Pseudoclypeina? *neocomiensis* (Radoičić, 1975)
Salpingoporella annulata Carozzi, 1953
Salpingoporella biokovensis Sokač and Velić, 1979
Salpingoporella dinarica Radoičić 1959
Salpingoporella genevensis (Conrad, 1969)
Salpingoporella hasi Conrad, Radoičić and Rey, 1976
Salpingoporella hispanica Conrad and Grabner, 1975
Salpingoporella katzeri Conrad and Radoičić 1978
Salpingoporella melitae Radoičić, 1967
Salpingoporella muehlbergii (Lorenz, 1902)
Salpingoporella polygonalis Sokač, 1996
Salpingoporella sp.
Salpingoporella turgida (Radoičić 1964)
Salpingoporella urladanasi Conrad, Peybernès and Radoičić, 1977
Salpingoporella verrucosa Sokač, 1996
Thaumatoporella parvovesiculifera (Raineri, 1922)
Thaumatoporella sp.
Triploporella bacilliformis Sokač, 1985
Triploporella marsicana Praturlon, 1964
Triploporella uragielliformis Conrad and Peybernès, 1976
Vermiporella tenuipora Conrad, 1970

Other

Bacinella irregularis Radoičić, 1959
Favreina sp.