MICROPALEONTOLOGICAL AND STRATIGRAPHIC ANALYSES OF THE UPPER JURASSIC – LOWER CRETACEOUS İNALTI FORMATION (BÜRNÜK, CENTRAL PONTIDES, TURKEY): REMARKS ON THE FACIES EVOLUTION

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ABSTRACT

MICROPALEONTOLOGICAL AND STRATIGRAPHIC ANALYSES OF THE UPPER JURASSIC – LOWER CRETACEOUS İNALTI FORMATION (BÜRNÜK, CENTRAL PONTIDES, TURKEY): REMARKS ON THE FACIES EVOLUTION

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This thesis aims to conduct a thorough investigation on the Upper Jurassic – Lower Cretaceous İnaltı Formation which is a significant unit for the regional geology of Turkey. Conducted investigation involves micropaleontological and microfacies analyses integrated with stratigraphic interpretations. In the vicinity of Bürnük Village, a 395 m thick stratigraphic section, overlying the Bürnük Formation and underlying the Çağlayan Formation, was measured and 101 samples were collected. Biostratigraphic and chronostratigraphic works are based on the benthic foraminifera and encrusting sponge *Calcistella jachenhausenensis*. 44 species of foraminifera belonging to 35 genera, and 13 species of microencrusters were identified and 3 biozones were established. The biozones are *Mesoendothyra izjumiana* zone, *Calcistella jachenhausenensis* zone and *Protopeneroplis ultragranulata* zone in ascending order.

Detailed microfacies analysis revealed the depositional history and carbonate platform evolution in the area. 15 microfacies types were determined in 5 different environments corresponding to slope, fore-reef, reef, back-reef and lagoonal environments on the carbonate platform. A vertical facies shift from platform margin (reef, fore-reef) - slope facies to inner platform (back reef-lagoonal) facies was observed in the Berriasian. Before cutting by Çağlayan clastics, again a facies shift towards the platform margin-slope facies took place in the studied part of the İnaltı carbonate platform. The studied section was correlated with some J-K boundary sections from different parts of the world. It is concluded that mentioning a general shallowing trend at/around the J-K boundary for all the correlated sections is not possible due to the preponderant local tectonics.

Keywords: Upper Jurassic, Lower Cretaceous, İnaltı Formation, micropaleontology, microfacies anlaysis

ÖZ

ÜST JURA – ALT KRETASE İNALTI FORMASYONU'NUN MİKROPALEONTOLOJİK VE STRATİGRAFİK ANALİZİ (BÜRNÜK, ORTA PONTİDLER, TÜRKİYE): FASİYES EVRİMİ ÜZERİNE NOTLAR

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Bu tez çalışması Türkiye'nin bölgesel jeolojisinde önemli bir yere sahip olan Üst Jura – Alt Kretase İnaltı Formasyonu'nun detaylı incelenmesini amaçlamaktadır. İnceleme, mikropaleontoloji ve mikrofasiyes analizleri ile beraber stratigrafik yorumlamaları da içeren bütünleşik bir yöntemle yapılmıştır. Bürnük Köyü civarında, Bürnük Formasyonu'nu üzerleyen ve Çağlayan Formasyonu altında yer alan İnaltı Formasyonu'nda 395 m kalınlığında stratigrafik kesit ölçülmüş ve 101 adet örnek toplanmıştır. Biyostratigrafik ve kronostratigrafik çalışmalar bentik foraminiferler ve sarıcı sünger *Calcistella jachenhausenensis* ile yapılmıştır. 35 cinse ait 44 foraminifer türü ve 15 mikrosarıcı türü tayin edilmiş ve 3 adet biyozon belirlenmiştir. Bu biyozonlar aşağıdan yukarıya doğru, *Mesoendothyra izjumiana* zonu, *Calcistella jachenhausenensis* zonu ve *Protopeneroplis ultragranulata* zonudur.

Detaylı mikrofasiyes analizleri alanın çökelim tarihçesini ve karbonat platform evrimini ortaya koymuştur. Karbonat plaformu üzerinde yamaç, resif-önü, resif, resif-arkası ve lagün ortamlarına ait 15 mikrofasiyes tipi belirlenmiştir. Beriaziyen içerisinde, platform kenarı (resif, resif önü) - yamaç fasiyeslerinden platform içi (resif-arkası, lagün) fasiyeslerine geçen dikey bir fasiyes değişimi gözlenmiştir. Çağlayan klastikleri tarafından uyumsuz olarak örtülmeden önce, İnaltı karbonat platformunun çalışılan kısmında, tekrar platform kenarı – yamaç fasiyeslerine geçen bir fasiyes değişimi meydana gelmiştir. İncelenen kesitin dünyanın farklı yerlerinde çalışılan, J-K sınır kesitleri ile korelasyonu yapılmıştır. Bu korelasyon sonucunda, incelenen bütün kesitler için Jura - Kretase sınırında veya sınır çevresinde, genel bir sığlaşma eğiliminden bahsetmek mümkün değildir. Bunu nedeni lokal tektonizmanın yarattığı etkidir.

Anahtar Kelimeler: Üst Jura – Alt Kretase, İnaltı Formasyonu, mikropaleontoloji, mikrofasiyes analizi

To my family and beloved wife…

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CHAPTER 1

INTRODUCTION

1.1 Purpose and scope

The related objectives of this dissertation are (1) to define the Upper Jurassic – Lower Cretaceous boundary using mostly benthic foraminifera and some microencrusters in a section measured mainly along the İnaltı Formation, widely extensive carbonate unit in the Pontides, Northern Turkey, (2) to describe the evolution of the depositional environments (and that of the carbonate platform) by using microfacies data. This study also presents global correlation of the Upper Jurassic – Lower Cretaceous boundary beds of the İnaltı Formation with some selected sections described in nearby areas and locations from different countries of the world.

Microfacies analyses have been carried out to determine the lithostratigraphic changes along the section and to elaborate the field observations. Microfacies types defined in this study reflect the changing patterns of the depositional environments and the evolution of the carbonate platform on which İnaltı carbonates were laid down. Distinct parts of the carbonate platform representing different microfacies were shifted in position during the evolution of the platform reflecting the effects of fluctuating sea level and local tectonics. Together with the microfacies analyses, facies dependence of some fossil groups has been used as a tool for understanding the evolution of the carbonate platform on which İnaltı carbonates were laid down. For these purposes benthic foraminifera and some enigmatic microencrusters (microproblematica) have been studied and documented taxonomically.

Late Jurassic witnessed one of the largest reefal expansions of the Phanerozoic. Coral reefs, siliceous sponge reefs (sometimes their collaboration as mixed reefs) and

microbial reefs were the prevailing reef types during these reefal expansions. The distribution of the Upper Jurassic – Lower Cretaceous reef belt along the platforms of Tethys has been studied and documented previously by various authors (Leinfelder, 1992; Leinfelder, 1993a, b; Leinfelder *et al*., 1993b, 2002; Aurell & Bádenas, 1997; Insalaco *et al*., 1997; Bertling & Insalaco, 1998; Pawellek & Aigner, 2003; Benito & Mas, 2006; Olivier *et al*., 2008; Krajewski, 2010; Guo *et al*., 2011). This dissertation documents the extension of this reef belt in Northern Turkey by analyzing the reefal material of the İnaltı carbonates. Faunal/floral content of the reefal İnaltı carbonates and the resemblance of İnaltı material with the European counterparts have been also evaluated in this study.

1.2 Geographic setting

The area studied in this paper, located close to the Kastamonu-Sinop road near the Bürnük Village, was preferred due to the accessibility to both the lower and the upper contact of the İnaltı Formation (Figure 1). It is situated on the topographic map Sinop –E33-d of 1/25.000 scale. The coordinates of the bottom of the measured section are 4611476 N and 655261 E (UTM Zone 36), and the coordinates of the top of the section are 4610563 N, 655203 E.

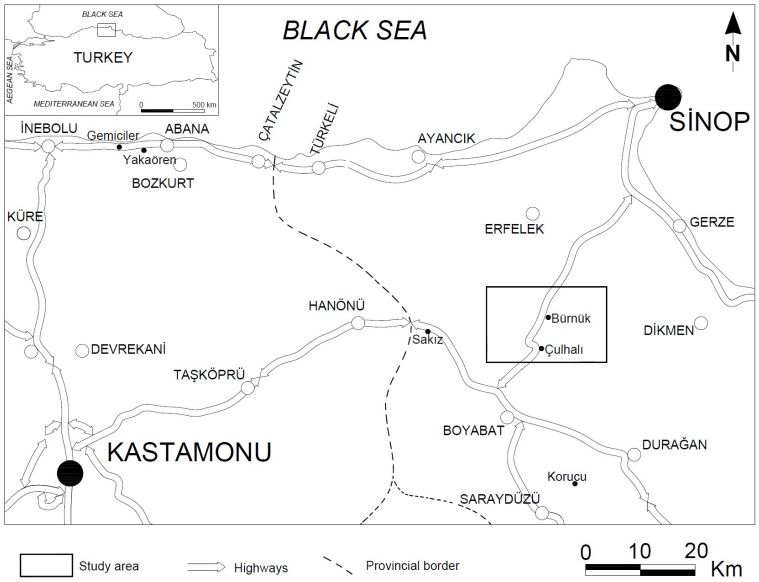


Figure 1 Location map of the study area

1.3 Methods of study

This thesis includes three different steps used as methods during the course of the study of the Upper Jurassic – Lower Cretaceous carbonates: (1) literature survey, (2) field work, and (3) laboratory work. Firstly, a detailed literature survey has been carried out and papers concerning Upper Jurassic – Lower Cretaceous deposits (mostly carbonates) from all around the world have been gathered. The stratigraphical, sedimentological, paleontological changes and events during Late Jurassic – Early Creteaceous have been examined in different regions of the world.

In the field work step, selected beds have been examined and interpreted in terms of their lithologies, textures and faunal contents by hand lense. 395 m thick section consisting of carbonates of İnaltı Formation and sandstones of Bürnük and Çağlayan Formations has been measured and 101 samples have been collected.

During the laboratory studies, detailed micropaleontological and microfacies analyses have been carried out. For these analyses 106 thin sections have been prepared from the collected samples in the thin section preparation laboratory of the Department of Geological Engineering, METU. Micropaleontological analyses have been done by investigating the morphology of the specimens (mainly foraminifera and microencrusters) and by measuring the dimensions for some of them. Individuals belonging to each species have been photographed and classified according to the taxonomical hierarchy. After the identification and classification of the foraminifera and microencrusters, by using their stratigraphical distributions (ranges), biozones have been constructed and the Upper Jurassic – Lower Cretaceous boundary has been delineated. Microfacies analyses include the examination of the thin sections of the carbonate samples based on their textural properties. (i.e. abundance and types of the allochems and the background material). Abundances of the allochems and the background material have been visually estimated by using visual estimation charts. Several types of microfacies have been defined and they have been photographed in order to display the defined microfacies properties. Vertical changes in the microfacies type and the faunal/floral content have been used in the interpretation of the evolution of the carbonate platform.

1.4 Previous works on the Upper Jurassic – Lower Cretaceous carbonates in the Pontides

Prior to the formal naming of the İnaltı Formation by Ketin & Gümüş (1963), it was Lucius (1925) who recognized the İnaltı carbonates for the first time as "massif limestones of Cumaakşamı Mountain" (Cumaakşamı Dağı'nın masif kalkeri). In the following years, the carbonates of the İnaltı Formation were studied as Upper Jurassic-Lower Cretaceous "cover limestone series" (Örtü Kalker Serisi) by Grancy (1938), Altınlı (1951a, 1951b), Fratschner (1952) and Wedding (1968, 1969), "reefal limestone" (resif kalkeri) or "Felsenkalke" by Blumenthal (1940), carbonates of the Zonguldak Formation by Tokay (1954, 1955) and Yergök *et al*. (1987), Massif limestone by Badgley (1959), Kestanedağı limestone by Akyol et al. (1974), carbonates of Yukarıköy Formation by Yılmaz (1979) and Akkaya limestone Formation by Gedik & Korkmaz (1984).

The İnaltı formation was first recognized and described by Ketin & Gümüş (1963) from the İnaltı Village which is located in the southwest of Sinop. They described the formation as reefal and shallow water carbonates containing algae, bryozoan, corals, gastropods, bivalves and some foraminifera (*Trocholina* sp., *Cyclammina* sp., *Choffotella* sp.) from the Malm – Lower Cretaceous interval. They also mentioned about the existence of some *Calpionella* species which attributes a peculiar pelagic characteristic to İnaltı carbonates.

Similarly, following studies attributed a wide age range to the İnaltı carbonates (Akyol *et al*., 1974, Saner *et al*., 1980, Saner *et al*., 1981, Yılmaz & Tüysüz, 1984). In later studies however, it was revealed that the carbonates of the İnaltı Formation were laid down during two different depositional intervals [Oxfordian – Berrriasian (? Valanginian) and Barremian – Albian] separated by an unconformity surface in the Western Pontides (Derman, 1990 and Akman, 1992). Recently the age of the İnaltı Formation has been revised as Oxfordian to Valanginian in the Western Pontides by Tüysüz *et al*. (2004).

Derman (1990) identifed the existence of an unconformable surface between Berrriasian and Barremian of İnaltı carbonates and interpreted that the gap was a result of block faulting and consequent uplift and erosion. This disruption of İnaltı

carbonates by Early Cretaceous extensional tectonics has also been mentioned in Derman & Sayılı (1995), and as a consequence of this disruption they concluded in the existence of the allochthonous İnaltı carbonates which were derived from the authochthonous ones. They also proposed a change for the type locality of İnaltı formation due to their assertion that the İnaltı Formation is not authochthonous in its proposed type locality by Ketin & Gümüş (1963). Tüysüz *et al*. (1990) ascribed both the origin of Early Cretaceous extensional tectonics and the other geological conditions under which İnaltı, Bürnük and Çağlayan Formations developed to the closure of Paleo-Tethys Ocean and the succeeding opening of the Neo-Tethys Ocean during Lias and lastly to the opening of Black Sea during early Late Cretaceous.

Akman (1992) defined two separate members of the İnaltı Formation between Amasra and Arıt regions as the Avlukaya Member and the İnpiri Member for the corresponding Oxfordian - Berrriasian carbonates and Barremian – Albian carbonates and clastics, respectively.

Papers by Charles (1932, 1933) and Maync (1959) are among the pioneering paleontological works that were carried out with İnaltı carbonates. A variety of *Spirocyclina choffati* Munier-Chalmas was described and figured from the Upper Jurassic İnaltı carbonates of Zonguldak as "*Spirocyclina choffati* Munier-Chalmas var. *euxina* nov. var." by Charles (1932, 1933). Maync (1959) indicated the morphological differences within the forms that were identified as *Spirocyclina* up to that time and consequently he divided those forms into two different genera as *Spirocyclina* and *Iberina*. He considered some *Spirocyclina* specimens of Charles (1932, 1933) from the İnaltı carbonates as *Iberina lusitanica* Egger.

Other remarkable paleontological efforts on İnaltı carbonates were made by Kirici (1986) and Sirel (1993). In 1986, Kirici carried out a micropaleontological study on İnaltı carbonates and he proposed a biostratigraphic framework consisting of four biozones for the Upper Jurassic and Lower Cretaceous. Sirel (1993) defined *Kastamonina abanica*, n.gen., n.sp from the İnaltı carbonates (Akkaya Limestone of Gedik & Korkmaz, 1984) of the Kastamonu region as a new complex conical lituolid foraminifera. He assigned a Kimmeridgian-Portlandian age due to the presence of

index-associated foraminiferal species "*Rectocyclammina chouberti* and *Anchispirocyclina neumannae*".

Other than the well-known İnaltı Limestones, widely distributed Upper Jurassic-Lower Cretaceous Limestones in the Pontides have been studied and named differently by several authors (See Figure 2). In the North-western Turkey, Upper Jurassic - Lower Cretaceous carbonates are generally known as Bilecik carbonates which belong to the Bilecik Formation whereas in the North-eastern part of Turkey coeval carbonates named and studied as Berdiga carbonates of the Berdiga Formation. In the central part of Northern Turkey these Upper Jurassic-Lower Cretaceous carbonates are defined as İnaltı carbonates of the İnaltı Formation.

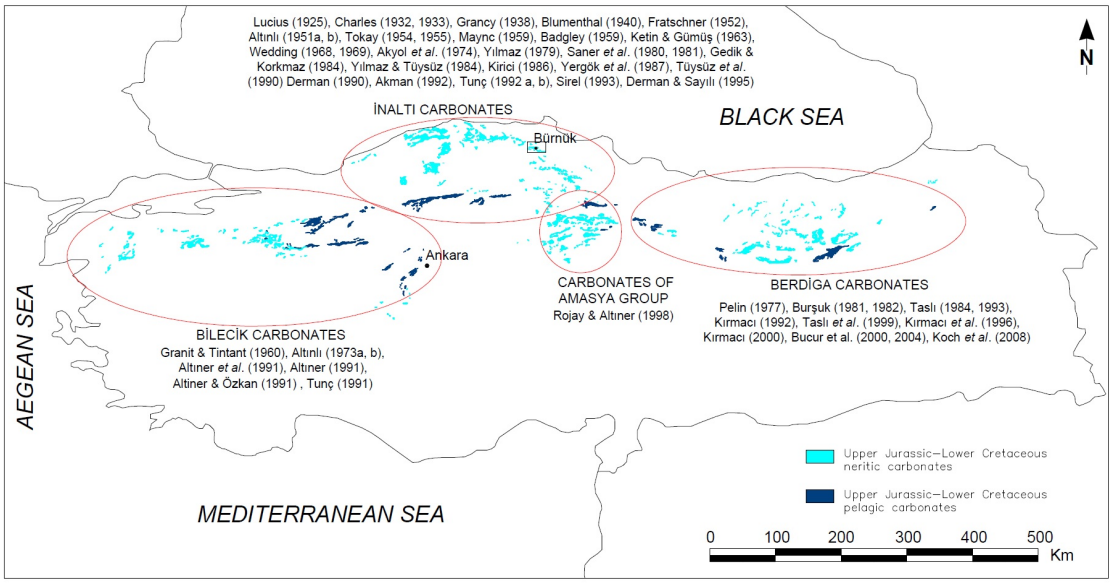


Figure 2 Distribution of the Upper Jurassic – Lower Cretaceous Carbonates in Northern Turkey and related references

In North-western Turkey, around the Bursa-Bilecik region the Jurassic stratigraphy was studied and Upper Jurassic Bilecik Limestone was firstly named informally by Granit & Tintant (1960). Altınlı (1973 a, b) also studied stratigraphy of the Bursa-Bilecik region and introduced the Lower Jurassic Soğukçam Limestone together with the Bilecik Limestone. In the southern part of the North-western Anatolia, Altıner *et al*. (1991) studied the stratigraphy and paleogeographic evolution of the Upper

Jurassic-Lower Cretaceous successions and they provided a revision for the lithostratigraphic ranking of some of the rock units in that region. Two previously named formations, The Bilecik Formation and the Halılar Formation were raised to the group rank and several new rock units defined at group, formation and member ranks. Among these rock units, Taşçıbayırı Formation and Günören Limestone of the Bilecik Group, and Pelagic Soğukçam Limestone overlying the Bilecik Group units, Kurcalıkdere Formation and Yosunlukbayırı Formation which were considered as separate from the Soğukçam Limestone and the newly introduced Dedeninseti and Aktaş Formations - which are laterally equivalent to the Yosunlukbayırı Formation – are the Upper Jurassic-Lower Cretaceous carbonates which are coeval to the İnaltı carbonates.

Biostratigraphic work (mainly based on foraminifera) was also carried out in the same North-western Anatolia region by Altıner (1991). Altıner (1991) introduced one single biostratigraphic scheme consisting of 9 main zones for 3 main paleogeographic domains characterized by different stratigraphic successions of Callovian-Aptian age in southern part of North-Western Anatolia. The studied material in Altıner (1991) comes from the Biga-Bursa-Bilecik Platform, Mudurnu Trough and Aktaş-Sekinindoruk High paleogeographic domains and these domains are described in detail in Altıner *et al*. (1991). Later in 1998, Rojay & Altıner recognized and stated the strong similarities in the evolution of the Jurassic – Lower Cretaceous carbonates between the Amasya Region and the Biga-Bursa-Bilecik Platform carbonates. They proposed a nearly identical biozonation scheme for the Amasya region carbonates and concluded that carbonate platform should be continuous from the west to the Central Pontides.

Varol & Kazancı (1981) studied the lithofacies and biofacies properties of the Upper Jurassic-Lower Cretaceous carbonate sequence from the Nallıhan-Seben (Bolu) region. The carbonate sequence they studied was previously named by Toker (1973) as the Nallıhan Formation. They separated the Upper Jurassic facies as slope to basin and basin deposits whereas Lower Cretaceous deposits were interpreted as neritic and pelagic carbonates.

In the Eastern Pontides time-equivalent of the İnaltı carbonates is known as the Berdiga Limestone which is first named by Pelin (1977) as the Berdiga Formation. Since then it has been considered as a valuable target for various studies dealing with its lithostratigraphy, biostratigraphy, facies analysis and evolutionary history as a carbonate platform. Taslı (1984) selected two different study areas for his M.Sc. study as İkisu (Gümüşhane) and Hamsiköy (Trabzon) and in the last part of his dissertation he attempted to correlate the carbonates of the Berdiga Formation from the two study areas by "the graphic correlation method" of Shaw (1964). But due to some reasons like the dolomitization of the bottom levels of the formation, facies dependency of the identified fossils and inadequate observations he did not manage to construct a reliable chronologic scale.

Kırmacı (1992) carried out a Ph.D. study investigating the sedimentology of the Berdiga Limestone sequence that is exposed extensively in the southern zone of the Eastern Pontides. He differentiated distinct lithofacies in the Berdiga Limestone and studied the effects of diagenesis on the targeted limestones. The same author in 2000, recognized 6 different lithofacies from the Berdiga platform carbonates in the Uluçayır (Bayburt) area and the evolution of the carbonate platform was explained by considering the sea-level changes and epirogenic movements in the region.

Kırmacı *et al*. (1996), carried out a facies analysis on a Lower Cretaceous section in the Kale (Gümüşhane) area consisting mainly Berdiga Limestone and in the upper part of the section they identified a bituminous thin-bedded to platy limestone horizon which is well correlated with the platform carbonate units in West Slovenia. They concluded that the bituminous limestone horizon appears to be a chronostratigraphic marker horizon for both regions marking Early/Late Aptian boundary. In the same Kale (Gümüşhane) area, Taslı (1993), Koch *et al*. (2008) and Bucur *et al*. (2000, 2004) also carried out micropaleontological studies. Taslı (1993) studied on 5 different sections and described many species of benthic foraminifera for the first time from the Upper Jurassic platform carbonates of that region. He described *Mayncina gediki* n. sp. as a new species. Koch *et al*. (2008) examined the biostratigraphy (based on calcareous algae and benthic foraminifera), facies distribution and diagenesis history of the Berdiga Limestone through a 320 thick profile. Bucur *et al*. (2004a) studied on the several sections of the Berdiga Limestone

around the Kale-Gümüşhane region and identified a rich assemblage of benthic foraminifera. They described the Lower Cretaceous species for the first time in this region. Bucur *et al*. (2000) on the other hand identified a rich assemblage of dasyclad algae of Berriasian-Barremian age from the same area and discussed on them.

Taslı *et al*. (1999) studied the Upper Jurassic – Lower Cretaceous carbonate sequence in the Başoba Yayla (Trabzon, NE Turkey) area which is located in the northern zone of the Eastern Pontides. They measured two partial sections from the Berdiga Formation and the overlying units and differentiated four (A, B, C, D) units based on their microfacies analysis and the macroscopic characteristics. They recognized the disruption of the autochtonous carbonate depositon (A, B and C units) after the Late Albian by the arrival of clastic materials associated with pelagic sediments (D unit). The uneven and sharp contact between unit C and D was interpreted as an erosional unconformity which was produced by submarine erosive processes.

Some other effort for the construction of calpionellid biostratigraphy of the Upper Jurassic-Lower Cretaceous carbonates of North Anatolia was also made by a number of authors. Burşuk (1981, 1982) worked mainly on the taxonomy and biostratigraphy of calpionellids from the Upper Jurassic – Lower Cretaceous carbonates of Eastern Pontides. Altıner and Özkan (1991) added one more calpionellid zone (Zone F) to the well-known zonations of Remane (1985) from several Upper Jurassic-Lower Cretaceous measured sections in North-western Anatolia. They also calibrated the stratigraphic ranges of several benthic foraminiferal assemblages based on the calpionellid zones they studied. Other biostratigraphic studies on calpionellids from the Upper Jurassic-Lower Cretaceous carbonates from Pontides were carried out by Tunç (1991, 1992a, 1992b). In 1991 paper, he studied around Ankara-Kızılcahamam region and recognized a Tithonian-Albian age for the pelagic limestones containing 6 calpionellid biozones. In 1992 papers, he concentrated on the biostratigraphy of Upper Jurassic-Lower Cretaceous limestones from eastern Pontides (Erzurum-Olur region) and he defined a new calpionellid species, *Crassicollaria remanei* n.sp.

The extent of the Late Jurassic reef belt along the Northern Tethys margin and in the Intra-Tethyan domain includes Portugal, Spain, France, Switzerland, Southern

Germany, Poland, Romania, Turkey, Crimea and Western Russian Caucasus (Leinfelder, 1992; Leinfelder, 1993a, b; Leinfelder *et al*., 1993b, 2002; Aurell & Bádenas, 1997; Insalaco *et al*., 1997; Bertling & Insalaco, 1998; Pawellek & Aigner, 2003; Benito & Mas, 2006; Olivier *et al*., 2008; Krajewski, 2010; Guo *et al*., 2011). Taxonomic compositions of the investigated reefal İnaltı carbonates show similarities with the other Upper Jurassic – Lower Cretaceous Tethyan examples. Due to this similarity it is worth to mention about some of the remarkable studies on coeval Tethyan examples of different regions. Leinfelder *et al*. (1993a) discussed about the Late Jurassic microbial crusts from Portugal, Spain and southern Germany by revealing the composition of microbial crusts and emphasizing their paleoecological significance in reef construction. Most of the accompanying microencrusters with variable abundances and diversities shown by Leinfelder *et al*. (1993a) are also observed from the samples of İnaltı carbonates. Late Jurassic reefs which are partly formed by those accompanying microencrusters are mentioned in detail with their paleoecology, growth parameters and dynamics in Leinfelder *et al*. (1996). Among those Late Jurassic reef types, one (Ota reef from Portugal) has an exceptional character which is well explained and studied in Leinfelder (1992). Ota Reef was different from the other high energy Late Jurassic reefs in having major participation of microbial crusts in building of the reef frame in a high energy environment. This distinct character of Ota reef is explained by its location near a steep margin which provides additional gravitational export of the surplus debris by Leinfelder (1992). Schmid (1996) interprets about the paleoecology and the origin of Late Jurassic microbialites which play a decisive role in the construction of Late Jurassic reefs. He also mentions about the associated encrusting microorganisms which show characteristic distributional patterns. He developed new interpretations about *Lithocodium* and *Tubiphytes morronensis* (*Crescentiella morronensis*) whose systematic positions are unclear. He interpreted *Lithocodium* as loftusiid foraminifera possessing endosymbiotic algae. Similarly *Tubiphytes morronensis* is interpreted as a foraminifer with twofold test with an outer part formed most probably by an endosymbiotic alga. By analyzing the relative abundances of micro-encrusters and microencruster associations, Dupraz and Strasser (1999) interpreted the evolution of the Late Jurassic reefal environment of Swiss Jura Mountains.

Guo *et al*. (2011) discuss about the depositional environments and developmental processes of Upper Jurassic reefs of Russian western Caucasus and give a detailed description of the different reef types and their components. Before their study, Upper Jurassic reefs in that region have been studied in a brief manner and many aspects of the reefs such as their composition, origin and facies associations have been barely studied (Siderenko 1968; Sedleskii *et al*. 1977; Bendukidze 1982; Rostovtsev 1992; Kuznetsov 1993).

Recent studies performed on the Upper Jurassic – Lower Cretaceous platform carbonates of Romania include biostratigraphic (Michetiuc *et al*., 2012; Turi *et al*., 2011; Pop and Bucur, 2001), sedimentological (Michetiuc *et al*., 2012;), microfacies (Dragastan *et al*., 2005; Săsăran *et al*., 1999; Săsăran *et al*., 2001; Catincut *et al*., 2011; Şerban *et al*., 2004; Bucur *et al*., 2010; Turi *et al*., 2011) and micropaleontological (Dragastan *et al*., 2005; Pleş *et al*., 2013; Ungureanu and Barbu, 2004; Uta and Bucur, 2003; Săsăran *et al*., 1999; Săsăran *et al*., 2001; Catincut *et al*., 2011; Şerban *et al*., 2004; Bucur *et al*., 2010) efforts. All these studies contributed more on the understanding of the Upper Jurassic-Lower Cretaceous stratigraphy and carbonate platform evolution of that time in Romania.

Intra-Tethyan Upper Jurassic reefs have also been investigated by several studies. Most of the earlier studies are descriptive (Barattolo and Pugliese, 1987; Bosellini *et al*., 1981; Catalano and D'Argenio, 1981; Cati *et al*., 1987; Colacicchi, 1967; Sartorio, 1987) whereas subsequent studies put more on sedimentological (Morsilli and Bosellini, 1997; Ricci and Rusciadelli, 2008; Schlagintweit *et al*., 2005a; Schlagintweit and Ebli, 1999), taxonomical (Schlagintweit and Ebli, 1999; Schlagintweit, 2004; Russo and Morsilli, 2007; Schlagintweit and Gawlick, 2011) and paleoecological (Leinfelder *et al*., 2005; Schlagintweit and Gawlick, 2008) understanding of the Intra-Tethyan Upper Jurassic reefs. Recently Rusciadelli *et al*. (2011) studied on the Upper Jurassic reefal carbonates of Central Apennines and they proposed a distribution model for the reef building organisms that were survived on the margins of Upper Jurassic Intra-Tethys platforms. Upper Jurassic – Lower Cretaceous platform carbonates of the Northern Calcareous Alps are evaluated in terms of microfacies, micropaleontology, biostratigraphy and sedimentology by Schlagintweit and Ebli (1999). Recently, Schlagintweit and Gawlick (2011)

described a new micro-encruster, *Perturbatacrusta leini*, from the Late Jurassic Plassen Carbonate Platform of the Northern Calcareous Alps. Possible sponge origin is interpreted for this microencruster of unknown systematic position. In addition to Austria, Bulgaria, Romania and Greece, *Perturbatacrusta leini* is also observed from the İnaltı carbonate samples in Northern Turkey. Lately Pleş *et al*. (2013) concluded in the resemblance of the Upper Jurassic Limestones of Southern Carpathians (Romania) with other carbonate deposits the Intra-Tethyan domain.

Apart from the Tethyan examples from Europe, similar biota composition for the Upper Jurassic –Lower Cretaceous carbonates is also observed in Japan. Shiraishi & Kano (2004) determined similar microencrusters and microbial crusts to the Tethyan examples from the Upper Jurassic – Lower Cretaceous Torinosu Limestone.

1.4 Regional geological setting

Pontides is a significant part of the Turkish orogenic collage which is a segment of the Tethyside superorogenic system (Yılmaz *et al*., 1997). Its significance comes from the fact that the record of the evolution of the Tethysides is nearly completely preserved in the geological entities of the Pontides (Yılmaz *et al*., 1997). Pontides has been ascribed as a tectonic unit for the classification of the tectonic units of Turkey since the 1850's. Earlier studies carried out for the division of the mountain chains of Anatolia into tectonic units (Naumann, 1896; Argand, 1924; Staub, 1924; Seidlitz, 1931; Kober, 1931) divided the mountain belts into 3 units as; "Pontides", "Zone intermediaire" and "Taurides" from north to south. The above referenced earlier studies were the pioneering works used Pontides as a tectonic unit. Among the subsequent studies; Arni (1939) proposed a division with more tectonic units for Anatolia including "Pontides" (together with northern and southern branches of it), "Anatolides", "Taurides", "Iranides" and "Plis bordiers" (Border Folds). Egeran (1947) added even more on the tectonic units by subdividing them and proposed 10 units including Pontides. Pınar and Lahn (1952) excluded Pontides unit and considered it as external part of Anatolides. Ketin, in his 1966 paper, after the completion of 1:500000 scale geologic map of Turkey, revised his division for the tectonic units of Turkey which he proposed in 1959. For the first time, ophiolitic belts were considered during the division of mountain belts into tectonic units in

Ketin (1966) and Brinkmann (1966). Ketin divided mountain belts as “Pontides”, “Anatolides”, “Taurides” and “Border Folds” in his 1966 revision. He defined Pontides as a unit containing Black Sea coastal mountain, some parts of Marmara and Aegean Sea coasts and the Northwestern Anatolian region which extends to the Karaburun Peninsula. In 1981, Şengör & Yılmaz in their epochal paper proposed tectonic units based on the plate tectonics theory. Their classified tectonic units from north to south were the Rhodope-Pontide fragment, the Sakarya Continent, the Anatolide-Tauride Platform and its elongated appendage, the Bitlis-Pötürge masssifs. Göncüoğlu *et al*. (1996-1997) reviewed the tectonic units of Turkey and described the Turkish terranes and composite terranes for the Alpine fragments. According to their terrane classification, North Anatolian Ophiolite Belt, Sakarya Composite Terrane, Intrapontide Ophiolite Belt and Istranca/Istanbul Terranes were the constituents of the classic Pontides. Okay & Tüysüz (1999) mentioned about the 6 tectonic units: the Strandja, the İstanbul and the Sakarya zone, the Anatolide-Tauride Block, the Kırşehir Massif and the Arabian Platform. Their first three units classically referred as Pontides in the literature. Lately Moix *et al*. (2008) re-defined the tectonic units as the Pontides domain, the Anatolian terrane, the Taurus terrane, the south Taurides exotic units and the peri-Arabian domain.

Yılmaz *et al*. (1997) gave a detailed description about the internal divisions and the orogenic evolution of the Pontides. The following general information about the Pontides was extracted from their study. The east-west trending Pontides orogenic belt extends from the Bulgarian Rhodope Mountains in the west to the Caucasus in the east. Pontides mountain chain elevated to its present height during the Late Miocene shortening. The northern boundary of the Pontides is hidden under the Black sea whereas its southern boundary in the east is the Erzincan-Ankara suture. Its southern boundary in the west splays into two branches, the northern Intra-Pontide suture and the southern İzmir-Ankara suture.

The paleogeographic evolution of the Pontides can be interpreted from two different pictures according to the different models proposed for the evolution of Paleo-Tethys Ocean and succeeding Neo-Tethys Ocean. As reviewed in Robertson *et al*. (2004) there are two different subduction polarities for the subduction of the Paleozoic Tethys Ocean. According to the first group of models Paleozoic Paleo-Tethys ocean

subducted southwards, causing rifting of continental fragments from Gondwana and opening of a Triassic Neo-Tethys Ocean to the south (Şengör & Yılmaz, 1981; Görür *et al*., 1984; Şengör *et al*., 1984). According to the second group of models, Paleozoic Tethys Ocean subducted northwards with an active northern Eurasian margin and southern passive Gondwana margin (Robertson & Dixon, 1984; Decourt *et al*., 1986, 1993, 2000; Robertson *et al*., 1996; Stampfli *et al*., 2001). In the first group of models, in which southward subduction proposed for the Paleozoic Tethys Ocean, the Pontides as a part of Cimmeria were separated from Eurasia by the Paleo-Tethys Ocean until the entire consumption of Paleo-Tethyan oceanic crust by latest Triassic time. For the other approach that assumes northward subduction, it was suggested that the Pontides was part of Eurasia during the Triassic-Jurassic period.

Tectonic division of the Pontides into three sectors as the Western Pontides, the Central Pontides and the Eastern Pontides was proposed by Yılmaz *et al*. (1997) and this division is being used by the later workers study Pontides. The Kargı Massif and the surrounding areas comprise the Central Pontides. The sector extending from west of Kargı Massif to the Bulgarian Rhodope Massif constitutes the Western Pontides. The third sector, the Eastern Pontides, is the westward extension of the Caucasus to the Kargı Massif. Each of these sectors, which represent an amalgamated tectonic mosaic, possesses different tectonic entities.

Within the aforementioned regional geological frame, our studied section is located in the Central Pontides and includes the carbonate material of the İnaltı Formation, and the clastics of Bürnük and Çağlayan Formations. The Middle Jurassic – Lower Cretaceous deposits in the Central Pontides occur as a transgressive sequence (representing a transition from continental to gradually deepening sea environment) over the older units consisting of amalgamated remnants of Paleo-Tethys ophiolites and metamorphic continental basement rocks (Tüysüz *et al*. 1990). From bottom to top, transgressive sequence includes Middle – Upper Jurassic basal conglomerates (Bürnük Formation), Upper Jurassic – Lower Cretaceous carbonates (İnaltı Formation) and Lower Cretaceous clastics (Çağlayan Formation) (Figure 3). Tüysüz *et al*. (1990) interpreted that all these units were deposited in a tectonically active; fault controlled environment. Rest of their interpretation is summarized in the succeeding sentences: following the regionwide transgression a carbonate platform

established in the region. Horsts and grabens formed with the rupturing of the carbonate platform. High areas provided the material supplies to the adjacent lows. This resulted in the occurrence of laterally and vertically changing sequences. At the beginning of the Late Cretaceous, the topographic irregularities in the area were covered with a regionwide pelagic red limestone unit (belonging to Kapanboğazı Formation) representing a progressive deepening.

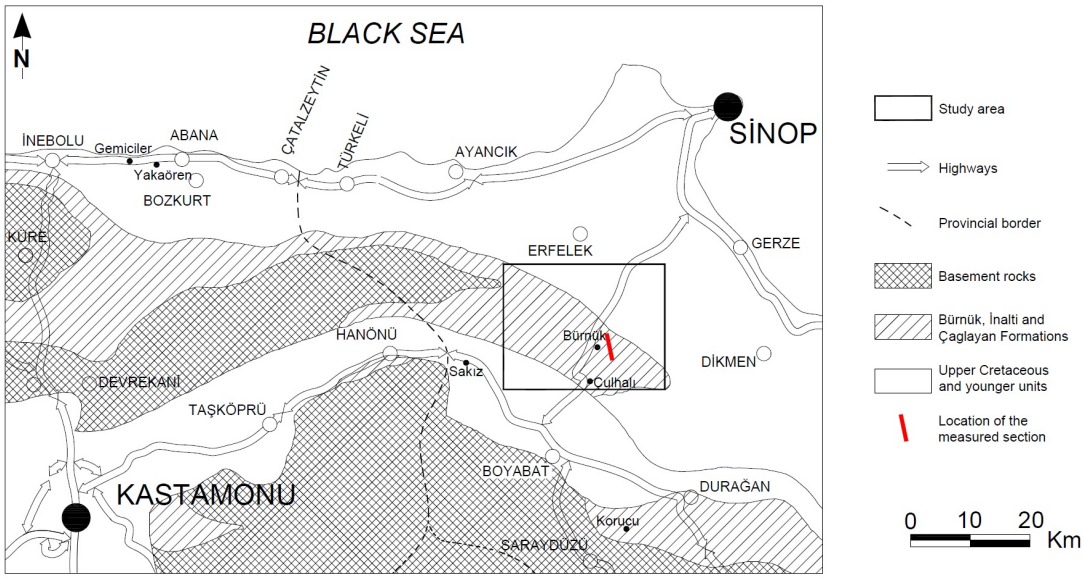


Figure 3 Distribution of the Bürnük Formation, the İnaltı Formation and the Çağlayan Formation in the Central Pontides (redrawn from Tüysüz *et al*., 1990).

CHAPTER 2

STRATIGRAPHY

2.1 Lithostratigraphy

As can be seen in Figure 4 and Figure 5, the studied section includes the carbonates of the Upper Jurassic - Lower Cretaceous İnaltı Formation and sandstones of the Middle Jurassic Bürnük Formation and Lower Cretaceous Çağlayan Formation.

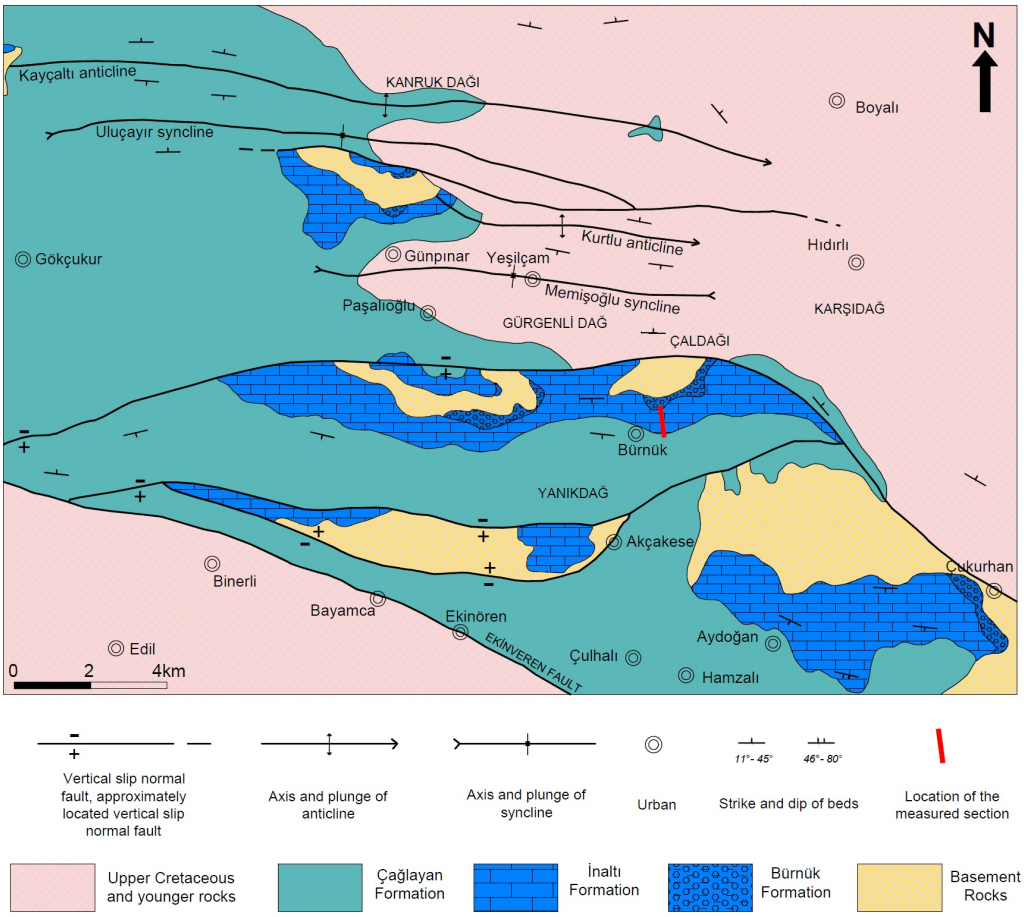


Figure 4 Geological map of the study area (Modified from Uğuz and Sevin, 2008)

As mentioned in section 1.4, the İnaltı Formation was established by Ketin & Gümüş (1963) from the İnaltı Village which is located in the southwest of Sinop. Other than İnaltı Village, İnaltı Formation gives exposures near Çangal Mountain, Çakırçay Village, Çukurhan Village, Kışlak Village, Bürnük Village, Gürgen Mountain and Vayısoğlu Village (Uğuz & Sevin, 2008). Ketin & Gümüş (1963) described the İnaltı Formation as reefal and shallow water carbonates containing algae, bryozoa, corals, gastropods, bivalves, benthic foraminifera (*Trocholina* sp., *Cyclammina* sp., *Choffotella* sp.) and calpionellids from the Malm – Lower Cretaceous interval. Uğuz & Sevin (2008) described the lower part of the İnaltı carbonates as light gray-whitish, thick bedded recrystallized limestones with gastropods, corals and algae. Upper parts are described as dark gray, medium bedded limestones with thin shale intercalations. İnaltı Formation has a comformable bottom contact with Bürnük Fomation, however, in some areas a contact between the İnaltı Formation and the older basement rocks can be observed, where Bürnük Formation does not appear.

Bürnük Formation includes continental conglomerates, sandstones, mudstones and their alternations (Uğuz & Sevin, 2008). This formation was first described by Ketin & Gümüş (1963) around Bürnük Village which is located on the way of Boyabat-Sinop. Bürnük Formation also crops out near Çukurhan Village and around Çakırçay. Uğuz & Sevin (2008) described the color of the units of Bürnük Formation as reddish-brownish, purple and ash gray. The observed sources of the clastic grains are granites, metamorphic rocks, ophiolites, spilitic basalts, quartzites and shales (Uğuz & Sevin, 2008). Brownish-yellowish sandstone unit of the Bürnük Formation has been observed at the bottom of the studied section below the İnaltı Formation with a conformable contact. Uğuz & Sevin (2008) interpreted that Bürnük Formation, displaying characteristic feautres of alluvial fans, may have been deposited in river or coastal transitional environments.

Lower Cretaceous Çağlayan Formation is composed of sandstones, siltstones, shales and conglomerates and breccias and it overlies İnaltı Formation. Like the Bürnük and İnaltı Formations, this formation was also described firstly by Ketin & Gümüş (1963). The sediments of the Çağlayan Formation were interpreted as syn-rift deposits of the Western Black Sea by Görür (1997). Görür *et al*. (1993) and Görür (1997) stated these deposits of the Çağlayan Formation are the evidence for anoxic

conditions due to the restricted water circulations. In the literature, both unconformable and conformable contact relation with the underlying İnaltı Formation have been mentioned for Çağlayan Formation. At the top of the measured section breccias and sandstones of Çağlayan Formation has been observed in this study and the observed transition between the İnaltı and Çağlayan Formations is unconformable.

Our studied/measured section represents the Upper Jurassic–Lower Cretaceous transition within the İnaltı Formation which overlies the sandstones of the Bürnük Formation and underlies the breccias and flyschoidal sandstones of Çağlayan Formation (Figure 7). The total thickness of the measured thickness is around 395 m. The collected samples from the measured section have been named as MK with samples numbers from 1 to 101. The level between MK-25 and MK-56 has been sampled with a narrow sample interval which is 20 -30 cm. It was aimed to conduct a detailed micropaleontological and microfacies study along the level with narrow sample interval. But a monotonous sequence has been observed in this level displaying similar facies throughout.

The measured section begins with the yellowish-brownish colored sandstone of the Bürnük Formation and the sample MK1 represents this level (Figure 6B and Figure 7). Above this sandstone unit, İnaltı Formation has been observed with brecciated carbonate units which are interpreted as fore-reef breccias which contain debris of the reefal zone. From MK-2 to MK-15 these breccias and some alternation of boundstones, packstones and grainstones which display reefal, fore-reefal characteristics have been observed (Figure 7).

Until MK-71 all the samples represents reef, fore-reef and slope characteristics (textures, faunal/floral content etc.) with related fauna (Figure 7). MK-71 and MK-72 includes back-reef bioclastic packstones. Between in the interval of MK-73 and MK-80 lagoonal carbonates with complex benthic foraminifera and sponges have been observed. The overlying interval from MK-81 to MK-84 is characterized by packstones of back-reefal facies. Till the contact with Çağlayan Formation the rest of the section includes reefal, fore-reefal and slope facies (Figure 7).

The details of the faunal content and chronostratigraphy of the lithologies are given in the Biostratigraphy part of this chapter and detailed microfacies analyses and depositional environmental interpretations have been discussed in the Microfacies Analyses Chapter (Chapter 3).

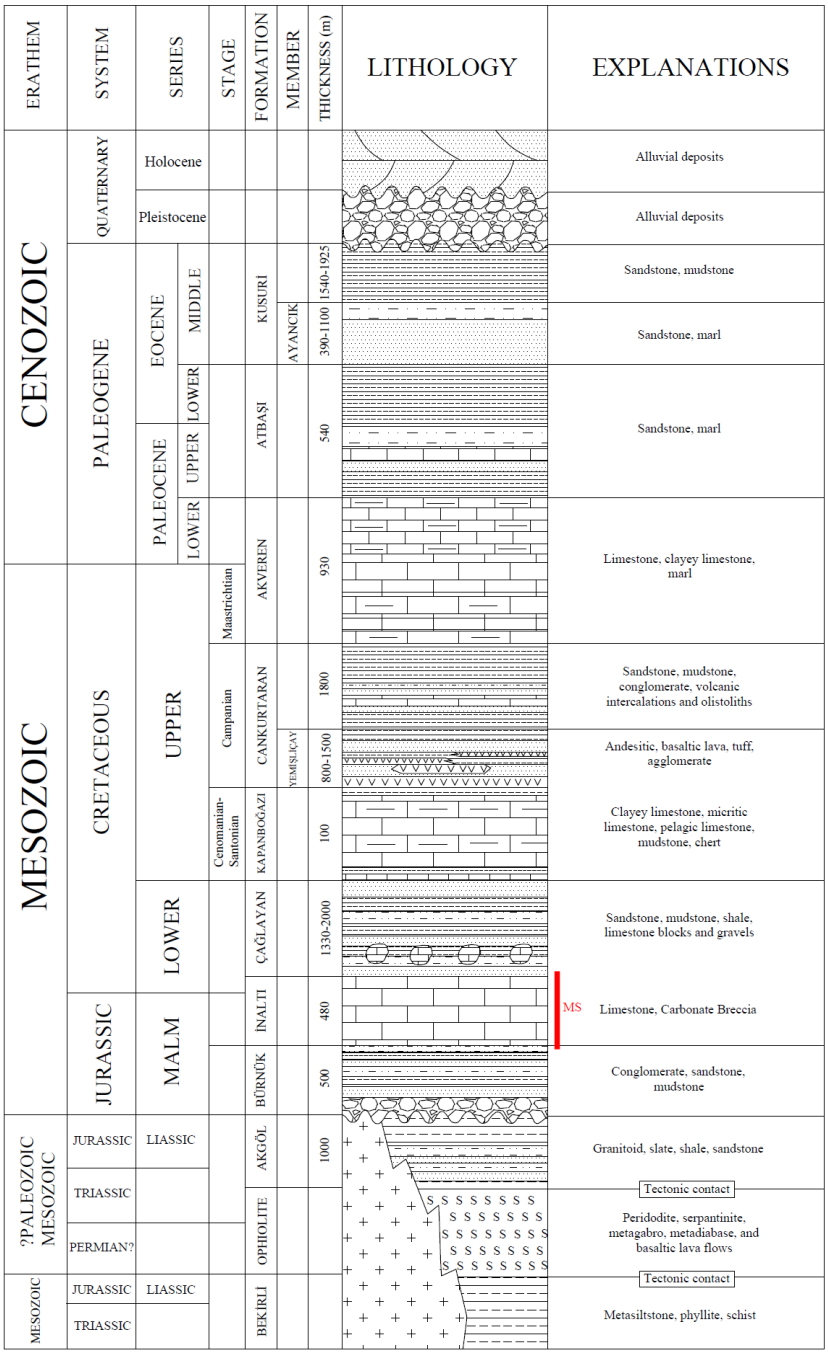


Figure 5 Generalized columnar section of the study area (Modified from Uğuz & Sevin, 2008)

Figure 6 Photographs from the field area. **A.** Conglomerates of the Bürnük Formation. **B.** Sandstones of the Bürnük Formation. **C. D. E.** Field views of the carbonates of the İnaltı Formation. **F.** Sandstones of the Çağlayan Formation. **G.** Irregular contact between the İnaltı carbonates and Çağlayan units

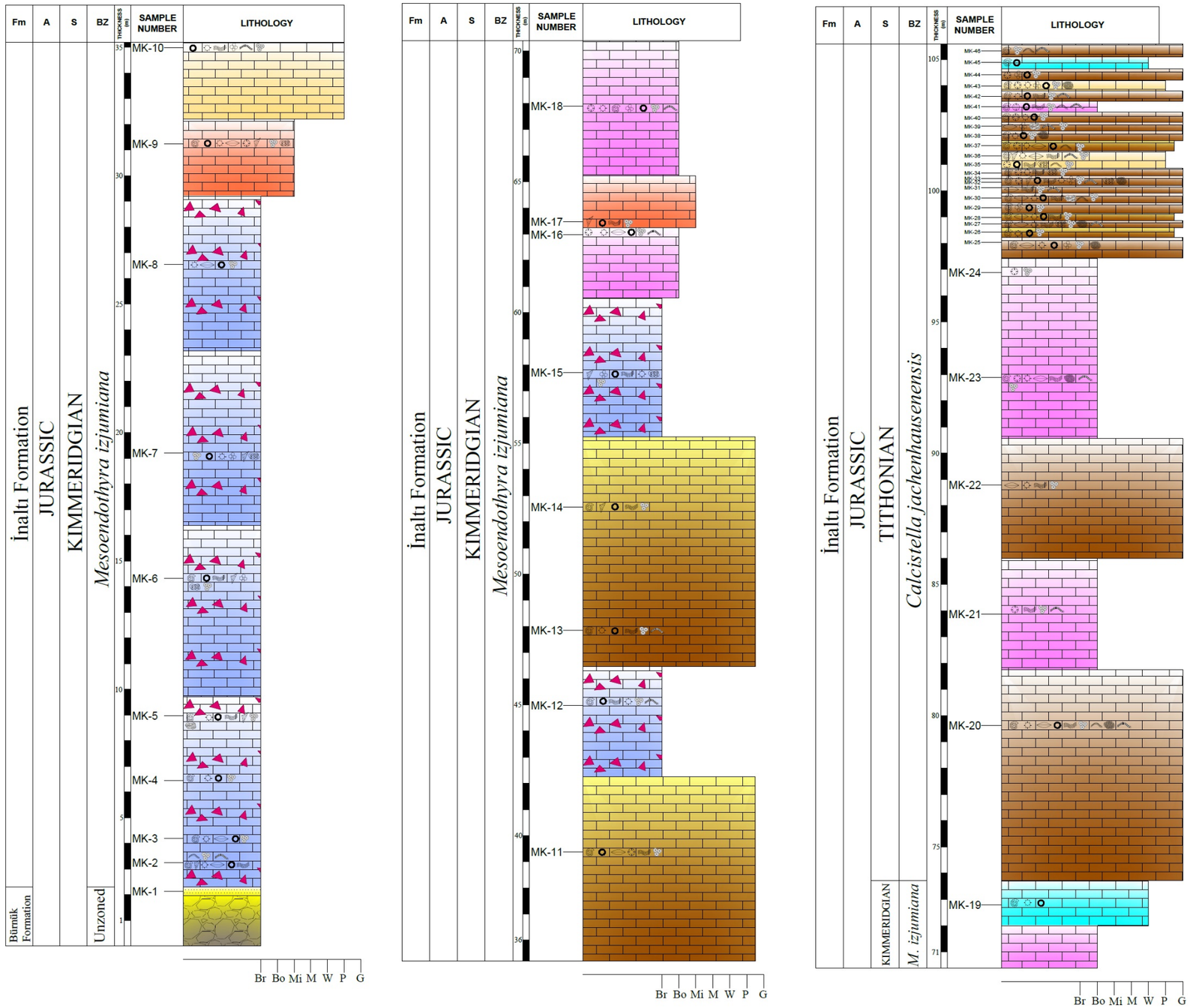


Figure 7 Lithostratigraphy of the measured section with the determined biozones. Fm: Formation, A: Age, S: Stage, BZ: Biozone

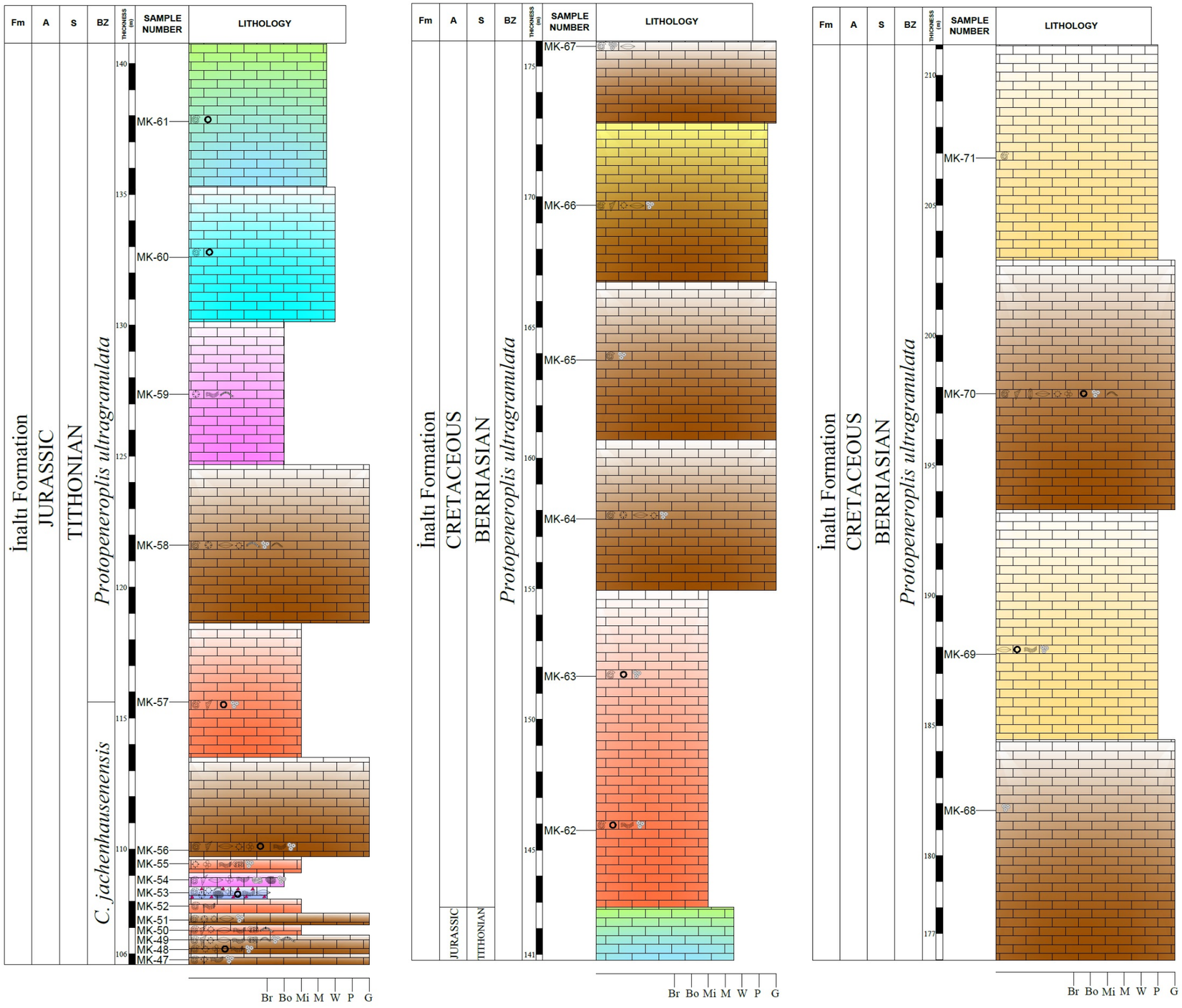
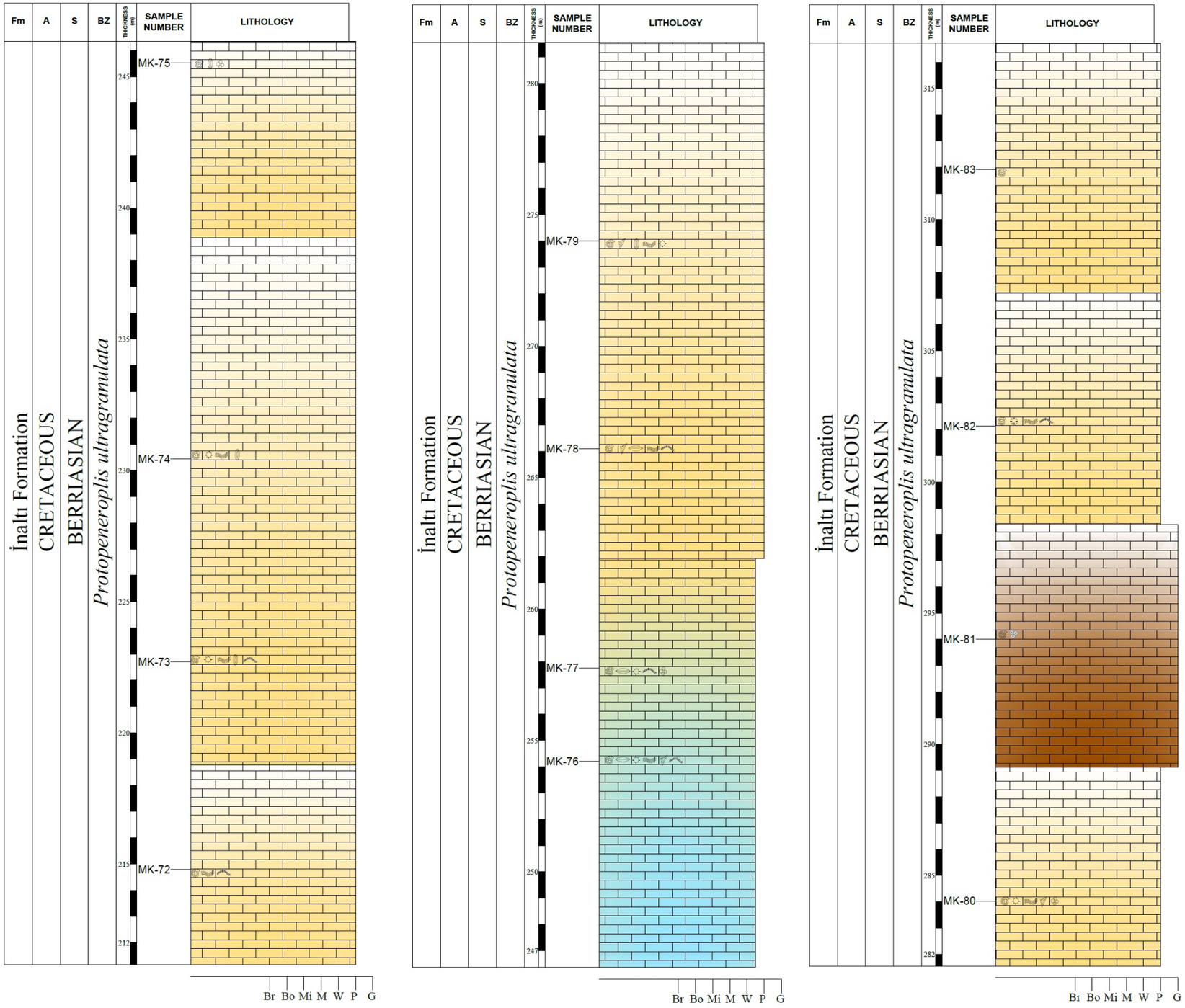


Figure 7 **Continued**



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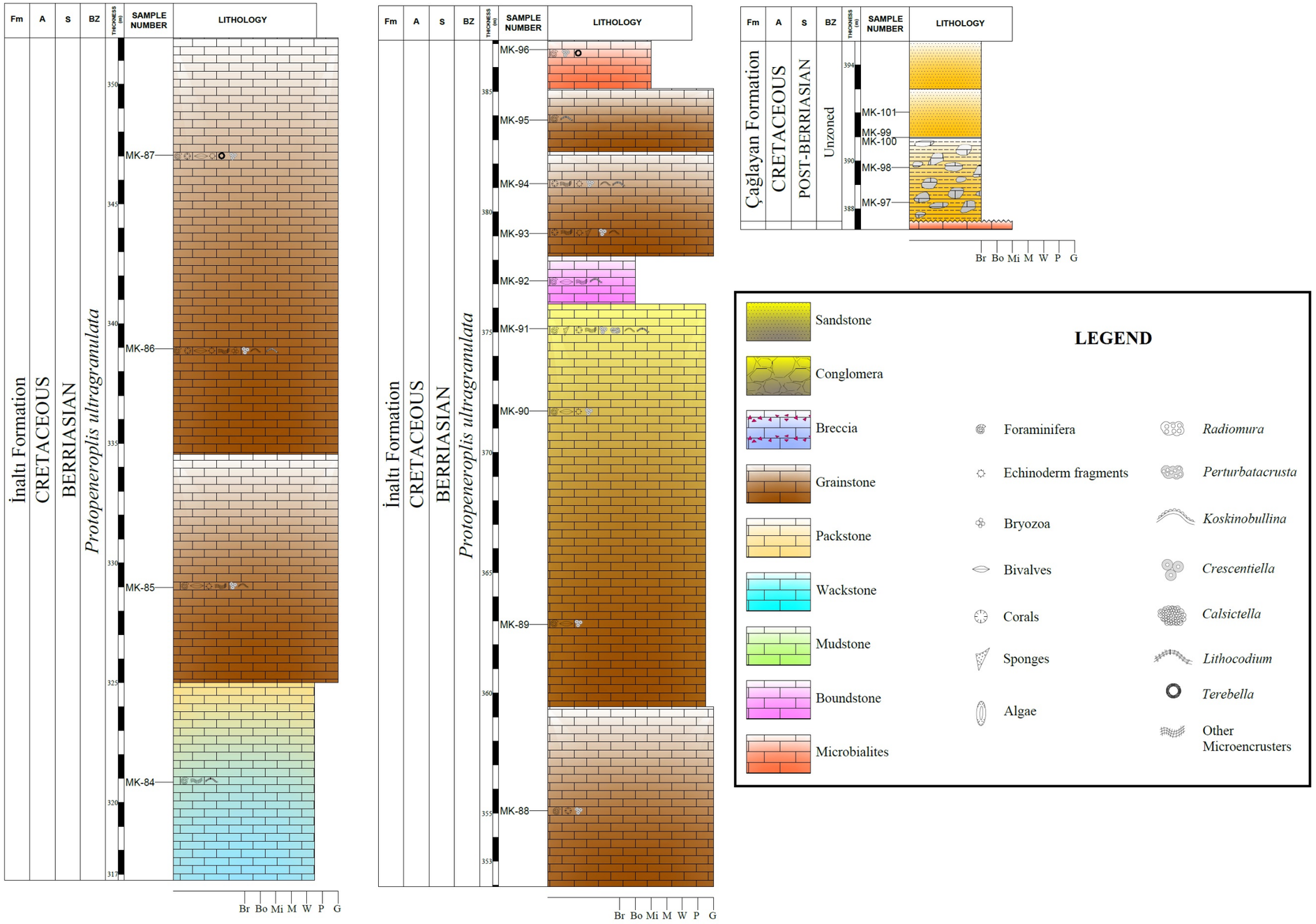


Figure 7 Continued

2.2 Biostratigraphy

Many workers have proposed their own biozones for the Kimmeridgian - Berriasian interval in various studies. Ammonites, calpionellids, benthic foraminifera, algae and some nannofossils are the mainly used fossils for the establishment of the biostratigraphic frameworks for the Upper Jurassic – Lower Cretaceous. Table-1 shows a comparison for some biostratigraphical zonations which are invoked for the establishment of the biostratigraphical framework in this study.

Rojay & Altıner (1998) defined the well known *Clypeina jurassica* Zone for the Kimmeridgian - Upper Tithonian interval in the Amasya region. The lower limit of the zone was not defined precisely due to intense dolomitization. However the upper boundary of the zone was defined by the first appearance of *Protopeneroplis ultragranulata*. The *Clypeina jurassica* Zone is subdivided into two subzones: *Mesoendothyra izjumiana – Alveosepta – Labyrinthina – Protopeneoplis striata* subzone (Subzone IIa) and *Saccocoma* subzone (Subzone IIb). Subzone IIa is characterized by the frequent occurrence of Kimmeridgian markers *Alveosepta gr. jaccardi* and *Mesoendothyra izjumiana* (Rojay & Altıner, 1998). The upper part of the *Clypeina jurassica* Zone is represented by *Saccocoma* subzone which is characterized by the frequent occurrence of pelagic crinoid *Saccocoma* (Altıner, 1991). Due to the occurrence of an Early Tithonian ammonite in the lower part, and the occurrence of calpionellid *Chitinoidella* (Middle Tithonian – early Late Tithonian) in the upper part, the subzone IIb was confined to Tithonian (Altıner, 1991). *Protopeneroplis ultragranulata* zone was defined as the interval between the successive appearances of *Protopeneroplis ultragranulata* and *Montsalevia salevensis* (Altıner, 1991). Because the first appearance of *Protopeneroplis ultragranulata* was dated as Late Tithonian, lower limit of the *Protopeneroplis ultragranulata* zone was defined as Upper Tithonian (Altıner, 1991).

A nearly identical biozonation scheme to the one in Amasya region had been established previously by Altıner (1991) for the Biga-Bursa-Bilecik platform. The main difference between the two biozonation schemes is the presence of *Clypeina jurassica* Zone in Amasya region which corresponds to *Tubiphytes morronensis* (*Crescentiella morronensis)* Zone in the Biga-Bursa-Bilecik platform. In the Biga-

Bursa-Bilecik platform, the interval from the first occurrence of *Tubiphytes morronensis* to the first occurrence of *Protopeneroplis trochoangulata* (*Protopeneroplis ultragranulata*) was defined as the *Tubiphytes morronensis* (*Crescentiella morronensis)* Zone (Altıner, 1991). The lower and upper limits of the *Tubiphytes morronensis* (*Crescentiella morronensis)* Zone were also calibrated with ammonites and calpionellids (Altıner, 1991; Altıner & Özkan, 1991).

Olszewska (2010) proposed three zones for the Kimmeridgian – Berriasian sedimentary successions from the southeastern Poland (Table 1). Kimmeridgian *Mesoendothyra izjumiana – Labyrinthina mirabilis* zone is considered to be equivalent to the *Mesoendothyra izjumiana – Alveosepta –Labyrinthina – Protopeneroplis striata* subzone of Altıner (1991). Berriasian *Protopeneroplis ultragranulata – Protomarssonella kummi* zone corresponds to the *Protopeneroplis trochoangulata* (*Protopeneroplis ultragranulata*) zone of Altıner (1991).

Arkad'ev *et al*. (2006) defined *Epistomina ventiosa – Melathrokerion eospirialis* zone according to the foraminiferal assemblage which is characteristic for the Kimmeridgian - Lower-Middle Tithonian interval. *Epistomina ventiosa* is known from Kimmeridgian sediments of Madagascar (Espitalie & Sigal, 1963) and *Melathrokerion eospiralis* was described from the Tithonian sediments in Eastern Crimea (Kuznetsova & Gorbacik, 1985). *Anchispirocyclina lusitanica* - *Melathrokerion spiralis* zone was used for the Upper Tithonian by Arkad'ev *et al*. (2006). The index species *Anchispirocyclina lusitanica* and *Melathrokerion spiralis* are characteristic for the Upper Tithonian sediments in Crimea (Arkad'ev *et al*., 2006). *Protopeneroplis ultragranulata* and *Siphoninella antiqua* are the used index forms for the *Protopeneroplis ultragranulata* - *Siphoninella antiqua* zone of Arkad'ev *et al*. (2006). In the Upper Tithonian sediments these index species were rarely observed by Arkad'ev *et al*. (2006).

By using benthic foraminifera and encrusting sponge *Calcistella jachenhausenensis* three biozones have been recognized along the measured section in this study: *Mesoendothyra izjumiana* zone, *Calcistella jachenhausenensis* zone and *Protopeneroplis ultragranulata* zone (Table 1).

The measured section contains reefal fauna (sponges and corals as framebuilders), microencrusters, mollusks shells, echinodermata spines, bryozoans, dasycladacean algae and microproblematica. However, these organism groups have not been used in the construction of the chronostratigraphic frame rather they have been played a significant role in the determination of microfacies types and depositional environments.

Table 1 Biostratigraphical zones in different studies

Age	Rojay & Altıner, 1998 - Turkey		Altıner, 1991 - Turkey		Olszewska, 2010 - Poland	Arkad'ev et al., 2006 - E. Crimea	This study- Turkey
Berriasian	*Protopeneroplis ultragranulata*	*Haplophragmoides jukowskyi*	*Protopeneroplis trochoangulata*	*Haplophragmoides jukowskyi*	*Protomarssonella kummi* *Protopeneroplis ultragranulata*	*Protopeneroplis ultragranulata* *Siphoninella antiqua*	*Protopeneroplis ultragranulata*
Tithonian	*Clypeina jurassica*	*Saccocoma*	*Tubiphytes morronensis*	*Saccocoma*	*Andersenolina alpina* *Rumanoloculina mitchurini*	*Anchispirocyclina lusitanica* *Melathrokerion spirialis*	*Calcistella jachenhausenensis*
Kimmeridgian		*Mesoendothyra izjumiana - Alveosepta - Labyrintina - Protopeneroplis striata*		*Mesoendothyra izjumiana - Alveosepta - Labyrintina - Protopeneroplis striata*	*Mesoendothyra izjumiana* *Labyrinthina mirabilis*	*Epistomina ventiosa* *Melathrokerion eospirialis*	*Mesoendothyra izjumiana*

2.2.1 *Mesoendothyra izjumiana* Zone

Mesoendothyra izjumiana Zone covers the lower part of the measured section corresponding to the lowest part of the İnaltı Formation. This level of the section includes generally fore-reef breccias, boundstones and bioclastic packstone-grainstones and peloidal packstones. The upper boundary of this zone is characaterized by the first appearance of the *Calcistella jachenhausenensis* which is an index form confined to the Tithonian (Pleş *et al*., 2013). This interval also includes *Mesoendothyra izjumiana* which adds some similarity to the Subzone IIa of Altıner (1991). The Subzone IIa of Altıner (1991) includes also *Alveosepta*, *Labyrinthina* and *Protopeneroplis striata* together with *Mesoendothyra izjumiana.* However, these forms could not been observed in our zone in this study. The presence of *Mesoendothyra izjumiana* dates the chronostratigraphic position of the zone as Kimmeridgian. Stratigraphic distribution of this zone is from the sample MK-2 to sample MK-20.

Following forms have been identified in this zone: *Troglotella incrustans*, ?*Aaptotoichus* sp., *Haghimashella arcuata*, *Haghimashella* sp., *Textularia* sp., *Sudelloidina luterbachi*, *Ammobaculites* sp., *Spirillina* sp., *Reophax* sp., *Lenticulina*

sp., *Earlandia* sp., ?*Rectoprotomarsonella* sp., *Nautiloculina* sp., *Verneuilinoides* sp., *Meandrospira* sp., *Neotrocholina* sp. (see plates in the Appendix).

2.2.2 *Calcistella jachenhausenensis* Zone

This interval is defined from the first occurrence of the Tithonian marker *Calcistella jachenhausenensis* to the first occurrence of *Protopeneroplis ultragranulata*. The occurrence of *Calcistella jachenhausenensis* in Tithonian was reported by Reitner (1992) and Pleş *et al*. (2013). The first occurrence of *Protopeneroplis ultragranulata* is known from the Latest Tithonian (Septfontaine, 1974). This interval includes the outer platform material (i.e. reef, fore reef and slope facies). Stratigraphic distribution of this zone is from the sample MK-20 to sample MK-58. The presence of the marker *Calcistella jachenhausenensis* confines the chronostratigraphic position of the zone in the Tithonian.

Following forms have been identified in this zone: *Aaptotoichus challengeri*, *Haghimashella arcuata*, *Haghimashella* sp., *Textularia* sp., *Ammobaculites* sp., *Spirillina* sp., *Reophax* sp., *Lenticulina* sp., ?*Rectoprotomarssonella* sp., *Nautiloculina* sp., *Nautiloculina bronnimanni*, *Meandrospira* sp., *Protopenereoplis striata*, *Mohlerina basiliensis*, *Coscinophragma cribrosum*, *Siphovalvulina* sp., *Charenita* sp., *Charentia cuvillieri*, ?*Quinqueloculina stella*, *Uvigerinammina uvigeriniformis*, *Ophthalmidium* sp., ?*Opthalmidium* sp., *Gaudryinopsis* sp., *Bullopora tuberculata*, *Redmondoides lugeoni*, *Trocholina* sp. (see plates in the Appendix).

2.2.3 *Protopeneroplis ultragranulata* Zone

This zone includes the upper part of the measured section covering the interval from sample Mk-58 to sample MK-96. Together with the outer platform facies this zone also includes inner platform facies (back reef and lagoonal facies). This zone is characterized by the first occurrence of *Protopeneroplis ultragranulata*. The studied section ends within this zone and due to this reason upper boundary was not defined. This zone is considered to be equivalent to the *Protopeneroplis trochoangulata* (*Protopeneroplis ultragranulata*) zone of Altıner (1991).

Following forms have been identified in this zone: *Troglotella incrustans, Haghimashella arcuata*, *Textularia* sp., *Ammobaculites* sp., *Spirillina* sp., *Reophax* sp., *Cornuspira* sp., *Earlandia* sp., ?*Protomarssonella* sp., *Nautiloculina* sp., *Nautiloculina bronnimanni*, *Istriloculina* sp., ?*Istriloculina* sp., *Istriloculina emiliae*, *Mohlerina basiliensis, Coscinophragma cribrosum*, *Siphovalvulina variabilis*, *Charenita* sp., *Charentia cuvillieri*, *Charentia evolute*, ?*Quinqueloculina robusta*, ?*Quinqueloculina egmontensis*, *Quinqueloculina* sp., *Pseudocyclammina lituus*, *Kastamonina abanica*, *Redmondoides lugeoni*, *Trochammina* sp., *Anchspirocyclina lusitanica*, *Trocholina* sp., *Neotrocholina* sp. (see plates in the Appendix).

Table 2 Foraminiferal distribution chart (also including the distribution of *C. jachenhausenensis*). Yellow colored sample numbers represent lagoonal facies whereas pink colored sample numbers correspond to pelagic facies. Blue colored sample numbers represent the zone with narrow sample interval.

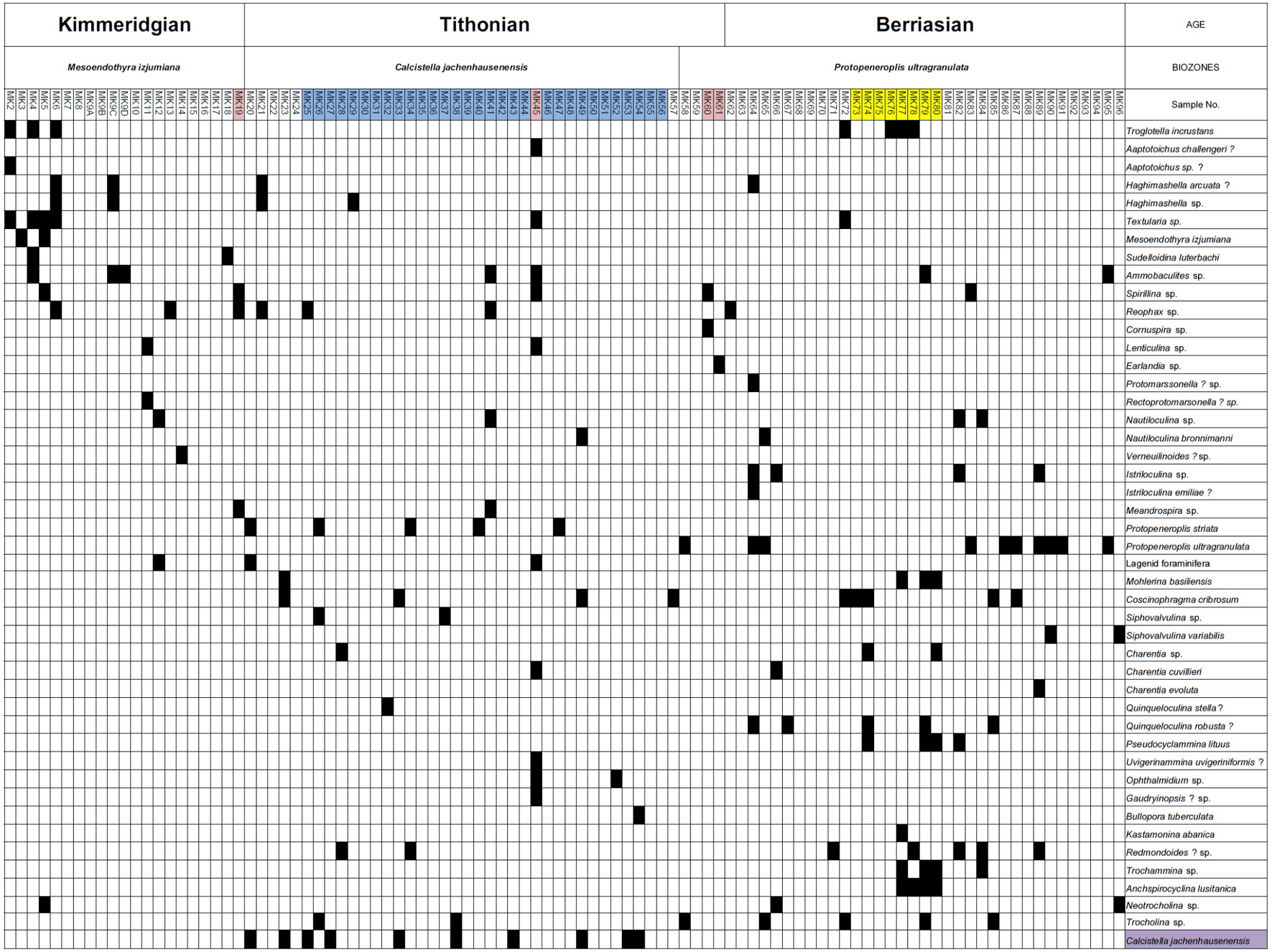
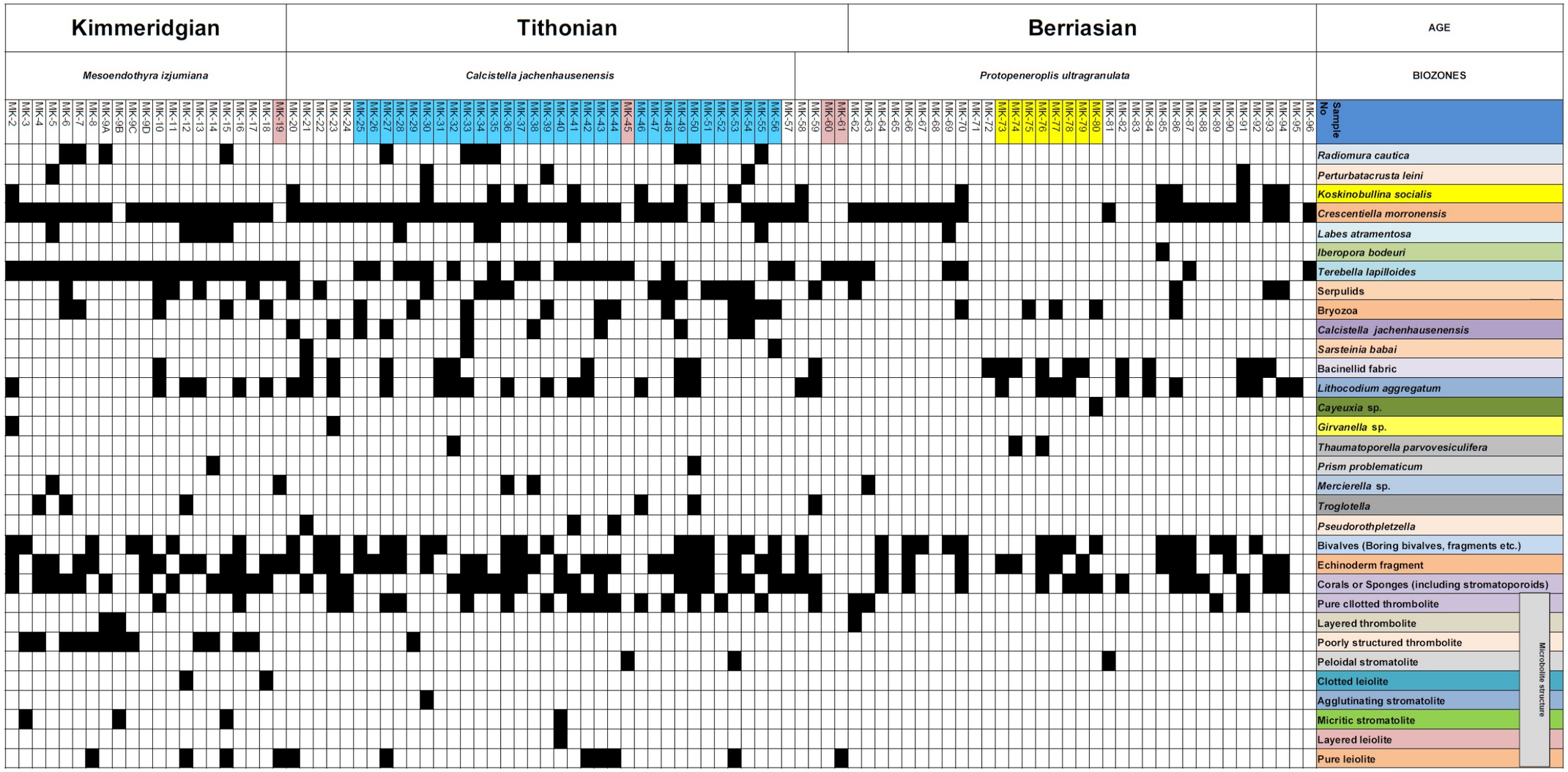


Table 3 Distribution chart for microencrusters. Yellow colored sample numbers represent lagoonal facies whereas pink colored sample numbers correspond to pelagic facies. Blue colored sample numbers represent the zone with narrow sample interval.



CHAPTER 3

MICROFACIES ANALYSES

3.1 Microfacies types and depositional environments

Originally only the petrographic and paleontological thin section studies constitute the microfacies analyses according to its earlier definitions. But the recent approach to the microfacies studies is more comprehensive, now it includes sedimentological and paleontological studies with thin sections, peels, polished slabs and rock samples. The parameters like the type of the grains and matrix and their related percentages, depositional fabrics, fossil types should all be considered during the microfacies analyses (Flügel, 2004).

Understanding and interpreting the evolution of the carbonate platform and the history of the depositional environment is the main aim of the microfacies analyes that were carried out in this study. This was done by examining the allochems and background materials (i.e. textures), macro- and microfossil associations of the samples. Field observations on the outcrops together with the lithological changes have also been considered during these analyses.

Dunham classification of carbonate rocks (1962) was the main source that was used for the textural classification of the İnaltı carbonates. The original classification of Dunham comprises of five textural classes. There are two major groups differentiated according to the original Dunham classification: (1) carbonates whose original components were originally bound together during deposition (i.e. boundstones), and (2) carbonates whose original components were not originally bound together. The second group further divided according to the grain support (packstone and grainstone) or mud support (mudstone and wackestone) and also according to the type of the background material either as micrite or sparry calcite. The percentages

of the allochems (grains) further divide the mud supported rocks into mudstone (less than 10% grians) and wackestone (more than 10 % grains). Later in 1971, Embry & Klovan expanded the Dunham classification by proposing two new names for the carbonate rocks whose original components were not organically bound during deposition. These are floatstone (mud-supported) and rudstone (grain-supported) both of which contain more than 10% of grains larger than 2 mm.

Macro- and microfossil assemblages and sometimes some facies-diagnostic fossils alone play a significant role during the differentiation and determination of microfacies types. All major fossil groups were examined carefully to detect the correct microfacies types. Some facies-diagnostic fossils (like *Terebella*, *Calcistella*) indicated us directly the facies types.

CLASSIFICATION OF LIMESTONES (DUNHAM 1962)

DEPOSITION TEXTURE RECOGNIZABLE					DEPOSITIONAL TEXTURE NOT RECOGNIZABLE
Original components not bound together during deposition				Original components were bound together during deposition as shown by intergrown or lamination contrary to gravity, sediment-floored cavities that are roofed over by organic or questionable organic matter and are too large to be interstices	CRYSTALLINE CARBONATE (Subdivide according classification designed to bear on physical texture or diagenesis)
Contains mud (particles of clay and fine silt size)			Lacks mud and is grain-supported		
Mud-supported		Grain-supported			
less the 10% grains	more than 10% grains				
MUDSTONE	WACKESTONE	PACKSTONE	GRAINSTONE	BOUNDSTONE	

EXPANDED CLASSIFICATION (EMBRY and KLOVAN 1971)

ALLOCHTHONOUS LIMESTONE ORIGINAL COMPONENTS NOT ORGANICALLY ORIGINAL BOUND DURING DEPOSITION						AUTOCHTHONOUS LIMESTONE COMPONENTS ORGANICALLY BOUND DURING DEPOSITION		
Less than 10% > 2 mm components contains lime mud (< 0.03 mm)			no lime mud	Greater than 10% > 2 mm components		by organisms which		
Mud supported		Grain-supported		Matrix-supported	> 2 mm component supported	build a rigid framework	encrust and bind	act as bafflers
less than 10% grains (> 0.03 mm and < 2 mm)	greater than 10% grains					BOUNDSTONE		
MUDSTONE	WACKESTONE	PACKSTONE	GRAINSTONE	FLOATSTONE	RUDSTONE	FRAMESTONE	BINDSTONE	BAFFLESTONE

Figure 8 Classifications of carbonate rocks by Dunham (1962) and Emry and Klovan (1971)

The two of the most frequently used microfacies models were proposed by Wilson (1975) and Flügel (2004) (Figure 9 and Figure 10, 11 respectively). Both of these detailed microfacies models have been examined and played a major role for rhe proposal of the model in this study. Wilson (1975) proposed a conceptual model and defined 9 Standart Facies Zones (FZ) which describe facies belts along an abstract transect from open marine deep basin across a slope, a platform marginal rim

(including reefs and sand shoals), and an inner platform to the coast (Figure 9). Flügel (2004) revised and modified the rimmed carbonate platform model of Wilson (1975). He also designated conceptual facies model for unrimmed, ramp type carbonate platforms. For the ramp type carbonate platforms he proposed 30 ramp Microfacies type (RMF). For the rimmed type carbonate shelves 26 Standard Microfacies Types (SMF) was also proposed by him.

Both of the facies models have been utilized for the interpretation and preparation of the facies model of this study. However, it should be noted that, these models are composite and highly generalized and recognition of the characteritics of all microfacies types described in these models with the same order and features is not possible.

Determining the type of the shelf is not easy but still according to the obtained observations it can be interpreted that some facies belts possess very similar characteristics with the rimmed shelf type. Presence of reefal facies and fore reef, slope material is an evidence for this particular shelf type. But still, further sedimentological work need to be done in order to be sure about the shelf type.

According to the gathered microfacies data 5 depositional environments (zones) have been determined. These environments are slope, fore-reef, reef, back-reef and lagoonal environments on a carbonate shelf. *In situ* basinal facies were not observed. Figure 12 illustrates those environments. Slope, fore-reef and reef environmets are grouped as “platform margin and slope facies” and considered as one main zone. Belonging to these depositional environments 15 microfacies types have been interpreted and they are grouped under the 3 main depositional zones.

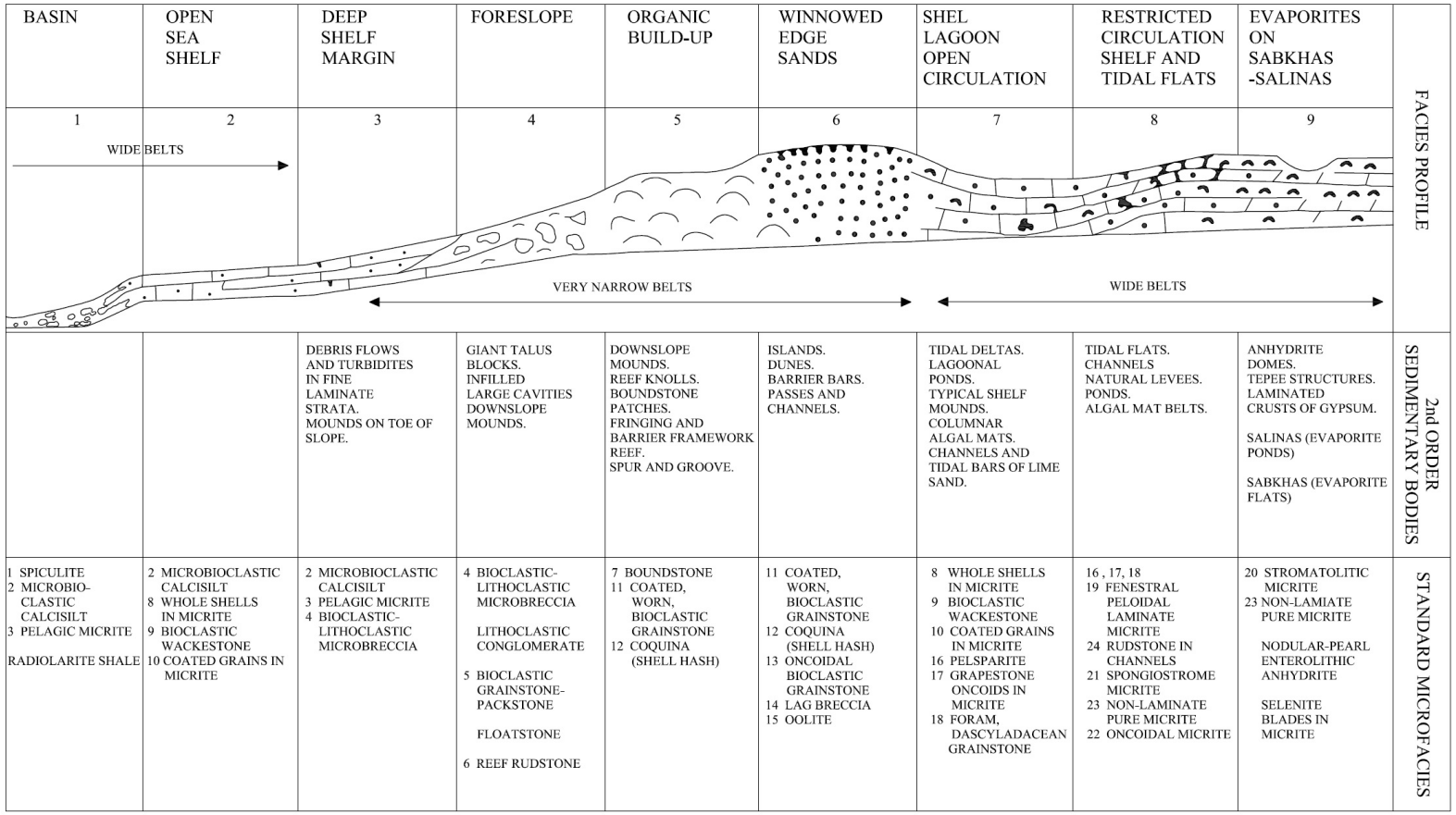


Figure 9 Carbonate depositional model showing standard facies belts and associated microfacies of Wilson (1975)

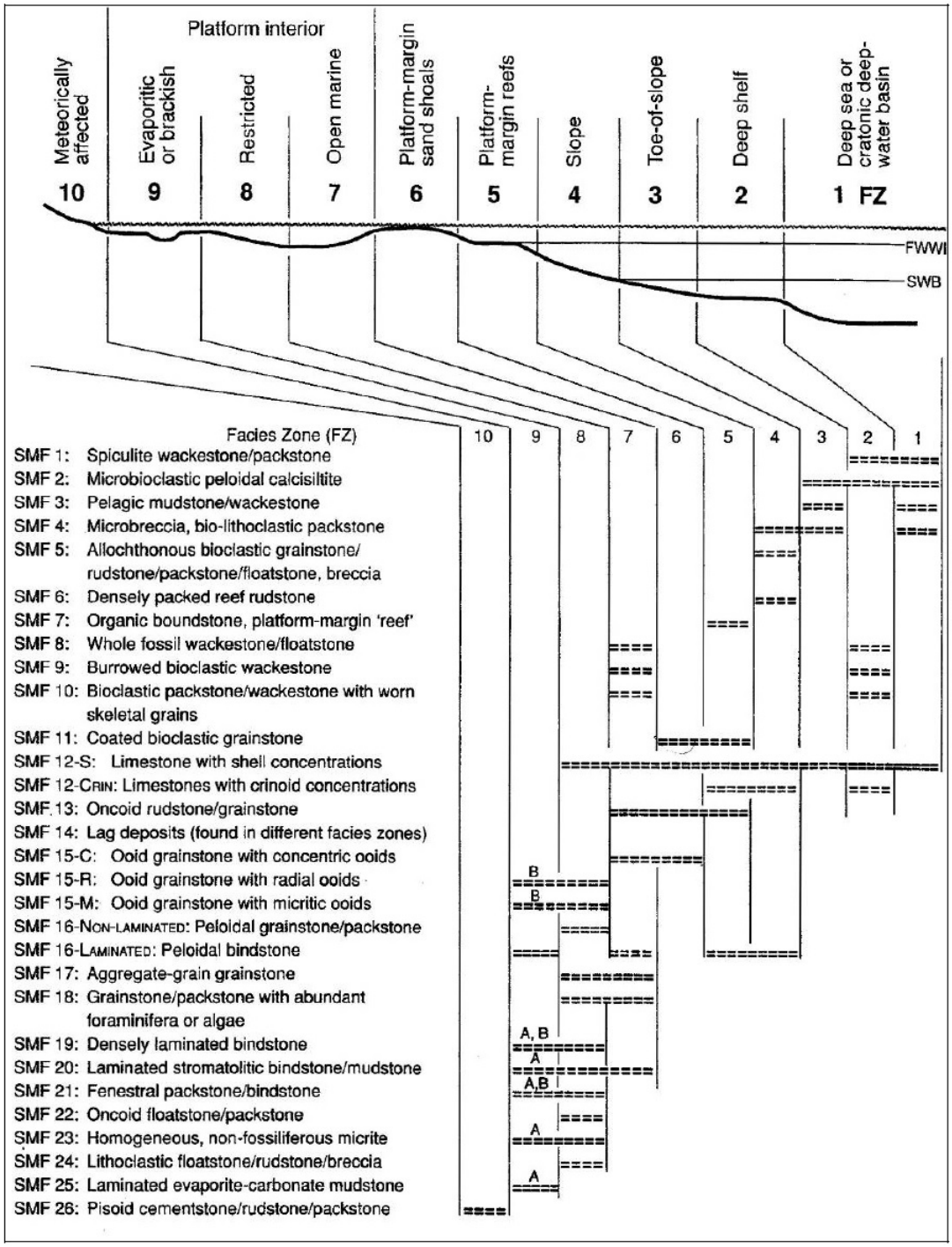


Figure 10 Generalized distribution of standard microfacies types (SMF) in the facies zones (FZ) on a rimmed carbonate platform model (A: evaporitic, B: brackish) (Flügel, 2004)

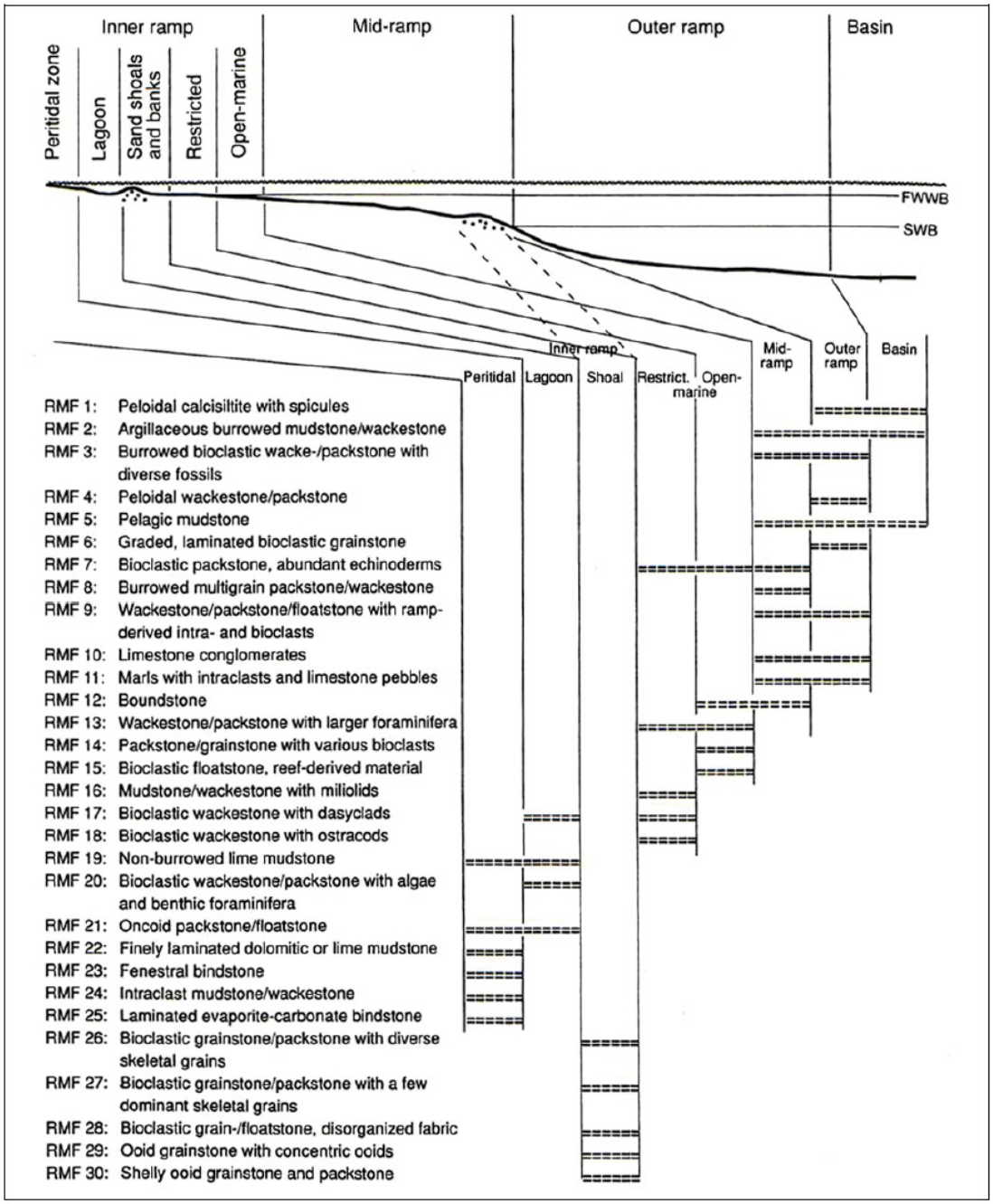


Figure 11 Generalized distribution of microfacies types (RMF) in different parts of a homoclinal carbonate ramp (Flügel, 2004)

Table 4 Microfacies and depositional environments defined in the studied section

Depositional environments	Microfacies No.	Microfacies	Main components	Sample No.
Platform margin (reef and fore-reef) and slope facies	MF 1	Bioclastic grainstone	Coral & sponge fragments, serpulids, *Terebella*, *Calcistella*, *Radiomura*, *Koskinobullina*, *Sarsteinia*, *Lithocodium*, Bacinellid fabric, bryozoa fragments, *Crescentiella*, *Labes*, echinoderm fragments and benthic foraminifera	MK-25, MK-30, MK-34, MK-48, MK-49, MK-51, MK-56, MK-58, MK-65, MK-70, MK-86, MK-87, MK-88, MK-95
	MF 2	Bioclastic packstone	Benthic foraminifera, echinoderm fragments, serpulids, bryozoan, sponge & coral fragmnets, *Crescentiella*, *Terebella*, *Radiomura*, *Lithocodium*, bacinellid-fabric, *Calcistella,* algal fragments	MK-10, MK-35, MK-36, MK-43
	MF 3	Bioclastic packstone to grainstone	Foraminifera, coral & sponge fragments, bivalves, *Crescentiella*, *Labes atramentosa*, *Terebella*, serpulids, *Lithocodium*, echinoderm fragments & spines, microbial peloids	MK-11, MK-13, MK-14, MK-26, MK-28, MK-37, MK-66, MK-89, MK-90, MK-91
	MF 4	Peloidal packstone	Peloids, *Terebella*, *Crescentiella*, *Labes* and benthic foraminifera	MK-69, MK-9C
	MF 5	Breccia	*Terebella*, *Crescentiella*, benthic foraminifera, coral & sponge fragments, *Radiomura*, *Perturbatacrusta*, *Lithocodium*, *Koskinobullina*, serpulids, bryozoa and *Labes*	MK-2, MK-3, MK-4, MK-5, MK-6, MK-7, MK-8, MK-12, MK-15, MK-53
	MF 6	Boundstone	Corals, Sponges, benthic foraminifera, annelids, microencrusting organisms, peloids (probably microbial in origin), bacinellid fabric	MK-16, MK-18, MK-21, MK-23, MK-24, MK-41, MK-54, MK-59, MK-92
	MF 7	Intraclastic bioclastic grainstone	Micritic intraclasts, *Terebella*, *Crescentiella*, *Radiomura*, *Calcistella*, *Lithocodium*, *Thaumatoporella*, *Sarsteinia*, *Koskinobullina*, bacinellid fabric, cephalopod fragments, echinoderm fragments, serpulids, benthic foraminifera	MK- 27, MK-32, MK-33, MK-38, MK-40, MK-46, MK-47, MK-64, MK-85, MK-93, MK-94
	MF 8	Intraclastic grainstone	Abundant micritic intraclasts, minor amount of bioclasts including *Crescentiella*, *Perturbatacrusta*, *Terebella*, *Koskinobullina*, *serpulids*, *Calcistella*, *Lithocodium*, bryozoa, bacinellid-fabric, benthic foraminifera	MK-20, MK-22, MK-29, MK-31, MK-39, MK-42, MK-44, MK-67, MK-68
	MF 9	Pelagic mudstone to wackestone	*Terebella*, foraminifera (which are diagnostic for an outer shelf - deep settings, e.g. *Lenticulina*), sponge spicules, calsicpheres, microbial peloids.	MK-19, MK-45, MK-60, MK-61
	MF 10	Microbialites	Microbial peloids, minor amount of *Terebella*, very rare occurrence of microencrusters, foraminifera, sponges & corals	MK-9, MK-17, MK-50, MK-52, MK-55, MK-57, MK-62, MK-63, MK-96

Table 4 Continued

Back reef facies	MF 11	Bioclastic wackestone - packstone	Benthic foraminifera, *Bacinella*-type structures, *Lithocodium* and coral fragments.	MK-72, MK-82, MK-84
	MF 12	Bioclastic peloidal packstone - grainstone	Benthic foraminifera, *Crescentiella* and other unrecognizable fossil fragments which are not easy to define	MK-81, MK-83,
	MF 13	Intraclastic packstone	Micritic intraclasts, rare benthic foraminifera	MK-71
Lagoonal facies	MF 14	Bioclastic packstone	Large complex benthic foraminifera (*Kastamonina*, *Anchispirocyclina*, *Coscinophragma* and *Pseudocyclammina*), *Mohlerina*, dasycladacean algae, inner platform sponges – stromatoporoids, bryozoa, *Lithocodium*, bacinnellid fabric, echinoderm fragments	MK-73, MK-74, , MK-75, MK-78, MK-79, MK-80
	MF 15	Bioclastic wackestone	Similar to the content of MF 14 but they occur with lesser amounts	MK-76, MK-77

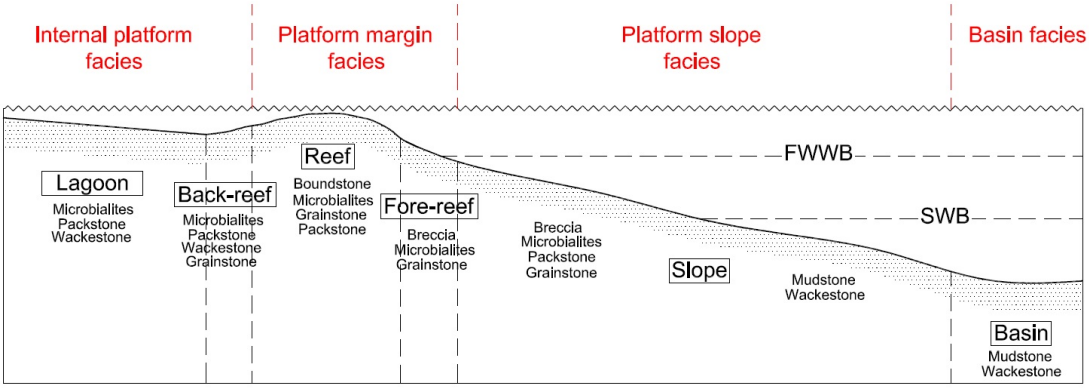


Figure 12 Generalized distribution of microfacies types in different settings of the İnaltı carbonate platform, FWWB: Fair weather wave base, SWB: Storm wave base

3.2 Platform margin (reef and fore-reef) and slope facies

3.2.1 MF 1, Bioclastic grainstone

This microfacies is characterized by abundant allochems with bio-origin and sparry calcite cement. Most of the allochems are fossils and fossil fragments. Larger allochems are generally coral or sponge fragments. Serpulids, *Terebella*, *Calcistella*, *Radiomura*, *Koskinobullina*, *Sarsteinia*, *Lithocodium*, Bacinellid fabric, bryozoa fragments, *Crescentiella*, *Labes*, echinoderm fragments and benthic foraminifera are the other type of fossil organisms observed in this microfacies type (Figure 19). Some minor amout of intraclasts may be seen in some parts of this microfacies type, but dominance of bioclasts is obvious so this type of textures have been defined as bioclastic grainstone.

This microfacies corresponds to SMF 5 or 11 of Wilson (1975) and SMF 11 of Flügel (2004) and it has been interpreted that depositon of this microfacies was in reef to fore-reef environment above fair weather wave base. Similar bioclastic grainstone microfacies have been observed in several studies (Carras & Georgala, 1998 in Microfacies-group LC-BA; peri-reef/bioclastic shoal facies (F7) of Ivanova *et al*., 2008; Săsăran *et al*., 2001; Upper talus facies of Schlagintweit & Ebli, 1999; Facies C of Bucur *et al*., 2010).

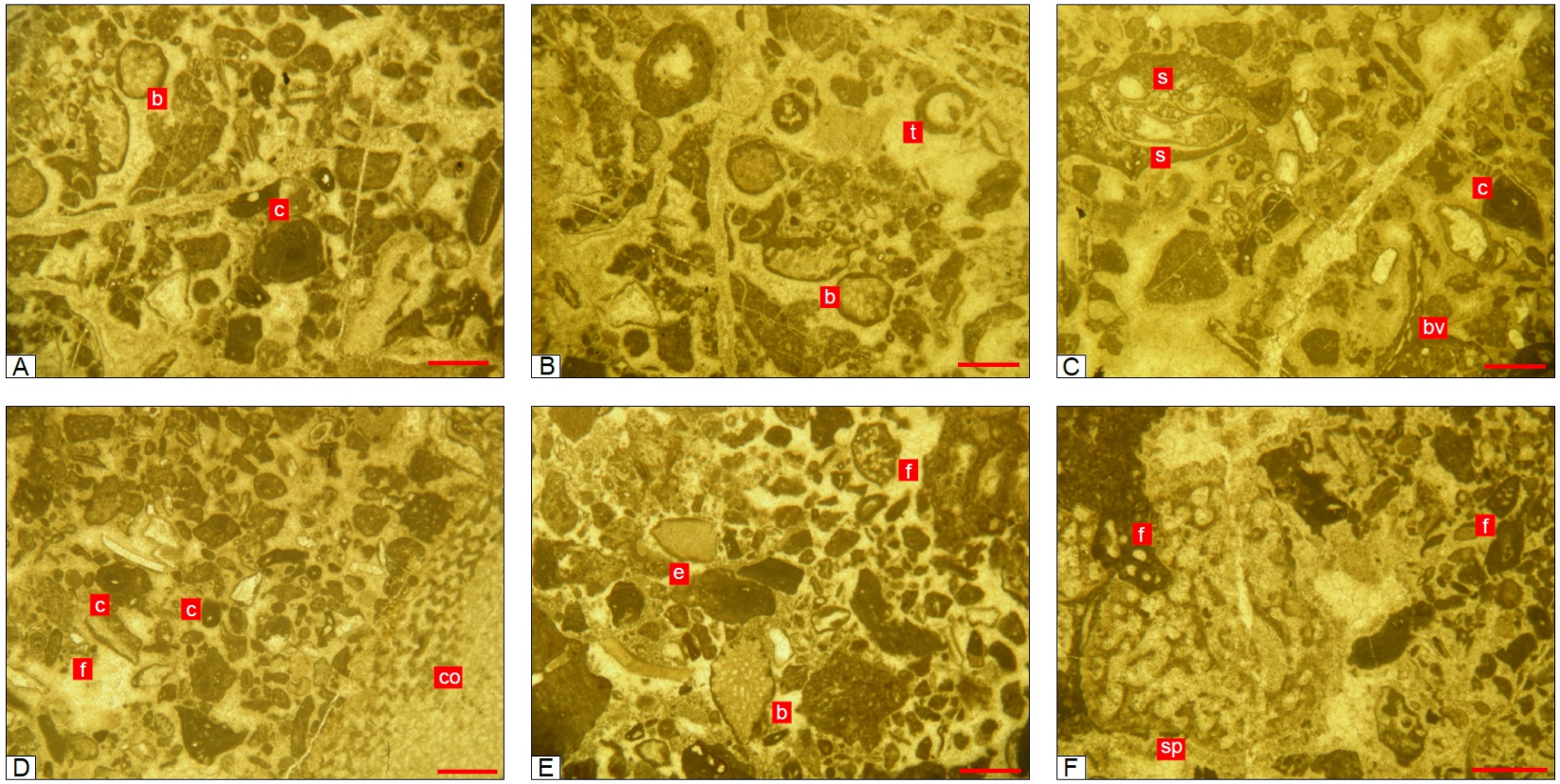


Figure 13 Photomicrographs of the bioclastic grainstone (MF 1). A. MK-25, b: Bryozoa, c: *Crescentiella*, scale bar: 1 mm, B. MK-25, b: Bryozoa, t: *Terebella*, scale bar: 1 mm , C. Mk-51, s: Serpulids, bv: Bivalve fragment, c: *Crescentiella*, scale bar: 1 mm, D. Mk-51, co: Corals, f: Foraminifera, c: *Crescentiella*, scale bar: 1 mm, E. MK-56, e: Echinoderm fragment, b: Bryozoa, f: Foraminifera, scale bar: 1 mm, F. MK-70, f: Foraminifera, sp: Sponge, scale bar: 1 m

3.2.2 MF 2, Bioclastic packstone

This microfacies can be recognized with its abundant bioclast content and micrite background. Its textural difference from MF1 is the presence of micrite as the background material. Benthic foraminifera, echinoderm fragments, serpulids, bryozoan, sponge and coral fragments, *Crescentiella*, *Terebella*, *Radiomura*, *Lithocodium*, bacinellid-fabric, *Calcistella,* algal fragments are the fossil allochems observed (Figure 13). Large allochems are generaly sponge and coral fragments. Below the fair weather wave base in the platform slope setting, MF2 can be deposited with the incoming bioclasts from the build-up and inner part of the platform.

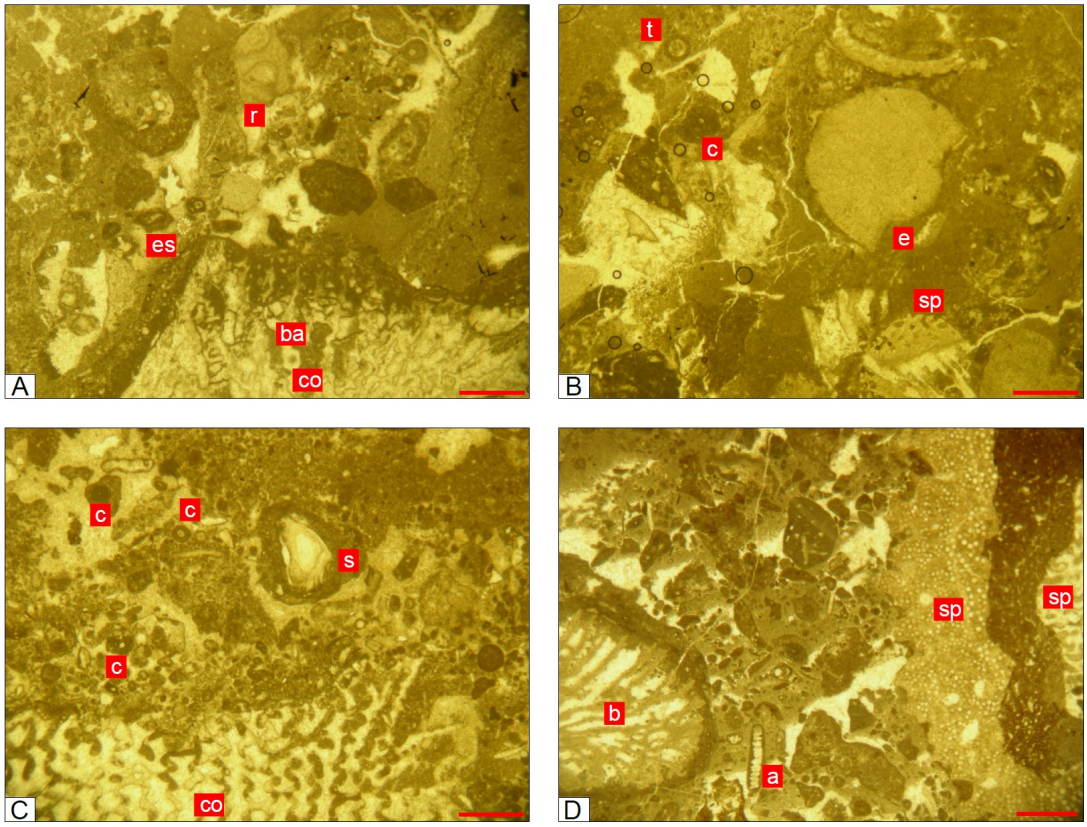


Figure 14 Photomicrographs of the bioclastic packstone (MF 2). A. MK-10, co: Coral fragment, ba: *Bacinella*, es: Echinodermata spine, r: *Radiomura*, scale bar: 1 mm, B. MK-10, sp: Sponge, e: Echinoderm fragment, c: *Crescentiella*, t: *Terebella*, scale bar: 1 mm, C. MK-35, c: *Crescentiella*, s: Serpulid, co: Coral fragment scale bar: 1 mm, D. MK-43, b: Bryozoa, a: Algae fragment, sp: Sponge, scale bar: 1 mm

This kind of platform margin/slope bioclastic packstone facies was also observed in Gawlick & Schlagintweit (2010). Also in some preserved cavities in the reefal setting, bioclastic packstone deposition can be observed. Bioclastic packstones in LC-BA microfacies group of Carras & Georgala (1998) are the similar facies on the high energy margin of a carbonate platform. Peloidal microbialites was also observed in some parts of this microfacies.

Based on the textural and compositional similarities it can be concluded that this microfacies is quite similar to SMF 5 of Wilson (1975) and SMF 10 or SMF4 of Flügel (2004).

3.2.3 MF 3, Bioclastic packstone to grainstone

This microfacies type is characterized by the presence of both micrite and sparry calcite cement as the background material with abundant bioclasts. Foraminifera, coral and sponge fragments, bivalves, *Crescentiella*, *Labes atramentosa*, *Terebella*, serpulids, *Lithocodium*, echinoderm fragments and spines are the fossil allochems that has been observed (Figure 20). Peloidal microbialites can also be observed in some parts of this microfacies. Based on its textural features it can be conluded that this microfacies has been deposited in platform slope or back reef facies. On the platform slope, above the storm wave base and below the fair weather wave base, occurrence of both micritic matrix and sparry calcitic cement can be expected.

SMF 5 of Wilson (1975) and SMF 18 of Flügel (2004) are the most similar microfacies to our MF3. Similar bioclastic packstone - grainstone microfacies have been observed by Turi *et al*. (2011) and as Facies C by Bucur *et al*. (2010).

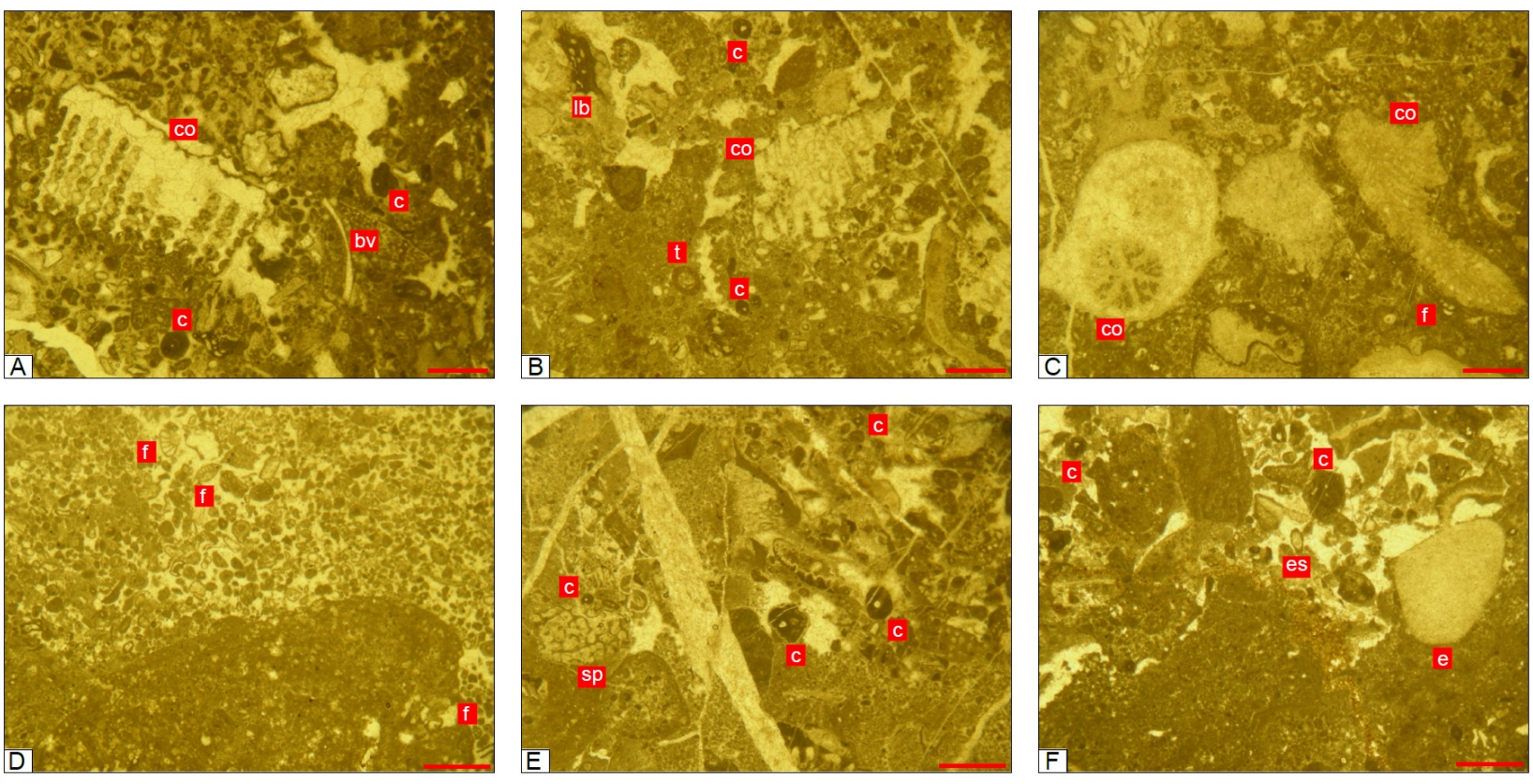


Figure 15 Photomicrographs of the bioclastic packstone to grainstone (MF 3). A. MK-11, co: Coral fragment, c: *Crescentiella*, bv: Bivalve fragment, scale bar: 1 mm, B. MK-28, t: *Terebella*, co: Coral fragment, lb: Labes, c: *Crescentiella*, scale bar: 1 mm, C. MK-37, co: Corals, f: Foraminifera, scale bar: 1 mm, D. MK-89, f: Foraminifera, scale bar: 1 mm, E. MK-90, sp: Sponge, c: *Crescentiella*, scale bar: 1 mm, F. MK-13, es: Echinodermata spine, e: Echinoderm fragment, c: *Crescentiella*, scale bar: 1 mm

3.2.4 MF 4, Peloidal packstone

MF4 is characterized by abundant presence of peloids as allochems in the micrite dominated matrix. *Terebella*, *Crescentiella*, *Labes* and benthic foraminifera are the bio-allochems observed in this microfacies type (Figure 14). Most of these peloids are probably related with microbial activity [microbial peloids as defined in Flügel (2004)]. Some may also be related to reworking of micritic carbonate grains [mud peloids as defined in Flügel (2004)] and biotic activities [fecal pellets as defined in Flügel (2004)]. Due to the presence of *Terebella* and absence of associated inner platform fossils it can be conluded that this microfacies type has been deposited in fore-reef to slope environment. SMF 16 of Flügel (2004) is the most similar microfacies type to our MF4. Similar peloidal packstones were also observed in the talus microfacies of Schlagintweit & Ebli (1999).

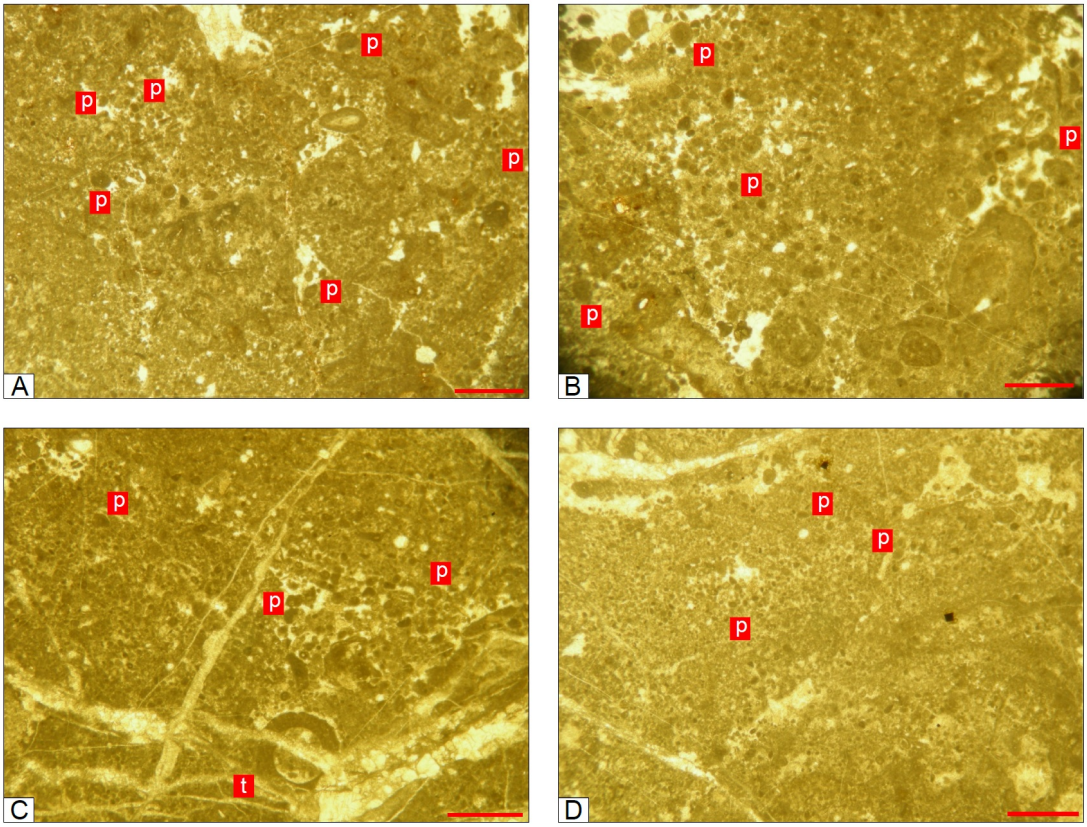


Figure 16 Photomicrographs of the peloidal packstone (MF 4). A. MK-9C, p: Peloids, scale bar: 1 mm, B. MK-9C, p: Peloids, scale bar: 1 mm, C. MK-69, p: Peloids, scale bar: 1 mm, D. MK-69, p: Peloids, t: *Terebella*, scale bar: 1 mm

3.2.5 MF 5, Breccia

MF 5, Breccia microfacies is classified as forereef and slope breccias according to its composition and texture. Included fossils are mainly reef builders and reef and slope dwellers. *Terebella*, *Crescentiella*, benthic foraminifera, coral and sponge fragments, *Radiomura*, *Perturbatacrusta*, *Lithocodium*, *Koskinobullina*, serpulids, bryozoa and *Labes* are among these fossils (Figure 21). Stylolitic boundaries filled with iron-bearing fill material between clasts can be observed (Figure 21B). The observed microfacies in the breccia clasts seems variable because clasts were derived from different parts of the reef complex, including reef flat, reef margin and various slope environments. Breccia fabric is clast supported. This microfacies has been observed in the lowermost part of the section, the latest one occuring in the sample MK-15. Based on the included fossils it can be concluded that MF 5 was deposited in the fore-reef to slope environment. When compared with SMFs of Wilson (1975) and Flügel (2004), MF 5 corresponds to SMF 4 of both models. F1 facies (breccia/microbreccia levels) of Pleş *et al*. (2013) and facies B of Bucur *et al*. (2010) are the similar breccia facies with the ones observed in this study.

3.2.6 MF 6, Boundstone

Three types of boundstones have been observed along the studied section; (1) coral boundstones (Figure 22), (2) sponge boundstones (Figure 15A, B and C) and (3) *Bacinella* boundstones (Figure 15D). All these boundstone facies are characterized by organical bounding at the time of deposition. This bounding may be represented by intergrown or lamination. The *in situ* growth position of the fossil organisms can be seen in boundstone facies. Corals and sponges played a framebuilder role during the formation of the reefs. Framebuilders (corals and sponges) were then encrusted by microencrusting organisms which may also add a secondary contribution to the reef formation. Bioerosion by boring organisms on the sponge/coral bodies may also be seen. Cavities and perforations (pore spaces) in between these framebuilding organisms are generally filled by allochems and micritic matrix or sparry calcitic cement depending on the preservation from high energy conditions. If the cavity/perforation is well preserved from high energy conditions micrite dominated interstitial sediments can be observed. Otherwise sparry calcite cement dominates the

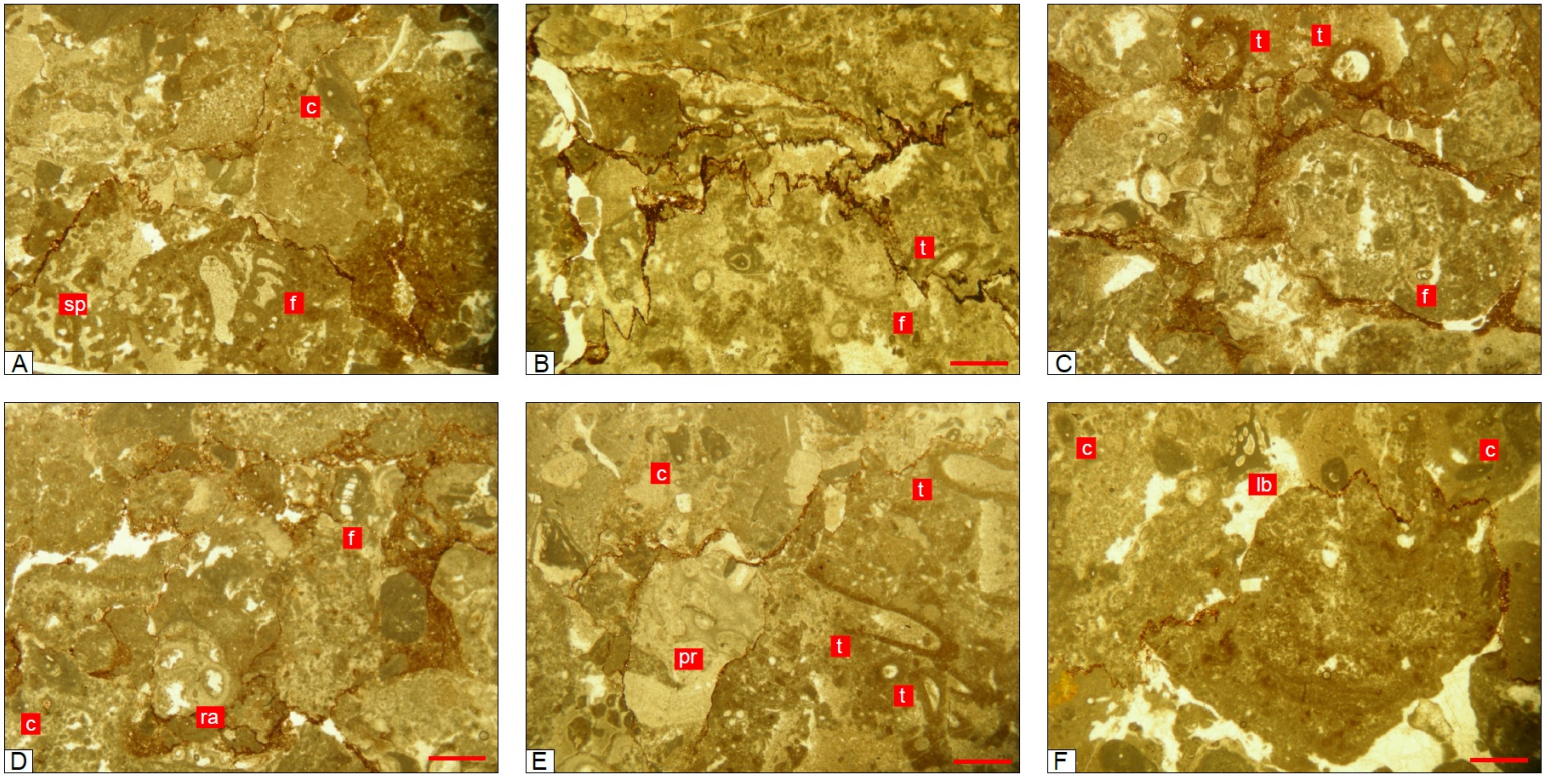


Figure 17 Photomicrographs of the breccia (MF 5). A. MK-4, f: Foraminifera, sp: Sponge, c: *Cresecentiella*, scale bar: 1 mm, B. MK-5, t: Terebella, f: Foraminifera, scale bar: 1 mm, C. MK-6, t: *Terebella*, f: Foraminifera, scale bar: 1 mm, D. MK-6, ra: *Radiomura*, f: Foraminifera, c: *Crescentiella*, scale bar: 1 mm, E. MK-15, t: *Terebella*, pr: *Perturbatacrusta*, c: *Crescentiella*, scale bar: 1 mm, F. MK-12, lb: *Labes*, c: *Crescentiella*, scale bar: 1 mm

interstitial pore spaces. Foraminifera, annelids, microencrusting organisms, peloids (probably microbial in origin) may exist in these interstitial sediments. Coral boundstone facies in our specimens is composed of the fossil scleractinian coral colonies and the interstitial allochems with (mainly) micritic matrix and sparry calcitic cement. Most of the time, coral bodies are recrystallized. Sponge boundstones are mainly dominated by coralline sponges (e.g. stromatoporoids) with accompanying microencrusters. Coral/sponge boundstone microfacies were formed in the marginal reefal setting on the platform. By looking at the composition and texture, it can be interpreted that coral and sponge boundstone microfacies (MF 6) correspond to SMF7 of Wilson (1975) and Flügel (2004). Frequent observation of similar coral boundstones and sponge boundstones were mentioned by many authors in the literature (see Facies A of Bucur *et al*., 2010; Săsăran *et al*., 2001; F6 facies of Ivanova *et al*., 2008; Turi *et al*., 2011; Catincut *et al*., 2011; Coralgal boundstones of Săsăran *et al*., 1999 for the analogues of the coral boundstones; see Leinfelder *et al*., 1993b; Leinfelder *et al*., 2005; Gawlick & Schlagintweit, 2010 for the analogues of the sponge boundstones). *Bacinella* boundstone is totally composed of *Bacinella*-like organisms. This third type of boundstone microfacies is associated with shallow-water environments due to the preferential occurrence of *Bacinella* in shallow-water environments. On the build-up (reef environment) this boundstone type may have been formed. As mentioned in Schmid (1996), *Bacinella* occurs in shallow water and reefal settings affected by moderate environmental stress and forms high diversity associations with other microencrusters. Gawlick & Schlagintweit (2006) reported the occurrence of similar *Bacinella* bindstones (boundstones) below the J-K boundary in the Northern Calcareous Alps, Austria.

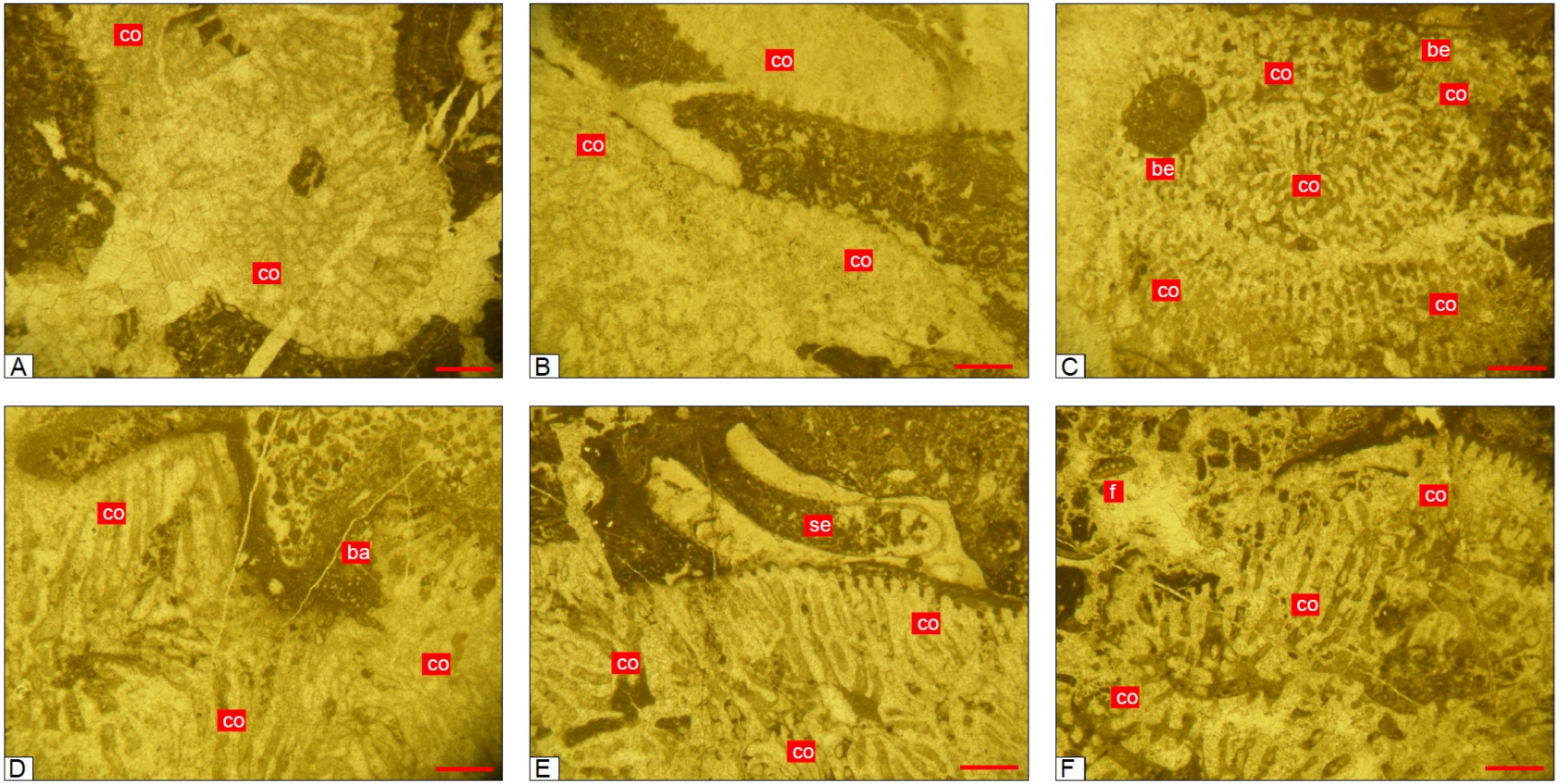


Figure 18 Photomicrographs of the coral boundstone (MF 6). A. MK-16, Coral Boundstone, co: Corals, scale bar: 1 mm, B. MK-16,Coral Boundstone, co: Corals, t: *Terebella*, scale bar: 1 mm, C. MK-18, Coral Boundstone, co: Corals, be: Bioerosion scale bar: 1 mm, D. MK-21,Coral Boundstone, co: Corals, ba: *Bacinella*-type structure, scale bar: 1 mm, E. MK-23, Coral Boundstone, co: Corals, se: Serpulid, scale bar: 1 mm, F. MK-23, Coral Boundstone, co: Corals, f: Foraminifera, scale bar: 1 mm

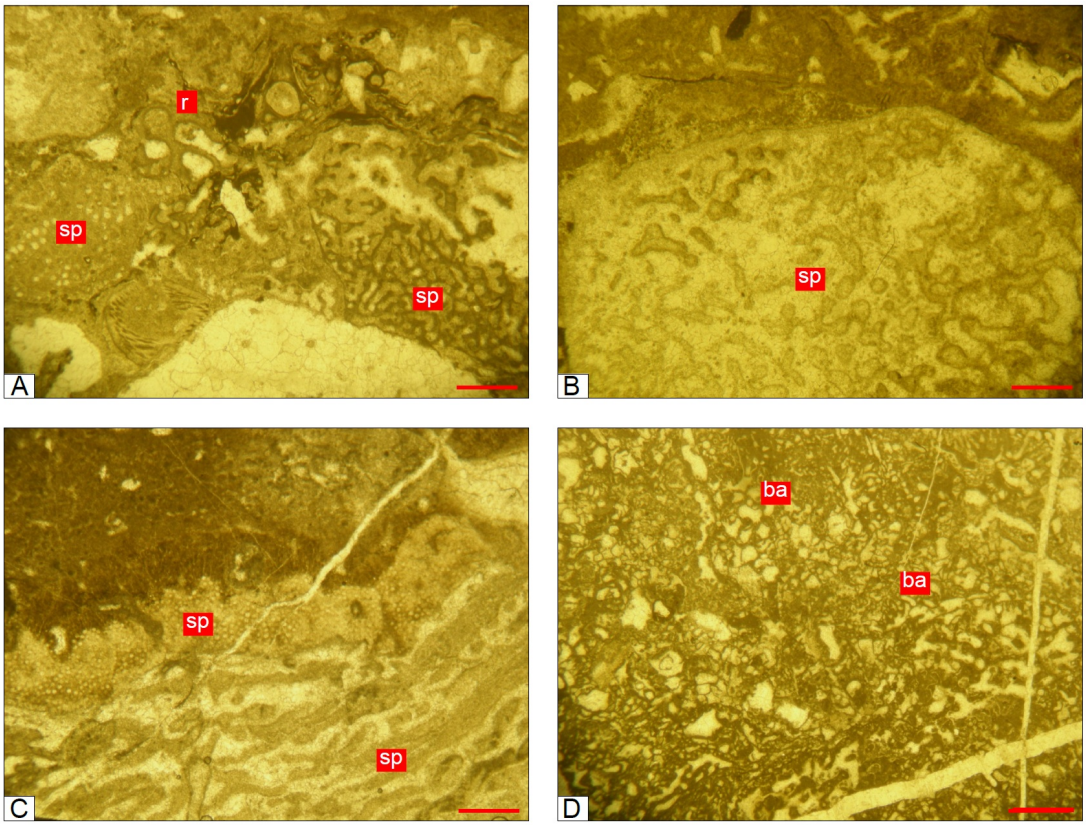


Figure 19 Photomicrographs of the sponge-*bacinella* boundstone (MF 6). A. MK-9A, Sponge boundstone, sp: Sponge, r: *Radiomura*, scale bar: 1 mm, B. MK-9A, Sponge boundstone, sp: Sponge, scale bar: 1 mm, C. MK-54, Sponge boundstone, sp: Sponge, scale bar: 1 mm, D. MK-92, *Bacinella* boundstone, ba: *Bacinella*-type structures, scale bar: 1 mm

3.2.7 MF 7, Intraclastic bioclastic grainstone

This microfacies is characterized by the presence of both bioclasts and intraclasts and sparry calcitic background material. Bioclasts are fossils and fossil content of the MF 7 includes *Terebella*, *Crescentiella*, *Radiomura*, *Calcistella*, *Lithocodium*, *Thaumatoporella*, *Sarsteinia*, *Koskinobullina*, bacinellid fabric, cephalopod fragments, echinoderm fragments, serpulids and benthic foraminifera (Figure 16). Intraclasts are relict clasts of reworked lithified mud (micritic) beds. The occurrence of intrclasts generally indicates wave dominated regimes and tides. Intraclastic grainstones are often interpreted as a product of storm wave erosion and reworking of various sediment types (Flügel, 2004). Parts of the slope above the storm wave base and the fore-reefal environments are the settings where we can expect the formation of intraclastic-bioclastic grainstone facies.

This microfacies is similar to SMF 4 of Flügel (2004) with one difference. MF 7 includes sparry calcitic cements as background material, whereas SMF 4 of Flügel (2004) is defined as packstone with micrite dominance. Săsăran *et al*. (2001) and Catincut *et al*. (2011) observed the similar intraclastic bioclastic grainstone facies in their Upper Jurassic – Lower Cretaceous material from Romania.

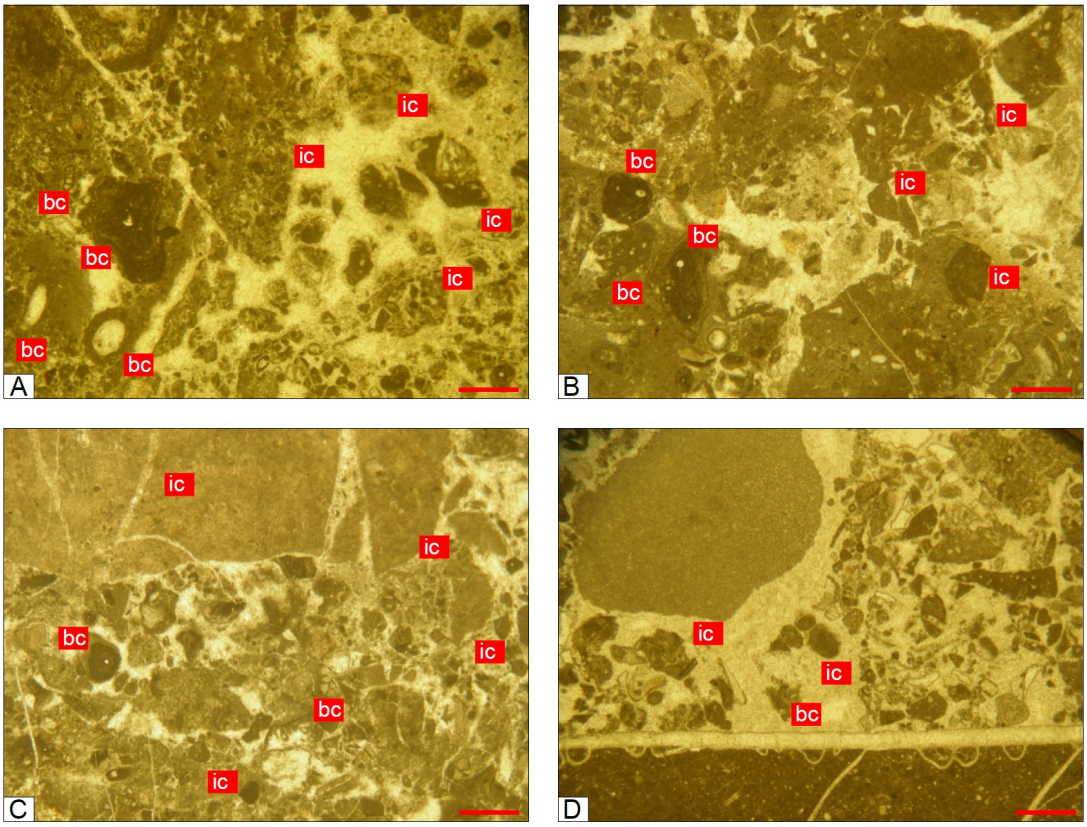


Figure 20 Photomicrographs of the intraclastic bioclastic grainstone (MF 7). A. MK-32, ic: Intraclast, bc: Bioclast, scale bar: 1 mm, B. MK-27, ic: Intraclast, bc: Bioclast, scale bar: 1 mm, C. MK-33, ic: Intraclast, bc: Bioclast, scale bar: 1 mm, D. MK-93, ic: Intraclast, bc: Bioclast, scale bar: 1 mm

3.2.8 MF 8, Intraclastic grainstone

MF 8 is composed of the mainly intraclasts and sparry calcite cement and seems like a microbreccia with angular micro-clasts. It differs from MF 7 in having minor amout of bioclasts. Ignorable amount of bioclasts are composed of *Crescentiella*, *Perturbatacrusta*, *Terebella*, *Koskinobullina*, serpulids, *Calcistella*, *Lithocodium*, bryozoa, bacinellid-fabric and benthic foraminifera. Intraclasts are often micrite

dominated muddy clasts (Figure 17). Clasts of wacke- to packstones can also be observed. As mentioned before intraclastic grainstones are related to storm wave erosion and reworking of various sediment types. Their depositional setting is interpreted as the slope environment abov the storm wave base. Microbreccia (SMF 4) facies of Flügel (2004) is the most similar one to MF 8 when considering its depositional setting and composition.

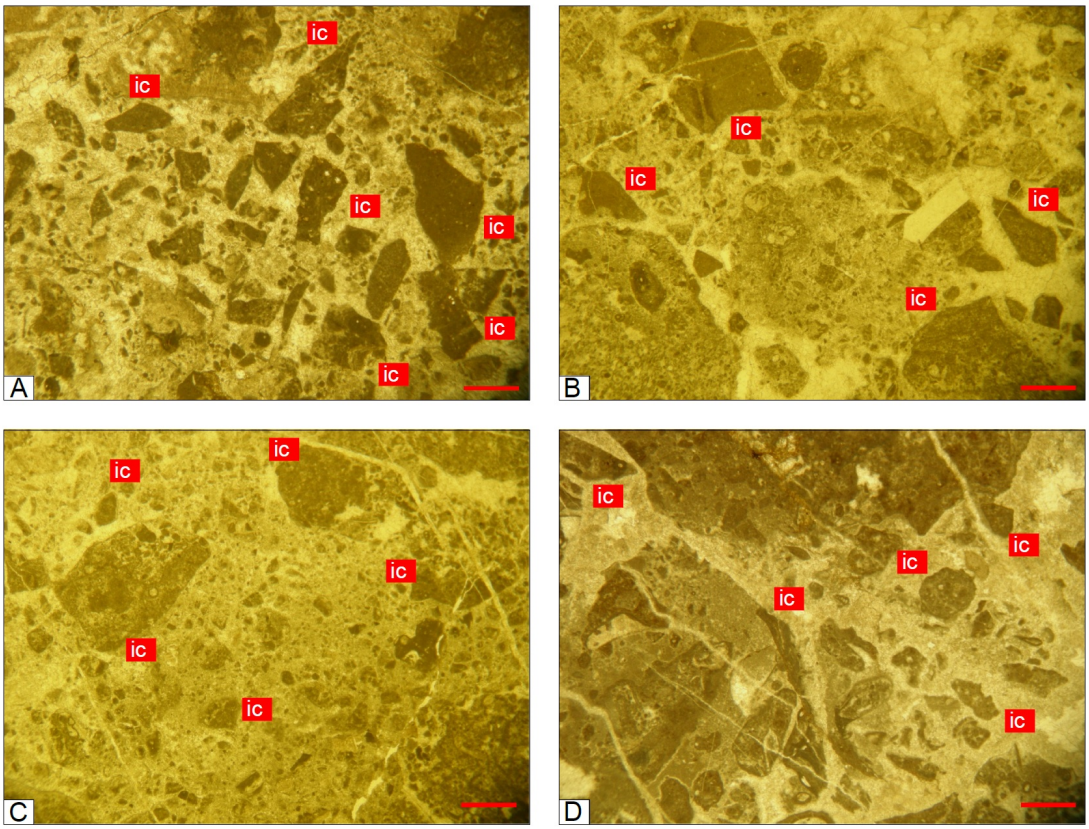


Figure 21 Photomicrographs of the intraclastic grainstone (MF 8). A. MK-22, ic: Intraclast, scale bar: 1 mm, B. MK-29, ic: Intraclast, scale bar: 1 mm, C. MK-31, ic: Intraclast, scale bar: 1 mm, D. MK-42, ic: Intraclast, scale bar: 1 mm

3.2.9 MF 9, Pelagic mudstone to wackestone

This microfacies represents an increase in the amount of micrite and decrease in the size and abundance of the allochems. The largest allochem observed is *Terebella*. Other allochems are foraminifera (which are diagnostic for an outer shelf - deep settings, e.g. *Lenticulina*), sponge spicules, calsicpheres and peloids (Figure 23). Observed peloids most probably possess a microbial origin. Due to the dominance of

micrite, it is interpreted that the depositional setting of this microfacies should be in a low energy environment. Slope environment below the storm wave base seems as the most suitable depositional setting for MF 9 considering the aforementioned interpretation and fossil content. SMF 9 of Wilson (1975) is the most similar microfacies to MF 9 when consider its depositional setting and composition. Hemipelagic limestones of Săsăran *et al*. (2001) and MF-1 of Krajewski *et al*. (2011) are the examples for the similar pelagic facies observed in the literature.

3.2.10 MF 10, Microbialites

Microbialites are defined as "organosedimentary deposits that have accreted as a result of a benthic microbial community trapping and binding detrital sediment and/or forming the locus of mineral precipitation" by Burne and Moore (1987). According to the classification of Schmid (1996) for Mesozoic microbialites which relies on microstructures in thin sections, three main types of microbialites can be distinguished: (1) microbialites with peloidal microstructure, (2) microbialites with laminated particle microstructure and (3) microbialites with dense microstructure (Figure 18). Microbialites observed in this study have generally peloidal microstructure (poorly structured thrombolite) (Figure 24). Some rare occurrence of layered microstructure has also been seen. Peloidal microbilaites consist of amalgamated peloids with spar-filled cavities representing fenestral fabrics. The common absence of distinct lamination prohibits an assignmnent as stromatolites. Occurrence of other type of fossils (microencrusters, foraminifera, sponges, corals etc.) is very rare in this microfacies type. Only minor amounts of *Terebella* have been observed in association with peloidal microbialites. This association of *Terebella* with peloidal microbialites indicates that depositional settings of observed microbialites are fore-reefal to slope environments. Similar peloidal microbialites were observed by Săsăran *et al*. (1999 and 2001), Şerban *et al*. (2004), Bucur *et al*. (2010), Krajewski *et al*. (2011) and Pleş *et al*. (2013).

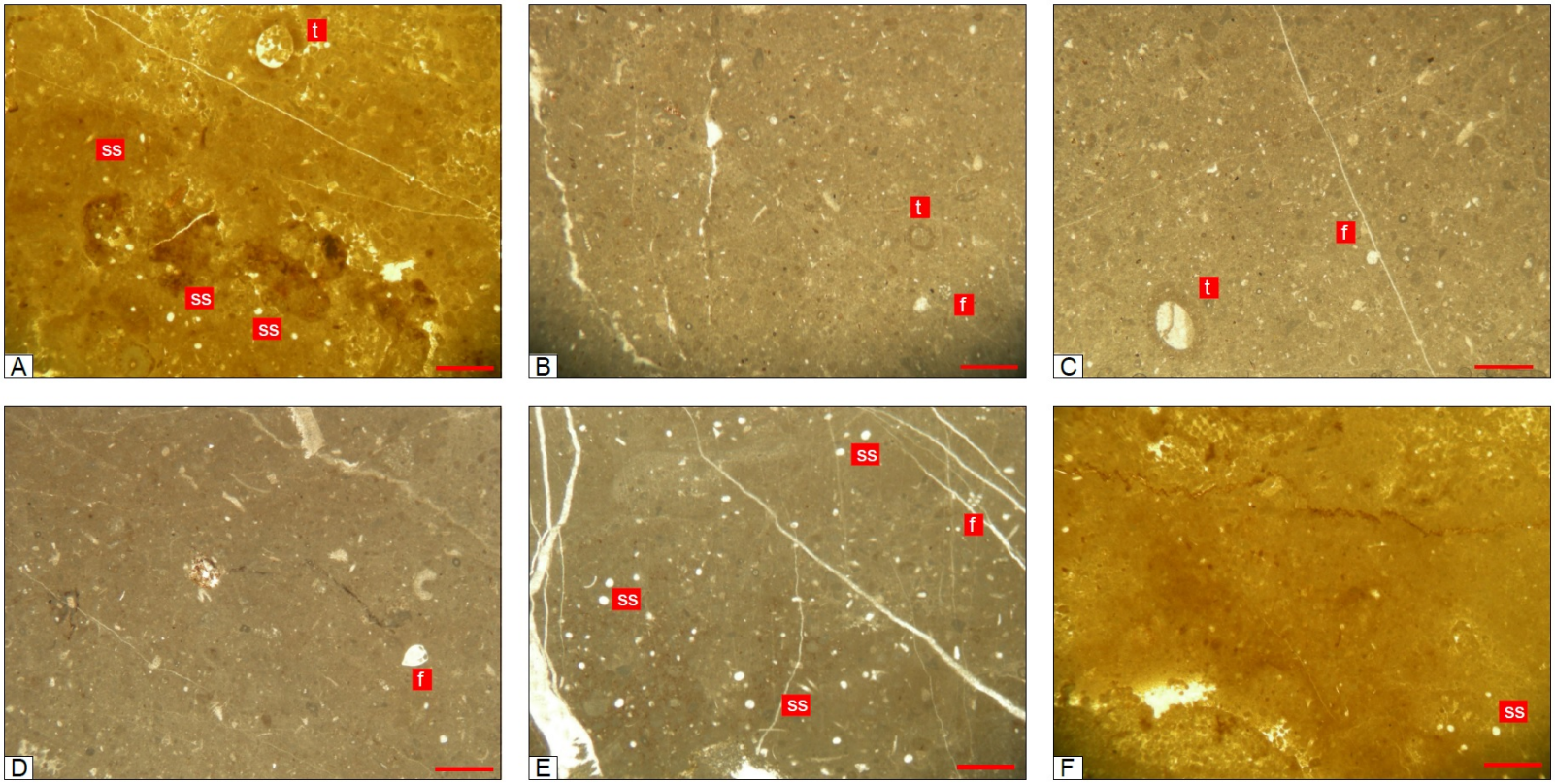


Figure 22 Photomicrographs of the pelagic mudstone to wackestone (MF 9). A. MK-61, Pelagic mudstone-wackestone, ss: Sponge spicules, t: *Terebella*, scale bar: 1 mm, B. MK-19, Pelagic wackestone, f: Foraminifera, t: *Terebella*, scale bar: 1 mm, C. MK-19, Pelagic wackestone, f: Foraminifera, t: *Terebella*, scale bar: 1 mm, D. MK-45, Pelagic wackestone, f: Foraminifera, scale bar: 1 mm, E. MK-60, Pelagic wackestone, ss: Sponge spicules, f: Foraminifera, scale bar: 1 mm, F. MK-61, Pelagic mudstone-wackestone, ss: Sponge spicules, scale bar: 1 mm

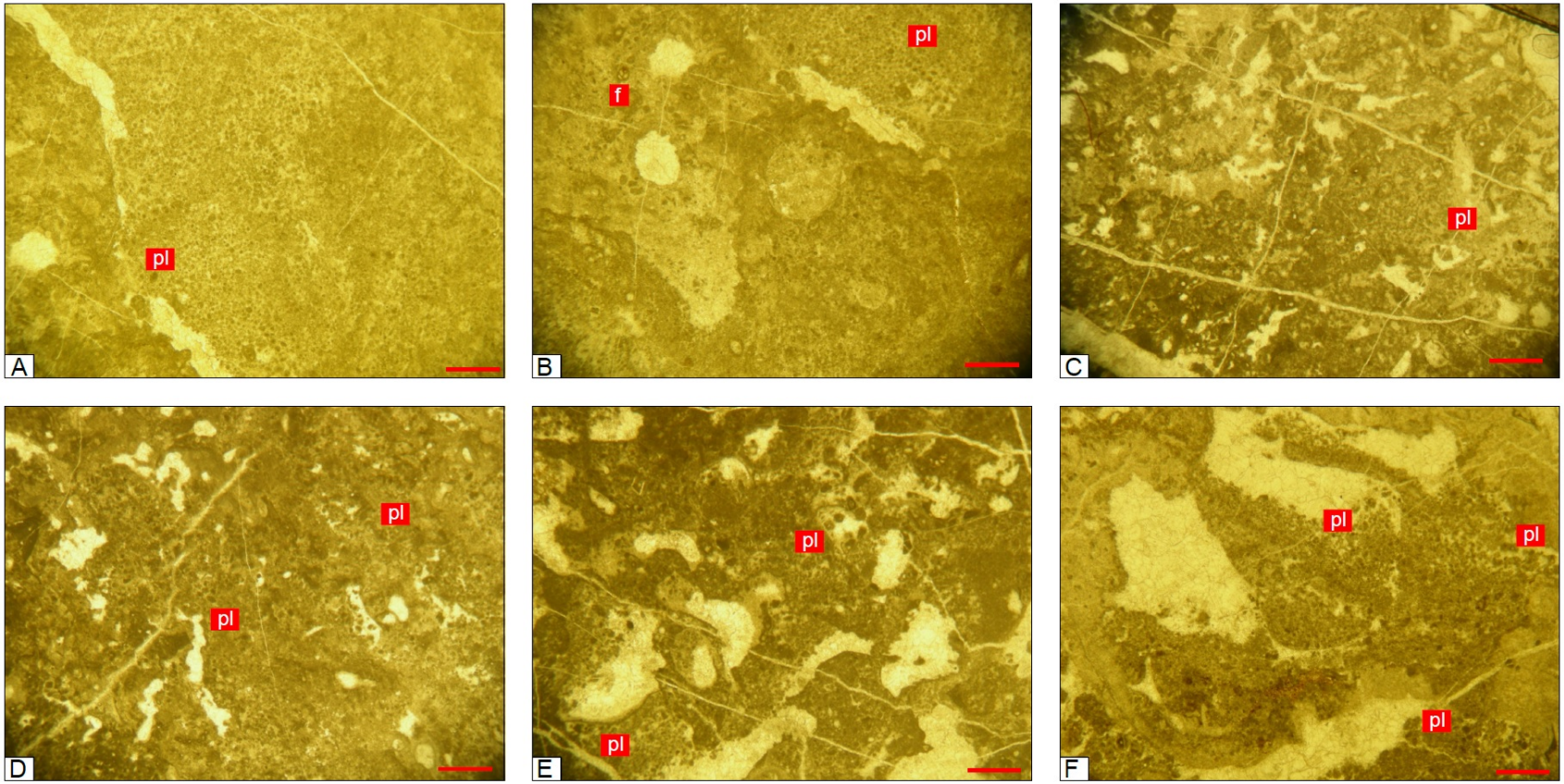


Figure 23 Photomicrographs of the peloidal microbialites (MF 10). A. MK-9B, pl: Peloids, scale bar: 1 mm, B. MK-9B, pl: Peloids, f: Foraminifera, scale bar: 1 mm, C. MK-17, pl: Peloids, scale bar: 1 mm, D. MK-50, pl: Peloids, scale bar: 1 mm, E. MK-50, pl: Peloids, scale bar: 1 mm, F. MK-52, pl: Peloids, scale bar: 1 mm

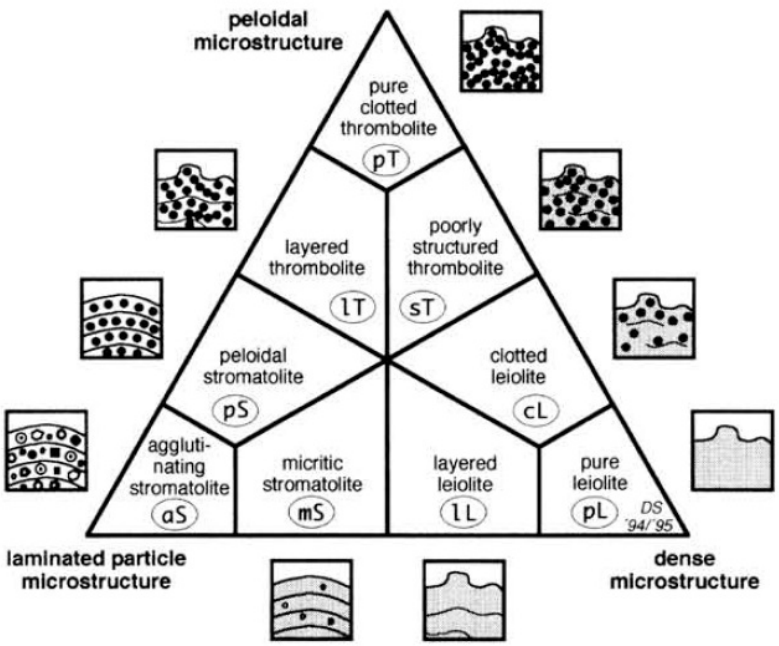


Figure 24 Classification of Mesozoic microbialites (Schmid, 1996)

3.3 Back-reef facies

3.3.1 MF 11, Bioclastic wackestone-packstone

This microfacies type includes mainly bioclasts as allochems and micrite as the dominant background material with rare, partly occured sparry calcite cement. Observed bioclasts are benthic foraminifera, *Bacinella*-type structures, *Lithocodium* and coral fragments (Figure 25D, E). SMF 10 of Flügel (2004) is the most similar microfacies to MF 11 considering its depositional setting and composition.

3.3.2 MF 12, Bioclastic peloidal packstone – grainstone

MF12 consists of abundant peloids, bioclasts, oolites and sparry calcitic cement (if the texture is dominantly grainstone) or micritic matrix (if the texture is dominantly packstone) as background material (Figure 25A, B and C). Observed bioclasts are benthic foraminifera, *Crescentiella* and other fossil fragments which are not easy to define. For some textures, it is obvious that the peloids are microbial in origin due to the layered (laminated) microstructure. However for some other textures, peloids are scattered on the background material with other allochems and do not represent a recognizable microstructure.

3.3.3 MF 13, Intraclastic packstone

Intraclastic packstone microfacies (MF 13) is characterized by the abundant occurrence of micritic intraclasts instead of bioclasts. Rarely occurred bioclasts are benthic foraminifera. The dominant background material is micrite. Intense fracturing and filling of those fractures with sparry calcite have been observed (Figure 25F).

3.4 Lagoonal facies

3.4.1 MF 14, Bioclastic packstone

This microfacies (MF 14) represents the typical association of lagoonal/inner platform organisms (complex structured larger benthic forams, dasycladacean algae, inner platform sponges – stromatoporoids) in a micritic matrix (Figure 26A, B, C and D). Allochems are mainly bioclasts. *Kastamonina*, *Anchispirocyclina*, *Coscinophragma* and *Pseudocyclammina* are the observed larger benthic forams with complex inner and wall structure. In addition to the appearance of *Mohlerina* in distal platform facies, its presence in the lagoonal setting has also been observed in MF 14. Similar patchy distribution of *Mohlerina* was also mentioned in the Swiss Jura by Védrine (2008). Bryozoa, *Lithocodium* and bacinnellid fabric, echinoderm fragments are the other fossil organisms observed. Bioclastic packstones of SMF 18 of Flügel (2004) is the most similar microfacies to MF 14 when considering the occurrence of benthic foraminifera and algae. Packstones in the microfacies group LC-LA of Carras & Georgala (1998) have similar lagoonal characterisitcs with MF 14.

3.4.2 MF 15, Bioclastic wackestone

This microfacies (MF 15) differs from MF 14 in having fewer amounts of bioclasts. Due to this reduction in the bioclast amount MF 15 considered as a separate microfacies and defined as bioclastic wackestone. Similar to MF 14, allochems are mainly bioclasts in a micritic matrix (Figure 26E, F). Fossil content of MF 15 is similar to that of MF 14. Thus, the same interpretation for the depositional setting can be made. This microfacies is similar to SMF 9 (bioclastic wackestone) of Wilson

(1975) which represents a depositon in the shelf lagoon environment. Inner platform facies of Schlagintweit & Ebli (1999) and Subtidal/lagoonal facies of Turi *et al*. (2011) are the similar facies examples to MF 15.

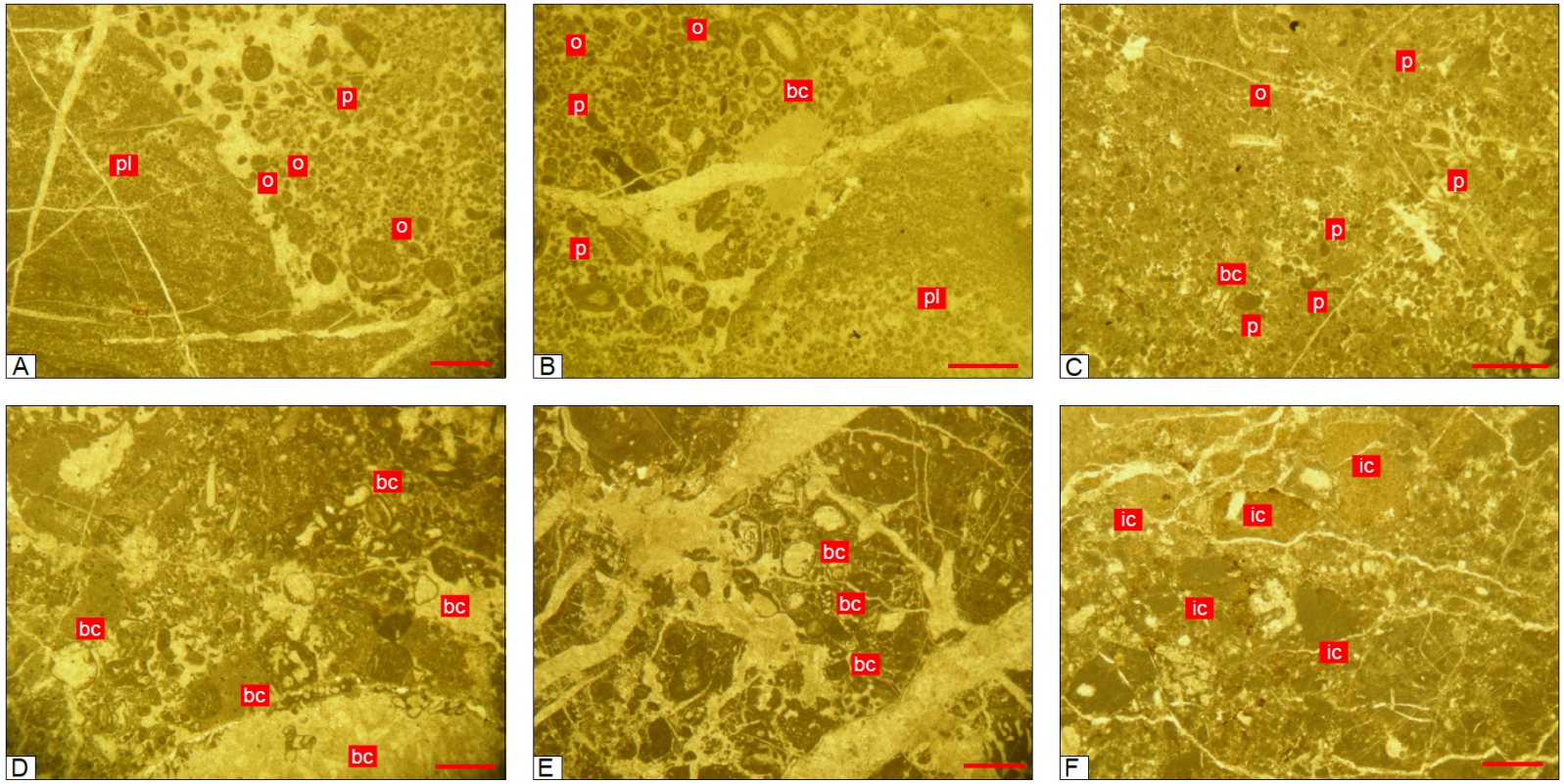


Figure 25 Photomicrographs of the back reef facies. A. MK-81, bioclastic peloidal packstone to grainstone, bc: Bioclast, pl: Peloidal microbialite, o: Oolites, p:Peloids, scale bar: 1 mm, B. MK-81, bioclastic peloidal packstone to grainstone, bc: Bioclast, pl: Peloidal microbialite, o: Oolites, p: Peloids, scale bar: 1 mm, C. MK-83, bioclastic peloidal packstone, bc: Bioclast, o: Oolites, p: Peloids, scale bar: 1 mm, D. MK-72, bioclastic packstone, bc: Bioclast, scale bar: 1 mm, E. MK-82, bioclastic packstone, bc: Bioclast, scale bar: 1 mm, F. MK-71, intraclastic packstone, ic: Bioclast, scale bar: 1 mm

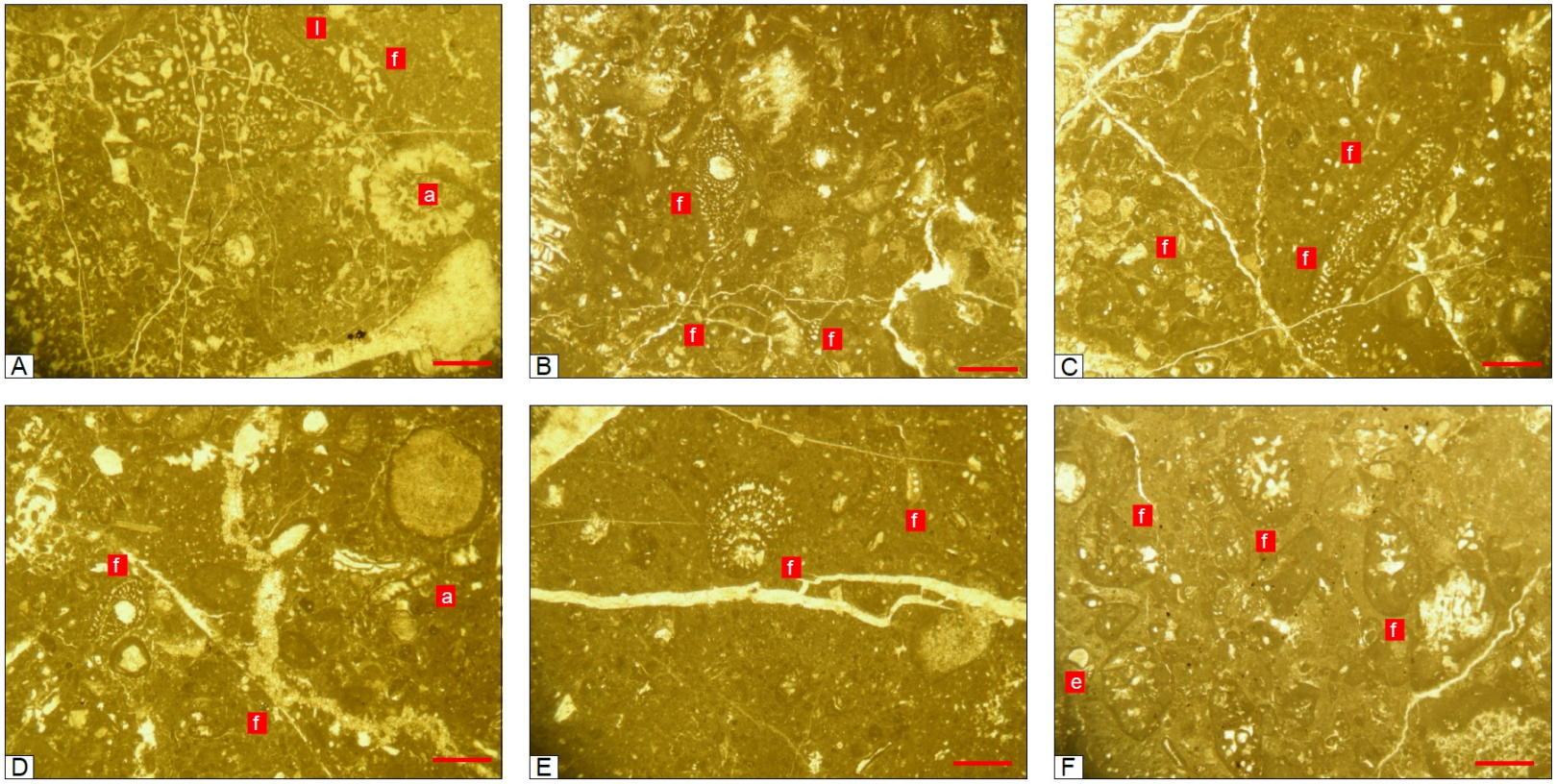


Figure 26 Photomicrographs of the lagoonal facies. A. MK-74, bioclastic packstone, f: Foraminifera, l: *Lithocodium*, a: Algae, scale bar: 1 mm, B. MK-79, bioclastic packstone, f: Foraminifera, scale bar: 1 mm, C. MK-79, bioclastic packstone, f: Foraminifera, scale bar: 1 mm, D. MK-80, bioclastic packstone, f: Foraminifera, a: Algae fragment, scale bar: 1 mm, E. MK-77, bioclastic wackestone, f: Foraminifera, scale bar: 1 mm, F. MK-76, bioclastic wackestone to packstone, f: Foraminifera, e: Echionid spine, scale bar: 1 mm

CHAPTER 4

MICROPALEONTOLOGY

A systematic micropaleontological study has been carried out on the benthic foraminifera and the microencrusters by analyzing the unoriented thin sections of systematically collected samples along the measured section. After the identification of the observed forms, representative ones were photographed and fossil plates were prepared.

The classification of the benthic foraminifera is mainly based on the taxonomic parameters such as wall structure, wall composition, manner of coiling, shape and arrangement of chambers, number of chambers, peripheral shape and position and shape of septa. For the suprageneric and generic classifications of foraminifera Loeblich and Tappan (1988) was the main reference material. In addition, recent literature (Krajewski and Olszewska, 2007; Ivanova and Kolodziej, 2010; Bucur *et al*., 1996) and online Ellis and Messina (1941-2004) catalogues for foraminifera were also used for the subgeneric classification of the Late Jurassic – Early Cretaceous benthic foraminifera.

Microencrsuters are understood in a broad sense in this thesis. Encrusting micro-organisms may include microbes (bacteria), algae, foraminifera and other metazoans such as annelids and sponges. For the taxonomic classification of the microencrusters, which are generally problematic in systematic position, Leinfelder *et al*. (1993a), Shiraishi and Kano (2004), Schmid (1996) were used. Taxonomic parameters for their identification may vary according to the different types of microencrusters. These parameters will be discussed during the explanation of these different microencruster types.

It should be reminded that this chapter includes only the short descriptions of the examined forms not the detailed explanations or the complete synonym lists.

Synonym lists were prepared by considering the recent and accessible literature. The given descriptions and remarks in this chapter reflect the author's observations on the identification criteria of the observed forms and also present some previous ideas and comparisons with similar forms from the literature.

ORDER FORAMINIFERIDA EICHWALD, 1830

SUBORDER TEXTULARIINA DELAGE & HEROUARD, 1896

SUPERFAMILY HORMOSINACEA HAECKEL 1894

FAMILY TELAMMINIDAE LOEBLICH & TAPPAN 1985

Genus *Troglotella* Wernli & Fookes, 1992

Type species: *Troglotella incrustans* Wernli & Fookes, 1992

Troglotella incrustans Wernli & Fookes, 1992

Pl. 1, Fig. 1-7

Selected synonymy [for further synonymy before 1996 see Schmid (1996)]

1992. *Troglotella incrustans* nov. gen., nov. sp.; Wernli & Fookes, p. 91, pl. 1-2

1996. *Troglotella incrustans* Wernli & Fookes; Schmid, p. 171, figs. 81-83

1999. *Troglotella incrustans* Wernli & Fookes; Schlagintweit and Ebli, p. 404, pl. 3, fig. 4; pl. 6, fig.7, 9, 10

2007. *Troglotella incrustans* Wernli & Fookes; Krajewski and Olszewska, p. 296, fig4b

2010. *Troglotella incrustans* Wernli & Fookes; Krajewski, p. 126, fig. 4.33/C; p. 130, fig. 4.35/A; p. 138, fig. 4.39/D; p. 142, fig. 4.41/D; p. 170, fig. 4.52/C; p. 180, fig. 4.57/D; p. 236, fig. 4.67/A

Description:

Early descriptions (Schlagintweit *et al*., 2005b) distinguish two different parts: an early part with uniserially arranged chambers and a later variously branching parts. In our specimens only the earlier part can be seen. The missing branching part in juvenile specimens is also mentioned in Schlagintweit (2012a). Early parts of our specimens show typical uniserial chambers of variable shape (i.e. rectangular, circular) in longitudinal sections. Rectangular chambers are connected by means of short neck-like extensions or tubes. Wall is finely agglutinated.

Dimensions:

Length: 608 – 898 μ

Chamber diameter: 98 – 223 μ

Wall thickness: 18-23 μ

Remarks:

The association of *Troglotella incrustans* with *Lithocodium aggregatum* was described in details by Schmid & Leinfelder (1996). They interpreted this association as a consortium of two foraminifera. Inside the empty sparite-filled chambers of *Lithocodium*, *Troglotella* dwells cryptobiotically according to their interpretation. Recently, Schlagintweit (2010) interpreted *Lithocodium* as a boring sponge and put a different type of association between *Lithocodium* and *Troglotella*.

Stratigraphic range:

The stratigraphic range of *Troglotella incrustans* is Middle Oxfordian to Early Cenomanian (Schlagintweit, 2012). In the studied section this form ranges from Kimmeridgian to Berriasian.

SUBORDER SPIROPLECTAMMININA MIKHALEVICH, 1992

SUPERFAMILY SPIROPLECTAMMINACEA CUSHMAN, 1927

FAMILY TEXTULARIOPSIDAE LOEBLICH & TAPPAN 1982

Genus *Aaptotoichus* Loeblich & Tappan, 1982

Type species: *Aaptotoichus clavellata* Loeblich and Tappan, 1946

Aaptotoichus challengeri Holbourn & Kaminski, 1995 ?

Pl. 1, Fig. 8

1995. *Aaptotoichus challengeri* Holbourn & Kaminski n. sp.; Holbourn & Kaminski, p. 444, pl. VII, figs. 1-6

2007. *Aaptotoichus challengeri* Holbourn & Kaminski; Krajewski & Olszewska, p. 296, fig 4C

Description:

Longitudinal section shows an early biserial stage with inflated chambers followed by a later uniserial portion of broad low chambers divided by horizontal sutures. Wall is finely agglutinated.

Dimensions:

Height: 469 μ

Wall thickness: 21 μ

Remarks:

The difference of *Aaptotoichus* from *Bigenerina* is its smaller size and its solid noncanaliculate wall. Also it differs from both *Bigenerina* and *Haimasiella* in possessing a wall of organic material with siliceous particles.

Aaptotoichus challengeri differs from the type species *Aaptotoichus clavellatus* in having fewer number of uniserial chambers separated by (horizontal or) slightly oblique sutures, and in its short neck. According to Holbourn & Kaminski (1995) *A.*

challenger may be considered as the intermediate form between the Upper Jurassic *"Bigenerina" jurassica* and the Aptian spcies *Aaptotichus pitmani*.

Stratigraphic range:

The stratigraphic range of *Aaptotoichus challengeri* is Tithonian – Barremian (Krajewski & Olszewska, 2007). In the studied section *Aaptotoichus challengeri* ? has been recognized in the Tithonian.

Aaptotoichus ? sp.

Pl. 1, Fig. 9

Description & Remarks:

Early biserial stage with globular chambers is followed by a later uniserial portion of broad low chambers divided by oblique sutures. Due to the presence of oblique sutures this form is defined here with a question mark. Wall is finely agglutinated.

Dimensions:

Height: 426 µ

Wall thickness: 14 µ

Stratigraphic range:

Aaptotoichus ? sp. has been recovered from the Kimmeridigian.

SUBORDER SPIROPLECTAMMININA MIKHALEVICH, 1992

SUPERFAMILY SPIROPLECTAMMINACEA CUSHMAN, 1927

FAMILY TEXTULARIOPSIDAE LOEBLICH & TAPPAN 1982

Genus *Haghimashella* Neagu & Neagu, 1995

Type species: *Haghimashella arcuata* Haeusler, 1890

Haghimashella arcuata Haeusler, 1890 ?

Pl. 1, Figs. 10-14

1890. Bigenerina arcuata Haeusler n. sp.; p.73, pl. 12, figs. 5-7

1995. *Haghimashella arcuata* Haeusler; Neagu and Neagu, p. 221, pl. 2, figs. 1-11

2007. *Haghimashella arcuata* Haeusler; Krajewski & Olszewska, p. 296, fig. 4D

2010. *Haghimashella arcuata* Haeusler; Ivanova & Kolodziej, p.23, pl. 1, fig. 17

Description:

Early biserial stage is followed by a later variously inclined uniserial adult part with globular chambers divided by deep oblique sutures. Wall is finely agglutinated.

Dimensions:

Height: 252-432 μ

Wall thickness: 14-23 μ

Remarks:

Haghimashella differs from *Bigenerina* by its compact non-canaliculate wall structure whereas by its smooth wall and the aspect of the adult uniserial chambers it differs from *Aaptotoichus*.

Stratigraphic range:

The stratigraphic range of *Haghimashella arcuata* is Middle Oxfordian-Berriasian (Krajewski & Olszewska, 2007). In the studied section *Haghimashella arcuata* ? has been recorded in the Kimmerdigian and Berriasian.

SUBORDER TEXTULARIINA DELAGE & HEROUARD, 1896

SUPERFAMILY TEXTULARIACEA EHRENBERG, 1838

FAMILY TEXTULARIIDAE EHRENBERG, 1838

SUBFAMILY TEXTULARIINAE EHRENBERG, 1838

Genus *Textularia* Defrance, 1824

Type species: *Textularia sagittula* Defrance, 1824

Textularia spp.

Pl. 1, Figs. 15-20

Description & Remarks:

Specimens that cannot be assigned to a particular species of the genus *Textularia* were grouped as *Textularia* spp. The biserial arrangement of the chambers shows the affiliation of these forms to the genus *Textularia*. Wall is finely agglutinated.

Dimensions:

Height: 165-488 µ

Wall thickness: 7-32 µ

Stratigraphic range:

In the studied section *Textlaria* spp. speciemens have been recovered in the Kimmerdigian and Berriasian.

SUBORDER LOFTUSIINA KAMINSKI & MIKHALEVICH, 2004

FAMILY MESOENDOTHYRAIDAE VOLOSHINOVA, 1958

Genus *Mesoendothyra* Dain, 1958

Type species: *Mesoendothyra izjumiana* Dain, 1958

Mesoendothyra izjumiana Dain, 1958

Pl. 1, Figs. 21, 22

1958. *Mesoendothyra izjumiana* n. sp.; Dain, In: Bykova *et al*., p. 20-21, pl. 4, figs.7-9

1991. *Mesoendothyra izjumiana* Dain; Altıner, p. 189, pl. 4, figs. 1-3

2010. *Mesoendothyra izjumiana* Dain; Olszewska, p. 22, pl. IV, figs. 4-5

Description:

Test is coiled streptospirally in the early stage, later it becomes asymmetrically planispiral. Wall is microgranular composed of agglutinated carbonate grains.

Dimensions:

Height: 170-297 μ

Wall thickness: 16-40 μ

Remarks:

Mesoendothyra izjumiana do not possess an uncoiled stage as observed in *Mesoendothyra croatica*, another species of the genus *Mesoendothyra*.

Stratigraphic range:

Stratigraphic range of *Mesoendothyra izjumiana* is from Late Oxfordian to Kimmeridigian (Olszewska, 2010). Our specimens have been recovered from the Kimmeridgian.

SUBORDER TEXTULARIINA DELAGE & HEROUARD, 1896

FAMILY PLACOPSILINIDAE RUMBLER, 1913

Genus *Subbdelloidina* Frentzen, 1944

Type species: *Subbdelloidina haeusleri* Frentzen, 1944

Subbdelloidina luterbachi Riegraf, 1987

Pl. 1, Figs. 23, 24

1987. *Subbdelloidina luterbachi* Riegraf n. sp.; Riegraf, p. 32, figs. 1-16, 20-59

2006b. *Subbdelloidina luterbachi* Riegraf; Schlagintweit & Gawlick, p. 58, text-fig, 5, pl. 1, figs.1-13

Description:

Irregularly-shaped test is attached to a hard substrate. The chambers are numerous, sutures are straight or oblique. The initial chambers are more rounded to subglobular, becoming more and more depressed in the later stages. Linear or pseudo-multiserial chamber arrangement is observed, so that the species seems to be branched. Wall is finely agglutinated with calcerous material.

Dimensions:

Height: 1360-1774 μ

Wall thickness: 73-100 μ

Remarks:

The wall composition of the *Subbdelloidina luterbachi* is dependent on the availability of the test building material (e.g. sponge spicules or rhaxes, quartz grains or micritic material). In our specimens wall is homogeneous and micritic. The most

similar genus to *Subbdelloidina* is *Placopsilina* due to the similar attached way of life, wall structure, aperture and rectilinear main test arrangement. The main distinction is the early planispirally enrolled stage of *Placopsilina*.

Stratigraphic range:

Stratigraphic range of *Subbdelloidina luterbachi* is given as Late Jurassic (Oxfordian) to Late Aptian by Sclagintweit & Gawlick (2006b). The present specimens have been recovered from the Kimmeridgian.

SUBORDER LITUOLINA LANKESTER, 1885

SUPERFAMILY LITUOLACEA DE BLAINVILLE, 1827

FAMILY LITUOLIDAE DE BLAINVILLE, 1827

SUBFAMILY AMMOMARGINULINAE PODOBINA, 1978

Genus *Ammobaculites* Cushman, 1910

Type species: *Spirolina agglutinans* d'Orbigny, 1846

Ammobaculites spp.

Pl. 2, Figs. 1-8

Description & Remarks:

Specimens that cannot be assigned to a particular species of the genus *Ammobaculites* were grouped as *Ammobaculites* spp. Early close coiling and later uncoling, rectilinear growth and coarsely agglutinated wall are the common features of the observed sepeciemens. Tests of the specimens seem rounded in section. Aperture is simple terminal.

Dimensions:

Height: 253-1562 μ

Wall thickness: 19-120 μ

Chamber width: 72 – 342 μ

Stratigraphic range:

Stratigraphic range of *Ammobaculites* is given as late Mississippian to Holocene by Loeblich & Tappan (1988). *Ammobaculites* spp. have been recovered from the Kimmeridgian – Berriasian interval in this study.

SUBORDER SPIRILLININA HOHENEGGER & PILLER, 1975

FAMILY SPIRILLINIDAE REUSS & FRITSCH, 1861

Genus *Spirillina* Ehrenberg, 1843

Type species: *Spirillina vivipara* Ehrenberg, 1843

Spirillina spp.

Pl. 2, Figs. 9-14

Description & Remarks:

Specimens that cannot be assigned to a particular species of the genus *Spirillina* were grouped as *Spirillina* spp. Test is discoidal. Globular proloculus is followed by a gradually enlarging enrolled, undivided tubular second chamber. Generally there exist 4-8 whorls in a complete specimen. The whorls are closely appressed causing each whorl to lie against the periphery of the preceding whorl. The earlist few whorls may be in a low trochospiral stage, later ones are planispiral. The wall composition is calcareous hyaline. *Spirillina* specimens identified in this study were observed in the pelagic/outer shelf material.

Dimensions:

Test diameter: 133-397 μ

Wall thickness: 9.0 – 9.8 μ

Stratigraphic range:

Stratigraphic range of *Spirillina* is given as Late Triassic to Holocene by Loeblich & Tappan (1988). *Spirillina* spp. have been recovered from the Kimmeridgian – Tithonian interval in this study.

SUBORDER TEXTULARIINA DELAGE & HEROUARD, 1896

FAMILY HORMOSINIDAE HAECKEL, 1894

SUBFAMILY REOPHACINAE CUSHMAN, 1910

Genus *Reophax* de Montfort, 1808

Type species: *Reophax scorpiurus* de Monfort, 1808

Reophax spp.

Pl. 2, Figs. 15-24

Description & Remarks:

Test is elongate with few rounded to pyriform chambers in slightly irregular series. Each succeeding chamber is attached near the base of the apertural neck of the preceding chamber. Depending on the section orientiation apertural neck may not be seen on the observed sepecimens. Wall is thin and agglutinated. Thin agglutinated wall and the early coiled stage of *Ammobaculites* are the main differences for the differentiation of this genus from *Ammobaculites*.

Dimensions:

Length: 182-701 μ

Wall thickness: 9 – 34 μ

Stratigraphic range:

Stratigraphic range of *Reophax* is given as Middle Ordovician to Holocene by Loeblich & Tappan (1988). *Reophax* spp. have been recovered from the Kimmeridgian – Berriasian interval in this study.

SUBORDER MILIOLINA DELAGE & HEROUARD, 1896

FAMILY CORNUSPIRIDAE SCHULTZE, 1854

SUBFAMILY CORNUSPIRINAE SCHULTZE, 1854

Genus *Cornuspira* Schultze, 1854

Type species: *Orbis foliaceus* Philippi, 1844

Cornuspira sp.

Pl. 2, Figs. 25

Description & Remarks:

Test is discoidal with globular proloculus followed by undivided planispirally enrolled, evolute tubular second chamber. Wall is calcareous, porcelaneous. Aperture is at the open end of the tube.

Dimensions:

Test diameter: 179 μ

Wall thickness: 9 μ

Proloculus diameter: 58 μ

Stratigraphic range:

Stratigraphic range of *Cornuspira* is given as Carboniferous to Holocene by Loeblich & Tappan (1988). *Cornuspira* sp. has been recovered from the Kimmeridgian – Berriasian interval in this study.

SUBORDER LAGENINA DELAGE & HEROUARD, 1896

SUPERFAMILY NODOSARICEA EHRENBERG, 1838

FAMILY VAGINULINIDAE REUSS, 1860

SUBFAMILY LENTICULININAE CHAPMAN, PARR & COLLINS, 1934

Genus *Lenticulina* Lamarck, 1804

Type species: *Lenticulites rotulatus* Lamarck, 1804

Lenticulina sp.

Pl. 2, Figs. 26-27

Description & Remarks:

Test is planispirally enrolled. Periphery is carinate. Chambers are relatively broad and low increasing slowly in size as added. Wall is calcareous, hyaline. *Lenticulina* specimens identified in this study were observed in the pelagic/outer shelf material.

Dimensions:

Max.test width: 305 - 318 µ

Stratigraphic range:

Stratigraphic range of *Lenticulina* is given as Triassic to Holocene by Loeblich & Tappan (1988). *Lenticulina* sp. has been recovered from the Kimmeridgian – Tithonian interval in this study.

SUBORDER FUSULININA WEDEIND, 1937

SUPERFAMILY EARLANDIACEA CUMMINGS, 1955

FAMILY EARLANDIIDAE CUMMINGS, 1955

Genus *Earlandia* Plummer, 1930

Type species: *Earlandia pervarva* Plummer, 1930

Earlandia sp.

Pl. 2, Figs. 28

Description & Remarks:

Test is elongate with globular proluculus followed by long, straight, undivided tubular chamber. Wall is calcareous microgranular. Aperture is simple and at the end of the tube.

Dimensions:

Height: 1303 μ

Diameter of the proloculus: 101 μ

Stratigraphic range:

Earlandia sp. has been recovered from the Kimmeridgian – Tithonian interval in this study.

SUBORDER TEXTULARIINA DELAGE & HEROUARD, 1896

SUPERFAMILY ATAXOPHRAGMIACEA SCHWAGER, 1877

FAMILY DOROTHIIDAE BALAKHMATOVA, 1972

SUBFAMILY DOROTHIINAE BALAKHMATOVA, 1972

Genus *Protomarssonella* Desai & Banner, 1987

Type species: *Dorothia hechti* Dieni & Massari, 1966

Protomarssonella ? sp.

Pl. 2, Figs. 29

Description & Remarks:

Test is conical with straight sides. Test is circular in section with tiny early trochospiral stage followed by a biserial stage of increasing diameter of chambers. This genus differs from *Marssonella* with its non-canaliculate agglutinated wall.

Dimensions:

Height: 385 µ

Wall thickness: 30 µ

Stratigraphic range:

Stratigraphic range of *Protomarssonella* is given as Late Jurassic – Early Cretaceous by Desai & Banner (1987). It is defined in the Berriasian in this study.

SUBORDER VERNEUILININA MIKHALEVICH & KAMINSKI 2004

SUPERFAMILY VERNEUILINACEA CUSHMAN, 1911

FAMILY PROLOXOPLECTIDAE LOEBLICH & TAPPAN, 1985

Genus *Rectoprotomarssonella* Kaminski, Bubík & Cetean, 2007

Type species: *Marssonella rugosa* Hanzlíková, 1953

Rectoprotomarssonella ? sp.

Pl. 2, Figs. 30

Description & Remarks:

Test is large and tapering towards the base with a flattened terminal face. Early stage trochospirally coiled, later triserial, biserial and finally uniserial. Wall is agglutinated, non-canaliculate.

The difference of this genus from *Protomarssonella* is the uniserial part of it which is missing in *Protomarssonella*. Here in this study this genus is defined with a question mark because its stratigraphic range was given as Campanian-Maastrichtian by Kaminski *et al*. (2007) wehereas we find it from the Kimmeridgian-Tithonian interval.

Dimensions:

Height: 260 µ

Wall thickness: 18 µ

Stratigraphic range:

Stratigraphic range of *Rectoprotomarssonella* is given as Campanian-Maastrichtian by Kaminski *et al*. (2007). This form has been found in the Kimmeridgian-Tithonian interval in this study.

SUBORDER MILIOLINA DELAGE & HEROUARD, 1896

SUPERFAMILY MILIOLACEA EHRENBERG, 1839

FAMILY NAUTILOCULINIDAE LOEBLICH & TAPPAN, 1985

Genus *Nautiloculina* Mohler, 1938

Type species: *Nautiloculina oolithica* Mohler, 1938

Nautiloculina bronnimanni, Arnaud Vanneau & Peybernès, 1978

Pl. 3, Figs. 4 – 5

1978. *Nautiloculina bronnimanni* n. sp.; Arnaud Vanneau & Peybernès, p. 70, pl. 1, figs. 6-8; pl. 2, figs. 4-11

1991. *Nautiloculina bronnimanni* Arnaud Vanneau & Peybernès; Altıner, p. 195, pl. 7, figs. 15, 16

1996. *Nautiloculina bronnimanni* Arnaud Vanneau & Peybernès; Bucur *et al*., p. 67, pl. 1, fig. 11

2004. *Nautiloculina bronnimanni* Arnaud Vanneau & Peybernès; Ivanova & Kolodziej, p. 71, text-fig. 1D

2005. *Nautiloculina bronnimanni* Arnaud Vanneau & Peybernès; Krobicki & Olszewska, p. 222, text-fig. 4A

2007. *Nautiloculina bronnimanni* Arnaud Vanneau & Peybernès; Krajewski & Olszewska, p. 296, text-fig, 4H

2010. *Nautiloculina bronnimanni* Arnaud Vanneau & Peybernès; Ivanova & Kolodziej, p. 25, pl. 2, figs. 2-4

2011. *Nautiloculina bronnimanni* Arnaud Vanneau & Peybernès; Catincut *et al*., p. 86, pl. IV, fig. 9

Description:

Axial sections show an acute periphery with quadrangular chambers which display a characteristic shape in the last whorl. Sutures are depressed. This species differs from *Nautiloculina cretacea* by its smaller size.

Dimensions:

Height: 345 - 490 µ

Max. test diameter: 197 – 292 µ

Remarks:

Nautiloculina has been assigned differently in the previous systematics. Mohler (1938) described it originally as calcareous and imperforate and he compared it to porcelaneous *Planispirina*. Loeblich & Tappan (1964) placed this genus into the miliolines. Later in 1985 Loeblich & Tappan reallocated *Nautiloculina* into the lituolids. Presently *Nautiloculina* has been placed systematically in the Miliolidae (BouDagher-Fadel, 2008).

Stratigraphic range:

Stratigraphic range of *Nautiloculina bronnimanni* is given as Late Tithonian to Late Albian by Ivanova & Kolodziej (2010). This form has been recovered from the Upper Tithonian – Berriasian interval in this study.

Nautiloculina spp.

Pl. 3, Figs. 1-3, 6-7

Description:

Specimens that cannot be assigned to a particular species of the genus *Nautiloculina* were grouped as *Nautiloculina* spp. Test is lenticular, biumbonate, nautiliform with globular proloculus followed by chambers increasing slowly in size per whorl. Test is enrolled planispirally and it is involute. Wall is calcareous porcelaneous.

Dimensions:

Height: 315 - 665 µ

Diameter of the proloculus: 34 – 85 µ

Max. test diameter: 203 – 366 µ

Remarks:

See remarks of *Nautiloculina bronnimanni.*

Stratigraphic range:

Stratigraphic range of *Nautiloculina* is given as Late Jurassic to Early Cretaceous by Loeblich & Tappan (1988). Undefined species of *Nautiloculina* are recovered from the Kimmeridigan – Berriasian interval in this study.

SUBORDER TEXTULARIINA DELAGE & HEROUARD, 1896

SUPERFAMILY VERNEUILINACEA CUSHMAN, 1911

FAMILY VERNEUILINIDAE CUSHMAN, 1911

SUBFAMILY VERNEUILININAE SULEYMANOV, 1973

Genus *Verneuilinoides* Loeblich & Tappan, 1949

Type species: *Verneuilinoides schizea* Cushman & Alexander, 1930

Verneuilinoides ? sp.

Pl. 3, Figs. 8 – 9

Description:

Test is rounded to lobulated in section, chambers are subglobular. Test is triserial throughout. Wall is finely agglutinated. Sutures are oblique and distinct. Aperture is interiomarginal.

Dimensions:

Height: 156 µ

Wall thickness: 9 – 11 μ

Remarks:

In transverse section it can be seen obviously that test is triserial and aperture is interiomarginal. In longitudinal section it is not clear to say that the test is triserial.

Stratigraphic range:

Stratigraphic range of *Verneuilinoides* is given as Jurassic to Cretaceous by Loeblich & Tappan (1988). *Verneuilinoides* ? sp. is recovered from the Kimmeridigan aged material in this study.

SUBORDER MILIOLINA DELAGE & HEROUARD, 1896

SUPERFAMILY MILIOLACEA EHRENBERG, 1839

FAMILY HAUERINIDAE SCHWAGER, 1876

SUBFAMILY HAUERININAE, SCHWAGER, 1876

Genus *Istriloculina* Neagu, 1984

Type species: *Pyrgo elliptica* Yovcheva, 1962

Istriloculina emiliae Neagu, 1984 ?

Pl. 3, Fig. 10

1984. *Istriloculina emiliae* n. sp.; Neagu, p. 88, pl. 2, figs. 22-25

2008. *Istriloculina emiliae* Neagu; Ivanova *et al*., p. 72, text-fig. 7K

2010. *Istriloculina emiliae* Neagu; Ivanova & Kolodziej, p. 25, pl. II, figs. 24-26

Description:

Test of *Istriloculina emiliae* ? is globular, ovate to subglobular with probably three chambers on each whorl. Wall is thin, calcareous imperforate and porcelaneous. Aperture is indistinct.

Remarks:

Due to the absence of transversal sections and the identification based on rare occurrence of the form, it has been defined with a question mark.

Stratigraphic range:

Stratigraphic range of *Istriloculina emiliae* is given as Tithonian to Barremian by Ivanova & Kolodziej (2010). *Istriloculina emiliae* ? is recovered from the Early Berriasian in this study.

Istriloculina spp.

Pl. 3, Figs., 11-14

Description & Remarks:

Test is elongate, ovate to subglobular with chambers without floors. Wall is thin, calcareous imperforate and porcelaneous. Aperture is indistinct. Coiling is quinquloculine during the early stage later pseudotriloculine to biloculine.

Stratigraphic range:

Stratigraphic range of *Istriloculina* is Tithonian to Aptian according to the findings in the literature. *Istriloculina* spp. have been recovered from the Berriasian in this study.

SUBORDER MILIOLINA DELAGE & HEROUARD, 1896

SUPERFAMILY CORNUSPIRACEA SCHULTZE, 1854

FAMILY CORNUSPIRIDAE SCHULTZE, 1854

SUBFAMILY MEANDROSPIRINAE, SAIDOVA, 1981

Genus *Meandrospira* Loeblich & Tappan, 1946

Type species: *Meandrospira washitensis* Loeblich & Tappan, 1946

Meandrospira sp.

Pl. 3, Figs. 15-16

Description & Remarks:

Test is small with proluculus followed by spirally coiled tubular undivided second chamber. Undivided second chamber meanders back and forth in involue zigzag bends which enroll planispirally so that the loops bend at the umbilicus. Not all the bends are visible from the exterior, only the bend of the final whorl is visible. Wall is calcareous, imperforate, porcelaneous.

Dimensions:

Test diameter: 107 - 131 μ

Wall thickness: 8 – 10 μ

Stratigraphic range:

Stratigraphic range of *Meandrospira* is given as Late Permian to Holocene by Loeblich & Tappan (1988). *Meandrospira* sp. is recovered from the Upper Kimmeridigan – Tithonian interval in this study.

SUBORDER INVOLUTININA HOHENEGGER & PILLER, 1977

FAMILY VENTROMALINIDAE WEYNSCHENK, 1950

Genus *Protopeneroplis* Weynschenk, 1950

Type species: *Protopeneroplis striata* Weynschenk, 1950

Protopeneroplis striata Weynschenk, 1950

Pl. 3, Figs. 17-22

1950. *Protopeneroplis striata* n. sp.; Weynschenk, p. 13, pl. 2, figs. 12-14

1991. *Protopeneroplis striata* Weynschenk; Altıner, p. 187, pl. 3, figs. 1-7

1996. *Protopeneroplis striata* Weynschenk; Bucur *et al*., p. 73, pl. 3, figs. 8-13

1999. *Protopeneroplis striata* Weynschenk; Schlagintweit & Ebli, p. 399, pl. 6, figs. 3-4

2001. *Protopeneroplis striata* Weynschenk; Săsăran *et al*., p. 51, pl. 9, fig. 5

2007. *Protopeneroplis striata* Weynschenk; Krajewski & Olszewska, p. 306, text-fig. 8D, E

2008. *Protopeneroplis striata* Weynschenk; Ivanova *et al*., p. 71, text-fig. 6J, K

2008. *Protopeneroplis striata* Weynschenk; Taslı *et al*., p. 439, pl. 4, fig. 7

2010. *Protopeneroplis striata* Weynschenk; Olszewska, p. 24, pl. V, fig. 9

2010. *Protopeneroplis striata* Weynschenk; Ivanova & Kolodziej, p. 32, pl. 5, figs. 7, 8

2010. *Protopeneroplis striata* Weynschenk; Bucur *et al*., p. 41, pl. III, fig. 15

Description:

Lenticular test is enrolled in rapidly enlarging and loosely coiled low trochospiral whorls (sometimes planispiral, but not observed in our specimens). Coiling is involute. Calcareous wall consists of two layers; microgranular inner layer and hyaline outer layer. Striations in the outer hyaline wall are characteristic for this species. Septa are generally made of microgranular inner layer while occasionally outer layer may also be observed.

Dimensions:

Max. test diameter: 235 - 359 μ

Remarks:

Its range has been extended to Berriasian by Bucur *et al*. (1993). But later Bucur *et al*. (2004a) mentioned about the uncertainity of the presence of *Protopeneroplis striata* in Berriasian aged material. Although Loeblich & Tappan (1988) have placed *Protopeneroplis* under suborder Involutinina, due to its inner microgranular wall structure some studies consider that it belongs to suborder the Fusulinina (Mekik, 1994; Görgün, 1995).

Stratigraphic range:

Stratigraphic range of *Protopeneroplis striata* is given as Aalenian – Upper Tithonian by Ivanova & Kolodziej (2010). *Protopeneroplis striata* is recovered from the Tithonian in this study.

SUBORDER INVOLUTININA HOHENEGGER & PILLER, 1977

FAMILY VENTROMALINIDAE WEYNSCHENK, 1950

Genus *Protopeneroplis* Weynschenk, 1950

Type species: *Protopeneroplis striata* Weynschenk, 1950

Protopeneroplis ultragranulata Gorbatchik, 1971

Pl. 3, Figs. 23-36

1971. *Hoeglundina* (?) *ultragranulata* n. sp.; Gorbatchik, p. 135, pl. 26, fig. 2

1991. *Protopeneroplis trochoangulata* Weynschenk; Altıner, p. 195, pl. 7, figs. 1-5

1993. *Protopeneroplis ultragranulata* Weynschenk; Bucur, p. 221, pl. 2, figs. 1, 2, 5, 8, 11-12

1996. *Protopeneroplis ultragranulata* Weynschenk; Bucur *et al*., p. 73, pl. 3, figs. 14-17

1999. *Protopeneroplis ultragranulata* Weynschenk; Moshammer & Schlagintweit, p. 561, pl. II, figs. 11, 13-14

2003. *Protopeneroplis ultragranulata* Weynschenk; Uta & Bucur, p. 10, Pl. 1, fig. 1

2005. *Protopeneroplis ultragranulata* Weynschenk; Bucur & Săsăran, p. 38, pl. IV, figs. 10-11

2007. *Protopeneroplis ultragranulata* Weynschenk; Krajewski & Olszewska, p. 304, text-fig. 7C

2008. *Protopeneroplis ultragranulata* Weynschenk; Ivanova *et al*., p. 72, text-fig. 7E, F

2010. *Protopeneroplis ultragranulata* Weynschenk; Ivanova & Kolodziej, p. 32, pl. 5, figs. 1-6

2010. *Protopeneroplis ultragranulata* Weynschenk; Olszewska, p. 24, pl. V, figs. 11-12

Description:

Lenticular test is enrolled in rapidly enlarging and loosely coiled, trochospiral whorls. It possesses a postulated dorsal side but this feature is not always well visible. Calcareous wall is double layered consisting of inner microgranular layer and outer hyaline layer. Generally outer hyaline wall is thicker than the inner microgranular wall. Septa are made up of only the internal microgranular layer.

Dimensions:

Max. test diameter: 326 - 707 μ

Remarks:

The difference of *Protopeneroplis ultragranulata* from *Protopeneroplis striata* is its trochospiral mode of coiling, its postulated dorsal side and the absence of microgranular striations in the hyaline wall. Gorbatchik (1971) originally defined *Protopeneroplis ultragranulata* as *Hoeglundina ultragranulata* even though the differences between the descriptions of *Protopenereoplis* and *Hoeglundina*. But his definition and measurements for *Hoeglundina ultragranulata* was identical to Septfontaine's (1974) definition of *Protopeneroplis trochangulata*. Due to the wrong assignment under *Hoeglundina*, Bucur (1993) proposed to keep the species name of Gorbatchik and the generic name of the Septfontaine and adopt *Protopeneroplis ultragranulata* as the valid taxon.

Stratigraphic range:

Heinz & Isenschmid (1988) reported the first occurrence of *Protopeneroplis ultragranulata* as Middle Tithonian. Altıner & Özkan (1991) established the stratigraphic range of *Protopeneroplis ultragranulata* as the Late Tithonian – Early Valanginian. Bucur (1993) enlarged the stratigraphical range of this species up to the Barremian. In the studied section *Protopeneroplis ultragranulata* has been recovered from the Late Tithonian - Berriasian.

SUBORDER ROTALIINA DELAGE & HEROUARD, 1986

FAMILY DISCORBIDAE EHRENBERG, 1838

Genus *Mohlerina* Bucur, Senowbari-Daryan and Abate, 1996

Type species: *Conicospirillina basiliensis* Mohler, 1938

Mohlerina basiliensis Mohler, 1938

Pl. 4, Figs. 7-11

1938. *Conicospirillina basiliensis* n. sp.; Mohler, p. 27, pl. 28-28; pl. 4, fig. 5

1991. "*Conicospirillina" basiliensis* Mohler; Altıner, p. 195, pl. 7, figs. 6-8

1996. *Mohlerina basiliensis* Mohler; Bucur *et al*., p. 72, pl. 3, figs. 3-6, p. 75, pl. 4, figs. 2, 3, 5-9

1999. *Mohlerina basiliensis* Mohler; Moshammer & Schlagintweit, p. 561, pl. II, fig. 7

2007. *Mohlerina basiliensis* Mohler; Krajewski & Olszewska, p. 306, text-fig. 8A

2010. *Mohlerina basiliensis* Mohler; Ivanova & Kolodziej, p. 31, pl. 5, figs. 12-18

2012b. *Mohlerina basiliensis* Mohler; Sclagintweit, p. 638, figs. 2, 3, 4, 5b, 5d, 6, 7d

Description:

Test is large and trochospirally enrolled. Apical angle is variable. Test shape is discoidal or conical depending on the apical angle. Chamber shapes are sub-globular to elongate. The test wall is calcareous bilamellar with an inner thin microcrystalline and an outer hyaline radial-fibrious calcite layer. With the formation of a new successive chamber, a new lamella is also added to the entire test. There exists an umbilical convex bulge which includes a couplet of a hyaline and thin microcrystalline layer corresponding to a chamber (Plate 4, fig. 10). A basal calcitic

(cement?) layer occurs below the superimposed couplets of the bilamellar chamber walls (Plate 4, figs. 7-9). Most of the observed specimens are dispersed as individual bioclasts in the micritic matrix or sparitic cement.

Remarks:

In 1938, this species was firstly described as *Conicospirillina basiliensis* by Mohler. Due to the inconsistencies such as being plurilocular and having a lamellar wall structure, it has been thought that it can not belong to *Conicospirillina basiliensis* (Bernier, 1984). Finally, Bucur *et al*. (1996) made a taxonomic revision by creating a new genus *Mohlerina* and a new combination *Mohlerina basiliensis*.

Mohlerina was placed within the family Discorbidae Ehrenberg by Bucur *et al*. (1996) at first. Hansen and Revets (1992) proposed a replacement of the Discorbidae family by Rosalinidae according to the revision of Levy *et al*. (1986). However this proposal has not been followed by any subsequent worker and Discorbidae has been preferred to use (Schlagintweit, 2012b). Unlike the free, vagile mode of life of the specimens observed from the literature, Schlaigntweit (2012b) found specimens with their tests attached to variety of hard substrates. This finding according to him provides further evidence for the inclusion of the genus *Mohlerina* within the calcareous Rotaliina as the modern trochospirally coiled and attached taxa belong to this group. Due to the absence of "an umbilical aperture with a distinct flap extending over the umbilical region in *Mohlerina*" which is a characteristic feature of the Discorbidae family, Schlagintweit (2012b) put this genus within the Family Rosalinidae Reiss with a question mark. It's double layered wall structure also led some aouthors to inclusion of this form into the suborder Fusilinina (e.g., Mekik, 1994). Knowing that the exact supragenetic position of *Mohlerina* still needs further classification we preferred to use the mostly accepted classification until now. *Mohlerina basiliensis* has been observed both from the low and high energy environments in this study.

Stratigraphic range:

Stratigraphic range of *M. basiliensis* is given as Middle Jurassic – Lower Cretaceous by Schlagintweit (2012b). *M. basiliensis* has been recovered from the Tithonian-Berriasian interval in this study.

SUBORDER BIOKOVININA MIKHALEVICH & KAMINSKI, 2004

SUPERFAMILY COSCINOPHRAGMATACEA THALMANN, 1951

FAMILY COSCINOPHRAGMATATIDAE THALMANN, 1951

Genus *Coscinophragma* Thalmann, 1951

Type species: *Lichenopora cribrosa* Reuss, 1846

Coscinophragma cribrosum Reuss, 1854

Pl. 4, Figs. 12-18; Pl. 5, Figs. 1-8

1846. *Lichenopora cribrosa* n. sp.; Reuss, p. 46, pl. 14, fig10; pl. 24, figs. 3-5

1957. *Coscinophragma cribrosum* Reuss; Maync, p. 184, text-figs. 1-3, p. 185, text-fig. 4

1996. *Coscinophragma cribrosum* Reuss; Bucur *et al*., p. 67, pl. 1, figs. 1, 5, 6; p. 79, pl. 6, figs. 1-3, 5

1999. *Coscinophragma cribrosum* Reuss; Schlagintweit & Ebli, p. 397, pl. 5, fig. 6

2010. *Coscinophragma cribrosum* Reuss; Ivanova & Kolodziej, p. 27, figs. 1- 4

Description:

Test is large and more or less cylindrical, sometimes a curved tube. Typical specimens of *Coscinophragma cribrosum* possess an external wall consisting of quartz. This is particularly absent in our specimens, which is probably due to the scaricity of quartz grains in the reefal and lagoonal environment. Commonly carbonate particles and sponge spicules are agglutinated in the test wall of our specimens. Due to the very thin canaliculi in the external wall, a pseudoalveolar structure may be seldom visible (Pl. 5, figs. 1,3). *Coscinophragma cribrosum* has been observed both from the low (lagoonal) and high (reefal) energy environments in this study.

Remarks:

In 1846, Reuss originally considered this form as a bryozoan and described it as *Lichenopora cribrosa*. After the study of numerous additional specimens, however, Reuss decided that *Lichenopora cribrosa* was a foraminifer and he erected the new genus *Polyphragma*.

Later in 1951, Thalmann proposed *Coscinophragma* generic name as a substitute for *Polyphragma* which has been used for a genus of annelid worms (Maync, 1957). *Polyphragma* Reuss, 1871 was therefore a homonym of *Polyphragma* Quatrefages, 1865 and has been replaced with *Coscinophragma* generic name.

The general dimensions of our observed specimens of *Coscinophragma cribrsoum* are much reduced when compared with the originally defined specimens. The type species of Coscinophragma may reach 34 mm in length whereas maximum length is ca.6 mm for our specimens.

Stratigraphic range:

Stratigraphic range of *Coscinophragma cribrsoum* is given as Late Tithonian – Early Aptian by Ivanova & Kolodziej (2010). *Coscinophragma cribrsoum* has been recovered from the Tithonian-Berriasian interval in this study.

SUBORDER ORBITOLININA KAMINSKI, 2004

SUPERFAMILY PFENDERINACEA SMOUT & SUGDEN, 1962

FAMILY PFENDERINIDAE SMOUT & SUGDEN, 1962

SUBFAMILY PSEUDOPFENDERININAE, 1988

Genus *Siphovalvulina* Septfontaine, 1988

Type species: *Siphovalvulina variabilis* Septfontaine, 1988

Siphovalvulina variabilis Septfontaine, 1988

Pl. 6, Figs. 3-4

1988. *Siphovalvulina variabilis* n. sp.; Septfontaine, p. 245, fig. 5

1991. *Siphovalvulina variabilis* Septfontaine; Darga & Schlagintweit, p. 223, fig. pl. 4, fig. 14

2007. *Siphovalvulina variabilis* Septfontaine; Krajewski & Olszewzka, p. 300, text-fig. 6A

2008. *Siphovalvulina variabilis* Septfontaine; Taslı *et al*., p. 433, pl. 1, figs. 18-20

2010. *Siphovalvulina variabilis* Septfontaine; Olsewszka, p. 23, pl. 5, Fig. 8

2010. *Siphovalvulina variabilis* Septfontaine; Ivanova & Kolodziej, p. 23, pl.1, fig. 19

Description:

Test is trochospirally enrolled with three chambers per whorl. Wall is finely agglutinated. The central siphonal canal parallel to the axis of coiling connects the successive apertures.

Dimensions:

Hegiht of the test: 201 – 328 μ

Max. test width: 100 - 125 μ

Remarks:

Siphovalvulina variabilis is identified with its central siphonal canal which makes it different from *Belorussiella*, *Trochammina* and *Gaudryina*.

Stratigraphic range:

The stratigraphic distribution of *Siphovalvulina variabilis* ranges from Hettangian-Late Barremian to? Late Cretaceous (Ivanova & Kolodziej, 2010). It has been recovered from the Upper Tithonian-Berriasian interval in this study.

Siphovalvulina sp.

Pl. 6, Figs. 1-2

Description & Remarks:

These forms identified under *Siphovalvulina* sp. have smaller dimensions than *S. variabilis* and they were differently identified from the lower parts of Tithonian.

Dimensions:

Hegiht of the test: 168 – 184 μ

Max. test width: 73 - 97 μ

SUPERFAMILY BIOKOVINACEA, GUSIC, 1977

FAMILY CHARENTIIDAE LEOBLICH AND TAPPAN, 1985

Genus *Charentia* Neumann, 1965

Type species: *Charentia cuvillieri* Neumann, 1965

Charentia cuvillieri Neumann, 1965

Pl. 6, Figs. 6-7

1965. *Charentia cuvillieri* n. gen., n. sp; Neumann, p. 63, pl. 2, figs. 6-12

1991. *Charentia cuvillieri* Neumann; Altıner, p. 194, pl. 7, fig. 18

1999. *Charentia cuvillieri* Neumann; Schlagintweit & Ebli, p. 397, pl. 5, figs. 1-3

2004. *Charentia cuvillieri* Neumann; Ivanova & Kolodziej, p. 71, fig. A

2008. *Charentia cuvillieri* Neumann; Ivanova *et al*., text fig. 7 G-H

2008. *Charentia cuvillieri* Neumann; Sudar *et al*., p. 24, text-fig. 9-1

2010. *Charentia cuvillieri* Neumann; Ivanova & Kolodziej, p. 27, pl.3, figs. 5-10

2012. *Charentia cuvillieri* Neumann; Rami *et al*., p. 68, text-fig. 6-7

Description:

Test is early planispirally coiled with a late tendency to uncoiling with one or two chambers. Periphery is biumbonate. Wall is finely agglutinated.

Dimensions:

Diameter of the test: 503 – 740 μ

Wall thickness: 25 - 31 μ

Height of the last chamber: 96-177 μ

Remarks:

Due to the thickening of the portion just beneath the aperture and against the previous whorl, in thin section this thickened portion of the wall appears as small triangular projections from the spiral septum. Leoblich and Tappan (1988) mentions about the resemblance of these projections to fusulinacean chomata. These chomatalike small triangular projections are not well pronounced in our specimens.

Stratigraphic range:

The stratigraphic distribution of *Charentia cuvillieri* ranges from Late Tithonian to Cenomanian (Ivanova & Kolodziej, 2010). This species has been recovered from the Late Tithonian in this study.

SUPERFAMILY BIOKOVINACEA, GUSIC, 1977

FAMILY CHARENTIIDAE LEOBLICH AND TAPPAN, 1985

Genus *Charentia* Neumann, 1965

Type species: *Charentia cuvillieri* Neumann, 1965

Charentia evoluta Gorbatchik, 1968 ?

Pl. 6, Figs. 10

1968. *Tonasia evoluta* n. sp.; Gorbatchik, p. 8-9, pl. 2, figs 1-5

2006. *Charentia evoluta* Gorbatchik; Kobayashi & Vuks, p. 838, text-fig. 4, 27-32

2007. *Charentia evoluta* Gorbatchik; Krajewski & Olszewska, p. 299, figs. 5G, H

2010. *Charentia evoluta* Gorbatchik; Olszewska, p. 22, pl. VI, figs. 1-2

2011. *Charentia evoluta* Gorbatchik; Catincut *et al*., p. 86, pl. IV, fig. 11

Description & Remarks:

Test is large, laterally compressed and asymmetric with early planispirally coiled part and late uncoiled uniserial part. Coiled part consists of broad, low, curved chambers, irregularly quadrangular in shape. Wall is agglutinated. It differs from *C. cuvillieri* in the more asymmetrical and more compressed test.

Dimensions:

Diameter of the test (oblique section): 928 µ

Wall thickness: 47 µ

Stratigraphic range:

The stratigraphic distribution of *Charentia evoluta* ranges from Late Kimmeridgian to Valanginian (Olszewska, 2010). It is recovered from the Berriasian in this study.

Charentia spp.

Pl. 6, Figs. 5, 8, 9

Description & Remarks:

All other forms having an early involute, planispirally coiled test with a late tendency to uncoiling have been grouped under *Charentia* spp. All these forms have finely agglutinated walls. Chomata-like small triangular projections are not well pronounced.

Dimensions:

Diameter of the test: 214 µ

Wall thickness: 12 - 58 µ

Height of the last chamber: 64 µ

Stratigraphic range:

The stratigraphic distribution of *Charentia* spp. in this study is Tithonian – Berriasian.

SUBORDER MILIOLINA, DELAGE & HEROUARD, 1896

SUPERFAMILY MILIOLOIDEA, EHRENBERG, 1839

FAMILY HAUERINIDAE SCHWAGER, 1876

Genus *Quinqueloculina* d'Orbigny, 1826

Type species: *Serpula seminulum* Linné, 1758

Quinqueloculina stellata Matseva & Temirbekova, 1989 ?

Pl. 6, Figs. 18

1989. *Quinqueloculina stellate* n. sp.; Matseva & Temirbekova, p. 115, pl. 1 figs. d, e, z

2007. *Quinqueloculina stellata* Matseva & Temirbekova; Krajewski & Olszewska, p. 304, text-fig. 7F

2010. *Quinqueloculina stellata* Matseva & Temirbekova; Olszewska, p. 27, pl. VI, fig. 3

Description:

Test is ovate in outline, chambers have quinqueloculine arrangement. Wall is calcareous porcelaneous. External periphery is truncate and has acute edges (triangular projections).

Remarks:

Genus *Quinqueloculina* includes several species which are morphologically variable and most authors generally prefer to group them as *Quinqueloculina* spp. Ivanova & Kolodziej (2010) assert that many of the *Quinqueloculina* species introduced as new for the Upper Jurassic – Lower Cretaceous interval are in fact synonyms and they require revision. Due to this fact and necessity quinqueloculinids were defined with question marks in this study.

Stratigraphic range:

The stratigraphic distribution of *Quinqueloculina stellata* ranges from Tithonian to Early Berriasian (Ivanova & Kolodziej, 2010). ?*Quinqueloculina stellata* is recovered from the Tithonian in this study.

Quinqueloculina robusta Neagu, 1968 ?

Pl. 6, Figs. 19 - 25

1968. *Quinqueloculina robusta* n. sp.; Neagu, p. 566, pl. 1, figs. 8-17; pl. 7, figs. 1-3

1991. *Quinqueloculina robusta* Neagu; Altıner, p. 201, pl. 10, figs. 1-4

2008. *Quinqueloculina robusta* Neagu; Ivanova *et al*., p. 72, text-fig. 7C-D

2011. *Quinqueloculina robusta* Neagu; Roozbahani, p. 55, pl. 1, fig. 8

2013. *Quinqueloculina robusta* Neagu; Carević *et al*., p. 122, text-fig. 14U-W

Description & Remarks:

Typically quinqueloculinid test was described as robust or very robust with frequently arched chambers according to the type description of Neagu (1968). Wall is calcareous, porcelaneous. Arnaud-Vanneau and Sliter (1995) consider this species as a synonym with *Rumanolulina robusta*.

Dimensions:

Longest dimesion: 219 - 348 µ

Max. test diameter observed: 204 – 334 µ

Stratigraphic range:

The stratigraphic distribution of *Quinqueloculina robusta* ranges from Late Tithonian to Early Valanginian (Ivanova *et al*., 2008). *Quinqueloculina robusta* ? has been identified from the Berriasian in this study.

SUBORDER TEXTULARIINA, DELAGE & HEROUARD, 1896

SUPERFAMILY LOFTUSIACEA, BRADY, 1884

FAMILY CYCLAMMINIDAE MARIE, 1941

SUBFAMILY CHOFFATELLINAE MAYNC, 1958

Genus *Pseudocyclammina* Yabe & Hanzawa, 1926

Type species: *Cyclammina lituus* Yokoyama, 1890

Pseudocyclammina lituus Yokoyama, 1890

Pl. 7, Figs. 1-4

1890. *Cyclammina lituus* n. sp.; Yokoyama, p. 26, pl. 5, fig.7

1991. *Pseudocyclammina lituus* Yokoyama; Altıner, p. 189, pl. 4, fig. 10, p. 195, pl. 7, fig. 14

2004b. *Pseudocyclammina lituus* Yokoyama; Bucur *et al*., p. 65, pl. III, fig. 1

2006. *Pseudocyclammina lituus* Yokoyama; Kobayashi & Vuks, p. 840, text-fig. 5 7-14

2007. *Pseudocyclammina lituus* Yokoyama; Krajewski & Olszewska, p. 301, text-fig. 6F

2008. *Pseudocyclammina lituus* Yokoyama; Omaña & Arreola, p. 805, text-fig. 4a-d

2010. *Pseudocyclammina lituus* Yokoyama; Ivanova & Kolodziej, p. 29, pl.4, figs. 1-10

2011. *Pseudocyclammina lituus* Yokoyama; Roozbahani, p. 55, pl. 1, fig. 5

Description:

Test is early planispirally enrolled and later uncoiling. Wall is coarsely agglutinated with coarse subepidermal network. Aperture is cribrate covering the apertural face.

Dimensions:

Height: 549 - 983 μ

Wall thickness: 94 – 163 μ

Remarks:

Pseudocyclammina and *Everticyclammina* may appear similar in some thin sections. *Pseudocyclammina* differs from *Everticyclammina* by its cribrate aperture. Aperture of *Everticyclammina*, however, is a simple, short vertical areal slit.

Stratigraphic range:

The stratigraphic distribution of *Pseudocyclammina lituus* ranges from Oxfordian to Hauterivian (Ivanova & Kolodziej, 2010). *Pseudocyclammina lituus* has been identified from the Berriasian in this study.

SUPERFAMILY VERNEUILINACEA, CUSHMAN, 1911

FAMILY VERNEUILINIDAE CUSHMAN, 1911

SUBFAMILY VERNEUILINIOIDINAE SULEYMANOV, 1973

Genus *Uvigerinammina* Majzon, 1943

Type species: *Uvigerinammina jankoi* Majzon, 1943

Uvigerinammina uvigeriniformis Seibold & Seibold, 1960 ?

Pl. 7, Fig. 5

1960. *Gaudryina uvigeriniformis* n. sp.; Seibold & Seibold, p. 334-335, text-fig. 8b, pl. 7, fig. 4

1995. *Uvigerinammina uvigeriniformis* Seibold & Seibold; Neagu & Neagu, p. 218, pl. 2, figs. 28-43; pl. 6, figs. 11-14

2007. *Uvigerinammina uvigeriniformis* Seibold & Seibold; Krajewski & Olszewska, p. 296, text-fig. 4G

2010. *Uvigerinammina uvigeriniformis* Seibold & Seibold; Olszewska, p. 21, pl.V, fig. 4

Description:

Sack-like chambers are characteristic for this species. Wall is finely agglutinated. In original definition test is triserial with sack-like chambers increasing in size as added. In our specimen, it is not possible to observe triserial chamber arrangement due to the section orientation. But due to the obvious sack-like shape of the chambers we define this form as *Uvigerinammina uvigeriniformis* with a question mark.

Remarks:

Loeblich and Tappan (1988) remarks that *Uvigerinammina* is typically found in flysch facies in which crushing and distortion is frequent. Our sample, however, has been idefintified from pelagic wackestone facies.

Stratigraphic range:

The stratigraphic distribution of *Uvigerinammina uvigeriniformis* ranges from Middle Oxfordian to Early Valanginian (Krajewski & Olszewska, 2007). *Uvigerinammina uvigeriniformis* ? has been recovered from the Tithonian in this study.

SUBORDER MILIOLINA, DELAGE AND HEROUARD, 1896

SUPERFAMILY CORNUSPIRACEA, SCHULTZE, 1854

FAMILY OPHTHALMIDIIDAE WIESNER, 1920

Genus *Ophthalmidium* Kübler & Zwingli, 1870

Type species: *Oculina liasica* Kübler & Zwingli, 1866

Ophthalmidium spp.

Pl. 7, Figs. 6-9

Description & Remarks:

Our description of this genus follows the emendation of Zaninetti (1969) and Brönnimann (1969). According to their description, the length of the chambers in this genus may differ and coiling may be planispiral or irregular at the beginning and later planispiral. They also interpreted the Genus *Ophthalmidium* in a broad sense including as synonyms the following genera: *Hauerina*, *Cornuloculina*, *Hauerinella*, *Spirophthalmidium*, *Praeophthalmidium* and *Eoophthalmidium*. Test is rounded to ovate. Wall is calcareous, porcelaneous.

Dimensions:

Axial diameter: 282 - 481 μ

Equatorial diameter: 152 – 276 µ

Stratigraphic range:

According to Pazdro (1972) *Ophthalmidium* occurs in the Triassic and Jurassic. The stratigraphic distribution of *Ophthalmidium* spp. in this study is Kimmeridgian to Tithonian.

SUPERFAMILY VERNEUILINACEA, CUSHMAN, 1911

FAMILY VERNEUILINIDAE CUSHMAN, 1911

SUBFAMILY VERNEUILINIOIDINAE SULEYMANOV, 1973

Genus *Gaudryinopsis* Podobina, 1975

Type species: *Gaudryina vulgaris* Kipriyanova, 1960

Gaudryinopsis ? sp.

Pl. 7, Fig. 10

Description & Remarks:

On original definition test is elongate with a short early triserial stage and later biserial. Observing such a chamber arrangement in our specimen is not possible. Thus it is defined with a question mark. Due to the nearly parallel sides test seems narrow and elongate. Chambers are subglobular to slightly appressed, and sutures seem depressed. Wall is finely agglutinated. Aperture is not visible.

Dimensions:

Height: 262 µ

Wall thickness: 12 µ

Stratigraphic range:

According to Loeblich and Tappan (1988) *Gaudryinopsis* occurs from Late Triassic and Late Eocene. *Gaudryinopsis* ? sp. has been identified from the Tithonian in this study.

SUBORDER LAGENINA DELAGE & HEROUARD, 1896

SUPERFAMILY NODOSARIACEA EHRENBERG, 1838

FAMILY POLYMORPHINIDAE D'ORBIGNY, 1839

SUBFAMILY WEBBINELLINAE RHUMBLER, 1904

Genus *Bullopora* Quenstedt, 1856

Type species: *Bullopora rosrata* Quenstedt, 1857

Bullopora tuberculata Sollas, 1877

Pl. 7, Fig. 11

1877. *Webbina tuberculata* n. sp.; Sollas, p. 104, pl. 6, figs. 4-7, 9

1994. *Bullopora tuberculata* Sollas; Mišík, p. 139, pl. 2, fig. C

1999. *Bullopora tuberculata* Sollas; Dupraz, p. 32, pl. 7, fig. 11

2007. *Bullopora tuberculata* Sollas; Védrine, p. 188, pl. 10, fig. 3

2008. *Bullopora tuberculata* Sollas; Reloid *et al*., p. 289, text-fig. 8A,

Description & Remarks:

Test is attached. Loosely arranged chambers are hemispherical and they joined by stolonlike connections. Chamber size increases with the addition of new ones. Wall is calcareous, hispid or finely tuberculate.

Stratigraphic range:

Bullopora tuberculata has been identified from the Tithonian in this study.

SUPERFAMILY LITUOLACEA D e BLAINVILLE, 1827

FAMILY HAURANIIDAE SEPTFONTAINE, 1988

SUBFAMILY AMIJIELLINAE SEPTFONTAINE, 1988

Genus *Kastamonina* Sirel, 1993

Type species: *Kastamonina abanica* Sirel, 1993

Kastamonina abanica Sirel, 1993

Pl. 7, Fig. 12

1993. *Kastamonina abanica* Sirel n. sp.; Sirel, p. 5, pl. I, figs. 1-12, p. 7, pl. II, figs. 1-11

Description:

Test is highly conical. Early chambers are arranged in arcuate series and later broad ones are arranged in a uniserial pattern. The diameter and the height of the uniserial chambers gradually increase from the early chambers to the later ones. Marginal zones of each chamber include subdivision by an intricate subepidermal network.

This subepidermal network consists of two generations of beams and rafters forming numerous irregular alveolar compartments. Wall is calcareous-agglutinated.

Dimensions:

Height: 1919 μ

Wall thickness: 111 μ

Remarks:

Amijiella is a similar genus to *Kastamonina* and according to Kaminski (2000) *Kastamonina* may be derived from *Amijiella*. Much reduced initial coiled portion and more complex internal structure of *Kastamonina* differentiates it from *Amijiella*. *Kastamonina's* difference from *Haurania* is the absence of a planispiral part and the lacking of endoskeletal pillars in the central part of the test (Kaminski, 2000).

Stratigraphic range:

According to Sirel (1993) *Kastamonina abanica* was found throughout the Kimmeridgian-Portlandian interval. In our study, however, it has been identified from the Berriasian

.

SUBORDER TEXTULARIINA DELAGE & HEROUARD, 1896

SUPERFAMILY CHRYSALIDINACEA NEAGU, 1968

FAMILY PARAVALVULINIDAE BANNER, SIMMONS & WHITTAKER, 1991

SUBFAMILY PARAVALVULININAE BANNER, SIMMONS & WHITTAKER, 1991

Genus *Redmondoides* Banner, Simmons & Whittaker, 1991

Type species: *Pseudomarssonella media* Redmond, 1965

Redmondoides ? sp.

Pl. 7, Figs. 13-20

Description & Remarks:

Observing characteristic qaudriserial chamber arrangement in our specimens is not possible due to the section orientation. Chambers are subglobular to hemispherical. Wall is finely agglutinated.

Dimensions:

Height: 238 - 269 μ

Wall thickness: 8 - 21 μ

Stratigraphic range:

Even though the known stratigraphic range of *Redmondoides* is defined as Bajocian - ?Kimmeridgian by Banner, Simmons & Whittaker (1991), later Ivanova & Kolodziej (2010) assigned a Bajocian to Valanginian stratigraphic range to *Redmondoides lugeoni* and extended the range of the genus as Bajocian - Valanginian. In our study, *Redmondoides* ? sp. has been identified from the Tithonian - Berriasian interval.

SUBORDER TEXTULARIINA DELAGE & HEROUARD, 1896

SUPERFAMILY TROCHAMMINACEA SCHWAGER, 1877

FAMILY TROCHAMMINIDAE SCHWAGER, 1877

SUBFAMILY TROCHAMMININAE SCHWAGER, 1877

Genus *Trochammina* Parker & Jones, 1859

Type species: *Nautilus inflatus* Montagu, 1808

Trochammina sp.

Pl. 7, Figs. 21-26

Description & Remarks:

Test is trochospirally coiled and has a rounded preiphery. 6 chambers have been observed in the last whorl. Chamber size increases gradually with the addition of new ones. Sutures are radial. Thick wall is finely agglutinated.

Dimensions:

Test Diameter: 337 - 366 μ

Wall thickness: 30 - 42 μ

Stratigraphic range:

Trochammina sp. has been identified from the Berriasian in this study.

SUBORDER TEXTULARIINA DELAGE & HEROUARD, 1896

SUPERFAMILY LOFTUSIACEA BRADY, 1884

FAMILY SPIROCYCLINIDAE MUNIER-CHALMAS, 1887

Genus *Anchispirocyclina* Jordan & Applin, 1952

Type species: *Anchispirocyclina henbesti* Jordan & Applin, 1952

Anchispirocyclina lusitanica Egger, 1902

Pl. 8, Figs. 1-10

1902. *Dicyclina lusitanica* n. sp.; Egger, p. 585-586, pl. 6, fig. 3-5

1991. *Anchispirocyclina lusitanica* Egger; Darga & Schlagintweit, p. 213, pl. 2, fig. 2; pl. 4 figs. 2, 3

1999. *Anchispirocyclina lusitanica* Egger; Schlagintweit & Ebli, p. 391, pl. 3, fig. 5; p. 397, pl. 5, fig. 9

2005. *Anchispirocyclina lusitanica* Egger; Bucur & Săsăran, p. 36, pl. II, figs. 13-15

2007. *Anchispirocyclina lusitanica* Egger; Krajewski & Olszewska, p. 300, text-fig. 6D, E

2011. *Anchispirocyclina lusitanica* Egger; Dragastan, p. 108, pl. 1, figs. 1-7; p. 109, pl. 2, figs. 1-6

Description:

Test is, in early stage, close, asymmetrically enrolled then planispirally coiled. Test is flat and circular in outline with broad chambers. Periphery is rounded. Wall is finely agglutinated and outer layer of the wall is underlained by a reticulate subepidermal network of rafters and beams. Broad chambers include irregular pillars which produce an irregular labyrinthic appearance.

Dimensions:

Height: 1042 - 4769 μ

Wall thickness: 50 - 92 μ

Remarks:

Anchispirocyclina lusitanica has been identified from the lagoonal-inner platform facies in this study.

Stratigraphic range:

According to Krajewski & Olszewska (2007) stratigraphic distribution of *Anchispirocyclina lusitanica* is between Tithonian and earliest Berriasian. In our material it has been identified from the Berriasian.

SUBORDER INVOLUTININA HOHENEGGER & PILLER, 1977

FAMILY INVOLUTINIDAE BUTSCHLI, 1880

SUBFAMILY TRIASININAE LOEBLICH AND TAPPAN, 1986

Genus Neot*rocholina* Reichel, 1956

Type species: *Neotrocholina valdensis* Reichel, 1956

Neotrocholina spp.

Pl. 9, Figs. 1-3

Description & Remarks:

Conical test has a planar or concave base. Spiral side is generally steeply convex. Bilocular test is trochospirally coiled and includes a globular proluculus and an undivided tubular chamber. The wall is radially perforate and hyaline. Wide umbilicus is deeply fissured and contains fibrous pillars of calcite. *Neotrocholina* mainly differs from *Trocholina* by having fibrious pillars and perforate calcitic test wall. The outer wall of *Neotrocholina* is generally thick whereas that of *Trocholina* is thin and often eroded or recrystallized. Because populations of various forms could not be encountered and the specimens of observed *Neotrocholina* forms are single, all specimens are grouped under *Neotrocholina* spp.

Stratigraphic range:

Neotrocholina spp. have been been identified from the Kimmeridgian-Berriasian interval in this study.

SUBORDER INVOLUTININA HOHENEGGER & PILLER, 1977

FAMILY INVOLUTINIDAE BUTSCHLI, 1880

SUBFAMILY TRIASININAE LOEBLICH AND TAPPAN, 1986

Genus *Trocholina* Paalzow, 1922

Type species: *Involutina conica* Schlumberger, 1898

Trocholina spp.

Pl. 9, Figs. 4-12; Pl. 10, Figs. 1-10

Description & Remarks:

Test is trochospirally coiled and conical in shape. Bilocular test made up of a globular proloculus and an undivided tubular chamber. Wide umbilicus may contain fillings of wall material. Wall is commonly recrystallized to homogenous microgranular structure. Due to bad preservation and recrystallization specific identifications of the forms have not been possible. See Description & Remarks part of *Neotrocholina* spp. for its comparison with *Neotrocholina*.

Stratigraphic range:

Trocholina spp. have been been identified from the Tithonian-Berriasian interval in this study.

MICROPROBLEMATICA

INCERTAE SEDIS

Genus *Radiomura* Senowbari-Daryan & Schäfer, 1979

Type species: *Radiomura cautica* Senowbari-Daryan & Schäfer, 1979

Radiomura cautica Senowbari-Daryan & Schäfer, 1979

Pl. 11, Figs. 1-8, Pl. 12, Figs. 1-8

1979. *Radiomura cautica* n.gen., n.sp. Senowbari-Daryan & Schäfer; Senowbari-Daryan & Schäfer, p. 29, pl. 2, fig. 6, pl. 4, figs. 1-4, pl. 5, figs. 2-3, pl. 6, fig. 4, pl. 7, fig. 1

2001. *Radiomura cautica* Senowbari-Daryan & Schäfer; Săsăran *et al*., p. 50, pl. VIII, fig. 5

2003. *Radiomura cautica* Senowbari-Daryan & Schäfer; Uta & Bucur, p. 6, not figured

2004. *Radiomura cautica* Senowbari-Daryan & Schäfer; Şerban *et al*., p. 482, pl. 2, fig. 8

2005. *Radiomura cautica* Senowbari-Daryan & Schäfer; Schlagintweit, p. 539, pl. II, fig. 3

2006b. *Radiomura cautica* Senowbari-Daryan & Schäfer; Schlagintweit & Gawlick, p. 59, text-fig 6, fig 1, 5

2006a. *Radiomura cautica* Senowbari-Daryan & Schäfer; Schlagintweit & Gawlick, p.256, not figured

2007. *Radiomura cautica* Senowbari-Daryan & Schäfer; Schlagintweit & Gawlick, p. 601, text-fig. 8

2008. *Radiomura cautica* Senowbari-Daryan & Schäfer; Ivanova *et al*., p. 79, text-fig. 13F, G

2011. *Radiomura cautica* Senowbari-Daryan & Schäfer; Catincut *et al*., p. 85, pl. III, fig. 8

2011. *Radiomura cautica* Senowbari-Daryan & Schäfer; Schlagintweit & Gawlick, p. 128, Fig. 5a, p. 130, fig. 6a-h

2013. *Radiomura cautica* Senowbari-Daryan & Schäfer; Pleş *et al*., p. 32, text-fig. 9g, text-fig. 12f-h

Description:

This micro-organism consists of several hemispheric or spherical chambers with smooth inner wall surfaces (Senowbari-Daryan & Schäfer, 1979). Generally chambers are not interconnected; interconnected chambers can be seen rarely. The external light-grey wall of the chambers comprises of fibrous calcite in which fibers are diverging and arranged obliquely. The inner wall boundary appears finer grained and therefore seems darker. Chamber arrangement may show a chain-like chamber row. The interior of the chambers is mostly filled with sparite, occasionally peloidal fabric can also bee seen.

Remarks:

In despite of the several proposals assigning *Radiomura cautica* to sponges, its systematic position is still uncertain (Pleş *et al*., 2013). This organism occurs in reefal (mostly fore-reefal) facies together with resembling species *Perturbatacrusta leini* (Schlagintweit & Gawlick, 2011). There are three main differences between *Radiomura cautica* and *Perturbatacrusta leini*. First one is the lacking of the radial diverging microcrystalline fibers of *Radiomura cautica* in *Perturbatacrusta leini*. The second difference is the interior of *Perturbatacrusta leini* which shows a labyrinthic canal system (Schlagintweit & Gawlick, 2011). Thirdly their stratigraphic ranges differ.

Stratigraphic range:

Radiomura cautica is so far known from the Late Triassic-Neocomian interval. (Schlagintweit & Gawlick, 2011). It has been recovered from the Kimmeridgian-Tithonian material in the studied section.

Genus *Perturbatacrusta* Schlagintweit & Gawlick, 2011

Type species: *Perturbatacrusta leini* Schlagintweit & Gawlick, 2011

Perturbatacrusta leini Schlagintweit & Gawlick, 2011

Pl. 13, Figs. 1-6

2011. *Perturbatacrusta leini* n.gen., n.sp., Schlagintweit & Gawlick; Schlagintweit & Gawlick, p. 129, Text-fig. 5c, d, g, h, p. 132, fig. 7a-g

2013. *Perturbatacrusta leini* Schlagintweit & Gawlick; Pleş *et al*., p. 26, text-fig 6d, p. 38, text-fig. 12a-e

Description:

Perturbatacrusta leini can be easily identified with is its labyrinthic internal structure composed of irregular interconnected tubes and lateral closed tubes, both with smooth walls, and with rounded terminations (Schlagintweit & Gawlick, 2011). Calcareous wall is thick, homogenous, light-grey and microcrystalline. The interior of the tubes are generally filled with sparry calcite, in some cases micritic-peloidal fabric can also be seen.

Remarks:

Perturbatacrusta leini has an unknown systematic position but mostly it resembles partly way of life of sponges but still lacks important diagnostic features of the sponge group (Schlagintweit & Gawlick, 2011). Its similarities and differences with *Radiomura cautica* have already been discussed in the remarks of *Radiomura cautica*.

Stratigraphic range:

The stratigraphic distribution of *Perturbatacrusta leini* ranges from Kimmeridgian to ?Berriasian (Schlagintweit & Gawlick, 2011). In our studied section it has been recovered from the Kimmeridgian – Berriasian interval.

Genus *Koskinobullina* Cherchi & Schroeder, 1979

Type species: *Koskinobullina socialis* Cherchi & Schroeder, 1979

Koskinobullina socialis Cherchi & Schroeder, 1979

Pl. 14, Figs. 1-8

1979. *Koskinobullina socialis* n. gen. n. sp.; Cherchi & Schroeder, pp. 519-523, pl. 1

1991. *Koskinobullina socialis* Cherchi & Schroeder; Altıner, p. 191, pl. 5, figs. 30-31

1993a. *Koskinobullina socialis* Cherchi & Schroeder; Leinfelder *et al*., p. 213, pl. 41, fig. 8

1996. *Koskinobullina socialis* Cherchi & Schroeder; Schmid, p. 207, text-figs. 122,123,125

1999. *Koskinobullina socialis* Cherchi & Schroeder; Schlagintweit & Ebli, p. 409, pl. 11, fig. 10

2003. *Koskinobullina socialis* Cherchi & Schroeder; Uta & Bucur, p. 13, pl. 4, fig. 3

2004. *Koskinobullina socialis* Cherchi & Schroeder; Schlagintweit, p. 11, pl. 1, figs. 2-4,6, p. 13, pl. 2, fig. 3

2004. *Koskinobullina socialis* Cherchi & Schroeder; Shiraishi & Kano, p. 221, text-fig. 5A-C, p. 223, text-fig. 7D

2007. *Koskinobullina socialis* Cherchi & Schroeder; Schlagintweit & Gawlick, p. 600, text-fig. 7-1

2013. *Koskinobullina socialis* Cherchi & Schroeder; Pleş *et al*., p. 34, text-fig. 10e-h

Description:

Koskinobullina socialis consists of hemispherical chambers with calcitic perforate walls arranged into encrusting multilamellar layers. Calcitic walls exhibits fine irregular pores and the inner cavities are filled by sparite.

Remarks:

Cherchi and Schroeder (1979) assigned *Koskinobullina socialis* as red algae whereas it has been categorized as foraminifera by Schmid (1996). Schimd (1996) also mentions about its association with another microencruster *Iberopora bodeuri*. Its hemispherical morphology and distribution in restricted spaces is also seen similar with Paleozoic genus *Wetheredella* which has been compared with modern cyanobacteria by Kazmeirczak & Kempe (1992).

Stratigraphic range:

Cherchi & Scroeder (1985) reported its stratigraphic range as Bathonian to Cenomanian. *Koskinobullina socialis* has been founded in the Kimmeridgian – Berriasian interval in the studied section.

Genus *Crescentialla* Senowbari-Daryan, Bucur, Schlagintweit, Săsăran & Matyszkiewicz 2008

Type species: *Crescentiella morronensis* Crescenti, 1969

Crescentiella morronensis Crescenti, 1969

Pl. 15, Figs. 1-33

Selected synonymy [for further synonymy before 2008 see Senowbari-Daryan *et al*. (2008)]

1969. *Tubiphytes morronensis* n. sp.; Crescenti, p. 35-37, figs. 10, 20-22

2008. *Crescentiella morronensis* Crescenti; Senowbari-Daryan *et al*., p. 191, pl. 1, figs. a-i, p. 193, figs. a-h, p. 195, pl. 3, figs. a-g, p. 199, pl. 4, figs. a-h, p. 201, pl. 5, figs- a-h, p. 203, pl. 6, figs. a-h, p. 205, pl. 7, figs. 1-e

Non 2010. *Crescentiella morronensis* Crescenti; Olszewska, pl. 1, fig. 15

2010. *Crescentiella morronensis* Crescenti; Gawlick and Schlagintweit, p. 66, text-fig. 7, figs. 3, 6, 7, p. 67, text-fig. 8, fig. 2

2011. *Crescentiella morronensis* Crescenti; Catincut *et al*., p. 85, pl. III, fig. 8

2013. *Crescentiella morronensis* Crescenti; Pleş *et al*., p. 34, text-fig. 10a-d

Description:

Crescentiella morronensis consists of a cylindrical (tube-like) micritic calcareous body with an internal cavity of variable diameters. In thin sections, the cylindrical body and the poorly-delimited external outline appear as a dense dark-colored material which consists of densely packed micritic layers showing a concentric display (Senowbari-Daryan *et al*., 2008). Internal part of the *Crescentiella morronensis* may be an amphora-like chambered foraminifera or a cylindrical tube with calcite cement or sometimes bioclasts or even dolomite crystals (Plate-5, Fig. 32). The length of the chamber of the foraminifera varies due to the short (Plate-5, Fig. 31) or long necks (Plate-5, Fig. 33) of the amphora-like chambers. Other internal component, the cylindrical tube is of uncertain affinity (Senowbari-Daryan *et al*., 2008).

Remarks:

Even though this enigmatic organism was mentioned in several studies, its systematic position is still debated. Flügel (1981) proposed a symbiosis between a nubecularid foraminifera and a cyanophycean for *Crescentiella*. *Crescentiella*

morronensis is recently interpreted as an association between cyanobacteria and nubecularid foraminifera by Senowbari-Daryan *et al*. (2008). They also consider the association between cyanobacteria and uncertain tubes or rarely other biogenic components for some specimens of *Crescentiella*.

Association of *Terebella lapilloides* with *Crescentiella* was reported by Leinfelder *et al*. (1993b). This association is characterized by a dense peloidal microbial fabric together with considerable quantities of *Crescentiella* and *Terebella lapilloides* with very rare occurrence of other encrusters. *Terebella-Crescentialla* association has a bathymetric significance implying its appearance in deep setting environments (Leinfelder *et al*., 1993a; 1993b; 1996). It is the preferential occurrence of *Terebella lapilloides* in deeper settings which makes the *Crescentiella-Terebella* association bathymetrically significant (Leinfelder *et al*., 1993b). Because *Crescentiella* may occur in both shallow and deep water environments (Leinfelder *et al*., 1993b).

Stratigraphic range:

Stratigraphic distribution of *Crescentiella morronensis* is between the Oxfordian-Barremian with an acme in the Kimmeridgian-Tithonian (Pleş *et al*., 2013). It has been defined all along the studied section, between Kimmeridgian and Berriasian.

Genus *Labes* Eliasova, 1986

Type species: *Labes atramentosa* Eliasova, 1986

Labes atramentosa Eliasova, 1986

Pl. 16, Figs. 1-11

1986. *Labes atramentosa* n. gen., n. sp.; Eliasova, p. 110, pl. 1-2

1996. "*Tubiphytes*"-Kamin (*Tubiphytes* chimney); Schmid, figs. 102-112

1996. "*Tubiphytes*" *morronensis* colony; Leinfelder *et al*., p. 231, fig. 4

2003. "*Tubiphytes*" like strucutre; Uta and Bucur, p. 13, pl. 4, fig. 4

2004. "*Tubiphytes*" *morronensis*; Şerban *et al*., p. 482, pl. 2, fig. 6

2008. *Labes atramentosa* Eliasova; Senowbari-Daryan *et al*., p. 207, pl. 8, fig. c

2013. *Labes atramentosa* Eliasova; Pleş *et al*., p. 40, text-fig. 14 e, f

Description:

This enigmatic organism consists of an internal cavity and a micritic cortex with tubes surrounding the internal cavity. The maximum height of the aggregates of this cylindrical to mostly conical shaped organism is 1.5 mm for our defined specimens whereas maximum basal diameter is 1.8 mm. Cortex of the *Labes atramentosa* is made up of dense micritic laminae separated by very thin darker lines and also cortex lacks incorporated bioclasts (Senowbari-Daryan *et al*., 2008).

Remarks:

Reconstruction of *Labes atramentosa* with different sections is well depicted by Schmid (1996) as "*Tubiphytes*" chimneys. Uta & Bucur (2004) used the term "*Tubiphytes*" like structure for *Labes atramentosa.* Its difference from *Crescentiella morronensis* is the microstructure of the cortex. Cortex of *Labes atramentosa* is made up of dense micritic laminae separated by very thin darker lines. Also lacking of bioclast incorporated in the cortex is another difference of *Labes atramentosa* from *Crescentiella morronensis*.

Stratigraphic range:

Stratigraphic distribution of *Labes atramentosa* in the studied section is Kimmeridgian-Berrriasian.

Genus *Iberopora* Granier & Berthou, 2002

Type species: *Iberopora bodeuri* Granier & Berthou, 2002

Iberopora bodeuri Granier & Berthou, 2002

Pl. 17, Figs. 1-2

2002. *Iberopora bodeuri* n. gen., n. sp.; Granier & Berthou, p. 121, pl. 2, figs. 2-4

2003. *Iberopora bodeuri* Granier & Berthou; Uta & Bucur, p. 12, pl. 3, fig. 4

2003. *Iberopora bodeuri* Granier & Berthou; Helm *et al*., pl. 1, fig 3

2004. *Iberopora bodeuri* Granier & Berthou; Şerban *et al*., p. 482, pl. 2, fig. 5

2004. *Iberopora bodeuri* Granier & Berthou; Schlagintweit, p.11, pl. 1, figs. 1-6, p. 13, pl. 2, figs. 4-7

2005. *Iberopora bodeuri* Granier & Berthou; Bucur et al., p. 121, pl. 5, figs. 6-8, 11,12

2013. *Iberopora bodeuri* Granier & Berthou; Pleş *et al*., p. 34, text-fig. 10f, p. 40, text-fig. 14h

2013. *Iberopora bodeuri* Granier & Berthou; Morycowa & Olszewska, p. 66, text-fig 3, fig. 2

Description:

Tiny bubble-like superimposed cells of *Iberopora bodeuri* occurs in layers parallel to the substratum and these cells forms the skeleton of *Iberopora bodeuri*. The cell wall is a thin micritic envelope and there is no connection between adjacent or superimposed cells. Thin sparitic layers occurring more or less regularly intercalated with the skeleton are observed and according to Schlagintweit (2004) these sparitic layers are a determining characteristic of the form.

Remarks:

Schmid (1996) described *Iberopora bodeuri* as “crust problematicum” and noted the possible relationship with red algae. Schmid (1996) also discussed the possible

similarities between *Iberopora* and the Palaeozoic cyanobacteria *Sphaerocodium*. Granier & Berthou (2002) noted the affinities of *Iberopora* with another problematic form *Solenomeris ogormani* (Douville) which has long been interpreted as Solenoporacean alga, and later regarded as encrusting foraminifera. Helm *et al*. (2003) proposed another possible origin by mentioning about the similarities in the structure of *Iberopora* with that of *Wetheredella* which indicates a cyanobacterial origin.

Stratigraphic range:

Stratigraphic range of *Iberopora bodeuri* is Oxfordian-Berriasian according to Schlagintweit (2004). It has been defined from the Berriasian along the studied section.

Genus *Lithocodium* Elliott, 1956

Type species: *Lithocodium aggregatum* Elliott, 1956

Lithocodium aggregatum Elliott, 1956

Pl. 23, Figs. 4-6, Pl. 25, Figs. 1-6, Pl. 26, Figs. 1-5

Selected synonymy [for further synonymy before 1996 see Schmid (1996)]

1956. *Lithocodium aggregatum* n. gen., n. sp.; Elliott, p. 331, pl. 1, fig. 2, 4, 5

1996. *Lithocodium aggregatum* Elliott; Schmid, p. 171, figs. 80, 83, 86-89, 94-95

1999. *Lithocodium aggregatum* Elliott; Dupraz, pl. 6, figs. 8-9, 10-15

2001. *Lithocodium aggregatum* Elliott; Săsăran *et al*., p. 45, pl. III, fig. 5, p. 50, pl. IIX, fig. 3, p. 52, pl. X, fig. 6

2004. *Lithocodium aggregatum* Elliott; Shiraishi & Kano, p. 220, text-fig. 4B, p. 221, text-fig. 5A, p. 223, text-fig. 7A, F, G

2007. *Bacinella irregularis* Radoičić - *Lithocodium aggregatum* Elliott; Bucur *et al*., p. 44, pl III, fig. 4, p. 48, pl. VII, fig. 3

2008. *Lithocodium aggregatum* Elliott; Krajewski, p. 246, text-fig. 7g

2009. *Lithocodium aggregatum* Elliott; Védrine & Strasser, p. 254, text-fig. 7d

2013. *Lithocodium aggregatum* Elliott; Pleş *et al*., p. 36, text figs. 11 a-d

2013 *Lithocodium aggregatum* Elliott; Cherchi and Schroeder, p. 52, text-fig. 3 a-d, p. 54, text-fig. 5 a-g

Description:

The enigmatic and intensely-debated *Lithocodium aggregatum* consists of two main parts; the micritic crust which seems bifurcated and the cavities within the micritic crust.

Remarks:

Elliot (1956) firstly described *Lithocodium aggregatum* as Codiacean algae. Leienfelder *et al.* (1993a) characterised it as an encrusting organism with an interior central cavity and an external part with radial or bifurcated filaments. The possibility of its microbial origin has also been mentioned by some authors (Camoin & Maurin, 1988; Riding, 1991). Schmid & Leinfelder (1995, 1996) also regarded *L. aggregatum* as encrusting Loftusiacean foraminifera. Koch *et al.* (2002) considered it to be a sponge. Cherchi & Schroeder (2006) interpreted this form as the colonies of calcified cyanobacteria. Recently it has been interpreted as sponge borings within microbial crusts by Schlagintweit (2010) and Cherchi & Schroeder (2010, 2013). The association of *Lithocodium aggregatum* with *Bacinella*-type structures and other encrusting organisms like *Troglotella incrustants* is encountered frequently for most of the Late Jurassic reefal material. Same association is also observed in our studied material.

Stratigraphic range:

The stratigraphic range of *Lithocodium aggregatum* is attributed to the (Oxfordian?) Tithonian-Coniacian interval (Pleş *et al*., 2013). In our studied section it has been identified from the Kimmeridgian-Berriasian interval.

Bacinella-type structures (Bacinellid fabrics)

(Pl. 24, Figs. 1-9)

Description & Remarks:

Enigmatic *Bacinella irregularis* was firstly described by Raoičić (1959) as an alga inceatae sedis. Later on, several authors proposed a microbial/cyanobacterial origin for this microproblematicum (Schäfer & Senowbari-Daryan, 1983; Maurin *et al*., 1985; Camoin & Maurin, 1988; Riding, 1991; Schmid & Leinfelder, 1996; Vachard *et al*., 2001; Uta & Bucur, 2003). Recently, Schlagintweit *et al*. (2010) and Schlagintweit & Bover-Arnal (2013) have assessed the *Bacinella* as a monotypic taxon and emended its diagnosis. They interpreted *Bacinella irregularis* as euendolithic algae with thallus consisting of cyclindrical filaments perforating bioclasts such as corals or *Lithocodium aggregatum* crusts. By this new restricted diagnosis, Schlagintweit & Bover-Arnal (2013) asserted that most of the *Bacinella irregularis* occurences reported in the literature do not belong to this taxon. They indicated that these occurences instead represent irregular vesicular crusts (or bacinellid fabrics) which possess a probable microbial origin. The identified specimens in this study are more similar to these bacinellid fabrics. These vesicular fabrics are composed of vesicles and micritic envelope forming the walls of the vesicles. Vesicles are mostly filled with sparry calcite.

Stratigraphic range:

Bacinellid strucutures have been detected abundantly in the Upper Jurassic-Lower Cretaceous deposits of the whole Tethys area. Borza (1975) and Senowbari-Daryan (1984) also described *Bacinella*-type structures from the Upper Triassic aged

materials. It has been observed from the Kimmeridgian – Berriasian interval along the measured section in this study.

Genus *Thaumatoporella* Raineri, 1922

Type species: *Thaumatoporella parvovesiculifera* Raineri, 1922

Thaumatoporella parvovesiculifera Raineri, 1922

Pl. 27, Figs. 1-2

1922. *Gyroporella prarvovesiculifer* n. sp.; Raineri, p. 38, pl. 13, figs. 17-18

1999. *Thaumatoporella parvovesiculifera* Raineri; Schlagintweit & Ebli, p. 407, pl. 10, fig. 3

2001. *Thaumatoporella parvovesiculifera* Raineri; Taslı, p. 13, pl. III, fig. 12

2001. *Thaumatoporella parvovesiculifera* Raineri; Săsăran *et al*., p. 48, pl. VI, figs. 4-5

2004. *Thaumatoporella parvovesiculifera* Raineri; Şerban *et al*., p. 483, pl. III, fig. 15

2004. *Thaumatoporella parvovesiculifera* Raineri; Schlagintweit, p. 45, pl. II, fig. 3

2005. *Thaumatoporella parvovesiculifera* Raineri; Schlagintweit, p. 537, pl. I, fig. 2, p. 539, pl. II, fig. 3

2005. *Thaumatoporella parvovesiculifera* Raineri; Bucur *et al*., p. 121, pl. 5, fig. 10

2013. Thaumatoporellaceans; Schlagintweit, p. 6, text-fig. 1 a-g, p. 7, text-fig. 2, a-b,

Description & Remarks:

Thaumatoporella parvovesicuifera is characterized by an irregular cyclindrical morphology and perforated wall according to its original description by Raineri (1922). Even though it is commonly interperated as having an algal origin, Flügel (1983) interpreted it as an organism with animal affinities. In the literature, monostromatic cell layers intermingled with and intercorporated into bacinellid crusts were also described as *Thaumatoporella* bridges or ladders (Schlagintweit, 2013). Although these cell layers are sometimes designated into different genus and species names (e.g. genus *Polygonella* with *Polygonella incrustata* type species, *Thaumatoporella occidentalis*) there seems to general consensus in the literature that they represent junior synonyms of *Thaumatoporella parvovesiculifera* (Schlagintweit, 2013). *Thaumatoporella parvovesiculifera* specimes observed in this study are similar to those single layered cells encrsting bacinellid-fabrics.

Stratigraphic range:

Thaumatoporella parvovesiculifera was observed from the Middle Triassic until the Early Cenozoic in the literature (Schlagintweit, 2013). It has been detected from the Berriasian in this study.

Genus *Pseudorothpletzella* Schlagintweit & Gawlick, 2007

Type species: *Pseudorothpletzella schmidi* Schlagintweit & Gawlick, 2007

Pseudorothpletzella schmidi Schlagintweit & Gawlick, 2007

Pl. 27, Fig. 3

2007. *Pseudorothpletzella schmidi* n. gen., n. sp. Schlagintweit & Gawlick; Schlagintweit & Gawlick, p. 597, text-fig. 2/1-2/2, p. 599, text-fig. 5/1, p. 600, text-fig. 6/3, p. 600, text-fig. 7/1, p. 603, pl. 1, figs. 1-6

Description & Remarks:

Pseudorothpletzella schmidi is an encrusting microorganism forming flat to dome shaped juxtaposed sheets. The superimposed layers of tiny tubes are not laterally continuous but are wedging out rapidly. Wall is thin and micritic. Schlagintweit & Gawlick (2007) proposed a possible microbial origin to *Pseudorothpletzella schmidi*. Its affinity to Palaezoic genus *Rothpletzella* was also mentioned by them.

Stratigraphic range:

Stratigraphic range of *Pseudorothpletzella schmidi* is given as ?late Middle Jurassic/Oxfordian to Late Tithonian/Early Berriasian by Schlagintweit & Gawlick (2007). It has been found in the Tithonian in this study.

PHYLUM ANNELIDA LAMARCK, 1809

CLASS POLYCHAETA GRUBE, 1850

ORDER TEREBELLIDA, ROUSE & FAUCHALD, 1997

FAMILY TEREBELLIDAE MALMGREN, 1867

Genus *Terebella* Linnaeus, 1767

Type species: *Terebella lapidaria* Linnaeus, 1767

Terebella lapilloides Münster, 1833

(Pl. 30, Figs. 1-8, Pl. 31, Figs. 1-6, Pl. 32, Figs. 4-5)

Selected synonymy [for further synonymy before 1993 see Schmid (1996)]

1833. *Terebella lapilloides* n. sp.; Münster (In: Goldfuss), pl. 71, fig. 16

1993a. *Terebella lapilloides* Münster; Leinfelder, Nose, Schmid and Werner, p. 206, pl. 41, figs. 1, 3

1995. *Terebella lapilloides* Münster; Hammes, p. 340

1995. Agglutinated worm tubes; Hammes, fig. 7

1996. *Terebella lapilloides* Münster; Schmid, p. 204, 205, fig. 74

1999 *Terebella*; Dupraz and Strasser, pl. 11, fig. 5

1999. *Terebella lapilloides* Münster; Dupraz, p.33, text fig 4.4, pl. 8, fig. 4

1999. *Terebella lapilloides* Münster; Schlagintweit and Ebli, p.382, pl. 1, fig. 5 - pl. 2, fig. 6 - pl. 12, figs. 6-11

2001 *Terebella* sp.; Săsăran *et al*., pl. V, fig. 2

2002 *Terebella*; Dupraz and Strasser, Text fig. 14c

?2003. *Terebella lapilloides* Münster; Olóriz, Reloid and Rodriguez-Tovar, p.536, text fig. 11B

2006. *Terebella lapilloides* Münster; Olóriz, Reloid, Rodriguez-Tovar, p.121 (not figured)

2006. *Terebella lapilloides* Münster; Helm and Schülke, p. 449 (not figured)

2008. *Terebella lapilloides* Münster; Schlagintweit and Gawlick, Text fig. 13a

2010. *Terebella lapilloides* Münster; Bucur *et al*., p. 36 (not figured)

Non 2010. *Terebella lapilloides* Münster; Olszewska, Pl. 1, fig 10

2011. *Terebella lapilloides* Münster; Krajewski, Matyszkiewicz, Król and Olszewska, text fig.4B

2011. *Terebella lapilloides* Münster; Lazăr *et al*., p. 636, text figs. 10e, 10f

Description:

Annelids consisting of an agglutinated tube are grouped under the generic name of "*Terebella*". Being a species of the genus *Terebella*, *Terebella lapilloides* Münster is

quite common in the late Jurassic reefal buildups. In cross section, the tube exhibits an agglutinated wall and the inner tube is filled with either blocky calcite or internal micritic sediments and peloids (Plate 30, Figures 1, 3, 4). The wall of *Terebella lapilloides* consists mostly of fine-grained calcareous particles (Plate 30, Figure 1, 4, 7; Plate 32, Figure 4). In some larger specimens, coarser particles such as foraminifera and peloids are also observed as agglutinated wall materials (Plate 32, Figure 3). Those larger forms are most probably among the hitherto undefined species of *Terebella*. The largest inner tube diameter obtained for these ill-defined forms is 925 µ. Data obtained from biometric measurements were utilized for the preparation of the frequency distribution histograms by STATISTICA version 8.0 (Figure 27, 28 and 29). As can be seen from Figure 28, the inner tube diameters vary between 675 µ and 131 µ and the mean for the inner tube diameter is 364 µ. The distribution of the wall thickness is between the range of maximum 250 µ and minimum 36 µ in thickness, and the mean is 71 µ (Figure 29). There is a general tendency for the forms having smaller inner tube diameters to have thinner walls and this positive correlation between the diameter of the inner tube and the wall thickness can be seen in Figure 30. The maximum length determined from the longitudinal sections is 1709 µ (1.7 mm).

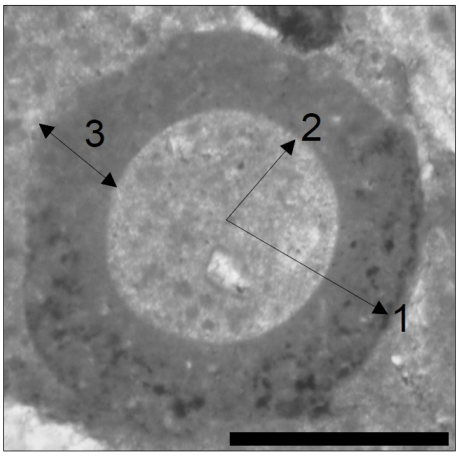


Figure 27 Parameters used for the biometric measurements of *Terebella*. 1: Outer wall diameter, 2: Inner wall diameter, 3: wall thickness. Bar scale: 500µ

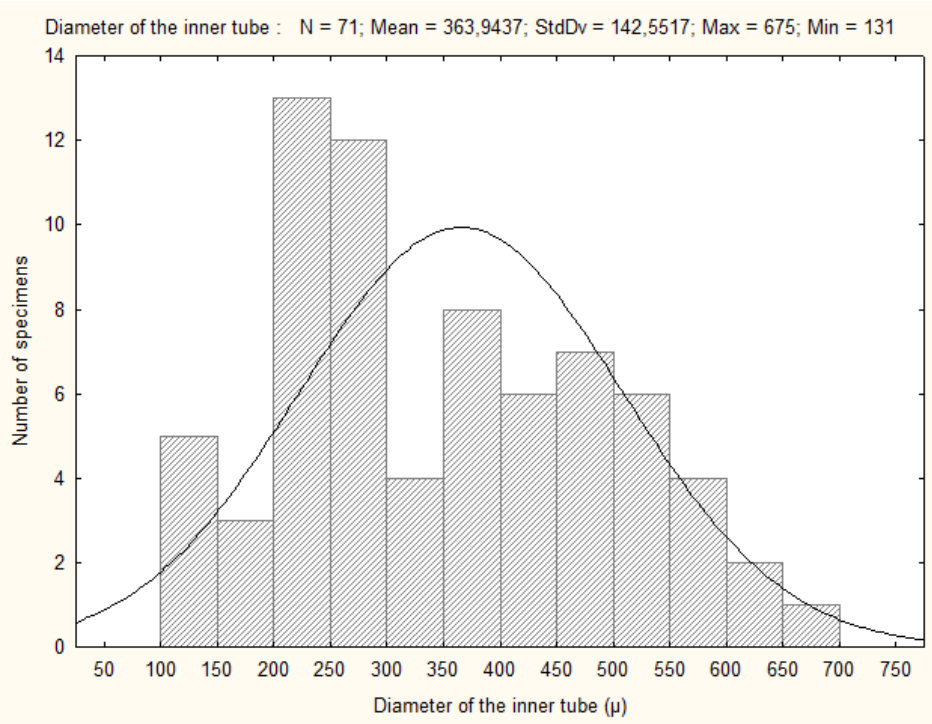


Figure 28 Histogram and normal curve of the frequency distribution of inner tube diameter

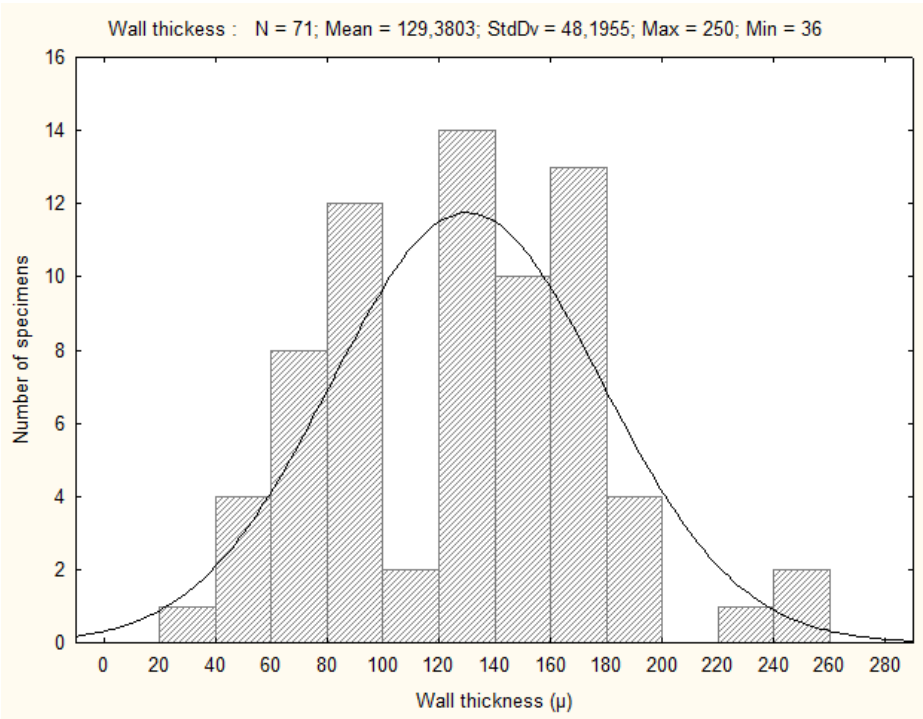


Figure 29 Histogram and normal curve of the frequency distribution of the wall thickness

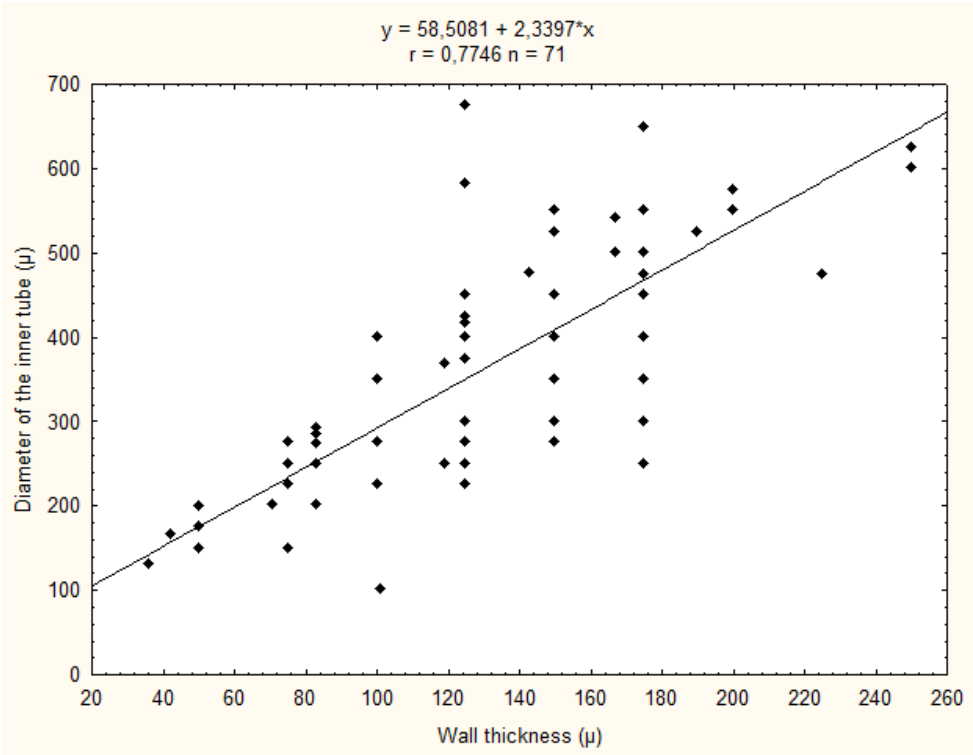


Figure 30 Scatter plot for the wall thickness and inner tube diameter

Table 5 Comparison of the biometric measurements of *Terebella lapilloides* in the literature with the ones in this study

	Brachert (1986)		Helm and Schülke (2006)	Schlagintweit and Ebli (1999)	Olóriz *et al.* (2003)	This study
Outer tube diameter	**6 mm (*max*)**	**1 mm (max)**	**1 – 3 mm**	**0.6 – 0.76 mm**	**1 cm**	**1.125 mm (max)**
Max. length	**-**	**-**	**-**	**1.1 mm**	**12 cm**	**1.7 mm**
Wall thickness	**1 mm (max)**	**0.1 mm (max)**	**-**	**0.25 – 0.3**	**-**	**0.25 mm (max)**

Remarks:

Previously *Terebella lapilloides* has been related to different organisms. Schorr & Koch (1985) described it as a microproblematic organism, whereas Flugel and

Steiger (1981) interpreted it as an agglutinated boring. Jansa *et al*. (1972), on the other hand, described it as allogromide foraminifera. Klieber (1985) with a different interpretation identified it as the agglutinating worm *Terebella lapilloides*.

Hammes (1995) reported the preferential association of *Terebella lapilloides* with peloidal crust and sponge skeletons in the late Jurassic sponge mud-mounds. He observed that the inner tubes are filled with either blocky calcite cement, micritic internal sediment, peloids or geopetal calcite and micritic internal sediment. Brachert (1986) distinguished two types of *Terebella lapilloides* by their size and coarseness of the wall material used. The first tube type has a large, coarse agglutinated wall with 1 mm thickness, and its diameter is up to 6 mm. The second tube type has a small, very fine grained agglutinated wall, up to 0.1 mm thickness, with a diameter up to 1 mm. Helm & Schülke (2006) also determined the variations in tube diameter from 1mm to around 3 mm. Schlagintweit & Ebli (1999), from their Berriasian aged specimens, identified two varieties of *Terebella lapilloides* that differ in the dimensions of their outer and inner tube diameters. Olóriz *et al*. (2003) state the occurrence of larger forms of *Terebella lapilloides* which can attain a diameter of 1 cm and a length of 12 cm (See Table 3 for the comparisons of the measurements with the ones in this study).

Dupraz (1999) reported that *Terebella lapilloides* in most cases prefer to agglutinate aluminosilicates to build its tube. He also noted the existence of other forms which agglutinate various elements such as ooids, quartz grains or spicules of sponge rhaxellide. Similarly, Helm & Schülke (2006) observed a few large arenaceous tubes agglutinating ooids, peloids, formainifera, and spiculae.

First discovery of *Terebella lapilloides* in Turkey is documented by Kaya & Altıner (2014). They also discuss about its paleoenvironmental and paleoecological significance and present a detailed review.

Stratigraphic range:

Stratigraphic range of *Terebella lapilloides* is Late Triassic to Early Cretaceous (Berriasian). It has been detected from the Kimmeridgian – Berriasian interval along the studied section.

PHYLUM PORIFERA GRANT, 1872

CLASS DEMOSPONGIAE SOLLAS, 1885

ORDER HADROMERIDA TOPSENT, 1894

FAMILY CHONDROSIIDAE SCHULZE, 1877

Genus *Calcistella,* Reitner, 1991

Type species: *Calcistella tabulata,* Reitner, 1991

Calcistella jachenhausenensis, Reitner 1992

Pl. 21, Figs. 1-4, Pl. 22, Figs. 1-3

1992. *Calcistella jachenhausenensis* n.sp., Reitner; Reitner, pl. 24, figs. 3-6

2008. *Calcistella jachenhausenensis*, Reitner; Schlagintweit & Gawlick, p. 215, text-fig. 6d, f

2013. *Calcistella jachenhausenensis*, Reitner; Pleş *et al*., p. 28, text-fig. 7a, p. 31, text-fig. 8e

Description:

One of the diagnostic features of this encrusting sponge is the dense packing of the euasters which form its primary skeleton. The organic tissue is divided into vertical tubes. Densely packed euasters are 40-60 μ in diameter. These euasters are packed tightly in the organic tissue. Primary skeleton also consists of vertical and radial tubes. Secondary calcareous skeleton is characterized by the organic skeleton and it has similarities with stromatoporoid organization. Secondary skeleton is dominated by vertical elements, horizontal elemets are rare.

Remarks:

Reitner (1992) differentiates *Calcistella jachenhausenensis* from *Calcistella tabulata* by the almost complete absence of the tabulae, by the presence of a different channel system and by the dense packing of the euasters. He aslo mentions about the similarities with the wall structure of the Devonian stromatoporoids.

Stratigraphic range:

Calcistella jachenhausenensis is an index fossil for the Tithonian according to Pleş *et al*. (2013). In this study it has also been identified in the Tithonian.

PHYLUM PORIFERA GRANT, 1872

CLASS CALCAREA? BOWERBANK, 1864

ORDER ASPICULATA RIGBY & SENOWBARI-DARYAN, 1996

SUBORDER INOZOIDA RIGBY & SENOWBARI-DARYAN, 1996

FAMILY?

Genus *Sarsteinia,* Schlagintweit & Gawlick, 2006

Type species: *Sarsteinia babai,* Schlagintweit & Gawlick, 2006

Sarsteinia babai, Schlagintweit & Gawlick, 2006

Pl. 23, Figs. 1-3

2006a. *Sarsteinia babai* n.sp., Schlagintweit & Gawlick; Schlagintweit & Gawlick, p.254, pl. 1, figs. 1-8, pl. 2, figs. 1-6

Description:

This sponge has massive-encrusting growth with irregular shapes. According to its original description by Schlagintweit & Gawlick (2006), the skeleton does not possess a prominent central cavity (spongocoel). It is penetrated by several coarse canals which are propbably used as exhalant canals. In our identified fragmental specimens those canals are not observed. Shape of the skeletal micritic fibres is irregulary vermiform (Worm-like, i.e. no clear distinction into vertical and horizontal elements). In cross-section shape of the pores are rounded to slightly polygonal.

Remarks:

Due to the lack of segmentation and a single central spongocoel and due the presence of the canals that pass through the sponge body Schlagintweit & Gawlick (2006) considered it as comparable to non-spiculated sponges.

Stratigraphic range:

Sarsteinia babai has been found in Kimmeridgian to Tithonian strata in Schlagintweit & Gawlick (2006). They also mentioned about its possible wider range between Oxfordian and Berriasian which can be identified elsewhere. In our studied section it has been defined from the Tithonian.

CHAPTER 5

GLOBAL CORRELATION OF THE NORTHERN TETHYAN JURASSIC-CRETACEOUS BOUNDARY SECTIONS

5.1 J/K Boundary Sections around the World

The Jurassic-Cretaceous (J-K) boundary is one of the most problematic boundaries on the geological time scale. Due to the absence of well-defined widely correlatable biostratigraphic levels and chemical and physical markers to fix the base of the Berriasian, the J-K boundary has not been defined by a Global Stratotype Section and Point (GSSP) until now (Dzyuba *et al*., 2013). During the last decades, numerous studies dealing with the Tethyan J/K boundary sections from different countries were carried out and published. Most of these studies also indicate the problem of proposing the possible J/K boundary stratotype which results from (1) the absence of global index fossils and (2) global sea level drop, (3) paleogeographic changes causing occurrence of isolated faices and (4) from the effect of Late Cimmerian Orogeny (Michalík & Reháková, 2011).

Since the first assignment of Portlandian and Purbeckian as two stages which mark the end of the Jurassic system by Brogniart (1829) this boundary interval became a matter of controversies. Although Ammonite, some microfossils (mainly calpionellids) and nannofossil zonations have been selected to fix this boundary (d'Orbigny 1842-1851; Hoedemaeker *et al*., 1993; Hoedemaeker, 1995; Allemann *et al*., 1971; Remane *et al*., 1986; Özkan, 1993) none of them is unanimously accepted (Houša *et al*., 2007). On the other hand, magnetostratigraphy has been successfully used across the boundary interval. Magnetic polarity zones are relatively easy to be identified, due to specific pattern of two long normal magnetozones (M20n and M19n) (Michalík & Reháková, 2011). Recently, a tentative poroposal has been given

by the Berriasian Working Group at the International Subcomission on Cretaceous Stratigraphy (ISCS) which determines the potential primary markers of J/K boundary as (1) the base of the Calpionella zone – Alpina Subzone which is characterized by an explosion of small, globular *Calpionella alpina*; (2) FADs of nannofossils *Nannoconnus steinmannii minor* and *Nannnoconus kamptneri minor*; and (3) the base of M18r magnetozone (Wimbledon *et al*., 2011).

This chapter aims to analyze some Tethyan boundary sections from different countries (together with one none-Tethyan section from Japan) and correlate them with our studied J-K section from Northern Turkey in terms lithological differences and similarities. Similarities and differences of the faunal/floral contents of the boundary sections will also be considered. The following boundary sections will be briefly introduced and discussed in the following pharagraphs; (1) boundary section of Vâlcan Mountains from Southern Carpathians, Romania (Michetiuc *et al*., 2012); (2) boundary section of Mount Plassen area from Austria (Gawlick & Schlagintweit, 2006); (3) boundary section of the Torinosu Group from Japan (Shiraishi & Kano, 2004); (4) sections from Yalta and Ay-Petri massifs from Crimea Mountains, Southern Ukraine (Krajewski, 2010); (5) Boundary section of the Sănduleşti Formation from Romania, (Săsăran *et al*., 1999); (6) section of Mateiaş Limestone from Romania (Bucur *et al*., 2010); (7) Boundary section from Hodobana-Gârda Seacă area (Bihor Mountains) from Romania (Turi *et al*., 2011); (8) Boundary sections of Lyalintsi and Velinovo areas from Bulgaria (Ivanova *et al*., 2008); (9) Sections from the Russian Western Caucasus (Guo *et al*., 2011); (10) Barlya section from Western Balcanides, Bulgaria (Lakova *et al*., 1999); (11) Boundary sections from North-Western Anatolia, Turkey (Altıner *et al*., 1991) (See Figure 31 for the location of the examined sections).

Figure 31 Locations of the investigated boundary sections in the World. (Numbers in parenthesis correspond to the sections studied in these regions. For the numbers assigned to the sections, see p. 140).

5.1.1 Boundary section of Vâlcan Mountains from Southern Carpathians, Romania

As mentioned by Pop & Bucur (2001) and Michetiuc *et al*. (2012), Upper Jurassic in the Valcan Mountains is represented by three formations: (1) the Valea Pragurilor Formation (Oxfordian) – a calcarenitic sequence with dolosparites, (2) the Valea Cheii Formation (Upper Oxfordian – Lower Kimmeridgian) – a silisiclastic formation with regressive character and (3) the Topeşti Formation (Kimmeridgian – Tithonian). Transgressive Topeşti Formation consists of shallow-water carbonate deposits dominated by black, dolosparitic calcarenites and calcilutites. Fossil assemblage found in the Topeşti Formation includes *Megaporella boulangeri*, *Salpingoporella annulata*, *Clypeina sultaca*, *Parurgonina caelinensis*, *Kurnubia palastiniensis*, *Neokilianina rahonensis*, *Labyrinthina mirabilis*, *Favreina* cf. *tabasensis* and charphyte gyrogonites.

On top of the Topeşti Formation, Urgonian limestones of Izvarna Formation (Barremian – Aptian) crops out. Carbonates of Izvarna Formation are commonly bedded to massive grayish limestones (Figure 33A).

Discontinous outcrop of Berriasian-Valanginian limestone with grainstone texture in Sudoeiş valley was also identified and described by Pop & Bucur (2001). Despite their identification they preferred to draw an unconformable surface between the Topeşti Formation (Kimmeridgian – Tithonian) and the Isvarna Formation (Barremian – Lower Aptian) with a question mark. We preferred to use a similar illustration with an unconformable surface between Topeşti and Isvarna Formations.

It is interpreted that facies/lithologies of the Upper Jurassic and Lower Cretaceous formations and the relations between them indicate an emergence of a structural high during the corresponding time interval (Pop & Bucur, 2001). This structural high was gradually segmented and block faulted by further extensional tectonics according to Pop & Bucur (2001).

5.1.2 Boundary section of Mount Plassen area, Northern Calcareous Alps from Austria

In the Mount Plassen area Kimmeridgian to Lower Berriasian is represented by Plassen Formation. Carbonates of the Plassen Formation are the products of the first carbonate platform in the Northern Calcareous Alps since the Late Triassic (Gawlick & Schlagintweit, 2006). The type locality of the Plassen Formation is Mount Plassen near Hallstatt in the Austrian Salzkammergut. Studies of the Plassen Formation at different localities revealed that Plassen Formation may show specific depositional environments and stratigraphic ranges at those different localities (Gawlick & Schlagintweit, 2006). According to Gawlick & Schlagintweit (2006) the Plassen carbonate platform can be interpreted as an isolated intraoceanic platform surrounded by deep water carbonate clastic radiolaritic flysch basins.

As described by Gawlick & Schlagintweit (2006), Upper Tithonian of Plassen Formation is represented by restricted lagoon and back reef facies including different types of wackestones with dasyclads and benthic foraminifera, stromatoporoids, mudstones, gastropod wacke- to floatstones, packstones and *Bacinella* bindstones.

The Jurassic-Cretaceous boundary is then marked by the occurrence of platform margin facies including coral-stromatoporoid limestones with few foraminifera. In the Lower Berriasian, platform margin deposits pass into slope deposits with bryozoans, brachiopods, echinoids, *Crescentiella* and reef debris (Figure 32A). Based on this vertical shift in microfacies and depositional environments it can be concluded that neritic to pelagic sedimentation change took place during the Berriasian (Gawlick & Schlagintweit, 2006).

Radiomura cautica, *Koskinobullina socialis*, *Crescentiella morronensis*, *Iberopora bodeuri*, serpulids, bryozoa, encrusting foraminifera, *Terebella lapilloides*, *Calcistella jachenhausenensis*, *Bullopora* sp. are the most commonly observed microencrusters in the Northern Calcareous Alps.

5.1.3 Boundary section of the Torinosu Group from Japan

In the southwest Japan, successions containing uppermost Jurassic – lowermost Cretaceous limestones are widespread and Torinosu Group has the widest distribution among those successions (Shiraishi & Kano, 2004). It consists of a mixture of siliciclastics and carbonates. Matsuoka (1992) interpreted that the Torinosu group was deposited in a forearc basin upon a Mesozoic accretional wedge.

Torinosu Group is usually subdivided into the Tsukadani Formation – including siliciclastics - (Kimmeridgian-Tithonian) and the Yatsuji Formation (Tithonian-Berriasian) which is composed of mudstones and limestone units (Shiraishi & Kano, 2004).

Torinosu limestone unit is thickly bedded and consists of mainly bioclastic packstone-wackestone according to Shiraishi & Kano (2004). The basal parts include more siliciclastic than the upper parts (Figure 33A). Bioclasts are corals, stromatoporoids, microencrusters, molluscs, brachiopods and echinoderm remains. Upward in the section corals and stromatoporoids increase in frequency and they can be found in their growth positions (Shiraishi and Kano, 2004).

The microencruster association of Torinosu limestone is composed of *Bacinella irregularis*, *Lithocodium aggregatum*, *Thaumatoporella parvovesiculifera*,

Koskinobullina socialis, *Iberopora bodeuri*, *Girvanella* sp. and *Crescentiella morronensis*.

5.1.4 Sections from Yalta and Ay-Petri massifs from Crimea Mountains, Southern Ukraine

Study of Krajewski (2010) deals with the Upper Jurassic (Kimmeridgian-Tithonian) – Lower Cretaceous (Lower Berriasian) sediments in the southwestern part of the Crimean Mountains (Yalta and Ay-Petri massifs, southern Ukraine). Previously noted presence of Oxfordian deposits in that area was not confirmed by Krajewski (2010). In the same study, evoulution of the Crimean carbonate platform was interpreted in three main stages as below: (1) platform slope setting during Kimmeridgian-Tithonian, (2) platform margin reefs, ooidal shoals and internal platform facies during Tithonian and (3) open/restricted internal platform during Tithonian – Lower Berriasian. Ay-Petri Massif includes mainly platform margin reef complex facies with sponges, algae, corals, microbialites and microencrusters. The Yalta Massif on the other hand, is represented mostly by internal platform facies. Parts of the studied sections including J-K boundary from the study of Krajewski (2010) will be introduced briefly in the following pharagraphs.

5.1.4.1 KA/KB sections from Ay-Petri massif

Upper Tithonian in the KA and KB sections is represented by platform margin reef and ooidal facies (Figure 33A). Framebuilding corals and sponges, micorbialites and oncoids were observed in this platform margin facies. Before the Tithonian – Berriasian boundary a change in the depositional environments – from platform margin facies to back reef and lagoonal facies – was observed. In the back reef and lagoonal facies commonly mirobialites and oncoids with *Bacinella* were identified.

5.1.4.2 KC section from Ay-Petri massif

KC section shows similar facies development and biota content during the Upper Tithonian and Lower Berriasian with KA and KB sections (Figure 33A). Upper Tithonain is mostly represented by platform margin reefs and ooid and back-reef facies whereas Berriasian includes back reef and lagoonal facies.

5.1.4.3 KE section from Ay-Petri massif

KE section includes lagoonal and intertidal facies during the Upper Tithonian and Lower Berriasian (Figure 33A). Macrofossils are rare wheresas *Bacinella*-bindstones and oncoids are common. Intertidal facies are characterized by numerous fenestral structures and cavities filled with vadose silt. The internal platform sponge *Cladocorapsis* (indicating open lagoonal environments) was observed frequently.

5.1.4.3 KF section from Ay-Petri massif

KF section represents a monotonous development during the Upper Tithonian and Lower Berriasian. Lagoonal and intertidal facies were observed with benthic foraminifera, microbialites, oncoids, gastropoda and internal platform sponges (e. g. *Cladocorapsis*) (Figure 33B).

5.1.4.4 KG section from Ay-Petri massif

Like KF section KG section has monotonous facies development and lagoonal and intertidal facies represents the Upper Tithonian and Lower Cretaceous deposits. Common fossil biota includes benthic foraminifera, microbialites, corals and internal platform sponges (Figure 33B).

5.1.4.5 KJ section from Yalta massif

KJ section is represented by internal platform and lagoonal microfacies during the Upper Tithonian and Lower Berriasian (Figure 33B). Other than the pure limestone textures KJ section also includes some shallow-marine limestones with silicilastics (marly limestones). J-K boundary is represented by a shift from coral, sponge and microbialite bearing boundstone texture to foraminifera bearing mudstone-wackestone texture.

5.1.4.6 KM section from Yalta massif

Upper Tithonian – Lower Berriasian sediments from KM section were interpreted as products of internal platform deposition based on the fossil assemblages and microfacies. Wackestone-packstones with benthic foraminifera and oncoids are the

common microfacies defined from the Upper Tithonian and Lower Berriasian deposits (Figure 33B).

5.1.4.7 KN section from Yalta massif

Upper Tithonian – Lower Berriasian deposits of KN section has similar microfacies and fossil content with the corresponding deposits of KM section. Wackestone and packstone textures bearing benthic foraminifera and oncoids were observed along the part of the section including the J-K boundary (Figure 33B).

5.1.4.8 KO section from Yalta massif

Upper Tithonian – Lower Berriasian is represented by the deposits of the lagoonal environment of the internal platform along the KO section. Mudstones and wackestones intercalating with marly limestones were observed for the Upper Tithonian part. Benthic foraminifera, echinoids and gastropoda are the observed fossils in the mudstone-wackestone textures. Boundstone texture with microbialites, microencrsuters, sponges and corals were defined from the Lower Berriasian part of the KO section (Figure 33B).

5.1.4.9 KR section from Ay-Petri massif

A facies shift from platform margin reefs and back reef facies to lagoonal facies was observed for the Upper Tithonian – Lower Berriasian part of the KR section (Figure 33C). That shift was characterized by a change from massive carbonates to bedded ones in the outcrop scale. Platform margin and back reef facies include oncoids, sponges and corals, and microbialites. Bedded lagoonal deposits have abundant oncoids, sponges, corals, microbialites and benthic foraminifera.

5.1.5 Boundary section of the Sănduleşti Formation from Romania

Northern margin of the Trascău Mountains is represented by the Upper Jurassic – Lower Cretaceous limestones in Romania (Săsăran *et al*., 1999). Those carbonates are separated into two units as Sănduleşti Formation (Upper Oxfordian – Lower Berriasian) and Petridu Formation (Upper Berriasian – Valanginian). Săsăran *et al*., (1999) described the microfacies - microfossil association and the sedimentary

evolution of the Sănduleşti Formation. As illustrated in thier study, section through the Sănduleşti Formation in Cheile Turzii area includes reefal carbonates and oncolithic limestones in the Upper Tithonian part. Reefal carbonates indicating shelf edge are characterized by corals, microbialites and oolithes mainly. Reefal carbonates with a considerable thickness suggest a constant vertical accretion which results in gradual decrease of accommodation space (Săsăran *et al*., 1999). Oncolithic limestones deposited in this decreased accommodation space. Oncolithes, oolithes and green algae were identified from the oncolithic limestones. Above the oncolithic limestones, at the J-K boundary a regional unconformity was observed. On that unconformable surface, freshwater limestones were laid down during early Berriasian. Above the fresh water limestones, bioclastic packstones/wackestones containing green algae, microbialites and oolithes were observed (Figure 33C).

5.1.6 Boundary section of Mateiaş Limestone from Romania

Mateiaş Limestone is a component of the the eastern part of the Getic carbonate platform (Bucur *et al*., 2010). A Kimmeridgain to possible lower Tithonian age was assigned to the Mateiaş Limestone according to its microfossil content by Bucur *et al*. (2010). In the same study, they concluded that Mateiaş Limestone is represented by coral-microbial carbonates associated with hemipelagic and turbiditic carbonates. They also interpreted that this association of carbonates indicates a fore-reef - slope depositional environment. Reefal limestones representing massive structure in the field are defined as coral-microbialite boundstones by Bucur *et al*. (2010). Association of encrusters (*Crescentiella morronensis*, *Radiomura cautica* and *Koskinobullina socialis*) and worm tubes (*Terebella lapilloides* and *Mercierella dacica*) with coral-microbialite boundstones are common. Overlying unconformably the reefal and associated turbiditic limestones are the Cretaceous carbonate and silisiclastic conglomerates (Figure 33C). Upper Tithonian deposits are missing along the section according to Bucur *et al*. (2010).

5.1.7 Boundary section from Hodobana-Gârda Seacă area (Bihor Mountains) from Romania

Turi *et al*. (2011) carried out a study on the Upper Jurassic – Lower Cretaceous limestones of the Bihor autochtonous unit near Hodobana Village along the Gârda Seacă Valley and they described three types of facies (external marginal, subtidal and peritidal) for the Upper Jurassic and two types of facies (coastal-peritidal and open shelf) for the Lower Cretaceous. In their generalized stratigraphic section J-K boundary is represented by an unconformity and bauxitic deposits which contain boulders of Jurassic limestones, plaeosols, lacustrine limestones and paleokarst filling (Figure 33C). This bauxitic deposits in the Bihor Mountains can be related to a regional uplift of the area during the Late Jurassic as noted by Ianovici *et al*. (1976).

5.1.8 Boundary sections of Lyalintsi and Velinovo areas from Bulgaria

Ivanova *et al*. (2008) studied the microfacies, biostratigraphy and platform evolution of the western part of the Moesian Platform by analyzing Upper Jurassic – Lower Cretaceous sections from SW Bulgaria. They divided the evolution of the carbonate platform into two stages. First mobile stage (during Late Kimmeridgian to Tithonian – Berriasian boundary) was affected by relative sea level fluctuations related to local tectonics. Occurrence of *Saccocoma* bearing limestones intercalated with reefal carbonates was interpreted as evidence for the interruption of reef development by rising sea level. During the second stable stage (Berriasian to Valanginian), due to the high carbonate production and decrease in the accommodation space, reef development diminished and carbonate production extended to distal parts of the platform.

Among the studied sections Lyalintsi and Velinovo sections are the ones including the J-K boundary. In the Lyalintsi section, Upper Tithonian - Lower Berriasian is represented principally by reefal and peri-reefal limestones (Figure 33C). No distinct change/shift in facies can be detected from the J-K boundary. Intervals of main coral reefs characterized by coral-microbial biostromes are present both in the Upper Tithonian and Lower Berriasian. Velinovo section on the other hand is characterized by inner platform deposits (lagoon and intertidal) (Figure 33C). A monotonous succession including grainstones with benthic foraminifera, algae, coated grains and

fenestral structures can be observed during the Upper Tithonian – Berriasian in the Velnovo section.

5.1.9 Boundary sections from the Russian Western Caucasus

The Russian Western Caucasus is divided into tectonostratigraphic zones and subzones having different Upper Jurassic stratigraphies (Guo *et al*., 2011). Guo *et al*. (2011) studied Upper Jurassic successions in the 6 of these tectonostratigraphic zones. Deeper water facies of the Greater Caucasus Basin were examined in the Abino-Gunayskaya zone, Chezhipsinskaya zone and Nevebskaya subzone whereas reefal facies were encountered in the shallow water Labinskaya (during Oxfordian-Early Kimmeridgian), Lagonakskaya and Akhtsu zones at the margins of the Greater Caucasus Basin by Guo *et al*. (2011).

5.1.9.1 Boundary section from Labinskaya Zone

Tithonian is represented by a lower evaporitic unit intercalated with marls and clays on top of dolostones and an upper lagoonal clastic unit in the Labinskaya Zone according to Guo *et al*. (2011). An unconformable surface lies on top of the lagoonal clastic unit at J-K boundary. Berriasain starts with a hiatus and then is represented by carbonates and interlayered mudstones and sandstones (Figure 33D).

5.1.9.2 Boundary section from Lagonakskaya Zone

Reefal limestones of Lagonakskaya Formation were observed along the Tithonian part of the section. Reefal limestones were conformably overlained by Berriasian oolitic and micritic limestones of the Balki Sukhoy unit according to Guo *et al*. (2011) (Figure 33D).

5.1.9.3 Boundary section from Abino-Gunayskaya Zone

Tithonian and Early Berriasian were represented by mainly slope deposits with detrital talus, gravity-flow-emplaced limestone blocks and interbedded marls-mudstones accorindg to Guo *et al*. (2011). After an erosion surface in the Early Berriasian, section continues with a transgressive sequence of conglomerates, sandstones, mudstones, limestones (Figure 33D).

5.1.9.4 Boundary section from Nevebskaya Subzone

Stratigraphic section of Nevebskaya subzone includes deep-water/slope deposits of the Greater Caucasus Basin for the Oxfordian and Kimmeridgian parts. Tithonian and Early Berriasian deposits are represented by mainly clastics which are again associated with basinal deposits (Figure 33D).

5.1.9.5 Boundary section from Chveshipsinskaya Zone

According to Guo *et al*. (2011) succession of Chveshipsinskaya Zone represents a possible upward transition from inner carbonate platform to outer platform-basin environments. Tithonian micritic limestone and mudstone alternation, displaying the inner carbonate platform depositional character, was observed until the Early Berriasian. Then the deposits of the outer platform/basin were seen as mainly clastics with micritic limestones (Figure 33D).

5.1.9.6 Boundary section from Akhtsu Zone

Tithonian was represented by reefal limestones in which the principal framebuilder organisms are corals and calcisponges. Upper Tithonian part of the succession contains intertidal-supratidal bioclastic limestones, abundant fenestral grainstone-packstones and algal packstones. J-K boundary was represented by an erosional surface and the later deposition could not be observed in Akhtsu Zone (Figure 33D).

5.1.10 Barlya section from the Western Balcanides, Bulgaria

Barlya section from the Western Balcanides was studied by Lakova *et al*. (1999) in terms of its calpionellid, nanofossil and calcareous dinoflagellate content. They determined the J-K boundary at the base of *Calpionella* zone by the explosion of *Calpionella alpina* and the last occurrence of *Calpionella elliptalpina*. Barlya section, very close to Bulgarian-Serbia border, provides an uninterrupted stratigraphic Kimmeridgian to Hauterivian succession. J-K boundary appears in the Upper Tithonian – Lower Berriasian Glozhene Formation which is mainly composed of grey micritic limestones (Figure 33E). Very thin marly interbeds occur randomly and separate micritic limestone beds. Above the Glozhene Formation, irregular alternation of micritic limestones, clayey limestones and marls (deposits of Salash

Formation) was observed. Below the Glozhene Formation, red limestones of Gintsi Formation appear in the Early and Middle Tithonian. These deposits observed in the aforementioned 3 formations were interpreted as the deposits of the slope and basinal enironments of the Late Jurassic - Early Cretacous basin in the West Balkan tectonic unit by Lakova *et al*. (2008).

5.1.11 Boundary sections from North-Western Anatolia, Turkey

A detailed stratigraphical study of Jurassic-Lower Cretaceous successions of the southern part of the North-Western Anatolia was carried out by Altıner *et al*. (1991). Their study covers the Edermit-Balya, Bursa, Bilecik, Mudurnu-Nallıhan-Beypazarı and Aktaş-Çerkeş regions. In addition to the detailed stratigraphical work, they also disucussed the evolution of the extensive Bursa-Biga-Bilecik carbonate platform and that of the Mudurnu trough. During Tithonian, an ongoing uplift since Kimmeridgian in the Edremit-Biga-Bursa-Bilecik regions caused domination of regressive type carbonate deposits in the successions of these regions. Regressive carbonate type deposits with similar evolution were also observed in the Aktaş-Sekinindoruk (Çerkeş) high. Olistoliths and olistostromes of the shelf and slope deposits invaded the Nallıhan and Beypazarı regions of the Mudurnu trough, whereas Mudurnu region was represented by calciturbidites of distal character (Altıner *et al*., 1991).

During Berriasian in the Edremit-Biga-Bursa-Bilecik regions same regressive carbonate type deposition prevailed with occasional cyclic sedimentation of subtidal and supratidal deposits. Reefal areas and their associated facies became extremely narrow. The grain size of the carbonate deposits in the Mudurnu trough became finer and deposition of the calpionellid micrites commenced. Algal boundstones or subtidal to tidal deposits were observed in the Aktaş and Sekinindoruk (Çerkeş) areas, respectively (Altıner *et al*., 1991).

Parts of the studied sections including J-K boundary from the study of Altıner *et al*. (1991) will be introduced briefly in the following pharagraphs.

5.1.11.1 AB section from Aktaş (Gerede) Area

Tithonian is represented by dolomites and bioclastic high energy limestones which are packstones, grainstones and wackestones rich in dasyclad algae, *Favreina*, diceratid rudists and gastropods. Altıner *et al*. (1991) interpreted that the observed dolomites have probable hydrothermal origins relating to volcanism in the Kimmeridgian. Early Berriasian includes laminated limestones with dasyclads and bivalves. Above laminated limestones, intraclastic and dascyclad algal packstones were observed (Figure 33E).

5.1.11.2 A section from Aktaş (Gerede) Area

Tithonian is represented by high energy limestones in the A section. These limestone levels are bioclastic, pelletic, oolitic and fossiliferous packstones – grainstones with *Crescentiella* and dasyclad algae. Berriasian starts with reefal limestones and then continues with oncolitic or bioclastic packstone, grainstone and algal boundstone facies. *Lithocodium* is abundant in the algal boundstones and it sometimes shows various growth patterns with *Koskinobullina*, bryozoans and other blue-green algae (Figure 33E). Bioclastic limestones and *Lithocodium* boundstones observed in this section are interpreted as platform margin deposits by Altıner *et al*. (1991).

5.1.11.3 AH section from Aktaş (Gerede) Area

The interpreted platform margin, on which the deposits of section A were laid down, provided the calciturbiditic materials observed in the section AH. Both Tithonian and Berriasian are represented by calciturbidites with calpionellids. The intercalation of detritic limestones with turbiditic breccias in the early Tithonian was observed (Figure 33E).

5.1.11.4 AÇ section from Aktaş (Gerede) Area

Turbiditic detritics and breccia containing green tuffaceous material and basaltic rock fragments have been observed in the Tithonian portion of the section. Fine detritic limestones are intercalated with marls and micritic limestones. In the uppermost Tithonian, slump structures have been observed. Berriasian deposition starts with turbiditic detritics and breccias at the J-K boundary. Above the detritics, sometimes

silicified, micritic and marly limestones appear in the Berriasian portion of the section (Figure 33E).

5.1.11.5 GO section from Bayırköy-Günören (Bilecik) Area

GO section includes an alternation of boundstones and grainstones in the Tithonian-Berriasian portion. The boundstones are rich in corals, stromotaporoids, echinoids and bryozoa. Reefal cavities are generally filled with bioclastic grainstones (Figure 33E).

5.1.11.6 Bİ-K section from Kınık (Bilecik) Area

Oncolite and nerineid gastropod rich limestones constitute the lower portion of the Tithonian – Berriasian section. Observed facies of these limestones are oncolitic, oolitic and pelletic packstones, oncolitic mudstone to grainstone and bioturbated and pelletic mudstone facies. Upper part of the section is mainly characterized by stromatolitic limestone levels. Facies of this upper part consists of bioturbated mudstones, laminated, pelletic and birdseye mudstones and oncolitic geainstones (Figure 33F).

5.1.11.7 ÇS section from Çerkeş Area

The Lower Tithonian portion of the section is characterized by micritic and pelmicritic limestones with bivalves. Above this level dolomitic limestones with iron-rich veins of hydrothermal origin occur. Then pellet, clast, oncolite and dasyclad algae rich packstones and grainstones follow the dolomitic limestones. These high energy limestones contain the J-K boundary. Early Berriasian is represented by dasyclad algae wackestones. Oolitic and intraclastic packstones and grainstones overlie the dasyclad algae wackestones in the Upper Berriasian portion of the section (Figure 33F).

5.1.11.8 ÇDS section from Çerkeş Area

Lower Tithonian portion of the ÇDS strats with stromatoporid rich boundstones and continues with micritic limestone level and micritic clast rich, dasyclad algal grainstones. Intraclastic mudstones-packestones with birdseyes and dasyclad algal

wackestones constitute the Middle Tithonian portion of the section. The Upper Tithonian – Lower Berriasian portion includes grainstones containing limestone clasts, oolites and volcanic rock fragmnets. Above the high enrgy limestones, an abrupt facies change into pelagic limestones with calpionellids has been observed (Figure 33F).

5.1.11.9 MK1 section from Mudurnu Area

Tithonian was represented by argillaceous limestones composed mainly of mudstones with fine detritics of volcanic origin. This argillaceous limestone unit includes the J-K boundary. Starting from the earliest Berriasian, MK 1 section passes into calpionellid packstones rich in silt and sand size pellets and inraclasts. Mudstones and breccioid limestones are interbedded with this Berriasian calpionellid and radiolaria bearing unit (Figure 33F).

5.1.11.10 MK2 section from Mudurnu Area

Tithonian is partly represented by calpionellid packstones containing pseudooolitic, oolitic clasts in the MK 2 section. This fine detritic limestone at the bottom of the section includes the J-K boundary. Similar lithologies have been observed for the Berriasian portion of the MK 2 section with corresponding portion of MK 1 section (Figure 33F). The uppermost slump structure together with the observed lithologies in the section indicates a tectonically unstable environment.

5.2 Correlation and discussion of some boundary sections

Locations of the examined sections within the paleogeographic configuration during the Late Jurassic (150 Ma) can be seen in Figure 32. As can be inferred from this figure, all these sections examined were located in the Laurasian part of the of the Late Jurassic configuration. Both the lithologies of the sections and their locations on the paleomap indicate deposition on carbonate platforms/ramps and deposition in the related deeper basins. As mentioned in Golonka (2004), reorganization of the Tethyan plate resulted in extensive fault movement and consequent tectonic horst and graben formations in the south margin of the Lauraisa during Late Jurassic – Early Cretaceous. These host and grabens played a significant role as structural highs

and lows for the formation of carbonate platform/ramp and deepar basinal environments. The northward-dipping subduction of Neotethys Ocean under the south margin of Laurasia was the main controlling factor on the extensive tectonics (Koçyiğit *et al*., 1991; Koçyiğit & Altıner, 2002).

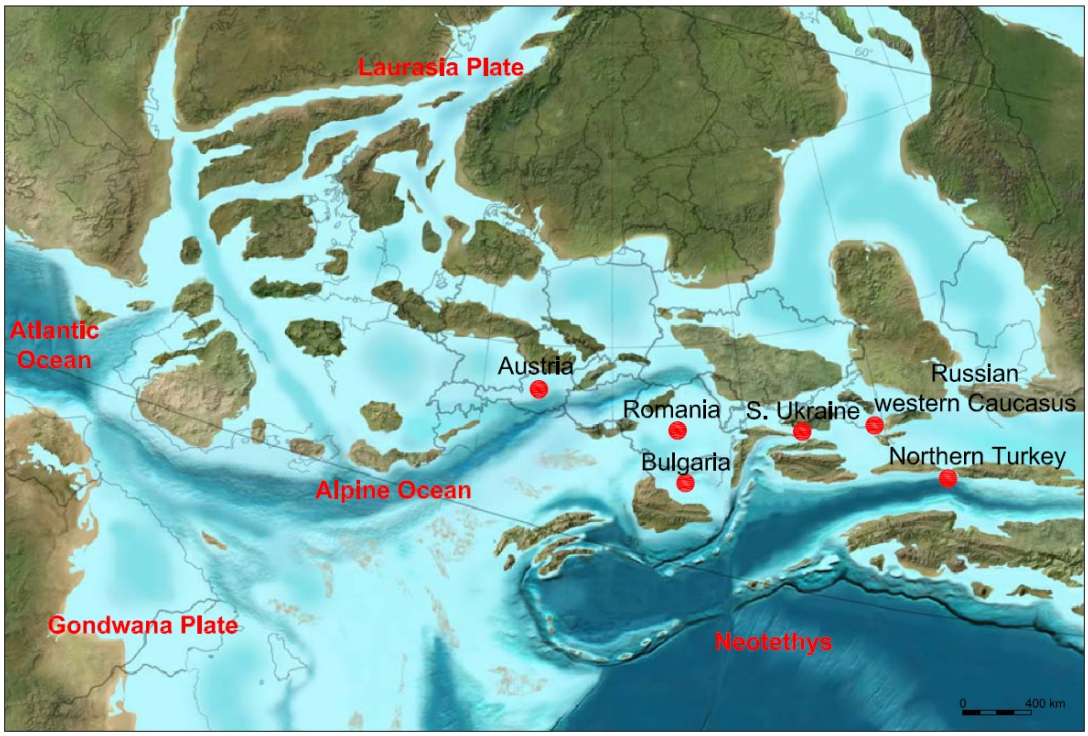


Figure 32 Paleogeographic locations of the investigated boundary sections during Late Jurassic (150Ma) (paleogeographic map was taken from Ron Blakey's web site: http://cpgeosystems.com/europaleogeography.html)

Domination of the carbonate settings and also the occurence of all other suitable conditions (suitable sea level, opening of ocean passageways, suitable shelf bathymetry, nutrition, climate etc.) resulted in the extensive reef development on the Northern and Southern margins of Tethys during Late Jurassic (Leinfelder *et al*., 2002). Similar reefal organisms – both coral/sponge framebuilders and other reef dwellers – can be observed in the examined different sections due to this extensive reef belt.

J-K boundary in sections measured from Romania (Section from Valcan mountains, section of Săndulaşti Formation, section of Mateiaş limestone, section from Hodobana-Gârda Seacâ area) is represented by an unconformable surface. An emergence on a structural high was interpreted for this unconformable surface during J-K transition in these close regions (Pop & Bucur, 2001). Except section of Mateiaş limestone and section of Săndulaşti Formation, all other examined sections from Romania consist of shallow marine carbonates during Tithonian – Berriasian. Section of Săndulaşti Formation includes fresh water limestones above the unconformity surface in the Berriasian. Emergence took place earlier in the area where Mateiaş limestones were laid down. Tithonian portion of the Mateiaş limestone section includes upper slope to basinal deposits whereas Cretaceous displays an abrupt facies shift above the unconformity surface by carbonate and silisclastic conglomerates.

J-K boundary in section of Mount Plassen in Austria is represented by a continous deposition. J-K transition is characterized by a shift from inner platform to outer platform-slope environments which ends with drowning of the platform with silisiclastic materials. This drowning and deepening of the platform was due to the ongoing tectonic shortening in the southern part of the Northern Calcaerous Alps, in an active continental margin and uplift of the accretionary wedge in Early Berriasian provided the silisclastic material according to Gawlick & Schlagintweit (2006). *Radiomura cautica*, *Koskinobullina socialis*, *Crescentiella morronensis*, *Iberopora bodeuri*, serpulids, bryozoa, encrusting foraminifera, *Terebella lapilloides*, *Calcistella jachenhausenensis*, *Bullopora* sp. are the observed microencrusters in the Northern Calcareous Alps most of which also observed from our measured section.

Section of Torinosu Group in Japan shows a continous deposition during Tithonian – Berriasian. Mudstones, siliciclastics and reefal carbonates are the observed lithologies during this time interval. The microencruster association of Torinosu limestone composed of *Bacinella irregularis*, *Lithocodium aggregatum*, *Thaumatoporella parvovesiculifera*, *Koskinobullina socialis*, *Iberopora bodeuri*, *Girvanella* sp. and *Crescentiella morronensis*. Most of these microencrusters were also identified in this study and in several studies from European-Tethys region. Similarities between the microencruster association of the Torinosu limestone and the European-Tethyan associations lead Shiraishi & Kano (2004) to interpret that

microencruster community extended geographically at least to the Tethyan gateway where the Japanese Island Arcs was located.

J-K boundary in all examined sections from Yalta and Ay-Petri Massifs from Southern Ukraine is represented by continuous carbonate deposition. As introduced in section 5.1.4, Crimean carbonate platform shows a shallowing evolution from Kimmeridgian to Berriasian (Platform slope to inner platform setting). This evolution is the reverse of the one observed in Mount Plassen, Austria.

All examined sections from Bulgaria (section from Lyalintsi area, section from Velinovo area and Barlya section from Western Balcanides) show continous, uninterrupted depositions at the J-K transition. Sections from Lyalintsi and Velinovo areas display generally a shallowing upward trend from Lower Kimmeridgian to Valanginian (Ivanova *et al*., 2008). Even though it is not evident from the illustrated Upper Tithonian – Lower Berriasian portion of the mentioned sections in this study, as can be seen in Ivanova *et al*. (2008), Berriasian is represented by regressive events decreasing accomodation space. Carbonates and marls of the Barlya section were interpreted as the deposits of the slope and basinal environments by Lakova *et al*. (2008) and observing a shallowing or deepening trend is not possible on the Barlya section.

Among the sections from the Russian Western Caucasus, two of them (section from the Labinskaya Zone and the Akthsu Zone) display unconformable surfaces at the J-K boundary. Section from the Abino-Gunayskaya Zone also includes an erosional surface, however it occured later in the Berriasian. All those erosional levels can be interpreted as emergent, exposed surfaces on the carbonate platform. Two of the sections (Section from Lagonakskaya Zone and section from Chvezhipsinskaya Zone) from Russian Western Caucasus are represented by uninterrupted carbonate depositon during the Tithonian-Berriasian interval. Sections including material of deeper water facies of the Greater Caucasus Basin (sections from the Abino-Gunayskaya zone, the Chezhipsinskaya zone and the Nevebskaya subzone) display both carbonate and silisclastic deposition. It is not possible to mention that all the examined sections show shallowing upward trens in the Russian Western Cuacasus.

Section from the Chvezhipsinskaya Zone displays a deepening trend (inner platform to outer platform-basinal deposits) from the Tithonaian to Berriasian.

Boundary sections from North-Western Anatolia, Turkey display uninterrupted carbonate dominated deposition at the J-K boundary. Both Tithonian and Berriasian were represented by carbonates with regressive type in the sections from Edremit-Biga-Bursa-Bileceik region. During the Berriasian reefal areas became extremely narrow and the grain size of the resedimented material in the Mudurnu Trough became finer. During Berriasian, a sudden subsidence in the southern part of the Aktaş – Çerkeş area was observed with the occurrence of calciturbiditic, breccioid and olistostromal deposition overlying the shallow water carbonates (Altıner *et al*., 1991).

In this study, both the Upper Tithonian and the lowest Berriasian are represented by platform slope carbonate facies. A shallowing trend (facies change from platform slope – margin to back reef and lagoonal deposits) was observed in the Berriasian. Tithonian – Berriasian transition is represented by a microfacies shift from pelagic mudstone to wackestone facies to microbialitic packstones to grainstones.

After examining all these sections including J-K boundary, it can be concluded that a general shallowing trend at the J-K boundary did not occur in all sections. Even though a sea level fall at/around the J-K boundary is well known from the proposed global sea level curves (Haq *et al*., 1988; Hallam, 1988; Haq, 2014) (See Chapter 6, Figure 35), local tectonics were most probably dominant and masked the effect of sea level fall for the examined sections. The reason for the domination of tectonic controls over the eustatic sea level controls was their paleogeographic positions being close to the active south margin of Lauraisa. It can be interpreted that other sections displaying a shallowing trend at the J-K boundary can provide evidences for the domination of the eustatic sea level controls over the tectonic controls in the areas they formed.

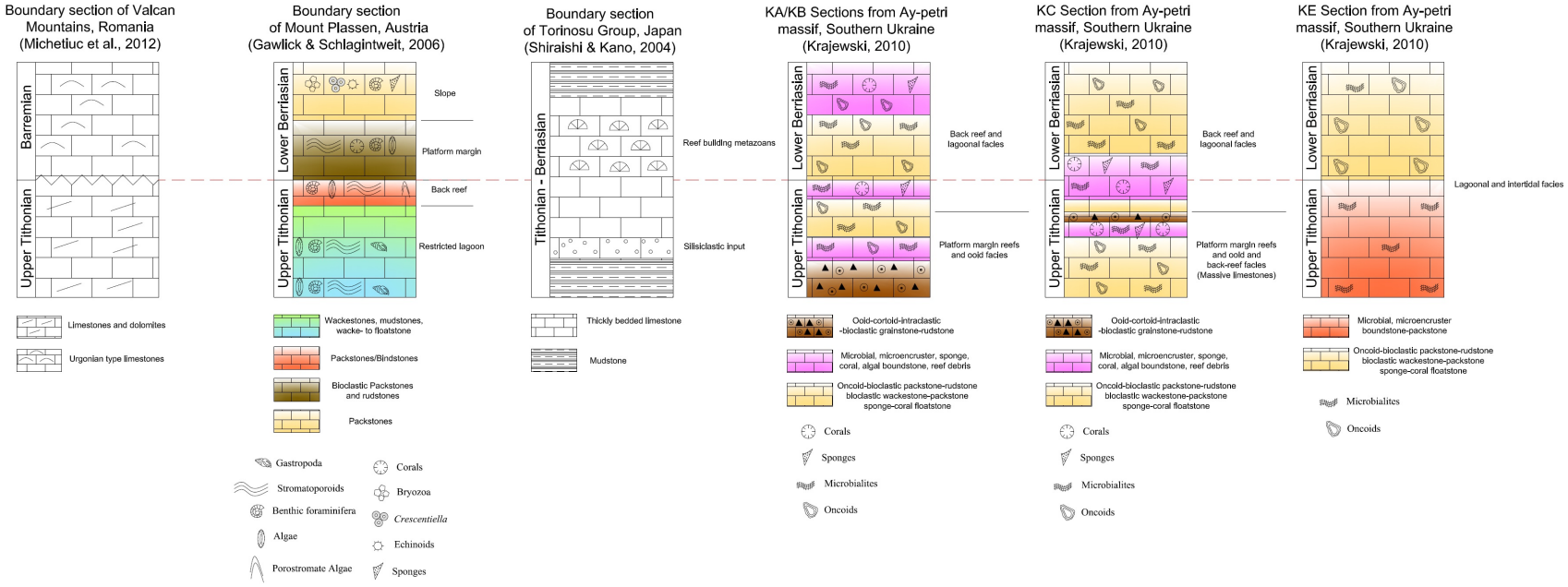


Figure 33A Correlation of the examined boundary sections

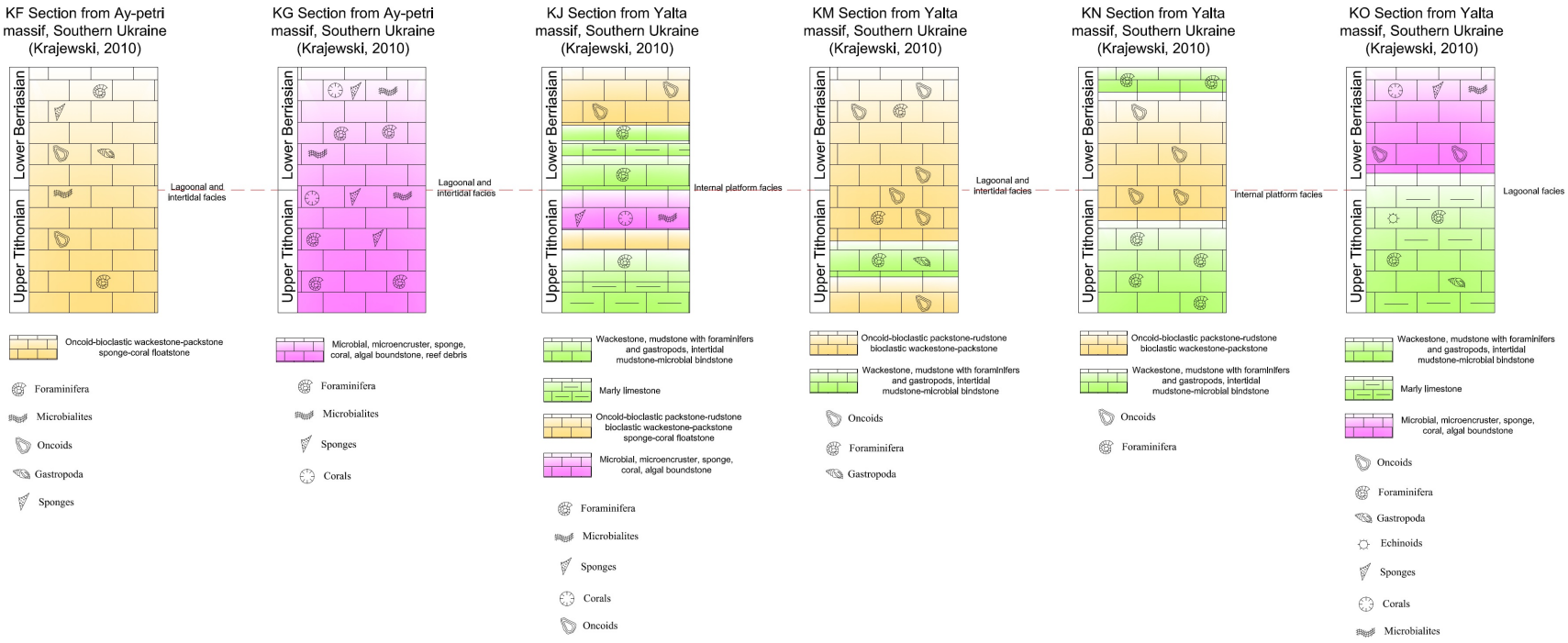


Figure 33B Correlation of the examined boundary sections

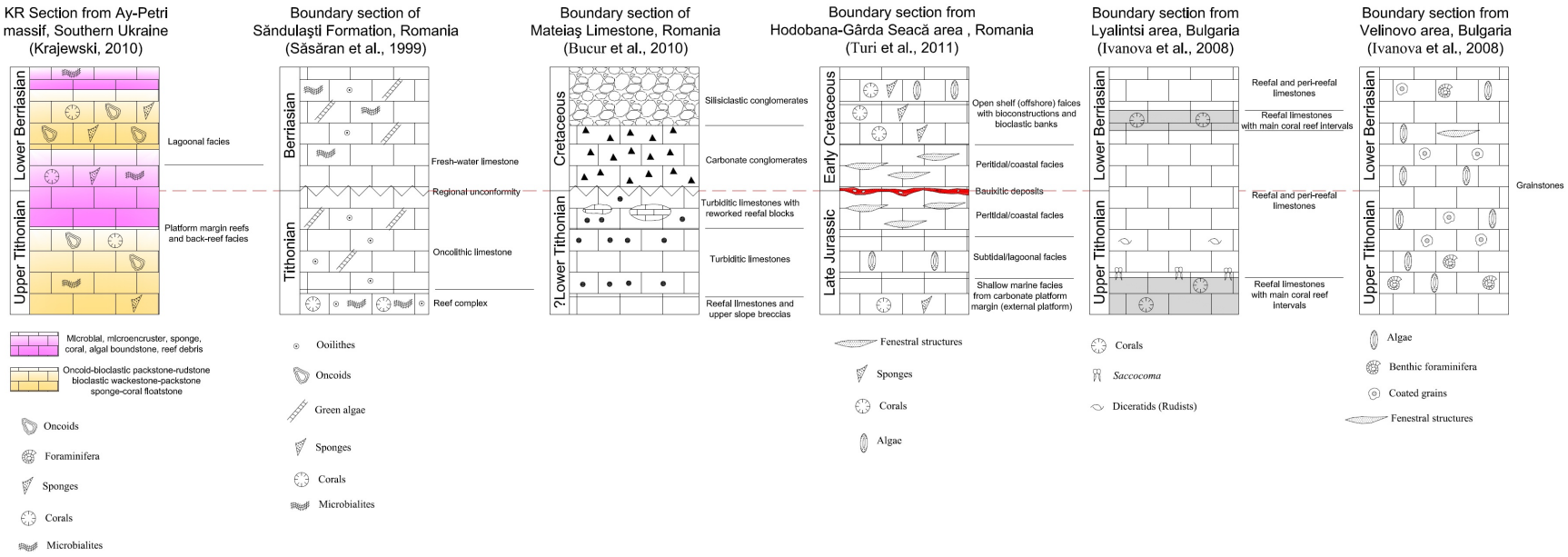


Figure 33C Correlation of the examined boundary sections

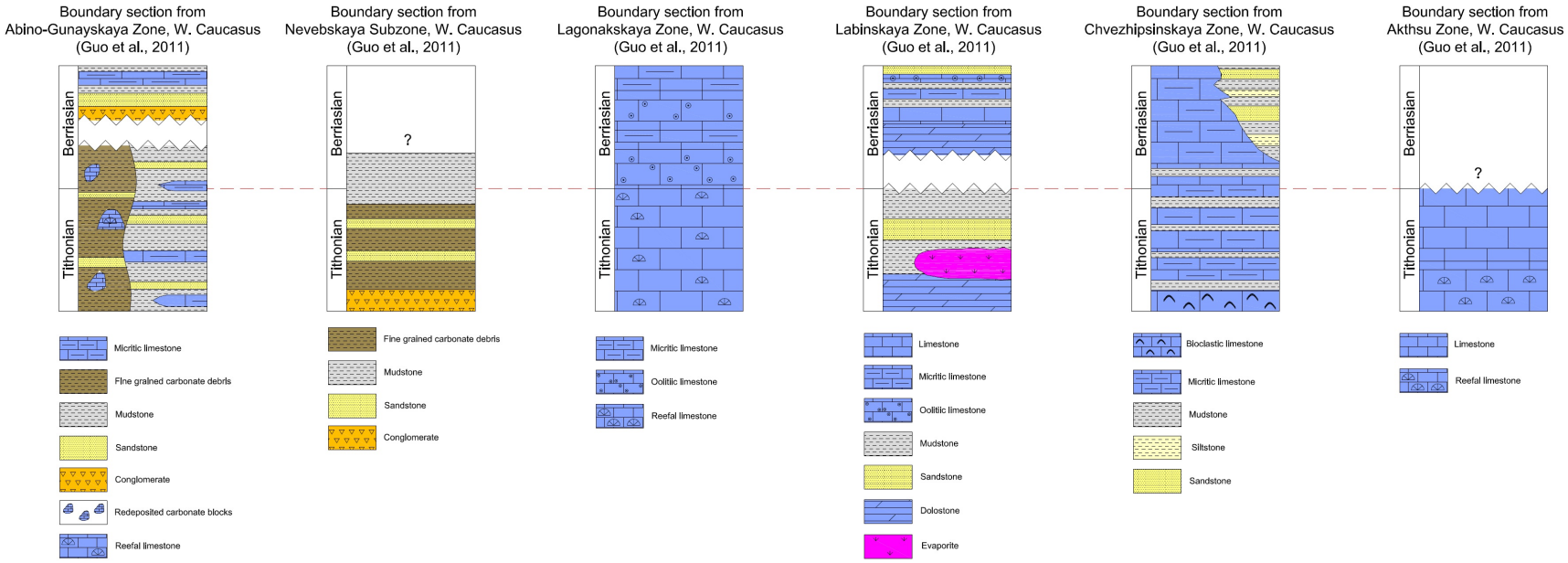


Figure 33D Correlation of the examined boundary sections

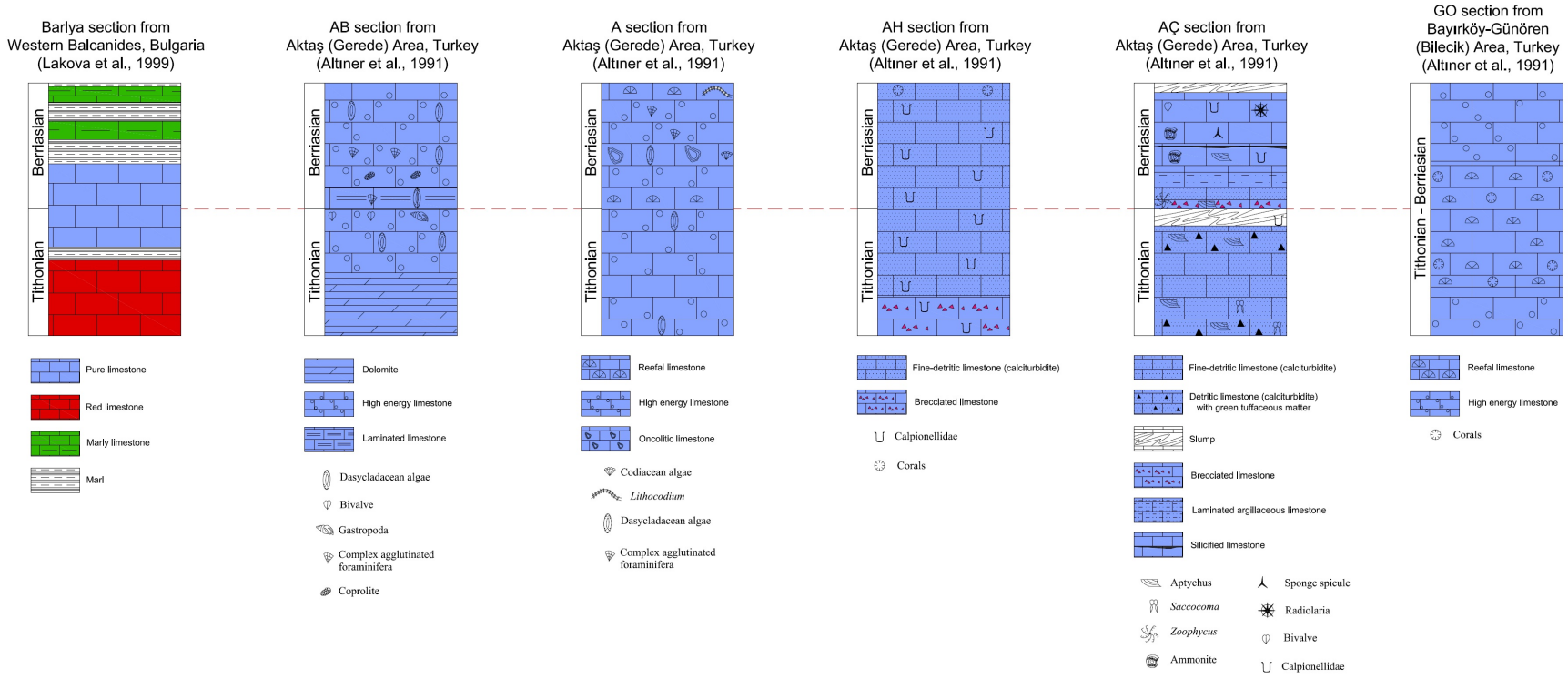


Figure 33E Correlation of the examined boundary sections

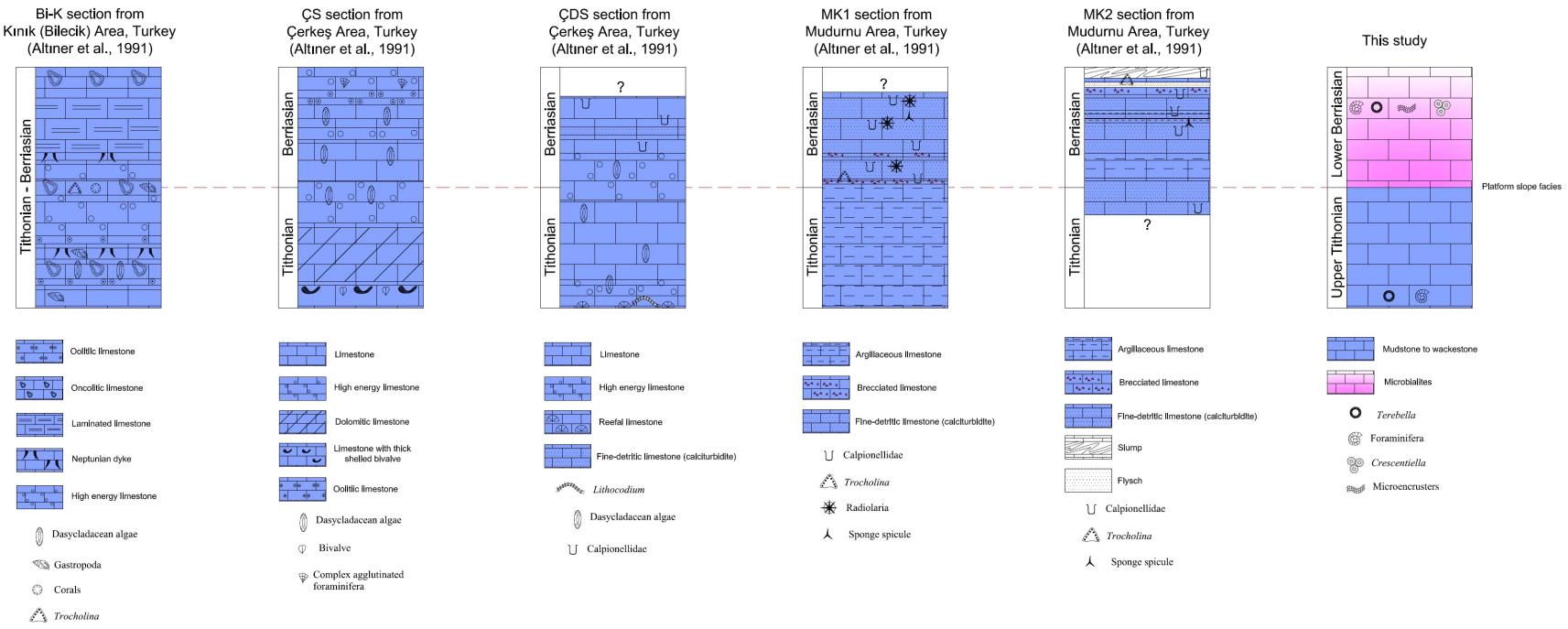


Figure 33F Correlation of the examined boundary sections

CHAPTER 6

DISCUSSION AND CONCLUSIONS

An Upper Jurassic – Lower Cretaceous section was measured and examined in the Bürnük Village region (Northern Anatolia, Turkey) in terms of its micropaleontology, biostratigraphy, microfacies and lithology. 395 m thick section including the lithology of İnaltı, Bürnük and Çağlayan Formations was measured and 101 samples throughout the section were collected and analyzed. In order to interpret the depositional history of the measured section, a detailed microfacies analysis was carried out and 16 microfacies types were determined and they were grouped under 5 main depositional zones. By viewing the vertical microfacies shifts throughout the measured section an obvious picture can be obtained about the evolution and depositional history of the carbonate platform (Figure 34). The base of the section starts with the sandstones of the Bürnük Formation and continues upward with the fore-reefal breccias of the İnaltı Formation in the Kimmeridgian. Between the levels of MK-2 and M-70 section includes reef-fore reef and slope facies. Kimmeridgian – Tithonian transition coincides with MK-19 and MK-20 transition where the Tithonian form *Calcistella* was observed for the first time in MK-20. MK-71 and MK-72 include facies of the back-reef depositional environment and represent the transition from reefal facies to lagoonal facies. Lagoonal facies were observed until the MK-80 and that shallowing corresponds to the Berriasian time. The last phase of the Berriasian corresponds to a deepening phase and the top of the İnaltı Formation is truncated by the flyschoidal material of the Çağlayan Formation in the post-Berriasain (Figure 34). Those observed vertical shifts in the microfacies are most probably associated with the sea level fluctuations. As can be seen in the sea level curve of Haq *et al*. (1988) (Figure 35), a transgression and a subsequent regression marks both the end of the Kimmeridgian and the end of the Tithonian. Both Haq *et*

al. (1988) and Hallam (1988) agree that Latest Tithonian marked a sea-level rise followed by a fall into the Earliest Cretaceous. In the proposed global sea level curve of Haq (2014) J-K boundary similalry marked by a sea level rise and then a fall in the Earliest Berriasian. Shallowing trends marked at the end of the Kimmeridgian and at the end of the Tithonian in the curve of Haq *et al*. (1988) coincide with the shallowing trends observed in this study during the corresponding times. End of the Kimmeridgian displays a microfacies shift from pelagic wackestones to intraclastic grainstone on the outer shelf. Similarly, Tithonian – Berriasian transition is represented by a microfacies shift from pelagic mudstone to wackestone facies to microbialitic packstones to grainstones displaying a shallowing trend.

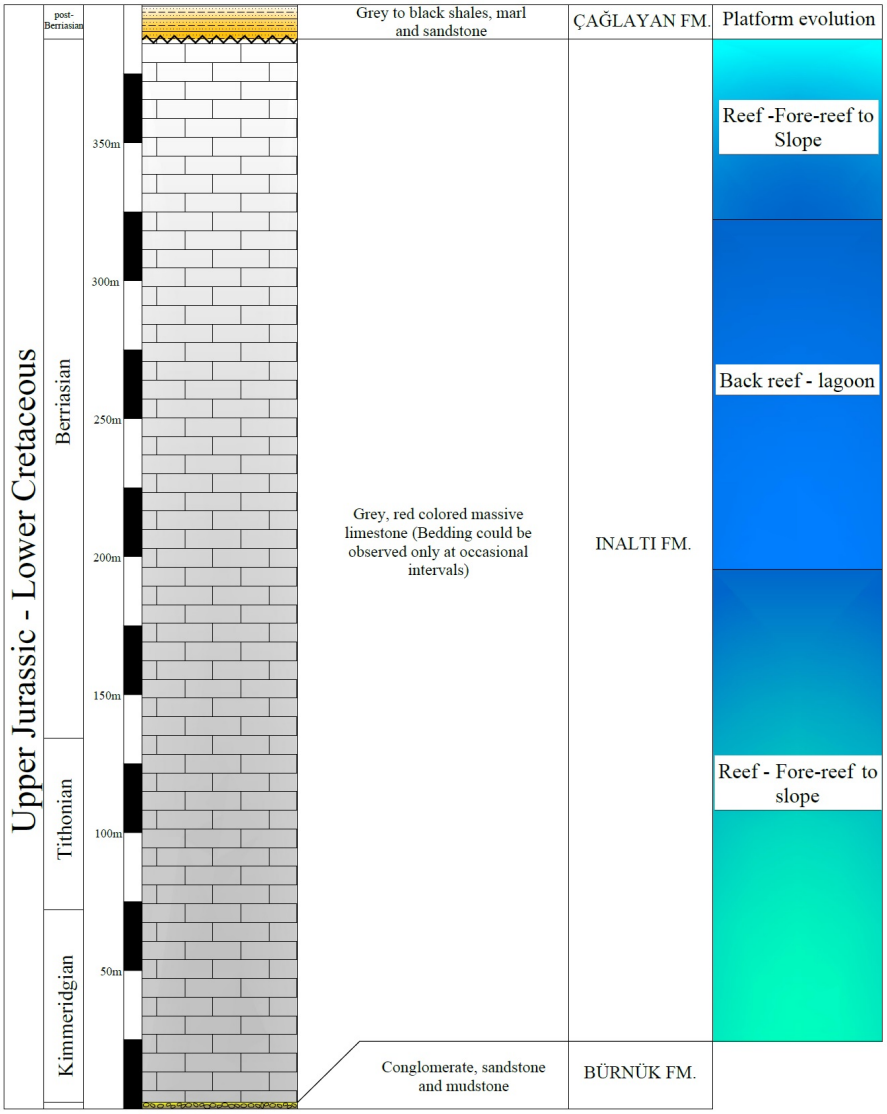


Figure 34 Simplified measured section and the vertical evolution of the depositional environments along the section

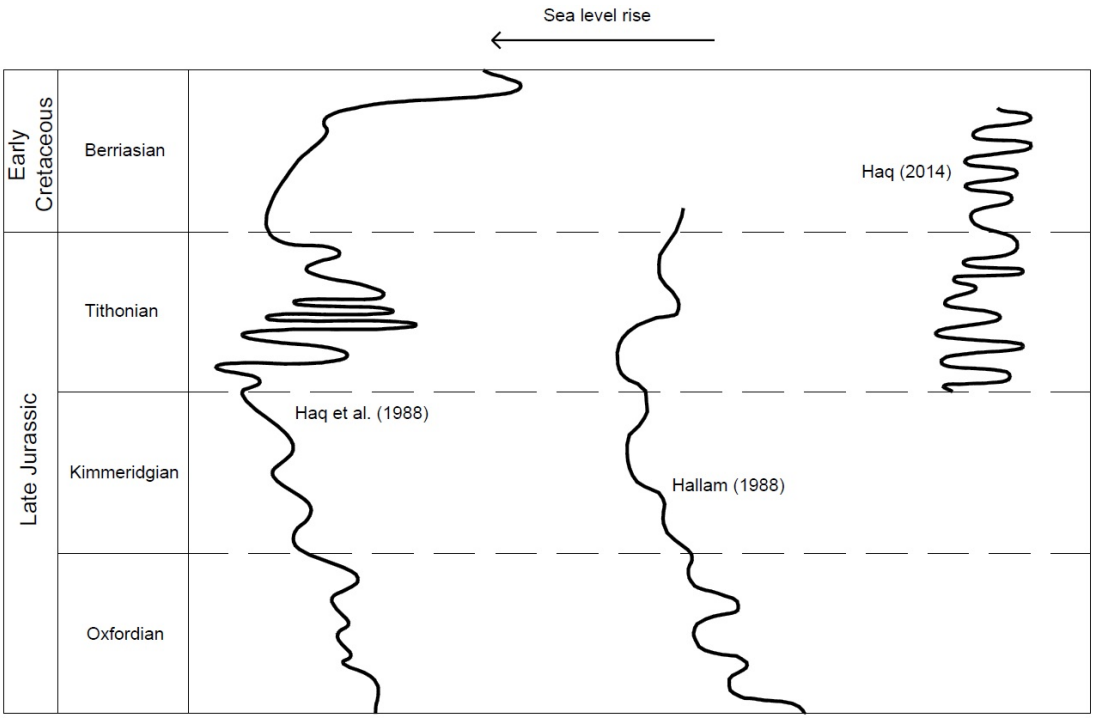


Figure 35 Global sea level curves proposed for the Late Jurassic – Early Cretaceous

A detailed taxonomical study was carried out for the foraminifera and the microencrusters. Taxonomical classification of the foraminifera was based on the wall type, coiling mode, number of volutions and chambers, shape of the chambers, shape of the umbilical region and periphery. 44 species belonging to 35 genera were identified in this study. For the identification of the microencrusters, various taxonomic parameters were utilized according to the different types of microencrusters. Some of these microencrusters (*Terebella lapilloides*, *Perturbatacrusta leini*, *Iberopora bodeuri*, *Calcistella Jachenhausenensis*) were determined and defined in Turkey for the first time. After their identification these fossil organisms were examined in terms of their facies dependency and facies distribution. The facies in which they were found (in situ or transported) have been also been evaluated and some previous studies on fossil distribution models on Late Jurassic – Early Cretaceous carbonate platforms have been compiled. As a result, the model in the Figure 36 has been prepared for the İnaltı Carbonates. Figure 36 illustrates the Late Jurassic - Early Cretaceous distribution pattern of some microencrusters and foraminifera in distinct parts of the İnaltı carbonate platform based on the available data in this study and the previous ideas and models proposed

by Leinfelder *et al*. (1993b), Schlagintweit & Gawlick (2006, 2011) and Flügel (2004). According to this model *Terebella-Crescentiella* association, *Radiomura* and *Perturbatacrusta* are confined to the relatively deeper parts of the carbonate platform. Other microencrusters are distributed generally on the shallower parts of the platform. This model also provides the distribution pattern of the observed foraminifera in the İnaltı carbonate platform. In the lagoonal-back-reef part of the platform miliolids, larger complex benthic foraminifera, *Coscinophragma* and *Mohlerina* can be observed. Reefal setting includes the trocholines and *Coscinophragma* whereas *Mohlerina* displaying larger facies tolerance and *Lenticulina* can be present in the fore-reef to slope facies.

Based on the first and last appearances of some key benthic foraminifera (*Mesoendothyra izjumiana* and *Protopeneroplis ultragranulata)* and encrusting sponge *Calcistella jachenhausenensis* three biozones have been recognized along the measured section in this study: *Mesoendothyra izjumiana* zone, *Calcistella jachenhausenensis* zone and *Protopeneroplis ultragranulata* zone (Older to younger in order).

The distribution of the Upper Jurassic – Lower Cretaceous reef belt along the platforms of the Tethys has been studied and documented previously by various authors (See Leinfelder *et al*., 2002 for revision). But the extension of this reef belt in Turkey has never been studied in detail regarding its faunal/floral content, its resemblance with the European counterparts etc. This study partly documents the faunal/floral content of the reefal material in the Northern Turkey and presents observed taxonomic similarities with the microencrusters described from the European Upper Jurassic.

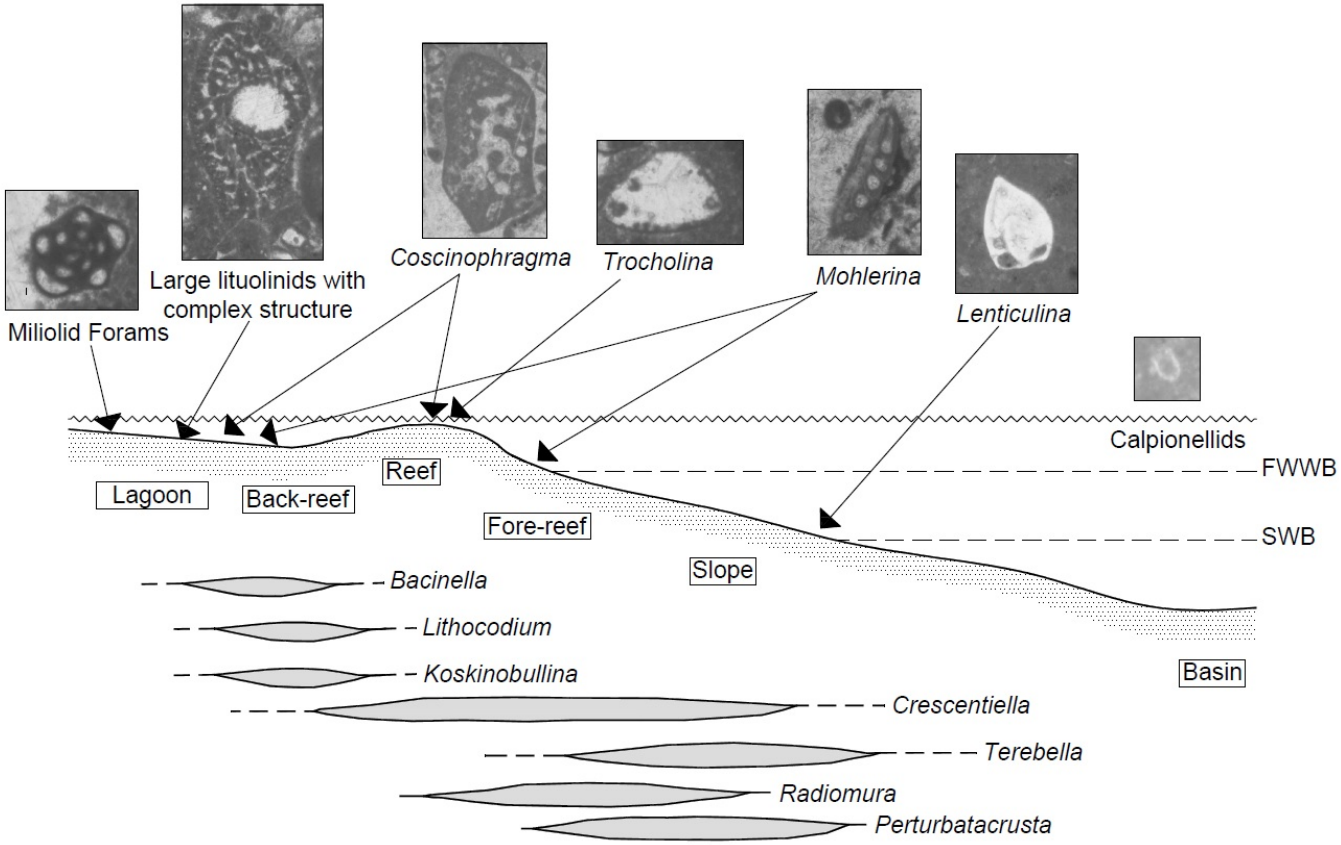


Figure 36 Facies distribution of some Upper Jurassic-Lower Cretaceous foraminifera, calpionellids and microencrusters in the İnaltı carbonate platform, FWWB: Fair weather wave base, SWB: Storm wave base

REFERENCES

Akman, Ü., 1992, Amasra-Arıt arasının Jeolojisi, Doktora tezi, Ankara Universitesi Fen Bilimleri Enstitüsü. 209 s

Akyol, Z., Arpat, E., Erdoğan, B., Göğer, E., Güner, Y., Şaroğlu, F., Şentürk, L., Tütüncü, K., Uysal, Ş., 1974, 1/50.000 ölçekli Türkiye Jeoloji Haritası Serisi, Zonguldak E29 a, E29 b, E29 c, E29d, Kastamonu E30 a, E30 d, MTA Enstitüsü Yayınları, Ankara

Allemann, F., Catalano, R., Farès, F., REmane, J., 1971, Standard calpionellid zonation (upper Tithonian-Valanginian) of the Western Mediterranean Province, In: Farinacci, A. (Ed.), Proceedings II Plantonic Conference, Rome, 1970, vol. 2, 1337-1340

Altıner, D., 1991, Microfossil Biostratigraphy (Mainly Foraminifers) of the Jurassic-Lower Cretaceous Carbonate Successions in North-Western Anatolia, Turkey, Geologica Romana, Vol. 27, pp. 167-213

Altıner, D., Koçyiğit, A., Farinacci , A., Nicosia, U., Conti, M., A., 1991, Jurassic-Lower Cretaceous Stratigraphy and Paleogeographic Evolution of the Southern Part of North-Western Anatolia, Turkey, Geologica Romana, Vol. 27, pp. 13-80

Altıner, D., and Özkan, S., 1991, Calpionellid Zonation in North-Western Anatolia (Turkey) and Calibration of the Stratigraphic Ranges of some Benthic Foraminifera at the Jurassic-Cretaceous Boundary, Geologica Romana, Vol. 27, pp. 215-235

Altınlı, İ., E., 1951a, Filyos Çayı batı kenarının jeolojisi, İstanbul Üniversitesi Fen Fakültesi Mecmuası, Seri B, Cilt XVI, Sayı 2, pp. 154-188

Altınlı İ., E., 1951b, Ilıksu civarının jeolojisi (Zonguldak vilayeti), İstanbul Üniversitesi Fen Fakültesi Mecmuası, Seri B, Cilt XVI, Sayı 4, pp. 301-323

Altınlı, İ. E., 1973a, Bilecik Jurasiği, Cumhuriyet'in 50. Yılı Yerbilimleri Kongresi, Tebliğler, 103-111

Altınlı, İ. E., 1973b, Orta Sakarya Jeolojisi, Cumhuriyet'in 50. Yılı Yerbilimleri Kongresi, Tebliğler, 159-191

Argand, E., 1942, La Tectonique de l'Asie, C. R. Congres Gtol Intern. XIII. Sess. Belgique, 1922, fasc. I

Arkad'ev, V. V., Fedora, A. A., Savel'eva, Y. N., Tesakova, E. M., 2006, Biostratigraphy of Jurassic-Cretaceous Boundary Sediments in the Eastern Crimea, Stratigraphy and Geological Correlation, Vol. 14, No. 3, pp. 302-330

Arnaud-Vanneau, A., Sliter, W. V., 1995, Early Cretaceous Shallow-water Benthic Foraminifers and Fecal Pellets from Leg 143 Compared with coeval Faunas from the Pacific Basin, Central America, and the Tehys, Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 143, 537-564

Arni, 1939, Doğu Anadolu ve mücavir mıntakalarının tektonik ana hatlarıö MTA Yayınları, seri B, no. 4, Ankara

Aurell, M. & Badenas, B., 1997, The pinnacle reefs of Jabaloyas (late Kimmeridgian, NW Spain): vertical zonation and associated facies related to sea level changes, Cuadernos de Geologia Ibérica, 22, pp. 37-64

Badgley, P.,C., 1959, Sinop havzasının petrol olanakları, Petrol İşleri Genel Müdürlüğü Arşivi

Barattolo, F., Pugliese, A., 1987, Il Mesozoico dell'Isola di Capri. Quaderni della Accademia Pontaniana 8, 1–172

Bendukidze, N.S., 1982, Late Jurassic Corals of Reef Deposits of the Caucasus and Crimea, Metsnienela, Tbilisi [in Russian]

Benito, M.I. & Mas, R., 2006, Sedimentary evolution of the Torrecilla reef complex in response to tectonically forced regression (Early Kimmeridgian, Northern Spain), Sedimentary Geology, 183, pp. 31–49

Bernier, P., 1984, Les formations carbonates du Kimmeridgien et du Portlandien dans le Jura méridional, Stratigraphie, micropaleontology, sedimentology, Doc Lab Geol, 92, 1 -803

Bertling, M. & Insalaco, E., 1998, Late Jurassic coral/microbial reefs from the northern Paris Basin – facies, palaeoecology and palaeobiogeography, Palaeogeography, Palaeoclimatology, Palaeoecology, 139, pp. 139-175

Blumenthal, M., 1940, Gökırmak ile Karadeniz arasındaki Pontid silsilelerinin jeoloji hakkında, MTA Enstitüsü derleme rapor no 1067

Borza, K., 1975, Mikroproblematika aus der oberen Trias der Westkarpeten, Geol. Carpat., 26, 199-210

Bosellini, A., Masetti, D., Sarti, M., 1981, A Jurassic 'Tongue of the Ocean' infilled with oolitic sands: the Belluno Trough, Venetian Alps, Italy, Marine Geology 44, pp.59–95

BouDagher-Fadel, M. K., 2008, Evolution and Geological Significance of Larger Benthic Foraminifera, Developments in Palaeontology and Stratigraphy, 21, Elsevier, Amsterdam, pp. 544

Brachert, T.C., 1986, Kontinuierliche und diskontinuierliche Sedimentation im süddeutschen Oberjura (unteres Kimmeridge; Ludwag/Oberfranken, Nördliche Frankenalb), Facies, 15, 233-284

Brinkmann, R., 1966, Geotektonische Gliederung von Westanatolien: Neues Jahrbuch für Geologie und Paläontologie Monatshefte, v. 10, p. 603-618

Brogniart, A. T., 1829, Tableau des terraines qui composent l'écorce du globe, Essai su la structure de la partie conue de la Terra Paris

Brönnimann, P., 1969, Sur la presence d'un foraminifere nouveau "Ophthalmidium tori" sp. n., dans le Carnien superieur de Venetie (Italie), Ibidem, 75, 4, 705-724

Bucur, I. I., 1993, Representetives of the Genus *Protopeneroplis* Weynschenk from the Lower Cretaceous Deposits in the Reşita-Moldova Noua Zone (Southern Carpathians, Romania), Revue de Micropaléontologie, 36, 213-223

Bucur, I. I., Cociuba, J. & Cociuba, M, 1993, Microfacies and microfossils in the Upper Jurassic-Lower Cretaceous Limestone in the Southern part of the Pădurea Craiului Mountains, Romanian Journal of Stratigraphy, 75, 33-40

Bucur, I. I., Senowbari-Daryan, B. and Abate, B., 1996, Remarks on some ăforaminifera from the Upper Jurassic (Tithonian) reef limestone of Madonie Mountain (Sicily), Bollettino della Società Paleontologica Italiana, 35 (1), pp. 65-80

Bucur, I. I., Koch, R., Kırmacı, M. Z., and Taslı, K., 2000, Les algues Dasycladales du Crétacé inférieur (Calcaire de Berdiga) de Kircaova (region de Kale-Gümüşhane, NE Turquie), Revue de Paléobiologie, V.19 (2), pp. 435-463

Bucur, I. I., Koch, R., Kırmacı, Z. M., Taslı, K., 2004a, Foraminifères du Jurassique supérieur et du Crétacé inférieur (Calcaire de Berdiga) de Kircaova (region de Kale-Gümüshane, NE Turquie), Revue de Paléobiologie, 23, (1), pp. 209-225

Bucur, I. I., Săsăran, L., Săsăran, E., Schuller, V., 2004b, Micropaleontological study of the Limestone Olistoliths within the Upper Cretaceous Wıldflysh from Hăşdate (Eastern Border of the Gılău Mountains), Acta Paleontologica Romaniae, v. 4, 55-67

Bucur, I. I., Piteiu, M. A., Săsăran, E., 2004c, The Mesozoic Carbonate Deposits from the Borehole 6042 Deleni (Transylvanian Depresison), Stud. Univ. Babeş-Bolyai, Geologia, XLIX, 2, 27-48

Bucur, I. I., Săsăran, E., 2005, Micropaleontological assemblages from the Upper Jurassic-Lower Cretaceous deposits of Trascău Mountains and their biostratigraphic significance, Acta Palaeontologica Romaniae, v. 5, 27-38

Bucur, I. I., Hoffmann, M. & Kolodziej, B, 2005, Upper Jurassic-Lowermost Cretaceous Benthic Algae from Tethys and the European Platform: A case study from Poland, Revista Espanola de Micropaleontologia, 37 (1), pp. 105-129

Bucur, I. I., Piteiu, M. –A. & Săsăran, E., 2007, The Mesozoic carbonate deposits from the borehole 6042 Deleni (Transylvanian Depression), Studia Univ. Babeş-Bolyai, Geol., XLIX, pp. 27-48

Bucur, I. I., Beleş, D., Săsăran, E., Balica, C., 2010, New data on facies development and micropaleontology of the eastern margin of the Getic Carbonate Platform (South

Carpathians, Romania): case study of the Mateiaş Limestone, Studia Universitatis Babeş-Bolyai, 55 (2), pp. 33-41

Burne, R.V. and Moore, L., 1987, Microbialites; organosedimentary deposits of benthic microbial communities, Palaios, 2, 241-254

Burşuk, A., 1981, Aşkale-Bayburt Yöresinde (KB Erzurum) Calpionellid Biyozonları, Karadeniz Teknik Üniversitesi Yer Bilimleri Dergisi, Jeoloji, 1: 1, pp. 21-28

Burşuk, A., 1982, Eight New Species of Calpionellidae from the Late Jurassic-Lower Cretaceous found in the Kop Mountains (Eastern Anatolia, Turkey), Karadeniz Teknik Üniversitesi Yer Bilimleri Dergisi, Jeoloji, 2: 1-2, pp. 81-86

Camelia, C., Michetiuc, M., Bucur, I. I., 2011, Microfacies and Microfossils of the Upper Tithonian-Lower Berriasian Calcareous Klippes from Ampoita (West of Alba Iulia, Romania), Acta Palaeontologica Romaniae, v. 7, pp. 77-86

Camoin, G., MAurin, A. F., 1988, Rôle des micro-organismes (bactéries, cyanobactéries) dans la genèse des “Mud Mounds”, Exemple du Turonien des Jebels Bireno et Mrhila (Tunusie), CR Acad. Sci., 307, pp. 401-407

Carras, N. & Georgala, D., 1998, Upper Jurassic to Lower Cretaceous Carbonate Facies of African Affinities in a Peri-European Area: Chalkidiki Peninsula, Greece, Facies, 38, 153-164

Catalano, R., D'Argenio, B., 1981, Paleogeographic evaluation of a continental margin in Sicily. Guidebook, Penrose Conference, Controls of Carbonate Platform Evolution, p. 142

Cati, A., Fichera, R., Cappelli, V., 1987, Northeastern Italy. Integrated processing of geophysical and geological data, Memorie della Società Geologica Italiana 40, pp .273–288

Catincut, C., Michetiuc, M. & Bucur, I. I., 2011, Microfacies and microfossils of the Upper Tithonian-Lower Berriasian calcareous klippes from Ampoita (West of Alba Iulia, Romania), Acta Palaeontologica Romaniae, v. 7, p. 77-86

Charles, F., 1932, Un examplaire du genre *Spirocyclina* dans les calcaires inférieurs de la region d'Heraclée (Asie Mineure), Soc. Géol. Belgique, Ann. (Bull.), vol. 55, no. 10, pp. 247-249

Charles, F., 1933, *Spirocyclina choffati* Munier-Chalmas var. euxina, nov. var., dans les calcaires inférieurs de la region d'Heraclée (Asie Mineure), Soc. Géol. France, Bull., ser. 5, vol.2 (1932), no. 5-7, pp. 465-475

Cherchi, A., Schroeder, R., 1979, *Koskinobullina* n. gen., microorganism en colonie incertae sedis (Algues?) du Jurassique-Crétacé de la region méditerranéenne; note préliminaire. Bull Centre Rech Elf Explor Prod 3, 519-523

Cherchi, A., Schroeder, R., 2006, Remarks on the systematic position of *Lithocodium* Elliott, a problematic microorganism from the Mesozoic carbonate platform of the Tethyan realm, Facies, 52, 435-440

Cherchi, A., Schroeder, R., 2010, Boring sponges (Entobia) in Mesozoic *Lithocodium* calcimicrobial crusts, Riv. Ital. Paleont. Strat., 116, 351-356

Cherchi, A., Schroeder, R., 2013, Revision of the holotype of *Lithocodium aggregatum* Elliott, 1956 (Lower Cretaceous, Iraq): new interpretation as sponge-calcimicrobe consortium, Faciesi 59, 49-57

Colacicchi, R., 1967, Geologia della Marsica orientale. Geologica Romana 4, 189–316

Carević, I., Khalil Abad, M. T., Ljubović-Obradović, D., Vaziri, S., H., Mirković, M., Aryaei, A. A., Stejić, P., Ashouri, A. R., 2013, Comparisons between the Urgonian platform carbonates from eastern Serbia (Carpatho-Balkanides) and northeast Iran (Kopet-Dagh Basin): Depositional facies, microfacies, biostratigraphy, palaeoenvironments and plaaeoecology, Cretaceous Research, 40, 110-130

Darga, V.R., Schlagintweit, F., 1991, Mikrofazies, Paläontologie und Stratigraphie der Lerchkogelkalke (Tithon-Berrias) des Dietrichshorns (Salzburger Land, Nördliche Kalkalpen), Jb. Geol. B.-A., 134, 205-226

Decourt, J., Zonenshain, L.P. & Ricou, L.E. ET AL.,1986, Geological evolution of the Tethysbelt from the Atlantic to the Pamirs since the Lias, Tectonophysics, 123, 241-315

Decourt, J., Ricou, L.E. & Vrielynck, B. (eds.) Atlas Tethys Paleoenvironmental Maps, Beicip-Franlab, Town

Decourt, J., Gaetani, M. & Vrielynck, B. (eds.) ET AL., 2000, Peri-Tethys Palaeogeographical Atlas

Derman, A., S., 1990, Batı Karadeniz Bölgesinin Geç Jura ve Erken Kretase'deki Jeolojik Evrimi, 8. Türkiye Petrol Kongresi, Bildiriler (jeoloji), Petrol Jeologları Derneği/TMMOB Petrol Mühendisleri Odası, pp. 328-339

Derman, A., S. and Sayılı, A., 1995, İnaltı Formation: a key unit for regional geology, in A. Erler, T. Ercan, E. Bingöl and S. Örçen (eds.), Geology of the Black Sea Region, General Directorate of Mineral Research and Exploration, and Chamber of Geological Engineers, Ankara-Turkey, pp. 99-103

Desai D., Banner, F. T., 1987, The evolution of Early Cretaceous Dorothiinae (Foraminiferida), Journal of Micropalaeontology, 6, 13-27

Dragastan, O. N., Popescu, I. S. and Popescu, A., 2005, Early Cretaceous Microfacies and Algae from the Central Eastern Sectors of the moesian Carbonate Platform, Acta Paleontologica Romaniae, v. 5, pp. 141-162

Dragastan, O., 2011, Early Cretaceous Foraminifera, Algal Nodules and Calpionellids from the LApoş Valley, Bicaz Gorges (Eastern Carpathians, Romania), Analele Stiintifice ale Universitatii "Al. I. Cuza" din lasi Seria Geologie, 57, 91-113

Dupraz, C., 1999, Paléontologie, paleoecology et evolution des facies récifaux de l'Oxfordien Moyen-Supérieur (Jura Suisse et français), PhD thesis, University of Fribourg, pp. 1-200

Dupraz, C., Strasser, A., 1999, Microbialites and Micro-encrusters in Shallow Coral Bioherms (Middle to Late Oxfordian, Swiss Jura Mountains), Facies, 40, pp. 101-130

Dupraz, C., Strasser, A., 2002, Nutritional Modes in Coral-Microbialte Reefs (Jurassic, Oxfordian, Switzerland): Evolution of Trophic Structure as a Response to Environmental Change, Palaios 17: 449-471

Dzyuba, O. S., Izokh, O. P., Shurygin, B. N., 2013, Carbon isotope excursions in Boreal Jurassic-Cretaceous boundary sections and their correlation potential, Palaeogeography, Palaeoclimatology, Palaeoecology, 381-382, pp. 33-46

Egeran, N., 1947, Tectonique de la Turquie et relations… etc. g. Thomas, Nancy

Eliasova, H., 1986, A new binding microorganism of shallow-water limestones, Vést. Ustř. Ust. Geol., 61, 109-111

Ellis, B., Messina, A., 1941-2004, Ellis and Messina catalogues, Catalogue of Foraminifera, New York: Micropaleontolgy Press, AMNH. Available from http://www.micropress.org/e_m.html

Elliot, G. F., 1956, Further records of fossil calcareous algae from the Middle East, Micropaleontology, 2, pp. 327-334

Espitalie, J. & Sigal, J., 1963, Contribution a l'etudes des Foraminiferes du Jurassique superieur et du Neocomien di Bassin de Majunga (Madagaskar), Ann. Geol. Madagaskar, No. 32, 1-100

Flügel, E., Steiger, T., 1981, An Upper Jurassic sponge-algal buildup from the north-eastern Frankenalb (W. Germany). In: Tommey D.F., editor. European Fossil Reef Models. Spec Publ Soc Econ Paleont Miner, Tulsa, 30, 371-397

Flügel, E., 1981, "Tubiphyten" aus dem fränkischen Malm. Geol Bl No-Bayern, 31, 126-142

Flügel, E., 1983, Mikrofazies der Pantokrator-Kalke (lias) von Korfu, Griechenland, Facies, 8, 263-300

Flügel, E., 2004, Microfacies of carbonate rocks: analysis, interpretation and application, Springer, 976 p.

Fratschner, W., Th., 1952, Kurucaşile-Eflani-Cide bölgesindeki saha etüdü hakkında ilk not, MTA Rap. No. 2061

Gawlick, H. J., Schlagintweit, F., 2006, Berriasian drowning of the Plassen carbonate platform at the type-locality and its bearing on the early Eoalpine orogenic dynamics in the Northern Calcareous Alps (Austria), Int. J. Earth. Sci. (Geol Rundsch), 95, 451-462

Gawlick, H. J., Schlagintweit, F., 2010, The Drowning Sequence of Mount Bürgl in the Salzkammergut Area (Northern Calcaerous Alps, Austria): Evidence for a Diachronous Late Jurassic to Early Cretaceous Drowning of the Plassen Carbonate Platform, Austrian Journal of Earth Sciences, V. 103/1, 58-75

Gedik, A., Korkmaz, S., 1984, Sinop Havzasının jeolojisi ve petrol olanakları, Jeoloji Mühendisliği, 19, 53-80

Golonka, J., 2004, Plate tectonic evolution of the southern margin of Eurasia in the Mesozoic and Cenozoic, Tectonophysics, 381, 235-273

Göncüoğlu, M.C., Dirik, K. & Kozlu, H., 1996-1997, Pre-Alpine and Alpine terranes in Turkey: explanatory notes to the terrane map of Turkey, Annales Géologique de Pays Hellenique, 37, 515-536

Görür, N., Oktay, F.Y., Seymen, I. & Şengör, A.M.C., 1984, Paleotectonic evolution of Tuz Gölü Basin complex, central Turkey, In: Dixon, J.E. & Robertson, A.H.F. (eds.) The Geological Evolution of the Eastern Mediterranean, Geological Society, London, Special publications, 17, pp. 81-96

Görür, N., Tüysüz, O., Akyol, A., Sakınc, M., Yiğitbaş, E., Akkök, R., 1993, Cretaceous red pelagic carbontes of Northern Turkey: their place in the opening history of the Black Sea, Eclogae Geology Helvetica, 86, 819-838

Görür, N., 1997, Cretaceous syn- to post-rift sedimentation on the southern continental margin of the Western Black Sea Basin, In Robinson, A. G. (ed.), Regional and Petroleum Geology of the Black Sea and Surrounding Region, AAPG Memoir, 68, 227-240

Görgün, S. B., 1995, Micropaleontologic Data from Damlaağaçderesi Sedimentary Melange in Alacaatlı Region (Ankara): Reconstruction of Jurassic-Cretaceous

Sedimentary Successions, M.S. Thesis, Geological Engineering Dept., METU, Ankara, Turkey, 269 pages

Grancy, W., 1938, Taşkömür zuhur edeceği umulan Antdere ve Pelitovası hakkında rapor, MTA Rap. No. 679

Granier, B. & Berthou, P.-Y., 2002, Algues calcaires fossils, nouvelles ou peu connues, du Portugal. Lere Partie [New or poorly known fossil calcareous algae of Portugal. Part I – in French] – In Bucur, I. I. & Filipescu, S. (eds.): Research Advances in Calcareous Algae and Microbial Carbonates, Proc. 4th IFAA Reg. Meet. Cluj-Napoca, August 29-September 5, 2001, 117-126, Cluj University Press

Granit, Y. & Tintant, H., 1960, Observation préliminaires sur le Jurassique de la region de Bilecik (Turquie), C. R. Acad. Sc. Paris, 251, 1807-1803

Guo, L., Vincent, S. J. & Lavrishchev, V., 2011, Upper Jurassic Reefs from the Russian Western Caucasus: Implications for the Eastern Black Sea, Turkish J. Earth Sci., V. 20, pp. 629-653

Hallam, A., 1988, A reevaluation of Jurassic Eustasy in the light of new data and the revised Exxon curve, , in C. K. Wilgus, B. Hastings, C. Ross, H. Posamentier, J. Van Wagoner and C. Kendall, eds., Sea-level changes: an integrated approach: Tulsa, Society for Sedimentary Geology (SEPM), p. 261-273

Hammes, U., 1995, Initiation and development of small-scale sponge mud-mounds, late Jurassic, southern Franconian Alb, Germany, In: Monty CLV, Bosence DWJ, Bridges PH, Pratt BR, editors, Carbonate mud-mounds, their origin and evolution, IAS Spec Publ 23, 335-357

Hansen, H.J, Revets, S.A., 1992, A revision and classification of the Discorbidae, Rosalinidae and Rotaliidae, J Forma Res, 22, 166-180

Haq, B. U., Hardenbol, J., Vail. P. R., 1988, Mesozoic and Cenozoic Chronostratigraphy and Cycles of Sea-level Change, in C. K. Wilgus, B. Hastings, C. Ross, H. Posamentier, J. Van Wagoner and C. Kendall, eds., Sea-level changes: an integrated approach: Tulsa, Society for Sedimentary Geology (SEPM), p. 71-108

Haq, B. U., 2014, Cretaceous euctasy revisited, Global and Planetary Change, 113, 44-58

Helm, C., Schülke, I. & Schlagintweit, F., 2003, Calcareous Algae ("Porostromata", Rhodophyta, Dasycladales) and microproblematica with algal affinity from the NW German Korallenoolith Formation (Oxfordian, Süntel Mountains), Facies, 49, 61-86

Helm, C., Schülke, I., 2006, Patch reef development in the florigemma-Bank Member (Oxfordian) from the Deister Mts (NW Germany): a type example for Late Jurassic coral thrombolite thickets, Facies, 52, 441-467

Hippolyte, J. C., Müller, C., Kaymakcı, N., Sangu, E., 2010, Dating of the Black Sea Basin: new nannoplankton ages from its inverted margin in the Central Pontides (Turkey), Geological Society, London, Special Publications, v. 340, p. 113-136

Hoedemaeker, P. J., Company, M. R., Aguirre Urreta, M. B., Avram, E., Bogdanova, T. N., Bujtor, L., Bulot, L., Cecca, F., DElanoy, G., Etiachfini, M., Memmi, L., Owen, H. G., Rawson, P. F., Sandoval, J., Tavera, J. M., Thieuloy, L. P., Tovbina, S. Z., Vašiček, Z., 1993, Ammonite zonation for the lower Cretaceous of the Mediterranean region, basis for the stratigraphic correlation within IGCP Project 262, Revista Espanola de Paleontologia, 8, 117-120

Hoedemaeker, P. J., 1995, Ammonite evidence for long-term sea-level fluctuations between the 2nd and 3rd order in the lowest Cretaceous, Cretaceous Research, 16, (2-3), 231-241

Holbourn, A. E. L. & Kaminski, M. A., 1997, Lower Cretaceous deep-water foraminifera of the Indian Ocean, Grzybowski Foundation Special Publication, 4, pp. 172

Houša, V., Pruner, P., Zakharov, V., Košták, M., Chadima, M., Rogov, M. A., Šlechta, A., Mazuch, M., 2007, Boreal-Tethyan correlation of the Jurassic-Cretaceous boundary interval by magnetostratigraphy and biostratigraphy, Stratigraphy and Geological Correlations, 15 (3), 297-309

Jansa, L.F., Termier, G., Termier, H., 1972, Les biohermes à algue, spongiaires et coraux des series carbonates de la flexure bordière du 'paléoshelf' au large du Canada oriental, Rev Micropaleontol, 25, 181-219

Ianovici, V., Borcoş, M., Bleahu, M., PAtrulius, D., Lupu, M., Dimitrescu, R. & Savu, H., 1976, Geology of the Apuseni Mountains, Editura Academiei RSR, Bucureşti, 631, (in Romanian)

Insalaco, E., Hallam, A. & Rosen, B., 1997, Oxfordian (Upper Jurassic) coral reefs in Western Europe: reef types and conceptual depositional model, Sedimentology, 44, pp. 707–734

Ivanova, D., Kolodziej, B., 2004, New foraminiferal data on the age of Stramberk-type limestones, Polish Carpathians, Comptes rendus de l'Académie, bulgare des Sciences, 57, 69-74

Ivanova, D., Kolodziej, B., Koleva-Rekalova, E. & Roniewicz, E., 2008, Oxfordian to Valanginian Palaeoenvironmental Evolution on the Western Moesian Carbonate Platform: A Case Study from SW Bulgaria, Annales Societatis Geologorum Poloniae, vol. 78, 65-90

Ivanova, D. and Kolodziej, B., 2010, Late Jurassic-Early Cretaceous foraminifera from Stamberk-type limestones, Polish Outer Carpathians, Studia Universitatis Babeş-Bolyai, Geologia, 55 (2), pp. 3-31

Kaminski, M. A., 2000, The New and Reinstated Genera of Agglutinated Foraminifera published between 1986 and 1996, In: Hart, M. B., Kaminski, M. A. & Smart, C. W. (eds.), Proceedings of the Fifth International Workshop on Agglutinated Foraminifera, Grzybowski Foundation Special Publication, 7, 185-219

Kaminski, M.A., Bubík, M., Cetean, C.G., 2007, *Rectoprotomarssonella* n. gen., a New Agglutinated Foraminiferal Genus from the Upper Cretaceous of the Carpathian Flysch, Micropaleontology, Vol. 53, No. 6, 517-521

Kaya, M. Y., Altıner, D., 2014, *Terebella lapilloides* Münster, 1833 from the Upper Jurassic – Lower Cretaceous İnaltı carbonates, northern Turkey: Its taxonomic

position and paleoenvironmental – paleoecological significance, Turkish Journal of Earth Sciences, 23: 166-183

Kazmierczak, J., Kempe, S., 1992, Recent cyanobacterial counterparts of Paleozoic *Wetheredella* and related problematic fossils, Palaios, 7, 294-305

Kırmacı, M. Z., 1992, Alucra-Gümüşhane-Bayburt Yörelerindeki (Doğu Pontid Güney Zonu) Üst Jura-Alt Kretase yaşlı Bedirgs Kireçtaşı'nın Sedimentolojik İncelemesi, Doktora tezi, Karadeniz Teknik Üniversitesi Fen Bilimleri Enstitüsü, Trabzon, 257 s

Kırmacı, M. Z., Koch, R., Bucur, J. I., 1996, An early cretaceous section in the Kiecaova area (Berdiga Limestone, NE-Turkey) and its correlation with platform carbonates in W-Slovenia, Facies, V. 34 (1), pp. 1-21

Kırmacı, M. Z., 2000, Geç Jura Yaşlı Karbonat Platformunun Litofasiyes Özellikleri ve Evrimi, Uluçayır Yöresi (Bayburt, Doğu Pontidler), T.J.K. Bült., C. 43, 2, pp. 33-47

Kirici, S., 1986, İnaltı Formasyonunun Biyostratigrafisi (II. ve IV. Bölgeler), T.P.A.O. Araştırma Arşivi Rap. No. 937

Klieber, D., 1985, Über einen Fund von '*Terebella*' *lapilloides* MÜNSTER (1833) aus dem Mitteloxford der Mittleren Frankenalb. Geol Bl NO-Bayern, 334, 125-136

Kober, L., 1931, Das Alpine Europa, Berlin

Koch, R., Moussavian, E., Ogorelec, B., Skaberne, D., Bucur, I. I., 2002, Development of a *Lithocodium* (syn. *Bacinella irregularis*) – reef-mound- a patch reef within Middle Aptian lagoonal limestone sequence near Nova Gorica (SAbotşn Mountain, W-Slovenia), Geologija, 45, 71-90

Koch, R., Bucur, I. I., Kırmacı, M. Z., Muhsin, E., Tsalı, K., 2008, Upper Jurassic and Lower Cretaceous carbonate rocks of the Berdiga Limestone – Sedimentation on an onbound platform with volcanic and episodic siliciclastic influx. Biostratigraphy, facies and diagenesis (Kırcaova, Kale-Gümüşhane area; NE Turkey), Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 247 (1), pp. 23-61

Koçyiğit, A., Altıner, D., Farinacci, A., Nicosia, U. & Conti, M. A., 1991, Late Triassic-Aptian Evolution of the Sakarya Divergent Margin: Implications for the Opening History of the Northern Neo-Tethys, in North-Western Anatolia, Turkey, Geologica Rom., 27, pp. 81-99

Koçyiğit, A. & Altıner, D., 2002, Tectonostratigraphic Evolution of the North Anatolian Palaeorift (NAPR): Hettangian-Aptian Passive Continental Margin of the Northern Neo-Tethys, Turkey, Turkish J. Earth Sci., 11, 169-191

Krajewski, M. and Olszewska, B., 2007, Foraminifera from the Late Jurassic and Early Cretaceous Carbonate Platform Facies of the Southern Part of the Crimea Mountains; Southern Ukraine, Annales Societatis Geologorum Poloniae, vol. 77, pp. 291-311

Krajewski, M., 2010, Facies, microfacies and development of the Upper Jurassic-Lower Cretaceous of the Crimean carbonate platform from the Yalta and Ay-Petri massifs (Crimea Mountains, Southern Ukraine), Dissertation Monographs 217, Wydawnictwa AGH, Krakow

Krobicki, M. & Olszewska, B., 2005, Urgonian-type microfossils in exotic pebbles of the Late Cretaceous and Palaeogene gravelstones from the Sromowce and Jarmuta formations (Pieniny Klippen Belt, Polish Carpathians), Stud. Geol. Pol., 124, 215-235

Kuznetsov, K. I. & Gorbachik, T. N., 1985, Upper Jurassic and Lower Cretaceous Stratigraphy and Foraminifers of the Crimea, Nuka, Moscow, in Russian

Kuznetsov, V.G., 1993, Late Jurassic–Early Cretaceous carbonate platform in the Northern Caucasus and Precaucasus. In: Simo, J.A., Scott, R.W. & Masse, J.-P. (eds), Cretaceous Carbonate Platforms. AAPG Memoir 56, pp. 455 –463

Lakova, I., Stoykova, k., Ivanova, D., 1999, Calpionellid, nannofossils and calcerous dinocyst bioevents and itegrated biochronology of the Tithonian to Valanginian in the West Balkan Mountains, Bulgaria, Geologica CArpathica, 50 (2), 151-168

Lakova, I., Rekalova, E. K., Ivanova, D., Metodiev, L., Petrova, S., 2008, Transgressive-Regressive cycles in the Tithonian and Berriasian pelagic limestones

of the west Balkan unit, Bulgaria, In: 1st International Meeting on Correlation of Cretaceous Micro- and Macrofossils, Vienna, 16th – 18th April, Berichte der Geologischen Bundesanstalt, 74, p. 47.

Lazăr, I., Panaiotu, C.E., Grigore, D., Sandy, M.R., Peckmann, J., 2011, An unusal brachiopod assemblage in a Late Jurassic (Kimmeridgian) stromatactis mud-mound of the Eastern Carpathians (Hăghimaş Mountains), Romania, Facies 57, 627-647

Leinfelder, R. R., 1992, A Modern-Type Kimmeridgian Reef (Ota Limestone, Portugal): Implications for Jurassic Reef Models, Facies, 26, pp. 11-34

Leinfelder, R. R., 1993a, A sequence stratigraphic approach to the Upper Jurassic mixed carbonate-siliciclastic succession of the central Lusitanian Basin, Portugal, Profil, 5, pp. 119-140

Leinfelder, R. R., 1993b, Upper Jurassic reef types and controlling factors: A preliminary report, Profil, 5, pp. 1-45

Leinfelder, R. R., Nose, M., Schmid, D. U. & Werner, W., 1993a, Microbial Crusts of the Late Jurassic: Composition, Palaeoecological Significance and Importance in Reef Construction, Facies, 29, pp. 195-230

Leinfelder, R. R., Krautter, M., Nose, M.i Ramalho, M. M. & Werner, W.,1993b, Siliceous sponge facies from the Upper Jurassic of Portugal, Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 189, pp. 199-254

Leinfelder, R. R., Werner, W., Nose, M., Schmid, D. U., Krautter, M., Laternser, R., Takacs, M., & Hartmann, D., 1996, Paleoecology, growth parameters and dynamics of coral, sponge and microbolite reefs from the Late Jurassic, In: Reitner, J., Neuweiler, F. & Gunkel, F. (eds.): Global and Regional Controls on Biogenic Sedimentation, I. Reef Evolution. Res. Reports, Göttinger Arb. Geol. Paläont. Sb2, pp. 227-248, Göttingen

Leinfelder, R. R., Schmid, D. U., Nose, M. & Werner, W., 2002, Jurassic reef patterns – the expression of a changing globe, In: Phanerozoic Reef Patterns, Kiessling, W., Flügel, E. & Golonka, J. (eds.), SEPM Special Publication 72, pp. 465-520

Leinfelder, R.R., Schlagintweit, F., Werner, W., Ebli, O., Nose, M., Schmid, D.U., Hughes, G.W., 2005, Significance of stromatoporoids in Jurassic reefs and carbonate platforms—concepts and implications, Facies 51, pp. 287–325

Levy, A., Mathieu, R., Poignant, A., Rosset Moulinier, M., 1986, Discorbidae and Rotaliidae: a classification to be revised, J Foram Res, 22, 166-180

Loeblich, A. R. Jr., Tappan, H., 1964, Protista 2, Sarcodina, chiefly "Thecamoebians" and Foraminiferida, In: Moore, R. C. (Ed.) Treatise on Invertebrate Paleontology, University of Kansas Press, Kansas, Part C, Vols. 1 and 2

Loeblich, A. R. Jr., Tappan, H., 1985, Some new and redefined genera and families of agglutinated foraminifera, I. J. Foraminiferal Res., 15, 91-104

Loeblich, A. R. Jr. and Tappan, H., 1988, Foraminiferal genera and their classification, Von Nostrand Reinhold Company, New York, 2v, 970 p

Lucius, M., 1925, Ekinveren (Boyabat) bölgesinin jeolojik etüdü (Sinop ili), MTA Enst. Der., Rap. No. 197, (unpublished), Ankara

Matsuoka, A., 1992, Jurassic-Early Cretaceous tectonic evolution of the southern Chichibu terrane, southwest Japan, Palaeogeogr Palaeoclimatol Palaeoecol, 96, 71-88

Maurin, A.F., Bernet-Rollande, M.C., Monty, C.L.V., Nazhat, S., 1985, The microbial nature of bacinellid textures, Sedimentological bearings, In: 9th European regional meeting of sedimentology, Leiden, abstracts, pp. 285-287

Maync, W., 1957, *Coscinophragma cribrosum* (Reuss) in a lower Cretaceous limestone from Switzerland, Micropaleontology, vol. 3, no. 2, pp. 183-186

Maync, W., 1959, The foraminiferal genera *Spirocyclina* and *Iberina*, Micropaleontology, 15/1, pp. 33-69

Mekik, A. F., 1994, An Attempt to Reconstruct the Jurassic-Cretaceous Successions of the Damlaağaçderesi Sedimentary Melnage: Stratigraphic and Micropaleontological Analyses, M.S. Thesis, Geological Enginnering Dept., METU, Ankara, Turkey, 526 pages

Michalík, J. and Reháková, D., 2011, Possible markers of the Jurassic/Cretaceous boundary in the Mediterranean Tethys: A review and state of art, Geoscience Frontiers, 2(4), 475-490

Michetiuc, M., Catincut, C. and Bucur, I. I., 2012, An Upper Jurassic-Lower Cretaceous carbonate platform from the Vâlcan Mountains (Southern Carpathians, Romania): paleoenvironmental interpretation. Geologica Carpathica, 63, pp. 33-48

Mišík, M., 1994, The Czorsztyn Submarine Ridge (Jurassic-Lower Cretaceous, Pieniny Klippen Belt): An Example of a Pelagic Swell, Mitt. Österr. Geol. Ges., 86, 133-140

Mohler, W., 1938, Mikropaläontologische Untersuchungen in der nordschweizerischen Jurafromation, Abh Schweiz Paläont Ges, 60, 1-53

Moix, P., Laurent, B., Kozur, W., Hochard, C., Rosselet, F., Stampfli, G.M., 2008, A new classification of the Turkish terranes and sutures and its implication for the paleotectonic history of the region, Tectonophysics, 4514, pp. 7-39

Morsilli, M., Bosellini, A., 1997, Carbonate facies zonation of the Upper Jurassic–Lower Cretaceous Apulia platform margin (Gargano Promontory, southern Italy), Rivista Italiana Paleontologia Stratigrafica 103, pp. 193–206

Morycowa, E. & Olszewska, B., 2013, Foraminiferal assemblage in the coral-bearing limestones of the Vrsatec area (Pieniny Klippen Belt, Western Carpathians, Slovakia), Geologica Carpathica, 64, 1, 63-69

Moshammer, B., Schlagintweit, F., 1999, The Ernstbrunn Limestone (Lower Austria): New data on Biostratigraphy and Applied Geology, Abh. Geol. B.-A., 56/2, 553-565

Nauman, E., 1886, Die Grundlinien Anatoliens und Zentralaseien, Geogr. Zs., 2

Neagu, T., Neagu, M., 1995, Smaller agglutinated foraminifera from the acanthicum Limestone (Upper Jurassic), Eastern Carpathians, Romania – In Proceedings of the 4th International Workshop on Agglutinated Foraminifera (Kaminski, M. A., Geroch, S. & Gasinski, M., Eds.), Grybowski Foundation Special Publication, 3, 211-225

Olivier, N. Pittet, B., Werner, W., Pierre, H., Gaillard, C., 2008, Facies distribution and coral-microbialite reef development on a low-energy carbonate ramp (Chay Peninsula, Kimmeridgian, western France), Sedimentary Geology, 205, pp. 14-33

Olóriz, F., Reolid, M., Rodriguez-Tovar, F.J., 2003, A Late Jurassic Carbonate Ramp Colonized by Sponges and Benthic Microbial Communities (External Prebetic, Sothern Spain), Palaios, 18, 528-545

Olóriz, F., Reolid, M., Rodriguez-Tovar, F.J., 2006, Approaching trophic structure in Late Jurassic neritic shelves: A western Tethys example from southern Iberia, Earth-sci Rev 76: 101-139

Olszewska, B., 2010, Microfossils of the Upper Jurassic-Lower Cretaceous formations of the Lubliin Upland (SE Poland) based on thin section studies, Polish Geological Institute Special Papers, 26, pp. 1-56

Omaña, L., Arreola, C. G., 2008, Late Jurassic (Kimmeridgian) larger benthic Foraminifera from Santiago Coatepec, SE Puebla, Mexico, Geobios, 41, 799-817

Orbigny d', A., 1842-1851, Paleontologie française, Terrains Jurassique, CEphalopodes, Paris

Özkan, S., 1993, Calcareous nannofossils from the Late Jurassic-Early Cretaceous of Northwestern Anatolia, Turkey, Geological Journal, 28, 295-307

Pawellek, T. & Aigner, T, 2003, Apparently homogenous 'reef '-limestones built by high-frequency cycles: Upper Jurassic, SW-Germany, Sedimentary Geology, 160, pp. 259–284

Pazdro, O., 1972, Remarks on the Genera Ophthalmidium and Palaeomiliolina (Foraminiferida), Acta Palaeontologica Polonica, vol. XVII, no. 4, 527-562

Pelin, S., 1977, Alucra (Giresun) Güneydoğu Yöresinin Petrol Olanakları Bakımından Jeolojik İncelenmesi, Doçentlik Tezi, K.T.Ü., Trabzon

Pınar, N. and Lahn, E., 1952, La position tectonique de l'Anatolie dans le Systeme orogenique Mediterraneen, C. R. Cong. Geol. Int., XIX, sess., section XV, fasc XVII, pp. 171-180, Alger, 1954

Pleş, G., Mircescu, C. V., Bucur, I. I., Săsâran, E., 2013, Encrusting micro-organisms and microbial structures in Upper Jurassic limestones from the Southern Carpathians (Romania), Facies, 59, pp. 19-48

Pop, G. & Bucur, I. I., 2001, Upper Jurassic and Lower Cretaceous Sedimentary Formations from the Vâlcan Mountains (South Carpathians), Studia UBB Geologia, XLVI (2), pp. 77-94

Radoičić, R., 1959, Some problematic microfossils from the Dinarian Cretaceous (in Serbian), Vesnik, 17, 87-92

Raineri, R., 1922, Alghe sifonee fossili della Libia, Nota I, Atti della Società italiana di scienze naturali e del Museo civico di storia natural di Milano, 61, 72-86

Rami, M., Reza Vaziri, M., Taherpour Khalil Abad, M., Abolfazl Hosseini, S., Carević, I., Allameh, M., 2012, Microbiostratigraphy of the Lower Cretaceous strata from the Bararig mountain, SE Iran: REvista Mexicana de Ciencias Geológicas, v. 29, 1, 63-75

Reitner, J., 1992, "Coralline Spongien" Der Versuch einer phylogenetisch-taxonomischen Analyse, Berliner geowiss. Abh., (E), 1, 352s

Reloid, M., Rodriguez-Tovar, F. J., Nagy, J., Olóriz, 2008, Benthic foraminiferal morphogroups of mid to outer shelf environments of the Late Jurassic (Prebetic Zone, southern Spain): Characterization of biofacies and environmental significance, Palaeogeography, Palaeoclimatology, Palaeoecology, 261, 280-299

Remane, J., 1985, Calpionellids, In Bolli, H. M., Saunders, J. B., and Perch-Nielsen, K. (Eds.): Plankton Stratigraphy, Cambridge Earth Science Series, Cambridge University Press, pp. 555-572

Remane J., Borza, K., Nagy, I., Bakalova-Ivanova, D., Knauer, J., Pop, G., Tardi-Filàcz, E., 1986, Agreement on the subdivision of the standard calpionellid zones defined at the IInd Planktonic Conference Roma 1970, Acta Geologica Hungarica, 29, 5-14

Ricci, C., Rusciadelli, G., 2008, Quantitative analysis of Upper Jurassic Ellipsactinia limestones: examples from the Lazio-Abruzzi platform margin (Central Apennines, Italy), Rendiconti online della Società Geologica Italiana 2, pp. 153–156

Riding, R., 1991, Calcified cyanobacteria, In: Riding, R. (ed.), Calcareous algae and stromatolites, Springer, Berlin, pp. 55-87

Riegraf, W., 1987, *Subbdelloidina luterbachi* sp. nov. (Foraminiferida) from Kimmeridgian to Tithonian (Upper Jurassic) sponge-algal facies of Southern Germany, Paläont. Z.,61/1-2, 29-40

Robertson, A.H.F. & Dixon, J.E., 1984, Introduction: aspects of the geological evolution of the Eastern Mediterranean, In: Dixon, J.E. and Robertson, A.H.F. (eds.), The Geological Evolution of the Eastern Mediterranean, Geological Society, London, Special Publications, 17, pp. 1-74

Robertson, A.H.F., Dixon, J.E. & Brown, S. ET AL., 1996, Alternative tectonic models for the Late Palaeozoic-Early Tertiary development of Tethys in the Eastern Mediterranean region, In: Morris, A. & Tarling, D.H. (eds.), Palaeomagnetism and Tectonics of the Mediterranean Region, Geological Society, London, Special Publications, 105, pp. 239-263

Robertson, A.H.F., Ustaömer, T., Pickett, E.A., Collins, A.S., Andrew, T., & Dixon, J.E., 2004, Testing models of Late Palaezoic –Early Mesozoic orogeny in Western Turkey: support for an evolving open-Tethys model, Journal of the Geological Society, London, Vol. 161, pp. 501-511

Rojay, B. & Altıner, D., 1998, Middle Jurassic-Lower Cretaceous Biostratigraphy in the Central Pontides (Turkey): Remarks on Paleogeography and Tectonic Evolution, Rivista İtaliana di Paleontologia e Stratigrafia, V. 104, (2), pp. 167-180

Roozbahani, P. R., 2011, Lithostratigraphy and Biostratigraphy of the Lower Cretaceous of the Jalmajird Area (Northeast of Khomeyn, Central Iran Basin), Iran, Geo. Alp., Vol. 9, pp. 48-58

Rostovtsev, K. O., 1992, Jurassic of Caucasus. Nauka, St. Petersburg [in Russian]

Rusciadelli, G., Ricci, C., & Lathuilière, B., 2011, The Ellipsactinia Limestone of the Marsica area (Central Apennines): A reference zonation model for Upper Jurassic Intra-Tethys reef complexes, Sedimentary Geology, 233, pp. 69-87

Russo, A., Morsilli, M., 2007, New insight on architecture and microstructure of Ellipsactinia and Sphaeractinia (Demosponges) from the Gargano promontory (southern Italy), Geologica Romana 40, 215–225

Saner, S., Taner, İ., Aksoy, Z., Siyako, M. and Bürkan, K. A., 1980, Safranbolu havzasının jeolojik yapısı ver Tersiyer Paleocoğrafyası, Türkiye 5. Petrol Kongresi, s. 11-122, Ankara

Saner, S., Siyako, M., Aksoy, Z., Bürkan, K., and Demir, O., 1981, Zonguldak dolayının jeolojisi, TPAO Arama Grubu Başkanlığı Raporu, Ankara

Sarı, A., 1994, Boyabat (Sinop) yöresi (Triyas-Kretase) birimlerinin organic fasiyes incelemesi, Türkiye Jeoloji Bülteni, C. 37, Sayı 2, 111-118

Sartorio, D., 1987, Reef and open episodes on a carbonate platform margin from Malm to Cenomanian: the Cansiglio example (Southern Alps), Memorie della Società Geologica Italiana 40, pp. 91–97

Săsâran, E., Hosu, A., Spălnăcan, R., Bucur, I. I, 1999, Microfacies, Microfossils and Sedimentary Evolution of the Sănduleşti Limestone Formation in Cheile Turzi (Apuseni Mountains, Romania), Acta Palaeontologica Romaniae, V. 2, pp. 453-462

Săsâran, E., Bucur, I. I., Prica, I., 2001, Microfacies and Microfossils in Upper Jurassic Limestones from Cheile Turenilor, Studia Universitatis Babeş-Bolya, XLVI, 2, pp. 35-52

Schäfer, P., Seonbari-Daryan, B., 1983, Die Kalkalgen aus der Obertrias von Hydra, Griechenland, Palaeontographica B., 185, 83-142

Schlagintweit, F. & Ebli, O., 1999, New Results on Microfacies, Biostratigraphy and Sedimentology of Late Jurassic – Early Cretaceous platform carbonates of the Northern Calcareous Alps – Part I: Tressenstein Limestone, Plassen Formation, Abh Geol BA, 56, pp. 379-418

Schlagintweit, F., 2004, *Iberopora bodeuri* GRANIER & BERTHOU 2002 (*incertae sedis*) from the Plassen Formation (Kimmeridgian-Berriasian) of the Tethyan Realm, Geologica Croatica, 57/1, pp. 1-13

Schlagintweit, F., 2005, *Consinocodium japonicum* ENDO, 1961 from the Upper Jurassic of the Northern Calcareous Alps of Austria: not a siphonous green alga, but a coralline sponge, Revue de Paléobiologie, 24 (2), 533-540

Schlagintweit, F., Gawlick, H.J., Missoni, S., Lein, R., 2005a, The reefal facies of the Upper Jurassic Plassen carbonate platform at Mt. Jainzen (Northern CalcareousAlps, Austria), Schriftenreihe der Deutschen Gesellschaft für Geowissenschaften 38, 130–131

Schlagintweit, F., Gawlick, H. J. & Lein, R., 2005b, Mikropaläontologie und Biostratigraphie der Plassen-Karbonat-platform der Typlokalität (Ober-Jura bis Unter-Kreide, Salzkammergut, Österreich), Journal of Alpine Geology, 47, 11-102

Schlagintweit, F. & Gawlick, H. J., 2006a, *Sarsteinia babai* n.gen., n. sp., A New Problematic Sponge (Inozoa?) from the Late Jurassic of the Northern Calcareous Alps, Austria, Rivista Italiana di Paleontologia e Stratigrafia, v. 122, no. 2, 251-260

Schlagintweit, F. & Gawlick, H. J., 2006b, "*Subbdelloidina*" *luterbachi* RIEGRAF, 1987 (Encrusting Foraminifera) from Late Jurassic to Early Cretaceous Reefal Limestones of Albania and the Northern Calcareous Alps (Austria), Jb. Geol. B.-A., 146, 53-63

Schlagintweit, F., Gawlick, H.J., 2007, *Pseudorothpletzella schmidi* n. gen., n. sp.: A New Microencruster incertae sedis from Late Jurassic Platform Fore-reefal Microframneworks of the Plassen Carbonate Platform (Northern Calcareous Alps, Austria) and the Albanides, Jb. Geol. B.-A., 147, 595-605

Schlagintweit, F., Gawlick, H.J., 2008, The occurrence and role of microencrusters frameworks in Late Jurassic to Early Cretaceous platform margin deposits of the Northern Calcareous Alps (Austria), Facies 54, pp. 207–231

Schlagintweit, F., 2010, Taxonomic revision of *Lithocodium aggregatum* ELLIOT sensu Schmid & Leinfelder, 1996, Jahrbuch der geologischen Bundesanstalt, 156 (3-4), 393-406

Schlagintweit, F., Bover-Arnal, T., Salas, R., 2010, New insights into *Lithocodium aggregatum* Elliott 1956 and *Bacinella irregularis* Radoičić 1959 (Late Jurassic-Lower Cretaceous): two ulvophycean green algae (?Order Ulotrichales) with a heteromorphic life cycle (epilithic/euendolithic), Facies, 56, 509-547

Schlagintweit, F., Gawlick, H.J., 2011, *Perturbatacrusta leini* n. gen., n. sp. A new microencruster incertae sedis (?sponge) from Late Jurassic to earliest Cretaceous platform margin carbonates of the Northern Calcareous Alps of Austria, Facies, 57, pp. 123-135

Schlagintweit, F., 2012a, New insights into *Troglotella incrustans* Wernli & Fookes, 1992, a fascinating Upper Jurassic-Upper Cretaceous foraminifer, Studia UBB, Geologia, 57 (2), 17-26

Schlagintweit, F., 2012b, *Mohlerina basiliensis* (Mohler, 1938): a Middle Jurassic-Early Cretaceous facultative (?) epilithic benthic foraminifer, Facies, 58, 637-647

Schlagintweit, F., Bover-Arnal, B., 2013, Remarks on *Bačinella* Radoičić, 1959 (type species *B. irregularis*) and its representatives, Facies, 59, 59-73

Schlagintweit, F., 2013, *Thaumatoporella* ladders unraveled, Studia UBB Geologia, 58, 5-9

Schmid, D. U., Leinfelder, R. R, 1995, *Lithocodium aggregatum* Elliott n'est pas une algue mais un foraminifère encroûtant, commensalisé par le foraminifère *Troglotella incrustans* Wernli & Fookes, CR Acad. Sci., Ser. 1, 320, pp. 531-538

Schmid, D. U., 1996, Marine Mikrobiolithe und Mikroinkrustierer aus dem Oberjura, Profil, 9, pp. 101-251

Schmid, D. U., Leinfelder, R. R., 1996, The Jurassic *Lithocodium aggreagatum-Troglotella incrustans* foraminiferal consortium, Palaeontology, 39 (1), 21-52

Schorr, M., Koch, R., 1985, Fazieszonierung eines oberjurassischen Algen-Schwamm-Bioherms (Herrlingen, Schwäbische Alb) Facies, 13, 227-270

Sedletskii, V.I., Boiko, N.I. & Derevyagin, V.S., 1977, Interrelation of the halogenic and bioherm sedimentation, Soviet Geology 12, 8–21 [in Russian]

Seidlitz, v. W., 1931, Diskordanz und Orogenese der Gebirge am Mittelmeer, Berlin

Senowbari-Daryan, B., 1984, Mikroproblematika aus den obertriadischen Riffkalken von Sizilien, Münster Forsch Geol. Paläont., 61, 1-81

Senowbari-Daryan, B., Bucur, I. I., Schlagintweit, F., Săsăran, E. & Matyszkiewicz, J., 2008, *Crescentiella*, a new name for "*Tubiphytes*" *morronensis* CRESCENTI, 1969: an enigmatic Jurassic-Cretaceous microfossil, Geologia Croatica, 61/2-3, 185-214

Septfontaine, M., 1974, Presence de *Protopeneroplis trochoangulata* sp. nov. (Foraminifére) dans le Crétacé inférieur du Jura mé ridional et revision de *Protopeneroplis* WEYNSCHENK, 1950, Eclogae geol Helv., 67, 605-628

Shaw, A. B., 1964, Time in Stratigraphy, New York, McGraw Hill, 365 p.

Shiraishi, F. & Kano. A., 2004, Composition and spatial distribution of microencrusters and microbial crusts in upper Jurassic-lowermost Cretaceous reef limestone (Torinosu Limestone, southwest Japan), Facies, 50, 217-227

Sidorenko, A.V., 1968, Geology of the USSR, Vol. IX: Geological Description, Part 1: Northern Caucasus, Nedra, Moscow [in Russian]

Sirel, E., 1993, *Kastamonina abanica*, n.gen., n.sp., a Complex Lituolid (Foraminiferida) from the Upper Jurassic Limestone of the Kastamonu Area (North Turkey), Geol. Croat., 46/1 pp. 1-7

Stampfli, G., Mosar, J., Faure, P., Pillevuit, A. & Vannay, J.C., 2001, Permo-Mesozoic evolution of the Western Tethys realm: the Neotethys East Mediterranean basin connection, In: Ziegler, P., Cavazza, W.,Robertson, A.H.F. & Crasquin-Soleau, A. (eds.) Peri-Tethyan Rift/Wrench Basins and Passive Margins, Peri-Tethys Memoir 5. Mémoires du Musée National d'Histoire Naturelle, 51-108

Staub, R., 1924, Der Bau der Alpen, Bern

Sudar, M., Jovanovic, D., Maran, A., Polavder, S., 2008, Late Barremian-Early Aptian Urgonian Limestones from the south-eastern Kučaj Mpunatins (Carpatho-Balkanides, eastern Serbia), Annales Geologiques de la Peninsule Balkanique, 69, 13-30

Şerban, D., Bucur, I. I., Săsăran, E., 2004, Micropaleontological Assemblages and Microfacies Characteristics of the Upper Jurassic Limestones from Căprioara-Pojoga (Mureş Trough), Acta Palaeontologica Romaniae, v. 4, pp. 475-484

Şengör, A.M.C. & Yılmaz, Y., 1981, Tethyan evolution of Turkey, a plate tectonic approach, Tectonophysics, 75, 181-214

Şengör, A.M.C., Yılmaz, Y. & Sungurlu, O., 1984, Tectonics of the Mediterranean Cimmerides: nature and evolution of the western termination of Palaeo-Tethys, In: Dixon, J.E. & Robertson, A.H.F. (eds.), The Geological Evolution of the Eastern Mediterranean, Geological Society, London, Special Publications, 17, pp. 77-112

Taslı, K., 1984, İkisu (Gümüşhane) ile Hamsiköy (Trabzon) Yörelerinin Jeolojisi ve Berdiga Formasyonu'nun Biyostratigrafik Deneştirmesi, Yüksek Lisans Tezi, K.T.Ü. Fen Bil. Enst., Trabzon

Taslı, K. 1993, Micropaleontology, Stratigraphy and depositional environment of the Jurassic Carbonate Platform Sequence of Kale-Gümüşhane Region (Eastern Pontides, Turkey), Revue De Micropaléontologie, V. 36 (1), 99. 45-65

Taslı, K., Özer, E., and Yılmaz, C., 1999, Biostratigraphic and Environmental Analysis of the Upper Jurassic – Lower Cretaceous Carbonate Sequence in the Başoba Yayşa Area (Trabzon, NE Turkey), Turk. J. of Earth Sci., 8, pp. 125-135

Taslı, K., 2001, Benthic Foraminifera of the Upper Jurassic Platform Carbonate Sequence in the Aydıncık (İçel) Area, Central Taurides, S Turkey, Geologia Croatica, 54, 1-13

Taslı, K. Altıner, D., Koç, H., Eren, M., 2008, Benthic Foraminiferal Biostratigraphy of the Jurassic Platform Carbonate Succession in the Bolkar Mountains (Southern Turkey), Micropaleontology, 54, 425-444

Tokay, M., 1954/1955, Filyos Çayı Ağzı-Amasra-Bartın-Kozcağız-Çaycuma Bölgesinin jeolojisi, MTA Derg., 46/47, pp. 58-74

Toker, V., 1973, Nallıhan – Bozyaka bölgesinde Üst Jura – Paleojen Stratigrafisi, TÜBİTAK IV. Bilim Kongresi Tebliğleri, Yerbilimleri Seksiyonu, Ankara, 1-8

Tunç, M., 1991, Aktaş (Kızılcahamam) yöresinin pelajik kireçtaşlarının biyostratigrafisi, Türkiye Jeoloji Bülteni, C. 34, pp. 27-42

Tunç, M., 1992a, Olur (Erzurum) yöresindeki Üst Jura-Alt Kretase yaşlı kireçtaşlarının biyostratigrafisi, T.J.K. Bült., 35/1, 121-130

Tunç, M., 1992b, Description of a new species of *Crassicollaria* from surrounding Olur (Erzurum-Turkey), Revue de Paleobiologie, Geneve, 11/2, pp. 463-468

Turi, V., Săsăran, E., Bucur, I. I., 2011, New data on the Upper Jurassic – Lower Cretaceous limestones from Bihor Mountains: case study of Gârda Seacă – Hodobana region, Romania, Studia UBB Geologia, 56 (1), pp. 11-27

Tüysüz, O., Yiğitbaş, E., Yılmaz, Y., Serdar, H., S., 1990, Orta Pontidlerde Üst Jura – Alt Kretase stratigrafisi ve tektonik anlamı, Türkiye 8. Petrol Kongresi Bildirileri, pp, 340-350

Tüysüz O., Aksay A., Yiğitbaş, E., 2004, Stratigraphic Nomenclature of the Western Black Sea Region. General Directorate of Mineral Research and Exploration, Commitee of Stratigraphy, Lithostratigraphy Units Serie I, Ankara [in Turkish]

Uğuz, M.F., Sevin, M., 2008, 1:100000 ölçekli Türkiye Jeoloji Haritaları No:77 Sinop-D33 ve E33 Paftaları, MTA, Jeoloji Etütleri Dairesi, Ankara

Ungureanu, D. & Barbu, E., 2004, Endemic Features of the Upper Jurassic Sponges in the Western Central Dobrogea (Atarnati-Cechirgea Perimeter), Acta Palaeontologica Romaniae, v. 4, pp. 493-502

Uta, A. & Bucur, I. I., 2003, Microbial Structures and Microencrusters in the Upper Jurassic-Lower Cretaceous Deposits from Buila-Vânturarita Massif (South Carpathians), Studia Universitatis Babeş-Bolyai, XLVIII, 2, pp. 3-14

Yergök, A., F., Akman, Ü., İplikçi, E., Karabalık, N., N., Keskin, İ., Mengi, H., Umut, M., Armağan, F., Erdoğan, K., Kaymakçı, H., ve Çetinkaya, A., 1987, Batı Karadeniz Bölgesinin Jeolojisi (I), MTA Rap. No. 8273 (unpublished)

Yılmaz, O., 1979, Daday-Devrekani masifi kuzeydoğu kesimi metamorfik petrolojisi (Phd Thesis) Hacettepe Üniversitesi, Yer Bilimleri Enstitüsü, 176 p.

Yılmaz, Y., and Tüysüz, O., 1984, Kastamonu-Boyabat-Vezirköprü_Tosya arasındaki bölgenin jeolojisi (Ilgaz-Kargı masiflerinin etüdü), MTA Raporu, 275 p.

Yılmaz, Y., Tüysüz, O., Yiğitbaş, E., Genç, S.C., Şengör, A.M.C., 1997, Geology and Tectonic Evolution of the Pontides, in A.G. Robinson, ed., Regional and petroleum geology of the Black Sea and surrounding region, AAPG Memoir68, pp. 183-226

Vachard, D., Hauser, M., Martini, R., Zaninetti, L., Matter, A., Peters, T., 2001, New algae and problematica of algal affinity from the Permi,an of the Aseelah Unit of the Batain Plain (East Oman), Géobios, 34, 375-404

Varol, B. and Kazancı, N., 1981, Nallıhan-Seben (Bolu) bölgesinde Üst Jura / Alt Kretase karbonat istifinin lito –ve biyofasiyes özellikleri, T. J. K. Bült., C. 24, pp. 31-38

Védrine, S., 2007, High-frequency palaeoenvironmental changes in mixed carbonate-siliciclastic sedimentary systems (Late Oxfordian, Switzerland, France, and southern Germany), University of Fribourg, Switzerland, Phd. Thesis, 216 pages

Védrine, S., 2008, Co-occurrence of the foraminifer *Mohlerina basiliensis* with *Bacinella-Lithocodium* oncoids: palaeoenvironmental and palaeoecological implications (Late Oxfordian, Swiss Jura), Journal of Micropalaeontology, 27, pp. 35-44

Védrine, S. & Strasser, A., 2009, High-frequency palaeonenvironmental changes on a shallow carbonate platform during a marine transgression (Late Oxfordian, Swiss Jura Mountains), Swiss Journ. Eart Sci., 102, pp. 247-270

Wedding, H., 1968, Amasra-Cide-Ulus bölgesinde Karbon gazı etüdleri, MTA Rap. No. 4004

Wedding, H., 1969, Amasra-Cide-Ulus bölgesinde Karbon gazı etüdleri, 2. Ümit verici sahanın batı kenarı (Zonguldak paftaları E28-b3 ve c2) MTA Rap. No. 4280

Wernli, R., Fookes, E., 1992, *Troglotella incrustans* n. gen., n. sp., un ètrange et nouveau foraminifère calcicavicole du complexe rècifal Kimméridgien de Saint-Germain-de-Joux (Ain, France), Bolletino della Societa Paleontologica Italiana, 31, pp. 95-103

Wilson, J. L., 1975, Carbonate facies in geologic history, Springer-Verlag, New York, 471 pp

Wimbledon, W.A.P., Casellato, C.E., Reháková, D., Bulot, L.G., Erba, E., Gardin, S., Verreussel, R.M.C.H., Munsterman, D.K., Hunt, C.O., 2011, Fixing a basl Berriasian and Jurassic-Cretaceous (J-K) boundary – is there perhaps some light at the end of the tunnel?, Rivista Italiana di Paleontologia e Stratigraphia, 117 (2), 295-307

Zaninetti, L., 1969, *Agathamminoides* gen. n. un nouveau genre de foraminiferes du Trias alpin, Note revtificatrice, Rev. ital.. paleont. Strat., 75, 4, 697-704

APPENDIX A

PLATE 1

Figure 1 *Troglotella incrustans*, MK-2, Scale bar is 250 µm

Figure 2 *Troglotella incrustans*, MK-4, Scale bar is 250 µm

Figure 3 *Troglotella incrustans*, MK-6, Scale bar is 250 µm

Figure 4 *Troglotella incrustans*, MK-72, Scale bar is 250 µm

Figure 5 *Troglotella incrustans*, MK-76, Scale bar is 250 µm

Figure 6 *Troglotella incrustans*, MK-77, Scale bar is 250 µm

Figure 7 *Troglotella incrustans*, MK-78, Scale bar is 250 µm

Figure 8 *Aaptotichus challenger* ?, MK-45, Scale bar is 125 µm

Figure 9 *Aaptotoichus* ? sp., MK-2, Scale bar is 250 µm

Figure 10 *Haghimashella arcuata* ?, MK-6, Scale bar is 125 µm

Figure 11 *Haghimashella arcuata* ?, MK-9C, Scale bar is 250 µm

Figure 12 *Haghimashella arcuata* ?, MK-21, Scale bar is 250 µm

Figure 13 *Haghimashella arcuata* ?, MK-29, Scale bar is 125 µm

Figure 14 *Haghimashella arcuata* ?, MK-64, Scale bar is 125 µm

Figure 15 *Textularia* sp., MK-45, Scale bar is 125 µm

Figure 16 *Textularia* sp., MK-2, Scale bar is 125 µm

Figure 17 *Textularia* sp., MK-4, Scale bar is 125 µm

Figure 18 *Textularia* sp., MK-5, Scale bar is 125 µm

Figure 19 *Textularia* sp., MK-6, Scale bar is 125 µm

Figure 20 *Textularia* sp., MK-72, Scale bar is 250 µm

Figure 21 *Mesoendothyra izjumiana*, MK-3, Scale bar is 250 µm

Figure 22 *Mesoendothyra izjumiana*, MK-5, Scale bar is 125 µm

Figure 23 *Subbdelloidina luterbachi*, MK-4, Scale bar is 250 µm

Figure 24 *Subbdelloidina luterbachi*, MK-18, Scale bar is 250 µm

PLATE 1

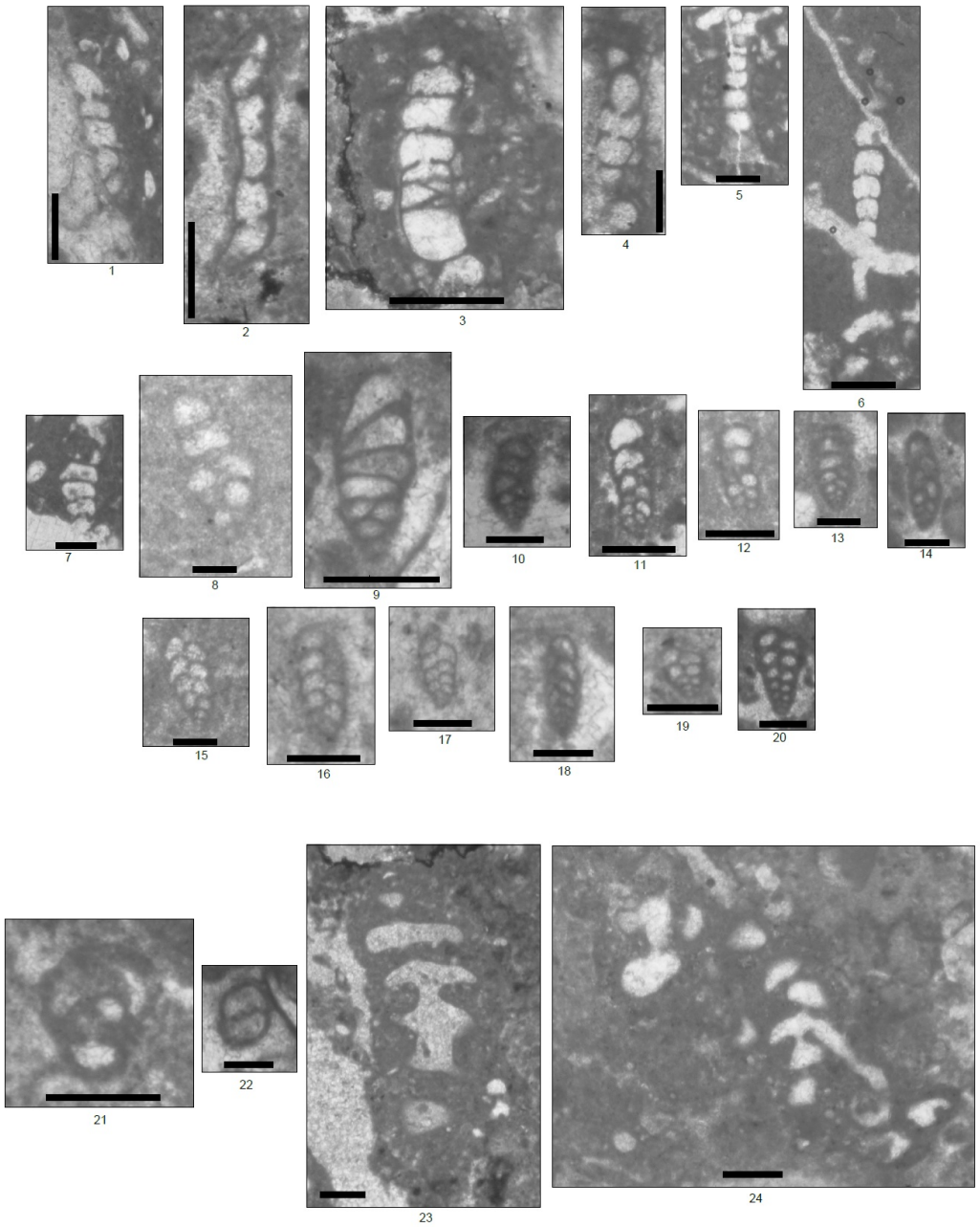


PLATE 2

Figure 1 *Ammobaculites* sp., MK-4, Scale bar is 250 µm

Figure 2 *Ammobaculites* sp., MK-9D, Scale bar is 250 µm

Figure 3 *Ammobaculites* sp., MK-41, Scale bar is 250 µm

Figure 4 *Ammobaculites* sp., MK-45, Scale bar is 125 µm

Figure 5 *Ammobaculites* sp., MK-95, Scale bar is 250 µm

Figure 6 *Ammobaculites* sp., MK-9C, Scale bar is 250 µm

Figure 7 *Ammobaculites* sp., MK-79, Scale bar is 250 µm

Figure 8 *Ammobaculites* sp., MK-6, Scale bar is 125 µm

Figure 9 *Spirillina* sp., MK-5, Scale bar is 250 µm

Figure 10 *Spirillina* sp., MK-19, Scale bar is 125 µm

Figure 11 *Spirillina* sp., MK-45, Scale bar is 125 µm

Figure 12 *Spirillina* sp., MK-45, Scale bar is 125 µm

Figure 13 *Spirillina* sp., MK-60, Scale bar is 125 µm

Figure 14 *Spirillina* sp., MK-83, Scale bar is 125 µm

Figure 15 *Reophax* sp., MK-6, Scale bar is 250 µm

Figure 16 *Reophax* sp., MK-6, Scale bar is 250 µm

Figure 17 *Reophax* sp., MK-19, Scale bar is 125 µm

Figure 18 *Reophax* sp., MK-21, Scale bar is 250 µm

Figure 19 *Reophax* sp., MK-41, Scale bar is 250 µm

Figure 20 *Reophax* sp., MK-62, Scale bar is 125 µm

Figure 21 *Reophax* sp., MK-13, Scale bar is 250 µm

Figure 22 *Reophax* sp., MK-25, Scale bar is 250 µm

Figure 23 *Reophax* sp., MK-12, Scale bar is 250 µm

Figure 24 *Reophax* sp., MK-87, Scale bar is 250 µm

Figure 25 *Cornuspira* sp., MK-60, Scale bar is 125 µm

Figure 26 *Lenticulina* sp., MK-11, Scale bar is 250 µm

Figure 27 *Lenticulina* sp., MK-45, Scale bar is 250 µm

Figure 28 *Earlandia* sp., MK-61, Scale bar is 125 µm

Figure 29 *Protomarssonella* ? sp., MK-64, Scale bar is 250 µm

Figure 30 *Rectoprotomarsonella* ? sp., MK-11, Scale bar is 250 µm

PLATE 2

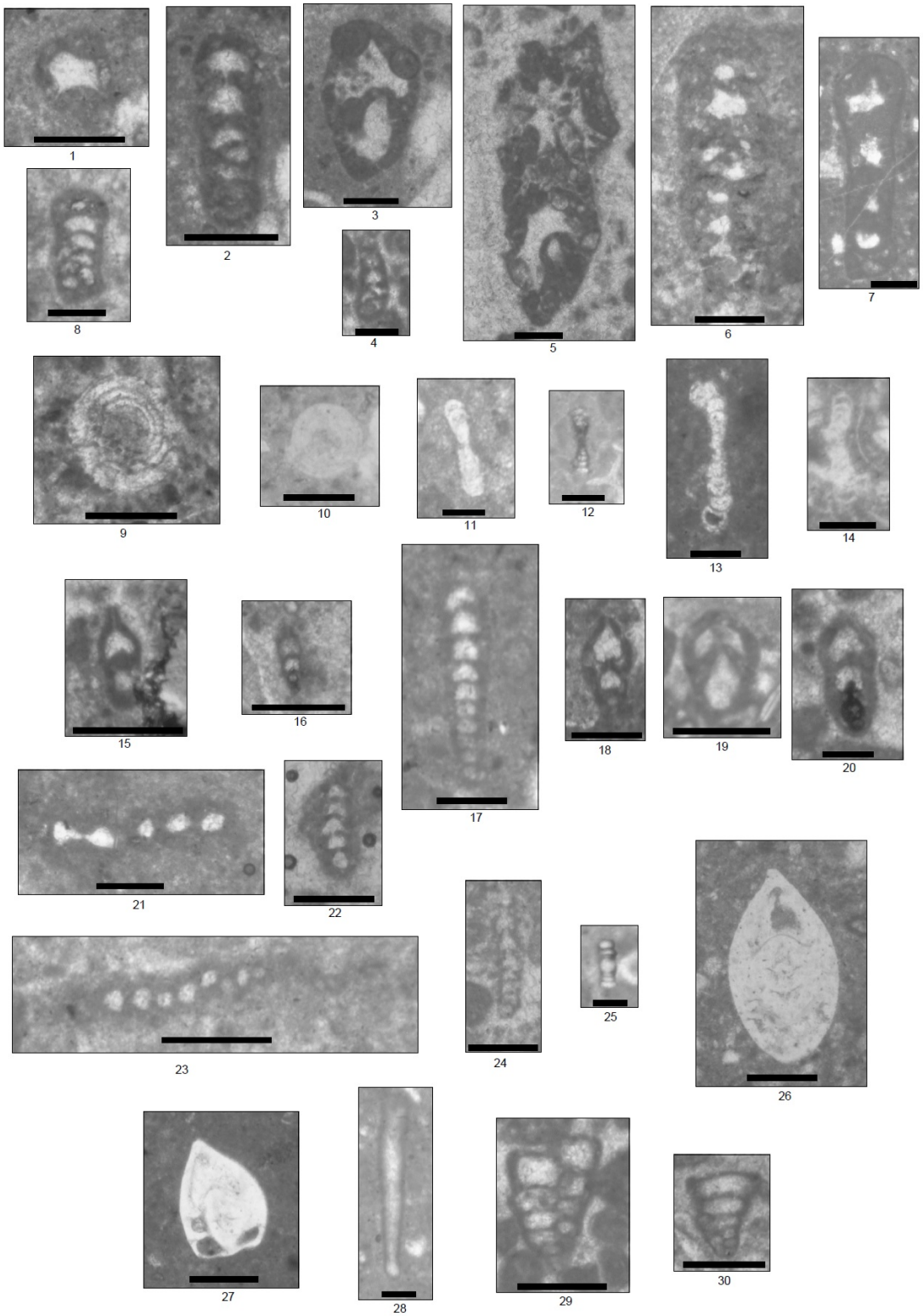

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PLATE 3

Figure 1 *Nautiloculina* sp., MK-12, Scale bar is 250 µm

Figure 2 *Nautiloculina* sp., MK-41, Scale bar is 250 µm

Figure 3 *Nautiloculina* sp., MK-41, Scale bar is 250 µm

Figure 4 *Nautiloculina bronnimanni*, MK-49, Scale bar is 250 µm

Figure 5 *Nautiloculina bronnimanni*, MK-65, Scale bar is 250 µm

Figure 6 *Nautiloculina* sp., MK-82, Scale bar is 250 µm

Figure 7 *Nautiloculina* sp., MK-84, Scale bar is 250 µm

Figure 8 *Verneuilinoides* ? sp., MK-14, Scale bar is 125 µm

Figure 9 *Verneuilinoides* ? sp., MK-14, Scale bar is 125 µm

Figure 10 *Istriloculina emiliae* ?, MK-64, Scale bar is 125 µm

Figure 11 *Istriloculina* sp., MK-66, Scale bar is 125 µm

Figure 12 *Istriloculina* sp., MK-66, Scale bar is 125 µm

Figure 13 *Istriloculina* sp., MK-82, Scale bar is 250 µm

Figure 14 *Istriloculina* sp., MK-89, Scale bar is 250 µm

Figure 15 *Meandrospira* sp., MK-19, Scale bar is 125 µm

Figure 16 *Meandrospira* sp., MK-41, Scale bar is 125 µm

Figure 17 *Protopeneroplis striata*, MK-20, Scale bar is 250 µm

Figure 18 *Protopeneroplis striata*, MK-26, Scale bar is 250 µm

Figure 19 *Protopeneroplis striata*, MK-34, Scale bar is 250 µm

Figure 20 *Protopeneroplis striata*, MK-34, Scale bar is 250 µm

Figure 21 *Protopeneroplis striata*, MK-40, Scale bar is 250 µm

Figure 22 *Protopeneroplis striata*, MK-47, Scale bar is 250 µm

Figure 23 *Protopeneroplis ultragranulata*, MK-58, Scale bar is 250 µm

Figure 24 *Protopeneroplis ultragranulata*, MK-64, Scale bar is 250 µm

Figure 25 *Protopeneroplis ultragranulata*, MK-65, Scale bar is 250 µm

Figure 26 *Protopeneroplis ultragranulata*, MK-65, Scale bar is 250 µm

Figure 27 *Protopeneroplis ultragranulata*, MK-83, Scale bar is 250 µm

Figure 28 *Protopeneroplis ultragranulata*, MK-86, Scale bar is 250 µm

Figure 29 *Protopeneroplis ultragranulata*, MK-86, Scale bar is 250 µm

Figure 30 *Protopeneroplis ultragranulata*, MK-86, Scale bar is 250 µm

Figure 31 *Protopeneroplis ultragranulata*, MK-87, Scale bar is 250 µm

Figure 32 *Protopeneroplis ultragranulata*, MK-89, Scale bar is 250 µm

Figure 33 *Protopeneroplis ultragranulata*, MK-89, Scale bar is 250 µm

Figure 34 *Protopeneroplis ultragranulata*, MK-90, Scale bar is 250 µm

Figure 35 *Protopeneroplis ultragranulata*, MK-91, Scale bar is 125 µm

Figure 36 *Protopeneroplis ultragranulata*, MK-95, Scale bar is 250 µm

PLATE 3

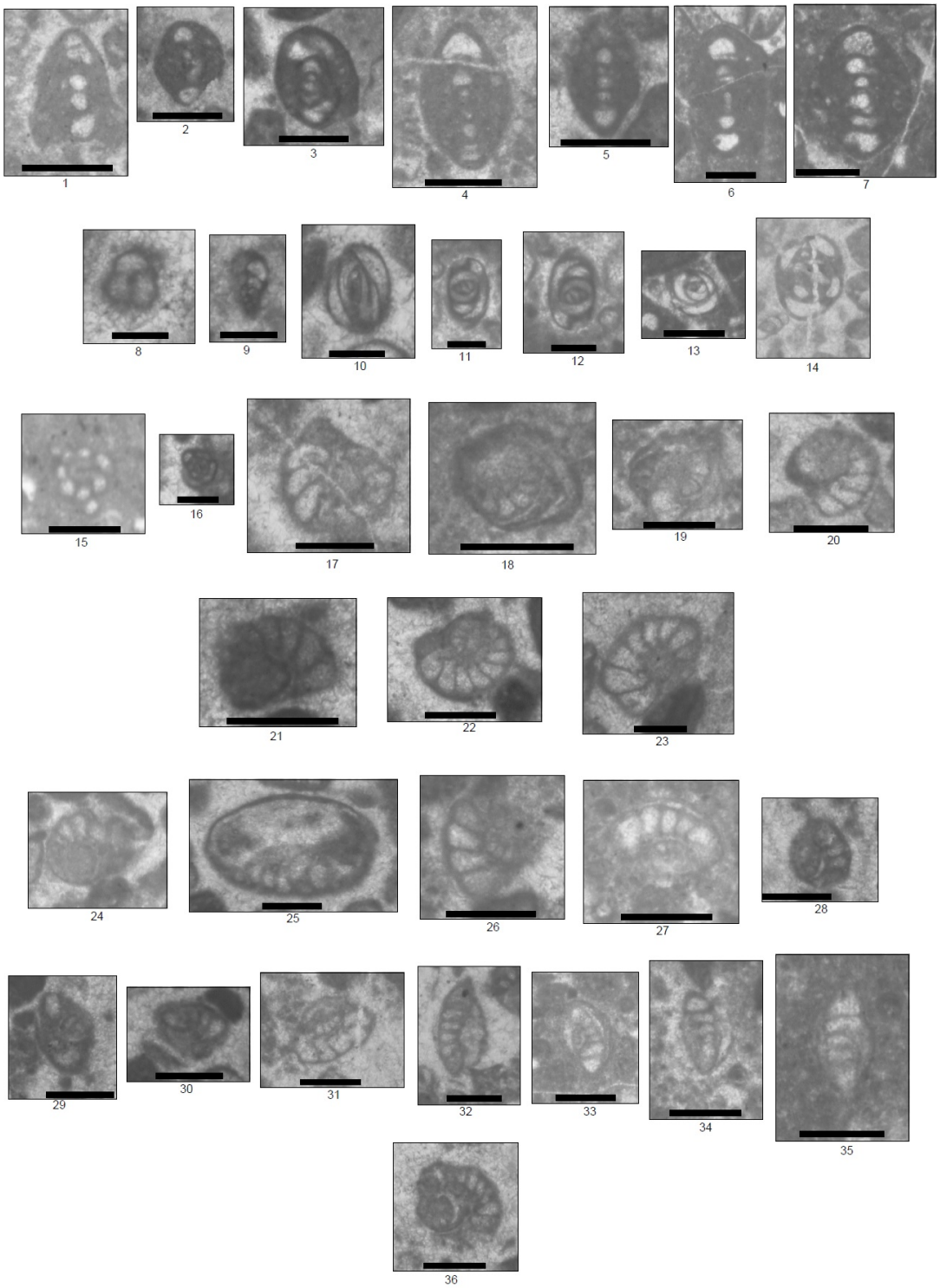
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PLATE 4

Figure 1 Lagenid foraminifera, MK-20, Scale bar is 125 µm

Figure 2 Lagenid foraminifera, MK-45, Scale bar is 250 µm

Figure 3 Lagenid foraminifera, MK-45, Scale bar is 250 µm

Figure 4 Lagenid foraminifera, MK-12, Scale bar is 250 µm

Figure 5 Lagenid foraminifera, MK-12, Scale bar is 250 µm

Figure 6 Lagenid foraminifera, MK-45, Scale bar is 250 µm

Figure 7 *Mohlerina basiliensis*, MK-23, Scale bar is 250 µm

Figure 8 *Mohlerina basiliensis*, MK-77, Scale bar is 250 µm

Figure 9 *Mohlerina basiliensis*, MK-77, Scale bar is 250 µm

Figure 10 *Mohlerina basiliensis*, MK-79, Scale bar is 250 µm

Figure 11 *Mohlerina basiliensis*, MK-80, Scale bar is 250 µm

Figure 12 *Coscinophragma cribrosum*, MK-33, Scale bar is 250 µm

Figure 13 *Coscinophragma cribrosum*, MK-37, Scale bar is 250 µm

Figure 14 *Coscinophragma cribrosum*, MK-40, Scale bar is 250 µm

Figure 15 *Coscinophragma cribrosum*, MK-43, Scale bar is 250 µm

Figure 16 *Coscinophragma cribrosum*, MK-49, Scale bar is 250 µm

Figure 17 *Coscinophragma cribrosum*, MK-57, Scale bar is 250 µm

Figure 18 *Coscinophragma cribrosum*, MK-23, Scale bar is 250 µm

PLATE 4

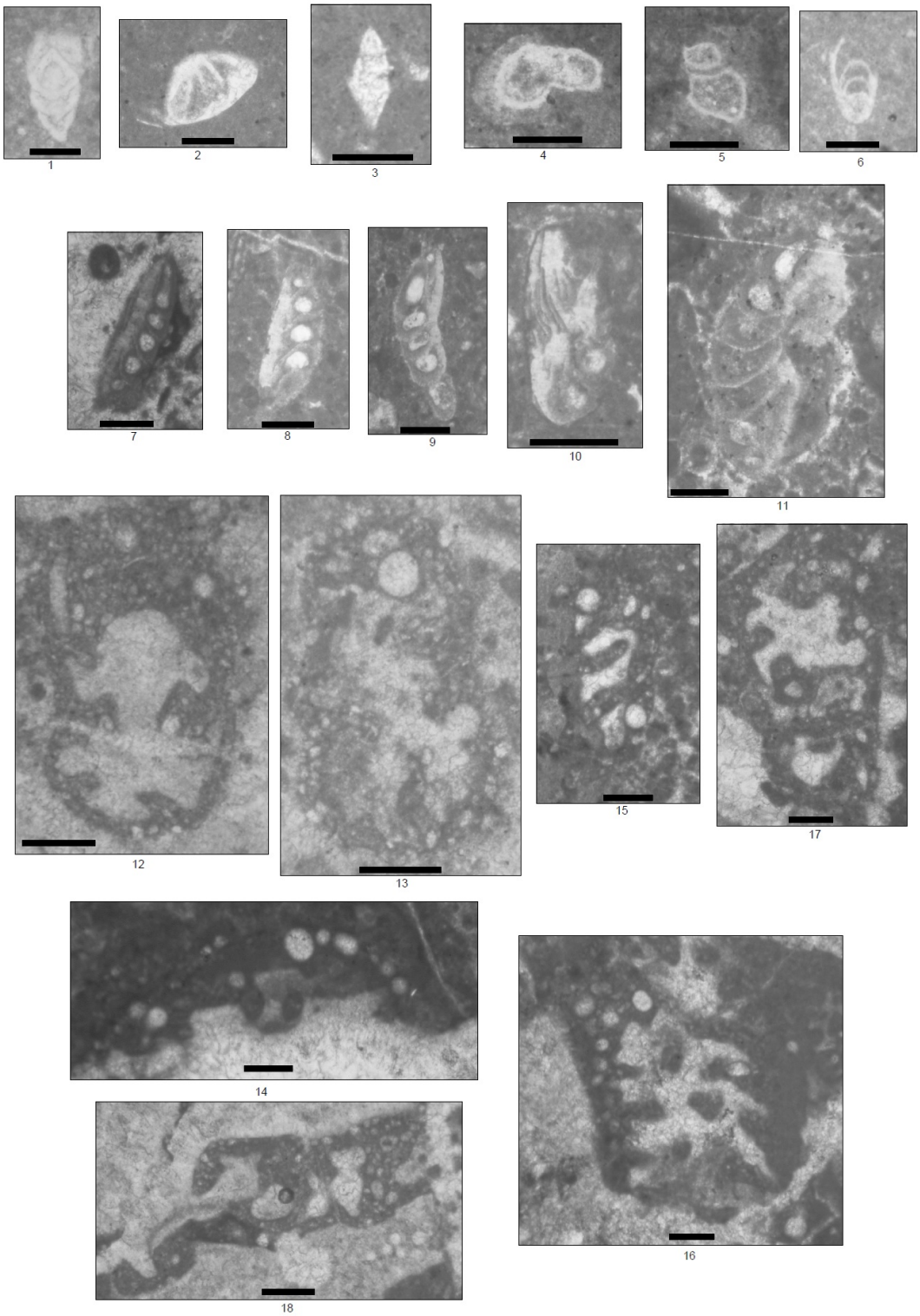

PLATE 5

Figure 1 *Coscinophragma cribrosum*, MK-72, Scale bar is 250 µm

Figure 2 *Coscinophragma cribrosum*, MK-72, Scale bar is 250 µm

Figure 3 *Coscinophragma cribrosum*, MK-72, Scale bar is 1000 µm

Figure 4 *Coscinophragma cribrosum*, MK-73, Scale bar is 250 µm

Figure 5 *Coscinophragma cribrosum*, MK-74, Scale bar is 250 µm

Figure 6 *Coscinophragma cribrosum*, MK-74, Scale bar is 250 µm

Figure 7 *Coscinophragma cribrosum*, MK-85, Scale bar is 250 µm

Figure 8 *Coscinophragma cribrosum*, MK-87, Scale bar is 250 µm

PLATE 5

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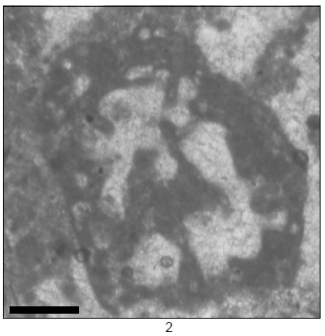
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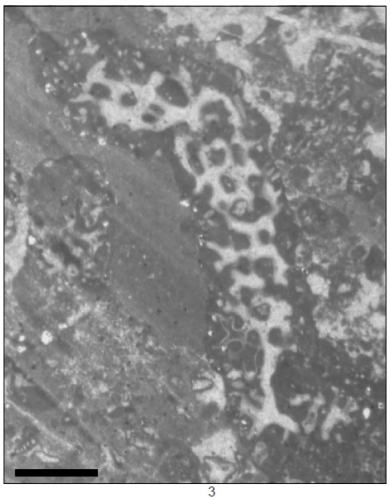
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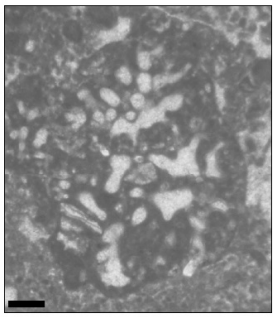
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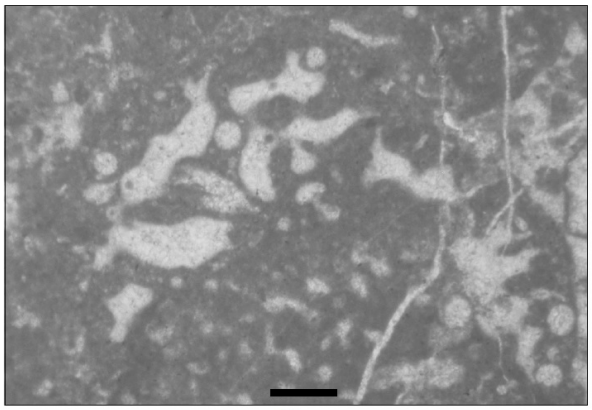
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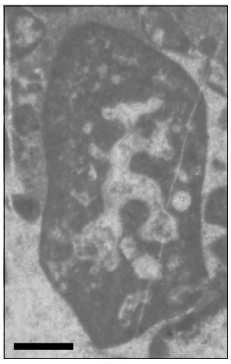
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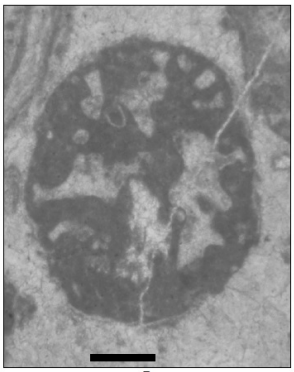
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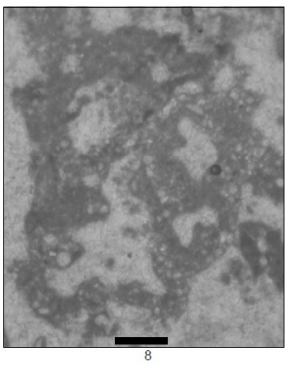
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PLATE 6

Figure 1 *Siphovalvulina* sp., MK-26, Scale bar is 125 µm

Figure 2 *Siphovalvulina* sp., MK-37, Scale bar is 125 µm

Figure 3 *Siphovalvulina variabilis*, MK-90, Scale bar is 250 µm

Figure 4 *Siphovalvulina variabilis*, MK-96, Scale bar is 125 µm

Figure 5 *Charentia* sp., MK-28, Scale bar is 250 µm

Figure 6 *Charentia cuvillieri*, MK-45, Scale bar is 250 µm

Figure 7 *Charentia cuvillieri*, MK-66, Scale bar is 250 µm

Figure 8 *Charentia* sp., MK-74, Scale bar is 250 µm

Figure 9 *Charentia* sp., MK-80, Scale bar is 250 µm

Figure 10 *Charentia evoluta* ?, MK-89, Scale bar is 250 µm

Figure 11 Encrusting foraminifera, MK-29, Scale bar is 250 µm

Figure 12 Encrusting foraminifera, MK-37, Scale bar is 250 µm

Figure 13 Encrusting foraminifera, MK-37, Scale bar is 250 µm

Figure 14 Encrusting foraminifera, MK-40, Scale bar is 250 µm

Figure 15 Encrusting foraminifera, MK-41, Scale bar is 250 µm

Figure 16 Encrusting foraminifera, MK-43, Scale bar is 250 µm

Figure 17 Encrusting foraminifera, MK-58, Scale bar is 250 µm

Figure 18 *Quinqueloculina stellata* ?, MK-32, Scale bar is 125 µm

Figure 19 *Quinqueloculina robusta* ?, MK-64, Scale bar is 250 µm

Figure 20 *Quinqueloculina robusta* ?, MK-64, Scale bar is 125 µm

Figure 21 *Quinqueloculina robusta* ?, MK-85, Scale bar is 250 µm

Figure 22 *Quinqueloculina robusta* ?, MK-74, Scale bar is 250 µm

Figure 23 *Quinqueloculina robusta* ?, MK-67, Scale bar is 250 µm

Figure 24 *Quinqueloculina robusta* ?, MK-79, Scale bar is 250 µm

Figure 25 *Quinqueloculina robusta* ?, MK-74, Scale bar is 250 µm

PLATE 6

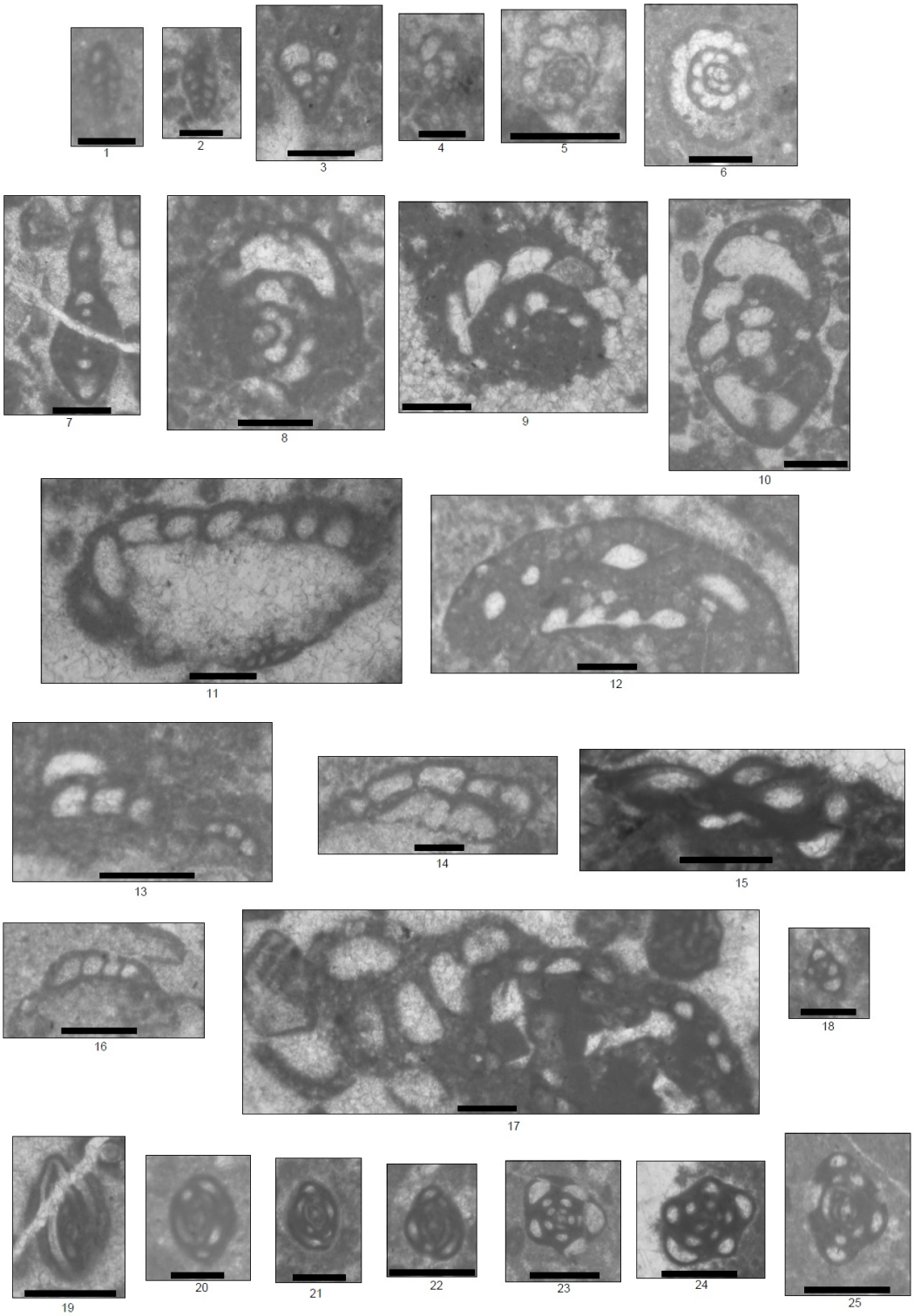


PLATE 7

Figure 1 *Pseudocyclammina lituus*, MK-74, Scale bar is 250 µm

Figure 2 *Pseudocyclammina lituus*, MK-79, Scale bar is 250 µm

Figure 3 *Pseudocyclammina lituus*, MK-80, Scale bar is 250 µm

Figure 4 *Pseudocyclammina lituus*, MK-82, Scale bar is 250 µm

Figure 5 *Uvigerinammina uvigeriniformis* ?, MK-45, Scale bar is 125 µm

Figure 6 *Ophthalmidium sp.*, MK-45, Scale bar is 250 µm

Figure 7 *Ophthalmidium sp.*, MK-52, Scale bar is 250 µm

Figure 8 *Ophthalmidium sp.*, MK-5, Scale bar is 250 µm

Figure 9 *Ophthalmidium sp.*, MK-45, Scale bar is 250 µm

Figure 10 *Gaudryinopsis* ? sp., MK-45, Scale bar is 250 µm

Figure 11 *Bullopora tuberculata*, MK-54, Scale bar is 500 µm

Figure 12 *Kastamonina abanica*, MK-77, Scale bar is 250 µm

Figure 13 *Redmondoides* ? sp., MK-84, Scale bar is 250 µm

Figure 14 *Redmondoides* ? sp., MK-82, Scale bar is 125 µm

Figure 15 *Redmondoides* ? sp., MK-28, Scale bar is 250 µm

Figure 16 *Redmondoides* ? sp., MK-34, Scale bar is 125 µm

Figure 17 *Redmondoides* ? sp., MK-89, Scale bar is 250 µm

Figure 18 *Redmondoides* ? sp., MK-71, Scale bar is 250 µm

Figure 19 *Redmondoides* ? sp., MK-84, Scale bar is 250 µm

Figure 20 *Redmondoides* ? sp., MK-78, Scale bar is 125 µm

Figure 21 *Trochammina* sp., MK-84, Scale bar is 250 µm

Figure 22 *Trochammina* sp., MK-80, Scale bar is 250 µm

Figure 23 *Trochammina* sp., MK-84, Scale bar is 250 µm

Figure 24 *Trochammina* sp., MK-84, Scale bar is 250 µm

Figure 25 *Trochammina* sp., MK-79, Scale bar is 250 µm

Figure 26 *Trochammina* sp., MK-77, Scale bar is 125 µm

PLATE 7

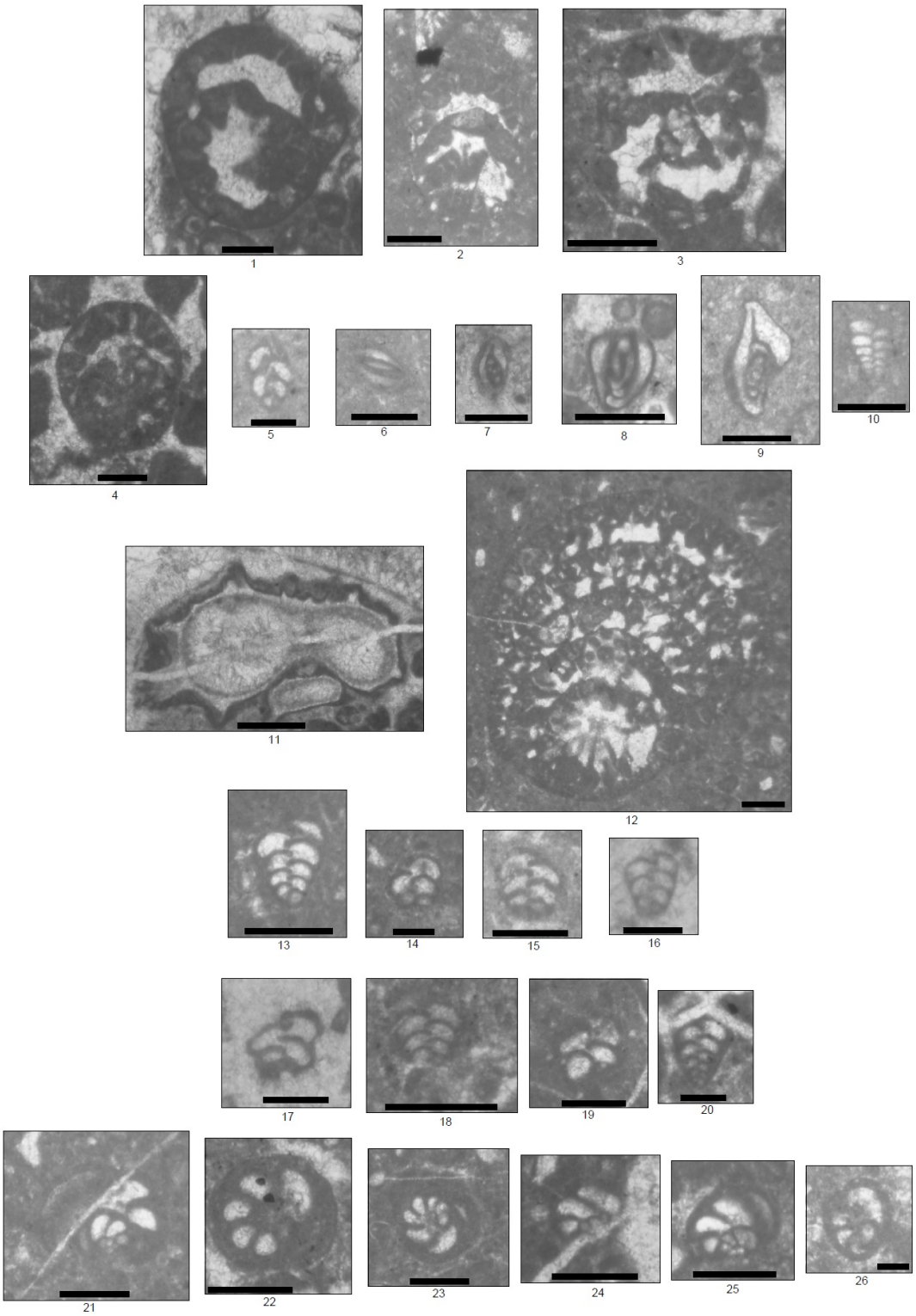


PLATE 8

Figure 1 *Anchispirocyclina lusitanica*, MK-79, Scale bar is 1000 µm

Figure 2 *Anchispirocyclina lusitanica*, MK-79, Scale bar is 1000 µm

Figure 3 *Anchispirocyclina lusitanica*, MK-79, Scale bar is 500 µm

Figure 4 *Anchispirocyclina lusitanica*, MK-79, Scale bar is 500 µm

Figure 5 *Anchispirocyclina lusitanica*, MK-79, Scale bar is 500 µm

Figure 6 *Anchispirocyclina lusitanica*, MK-80, Scale bar is 250 µm

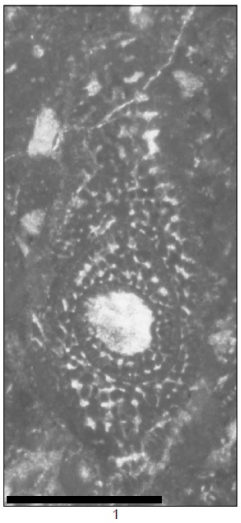
Figure 7 *Anchispirocyclina lusitanica*, MK-77, Scale bar is 250 µm

Figure 8 *Anchispirocyclina lusitanica*, MK-77, Scale bar is 250 µm

Figure 9 *Anchispirocyclina lusitanica*, MK-78, Scale bar is 250 µm

Figure 10 *Anchispirocyclina lusitanica*, MK-77, Scale bar is 125 µm

PLATE 8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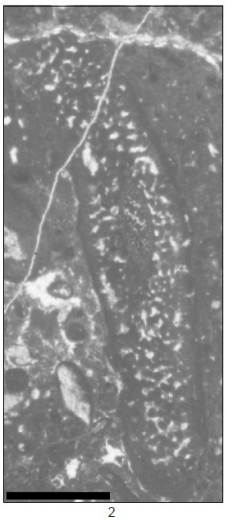
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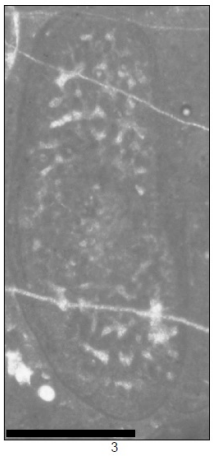
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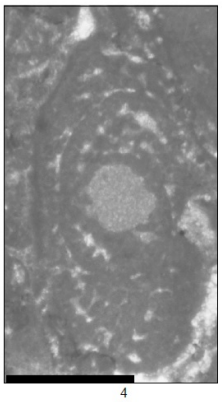
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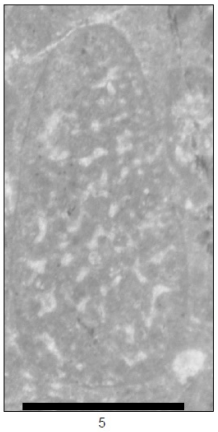
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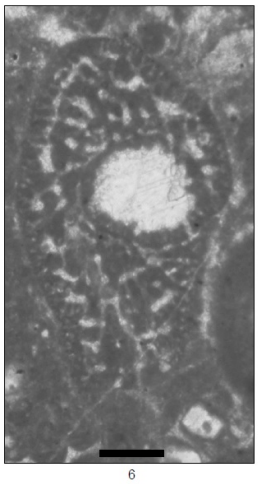
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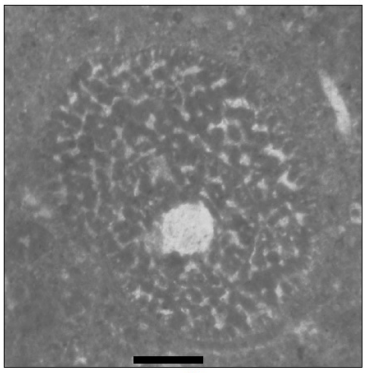
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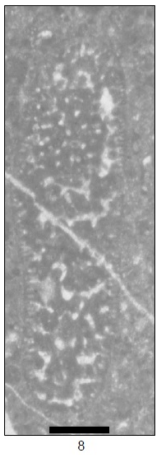
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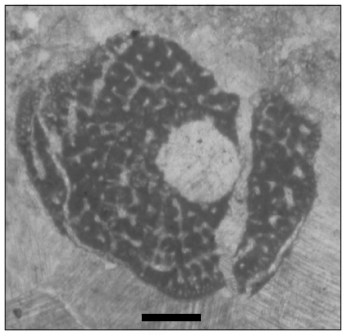
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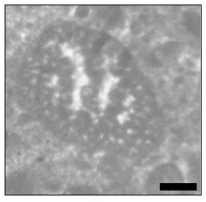
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PLATE 9

Figure 1 *Neotrocholina* sp., MK-5, Scale bar is 125 µm

Figure 2 *Neotrocholina* sp., MK-96, Scale bar is 125 µm

Figure 3 *Neotrocholina* sp., MK-66, Scale bar is 250 µm

Figure 4 *Trocholina* sp., MK-58, Scale bar is 250 µm

Figure 5 *Trocholina* sp., MK-58, Scale bar is 250 µm

Figure 6 *Trocholina* sp., MK-65, Scale bar is 250 µm

Figure 7 *Trocholina* sp., MK-65, Scale bar is 250 µm

Figure 8 *Trocholina* sp., MK-26, Scale bar is 250 µm

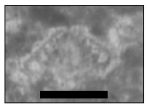
Figure 9 *Trocholina* sp., MK-72, Scale bar is 250 µm

Figure 10 *Trocholina* sp., MK-26, Scale bar is 250 µm

Figure 11 *Trocholina* sp., MK-72, Scale bar is 250 µm

Figure 12 *Trocholina* sp., MK-58, Scale bar is 250 µm

PLATE 9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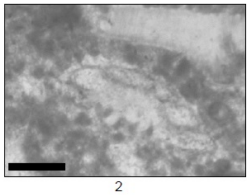
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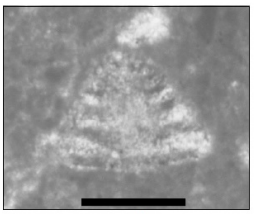
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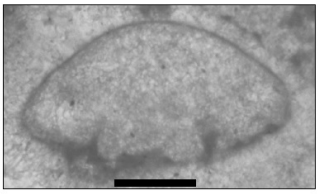
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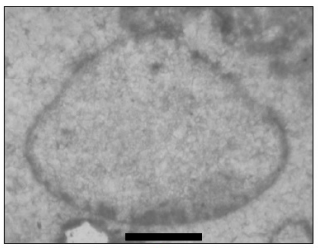
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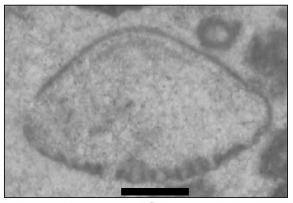
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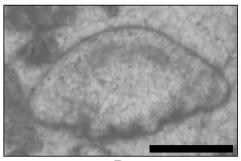
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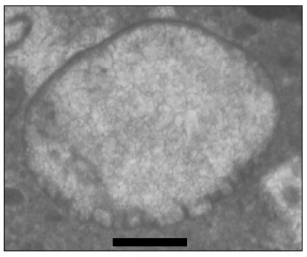
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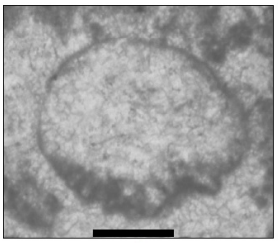
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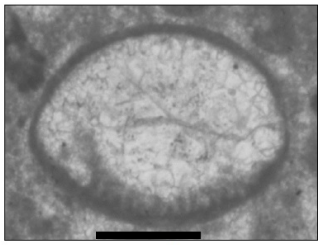
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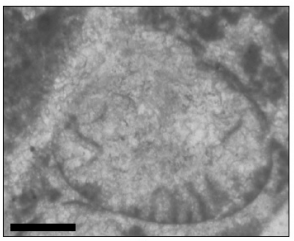
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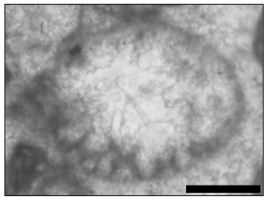
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PLATE 10

Figure 1 *Trocholina* sp., MK-79, Scale bar is 250 µm

Figure 2 *Trocholina* sp., MK-85, Scale bar is 250 µm

Figure 3 *Trocholina* sp., MK-38, Scale bar is 250 µm

Figure 4 *Trocholina* sp., MK-58, Scale bar is 250 µm

Figure 5 *Trocholina* sp., MK-65, Scale bar is 250 µm

Figure 6 *Trocholina* sp., MK-58, Scale bar is 250 µm

Figure 7 *Trocholina* sp., MK-79, Scale bar is 250 µm

Figure 8 *Trocholina* sp., MK-85, Scale bar is 250 µm

Figure 9 *Trocholina* sp., MK-26, Scale bar is 250 µm

Figure 10 *Trocholina* sp., MK-65, Scale bar is 250 µm

PLATE 10

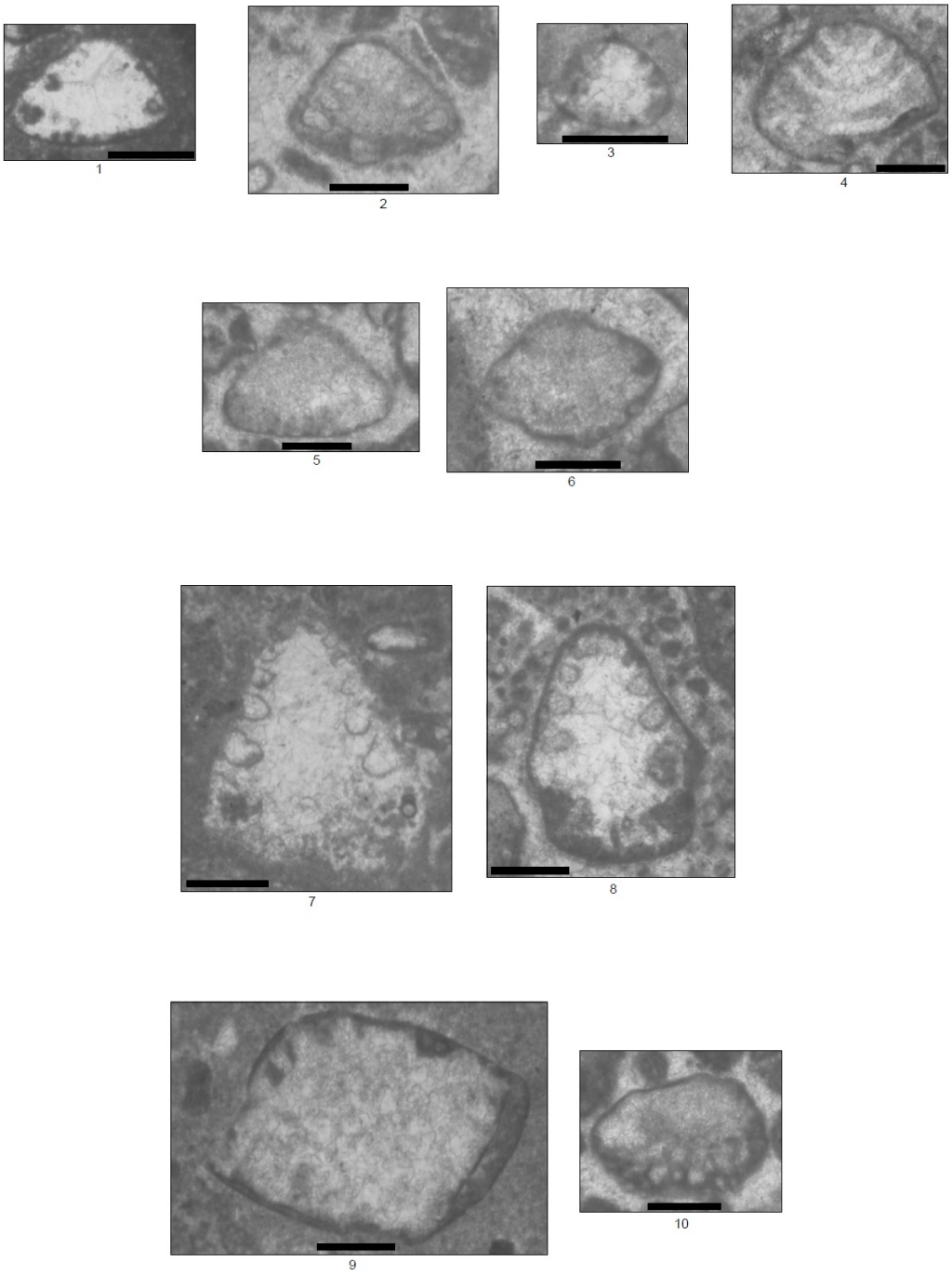


PLATE 11

Figure 1 *Radiomura cautica*, MK-33, Scale bar is 500 µm

Figure 2 *Radiomura cautica*, MK-55, Scale bar is 500 µm

Figure 3 *Radiomura cautica*, MK-35, Scale bar is 500 µm

Figure 4 *Radiomura cautica*, MK-49, Scale bar is 500 µm

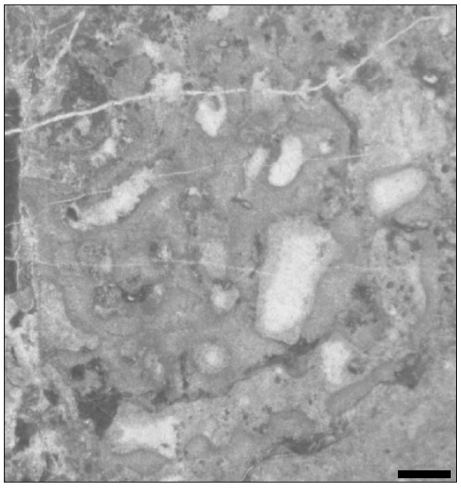
Figure 5 *Radiomura cautica*, MK-9A, Scale bar is 500 µm

Figure 6 *Radiomura cautica*, MK-7, Scale bar is 500 µm

Figure 7 *Radiomura cautica*, MK-6, Scale bar is 500 µm

Figure 8 *Radiomura cautica*, MK-50, Scale bar is 500 µm

PLATE 11



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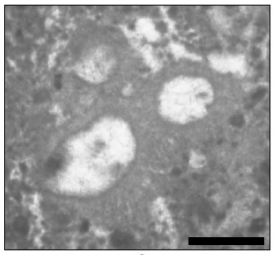

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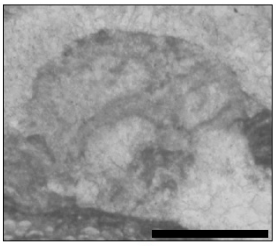

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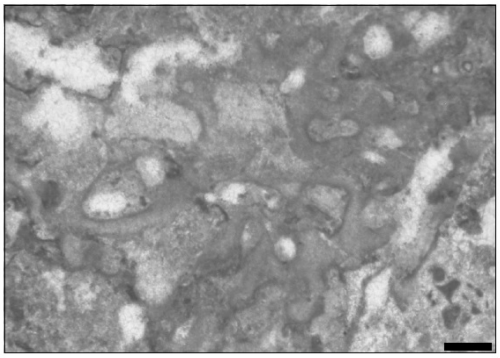

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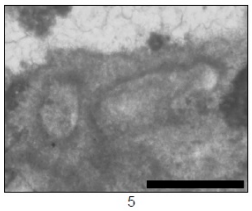

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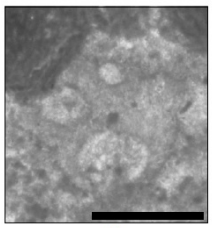

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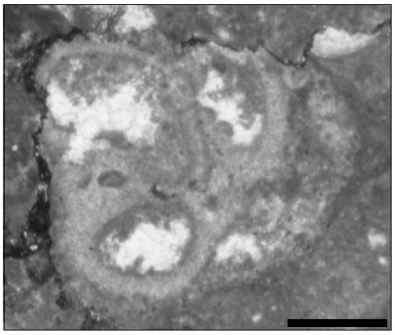

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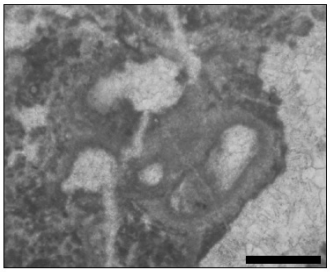

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PLATE 12

Figure 1 *Radiomura cautica*, MK-27, Scale bar is 500 µm

Figure 2 *Radiomura cautica*, MK-9A, Scale bar is 500 µm

Figure 3 *Radiomura cautica*, MK-34, Scale bar is 500 µm

Figure 4 *Radiomura cautica*, MK-55, Scale bar is 500 µm

Figure 5 *Radiomura cautica*, MK-15, Scale bar is 500 µm

Figure 6 *Radiomura cautica*, MK-9A, Scale bar is 500 µm

Figure 7 *Radiomura cautica*, MK-9A, Scale bar is 500 µm

Figure 8 *Radiomura cautica*, MK-6, Scale bar is 500 µm

PLATE 12

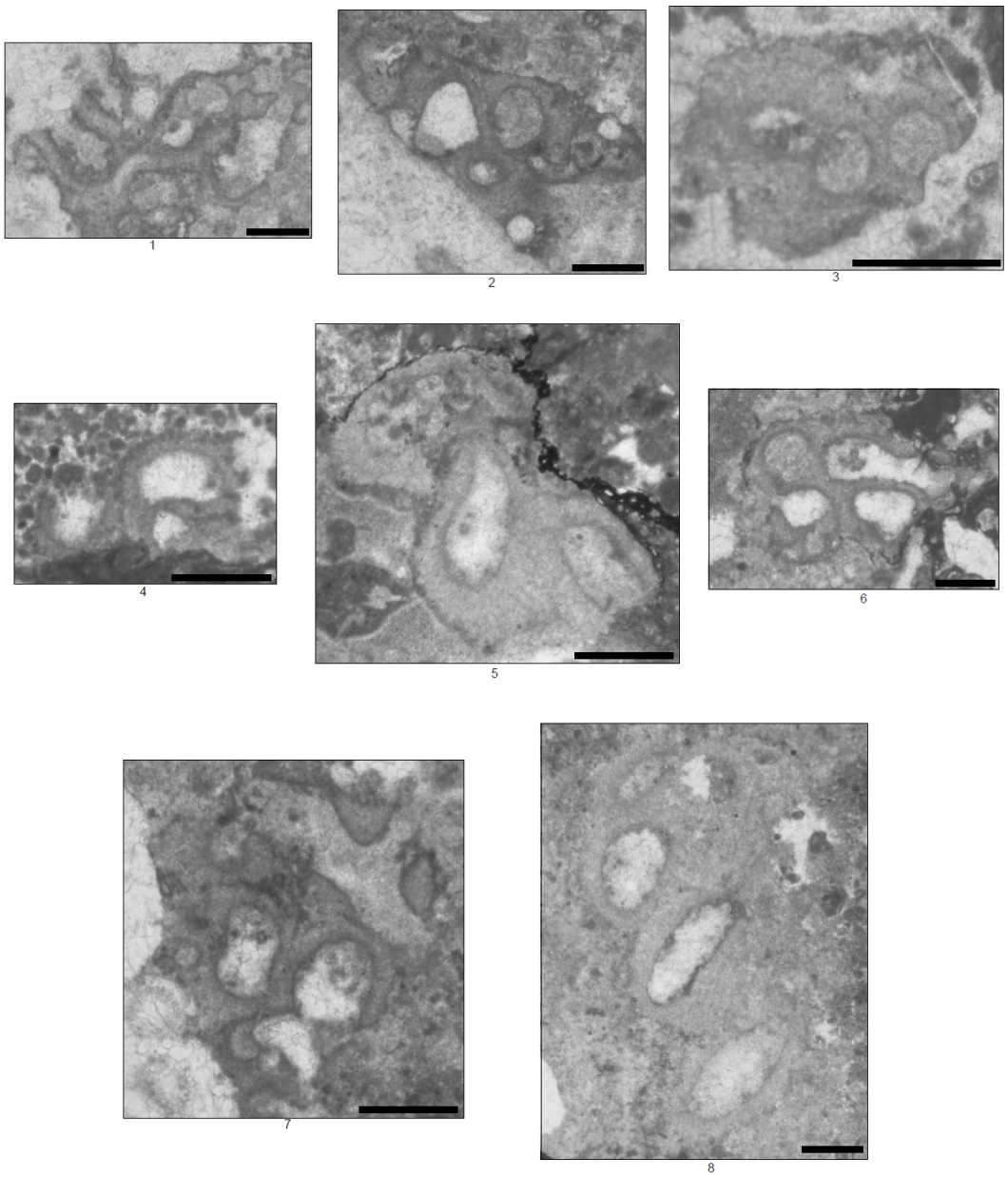


PLATE 13

Figure 1 *Perturbatacrusta leini*, MK-5, Scale bar is 500 µm

Figure 2 *Perturbatacrusta leini*, MK-5, Scale bar is 500 µm

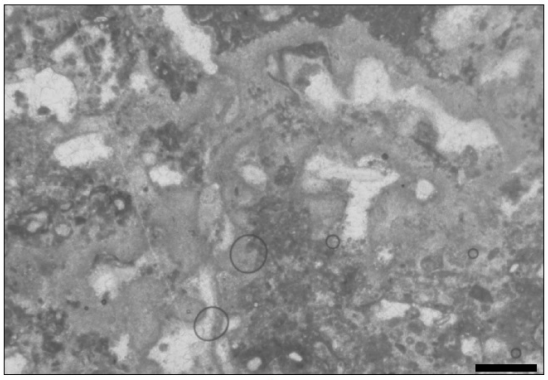
Figure 3 *Perturbatacrusta leini*, MK-30, Scale bar is 500 µm

Figure 4 *Perturbatacrusta leini*, MK-39, Scale bar is 500 µm

Figure 5 *Perturbatacrusta leini*, MK-54, Scale bar is 500 µm

Figure 6 *Perturbatacrusta leini*, MK-91, Scale bar is 500 µm

PLATE 13



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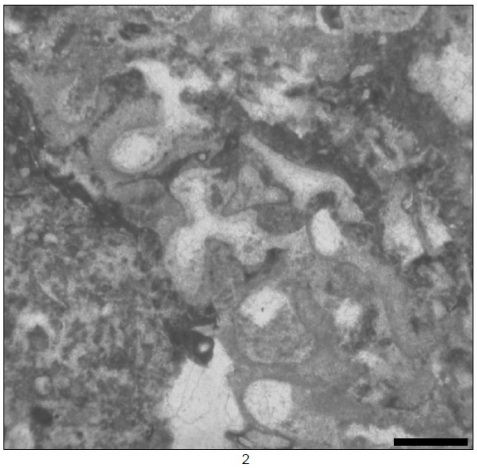

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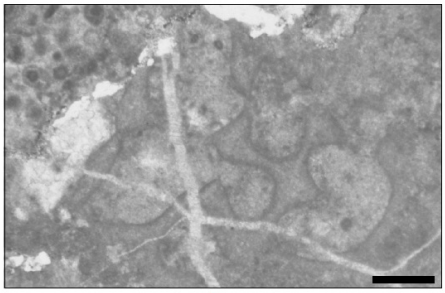

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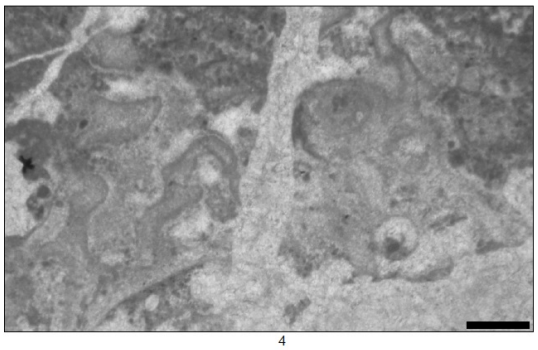

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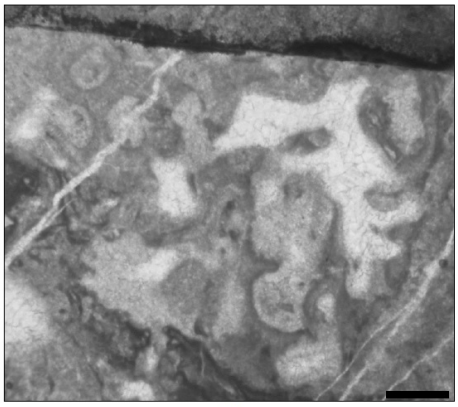

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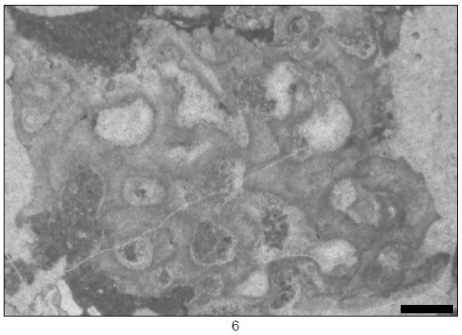

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PLATE 14

Figure 1 *Koskinobullina socialis*, MK-2, Scale bar is 500 µm

Figure 2 *Koskinobullina socialis*, MK-20, Scale bar is 500 µm

Figure 3 *Koskinobullina socialis*, MK-70, Scale bar is 500 µm

Figure 4 *Koskinobullina socialis*, MK-94, Scale bar is 500 µm

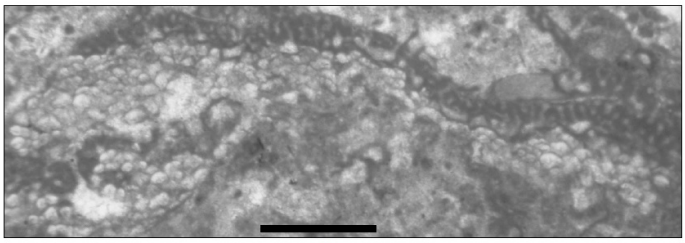
Figure 5 *Koskinobullina socialis*, MK-30, Scale bar is 500 µm

Figure 6 *Koskinobullina socialis*, MK-35, Scale bar is 500 µm

Figure 7 *Koskinobullina socialis*, MK-35, Scale bar is 500 µm

Figure 8 *Koskinobullina socialis*, MK-41, Scale bar is 500 µm

PLATE 14



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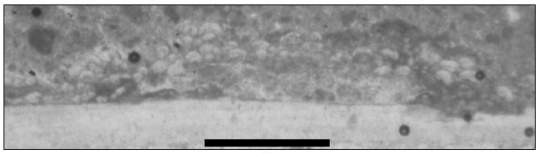

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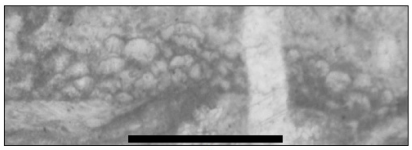

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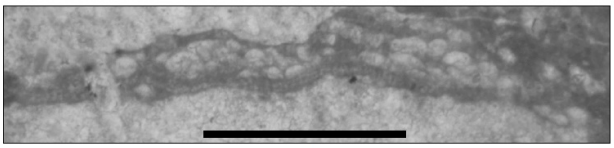

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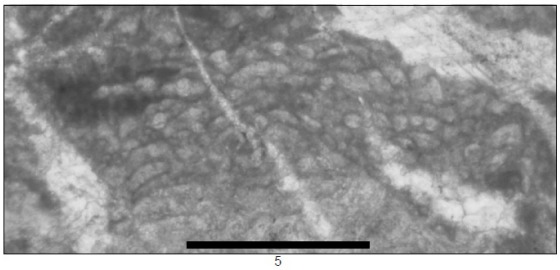

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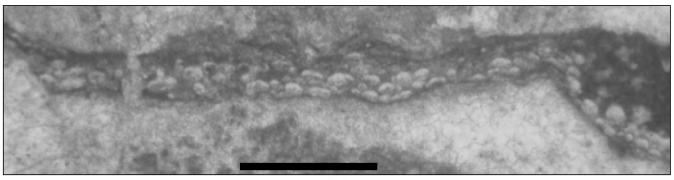

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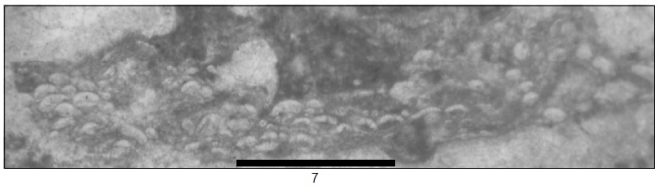

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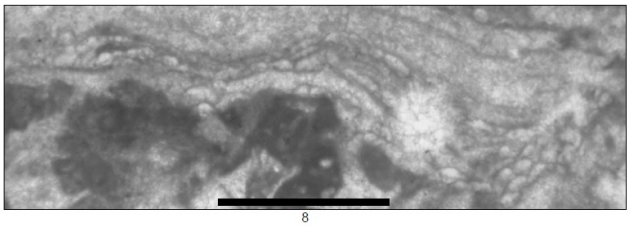

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PLATE 15

Figure 1 *Crescentiella morronensis*, MK-2, Scale bar is 250 µm

Figure 2 *Crescentiella morronensis*, MK-2, Scale bar is 250 µm

Figure 3 *Crescentiella morronensis*, MK-2, Scale bar is 250 µm

Figure 4 *Crescentiella morronensis*, MK-4, Scale bar is 250 µm

Figure 5 *Crescentiella morronensis*, MK-4, Scale bar is 250 µm

Figure 6 *Crescentiella morronensis*, MK-5, Scale bar is 250 µm

Figure 7 *Crescentiella morronensis*, MK-5, Scale bar is 250 µm

Figure 8 *Crescentiella morronensis*, MK-5, Scale bar is 250 µm

Figure 9 *Crescentiella morronensis*, MK-6, Scale bar is 250 µm

Figure 10 *Crescentiella morronensis*, MK-6, Scale bar is 250 µm

Figure 11 *Crescentiella morronensis*, MK-7, Scale bar is 250 µm

Figure 12 *Crescentiella morronensis*, MK-7, Scale bar is 250 µm

Figure 13 *Crescentiella morronensis*, MK-7, Scale bar is 250 µm

Figure 14 *Crescentiella morronensis*, MK-7, Scale bar is 250 µm

Figure 15 *Crescentiella morronensis*, MK-8, Scale bar is 250 µm

Figure 16 *Crescentiella morronensis*, MK-8, Scale bar is 250 µm

Figure 17 *Crescentiella morronensis*, MK-8, Scale bar is 250 µm

Figure 18 *Crescentiella morronensis*, MK-8, Scale bar is 250 µm

Figure 19 *Crescentiella morronensis*, MK-8, Scale bar is 250 µm

Figure 20 *Crescentiella morronensis*, MK-9A, Scale bar is 250 µm

Figure 21 *Crescentiella morronensis*, MK-9A, Scale bar is 250 µm

Figure 22 *Crescentiella morronensis*, MK-9C, Scale bar is 250 µm

Figure 23 *Crescentiella morronensis*, MK-9C, Scale bar is 250 µm

Figure 24 *Crescentiella morronensis*, MK-9D, Scale bar is 250 µm

Figure 25 *Crescentiella morronensis*, MK-9D, Scale bar is 250 µm

Figure 26 *Crescentiella morronensis*, MK-9D, Scale bar is 250 µm

Figure 27 *Crescentiella morronensis*, MK-9D, Scale bar is 250 µm

Figure 28 *Crescentiella morronensis*, MK-11, Scale bar is 250 µm

Figure 29 *Crescentiella morronensis*, MK-11, Scale bar is 250 µm

Figure 30 *Crescentiella morronensis*, MK-13, Scale bar is 250 µm

Figure 31 *Crescentiella morronensis*, MK-15, Scale bar is 250 µm

Figure 32 *Crescentiella morronensis*, MK-70, Scale bar is 250 µm

Figure 33 *Crescentiella morronensis*, MK-93, Scale bar is 250 µm

PLATE 15

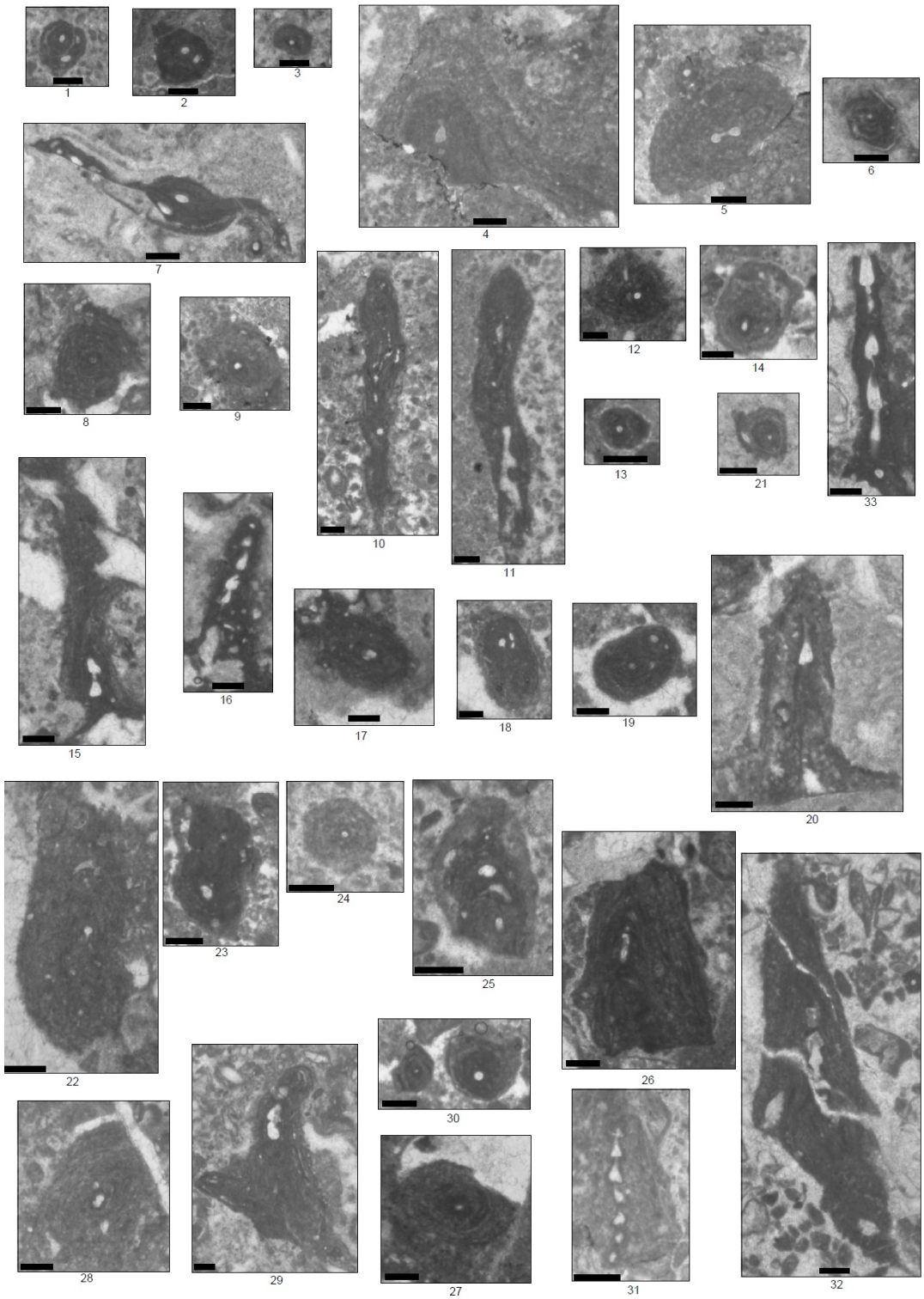
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PLATE 16

Figure 1 *Labes atramentosa*, MK-5, Scale bar is 250 µm

Figure 2 *Labes atramentosa*, MK-12, Scale bar is 250 µm

Figure 3 *Labes atramentosa*, MK-13, Scale bar is 250 µm

Figure 4 *Labes atramentosa*, MK-14, Scale bar is 500 µm

Figure 5 *Labes atramentosa*, MK-15, Scale bar is 500 µm

Figure 6 *Labes atramentosa*, MK-28, Scale bar is 500 µm

Figure 7 *Labes atramentosa*, MK-34, Scale bar is 500 µm

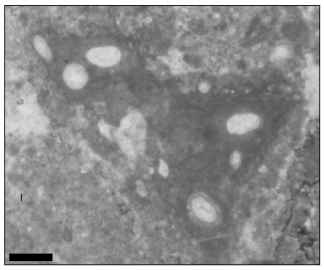
Figure 8 *Labes atramentosa*, MK-35, Scale bar is 500 µm

Figure 9 *Labes atramentosa*, MK-41, Scale bar is 500 µm

Figure 10 *Labes atramentosa*, MK-55, Scale bar is 500 µm

Figure 11 *Labes atramentosa*, MK-69, Scale bar is 500 µm

PLATE 16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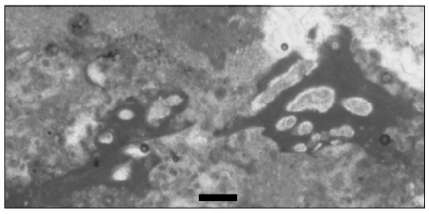
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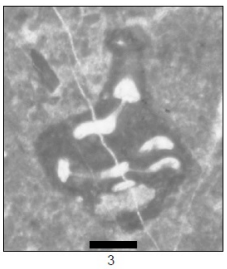
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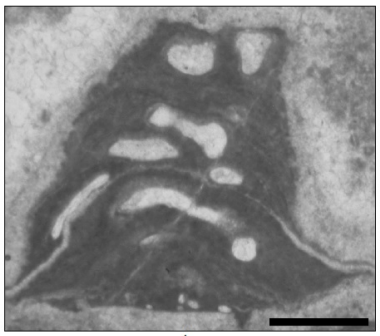
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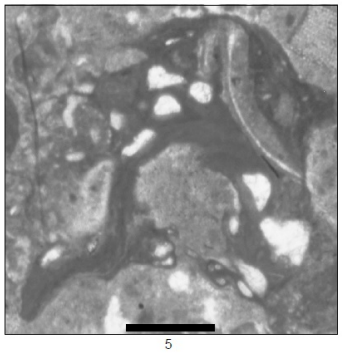
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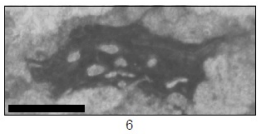
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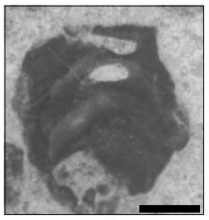
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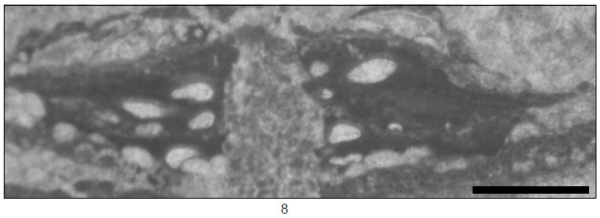
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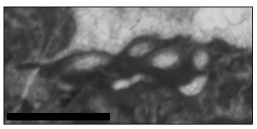
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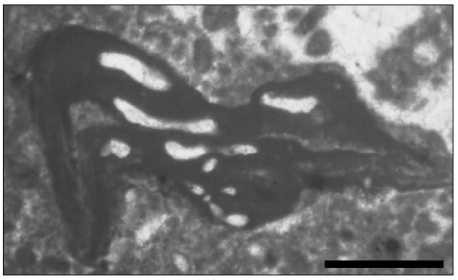
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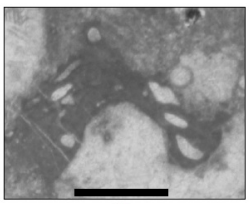
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PLATE 17

Figure 1 *Iberopora bodeuri*, MK-85, Scale bar is 1000 µm

Figure 2 *Iberopora bodeuri* (close view), MK-85, Scale bar is 500 µm

Figure 3 Serpulids, MK-62, Scale bar is 250 µm

Figure 4 Serpulids, MK-86, Scale bar is 250 µm

Figure 5 Serpulid, MK-54, Scale bar is 250 µm

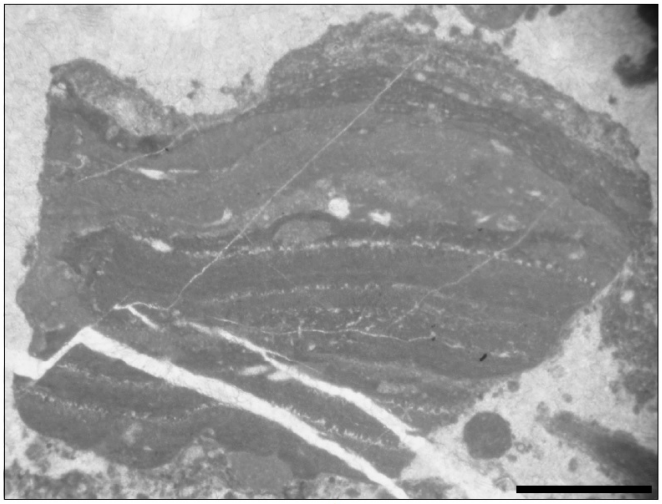
Figure 6 Serpulid, MK-59, Scale bar is 250 µm

Figure 7 Serpulid, MK-93, Scale bar is 250 µm

Figure 8 Serpulid, MK-93, Scale bar is 250 µm

Figure 9 Serpulid, MK-54, Scale bar is 250 µm

PLATE 17



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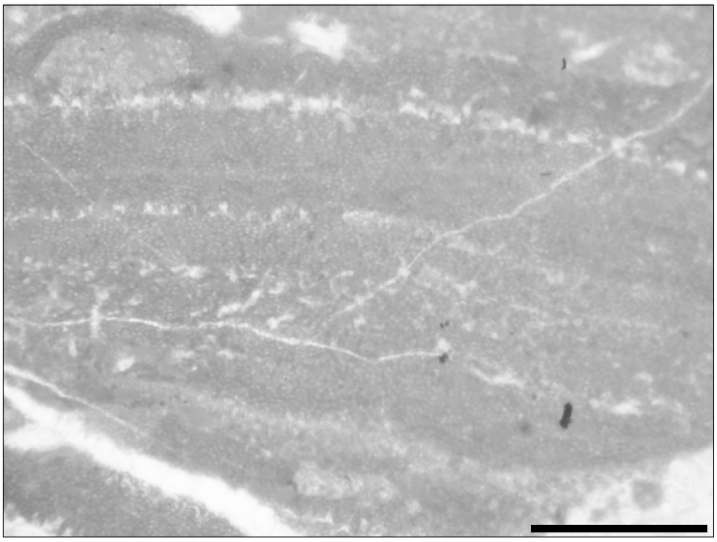

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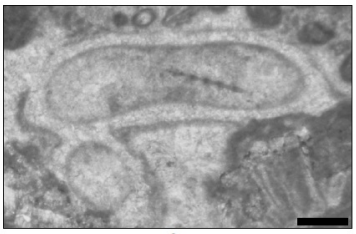

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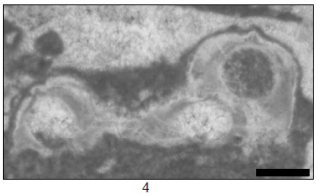

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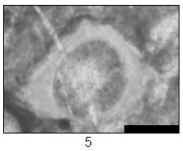

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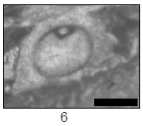

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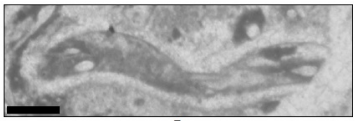

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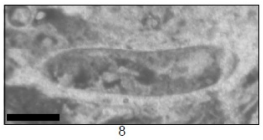

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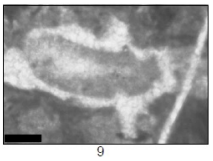

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PLATE 18

Figure 1 Serpulid, MK-6, Scale bar is 500 µm

Figure 2 Serpulid, MK-10, Scale bar is 500 µm

Figure 3 Serpulid, MK-11, Scale bar is 250 µm

Figure 4 Serpulids, MK-13, Scale bar is 250 µm

Figure 5 Serpulid, MK-13, Scale bar is 250 µm

Figure 6 Serpulid, MK-20, Scale bar is 250 µm

Figure 7 Serpulid, MK-30, Scale bar is 250 µm

Figure 8 ?Serpulid, MK-35, Scale bar is 250 µm

Figure 9 Serpulid, MK-36, Scale bar is 250 µm

Figure 10 Serpulid, MK-36, Scale bar is 500 µm

Figure 11 Serpulid, MK-48, Scale bar is 250 µm

Figure 12 Serpulid, MK-49, Scale bar is 250 µm

Figure 13 Serpulid, MK-49, Scale bar is 250 µm

Figure 14 Serpulid, MK-51, Scale bar is 250 µm

Figure 15 Serpulid, MK-51, Scale bar is 250 µm

Figure 16 Serpulid, MK-52, Scale bar is 500 µm

Figure 17 Serpulid, MK-52, Scale bar is 500 µm

Figure 18 Serpulids, MK-53, Scale bar is 250 µm

Figure 19 Serpulid, MK-53, Scale bar is 250 µm

Figure 20 Serpulid, MK-94, Scale bar is 250 µm

Figure 21 Serpulid, MK-54, Scale bar is 250 µm

PLATE 18

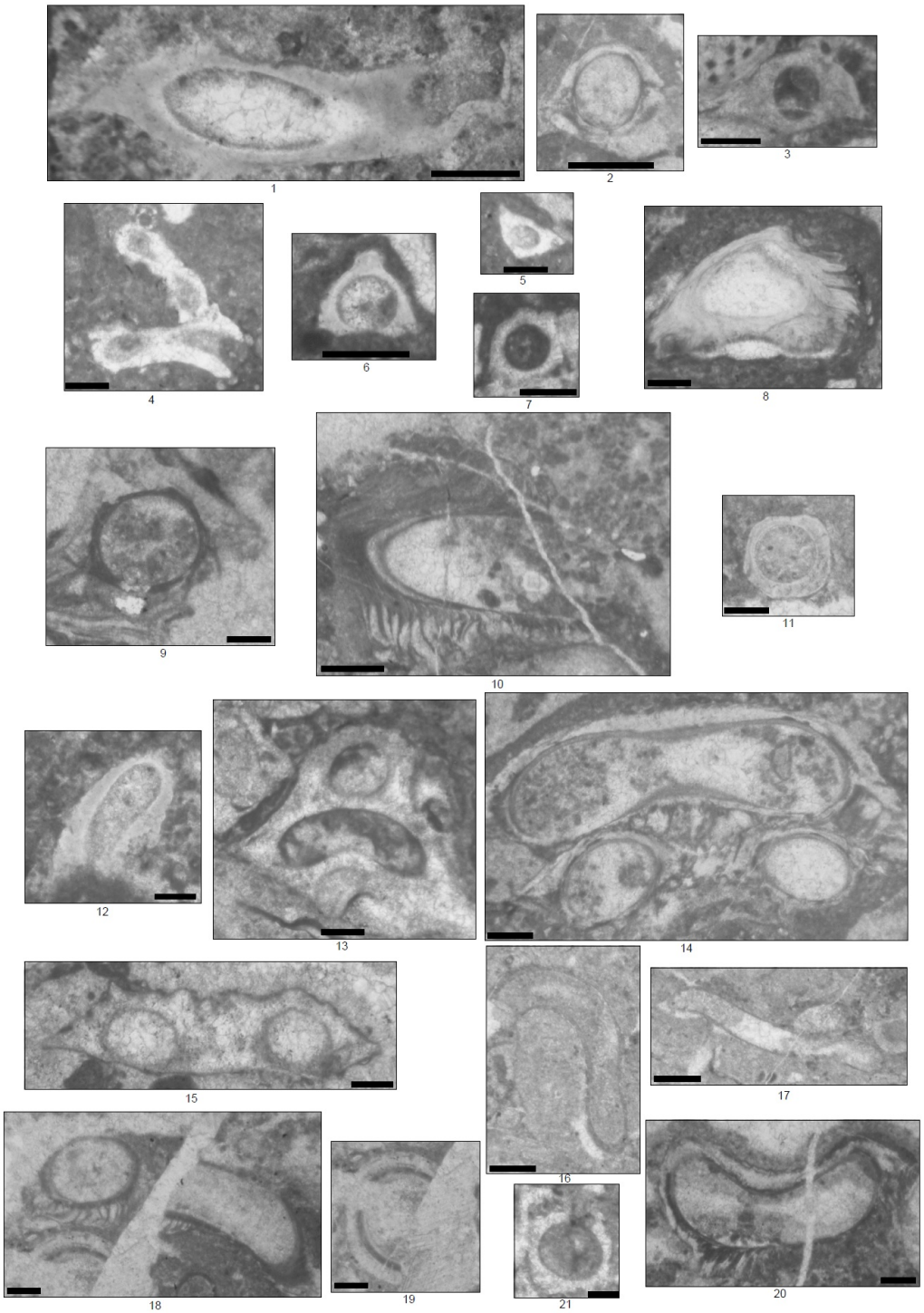


PLATE 19

Figure 1 Bryozoa, MK-6, Scale bar is 500 µm

Figure 2 Bryozoa, MK-7, Scale bar is 500 µm

Figure 3 Bryozoa, MK-7, Scale bar is 500 µm

Figure 4 Bryozoa, MK-7, Scale bar is 500 µm

Figure 5 Bryozoa, MK-7, Scale bar is 500 µm

Figure 6 Bryozoa, MK-10, Scale bar is 500 µm

Figure 7 Bryozoa, MK-18, Scale bar is 500 µm

Figure 8 Bryozoa, MK-18, Scale bar is 500 µm

Figure 9 Bryozoa, MK-18, Scale bar is 500 µm

Figure 10 Bryozoa, MK-18, Scale bar is 500 µm

Figure 11 Bryozoa, MK-18, Scale bar is 500 µm

Figure 12 Bryozoa, MK-39, Scale bar is 500 µm

Figure 13 Bryozoa, MK-43, Scale bar is 500 µm

Figure 14 Bryozoa, MK-48, Scale bar is 500 µm

PLATE 19

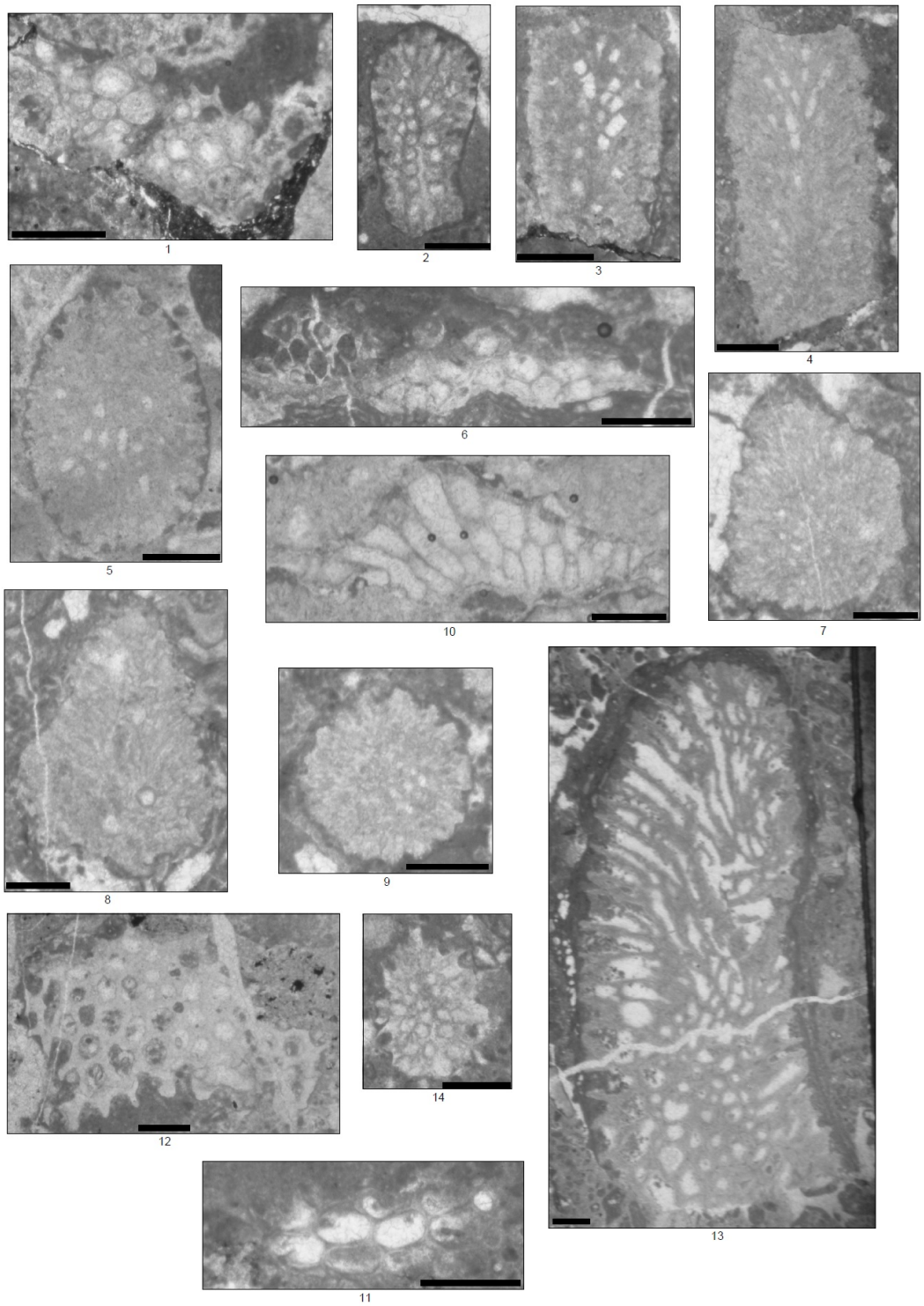


PLATE 20

Figure 1 Bryozoa, MK-54, Scale bar is 500 µm

Figure 2 Bryozoa, MK-55, Scale bar is 500 µm

Figure 3 Bryozoa, MK-56, Scale bar is 500 µm

Figure 4 Bryozoa, MK-70, Scale bar is 500 µm

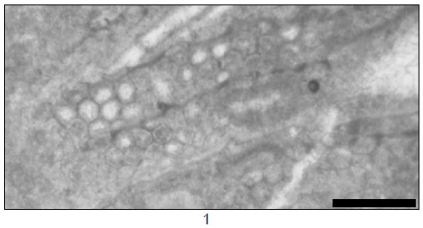
Figure 5 Bryozoa, MK-75, Scale bar is 500 µm

Figure 6 Bryozoa, MK-80, Scale bar is 500 µm

Figure 7 Bryozoa, MK-86, Scale bar is 500 µm

Figure 8 Bryozoa, MK-86, Scale bar is 500 µm

PLATE 20



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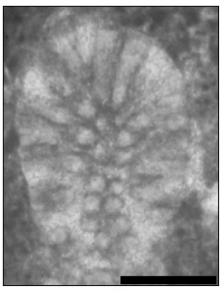

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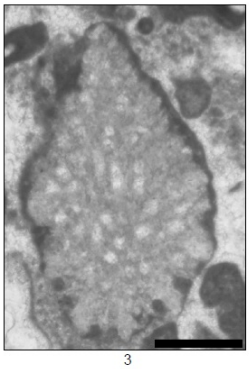

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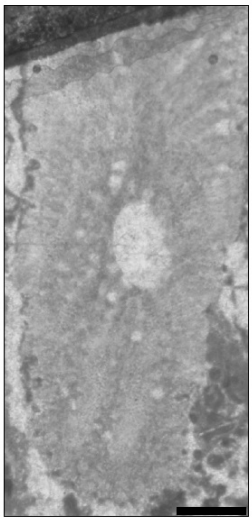

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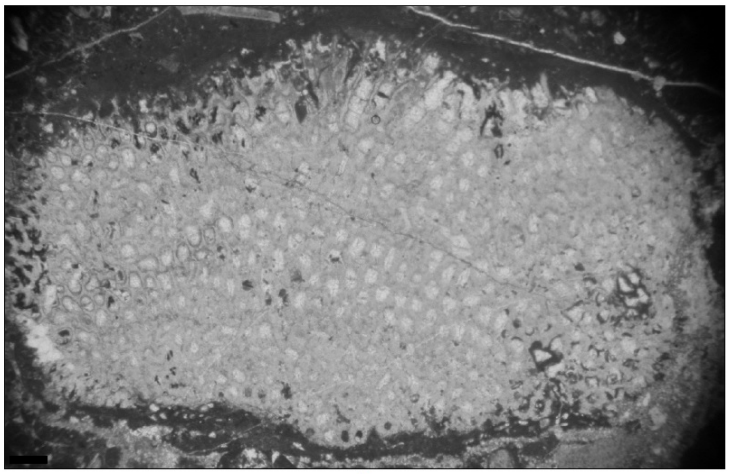

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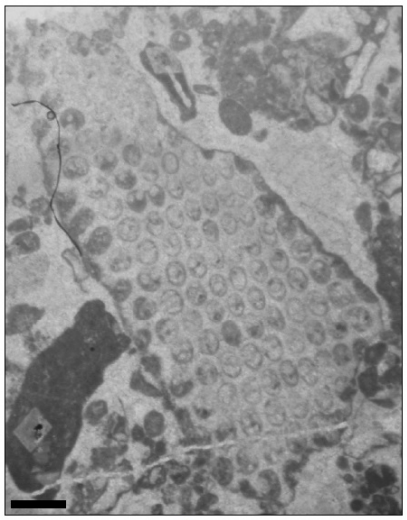

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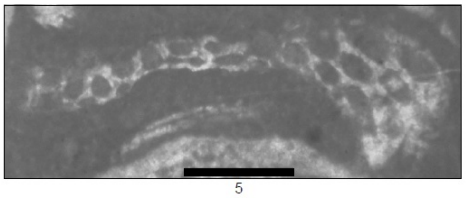

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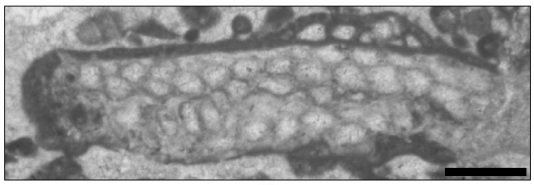

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PLATE 21

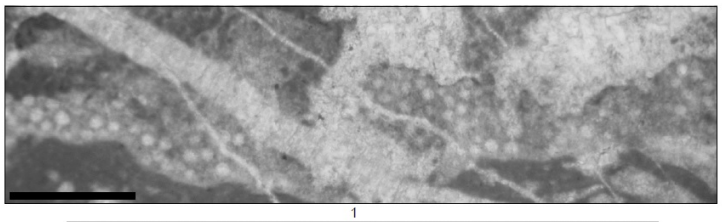
Figure 1 *Calcistella jachenhausenensis*, MK-20, Scale bar is 500 µm

Figure 2 *Calcistella jachenhausenensis*, MK-20, Scale bar is 500 µm

Figure 3 *Calcistella jachenhausenensis*, MK-38, Scale bar is 500 µm

Figure 4 *Calcistella jachenhausenensis*, MK-43, Scale bar is 1000 µm

PLATE 21



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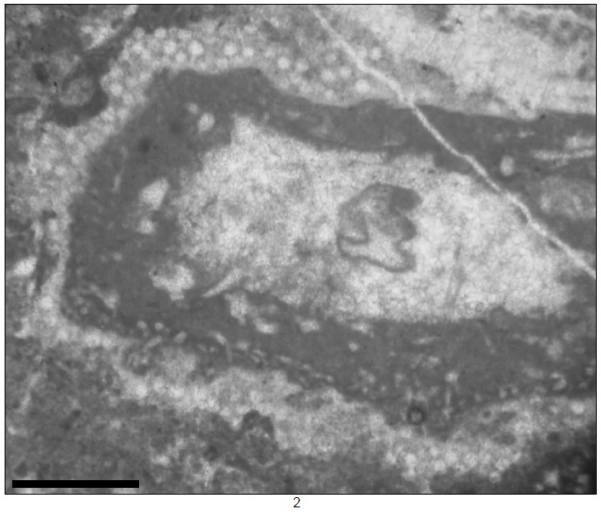

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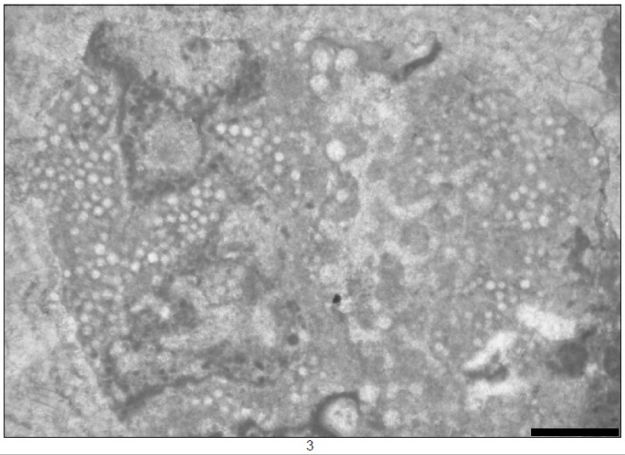

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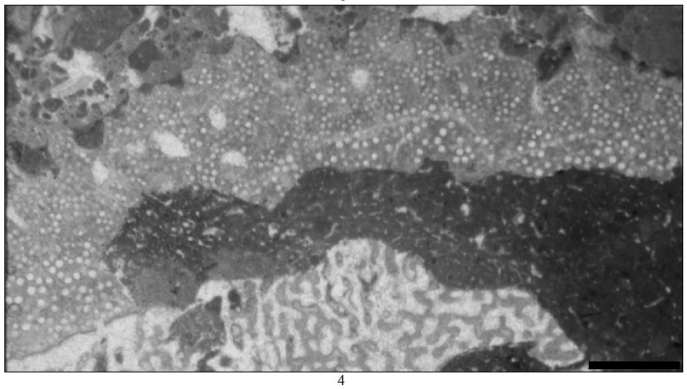

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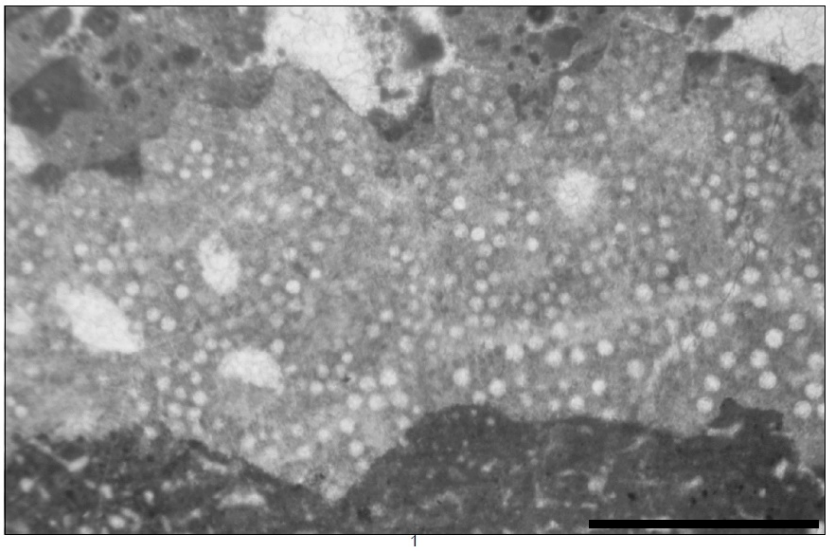
PLATE 22

Figure 1 *Calcistella jachenhausenensis*, MK-43, Scale bar is 1000 µm

Figure 2 *Calcistella jachenhausenensis*, MK-54, Scale bar is 1000 µm

Figure 3 *Calcistella jachenhausenensis*, MK-54, Scale bar is 1000 µm

PLATE 22



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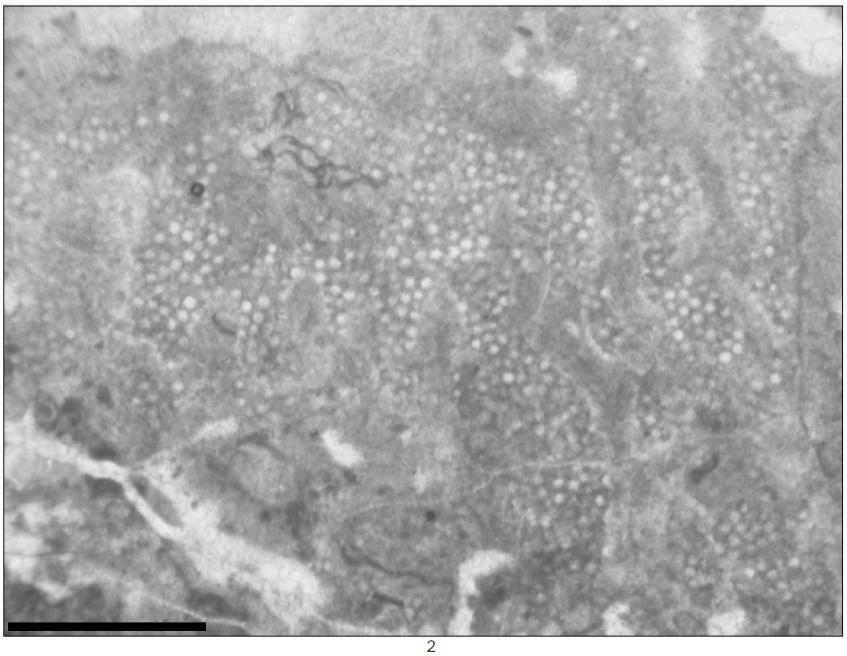

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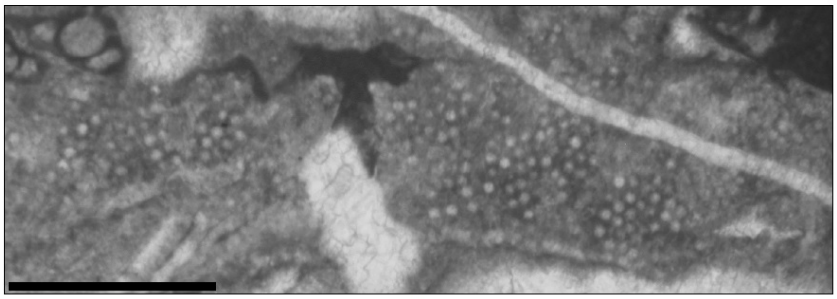

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PLATE 23

Figure 1 *Sarsteinia babai*, MK-21, Scale bar is 250 µm

Figure 2 *Sarsteinia babai*, MK-33, Scale bar is 500 µm

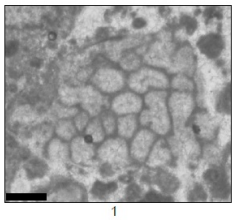
Figure 3 *Sarsteinia babai*, MK-56, Scale bar is 500 µm

Figure 4 *Lithocodium aggregatum*, MK-49, Scale bar is 500 µm

Figure 5 *Lithocodium aggregatum*, MK-41, Scale bar is 500 µm

Figure 6 *Lithocodium aggregatum*, MK-10, Scale bar is 500 µm

PLATE 23



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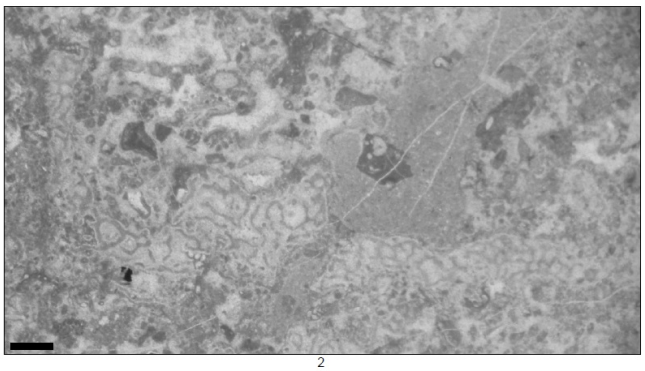

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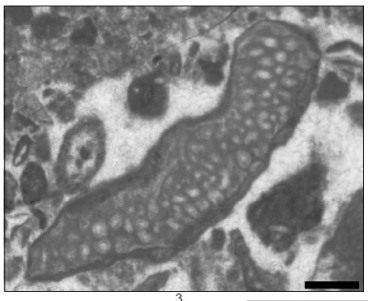

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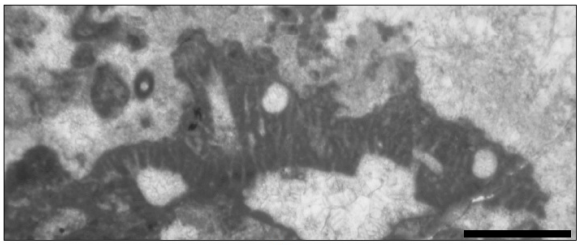

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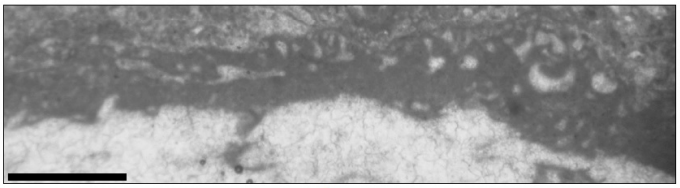

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PLATE 24

Figure 1 *Bacinella*-type structures, MK-92, Scale bar is 500 µm

Figure 2 *Bacinella*-type structures, MK-42, Scale bar is 500 µm

Figure 3 *Bacinella*-type structures, MK-59, Scale bar is 500 µm

Figure 4 *Bacinella*-type structures, MK-10, Scale bar is 500 µm

Figure 5 *Bacinella*-type structures, MK-21, Scale bar is 500 µm

Figure 6 *Bacinella*-type structures, MK-23, Scale bar is 500 µm

Figure 7 *Bacinella*-type structures, MK-73, Scale bar is 500 µm

Figure 8 *Bacinella*-type structures, MK-76, Scale bar is 500 µm

Figure 9 *Bacinella*-type structures, MK-79, Scale bar is 500 µm

PLATE 24

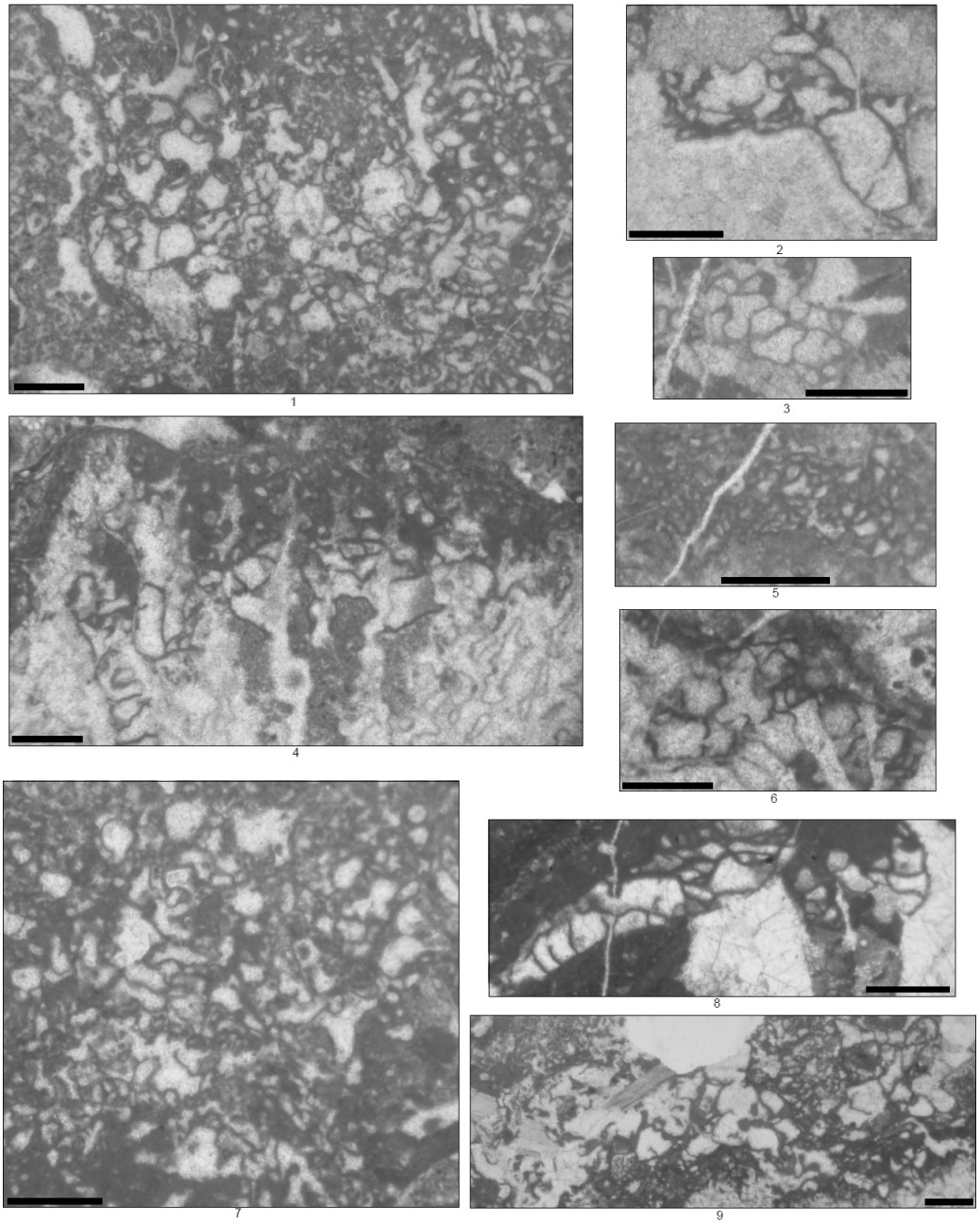


PLATE 25

Figure 1 *Lithocodium aggregatum*, MK-2, Scale bar is 500 µm

Figure 2 *Lithocodium aggregatum*, MK-42, Scale bar is 500 µm

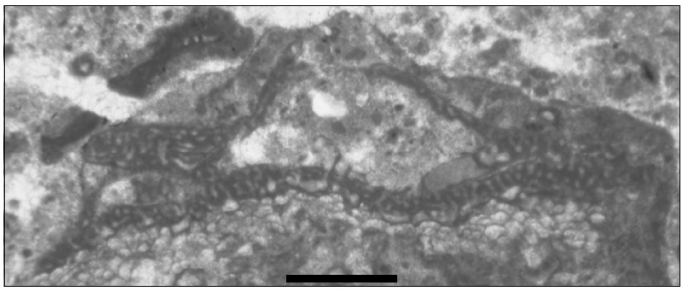
Figure 3 *Lithocodium aggregatum*, MK-13, Scale bar is 500 µm

Figure 4 *Lithocodium aggregatum*, MK-18, Scale bar is 500 µm

Figure 5 *Lithocodium aggregatum*, MK-27, Scale bar is 500 µm

Figure 6 *Lithocodium aggregatum*, MK-32, Scale bar is 500 µm

PLATE 25



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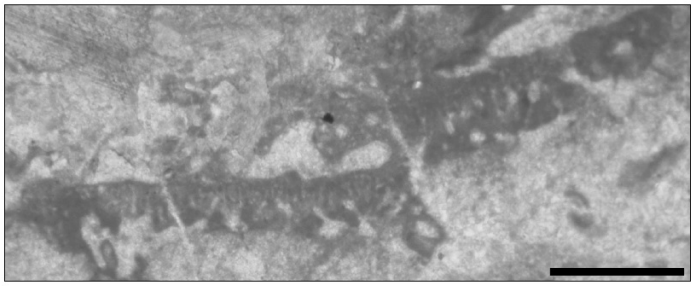

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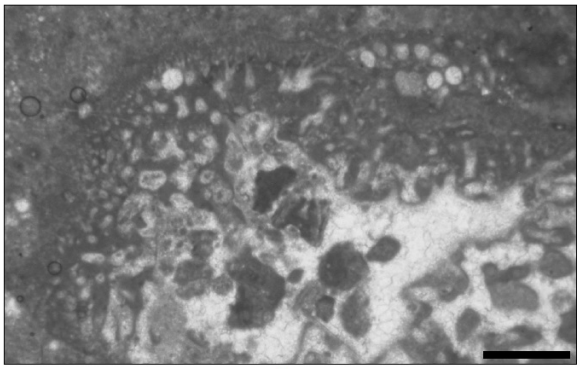

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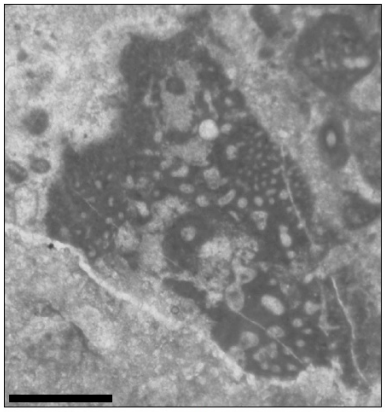

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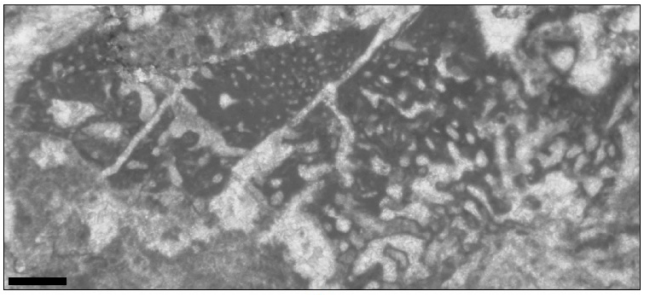

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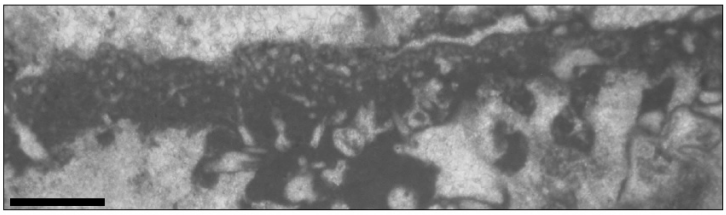

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PLATE 26

Figure 1 *Lithocodium aggregatum*, MK-59, Scale bar is 500 µm

Figure 2 *Lithocodium aggregatum*, MK-73, Scale bar is 500 µm

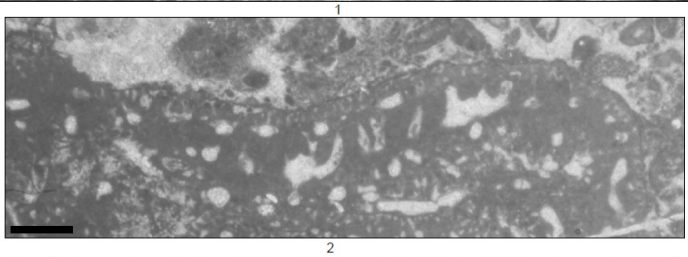
Figure 3 *Lithocodium aggregatum*, MK-76, Scale bar is 500 µm

Figure 4 *Lithocodium aggregatum*, MK-94, Scale bar is 500 µm

Figure 5 *Lithocodium aggregatum*, MK-95, Scale bar is 500 µm

PLATE 26

1



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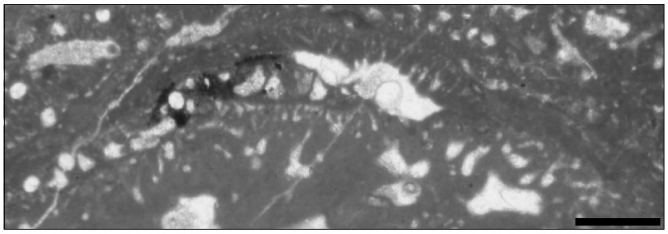

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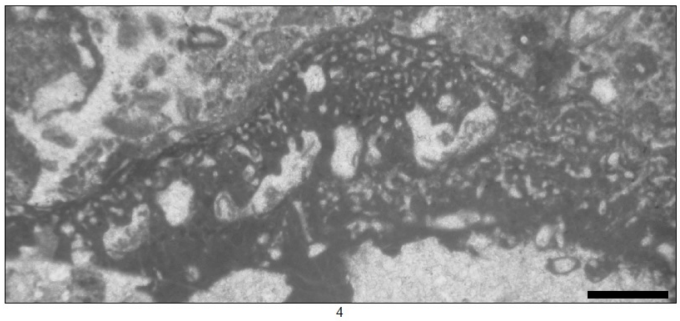

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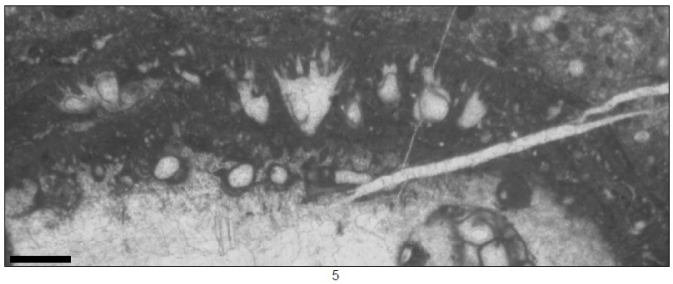

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PLATE 27

Figure 1 *Thaumatoporella parvovesiculifera*, MK-74, Scale bar is 500 µm

Figure 2 *Thaumatoporella parvovesiculifera*, MK-76, Scale bar is 500 µm

Figure 3 *Pseudorothpletzella schmidi*, MK-44, Scale bar is 500 µm

Figure 4 Sponge, MK-2, Scale bar is 1 mm

Figure 5 Sponge, MK-9A, Scale bar is 1 mm

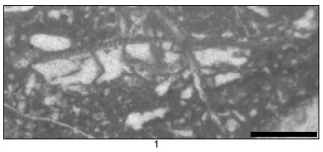
Figure 6 Sponge, MK-5, Scale bar is 1 mm

Figure 7 Sponge, MK-6, Scale bar is 1 mm

Figure 8 Sponge, MK-4, Scale bar is 1 mm

Figure 9 Sponge, MK-9A, Scale bar is 1 mm

PLATE 27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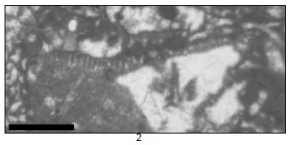
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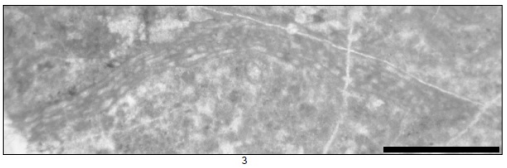
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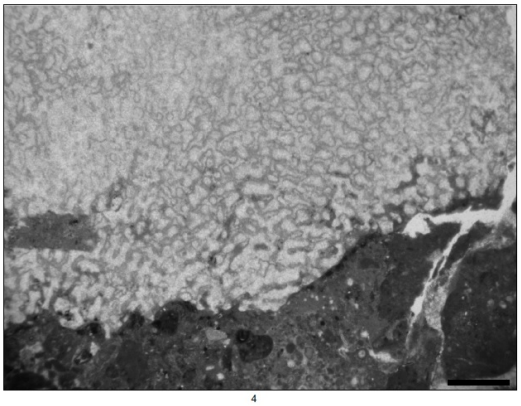
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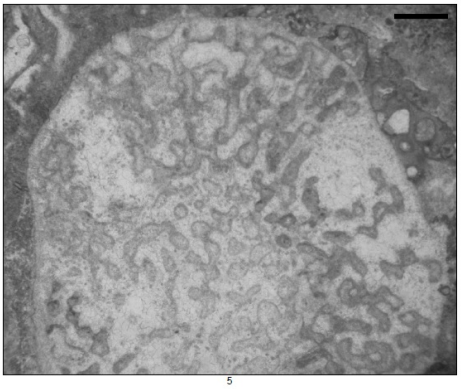
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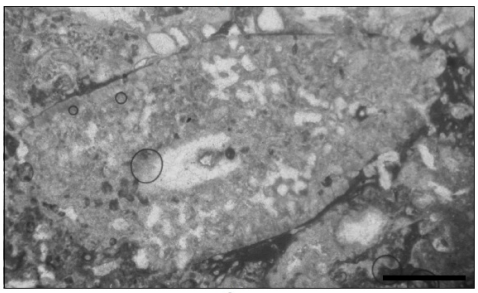
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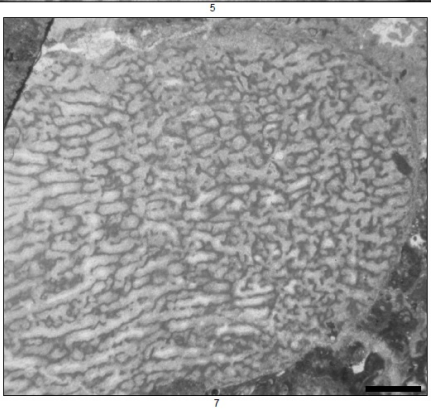
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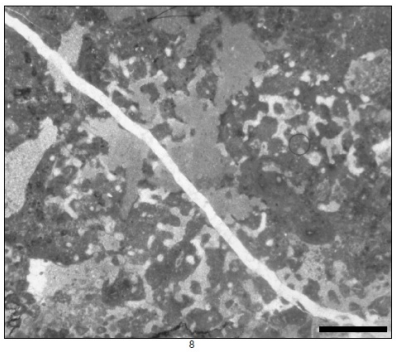
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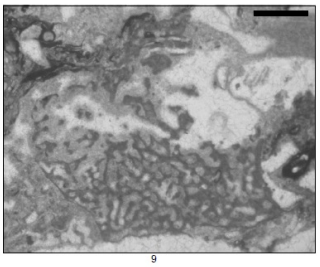
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PLATE 28

Figure 1 Corals, MK-14, Scale bar is 1 mm

Figure 2 Corals, MK-16, Scale bar is 1 mm

Figure 3 Coral, MK-16, Scale bar is 1 mm

Figure 4 Corals, MK-18, Scale bar is 1 mm

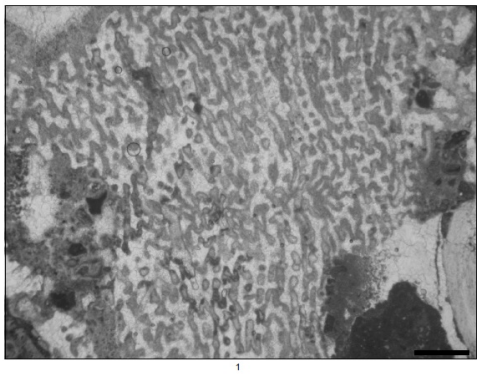
Figure 5 Corals, MK-21, Scale bar is 1 mm

Figure 6 Corals, MK-21, Scale bar is 1 mm

Figure 7 Corals, MK-23, Scale bar is 1 mm

Figure 8 Corals, MK-32, Scale bar is 1 mm

PLATE 28



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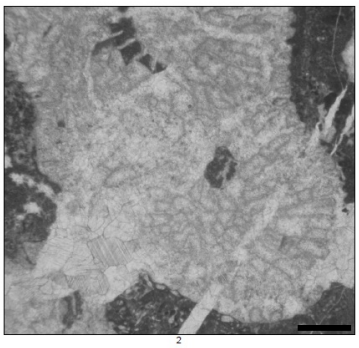

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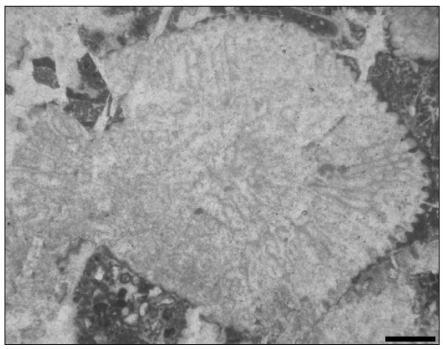

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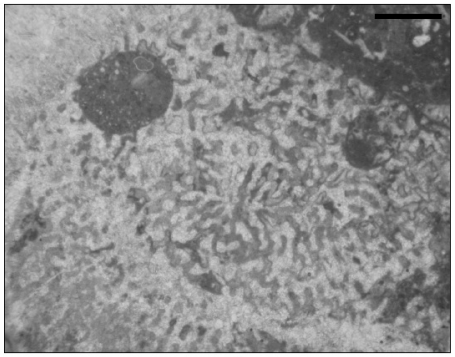

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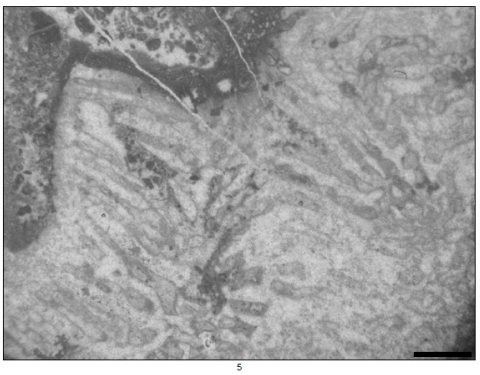

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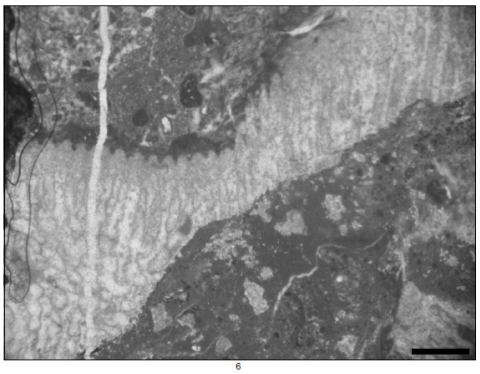

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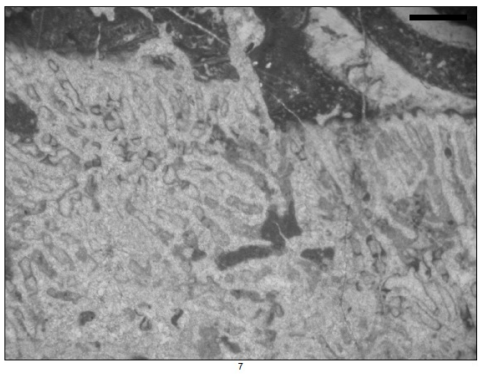

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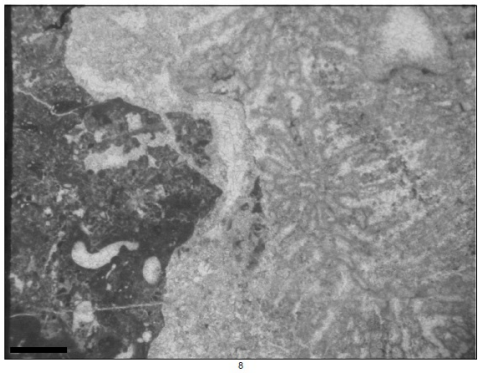

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PLATE 29

Figure 1 Coral, MK-41, Scale bar is 1 mm

Figure 2 Corals, MK-43, Scale bar is 1 mm

Figure 3 Corals, MK-54, Scale bar is 1 mm

Figure 4 Sponge, MK-56, Scale bar is 1 mm

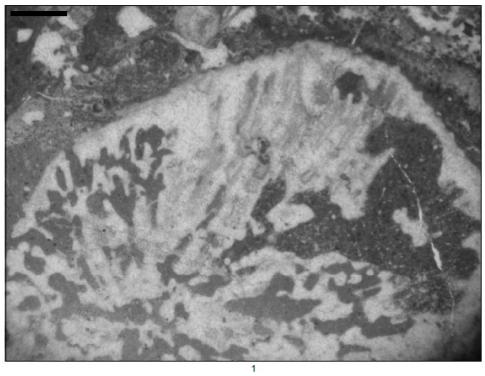
Figure 5 Sponge, MK-57, Scale bar is 1 mm

Figure 6 Corals, MK-59, Scale bar is 1 mm

Figure 7 Sponge, MK-78, Scale bar is 1 mm

Figure 8 Sponge, MK-78, Scale bar is 1 mm

PLATE 29



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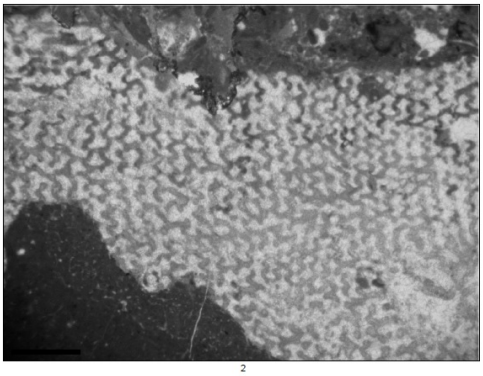

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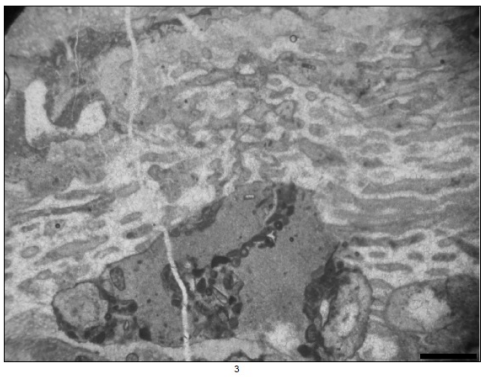

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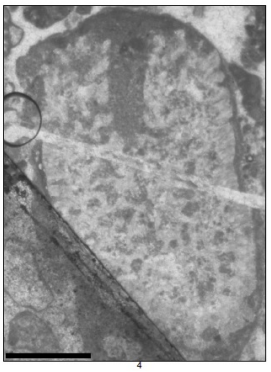

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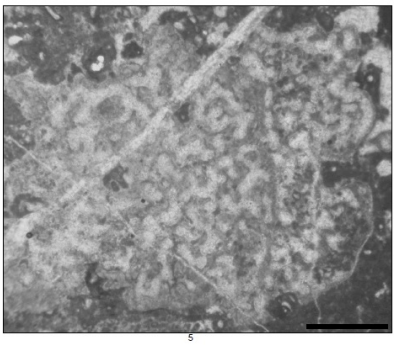

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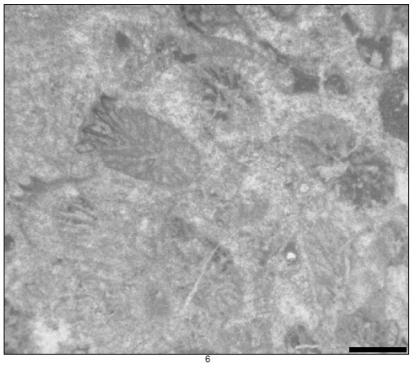

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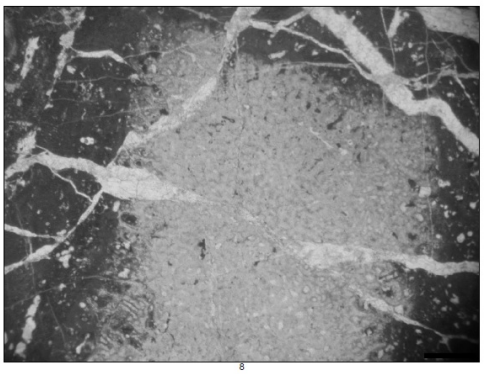

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PLATE 30

Figure 1 *Terebella lapilloides* Münster. Transverse section MK-2.

Figure 2 *Terebella lapilloides* Münster. Oblique sections MK-3.

Figure 3 *Terebella lapilloides* Münster. Oblique sections MK-3.

Figure 4 *Terebella lapilloides* Münster. Transverse section MK-6.

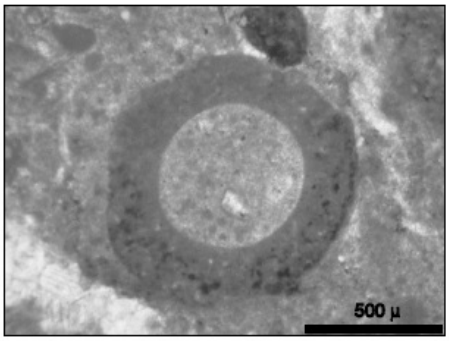
Figure 5 *Terebella lapilloides* Münster. Oblique and transverse sections MK-3.

Figure 6 *Terebella lapilloides* Münster. Oblique sections MK-12.

Figure 7 *Terebella lapilloides* Münster. Tansverse section MK-10.

Figure 8 *Terebella lapilloides* Münster. Oblique sections MK-19.

PLATE 30



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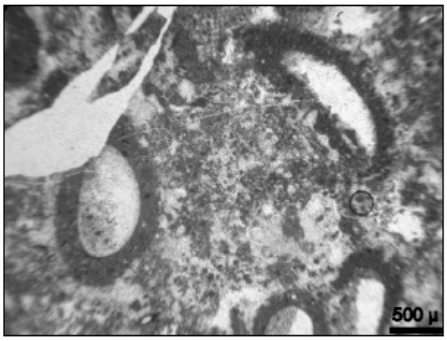

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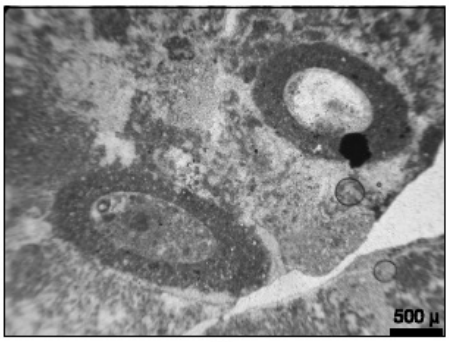

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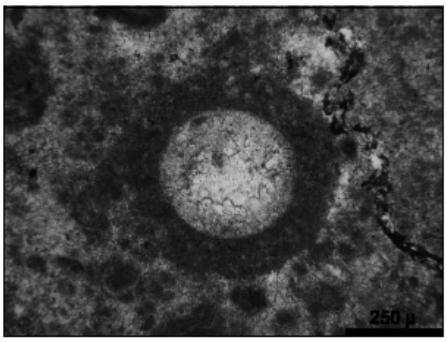

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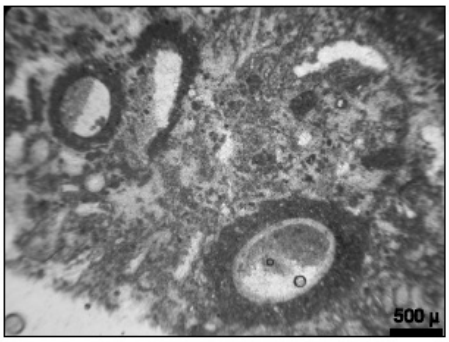

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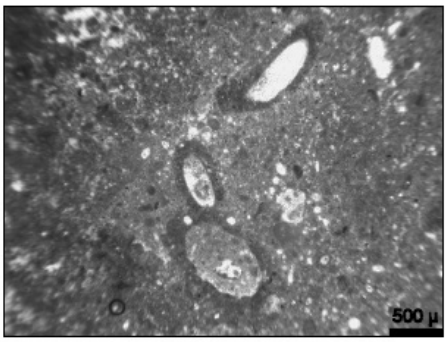

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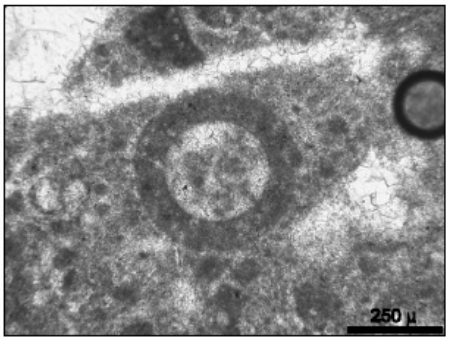

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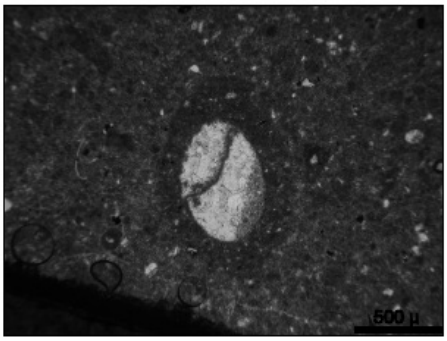

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PLATE 31

Figure 1 *Terebella lapilloides* Münster. Part of a longitudinal section MK-4.

Figure 2 *Terebella lapilloides* Münster. Part of a longitudinal section MK-42.

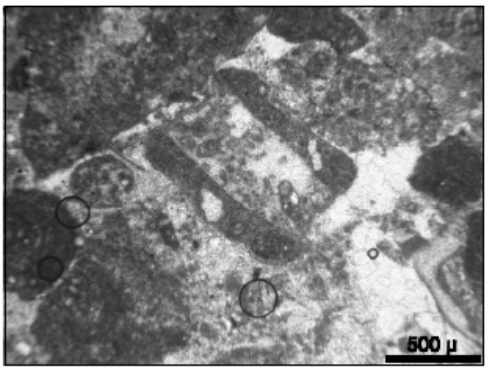
Figure 3 *Terebella lapilloides* Münster. Longitudinal section MK-9D.

Figure 4 *Terebella lapilloides* Münster. Part of a longitudinal section MK-14.

Figure 5 *Terebella lapilloides* Münster. Longitudinal sections MK-57.

Figure 6 *Terebella lapilloides* Münster. Longitudinal sections MK-30.

PLATE 31



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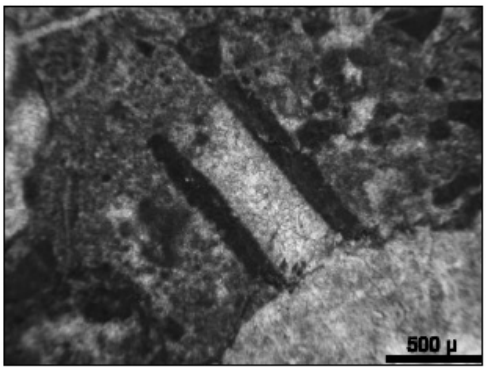

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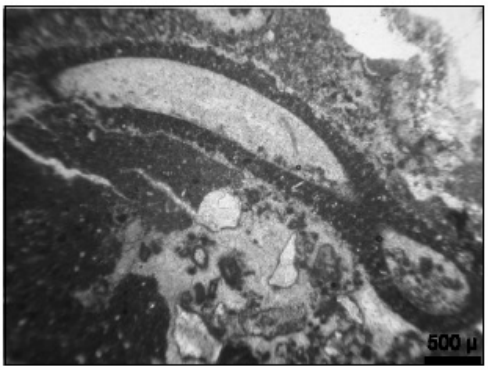

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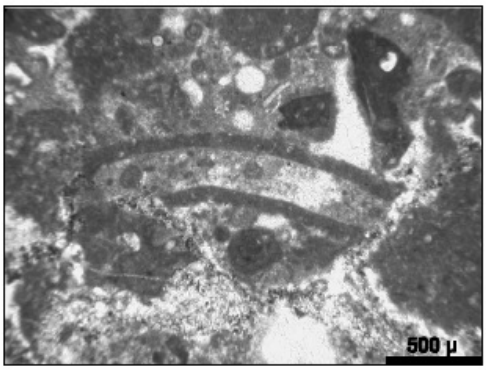

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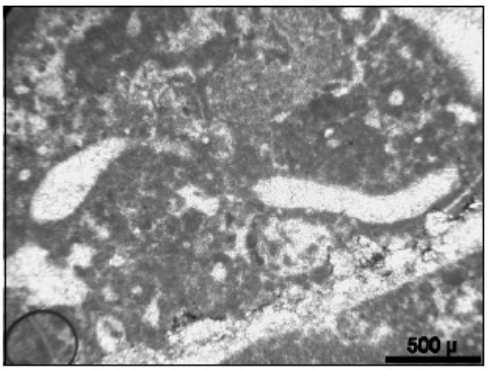

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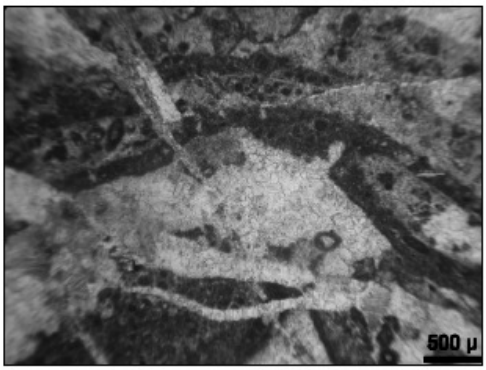

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PLATE 32

Figure 1 *Terebella*? sp. Note agglutinated coarser particles, Transverse section MK-8.

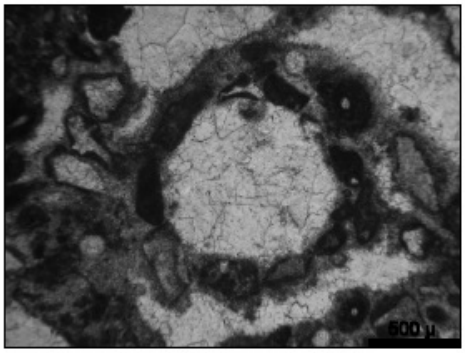
Figure 2 *Terebella*? sp. Note agglutinated coarser particles, Transverse section MK-9B.

Figure 3 *Terebella*? sp. Note agglutinated coarser particles, Transverse section MK-21.

Figure 4 *Terebella lapilloides* Münster. Longitudinal and oblique sections MK-32.

Figure 5 *Terebella lapilloides* Münster. Longitudinal section MK-38.

PLATE 32



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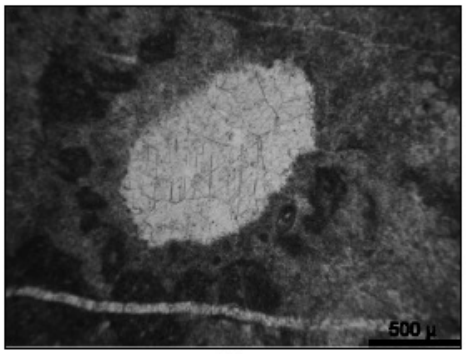

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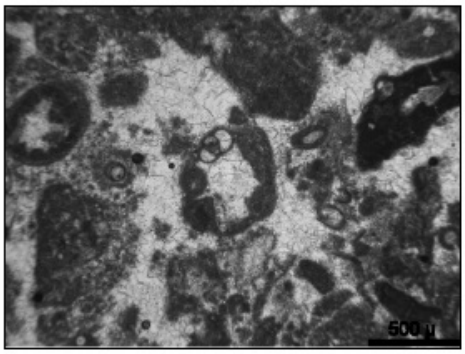

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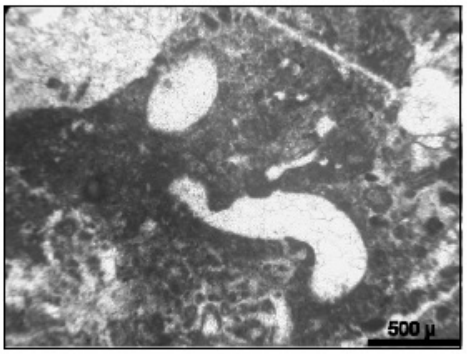

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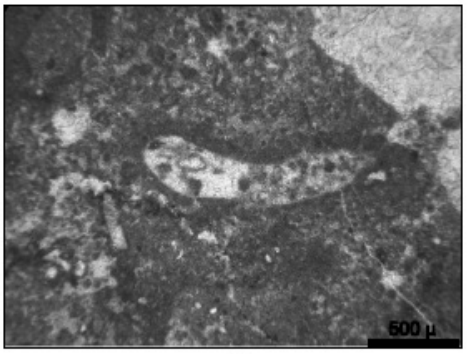

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