FORAMINIFERAL AND CALPIONELLID BIOSTRATIGRAPHY, MICROFACIES ANALYSES AND TECTONIC IMPLICATIONS OF THE UPPER JURASSIC – LOWER CRETACEOUS CARBONATE PLATFORM TO SLOPE SUCCESSIONS IN SİVRİHİSAR REGION (ESKİŞEHİR, NW TURKEY)

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submitted by **SERDAR GÖRKEM ATASOY** in partial fulfillment of the requirements for the degree of **Master of Science in Geological Engineering Department, Middle East Technical University** by,

Prof. Dr. Gülbin DURAL ______________________
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. Erdin BOZKURT ______________________
Head of Department, **Geological Engineering**

Prof. Dr. Demir ALTINER ______________________
Supervisor, **Geological Engineering Dept., METU**

Examining Committee Members:

Prof. Dr. Bora ROJAY ______________________
Geological Engineering Dept., METU

Prof. Dr. Demir ALTINER ______________________
Geological Engineering Dept., METU

Assoc. Prof. Dr. İsmail Ömer YILMAZ ______________________
Geological Engineering Dept., METU

Assoc. Prof. Dr. Kaan SAYIT ______________________
Geological Engineering Dept., METU

Prof. Dr. Aral OKAY ______________________
Geological Engineering Dept., İTU

Date: 25.01.2017

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: Serdar Görkem Atasoy

Signature:

ABSTRACT

FORAMINIFERAL AND CALPIONELLID BIOSTRATIGRAPHY, MICROFACIES ANALYSES AND TECTONIC IMPLICATIONS OF THE UPPER JURASSIC – LOWER CRETACEOUS CARBONATE PLATFORM TO SLOPE SUCCESSIONS IN SİVRİHİSAR REGION (ESKİŞEHİR, NW TURKEY)

ATASOY, Serdar Görkem
M.Sc., Department of Geological Engineering
Supervisor: Prof. Dr. Demir ALTINER

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This study focuses on the biostratigraphy, microfacies analyses and the tectonic interpretation of an Upper Jurassic – Lower Cretaceous carbonate succession widely exposed in a tectonic klippe of the Sakarya Zone (Pontides), north of Sivrihisar region (Eskişehir). For this purpose two stratigraphic sections were measured (925 m thick in total) along the carbonate rocks that crop out north of the Dümrek Village.

According to the biozonation and the microfacies types, two coeval but dissimiliar depositional domains, separated by an overthrust, have been detected along the measured sections. The one on the southern part shows a slope to basin facies and is characterized by the Kimmeridgian – Berriasian Yosunlukbayırı Formation and the overlying Valanginian Soğukçam Limestone. Within these deposits the following biozones were defined: *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), *Crescentiella morronensis* (*Saccocoma* subzone) Zone (Lower Tithonian), *Protopeneroplis ultragranulata* Zone (Upper Tithonian), *Crassicollaria* (*massutiniana* subzone) Zone (uppermost Tithonian), *Calpionella* (*alpina*, *Remaniella* and *elliptica* subzones) Zone (Lower Berriasian), *Calpionellopsis* (*simplex* and *oblonga* subzones) Zone (Upper Berriasian) and *Calpionellites* (*darderi* subzone) Zone (Lower Valanginian). The Jurassic – Cretaceous boundary is located at the base of the *Calpionella* Zone. This succession overthrusted from north to south by a thin slice of the Berriasian Yosunlukbayırı Formation and an overlying thicker slice consisting of the Kimmeridgian Günören Limestone which is a part of the Edremit – Bursa - Bilecik Carbonate Platform. Within the Günören Limestone, *Labyrinthina mirabilis – Protopeneroplis striata* (Kimmeridgian) Zone was recognized. A much thinner section, measured to the north of these successions, consists of the Yosunlukbayırı Formation of Early Berriasian age deposited on the slope and the basinal Soğukçam Limestone. The boundary of these two formations is probably tectonic.

If the positions of the studied sections with respect to the Edremit – Bursa – Bilecik Carbonate Platform is considered, the studied basin and slope facies should represent the southern platfrom margin and slope environmnets of this carbonate platform that faced an ocean to the south during the Jurassic – Cretaceous interval. The slope and basinal facies (the Yosunlukbayırı Formation and the Soğukçam Limestone) overthrusted by the shallow marine deposits (the Günören Limestone) in a region studied to the south of the main İzmir – Ankara – Erzincan (İAE) suture suggests an important disruption and shortening of the Edremit – Bursa – Bilecik Carbonate Platform margin and slope deposits probably related to the closure of the İAE ocean.

Keywords: Biostratigraphy, Jurassic – Cretaceous boundary, foraminifera, calpionellids, Edremit – Bursa – Bilecik Carbonate Platform, microfacies, Pontides

ÖZ

SİVRİHİSAR (ESKİŞEHİR, KB TÜRKİYE) BÖLGESİ ÜST JURA – ALT KRETASE KARBONAT PLATFORMU VE YAMAÇ İSTİFLERİNDE FORAMİNİFER VE KALPİONELLİD BİYOSTRATİGRAFİSİ, MİKROFASİYES ANALİZLERİ VE TEKTONİK ÇIKARIMLAR

ATASOY, Serdar Görkem
Yüksek Lisans, Jeoloji Mühendisliği Bölümü
Tez Yöneticisi: Prof. Dr. Demir Altıner

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Bu çalışmanın amacı Sivrihisar (Eskişehir)'in kuzeyinde, Sakarya Zonu'na ait bir tektonik klipte yer alan Geç Jura – Erken Kretase yaşlı karbonat istifindeki birimlerin çökelme yaşlarının ayrıntılı şekilde belirlenmesi, mikrofasiyes evriminin ortaya konulması ve bu çökellerin Jura – Erken Kretase aralığında Sakarya Zonu üzerinde gelişen karbonat platform sistemindeki yerinin belirlenmesidir. Bu amaçla, Dümrek köyünün hemen kuzeyinde yüzeylenen karbonat istifleri boyunca toplam kalınlığı 925 m olan iki adet stratigrafik kesit ölçülmüş ve detaylı örnekleme yapılmıştır.

Elde edilen veriler doğrultusunda benzer yaş aralığında iki farklı çökelme ortamına ait kayaçların bindirme fayı dokanağı ile bir araya geldiği belirlenmiştir. Bunlardan güneyde bulunan kayaç dizilimi havza ve yamaç fasiyeslerini göstermekte olup, Kimmericiyen – Berriyasiyen yaşlı Yosunlukbayırı Formasyonu ve üzerini örten Valanjiniyen yaşlı Soğukçam Kireçtaşı ile temsil edilmektedir. Bu çökellerde *Globuligerina oxfordiana – Mohlerina basiliensis* Zonu (Kimmericiyen), *Crescentiella morronensis* (*Saccocoma* alt zonu) Zonu (Alt Titoniyen), *Protopeneroplis ultragranulata* Zonu (Üst Titoniyen), *Crassicollaria* (*massutiniana* alt zonu) Zonu (en Üst Titoniyen), *Calpionella* (*alpina, Remaniella* ve *elliptica* alt zonları) Zonu (Alt Berriyasiyen), *Calpionellopsis* (*simplex* ve *oblonga* alt zonları) Zonu (Üst Berriyasiyen) ve *Calpionellites* (*darderi* alt zonu) Zonu (Alt Valanjiniyen) ayırtlanmış ve Jura – Kretase sınırı *Calpionella* Zonu'nun tabanı olarak belirlenmiştir. Bu istifin üstüne ise, araya Yosunlukbayırı Formasyonu'na ait yamaç fasiyesinde, Berriyasiyen yaşlı bir dilimi alarak ters fay dokanağı ile Kimmericiyen yaşlı, tipik bir karbonat platform fasiyesi ile karakterize olan Günören Kireçtaşı gelmektedir. Bu çökellerde *Labyrinthina mirabilis – Protopeneroplis striata* (Kimmericiyen) Zonu ayırtlanmıştır. Bu birimlerin kuzeyinde, daha kısa ek bir stratigrafik kesit boyunca örneklenen, üst yamaç fasiyesindeki, Erken Berriyasiyen yaşlı Yosunlukbayırı Formasyonu ile bu çökellerin üstünde muhtemelen bir tektonik dokanakla oturan Soğukçam Kireçtaşı bulunmaktadır.

Edremit – Bursa – Bilecik Karbonat Platfromunun, çalışma alanına göre konumu göz önüne alındığında, çalışılan havza ve yamaç çökellerinin, bu platformun güneyinde Jura – Kretase zaman aralığında bulunan bir okyanusa bakan ve bu platformdan beslenen şelf yamacı – havza ortamını temsil ettiği düşünülmektedir. Bu birimlerin üstüne bindiren sığ platform karbonatlarının varlığı, çalışma alanının İzmir – Ankara – Erzincan (İAE) kenet kuşağının güneyinde yer almış olması ile birlikte değerlendirildiğinde, Edremit – Bursa – Bilecik Karbonat Platformu kenar ve yamaç çökellerinin, muhtemelen İAE okyanusunun kapanmasına bağlı olarak önemli bir deformasyon ve kısalma gösterdiği anlaşılmaktadır.

Anahtar Kelimeler: Biyostratigrafi, Jura – Kretase sınırı, foraminifera, kalpionellidler, Edremit – Bursa – Bilecik Karbonat Platformu, mikrofasiyes, Pontid

To my family…

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CHAPTER 1

INTRODUCTION

1.1. Purpose and Scope

The İzmir-Ankara-Erzincan (İAE) suture defines the limit between the two major tectonic units in Anatolia; namely the Pontides (to the north) and the Anatolide – Tauride Block (to the south) (Ketin, 1966; Şengör & Yılmaz, 1981; Okay & Tüysüz, 1999). An imbricated succession that includes rock assemblages belong both to the Pontides and the Anatolides - Taurides crops out north of the Sivrihisar (Eskişehir) region (Gautier, 1984; Okay, 1984; Monod et al., 1991; and Okay & Tüysüz, 1999) (Fig. 1). Within this unit, a fault-bounded sequence of the Sakarya Zone has been defined as a klippe by Okay and Tüysüz (1999), resting on the blueschists and peridotites of the Tavşanlı Zone. Although there are several studies which merely or partly focused on the geology of this area (Kulaksız, 1981; Gautier, 1984; Monod et al., 1991; Okay & Tüysüz, 1999), the Upper Jurassic – Lower Cretaceous carbonate successions of this klippe has not been studied in detail.

The purpose of this study is to make a detailed characterization of these carbonate successions of the Sivrihisar Area along two measured stratigraphic sections (1 main and 1 supporter section). This thesis includes (1) a biozonation study mainly based on foraminifera and calpionellids, (2) microfacies analyses and interpretation of the facies change through time, (3) comparision of these facies with well-known carbonate successions of the northwestern Turkey and interpretation of the place and importance of these deposits within the carbonate platform system that developed on the Sakarya Zone during the Jurassic - Early Cretaceous interval and (4) micropaleontological analyses with detailed documentation of the observed fossil groups.

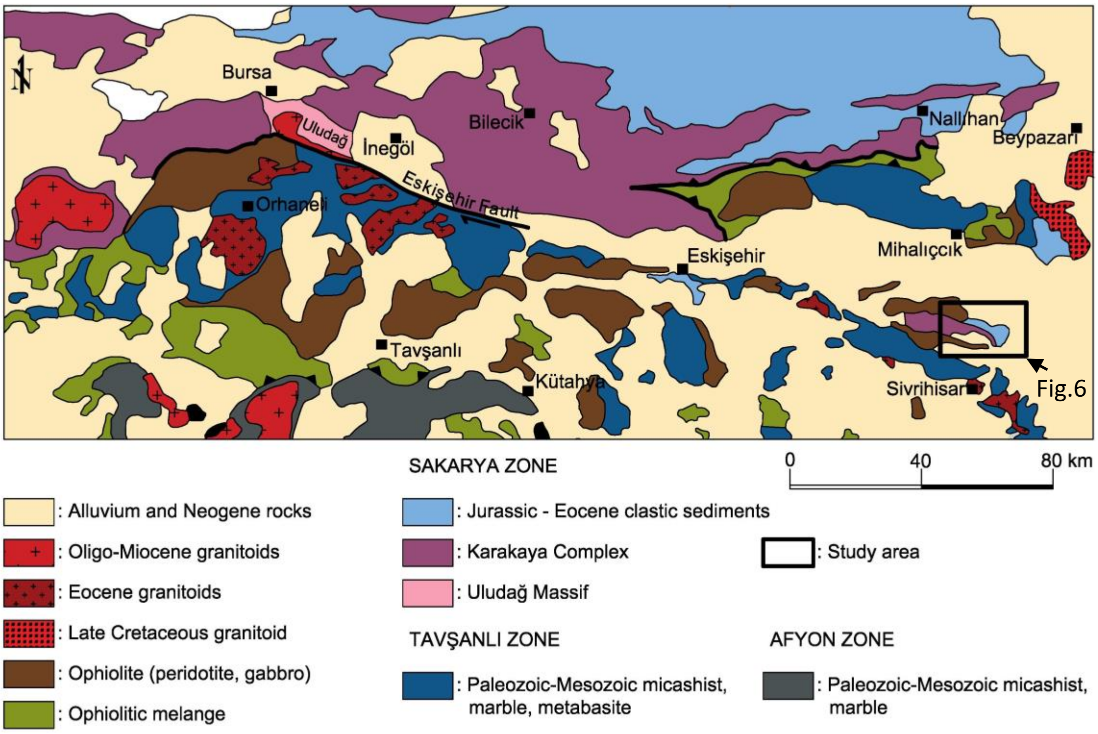


Figure 1. Geological map of the Bursa - Kütahya - Eskişehir region showing the location of the study area (from Okay & Whitney, 2010).

This study also includes the delineation of the Jurassic - Cretaceous boundary by calpionellids in a slope environment that has both its own advantages (providing secondary control on the pelagic calpionelllid biostratigraphy with fossil groups synchronously derived from the platform margin) and disadvantages (distrubance of the continuous pelagic deposition by calciturbiditic intercalations) for precise determination.

The Upper Jurassic - Lower Cretaceous (Kimmeridgian – Hauterivian) carbonate outcrops of the Sakarya Zone have a rather strange facies distribution that successions very close to the İAE suture still show shallow marine characteristics, like the ones in the southern parts of the Bursa region (Fig.2; Altıner et al., 1991; Okay & Tüysüz, 1999). This gives an impression that the slope and deep marine successions are missing or eroded (Okay & Tüysüz, 1999) except the intervening trough successions (Forquin, 1975; Toker, 1976; Saner, 1980; Yılmaz et al., 1981; Önal et al., 1988; Altıner et al., 1991; Yılmaz et al., 2016) and the successions in the

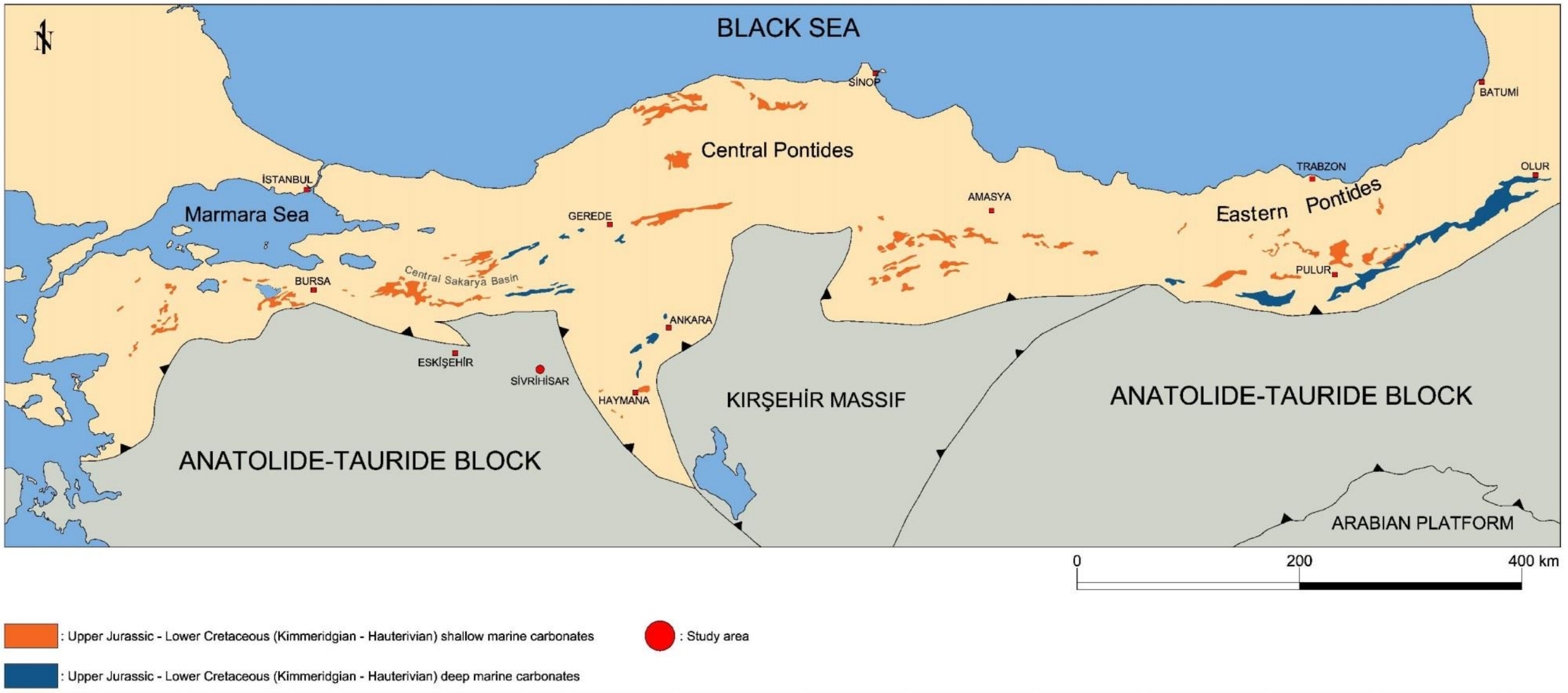


Figure 2. Distribution of the Upper Jurassic – Lower Cretaceous Carbonates in the Pontides (modified from Okay & Altıner, 2015).

southern part of the eastern Pontides (Burşuk, 1981, 1982; Rojay, 1985). Another contribution of this study is the discovery of slope deposits thrusted by coeval shallow marine platform carbonates on a tectonic klippe situated 50 km south of the main İAE suture trace, suggesting important distruption and shortening related to the closure of the İzmir – Ankara - Erzincan ocean.

1.2. Geographical Setting

The study area is located near Dümrek Village which is nearly 14 km north of Sivrihisar (Eskişehir) (Fig. 3) situated on the toporaphic map of Ankara -İ27–d4 (1/25000 scale). The study area can be reached from the Ankara – Eskişehir main road by making a turn at the Mihallıççık – Yunus Emre road separation near the Nasrettin Hoca Village (Fig.3). The studied sections are located to the north of the Dümrek Village (on the Dümrek Tepe). The bottom and top coordinates are 36N 372471/ 4384153 and 36 N 372862/ 4384570 for the STG measured section and 36 N 375033/ 4384913 and 36N 375097/ 4384966 for the SS section.

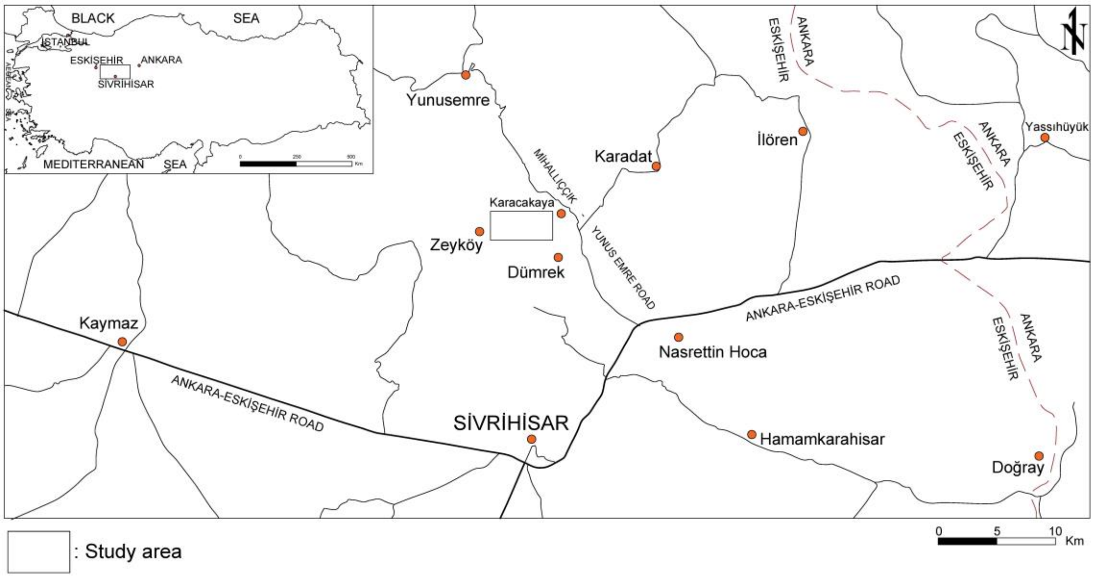


Figure 3. Location map of the study area.

1.3. Methods of Study

This study has two parts; field and laboratory works. Two stratigraphic sections (STG and SS sections) were measured; 173 samples from 748 m thick STG section and 27 samples from 177 m thick SS section were collected. During field logging, in addition to the observations made on the lithostratigraphic properties of rocks (color, lithology, bed thickness etc.), microfacies and fossil content were constantly checked with a hand-lense to detect facies changes.

200 thin sections were prepared in the thin section preparation laboratory of the Department of Geoloical Engineering, METU for micropaleontological and microfacies analyses. Fossil content and constituent composition of each sample were documented and in the light of obtained data, microfacies and depositional environments were determined. For microfacies analyses, the revised (by Embry & Klovan, 1971) version of Dunham's (1962) carbonate rock classification and the facies analyses methodology of Flügel (2004) were followed. For the biozonation, variety of fossil groups (foraminifera, calpionellids, microproblematica (*incertea sedis*), crinoids etc.) were used. The zonal boundaries were positioned between the two closest samples with different fossil content. The chronostratigraphic position of the studied successions was determined by the correlation of the established biozonations with the previously published schemes. For percentage estimations of the rock constituents and the relative abundance estimation of the fossil contents, visual comparision charts were used (Baccelle & Bosellini, 1965).

1.4. Previous Works on the Upper Jurassic – Lower Cretaceous Carbonates of the Sakarya Zone

The Upper Jurassic – Lower Cretaceous carbonate rocks of the Sakarya Zone (Fig.2) are known as the Bilecik Limestone in the Western Pontides (Granit & Tintant, 1960; Altınlı, 1973a,b; Okay et al., 1990; Altıner et al., 1991). They have been studied and named as the İnaltı Carbonates in the northern part of the Central Pontides (Ketin & Gümüş, 1963; Saner et al., 1980; Yılmaz & Tüysüz, 1984; Tüysüz et al., 1990;

Derman & Sayılı, 1995) and as the Carbonates of Amasya Group (Rojay, 1995; Rojay & Altıner, 1998) in the southern part of the Central Pontides. Their coeval carbonates in the Eastern Pontides are known as the Berdiga Carbonates (Pelin, 1977; Taslı, 1984; Rojay, 1985; Kırmacı, 1992).

Figure 4 illustrates a summary of the informally and formally named lithologic units in the NW Turkey. The nomenclature revision of the Jurassic – Lower Cretaceous successions was made by Altıner et al. (1991) (Fig.4). Regarding the Jurassic – Lower Cretaceous interval, the first study that followed lithostratigraphic nomenclature standards was carried out by Granit and Tintant (1960) who differentiated the Lower Jurassic shallow marine Bayırköy Sandstone and the overlying shallow marine Yediler Limestone and the Bilecik Limestone. Following studies (Altınlı, 1965a, b; Eroskay, 1965; Altınlı et al. 1970; Altınlı & Saner, 1971; Altınlı & Yetiş, 1972) used the same lithostratigraphic units. Altıntlı (1973a, b) introduced the pelagic Lower Cretaceous Soğukçam Limestone, and the Lower Jurassic Kapıkaya Formation which is the lateral equivalent of the Bayırköy Sandstone. For the Bursa-Bilecik region, previously defined Bilecik Limestone has been raised to a group rank and two formations have been differentiated; namely, the Taşçıbayırı Formation and the Günören Limestone, by Altıner et al. (1991). This Bilecik Group was previously studied under the name of Alancık Formation in the Biga Peninsula by Bingöl et al. (1973) and was replaced by Bilecik Group (Altınlı, 1965a, b) due to priority rules. For the underyling clastic rocks, Halılar Group was introduced and the previously defined Halılar Formation of Rushensky et al. (1980) was divided into two distinct formations; namely, Bağcağız and Sakarkaya Formations in the Biga (Edremit) regions (Altıner et al., 1991). The Middle Jurassic volcano-sedimentary units in the Mudurnu – Nallıhan – Beypazarı region was previously named as the Mudurnu Formation by Saner (1980) and the overlying Upper Jurassic – Lower Cretaceous pelagic deposits were defined as the Soğukçam Limestone (Saner, 1980; Yılmaz et al., 1981). While the Mudurnu Formation name was kept by Altıner et al. (1991), three distinct units were introduced for the overlying pelagic successions. For the detrital parts including olistostromes, volcanics and carbonate turbidites the Kurcalıkdere and the Yosunlukbayırı Formations were defined and for the overlying Lower Cretaceous porcellaneous and

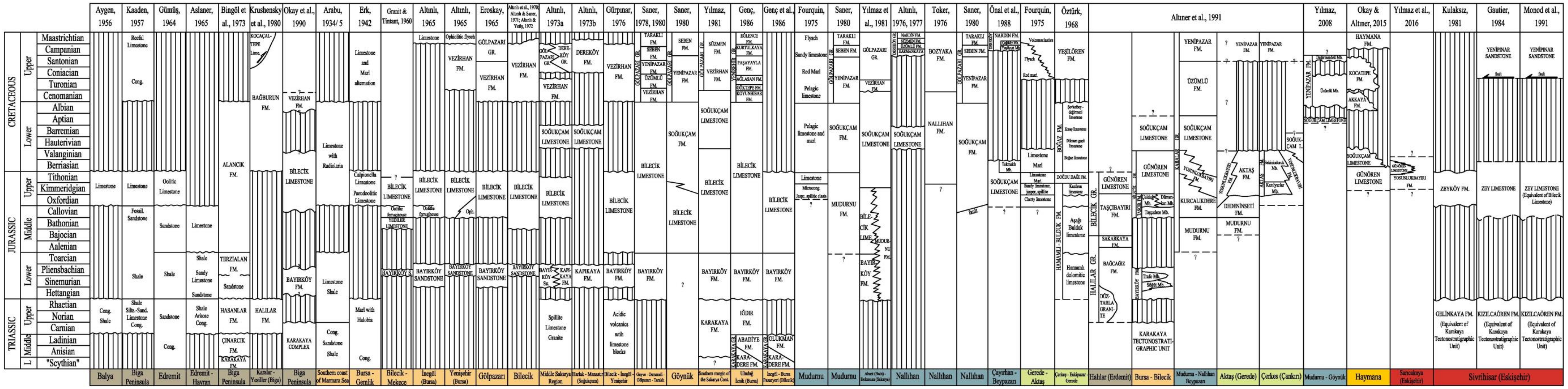


Figure 4. Summary of the informally and formally established lithologic units in the NW Turkey and their correlations. This chart does not follow a chronological order. Studies within the same regions are grouped together and indicated with the same colour at the bottom "location line". Their revised equivalent nomenclatures are highlighted with the same colours and given under the column "Altıner et al. (1991)". Six sections from Mudurnu, Haymana and Eskişehir regions were added and correlated to previously established successions. Vertical hatching indicates time gap (modified from Altıner et al. 1991).

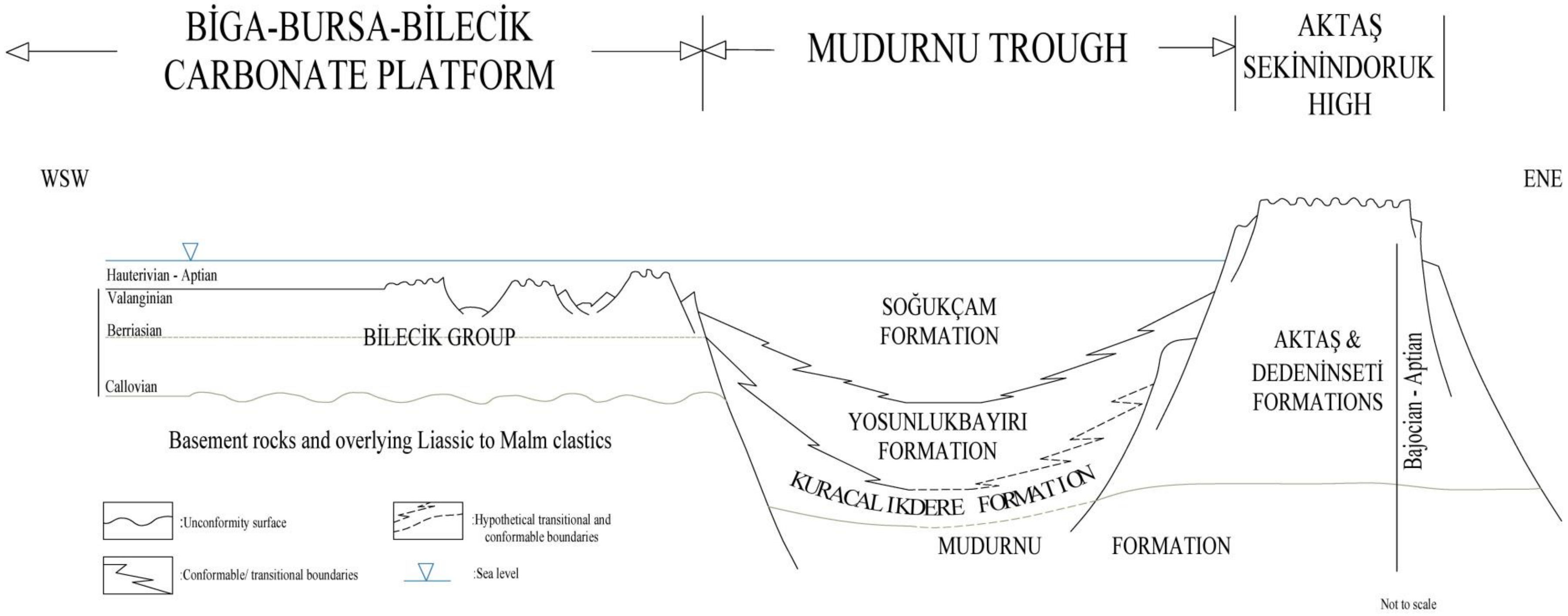


Figure 5. Callovian – Aptian tectono-stratigraphic reconstruction of the southern part of the NW Turkey (simplified from Koçyiğit et al., 1991).

argillaceous successions, Soğukçam Limestone formation name has been adopted. For the Aktaş – Çerkeş region, Dedeninseti and Aktaş Formations were introduced for the pelagic carbonates intercalated with volcanics and the overlying shallow water carbonates which overlies the Mudurnu Formation, respectively (Altıner et al., 1991).

The Edremit – Balya sequence is characterized by an Upper Triassic – Lower Cretaceous continuous succession (Altıner et al., 1991). The Upper Triassic – Lower Dogger Halılar Group is characterized by clastics (Bağcağız Formation: sandstone and shale; Sakarkaya Formation: sandstone and conglomerate) and overlying Upper Dogger – Lower Cretaceous Bilecik Group is composed of carbonates. This Halılar Group was interpreted as the record of the remnant Karakaya Basin by Altıner et al.(1991) and Koçyiğit et al. (1991). On the contrary, Okay et al. (1990) defined a succession similiar to the Bilecik region for the Biga Peninsula. They differentiated three Mesozoic formations which unconformably overlie the Karakaya Complex; namely, the Bayırköy Formation, the Bilecik Limestone and the Vezirhan Formation (Fig.4). Although the age of the Bayırköy Formation in the Biga Peninsula has not been independently determined by Okay et al. (1990), they suggested a presence of an unconformity between the Bayırköy Formation and the Bilecik Limestone in the Biga Peninsula similiar to the Bursa-Bilecik succession of Altıner et al. (1991) (Fig.4).

The Bursa – Bilecik sequence which has the type locality of the Bilecik Group commences with the Liassic (Hettangian – Pliensbachian) clastics of the Bayırköy Formation (including Rosso Ammonitico condensed lenses) overlying the basement rocks of pre-Triassic metamorphics or Triassic Karakaya tectono-stratigraphic unit unconformably and represents the Liassic transgression over the Karakaya Orogen (Görür et al., 1983; Saner, 1980; Altıner et al., 1991; Koçyiğit et al., 1991, Koçyiğit and Altıner, 2002). These rocks are unconformably overlain by the Upper Dogger – Lower Cretaceous shallow marine and pelagic carbonates of the Bilecik Group and the Soğukçam Limestone (Altıner et al., 1991). The Bilecik Group has two formations; namely, the Taşçıbayırı Formation and the Günören Limestone. The Callovian – Kimmeridgian Taşçıbayırı Formation overlies the Bayırköy Formation unconformably and is composed of cherty and nodular limestones. The uppermost levels of the Taşçıbayırı Formation contains of *Tubiphytes morronensis* as bioclasts transported from high-energy environments, indicating approaching shallow marine conditions (Günören Limestone) (Altıner et al., 1991). The pelagic character of the Taşçıbayırı Formation (pelltic, ooidal packestone and grainstone) comes from the pelagic bioclasts of ammonites, *Globochaete* and *Globuligerina* that form the cortex of those "oolites" and Altıner et al. (1991) interpreted these facies as the pelagic "oolites" and pellets deposited over a continental plateau (Jenkyns, 1972; Jenkyns, 1986). The conformably overlying shallow water carbonates of the Günören Limestone has (1) thick bedded to massive, white – grey, reefal carbonates (boundstones and grainstones rich in scleractinian corals, *Tubiphytes*, echinoids, bryozoa, *Lithocodium* and foraminifers), (2) poorly bedded, grey, inner platform or peritidal carbonates (miliolid - rich dismicritic, intraclastic, oncolitic, micritic limestone, dascylad algal wackestones, pelmicrites with birdseyes, stromatolitic bindstones) and (3) medium to thick – bedded low open shore facies (wackestones – packstones and grainstones with abundant crinoid remains and bryozoa). Depending on the position of the studied outcrops within the Bilecik carbonate platform, several or whole types of these Günören Limestone facies can be observed. The studied fossil content, mainly dominated by foraminifera suggests a Kimmeridgian – Early Hauterivian age (Altıner, 1991). Depending on the paleo-topography, the Günören Limestone, in the Bursa – Bilecik area, was diachronically overlain by porcelaneous, planktonic foraminifera- and nannoconid-bearing pelagic Soğukçam Limestone through an unconformity surface of varying hiatus, illustrating iron-oxide, neptunian dykes and travertine occurences (Altıner et al., 1991). This abrupt facies changes was interpreted as a platform drowning event (Saner, 1980; Şengör & Yılmaz, 1981; Görür et al. 1983; Altıner et al., 1991).

The Mudurnu – Nallıhan sequence commences with the volcano - clastic Mudurnu Formation which is composed of tuff, lime-rich tuffaceous lithology and volcanogenic litharenites in the lower parts and highly altered spilitic basalt in the upper parts (Saner, 1980; Altıner et al., 1991). Depending on the presence of a few unidentified foraminifers found in the limy tuffaceous levels, marine environment was interpreted for this formation by Altıner et al., (1991). Regarding its basement rocks, since they are not exposed in the area, there are two hypothesis: (1) they may be similiar with the Bilecik - Bursa sequence and the transgressive Bayırköy Formation unconformably overlies the Karakaya tectono-stratigraphic unit or any other pre-Liassic basement rocks and the overlying volcanics of the Mudurnu Formation represents the rifting of the Mudurnu - Nallıhan trough or (2) the transgression probably had started in pre-Liassic times and deep marine deposits were laid down during Liassic as the time-equivalent of the Bayırköy Formation. The Mudurnu Formation conformably succeded these rocks, forming a continuous succession that resembles the lower parts of the Halılar – Edremit sequence (Saner, 1980; Altıner et al., 1991). For the first possibility, the Mudurnu Formation must be younger than the Bayırköy Formation, and older than the overlying Callovian pelagic successions of the Kurcalıkdere Formation. Thus roughly a Dogger age can be assigned for this formation (Altıner et al., 1991; Figs. 4 & 5). The Kurcalıkdere Formation conformably overlies the Mudurnu Formation in this region and starts with radiolaria – rich wackestones and chert nodules and continues with red jasper, green tuff, sandstone levels (with abundant belemnites), bivalve – rich pelletic mudstones, breccia levels (containing clasts of *Tubiphytes*-rich boundstones and grainstones, packstones with pelagic "oolite" and mudstones) and spilitic basalt levels (Altıner et al., 1991). This succession includes olistostrome levels containing abundant limestone blocks in boundstone and foraminiferal grainstone textures, probably derived from the Günören Limestone (Altıner et al., 1991). A Callovian age has been assigned to the lowermost parts of the formation based on belemnites (Doyle & Mariotti, 1991). Microfossils from the pebbles of the olistostromes indicated a Kimmeridgian age for the upper part of the unit (Altıner et al., 1991). This formation was interpreted as the transitional facies between the Mudurnu Formation and the pelagic deposits of the Yosunlukbayırı Formation and the Soğukçam Limestone (Saner, 1980; Altıner et al., 1991). The Kurcalıkdere Formation is conformably followed by thin- to medium- bedded, grey-white argillaceous limestones, calpionellid packestones and brown calpionellid packestones with intercalations of mudstones and breccioid limestones (containing coral, echinoid and limestone lithoclasts) of the Yosunlukbayırı Formation (Altıner et al., 1991). The calpionellids, foraminifera, algae and incertae sedis associations indicated a

Tithonian – Valanginian age for the Yosunlukbayırı Formation (Altıner, 1991; Altıner & Özkan, 1991; Özkan, 1993a). This formation, with common calciturbiditic depositions punctuated with breccia levels and slump structures, was interpreted as the deposits laid down in an actively subsiding basin fed by material derived from the surrounding shallow marine carbonates (Bursa – Bilecik platform and Aktaş-Sekinindoruk High) (Saner, 1980; Varol & Kazancı, 1981; Altıner et al., 1991). The overlying medium-bedded cream colored limestones of the Soğukçam Limestone starts with mudstone and wackestone facies and contains echinoid fragments, radiolaria, siliceous sponge spicules, nannoconids, aptychi, calpionellids and planktonic foraminifera. It continues upwards with alternation of marls and limestones (Altıner et al., 1991). The studied microfossil associations suggest an age ranging from Late Tithonian to Aptian (Altıner, 1991; Altıner & Özkan, 1991; Özkan, 1993a). This formation represents the calm pelagic sedimentation in basinal conditions (Saner, 1980; Altıner et al., 1991).

The main difference of the Aktaş – Çerkeş sequence from the Bursa-Bilecik and Mudurnu-Nallıhan seuquences is the presence of two new rock formations, depicting a different paleogeographic domain in Northwestern Anatolia. The Dedeninseti Formation which conformably overlies the Mudurnu Formation and shows a tranisiton with the Yosunlukbayırı Formation (Fig. 4). The Dedeninseti Formation, the time-equivalent of the Taşçıbayırı Formation, starts with ammonite-rich nodular limestones and continues with thin- to medium-bedded, sometimes dolomitized cherty dark limestones with pyroclastic levels (Altıner et al. 1991). In addition to ammonites, aptychi and crinoids, microfossils suggest a Callovian – Early Kimmeridgian interval (Altıner, 1991). The facies of this formation again indicates a pelagic plateu type environment quite similiar with the Taşçıbayırı Formation (Altıner et al., 1991). It is conformably overlain by the shallow marine carbonates of the Aktaş Formation which is characterized by middle to thick-bedded, monotonous, cream or pinkish bioclastic limestones in its lower levels. This formation continues upwards with medium to thick-bedded, cream oncolitic, bioclastic and algae-bearing limestones (Altıner et al., 1991). Fossils indicate a Kimmeridgian to Valanginian interval for the Aktaş Formation (Altıner, 1991). The shallow marine platform carbonates of the Aktaş Formation are comparable with the Günören Limestone of the Bursa-Bilecik sequence both of whom supplied materials to the intervening Mudurnu-Göynük trough, and fed the Yosunlukbayırı Formation.

The relationship of the mentioned formations is summarized in Figure 5 on a WSW – ESE section trough the southern part of the NW Turkey for the Callovian – Aptian interval without emphasis on the member level subdivisions within formations. The tectonostratigraphic interpretation of those deposits are summarized in the studies of Saner (1980), Şengör and Yılmaz (1981), Görür et al. (1983), Okay et al. (1990), Altıner et al. (1991), Koçyiğit et al. (1991) and Koçyiğit and Altıner (2002). Liassic transgression started with widespread shallow marine clastic deposition of the Bayırköy Formation that also has condensed Rosso Ammonitico lenses over the pre-Liassic basement rocks of Karakaya orogeny or any other crystalline basement. In contrast to Okay et al. (1990), Altıner et al. (1991) suggests a continuous succession in the Edremit area from Upper Triassic to Lias (Halılar Group) without any gap. Then a part of the platform was emerged, except may be the Edremit area a Toarcian – Bathonian gap occured in the Bursa-Bilecik region. Aalenian onward the onset of a rifting event gave rise to “platform - trough” differentiation along the platform and this was recorded as the formation of basalt and volcanoclastic layers in the Mudurnu Formation. An oceanic plateau – type pelagic sedimentation took place over the platform diachronocially (Late Bajocian onward in the westernmost parts and Callovian onward in the Bursa-Bilecik area), represented by the Taşçıbayırı and the Dedeninseti Formations, while the Mudurnu area recieved olistostromal and calciturbiditic deep marine sedimentation with volcanoclastic levels indicating trough development between two paleohighs (Biga - Bursa - Bilecik Paltfrom and Aktaş – Sekinindoruk High). These formations were regressively covered by the Günören Limestone and the Aktaş Formation which represent shallow marine carbonate deposition that provide materials to surrounding troughs, feeding the calciturbiditic Yosunlukbayırı Formation which has a transitional relation with the overlying pelagic Soğukçam Limestone (Fig. 5). The top of the carbonate platform represented by the Günören Limestone is characterized by a rapid facies change caused by a carbonate platform drowning event in the Hauterivian times (Fig. 5)

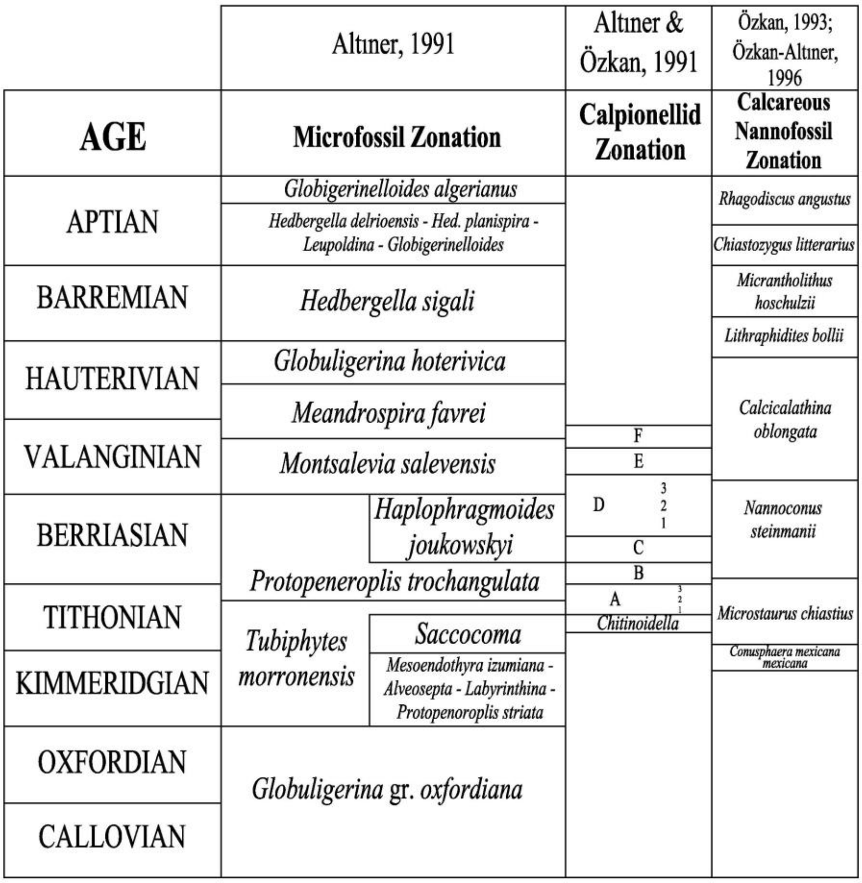
This drowning event occured as early the as mid-Berriasian time in the Haymana region (Okay & Altıner, 2015) which displays an active-platform margin character quite different than the successions of the Edremit-Bursa-Bilecik Platform (Fig. 4).

Yılmaz et al. (2016) introduced a succession from the Sarıcakaya (Eskişehir) that shows an intercalation of the Günören Limestone with the Yosunlukbayırı Formation (Fig. 4). Regarding the relatively poorly – known carbonate succession of the Sivrihisar (Eskişehir) area, Kulaksız (1981) defined a succession that starts with the "Gelinkayası" Formation which consists of Permo – Carboniferous limestone blocks, metagraywacke, quartz schist, metamorphic limestones and metadiabase and the unconformably overlying Zeyköy Formation characterized by conglomerate and sandstone at the bottom and grey to cream coloured, commonly massive, slightly recrystallized limestone which is poor in fossils. The Zeyköy Formation is quite similiar to the Bursa-Bilecik succession defined by Altıner et al. (1991) (Fig.4). Weingart (1954) assigned Late Cretaceous age for these limestones however Kulaksız (1981) interpreted the age of the Zeyköy Formation as Late Jurassic based on the microfossils including *Protopeneroplis* sp., *P. striata, Pseudocyclammina* sp., *Trocholina* sp., *Conicospirillina* sp., *Labyrinthina* sp., *Nautiloculina* sp. Gautier (1984) carried out a doctoral thesis in the Sivrihisar region to solve the relationships between the units of the Pontides and the Anatolide-Tauride in this area. He defined a 800 m thick transgressive cover rocks ("La transgression Jurassique: Le calcaire de Zey") that overlies unconformably the Kızılcaören Formation with argillaceous schists, volcanics and greywackes with Permo – Carboniferous limestone blocks. The cover rocks are composed of basal clastics and a limetone succession ("Le détrique de base" and "Le calcaire de Zey"). The Upper Dogger – Lower Malm carbonates are high energy, neritic limestones ("calcaire blanc zoogene de Zey"). The Upper Malm is represented by a red breccia interpreted as the record of the onset of platform collapse ("breche rouge de Dümrek") and the Lower Cretaceous is composed of white pelagic limestones ("facies pélagique de Dümrek") that has mudstone facies with calpionellids and radiolarians (Gautier, 1984). For the neritic limestones; packstones, pelloidal micrites and bioclastic grainstone facies with *Protopeneroplis striata, Thaumatoporella* sp., *Lenticulina* sp., *Pseudocyclammina* sp., *Cladocoropsis* sp., corals, algae, gastropods were described. Dümrek breccia succession was defined as the intercalations of white cabonates in ooidal, bioclastic grainstone and the red breccia with *Trocholina* sp., echinoids, gastropods algae and calpionellid (within a limited level) content (Gautier, 1984). The overlying pelagic mudstones has *Calpionellopsis simplex, Calpionellopsis* sp., *Cps. oblonga, Tintinopsella longa, T. carpathica, Calpionella alpina* and radiolaria fossils (Gautier, 1984). The Yeni Pınar Sandstone has a fault contact with the underlying succession and has *Globoturuncana* sp, sponge spicules and algae indicating Late Cretaceous age (Gautier, 1984). Monod et al. (1991), whose study is mainly based on the previous work of Gautier (1984), came to the same conclusion about these carbonates. Okay and Tüysüz (1999) interpreted the underlying greywackes and shales with blocks of basalt and Carboniferous, Permian and Middle Triassic limestones as the Karakaya Complex. The overlying basal clastics and limestone succession was accepted as the Bilecik Group of the western Sakarya Zone (Okay & Tüysüz, 1999).

Previous works before 1990s generally gave documentation of the fossil contents to characterize the lithologic units and to roughly determine the age span without any intention of establishing a biostratigratigraphic framework (e.g. Öztürk, 1968; Fourquin, 1975; Toker, 1976; Varol & Kazancı, 1981; Kulaksız, 1981; Gautier, 1984; Genç, 1986; Genç et al., 1986; Önal et al., 1988). Tunç (1991) defined six calpionellid zones from the Aktaş (Kızılcahamam) namely; *Crassicollaria intermedia, Calpionella alpina, C. ellitica, Calpionellopsis simplex – Cs. oblonga, Calpionellites darderi, Tintinopsella carpathica*. In this study, fossils were poorly figured and the biozone boundaries were tentatively placed. The most comprehensive biozonation study was carried out by Altıner (1991). This biozonation, mainly based on the benthic and planktonic foraminifera, is applicable both for the shallow marine and the basin environments due to the wide environment tolerance of the used taxa and their easily transportable nature, e.g. *Tubiphytes, Protopeneroplis, Montsalevia* and *Meandrospira*. *Globuligerina oxfordiana*, *Montsalevia salevensis,* and *Meandrospira favrei* zones were introduced for the first time and the last one was used as the link between the benthic zonations and the overlying planktonic zones of basinal associations (Table 1). These zones were calibrated with ammonites (Cope, 1991), belemnites (Doyle & Mariotti, 1991) and calpionellids (Altıner & Özkan,

1991) (Table 1). Altıner and Özkan (1991) carried out callpionellid biozonation study and differentiated A – E zones of the Vocontian Trough, SE France (Remane, 1974, 1985) and introduced the F Zone defined between the successive last appearances of *Calpionellites darderi* and *Tintinopsella carpathica*. This biostratigraphic distribution of *T. carpathica* was previously observed by Trejo (1980) but it was not described as a distinct zone. Fiorentino (1991) studied the nannofossil stratigraphy of the Soğukçam Limestone but as a result of the poor preservation conditions of the key taxa, it was not possible to define the biohorizones precisely. Özkan (1993) established the calcareous nannofossil framework of the NW Turkey from the Yosunlukbayırı Formation and the Soğukçam Limestone for the Kimmeridgian-Valanginian interval, then Özkan-Altıner (1996) extended the biozonation by including Valanginian – Aptian interval (Table 1).

Table 1. Upper Jurassic – Lower Cretaceous biozonations for the NW Turkey.



	Altıner, 1991	Altıner & Özkan, 1991	Özkan, 1993; Özkan-Altıner, 1996
AGE	**Microfossil Zonation**	**Calpionellid Zonation**	**Calcareous Nannofossil Zonation**
APTIAN	*Globigerinelloides algerianus* *Hedbergella delrioensis - Hed. planispira - Leupoldina - Globigerinelloides*		*Rhagodiscus angustus* *Chiastozygus litterarius*
BARREMIAN	*Hedbergella sigali*		*Micrantholithus hoschulzii* *Lithraphidites bollii*
HAUTERIVIAN	*Globuligerina hoterivica* *Meandrospira favrei*		*Calcicalathina oblongata*
VALANGINIAN	*Montsalevia salevensis*	F E	
BERRIASIAN	*Haplophragmoides joukowskyi* *Protopeneroplis trochangulata*	D 3 2 1 C B	*Nannoconus steinmanii*
TITHONIAN	*Tubiphytes morronensis* *Saccocoma*	A 3 2 1 *Chitinoidella*	*Microstaurus chiastius*
KIMMERIDGIAN	*Mesoendothyra izumiana - Alveosepta - Labyrinthina - Protopenoroplis striata*		*Conusphaera mexicana mexicana*
OXFORDIAN	*Globuligerina gr. oxfordiana*		
CALLOVIAN			

1.5. Regional Geological Setting

The mountain belt of northern Turkey has been classified as a part of the Pontide tectonic unit since the earlier works of Naumann (1896), Argand (1924), Staub (1924, 1928), Seidlitz (1931) and Kober (1931, 1942). These studies suggest a division of the belts from north to south as “Pontides”, “Zone intermediaire” and “Taurides”. Pontides were considered as the eastern continuation of Alpides. Arni (1939) further introduced more tectonic subdivisions for the southeastern Anatolia and proposed a classification of the tectonic units from north to south as; the “Pontides”, “Anatolides”, “Taurides”, “Iranides” and “Plis bordiers”. Following this study, Blumenthal (1946) and Egeran (1947) incorporated more divisions to the original classification of Arni (1939). As pointed out by Ketin (1959), these previous studies based their conclusions mainly on the stratigraphic successions and magmatic characteristics of the units. Ketin (1959) considered orogenic processes as the main criteria for his classification and defined the Pontide unit (including northern Anatolia mountain belts, Marmara basin, Biga and Karaburun peninsulas) as the oldest mountain belt of Turkey displaying Caledonian and Hercynian orogenic imprints. In 1966, Ketin revised his classification and redrawn the boundaries of the tectonic units by considering the ophiolite belt distributions additionally in his maps.

The first modern tectonic approach to the geology of Turkey came from Şengör and Yılmaz (1981). They analysed and modeled the tectonic evolution of Turkey within the framework of the Tethyside tectonic history. In their model to account for the closure of the westward narrowing Tethys ocean between Gondwana and Laurasia (Şengör, 1979) southward subduction of Paleotethys beneath the northern margin of Gondwanaland was proposed. This resulted in back-arc spreading and isolation of a Cimmerian Continent during Late Triassic and disintegration of that continent behind a Paleotethyan arc during Late Triassic – Early Jurassic. Cimmerian Continent descendent continental fragments accreted to the southern margin of Laurasia diachronically through Late Jurassic (closure of Paleotethys) to Middle Miocene (closure of Northern Neotethys). Şengör and Yılmaz (1981)’s model divided Pontides into two tectonic units; namely, the Rhodope - Pontide Fragment and the Sakarya Continent and indicated Gondwanaland origin for the Sakarya Continent and western part of the Rhodope – Pontides Fragment. Görür et al. (1983) interpreted facies differentiation of the Lias cover of Pontides as the evidence of block-faulting related to the rifting of the northern branch of Neotethys. Şengör et al. (1984) tried to explain the tectonic evolution of the Mediterranean Cimmerides that placed Turkey within the larger framework of the Cimmeride orogenic system (Şengör, 1984) and retained the Gondwana origin for the Pontides within which the Istanbul Nappe was also differentiated additional to the Sakarya Continent and the Rhodope-Pontide Fragment. Similiar interpretation also came from Robertson and Dixon (1984) who reviewed all previously proposed models and while assuming a Gondwana origin for the Sakarya Continent, they placed the Rhodope-Pontide Fragment to the southern margin of Laurasia and Paleotethys to the north of the Sakarya Continent for Permian – Triassic interval. Şengör et al. (1988), which is one of the pioneering study that incorporates paleobioprovinces of important taxa (especially foraminifera) for delimination of tectonic units, reviewed the Tethyside superorogenic complex. This paper again speculated similiar evolution for the Turkish segment of the Tethyside collage as in the original 1981 model.

Okay (1984 and 1986) introduced Sakarya Zone that grouped the Sakarya Continent of Şengör and Yılmaz (1981) and the Central and the Eastern Pontides based on the recognition of that the Karakaya Complex (Bingöl et al., 1973; Tekeli, 1981; Okay, 2000; Okay and Göncüoğlu, 2004) forms the pre-Jurassic basement of stratigraphically similiar Mesozoic and younger cover rocks. The Pontides was divided into 3 major tectonic units; namely, the Istranca Massif, Istanbul Zone and Sakarya Zone by Okay (1989). Following the definition of the Tavşanlı Zone (Okay, 1984; 1986) in the northenmost part of the Anatolides in the west, Okay and Siyako (1991) have shifted the position of the İzmir-Ankara suture about 40 km further north by introducing another unit within the Anatolides, the Bornova Flysch Zone situated north of the Tavşanlı Zone. By this revision the extent of the Sakarya Zone of the Pontides in the west has been limited.

Based on the comprehensive study that revised the Jurassic – Lower Cretaceous stratigraphy of the southern part of the northwestern Turkey (nearly within the limit of Şengör and Yılmaz (1981)'s Sakarya Continent), Altıner et al. (1991) and

Koçyiğit et al. (1991) proposed a tectonic model for the isolation of the “Sakarya Continent” during Jurassic, and indicated again a Gondwanaland origin for the Sakarya Continent. The boundary of the Istanbul and the Sakarya Zone was revised in the light of Late Cretaceous opening of the Black Sea by Okay et al. (1994). Okay et al. (1996) defined the Sakarya Zone as the “Hercynian fragment with Paleotethyan active-margin accretionary units” and proposed Laurasian affinity for this unit as previously implied for the Pontides by Biju-Duval et al. (1977).

Göncüoğlu et al. (1997) classified the tectonic units of Turkey in terms of terrane concept and divided Pontides into four terranes; the North Anatolian Ophiolite Belt, Sakarya Composite Terrane, Intrapontide Ophiolite Belt and Istranca/ Istanbul Terranes. Their Sakarya Composite Terrane nearly corresponds to the Sakarya Zone of Okay (1986; 1986). Okay & Tüysüz (1999) reviewed Tethyan sutures of Turkey and divided Pontides into three tectonic units; the Strandja, Istanbul and Sakarya Zones. They further proposed that the İzmir - Ankara - Erzincan suture represents both the Paleo- and Neo-Tethyan sutures and indicated a Laurasian affinity for the Sakarya Zone that had faced Paleotethys (Carboniferous to Triassic) and Neotethys (Triassic to Cretaceous) in the south. Paleontological evidence for that interpretation came from Altıner et al. (2000) who studied the Late Permian biofacies belts (Southern and Northern Biofacies Belts) and concluded that allochthonous limestone blocks distributed within the Karakaya Complex have northern biofacies belt characteristics and grouped the Upper Permian limestone blocks of the Karakaya Complex and the Bolkar Dağı Unit of Özgül (1976) in a single biofacies belt and rejected Gondwana origin for the Sakarya Continent (or Sakarya Zone). Yılmaz et al. (2000) correlated the Sakarya Zone with Lesser Caucasus and extended it further east. Koçyiğit and Altıner (2002) extended their previous study on the Jurassic – Lower Cretaceous succesions of the northwestern Turkey (Koçyiğit et al.1991) further east by including sections from the eastern Pontides and differentiated platforms and basins along the northern Turkey. They again interpreted these cover rocks of the Pontides as the rifting infill of the Northern Neo-Tethys (Şengör and Yılmaz, 1981), suggesting Gondwana origin for the Sakarya Zone.

More recently Okay et al. (2006), Okay et al. (2008) and Okay and Nikishin (2015) differentiated Baltica (East European Platform, EEP) and accreted terranes (Avalonia and Armorica type terranes with Rheic suture between them) within circum-Black Sea region during Paleozoic based on the type of the basement rocks. By comparing Variscan terranes of the central and western Europe (situated between Laurasia and Gondwana) with the terranes bordering the southern margin of Laurasia in the Black Sea region for Paleozoic evolution, Armorica terrane type (accreted to EEP during the Carboniferous), characterized by Carboniferous plutonism and high - temperature metamorphism and Paleozoic succession of which are metamorphosed or not present, has been interpreted for the Greater and Lesser Caucasus, the Strandja Massif and the Sakarya Zone blocks; while Avalonia type (accreted to EEP during the Early Paleozoic), characterized by a Late Neoproterozoic granitic basement overlain by a Paleozoic sedimentary sequences of Ordovician to Carboniferous age, has been reserved for the Moesia, Dobrugea, Istanbul terrane and probably a part of the Scythian Platform. Although the nature of the contact of Istanbul and Sakarya terranes have not been fully understood since present configuration includes overprint of the post-Variscan tectonics, for Pontides Laurasian affinity is widely accepted.

In summary, the Sakarya Zone of the Pontides has a crystalline basement consisting of Variscan metamorphics (Pulur, Kazdağ, Devrekani and Gümüşhane massifs), Paleozoic granitoids (with Devonian, Carboniferous or Permian crystallization ages) and lower Karakaya Complex (a low-grade metamorphic complex) (Okay & Tüysüz, 1999; Okay et al., 2006). This basement (with the Upper Karakaya Complex) is unconformably overlain by Jurassic – Lower Cretaceous sedimentary rocks made up of dominantly carbonate rocks. Among these cover rocks, the Upper Jurassic – Lower Cretaceous Bilecik Group and the overlying pelagic Soğukçam Limestone (Altıner et al., 1991) (widely known as Bilecik Limestone *sensu lato*) forms the most distinctive and laterally traceable succession in the Pontides with intervening basinal associations (Okay et al., 1990; Altıner et al., 1991; Rojay & Altıner, 1998; Koçyiğit & Altıner, 2002; Okay & Altıner, 2015; Yılmaz et al., 2016). Mid-Cretaceous onward, the differentiation in the history of different parts of the Sakarya zone was initiated until Middle Campanian marking the onset of widespread siliciclastic turbidite – flysch deposits in the Pontides (Okay & Altıner; 2015).

Within this tectonic framework the study area is located 50 km south of the main İzmir – Ankara – Erzincan suture trace and represents a klippe of the Sakarya Zone which has been thrusted to the south over the Tavşanlı Zone of the Taurides (Okay & Tüysüz, 1999) (Figure 1 & 6). It is characterized by the Upper Karakaya Complex (strongly sheared greywackes and shales with exotic blocks of limestones and basalts) at the base that is unconformably overlain by Jurassic basal clastics passing into Jurassic to Lower Cretaceous limestones which resemble to successions in the Central Sakarya Basin north of Bilecik (Kulaksız, 1981; Gautier, 1984; Monod et al., 1991; Okay & Tüysüz, 1999). The studied successions belong to these carbonate cover rocks (Fig.6).

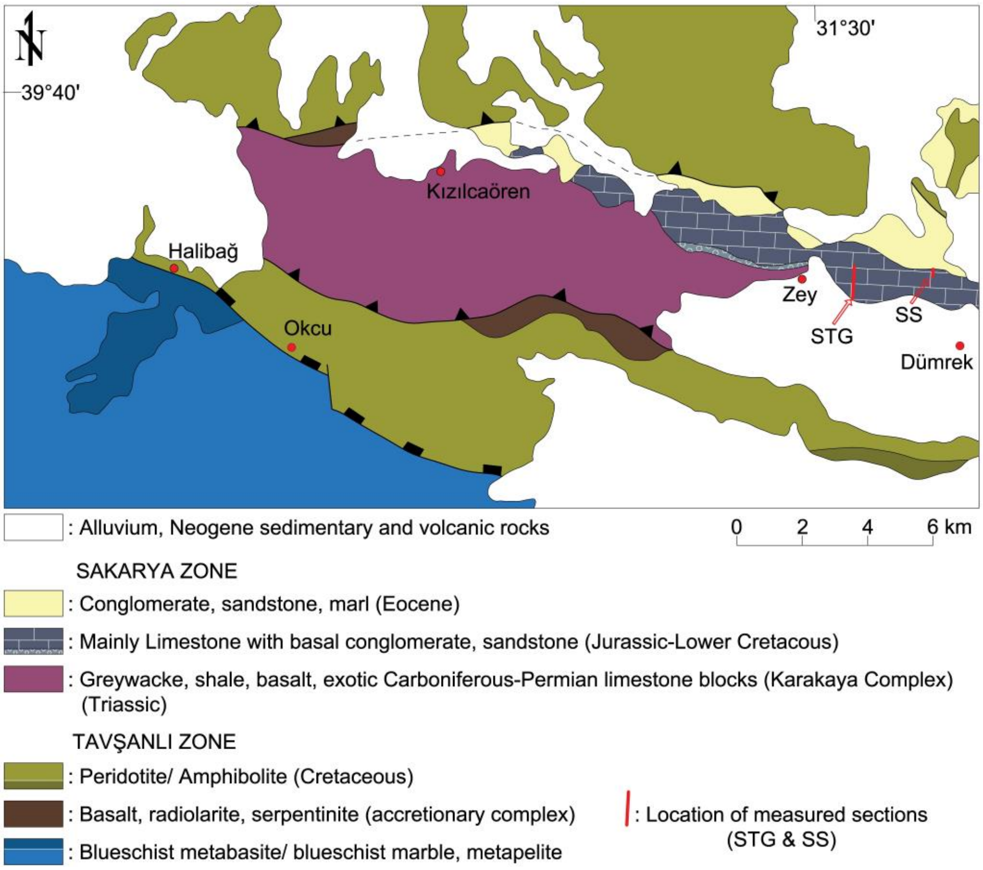


Figure 6. Geological map of the study area illustrating the outcrops of the studied carbonate successions (modified from Okay & Tüysüz, 1999).

CHAPTER 2

STRATIGRAPHY

2.1. Lithostratigraphy

As mentioned in the Chapter 1.4, the carbonate rocks cropping out north of the Dümrek Village were previously studied by Kulaksız (1981), Gautier (1984) and Monod et al. (1991) under different formation names. In general they defined a succession commencing with a chaotic unit that includes Permo – Carboniferous limestone blocks, metagraywacke, quartz schist, metamorphic limestones and metadiabase (Gelinkayası Formation of Kulaksız (1981); Kızılcaören Formation of Gautier (1984) and Monod et al. (1991)). This unit is unconformably overlain by basal clastics (conglomerate and sandstone) and succeded by grey to cream colored, medium- to thick-bedded and generally massive limestones (Zeyköy Formation of Kulaksız (1981); Zey Limestone of Gautier (1984) and Monod et al., (1991)). Gautier (1984) assigned Late Jurassic – Early Cretaceous age for this carbonate succession. Okay and Tüysüz (1999) recognized the underlying greywackes and shales with blocks of basalt and Carboniferous, Permian and Middle Triassic limestone as the Karakaya Complex and the overlying basal clastics and limestone succession the equivalent of the Bilecik Group. These carbonate rocks are unconformably overlain by the Eocene terrigenous to shallow marine sedimentary rocks in the north of the study area (Okay and Tüysüz, 1999) (Fig.6 & 7).

Two stratigraphic sections (STG and SS sections, 925 m long in total) were measured along the carbonate rocks to the north of the Dümrek Village (7, 8 & 10). According to the biozonation and the microfacies types, two coeval but dissimiliar depositional domains, separated by an overthrust, have been detected along the STG section (Fig.7). The one on the southern part show a “slope to basin” facies associations, on the other hand, the rock packages overthrusting from the north show “platform, platform margin and basinal” facies. A simplified tectonostratigraphic column of those domains is given in the Figure 8.

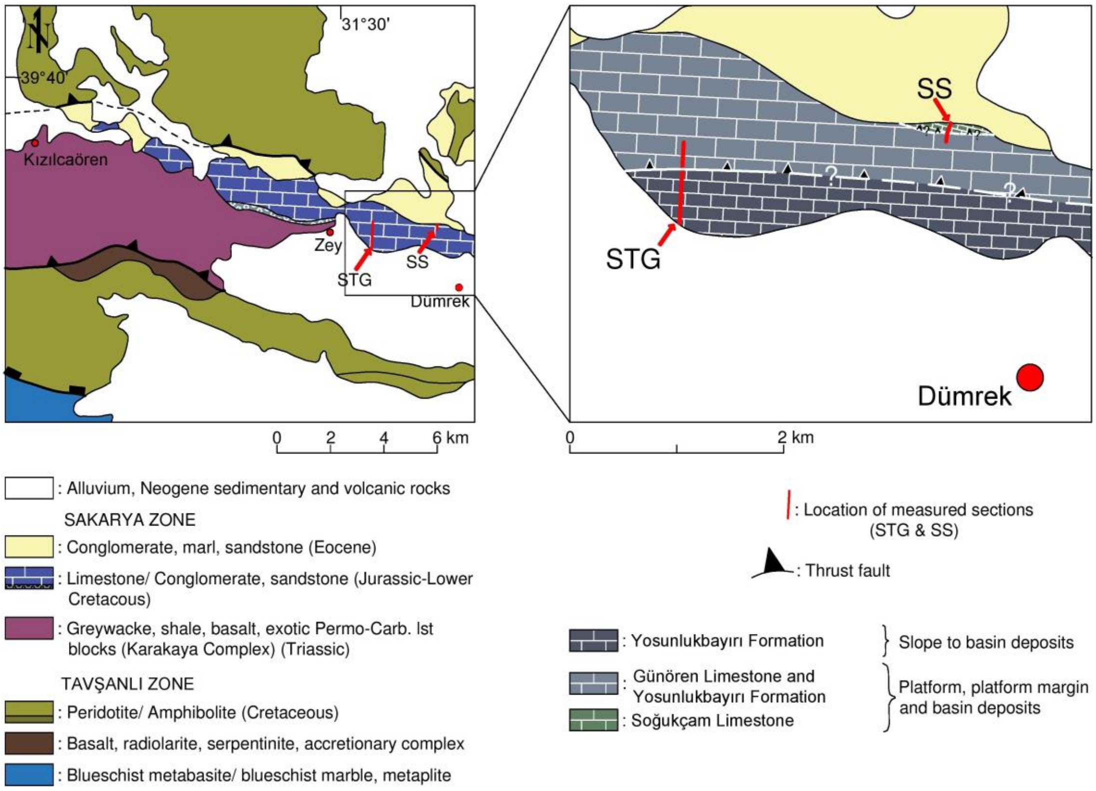


Figure 7. Close-up view of the study area showing the measured section locations and the main thrust contact between the “Slope to basin deposits” and the “Platform, platform margin and basin deposits”. The continuation of the thrust fault to the further east away from the STG section was interpreted from Google Earth - satellite images (modified from Gautier, 1984; Okay & Tüysüz, 1999).

2.1.1. STG measured section

Along the 748 m-thick STG section, 173 samples were collected. The section starts with thin- to medium- bedded, place to place thick-bedded, grey to cream coloured limestone that have some chert layers and nodules in the lower parts (from STG-1 to STG-36) (Fig. 9B, C & 10). Until the sample STG-37 (~176 m level), the succession

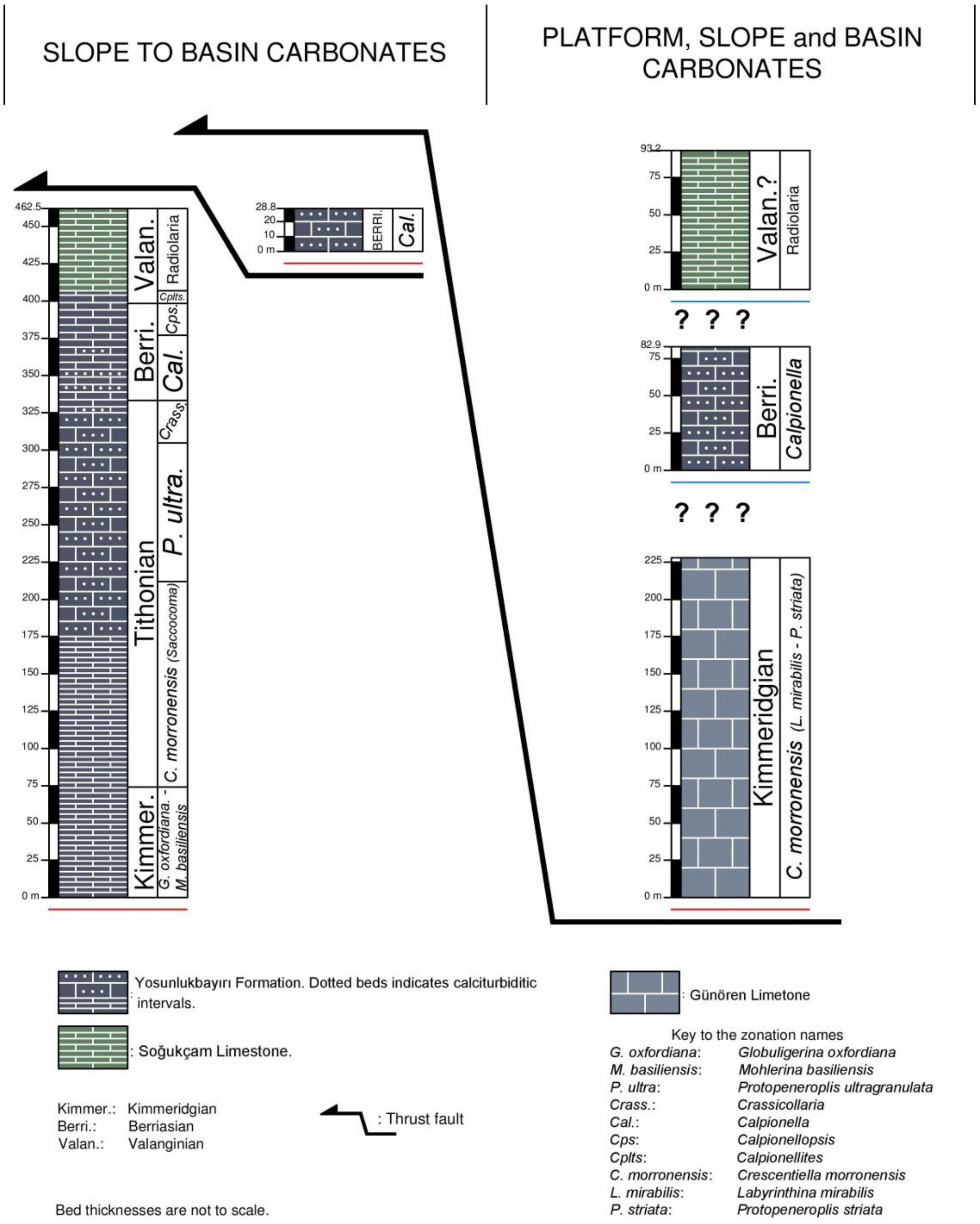


Figure 8. Simplified tectonostratigraphic column of the studied successions. The thin lines at the bottoms of each slice indicates the measured section through which they were recorded. Red line: STG section. Blue line: SS section.

is characterized by toe-of-slope facies dominated by packstone (STG-1, STG-3 to STG-7, STG-9 to STG-11, STG-13 to STG-30) with alternations of wackestone (STG-31 to STG-36) and mudstone (STG-2, STG-8, STG-12 and STG-31 to STG-

35) containing some pelagic and benthic fauna (*Globochaete* sp., *Pithonella* sp., *Saccocoma* sp., calcareous dinocysts, and an individual of *Globuligerina oxfordiana* and rare platform derived foraminifera including *Mohlerina basiliensis* and *Lenticulina* sp.). Overlying this interval, the colour changes into whitish grey to white and the bed thicknesses increase (generally thick to very thick and massive) (Fig.9D). These macro-scale changes are reflected as a shift in the facies type from packstone towards grainstone (STG-46, STG-50, STG-56 to STG-64 and STG-66), floatstone (STG-42, STG-43, STG-45, STG-47, STG-49, STG-53, STG-64A, STG-65, STG-66A to STG-67 and STG-69) and rudstone (STG-52, STG-55 and STG-68A). These coarse-grained deposits are punctuated by packstone intervals (STG-37 to STG-41, STG-44, STG-48, STG-51, STG-54, STG-67A to STG-68) that represent quiescence periods in terms of the amount of platform derived material. As the number of platform derived bioclasts increases (e.g. *M. basiliensis, Protopeneroplis ultragranulata, Coscinoconus* sp., *Crescentiella morronensis, Lithocodium aggregatum, Labes antramentosa,* corals, bryozoa, sponge and echinoids), the facies gains a calciturbiditic character, representing the slope facies (Fig.8 & 10). The background pelagic sedimentation continued which is represented by calpionellids (STG-66A-onward), calcareous dinocysts, *Pithonella* sp. and calcified radiolaria. These taxa are abundant in the packstone facies and present in the matrix of the coarse-grained deposits (see Appendix A for sample-by-sample distribution). From about 335 m level (STG-70), thin to thick bedded, mostly poorly bedded, generally massive looking (due to wheathering effect), cream to brownish cream colored limestone appears in the succession (Fig.9E). Background sedimentation starts to dominate the facies and the platform derived material decrased in amount. Calpionellid wackestones and packstones are the common facies (STG-70, STG-70A, STG-71A, STG-72, STG-74, STG-80 to STG-92A) with some intraclastic, bioclastic packstone (STG-73 STG-74A to STG-75A), grainstone (STG-71, STG-76), floatstone (STG-72A, STG-77 and STG-78) and rudstone (STG-79 and STG-93) intercalations indicating intervals of increased shallow marine derived material (Fig.10). This lower portion (between the samples STG-1 and STG-94) resembles to the Yosunlukbayırı Formation defined in the Mudurnu region (Altıner et al., 1991), with its pelagic, calciturbiditic character and chronostratigraphic position.

Figure 9. Field view of the STG section. A) General view, B) representative photo of the thin to medium bedded and C) the massive portion of the lower toe-of-slope facies, D) close-up view of the thick to very thick bedded and generally massive part of the overlying slope facies, E) overlying pelagic deposits, F) closer view of the tectonic slices, lines with triangles on them indicate thrust faults, G) close-up view of the Soğukçam Limestone, H) representative beds of the first tectonic slice and I) uppermost tectonic slice with shallow marine facies (for detail see the text).

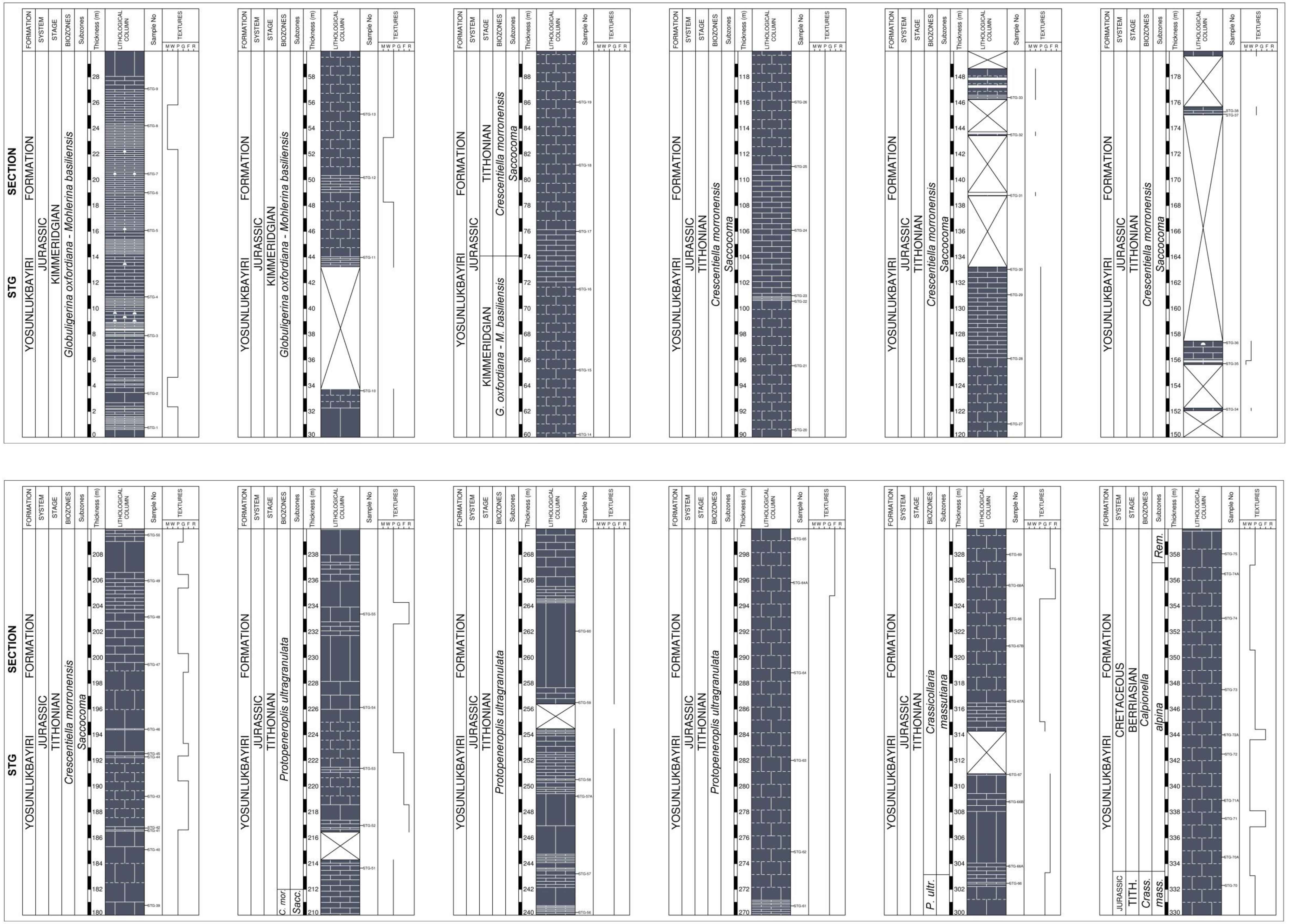


Figure 10. Lithostratigraphy and biozones of the STG and SS measured sections.

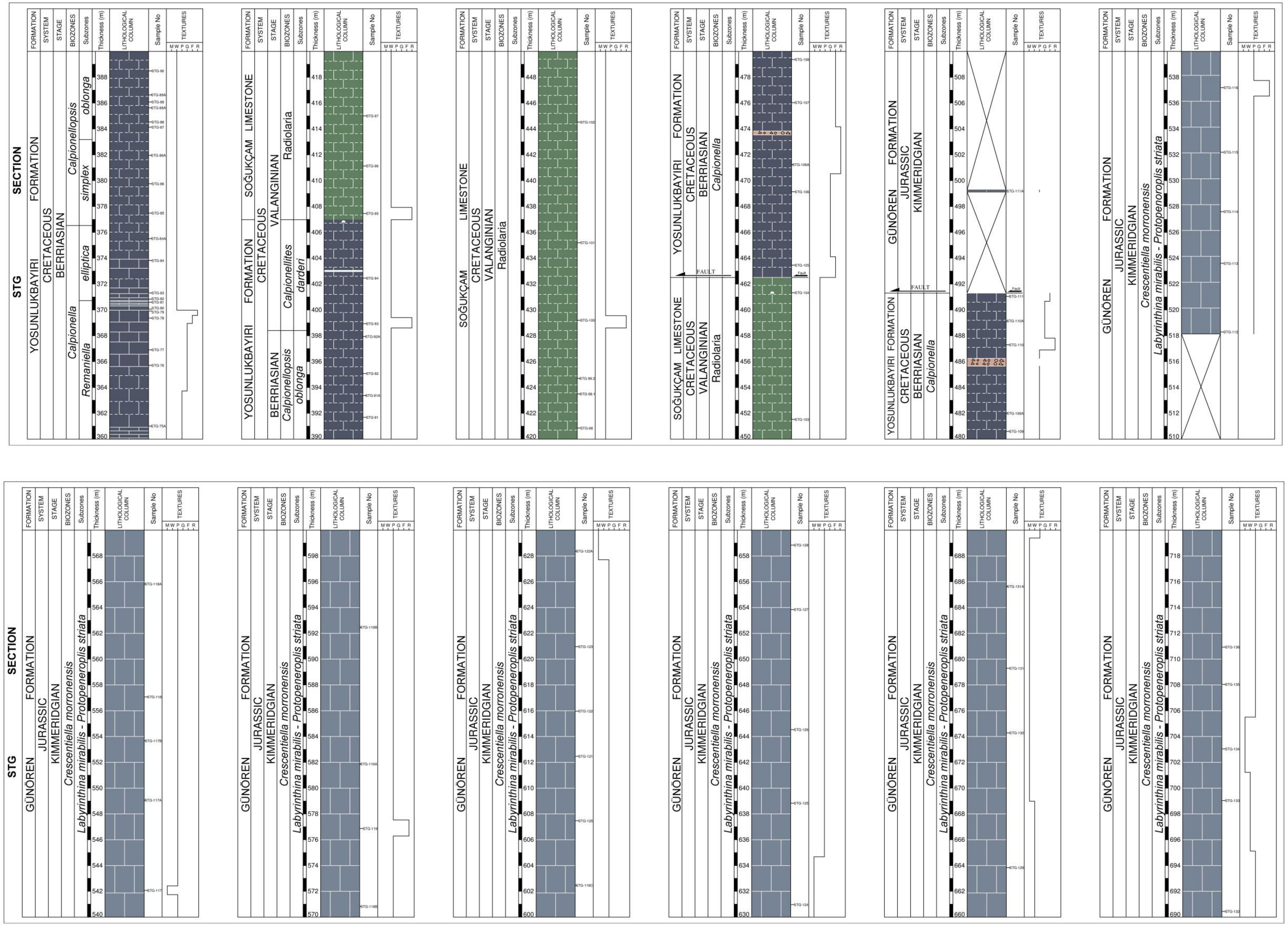


Figure 10 cont’d

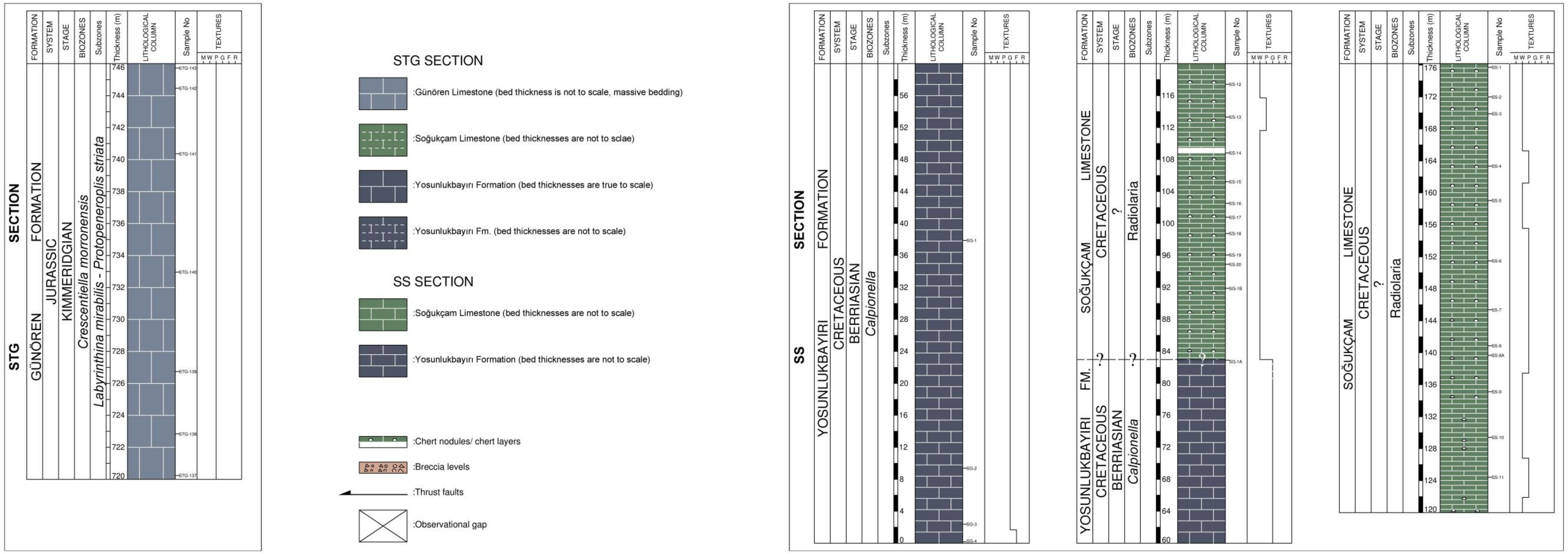


Figure 10 cont’d

After the sample STG-95 (~407 m), the succession continues with porcelaneous white to begie coloured, thin- to medium-bedded limestone in radiolarian wackestone to packstone facies, representing pelagic sedimentation (Fig.9G & 10). This part shows similarities with the Soğukçam Limestone in terms of colour, lithology, stratigraphic position, microfacies and fossil content. At nearly 463 m level, a tectonic slice of about 30 m-thick (between the samples of STG-105 and STG-111) is detected with repetitve fossil assemblages (repetition of the *Calpionella* Zone defined in the Yosunlukbayırı Formation) and facies similiar to the underlying levels (Fig.9F, 9H & 10). This slice is overthrusted by another carbonate package that has completely different facies and fossil associations (especially the occurence of Late Jurassic foraminifera *Protopeneroplis striata*) indicating older depositional intervals (Fig. 9F, 9I & 10). This final unit (from STG-111A to STG-143) is characterized by dominantly massive, medium to thick and very thick bedded, sometimes poorly bedded, white to whitish grey shallow marine limestones in packstone and mudstone facies with shallow marine biota including *Labyrinthina mirabilis, Protopeneroplis striata, Mohlerina basiliensis, Pseudocyclammina lituus, Cayeuxia* sp., *Crescentiella morronensis* and coral fragments. The facies types and contained biota indicate the Günören Limestone of Altıner et al. (1991) which was laid down in a shallow marine carbonate platform. These observations lead us to arrive a conclusion that the slope facies of the Yosunlukbayırı Formation (studied from sample STG-1 to STG-94) and the overlying pelagic Soğukçam Limestone (interval from sample STG-95 to STG-104) were overthrusted by shallow marine platform deposits of the Günören Limestone (samples from STG-111A to STG-143) with an intervening slice of the Yosunlukbayırı Formation (characterized between samples STG-105 – STG-111) (Fig.8, 9 & 10). This conclusion is contrasting with the previous observations of Kulaksız (1981) and Gautier (1984) who generally defined a continuous succession of shallow marine deposits finally overlain by pelagic limestones.

2.1.2. SS measured section

Additional to the main STG section, the SS section was studied with the purpose of checking whether there is a record of a well documented Bilecik Carbonate Platform drowning event (Şengör & Yılmaz, 1981; Görür et al., 1983; Altıner et al., 1991; Altıner, 1991; Koçyiğit et al., 1991 Okay & Altıner, 2015 and Yılmaz et al., 2016). The map of Gautier (1984) shows pelagic deposits to the north of the carbonate belt and a 177 m thick section was measured in that area (Fig.7, 10 & 11). This section crosses the uppermost parts of the northern flank carbonates characterized by whitish grey to white coloured carbonates with grainstone to floatstone texture including both pelagic (calpionellids) and shallow marine (benthic foraminifera, microencrusters and sponge) fauna suggesting upper slope facies (samples from SG-4 to SG-1A). The overlying porcelaneous white to begie coloured, thin to medium bedded pelagic limestones are characterized by radiolarian wackestone to packstone facies (samples from SG-1B to SS-1). The underlying slope facies is defined as the Yosunlukbayırı Formation, and the overlying deposits belong to the pelagic porcelaneous Soğukçam Limestone. In contrasts with the general north-dipping trend of the carbonate rocks in the study area, these pelagic carbonates dip towards south under the older units. Although Gautier (1984) defined a continuous succession and conformable contact, the arrival of the pure pelagic conditions (Soğukçam Limestone) is rather abrupt in the SS section (after the *Calpionella* Zone, Lower Berriasian) when compared with the STG section (after the *darderi* subzone, Lower Valanginian). If these observations and the abnormal dip directions of the Soğukçam Limestone in the SS section are considered there could be a tectonic contact between these two formations. Another possibility for the contact may well be the presence of an unconformity surface. In this case, the platform margin deposits in the Sivrihisar region would had been exposed in post - Berriasian times. Because of poor outcrop conditions in this interval (that disables observation of any unconformity surface indicators like neptunian dykes, travertine occurences etc.) and fossil assemblages of the Soğukçam Limestone that does not deliver a distinctive chronostratigraphy, the nature of this contact could not be precisely determined.

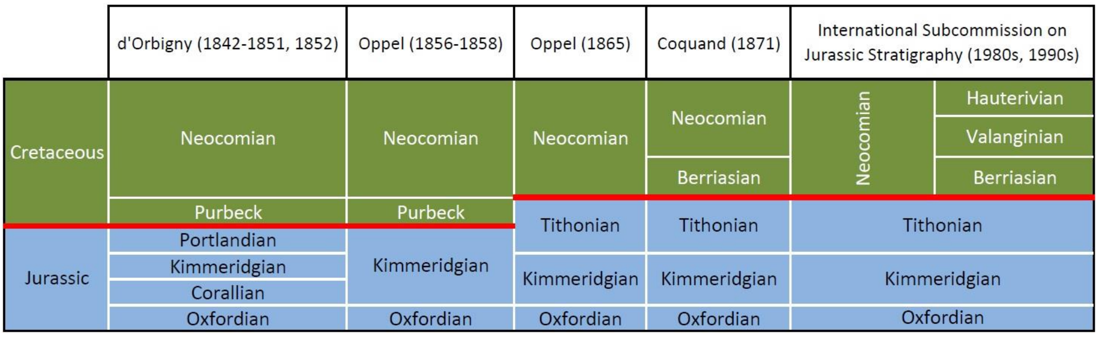
Figure 11. Field view of the SS section. A), B) General view of the SS section. C), D) Close – up view of the Soğukçam Limestone.

2.2. Biostratigraphy

The main parameter that differs geology from all other branches of sciences (except from evolutionary biology and history) is the essential and inevitable interference of time concept. But placing all the rock records in their correct chronological order is not a straightforward practice. The Upper Jurassic – Lower Cretaceous chronostratigraphy may be one of the most problematic strata that have not been standardized yet and includes the only System boundary (Jurassic-Cretaceous boundary; J-K boundary) that has no reference Global Boundary Stratotype Section and Point (GSSP) in the Phanerozoic (Birkelund et al., 1984; Remane, 1991; Cope, 2008; Wimbeldon, 2008; Michalik & Rehakova, 2011; Wimbeldon et al., 2011; Ogg & Hinnov, 2012).

Since the beginning of the stratigraphical practice, fossil assemblages have formed the main tool for the relative age assigenment of rock successions and construction of the Geological Time Scale. The irreversable character of evolution provides nonrepetitive, unique fossil assemblages that provides independent tool for relative age determination and correlation (unlike repetitive patterns of magnetostratigraphic and chemostratigraphic signals which are although very useful as a secondary high-resolution correlation tools). Jurassic System was introduced by Alexander von Humboldt (1799) who defined the carbonate shelf deposits of the Jura region of northernmost Switzerland as “Jura Kalkstein” (Wimbeldon et al., 2011; Ogg & Hinnov, 2012). Since the first attempts by Alcide d’Orbigny (1842-1851, 1852) and Alfred Oppel (1956-1958) for interregional correlation of those strata with the ones in France, Germany and England, ammonites have been used as the main tool for Jurassic biostratigraphy (Remane, 1991; Cope, 2008; Wimbeldon, 2008; Michalik and Rehakova, 2011; Wimbeldon et al., 2011; Ogg & Hinnov, 2012). For Upper Jurassic strata in southern England, d’Orbigny (1842-1851, 1852) named four stages (Oxfordian, Corallian, Kimmeridgian and Portlandian) and he defined the base of the Cretaceous as a Purbeck Stage followed by a Neocomian Stage (Table 2, Ogg & Hinnov, 2012). Oppel (1856-1858), who is the one first applied the modern biozone concepts, extended the Kimmeridgian Stage to the base of the Purbeckian (Table 2, Ogg & Hinnov, 2012). Later, Oppel (1865) introduced a new uppermost Jurassic stage. With a romantic decision, he named it “Tithonian” (the lover of goddes of dawn Eos, the Tithon in Greek mythology in a sense that Tithonian is in the dawn of Cretaceous) without specifying a reference sections (Ogg & Hinnov, 2012). This stage included the upper part of his previous “Kimmeridgian group”, the former Purbeckian Stage and extended until the base of the Neocomian Stage (Table 2, Ogg & Hinnov, 2012). This problem of shuffling Upper Jurassic stage nomenclature was further distorted by the introduction of the “Berriasian” Stage by Couquand (1871) which overlapped partly with the Oppel’s Tithonian Stage (Table 2, Ogg & Hinnov, 2012).

Table 2. Summary of the nomenclature modifications to Upper Jurassic – Lower Cretaceous chronostratigraphy.



	d'Orbigny (1842-1851, 1852)	Oppel (1856-1858)	Oppel (1865)	Coquand (1871)	International Subcommission on Jurassic Stratigraphy (1980s, 1990s)	
Cretaceous	Neocomian	Neocomian	Neocomian	Neocomian	Neocomian	Hauterivian
						Valanginian
				Berriasian		Berriasian
	Purbeck	Purbeck	Tithonian	Tithonian	Tithonian	
Jurassic	Portlandian	Kimmeridgian				
	Kimmeridgian		Kimmeridgian	Kimmeridgian	Kimmeridgian	
	Corallian					
	Oxfordian	Oxfordian	Oxfordian	Oxfordian	Oxfordian	

The problems of shuffling nomenclature and imprecise definitions have been magnified by ammonite provincialism (Remane, 1991; Hardenbol et al., 1998; Cope, 2008; Wimbeldon, 2008; Page, 2008; Michalik & Rehakova, 2011; Wimbeldon et al., 2011; Ogg & Hinnov, 2012) and hiatuses present in the original shallow marine “stratotypes” (Hardenbol et al., 1998; Michalik & Rehakova, 2011; Wimbeldon et al., 2011; Ogg & Hinnov, 2012), resulted in erection of local chronostratigaphic nomenclatures (e.g. local charts for Tethys amd Boreal realms with their own subdivisions) and still unstandardized international chronostratigpraphy. There is also an unique way of usage of the ammonite biozonations in northwestern Europe. These biozones are named as the “Standard Chronozones” in which the nomenclature is not directly associated with the range of the name-giving species (Ogg & Hinnov, 2012). For example *Cardioceras cordatum* appears in the higher levels of Cordatum Zone (Ogg & Hinnov, 2012). This unusal type of biozonation has also introduced additonal uncertainities, especially regarding the deliniation of the zonal basal boundaries (Ogg & Hinnov, 2012). Despite of these difficulties, ammonites have been used as the main fossil group for the Jurassic – Lower Cretaceous chronostratigraphy and all other fossil groups have been calibrated to the ammonite biozones like in the comprehensive work of Hardenbol et al. (1998). Recently, taxonomy of the base – Berriasian – index ammonite *Berriasella jacobi* has been revised (Frau et al., 2016), raising questions for its usage as a boundary marker. On the other hand, there is an important consensus on the rather less problematic calpionellid biozonation which has been widely applied in the Tethyside regions (Allemann et al., 1971; Remane, 1971; Remane et al., 1986; Pop, 1994a, 1997; Altıner and Özkan, 1991; Reháková & Michalik, 1997a, b; Grün & Blau, 1997; Skourtsis-Coroneou & Solakius, 1999; Housa et al., 1999; Lakova et al., 1999; Andreini et al., 2007; Michalik & Rehakova, 2011; Petrova et al., 2012; Lakova & Petrova, 2012; Lakova & Petrova, 2013). This applicability of calpionellids for the Tithonian – Valanginian interval make them an important fossil group and a prominent candidate for the Jurassic – Cretaceous boundary indicator (Wimbledon et al., 2011; Michalik & Rehakova, 2011; Wimbledon, 2014; Ogg et al., 2016).

The facies and time intervals present in an area dictates the fossil groups that are used for the construction of biostratigraphic framework. Since the measured Sivrihisar sections includes several different facies (from basin and slope to shallow marine environments) and the rock packages transgressing several intervals of geologic time (Kimmeridgian to Valanginian) variety of fossil groups were studied (e.g. foraminifera, calpionellids, microencrusters, sponges, bryozoa, corals, echinoids, radiolarians etc.). The proposed biozonation is mainly based on the foraminifera, calpionellids, pelagic crinoid *Saccocoma* and an enigmatic encruster *Crescentiella morronensis*.

Table 3 gives a comparision chart of the biozonations which were used in the construction of the biostragraphical framework and the proposed biozonation in this study. It includes biozonations both based on shallow marine fossil groups (Altıner, 1991; Rojay & Altıner, 1998; Ivanova, 1999; Arkad'ev et al., 2006; Olszewska, 2010) and pelagic calpionellids (Alleman et al., 1971; Remane, 1971; Trejo, 1980; Remane et al., 1986; Bakalova, 1977, 1986; Altıner & Özkan, 1991; Tunç, 1991, 1992; Pop, 1994a, 1997; Rehåkovå & Michalik, 1997a, b; Grün & Blau, 1997; Skouurtis-Coroneou & Solakius, 1999; Andreini et al., 2007; Lakova et al., 1997, 1999; Lakova & Petrova 2013).

Although it seems like it is mainly based on shallow marine fauna, Altıner (1991)'s biozone scheme for the Biga-Bursa-Bilecik platform has a homogenizing character that is both applicable to platform and adjacent slope environments due to the easily transportable nature of the used fossil groups (like "*Tubiphytes*" *morronensis, Protopeneroplis "trochangulata", Montsalevia salevensis* and *Meandrospira favrei*). This property of the used assemblages made direct calibration of them with ammonites and calpionellids of basinal associations possible (Altıner, 1991; Cope, 1991; Altıner & Özkan, 1991). Altıner (1991) introduced the "*Tubiphytes*" *morronensis* interval zone defined at its base by the first occurrence of the microencruster *"Tubiphytes" morronensis* and at its upper boundary by the first occurrence of *Protopeneroplis "trochangulata".* It has two subzones; namely, the *Mesoendothyra izjumiana – Alveosepta – Labyrinthina – Protopeneroplis striata* assemblage subzone, indicating the Kimmeridgian age and the *Saccocoma* range subzone whose base corresponds to the base of the Tithonian. *Protopeneroplis "trochangulata"* zone was defined between the successive first appearances of *P. "trochangulata"* and *Montsalevia salevensis* and the base of this zone is considered to be Upper Tithonian. This zone has *Haplophragmoides joukowskyi* subzone marked at its base by the first occurrence *H. joukowskyi*. The following *Montsalevia salevensis* and *Meandrospira favrei* zones were defined by the successive first occurrences of the name giving taxa, respectively. A very similiar biozone scheme was porposed by Rojay and Altıner (1998) for the Amasya region with the only difference of the *Clypeina jurassica* zone (defined at the base by the first occurrence of *C. jurassica*). This zone is identical with respect to its chronostratiraphic position to the "*Tubiphytes" morronensis* zone of Altıner (1991) (Table 3).

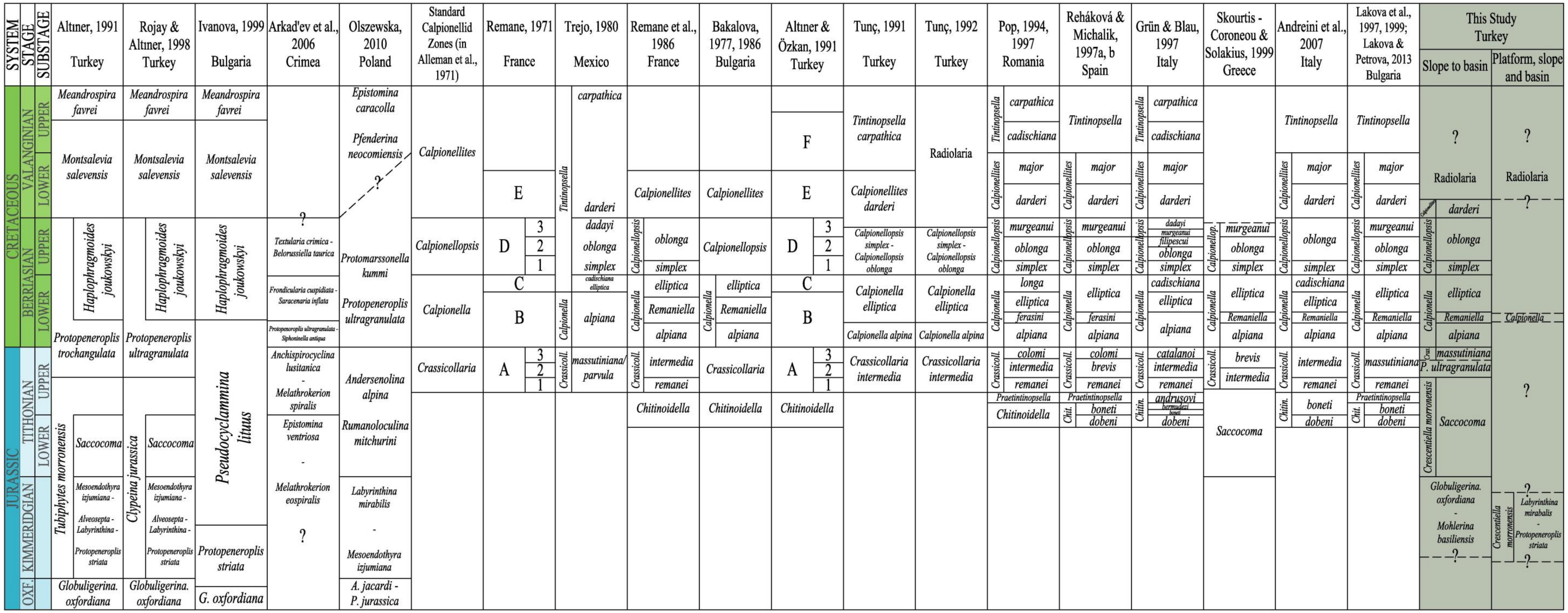
Ivanova (1999) established another zonal scheme from Bulgaria. While she kept the general outline of Altıner (1991)'s zonation, *Protopeneroplis striata* and *Pseudocyclammina lituus* zones were introduced for the first time (Table 3). The bases of these zones were marked by the successive first appearances of *P. striata* and *P. lituus.*

Arkad'ev et al. (2006) carried out a detailed work from Crimea and described biostratiraphic units based on ammonites, foraminifers and ostracodes. They introduced a foraminiferal scheme from Crimea which mainly utilizes assambleage zones instead of first appearances of taxa, characterized by co-occurrence of name delivering fossils (Table 3). They placed the J-K boundary at the base of their *Protopeneroplis ultragranulata – Siphoninella antiqua* assemblage zone.

Olszewska (2010) defined four assamblage biozones from Poland for the Kimmeridian – Valanginian interval, calibrated by ammonites. Her *Labyrinthina mirabilis – Mesoendothyra izjumiana* zone is comparable with the *M. izjumiana – Alveosepta – Labyrinthina – P. striata* subzone of Altıner (1991) (Table 3). The base of the *Protopeneroplis ultragranulata – Protomarssonella kummi* assemblage zone is correlatad with the base of Berriasian.

After the first agreed standard calpionellid biozonation scheme (Alleman et al., 1971) which introduced four main zones (*Crassicollaria, Calpionella, Calpionellopsis, Calpionellites*), higher resolution have achieved with increasing information gained about the calpionellid assemblages. This gave rise to recognition of many new species and introduction of many subzones. The most famous and widely used scheme was proposed by Remane in 1971 (Table 3). His Zone A (corresponding to the base of the standard *Crassicollaria* zone) was defined by the first occurrence of calpionellids with fully hyaline loricas (calpionellid test). Three subzones, A1, A2 and A3 were introduced. The base of A1 corresponds to the base of the Zone A. The A2 subzone is marked by the first occurrence of the large variety of *Calpionella alpina* (*Calpionella grandalpina*). The A3 subzone is characterized by the predominance of *Crassicollaria brevis* over *Crassicollaria intermedia*. Remane (1971) differentiated two subzones within the *Calpionella* standard zone. The B zone is defined at its base by the acme of spherical forms of *Calpionella alpina*, correspo-

Table 3. Comparision chart of the biostratigraphical zonations used in this study and the porposed scheme for the Sivrihisar region.



SYSTEM	STAGE	SUBSTAGE	Altıner, 1991 Turkey	Rojay & Altıner, 1998 Turkey	Ivanova, 1999 Bulgaria	Arkad'ev et al., 2006 Crimea	Olszewska, 2010 Poland	Standard Calpionellid Zones (in Alleman et al., 1971)	Remane, 1971 France
CRETACEOUS	VALANGINIAN	UPPER	*Meandrospira favrei* *Montsalevia salevensis*	*Meandrospira favrei* *Montsalevia salevensis*	*Meandrospira favrei* *Montsalevia salevensis*		*Epistomina caracolla* *Pfenderina neocomiensis*	*Calpionellites*	
		LOWER					?		E
	BERRIASIAN	UPPER	*Haplophragmoides joukowskyi*	*Haplophragmoides joukowskyi*	*Haplophragmoides joukowskyi*	? *Textularia crimica - Belorussiella taurica*	*Protomarssonella kummi*	*Calpionellopsis*	D: 3 2 1
		LOWER	*Protopeneroplis trochangulata*	*Protopeneroplis ultragranulata*	*Pseudocyclammina lituus*	*Frondicularia cuspidiata - Saracenaria inflata* *Protopenoroplis ultragranulata - Siphoninella antiqua*	*Protopeneroplis ultragranulata*	*Calpionella*	C B
JURASSIC	TITHONIAN	UPPER	*Tubiphytes morronensis*	*Clypeina jurassica*		*Anchispirocyclina lusitanica* - *Melathrokerion spiralis*	*Andersenolina alpina*	*Crassicollaria*	A: 3 2 1
		LOWER	*Saccocoma*	*Saccocoma*		*Epistomina ventriosa* - *Melathrokerion eospiralis*	*Rumanoloculina mitchurini*		
	KIMMERIDGIAN		*Mesoendothyra izjumiana - Alveosepta - Labyrinthina - Protopeneroplis striata*	*Mesoendothyra izjumiana - Alveosepta - Labyrinthina - Protopeneroplis striata*	*Protopeneroplis striata*	?	*Labyrinthina mirabilis* - *Mesoendothyra izjumiana*		
	OXF.		*Globuligerina. oxfordiana*	*Globuligerina. oxfordiana*	*G. oxfordiana*		*A. jacardi - P. jurassica*		

SYSTEM	STAGE	SUBSTAGE	Trejo, 1980 Mexico	Remane et al., 1986 France	Bakalova, 1977, 1986 Bulgaria	Altıner & Özkan, 1991 Turkey	Tunç, 1991 Turkey	Tunç, 1992 Turkey	Pop, 1994, 1997 Romania
CRETACEOUS	VALANGINIAN	UPPER	*Tintinopsella*: *carpathica*			F	*Tintinopsella carpathica*	Radiolaria	*Tintinopsella*: *carpathica* *cadischiana*
		LOWER	*darderi*	*Calpionellites*	*Calpionellites*	E	*Calpionellites darderi*		*Calpionellites*: *major* *darderi*
	BERRIASIAN	UPPER	*dadayi* *oblonga* *simplex*	*Calpionellopsis*: *oblonga* *simplex*	*Calpionellopsis*	D: 3 2 1	*Calpionellopsis simplex - Calpionellopsis oblonga*	*Calpionellopsis simplex - Calpionellopsis oblonga*	*Calpionellopsis*: *murgeanui* *oblonga* *simplex*
		LOWER	*cadischiana elliptica* *Calpionella*: *alpiana*	*Calpionella*: *elliptica* *Remaniella* *alpiana*	*Calpionella*: *elliptica* *Remaniella* *alpiana*	C B	*Calpionella elliptica* *Calpionella alpina*	*Calpionella elliptica* *Calpionella alpina*	*Calpionella*: *longa* *elliptica* *ferasini* *alpiana*
JURASSIC	TITHONIAN	UPPER	*Crassicoll.*: *massutiniana/ parvula*	*Crassicoll.*: *intermedia* *remanei* *Chitinoidella*	*Crassicollaria* *Chitinoidella*	A: 3 2 1 *Chitinoidella*	*Crassicollaria intermedia*	*Crassicollaria intermedia*	*Crassicoll.*: *colomi* *intermedia* *remanei* *Praetintinopsella* *Chitinoidella*
		LOWER							
	KIMMERIDGIAN								
	OXF.								

SYSTEM	STAGE	SUBSTAGE	Reháková & Michalik, 1997a, b Spain	Grün & Blau, 1997 Italy	Skourtis - Coroneou & Solakius, 1999 Greece	Andreini et al., 2007 Italy	Lakova et al., 1997, 1999; Lakova & Petrova, 2013 Bulgaria	This Study Turkey: Slope to basin	This Study Turkey: Platform, slope and basin
CRETACEOUS	VALANGINIAN	UPPER	*Tintinopsella*	*Tintinopsella*: *carpathica* *cadischiana*		*Tintinopsella*	*Tintinopsella*	?	?
		LOWER	*Calpionellites*: *major* *darderi*	*Calpionellites*: *major* *darderi*		*Calpionellites*: *major* *darderi*	*Calpionellites*: *major* *darderi*	Radiolaria *Calpionellites*: *darderi*	Radiolaria ?
	BERRIASIAN	UPPER	*Calpionellopsis*: *murgeanui* *oblonga* *simplex*	*Calpionellopsis*: *dadayi* *murgeanui* *filipescui* *oblonga* *simplex*	*Calpionellop.*: *murgeanui* *oblonga* *simplex*	*Calpionellopsis*: *oblonga* *simplex*	*Calpionellopsis*: *murgeanui* *oblonga* *simplex*	*Calpionellopsis*: *oblonga* *simplex*	
		LOWER	*Calpionella*: *elliptica* *ferasini* *alpiana*	*Calpionella*: *cadischiana* *elliptica* *alpiana*	*Calpionella*: *elliptica* *Remaniella* *alpiana*	*Calpionella*: *cadischiana* *elliptica* *Remaniella* *alpiana*	*Calpionella*: *elliptica* *Remaniella* *alpiana*	*Calpionella*: *elliptica* *Remaniella* *alpiana*	*Calpionella*
JURASSIC	TITHONIAN	UPPER	*Crassicoll.*: *colomi* *brevis* *remanei* *Praetintinopsella* *Chit.*: *boneti* *dobeni*	*Crassicoll.*: *catalanoi* *intermedia* *remanei* *Chitin.*: *andrusovi* *bermudezi* *boneti* *dobeni*	*Crassicoll.*: *brevis* *intermedia* *Saccocoma*	*Crassicoll.*: *intermedia* *remanei* *Chitin.*: *boneti* *dobeni*	*Crassicoll.*: *massutiniana* *remanei* *Praetintinopsella* *Chit.*: *boneti* *dobeni*	*Cras.*: *massutiniana* *P. ultragranulata* *Crescentiella morronensis*: *Saccocoma*	?
		LOWER							
	KIMMERIDGIAN							*Globuligerina. oxfordiana* - *Mohlerina basiliensis* ?	? *Crescentiella morronensis*: *Labyrinthina mirabalis* - *Protopeneroplis striata* ?
	OXF.								

nding to the base of the standard *Calpionella* zone. The first appearance of the large variety of *Tintinopsella carpathica* marks the base of the C zone (Remane, 1971). Subzone D1 is defined at the base by the first occurrence of *Calpionellopsis simplex*. This also defines the base of the zone D that corresponds to the base of the standard *Calpionellopsis* zone (Alleman et al., 1971; Remane, 1971). The subzone D2 is characterized by the predominance of *Calpionellopsis oblonga* over *Calpionellopsis simplex*. The first occurrences of *Lorenziella hungarica* and *Calpionellites darderi* define the bases of the subzone D3 and zone E, respectively.

Remane et al. (1986) modified the 1971 scheme. Regarding the *Crassicollaria* zone, they defined *remanei* and *intermedia* subzones characterized by the dominance of the name giving taxa and correspond to the bases of the previously defined A1 and A2 subzones (Table 3). They also introduced a *Remaniella* subzone within the *Calpionella* zone, defined by the first occurrence of *Remaniella* genus. Remane's previous C zone is discarded and replaced by the *elliptica* subzone defined by Pop (1974). This subzone is characterized at its base by the first appearance of *Calpionella elliptica* (Remane et al., 1986). For the *Calpionellopsis* zone, two subzones were defined; namely, the *simplex* and *oblonga* subzones. Their bases are defined by the first occurrences of *Calpionellopsis simplex* and *Calpionellopsis oblonga*, respectively. The definition of the E zone was not changed and named as the *Capionellites* zone. They also introduced a *Chitinoidella* zone for the lower portion of the Upper Tithonian. This zone is characterized by the first occurrence of chitinoidellids (the ancestors of calpionellids with microgranular or double layer lorica walls).

A similiar biozonation was proposed from Bulgaria by Bakalova (1977, 1986). In this scheme, the *Crassicollaria* and *Calpionellopsis* zones were used without any subzonal divisions.

In the following years general outline of the Remane et al. (1986)'s was kept. Altıner and Özkan (1991) introduced an additional F zone to the Remane's 1971 shceme. The boundaries of this F zone were defined by the successive last occurrences of *Calpionellites darderi* and *Tintinopsella carpathica*, respectively. This occurence of *T. carpathica* after the extinction of *Cpts. darderi* had also been observed by Trejo

(1980) but he did not define a formal zone with well-defined boundaries. Other calpionellid zonations from Turkey includes the works of Tunç (1991, 1992) and Burşuk (1992). In their schemes, mainly the standard zones were used. Tunç (1991, 1992) defined assamblege zones like *Calpionellopsis simplex – Calpionellopsis oblonga* zone. Both the works of Tunç (1991, 1992) and Burşuk (1992) indicated a rather strange chronostratigraphic position for the *C. elliptica* zone (Table 3). Calpionellids in the works of these authors were poorly illustrated and erroneous interpretations have led to an artificial taxonomy.

Especially after the emendations on the genus *Remaniella* (Pop, 1994a; Grün & Blau, 1996), revisions have been made to the previously published biozonation schemes with introduction of more subdivisions (Pop, 1994b, 1997; Rehȧkovȧ & Michalik, 1997a, b; Grün & Blau, 1997; Lakova et al., 1997, 1999; Skourtsis-Coroneou & Solakius, 1999), although the main zonal boundaries have remained the same with the Remane's 1971 scheme (Table 3). Among them, Grün and Blau (1997)'s scheme proposed an unusual first occurrence for the *Remaniella catalanoi* in the *Crassicollaria* zone. They introduced a *catalanoi* subzone as the equivalent of the previously defined *colomi* subzone (Table 3). Then it was understood that the Late Tithonian *Crassicollaria* zone is missing and *elliptica* subzone (of *Calpionella* zone) is in direct contact with the *remanei* subzone (of *Crassicollaria* zone) in the Rau Stau section on which Grün and Blau (1997) based their biozonation (Rehȧkovȧ, 1998).

Skourtis-Coroneou and Solakiu (1999) established a biozonation from Greece similiar to the scheme of Reháková and Michalik (1997a, b). They did not recognize any specimen of chitinoidellids and instead of they defined a *Saccocoma* zone similiar to Altıner (1991) whose base indicates the base of Tithonian. Their *brevis* subzone was placed rather higher than the previously established zonations (Table 3). They chose to use two- and three-fold subdivisions for the *Crassicollaria* and *Calpionella* zones, respectively.

More recently, Lakova and Petrova (2012, 2013) tried to synthesize previously published biozonation schemes and proposed a standard global calpionellid zonation. In order to achieve this aim, they discarded taxons with controversial vertical ranges and morphologies and subzones that are not recognized globally. Their biozonations dismissed *colomi* subzone in *Crassicollaria* standard zone, *cadischiana* subzone in *Calpionella* zone, C zone based on the predominance of *Tintinopsella carpathica* and D3 subzone characterized by the first occurrence of *Lorenziella hungarica* (Table 3). They only utilized first occurrence bioevents for the determination of the zones/ subzones which are globally recognized. Only exception is the usage of the last occurrence of *Calpionellites* to define the base of the *Tintinopsella* zone since no evolutionary event among calpionellids is present for this interval. The following bioevents were used for their biozonation in ascending order; first occurrences of chitinoidellids, *Chitinoidella boneti, Praetintinopsella andrusovi,* hyaline-walled calpionellids (*Tintinopsella carpathica, T. remanei*), *Calpionella grandalpina* and *C. alpina*, explosion of *Calpionella alpina* (and coeval decline of the genus *Crassicollaria* and last occurrence of *Calpionella elliptalpina*), first occurrences of *Remaniella* (*Remaniella ferasini* and *R. duranddelgai*), *Calpionella elliptica, Calpionellopsis simplex, Calpionellopsis oblonga, Praecalpionellites murgeanui, Calpionellites darderi, Calpionellites major* and the last occurrence of *Calpionellites* (Lakova and Petrova 2012, 2013). The Jurassic – Cretaceous boundary is placed at the base of the *alpina* subzone (base of the *Calpionella* zone), characterized by the acme of *Calpionella alpina* (spherical forms) (Table 3). The boundary between the Lower and Upper portion of the Berriasian is defined by the base of the *simplex* subzone (base of the *Calpinellopsis* zone). The base of the *Calpionellites* zone (base of the *darderi* subzone) marks the base of Valanginian (Table 3).

The presence of two different domains ("slope to basin" and "platform, slope and basin" deposits) in the studied area (see Chapter 2.1) gave rise to the establishment of two separate but mutually inclusive biozonation schemes since they represent different depositional environments of the same carbonate platform (Table 3). The biozonations are based on the foraminifera, calpionellids, pelagic crinoid *Saccocoma* and microencruster *Crescentiella morronensis*. For full documentation of the fossil contents and their range along the measured sections please see the provided excel sheet with a CD in the Appendix A. A simplified version of the range chart with principal microfossil content is given in the Figure 12.

2.2.1. Biozonation of the Slope to basin deposits

Globuligerina oxfordiana – Mohlerina basiliensis Zone

This zone represents the lowermost levels of the measured STG section from STG-1 to STG-16. It was hard to assign a well-defined chronostratigraphic level to this part due to the rare occurrences of index fossils. There is only an one specimen of *Globuligerina oxfordina*, considered to range Callovian – Middle Kimmeridgian (Banner & Desai, 1988; Altıner, 1991; Grigelis, 2016). The occurrence of *Mohlerina basiliensis* in this zone suggests Oxfordian-onward chronostratigrapic levels (Altıner, 1991; Cope, 1991; Schlagintweit, 2012). So, based on the co-occurence of these two fossils and the presence of the overlying Tithonian *Saccocoma* zone, a possible Kimmeridgian age is assigned to the *Globuligerina oxfordiana – Mohlerina basiliensis* assemblage zone. The chronostratigpraphic level of the lower boundary is not exactly determined, nevertheless the base of the zone is possibly within the Kimmeridgian stage (Table 3, Fig. 12).

In addition to *G. oxfordiana* and *M. basiliensis*, this zone also includes *Spirillina* spp., *Lenticulina* sp., *Patellina* sp., *Ophthalmidium* sp., *Quinqueloculina* spp., *Meandrospiranella* sp., *Glomospira* sp., *Redmondoides*? sp., *Textularia* sp., *Pithonella* sp., *Globochaete* sp., *Mercierella* ? *dacica*, aptychi, calcareous dinocysts, nannoconids, echinoid spines, bivalve and crinoid fragments, and calcified radiolarians.

Crescentiella morronensis Zone/ *Saccocoma* subzone

This zone is defined as the interval between the successive first occurrences of *Saccocoma* sp. and *Protopeneroplis ultragranulata*. Altıner (1991) introduced the *"Tubiphytes" morronensis* zone above his *Globuligerina oxfordiana* zone. This boundary may seem like a facies controlled one, a pelagic fossil zone is followed by a platform margin – dwelling - taxon zone (Table 3). However, this is the result of geological evolution of the area in which his stratigraphical sections placed. This zonal succession resulted from the development of a pelagic plateau type sedimentation (Taşçıbayırı Formation of NW Turkey, see Chapter 1) into a carbonate

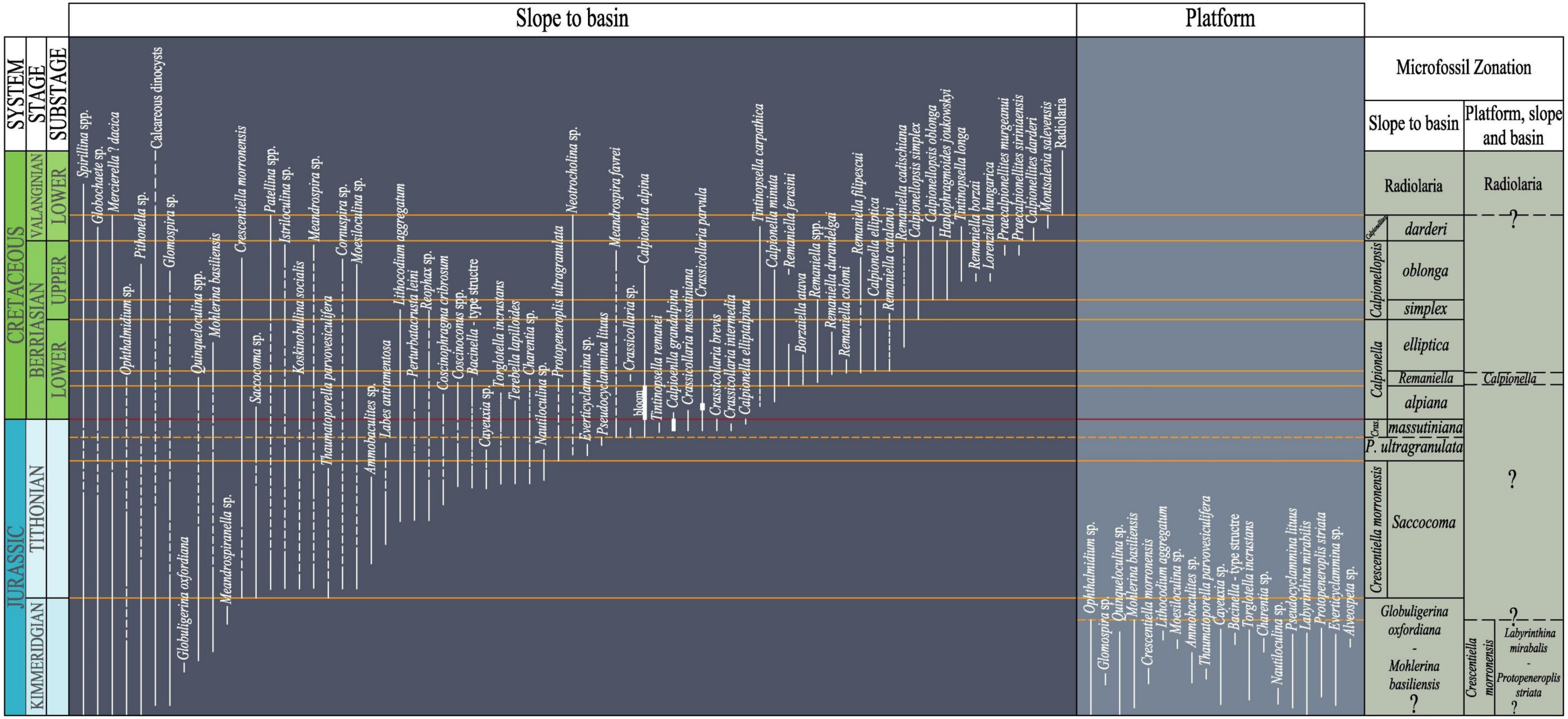


Figure 12. Stratigraphic range chart of the principal microfossils and the proposed biozonation scheme for the "slope to basin" and "platform" deposits. The fossil ranges for the upper levels of the "platform, slope and basin" deposits are not shown. Due to the leveling of the depositional environments (arrival of slope and basinal facies), the upper levels show similiar assamblages with the "slope to basin" successions. Thicker portions of the range lines indicate "acme" of the related taxon. For detailed documentation of the fossil content, please see the excel sheet given in the attached CD.

platform type (Günören Limestone of NW Turkey, see Chapter 1) (Altıner, 1991). Its calibration with Jurassic ammonites suggested a Kimmeridgian age for the base of *“Tubiphytes” morronensis* zone (Altıner, 1991; Cope, 1991). Altıner (1991) also differentiated a *Saccocoma* subzone within the upper levels of the *“Tubiphytes” morronenesis* zone (Table 3). The first occurrence of pelagic crinoid *Saccocoma* has been considered to mark the base of Tithonian (Nicosia & Parisi, 1979; Altıner, 1991; Skourtis-Coroneou & Solakius, 1999).

The coeval first occurrence of *Saccocoma* sp. and *Crescentiella morronensis* in Sivrihisar succession is rather unusual when compared with Altıner (1991)’s scheme (Table 3). This contradiction can be explained by a facies controlled distribution of the platform derived *Crescentiella morronensis* in the measured STG section. It was recorded from Tithonian – Berriasian interval in the slope deposits (Yosunlukbayırı Fm.) and from Kimmeridgian in the platform carbonates (Günören Limestone) (Fig. 12). This diachronism clearly indicates facies controlled distribution and local first occurrence of *C. morronensis* in the slope to basin deposits. There should not be any question regarding the usage of the pelagic crinoid *Saccocoma* as the Tithonian base marker here, since the facies of this zone in the STG section represents toe-of-slope pelagic environments.

Following taxa have been identified within this zone: *Ophthalmidium* sp., *Quinqueloculina* spp., *Istriloculina* sp., *Moesiloculina* sp., *Meandrospira* sp., *Glomospira* sp., *Cornuspira* sp., *Redmondoides*? sp., Verneulinidae, *Textularia* sp., *Reophax* sp., *Ammobaculites* sp., *Haghimashella* sp., *Protomarsonella* sp., *Charentia* sp., *Nautiloculina* sp., *Mohlerina basiliensis*, *Patellina* sp., *Spirillina* spp., *Lenticulina* sp., *Coscinoconus* spp., *Trogrotella incrustans*, *Pithonella* sp., *Globochaete* sp., *Mercierella* ? *dacica*, *Saccocoma* sp., *Crescentiella morronensis*, *Koskinobullina socialis*, *Lithocodium aggregatum*, *Labes antramentosa*, *Radiomura cautica*, *Perturbatacrusta leini*, *Bacinella*-type structure, *Coscinophragma cribrosum*, *Cayeuxia* sp., *Terebella lapilloides*, *Thaumatoporella parvovesivulifera*, calcareous dinocysts, aptychi, ostracods, echinoids spines, crinoid fragments, bivalve fragments, calcified radiolarians, bryozoa fragment, sponge and coral fragment.

The platform derived materials increased within this zone especially towards the upper parts (Fig.8, 10 & 12). Although it may distrupted the pelagic background sedimentation, the fauna transported by calciturbiditic fluxes provides secondary data to check the chronostratigraphic positions of the successions.

Protopeneroplis ultragranulata Zone

The base of this zone is marked by the first occurrence of *Protopeneroplis ultragranulata* (STG-51). In accordance with previously published biostratigraphical charts and data (Septfontaine, 1974; Altıner, 1991; Bucur, 1997; Altıner & Rojay, 1998; Hardenbol et al., 1998; Ivanova, 1999; Velíc, 2007) a latest Tithonian age is assigned to the lower boundary of this zone (Table 3). The upper boundary is delineated by the local first occurrence of calpionellids (represented by *Crassicollaria* sp. and *Calpionella alpina* in sample STG-66A). This upper boundary is a transitional one simply a result of a biofacies change in the studied section STG (Table 3). However, since it emerges within the *P. ultragranulata* zone and is bounded above by the base of *Calpionella* Zone there should not be any doubt regarding its chronostratigraphic position.

The following fossils were defined from this zone; *Protopeneroplis ultragranulata*, *Mohlerina basiliensis*, *Everticyclammina* sp., *Pseudocyclammina lituus*, *Redmondoides*? sp., *Siphovalvulina*? sp., Verneulinidae, *Textularia* sp., *Charentia* sp., *Nautiloculina* sp., *Ophthalmidium* sp., *Moesiloculina* sp., *Istriloculina* sp., *Lenticulina* sp., *Patellina* sp., *Coscinoconus* spp., *Neotrocholina* sp., *Crescentiella morronensis*, *Coscinophragma cribrosum*, *Trogrotella incrustans*, *Pithonella* sp., *Globochaete* sp., *Mercierella ? dacica*, *Saccocoma* sp., *Koskinobullina socialis*, *Lithocodium aggregatum*, *Labes antramentosa*, *Perturbatacrusta leini*, bacinella type structure, *Cayeuxia* sp., *Terebella lapilloides*, serpulids, aptychi, calcareous dinocysts, echinoid spines, crinoid fragments, bivalve fragments, bryozoa, coral, gastropods, dasycladacean algae and sponge.

Crassicollaria Zone/ *massutiniana* subzone

As previoulsy explained the lower boundary of this subzone is marked by the local first occurrence of *Crassicollaria* sp. and *Calpionella alpina* (STG-66A). A latest Tithonian age is assigned to the basal boundary of this zone since it is bounded by the *alpina* subzone at its top.

The fossil content includes, *Crassicollaria* sp., *Crassicollaria massutiniana*, *Crassicollaria intermedia*, *Crassicollaria parvula*, *Crassicollaria brevis*, *Calpionella alpina*, *Calpionella grandalpina*, *Calpionella elliptalpina*, *Calpionella* sp., *Tintinopsella remanei*, *Protopeneroplis ultragranulata*, *Mohlerina basiliensis*, *Spirillina* spp., *Lenticulina* sp., *Patellina* sp., lagenid foraminifera, *Redmondoides*? sp., Verneulinidae, *Textularia* sp., *Reophax* sp., *Siphovalvulina*? sp., *Charentia* sp., *Meandrospira favrei*, *Moesiloculina* sp., *Trogrotella incrustans*, *Pithonella* sp., *Globochaete* sp., *Mercierella* ? *dacica*, *Crescentiella morronensis*, *Lithocodium aggregatum*, *Koskinobullina socialis*, *Perturbatacrusta leini*, bacinella type structure, *Terebella lapilloides*, calcareous dinocysts, nannoconids, *Saccocoma* sp., aptyhci, ostracods, echinoid spines, echinoid and crinoid fragments, bivalve fragment, bryozoa, coral fragment, serpulids, gastropods and sponge.

C. elliptalpina, limited to *massutiniana* subzone, appears higher in the zone near the J-K boundary in accordance with previous observations (Remane, 1971; Trejo, 1980; Remane et al., 1986; Bakalova, 1986; Altıner & Özkan, 1991; Pop, 1994a, 1997; Rehákoá & Michalik, 1997a, b; Skourtis-Coroneou & Solakius, 1999; Andreini et al., 2007; Lakova et al., 1999; Lakova & Petrova, 2013). In this zone, it is hard to differentiate some specimens of *Crassicollaria* from the early representatives of the genus *Tintinopsella* as previoulsy mentioned by Remane (1985). This subzone is additionally characterized by the diversity of the genus *Crassicollaria* and the abundance of *C. grandalpina*.

The unexpected occurrence of *Meandrospira favrei* in this zone (samples STG-66A and STG-67A) is unusual and contradicts with the previously published data. Altıner (1991), Rojay and Altıner (1998) and Ivanova (1999) reported Late Valanginian onward occurrence of this taxon (Table 3). Although there are other studies suggesting a base-Valanginian first occurrence like Ivanova et al. (2008, from

Bulgaria), Ivanova and Kolodziej (2010, from Polish Carpathians) and Bucur et al. (2014, from southern Carpathians Romania) and latest Berriasian first appearance like Krajewski and Olszewska (2007, from Crimea Mountains) and Velić (2007, from Karst Dinarides), there is no report on the Tithonian occurrence of the form. There can be two possiblities; (1) the identification in this study could well be erroneous, the identified specimens may belong to another species of the genus that shows great convergent evolutionary morphology to the *M. favrei* or (2) the taxon could have been evolved in an anonymous period in the Jurassic with a modest population size and then may have been dispersed and its acme may have been recorded diachronously in the Late Valanginian (Altıner, 1991; Rojay & Altıner, 1998 and Ivanova, 1999), at the base of Valanginian (Ivanova & Kolodziej, 2010; Bucur et al., 2014) and in the latest Berriasian (Krajewski and Olszewska, 2007; Velić, 2007). For the first case, all previously proposed first occurrences could be the real first occurrences for the studied areas indicating slight diachronism in the dispersion of the taxon. In the second case, all other reported first occurences should represent local first occurrences and the acme of the taxon. In any case, the biozones defined by the first occurrence of *Meandrospira favrei* in the works of Altıner (1991), Rojay and Altıner (1998) and Ivanova (1999) still provide useful biohorizon at least for regional correlations, if not present a biozone with globally synchronous basal boundary.

***Calpionella* Zone/ *alpina* subzone**

The *alpina* subzone (and the base of the *Calpionella* Zone) is defined at the base by the acme of *Calpionella alpina* (spherical forms) (STG-70A). The upper boundary is marked by the first occurrence of calpionellids with remaniellid lorica.

The following taxons were identified in this zone; *Calpionella alpina*, *Calpionella grandalpina*, *Calpionella minuta*, *Crassicollaria massutiniana*, *Crassicollaria parvula*, *Tintinopsella carpathica*, *Redmondoides*? sp., *Coscinoconus* spp., *Neotrocholina* sp., *Lenticulina* sp., *Spirillina* sp., *Patellina* sp., *Glomospira* sp., *Quinqueloculina* spp., *Moesiloculina* sp., *Istriloculina* sp., Verneulinidae, *Textularia* sp., *Protomarsonella* sp., *Pithonella* sp., *Coscinophragma cirbrosum*, *Globochaete* sp., *Mercierella* ? *dacica*, *Terebella lapilloides*, *Crescentiella morronensis*, *Lithocodium aggregatum*, *Koskinobullina socialis*, *Perturbatacrusta leini*, *Bacinella*-type structure, *Saccocoma* sp., ostracods, echinoid spines, crinoid and bivalve fragments, bryozoa, aptyhci, calcified radiolarians, serpulids and sponge. A specimen of *Mesoendothyra izjumiana* was also observed, which must have been reworked from the Kimmeridgian (STG-71A).

The Jurassic-Cretaceous boundary has been located at the base of this zone following the recent suggestions of Wimbledon et al. (2011), Michalik and Rehakova (2011), Lakova and Petrova (2012), Lakova and Petrova (2013), Wimbledon (2014), Ogg et al. (2016) and Frau et al. (2016). Rather than the acme of *C. alpina*, nearly synchronous last occurrences of *C. elliptalpina* and *Cr. brevis* are other important biovents among calpionellids at the J-K boundary (see Fig. 12 and Appendix A).

After the bloom of *Calpionella alpina* (STG-70A), *C. minuta* appears in the higher levels of the zone (sample STG-73). *C. grandalpina* occurs only in the lower parts of the zone that show significant decrease in abundance (sample STG-70A - 71A). *Cr. parvula* increases in abundance in the sample STG-72. This kind of acme of *Cr. parvula* was also reported by Lakova and Petrova (2013). *Tintinopsella carpathica* does not show abundant representatives in this portion of the STG section.

***Calpionella* Zone/ *Remaniella* subzone**

The lower boundary of this subzone is traced at the first occurrence of calpionellids with remaniellid lorica (bipartite collars) which are represented by *Remaniella ferasini* in the sample STG-75. The upper boundary is marked by the first occurrence of *Calpionella elliptica* (STG-82). The basal boundary of this subzone represents the mid-Lower Berriasian (Fig.12).

The fossil content of this zone includes, *Calpionella alpina*, *C. minuta*, *Crassicollaria parvula*, *Crassicollaria*? sp., *Tintinopsella carpathica*, *Remaniella filipescui*, *Remaniella ferasini*, *R. durandelgai*, *R. colomi*, *Remaniella* sp., very rare *Borzaiella atava*, *Meandrospira* sp., *Ophthalmidium* sp., *Quinqueloculina* spp., *Cornuspira* sp., *Moesiloculina* sp., *Spirillina* sp., *Lenticulina* sp., *Patellina* sp., lagenid foraminifera, *Charentia* sp., *Redmondoides*? sp., *Textularia* sp., Verneulinidae, *Protopeneroplis ultragranulata, Mohlerina basiliensis, Coscinoconus* spp., *Neotrocholina* sp., *Pithonella* sp., *Globochaete* sp., *Mercierella* ? *dacica, Koskinobullina socialis, Crescentiella morronensis, Lithocodium aggregatum, Perturbatacrusta leini,* bacinellid structure, calcareous dinocysts, ostracods, echinoid spines, bivalve and echinoid fragments, calcified radiolarians, bryozoa, coral fragment, serpulids and gastropods.

Additional to the first occurrence of *Remaniella ferrasini*, in the higher levels of the subzone (sample STG-80) other species *R. durandelgai* and *R. colomi* appears for the first time (Fig.12).

***Calpionella* Zone/ *elliptica* subzone**

The first occurrence of *Calpionella elliptica* (STG-82) marked the lower boundary of this subzone (upper portion of the Lower Berriasian) (Fig. 12). The upper boundary is delineated by the first occurrence of *Calpionellopsis simplex*.

The fossil content of this subzone includes, *Crassicollaria parvula*, *Calpionella alpina*, *Calpionella minuta*, *Calpionella elliptica*, *Remaniella cadischiana*, *Remaniella filipescui*, *Remaniella ferasini*, *Remaniella durandelgai*, *Remaniella catalanoi*, *Remaniella colomi*, *Remaniella* spp., *Tintinopsella carpathica*, *Borzaiella atava*, *Mohlerina basiliensis*, *Spirillina* sp., *Patellina* sp., *Redmondoides*? sp., Verneulinidae, *Reophax* sp., *Neotrocholina* sp., *Istriloculina* sp., *Crescentiella morronensis*, *Globochaete* sp., *Mercierella* ? *dacica*, calcareous dinocysts, echinoid spines and calcified radiolarians.

***Calpionellopsis* Zone/ *simplex* subzone**

The first occurrence of *Calpionellopsis simplex* (STG-85) markes both the lower boundary of the *Calpionellopsis* Zone (*simplex* subzone) and the Lower-Upper Berriasian boundary (Fig.12). The upper boundary of the *simplex* subzone is delineated by the first occurrence of *Calpionellopsis oblonga* (STG-87).

The fossil content of the zone is represented by *Calpionellopsis simplex*, *Calpionella alpina*, *Calpionella minuta*, *Calpionella elliptica*, *Remaniella* sp., *Remaniella cadischiana*, *Remaniella catalanoi*, *Tintinopsella carpathica*, *Crassicollaria parvula*, *Lenticulina* sp., *Patellina* sp., *Spirillina* sp., *Neotrocholina* sp., *Istriloculina* sp., *Moesiloculina* sp., *Pithonella* sp., *Globochaete* sp., *Mercierella* ? *dacica*, echinoid spines, calcareous dinocysts and radiolaria.

There is a decrease in abundance of *C. minuta* in this zone.

***Calpionellopsis* Zone/ *oblonga* subzone**

The lower and upper boundaries of this subzone (Upper Berriasian) are characterized by the successive first occurrences of *Calpionellopsis oblonga* (STG-87) and *Calpionellites darderi* (STG-93), respectively (Fig.12).

Besides from *Calpionellopsis oblonga*, the following fossils were observed within this zone; *Calpionellopsis simplex*, *Tintinopsella carpathica*, *Tintinopsella longa*, *Remaniella cadischiana*, *Remaniella filipescui*, *Remaniella ferasini*, *Remaniella borzai*, *Praecalpionellites murgeanui*, *Preacalpionellites sriniaensis*, *Calpionella alpina*, *Calpionella minuta*, *Lorenziella hungariaca*, *Haplophragmoides joukowskyi*, *Reophax* sp., *Textularia* sp., *Siphovalvulina*? sp., *Neotrocholina* sp., *Patellina* sp., *Spirillina* sp., *Lenticulina* sp., lagenid foraminifera, *Meandrospira favrei*, *Meandrospira* sp., *Cornuspira* sp., *Moesiloculina* sp., *Istriloculina* sp., *Glomospira* sp., *Pithonella* sp., *Globochaete* sp., *Mercierella* ? *dacica*, *Crescentiella morronensis*, *Radiomura cautica*, calcareous dinocysts, echinoid spines and fragments, calcified radiolarians (increased abundance), an apthycus and bryozoa.

M. favrei reappers in the highest level of this zone (STG-91). The first occurrences of *H. joukowskyi* (STG-87) and *L. hungarica* (STG-89) are also recorded within this subzone.

A *murgeanui* subzone has also been defined by Pop (1994a, 1997, Romania), Rehåkovå and Michalik (1997a, b, Spain), Grün and Blau (1997, Italy), Skourtis-Coraneau and Solakius (1999, Greece), Lakova et al. (1997, 1999, Bulgaria) and

Lakova and Petrova (2013, Bulgaria) in the uppermost levels of the *Calpionellopsis* Zone (Table 3). Although, the first occurrence level of *Praecalpionellites murgeanui* in this study is consistent with the literature (Table 3 and Fig.12), the very rare occurrence of this species in the NW Turkey (Altıner & Özkan, 1991) and in this study, the varying definition of the genus *Praecalpionellites* from author to author (like very different definition of this genus by Grün and Blau, 1997) and the morphological varieties that have been shown by the illustrations of the calpionellid workers (Remane et al., 1986; Grün & Blau, 1997,1999; Lakova et al., 1999; Rehảkovả, 2000; Concetta et al., 2004; Andreini et al., 2007; Fözy et al., 2010; Lakova & Petrova, 2013) have raised some doubts regarding the differentiation of the *murgeanui* subzone. So, this subzone is not used in this study.

Additionally, *Praecalpionellites siriniaensis* firstly occurred within the uppermost levels of this zone, nearly coeval with the *P. murgeanui* (Fig. 12). *Calpionellopsis simplex* seems to disappear within this zone in accordance with the previously published data (Fig.12).

***Calpionellites* Zone/ *darderi* subzone**

The base of this zone/ subzone is traced at the first occurrence of *Calpionellites darderi* (STG-93) and defines the Berriasian - Valanginian boundary (Tab. 3 & Fig.12). The upper boundary of this zones is a facies controlled one, characterized by the arrival of radiolaria-rich facies defined in the field as a typical facies recorded in the Soğukçam Limestone (see Chapter 2.1).

The following forms were observed in this subzone, *Calpionellites darderi*, *Calpionellopsis oblonga*, *Tintinopsella longa*, *Tinitnopsella carpathica*, *Neotrocholina* sp., *Montsalevia salevensis*, *Textularia* sp., *Spirillina* sp., *Patellina* sp., lagenid foraminifera, *Globochaete* sp., *Mercierella* ? *dacica*, calcareous dinocysts, echinoid spines, fragments and calcified radiolarians.

Due to the rather short record of this subzone within the measured STG section made it impossible to further comment on the range of the *Praecalpionellites, Calpionellites* and *Tintinopsella* species in the study area. Neverthless first occurrence of the *Cpts. darderi* here is in accordance with the previous studies (Lakova et al., 1999; Lakova & Petrova, 2013).

Radiolaria “Zone”

After the *darderi* subzone a radiolaria - rich facies starts to dominate the system (STG-95 to STG-104). From this interval, besides from radiolaria (diversified), *Spirillina* sp., calcareous dinocysts and nannoconids (within the matrix) were observed. Since this facies immeadiately appears just after the first occurrence of *Calpionellites darderi*, a Valanginian age could be assigned to this “zone”.

The upper boundary of this radiolarian rich zone is defined by an abrupt lithological change in the field (from thin to medium bedded, porcelanous limestone to thin to thick bedded, generally massive cream to brownish colored limestone). The fossil content of the overlying limestone (STG-105 to STG-111) reveals a repetition of a portion of the *Calpionella* zone with the following fossil content; *Calpionella alpina*, *Calpionella minuta*, *Crassicollaria*? sp., *Crassicollaria parvula*, *Remaniella ferasini*, *Protopeneroplis ultragranulata*, *Neotrocholina* sp., *Coscinoconus* spp., *Quenqueloculina* spp., *Lenticulina* sp., *Redmondoides*? sp., *Siphovalvulina*? sp.,, *Trogrotela incrustans*, *Coscinophragma cribrosum*, *Cayeuxia* sp., *Perturbatacrusta leini*, *Lithocodium aggregatum*, *Crescentiella morronensis*, *Koskinobullina socialis*, *Mercierella* ? *dacica*, calcareous dinocysts, sponge, gastropods, echinoid and crinoid fragments, bryozoa, calcified radiolarians and bivalve fragments. If the absence of *C. elliptica* and *Calpionellopsis* species and the presence of *R. ferasini* are considered, this slice should represent *Remaniella* subzone of the *Calpionella* Zone. This observation is explained by a thrusting of a slice from north which was derived within the same slope system (see Chapeter 2.1). This slice was also overthrusted by the platform carbonates.

2.2.2. Platform, slope and basin depositional environments biozonation

This bizonation covers the highest levels of STG section (~492m onwards) and the complete SS section.

***Crescentiella morronensis* (*Labyritnhina mirabilis – Protopeneroplis striata*) Zone**

This zone is characterized by an assemblage of *Protopeneroplis striata*, *Labyrinthina mirabilis* and *Crescentiella morronensis* (STG-111A to STG-143). The co-ocurence of these fossils suggests a Kimmeridgian age in accordance with the observations on the range of these taxa (Altıner, 1991; Bucur, 1997; Rojay & Altıner, 1998; Ivanova, 1999; Olszewska, 2010; Ples et al., 2015).

Besides from the name-landing taxa, the following fossils were also observed within this interval; *Mohlerina basiliensis*, *Pseudocyclammina lituus*, *Everticyclammina* sp., an broken speciemen of *Alveosepta* sp., *Textularia* sp., *Redmondoides*? sp., Verneulinidae, *Haghimashella* sp., *Trochammina*? sp., *Ammobaculites* sp., *Nautiloculina* sp., *Charentia* sp., *Quenqueloculina* spp., *Ophthalmidium* sp., *Glomospira* sp., *Moesiloculina* sp., Miliolidae, *Lenticulina* sp., lagenid foraminifera, *Trogrotella incrustans*, *Cayeuxia* sp., a specimen of *Globochaete* sp., very rare *Mercierella* ? *dacica*, *Lithocodium aggregatum*, bacinellid structure, *Thaumatoporella parvovesivulifera* (ladders), echinoid spines, bivalve fragment, echinoid fragments, crinoid fragments, coral fragment and sponge.

***Calpionella* Zone**

This subzone was defined at the lowermost levels of the SS seciton (SG-4 to SG-1A) and is very similiar with the *Calpionella* Zone of the STG section. The lower boundary is indicated with a dashed line in the Table 3 and Figure 12, since it was determined by the lower boundary of the SS section. The upper boundary is again defined by a lithological change from whitish grey to white coloured carbonates of slope facies (the Yosunlukbayırı Formation) to radiolaria - dominated, porcelaneous white to beige coloured basinal deposits (the Soğukçam Limestone) (see Chapter 2.1).

The following taxa were identified in this zone; *Calpionella alpina*, *Calpionella minuta*, *Crassicollaria parvula*, *Crassicollaria*? sp., *Remaniella* sp., *Protopeneroplis ultragranulata*, *Redmondoides*? sp., *Ammobaculites* sp., a specimen of *Pseudocyclammina lituus*, *Coscinoconus* spp., *Lenticulina* sp., *Globochaete* sp., *Mercierella* ? *dacica*, *Crescentiella morronensis*, *Labes antramentosa*, *Lithocodium aggregatum*, *Koskinobullina socialis*, *Perturbatacrusta leini*, echinoid spines, echinoid and bivalve fragments, gastropoda, serpulids, sponge and calcified radiolarians.

If the absence of *C. elliptica* and *Calpionellopsis* species and the presence of the individuals belonging to the genus *Remaniella* are considered, this slice should represent *Remaniella* subzone of the *Calpionella* Zone. If not, it is certain that this portion of the SS section represents Lower Berriasian in any case.

Radiolaria “Zone”

As previoulsy explained the lower boundary of this zone corresponds to a lithological change in the field. The nature of the contact between this zone and the underlying successions is not certain, but the dip directions of the overlying pelagic Soğukçam Limestone and rather earlier arrival of the pure pelagic facies in the SS section when compared with the STG section, suggest a tectonic contact (see Chapter 2.1).

The following specimens were identified within this zone; radiolaria (diversified), *Spirillina* sp., *Lenticulina* sp., lagenid foraminifera, *Pithonella* sp., an specimen of *Mercierella* ? *dacica*, ostracoda, echinoid spines and fragments, bivalve fragments and aptychi.

The age assignement to this zone is rather difficult when compared to the Radiolaria “Zone” of the STG section. Although both zones present identical radiolaria assamblages, the stratigraphic position of this zone in the SS section is certainly earlier than Late Berriasian, depending on the absence of *Calpionella elliptica* and *Calpionellopsis* species within the underlying *Calpionella* Zone. As a result of that the chronostratigraphic position of this zone is not exact and the lower boundary is shown with a dotted line in the Table 3.

CHAPTER 3

MICROFACIES ANALYSES

3.1. Microfacies types and depositional environments

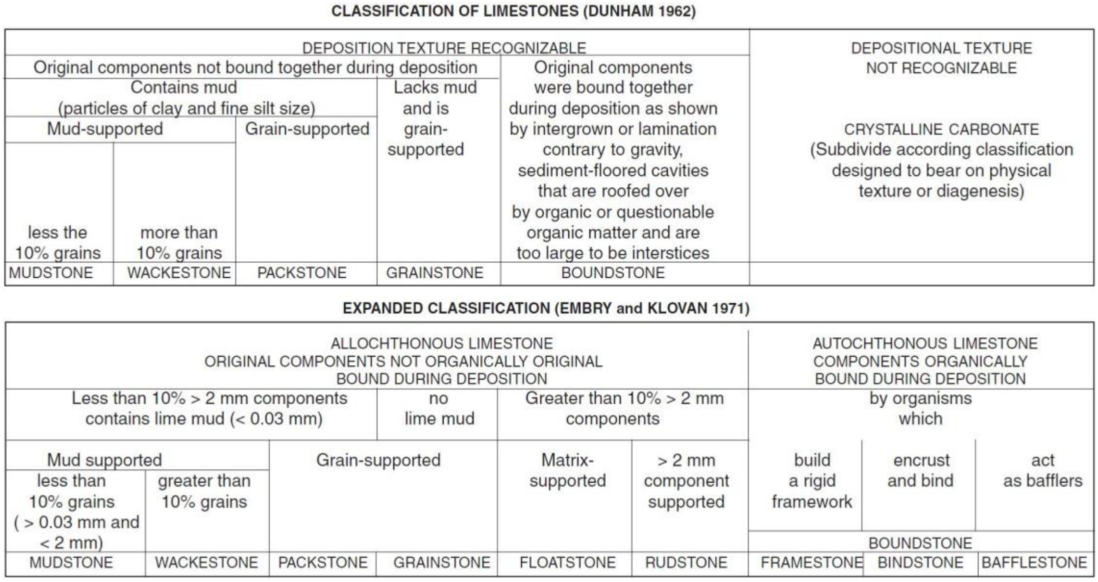
Microfacies analyses include both lithofacies analysis (determination of the depositional texture of rocks, composition of the grains and the back-ground material) and biofacies analysis (examination of fossil associations). Since the similiar lithofacies can occur in variety of depositional environments and the diagenetic processes can greatly modify the original texture (e.g. compaction can transform a wackestone into a packstone or background micrite can be replaced by sparite etc.), biofacies data are especailly important to interpretate the depositional settings.

Since the "X-Y-Z model" of Irwin (1965), new concepts and several models has been introduced mainly based on the investigation of the analogous modern subtropical and tropical carbonates and their comparision with the ancient ones. It is obvious that each depositional time interval (determining type of the faunal and floral associations), latidunal position (warm- vs. cool-water carbonates), morphology of the shelf (ramp vs. platform with slope break), sedimentation rates (drowned platform vs. rimmed platform), siliciclastic input, paleoceanographic conditions and many other parameters affect the microfacies types and their distribution. Several models have been proposed for the ramp carbonates, rimmed platforms, non-rimmed shelves and isolated platforms (and atolls).

One of the widely known models is the Wilson's Standard Facies Model (1975) that describes 9 Standard Facies Zones (FZ) with 24 Standard Microfacies Types (SMF) for a rimmed tropical carbonate platfrom. A revision of this model was made by Flügel (2004) that includes 26 SMF Types for a rimmed carbonate platform with 10

Facies Zones. Another model for the ramp type carbonate platforms was also proposed by him with 30 Ramp Microfacies Type (RMF).

In this study, the expanded version of Dunham’s (1962) classification of carbonate rocks by Embry and Klovan (1971) was used for the textural classification of each sample (Fig.13). Embry and Klovan (1971) introduced grain size parameter (2 mm as the criterion) and two new classifications; namely, the floatstone and rudstone as the equivalents of the wackestone-packstone and grainstone, respectivley (Fig. 13).



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	
Contains mud (particles of clay and fine silt size)			Lacks mud and is grain-supported		
Mud-supported		Grain-supported			CRYSTALLINE CARBONATE (Subdivide according classification designed to bear on physical texture or diagenesis)
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 13. Origianal carbonate rock classification by Dunham (1962) and the expanded version by Embry and Klovan (1971) (from Flügel, 2010).

By the integration of the biofacies data with the textural classification of each sample, microfacies types were determined. The comparision of them with the SMF types and the distribution of the microfacies through the measured sections (to eliminate local energy changes that may hinder the original depositional environment) helped in the determination of the depositional environments in the study area. For comparision, SMF types of Flügel (2004) for a rimmed carbonate platform was used (Fig. 14). The choice of a rimmed platform model is based on the fact that the Edremit - Bursa – Bilecik Carbonate Platform includes Günören Limest-

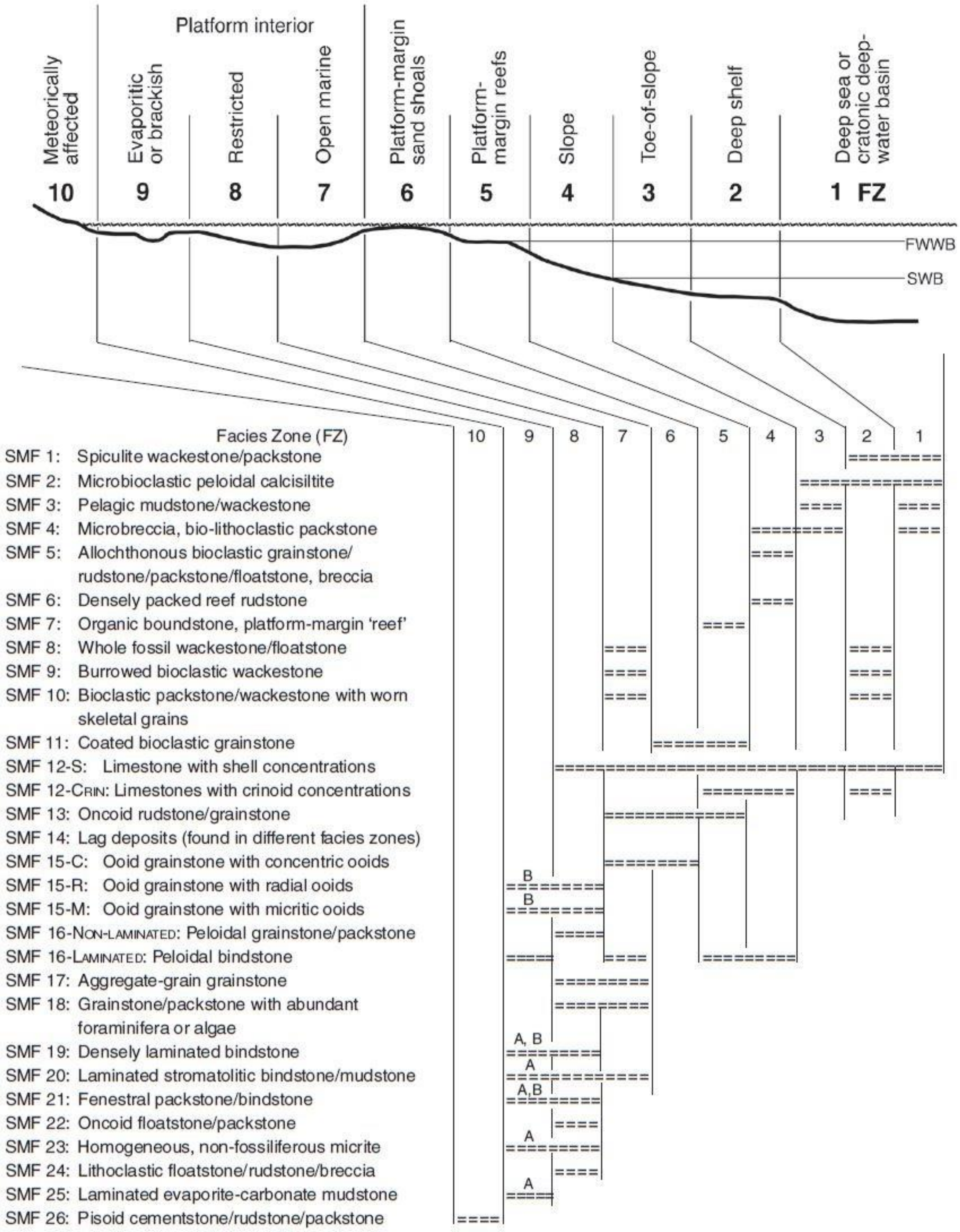


Figure 14. The facies zones (FZ) of the rimmed carbonate platform model and the distribution of the standard microfacies types (SMF). Note that same SMF type can occur in several FZs which make the integration of biofacies data and the examination of microfacies distribution within a studied succession necessary for the determination of depositional environment (A: evaporitic, B: brackish) (Flügel, 2010).

)

one with reefal belts and back-reef lagoonal facies and the presence of Yosunlukbayırı Formation with shallow-water derived clasts deposited as intercalated beds between the background pelagic deposits, representing a slope environment of a rimmed platform (Altıner et al., 1991). In this study, 10 microfacies types and 4 depositional environments were identified (Table 4). For detailed documentation of each sample, please see the “Excel” file in the attached CD (Appendix A).

3.2. Slope to basin Facies

These facies are represented by the Yosunlukbayırı Formation and the overyling Soğukçam Limestone of both the STG and SS sesctions. The slope to basin facies are characterized by the continuous pelagic background sedimentation with related pelagic taxa (like calpionellids, *Saccocoma* sp., planktonic foraminifera, *Pithonella* sp., *Globochaete* sp., calcareous dinocysts, radiolaria and aptychi) punctuated by the calciturbiditic intercalations that are represented by the platform derived material (benthic foraminifera, microencrusters, fragments of coral, bivalve, bryozoa, echinoids, crinoids, sponges and worm tubes) and the resedimented clasts.

3.2.1. MF 1, Peloidal, bioclastic packstone/ Bioclastic packstone

The dominant allochems of this facies are the peloids and bioclasts (Table 4 & Fig.15). The bioclasts include *Globochaete* sp., *Mercierella* ? *dacica*, *Saccocoma* sp., very rare planktonic foraminifera, small amount of smaller and larger benthic foraminifera, *Pithonella* sp., calcareous dinocysts and rare macrofossil fragments. The background material is micrite. Additionally, within this micrite, many silt size unidentified bioclast fragments occur.

According to the textural classification and the fossil content, this microfacies shows similarity with the SMF 2 of Flügel (2010) (Table 4 & Fig.14) and indicates toe-of-slope depositional environment. Similar microfacies have been identified in the Oberalm Formation (Boorová et al., 2015; biogenic wackestone/ rarely biogenic packstone with radiolaria and calpionellid, Northern Calcareous Alps, Salzburg Area, Austria), the Plassen Formation (Gawlick & Schlagintweit, 2006; wackestones with “protoglobigerines”, *Saccocoma* and resedimented shallow water debris/ fine-grained packstones with foraminifera, Northern Calcareous Alps, Austria), the Rosso Ammonitico Unit of the Trapanese Domain (Andreini et al., 2007; peloidal packstone with *Saccocoma*, radiolaria, calpionellids, *Globochaete*, *Cadosina*, *Lenticulina*, Siciliy, Italy), the Rogoźa Coquina Member (Reháková & Wierzbowski, 2005; wackestones to packstones of the *Saccocoma*/ *Globochaete* microfacies, Pieniny Klippen Belt, Carpathians, Poland) and the Slivnitsa Formation (Ivanova et al., 2008; microfacies F4-peloidal *Saccocoma* wackestone and packstones with chert nodules, F4a-peloidal wackestones with radiolaria, Moesian Carbonate Platfrom, Bulgaria) and interpreted as the lower slope-basinal deposits.

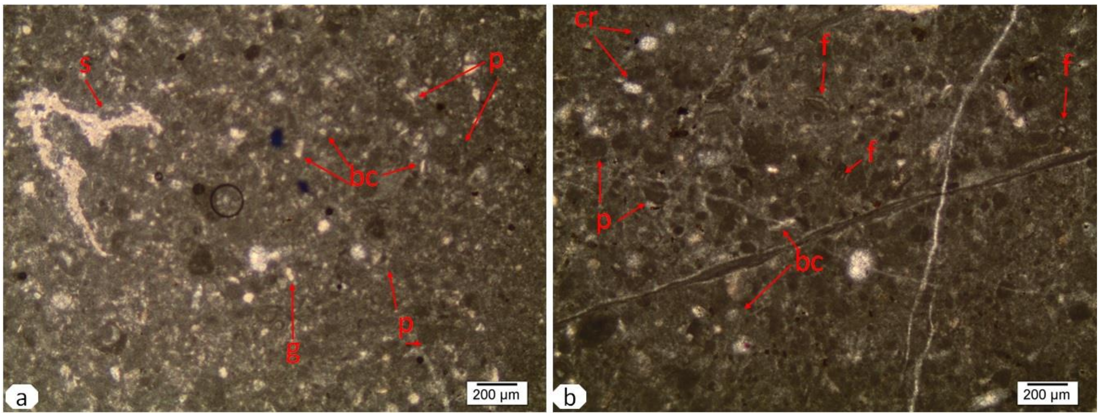


Figure 15. Photomicrographs of the peloidal, bioclastic packstone facies (MF 1). **a)** STG-26, s: *Saccocoma* sp., g: *Globochaete* sp., p: peloids. **b)** STG-30, f: foraminifera, cr: calcified radiolarians, p: peloids. Also note that there are many silt size bioclast fragments dispersed within the micrite matrix (bc).

3.2.2. MF 2, Bioclastic mudstone

This is probably the least exciting facies present in the studied sections in terms of the fossil content. This facies offers rare fossils, including *Globochaete* sp., *Mercierella* ? *dacica*, calcareous dinocysts, *Saccocoma* sp., calcified radiolarions and small miliolids. The background material is micrite (Fig.16). The amount of peloid is also negligible. This microfacies shows similarity with the SMF 3 of Flügel (2010) (Table 4 & Fig.14) and indicates toe-of-slope depositional environment. In previous studies, similiar facies from the Rogoźa Coquina Member (Reháková & Wierzbowski, 2005; mudstones of radiolarian-calpionellid facies, Pieniny Klippen Belt, Carpathians, Poland), the Rosamač Limestone (Petrova et al., 2012; MF1-microfossil-bearing mudstones with calpionellids, calcareous dinocysts, calcified sponge spicules and radiolarians, *Globochaete alpina*, ostracoda, sporadic benthic foraminifera, Stara Planina-Poreč Zone, Eastern Serbia) and the Braşov Formation (Grădinaru et al., 2016; MF-7-bioclastic wackestone-mudstone with pelagic bivalve shells, echinoid fragments and spines, benthic and planktonic foraminifera, rare radiolarians and ostracods; MF-18-biocalstic wackestone-mudstone with calcified radiolarians, sponge spicules, pelagic bivalve shells, echinoid fragments and spines, planktonic foraminifera, rare calpionellids and ostracods, Getic Carbonate Platform, Southern Carpathians, Romania) have been reported. For these microfacies basinal environments have been interpreted.

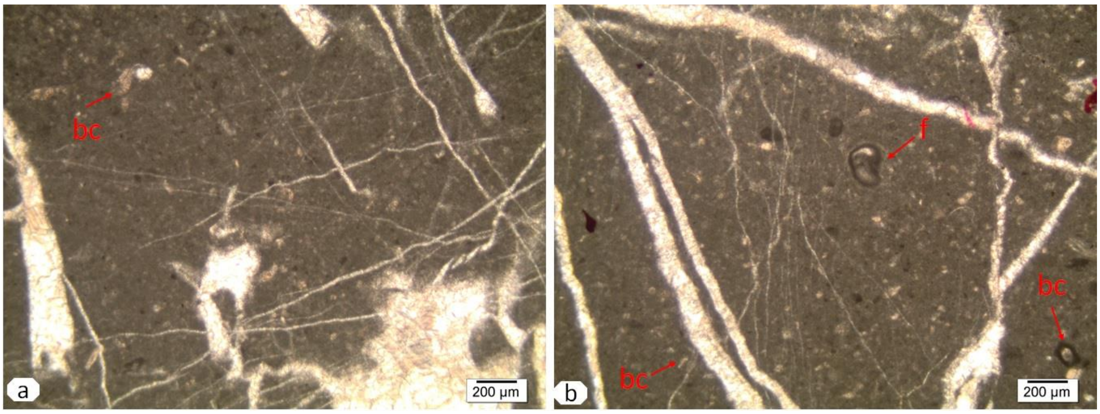


Figure 16. Photomicrographs of the bioclastic mudstone facies (MF 2). **a, b)** STG-2, f: foraminifera, bc: bioclast.

Table 4. Summary of the microfacies types and interprated depositional environments for the Sivrihisar successions. "Standard Microfacies Types" and "Facies Zone" columns indicate the equivalent of the "Microfacies Types" in terms of Flügel's methodology (2010). Empty boxes indicate no match between the determined microfacies and the SMF of Flügel. For detailed documentation please see the "Excel" sheet in the attached CD (Appendix A).

Depositional Environment	Microfacies Type	Microfacies	Standard Microfacies Type (SMF) (Flügel, 2010)	Facies Zone (FZ) (Flügel, 2010)	Main Components	Sample No.
Toe of Slope	MF 1	Peloidal, bioclastic packstone/ Bioclastic packstone	SMF 2	FZ 3	Peloids, *Globochaete* sp., *Mercierella ? dacica*, *Pithonella* sp. *Saccocoma* sp., rare planktonic and smaller and rare larger benthic foraminifera, aptychi, calcareous dinocysts, nannoconids, echinoid spines, bivalve and crinoid fragments, and calcified radiolarians.	STG-1, STG-3, STG-4, STG-5, STG-6, STG-7, STG-10, STG-11, STG-14, STG-15, STG-16, STG-17, STG-18, STG-19, STG-20, STG-21, STG-22, STG-23, STG-24, STG-25, STG-26, STG-27, STG-28, STG-29, STG-30, STG-37, STG-39
	MF 2	Bioclastic mudstone	SMF 3	FZ 3	*Globochaete* sp.,*Mercierella ? dacica*, calcareous dinocyts, echinoid spines, *Saccocoma* sp., calcified radiolarians, rare smaller benthic foraminifera	STG-2, STG-8, STG-12, STG-35
	MF 3	Bioclastic/ Calpionellid/ Radiolarian wackestone-packstone	SMF 3	FZ 3	Calpionellids, radiolaria, rare smaller benthic foraminifera, incertae sedis, *Globochaete* sp., *Mercierella ? dacica*, *Saccocoma* sp., *Crescentiella morronensis*, *Pithonella* sp., calcareous dinocysts, aptychi, ostracods, echinoids spines, crinoid fragments, bivalve fragments	STG-31, STG-32, STG-33, STG-34, STG-36, STG-67B, STG-70A, STG-71A, STG-72, STG-74, STG-80, STG-81, STG-82, STG-83, STG-84, STG-84A, STG-85, STG-86, STG-86A, STG-87, STG-88, STG-88A, STG-89A, STG-90, STG-91, STG-91A, STG-92, STG-92A, STG-94, STG-96, STG-97, STG-98, STG-99, STG-100, STG-101, STG-102, STG-103, STG-104, SG-1B, SS-20, SS-19, SS-18, SS-17A, SS-16, SS-15, SS-14, SS-12, SS-11, SS-10, SS-9, SS-8A, SS-8, SS-7, SS-6, SS-5, SS-4, SS-3, SS-2, SS-1
Slope	MF 4	Bioclastic, lithoclastic, peloidal/ lithoclastic, peloidal packstone	SMF 4	FZ 4	Larger and smaller benthic foraminifera, microencrusters (*Crescentiella morronensis, Lithocodium aggreagtum, Koskinobullina socialis, Labes antramentosa, Perturbatacrusta leini, Radiomura cautica,* bacinellid structure), *Saccocoma* sp., calpionellids, *Mercierella ? dacica*, bivalve, crinoid and echinoid fragments, bryozoa and coral fragments, *Terebella lapilloides* and other serpulid tubes, calcareous dinocysts, *Pithonella* sp., *Globochaete* sp., aptychi, calcified radiolarians, peloids, lithoclasts	STG-38, STG-40, STG-41, STG-44, STG-48, STG-51, STG-54, STG-68, STG-73, STG-74A, STG-75, STG-75A, STG-109, STG-109A, STG-110A, SS-13
	MF 5	Peloidal, intraclastic/ intraclastic, bioclastic rudstone to grainstone/ packstone to grainstone	SMF 5	FZ 4	Peloids, intraclasts, larger and smaller benthic foraminifera, microencrusters *(Crescentiella morronensis, Lithocodium aggreagtum, Koskinobullina socialis, Labes antramentosa, Perturbatacrusta leini, Radiomura cautica*, bacinellid structure), calpionellids, *Saccocoma* sp., *Mercierella ? dacica*, bivalve, crinoid and echinoid fragments, bryozoa and coral fragments, *Terebella lapilloides* and other serpulid tubes, *Cayeuxia* sp., *Globochaete* sp., aptychi, calcified radiolarians	STG-46, STG-50, STG-56, STG-57, STG-57A, STG-58, STG-59, STG-60, STG-61, STG-62, STG-63, STG-64, STG-66, STG-67A, STG-76, STG-106, SG-3, SG-2, SG-1
	MF 6	Bioclastic, lithoclastic floatstone/ rudstone	SMF 5	FZ 4	Lithoclasts, larger and smaller benthic foraminifera, microencrusters (*Crescentiella morronensis, Lithocodium aggreagtum, Koskinobullina socialis, Labes antramentosa, Perturbatacrusta leini, Radiomura cautica,* bacinellid structure), calpionellids, *Mercierella ? dacica*, bivalve, crinoid and echinoid fragments, bryozoa and coral fragments, Terebella lapilloides and other serpulid tubes, *Cayeuxia* sp., *Globochaete* sp., aptychi, calcified radiolarians	STG-42, STG-43, STG-45, STG-47, STG-49, STG-52, STG-53, STG-55, STG-64A, STG-65, STG-66A, STG-66B, STG-67, STG-68A, STG-69, STG-70, STG-71, STG-72A, STG-77, STG-78, STG-79, STG-93, STG-95, STG-105, STG-106A, STG-107, STG-110, STG-111, SG-4
Platform (Back-reef)	MF 7	Peloidal/ peloidal, intraclastic packstone/ poorly washed grainstone wtih bioclasts	SMF 16 & SMF 18	FZ 7	Peloids, intraclasts, larger and smaller benthic foraminifera, *Crescentiella morronensis*, *Lithocodium aggregatum*, *Thaumatoporella parvovesiculifera*, *Cayeuxia* sp., bacinellid structre, echinoid spines, echinoid fragments, rare coral fragments, very rare *Mercierella ? dacica*	STG-111A, STG-114, STG-115, STG-117A, STG-117B, STG-118A, STG-118B, STG-119B, STG-119C, STG-120, STG-123, STG-125, STG-127, STG-128, STG-132, STG-135, STG-136, STG-137, STG-138, STG-139, STG-141, STG-142, SSTG-143
	MF 8	Bioclastic mudstone/ wackestone	SMF 8	FZ 7	Larger and smaller benthic foraminifera, echinoid and bivalve fragments, peloids	STG-113, STG-117, STG-123A, STG-124, STG-129, STG-130, STG-131, STG-131A, STG-133, STG-134
	MF 9	Intraclastic packstone	-	FZ 7	Intraclasts, peloids rare larger benthic foraminifera,echinoid fragments, bivalve fragments	STG-112, STG-118, STG-121, STG-122, STG-126, STG-140
	MF 10	Intraclastic rudstone (microbreccia)	-	FZ 7	Intraclasts (clasts have peloidal packstone texture with rare benthic foraminifera), peloids, very rare larger benthic foraminifera, echinoid fragments, *Crescentiella morronensis* and *Cayeuxia* sp.	STG-116, STG-119

3.2.3. MF 3, Bioclastic/ Calpionellid/ Radiolarian wackestone-packstone

This is the most dominant facies type again representing background pelagic sedimentation of quiescence periods in terms of platform derived grativy flow deposits (Fig.17). Bioclasts include mainly pelagic groups like calpionellids, radiolaria, *Saccocoma* sp., *Globochaete* sp., *Pithonella* sp., calcareous dinocysts and aptychi. Additionally, rare smaller benthic foraminifera, *Crescentiella morronensis*, ostracods, echinoid spines, echinoderm and bivalve fragment occur.

This microfacies shows similarity with the SMF 3 of Flügel (2010) (Table 4 & Fig.14) and indicates toe-of-slope depositional environment. The Oberalm Formation (Boorová et al., 2015; radiolarian/ calpionellid wackestone-packstone, Northern Calcareous Alps, Salzburg Area, Austria), the Plassen Formation (Gawlick & Schlagintweit, 2006; wacke-/ packe-stones with calpionellids/ radiolaria, Northern Calcareous Alps, Austria), the Lattimusa Formation (Andreini et al., 2007; calpionellid-bearing mudstone to wackestone-packstone with radiolarians, *Globochaete*, Siciliy, Italy), the Rogoźa Coquina Member (Reháková & Wierzbowski, 2005; calpionellid-radiolarian wackestones, Pieniny Klippen Belt, Carpathians, Poland), the Săduleşti Formation (Săsăran et al., 2001; bioclastic wackestone/ packstone with sponge spicules, frequent echinoderm plates, small belemnites, ammonites and *Lenticulina* sp., Cheile Turenilor, Romania), the Cetatea Neamţţului Member of the Dâmbovicioara Formation, (Grădinaru et al., 2016; MF-9-bioclastic wackestone with echinoid fragments and spines, benthic shark teeth, sponge spicules, ostracods, pelagic bivalve shells, benthic foraminifera, planktonic foraminifera, peloids, radiolarians and rare gastropods, bivalves, brachiopod shells and shallow-water resedimented lithoclasts; MF-11-bioclastic packstone-wackestone with pelagic bivalve shells, echinoid fragments, echinoid spines, sponge spicules, intraclasts and rare shallow-water fossils, Getic Carbonate Platform, Southern Carpathians, Romania) and the Rosomač Limestone (Petrova et al., 2012; MF-2-microfossiliferous wackestone with calpionellids, calcareous dinocysts, radiolarians and *Globochaete alpina*, rare benthic foraminifera and aptychi; MF-4-fine bioclast-fossiliferous wackestones with calpionellids, *Globochaete alpina*, calcified radiolarians and calcareous dinocysts, benthic foraminifera, aptychi) show similiar microfacies, representing the toe-of-slope/ basinal depositional environments.

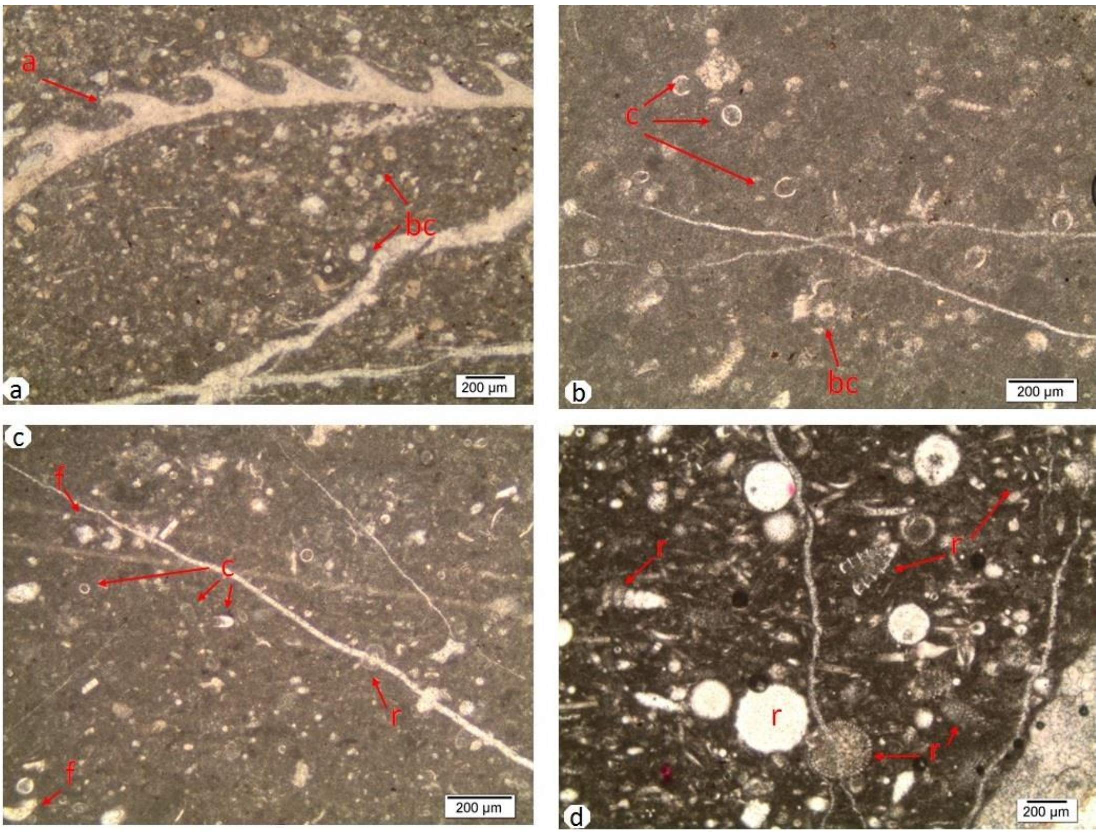


Figure 17. Photomicrographs of the bioclastic/ calpionellid/ radiolarian wackestone-packstone facies (MF 3). **a)** STG-31, bioclastic packstone, a: aptychus, bc:bioclast. **b)** STG-70A, calpionellid wackestone, c: calpionellid, bc: bioclast. **c)** STG-88A, bioclastic wackestone, f: foraminifera, c: calpionellid, r: radiolaria. **d)** SS-4, radiolarian packstone, r: radiolaria.

3.2.4. MF 4, Bioclastic, lithoclastic, peloidal / lithoclastic, peloidal packstone

This facies represents distal parts of gravity – induced deposits that transport material from the shelf margin (in this case from the Günören Limestone). Benthic bioclastic allochems increase in amount and larger benthic foraminifera, microencrusters (like *Lithocodium aggregatum, Koskinobullina socialis, Labes antramentosa, Perturbatacrusta leini, Radiomura cautica, Crescentiella morronensis* and *Bacinella*-type structure), bivalve, crinoid, echinoid, bryozoa and coral fragments, *Terebella lapilloides* and serpulid tubes dominate the bioclastic assamblages (Fig.18). The background material is again composed of micritic matrix within which individuals of calpionellids, *Saccocoma* sp., calcareous dinocysts, *Pithonealla* sp., *Globochaete* sp., aptychi and calcified radiolarians are present as the pelagic constituents. Resedimented intraclasts and peloids are common.

This microfacies show similarity with the SMF 4 of Flügel (2010) (Table 4 & Fig.14) and indicates slope depositional environment. From the Schrambach Formation (Boorová et al., 2015; intraclast-biogenic-peloidal packstone/ intraclast-biogenic-peloidal wackestone with radiolaria, spicules and calcareous dinocysts, Northern Calcareous Alps, Salzburg Area, Austria), the Rossfeld Formation (Boorová et al., 2015; intraclast-peloid-biogenic wackestone with radiolaria, sponge spicules, calpionellids and benthic foraminifera, Northern Calcareous Alps, Salzburg Area, Austria), the Plassen Formation (Gawlick & Schlagintweit, 2010; fine-grained packstones with small benthic foraminifera, microencruster *Crescentiella morronensis*, Plassen Carbonate Platform, Austria), the Bohinj Formation (Kukoč et al., 2012; lithoclastic packstone-breccia with radiolarian-rich and calpionellid-bearing lime mudstone matrix, Bohinj Area, Internal Dinarides, NW Slovenia), the Ardeu Unit (Pleş et al., 2015; F5-bio-intraclastic packstone with fragments of microencrusters, corals, mollusk shells, *Crescentiella morronensis*, calpionellids and calcareous dinocysts, Metaliferi Mountains, Romania) and the Lespezi Formation (Grădinaru et al., 2016; bioclastic, lithoclastic packstone-wackestone with abundant calpionellids, lithoclasts, pelagic bivalve shells, ostracods, peloids, echinoid fragments, sponge spicules and fragments, *Crescentiella morronensis*, serpulids, bryozoans and benthic foraminifera, Bucegi Mountains, Southern Carpathians, Romania) similiar microfacies have been interpreted as slope deposits.

3.2.5. MF 5, Peloidal, intraclastic/ intraclastic, bioclastic rudstone to grainstone/ packstone to grainstone

This facies is similiar with the MF 4 in terms of the type of grains. The only differences are the dominance of inctraclasts and peloids over bioclasts and sparry calcite cement suggesting higher energy emvironments, probably proximal parts of the gravity flow deposits.

The main components of this facies are nearly identical with the MF 4 (Table 4). This microfacies shows similarity with the SMF 5 of Flügel (2010) (Table 4 & Fig.14) and indicates the slope depositional environment. Similiar microfacies have been identified from the Buila-Vânturariţa Massif (Pleş et al., 2013; F1-intraclastic, bioclastic rudstone-grainstone with fragments of corals, sponges, bryozoans, foraminifera, microencrusters, calcareous algae, gastropods, bivalves and worm tubes, Southern Carpathians, Romania), the Săduleşti Formation (Săsăran et al., 2001; intraclastic, bioclastic rudstone/ grainstone with *"Tubipyhtes" morronensis*, *Mercierella dacica*, benthic foraminifera, fragments of corals, bryozoans, sponges and echinoderms, Cheile Turenilor, Romania), the Lespezi Formation (Grădinaru et al., 2016; MF-14-bioclastic, lithoclastic packstone-grainstone with *Crescentiella morronensis, Terebella lapilloides,* benthic foraminifera, bryozoans, serpulids, bivalve fragments and rare calpionellids, Southern Carpathians, Romania), the Ardeu Units (Pleş et al., 2015; F4-bioclastic, intraclastic grainstones/ rudstones with sponge fragments, echinoid plates, foraminifera, *Crescentiella morronensis* and reefal intraclasts, Metaliferi Mountains, Romania), the Mateiaş Limestone (Bucur et al., 2010; fine-grained grainstone-packstone with benthic foraminifera, sponge spicules and fragments of reefal limestone, South Carpathians, Romania), the Slivnitsa Formation (Ivanova et al., 2008; F5-bio-lithoclastic grainstones to rudstones with *Saccocoma*, foraminifera, *"Tubiphytes" morronensis*, peloids and intraclasts, Moesian Platform, SW Bulgaria), the Plassen Formation (Gawlick & Schlagintweit, 2006; bioclastic packstones-rudstones with reefal debris, Northern Calcareous Alps, Austria) and the Rosomač Limestone (Petrova et al., 2012; MF5-peloidal and intraclastic-bioclastic grainstones with calpionellids, *Globochaete alpina*, calcified radiolarians, sponge spicules and calcareous dinocysts bearing intraclasts, fragments of crinoids, corals, algae, *Crescentiella morronensis*, benthic foraminifera and aptychi, Stara Planina-Preč Zone, eastern Serbia) which have been interpreted as the shelf margin-slope deposits.

Representative thin section photomicrographs are illustrated in the Figure 19.

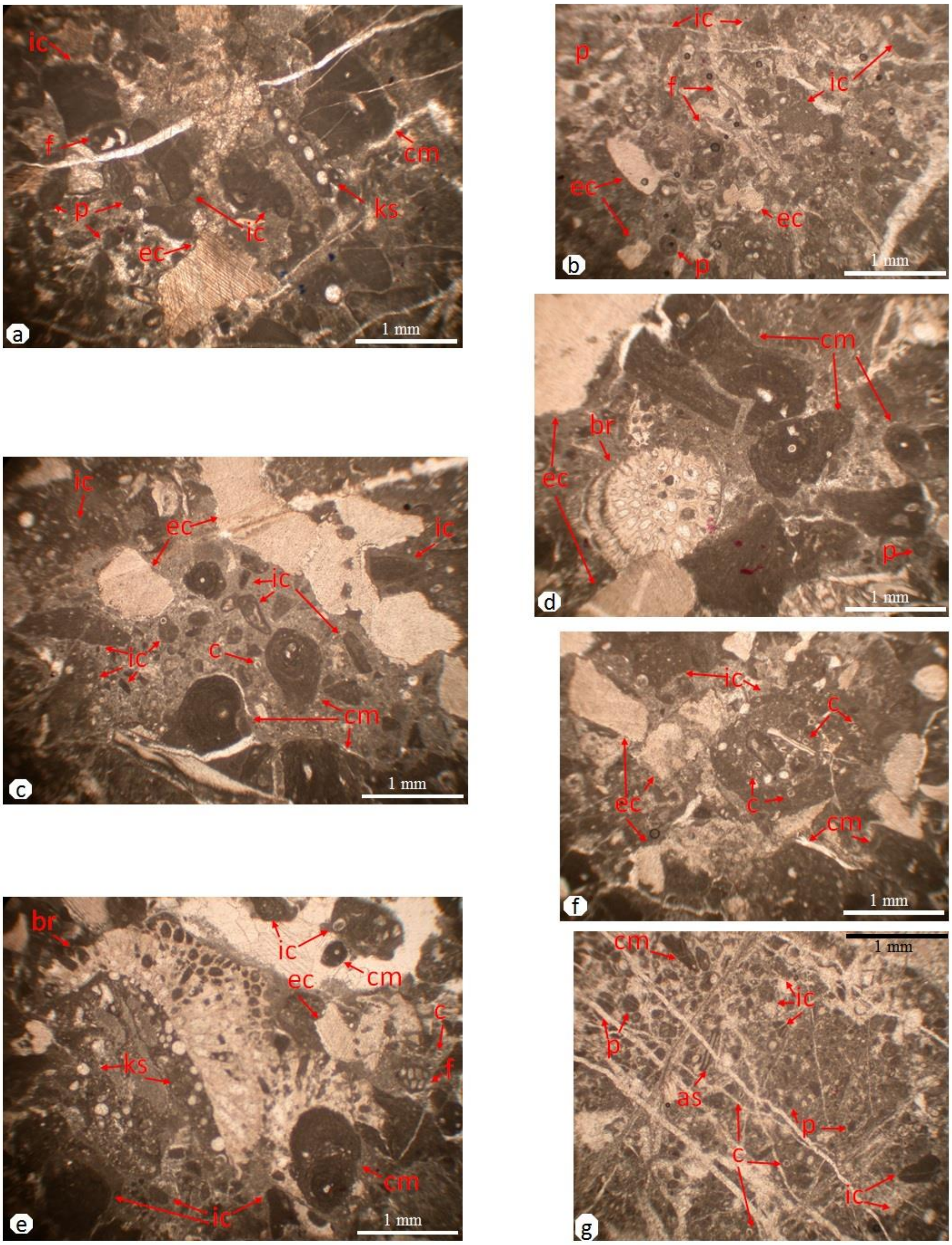


Figure 18. Photomicrographs of the bioclastic, lithoclastic, peloidal/ lithoclastic, peloidal packstone (MF 4). **a)** STG-41, lithoclastic, peloidal packstone. **b)** STG-54, bioclastic, peloidal packstone. **c, d, e, f)** STG-75A, intraclastic, bioclastic packstone. **g)** STG-110A, peloidal, intraclastic poorly washed grainstone to packstone. ic: intraclast, p: peloid, f: foraminifera, ec: echinoid fragment, ks: *Koskinobullina socialis*, cm: *Crescentiella morronensis*, br: bryozoa, c: calpionellid.

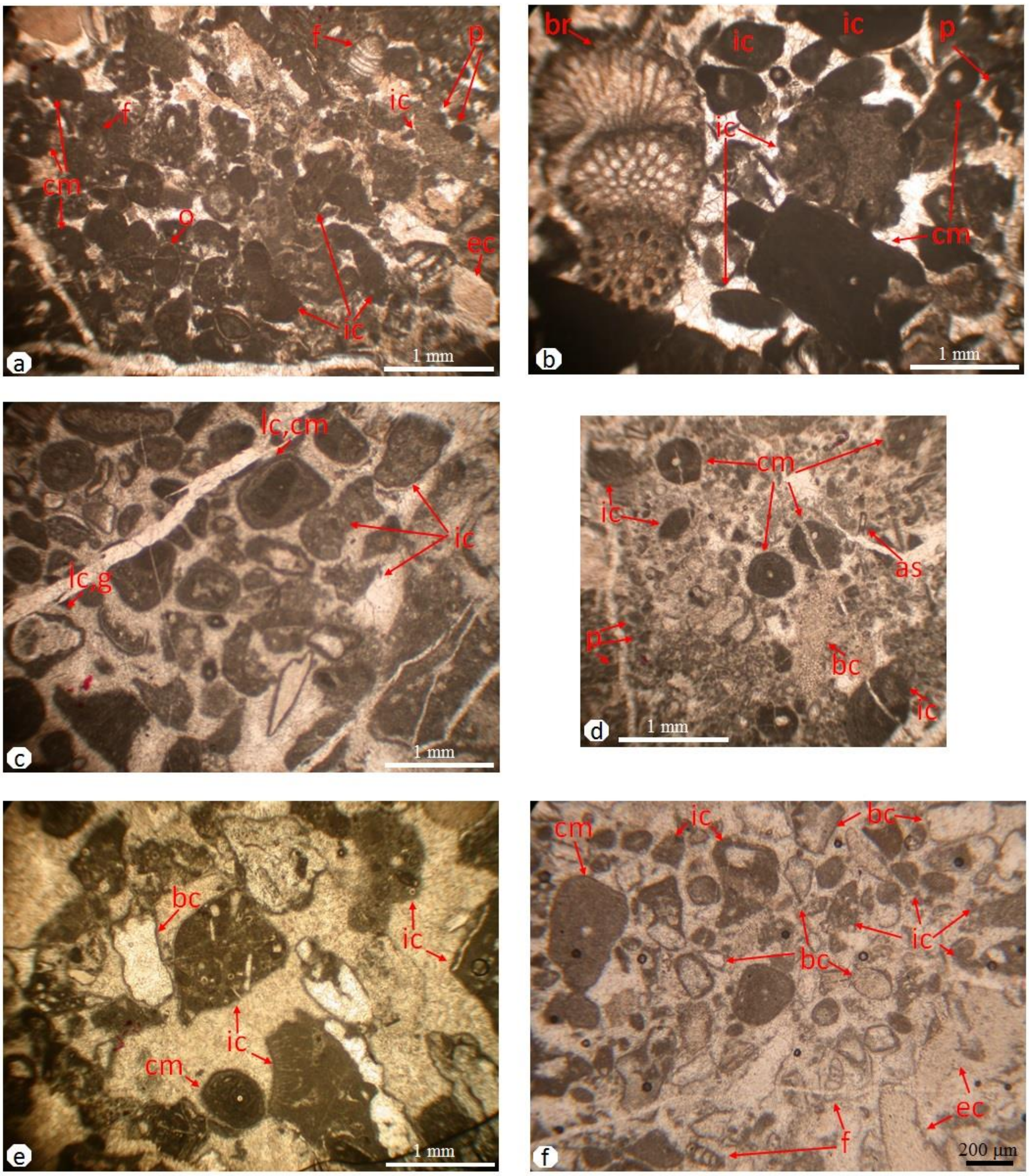


Figure 19. Photomicrographs of the peloidal, intraclastic/ intraclastic, bioclastic rudstone to grainstone/ packstone to grainstone (MF 5). **a)** STG-46, peloidal, intraclastic grainstone with bioclasts. **b)** STG-61, intraclastic, bioclastic grainstone. **c)** STG-62, intraclastic, bioclastic poorly washed grainstone. **d)** STG-67A, peloidal, intraclastic, bioclastic packstone to grainstone. **e)** SG-3, intraclastic, bioclastic grainstone. **f)** SG-1, bioclastic, intraclastic grainstone. ic: intraclast, ic,cm: intraclast with *Crescentiella morronenesis*, ic,g: intraclast with gastropod, p: peloid, o: ooid, bc: bioclast, f: foraminifera, ec: echinoid fragment, cm: *Crescentiella morronensis*, br: bryozoa, c: calpionellid.

3.2.6. MF 6, Bioclastic, lithoclastic floatstone/ rudstone

This facies is comparable with MF4 and MF 5 in terms of the grain content. In contrast, more than 10% of the grains are larger than 2mm sand size in MF 6 (Fig.20).

This microfacies shows similarity with the SMF 5 of Flügel (2010) (Table 4 & Fig.14) and indicates slope depositional environment. Similiarly, microfacies from the Plassen Formation (Gawlick & Schlagintweit, 2006; rudstones with reefal debris/ grainstones with foraminifera, reefal fragments and microencrusters, Northern Calcareous Alps, Austria), the Mateiaş Limestone (Bucur et al., 2010; bioclastic-intraclasitc rudstone with coral fragments, intraclasts and matrix including fragments of corals, bivalves, gastropods, brachiopods, bryozoans, worm tubes, echinoderms, algae and benthic foraminifera, *Crescentiella morronensis, Radiomura cautica, Koskinobullina socialis*, South Carpathians, Romania), the Sănduleşti Formation (Săsăran et al. 2001; intraclastic, bioclastic rudstone with coarse-grained reefal detritus, benthic foraminifera, *"Tubiphytes" morronensis*, *Lithocodium aggregatum*, *Thaumatoporella parvovesiculifera*, *Koskinobullina socialis*, *Radiomura cautica*, *Troglotella incrustans*, *Bacinella irregularis*, *Mercierella dacica*, and *Terebella* sp., Cheile Turenilor, Romania), the Ardeu Unit (Pleş et al., 2015; F5-intra-skeletal rudstone/ floatstone with microencrusters, corals, sponges, foraminifera, *Crescentiella morronensis*, calpionellids and calcareous dinocysts, Metaliferi Mountains, Romania), the Slivnista Formation (Ivanova et al., 2008; F7-bio-lithoclastic grainstones to rudstones with coral fragments, *Lithocodium aggregatum*, sponges, bryozoans, serpulids, foraminifera, *"Tubiphytes" morronensis*, algae and lithoclasts of reef debris, Moesian Carbonate Platform, SW Bulgaria) and the Rosomač Limestone (Petrova et al., 2012; MF-6-bioclastic-intraclastic floatstone with wackestone intraclasts including calpionellids, calcified radiolarians, *Globochaete alpina* and calcareous dinocysts and shallow-water bioclasts, MF-7-bioclastic-intraclastic rudstone with similiar grain content, Stara Planina-Poreč Zone, eastern Serbia) has been interpreted as the slope breccia, representing gravity-induced carbonate deposits.

3.3. Platform Facies

This facies belong to the Günören Limestone that overthrusted the slope to basin deposits of the Yosunlukbayırı Formation and the Soğukçam Limestone (see Chapter 2). The platform facies is characterized by larger (*Labyrinthina*, *Pseudocyclammina* etc.) and smaller benthic foraminifera, microencrusters (*Crescentiella morronensis, Lithocodium aggregatum* etc.), algae (*Cayeuxia* sp.) and macrofossil fragments. The intraclasts and peloids also form important constituents of these facies. The main differences betwen the platform and slope to basin facies are the lack of pelagic organisms, the presence of complex larger foraminifera and the lack of transported, resedimented, broken clasts in the platform facies.

3.3.1 MF 7, Peloidal/ peloidal, intraclastic packstone/ poorly washed grainstone with bioclasts

The dominant allochems of this facies are the peloids and intraclasts (Table 4 & Appendix A). The bioclasts include larger and smaller benthic foraminifera, microencruster (*Crescentiella morronensis*, *Lithocodium aggregatum*, *Thaumatoporella parvovesiculifera*, *Bacinella* - type structure), algae (*Cayeuxia* sp.), very rare *Mercierella* ? *dacica*, echinoid and rare coral fragments (Fig.21).

SMF-16 and SMF-18 of Flügel (2010) are the most similiar microfacies types to our MF 7 (Table 4 & Fig.14). If the occurrence of shallow marine fauna (complex benthic foraminifera) without pelagic organisims is considered, platform depositional environments are interpreted for this facies. The co-occurrence of *Protopeneroplis striata* and *Mohlerina basiliensis* (abundant in the shelf edge, reefal areas) with the complex benthic foraminifera like *Labyrinthina mirabilis* and the presence of peloids and intraclasts suggest back-reef lagoonal areas that should not be so far away from the reefal shelf-edge. Similiar microfacies has been reported from the Ardeu Unit (Pleş et al., 2015; F1-bio-intraclastic grainstone/ packstone with *Labyrinthina mirabilis, Everticyclammina praekelleri, Ammobaculites* sp., other benthic foraminifera, algae and *Thaumatoporella parvovesiculifera*, Metaliferi Mountains, Romania) and the Yalta and Ay-Petri Massifs (Krajewski, 2010; peloidal packstones

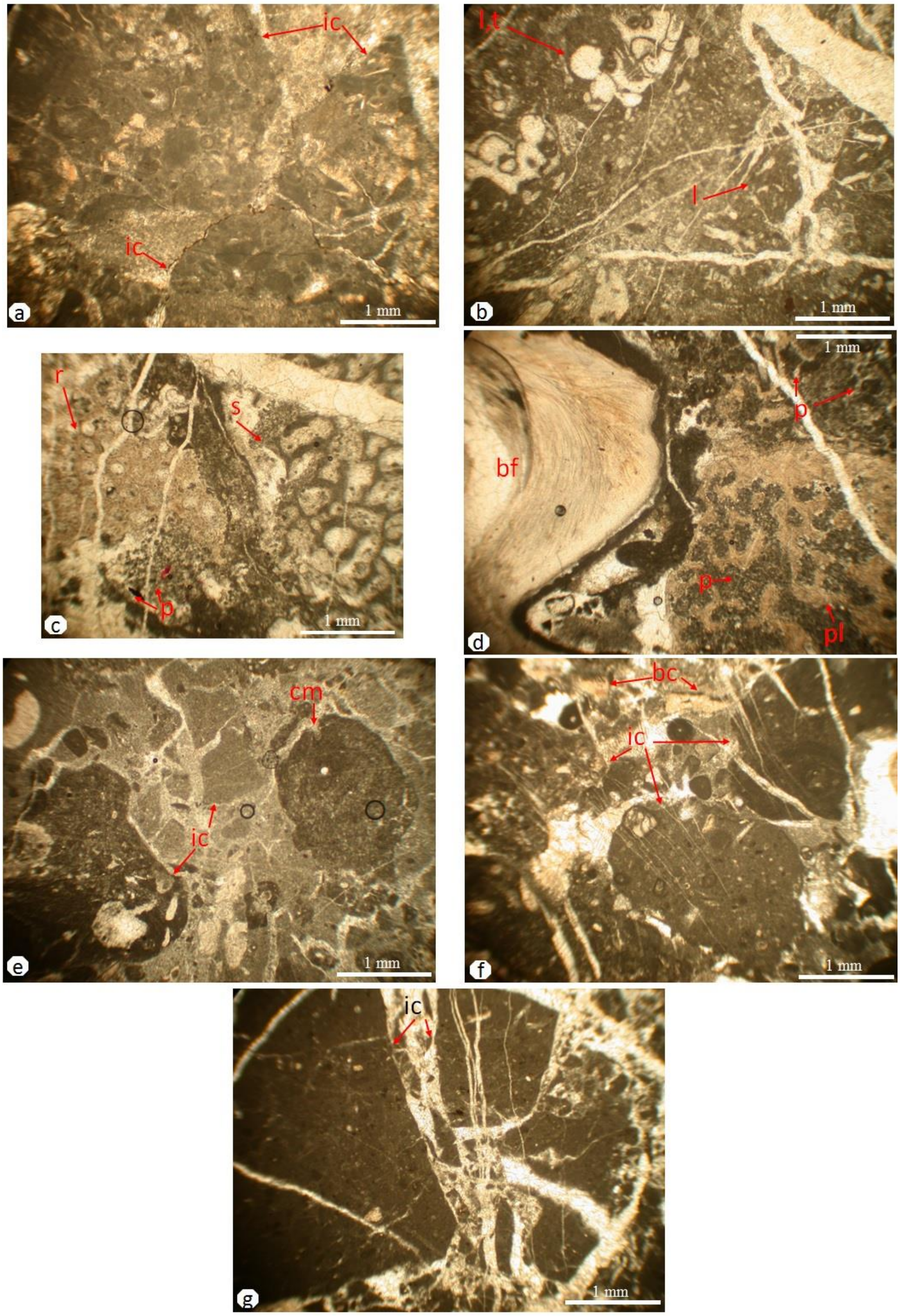


Figure 20. Photomicrographs of the bioclastic, lithoclastic floatstone/ rudstone (MF 6). **a)** STG-43, lithoclastic floatstone (microbreccia). **b)** STG-53, bioclastic floatstone. **c)** STG-64A, bioclastic floatstone, background has peloidal grainstone to

and grainstones with benthic foraminifera, Crimea Mountains, Southern Ukraine) and shallow-marine platform depositonal environments has been interpreted.

3.3.2 MF 8, Bioclastic mudstone/ wackestone

Benthic foraminifera is the dominant allochem of this facies (Table 4 & Appendix A). Additionally, echinoid and bivalve fragments occur. Peloids are also present in the background.

The most similiar standard microfacies type of Flügel (2010) for this facies is the SMF 8 (Table 4 & Fig.14). Similiar to the MF 7, shallow marine, back-reef environment is suggested for this facies type. Krajewski (2010) defined similiar facies from the Yalta and Ay-Petri Massifs (mudstone-foraminiferal wackestone, Crimea Mountains, Southern Ukraine)

Figure 22 illustrates representative thin section photomicrograph of this facies.

3.3.3 MF 9, Intraclastic packstone

This facies is characterized by the dominance of intraclasts and peloids. Some benthic foraminifera and other bioclasts (echinoid and bivalve fragments) show rare occurrences (Table 4 & Fig.23).

There is no equivalence of this facies in the SMF of Flügel (2010). The occurrence of shallow marine benthic foraminifera without any record of pelagic organisms and the intercalation of this facies with the back-reef, lagoonal platform carbonates suggest similiar depositional environment. Ivanova et al. (2008) from the Slivnitsa Formation

➡**Figure 20 cont'd.** packstone texture. **d)** STG-66A, bioclastic floatstone to rudstone with peloidal, bioclastic, poorly washed grainstone to packstone matrix. **e)** STG-66B, bioclastic floatstone with intraclastic, bioclastic packstone background. **f)** STG-79, intraclastic, bioclastic rudstone to grainstone (microbreccia). **g)** STG-93, intraclastic rudstone, clasts have bioclastic wackestone texture. ic: intraclast, p: peloid, l,t: *Lithocodium aggregatum* with *Trogrotella incrustans*, r: *Radiomura cautica*, s: sponge, bf: bivalve fragment, pl: *Perturbatacrusta leini*, cm: *Crescentiella morronensis*, bc: bioclast.

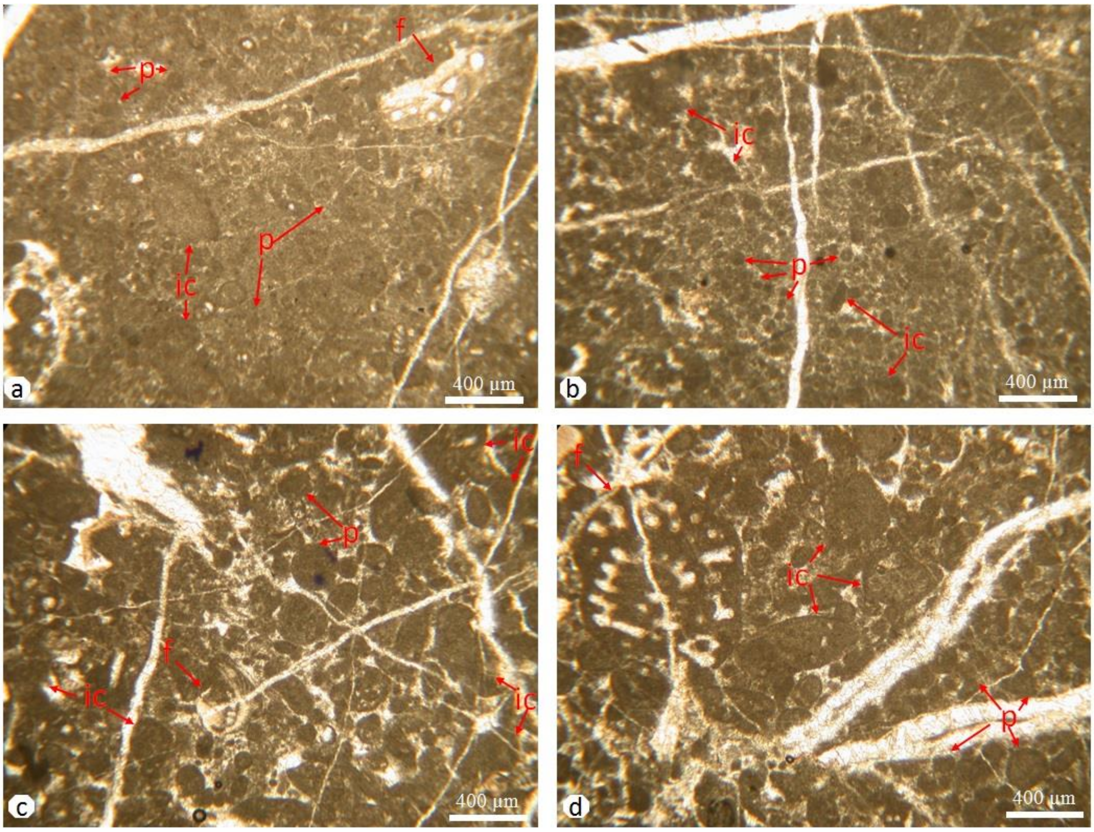


Figure 21. Photomicrographs of the peloidal/ peloidal, intraclastic packstone/ poorly washed grainstone with bioclasts (MF 7). **a)** STG-114, peloidal, intraclastic packstone with bioclasts. **b)** STG-117A, peloidal, intraclastic packstone. **c, d)** STG-136, peloidal packstone to poorly washed grainstone with foraminifera. ic: intraclast, p: peloid, f: foraminifera.

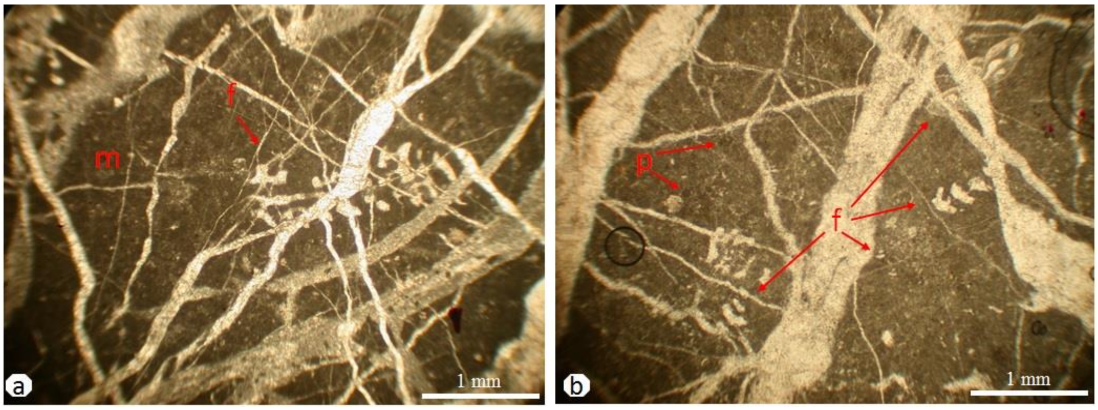


Figure 22. Photomicrographs of the bioclastic mudstone/ wackestone (MF 8). **a)** STG-113, bioclastic mudstone. **b)** STG-123A, benthic foraminiferal mudstone to wackestone. f: foraminifera, p: peloid, m: micrite.

(F10-intraclastic breccia with rare foraminifera, Moesian Carbonate Platform, SW Bulgaria) and Krajewski (2010) from the Ay-Petri Massif (microbreccia with bioclasts, Crimea Mountains, Southern Ukraine) reported similiar facies, indicating shallow marine, lagoonal depositional environments.

3.3.4 MF 10, Intraclastic rudstone (microbreccia)

This facies is characterized again by the dominance of intraclasts and peloids. Some benthic foraminifera and other bioclasts (echinoid and bivalve fragments, *Crescentiella morronensis, Cayeuxia* sp.) show very rare occurrences (Table 4). This is actually a MF 9 type facies with larger clast sizes (more than 10% of the grains has size larger than 2 mm) (Fig.23).

There is no equivalence of this facies in the SMF of Flügel (2010). Similiar to the MF 9 interpratation, same depositional environment is suggested for the MF 10 (Tabel 4). Similiar microfacies has been reported from the Ay-Petri Massif (Krajewski, 2010; breccia consists of lithoclasts and cement, Crimea Mountains, Southern Ukraine) and interperetd as the lagoonal deposits.

The slope to basin facies of the STG section shows transition from the toe-of-slope basinal facies (MF1 and MF2) to the slope facies (MF4, MF5 and MF6, representing the gravity flow induced, calciturbiditic deposits and MF 3, characterizing the background continous pelagic deposition on the slope). Especially, Tithonian onward, the amount of platform derived material increased (Figure 12 & Appendix A). The facies-controlled local first occurrences of shallow marine dwelling fauna (e.g. *Crescentiella morronensis*, *Lithocodium aggregatum*, *Moesiloculina* sp., *Ammobaculites* sp., *Cayeuxia* sp., bacinellid structure, *Trogrotella incrustans*, *Charentia* sp., *Nautiloculina* sp., *Pseudocyclammina lituus* and *Everticyclammina* sp.) in the slope facies of the Yosunlukbayırı Formation are in much higher chronostratigraphic positions when compared to their Kimmeridgian occurrences in the platform carbonates of the Günören Limestone (Figure 12). The amount of the ti-

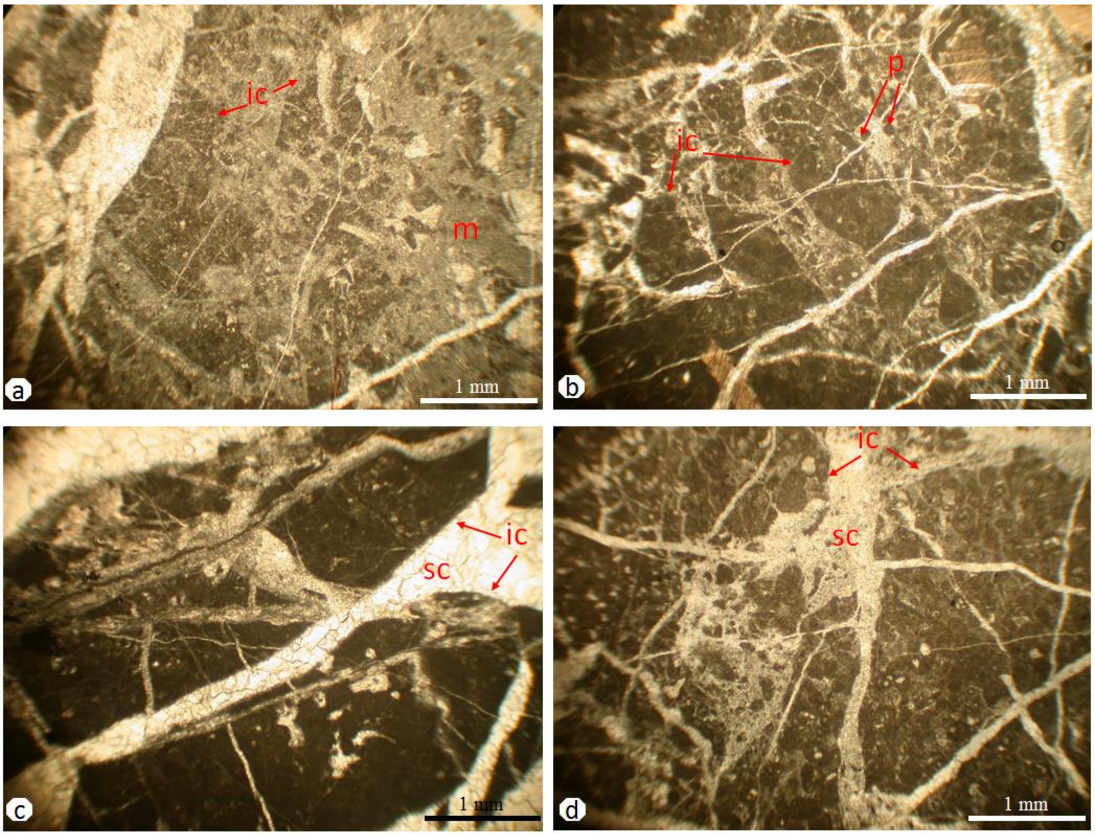


Figure 23. Photomicrographs of the intraclastic packstone and rudstone facies (MF 9 & 10). **a)** STG-112, intraclastic packstone. **b)** STG-122, intraclastic packstone, clasts have peloidal packstone texture. **c)** STG-116, intraclastic rudstone (microbreccia), clasts have peloidal packstone texture with very rare benthic foraminifera. **d)** STG-119, intraclastic rudstone (microbreccia), clasts have peloidal, intraclastic packstone texture. ic: intraclast, p: peloid, m: micrite, sc: sparry calcite.

me lag between the local first occurrences of these taxa in the slope environments and their first occurrences in the platform carbonates must be related to their environmental distribution. The ones that occupied areas closer to the shelf edge would be more prone to resedimentation in the slope environments and they would be recorded nearly simultaneously both in the slope and platform environments. Based on the determined microfacies types and fossil assemblages, a microfacies model for the studied succession is proposed in Figure 24. If the position of the studied sections with respect to the Edremit – Bursa – Bilecik Carbonate Platform is considered, the studied basin and slope facies should represent the southern platform margin and slope environments of this carbonate platform that faced probably an ocean to the south during the Jurassic-Cretaceous interval. The Jurassic transgression over the basement rocks of the Sakarya Zone is represented by the clastics of the Bayırköy Formation in the western Turkey. This formation is unconformably overlain by the carbonates of the Taşçıbayırı Formation with the Rosso Ammonitico levels (see Chapter 1). The Taşçıbayırı Formaiton represents the condensed “start-up phase” (in the sense of Neumann & Macintyre, 1985; Sarg, 1988) deposits indicating the onset of a carbonate platform development. As the carbonate platform with a healthy, productive margin was established and the rate of carbonate production increased, the system passed into a “keep-up phase” (phase in which carbonate production can keep pace with the relative rise of sea level or accomodation space) through a “catch-up phase” (period during which the rate of accomodation creation is slightly higher than the rate of carbonate production) (Neumann & Macintyre, 1985; Sarg, 1988; Emery & Myers, 1996). This “keep-up phase” is characterized by overproduction of carbonate grains. As the rate of accomodation space decreased, overproduced carbonate sediments were redeposited from the platform margin into the interior of platform and/or they were shedded into deep water environments by gravity flow processes and by deposition from suspension. This last process is named as the highstand shedding and it is mostly encountered in great frequency during highstands (Schlager et al., 1994; Emery & Myers, 1996; Flügel, 2010) although the timing may vary depending on the relationship between the rate of accomodation space added and the rate of carbonate production. The Günören Limestone may be thought as a deposit of a platform in “keep-up phase” that was shedding large amounts of shallow marine carbonates to the surrounding basins. This shedded material constitutes the gravity flow deposits of the Yosunlukbayırı Formation which could be defined as a pelagic deposit punctuated by intervals of transported shallow marine intercalations. This formation forms the transitional facies between shallow marine platform (Günören Limestone) and pelagic facies (Soğukçam Limestone) (Fig.5 & 24).

Regarding the slope deposits of MF4, 5 and 6, although theres is no sedimentary structures indicating turbidite deposition such as erosive base, fully or partially developed Bouma Sequences and sole marks, the presence of shallow marine material intercalated with basinal sequences indicate pulses of gravity flow processes

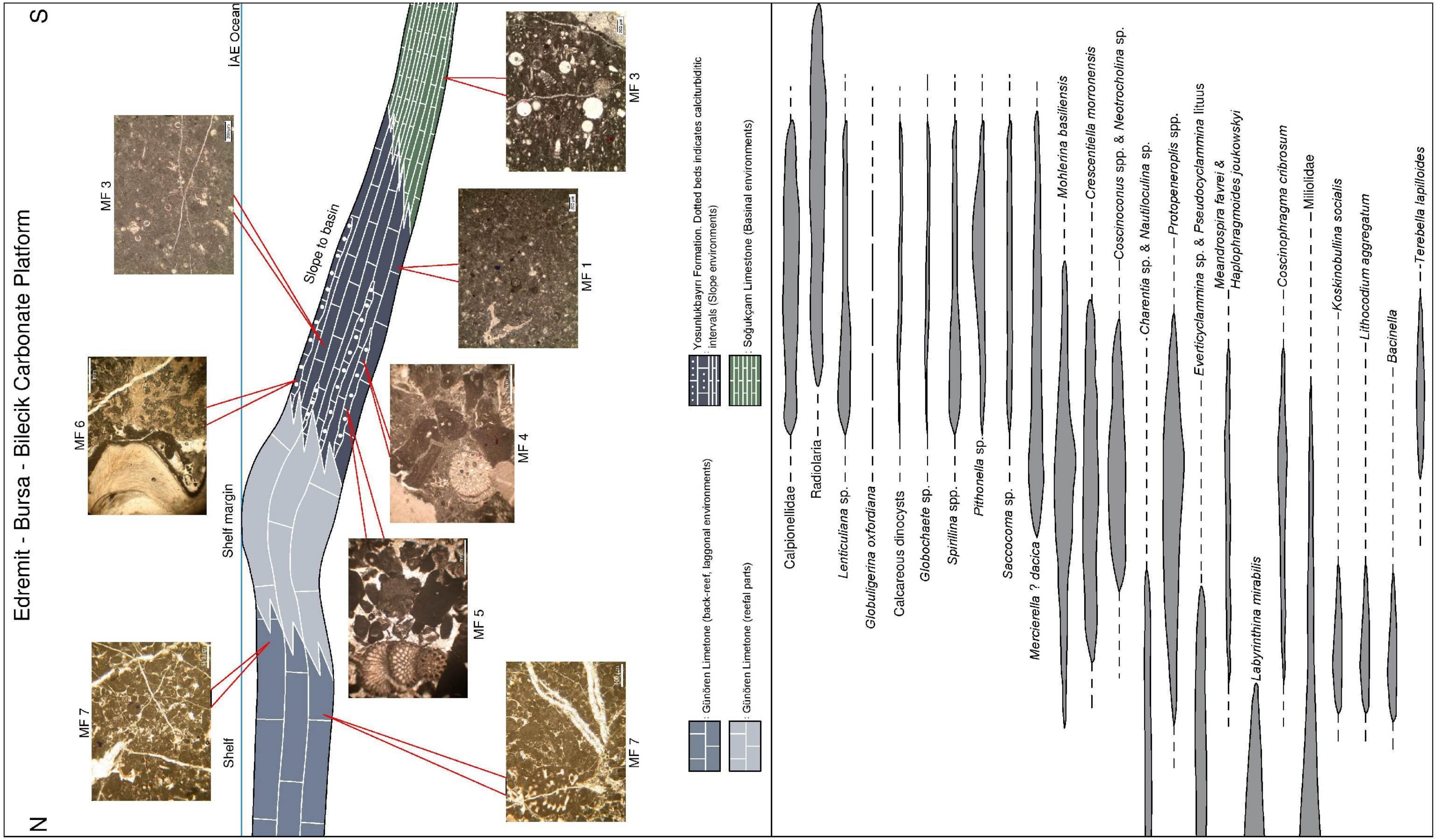


Figure 24. Microfacies distribution of the southern platform margin and slope environments of the Edremit-Bursa-Bilecik Carbonate Platform during Kimmeridgian – Berriasian interval. There is no direct observation on the reefal parts of this platform, since the studied successions do not reveal such facies. The relationship of the studied formations are illustrated along a model with related facies photomicrographs. Additionally facies distribution of some important microfossils are shown. For microfacies types see Table 4. Note that fossil distributions in environment are time-dependent (e.g. calpionellids occur in latest Tithonian onward).

which may represent debris-flow deposits that show massive beds of packstone - grainstone to microbreccia (rudstone to floatstone) types similiar to Drzewiecki and Simó (2002)’ s debris-flow deposits. In fact, all these slope processes form a continuum; debris-flow may trigger and be transformed into turbidity flow distally down-slope (Drzewiecki & Simó, 2002). Upper Jurassic – Lower Cretacous carbonates of similiar microfacies have also been interpreted as the slope deposits in previous studies; the Rosomać Limestone (Petrova et al., 2012, Serbia), the Cieszyn Limestone (Matyszkiewicz & Slomka, 1994, Outer Carpathians, Poland), the Barmstein Limestone (Schlagintwiet & Gawlick, 2007, Northern Calacareous Alps), the Tressenstein Limestone (Schlagintweit & Ebli, 1999, Northern Calcareous Alps), the Rettenstein Debris Flow (Auer et al., 2009, Northern Calcareous Alps), the Mateiaş Limestone (Bucur et al., 2010, Southern Carpathians, Romania) and the Lower Cretaceous carbonate gravity-flow deposits (Kukoc et al., 2012, Internal Dinaride, Slovenia).

Since during lowstand exposures carbonate systems will not experince as much instense erosion as the siliciclastic systems (with processes like stream rejuvenation) due to chemical erosion rather than physical erosion and processes like rapid meteoric and marine lithification preventing mechanical erosion (Sarg, 1988; Emery & Myers, 1996; Flügel, 2010), the continuous intercalation of platform derived material in the studied section most probably represents highstand shedding.

CHAPTER 4

MICROPALEONTOLOGY

The main purpose of this chapter is to clarify the criteria used in the taxonomic classification of the identified fossil assemblages that form the main frame of this study on which all other interpretations based (like biostratigraphy, microfacies evolution etc.). The identifications were carried out on randomly oriented thin sections.

This chapter mainly includes brief descriptions, author's remarks on the morphology and stratigraphic ranges. This chapter is not an attempt to compile all the synonym lists or all the historical background of each taxon.

Mainly 3 groups have been studied; calpionellids, foraminifera and incertae sedis. The study of Remane (1985) is mainly used for the generic classification of the calpionellids. For the new genera introduced after this publication and for all the species, the original papers and the more recent ones were used. Loeblich and Tappan (1988), Kaminski (2004) and Pawlowski et al. (2013) are the main reference used in this study for the suprageneric and generic classification of the foraminifera. Recent papers were used for the species descriptions. For microproblematica, there is no single complier reference, several papers were used for their classifications. The related papers were listed in the synonym lists.

In the following pages information on each fossil group will be given. The related thin section plates are illustrated in the Appendix B.

4.1. Calpionellid Taxonomy

FAMILY CALPIONELLIDAE, Bonet 1956

Genus *Crassicollaria* Remane, 1962

Type species: *Crassicollaria brevis* Remane, 1962

Crassicollaria brevis Remane, 1962
Pl. 1, Figs. a-d

1962 *Crassicollaria brevis* n. sp.; Remane, 16, Figs. 19-26
1971 *Crassicollaria brevis* Remane, Remane, Pl. 3, Figs. 5-6
1991 *Crassicollaria brevis* Remane, Altıner & Özkan, Pl. 3, Figs. 6-8
1991 *Crassicollaria brevis* Remane, Tunç, Pl. 3, Fig. 1
1992 *Crassicollaria brevis* Remane, Tunç, Pl. 2, Fig. 3
1995 *Crassicollaria brevis* Remane, Olóriz et al., Pl. 1, Fig. 9
1999 *Crassicollaria brevis* Remane, Lakova et al., Pl. 1, Fig.6
2001 *Crassicollaria brevis* Remane, Ciborowski & Kołodziej, 345, Fig. 4
2004 *Crassicollaria brevis* Remane, Marino et al., Pl. 3, Fig. 3
2007 *Crassicollaria brevis* Remane, Andreini et al., Pl. 1, Figs. 19, 20
2012 *Crassicollaria brevis* Remane, Petrova et al., 58, Figs. 28, 29
2013 *Crassicollaria brevis* Remane, Lakova & Petrova, Pl. 2, Figs. 2,3; P. 6, Figs. 18, 19

Description & Remarks: The lorica is hyaline. The transition from the collar to the body of lorica is rather smooth in *Crassicollaria* when compared with the *Calpionella* genus. *Crassicollaria* has wider opening due to the lack of shoulders present in *Calpionella*. It has swelling below the collar and a caudal appandage in the aboral part.

Cr. brevis is characterized by the swelling below the collar, the deflection of the distal parts of its collar and short caudal appendage. It differs from the *Cr. intermedia* by its smaller size.

Its first occurrence is in the *massutiniana* subzone of the *Crassicollaria* subzone (latest Tithonian) and disppears at the J-K boundary (Lakova & Petrova, 2013) (Table 3). Specimens were recovered from the same subzone in this study (Figure 12).

Crassicollaria intermedia Durand-Delga, 1957
Pl. 1, Figs. e-h

1957 *Crassicollaria intermedia* n. sp., Durand-Delga, Pl. 1, Figs. 2, 4
1971 *Crassicollaria intermedia* Durand-Delga, Remane, Pl. 3, Figs. 7
1991 *Crassicollaria intermedia* Durand-Delga, Altıner & Özkan, Pl. 3, Figs. 9-12
1992 *Crassicollaria intermedia* Durand-Delga, Tunç, Pl. 2, Fig. 1
1992 *Crassicollaria intermedia* Durand-Delga, Bucur, 572, Fig. 4b
1995 *Crassicollaria intermedia* Durand-Delga, Olóriz et al., Pl. 1, Figs. 6, 7
1995 *Crassicollaria colomi* Durand-Delga, Olóriz et al., Pl. 1, Fig. 8
2004 *Crassicollaria intermedia* Durand-Delga, Marino et al., Pl. 3, Fig. 1
2007 *Crassicollaria intermedia* Durand-Delga, Andreini et al., Pl. 1, Figs. 28, 29
2012 *Crassicollaria intermedia* Durand-Delga, Petrova et al., 58, Figs. 22-24
2013 *Crassicollaria intermedia* Durand-Delga, Lakova & Petrova, Pl. 1, Figs. 32, 33; Pl.5, Figs. 44-46

Description & Remarks: As previously mentioned, it is a scaled-up version of *Cr. brevis* with cylindrical lorica wall rather than general conical shape of *Cr. brevis*.

Its first occurrence is in the *remanei* subzone of the *Crassicollaria* subzone (Late Tithonian) and disppears at the J-K boundary in coherence with the *Cr. brevis* (Lakova & Petrova, 2013) (Table 3). Specimens were recovered from the *massutiniana* subzone in this study due to the facies controlled arrival of calpionellid-rich facies (see Chapter 2 and 3) (Figure 12).

Crassicollaria massutiniana Colom, 1948
Pl. 1, Figs. i-o

1948 *Crassicollaria massutiniana* n. sp., Colom, 243, Fig. 11
1971 *Crassicollaria massutiniana* Colom, Remane, Pl. 3, Figs. 10
1991 *Crassicollaria massutiniana* Colom, Altıner & Özkan, Pl. 3, Figs. 13, 14
1992 *Crassicollaria remanei* n. sp., Tunç, Pl.1, Figs. 3-5
1995 *Crassicollaria parvula* Remane, Olóriz et al., Pl. 1, Fig. 10
2004 *Crassicollaria massutiniana* Colom, Marino et al., Pl. 3, Fig.4
2007 *Crassicollaria massutiniana* Colom, Andreini et al., Pl. 1, Fig. 24
2012 *Crassicollaria massutiniana* Colom, Petrova et al., Pl. 1, Figs. 24-26
2013 *Crassicollaria massutiniana* Colom, Lakova & Petrova, Pl.2, Fig.1; Pl.5, Figs. 47, 48
2013 *Crassicollaria massutiniana* Colom, Krische et al., 39; Fig. E, F.

Description & Remarks: The lorica is elongated with a conical aboral pole. The collar is cylindrical. It differs from the *Cr. parvula* by its larger size and massive swelling below the collar. It is distinguished form *Cr. brevis* and *Cr. intermedia* by its cyclindrical collar, and the conical aboral pole that does not show caudal appendage.

Cr. massutiniana appears in the *remanei* subzone, shows increase in the abundance in the *massutiniana* subzone and disappears in the lowest levels o the *alpina* subzone just above the J-K boundary (Michalík & Rehakova, 2011; Lakova & Petrova, 2013). *Cr. massutiniana* specimens were recovered from the latest Tithonian (*massutiniana* subzone) – earliest Berriasian (lowest part of the *alpina* subzone) interval (Fig.12).

Crassicollaria parvula Remane, 1962

Pl. 1, Figs. p-ag

1962 *Crassicollaria parvula* n. sp., Remane, 19, Figs. 36-45
1971 *Crassicollaria parvula* Remane, Remane, Pl.3, Figs. 8-9
1991 *Crassicollaria parvula* Remane, Altıner & Özkan, Pl. 3, Figs. 15-20
1992 *Crassicollaria parvula* Remane, Tunç, Pl. 2, Fig. 2
1995 *Crassicollaria massutiniana* Colom, Olóriz et al., Pl. 1, Fig. 10
1999 *Crassicollaria massutiniana* Colom, Skourtsis-Coroneou & Solakius, 589, Fig. 6
2001 *Crassicollaria parvula* Remane, Olszewska & Wieczorek, 8, Fig. (6) 2
2007 *Crassicollaria parvula* Remane, Andreini et al., Pl. 1, Figs. 21, 22
2012 *Crassicollaria parvula* Remane, Petrova et al., 58, Fig. (4) 32, 33
2013 *Crassicollaria parvula* Remane, Lakova & Petrova, Pl. 2, Figs. 4, 5; Pl. 5, Fig. 49; Pl. 6, Figs. 20-29
2013 *Crassicollaria colomi* Doben, Lakova & Petrova, Pl. 2, Fig. 7
2015 *Crassicollaria parvula* Remane, Boorovȧ et al., Fig. 6B

Description & Remarks: It differs from the *Cr. massutiniana* by its weak swelling below the cylindrical collars and generally smaller size.

It ranges from *massutiniana* subzone (latest Tithonian) to *simplex* subzone (early Late Berriasian) (Petrova et al., 2012). This species occurs from the *massutiniana* subzone to the *simplex* subzone and shows an acme within the *alpina* subzone in accordance with the observations of Lakova and Petrova (2013) (Figure 12).

Genus *Calpionella* Lorenz, 1902

Type species: *Calpionella alpina* Lorenz, 1902

Calpionella alpina Lorenz, 1902

Pl. 2, Figs. f-o, r

1902 *Calpionella alpina* n. sp., Lorenz, Pl. 6, Fig. 1
1971 *Calpionella alpina* Lorenz, Remane, Pl. 3, Figs. 1-2
1991 *Calpionella alpina* (spherical form) Lorenz, Altıner & Özkan, Pl. 1, Figs. 3-8
1992 *Calpionella alpina* Lorenz, Tunç, Pl. 2, Fig. 4
1992 *Calpionella alpina* Lorenz, Bucur, 572, Fig. 4e
1995 *Calpionella alpina* Lorenz, Olóriz et al., Pl. 1, Figs. 12, 13
1997 *Calpionella alpina* Lorenz, Grün & Blau, Pl. 1, Figs. 11, 12
1999 *Calpionella alpina* Lorenz, Lakova et al., Pl. 1, Fig. 9
2001 *Calpionella alpina* Lorenz, Ciborowski & Kołdziej, 345, Fig. (2) 3
2004 *Calpionella alpina* Lorenz, Marino et al., Pl. 3, Fig. 9
2007 *Calpionella alpina* Lorenz, Andreini et al., Pl. 1, Figs. 12, 13
2012 *Calpionella alpina* Lorenz, Petrova et al., 60, Figs. (5) 1-7
2015 *Calpionella alpina* Lorenz, López-Martinez et al., 586, Fig. 5I; 288; Fig. 7C, D
2016 *Calpionella alpina* Lorenz, Maalaoui & Zargouni, 50, Figs. (4) 1-3

Description & Remarks: This species is characterizd by spherical hyaline lorica with restricted oral end, well-developed shoulder, cylindrical collar and rounded aboral part. The acme of this species defines the base of the *alpina* subzone and the J-K boundary.

C. alpina ranges from the *massutiniana* subzone (latest Tithonian) to the *oblonga* subzone (Late Berriasian). Similiarly, this species were observed from the *massutiniana* subzone to the *oblonga* subzone in this study (Figure 12). The acme of this species was used as the indicator of the J-K boundary following the suggestions of Wimbledon (2011), Michalik and Rehakova (2011), Lakova and Petrova (2012), Lakova and Petrova (2013), Frau et al. (2016) (see Chapter 2).

Calpionella grandalpina Nagy, 1986

Pl. 2, Figs. a-e

1986 *Calpionella grandalpina* n. sp., Nagy, Pl. 1, Fig. 3, 8
1991 *Calpionella alpina* (large form) Lorenz, Altıner & Özkan, Pl. 1, Figs. 1, 2
1999 *Calpionella grandalpina* Nagy, Lakova et al., Pl. 1, Fig. 7
2012 *Calpionella grandalpina* Nagy, Petrova et al., 58, Figs. (4) 37-39
2013 *Calpionella grandalpina* Nagy, Lakova & Petrova, Pl 2, Figs. 8, 9; Pl.5, Figs. 53, 54; Pl. 6, Fig. 1
2015 *Calpionella grandalpina* Nagy, Lopez-Martinez et al., 586, Fig. 5g

Description & Remarks: This species is the scaled-up version of *C. alpina*, known as the "large form" in the literature. It may be confused with the *C. elliptalpina*. It appears in the upper levels of the *massutiniana* subzone and its abundance greatly decreases at the J-K boundary synchronously with the bloom of the *C. alpina* (Remane et al., 1986; Lakova et al., 1999; Petrova et al., 2012; Lakova & Petrova, 2013).

The representatives of this species were recoverd from the upper levels of the *massutiniana* subzone (latest Tithonian) and the lowest levels of the *alpina* subzone just after the J-K boundary (Fig. 12).

Calpionella minuta Houša, 1990

Pl. 2, Figs. p-v

1985 *Calpionella alpina* (small form) Lorenz, Remane, 570, Fig. (18) 3
1991 *Calpionella alpina* (small form) Lorenz, Altıner & Özkan, Pl. 1, Figs. 9, 10
1991 *Calpionella alpina* Lorenz, Tunç, Pl. 3, Fig. 3
1995, *Calpionella alpina* Lorenz, Olóriz et al., Pl. 1, Figs. 14
1999, *Calpionella minuta* Houša, Lakova et al., Pl.1, Fig.4

2001, *Calpionella alpina* (small, spherical form) Lorenz, Ciborowski & Kołodziej, Figs. (2) 6-9
2007 *Calpionella alpina* Lorenz, Andreini et al., Pl. 1, Figs. 10, 11
2012 *Calpionella minuta* Houša, Petrova et al., Figs. (5) 8-10
2013 *Calpionella minuta* Houša, Lakova & Petrova, Pl. 2, Figs. 17-20; Pl. 3, Fig. 4; Pl. 6, Figs. 8, 9

Description & Remarks: This species has generally been defiend as the ”small form” of *Calpionella alpina*. Houša (1990) introduced *C. minuta* name and in recent studies this name has mostly been used.

This species appears in the upper levels of the *alpina* subzone and ranges into the upper parts of the *darderi* subzone (Lakova et al., 1999; Petrova et al., 2012; Lakova & Petrova, 2013). In this study, *C. minuta* ranges from the upper levels of the *alpina* subzone (earliest Berriasian) to the middle of the *oblonga* subzone (latest Berriasian) (Fig. 12).

Calpionella elliptalpina Nagy, 1986
Pl. 2, Figs. w, x

1985 *Calpionella alpina* Lorenz, Remane, 570, Fig (18) 1
1986 *Calpionella elliptalpina* n. sp., Nagy, Pl. 1, Fig. 4
1991 “Homeomorph” of *Calpionella elliptica* Cadisch, Altıner & Özkan, Pl. 1, Fig. 19
1992 *Calpionella elliptica* Cadisch, Tunç, Pl. 2, Fig. 9
1995 *Calpionella alpina* (ejampler grande con ragos proximos a las formas de transicion a *C. elliptica*) Lorenz, Olóriz et al., Pl. 1, Figs. 15
1999, *Calpionella elliptalpina* Nagy, Lakova et al., Pl. 1, Fig. 8
2006, *Calpionella alpina* Lorenz, Grabowski & Pszczółkowski, 405, Figs. 7D
2012, *Calpionella elliptalpina* Nagy, Petrova et al., 58, Fig. (4) 40, 41

2013, *Calpionella elliptalpina* Nagy, Lakova & Petrova, Pl. 2, Figs. 10, 11; Pl. 6, Fig. 2

Description & Remarks: This species had generally been defined as the "homeomorph" of *Calpionella elliptica* (Remane, 1985; Altıner & Özkan, 1991) and recently the *C. elliptalpina* Nagy name has been used.

Its range is restricted to a limited interval at the uppermost parts of the *massutiniana* subzone just below the J-K boundary (Petrova et al. 2012; Lakova & Petrova, 2013). The individuals of this species were recoverd in the uppermost part of the *massutiniana* subzone (latest Tithonian) in this study (Fig. 12).

Calpionella elliptica Cadisch, 1932
Pl. 2, Figs. y-aa

1932 *Calpionella elliptica* n. sp., Cadisch, 249, Fig (3) 10, 11, 17
1971 *Calpionella elliptica* Cadisch, Remane, Pl. 3, Figs. 3, 4
1985 *Calpionella elliptica* Cadisch, Remane, 570, Fig (18) 4
1991 *Calpionella elliptica* Cadisch, Altıner & Özkan, Pl. 1, Fig. 11-18
1992 *Calpionella elliptica* Cadisch, Bucur, 572, Fig. (4) g-j
1995 *Calpionella elliptica* Cadisch, Olóriz et al., Pl. 1, Fig. 17
1997 *Calpionella elliptica* Cadisch, Grün & Blau, Pl. 1, Figs. 17, 18
1999 *Calpionella elliptica* Cadisch, Lakova et al., Pl. 1, Fig. 11
2006 *Calpionella elliptica* Cadisch, Grabowski & Pszczółkowski, 405, Fig. 7G
2007 *Calpionella elliptica* Cadisch, Andreini et al., Pl. 2, Figs. 1, 2
2010 *Calpionella elliptica* Cadisch, Fözy et al., 537, Fig. 9U
2012 *Calpionella elliptica* Cadisch, Petrova et al., 60, Figs. (5) 13-17
2013 *Calpionella elliptica* Cadisch, Lakova & Petrova, Pl. 2, Figs. 36, 37; Pl. 3, Figs. 1, 2; Pl. 6, Fig. 14
2015 *Calpionella elliptica* Cadisch, Boorovȧ et al., 103, Fig. (6) I, J
2015 *Calpionella elliptica* Cadisch, López-Martinez et al., 588, Fig. 7N
2016 *Calpionella elliptica* Cadisch, Maalaoui & Zargouni, 50, Fig. (4) 4-6

Description & Remarks: It differs from all other species of the *Calpionella* genus by its elongated, cylindrical lorica. Its first occurrence defines the basal boundary of the *elliptica* subzone (Table 3). The oblique sections of this species may be confused with *C. alpina*. Remane (1963, 1964, 1985) offers a length (without collar) to width (largest portion) ratio for their differentiation; all sections with ratio larger than 1.35 should be named as *C. elliptica*, ratio smaller than 1.25 indicates *C. alpina* and individuals with intermediate values should be named as *Calpionella* sp., regardless of whether they are real transitional forms between *C. alpina* and *C. elliptica* or not. The individuals observed in this study ranges from the base of the *elliptica* subzone (middle Berriasian) to the base of the *oblonga* subzone (late Berriasian) (Fig. 12).

In general there is a tendency towards smaller sizes in the genus *Calpionella* from latest Jurassic to earliest Cretaceous except the species *Calpionella elliptica*.

Genus *Tintinnopsella* Colom, 1948

Type species: *Calpionella carpathica* Murgeanu and Filipescu, 1933

Tintinnopsella remanei Borza, 1969
Pl. 3, Figs. a-c

1969 *Tintinnopsella remanei* n. sp., Borza, Pl. 80, Figs. 7-16
1995 *Tintinnopsella remanei* Borza, Ołoriz et al., Pl. 1, Figs. 19
1999 *Tintinnopsella remanei* Borza, Lakova et al., Pl. 1, Fig. 3
2012 *Tintinnopsella remanei* Borza, Petrova et al., 58, Figs. (4) 20, 21
2013 *Tintinnopsella remanei* Borza, Lakova & Petrova, Pl. 1, Fig. 34; Pl. 5, Figs. 42, 43

Description & Remarks: This species is characterized by small hyaline lorica, smooth transition from the body of lorica to funnel-shaped collar (divergent linear collars in thin section). The aboral part is subrounded without caudal prolongation.

They may be confused with the oblique sections of *T. carpathica*. It seems like *T. remanei* did not range beyond the J-K boundary (Lakova et al., 1999; Petrova et al., 2012; Lakova & Petrova, 2013), so there should not be any confusion in differentiation with the oblique sections of *T. longa* which occurs within the *oblonga* subzone.

The individuals of *T. remanei* were recovered from the *massutiniana* subzone (latest Tithonian).

Tintinnopsella carpathica Murgeanu & Filipescu, 1933
Pl. 3, Figs. d-t

1933 *Calpionella carpathica* n. sp., Murgeanu & Filipescu, Pl. 1, Figs. 20-23
1969 *Tintinnopsella carpathica* Murgeanu & Filipescu, Borza, Pl. 78, Figs. 1-16; Pl. 79, Figs. 1-8
1971 *Tintinnopsella carpathica* Murgeanu & Filipescu, Remane, Pl. 3, Figs. 11, 12
1991 *Tintinnopsella carpathica* Murgeanu & Filipescu, Altıner & Özkan, Pl. 2, Figs. 1-12
1991 *Tintinnopsella longa* Colom, Tunç, Pl.3, Fig. 9
1992 *Tintinnopsella carpathica* Murgeanu & Filipescu, Tunç, Pl. 2, Fig. 7
1992 *Tintinnopsella carpathica* Murgeanu & Filipescu, Bucur, 572, Figs. (4) l, m
1994b *Tintinnopsella carpathica* Murgeanu & Filipescu, Pop, Pl. 2, Fig. 15
1995 *Tintinnopsella carpathica* Murgeanu & Filipescu, Olóriz et al., Pl. 1, Figs. 21-23
1997 *Tintinnopsella carpathica* Murgeanu & Filipescu, Grün & Blau, Pl. 1, Figs. 15, 16
2004 *Tintinnopsella carpathica* Murgeanu & Filipescu, Concetta Marino, Pl. 3, Fig. 15
2007 *Tintinnopsella carpathica* Murgeanu & Filipescu, Andreini et al., Pl. 1, Figs. 16-18; Pl. 2, Figs. 5, 14, 15
2012 *Tintinnopsella carpathica* Murgeanu & Filipescu, Petrova et al., 58, Fig. (4) 19;

62, Fig. (6) 14-22

2013 *Tintinnopsella carpathica* Murgeanu & Filipescu, Lakova & Petrova, Pl. 1, Figs. 35, 36; Pl. 2, Fig. 34; Pl. 3, Figs. 41-44; Pl. 4, Figs. 47-49; Pl. 5, Figs. 38-41; Pl. 6, Fig. 32; Pl. 7, Figs. 36-41

2013 *Tintinnopsella carpathica* Murgeanu & Filipescu, López-Martinez et al., 6, Fig. 5K; 7, Fig. 6H

2013 *Tintinnopsella carpathica* Murgeanu & Filipescu, Krische et al., 39, Figs. (12) A, B

2015 *Tintinnopsella carpathica* Murgeanu & Filipescu, Boorovȧ et al., 103, Fig. (6) K

2015 *Tintinnopsella carpathica* Murgeanu & Filipescu, López-Martinez et al., 588, Figs. (7) E, J, K

2016 *Tintinnopsella carpathica* Murgeanu & Filipescu, Maalaoui & Zargouni, 50, Figs. (4) 8, 9

Description & Remarks: This species is characterized by ovoid or cylindrical lorica with a pronounced caudal prolongation at the conical aboral pole and by its distinctive, somewhat right angle, funnel-shaped collar that may show upward deflection at the outer parts. It differs from the *T. remanei* with its larger size and aboral prolongation.

This species has the longest stratigraphic range amongst the calpionellids that spans from the *remanei* subzone to the extinction of the calpionellids (F Zone of Altıner & Özkan, 1991) (Trejo, 1980; Remane, 1985; Altıner & Özkan, 1991; Lakova et al., 1999; Petrova et al., 2012; Lakova & Petrova, 2013). The representatives of this species were recovered from *alpina* subzone (earliest Berriasian) to *darderi* subzone (earliest Valanginian) interval (Fig. 12).

Tintinnopsella longa Colom, 1939

Pl. 3, Figs. u-z

1939 *Calpionella longa* n. sp., Colom, Pl. 2, Fig. 9; Pl. 3, Fig. 3
1969 *Tintinnopsella longa* Colom, Borza, Pl. 79, Figs. 9-16
1975 *Tintinnopsella longa* Colom, Trejo, Pl. 5, Figs. 4-10; Pl. 6, Fig. 5; Pl. 16, Figs. 15-17?; Pl. 17, Figs. 1-5
1991 *Tintinnopsella longa* Colom, Altıner & Özkan, Pl. 2, Figs. 13-17
1992 *Tintinnopsella longa* Colom, Bucur, 572, Figs. (4) q-s
1994b *Tintinnopsella longa* Colom, Pop, Pl. 2, Fig. 16
1995 *Tintinnopsella longa* Colom, Olóriz et al., Pl. 1, Fig. 24
1997 *Tintinnopsella longa* Colom, Grün & Blau, Pl. 1, Figs. 19, 20
1999 *Tintinnopsella longa* Colom, Lakova et al., Pl. 1, Fig. 14
2004 *Tintinnopsella longa* Colom, Concetta Marino et al., Pl. 1, Fig. 11
2007 *Tintinnopsella longa* Colom, Andreini et al., Pl. 3, Fig. 3
2010 *Tintinnopsella longa* Colom, Főzy et al.,537, Fig. 9Q
2012 *Tintinnopsella longa* Colom, Petrova et al., 62, Figs. (6) 10-13
2013 *Tintinnopsella longa* Colom, Lakova & Petrova, Pl. 2, Fig. 35; Pl. 3, Figs. 38-40; Pl. 4, Figs. 50-53; Pl. 7, Figs. 45-48
2013 *Tintinnopsella longa* Colom, López-Martinez et al., 8, Fig. 7K
2013 *Tintinnopsella longa* Colom, Krische et al., 39; Fig. 12P
2015 *Tintinnopsella longa* Colom, Boorovȧ, 103, Fig. 6L
2016 *Tintinnopsella longa* Colom, Maalaoui & Zargouni, 50, Figs. (4) 19, 20

Description & Remarks: This species differs from the *T. carpathica* by its elongated, cylindrical lorica with rounded aboral pole without a caudal prolongation. and from the *T. remanei* by its much larger size and its stratigraphic position. The first occurrence of *T. longa* has generallay been reported from the *simplex* subzone (Altıner & Özkan, 1991; Lakova et al., 1999; Skourtsis-Coroneou & Solakius; Andreini et al. 2007; Grabowski et al., 2010; Petrova et al., 2012) or from the *elliptica* subzone (Lakova & Petrova, 2013). This different reports on the first occurrence probably a confusion introduced by oblique sections, but the stratigraphic position of this species is not important in the determinations of subzones.

In this study, *T. longa* was recovered from *oblonga* (latest Berriasian) and *darderi* (earliest Valanginian) subzones (Fig. 12).

Genus *Calpionellopsis* Colom, 1948

Type species: *Calpionella thalmanni* Colom, 1939

Calpionellopsis simplex Colom, 1939

Pl. 4, Figs. a-k

1939 *Calpionella simplex* n. sp., Colom, Pl. 2, Fig. 11; Pl. 3, Fig. 9
1948 *Calpionellopsis simplex* Colom, Colom, 256, Fig. (11) 10
1985 *Calpionellopsis simplex* Colom, Remane, 570, Fig. (18) 9, 10
1991 *Calpionellopsis simplex* Colom, Altıner & Özkan, Pl. 4, Figs. 1-10
1991 *Calpionellopsis simplex* Colom, Tunç, Pl. 4, Fig. 2
1992 *Calpionellopsis simplex* Colom, Tunç, Pl. 2, Fig. 10
1992 *Calpionellopsis simplex* Colom, Bucur, 572, Fig. (4) t-v
1994b *Calpionellopsis simplex* Colom, Pop, Pl. 2, Fig. 1
1996, *Calpionellopsis simplex* Colom, Grün & Blau, Pl. 2, Figs. 14, 15
1999 *Calpionellopsis simplex* Colom, Lakova et al., Pl. 1, Fig. 12
2006 *Calpionellopsis simplex* Colom, Grabowski & Pszczółkowski, 405, Fig. 7I
2007 *Calpionellopsis simplex* Colom, Andreini et al., Pl. 2, Figs. 10, 11
2010 *Calpionellopsis simplex* Colom, Fözy et al., 537, Fig. 9S
2012 *Calpionellopsis simplex* Colom, Petrova et al., 60, Figs. (5) 22-26
2013 *Calpionellopsis simplex* Colom, Lakova & Petrova, Pl. 3, Figs. 19-26; Pl. 7, Fig. 1, 2
2015 *Calpionellopsis simplex* Colom, López-Martinez et al., 589, Fig. 8D

Description & Remarks: *Calpionellopsis simplex* is characterized by cylindrical lorica with parallel lateral walls (curved in oblique sections), subrounded aboral pole and an internal cylindrical collar that show extinctions between crossed nicols at 45°. The collar looks like two symmetrical nodes superimposed on the lorica wall.

Its first occurrence defines the basal boundary of the *Calpionellopsis* Zone and the *simplex* subzone (Table 3). The representatives of this species were recovered from *simplex* subzone (earliest Late Berriasian) to the base of the *darderi* subzone (earliest Valanginian) (Fig. 12).

Calpionellopsis oblonga Cadisch, 1932

Pl. 4, Figs. l-w

1939 *Calpionella oblonga* n. sp., Cadisch, 251, Figs. 20, 21

1948 *Tintinnopsella oblonga* Cadisch, Colom, Pl. 33, Fig. 5; 256, Fig. 13; 258, Fig. 57; 260, Fig. 5

1985 *Calpionellopsis oblonga* Cadisch, Remane, 570, Fig. (18) 7, 8

1991 *Calpionellopsis oblonga* Cadisch, Altıner & Özkan, Pl. 4, Figs. 11-20

1991 *Calpionellopsis oblonga* Cadisch, Tunç, Pl. 4, Fig. 3

1992 *Calpionellopsis oblonga* Cadisch, Tunç, Pl. 2, Fig. 11

1992 *Calpionellopsis oblonga* Cadisch, Bucur, 572, Fig. (4) x, y

1994b *Calpionellopsis oblonga* Cadisch, Pop, Pl. 2, Fig. 2

1999 *Calpionellopsis oblonga* Cadisch, Lakova et al., Pl. 1, Fig. 15

2004 *Calpionellopsis oblonga* Cadisch, Concetta Marino et al., Pl. 3, Fig. 10

2006 *Calpionellopsis oblonga* Cadisch, Grabowski & Pszczółkowski, 405, Fig. 7J

2007 *Calpionellopsis oblonga* Cadisch, Andreini et al., Pl. 2, Figs. 12, 1

2010 *Calpionellopsis oblonga* Cadisch, Főzy et al., 537, Figs. (9) H, O

2012 *Calpionellopsis oblonga* Cadisch, Petrova et al., 60, Figs. (5) 27-29

2013 *Calpionellopsis oblonga* Cadisch, Lakova & Petrova, Pl. 3, Figs. 27-33; Pl. 4, Figs. 1-3; Pl. 7, Figs. 3-6

2013 *Calpionellopsis oblonga* Cadisch, López-Martinez et al., 202, Fig. 7G

2015 *Calpionellopsis oblonga* Cadisch, Boorovȧ et al., 103, Fig. 6Q

2015 *Calpionellopsis oblonga* Cadisch, López-Martinez et al., 589, Fig. 8E

Description & Remarks: It differs from the *Calpionellopsis simplex* by its convergent lorica walls rather than parallel ones and conical aboral part. This gave rise to the largest portion being in the lower parts of the lorica near the aboral area. The collar is similiar to the *Cs. simplex*.

The first occurrence of this species defines the lower boundary of the *oblonga* subzone. The specimens were observed from the *oblonga* (latest Berriasian) and *darderi* (earliest Valanginian) subzones (Fig. 12).

Genus *Remaniella* Catalano, 1965

Type species: *Tintinopsella cadsichiana* Colom, 1948

Remaniella ferasini Catalano, 1965

Pl. 5, Figs. a-f

1965 *Calpionellites ferasini* n. sp., Catalano, Pl. 2, Figs. 1-5; Pl. 3, Figs. 5-7
1969 *Remaniella cadischiana* Colom, Borza, Pl. LXXXI, Fig.4
1986 *Remaniella ferasini* Catalano, Borza & Michalík, Pl. 4, Fig. 4
1991 *Remaniella ferasini* Catalano, Altıner & Özkan, Pl. 5, Figs. 1, 2
1991 *Remaniella ferasini* Catalano, Tunç, Pl. 3, Fig. 6
1994b *Remaniella ferasini* Catalano, Pop, Pl. 1, Figs. 5, 6
1996 *Remaniella ferasini* Catalano, Grün & Blau, Pl. 1, Figs. 12-15; Pl. 3, Fig. 7
1998 *Remaniella ferasini* Catalano, Rehảkovả, Pl. 1, Figs. 1, 2
1999 *Remaniella ferasini* Catalano, Lakova et al., Pl. 1, Fig. 10
2004 *Remaniella ferasini* Catalano, Concetta Marino, Pl. 3, Fig. 5
2007 *Remaniella ferasini* Catalano, Andreini et al., Pl. 1, Figs. 30, 31
2012 *Remaniella ferasini* Catalano, Petrova et al., 60, Figs. 37-39
2013 *Remaniella ferasini* Catalano, Lakova & Petrova, Pl.2, Figs. 23-25; Pl. 6, Figs. 36-41
2013 *Remaniella ferasini* Catalano, López-Martinez et al., 7, Figs. (6) F, G
2015 *Remaniella ferasini* Catalano, López-Martinez et al., 587, Fig. 7H
2016 *Remaniella ferasini* Catalano, Maalaoui & Zargouni, 50, Fig. (4) 11

Description & Remarks: It has a small ovoid lorica with bipartite detached collars. The collars are nearly equal in dimension and have triangular shaped profiles (in longitudinal sections). The inner collar is inwardly deflected and the outer one is little bit divergent in orientation; more or less upwardly directed two triangles in thin sections. The inner on show extinction at 45° under polarized light.

Its first occurrence defines the basal boundary of the *Remaniella* subzone (Table 3). The specimens of this species were identifeid from *Remaniella* (middle Early Berriasian) and *elliptica* (Late Berriasian) subzones (Fig. 12).

Remaniella duranddelgai Pop, 1996

Pl. 5, Figs. g-i

1969 *Remaniella cadischiana* Colom, Borza, Pl. LXXXI, Figs. 2, 3, 5-7
1991 *Remaniella cadischiana* Colom, Altıner & Özkan, Pl. 5, Fig. 3
1992 *Remaniella cadischiana* Colom, Bucur, 572, Fig. 4o
1996 *Remaniella duranddelgai* n. sp., Pop, Pl. 2, Figs. 1-6
1996 *Remaniella duranddelgai* Pop, Grün & Blau, Pl. 1, Fig. 11
1997 *Remaniella duranddelgai* Pop, Grün & Blau, Pl. 2, Fig. 9
1998 *Remaniella duranddelgai* Pop, Rehảkovả, Pl. 1, Fig. 6, 7
2004 *Remaniella duranddelgai* Pop, Concetta Marino, Pl. 3, Fig. 7
2007 *Remaniella duranddelgai* Pop, Andreini et al., Pl. 2, Figs. 3, 6
2010 *Remaniella colomi* Pop, Fözy et al., 537, Fig. 9P
2012 *Remaniella duranddelgai* Pop, Petrova et al., 60, Fig. (5) 40-43
2013 *Remaniella duranddelgai* Pop, Lakova & Petrova, Pl. 2, Figs. 26-28; Pl. 3, Fig. 12; Pl. 6, Figs. 42-49
2015 *Remaniella duranddelgai* Pop, Boorovả et al., 103, Fig. 6D
2015 *Remaniella duranddelgai* Pop, López-Martinez et al., 589, Fig. 8I

Description & Remarks: It is characterized by bell-shaped to slightly ovoid lorica. The aboral pole is conical with a short caudal appandage. The bipartite collar is inequal in size and shape. The inner one is more or less in the direction of the lorica wall and has triangular shape. The other one has lenticular shape.

Its first occurrence observed in the middle part of the *Remaniella* subzone (middle Early Berriasian) in accordance with the Rehảkovả (1998) and Lakova and Petrova (2012) (Fig. 12). Some authors (Lakova & Petrova, 2013) suggest nearly synchronous first occurrence of it with the *R. ferasini* at the base of the *Remaniella* subzone.

Remaniella colomi Pop, 1996

Pl. 5, Figs. j, k

1991 *Remaniella* cadischiana Colom, Altıner & Özkan, Pl. 5, Fig. 7
1994b *Remaniella cadischiana* Colom, Pop, Pl. 1, Fig. 4
1996 *Remaniella colomi* n. sp., Pop, Pl. 2, Figs. 7-9
1996 *Remaniella colomi* Pop, Grün & Blau, Pl. 1, Figs. 8-9, ?10
1997 *Remaniella colomi* Pop, Grün & Blau, Pl. 2, Fig. 2
1998 *Remaniella colomi* Pop, Rehảkovả, Pl. 1, Figs. 8, 9
2007 *Remaniella colomi* Pop, Andreini et al., Pl. 2, Fig. 9
2012 *Remaniella colomi* Pop, Petrova et al., 62, Fig. (6) 1-3
2013 *Remaniella colomi* Pop, Lakova & Petrova, Pl. 2, Figs. 29-32; Pl. 3, Figs. 13-16; Pl. 6, Figs. 50, 51
2015 *Remaniella filipescui* Pop, Boorovả et al., 103, Fig. 6E
2015 *Remaniella colomi* Pop, López-Martinez et al, 589, Fig. 8G
2016 *Remaniella ferasini* Catalano, Maalaoui & Zargouni, 50, Fig. (4) 10

Description & Remarks: *Remaniella colomi* differs from *R. duranddelgai* by its cylindrical lorica shape. The other properties are nearly the same. The outer collar is more developed than the inner one.

It was observed in the uppermost part of the *Remaniella* subzone (middle Early Berriasian) and the lowermost parts of the *elliptica* subzone (late Early Berriasian) (Fig. 12).

Remaniella catalanoi Pop, 1996 ?

Pl. 5, Figs. l, m

1995 *Remaniella cadischiana* Colom, Olóriz et al., Pl. 1, Fig. 25
1996 *Remaniella catalanoi* n. sp., Pop, 320, Figs. 10-15
1997 *Remaniella catalanoi* Pop, Grün & Blau, Pl. 1, Figs. 13, 14
1998 *Remaniella catalanoi* Pop, Rehåkovå, Pl. 1, Figs. 3-5
2007 *Remaniella catalanoi* Pop, Andreini et al., Pl. 2, Fig. 4
2007 *Remaniella cadischiana* Colom, Andreini et al., Pl. 2, Figs. 7, 8
2012 *Remaniella catalanoi* Pop, Petrova et al., 62, Figs. (6) 4-6
2013 *Remaniella catalanoi* Pop, Lakova & Petrova, Pl. 6, Figs. 52-55
2016 *Remaniella catalanoi* Pop, Maalaoui & Zargouni, 50, Fig. (4) 16

Description & Remarks: The lorica is similiar to the *R. duranddelgai*, bell-shaped to ovoid with conical aboral pole that include a short caudal appendage. It differs from it by the configuration of the collar. The outer collar is similiar but the inner one is filiform seen as two symmetrical points in thin section.

The representatives of this species was identified from the *Remaniella* (middle Early Berriasian) and the *elliptica* (latest Early Berriasian) subzones (Fig. 12). Although the lorica shape is easy to recognize and differentiates them from *R. filipescui* and *R. cadischiana,* taking a good photograph that clearly show the inner collar was very hard. This is why the identified specimens were named with a question mark.

Remaniella borzai Pop, 1994

Pl. 5, Fig. n

1994b *Remaniella borzai* n. sp., Pop, Pl. 1, Figs. 13-16
1998 *Remaniella borzai* Pop, Rehåkovå, Pl. 1, Figs. 11-12
2007 *Remaniella borzai* Pop, Andreini et al., Pl. 2, Fig. 19

2012 *Remaniella borzai* Pop, Petrova et al., 62, Fig. (6) 9

2013 *Remaniella borzai* Pop, Lakova & Petrova, Pl. 7, Fig. 22

2016 *Remaniella borzai* Pop, Maalaoui & Zargouni, 50, Fig. (4) 18

Description & Remarks: It differs from the *R. catalanoi* by its elongated cylindrical lorica. The collars are similiar, again the inner one is filiform and the outer collar is divergent, lenticular. It may be hard to differentiate this species with *Tintinopsella longa* when the inner collar is hard to recognize.

Only an individual of this species was identified from the *oblonga* subzone (Late Berriasian) in this study (Pl. 5, Fig. n) which show an oblique section of this species.

Remaniella filipescui Pop, 1994

Pl. 5, Figs. o-u

1965 *Remaniella cadischiana* Colom, Catalano, Pl.1, Fig. 13

1985 *Remaniella cadischiana* Colom, Remane, 570, Fig. (18) 19

1991 *Remaniella cadischiana* Colom, Altıner & Özkan, Pl. 5, Figs. 4-6, 8, 9

1994b *Remaniella filipescui* n. sp., Pop, Pl. 1, Figs. 7-12

1996 *Praecalpionellites filipescui* Pop, Grün & Blau, Pl. 2, Figs. 7, 10.

1997 *Praecalpionellites filipescui* Pop, Grün & Blau, Pl. 2, Fig. 4

1998 *Remaneialla filipescui* Pop, Rehȧkovȧ, Pl. 1, Figs. 13-15

1999 *Praecalpionellites filipescui* Pop, Grün & Blau, 207, Fig. 3

2006 *Praecalpionellites filipescui* Pop, Grabowski & Pszczółkowski, 405, Fig. 7K

2007 *Remaniella filipescui* Pop, Andreini et al., Pl. 2, Figs. 20, 22

2010 *Praecalpionellites filipescui* Pop, Fözy et al., 537, Figs. 9N, ?9T

2013 *Remaniella filipescui* Pop, Lakova & Petrova, Pl. 3, Fig. 17; Pl. 4, Fig. 10

2015 *Remaniella filipescui* Pop, Boorovȧ et al., 103, Fig. 6E

Description & Remarks: It differs from the *R. cadischiana* by its bell-shaped lorica with conical aboral part that show caudal appandage. It has two unequal, divergent collars that are oblique in position with respect to the lorica wall. This configuration of the collar differs this species from the other members of *Remaniella*. Its maximum with is near the oral part (in axial sections, oblique sections will reveal convex lorica walls that may give a view of slight restriction at the oral end).

It ranges from the uppermost parts of the *Remaniella* subzone (middle Ealry Berriasian) to the upper parts of the *oblonga* subzone (latest Berriasian) in the studied samples (Fig. 12).

Remaniella cadischiana Colom, 1948

Pl. 5, Figs. v-aa

1948 *Tintinnopsella cadischiana* n. sp., Colom, Pl.12, Figs. 34-35
1965 *Remaniella cadischiana* Colom, Catalano, Pl. 1, Figs. 6, 7, 11-14; Pl. 3, Fig. 1
1994b *Remaniella cadischiana* Colom, Pop, Pl. 1, Figs. 1-4
1996 *Praecalpionellites dadayi* Knauer, Grün & Blau, Pl. 1, Figs. 1-3
1996 *Remaniella cadischiana* Colom, Grün & Blau, Pl. 1, Figs. 4-7
1997 *Remaniella cadischiana* Colom, Grün & Blau, Pl. 2, Fig. 1
1997 *Praecalpionellites dadayi* Knauer, Grün & Blau, Pl. 2, Fig. 5
1998 *Remaniella cadischiana* Colom, Rehảkovả, Pl. 1, Figs. 16, 17
2004 *Praecalpionellites dadayi* Knauer, Concetta Marino et al., Pl. 3, Fig. 13
2006 *Remaniella cadischiana* Colom, Grabowski & Pszczółkowski, 405, Fig. 7H
2007 "*Praecalpionellites*" *dadayi* Knauer, Andreini et al., Pl. 2, Fig. 21
2010 *Praecalpionellites dadayi* Knauer, Fözy et al., 537, Fig. 9C
2010 *Remaniella cadischiana* Colom, Fözy et al., 537, Fig. 9K
2012 *Remaniella cadischiana* Colom, Petrova et al., 62, Figs. (6) 7, 8
2013 *Remaniella cadischiana* Colom, Lakova & Petrova, Pl. 3, Fig. 18; Pl. 7, Figs. 23, 24
2015 *Remaniella cadischiana* Colom, Boorovả et al., 103, Fig. 6F
2016 *Remaniella cadischiana* Colom, Maalaoui & Zargouni, 50, Figs. (4) 13, 14

Description & Remarks: It differs from the *R. filipescui* by its cylindrical, elongated lorica with acute aboral part that has caudal appendage. The collar configurations is similiar with the *R. filipescui*.

The specimens of *R. cadischiana* were recovered from middle of the *elliptica* subzone (Late Berriasian) to the uppermost levels of the *oblonga* subzone (latest Berriasian) (Fig. 12).

Generally, after the emendations on the genus *Remaniella* (Pop, 1994a; Grün & Blau, 1996), revisions have been made to the previously published bizonation schemes with introduction of more subdivisions, although the main zonal boundaries have remained the same with the Remane's 1971 scheme (Table 3). Among them, Grün and Blau (1997)'s scheme proposed an unusual first occurrence for the *Remaniella catalanoi* in the *Crassicollaria* zone. They introudced a *catalanoi* subzone as the equivalent of the previously defined *colomi* subzone (Table 3). Then it was understood that the Late Tithonian *Crassicollaria* zone is missing and *elliptica* subzone (of *Calpionella* zone) is in direct contact with the *remanei* subzone (of *Crassicollaria* zone) in the Rau Stau section on which Grün and Blau (1997) based their biozonation (Rehåkovå, 1998). Additionally the definition of the genera *Remaniella* and *Praecalpionelllites* in the studies of Grün and Blau (1996, 1997) were very unusual that differentiates them mainly according to the shape of the lorica instead of the collar partitions. They eliminated the tripartite collar definition. This emendation had introduced additional problems in the identification of the remaniellid calpionellids and the determination of their stratigraphical ranges. In this study, Pop (1994a, 1996)' s emendations were followed for the identification of them. In most recent studies mainly these definitions have been followed as the synonmy lists indicate. As mentioned in the Chapter 2, more recently, Lakova and Petrova (2012, 2013) tried to synthesize a global standard calpionellid zonation scheme. In order to achieve this aim, they discarded taxa with controversial vertical ranges and morphologies and subzones that are not recognized globally. They dismissed all zonation based on the controversial taxa like *R. borzai*, *R. colomi*, *R. catalanoi*, *R. catalanoi* and *R. cadischiana*. So the identification of remaniellid calpionellids are not so important in terms of biostratigraphy, except from the *Remaniella ferasini* that defines the lower boundary of the *Remaniella* subzone.

Genus *Lorenziella* Knauer & Nagy, 1963

Type species: *Lorenziella hungarica* Knauer & Nagy, 1963

Lorenziella hungarica Knauer & Nagy, 1963

Pl. 6, Fig. b

1963 *Lorenziella hungarica* n. sp., Knauer & Nagy, Pl. 1, Figs. 1, 4, 7, 8
1985 *Lorenziella hungarica* Knauer & Nagy, Remane, 570, Figs. (18) 16-18
1991 *Lorenziella hungarica* Knauer & Nagy, Altıner & Özkan, Pl. 5, Figs. 17-18
1991 *Lorenziella hungarica* Knauer & Nagy, Tunç, Pl. 4, Fig. 1
1992 *Lorenziella hungarica* Knauer & Nagy, Tunç, Pl. 2, Fig. 12
1996 *Lorenziella hungarica* Knauer & Nagy, Grün & Blau, Pl. 2, Fig. 5
1997 *Lorenziella hungarica* Knauer & Nagy, Grün & Blaue, Pl. 2, Figs. 6, 7
1999 *Lorenziella hungarica* Knauer & Nagy, Lakova et al., Pl. 1, Fig. 5
2006 *Lorenziella hungarica* Knauer & Nagy, Grabowski & Pszczółkowski, 405, Fig. 7L
2010 *Lorenziella hungarica* Knauer & Nagy, Fözy et al., 537, Fig. 9F
2012 *Lorenziella hungarica* Knauer & Nagy, Petrova et al., 60, Figs. (5) 18-21
2013 *Lorenziella hungarica* Knauer & Nagy, Lakova & Petrova, Pl. 3, Figs. 5-8; Pl. 7, Figs. 9-12

Description & Remarks: *Lorenziella hungarica* is characterized by a small test with a rounded aboral pole and suboral constriction. The funnel-shaped collar is reduced in size seen as inwardly convex symmetric crescentic shapes at the oral part in thin sections. There is no shoulder or swelling below the collar. It may be confused with oblique sections of smaller forms of *T. carpathica*.

This species was recovered from the *oblonga* subzone (Late Berriasian) (Fig. 12) and is very rare in the studied sections.

Genus *Borzaiella* Grün & Blau, 1996

Type species: *Borzaiella atava* Grün & Blau, 1996

Borzaiella atava Grün & Blau, 1996

Pl. 6, Figs. e-g

1996 *Borzaiella atava* n. gen., n. sp., Grün & Blau, Pl. 2, Figs. 1, 2, 6
1997 *Borzaiella atava* Grün & Blau, Grün & Blau, Pl. 2, Fig.3
2007 *Borzaiella atava* Grün & Blau, Andreini et al., Pl. 2, Fig. 23
2012 *Borzaiella atava* Grün & Blau, Petrova et al., 62, Fig. (6) 28

Description & Remarks: The characteristic feature of this species is the single comma-shaped collar that abuts the wall of lorica at the oral end. The lorica is amphora-shaped with caudal appendage. This species has been considered to be very rare (Andreini et al., 2007).

The representatives of this species were recovered from the *oblonga* subzone (Late Berriasian) (Fig. 12). In our samples, mostly the oblique sections were encountered that do not show caudal appandage.

Genus *Praecalpionellites* Pop, 1986

Type species: *Calpionellites murgeanui* Pop, 1974

Praecalpionellites murgeanui Pop, 1974

Pl. 6, Figs. c

1974 *Calpionellites murgeanui* n. sp., Pop, 105, Figs. 1a-b; Pl. 1, Figs. 1-5, 7-9
1985 *Remaniella murgeanui* Pop, Remane, 570, Fig. (18) 20
1986 *Praecalpionellites murgeanui* Pop n. gen., Pop, 104, Figs. 1c-d; Pl. 1, Figs. 4, 5
1991 *Remaniella murgeanui* Pop, Altıner & Özkan, Pl. 5, Fig. 10
1994b *Praecalpionellites murgeanui* Pop, Pop, Pl. 2, Figs. 4, 5
?1996 *Praecalpionellites murgeanui* Pop, Grün & Blau, Pl. 2, Fig. 11
1997 *Praecalpionellites murgeanui* Pop, Grün & Blau, Pl. 2, Fig. 11
1999 *Praecalpionellites murgeanui* Pop, Lakova et al., Pl. 1, Fig. 16
1999 *Praecalpionellites murgeanui* Pop, Grün & Blau, 207, Fig. 2

?2007 *Praecalpionellites murgeanui* Pop, Andreini et al., Pl. 2, Fig. 17; Pl. 3, Figs.1, 6
2010 *Praecalpionellites murgeanui* Pop, Fözy et al., 537, Fig. 9D
2013 *Praecalpionellites murgeanui* Pop, Lakova & Petrova, Pl. 4, Figs. 12-15; Pl. 7, Figs. 15-17

Description & Remarks: The most characteristic feature of this genus is the tripartite collar system (actually a bipartite collar placed just below the end of the lorica, giving a tripartite appearance in the sense of Grün & Blau, 1999). It differs from the *Pcts. siriniaensis* by its smaller, amphorellid lorica.

This species is very rare in the studied sections and was recorded from the uppermost parts of the *oblonga* subzone (latest Berriasian) (Fig. 12).

Praecalpionellites siriniaensis Pop, 1986

Pl. 6, Figs. d

1986 *Praecalpionellites siriniaensis* n. sp., Pop, 105, Figs. 1a-b; Pl. 1, Figs. 1-3
1994b *Praecalpionellites siriniaensis* Pop, Pop, Pl. 2, Fig. 6
1997 *Praecalpionellites siriniaensis* Pop, Grün & Blau, Pl. 2, Fig. 10
2010 *Praecalpionellites siriniaensis* Pop, Fözy et al., 537, Fig. 9E
2013 *Praecalpionellites siriniaensis* Pop, Lakova & Petrova, Pl. 4, Figs. 16, 17; Pl. 7, Figs. 18-20

Description & Remarks: *Pcts. sirniaensis* differs form *Pcts. murgeanui* by its elongated, cylindrical lorica. It also has tripartite collar.

This species was recorded from the uppermost part of the *oblonga* subzone (latest Berriasian) (Fig. 12).

Genus *Calpionellites* Colom, 1948

Type species: *Calpionella darderi* Colom, 1934

Calpionellites darderi Colom, 1934

Pl. 6, Figs. a

1934 *Calpionella darderi* n. sp.,Colom, Pl. 31, Fig. 3
1948 *Calpionellites darderi* Colom n. gen., Colom, 258, Fig. (12) 1-15
1985 *Calpionellites darderi* Colom, Remane, 570, Fig. (18) 5, 6
1991 *Calpionellites darderi* Colom, Altıner & Özkan, Pl. 5, Figs. 11-16
1991 *Calpionellites darderi* Colom, Tunç, Pl. 4, Figs. 4, 5
1994b *Calpionellites darderi* Colom, Pop, Pl. 2, Figs. 7, 8
1997 *Calpionellites darderi* Colom, Grün & Blau, Pl. 2, Fig. 12
2004 *Calpionellites darderi* Colom, Concetta Marino et al., Pl. 3, Fig. 16
2007 *Calpionellites darderi* Colom, Andreini et al., Pl. 3, Fig. 5
2010 *Calpionellites darderi* Colom, Fözy et al., 537, Fig. 9A-B
2013 *Calpionellites darderi* Colom, Lakova & Petrova, Pl. 4, Figs. 20-24; Pl. 7, Figs. 25, 26
2015 *Calpionellites darderi* Colom, Boorovȧ, 103, Fig. 6S

Description & Remarks: *Cts. darderi* is characterized by oral restriction resulted from an inward deflection of a collar just below the end of the lorica wall. It differs from the *Cts. major* by its bell-shaped shorter lorica and from other species (*Cts. coronatus* and *Cts. caravacaensis*) of this genus by its simple conical collar.

The first occurrence of this species determines the basal boundary of the *Calpionellites* Zone/ *darderi* subzone and the Berriasian – Valanginian boundary (Table 3, Fig. 12).

4.2. Foraminifera Taxonomy

PHYLUM FORAMINIFERA d’Orbigny 1826

FAMILY GLOBULIGERINIDAE Loeblich & Tappan 1984

Genus *Globuligerina* Bignot & Guyader, 1971

Type species: *Globuligerina oxfordiana* Grigelis, 1958

Globuligerina oxfordiana Grigelis, 1958

Pl. 8, Fig. a

1958 "*Globigerina*" *oxfordiana* n. sp., Grigelis, 110-111, Fig. 1

1966 *Globigerina oxfordiana* Grigelis, Bignot & Guyader, Pl. 1, Figs. 1-11

1971 *Globuligerina oxfordiana* Grigelis, Bignot & Guyader, Pl.1, Figs. 1-4; Pl. 2, Figs. 3, 4

1991 *Globuligerina* gr. *oxfordiana* Grigelis, Altıner, Pl. 1, Figs. 1-9

1997 *Globuligerina oxfordiana* Grigelis, Boudagher-Fadel et al., Pl. 1.1, Fig. 1; Pl. 1.2, Figs. 1-5; Pl. 2.9; Figs. 1-15

1998 *Globuligerina oxfordiana* Grigelis, Banner & Desai, Pl. 1, Figs. 1-3

2002 *Globuligerina oxfordiana* Grigelis, Görög & Wernli, Pl. 1, Figs. 1-27

2016 *Globuligerina oxfordiana* Grigelis, Grigelis, Pl. 1, Figs. 1-4; Pl. 2, Figs. 1-4; Pl. 3, Figs. 1-4; Pl. 5, Figs. 1-4

Description & Remarks: The wall is hyaline. It is trochospirally coiled with two whorls. Each whorl includes 4 globular chambers, easily recognizable in equatorial sections (like in the Pl. 8, Fig.a). The test is small with a narrow umbilicus. The outline the test is rounded. Only one specimen of this species was recovered from the Kimmeridgian (Fig. 12).

Test diameter: 120 µm

Test wall thickness: 8.29 - 12.75 µm

?FAMILY ROSALINIDAE REISS 1963

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

Type species: *Conicospirillina basiliensis* Mohler, 1938

Mohlerina basiliensis Mohler, 1938

Pl. 8, Figs. b-l

1938 *Conicospirillina basiliensis* n. sp., Mohler, Pl. 28-28; Pl. 4, Fig.5
1991 "*Conicospirillina*" *basiliensis* Mohler, Altıner, Pl. 3, Figs. 8, 9; Pl. 7, Figs. 6-8
1996 *Mohlerina basiliensis* Mohler, Bucur et al., Pl. 3, Figs. 3-6; Pl. 4, Figs. 2, 3, 5-9
2010 *Mohlerina basiliensis* Mohler, Ivanova & Kolodziej, Pl. 5, Figs. 12-18
2012 *Mohlerina basiliensis* Mohler, Schlagintweit, 639, Figs. (2) a-j; 640, Figs. (3) a-d; 641, Figs. (4) a-f; 642, Figs. (5), (6) a-e; 643, Fig. 7d
2015 *Mohlerina basiliensis* Mohler, Okay & Altıner, Fig. (5) 9
2015 *Mohlerina basiliensis* Mohler, Pleş et al., 51, Figs. (4) g, h

Description & Remarks: The test wall consits of two layers; inner microgranular and outer hyaline. Test is large, trochospirally coiled. It may fix itself to any substratum (any type of sediment grains or other fossils) via a basal cement layer. With these characteristics it presents great similarities with Paleozoic foraminifera *Tetrataxis* that has the layers of the test in the other way around (inner hyaline, outer microgranular) (for more discussion see Schlagintweit, 2012). In our material no specimen was observed in encrusting position. Individuals of this species were recovered from the slope and carbonate platform environments in this study and generally represented by resedimented individuals. The reported wide range of test dimensions most probably a function of the encrusting processes (depending on the shape of the substratum to which organism attached itself) (Schlagintweit, 2012).

It ranges from Middle Jurassic to Early Cretaceous and recorded from the Kimmeridgian to Early Berriasian interval in this study (Fig. 12). The most of the examples identified here represents the transported, resedimented individuals.

Max. test diameter: 537 - 1227 μm
Max. test height: 159 - 395 μm
Max. test apex angle (spiral side): 96 - 162°

FAMILY VENTROLAMINIDAE WEYNSCHENCK 1950

Genus *Protopeneroplis* Weynschenk, 1950

Type species: *Protopeneroplis striata* Weynschenk, 1950

Protopeneroplis striata Weynschenk, 1950

Pl. 7, Figs. a-c

1950 *Protopeneroplis striata* n. sp., Weynschenk, Pl. 2, Figs. 12-14
1974 *Protopeneroplis striata* Weynschenk, Septfontaine, Pl. 2, Figs. 1-15
1991 *Protopeneroplis striata* Weynschenk, Altıner, Pl. 3, Figs. 1-7
1997 *Protopeneroplis striata* Weynschenk, Bucur, Pl 1, Figs. 1-12
2010 *Protopeneroplis striata* Weynschenk, Ivanova & Klodziej, Pl. 5, Figs. 7, 8
2015 *Protopeneroplis striata* Weynschenk, Pleş et al., 48, Fig. 3o

Description & Remarks: The test is involute, planispirally or slightly trochospirally coiled with double wall; inner layer microgranular and outer layer hyaline. This double layering form striation in this species and differentiates it from *Protopeneroplis ultragranulata* (Pl. 7, a-c). In our specimens, mostly oblique sections were encountered.

Some studies (Bucur et al., 1993; Bucur, 1997) extends the range of *P. striata* into Berriasian but generally Aalenian – Late Tithonian interval is accepted for its range (Loeblich & Tappan, 1988; Velic, 2007; Ivanova & Kolodziej, 2010). The represntatives of this species were only recovered from the Kimmeridgian platform succession (Günören Limestone) in this study (Fig. 12).

Max. test width (in axial section): 376 μm (only one specimen provide an axial section)
Max. test diameter: 425 - 471 μm

Protopeneroplis ultragranulata Gorbatchik, 1971

Pl. 7, Figs. e-p

1971 *Hoeglundina* (?) *ultragranulata* n. sp., Gorbatchik, Pl. V, Figs. (2) a-c
1974 *Protopeneroplis trochangulata* n. sp., Septfontaine, Pl. 1, Figs. 1-18
1991 *Protopeneroplis trochangulata* Septfontaine, Altıner, Pl. 7, Figs. 1-5
1993 *Protopeneroplis ultragranulata* Gorbatchik, Bucur, Pl. 2, Figs. 1, 2, 5, 8, 11, 12
1996 *Protopeneroplis ultragranulata* Gorbatchik, Bucur et al., Pl. 3, Figs. 14-17
1997 *Protopeneroplis ultragranulata* Gorbatchik, Bucur, Pl. 1, Figs. 13-16; Pl. II, Figs. 1-14; Pl. III, Figs. 1-3
2010 *Protopeneroplis ultragranulata* Gorbatchik, Ivanova & Klodziej, Pl. 5, Figs. 1-6
2012 *Protopeneroplis ultragranulata* Gorbatchik, Petrova et al., 66, Fig. (8) 28
2015 *Protopeneroplis ultragranulata* Gorbatchik, Okay & Altıner, Fig. (5) 1-5

Description & Remarks: It differs from the *P. striata* by its trochospiral coiling. It ranges from Late Tithonian to Early Valanginian (See Chapter 2). *P. ultragranulata* were recovered from latest Tithonian to Early Berriasian (Fig. 12). As discussed in Chpt. 2, the first occurrence of this species within the studied slope deposits of the Yosunlukbayırı succession is facies controlled, but since it appears within the *Saccocoma* subzone there should not be any question about its proposed stratigraphic position in this study.

Max. test diameter: 376 - 570 μm
Max. test height: 266 - 311 μm

FAMILY MESOENDOTHYRIDAE VOLOSHINOVA, 1958

Genus *Labyrinthina* Weynschenk, 1951

Type species: *Labyrinthina mirabilis* Weynschenk, 1951

Labyrinthina mirabilis Weynschenk, 1951

Pl. 11, Figs. a-f

1951 *Labyrinthina mirabilis* n. sp., Weynschenk, Pl. 1, Figs. 5, 7, 8
1988 *Labyrinthina mirabilis* Weynschenk, Septfontaine, Pl. 1, Figs. 10, 12
1991 *Labyrinthina mirabilis* Weynschenk, Altıner, Pl. 3, Figs. 17-24
2005 *Labyrinthina mirabilis* Weynschenk, Schlagintwiet et al., 31, Figs. (13) a, b
2015 *Labyrinthina mirabilis* Weynschenk, Pleş et al., 46, Figs. (2) a-h

Description & Remarks: The simple, imperforate, microgranular test shows early involute planispiral coiling (Pl.11, Figs. c, d, e & f) and later posses an uncoiled portion (Pl.11, Figs. b, c, d & e). The outer wall includes exoskeletal beams that do not reach to the median parts of the test. They may introduce additional thickness the wall in thin section views (Pl.11, Figs. a-f). The endoskeletal pillars are clearly seen in the uncoiled stage (Pl.11, Figs. a-f). Septfontaine (1988) restricted the stratigraphic range of this species to Late Jurassic. The representatives of this species were identified from Kimmeridgian in this study.

Max. test diameter (coiled portion): 842 – 1197 μm
Max. test width (in longitudinal sections and transverse sections that cut coiled involute portion): 695 – 1071 μm
Max. test height: 1412 – 1869 μm

Genus *Mesoendothyra* Dain, 1958

Type species: *Mesoendothyra izjumiana* Dain, 1958

Mesoendothyra? sp.

Pl. 12, Figs. k

Description & Remarks: Involute enrolled test shows early streptospiral stage, later planispiral but not symmetrical. The wall is microgranular; outer wall imperforate, the inner one alveolar. Only one speciemen was recorded in this study that show early streptospiral stage and later planispiral coiling in the earliest Berriasian, suggesting reworking. The presence of a halo around the specimen (probably a relict of earlier cementation) also support this interpretation.

Test width: 163 μm

Test diameter: 249 μm

FAMILY HAURANIIDAE SEPTFONTAINE, 1988

Genus *Pseudocyclammina* Yabe & Hanzawa, 1926

Type species: *Cyclammina lituus* Yokoyama, 1890

Pseudocyclammina lituus Yokoyama, 1890

Pl. 11, Figs. g-i; Pl. 12, Figs. a, c

1890 *Cyclammina lituus* n. sp., Yokohama, Pl. 5, Fig. 7
1926 *Pseudocyclammina lituus* Yokohama, Yabe & Hanzawa, Pl. 2, Figs. 3-6
1991 *Pseudocyclammina lituus* Yokohama, Altıner, Pl. 4, Fig. 10; Pl. 7, Fig. 14
2005 *Pseudocyclammina lituus* Yokohama, Schlagitnweit, Gawlick & Lein, 38, Figs. 22a-d
2007 *Pseudocyclammina lituus* Yokohama, Krajewski & Olszewska, 301, Fig. 6F
2010 *Pseudocyclammina lituus* Yokohama, Ivanova & Kolodziej, Pl. 4, Figs. 1-10
2015 *Pseudocyclammina lituus* Yokohama, Okay & Altıner, Fig. (5) 24

Description & Remarks: This species is characterized by an early involute planipiral stage (clearly seen in Pl. 12, Fig.a), later uncoiled and by its coarsely alveolar wall and septa (Pl.11 Figs. g-i; Pl. 12, Figs. a, c). In our material except form an individual (Pl. 12, Fig.a), none of the thin sections we assign to this species is a characteristic section of the taxon. Mostly longitudinal, tangential and oblique-transverse sections were encountered in which the recognition of the planispiral stage is not easy. *Pseudocyclammina lituus* ranges from Oxfordian to Hauterivian (Ivanova & Kolodziej, 2010). In this study, it was recovered from the Kimmeridgian of Günören Limestone and the uppermost Tithonian of Yosunlukbayırı Formation (Fig. 12).

Test width: 775 – 1425 μm
Max. test height: 1891 – 2671 μm
Wall thickness: 29 – 157 μm

Genus *Alveosepta* Hottinger, 1967

Type species: *Cyclammina jaccardi* Schrodt, 1894

Alveosepta? sp.

Pl. 12, Fig. b

Description & Remarks: This genus is characterized by planispiral coiling, and an agglutinated wall that bears exoskeleton beams and rafters forming subepidermal network. Septa are also alveolar. It ranges from Oxfordian – Kimmeridgian (Loeblich & Tappan, 1988). Only a questionable broken specimen of this genus was recoverd from Kimmeridgian that show subepidermal network and alvolar septa (Fig. 12). At the center of the thin section photograph, chambers of previous tours can also be seen.

Max. test diameter: 1178 μm

FAMILY EVERTICYCLAMMINIDAE SEPTFONTAINE, 1988

Genus *Everticyclammina* Redmond, 1964

Type species: *Everticyclammina hensoni* Redmond, 1964

Everticyclammina sp.

Pl. 12, Figs. d-i

Description & Remarks: It differs from *Pseudocyclammina* by its short, non-alveolar septa that seen as triangular to rectangular thickened prolongation at the base of the septal face in the equatorial section (Pl. 12, Figs. f, h & j). In comparision to the cribrate aperture of the *Pseudocyclammina*, *Evericyclammina* has simple, short vertical areal slit (Pl. 12, Fig.s d-h). It ranges from Middle Sinemurian to Aptian (Boudagher-Fadel, 2008). The representatives of this genus were recorded from the Kimmeridgian of the Günören Limestone and from the uppermost Tithonian of the Yosunlukbayırı Formation (Fig. 12).

Test width: 859 - 1013 µm

Test height: 851 - 2362 µm

Test diameter: 381 - 1452 µm

FAMILY LITUOLIDAE de BLAINVILLE, 1827

Genus *Ammobaculites* Cushman, 1910

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

Ammobaculites sp.

Pl. 17, Figs. g-i

Description & Remarks: Test is coarsely agglutinated. The early stage is tightly coiled (Pl. 17, Figs. g & i) later uncoiled with rectilinear chambers. Aperture is single, that can be clearly seen in longitudinal thin sections cutting across septal face (Pl. 17, Figs. g-i). In the observed specimens, the apertural face of the previous chamber seems to be penetrating into the succeeding chamber, suggesting slight overlap in addition of new chambers at the outer walls. This genus was observed Kimmeridgian – Tithonian rocks in this study (Fig. 12).

Test length: 379 - 846 μm
Wall thickness: 48 - 53 μm

FAMILY HORMOSINIDAE HAECKEL, 1894

Genus *Reophax* de Montfort, 1808

Type species: *Reophax scorpiurus* de Monfort, 1808

Reophax spp.

Pl. 17, Figs. j-m

Description & Remarks: *Reophax* differs from *Ammobaculites* in having thin wall and by the absence of early coiled stage (Pl. 17, Figs. j-m). It has terminal, rounded aperture situated on a short neck (Pl.17, Figs. k & l). Individuals of this species were observed Tithonian – Berriasian interval in this study.

Test length: 266 - 524 μm
Wall thickness: 16 - 24 μm

FAMILY PFENDERINIDAE SMOUTH & SUGDEN, 1962

Genus *Siphovalvulina* Septfontaine, 1988

Type species: *Siphovalvulina variabilis* Septfontaine, 1988

Siphovalvulina? sp.

Pl. 17, Figs. n-p

Description & Remarks: *Siphovalvulina* has trochospirally coiled, finely agglutinated test. The most caharacteristic feature of this genus is the twisted siphonal canal that travel the test and connects the apertures. Especially longitudinal sections reveals this canal. Additionally in transverse sections the canal can be seen as an inward deflection of a chamber wall. In observed specimens only some transverse sections were recorded that show traces of siphonal canal between the chambers. But, the presence of only two chambers may suggest a biserially coiled form like *Belorussiella*. As Ivanova and Kolodziej (2010) suggest *Belorussiella* does not posses siphonal canal. With this uncertainities, the observed specimens were grouped under the name *Siphovalvulina*? sp. They were recoverd from Tithonian – Berriasian interval in this study.

FAMILY CHARENTIIDAE LOEBLICH and TAPPAN, 1985

Genus *Charentia* Neumann, 1965

Type species: *Charentia cuvillieri* Neumann, 1965

Charentia sp.

Pl. 13, Figs. d-h

Description & Remarks: Test is lenticular and early stage is planispiral involute later with a tendency to uncoil. This uncoiled portion is not observed in our specimens. The base of the apertural face is thickened and may seen as a chomota-like small triangular swellings at the base of the septa. Wall is microgranular. *Charentia* sp. was observed from the Kimmeridgian and from the Upper Tithonian to Lower Berriasian (Fig. 12).

Test diameter: 388 - 621 μm
Test width: 241 - 302 μm
Wall thickness: 7 - 47 μm

FAMILY HAPLOPHRAGMOIDIDAE MAYNC, 1952

Genus *Haplophragmoides* Cushman, 1910

Type species: *Nonionina canariensis* d'Orbigny, 1839

Haplophragmoides joukowskyi (Charollais, Brönnimann & Zaninetti, 1966)

Pl. 17, Figs. a-e

1966 *Haplophragmoides joukowskyi* n. sp., Charollais, Brönnimann & Zaninetti, Pl. 2, Figs. 1, 5, 7; text-fig. 2, 3
1991 *Haplophragmoides joukowskyi* Charollais, Brönnimann & Zaninetti, Altıner, Pl. 8, Figs. 1-16
2005 *Haplophragmoides joukowskyi* Charollais, Brönnimann & Zaninetti, Bucur & Sásáran, Pl. 4, Figs. 1, 2
2008 *Haplophragmoides joukowskyi* Charollais, Brönnimann & Zaninetti, Ivanova et al., 72, Fig.7I
2012 *Haplophragmoides joukowskyi* Charollais, Brönnimann & Zaninetti, Olszewska et al.,Pl. 2, Fig. 3; Pl. 10, Fig. 1
2014 *Haplophragmoides joukowskyi* Charollais, Brönnimann & Zaninetti, Bucur et al., 75, Figs. (8) u-v

Description & Remarks: Small agglutinated tests are planispirally coiled and involute. Test shows umbilical depressions on both sides. In our material, the individuals are usually composed of 7 to 9 chambers in the last whorl (Pl.17, Figs. a-e). Aperture is an elongated equatorial slit at the base of the apertural face, can be recognized in the equatorial sections by the absence of wall material near the base of the septa (Pl. 17, Fig. e). It has been reported from the Berriasian – Valanginian interval (Altıner, 1991; Ivanova, 2000; Olszewska et al.). *H. joukowskyi* were identified form Late Berriasian (*oblonga* subzone) in this study (Fig. 12).

Test diameter: 127 - 147 μm

FAMILY MONTSALEVIIDAE ZANINETTI, SALVINI-BONNARD, CHAROLLAIS & DECROUEZ, 1987

Genus *Montsalevia* Zaninetti, Slavini-Bonnard, Charollais & Decrouez, 1987

Type species: *Montsalevia elavata* Zaninetti, Salvini-Bonnard, Charollais & Decrouez, 1987

Montsalevia salevensis (Charollais, Brönnimann & Zaninetti, 1966)

Pl. 17, Fig. f

1966 *Pseudotextularia salevensis* n. sp. ,Charollais, Brönnimann & Zaninetti, Pl. 1, Figs. 1-5; Pl. 2, Figs. 2, 6; text-fig. 1

1987 “*Montsalevia*” *salevensis* Charollais, Brönnimann & Zaninetti; Zaninetti, Salvini-Bonnard & Decrouez, p. 166

1991 *Montsalevia salevensis* Charollais, Brönnimann & Zaninetti; Altıner, Pl. 11, Figs. 1-23

2005 *Montsalevia salevensis* Charollais, Brönnimann & Zaninetti; Bucur & Sásáran, Pl. 4, Figs. 3-8

2007 *Montsalevia salevensis* Charollais, Brönnimann & Zaninetti; Krajewski & Olszewska, 298, Fig. 5K

2010 *Montsalevia salevensis* Charollais, Brönnimann & Zaninetti; Ivanova & Kolodziej, Pl. 2, Fig. 10

2014 *Montsalevia salevensis* Charollais, Brönnimann & Zaninetti; Bucur et al., 78, Figs. (8) j-r

Description & Remarks: Test is conical, small. Chambers are biserially arrenged. Chambers aditionally are subdivided by exoskeletal beams that can be easily seen in transervse sections, and tangential sections. It ranges from Late Berriasian to Hauterivian (Krajewski & Olszewska, 2007). Only one specimen was observed from Lower Valanginian rocks in this study (Fig. 12).

Test length: 162 µm
Chamber height: 12 - 23 µm (from the first series to the final chambers)
Wall thickness: 5 - 10 µm
Beam thickness: 4 - 10 µm

FAMILY COSCINOPHRAGMATATIDAE THALMANN, 1951

Genus *Coscinophragma* Thalmann, 1951

Type species: *Lichenopora cribrosa* Reuss, 1846

Coscinophragma cribrosum Reuss, 1854

Pl. 13, Figs. a-c

1846 *Lichenopora cribrosa* n. sp., Reuss, Pl. 14, Fig. 10; Pl. 24, Figs. 3-5
1957 *Coscinophragma cribrosum* Reuss, Maync, 184, Figs. 1-3; 185, Fig. 4
1996 *Coscinophragma cribrosum* Reuss, Bucur et al., Pl. 1, Figs. 1, 5, 6; Pl. 6, Figs. 1-3, 5
1999 *Coscinophragma cribrosum* Reuss, Schlagintweit & Ebli, Pl. 5, Fig. 6
2010 *Coscinophragma cribra* Reuss, Bucur et al., Pl. 3, Fig. 13
2010 *Coscinophragma cribrosum* Reuss, Ivanova & Kolodziej, 27, Figs. 1-4

Description & Remarks: The test is more or less cylindrical or curved tube. The anastomosing character of the irregular internal projections forms a coarsely cellular structure. It was recorded from the Late Tithonian – Early Berriasian interval (Fig. 12).

FAMILY NAUTILOCULINDAE LOEBLICH and TAPPAN, 1985

Genus *Nautiloculina* Mohler, 1938

Type species: *Nautiloculina oolithica* Mohler, 1938

Nautiloculina sp.

Pl. 13, Figs. i-k

Description & Remarks: Previously, debate on the wall type (whether the wall is microgranular or porcelaneous) gave rise to placement of this genus into different taxonomic levels (into lituloids by Loeblich & Tappan, 1988; into miliolines by Loeblich & Tappan, 1964 and Boudagher-Fadel, 2008). Recently, Kaminski (2004) has grouped Nautiloculunidae under suborder Nezzazatina that is characterized by trochospiral to planispiral test with simple microgranular wall.

The shape of the test is nautiliform, planispirally coiled, involute. The inner and outer wall is simple without any exoskeletal and endoskeletal structure. In thin section it may be easily confused with *Charentia*. *Nautiloculina* differs from the *Charentia* by the absence of chomata-like, basal septal projections and in having blunt septa characteristicly seen in equatorial sections.

The individuals of this genus were recovered from Kimmeridgian and Tithonina intervals in this study (Fig. 12).

Test diameter: 348 - 538 µm

Test width: 214 - 390 µm

Wall thickness: 11 - 34 µm

FAMILY TEXTULARIOPSIDAE LOEBLICH & TAPPAN, 1982

Genus *Haghimashella* Neagu & Neagu 1995

Type species: *Haghimashella arcuata* Haeusler, 1890

Haghimashella? sp.

Pl. 18, Figs. a-c

Description & Remarks: *Haghimashella* has early biserial stage and later uniserial. The biserial stage show deep oblique sutures resulted from the chamber shape and slight overlapping of each successive chambers. The observed individuals in this study show two-series of biserial arrengment then continue with uniserial part that has 2 to 3 chambers. The samples were identified from the Kimmeridgian – Tithonian interval.

FAMILY TEXTULARIIDAE EHRENBERG, 1838

Genus *Textularia* Defrance, 1824

Type species: *Textularia sagittula* Defrance, 1824

Textularia spp.

Pl. 18, Figs. d-i

Description & Remarks: All finely agglutinated tests showing biserial arrangement. were grouped under *Textularia* spp. in this study. These forms generally show 5 to 7 rows of bisearial chambers with globular, semiglobular and rectengular chambers. The individuals were recovered from the Kimmeridgian – Valanginian interval in this study.

FAMILY TROCHAMMINIDAE SCHWAGER, 1877

Genus *Trochammina* Parker & Jones, 1859

Type species: *Nautilus inflatus* Montagu, 1808

Trochammina sp.

Pl. 18, Fig. s

Description & Remarks: Trochospiral test with thick agglutinated wall. Periphery is rounded. *Trochammina* sp. was identified from the Kimmeridgian in this study.

FAMILY PARAVAVULINIDAE BANNER, SIMMONS & WHITTAKER, 1991

Genus *Redmondoides* Banner, Simmons & Whittaker, 1991

Type species: *Pseudomarssonella media* Redmond, 1965

Redmondoides? sp.

Pl. 18, Figs. k-n

Description & Remarks: Wall is finely agglutinated. Characteristic quadriserial arrangement could not be observed in the studied samples. Due to the great similarites of the observed samples with the individuals attributed to the *Redmondoides* genus in the literature (like Ivanova et al., 2008, p. 71, Fig.&H ;Ivanova & Kolodziej, 2010, Pl. 1, Figs. 6-8), specimens with at least 5 rows of chambers that show agglutinated wall and well separated septal flaps were grouped under *Redmondoides*? sp..

The specimens were observed from the Kimmeridgian – Berriasian interval in this study.

FAMILY PROLIXOPLECTIDAE LOEBLICH & TAPPAN 1985

Genus *Protomarssonella* Desai & Banner, 1987

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

Protomarssonella sp..

Pl. 18, Fig. j

Description & Remarks: The most characteristic feature of this genus is the conical test shape with straight side walls and flattend septal surface. Coiling is early trochospiral to biserial. It is identfied from the Tithonian – Berriasian interval in this study.

FAMILY HAUERINIDAE SCHWAGER, 1876

Genus *Quinqueloculina* d'Orbigny, 1826

Type species: *Serpula seminulum* Linné, 1758

Quinqueloculina spp.

Pl. 13, Figs. l-o Pl. 14, Figs. a-m

Description & Remarks: Porcelaneous test is ovate in outline. It shows quinqueloculine coiling that is coiling axis shift 72° in each half of coiling resulted in 144° gap between successive chambers in transverse sections. In axial sextions, it is not possible to trace all chambers from the proloculus to the final chamber without coming across wtih the wall material as a result of shift in coiling axis. The individuals of this genus were identified from the Kimmeridgian to Early Berriasian interval in this study (Fig. 12).

Genus *Moesiloculina* Neagu, 1984

Type species: *Quinqueloculina danubiana* Neagu, 1968

Moesiloculina spp.

Pl. 15, Figs. a, b, d-h

Description & Remarks: Porcelaneous test is ovate in outline. Coiling is quinqueloculine. Carinae like thickening is characteristic in transverse sections, at the periphery of the test.

This genus was recorded from the Tithonian - Berriasian interval in this study (Fig. 12).

Genus *Istriloculina* Neagu, 1984

Type species: *Pyrgo elliptica* Yovcheva, 1962

Istriloculina spp.
Pl. 15, Figs. i-n

Description & Remarks: The most characteristic feature of this genus is the thin porcelaneous wall. The coiling is quinqueloculine in the early stage, later pseudotriloculine to biloculine. The individuals of this genus were identified from the Tithonian – Berriasian interval (Fig. 12).

FAMILY CORNUSPIRIDAE SCHULTZE, 1854

Genus *Cornuspira* Schultze, 1854

Type species: *Orbis foliaceus* Philippi, 1844

Cornuspira sp.
Pl. 15, Figs. o-s

Description & Remarks: Discoidal test planispirally coiled and evolute. Proloculus is followed by undivided second chamber and the wall is porcelaneous. It was identified from the Tithonian – Berriasian interval (Fig. 12).

Genus *Meandrospira* Loeblich & Tappan, 1964

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

Meandrospira favrei Charollais, Brönnimann & Zaninetti, 1966
Pl. 16, Figs. l-m

1966 *Citaella*? *favrei* n. sp., Charollais, Brönnimann & Zaninetti, Pl. 2, Figs. 3, 4; Pl. 3, Figs. 1-5; Pl.5, Figs. 1, 2; text-figs. 4-6

1988 *Meandrospira favrei* Charollais, Brönnimann & Zaninetti, Bucur, Pl. 2, Figs. 1-3

1991 *Meandrospira favrei* Charollais, Brönnimann & Zaninetti, Altıner, Pl. 13, Figs. 1-5

1999 *Meandrospira favrei* Charollais, Brönnimann & Zaninetti, Schlagintwiet & Ebli, Pl. 4, Figs. 8, 11

2008 *Meandrospira favrei* Charollais, Brönnimann & Zaninetti, Ivanova et al., 72, Figs. (7) N, O

2012 *Meandrospira favrei* Charollais, Brönnimann & Zaninetti, Olszewska et al., Pl. 2, Figs. 4a, b; Pl. 10, Fig. 3

Description & Remarks: Porcelaneous test is composed of a proloculus which is followed by a second undivided tube that bends back and forth in involute zigzag bends (meandering second tube). Exact equatorial sections gives an impression of planispiarlly coiled multilocular specimen. Slight obliquity in a section is enough to reveal zigzag bends. The specimens were identified from the latest Tithonian – Late Berriasian interval.

As previoulsy discussed in Chpt. 2, the unexpected occurrence of *Meandrospira favrei* in the *massutiniana* subzone (latest Tithonian) is unusual and contradicts with the previously published data. Altıner (1991), Rojay and Altıner (1998) and Ivanova (1999) reported Late Valanginian onward occurrence of the taxon (Table 3). Although there are other studies suggesting base Valanginian first occurrence like Ivanova et al. (2008, from Bulgaria), Ivanova and Kolodziej (2010, from Polish Carpathians) and Bucur et al. (2014, from southern Carpathians Romania) and latest Berriasian first appearance like Krajewski and Olszewska (2007, from Crimea Mountains) and Velić (2007, from Kars Dinarides), there is no report on the Tithonian occurrence of the form. There can be two possiblities; (1) the identification in this study could well be erroneous, the identified specimens may belong to another species of the genus that shows great convergent evolutionary morphology to the *M.*

favrei or (2) the taxon could have been evolved in an anonymous period in the Jurassic with a modest population size and then may have been dispersed and its acme may have been recorded diachronously in the Late Valanginian (Altıner, 1991; Rojay & Altıner, 1998 and Ivanova, 1999), at the base of Valanginian (Ivanova & Kolodziej, 2010; Bucur et al., 2014) and in the latest Berriasian (Krajewski and Olszewska, 2007; Velić, 2007). For the first case, all previously proposed first occurrences could be the real first occurrences for the studied areas indicating slight diachronism in the dispersion of the taxon. In the second case, all other reported first occurrences should represent local first occurrences and the acme of the taxon. In any case, the biozones defined by the first occurrence of *Meandrospira favrei* in the works of Altıner (1991), Rojay and Altıner (1998) and Ivanova (1999) still provide useful biohorizon at least for regional correlations, if not present a biozone with globally synchronous basal boundary.

Test diameter: 108 - 115 μm

Genus *Meandrospira* Loeblich & Tappan, 1964

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

Meandrospira spp.
Pl. 16, Figs. e-k

Description & Remarks: Individuals that cannot be assigned a certain species of *Meandrospira* genus are grouped under *Meandrospira* spp. They were observed from the Early Tithonian – Late Berriasian interval in this study.

Genus *Meandrospiranella* Salaj, 1969

Type species: *Meandrospiranella samueli* Salaj in Salaj et al., 1967

Meandrospiranella sp.

Pl. 16, Fig. n

Description & Remarks: Early stage is *Meandrospira*-like, later irregular and uncoiling. Wall is porcelaneous. A speciemen of this genus was identifed from the Kimmeridgian in this study.

FAMILY AMMODISCIDAE REUSS, 1862

Genus *Glomospira* Rzehak, 1885

Type species: *Trochammina squamata* Jones & Parker, 1860

Glomospira sp.

Pl. 16, Figs. a-d

Description & Remarks: Proloculus is followed by stretptopirally to irregularly coiled second undivided tube. Wall is finel-agglutinated. The examples of this genus were identified from the Kimmeridgian – Berriasian interval (Fig. 12).

FAMILY TROCHOLINIDAE KRISTAN-THOLMANN, 1963

Genus *Coscinoconus* Leupold *in* Leupold and Bigler, 1936

Type species: *Coscinoconus alpinus* Leupold *in* Leupold and Bigler, 1936

Coscinoconus spp.

Pl. 19, Figs. a-h; Pl. 20, a-e

Description & Remarks: It is characterized by reduced lamellae on the spiral side. The aragonitic test is low (Pl. 19, Figs. a & c; Pl. 20, Fig. e) to high (Pl. 19, Figs. b, d-h; Pl. 20, Figs. a-e) trochospirally coiled, proloculus followed by second chamber. The stratigraphical range includes Bathonian – Cenomanian interval (Rigaud et al., 2013). The representatives of the genus were recovered from Upper Tithonian – Lower Berriasian successions in this study (Fig. 12).

Neotrocholina spp.

Pl. 20, Figs. f-l

Description & Remarks: The most characteristic feature of this trochospirally coiled form is the presence of well-defined umbilical pillars. The outer wall is thicker when compared with *Coscinoconus*. Rigaud et al. (2013) discarded this genus from Trocholinidae due to the calcitic wall material. Individuals of this genus were identified from the the Tithonian – Valanginian interval in this study.

FAMILY SPIRILLINIDAE REUSS & FRITSCH, 1861

Genus *Spirillina* Ehrenberg, 1843

Type species: *Spirillina vivipara* Ehrenberg, 1843

Spirillina spp.

Pl. 21, Figs. b-i

Description & Remarks: The calcite, discoidal test is planispirally coiled. The proloculus is followed by a seconday undivided tube. Plane of coiling may show slight oscilations as can be seen in the illustrated samples (Pl. 21, Figs. b, d, g, l). The genus was identified from the Kimmeridgian – Valanginian interval in this study (Fig. 12).

FAMILY VAGINULINIDAE REUSS, 1860

Genus *Lenticulina* Lamarck, 1804

Type species: *Lenticulina rotulatus* Lamarck, 1804

Lenticulina sp.

Pl. 21, Figs. m, n

Description & Remarks: The hyline test is planispirally coiled, involute. Test is biconvex (Pl. 21, Fig. m). Chambers somewhat rapidly increasing in size as new chambers added (Pl. 21, Fig. n). *Lenticulina* sp. was recorded from the Kimmeridgian – Valanginian interval.

FAMILY PATELLINIDAE RHUMBLER, 1906

Genus *Patellina* Williamson, 1858

Type species: *Patellina corrugata* Williamson, 1858

Patellina sp.

Pl. 22, Figs. a-d

Description & Remarks: The test shape is conical with flat umbilical side. Wall is calcareous. Presence of keel like projections. Early trochospiral stage (proloculus followed by undivided second chamber) is followed by biserial later stage with crescentic chambers. The representatives of this genus was recovered from the Tithonian to Valanginian interval.

FAMILY TELAMMINIDAE LOEBLICH & TAPPAN, 1985

Genus *Troglotella* Wernli & Fookes, 1992

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

Troglotella incrustans Wernli & Fookes, 1992

Pl. 22, Figs. e-g

1992 *Troglotella incrustans* n. sp., Wernli & Fookes, Pl. 1, 2

1996 *Troglotella incrustans* Wernli & Fookes, Schmid & Leinfelder, 22, Figs. 1, 2; 27, Fig. 3; 28, Fig. 4; Pl. 1, Fig.d 1-6; 36, Fig. 6; Pl. 2, Figs. 1-5

1999 *Troglotella incrustans* Wernli & Fookes, Schlagintweit & Ebli, Pl. 3, Fig. 4; Pl. 6, Fig. 7, 9, 10

2007 *Troglotella incrustans* Wernli & Fookes, Krajewski & Olszewska, 296, Fig. 4b

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

2012a *Troglotella incrustans* Wernli & Fookes, Schlagintweit, 18, Fig. 1; 19, Fig. 3, 4; 20, Fig.5, 6;21, Figs. 7, 8; 22, Fig. 9; 23, Fig. 12;
25, Fig. 15

2015 *Troglotella incrustans* Wernli & Fookes, Pleş et al., 51, Fig. (4) g-i

2015 *Troglotella incrustans* Wernli & Fookes, Okay & Altıner, Fig. (5) 11, 12

Description & Remarks: Typical buble-shaped chambers that grow in uniserial early stage (Pl. 22, Figs. f, g), later irregular (Pl. 22, Fig. e). *Trogrotella incrustans* is commonly associated with enigmatic encruster *Lithocodium aggregatum*, interprated as a commensal relationship (Schmid & Leinfelder, 1996).

The stratigraphic range covers the Kimmeridgian – Berriasian interval (Krajewski & Olszewska, 2007). This taxon was identified from the Kimmeridgian – Berriasian interval in this study (Fig. 12). It is mostly encountered in the Kimmeridgian of Günören Limestone (platform carbonates) and generally found in association with *Lithocodium aggregatum*.

4.3. Taxonomy of *Incertae sedis*, annelids and crinoids

INCERTAE SEDIS (Microproblematica)

Genus *Lithocodium* Elliott, 1956

Type species: *Lithocodium aggregatum* Elliott, 1956

Lithocodium aggregatum Elliott, 1956
Pl. 23, Figs. a-f; Pl. 24, Fig. a, b

1956 *Lithocodium aggregatum* n. sp., Elliott, Pl. 1, Figs., 2, 4, 5
1971 *Lithocodium aggregatum* Elliott, Basson & Edgell, Pl. 1, Fig. 1
1996 *Lithocodium aggregatum* Elliott, Schmid & Leinfelder, 22, Figs. 1, 2; 27, Fig. 3; 28, Fig. 4; Pl. 1, Fig.d 1-6; 36, Fig. 6; Pl. 2, Figs. 1-5
2007 *Lithocodium aggregatum* Elliott, *Bacinella irregularis* Radoičić – *Lithocodium aggregatum* Elliott, Bucur et al., Pl. 3, Fig. 4; Pl. 7, Fig. 3
2010 *Lithocodium aggregatum* Elliott, Bucur et al., Pl. 1, Figs. 4, 5
2013 *Lithocodium aggregatum* Elliott, Pleş et al., 36, Figs. (11) a-d
2014 *Lithocodium aggregatum* Elliott, Kaya & Altıner, Pl. 3, Fig. 3
2015 *Lithocodium aggregatum* Elliott, Pleş et al., 51, Fig. (4) i

Description & Remarks: This encrusting organism is characterized by micritic crust that bears cavities along it that look like alveolar structures. As mentioned previously *Lithocodium aggregatum* is mostly found in association with *Troglotella incrustans* and bacinellid structures. This encruster was identified from the Kimmeridgian – Berriasian interval.

Bacinella (Radoicic 1959) – type structre

Pl. 22, Figs. h, i

Description & Remarks: *Bacinella* is characterized by somewhat regular to irregular cell assemblages. It is commonly associated with *Lithocodium aggregatum* and *Troglotella incrustans*. This type of fabric is known form Middle Triassic to Late Cretaceous (Flügel, 2010) and is observed from the Kimmeridgian – Berriasian interval in this study (Fig. 12).

Genus *Koskinobullina* Cherchi & Schroeder, 1979

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

Koskinobullina socialis Cherchi & Schroeder, 1979

Pl. 24, Figs. c-f

1979 *Koskinobullina socialis* n. sp., Cherchi & Schroeder, Pl. 1

1991 *Koskinobullina socialis* Cherchi & Schroeder, Altıner, Pl. 5, Figs. 30, 31

1999 *Koskinobullina socialis* Cherchi & Schroeder, Schlagintweit & Ebli, Pl. 5, Fig. 7; Pl. 11, Fig. 10

2007 *Koskinobullina socialis* Cherchi & Schroeder, Schlagintweit & Gawlick, 600, Fig. 7l

2013 *Koskinobullina socialis* Cherchi & Schroeder, Pleş et al., 34 ,Fig. 10 e-h
2014 *Koskinobullina socialis* Cherchi & Schroeder, Kaya & Altıner, Pl. 3, Fig. 5

Description & Remarks: *Koskinobullinas socialis* is characterized by superimposed assemblages of hemispherical chambers with calcitic walls that bear irregular pores. It was recoderd from the Tithonian – Lower Berriasian rocks in this study (Fig. 12).

Genus *Thaumatoporella* Raineri, 1922

Type species: *Gyroporella parvovesiculifera*, 1922

Thaumatoporella parvovesiculifera Raineri, 1922

Pl. 26, Figs. h-j

1922 *Gyroporella parvovesiculifera* n. sp., Raineri, Pl. 13, Figs. 17, 18
1999 *Thaumatoporella parvovesiculifera* Raineri, Schlagintweit & Ebli, Pl. 10, Fig. 3
2005 *Thaumatoporella parvovesiculifera* Raineri, Bucur et al., Pl. 5, Fig. 10
2013 *Thaumatoporella parvovesiculifera* Raineri, Schlagintweit, 6, Fig. (1) a-g; 7, Fig. (2) a, b
2014 *Thaumatoporella parvovesiculifera* Raineri, Kaya & Altıner, Pl. 3, Fig. 8

Description & Remarks: Also known as *Thamatoporella* ladders in the literature, this microproblematica is closely related with bacinellid structures, found intermingled with each other. *T. parvovesiculifera* shows a layer of cells, giving comb-like view. They can be found isolated (Pl. 26, i, j) or in an encrusting position (Pl. 26, h) as mentioned by Schlagintweit (2013). The isolated examples have been generally named as *Thaumatoporella* “ladders” (Schlagintweit, 2013). It was observed from the Kimmeridgian – Tihonian interval in this study.

Genus *Crescentiella* Senowbari-Daryan, Bucur, Schlagintweit, Săsăran &

Matyszkiewicz 2008

Type species: *Tubiphytes morronensis* Crescenti, 1969

Crescentiella morronensis Crescenti, 1969

Pl. 9, Figs. a-f; Pl. 10, Figs. a-g

1969 *Tubiphytes morronensis* n. sp., Crescenti, 35-37, Figs. 10, 20-22

1991 *Tubiphytes morronensis* Crescenti, Altıner, Pl. 6, Figs. 4-8

2008 *Crescentiella morronensis* Crescenti, Senowbari-Daryane et al., Pl. 1, Figs. a-i; 193, Figs. a-h; Pl. 3, Figs. a-g; Pl. 3, Figs. a-h; Pl. 5, Figs. a-h; Pl. 6, Figs. a-h; Pl. 7, Figs. l-e

2012 *Crescentiella morronensis* Crescenti, Olszewska et al., Pl. 6, Fig. 1; Pl. 16, Fig. 2

2013 *Crescentiella morronensis* Crescenti, Pleş et al., 26, Figs. (6) d, e; 28, Fig. 7a; 34, Figs. (10) a-d

2015 *Crescentiella morronensis* Crescenti, Okay & Altıner, Fig. (5) 29

Description & Remarks: The most characteristic feature of *C. morronensis* is the dark micritic envelopes and the general outline having a tube-like shape. This encruster may have foraminifera with amphorellid chambers (Pl., 9, d; Pl. 10, b, c) or any other type of clasts in the cortext. The envelope may include any kind of encrusted clats. In this study foraminifera (Pl. 9, Fig. e) and even calpionellids (Pl. 10, Fig. f) were found within the micritic envelops. The last one especially indicates open marine environments for that specific individual that enveloped the calpionellid and then resedimented on a slope environment (the Yosunlukbayırı Formation, see Chapter 3).

The stratigraphic range covers the Oxfordian – Berriasian interval and this species shows an acme in the Kimmeridgian – Tithonian inteval (Pleş et al. 2013). Altıner (1991) used this taxon as a Kimmeridgian-base index fossil in his biozonations (Table 3). As discussed in Chpt. 2, the first occurrence of this taxon is synchronous with the acme of *Saccocoma* sp. (Tithonain base indicator), indicating a facies controlled first occurrence for *Crescentiella morronensis* in this study. It was recorded from the Tithonian – Berriasian interval in the slope deposits (Yosunlukbayırı Fm.) and from the Kimmeridgian in the platform carbonates (Günören Limestone) (Fig. 12). This diachronism clearly indicates a facies controlled distribution and first occurrence of *C. morronensis* in the slope to basin deposits.

Genus *Labes* Eliasova, 1986

Type species: *Labes antramentosa* Eliasova, 1986

Labes antramentosa Eliasova, 1986

Pl. 25, Figs. a-d

1986 *Labes antramentosa* n. sp., Eliasova, Pl. 1, 2
1996 "*Tubiphytes*" *morronensis* colony, Leinfelder et al., 231, Fig. 4
2003 "*Tubiphytes*" like structure, Uta & Bucur, Pl. 4, Fig. 4
2008 *Labes antramentosa* Eliasova, Senowbari-Daryan et al., Pl. 8, Fig. c
2013 *Labes antramentosa* Eliasova, Pleş et al., 40, Figs. (14) e, f

Description & Remarks: As the synonym list suggests (Leinfelder et al., 1996; Uta & Bucur, 2003) it shows similarity with the *Crescentiella morronensis* in having micritic cortex and internal cavity. This encruster differs from *C. morronensis* in having additional tubular cavities in the cortex. It was identified from the Tithonian in this study.

Genus *Radiomura* Senowbari-Daryan & Schäfer, 1979

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

Radiomura cautica Senowbari-Daryan & Schäfer, 1979

Pl. 26, Fig. g

1979 *Radiomura cautica* n. sp., Senowbari-Daryan & Schäfer, Pl. 2, Fig. 6; Pl. 4, Figs. 1-4; Pl. 5, Figs. 2, 3; Pl. 6, Fig. 4; Pl. 7, Fig. 1
2005 *Radiomura cautica* Senowbari-Daryan & Schäfer, Schlagintweit, Pl. 2, Fig. 3 2007 *Radiomura cautica* Senowbari-Daryan & Schäfer, Schlagintweit & Gawlick, 601, Fig. 8
2008 *Radiomura cautica* Senowbari-Daryan & Schäfer, Ivanova et al., 79, Fig. (13) F, G
2013 *Radiomura cautica* Senowbari-Daryan & Schäfer, Pleş et al., 32, Fig. 9g, 39, Figs. (12) e-h
2014 *Radiomura cautica* Senowbari-Daryan & Schäfer, Kaya & Altıner, Pl. 3, Fig. 6

Description & Remarks: This microproblematica is characterized by spherical chambers that has darker, finer grained inner wall. The outer wall is light grey composed of fibrous calcite. The tubes do not show interconnection. Rare individuals were recorded in the Tithonian and Late Berriasian in this study.

Genus *Perturbatacrusta* Schlagintweit & Gawlick, 2011

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

Perturbatacrusta leini Schlagintweit & Gawlick, 2011

Pl. 26, Figs. a-f

2011 *Perturbatacrusta leini* n. sp., Schlagintweit & Gawlick, 129, Figs. (5) c, d, g, h; 132, Figs. (7) a-g
2013 *Perturbatacrusta leini* Schlagintweit & Gawlick, Pleş et al., 26, Fig. 6d; 38,

Figs. (12) a-d

2014 *Perturbatacrusta leini* Schlagintweit & Gawlick, Kaya & Altıner, Pl. 3, Fig. 7

Description & Remarks: *Perturbatacrusta leini* differs from *Radiomura cautica* by its interconnected tubes and lateral closed tubes. *P. leini* was identified from the Tithonian – Berriasian interval in this study.

Genus *Globochaete* Lombard, 1945

Type species: *Globochaete alpina* Lombard, 1945

Globochaete sp. Lombard, 1945

Pl. 27, Figs. k-aa

Description & Remarks: *Globochaete* is characterized by kidney-shaped (Pl. 27, Figs. m, o, r, t), spherical (Pl. 27, Figs. l, n, p, r) calcite bodies that has micritic nucleus (Pl. 27, Figs. k, p s). They may show serial arrangement (Pl. 27, Figs. n, p, s), occur in clusters (Pl. 27, Figs. r, o). They may attach to a calcitic plates (Pl. 27, Figs. l, n). They are abundant in Late Jurassic deep waters (Brönnimann, 1965; Skompski 1982; Altıner, 1991; Flügel, 2010) and attributed to a planktonic single-celled green algae (Skompski 1982). *Globochaete* is observed from the Kimmeridgian – Valanginian interval in this study.

Genus *Pithonella* Lorenz, 1902

Type species: *Pithonella ovalis* Kauffmann in Heer, 1865

Pithonella? sp. Lorenz, 1902

Pl. 21, Figs. r-u

Description & Remarks: Calcareous shell with spherical, elongated, flattened and pyramidal shapes that bear main apical and antapical pores. An affinity to cyst-forming organism dinoflagellates has been suggested by Wendler et al. (2013), recently.

The individuals attributed to this taxon were observed the Kimmeridgian-Berriasian interval in this study (Fig. 12).

Genus *Cayeuxia* Frollo, 1938

Type species: *Cayeuxia piae* Frollo, 1938

Cayeuxia sp. Frollo, 1938

Pl. 22, Figs. j-l

Description & Remarks: *Cayeuxia* is characterizd by parallel tubes showing radial branching in longitudinal sections. This taxon has been attributed to calcareous algae and calcimicrobes (Basson & Edgell, 1971; Flügel, 2010). Representative individuals were recovered from the Kimmeridgian – Tithonian interval in this study (Fig. 12).

PHYLUM ANNELIDA LAMARCK, 1809

FAMILY TEREBELLIDAE MALMGREN, 1867

Genus *Terebella* Linnaeus, 1767

Type species: *Terebella lapidaria* Linnaeus, 1767

Terebella lapilloides Münster, 1833

Pl. 28, Figs. a-h

1833 *Terebella lapilloides* n. sp., Münster, Pl. 71, Fig. 16
1993 *Terebella lapilloides* Münster, Leinfelder et al., Pl. 41, Figs. 1, 3
1996 *Terebella lapilloides* Münster, Schmid, 204 – 205, Fig. 74
1999 *Terebella lapilloides* Münster, Schlagintweit and Ebli, Pl. 1, Fig. 5; Pl. 2, Fig. 6; Pl. 12, Figs. 6-11
2008 *Terebella lapilloides* Münster, Schlagintweit & Gawlick, Fig. 13a
2011 *Terebella lapilloides* Münster, Krajewski et al., Fig. 4B
2014 *Terebella lapilloides* Münster, Kaya & Altıner, Pl. 1, Figs. 1-16; Pl. 2, Figs. 1-8; Pl. 3, Fig. 1

Description & Remarks: *Terebella lapilloides* is an annelid with an agglutinated tube that is common in Late Jurassic reefal, fore-reef and slope environments (Leinfelder et al., 1993; Kaya & Altıner, 2014). The worm tubes belong to this species were identified from the latest Tithonian – earliest Berriasian interval in this study (Fig. 12).

FAMILY SERPULIDAE Burmeister, 1837

Genus *Mercierella* Fauvel, 1923

Type species: *Mercierella enigmatica* Fauvel, 1923

Mercierella ? *dacica* Münster, 1833

Pl. 27, Figs. a-j

(For synonyms before the year 1998 see Miík et al. 1999)

1966 *Mercierella* ? *dacica* n. sp., Dragastan, 148, Fig. 1; 149, Fig. 2
1991 *Mercierella* ? *dacica* Dragastan, Altıner et al., not illustrated
1999 *Mercierella* ? *dacica* Dragastan, Miík et al. 1999, Pl. 1, Figs. 1-11
2001 *Mercierella* ? *dacica* Dragastan, Sȧsȧran et al., Pl. 10, Fig. 1

2005 *Mercierella* ? *dacica* Dragastan, Dragastan et al., not illustrated
2010 *Mercierella* ? *dacica* Dragastan, Bucur et al., not illustrated

Description & Remarks: *Mercierella dacica* is characterized by a microgranular tube, open at both ends, with unequally spaced collars (3 collars according to Miík et al. 1999). The generic name has a question mark in the literature (and here) due to the fact that Fauvel (1923) described this genus from brackish water limestones however, *M. dacica* has been found in generally platform margin environments (fore-reef, slope, outer shelf), associated with calpionellids, *Crescetiella morronensis* and *Mohlerina basiliensis* (Dragastan, 1966; Miík et al. 1999; Såsåran et al.; Dragastan et al. and Bucur et al. 2010) which is the same case in this study.

It is nearly impossible to differentiate oblique sections and incomplete tubes of *M. dacica* from *Aeolisaccus* or *Earlandia* in thin sections. Unlike *Earlandia*, *Aeolisaccus* and *Mericierella* do not have a proloculus and a second tubular chamber. They are characterized by a microgranular tube with open ends. *Mercierella* differs from *Earlandia* in having collars diverging from the wall of the tube in irregularly spaced intervals.

This species have been identified from the Kimmeridgian – Berriasian interval (Miík et al. 1999; Dragastan, 2005). In this study *Mercierella* ? *dacica* was identified from the Kimmeridgian to earliest Valanginian interval (Fig. 12).

ClASS CRINOIDAE MILLER, 1821

FAMILY SACCOCOMIDAE D’ ORBIGNY, 1852

Genus *Saccocoma* Agassiz, 1853

Saccocoma sp.

Pl. 10, Figs. h-m

Description & Remarks: In thin sections, they are recognized by their characteristic antler-shaped calcitic structures (facetalia and brachilia). This pelagic crinoids were placed under different genera by several authors like *Eothrix* (by Lombard, 1945) and *Lombardia* (by Brönniman, 1955). They range from Middle Oxfordian to latest Tithonian (Nicosia & Parisi, 1979; Kroh & Lukeneder, 2009). *Saccocoma* shows important abundance in the Tithonian which was used as a possible base-Tithonian marker event in several studies (Nicosia & Parisi, 1979; Altıner, 1991; Skourtis-Coroneou & Solakius, 1999). This pelagic crinoid has generally been considered as Middle to Late Jurassic – confined taxon that did not extend into the Berriasian in the literature but *Saccocoma* was identified from Tithon – earliest Berriasian interval in this study (Fig. 12). This anomaly can be explained by the different interpration of the J-K boundary (see Chpt. 2).

CHAPTER 5

DISCUSSION AND CONCLUSION

The Upper Jurassic – Lower Cretaceous carbonate succession that crop out to the north of Sivrihisar (Eskişehir) was studied in detail. Along two measured stratigraphic sections (925 m thick in total), 200 samples were collected.

According to the micropaleontological analyses, biozonation and microfacies types, two coeval but dissimilar depositional domains, seperated by an overthrust, have been detected along the measured sections. The one on the southern part shows a slope to basin facies and is characterized by the Kimmeridgian – Berriasian Yosunlukbayırı Formation and the overlying Valanginian Soğukçam Limestone. Two depositional environments were identified; namely, the “toe of slope” facies and the “slope” facies. The microfacies of the “toe of slope” deposits are generally characterized by peloidal, bioclastic packstone, bioclastic mudstone and bioclastic/ calpionellid/ radiolarian wackestone – packstone facies with related pelagic taxa (calpionellids, radiolaria, *Globochaete* sp., *Pithonella* sp., *Saccocoma* sp., calcareous dinocysts, aptychi and very rare planktonic foraminifera and nannoconids) and rare platform derived groups (larger and smaller foraminifera, microencrusters, *Mercierella* ? *dacica*, echinoid spines, bivalve fragments, crinoid and echinoid fragments). These deposits represent the background pelagic deposition on a slope. The “slope” facies are mainly represented by bioclastic, peloidal/ bioclastic, lithoclastic packstone, peloidal, intraclastic/ intraclastic, bioclastic grainstone/ rudstone to grainstone, bioclastic, lithoclastic floatstone/ rudstone facies characterized by a gradual increase in the amount of platform derived material (larger and smaller benthic foraminifera, microencrusters, worm tubes, corals, sponges, bryozoa). The matrix of these coarse grained deposits also includes pelagic taxa like (calpionellids, radiolaria, *Saccocoma* sp., *Globochaete* sp., *Pithonella* sp., aptyhci). The slope facies also shows intercalations with the “toe of slope” type facies indicating quiescence periods, dominated by background pelagic sedimentation.

Within the slope to basin deposits, the following biozones were defined: *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), *Crescentiella morronensis* (*Saccocoma* subzone) Zone (Lower Tithonian), *Protopeneroplis ultragranulata* Zone (Upper Tithonian), *Crassicollaria* (*massutiana* subzone) Zone (uppermost Tithonian), *Calpionella* (*alpina*, *Remaniella* and *elliptica* subzones) Zone (Lower Berriasian), *Calpionellopsis* (*simplex* and *oblonga* subzones) Zone (Upper Berriasian) and *Calpionellites* (*darderi* subzone) Zone (Lower Valanginian). The Jurassic – Cretaceous boundary is located at the base of the Calpionella Zone.

This succession is overthrusted from north to south by a thin slice of the Berriasian Yosunlukbayırı Formation and an overlying thicker slice consisting of the Kimmeridgian Günören Limestone which is a part of the Edremit – Bursa - Bilecik Carbonate Platform. Platform carbonates of the Günören Limestone are characterized by peloidal/ peloidal, intraclastic poorly washed grainstone with bioclasts, bioclastic mudstone/ wackestone, intraclastic packstone/ rudstone including shallow marine groups (larger and smaller benthic foraminifera, encrustres and rare echnoid, bivalve and coral fragments) without any pelagic taxa. These carbonates were interpreted as back-reef platform deposits that should not be so far away from the platform margin due to the co-occurrence of *Protopeneroplis striata* and *Mohlerina basiliensis* (abundant in the reefal areas along the shelf edge) with the complex benthic foraminifera like *Labyrinthina mirabilis* (abundant in lagoonal areas). Within the Günören Limestone, *Labyrinthina mirabilis – Protopeneroplis striata* (Kimmeridgian) Zone was recognized.

After detecting the presence of Günören Limestone in the study area, a much thinner section was measured to the north of these successions with the purpose of checking whether there is any record of the well documented Bilecik Carbonate Platform drowning event. However, on the contrary of our expectations, a succession consisting of the Early Berriasian Yosunlukbayırı Formation deposited on the slope and the basinal Soğukçam Limestone was recorded. The boundary of these two formations is probably tectonic. These formations show similiar facies characteristics with the slope to basin successions.

Due to the presence of two different depositional domains and wide time span of the successions, various fossil groups were studied, including foraminifera, calpionellids, incertae sedis and worm tubes. The established biozonation for the slope to basin facies may seem to be facies controlled; *G. oxfordiana – M. basiliensis* Zone using a pelagic and benthic foraminifera association is followed by a pelagic taxon zone (*Saccocoma* zone) and again followed by a benthic foraminifera zone (*Protopeneroplis ultragranulata* zone). But this is the nature of the fossil associations of slope environments continuously fed by surrounding carbonate platforms (the Günörene Limestone in this case). There should not be any question about the first occurrences of the pelagic taxa in this slope environments like the first occurrences of *Saccocoma* sp. and calpionellid species. Although some benthic taxa show slight diachronism in their first occurrences in the study area like *Crescentiella morronensis* (which has been recorded in the Kimmeridgian of Günören Limestone and observed Tithonian onwards in the Yosunlukbayırı Formation), there should not be any doubt about the chronostratigraphic position of the *Protopeneroplis ultragranulata* Zone. Even if the basal boundary of this zone is diachronic, it still indicates a Late Tithonian time since it is bounded below and above by the Tithonian *Saccocoma* Zone and latest Tithonian *massutiniana* subzone, respectively. Additionally, due to the nature of environment they inhabit (mostly platform margin), *P. ultragranulata* and *Crescentiella morronensis* were easily transported into the slope facies without causing important diachronism regarding their first occurrences. Pelagic calpionellid - based bizonation follows this *P. ultragranulata* zone as a result of latest Tithonian onward decrease in the platform derived material and domination of the background pelagic sedimentation.

If the position of the studied sections with respect to the Edremit – Bursa - Bilecik Carbonate Platform is considered, the studied basin and slope facies should represent the southern platform margin and slope environments of this carbonate platform that faced an ocean to the south during the Jurassic – Cretaceous interval. The slope and basinal facies (the Yosunlukbayırı Formation and the Soğukçam Limestone) overthrusted by the shallow marine deposits (the Günören Limestone) in a region situated to the south of the main İzmir-Ankara-Erzincan (İAE) suture suggests an important disruption and shortening of the Edremit – Bursa - Bilecik Carbonate Platform margin and slope deposits, probably related to the closure of the İAE ocean.

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APPENDIX A

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APPENDIX B

PLATE 1

All scale bars 50µm

a. *Crassicollaria brevis,* STG-67B, *massutiniana* subzone (latest Tithonian), STG section

b. *Crassicollaria brevis*, STG-67B, *massutiniana* subzone (latest Tithonian), STG section

c. *Crassicollaria brevis,* STG-67B, *massutiniana* subzone (latest Tithonian), STG section

d. *Crassicollaria brevis*, STG-70, *massutiniana* subzone (latest Tithonian), STG section

e. *Crassicollaria intermedia*, STG-67B, *massutiniana* subzone (latest Tithonian), STG section

f. *Crassicollaria intermedia*, STG-67B, *massutiniana* subzone (latest Tithonian), STG section

g. *Crassicollaria intermedia,* STG-69, *massutiniana* subzone (latest Tithonian), STG section

h. *Crassicollaria intermedia*, STG-70, *massutiniana* subzone (latest Tithonian), STG section

i. *Crassicollaria massutiniana*, STG-67B, *massutiniana* subzone (latest Tithonian), STG section

j. *Crassicollaria massutiniana,* STG-67B, *massutiniana* subzone (latest Tithonian), STG section

k. *Crassicollaria massutiniana*, STG-67B, *massutiniana* subzone (latest Tithonian), STG section

l. *Crassicollaria massutiniana*, STG-70, *massutiniana* subzone (latest Tithonian), STG section

m. *Crassicollaria massutiniana*, STG-70A, *alpina* subzone (earliest Berriasian), STG section

n. *Crassicollaria massutiniana*, STG-70A, *alpina* subzone (earliest Berriasian), STG section

o. *Crassicollaria massutiniana*, STG-71A, *alpina* subzone (earliest Berriasian), STG section

p. *Crassicollaria parvula*, STG-67B, *massutiniana* subzone (latest Tithonian), STG section

r. *Crassicollaria parvula*, STG-67B, *massutiniana* subzone (latest Tithonian), STG section

s. *Crassicollaria parvula*, STG-69, *massutiniana* subzone (latest Tithonian), STG section

t. *Crassicollaria parvula*, STG-70, *massutiniana* subzone (latest Tithonian), STG section

u. *Crassicollaria parvula*, STG-70A, *alpina* subzone (earliest Berriasian), STG section

v. *Crassicollaria parvula*, STG-71A, *alpina* subzone (earliest Berriasian), STG section

w. *Crassicollaria parvula*, STG-71A, *alpina* subzone (earliest Berriasian), STG section

x. *Crassicollaria parvula*, STG-72, *alpina* subzone (earliest Berriasian), STG section

y. *Crassicollaria parvula*, STG-72, *alpina* subzone (earliest Berriasian), STG section

z. *Crassicollaria parvula*, STG-75, *Remaniella* subzone (Early Berriasian), STG section

aa. *Crassicollaria parvula*, STG-79, *Remaniella* subzone (Early Berriasian), STG section

ab. *Crassicollaria parvula*, STG-80, *Remaniella* subzone (Early Berriasian), STG section

ac. *Crassicollaria parvula*, STG-82, *elliptica* subzone (Early Berriasian), STG section

ad. *Crassicollaria parvula*, STG-84, *elliptica* subzone (Early Berriasian), STG section

ae. *Crassicollaria parvula*, STG-86A, *simplex* subzone (Late Berriasian), STG

section

af. *Crassicollaria parvula*, STG-109A, *Calpionella* Zone (Early Berriasian), STG section

ag. *Crassicollaria parvula*, SG-4, *Calpionella* Zone (Early Berriasian), SS section

PLATE 1

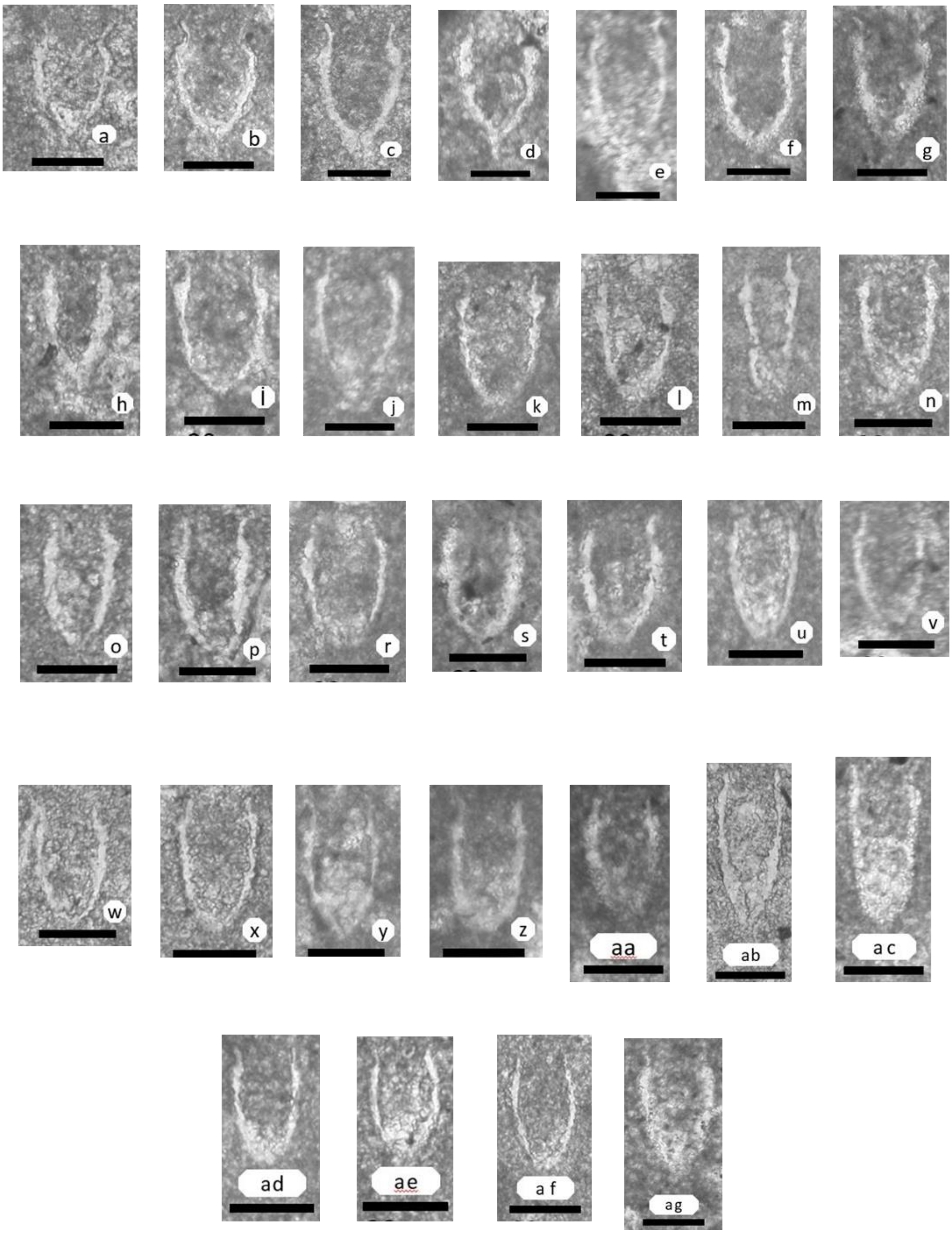


PLATE 2

All scale bars 50µm

a. *Calpionella grandalpina,* STG-67B, *massutiniana* subzone (latest Tithonian), STG section

b. *Calpionella grandalpina,* STG-67B, *massutiniana* subzone (latest Tithonian), STG section

c. *Calpionella grandalpina,* STG-67B, *massutiniana* subzone (latest Tithonian), STG section

d. *Calpionella grandalpina,* STG-70A, *alpina* subzone (earliest Berriasian), STG section

e. *Calpionella grandalpina,* STG-67B, *massutiniana* subzone (latest Tithonian), STG section

f. *Calpionella alpina,* STG-66B, *massutiniana* subzone (latest Tithonian), STG section

g. *Calpionella alpina,* STG-70A, *alpina* subzone (earliest Berriasian), STG section

h. *Calpionella alpina,* STG-70A, *alpina* subzone (earliest Berriasian), STG section

i. *Calpionella alpina,* STG-70A, *alpina* subzone (earliest Berriasian), STG section

j. *Calpionella alpina,* STG-70A, *alpina* subzone (earliest Berriasian), STG section

k. *Calpionella alpina,* STG-72, *alpina* subzone (earliest Berriasian), STG section

l. *Calpionella alpina,* STG-75, *Remaniella* subzone (Early Berriasian), STG section

m. *Calpionella alpina,* STG-81, *Remaniella* subzone (Early Berriasian), STG section

n. *Calpionella alpina,* STG-84A, *elliptica* subzone (Early Berriasian), STG section

o. *Calpionella alpina,* STG-86A, *elliptica* subzone (Late Berriasian), STG section

p. *Calpionella minuta,* STG-109A, *Calpionella* Zone (Early Berriasian), STG section

r. *Calpionella alpina* and *Calpionella minuta,* STG-82, *elliptica* subzone (Early Berriasian), STG section

s. *Calpionella minuta,* STG-74, *alpina* subzone (Early Berriasian), STG section

t. *Calpionella minuta,* STG-75, *Remaniella* subzone (Early Berriasian), STG section

u. *Calpionella minuta,* STG-84, *elliptica* subzone (Early Berriasian), STG section

v. *Calpionella minuta,* STG-109A, *Calpionella* Zonze (Early Berriasian), STG section

w. *Calpionella elliptalpina,* STG-70, *massutiniana* subzone (latest Tithonian), STG section

x. *Calpionella elliptalpina,* STG-70, *massutiniana* subzone (latest Tithonian), STG section

y. *Calpionella elliptica,* STG-84, *elliptica* subzone (Early Berriasian), STG section

z. *Calpionella elliptica,* STG-86A, *simplex* subzone (Early Berriasian), STG section

aa. *Calpionella elliptica,* STG-84, *elliptica* subzone (Early Berriasian), STG section

PLATE 2

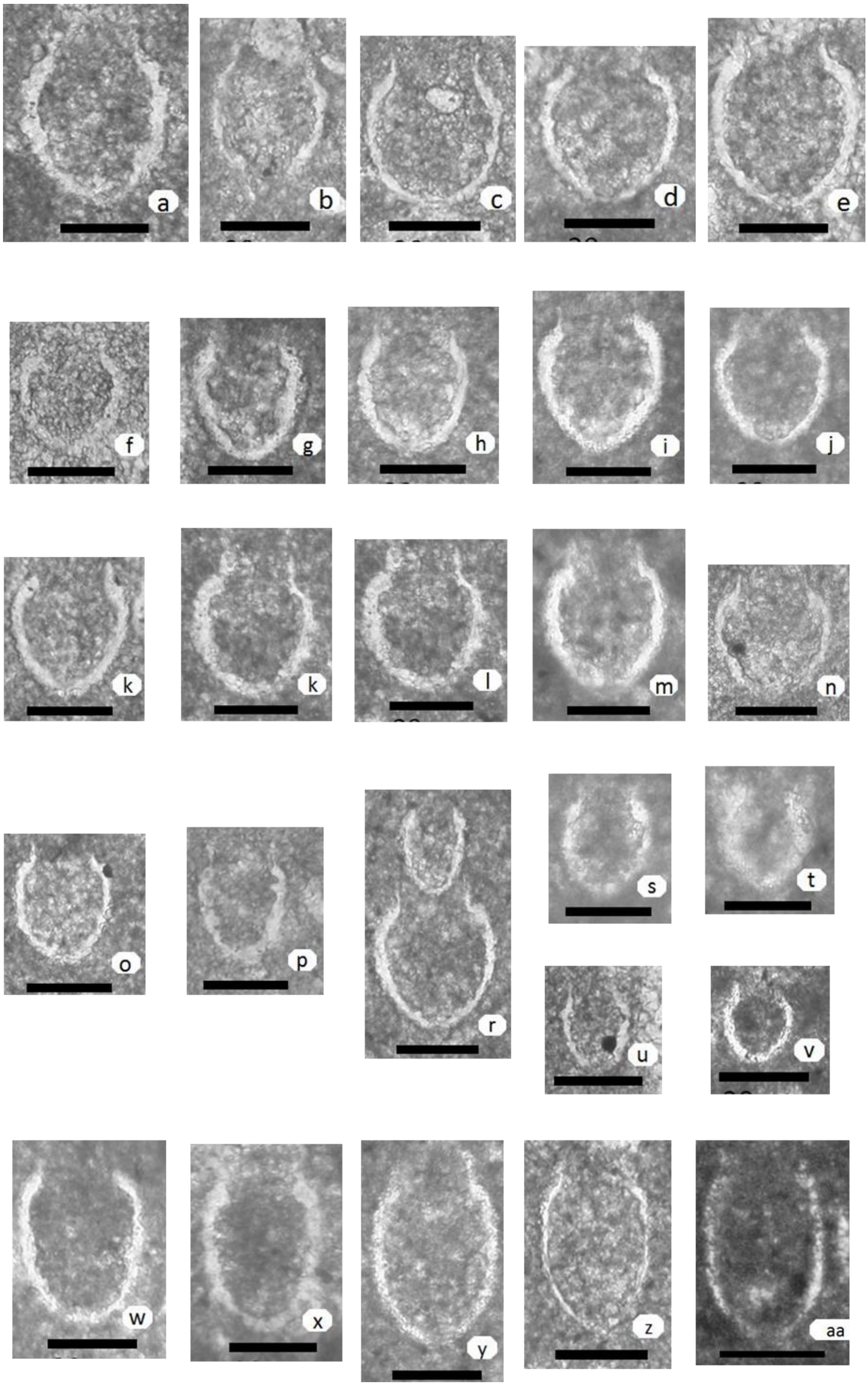


PLATE 3

All scale bars 50µm

a. *Tintinnopsella remanei,* STG-67B, *massutiniana* subzone (latest Tithonian), STG section

b. *Tintinnopsella remanei,* STG-67B, *massutiniana* subzone (latest Tithonian), STG section

c. *Tintinnopsella remanei,* STG-69, *massutiniana* subzone (latest Tithonian), STG section

d. *Tintinnopsella carpathica,* STG-80, *Remaniella* subzone (Early Berriasian), STG section

e. *Tintinnopsella carpathica,* STG-80, *Remaniella* subzone (Early Berriasian), STG section

f. *Tintinnopsella carpathica,* STG-80, *Remaniella* subzone (Early Berriasian), STG section

g. *Tintinnopsella carpathica,* STG-84, *elliptica* subzone (Ealry Berriasian), STG section

h. *Tintinnopsella carpathica,* STG-84A, *elliptica* subzone (Early Berriasian), STG section

i. *Tintinnopsella carpathica*, STG-84A, *elliptica* subzone (Early Berriasian), STG section

j. *Tintinnopsella carpathica*, STG-87, *oblonga* subzone (Late Berriasian), STG section

k. *Tintinnopsella carpathica,* STG-87, *oblonga* subzone (Late Berriasian), STG section

l. *Tintinnopsella carpathica*, STG-87, *oblonga* subzone (Late Berriasian), STG section

m. *Tintinnopsella carpathica,* STG-88A, *oblonga* subzone (Late Berriasian), STG section

n. *Tintinnopsella carpathica,* STG-89, *oblonga* subzone (Late Berriasian), STG section

o. *Tintinnopsella carpathica,* STG-89, *oblonga* subzone (Late Berriasian), STG

section

p. *Tintinnopsella carpathica*, STG-89, *oblonga* subzone (Late Berriasian), STG section

r. *Tintinnopsella carpathica*, STG-89A, *oblonga* subzone (Late Berriasian), STG section

s. *Tintinnopsella carpathica*, STG-89A, *oblonga* subzone (Late Berriasian), STG section

t. *Tintinnopsella carpathica*, STG-93, *darderi* subzone (earliest Valanginian), STG section

u. *Tintinnopsella longa*, STG-89, *oblonga* subzone (Late Berriasian), STG section

v. *Tintinnopsella longa*, STG-89A, *oblonga* subzone (Late Berriasian), STG section

y. *Tintinnopsella longa*, STG-91, *oblonga* subzone (Late Berriasian), STG section

z. *Tintinnopsella longa*, STG-92A, *oblonga* subzone (Late Berriasian), STG section

PLATE 3

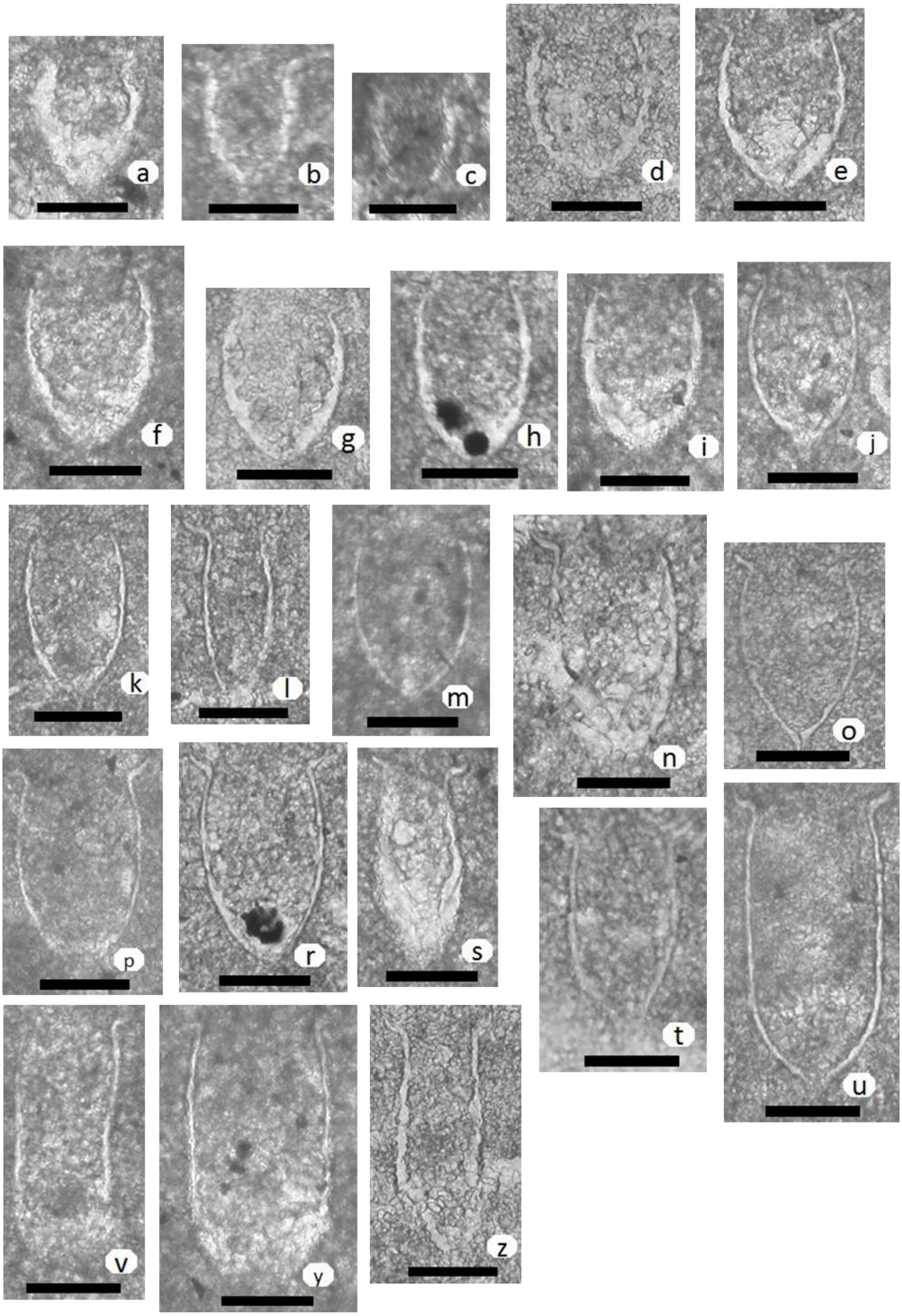


PLATE 4

All scale bars 50µm

a. *Calpionellopsis simplex,* STG-87, *oblonga* subzone (Late Berriasian), STG section
b. *Calpionellopsis simplex,* STG-87, *oblonga* subzone (Late Berriasian), STG section
c. *Calpionellopsis simplex,* STG-88, *oblonga* subzone (Late Berriasian), STG section
d. *Calpionellopsis simplex,* STG-88, *oblonga* subzone (Late Berriasian), STG section
e. *Calpionellopsis simplex,* STG-88A, *oblonga* subzone (Late Berriasian), STG section
f. *Calpionellopsis simplex,* STG-89, *oblonga* subzone (Late Berriasian), STG section
g. *Calpionellopsis simplex,* STG-89, *oblonga* subzone (Late Berriasian), STG section
h. *Calpionellopsis simplex,* STG-89A, *oblonga* subzone (Late Berriasian), STG section
i. *Calpionellopsis simplex,* STG-90, *oblonga* subzone (Late Berriasian), STG section
j. *Calpionellopsis simplex,* STG-91, *oblonga* subzone (Late Berriasian), STG section
k. *Calpionellopsis simplex,* STG-85, *simplex* subzone (Late Berriasian), STG section
l. *Calpionellopsis oblonga,* STG-87, *oblonga* subzone (Late Berriasian), STG section
m. *Calpionellopsis oblonga,* STG-87, *oblonga* subzone (Late Berriasian), STG section
n. *Calpionellopsis oblonga,* STG-87, *oblonga* subzone (Late Berriasian), STG section
o. *Calpionellopsis oblonga,* STG-88, *oblonga* subzone (Late Berriasian), STG section
p. *Calpionellopsis oblonga,* STG-88A, *oblonga* subzone (Late Berriasian), STG section
r. *Calpionellopsis oblonga,* STG-89, *oblonga* subzone (Late Berriasian), STG section
s. *Calpionellopsis oblonga,* STG-89, *oblonga* subzone (Late Berriasian), STG section
t. *Calpionellopsis oblonga,* STG-91, *oblonga* subzone (Late Berriasian), STG section
u. *Calpionellopsis oblonga,* STG-92, *oblonga* subzone (Late Berriasian), STG section
v. *Calpionellopsis oblonga,* STG-92, *oblonga* subzone (Late Berriasian), STG

section

w. *Calpionellopsis oblonga*, STG-92, *oblonga* subzone (Late Berriasian), STG section

PLATE 4

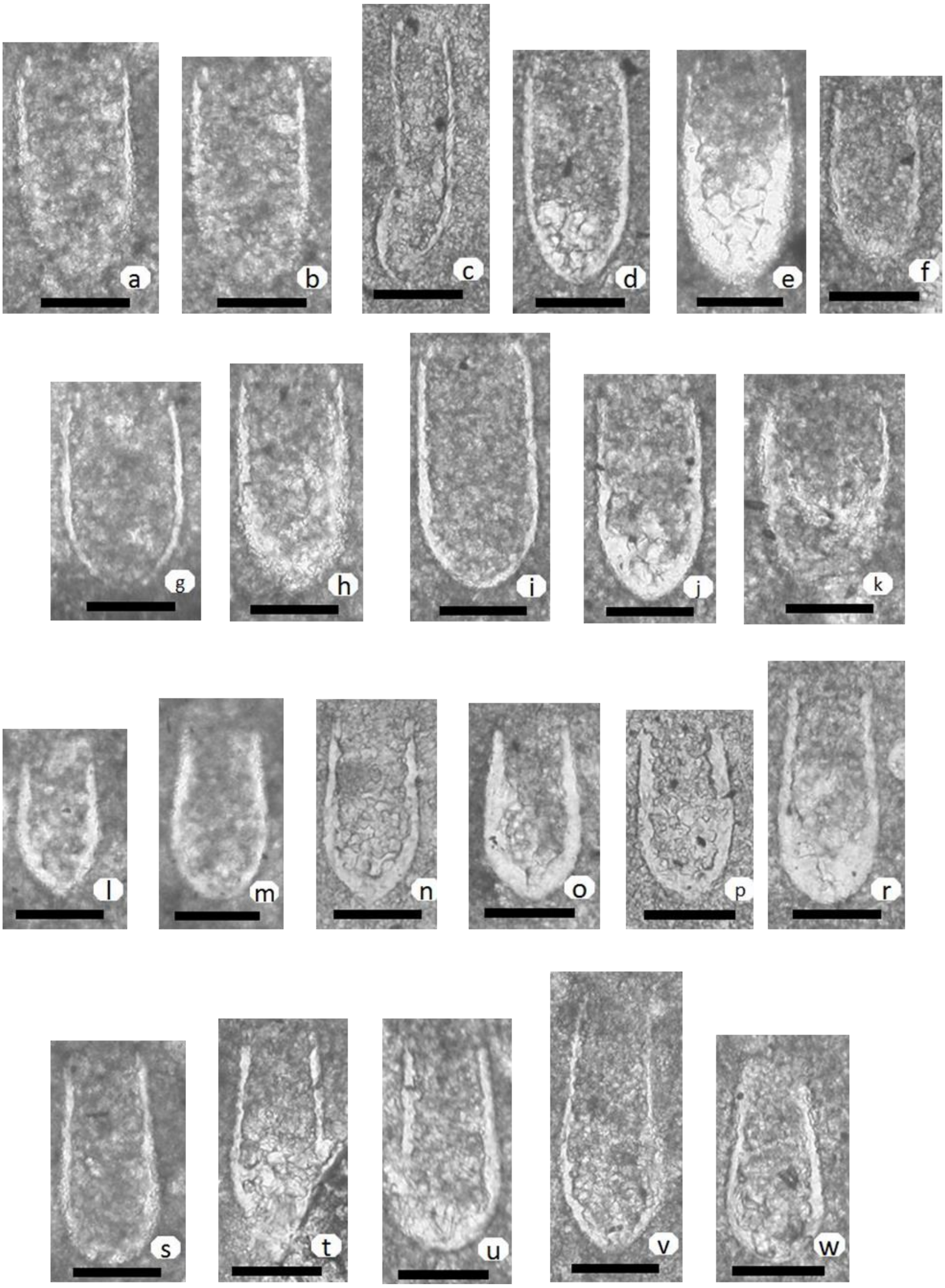


PLATE 5

All scale bars 50µm

a. *Remaniella ferasini,* STG-75A, *Remaneilla* subzone (Early Berriasian), STG section

b. *Remaniella ferasini,* STG-76, *Remaneilla* subzone (Early Berriasian), STG section

c. *Remaniella ferasini,* STG-80, *Remaneilla* subzone (Early Berriasian), STG section

d. *Remaniella ferasini,* STG-90, *oblonga* subzone (Late Berriasian), STG section

e. *Remaniella ferasini*?, STG-109A, *Calpionella* Zone (Early Berriasian), STG section

f. *Remaniella ferasini,* STG-75, *Remaneilla* subzone (Early Berriasian), STG section

g. *Remaniella duranddelgai,* STG-80, *Remaneilla* subzone (Early Berriasian), STG section

h. *Remaniella duranddelgai,* STG-83, *elliptica* subzone (Early Berriasian), STG section

i. *Remaniella duranddelgai,* STG-84, *elliptica* subzone (Early Berriasian), STG section

j. *Remaniella colomi,* STG-81, *Remaneilla* subzone (Early Berriasian), STG section

k. *Remaniella colomi,* STG-82, *elliptica* subzone (Early Berriasian), STG section

l. *Remaniella catalanoi*?, STG-82, *elliptica* subzone (Early Berriasian), STG section

m. *Remaniella catalanoi*?, STG-85, *simplex* subzone (Late Berriasian), STG section

n. *Remaniella borzai,* STG-89, *oblonga* subzone (Late Berriasian), STG section

o. *Remaniella filipescui,* STG-82, *elliptica* subzone (Early Berriasian), STG section

p. *Remaniella filipescui,* STG-83, *elliptica* subzone (Early Berriasian), STG section

r. *Remaniella filipescui,* STG-87, *oblonga* subzone (Late Berriasian), STG section

s. *Remaniella filipescui,* STG-89, *oblonga* subzone (Late Berriasian), STG section

t. *Remaniella filipescui,* STG-90, *oblonga* subzone (Late Berriasian), STG section

u. *Remaniella filipescui,* STG-91A, *oblonga* subzone (Late Berriasian), STG section

v. *Remaniella cadischiana,* STG-84, *elliptica* subzone (Early Berriasian), STG section

w. *Remaniella cadischiana,* STG-84, *elliptica* subzone (Early Berriasian), STG section

x. *Remaniella cadischiana,* STG-84, *elliptica* subzone (Early Berriasian), STG section

y. *Remaniella cadischiana,* STG-84A, *elliptica* subzone (Early Berriasian), STG section

z. *Remaniella cadischiana,* STG-86A, *simplex* subzone (Late Berriasian), STG section

aa. *Remaniella cadischiana,* STG-87, *oblonga* subzone (Late Berriasian), STG section

PLATE 5

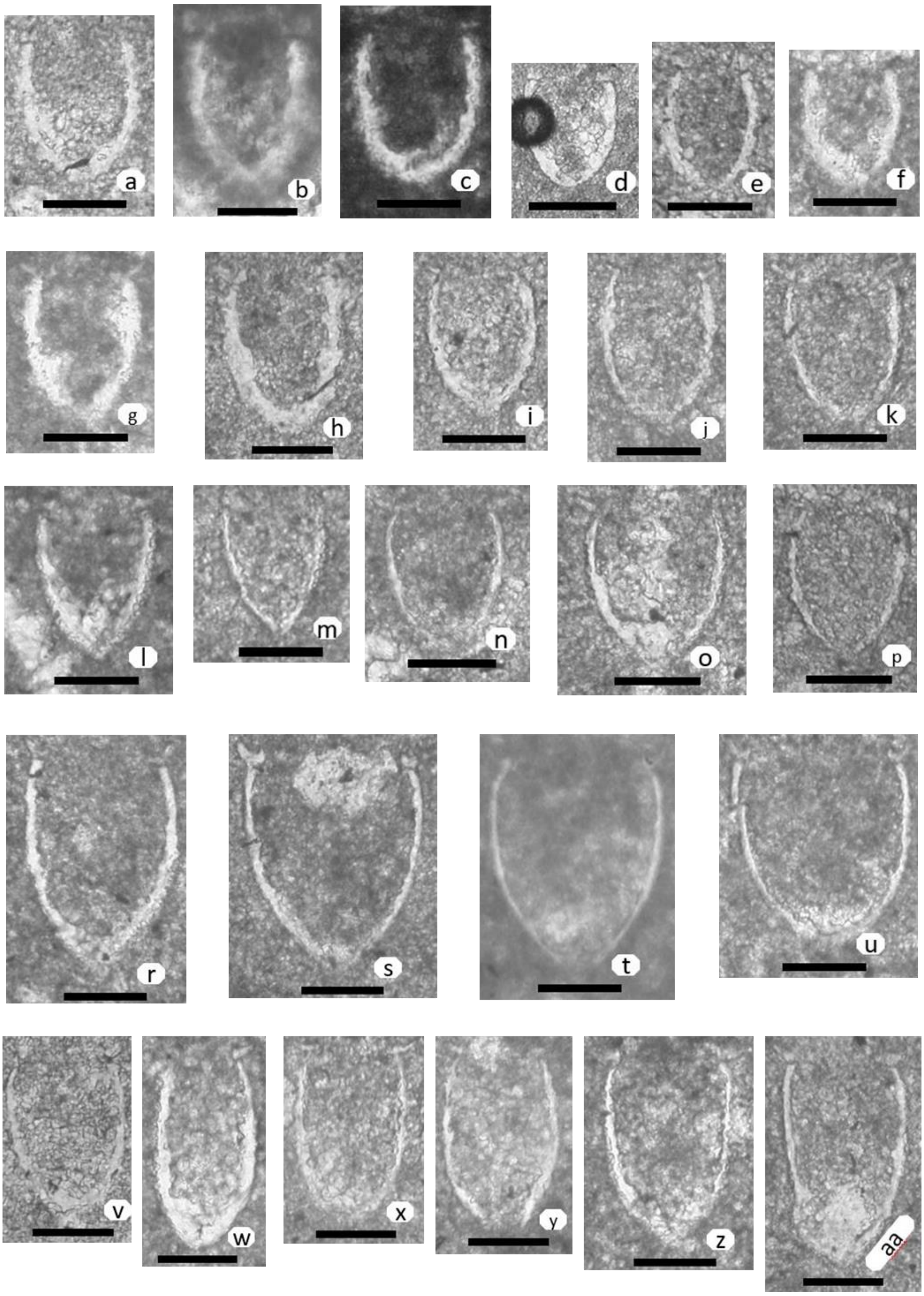


PLATE 6

All scale bars 50μm

a. *Calpionellites darderi,* STG-93, *darderi* subzone (earliest Valanginian), STG section

b. *Lorenziella hungarica*, STG-89, *oblonga* subzone (Late Berriasian), STG section

c. *Praecalpionellites murgeanui,* STG-92, *oblonga* subzone (Late Berriasian), STG section

d. *Praecalpionellites siriniaensis,* STG-92, *oblonga* subzone (Late Berriasian), STG section

e. *Borzaiella atava*, STG-75A, *Remaniella* subzone (Early Berriasian), STG section

f. *Borzaiella atava,* STG-76, *Remaniella* subzone (Early Berriasian), STG section

g. *Borzaiella atava*, STG-83, *elliptica* subzone (Early Berriasian), STG section

PLATE 6

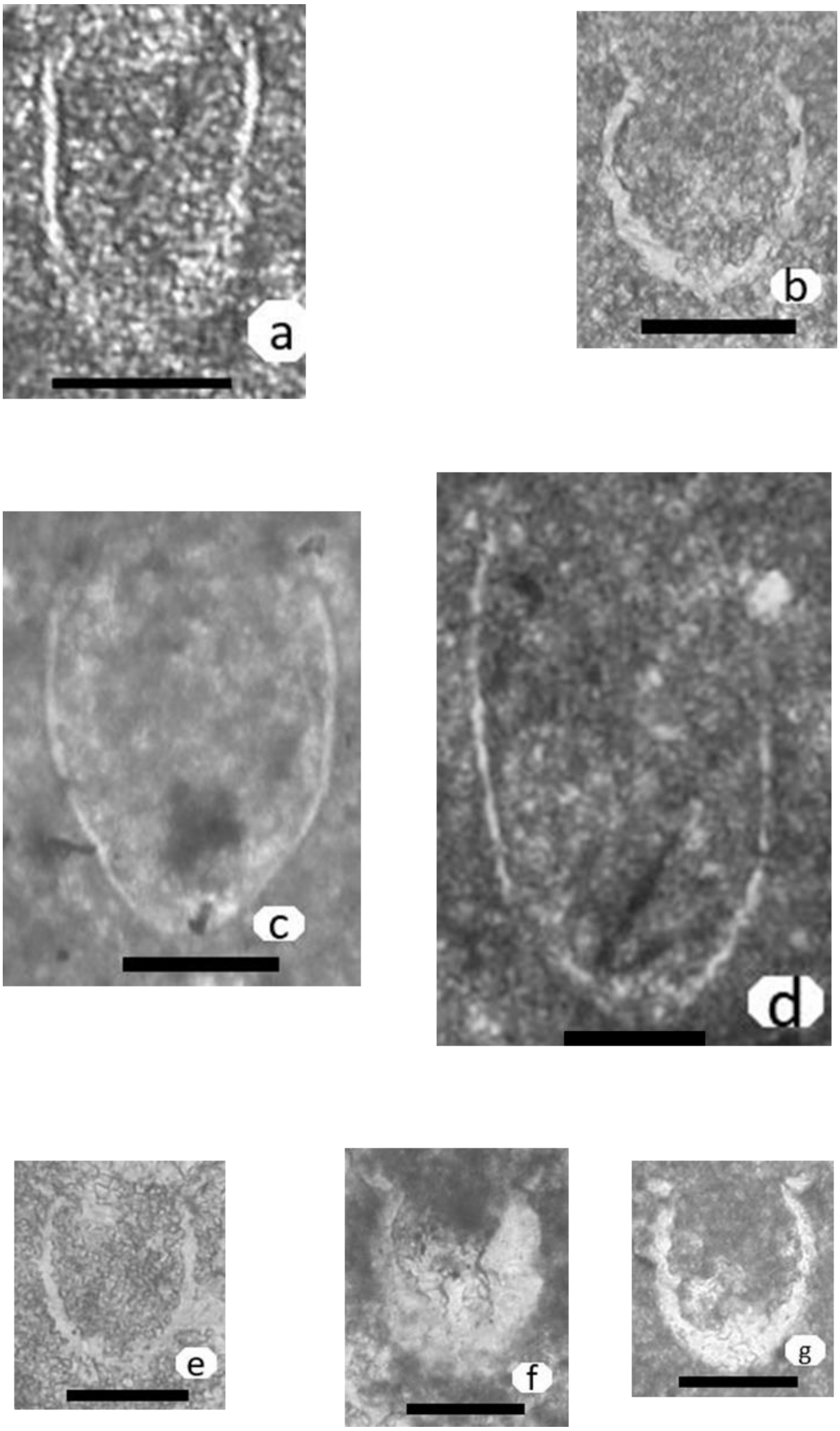


PLATE 7

All scale bars 200 µm

a. *Protopeneroplis striata*, STG-120, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction
b. *Protopeneroplis striata,* STG-136, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction
c. *Protopeneroplis striata,* STG-139, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction
d. *Protopeneroplis ultragranulata,* STG-54, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section
e. *Protopeneroplis ultragranulata*, STG-51, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section
f. *Protopeneroplis ultragranulata,* STG-57, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section
g. *Protopeneroplis ultragranulata*, STG-75, *Remaniella* subzone (Early Berriasian), STG section
h. *Protopeneroplis ultragranulata,* STG-75, *Remaniella* subzone (Early Berriasian), STG section
i. *Protopeneroplis ultragranulata,* STG-106A, *Calpionella* Zone (Early Berriasian), STG section
j. *Protopeneroplis ultragranulata,* STG-77, *Remaniella* subzone (Early Berriasian), STG section
k. *Protopeneroplis ultragranulata*, SG-3, *Calpionella* Zone (Early Berriasian), SS section
l. *Protopeneroplis ultragranulata,* SG-2, *Calpionella* Zone (Early Berriasian), SS section
m. *Protopeneroplis ultragranulata*, SG-2, *Calpionella* Zone (Early Berriasian), SS section
n. *Protopeneroplis ultragranulata,* SG-1, *Calpionella* Zone (Early Berriasian), SS section

o. *Protopeneroplis ultragranulata*, SG-1, *Calpionella* Zone (Early Berriasian), SS section

PLATE 7

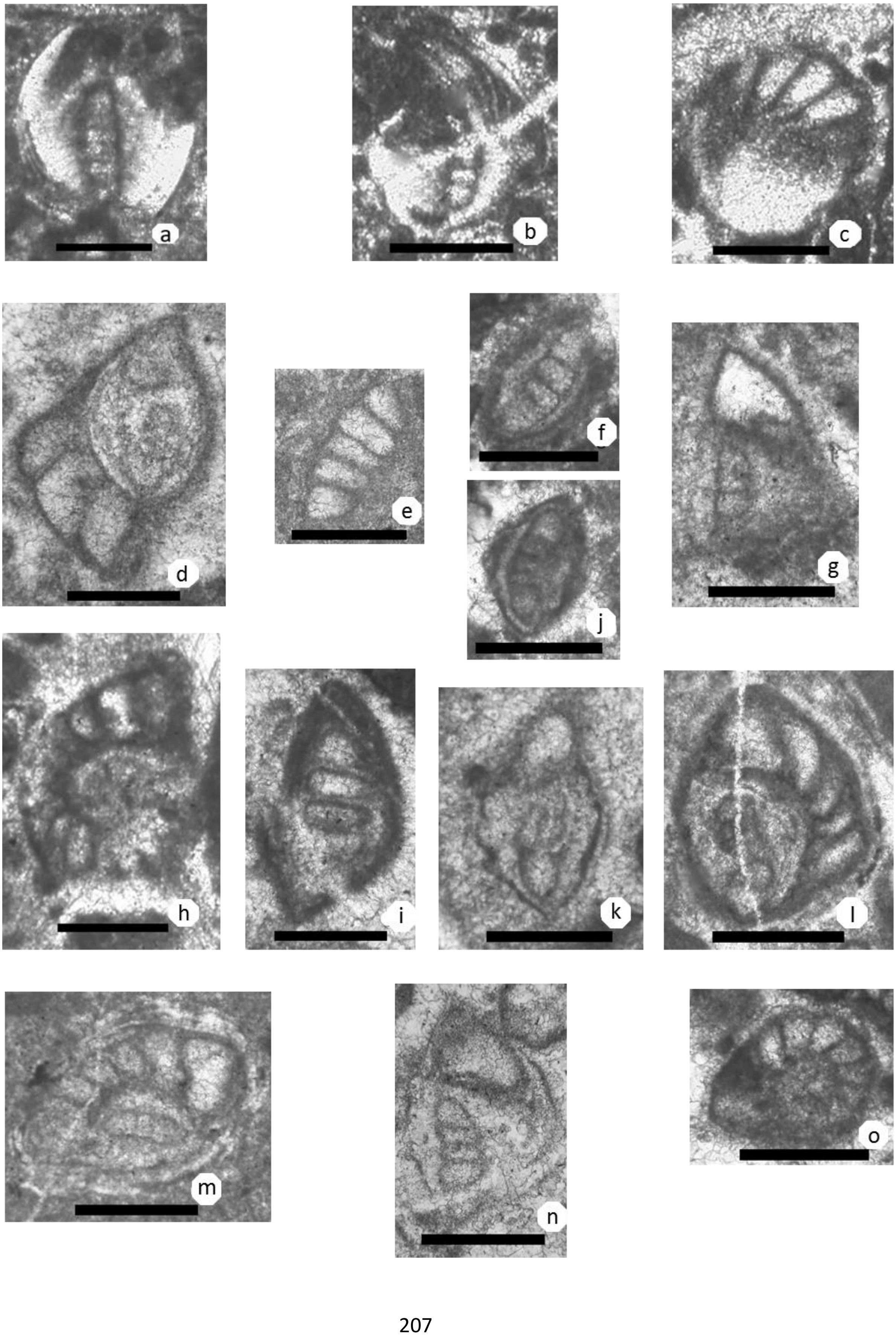


PLATE 8

a. *Globuligerina* gr. *oxfordiana*, STG-6, Scale 50 µm, *Globuligerina oxfordiana* – *Mohlerina basiliensis* Zone (Kimmeridgian), STG section

b. *Mohlerina basiliensis*, STG-14, Scale 200 µm, *Globuligerina oxfordiana* – *Mohlerina basiliensis* Zone (Kimmeridgian), STG section

c. *Mohlerina basiliensis*, STG-17, Scale 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

d. *Mohlerina basiliensis*, STG-46, Scale 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

e. *Mohlerina basiliensis*, STG-51, Scale 200 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

f. *Mohlerina basiliensis*, STG-66, Scale 200 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

g. *Mohlerina basiliensis*, STG-79, Scale 200 µm, *Remaniella* subzone (Early Berriasian), STG section

h. *Mohlerina basiliensis*, STG-114, Scale 200 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

i. *Mohlerina basiliensis*, STG-115, Scale 200 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

j. *Mohlerina basiliensis*, STG-135, Scale 200 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

k. *Mohlerina basiliensis*, STG-138, Scale 200 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

l. *Mohlerina basiliensis*, STG-139, Scale 200 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

PLATE 8

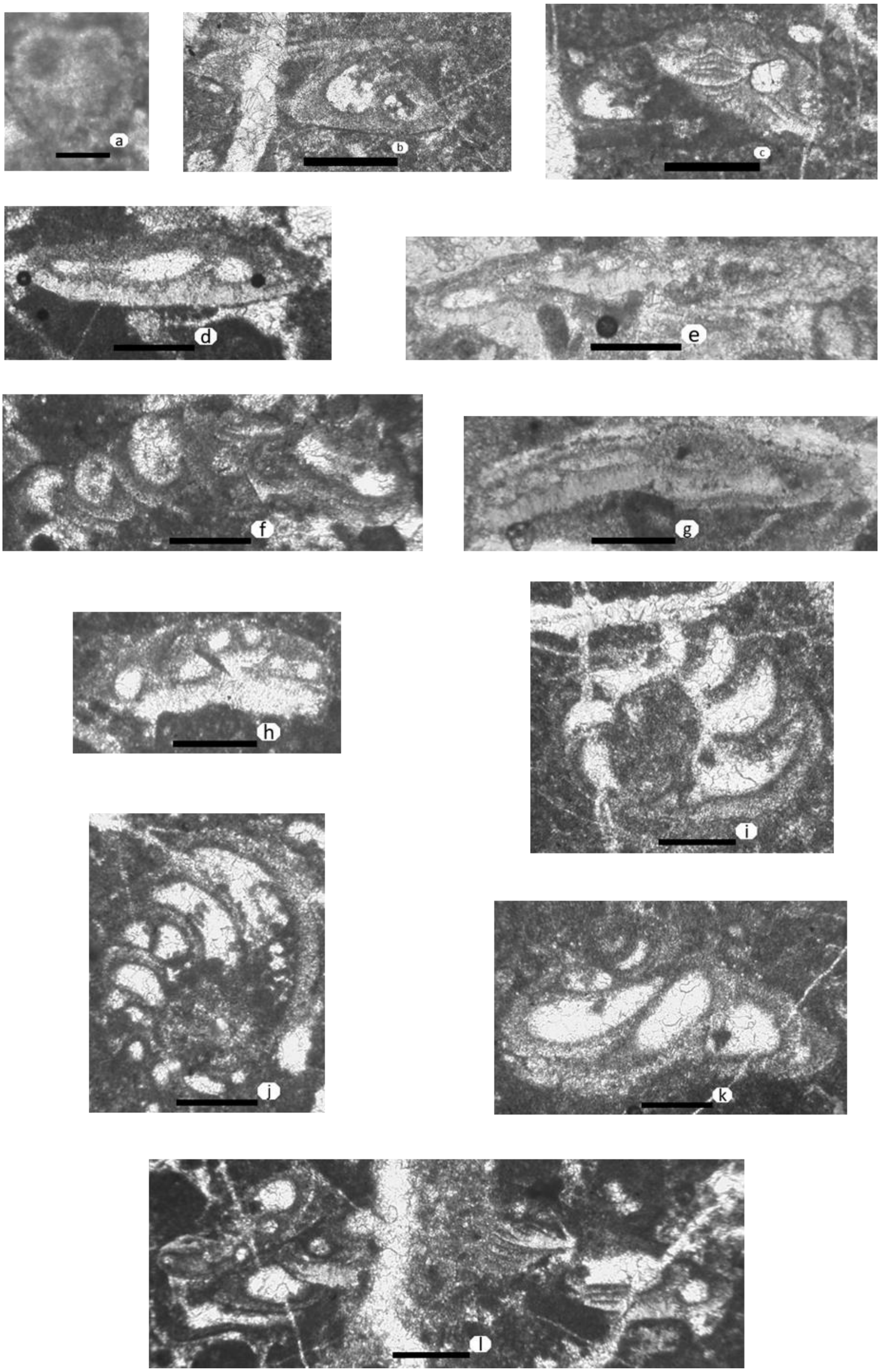


PLATE 9

a. *Crescentiella morronensis*, STG-38, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

b. *Crescentiella morronensis,* STG-46, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

c. *Crescentiella morronensis* with bryozoa, STG-48, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

d. *Crescentiella morronensis*, STG-56, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

e. *Crescentiella morronensis* showing two stages of encrusting including a foraminifera in the second phase, STG-59, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

f. *Crescentiella morronensis,* STG-59, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

PLATE 9

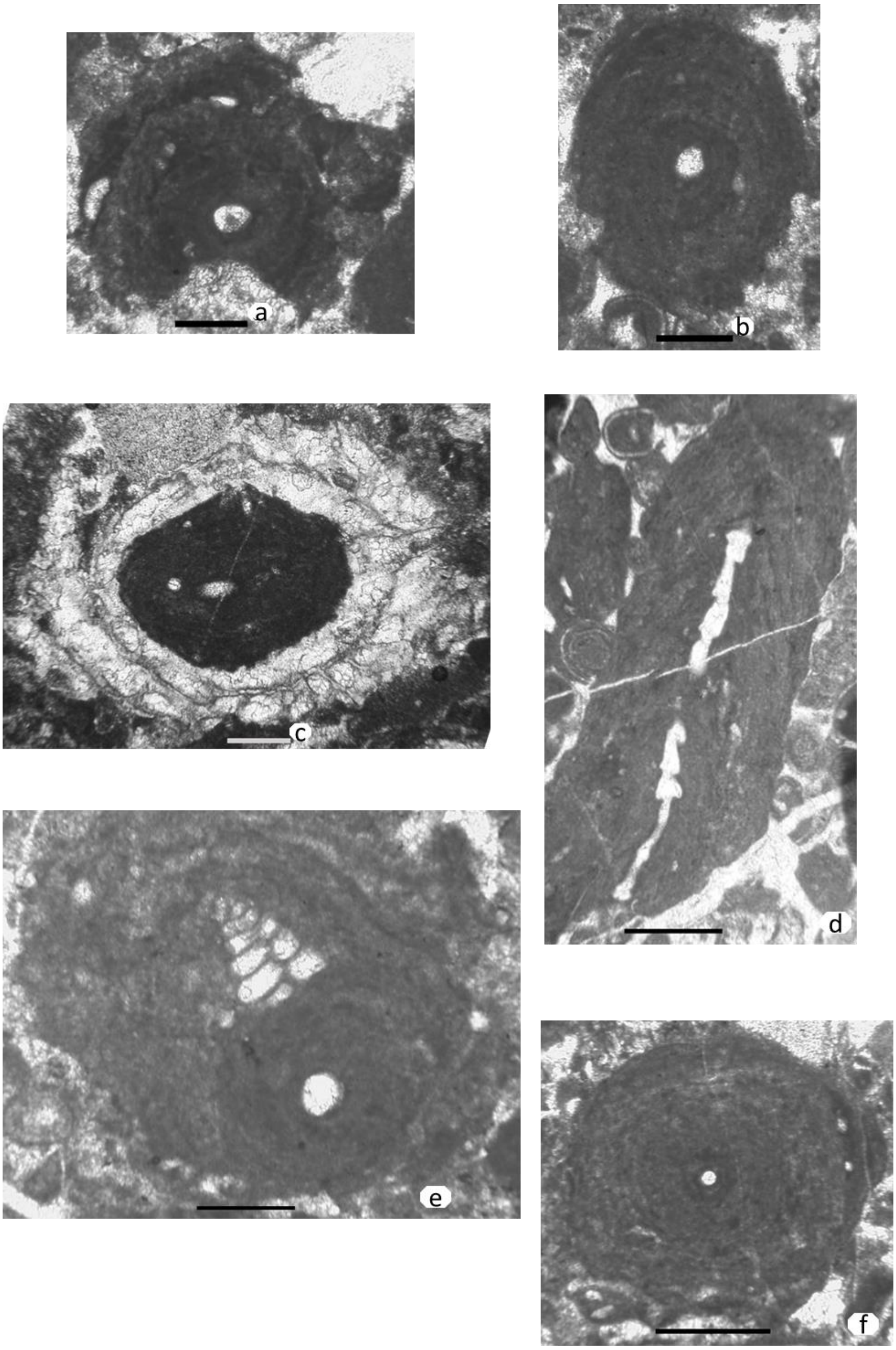


PLATE 10

a. *Crescentiella morronensis*, STG-66A, 400 µm, *massutiniana* subzone (latest Tithonian), STG section

b. *Crescentiella morronensis,* STG-66A, 400 µm, *massutiniana* subzone (latest Tithonian), STG section

c. *Crescentiella morronensis*, STG-71A, 200 µm, *alpina* subzone (Early Berriasian), STG secion

d. *Crescentiella morronensis*, STG-72, 400 µm, *alpina* subzone (Early Berriasian), STG secion

e. *Crescentiella morronensis*, SG-3, 400 µm, *Calpionella* Zone (Early Berriasian), SS section

f. *Crescentiella morronensis* with a calpionellid in the micritic envelope, STG-87, 400 µm, *oblonga* subzone (Late Berriasian), STG section

g. *Crescentiella morronensis*, STG-75A, 400 µm, *Remaniella* subzone (Early Berriasian), STG section

h. *Saccocoma* sp., STG-18, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

i. *Saccocoma* sp., STG-26, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

j. *Saccocoma* sp., STG-31, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

k. *Saccocoma* sp., STG-35, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

l. *Saccocoma* sp., STG-31, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

m. *Saccocoma* sp., STG-71A, 200 µm, *alpina* subzone (Early Berriasian), STG section

n. Aptychus fragment, STG-31, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

PLATE 10

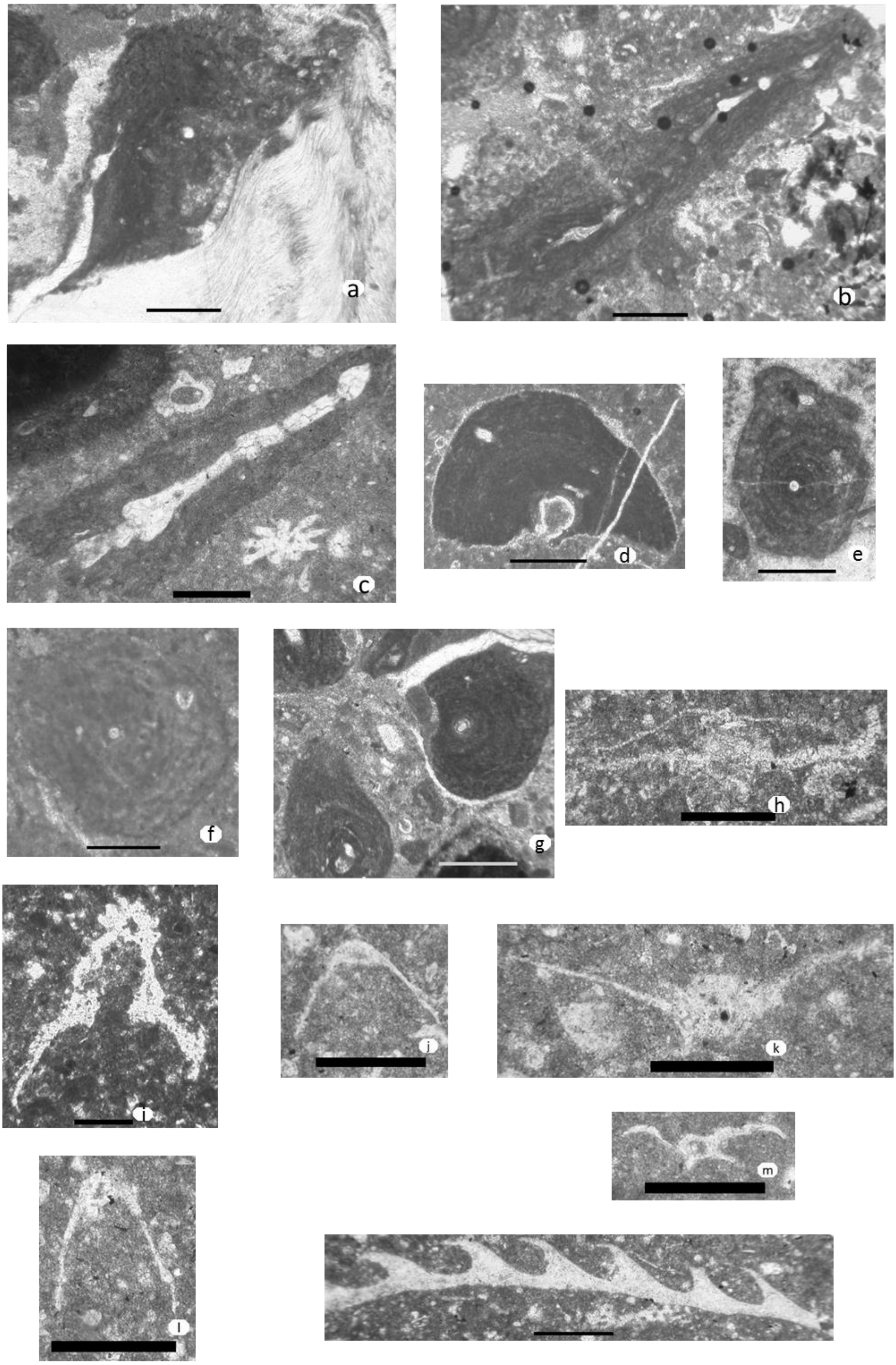


PLATE 11

a. *Labyrinthina mirabilis*, STG-111A, 200 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

b. *Labyrinthina mirabilis*, STG-113, 400 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

c. *Labyrinthina mirabilis*, STG-115, 400 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

d. *Labyrinthina mirabilis*, STG-117, 400 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

e. *Labyrinthina mirabilis*, STG-134, 400 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

f. *Labyrinthina mirabilis*, STG-136, 400 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

g. *Pseudocyclammina lituus*, STG-66, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

h. *Pseudocyclammina lituus*, STG-114, 400 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

i. *Pseudocyclammina lituus*, STG-114, 400 µm, *Labyrinthina mirabilis* – *Protopeneroplis striata* Zone (Kimmeridgian), STG sction

PLATE 11

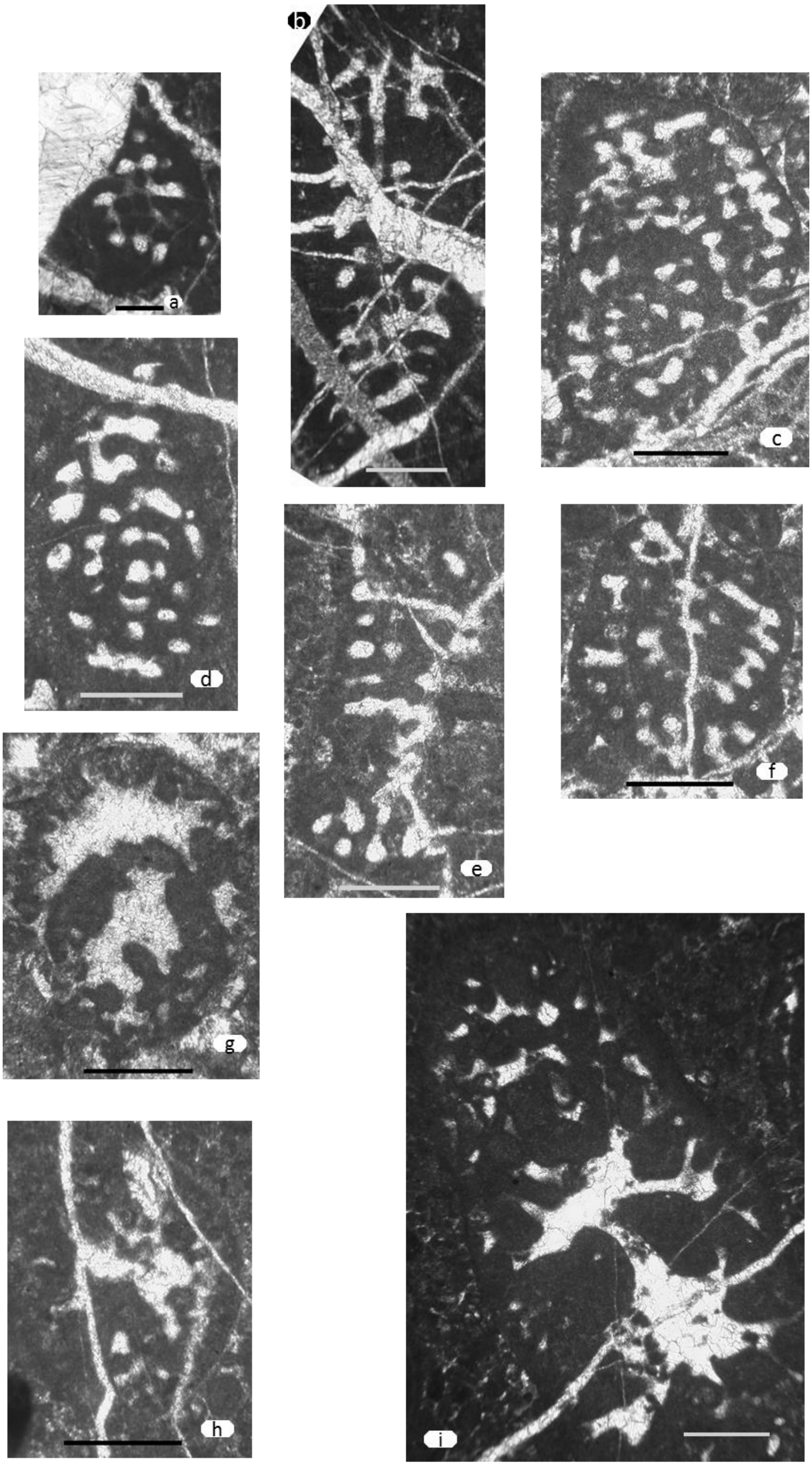


PLATE 12

a. *Pseudocyclammina lituus*, STG-129, 400 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

b. *Alveosepta*? sp., STG-129, 400 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

c. *Pseudocyclammina lituus*, SG-1, 400 µm, *Calpionella* Zone (Early Berriasian), SS section

d. *Everticyclammina* sp., STG-56, 400 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

e. *Everticyclammina* sp., STG-114, 400 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

f. *Everticyclammina* sp., STG-114, 400 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

g. *Everticyclammina* sp., STG-114, 400 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

h. *Everticyclammina* sp., STG-117B, 400 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

i. *Everticyclammina* sp., STG-134, 400 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

j. Unidentified foraminifera, SG-1, 200 µm, *Calpionella* Zone (Early Berriasian), SS section

k. *Mesoendothyra*? sp., STG-71A, 200 µm, *alpina* subzone (Early Berriasian), STG section

PLATE 12

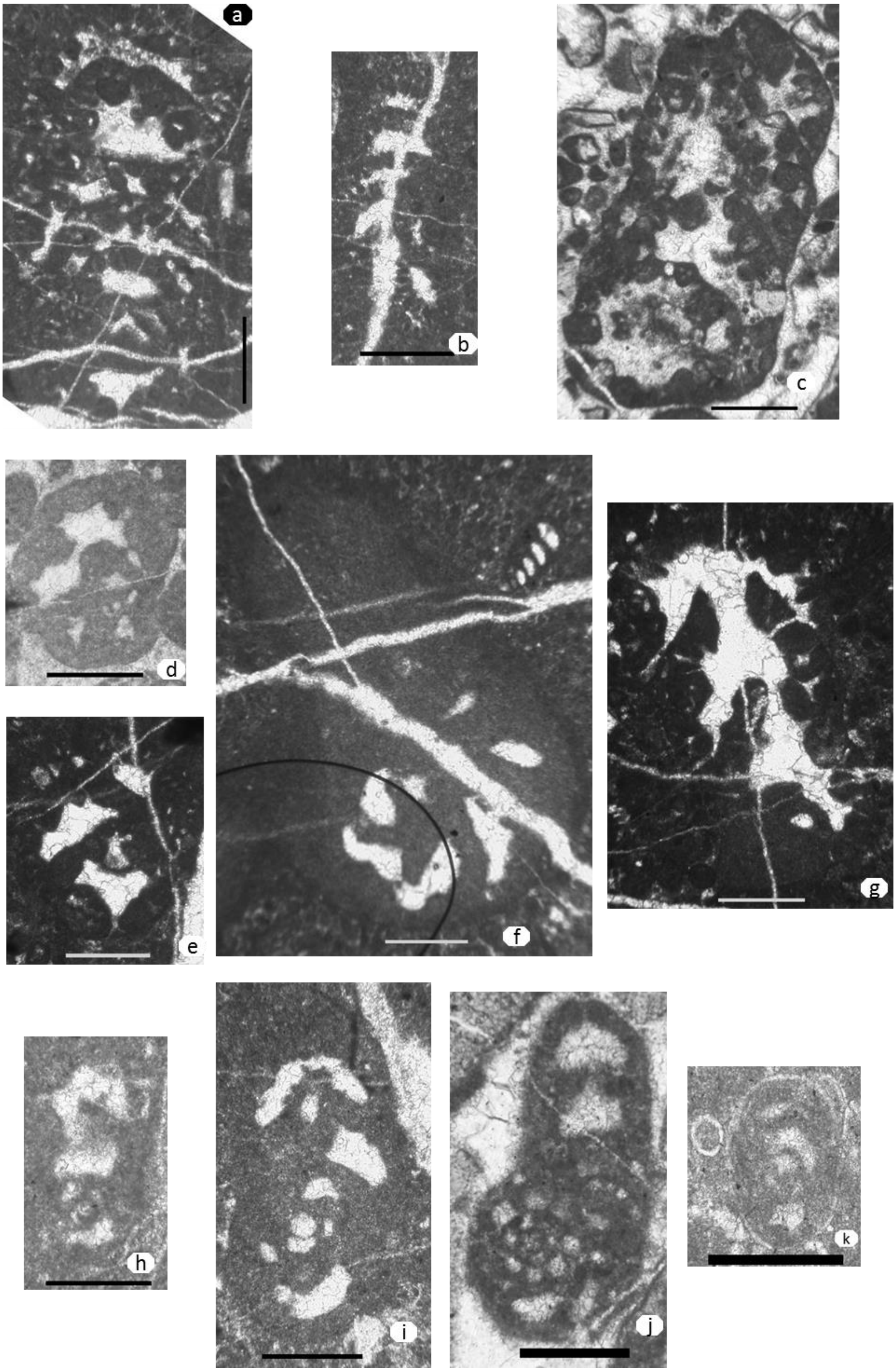


PLATE 13

a. *Coscinophragma cribrosum*, STG-57, 400 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

b. *Coscinophragma cribrosum*, STG-72, 400 µm, *alpina* subzone (Early Berriasian), STG section

c. *Coscinophragma cribrosum*, STG-72A, 400 µm, *alpina* subzone (Early Berriasian), STG section

d. *Charentia* sp., STG-56, 200 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

e. *Charentia* sp., STG-57, 200 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

f. *Charentia* sp., STG-75, 200 µm, *Remaneilla* subzone (Early Berriasian), STG section

g. *Charentia*? sp., STG-133, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

h. *Charentia* sp., STG-46, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

i. *Nautiloculina* sp., STG-51, 200 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

j. *Nautiloculina* sp., STG-117A, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

k. *Nautiloculina* sp., STG-114, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

l. *Quinqueloculina*? sp., STG-28, 50 µm, *Saccocoma* Zone (Early Tithonian), STG section

m. *Quinqueloculina*? sp., STG-29, 50 µm, *Saccocoma* Zone (Early Tithonian), STG section

n. *Quinqueloculina* sp., STG-19, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

o. *Quinqueloculina* sp., STG-30, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

p. *Ophthalmidium* sp., STG-14, 200 µm, *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), STG section

r. *Ophthalmidium* sp., STG-1, 200 μm, *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), STG section

PLATE 13

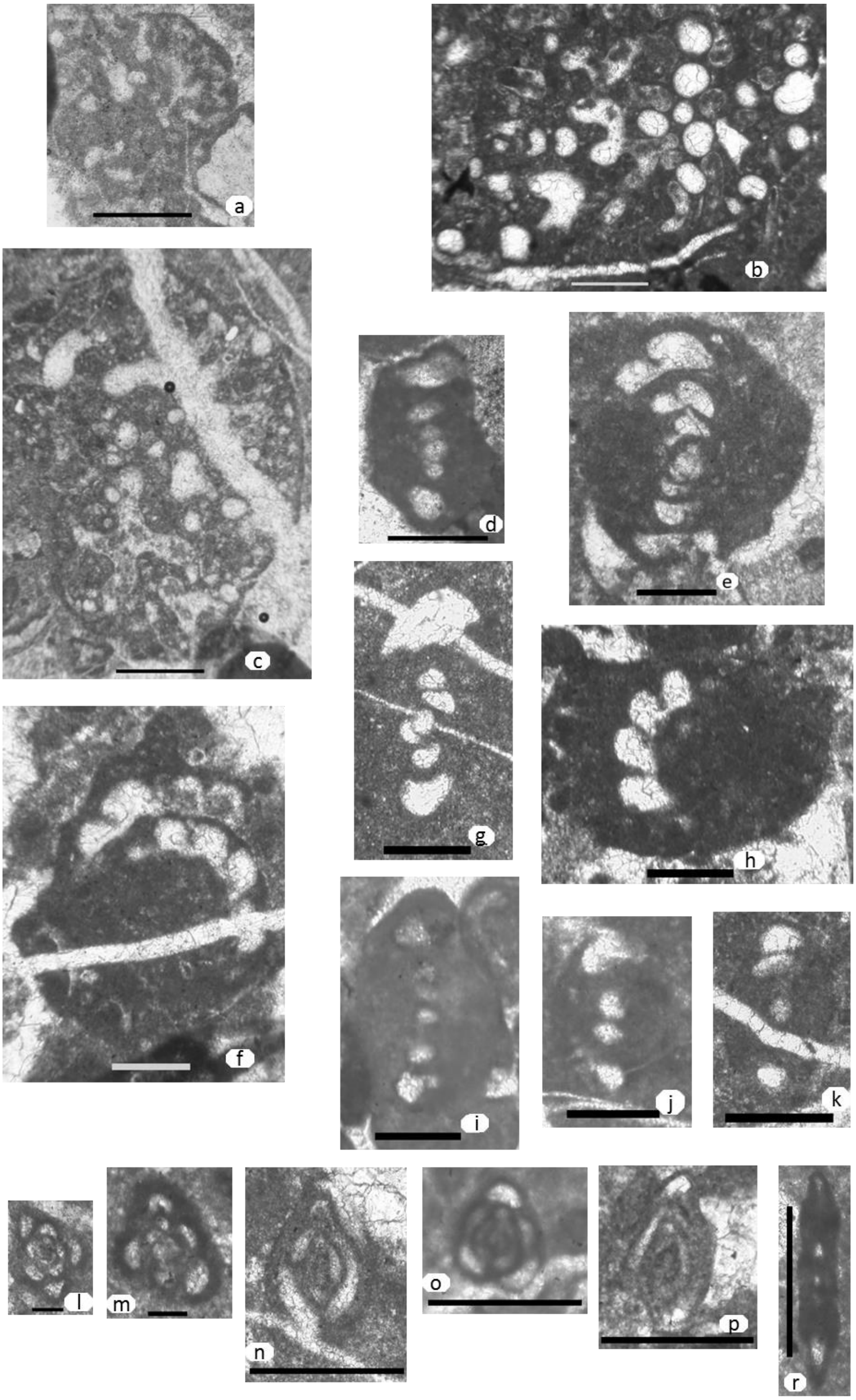


PLATE 14

a. *Quinqueloculina* sp., STG-72A, 200 µm, *alpina* subzone (Early Tithonian), STG section

b. *Quinqueloculina* sp., STG-72A, 200 µm, *alpina* subzone (Early Tithonian), STG section

c. *Quinqueloculina* sp., STG-75, 200 µm, *Remaniella* subzone (Early Tithonian), STG section

d. *Quinqueloculina* sp., STG-109A, 100 µm, *Calpionella* Zone (Early Berriasian), STG section

e. *Quinqueloculina* sp., STG-114, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

f. *Quinqueloculina* sp., STG-114, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

g. *Quinqueloculina* sp., STG-115, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

h. *Quinqueloculina* sp., STG-116, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

i. *Quinqueloculina* sp., STG-118B, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

j. *Quinqueloculina* sp., STG-119, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

k. *Quinqueloculina* sp., STG-129, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

l. *Quinqueloculina* sp., STG-130, 100 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

m. *Quinqueloculina* sp., STG-135, 100 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

n. *Ophthalmidium* sp., STG-25, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

o. *Ophthalmidium* sp., STG-111A, 100 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

p. *Ophthalmidium* sp., STG-119C, 100 µm, *Labyrinthina mirabilis –*

Protopeneroplis striata Zone (Kimmeridgian), STG sction

r. *Ophthalmidium* sp., STG-30, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

s. *Ophthalmidium*? sp., STG-60, 100 µm, *Protopeneroplis ultragranulata* (Late Tithonian) STG section

t. *Ophthalmidium* sp., STG-79, 100 µm, *Remaneilla* subzone (Early Berriasian), STG section

PLATE 14

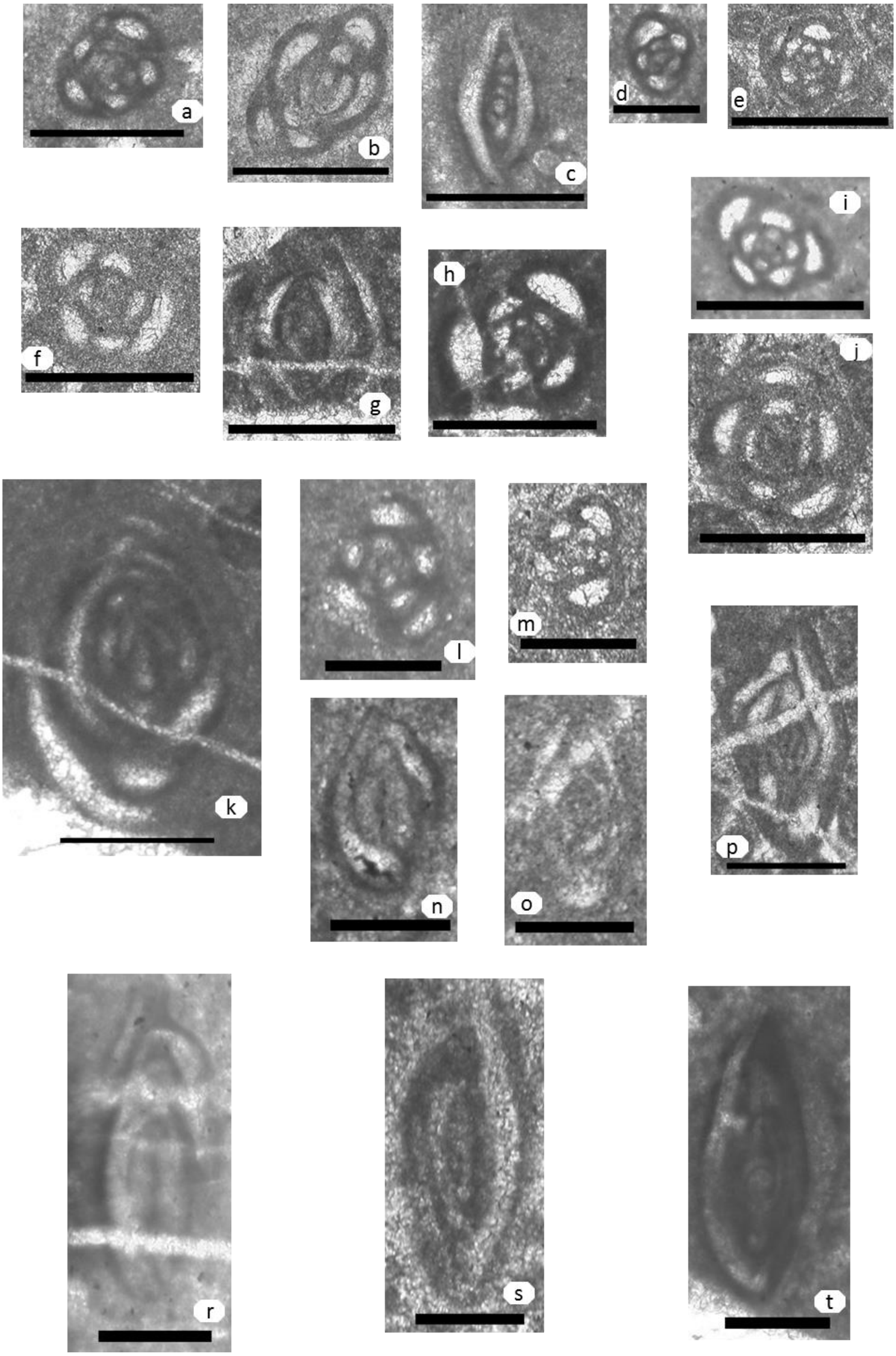


PLATE 15

a. *Moesiloculina*? sp., STG-20, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

b. *Moesiloculina*? sp., STG-26, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

c. Unidentified miliolid, STG-52, 100 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

d. *Moesiloculina* sp., STG-59, 100 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

e. *Moesiloculina* sp., STG-65, 100 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

f. *Moesiloculina* sp., STG-71, 100 µm, *alpina* subzone (Early Berriasian), STG section

g. *Moesiloculina* sp., STG-90, 100 µm, *oblonga* subzone (Late Berriasian) STG section

h. *Moesiloculina*? sp., STG-129, 100 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

i. *Istriloculina* sp., STG-21, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

j. *Istriloculina* sp., STG-25, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

k. *Istriloculina* sp., STG-48, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

l. *Istriloculina* sp., STG-72, 100 µm, *alpina* subzone (Early Berriasian), STG section

m. *Istriloculina* sp., STG-84, 100 µm, *elliptica* subzone (Early Berriasian), STG section

n. *Istriloculina* sp., STG-86, 100 µm, *simplex* subzone (Late Berriasian), STG section

o. *Cornuspira* sp., STG-21, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

p. *Cornuspira* sp., STG-77, 100 µm, *Remaniella* subzone (Early Berriasian), STG section

r. *Cornuspira* sp., STG-80, 100 µm, *Remaniella* subzone (Early Berriasian), STG section

s. *Cornuspira* sp., STG-90, 100 µm, *oblonga* subzone (Late Berriasian) STG section

PLATE 15

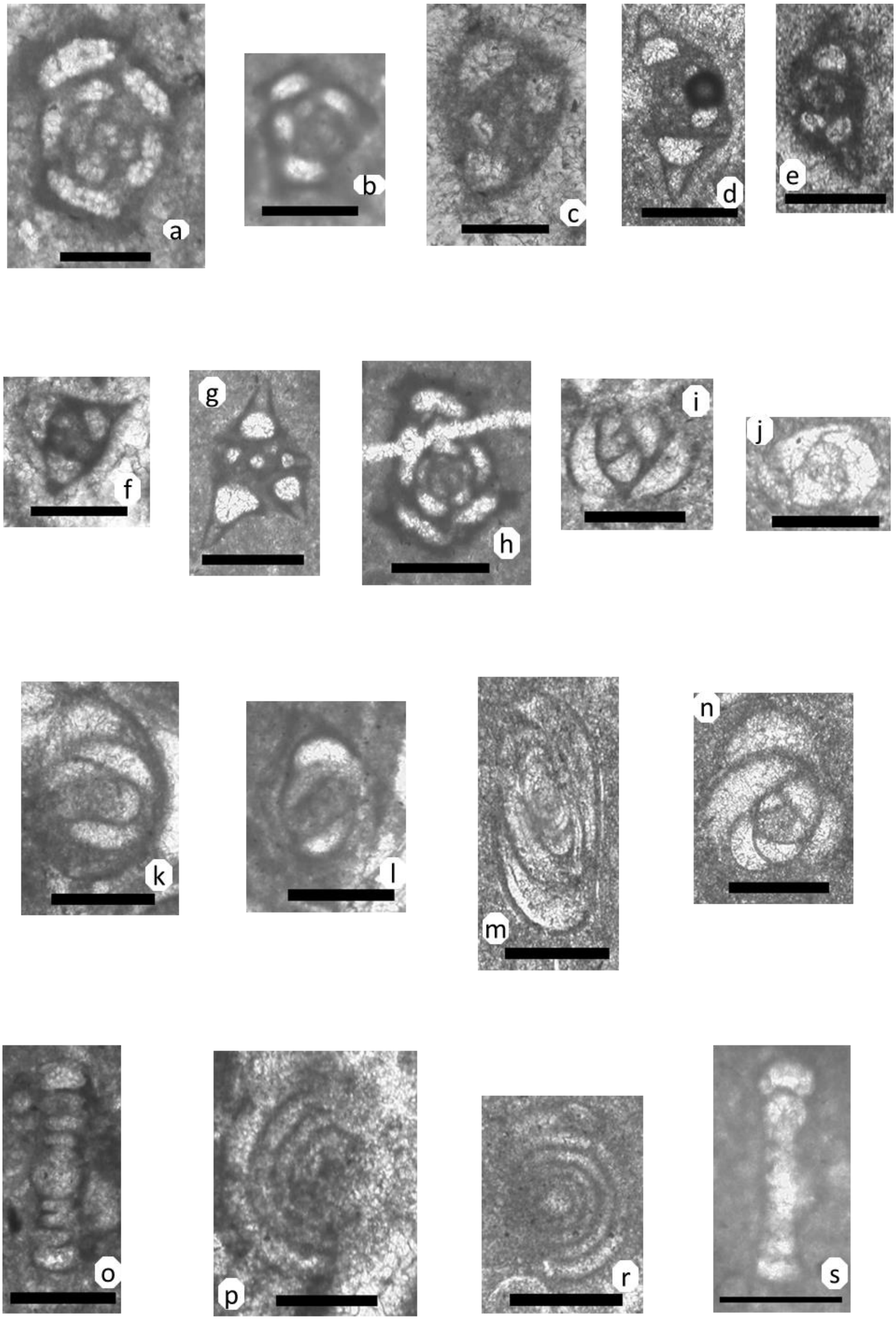


PLATE 16

a. *Glomospira* sp., STG-14, 100 µm, *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), STG section

b. *Glomospira* sp., STG-72, 100 µm, *alpina* subzone (Early Berriasian), STG section

c. *Glomospira* sp., STG-88A, 100 µm, *oblonga* subzone (Late Berriasian) STG section

d. *Glomospira* sp., STG-119A, 100 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

e. *Meandrospira*? sp., STG-39, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

f. *Meandrospira*? sp., STG-43, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

g. *Meandrospira* sp., STG-20, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

h. *Meandrospira* sp., STG-40, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

i. *Meandrospira* sp., STG-79, 100 µm, *Remaniella* subzone (Early Berriasian), STG section

j. *Meandrospira* sp., STG-92A, 100 µm, *oblonga* subzone (Late Berriasian) STG section

k. *Meandrospira* sp., STG-66A, 100 µm, *massutiniana* subzone (latest Tithonian), STG section

l. *Meandrospira favrei*, STG-67A, 100 µm, *massutiniana* subzone (latest Tithonian), STG section

m. *Meandrospira favrei*, STG-91, 100 µm, *oblonga* subzone (Late Berriasian) STG section

n. *Meandrospiranella* sp., STG-15, 100 µm, *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), STG section

PLATE 16

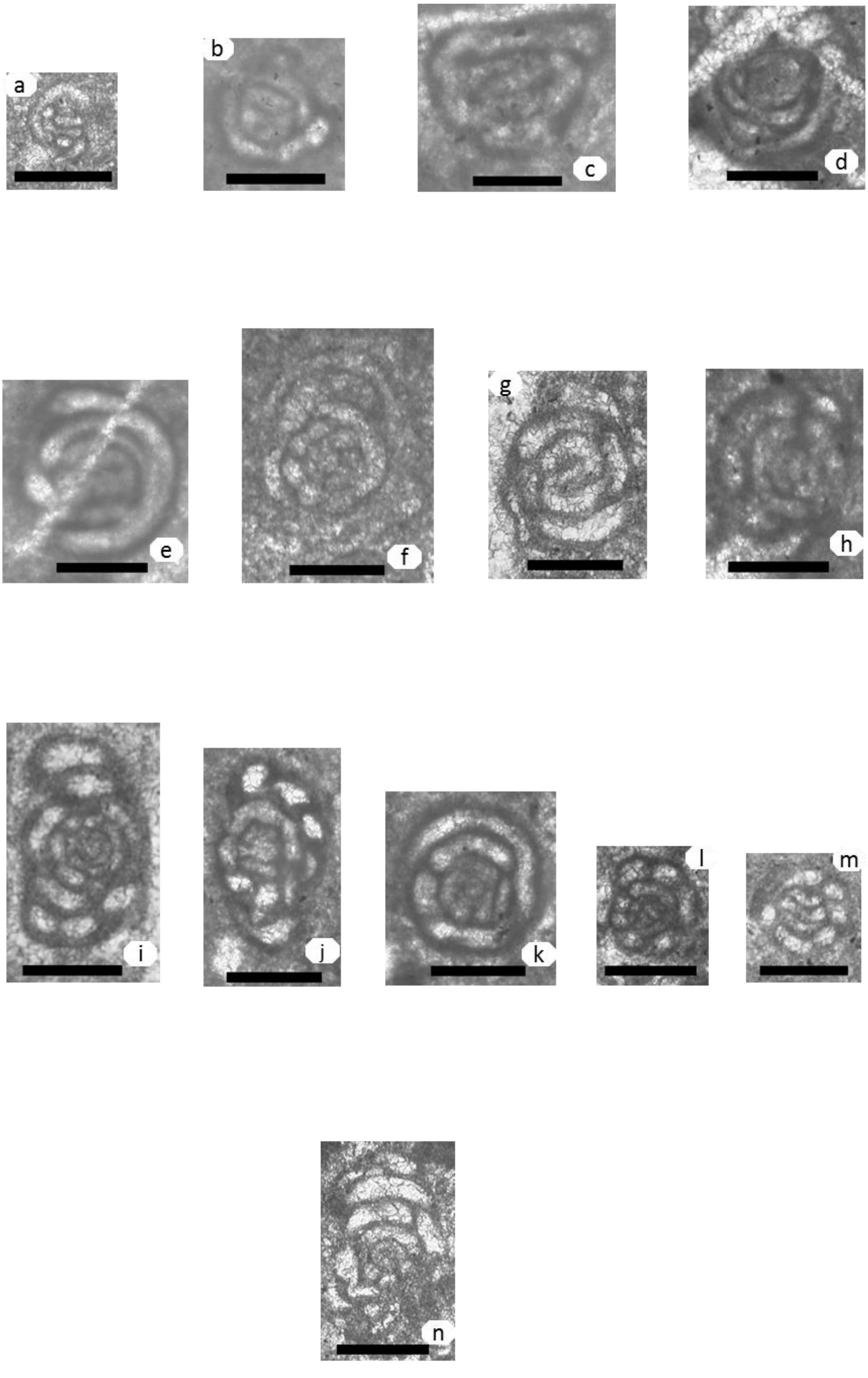


PLATE 17

a. *Haplophragmoides joukowskyi*, STG-90, 100 µm, *oblonga* subzone (Late Berriasian), STG section

b. *Haplophragmoides joukowskyi*, STG-88, 100 µm, *oblonga* subzone (Late Berriasian), STG section

c. *Haplophragmoides joukowskyi*, STG-90, 100 µm, *oblonga* subzone (Late Berriasian), STG section

d. *Haplophragmoides joukowskyi*, STG-91A, 100 µm, *oblonga* subzone (Late Berriasian), STG section

e. *Haplophragmoides joukowskyi*, STG-92, 100 µm, *oblonga* subzone (Late Berriasian), STG section

f. *Montsalevia salevensis*, STG-94, 100 µm, *darderi* subzone (Earliest Valanginian), STG section

g. *Ammobaculites* sp., STG-25, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

h. *Ammobaculites* sp., STG-40, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

i. *Ammobaculites* sp., STG-131, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

j. *Reophax* sp., STG-40, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

k. *Reophax* sp., STG-70, 100 µm, *massutiniana* subzone (latest Tithonian), STG section

l. *Reophax* sp., STG-88A, 100 µm, *oblonga* subzone (Late Berriasian), STG section

m. *Reophax* sp., STG-87, 100 µm, *oblonga* subzone (Late Berriasian), STG section

n. *Siphovalvulina*? sp., STG-51, 100 µm, *Protopeneroplis ultragranulata* Zone (Late Tihonitan) STG seciton

o. *Siphovalvulina*? sp., STG-70, 100 µm, *massutiniana* subzone (latest Tithonian), STG section

p. *Siphovalvulina*? sp., STG-91A, 100 µm, *oblonga* subzone (Late Berriasian), STG section

PLATE 17

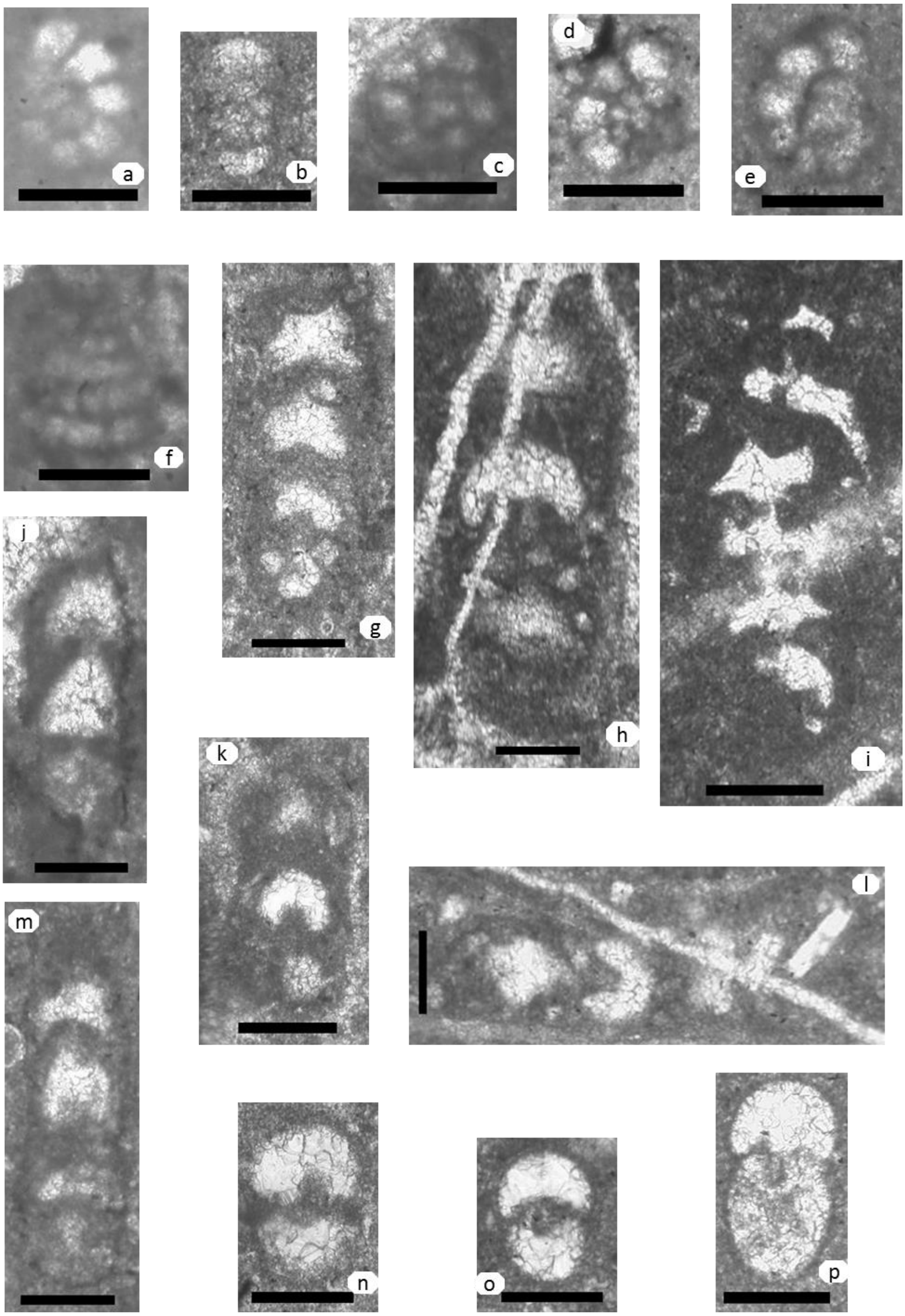


PLATE 18

a. *Haghimashella*? sp., STG-20, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

b. *Haghimashella*? sp., STG-119A, 100 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

c. *Haghimashella*? sp., STG-130, 100 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

d. *Textularia* sp., STG-17, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

e. *Textularia* sp., STG-19, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

f. *Textularia* sp., STG-47, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

g. *Textularia*? sp., STG-60, 100 µm, *Protopeneroplis ultragranulata* Zone (Late Tihonitan) STG seciton

h. *Textularia* sp., STG-76, 100 µm, *Remaniella* subzone (Early Berriasian), STG section

i. *Textularia* sp., STG-91A, 100 µm, *oblonga* subzone (Late Berriasian), STG section

j. *Protomarssonella* sp., STG-22, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

k. *Redmondoides*? sp., STG-20, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

l. *Redmondoides*? sp., STG-24, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

m. *Redmondoides*? sp., STG-115, 100 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

n. *Redmondoides*? sp., STG-84, 100 µm, *elliptica* subzone (Early Berriasian), STG section

o. Verneuilinid foraminifera, STG-57, 200 µm, *Protopeneroplis ultragranulata* Zone (Late Tihonitan) STG seciton

p. Verneuilinid foraminifera, STG-111A, 100 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

r. Verneuilinid foraminifera, STG-113, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

s. *Trochammina* sp.., STG-133, 100 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

PLATE 18

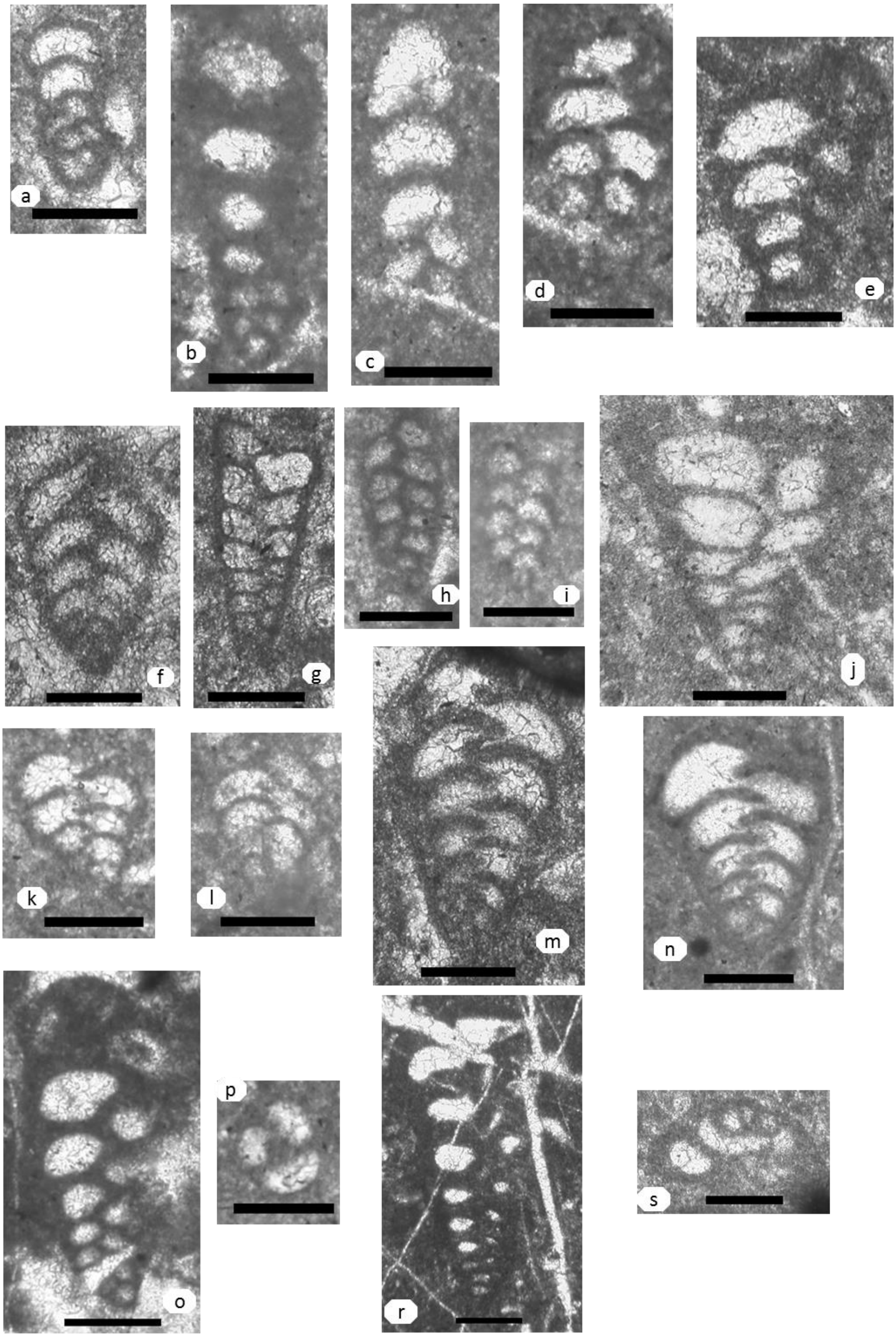


PLATE 19

a. *Coscinoconus* sp., STG-46, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

b. *Coscinoconus* sp., STG-56, 200 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

c. *Coscinoconus* sp., STG-56, 200 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

d. *Coscinoconus* sp., STG-51, 100 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

e. *Coscinoconus* sp., STG-56, 100 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

f. *Coscinoconus* sp., STG-56, 100 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

g. *Coscinoconus* sp., STG-75, 200 µm, *Remaniella* subzone (Early Berriasian), STG section

h. *Coscinoconus* sp., STG-75, 200 µm, *Remaniella* subzone (Early Berriasian), STG section

PLATE 19

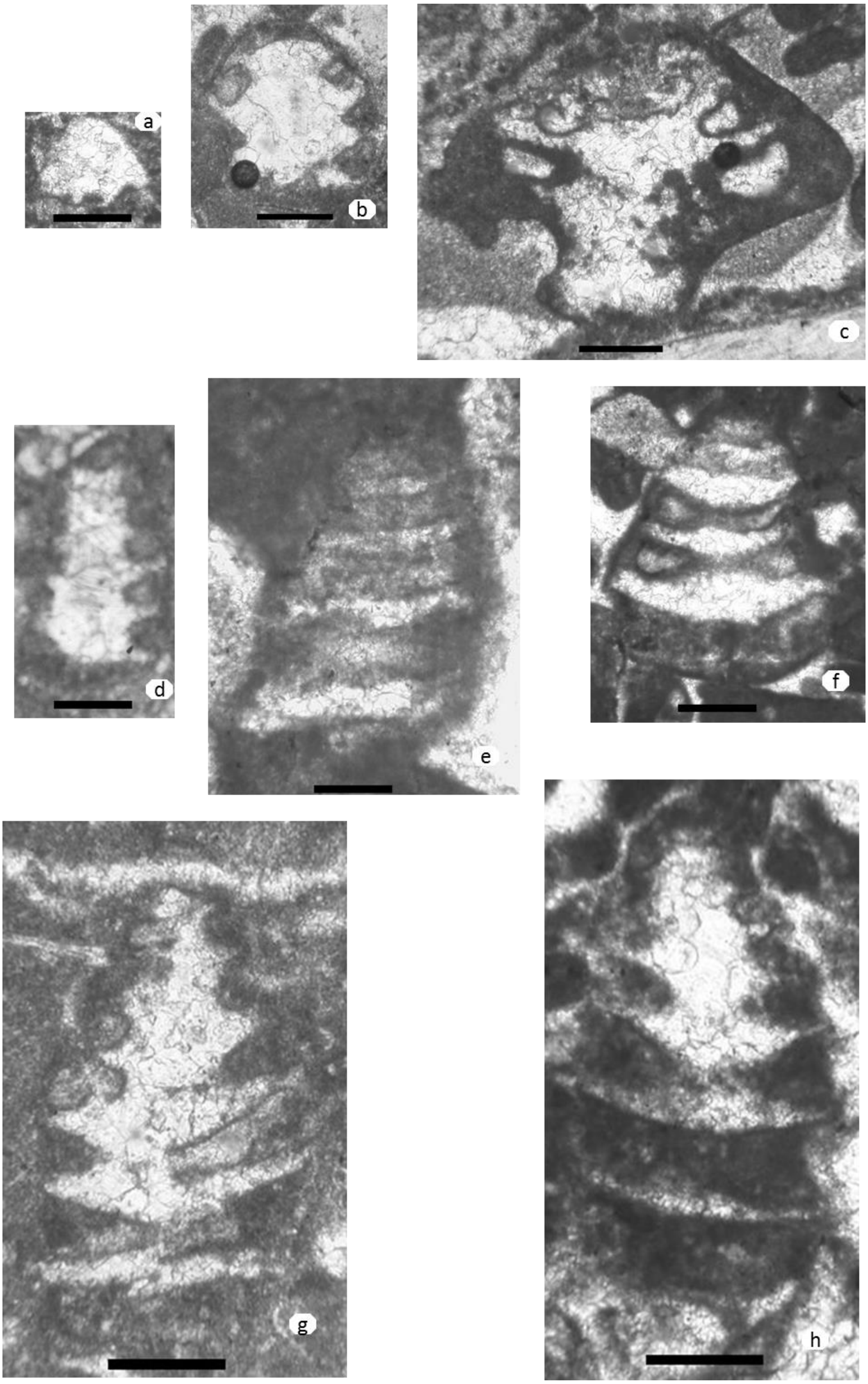


PLATE 20

a. *Coscinoconus* sp., STG-109, 200 µm, *Calpionella* Zone (Early Berriasian), STG section

b. *Coscinoconus* sp., SG-1, 200 µm, *Calpionella* Zone (Early Berriasian), SS section

c. *Coscinoconus* sp., STG-71A, 100 µm, *alpina* subzone (Early Berriasian), STG section

d. *Coscinoconus* sp., STG-86A, 100 µm, *simplex* subzone (Late Berriasian), STG section

e. *Coscinoconus* sp., STG-56, 200 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

f. *Neotrocholina* sp., STG-54, 200 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

g. *Neotrocholina* sp., STG-73, 200 µm, *alpina* subzone (Early Berriasian), STG section

h. *Neotrocholina* sp., STG-80, 200 µm, *Remaniella* subzone (Early Berriasian), STG section

i. *Neotrocholina* sp., STG-84, 200 µm, *elliptica* subzone (Early Berriasian), STG section

j. *Neotrocholina* sp., STG-88A, 200 µm, *oblonga* subzone (Late Berriasian), STG section

k. *Neotrocholina* sp., STG-93, 200 µm, *darderi* subzone (earliest Valanginian), STG section

l. *Neotrocholina* sp., STG-109A, 200 µm, *Calpionella* Zone (Early Berriasian), STG section

PLATE 20

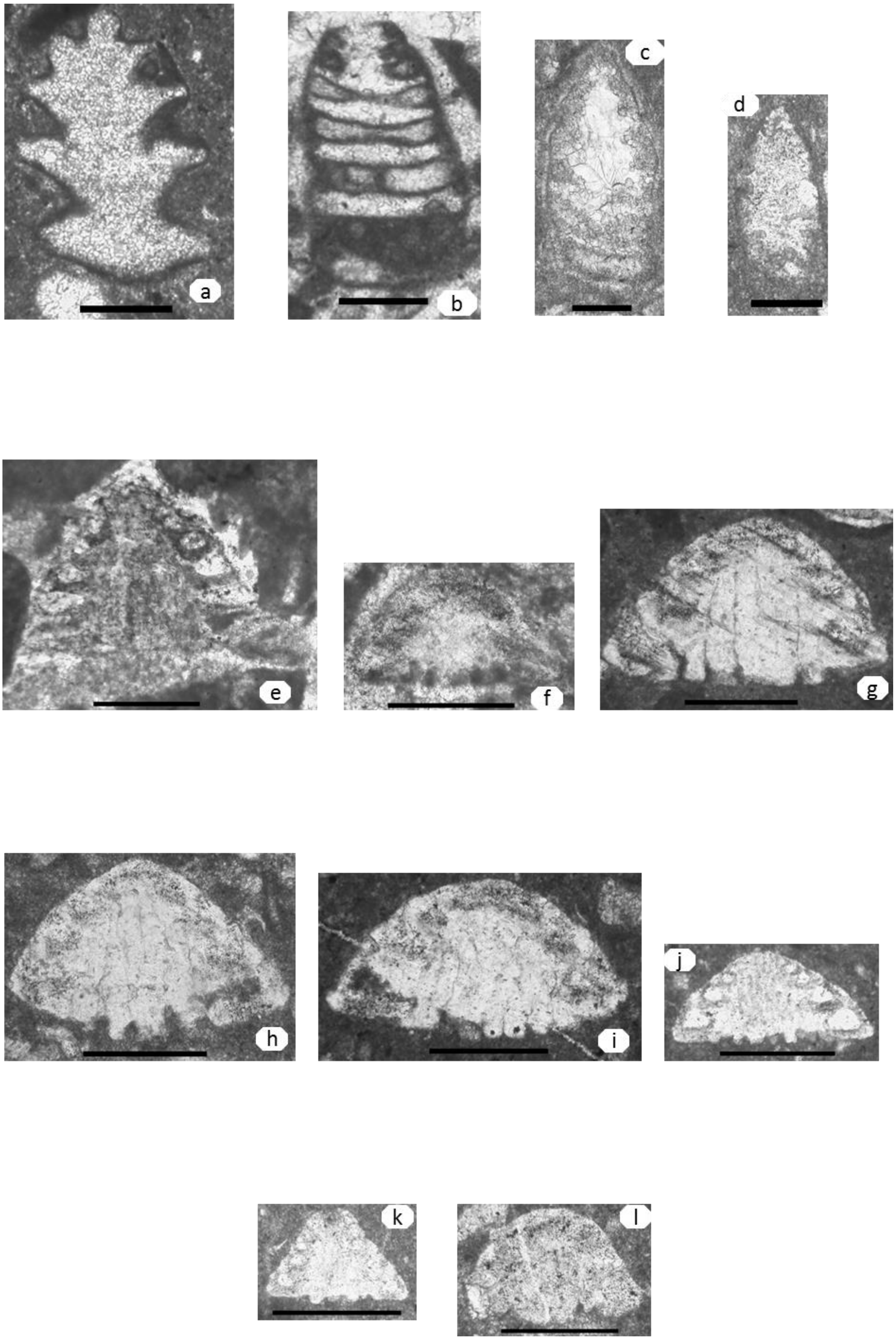


PLATE 21

a. Lagenid foraminifera, STG-83, 50 µm, *elliptica* subzone (Ealry Berriasian), STG section

b. *Spirillina* sp., STG-1, 50 µm, *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), STG section

c. *Spirillina* sp., STG-1, 50 µm, *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), STG section

d. *Spirillina* sp., STG-15, 50 µm, *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), STG section

e. *Spirillina* sp., STG-21, 50 µm, *Saccocoma* Zone (Early Tithonian), STG section

f. *Spirillina* sp., STG-70, 50 µm, *massutiniana* subzone (latest Tithonian), STG section

g. *Spirillina* sp., STG-75, 50 µm, *Remaniella* subzone (Early Tithonian), STG section

h. *Spirillina* sp., STG-80, 50 µm, *Remaniella* subzone (Early Tithonian), STG section

i. *Spirillina* sp., STG-90, 50 µm, *oblonga* subzone (Late Berriasian), STG section

k. Lagenid foraminifera, STG-43, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

l. Lagenid foraminifera, STG-71A, 100 µm, *alpina* subzone (Early Berriasian), STG section

m. *Lenticulina* sp., STG-79, 100 µm, *Remaniella* subzone (Early Tithonian), STG section

n. *Lenticulina* sp., STG-87, 100 µm, *oblonga* subzone (Late Berriasian), STG section

o. . Lagenid foraminifera, STG-87, 100 µm, *oblonga* subzone (Late Berriasian), STG section

p. Lagenid foraminifera, SG-1, 100 µm, *Calpionella* Zone (Early Berriasian), SS section

r. *Pithonella* sp., STG-1, 50 µm, *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), STG section

s. *Pithonella* sp., STG-20, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

t. *Pithonella* sp., STG-25, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

u. *Pithonella* sp., STG-1, 50 μm, *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), STG section

PLATE 21

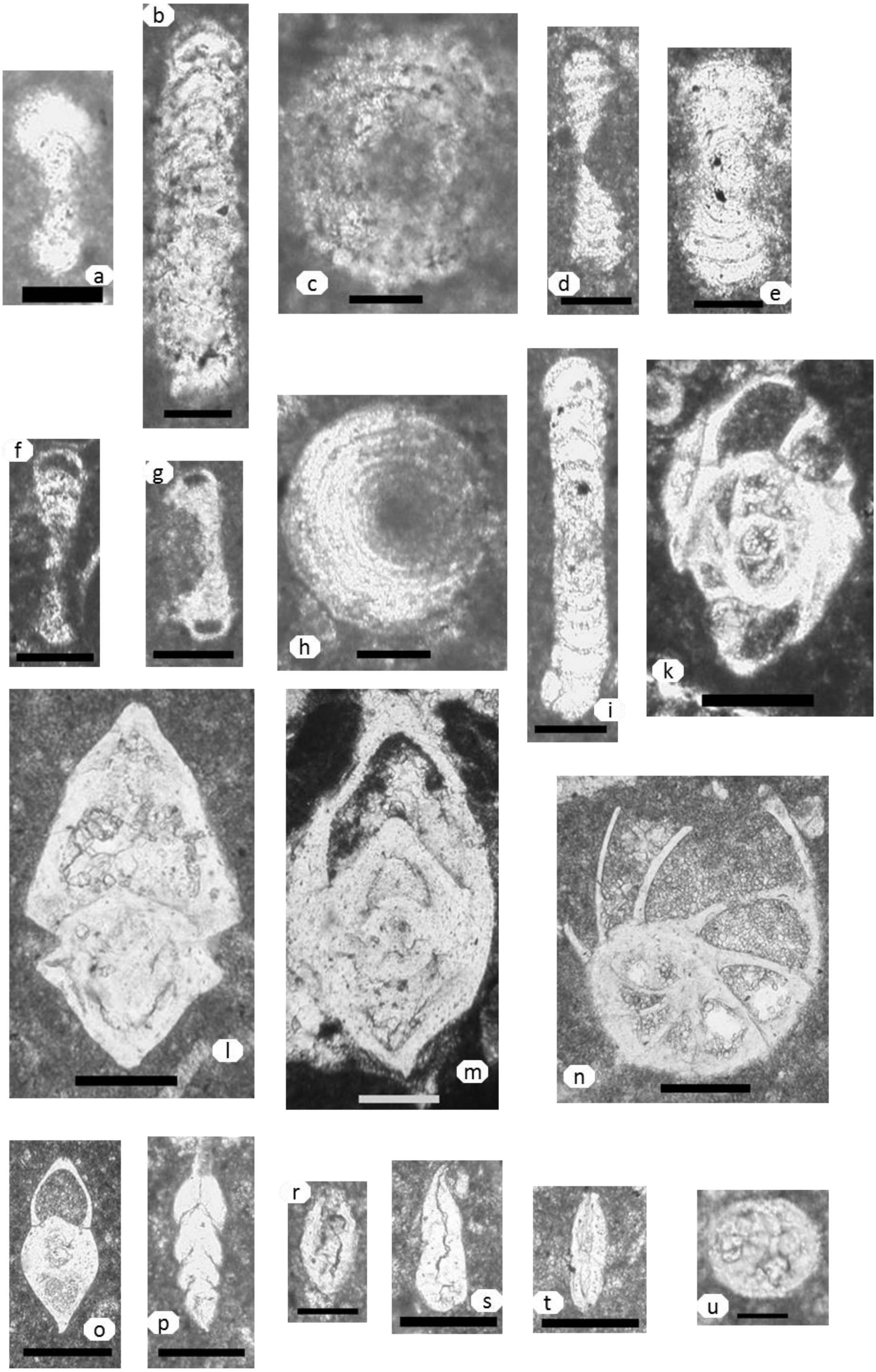


PLATE 22

a. *Patellina* sp., STG-39, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

b. *Patellina* sp., STG-85, 100 µm, *simplex* subzone (Late Berriasian), STG section

c. *Patellina* sp., STG-87, 100 µm, *oblonga* subzone (Late Berriasian), STG section

d. *Patellina* sp., STG-94, 100 µm, *darderi* subzone (earliest Valanginian), STG section

e. *Troglotella incrustans*, STG-47, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

f. *Troglotella incrustans*, STG-47, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

g. *Troglotella incrustans*, STG-119A, 400 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

h. Bacinellid fabric, STG-47, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

i. Bacinellid fabric, STG-47, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

j. *Cayeuxia* sp., STG-42, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

k. *Cayeuxia* sp., STG-56, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

l. *Cayeuxia* sp., STG-119, 400 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

PLATE 22

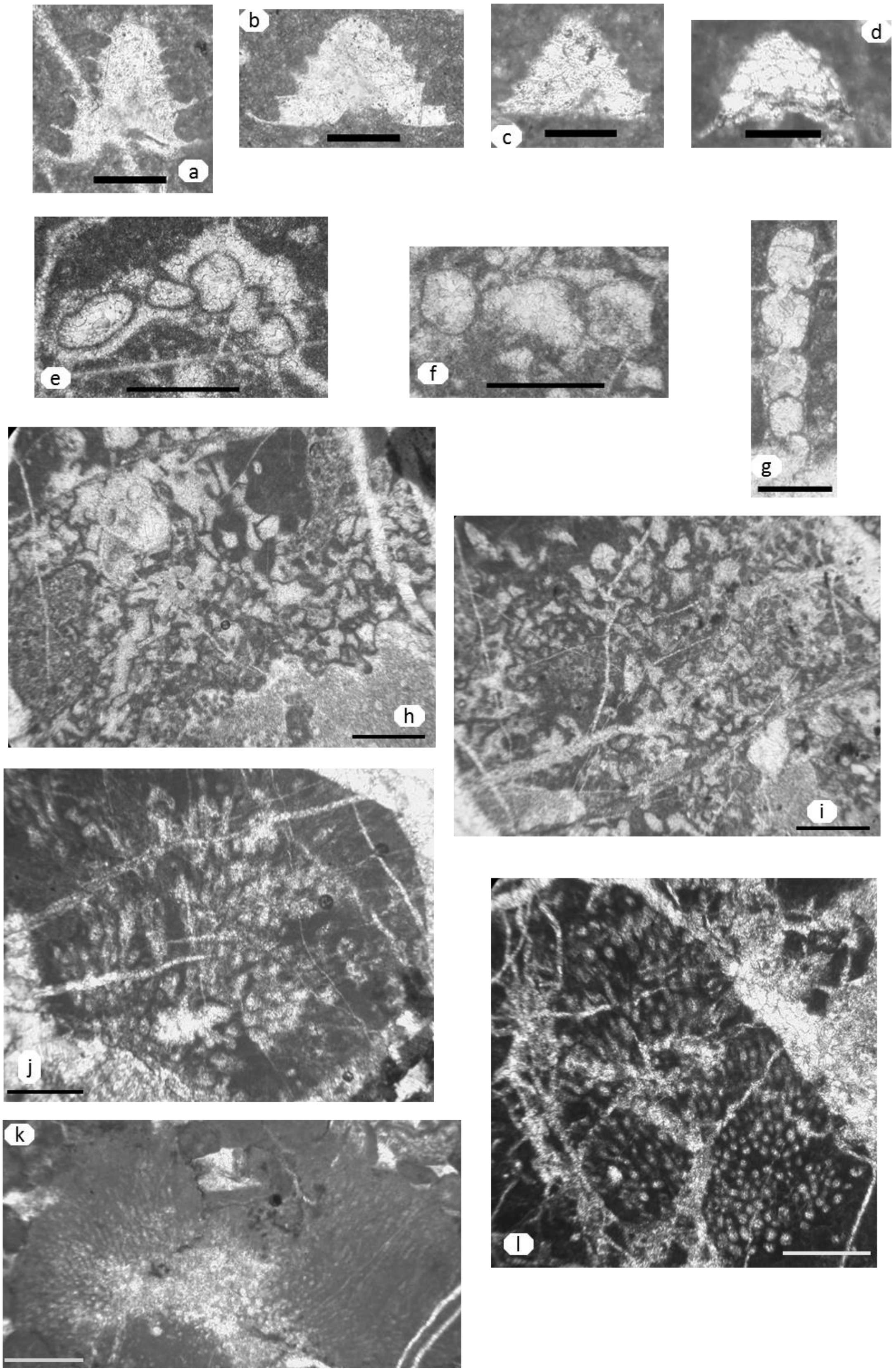


PLATE 23

a. *Lithocodium aggregatum*, STG-39, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

b. *Lithocodium aggregatum*, STG-50, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

c. *Lithocodium aggregatum*, STG-56, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

d. *Lithocodium aggregatum*, STG-44, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

e. *Lithocodium aggregatum*, STG-66A, 400 µm, *massutiniana* subzone (latest Tithonian)

f. *Lithocodium aggregatum*, STG-68, 400 µm, *massutiniana* subzone (latest Tithonian)

PLATE 23

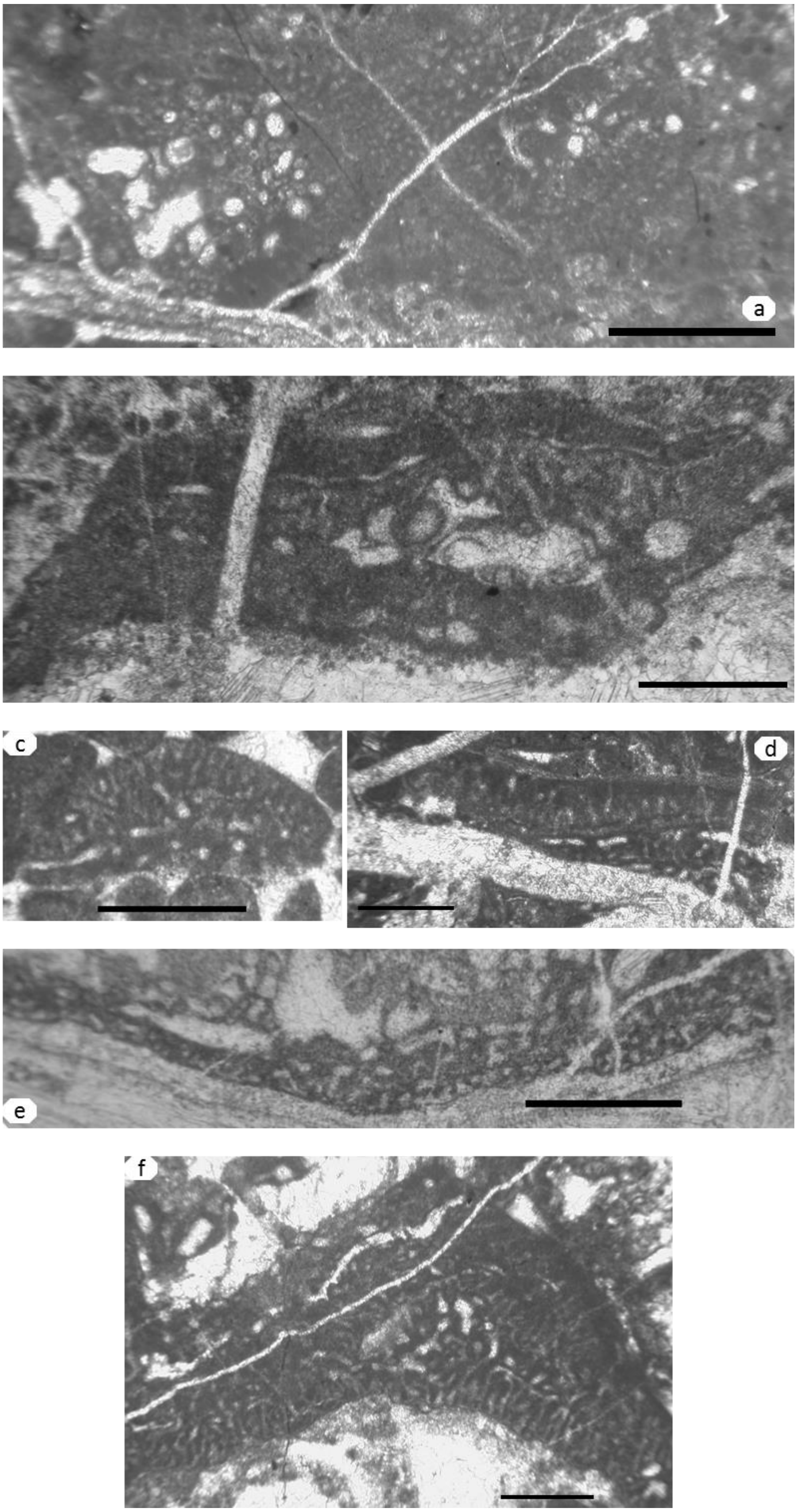


PLATE 24

a. *Lithocodium aggregatum*, STG-106A, 400 µm, *Calpionella* Zone (Early Berriasian), STG section

b. *Lithocodium aggregatum*, SG-4, 400 µm, *Calpionella* Zone (Early Berriasian), SS section

c. *Koskinobullina socialis*, STG-49, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

d. *Koskinobullina socialis,* STG-69, 400 µm, *massutiniana* subzone (latest Tithonian), STG section

e. *Koskinobullina socialis*, STG-73, 400 µm, *alpina* subzone (Early Berriasian), STG section

f. *Koskinobullina socialis*, SG-4, 400 µm, *Calpionella* Zone (Early Berriasian), SS section

PLATE 24

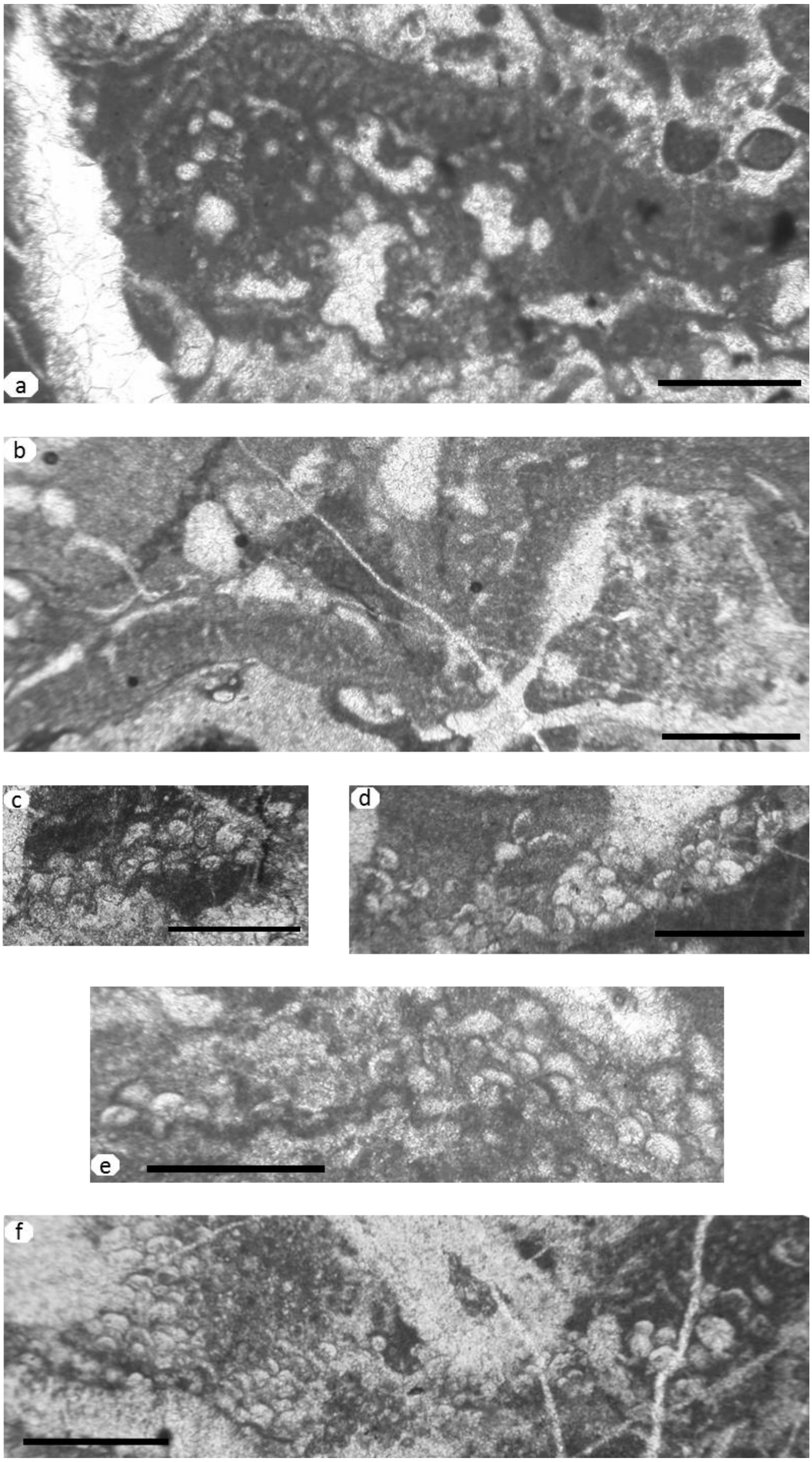


PLATE 25

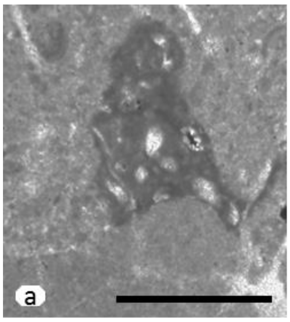
a. *Labes atramentosa*, STG-30, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

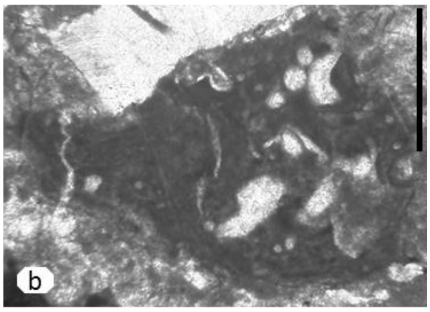
b. *Labes atramentosa*, STG-38, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

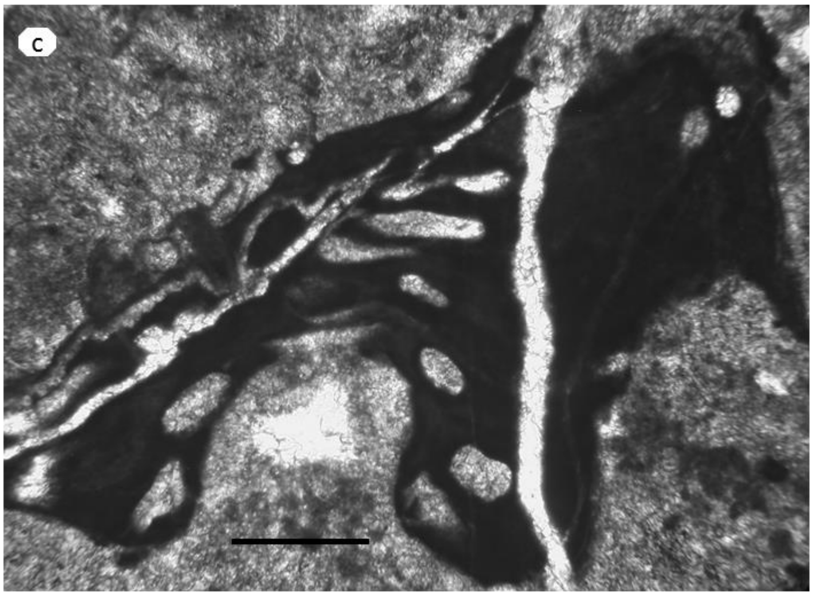
c. *Labes atramentosa*, STG-55, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

d. *Labes atramentosa*, STG-61, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

PLATE 25







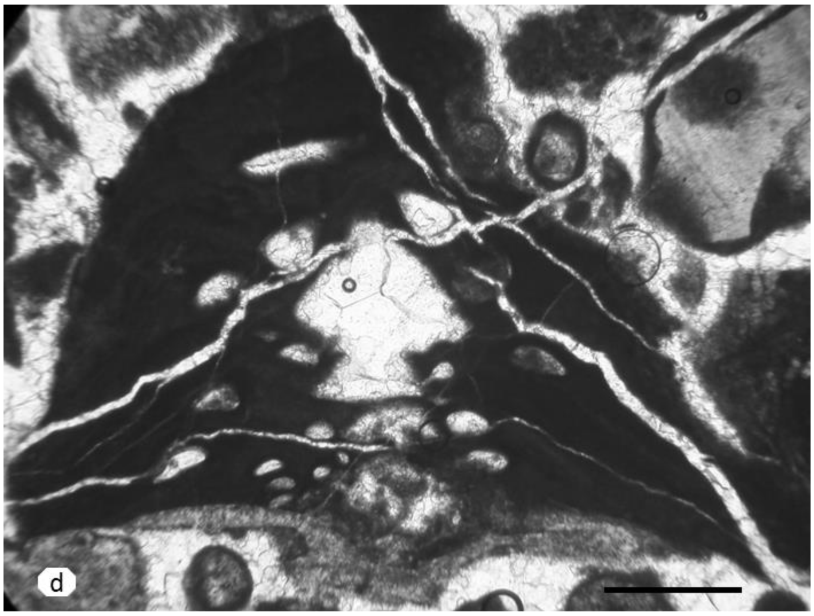


PLATE 26

a. *Perturbatacrusta leini*, STG-41, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

b. *Perturbatacrusta leini*, STG-50, 400 µm, *Saccocoma* Zone (Early Tithonian), STG section

c. *Perturbatacrusta leini*, STG-64A, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

d. *Perturbatacrusta leini*, STG-66A, 400 µm, *massutiniana* subzone (latest Tithonian), STG section

e. *Perturbatacrusta leini*, STG-66B, 400 µm, *massutiniana* subzone (latest Tithonian), STG section

f. *Perturbatacrusta leini*, STG-74A, 400 µm, *alpina* subzone (Early Berriasian), STG section

g. *Radiomura cautica*, STG-91, 200 µm, *oblonga* subzone (Late Berriasian), STG section

h. *Thaumatoporella parvovesiculifera*, STG-17, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

i. *Thaumatoporella parvovesiculifera*, STG-46, 200 µm, *Saccocoma* Zone (Early Tithonian), STG section

j. *Thaumatoporella parvovesiculifera*, STG-119B, 200 µm, *Labyrinthina mirabilis – Protopeneroplis striata* Zone (Kimmeridgian), STG sction

PLATE 26

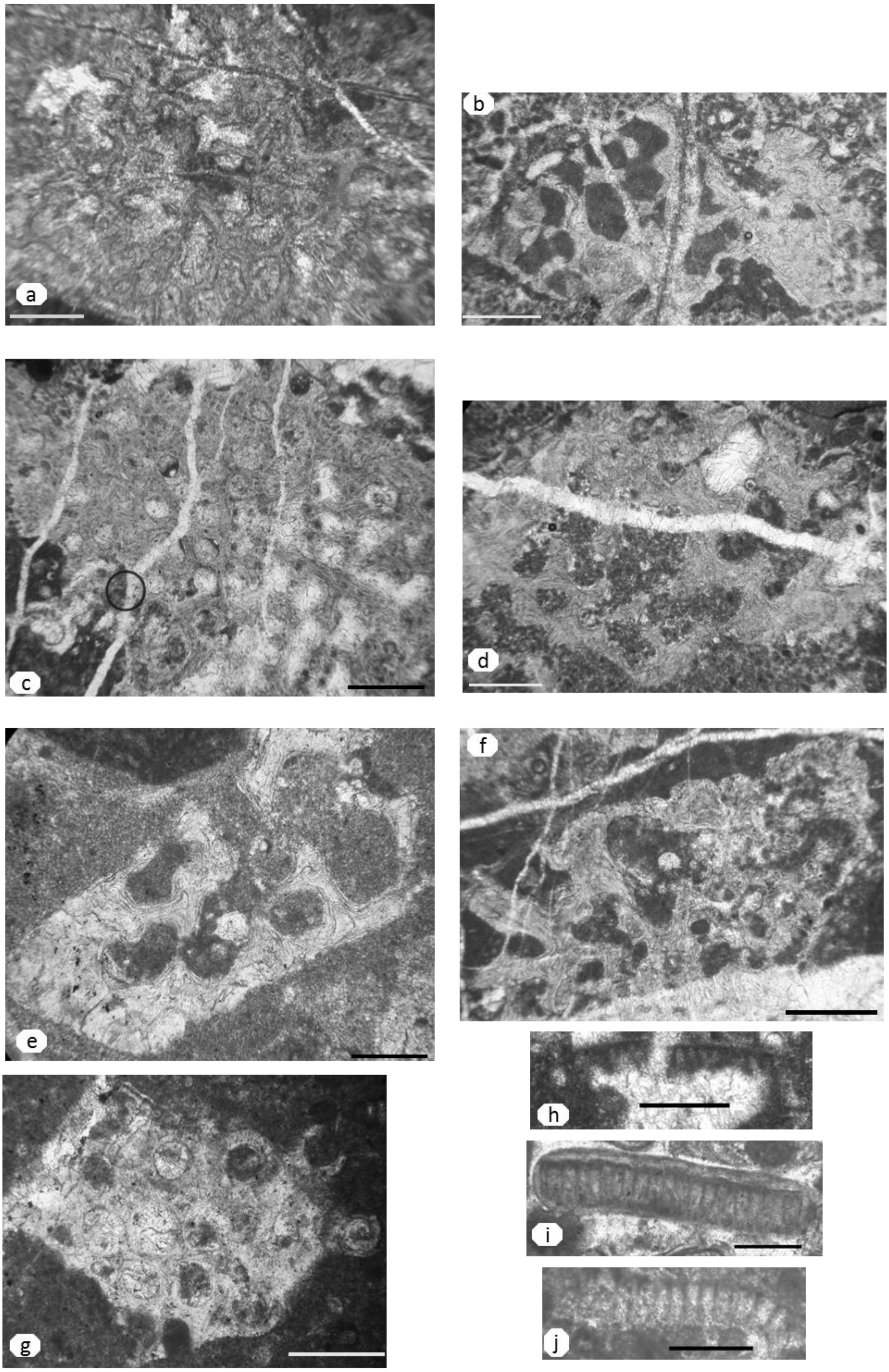


PLATE 27

a. *Mercierella* ? *dacica*, STG-1, 100 µm, *Globuligerina oxfordiana – Mohlerina basiliensis* Zone (Kimmeridgian), STG section

b. *Mercierella* ? *dacica*, STG-21, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

c. *Mercierella* ? *dacica*, STG-23, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

d. *Mercierella* ? *dacica*, STG-29, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

e. *Mercierella* ? *dacica*, STG-31, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

f. *Mercierella* ? *dacica*, STG-50, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

g. *Mercierella* ? *dacica*, STG-64A, 100 µm, *Protopeneroplis ultragranulata* Zone (Late Tithonian), STG section

h. *Mercierella* ? *dacica*, STG-66A, 400 µm, *massutiniana* subzone (latest Tithonian), STG section

i. *Mercierella* ? *dacica*, STG-67A, 400 µm, *massutiniana* subzone (latest Tithonian), STG section

j. *Mercierella* ? *dacica*, STG-73, 400 µm, *alpina* subzone (Early Berriasian), STG section

k. *Globochaete* sp., STG-23, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

l. *Globochaete* sp., STG-24, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

m. *Globochaete* sp., STG-28, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

n. *Globochaete* sp., STG-29, 100 µm, *Saccocoma* Zone (Early Tithonian), STG section

o. *Globochaete* sp., STG-29, 50 µm, *Saccocoma* Zone (Early Tithonian), STG section

p. *Globochaete* sp., STG-35, 100 µm, *Saccocoma* Zone (Early Tithonian), STG

section

r. *Globochaete* sp., STG-70A, 50 µm, *alpina* subzone (Early Berriasian), STG section

s. *Globochaete* sp., STG-89, 100 µm, *oblonga* subzone (Late Berriasian), STG section

t. *Globochaete* sp., STG-89A, 50 µm, *oblonga* subzone (Late Berriasian), STG section

u. Calcareous dinocyst, STG-20, 50 µm, *Saccocoma* Zone (Early Tithonian), STG section

v. Calcareous dinocyst, STG-31, 50 µm, *Saccocoma* Zone (Early Tithonian), STG section

w. Calcareous dinocyst, STG-75A, 50 µm, *Remaniella* subzone (Early Tithonian), STG section

x. Calcareous dinocyst, STG-88, 50 µm, *oblonga* subzone (Late Berriasian), STG section

y. Calcareous dinocyst, STG-90, 100 µm, *oblonga* subzone (Late Berriasian), STG section

z. Calcareous dinocyst, STG-91, 50 µm, *oblonga* subzone (Late Berriasian), STG section

aa. Calcareous dinocyst, STG-91A, 50 µm, *oblonga* subzone (Late Berriasian), STG section

ab. Radiolaria, SS-8, 100 µm, “Radiolaria Zone” (Late Berriasian ?), SS section

ac. Radiolaria, SS-8, 100 µm, “Radiolaria Zone” (Late Berriasian ?), SS section

ad. Radiolaria, SS-8, 100 µm, “Radiolaria Zone” (Late Berriasian ?), SS section

ae. Radiolaria, SS-7, 100 µm, “Radiolaria Zone” (Late Berriasian ?), SS section

af. Radiolaria, SS-7, 100 µm, “Radiolaria Zone” (Late Berriasian ?), SS section

ag. Radiolaria, SS-7, 100 µm, “Radiolaria Zone” (Late Berriasian ?), SS section

ah. Radiolaria, SS-7, 100 µm, “Radiolaria Zone” (Late Berriasian ?), SS section

ai. Radiolaria, STG-95, 100 µm, “Radiolaria Zone” (Valanginian), STG section

aj. Radiolaria, STG-98, 100 µm, “Radiolaria Zone” (Valanginian), STG section

ak. Radiolaria, STG-100, 100 µm, “Radiolaria Zone” (Valanginian), STG section

al. Radiolaria, STG-102, 100 μm, “Radiolaria Zone” (Valanginian), STG section
am. Radiolaria, STG-102, 100 μm, “Radiolaria Zone” (Valanginian), STG section

PLATE 27

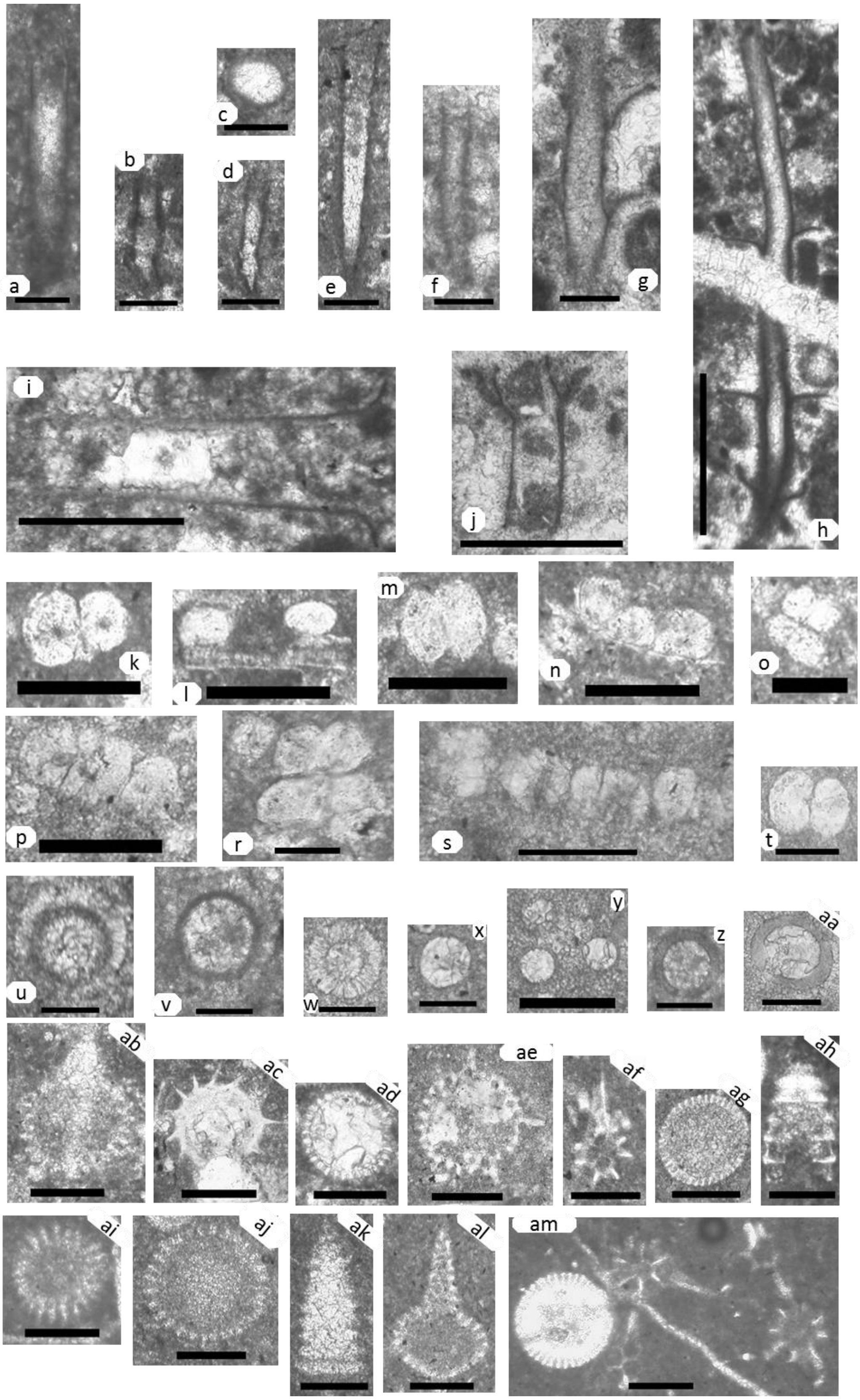

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PLATE 28

a. *Terebella lapilloides*, STG-46, 400 µm, *Saccocoma* (Early Tithonian), STG section

b. *Terebella lapilloides*, STG-54, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

c. *Terebella lapilloides*, STG-61, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

d. *Terebella lapilloides*, STG-61, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

e. *Terebella lapilloides*, STG-64A, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

f. *Terebella lapilloides,* STG-66A, 400 µm, *massutiniana* subzone (latest Tithonian), STG section

g. *Terebella lapilloides*, STG-66A, 400 µm, *massutiniana* subzone (latest Tithonian), STG section

h. *Terebella lapilloides*, STG-66A, 400 µm, *massutiniana* subzone (latest Tithonian), STG section

i. Serpulid, STG-51, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

j. Serpulid, STG-57, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

k. Serpulid, STG-61, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

l. Serpulid, STG-61, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

m. Serpulid, STG-62, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

n. Serpulid, STG-63, 400 µm, *Protopeneroplis ultragranulata* (Late Tithonian), STG section

o. Serpulid, STG-72A, 400 µm, *alpina* subzone (Early Berriasian), STG section

p. Serpulid, STG-77, 400 µm, *Remaniella* subzone (Early Berriasian), STG section

r. Serpulid, SG-3, 400 µm, *Calpionella* Zone (Early Berriasian), SS section

PLATE 28