ISTANBUL TECHNICAL UNIVERSITY★ GRADUATE SCHOOL

MIOCENE FORAMINIFERAL PALEONTOLOGY OF WESTERN TAURIDES (FINIKE)

M.Sc. THESIS

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Department of Geological Engineering

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İSTANBUL TEKNİK ÜNİVERSTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

BATI TOROSLARIN MİYOSEN FORAMİNİFER PALEONTOLOJİSİ

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This thesis is dedicated to my supervisor Prof. Dr. Ercan ÖZCAN

That is great loss for me and paleontologists. I feel honoured to be student of Ercan Özcan. It is impossibe to explain special feelings and admiration to his love of science. He teached me that science is passion, love and curiousity. He dedicated all life to LBF (Larger Benthic Foraminifera). Atlas of The Tethyan Orthophragmines was the signature study of Ercan Özcan. That study is the compendium publication of enourmous work of him as Johannes Pignatti referred.

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ABBREVIATIONS

AAC : Accessory auxiliary chamber

aff : Affinity

cp : *Cycloclypeus*

da : *Discocyclina*

eu : *Eulepidina*

EAT : East Anatolian Transform Fault

Fm : Formation

He : *Heterostegina*

KSL : Karakaya Suture

LBF : Larger Benthic Foraminifera

NAT : North Anatolian Transform Fault

Ne : *Nephrolepidina*

nu : *Nummulites*

mi : *Miliolipora*

PAC : Primary auxiliary chamber

pf : Planktic foraminifera

PM : Pötürge Massif

PTS : Paleo-Tethyan Suture

SBZ : Shallow Benthic Zonation

sp : Specie

YK : Yeşilköy Section

SYMBOLS

A **:** Embracement of protoconch by the deuteroconch

C **:** Number of auxiliary chambers

D **:** Diameter of second whorl

D **:** Deuteroconch size

M **:** Sum of the distance from second and thirld whorl to proluculus

D 1**:** Deuteroconch size

I **:** Circumference of the protoconch embraced

J **:** Circumference of the protoconch not embraced

K **:** Spiral opening ındex

P **:** Proluculus size

S_{4+5} **:** Number of chambers of Heterosteginids in the fourth and fifth whorl

S_{14} **:** Number of chambers of Heterosteginids in the fourteenth whorl.

V **:** Internal symmetry ındex

γ **:** Angle between apical frontal line and embryonic axis

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MIOCENE FORAMINIFERAL PALEONTOLOGY OF WESTERN TAURIDES (FINIKE)

SUMMARY

The Early Miocene Western-Tethyan fauna is mainly represented by existence of *Lepidocyclina, Nummulites, Operculina, Heterostegina, Cycloclypeus* and *Miogypsina* genuses. Altough the paleobiogeographic distribution of larger hyaline foraminifera in the Early Micoene is well known, lack of biometric data and requirement of more detailed morphometric analyses are reported by many researchers. Tethyan fauna is mainly subdivided in two: Mediterrenean and Indo-Pacific. Moreover studies from the western Taurides, Sivas and Eastern Anatolia, co-occurence of both Mediterrenean and Indo Pacific fauna is reported by many studies. In same studies existence of *Eulepidina* aff. *formosa and Spiroclypeus blanckerhorn* are interpreted as result of the Burdigalian migration.

In this study, biometric analyses of the Early Miocene larger hyaline foraminifera assemblages belonging to the shallow marine packages of Karabayır Fm. which unconformably overlines the Cretaceous age Beydağları Fm. are done. *N. praemarginata, N. morgani, N. ex. interc morgani-tourneri* and *N. tourneri* are in Yeşilköy section. Based on the biometric analysis, A_{mean} values for these species were determined as 37,27, 42,44, 46,74 and 51.35, respectively. D (deuteroconch size) values are in the range of 185-665 μm, 205-710 μm, 270-645 μm and 250-655 μm, respectively. Furthermore existence of *E.* aff. *formosa* and *E. dilatata* in these shallow marine environment represents the Burdigalian migration of Indo-Pacific fauna to Mediterrenean region. Biometric data and existence of *M.globulina* and *M. globulina-tani* indicates the Aquitanian-Burdigalian age. For *M. globulina,* X values (number of chambers in the first spiral) were measured in the range of 6-14, and ɣ values in the range of 0-54. ɣ values for *M. globulina-tani* are measured in the range of (-125) – (-14). There is no evidence for existence of *Miolepidocyclina* which is diagnostic assemblage for European fauna. In Yeşilköy section, just single population of *Cycloclypeus eidae* is observed. Within these, existence of such genuses as *Heterostegina asiilinoides, Opertorbitolites* sp. *, Operculina complanata, N. bormidiensis* and *Miliolipora* sp. are determined. *Spiroclypeus* is not recorded in Yeşilköy section.

BATI TOROSLARIN MİYOSEN FORAMİNİFER PALEONTOLOJİSİ

ÖZET

Batı Tetis iri bentik faunası Erken Miyosende başlıca *Lepidocyclina, Nummulites, Operculina, Heterostegina, Cycloclypeus* ve *Miogypsina* toplulukları ile temsil edilmektedir. Burdigalyen faunasının paleobiocoğrafik dağılımı bilinmekle birlikte biyometrik verilerin ve detaylı morfometrik analizlerin eksikliği birçok araştırmacı tarafından belirtilmiştir. Tetis faunası paleobiocoğrafik olarak başlıca Akdeniz ve Hindi-Pasifik olarak ikiye ayrılmıştır. Bununla birlikte Batı Toroslar, Sivas ve Doğu Anadolu bölgesinde yapılan çalışmalarda bu iki faunanın ortak kaydı ve Burdigalyendeki Hindi-Pasifik göçü *Eulepidina* aff. *formosa* Schlumberger *ve Spiroclypeus blanckernhorni* Henson topluluklarının varlığı ile ortaya konulmuştur.

Türkiye bölgesinde çok farklı lokalitelerden elde edilden bulgularda Türkiye bölgesine ait takson grupları genişletilmiş ve daha ayrıntılı morfometrik çalışmalar yapılmıştır. Türkiye Miyoseninde Sivas, Muş, Van ve Antalya bölgelerinde birçok kesit üzerinde detaylı çalışmalar yapılmıştır. Sivas havzasında Nephrolepidina cinsine ait 3 farklı tip tanımlanarak Akitaniyende *N. morgani-tourneri* geçişi kaydedilmiş ve *M. bantamensis* ve *M. gunteri* toplulukları tanımlanmıştır. Burdigalyende *E.* aff. *formasa* zonu Hindi-Pasifik etkisi olarak değerlendirilmiştir. *Miyopsinidae, Lepidocyclinidae ve Nummulitidae* gruplarının biyometrik ve analizlerinde kullanılan paramatreler Drooger 1993, Drooger ve Armato 1963 çalışmalarında belirtilmiştir. Buna göre *Nephrolepidina* türleri için kullanılan başlıca parametreler P(µm),D (µm), C (odoksiler loca sayısı), A ve n olarak tanımlanmıştır. Batı Tetis faunasından elde edilen paramtreler, ($1<C<3$, $35<A<40$), *N. morgani* ($3<C<5.25$, $40<A<45$), N. *tournoueri* ($C>5.25$, $A>45$) olarak belirtilmiştir. Bununla birlikte Burdigalian döneminde Akdeniz bölgesinde foraminifer topluluklarında değişiklik meydana geldiği önceki çalışmalarda belirtilmiştir. *Eulepidina* aff. *formosa- Cycloclypeus eidae, Nephrolepidina* aff. *sumatrensis* toplulukları ile gösterilmiştir. (Örçen, 2001) çalışmasında da benzer şekilde bazı *Miyogpsinoides* türlerinin doğuda İran ve Hindistan bölgelerinde devamlılıkları araştırılmış ve Akitaniyende başlıca *M. gunteri* Cole, *M. complanatus* Sclumberger olmak üzere bununla birlikte Burdigalyen'de *M. irregularis, M. intermedia* Drooger, *Miyogpsina* dehartii Van der Vlerk gibi Hindi-Pasifik kökenli türlerin varlığı yoluyla Arab-Güneydoğu Platformu arasında bir denizel bağlantının muhtemel olduğu ileri sürülmüştür. Akdeniz bölgesindeki foraminifer gruplarının korelasyonu açısından bir diğer önemli farklılıkta Batı Tetiste yar alan bazı taksonların (*Eulepidina ve Spiroclypeus*) Burdigaliyen sonunda yok olması olarak değerlendirilirken devam eden çalışmalarla bu grupların Batı Toroslarda bulunması önemli bir kayıt olarak sunulmaktadır. Batı Torosların jeolojik evrimi üzerine yapılan çalışmalarda Akdeniz bölgesi için tipik orojenez sürecinin varlığı tespit edilmiştir. Bölgenin Neo-Tetis evrimsel süreci çeşitli araştırmacılar tarafından başlıca üç farklı birim üzerinden değerlendirilmiştir. Bu birimler sırasıyla ilksel ofiyolitik yerleşiminden kabuk

incelimine kadar ki mevcut kayıtları içeren Likya Napları, Menderes Masifi ve Beydağları olarak tanımlanmıştır.

Bölgenin Oligo-Miyosen dönemindeki evrimsel süreci Likya naplarının üzerine Beydağları otoktonun yerleşmesiyle ve genişlemeli havzaların gelişmesi ile ilişkilendirilmektedir. Mesozoyik yaşlı birimlerden meydana gelen Beydağları otoktonun üzerine uyumsuzlukla Oligo-Miyosen birimleri gelmektedir. Batı Toroslarda yer alan Miyosen istiflerinin foraminifer içeriği ile ilgili literatüre bakıldığında yaygın olan başlıca gruplar *Heterostegina, Spiroclypeus, Nummulites, Eulepidina, Nephrolepidina, Operculina* ve *Miyogpsinoides* olarak belirlenmiştir. Bu cinslerin altında gruplanan taksonların Avrupa faunasına olan benzerliği ortaya konulmuştur. Ayrıca yüksek çözünürlüklü biyostratigrafik içerikle birlikte bu çalışmada farklı takson gruplarından elde edilen biyometrik analizler Chauzac ve Poignant 1977 tarafından sunulan SBZ (Sığ Bentik Zonasyonu)'nda kullanılarak bölgesel anlamda SBZ 22- SBZ 25 Şattian-Burdigalian korelasyonu elde edilmiştir. Bununla birlikte belirli lokalitelerde Oligosen kaydının eksikliği Beydağları karbonat platformunun ayırt edici özelliği olarak vurgulanmıştır. Batı Toroslarda iri hyaline gruplarının dağılımı genellikle bilinmekte, biyometrik analizlerin yetersizliği nedeniyle Burdigaliyen'deki Hindi Pasifik göçünün Akdeniz faunası üzerindeki etkilerinin detaylı bir şekilde ortaya konulmasında çeşitli problemler teşkil etmektedir. Elmalı-Kaş yolu üzerinde ölçülen iri bentik faunası ile SBZ24-25 korelasyonu elde edilmiştir. Erken Miyosen sığ denizel istifinin tabanını oluşturan Karabayır Formasyonunu temsil eden iri hyalin gruplarının detaylı morfometrik ve biyometrik analizleri yapılmıştır.

Bu çalışmada Finike bölgesinde ölçülen Yeşilköy kesitinde Kretase yaşlı neritik kireçtaşları ile temsil edilen Beydağları Fm. üzerine gelen ve Erken Miyosen sığ denizel paketinin tabanını karakerize etmekte olan Karabayır Formasyonuna ait iri hyaline foraminifer gruplarının biyometrik analizleri yapılmıştır. *Lepidocyclina (Nephrolepidina)* topluluğuna ait *N. praemarginata, N. morgani, N. morgani-tourneri ve N. tourneri* türlerinin kaydı belirlenmiştir. Bu türler için A_{ort} değerleri sırasıyla 37.27, 42.44, 46,74 ve 51,35 olarak belirlenmiştir. D (deuteroconch size) değerleri ise sırasıyla 185-665 μm, 205-710 μm, 270-645 μm ve 250-655 μm aralığındadır. Ayrıca *Eulepidina aff.* formasa ve *Eulepidina dilatata* türlerinin varlığı Burdigalyendeki Hindi-Pasifik göçünü karakterize etmektedir. Biometrik analizler metrik analizler sonucunda *Miogypsina globulina ve M. globuna-tani* geçişi Akitaniyen-Burdigalyeni işaret etmektedir. *M. globulina* için X değerleri (ilk spiraldeki loca sayısı) 6-14, ɣ değerleri ise 0-54 aralığında ölçülmüştür. *M.globulina-tani* için ɣ değerleri (-125)-(-14) olarak belirlenmiştir. Akdeniz faunası için karakteristik olan *Miogypsinoides* topluluğunun varlığından ise söz edilememektedir. *Cycloclypeus eidae* türüne ait sadece bir popülasyon tanımlanmıştır. Bununla birlikte *Heterostegina assilinoides, N. bormidiensis ve Operculina complanata, Opertorbitolites sp. Miliolipora* sp. *Alveolina* sp. türleri tayin edilmiştir. *Spiroclypeus* ise Yeşilköy kesitinde gözlenmemiştir. Biyostratigrafik açıdan ise *N. morgani-tourneri* geçişi biostratigrafik açıdan bir takım korelasyon zorluklarına neden olmaktadır. Bununla birlikte C_{mean} değerleri *Nephrolepidina morgani* için 2,66-3,66, *Nephrolepidina morgani- tourneri* için 3,58-4,42, *N. tourneri* için ise 5-7 olarak belirlenmiştir. Bununla birlikte bu türler için n değerleri sırasıyla 16-25, 17-26 ve 11-21 aralığında ölçülmüştür. *Lepidocyclina* cinsine ait embryon boyutları Hindi-Pasifik kaydı ile karşılaştırıldığında belirgin farklılıkların olduğu görülmektedir. *Eulepidina* cinsine ait biyometrik analizlerde ise *Eulepidina* aff. *formosa* türüne ait P değerleri YK33, YK37, seviyelerinde sırasıyla ortalama değer olarak 610 ve 415 olarak ölçülmüştür. Bununla birlikte D değerleri YK31, YK33, YK37, YK43 ve YK47 seviyelerinde sırasıyla 655- 1245, 1160-1385, 910, 1110 ve 1500 olarak ölçülmüştür.

Bu tür için Aort değerleri ise 75.94, 88,96 ve 92.33 olarak ölçülmüştür. *Cycloclypeus* eidae türüne ait sadece bir populasyon tanımlanmış ve P değeri 90 um olarak belirlenmiştir. *Heterostegina assilinoides* türüne ait d değerleri Yeşilköy kesitinde 935-1535 um ve K parametresi ise 39,47-52,81 olarak belirlenmiştir. *Heterostegina assilinoides* için P ve D değerleri 165-330 ve 140-395 aralığındadır.

Üst Kreatese yaşlı neritik karbonat çökellerini uyumsuzlukla üzerleyen sığ denizel Miyosen paketinde ayrıca mercan, bryozoa, textularid ve rodolit gözlemlenmiştir. Ara seviyelerde Eocene faunasına ait *Discocyclina* ve *Orbitoclypeus* türlerinin kaydı belirlenmiştir. Tüm Faunal içerikle birlikte detaylı biyostratigrafik tanımlamalar ve biometrik veri sağlanmıştır. Bununla birlikte bölgedeki diğer kesitlerle karşılaştırıldığında değişen paleoeekoloji ve ortamsal faktörler nedeniyle bazı türlerin kaydına rastlanmadığı sonucuna varılmıştır. Çalışma alanı içerisinde yer alan Yeşilköy kesitinde Miyosen istifinin altında yer alan Beydağları Formasyonuna ait ise detaylı bir faunal çalışma yapılmamıştır. Bununla birlikte bundan sonraki çalışmaların amacı daha detaylı biostratigrafik çalışmalarla birlikte Üst Kretase yaşlı dern denizel istifle bunları uyumsuzlukla üzerleyen Akitaniyen- Burdigaliyen yaşlı Karabayır Formasyonu arasındaki stratigrafik ilişkinin kapsamlı bir şekilde ortaya konulmasıdır. Burdigaliyen paleoekolojisinin detaylı çalışılması ve olası izotop yöntemlerinin kapsamlı bir ortamsal analizde kullanılması ile daha kapsamlı ortamsal yorumların yapılması ise oldukça önemlidir. İlerleyen çalışmalarda özellikle Umman, Hindistan ve İran örnekkeri üzerinde daha detaylı çalışılarak Akdeniz ve Hindi-Pasifik bölgelerindeki iri hyaline foraminifer gruplarına ait biyometrik verilerin genişletilmesi ve Burdigaliyen döneminde meydana gelen global değişikliklerin faunal çeşitlilik ve paleoekolojik sonuçları üzerinde daha kapsamlı veriler elde edilmesi gerektiği görülmektedir.

1. INTRODUCTION

The Oligo-Miocene hyaline larger foraminifer record in the Western-Tethyan realm is mainly represented by miogypsinid, lepidocyclinid and nummulitid assemblage. They are used as an advance convenient agents for zonation and correlation (Chauzac and Poignant, 1997, Drooger, 1993). Within the scope of biometrical analyses and SBZ22-24 (Rupelian-Chattian) correlations, the most significant groups in terms of stratigraphic aspect are *Nummulites, Heterostegina, Miogypsina, Nephrolepidina, Eulepidina, Cycloclypeus, Spiroclypeus and Operculina.* These groups with the exception of *Cycloclypeus*, have been identified from many shallow-marine successions in a wide geography extending from the Mediterranean region to the Indo-Pacific and Central America (Martin, 1891; Brady, 1881; Tan, 1930). However, in this period, geography, genus types and distribution of these groups are not the same in everywhere. In many previous studies (Adams et al., 1983; Poignant and Lorenz 1985, Drooger, 1993, Rögl, 1999) the Oligo-Miocene hyaline larger foraminifera are divided into two main units according to the paleobiogeographic features, they are Indo-Pacific and Mediterranean Provinces. However, there are strong problematic issues caused by the lack of biometric data and discontinuous stratigraphic records generate some difficulties for a comparison between the Mediterranean and Indo-Pacific regions. Parameters used for morphometric analysis of the *Miogypsinidae, Lepidocyclinidae and Nummulitidae* assemblages are demonstrated in the previous studies (Drooger, 1993; Amato and Drooger, 1963).

In morphometric analyses of *Nephrolepidina* assemblage A (embracement of deuteroconch by protoconch), C (number of adauxiliary chambers) , I and J parameters are used. Although, the biometric data is limited from the Far East is limited, the existence of these parameters are widely reported. *N.sumatrenis, N. isolepidinoides, N.angulosa, N.martini and N. rutteni* existence in Indo- Malasian region are well known. European fauna contains *N.praemarginata* ($1 < C < 3.35$, $A<40$) , *N.morgani (*$3 < C < 5.25$, $40 <A<45$), *Nephrolepidina tourneri Cmean*

<5.25, Amean <45) and N.aff sumatrensis. Ribbed *Nephrolepidina* species are distinguished for European fauna and have not been recorded in the Far East so far. *Mioypsinoides* assemblages are as distinguished for European fauna. The typical characteristic of *Miogypsinoides* demonstrates lateral chamberlets.

The first record of *Eulepidina* and *Cycloclypeus* in the Mediterranean region was reported by (Özcan and Less, 2009). In the findings obtained from different localities in the Türkiye (Sivaş Muş, Western Taurides and Van), taxa groups of the Turkish region expanded and more detailed morphometric studies were carried out. Moreover, change of the faunal assemblages in the Mediterranean region was reported with *Eulepidina* aff. *formasa* and *Cycloclypeus eidae* assemblages from the western Taurides by Özcan et al, 2009, and Özcan and Less, 2009. Örçen, 2001 also investigated the continuity of some *Miogypsinoides* genuses in Iran and India region. Via the existence of the *M. gunteri* Cole, *M. complanatus* Schlumberger in the Aquitanian and the existence of Indo-Pasific origin *Miogyspinoides* in the Burdigalian (*M.intermedia*, Drooger, *Miogypsina dehartii* Van der Vlerk) the possible connection between the Arabian region and Southeastern Anatolia region is suggested. For Turkish fauna, findings with the studies in Eastern Anatolia, Sivas, Muş and Adilcevaz regions also support the migration from the Far East to the Mediterranean region by the existence of the *Eulepidina* (Özcan et al, 2009; Özcan and Less, 2009, Özcan et al, 2008). Faunal incursion obtained in Western Taurides has a crucial significance and distinguishing feature. Another important event in the Miocene of western Taurides is the transgression at the Early Aquitanian–Late Burdigalian (SBZ24-25).

For the purpose of expanding biometric analyses belonging to the aforementioned hyaline larger foraminifera groups in Yeşilköy section were done. In this chapter, the geographical location of the studied section, geological settings, stratigraphy, distribution of the Miocene shallow marine deposits and significance of hyaline larger foraminifera will be discussed. Within these all morpological features of each genus that obtained in study area and detailed geological back ground comprises this study. In study area, the stratigraphic relationship of the shallow marine Miocene packages that is represented by Karabayır Formation with Upper Creataceous age Beydağları Fm. is investigated.

1.1 Study Area and Geographic Position

The study area is located in the western Tauride (SW Turkey), about 70 km from Antalya. One section is measured and sampled from the Beydağları and Karabayır Formations. The section measured from the study area is informally named Yeşilköy section (YK). The geogragraphical location of the Yeşilköy section is demonstrated in Figure 1.1. The basal part of the Yeşilköy section contains the Upper Maastrichtian carbonaceous clastics represented by Beydağları Fm. This pelagic deposits are unconformably overlained by shallow-marine clastics of the Miocene age Karabayır Fm. YK18 which represents the basal part of the Miocene packages is placed in yelowish part at the Figure 1.1. This thesis is mainly based on this part of the section.

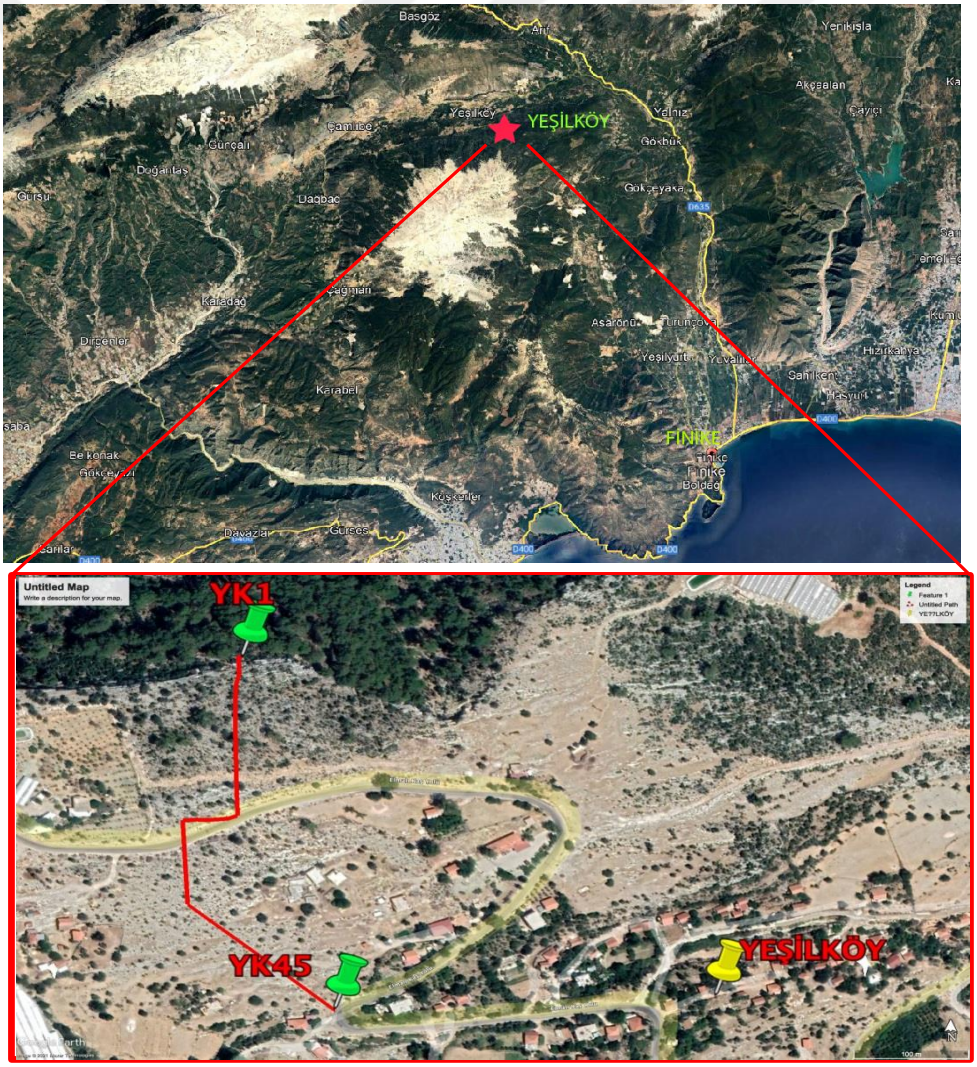


Figure 1.1 : Location of the studied sections near the Yeşilköy village.

1.2. Method of Study

For this study, the samples were collected from Yeşilköy section. Fourthy-eight levels that belong to Yeşilköy section are measured and sampled. YK23-YK48 levels represent the Miocene age shallow-marine clastic deposits. Geological map of the Finike region is done after the field works. Microfacies properties of each level were determined by using the laboratories of ITU Geological Engineering.

Laboratory works contain the facies analyses via petrographic thin sections prepared by ITU Thin Section Laboratory. In this process, thin sections prepared by the hard part of the rock samples and detailed faunal and facies analyses of each section has done. Within these, some grain samples are used to prepare oriented thin sections. The stages in oriented thin section preparation are demonstrated at the Figure 1.2. Both axial and equatorial sections were preapared to determine each genus. Internal morphology and biometric features of species were obtained beyond that methods. For biometric observations and photographing process binocular microscope in Eurasia Earth Sciences in ITU were used.



Figure 1.2 : Preparation of oriented thin sections of larger foraminifera (Özcan et al, 2022).

1.3. Purpose of Study

Within the scope of this project, it is aimed to expand the findings of the large foraminifer taxa obtained in the western Taurus and to compare the evolutionary lineages of species and biometric records of the *Nephrolepidina, Eulepidina and Miogypsinoides* communities with the hyaline large foraminifer groups in the Western Tethys and Indo-Pacific regions. It is aimed to create high-resolution biostratigraphy, facies analysis and detailed analysis of taxonomic groups of shallow marine Miocene packages in Yeşilköy section and its vicinity as indicated in Figure 1. Contributing to the Miocene large hyaline foraminifer literature in Turkey is one of the important goals of this project. In addition, it is very important to reveal the stratigraphic relationships with the Beydağları autochthon, which consists of shallow marine packages and the Maastrichtian-Cenomanian aged stable carbonate platform deposits. In this context, it is aimed to make biometric analyzes of *Heterostegina, Spiroclypeus, Nephrolepidina, Operculina, Nummulites and Miogpsina* genera in Yeşilköy section and to compare the analysis results with Western Tethys and Indo-Pacific fauna.

1.4 Previous Studies

In the studies on the geological evolution of the Western Taurus, the existence of a typical orogeny process for the Mediterranean region has been determined (Şengör and Yılmaz, 1981, Collins and Robertson, 1998). The Neo-Tethys evolutionary process of the region has been evaluated by various researchers on three main different units. These units are defined as Lycian Nappes, Menderes Massif and Beydağları, which contain the existing records from the primary ophiolitic settlement to crustal thinning, respectively (Poisson, 1977, Şenel 1977a, Collins and Robertson, 2003). The evolutionary process of the region in the Oligo-Miocene period is associated with the settlement of the Beydağları autochthon on the Lycian nappes and the development of extensional basins. Oligo-Miocene units unconformably overlie the Beydağları autochthon, which consists of Mesozoic aged units. When we look at the literature on the foraminiferal content of the Miocene successions in the Western Taurus, the main groups that are common are *Heterostegina Spiroclypeus, Nummulites, Eulepidina, Nephrolepidina, Operculina and Miogpsinoides*. The similarity of the taxa grouped under these genera to the European fauna has been revealed (Özcan et al., 2009). In addition, with high resolution biostratigraphic

content, biometric analyzes obtained from different taxa groups in this study were used in the SBZ (Shallow Benthic Zone) presented by Chauzac and Poignant 1977, and a regional SBZ 22 - SBZ 25 Şattian-Burdigalian correlation was obtained. However, the lack of Oligocene records in certain localities has been emphasized as the distinguishing feature of the Beydağları carbonate platform. Studies have pointed out that there are significant differences between foraminiferal assemblages in the Indo-Pacific and Mediterranean regions (Drooger 1993; Rögl 1999; Harzhauser; et al 2007). However, in many similar studies (Adams, 1983, Adams et al, 1983; Poignant and Lorenz 1985, Butterlin, 1987, Drooger, 1993 Rögl, 1999), large foraminiferal groups in Tethys are mainly Western Tethys (Mediterranean) and Turkey. The fauna of the Pacific region is divided into two groups. In this context, the fauna of Iran and Pakistan and Turkey were compared in terms of invertebrate fossil record. Although the records of the large benthic fauna of Turkey were limited or insufficient in the past, the similarity of the large benthic foraminifer groups in this region with the Mediterranean fauna has been pointed out in further studies (Sirel, 2003). The first record of *Eulepidina and Spiroclypeus* species in the Mediterranean Miocene was reported in the study (Özcan and Less, 2009). In the findings obtained from many different localities in the Turkish region, taxa groups belonging to the Turkish region were expanded and more detailed morphometric studies were carried out. In the Miocene of Turkey, detailed studies were carried out on many sections in Sivas, Muş, Van and Antalya regions. In the Sivas basin, 3 different types belonging to the genus Nephrolepidina were defined and the *N. morgani-tourneri* transition was recorded in the Aquitanian *and M. bantamensis and M. gunteri* assemblages were defined. *The E.*aff *formasa* zone in the Burdigalian was evaluated as the Indo-Pacific effect. In addition, one of the most important difficulties in the correlation of the large benthic foraminifers in both regions is the inability to correlate the phylogenetic stages of these groups, since the biometric characteristics of the large benthic foraminifer groups, especially in the Indo/Pacific region, are not known (Renema, 2007).

It is aimed to study the Yeşilköy section and to carry out comprehensive morphometric and biometric analyzes. It is aimed to reveal the relationships between the deep marine carbonate deposits of the Cenomanian-Mastrichtian aged Beydağları autochthon and the Miocene aged Karabayır Formation by performing facies analysis together with petrographic section analyses.

1.5. Geological settings and stratigraphy of the Miocene units.

Regional geological settings in Early Miocene for the Mediterranean region is controlled by closure events from Burdigalian. According to Nb and Sr analyses in the Mediterranean region demonstrates the intermitting connection with the Indian Ocean. (Cornocchian et al., 2021). This situation affects the paleobiogeographic distribution of some faunal groups depending on changing environmental conditions (Cornacchia et al., 2021) The evolution of the Mediterranean sea is demonstrated in Figure 1.3. For the LBF assemblage in Mediterrenean region, the closure event of the Indian-Ocean in the Aquitanian is suggested to major effect in diversification and environmental conditions. In Burdigalian, closure of the Indian Ocean was reported by various researchers (Rögl, 1999; Popov et al; 2004; Harzhauser et al, 2007). This first closure event of the Indian Ocean results in changed circulation and weakened. After the Burdigalian, a connection between the Mediterranean and Indo-Pacific regions is severally reopened in Langhian–Serrevallian time period.

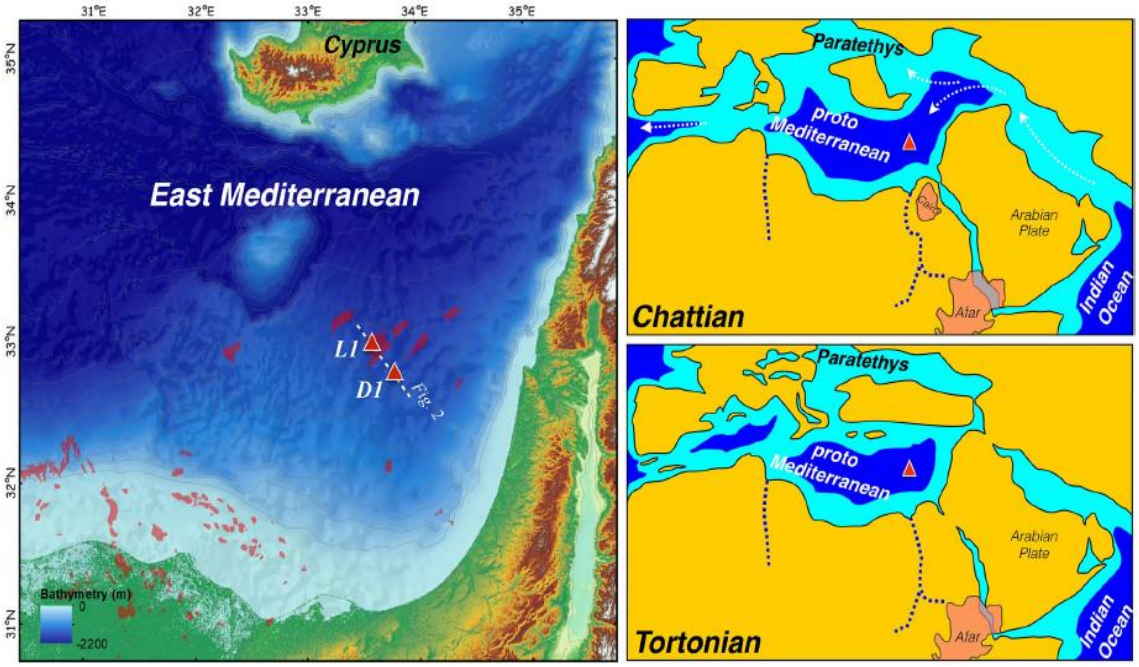


Figure 1.3 : Oligo-Miocene evolution of the proto- Mediterrenean Sea. (modified from Torfstein and Steinberg, 2020).

Paleocteonic map of the Mediterranean is demonstrated in Figure 1.4. Altough some debateble tetonic reconstruction models belongs to Eastern Mediterrenean region, evolutionary history of the Eastern Mediterrenean is linked with the opening of the Neotethys, between Gondwana and smaller rifted blocks.

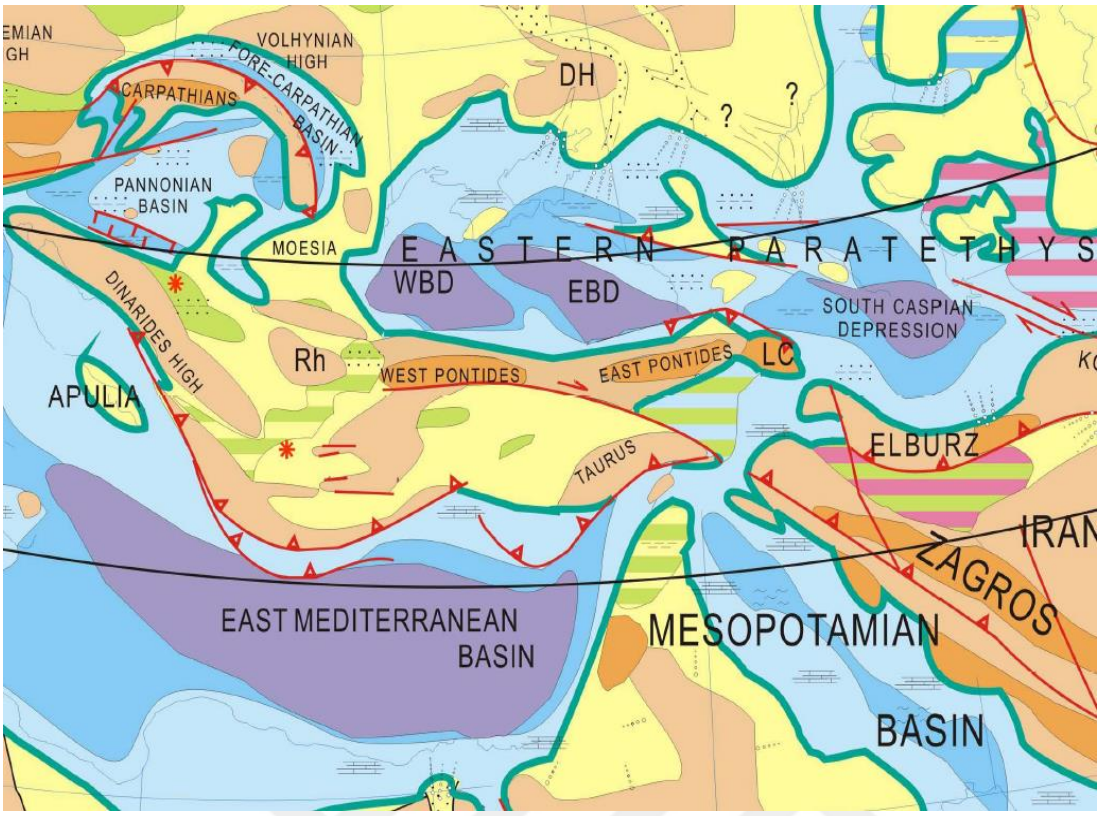


Figure 1.4 : Paleogeographic and tectonip map of Paratethys in the Early Miocene (taken from Popov et al; 2004).

In the Early Miocene, orogeny has a significant agent that controls the geological settings. Depending on these highlands that cover a huge area in Paratethys in Burdigalian. Depositional sequences are subdivided in marine, brackish and continental sequences. Thrusts are very common along especially in the Black sea, Caucasus and Balkanian regions. Taurus high and opening and closing connection between the Mediterranean and the Indian Ocean has affected the paleo-biogeographical distribution of the LBF contents by the changes in circulations. This situation also affects the paleobiodiversity and evolutionary lineages of species and subspecies.

The southwestern part of Turkey has typical Mediterranean-type orogeny (Sengor and Yılmaz, 1981). It is previously reported that there are several tectonic units that provide to understand tectonic events completely (Sengör and Yılmaz, 1981; Collins and Robertson, 1998, 2003). In western Taurides the main geological units are classified under four major units including : Menderes Massif, Beydağları Autochton, Lycian Nappes and supra-allochton sediments (Collins and Robertson, 2003). Stratigraphic units in the western Taurides are differently named by some

researchers (Pisoni, 1967; Poisson; 1977, Önalan; Colin H, 1956; 1980; Şenel et al 1981; and Hayward 1982). The oldest unit in the western Taurides has consisted of Paleozoic age deposits which are named Beydağları Autochthon. The name of this unit comes from the Beydağları Mountains which places in a huge area in the Tauride region. Succession belongs to Beydağları Autochthon and supra-allochthon sequences are controlled by extensional tectonic regimes. Difficulties for determining faunal diversity and lack of biometrical data belonging to Beydağları Autochthon and supra-allochthonous units are aforementioned in Özcan et al., 2009. From causes of extensional collapse in the region, the Beydağları platform comes over the Lycian Nappes. The Formation that overlaps the Lycian Autochthon has the Oligo-Miocene age thick sequences that are generated by the extensional regime in the region. Lycian Nappes includes various facies and structural properties. The complexity caused by this variety and differences of each structural units, results in serious problematic issues to understand the evolutionary mechanism of Lycian Nappes. Various researchers suggested the Late Creataceous-Miocene time interval for the transportation of Lycian Nappes in the region (Hayward,1984; Collins and Robertson, 2003). The Miocene units in Western Taurides which belonging to the Torid-Anatolide Tauride (Ketin, 1977) block are determined by some researchers as the Aquitanian- Burdigalian.

The regional geology map of the study area is demonstrated at Figure 1.4. The oldest rocks have consisted of Paleozoic basement rocks. Around the Kemer region Paleozoic age rock gives huge outcrops. In the nortwestern part of the study area and region bounded between Kemer and Finike region volcanic, metamorphic and ophiolitic emplacements covers huge area. The Paleozoic age sequences are overlain by the Triassic clastics and carbonate rocks. In the study area mainly the Cretaceous age clastics and carbonaceous clastic cover a huge area from the southern to the northern part. Distribution of the Paleocene sequences is mainly restricted in the study area. The Eocene-age clastics unconformably overlie the Triassic, Jurassic and Cretaceous age carbonaceous rocks and clastics. The region is tectonically controlled by various thrusts in the Miocene period. Undifferentiated Neogene rocks give outcrops around the Korkuteli and also in the southwestern and the northeastern part of the study area.

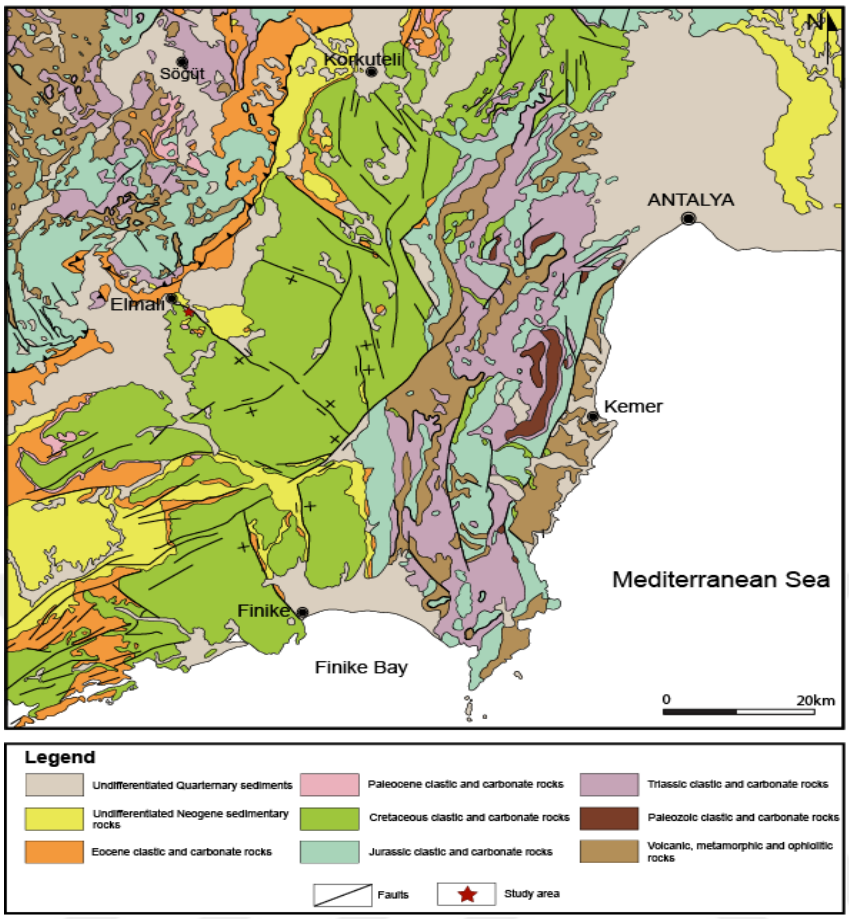


Figure 1.5 : Finike geological map and location of study area.

1.5.1 Tectonic Settings

1.5.1.1 Antalian Nappes

The emplacement age of the Antalia Nappes to the region is suggested to the Danian. After the emplacement, Antalian Nappes are thrusted to other units within the tectonic causes. Antalian Nappes are subdivided by many researchers under the various units. The main units classified under the Antalian Nappes are Çataltepe Unit, Alakırçay Unit and Tahtalıdağ Unit (Brunn et al, 1971). Each unit represents the Upper, Middle and Lower parts of the Antalian Nappes.

1.5.1.2 Lycian Nappes

Lycian Nappes are subdivided into various units by various researchers as Çataltepe Nappes, Alakırçay Nappes, Tahtalıdağ Nappes, Domuzludağ Nappes, Tekirova ophiolitic nappes. The emplacement age of Lycian Nappes to the region is questionable. Lycian Nappes have consisted of platform, slope,

basin and oceanic crust origin rocks (Şenel, 2004). The emplacement age of Lycian Nappes are differently suggested by many researchers. Okay, 1989 suggested the Middle Eocene for the emplacement age of the Lycian Nappes to the region. In Lower Langian Lycian Nappes are emplaced to the northern and northeastern part of the Beydağları Autochthon. N-W compressional trends result in faulting and folding in Beydağları Autochthon (Poisson 1977; Farinacci & Koyluoğlu 1982; Robertson 1993).

1.5.1.3 Beydağları Autochthon

The detailed stratigraphy of the Beydağları Autochthon is firstly investigated by Poisson (1977). Beydağları Autochthon which consisted of platform- type clastics is named by many researchers under various names (Brunn et al; 1973; Poisson, 1977; Marcoux, 1977; Önalan, 1979; Şenel 1984): Tauride Carbonate Platform, Taurus Limestone Axis, Geyikdağı Unit, Beydağları Zone, Beydağları Massif, Hayward 1982, Beydağları and Susuzdağ Massif. Ersoy 1990 named all units in the region between Menderes Massif and Beydağları Mountains, 'Western Tauride Nappes'. These clastics are classified under three major units: autochton, paraaoutochton and allochton. The basal part of the Beydağları Autochthon is consisted of Upper Triassic- Lias age dolomitic limestone. In the Jurassic-Cretaceous period, typical carbonate platform clastics are deposited. The northern and northeastern margin of the Beydağları Autochthon is covered by the Antalia Nappes. In thewestern part of the Autochthon is bounded by Lycian Nappes. The emplacement age of the Lycian Nappes to the region is suggested by (Poisson, 1977) as Langian. Günay, Bölükbaşı and Yoldemir, 1982 classified depositional facies under three main units; Elmalı Group, Antalia Group and Beydağları Group. Beydağları Autochthon comprises several units. The basal part of the autochton is consisted of Beydağları Fm.

1.5.2 Formations

1.5.2.1 Beydağları Formation (Fm).

The depositional units around the region are named Kuyubaşı Dolomites which comprises the Upper Triassic age dolomitic facies. They have also named the unit includes the Jurassic-Creatceous age neritic limestones Beydağları Fm. According to this, Beydağları Fm is divided into 6 units. They are Darımdağ Limestone, Ergenler Limestone, Akdağ Limestone, Çamdağ Limestone and Akdağ Limestone.

The type locality of Beydağları Fm. was obtained in Bucak- Karaeliler villages by (Poisson 1997). Stratigraphically thin section of the Beydağları Fm. is also clearly visible at the valley near the Demre Çayı. The upper level of Beydağları Fm. is consisted of the Upper Campanian- Maastrichtian age hemipelagic carbonate deposits (Şenel et al, 1994). The Cenomanian age carbonaceous clastic gives a beige, brownish, whitish grey and whitish colour outcrops that contain coral, gastropoda and algae. Some levels of the Cretaceous age carbonaceous clastics include dolomite and recrystallized limestone. Rudist and patch reefs are typical for the top part of the succession belonging to Beydağları Fm. In the region bounded between Fethiye-Kaş and Kemer, (southern Turkey), the Cenomanian clastics include *Siderolites calcitropoides, Orbitoides media, Helleneocyclina beatica, Rapydionine liburnica and Cryysdidina gradata* (Şenel et al, 1994). These units are overlain in some areas by the Paleogene-Eocene age Gedikbaşı Formation. The Miocene clastics are classified under different formations with the Sinekçi, İmrezi Fm. and Kasaba Fm. Karabayır Formation has a transitional stage in some region with faunal content such as: *Lithothamnium concretum*, Howel, *L. caravallense*, Lemoine, *L. macrosporangium*. Poisson, (1977) has determined the new *Lithothamnium* genus in Beydağları Autochthon.

1.5.2.2 Gedikbaşı Formation

Gedik Başı Formation which is consisted of neritic limestones is named by Önalan, 1979. Paleocene records have been already known by different researchers (Pisoni, 1967, Poisson,1977., Önalan, 1979). Günay et al., 1982 renamed that unit 'Gedik Formation'. The Paleocene-Eocene. age Gedikbaşı formation mainly gives huge outcrops near the Kocapınar, Kömürlük Hill, Duvacı Hill, Adatepe, Orta, Küçükkız, and Avşar Yayla (Şenel et al, 1989). Gedikbaşı Fm. is lithologically consisted of middle-thick bedded beige, cream coloured, and whitish limestones which are rich in *Miliolidae*. In some localities, Gedikbaşı Fm is represented by micritic limestones. Gedikbaşı Fm. is unconformably overlain by the Middle Eocene and Miocene stratigraphic sequences. Around the Tekke Village, this unit is unconformably overlain by Karabayır Fm. Faunal content is consisted of mainly *Globorotalia* sp., *Quinqueloculina* sp., *Discocyclina* sp., *Sphareogypsina* sp., *Orbitolites* sp., *Nummulites* sp., *Planorbulina* sp .and *Operculina* (Senel et al 1984). There is also

algaen fauna with gastrapod, pelecypods, echinoid and coral content. Petrographically, Gedik Fm. includes biomicrite and biosparite with intraclasts. The depositional environment of the unit is suggested to back-reef environment to the open sea.

1.5.2.3 Susuzdağ Fm.

Suzusdağ Fm. which consisted of middle-thick bedded neritic limestones is named by Önalan, 1979. That unit is also named differently by various researchers (Rathur, 1967, Şenel 1980, Şenel et al,, 1981). Susuzdağ Fm. includes middle-thick bedded White, cream , grey and whitish brown coloured neritic limestones that are rich in *Nummulites* and *Alveolina*. According to various researchers the thickness of Susuzdağ Fm. is determined in 5-500 meter range in different localities. The precise age of the unit is determined by Şenel (1989) as the Middle- Upper Eocene (Lutetian-Priabonian). In some places, the unit consisted of dolomitic and recrystallized limestones. Susuzdağ Fm. unconformably overlies the Creataceous age Beydağları Fm. and overlain with angular conformity by Karabayır and Sinekçi Fm.

1.5.2.4 Karabayır Formation

This unit that consisted of very thick algaen fauna is named by Poisson and Poignant (1974). This lithologic unit gives huge outcrops near the Kaş-Kasaba villages and around the northern part of the Finike. Some units has similar features to the Karabayır Fm. give huge outcrops in the northern part of Isparta and Kaş-Kasaba villages are named ‘Yazır Limestone’ by Karaman 1990 and Yağmurlu 1994.

The thickness middle and thick bedding with beige, and whitish grey colour. These whole horizons demonstrate breccia limestone features. In the southern part of the Elmalı region, the Upper Cretaceous, Paleogene and Eocene age clastics are unconformably overlain by Karabayır Formation. In the study area Beydağları Fm. is unconformably overlined the Miocene age carbonaceous clastics of Karabayır Formation. Karabayır Formation sequences are deposited in shallow-marine environment under a rapid transgressions. Faunal content of Karabayır Fm. includes *Lepidocyclina* sp., *Eulepidina* sp., *Miogypsinoides complanatus,(*Schlumberger), *Amphistegina lessoni* (D’Orbigny), *Operculina complanatus* (Defrance), *Pararotalia* sp., *Gypsina* sp., *Microcodium* sp., *Quinqueloculina* sp., Spiroclypeus Blanckernhorn sp., *Lithothothamnium* sp., *Microcodium* sp., *Melobasia* sp., *Victoriella* sp.,

Globigerina sp., *Bryozoa*, *Rotaliidae* and *Textularidae* sp. The stratigraphic position of Karabayır Fm. is demonstrated in Fig. 1.6.

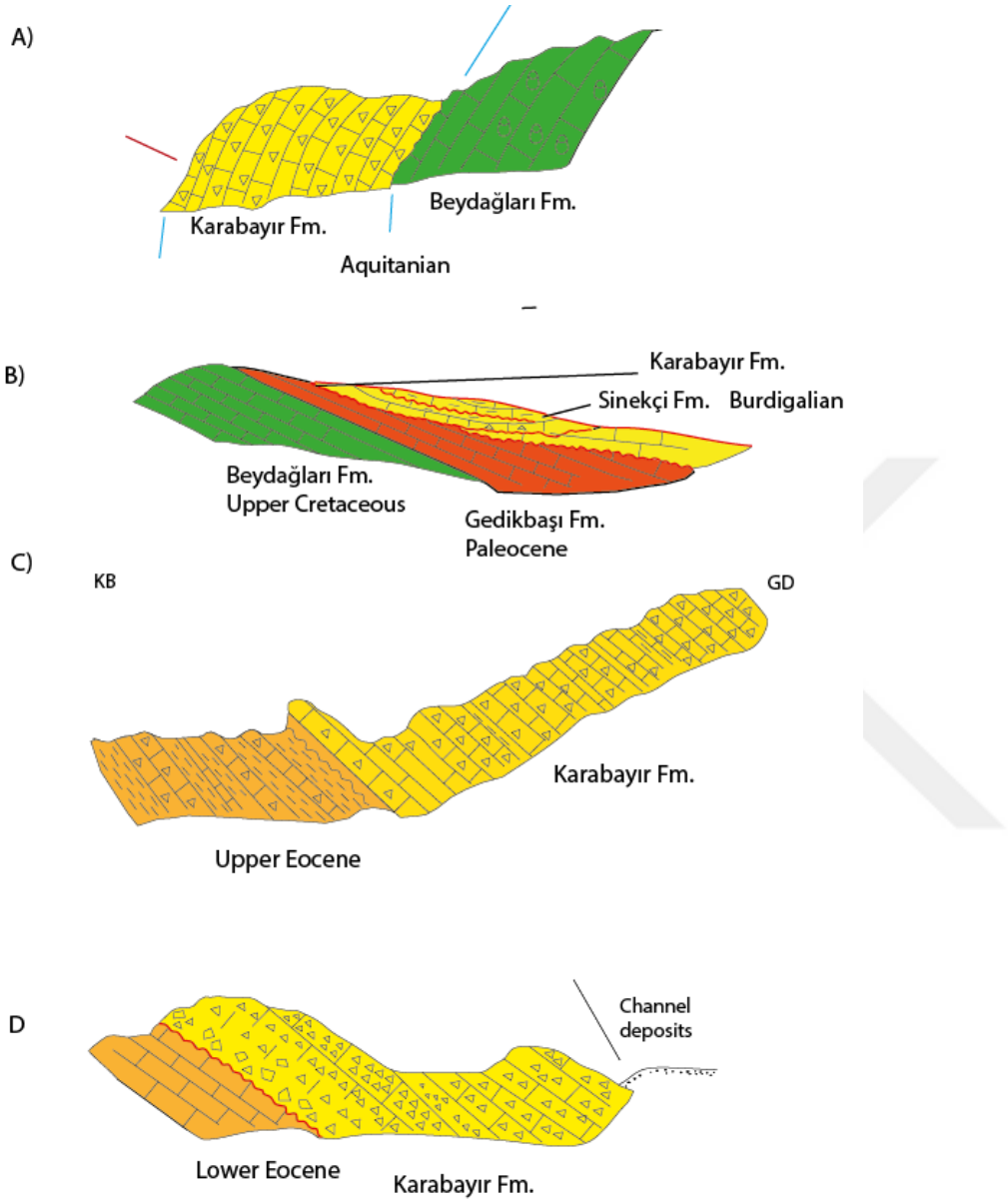


Fig. 1.6: Position of Karabayır Fm. and stratigraphic relationsips with the Paleocene-Eocene units and the Cretaceous age Beydağları Fm. (Coloured and modified by Şenel et al 1994**).**

The approximate stratigraphic position of Karabayır Fm. in Çatallar Basin is demonstrated in Figure 1.7. The Aquitanian- Burdigalian neritic and pelagic limestones of the Karabayır Fm. unconformably overlies the Upper Creataceous age carbonaceous clastics. Fossil content of the Karabayır Formation in Çatallar Basin includes *Globigerinoides* sp. , *G. altiapertus*, *Paraturbolia siakensis*, *P. acrostoma*,

Miogypsinidae, *Lepidocyclinidae and Miogypsinoides* assemblages. This unit is overlain by the Langhian age marls and turbiditic calcerous siltstone and sandstone beds of the Akçay Formation (Kosun et al., 2009). In some levels, several olistostromal units are defined. Depending on fossil content these levels of Akçay sequences are correlated with the N8 zone.

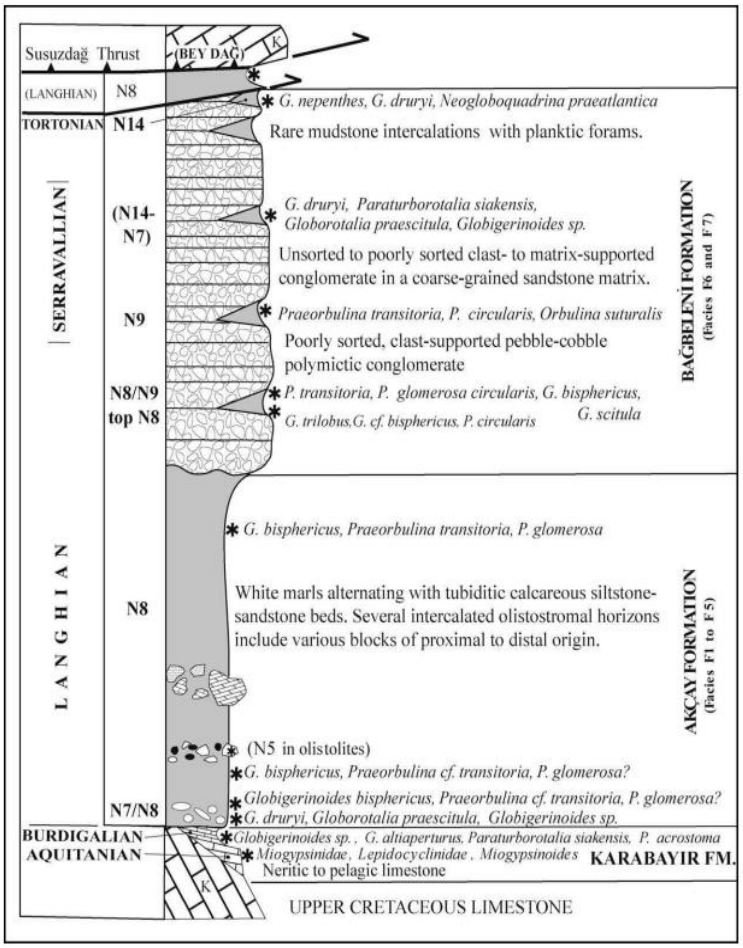


Figure 1.7 : Approximate stratiraphic position of Karabayır Formation in Çatallar Basin and diagnostic planktic assemblages (Biozenes N5 to N14)- (Kosun et al, 2009).

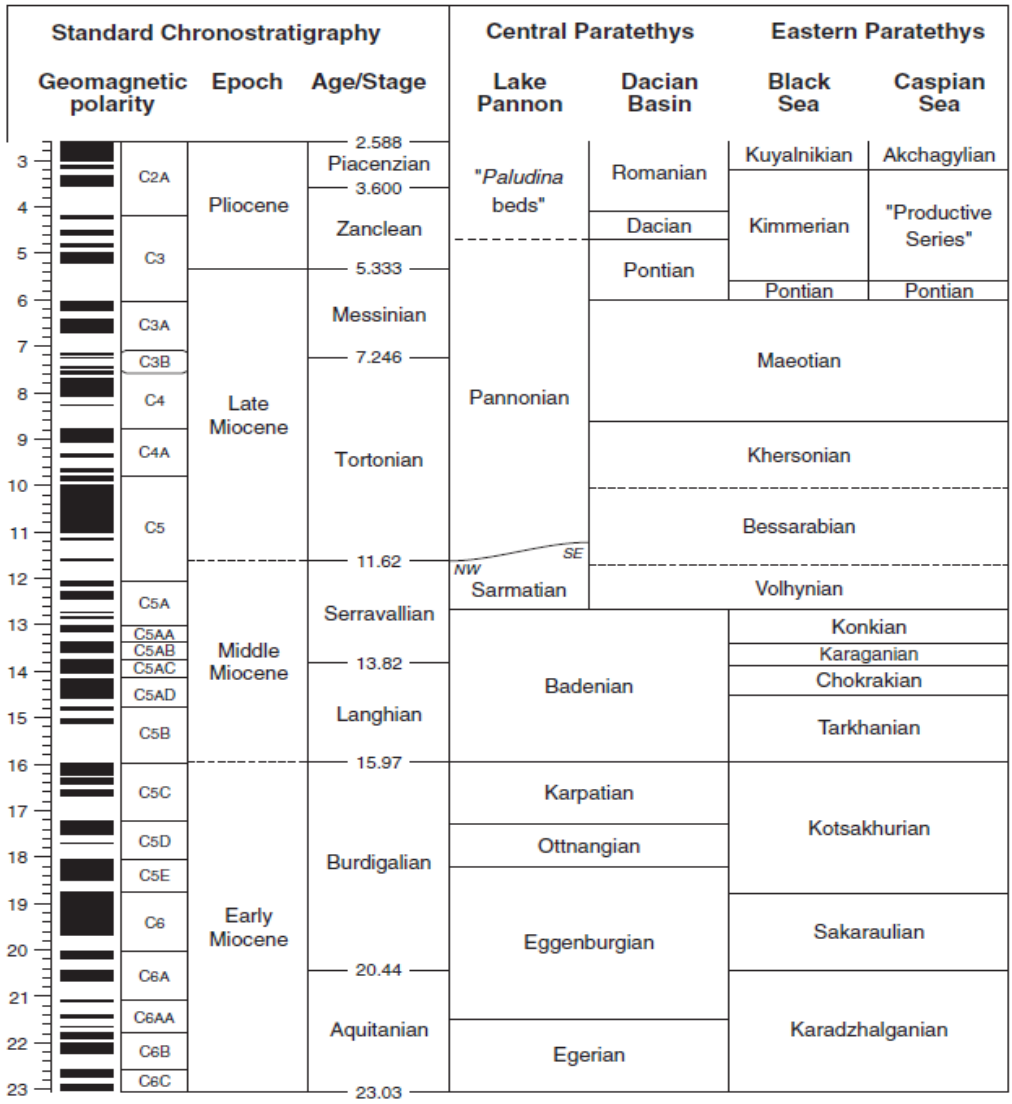


Figure 1.8 : Geomagnetic polarity and chronostratigtaphy of the Central and Eastern Paratethys from the data belongs to Lake Pannon, Dacian Basin, Black Sea and Caspian Sea. (Harzhauser & Kowalke, 2004).

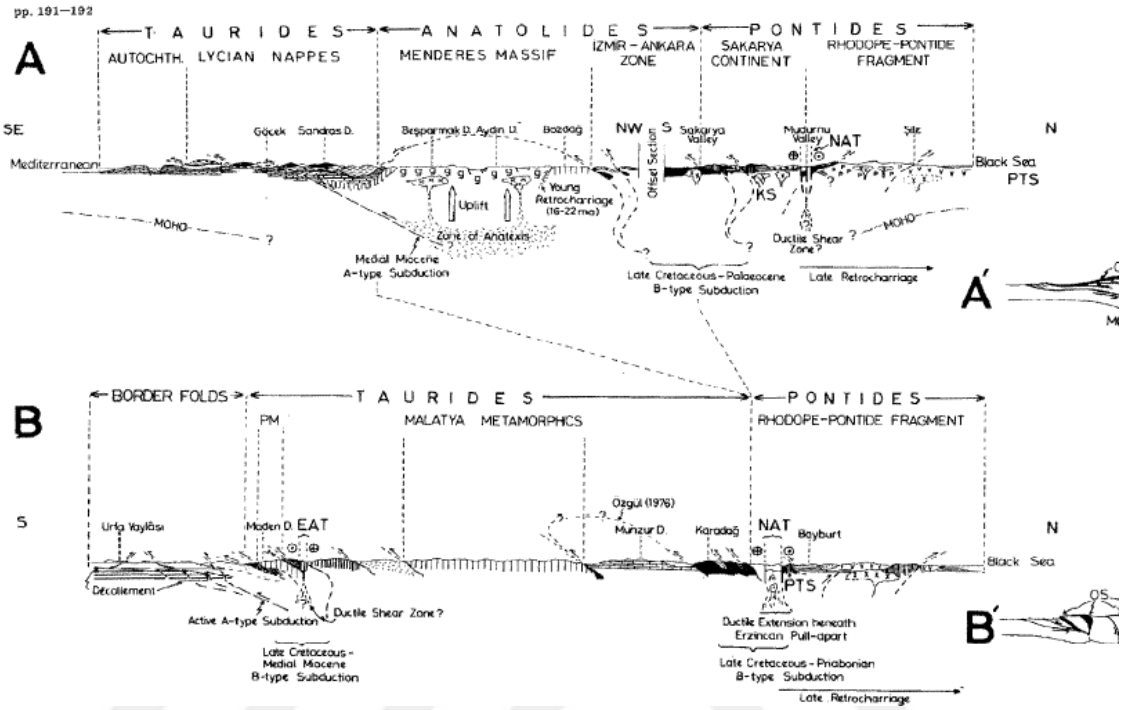


Figure 1.9 : Schematized geological cross section of Turkey, The cartoons in A' and B' are drawn to emphasise the fundamentally different tectonic styles of the collisonal orogen in Turkey along three cross sections. KSL the Karakaya suture. PTS shows the probable location of the Paleo-Tethyan suture along this cross-section. PM is the Pötürge Massif. EAT is the East Anaotlian transform fault. NAT is the North Anatolian transform fault (Şengör and Yılmaz,1981).

2. DESCRIPTION OF THE SECTION

2.1. YEŞİLKÖY SECTION

This section which consisted of 43 m thick deep marine marls of Beydağları Fm and shallow marine carbonates of Karabayır Fm. is located in Yeşilköy Village and near the Elmalı-Kaş Road. Sampling locations are demonstrated at Figure 2.1. YK1-YK18 belongs to deep marine carbonates of Beydağları Fm. which planktonic foramnifera is rich. YK18-YK48 levels contains Miocene age larger hyaline fauna. Loose samples are collected from 5 section.

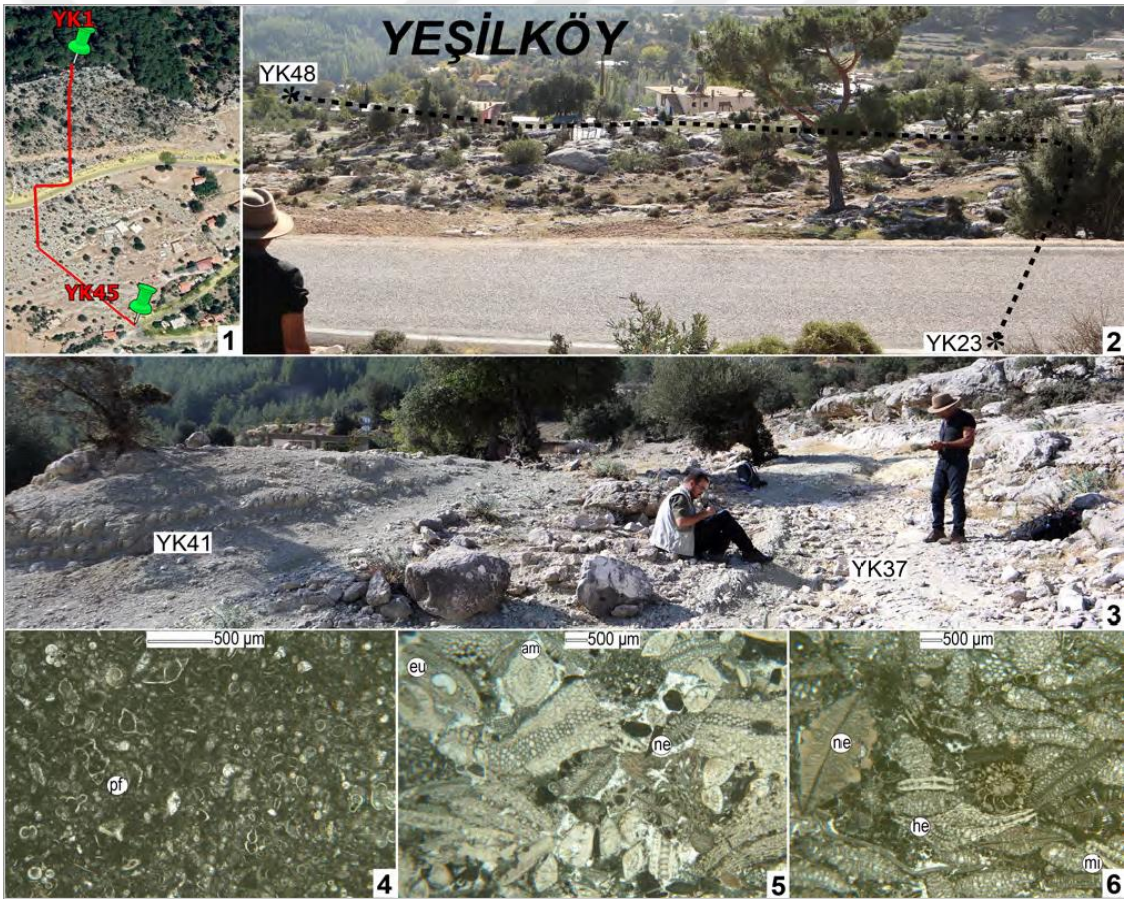


Figure 2.1 : Field view and microphotograph belongs to Yeşilköy section 4. pf: planktic foraminifera, ne: *nephrolepidina.*YK18-YK48 levels belonging to Miocene shallow marine packages is represented by packstone and wackestone. These shallow marine deposits gives beige-gray, cream and whitish brown colur outcrops in Yeşilköy section.

The distribution of Early Miocene larger hyaline foraminifera in Yeşilköy section is demonstrated in Figure 2.2. Larger hyaline content of Karabayır Fm. in the Yeşilköy section is mainly represented by *Nephrolepidina praemarginata* (Leomoine and R. Douville 1908*)*, *Nephrolepidina morgani* (Lemoine and R. Douville 1904*)*, *Nephrolepidina* ex. interc *morgani- tourneri*, (Lemoine and R. Douville 1904*)*, *Nephrolepidina tourneri*, (Leomoine and R. Douville 1911*)*, *Miogypsina globulina*, *Miogypsina* ex.interc *globulina tani*, *Heterostegina assilinoides* (Blanckernhorn 1890), *Nummulites bormodiensis* (Tellini, 1888) *N. kecksemetti*, *Operculina complanata Defrance* , *Cycloclypeus eidae Opertorbitolites* sp. and *Miliolipora* sp.

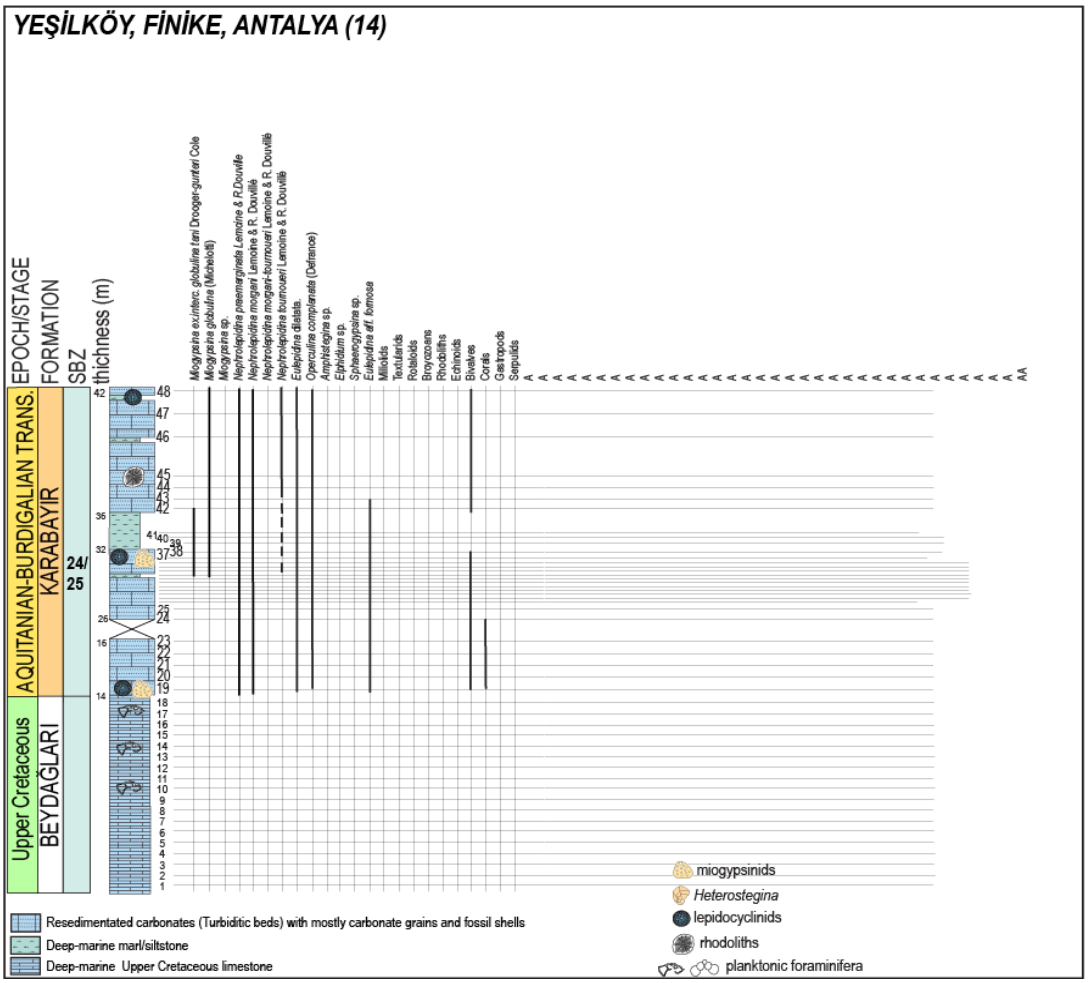


Figure 2.2 : Stratigraphic section and distrubution of fossil content belongs to Yeşilköy Section.

The basal part of the Yeşilköy section is consisted of the Upper Cretaceous age deep marine carbonates of Beydağları Fm. that are rich in planktic foraminifera. These deep marine carbonates and siliciclastic are overlained by Aquitanian-Burdigalian

age shallow marine neritic limestones. Microfacies photograph of each level belonging to Yeşilköy section is demonstrated in Figure 2.4. According to these, basal part of Miocene shallow marine carbonaceous clastics is consisted of biosparitic limestones with intraclasts. Field viev are demonstrated in Figure 2.3. *Nephrolepidina and Nummulites* assemblages are common. These Early Miocene neritic shallow marine packages contain *Eulepidina* and *Heterostegina.* These shallow marine carbonates have a vertical transition in deep marine siltstones and marls. These indicate Burdigalian transgression.



Figure 2.3 : Field observations

In Yeşilköy Section, Karabayır Formation is mainly represented by packstone facies In general texture demonstrates the reefal features. Total thickness of shallow marine sequences in the Yeşilköy section is measured 43m. Grey, beige, cream and brownish- coloured limestones are obtained in field observations. These sequences are intercalated with micritic nummulitic rich limestones. Allochems in a micritic

matrix are grain supported in some levels. Coral, bivalve, algae and gastropoda fossils were found in reefal limestones with microspar calcite matrix.

Faunal assemblage in the upper part of the Yeşilköy section is represented mainly by larger hyaline foraminifera. Field viev is demonsrated in Figure 2.4. The main groups are *Miogypsina globulina*, *Miogypsina globulina-tani*, *Nephrolepidina praemarginata*, *N. morgani*, *N. morgani-tourneri*, *N. tourneri*, Eulepidina, Heterostegina, Operculina complanata, *N. kecksemetii* and *N. bormidiensis*, *Sphareogypsina*, *Miliolida*, *Textularida* sp. *Amphistegina* sp. and *Elphidium* sp. There are also corals, bryozoans, rhodolits, bivalves and echinoids.



Figure 2.4 : General viev of YK section and sample locations.

2.2. Sampled Levels of YK Section

2.2.1 YK19 Sample

The basal part of the Early Miocene succession is consisted of mainly *Nephrolepidina, Nummulites* and bryozoans existence. Only one genus of *Cycloclypeus* is determined in petrographic sections for this shallow marine packages.

Eulepidina is obtained with larger embryon in this level. There is also a few Globigerina sp. in thin sections. *Eulepidina dilatata* (Michelotti, 1861).

Eulepidina aff. *formosa* (Schlumberger, 1902)
*Nephrolepidina morgani (*Lemoine and R. Douville 1908*)*
*Nephrolepidina morgani-tourneri (*Lemoine and R. Douville 1908*)*
*Nephrolepidina praemarginata (*Lemoine and R. Douville 1908)
Cycloclypeus eidae (Carpenter, 1856)
Globigerina sp.
Miliolipora sp. (Brönnimann & Zanietti, 1971)
Nummulites kecksemetii (Less)
Operculina complanata (Defrance)

2.2.2 YK25 Sample

In petrographic section Eocene fauna are obtained. *Discocylina* and *Orbitoclypeus* genuses are also determined. Faunal diversity is more than upper levels. Discocyclina is predominant asseblage in that section. From YK25 to YK29, faunal assemblages represents the Eocene. Orthopragminid are more common groups in section. LBF fauna belonging to YK25 is listed below:

Nummulites.
Discocylina sp. (Gümbel)
Orbitoclypeus sp.
Heterostegina assilinoides (Blanckernhorn)
Operculina complanata (Defrance)
*Nephrolepidina morgani (*Lemoine and R. Douville)
Nephrolepidina morgani- tourneri (Lemoine and R. Douville)
Miliolipora sp. (Brönnimann & Zanietti)
Opertorbitolites sp. (Nuttal)
Miogpsina globulina (Michelotti)

2.2.3 YK34 Sample

This samples belongs to YK34 demosntrates reefal characteristic. Corals and bryozoans are predominant in middle part of the Miocene packages in Yeşilköy section. LBF occurrence is very narrow with out *Nummulites* and *Operculina* existence. Facies represent reefal packstone features. Upper levels of this samples

consisted of Eocene sequences. Depositional environments depend on coral abundance and non-existence of LBF indicates deeper environment with marl and siltsone intercalations. Microphotograph and facies properties are demonstrated in Figure 2.5. Faunal content is listed as below:

Bryozoans

Nummulites bormidiensis (Tellini)

N.kecksemeti (Less)

Operculina complanata (Defrance)

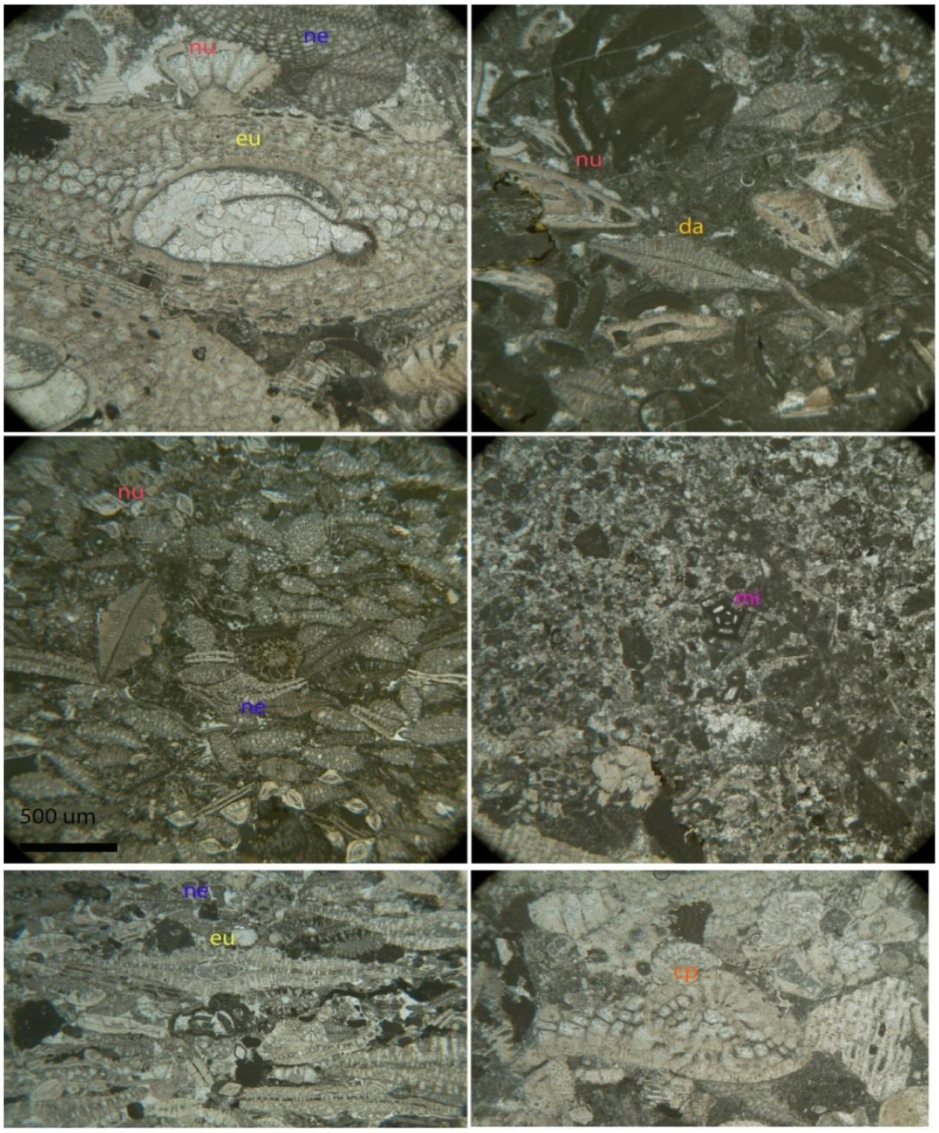


Figure 2.5 : Photomicrographs of some level belong to Yeşilköy Section packstone 1: benthic foraminiferal packstone 2: benthic foraminiferal packstone 3: packstone 4:wackestone/packstone 5:benthic and planktic packstone.

2.2.4 YK44 Sample

This levels consisted of abundance of larger hyaline foraminifera. Upper level of YK36 demonstrates the shallow marine environment. This indicates Burdigalian trangression. Existence of Eulepidina aff. *formosa* indicates clearly Indo-Pacific influence. Within the larger hyaline foraminifera, existence of *Alveolina* shows the transportation from Eocene deposits in these Miocene shallow marine packages. Co-occurrence of both faunal assemblages evidences that situation.

Eulepidina aff. *formosa* (Schlumberger,1902)

Opertorbitolites sp. (Nuttal, 1925)

Miogypsina globulina (Michelotti,1841)

Miogypsina ex. interc *globulina-tani*

Alveolina sp. *(*d'Orbigny 1826*)*

Nummulites kecksemetii (Tellini,1888)

Nephrolepidina morgani (Lemoine and R. Douville)

Biometric data belonging to Yeşilköy section is demonstrated in Table 2.6, Table 2.7 and Table 2.8. Microfacies from the levels between YK19-YK48 is mainly consisted of packstone. In some sections, wackestone features were obtained. Stratigraphic section belonging to Yeşilköy section and microfacies of each section for shallow marine Miocene packages are demonstrated in Figure 2.9. Faunal content is manily consisted of *Nephrolepidina, Eulepidina, Heterostegina, Miogypsina, Nummulites* and *Operculina*. From YK32 section shallow marine clastics are overlained by thin deep marine marls and from the YK36 shallow marine clastics are obtained. There are also *Miliolida, Sphareogypsina, Opertorbitolites* and *Alveolina* are observed. In some level, some Eocene age faunal content such as *Discocyclina* and *Orbitoclypeus* were obtained. There are also rhodolits, corals, textularids and bryozans in Yeşilköy section. All of this taxa represent inner shelf environment. In only one levels of Yeşilköy section includes *Cycloclypeus eidae* which is characteristic for European fauna. The thin sections and oriented thin sections were analyzed for microfacies analyzes and genus determination.

Table 2.6 : Biometric data of *Nephrolepidina* and *Eulepidina* species belongs to Yeşilköy section.

Parameter	Samples	Num.	P1		D		C	A	n
			mean	range	mean	range	mean		
Nephrolepidina praemarginata	YK31	6	244,16	190-260	327,5	225-405	2,6	35,26	20-25
	YK33	6	217,5	145-270	312,5	220-360	2,66	38,20	21-24
	YK37	10	257,22	165-410	352	185-540	2,77	37,8	20-25
	YK43	13	221,15	150-395	311,92	200-635	2-4	37,47	16-24
	YK47	5	248	180-325	349	240-665	2,66	37,04	21-25
Nephrolepidina morgani	YK31	6	264,5	235-315	327,5	270-615	3,66	42,92	17-26
	YK33	7	216,42	130-270	334,28	215-470	3,66	42,11	19-24
	YK37	12	248,91	135-340	378,20	205-515	3,62	42,14	20-24
	YK43	14	248,46	165-425	372,69	245-670	3,59	42,26	18-25
	YK47	13	242,5	175-420	361,25	205-710	3,64	42,89	22,37
Nephrolepidina morgani-tourneri	YK31	4	268,75	180-315	437,5	405-495	3,58	45,18	18-25
	YK33	4	260	220-345	426,25	320-565	3,66	46,88	17-25
	YK37	4	315	135-340	572,5	465-645	4,66	47,84	19-26
	YK43	2	242,5	240-245	432,5	425-440	3,63	46,45	17-20
	YK47	4	237,5	215-270	340	270-395	4,42	47,22	18-23
Nephrolepidina tourneri	YK33	2	300	235-365	552,5	415-690	7	50,4	19-21
	YK37	2	340	320-360	592,5	485-700	5	52,86	20
	YK47	4	233,75	155-330	390	250-655	7	51,07	14-23
Eulepidina aff. *formosa*	YK31	2	745	730-760	1302,5	1295-1310	-	90,82	11-13
	YK33	2	610	560-660	1272,5	1160-1385	-	92,33	11-14
	YK37	1	415	415	910	910	-	88,96	12
	YK43	1	-	-	1110	1110	-	-	13
	YK47	1	-	-	1500	1500	-	-	11
Eulepidina dilatata	YK31	2	550	345-755	950	655-1245	-	75,94	13
	YK33	1	740	740	1270	1270		83,87	12
	YK43	1	910	910	1530	1530	-	77,70	11
	YK47	2	580	525-975	1187,5	975-1400	-	87,88	10

Table 2.7 : Biometric data of *H. assilinoides*, *N. kecksemetii* and *N. bormidiensis* from the Yeşilköy sections.

Parameters	Samp.	N	P1		D1		d	K
			mean	range	mean	range	S	
Heterostegina assilinoides	YK31	6	217,5	165-320	267,5	180-395	1046,5	45,03
	YK33	4	185	145-245	197,5	140-265	935	51,67
	YK37	7	252,14	170-330	251,42	185-365	1565	39,47
	YK43	5	248	185-285	258	190-290	985	52,81
	YK47	2	217,5	185-250	192,5	15-235	1172,5	41,34
Nummulites kecksemetii	YK31	3	131,6	75-140	116,66	65-125	1054	39,93
	YK33	2	167,5	160-175	175	170-180	1177	-
Nummulites bormidiensis	YK43	1	450	450	380	380	-	-
	YK47	1	995	995	-	-	-	-

Table 2.8 : Biometric data of *Miogypsinoides* from the Yeşilköy sections.

Taxon	P1	D1	X	γ	Sample no
	P	X			
M.globulina	170	130	?	27	YK47-12
M.globulina	170	155	14	22	YK47-23
M.globulina	165	130	6	28	YK47-24
M.globulina	165	180	7	33	YK47-27
M.globulina	140	190	7?	32	YK47-28
M.globulina	140	-	8	54	YK47-32
M.globulina	205	245	6-7	-23	YK47-33
M.globulina	105?	135?	-	30	YK47-40
M.globulina	185	205	6	33	YK47-44
*M.*ex.interc *globulina.*	185	170	11	-125	YK37-7
*M.*ex.interc *globulina.*	110	100	8	1	YK37-15
M.globulina	205	195	7	22	YK37-53
*M.*ex.interc *globulina.*	210	200	8	9	YK43-1
*M.*ex.interc *globulina.*	195	170	6	5	YK43-2
M.globulina	170	185	9	45	YK43-3
*M.*ex.interc *globulina.*	195	210	7	-14	YK43-4
M.globulina	205	160	10	?	YK43-32

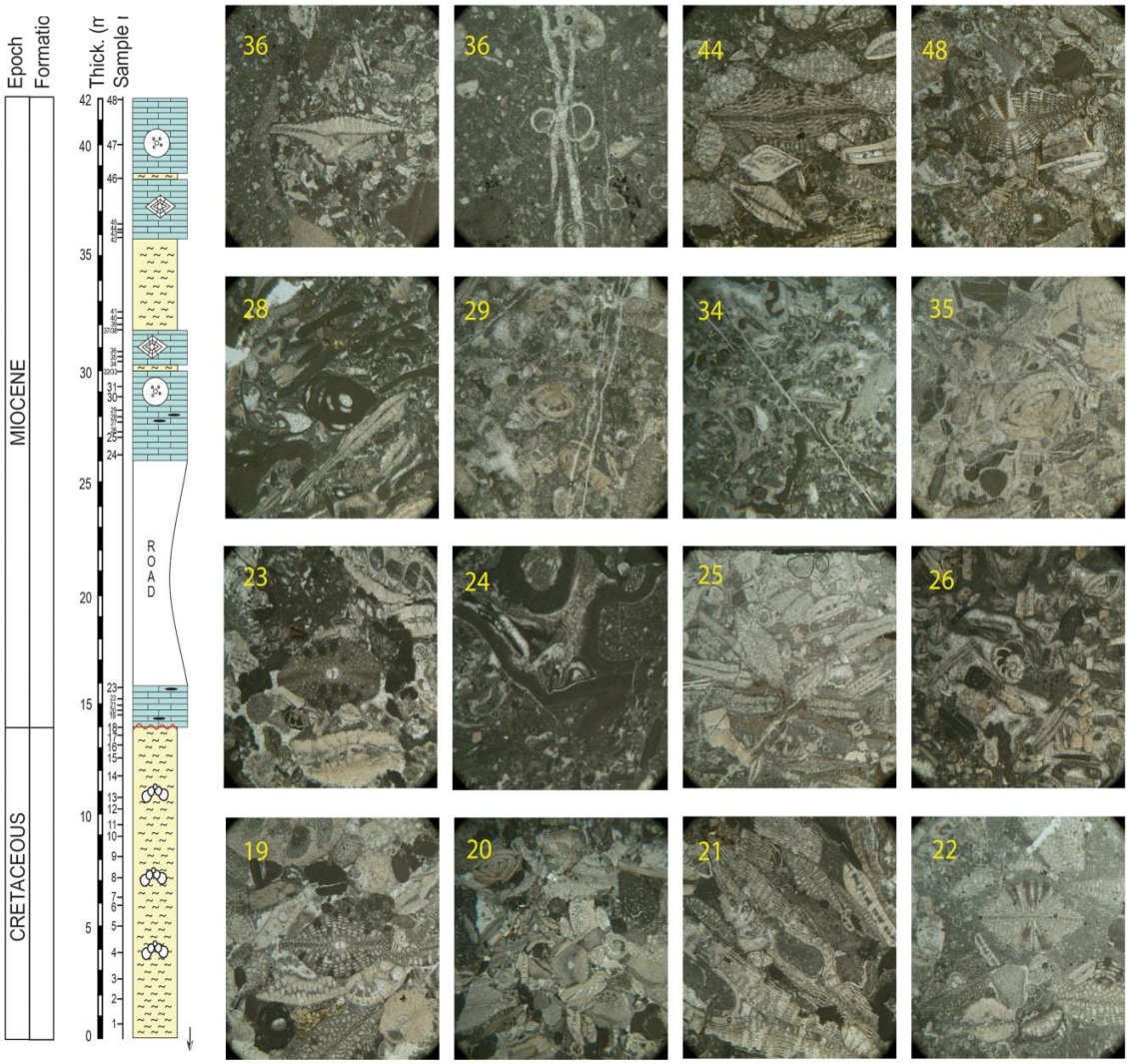


Figure 2.9 : Facies photograph of the shallow marine clastics of Karabayır Fm.

3. MORPHOLOGICAL ANALYSES AND DESCRIPTIONS

The parameters used in biometrical analyses of the hyaline larger foraminifera groups mainly (lepidocyclinids, nummulitids, and miogypsinoids) are explained and schematized (Drooger, 1993, and Drooger and Armato, 1963). The internal morhology and parameters used in internal morphological features are also shown in Figure 3.1. These are depend on the species. In *Miogpsinoides*, these parameters are P, D, Y, X, A and B. P (size of the protoconch, D (size of the deteureconch), Y (angle between frontal margin and apical margin). The parameters are measured in all genuses. Additionally, in the description of the *Nephrolepidina* assemblages, A, I, C and n parameters are significant. A parameter defines the embracement of the deuteroconch by the protoconch, and C is the number of adauxilary chambers. A is calculated parameter by using formula as given, A=100 x (I + J). The number of annuli from 1 mm distance to the embryon's rim is shown with the n parameters.

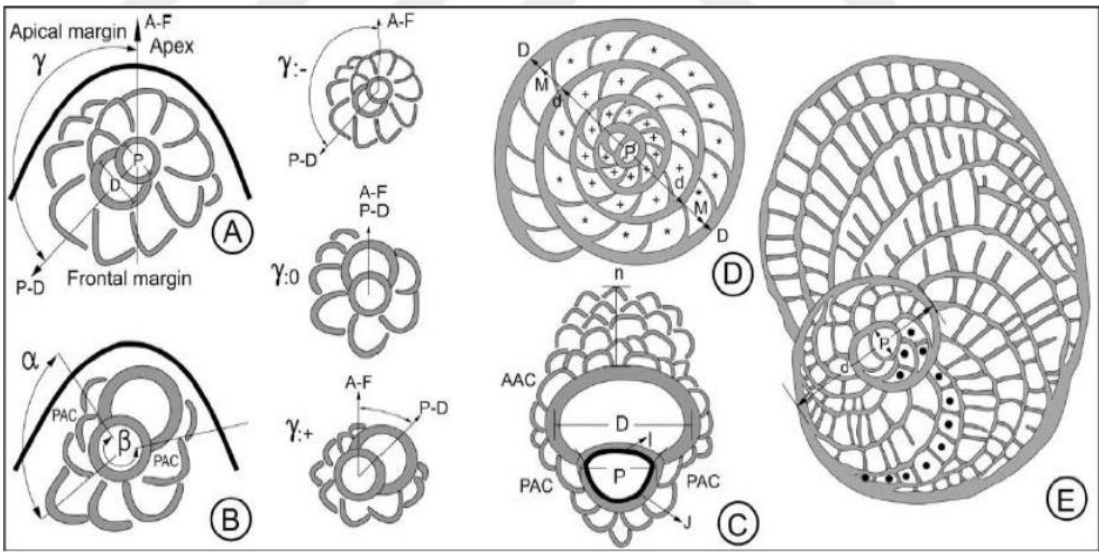


Figure 3.1. : Parameter used in megalosperic hyaline larger formainifera. n: number of the annuli in 1mm distance from the embryon's rim. A-F (apical and frontal axis),P-D (embryonic axis). PAC (principal adauxiliary chamber) D: the distance between second and third whorl. Heterostegina (S_4, S_{14+15}) number of chamberlets in fourth whorl, sum of the number of chamberlets in 14th and 15th whorl. (Özcan et al, 2009).

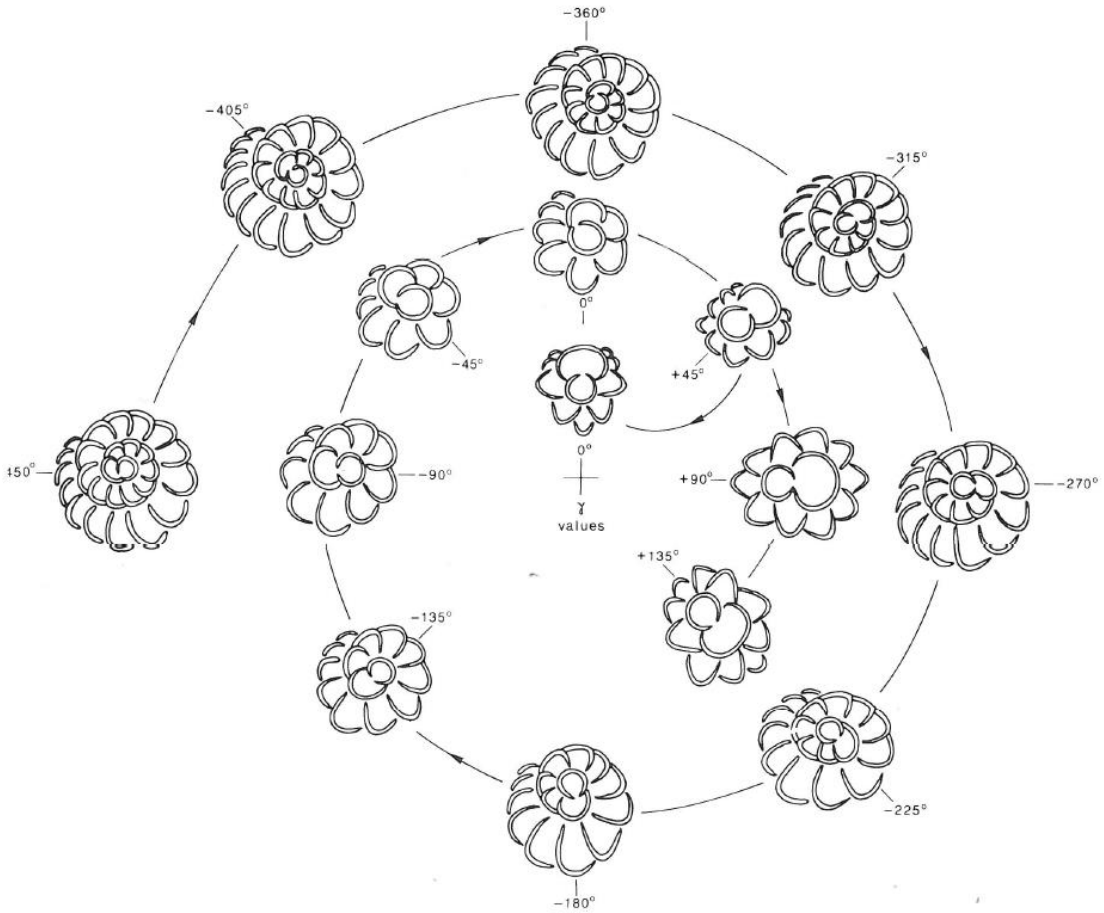


Figure 3.2. Embryonic-nepionic types of *Miogypsina* and the corresponding y values (after Armato and Drooger, 1963). The arrows give the direction of nepionic accelaration.

In *Miogypsina* species, the gamma value represents the orientation of the embryonic axis relatively to the apical frontal axis is a significant parameter for description. In this biometrical analysis, to measure the gamma values , the direction of the spiral from the embryonal side should be in clockwise. The measurement concept of gamma value is demonstrated in Figure 3.2. Also, X parameter that represents the number of the chamber in the first spiral is another significant parameter to determine species or subspecies. A angles represents the angle between the nearest primary adauxiliary chambers that close to the embryonic side and the last chamber in that spiral. V= 100 x (α/β) demonstrates the degree of symmetry. This symmetry is related with the evolutionary lineages of the *Miogypsina* assemblage. The measurement concept in *Miogypsinoides* is demonstrated in Figure 3.2.

In *Heterostegina*, within the P and D diameters d, K and S_4 and S_{14+15} parameters are measured. D represents the distance between the two sides of the second whorl in the

embryonic axis direction. (D-d)/(D-P) x100 gives the K parameter that represents the spiral opening. S_4 and S_{14+15} show the level of chamber division. The number of chamberlets in the early stage gives a chance for determining evolutionary advanced stage.

Evolutionary stages of *Lepidocyclinids* are demonstrated in Figure 3.5 Oldmost ancestor of *Lepidocyclina (Nephrolepidina) is* Amphisteginidae. Planispiral growth transforms slowly to orbitoidal growth with *Helicostegina* and *Helicolepidina* assemblages which comprises the Middle and the Upper Eocene. This transitional stage has ended with *Eulinderina*, orbital growth fully completed and continues with *Polylepidina* and *Lepidocyclina* genuses.

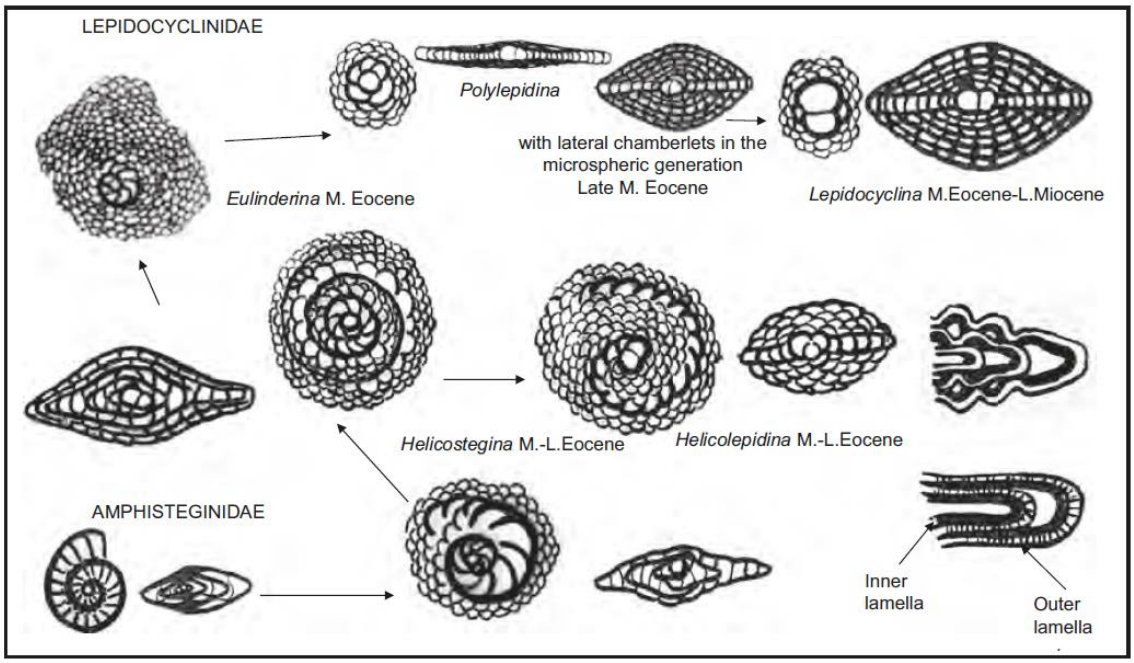


Figure 3.3 : Origin and evoulution of *Lepidocyclinids* (Boudagher-Fadel, M.K, 2008)

A parameters increases from Chattian to end of Burdigalian. Geological time controls the embracement of protoconch by the deuteroconch. Thus there is a linear evolutionary trend from *N. praemarginata* to *N. tourneri* which tends to decrease J and increase I parameters. Within these n parameters (number of annuli in 1mm distance from the embryon's rim) indicates evoulutionary stage of Lepidocylinids.

4.SYSTEMATIC PALEONTOLOGY

Family LEPIDOCYCLINIDAE Scheffen, 1932

Lepidocyclina (Nephrolepidina)

The test is lenticular and is in different sizes. The *Nephrolepidina* genus has a bilocular embryonic structure. Embryon shape at the close side of the embryon is angular arc, since in the margin side they are hexagonal. For the Western Tethyan fauna species designation is determined by A and C parameters. According to these, *N. praemarginata*, *N. morgani*, *N.* ex. interc *morgani-tourneri*, *N*.ex. interc. *tourneri* –morgani and *N. tourneri* are determined. Biometric limits which are determined for N.praemarginata is 1< C < 3.25, A < 40, *N.morgani* 3< C < 5, A > 40, *N.tourneri* C>5 A>45.

Nephrolepidina praemarginata Douville 1908

Figures 15. 1-8, 10-12, fig. 16.

Lepidocyclina praemarginata – Douville, p.91, figs. 1, 2, 4a.

Lepidocyclina (Nephrolepidina) praemarginata – Douville 1975, de Mulder, p. 62-69, pl. 3, figs. 6-8: pl. 4, figs. 8-11

Remarks: First biometric data belonging to *N. praemarginata* from Turkey is reported by Özcan et al, 2009. In the same study it is also discussed that *N. partita* existence in eastern Turkey reported by Sirel, 2003. These both species are interpreted as synonyms. P_{mean} and D_{mean} values of *Nephrolepidina praemarginata* in the Yeşilköy section are determined as 217,2-257,5 and 312,5- 357,52

Description:In Western Tethyan realm biometric limit of *Nephrolepidina praemarginata* is limited by the number of adauxiliary chambers and embracement of protoconch by deuteroconch that are determined from Greece by Mulder 1975 as 1 < C_{mean} < 3,35 A < 40. In YK Sections A values are determined in a range between 37,47 - 38,20. P and D values are between 145-395 and 185-665. N parameter (number of annuli in 1mm distance from the embryon's rim) is in 16-24 range.

Nephrolepidina morgani Lemoine and R. Douville 1904*Lepidocyclina* (*Nephrolepidina) morgani* – Lemoine and R. Douville1904, pl.1, figs. 12, 15, 17; pl. 2, figs. 4, 12; pl.3, fig. 2 – deMulder 1975. p.64, pl. 3, fig. 9; pl,4 figs. 4-7- Less 1991. pp. 445-446, pl. 7, figs, 1-6; pl.8 figs. 1-6, pl. 9, figs. 1-2.

Nephrolepidina morgani (Lemoine and R. Douville) – Schiavonotto and Verrubbi 1994. pl. 4, fig. 2-5

Description: The number of adauxiliary chambers is limited for *Nephrolepidina morgani* in $3 < C_{mean} < 5.25$ $40 < A < 45$ range. *N. morgani* is the most common *Nephrolepidina* species in the YK section. *N.morgani* exists from the bottom to the top of section. A value of *N. morgani* is between 40 and 44.73 in YK Section.

A wide stratigrapic range of *N. morgani* is reported especially from Sivas, Kelereşdere (Ahlat) region by Özcan et al, 444, . The abundance *of N. morgani* is also known from the Western Taurides was reported in Özcan et al, 2009. P_{mean} and D_{mean} values which belongs to *N. morgani* assemblage in the Yeşilköy section is between

Nephrolepidina ex. interc. *morgani – tourneri* Lemoine and R. Douville 1904

Plate 4, figure 6-25; plate 5, figures 3, 5, 6, 8; text figures 13-14.

Lepidocyclina tourneri Lemoine and R. Douville, 1904 – Dizer 1962. pp. 73-74, pl. 8, fig. 4-6.

Nephrolepidina ex. interc. *morgani – tournoueri* Lemoine et Douville – Özcan et al. 2009, p.751, figs 15.14 and 16.

Description: Some specimens that are difficult to differentiate depending on biometric limits are assigned to *N.i* ex. interc. *morgani-tourneri*. A parameter are higher tha 45, C parameters are less than 5.25 limit.

Nephrolepidina tourneri 1990 Lemoine and R. Douville – Giovagnali and Schiavinotto

Description: This species of *Nephrolepidina* is differentiated by the biometric limit that are defined as C>5 and A>45. The existence of N.tourneri is very narrow in Yeşilköy section.

N. tourneri assigned to Yeşilköy section has much higher A values than biometric limits. A values defined for N.tourneri is measured as 50,4 in YK33, 52.86 in YK37 and 51,07 in YK47. Parameter n (number of annuli in 1mm distance from the embryon's rim) are in 14-23 range. The existence of N.tourneri in central Anatolia and in western Taurides has already well kown.

Family NUMMULITIDAE De Blainville 1825

Genus Operculina d' Orbigny 1826

Operculina complanata (Defrance 1822)

Plate 3, figure 31

Lenticulites complanata – Defrance 1822. p.453.

Planoperculina complanata (Defrance) – Less 1991. Pp. 441-442, pl. 2, figs 4-5; pl. 3, figs 1-4

Description: *Operculina* complanata is the only species represents the *Operculina* assemblage in Western Tethyan realm. This species has a wide time range distrubition from the Early Rupelian to Tortonian SBZ21-26 (Chauzac and Poignant, 1997). Remarkable evolutionary changes are not obtained belongs to Operculina during that time period. In this study, several biometrical parameter such as P,D diamater d (distance between two opposite end point of second whorl) and K= 100x(D-d)/(D-p) that represents the spiral opening are measured. According to d and K parameters *Operculina complanata* determined in Yeşilköy section with smaller embryonic diameter 90-145 um.

Remarks: Miocene in Western Tethyan realm is mainly represented by *Operculina complanata*. Existence of *Operculina complanata* in Western Taurides is already known from previous studies. In this study, there is no biometric data from some levels in YK section. In YK31 section, only single specimen of *Operculina complanata* is obtained in oriented sections. P_{mean} and D_{value} are 80 and 95. For YK33 Section P and D values are in 120-140 and 140-225 range.

Heterostegina

Heterostegina in Yeşilköy section is represenetd by only existence of *Heterostegina assilinoides.* Eocene *Heterosteginids* from Turkey shows a great diversification. However, in Eary Miocene Heterosteginids that represented by B forms has not significant evolutionary change or stable.

Heterostegina assilinoides (Blanckernhorn,1890 emend. Henson 1937)

Description: The difference of *H. assilinoides* from *H.*cf. precursor is discussed in (Özcan et al, 2009). It is difficult to differentiate these two taxa from each other, beacuse they have slightly differentiated from another by morphological features. In Özcan et al, 2009 one parameter is added one parameter (S_{4+5})to description of B forms represents the Oligo-Miocene Heterosteginid forms are differentiated from Bartonian-Priabonian Heterostegina species (A form) with internal morphology and chamber division in early stage.

Remarks: There are also some cyclocylpeid *Heterostegina assilinoides* specimens in Yeşilköy section as previously reported in Özcan et al, 2009 from Hacımaşlı and Yuvaköy sections. There is only one species of *Heterostegina* defined in the Yeşilköy section. The d parameter is measured in range between 800 and 1245 um. K parameters 100x(D-d) / (D-P) represents the spiral opening of genus. In previous studies belonging to the Yuvaköy, Hacımaşlı and Korkuteli area, *Heterostegina assilinoides* co-occurs with the *Spiroclypeus blanckernhorn.* However, in Yeşilköy section there is no finding about existence of *Spiroclypeus* sp. which represents the Indo-Pacific influence. P_{mean} value is in 185-252 range,14, D_{mean} is between 192,5 and 267,5. D_2 values are in 935-1565 range.

Nummulites bormidiensis (Tellini, 1888)

Description: In Oligo-Miocene of Turkey Nummulites lineage is mainly represented by *N.bormidiensis* and *N.kecksemetii.*

Nummulites bormidiensis is a member of *N. fabianni* lineage. *N. fabianii* lineage is subdividied in 6 (Less, 566).

Others are *N. fabiani*, *N.bormodiensis*, *N. fichtelli.* look at Less et al, 2008

Co-occurence of *N. bormidiensis* with the *N. kecksmetii* is reported in Özcan, 2009.

Miogypsinoides

Miogypsinoides lineage in Western Tethyan realm is obtained in Chattian – Burdigalian time interval. This taxa is subdivided in two: *Miogypsina and Miolepidocylina.* They both have a lateral chamberlets. The most significant diagnostic character that used to differentiate *Miolepidocyclina* from *Miogypsina* is a periphery position. There is no evidence for existence of *Miolepidocyclina* in Indo-Pacific.

Miogypsina globulina (Michelotti, 1841)

Nummulites globulina – Michelotti 1841 p. 297, pl.3, fig. 6.
Miogypsina irregularis (Michelotti) - Drooger 1952, p. 54, pl. 2, figs. 25-29
Miogypsina globulina (Michelotti)- Drooger and Socin 1959, pl. 1, figs. 5. Özcan and Less 2009. p.33, pl. 1, figs.24-25, pl. 2, fig.6, text-fig 8.

Mioypsina (*Miogypsina*) *globulina* (Michelotti) – Raju 1974. p. 82-83, pl. 2, figs,1-4;pl. 5, figs. 6-7; pl.6, fig. 1. Delicati and Schianivotto 1985, p. 119-120, pl. 5, figs. 5-6.

Description: 0< Vmean < 45 and positive Y parameters are diagnostic for determining *M.globulina.*
Remarks: Co-occurence of *M. globulina* with the *M. intermedia* from the Western Taurides is reported in Özcan et al, 2009a. However, in the Yeşilköy section, Burdigalian is represented by mainly *M. globulina.* In some levels *M. gobulina- tani* transition is obtained. These assemblages demonstrate Western Tethyan affinity however, there is no *Miolepidocyclina* existence that is distinctive for Mediterranean fauna. Having a second primary auxiliary chamber is a diagnostic feature of *M. globulina*.
Another diagnostic morphometric feature of *M. globulina* is the further evolutionary stage compared to *M. tani.* Y values are positive. In the Yeşilköy section, there is no existence of *M. gunteri.*

Miogypsina** ex. interc**. globulina- tani Drooger 1952 et globulina (Michelotti, 1841)

Plate 2, figures18, 19, text fig.11

Description: The ɣ low angles are characteristic and represents Aquit.-Burdigalian.

Remarks: It is previously reported that *M. globulina and M.* ex. interc. *globulina-tani* existence has a crucial significance to chronology in Western Taurides (Özcan et al, 2009). Therefore in the same study the existence of these assemblages in KUŞ9 and KUŞ10 sections are sugessted to determine the age of Miocene transgression. This species transition is interpreted as, this taxon corresponding to the Aquitanaian – Burdigalian. In Turkey, there are various data sets from the Sivas Basin and western Taurides (Ozcan et al, 2008, Ozcan et al, 2009). These evolutionary lineage has also already discussed in Drooger, (1993).

P_{mean} (size of the proluculus) for mentioned levels are 163,4 and 165,9 in the YK section.

Eulepidina (H. Douville 1911)

Description: Embryonic chambers are bilocular, and protoconch is embraced by larger size deuteroconchal septa. The geometry of the equatorial chambers is like in arc, rhombic or spatule shape. They can be also hexagonal. The *Eulepidina* genus range is determined as the Upper Eocene-Middle Miocene age.

Remarks: Western Pacific *Eulepidina* genus has a smaller embryon diamaters than Mediterrenean Eulepidines. The exchange of faunal assemblages from two regions are demonstrated in Özcan et al (2009a, 2009b, 2010a) and Özcan and Less (2009). Also debated by Less et al, 2018. Firstly the existence of *the Eulepidina* species in the Western Tethyan realm is demonstrated by Özcan et al., (2008). This is interpreted as the migration of some species from Indo-Pacific region by currents.

Eulepidina dilatata (Michelotti,1861)

Description: D diameter size is diagnostic for *Eulepidina dilalata*. This assemblage is co-occurs with *Eulepidina* aff. *formosa* in western Taurides. The occurrence of *Eulepidina* genuses in eastern Turkey indicates the Burdigalian migration of such taxa from the Indo-Pacific region to Mediterranean. The first record of *Eulepidina* genuses and co-occurence with the Mediterranean fauna is reported by Özcan et al., (2009). *Eulepidina* lineages are subdivided into two taxa in Turkey. *E. dilatata and E.*aff *formosa*. These two genuses have similar biometric features. Detailed morphometric features of *Eulepidina* from central and eastern Anatolia (Rupelian-Chattian) is well known from various studies (Özcan et al, 2009; Özcan and Less, 2009, Özcan et al, 2008). Morphometric limits for *E. dilatata* are determined by such

parameters; A> 83 (embracement of protoconch by deuteroconch) and D_{mean} (size of deuteroconch) = 1250.

Remarks: The distinguishing features of *Eulepidina aff. formosa* from *Eulepidina formosoides* which has similar biometric features is the degree of embracement in protoconch by deuteroconch. A parameter is much higher than %83 in *E.dilatata.*

Eulepidina* aff. *formosa (Schlumberger, 1902).
Plate 4, figures 26-29; plate 5, figs. 1, 2, 4, 7, 9

Lepidocyclina formosa n. sp. – Schlumberger 1902. pp. 31-33, pl. 2, figs. 1-3.

Eulepidina aff. formosa Schlumberger – Özcan and Less 2009. pp. 31-33, pl. 2, figs. 7-10. – Özcan et al 2009. pp. 752-754, figs. 15, 21, 22.

Description: The diagnostic features recognized for *Eulepidina* aff. *formosa* is mainly having a moderately large eulepidine embryon. D_{mean} is 1000um.

Remarks: The stratigraphic significance of the *Eulepidina* aff. *formosa* is explained in Özcan et al; 2009. The co-occurrence of *E.* aff *formosa* with the *M. globulina* and *Miolepidocyclina burdigaliensis* is also interpreted as a significant tool in the stratigraphic aspect. The existence of *Eulepidina* aff. *formosa* demonstrates Indo-Pacific influence. The biometric data for *E.* aff. *formosa* is limited in Mediterranean region, however, wide occurrence is well known from the Indo-Pacific region (Coleman, 1963; Cole 1963; Hashimotı et al 1977; Butterlin 1991 and Drooger 1993).

Cycloclypeus

Cycloclypeus eidae Tan Sin Hok *1932*

Fig. 6N.

Cycloclpeus eidae Tan Sin Hok 1932 50-59, pl.12, figs.2, 3, pl.13, figs. 1, 2, 4-6

Cycloclypeus eidae Tan Sin Hok, 1932 – Özcan & Less 2009; 33,pl. 2: 11 11-21, 23-27.

Remarks: There is only one specimen belonging to *Cycloclypeus eidae* is obtained in YK37-9 (equatorial section). P value is measured 90 um. The occurrence of

Cycloclypeus eidae indicates the Indo-Pacific influence to the European fauna. Özcan et al, 2009 firstly reported that the occurence of *Cycloclypeus* in Mediterranean region. Annular growth in the specimen was not obtained. This genus represents the most primitive form of *Cycloclypeus eidae*. Embryon drawings of each species are demosnstrated between Figure 4.1 Figure 4.5 and Figure 4.7.

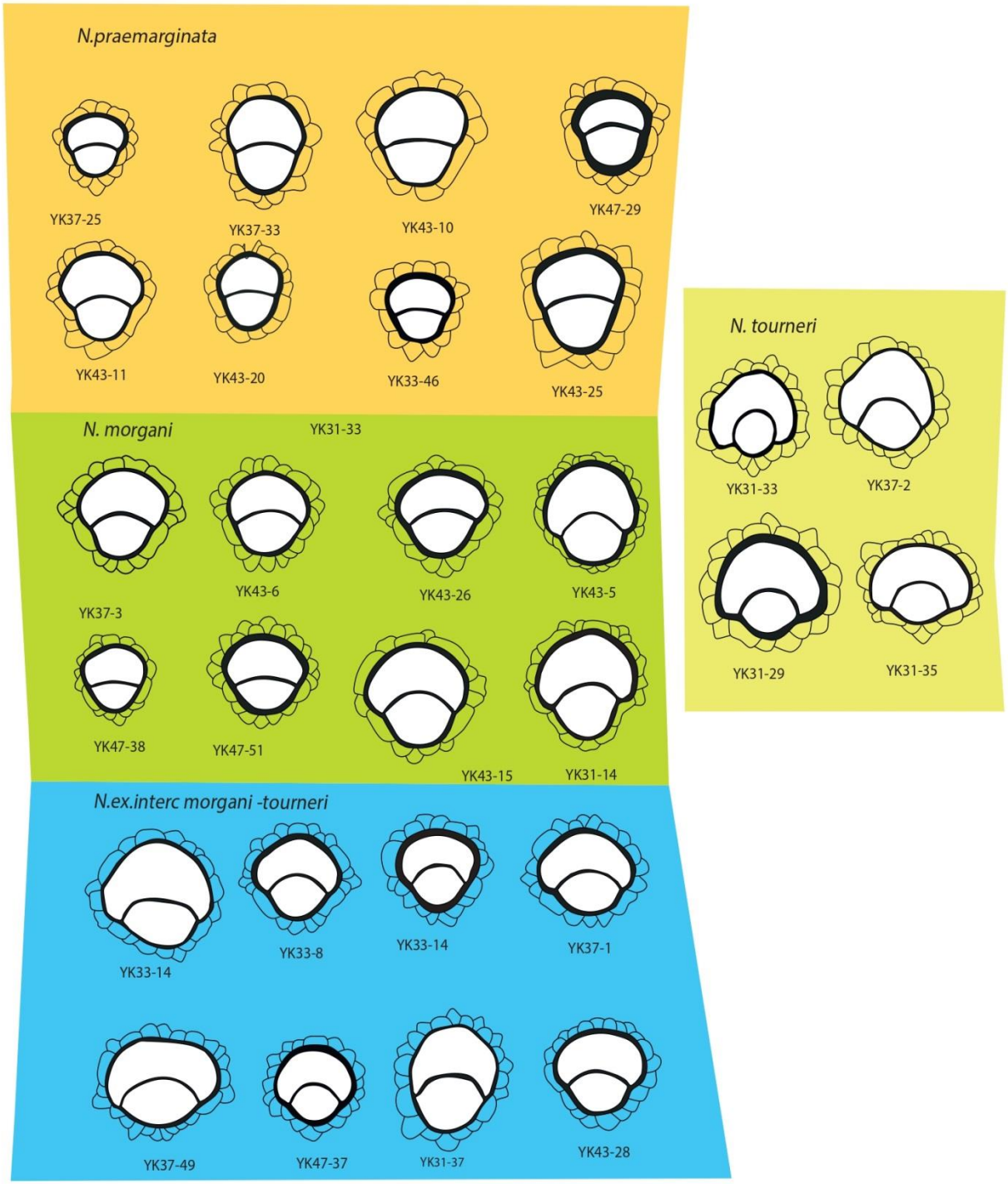


Figure 4.1 : Embryon drawings of *N. praemarginata*, *N. morgani*, *N*. ex. interc. *morgani-tourneri* and *N. tourneri* species.

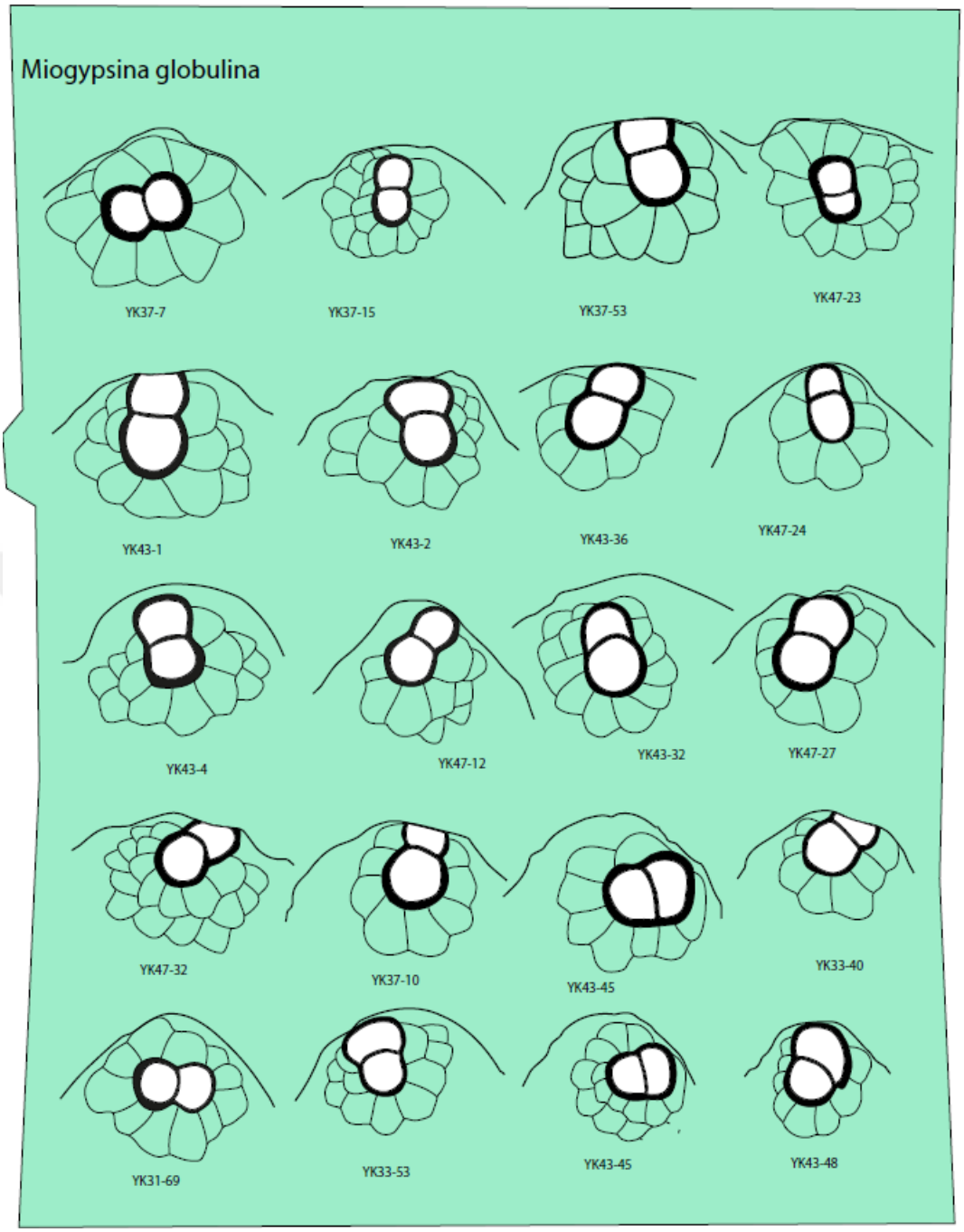


Figure 4.2 : Line drawings of *M .globulina* in YK37,YK47 and YK43 sections.

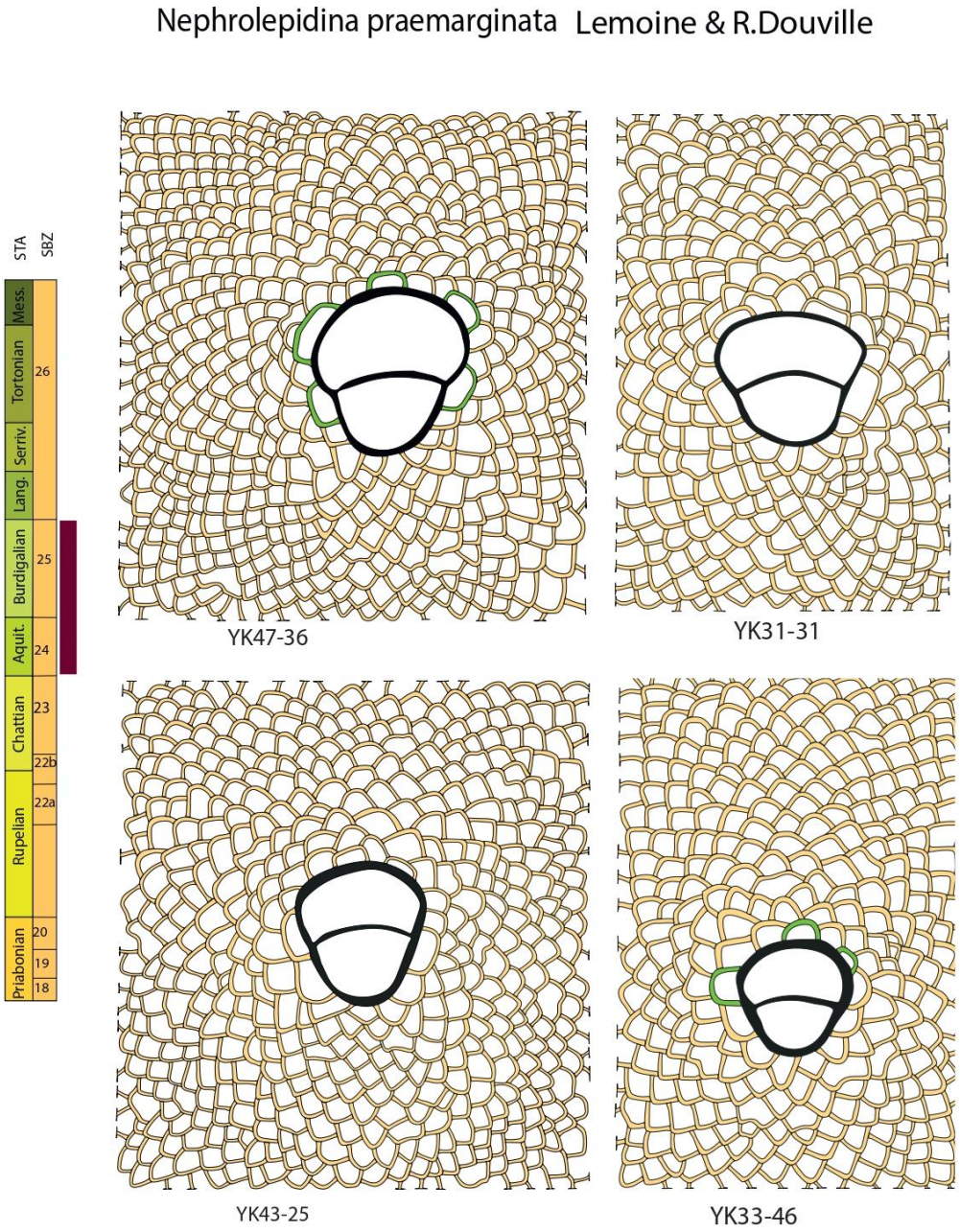


Figure 4.3 : Line drawings of *Nephrolepidina praemarginata* Lemoine & Douville (1911).

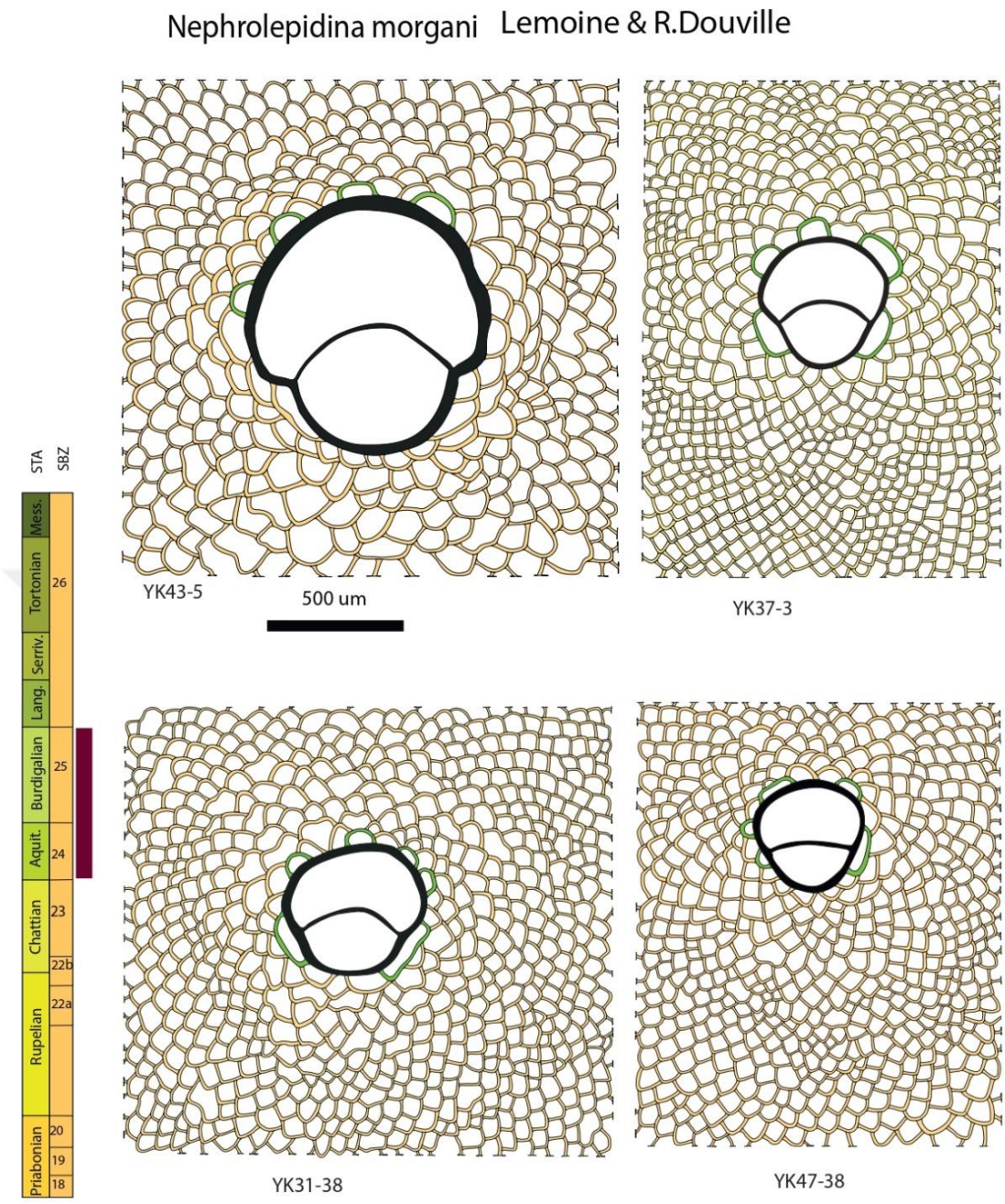


Figure 4.4 : Line drawings of *Nephrolepidina morgani* Lemoine & Douville (1911)

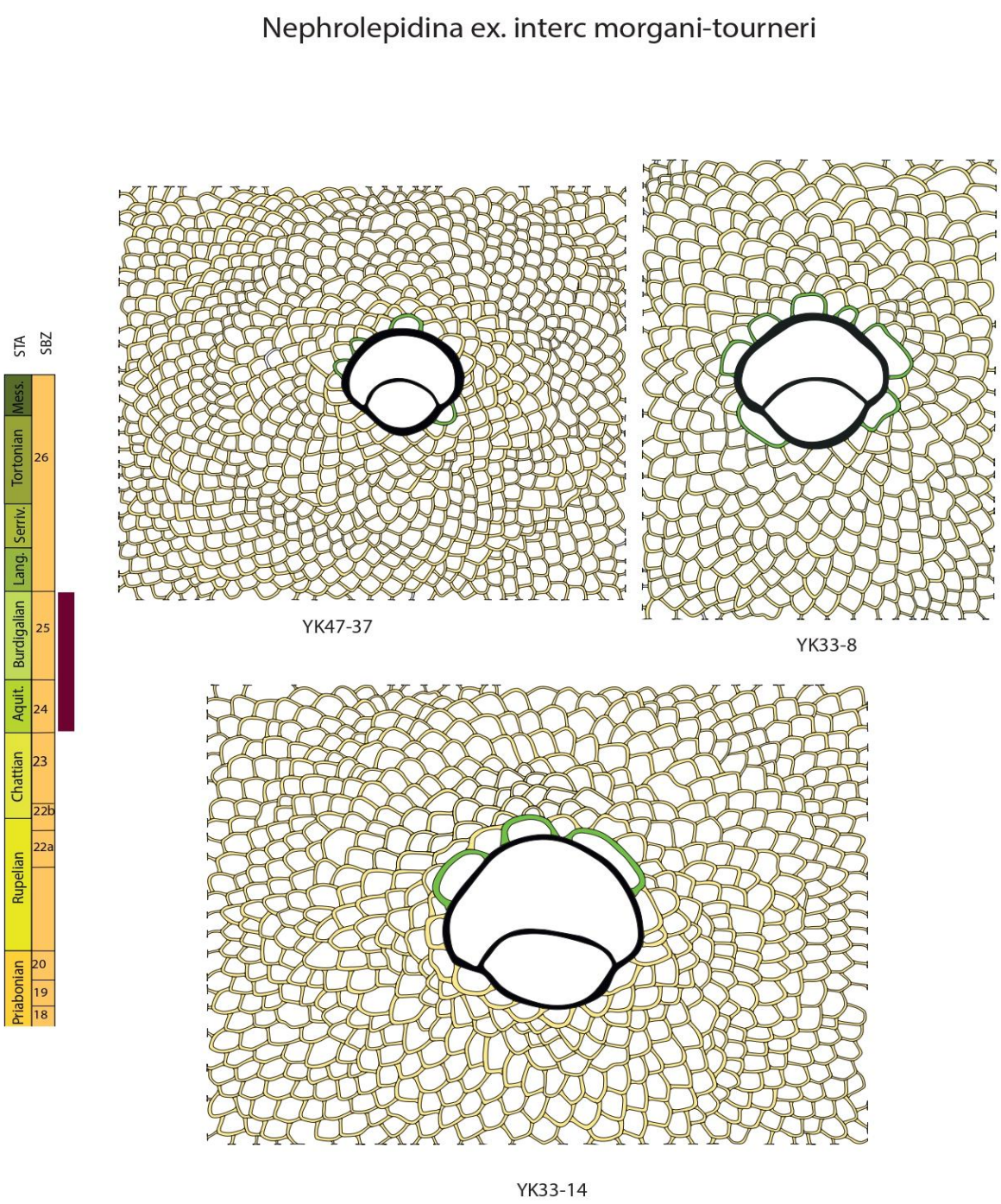


Figure 4.5 : Line drawings of *Nephrolepidina* ex.interc. *morgani-tourneri* Lemoine & Douville (1911).

The biometrical analyses belongs the *Nephrolepidina praemarginata* and *N. morgani* in Yeşilköy section is demonstrated at Figure 4.6.

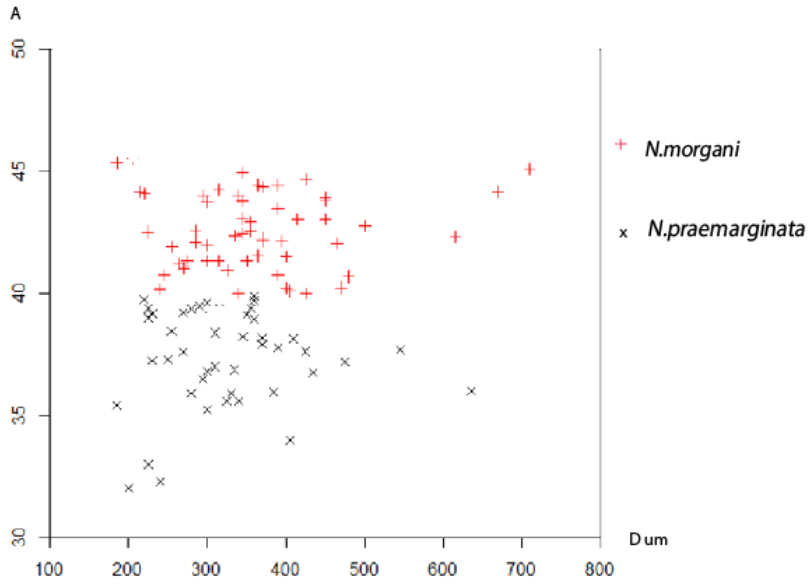


Figure 4.6 : D and A parameters and biometric differences of *N. praemarginata and N. morgani* in Yeşilköy section.

A and D_{mean} parameters are demonstrated in Figure 4.6. *N. morgani* is differentiated from N. praemarginata with the larger A = 100 x(I/ (I+J) values. *N.morgani* is more abundant in Yeşilköy section than *N. praemarginata.*

Heterostegina assilinoides Henson 1937

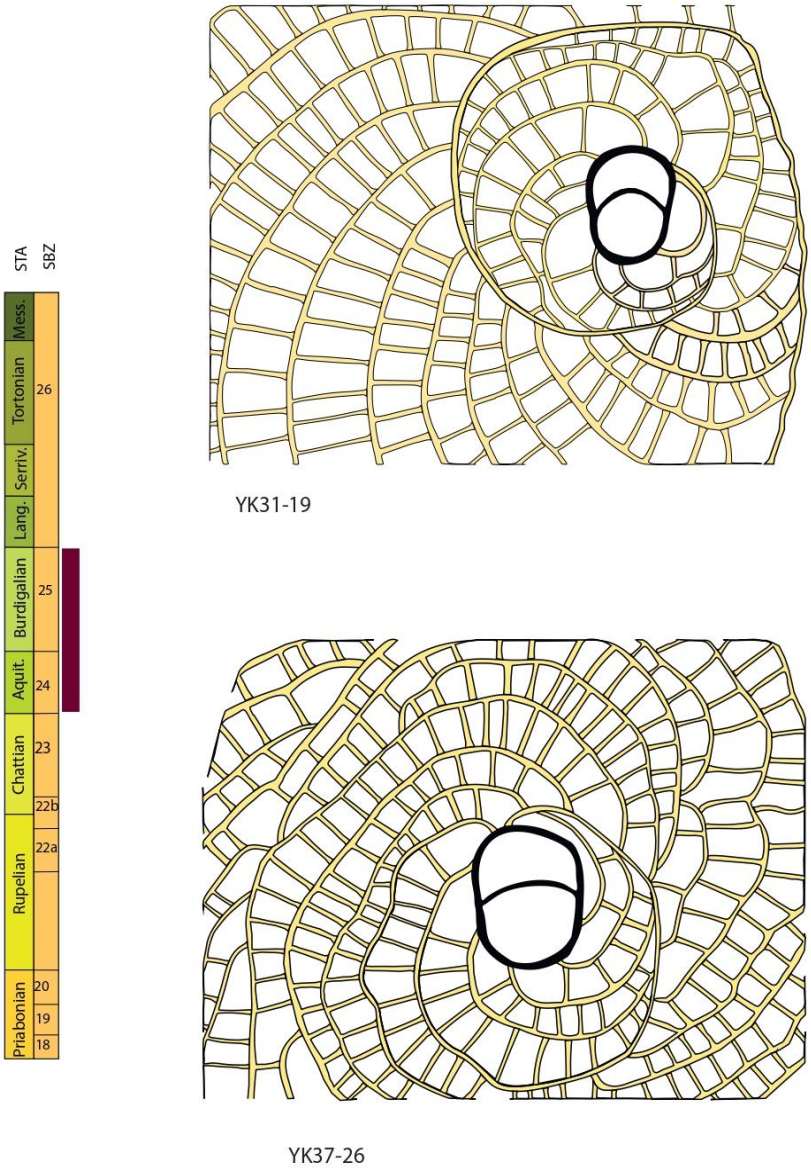


Figure 4.7 : Line drawings of *Heterostegina assilinoides* Blanckernhorn 1879 Henson 1937.

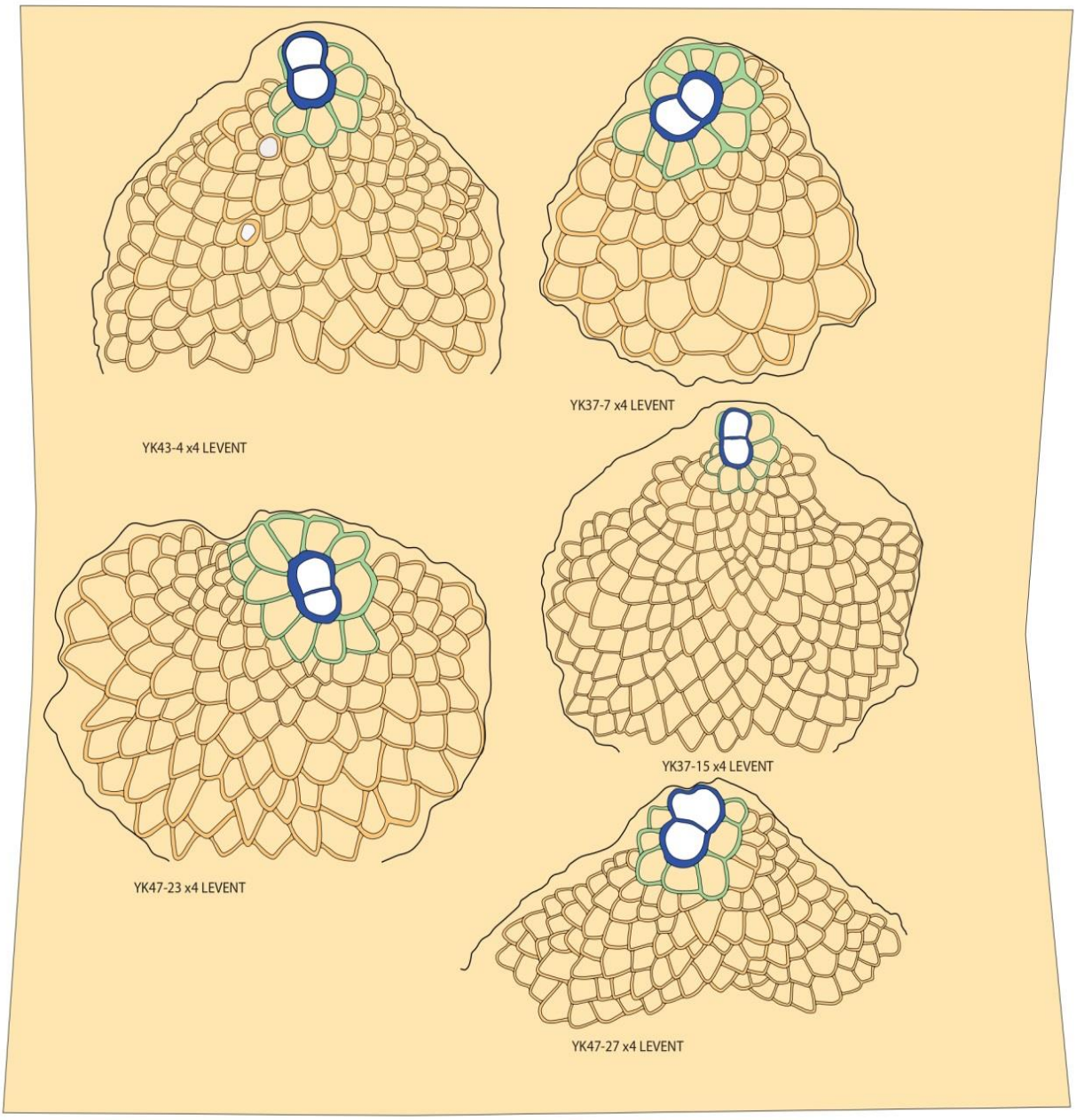


Figure 4.8 : Line drawings of the *Miogypsina globulina.*

5. PALEOBIOGEOGRAPHY

The Oligo- Miocene larger hyaline foraminiferal assemblages are mainly represented by *Nummulites*, *Nephrolepidina*, *Eulepidina*, *Cycloclypeus*, *Operculina* and *Heterostegina*. Distribution of these taxons is mainly subdivided into two main paleobiogeographic units as: Mediterranean and the Indo-Pacific region (Adams 1987, Drooger, 1993). The evolutionary lineage of *Miogypsinoides* assemblages is remarkably different from the Indo-Pacific region. The existence of *Miolepidocyclina* genuses such as *M. burdigaliensis* is diagnostic for Western Tethyan fauna during the Burdigalian. The diversification of faunal assemblages are affected by the closure of the Indian Ocean during the Burdigalian. Current directions are showned in Figure 5.1.

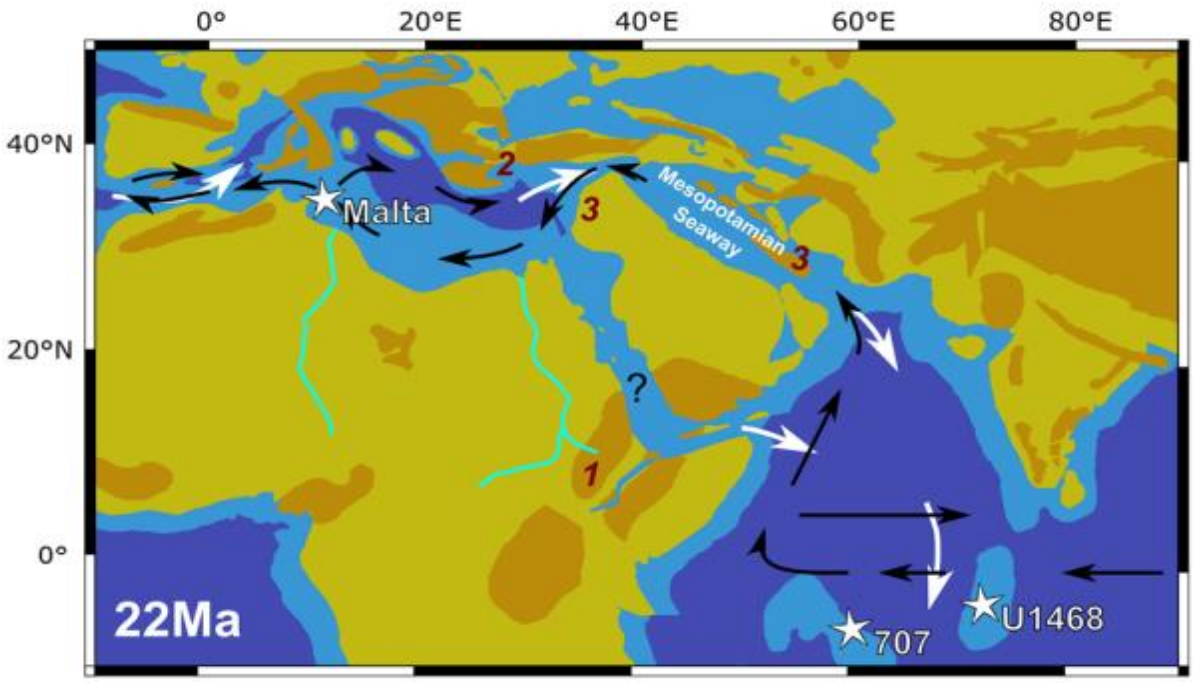


Figure 5.1 : The Early Miocene paleogeography of the Mediterrenean Sea and western Indian Ocean. Arrows indicate surface circulation patters, eith black arrow indicate surface waters and White intermediate to deep water. Red numbers indicate potential source areas of runof with positive εNd signatures. (Bialik et al 2019).

This event results in circulation weakness in Mediterranean region and shallowing in the Indian Ocean Tethys domination was affected the global circulation and environmental conditions in both Mediterranean and Indian Ocean during Mesozoic and Cenozoic. This domination has provided the heat transfer and huge amount of nutrient supply. Besides the tectonical movement of Africa, Australian and Indian plates during the Cretaceous-Oligocene resulted in the enclosing event of the Tethys. This closure event blocked the circulation in Mediterrenan and resulted in anoxic and suboxic environmetal conditions for a long period (Bialik et al, 2019). That event affected the LBF diversity and distrubition. Geographic distrubition of *Cyclcoclypeus* is demonstrated in Figure 5.2.

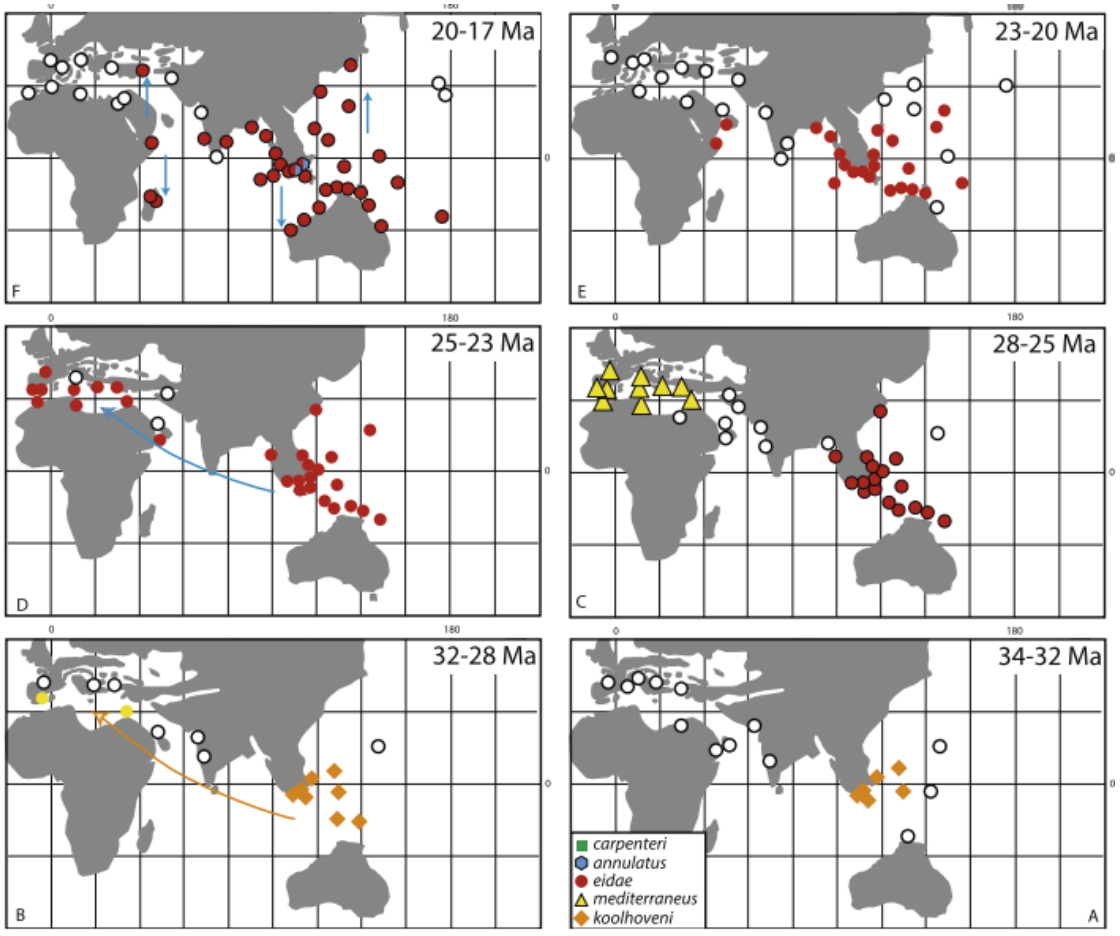


Figure 5.2 : Geographic distribution of species in the genus *Cycloclypeus* during the Oligocene- Recent. (A) Early Rupelian;(B) late Rupelian-earliest Chattian; (C) middle Chattian; (D) late Chattian; (E) Aquitanian; (F) Early Burdigalian. Open circles represents localities with samples in suitable facies types, but without *Cycloclypeus* (Renema, 2015).

6. CONCLUSIONS

The Early Miocene shallow-marine neritic clastics of Karabayır Fm. that are measured in the Yeşilköy section (southern Turkey) are studied in this thesis study. We aims to investigate the Burdigalian faunal assemblage in the Yeşilköy section and determining morphometric and biometric features of assemblages, field observations and sampling. To achieve this, thirty-one levels belonging to the Yeşilköy section have been studied. This study also comprises expanding biometric data of Mediterranean region and discussing the co-occurence of Indo-Pacific and Mediterranean fauna. Major groups in sections are represented by LBF groups such as Miogypsina, Nephrolepidina, Operculina, Heterostegina and *Nummulites*. *Miogypsinoides* are the most significant groups for determining the precise age of the basal part of Early Miocene sequences. *Miogypsina globulina* and *M.* ex. interc *globulina-tani* are also determined in the Yeşilköy section. We conclude the followings below:

There is no evidence for the existence of *Miolepidocyclina* which group is characteristic for European fauna. Within these, *Nephrolepidina* is the most common group in Yeşilköy section. This genus is represented by 4 species: *N. praemarginata, N. morgani, N.ex. interc morgani- tourneri and N. tourneri*. There is only one species of *Operculina* (*Operculina complanata* Defrance) is determined in neritic carbonate sequences of the Karabayır Formation. *Heterostegina* assemblages are also represented by the existence of *Heterostegina assilinoides.* In contrast to previous studies belonging to the Yuvaköy, Korkuteli and Hacımaşlı villages, there is no existence of *Spiroclypeus* in the Yeşilköy section. Biometrical analyses from *Nephrolepidina* (*Lepidocyclina*) genuses and several species of *N.tourneri* are obtained in the section. In determination of *Lepidocyclina* genuses, mainly A (embracement of protoconch by the deuteroconch) I, C (number of adauxiliary chambers), n (number of annuli in 1mm distance from the embryon's rim) and P-D parameters are used. In Western Tethyan fauna, A parameters were determined in limites orderly, A<40, A<45, A>45 and C parameters are also defined in range 1-

3,25; 3-5 and > 5. In biometrical analyses methods demonstrated by Drooger and Armato 1963 are used. *N. morgani-tourneri* faunal transition causes problematic issues in the biostratigraphic frame.

2- According to these faunal assemblages SBZ24-25 (Chauzac and Poignant, 1997) correlation is defined for the basal part of the Early Miocene succession by the existence *of M. globulina and M.* ex. interc. *globulina-tani*. This transition indicates the Aquitanian-Burdigalian age for the basal part of the Karabayır Fm. in the Yeşilköy section. Existence of *Eulepidina* aff. *formasa* and *Eulepidina dilatata* and larger embryonic sizes in *Nephrolepidina* demonstrates the Burdigalian migration that was suggested in various previous studies. However, there is no existence of ribbed form of Nephrolepidina which is characteristic for the Indo- Pacific region. Within these, only one population of *Cycloclypeus* is obtained in the Early Miocene neritic carbonate sequences. That only single population is determined as *Cycloclypeus eidae*. There are also *Nummulites bormidiensis* and *N. kecksemetii* assemblages defined in the Yeşilköy section. The detailed biostratigraphy of the Upper Createceous age Fm. which overlies the Early Miocene age sequences is undefined yet. For understanding the relationship between two units this future study can provide more precise data.

3- We extends the biometric data sets belonging to larger hyaline foraminifera in the Western Tethyan realm and more data to better understanding the co-occurence of both faunal assemblages subdivided in two paleobiogeographic units: Mediterranean and Indo-Pacific. Amean values for these species were determined as 37,27, 42,44, 46,74 and 51.35, respectively. D (deuteroconch size) values are in the range of 185-665 μm, 205-710 μm, 270-645 μm and 250-655 μm, respectively. The existence of *Eulepidina dilatata* and *E.* aff *formosa* indicates Indo-Pacific migration in Burdigalian. It is discussed in Özcan et al 2009. Oligo-Miocene *Heterosteginids* are differentiated from Bartonian-Priabonian *Heterosteginids*. In that aspects, S_{4+5} parameter is added to biometrical analyses to understand the evolutionary trend by obtaining chamber division in the early stage (number of chamberlets in fourth and fifth growth stages). In the Yeşilköy section *Heterosteginid* groups are represented by the existence of only one species: *Heterostegina assilinoides* Blanckernhorn 1890 emend. Henson 1937. These genus has similar morphological features to Spircolypeus. D (distance between two opposite sides of 2nd whorl) and K paramaters (represents the spiral opening) are measured in Yeşilköy section. Nummulites assemblage is reprsented by the existence of *N.bormidiensis* and *N.kecksemetii*. Moreover, there is no existence of *Spiroclypeus blanckernhorni*.

For *M. globulina* X values (number of chambers in the first spiral) were measured in the range of 6-14, and ɣ values in the range of 0-54. ɣ values for *M. globulina-tani* are measured in the range of (-125) – (-14). There is no evidence for existence of *Miolepidocyclina* which is diagnostic assemblage for European fauna.

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APPENDICES

APPENDIX A: Plates

PLATE 1

1: YK37-3

2: YK43-5

3: YK43-15

4: YK31-33

5: YK33-8

6: YK47-37

7: YK37-71

8: YK31-45

9: YK43-28

7: external photo 8: axial section 1-6,9: equatorial sections.

APPENDIX A

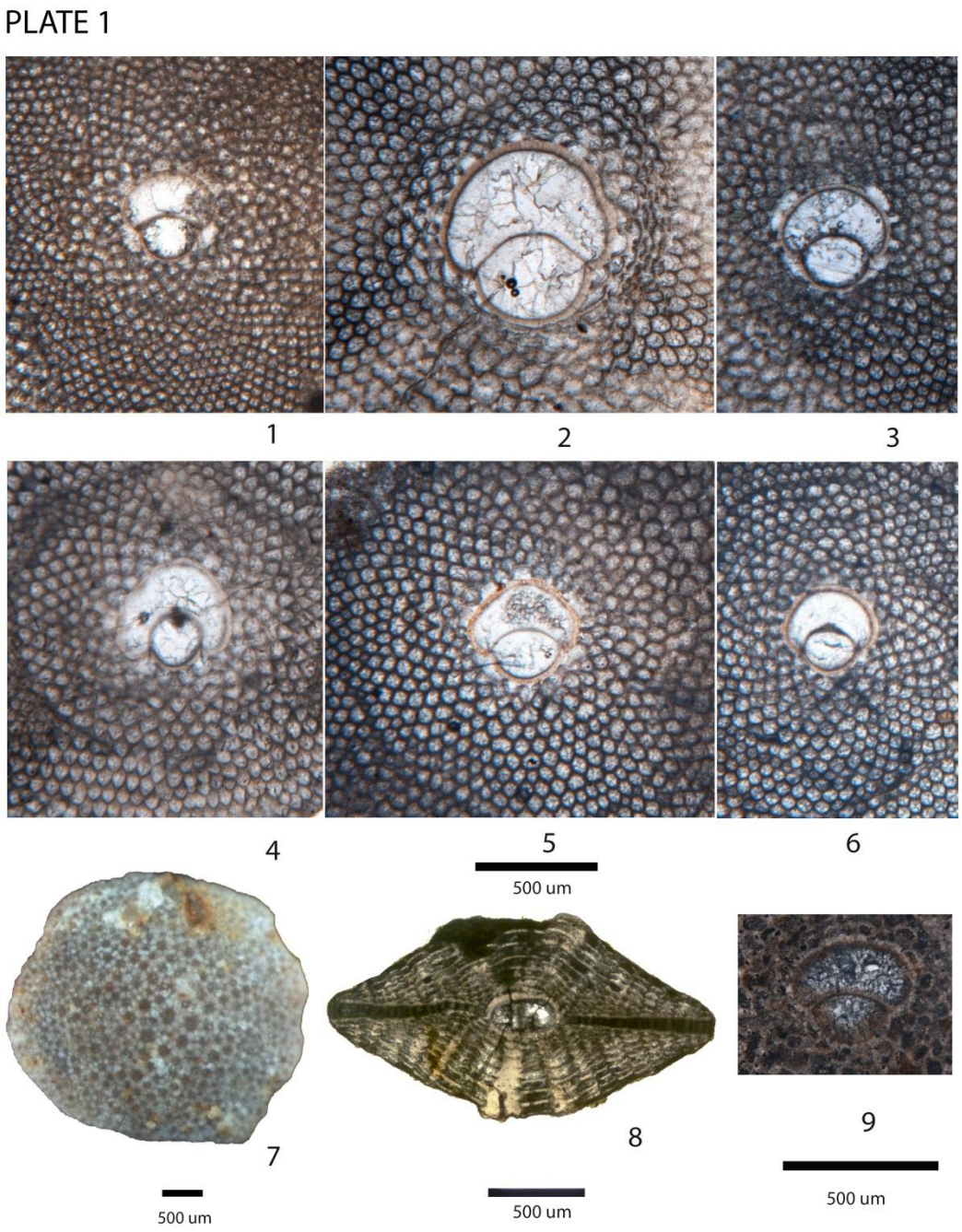


Figure A.1: Images of *Nephrolepidina* species within the YK section.

PLATE 2

1-9 *Eulepidina dilatata*

1: YK31-11

2: YK43-16

3: YK47-15

4: YK31-2

5: YK33-3

6: YK33-21

7: YK47-2

8: YK44-8

9: YK31-12

6: external photo 8: axial section, others are equatorial section.

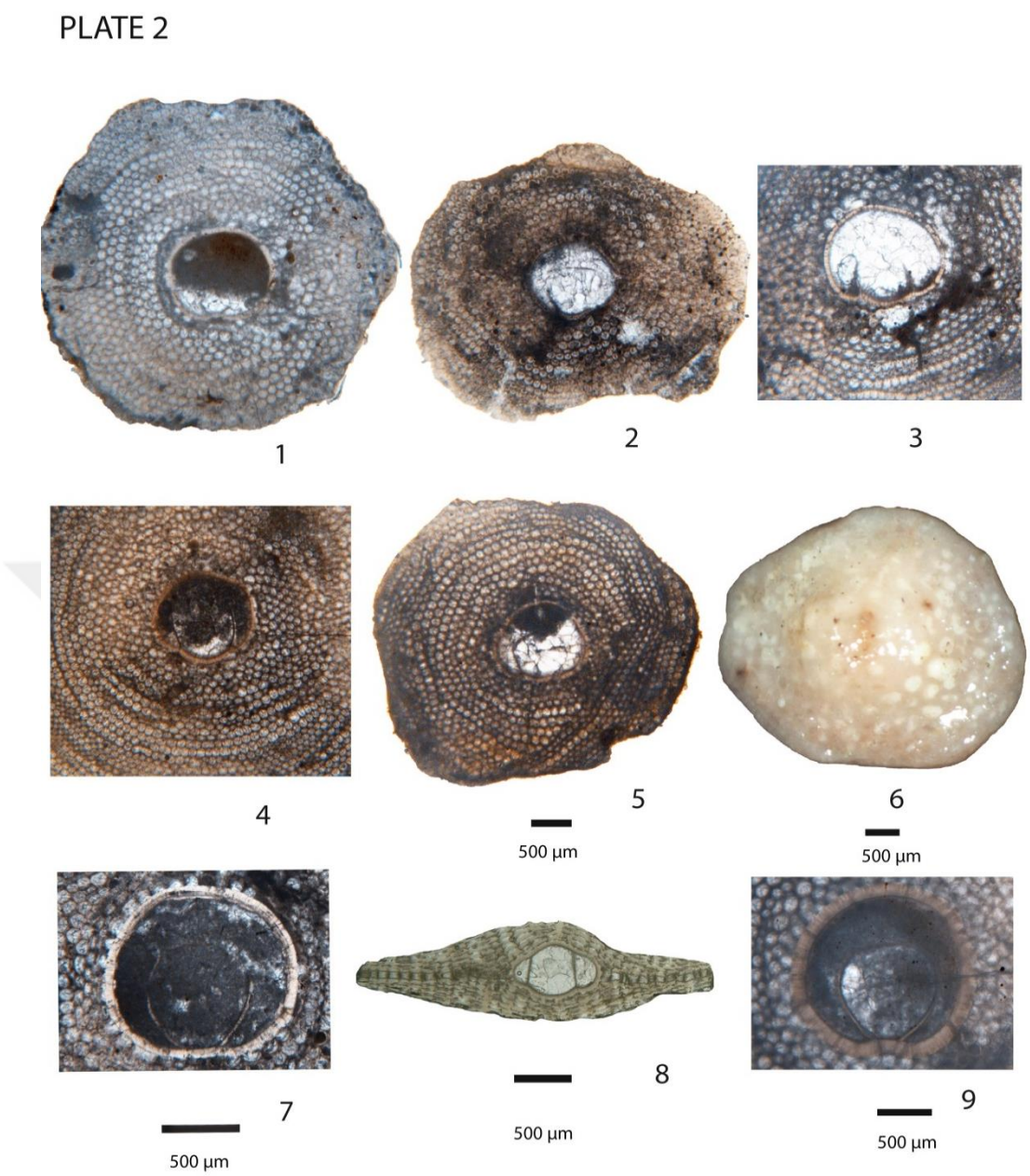


Figure A.2: Images of *Eulepidina* species within the YK section.

PLATE 3

1,2,10: *Operculina complanata* Defrance

3,4,7, 9: *Heterostegina assilinoides*

5-6: *Nummulites bormodiensis*

8: *Cycloclypeus eida*

1: YK43-38

2: YK31-13

3-YK37-11

4:YK31-19

5:YK31-30

6:YK31-43

7:YK31-25

8:YK37-9

9:YK37-22

10: YK33-19

1-9 equatorial sections 10- external photo

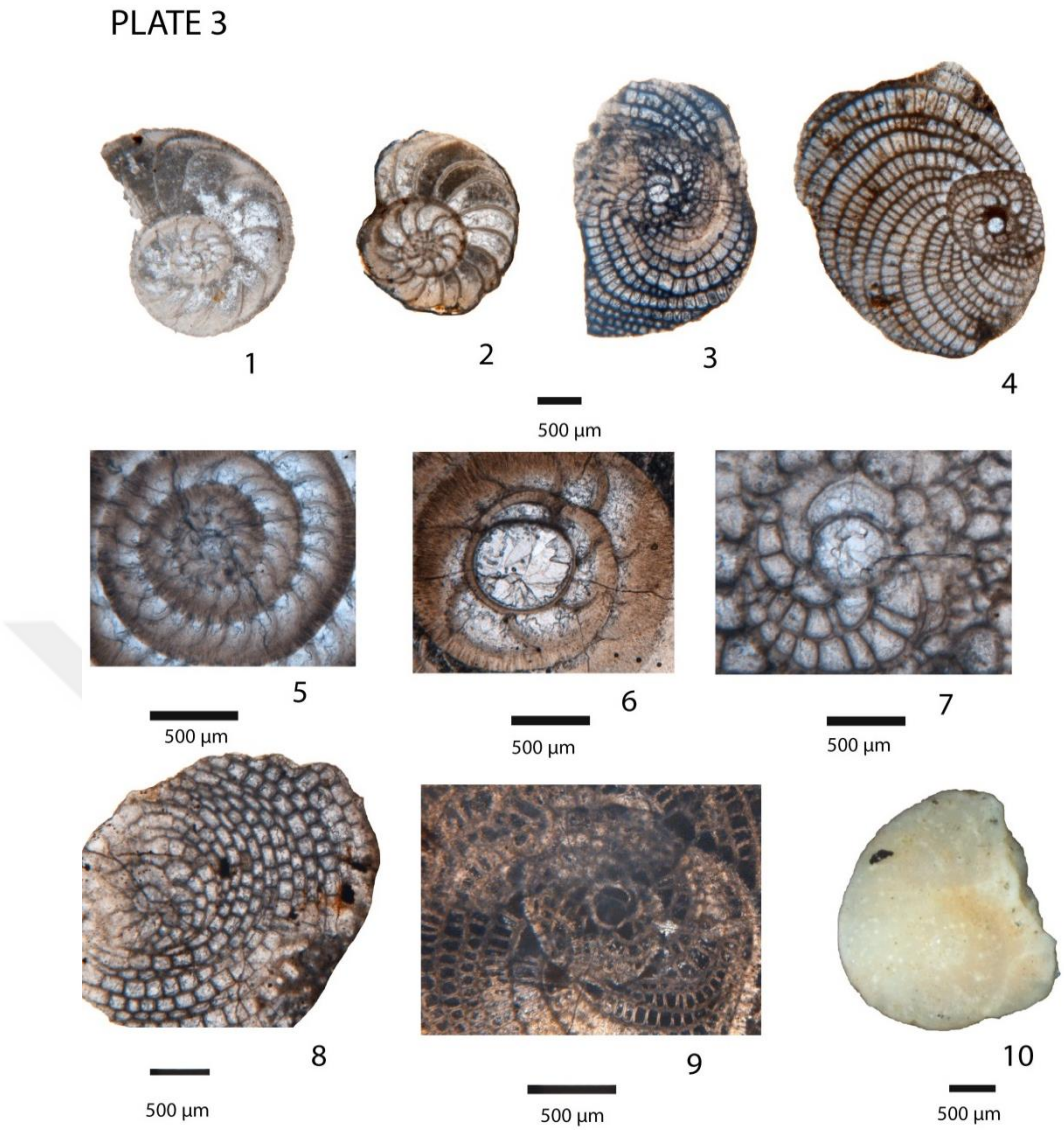


Figure A.3: Images of *Heterostegina*, *Nummulites* and *Cycloclypeus* species within the YK section.

PLATE 4

1,4,6,8,10 *Miogypsina globulina*

2,5,7 *M.globulina-tani*

1: YK47-27

2: YK43-4

3: YK43-2

4:YK37-7

5:YK37-15

6: YK47-23

7:YK47-28

8: YK33-18

9: YK47-32

1-7;9 equatorial sections 8:external photo

PLATE 4

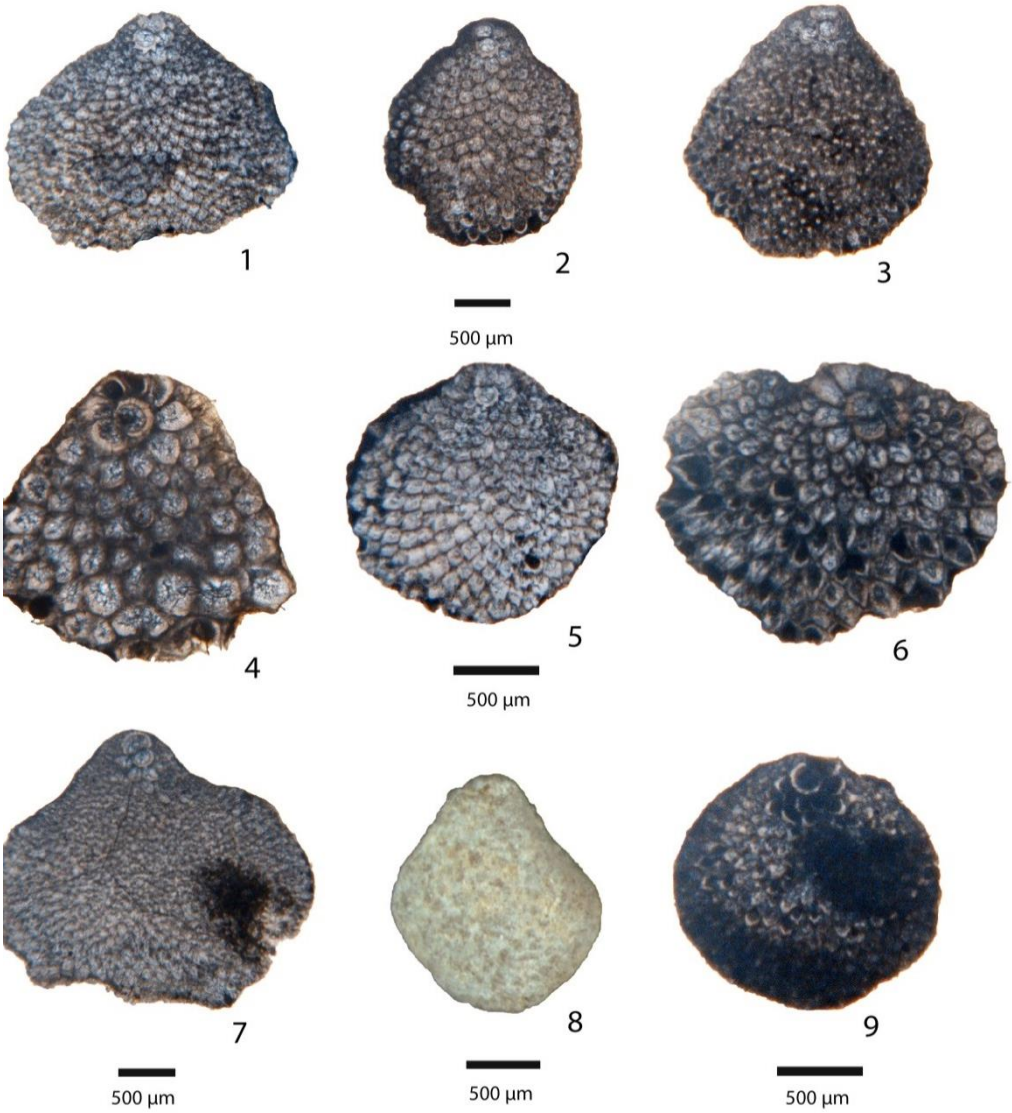


Figure A.4: Images of *Miogypsina* species within the YK section.

PLATE 5

1-4 *Heterostegina assilinoides*

5: Amphistegina sp.

6,8: *Nummulites bormodiensis*

7: *Operculina complanata*

1:YK33-10

2: YK31-46

3:YK31-5

4: YK37-26

5:YK31-4

6:YK33-28

7:YK33-26

8:YK43-50

9:YK47-29

1-6;8,9 equatorial sections 7:external photo

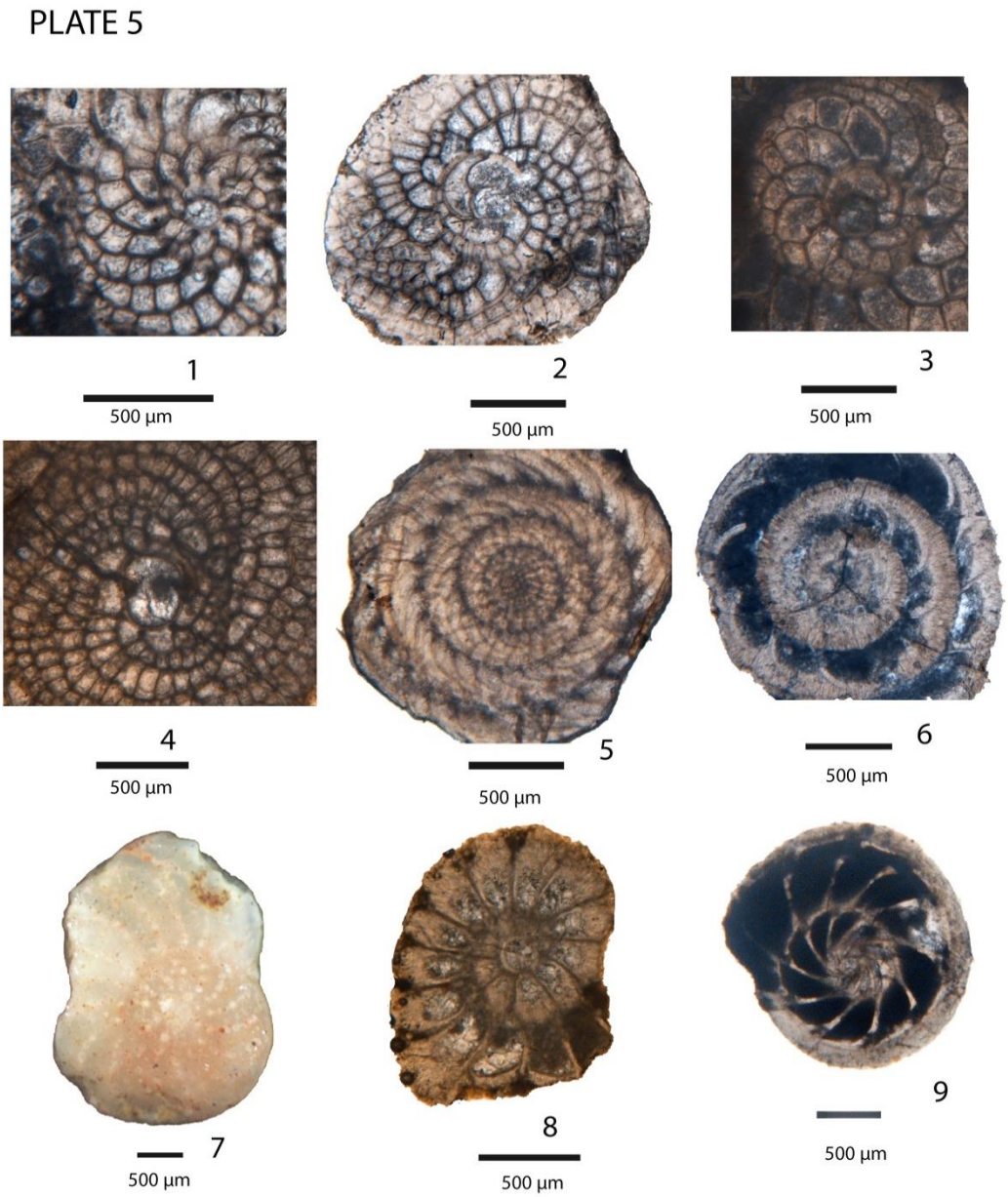


Figure A.5: Images of *Heterostegina*, *Amphistegina* and *Nummulites* species within the YK section.

PLATE 6

Miogypsina from the YK31,YK33 and YK43 sections

1,3-8 *Miogypsina globulina*

2, 9 *M.globulina-tani*

1 : YK31- 69

2: YK33 – 36

3: YK43-3

4: YK33-40

5: YK43-43

6: YK43-48

7: YK43-52

8: YK43-53

9: YK43-71

All equatorial sections

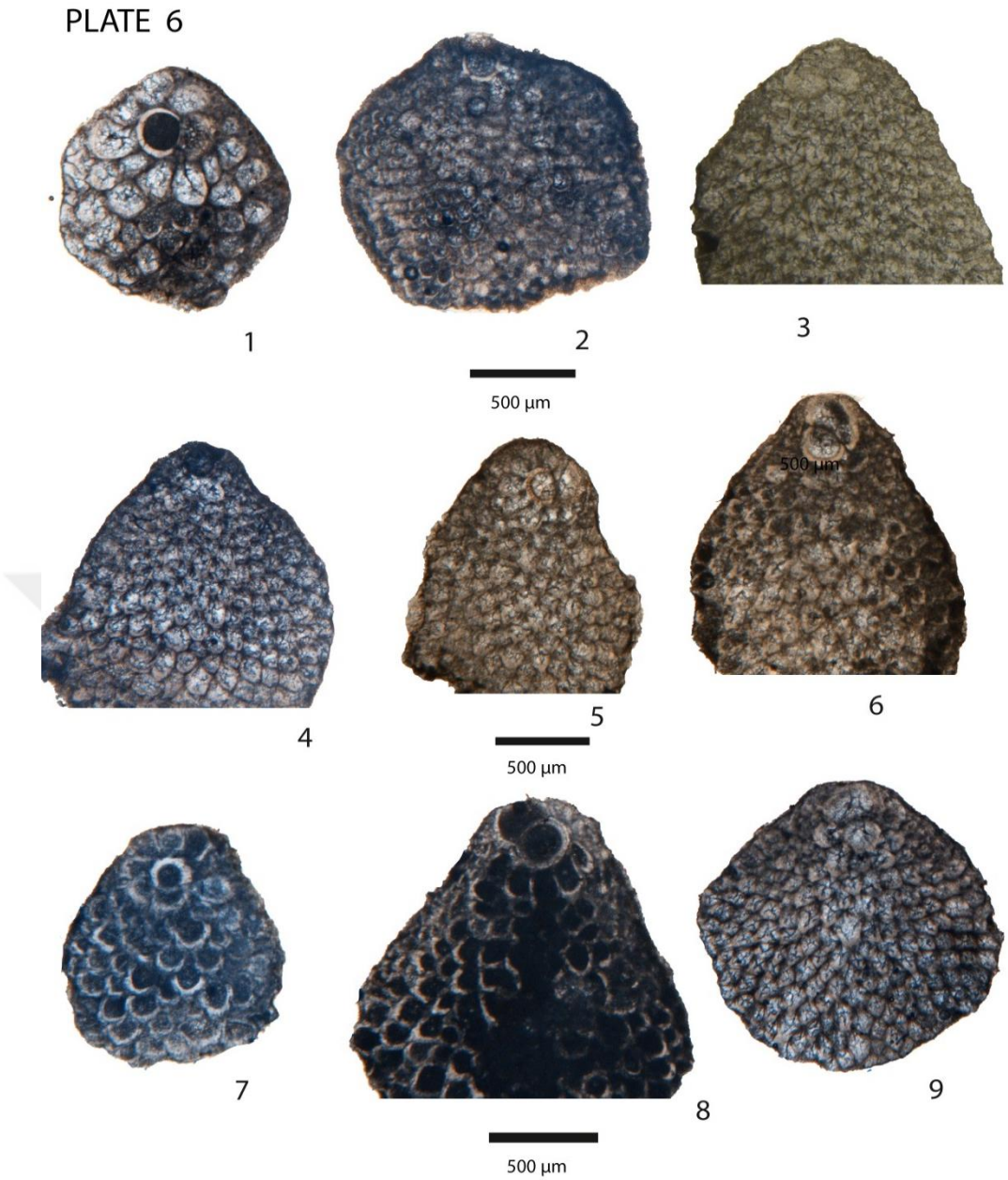


Figure A.6: Images of *Miogypsina* species within the YK section.

PLATE 7

1-8;11,12 *Operculina complanata*

9-10 *Amphistegina sp.*

1:YK33-49

2:YK37-77

3:YK43-49

4:YK31-68

5:YK43-62

6:YK43-64

7:YK43-73

8:YK43-66

9:YK31-62

10:YK31-71

11:YK33-38

12:YK33-17

1-11 equatorial sections 12 external photo

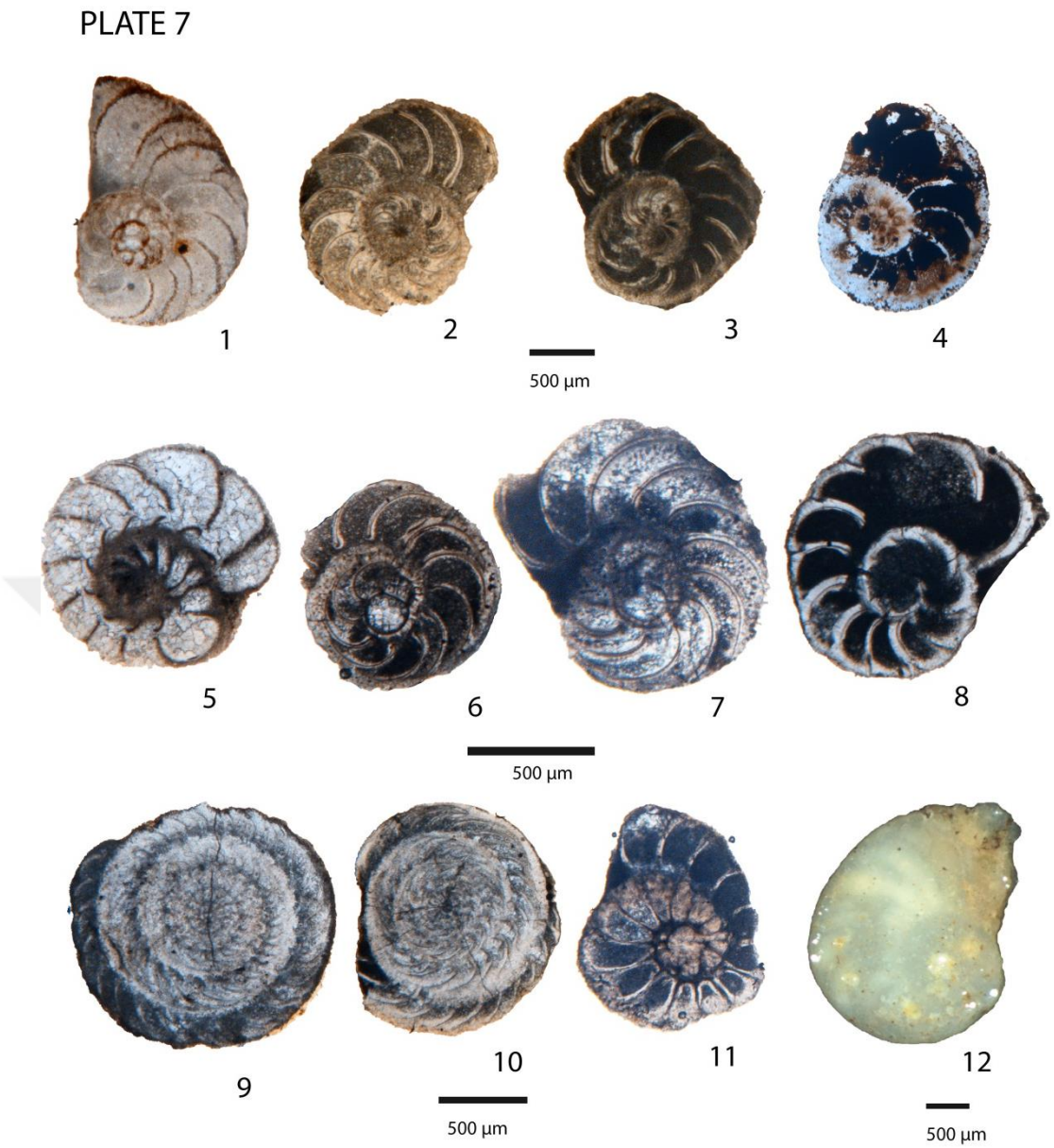


Figure A.7: Images of *Operculina* and *Amphistegina* species.

PLATE 8

1-9 *Nephrolepidina praemarginata*

1: YK43-10

2:YK37-23

3:YK37-31

4:YK37-48

5:YK47-36

6:YK43-18

7:YK47-29

8:YK43-9

9:YK33-2

All equatorial sections and scale is 500 microns

PLATE 8

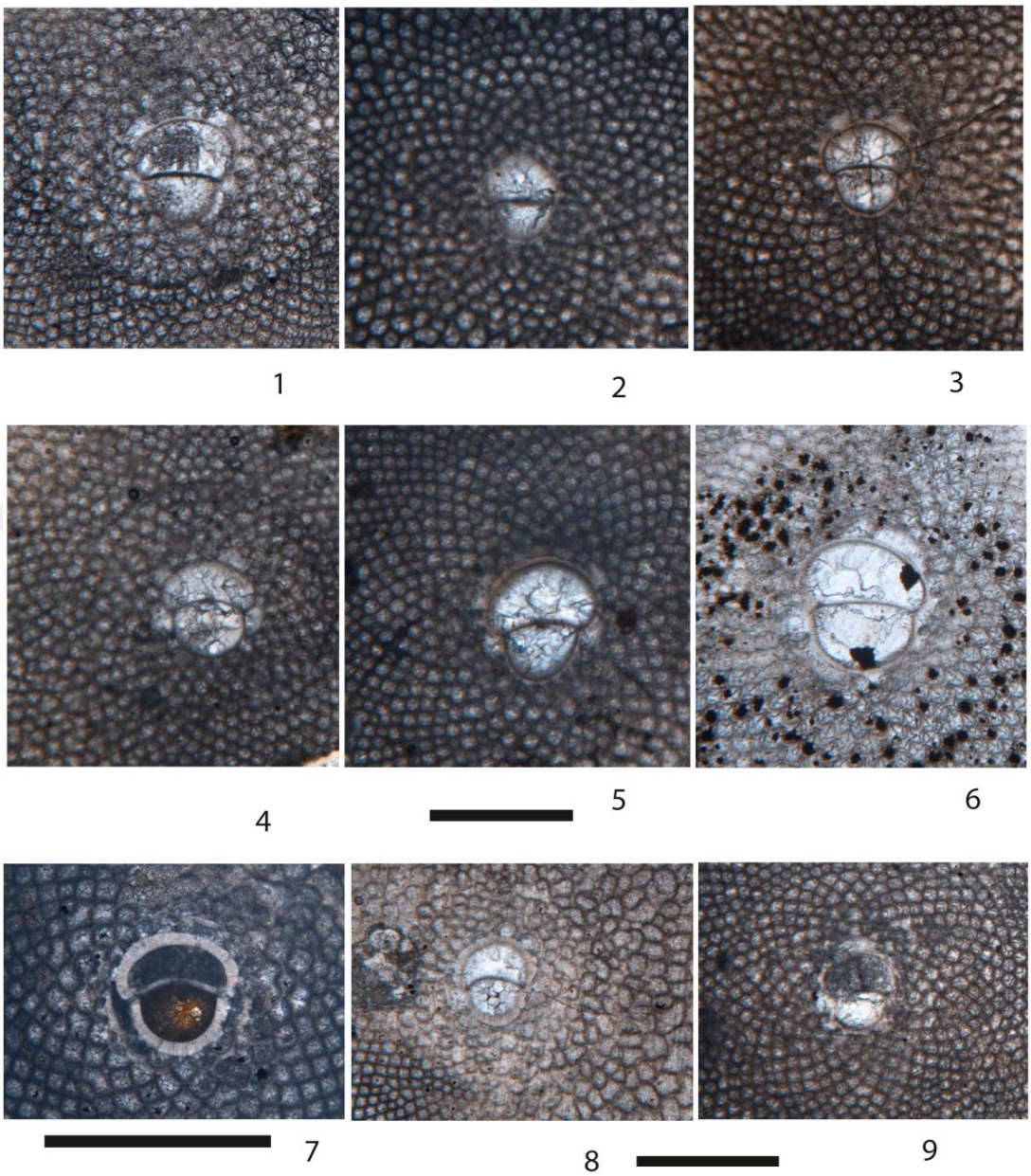


Figure A.8: Images of *Nephrolepidina* species within the YK section.

PLATE 9

Miogypsina globulina

Miogypsina tani

1: YK33-54

2: YK43-51

3: YK43-58

4: YK31-59

5: YK43-59

6: YK43-67

7: YK43-80

8: YK43-36

9: YK43-72

10: YK43-79

11: YK43-58

12: YK43-60

All are equatorial sections and scale is 500 microns.

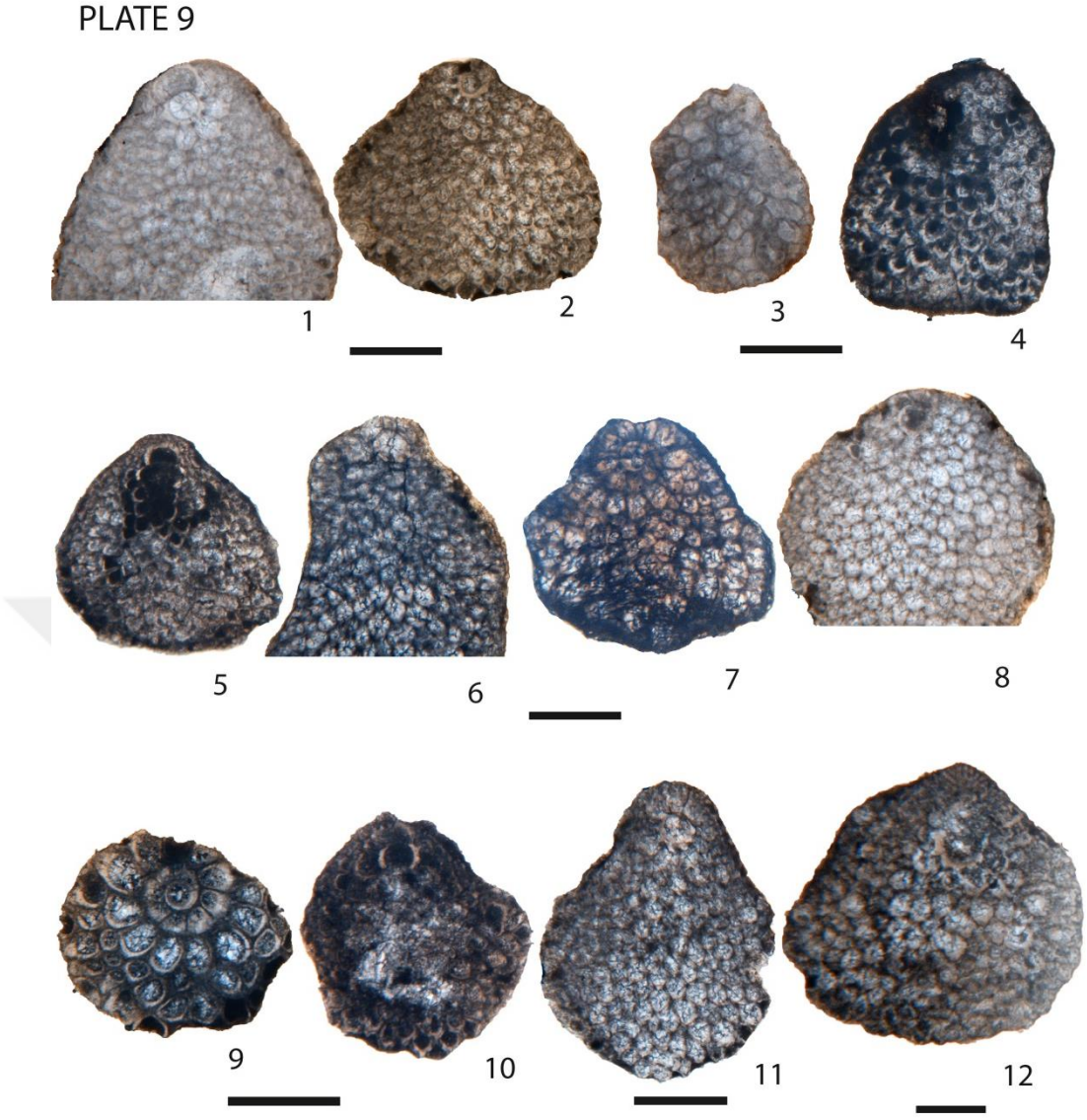


Figure A.9: Images of *Miogypsina* species within the YK section.

PLATE 10

N.tourneri

N.morgani-tourneri

1:YK33-30

2:YK33-11

3:YK37-2

4:YK47-55

5:YK37-40

6:YK47-39

7:YK47-56

8:YK47-57

9:YK37-1

All are 500 microns.

PLATE 10

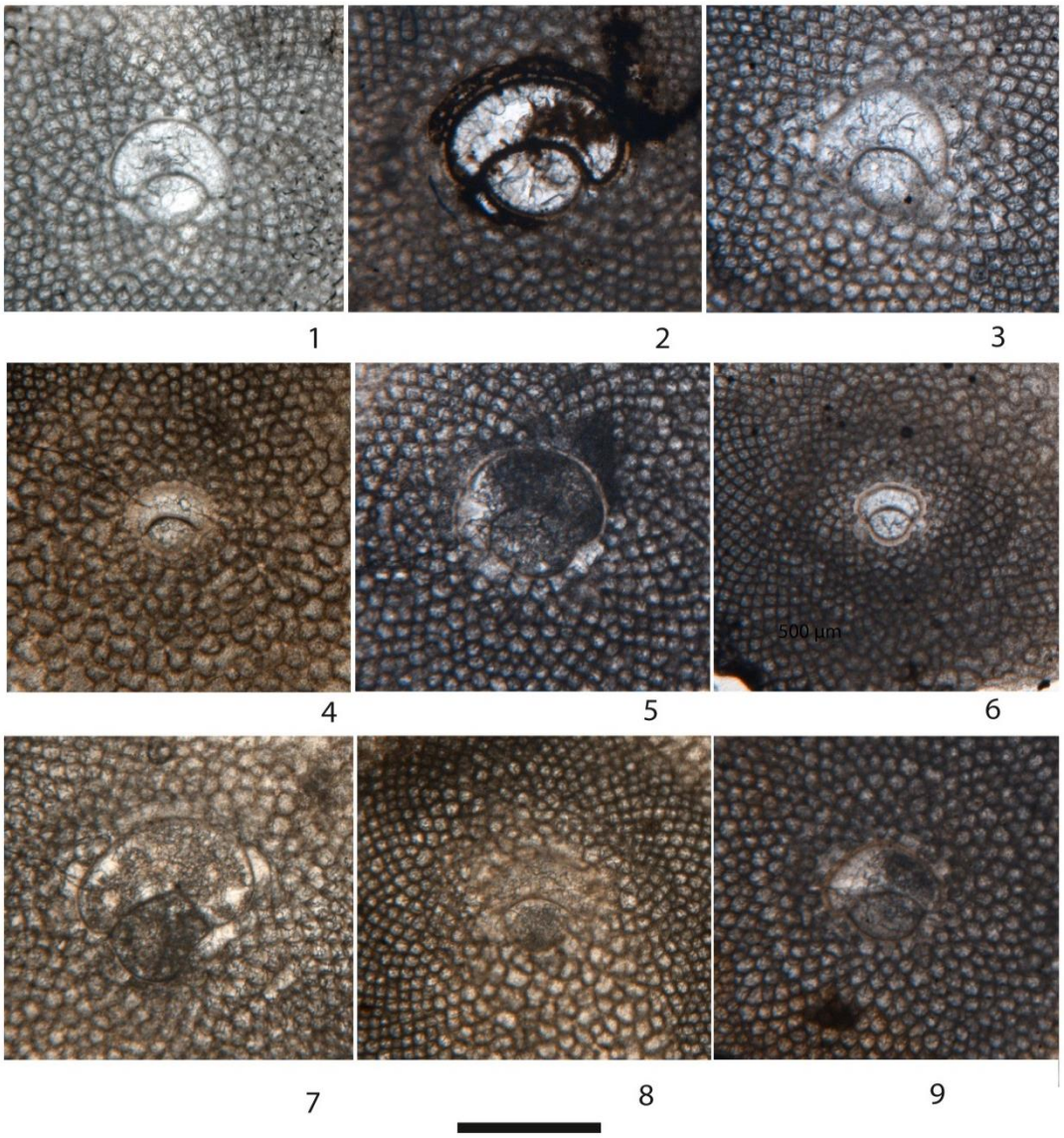


Figure A.10: Images of *Nephrolepidina* species within the YK section.

PLATE 11

1: YK31-41

2: YK33-5

3: YK43-28

4: YK33-14

5: YK47-37

6: YK31-32

7: YK43-7

8: YK47-7

9: YK31-39

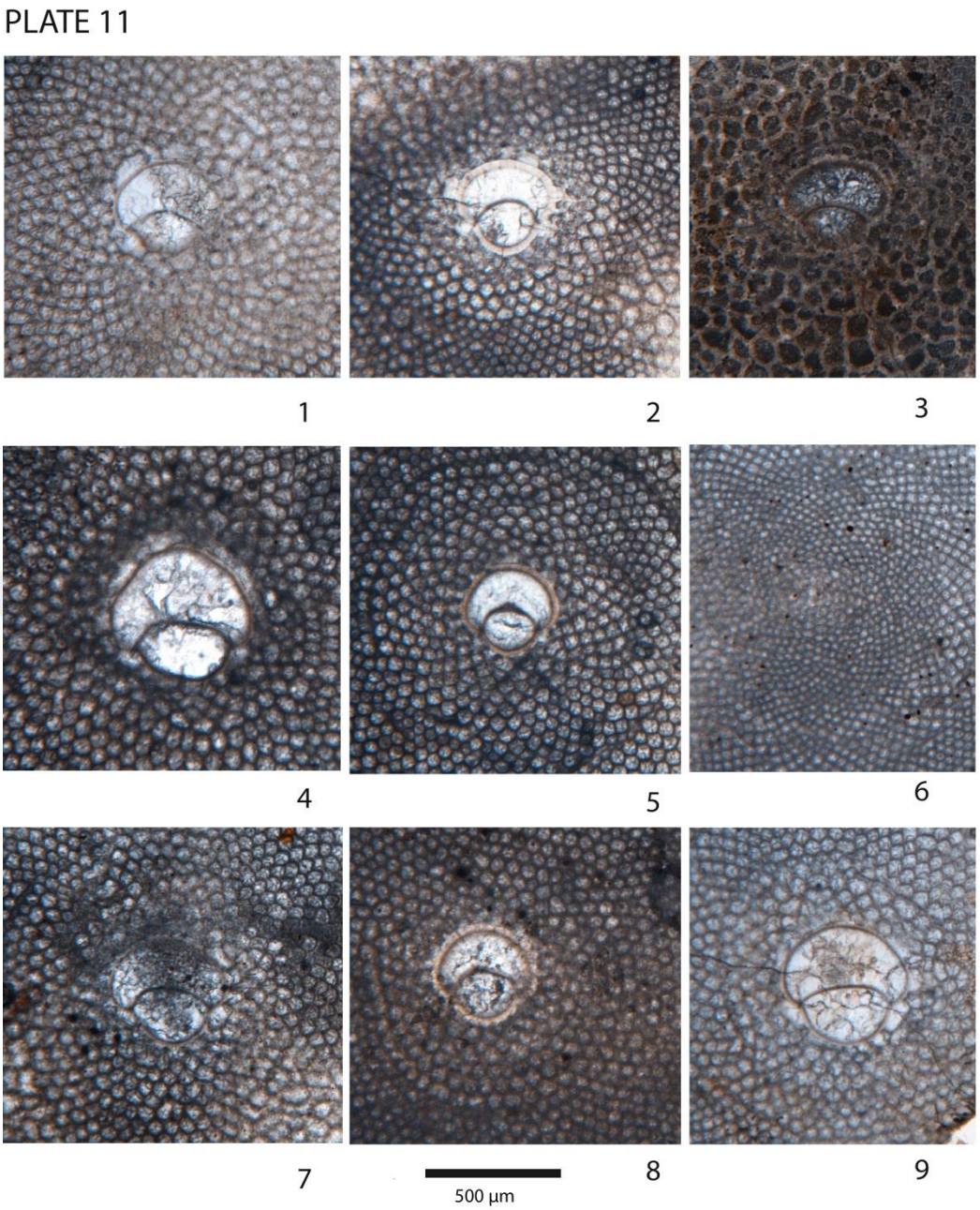


Figure A.11: Images of *Nephrolepidina* species within the YK section.

PLATE 12

Eulepidina dilatata

Eulepidina aff. *formosa*

1: YK31-22

2: YK47-18

3: YK47-16

4: YK31-48

5: YK33-22

6: YK33-26

7: YK37-57

8: YK43-23

9: YK31-28

PLATE 12

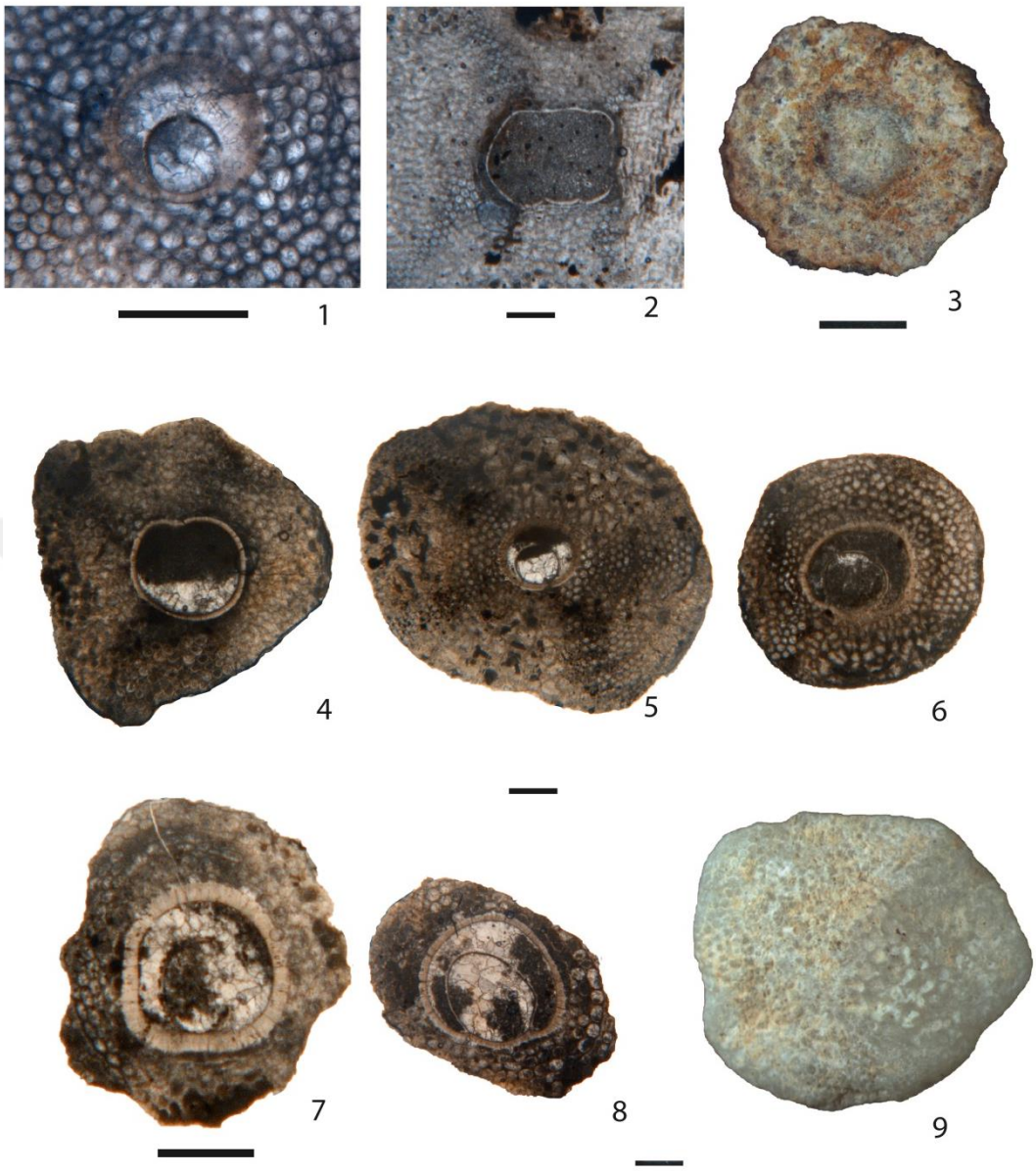


Figure A.12: Images of *Eulepidina* species within the YK section.

PLATE 13

1: YK31-15

2: YK31-9

3: YK31-28

4: YK43-76

5: YK33-39

6: YK33-44

7: YK43-56

8: YK43-81

9: YK37-58

10: YK37-60

11: YK44 x10 – 70

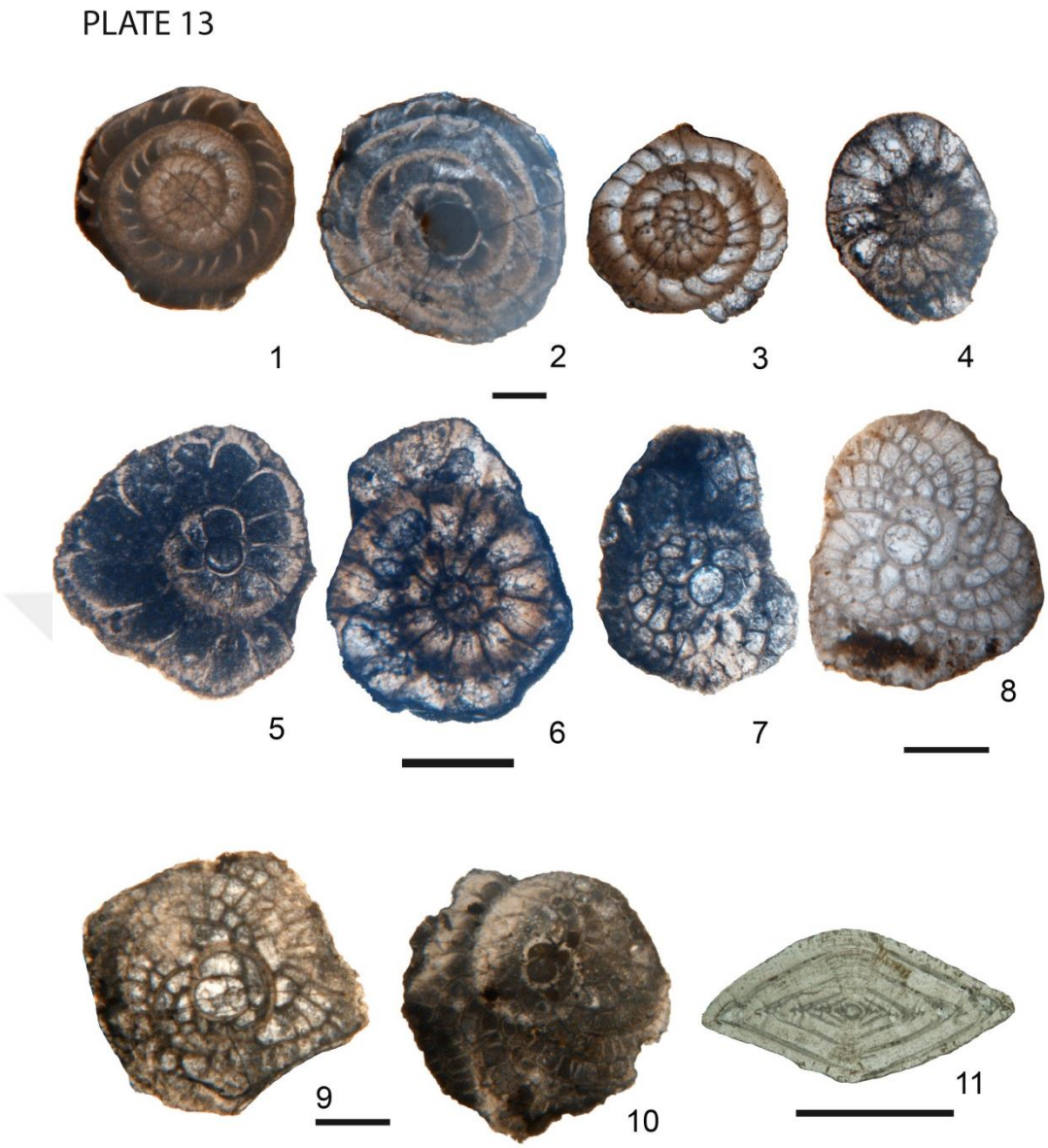


Figure A.13: Images of *Heterostegina* and *Nummulites* species within the YK section.

PLATE14

1-5 *Opertorbitolites* sp. 3-4 *Miliolipora* *9-Alveolina*

1: YK44 x10 -85

2: YK24 x 10 -52

3: YK24 x10 -34

4:

5: YK34 x 10 -52

6:YK48 x10 -65

7: YK19 x10 -71

8: YK34 x10 -60

9:YK47 x10 - ?



Figure A.14: Images of *Miliolida* species and other genuses within the YK sections.

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PUBLICATIONS, PRESENTATIONS AND PATENTS ON THE THESIS

ARTICLES

- Özcan, E., Abbasi, İ. A., Yücel, A. O., Aşcı, S. Y., Erkızan, L. S., El-Ghali, M. A., ... & Kayğılı, S. (2022). First record of the foraminiferal genera *Clypeorbis* Douvillé and Ilgazina Erdoğan from the Maastrichtian of the Arabian Peninsula (Simsima Formation, North Oman): Paleobiogeographic implications. *Cretaceous Research*, *138*, 105290.
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- Erkızan, L.S., Yücel, A.O., Erbay, S., Özcan, E., Okay, A.I. (2019) Orthophragminids from the Ciciler Formation: A Revised Age and its significance for the Eocene Stratigraphy in Pamukova-Geyve (Mekece, Pamukova, Turkey*). 72. Geological Conference of Turkey.* Ankara, Turkey.

EXTRA CIRRICULUM ACTIVITIES

- Board Member in Philosophical Society of Aristotle (AFED) **2019-continues**
- Member in Turkish Mining Devolopment Foundation Youth Comittee **2017-2018**
- Assistant Club Chairman in Geology Engineering Student Club **2017-2018**
- Board Member in Geology Engineering Student Club **2016-2017**
- 1607 National Rating (UKD) in Chess (34545727 – FIDE Number
- Winner of several medals and cups in chess.