Bull. Min. Res. Exp. (2024) 173: 107-151

Bulletin of the Mineral Research and Exploration

http://bulletin.mta.gov.tr

Paleocene-Eocene foraminifera from the Tuz Gölü Basin (Salt Lake Basin, Central Türkiye) and their paleoenvironmental interpretations

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Research Article

Keywords:
Paleocene, Eocene, Foraminifera, Central Türkiye.

Received Date: 06.09.2022
Accepted Date: 30.03.2023

ABSTRACT

Paleocene-Eocene aged sediments from the east of Tuz Gölü Basin (Central Türkiye) provide significant data for foraminifera contents and their paleoenvironmental clues. They are important in revealing the stratigraphy of the region and the Paleocene-Eocene geological history of Türkiye. The sediments, composed mainly of carbonates, are known as Karapınaryaylası Formation. In this formation, benthic foraminifera representing SBZ2 to SBZ12 biozones corresponding to the Selandian-Late Cuisian time interval were identified in ten measured stratigraphical sections. The zonal interval from the E7 Zone (late Ypresian) to the E10 Zone (Lutetian) is characterized by the marker species of planktonic foraminifera defined in the clayey limestones from the uppermost part. The studied formation is divided into four main facies and eleven sub-microfacies types. The clayey limestone levels of the Karapınaryaylası Formation, which generally starts with a transgressive sequence, contain abundant planktonic foraminifers, while the lithologies of grainstone, packstone and wackestone are rich in benthic foraminifers. Benthic foraminifer assemblages indicate different paleoenvironments from lagoon to back-bank, bank and fore-bank. The obtained foraminiferal data show the Selandian-Lutetian age range and various paleoenvironments from the lagoon to the open sea.

1. Introduction

Kırşehir Block is located to the east of the graben basin known as the Tuz Gölü Graben (the Salt Lake) in the Central Anatolia Region and bounded by the Tuz Gölü Fault in the east of Tuz Gölü (Koçyiğit, 2000) (Figure 1). Two different study areas are near to the Tuzgölu Fault Zone in the southwest of the Kırşehir Block. The first area is approximately 20 square kilometres, including Elmakayası and Delikönü Hill, approximately 9 kilometres west of Aksaray, to the east of Tuz Gölü in the Kırşehir Block. The second is about 12 square kilometres around Musular Hill, 16 kilometres far from the Aksaray city to the southeast (Figures 2-3).

Paleogene sediments in the area contain abundant amounts of different larger and smaller foraminifera. As it is known, Paleocene (66-56 Ma) and Eocene (56-33.9 Ma) Periods are the periods that play an important role in the explanation of the Cenozoic geological history with their benthic foraminifera contents. The Paleocene and Eocene Periods comprise benthic foraminiferal biozones and contents (i.e. Serra-Kiel et. al., 1998; Consorti and Schlagintweit, 2022).

Citation Info: Görmüş M., Yıldız M., Bozkurt A., Hakyemez A. 2024. Paleocene-Eocene foraminifera from the Tuz Gölü Basin (Salt Lake Basin, Central Türkiye) and their paleoenvironmental interpretations. Bulletin of the Mineral Research and Exploration 173, 107-151. https://doi.org/10.19111/bulletinofmre.1268147

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Although some studies particularly for the tectonics, sedimentology and hydrogeology of the Kırşehir Block and the Tuz Gölü Basin were presented in the symposiums held on (e.g. Derman and Tekin, 2000), detailed age data and paleoenvironments of Paleocene and Eocene sediments based on foraminiferal content are not well documented.

Only one research around Asmayaylası was carried out on the findings of planktonic foraminifera and particularly nannofossils from the Asmaboğazı and Karapınaryaylası formations by Yıldız (2000). She recorded the ages of the formations based on the following microorganisms: *Chiasmolithus danicus, Elpsolithus macellus, Fasciculithus tympaniformis, Heliolithus kleinpellii*–nannofossils and *Morozovella uncinata, M. angulata, Planorotalites pusilla pusilla*–foraminifera in the Asmaboğazı Formation, Danian to Selandian in age; *Fasciculithus tympaniformis*–nannofosil*, Morozovella trinidadensis, Planorotalites compressa, Globigerina* sp., *Kathina selveri, Smoutina crysi, Miscellenea* sp., *Textularia* sp., Miliolidae and other microfossils in the Karapınaryaylası Formation, Selandian-Thanetian in age.

This study provides new detailed important data for the Karapınaryaylası Formation on both benthic and planktonic foraminifera, the Paleogene stratigraphy and geological history of the studied region. For this reason, biostratigraphic and environmental interpretations and approaches to geological history based on both larger and smaller benthic and planktonic foraminifera contents in the investigated areas were aimed in this study.

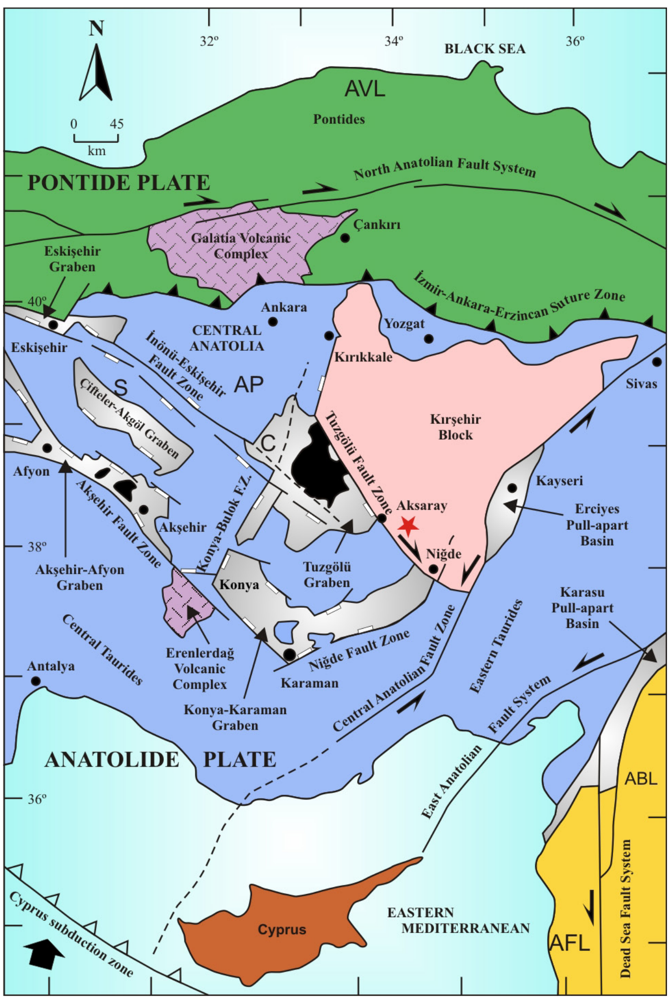

Figure 1- Location of the study area (red star) within the Kırşehir Block (re-drawn from Koçyiğit, 2000), A P. Anatolian Plate, ABL. Arabian Plate, AFL. African Plate, AVL: Eurasia Plate, C. Cihanbeyli, S. Sivrihisar.

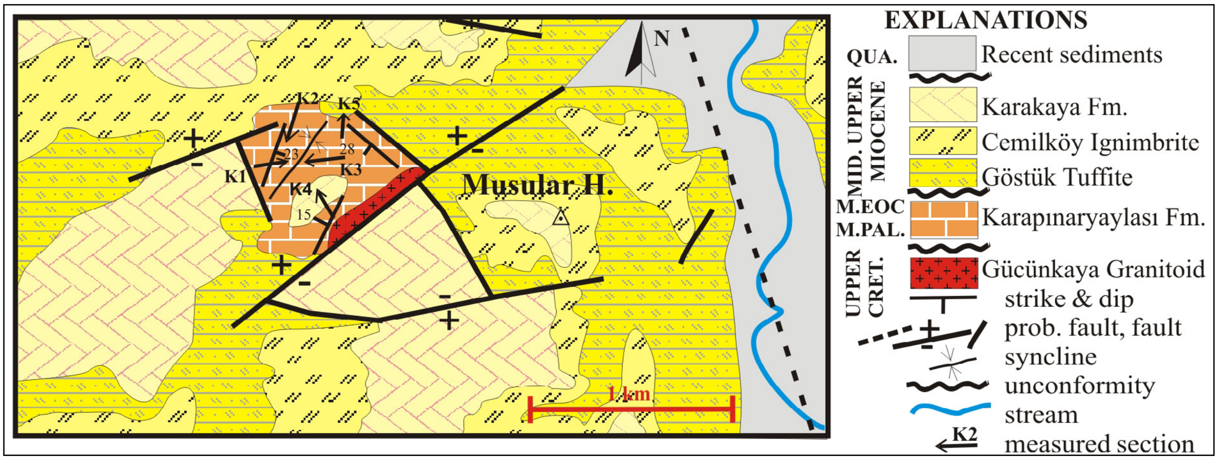

Figure 2- Geological map of the Musular Hill and its surrounding area, and measured section locations, CRET. Cretaceous, M.PAL. Middle Paleocene, M.Eoc. Middle Eocene, MID. Middle, QUA . Quaternary, Fm. Formation.

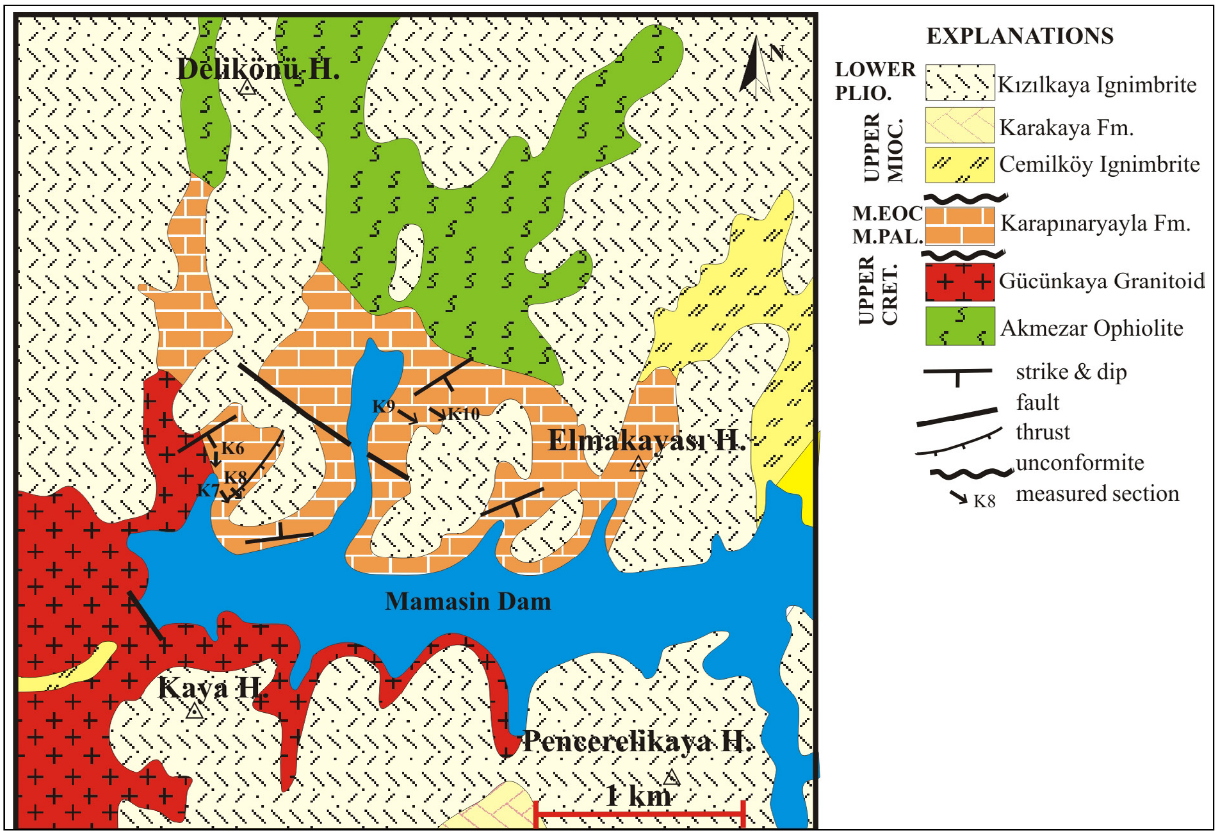

Figure 3- Geological map of the Elmakayası and Delikönü Hills and their surrounding area, and measured section locations. H. Hill, CRET. Cretaceous, M.PAL. Middle Paleocene, M.EOC. Middle Eocene, MIOC. Miocene, PLIO. Pliocene, Fm. Formation, Blue shows the water column of the Mamasin Dam.

2. Material and Method

Palaeocene-Eocene deposits were investigated by field studies carried out in the study areas. A total of ten stratigraphical sections were measured, five in the vicinity of Musular Hill and five in the Elmakayası-Delikönü area. Measured section thicknesses are between 20 and 55 meters (m). Laboratory studies were carried out at the Ankara University and MTA General Directory. Petrographic thin sections were taken from the collected hard rock samples. These samples were examined under the research microscope, and their foraminifera contents were determined. Planktonic foraminifera were defined from thin sections because the washing processes carried out on hard limestones did not yield any better results. Postuma (1971) and Premoli Silva et al. (2003) are mainly followed for taxonomic analyses of planktonic foraminifera.

3. Stratigraphy

The geological maps and stratigraphical sequences in the studied areas are shown in Figures 2-3. The stratigraphical sequence can be summarised from bottom to top as follows: The Akmezar Ophiolite appears as basement rocks (Yıldız and Kalkan, 2018). These basement rocks are cut by the Gücünkaya Granitoid (Güllü and Yıldız, 2012). The Karapınaryaylası Formation overlies unconformably the basement rocks. It is composed of siliciclastic and carbonate sedimentary rocks, the Paleocene-Eocene in age. The relationship between the Paleogene deposits and its overlying middle-upper Miocene units namely as Göstük Tuffites, the Cemilköy Ignimbrite and Karakaya Formation is unconformable. The Pliocene-aged Kızılkaya Ignimbrite and Recent sediments observed towards the top are the youngest geological units (Figures 2 and 3). The subject of this study is only Paleocene-Eocene Karapınaryaylası Formation deposits. For this reason, the stratigraphic sequence has been considered as basement rocks, Paleocene-Eocene sediments and cover rocks.

3.1. Basement Units

Ophiolites known as the Akmezar ophiolite (Yildiz and Kalkan, 2018) are located in the basement and crop out between Elmakayası and Delikönü hills. The Gücünkaya Granotoid outcrops in the northwest of Kale Tepe, west of Mamasin Dam. In the literature, the ages of these units are given as Late Cretaceous (Dirik and Erol, 2000; Güllü and Yıldız, 2012). Upper Cretaceous Asmaboğazı Formation has been aged as Paleocene by Yıldız (2000). Although this unit is not seen in the studied areas, it is known as the unit under the Paleocene-Eocene sediments (Yıldız, 2000).

3.2. Paleocene-Eocene Sediments

Karapınaryaylası Formation was named for the first time by Dellaloğlu and Aksu (1984) from Karapınaryaylası Village. The same name was also used by Oktay and Dellaloğlu (1987), Dellaloğlu (1991) and Yıldız (2000). The formation was reported with different age ranges and different names in different parts of the Central Anatolia Region. For example, Paleocene-aged sections are called Kırkkavak formation in the Haymana-Polatlı basin, and Eocene sediments are named Eskipolatlı formation (Görür and Derman, 1978; Derman, 1980). The unit crops out in a limited area in the northwest of Musular Hill in the Musular area and in the northern part of the Mamasin Dam in the Elmakayasi-Delikönü area (Figures 2 and 3). The sequence starts with coarse to medium-grained siliciclastic sediments at the bottom. The thickness of the clastic layers at the base varies between 10-25 m. Medium, thick-bedded, red-coloured coarse and medium-grained clastics also contain mudstone intercalations. Towards the upper part of the formation, limestones are observed on the conglomerates and sandstones. The thickness of the limestones seen at the top of the Karapınaryaylası Formation is between 20 and 55 m. The upper limestones present lateral transitions or facies changes with red clayey limestones. Sandy and silty limestones are also observed at intermediate levels. It is stated that the Karapınaryaylası Formation overlies the Asmaboğazı Formation in the north of Aksaray (Yıldız, 2000). However, different rock unconformities are seen in the investigation areas. The unit's initiation with red-coloured clastics and the fact that the clastics contain pebbles of the underlying units indicates the presence of a distinct unconformity or with a differentiated rock as a nonconformity. Miocene-aged volcanoclastic units overlie the unit unconformably. Angular differences and age differences are clear. The formation has been aged as Selandian around Asmayaylası by Yıldız (2000).

In this study, the following benthic and planktonic foraminifera were identified, benthic foraminifera: *Alveolina (Alveolina)* cf. *acari* Bozkurt and Görmüş, *A. (A.)* aff. *avsari* Sirel and Acar, *A. (A.) barattoloi* Sirel and Acar, *A. (A.) corbarica* Hottinger, *A. (A.)* cf. *dolioliformis* Schwager, *A. (A.)* cf. *erki* Acar, *A. (A.)* cf. *laxa* Hottinger, *A. (A.) levantina* Hottinger, *A. (A.) violae* Checchia-Rispoli, *Ankaraella minima* Sirel, *Asterigerina rotula* (Kaufmann), *Gypsina* *marianensis* Hanzawa, *Haymanella* cf. *elongata* Sirel, *H.* cf. *paleocenica* Sirel, *Idalina sinjarica* Grimsdale, *I.*cf. *causae* Sirel, *I.* cf. *grelaudae* Gallardo-Garcia and Serra-Kiel, *I.* cf. *pignatti* Gallardo-Garcia and Serra-Kiel, *Kayseriella decastroi* Sirel, *Lockhartia* cf. *conditi* (Nuttall), *L. haimei* Davies, *Missisippina binkhorsti* Reuss, *Orbitotolites* cf. *complanatus* Lamarck, *Parahaymanella bozkurti* Acar, *Rotalia trochidiformis* (Lamarck), *Sphaerogypsina globula* (Reuss), *Triloculina tricarinata* (d'Orbigny), *T. angulata* Karrer, *Alveolina (Alveolina)* sp., *Amphistegina* sp., *Assilina* sp., *Asterigerina* sp., *Cribrobulimina* sp., *Discocyclina* sp., *Elazigina* sp., *Gyroidinella* sp., *Haymanella*? sp., *Heterostegina?* sp., *Lockhartia* sp., *Nummulites* sp., *Orbitolites* sp., *Opertorbitolites* sp., *Parahaymanella* sp., *Peneroplis* sp., *Quinqueloculina* sp., *Rotalia* sp., *Soriella*? sp., *Spiriloculina* sp., *Thalmannita* sp. According to the identified benthic foraminifer fossil findings, the age is Selandian-late Cuisian. Planktonic foraminifera contents are as follows: *Acarinina bullbrooki* (Bolli), *A. boudreauxi* Fleisher, *A. praetopilensis* (Blow) and *A. pseudosubsphaerica* Pearson and Berggren; *Guembelitrioides nuttalli* (Hamilton), *Globigerinatheka kugleri* (Bolli, Loeblich and Tappan), *G. index* (Finlay) and *G. mexicana* (Cushman), towards to upper part *Guembelitrioides nuttalli* (Hamilton), *Morozovelloides bandyi* (Fleisher), *Pearsonites broedermanni* (Cushman and Bermudez), *Acarinina boudreauxi* Fleisher, *Acarinina pseudosubsphaerica* Pearson and Berggren and *Turborotalia pomeroli* (Toumarkine and Bolli) were found. Based on the planktonic foraminiferal data, the age of the upper part of the formation is from Cuisian to Lutetian. Evaluation of all foraminiferal data shows that the age of the formation is from Selandian to Lutetian. Levels with small miliolids and alveolins indicate the back-reef paleoenvironment while rich nummulits show near the nummulit bank or fore bank deposits. Clayey carbonate deposits with rich planktonic foraminifera are from an open marine paleoenvironment.

3.3. Cover Rocks

Generally, horizontal volcanoclastic rocks are observed on the Paleocene-Eocene deposits. From bottom to top, these are the Middle-Upper Miocene Göstük Tuffites, the Cemilköy Ignimbrite, the Karakaya Formation, the Pliocene Kızılkaya Ignimbrite and the Recent deposits (Figures 2-4).

4. Foraminiferal Contents and Biostratigraphy

Musular Hill and Elmakayası Hill and their surroundings are remarkable with their rich foraminifera contents (Figure 4). The figures 5-16 show foraminiferal distributions of ten measured sections and their correlations. The figures 17-18 indicate range distribution of some important benthic foraminifera and the zonal markers of the shallow benthic zones. Plate I to IX illustrates the foraminiferal content. The list of foraminiferal contents of the Karapınaryaylası Formation was presented above within the stratigraphy section. Considering the stratigraphical distributions of foraminifera, SBZ2 to SBZ12 biozones defined by Serra-Kiel et. al. (1998, 2020) were determined. In addition, planktonic foraminifers representing the E7-E10 planktonic biozones were also defined from thin sections. The biozone explanations are summarized as follows:

4.1. SBZ 2 (Selandian)

SBZ 2 was identified in K6 measured section (Figure 11). This biozone is characterized by the assemblage consisting of *Ankaraella minima*, *Kayseriella decastroi* and *Parahaymanella bozkurti* in the study area (Plate III, Figures 5-8, 17, 21). Although Sirel (1998) first reported *Kayseriella decastroi* from Danian, this species has been reported in Dainan to Selandian beds by some later researchers (e.g., Ogorelec et al., 2001; Sirel, 2018). Finally, Serra-Kiel et al. (2020) defined this species as an index form of SBZ2 biozone. In addition, Acar (2019) indicated that the species *Ankaraella minima* and *Parahaymanella bozkurti* known from the Selandian are also significant species of SBZ2 biozone. Other associated miliolid fauna such as *Idalina causae, I. sinjarica* ranges to Thanetian and Ypresian (Serra-Kiel et. al., 1998; Özgen-Erdem, 2008; Özgen-Erdem et. al., 2016; Sirel, 2018; Bozkurt and Görmüş, 2021).

4.2. SBZ 3-4 (Thanetian)

These biozones were identified in K6 measured section (Figure 11). *Idalina causae, I. sinjarica* were

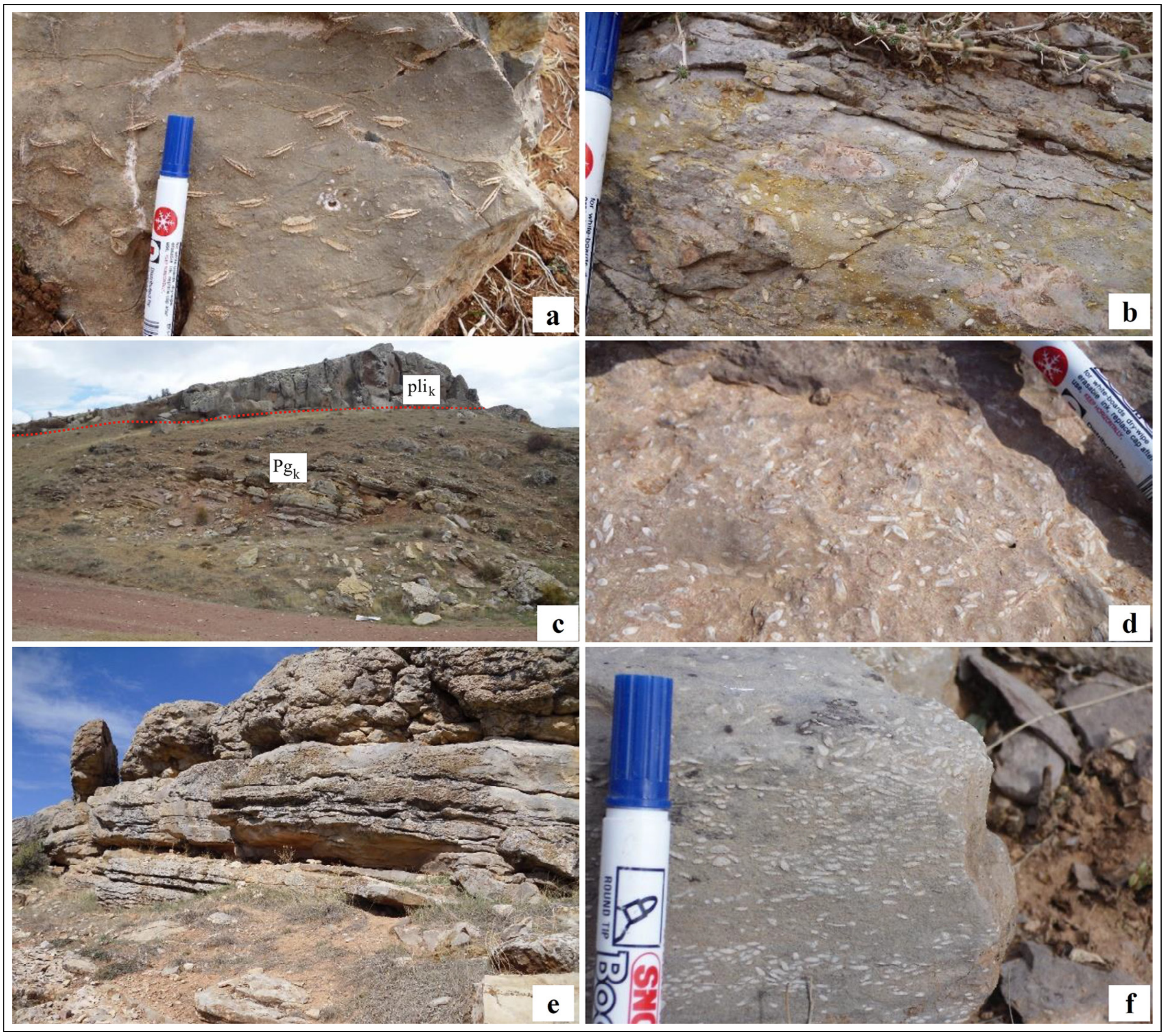

Figure 4- Field views of the Karapınaryaylası Formation, a) Nummulitid forms, b) Alveolinid forms, c) Delikönü Hill, K6 measured section (Pgk. Karapınaryaylası Fm., plik. Kızılkaya ignimbirite), d) Alveolinid forms, Elmakayası, K9 measured section, e) Carbonates (Musular, K5 measured section), f) Alveolinid forms (K5 measured section).

seen in this zone of sediments (Plate II, Figures 22-23). Associated fauna is mainly smaller miliolids in wackestone lithology. The first appearances of *Lockhartia conditi* and *L. haimei* are reported as SBZ 3 and SBZ 4 by Serra-Kiel et al. (1998) and Hottinger (2014). However, these forms in our study were observed in the younger levels at the measured section 1 (Figure 5).

4.3. SBZ 5-8 (Early - Middle Ilerdian)

SBZ 5-8 interval were identified in the K1, K3, K5 and K10 measured-sections (Figures 5, 7, 9, 15). These biozones were generally determined by species of the genus *Alveolina*. In the literature, it is known that *A. (A.) acari*, *A. (A.) avsari, A. (A.) corbarica*, *A. (A.) dolioliformis*, *A. (A.) erki*, *A. (A.) laxa* range from SBZ 5 to SBZ 9 biozones (Serra-Kiel et al., 1998; Sirel and Acar, 2008; Özgen-Erdem, 2008; Bozkurt and Görmüş, 2021). Determination of the SBZ 5-7 in the K1 section (Figure 5) mainly relies on the occurrences of the species of *Lockhartia* (Figure 5; Plate VII, Figures 10-11). The time interval that *Lockhartia conditi* and *L. haimei* are found together corresponds to SBZs 4-7 (Figure 17). Other accompanying taxa in this section limit the age to be younger than SBZ 4 (Figure 5). In the K3 section (Figure 7), the *Alveolina* species, which were identified as *Alveolina* sp., resemble the Ilerdian forms. No species of the

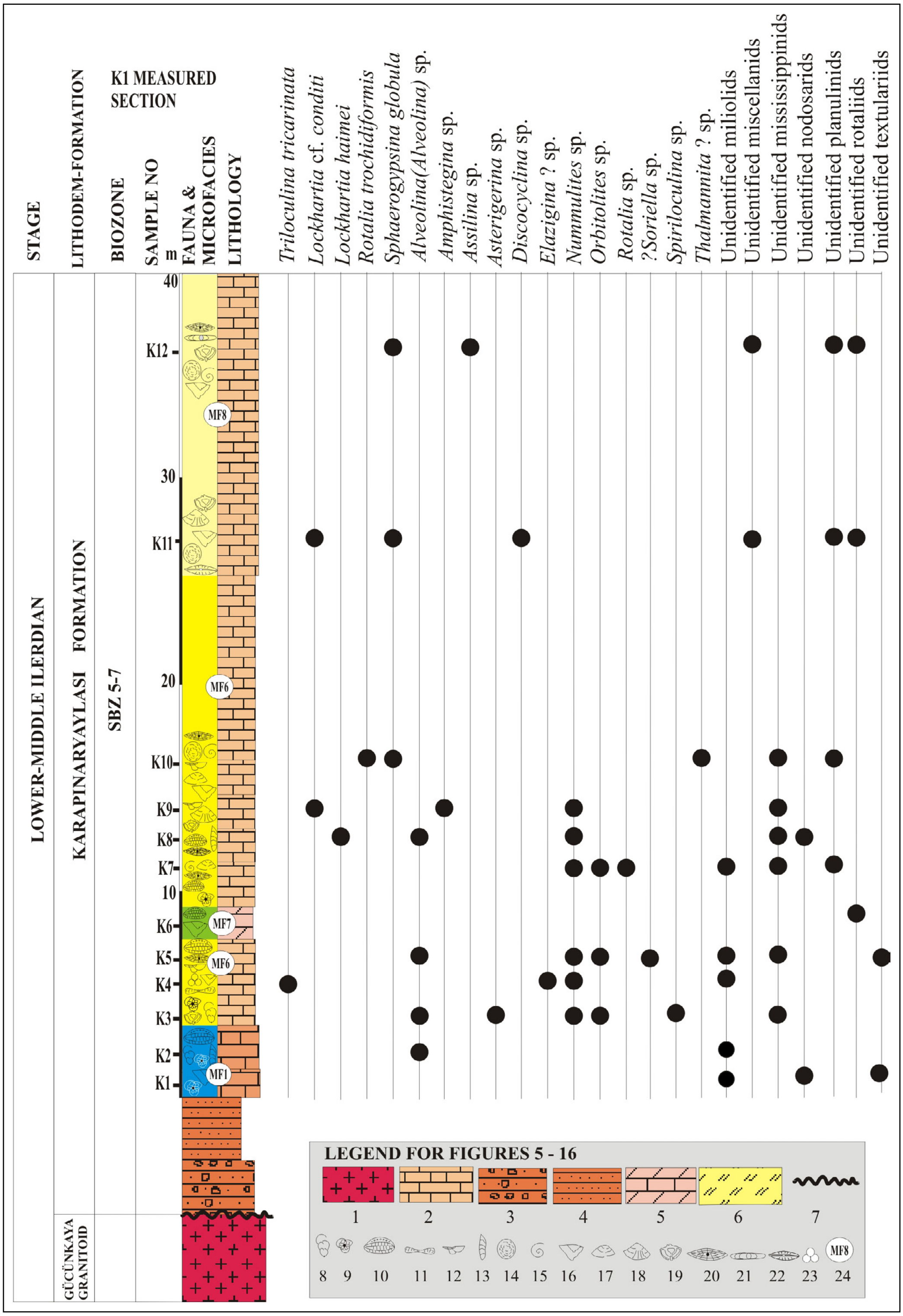

Figure 5- Measured Section 1 (K1) around the Musular Hill. 1. Granitoid, 2. Limestone, 3. Conglomerates252 sandstones, 4. Sandstones, 5. Limestone, dolomitic limestone, 6. Volcanoclastics, 7. Unconformity, 8. Textulariids, 9. Miliolids, 10. *Alveolina* sp., 11. *Orbitolites* sp.-*Operorbitolites* sp. 12. Missisipinids, 13. Nodosariids, 14. *Sphaerogypsina* sp., 15. ?*Gyroidinella* sp. 16. Rotaliids, 17. *Rotalia* sp., 18. *Lockhartia* sp., 19. Miscellenid-rotaliids, 20. *Nummulites* sp., 21. *Assilina* sp., 22. *Discocyclina* sp., 23. Planktonic foraminifera, 24. Microfacies type.

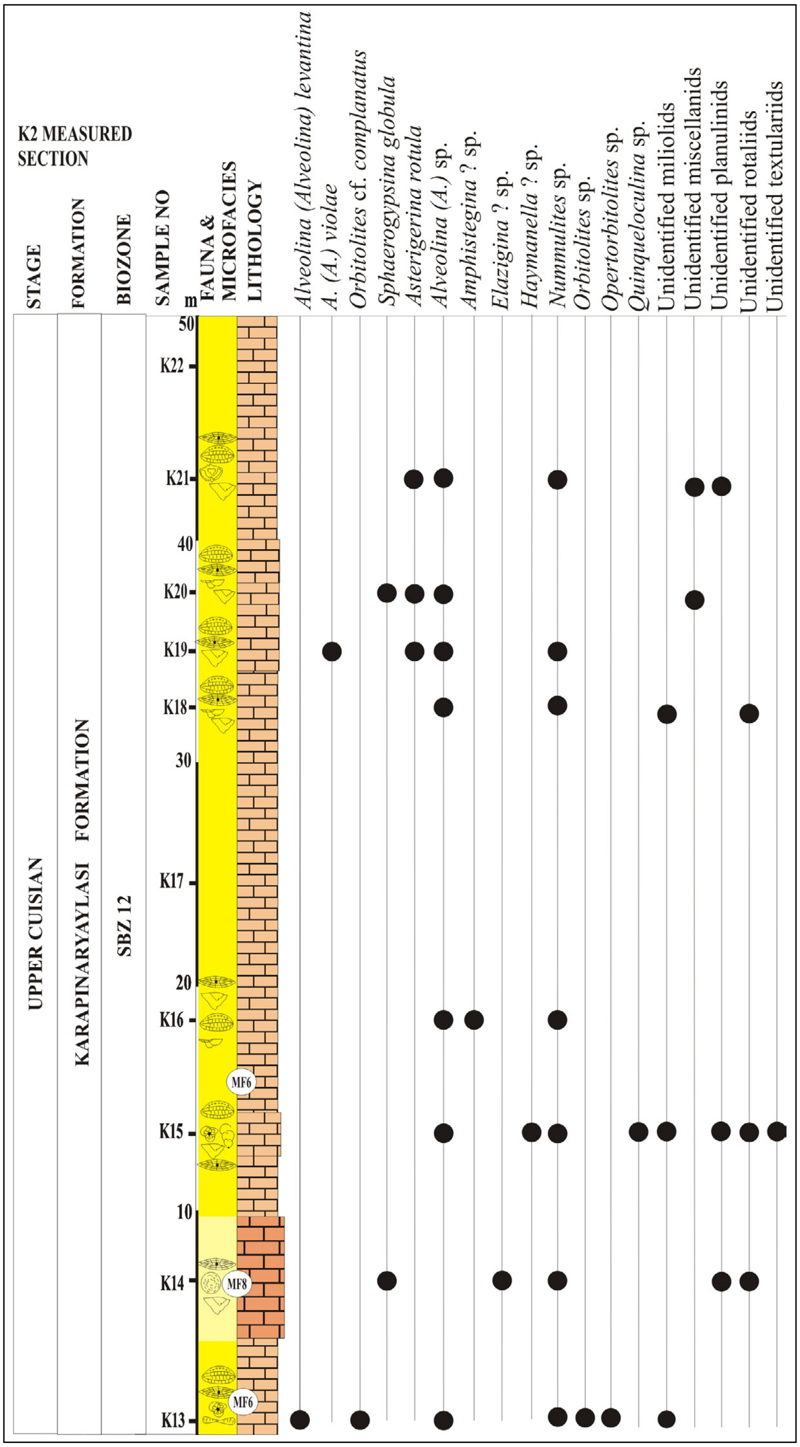

Figure 6- Measured Section 2 (K2) around the Musular Hill, see Figure 5 for legend.

subgenus *Alveolina* (*Alveolina*) is known from SBZ 3. Other larger benthic foraminifera determined in this section (e.g. *I. sinjarica*) offer that the age of this section should be older than late Ilerdian. In the K4 section (Figure 8), *Alveolina* species such as *A.* (*A.*) cf. *acari* (Plate IV, Figure 9) and *A. (A.)* cf. *laxa* (Plate V, Figure 4) mark the SBZ 7 in the upper levels of the section. *A. (A.) corbarica* (Plate IV, Figures 3-4) and *A. (A.)* cf. *dolioliformis* (Plate IV, Figure 1) are the markers determining SBZ 7-8 biozones in K5 and K10 sections (Figures 9 and 15). Particular levels of some other sections examined in this study (such as

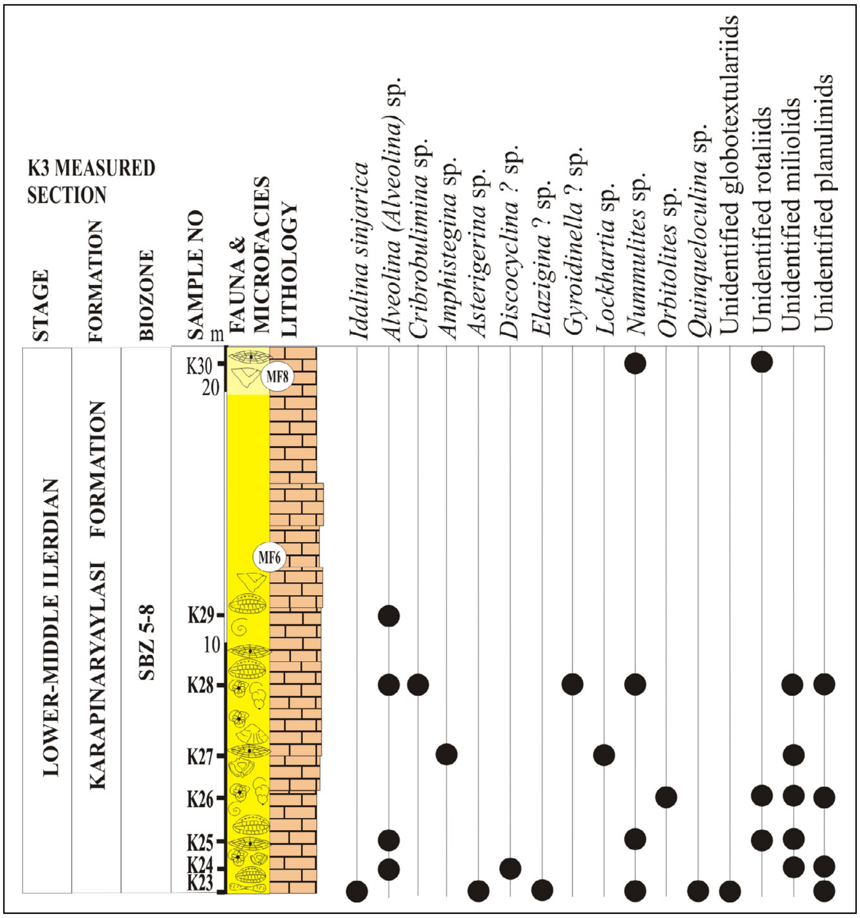

Figure 7- Measured Section 3 (K3) around the Musular Hill, see Figure 5 for legend.

upper parts of K6 and lower parts of K7 sections) indicate Ilerdian age with their benthic foraminiferal assemblages, yet not provide biozones (Figures 11 and 12).

4.4. SBZ 10-12 (Cuisian)

SBZ 10-11 interval was mainly determined based on the occurrences of *Alveolina (Alveolina) barattoloi* (Figure 12; Plate IV, Figure 8). Sirel and Acar (2008) described *A. (A.) barattoloi* from SBZ 10 and the lower part of SBZ 11. In the K7 section of the study area, this species is also associated by *A.* (*A.*) aff. *avsari* (Figure 12; Plate V, Figure 11). In the K2 section (Figure 6), *A. (A.) levantina* (Plate IV, Figure 11) and *A. (A.) violae* (Plate IV, Figure 13) were the index taxa that define SBZ 12 (Figure 6). Serra-Kiel et al. (1998) report the biostratigraphical range of *A. (A.) levantina* from the upper part of SBZ11 to the end of SBZ12. Some researchers also suggest a wide range for this species extending from SBZ11 to the lower part of SBZ 15 (Hottinger 1974; Drobne 1977; Serra-Kiel et al., 2016). In addition, Serra-Kiel et al. (1998) give the species *A.* (*A.*) *violae* as an index form of SBZ12.

4.5. Zones E7-E10 (late Ypresian-Lutetian)

The lower part of the K8 section between samples K75-K78 contains rare and less diverse planktonic foraminifera (Figure 13). *Acarinina bullbrooki, A. boudreauxi, A. praetopilensis* and *A. pseudosubsphaerica* in the assemblage (Plate IX, Figures 14-15, 19-21, 25-27, 31, 39-41, 42-43, 45-46) are the marker species of the E7 Zone (Berggren et. al., 2006). The presence of *Guembelitrioides nuttalli* in K79 and *Globigerinatheka kugleri, G. index*, *G. mexicana* in K81 (Plate IX, Figures 6, 10) indicates the E8 and E9 zones, respectively (Berggren and Pearson, 2005; Premoli Silva et al., 2006; Wade et al., 2011). Samples K81-K83 in the upper part of the

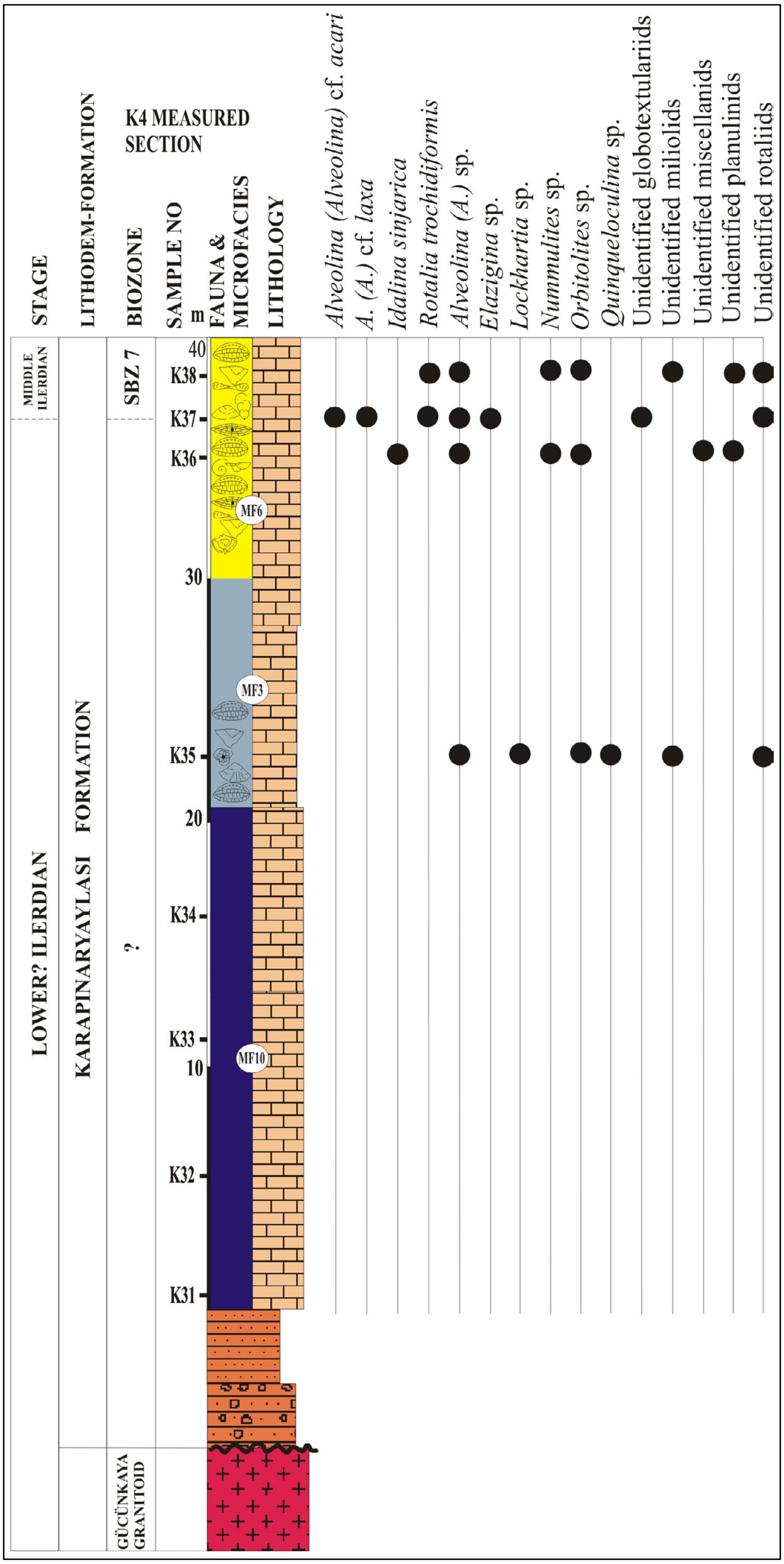

Figure 8- Measured Section 4 (K4) around the Musular Hill, see Figure 5 for legend.

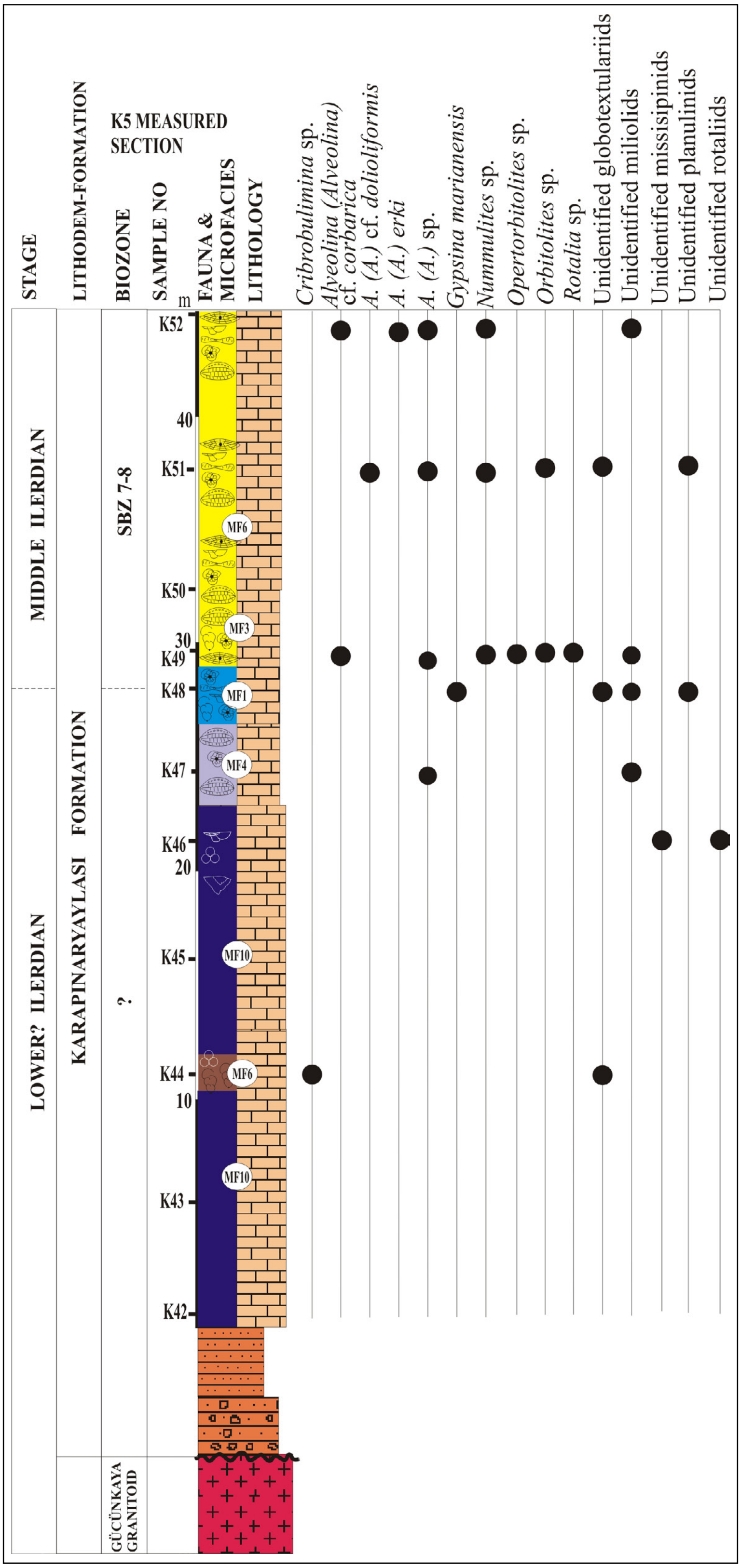

Figure 9- Measured Section 5(K5) around the Musular Hill, see Figure 5 for legend.

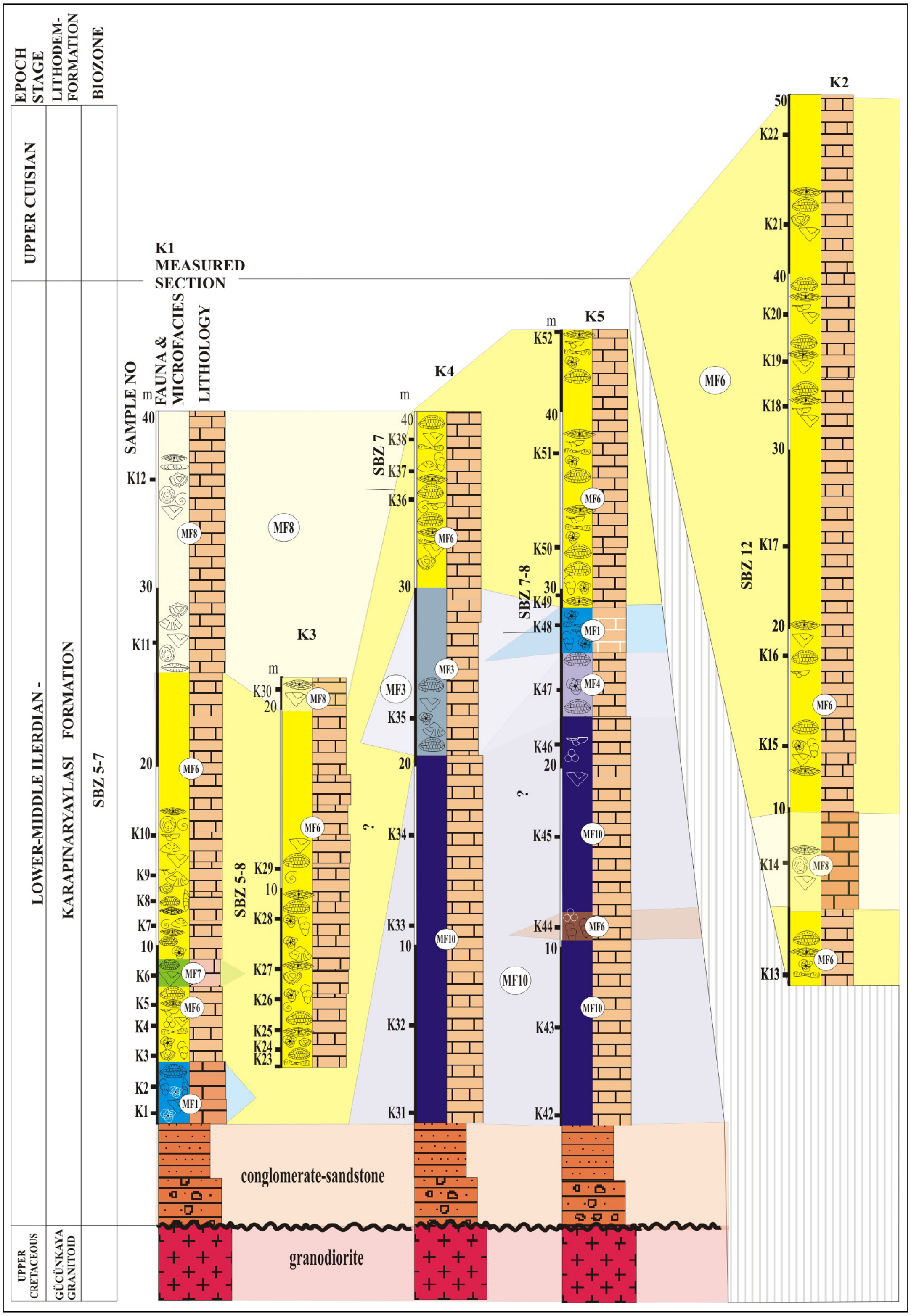

Figure 10- Correlation of measured sections around the Musular Hill, see Figure 5 for legend.

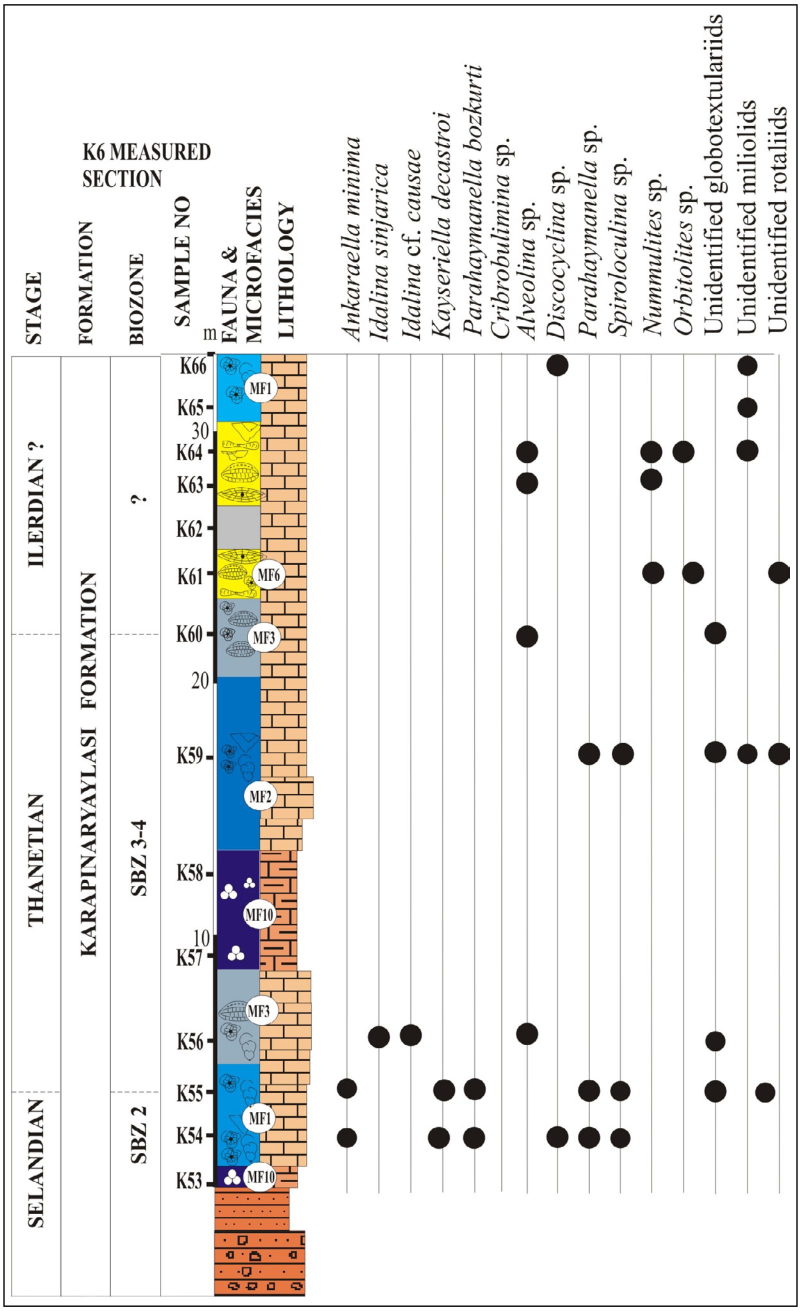

Figure 11- Measured Section 6 (K6) around Elmakayası, see Figure 5 for legend.

section are represented by more abundant and diverse planktonic foraminiferal assemblages, including *Guembelitrioides nuttalli, Morozovelloides bandyi, Pearsonites broedermanni, Acarinina boudreauxi, Acarinina pseudosubsphaerica* and *Turborotalia pomeroli* (Plate IX, Figures 7-8, 17, 34-36, 39, 41-42, 45-46, 48) and can be correlated with E9-E10 zones (Pearson et. al., 2006).

Benthic foraminiferal assemblage obtained in the section 9 cannot provide biozonation (Figure 14). However, the assemblage containing species such as *Idalina* cf. *grelaudae* (Plate II, Figure 5) and *Rotalia trochidiformis* suggests an interval of Ypresian-Lutetian.

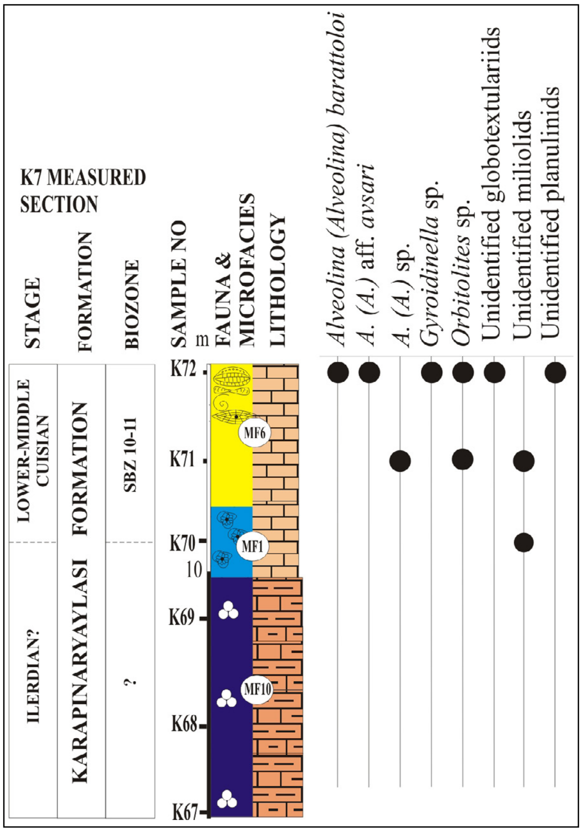

Figure 12- Measured Section 7 (K7) around Elmakayası, see Figure 5 for legend.

5. Microfacies and Paleoenvironmental Interpretations

The studied succession, which starts with siliciclastic rocks over the Gücünkaya Granitoid in the measured sections K1, K4 and K5, continues upwards with carbonate rocks in the Musular area (Figure 10). In sections K2 and K3, only carbonate rocks were measured. In the measured sections around the Elmakayası, the Gücünkaya Granitoid are only seen at the base of the K9 section (Figure 16). In the measured sections of K6, K9 and K10, the Karapınaryaylası Formation begins with siliciclastic rocks and continues with carbonates. In the measured sections of K9 and K10, Kızılkaya Ignimbrites unconformably cover the Karapınaryaylası Formation. The microfacies that can be identified in the Karapınaryaylası Formation deposits have lateral and vertical relationships with each other in both studied areas. The carbonate succession of the formation is divided into 4 main microfacies according to the dominant fossil contents and lithological features. These are miliolid-dominated wackestone-packstone-grainstone (MMF1), miliolid-rotaliid-dominated wackestone-packstone (MMF2), and rotaliid-dominated wackestone-packstone (MMF3) and planktonic foraminifera dominated wackestone facies (MMF4) (Figure 19).

It is observed that these differentiated microfacies begin with lagoonal facies on the clastic deposits around Musular Tepe and pass upwards to shallow carbonate platform deposits dominated by rotaliid forms. In the vicinity of Elmakayası, it is observed that lagoonal and shallow facies have lateral and vertical facies that change each other. In this second area, the facies accompanied by planktic foraminiferous predominance indicate open marine paleoenvironment. The facies thicknesses are variable, and it has been revealed that facies containing miliolids and facies containing rotaliids are the most observed facies. In facies definitions, Dunham's (1962) nomenclature was used together with the dominant or important fossil groups and the lithological features. The general features and interpretations of identified main facies and subfacies can be summarized as follows:

5.1. Microfacies 1: Miliolid-dominated wackestone-packstone-grainstone facies (MMF1)

In these determined lithofacies, miliolids are the predominant fossil group within the various carbonate matrix. This facies is divided into five sub-facies within itself, and the explanations about the sub-facies are as follows:

5.1.1. Smaller miliolid-dominated packstone-grainstone sub-facies (MF1)

Benthic foraminifers with a porcellaneous test, usually smaller than 2 mm, are common in a sparitic cement (Plate X, Figure 1-2, 13-14). It is usually grain-supported.

Interpretation: Miliolid dominance indicates the presence of a lagoonal environment (Hallock and Glenn, 1986; Armstrong and Brasier, 2005).

5.1.2. Milliolid-textulariid dominated packstone sub-facies (MF2)

These facies, in which usually textulariid and small miliolid forms are observed together, are not very

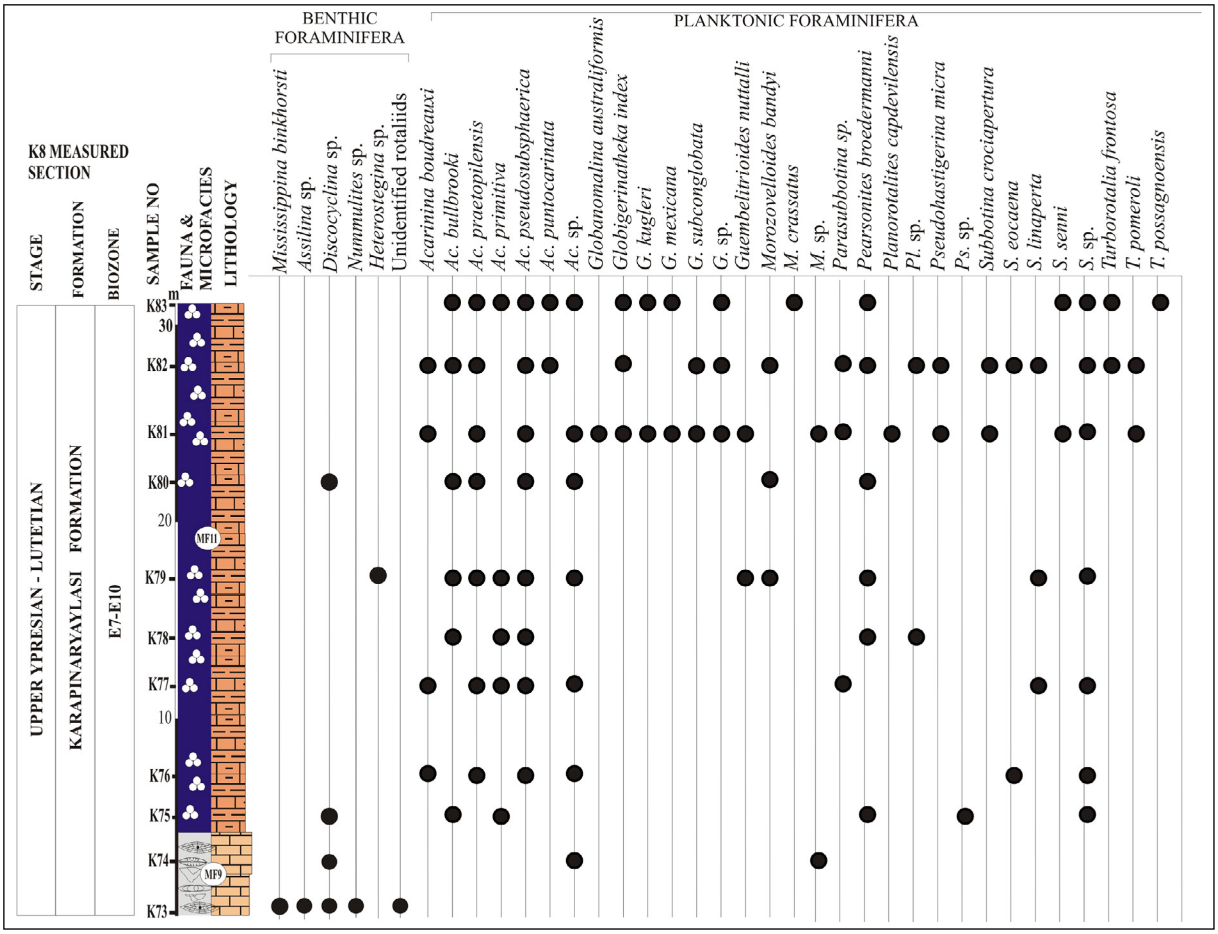

Figure 13- Measured Section 8 (K8) around Elmakayası,see Figure 5 for legend.

common (Plate X, fig. 3). The observed textulariid forms are *Haymanella* cf. *elongata, Parahaymanella* sp., *Haymanella* cf. *paleocenica, Cribrobulimina* sp. *Valvulina* sp. *Textularia* sp. *Bigenerina* sp.

Interpretation: Co-observation of miliolid forms and agglutinant walled foraminifera indicates a shallow marine lagoon environment within the platform (Flügel, 2010).

5.1.3. Alveolinid and other smaller miliolid-dominated packstone sub-facies (MF3)

Smaller miliolid forms are observed together with alveolinids. Unlike MF1, alveolinids accompany other smaller and medium-sized miliolids (Plate X, Figure 4). Micritic cement is also observed.

Interpretation: The carbonate deposits of these facies also belong to a lagoon environment. It is known that benthic forms with porcellaneous tests indicate the lagoon environment (Armstrong and Brasier, 2005).

5.1.4. Alveolinid-dominated packstone sub-facies (MF4)

Alveolinids are seen as predominant forms in these sub-facies (Plate X, Figure 5). In addition to alveolinids larger than 2 mm, other small miliolid forms are also observed in small proportions. The observed alveolinids with a size of a few cm are *Alveolina (Alveolina)* cf. *acari* Bozkurt and Görmüş, *A. (A.)* aff. *avsari* Sirel and Acar, *A. (A.) barattoloi* Sirel and Acar, *A. (A.)* cf. *corbarica* Hottinger, *A. (A.)* cf. *dolioliformis* Schwager, *A. (A.)* cf. *erki* Acar, *A. (A.)* cf. *laxa* Hottinger, *A. (A.) levantina* Hottinger, *A. (A.) violae* Checchia-Rispoli.

Interpretation: Alveolina dominance indicates lagoon shallow water environments (Armstrong and Brasier, 2005).

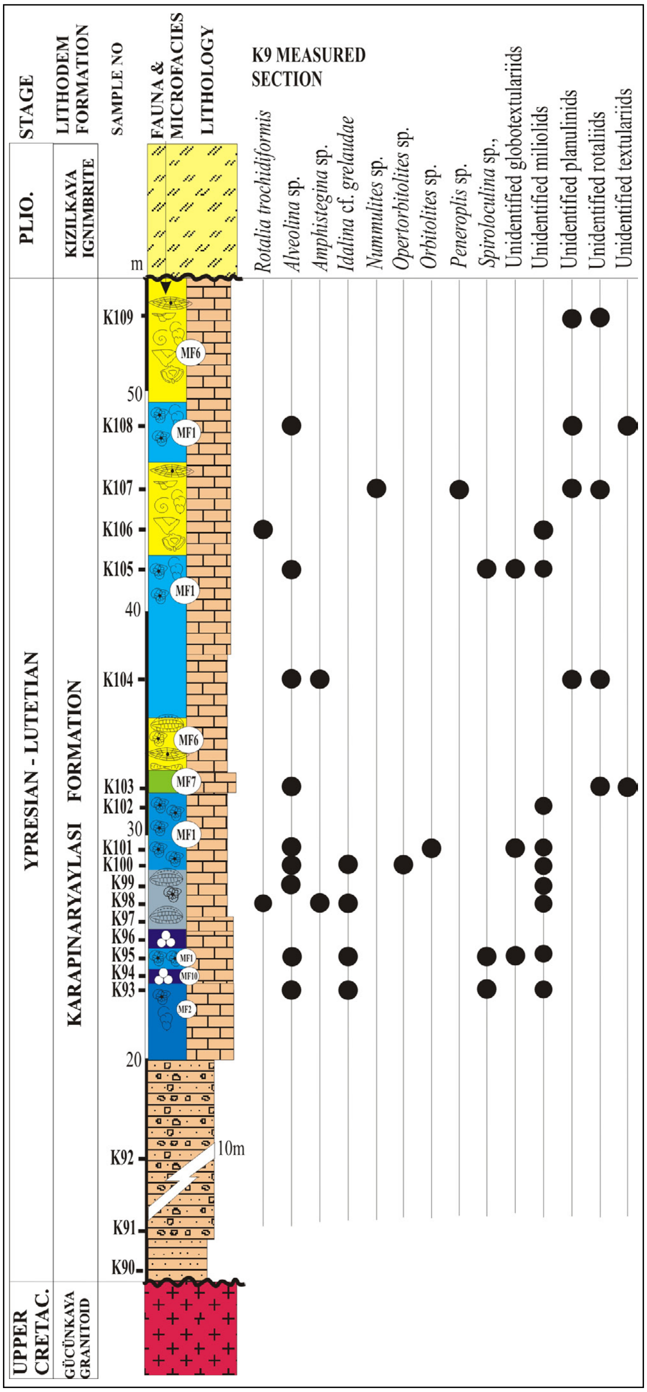

Figure 14- Measured Section 9 (K9) around Elmakayası, see Figure 5 for legend.

5.1.5. Wackestone-packstone sub-facies containing less textulariid sub-facies (MF5)

Facies which are not much common, are observed at mud-containing levels (Plate X, Figure 6). A small percentage of textulariid forms are seen between 2-5%.

Interpretation: Agglutinant-walled foraminifers refer to environments ranging from shallow to offshore environments (Armstrong and Brasier, 2005). These facies deposits have lateral relations with other miliolid-bearing facies. For this reason, it is thought that it was deposited in a shallow marine environment.

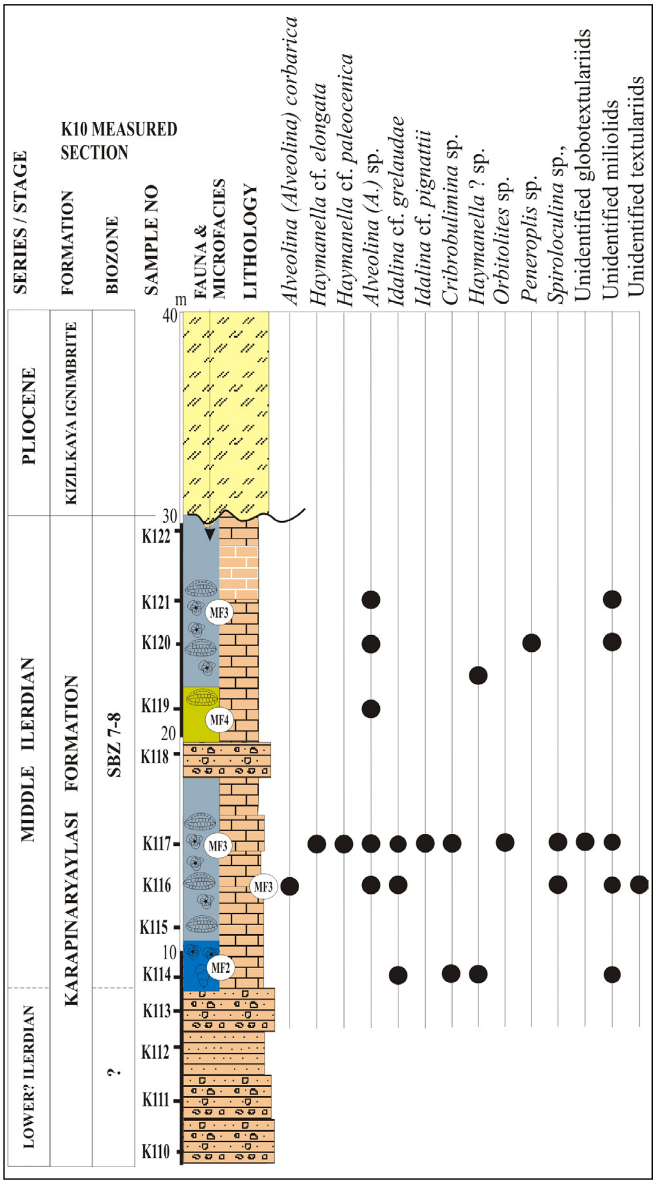

Figure 15- Measured Section 10 (K10) around Elmakayası, see Figure 5 for legend.

5.2. Microfacies 2: Miliolid-rotaliid, dominated wackestone-packstone facies (MMF2)

In these determined lithofacies, miliolid and rotaliid forms are almost equal proportions. This facies only includes one sub-facies identified as MF6.

5.2.1. Alveolinid and nummulitid-dominated wackestone-packstone sub-facies (MF6)

In these determined lithofacies, miliolid and rotaliids are almost equal proportions (Plate X, Figure 7). Alveolinid and nummulitid forms are observed together. Forms up to a few cm in size are in micritic cement.

Interpretation: The co-occurrence of nummulitids and alveolinids was interpreted as open-shelf lagoons (Amirshahkarami and Zebarjadi, 2018). Geel (2000) emphasized that this fossil association can be seen at depths of 50-80 m. It is seen that these facies, in which alveolinid and nummulitids are observed together, are close to the nummulite sets.

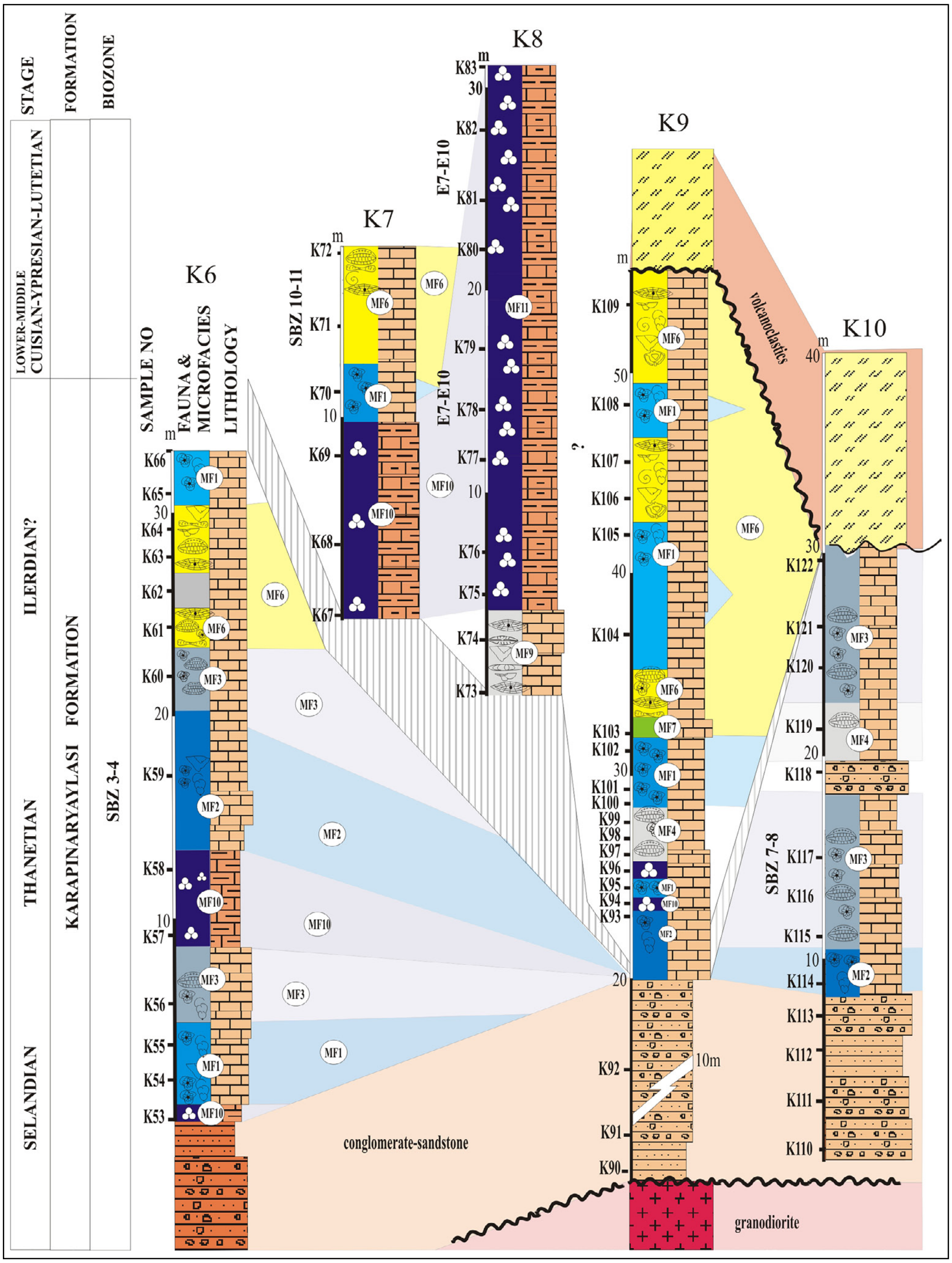

Figure 16- Correlation of measured sections around the Elmakayası, see Figure 5 for legend.

5.3. Microfacies 3: Rotaliid-dominated wackestone-packstone facies (MMF3)

Small and large benthic rotaliids are dominant in these lithofacies. This facies is divided into three sub-facies within itself, and the explanations about the sub-facies are as follows.

5.3.1. Less rotaliid bearing silty mudstone sub-facies (MF7)

In these facies deposits, silt fragments are observed in the mudstones. Rotoliids, which are difficult to identify, are seen at a small rate1-2%. Limestones were recrystallized (Plate X, Figure 8).

Interpretation: They show a shallow marine environment.

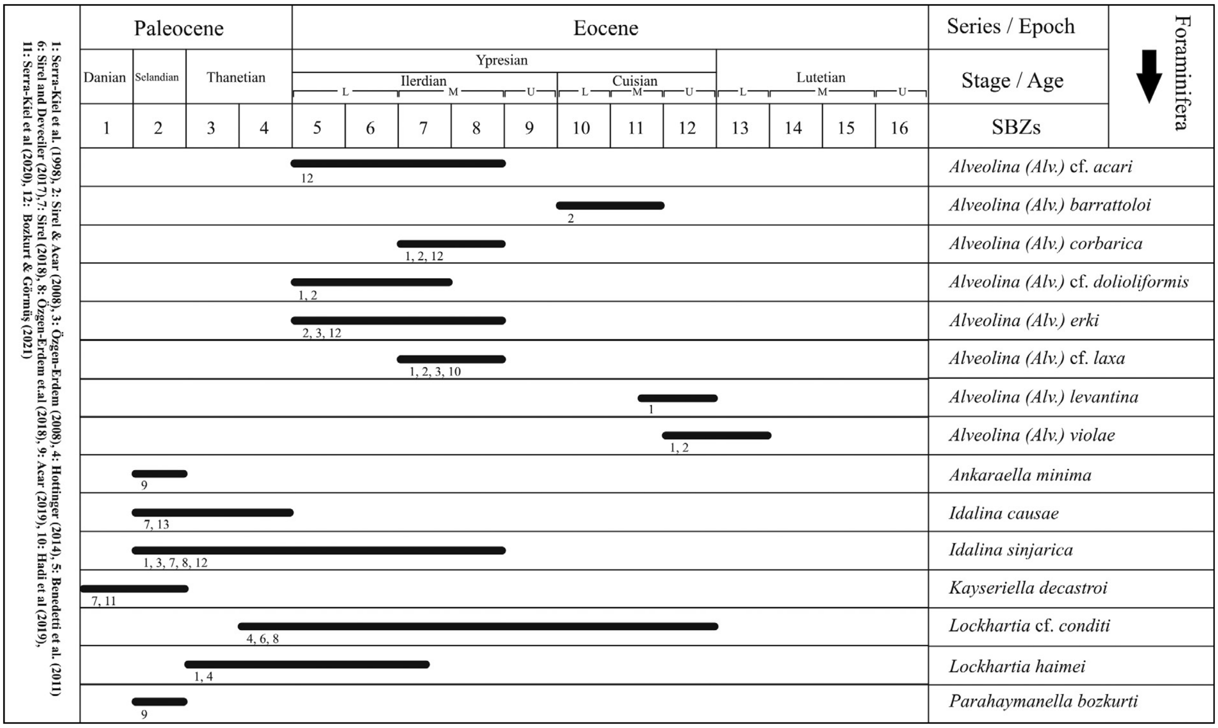

Figure 17- Range distribution of some important benthic foraminiferal species used in this study (Numbers located under the black lines indicate related literature in the box at the left, in which that age was assigned).

System	Series	Stage		Numerical Age (Ma)	Shallow Benthic Zones (SBZ)	Benthic Foraminiferal Species: Serra-Kiel et al (1998)	Benthic Foraminiferal Species: This study
Paleogene	Eocene	Ypresian	Cuisian	47,8	SBZ 12	*Alveolina* (*Alveolina*) *violae, A.*(*A.*) *rakoveci, A.*(*A.*) *azzarolii, A.*(*A.*) *cuspidata, Nummulites manfredi, N. angularis, N. campesinus, N. quasilaevigatus, N. caupennensis, Assilina maior, Ass. cuvillieri*	*Alveolina* (*Alveolina*) *barattoloi, A.*(*A.*) *levantina, A.*(*A.*) *violae*
					SBZ 11	*Alveolina* (*Alveolina*) *dainellii, A.*(*A.*) aff. *canavarii, A.*(*A.*) *histrica histrica, A.*(*A.*) *decastroi, A.*(*A.*) *cremae, Nummulites praelaevigatus, N. burdigalensis contabricus, N. kapellosi, N. escheri, N. nitidus, N. archiaci, Assilina laxispira, Discocyclina fortisi simferepolensis*	
					SBZ 10	*Alveolina* (*Alveolina*) *schwageri, A.*(*A.*) *indicatrix, A.*(*A.*) *canavarii, A.*(*A.*) *cosinensis cosinensis, A.*(*A.*) *haymanensis, A.*(*A.*) *minuta, Nummulites planulatus, N. aquitanicus, N. rotularius, N. burdigalensis burdigalensis, N. subramondi thalmanni, N. pavloveci, N .subdistans, Assilina plana, Ass. placcentula, Ass. aspensis, Ass. karreri, Ass. escheri, Discocyclina archiaci archiaci*	
			Ilerdian	52,5	SBZ 9	*Alveolina* (*Alveolina*) *trempina, A.*(*A.*) *citrea, A.*(*A.*) *polatliensis, Nummulites involutus, Assilina adrianensis, Ass. pomeroli*	*Alveolina* (*Alveolina*) cf. *acari, A.*(*A.*) aff. *avsari, A.*(*A.*) cf. *corbarica, A.*(*A.*) cf. *dolioliformis, A.*(*A.*) cf. *erki, A.*(*A.*) cf. *laxa*
					SBZ 8	*Alveolina* (*Alveolina*) *corbarica, A.*(*A.*) *recondita, A.*(*A.*) *brassica, Nummulites exilis, N. atacicus, N. globulus nanus, N. globulus latior, Assilina leymeriei, Ass. canalifera*	
					SBZ 7	*Alveolina* (*Alveolina*) *moussoulensis, A.*(*A.*) *subpyrenaica, A.*(*A.*) *laxa, A.*(*A.*) *dedolia, Nummulites robustiformis, N. carcasonensis, N. praecursor, N. oblaticus, Assilina aranensis, Orbitoclypeus schopeni neumannae*	
					SBZ 6	*Alveolina* (*Alveolina*) *ellipsoidalis, A.*(*A.*) *daniensis, A.*(*A.*) *pasticillata, A.*(*A.*) *solida, Nummulites minervensis*	
					SBZ 5	*Orbitolites gracilis, Daviesina tenuis, Alveolina* (*Alveolina*) *vredenburgi, A.*(*A.*) *avellana avellana, A.*(*A.*) *aramea aramea, A.*(*A.*) *varians, Nummulites gamardensis, Assilina dandotica, Ass. prisca*	
	Paleocene	Thanetian		56,0	SBZ 4	*Alveolina* (*Glomalveolina*) *levis, Hottingerina lukasi, Miscellanea meandrina,Daviesina garumnensis, Dictyokathina simplex, Nummulites catari, Assilina azilensis, Ass. yvettae*	*Idalina causae, I. sinjarica*
					SBZ 3	*Alveolina* (*Glomalveolina*) *primaeva, Periloculina slovenica, Coskinon rajkae, Fallotella alavensis, Cribrobulimina carniolica, Vania anatolica, Miscellanea yvettae, Ranikothalia bermudezi, Discocyclina seunesi, Nummulites heberti*	
		Selandian		59,2 – 61,6	SBZ 2	*Miscellanea globularis, Ornatononion minutus, Paralockhartia eos, Lockhartia akbari*	*Kayseriella decastroi, Ankaraella minima, Parahaymanella bozkurti*

Figure 18- A table illustrating both the zonal markers of some shallow benthic zones (SBZs) and the taxa used in this study to define biozones.

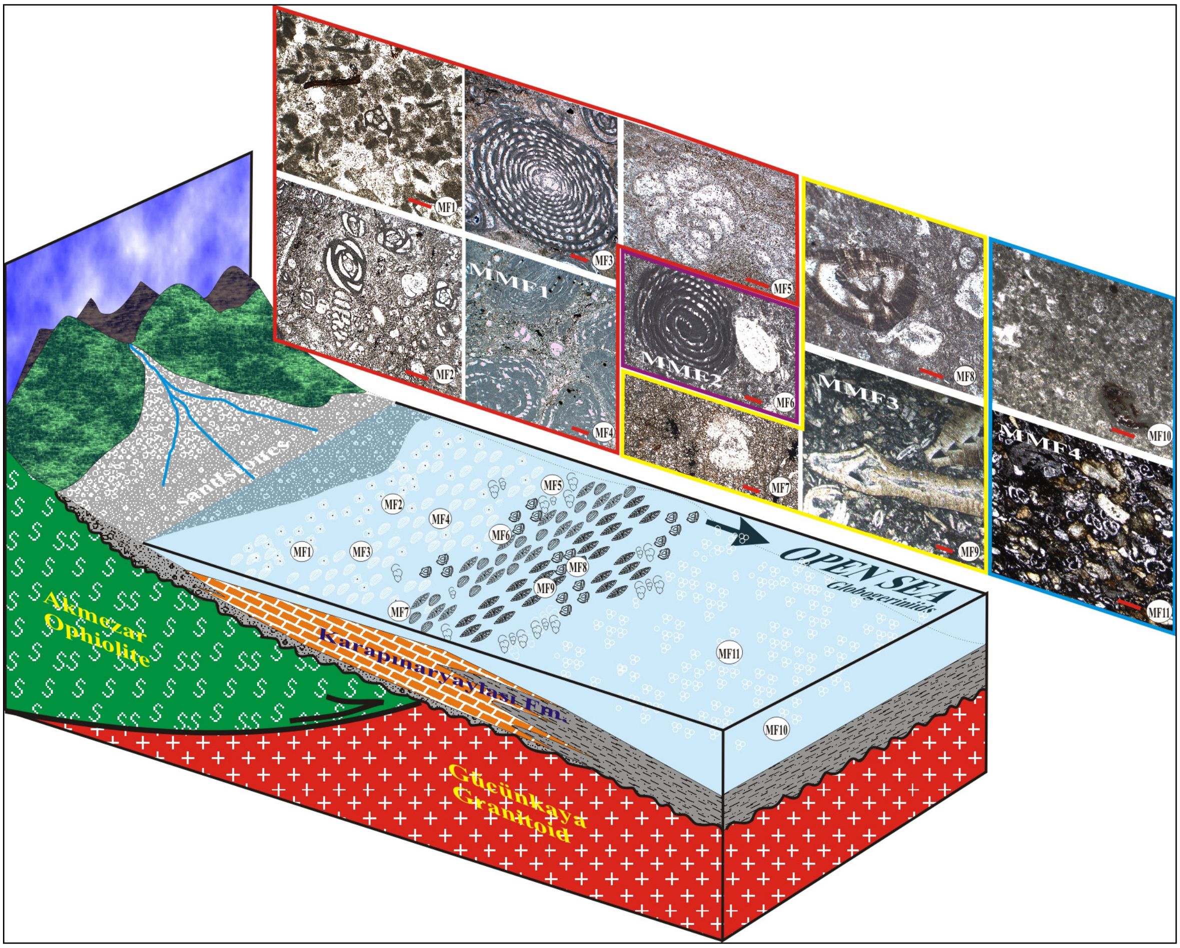

Figure 19- A schematic block diagram of the facies identified from the Karapınaryaylası Formation, MMF1. Miliolid-dominated wackestone-packstone-grainstone facies, MMF2. Miliolid-rotaliid, dominated wackestone-packstone facies, MMF3. Rotaliid-dominated wackestone-packstone facies, MMF4. Planktonic foraminifera-dominated wackestone, MF1. Smaller miliolid-dominated packstone-grainstone sub-facies,sample no 1; MF2. Milliolid-textulariid dominated packstone sub-facies,sample no 93; MF3. Alveolinid and other smaller miliolid-dominated packstone sub-facies, sample no 117; MF4. Alveolinid dominated packstone sub-facies, sample no 47; MF5. Wackestone-packstone sub-facies containing less textulariid, sample no 44; MF6. Alveolinid and nummulitid-dominated wackestone-packstone sub-facies, sample no 50; MF7. Less rotaliid bearing silty mudstone sub-facies, sample no 6; MF8. Rotaliid dominated wackestone-packstone sub-facies, sample no 11; MF9. Packstone containing *Nummulites, Assilina* and *Discocyclina*, sample no 73; MF10. Less planktonic foraminiferous mudstone sub-facies, sample no 56; MF11. Wackestone sub-facies with rich planktonic foraminifera, sample no 81, depth is unscaled, scale shows 200 µ. textulariids, smaller miliolids, alveolinids, rotaliids, nummulitids, planktonic foraminifera.

5.3.2. Rotaliid-dominated wackestone-packstone sub-facies (MF8)

Wackestones and packstones are dominated by rotaliid forms, and a few mm-sized rotaliids are dominant (Plate X, Figure 9).

Interpretation: Medium-sized rotaliids are common, and are thought to be near the nummulit bank, fore-bank or back-bank. Hallock and Glenn (1986) also mention the presence of medium-sized rotaliids shows open platform deposits.

5.3.3. Packstone containing Nummulites, Assilina and Discocyclina sub-facies (MF9)

The main microfauna of these facies are *Nummulites, Assilina* and *Discocyclina*. *Nummulites* and *Assilina* are more common (Plate X, Figure 10).

Interpretation: These levels, which include larger-sized *Nummulites, Assilina*, and *Discocylina*, are associated with "nummulit sets".

5.4. Microfacies 4: Planktonic foraminifera-dominated wackestone (MMF4)

Planktic foraminifers are common in the lithofacies. This facies is divided into two sub-facies within itself.

5.4.1. Less planktonic foraminiferous mudstone sub-facies (MF10)

Planktonic foraminifers are observed in the mudstones at a rate of 1-5% (Plate X, Figure 11).

Interpretation: Micritic carbonates are thought to be offshore sediments.

5.4.2. Wackestone sub-facies with rich planktonic foraminifera (MF11)

In these biomicrite facies, in which globigerinid forms are rich (Plate X, Figure 12).

Interpretation: The dominance of planktonic foraminifera indicates an open marine environment (Armstrong and Brasier, 2005).

6. Conclusions

Paleocene-Eocene aged sediments in the east of Tuz Gölü Basin (Salt Lake, Central Anatolia) are known as the Karapınaryaylası Formation. The formation rests on the basement rocks unconformably. The formation represented by limestones and clayey limestones is rich in both benthic and planktonic foraminifera. In benthic foraminiferal biozonation, which is generally based on *Alveolina* species, it has been determined that the assemblages represent biozones between SBZ 2-12. In addition, it was determined that some levels in pelagic facies that do not contain benthic foraminifera correspond to E8-E10 biozones according to their planktonic foraminifer contents. For this reason, the age range of the formation is Selandian-Lutetian according to the determined species. Four main microfacies and eleven sub-microfacies have been identified. These are small miliolid dominated packstone-grainstone (MF1), miliolid-textulariid dominated packstone (MF2), alveolinid and small milliolid dominated packstone (MF3), alveolinid dominated packstone (MF4), less textulariid-containing wackestone-packstone (MF5), alveolinid and nummulitid dominated wackestone-packstone (MF6), silty mudstone with less rotaliid (MF7), rotaliid dominated wackestone-packstone (MF8), *Nummulites, Assilina, Discocyclina* packstone (MF9), mudstone with less planktonic foraminifera (MF10), and mudstone with rich planktonic foraminifera (MF11). Benthic and planktonic foraminifera descriptions and data obtained from microfacies studies indicate the Selandian-Lutetian age range and environments that developed from the lagoon to the open sea.

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PLATES

Plate I

1-3, 7: Miliolid forms, longitudinal sections; **1.**Sample no.13, K2 Section, SBZ12; **2-3**.Sample no 59, K6 Section, SBZ3-4.

4: *Haymanella* cf. *elongata*, longitudinal section, Sample no. 117, K10 Section, SBZ7-8.

5-6: Textulariids?, Sample no 93, K9 Section, SBZ?

7: *Parahaymanella* sp., Sample no 59, K6 Section, SBZ3-4.

8: *Haymanella* cf. *paleocenica*, longitudinal section, Sample no. 117, K10 Section, SBZ7-8

9-15: *Cribrobulimina* sp; **9, 11, 13** Sample no. 117, K10 Section, SBZ7-8; **10.**Sample no 44, K5 Section, SBZ?; **12.**Sample no 114, K10 Section, SBZ7-8; **13.**Sample no. 54, K6 Section, SBZ3-4; **15.**Sample no 28, K3 Section, SBZ5-8.

16-21: Planspiral coiled textulariids, **16-17**.Sample no 93, K9 Section, SBZ?; **18.**Sample no 95, K9 Section,SBZ?; **19.**Sample no 59, K6 Section, SBZ3-4; **20**.Sample no 44, K5 Section, SBZ?; **21**.Sample no 56, K6 Section, SBZ3-4.

22-24: Biserial coiled textulariids, **22.**Sample no 59, K6 Section, SBZ3-4; **23**.Sample no 116, K10 Section, SBZ?; **24.**Sample no 54, K6 Section, SBZ3-4.

25-26: *Vulvulina* sp. **25**.Sample no 47, K5 Section, SBZ?; **26**.Sample no 23, K3 Section, SBZ5-8.

27: *Textularia* sp. Sample no 107, K9 Section, SBZ?.

28-30: Unidentified textulariids, **28**.Sample no 117, K10 Section, SBZ7-8, **29**.Sample no 105, K9 Section, SBZ?; **30**.Sample no 15, K2 Section, SBZ12.

31-32: Unidentified textulariids, **31**. Sample no 47, K5 Section, SBZ?; **32**. Sample no 114, K10 Section, SBZ7- 8.

33-34: Uniserial coiled textulariids, **33**. Sample no 56, K6 Section, SBZ3-4; **34**. Sample no 117, K10 Section, SBZ7-8.

35-40: *Bigenerina* sp. **35**. Sample no 114, K10 Section, SBZ7-8; **36-37**.Sample no 93, K9 Section, SBZ?; **38**. Sample no 47, K5 Section, SBZ?; **39**.Sample no 99, K9 Section, SBZ?; **40**.Sample no 100, K9 Section, SBZ?

41: Unidentified textulariids, Sample no 114, K10 Section, SBZ7-8

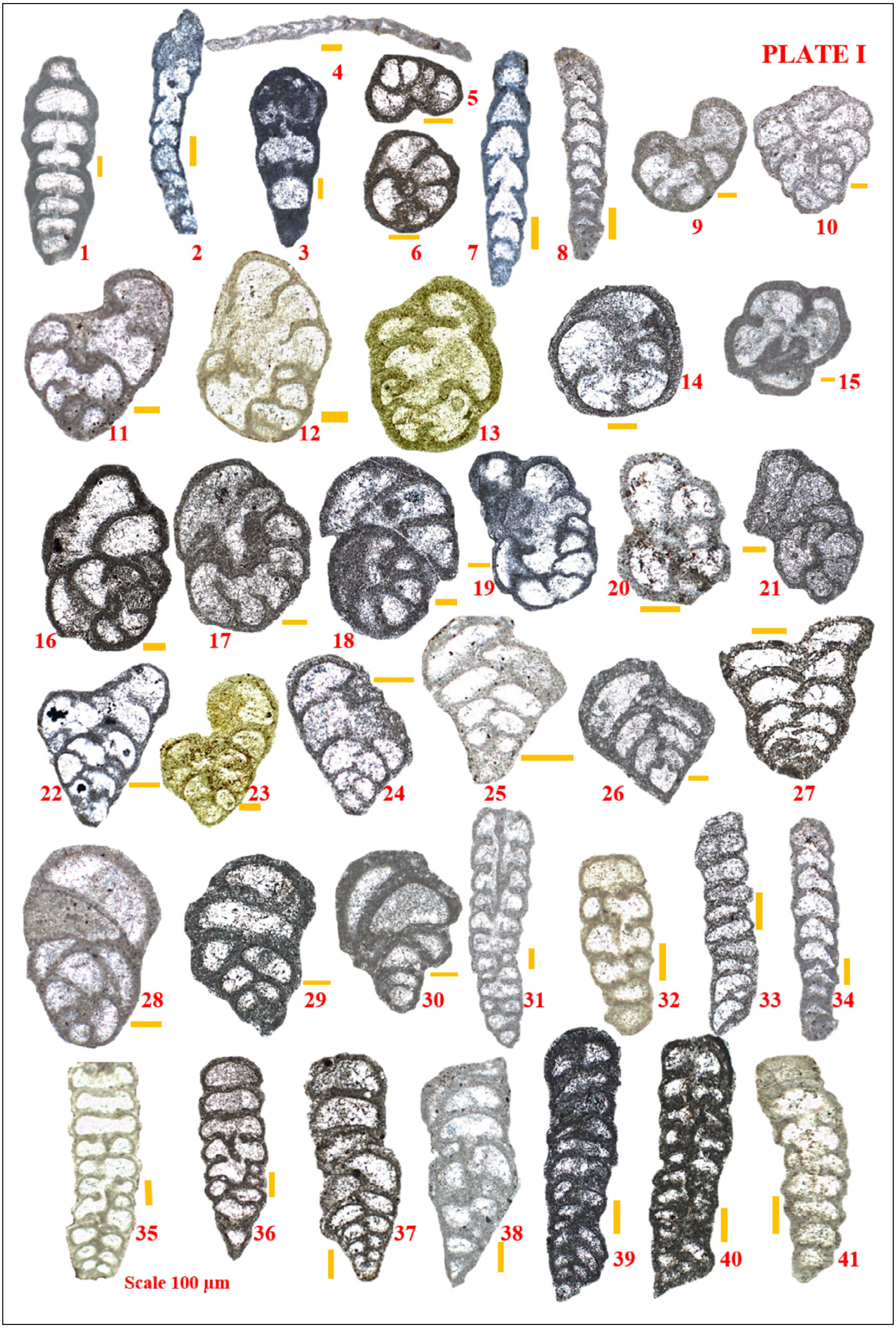
PLATE I
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Scale 100 µm

Plate II

1-2: *Peneroplis* sp., equatorial sections, **1**.Sample no 107, K9 Section, SBZ?; **2**.Sample no 1, K1 Section, SBZ5-7.

3-4: Unidentified miliolid, centered section perpendicular to the coiling axis, **3**.Sample no 15, K2 Section, SBZ12; **4**. Sample no 23, K3 Section, SBZ5-8.

5: *Idalina* cf. *grelaudae*, centered section perpendicular to the coiling axis, Sample no 95, K9 Section, SBZ?

6-10: Unidentified miliolids, centered section perpendicular to the coiling axis, **6**.Sample no 35, K4 Section, ?SBZ5-8; **7**.Sample no 94, K9 Section, SBZ?; **8**.Sample no 64, K6 Section, SBZ3-4.; **9**. Sample no 35; K4 Section, SBZ?; **10**. Sample no 93, K9 Section, ?SBZ10-11.

11-14: *Idalina* cf. gralaudae, centered section perpendicular to the coiling axis, **11-12, 14.** Sample no 117, K10, Section, SBZ7-8; **13**.Sample no 116, K10 Section, SBZ7-8

15: Unidentified miliolid, centered section perpendicular to the coiling axis, Sample no 1, K1 Section, SBZ5-7.

16: *Triloculina tricarinata*, Sample no 4, K1 Section, SBZ5-7.

17-18: *Triloculina angulata*, **17**.Sample no 15, K2 Section, SBZ12; **18**.Sample no 27, K3 Section, SBZ5-8 657

19: *Idalina* cf. *pignattii?*, Sample no 117, K10 Section, SBZ7-8.

20-21: Unidentified miliolids, centered section perpendicular to the coiling axis, **20-21**. Sample no 93, K9 Section, SBZ9.

22: *Idalina sinjarica*, Sample no 56, K6 Section, SBZ3-4.

23: *Idalina* cf. causae, Sample no 56, K6 Section, SBZ3-4. 662

24-29: Unidentified miliolids, **24**.longitudinal section, Sample no 4, K1 Section, SBZ5-7; **25**. uncentered section perpendicular to the coiling axis, Sample no 117, K10 Section, SBZ7-8; **26**.Unidentified miliolid, centered section perpendicular to the coiling axis, Sample no 35, K4 Section, SBZ?; **27**.Sample no 24, K3 Section, SBZ5-8; **28**.Sample no 2, K1 Section, SBZ5-7; **29**.Sample no 105, K9 Section, SBZ?. 666

30: *Idalina sinjarica?*, longitudinal section, Sample no 23, K3 Section, SBZ5-8. 667

31-33: Unidentified miliolids, **31**. Sample no 26, K3 Section, SBZ5-8; **32**.longitudinal section, Sample no 54, 668 K6 Section, SBZ3-4; **33**.Sample no: 54, K6 Section, SBZ3-4. 669

34: *Parahaymanella* sp., oblique equatorial section, Sample no 54, K6 Section, SBZ3-4. 670

35-40: Unidentified miliolids, **35**.Sample no 54, K6 Section, SBZ3-4; **36**.Sample no 66, K6 Section, SBZ3-4; 671 **37-38**. Sample no 55, K6 Section, SBZ3-4; **39-40**. Sample no 93, K9 Section, SBZ?

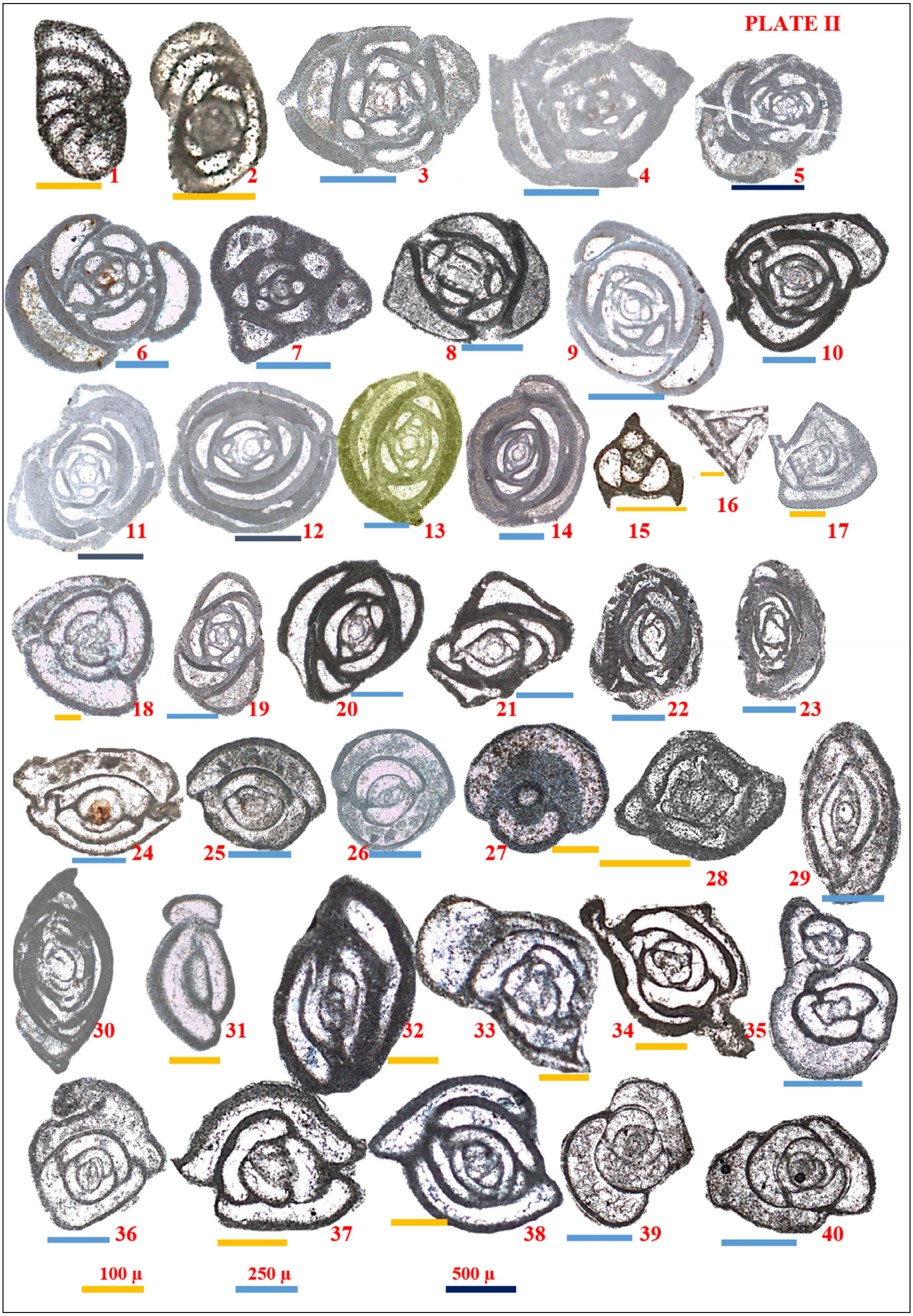
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Plate III

1-4: *Unidentified miliolids*, **1-2.**Sample no 93, K9 Section, SBZ?; **3-4**.Sample no 95, K9 Section, SBZ?

5-6: *Ankaraella minima*, subvertical section, Sample no 55, K6 Section, SBZ3-4.

7-8: *Kayseriella decastroi*,subvertical section, Sample no 55, K6 Section, SBZ3-4.

9: *Spiroloculina* sp., subvertical section, Sample no 94, K9 Section, SBZ?

10: Unidentified miliolid, Sample no 2, K1 Section, SBZ5-7

11-13: *Spiroloculina* sp., subvertical section, **11**.Sample no 2, K1 Section, SBZ5-7; **12**.Sample no 116, K10 Section, SBZ7-8; **13.**Sample no 117, K10 Section, SBZ7-8.

14-15: Unidentified miliolids, **14**.Sample no 101, K9 Section, SBZ?; **15**.Sample no 116, K10 Section, SBZ7-8.

16: *Parahaymanella* sp., subequatorial section, Sample no 59, K6 Section, SBZ3-4.

17: *Parahaymanella bozkurti*, subequatorial section, Sample no 55, K6 Section, SBZ3-4.

18: Unidentified miliolid, Sample no 105, K9 Section, SBZ?.

19-20: *Parahaymanella*? sp., subequatorial section (?), **19-20.** Sample no 55, K6 Section, SBZ3-4.

21: *Parahaymanella bozkurti*, subequatorial section, Sample no 55, K6 Section, SBZ3-4.

22: *Parahaymanella* sp., subequatorial section, Sample no 55, K6 Section, SBZ3-4.

23-26: Unidentified miliolids (?), **23**. Sample no 102; **24-25**.Sample no 56, K6 Section, SBZ3-4; **26**. Sample no 47, K5 Section, SBZ?.

27: Parahaymanella sp., subequatorial section, Sample no 55, K6 Section, SBZ3-4.


PLATE III
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Plate IV

1: *Alveolina* cf. *dolioliformis*, axial section, Sample no 51, K5 Section, SBZ7-8.

2: *Alveolina* cf. *corbarica*, uncentered axial section, Sample no 49, K5 Section, SBZ7-8.

3-4: *Alveolina corbarica*, axial sections, 3.Sample no 52, K5 Section, SBZ7-8; 4. Sample no 116, K10 Section, SBZ7-8

5: *Alveolina* cf. *levantina*, oblique axial section, Sample no 13, K2 Section, SBZ12.

6-7: *Alveolina* sp., **6**. oblique axial section, Sample no 51, K5 Section, SBZ7-8; **7.**tangential section, Sample no 116, K10 Section, SBZ7-8.

8: *Alveolina barattoloi*, slightly oblique axial section, Sample no 72, K7 Section, SBZ10-11.

9: *Alveolina* cf. acari, Sample no 37, K4 Section, SBZ7

10: *Alveolina* sp., tangential section, Sample no 52, K5 Section, SBZ7-8.

11: *Alveolina levantina*, axial section, Sample no 13, K12 Section, SBZ12.

12: *Alveolina erki*, axial section, Sample no 52, K5 Section, SBZ7-8.

13: *Alveolina violae*, Sample no 19, K2 Section, SBZ12.

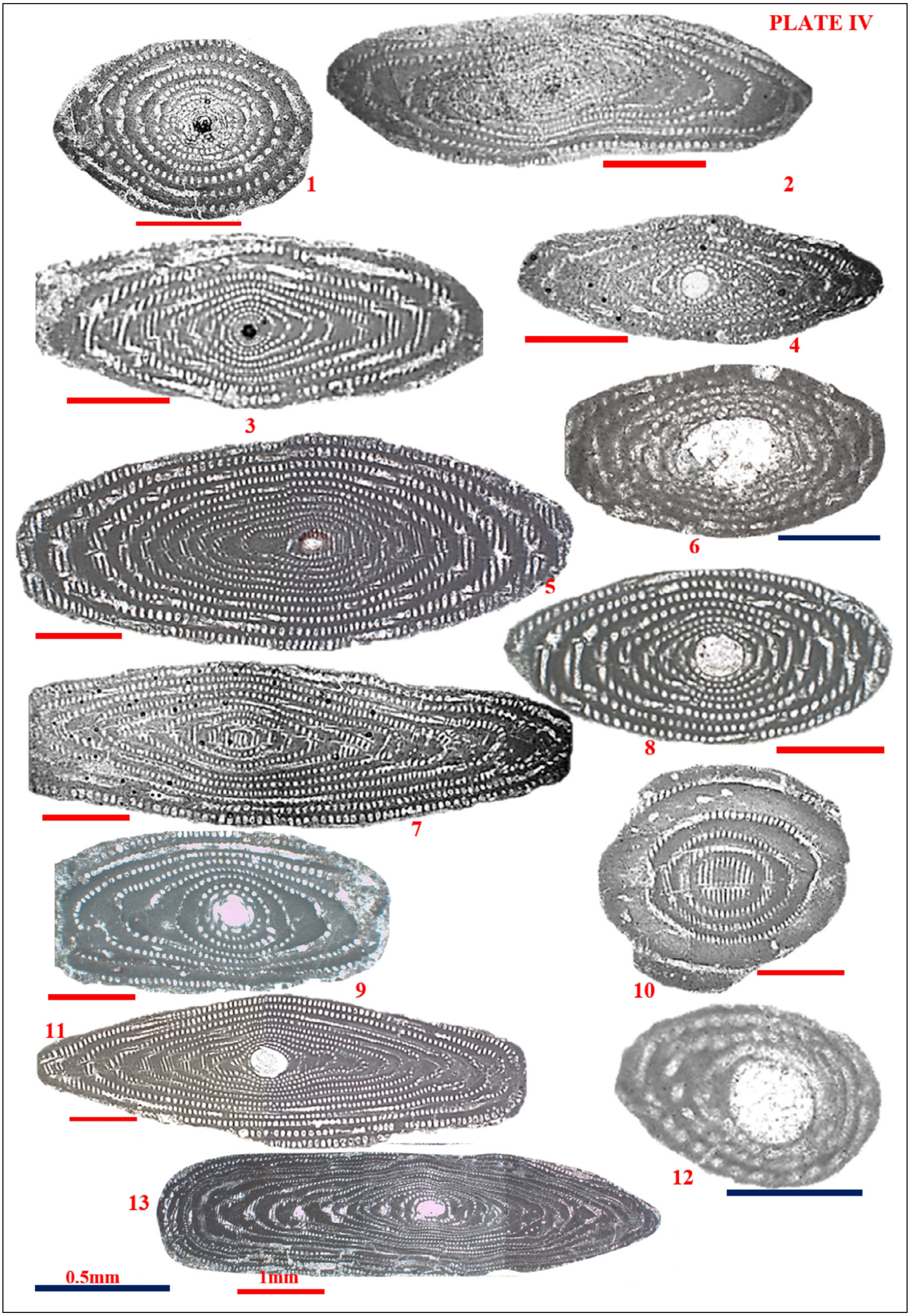
PLATE IV
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Plate V

1-2: *Alveolina* sp., oblique axial sections,Sample no 13, K2 Section, SBZ12.

3: *Alveolina* sp., oblique equatorial section; Sample no 56, K6 Section, SBZ3-4.

4: *Alveolina* cf. laxa, axial section with a broken juvenile stage, Sample no 37, K4 Section, SBZ7.

5-10: *Alveolina* sp., **5, 7**. oblique equatorial sections, Sample no 117, K10 Section, SBZ7-8; **6**.subequatorial section, Sample no 49, K5 Section, SBZ7-8; **8**. subequatorial section, Sample no 117, K10 Section, SBZ7-8;

9. oblique axial section, Sample no 56, K6 Section, SBZ3-4; **10.**subaxialsection, Sample no 64, K6 Section, SBZ3-4.

11: *Alveolina* aff. *avsari*, slightly oblique axial section, Sample no 72, K7 Section, SBZ10-11.

12-17: *Alveolina* sp. **12**. oblique equatorial section, Sample no 105, K9 Section, SBZ?; **13**. nearly equatorial section, Sample no 35, K4 Section, SBZ?; **14-15.** axial sections, Sample no 98, K9 Section, SBZ?, **16.** equatorial section,Sample no 100, K9 Section, SBZ?, **17.** oblique section, Sample no 104, K9 Section, SBZ?.

18-20: Alveoliniids?, **18.**Sample no 98, K9 Section, SBZ?; **19.**Sample no 100, K9 Section, SBZ?; **20.** Sample no 102, K9 Section, SBZ?


PLATE V
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Plate VI

1-5. *Valvulineria orali*, equatorial sections or nearly equatorial sections, **1**.Sample no 3, K1 Section, SBZ5-7; **2**. Sample no 7, K1 Section, SBZ5-7; **3**.Sample no 12, K1 Section, SBZ5-7; **4**.Sample no 105, K9 Section, SBZ?; **5**.Sample no 109, K9 Section, SBZ?

6: *Gyroidinella* sp.Sample no 28, K3 Section, SBZ5-8

7-10, 12-16: ?Valvulineria sp. axial or oblique sections, **7**.Sample no 7, K1 Section, SBZ5-7; **8-9**.Sample no 11, K1 Section, SBZ5-7; **10**.Sample no 10, K1 Section, SBZ5-7; **12, 14, 15.**Sample no 109; K9 Section, SBZ?, **13**.Sample no 50, K2 Section, SBZ12; **16**.Sample no 3, K1 Section, SBZ5-7.

11: Rotaliid form, Sample no. 10, K1 Section, SBZ5-7.

17-22: Unidentified mississippinids, subaxial sections, **17**.Sample no 3, K1 Section, SBZ5-7; **18, 21**. Sample no 109, K9 Section, SBZ?; **19**.Sample no 107, K9 Section, SBZ?, **20**.Sample no 48, K5 Section, SBZ7-8, **22**. Sample no 109, K9 section.

23: *Orbitolites* sp.subaxial section,Sample no 13, K2 Section, SBZ12.

24-25: *Opertorbitolites* sp., oblique axial section of a broken specimen, **24**.Sample no 100, K9 Section, SBZ?;

25.Sample no 117, K10 Section, SBZ7-8.

26-28: *Orbitolites* sp., subaxial section, **26-27**.Sample no 13, K2 Section, SBZ12; **28**.Sample no. 101, K9 Section, SBZ?

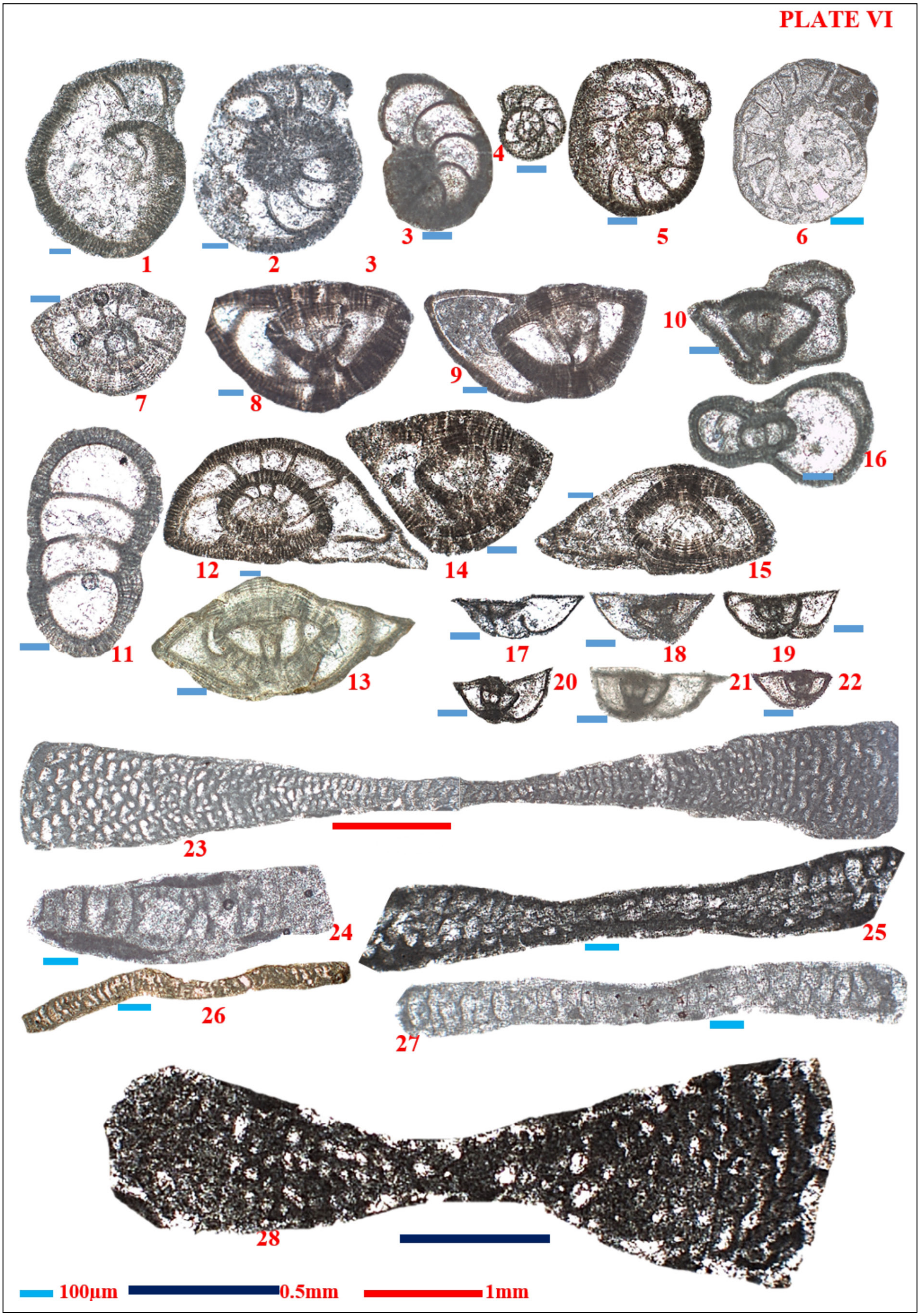
PLATE VI
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Plate VII

1: Rotaliid, subaxial section, Sample no 3, K1 Section, SBZ5-7.

2-3: *Pseudokathina selveri*, axial sections, **2**.Sample no 10,K1 Section, SBZ5-7; **3**.Sample no 107; K10 Section, SBZ7-8

4: Rotaliid, Sample no 64, K6 Section, SBZ3-4.

5: *Nummulites* sp., axial section, Sample no 16, K2 Section, SBZ12

6, 8: *Rotalia trochidiformis*, subvertical sections, **6, 8.**Sample no 10, K1 Section, SBZ5-7.

7: *Rotalia* sp., subvertical section, Sample no 8, K1 Section, SBZ5-7.

9: *Thalmannita?* sp., axial section, Sample no 10, K1 Section, SBZ5-7.

10: *Lockhartia haimei*, vertical section Sample no 8, K1 Section, SBZ5-7.

11: *Lockhartia* cf. *conditi*, subvertical section, Sample no 11, K1 Section, SBZ5-7.

12: *Lockhartia* sp., subvertical section, Sample no 98, K9 Section, SBZ?

13-17: Unidentified rotaliids, subvertical sections, **13**. Sample no 73,K8 Section, E7-E10; **14**. Sample no 12, K1 Section, SBZ5-7; **15**. Sample no 104, K9 Section, SBZ?; **16**. Sample no 4, K1 Section, SBZ5-7; **17**. Sample no 8, K1 Section, SBZ5-7.

18: Unidentified miscellanid, oblique section, Sample no 1, K1 Section, SBZ5-7

19: Unidentified rotaliid, Sample no 11, K1 Section, SBZ5-7.

20: *Soriella?* sp., vertical section, Sample no 5,K1 Section, SBZ5-7

21: *Elazigina?* sp., Sample no 23, K3 Section, SBZ5-8

22-25: Unidentified rotaliids, vertical section, **22**. Sample no 3,K1 Section, SBZ5-7; **23**. Sample no 7, K1 Section, SBZ5-7; **24**. Sample no 6, K1 Section, SBZ5-7; **25**. Sample no 10, K1 Section, SBZ5-7.

26: *Gyroidinella* sp., equatorial section, Sample no 72, K7 Section, SBZ10-11.

27-29: ?Unidentified rotaliids, **27**. Sample no 48, K5 Section, SBZ7-8; **28**. Sample no 10, K1 Section, SBZ5-7; **29**. Sample no 12, K1 Section, SBZ5-7.

30-31: Nodosariids, vertical sections, **30-31**.Sample no 8, K1 Section, SBZ5-7.


PLATE VII
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Plate VIII

1-6: *Discocyclina* sp., axial or subaxial sections, **1, 3.** Sample no 74, K8 Section, SBZ?; **2, 4, 6**. Sample no 73, K8 Section, SBZ?; **5.**Sample no 11, K1 Section, SBZ5-7.

7-9: *Nummulites* sp., axial sections, **7.** Sample no 52, K5 Section, SBZ7-8; **8**. Sample no 4, K1 Section, SBZ5-7;

9. Sample no 64, K6 Section, SBZ3-4.

10: *Asterigerina* ? sp., equatorialsection, Sample no 52, K5 Section, SBZ7-8.

11-13, 15: *Nummulites* sp., axial sections, **11-12**. Sample no 13, K2 Section, SBZ12; **13**. Sample no 15, K2 Section, SBZ12; **15**. Sample no 74, K8 Section, SBZ?

14: *Heterostegina* ?, subaxial section, Sample no 74, K8 Section, SBZ?

16: Nummulitidae gen. indet., Sample no 73, K8 Section, SBZ?

17: *Ranikothalia* sp., subaxial sections, Sample no 73, K8 Section, SBZ?

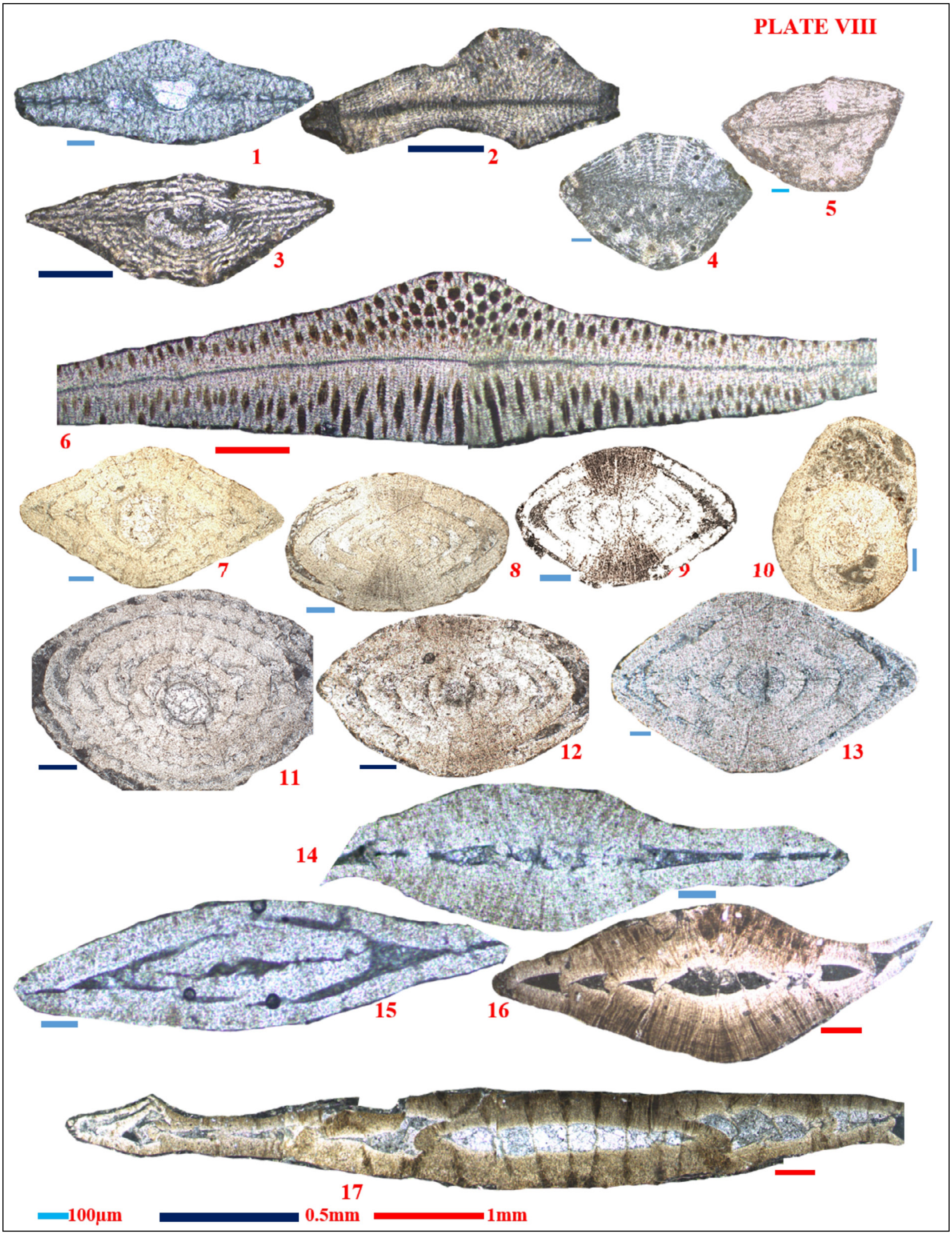
PLATE VIII
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Plate IX

1, 3, 5: *Globigerinatheka* sp., **1**. Sample no K83; K8 Section, E7-E10; **3, 5.** Sample no K81, K8 Section, E7-E10.

2, 10: *Globigerinatheka index*, **2.** Sample no K82, K8 Section, E7-E10; **10**. Sample no K81, K8 Section, E7-E10.

4, 6: *Globigerinatheka mexicana*, **4**. Sample no K83, K8 Section, E7-E10; **6**. Sample no K81, K8 Section, E7-E10.

7, 8: *Guembelitrioides nuttalli*, Sample no K81, K8 Section, E7-E10.

9: *Globigerinatheka kugleri*, Sample no K83, K8 Section, E7-E10.

11: *Subbotina crociapertura*, Sample no K82, K8 Section, E7-E10.

12, 13: *Pseudohastigerina micra*, Sample no K81, K8 Section, E7-E10.

14-15: *Acarinina bullbrooki*, **14**. Sample no K83, K8 Section, E7-E10; **15**. Sample no K82, K8 Section, E7-E10.

16: *Globigerinatheka subconglobata*, K82, K8 Section, E7-E10.

17: *Turborotalia pomeroli*, K82, K8 Section, E7-E10.

18: *Subbotina eocaena*, Sample no K82, K8 Section, E7-E10.

19-21: *Acarinina bullbrooki*, **19**. Sample no K75, K8 Section, E7-E10; **20**. Sample no K83, K8 Section, E7-E10; **21**. Sample no K80, K8 Section, E7-E10.

22: *Acarinina primitiva*, Sample no K78, K8 Section, E7-E10.

23: *Turborotalia frontosa*, Sample no K82, K8 Section, E7-E10.

24: *Turborotalia possagnoensis*, Sample no K83, K8 Section, E7-E10.

25-27: *Acarinina praetopilensis*, **25**.Sample no K81, K8 Section, E7-E10; **26**.Sample no K77, K8 Section, E7-E10; **27**.Sample no K80, K8 Section, E7-E10.

28, 29: *Globanomaina australiformis*, Sample no K81, K8 Section, E7-E10.

30: *Morozovelloides crassatatus*, Sample no K83, K8 Section, E7-E10.

31: A*carinina praetopilensis*, Sample no K79, K8 Section, E7-E10.

32-33: *Acarinina puntocarinata*, **32**.Sample no K82; **33**. Sample no K83;

34-36: *Morozoveloides bandyi*, Sample no K82, K8 Section, E7-E10.

37: *Acarinina* sp., Sample no K81, K8 Section, E7-E10.

38: *Subbotina linaperta*, Sample no K77, K8 Section, E7-E10.

39-41: *Acarinina boudreauxi*, **39**. Sample no K81, K8 Section, E7-E10; **40**. Sample no K76, K8 Section, E7-E10; **41**. Sample no K82, K8 Section, E7-E10.

42-43: *Acarinina pseudosubsphaerica*, **42**. Sample no K81, K8 Section, E7-E10; **43**. Sample no K80, K8 Section, E7-E10.

44: *Parasubbotina* sp., Sample no K81, K8 Section, E7-E10.

45-46: *Acarinina pseudosubsphaerica*, **45**. Sample no K81, K8 Section, E7-E10; **46**.Sample no K82, K8 Section, E7-E10, K8 Section, E7-E10.

47-48: *Pearsonites broedermanni*, **47**.Sample no K75, K8 Section, E7-E10; **48**.Sample no K83, K8 Section, E7-E10.

49-50: *Planorotalites capdevilensis*, Sample no K81, K8 Section, E7-E10.

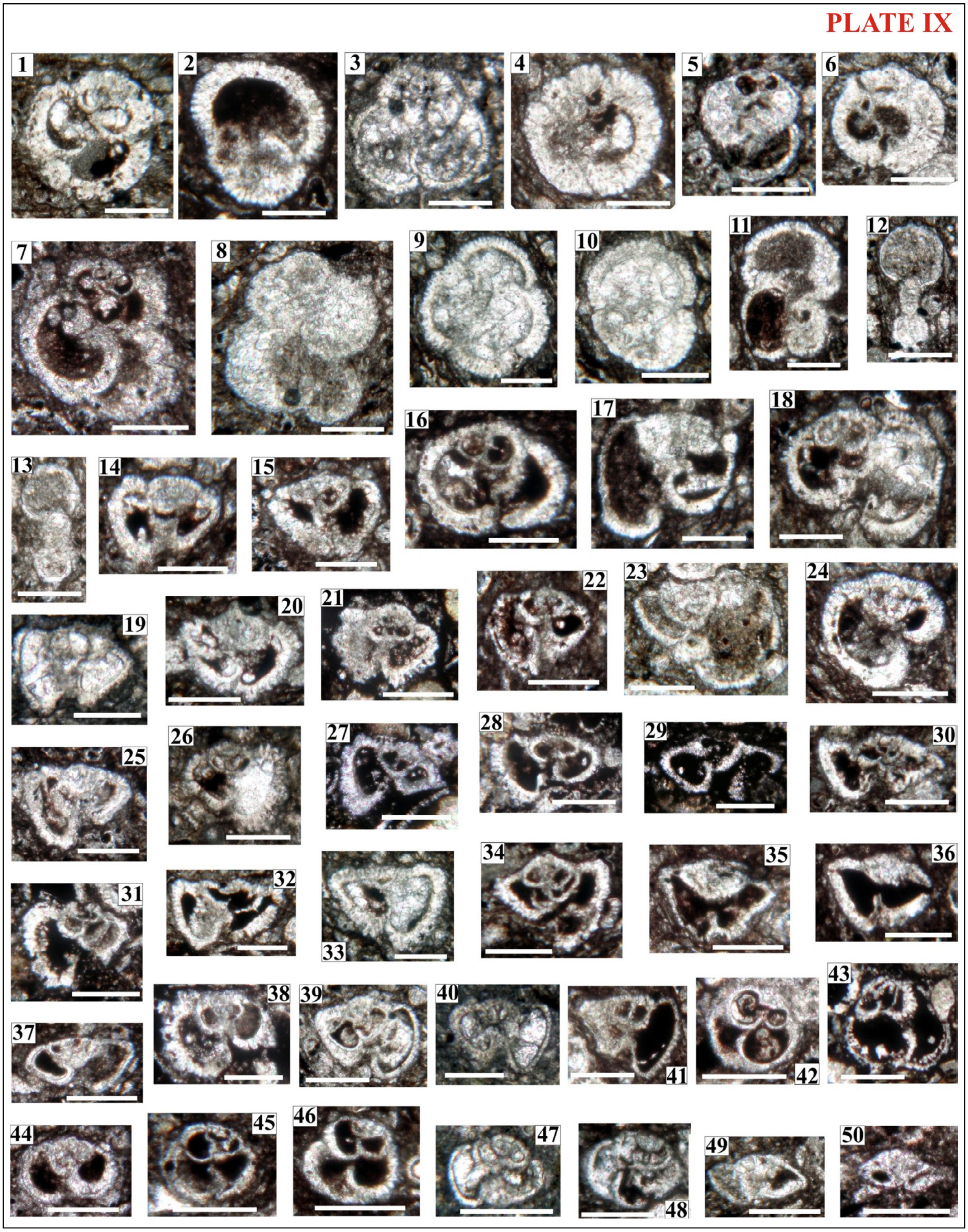
PLATE IX
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Plate X

Thin section views of described microfacies, mi. smaller miliolid, al. alveolinid, t. textulariid, n. nummulitids, r. rotaliid, pl. planktonic foraminifera, s. sparite, m. micrite, i. intraclast, q. quartze.

1-2: MF1. Smaller miliolid-dominated packstone-grainstone sub-facies, sample no.1 and 54.

3: MF2. Miliolid-textulariid dominated packstone sub-facies, sample no. 114

4: MF3. Alveolinid and other smaller miliolid-dominated packstone sub-facies, sample no. 117

5: MF4. Alveolinid-dominated packstone sub-facies,sample no. 47

6: MF5. Wackestone-packstone sub-facies containing less textulariid, sample no. 44

7: MF6. Alveolinid and nummulitid-dominated wackestone-packstone sub-facies, sample no. 49

8: MF7. Less rotaliid bearing silty mudstone sub-facies,sample no. 6

9: MF8. Rotaliid-dominated wackestone-packstone sub-facies, sample no.14

10: MF9. Packstone containing nummulitid form,sample no. 73

11: MF10. Less planktonic foraminiferous mudstone sub-facies,sample no. 56

12: MF11. Wackestone sub-facies with rich planktonic foraminifera,sample no. 81

13-14: MF1,sample no. 95

15: Grain supported sandstones, Sample no 110.

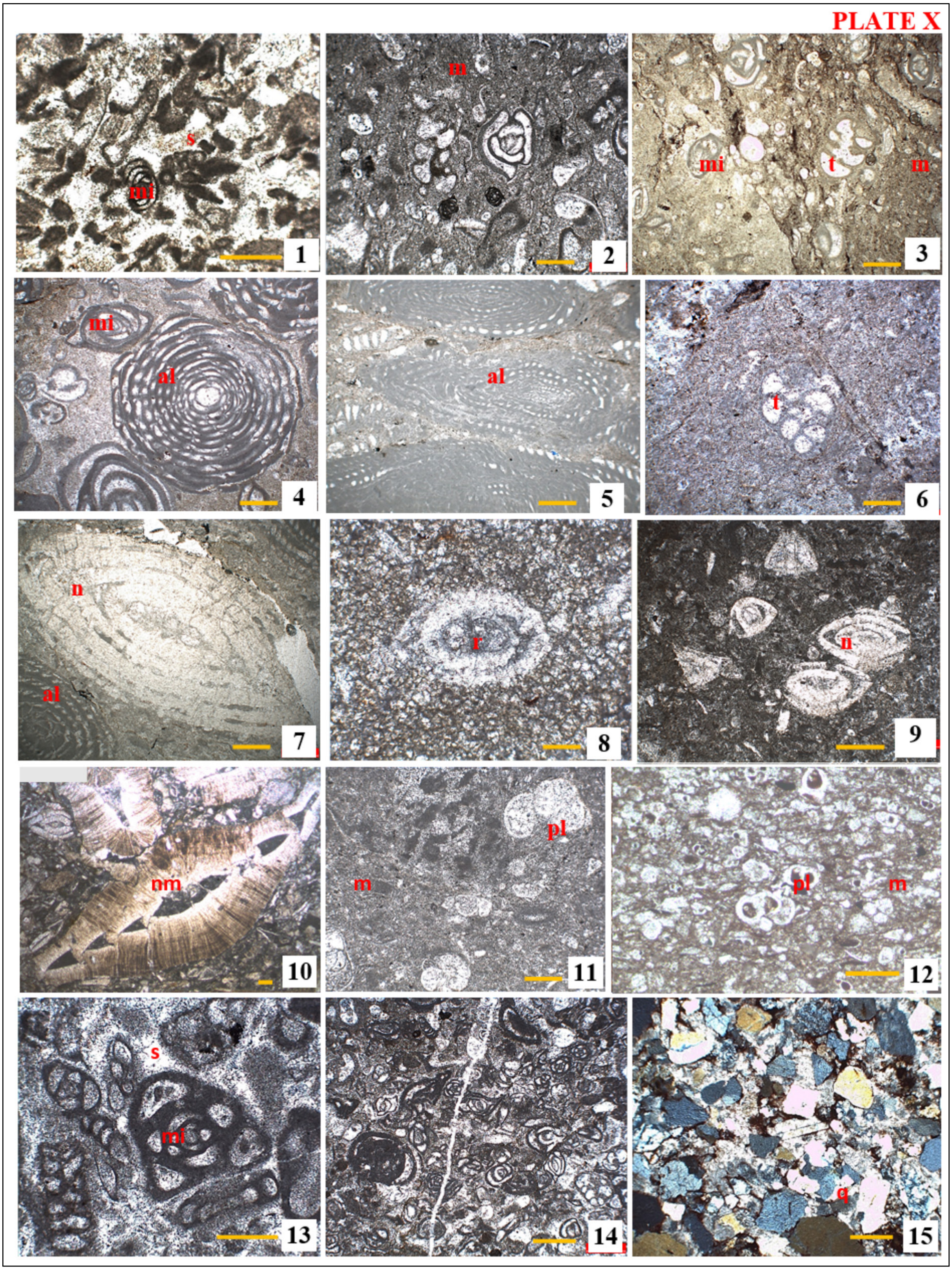
PLATE X
s
mi
1
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