Upper Maastrichtian – Eocene Planktonic Foraminiferal Zonation in the Beşparmak Range, Northern Cyprus

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ABSTRACT: The Lapta Group, Late Cretaceous-Middle Eocene in age, mainly consists of basal breccias, micritic limestones and clayey limestones with volcanic, calciturbidite and breccia interbeds. It unconformably overlies the Triassic-Lower Cretaceous platform carbonates in the Beşparmak (Kyrenia) Range. The detailed study of planktonic foraminiferal assemblages obtained from three stratigraphic sections through the Lapta Group revealed six biozones: *Racemiguembelina fructicosa* Zone and *Abathomphalus mayaroensis* Zone of Maastrichtian age; and *Acarinina uncinata* Zone (P2), *Morozovella angulata* Zone (P3), *Globanomalina pseudomenardii* Zone (P4) and *Morozovella velascoensis* Zone (P5) of Paleocene age. The Cretaceous-Tertiary boundary and the lower part of the Danian including *Guembelitria cretacea* (P0), *Parvularugoglobigerina eugubina* (Pa) and *Parvularugoglobigerina eugubina-Praemurcia uncinata* (P1) zones have not been recorded. Absence of this interval has been attributed to the volcanic level between micritic limestones and clayey limestones in the lower part of the sequence. The clayey limestones of the Lapta Group are overlain by radiolarian calcareous mudstones which pass into alternating siltstone and sandstone of the Ardahan Formation. In contrast to the Lapta Group, the Ardahan Formation lacks zonal marker species and is characterized generally by poorly preserved, less diverse and less abundant planktonic foraminiferal assemblages which hamper biozonation. However, the occurrences of typical Middle Eocene planktonic foraminiferal taxa such as *Acarinina bullbrooki* (Bolli)*, Globigerinatheka kugleri* (Bolli, Loeblich and Tappan), *Globigerinatheka subconglobata* (Shutskaya)*, Morozovella spinulosa* (Cushman), *Morozovella lehneri* (Cushman and Jarvis), *Truncorotaloides topilensis* (Cushman) and *Truncorotaloides rohri* Brönnimann and Bermudez together with *Turborotalia cerroazulensis cerroazulensis* (Cole) and *Globorotaloides suteri* Bolli suggest a Bartonian age for the Ardahan Formation.

INTRODUCTION

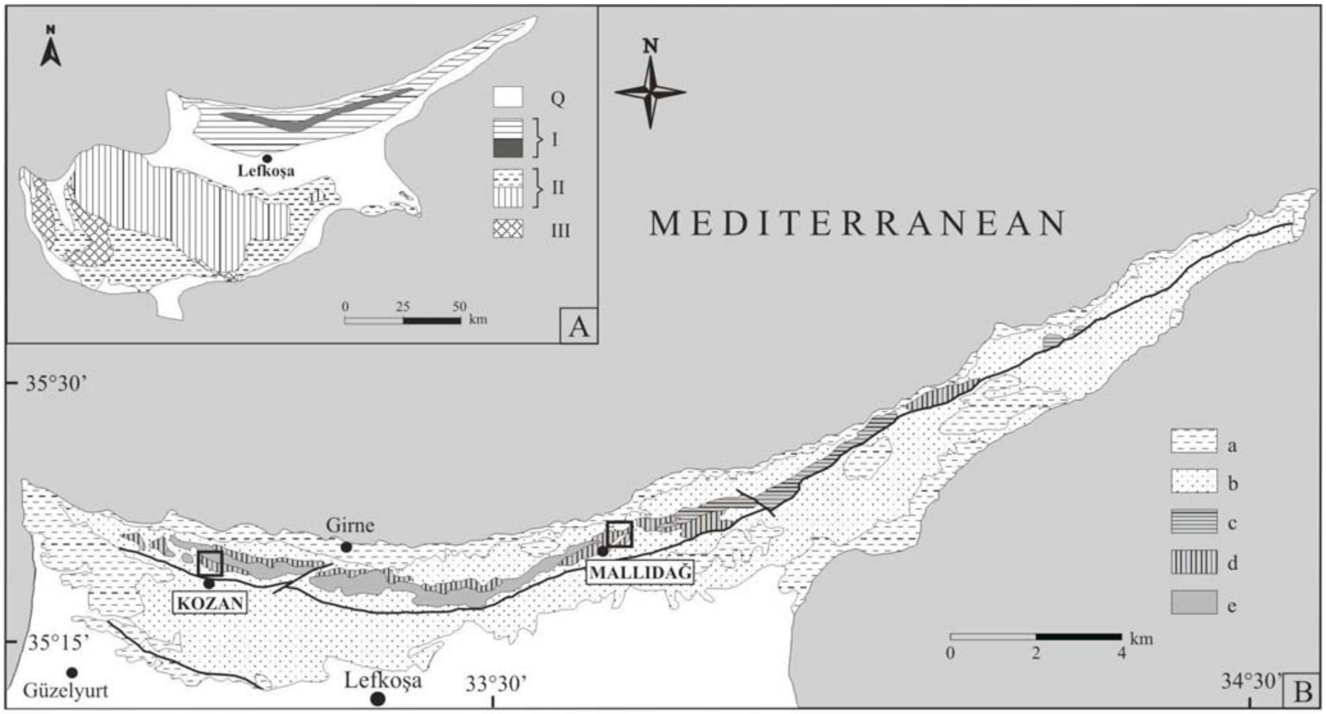
The main lithostratigraphic units on the island of Cyprus were identified by numerous studies ending in the 1940s (Gaudry 1862; Russell 1882; Bergeat 1892; Bellamy and Jukes-Browne 1905; Reed 1929, 1930; Browne and Mc Ginty 1939, 1946; Henson et al. 1949). Since 1960, more comprehensive investigations on the structural framework of the island have been carried out (Gass and Masson Smith 1963; Gass 1968; Pantazis 1968; Lapierre 1968 a, b; Knup and Kluyver 1969; Ducloz 1972; Robertson and Hudson 1974; Lapierre 1975; Robertson 1975, 1976, 1977 a, b, c; Baroz 1979; Robertson and Woodcock 1979, 1980, 1986). These studies formed the basis for a geological synthesis of Cyprus presented by Robertson (1990). According to him, Cyprus comprises three tectonostratigraphic units, as follows (text-fig.1A):

1) The Troodos Ophiolite is the preserved remnant of a small ocean during late Cretaceous time. 2) The Mamonia Complex comprises Triassic extrusive rocks of a small ocean basin and Mesozoic sedimentary rocks of a passive margin. 3) The Beşparmak (Kyrenia) Range is an Alpine-type fold and thrust belt in northern Cyprus. It is genetically related to the southernmost part of the Tauride Belt of southern Turkey and was deformed in the Late Cretaceous (pre-late Campanian) (Pantazis 1968; Dreghorn 1978; Robertson and Xenophontos 1993). The range has been divided into western, central and eastern parts (Robertson and Woodcock 1986). The central and eastern parts of the Beşparmak Range, in which our studied sections were measured, consist of a thick neritic and pelagic carbonate succession ranging in age from Triassic to Middle Eocene (text-fig.1B). The carbonate succession is overlain by clastic units of Middle-Late Eocene age (Baroz 1979; Robertson and Woodcock 1986; Hakyemez et al. 2002).

This study has focused on the Upper Cretaceous-Middle Eocene sequence of the Beşparmak Range. The studied succession includes the following four lithostratigraphic units: the Selvilitepe Breccia, the Mallıdağ Formation, the Yamaçköy Formation of the Lapta Group and lastly the Ardahan Formation. These units overly platform carbonates of Triassic-Early Cretaceous age. The sequence was previously dated as Late Cretaceous (Campanian)-Middle Eocene age (Henson et al. 1949; Knup and Kluyver 1969; Ducloz 1972; Baroz 1979; Hakyemez et al. 2002). The planktonic foraminiferal assemblage of the sequence has not been studied in detail except by Baroz (1979).

The aim of this study is to establish the basic biostratigraphic framework from Upper Cretaceous to Middle Eocene, to correlate it to standard biozonal schemes (Toumarkine and Luterbacher 1985; Premoli Silva and Sliter 1994; Berggren et al. 1995) and to evaluate the completeness of the sequence of the Lapta Group in the Beşparmak Range.

Three stratigraphic sections have been measured from the Lapta Group and the Ardahan Formation (text-fig. 1B). The lower part of the studied sequence including the Selvilitepe Breccia is rarely exposed throughout the Beşparmak Range. The Kozan



TEXT-FIGURE 1
A) Generalized main tectonostratigraphic units of Cyprus. I. Beşparmak Sequence, II: Troodos Ophiolite and circum-Troodos sedimentary rocks, III: Mamonia Complex, Q : Quaternary sediments (simplified from McCallum and Robertson 1995), B) Simplified geological map of Beşparmak Range. a: Mesaoria Group, b: Değirmenlik Group, c: Ardahan and Kantara formations, d: Lapta Group, e: Tripa Group (modified after Cyprus Geological Survey Department 1995).

Section was measured north of Kozan village in the central part of the Beşparmak Range. Middle and upper parts of the studied sequence, which include the Mallıdağ, Yamaçköy and Ardahan formations, are well exposed northeast of Mallıdağ village, in the eastern part of the Beşparmak Range. The Mallıdağ-I and -II composite section was measured along the Yamaçköy - Mallıdağ road in this region (text-fig. 1).

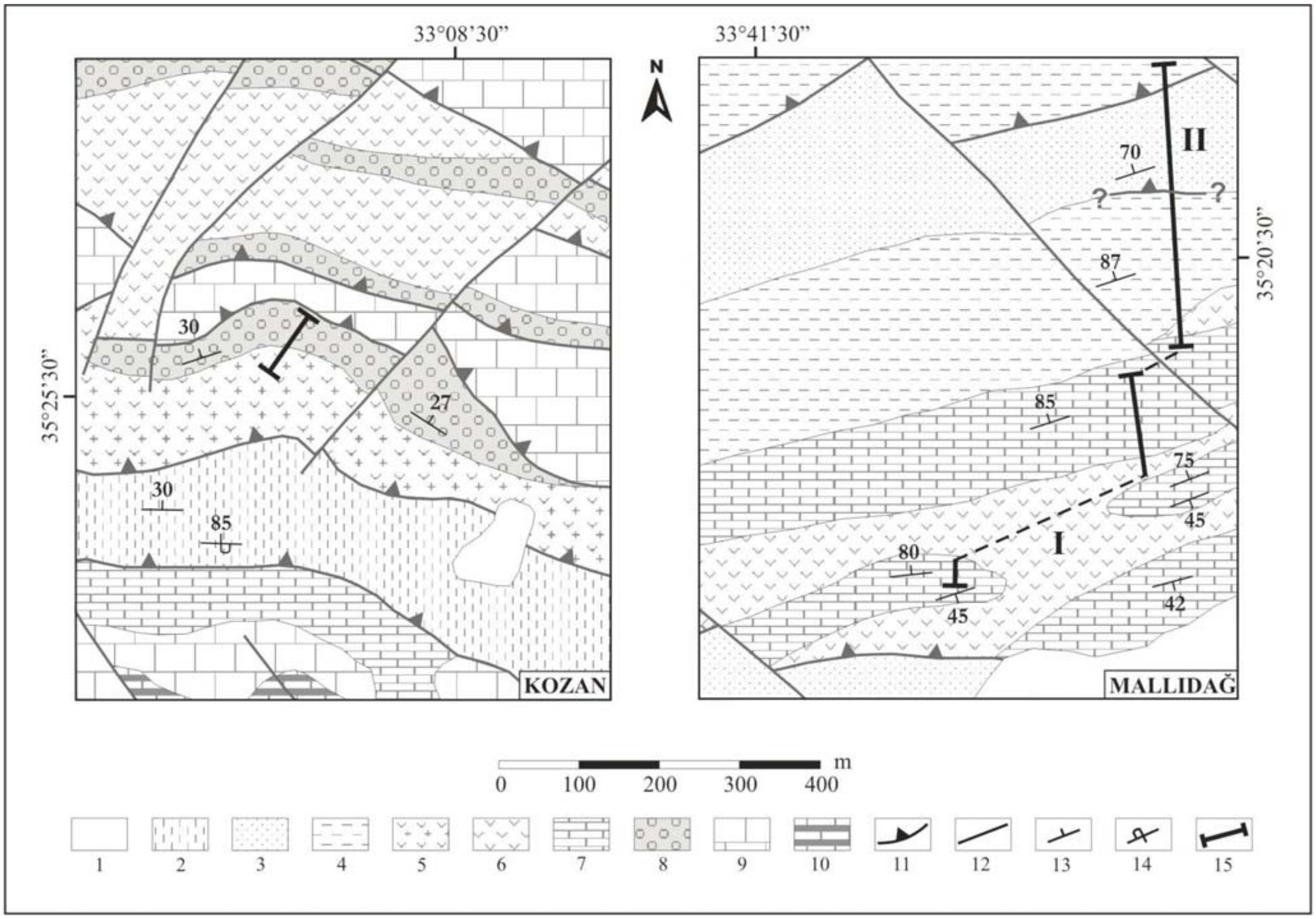
MATERIAL AND METHODS

A total of 86 samples was collected from three sections (text-fig. 2). The micritic limestone samples from the Kozan and Mallıdağ-I sections (Selvilitepe and Mallıdağ Formations) were studied in thin sections. However, samples from the Mallıdağ-II section (Mallıdağ, Yamaçköy and Ardahan Formations) were analysed in washed residues. In order to obtain isolated specimens of planktonic foraminifers, the clayey limestone samples were disaggregated by using acetic acid / chloroform technique modified after Knitter (1979), whereas samples of friable marls, siltstones and sandstones were treated with hydrogen-peroxide. All samples were washed through 250, 125 and 63µm sieves.

Stratigraphy of the Beşparmak Range

The lithostratigraphic sequence of the Beşparmak Range, one of the main tectonostratigraphic units of the Cyprus Island, ranges from Triassic to Late Miocene in age and comprises the following units (text-figs. 1, 2, 3):

The Tripa (Trypa) Group forms the main thrusted unit of the Beşparmak Range and consists mainly of dolomites and recrystallized limestones of Triassic-Early Cretaceous age (Ducloz 1964, 1972; Baroz 1979; Robertson and Woodcock 1986). The Alevkaya Melange overlies the Tripa Group and contains recrystalized limestone, radiolarite, volcanic and metamorphic rock blocks within a metasedimentary and metavolcanic matrix (text-fig. 3) (Hakyemez et al. 2002). It corresponds to the Kiparisso Vouno Formation of Late Campanian age (Baroz 1979). The Lapta Group, the main focus of this study, is Late Cretaceous-Middle Eocene in age and unconformably overlies the older rock units of the range. It comprises the Selvilitepe Breccia, Mallıdağ and Yamaçköy formations together with Yıldıztepe (andesite, rhyolite, dacite) and Çınarlı (basalt) volcanics (text-fig. 2, 3). The Selvilitepe Breccia consists of breccias with micritic limestone and calcarenite interbeds. North of Kozan village where the Kozan Section was measured (text-fig. 2A), the Selvilitepe Breccia has contacts stratigraphically with the Yıldıztepe volcanics at the bottom and Çınarlı volcanics at the top (Hakyemez et al. 2002). The Mallıdağ Formation is composed of micritic limestones including calciturbidite and volcanic beds. It is conformably overlain by the Yamaçköy Formation, whereas the lower contact of the formation with the Selvilitepe Breccia is not exposed in the studied areas (text-fig. 2A, 2B). The Yamaçköy Formation consists of clayey limestones with calciturbidite and breccia interbeds and is unconformably overlain by the Ardahan Formation. The latter in turn is composed of alternating siltstone



TEXT-FIGURE 2
Geological maps of Kozan (A) and Mallıdağ (B) areas 1. Alluvium, 2. Değirmenlik Group, 3. Ardahan Formation, 4. Yamaçköy Formation, 5. Yıldıztepe Volcanics, 6. Çınarlı Volcanics, 7. Mallıdağ Formation, 8. Selvilitepe Breccia, 9. Hillarion Formation, 10. Kaynakköy Formation, 11. thrust, 12. fault, 13. strike and dip, 14. strike and dip of overturned bed, 15. route of measured stratigraphic section (Baroz 1979; Hakyemez et al. 2002).

and sandstone with olistrostromal bodies (text-fig. 2B). It grades laterally and vertically into the Kantara Formation, which is made up of an olistrostromal unit containing pebbles and large limestone blocks of various ages from Late Permian to Middle Eocene (text-fig. 3) (Hakyemez et al. 2002). The Ardahan and Kantara formations, Middle-Late Eocene in age, were commonly combined under the name Kalogria-Ardana Formation in previous studies (Knup and Kluyver 1969; Baroz 1979; Robertson and Woodcock 1986). The thick turbiditic sequence of the Değirmenlik Group includes Messinian gypsum deposits in its uppermost parts. It is Oligocene-Miocene in age and unconformably overlies all older units in the range (text-fig. 1B, text-fig. 3).

Studied Sections

Kozan Section

The Kozan section was measured through the 20m thick breccias, the sandy calcarenites and sandy micrites of the Selvilitepe Breccia (text-fig. 4). A total of 11 samples was collected along the section. The lowest part of the section is represented by red, thin bedded micritic limestone (0.5m) resting on the volcanic rocks. The sequence passes upward into a brownish red, thick bedded sandy calcarenite (7.2m) which is barren of planktonic foraminifera. The sandy calcarenite is overlain by a second micritic limestone level (0.5m). These units are followed by yellowish green, sandy, micritic limestones (2m) and brown-red, massive breccias (9.5m). The clasts of breccias were derived from the dolomites and recrystalized limestones of the Tripa Group, and chert, phyllite, metavolcanic and serpentinite of the Alevkaya Melange. The uppermost part of the section is represented by pebbly, sandy calcarenites (0.5m) and then the breccia level (2m).

All samples, except K11 which was analysed in washed residue, were studied in thin sections (text-fig. 4). Moderately diverse and abundant planktonic foraminiferal assemblages in the samples indicate that the Selvilitepe Breccia in the Kozan Section is assignable to the *Abathomphalus mayaroensis* Zone (text-fig. 4).

The Mallıdağ-I Section

This section was measured through the Mallıdağ Formation, which is composed of micritic limestone and volcanic units (text-fig. 5). A total of 25 samples was collected from the sequence (72m). In the lower part of the section, thin bedded, reddish brown micritic limestones (4m) are followed by a volcanic unit (8m) including two interbeds of red, clayey limestones. The middle and upper parts (60m) of the section are composed of a lower micritic limestone (25m), a volcanic unit (15m), and then a second micritic limestone level (20m). The micritic limestones are commonly greenish grey (red in few levels) and thin bedded (text-fig. 5).

Because of the highly indurated lithology of most samples, planktonic foraminiferal assemblages were analyzed in thin sections. Only seven of 25 samples were studied in washed residues (text-fig.5). Highly diverse and abundant planktonic foraminiferal assemblages in the samples indicate that Mallıdağ Formation in the Mallıdağ-I section is assignable to the *Contusotruncana contusa-Racemiguembelina fructicosa* and *Abathomphalus mayaroensis* Zones (text-fig. 5).

Mallıdağ-II Section

The Mallıdağ-II section was measured through the Mallıdağ, Yamaçköy and Ardahan formations, successively (text-fig. 6, 7). A total of 50 samples was collected along the 210m thick section.

Reddish brown, thin bedded, micritic limestones at the base of the section (5m) are followed by andesitic volcanic rocks (12m) (text-fig. 6). The section continues with pink, fissile and thin bedded clayey limestones (25m) with rare intercalations of brown, medium bedded calciturbidites. The clayey limestones pass into alternating clayey limestone and marl (10m) including a covered part (3.5m). Following a 20 m thick covered interval, the clayey limestone and marl alternation (12m) continues and includes a breccia interbed (2m) whose grains were derived from rocks of Tripa Group. Radiolaria bearing calcareous mudstones with calciturbidite intercalations (7m) occur above the clayey limestones (text-fig. 6). The radiolarian mudstones are succeeded by siltstones, including conglomeratic channel deposits (4m) and calciturbidite and sandstone interlevels (25m) (text-fig. 7). Above, the succession continues with alternating thin bedded, green and grey sandstone and siltstone. In this part of the section, 10m cover could not be sampled. This clastic unit contains reworked planktonic foraminiferal assemblages derived from the Lapta Group (text-fig. 7). In the uppermost part of the section, the radiolarian mudstones (3.5m) are followed by an olistrostromal level with sandstone matrix (3m). The olistrostrome consists of various sizes of basic volcanics, chert, calciturbidite, ophiolite, metamorphic rock and clayey limestone clasts derived from the Lapta Group and Alevkaya Melange. This unit is tectonically overlain by pink, thin and fissile bedded clayey limestones of the Yamaçköy Formation (text-fig. 7).

The recorded planktonic foraminiferal assemblages of the Mallıdağ-II section represent the interval from uppermost Maastrichtian to Middle Eocene. At the base of the section, highly diverse and abundant specimens in the micritic limestone indicate that the Mallıdağ Formation is assignable to the *Abathomphalus mayaroensis* Zone (text-fig. 6). The clayey limestone samples of the section yield a moderately diverse planktonic foraminiferal assemblage. This assemblage indicates that the Yamaçköy Formation belongs to the *Acarinina uncinata* Zone (P2), *Morozovella angulata* Zone (P3), *Globanomalina pseudomenardii* Zone (P4) and *Morozovella velascoensis* Zone (P5) (text-fig. 6). The samples from the clastic sediments of the section yield a low diversity, low abundance and poorly preserved planktonic foraminiferal assemblage. This assemblage is dominated by *Acarinina bullbrooki* (Bolli), *Globigerinatheka subconglobata* (Shutskaya), *Globigerinatheka mexicana* (Cushman), *Globigerinatheka kugleri* (Bolli, Loeblich and Tappan), *Truncorotaloides topilensis* (Cushman), *Truncorotaloides rohri* Brönnimann and Bermudez, *Morozovella spinulosa* (Cushman), *Morozovella lehneri* (Cushman and Jarvis), *Globorotaloides suteri* Bolli and *Turborotalia cerroazulensis cerroazulensis* (Cole). The last two species indicate a Bartonian age for the Ardahan Formation (text-fig. 7). In the uppermost part of the section, the planktonic foraminiferal assemblage of the clayey carbonates has revealed the existence of two tectonic slices in the Yamaçköy Formation. The lower slice is represented by the Lower Eocene *Morozovella formosa* Zone (P7) and the upper slice corresponds to the Upper Paleocene *Morozovella velascoensis* Zone (P5) (text-fig. 7).

BIOSTRATIGRAPHY

Upper Maastrichtian - Middle Eocene strata in the Beşparmak Range contain 103 planktonic foraminiferal species belonging to 30 genera. The assemblage is moderately abundant and more diverse in the Selvilitepe Breccia, the Mallıdağ and Yamaçköy formations than in the Ardahan Formation. Preservation is moderately good, except in some Paleocene specimens which are mostly fragmented and display traces of dissolution. The specimens recorded from the Ardahan Formation are commonly badly preserved and they include a few reworked taxa. Several samples of this formation are barren of planktonic foraminifers.

The classifications of Robaszynski et al. (1984), Caron (1985), Loeblich and Tappan (1988), Premoli Silva and Verga (2004) are employed here for Maastrichtian taxa, whereas Paleocene taxa are classified according to Blow (1979), Toumarkine and Luterbacher (1985), Arenillas and Molina (1997), and Olsson et al. (1999) and Berggren and Norris (1997). The Maastrichtian-Paleocene interval of the studied sequence is assignable to the following six biostratigraphic zones (ascending order).

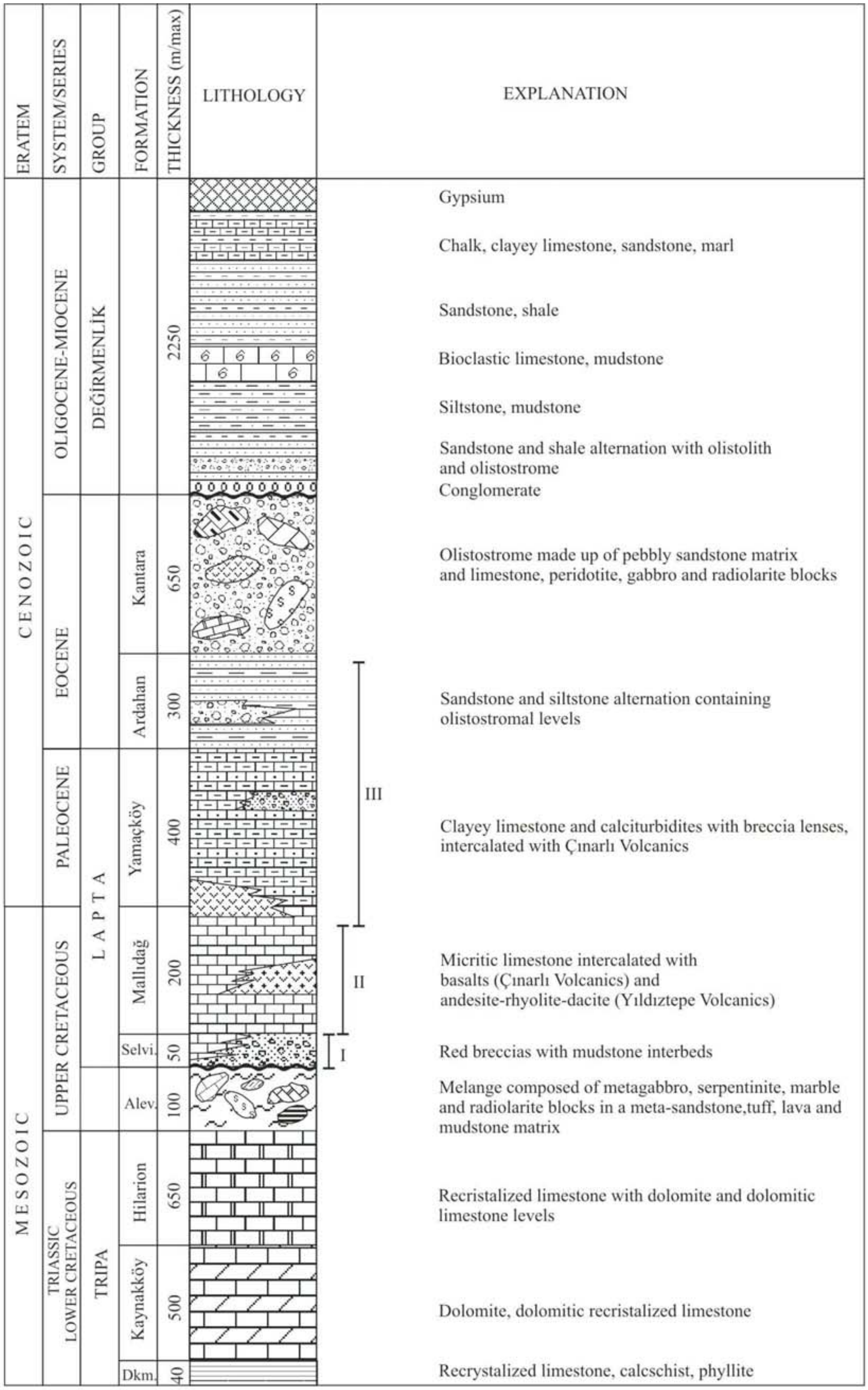
Racemiguembelina fructicosa Interval Zone

Definition: Interval between the first occurrences (FO) of *Racemiguembelina fructicosa* (Smith and Pessagno) and the FO of *Abathomphalus mayaroensis* (Bolli) (text-fig. 8).

Author: Smith and Pessagno (1973)

Age: Early to Late Maastrichtian

Remarks: This is the lowest zone encountered in this study. It was first defined as an upper zonule of the *Globotruncana gansseri* Subzone by Smith and Pessagno (1973). At the same time, *Contusotruncana contusa* Zone was separated from the *Gansserina gansseri* Zone by Premoli Silva and Bolli (1973) and then was emended by Premoli Silva and Sliter (1994) as the *Contusotruncana contusa-Racemiguembelina fructicosa* Zone. Although the first occurrences of *Contusotruncana contusa* and *Racemiguembelina fructicosa* are regarded as coeval in Premoli Silva and Sliter (1994)'s zonal scheme, Li and Keller (1998), and Arz and Molina (2002) recognized their first appearances in two successive levels. In this study, the first occurrences of *Contusotruncana contusa* and *Racemiguembelina fructicosa* were not observed successively because their actual first occurrences fall below the sampled interval. In Li and Keller's zonal scheme (1998), the Maastrichtian stage is subdivided into nine zones (CF9-CF1), two of which have been defined separately as



TEXT-FIGURE 3
Generalized stratigraphic section of the Beşparmak Range

the *Contusotruncana contusa* Zone (CF6) and the *Racemiguembelina fructicosa* Zone (CF4).

Specimens are moderately abundant in this zone. In washed samples (M23, M21), the population is characterized by poorly preserved, relatively rare taxa (text-fig. 5). Whereas *Racemiguembelina fructicosa* is consistently present in the zone, *Contusotruncana contusa* is very scarce. *Globotruncanita pettersi* (Gandolfi)*, Kuglerina rotundata* (Brönnimann)*, Globotruncanella citae* (Bolli) were recognized only in one sample (text-fig. 5).

The *Racemiguembelina fructicosa* Zone corresponds to the uppermost part of the *Gansserina gansseri* Zone. This zone is nearly equivalent to the *Globotruncana contusa contusa* Zone in Turkey (Meriç and Dizer 1980-1981; Güray 2006; Esmeray 2008). The *Racemiguembelina fructicosa* (CF4) Zone was also recorded in Egypt by Obaidalla (2005).

Stratigraphic distribution: In the Mallıdağ-I section, the *Racemiguembelina fructicosa* Interval Zone is represented by the interval between samples M25 and M19 (17.2m) (text-fig. 5).

Abathomphalus mayaroensis Total Range Zone

Definition: Interval of total range of *Abathomphalus mayaroensis* (Bolli) (text-fig. 8).

Author: Brönnimann (1952).

Age: Late Maastrichtian

Remarks: Due to the scarcity or absence of *Abathomphalus mayaroensis*, alternative biozones initially were used to characterize the uppermost Maastrictian, such as the *Globotruncana esnehensis* Zone (El Naggar 1966; Özkan and Altıner 1987) and the *Globotruncana falsocalcarata* Subzone (Kassab 1976) in the Tethyan Realm. Later, Keller (1988) proposed a new *Pseudotextularia deformis* Zone in El Kef (Tunisia), and Ion and Szasz (1994) proposed a new *Plummerita hantkeniniodes* Zone in Romania for the top of the Maastrichtian. Li and Keller (1998) proposed four zones in NW Tunisia: the *Plummerita hantkeniniodes, Pseudoguembelina palpebra, Pseudoguembelina hariaensis* and *Racemiguembelina fructicosa* zones. More recently, Arz and Molina (2002) subdivided the *Abathomphalus mayaroensis* Zone into three subbiozones: *Abathomphalus mayaroensis, Pseudoguembelina hariaensis* and *Plummerita hantkeniniodes* Subzones.

All of the recorded species of the *Contusotruncana contusa - Racemiguembelina fructicosa* Zone have also been recognized in the *Abathomphalus mayaroensis* Zone, but the planktonic foraminiferal assemblages of the latter are more abundant and diverse than in the former. In the Mallıdağ-I section, *A. mayaroensis* is almost consistently present throughout the zone but it is very poorly preserved in the upper part of the section. *Racemiguembelina fructicosa, Globotruncanita pettersi, Globotruncana dupeublei* (Caron, Gonzalez Donoso, Robaszynski and Wonders), and *G. esnehensis* Nakkady are recognized in most of the samples whereas *Contusotruncana plicata* (White), *Globotruncanita angulata* (Tilev), *Plummerita reicheli* (Brönnimann)*, Rugoglobigerina macrocephala* Brönnimann, *Rugoglobigerina hexacamerata* Brönnimann, *Schackoina multispinata* (Cushman and Wickenden), and *Kassabiana falsocalcarata* (Kernady and Abdelsalam) are very rare (text-fig. 5). The *Abathomphalus mayaroensis* Zone has been recorded also in the Kozan and Mallıdağ-II sections (text-fig. 4, 6), where planktonic foraminiferal assemblages are very similar to those of the Mallıdağ-I section.

The *Abathomphalus mayaroensis* Zone has been recorded in Turkey (Dizer and Meriç 1980-1981; Güray 2006); Tunisia (Peybernés et al. 1996; Molina et al. 1996; Karoui-Yaakoub et al. 2002; Arenillas et al. 2000a,b); Austria (Peryt et al. 1993) and Spain (Apellaniz et al. 1997; Arz and Molina 2002). The *Plummerita hantkeninoides* Zone was recorded by numerous authors in Spain and Tunisia below the K/T boundary, above or within the *Abathomphalus mayaroensis* Zone (Molina et al. 1996, 1998, 2006; Arenillas et al. 2000a, b; Karoui-Yaakoub et al. 2002). In Egypt, Keller et al. (2002) also recognized the *Plummerita hantkeninoides* Zone (CF1) above the *Pseudoguembelina hariaensis* and *Pseudoguembelina palpebra* zones (CF3, CF2 respectively).

Stratigraphic distribution: The *Abathomphalus mayaroensis* Zone corresponds to the interval between M18 and M1 (54.6m) in the Mallıdağ-I section, between K11 and K1 (20m) in the Kozan section and between A1 and A4 (5m) in the Mallıdağ-II section (text-fig. 4, 5, 6).

Acarinina uncinata Interval Zone (P2)

Definition: Interval between the FO of *Acarinina uncinata* (Bolli) and the FO of *Morozovella angulata* (White) (text-fig. 8).

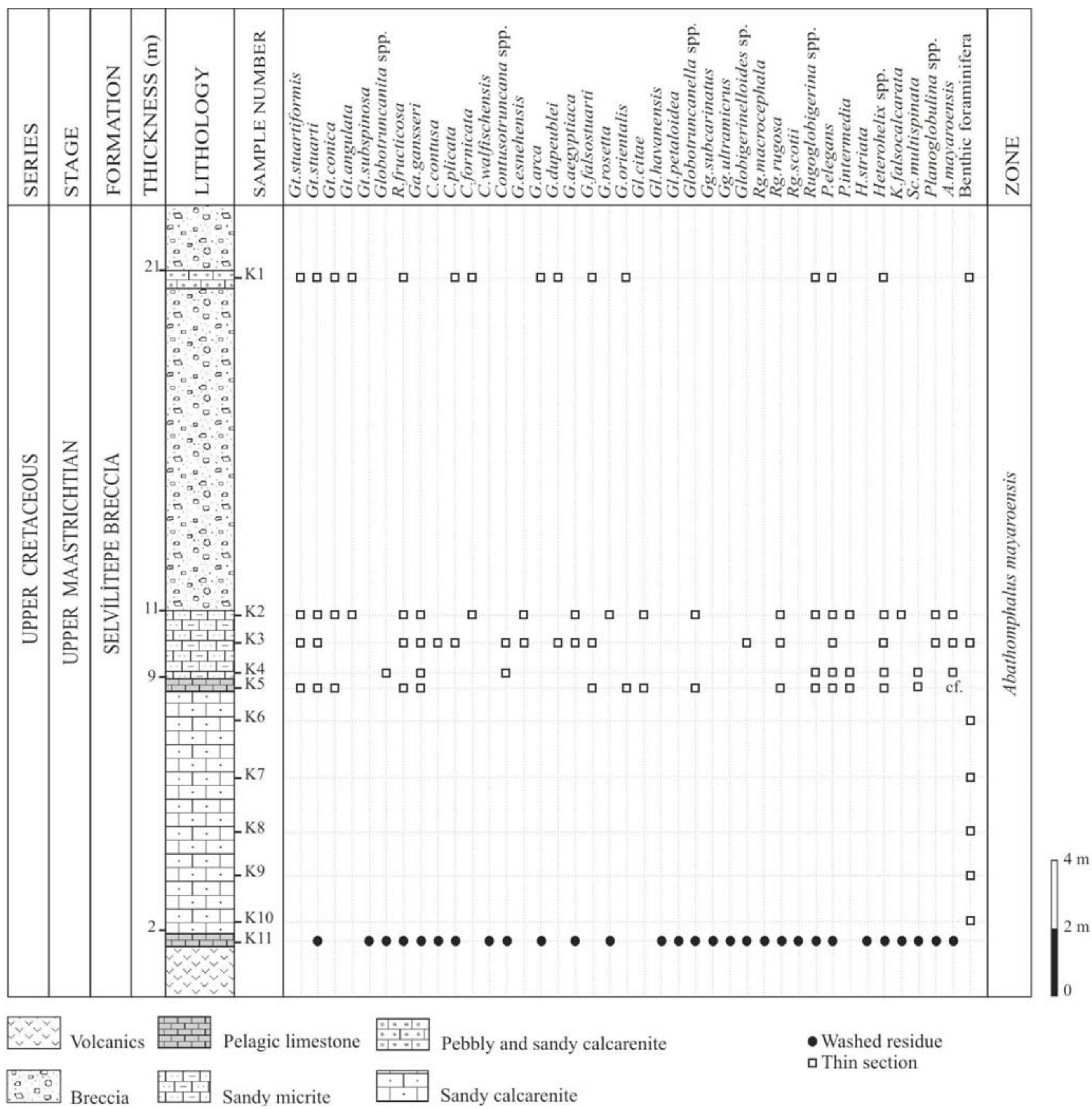
Author: Bolli 1957; emended by Bolli 1966

Age: late Early Paleocene (late Danian)

Remarks: This zone was introduced by Bolli (1957) as the *Globorotalia uncinata* Zone. He defined this zone by using the FO of *Globorotolia uncinata* (Bolli) and the FO of *Globorotalia pusilla pusilla* (Bolli) and then Bolli (1966) emended the definition of the upper boundary by using the FO of *Globorotolia angulata* (White) instead of *Globorotolia pusilla pusilla*. Berggren et al. (1995) renamed this zone the *Praemurica uncinata - Morozovella angulata* Interval Zone (P2) by using the same bioevents. The zone is also equivalent to the *Morozovella uncinata - Igorina spiralis* Zone (Berggren 1969; Berggren and Miller 1988).

The planktonic foraminiferal fauna, characterized by very abundant but low diversity assemblages, is dominated by *Parasubbotina pseudobulloides* (Plummer) and *Praemurica inconstans* (Subbotina). *Subbotina triloculinoides* (Plummer), *Eoglobigerina edita* (Subbotina) and *Globanomalina compressa* (Plummer) are rare components of the assemblage (text-fig. 6). *Globanomalina ehrenbergi* (Bolli) first appears in the uppermost part of the zone, and *Eoglobigerina edita* disappears in the same sample (A10).

This zone has been defined also as the *Globorotalia uncinata* Zone in Cyprus (Baroz 1979) (text-fig. 9) and Egypt (Faris 1984), as the *Acarinina uncinata* Zone in Spain and Italy (Canuda and Molina 1992; Arenillas and Molina 1997; Arenillas 1998) and in southern Cyprus and Syria (Krasheninnikov and Kaleda 1994; Krasheninnikov 1994) (text-fig. 9), as the *Morozovella uncinata* Zone in Turkey (Tansel 1989) and Egypt (Strougo et al. 1992; Shahin 1992), and as the



TEXT-FIGURE 4
Stratigraphic distribution of planktonic foraminifers in the Kozan section. ***A:*** *Abathomphalus*, ***C:*** *Contusotruncana*, ***Ga:*** *Gansserina*, ***Mg:*** *Macroglobigerinelloides*, ***G:*** *Globotruncana*, ***Gl:*** *Globotruncanella*, ***Gt:*** *Globotruncanita*, ***H:*** *Heterohelix*, ***K:*** *Kassabiana*, ***Kg:*** *Kuglerina*, ***R:*** *Racemiguembelina*, ***Rg:*** *Rugoglobigerina*, ***P:*** *Pseudotextularia*, ***Pl:*** *Plummerita*, ***Tn:*** *Trinitella*, ***Sc:*** *Schackoina*, ***Ac:*** *Acarinina*, ***E:*** *Eoglobigerina*, ***Gb:*** *Globanomalina*, ***Gn:*** *Globigerinatheka*, ***Gd:*** *Globorotaloides*, ***Ha :*** *Hantkenina*, ***I:*** *Igorina*, ***M:*** *Morozovella*, ***Pa:*** *Parasubbotina*, ***Pr:*** *Praemurica*, ***S:*** *Subbotina*, ***T:*** *Truncorotaloides*, ***Tb:*** *Turborotalia*

Praemurica uncinata Zone in Egypt (Marzouk and Lüning 1998; El-Nady 2005; Abdel-Kireem and Samir 1995).

Stratigraphic distribution: This zone corresponds to the interval between samples A6 and A10 (25m) in the Mallıdağ-II section.

Morozovella angulata **Interval Zone (P3)**

Definition: Interval between the FO of *Morozovella angulata* (White) and the FO of *Globanomalina pseudomenardii* (Bolli) (text-fig. 8).

Author: Alimarina 1963 (in Tourmarkine and Luterbacher 1985); emended in Berggren et al. 1995.

Age: Late Paleocene (Selandian)

Remarks: This zone was proposed by Alimarina (1963) as the *Globorotalia angulata* Zone. It was redefined by Bolli (1966) as the successive FOs of *Globorotalia angulata* and *Globorotalia pusilla pusilla.* However, Blow (1979) pointed out that the FO of *Globorotalia (Planorotalites) pusilla pusilla* was earlier than that of *Globorotalia (Morozovella) angulata angulata*. Therefore, the *Globorotalia pusilla pusilla* Zone, which was favored over the *Globorotalia angulata* Zone by Bolli (1966), was included in the *Globorotalia (Morozovella) angulata angulata* Zone in Blow's (1979) zonal scheme. Berggren and Miller (1988) subdivided the *Morozovella angulata* Zone into two subzones: the *Morozovella angulata* Subzone (P3a) and the *Morozovella angulata - Igorina pusilla* Subzone (P3b) based on the FO of *Igorina pusilla*. However, Berggren et al. (1995) showed that the FO of *Igorina pusilla* coincided with the FO of *Morozovella angulata*, as did Blow (1979). Therefore, they have used the FO of *Igorina albeari* (Cushman and Bermudez) instead of the FO of *Igorina pusilla* in their zonation and have proposed two subzones: the *Morozovella angulata-Igorina albeari* Interval Subzone (P3a) and the *Igorina albeari-Globanomalina pseudomenardii* Interval Subzone (P3b) (text-fig. 8). Arenillas and Molina (1997) subdivided this zone into three zones: *Morozovella angulata, Morozovella crosswicksensis,* and *Igorina albeari*.

The *Morozovella angulata* Zone of this study comprises the P3a and P3b subzones of Berggren et al. (1995). The FOs of *Morozovella angulata* and *Igorina albeari* were recorded in samples A11 and A13, respectively. Based on these bioevents, samples A11-A12 correspond to Berggren et al.'s (1995) *Morozovella angulata - Igorina albeari* Interval Subzone (P3a). However, *Igorina albeari* has been recognized in only one sample (A13) which was collected from one exposed level within a thick covered interval. The presence of *Igorina albeari* and the absence of *Globanomalina pseudomenardii* indicates that this level could be assigned to *Igorina albeari - Globanomalina pseudomenardii* Subzone (3b) (text-fig. 6, 8).

The assemblage is moderately diverse and better preserved than that of the underlying zone, and is dominated by *Acarinina uncinata, Parasubbotina pseudobulloides, Subbotina triloculinoides* and *Globanomalina ehrenbergi*. Whereas first occurrences of *Parasubbotina varianta* (Subbotina), *Pa. variospira* (Belford) and *Morozovella conicotruncata* (Subbotina) were recorded in the lowest part of the zone, the local first occurrences of *Subbotina velascoensis* (Cushman), *Igorina pusilla* and *Acarinina strabocella* (Loeblich and Tappan) are in the upper part of the zone. *Globanomalina compressa* disappeared within this interval. The upper boundary has not been identified exactly because of the 20m thick covered interval.

This zone is equivalent to the *Globorotalia angulata* Zone in Cyprus (Baroz 1979) (text-fig. 9), Egypt (Faris 1984) and Turkey (Meriç et al. 1987); and the *Morozovella angulata* Zone in Turkey (Tansel 1989), Spain (Canuda and Molina 1992), Egypt (Strougo et al. 1992; Shahin 1992; El-Nady 2005; Abdel-Kireem and Samir 1995; Marzouk and Lüning 1998), southern Cyprus and Syria (Krasheninnikov and Kaleda 1994; Krasheninnikov 1994) (text-fig. 9), and Italy (Konijnenburg et al. 1998).

Stratigraphic distribution: In the Mallıdağ-II section, this zone corresponds to the interval including samples A11, A12, A13 (10m).

Globanomalina pseudomenardii **Total Range Zone (P4)**

Definition: Interval of the total range of *Globanomalina pseudomenardii* (Bolli) (text-fig. 8).

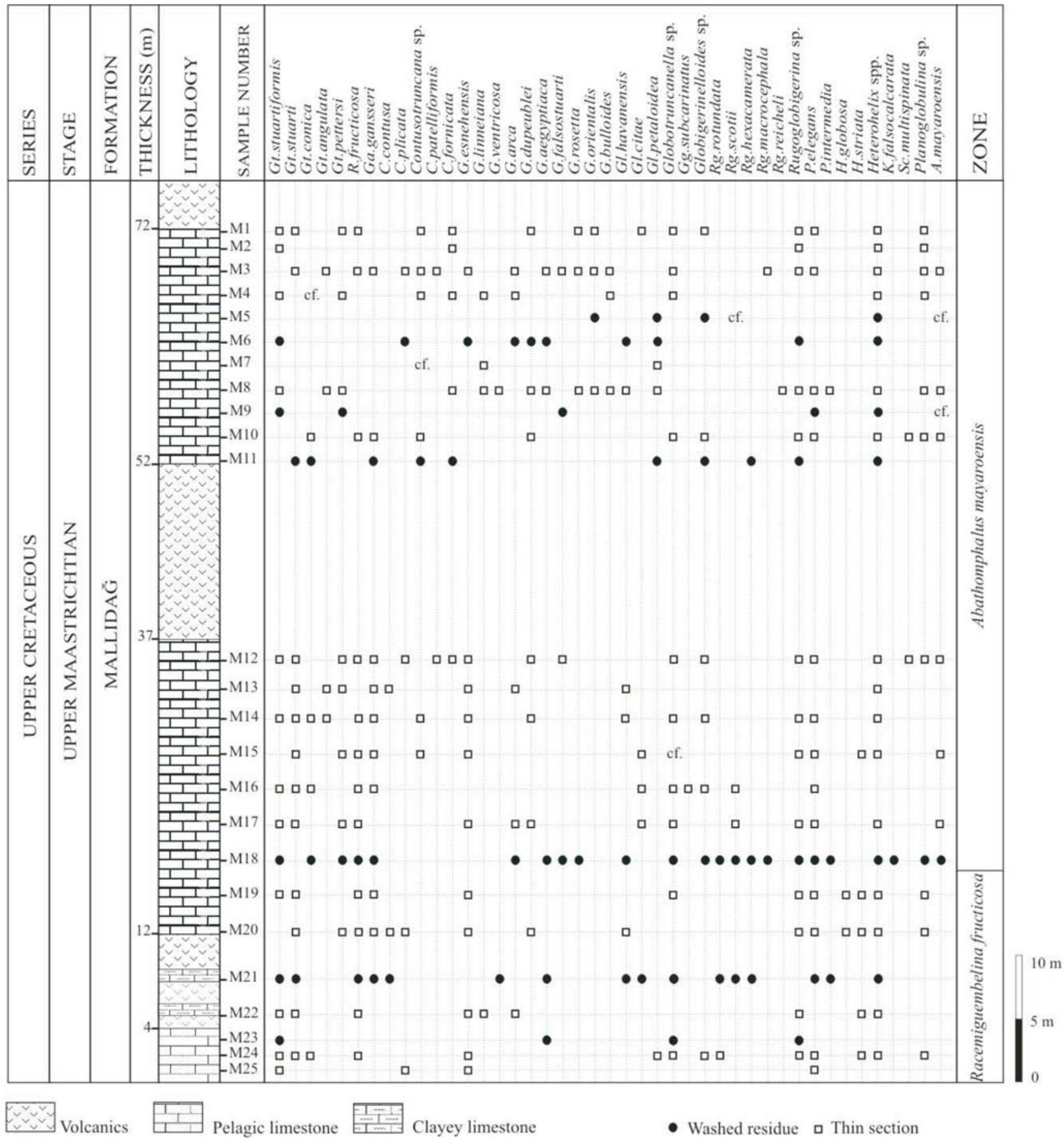
Author: Bolli 1957.

Age: Late Paleocene (late Selandian-Thanetian)

Remarks: An alternative zone replacing the *Globorotalia pseudomenardii* Zone has not been proposed since it was first defined by Bolli (1957) because the zonal taxon, *Globanomalina pseudomenardii* has an easily recognizable morphology, wide geographic range and short stratigraphic range. Nevertheless, Berggren et al. (1995) subdivided this zone into the following three subzones: *Globanomalina pseudomenardii - Acarinina subsphaerica* Concurrent Subzone (P4a), *Acarinina subsphaerica - Acarinina soldadoensis* Interval Subzone (P4b), and *Acarinina soldadoensis - Globanomalina pseudomenardii* Concurrent Range Subzone (P4c). Similarly, Arenillas and Molina (1997) and Molina et al. (1999) subdivided this biozone into two subbiozones: *Luterbacheria pseudomenardii* and *Muricoglobigerina soldadoensis* Subzones.

In this study, the *Globanomalina pseudomenardii* Zone is correlated to the *Globanomalina pseudomenardii - Acarinina subsphaerica* Concurrent Range Subzone (P4a) of Berggren et al.'s scheme (1995). *Globanomalina pseudomenardii* has been recognized together with *Acarinina subsphaerica* (Subbotina 1947) in samples A14 and A15 from the clayey limestones above the thick covered interval (20m). Subzones P4b and P4c of Berggren et al.'s (1995) zonal scheme could not be recognized because of the presence of a breccia unit (2m) above sample A15 (text-fig. 6). Since the *Morozovella velascoensis* Zone (P5) has been recognized in the first sample of the clayey limestone level above the breccia, the unrecorded P4b and P4c subzones might correspond to the breccia level (text-fig. 6).

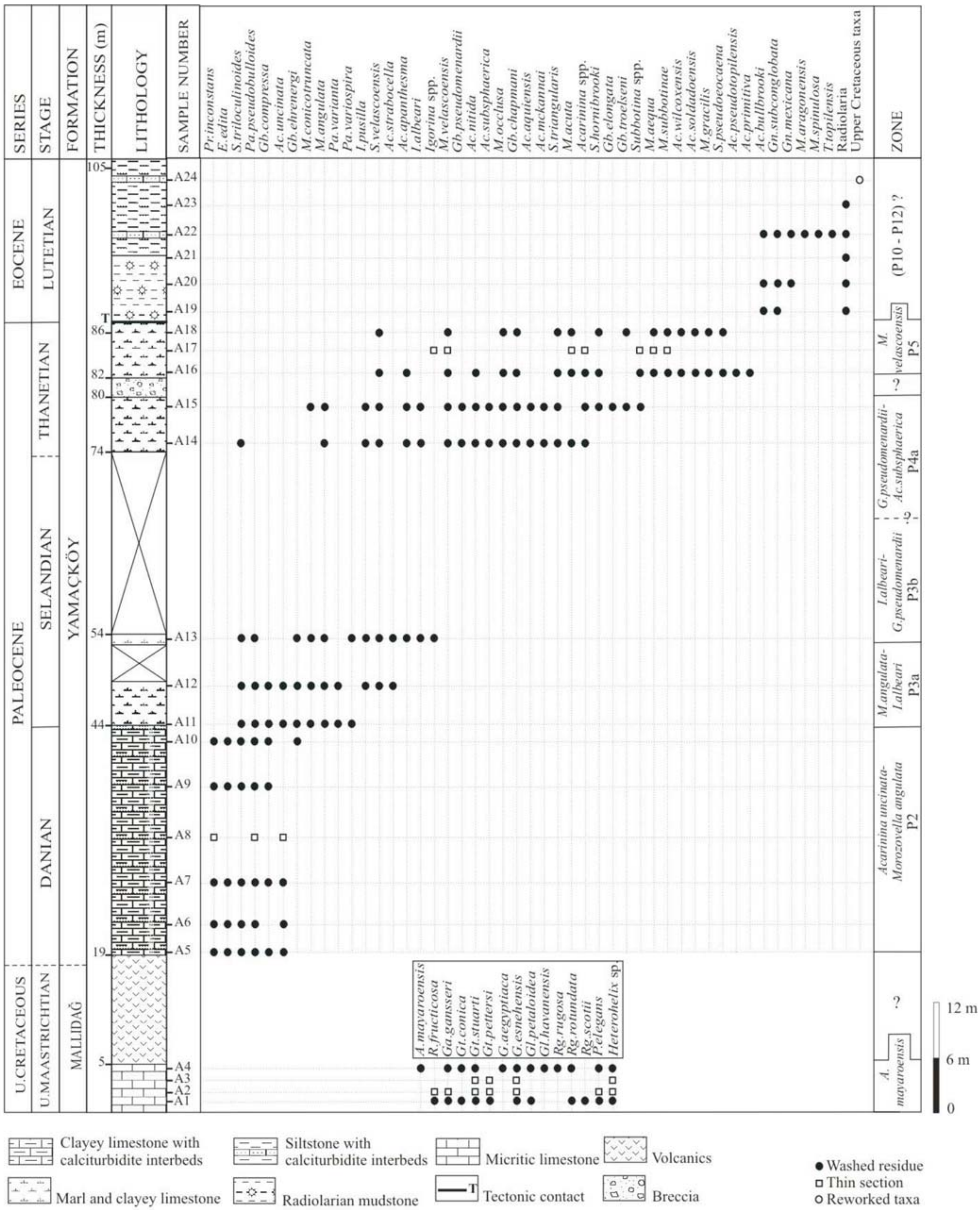
The assemblage in this interval is characterized by abundant and diverse morozovellids, subbotinids and acarininids (text-fig. 6). Besides the zonal marker, other species that first occur in this subzone are *Acarinina subsphaerica*, *Morozovella velascoensis, M. acuta* (Toulmin)*, M. occlusa* (Loeblich and Tappan)*, Acarinina mckannai* (White), *Ac.nitida* (Martin), *Ac. aquiensis* (Loeblich and Tappan)*, S. triangularis* (White), *S. hornibrooki* (Bronnimann), *Globanomalina chapmani* (Parr)*, Gb. elongata* (Glaessner)*,* and *Gb. troelseni* (Loeblich and Tappan)*. Acarinina apanthesma* (Loeblich and Tappan) and *Subbotina*



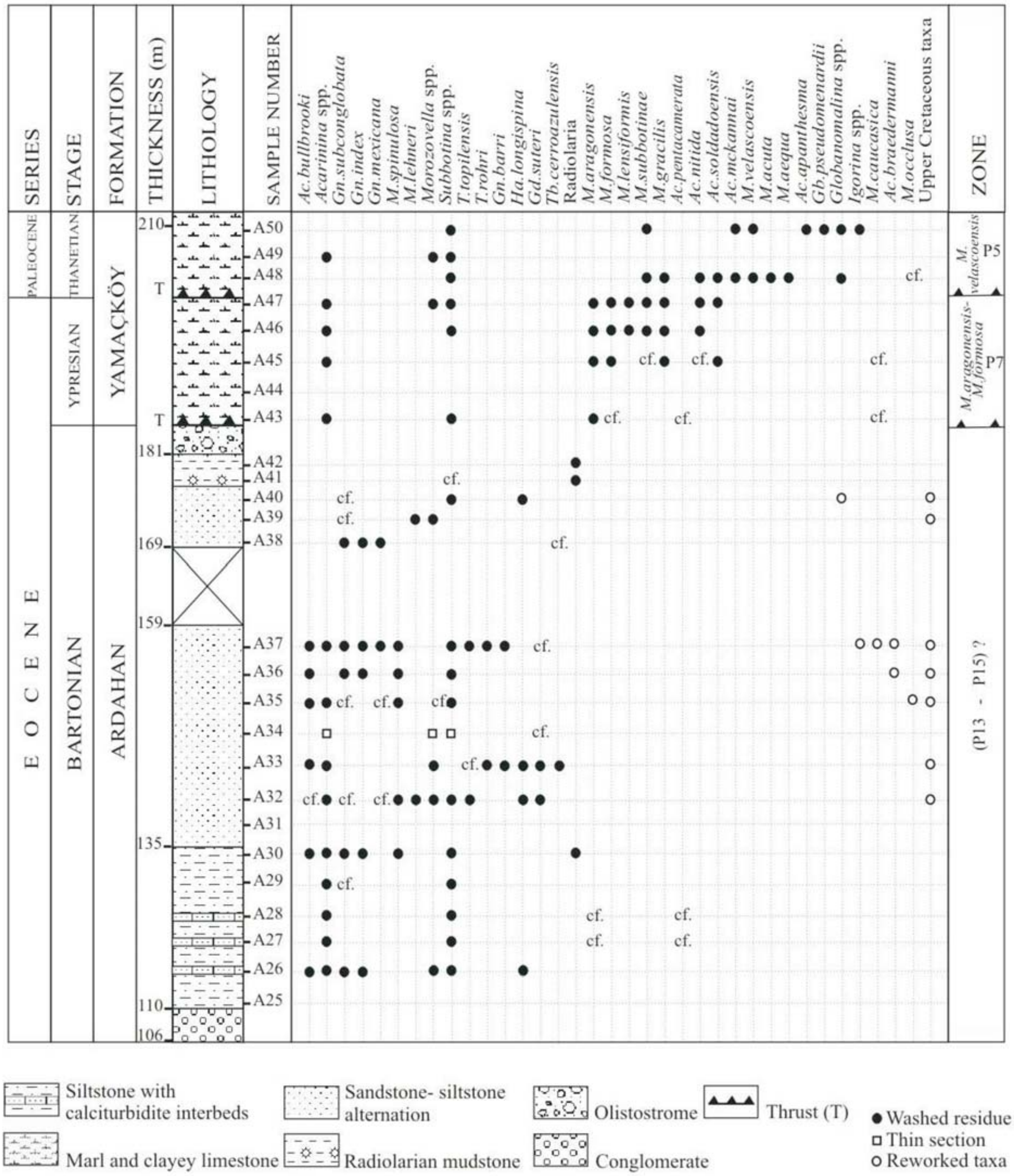
TEXT-FIGURE 5
Stratigraphic distribution of planktonic foraminifera in the Mallıdağ-I section.

velascoensis range into this zone from below, and *Morozovella angulata, M. conicotruncata, Subbotina triloculinoides, Igorina pusilla,* and *I. albeari* disappear within this zone (text-fig. 6).

This zone is equivalent to the *Globorotalia pseudomenardii* Zone in Cyprus (Mantis 1970; Baroz 1979) (text-fig. 9), Turkey (Dizer and Meriç 1980-1981) and Egypt (Faris 1984); the *Planorotalites pseudomenardii* Zone in Turkey (Tansel 1989), Egypt (Strougo et al. 1992; Shahin 1992; Abdel-Kireem and Samir 1995), southern Cyprus and Syria (Krasheninnikov and Kaleda 1994 and Krasheninnikov 1994) (text-fig. 9), Spain (Canuda and Molina 1992; Bolle et al. 1998; Molina et al. 1994; Canudo et al. 1995; Lu et al. 1998), Israel (Lu et al. 1998), Italy



TEXT-FIGURE 6
Stratigraphic distribution of planktonic foraminifera in the Mallıdağ-II section



TEXT-FIGURE 7
Stratigraphic distribution of planktonic foraminifera in the Mallıdağ-II section (continued)

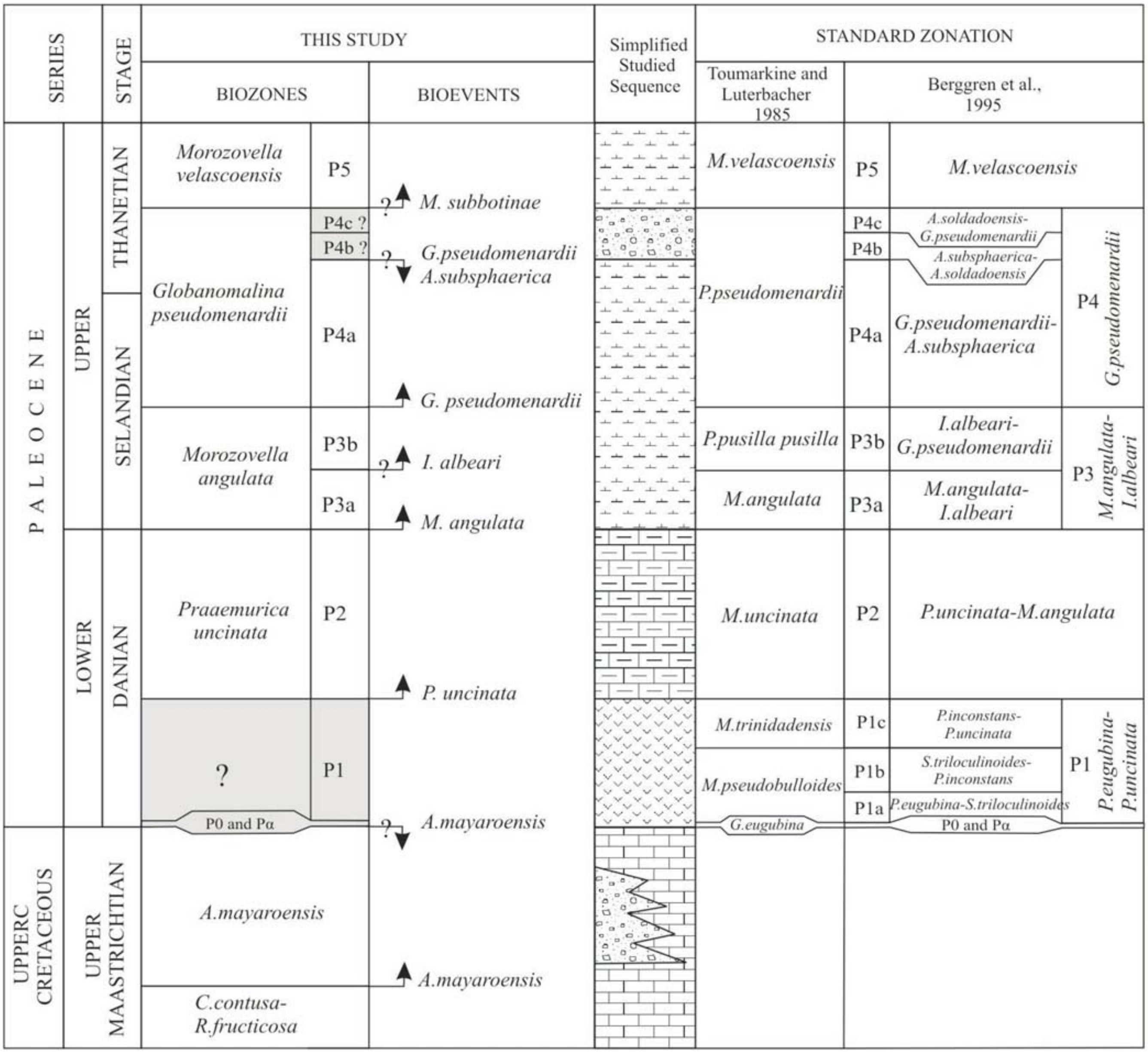
(Konijnenburg et al. 1998) and France (Steurbaut and Sztràkos 2002); and the *Globanomalina pseudomenardii* Zone in Egypt (Marzouk and Lüning 1998; El-Nady 2005).

Stratigraphic distribution: In the Mallıdağ-II section this zone is present in samples A14 and A15 (minimum thickness is 6m).

Morozovella velascoensis **Interval Zone (P5)**

Definition: Interval between the LO of *Globanomalina pseudomenardii* (Bolli) and the LO of *Morozovella velascoensis* (Cushman) (text-fig. 8).

Author: Bolli 1957

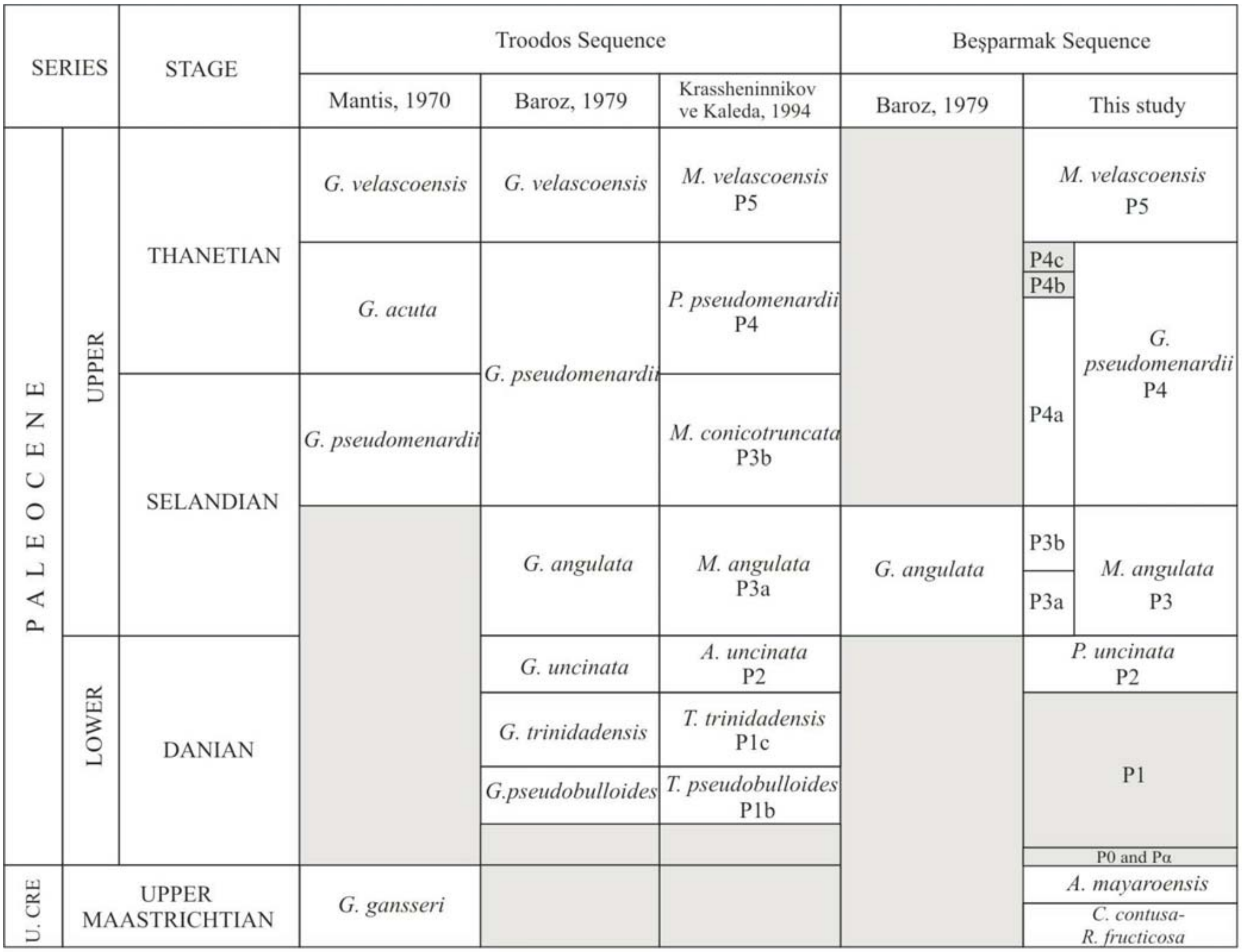


TEXT-FIGURE 8
Planktonic foraminiferal zonation scheme and bioevents utilized in this study and their correlation with the standard zonations of Toumarkine and Luterbacher (1985) and Berggren et al. (1995).

Age: Latest Paleocene (latest Thanetian)

Remarks: Berggren and Miller (1988) modified the *Morozovella velascoensis* Zone as a partial range zone between the LO of *Globanomalina pseudomenardii* and the FO of *Morozovella subbotinae*. Since the contiguity of these bioevents was established, the original definition (Bolli 1957) was resurrected by Berggren et al. (1995). Strougo et al. (1992) could not separate the *Morozovella velascoensis* Zone from the *Planorotalites pseudomenardii* Zone because of extensive reworking of *Planorotalites pseudomenardii* in Egypt. Molina et al. (1999) subdivided the *Morozovella velascoensis* Zone into five subbiozones: *Morozovella aequa*, *Morozovella gracilis*, *Acarinina berggreni*, *Acarinina sibaiyaensis* and *Pseudohastigerina wilcoxensis* Subzones. The lower boundaries of these subbiozones are respectively the following: the LO of *L. pseudomenardii*, the FO of *M. gracilis*, the FO of *A. berggreni*, the FO of *A. sibaiyaensis* and the FO of *P. wilcoxensis*. Recently, P5 Zone is emended as a *Morozovella velascoensis* Partial-range Zone by Berggren and Pearson (2005). This interval corresponds to partial range of zonal taxon between the LO of *Gobanomalina pseudomenardii* and the FO of *Acarinina sibaiyaensis*

The planktonic foraminiferal assemblages of this zone are characterized by heavily ornamented morozovellids such as *Morozovella velascoensis, M. acuta, M. aequa, M. subbotinae, M. gracilis, M. occlusa. Morozovella aequa, M. gracilis* and *M.*



TEXT-FIGURE 9
Correlation chart of the biostratigraphic studies based on planktonic foraminifera in Cyprus.

subbotinae appear in the basal part of this zone (text-fig. 6). The upper boundary of the zone has not been located precisely in the study area because of the tectonic contact with radiolaria-bearing mudstone of Bartonian age (text-fig. 6).

This zone corresponds to the *Globorotalia velascoensis* Zone in Turkey (Dizer and Meriç 1980-1981), Egypt (Faris 1984), and southern Cyprus (Mantis 1970; Baroz 1979) (text-fig. 9). The *Morozovella velascoensis* Zone also is recognized in Turkey (Tansel 1989), Egypt (Marzouk and Lüning 1998; El-Nady 2005; Shahin 1992; Abdel-Kreem and Samir 1995), Syria and southern Cyprus (Krasheninnikov 1994; Krasheninnikov and Kaleda 1994) (text-fig. 9), Spain (Arenillas and Molina 1996, 1997, 2000; Bolle et al. 1998; Lu et al. 1998), Italy (Konijnenburg et al. 1998; Arenillas 1998; Arenillas et al. 1999), France (Steurbaut and Sztràkos 2002), and Israel (Lu et al. 1998).

Stratigraphic distribution: In the Mallıdağ-II section this zone corresponds to the interval between samples A16 and A18 (6m).

The *Morozovella velascoensis* Zone was recorded once more time in the uppermost part of the Mallıdağ-II section (A48 - A50) (text-fig. 7). This unit was thrusted over the underlying unit. Although its lower and upper boundaries could not be defined properly, co-occurrences of *Morozovella velascoensis* and *Morozovella subbotinae* (A48) points out the existence of the *Morozovella velascoensis* Zone.

DISCUSSION AND CONCLUSIONS

Since the 1970s, many investigations have been concentrated on the Troodos Ophiolite and related units on Cyprus because of their crucial role in the testing and development of the theory of plate tectonics. The biostratigraphy of the sedimentary cover of the Troodos Massif also has been subjected to several studies (Mantis 1970; Baroz 1979; Krasheninnikov and Kaleda 1994) (text-fig. 9). In contrast, whereas the lithostratigraphic units and the tectonostratigraphy of the Beşparmak Range have been addressed in a few studies, the biostratigraphy of its sedimentary sequence has not. In the Beşparmak Range, Baroz (1979) mentioned three biozones (*Globorotalia angulata, Globorotalia rex, Globorotalia formosa-aragonensis* zones) in the

Maastrichtian-Eocene interval, but the zonation was not discussed in detail (text-fig. 9). Because of the insufficiency of the biostratigraphic data in the Maastrichtian-Eocene sequence, this study focused on the biostratigraphic framework of the Lapta Group and Ardahan Formation. The present biostratigraphic zonation provides a means for assessing the completeness of the studied sedimentary sequence.

The lower part of the Lapta Group is represented by the Selvilitepe Breccia, which has limited exposures along the Beşparmak Range. On the basis of planktonic foraminiferal assemblage recorded from the pelagic limestone interbeds of the breccia unit, the Selvilitepe Breccia is interpreted as Late Maastrichtian in age (*Abathomphalus mayaroensis* Zone).

The middle and upper parts of the Lapta Group are represented by the Mallıdağ and Yamaçköy formations. The Mallıdağ Formation is characterized by micritic limestones alternating with volcanic and rare calciturbidite beds, whereas the Yamaçköy Formation consists of alternating clayey limestones and marls with calciturbidites. Within these formations several volcanic and breccia units occur. Robertson and Woodcock (1986) reported that the occurrences of volcanic and breccia units could be explained by regional strike-slip faulting, compression, and thrusting. They suggested that the volcanic levels took place in several phases: Campanian, Maastrichtian, Paleogene and Miocene, respectively. The lowest volcanic level has been observed in the Mallıdağ Formation. The planktonic foraminiferal assemblage from the formation is assigned to the *Racemiguembelina fructicosa* and *Abathomphalus mayaroensis* zones of the Upper Maastrichtian. Previous studies suggested that the Selvilitepe Breccia was either overlain by the Mallıdağ Formation or graded laterally into the lower part of the Mallıdağ Formation (Ducloz 1974; Baroz 1979; Robertson and Woodcock 1986). In this study, however, the *Abathomphalus mayaroensis* Zone, which has been recognized in the Selvilitepe Breccia, shows that deposition of the breccia continued into the Late Maastrichtian. As mentioned above, the upper part of the Mallıdağ Formation is also Late Maastrichtian in age. Thus, the lateral equivalency of the Selvilitepe Breccia with the upper part of the Mallıdağ Formation, and the continuation of the breccia deposition into the Maastrichtian, has been displayed for the first time.

The Mallıdağ Formation is overlain by the Yamaçköy Formation in the upper part of the sequence. The transition from the Mallıdağ Formation to the Yamaçköy Formation is marked by a second volcanic unit measuring 12m in thickness. The second volcanic unit corresponds to the Paleogene volcanic phase of Robertson and Woodcock (1986). Herein we more precisely dated this unit as Danian.

The occurrences of moderately rich and diverse planktonic foraminiferal assemblages in the Yamaçköy Formation allowed

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PLATE 1
Scale bar: 100µm

1 *Abathomphalus mayaroensis* (Bolli), spiral view, Kozan Section, K11

2 *Abathomphalus mayaroensis* (Bolli), umbilical view, Kozan Section, K11

3 *Abathomphalus mayaroensis* (Bolli), side view, Kozan Section, K11

4 *Abathomphalus mayaroensis* (Bolli), side view, Kozan Section, K11

5 *Rugoglobigerina* cf. *hexacamerata* Brönnimann, umbilical view, Mallıdağ Section I, A4

6 *Rugoglobigerina hexacamerata* Brönnimann, umbilical view, Kozan Section, K11

7 *Trinitella scotti* (Brönnimann), side view, Mallıdağ Section II, A4

8 *Gansserina gansseri* (Bolli), side view, Kozan Section, K11

9 *Globotruncanita stuarti* (de Lapparent), spiral view, Mallıdağ Section II, A4

10 *Globotruncanita stuarti* (de Lapparent), side view, Mallıdağ Section II, A4

11 *Globotruncana aegyptiaca* Nakkady, side view, Kozan Section, K11

12 *Globotruncanella petaloidea* (Gandolfi), umbilical view, Kozan Section, K11

13 *Contusotruncana contusa* (Cushman), spiral view, Mallıdağ Section I, A4

14 *Contusotruncana contusa* (Cushman), side view, Kozan Section, K11

15 *Globotruncana arca* (Cushman), umbilical view, Kozan Section, K11

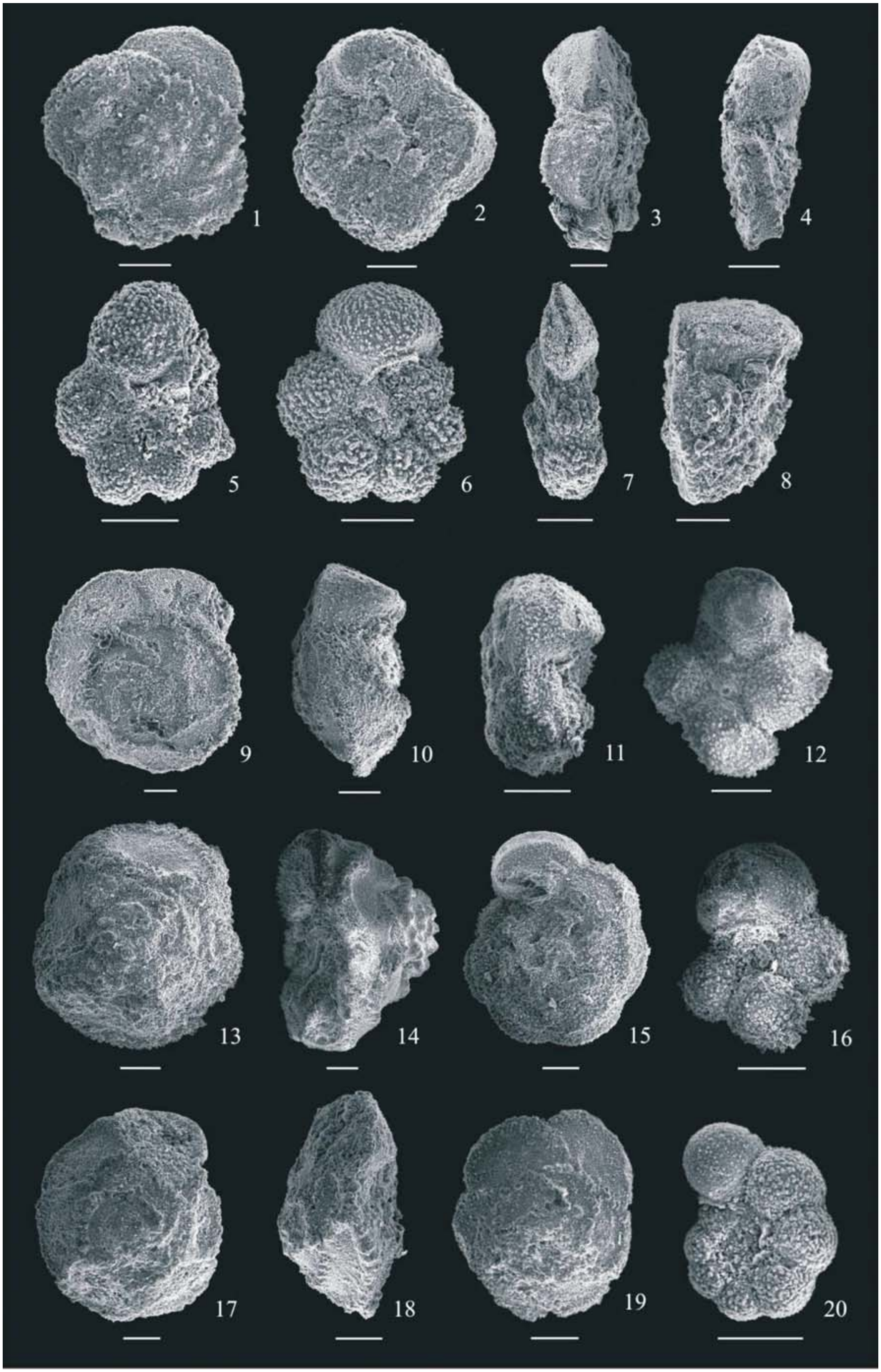
16 *Globotruncanella minuta* Caron and Gonzalez Donoso, umbilical view, Kozan Section, K11

17 *Globotruncanita conica* (White), spiral view, Mallıdağ Section II, A4

18 *Globotruncanita conica* (White), side view, Mallıdağ Section I, M11

19 *Globotruncana esnehensis* Nakkady, spiral view, Mallıdağ Section I, A4

20 *Macroglobigerinelloides ultramicrus* (Subbotina), Kozan Section, K11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us to recognize four zones of the Paleocene: *Acarinina uncinata* Zone (P2), *Morozovella angulata* Zone (P3), *Globanomalina pseudomenardii* Zone (P4) and *Morozovella velascoensis* Zone (P5) (text-fig. 8). The successive occurrences of planktonic foraminiferal species in the Yamaçköy Formation are similar to those of the standard zonation (Berggren et al. 1995), except for the Lower Danian and a part of the Thanetian in which the volcanic and breccia levels occur (text-fig. 6). The unrecognized *Guembelitria cretacea* (P0), *Parvularugoglobigerina eugubina* (Pa) and *Parvularugoglobigerina eugubina-Praemurcia uncinata* (P1) zones by Berggren et al. (1995) of the Lower Danian might correspond to the second volcanic unit, whereas the boundary between the *Globanomalina pseudomenardii* and *Morozovella velascoensis* zones might be within the breccia interval.

Towards the upper part of the sequence, the clayey limestones of the Yamaçköy Formation are overlain by radiolarian-rich, calcareous mudstones and calciturbidite interbeds of the Ardahan Formation (text-fig. 6). These flyshoidal sediments and associated olistrostromes in the upper part of the formation probably were formed by a compressional regime in the Beşparmak Range during the Middle-Late Eocene (Bartonian-Priabonian) (Robertson and Woodcock 1986). The sediments of

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PLATE 2

Scale bar: 100µm for SEM photos, 250µm for thin section photos.

1 *Macroglobigerinelloides ultramicrus* (Subbotina), spiral view, Kozan Section, K11

2 *Macroglobigerinelloides ultramicrus* (Subbotina), umbilical view, Kozan Section, K11

3 *Pseudotextularia intermedia* De Klasz, side view, Mallıdağ-I Section, M-18

4 *Racemiguembelina* cf. *fructicosa* (Egger), side view, Mallıdağ-II Section, A1

5 *Heterohelix navarroensis* Loeblich, side view, Kozan Section, K11

6 *Heterohelix punctulata* Cushman, side view, Kozan Section, K11

7 *Heterohelix labellosa* Nederbraght, side view, Kozan Section, K11

8 *Heterohelix striata* (Ehrenberg), side view, Kozan Section, K11

9 *Pseudotextularia deformis* Kikoine, edge view, Mallıdağ-II Section, A4

10 *Abathomphalus mayaroensis* (Bolli), axial section, Kozan Section, K3

11 *Abathomphalus mayaroensis* (Bolli), axial section, Mallıdağ-I Section, M15

12 *Gansserina gansseri* (Bolli), axial section, Mallıdağ-I Section, M14

13 *Gansserina gansseri* (Bolli), axial section, Mallıdağ-I Section, M12

14 *Trinitella scotti* Brönnimann, axial section, Mallıdağ-I Section, M16

15 *Abathomphalus mayaroensis* (Bolli), axial section, Kozan Section, K3

16 *Trinitella scotti* Brönnimann, axial section, Mallıdağ-I Section, M17

17 *Kuglerina rotundata* (Brönnimann), axial section, Mallıdağ-I Section, M24

18 *Globotruncanella pschadae* (Keller), axial section, Mallıdağ-I Section, M17

19 *Globotruncanella havanensis* (Voorwijk), axial section, Mallıdağ-I Section, M8

20 *Plummerita reicheli* (Brönnimann), axial section, Mallıdağ-I Section, M8

21 *Schackoina multispinata* (Cushman and Wickenden), axial section, Kozan Section, K11

22 *Globotruncanita stuarti* (de Lapparent), axial section, Kozan Section, K3

23 *Globotruncanita stuartiformis* (Dalbiez), axial section, Kozan Section, K3

24 *Globotruncanita stuarti* (de Lapparent), axial section, Mallıdağ-I Section, M15

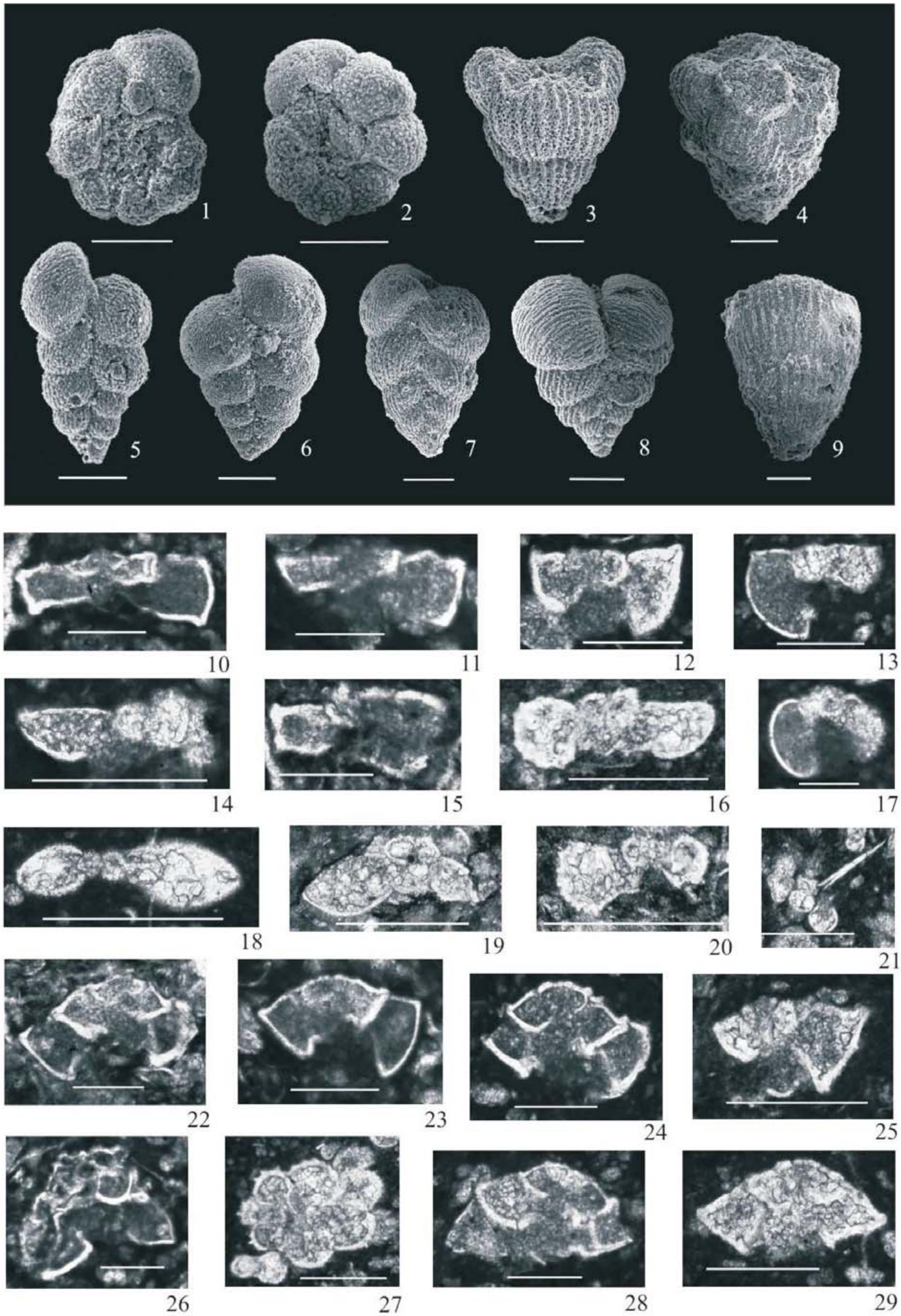
25 *Globotruncanita pettersi* (Gandolfi), axial section, Mallıdağ-I Section, M17

26 *Contusotruncana contusa* (Cushman), axial section, Kozan Section, K3

27 *Racemiguembelina fructicosa* (Egger), transverse section, Mallıdağ-I Section, M20

28 *Globotruncanita conica* (White), axial section, Mallıdağ-I Section, M16

29 *Globotruncana esnehensis* Nakkady, axial section, Mallıdağ-I Section, M17



the Ardahan Formation contain scarce and badly preserved planktonic foraminiferal assemblages with some reworked Cretaceous and Paleocene taxa (text-fig. 7). Based on *Globorotaloides suteri* and *Turborotalia cerroazulensis cerroazulensis* together with *Acarinina bullbrooki, Truncorotaloides topilensis, T. rohri, Morozovella spinulosa, M. lehneri, Globigerinatheka subconglobata,* and *G.kugleri,* the age of the Ardahan Formation is Bartonian (text-fig. 7). Thus, a physical gap between Thanetian and Bartonian intervals in the studied succession, not apparent in the field, has been revealed by the biostratigraphic data. A regional compressional tectonic regime (southward thrusting of the Beşparmak Range), rather than non-deposition or erosion might explain the incompleteness of the Ypresian and Lutetian intervals in the sequence (Robertson and Woodcock 1986). Although the age of Ardahan Formation has been given as Bartonian-Priabonian in previous studies (Baroz 1979; Robertson and Woodcock 1986; Hakyemez et al. 2002), we find no evidence supporting a Priabonian age. The reason for this difference can be explained by the emplacement of two tectonic units above the olistostromal level (text-fig. 7). The lower thrusted unit contains the *Morozovella formosa* Zone (P7) of the Lower Eocene, and the upper thrusted unit contains the *Morozovella velascoensis* Zone (P5) of the Upper Paleocene.

ACKNOWLEDGMENTS

Dr. Yavuz Hakyemez is gratefully acknowledged for assistance in the field work and for insightful discussion that improved many aspects of this study. The authors thank Dr. John Groves for critical comments on the manuscript and for improving English of the paper. We wish to thank Dr. Ercan Özcan for through reviewing of the paper. We are also grateful to Dr. Isabella Premoli Silva for discussions on the some taxonomic concepts. We wish to express our sincere gratitude to Dr. Ignacio Arenillas for critical, constructive review of an earlier version of this paper.

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ARENILLAS, I., 1998. Biostratigrafía con foraminíferos planctónicos del Paleoceno y Eoceno inferior de Gubbio (Italia): calibración

PLATE 3

Scale bar: 100µm

1 *Acarinina uncinata* (Bolli), spiral view, Mallıdağ-II Section, A12

2 *Acarinina uncinata* (Bolli), spiral view, Mallıdağ-II Section, A12

3 *Acarinina uncinata* (Bolli), umbilical view, Mallıdağ-II Section, A12

4 *Praemurica inconstans* (Subbotina), spiral view, Mallıdağ-II Section, A5

5 *Parasubbotina pseudobulloies* (Plummer), umbilical view, Mallıdağ-II Section, A.13

6 *Parasubbotina pseudobulloies* (Plummer), spiral view, Mallıdağ-II Section, A.13

7 *Morozovella angulata* (White), umbilical view, Mallıdağ-II Section, A12

8 *Morozovella angulata* (White), spiral view, Mallıdağ-II Section, A12

9 *Morozovella angulata* (White), spiral view, Mallıdağ-II Section, A11

10 *Morozovella angulata* (White), side view, Mallıdağ-II Section, A11

11 *Morozovella angulata* (White), side view, Mallıdağ-II Section, A12

12 *Acarinina apanthesma* (Loeblich and Renz), umbilical view, Mallıdağ-Mallıdağ-II Section, A16

13 *Acarinina apanthesma* (Loeblich and Renz), spiral view, Mallıdağ-II Section, A13

14 *Acarinina apanthesma* (Loeblich and Renz), side view, Mallıdağ-II Section, A13

15 *Morozovella aequa* (Cushman and Renz), spiral view, Mallıdağ-II Section, A16

16 *Morozovella aequa* (Cushman and Renz), umbilical view, Mallıdağ-II Section, A16

17 *Morozovella subbotinae* (Morozova), umbilical view, Mallıdağ-II Section, A16

18 *Morozovella subbotinae* (Morozova), spiral view, Mallıdağ-II Section, A16

19 *Morozovella acuta* (Toulmin), umbilical view, Mallıdağ-II Section, A14

20 *Igorina* sp., spiral view, Mallıdağ Section II, A13

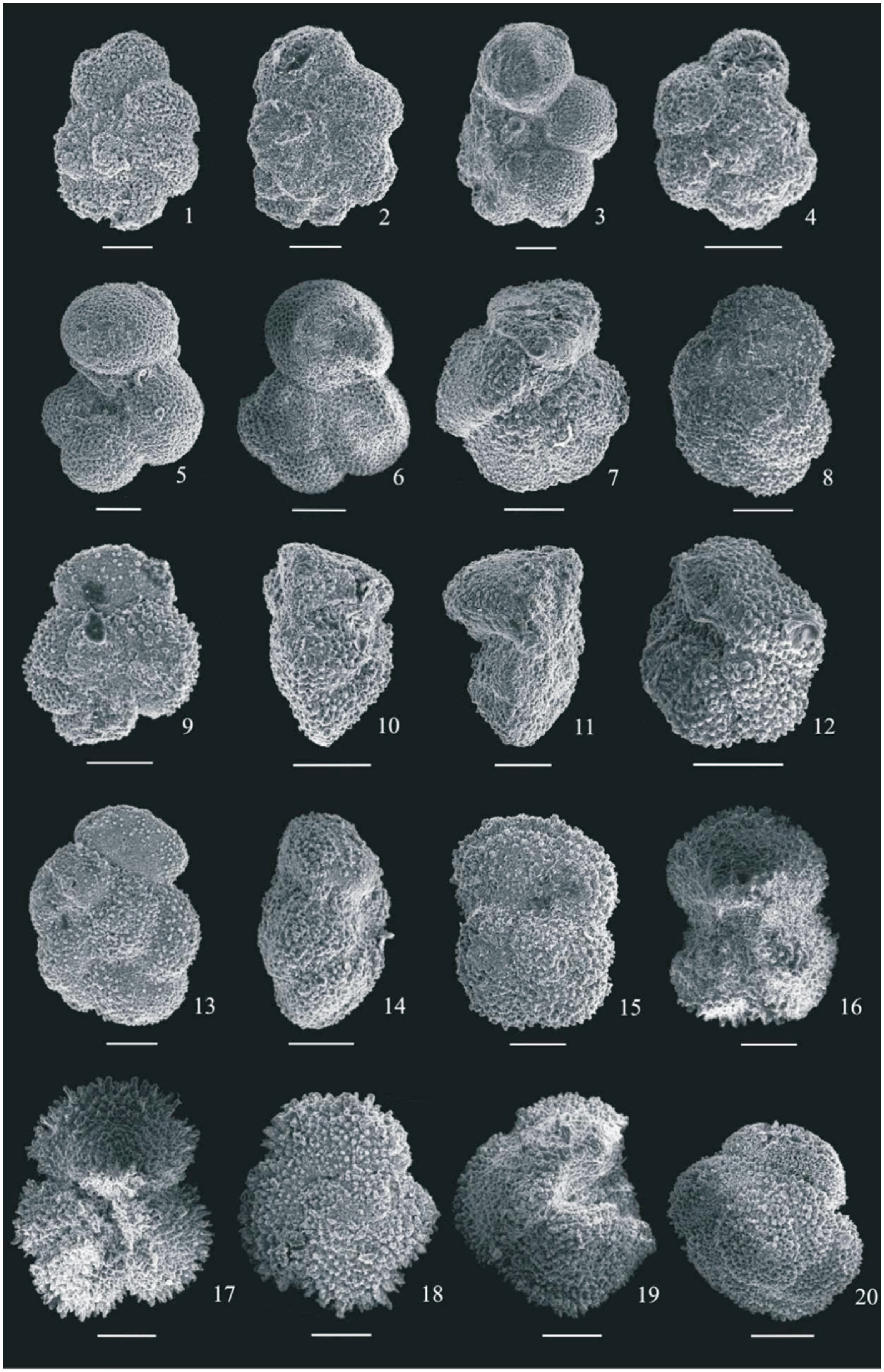
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PLATE 4

Scale bar: 100µm

1 *Morozovella velascoensis* (Cushman), umbilical view, Mallıdağ-II Section, A18

2 *Morozovella velascoensis* (Cushman), spiral view, Mallıdağ-II Section, A18

3 *Morozovella velascoensis* (Cushman), side view, Mallıdağ-II Section, A16

4 *Morozovella occlusa* (Loeblich and Tappan), umbilical view, Mallıdağ-II Section, A13

5 *Globanomalina pseudomenardii* (Bolli), spiral view, Mallıdağ-II Section, A15

6 *Globanomalina pseudomenardii* (Bolli), oblique view, Mallıdağ-II Section, A15

7 *Globanomalina pseudomenardii* (Bolli), spiral view, Mallıdağ-II Section, A15

8 *Morozovella occlusa* (Loeblich and Tappan), spiral view, Mallıdağ-II Section, A13

9 *Globanomalina chapmani* (Parr), umbilical view, Mallıdağ-II Section, A15

10 *Globanomalina chapmani* (Parr), umbilical view, Mallıdağ-II Section, A15

11 *Globanomalina ehrenbergi* (Bolli), side view, Mallıdağ-II Section, A12

12 *Igorina albeari* (Cushman and Bermudez), spiral view, Mallıdağ-II Section, A13

13 *Acarinina mckannai* (White), spiral view, Mallıdağ-II Section, A14

14 *Igorina pusilla* (Bolli), spiral view, Mallıdağ-II Section, A13

15 *Igorina pusilla* (Bolli), umbilical view, Mallıdağ-II Section, A13

16 *Igorina albeari* (Cushman and Bermudez), side view, Mallıdağ-II Section, A13

17 *Acarinina subsphaerica* (Subbotina), side view, Mallıdağ-II Section, A14

18 *Acarinina subsphaerica* (Subbotina), side view, MallÏdağ-II Section, A14

19 *Acarinina soldadoensis* (Brönnimann), spiral view, Mallıdağ-II Section, A14

20 *Acarinina soldadoensis* (Brönnimann), side view, Mallıdağ-II Section, A16

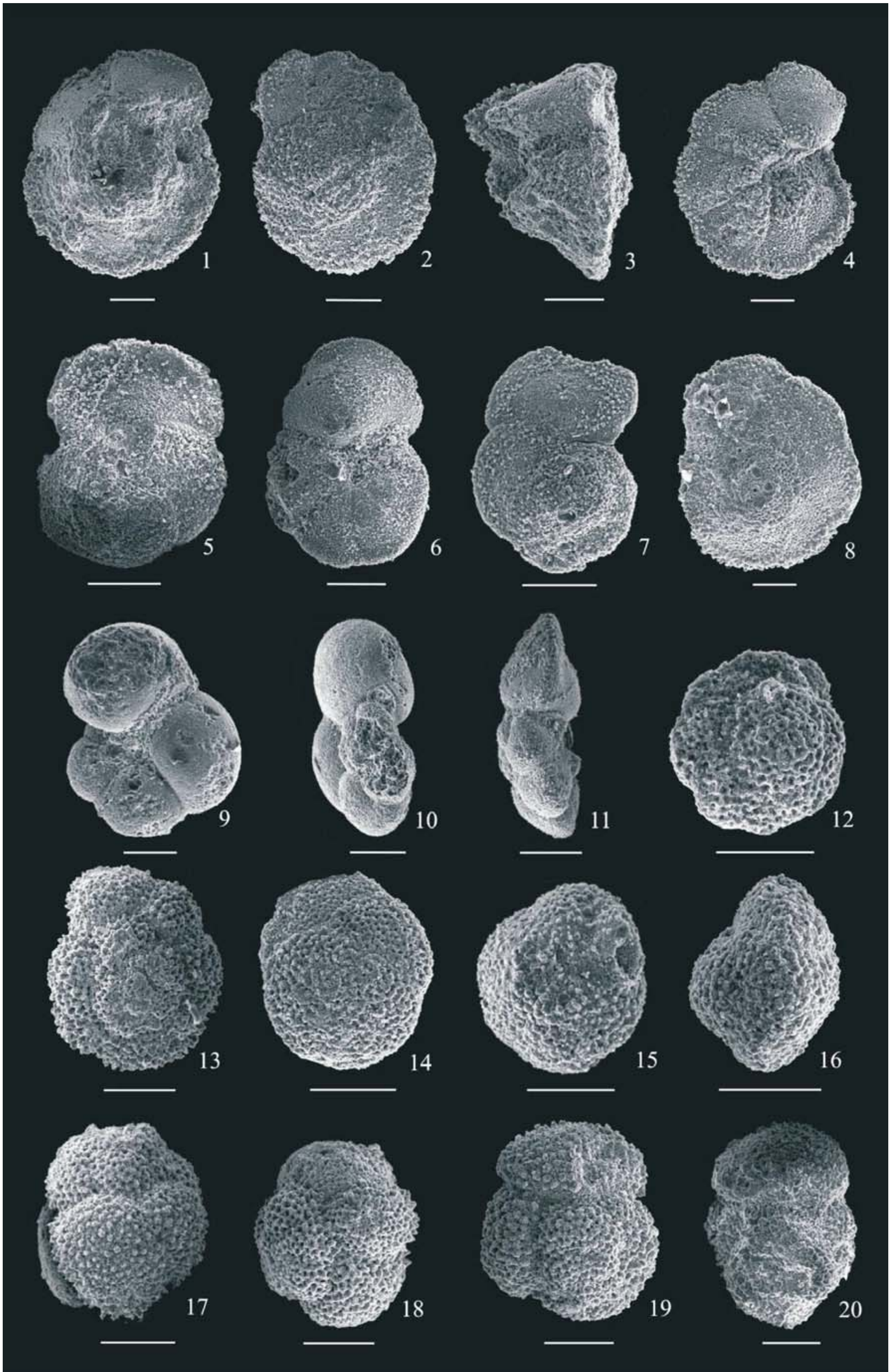
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PLATE 5

Scale bar: 100µm

1 *Subbotina pseudoeocaena* (Subbotina), umbilical view, Mallıdağ-II Section, A16

2 *Subbotina triloculinoides* (Plummer), umbilical view, Mallıdağ-II Section, A11

3 *Subbotina velascoensis* (Cushman), spiral view, Mallıdağ-II Section, A14

4 *Subbotina hornibrooki* (Brönnimann), umbilical view, Mallıdağ-II Section, A16

5 *Acarinina pseudotopilensis* Subbotina, umbilical view, Mallıdağ-II Section, A16

6 *Acarinina bullbrooki* (Bolli), umbilical view, Mallıdağ-II Section, A20

7 *Acarinina bullbrooki* (Bolli), side view, Mallıdağ-II Section, A20

8 *Globigerinatheka mexicana* (Cushman), side view, Mallıdağ-II Section, A22

9 *Globigerinatheka index* (Finlay), spiral view, Mallıdağ-II Section, A26

10 *Globigerinatheka index* (Finlay), umbilical view, Mallıdağ-II Section, A26

11 *Globigerinatheka subconglobata* (Shutskaya), side view, Mallıdağ-II Section, A20

12 *Globigerinatheka subconglobata* (Shutskaya), side view, Mallıdağ-II Section, A20

13 *Globigerinatheka barri* Brönnimann, side view, Mallıdağ-II Section, A33

14 *Turborotalia cerroazulensis cerroazulensis* (Cole), side view, Mallıdağ-II Section, A33

15 *Globorotaloides suteri* Bolli, umbilical view, Mallıdağ-II Section, A30

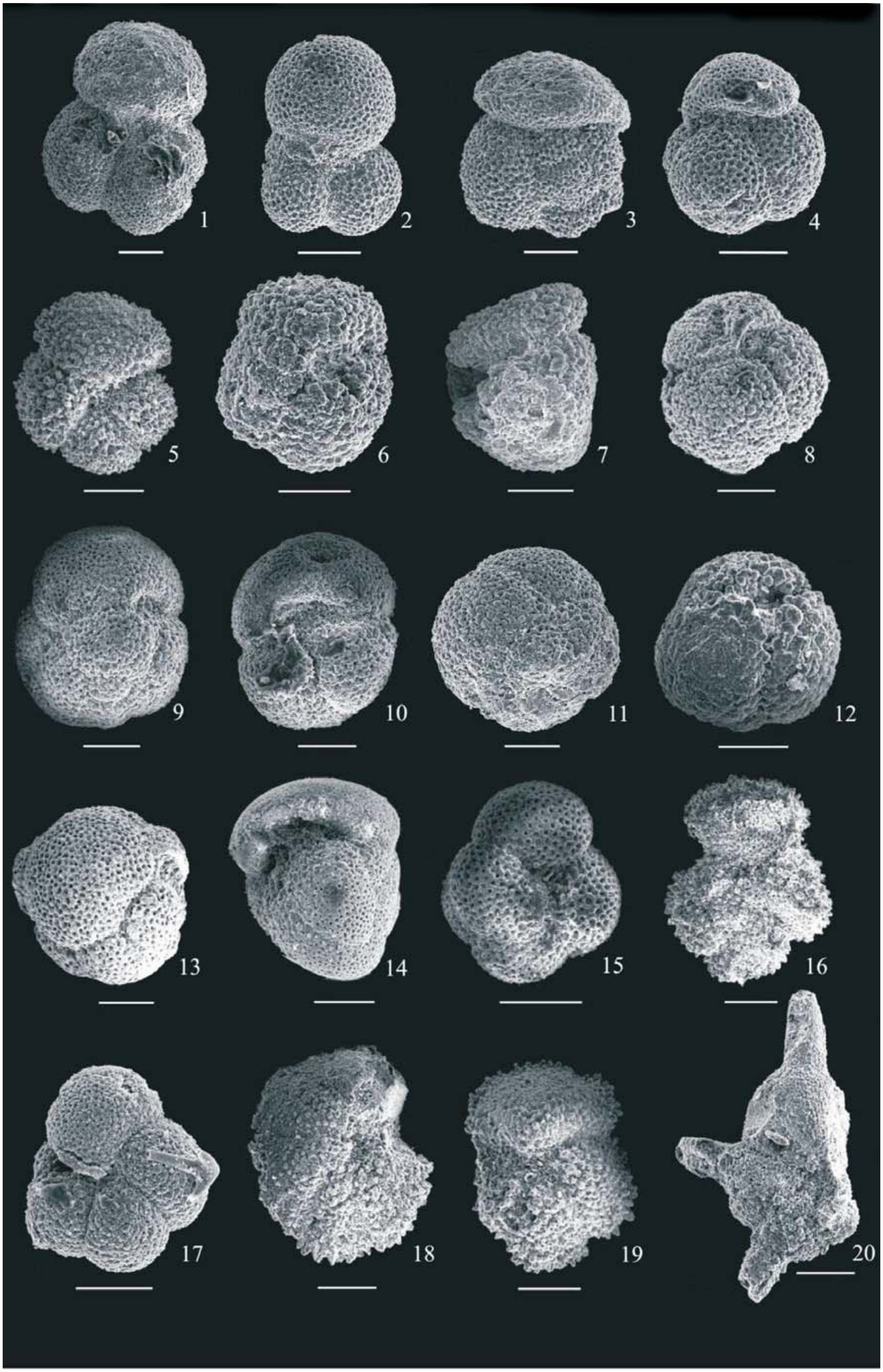
16 *Truncorotaloides rohri* (?) Brönnimann and Bermudez, spiral view, Mallıdağ-II Section, A33

17 *Turborotalia* (?) sp., umbilical view, Mallıdağ-II Section, A20

18 *Morozovella lehneri* (Cushman and Jarvis), umbilical view, Mallıdağ-II Section, A32

19 *Morozovella spinulosa* (Cushman), umbilical view, Mallıdağ-II Section, A30

20 *Hantkenina longispina* Cushman, Mallıdağ-II Section, A32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Manuscript received December 10, 2008
Manuscript accepted September 17, 2009