Biometric analysis of middle and upper Eocene Discocyclinidae and Orbitoclypeidae (Foraminifera) from Turkey and updated orthophragmine zonation in the Western Tethys

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**INTRODUCTION**

This paper is the fourth in the series systematically elaborating Turkish orthophragmines based on their internal morphology, aimed at providing a better understanding not only of their evolutionary development but also of their stratigraphic significance. In the first three papers (Özcan et al. 2001; Özcan 2002; Çolakoglu and Özcan 2003), orthophragminid assemblages were introduced from several shelf-edge marine successions, formerly proposed to serve as reference sections for late Paleocene and early Eocene in Turkey (Serra-Kiel et al. 1995). The present study focuses on younger stratigraphic levels. The three studied sections have a very rich orthophragminid fauna, whose evolution can be followed from the late Lutetian (Alaman section, Sivas region, Central Anatolia) through the Bartonian (Keçili section, Elazig region, Eastern Anatolia) to the early Priabonian (Sarköy section, Tekirdag region, Northwestern Turkey). Orthophragmines are accompanied by nummulitids and other benthic taxa in many horizons.

Figured specimens marked by O/ are deposited in the Özcan collection of the Geology Department in Istanbul Technical University while those marked by E. are in the Eocene collection of the Geological Institute of Hungary.

**ABSTRACT:** Orthophragmines from late Lutetian (Alaman), Bartonian (Keçili) and early Priabonian (Sarköy) localities in Turkey are described and illustrated for the first time. Biometry of megalospheric individuals, based on a large number of free specimens sectioned mainly in the equatorial plane, contributes to our knowledge about the orthophragmines in several aspects. They are of western Tethyan affinity and belong to the evolutionary lineages of the genera Discocyclina, Nemkovella, Orbitoclypeus and Asterocyclina, known mainly from the European part of peri-Mediterranean region. Identified foraminifera are categorized into evolutionary lineages, different developmental stages of which are distinguished by biometrically defined subspecies. Two new species of Asterocyclina, A. sireli n. sp. and A. ferrandizi n. sp. from the late Lutetian and early Bartonian respectively, one subspecies of Discocyclina, D. trabayensis elazigensis n. sp. and one of Orbitoclypeus, O. douvillei malayaensis n. sp., both from the Bartonian, are introduced. An emended description of Nemkovella daqinii, the poorly known orthophragminid taxon (formerly ascribed to Orbitoclypeus), is given, with emphasis on equatorial development and generic position. Stratigraphic position of orthophragminid populations is ascertained from the calcareous nannoplankton, planktonic foraminifera and the assemblages of accompanying larger foraminifera, such as Heterostegina, Spirochlypeus and some lineages of Nummulites (especially of N. fabiani and N. perforatus). The stratigraphic distribution of some orthophragminid taxa is rearranged and a revision of late Lutetian to early Priabonian orthophragminid foraminiferal zones (marked by OZ), in the context of shallow benthic zonation of Tethyan early Paleogene, is proposed. In the updated zonation, OZ 12 corresponds to the latest Lutetian to earliest Bartonian interval, OZ 13 to the late early Bartonian, and OZ 14 to the late Bartonian to earliest Priabonian time-span.

**ABBREVIATIONS FOR BIOZONES:** NP: Paleogene calcareous nannoplankton zones by Martini (1971); OZ: Orthophragminid zones for the Mediterranean Paleocene and Eocene by Less (1998) with correlation to the SBZ zones; P: Paleogene planktic foraminiferal zones by Blow (1969) and updated by Berggren et al. (1995); SBZ: Shallow benthic foraminiferal zones for the Tethyan Paleocene and Eocene by Serra-Kiel et al. (1998) with correlation to the planktic and magnetic polarity zones.

**REVIEW ON THE RECENT KNOWLEDGE ON ORTHOPHRAGMINES**

According to Brönnimann (1945) late Paleocene and Eocene orbitoidal larger foraminifera with almost rectangular equatorial chamberlets constitute two systematically independent families, namely Discocyclinidae Galloway 1928 and Orbitoclypeidae Brönnimann 1945, based on their significantly different microspheric juvenarium. Their morphostructure is otherwise quite similar (for details see Brönnimann 1945, 1951; Caudri 1972; Less 1987; Sirotti 1987; Ferrández-Cañadell and Serra-Kiel 1992; Drooger 1993; Ferrández-Cañadell 1998b and b). Therefore, and because these probable symbiont-bearing benthic forms can be found together at least in the peri-Mediterranean region (commonly in the deeper part of the photic zone), orthophragmines, an informal collective name, is used to refer...
to both groups. In the peri-Mediterranean region, Discocyclinidae are represented by two genera: *Discocyclina* Gümbel 1870 and *Nemkovella* Less, 1987. Orbitoclypeidae have also two genera; *Orbitoclypeus* Silvestri 1907 and *Asterocyclina* Gümbel 1870 in this realm. The formerly widely used name of *Aktinocyclina* (or *Actinocyclina*) is invalid, since ribbing on the surface of the test (the diagnostic feature of this genus) can be observed in all four genera. Therefore ribbing is useful taxonomically only on the species level (Less 1987 and 1993 and Ferrández-Cañadell 1997). A synoptic summary for distinguishing the four peri-Mediterranean genera is shown in text-fig. 1.

Less (1987, 1998) presented the most elaborate taxonomic subdivision of the Eurasian orthophragmines based on ample material from Hungary, France, Italy, Israel, Spain, Bulgaria, Austria, and Crimean sections in the former Soviet Union. He separated particular species typologically using some qualitative features (text-fig. 2) that are (excepting the type of the rosette) recognizable in the equatorial section of the A-forms. Therefore, the significance of microspheric forms (constituting only about 10% of most of the populations) is subordinate in the specific determination.

Most of the species constitute long-living evolutionary lineages with definite internal development that allows their morphometric subdivision into artificial subspecies (for theoretical background see Drooger 1993). According to Less (1998) these subspecies are defined by biometric limits of the populational means of the outer cross diameter of the deuteroconch in equatorial section (marked by “d”, see text-fig. 4). This quantitative feature has been chosen from among several other evolutionary parameters because it is most easily and objectively measurable and also it reveals the fastest and the least variable evolutionary progress (Less 1998).

The joint occurrence of simultaneously developing lineages allowed to recognize characteristic assemblages of co-occurring chronosubspecies (Less 1987, 1998). Based on the geological superposition, the accompanying fossils, and the mutual control of co-existing evolutionary lineages these assemblages can be arranged into a succession that is in fact a zonation with Oppelian zones. Less (1998, see also for the principles in detail) separated eighteen such orthophragminid zones (marked in this paper by OZ), from OZ 1a to 16, ranging from early Thanetian to late Priabonian, having extended his (Less 1987) sixteen “protozones” (O. 1–16) by subdividing the former 1st and 8th zone into 1a and 1b and 8a and 8b, all four with zonal rank, in the new scheme. The stratigraphic ranges of particular orthophragminid taxa (subspecies and unsubdivided species) are evaluated by Less (1998) and followed also in this paper in the frame of this zonation taking also into consideration new data from Turkey. It is worth noting that the artificial subdivision of the (supposedly gradual) evolutionary lineages causes overlaps between the stratigraphical ranges of neighboring subspecies (text-fig. 3) since there are always spatial, ecological and random deviations from the “medium” evolutionary track, and thus, the latter has a variation field. Simultaneously, ortho-
Phragminid data have been integrated into the zonation of shallow marine Tethyan Paleocene and Eocene based on mostly alveolinids and nummulitids (and correlated with planktonic and magnetostratigraphic data) resulting in the establishment of twenty shallow benthic zones (SBZ 1–20) for the Mediterranean region.

**BIOMETRY OF ORTHOPHRAGMINES AND PRINCIPLES OF THEIR SUBSPECIFIC DETERMINATION**

Biometric features of the orthophragmines were studied in thin-sections, prepared through the equatorial plane of free specimens. Using the terminology proposed by Less (1987, 1993), eight measurements (in µm) and counts from 697 specimens are used to characterize the taxa, as illustrated in text-figure 4, tabulated and listed below:

- **p and d:** outer diameter of the protoconch and deuteroconch perpendicular to their common axis (corresponding to P₁ and D₁ in Less 1987)
- **N:** number of the adauxiliary chamberlets (in text-fig. 4, N=15)
- **H and W:** height and width of the adauxiliary chamberlets (corresponding to H and L in Less 1987)
- **n:** number of annuli within 0.5mm distance measured from the deuteroconch along the axis of the embryo (corresponding to n₀.₅ in Less 1987)
- **h and w:** height and width of the equatorial chamberlets around the peripheral part of the equatorial layer (corresponding to h and l in Less 1987).

Biometric data are summarized in tables 1 and 2. Since the orthophragminid fauna of the studied localities is extremely diverse and, at the same time, the thin-sectioning is rather time-consuming, we could not reach a sufficient number of preparations for each species from every sample. Therefore, samples close to each other and containing practically the same assemblages with similar parameters are evaluated both separately and jointly. However, the subspecific determination of particular species is given for the joint samples on the basis of the increased (in such a way) number of specimens. These data are marked always with bold letters. Because of the limited space, a complete statistical evaluation with the number of specimens (n⁰), arithmetical mean and standard error (s.e.) is given only for deuteroconchal size (d), the crucial parameter in subspecific determination.

Subspecies are determined according to the biometrical limits of subspecies for populations presented in the description of the given species. No subspecies is determined if only a single specimen is available from joint samples. If the number of specimens is two or three, the subspecies is determined as “cf.”. If this number is four or more, however, the dmean value of the given population is closer to the biometrical limit of the given subspecies than 1 s.e. of dmean, we use an intermediate denomination between the two neighboring subspecies. In these cases we adopt Drooger’s (1993) proposal in using the notation exemplum intercentrale (abbreviated as ex. interc.), followed by the names of the two subspecies on either side of the limit and putting that name into the first place to which the assemblage is closer.
DETERMINATION OF SOME NUMMULITIDS AND THE PLANKTONIC FOSSILS

The nummulitid larger foraminifera Assilina, Operculina, Heterostegina and Spiroclupeus were studied both in split specimens and oriented thin-sections, whereas Nummulites were studied only in split specimens. According to Hottinger (1977) and Schaub (1981), their taxonomical concept is typological and we mostly followed this practice in the determinations. Simultaneously, we tried to apply the morphometric method, used for the orthophragmines, to some nummulitid lineages, such as those of Heterostegina, Spiroclupeus, and also some Nummulites (N. fabianii, N. perforatus, N. millocapra, N. gizehensis). Although these results will be published later in separate papers (Less et al. in review and Less and Özcan in review), the most important biometric results are summarized in table 3. Here “P” indicates the inner cross-diameter of the proloculus of megalospheric forms (only in the case of Heterostegina and Spiroclupeus), “X” marks the number of unsubdivided (operculind) chambers following the two-chambered embryon and before the first subdivided (heterosteginid) chamber. The most diagnostic nummulitids are figured in plate 1.

In determining and dating calcareous nannofossils, standard methods are used (e.g. Martini 1971; Bukry 1973; Báldi-Beke 1984; Perch-Nielsen 1985) while the study of the planktonic foraminifera is based on Toumarkine and Luterbacher (1985).

REGIONAL GEOLOGICAL SETTING AND DESCRIPTION OF SECTIONS

The mountain ranges of Turkey constitute the easternmost segment of the Mediterranean Alpides, situated between Gondwana in the south and Laurasia in the north. The present tectonic framework has been formed as a result of closure of the multi-branched Neotethyan Ocean during the late Mesozoic and Cenozoic (Sengör and Yilmaz 1981; Okay et al. 2001; Görür and Tüysüz 2001). Thus, the Alpine orogeny in Turkey is characterized by different continental units, separated by complex suture systems (text-fig. 5). In this framework, the studied Eocene sections represent different depositional settings in three continental basement blocks with either Gondwanian (Kirsehir Block: Alaman section, upper Lutetian Malakköy Formation and Anatolide-Tauride Block: Keçili section, Bartonian Kirkgeçit Formation) or Laurasian affinity (Sakarya continent: Sarköy section, lower Priabonian Sogucak Formation). In these marine sections a relatively complete stratigraphic sequence of orthophragminid lineages can be followed from late Lutetian through Bartonian and until the early Priabonian.

Alaman Section (Kirsehir Blok)

At the eastern part of Kirsehir block, Paleocene (?)–Eocene marine sedimentary deposits directly overlay the metamorphics (Ketin 1955). A marine Eocene profile with abundant larger foraminifera in some horizons (Malakköy Formation) crops out in the vicinity of the village Alaman (Sarkisla, Sivas region). This 126m thick section, exposed along the road from Alaman to Sarkisla and sampled immediately northeast of Alaman village (from 39°34'7.74"N, 36°15'40.40"E to 39°34'17.31"N, 36°16'3.71"E), is characterized by a lower, deepening-upward and an upper, shallowing-upward sequence below the continental Oligocene units (text-fig. 5). Microfossils of the section are listed in text-figure 6.

The basal part of the lower cycle of the Malakköy Formation comprises a 20m thick succession of shallow-water argillaceous limestones and fine-clastics, which contain only alveolinid foraminifera, succeeded by a 12m thick massive argillaceous
limestone bed. This horizon (sample ALM 5) contains only syndepositional nummulitids. The overlying 25 m thick succession is characterized by the alternation of marl/shale and argillaceous limestones. This part of the section, especially its two 40-50 cm thick marly horizons (ALM 6 and 7), is predominantly rich in orthophragmines and partly nummulitids. Calcareous nanoplankton has also been studied from sample ALM 7. At the top of the unit (sample ALM 8A) *Nummulites* occur abundantly. Upward in the section, pelagic siliciclastic deposits, described as more than 25 m thick shale/marl unit, overlie the lower shallow-water sequence. This unit was found to be predominantly rich in calcareous nanoplankton and planktonic foraminifera. Pelagic marls are immediately overlain by 5 to 6 m thick fragmental shallow-water marly limestone and sandstone beds, extremely rich in orthophragmines while *Nummulites* is less frequent. The upper part of Alaman section comprises restricted shallow-water clayey limestone, grading upward into alveolinid limestone. In these horizons, orthophragmines could not be identified. Oligocene gypsiferous continental beds are unconformable over the marine succession.

As it can be read from the fossil list (text-fig. 6) and biometrical data of larger foraminifera (tables 1 to 3), they are not really different in the lower and upper horizons. The rich orthophragminid fauna indicates a mixture of OZ 11 and 12 with Ajka as key-locality for the first and Dudar for the second (both in Hungary). *Discocyclina augustea* Weijden 1940 *atlantica* Less 1987 (with transition to *D. a. sourbetensis*), *D. pratti* (Michelin 1846) *montfortensis* and *Nemkovella strophiolata strophiolata* (Gümbel 1870) detect the older zone whereas *Discocyclina pulcra* (Checchia-Rispoli 1909) *baconica* Less 1987 (with transition to *D. p. balatonica*) and *Orbitoclypeus varians* (Kaufmann 1867) *scalaris* Schlumberger 1903 (with transition to *O. v. roberti*) the younger one. The nummulitid fauna is prac-
tically identical with that from Ajka, however significantly older than that of Dudar. Taking also into account the lack of the Operculina bericensis-rosselli-gomezi lineage (which has a first appearance in the Bartonian), the nummulitid fauna indicates the SBZ 15-16 zones.

The calcareous nannoplankton from the top of the lower carbonate horizon and from the pelagic marl between the two larger foraminiferal levels indicates the middle of the NP15 zone based on the rare occurrence of Chiasmolithus gigas (Bramlette and Sullivan 1961). Some other forms (Reticulofenestra placomorpha (Kamptner 1952), Discoaster floreus Bystricka 1964) are characteristic for the middle and upper part of the Lutetian (NP 15-16 zones). The assemblage of planktonic foraminifera detects the interval from the middle of the Globigerinatheka subconglobata subconglobata (P 11) zone up to the end of the Globorotalia lehneri zone (P 12).

Summarizing all these data, a late Lutetian age seems to be the most probable, and is confirmed by independent ages obtained by planktonic foraminifera and nummulitid forms. The rare Chiasmolithus gigas may be redeposited; the other possibility is that its range spreads into higher horizons, as indicated by Proto Decima et al. (1975) from Possagno (Northern Italy). The orthophragminid assemblage suggests a Lutetian-Bartonian transitional age. However, in light of new data based on the stratigraphic distribution of orthophragmines from Alaman, the boundary of the OZ 11 and 12 is redefined to fall into the upper part of Lutetian.

**Keçili Section (Anatolide-Tauride Platform)**

In the eastern part of the Anatolide-Tauride block, around the Baskil-Elazig region, the upper Cretaceous basement rocks of Baskil magmatics are overlain by upper Cretaceous to Miocene marine successions (Bingöl 1983). The Eocene Kirkgeçit Formation comprises mainly pelagic marl/shale-siltstone beds intercalated with coarse clastics, including olistostromal horizons. This unit, which contains typical Bartonian fauna in its upper part, crops out along the road from Baskil to Aydinlar through Keçili in the western part of Elazig region. The Keçili section (text-fig. 7) represents one of the most fossiliferous Bartonian marine sequences in the Mediterranean region. This, almost 280 m thick rock sequence is dominated by monotonous thick-bedded to massive pelagic fine-siliciclastic beds, which comprise intercalations of mostly resedimented limy sandstones containing abundant benthic foraminifera, mainly orthophragmines, and also different nummulitids, Pellatispira Boussac 1906, Chapmanina Silvestri 1905, and Linderina Schlumberger 1893. The sequence can be subdivided into three horizons based on its larger foraminiferal content. Their list and distribution in the section are given in text-figure 8, while those of the planktonic microfossils are shown in text-figure 9.

The lower horizon is about 30 m thick and contains two sandy limestone beds (KEÇ 1 and 2, seemingly not olistoliths), both are about 2m thick. The orthophragminid assemblage marks the OZ 13 zone based on the joint first appearance of Orbitoclypeus varians varians (Kaufmann 1867) and O. douvillei (Schlumberger 1903) malatyaensis n. ssp., and last appearance of Asterocyclina stellata stellata (d’Archiac 1846). Nummulitids (studied from sample KEÇ 1) are also abundant and mark the SBZ 17 zone based on the occurrence of Nummulites perforatus (Montfort 1808), N. hottingeri Schaub 1981 and Operculina ex. gr. roselli Hottinger 1977–gomezi Colom and Bauzà 1950 combined with the absence of Heterostegina d’Orbigny 1826. Based
on the joint occurrence of *Reticulofenestra placomorpha* (appearing in NP 16) and *Chiasmolithus grandis* (Bramlette and Riedel 1954) (marking the upper boundary of NP 17), the calcareous nanoplankton identified from the pelagic siltstone of sample KEÇ 1A (just below sample KEÇ 1) signs the NP 16-17 zones. The frequent occurrence of *Reticulofenestra bisecta* (Hay, Mohler and Wade 1966) suggests that the age is improbably older than Bartonian. To sum up: the age of the lower larger foraminiferal horizon in the Keçili section can reasonably be judged as late early Bartonian.

The middle horizon is about 200m thick and contains several huge larger foraminiferal sandy limestone olistholiths (slumped blocks) – both single and composite, with thicknesses of up to 5m – in the pelagic silty/marly matrix. Lithologically the middle horizon cannot be distinguished from the upper horizon; however there are slight differences in fossil content. Larger foraminifera have been investigated from samples KEÇ 3-5. The abundant and extremely diverse orthophragminid fauna marks the OZ 14 zone, based on the occurrence of *Discocyclina dispansa dispansa* (Sowerby 1840) (the zonal marker) and also on the joint occurrence of the appearing *D. trabayensis* Neumann 1955 elazigensis n. ssp., *Nemkovella strophiolata tenella* (Gümbel 1870), *Asterocyclina stellata* (d’Archiac 1846) *stellaris* Brünner 1846 in Rutimeyer 1850 and the disappearing *A. stella stella* (Gümbel 1861) and *Discocyclina augustae oliaeae*.

The nummulitid assemblage (genus *Nummulites* has been studied only from sample KEÇ 3) is significantly different from that of the lower larger foraminiferal horizon in containing large *Nummulites* only occasionally. In addition, *Heterostegina* first appears in these levels. The occurrence of *Nummulites hornensis* Nuttall and Brighton 1931 (‘praefabianii’), *Heterostegina armenica* (Grigoryan 1986) and *Chapmanina gassinensis* Silvestri 1905 suggests the SBZ 18 zone (1998); only the presence of *Nummulites gizehensis* (Forskål 1775) indicates a slightly older age. Considering this, the base of SBZ 18 zone seems to be the most reasonable estimate.

The silty/marly matrix of the olisthostrome of the middle horizon has also been investigated for planktonic organisms from the neighborhood of samples KEÇ 3 and 4 (samples KEÇ 3A, and 4A, respectively). Regarding to the calcareous nanoplankton, the first occurrence of *Reticulofenestra placomorpha* and *Lanternithus minutus* Stradner 1962 is in NP 16, while *Chiasmolithus solitus* (Bramlette and Sullivan 1961) is a marker for the top of NP 16. *Pemma* spp., *Sphenolithus spiniger* Bukry 1971 and *S. radians* Deflandre 1952 are common forms only in the middle Eocene. As concerns the planktonic foraminifera,
the first occurrence of *Globorotalia cerroazulensis cerroazulensis* (Cole 1928) and *Globigerinatheka index tropicalis* (Blow and Banner 1962) can be placed into the middle of the *Truncorotaloides rohri* (P 14) zone. Large *Globigerinae* like *G. eocaena* Gumbel 1870, *G. hagni* Gohrbant 1963 and *G. venezuelana* Hedberg 1937 are quite common, however muri cate species of *Globorotalia* and *Truncorotaloides* (their disappearance usually indicates the end of the middle Eocene) are surprisingly lacking. The upper part of zone P 14 is the most reasonable estimate for the age of the samples, however a slightly younger age cannot be excluded either.

In summarizing age-data from independent fossil groups, it can be stated first that no real difference can be detected between the age of the matrix and that of the olistostromes. The oldest age is given by the calcareous nanoplanckton based on the rare occurrence of *Chiasmolithus solitus* in sample KEÇ 4A. Since resedimentation is a common feature in the upper part of the Keçili section, it cannot be excluded here. In this case the controversy between the ages given by the two planktonic groups (the NP 16 terminates earlier than the P 14 starts) can be eliminated. The age given by nummulitids is in accord with the planktonic foraminiferal data. However the lower boundary of the OZ 14 zone has to be extended downward more than was suggested by Less (1998) having correlated it with the base of the Priabonian. Thus, the age of the middle horizon of the larger foraminiferal part of the Keçili section can be estimated as about the base of late Bartonian. The lack of the *Heterostegina reticulata*-lineage characteristic of the more upper part of upper Bartonian, and its appearance in younger parts of the section, seem to confirm this statement.

The upper part of the Keçili section is about 50m thick and lithologically does not differ from the olistostrome of the middle part (text-fig. 10). Orthophragmines have been investigated from five mass-transported beds (KEÇ 8-9, 11, 13 and 14) and since their faunal content is quite similar (also to that from the middle horizon), they are discussed together. Although *Discocyclina dispansa* is very rare in these beds and, therefore its occurrence is not diagnostic, the other forms indicate OZ 14 zone for the upper larger foraminiferal horizon of the Keçili section like for the middle horizon (see also the arguments there).

Other larger foraminifera, including the *Nummulites* only from KEÇ 11, 15 and 16, were studied from samples KEÇ 8, 9, 11, 13-16. Their assemblage slightly differs from that of the middle horizon, although large *Nummulites* are occasional and quite rare here, too. It is worth noting that *Spiroplecyx*, whose appearance marks the base of the Priabonian, is missing. This assemblage is slightly younger than that of the middle horizon in the appearance of *Pellatispira* and the *Heterostegina reticulata*-lineage that is represented by its most primitive developmental stage known so far in the Mediterranean region. Within phylectic lineages, the evolution can be detected in replacing *Nummulites gizehensis* by *Nummulites lyelli d’Archiac and Haim 1853* and in the more advanced X parameter of *Heterostegina armenica*. The listed larger foraminiferal assemblage as a whole can be placed into the lower part of the SBZ 18 zone, taking into account that the stratigraphical range of some taxa (*Nummulites lyelli*, *Pellatispira madaraszi* (Hantken 1875) and *Chapmanina gassinensis*) is to be modified, i.e. for *Nummulites lyelli* upward, whereas for *Pellatispira madaraszi* and *Chapmanina gassinensis* downward.

From the matrix of the olistostrome one sample (KEÇ 15A) has been studied for calcareous nannoplankton. This assemblage is poor and the preservation is bad. Middle-late Eocene age without zonal limitation could be given. Based mostly on nummulitid forms, a late (but not latest) Bartonian age seems to be the most reasonable estimate for the age of the upper larger foraminiferal horizon.

**Sarköy Section (Thrace Basin, Sakarya Continent)**

An outcrop of Bartonian (?) to lower Priabonian shallow-marine carbonates and overlying calcarenites and clastics are found near the town of Sarköy (Dolucatepe, 9km northeast of Sarköy) (text-fig. 5). This carbonate-dominated succession here
is interpreted either as part of a large olistolith in Eocene basinal sediments (Okay et al. 2001) or as part of a main transgressive carbonate unit (Sümengen et al. 1987). The Sarköy section, about 28m in thickness, has been sampled along the road from Tepeköy to Çengelli (from 40°39’18.83”N, 27°10’7.42”E to 40°39’16.39”N, 27°9’8.66”E) and stratigraphically corresponds to the upper part of Sogucak Formation. It comprises a 28m-thick sequence of sandy calcarenites, bioclastic sandy limestones and sandstones, regarded as deposited in a shelf-margin setting. Microfossils are listed in text-figure 11.

Bioclastic limestone horizons consist of abundant bryozoans, red algae, corals and fragments of Echinodermata. Sporadic occurrence of planktonic foraminifera indicates open-marine influence. Larger foraminifera (orthophragmines and nummulitids) have been found in three beds. The lower two (SAR 2 and 4) are in close vicinity and contain practically identical forms. The orthophragminid assemblage as a whole can be evaluated as belonging to the OZ 14 zone, although Discocyclina dispansa umbilicata (Deprat 1905) indicates a somewhat younger evolutionary degree of both the Spirolyceus and Heterostegina reticulata from Sarköy are practically identical with those from the basal Priabonian beds of Mossano (Northern Italy, Bassi et al. 2000) and Úrhida (Hungary, Less et al. 2000). Sample SAR 4 has also been investigated for calcareous nannoplankton. Only an early Bartonian to late Priabonian age-interval (NP 16 to 21) can be detected based on this assemblage. To sum up: the earliest Priabonian age given by nummulitids is the most precise one that can be assigned to samples SAR 2 and 4. The upper, early Priabonian part of OZ 14 zone is recognized from Mossano, Verona, Castel San Felice (both Northern Italy) and Úrhida (Hungary). The characteristic feature of these localities is the presence of some survivor mid-Hercynian orthophragmines (Discocyclina pratti, Nemkovella strophiolata, Asterocyclina alticostata (Nuttall 1926) and A. kecskemetii Less 1987), unknown from the higher horizons of the Priabonian, together with primitive Spirolyceus and with Heterostegina reticulata of the same evolutionary degree.

From sample SAR 9 only the fauna of orthophragmines has been investigated. This assemblage is almost the same as that of the lower samples with some minor differences: Discocyclina pratti is significantly more advanced and Asterocyclina alticostata could not be found as compared to samples SAR 2 and 4. The boundary of the OZ 14 and 15 zones seems to be the most realistic age-estimate that corresponds still to the early (but not earliest) Priabonian.

**SYSTEMATIC DESCRIPTION OF THE ORTHOPHRAGMINES**

We only give full description for the new species and subspecies. A short review is given for each species. It includes the most characteristic morphological features, the geographic and stratigraphic range, the references to more detailed descriptions, the up-to-date subdivision into subspecies with their biometric limits and the characteristics (occurrence, evolution and possible deviations) of the Turkish material. In the descriptions, for characterizing some qualitative features, we adopt the terminology introduced by Less (1987, 1993) and illustrated in text-figure 2.
**Discocyclina aff. D. augustae** van der Weijden 1940
Plate 2, figure 11; plate 4, figure 21

Some *Discocyclina augustae* specimens in the lower Priabonian Sarköy section (OZ 14 and 14/15 zones) have an almost eulepidine embryonic configuration and slightly arcuate adauxiliary chamberlets. One specimen from the upper Lutetian Alaman section (OZ 11/12 zones) presents typical nephrolepidine embryon, and has arcuate adauxiliary chamberlets with faintly arcuate distal walls. Because of these variations, these specimens, otherwise having morphological features closely resembling to their accompanying *D. augustae*, are designated as *D. aff. augustae*.

**Discocyclina trabayensis** Neumann 1955

*Discocyclina trabayensis* is an unribbed species having a very small, iso- to nephrolepidine embryon, very low, relatively wide, peculiar “varians” type adauxiliary chamberlets and narrow equatorial chamberlets with “trabayensis” type growth pattern. It is a rather sporadic taxon with a geographic distribution, known from Southwestern France to Anatolia. The earliest occurrence is reported from the early Cuisian (OZ 6) and then it spreads until the very end of the Eocene becoming quite frequent in the upper Priabonian. It forms an evolutionary lineage—developing very slowly in the early and middle Eocene, however accelerating in the Priabonian—with three successive subspecies. The detailed description of the species and those of the firstly described three subspecies (*D. t. trabayensis*, *D. t. concentrica* and *D. t. vicenzensis*) can be found in Less (1987). However, later Less (1998) united the first two subspecies under the name of *D. t. trabayensis*, meanwhile a new subspecies—informally called as *D. trabayensis* n. ssp. Mossano—has been erected for the less advanced developmental stage of *D. t. vicenzensis* which was actually attributed only to the upper Priabonian forms having the largest embryon dimensions of the evolutionary lineage (Less 1999). The informal name of *D. trabayensis* n. ssp. Mossano is replaced here by *D. t. elazigensis* n. ssp., adopting the same biometric limits. The updated subdi-
vision of the lineage, following the above modifications, is as follows:

- **D. t. trabayensis** $d_{\text{mean}} < 125\mu m$
- **D. t. elazigensis n. ssp.** $d_{\text{mean}} = 125–170\mu m$
- **D. t. vicenzensis** $d_{\text{mean}} > 170\mu m$

In the Turkish material, *D. trabayensis* is easily recognizable and represented almost exclusively by *D. t. elazigensis n. ssp.*

In the upper Lutetian Alaman section (OZ 11/12) only one single specimen has been found, therefore it is not determined on the subspecific rank. The upper horizon in Keçili (OZ 14, upper Bartonian) serves as type level of the new subspecies; it also occurs in the middle horizon (OZ 14, upper Bartonian). In the lower Priabonian Sarköy section (OZ 14 and 14/15) it occurs quite rarely; in sample SAR 4 the size of the deutoconch appears to be a little smaller and, therefore this population consisting of only four specimens was determined as *D. trabayensis* ex. interc. *elazigensis–trabayensis*. The stratigraphic range of *D. t. elazigensis* remains OZ 14–15 as it was designated for *D. trabayensis* n. ssp. Mossano by Less (1998), however the newly defined OZ 14 comprises not only a part of the early Priabonian but also the late Bartonian.

**Discocyclina trabayensis** Neumann 1955 *elazigensis* Özcan and Less n. ssp.

Plate 2, figures 7-9, text-figure 12


Etymology. Named after the city of Elazığ, which is close to the type-locality of the taxon in Eastern Turkey.

Holotype. Preparation O/KEÇ 11-35 (pl. 2, fig. 8, text-fig. 12).

Depository. Geology Department of Istanbul Technical University.

Type locality. Sample KEÇ 11, around Keçili village (Baskıl, Elazığ, Eastern Turkey).

Type level. Upper Bartonian, orthophragminid zone 14.

Occurrence. Megalospheric specimens from samples KEÇ 4, 5, 9 and 11 (OZ 14, upper Bartonian of Keçili, text-figs. 5, 7, 8).

Diagnosis. Populations of *Discocyclina trabayensis* with $d_{\text{mean}}$ ranging between 125 and 170µm.

Description (see also table 1): The test is markedly thin and flat (2-4mm in diameter and 0.3-0.5mm in thickness) with central umbonal region. The small embryon is of nephrolepidine configuration. The few adauxiliary chamberlets are of “varians” type (conspicuously arcuate to wedge-shaped in their outer part). The growth pattern of the equatorial annuli is of “trabayensis” type, i.e. in the early stage of development the chamberlets are very low and narrow whereas they are high and narrow, typically rectangular through the peripheries.

Remarks. Since the test of *D. trabayensis* and the annular development of its chamberlets are very similar to that of *D. augustae*, the only distinction can be made regarding the early ontogenetic stage of the taxon. This taxon differs from *D. augustae* in possessing fewer adauxiliary chamberlets, which are more elongated in annular direction and strongly arcuate in their distal parts, giving the first annulus a lobulate outline.

**Discocyclina aff. D. trabayensis** Neumann 1955

Plate 3, figures 3-6; text-figure 12

Several discocyclinid specimens in the upper Lutetian Alaman (OZ 11/12) and Keçili (OZ 14) sections have typical iso- to nephrolepidine embryonic configuration and few adauxiliary chamberlets, which seem faintly arcuate or even straight on distal sides. These specimens that do not present typical arcuate chamberlets of the first annulus are treated separately.

**Discocyclina dispansa** (Sowerby 1840)

Plate 2, figures 15-21; text-figure 13

*Discocyclina dispansa* is an unribbed form with a small to medium-sized, semi-nephro- to trybliolepidine embryo, moderately wide and high, “archiaci” type adauxiliary chamberlets and also moderately wide and high equatorial chamberlets. It is probably the most widespread orthophragminid taxon with a
geographic distribution that can be followed from Northeastern Spain to the Fiji Islands. It first appears in the middle Ilerdian (OZ 3), and becomes frequent at the beginning of Cuisian and then extends to the upper part of the Priabonian forming a quite rapidly developing evolutionary lineage with six successive subspecies. The detailed description of the species and its subspecies can be found in Less (1987, 1998, 1999) and Özcan (2002). According to Less (1998, 1999), the recent biometric subdivision of the species, with its successive subspecies is as follows:

- D. d. broennimanni $d_{\text{mean}} < 160\mu$m
- D. d. taurica $d_{\text{mean}} = 160–230\mu$m
- D. d. hungarica $d_{\text{mean}} = 230–290\mu$m
- D. d. sella $d_{\text{mean}} = 290–400\mu$m
- D. d. dispensa $d_{\text{mean}} = 400–520\mu$m
- D. d. umbilicata $d_{\text{mean}} > 520\mu$m

In the Turkish material D. dispensa is represented by three distinct subspecies in accord with the evolution of the lineage. D. dispensa sella (pl. 2, figs. 15–16, text-figure 13) is widespread in the upper Lutetian Alaman section (OZ 11/12). D. dispensa ex. interc. dispensa–sella (pl. 2, fig. 20, Text figure 13) has been found in the lower levels of the Keçili section (KEÇ 1 and 2, OZ 13, lower Bartonian), while it is followed by the closely related D. d. dispensa (pl. 2, fig. 18, Text figure 13) in the middle levels (KEÇ 3–5, OZ 14, upper Bartonian). The species is quite rare in the upper levels of Keçili (KEÇ 8–14, OZ 14, upper Bartonian), and therefore no firm conclusions can be derived from the determination of D. dispensa cf. sella (pl. 2, fig. 17) based on two specimens. Finally, D. d. umbilicata (pl. 2, fig. 21, text-fig. 13) is rather common in the lower Priabonian Sarpköy section (OZ 14 and 14/15). Based on these new data, the stratigraphic range of D. d. dispensa [upper part of OZ 13 and the whole OZ 14 instead of exclusively OZ 14 (Less 1998)] and D. d. umbilicata [the upper, Priabonian part of OZ 14 to OZ 16 instead of exclusively OZ 15 (Less 1998) and OZ 15–16 (Less 1999)] is to be modified.

Discocyclina pratti (Michelin 1846)

Plate 2, figures 22–23, 28; plate 3, figure 1; plate 4, figure 14; text-figure 14

Discocyclina pratti is an unribbed species having a medium-sized to large, tryblion- to excentrilamid embryo, numerous moderately wide and high, "pratti" type adauxiliary chamberlets and narrow but high equatorial chamberlets with "pulcra" type growth pattern. It is a quite common taxon with a wide geographic distribution from Southwestern France to Anatolia. The earliest occurrence is known from the early Lutetian (OZ 8b, see notes in Less 1998) and then it can be followed until the end of the early Priabonian (OZ 14/15). It forms a moderately fast evolving lineage, presenting quite large fluctuations especially in the Bartonian to early Priabonian timespan. In the assemblages of this interval, usually two morphotypes can be observed; one of them having smaller, tryblion- and umbilicolepidine embryo ("pratti") whereas the other has larger, mostly excentrilamid embryo ("minor"). However, several transitional forms can also be found, therefore their exact separation is practically impossible. Discocyclina pratti originally was subdivided into four subspecies by Less (1987), however later Less (1998) excluded "aquitanica" from the lineage and segregated it into a separate species. On the basis of the rather rich Turkish material it is expedient to redefine the biometric limits of subspecies for populations as follows:
D. p. montfortensis \( \text{d}_{\text{mean}} < 510 \mu m \)
D. p. pratti \( \text{d}_{\text{mean}} = 510-700 \mu m \)
D. p. minor \( \text{d}_{\text{mean}} > 700 \mu m \)

The detailed description of the species and its subspecies can be found in Less (1987), however the above biometric rearrangements in the subspecific boundaries have to be taken into consideration for D. p. montfortensis and D. p. pratti.

In the Turkish material D. pratti is represented by two distinct developmental stages in accord with the evolution of the lineage. D. pratti montfortensis (pl. 2, figs. 22-23 and 28, Text figure 14) is common in the upper Lutetian Alaman section (OZ 11/12), whereas the upper Bartonian and lower Priabonian assemblages with considerably larger embryo are quite close to each other and are described as D. p. pratti (from the middle layers of Keçili, OZ 14; pl. 4, fig. 14, text-figure 14), D. pratti ex. interc. minor-pratti (from the upper layers of Keçili, OZ 14; pl. 3, fig. 1), D. pratti cf. pratti (only three specimens from sample SAR 4 of Sarköy, OZ 14) and D. pratti ex. interc. pratti-minor (from sample SAR 9 of Sarköy, OZ 14/15). From the two morphotypes mentioned above “pratti” dominates over “minor” that forms the minority of the D. pratti assemblages in samples KEÇ 4, 5, 11 and SAR 9. With the redefinition of biometric limits separating subspecies, their stratigraphic ranges have also to be modified compared to Less (1998). In the case of the redefined D. p. montfortensis it is OZ 8b–12 instead of OZ 8b–9, for D. p. pratti OZ 11/12–14 instead of OZ 10–13, whereas it is only OZ 14 instead of OZ 14-15 for D. p. minor. This means that D. p. montfortensis is characteristic tentatively for the Lutetian, D. p. pratti for the Bartonian while D. p. minor for the early Priabonian. However the large fluctuations (characteristic for the evolutionary track of D. pratti mentioned above) cause considerable overlaps between the stratigraphical ranges of the neighboring subspecies.

**Discocyclina aff. D. pratti** (Michelin 1846)
Plate 3, figure 2

Some specimens from the middle and upper layers of Keçili (OZ 14, upper Bartonian) have the similar size of embryo with that of typical Discocyclina pratti from the same beds, however they differ from them in having rather trybliolepidine (instead of umbilico-excentrilepidine) embryo and somewhat shorter adauxiliary and equatorial chamberlets, also the latter are wider than those of the typical D. pratti. These forms probably belong to a separate lineage, however since their small number does not justify their separation, they are provisionally described here under the name of D. aff. D. pratti.

**Discocyclina aff. D. samantai** Less 1987
Plate 3, figure 19, text-figure 15

Discocyclina samantai is a ribbed form with a large, excentrilepidine embryo, many wide and high, “pratti” type adauxiliary chamberlets and narrow but high equatorial chamberlets with “pulcra” type growth pattern. According to Less’s (1987) original description, it corresponds to the unribbed D. pratti minor occurring only in Lábatlan (Hungary) whose age was considered to be middle Priabonian (OZ 15 zone). Since then, the species has also been recorded in the middle Priabonian of Austria (Rasser et al. 1999) and also in the middle Priabonian “Discocyclina” beds of Priabona (studied by Less in Utrecht, in the unpublished material of Setiawan). In the light of new sedimentologic and paleontologic data, the age of the Lábatlan locality, however, is to be rearranged into the OZ
The very rare and sporadic occurrences of *D. samantai* do not allow the establishment of an evolutionary lineage. In the Turkish material very few ribbed specimens from the middle layers of Keçili (OZ 14 zone, upper Bartonian) can correspond to the accompanying, unribbed *D. pratti pratti* from the same horizon. Their internal parameters are practically the same; the presence/absence of ribbing is the only feature distinguishing the two taxa. As far as the original material is considered, *D. samantai* differs from our specimens by somewhat bigger excentrilepidine embryo (Keçili specimens are of umbilico- to multilepidine embryo configuration) and also by other internal parameters, larger than those of the Keçili forms. Keçili forms can only be described here under the name of *D. aff. samantai* since their low number does not allow the assignment of a new taxon.

**Discocyclina pulcra** (Checchia-Rispoli 1909)
Plate 3, figures 24-25; plate 4, figure 13

*Discocyclina pulcra* is an unribbed species having a large to giant centrilepidine embryo, numerous wide and high to very high, “pratti” type adauxiliary chamberlets and relatively narrow but high to very high equatorial chamberlets with “pulcra” type growth pattern. It is comparatively rare, however known to occur from Southwestern France to Anatolia. The earliest appearance is known from the early Cuisian (OZ 6) of Southwestern France (Horsarrieu, marnière Sourbet); however all its other occurrences are known from the middle Eocene, Dudar (Suruhegy) of OZ 12 zone being the youngest one. *D. pulcra* forms a nicely developing evolutionary lineage with five successive subspecies. The detailed description of the species and its particular subspecies can be found in Less (1987, 1989, 1998). The biometric limits of *D. pulcra* subspecies are delimited by Less (1998) as follows:

* D. *p. landesica*  
  \[ d_{\text{mean}} < 800\mu m \]
* D. *p. pulcra*  
  \[ d_{\text{mean}} = 800–1000\mu m \]
* D. *p. n. ssp. Angoumé*  
  \[ d_{\text{mean}} = 1000–1250\mu m \]
* D. *p. balatonica*  
  \[ d_{\text{mean}} = 1250–1600\mu m \]
* D. *p. baconica*  
  \[ d_{\text{mean}} > 1600\mu m \]

*D. pulcra* occurs throughout the upper Lutetian Alaman section (OZ 11/12 zones). Its two populations are quite close to each other, however according to the principles of subspecific determination described above, the lower population is assigned to *D. p. baconica* (pl. 3, figs. 24–25; pl. 4, fig. 13) while the upper one to *D. pulcra* ex. interc. *D. baconica-balatonica* though the latter is based on rather few specimens. It has to be said however, that the height of both the adauxiliary and equatorial chamberlets of the Alaman forms is significantly less than that of the topotypical *D. p. baconica* from Dudar (Suruhegy). The stratigraphic range of *D. p. baconica* remains OZ 12, however based on the new data from Alaman this zone incorporates not only the lower (maybe only lowermost) part of the Bartonian but also the topmost part of the Lutetian.

**Discocyclina discus** (Rütimeyer 1850)

*Discocyclina discus* is an unribbed form with a giant, mostly umbilicolepidine (rarely also tryblo- or excentrilepidine) embryo, numerous, wide and high, “archiaci” or transitional “archiaci-pratti” type adauxiliary chamberlets and wide and high equatorial chamberlets with “archiaci” or transitional “archiaci-pulcra” type growth pattern. It is the descendant of *D. archiaci* and rather common from France to Cutch (Western India, Samanta and Lahiri 1985). The earliest occurrence is known from the middle Lutetian (OZ 9) and ranges up to the end of the Bartonian (lower part of OZ14 zone). Based on its very rare (one single specimen) occurrence in Lábatlan (Hungary) its stratigraphic range was also extended into the Priabonian (Less 1987, 1998). However, the sedimentologic and taxonomic revision of the fauna from this locality showed that upper Bartonian and lower Priabonian elements are resedi-
TEXT-Figure 15
Types of embryon and their variation in *Orbitocyclus varians*, *O. aff. O. varians*, *Discocyclina radians*, *D. aff. D. samantai* and *D. euanensis*. All ×40.
mented and mixed. *Discocyclina discus* forms a rather slowly developing evolutionary lineage with two successive subspecies. The detailed description of the species and its particular subspecies can be found in Less (1987, 1998). According to Less (1998), the biometric limits of subspecies for populations are considered as follows:

- *D. d. discus*: \( d_{\text{mean}} < 1350 \mu\text{m} \)
- *D. d. adamsi*: \( d_{\text{mean}} > 1350 \mu\text{m} \)

In the Turkish material only one single, rather badly preserved specimen of *D. discus* with strongly deformed embryon could be found in Alaman (sample ALM 6, OZ 11/12 zones, upper Lutetian). Therefore, no comment on taxonomy and stratigraphic evolution of this taxon can be made.

### Discocyclina radians (d’Archia 1850)

*Discocyclina radians* is a ribbed form with a small to medium-sized semi-nephro- to trybliolepidine embryon, wide and moderately high, “pratti” type adauxiliary chamberlets and narrow and high equatorial chamberlets with “pulcra” type growth pattern. It is quite common from Spain to Armenia. The earliest appearance is known from the early Lutetian (OZ 8b) and then it spreads until the end of the Priabonian forming an evolutionary lineage – developing quite rapidly in the Lutetian, however rather stagnating later – with four successive subspecies. The detailed description of the species and its particular subspecies can be found in Less (1987, 1998, 1999). According to Less (1998), the biometric limits of subspecies for populations are considered as follows:

- *D. r. radians*: \( d_{\text{mean}} = 240–375 \mu\text{m} \)
- *D. r. labatlanensis*: \( d_{\text{mean}} > 375 \mu\text{m} \)

In the Turkish material *D. radians* is common only in the upper part of the upper Lutetian Alaman section (OZ 11/12) where it is represented by *D. radians* ex. interc. labatlanensis-radians (pl. 3, figs. 16 and 18, Text figure 15). Only one single specimen each has been found in the lower part of the Keçili section (pl. 3, fig. 17, OZ 13, early Bartonian) and also in the lower part of the Sarköy section (OZ 14, early Priabonian), therefore these are not determined on the subspecific level. Based on the embryonic dimension of the Alaman population, the stratigraphic range of *D. r. labatlanensis* has to be slightly modified from OZ 12 to 16 instead of OZ 13–16 in Less (1998).

### Discocyclina euensis Whipple 1932

*Discocyclina euensis* Whipple 1932

Plate 3, figures 20-21, 23; text-figure 15

*Discocyclina euensis* n. sp. - WHIPPLE 1932. p. 84, pl. 22, figs. 3-7, text fig. 6.

- *Discocyclina (Discocyclina) assamica* n. sp. – SAMANTA 1963. p. 658-661, pl. 94, figs. 1-6, text fig. 6.

*Discocyclina euensis* Whipple 1932. – LESS 1987. p. 175-176, pl. XIX, figs. 4-6, text fig. 28d (with synonymy).

In Less’s (1987) interpretation *Discocyclina euensis* is a rare, unribbed upper Eocene form having practically the same internal features as those of its contemporaneous ribbed *D. radians*. Its first occurrence is earlier than it was suggested by Less (1987, 1998). *Discocyclina euensis* is known already from the Bartonian of Cutch (Samanta and Lahiri 1985, under the name of *D. assamica*). This species is more common in the upper Eocene of the Far East (Tonga Islands, New Caledonia), India (Assam), Hungary and Northern Italy. The last occurrence is known from the “Asterocyclina” beds of Priabona (Setiawan 1983), thus it most likely ranges to the end of the late Eocene. Based on the very scarce data, it seems that populations with
The mean below 400–450µm are characteristic for the Bartonian while the ones with d mean above this value represent the Priabonian. However the available data are not yet sufficient to subdivide the species into subspecies.

In the Turkish material a few specimens of *D. euaensis* are found in the middle and upper levels of Keçili (upper Bartonian, OZ 14). Externally these forms are very small and slightly inflated in contrast with the large, flat forms described from the other localities. Nevertheless, the internal characteristics fit well, especially with those from the Bartonian of Cutch. The average size of the deuterococonch is around 300µm in both localities as compared to 400–600µm reported from the other sites. Based on the occurrences in Keçili and also in Cutch, the stratigraphic range of *D. euaensis* has to be extended into at least the late Bartonian–Priabonian interval instead of only the middle–late Priabonian suggested by Less (1987, 1998).

*Discocyclina nandori* Less 1987
Plate 3, figure 22

*Discocyclina nandori* n. sp. - LESS 1987. p. 169-170, pl. XVI, figs. 8-12, text figs. 27y-z.

*Discocyclina nandori* is a ribbed form with a small, semi-nephro- to trybliolepidine embryon, rather few, moderately wide and average-sized, “pratti” type adauxiliary chamberlets and narrow equatorial chamberlets with “trabayensis–pulcra” type growth pattern (low near the embryon and high at the peripheries). It is very rare; Less (1987) reported it from the lower and middle Priabonian of Northern Italy and Hungary. Since then, it has been also recorded in the upper Bartonian beds of Hungary (Bajót, unpublished data by Less). Nevertheless, the stratigraphic range of the species remains OZ 14–15 as in Less (1987, 1998), keeping in mind that the OZ 14 zone incorporates not only early Priabonian but also late Bartonian. The very scarce data of *D. nandori* do not allow the biometric subdivision of the species. In addition, some kind of relationship with the Lutetian to early Bartonian *D. knessae* (another very rare and poorly known taxon) cannot be excluded, either. In the Turkish material two specimens with faintly developed ribs, otherwise bearing the internal characteristics of *D. nandori*, have been found in the basal Priabonian beds of Sarköy (OZ 14). This observation significantly extends the geographical range of the species in the western Tethys.

Genus *Nemkovella* Less 1987

*Nemkovella strophiolata* (Gümbel 1870)
Plate 3, figures 8-11; text-figure 13

*Nemkovella strophiolata* is an unribbed species with a small semi-iso to nephrolepidine embryon, low but relatively wide, very diagnostic, arcuate, “varians” type adauxiliary chamberlets and moderately narrow and low equatorial chamberlets with “strophiolata” type growth pattern. It occurs in the orthophragmimid assemblages from Southwestern France to Anatolia. The earliest sporadic occurrence is known from about the Ilerdian/Cuisian boundary (OZ 4/5), then it becomes more frequent in the Middle Eocene and can be followed until the early Priabonian (boundary of OZ 14 and 15 zones), forming a rather slowly but steadily developing evolutionary lineage with four successive subspecies. The detailed description of the species and its particular subspecies can be found in Less (1987, 1998).
### TABLE 1

Statistical data of discocyclinid populations (see the text for the abbreviations of parameters).

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<th>d (µm)</th>
<th>p (µm)</th>
<th>N</th>
<th>H (µm)</th>
<th>W (µm)</th>
<th>n</th>
<th>h (µm)</th>
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<td>100</td>
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<td>ex. intere. adelantho-wendtensis</td>
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</tbody>
</table>

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**Notes:**
- **n°:** Number of specimens.
- **d (µm):** Disc diameter.
- **p (µm):** Perforation diameter.
- **N:** Number of specimens.
- **H (µm):** Height.
- **W (µm):** Width.
- **n:** Number of specimens.
- **h (µm):** Height.
- **w (µm):** Width.

---

**Abbreviations:**
- **ALM:** Alanya-Mersin Province
- **SAR:** Sari-Sultan Province
- **D. aff. Augustae:** Discocyclina augustae
- **D. aff. Trubovayensis:** Discocyclina trubovayensis
- **D. disparva:** Discocyclina disparva
- **D. pratti:** Discocyclina pratti
1998), Özcan (2002) and Colakoglu and Özcan (2003). Subspecies limits delimited by Less (1998) are as follows:

- **N. s. fermonti**
  \[ d_{\text{mean}} < 150 \mu m \]

- **N. s. strophiolata**
  \[ d_{\text{mean}} = 150–185 \mu m \]

- **N. s. n. ssp. Padragkút**
  \[ d_{\text{mean}} = 185–230 \mu m \]

- **N. s. tenella**
  \[ d_{\text{mean}} > 230 \mu m \]

In the Turkish material **N. strophiolata** is rather rare, nevertheless two distinct subspecies in accord with the evolution of the lineage could be identified. **Nemkovella strophiolata strophiolata** (pl. 3, fig. 8, Text figure 13) is characteristic for the upper Lutetian (OZ 11/12) Alaman section (although in the lower part it could be determined only as “cf.” based on only two specimens) whereas **N. s. tenella** (pl. 3, figs. 9-11, Text figure 13) is detected from the middle part of the Keçili section belonging to the Bartonian part of the OZ 14 zone. The single specimen found in the lower part of the section (OZ 13 zone) does not permit any subspecific designation. Based on these and other unpublished new data and also taking into account the revision of the Lábatlan locality (for more details see the description of **Discocyclina discus**), the stratigraphic range of **N. s. strophiolata** [OZ 8b–11/12 instead of OZ 8b–11] and **N. s. tenella** [OZ 14–15? instead of OZ 15] is slightly modified as compared to Less (1998).

**Nemkovella daguini** (Neumann) 1958
Plate 2, figures 1-4; plate 3, figure 14; plate 5, figure 6; text-figure 12

**Discocyclina daguini** n. sp. – NEUMANN 1958, p. 89, pl. 17, figs. 7-10.

**Orbitoclypeus daguini** (Neumann 1958). – LESS 1987, p. 222-224, pl. 36, figs. 1-6, text figs. 31 a and b (with synonymy).


Emended description.

**Megalospheric generation.** The test is typically small (less than 2mm in diameter), strongly inflated, and without any ribbing. The embryo is iso- to nephrolepidine with a very small, spherical protoconch varying in diameter between 25 and 65µm (45 to 65µm in our material), followed by a slightly larger deuteroconch varying in diameter between 45 and 110µm (65 to 110µm in our material). The arrangement of the equatorial chamberlets around the deuteroconch is typically orbitoidal (“daguini” type of Less 1987). These and the adiauxiliary chamberlets are isolated and arcuate in shape. The number of adiauxiliary chamberlets ranges between 1 and 2 (in the Turkish material all but one specimen had 2 and a single specimen had 3 such chamberlets). Cyclic growth is attained in the successive growth stages following the first few annuli. At these ontogenetic stages, chamberlets are low hexagonal (because of the lack of the annular stolon, see Less 1987, pl 36, figs. 5, 6) and progressively tend to be highly rectangular (25-30µm wide and 70-90µm high) towards the periphery. Most of the specimens possess wavy annuli, at least in the early part of development; their number varies between 4 and 5. This wavy pattern is attenuated with successive growth and latest equatorial chamberlets are in regular annuli with circular outline. The chamberlets in the ‘rays’ are distinctly higher than those in the ‘inter-ray’ areas. In vertical section (pl. 5, fig. 6), the height of the protoconch and deuteroconch is about 90 and 125µm, respectively. The equatorial layer is 25µm thick near the embryo.
and it thickens to 40\mu m towards the edges. The lateral chamberlets are 20-25\mu m in height.

**Microspheric generation:** A single microspheric specimen (pl. 3, fig. 14) has been found for the first time in sample SAR 4 (basal Priabonian of Sarköy). Externally it does not differ from the megalospheric forms. The initial spiral is followed by semi-circular and circular annuli having low elongated chamberlets. Later chamberlets are arranged in regular annuli. This spiral arrangement of the juvenarium together with the absence of annular stolon of the equatorial chamberlets enables the generic assignment of the taxon to *Nemkovella* instead of *Orbitoclypeus* by Less (1987, 1998).

**Remarks:** *Nemkovella daguini* is a poorly known orthophragminid taxon from the Lutetian and Bartonian of the Western Tethys (from Spain to Turkey) either because of its sporadic occurrence or its size, too small for easy detection. Identification of *N. daguini* in the Sarköy material, in which it occurs very frequently in sample SAR 4 (OZ 14, basal Priabonian of Sarköy), enables us to extend its stratigraphic range into the early Priabonian. The biometric subdivision of the taxon based on the deuterococonch size is not yet possible because of lack of data especially from the Lutetian. However, it is worth mentioning that all the (few) specimens from the Lutetian (Saint- Barthélémy, Ajka) have only one adauxiliary chamberlet while most of the Bartonian (Keçili – OZ 13 and 14, Ürhid – Less and Gyalog 2004, Gurb – Serra-Kiel et al. 2003) and lower Priabonian forms (Sarköy, OZ 14 and 14/15) have more, usually two.

Family ORBITOCLYPEIDAE Brönnimann 1945
Genus *Orbitoclypeus* Silvestri 1907

*Orbitoclypeus varians* (Kaufmann 1867)
Plate 2, figures 12, 14 and 19; plate 3, figure 15; plate 5, figures 7-8; text-figure 15

*Orbitoclypeus varians* is an unribbed form with “marthae” type rosette (pl. 5, fig. 8), small to medium-sized excentri- to eulepidine embryo, adauxiliary chamberlets of “varians” type with average size and shape and also moderately wide and high equatorial chamberlets arranged into undulated annuli with “varians” type growth pattern. The biserial juvenarium of the microspheric forms (characteristic for Orbitoclypeidae) is shown in plate 3, figure 15. The characteristics of the vertical section are described in Less (1987) and illustrated in plate 5, figure 7. *Orbitoclypeus varians* is one of the most common and widely distributed orthophragminid taxa from Spain to Armenia. The earliest occurrence is known from the lowest Cuisian (OZ 5 zone) of the Haymana-Polatlı Basin in Turkey (Özcan 2002). However, it becomes frequent only at the beginning of Lutetian and then continues until the very end of the Priabonian, forming a rapidly evolving lineage with six successive subspecies. The detailed description of the taxon can be found in Less (1987, 1998, 1999), and Özcan (2002). According to Less (1998), the biometric subdivision of the species, with its successive subspecies, is as follows:

- *O. v. portnayae* $d_{\text{mean}} < 165\mu m$
- *O. v. n. ssp. Caupenne* $d_{\text{mean}} = 165-205\mu m$
- *O. v. angouemensis* $d_{\text{mean}} = 205-255\mu m$
- *O. v. roberi* $d_{\text{mean}} = 255-320\mu m$
- *O. v. scalaris* $d_{\text{mean}} = 320-400\mu m$
- *O. v. varians* $d_{\text{mean}} > 400\mu m$

In the Turkish material *O. varians* is one of the most common taxa, represented by two morphotypes. The typical *O. varians* with wavy annuli is represented by two distinct subspecies. In general, less developed specimens can be found in the upper Lutetian Alaman section (OZ 11/12) suggesting an evolution from the lower towards the upper populations. In Alaman, the less developed one is determined as *O. varians* ex. interc. *scalaris-roberti* (pl. 2, figs. 12, 19, text-fig. 15), while the more advanced form is considered *O. v. scalaris* (pl. 3, fig. 15; pl. 5, figs. 7-8, text-fig. 15). More developed forms can be found throughout the Bartonian Keçili (OZ 13 and 14) and lower Priabonian Sarköy sections (OZ 14 and 14/15). According to the principles of subspecific determination stated earlier, these populations are designated as *O. v. varians* (text-figure 15), *O. varians* ex. interc. *O. varians-scalaris* (pl. 2, fig. 14, text-fig. 15) and *O. varians* ex. interc. *scalaris-variants* and, when only two or three specimens were found, as *O. varians* cf. *variants*. Our data indicates that the stratigraphic range of *O. v. scalaris* needs to be slightly modified as compared to Less (1998). Instead of strictly OZ 12 zone, it has to be extended downward to include OZ 11/12 and in individual cases upward to include OZ 14. However the main occurrence of the subspecies remains in OZ 12.

*Orbitoclypeus aff. O. varians* (Kaufmann 1867)
Plate 2, figure 13; text-figure 15

Many specimens from the Bartonian Keçili section (in OZ 13 zone and especially in the middle and upper layers of OZ 14) and one single specimen from lower Priabonian of Sarköy (OZ 14/15) are externally very similar to the typical *Orbitoclypeus varians* of the same beds. However, these medium- to large-sized, moderately inflated, unribbed forms have somewhat larger embryos, and hence somewhat more adauxiliary chamberlets than *O. varians* s.s. In contrast to *O. varians* s.s., their annuli are not undulated and form regular cycles throughout the median layer. These forms are described here as *O. aff. varians*.

*Orbitoclypeus furcatus* (Rütimeyer 1850)
Plate 3, figures 7 and 12

*Orbitoclypeus furcatus* is a species with bifurcating ribs, “marthae” type rosette and with almost the same internal characteristics as for *O. varians* (see above); however the undulation of the equatorial annuli is even more expressive. It belongs to the less frequent orthophragminid taxa and occurs from Southwestern France to Armenia. According to Less and Ö. Kovács (1996), its evolution runs parallel with the unribbed *O. varians*. The earliest appearance is known from the early/middle Cuisian (OZ 6/7 zones) of Horsarrieu (Less and Ö. Kovács 1996); however most of its occurrences are known only from the beginning of Late Lutetian, then it continues until the very end of the Priabonian (Sirotti 1978). *Orbitoclypeus furcatus* forms a moderately quickly developing evolutionary lineage with four successive subspecies. The detailed description of the species and its particular subspecies can be found in Less (1987, 1998). Based on Less (1998), the biometric limits of subspecies are considered as follows:

- *O. f. n. ssp. Horsarrieu* $d_{\text{mean}} < 200\mu m$
- *O. f. n. ssp. Gilber* $d_{\text{mean}} = 200-270\mu m$
- *O. f. rovaxendai* $d_{\text{mean}} = 270-340\mu m$
- *O. f. furcatus* $d_{\text{mean}} > 340\mu m$
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**TABLE 2**

Statistical data of orbitoclypeid populations (see the text for the abbreviations of parameters).
In the Turkish material *O. furcatus* occurs very rarely. In the lower part of the upper Lutetian Alaman section (OZ 11/12) as well as in the middle and upper part of the Bartonian Keçili section (OZ 14), only single individuals (pl. 3, fig. 7) could be found, therefore these are not determined at the subspecific level. More specimens occur only in the upper part of the upper Lutetian Alaman section (sample ALM 11, OZ 11/12 zones); they belong to *O. f. rovasendai* (pl. 3, fig. 12). This finding fits well with the stratigraphic range given by Less (1998) as OZ 10–12.

**Orbitoclypeus douvillei** (Schlumberger 1903)
Plate 2, figures 24-27; plate 3, figure 13; plate 5, figures 9-11; text-figure 16

*Orbitoclypeus douvillei* is an unribbed species having “chu- deauii” type rosette, a small to relatively large, eu-, then tryblo- and excentrilepidine embryo, wide and moderately high, “varians” type adauxiliary chamberlets and also wide and moderately high equatorial chamberlets arranged into circular annuli with “varians” type growth pattern. The biserial juvenarium of the microspheric forms (characteristic for Orbitoclypeidae) is shown in plate 3, figure 13. The characteristics of the vertical section are described in Less (1987, see also the description of *Orbitoclypeus chudeaui*) and illustrated in plate 5, figures 9-10. *O. douvillei* occurs in the orhophragminid assemblages from Southwestern France to Anatolia and Israel. Based on our unpublished data, its earliest occurrence in Tethys is known from the late Ilerdian (OZ 4) of Kastamonu section in central Turkey. Less (1998) reported its highest occurrence from the lowermost Bartonian of Dudar (Hungary) and San Pancrazio in Italy (both OZ 12). Our data extend its stratigraphic range into the whole early Bartonian (including OZ 13). *O. douvillei* forms a rapidly developing, very reliable evolutionary lineage with six successive subspecies, including *O. d. malatyaensis* n. ssp., the most evolved developmental stage of the lineage from OZ 13, described below. The detailed description of the species and of the earlier described subspecies (*O. douvillei* n. ssp. Gibret will be described later) can be found in Less (1987, 1998), Köhler and Salaj (1999), Özcan (2002), Çolakoglu and Özcan (2003). Based on Less (1998) and Özcan (2002), and taking into account the introduction of the new taxon, the biometric limits of subspecies are considered as follows:

- *O. d. douvillei* \(d_{\text{mean}} < 200\mu m\)
- *O. d. vesylartensis* \(d_{\text{mean}} = 200–260\mu m\)
- *O. d. n. ssp. Gibret* \(d_{\text{mean}} = 260–340\mu m\)
- *O. d. chudeaui* \(d_{\text{mean}} = 340–425\mu m\)
- *O. d. pannonicus* \(d_{\text{mean}} = 425–580\mu m\)
- *O. d. malatyaensis* n. ssp. \(d_{\text{mean}} > 580\mu m\)

*O. douvillei* is represented by two distinct subspecies. *O. douvillei pannonicus* (pl. 2, fig. 24; pl. 3, fig. 13. Text figure 16) occurs in the upper Lutetian Alaman section (OZ 11/12, in the lower population it is determined as *O. douvillei* cf. *pannonicus* by the presence of only three specimens) whereas *O. d. malatyaensis* in the lower part of the Keçili section (samples KEÇ 1 and 2, OZ 13 zone, lower Bartonian). This is the highest occurrence of *O. douvillei* so far reported, not only in the Turkish material, but in the whole Mediterranean realm. Based on the new data the stratigraphic range of *O. d. pannonicus* (OZ 11–12 by Less 1998) is confirmed, while that of *O. d. malatya- ensis* is considered as OZ 13.

**Orbitoclypeus douvillei** (Schlumberger 1903) *malatyaensis* n. ssp.
Plate 2, figures 25-27; plate 5, figures 9-11; text-figure 16

**Etymology:** Named after the city of Malatya, which is close to the type-locality of the taxon in Eastern Turkey.

**Holotype:** Preparation O/KEÇ 1-49 (pl. 2, fig. 25, text-fig. 16).

**Depository:** Geology Department of Istanbul Technical University.

**Type locality:** Sample KEÇ 1, near to Keçili village (Baskil-Elazig, Eastern Turkey).

**Type level:** Lower Bartonian, orthophragminid zone 13.

**Occurrence:** Megalospheric specimens from samples KEÇ 1 and 2 (OZ 13, lower Bartonian of Keçili, text-figs. 5, 7, 8, 9).

**Diagnosis:** *Orbitoclypeus douvillei* populations with \(d_{\text{mean}}\) exceeding 580µm.

**Description:** Medium-sized (3-5mm in diameter), strongly inflated forms with “chu-deauii” type rosette (pl. 5, fig. 11). The large embryo is most commonly of excentri-, less frequently of umbilicolepidine configuration. The “varians” type adauxiliary chamberlets are moderately numerous, high and wide. The equatorial chamberlets are arranged into circular annuli, characteristically wide and high, and commonly very high at the peripheral part. Their definite spatulate shape is due to the lack of the annular stolon, one of the most important generic features of the genus *Orbitoclypeus*.(see also table 2).

**Remarks:** *Orbitoclypeus douvillei malatyaensis* n. sp. represents the latest phylogenetic stage of the *O. douvillei* lineage in the early Bartonian (OZ 13). This taxon differs from its ancestor, *O. d. pannonicus* not only in the range of quantitative parameters (compare them in table 2) but also in having mostly typical excentrilepidine embryonic configuration, which has not been previously documented from the Tethyan Eocene. Among the Eocene orthophragmines this lineage probably best illustrates the embryonic acceleration from almost nephr– euclidean in the Cuisian to excentrilepidine configuration in the late early Bartonian.

Genus *Asterocyclina* Gümbel 1870

*Asterocyclina sireli* Özcan et Less n. sp.
Plate 3, figure 32; plate 4, figures 1-3; plate 5, figures 1-5; text-figure 12

**Etymology:** Named in honor of Dr. Ercüment Sirel, Department of Geological Engineering, Ankara University, Ankara.

**Holotype:** Preparation O/ALM 6-76 (pl. 3, fig. 32, text fig. 12).

**Depository:** Geology Department of Istanbul Technical University.

**Type locality:** Sample ALM 6, around Alaman village (Sarkisla, Sivas, central Turkey).

**Type level:** Late Lutetian, orthophragminid zone 11/12.

**Occurrence:** Megalospheric specimens from samples ALM 6, 7 and 11 (OZ 11/12, upper Lutetian of Alaman, Figs. 5, 6).
Diagnosis: Medium to large, flat forms with mostly four radial ribs and “martaque” type rosette. The embryo is small, iso- to nephrolepidine. The deuteroconchal wall corresponding to the position of the successive stage of the developing rib is mostly depressed. The adauxiliary chamberlets are few (2-4) in number, low and moderately wide. The equatorial annuli are arranged usually in four rays.

Description: Medium- to large-sized (3-8mm), flat forms with four, very rarely five, well-developed radial ribs (pl. 5, figs. 4-5). The megalospheric embryo is semi-nephro- to nephrolepidine, characterized by a protoconch measuring between 60 and 100µm and by a deuteroconch measuring between 110 and 160µm. The deuteroconchal wall, corresponding to the position of the successive stage of the developing rib, is mostly depressed. The adauxiliary chamberlets are of “varians” type, moderately low and wide (H: 25–45µm, W: 30–70µm) and few in number (N: 2-4). The equatorial annuli are arranged in usually four rays. Only a few specimens, out of 34, present 5 rays. The equatorial chamberlets in the interray areas are moderately high and wide (n: 14–17, w: 25-35µm), the growth pattern of the annuli is of the “varians” type. In vertical section (pl. 5, figs. 1-3), the height of the embryo is about 110µm. The equatorial layer is 30µm thick near the embryon and it thickens to 125-150µm towards the edges. The lateral chamberlets are 20-25µm in height.

Remarks: The asterocyclinid specimens, which are mostly 4-ribbed externally and having a small embryo with 2 to 4 adauxiliary chamberlets in upper Lutetian, are considered to represent a new asterocyclinid taxon. The depression on the deuteroconch wall corresponding to the position of the successive stage of the developing rib is very conspicuous and gives the deuteroconch a rather irregular shape in equatorial section. Among the other Asterocyclina, our new taxon presents some similarities only to A. stellata regarding the development of adauxiliary chamberlets around the deuteroconch, however, the embryo size of the new species is considerably lower than those of A. stellata known from the contemporaneous levels (OZ 11 and 12) of Western Tethys.

Some large orthophragminid specimens having numerous ribs externally proved to be very similar to newly described taxon. The occurrence of the species and its particular subspecies can be found in the west-

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The asterocyclinid specimens, which are mostly 4-ribbed externally and having a small embryo with 2 to 4 adauxiliary chamberlets in upper Lutetian, are considered to represent a new asterocyclinid taxon. The depression on the deuteroconch wall corresponding to the position of the successive stage of the developing rib is very conspicuous and gives the deuteroconch a rather irregular shape in equatorial section. Among the other Asterocyclina, our new taxon presents some similarities only to A. stellata regarding the development of adauxiliary chamberlets around the deuteroconch, however, the embryo size of the new species is considerably lower than those of A. stellata known from the contemporaneous levels (OZ 11 and 12) of Western Tethys.

Asterocyclina stella (d’Archiac 1846)
Plate 4, figures 8-12; text-figure 12

Asterocyclina stella is a star-shaped form usually with five rays and “martaque” type rosette. It has a small semi-is- to nephrolepidine embryo, few, wide and low, “stellata” type adauxiliary chamberlets and also narrow and low equatorial chamberlets arranged into asteroidal annuli with “strophiolata” type growth pattern. It is the most common Asterocyclina from Northeastern Spain to Assam (India) or maybe even to Indonesia. The earliest occurrence is known from the early Cuisian (OZ 6 zone); however it becomes dominant from the middle Eocene and ranges up to the end of the Priabonian forming a rather slowly developing, however quite reliable evolutionary lineage, with four successive subspecies. The detailed description of the species and its particular subspecies can be found in the west-

### A. s. adourensis
- dmean < 150µm

### A. s. stellata
- dmean = 150–190µm

### A. s. stellaris
- dmean = 190–240µm

### A. s. buekkensis
- dmean > 240µm

In the Turkish material A. stellata is substituted by A. sireli n. sp. in the Alaman section, at the same time well recognizable throughout the Keçili and Sarköy sections where two distinct subspecies can be detected. A. stellata stellata (text-figure 12) could be found in the lower part of the Keçili profile (OZ 13 zone, lower Bartonian, whereas A. s. stellaris (pl. 4, figs. 8-12, text-figure 12) is widespread in the middle and upper part of the same section (belonging to the late Bartonian part of the OZ 14 zone) as well as in the Sarköy profile (early Priabonian, upper part of the OZ 14 zone). The population of sample SAR 9 from Sarköy (OZ 14/15) can only be determined as A. stellata cf. stellaris based on the few available specimens. Based on the new data, the stratigraphic range of A. s. stellata (OZ 10–13 zones instead of OZ 10–12 zones) is to be slightly modified as compared to Less (1998) while that of A. s. stellaris remains OZ 13–15 zones.

Asterocyclina stella (Gümbel 1861)
Plate 4, figures 4-7

Asterocyclina stella has the same morphological characteristics as A. stellata except for the type of adauxiliary chamberlets, which are of “varians” type, and, therefore their number is somewhat higher as well. The occurrence of A. stella in the western Tethys (from Southwestern France to Anatolia and Israel) is subordinate as compared to that of A. stellata, especially in the west-

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Less (1987, 1998, 1999). According to Less (1998, 1999), the biometric limits of subspecies are considered as follows:

- **A. s. adourensis**
  - dmean < 150µm
- **A. s. stellata**
  - dmean = 150–190µm
- **A. s. stellaris**
  - dmean = 190–240µm
- **A. s. buekkensis**
  - dmean > 240µm

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<table>
<thead>
<tr>
<th>Genus</th>
<th>Group</th>
<th>Taxon</th>
<th>Horizon</th>
<th>X</th>
<th>mean ± s.e.</th>
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<td>Sputroepyclus carpaticus</td>
<td>siriotti n. sp.</td>
<td>SAR 4</td>
<td>15</td>
<td>1–5</td>
<td>2,07 ± 0,32</td>
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<tr>
<td></td>
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<td>12</td>
<td>7–19</td>
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<td>KEG 11</td>
<td>32</td>
<td>3–20</td>
<td>6,75 ± 0,63</td>
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<tr>
<td></td>
<td>m o n o c o n c h n. sp.</td>
<td>KEG 11</td>
<td>9</td>
<td>15–33</td>
<td>24,11 ± 1,92</td>
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<td>s i r i o t t i n. sp.</td>
<td>SAR 2</td>
<td>62</td>
<td>1–5</td>
<td>2,37 ± 0,10</td>
</tr>
</tbody>
</table>
Lutetian–Priabonian part of their simultaneous evolution (see Less and Ö. Kovács 1996). Its first appearance in the Tethys is known from the Ilerdian/Cuisian boundary (OZ 4/5) in Sakarya section in Turkey (Çolakolu and Özcan 2003). Less (1998) reported its highest occurrence from the upper Priabonian of Mossano and Priaona (both are arranged in the OZ 16 zone). However, based on our recent studies on the Turkish material, these forms are different from *A. stella*, and designate *A. ferrandezi* n. sp. Therefore, the upper limit of the stratigraphic range of *A. stella* is lowered into the middle Priabonian (OZ 15 zone) with its known last occurrence in the “Discocyclina beds” of Priaona (Less 1998). *Asterocyclina stella* constitutes a slowly developing evolutionary lineage with three successive subspecies defined and delimited by Less (1998). However, the assignment of specimens from the OZ 16 zone to *A. ferrandezi* n. sp. (see above) also necessitates the reevaluation of the biometric limits of *A. stella* assemblages with dmean above 150µm on more specimens. Until then, the species can be subdivided only into two subspecies as follows:

<table>
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<th>Subspecies</th>
<th>dmean Limit</th>
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<tbody>
<tr>
<td><em>A. s. n. ssp. Horsarrieu</em></td>
<td>dmean &lt; 150µm</td>
</tr>
<tr>
<td><em>A. s. stella</em></td>
<td>dmean &gt; 150µm</td>
</tr>
</tbody>
</table>

The detailed description of the species and its particular subspecies can be found in Less 1987, 1998 and Çolakolu and Özcan 2003. Although the increase of the deuteroconch size of the assemblage from the middle layers of Keçili (KEÇ 3–5, OZ 14, upper Bartonian) is determined to be *A. stella stella* (pl. 4, figs. 4–6), that of sample SAR 4 (Sarköy, OZ 14, earliest Priabonian) as *A. stella cf. stella*, while the single specimen from sample SAR 9 (pl. 4, fig. 7, OZ 14/15, early Priabonian) is not determined on the subspecific level.

With the re-definition of the biometric limits of *A. s. stella*, its stratigraphic range has to be modified as OZ 9–15 zones, instead of OZ 9–13 in Less (1998).

*Asterocyclina kecskemëti* Less 1987 Plate 4, figures 15-18; text-figure 12

*Asterocyclina kecskemëti* n. sp. – LESS 1987, p. 239-240, pl. XLI, figs. 9-11, pl. XLII, figs. 1-6, text figs. 32k-n (with synonymy).


*Asterocyclina kecskemëti* is a star-shaped form with five to six rays and “chudeauï” type rosette. It has a medium-sized nephroto semi-isolepidine embryo, with relatively wide and high, “varians” type adauxiliary chamberlets. The two principal auxiliary chamberlets are of average width and height, arranged into sharp asteroidal annulli, while their growth pattern is of “strophiolata” type. It is rather rare and can be found from

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**PLATE 1**

1  *Nummulites aturicus* Joly et Leymerie, ALM 5, E. 9475; equatorial section, ×10.

2  *Nummulites aff. alponensis* Schaub, ALM 6, E. 9476; equatorial section, ×10.

3  *Nummulites maximus* d’Archiac, KEÇ 1, E. 9477; equatorial section, ×10.

4  *Nummulites garganicus* Tellini, KEÇ 1, E. 9478; equatorial section, ×10.

5  *Nummulites perforatus* (Montfort), KEÇ 1, E. 9479; equatorial section, ×10.

6  *Nummulites hottingeri* Schaub, KEÇ 1, E. 9480; equatorial section, ×10.

7  *Nummulites lyelli* d’Archiac et Haime, KEÇ 11, E. 9481; equatorial section, ×10.

8  *Nummulites aff. cyrenaicus* Schaub, KEÇ 1, E. 9482; equatorial section, ×10.

9, 17  *N. hormoensis* Nuttall, 9, KEÇ 11, E. 9483; external view, ×10. 17, KEÇ 3, E. 9485; equatorial section, ×10.

10  *Pellatispira madaraszi* (Hantken), O/KEÇ 15-1, ×10.


12  *Nummulites incrassatus* de la Harpe, KEÇ 15, E. 9484; equatorial section, ×10.

13  *Linderina* 2, O/KEÇ 1-40; equatorial section, ×50.

14  *Linderina* 1, O/KEÇ 1-58; equatorial section, ×50.

15  *Heterostegina reticulata* (Rütimeyer) *tronensis* n. sp., O/KEÇ 11-39; equatorial section, ×20.

16  *Heterostegina armenica* Grigoryan, O/KEÇ 11-38; equatorial section, ×20.

18  *Assilina* ex gr. *A. schwageri* Silvestri – *alpina* Douvillé, KEÇ 11, E. 9486; equatorial section, ×10.

19  *Heterostegina reticulata* (Rütimeyer) *mossanensis* n. sp., O/SAR 4-83; equatorial section, ×20.

20  *Spiroclypeus sirottii* n. sp., O/SAR 4-71; equatorial section, ×20.
Southwestern France to Anatolia (according to our new data). The earliest certain occurrence is known from the middle/upper Lutetian of Angoumé (France), while the last appearance has recently been reported from the basal Priabonian of Ūrhida (Hungary, Less et al. 2000; Less and Gyalog 2004). Based on data mostly from the Bartonian some intraspecific evolution can be recognized (Less and O. Kovács 1996); however the species has not been subdivided into subspecies yet. It occurs in the Turkish material rarely and only in the upper Bartonian of Keçili (OZ 14). However those specimens correspond well to the detailed description given by Less (1987). One specimen with an exceptionally large embryon was also found in sample KEÇ 3. The late Bartonian age of the Turkish populations fits well with the age given by Less (1998) and then modified as OZ 14–15, lower Priabonian, text-figs. 5, 11.

Asterocyclina ferrandezi Özcanc and Less n. sp.
Plate 3, figures 29-31; plate 5, figures 13-14; text-figure 13

Asterocyclina stella (Gümbel) 1861. – SIROTTI 1978. p. 62, 64, pl. 4, figs. 11–14.
Asterocyclina stella praestellaris Brönnimann 1940. – STOCKAR 1999. p. 9, 11, pl. 4, figs. 2-3, pl. 5, figs. 3–10.
Asterocyclina sp. 1. – STOCKAR 1999. p. 14, pl. 4, fig. 6, pl. 7, figs. 3-4.

Etymology: Named in honor of Dr. Carles Ferràndez-Cañadell, Catalan larger foraminiferal researcher (Universitat de Barcelona).

Holotype: Preparation O/SAR 4-131 (pl. 3, fig. 29, text fig. 13).
Depository: Geology Department of Istanbul Technical University.
Type locality: Sample SAR 4 near to Tepeköy village, north of Sarköy (Tekirdag, Western Turkey).
Type level: Basal Priabonian, orthophragminid zone 14.
Occurrence: Megalospheric specimens from Sarköy (text-fig. 11); samples SAR 2 and 4 (OZ 14, basal Priabonian) and SAR 9 (OZ 14/15, lower Priabonian, text-figs. 5, 11).
Diagnosis: Large, inflated forms, usually with five very short radial ribs and “chudeaui” type rosette. The embryon is medium-sized, iso- to nephrolepidine. The “varians” type adaxial chamberlets are few in numbers, moderately low and quite wide. The equatorial annuli are asteroidal with usually five rays. In the interray area the chamberlets are moderately wide and high. The growth pattern of the annuli is of the “varians” type.

Description: Large-sized (4-8mm), strongly swollen forms with almost indistinct radial ribs and “chudeaui” type rosette (pl. 5, fig. 13). The megalospheric embryon is generally semi-iso-lepidine (ranges from almost iso- to almost nephrolepidine), characterized by a protoconch measuring from 170 to 250µm and by a deuteroconch measuring from 230 to 450µm. The adaxial chamberlets are of “varians” type, moderately low

PLATE 2
All A-forms and equatorial sections.

1-4 Nemkovella daguini (Neumann), 1, O/KEÇ 5-9, ×30. 2, O/KEÇ 5-9, ×60; 3, O/KEÇ 3-49, ×30; 4, O/KEÇ 11-8, ×40.
5 Discocyclina augustae van der Weijden atlantica Less, O/ALM 7-30, ×40.
6, 10 Discocyclina augustae van der Weijden, olianae Almela et Rios, 6, O/SAR 4-26, 10, O/KEÇ 1-9, ×40.
7-9 Discocyclina trabayensis Neumann elazigensis n. ssp., 7, O/KEÇ 9-12. 8, holotype, O/KEÇ 11-35; 9, O/KEÇ 4-39, ×40.
11 Discocyclina aff. augustae van der Weijden, O/SAR 9-37, ×40.
12, 19 Orbitoclypeus varians (Kaufmann) ex. interc. scalaris (Schlumberger) roberti (Douvillé), O/ALM 7-9; 12, ×40; 19, ×20.
14 Orbitoclypeus varians (Kaufmann) ex. interc. varians–scalaris (Schlumberger), O/KEÇ 3-79, ×20.
15-16 Discocyclina dispensa (Sowerby) sella (d’Archiac), 15, O/ALM 12-36, ×40; 16, O/ALM 12-34, ×40.
17 Discocyclina dispensa (Sowerby) cf. sella (d’Archiac), O/KEÇ 1 1-17a, ×40.
18 Discocyclina dispensa dispensa (Sowerby), O/KEÇ 4-30, ×40.
19 Discocyclina dispensa dispensa (Sowerby) ex. interc. dispensa–sella (d’Archiac), O/KEÇ 1-35, ×40.
20 Discocyclina dispensa dispensa (Sowerby) umbilicata (Deprat), O/SAR 4-41, ×40.
21-23, 28 Discocyclina pratti (Michelin) montfortensis Less, 22, O/ALM 7-27, ×40; 23, O/ALM 7-38, ×20; 28, O/ALM 12-12, ×40.
24 Orbitoclypeus douvillei (Schlumberger) pannonicus Less, O/ALM 11-6, ×40.
and quite wide (H: 35–50 µm, W: 40–110 µm), and few in number (N: 5–10). The equatorial annuli are asteroidal, however the rays are not too strong. Their number is usually five, rarely four or six. The equatorial chamberlets in the interray areas are moderately high and wide (n: 13–17); the growth pattern of the annuli is of the “varians” type. In vertical section (pl. 5, fig. 14), the height of the protoconch and deuteroconch is about 175 and 220 µm, respectively. The equatorial layer is 40-45 µm thick near the embryo and it thickens to 70 µm towards the edges. The lateral chamberlets are 35 µm in height.

Remarks. The new taxon is a characteristically highly inflated form with indistinct ribbing. Sirotti (1978) described such forms from the “Asterocyclina” beds of Priabona under the name of *A. stella* giving the details of the external and internal features. From Southern Switzerland, Stockar (1999) presented a good description and depiction of very similar forms from the upper Bartonian (the precise age is given by the actual developmental stage of *Heterostegina reticulata*), that were redeposited as pebbles into Quaternary deposits. In our opinion, *A. ferrandezi* differs from *A. stella* (compare them in Table 2) in having a much larger test, which is thick and swollen, and also in bearing a much larger embryo and fewer adaxial chamberlets. Following the above arguments on *A. ferrandezi*, its stratigraphic range can be proposed to cover the interval from late Bartonian until the end of the Priabonian (OZ 14 to OZ 16).

*Asterocyclina alticostata* (Nuttall 1926)
Plate 3, figures 26-28; plate 4, figure 22

*Asterocyclina alticostata* is a star-shaped species usually with five to seven rays and “chudeaui” type rosette. It has a medium-sized to relatively large isolepidine embryo, very few, very wide and moderately low, “alticostata” type adaxial chamberlets and also wide and moderately high equatorial chamberlets arranged into asteroidal annuli with “strophiolata” or “varians” type growth pattern. It occurs in the orthophragminid assemblages from Southwestern France to Israel and Cutch (India). Based on our unpublished data, its earliest occurrence in Tethys is from the early Cuisian (OZ 6 zone) of Safranbolu section in central Turkey. Then it becomes more frequent in the middle Eocene and can be followed until the early Priabonian (boundary of OZ 14 and 15 zones, taking into consideration also the age-revision of the Lábatlan locality from Hungary – see the discussion in *Discocyclina discus*). It forms a steadily developing, reliable evolutionary lineage with four successive subspecies. The detailed description of the species and its particular subspecies can be found in Less (1987, 1998). Ac-

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**PLATE 3**
All equatorial sections.

7 *Orbitoclypeus furcatus* indet. ssp., O/KEÇ 5-10, A-form, ×20.
8 *Nemkovella strophiolata strophiolata* (Gümbel), O/ALM 11-60, A-form, ×40.
9-11 *Nemkovella strophiolata tenella* (Gümbel), 9, O/KEÇ 4-16, 10, O/KEÇ 4-8, 11, O/KEÇ 4-14; A-forms, ×40.
12 *Orbitoclypeus furcatus* (Rutimeyer) rovasendai (Prever), O/ALM 11-84, A-form, ×40.
13 *Orbitoclypeus dounvillei* (Schlumberger) pannonicus Less, O/ALM 12-23, B-form, ×40.
14 *N. daguini* (Neumann), O/SAR 4-112, B-form, ×40.
15 *Orbitoclypeus varians* (Kaufmann) scalaris (Schlumberger), O/ALM 11-76, B-form, ×40.
32 *A. sireli* n. sp., holotype, O/ALM 6-16, A-form, ×40.
In the Turkish material *A. alticostata* is easily recognizable but rather rare, although it can be found in all of the three localities. Of these, only one specimen has been found in Alaman (pl. 3, fig. 26, upper Lutetian, OZ 11/12 zone) making the subspecific determination unreliable. The two lower assemblages from Keçili do not contain a considerable number of specimens either, therefore they are determined as *A. alticostata* cf. *A. alticostata* (KEÇ 1 and 2, OZ 13 zone, lower Bartonian) and *A. alticostata* cf. *danubica* (KEÇ 3 and 5, OZ 14 zone, upper Bartonian, Pl. 3, fig. 27; pl. 4, fig. 22), respectively. Since comparatively more *danubica* cf. (KEÇ 1 and 2, OZ 13 zone, lower Bartonian) and *A. alticostata* (KEÇ 3 and 5, OZ 14 zone, upper Bartonian) orthophragmines are described from three localities in Turkey. These faunas show great similarity to those reported from the more western parts of the peri-Mediterranean realm. All the four genera (*Discocyclina*, *Nemkovella*, *Orbitoclypeus* and *Asterocyclina*) have been found, and their important lineages identified. Some deviations from the typical forms could also be recognized; they have been described as *Discocyclina* aff. *augustae*, *D. aff. D. trabayensis*, *D. aff. pratti*, *D. aff. D. samantai* and *Orbitoclypeus* aff. *varians*. Minor differences as compared to the more western occurrences were also observed in the proportions of different lineages. *Discocyclina augustae*, *D. pratti*, *D. trabayensis*, *Nemkovella daguini* and *Orbitoclypeus varians* are somewhat more common in Turkey, while *Discocyclina discus*, *D. radians*, *Nemkovella strophiolata*, *Orbitoclypeus furcatus* and *Asterocyclina alticostata* turned out to be less frequent.

The newly described species *Asterocyclina sireli* from Alaman seem to be endemic so far; however the second one (*Asterocyclina ferrandezii* from Sarköy) has been identified by us from Northern Italy and Southern Switzerland, as well. Two new subspecies (*Discocyclina trabayensis elazigensis* and *Orbitoclypeus douvillei malayenaensis*, both from Keçili) have also been described. The first one can also be found in Western Europe; however the second one, demonstrating the most advanced developmental stage of its lineage is still exclusive to Turkey.

Nevertheless, in comparing Turkish material to those reported from the more western parts of Europe, their similarities are much more impressive than the differences. Therefore, our study increases the impact of the existing orthophragminid stratigraphy whilst extending it significantly eastward, to the Asian part of Turkey. Based on the statistically evaluated biometrical investigation of particular lineages from the different horizons of the three studied profiles, these horizons could be located in the orthophragminid zonation of Less (1998). Both horizons of the Alaman section can be put approximately to the boundary of OZ 14–15.

**CONCLUSIONS AND REVISION OF LATE LUTETIAN TO EARLY PRIABONIAN ORTHOPHRAGMINID ZONES**

A rich assemblage of late Lutetian (Alaman) through Bartonian (Keçili) to early Priabonian (Sarköy) orthophragmines is described from three localities in Turkey. These faunas show great similarity to those reported from the more western parts of the peri-Mediterranean realm. All the four genera (*Discocyclina*, *Nemkovella*, *Orbitoclypeus* and *Asterocyclina*) have been found, and their important lineages identified. Some deviations from the typical forms could also be recognized; they have been described as *Discocyclina* aff. *augustae*, *D. aff. D. trabayensis*, *D. aff. pratti*, *D. aff. D. samantai* and *Orbitoclypeus* aff. *varians*. Minor differences as compared to the more western occurrences were also observed in the proportions of different lineages. *Discocyclina augustae*, *D. pratti*, *D. trabayensis*, *Nemkovella daguini* and *Orbitoclypeus varians* are somewhat more common in Turkey, while *Discocyclina discus*, *D. radians*, *Nemkovella strophiolata*, *Orbitoclypeus furcatus* and *Asterocyclina alticostata* turned out to be less frequent.

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**PLATE 4**

All A-forms and equatorial sections.

1-3 *Asterocyclina sireli* n. sp., 1, O/ALM 6-74, ×40; 2, O/ALM 6-74, ×20; 3, O/ALM 11-69, ×40.

46 *Asterocyclina stella stella* (Gümbel), 4, O/KEÇ 5-7, ×40; 5, O/KEÇ 3-14, ×40; 6, O/KEÇ 4-130, ×40

7 *Asterocyclina stella* indet. sp., O/SAR 9-11, ×40.

8-12 *Asterocyclina stallata* (d’ Archiac) *stellaris* (Brünner), 8, O/KEÇ 5-28, ×40; 9, O/KEÇ 4-97, ×40; 10, O/KEÇ 5-30, ×40; 11, O/SAR 4-99, ×40; 12, O/KEÇ 4-32, ×80.


14 *Discocyclina pratti pratti* (Michelin), O/KEÇ 4-69, ×20.


19-20 *Discocyclina augustae* van der Weijden *oliana* Almela et Rios, 19, O/SAR 4-26, ×40; 20, O/SAR 4-91, ×40.

21 *Discocyclina* aff. *D. augustae* van der Weijden, O/SAR 9-33, ×40.

22 *Asterocyclina alticostata* (Nuttall) cf. *danubica*, O/KEÇ 5-7, ×40.

11 and 12 zones. The lower horizon in Keçili is determined as belonging to OZ 13 zone whereas the middle and upper horizons are definitively younger and bear the characteristics of OZ 14 zone. The lower samples of the Sarköy section fall also into this zone whereas the upper sample is somewhat younger and determined as belonging to OZ 14/15 zones.

Based on our new data from Alaman, Keçili and Sarköy, the stratigraphic range of several orthophragminid taxa had to be modified as they are discussed in detail in the description of particular species in the systematical part. A summary of our up-to-date knowledge on the distribution of orthophragmines and also of some nummulitid taxa in the late Lutetian to Priabonian time-span taking into account also preliminary data from some Hungarian (Bajót and Úrhida, see Less et al. 2000 and Less and Gyalog 2004) and Northern Italian (Verona, Castel San Felice, Mossano; Less and Papazzoni 2000) localities is presented in text-figure 17.

According to Less (1998) the Lutetian/Bartonian boundary corresponds to the limit of OZ 11 and 12 zones, while that of the Bartonian and Priabonian coincides with the boundary of OZ 14 and 15 zones. Taking into consideration the results obtained from above mentioned central European localities, Less and Papazzoni (2000) modified the above correlation of the OZ 14 zone, having extended it into the terminal Bartonian, too. Thus, this zone crosses the Bartonian/Priabonian boundary.

The integrated study of all the three Turkish localities, incorporating the investigation of not only orthophragmines but also nummulitids, planktonic foraminifera and the calcareous nannoplankton, allowed us to make the correlation of orthophragminid zones with other zonations much more well-established and precise than reported by Less (1987, 1998). This state-of-the-art correlation is also presented in text-figure 17. The nummulitids and also both planktonic groups indicate a late Lutetian age for the Alaman section (see the discussion at the description of the section). This means that the boundary of OZ 11 and 12 zones has to be lowered as compared to Less (1998) so that OZ 12 starts in the late Lutetian. In our opinion, the appearance of the Operculina gomezi group in the Tethyan larger foraminiferal assemblages is probably the best marker to distinguish the Lutetian from the Bartonian, since it represents a bioevent while the evolution within nummulitid phyla (proposed by Serra-Kiel et al. 1998 to separate the two stages) bears gradual character. Since Operculina gomezi is missing in Alaman, however it can already be found in Dudar (Hungary) and San Pancrazio (Northern Italy), all belonging to OZ 12, this zone crosses the Lutetian/Bartonian boundary. Its lower part lacking the Operculina gomezi group and containing the newly defined Discocyclina pratti montfortensis corresponds to the upper(most) Lutetian while the upper part, containing the above mentioned operculinids and the newly defined D. pratti pratti, belongs to the early part of the early Bartonian (see also the correlation of OZ 13 below). Nummulitids indicate early Bartonian age (SBZ 17 zone) for the lower horizons of the Keçili section and the calcareous nannoplankton data do not contradict to this, either (see in detail at the description of the locality). This means that the OZ 13 zone can be correlated only with the later part of the early Bartonian because at the base of the late Bartonian (found in the middle horizon of the Keçili section) the orthophragmines belong already to the OZ 14 zone.

The presence of the upper Bartonian (the early/late Bartonian boundary corresponds to the SBZ 17/18 zones) is recognized in the middle horizons of the Keçili section by the first appearance of genus Heterostegina (H. armenica), by the partial disappearance of large Nummulites (from here upwards they can be found only sporadically as opposed to their continuous presence in the lower horizons), by the replacement of Nummulites garganicus with N. hormoensis (formerly N. ’ptukhiani’), and by orthophragmines belonging already to OZ 14 zone. The age given by planktonic foraminifera (the upper part of P 14) coincides with the nummulitid data, while at least part of the calcareous nannoplankton seems to be resedimented (see in detail at the description of the Keçili section). Thus, the lower boundary of OZ 14 zone corresponds approximately to the base of the late Bartonian.

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**PLATE 5**
All A-forms, ×30.

1-5 *Asterocyclina sireli* n. sp., 1, O/ALM 6-79, vertical section; 2, O/ALM 6-80, vertical section; 3, O/ALM 6-78, vertical section; 4, O/ALM 7-62, external view; 5, O/ALM 7-63, external view.

6 *Nemkovella daguini* (Neumann), 0/SAR 4-114, vertical section.

7-8 *Orbitoclypeus varians* (Kaufmann) *scalaris* (Schlumberger), 7, O/ALM 11-64, vertical section; 8, O/ALM 11-111, external view.

9-11 *Orbitoclypeus dowillei* (Schlumberger) *malatyaensis* n. ssp., 9, O/KEÇ 1-66, vertical section; 10, O/KEÇ 1-67, vertical section; 11, O/KEÇ 1-68, external view.

12 *Asterocyclina sp.*, O/ALM 11-110, external view.

13-14 *Asterocyclina ferrandezii* n. sp., 13, O/SAR 4-120, external view; 14, O/SAR 4-135, vertical section.
OZ 14 can be followed also in the upper horizon in the Kecili section corresponding to about the early (but not earliest) part of the late Bartonian. Compared to the middle horizon at Kecili, minor changes can be recognized only in the composition of larger benthic foraminifera other than the orthophragmines. These changes include the first appearance of the *Heterostegina reticulata*-lineage (represented by its most primitive developmental stage known so far) and of *Pellatisspira madaraszii*, formerly thought to be an exclusively Priabonian taxon. Romero et al. (1999) also have recently reported this species from the upper Bartonian of Puig Aguilera (Northeastern Spain).

The upper boundary of OZ 14 zone is redefined by Less and Papazzoni (2000) as the disappearance of survivor middle Eocene orthophragmines such as *Discocyclina pratti*, *Nemkovaella strepholata*, *Asterocyclina alticostata* and A. keckenetii. These forms certainly cross the Bartonian/Priabonian boundary since in different localities (Mossano; Verona, Castel San Felice, both in Northern Italy, see also Less and Papazzoni, 2000 and Úrhida in Hungary, see Less et al. 2000) they can be found together with primitive *Spirocyclus* whose first appearance seems to be the best marker for detecting the base of the Priabonian in the facies favourable for the orthophragmines. In the lower beds of Sarköy we have found the same larger foraminiferal fauna of both the orthophragmines and the opeculinids as in the sites listed above. Another common feature is the very similar evolutionary degree of both the *Heterostegina reticulata* (*X*_mean* between 1.8 and 2.6 and *P*_mean* between 120 and 140µm) and *Spirocyclus*-lineage (*X*_mean* between 2.8 and 4.3 and *P*_mean* between 85 and 105µm). Since the Mossano locality is just in the base of the Priabonian in a continuous Bartonian to Priabonian section (Bassi et al. 2000), all the listed localities including the lower beds at Sarköy (SAR 2 and 4) belong to the basal part of the Priabonian.

The upper sample in Sarköy (SAR 9) can be placed roughly into the upper boundary of OZ 14 since only *Discocyclina pratti* could be recorded from the survivor middle Eocene orthophragmines listed above. Its age is considered as early (but not earliest) Priabonian. Thus, the OZ 14 zone includes the whole late Bartonian and also the earliest part of the Priabonian since their orthophragminid faunas are practically the same with one single exception: *Discocyclina discus* very probably did not cross the Bartonian/Priabonian boundary. Unfortunately, this species is exceptionally rare in our Turkish material. The revision of *Orthophragminidae* faunas is practically the same with one single exception: *Discocyclina discus* very probably did not cross the Bartonian/Priabonian boundary. Unfortunately, this species is exceptionally rare in our Turkish material. The revision of orthophragminid zones below OZ 12 and above OZ 14 are beyond the scope of our study. Our new results including the revised ranges of orthophragminid taxa are synthesized in text-figure 17.

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