Miocene Lacustrine Diatoms from Turkey

by

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Abstract: Analysis of diatomaceous earth collected in the Bes Konak Basin located in northern Anatolia and in the Emet Basin, located 300 kms west of Ankara, shows that the diatom floras, in these early to middle Miocene basins, are quite different.

The first is characterized by a very small *Melosira*, closely related to *Melosira jouseana* Mois., changing with time from a trilobate to a sub-circular shape.

The second basin contains a variable *Actinocyclus* sp., quite similar to *Actinocyclus* sp. from Miocene deposits of China, and to *Stephanodiscus fragilis* Řeháková.

It is proved from the diatom assemblages, fossil plant and animal remains (Paicheler 1978), that the paleoecological environment was typically fresh water in *low level* lakes in a warm-temperate to sub-tropical climate.

Key words:fi Fossil diatoms – freshwater, Miocene, Turkey

Introduction

THE BES KONAK BASIN

The Bes Konak basin is 100 kms north of Ankara (Fig. 1a). the lacustrine deposits mainly outcrop along the Gurcu Dere Valley (Fig. 1b). They belong to a wide continental domain deposited at the beginning of the Tertiary (perhaps during the late Cretaceous) on a massif, uplifted during the main tectonic late Cretaceous phase which determined the major paleogeographical features of this continental Miocene landscape.

Lithostratigraphy and age of the formations

The volcano-sedimentary formations which have been studied are interbedded in the volcanic complex called 'Andesitic Galate Massif' (Fig. 1c-d).

Lithostratigraphical detail

– Discontinuous beds of diatomites (level 18). Layered in discordance on Cretaceous limestones are the lateral equivalent of marine late Cretaceous sediments near Gerede. Only two samples could be analysed because these diatomites have been almost completely eroded by the deposit of Cretaceous and Eocene lava (level 17).

– A volcano-detrital formation (level 16, 16a, 16b) very thick in the North-Western part of the basin, decreasing towards the South-East. Essentially composed of pumices and diatomites. Near Kilisekôy, from the section 13C, 45 samples (13C47 to 13C 1) have been analysed (Fig.2).

This level, immediately beneath the trachy-andesite level 13, dated at 18.5 m.y., can be considered as *early Miocene*.

– A very thick deposit of basaltic, andesitic and trachy-andesitic lava (levels 13, 12, 11, 9) very thick in the southern part, disappearing towards the North. The level 13 has been dated at 18.5 m.y.

– A volcano-sedimentary formation (level 8) composed of pyroclastics and fossiliferous diatomites, spreading across the whole basin, with a maximum development along the Gurcu Dere valley. Near Eminbey, 96 samples have been studied in the section 10CO (samples 10C044 to 10CO 1) and 10C (samples 10C2 to 10C53) (Fig.2.).

The sample 10CO39, dated at 18 m.y., indicates an Aquitanian-Burdigalian or *lower Miocene* age, for the base of the Log 10CO. The sample 10C52 at the top of the Log 10C, gave an age of 13 m.y., that is, *middle Miocene* or Serravallian.

– The terminal acid volcanic deposits (essentially ignimbrite in level 7, and rhyolite in level 6) thicker in the northern part of the basin, are covered in the South by different levels of andesites and basalts (levels 3, 4, 5).

– The upper rhyolites (level 6) dated at 10 m.y. and 9.5 m.y. are late Miocene or Tortonian.

Paleontology

The diatomites and also the finest volcano-sedimentary levels have yielded a very rich, diversified and well-preserved fauna and flora. The paleoflora indicates a warm-temperate local climate tending to be subtropical to tropical on the lake and its nearest surroundings. The pollen indicates a more temperate climate for the whole region.

Descriptions of species

Melosira aff.*jouseana* Moisseva, Figs 3-19.

The cells are 10-11 µm wide and 4-5 µm high. The width/length ratio is always large. They are united valve face to valve face and form straight filaments of an undetermined number of cells; the mantle is punctate, puncta about 12 in 10 µm, arranged in straight linear rows, 14 in 10 µm; strong costae, 6 in 10 µm, extend from the base of the linking spines to the mantle edge (Fig.11). The linking spines are short and regularly distributed. The cingulum is simple, only one band without ornamentation. The valve face has a variable shape; it is entirely punctate (Fig.17). The inner valve view shows a broad 'sulcus'; its internal rim is circular (Fig.19), oval (Fig.15) or trilobate (Figs 5 and 18).

Viewed in the SEM, the areolae are loculate (Fig.8), with the velum on the inner side of the wall. The mantle and valve face are covered by granules (Fig.17). The linking spines are short, inserted between the rows of areolae (Fig.17). The inner view shows some septa (or thickened internal axial ribs) (Fig.18), the number differing from one specimen to another. The rimoportulae could not be observed.

The most distinctive morphological feature of this species is the presence of these internal septa, which clearly appear under LM, in both valve and lateral view (Fig.16). The modification of the valve shape up the core is also distinctive.

We can distinguish perfect trilobate (Figs 3-4), sub-rectangular (Figs 12-16), triangular (Figs 9-10) and bilobate forms (Fig.5); finally, the decrease of one of the two lobes gives an almost circular shape to the valve face (Figs 6-7).

These modifications are restricted to the shape of the frustule in valve view, they do not affect the other morphological features of the valves. All the different types are characterized by a large sulcus, well developed septa, easily seen under the light microscope, and a valve face entirely covered with puncta. They can be related to a similar morphological evolution in water bodies with the same chemical evolution at two different periods of time, but not to a phylogenetic evolution because these morphological changes are similar in both sections 13C and 10CO – 10C (Fig.2), which are not of the same age; different morphological forms, triangular and sub-rectangular, may appear in the same level.

In Miocene deposits of the world, some non-circular and septate species of the genus *Melosira* have been described by VanLandingham (1967), who found in the sample 89a from the Otis Basin-Juntura, Oregon, an oval *Melosira distans* var.*ovata* Iwahashi (Plate 14, Figs 18-20, 23) which seems very similar to the sub-rectangular Turkish one. In the same sample, he found a circular *Melosira granulata* (Plate 14, Figs 25-29, Plate 16, Fig.17) with oblique apparent septa, coarse quadrangular areolae, and deep mantle; this seems to be very similar to the *Melosira* observed (S.S-V.) in some samples taken at Faufouilloux in 1984 during the excursion after the Eighth Symposium and reported as *M.canalifera* var.*anastomosans* by Heribaud (1903).

Huang Chengyan and Wang Yuzhuo (1977) found *Melosira canalifera* var.*anastomosans* Herib. in Chinese Miocene deposits. This is very well illustrated in their Plate 2. The lateral view is very similar to the Turkish *Melosira* with its strong septa, but it differs in the ornamentation of the valve face, which is not entirely covered by punctae. These specimens seem to differ from the *Melosira* observed at Faufouilloux and are more similar to the *Melosira* sp. aff.*M.jouseana* described by Bradbury & Krebs 1982, which has strong septa and an entirely punctate valve face.

I regard the shape of the valve as a minor character that cannot be sufficient for specific separation. So the different forms of the Turkish *Melosira* are considered as variants of the same species. It seems to be closely related to *M.jouseana*, but until SEM investigations are made on that species the final identification remains an open question.

Triangular species of other genera have been found in lacustrine deposits of different ages: a triangular *Stephanodiscus carconensis* in the Black Sea, DSDP leg 42, sample 390A-41-1, of Waalien age, by Schrader (1978), who considered the valves to be abnormal forms and interpreted them as 'ecological modifications produced by restricted environmental conditions during a cold season'. Similar valve forms have been recorded in *Stephanodiscus pontica* also in the Black Sea, DSDP leg 42, samples 380A-41-46, and particularly abundant during late Pliocene, by Jousé & Mukhina (1978) and in *Cyclotella* sp. in the upper Miocene of Spain by Servant-Vildary (1986).

Melosira undulata (Ehr.) Kützing

M.undulata (Fig.21) is the second interesting species found in the Bes-Konak basin; it is abundant and distributed throughout the cores under all paleoecological conditions. It is widely distributed in Miocene deposits from many parts of the world. According to VanLandingham (1967), p.15, its stratigraphic range is Oligocene to recent, and Řeháková (1965), p.26, says 'fossile exemplare sind in ganz Europa in Tertiärablagerungen haüfig....rezente Art lebt nach Hustedt heute nur in den Tropen, im Litoral der Süsswasser becken'. These data agree with the tropical climate of the basin.

Huang Chengyan (1977) reports a Chinese association of *M.undulata* and *M.arenaria* (Fig.20) similar to that found in the Turkish deposits.

Navicula reimerites VanLandingham
VanLandingham (1964) plate 45, figs 9-13

The size and shape variations of *N.reimerites* in the Bes Konak deposits are the same as those illustrated in VanLandingham's plate 45. They are very abundant in sample 10C041, associated with a great variety of fresh water Pennate diatoms whose general features are very similar to the same species in the Yakima and Otis deposits, viz. *Navicula gastrum* (V.L. plate 44), *Gomphonema lanceolatum* (V.L. plate 30), *Fragilaria pinnata* (V.L. plate 27, figs 10-11), *Cymbella cistula* (V.L. plate 22), *Fragilaria lapponica* (V.L. plate 12, figs 57-68), *F.construens* var.*venter* (V.L. plate 12, figs 16-18), *Achnanthes conspicua* (V.L. plate 4, figs 1-8) and *A.lanceolata* (V.L. plate 4, figs 15-21).

Cymbella cistula var.*maculata* (Kütz.) Van Heurck
Andrews (1971) plate 2, fig.12.

Length 50 μm, width 18 μm. Valve with markedly convex dorsal side and ventral side with a slight ventral swelling. Axial area narrow, raphe central, distal ends of raphe dorsally deflected. Dorsal striae 5 in 10 μm at the centre, more closely spaced near the apices, 8 in 10 μm; 6 ventral striae in 10 μm, becoming 8-9 near the extremities, 12 puncta in 10 μm, no isolated punctum.

Synedra amphicephala var.*austriaca* (Grun.) Hustedt
Patrick & Reimer (1966) p.138.

Linear-lanceolate valve, attenuate-capitate apices. Pseudoraphe narrow, central area lacking. Length 25-30 μm, width 3-4 μm, 12-14 striae in 10 μm. Pores not seen under the light microscope. The living species is a cold water taxon.

Stratigraphic significance

Late Cretaceous diatoms (level 18, Figs 1c-d)

The bad preservation of this level, destroyed by the emission of lava, did not allow us to make an intensive study. The two samples which have been analysed contain the same diatom flora. The dominant species is *Melosira islandica* var.*varnensis* A.Cl. (Cleve-Euler, Fig.14i) characterized by very thick walls, and a large sulcus (Figs 22-24). The sub-dominant species is *Melosira* aff.*jouseana*, essentially of the trilobate form, which characterized all the Miocene deposits of this basin.

There are some *Fragilaria bituminosa*, *F.leptostauron* and *Hantzschia amphioxys*, indicating a fresh water and low level environment. According to Ross (personal communication), the earliest fresh-water deposits containing diatoms reported up until now are of late Eocene age. The family Nitzschiaceae have not been reported any earlier than that. A late Cretaceous deposit with all these species is very surprising and suggests that there is some doubt about the age of this level. But if this age is true, we should point out that it is considerably earlier than any other known fresh-water diatom deposit, and the occurrence in it of *Hantzschia amphioxys* takes the first record of the Nitzschiaceae back from the late Eocene to the late Cretaceous.

The early Miocene diatoms (level 16, core 13C near Kiliseköy) (Fig.2)

The core is 75 meters long. 47 samples have been analysed, the majority of them are of pyroclastic material without diatoms, or silicified diatomites where the diatoms were eroded or had disappeared completely. Only 9 samples contain a well preserved diatom flora although many large species are broken. Three main assemblages have been recognized:

1. At the base of the core (sample 13C42) the assemblage is characterized by many small trilobate *Melosira*, and some *Melosira arenaria*, *M.undulata* and *Fragilaria construens*.
2. In the middle (samples 13C24-22) the dominant diatom is a sub-rectangular form of *Melosira*. These levels also contain a high number of large triangular *Melosira* valves then, in the level 13C16, the sub-circular valves appear.
3. At the top, *Melosira* aff.*jouseana* almost disappears and an assemblage of Pennate diatoms now characterizes these uppermost levels, with abundant *Fragilaria* (*F.construens*, *F.bituminosa*, *F.leptostauron*, *F.pinnata*), or *Synedra amphicephala* var.*austriaca*, particularly abundant in the level 13C6, with a typical fresh water and epiphytic assemblage (*Achnanthes*, *Gomphonema*, *Cymbella*).

The early-middle Miocene diatoms (level 8, section 10C0-10C near Emimbay) (Fig.2)

There are more numerous pure diatomite levels in this section than in the section 13C and not so many diatomite levels are silicified, so more varied diatom assemblages were found. The precise study with counting of diatoms has not yet been made, so we can only suggest some preliminary results about the variations of the diatom flora through this part of the core:

At the base, the sample 10C042 contains an assemblage of fresh water diatoms, with dominant *Synedra amphicephala* var.*austriaca*, very similar to that of the 13C6 diatom assemblage.

Level 10C032 is separated from the former by a thick volcano-detritital formation without diatoms, or with some broken valves. It contains a diatom flora very similar to the diatom flora of level 13C42, characterized by small trilobate *Melosira* and some *Melosira undulata* and *M.arenaria.*

Level 10C015 contains almost exclusively *Cymbella cistula* var.*maculata* with few trilobate *Melosira* and *Pinnularia borealis.*

Levels 10C014 to 10C012 are pure diatomites with sub-rectangular and triangulate *Melosira.* This assemblage is similar to the 13C24 and 13C22 assemblage. *Pinnularia borealis* still exists.

Level 10C011 to 10C01 are poor. *Melosira undulata* is always broken, the 10C011 level contains many bilobate *Melosira.*

Level 10C1 to 10C13 are rich but the valves are broken. They are characterized by the absence of trilobate *Melosira.* At the beginning the diatom flora with a high percentage of *Melosira undulata* is similar to the level 10C01. The deposit of a thick layer of pumice seems not to have modified the lacustrine environment. The level 10C9 contains a very particular diatom flora with a great quantity of *Navicula* sp., with very thin walls, often broken, characterized by a large lanceolate hyaline area and short striae composed of few puncta.

In levels 10C16 to 10C29, bilobate *Melosira* are very frequent and some triangular ones also occur; they are associated with *Melosira undulata* and *M.arenaria.* The level 10C23 contains a great quantity of *M.undulata.* The genus *Fragilaria* is represented by *F.bituminosa* and *F.lapponica.* The level 10C17 differs from the level 10C23 in the presence of larger bilobate *Melosira.*

In levels 10C30 to 10C44, *Melosira* valves are becoming more and more circular.

THE EMET BASIN

This basin is in Western Anatolia, 300 kms west of Bes Konak basin (Fig.25a). The Neogene volcano-sedimentary deposits are, from the base to the top (Fig.25d):

50 metres of volcanic rocks deposited on the Mesozoic basement;

70 metres of limestones and sandstones;

150 metres of pyroclastic deposits essentially composed of tuffs; 25 metres of laminated limestones, grading laterally to diatomaceous earth. It is this which has been studied (Fig.25e);

200 metres of detrital deposits composed of conglomerates and sandstones, both of fluvial origin;

Pliocene sedimentation beginning with borate deposits.

The lithological and sedimentary structures suggest that they accumulated in fluvio-lacustrine environments. The diatomite deposits are related to an episode of maximum lacustrine extension of the Emet Lake, during the middle Miocene, but its depth was never very great. In the North-Western part of the basin, these diatomites are interbedded with conglomerates; these detrital deposits suggest that the diatomites were deposited near the margin of the lake with fresh water inflows.

The pyroclastic deposits which outcrop in the eastern part of the basin are middle Miocene, the diatomites lying just above them in the western part are middle or middle-late Miocene.

Diatoms have been studied in five samples (Fig.25e), all of which contain an abundant diatom flora essentially composed of *Synedra amphicephala* var.*austriaca* (Fig.34), *Melosira* cf. *lirata* (Ehr.) Grun. (Figs 35-38) and an *Actinocyclus* sp. (Figs 26-33 and 39-48).

Actinocyclus sp.

The frustules are cylindrical, 30-60 μm in diameter; the cingulum is composed of closed bands, the valvocopula is wide and hyaline (Fig.42). The valves are circular, flat (Fig.39) or slightly depressed in the centre (Fig.42). The areolae are in radial rows arranged in fascicles in the marginal zone, 10-14 in 10 μm. These radial rows of areolae continue towards the centre in some specimens (Fig.26), or the areolae may become more widely spaced (Fig.33), or irregularly distributed and 6-10 in 10 μm (Figs 30-31). They become smaller on the mantle, 14-18 in 10 μm (Figs 28-29). The rimoportulae can be clearly seen in LM (Figs 29-30), are regularly spaced every 10 μm, their number between 11 to 15.

In SEM, the foramina with a raised rim surrounding them, are internal (Figs 44-45) and the cribra are external (Fig.41); in some well-preserved valves, granules are present between the cribra (Fig.47). Near the mantle, coinciding with the boundaries of the fascicles (Fig.39) a ring of broad, short hyaline radial rays are associated with the rimoportulae (Figs 29-30) constituting the most striking feature of the Emet *Actinocyclus*. The external openings of the rimoportulae are long tubes looking like spines (Fig.47), circular in cross-section (Fig.48). Internally, the rimoportulae are broadly fan-shaped (Fig.44) with short stems, circular in cross-section. The pseudonodulus, clearly seen in LM (Figs 28-29), is located in the middle of a fascicle (Figs 28-29) or on one side of a rimoportule (Fig.45). It is presumably luminate (Simonsen 1975), perhaps operculate.

Cross-section of the walls (Fig.46) shows an internal constriction in the internal chambers of the areolae, and also the presence of numerous bubbles (bullulae) in the wall between the chambers, completely different from the internal structure of *Actinocyclus* sp. cf. *Coscinodiscus gorbunovii* Shesh. described by Bradbury (1985, Fig.5). It has, however, some similarity to the structure of *A.octonarius* as illustrated by Ross & Sims (1972, Fig.13) in which the interior of the valve between the walls of the chambers is completely hollow.

Discussion

The most distinctive feature of the Emet *Actinocyclus* is the presence of broad hyaline rays regularly distributed around the valve, closely associated with the rimoportulae, located at the boundaries of the fascicles.

It differs from *Coscinodiscus variabilis* Frenguelli (Frenguelli 1968, lamina 14, figs 6-9), by the length of these rays, which never reach the centre of the valve. Sometimes they are very short (Fig.26). The *Coscinodiscus* cf.*variabilis* of Khursevich (1982, Plate 1, figs 18-20) appears to differ from Frenguelli's illustrations.

The *Actinocyclus* sp. of Kazarina (1982, Plate 2, Fig.6) is quite similar but lacks hyaline rays.

The Emet *Actinocyclus* closely resembles the *Actinocyclus* from the Xian Feng Basin, Yunnan Province, China described by Bradbury (1984, Figs 12-15), but differs in the coarser areolation (10 areolae instead of 13 in 10 μm), and by the rimoportulae which are more broadly fan-shaped, and have shorter stems which are circular and not elliptical in cross-section. The Emet *Actinocyclus* does not exhibit a submarginal concentric undulation.

Many features of *Stephanodiscus fragilis* Řeháková (Řeháková 1980) are similar to the Emet *Actinocyclus* in size, number of areolae, and mainly length, width and number of hyaline radial rays, but according to the LM photomicrographs of this author, *S.fragilis* always shows a very regular areolation in the centre; there seems little doubt that this species belongs to the genus *Actinocyclus*.

Conclusion

All these comparisons show that specific delimitation is untimely, in part because of very confusing generic attributions. It will not be possible to provide good generic, specific or varietal criteria until all the specimens have been studied under SEM and the morphological variability is better understood.

This study shows that the shape of the valve cannot be used as a generic criterion. Equally, the morphological variability of the rimoportulae, of the wall ultrastructure and of the areolation need further consideration as taxonomic criteria.

During the middle Miocene, the diatom flora was different in the two basins in Turkey. It appears that more well-dated sediments from many parts of the world need to be studied before diatoms can be considered as biostratigraphic markers for this period of time.

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PLATES

All LM photomicrographs: scale bars = 10 μm.

Figs 3-19. *Melosira* aff.*jouseana* Mois.

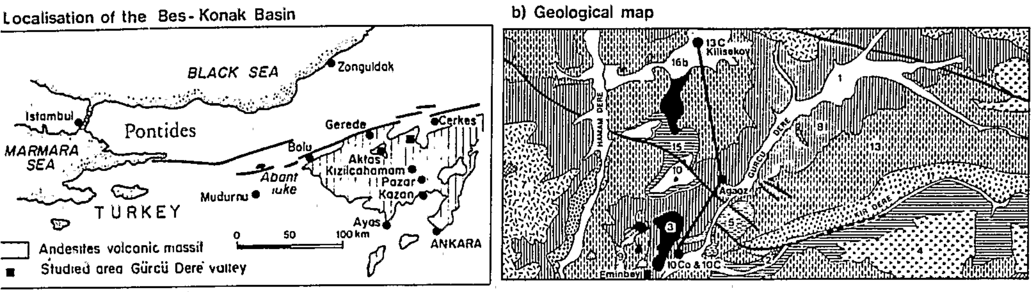
Fig.3. Trilobate form, inner valve view. Fig.4. Punctate valve face. Fig.5. Inner valve view of bilobate form. Fig.6. Inner valve view of sub-circular form. Fig.7. Valve face. Fig.8. Detail of internal cribrum of the pores. Fig.9. Inner valve view of triangulate form. Fig.10. Valve face. Fig.11. Lateral view of trilobate form. Fig.12. Valve face of rectangular form. Fig.13. Inner valve view, very large sulcus, circular inner rim. Fig.14. Valve face, showing a reduced number of septae. Fig.15. Inner valve view. Fig.16. Lateral view of triangular and sub-rectangular form. Fig.17. SEM. Valve face of bilobate form. Fig.18. SEM. Inner valve view with septae. Fig.19. SEM. Inner valve view of trilobate form, sulcus with circular inner rim.

Fig.20. *Melosira arenaria* Moore. Fig.21. *Melosira undulata* (Ehr.) Kützing. Figs 22-24. *Melosira islandica* var.*varnensis* A.Cl.

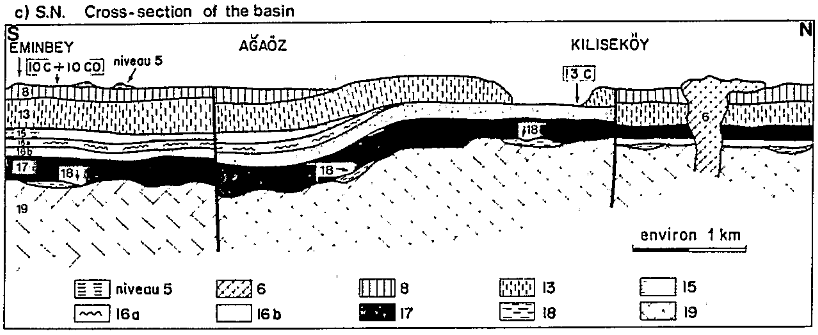
Figs 26-34. *Actinocyclus* sp.

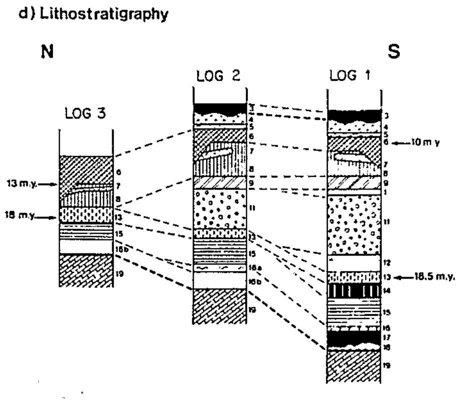
Fig.26. Focus on the centre, radial rows regular, central circular area without areolae. Fig.27. Focus on the marginal zone of the valve face. Fig.28. Focus on the mantle, rimoportulae and pseudonodulus at the

Fig. 1. Bes-Konak, stratigraphy, age of the formations.


a) Localisation of the Bes-Konak Basin

b) Geological map


c) S.N. Cross-section of the basin


d) Lithostratigraphy

LEGEND FOR THE GEOLOGICAL MAP (b),
THE NNW - SSE SCHEMATIC CROSS-SECTION (c) AND THE LOGS (d)

1 - QUATERNARY ALLUVIUM

C E N O Z O I C

3 - BASALT
4 - ANDESITE
5 - BASE OF ANDESITE AND VOLCANO-SEDIMENTARY DEPOSITS
6 - UPPER TRACHYTE _ 10 m.y
7 - RHYOLITES AND TRACHYTES
8 - CONTINENTAL LACUSTRINE DEPOSITS AND FOSSILIFEROUS DIATOMACEOUS EARTH : LOG 10 C AND 10 CO
9 - UPPER TRACHYANDESITE
10 - VOLCANODETRITIC HORIZON
11 - 12 BASALTIC AND ANDESITIC LAVAS
13 - CONGLOMERATES, SANDSTONES, PYROCLASTICS _ 18.5 m.y
14 - LOWER TRACHYTE
15 - ANDESITIC AND TRACHYANDESITIC LAVAS
16 - VOLCANO-SEDIMENTARY HORIZON
16A - CONGLOMERATES
16B - PUMICES WITH DIATOMITES INTERBEDDED LOG 13 C
17 - BASALT
18 - VOLCANO-SEDIMENTARY FORMATION RICH IN PUMICES. DIATOMITES INTERBEDDED.

M E S O Z O I C

19 - CRETACEOUS LAYERED LIMESTONES

boundary of the valve face and mantle. Small areolae. Fig.29. Pseudonodulus (arrow). Fig.30. Focus on the central area showing disorganized disposition of coarse areolae. Fig.31. Focus on the marginal zone, broad hyaline rays. Fig.32. Focus on the inside part of the valve, broad fan-shaped rimoportula. Fig.33. Same specimen, focus on the outside part of the valve.

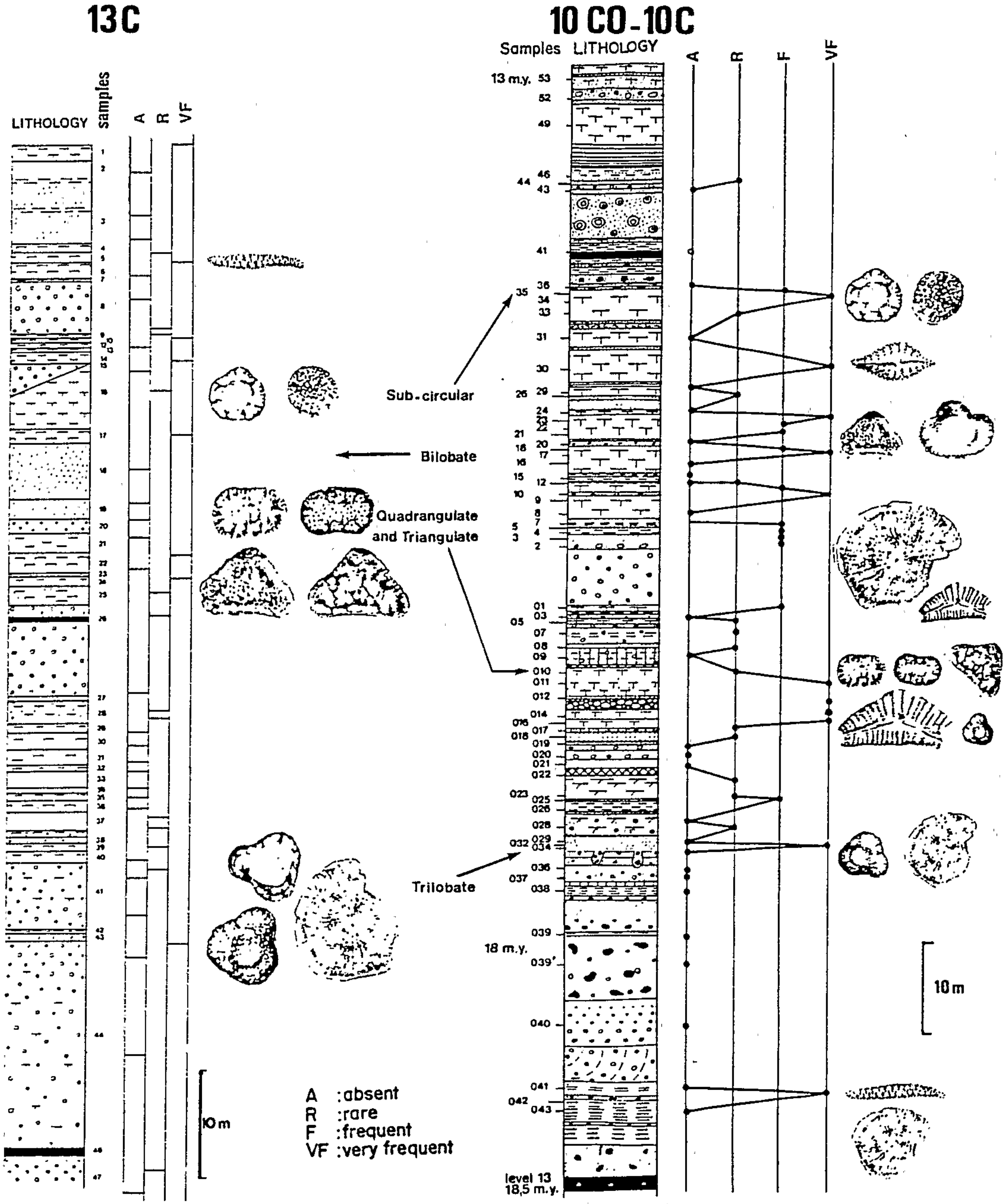
Fig.34. *Synedra amphicephala* var.*austriaca* (Grun.) Hustedt.

Figs 35-38. *Melosira* aff.*lirata* (Ehr.) Grun. Fig.35. Lateral view. Fig.36. Valve face. Fig.37. Inner valve view. Fig.38. Lateral view, focus on sulcus.

Figs 39-48 SEM. *Actinocyclus* sp.

Fig.39. External valve view. Radial rows of areolae reaching the centre. Fig.40. Hyaline radial rows at the boundary of the fascicles. Fig.41. Detail of external vela. Fig.42. Valve slightly depressed. Fig.43. Internal valve view. Fig.44. Detail of the internal ring of areolae, broadly fan-shaped rimoportulae. Fig.45. Pseudonodulus located on a side of a broken rimoportula. Fig.46. Cross-section of the wall. Between the internal chambers (arrows), the wall is bullulate. Fig.47. External view of the mantle, granules between the cribra, external apertures of rimoportulae looking like spines. Fig.48. Cross-section of external tubes of the foramen.

Fig. 2. Similar morphological modifications of the Genus Melosira, along two cores of different age.

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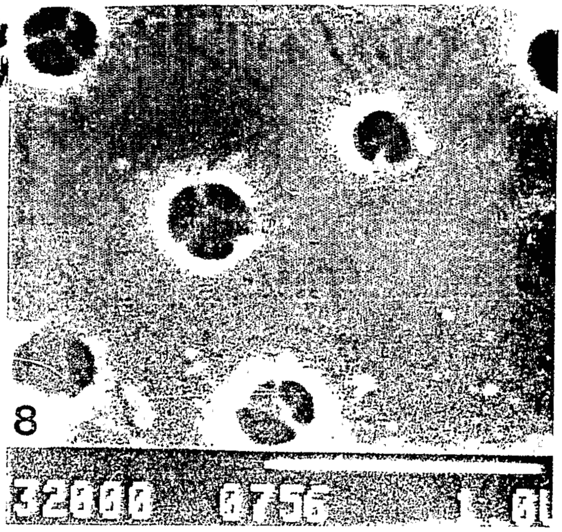

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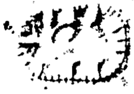
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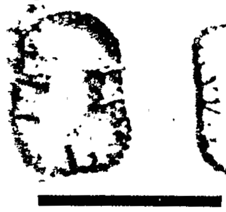
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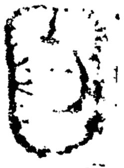
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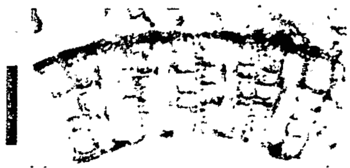
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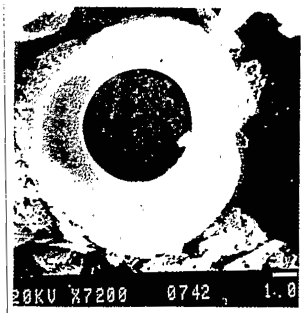

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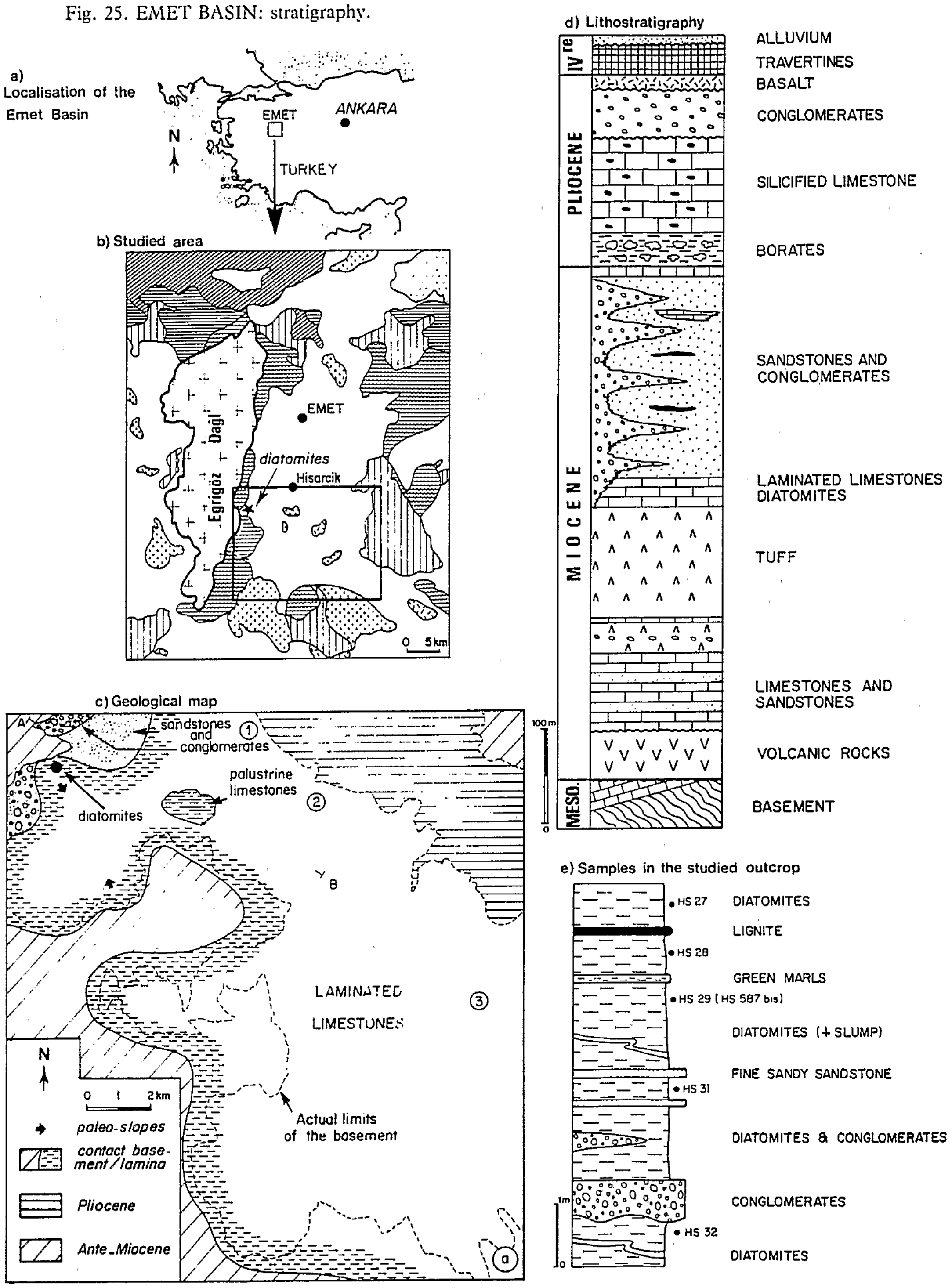
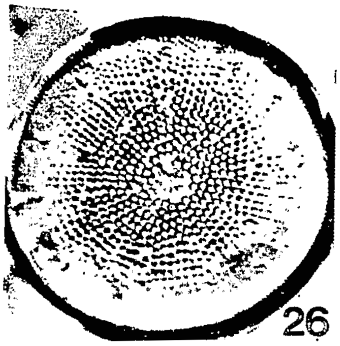
Fig. 25. EMET BASIN: stratigraphy.

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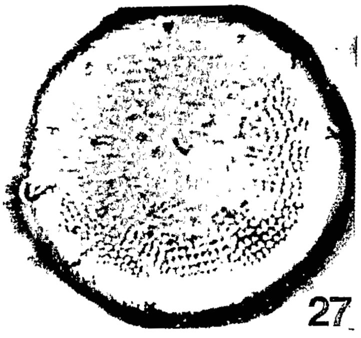
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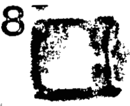
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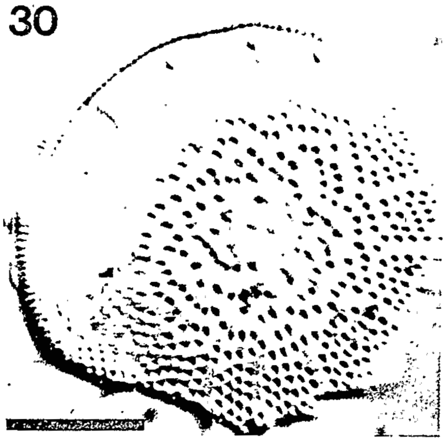
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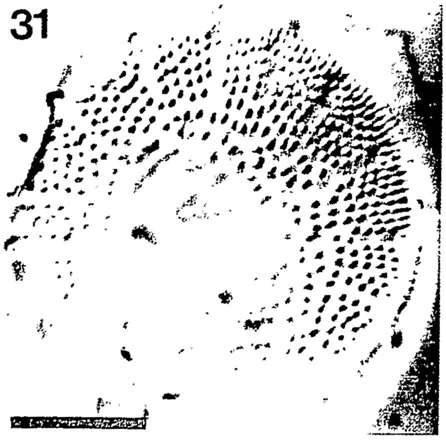
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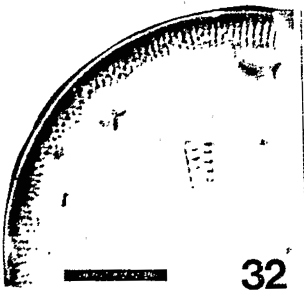
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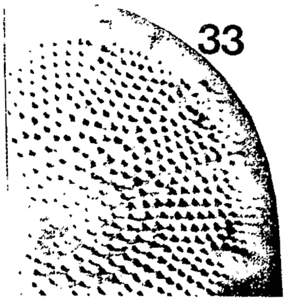
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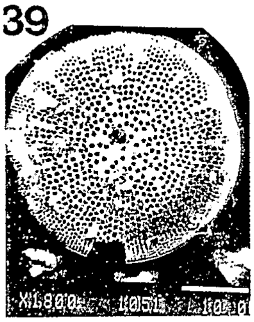

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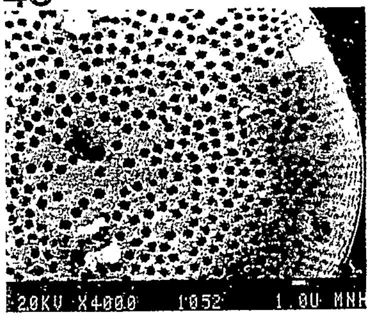

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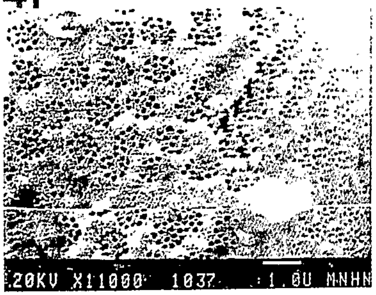

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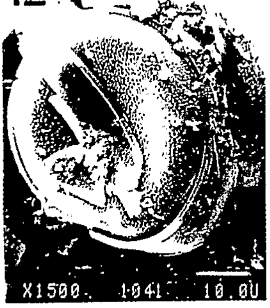

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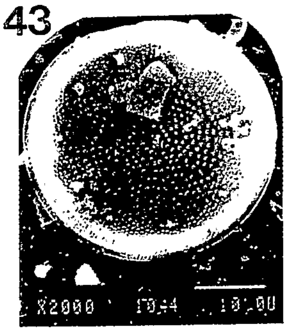

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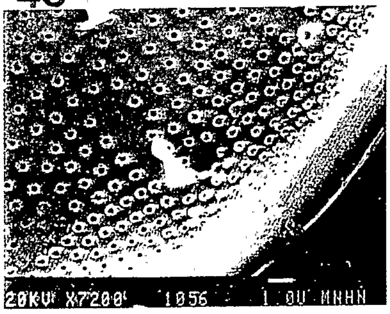

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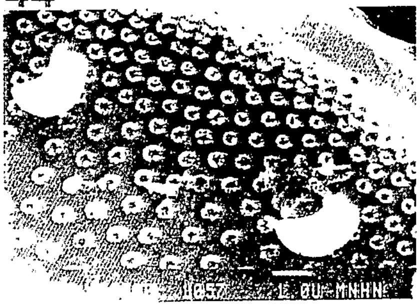

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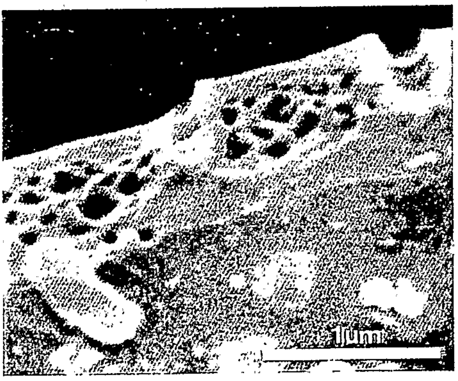

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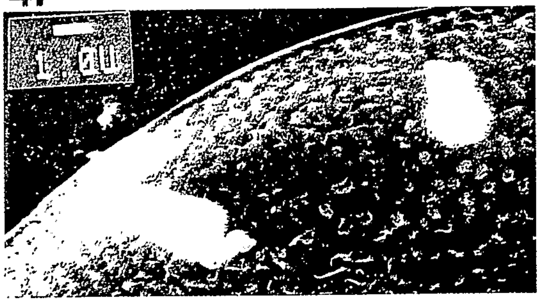

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