Chattian larger foraminifera from Risan Aneiza, northern Sinai, Egypt, and implications for Tethyan paleogeography

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ABSTRACT: Micropaleontologic studies on newly discovered, isolated occurrences of carbonate strata at Risan Aneiza, Northern Sinai, identified six corallinacean taxa,five larger foraminifera taxa and two smaller foraminifera, among the larger foraminifera, one genus, *Risananeiza* (type species: *Risananeiza pustulosa*) and one species: *Nephrolepidina sinaica* n.sp. are believed to be new. The larger foraminifera are classified, described and illustrated. Among them *Miogypsinoides complanatus* is an index taxon according to Cahuzac and Poignant (1997), for shallow water Oligocene deposits of western European basins. This species indicates SB 23 (SB=shallow water benthic) - a late Oligocene, Chattian age (24.5 Ma, Gradstein et al. 2004). The exposures are the first documented shallow marine strata of Upper Oligocene (Chattian) age for the region. Their location between coeval continental strata to the south and fine-grained siliciclastics found in offshore wells is clear evidence of the position of the contemporaneous shoreline, and adds an important segment to the paleogeography of the final stage of Tethys evolution.

INTRODUCTION

Geologic setting

Most of the Oligocene sediments exposed in Egypt are represented by patchy occurrences of continental or fluviatile deposits. Only in the subsurface of north Egypt (including north Sinai), fine-grained marine Oligocene siliciclastic beds have been found in several wells (Soliman and Orabi 2000, El Heini and Enani 1996) that reach a thickness of several hundred meters.

In the Eastern Desert of Egypt (Quseir area), the Oligocene Nakhul Formation (El Akkad and Dardir 1966) is composed of 60m beds of coarse breccia and angular limestone and chert concretions derived from the underlying Thebes Formation. Moustafa (2004) mapped the Abu Zenima Formation of Oligocene age along the western coasts of Sinai and described lateral changes in thickness from 20m to more than 110m. The section at Abu Zenima is made of red, purple, and varicolored siltstones, mudstones and coarse-grained, cross-bedded ferruginous sandstones with some polymictic conglomerate beds and plant remains.

The newly discovered shallow-marine carbonates of the Wadi Arish Formation (Kuss and Boukhary 2008) are composed of limestones and marls of upper Oligocene age (text-fig. 1). The Wadi Arish formation is subdivided into three members and six lithostratigraphic units, with litho- and microfacies characteristics that are described in the present study and have been described in detail by Kuss and Boukhary (2008). At Gebel Risan Aneiza (Northern Sinai) the Oligocene section attains a thickness of 77m, exposed in isolated outcrops along the eastern scarp.

The occurrence of carbonate beds in the Oligocene sections, here in Sinai, is of particular importance as these have never been recorded in the Oligocene of Egypt.

METHODS AND DEPOSITORY

This study is based on 47 thin sections (cut perpendicular to the bedding plane) of 8x10cm size. Four marly shale samples were washed and micropaleontologically studied; 37 additional thin-sections have been made from isolated foraminifera and rhodoliths. Supraspecific classification of foraminifers mainly follow Loeblich and Tappan (1988). Determinations of red algae follow Bassi (1998), Bosence (1983), Braga et al. (1993), Braga and Aguirre (1995) and Rasser and Piller (1999).

Digital photographs of thin sections have been taken with an Olympus DP 15 camera mounted on a Vanox microscope. The thin sections used are deposited at the Geochronology group of the University of Bremen (Germany) and at the stratigraphy group of Ain Shams University Cairo (Egypt).

LITHOSTRATIGRAPHY AND BIOSTRATIGRAPHY

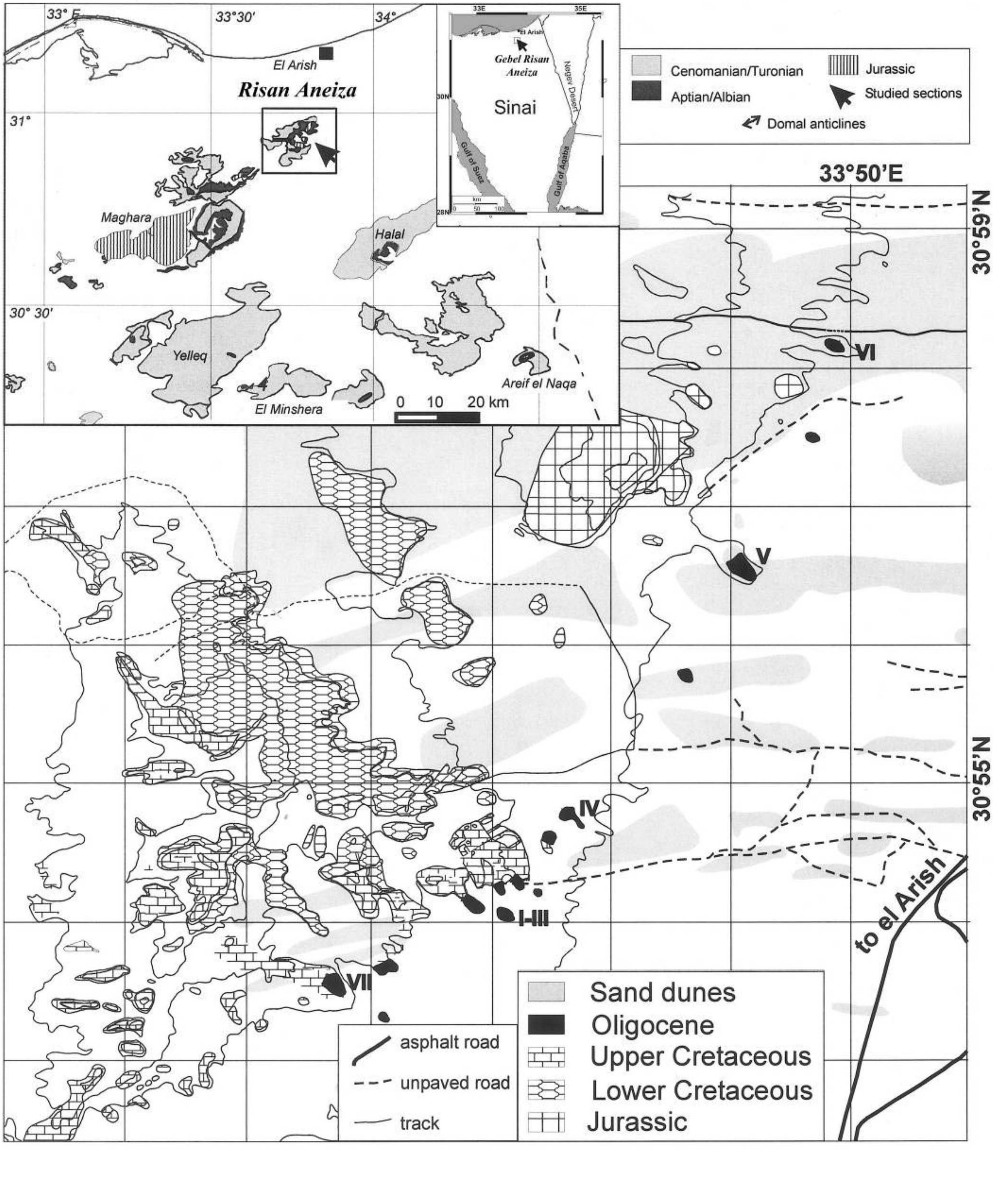
The Wadi Arish Formation (text-fig. 2) is subdivided into the following three members (Kuss and Boukhary 2008):

Lower Wadi Arish Member: Composed of coarse grained sandstone intercalated with gypsum layers at the base and massive or well-bedded limestones above. Foraminifers and corallinaceans are frequent constituents in this member that measures about 42m in thickness.

Middle Wadi Arish Member: Composed of greyish-bluish claystone with thin intercalated layers of nodular limestones or rhodoliths. Isolated larger foraminifera are frequent constituents. It measures 10m in thickness.

Upper Wadi Arish Member: Composed of 25m pure limestone, either massive or well-bedded. Larger foraminifers as well as algal rhodoliths are common in this member.

The biozonation of the Oligocene section of Risan Aneiza is based on larger foraminifera. The examined samples are barren of nannoplankton (Marzouk pers. comm.). Biostratigraphic



TEXT-FIGURE 1
Location Map of the position of the Upper Oligocene sections at Risan Aneiza mountains. The isolated outcrops measured at sections VII (south) to VI (north) are drawn in text-figure 3.

concepts proposed by earlier authors for the marine Oligocene sediments of Egypt have been taken into consideration (Hassan et al. 1984, Cherif et al. 1993) and compared with supra-regional schemes (Cahuzac and Poignant 1997, Sharland et al. 2004). Additional data are also included for supra-regional comparisons.

The marker species of the Risan Aneiza section of biostratigraphic importance are: *Nephrolepidina sinaica n.sp., Miogypsinoides complanatus*, *Eulepidina elephantina* Lemoine and Douville 1904 and *Globotextularia* sp. Following the biozonation concept proposed by Cahuzac and Poignant (1997) for shallow-water Oligocene deposits of western European basins, the marker species *M. complanatus* of Risan Aneiza section indicates SB 23 (SB = shallow water benthic zonation). A late Oligocene (Chattian) age (lower SB 23) seems most probable. According to Sharland et al. (2004) *Miogypsinoides complanatus* is the most indicative species of the late Oligocene (Chattian) in the Middle East. The authors redefined the circum-Arabian maximum flooding surfaces (MFS) of the late Paleogene and compare clean carbonates with *M. complanatus* of the Zagros range and in northern Iraq with a new MFS Pg50 (“Maximum Flooding Surface”) of Chattian age. A correlation of the Oligocene carbonates of Risan Aneiza with MFS Pg50 seems most probable (Kuss and Boukhary, 2008). The distribution of some larger foraminifera as well as corallinaceans is shown on text-figure 4.

SYSTEMATIC DESCRIPTION

The biogenic components in the studied material are dominated by coralline red algae, larger benthic foraminifers and echinoderms, while corals, smaller benthic foraminifera, bryozoans and molluscs are of subordinate importance. Many of these fossil remains were subjected to fragmentation, bioerosion and encrustation, but preservation is still good.

Calcareous algae

Coralline red algae are the most characteristic and dominant biogenic components of the Upper Oligocene carbonates of the Wadi Arish Formation. They are generally well preserved and often show diagnostic features used in modern taxonomy of coralline algae (Braga et al 1993, Rasser and Piller 1999). Further investigation of their taxonomy and paleoecology is investigated for a forthcoming publication.

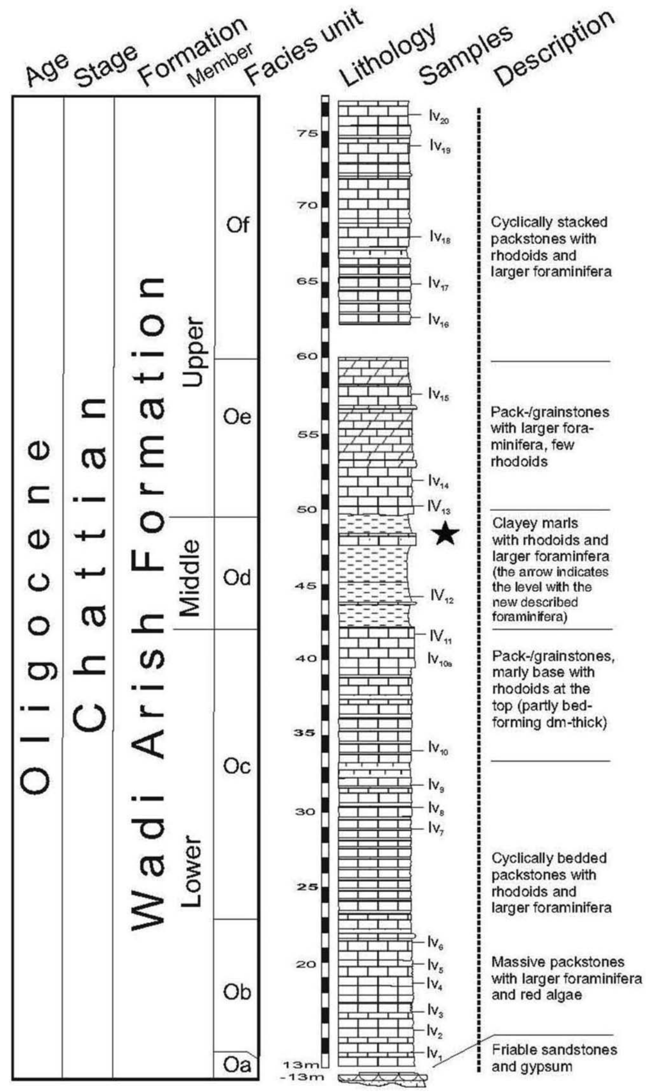
The algal flora consists of 6 taxa of the Mastoporidae and Melosbesioidae, described at different taxonomic levels. The following form has been recognized.

Lithoporella melobesioides Foslie 1909, *Spongites* sp., *Lithothamnium* cf. *ramosissimum* Conti 1946a, *Lithothamnium* sp. and *Sporolithon* sp. and the geniculate coralline algae *Neogoniolithon* sp.

There is a considerable variation in growth-forms of the studied coralline algae, following the nomenclature of Woelkerling et al (1993): encrusting types, protuberances and lamellate growth-forms. They show distinct distribution with respect to taxonomy and growth-form, important for facies interpretation. (compare Bosence1991).

SYSTEMATIC PALEONTOLOGY

Larger foraminifera are the most important components of the studied Upper Oligocene succession. They allow the biostratigraphic subdivision of the studied sections. A total number of 7 taxa have been identified, one from the family Amphisteginidae: (*Amphistegina* sp.), two from the family Lepidocyclinidae: *Nephrolepidina sinaica* n. sp. and *Eulepidina elephantina* Lemoine and Douvillé 1904, one from the family Nummulitidae*: Heterostegina (Vlerkina) assilinoides,* Blanckenhorn 1890 emend Henson 1937, one from the family Miogypsinidae: *Miogypsinoides complanatus* (Schlumberger 1900), one from the family Globotextulariidae: *Globotextularia* sp. (pl. 2, fig. 24) and one from the family Rotaliidae: *Risaneaneiza pustulosa* n. gen., n. sp.

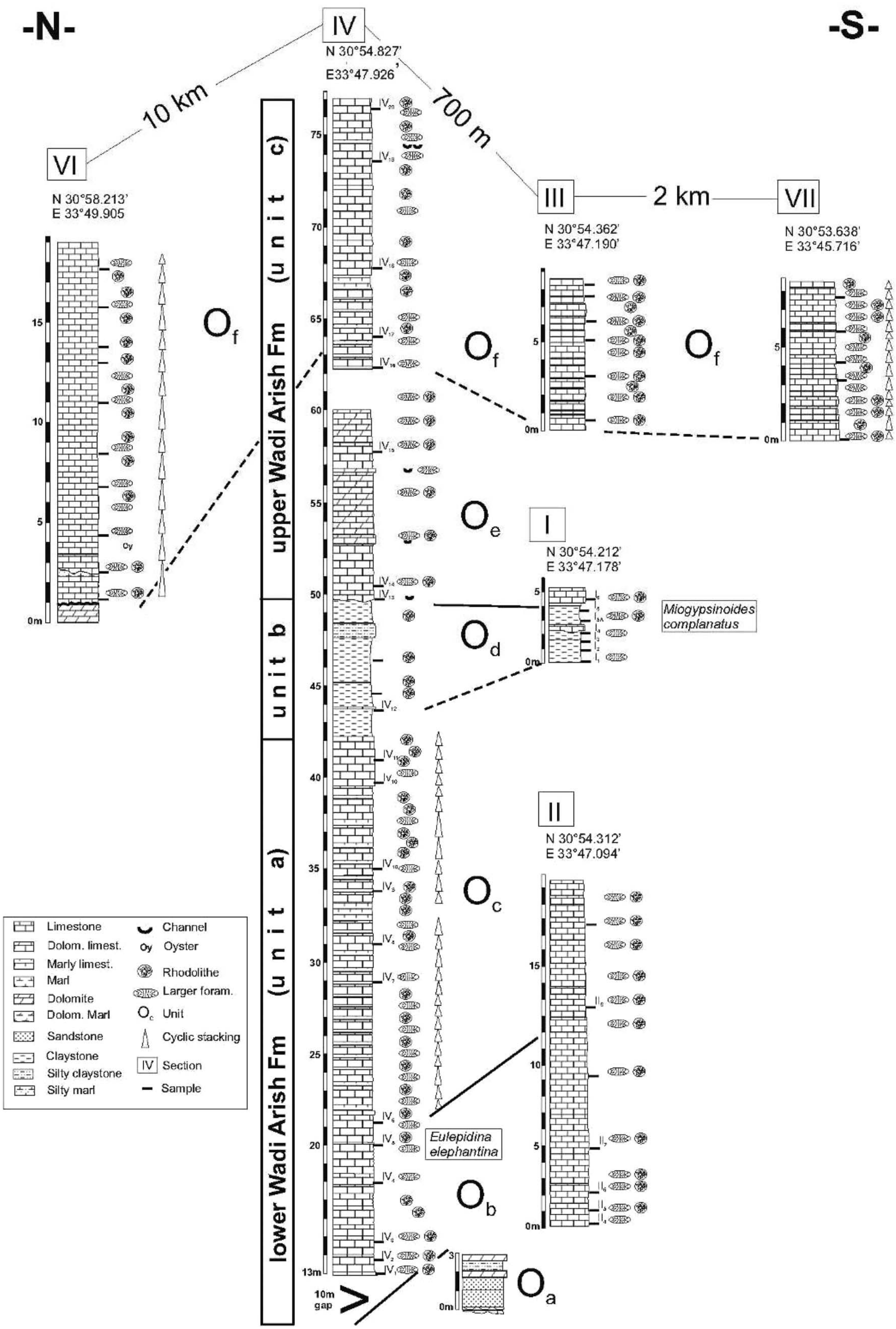


TEXT-FIGURE 2
Composite section of the Upper Oligocene Wadi Arish formation.

Order Foraminiferida Eichwald 1830
Family Lepidocyclinidae Scheffen 1932
Subfamily *Helicolepidininae* Tan 1936
Genus *Nephrolepidina* Douvillé 1911

Nephrolepidina sinaica Boukhary, Kuss and Abdelraouf, **n. sp.**
Plate 2, figures 1-22

Etymology: After the locality from where the species has been collected.



TEXT-FIGURE 3
A correlation of the upper Oligocene carbonates of Risan Aneiza. For location see text-figure 1.

TABLE 1
Comparison between the megalospheric generation *Nephrolepidina morgani* (Lemoine and Douvillé 1904) and *Nephrolepidina sinaica* n. sp.

Dimensions	*Lepidocyclina* (*Nephrolepidina*) *morgani* (Lemoine and Douvillé 1904) (after Chatterji 1961)	*Nephrolepidina sinaica* n.sp.
Diameter of test (D)	1.600mm to 2.770mm	1.600mm to 5.050mm
Thickness of test (T)	0.650mm to 1.520mm	0.700mm to 1.675mm
D/T	1.822mm to 2.460mm	2.280mm to 3.014mm
Embryonic chambers		
a) Diameter of Protoconch	133.9μm to 202.1μm	200μm to 350μm
b) Diameter of Deuteroconch	193.5μm to 296.7μm	350μm to 575μm
Ratio of a/b	1.445 to 1.468	1.75 to 1.642
Thickness of partition wall	17.20μm to 21.5μm	10μm to 30μm
Thickness of outer wall	25.80μm to 30.1μm	20μm to 44μm

TABLE 2
Measurements of the variables of *Nephrolepidina sinaica* n. sp.

Specimen no.	A	C	P	DI	DII
1	43.64	4	23	0.3	0.45
2	40.85	2	15	0.2	0.31
3	45.5	5	16	0.22	0.38
4	43.18	2	16	0.25	0.37
5	41.67	4	18	0.23	0.36
Average	42.968	3.4	17.6	0.24	0.374
STDV	1.808195	1.341641	3.209361	0.038079	0.050299

Measurements: A, C, P, DI, DII after Heck and Drooger (1984):
A=100 X
C: number of accessory auxiliary chambers on the deuteroconch
P: total number of peri- embryonic chambers
DI: maximum diameter of the protoconch
DII: maximum diameter of the deuteroconch

Holotype: Plate 2, figure 6.

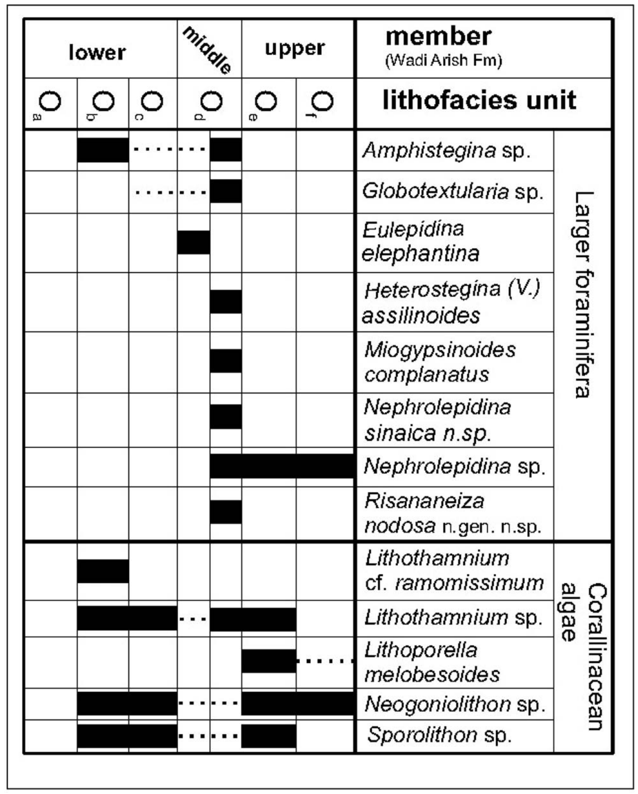
Paratypes: 60 megalospheric specimens

Locus typicus: Risan Aneiza, stratigraphic section OI5a.

Stratum typicum: Yellow soft marls of unit OI5a

Description (megalospheric form): Test lenticular, highly inflated centrally with thin periphery, circular in outline, wall calcareous hyaline, surface reticulate resembling honey-comb with 3-6 small granules in the central part. Diameter ranges from 1.6mm to 5.05mm and thickness ranges from 0.7mm to 1.675mm.

The embryonic chambers consist of a protoconch and a deuteroconch of typical Nephrolepidine type; the latter embraces the former. The thickness of the outer wall of the embryonic chambers ranges from 20μm to 44μm. Diameter of protoconch ranges from 200μm to 350μm and the deuteroconch ranges from 350μm to 575μm. The thickness of the partition wall between the protoconch and the deuteroconch ranges from 10μm to 30μm (Table 1).

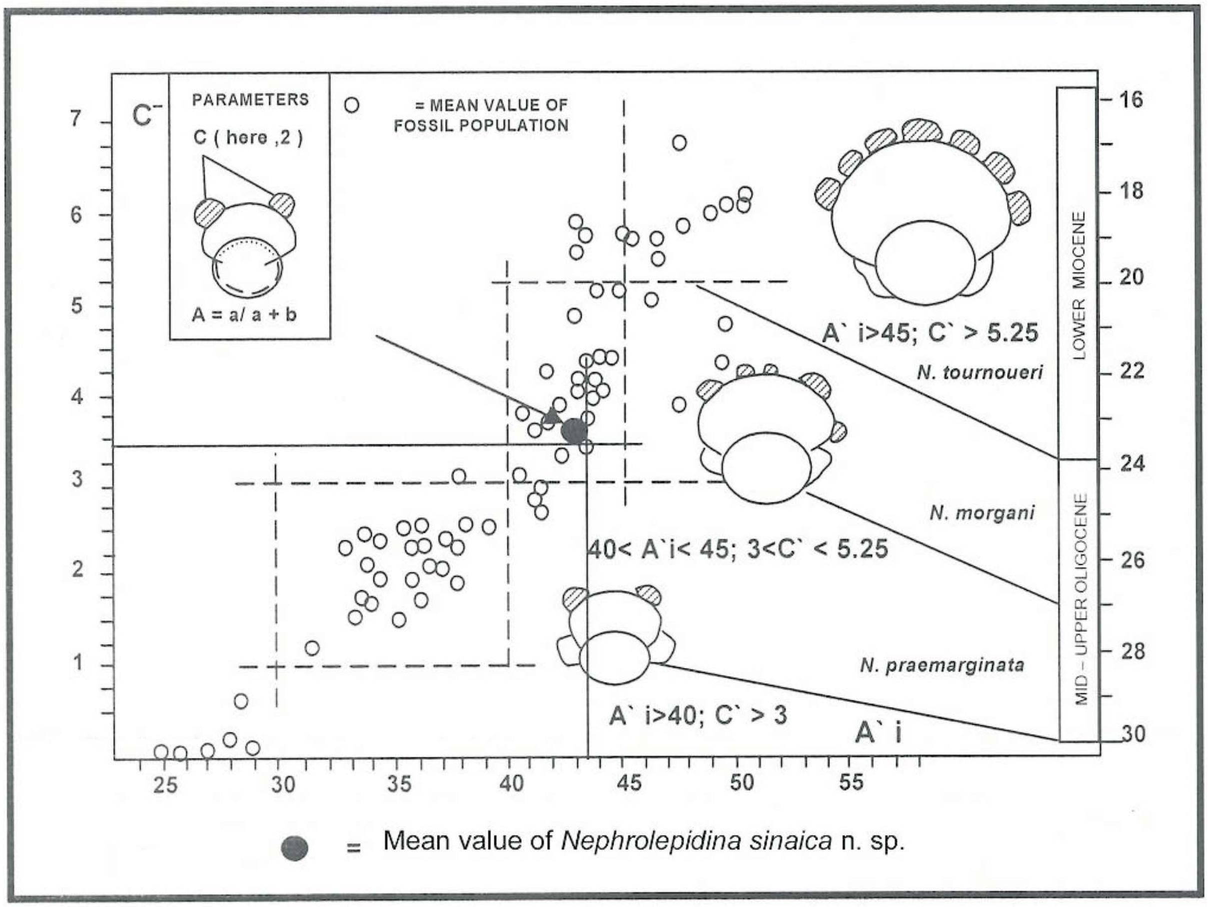


TEXT-FIGURE 4
Stratigraphic distribution of the larger foraminifera and corallinaceans within the six members of the Wadi Arish Formation.

The equatorial sections are nonpolygonal near the center and polygonally arranged in concentric rings toward the periphery becoming more elongate and hexagonal near the periphery.

Remarks: Only the megalospheric form is recorded. This species is typically related to *Nephrolepidina* following the scheme of Eames et al (1962); the embryonic chambers being surrounded by a set of primary auxiliary, and adauxiliary, protoconchal symmetrical auxiliary and interauxilary chambers. *Nephrolepidina sinaica* differs from *Nephrolepidina morgani* in having larger size of the test, larger protoconch and it lacks the well developed central bulb. Text-figure 5 shows that the plotting of the average value of the ratio A'i (length of the common wall between the protoconch and deuteroconch of the embryonic apparatus of the nominate species divided by the total circumference of the protoconch calculated for 4 (better more) specimens provided from a single sample) plotted against the average number of accessory chambers on the deuteroconch of the same specimen (C) falls within the limits of *Nephrolepidina* gr. *morgani.*

The biometry of lineage of *Nephrolepidina* in the Oligocene-Miocene of the Mediterranean region (after Pignatti 2003) and *Nephrolepidina sinaica* n. sp., from Risan Aneiza is shown on text-figure 5. It seems that the relation between these two parameters shows a linear progression with time hence it can be used to determine the concerned geologic time. The absolute size of tests and embryonic chambers, however, seems to de-



TEXT-FIGURE 5
Biometry of lineage of *Nephrolepidina* in the Oligocene-Miocene of the Mediterranean region (after Pignatti 2003), and *Nephrolepidina sinaica* n.sp. from Risan Aneiza.

pend on local genetic factors due to isolation of populations in particular areas (provinces), including local specification, probably related to local environmental factors (temperature, availability of nutrients or any other unknown factor).Thus, we suggest to name a distinct species of *Nephrolepidina* on the basis of size difference. This species is yielded from sample OI5a. The final conclusions on that new species were finished after a precursor manuscript appeared (Kuss and Boukhary 2008, fig. 6), where the same new species were attributed to *N.* cf. *morgani*.

Genus *Eulepidina* Douvillé 1911

Eulepidina elephantina Lemoine and Douvillé 1904
Plate 2, figure 23

Lepidocyclina (Eulepidina) elephantina LEMOINE and DOUVILLÉ 1904, p. 13 pl. 2, fig. 13, 19. – LLUECA 1929pp. 336-337, pl. 28, figs. 1-2 (fide Ellis and Messina, 1965). – SILVESTRI 1937, pp. 180-182, pl. 18, figs. 1-2; pl. 20, figs. 2-3

Remarks: Only the microspheric form is recorded in thin sections, since no free specimens are obtained. This species of *Eulepidina* is too large, which attains a diameter of 6-8cm. This species is recorded from Risan Aneiza in stratigraphic section IV5.

Superfamily: Rotaliaceae Ehrenberg 1839

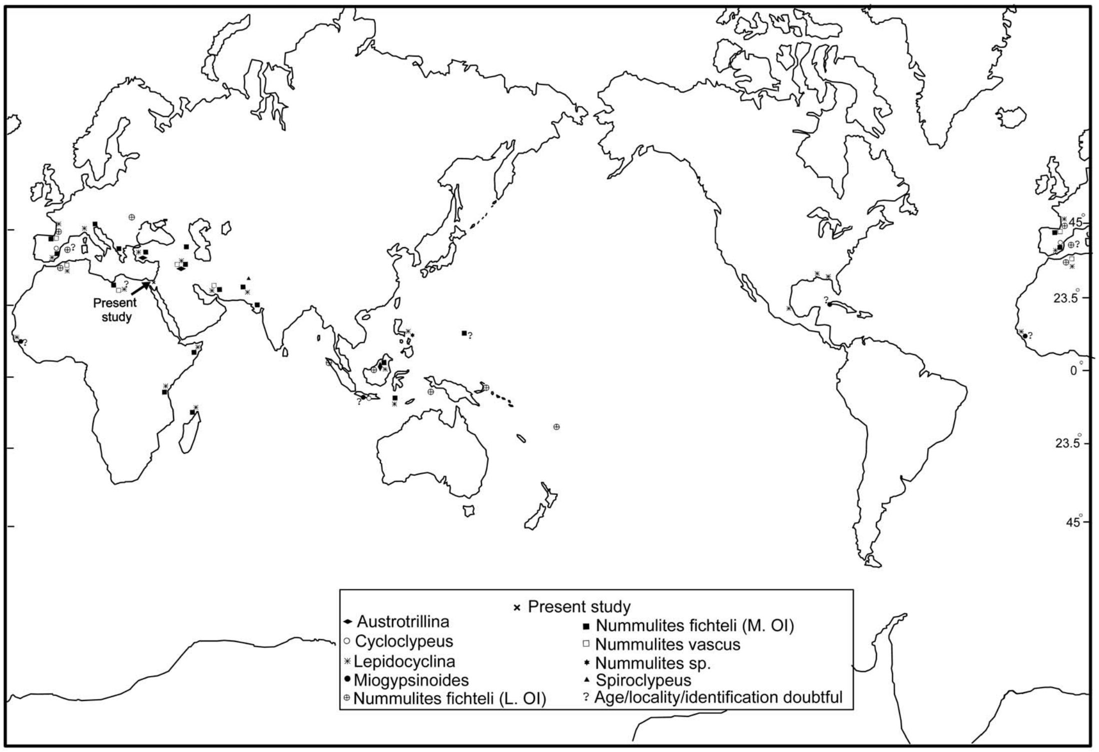
Genus ***Risananeiza*** Boukhary, Kuss and Abdelraouf, **n. gen.**
Type species: Risananeiza pustulosa n. gen., n. sp.

Etymology of the genus: After the locality, from which the genus is described.

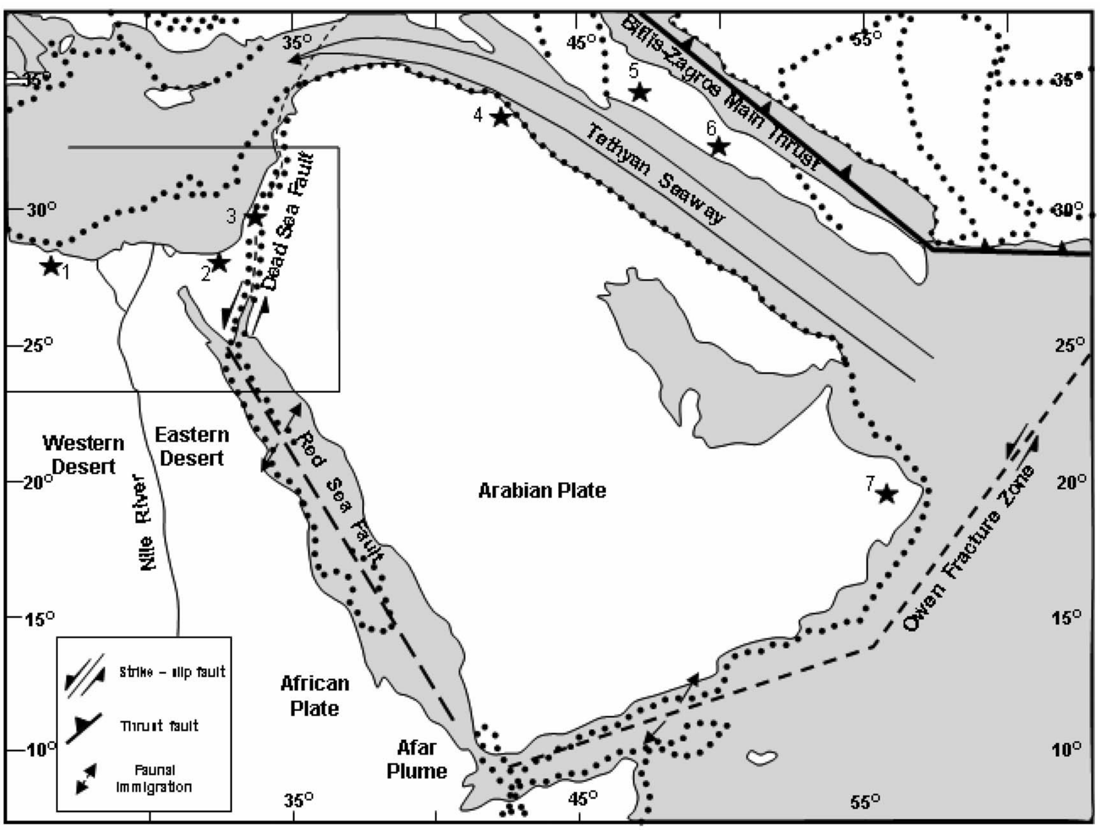
Diagnosis of genus: Test trochospiral, planoconvex to nearly biconvex, subcircular, wall calcareous hyaline, surface highly granulated, dorsal side more convex, ventral side more or less flattened. Chambers numerous, higher than long; sutures strongly incised. Aperture, terminal, wide, triangular and is seen ventrally. Dimorphism is pronounced.

Discussion: Risananeiza n.gen. is typically a rotaliid form and differs from *Neorotalia mexicana* Bermudez 1952 (type species) in possessing coarse pustules on both dorsal and ventral sides and in lacking the ventral wide plug and the chambers surrounding the boss. In addition the aperture of *Neorotalia mexicana* is narrow and extends from the umbilicus to the periphery, while it is basal in *Risananeiza* in the peripheral view.

Risananeiza pustulosa Boukhary, Kuss and Abdelraouf, **n. sp.**
Plate 1, figures 1-18



TEXT-FIGURE 6
Distribution of some Lower and Middle Oligocene Foraminifera (after Adams 1973, with modification)



TEXT-FIGURE 7
Paleoshore line map of the Oligocene in the Middle East. (dotted lines) compared with the actual shorelines (Plate-tectonic basemap at 28.4 My - base Chattian from http://www.odsn.de./odsn/services/paleomap/paleomap.html). Asterisks indicate descriptions of Chattian shallow-water limestones with larger foraminifera: (1) Ouda (1998), (2) own description, (3) Buchbinder et al. (2005), (4) van Bellen (1956)-revised by Sharland et al. (2004), (5) James and Wynd (1965), (6) Amir-Shahkarami et al. (2007), and (7) Jones and Racey (1994).

Etymology of the species: From the pustules covering the whole surface of the test.

Locus typicus: Risan Aneiza, stratigraphic section OIV.

Stratum typicum: sample OIV12

Holotype: Plate 1, figure 8.

Paratypes: 3 microspheric specimens and 47 megalospheric specimens.

Microspheric form: Test trochoid, relatively small, slightly biconvex, average diameter about 5.375mm, average thickness 1.25mm. Wall calcareous hyaline, pierced by coarse radial canals, less granulate than that in the megalospheric form. The granules are arranged spirally. Number of whorls per radius: 3 whorls in a radius of 3.4mm. In axial sections, thick polar pillars are pronounced.

Megalospheric form: Test trochoid, surface granulate, subcircular, planoconvex to slightly biconvex, dorsal side convex and the ventral is more or less flattened, wall calcareous hyaline pierced by coarse radiated canals. Diameter ranges from 2.9mm to 0.925mm, and thickness ranges from 1.625mm to 0.55mm. Number of whorls per radius: 2 whorls in a radius of 1.125mm to 1.225mm. Chambers are higher than long. Number of chambers in the last whorl ranges from 15 to 16. Aperture, basal in apertural view, wide, triangular and seen ventrally modules. Protoconch is larger than the deuteroconch and it ranges from 0.15mm to 0.25mm.

Remarks: Risananeiza pustulosa n. sp. is similar to *Neorotalia tectoria* (Todd and Post 1954) in the ornamentation, both are highly and coarsely granulate although the latter species possesses aligned granules. It differs in lacking the central boss and its surrounding chambers. *Risananeiza pustulosa* n.sp. is possibly compared with *Neorotalia alicantina* (Colom 1954) being larger, more granulate and both are similar in the character of the aperture. The final conclusions on this new species were finished after a precursor manuscript appeared (Kuss and Boukhary 2008, fig. 6) where the same new species was attributed to *Risananeiza nodosa.*

Subfamily Heterosteginae de Blainville 1827
Genus *Heterostegina* d'Orbigny 1826
Subgenus *Heterostegina (Vlerkina)* Eames, Clarke, Banner, Smout and Blow 1968

Heterostegina* (*Vlerkina*) *assilinoides Blanckenhorn 1890 emend Henson 1937
Plate 3, figures 8-21

Heterostegina assilinoides BLANCKENHORN 1890, p. 342, pl. 17, fig. 5 (not figs. 4 and 6). – HENSON 1937, p. 48, pl. 4 figs. 1-5 text-figs. 1, 2.
Heterostegina (*Vlerkina*) *assilinoides* Blanckenhorn.- BANNER and HODGEKINSON 1991 p. 115, p. 4, figs. 4-6.
Heterostegina assilinoides Blanckenhorn emend. Henson 1937.- RACEY 1995, p. 79, pl.11, figs. 1, 2.

Megalospheric form: Only megalospheric form is recorded. Test subcircular, involute becoming planispiral at the last stage; strongly flaring and widely opening, fan shape in the initial stage as seen in the equatorial section becoming subcircular in the outer stage. In some specimens there are some granules on the sutures in the initial stage, also punctation is observed. Small polar boss also exits. Diameter ranges from 2.37mm to 3.9mm and thickness ranges from 0.5mm to 0.725mm. Chambers are arched, divided into subquadrangular to subrectangular chambers. Alar prolongation exists. Protoconch is larger or sometimes equal to the deuteroconch subcircular in median section and ranges from 0.20mm to 0.30mm. Chambers in the early stage are polygonal stellate following the nepionic chambers. In axial sections thick pillars exist throughout growth.

Remarks: Our specimens compare well with the description and figures given by Henson 1937. *Heterostegina (Vlerkina) assilinoides* is similar to *Grzybowskia reticulata* (Rutimeyer 1850) in the internal stellate chambers surrounding both, the protoconch and the deuteroconch, and it differs in having maturo-evolute terminal stage and in possessing alar prolongation. *Heterostegina (Vlerkina) assilinoides* Blanckenhorn 1890 in possessing rectangular to subrectangular chamberlets. It differs from *H. (V.) borneensis*, being more flattened and displaying a ler protoconch. This species is yielded from sample OI5a.

Superfamily Orbitoidacea Schwager 1876
Family Miogypsinidae Vaughen 1928
Miogypsinoides Yabe and Hanzawa 1928

Miogypsinoides complanatus (Schlumberger 1900)
Plate 3, figure 1-7

Miogypsina complanata SCHLUMBERGER 1900, p. 330, figs. 13-16; pl. 3, figs. 18-21. – NUTTALL 1933 (from Ellis and Messina 1965, figs. 18-22)
Miogypsinoides complanatus (Schlumberger 1900). – SIREL 2003, p. 301, pl. xv, figs. 1-16.

Description: The test is fan shaped, wall calcareous hyaline, the external surface of the test is covered by granules which are scattered in the early stage and aligned in the most external part of the test. The diameter of the test ranges from 0.78mm to 1.85 mm, and the thickness ranges from 0.4mm to 0.88 mm, the extremity of the test is zigzag in shape. The protoconch is spherical to semi-spherical (its diameter ranges from 0.1mm to 0.15

PLATE 1

1-18: *Risananeiza pustulosa* n.gen. n. sp. Depository numbers OI5a1 – OI5a18.

1, 2 microspheric form, external view;

3 microspheric form, equatorial section;

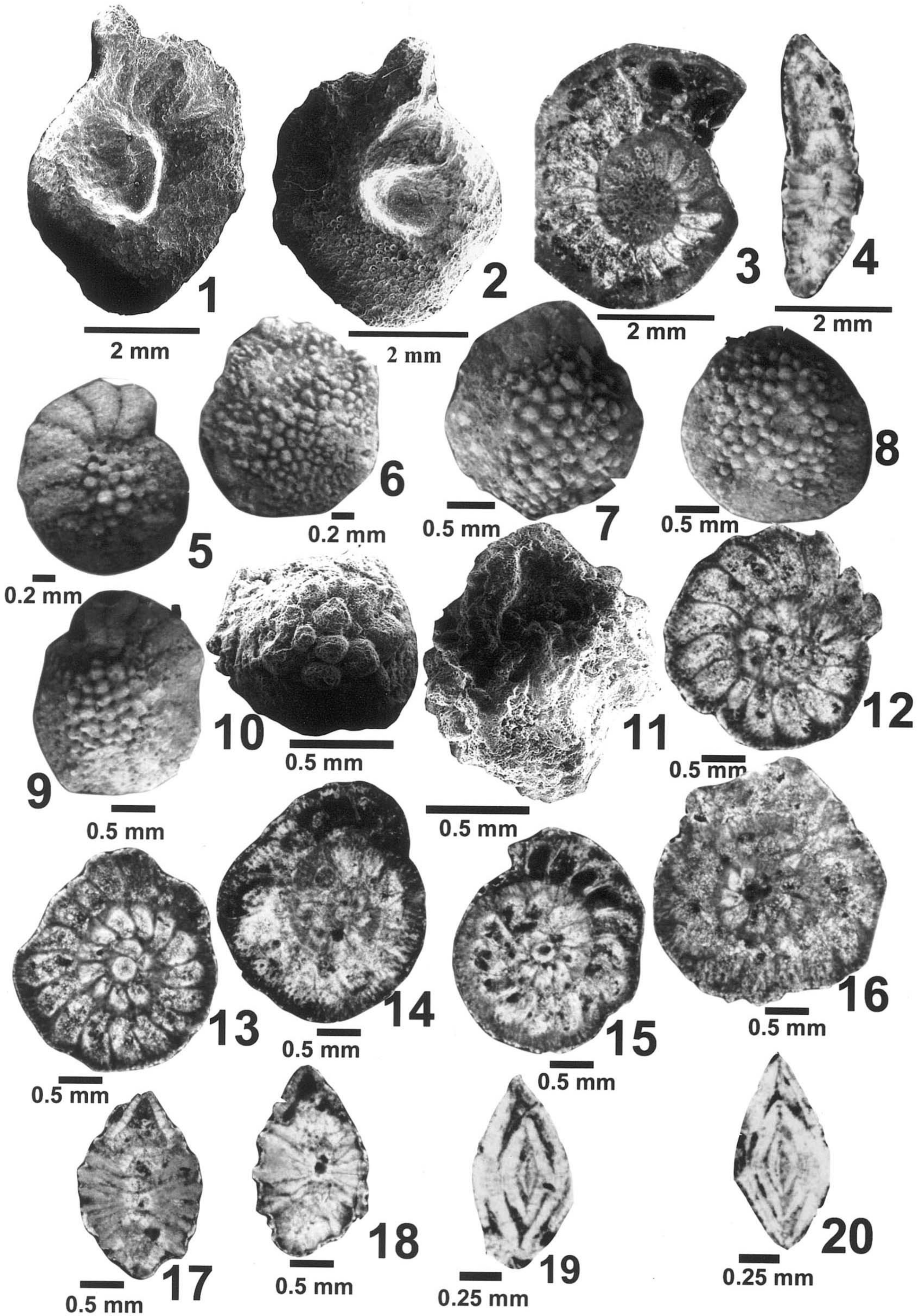
4 microspheric form, axial section;

5-10, 12-16 megalospheric form, equatorial section;

11 megalospheric form, apertural view;

17, 18 megalospheric form, axial section.

19, 20 *Amphistegina* sp., axial sections. Depository number: OI5a19-OI5a20.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mm and deuteroconch ranges from 0.075mm to 0.15 mm. The wall of the spiral stage is thickened, the spiral chambers range from ¾ whorl to 1 1/2 whorls following the embryonic chamber. The number of spiral chambers following the deuteroconch ranges from 5 to 14 chambers. Aperture is peripheral and multiple, with circular shape.

Remarks: Miogypsinoides complanatus differs from *Miogypsinoides bermudezi* in having less size tests with thick spiral lamina and dense granulations, the granules being radially aligned. It is recorded by Drooger and Magne (1959) from the Chattiän of Algeria. This species is abundant in the studied material and is recorded from sample OI5a.

Paleogeography of the Oligocene in Northeast Africa and Arabia

The new marine record of Late "Chattian" argillaceous limestones in Risan Aneiza helps in reconstructing the shore-line during this time in north Egypt. Sharland et al (2001, 2004) reconstructed sea-level fluctuations of the Arabian Plate during the Oligocene that can be compared with the new record from Egypt.

Until very recently the Oligocene shore-line skirts the northern part of the Fayoum depression i.e. 29º31'N (Beadnell 1905, Said 1962, Bown and Kraus 1988). Osman (2003) extended the paleo-shoreline further west when he gave a record for marine Oligocene from El Arag area to the east of Siwa Oasis. With this record in the Western Desert (El Arag) and the Risan Aneiza in Sinai (present work) 700km further east, the paleo-shoreline of Tethys Sea during the Oligocene is almost delineated. South of this line, deltaic sediments were known whereas to the north of this line marine conditions prevailed.

El Heini and Enani (1996) introduced the Tineh Formation from the subsurface Offshore. These strata represents prodeltaic facies interfingering with open marine basinal deposits further offshore according to Dolson et al. (2002). Further east, Avnimetech (1939) described a succession of Upper Oligocene carbonates up to 50m thick with larger foraminifera from the Judean Mountains that are intertonguing with deltaic-fluviatile clastics of the Lakhish Formation (Hirsch 2002).

Buchbinder et al. (2005) interpreted these limestones as mass-transported boulders of the Ramla Member, indicating a redeposited carbonate platform further east. Hottinger (1977) described *Heterostegina assilinoides* Blanckenhorn emend. Henson from Oligocene of Batn el Adas, Ramleh, Israel, which is well correlatable with strata of Risan Aneiza and those from Aintab, Syria by Henson (1937).

Racey (1995) recported Early to Late Oligocene strata from Northern Oman. The Early Oligocene yielded *Nummulites fichteli* which is known from the Tethyan as well as Indopacific realms. In addition, *N. vascus* is reported which is characteristic for the Western Tethys (Mediterranean and Middle East) and Indopacific. The late Oligocene is characterized by *Heterostegina borneensis* and *Cycloclypeus eidae*, the latter known from Mediterranean, Malay, Archipaleogo and Western Pacific. The distribution of the most important larger foraminifera indicating late Oligocene is shown on text-figure 6. Text-figure 7 shows the major tectonic elements affecting the Arabian plate during Oligocene-Early Miocene times and paleoshore line which extend in Egypt's Western Desert nearly coinciding with Tethyan latitude 29°30'.

CONCLUSIONS

The newly described marine Oligocene rocks of the Wadi Arish Formation from Gebel Risan Aneiza area (North Sinai) yield a characteristic microfauna and flora. This finding has a great bearing on the palaeogeographic extension of the Oligocene sea over Northern Egypt. Marine Oligocene was recorded by De La Harpe (1883) in Siwa Oasis. Osman (2003) extended the marine Oligocene in El Arag area which lies to the east of Siwa. With the new record of this Oligocene fauna in Sinai, it becomes evident that marine transgression covered the north part of Egypt till latitude 29°12'00", South of this latitude fluvial, deltaic and non-marine Oligocene sediments were well developed in the Fayoum area (Beadnall 1905). Marine beds of this epoch were also recorded in the subsurface (El Heini and Enani 1996). Five larger and one smaller foraminiferal species are identified, classified and illustrated. Among those, one genus and one species are believed to be new.

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PLATE 2

1-22: *Nephrolepidina sinaica* n.sp., all figures are megalospheric. Depository number: OI5a21-OI5a42

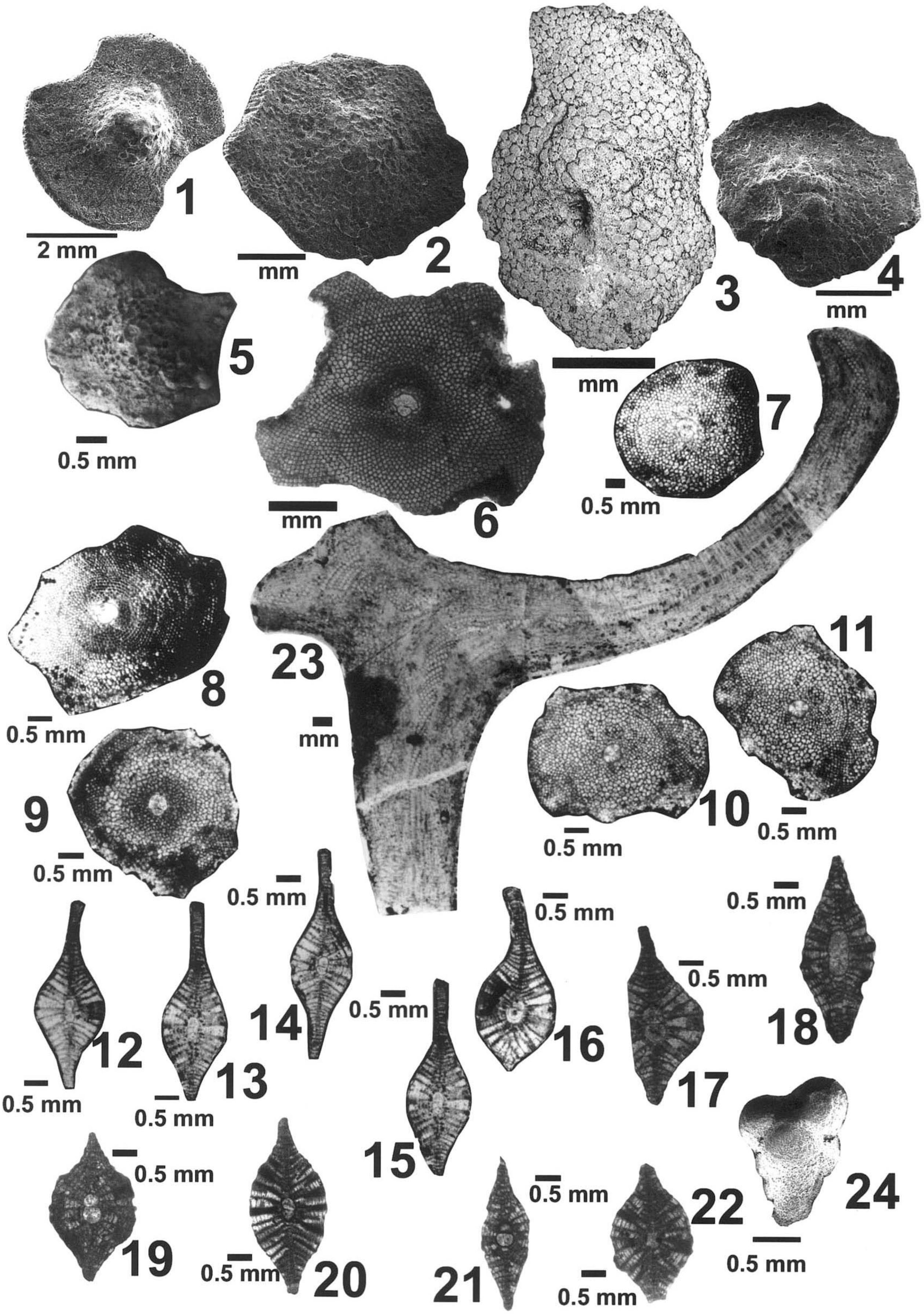
1-5 external view;

6-11 equatorial section;

12-22 axial sections. .

23 *Eulepidina elephantina* (Lemoine and Douville): *microspheric*, oblique section. Depository number: OIV543.

24 *Globotextularia* sp. Depository number: OI5a44.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knowledged. Finally we would like to thank R. Bätzel (Bremen) for the preparation of thin sections.

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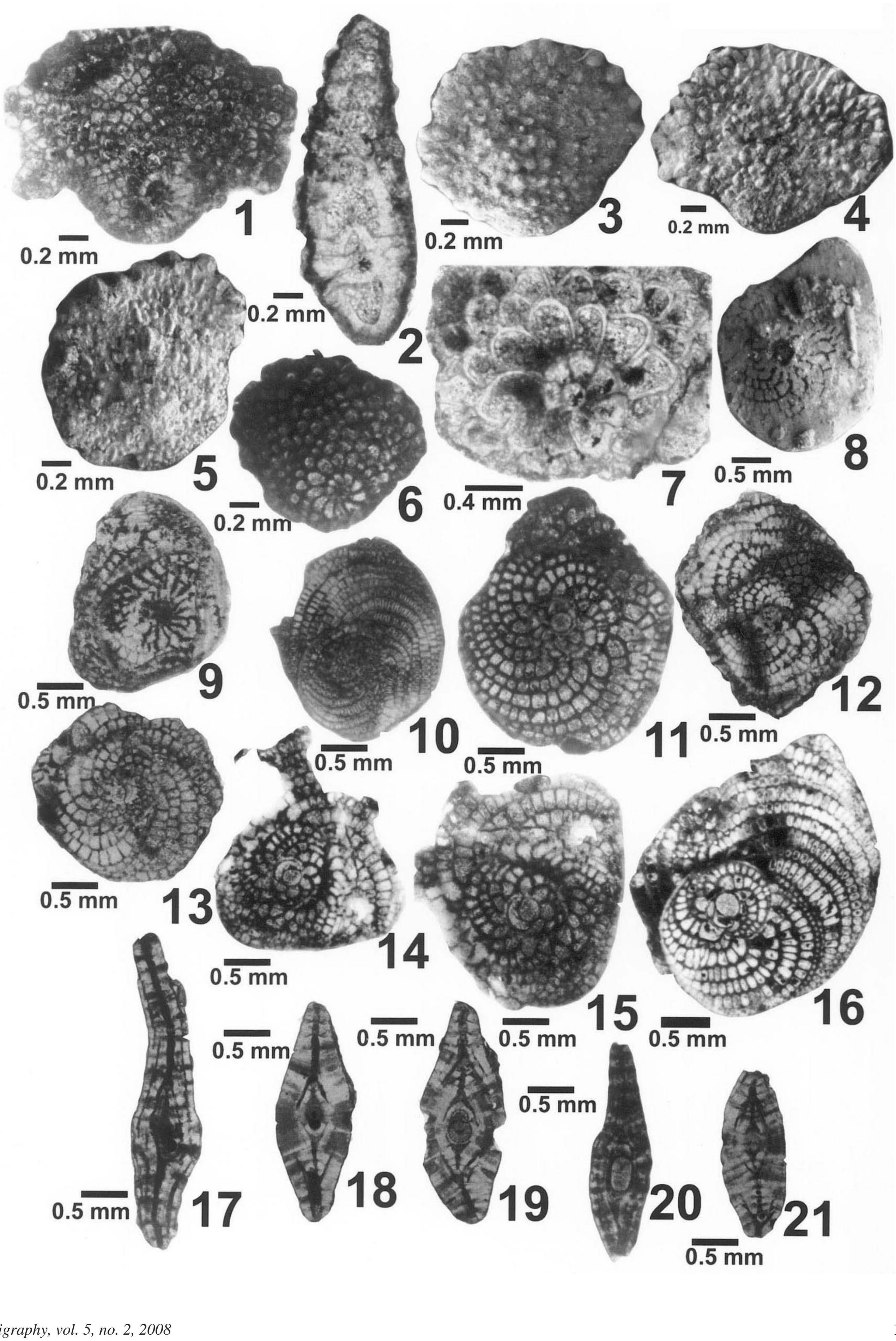
PLATE 3

Figs. 1-7: *Miogypsinoides complanatus* (Schlumberger 1900), sample OIV5a. Depository number: OI5a1-OI5a7.

- 1,6-7 equatorial section
- 2 axial section, B-form, microspheric
- 3-5 external surface with granules

Figs. 8–21: *Heterostegina (Vlerkina) assilinoides* Blanckenhorn. Sample, OI5a. Depository number OI5a50-OI5a71.

- 9, 10 external view;
- 11-16 equatorial section
- 17-21 axial section.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