

Agglutinated Foraminifera from Danian sediments of the northeastern Sirte Basin

AHMED M. MUFTAH

Arabian Gulf Oil Co., Exploration Division, P.O. Box 263, Benghazi, Libya, G.S.P.L.A.J. and Research School of Geological & Geophysical Sciences, University College London, Gower Street, London WC1E 6BT, U.K.

ABSTRACT

Twenty-two species assigned to sixteen genera of flysch-type cosmopolitan agglutinated foraminifera, associated with radiolaria, are reported for the first time from subsurface Danian sediments of the northeastern Sirte Basin, Libya.

The most diagnostic genera recorded are: A) tubular, medium-sized finely agglutinated *Rhizammina*, *Hyperammina*, and *Bathysiphon*; B) small to medium-sized, finely agglutinated *Ammodiscus*, *Glomospira*, *Rzehakina*, and *Saccammina*; and C) large, often pyritized, coarsely agglutinated *Clavulinoides* and *Dorothia*. This assemblage is assigned to the *Rzehakina fissistomata* Zone of Geroch & Nowak (1984).

Based on a comparison with similar flysch-type assemblages of Maastrichtian to Danian Guayaquayare and Lizard Springs Formations in Trinidad, it is concluded that the studied Danian deposits were deposited in a poorly-oxygenated environment at upper to lower bathyal depths.

INTRODUCTION

This study presents a brief description of a "flysch-type" cosmopolitan agglutinated foraminiferal assemblage, documented for the first time in the lower part of the Hagfa Shale Formation in exploratory Well A1-41 in the Ajdabya Trough area of northeast Libya (Fig. 1). The term "flysch-type" is given to diverse agglutinated foraminiferal assemblages characterized by abundant primitive taxa (Gradstein & Berggren, 1981), previously described by Grzybowski (1898). The interval yielding the agglutinated assemblage (12,885'-12,913'), is equivalent to the basal part of the Hagfa Shale Formation. This shale is homogeneous, calcareous, pyritiferous interbedded with limestone. The limestone (lithoclastic floatstone) was deposited in off-shore, intertidal channels. Although Paleocene rocks crop out almost continuously along the southwestern and western margin of the Sirte Basin (Berggren, 1974), only the agglutinated foraminifera bearing interval is highlighted in this study because of the bathymetric importance of this assemblage. These foraminifera characterise a deep water environment and are of sophisticated nature in response to the external conditions.

METHODS:

This study is based on analysis of twenty samples from the interval 12,885'-12,913'. These samples have been treated by soaking in hydrogen peroxide until disaggregated, then gently washed over 250 mesh (63 µm) sieve. The residue was air-dried, and fauna picked. Both benthic and planktic foraminifers are common to abundant, and generally poorly to well preserved. Most selected species are illustrated by SEM microphotographs (Plates 1 and 2). Only two

genera, whose diagnostic characteristics are best seen in transmitted light, have been illustrated by means of camera lucida line drawing (Plate 3).

GEOLOGICAL SETTING

The Sirte Basin is the youngest and the most oil productive sedimentary basin of the North African Craton, occupying most of the central part of Libya (Fig. 1). It is an elongated embayment in which several NW-SE trending faults, initiated in the Late Jurassic to Early-Cretaceous time are reflected in basement block-faults, tilted horsts and grabens. Subsidence was active throughout the Late Cretaceous and most of the Cenozoic, until at least Miocene and probably Holocene times (Conant & Goudarzi, 1967; Gumati & Kanes, 1985). As subsidence continued, shales, carbonates and to a lesser extent evaporites, all preceded by sandstones, were deposited in the Basin (Barr & Weegar, 1972). The subsidence of the basin reached a climax during the Paleocene and Eocene times resulting in the deposition of thick Tertiary marine sequences.

The Sirte basin in Paleocene times received sediments which reflect the prevalence of subsidence and rifting followed by marine transgression. The presence of interbedded deep and shallow marine deposits appear to reflect sea level fluctuations. Renewed uplifting in the region, followed by weathering, caused total, and/or local partial removal of Paleocene strata from elevated areas such as the (Jabal Al- Akhdar and Cyrenaica Platform). By contrast, considerable thicknesses of Paleocene strata have been preserved in topographically low areas, such as the Ajdabya Trough.

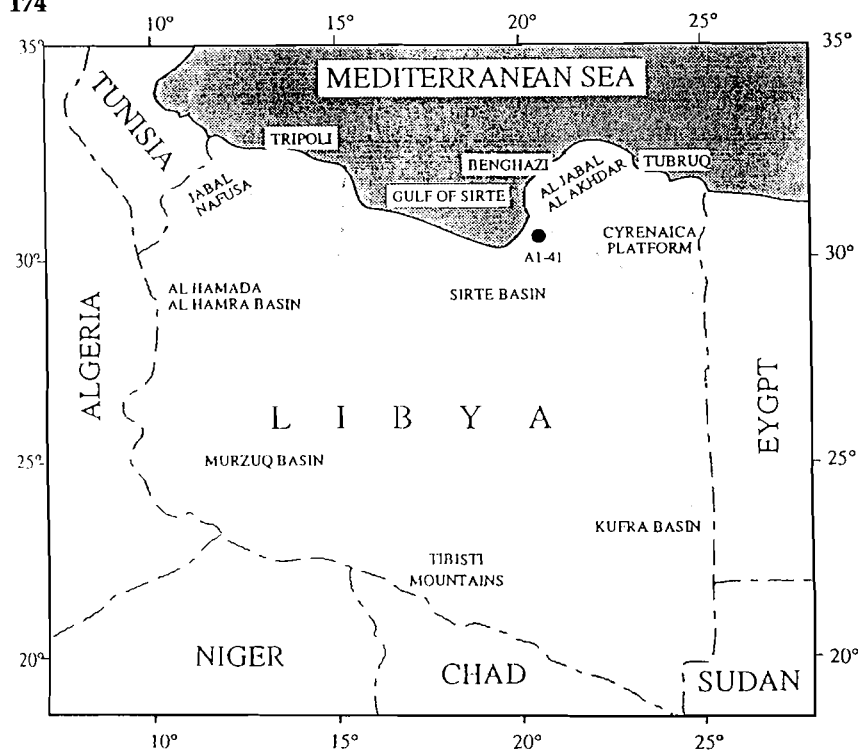


Figure 1. Location of the A1-41 well in the Sirte Basin, northeast Libya.

FAUNAL COMPOSITION

The agglutinated benthic foraminiferal assemblage of the studied interval is rich, but moderately diverse, mostly consisting of agglutinated "flysch-type" assemblage, dominated by astrorhizids, ammodiscids and rzehakinids with hormosinids and lituolids being conspicuous but less abundant. Trochaminids and haplophragmoidids are rare.

Large-sized, coarse-medium grained agglutinants such as textulariids are relatively less abundant. Minor, poorly preserved planktic foraminifers, calcareous benthic and common calcified spumellarian radiolaria are also recorded. The agglutinated assemblage displays moderate to good preservation partly exhibiting test collapse, but generally little distortion is observed in squashed *Ammodiscus*, *Rhizammina*, *Trochammina*, *Trochamminoides*, *Paratrochamminoides*, *Saccammina*, and *Hormosina* specimens. Distortion appears due to physical compaction, but may also be explained by crushing during a possible tectonic activity. The studied assemblage is closely comparable to the "*Rzehakina epigona*" Zonule of Bolli (1957), and is specifically assigned to the "*Rzehakina epigona fissistomata*" Zone of Geroch & Nowak (1984). In the Sirte Basin, the latter is approximately equivalent to the lower part of "*Subbotina pseudobulloides*" Zone of Bolli (1966). This assignment is based on the presence of *Subbotina pseudobulloides*, *S. cf. S. inconstans*, *S. triloculinoides*, *Planorotalites compressa*, *Chiloguembelina* spp., and *Eoglobigerina* spp. in the studied assemblage.

The agglutinated foraminifers in this study have been divided into three morphogroups based on the size and shape of the test, and wall composition.

A. Tubular-shaped morphogroup: Representing portions medium sized pre-mortum test, and finely agglutinated walls. The most common species are

Rhizammina indivisa, *Rhizammina* sp., *Hyperammina* sp., and few *Bathysiphon* sp..

B. Flattened morphogroup: Small to medium sized, somewhat flattened tests, fine to medium grained walls of originally globular, coiled planispiral/ trochospiral and uniserial tests of *Ammodiscus cretaceus*, *Rzehakina epigona*, *R. fissistomata*, *Glomospira charoides*, *G. gordialis*, *Glomospirella* cf. *G. biedai*, *Trochammina* sp., *Paratrochamminoides* sp., *Trochamminoides dubius*, *T. subcoronatus*, *Hormosina velascoensis*, *H. trinitatensis*, *Saccammina placenta*, *Reophax duplex* and *Recurvoides* sp.

C. Larger morphogroup: Large sized tests with robust coarse agglutinated walls, with tests partly replaced by pyrite. The most common species in this category are *Clavulinoides globulifera*, *C. aspera* and *Dorothia* cf. *D. trochoides*.

The calcareous benthic foraminiferal representatives are characterized by a relatively few genera, of deep water environment including, *Nutallinella florealis*, *Fissurina* sp., *Ceratolamarkina* cf. *C. tuberculata*, *Oridosalis* sp., *Guttulina* sp., *Stensioeina* sp. and *Anomalinoidea vanbelleni*. Most of these are replaced by pyrite, thus affecting their preservation potential. In general the ratio of the planktic foraminifera tests to the benthic ones was roughly estimated to be lower in the basal part of the studied core. Planktic foraminifers are poorly preserved forms of the *Subbotina pseudobulloides* Zone assemblage.

Stratigraphically, the majority of the agglutinated species recorded are long-ranging and thus not useful for age determination. Only *Rzehakina fissistomata* and *Clavulinoides globulifera* were treated as indicator of Danian age (Fig. 2). Mass extinctions of the flysch-type agglutinated foraminifera at the K/T boundary are not pronounced (Beckmann *et al.*, 1982). The K/T

SPECIES	STAGE	
	DANIAN	HAASTRICHTIAN
<i>Rzehakina fissistomata</i>		
<i>Clavulinoides globulifera</i>		
<i>Rhizammina indivisa</i>		...
<i>Hormosina velascoensis</i>		..
<i>Glomospira charoides</i>		.
<i>Saccammina placenta</i>		..
<i>Glomospira gordialis</i>		
<i>Ammodiscus cretaceous</i>		
<i>Hormosina trinitatis</i>		
<i>Trochamminoides dubius</i>		
<i>Rzehakina epigona</i>		
<i>Clavulinoides aspera</i>		

Figure 2. Stratigraphic distribution of selected agglutinated foraminifers, compiled from Geroch & Nowak (1984), Kaminski *et al.* (1988), and Bolli (1957).

boundary is masked by the complete absence of the Late Cretaceous diagnostic organisms as well as the only presence of *Subbotina pseudobulloides* Zone of Bolli (1966), and the boundary could be very close to the base of the sample interval in the A1-41 well, due to the co-occurrence of a single inoceramus prism which can be explained as tectonic derivative.

PALEOECOLOGY

The "flysch-type" cosmopolitan agglutinated foraminiferal assemblage encountered in the present study, including species of the above-mentioned morphogroups "A and B" is considered to be characteristic of deep water environments (Kaminski *et al.*, 1988; Kuhnt, 1988). The accompanying calcareous benthic foraminiferal assemblage is interpreted as deep water forms and partly derived from shallow water source. The above-mentioned morphogroups "A and B", are indicative of upper to lower bathyal paleodepths. Abundant and diverse, present day tubular forms are associated with quiescent middle to lower bathyal and abyssal environments (Chamney, 1976; Brasier, 1981). The abundance and relatively low diversity of the tubular forms indicate a bathyal environment with oxygen deficiency on the sea floor (Fig. 3). This interpretation is supported by the presence of radiolarians replaced by calcite indicating deposition above the calcium compensation depth (CCD). The occurrence of abundant *Rzehakina epigona* and *Ammodiscus cretaceus* may be associated with increased input of organic matter (Kuhnt & Kaminski, 1990), and also suggests oxygen deficiency on sea floor.

Morphogroup "C" is indicative of shallower paleodepths (probably slope-derived faunas) formed as result of synsedimentary slumping, with *Clavulinoides globulifera* being found at paleodepths shallower than 1800 m. (Kaminski *et al.*, 1988). The test replacement by pyrite with the presence of pyrite

aggregates in large amounts point to reducing conditions. The interval containing the studied agglutinated assemblage is considered as a mixture of autochthonous fauna (morphogroup A and B) and other slope-derived fauna (morphogroup C).

COMPARISON

All the reported agglutinated foraminifers are cosmopolitan; faunal provincialization is not observed. This A1-41 assemblage is closely comparable to the agglutinated assemblages described by Kaminski *et al.* (1988) from the Guayaguayare and Lizard Spring formations of Trinidad. There is a possibility of some endemism due to the absence of *Rzehakina fissistomata* reported from the Trinidad localities. The only notable differences between both sites is the low abundance and diversity of the superfamilies Haplophragmiacea and Textulariaceae, with lower specific diversity of ammodiscids and rzehakinids in the A1-41 well in comparison to Trinidad faunal assemblages. The agglutinated assemblage recorded provide an important contribution to the stratigraphic and biogeographic distribution of these deep water faunas. They act as a bridge in correlation of the strata containing these assemblages, indicating deep water connections with the Tethys ocean.

This flysch-type assemblage is not observed in oil exploratory wells on-shore Cyrenaica or from the Cyrenaica Platform wells where the lithological character changes to an evaporitic sequence. Furthermore, Duronio *et al.* (1991) reported a regional unconformity at the Danian level in wells drilled in offshore Cyrenaica.

CONCLUSIONS

1. A Danian age is assigned to the flysch-type assemblage in the A1-41 well based on the presence of *Rzehakina fissistomata*, in association with *Planorotalites compressa* and *Subbotina pseudobulloides*.
2. Lower to upper bathyal depths in an oxygen-deficient deep sea environment is suggested by:
 - a. Low species diversity, but moderately diverse genera.
 - b. Abundance and dominance of smooth-walled ammodiscids, rzehakinids and rhizamminids.
 - c. Larger morphogroup replaced by pyrite with the presence of large amounts of pyrite aggregation.
3. The assemblage is closely comparable to the "flysch-type" agglutinated foraminiferal assemblages described by Kaminski *et al.* (1988) from Trinidad.

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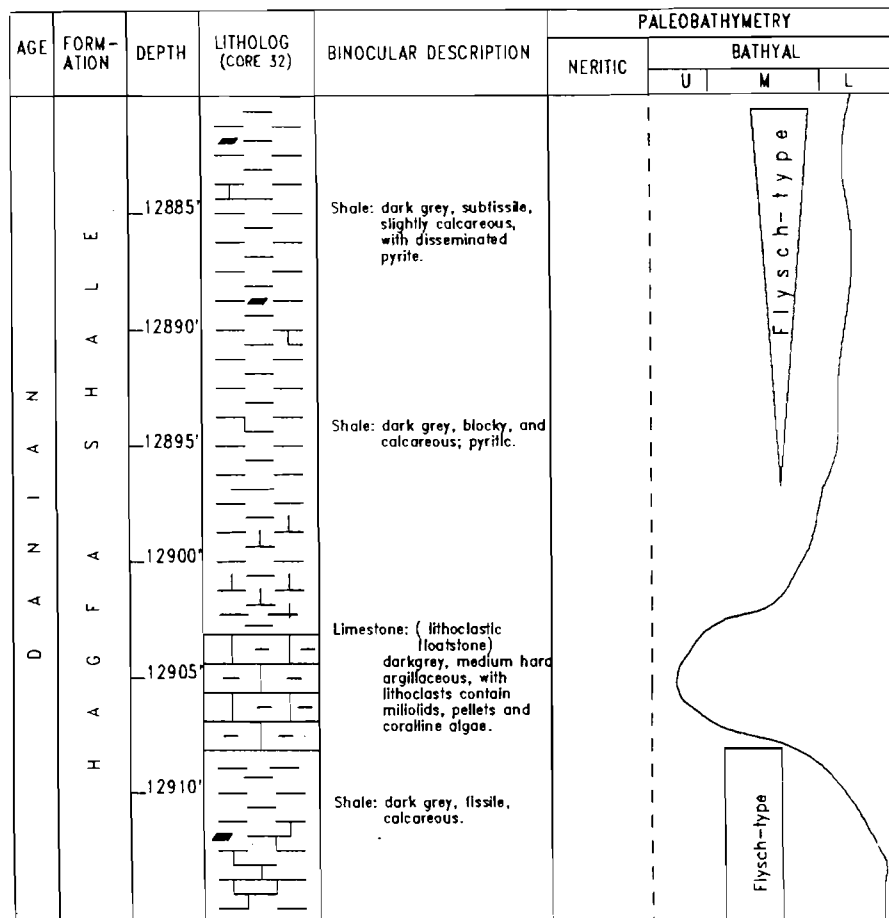


Figure 3. Lithology and interpreted paleobathymetry in the cored interval of the Hagfa Shale Formation (Danian) in well A1-41, northeastern Sirte Basin.

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TAXONOMIC NOTES

All agglutinated foraminiferal species recovered from the A1-41 well are listed herein. For generic classification Loeblich & Tappan (1987) has been followed. Taxonomic remarks are provided for selected species. All the specimens used in this study are housed in the Geological Laboratory Micropaleontological Collection of the Arabian Gulf Oil Company, Benghazi.

Superfamily: ASTRORHIZACEA Brady, 1881

Bathysiphon sp.
Pl. 1, Fig. 1

Remarks: straight broken tube and smooth wall. Rare.

Rhizammina indivisa Brady
Pl. 1, Fig. 2

Remarks: Unbranched curved tubes, finely finished. The morphotype resembling Brady's forms with planktic forams are not reported. Abundant.

Rhizammina sp.
Pl. 1, Fig. 3

Remarks: More flattened. Present in low numbers.

Saccamina placenta (Grzybowski)
Pl. 1, Fig. 4

Remarks: Common.

Superfamily: HIPPOCREPINACEA Rumbler, 1895

Hyperammina sp.
Pl. 1, Fig. 5

Remarks: Rare.

Superfamily: AMMODISCACEA Reuss, 1862

Ammodiscus cretaceus (Reuss)
Pl. 1, Fig. 6

Remarks: The undeformed forms are usually discoidal and circular in outline but the deformed elliptical, elongate forms with compressed whorls may belong to *Ammodiscus peruvianus* Berry as illustrated by Kaminski *et al.* (1988, p. 185, pl. 3, figs. 11, 12). Abundant.

Glomospira charoides (Jones & Parker)
Pl. 1, Fig. 7; Pl. 3, Fig. 1

Remarks: The variation shown in the illustrated specimens (pl. 3) is considered to be ontogenetic. Others,

eg. de Klasz & de Klasz (1990, pl. 2, fig. 8), have assigned the larger form with more whorls and irregular coiling (pl. 3, fig. 1b) to another species *Glomospira corona* Cushman & Jarvis as illustrated by de Klasz & de Klasz (1990, pl. 2, fig. 8). Common.

Glomospira gordialis (Jones & Parker)
Pl. 1, Fig. 8

Remarks: Common.

Glomospirella grzybowskii (Jurkiewicz)
Pl. 1, Fig. 9

Remarks: Rare.

Superfamily: RZEHAKINACEA Cushman, 1933

Rzehakina epigona (Rzehak)
Pl. 1, Fig. 10; Pl. 3, Fig. 2

Remarks: There are two different ontogenetic stages of the same species, the larger stage (length: 0.8 mm, width: 0.6 mm) was assigned to *Rzehakina epigona* var. *lata* by Cushman & Jarvis (1928, pl. 13, fig. 11). Common.

Rzehakina fissistomata (Grzybowski)
Pl. 1, Fig. 11; Pl. 3, Fig. 3

Remarks: Only two specimens were recovered in this study.

Superfamily: HORMOSINACEA Haeckel, 1894

Reophax duplex Grzybowski
Pl. 2, Fig. 1

Remarks: Common.

Hormosina trinitatensis Cushman & Renz
Pl. 2, Fig. 2

Remarks: Several authors use *Reophax pilulifer* Brady, for this species. But here it is placed under *Hormosina* based on Hofker's (1972) definition of *Hormosina* possessing a multilayer wall. Common.

Hormosina velascoensis (Cushman)
Pl. 2, Fig. 3

Remarks: Only one specimen was recovered in the present study.

Superfamily: LITUOLACEA de Blainville, 1827

Paratrochamminoides sp.
Pl. 2, Fig. 4

Remarks: Rare.

Trochamminoides dubius (Grzybowski)
Pl. 2, Fig. 5

Trochamminoides subcoronatus (Grzybowski)
Pl. 2, Fig. 6

Remarks: Both species present in low numbers.

Superfamily: HAPLOPHRAGMIACEA Eimer & Fickert, 1899

Recurvoides sp.
Pl. 2, Figs. 7 and 8

Remarks: Present in low numbers.

Superfamily: TROCHAMMINACEA Schwager, 1877

Trochammina sp.
Pl. 2, Fig. 9

Remarks: Rare.

Superfamily: TEXTULARIACEA Ehrenberg, 1838

Dorothia cf. *D. trochoides* (Marsson)
Pl. 2, Fig. 10

Remarks: Present in low numbers.

Clavulinoides aspera (Cushman)
Pl. 2, Fig. 11

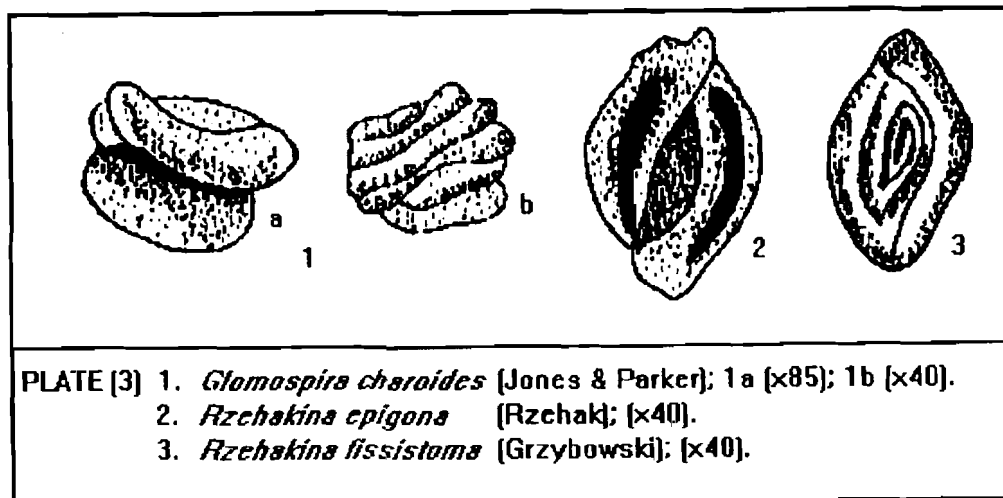
Clavulinoides globulifera (Ten Dam & Sigal)
Pl. 2, Fig. 12

Remarks: The above mentioned *Clavulinoides* do not possess an internal tooth plate, which excludes them from the genus *Tritaxia*. Specimens have been sectioned to examine the internal structure, they displayed neither canaliculi nor pseudopores, but were solid. If pores were present they were possibly destroyed by pyritization. Therefore they have been excluded from *Pseudoclavulina*. Abundant.

REFERENCES

- Barr, F.T. & Weegar, A.A. 1972. *Stratigraphic Nomenclature of Sirte Basin, Libya*. Petroleum Exploration Society of Libya, Tripoli, 179 p.
- Beckmann, J.P., Bolli, H.M., Kleboth, P. & Proto-Decima, F. 1982. Micropaleontology and biostratigraphy of the Campanian to Paleocene of the Monte Giglio, Bergamo Province, Italy. *Memorie di Scienze Geologiche, Padova*, 35, 91-172.
- Berggren, W.A. 1974. Paleocene benthic foraminiferal biostratigraphy, biogeography and paleoecology of Libya and Mali. *Micropaleontology*, 20, (4), 449-465.
- Bolli, H.M. 1957. The genera *Globigerina* and *Globorotalia* in the Paleocene - Lower Eocene Lizard Springs Formation of Trinidad, B.W.I. *U.S. National Museum Bulletin*, 215, 61-82.
- Bolli, H.M. 1966. Zonation of Cretaceous to Pliocene marine sediments based on planktonic foraminifera. *Bol. Inform. Asoc. Venez. Geol. Minería. Petroleo*, 9, 3-32.
- Brasier, M.D. 1981. Architecture and evolution of the foraminiferid test. A theoretical approach. In: F.T. Banner & A.R. Lord (eds). *Aspects of Micropaleontology*. George Allen & Unwin. London, 1-41.
- Chamney, T.P. 1976. Foraminiferal morphogroup symbol for paleoenvironmental interpretation of drill cutting samples: Arctic America, Albian continental margin. *Maritime Sediments, Special Publication*, 1B, 585-624.

- Cushman, J.A. & Jarvis, P.W. 1928. Cretaceous foraminifera from Trinidad. *Contributions from the Cushman Laboratory for Foraminiferal Research*, 4, 85-103.
- Conant, L.C. & Goudarzi, G.H. 1967. Stratigraphic and tectonic framework of Libya. *American Association of Petroleum Geologists Bulletin*, 51, (5), 719-730.
- Duronio, P., Dakshe, A. & Bellini, E. 1991. Stratigraphy of the offshore Cyrenaica (Libya). In: M.J. Salem, O.S. Hammuda & B.A. Eliagoubi. (eds.) *The Geology of Libya*. Fac. Sci., Univ. Al-Fateh, (Tripoli 1987), IV, 1589-1620.
- Geroch, S. & Nowak, W. 1984. Proposal of zonation for the Late Tithonian-Eocene, based upon the arenaceous foraminifera from the outer Carpathians, Poland. In: Oertli, H., (Ed.) *Benthos '83; 2nd International Symposium on Benthic Foraminifera Pau (France), April 11-15, 1983*. Elf Aquitaine, ESSO REP and TOTAL CFP, Pau & Bourdeaux, pp. 225-239.
- Gradstein, F.M. & Berggren, W.A. 1981. Flysch-type agglutinated foraminifera and the Maastrichtian to Paleogene history of the Labrador and North Seas. *Marine Micropaleontology*, 6, 211-268.
- Grzybowski, J. 1898. Otwornice pokładów naftonośnych okolicy Krosna. *Rozprawy Akademii Umiejętności w Krakowie, Wydział Matematyczno-Przyrodniczy, Kraków, ser. 2, 33, 257-305*.
- Gumati, Y.D. & Kanes, W.H. 1985. Early Tertiary subsidence and sedimentary facies - northern Sirte Basin, Libya. *American Association of Petroleum Geologists Bulletin*, 69, 39-52.
- Hofker, J., sen. 1972. *Primitive agglutinated foraminifera*. E.J. Brill, Leiden, Netherlands, 95 pp.
- Kaminski, M.A., Gradstein, F.M., Berggren, W.A., Geroch, S. & Beckmann, J.P. 1988. Flysch-type agglutinated foraminiferal assemblages from Trinidad: taxonomy, stratigraphy and paleobathymetry. *Abhandlungen der Geologischen Bundesanstalt*, 41, 155-227.
- Klasz, I. de & Klasz, S. de. 1990. Danian deep water (bathyal) agglutinated foraminifera from Bavaria and their comparison with approximately coeval agglutinated assemblages from Senegal and Trinidad. In: Hemleben, C., Kaminski, M.A., Kuhnt, W. & Scott, D.B. (eds). *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera*. NATO ASI Series C.327, Kluwer Academic publishers, 387-431.
- Kuhnt, W. 1988. Upper Cretaceous foraminiferal assemblages of the external units of the Rif (Northern Morocco); a paleobathymetric model of the Late Mesozoic North African continental margin. X Coll. Afr. Micropaleontol., Rabat 1987, B. Le Mesozoïque. *Geologie Méditerranéenne*, 14, (2), 109-131.
- Kuhnt, W. & Kaminski, M.A. 1990. Paleoecology of Late Cretaceous to Paleocene deep-water Agglutinated Foraminifera from the North Atlantic and Western Tethys. In: Hemleben, C., Kaminski, M.A., Kuhnt, W. & Scott, D.B. (eds). *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera*. NATO ASI Series C.327, Kluwer Academic publishers, 433-505.
- Loeblich, A.R. Jr. & Tappan, H. 1987. *Foraminiferal genera and their classification*. Van Nostrand Reinhold company, New York, 1-970.



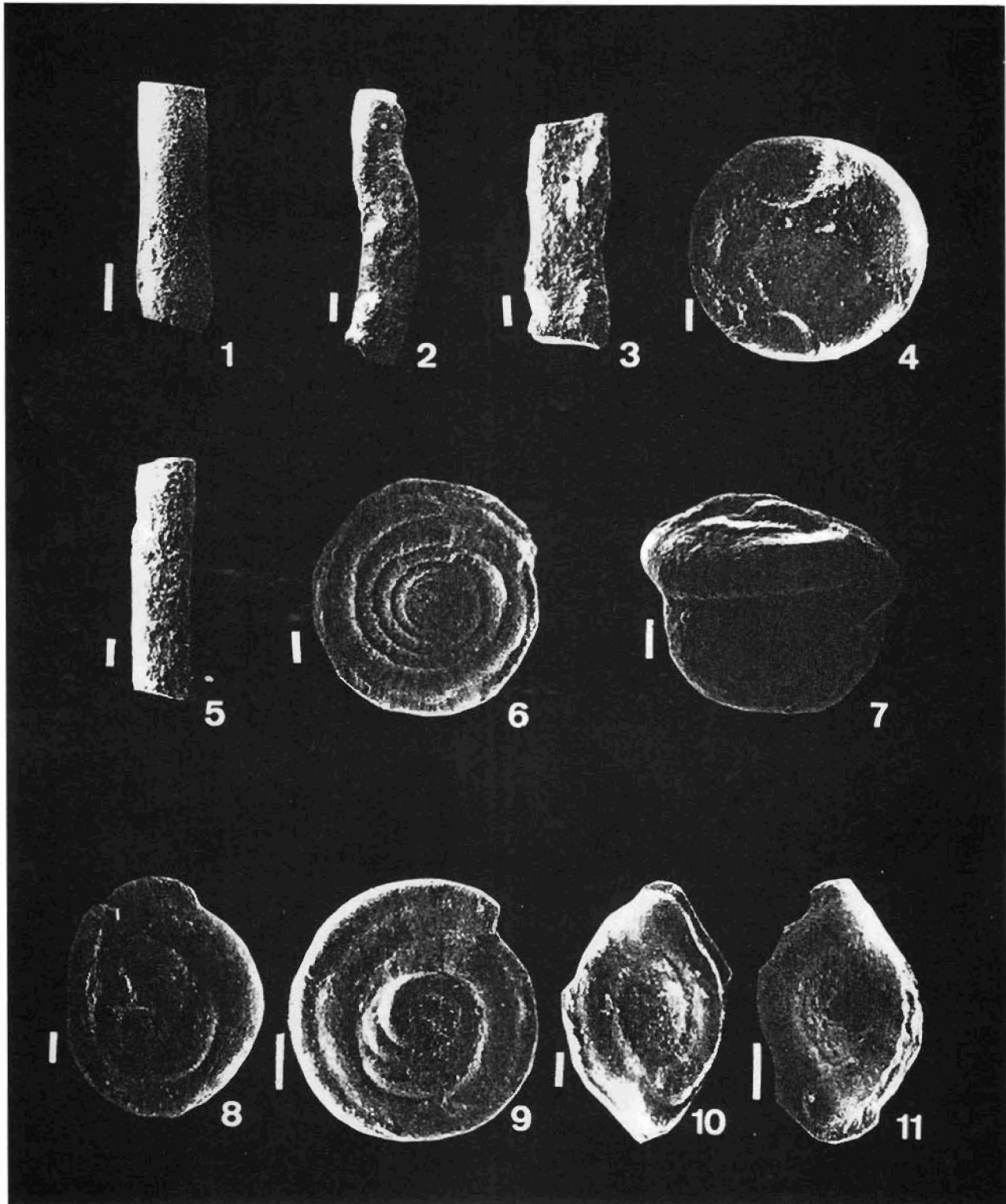


PLATE 1. (scale bar). 1. *Bathysiphon* sp. (200 μ m); 2. *Rhizammina indivisa* Brady (200 μ m); 3. *Rhizammina* sp. (200 μ m); 4. *Saccammina placenta* (Grzybowski) (100 μ m); 5. *Hyperammina* sp. (200 μ m); 6. *Ammodiscus cretaceus* (Reuss), (100 μ m); 7. *Glomospira charoides* (Jones & Parker) (50 μ m); 8. *Glomospira gordialis* (Jones & Parker) (50 μ m); 9. *Glomospirella grzybowskii* (Jurkiewicz) (100 μ m); 10. *Rzehakina epigona* (Rzehak) (100 μ m); 11. *Rzehakina fissistomata* (Grzybowski) (200 μ m).

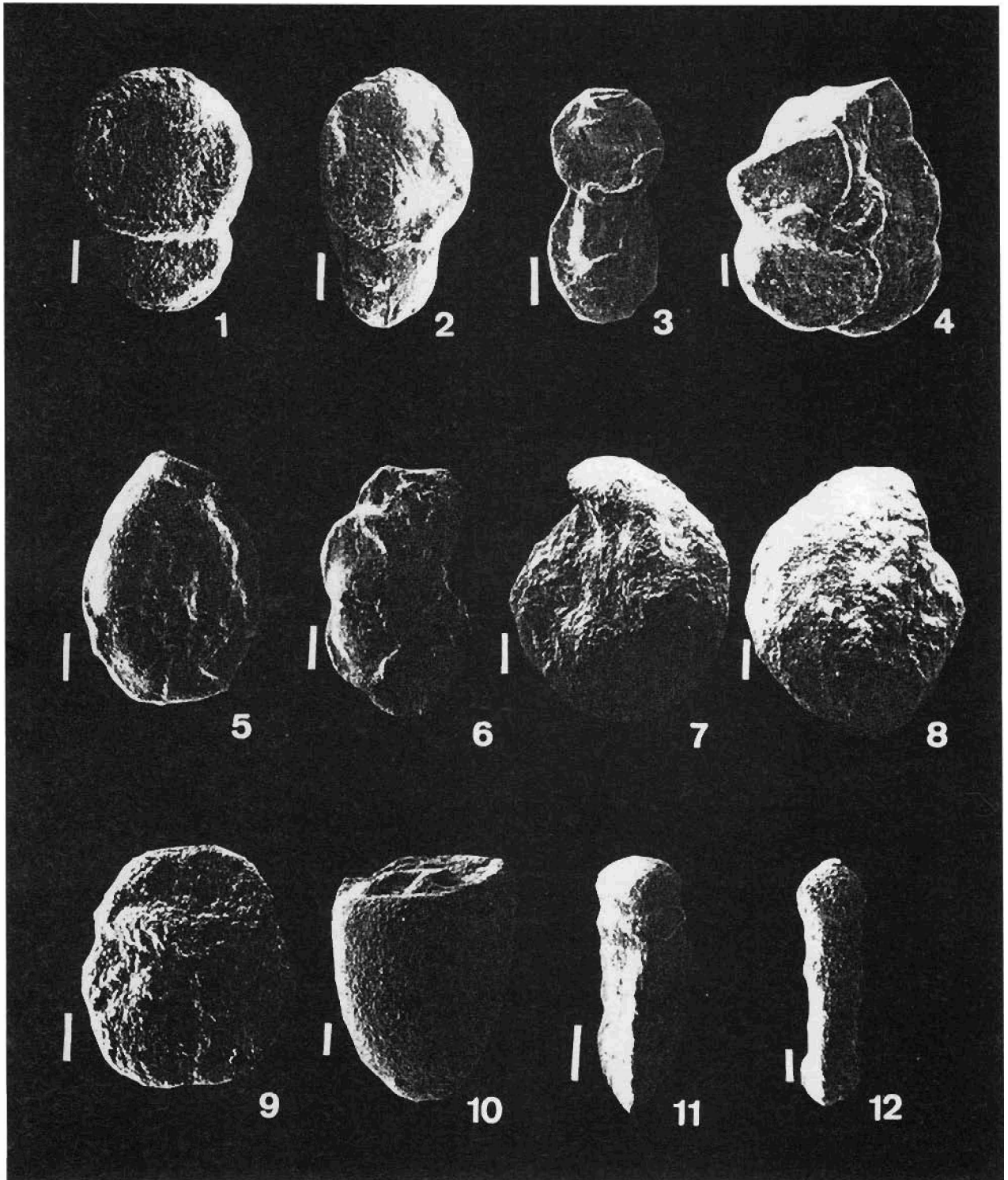


PLATE 2. (scale bar). 1. *Reophax duplex* Grzybowski (200 μm); 2. *Hormosina trinitatensis* Cushman & Renz (200 μm); 3. *Hormosina velascoensis* (Cushman) (200 μm); 4. *Paratrochamminoides* sp. (100 μm); 5. *Trochamminoides dubius* (Grzybowski) (200 μm); 6. *Trochamminoides subcoronatus* (Grzybowski) (200 μm); 7,8. *Recurvoides* sp. (100 μm); 9. *Trochammina* sp. (100 μm); 10. *Dorothia* cf. *D. trochoides* (Marsson) (50 μm); 11. *Clavulinoides aspera* (Cushman) (500 μm); 12. *Clavulinoides globulifera* (Ten Dam & Sigal) (200 μm).