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The Benthonic Foraminifera across the Cretaceous-Tertiary boundary in the Zin Valley, Negev, Israel.

Thesis submitted for the Degree of the

Master of Science in Micropalaeontology

in The University of Hull

by

Alexander John Chepstow-Lusty. B.Sc. (Joint Hons.)

Department of Geology, September 1986.

ABSTRACT

Closely spaced samples from two sections of the marly Taqiye Formation in the Zin Valley (southern Israel), Ein Mor (EM) and Hor HaHar (HH) containing the Cretaceous-Tertiary (K/T) boundary, have been analysed for benthonic foraminifera within the framework of nannofossil and planktonic foraminiferal zones.

In Israel there exists section below the defined K/T boundary, containing the 'Danian' planktonic foraminifer '*Globigerina*'. *eugubina*, not known from other sections, and a Midway-type fauna was found to be present above and below the boundary.

After the boundary, a Velasco-type element occurs, which may indicate a slight increase in depth towards the outer shelf range.

Some Maastrichtian benthonic forms were found to survive into the Danian, which is a special feature of this region. The Midwayan fauna has many similarities with assemblages from Egypt, sharing some species only known from Egypt.

HH was thought to be the locus of continuous or nearly continuous deposition, while the EM section may have had a slight hiatus. The environment was probably partially isolated from the open Tethys by a series of mild submarine elevations.

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To my parents

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1. INTRODUCTION

The Hor HaHar (HH) section in the Zin Valley (southern Israel) appears to represent an example of more or less continuous deposition across the K/T boundary (Magaritz et al., 1985). This is based on the gradual $\delta^{13}C$ decrease found in the $CaCO_3$ (mostly as nannoplankton), together with evidence from biostratigraphy such as the first appearance of the planktonic foraminifer 'Globigerina' eugubina, appearing in samples containing otherwise entirely Cretaceous foraminiferal and nanno-species, some 1.20 m below the level of extinction of most Cretaceous planktonic foraminiferal taxa. Further evidence for a transitional biostratigraphic sequence across the K/T boundary at HH comes from magnetostratigraphy. This gradual depletion in $\delta^{13}C$ at the base of the Tertiary is a unique occurrence.

However at the Ein Mor (EM) section, there is a steeper decrease in $\delta^{13}C$ than at HH which is similar to other K/T sequences in the western Tethyan region, and strongly suggests that the EM section may have had a slight hiatus.

Preservation in the benthonic foraminifera below the K/T boundary at EM is much better than HH, where it is particularly poor at HH21. However preservation on the whole is fairly good and most samples are rich in benthonic foraminifera. Ostracods appear relatively common and well preserved in most samples, but these were not investigated.

The marls appear very homogenous and contain abundant pyrite which suggests that a few cms below the seawater/sediment interface, the environmental conditions would have been depleted in oxygen and toxic to most benthic macrofauna. This is supported by only a few bivalve fragments and possible sponge spicules, but no gastropods, being found in total throughout the two sections. Such near anoxic conditions are supported by the presence of the Chondrites burrow system in the absence of other trace fossils (Bromley and Ekdale, 1984).

2. APPROACH TO INVESTIGATION

Prepared samples of the Ein Mor (EM) and Hor HaHar (HH) sections were obtained from Dr. Chaim Benjamini (Ben Gurion University, Beersheva, Israel) and Dr. Hans-Jorgen Hansen (University of Copenhagen, Denmark) who had co-operated with Magaritz et al. (1985) to investigate the carbon isotope, magnetostratigraphy and biostratigraphy (planktonic foraminifera and nannofossil) across the K/T boundary. This provided a biostratigraphic framework within which to analyse the benthonic foraminifera which would give further information about palaeoecology, bathymetry and possible position of the K/T boundary.

Closely spaced samples (32 in total) were selected from the 2 sections, using mostly Benjamini's while Hansen's contributed additional information, though samples were collected at the same sites at the same time.

The original samples were treated by washing with sodium hexametaphosphate, sodium carbonate and hydrogen peroxide through a 63 μm sieve to eliminate the clay fraction, and then dried. Samples were divided using a splitter a number of times to obtain small unbiased fractions which were totally picked for approximately 200 - 400 benthic foraminiferal specimens. Most samples were very rich in benthic foraminifera, though HH21 was particularly poor.

Prepared samples from 3 other sections in southern Israel possibly crossing the K/T boundary were analysed and picked:- Zomet Ha Negev (ZHN), between Beersheva and Sde Boker in the Negev Desert; a ditch cutting in the Paran Valley; Har Saggi (HS), south of Mizpe Ramon and towards the Egyptian border. These had been prepared in the same way as EM and HH.

In northern Israel at Har Gilboa, north of Beit Shean, Benjamini, Moshkovitz and Chepstow-Lusty (April, 1986) logged and collected samples from 2 sections (BN and NBK) possibly crossing the K/T boundary. The 2 sections, unlike the other sections examined, were of mixed lithofacies, consisting of indurated limestones with marls to a lesser extent. Chepstow-Lusty used the same chemical preparation technique as mentioned, but the limestones were broken down into fragments, approximately 1 cm in diameter, and the method involved sessions of boiling, followed by washing to obtain sufficient residue.

However none of these other sections had been investigated properly to produce a biostratigraphic framework to work within.

Benthonic foraminifera were identified utilizing the following sources:- Cushman (1951), LeRoy (1953), Reiss (1954), Said and Kenawy (1956), Hofker (1957), Olsson (1960), Berggren (1974a), Berggren and Aubert (1975) and Pozaryska and Szczechura (1980). The literature was found to be highly confusing, and there was a tendency for the same species from different areas to have different names. This problem was largely overcome by referring to the most recent literature giving lists of synonomies or up to date names:- Berggren and Aubert (1975), Youssefnia (1978), and Kureshy (1984). A decisive philosophy of lumping as opposed to splitting species e.g. *Cibicidoides alleni* was applied because many of the species exhibited a high degree of intraspecific variation.

Only the species from EM and HH were counted, and from the raw data relative abundancies, species diversity and agglutinated/calcareous benthonic foraminiferal ratios were calculated, and represented graphically.

Subsequently key Midway forms and other common species were selected and photographed under scanning electron microscopy.
A total of 60 species were identified.

3. GEOLOGICAL BACKGROUND

Most of the detailed studies of benthonic foraminifera across the K/T boundary in the marine realm have occurred in the Atlantic Ocean, in Western Europe, and North Africa. This investigation is of a region located to the east along the southern margin of the central Tethys, north of the Arabo-Nubian massif.

The Zin Valley is a structurally low region lying to the south of a belt of northeast trending anticlines and extends from the central part of the Negev (southern Israel) eastwards to the Dead Sea Rift (Figs. 1 & 2). Deep shelf pelagic sediments (chalk, marl, chert) were formed in synclinal areas from the Santonian until the Middle Eocene, interrupted late in the Campanian by episodes of shallower and partially restricted facies.

The K/T boundary interval was located by Romein (1979) in the lower part of the Taqiye Formation within a sequence of pyritic marls, grey in colour, consisting of 50 - 80% $CaCO_3$ predominantly as calcareous nannoplankton, but also containing planktonic and benthonic foraminifera (Magaritz et al. 1982). Clay minerals and pyrite compose the remainder of the marl (Arkin et al. 1972). Modern weathering related to the acid conditions had produced Fe oxides and gypsum.

Two sites were analysed in the Zin Valley. The HorHaHar section (HH) is located in the centre of the Zin syncline, approximately 2500 m basinward from the nearest dipping beds. The Ein Mor site (EM), equivalent to the Nahal Avedat section of Romein (1979), is located some 30 Km further to the west, in a region that was affected by minor Late Cretaceous folding and faulting, approximately 500 m from the nearest steeply dipping anticlinal flank.

The studied sections lack a clay concentration at the boundary ('boundary clay').

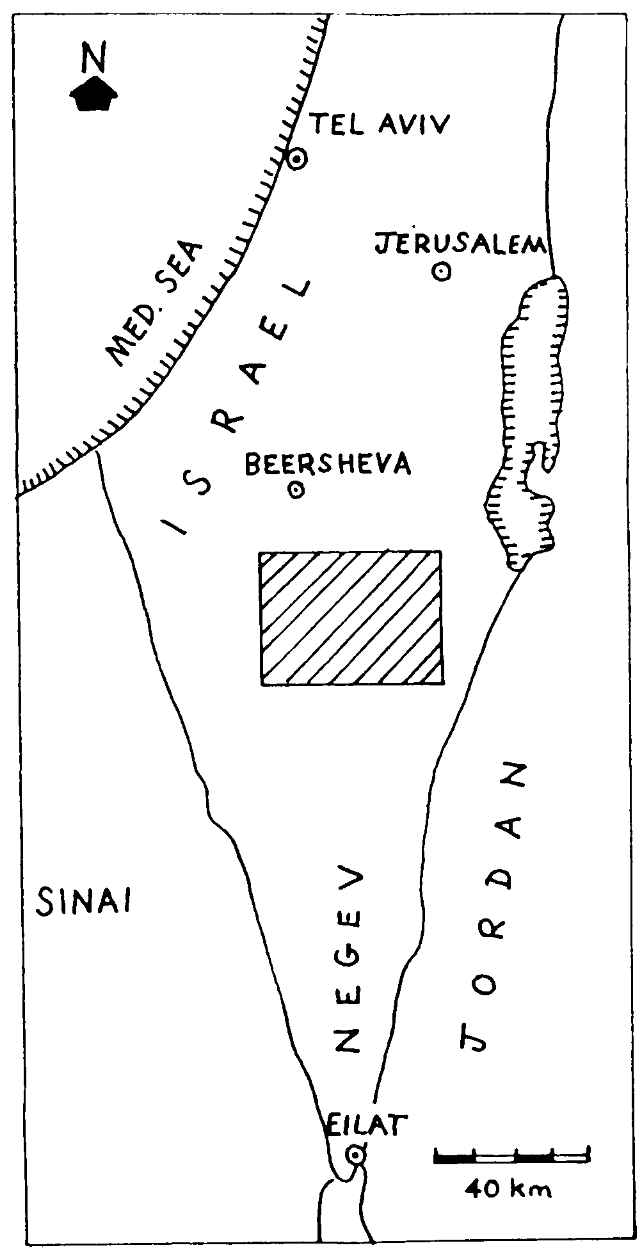


Fig. 1. Location map showing area of the studied sections.

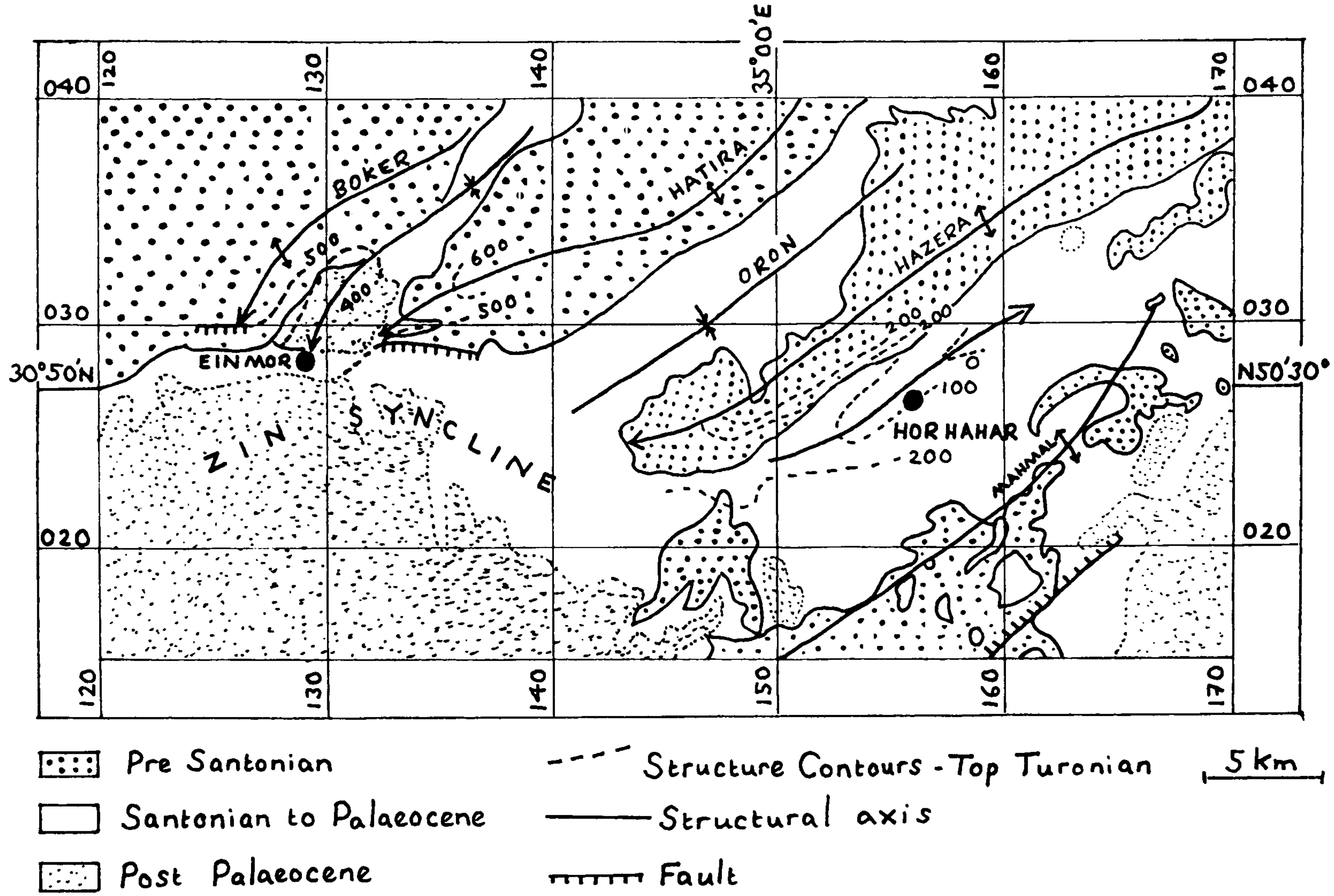


Fig. 2. Geological setting of the sections Ein Mor and Hor Ha Har.

4. NANNOFOSSIL BIOSTRATIGRAPHY:

Calcareous nannofossil zonation at HH and EM was worked out by Magaritz et al. (1985) as shown in Figs. 3 & 4. Most of the calcareous nannofossils are of Late Cretaceous origins throughout the studied intervals. Early Palaeocene species, after their appearance, remain rather scarce. Micula murus (Martini), M. prinsii (Perch-Nielsen) and Lithraphidites quadratus (Bramlette & Martini), found at the base of the EM and HH sections, indicate the presence of the latest Maastrichtian M. prinsii zone (Perch-Nielsen et al. (1982). These species are accompanied by a diverse assemblage including Micula decussata (Vekshina), Arkhangelskiella cymbiformis (Vek.), Cribrosphaerella ehrenbergi (Arkhangelsky), Prediscosphaera cretacea (Arkh.), Eiffellithus turriseiffeli (Deflandre), Watznaueria barnesae (Black), numerous fragments of Thoracosphaera spp, and others.

Markalius inversus (Deflandre), Biantholithus sparsus (Bramlette & Martini), and small coccoliths of the Cyclagelosphaera ?alta gp (Perch-Nielsen) occur for the first time between samples HH24 and HH25. Since these forms all mark the basal Danian B.sparsus zone (Perch-Nielsen , 1971), and as their occurrence coincides with the extinction of most Cretaceous planktonic foraminifera, this is thought to mark the level of the K/T boundary.

Above this level, Biscutum cf. romeini (Perch-Nielsen) and B. cf. parvulum (Romein) occur together and hence it is not possible to distinguish the subzonation of the B. sparsus zone by means of these coccoliths (Perch-Nielsen 1981). In samples HH26 to HH28, B. sparsus and C. ?alta gr. become more common, though the bulk of the nannofossils are the same as below the K/T boundary. Braarudosphaera is completely absent in the study sections. This is significant because this group is known to be a marine hypohaline indicator (Gran & Braarud, 1935, Bukry, 1974) and is abundant at or near the K/T boundary at Gredero, Zumaya, Gubbio, and El Kef (Percival & Fischer, 1977, Perch-Nielsen 1981).

Small specimens of Cruciplacolithus primus (Perch-Nielsen), the zonal marker of the next higher Danian zone (Romein 1979, Perch.-Nielsen et al. 1982) appear at sample HH41. However benthonic foraminifera were only investigated as high as sample HH40.

5. PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY

Planktonic foraminiferal zonations of HH and EM were worked out by Magaritz et al. (1985) as shown in Figs. 3 & 4. The latest Maastrichtian index forms Abathomphalus mayaroensis (Bolli), Plummerita and Trinitella were recovered from just below the level of apparent extinction of Globotruncana, Rugoglobigerina, Globigerelloides, and large Heterohelicidae at HH25. Since this level coincides with the first appearance of B. sparsus, the first Danian nannospecies, the K/T boundary is placed there.

'Globigerina' eugubina (Luterbacher & Premoli-Silva) first appears unequivocally at sample HH16, together with the typical latest Maastrichtian foraminiferal assemblage and well below the B. sparsus appearance. However other foraminiferal or nannospecies characteristic of the Danian are absent until HH25. It therefore is considered to occur in the Cretaceous.

New Danian forms appearing above the extinction level (from HH25) include Chiloguembelina, appearing after a short interval lacking in biserial planktonics; Eoglobigerina, first E. danica (Bang), followed by a more diverse Eoglobigerina fauna; and finally Subbotina pseudodobulloides (Plummer). Some Hedbergella-like forms carry on upwards in the Danian. Guembelitria continues upwards above the pseudobulloides datum, and 'Globigerina' eugubina appears to become extinct at that level.

Zone 'Po' of the zonation scheme of Smit (1982), the Guembelitria cretacea Zone, is not distinguished at HH or EM, as it is defined as a Danian zone predating the 'G.' eugubina datum, while 'G.' eugubina already appears at HH and EM in the Cretaceous. Zone 'P1a', dominated by 'Globigerina' eugubina but containing also eoglobigerinids, is the interval at HH and EM above the Cretaceous extinctions and below the S. pseudobulloides appearance. This would then include the time interval represented by zone 'Po' as originally defined. Beneath it is an interval above the extinction level with 'G.' eugubina but prior to Chiloguembelina appearance. This interval is not 'Po', which is either absent (or possibly missed in sampling) at EM.

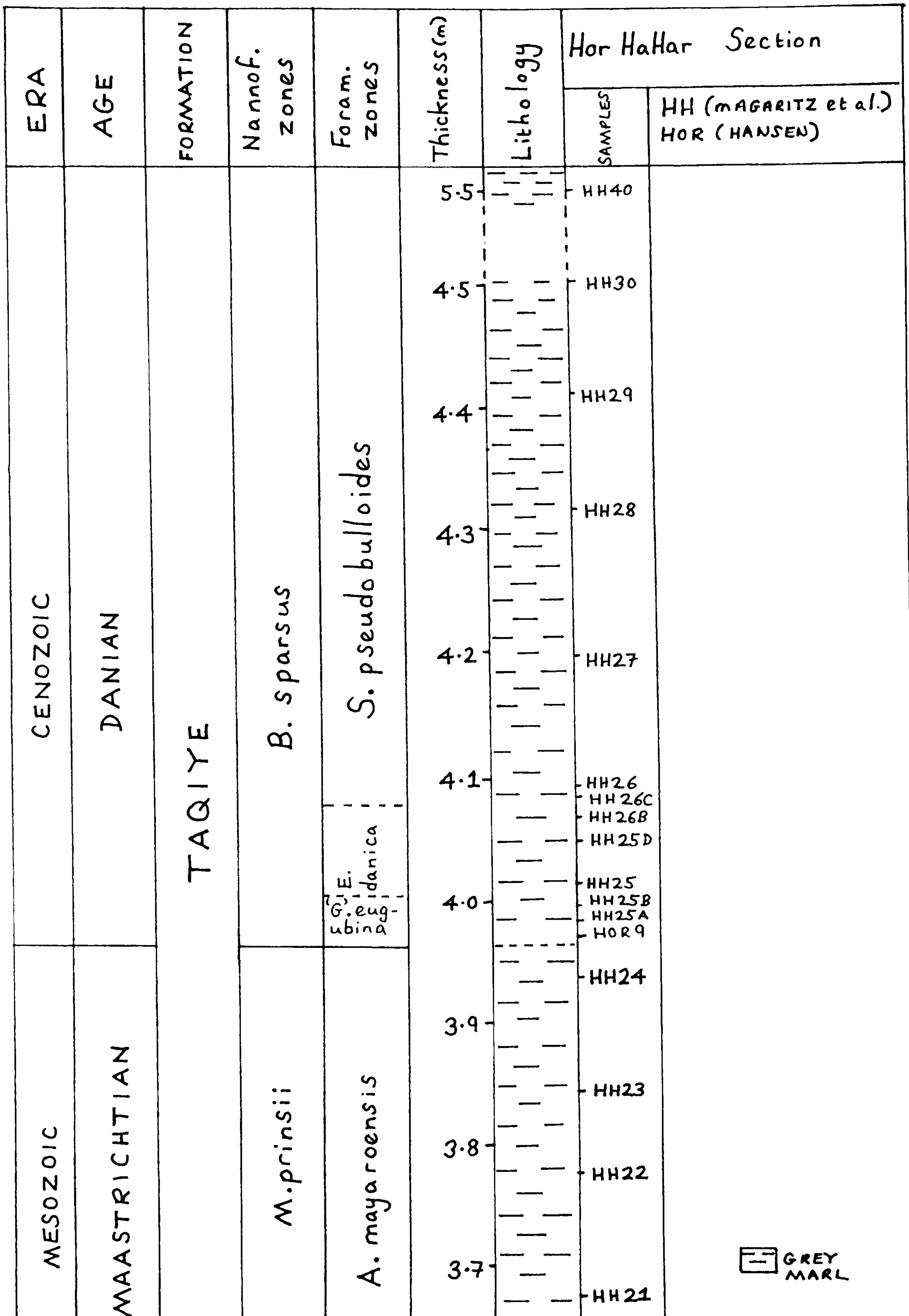


Fig.3. Hor HaHar section showing biozonation and sample numbers (after Magaritz et al., 1985)

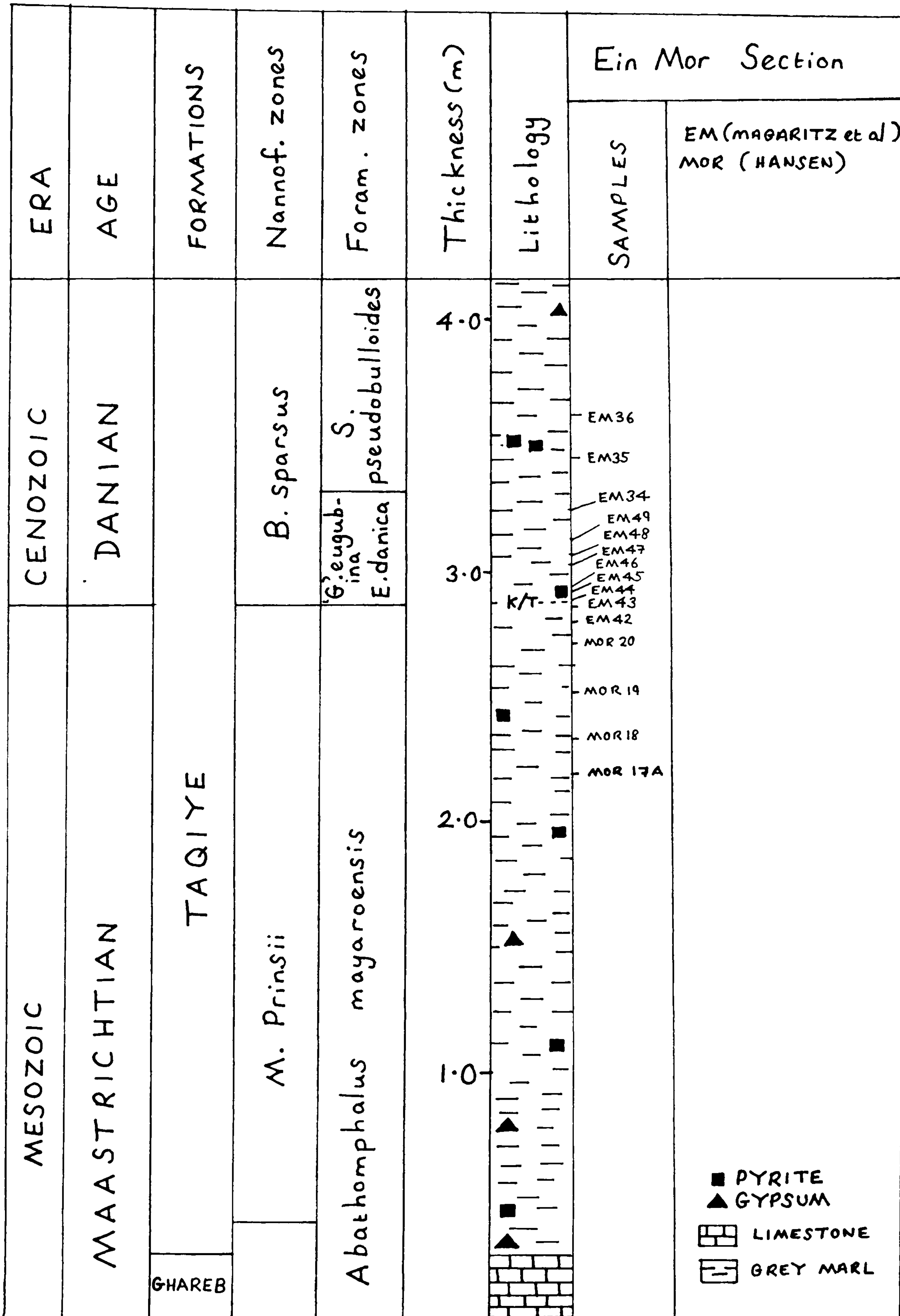


Fig. 4. Ein Mor section showing biozonation and sample numbers (after Magaritz et al., 1985)

6. PREVIOUS WORK IN NORTH AFRICA AND THE MIDDLE EAST

Prior to 1950 only two investigations of any significance had been made on the smaller foraminifera of the Lower Tertiary of Egypt, that of Schwager (1883) dealing with Eocene outcrops at Guss Abu Said and that of Nakkady (1950) investigating the Esna Shale and Upper Cretaceous chalk of Egypt.

Midway-type faunal elements were recorded from Algeria by Ten Dam and Sigal (1950) and Drooger (1952), but the first comprehensive treatment of Palaeocene faunas of North Africa was by LeRoy (1953) who described the stratigraphy and foraminifera of the Maqfi section, Egypt (Upper Cretaceous to Lower Tertiary). This exhibits a close relationship with the faunas in the Palaeocene of the Gulf Coastal Plain, as well as the Palaeocene of northern Europe. The fauna, in general, also shows a strong similarity with Middle and Upper Palaeocene faunas of Libya, many of the species being common to the two areas (Berggren, 1969).

Rey (1954) points out the strong similarity between Palaeogene benthonic foraminiferal faunas of Morocco and the Gulf Coast and Caribbean regions. Morocco includes both a deep water (Velasco-type) assemblage and shallow-water (Midway-type) assemblage.

Similar Midway-type assemblages were recorded from Algeria, Tunisia, Lebanon and Syria (Cuvillier et al., 1955). Said and Kenawy (1956) described the foraminifera from the Upper Cretaceous and Lower Tertiary strata of the northern part of the Sinai Peninsula, Egypt. The benthonic foraminiferal fauna of the Lower Tertiary part of the section shows an affinity with Midway faunas of the Gulf Coastal Plains.

Berggren and Aubert (1975) have investigated Tunisian Palaeocene benthonic foraminiferal faunas, which are typically Midwayan in composition. They are similar to those recorded by Berggren (1969) from the Sirte Basin of Libya (Berggren, 1969, 1974b).

Several Midway-type forms have been recorded from Saudi Arabia by El Khayal (1969) in association with a Tethyan carbonate fauna, which is a shallow water, inner to middle shelf assemblage ($<$ 30 - 50 m).

Finally, in Israel, very little work has been done on the benthonic foraminifera across the K/T boundary. Reiss (1954) made a study of Upper Cretaceous and Lower Tertiary Bolivinoides, but no comprehensive investigation has been made. Reiss and Hamaoui (unpublished report, 1963) produced a very limited range chart of benthonic foraminifera of the Taqiye Formation, but the short report concentrated completely on plankton stratigraphy.

7. MIDWAY-TYPE FAUNAL ASSEMBLAGE

This assemblage is termed, for convenience, the "Midway-type" faunal assemblage (MF) because it has been described and illustrated repeatedly in the rocks of the Midway Group of the Gulf Coastal Plain and equivalent rocks in the Atlantic Coastal Plain and circum-Caribbean and Antillean region.

It is thought to represent a middle to outer shelf assemblage (50 - 200 m water depth) developed in a shale-marl environment characterized by species of e.g. *Cibicidoides alleni* (Plummer), *Anomalinoides acuta* (Plummer), *A. midwayensis* (Plummer), *Gavelinella danica* (Brotzen) and *Osangularia plummerae* (Brotzen), as well as various lagenids, polymorphinids and textulariids.

The study of Palaeocene benthonic foraminifera of the western North Atlantic region began with Plummer (1927), who examined and described foraminifera from the Midway Group of Texas. This work was subsequently expanded by Kellough (1959, 1965), who presented a detailed, quantitative picture of the composition of the foraminiferal faunal components of the Midway assemblages. Palaeocene foraminiferal faunas had, meanwhile, been synthesized by Cushman (1951) for the two and a half decades following the appearance of Plummer's investigations.

Elements of this faunal assemblage have been recorded from geographically diverse areas of the world indicating that these benthic forms displayed widespread geographic dispersal : North America, South America, North Atlantic, Europe, Africa, Middle East, Soviet Union, Pakistan and Oceania.

Therefore the characteristics of the Midway benthonic foraminiferal fauna are a rich, taxonomically diverse assemblage, associated primarily with clastic deposition (shales, silty shales, marls and sandy limestones), characterized by a distinct assemblage of species.

However almost all these studies are limited to the description and illustration of different species from certain localities. Studies of the geographic distributions of Palaeocene species are rare, and consequently, many of the same Palaeocene species, in different geographic areas have been given different names by different workers. A few papers like Kellough (1965), Berggren (1974a,b), Berggren and Aubert (1975), Youssefnia (1978), and Kureshy (1984) deal with limited aspects of the bathymetry or distribution of these organisms.

It would appear that Israel possesses a related "Midway-type" faunal assemblage, but certain elements are of the "Velasco-type" fauna.

8. VELASCO-TYPE FAUNAL ASSEMBLAGE.

This assemblage is called here, for convenience, the "Velasco-type" faunal assemblage (VF) because it has been described and illustrated in several publications from the Velasco Formation of Mexico.

It is thought to represent a continental slope, continental rise and abyssal plain faunal assemblage (> 200 m water depth) characterized by, amongst others *Angulogavelinella beccariiformis* (White), *Gavelinella rubigonosa* (Cushman), *G. velascoensis*, *Nuttallides truempyi*, *Nuttalinella florealis*, lagenids (including nodosariids and dentalinids), small agglutinated forms (*Dorothia*, *Gaudryina* and *Tritaxia*) and various gyroidinids and buliminids.

Although the majority of these forms were not recovered in Israel, or in any significant numbers, *Angulogavelinella beccariiformis* is one of the 4 most dominant species at EM and HH above the K/T boundary. It may indicate deeper water conditions for what is otherwise a Midway-type faunal assemblage. Reiss et al. (unpublished report, 1963) also notes *Nuttallides truempyi* through his log of the Taquiye

Formation. This could not be verified though a few possible Nuttallides sp. were found.

Fig. 8 shows how insignificant the agglutinated forms feature as a percentage of the total number of benthic foraminifera from each sample, which would otherwise be indicative of much deeper water conditions.

9. SYSTEMATIC DESCRIPTIONS

(Haynes, (1981) classification is used above the generic level).

ORDER FORAMINIFERIDA Eichwald, 1830

Suborder LITUOLIDA

Superfamily LITUOLACEA

Family TEXTULARIIDAE

Genus Spiroplectammina Cushman, 1927

Spiroplectammina henryi LeRoy , 1953 (Plate 1,B).

Spiroplectammina henryi LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 50, pl. 2, figs. 14-15.

DESCRIPTION: Species characterized by a test which is moderately thickened along median portion, initial extremity sharply rounded and coiled, gradually expanding toward apertural end; chambers low, distinct, numerous, noninflated; sutures distinct, raised, wide, strongly arched downwards; periphery acute.

COMMENTS: Occurs sporadically in the Danian appearing earlier at Ein Mor than Hor Hahar; specimens similar to those described by LeRoy (1953); Reiss et al. (unpublished report, 1963) make no mention of this species in Israel.

Superfamily ATAXOPHRAGMIACEA

Family VERNEUILINIDAE

Subfamily VERNEUILININAE Cushman, 1911

Genus Dorothia Plummer, 1931

Dorothia bulletta (Carsey)

Dorothia bulletta (Carsey); Cushman, 1937, Cushman Lab. Foram. Res., Spec. Pub. 7, p. 84, pl. 9, figs. 6-7.

DESCRIPTION: This species has an elongate test, and the chambers are distinct particularly in the biserial stage; wall finely arenaceous, smooth; aperture at base of inner margin of last chamber.

COMMENTS: Very rare, a few specimens were recovered from above the K/T boundary; similar in appearance to those described by LeRoy (1953) from Egypt; noted by Reiss et al. (unpublished report, 1963) from Israel.

Dorothia pupa (Reuss)

Dorothia pupa (Reuss); Cushman, 1937, Cushman Lab. Foram. Res., Spec. Pub. 8, p. 78, pl. 8, figs. 20-24; LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 28, pl. 1, figs. 14-15.

DESCRIPTION: This species is characterized by having a small number of distinct, inflated chambers, arranged biserially, a slightly compressed outline in transverse view and a smooth, fine-textured, arenaceous wall.

COMMENTS: Quite rare, most specimens were recovered from above the K/T boundary; similar to forms described by LeRoy (1953) and Said and Kenawy (1956) from Egypt; no mention is made of it by Reiss et al. (unpublished report, 1963) from Israel.

Genus *Gaudryina* d'Orbigny, 1839

Gaudryina pyramidata Cushman ,1930 (Plate 1,A).

Gaudryina (*Pseudogaudryina*) *pyramidata* Cushman, 1930, Cushman Lab. Foram. Res., Spec. Pub. 7, p. 87, pl. 12, fig. 13.

DESCRIPTION: This species is characterized by a test somewhat longer than broad and triangular in transverse section; wall rather coarsely arenaceous, but usually with a smooth surface.

COMMENTS: Occurs sporadically above and below the K/T boundary; mentioned by LeRoy (1953) and Said and Kenawy (1956) from Egypt; a species noted as *Pseudogaudryina pyramidata* (Cushman) by Reiss et al. (unpublished report, 1963) is presumably the same species as above.

Genus Marssonella Cushman, 1933

Marssonella oxyconus (Reuss), 1863

Gaudryina oxycona Reuss, Akad. Wiss. Wien. Math-naturwiss. Kl., Sitzungsber., vol. 40, p. 229, pl. 12, fig. 3, 1860; idem, vol. 46, pt. 1, p. 33, 1862 (1863).

Marssonella oxycona Cushman, Cushman Lab. Foram. Research Contr., vol. 9, p. 36, pl. 4, fig. 13, 1933.

DESCRIPTION: This species is distinguished by a conical test, moderately flaring, round in transverse section; chambers distinct, noninflated, last 2 chambers making up about a fourth of the test; wall rather arenaceous; aperture a low opening at inner margin of last formed chamber; high degree of variability in shape.

COMMENTS: Specimens similar to those described by LeRoy (1953) from Egypt; appears to be commoner above the K/T boundary, though it does seem to occur below the boundary; occurs inconsistently; not noted by Reiss et al. (unpublished report, 1963) in Israel.

Genus Tritaxia Reuss, 1860

Tritaxia midwayensis (Cushman), 1936

Clavulina angularis Plummer, 1927, Texas Univ. Bull., no. 2644 : 70, pl. 3, figs. 4,5 (Midway Formation, Texas).

Clavulinoides midwayensis, Cushman; Cushman, 1936, Cushman Lab. Foram. Res., Spec. Publ., 6: 21, pl. 3, figs. 9,15; Cushman, 1951, U.S. Geol. Surv. Prof. Pap., 206 : 8, pl. 2, figs. 10-16.

?Clavulinoides rugulosa, Ten Dam and Sigal, 1950, Contrib. Cushman Found. Foram. Res., 1 (pts. 1 and 2): 32, pl. 2, figs. 8-10 (Dano-Montian of Algeria).

DESCRIPTION: Test in the microspheric form very rapid increase in diameter towards the apertural end, and test in the megalospheric form with the sides parallel in the adult. Triangular throughout, or in the megalospheric form the later portion is rounded. Chambers distinct, not inflated except in the last chambers of the megalospheric form; wall coarsely arenaceous.

COMMENTS: This species does not appear to occur below the K/T boundary. At Hor Hahar it appears first at HH 25D, and at Ein Mor at EM47 which is approximately the same level; only occurs in limited numbers onwards; very typical of Midway-type faunas.

Family VALVULINIDAE

Genus *Clavulinoides* Cushman, 1936

Clavulinoides asper Cushman , 1937

Clavulinoides asper Cushman, 1937, Cushman Lab. Foram. Res., Spec. Pub. 7, p. 122, pl. 16, figs. 27-31; pl. 17, figs. 1-3; LeRoy, 1953. Geol. Soc. Amer., Mem. 54, p. 25, pl. 1, figs. 5-6.

DESCRIPTION: This species is characterized by its triangular outline with flat to very faintly concave sides and subrounded peripheral angles; wall coarsely arenaceous.

COMMENTS: Very rare, a few specimens were found above and below the K/T boundary; specimens similar to those described by LeRoy (1953).

Suborder MILIOLIDA

Superfamily NUBECULARIACEA

Family CORNUSPIRIDAE

Genus *Cornuspira* Schultze, 1854

Cornuspira polygyra Reuss , 1863 (Plate 2,F)

Cornuspira polygyra Reuss, 1863, K. Akad. Wiss., Math. Naturw. Cl., Sitzber., Wien, Osterreich, Bd. 48, Abt. 1, p. 39, pl. 1, fig. 1.

DESCRIPTION: This species is distinguished by a small, white, planispiral test; umbilical region slightly depressed; periphery rounded; wall smooth; aperture open, no lip.

COMMENTS: Extremely rare; the few specimens that were recovered were from above the K/T boundary, except for one close to the boundary; very similar to the species recorded by LeRoy (1953) from Egypt.

Superfamily MILIOLACEA

Family MILIOLIDAE

Genus *Quinqueloculina* d'Orbigny, 1826

Quinqueloculina sp. aff. *Q. stelligera* Schlumberger , 1893 (Plate 2,E)

Quinqueloculina stelligera Schlumberger, 1893, Soc. Zool. France Mem., Paris, France, tome 6, p. 68, pl. 2, figs. 58-59; LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 40, pl. 8, figs. 28-29.

DESCRIPTION: Species characterized by an elongate test about twice as long as broad; chambers distinct, noninflated, angles moderately round to somewhat truncate; aperture broadly elliptical.

COMMENTS: Very rare, a few specimens were recovered from above and below the K/T boundary: specimens resemble those described by LeRoy (1953) from Egypt; no mention is made of this species by Reiss et al. (unpublished report, 1963) from Israel.

Suborder ROTALIINA Delage and Herouard, 1896

Superfamily NODOSARIACEA Ehrenberg, 1838

Family NODOSARIIDAE Ehrenberg, 1838

Subfamily NODOSARIINAE Ehrenberg, 1838

Genus Lenticulina Lamarck, 1804

Lenticulina midwayensis (Plummer) 1927

Cristellaria midwayensis Plummer, Texas Univ. Bull. 2644, p. 95, pl. 13, fig. 5, 1927.

Lenticulina midwayensis (Plummer); idem. Bull. 3201, pp. 54, 61, 64. 1933

Robulus midwayensis (Plummer); Cushman and Todd, Cushman Lab. Foram. Res. Contr., vol. 22, p. 47, pl. 7, fig. 7, 1946.

DESCRIPTION: This species is distinguished by a large, circular, closely coiled test; chambers 10-12 in adult form radiate from a distinctive central boss; aperture at apex of broad septal face. Diameter up to 1.5 mm.

COMMENTS: Occurs sporadically above and below the K/T boundary; typical species of midway-type faunas; mentioned by Said and Kenawy (1956) from Egypt, but not LeRoy (1953); Berggren and Aubert (1975) note its presence in Tunisia and Morocco, and El Khayal (1969) records it from Saudi Arabia; no mention is made by Reiss et al. (unpublished report, 1963) from Israel.

Genus Dentalina D'Orbigny, 1826

Dentalina colei Cushman and Dusenbury , 1934 (Plate 2,A)

Dentalina colei Cushman and Dusenbury, 1934, Cushman Lab. Foram. Res., Contrib., vol. 10, pt. 3, p. 54, pl. 7, figs. 10-12; Cushman and Todd, 1946. Cushman Lab. Foram. Res., Contrib., vol. 22, pt. 2, p. 49, pl. 8, fig. 2.

DESCRIPTION: This species is easily distinguished by an elongate, moderately curved, slightly compressed test which tapers gradually toward a blunt initial end; chambers generally slightly inflated, gradually increasing in height as added; aperture is radiate and projecting.

COMMENTS: Fairly common, occurring consistently above and below the K/T boundary; typical of Midway-type faunas; recorded by LeRoy (1953) from Egypt, but no mention is made of it by Reiss et al. (unpublished report, 1963) from Israel, though it is a distinctive species.

Dentalina eocenica Cushman , 1944 (Plate 2,B)

Nodosaria pauperata Plummer, Texas Univ. Bull. 2644, p. 79, pl. 4, fig. 11, 1927

Dentalina eocenica Cushman, Cushman Lab. Foram. Research Contr., vol. 20, p. 36, pl. 6, fig. 1, 1944.

DESCRIPTION: Species characterized by a slender, slightly curved test, increasing very slightly in diameter; chambers distinct, increasing gradually in size; the last formed one in the adult nearly twice as high as broad; wall smooth; aperture radiate and terminal.

COMMENTS: Occurs sporadically above and below the K/T boundary; typical species of Midway-type faunas; not mentioned by either LeRoy (1953) or Said and Kenawy (1956) from Egypt; Reiss et al. (unpublished report, 1963) in Israel do not record this species.

Genus *Nodosaria* Lamarck, 1812

Nodosaria affinis Reuss

Nodosaria affinis Reuss; Cushman, 1940, Cushman Lab. Foram. Res., Contrib., vol. 16, pt. 4. p. 86, pl. 15, figs. 8-23.

DESCRIPTION: Species distinguished by elongate test ornamented with eight or ten heavy, uniformly spaced, longitudinal costae which extend non-interruptedly across sutures; chambers slightly to moderately inflated.

COMMENTS: Very rare, a few specimens recovered from above and below the K/T boundary; specimens similar to those described by LeRoy (1953) from Egypt.

Nodosaria sp. aff. N. longiscata d'Orbigny

Nodosaria longiscata D'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p. 32, pl. 1, figs. 10-12; LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 40, pl. 4, fig. 3.

DESCRIPTION: Species characterized by a long, slender test with elongate, smooth and cylindrical chambers; aperture terminal and probably radiate (all specimens incomplete).

COMMENTS: Occurs sporadically above and below the K/T boundary; specimens similar to those described by LeRoy (1953) from Egypt.

Nodosaria paupercula Reuss

Nodosaria paupercula Reuss; Cushman, 1946, U.S. Geol. Survey, Prof. Paper 206, p. 75, pl. 27, figs. 10-12.

DESCRIPTION: Species distinguished by an elongate test with bulbous chambers, slightly longer than wide; sutures strongly constricted; 10 well-developed costae extending across sutural areas.

COMMENTS: Very rare, only a few specimens recovered all from below the K/T boundary, except for one; specimens similar to those described by LeRoy (1953) from Egypt.

<u>Nodosaria</u> <u>semispinosa</u> LeRoy , 1953

<u>Nodosaria</u> <u>semispinosa</u> LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 41, pl. 4, fig. 10.

DESCRIPTION: Species distinguished by elongate, slender test with numerous plate-like longitudinal costae commonly extending across sutures and tending to develop projections near base of chambers.

COMMENTS: Very rare, only a few specimens recovered from above the K/T boundary; specimens similar to those described by LeRoy (1953) from Egypt.

Genus <u>Elipsonodosaria</u> Silvestri, 1900

<u>Ellipsonodosaria</u> (?) <u>granti</u> (Plummer), 1927

<u>Nodosaria</u> <u>granti</u> Plummer, 1927, Texas Univ. Bull. 2644, p. 83, pl. 5, figs. 9a-d.

<u>Ellipsonodosaria</u> <u>granti</u> (Plummer); Cushman, 1940. Cushman Lab. Foram. Res., Contrib., vol. 16, pt. 3, p. 69, pl. 12, fig. 3.

DESCRIPTION: Species characterized by very long, slender, arcuate, smooth test; chambers varying from compact to elongate chambers twice as long as broad, cylindrical to gently inflated, elliptical to ovoid; sutures transverse, unconstricted to gently constricted.

COMMENTS: Occurs sporadically above and below the K/T boundary; specimens similar to those described by LeRoy (1953) from Egypt.

Genus <u>Lagena</u> Walker and Jacob, 1798

<u>Lagena</u> <u>apiculata</u> Reuss

<u>Lagena</u> <u>apiculata</u> Reuss; Cushman, 1946, U.S. Geol. Survey, Prof. Paper 206, p. 94, pl. 39, fig. 23.

Lagena _apiculata_ _apiculata_ Reuss. Bartenstein and Brand, 1951, Abh. Senckenb. Naturf. Ges., no. 485, p. 316.

DESCRIPTION: This species is distinguished by a smooth ellipsoidal test tapering towards the aperture. A number of variable forms are included here.

COMMENTS: Present consistently in small numbers above and below the K/T boundary; not recorded by LeRoy (1953), but noted by Said and Kenawy (1956) in Egypt.

Lagena _globosa_ (Montagu) (Plate 1,D)

Lagena cf. _globosa_ (Montagu); Cushman and Hedberg, 1941, Cushman Lab. Foram. Res., Contrib., vol. 17, pt. 4, p. 91, pl. 22, figs. 11-13.

DESCRIPTION: This species is distinguished by a small, nearly spherical test with a smooth surface and short neck. A number of variable globose and smooth forms are included here.

COMMENTS: Present consistently in small numbers above and below the K/T boundary; recorded by both LeRoy (1953) and Said and Kenawy (1956) from Egypt.

Lagena _hispida_ Reuss , 1863 (Plate 1,F)

Lagena _hispida_ Reuss; Cushman, 1946, U.S. Geol. Survey, Prof. Paper 206, p. 93, pl. 39, fig. 13; Frizzell, 1954, Univ. Texas Rept. Invest. no. 22, p. 102, pl. 14, fig. 8.

DESCRIPTION: This species is characterized by a spherical, inflated test; surface is fine to coarsely hispid; aperture central, simple, on a long tubular neck.

COMMENTS: Quite rare, occurring sporadically above and below the K/T boundary; recorded by Said and Kenawy (1956), but not LeRoy (1953) in Egypt.

Lagena sulcata (Walker and Jacob), 1798 (Plate 1,E)

Lagena sulcata (Walker and Jacob); Cushman, 1929. Cushman Lab. Foram. Res., Contrib., vol. 5, pt. 3, p. 70, pl. 11, fig. 5.

DESCRIPTION: Species characterized by a subglobose test, slightly longer than broad; wall with numerous, rather coarse, longitudinal costae, neck extended with phialine lip.

COMMENTS: Occurs sporadically above and below the K/T boundary; noted by both LeRoy (1953) and Said and Kenawy (1956) from Egypt.

Superfamily BULIMINACEA Jones, 1875

Family BOLIVINITIDAE Cushman, 1927

Genus Bolivina D'Orbigny, 1839

Bolivina decurrens (Ehrenberg), 1854 (Plate 3,G)
in Said and Kenawy, 1956

DESCRIPTION: Species characterized by elongate, slender test. 2-3 times as long as wide, initially bluntly pointed, occasionally spinose; test compressed; chambers biserial throughout.

COMMENTS: Occurs sporadically above and below the K/T boundary; not mentioned by LeRoy (1953), but a similar form Bolivina decurrens parallela (Said and Kenawy) was recorded by Said and Kenawy (1956) in Egypt; Reiss et al. (unpublished report, 1963) make no mention of this distinctive species in Israel.

Bolivina incrassata Reuss , 1851 (Plate 4,D,E,H)

Bolivina incrassata Reuss; Cushman, 1937, Cushman Lab. Foram. Res., Spec. Pub. 9, p. 38, pl. 5, figs. 19-28.

DESCRIPTION: This species shows a high degree of variation, but it is relatively easy to identify. The test ranges from long slender forms to types that are very stout and robust; test compressed, with sub-rounded margins; chambers numerous; sutures steeply inclined; aperture elongate, wide, ovate, highly inclined subterminal opening; fine longitudinal striae may be present on the lower part of the test.

COMMENTS: Occurs above and below the K/T boundary; present in most units with great variation in numbers; species typical of Midway-type faunas; reported by LeRoy (1953) and Said and Kenawy (1956) from Egypt; noted by Berggren (1974b) from Tunisia and by Reiss et al. (unpublished report, 1963) from Israel.

Genus *Bolivinoides* Cushman, 1927

Bolivinoides curtus Reiss , 1954 (Plate 4,C)

Bolivinoides curtus Reiss; 1954, Contr. Cushman Found. Foram. Res., vol. 5, p. 158, pl. 30, figs. 15-16.

DESCRIPTION: This species is distinguished by a small test, which is rather flat and elongated, often subelliptical; periphery acute; ornamentation consisting of rather strong, short, ribs, formed by raised lobes, covering very regularly the chambers of the whole test; suture lines marked by ornamentation pattern.

COMMENTS: Occurs consistently above the K/T boundary, seemingly replacing *Bolivinoides draco* gp. At Ein Mor, it even appears to occur below the boundary event. Reiss (1954) first described it from Israel; Said and Kenawy (1956) report it from Egypt.

Bolivinoides draco draco (Marsson) 1878 (Plate 4,A)

Bolivina draco Marsson, 1878. p. 157, pl. 3, 25a-d

Bolivinoides draco draco (Marsson) ; Hiltermann and Koch, 1950 Geol. Jahrb., vol. 64, p. 598, text-fig. 1, nos. 72a-c, 73a-b; text-figs. 2-4, nos. 52-54, 58-60; text-fig. 5, nos. 53, 69, 70; Reiss, 1954, Contr.

Cushman Found. Foram. Res., vol. 5, p. 155, pl. 29, figs. 1-3.

DESCRIPTION: Species is characterized by a rhomboidal, compressed test; test covered by strongly developed, longitudinally elongated lobes, which coalesce to form longitudinal ribs; the central groove produced is highly distinctive.

COMMENTS: This subspecies is a guide-fossil for the Maestrichtian of Israel. In the higher Maestrichtian it occurs associated with the closely related *B. draco dorreeni* Finlay . A few specimens occur above the K/T boundary and are probably reworked. This is one of the few benthic species which shows definite extinction at the K/T boundary, as the majority appear largely unaffected; distinctive species, but not very common; noted by Said and Kenawy (1956), but not LeRoy (1953) from Egypt; Reiss (1954) made a comprehensive study on Upper Cretaceous and Lower Tertiary *Bolivinoides* from Israel.

Bolivinoides draco dorreeni Finlay, 1940 (Plate 4,B)

Bolivinoides draco dorreeni Finlay; Reiss, 1954, Contr. Cushman Found. Foram. Res., vol. 5, p. 155, pl. 29, figs. 4-7.

DESCRIPTION: This species is characterized by the prominently "fenestrate" or reticulate ornamentation, which distinguishes it from *B. draco draco*. It is, however, closely related to this latter subspecies and connected by transition forms.

COMMENTS: This is a good marker for the Upper Maestrichtian of Israel. (Reiss, 1954); occurs associated with its subspecies *B. draco draco*.

Genus Loxostomoides Reiss, 1957

Loxostomoides applinae (Plummer), 1927 (Plate 3,B)

Bolivina applini Plummer, 1927, Univ. Texas Bull., no. 2644: 69, pl. 4, fig. 1.

Loxostomoides applinae (Plummer); Kellough, 1965, Gulf Coast Assoc. Geol. Soc., Trans., 15: 112, pl. 12, fig. 4.

DESCRIPTION: Test easily distinguished by its long, slender compressed shape, striae on the lower portion, and suture crenulations on the chambers of the upper part of the test.

COMMENTS: This species is common below and above the K/T boundary in the sections studied, though numbers seem to increase dramatically at the boundary and onwards; very typical of Midway-type faunas; LeRoy (1953) records this species in Egypt and Reiss et al. (unpublished report, 1963) indicates its presence in Israel; Berggren and Aubert (1975) record it in Tunisia and Morocco, and El Khayal (1969) notes it in Saudi Arabia.

Family EOUVIGERINIDAE, Cushman, 1927

Genus Eouvigerina, Cushman, 1926

Eouvigerina aff. E. cretacea (Heron-Allen and Earland) 1910, (Plate 3,A)
in Hofker 1957

Sagrina cretacea, Heron-Allen and Earland, 1910, S. 123, Taf. 8, Fig. 8-10

Eouvigerina aculeata, Cushman, 1933, S. 62, Taf. 7, Fig. 8

Eouvigerina aspera (Marsson) var. laevigata Marie, S. 193, Taf. 29, Fig. 284.

DESCRIPTION: This species is distinguished by a biserial test throughout, but maybe slightly twisted; final chamber nearly central in position;

sutures depressed; surface is distinctly hispid; aperture terminal with neck and phialine lip.

COMMENTS: Fairly common above and below the K/T boundary, quite variable in abundance; does not appear to occur in Egypt, LeRoy (1953) and Said and Kenawy (1956); Reiss et al. (unpublished report, 1963) make no mention of anything similar to this species; most similar to forms of E. cretacea illustrated by Hofker (1957), but these forms are more hispid and may be an endemic variety.

Genus Siphogenerinoides Cushman, 1927

Siphogenerinoides eleganta (Plummer), 1926 (Plate 1,C)

Siphogenerina eleganta Plummer, 1926, Texas Univ. Bull. 2644, p. 126, pl. 8, figs. 1a-c.

Siphogenerinoides eleganta (Plummer); Cushman and Todd, 1946. Cushman Lab. Foram. Res., Contrib., vol. 22, pt. 2, p. 59, pl. 10, fig. 18.

DESCRIPTION: This species is distinguished by an elongate test with early chambers in a biserial arrangement merging into a succession of alternately oblique chambers that very rarely reach a Nodosarian development.

COMMENTS: Occurs sporadically above and below the K/T boundary; typical species of Midway-type faunas; mentioned by LeRoy (1953) in Egypt, El Khayal (1969) in Saudi Arabia, Berggren (1974b) in Tunisia and Reiss et al. (unpublished report, 1963) in Israel.

Genus Stilostomella Guppy, 1894

Stilostomella midwayensis (Cushman and Todd), 1946 (Plate 2,H)

Ellipsonodosaria spinulosa (Plummer); Cooper, Jour. Paleontology, vol. 18, p. 352, pl. 54, fig. 20, 1944.

<u>Nodosaria spinulosa</u> Plummer, Texas Univ. Bull. 2644, p. 84, pl. 4, fig. 19, 1927.

<u>Ellipsonodosaria midwayensis</u> Cushman and Todd, Cushman Lab. Foram. Research Contr., vol. 22, p. 61, pl. 10, fig. 25, 1946.

DESCRIPTION: Species distinguished by elongate, slender, gradually tapering test from the acute initial end to the greatest width at the last formed chamber; wall ornamented with longitudinal costae, composed of distinct spinose projections; chambers distinct, pyriform in shape and aperture terminal, with a very short neck and clearly defined lip.

COMMENTS: Occurs below the boundary, but much commoner at and after the boundary event; very typical species of Midway-type faunas; noted in Egypt by Said and Kenawy (1956), and possibly by LeRoy (1953), under the name of <u>Ellipsonodosaria spinea</u> (Cushman), as this species appears identical; Reiss et al. (unpublished report ,1963) make no mention of it, though it is highly distinctive and common.

Genus <u>Tappanina</u> Gallitelli, 1956

<u>Tappanina selmensis</u> (Cushman), 1933 (Plate 3,D)

<u>Eovigerina excavata</u> Cushman, 1940, p. 66, pl. 11, fig. 18

<u>Tappanina selmensis</u> Gallitelli, 1956, p. 37, pl. 7, figs. 3,4.

<u>Bolivina selmensis</u> Hofker, 1955, p. 8, pl. 4.

<u>Bolivinita selmensis</u> Cushman, 1933, p. 58, pl. 7, figs. 3,4; 1946, p. 114, pl. 49, figs. 1.

DESCRIPTION: This species is characterized by the minute biserial test, concave chamber faces and strong horizontal and lateral carinae; aperture a narrow arch at base of the final chamber.

COMMENTS: It appears to occur in low numbers below the K/T boundary, but it is consistently quite common from the boundary onwards; not recorded in Egypt by LeRoy (1953) and Said and Kenawy (1956), but Reiss et al. (unpublished report, 1963) mention it from Israel; indicative of normal marine conditions.

Family BULIMINIDAE Jones, 1875

Subfamily BULIMININAE Jones, 1875

Genus Bulimina d'Orbigny

Bulimina cacumenata Cushman and Parker , 1936, (Plate 3,E)

Bulimina cacumenata Cushman and Parker, 1936, Cushman Lab. Foram. Research Contr., vol. 12, p. 40, pl. 7, fig. 3.

DESCRIPTION: This species is characterized by a fusiform test, gradually tapering to a long, subacute point with the wall, except for the last whorl, covered with irregular, low, closely set costae; last whorl smooth, coarsely perforate.

COMMENTS: Fairly common, occurring in nearly all samples analysed above and below the K/T boundary; typical of Midway-type faunas; LeRoy (1953) and Said and Kenawy (1956) make no mention of this species in Egypt; Reiss et al. (unpublished report, 1963) refer to a species Pyramidina cf. cacumenata (Cushman and Parker) which is presumably a synonym for B. cacumenata.

Bulimina midwayensis Cushman and Parker, 1936 (Plate 4,F,G)

Bulimina aculeata d'Orbigny. Plummer, 1927, Univ. Texas Bull., no. 2644: 73, pl. 4, fig. 3

Bulimina midwayensis Cushman and Parker; Brotzen, 1948, Sver. Geol. Unders., Ser. C. no. 493: 58, pl. 10, fig. 8.

Bulimina midwayensis Cushman and Parker; Kellough, 1965, Gulf Coast

Assoc. Geol. Soc., Trans., 15: 113, pl. 12, fig. 6.

DESCRIPTION: The test is characterized by sharp spines which project from the lower edges of the chambers, except the wall of the last formed whorl which is smooth.

COMMENTS: This species occurs only rarely above and below the K/T boundary; typical of Midway-type faunas; LeRoy (1953) makes no mention of this species in Egypt, though it was recorded by Said and Kenawy (1956); Aubert and Berggren (1975) report it from Tunisia and Libya, and Reiss et al. (unpublished report, 1963) indicates its presence in Israel on a distribution chart of the Taquiya Formation; El Khayal (1969) notes its presence in Saudi Arabia.

Family TURRILINIDAE

Genus Buliminella Cushman, 1911

Buliminella cushmani Sandidge , 1932 (Plate 3,F)

Buliminella cushmani Sandidge, 1932, Journ. Paleont., vol. 6, no. 3, p. 280, pl. 42, figs. 18-19;- Cushman, 1946, U.S. Geol. Survey, Prof. Paper 206, p. 119, pl. 50, fig. 15; LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 22, pl. 8, fig. 12.

DESCRIPTION: This species is distinguished by a compactly fusiform, spirally coiled, involute test, circular in transverse section with the initial end pointed; the apertural end tapers more gradually and is rounded at the top; wall smooth, finely perforate; aperture a comma-like opening at the end of the last chamber, extending from near the apex down to the last whorl.

COMMENTS: Fairly common, above and below the K/T boundary; recorded by both LeRoy (1953) and Said and Kenawy (1956) from Egypt; Reiss et al. (unpublished report, 1963) refers to Praebulimina cushmani Sandidge from Israel, which is presumably a synonym of this species.

Superfamily CASSIDULINACEA

Family PLEUROSTOMELLIDAE

Genus Pleurostomella Reuss, 1860

Pleurostomella paleocenica Cushman , 1947 (Plate 2,G).

Pleurostomella alternans Plummer, Texas Univ. Bull. 2644, p. 69, pl. 4, fig. 2, 1927.

Pleurostomella paleocenica Cushman, Cushman Lab. Foram. Research. Contr., vol. 23, p. 86, pl. 18, figs. 14, 15, 1947.

DESCRIPTION: Species distinguished by its very small, slender, tapering test from the slightly rounded base to the greatest breadth formed by the last pair of chambers; nearly circular in transverse section; wall smooth; aperture on the upper part of the inner face of the last formed chamber.

COMMENTS: Appears to range a short distance below the K/T boundary, but it seems to have its base around the boundary itself; not common, occurring sporadically; fairly typical species of Midway-type faunas; LeRoy (1953) in Egypt and Reiss et al. (unpublished report, 1963) in Israel make no mention of this species.

Superfamily DISCORBACEA

Family CANCRISIDAE

Genus Gyroidinoides Brotzen, 1942.

Gyroidinoides planulata Cushman and Renz , 1941

Gyroidina planulata Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contrib., vol. 17, p. 23, pl. 4, fig. 1; LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 35, pl. 11, figs. 1-3.

DESCRIPTION: Species characterized by a biconvex test, nearly circular in transverse section, slightly more convex ventrally than dorsally, compressed; chambers distinct, 8-10 in last formed whorl, only faintly inflated; last chamber sometimes extending slightly into ventral umbilical region; periphery rounded; aperture a narrow slit at base of last formed chamber, extending into umbilical region, with narrow lip.

COMMENTS: Appears to be mostly limited to below the K/T boundary; intraspecific variation in G. subangulata is quite extreme, producing forms sometimes with a low profile, so that G. planulata may have been misidentified and placed in this species; specimens resemble those described by LeRoy (1953) from Egypt; Reiss et al. (unpublished report, 1963) do not refer to this species in Israel.

Gyroidinoides subangulata (Plummer, 1927) (Plate 6, A,B,C)

Rotalia soldanii (d'Orbigny) var. subangulata Plummer, 1927, Univ. Texas Bull., no. 2644: 154, pl. 12, fig. 1

Gyroidinoides subangulata (Plummer); Olsson, 1960, J. Paleontol., 34(1): 36, pl. 5, figs. 24,25.

DESCRIPTION: This species is distinguished by the nearly plano-convex test; strongly convex umbilical side; slightly depressed sutures around the umbilicus; aperture a long narrow slit at the base of a broad septal face.

COMMENTS: Very common species above and below the K/T boundary; typical of Midway-type faunas, and is one of the most widely recorded species in Palaeocene assemblages of the world. It has been observed in N. Africa (Libya, Egypt, Tunisia), S. W. France, Mozambique and Timor, among other places; noted by Reiss et al. (unpublished report, 1963) from Israel.

Genus *Gavelinella* Brotzen, 1942

Gavelinella danica (Brotzen), 1948 (Plate 7,C)

Anomalina grosserugosa Franke, 1927, Dan. Geol. Unders., RII(46): 37, pl. 4, fig. 3.

Anomalinoides danica Brotzen, 1948, Sver. Geol. Unders., Ser. C, no. 493 : 87, pl. 14, figs. 1-3.

Anomalina granosa LeRoy, 1953, Mem. Geol. Soc. Am., 34 : 17, pl. 6, figs. 1-3

Gavelinella danica (Brotzen); Hofker, 1955, Rep. McLean Foram. Lab., no. 2 : 11, pl. 11, fig . 1

Anomalinoides longi (McLean); Olsson, 1960, J. Paleontol., 34(1) : 51, pl. 11, figs. 12-14.

DESCRIPTION: This species is distinguished by its large, rounded, nearly bilaterally symmetrical test. There are 7-8 chambers in the last whorl which are strongly inflated, gradually increasing in size as added; wall coarsely perforate; aperture at base of last chamber extends somewhat into ventral umbilical area.

COMMENTS: Occurs sporadically above and below the K/T boundary. It has been recorded under a number of names in the literature e.g. *Anomalinoides granosa* (Hantken) in Egypt (LeRoy, 1953); typical species of Midway-type faunas; noted in Tunisia and Morocco by Berggren and Aubert (1975) and in Israel (Reiss et al., unpublished report, 1963).

Berggren and Aubert (1975) indicate that the typical *G. danica* is more common in middle shelf depths (~ 100 m).

Genus Angulogavelinella Hofker, 1957

Angulogavelinella beccariiformis, White, 1928 (Plate 6,H)

Angulogavelinella beccariiformis White ; Pozaryska and Szczechura, 1980, Annales des Mines et de la Geologie, Tunis, no. 28, Tome 3, pp. 267-277

DESCRIPTION: This species is distinguished by a trochospiral, lenticular, inequally biconvex test; chambers are numerous and arched; coarsely perforate on umbilicate side; aperture is a somewhat oblique, high interiomarginal arch midway between periphery and umbilicus; an extension of the last chamber covers the umbilicus.

COMMENTS: Very common species, occasionally even outnumbering Cibicidoides alleni; appears to occur for the first time just below the boundary; LeRoy (1953) and Said and Kenawy (1956) make no mention of this species from Egypt; Reiss et al. (unpublished report, 1963) note this species from Israel; Berggren (1974b) mentions it from Tunisia, where it supposedly indicates outer shelf to deeper-water facies.

A. beccariiformis is meant to be a typical species of the "Velasco-type fauna", which is a continental slope, continental rise and abyssal plain faunal assemblage (> 200 m water depth). It would appear we are dealing with a Midway-type fauna, with some Velasco-type elements, and that these types of assemblages are not so clearly distinct.

Quadrimorphina allomorphinoides (Reuss), 1860 (Plate 6,D)

Valvulina allomorphinoides Reuss, 1860, Akad. Wiss. Wien. Math.-naturwiss. Kl., Sitzungsber., vol. 40, p. 223, pl. 11, figs. 6a-c.

Valvulineria allomorphinoides Cushman, 1951, U.S. Geol. Survey, Prof. Paper 232, p. 50, pl. 14, figs. 8,9.

DESCRIPTION: This species is characterized by a trochoid, biconvex test, slightly longer than broad; periphery rounded; slightly inflated chambers, usually 5 in the adult whorl; aperture on the ventral side beneath an overhanging lip.

COMMENTS: Consistently present in low numbers in most units above and below the K/T boundary; typical species of Midway-type faunas; not recorded by LeRoy (1953) or Said and Kenawy (1956) from Egypt; Reiss et al. (unpublished report, 1963) refer to this species in Israel.

Genus Valvulineria Cushman, 1926

Valvulineria aegyptiaca LeRoy, 1953 (Plate 5,H)

Valvulineria aegyptiaca LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 53, pl. 9, figs. 21-23.

DESCRIPTION: Species is characterized by a test slightly longer than broad, slightly more convex ventrally than dorsally; chambers distinct, generally 7 in last whorl, enlarging rather rapidly as added, last 2 moderately inflated, preceding ones less so; side of last chamber extended and covering part of the ventral umbilical region; periphery broadly rounded; wall rather coarsely perforate, smooth; aperture low, arched at base of last chamber below a lunate area and extending into ventral region.

COMMENTS: Occurs fairly consistently in low numbers above and below the K/T boundary; specimens resemble those described by LeRoy (1953) from Egypt; Reiss et al. (unpublished report, 1963) do not record this species from Israel.

Superfamily ASTERIGERINACEA

Family EPONIDIDAE

Genus *Eponides* Montfort, 1808

Eponides plummerae Cushman , 1948 (Plate 5,D,E)

Eponides sp. Cushman; idem, vol. 16, p. 71, pl. 12, fig. 8, 1940

Truncatulina tenera Plummer, Texas Univ. Bull. 2644, p. 146, pl. 9, fig. 5, 1927

Eponides plummerae Cushman, Cushman Lab. Foram. Research contr., vol. 24, p. 44, pl. 8, fig. 9, 1948.

DESCRIPTION: Species distinguished by a small, biconvex test with a subacute periphery; usually six chambers in the adult whorl increasing very uniformly in size: wall smooth, polished; aperture elongate, narrow, on the ventral side of the last formed chamber often with a very slight overhanging lip.

COMMENTS: Consistently fairly common across the K/T boundary; typical species of Midway-type fauna; not mentioned under this name by LeRoy (1953) or Said and Kenawy (1956) from Egypt; Berggren (1974b) notes its presence in Tunisia, but no mention is made of any *Eponides* sp. by Reiss et al. (unpublished report, 1963) in Israel.

Family ALABAMINIDAE Hofker, 1951

Genus *Alabamina* Toulmin, 1941

Alabamina midwayensis Brotzen, 1948 (Plate 6,F,G)

Pulvinulina exigua H. B. Brady var. *obtusa* Burrows and Holland; Plummer, 1926, Univ. Texas Bull., no. 2644 : 150, pl. 11, fig. 2.

Alabamina midwayensis Brotzen, 1948, Sver. Geol. Unders., Ser. C, no. 493 : 99, pl. 16, figs. 1,2, text-figs, 25,26.

DESCRIPTION: Test subcircular in outline, unequally biconvex or planoconvex, ventral side strongly convex; acute axial periphery; aperture a long narrow opening on the ventral side at the base of the septal face.

COMMENTS: The few specimens recovered were all from the Palaeocene; typical of Mid-way type faunas; LeRoy (1953) makes no mention of this species in Egypt, though it was recorded by Said and Kenawy (1956) as Alabamina wilcoxensis, which may be a synonym for A. midwayensis, though Toulmin (1941) and Brotzen (1948) support a separation of these two species. Reiss et al. (unpublished report, 1963) indicate its presence in Israel on a distribution chart of the Taqiya Formation. Aubert and Berggren (1975) similarly report it from Tunisia, and El Khayal (1969) notes its presence in Saudi Arabia.

Family OSANGULARIIDAE Loeblich and Tappan, 1964

Genus Osangularia, Brotzen, 1940

Osangularia lens Brotzen, 1940, (Plate 5,F,G).

Osangularia lens, Brotzen, 1940, S.30, Abb. 8,1; Hofker, 1957, Beihefte zum Geologischen Jahrbuch, Heft 27.

DESCRIPTION: This species is distinguished by a trochospiral, biumbonate, lenticular test; periphery carinate; all whorls visible on spiral side, only final whorl visible on opposite side; wall calcareous, finely perforate, granular in structure; aperture a bent opening, lying along base of final chamber on umbilical side and bending at oblique angle up apertural face; distinguished from close relatives e.g. O. plummerae by more robust test, higher conical spiral side and less well developed peripheral keel.

COMMENTS: Extremely common species above and below the K/T boundary, sometimes the second most abundant after Cibicidoides alleni; LeRoy (1953) makes no mention of this species, but Said and Kenawy (1956) record a closely related species, Osangularia plummerae (Brotzen) from Egypt; Reiss et al. (unpublished report, 1963) note O. lens from Israel.

If similar in ecological requirements to O. plummerae, O. lens will be distributed throughout the depth range of the continental shelf (Berggren, 1974a).

Family SIPHONINIDAE

Genus Pulsiphonina Brotzen, 1948

Pulsiphonina prima (Plummer), 1927 (Plate 5,B.C).

Siphonina prima Plummer, 1927, Texas Univ. Bull., no. 2644, p. 148, pl. 12, fig. 4.

Pulsiphonina elegans Brotzen, 1948, Sver. Geol. Unders., Ser. A, no. 493 : 107, pl. 17, fig. 4.

Pulsiphonina prima (Plummer); Olsson, 1960, J. Pal eontol., 30(1) : 39, pl. 7, figs. 1-3.

Siphonina (Pulsiphonina) prima Plummer; Kellough, 1965, Gulf Coast Assoc. Geol. Soc., Trans., 15 : 121, pl. 13, fig. 9.

DESCRIPTION: This species is characterized by a small, nearly circular, almost equally biconvex, but very compressed test; periphery angled, sharply acute, delicately serrate and very slightly lobate; aperture a small, narrowly elliptical opening on the ventral side close to the periphery, without a definite neck.

COMMENTS: Occurs sporadically above and below the K/T boundary, possibly being more frequently observed beneath. This small species is apparently cosmopolitan in distribution and occurs most commonly in mid-shelf deposits (20 - 100 m), mainly muddy substrates.

Superfamily ORBITOIDACEA

Family ANOMALINIDAE Cushman, 1927

Subfamily ANOMALININAE Cushman, 1927

Genus Anomalinoides Brotzen, 1942

Anomalinoides acuta (Plummer), 1927 (Plate 7,F,G)

Anomalina ammonoides (Reuss) var. acuta Plummer, 1927, Univ. Texas Bull., no. 2644 : 149, pl. 10, fig. 2.

Anomalina acuta Plummer; Glaessner, 1937, Moscow University, Problems of Paleontology, 2-3 : 386, pl. 5, no. 40.

Anomalinoides acuta (Plummer); Brotzen, 1948, Sver. Geol. Unders., Ser. C, no. 493 : 87, pl. 15, figs. 2a-c.

Anomalina praeacuta Vasilenko; Pozaryska, 1965, Palaeontol. Pol., no. 14 : 129, pl. 28, figs. 2a-c.

DESCRIPTION: This species is characterized by a compressed, moderately biconvex, involute test with numerous chambers and subacute periphery. There is a marked variation in the nature and size of the glossy umbilical plug.

COMMENTS: Very common species above and below K/T boundary; very typical of Midway-type faunas; this species appears to have a cosmopolitan distribution and relatively broad depth tolerance, although it becomes less common with increasing depth; it has been observed in the Midway Formation of the Gulf Coast, Aquitaine Basin, Morocco, Tunisia, Libya, Egypt and Mozambique; Reiss et al. (unpublished report, 1963) mention Anomalinoides pseudoacuta (Nakkady), which is probably this species.

Anomalinoides midwayensis (Plummer), 1927 (Plate 7,H)

Truncatulina midwayensis Plummer, 1927, Texas Univ. Bull., no. 2644 : 141, pl. 9, fig. 7; pl. 15, fig. 3.

<u>Anomalinoides</u> <u>midwayensis</u> (Plummer); Brotzen, 1948, Sver. Geol. Unders., Ser. C, no. 493 : 88, pl. 14, figs. 3a-c.

<u>Anomalina</u> <u>midwayensis</u> (Plummer); Cushman, 1951, U.S. Geol. Surv. Prof. Pap., 232 : 62, pl. 17, figs. 17,18,19.

<u>Gavelinella</u> <u>midwayensis</u> (Plummer); Malumian, 1970. Ameghiniana, Rev. Assoc. Paleontol. Argent., 7(4) : 360, pl. 2, fig. 6.

DESCRIPTION: This species is characterized by the equally biconvex, strongly punctate test, and the broadly curving and elevated sutures on both sides of the test. The peripheral margin is rounded and the aperture is a slit at the base of the septal face.

COMMENTS: Relatively common beneath the K/T boundary, after which it persists in low numbers; LeRoy (1953) and Said and Kenawy (1956) do not mention this species in Egypt, though Berggren (1969) notes its presence in Libya; Reiss et al. (unpublished report, 1963) make no mention of this species in Israel.

<u>Anomalinoides</u> <u>welleri</u> (Plummer), 1927 (Plate 7,A,B).

<u>Truncatulina</u> <u>welleri</u> Plummer, 1927, Texas Univ. Bull., no. 2644 : 143, pl. 9, fig. 6.

<u>Anomalina</u> <u>welleri</u> (Plummer); Cushman 1951, U.S. Geol. Surv., Prof. Pap., 232 : 63, pl. 18, fig. 12.

<u>Anomalinoides</u> <u>welleri</u> (Plummer); Kellough, 1965, Gulf Coast Assoc. Geol. Soc., Trans., 15 : 117, pl. 15, fig. 5.

DESCRIPTION: This species is distinguished by an equally biconvex, considerably compressed, coarsely punctate test and the periumbilical ridge formed by the adumbilical coalescence of the sutures.

COMMENTS: Uncommon species, but it occurs in low numbers above and below the K/T boundary; LeRoy (1953) and Said and Kenawy (1956) do not mention this species in Egypt; Reiss et al. (unpublished report, 1963) make no mention of this species in Israel, however it is quite typical of Midway-type faunas.

Genus Cibicidoides Thalmann, 1939

Cibicidoides alleni (Plummer), 1927 (Plate 7,D,E)

?Rotalia mortoni Reuss, 1862, Palaontol. Beitr., K. Akad. Wiss. Wien, Math.-Naturw. Cl., Sitzber., Wien, Osterreich, 44 (Jahrg. 1861), Abth. 1 : 337, pl. 8, fig. 1.

Cibicides alleni Plummer,1927, Univ. Texas Bull., no. 2644 : 144, pl. 10, fig. 4.

?Cibicides proprius Brotzen; Kiesel, 1970, Palaontol. Abh. A, Palaozool., 4(2) : 310, pl. 20, fig. 1.

DESCRIPTION: This species is distinguished by its conspicuous ventral umbo, its rather large size, and its deeply depressed, somewhat irregular dorsal spiral suture. The degree of convexity of the test can be highly variable, ranging from relatively flat and low-biconvex to forms which are relatively strongly biconvex. There is also a tendency for the thick periumbilical rim of material on the spiral side to coalesce into a central plug.

COMMENTS: This is easily the dominant species throughout, occurring in large numbers above and below the K/T boundary, but it exhibits immense intraspecific variation. It appears to have been recorded in many areas under different names e.g. Cibicides libycus LeRoy in Egypt (LeRoy, 1953) and Israel (Reiss et. al., unpublished report, 1963).

This is a distinct biconvex rotaliid characteristic of the continental shelf environment (water depth $<$ 200 m), particularly the middle shelf (30 - 100 m); cosmopolitan in distribution, occurring throughout the Tethys region and in the Atlantic from Rockall Bank to central Argentina.

Superfamily NONIONACEA Loeblich and Tappan, 1974

Family NONIONIDAE

Subfamily NONIONINAE

Genus Nonionella Cushman, 1926

Nonionella africana LeRoy , 1953 (Plate 3,C)

Nonionella africana LeRoy, 1953, Geol. Soc. Amer., Mem. 54, p. 68, pl. 10, figs. 9-11.

DESCRIPTION: Species distinguished by a small, rather compressed test, about 1½ times as long as broad; chambers distinct, 9-10 in last whorl, enlarging rather rapidly as added, last chamber covering umbilical area for most part on involute side; sutures distinct, gently curved; aperture on low slit at base of last chamber.

COMMENTS: Very rare, a few specimens were recovered from a number of units above and below the K/T boundary; species very similar to those described by LeRoy (1953) in Egypt; no mention is made of it by Reiss et al. (unpublished report, 1963) from Israel.

Nonionella insecta (Schwager), 1883

Anomalina insecta Schwager, 1883, Palaeontogr. Beitr. Naturg. Vorzeit, Cassel, Deutschland, Bd. 30, Pal. Theil, Abth. 1, p. 128, pl. 28(5), fig. 2.

Nonionella insecta (Schwager); Cushman and Ponton, 1932 Cushman Lab. Foram. Res., Contrib., vol. 8, pt. 3, p. 65, pl. 8, figs. 13-14.

DESCRIPTION: Species is distinguished by a biumbilicate test, slightly longer than broad; apertural face moderately convex; chambers distinct, usually 9 in last whorl, gradually increasing in size as added; sutures distinct, gently curved; aperture a low arched slit at base of last chamber.

COMMENTS: Rare, a few specimens were recovered from a number of units above and below the K/T boundary; species noted by LeRoy (1953) in Egypt; no mention is made of it by Reiss et al. (unpublished report, 1963) from Israel.

Family CHILOSTOMELLIDAE

Genus Pullenia Parker and Jones, 1862

Pullenia quinqueloba (Reuss), 1851 (Plate 6,E)

Nonionina quinqueloba Reuss, 1851, Zeit. Deutsch. Geol. Gesell., vol. 3, p. 47, pl. 5, fig. 31.

Pullenia quinqueloba (Reuss); Plummer, 1926, Texas Univ. Bull. 2644, p. 136, pl. 8, figs. 12a-b.

DESCRIPTION: Species easily distinguished by a bilaterally symmetrical, closely coiled, completely embracing test; periphery broadly rounded; 5 chambers in final convolution; wall smooth; aperture a long narrow slit extending over the periphery at base of septal face.

COMMENTS: Occurs consistently in low numbers above and below the K/T boundary; species typical of Midway-type faunas; recorded by both LeRoy (1953) and Said and Kenawy (1956) from Egypt; no mention is made of it by Reiss et al. (unpublished report, 1963) from Israel, though it is a distinctive species; it is thought to indicate normal marine conditions of the mid shelf with a muddy substrate.

10. POSITION OF THE K/T BOUNDARY

The K/T boundary marks a time of major upheaval in the biosphere. Speculations vary greatly regarding the nature of this event, whether uniformitarian, e.g. productivity changes (Tappan, 1968), CCD changes (Worsley, 1971), or coincidence of factors leading to palaeoecologic stress (Ekdale & Bromeley, 1984), or catastrophic e.g. impact event (Alvarez et al, 1980, Smit and Hertogen, 1980).

The K/T boundary according to Magaritz et al. (1985) at EM and HH is placed at the level in which the greater part of the extinctions take place, which is equivalent to the appearance of Danian nannofossils (B. sparsus, M. inversus). Other possibilities for placement of the boundary horizon are at the FAD of 'G.' eugubina (HH16 or slightly lower), or at the point of initiation of the C isotope depletion (HH12).

However the benthonic foraminifera do not necessarily clarify the boundary event. The majority of the Midwayan fauna are index fossils for the Palaeocene, but occur below the defined K/T boundary, though a few species are recorded elsewhere from the Upper Maastrichtian e.g. Pullenia quinqueloba (Olsson, 1960), Tappanina selmensis (Olsson, 1960) and Bolivina incrassata (LeRoy, 1953).

Bolivinoides draco gp. is replaced by Bolivinoides curtus at the boundary defined, if slight bioturbation and reworking is allowed for. At EM, Magaritz et al. (1985) believe reworking in general is more prominent as shown by reworking of such robust planktonic forms such as Globotruncana sp, whereas at HH reworking is rare and confined to fragments and smaller forms. However it really does appear that a Danian assemblage is existing below the K/T event as defined, dominated by Cibicidoides alleni, Anomalinoides acuta, Osangularia lens and Gyroidinoides subangulata, though most Midwayan forms appear to increase in abundance after the event e.g. Tappanina selmensis, Loxostomoides _applinae_ and _Stilostomella_ _midwayensis_.

A further complication is the continuation of Maastrichtian benthonic forms into the Danian which do not appear to be reworked e.g. _Bolivina_ _decurrens_ and _Eouvigerina_ aff. _E_. _cretacea_.

The other possibilities for changing the position of the boundary as mentioned require significant upward reworking of much Cretaceous material, selective downward leaking of small amounts of Tertiary material, and together with either of these, necessary redefinition of the horizon itself. Magaritz et al. (1985) were not taking into account the Midwayan fauna so prominent beneath the defined K/T boundary, but since no samples were examined as far down as HH16 or HH12, one cannot comment when the Midway fauna makes its first appearance.

It is thought by Magaritz et al. (1985) that the sections at EM. and especially HH which were not influenced by 'boundary-clays' and possess unique geochemical anomalies contain section not represented elsewhere; this is the part of the section containing '_G_.' _eugubina_ in the Cretaceous, and perhaps also the part following the _B_. _sparsus_ appearance with '_G_.' _eugubina_, but prior to _Chiloguembelina_ FAD. The latter zonule is absent, or was missed in sampling at EM. If this is true then it follows that a Midwayan fauna may be present in the section absent elsewhere.

Further evidence supporting the defined K/T boundary and the reality of a Midwayan fauna beneath it in this unique section arises from four sources (Magaritz et al, 1985).

(A) Absence of other Tertiary species (other nannofossils, foraminifera such as _Chiloguembelina_) at the '_G_.' _eugubina_ FAD, making upward reworking of Cretaceous material on a massive scale highly unlikely.

(B) A strong palaeomagnetic signal, which would not have been preserved through significant bioturbation.

(C) Negative ichnological evidence for homogenization by bioturbation on a large scale, making downward leaking improbable. The only trace fossils indicative of bioturbation which may have led to downward mixing of the fauna and flora are small Chondrites burrows in sets a centimeter or two in thickness; the sampling interval of 5 cm or more eliminates the uncertainty caused by biogenic mixing.

(D) Unacceptability of redefining the K/T boundary. K/T boundary as used here (extinction events coincident with nannofossil appearance), is consistent with practice at other boundary localities, the only difference being the slightly earlier appearance of 'G.' eugubina and a Midwayan fauna within the Cretaceous; the zonation scheme differs slightly but can be correlated with biozones elsewhere. If the boundary definition is taken at a lower level, the biozonation would completely differ, and only in the Negev localities would first appearance of 'G.' eugubina or isotope depletion be taken to indicate the boundary horizon. This would involve lowering the K/T boundary in time, which would mean predating even the major extinction event.

Many of the Midwayan forms pre-dating the boundary appear to be quite oblivious of it, though some forms definitely appear to increase in abundance from the event onwards.

One of the most significant species to appear close to the boundary, and to become one of the four most dominant species is Angulogavelinella beccariiformis, and this may reflect a change in bathymetry at the boundary in Israel.

11. RELICTS AND SURVIVORS

Magaritz et al. (1985) have shown that the Danian nannofossils, in spite of their predominantly 'Cretaceous' taxonomic affinity, are survivors, and are not reworked from the Maastrichtian, as they bear low Danian $\delta^{13}C$ signatures. This would support certain benthonic foraminifera e.g. *Bolivina decurrens* and *Eouvigerina* aff. *E. cretacea* being survivors from the Cretaceous.

Several writers (Romein, 1977, Percival and Fischer, 1977, Thierstein, 1981) have provided evidence for the continuation of Cretaceous nannoplankton into the Danian. Likewise, Magaritz et al. (1985) have shown that some smaller planktonic foraminifera species, particularly *Guembelitria*, *'Globigerina' eugubina* and the smaller pustulose *Hedbergella* pass through from the Maastrichtian into the Danian, unaccompanied by the morphologically and hydrodynamically similar, but exclusively Cretaceous, *Globigerinelloides* and *Heterohelix*.

The fact that a Midway fauna and Danian planktonic foraminifera e.g. *'G.' eugubina* make their appearance in the Negev sections already in the Cretaceous, coupled with the survival of Cretaceous species well into the Danian, must be considered as a special feature of this region. The survival of the Cretaceous forms indicates persistence of a relict assemblage in a partially isolated habitat. This is not an unusual phenomenon for the region, which shows the persistence of relict assemblages as far back as the Middle Triassic (Benjamini and Chepstow-Lusty, 1986).

12. PALAEOBIOGEOGRAPHY

During the Mesozoic and Cenozoic a large east-west seaway, the Tethys Sea, extended from the Indo-Pacific area in the east to the Atlantic Ocean in the west, thus linking the Atlantic and Pacific in a circumglobal equatorial current. The Tethys Sea, which has existed in one form or another since the Cambrian was responsible for the world-wide distribution of marine fauna throughout geologic time. Today it exists in the form of the Mediterranean.

The southern limit of the Tethys Sea in Libya and Egypt lay between the equator and 10°N during the early Cenozoic, while a broad shallow seaway extended across northwest Africa from Algeria to Nigeria and connected the Tethys Sea with the South Atlantic. The Atlas Mountains of Algeria and Morocco, in northwestern Africa at about 20°N, defined the southern extent of the Tethys Sea in this area. Israel was located to the east along the southern margin of the central Tethys, north of the Arabo-Nubian massif.

Although some species appear to be restricted to either the Tethyan-European area or to the western Atlantic, the majority of species are amphi-Atlantic and Tethyan in distribution. The cosmopolitan distribution is attributed to more equitable climatic conditions (lower polar-equatorial thermal gradient) and warmer, more uniform thermal structure of the oceans and different palaeogeographic and palaeo-oceanographic conditions. The dominant surface currents flowed from east to west and were responsible for the trans-Atlantic migration of numerous elements in the microfaunas. (Berggren and Aubert, 1975).

Berggren and Phillips (1972) stated that benthic foraminiferal species from widely separated regions of the world have been recorded under the same name. The widespread geographic distribution of some species of benthic foraminifera suggests extensive migration over large distances. They further stated that the extensive distribution of benthic foraminifera is still occurring today and that it occurred with greater frequency in the geologic past so that during the Palaeocene, the Mediterranean and eastern region was a more or less uniform zoogeographic province. Berggren and Aubert (1975) also stated that the palaeogeographic distribution of Palaeocene benthic foraminifera in the Atlantic, Caribbean and Mediterranean regions is somewhat similar, and it is not even possible, in most cases, to know with certainty the area of origin of a particular species.

In Israel (Magaritz et al., 1985), where no 'boundary clays' exist, which are thought in other sections to be derived from intensive vulcanism associated with Laramide movements (Ekdale and Bromley, 1984), the HH and EM sections are thought to have been developed in shelf conditions separated from the open Tethys by a series of mild submarine elevations, which cut the region off from supply of fine clastics derived from the Atlantic side of the Tethyan system.

Clay-rich horizons at the K/T boundary are particularly well developed in Western Europe, North Africa and Atlantic Ocean sections, but localities from further east to which attention is only now being paid seem to lack such concentrations (Turkey, Pakistan, Egypt as well as Israel).

Israel appears to have closest faunal affinities with Egypt (LeRoy, 1953; Said and Kenawy, 1956) which is understandable due to its proximity. Certain species only known from Egypt were found in Israel e.g. *Valvulineria aegyptiaca*, *Spiroplectammina henryi* and *Nonionella africana*.

However some important differences are apparent, as no mention is made of *Anomalinoides midwayensis*, *A. welleri* or *Angulogavelinella beccariiformis* from Egypt.

13. PALAEOECOLOGY

Benthonic foraminifera are very responsive to variation in the depositional environment (Kureshy, 1969; Phleger, 1960; Murray, 1973). Their distribution is mainly controlled by various ecological factors among which the most important are water depth, temperature and salinity. Similar Midwayan faunas to those found in Israel have been recorded in geographically distinct areas of the world, which suggests that these benthic forms were widespread in palaeogeographic distribution where the palaeoecological environments were very similar.

The Midwayan fauna described is characterized by high species diversity, large populations, high morphologic variability of species, low proportions of agglutinated forms and dominance of a few species, with a significant addition of a new co-dominant species after the K/T boundary. Below the boundary *Cibicidoides alleni*, *Anomalinoides acuta* and *Osangularia lens* are dominant, but after the boundary *Angulogavelinella beccariiformis* becomes very important.

If not for the presence of *A. beccariiformis* the faunal assemblage could be interpreted as a typical "Midway-type" fauna, characteristic of a middle to outer shelf assemblage (50 - 200 m water depth). However *A. beccariiformis* is typical of a "Velasco-type" faunal assemblage characteristic of a continental slope, continental rise and abyssal plain faunal assemblage (> 200 m water depth). It is assumed that *A. beccariiformis* was not transported in from an area outside the region of deposition, as this would be difficult since they occur at a greater depth, and likewise transporting a complete Midwayan fauna into a deeper water area seems improbable and one would expect more Velasco-type elements to be present.

Therefore, above the K/T boundary, there appears to be a Midwayan-fauna associated with some Velasco-type elements. This may be interpreted by the Midwayan fauna occurring in the outer shelf ranging downwards to the 200 m water depth, and _A_. _beccariiformis_ ranging upwards from bathyal depths, so that co-existance occurs.

However _A_. _beccariiformis_ only occurs a very short way beneath the defined K/T boundary. In terms of stratigraphy it should not occur, but at these unique sections there is a Midwayan fauna occurring beneath. This may be explained in terms of a change in bathymetry. Beneath the boundary it may be too shallow for _A_. _beccariiformis_, but deepening may occur approximately at the boundary event so that conditions became tolerable.

K/T

17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Number
HH21	HH22	HH23	HH24	HOR9	HH25A	HH25B	HH25	HH25D	HH26B	HH26C	HH26	HH27	HH28	HH29	HH30	HH40	Sample
127	212	192	542	281	283	263	302	293	322	333	323	397	315	339	359	312	Total number counted
0.8	1.4	0.5	2.2	0.4	0	0.4	0.3	1.0	0	0	0.3	0	0	0.3	0.3	0	*Bathysiphon* spp.
0	0	0	0	0	0	0	0	0.3	0.6	0	0.3	0.3	0	0.3	1.4	5.1	*Spiroplectammina henryi*
0	0	0	0	0	0.4	0	0	0.3	0	0	0.3	0.3	0	0.6	0	0	*Dorothia bulletta*
0	0	0	0	0	0.4	0	0.3	0	0.3	0.3	0.9	0.3	1.3	0.9	0	0	*Dorothia pupa*
0.8	2.8	0.5	0	0.7	0.7	0	0	0	0	0.3	0.3	0.8	0.6	0.6	1.1	0.6	*Gaudryina pyramidata*
0	0	0	0.2	1.4	0	0	0.7	0.3	0.9	1.8	2.2	1.3	0	0.9	1.9	0	*Marssonella oxyconus*
0	0	0	0	0	0	0	0	0.7	0.6	0.9	0.6	1.0	0.3	0.3	3.9	1.0	*Tritaxia midwayensis*
0	0.5	0	0	0	0	0	0.3	0.3	0	0.3	0	0	0	0	0	0	*Clavulinoides asper*
0	0	0	0	0.4	0	0	0	0	0	0	0	0	0.3	0	0	0	*Cornuspira polygyra*
0	0.5	0	0	0.4	0	0.4	0.3	0	0	0	0	0	0	0	0	0	*Quinqueloculina* aff. *Q. stelligera*
0	0.5	1.0	0	0.7	0	0	0	0.3	0	0.6	0.3	0.5	0.6	0.3	0.3	0.6	*Lenticulina midwayensis*
3.1	1.4	2.6	0.9	1.4	1.8	1.9	0.3	1.0	0.9	0.9	1.5	1.8	1.3	3.8	3.1	4.8	*Lenticulina* spp.
0	0	0	0.2	0	0	0	0.7	0.7	0	0	0	0	0	0	0.8	0	*Astacolus* sp.
0.8	0.5	0	0.6	1.1	2.5	1.1	1.0	1.7	1.6	1.8	0.9	3.0	1.6	0.3	2.8	1.0	*Dentalina colei*
0	0.5	0	0.2	1.1	0.7	0	0	0.7	0	0.3	0	0	0	0	0.6	0	*Dentalina eocenica*
3.1	0.9	0	1.1	0	0.4	0.8	1.0	0.3	0.9	1.5	0.3	1.0	1.9	0.6	1.7	0.3	*Dentalina* spp.
0	0	0	0.2	0.4	0	0	0	0.3	0.3	0	0	0.5	0.3	0	0	0.6	*Nodosaria affinis*
0	1.4	0.5	0.6	0.4	0.7	0.8	0.7	0.3	0	0	0	0	0	0.3	0	0	*N. longiscata*
0	1.4	0.5	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	*N. paupercula*
0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0.6	0	*N. semispinosa*
0	0.5	1.0	0.2	1.4	0	0.4	0	0.7	0.9	0.3	0	0.8	1.0	0.6	0.3	0	*Ellipsonodosaria* (?) *granti*
0	0.5	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0.3	0	*Frondicularia* spp.
3.1	2.8	1.0	0.9	1.1	1.4	1.5	1.3	2.0	1.2	0.9	2.5	2.3	1.3	1.2	1.4	1.0	*Lagena apiculata*
0	0	0	1.3	2.1	2.5	1.1	0.3	0.7	0.6	1.2	0.9	2.0	3.2	0.9	2.2	1.3	*L. globosa*
2.4	0.5	0	0.4	0	0	0.4	0	0	0	0	0	0	0	0.3	1.7	0.3	*L. hispida*
0.8	0.5	1.0	0	0.7	0	0.4	1.3	0	1.2	0	0.3	0.5	0.3	0	0.6	0	*L. sulcata*
0.8	0	0	0	0	0	0	0	0.3	0	0	0	0.3	0	0.6	0.6	0.3	*Guttulina* spp.
0	0	0	0.2	0	0	0	0.7	0	0	0	0.3	0	0.3	0	0	0	*Ramulina* spp
5.5	2.4	2.1	0.7	1.1	0.4	0	0.3	0	0	1.2	0	0.8	0	0	0.3	0.3	*Bolivina decurrens*
0.8	0.9	2.1	0	0.4	0	0	0	1.4	0.9	0.9	1.5	2.0	4.8	5.6	2.5	3.5	*B. incrassata*
0	0	0	0	1.1	1.1	1.1	0.3	0.7	0.3	0.3	0.9	2.0	1.3	1.5	0.8	0.6	*Bolivinoides curtus*
1.6	0.5	0	0.9	0.4	0	0	0	0	0	0	0	0	0	0	0	0	*B. draco* gp.
1.6	0.5	2.6	6.6	7.5	4.6	7.6	6.3	5.5	5.6	11.7	5.0	6.8	5.1	4.1	4.2	6.4	*Loxostomoides applinae*
0	0	1.6	1.1	0.4	3.2	0.8	3.6	0.7	0.6	0.3	0.6	0.5	0.3	0	0	0.6	*Eouvigerina* aff. *E. cretacea*
0	0.9	1.0	0.9	0.4	2.5	1.1	2.3	0.7	0	0.6	0	0.5	0	0	0	1.0	*Siphogenerinoides eleganta*
0	0.5	1.0	6.8	6.1	6.0	6.5	7.0	4.1	4.0	2.7	2.5	5.5	4.8	3.5	2.5	4.8	*Stilostomella midwayensis*
0	0	0.5	1.5	1.4	2.8	1.5	4.0	0.7	1.9	4.8	6.8	6.0	4.4	4.7	3.1	4.8	*Tappanina selmensis*
0	0.9	1.6	1.3	1.4	1.4	1.1	1.0	0.3	1.2	0.3	0.9	0.8	0.3	0.3	0.3	1.3	*Bulimina cacumenata*
0	0.9	0	0.2	0	0.7	0	0	0	0	0	0	0	0	0.3	0.3	0	*B. midwayensis*
6.3	6.6	5.7	0.2	1.4	0.4	1.1	0.7	0.3	2.5	1.5	2.5	2.5	1.9	2.4	4.7	1.0	*Buliminella cushmani*
0	0.9	0	0	1.1	0	0.4	0	0	0	0	0.9	0.3	0.6	0.3	0	0.6	*Pleurostomella paleocenica*
0	0	0	0.2	0	0	0	0	0	0	0	0	0.3	0	0.3	0	0	*Fissurina* sp.
0	2.4	1.6	1.1	0.4	0	0	0	0	0	0	0	0	0.3	0	0	0	*Gyroidina planulata*
5.5	2.8	2.6	5.0	4.6	5.7	6.1	8.6	5.5	6.2	6.9	8.4	7.6	5.4	7.1	3.9	4.8	*Gyroidinoides subangulata*
0	0.5	0	0.4	1.1	1.1	1.5	1.3	0	0	0	0	0	0	0	0	0	*Gavelinella danica*
0	0	0	0.2	6.8	5.3	4.6	5.0	3.1	11.8	13.2	9.3	12.8	12.1	13.0	9.5	11.2	*Angulogavelinella beccariiformis*
0.8	1.4	0.5	0.4	0.4	0.4	0.4	0.3	0	0	0.3	0.3	0	0.3	0.3	0.6	0.3	*Quadrimorphina allomorphinoides*
0	0.5	0	1.8	0	1.1	0.8	0.3	1.4	0.9	1.2	2.2	1.0	1.3	0.6	1.9	0	*Valvulineria aegyptiaca*
3.9	3.8	1.0	0.7	1.8	1.8	0	1.0	0.7	0.9	2.1	2.5	1.3	2.2	2.7	3.3	3.2	*Eponides plummerae*
3.1	1.4	0.5	0.6	0	0	0.4	0	0	0	0.3	0	0	0	0	0	0	*Nuttallides* sp
0	0	0	0	0	0.4	0.4	0	0.3	0	0	0	0.3	0	0	0	0.3	*Alabamina midwayensis*
5.5	10.8	10.9	17.9	12.9	15.5	11.0	14.2	13.7	11.5	4.5	7.1	6.0	10.5	8.3	8.4	1.0	*Osangularia lens*
7.1	0.9	1.0	0.2	1.4	0	0.4	0.3	0.3	0	0.3	0.3	1.3	0	0	0	0.3	*Pulsiphonina prima*
9.4	13.2	15.1	16.6	7.1	8.5	10.3	8.6	14.7	4.0	3.9	3.7	4.8	4.1	6.2	4.2	6.4	*Anomalinoides acuta*
13.4	6.6	4.7	1.1	2.1	0.7	1.1	1.0	3.1	0	0.6	0.9	1.8	2.2	1.5	0	0.3	*A. midwayensis*
0	3.8	3.6	1.1	2.1	1.1	3.0	1.0	1.4	0	0.3	0.6	0.3	0	0.3	0	0	*A. welleri*
18.9	18.4	30.2	22.1	23.6	21.9	29.3	23.5	29	35.7	30.3	30	17.6	21.9	22.1	23.7	29.2	*Cibicidoides alleni*
0	0.9	0	0.2	0	0	0	0	0	0	0	0	0.3	0.3	0.3	0	0	*Nonionella africana*
0.8	0	0.5	0.4	0.4	0.7	0	0.3	0	0.3	0.3	0	0	0	0	0.3	0.3	*N. insecta*
0	0.5	0.5	0.6	1.4	1.8	0	0.3	0.3	0.6	0.6	0.9	0.8	1.3	2.1	0.6	0	*Pullenia quinqueloba*

TABLE 1. Percent abundance of benthic foraminiferal taxa at Hor Ha Har section.

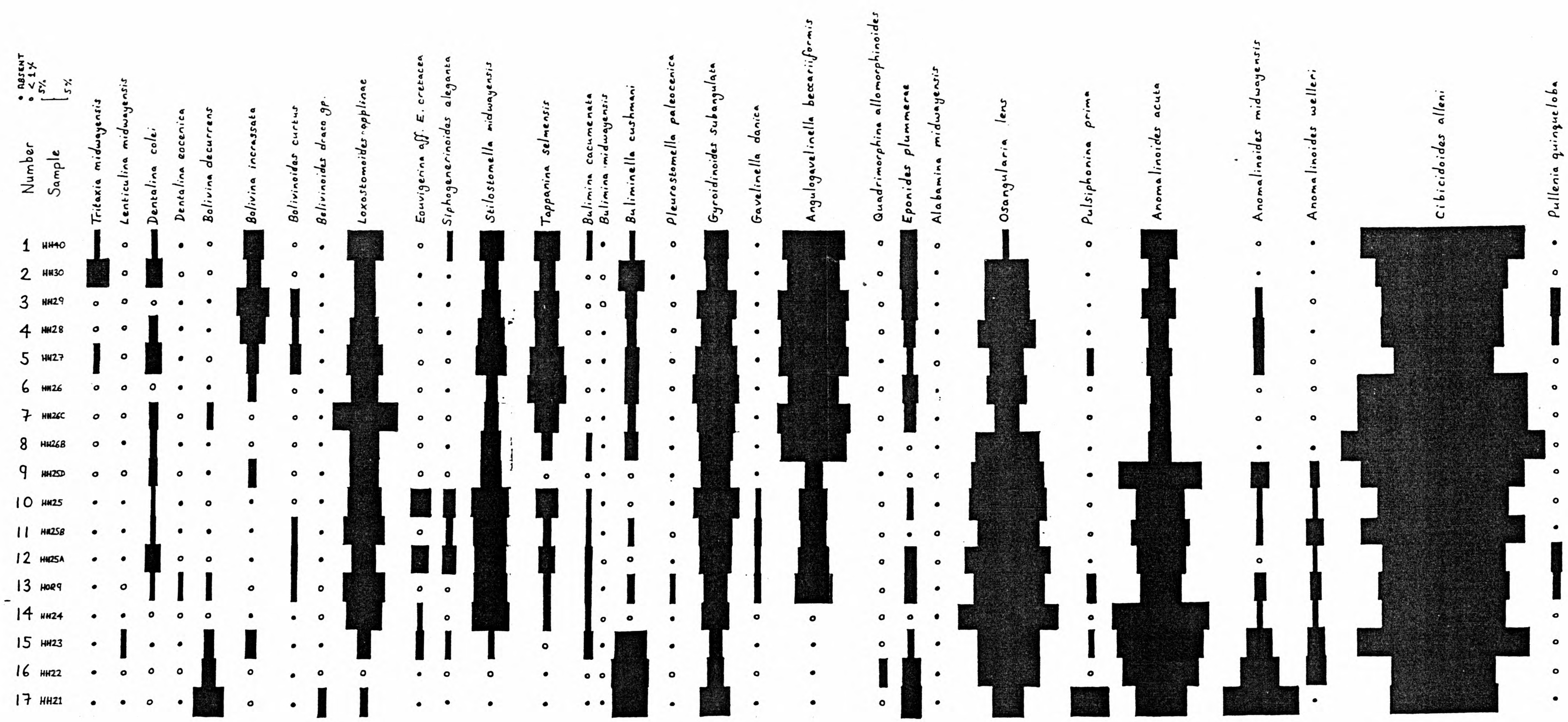


Fig. 5. Frequency distribution of important taxa found at Hor Ha Har section.

K/T

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Number
MOR 17A	MOR 18	MOR 19	MOR 20	EM42	EM43	EM44	EM45	EM46	EM47	EM48	EM49	EM34	EM35	EM36	Sample
209	251	213	211	302	387	356	397	363	317	351	249	416	245	266	Total number counted
0.5	0	0	1.4	0	0	0	0	0	0.3	0.3	0	0.2	0	0	*Bathysiphon* spp.
0	0	0	0	0	0	0	0.5	0	0.6	0.3	0	0.2	0.8	0.4	*Spiroplectammina henryi*
0	0	0	0	0	0	0	0.5	0	0	0	0	0.2	0	0	*Dorothia bulletta*
0	0	0	0.9	0.3	0	0	0	0	0	0	0	0.5	0.4	0.4	*Dorothia pupa*
2.4	5.2	0	3.3	2.3	0.5	0.3	0.5	0.8	0.3	0	0.4	0	0.4	0	*Gaudryina pyramidata*
0	0.4	0	1.4	0.7	0.8	0.3	0.3	0	0	0	0	0.7	2.0	0	*Marssonella oxyconus*
0	0	0	0	0	0	0	0	0	0.3	0	0.4	0	0.8	0.4	*Tritaxia midwayensis*
0	0.4	0.5	0.5	0	0.3	0	0	0	0	0	0	0	0	0.4	*Clavulinoides asper*
0	0	0	0	0	0.3	0	0.3	0	0	0.3	0	0.2	0	0	*Cornuspira polygyra*
0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	*Quinqueloculina* aff. *Q. stelligera*
1.4	0.4	2.3	0	0.3	0	0	1.3	0	0	0	0	0.5	0	0.4	*Lenticulina midwayensis*
2.9	0.4	1.9	1.9	2.0	1.3	0	0	0.6	0.9	1.4	2.0	0.5	0.4	0.8	*Lenticulina* spp.
0.5	0.4	0	1.9	0.3	0.5	0	0	0.6	0.3	0	0	0	0	0.8	*Astacolus* sp.
0.5	0.8	1.4	0.5	0.7	1.3	0.8	1.3	1.4	1.6	1.4	0.8	0.2	0.4	1.1	*Dentalina colei*
0	0	0	0	0.7	0.3	0.3	0.3	0	0	0	0.4	0.5	0	0.4	*Dentalina eocenica*
1.9	0	2.8	1.9	0	0	0.6	0.5	0	0.3	0.3	0.8	0	1.2	1.5	*Dentalina* spp.
0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	*Nodosaria affinis*
0	0.4	0.5	1.9	0	0.8	0.3	0	0	0.3	0	0	0	0.4	0.8	*N. longiscata*
0	0.4	0	0.5	0	0	0	0	0	0	0	0	0	0	0	*N. paupercula*
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	*N. semispinosa*
1.9	1.2	1.4	1.4	1.3	0.5	0	0.3	0.6	0.3	0.3	0	0.5	0.4	0	*Ellipsonodosaria* (?) *granti*
1.4	0	0.5	0	0.7	0	0	0	0	0	0	0	0	0	0.4	*Frondicularia* spp.
1.0	4.0	4.2	3.3	2.6	1.3	1.1	0.8	1.1	0	0.6	0.4	0.7	0.8	1.5	*Lagena apiculata*
1.9	4.4	2.8	2.4	2.0	1.0	0.6	0.5	0.8	1.3	0.3	0	0.5	1.2	1.1	*L. globosa*
0.5	0.8	0	0	1.0	0.3	0.3	0.3	0.3	0.3	0	0	0.2	0.4	0.8	*L. hispida*
0.5	0.4	1.4	0.9	0.3	0	0.3	0	0	0.3	0	0.4	0.2	0.8	0	*L. sulcata*
0	0	0	0.5	0.7	0.5	0	0	0	0.3	0.3	0	0	0	0.4	*Guttulina* spp.
0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	*Ramulina* spp
1.0	0.8	2.3	2.4	1.3	2.1	2.0	0.8	0.6	0.6	0.9	0	0.7	0.8	1.1	*Bolivina decurrens*
1.0	5.6	6.1	1.9	1.3	1.3	2.0	4.8	2.8	0.9	1.4	0	6.7	2.4	6.0	*B. incrassata*
0	0	0	0	1.0	2.6	3.9	1.8	1.7	2.5	3.1	0.8	2.6	0.4	0.8	*Bolivinoides curtus*
3.8	2.0	0.5	0.9	1.0	0.3	0.3	0	0	0	0	0	0	0	0	*B. draco* gr.
3.3	2.8	3.3	1.9	3.6	6.7	6.5	6.6	5.5	5.4	6.0	2.4	3.1	2.9	3.0	*Loxostomoides applinae*
10.5	0.4	1.4	0.5	0.7	0.8	1.1	1.5	0.8	2.2	5.7	2.8	2.2	0.4	1.1	*Eouvigerina* aff. *E. cretacea*
0	0	0	0.5	1.0	0.5	0.3	0.5	0.6	0	0.3	0.4	0	0	0	*Siphogenerinoides elegante*
1.4	0.8	1.9	3.8	3.6	1.6	7.6	6.3	4.7	2.5	2.6	4.4	6.0	3.7	4.9	*Stilostomella midwayensis*
0	1.2	0.5	1.4	1.3	1.6	3.4	4.3	2.8	2.5	1.7	2.8	4.6	4.5	4.5	*Tappanina selmensis*
0.5	0.8	0.9	1.9	1.3	2.6	2.5	2.8	1.1	5.7	6.6	3.6	1.4	2.4	0.8	*Bulimina cacumenata*
0	0.4	1.4	0.5	2.0	0	0	0.3	0	0	0.6	0	0	0	0	*B. midwayensis*
6.7	6.8	12.2	8.5	5.0	2.3	1.4	3.3	1.4	1.3	1.7	0.8	1.4	0.8	1.1	*Buliminella cushmani*
0	0	0	0.5	1.3	1.8	0.6	1.8	0.6	0.6	0.9	2.0	0.7	0.4	0.4	*Pleurostomella paleocenica*
1.0	0.8	0	0	0	0	0	0	0.3	0	0	0	0.2	0	0.8	*Fissurina* sp.
0.5	0.8	0	0.5	0.3	0	0	0.5	0.3	0	0	0	0.2	0	0	*Gyroidina planulata*
6.2	6.8	2.8	7.6	6.6	6.5	7.3	8.1	6.1	6.0	4.8	3.6	2.6	2.4	3.8	*Gyroidinoides subangulata*
0	0.8	1.4	0	1.7	0.3	0.3	0	0	0	0	0.4	0	0	0	*Gavelinella danica*
0	0	0	0.9	3.3	1.8	6.5	10.1	20.7	14.5	14.8	23.3	25.5	28.2	26.7	*Angulogavelinella beccariiformis*
1.9	0.4	1.9	0.5	0	0.3	0.3	0.5	0.6	0.3	0.9	0.8	0.5	0	0.4	*Quadrimorphina allomorphinoides*
0	0.8	0.9	0.9	0.7	0.3	0	0.3	0.3	0	0	0	0.7	1.2	0	*Valvulineria aegyptiaca*
3.8	1.2	5.6	1.4	2.0	0	1.7	1.8	2.2	3.8	0.9	2.8	1.2	1.6	4.5	*Eponides plummerae*
0	0	0.5	0	0.3	0	0	0	0	0	0	0	0	0	0	*Nuttallides* sp
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	*Alabamina midwayensis*
8.6	11.6	8.9	7.1	8.3	5.9	13.2	9.6	8.0	10.7	15.7	17.3	5.8	7.3	7.1	*Osangularia lens*
2.9	0.4	0	3.3	0.3	0.3	0	0	0.3	0	0	0	0	0	0.4	*Pulsiphonina prima*
6.7	8.0	6.1	7.6	5.0	8.8	7.9	5.8	6.9	9.1	9.7	6.4	3.8	4.1	2.3	*Anomalinoides acuta*
7.2	5.2	4.7	1.4	1.3	0.8	2.3	1.0	1.1	0.3	0.9	0.4	0.2	0	1.1	*A. midwayensis*
1.4	1.2	0.9	0	0	1.0	0.6	0.3	0.6	1.3	0.3	1.2	0.2	0.4	0	*A. welleri*
11.0	19.9	15.0	17.1	26.5	37.7	23.1	19.7	24.0	20.8	14.2	18.1	22.1	24.5	15.4	*Cibicidoides alleni*
0.5	0	0	0	0	0.3	0	0	0.3	0	0.3	0	0.2	0	0.4	*Nonionella africana*
0.5	0.4	0	0	0.7	0.5	0.3	0.3	0	0	0	0	0	0	0	*N. insecta*
1.9	1.2	1.4	0.9	1.3	2.1	0.3	0.8	0.8	1.3	0	0.4	1.0	0.8	1.1	*Pullenia quinqueloba*

TABLE 2. Percent abundance of benthic foraminiferal taxa at EinMor section.

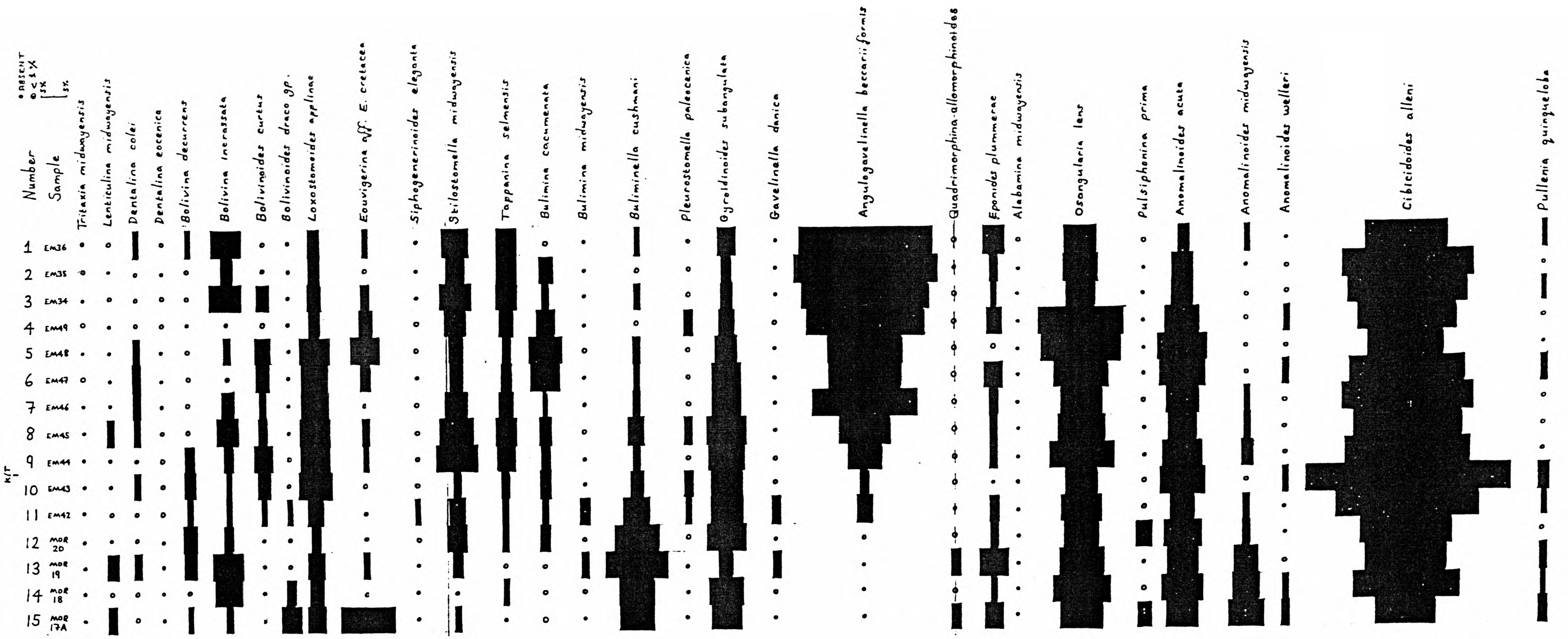
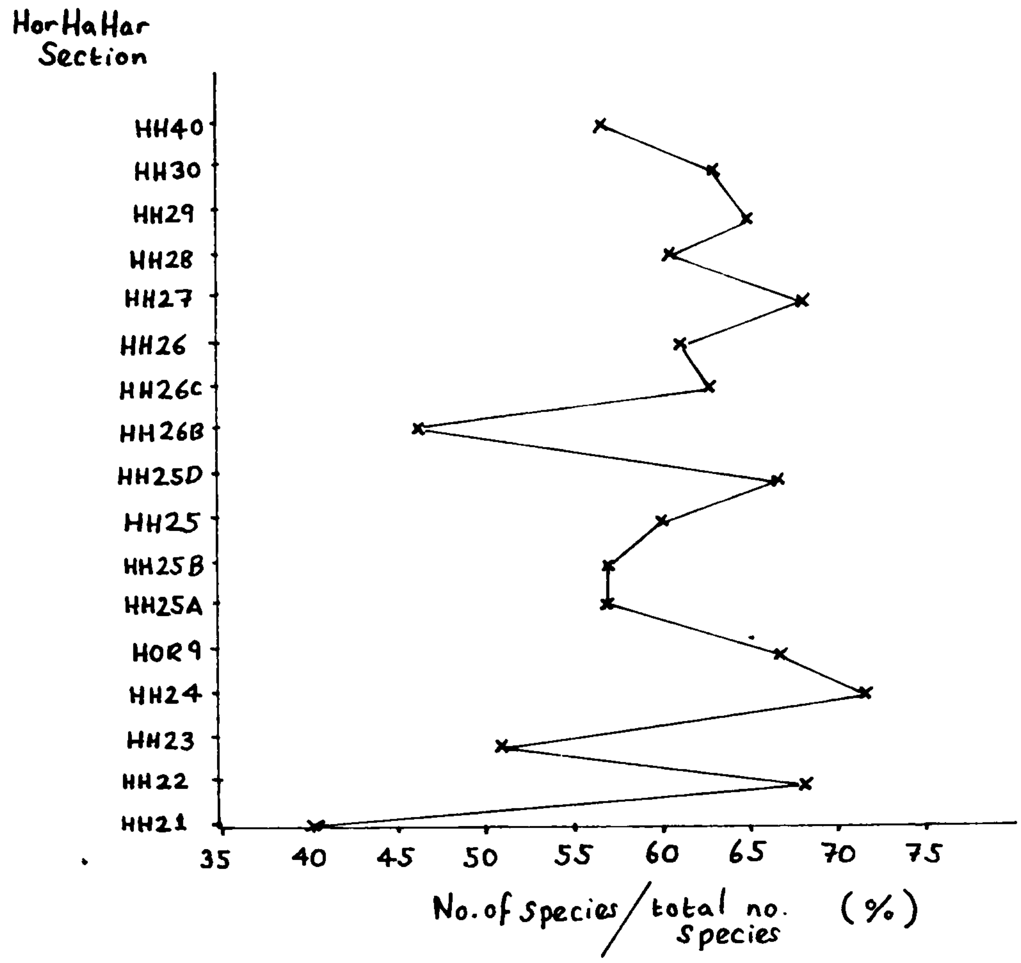


Fig. 6. Frequency distribution of important taxa found at Ein Mor Section.



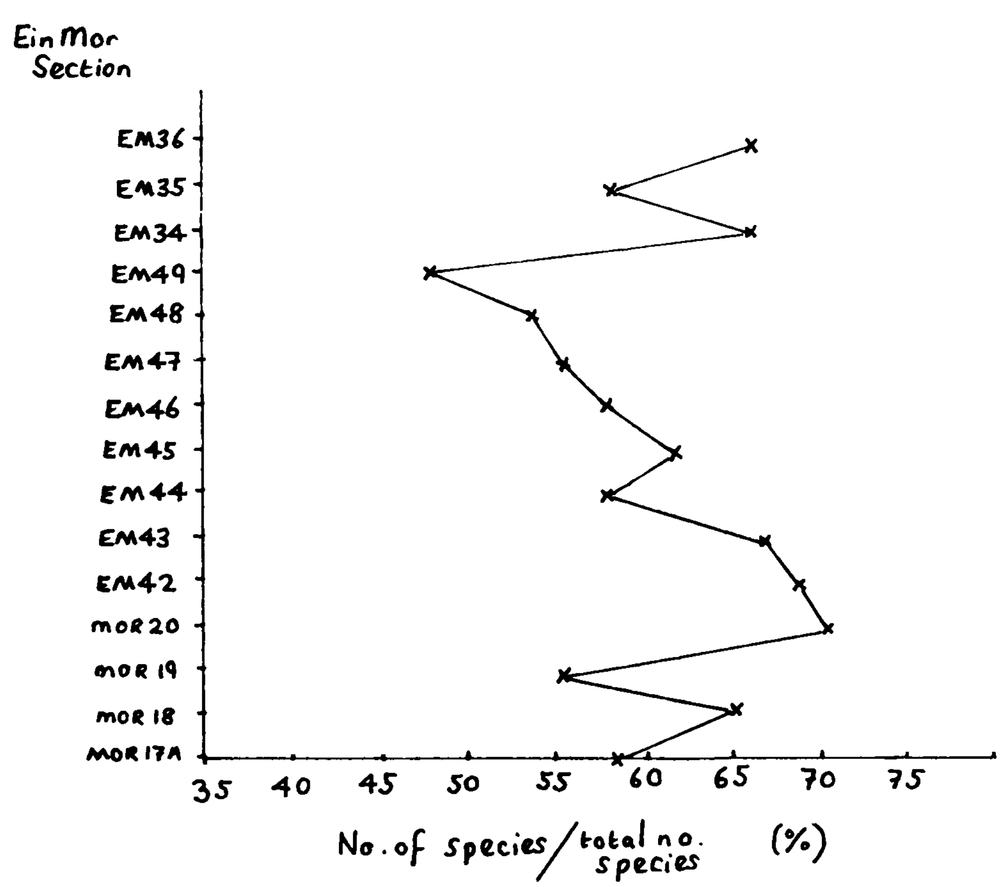
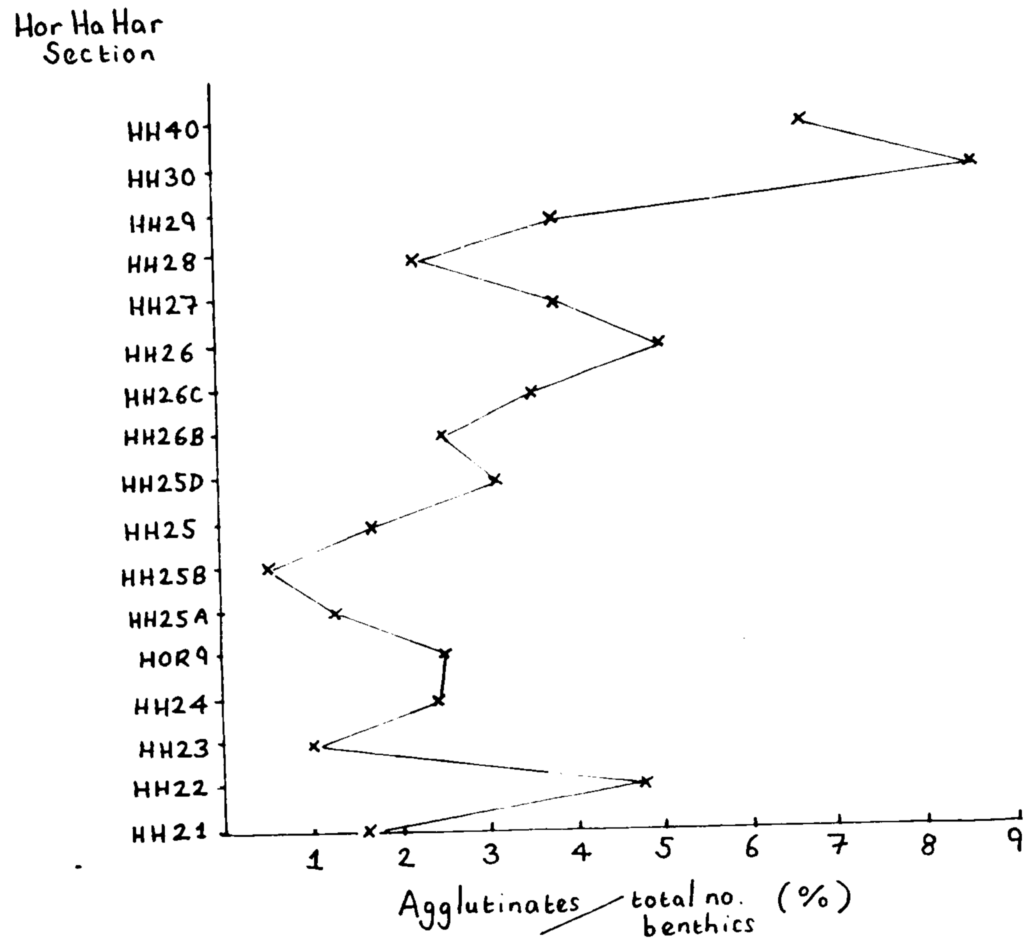


Fig. 7. Species diversity of benthonic foraminifera at Hor HaHar and Ein Mor.



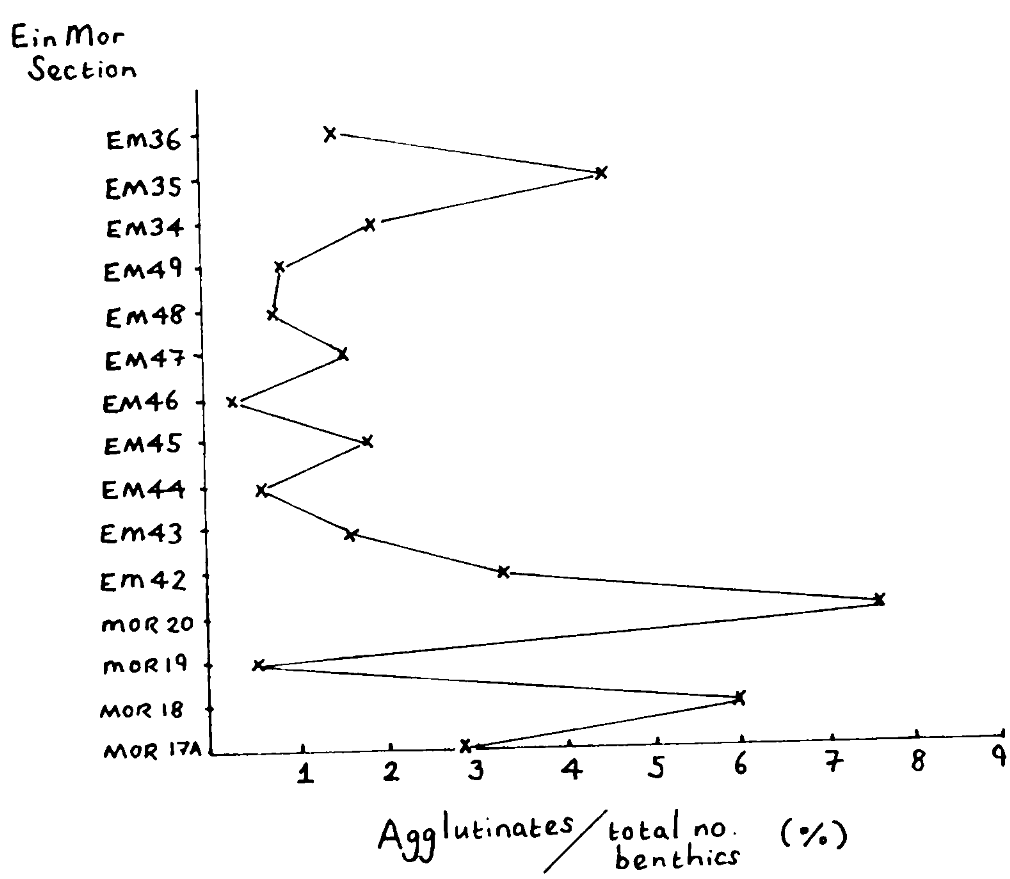


Fig. 8. Percent abundance of agglutinated benthonic foraminifera at Hor Ha Har and Ein Mor.

14. FURTHER WORK

There was only time to examine 2 sections (EM and HH) crossing the K/T boundary in Israel. A cursory examination was made of 3 sections from southern Israel, which showed excellent preservation and typical Midwayan type fauna. 2 other sections were sampled from northern Israel, which showed poor preservation, but contained Midwayan assemblages.

It would be interesting to analyse these sections within a general biostratigraphic framework, as well as others as yet unsampled from further north in Israel to give a comprehensive view, evaluate any regional palaeoecological differences, and verify that the Midwayan fauna does appear beneath the K/T boundary at all sites.

At EM and HH, it is important to analyse the samples further down in the sections to discover exactly when the Midwayan fauna first appears, en masse or different species at different times.

15. CRITICISMS

The scale of the project to begin with was meant to include all the 7 sections, but this was unrealistic in terms of the time available, and it was necessary to limit the project to only the sections EM and HH for which much background information and a biostratigraphic framework existed.

However it was intended by concentrating on the 2 sections that a clearer scenario could be transmitted. Evidence from the other sections would be difficult to relate to EM and HH if the K/T boundary and biostratigraphic framework were nebulous, especially since the Midwayan fauna does not define the base of the Danian in Israel.

In retrospect, a number of species recovered were not illustrated which were not considered significant, typically Midwayan or abundant at the time, but a few should have been included e.g. *Tritaxia midwayensis* and *Lenticulina midwayensis*. These can be seen clearly displayed by Berggren and Aubert (1975).

16. CONCLUSIONS

The HH and EM sections in the Zin Valley (southern Israel) appear to a degree sheltered from events taking place in the open Tethys, allowing the development of a Midway fauna beneath the defined K/T boundary. After the boundary, a Velasco-type element occurs, notably the presence of Angulogavelinella beccariiformis which may indicate a slight increase in depth towards the outer shelf range.

Some Maastrichtian benthonic forms appear to survive into the Danian, which must be interpreted as a special feature of this region. The Midwayan fauna is most similar to assemblages from Egypt, sharing some species only known from Egypt.

It must be remembered that in Israel there appears to be section recorded below the K/T boundary, containing the 'Danian' planktonic foraminifer 'G.' eugubina, not known from other sections, which gives this area the possibility for local evolution of forms which may eventually have migrated to the open sea to become part of the characteristic fauna of the Early Tertiary.

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All faunal slides and residues deposited at Hull University Geology Dept.

Specimens from plates in faunal slide HU.341, under following no.'s
T. 1-56

No. Species	SPECIES	BOX NUMBER(S)	PLATE NUMBER
1	*Gaudryina pyramidata* Cushman	1	PL 1, A
2	*Spiroplectammina henryi* Le Roy	2	PL 1, B
3	*Siphogenerinoides eleganta* (Plummer)	3	PL 1, C
4	*Lagena globosa* (Montagu)	4	PL 1, D
5	*Lagena sulcata* (Walker and Jacob)	5	PL 1, E
6	*Lagena hispida* Reuss	6	PL 1, F
7	*Lenticulina spp.*	7 - 9	PL 1, G,H,I
8	*Dentalina colei* Cushman and Dusenbury	10	PL 2, A
9	*Dentalina eocenica* Cushman	11	PL 2, B
10	*Frondicularia sp* ORIGINAL LOST REPLACED FROM EM42	12	PL 2, C
11	*Dentalina sp.*	13	PL 2, D
12	*Quinqeloculina sp aff. Q. stelligera* Schlumberger	14	PL 2, E
13	*Cornuspira polygyra* Reuss	15	PL 2, F
14	*Pleurostomella paleocenica* Cushman	16	PL 2, G
15	*Stilostomella midwayensis* (Cushman and Todd)	17	PL 2, H
16	*Eouvigerina sp. aff. E. cretacea* (Heron-Allen and Earland)	18	PL 3, A
17	*Loxostomoides applinae* (Plummer)	19	PL 3, B
18	*Nonionella africana* Le Roy	20	PL 3, C
19	*Tappanina selmensis* (Cushman)	21	PL 3, D
20	*Bulimina cacumenata* Cushman and Parker	22	PL 3, E
21	*Buliminella cushmani* Sandidge	23	PL 3, F
22	*Bolivina decurrens* (Ehrenberg)	24	PL 3, G
23	*Bolivinoides draco draco* (Marsson)	25	PL 4, A
24	*Bolivinoides draco dorreeni* Finlay	26	PL 4, B
25	*Bolivinoides curtus* Reiss	27	PL 4, C
26	*Bolivina incrassata* Reuss	28, 29, 32	PL 4, D,E,H
27	*Bulimina midwayensis* Cushman and Parker	30, 31	PL 4, F,G
28	*Fissurina sp.*	33	PL 5, A
29	*Pulsiphonina prima* (Plummer)	34, 35	PL 5, B,C
30	*Eponides plummerae* Cushman	36, 37	PL 5, D,E
31	*Osangularia lens* Brotzen	38, 39	PL 5, F,G
32	*Valvulineria aegyptiaca* Le Roy	40	PL 5, H
33	*Gyroidinoides subangulata* (Plummer)	41 - 43	PL 6, A-C
34	*Quadrimorphina allomorphinoides* (Reuss)	44	PL 6, D
35	*Pullenia quinqueloba* (Reuss)	45	PL 6, E
36	*Alabamina midwayensis* Brotzen 1 SPECIMEN LOST	47	PL 6, G
37	*Angulogavelinella beccariiformis* White	48	PL 6, H
38	*Anomalinoides welleri* (Plummer)	49, 50	PL 7, A,B
39	*Gavelinella danica* (Brotzen)	51	PL 7, C
40	*Cibicidoides alleni* (Plummer)	52, 53	PL 7, D,E
41	*Anomalinoides acuta* (Plummer)	54, 55	PL 7, F,G
42	*Anomalinoides midwayensis* (Plummer)	56	PL 7, H

PLATE 1

A. <u>Gaudryina</u> <u>pyramidata</u> Cushman X225, EM42

B. <u>Spiroplectammina</u> <u>henryi</u> LeRoy X225, HH40

C. <u>Siphogenerinoides</u> <u>eleganta</u> (Plummer) X225, HH24

D. <u>Lagena</u> <u>globosa</u> (Montagu) X225, HH28

E. <u>Lagena</u> <u>sulcata</u> (Walker and Jacob) X225, EM42

F. <u>Lagena</u> <u>hispida</u> Reuss X250, HH30

G. <u>Lenticulina</u> sp. X250, EM48

H. <u>Lenticulina</u> sp. X225, HH29

I. <u>Lenticulina</u> sp. X225, HH29

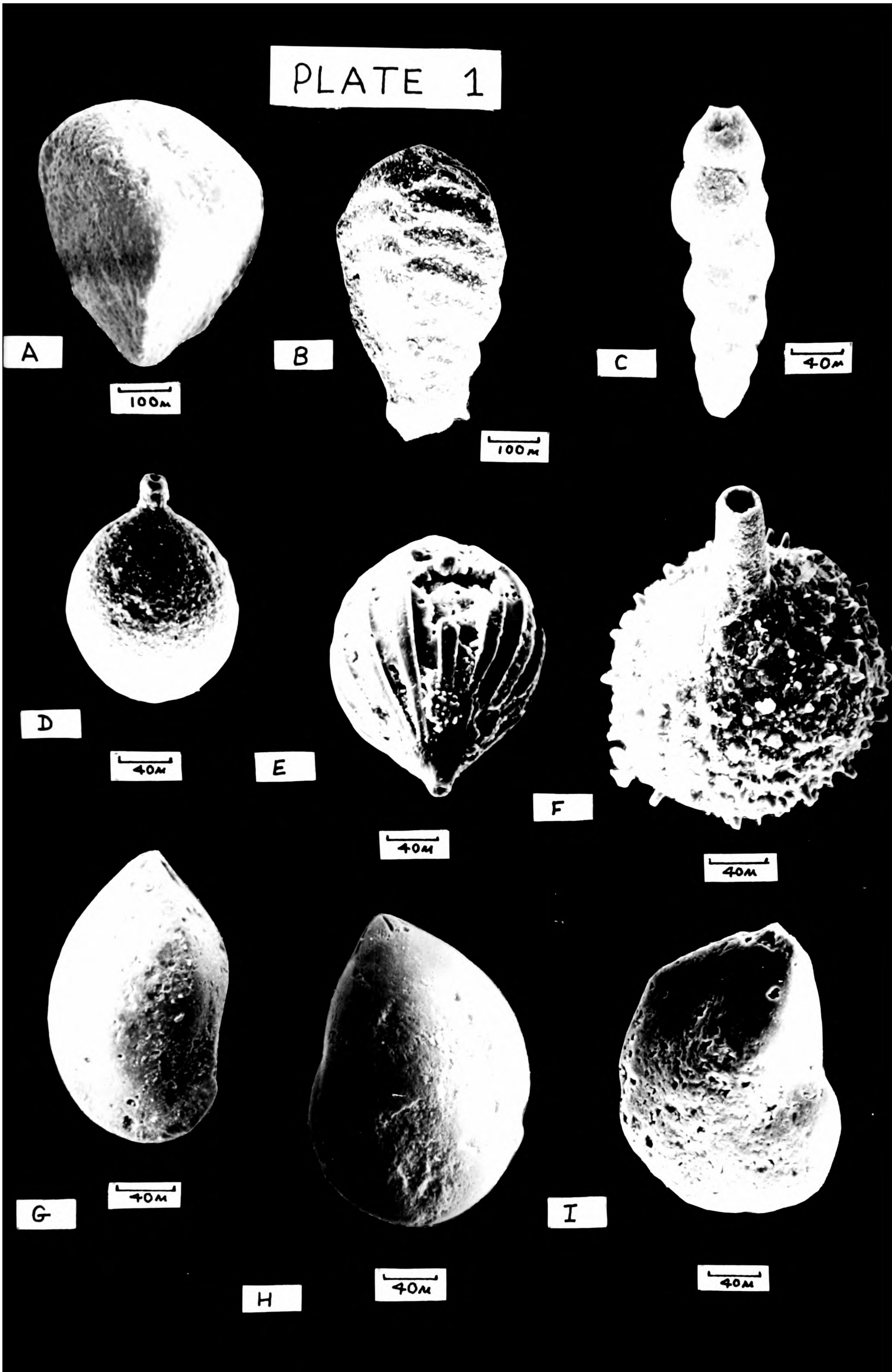
PLATE 1
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PLATE 2

A. *Dentalina colei* Cushman and Dusenbury X70, HH30

B. *Dentalina eocenica* Cushman X90, HOR9

C. *Frondicularia* sp. X70, MOR 17A

D. *Dentalina* sp. X225, HH28

E. *Quinqueloculina* sp. aff. *Q. stelligera* Schlumberger X100, HH25

F. *Cornuspira polygyra* Reuss X100, EM43

G. *Pleurostomella paleocenica* Cushman X225, HH27

H. *Stilostomella midwayensis* (Cushman and Todd) X225, HH24

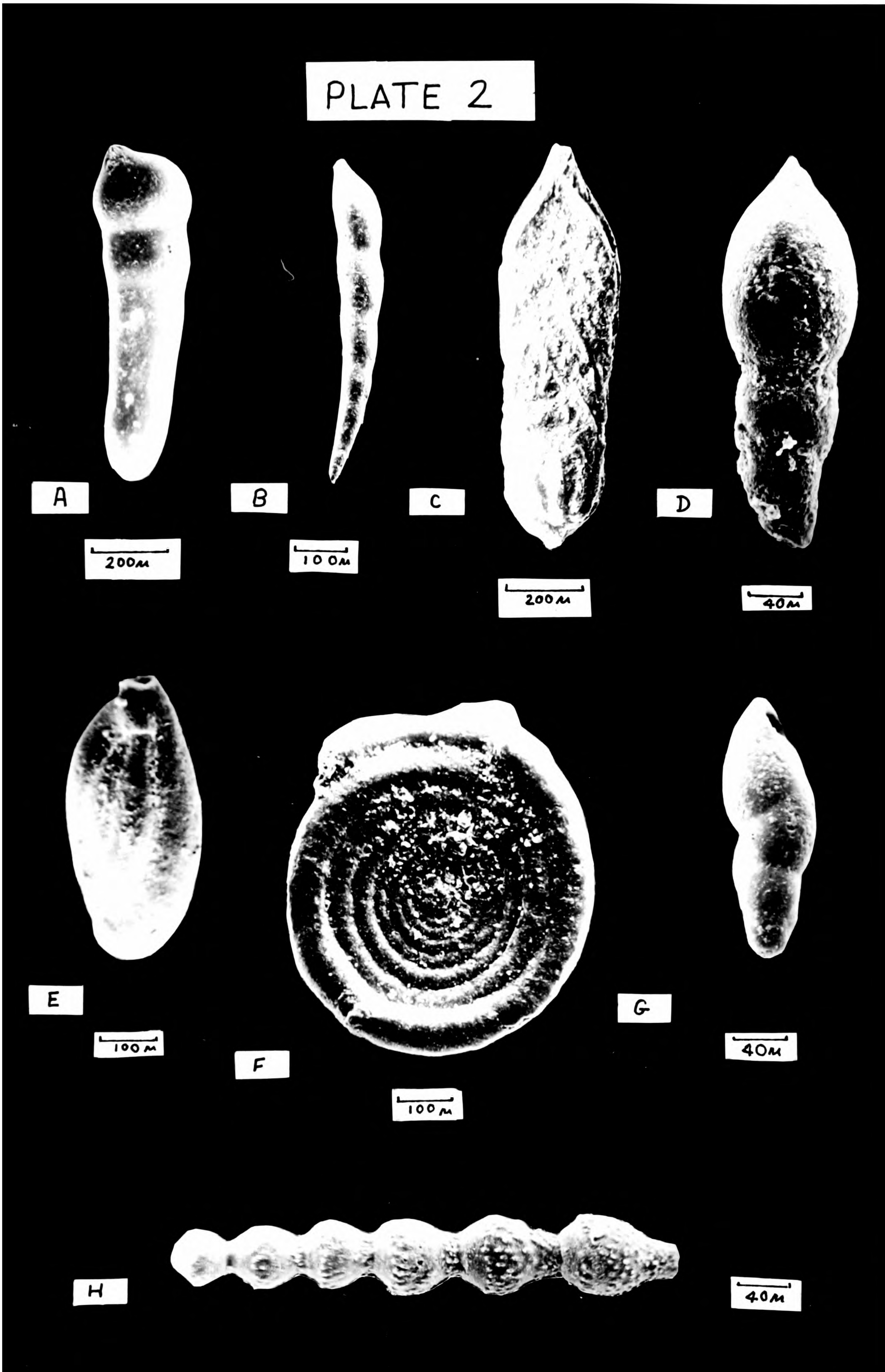
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PLATE 3

A. *Eouvigerina* sp. aff. *E. cretacea* (Heron-Allen and Earland) X225, EM48

B. *Loxostomoides applinae* (Plummer) X90, HH24

C. *Nonionella africana* LeRoy X300, EM48

D. *Tappanina selmensis* (Cushman) X300, HH27

E. *Bulimina cacumenata* Cushman and Parker X275, HH24

F. *Buliminella cushmani* Sandidge X225, HH26B

G. *Bolivina decurrens* (Ehrenberg) X225, HH27

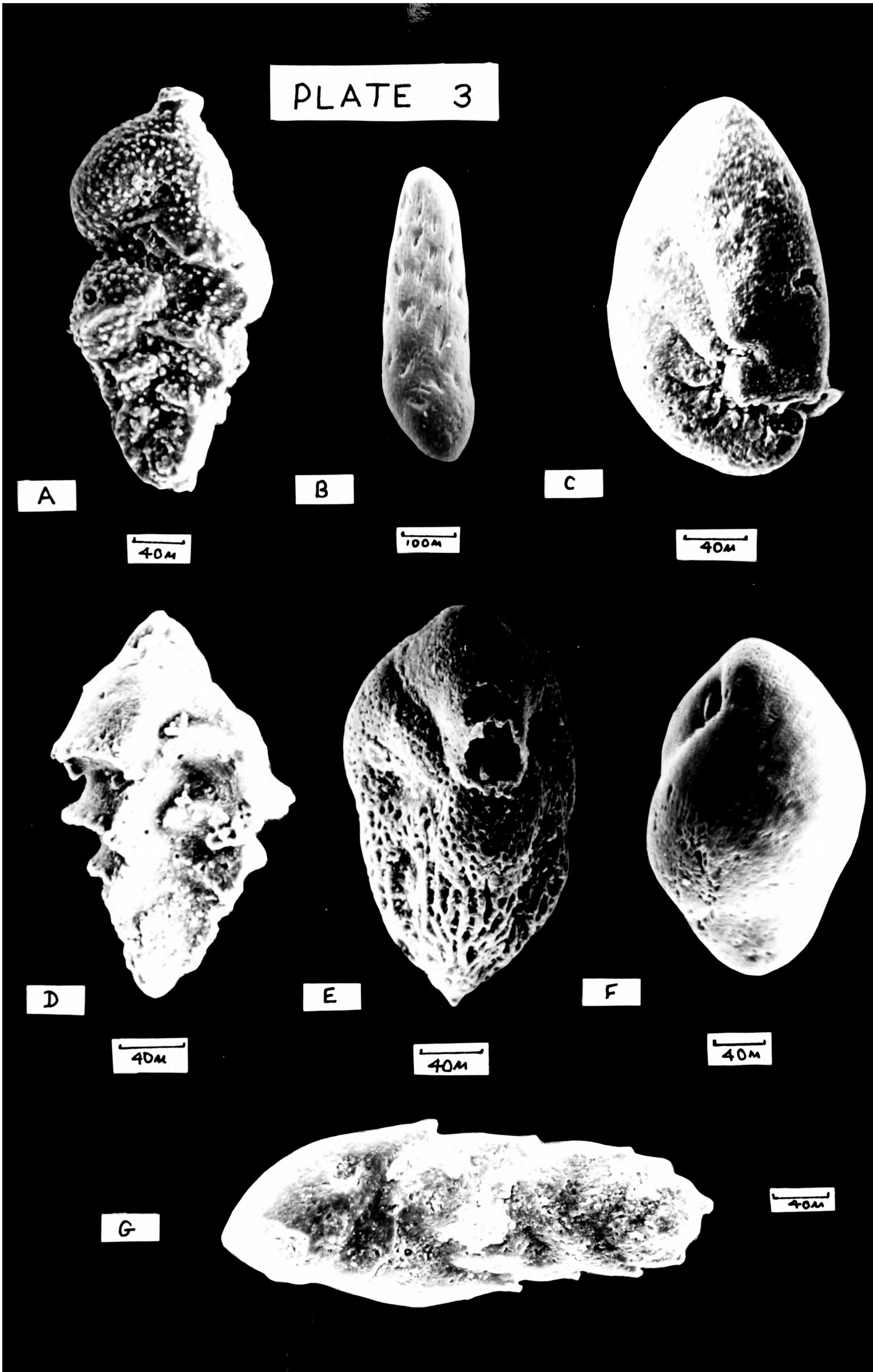
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PLATE 4

A. Bolivinoides draco draco (Marsson) X225, MOR 18

B. Bolivinoides draco dorreeni Finlay X80, MOR 20

C. Bolivinoides curtus Reiss X225, HH27

D, E. Bolivina incrassata Reuss

- D. X90, HH27
- E. X225, MOR 19

F, G. Bulimina midwayensis Cushman & Parker X225

- F. HH29
- G. HH25A

H. Bolivina incrassata Reuss X110, HH28

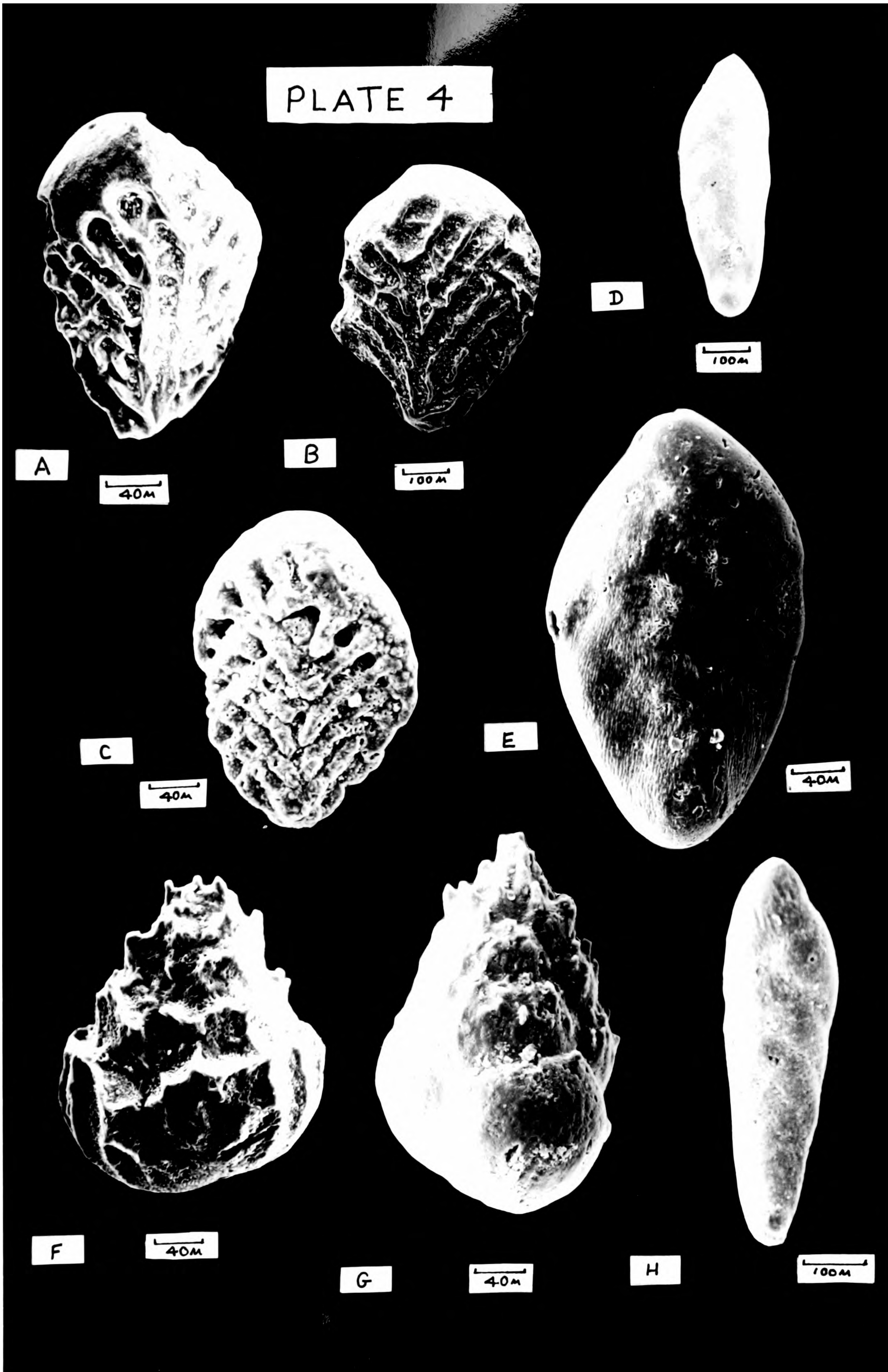
PLATE 4
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PLATE 5

A. *Fissurina* sp. X300, EM36

B, C. *Pulsiphonina prima* (Plummer) X275

B. Ventral view, EM36

C. Dorsal view, HH21

D, E. *Eponides plummerae* Cushman

D. Dorsal view, X225, HH22·

E. Ventral view, X275, HH26

F, G. *Osangularia lens* Brotzen X225, HH24

F. Ventral view

G. Dorsal view

H. *Valvulineria aegyptiaca* LeRoy

Ventral view, X90, HH24

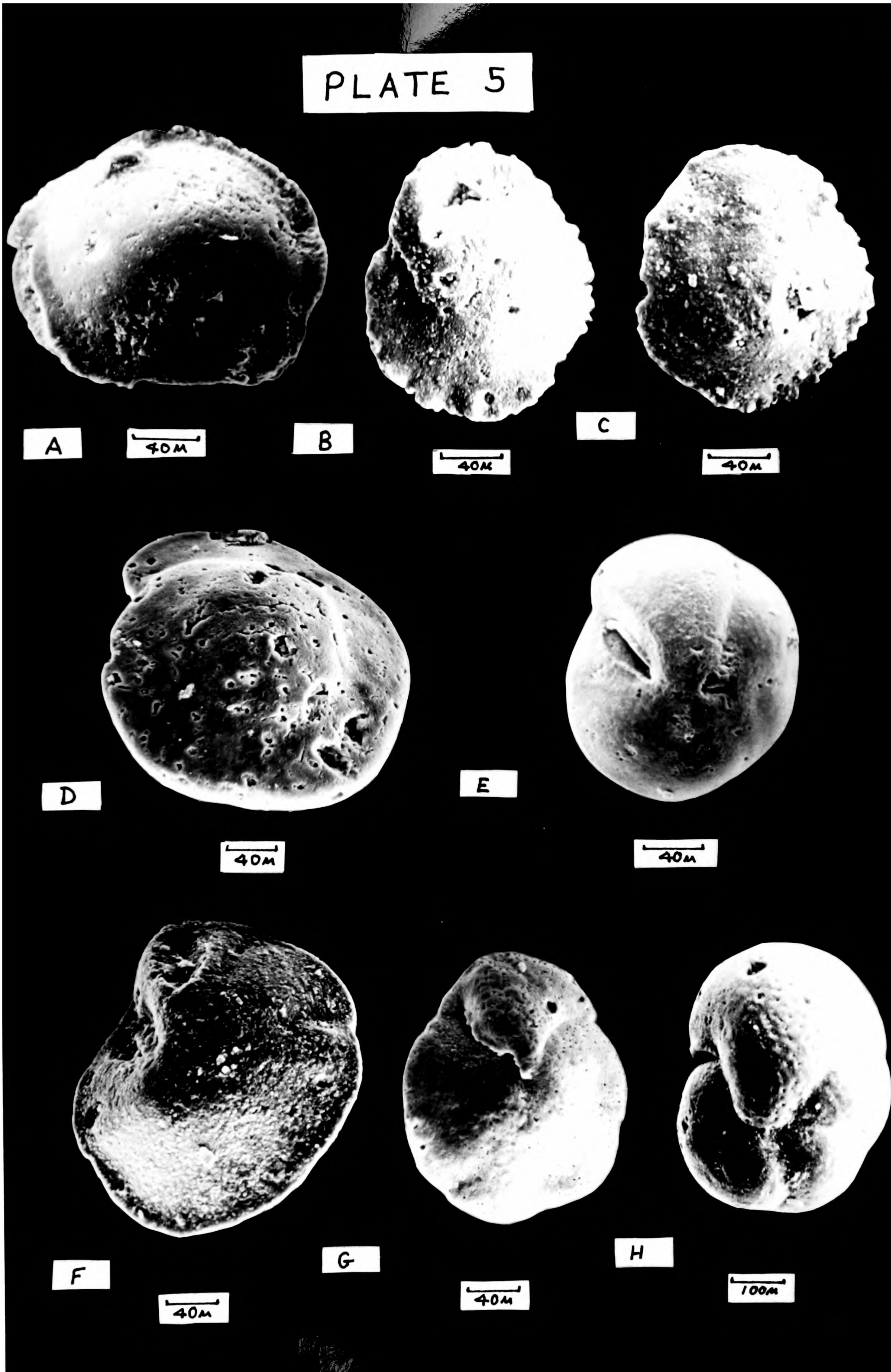

PLATE 5
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PLATE 6

A - C. Gyroidinoides subangulata (Plummer) X140, HH24

A. Dorsal view

B. Ventral view

C. Profile

D. Quadrimorphina allomorphinoides (Reuss) X200, HH22

E. Pullenia quinqueloba (Reuss) X225, HH29

F, G. Alabamina midwayensis Brotzen X225

F. Ventral view, HH25B

G. Dorsal view, HH25D

H. Angulogavelinella beccariiformis White

Ventral view X120, HH27

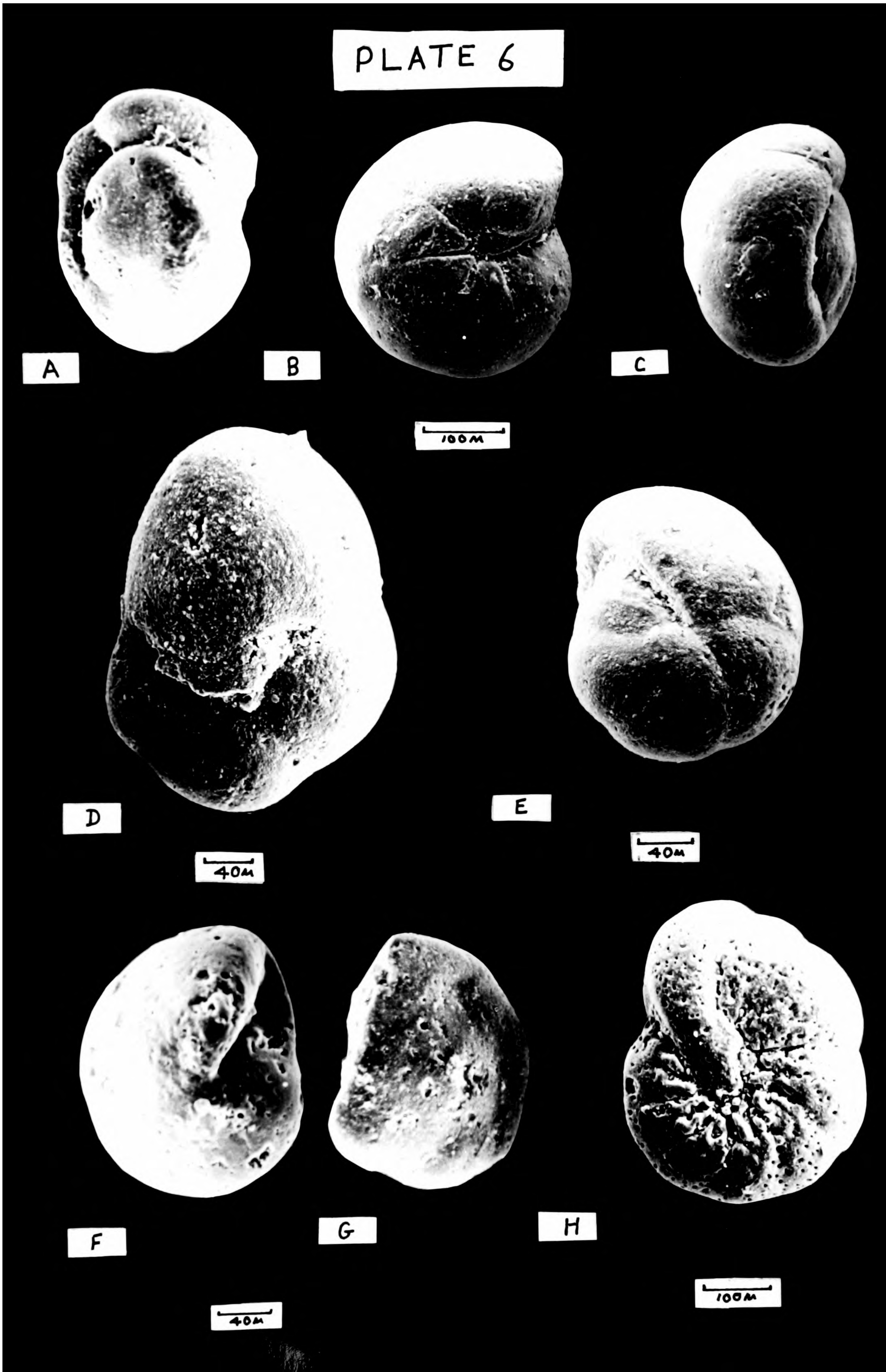
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PLATE 7

A, B. Anomalinoides welleri (Plummer)

A. Ventral view, X250, HH24

B. Dorsal view, X90, HH22

C. Gavelinella danica (Brotzen) X225, HH25

D, E. Cibicidoides alleni (Plummer) X90, HH24

D. Ventral view

E. Dorsal view

F, G. Anomalinoides acuta (Plummer), HH24

F. Dorsal view, X120

G. Ventral view, X90

H. Anomalinoides midwayensis (Plummer)

Ventral view, X225, HOR9

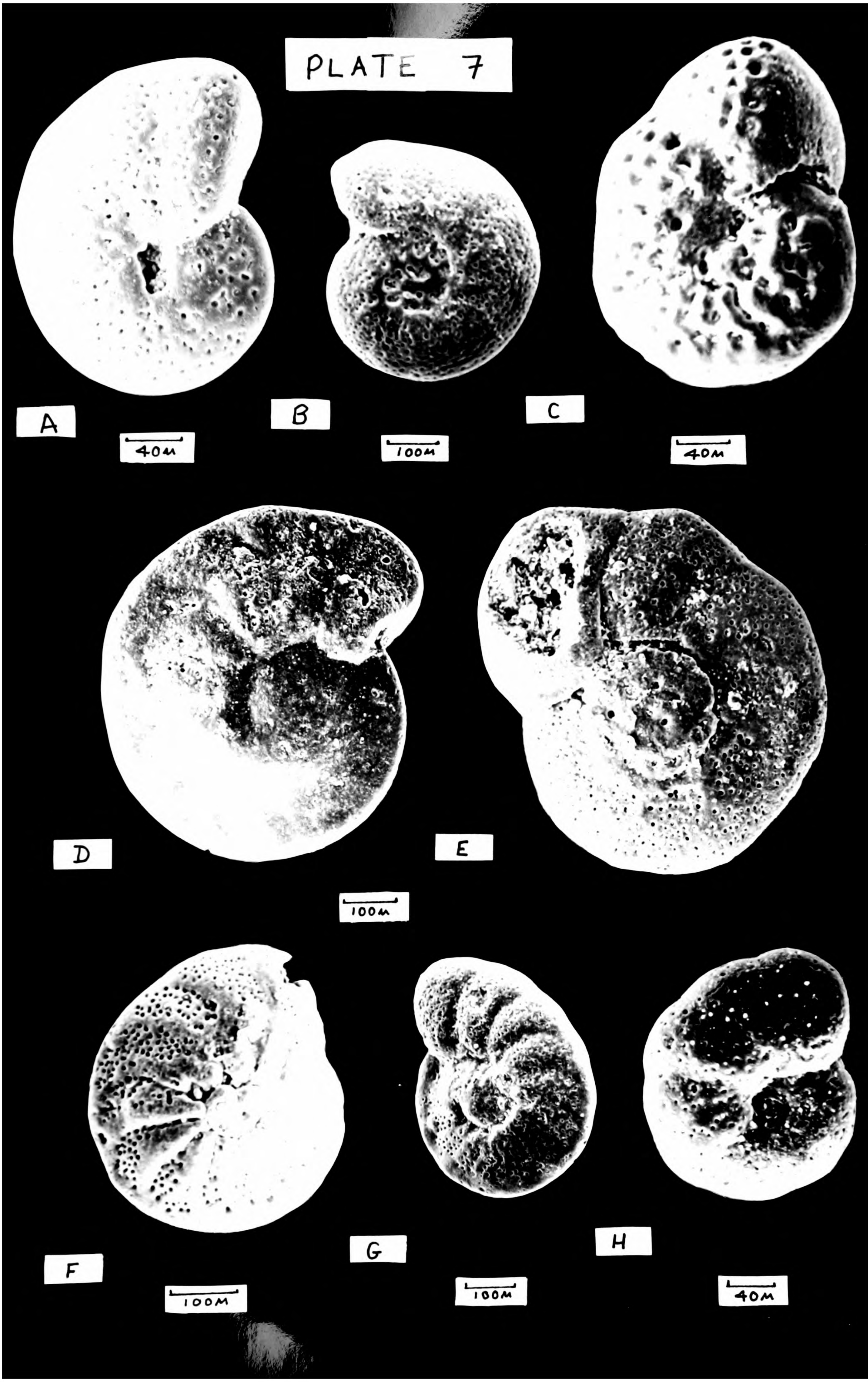
PLATE 7
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17	16	15	K/T 14	13	12	11	10	9	8	7	6	5	4	3	2	1	Number
HH21	HH22	HH23	HH24	HOR9	HH25A	HH25B	HH25	HH25D	HH26B	HH26C	HH26	HH27	HH28	HH29	HH30	HH40	Sample
127	212	192	542	281	283	263	302	293	322	333	323	397	315	339	359	312	Total number counted
1	3	1	12	1	0	1	1	3	0	0	1	0	0	1	1	0	*Bathysiphon spp.*
0	0	0	0	0	0	0	0	1	2	0	1	1	0	1	5	16	*Spiroplectammina henryi*
0	0	0	0	0	1	0	0	1	0	0	1	1	0	2	0	0	*Dorothia bulletta*
0	0	0	0	0	1	0	1	0	1	1	3	1	4	3	0	0	*Dorothia pupa*
1	6	1	0	2	2	0	0	0	0	1	1	3	2	2	4	2	*Gaudryina pyramidata*
0	0	0	1	4	0	0	2	1	3	6	7	5	0	3	7	0	*Marssonella oxyconus*
0	0	0	0	0	0	0	0	2	2	3	2	4	1	1	14	3	*Tritaxia midwayensis*
0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	*Clavulinoides asper*
0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	*Cornuspira polygyra*
0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	*Quinqueloculina aff. Q. stelligera*
0	1	2	0	2	0	0	0	1	0	2	1	2	2	1	1	2	*Lenticulina midwayensis*
4	3	5	5	4	5	5	1	3	3	3	5	7	4	13	11	15	*Lenticulina spp.*
0	0	0	1	0	0	0	2	2	0	0	0	0	0	0	3	0	*Astacolus sp.*
1	1	0	3	3	7	3	3	5	5	6	3	12	5	1	10	3	*Dentalina colei*
0	1	0	1	3	2	0	0	2	0	1	0	0	0	0	2	0	*Dentalina eocenica*
4	2	0	6	0	1	2	3	1	3	5	1	4	6	2	6	1	*Dentalina spp.*
0	0	0	1	1	0	0	0	1	1	0	0	2	1	0	0	2	*Nodosaria affinis*
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0	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	*N. paupercula*
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0	1	2	1	4	0	1	0	2	3	1	0	3	3	2	1	0	*Ellipsonodosaria (?) granti*
0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	*Frondicularia spp.*
4	6	2	5	3	4	4	4	6	4	3	8	9	4	4	5	3	*Lagena apiculata*
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3	1	0	2	0	0	1	0	0	0	0	0	0	0	1	6	1	*L. hispida*
1	1	2	0	2	0	1	4	0	4	0	1	2	1	0	2	0	*L sulcata*
1	0	0	0	0	0	0	0	1	0	0	0	1	0	2	2	1	*Guttulina spp.*
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7	5	4	4	3	1	0	1	0	0	4	0	3	0	0	1	1	*Bolivina decurrens*
1	2	4	0	1	0	0	0	4	3	3	5	8	15	19	9	11	*B. incrassata*
0	0	0	0	3	3	3	1	2	1	1	3	8	4	5	3	2	*Bolivinoides curtus*
2	1	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	*B. draco gr.*
2	1	5	36	21	13	20	19	16	18	39	16	27	16	14	15	20	*Loxostomoides applinae*
0	0	3	6	1	9	2	11	2	2	1	2	2	1	0	0	2	*Eouvigerina aff. E. cretacea*
0	2	2	5	1	7	3	7	2	0	2	0	2	0	0	0	3	*Siphogenerinoides elegante*
0	1	2	37	17	17	17	21	12	13	9	8	22	15	12	9	15	*Stilostomella midwayensis*
0	0	1	8	4	8	4	12	2	6	16	22	24	14	16	11	15	*Tappanina selmensis*
0	2	3	7	4	4	3	3	1	4	1	3	3	1	1	1	4	*Bulimina cacumenata*
0	2	0	1	0	2	0	0	0	0	0	0	0	0	1	1	0	*B. midwayensis*
8	14	11	1	4	1	3	2	1	8	5	8	10	6	8	17	3	*Buliminella cushmani*
0	2	0	0	3	0	1	0	0	0	0	3	1	2	1	0	2	*Pleurostomella paleocenica*
0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	*Fissurina sp.*
0	5	3	6	1	0	0	0	0	0	0	0	0	1	0	0	0	*Gyroidina planulata*
7	6	5	27	13	16	16	26	16	20	23	27	30	17	24	14	15	*Gyroidinoides subangulata*
0	1	0	2	3	3	4	4	0	0	0	0	0	0	0	0	0	*Gavelinella danica*
0	0	0	1	19	15	12	15	9	38	44	30	51	38	44	34	35	*Angulogavelinella beccariiformis*
1	3	1	2	0	1	1	1	0	0	1	1	0	1	1	2	1	*Quadrimorphina allomorphinoides*
0	1	0	10	0	3	2	1	4	3	4	7	4	4	2	7	0	*Valvulineria aegyptiaca*
5	8	2	4	5	5	0	3	2	3	7	8	5	7	9	12	10	*Eponides plummerae*
4	3	1	3	0	0	1	0	0	0	1	0	0	0	0	0	0	*Nuttallides sp*
0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	1	*Alabamina midwayensis*
7	23	21	97	36	44	29	43	40	37	15	23	24	33	28	30	3	*Osangularia lens*
9	2	2	1	4	0	1	1	1	0	1	1	5	0	0	0	1	*Pulsiphonina prima*
12	28	29	90	20	24	27	26	43	13	13	12	19	13	21	15	20	*Anomalinoides acuta*
17	14	9	6	6	2	3	3	9	0	2	3	7	7	5	0	1	*A. midwayensis*
0	8	7	6	6	3	8	3	4	0	1	2	1	0	1	0	0	*A. welleri*
24	39	58	120	66	62	77	71	85	115	101	97	70	69	75	85	91	*Cibicidoides alleni*
0	2	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	*Nonionella africana*
1	0	1	2	1	2	0	0	1	0	1	1	0	0	0	1	1	*N. insecta*
0	1	1	3	4	5	0	1	1	2	2	3	3	4	7	2	0	*Pullenia quinqueloba*

Appendix 1. Raw data: abundance of benthonic foraminifera at Hor Hahar.

K/T

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Number
MOR 17A	MOR 18	MOR 19	MOR 20	EM42	EM43	EM44	EM45	EM46	EM47	EM48	EM49	EM34	EM35	EM36	Sample
209	251	213	211	302	387	356	397	363	317	351	249	416	245	266	Total number counted
1	0	0	3	0	0	0	0	0	1	1	0	1	0	0	*Bathysiphon spp.*
0	0	0	0	0	0	0	2	0	2	1	0	1	2	1	*Spiroplectammina henryi*
0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	*Dorothia bulletta*
0	0	0	2	1	0	0	0	0	0	0	0	2	1	1	*Dorothia pupa*
5	13	0	7	7	2	1	2	1	1	0	1	0	1	0	*Gaudryina pyramidata*
0	1	0	3	2	3	1	1	0	0	0	0	3	5	0	*Marssonella oxyconus*
0	0	0	0	0	0	0	0	0	1	0	1	0	2	1	*Tritaxia midwayensis*
0	1	1	1	0	1	0	0	0	0	0	0	0	0	1	*Clavulinoides asper*
0	0	0	0	0	1	0	1	0	0	1	0	1	0	0	*Cornuspira polygyra*
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	*Quinqueloculina aff. Q. stelligera*
3	1	5	0	1	0	0	5	0	0	0	0	2	0	1	*Lenticulina midwayensis*
6	1	4	4	6	5	0	0	2	3	5	5	2	1	2	*Lenticulina spp.*
1	1	0	4	1	2	0	0	2	1	0	0	0	0	2	*Astacolus sp.*
1	2	3	1	2	5	3	5	5	5	5	2	1	1	3	*Dentalina colei*
0	0	0	0	2	1	1	1	0	0	0	1	2	0	1	*Dentalina eocenica*
4	0	6	4	0	0	2	2	0	1	1	2	0	3	4	*Dentalina spp*
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	*Nodosaria affinis*
0	1	1	4	0	3	1	0	0	1	0	0	0	1	2	*N. longiscata*
0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	*N. paupercula*
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	*N. semispinosa*
4	3	3	3	4	2	0	1	2	1	1	0	2	1	0	*Ellipsonodosaria (?) granti*
3	0	1	0	2	0	0	0	0	0	0	0	0	0	1	*Frondicularia spp.*
2	10	9	7	8	5	4	3	4	0	2	1	3	2	4	*Lagena apiculata*
4	11	6	5	6	4	2	2	3	4	1	0	2	3	3	*L. globosa*
1	2	0	0	3	1	1	1	1	1	0	0	1	1	2	*L. hispida*
1	1	3	2	1	0	1	0	0	1	0	1	1	2	0	*L. sulcata*
0	0	0	1	2	2	0	0	0	1	1	0	0	0	1	*Guttulina spp.*
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	*Ramulina spp*
2	2	5	5	4	8	7	3	2	2	3	0	3	2	3	*Bolivina decurrens*
2	14	13	4	4	5	7	19	10	3	5	0	28	6	16	*B. incrassata*
0	0	0	0	3	10	14	7	6	8	11	2	11	1	2	*Bolivinoides curtus*
8	5	1	2	3	1	1	0	0	0	0	0	0	0	0	*B. draco gr.*
7	7	7	4	11	26	23	26	20	17	21	6	13	7	8	*Loxostomoides applinae*
22	1	3	1	2	3	4	6	3	7	20	7	9	1	3	*Eouvigerina aff. E. cretacea*
0	0	0	1	3	2	1	2	2	0	1	1	0	0	0	*Siphogenerinoides eleganta*
3	2	4	8	11	6	27	25	17	8	9	11	25	9	13	*Stilostomella midwayensis*
0	3	1	3	4	6	12	17	10	8	6	7	19	11	12	*Tappanina selmensis*
1	2	2	4	4	10	9	11	4	18	23	9	6	6	2	*Bulimina cacumenata*
0	1	3	1	6	0	0	1	0	0	2	0	0	0	0	*B. midwayensis*
14	17	26	18	15	9	5	13	5	4	6	2	6	2	3	*Buliminella cushmani*
0	0	0	1	4	7	2	7	2	2	3	5	3	1	1	*Pleurostomella paleocenica*
2	2	0	0	0	0	0	0	1	0	0	0	1	0	2	*Fissurina sp.*
1	2	0	1	1	0	0	2	1	0	0	0	1	0	0	*Gyroidina planulata*
13	17	6	16	20	25	26	32	22	19	17	9	11	6	10	*Gyroidinoides subangulata*
0	2	3	0	5	1	1	0	0	0	0	1	0	0	0	*Gavelinella danica*
0	0	0	2	10	7	23	40	75	46	52	58	106	69	71	*Angulogavelinella beccariiformis*
4	1	4	1	0	1	1	2	2	1	3	2	2	0	1	*Quadrimorphina allomorphinoides*
0	2	2	2	2	1	0	1	1	0	0	0	3	3	0	*Valvulineria aegyptiaca*
8	3	12	3	6	0	6	7	8	12	3	7	5	4	12	*Eponides plummerae*
0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	*Nuttallides sp*
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	*Alabamina midwayensis*
18	29	19	15	25	23	47	38	29	34	55	43	24	18	19	*Osangularia lens*
6	1	0	7	1	1	0	0	1	0	0	0	0	0	1	*Pulsiphonina prima*
14	20	13	16	15	34	28	23	25	29	34	16	16	10	6	*Anomalinoides acuta*
15	13	10	3	4	3	8	4	4	1	3	1	1	0	3	*A. midwayensis*
3	3	2	0	0	4	2	1	2	4	1	3	1	1	0	*A. welleri*
23	50	32	36	80	146	82	78	87	66	50	45	92	60	41	*Cibicidoides alleni*
1	0	0	0	0	1	0	0	1	0	1	0	1	0	1	*Nonionella africana*
1	1	0	0	2	2	1	1	0	0	0	0	0	0	0	*N. insecta*
4	3	3	2	4	8	1	3	3	4	0	1	4	2	3	*Pullenia quinqueloba*

Appendix 2. Raw data: abundance of benthonic foraminifera at Ein Mor.

Number	Sample	No. of agglutinates	Total no. of benthics	agglutinates/total no. benthics (%)	No. of Species	No. of Species/total no. Species (60) (%)
1	HH40	21	312	6·7	34	56·7
2	HH30	31	359	8·6	38	63·3
3	HH29	13	339	3·8	39	65
4	HH28	7	315	2·2	36	60
5	HH27	15	397	3·8	41	68·3
6	HH26	16	323	5·0	37	61·7
7	HH26C	12	333	3·6	38	63·3
8	HH26B	8	322	2·5	28	46·7
9	HH25D	9	293	3·1	40	66·7
10	HH25	5	302	1·7	36	60
11	HH25B	1	263	0·4	34	56·7
12	HH25A	4	283	1·4	34	56·7
13	HOR 9	7	281	2·5	40	66·7
14	HH24	13	542	2·4	43	71·7
15	HH23	2	192	1·0	31	51·7
16	HH22	10	212	4·7	41	68·3
17	HH21	2	127	1·6	24	40

Appendix 3: Percent abundance of agglutinates and species diversity at Hor Ha Har.

Number	Sample	No. of agglutinates	Total no. of benthics	agglutinates / total no. benthics (%)	No. of species	No. of species / total no. species (60) (%)
1	EM36	4	266	1·5	39	65
2	EM35	11	245	4·5	34	56·7
3	EM34	8	416	1·9	39	65
4	EM49	2	249	0·8	28	46·7
5	EM48	2	351	0·6	32	53·3
6	EM47	5	317	1·6	33	55
7	EM46	1	363	0·3	34	56·7
8	EM45	7	397	1·8	38	63·3
9	EM44	2	356	0·6	34	56·7
10	EM43	6	387	1·6	40	66·7
11	EM42	10	302	3·3	41	68·3
12	MOR 20	16	211	7·6	42	70
13	MOR 19	1	213	0·5	33	55
14	MOR 18	15	251	6	39	65
15	MOR 17A	6	209	2·9	35	58·3

Appendix 4: Percent abundance of agglutinates and species diversity at Ein Mor.