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BIOSTRATIGRAPHY AND TECTONICALLY CONTROLLED SEDIMENTATION OF THE MAASTRICHTIAN IN ISRAEL AND ADJACENT COUNTRIES

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ABSTRACT

Maastrichtian argillaceous chalks of the Ghareb Formation are widespread throughout Israel, both in exposures and in the subsurface. These strata contain a rich fauna of foraminifera and calcareous nannoplankton, allowing detailed biozonation of the sediments, which were deposited in a series of basins in an outer-shelf to upper-slope environment. The distribution of benthonic and planktonic foraminifera from a reference section in southern Israel is described. Three planktonic foraminiferal tethyan chronozones, the *Globotruncana falsostuarti, Gansserina gansseri* and *Abathomphalus mayaroensis* zones, are identified. The middle and upper parts of the Maastrichtian succession are fully recorded in the section. The common occurrence of *Abathomphalus mayaroensis* and *Plummerita hantkeninoides* at the top of the Maastrichtian strata indicate a continous sedimentation till the Cretaceous/Tertiary boundary. The Maastrichtian beds in Israel vary in thickness from 0 to 200 m and reflect structures, controlled by the Syrian Arc fold system, which evolved during pre- and syn-Maastrichtian times. Their isopach contours are in good agreement with present-day structural axes. The lithostratigraphy and tectonic events during the Maastrichtian in Israel are compared with those of other countries in the eastern Mediterranean.

Keywords: Maastrichtian, Danian, biostratigraphy, planktonic foraminifera, benthonic foraminifera, isopachs, tectonics, Syrian Arc structure, Israel, Middle East.

RESUMEN

La formación Ghareb, creta arcillosa de edad Maastrichtiense, está ampliamente representada en Israel, tanto en afloramientos como por los datos del subsuelo. Contiene una rica fauna de foraminíferos, así como de nanoplancton calcáreo, que permiten una biozonación detallada. Estos materiales se depositaron en varias cuencas de ambientes de plataforma externa y talud superior. Se describe la distribución de los foraminíferos de una sección de referencia del Sur de Israel. Se han identificado tres cronozonas del ámbito del Tethys: Zona de *Globotruncana falsostuarti,* Zona de *Gansserina gansseri*, Zona de *Abathomphalus mayaroensis.* Las partes media y superior del Maastrichtiense están completas. La presencia de *A. mayaroensis* y de *Plummerita hantkeninoides* en la parte superior del Maastrichtiense indican una sedimentación continua hasta el límite Cretácico-Terciario. La secuencia del Maastrichtiense tiene una potencia variable entre 200 y 0 m. con estructuras tectónicas ligadas al sistema del Arco Plegado Sirio, que evolucionó durante los tiempos pre- y Maastrichtiense. Sus isopacas dibujan formas que están acordes con los actuales ejes estructurales. Los acontecimientos litoestratigráficos y tectónicos maastrichtienses en Israel se comparan con los de otros países del Mediterráneo oriental.

Palabras clave: Maastrichtiense, Daniense, bioestratigrafía, foraminíferos planctónicos, foraminíferos bentónicos, isopacas, tectónica, Arco Sirio, Israel, Oriente Medio.

INTRODUCTION

The Maastrichtian strata are widespread in Israel, both in outcrops and in the subsurface. They are built mainly of argillaceous chalks of the Ghareb Fromation containing a profusion of microfauna (calcareous nannoplankton, foraminifera, and ostracodes) and some megafauna (ammonites, bivalves, Reiss *et al.,* 1985). Thickness variations, observed in many boreholes and field sections, enable the delineation of isopachs expressing paleo- and synsedimentary structures. The lithostratigraphy and tectonic events in Israel during the late Cretaceous are controlled by the Syrian Arc fold system (Flexer, 1987; Honigstein *et al.,* 1988). Their Maastrichtian phase is compared with those of neighbouring countries, ena-

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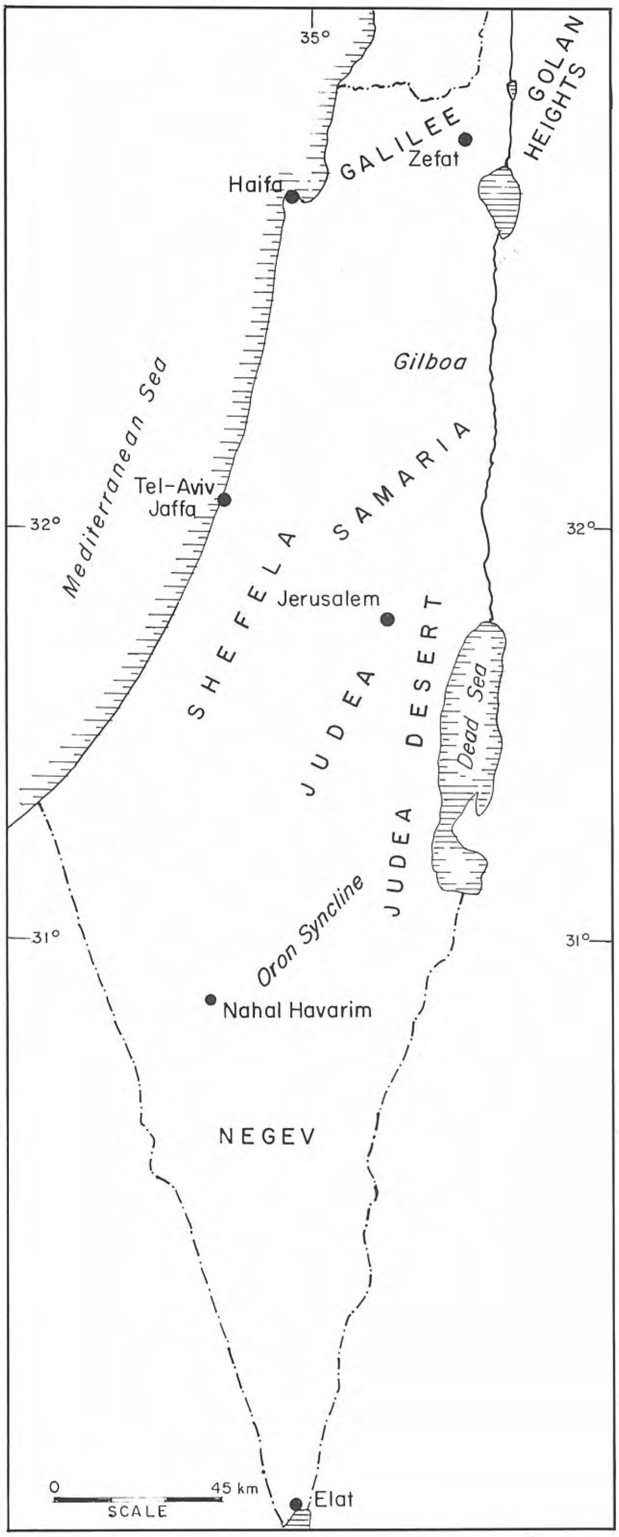


Figure 1. Location map.

bling a better understanding of the geological evolution of the area located between the Arabo-Nubian craton in the south and the Alpine orogenic belt in the north.

The location of the Syrian Arc fold belt together with the Zagros-Taurus Cypriot and the Hellenic arcs thrust zone, between Eurasia in the north and Arabia and Africa in the south, has interested geologists for decades. The Maastrichtian syntectonic activity in Israel is contemporaneous with intensive tectonism, comprenssion, thrusting, folding and emplacement of ophiolites that took place closer to the Alpine thrust belt in Cyprus, northern Syria and Turkey (Robertson, 1978; Biju-Duval *et al.,* 1979; Delaloye & Wagner, 1984). The advent of plate tectonics led to new explanations of the relationship between these two continental masses, with the basic concept being that the African-Arabian plate is moving relatively northward and underthrusting the Eurasian plate (Scott, 1981).

This study presents the litho- and biostratigraphy of the Maastrichtian in Israel, using an extended field section at Nahal Havarim in southern Israel (Fig. 1) as a reference section. The study is based on many unpublished M.Sc. and Ph.D. theses as well as on voluminous published information. Key works among others are: Bentor & Vroman (1957, 1960); Shahar (1968); Flexer (1968, 1971); Gvirtzman *et al.* (1985, 1989); Reiss *et al.* (1985).

LITHOSTRATIGRAPHY

The Maastrichtian sediments are represented mostly by the Ghareb Formation (Fig. 2), found all over Israel. The formation is composed of white-yellow to greyish argillaceous chalk, alternating with chalky limestone beds and calcareous shales. The yellowish rusty colour of the formation is due to profusion of limonitic stains.

The lower formation boundary is usually conformable with the Mishash and the En Zetim formations (Flexer, 1968; Reiss *et al.,* 1985). It is easily discerned, since the limonitic (and is places glauconitic) argillaceous chalks of the Ghareb Formation overlie the white massive chalks of the En Zetim Formation in the Galilee or the hard flint and phosphorite beds of the Mishash Formation elsewhere in Israel. The upper boundary with the blue-grey calcareous shales of the Taqiye Formation is also very distinct. The Cretaceous/Tertiary (K/T) boundary in Israel is well exposed in many localities and easily accessible. Microfaunal extinctions, metal enrichment and $\delta^{13}C$ decrease near the K/T boundary were recorded hitherto from sections in southern Israel (Magaritz *et al.,* 1985; Keller and Benjamini, 1988; Rosenfeld *et al.,* 1989).

The Ghareb Formation in the northern Negev is subdivided into three members (Fig. 1): the Oil Shale Member, Marly Member and Chalky Member (Shahar, 1968). The succession starts with a thin horizon of marls, containing rounded chert pebbles, phosphate concretions and iron oxide fragments. In its type section in the Oron syncline (Fig. 1), the brown to yellowish grey beds of the Oil Shale Member are about 20 m thick. They contain less than 60 % $CaCO_3$, up to 10 % fish bones and ovulitic phosphorite, gypsum, as well as up to 15 % organic matter. The 18 m thick yellowish grey Marly Member is characterized by biomicritic, dolomitic and

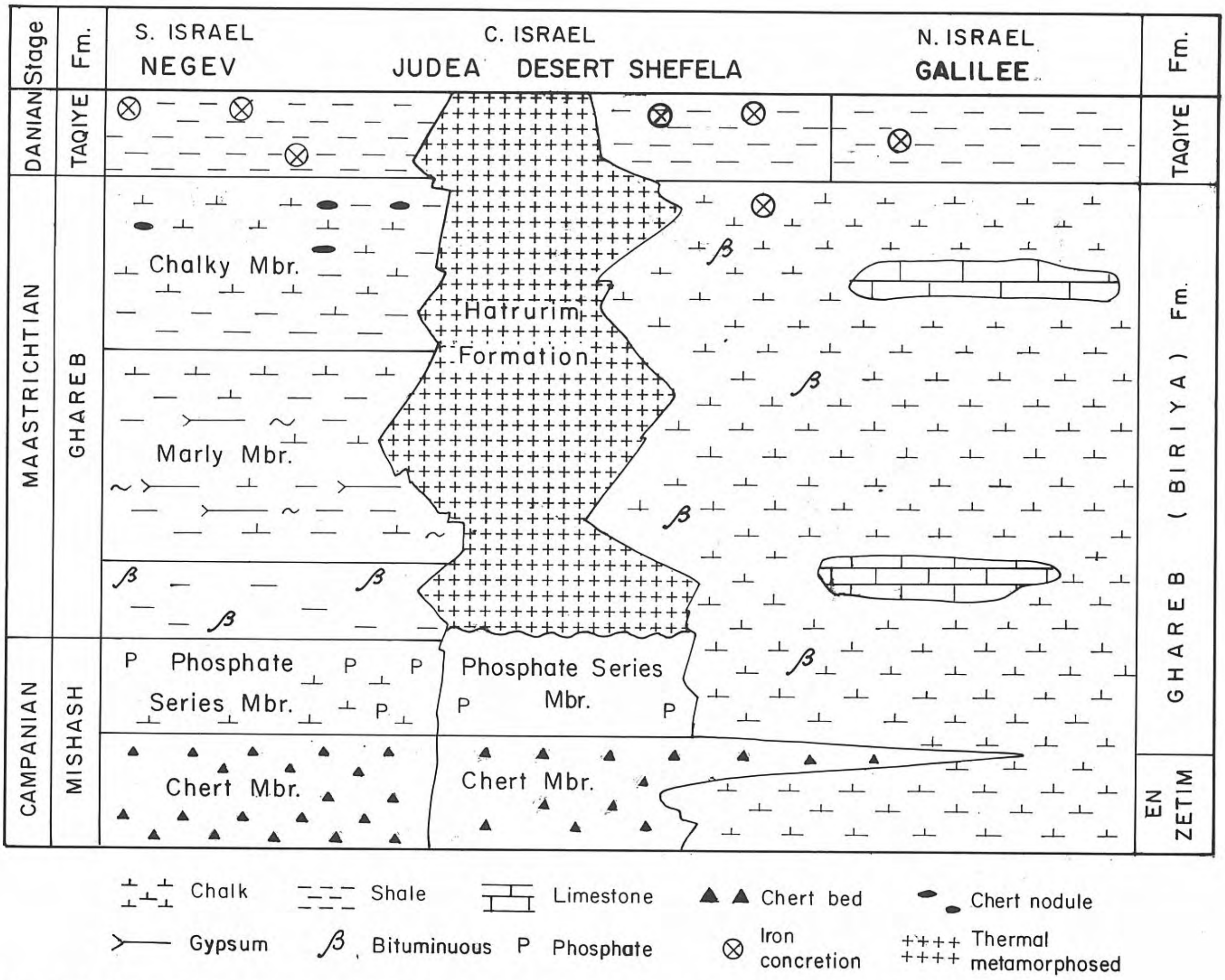


Figure 2. Generalized columnar section of the late Cretaceous/early Tertiary formations in Israel.

phosphatic marls, containing 60-75 % $CaCO_3$. The yellowish-grey well-bedded upper Chalky Member is approximately 38 m thick, usually built of layers of chalks, 30-50 cm thick. These sediments consist mainly of biomicritic chalks, their $CaCO_3$ content exceeds 75 % (Shahar, 1968).

In central Israel, Maastrichtian sediments reach thicknesses of more than 130 m. (Arkin, 1976; Gvirtzman *et al.,* 1989). They are built mainly by bituminous argillaceous chalks with up to 10 % organic matter (Shirav & Ginzburg, 1978). A unique rock complex, the Hatrurim Formation, is exposed mainly in the Judea area. This formation is largely composed of high-temperature, low-pressure metamorphic minerals that transformed the normal marine chalky and marly sequence of Maastrichtian-Danian strata (Gross, 1977). In the Shefela area, Maastrichtian sediments were only found in the subsurface.

In the Galilee, the Maastrichtian strata (there also called Biriya Formation) vary in thickness; in the Zefat section (Fig. 1) it attains a thickness of 100 m (Flexer, 1971). The rocks are composed of chalks, argillaceous chalks and marls with limonitic stains.

BIOSTRATIGRAPHY

Calcareous marine organisms occur in variable abundances within the Maastrichtian sediments in Israel and enable us to divide this stage into biozones. A multiple stratigraphic framework, compiled by Reiss *et al.* (1985) and Gvirtzman *et al.* (1989) is based mainly on the Tethyan biozonation (for references see Reiss *et al.,* 1985).

The exact position of the Campanian-Maastrichtian boundary in Israel is still in question. The chalks, porcelanites and phosphates of the Mishash Formation in the Negev contain only a very low diversified benthonic foraminifera assemblage, composed mainly by buliminids, indicating low oxygen conditions (Reiss, 1988). These sediments were suggested to be late Campanian in age (Reiss *et al.,* 1985). The overlying lower unit of the Oil Shale Member exhibits a typical Maastrichtian foraminiferal assemblage with rare *Globotruncana falsostuarti* and *Gansserina wiedenmayeri* (Honigstein *et al.,* 1987; Gvirtzman *et al.,* 1989).

A three-folded division of the Maastrichtian in

Israel is suggested based on planktonic foraminifera (Reiss *et al.*, 1985, 1986; Almogi-Labin *et al.*, 1986), namely on the index fossils *G. falsostuarti* in the early Maastrichtian, *Gansserina gansseri* in the middle part and *Abathomphalus mayaroensis* in the late Maastrichtian. Five calcareous nannoplankton biozones were recognized in the succession (Moshkovitz, 1984; Gvirtzman *et al.*, 1985, 1989). The early Maastrichtian *Quadrum trifidium* zone is followed by the *Arkhangelskiella cymbiformis* and *Lithraphidites quadratus* zones in the middle part of the Maastrichtian and the *Micula murus* and *Micula prinsii* zones in the late Maastrichtian. Only a few age diagnostic fossils of ostracodes and megafauna were recorded. They make detailed biozonation for this period rather difficult.

The Maastrichtian strata in Israel were deposited in a series of basins in an outer-shelf to upper-slope environment (Flexer, 1971; Reiss, 1988; Almogi-Labin *et al.*, 1989). During the early Maastrichtian the sediments reflect a high productivity domain. The enhanced accumulation of organic matter (up to 15 %; Shahar, 1968) indicates an intensified upwelling system. The preservation of organic matter, together with the diversified benthonic foraminifera fauna (about 20-30 species) point to dysaerobic conditions on the bottom of the sea. Towards and during the middle part of the Maastrichtian the primary production level decreased and more normal marine conditions prevailed. The more diversified assemblages of planktonic foraminifera at that time (about 15 species) point to a well ventilated water column during the acme of the transgression of the sea. During the late Maastrichtian, diversity fluctuations in the Globotruncanids suggest that the productivity increased again slightly, while the low diversified benthonic assemblages indicate some restriction in ventilation of bottom water.

THE NAHAL HAVARIM SECTION

The Nahal Havarim (Hebrew for "river of marls") field section (Figs. 3, 4) was chosen for a detailed study of the lithology and microfaunal content of the Maastrichtian strata in Israel. The distribution of planktonic foraminifera in this section is shown in Fig. 3, that of benthonic species, in Fig. 4.

The lower part of the section is composed of the Chert Member and Phosphate Series Member of the Campanian Mishash Formation. The Maastrichtian succession (Ghareb Formation) starts with 11 m of thick white chalks, alternating with bituminous marl beds and red layers, comparable with the upper part of the Oil Shale Member. Above them, approximately 16 m of thick grey shales alternate with minor chalky red layers (Marly Member). The upper Chalky Member (~37 m thick) is characterized by massive chalks and by cycles of hard white chalk and softer bituminous argillaceous chalks at the upper part of this member. Whereas the lower member is reduced in the Nahal Havarim section, the thickness of the two upper members of the Ghareb Formation there is nearly identical with that of the type section in the Oron syncline (Shahar, 1968). Large (up to 30 cm diameter) pyrite concretions occur here in the uppermost 60 cm of the Ghareb Formation, just below the K/T boundary.

The section ranges from the latest Campanian to the Danian. Its Maastrichtian part is about 60 m thick. The foraminiferal assemblages are in general well diversified, while ostracodes were not observed in the studied samples. The composition and abundance of the Maastrichtian benthonic fauna point to an outer-shelf environment of deposition (Sliter, 1977; Nyong & Olsson, 1984). The rare occurrence of some planktonic index fossils, such as *G. falsostuarti* in the early Maastrichtian and *G. gansseri* in the middle part of the Maastrichtian of this section, allows biozonation of these layers only by the help of assemblage zones. These zones are used in the concept of chronozones. Therefore, besides the ranges of Globotruncanidae, such as *Globotruncana* and *Globotruncanita*, also the ranges of various genera of Heterohelicidae, such as *Planoglobulina, Pseudoguembelina* and *Racemiguembelina* (Weiss, 1983) were used.

A typically low diversified buliminid fauna occurs in the lowest smaples of the Mishash Formation of late Campanian age (Fig. 4: *Globotruncana calcarata* Zone; Reiss, 1988). About 20 m above the base of the section, within the Ghareb Formation, the first Maastrichtian species were identified. The planktonic foraminifera *Globotruncana esnehensis* and the relatively high diversified benthonic foraminifera assemblage with *Praebulimina arkadelphiana* and *Pullenia cretacea* (Pl. 1, Fig. 3) indicate upper levels of the *G. falsostuarti* zone (Almogi-Labin *et al.*, 1986). Basal Maastrichtian sediments are thus either condensed or lacking in the Nahal Havarim section, as in some sections in the Negev (e.g. Shiloni *et al.*, 1988) and Egypt (Luger, 1988), pointing to a regressive phase of the sea or to syntectonic activity during the early Maastrichtian. In the Nahal Havarim section, the diversity of the planktonic forms increases towards the middle and late Maastrichtian layers of the section (Fig. 3). The middle part of the Maastrichtian (*G. gansseri* Zone) is determined by the first occurrence of the planktonic foraminifera *Globotruncanella pschadae* and *Globotruncanita pettersi* and the benthonic species *Bolivinoides dorreeni* and *Neoflabellina jarvisi* (Reiss *et al.*, 1985, 1986; Almogi-Labin *et al.*, 1986). In the late Maastrichtian a diversified planktonic assemblage is observed, whereas the number of benthonic forms in this part is generally reduced. The lower part of the late Maastrichtian was determined by the first occurrence of *Planoglobulina brazoensis* (Pl. 1, Fig. 7) and *Globotruncanita angulata* (Weiss, 1983; Almogi-Labin *et al.*, 1986). In other sections from southern Israel, *P. brazoensis* appears above, but close to the first occurrence of *A. mayaroensis*. This late Maastrichtian index fossil *A. mayaroensis* (Pl. 1, Figs. 11-12) occurs in our section only in the uppermost 3 m of the section. *A. mayaroensis* was recorded in a nearby locality in the upper 25 m of Maastrichtian strata. In Egypt, *A. mayaroensis* is absent in late Maastrichtian strata,

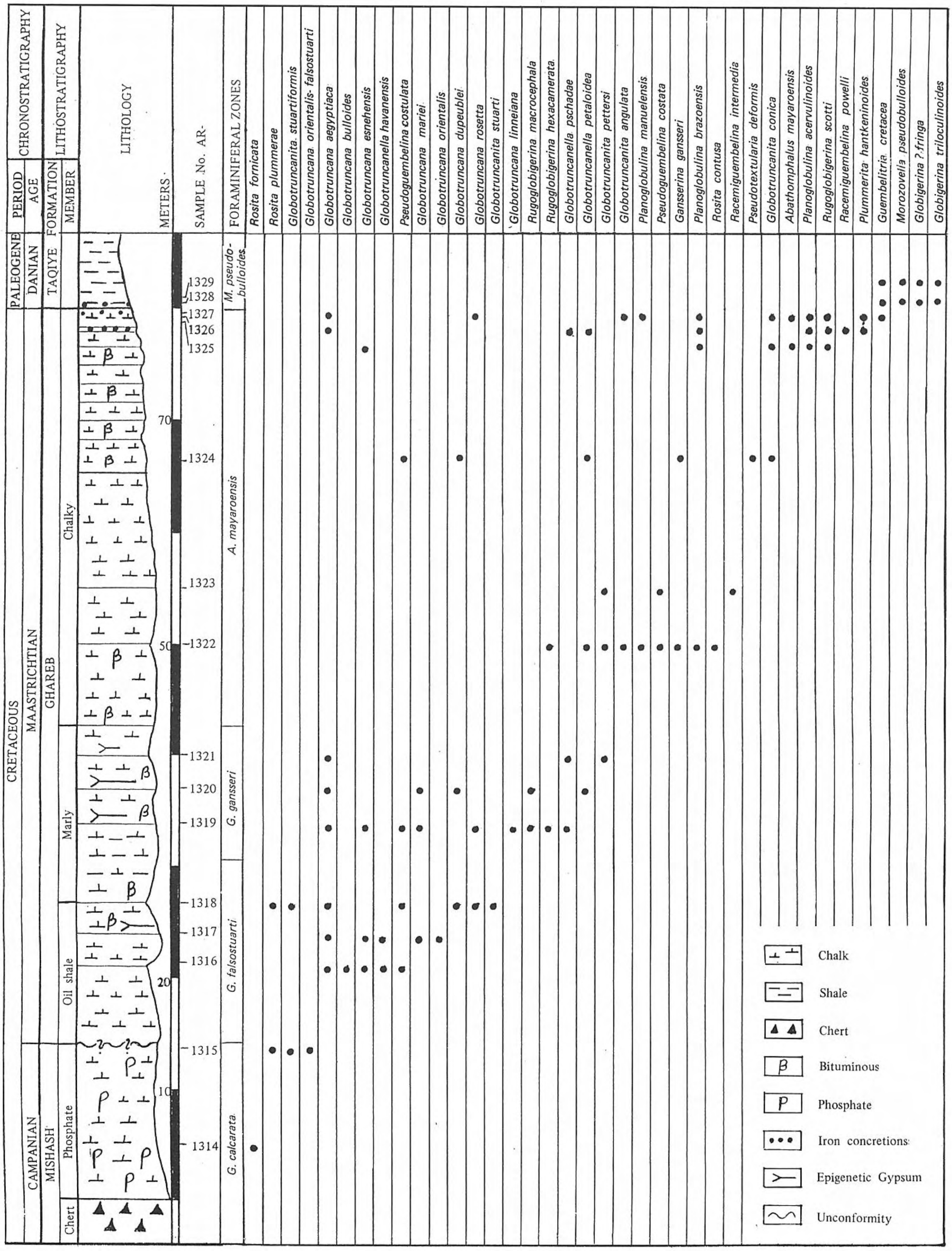


Figure 3. The Nahal Havarim section. Lithostratigraphy and planktonic foraminiferal distribution.

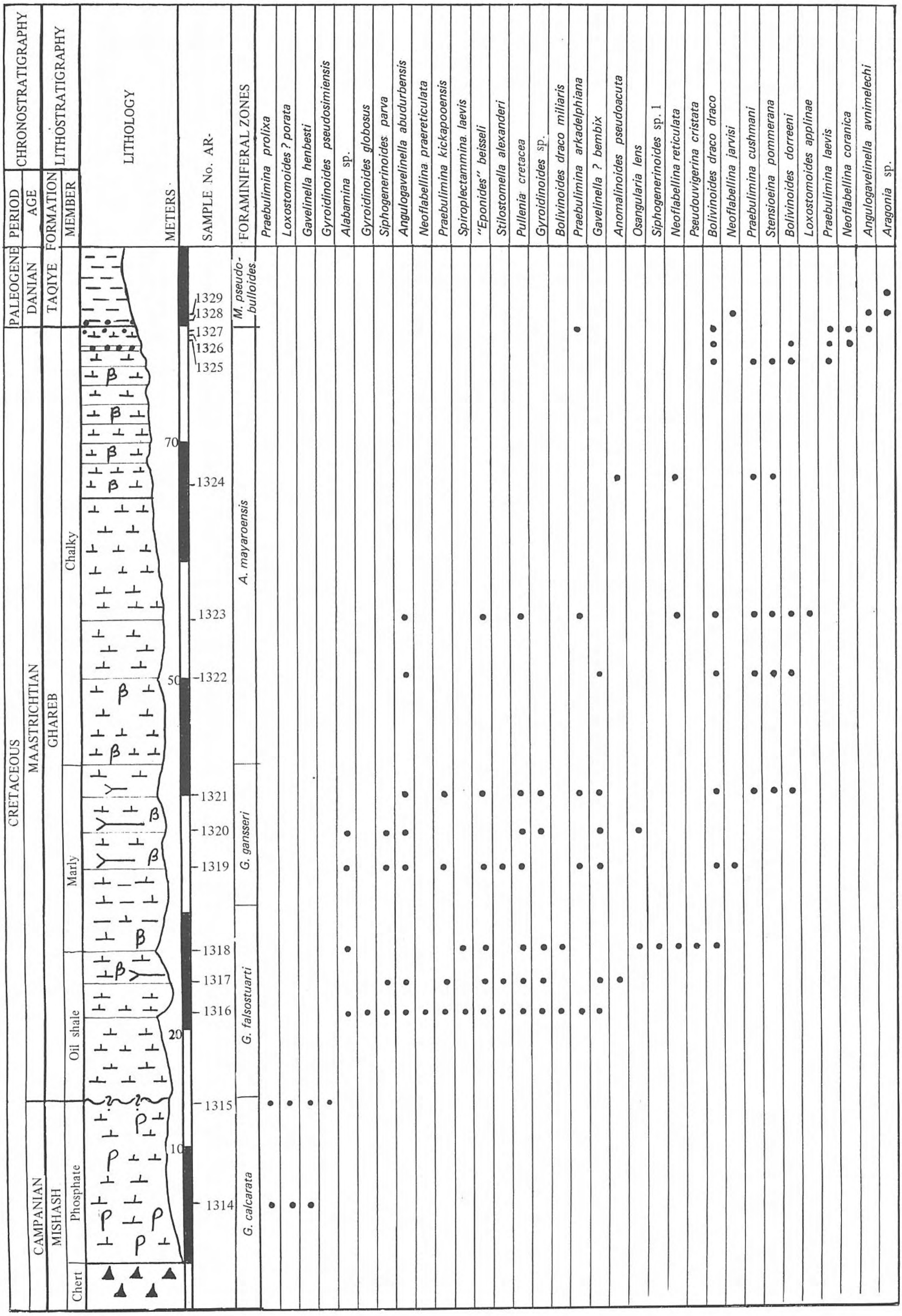


Figure 4. The Nahal Havarim section. Lithostratigraphy and benthonic foraminiferal distribution.

where among others *P. brazoensis* is described (Luger, 1988). *A. mayaroensis* occurs in the Nahal Havarim section together with *Planoglobulina acervulinoides* and especially *Plummerita hantkeninoides* (Pl. 1, Figs. 8-9) with well developed tubulospines in the last whorl in the uppermost 2 m of the sequence, suggesting a full sequence with continous sediment deposition at this level. *P. hantkeninoides* was described from Egypt in a similar stratigraphic level, close to the K/T boundary (Luger, 1988). The earliest Danian *Globigerina eugubina* zone was not observed in the Nahal Havarim section, pointing there to a brief hiatus within a regressive phase, similar to several sections in Egypt (Hendriks *et al.,* 1987). The first foraminifera of Danian age, such as *Morozovella pseudobulloides* and *Globigerina triloculinoides*, were observed in the Nahal Havarim section 10 cm above the last occurrence of *A. mayaroensis.* The exact position of the K/T boundary in our section will be defined by calcareous nannofossils and geochemical results in a later stage of the project.

THE ISOPACH MAP AND STRUCTURAL EVOLUTION

Thickness variations are common within the Maastrichtian sediments in Israel, the resulting isopach contours are shown on Fig. 5. This isopach map has been delineated only from field sections or drillholes that penetrate the top and the bottom of the Maastrichtian strata, including those with some minor intra-Maastrichtian unconformities. The data base bas been built from numerous unpublished reports and published articles (Arad, 1965; Bartov & Steinitz, 1977; Bentor & Vroman, 1957, 1960; Flexer, 1971; Mimran, 1984; Mimran *et al.,* 1985; Reiss *et al.,* 1985; Shahar, 1968; Gvirtzman *et al.,* 1989). The approximately 50 locations and their thickness values for Maastrichtian sediments presented in Fig. 5 are key points; nearby points with equal or very similar thickness values have been omitted in order to keep the map readable. The data base is not dense enough in certain parts of the country (i.e., the Shefela area: only subsurface), therefore the discrete isolation of each structure by contours is impossible. Moreover, even a denser data base may not necessarily show each present-day structure if the structures were only in their embryonic stage of evolution during the Maastrichtian time and evolved after.

The Maastrichtian beds vary in thickness from a few tens of meters in the central Negev to more than 200 m in the northern Samaria area. The present-day structures (Fig. 5) are indicated on the isopach map with the symbols A - K. For example, the central Galilee high structure (A) is characterized by a reduced thickness of the Maastrichtian strata. The Zefat-Rosh Pinna (B) and Shefaram synclines (C), east and southwest of the central Galilee high, are clearly discerned. The Judea-Samaria anticlinorium (D) is also distinguished by its reduced thickness, whereas thicker sedimentation (up to 200 m) occurs in the Gilboa area (E) in the north, the Shefela syncline (F) in the west and the Judean Desert (G) in the east. Low thickness values were also given for the central and northern Negev areas. These regions are built of a series of anticlinal structures (e.g., the Ramon (H), Hazera (I) and Hatira (J) structures). The isopach contours reflect therefore high and low

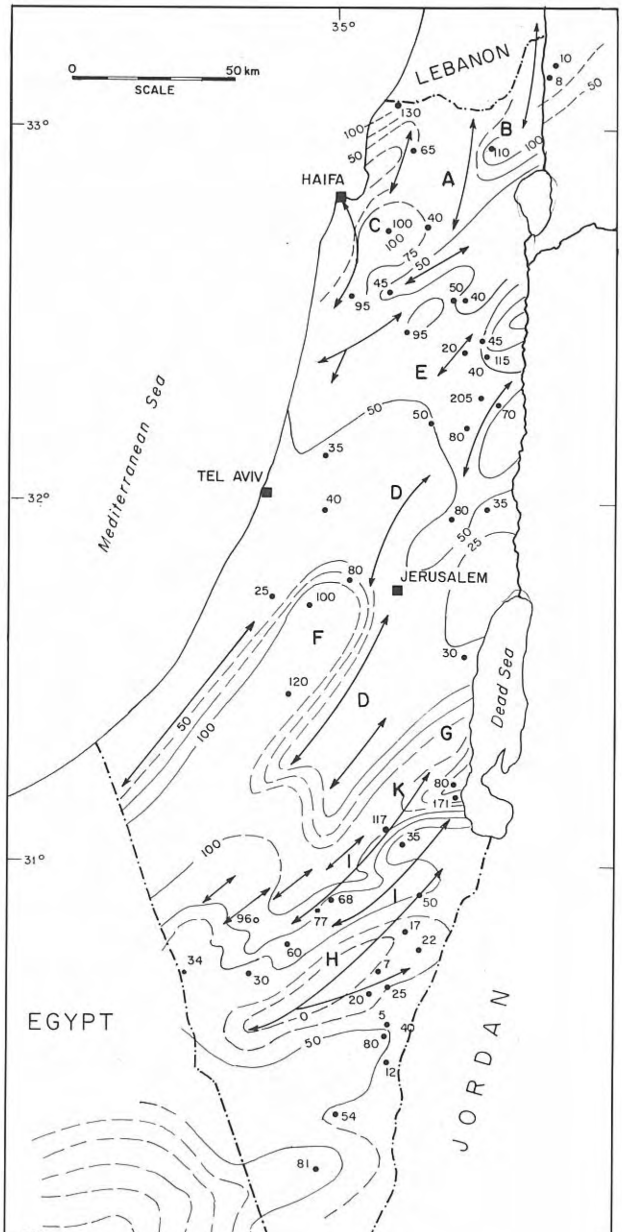


Figure 5. Isopach map of the Maastrichtian stage. The contour lines illustrate the fold pattern that evolved in pre- and during the Maastrichtian time. The resulting pattern coincides with the present-day structures (solid lines with arrows).

structures which coincide with the present-day structural axes.

The thickness changes reflect structures that evolved during two pre-Maastrichtian successive folding phases, the first during the late Turonian-Coniacian and the second during the late Campanian (Flexer, 1971; Braun *et al.,* 1987; Honigstein *et al.,* 1988). A third phase occurred during the Maastrichtian. The anticlines shown on Fig. 5 represent present-day structures that may have existed since the above-mentioned folding phases, but also may have been formed as a result of post-Maastrichtian (Eocene and Neogene) tectonic events. Syn-Maastrichtian tectonic movements have been interpreted at different locations in Israel, such as the Galilee (Flexer, 1971). The omission of considerable parts of the Maastrichtian succession over short distances in the Golan Heights and eastern Samaria was interpreted as evidence for contemporaneous tectonics during sedimentation (Mimran, 1984; Mimran *et al.,* 1985). A consistent decrease in thickness occurs towards the anticlinal axes in the Shefela area (Gvirtzman *et al.,* 1989). There, the stratigraphic condensation of Maastrichtian units proves also synsedimentary tectonic activity. A similar thickness reduction in sediments of the Ghareb Formation and a gradual onlap is reported from the Zohar anticline (Fig. 5, K). The main folding phase was suggested to occur around the Campanian/Maastrichtian boundary, together with abrupt thickness changes of Maastrichtian sediments in the folded uplifted areas (Zohar & Moshkovitz, 1984). The hiatus in basal Maastrichtian deposits in the northeastern Negev (Shiloni *et al.,* 1988) also confirms synsedimentary tectonics during a regressive phase of the sea.

PALEOGEOGRAPHY AND REGIONAL COMPARISON

The Maastrichtian transgression that encroached upon the Afro-Arabian shield, invaded intracratonic basins and is remarkable for its wide regional extent (Flexer & Reyment, 1989). The result was the deposition of monotonous open-sea argillaceous chalk in the Middle East. This uniform sediment might indicate that stable marine conditions prevailed during

TECTONIC EVENTS -ENVIRONMENTS OF DEPOSITION	LITHOSTRATIGRAPHIC UNITS	
Increased subsidence with three transgresive peaks. Open marine sediments whit intervening deltaic complexes Open marine sedimentation	Hiatus Dakhla Lower Sharawna Sharib Shale Karga Shab Shale Fm. Shale Hamana Beris Oyster Marl Mawhoob Shale Sudr Duwi Fm. Fm.	EGYPT (Luger, 1988; Said, 1962) Western Desert Eastern Desert
Evolving Syrian Arc structure controls sedimentation. Open nomal marine deposition.	Ghareb Fm. Chalky Mbr. Marly Mbr. Oil Shale Mbr. (Hatrurim Fm.	ISRAEL
	Ghareb Fm.	JORDAN (Daniel, 1963; Bender, 1974)
	Chekka white marls Shiranish Fm.	SYRIA AND LEBANON (Dubertret, 1963)
Block faulting controls sedimentation. Shallow marine to deep shelf and upper slope deposition	Lower Kalash Waha Tar Limestone Limestone Marl	LIBYA (Eliagoubi & Powell 1980; Megeriski & Mamgain, 1980) NW - SIRT BASIN- SE
Faulting (Thrusting) and folding accompany sedimentation. Ophiolite and radiolarian cherts in the deep throughs.	Germav Fm.	SE TURKEY AND NORTHERN SYRIA (Dubertret, 1963)
Major phase of deformation and emplacement of allochthonous rocks. Intensive erosion, melange sedimentation and ophiolites. Volcanoclastic series submarine debris flows.	Kathikas Fm Dhiarizos Group Kannaviou Fm.	CYPRUS (Swarbrick & Robertson, 1980)

Table 1. Correlation of Maastrichtian lithostratigraphic units in the Middle East. Environments of deposition and tectonic events.

Plate I. Scale bar = 100 microns, all specimens from the Nahal Havarim section

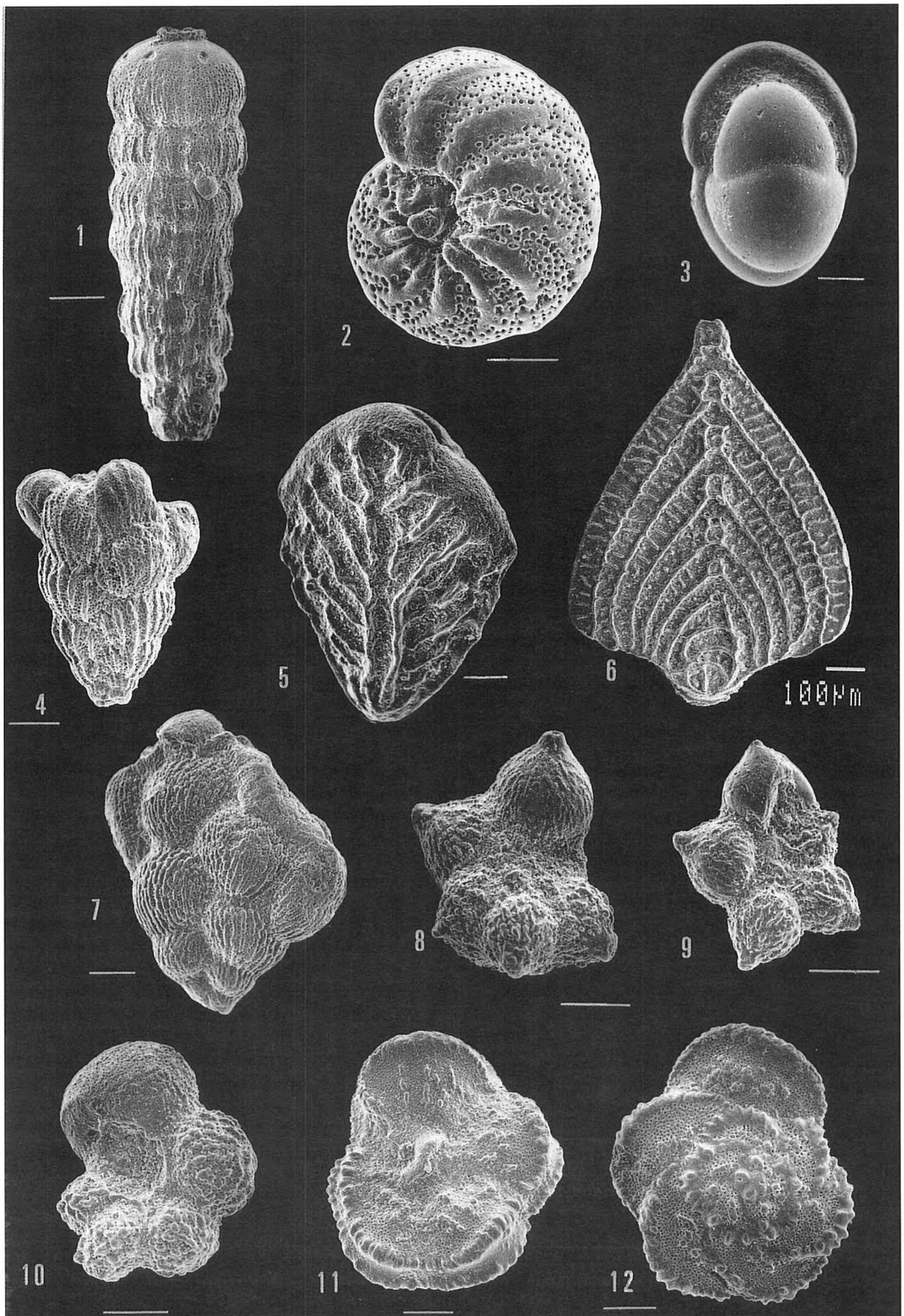
1. *Siphogenerinoides parva* Cushman, sample AR-1319
2. *Angulogavelinella abudurbensis* (Nakkady), sample AR-1319
3. *Pullenia cretacea* Cushman, sample AR-1317
4. *Racemiguembelina powelli* Smith & Pessagno, sample AR-1326
5. *Bolivinoides draco draco* (Marsson), sample AR-1325
6. *Neoflabellina praereticulata* Hiltermann, sample AR-1316
7. *Planoglobulina brazoensis* Martin, sample AR-1325

8-9. *Plummerita hantkeninoides* (Brönnimann), sample AR-1327

10. *Rugoglobigerina scotti* (Brönnimann), sample AR-1327

11-12. *Abathomphalus mayaroensis* (Bolli), sample AR-1327

Plate I



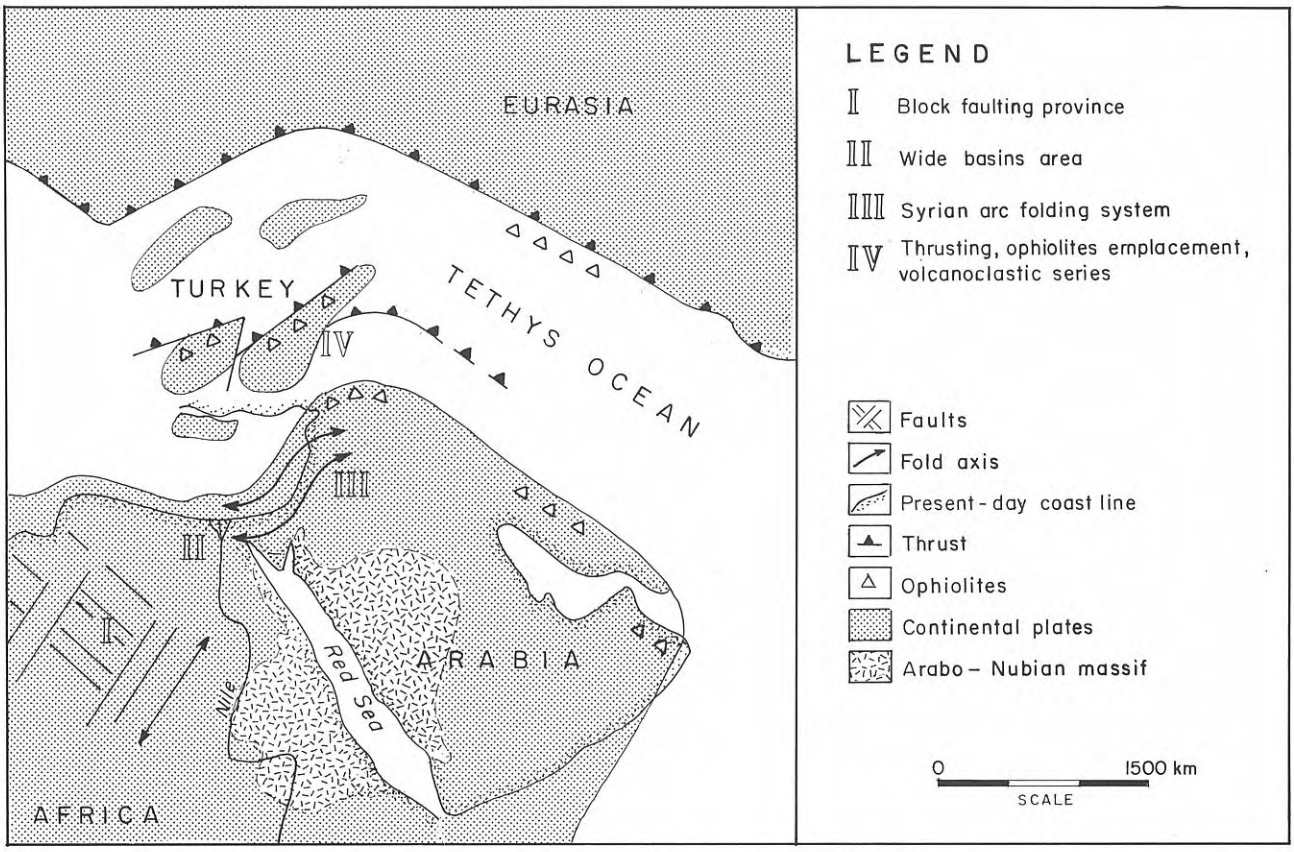


Figure 6. Reconstruction of the central Tethys during the Maastrichtian (modified after Klitzsch, 1971; Robertson & Dixon, 1984; Hendriks, 1985; Courtillot *et al.,* 1986; Olivet *et al.,* 1987; Besse & Courtillot, 1988). The African and Arabian continental plates were covered by the sea. The paleo-shore line generally follows the outline of the Arabo-Nubian Massif.

this time interval. However, a detailed examination of the sedimentological aspects, thickness of strata, faunal content and magmatic occurrences show that sedimentation was controlled by evolving structures, tectono-eustatic processes and magmatic activity (Table 1).

Table 1 and Fig. 6 illustrate the lithostratigraphy, tectonic events and environment of deposition in the eastern Mediterranean countries, Libya, Egypt, Israel, Jordan, Syria, Lebanon, Turkey and Cyprus. The Tethys ocean was reduced during the Maastrichtian to a long channel of > 7000 km length and 1500-2000 km width. Tectonically, the region includes, from south to north, four tectono-sedimentary provinces: the Arabian-African craton (Fig. 6, I), the stable province (II), the unstable (= mobile) province (III) and the thrust zone or orogenic belt (IV, Cohen *et al.,* 1988 and references therein). The transition from relatively stable passive tectonic provinces to rather mobile and active regions is reflected by the different litho-, bio- and tectonofacies of the various Maastrichtian formations in the adjacent countries.

In Libya, block faulting controls the facies and sedimentation. The shallow marine, high energy Waha limestones in the southeast of the country grade through an intermediate facies (Kalah limestones) of the outer shelf, to upper-slope marls of the lower Tar Formation in NW Lybia (Eliagoubi & Powell, 1980; Megeriski & Mamgain, 1980).

In Egypt, the tectonic control is less significant, whereas regional sea-level changes have greater influence on the sedimentation. The Maastrichtian is characterized by increasing subsidence and open marine sedimentation. Three transgressive peaks during the late early, the middle and the late parts of the Maastrichtian are discernible. The open marine facies was bordered by northward prograding deltaic complexes. These regressive peaks occur at the earliest Maastrichtian and the early Paleocene (Said, 1962; Luger, 1988).

The sedimentation in the areas bordering the thrust belt (southeastern Turkey and Cyprus) was controlled by intensive faulting, folding, volcanism, ophiolite emplacement and erosion (Dubertret, 1963; Swarbrick & Robertson, 1980). The Maastrichtian sediments there include radiolarian cherts in deep troughs in SE Turkey as well as volcanoclastic series of submarine debris flows in Cyprus.

The evolving Syrian Arc fold system is responsible for marked thickness variations (0-200 m) in Sinai, Israel, Jordan, Lebanon and Syria. Southern Israel and southern Jordan were located at these times at the stable province in their southern parts and at the unstable province in the northern parts of both countries. They share the same geological history during the deposition of the sediments of the Ghareb Formation, confined by two regressive phases.

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