«ANNALES DU MUSÉUM D'HISTOIRE NATURELLE DE NICE - TOME IV - 1976»

MID-CRETACEOUS STRATIGRAPHY OF THE MIDDLE EAST

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ABSTRACT

The Mid-Cretaceous rocks are extensively exposed in the Middle East. They are mainly composed of alternations of limestone, dolostone, marl and chalk, with increasing amounts of sandstone towards the east and south (landward). Rich assemblages of fossils occur throughout the sequence, especially in the soft rocks. However, biozonation and dating could be established mainly on the basis of ammonites, the other groups enabling only a local tentative zonation. One ammonite zone (*Knemiceras* Zone) could be recognized in the Albian; three (CE 1 - CE 3) in the Lower Cenomanian and one (CE 4) in the Upper Cenomanian; seven zones (T 1 - T 7) in the Lower Turonian and two (T 8 - T 9) in the Upper Turonian; three (CA 1 - CA 3) in the Lower Coniacian and two (CA 4 - CA 5) in the Upper Coniacian.

Most of the exposed Mid-Cretaceous strata in the Middle East were deposited on a very broad, shallow shelf platform. They contain benthonic fossils, especially rudists and oysters. The off-shelf sediments of that time are fine grain bioclastic limestones and chalks which occur mainly in the subsurface of the present-day Middle East Mediterranean coastal plain and seawards.

INTRODUCTION

An attempt is made herein to present a preliminary description of the Mid-Cretaceous sequences and events in the Middle East, based on available literature both published and unpublished (Internal Reports, Ph. D. and M. Sc. Theses) as well as on current research of the authors and their colleagues. (Thanks are due to the Authority for Research and Development, the Hebrew University, which sponsored a part of this study). Several species of ammonites characterizing some of the zones mentioned herein, were never recorded before from our region, and are therefore also illustrated (Plates 1 and 2).

The religious and historical background of the Middle East drew the attention of many expeditions and individual scientists since the early 18th century. Some of the published reports from the 18th-19th centuries are still of great importance. But to avoid this report from becoming merely a bibliographical list, only a few of the ancient studies were mentioned among the recent works cited herein, while most of the others are cited in the more recent literature, as well as in the Bibliography of Levant Geology (Avnimelech, 1965a, 1969).

Mid-Cretaceous rocks are exposed over large areas in the Middle East and therefore were studied by many geologists. Unfortunately, little attention has been paid to the precise sampling and recording of the fossils. Lists of megafossils, originating from large lithostratigraphic units, given in the literature are inadequate for precise correlation.

GEOLOGIC BACKGROUND

In the Latest Jurassic to Early Cretaceous times, the sea retreated from the Jurassic shelf regions. During the Early Cretaceous, a humid, fluvial climate prevailed in the Middle East (fresh water lakes ; Nevo, 1968) under which intensive erosion of the exposed area began. Tectonic movements elevated the landward region, increasing the intensity of the erosion, which truncated Jurassic to Cambrian rocks (Freund et al., 1975). Opposite the outlets of large rivers, submarine canyons were cut through Jurassic rocks down to Bajocian strata (Derin, 1974 ; Cohen, 1976). Broad rivers carried clastic material from the continent towards the sea (Karcz, 1965). Most of the coarse fraction (conglomerate and sand) was deposited on the continent in floodplains, lakes and other morphological depressions. Some of the sand reached the shelf region (Shenhav, 1971) where it was mixed with calcareous sediments (Helez and Telamin Formations). Larger masses of sand were eventually carried into deeper marine environments, forming tongues and lenses in the finer argillaceous fraction (Gevar 'am Formation) deposited in the submarine canyons (Cohen, 1976), outer shelf and the continental slope.

The Cretaceous transgression over the margins of the Arabo-Nubian craton, reached Northern Sinai, the Northeastern Negev, the Israeli coastal plain and Lebanon in ?Barremian to Aptian times.

A short Late Aptian regression (Yavne Shale) ended the Early Cretaceous (Berriasian-Aptian) sedimentary cycle characterized mainly by non biogenic components (clay and sand).

The following Mid-Cretaceous transgression, progressed on an almost level landmass formed during a period of intensive erosion. Less clastic material from the continent was transported by the rivers into the rapidly advancing sea. Shallow marine calcareous sediments were deposited on the increasing, nearly flat shelf regions. Some of these sediments contain pelagic elements drifted from the open sea. Even small sea-level oscillations, on the extremely broad (200-300 km) Cenomanian-Turonian shelf, strongly affected the biota and the sediment (including early diagenetic processes such as dolomitization), creating a complex litho- and biofacies pattern. The lower part of the transgression is diachronous and is characterized by clastic material grading into a calcareous-dolomitic sequence. The upper contact of the Mid-Cretaceous sequence with the Senonian chalk is quite sharp, due to local unconformities caused by conspicuous Late Coniacian environmental changes. The Coniacian shelf sediments of the Middle East still belong lithologically and faunistically to the Mid-Cretaceous calcareous sequence, even though, the sediments comprise more argillaceous material.

The off-shelf sediments during the Albian-Turonian times, are characterized by fine grained, calcareous bioclastic material (Talme-Yafe Formation), most of which was removed from the shelf, and was carried downslope by strong currents (Bein, 1976). This sediment contains different amounts of pelagic elements (oligosteginids, coccolithophorids and planktonic foraminiferids. (Bein and Reiss, 1976).

From the Late Jurassic onwards, throughout the Cretaceous times, a tensional tectonic regime characterized the Middle East. Normal faulting and magmatism (intrusive and extrusive) occurred throughout the Levant (Freund et al., 1975). The most important of these fault regions (the "hinge line", Gvirtzman and Klang, 1972) was located nearly parallel to the present-day Israeli shoreline (Fig. 2) and controlled the configuration and position of the shelf and the continental slope of that time. It separated between two marine environments : a quite stable, broad shelf, subsiding more or less gradually following the rate of sediment accumulation, and a slope region, which slowed its subsidence rate toward the Turonian times, when the shelf region extended more to the west (seawards) (Bein, 1974). The border between both marine environments was characterized by rudistid "reefs" during the Albian-Turonian times (Bein, 1976).

During the Senonian times, an open-marine environment prevailed over the shelf regions, resulting in the deposition of chalk and chalky limestone even in shallow marine regions. With this conspicuous lithofacies change the Mid-Cretaceous sedimentary event ended.

AMMONITE BIOSTRATIGRAPHY

The Mid-Cretaceous ammonites of the Middle East offer the best means of biozonation and long range correlation, although they have a certain ecologic sensitivity. Some of these ammonites occur in Western Europe and Texas, and enable the chronostratigraphy as established in those well studied areas to be applied to our region. Strata devoid of ammonites or any other age-indicative fossils could not be undoubtedly attributed to any of the adjacent biozones. Therefore, the exact stratigraphic position of most of the age boundaries is uncertain.

ALBIAN

Engonoceratid ammonites (the earliest representatives of which appear in the Albian (Wright, in Moore, 1957)) occur in the Middle East in the lower part of the marine Mid-Cretaceous sequence. The stratigraphically nearest, earlier ammonites were found in Gebel Maghara only (N. Sinai ; Douvillé, 1916). It should be mentioned that Douvillé's (op. cit.) Aptian *Knemiceras priscum* is not an engoceratid but a puchelliid (*Mogharaeceras*. Breistroffer, 1940, included in *Subpulchellia* Hyatt, 1903) of Barremian-Aptian age.

The Albian engonoceratids of Lebanon and Israel occur in two different levels. The lower level is usually associated with a layer of marly limestone with iron-oxide oolites (Fig. 3). The lack of detailed information on the stratigraphic distribution of the Albian ammonites in the Middle East, renders the establishment of a detailed formal biostratigraphic zonation impossible. Therefore, all the occurrences of Albian ammonites (Table 1) have been included in a single tentative Early Mid-Cretaceous Zone, viz. *Knemiceras* Zone.

CENOMANIAN

CE 1 : - *Graysonites* Assemblage Zone : Several ammonites, belonging to stratigraphically diagnostic species (Table 2), characterize this assemblage zone, which can be traced at the base of a marly or argillaceous limestone sequence in the Jerusalem area, in the Northern and Northeastern Negev (Fig. 3) and in Northwestern Sinai. Most of the species characterizing this zone were never recorded before from our region, and since they are indispensable for the definition of this zone, they are also illustrated herein (see Plate 1, figs. 1-3, 11-13). The occurrence of *Graysonites wooldridgei* Young and *Stoliczkaia amanoi* Matsumoto and Inoma, indicates a lowermost Cenomanian age for this zone and enables its correlation with Portugal (Wiedmann, 1964) on the one hand, and with Japan (Matsumoto and Inoma, 1975) on the other. *Utaturiceras bethlehemense* Avnimelech and Shoresh (1962) was erroneously attributed by these authors (1962) to the "calcaire à *Acanthoceras*" (i.e. Kefar Sha'ul Formation). This species was later found to be associated with *Graysonites* at a lower stratigraphic level (Base Bet-Me'ir Formation, Jerusalem area and the Northern Negev) and was therefore assigned herein to this zone.

CE 2 : This biozone is based on a few ammonites collected from the interval between CE 1 and CE 3. *Metoicoceras besairiei* Collignon (Plate 1, Fig. 10) occurs in the Jerusalem area (Moza Formation), Makhtesh Ramon ('En Yorqe'am, Member of the Hazera Formation) and in Gebel Halal (Northern Sinai). It is the only species having a considerable geographic distribution. All the other species (Table 2) were collected from Mt. Carmel (Isfiya Chalk), from where only *Hyphoplites falcatus* (Mantell) was formerly recorded in the literature (Avnimelech, 1975).

CE 3 : *Sharpeiceras* Assemblage Zone : The rich assemblage of ammonites characterizing this zone (Table 2) occurs in Israel, in the lower part of the Khureibe Chalk (Mt. Carmel). All the specimens sampled in the past, have no indication as to which part of the approx. 100 m thick Khureibe Chalk they belong, and they comprise typical Early Cenomanian forms such as *Sharpeiceras* and *Mantelliceras*, which belong to this zone (CE 3), beside Late Cenomanian ones (e.g. *Euomphaloceras, Calycoceras*) which belong to the following zone (CE 4). This stratigraphic discrepency has been recently confirmed by a more accurate (though preliminary) sampling. As already mentioned by Kennedy (1971, p. 112), the Lebanese ammonites recorded by Basse (1937, 1940) originate from different stratigraphic levels. However, part of these ammonites could be clearly attributed to this Early Cenomanian zone (Table 2).

CE 4 : *Calycoceras-Neolobites* Assemblage Zone : This biozone is characterized by the occurrence of *Calycoceras, Eucalycoceras, Euomphaloceras* and *Neolobites* and comprises all the Late Cenomanian ammonites (Table 2). The *Calycoceras* sp. *Exogyra olisipoenensis* (Sharpe) Zone (Freund and Raab, 1969) is included in it. This single Late Cenomanian biozone, in the sense of a twofold subdivision of the Cenomanian (See Chronostratigraphy) could not be further split and it comprises several forms (e.g. *Calycoceras newboldi* (Kossmat), *Euomphaloceras cunningtoni* (Sharpe), *Turrilites acutus* Passy) which are attributed to the Middle Cenomanian *Acanthoceras rhotomagense* Zone (Kennedy, 1971). Although most of these ammonites occur in the *Acanthoceras rhotomagense* Zone, a few of them may range into the overlying *Calycoceras naviculare* Zone. No *C. naviculare* or any other indicative ammonite of the latter zone or of the following *Metoicoceras gaselinianum* and *M. goudroni* Zones (Kennedy, 1971) have been hitherto recognized in the Middle East. Therefore, it is plausible that CE 4 Zone is the biostratigraphic equivalent of the *A. rhotomagense* Zone and probably also to part of the *C. naviculare* Zone. The CE 4 Zone is widespread in the Middle East, extending from Western Syria (Gebel Ansariya) and Lebanon in the north, through Israel to Sinai in the South.

TURONIAN

The Turonian ammonite biozones (Table 3) were established by Freund and Raab (1969) and by Lewy (1975) and were based on rich assemblages carefully sampled in detail from well exposed strata.

The *Kanabiceras* sp. of Zone T 1 is associated with *Para-*

[illegible] *Schneegans* and *Vascoceras* cf. [illegible] (Freund and Raab, 1969). This asso- [illegible] Turonian (Lower) age for this *Kanabice-* [illegible] in the Middle East, whereas the earliest assemblage comprising *Kanabiceras* is found in Europe already in the Uppermost Cenomanian (Kennedy, 1971).

The *Coilopoceras* sp., characterizing the *Coilopoceras* sp. Zone (Freund and Raab, 1969; designated herein T 8), is distinguished from those *Coilopoceras* of the *C. requienianum* Zone (T9) by its suture details. Zone T9 occurs much higher in the section, overlying a considerable sequence barren of ammonites.

CONIACIAN

The biostratigraphy of the Coniacian ammonites is based on Lewy (1975) and Parnes (1964). Five Coniacian biozones (designated CA 1-5 in Table 4) were recorded.

Zones CA 1 - CA 3 are of Early Coniacian age and Zones CA 4 - CA 5 are of Late Coniacian age. They occur from the Israeli Negev southwards and westwards (Sinai, North Africa), whereas northwards (Central and Northern Israel, Transjordan and Lebanon), they could not be recognized. However, two isolated peroniceratine ammonites were found in Central Israel. Coniacian (most probably Early) ammonites (Table 4) were recorded futher to the north from Northwestern Syria (Ponikarov, 1966). Species of *Heterotissotia*, recorded from the Eastern Desert of Egypt (Greco, 1915) do not occur eastwards in Sinai and Israel and therefore, could be tentatively attributed to Zone CA 4 of *Heterotissotia neoceratites-Buchiceras bilobatum* (Table 4).

CA 4 comprises species of the *Metatissotia ewaldi* Zone in Europe, whereas no exclusive ammonite species of the following Latest Coniacian European *Parabevahites emscheris* Zone has been hitherto found in the Middle East.

BIOSTRATIGRAPHY OF OTHER FAUNAL GROUPS
(excluding ammonites)

As most of the exposed Mid-Cretaceous rocks were deposited on a shelf platform under shallow waters, the dominating fossil groups are benthonic. A few pelagic groups (especially microfossils), become more abundant toward the west and northwest i.e., toward the open sea. The benthonic groups contribute mainly to the understanding of the shelf environments and microfacies.

The microfossils, especially the planktonic ones, are the only means of dating pelagic and for correlating subsurface sequences. Several studies on the Mid-Cretaceous microfossils (most of them internal reports) were published. An attempt has been made in some of them to establish a local biostratigraphic zonation or to apply European biozones to our region. However, none of them provide a more detailed and accurate dating than that of the ammonites. Most of these biostratigraphic units are informal and serve only in local correlation. Thus, several biostratigraphic units, most probably local assemblage zones, were established by Grader, Reiss and Klug (1960) for correlation of the Lower Cretaceous, including Early Mid-Cretaceous strata, in boreholes in the Israeli Coastal Plain. *Gavelinella aumalensis* Zone (Arkin and Hamaoui, 1967), a local assemblage zone of Early Cenomanian age, was also used for correlation in the subsurface of the Coastal Plain as well as in outcrops in the Northern Negev. The European *Helvetoglobotruncana helvetica* Zone (Reiss, 1958) was locally used for correlation of a marly facies of Uppermost Cenomanian to Turonian age, both in the surface and the subsurface.

Globotruncana concavata (Brotzen) was first described from a Santonian *(Texanites)* chalk near Mount Carmel, Israel (Brotzen, 1934), and for a long time was regarded as an exclusive Santonian index fossil. This species was later found associated with Coniacian ammonites (de Klasz, 1961) and its Santonian occurrence is thus a partial range zone. The indicative *Globotruncana* species (including the species : *G. renzi* Gandolfi, *G. schneegansi* Sigal, *G. sigali* Reichel) occur in the Middle East in marl or chalky limestone of the open sea (pelagic) environment (Lewy, 1975) and therefore are of minor biostratigraphic significance for the zonation of the shallow shelf regions of the Mid-Cretaceous times. The same is true for the Cenomanian-Turonian ostracode zones in Israel (Rosenfeld and Raab, 1974) which should be reevaluated in view of the recent advances in the dating of the different lithofacies.

The following is a list of the latest micropaleontological studies : NANNOPLANKTON : Moshkovitz, 1972 ; FORAMINIFERIDA : Arkin and Hamaoui, 1967 ; Grader and Reiss, 1958, Grader, Reiss and Klug, 1960 ; Hamaoui and Gerry, 1965 ; Hamaoui and Raab, 1965, 1965a; Hamaoui and Saint-Marc, 1970 ; Said and Barakat, 1957 ; Saint-Marc, 1974 ; OSTRACODA : Bold, 1964 ; Colin and Dakkak, 1975 ; Damotte and Saint-Marc, 1972 ; Koch, 1968 ; Rosenfeld and Raab, 1974 ; PALYNOLOGY : Brenner, 1974.

A very rich variety of bivalves and gastropods occurs in the Mid-Cretaceous rocks in the Middle East. They were a subject of many studies (e.g. Abbass, 1962, 1963; Blanckenhorn, 1927, 1934 ; Déchaseaux, 1954 ; Delpey, 1940 ; Douvillé, 1916 ; Fawzi, 1963, 1964 ; Fourtau, 1904, 1917 ; Greco, 1916, 1917 ; Mahmoud, 1955 ; Shalem, 1928) though none of them provided any biostratigraphic zonation. It should be mentioned that inocerami are very rare (due to the unfavourable shelf conditions) whereas oysters and rudists are very abundant.

Oysters occur either as a part of heterogeneous biota, which apparently indicates normal marine conditions, or as monospecific (e.g. *Pycnodonte vesiculosa* (Sow.) ; *Exogyra conica* (Sow.)) bank-like concentrations of well preserved specimens (resembling the thicket-building rudists). Some *Exogyra* as well as *Neithea* species seem to occur in definite stratigraphic positions (See Table 5 and Fawzi, 1964).

Rudists were studied by Blanckenhorn (1934), Déchaseaux (1954), Douvillé (1910), Keller (1933) and Vautrin (1933) mainly from Syria and Lebanon where they persist till Maastrichtian times. The latest rudists in Israel and Sinai are of Late Turonian age (*Bournonia judaica* Blanckenhorn, Lewy, 1975).

Echinoids are quite abundant in the Mid-Cretaceous rocks of the Middle East, and seem to be biostratigraphically significant. Nevertheless, they were hitherto studied only systematically (e.g. Blanckenhorn, 1925 ; Keller and Vautrin, 1937 ; Fourtau, 1914).

Vertebrates are rare. Most notable, however, is the occurrence of fossil fish in a few restricted localities in Lebanon (Hakel and Hajula) and in Israel (Jerusalem area). They occur in fine grained limestone associated with crustaceans and plant remains and in Israel also with aquatic chelonians and ammonites (among a few representatives of other groups). A Middle Cenomanian age was tentatively assigned to the Lebanese fishes by Patterson (1967, 1970), whereas Hückel (1970) attributed them to the Late Early Cenomanian and Saint-Marc (1974) to the transition from Lower to Middle Cenomanian ($C4_1$-$C4_2$). In Israel, however, the accompanying *Neolobites vibrayeanus* (d'Orbigny) indicates a definite Late Cenomanian age (CE 4). This difference in age explains the fact that none of the Lebanese species occurs in Israel. The aquatic chelonians are of the oldest known *Podocnemis* (G. Haas, the Hebrew Univ. of Jerusalem, Dept. of Zoology, 1976, pers. comm.). Land-dinosaur tracks were found in the Soreq Formation dolostone (attributed herein to the Albian) near Jerusalem (Avnimelech, 1962). They indicate the shallowness of the shelf which was considerably remote from the coeval shoreline in Jordan (Fig. 2). A rich vertebrate assemblage, comprising mainly shallow marine and continental forms (e.g. tortoises, crocodiles, dinosaurs), was described by Stromer (in : Blanckenhorn, 1921 ; Hooijer, 1968) from

Lower Cenomanian, sandy-shale beds, some [illegible] m below *Neolobites fourtaui* Pervinquière ([illegible] Said, 1962) in the region of the Bahariya Oasis (Egypt). Another dinosaur, of Cenomanian or Uppermost Cretaceous age was recorded from Syria by Hooijer (1968).

Several biostratigraphic data are recorded in the following latest stratigraphical studies from the Middle East countries : Bender, 1968, 1974 ; Bogdanov, 1963 ; Ponikarov, 1966 ; Said, 1962 and Wolfart, 1967.

CHRONOSTRATIGRAPHY

ALBIAN

The lowest *Knemiceras* in Northern Sinai (Bir Lugama near Gebel Maghara, Douvillé, 1916) is accompanied by *Douvilleiceras mammilatum* (Schloth.) indicating an Early Albian age (Jeletzy, 1968). As mentioned above, the earliest occurrences of *Knemiceras* in the Middle East (Northern Sinai, Northern Negev, Galilee, Lebanon : Fig. 3) are usually associated with iron-oxide oolites. According to the age of this phenomenon in Northern Sinai (Douvillé, 1916), an Early Albian age can be assumed for all other lower occurrences of *Knemiceras*. Rosenberg (1960) recorded a *Knemiceras* sp. from a marly layer, just below the iron-oxide oolite-bearing unit, in the upper part of the "Couches à Orbitolines" (Heybroek, 1942) in the Northern Galilee, indicating an Early Albian age for this layer (formerly regarded as of Aptian age), as well as to the correlatable C2₂ unit of Saint-Marc (1974). The upper level of *Knemiceras* occurs rather close to the lower one, and considerably lower than the earliest Cenomanian ammonites. An Early to probably Middle Albian age is therefore suggested for the upper *Knemiceras* level.

CENOMANIAN

An ammonite-barren sequence ($C3_3$ of Saint-Marc, 1974) occurs between the upper *Knemiceras* unit (of Early and Middle Albian age) and the lowermost Cenomanian ammonite zone CE 1. Since CE 1 Zone, containing *Stoliczkaia* and *Graysonites* is of earliest Cenomanian age (Kennedy, 1971), the dolomitic unit below it may be attributed to the Late Albian. The Albian-Cenomanian boundary is, therefore, tentatively inserted at the top of this unit (Fig. 2).

Biozones CE 1 - CE 3 contain species of *Graysonites*, *Stoliczkaia*, *Mantelliceras*, *Sharpeiceras*, *Acompsoceras*, *Paracalycoceras* and *Hyphoplites*. This assemblage characterizes the Early Cenomanian *Mantelliceras mantelli* Zone in Europe (Kennedy, 1971).

Biozone CE 4 comprises typical West European, Middle to Late Cenomanian ammonites such as *Euomphaloceras*, *Eucalycoceras* and *Pseudocalycoceras*. The assemblages of the Cenomanian ammonites thus, enable a twofold chronostratigraphic division of the Cenomanian namely Early and Late, the latter comprising also the Western European Middle Cenomanian. Ammonites of CE 4 Zone occur in the Judea Mountains and in the Negev (Israel) just above a limestone-dolostone unit (50-100m) overlying CE 2. The first *Heterohelix* (Foraminiferida), indicating a Late Cenomanian age, occurs in the lower part of this zone in the Northern Negev (Hamaoui and Gerry, 1965) a few meters above *Neolobites fourtaui* Perv.. It seems that the limestome-dolostone unit in between CE 2 and CE 4 is partly or completely of Early Cenomanian age (i.e. the stratigraphic equivalent of CE 3).

TURONIAN

The Cenomanian-Turonian boundary in Southern Israel and Sinai can easily be traced by means of the ammonites. Towards Central Israel, ammonites of the Early Lower Turonian zones disappear. Their assumed lithostratigraphic equivalent consists of dolomites and limestones with rudists which can be generally dated as of Turonian age. Zones T 1 - T 6 are undoubtedly of Early Turonian age. Zone T 7 comprises exclusively Early Turonian ammonites, beside species which extend into the Late Turonian, and exclusively Late Turonian ones. The Early/Late Turonian boundary lies, therefore, somewhere within this zone (see also Freund and Raab, 1969). Zone T 9 of *Coilopoceras requienianum* (d'Orbigny), which is the last Late Turonian biozone in the Middle East, is not the latest Turonian biozone in Europe (Jeletzky, 1968). Biozone T 9 is overlain by an ammonite-barren sequence above which appears the first Coniacian zone (CA 1).

CONIACIAN

The lowermost Coniacian zone (CA 1) in the Middle East is not of a lowest Coniacian age, since *Proplacenticeras eboroense* Collignon occurs in the Mid-Coniacian (*Barroisiceras onilahyense* - *Kossmaticeras theobaldi* Zone) of Madagascar (Collignon, 1965) and *P. tamulicum* (Blanford), though being characteristic to the Indian Santonian Zone 6, may occur in the Coniacian Zone 5 (Sastry, Rao and Mamgain, 1968).

CA 2 comprises, in addition to local species, badly preserved *Barroisiceras onilahyense* Basse (Table 4) attributed to the Lower Coniacian. CA 3 contains the latest Early Coniacian ammonites such as *B. onilahyense* Basse, *Allotissotia galeppei* (Perv.) (Table 4). CA 4 is characterized by *Heterotissotia*-species, *Buchiceras bilobatum* Hyatt and *Roemeroceras tunisiense* (Hyatt). The Early/Late Coniacian boundary is drawn between the latest *Barroisiceras* and the earliest *Heterotissotia*. Zone CA 4 is, therefore, of Late Coniacian age. CA 5 is the uppermost local Coniacian zone, comprising *Metatissotia*-species, *Reesideoceras* and *Protexanites* at its top (Lewy, 1975). It is followed by a sequence of ammonite-barren chalk which is overlain (in places disconformably) by marl containing *Spinaptychus spinosus* (Cox) and *Sigalia deflaensis* (Sigal) (Foraminiferida), which are the earliest Santonian indicative fossils.

The chalk sequence below the spinaptychi-bearing unit, may be coeaval with the Western European latest Coniacian *Parabevahites emscheris* Zone (Lewy, 1975) which was not recognized in the Middle East.

LITHO- AND BIOFACIES

As mentioned above, most of the exposed Mid-Cretaceous strata in the Middle East were deposited on a broad, shallow shelf, whereas the deeper environments of deposition are encountered only in drillings, along the recent Mediterranean coastal plain and seawards. During those times, the shelf was quite stable, keeping a rather similar water depth where subsidence was almost equal to the rate of sedimentation. Rudists and their biolithites are most significant from the litho- and biofacial point of view in the Mid-Cretaceous sediments. The ecology and configuration of the Cretaceous rudistid biolithites in Northern Israel were discussed by Bein (1976) and by Freund (1965).

The rudistids in the Middle East build several kinds of biogenic calcareous structures, which can be classified into two major types : (1) narrow belts of wave-resistant vertically growing rudistid "reefs" and (2) a laterally widespreading thicket of one or two rudist generations. Small clusters of vertically growing rudists (like coral pinnacles) which are usually associated with other molluscs (e. g. *Nerinea*, *Trochactaeon*) and horn-like, unattached rudists (*Ichthyosarcolites*), occur in addition to those end-types.

The rudistid "reef" belt (1) characterizes the edge of the shelf platform. There, cone-like attached rudists built a wave-resistant structure (Bein, 1976). Level bottoms of low-energy marine environment, provided a substrate for a monospecific rudist population (mostly a single generation), spreading over large areas. Due to the shallowness of the water, this environment was unstable, and emergence or covering by unconsolidated sediments, causing the death of the whole population, eventually occurred. Several consecutive rudist thickets indicate such cycles of population and mortality.

Morphological highs on the shallow shelf provided substrates for small rudist clusters of a heterogeneous nature. Firmly attached cone-like rudists occurred on these highs, occasionally cemented to each other (Bein, 1976) and associated with poorly attached, curved rudists such as *Toucasia*, *Apricardia*, *Caprina*, *Caprinula* and completely free forms such as *Ichthyosarcolites*. They are also associated with other bivalves and gastropods, occupying the more protected, calm niches.

The rudists contribute their debris to the surrounding area. Skeletal material is deposited almost over the whole shelf platform and also carried downward the continental slope (mainly the calcilutite) where it is deposited as "alternating laminae of calcilutite and fine calcarenite " (Bein, 1976, p. 264). Although rudists inhabited shallow waters, they did not live near the shore and in environments of high sedimentation rates or muddy bottoms. Such unfavourable conditions may be the cause for the absence of rudists from the Latest Turonian onwards in Israel and Sinai (Jordan and Egypt ?).

Echinoids, gastropods and infaunal bivalves which prefer a fine grained substrate, occur in marl, marly and chalky limestones or calcareous sandstones, all of a relatively soft nature. Hard bioclastic limestones contain only a few well preserved magafossils and indicate a relatively high-energy environment of deposition. On the other hand, these bioclastic limestones may contain rudists which need suitable substrates and tolerate water turbulence.

Low-energy marine environments prevailed in restricted shallow basins in Cenomanian times (Hajula and Hakel in Lebanon, and Jerusalem area in Israel). There the sediments were deposited in laminae, forming a platy limestone which contains extraordinarily well preserved fishes, ophiuroids and chelonians, in addition to other faunal groups (Hückel, 1970). This biota is associated with terrestrial plant remains drifted from the nearby land bodies. (i.e. exposed rims of these basins and islands, since the shoreline of the continent was much further eastwards). This peculiar environment of deposition occurred during the lowering of the sea level (followed in the Jerusalem area by the deposition of dolostone) through which underwater depressions became partly or completely closed shallow basins. The rarity of megafossils in the dolostones may be due to the primary unfavourable environment (high salinity) as well as secondary destruction through dolomitization.

REFERENCES

ABBASS H.L., (1962) — A monograph on the Egyptian Cretaceous pelecypods. Geol. Mus. Cairo, Paleont. Ser., Monograph 1, 1-224, 24 pls. 1 map.

ABBASS H.L., (1963) — A monograph on the Egyptian Cretaceous Gastropods. Geol. Mus. Cairo, Paleont. Ser., Monograph 2, 146 pp., 11 pls., 10 figs.

ARKIN Y., BRAUN M. and STARINSKY A., (1965) — Type sections of Cretaceous formations in the Jerusalem - Bet Shemesh Area. Geol. Surv. Israel, Stratigraphic Sections 1, 42 pp., Charts and Sect., 6 pls.

ARKIN Y. and HAMAOUI M., (1967) — The Judea Group (Upper Cretaceous) in Central and Southern Israel. Geol. Surv. Israel, Bull. 42, 16 pp., 2 pls., 17 figs.

AVNIMELECH M., (1962) — Dinosaur tracks in the Lower Cenomanian of Jerusalem. Nature, 196, 264.

AVNIMELECH M., (1965) — Sur la présence de *Hyphoplites falcatus* (Mantell) (Ammonoides : Hoplitidae) dans le Cénomanien inférieur du Carmel (Israël). C.R. somm. Scéan. Soc. géol. Fr., 5. 160-161, 1 fig.

AVNIMELECH M.A., (1965a) — Bibliography of Levant Geology. 1, 192 pp., Israel Prog. Sci. Trans. Jerusalem.

AVNIMELECH M.A., (1969) — Bibliography of Levant Geology. 2, 184 pp., Israel Prog. Sci. Trans. Jerusalem.

AVNIMELECH M. and SHORESH R., (1962) — Les Céphalopodes cénomaniens des environs de Jérusalem. Bull. Soc. géol. France, 4, 528-535, pl. 15, 3 figs.

BARTOV J., EYAL Y., GARFUNKEL Z. and STEINITZ G., (1972) — Late Cretaceous and Tertiary stratigraphy and paleogeography of Southern Israel. Israel J. Earth-Sci., 21, 60-97, 15 figs.

BASSE E., (1937) — Les Céphalopodes crétacés des massifs côtiers syriens. Notes et Mém. Haut-Commiss. Rép. Fr. Syrie-Liban, 2, 165-200, pls. 8-11, figs. 50-57.

BASSE E., (1940) — Les Céphalopodes crétacés des Massifs côtiers syriens, Pt. 2, Notes et Mém. Haut-Commiss. Rép. Fr. Syrie-Liban, 3, 412-490, pls. 1-9.

BASSE E., (1954) — Sur une ammonite nouvelle du Turonien au Liban. Notes et Mém. Moyen Orient, 5, 199-203, 3 figs., pl. 4.

BEIN A., (1974) — Reef development in the Judea Group from the Carmel and the coastal plain. Israel. Ph. D. Thesis, The Hebrew Univ. Jerusalem (in Hebrew, English abstract), 169 pp., 16 pls., 25 figs.

BEIN A., (1976) — Rudistid fringing reefs of Cretaceous shallow carbonate platform of Israel. Amer. Assoc. Petrol. Geol. Bull., 60 (2), 258-272, 15 figs.

BEIN A. and REISS Z., (1976) — Cretaceous *Pithonella* from Israel. Micropaleontology, 22(1), 83-91, pls. 1-3, 1 Textfig.

BENDER F., (1968) — Geologie von Jordanien. Beitr. Reg. Geol. der Erde, 7, 230 pp., 177 figs., Gebrüder Borntraeger, Berlin

BENDER F., (1974) — Geology of Jordan. (supp. of vol. 7, Reg. Geol. Earth) Gebrüder Borntraeger, Berlin, 196 pp., 40 figs.

BENJAMINI C., (1973) — The stratigraphy and structural geology of the Sartaba Area (Samaria). M. Sc. Thesis, The Hebrew Univ. Jerusalem, 98 pp., 4 pls.

BLANCKENHORN M., (1921) — Aegypten in : Steinmann G. and Wilckins O., Handbuch der regionalen Geologie, 7(9), 244 pp., 30 figs., Heidelberg.

BLANCKENHORN M., (1925) — Die Seeigelfauna der Kreide Palästinas. Palaeontographica. 67. Abt. A, 83-113, pls. 7-8.

BLANCKENHORN M., (1927) — die Fossilen Gastropoden und Scaphopoden der Kreide von Syrien-Palästina. Palaeontographica, 69, Abt. A, 11-186, pls. 5-10.

BLANCKENHORN M., (1934) — Die Bivalven der Kreideformation von Syrien-Palästina. Palaeontographica, 81, Abt. A, 161-296, 8 pls., 2 figs.

BOGDANOV A.A., (Editor), (1969) — Geology and mineral resources of foreign countries Syria. (in Russian) "Nedra", Leningrad, 215 pp., 26 figs., 4 charts.

BOLD W.A. van den, (1964) — Ostracoden aus der Oberkreide von · Abu-Rawash, Aegypten. Palaeontographica, 123, Abt. A, 11-136, pls. 13-15.

BRAUN M., (1970) — Facies changes of the Judea Group in Judea and Samaria. Israel Geol. Soc., Annual Meeting 1970 (abstract), 29-35, 1 chart.

BREISTROFFER M., (1940) — Révision des ammonites du Vraconien de Salazac (Gard) et considérations générales sur ce sous-étage Albian. Trav. Lab. Géol. Univ. Grenoble, 22 (1938-1939), 71-171.

BRENNER G.J., (1974) — Palynostratigraphy of the Lower Cretaceous Gevar'am and Talme-Yafe Formations in the Gevar'am 2 well (Southern Coastal Plain, Israel), Geol. Surv. Israel, Bull., 59, 27 pp., 10 pls.

BROTZEN F., (1934) — Foraminiferen aus dem Senon Palästinas. Zeit. Deutsch. Palästina-Vereins, 57, 28-72, pls. 1-4.

COHEN Z., (1976) — Early Cretaceous Buried Canyon : Influence on Accumulation of Hydrocarbons in Helez Oil Field, Israel. Amer. Assoc. Petrol. Geol. Bull. 60(1), 108-114, 4 figs.

COLIN J.-P. and EL DAKKAK M.W., (1975) — Quelques ostracodes du Cénomanien du Djebel Nezzazat, Sinai, Egypte. Rev. Espñ. Micropal., Num.esp., 49-60, 2 pls.

COLLIGNON M., (1965) — Atlas des fossiles caractéristiques de Madagascar (Ammonites). Fasc. 13 : Coniacien, 88 pp., pls. 414-454.

DAMOTTE R. et SAINT-MARC P., (1972) — Contribution à la connaissance des ostracodes crétacés du Liban. Rev. Espñ. Micropal., 4(3), 273-296, 1 fig., 3 pls.

DECHASEAUX C., (1954) — Etude sur un rudiste de Syrie, le genre *Vautrinia* Milovanović. Notes et Mém. Moyen Orient, 5, 173-190, figs. 1-11, pls. 1-4.

DELPEY G., (1940) — Les gastéropodes Mésozoïques de la région Libanaise. Haut Commiss. Rép. Fr., Syrie-Liban, 3, 5-292, 189 figs.n 5 maps, 11 pls.

DERIN B., (1974) — The Jurassic of Central and Northern Israel. Ph. D. Thesis, The Hebrew University, Jerusalem, (in Hebrew, English abstract), 152 pp., 18 pls.

DOUVILLÉ H., (1910) — Etude sur les Rudistes : Rudistes de Sicile, d'Algérie, d'Egypte, du Liban et de la Perse. Mém. Soc. géol. France, 41, Paléont., 5-83, 7 pls., 77 figs.

DOUVILLÉ H., (1916) — Les terrains secondaires dans le Massif du Moghara à l'Est de l'Isthme de Suèz, Paléontologie. Mém. Acad. Sci., 65, 2e série, 184 pp., 21 pls., 50 figs.

DOUVILLÉ H., (1928) — Ammonites de la Craie Supérieure en Egypte et au Sinaï. Mém. Acad. Sci., Inst. Fr., 60, 41 pp., 7 pls.

DUBERTRET L. et VAUTRIN H., (1937) — Révision de la stratigraphie du Crétacé du Liban. Notes et Mém., Haut Commiss. Rép. Fr. Syrie-Liban, 2, 43-73, figs. 26-35.

ECK O., (1915) — Die Cephalopoden der Schweinfurthschen Sammlung aus der Oberen Kreide Aegyptens. Zeit. deut. geol. Ges., 66, 179-216, pls. 9-20.

FAWZI M.A., (1963) — La faune cénomanienne d'Egypte. Geol. Mus. Paleont. Ser. Monogr. 2, 133 pp., 8 pls., 1 chart.

FAWZI M.A., (1964) — On the phylogenetic trends and transitional stages of Cretaceous oysters. Bull. Fac. Sci. Alexandria Univ., 6, 225-240. 2 pls.

FOLKMAN Y., LASMAN N. and RAAB M., (1966) — Lower Cretaceous outcrops on Mount Carmel (Northern Israel). Israel J. Earth-Sci. 15, 38-41, 2 figs., 1 pl.

FOURTAU R., (1904) — Etude de la faune crétacique d'Egypte. Bull. Inst. Egyptien, Sér. 4, 4, 231-350, pl. 1-5.

FOURTAU R., (1914) — Catalogue des Invertébrés Fossiles de l'Egypte. Terrains Crétacés. 1ère Partie : Echinodermes. Geol. Surv. Egypt., Paleont. 2, 109 pp., 8 pls.

FOURTAU R., (1917) — Catalogue des Invertébrés Fossiles de l'Egypte. Terrain Crétacés. 2ème Partie : Mollusques Lamellibranches. Geol. Surv. Egypt, Paleont., 3, 108 pp., 7 pls.

FREUND R., (1961) — Distribution of Lower Turonian ammonites in Israel and the neighbouring countries. Bull. Res. Counc., Israel, 10G, 79-100, 5 figs.

FREUND R., (1965) — Upper Cretaceous reefs in Northern Israel. Israel J. Earth-Sci., 14, 108-121, 3 pls., 5 figs.

FREUND R. and RAAB M., (1969) — Lower Turonian ammonites from Israel. Spec. Paper Palaeont., 4, 83 pp., 15 Text-figs., 10 pls.

FREUND R., GOLDBERG M., WEISSBROD T., DRUCKMAN Y. and DERIN B., (1975) — The Triassic-Jurassic structure of Israel and its relation to the origin of the Eastern Mediterranean. Geol. Surv. Israel, Bull. 65, 26 pp., 10 figs.

GARFUNKEL Z., (1964) — Tectonic problems along the Ramon Lineament. M.Sc. Thesis The Hebrew Univ., Jerusalem, (in Hebrew, unpublished).

GOLANI U., (1961) — On the Cenomanian-Turonian Lithostratigraphy of Central Galilee. Bull. Res. Counc. Israel, 10G, 116-146, 9 figs.

GRADER P. and REISS Z., (1958) — On the Lower Cretaceous of the Heletz Area. Geol. Surv. Israel, Bull. 16, 14 pp., 17 pls., 1 fig., 1 chart.

GRADER P., REISS Z. and KLUG K., (1960) — Correlation of sub-surface Lower Cretaceous units in the Southern Coastal Plain of Israel. Geol. Sur. Israel. Bull. 28, 7 pp., 4 charts.

GRECO B., (1915) — Fauna Cretacea dell'Egitto. Part I : Cephalopoda. Palaeontographica Italica. 21, 189-231, pl. 17-22, figs. 1-11.

GRECO B., (1916) — Fauna Cretacea dell'Egitto. Part II : Pisces, Caphalopoda (addenda) et Gastropoda. Palaeontographica Italica, 22, 103-169, pls. 15-19.

GRECO B., (1917) — Fauna Cretacea dell'Egitto. Part III : Lemellibranchiata. Palaeontographica Italica. 23, 93-161, pls. 13-17.

GREENBERG M., (1968) — Type section of the Lower Cretaceous Hatira Formation in Hamakhtesh Hagadol, Northern Negev. Geol. Surv. Israel, Strat. Sec., 5, 6 pp., 1 fig., 1 charts.

GVIRTZMAN G. and KLANG A., (1972) — A structural and depositional hinge line along the Coastal Plain of Israel, evidenced by magneto-tellurics. Geol. Surv. Israel, Bull. 55, 18 pp., 8 figs.

HAMAOUI M. and GERRY E., (1965) — Biostratigraphy of the Cenomanian type Hazera Formation. Geol. Surv. Israel, Star. Sec., 2b, 27 pp., 15 pls.

HAMAOUI M. and RAAB M., (1965) — Type Sections of Cretaceous Formations in the Jerusalem-Bet-Shemesh Area. II. Biostratigraphy. Geol. Surv. Israel. Strat. Sec., 1, 42 pp., 6 pls., 14 figs.

HAMAOUI M. and RAAB M., (1965a) — Biostratigraphy of the type Shivta and Nezer Formations. Geol. Surv. Israel, Strat. Sec., 2c, 12 pp., 10 pls.

HAMAOUI M. and SAINT-MARC P., (1970) — Microfaune et microfaciès du Cénomanien du Proche-Orient. Bull. Centre Rech. Pau-SNPA, 4(2), 257-352, 6 figs., 40 pls.

HEYBROEK F., (1942) — La géologie d'une partie du Liban sud. Leid. Geol. Meded. 12(2), 251-470, pl. 4-9, 57 figs.

HOOIJER D.A., (1968) — A Cretaceous Dinosaur from the Syrian Arab Republic. Koninkl. Nederl. Akad.

Wetensch. Amsterdam, Ser. B. 71(2), 150-152.

HUECKEL U., (1970) — Die Fischschiefer von Haqel und Hjoula in der Oberkreide des Libanon. N. Jb. Geol. Paläont. Abh., 135(2), 113-149, 17 figs.

JELETZKY J.A., (1968) — Macrofossiles zones of the marine Cretaceous of the Western Interior of Canada and their correlation with the zones and stages of Europe and the Western Interior of the United States. Geol. Surv. Canada, Paper 67-72, 66 pp.

KARCZ I., (1965) — Lower Cretaceous fluviatites in the Levant. Nature, 207(5002), 1145-1146, 2 figs.

KELLER A., (1933) — Sur quelques rudistes du Djebel Ansaryeh et de l'Amanus (Syrie Septentrionale). Notes et Mém. Haut Commiss. Rép. Fr., Syrie-Liban, 1, 45-52, figs. 12-13, pl. 6, pl. 7, figs. 1-7.

KELLER A. and VAUTRIN H., (1937) — Nouvelle contribution à l'étude des échinides de la Syrie et du Liban. 1ère Pt. Crétacé. Notes et Mém. Haut Commiss. Rép. Fr., Syrie-Liban, 2, 137-164, figs. 44-49, pls. 5-7.

KENNEDY W.J., (1971) — Cenomanian ammonites from Southern England. Spec. Paper Palaeont., 8, 133 pp., 64 pls.

KLASZ I. de, (1961) — Présence de *Globotruncana concavata* (Brotzen) et *Gl. concavata carinata* Dalbiez (Foraminifères) dans le Coniacien du Gabon (Afrique Equatoriale). C.R. Som. Séan. Soc. géol. Fr., 123-124.

KOCH von W., (1968) — Zur Micropaläontologie und Biostratigraphie der Oberkreide und des Alttertiärs von Jordanien. Geol. Jb., 85, 627-668, 4 text-figs., 1 tab., pls. 58-61.

LEWY Z., (1975) — The geological history of Southern Israel and Sinai during the Coniacian. Israel J. Earth-Sci., 24, 19-43, 1 pl., 15 figs.

MAHMOUD I.G.D., (1955) — Etudes paléontologiques sur la faune crétacique du Massif du Moghara (Sinai-Egypte). Publ. Inst. Désert d'Egypte, 8, 192 pp., 19 pls., 81 figs.

MATSUMOTO T. and INOMA A., (1975) — Mid-Cretaceous Ammonites from the Shumarinai-Soeushinai Area, Hokkaido. Mem. Fac. Sci., Kyushu Univ., Ser. D., Geol., 23(2), 263-293, figs. 1-16, pls. 38-42.

MIMRAN Y., (1969) — The geology of Wadi el-Malih region. M. Sc. Thesis, The Hebrew University, Jerusalem, (in Hebrew).

MOORE R.C., (Ed.), (1957) — Treatise on Invertebrate Paleontology, Part L : Mollusca 4, Cephalopoda, Ammonoidea. Geol. Soc. Amer. and Univ. Kansas Press.

MOSHKOVITZ S., (1972) — Biostratigraphy of the genus *Nannoconus* in the Lower Cretaceous sediments of the subsurface : Ashqelon-Helez Area, Central Israel. Israel J. Earth-Sci., 21, 1-28, 3 pls.

NEVO E., (1968) — Pipid Frogs from the Early Cretaceous of Israel and Pipid Evolution. Bull. Mus. Comp. Zool. Harvard, 136(8), 255-318, 11 pls., 18 figs.

PARNES A., (1964) — Coniacian Ammonites from the Negev (Southern Israel). Geol. Surv. Israel, Bull. 39, 37 pp., 4 pls.

PATTERSON C., (1967) — New Cretaceous Berycoid fishes from the Lebanon. Bull. Brit. Mus. (Nat. Hist.) Geol., 14(3), 69-109, 11 figs., 4 pls.

PATTERSON C., (1970) — Two Upper Cretaceous Salmoniform fishes from the Lebanon. Bull. Brit. Mus. (Nat. Hist.) Geol., 19(5), 205-296, 5 pls., 48 Text-figs.

PICARD L. and KASHAI E., (1958) — On the lithostratigraphy and tectonics of the Carmel. Bull. Res. Counc. Israel, 7G, 1-19, 2 figs.

PONIKAROV V.P., (Ed.), (1966) — The geological map of Syria, Scale 1 : 1.000.000. Explanatory notes. 111pp., 34 figs. (Translated into English by T.F. Lokhova). Syrian Arab Republic, Ministry of Industry, Dept.of Geol. and Min. Res.

REISS Z., (1958) — Notes on Foraminifera from Israel, 7. Remarks on the age of the so called "Dalia-marls" in Northern Israel.Geol. Surv. Israel, Bull. 17, 3-4.

ROSENBERG E., (1960) — Geologische Untersuchungen in den Naftalibergen (am Rande des nördlichsten Teils der Jordansenke, Israel) Mitt. Geol. Inst. E.T.H. Univ. Zürich, Ser. C (80), 107 pp., 9 phot., 10 figs.

ROSENFELD A. and RAAB M., (1974) — Cenomanian-Turonian ostracodes from the Judea Group in Israel. Geol. Surv. Israel, Bull. 62, 32 pp., 6 pls., 36 figs.

SAID R., (1962) — The geology of Egypt. Elsevier, Amsterdam-New York, 377 pp., 71 figs., 10 pls.

SAID R. and BARAKAT M.G., (1957) — Lower Cretaceous Foraminifera from Khasham el Mistan, Northern Sinai, Egypt. Micropaleontology, 3(1), 39-46, 1 pl.

SAINT-MARC P., (1974) — Etude stratigraphique et micropaléontologique de l'Albien, du Cénomanien et du Turonien du Liban. Notes et Mém. Moyen-Orient, 13, 9-342, 20 pls., 57 figs.

SASTRY M.V.A., RAO B.R.J. and MAMGAIN V.D., (1968) — Biostratigraphic zonation of Upper Cretaceous formations of Trichinopoly district, South India. Geol. Soc. Ind. Mem., 2, 10-17, 4 pls.

SHALEM N., (1928) — Fauna nuova cenomaniana delle argille verdi di Gerusalemme. Boll. Soc. Geol. Ital., 47(1), 69-108, pls. 3-5.

SHENHAV H., (1971) — Lower Cretaceous sandstone reservoirs, Israel : Petrography, porosity, permeability. Amer. Assoc. Petrol. Geol. Bull., 55(12), 2194-2224, 25 figs.

TAUBENHAUS H., (1920) — Die Ammoneen der Kreideformation Palästinas und Syriens. Zeit. Deutsch. Palästina-Vereins, 43, 58 pp., 9 pls.

VAUTRIN H., (1933) — Sur quelques formes nouvelles de rudistes recueillies en Syrie Septentrionale. Notes et Mém. Haut Commiss. Rép. Fr., Syrie-Liban, 1, 29-43, figs. 5-11, pl. 1, fig. 1, pls. 2-5.

WETZEL R. and MORTON D.M., (1959) — Contribution à la géologie de la Transjordanie. Notes et Mém. Moyen-Orient, 7, 95-191, 25 figs.

WIEDMANN J., (1964) — Le Crétacé Supérieur de l'Espagne et du Portugal et ses Céphalopodes. Est. Geol., 20, 107-148, 39 figs.

WOLFART R., (1967) — Geologie von Syrien und dem Libanon. Beitr. Reg. Geol. Erde, 6, 326 pp., 78 figs., Gebrüder Borntraeger, Berlin.

Dépôt du manuscrit : 30 Mai 1976

Table 1 : ALBIAN AMMONITES
After : Basse, 1937, 1940; Douvillé, 1916, 1928;Mahmoud, 1955.

	Lebanon & Syria	Israel	Sinai	Egypt
Hypophylloceras aphrodite venus Mahmoud			+	
H. aegyptiacum Mahmoud			+	
H. moreti Mahmoud			+	
Ammoniceratites vicinum (Douvillé)			+	
Eotetragonites breistrofferi Mahmoud			+	
E. cf. *E. plurisulcatus* Breistroffer			+	
E. aff. *E. umbilicostriatum* Collignon			+	
Tetragonites cf. *T. duvali* (d'Orbigny)			+	
Protanisoceras trituberculatum Collignon			+	
"*Crioceras*" cf. *C. munieri* Sarrasin & Schöndel			+	
Puzosia lata Seitz			+	
P. aff. *P. communis* Spath			+	
"*Valdedorsella*" *gignouxi* Mahmoud			+	
Beudanticeras beudanti (Brongniart)			+	
B. revoili elegans Mahmoud			+	
Neosilesites nepos (Douvillé)			+	
N. spathi Mahmoud			+	
Desmoceras latidorsatum (Michelin)			+	
Douvilleiceras mammillatum (Schlotheim)			+	
Knemiceras aegyptiacum Mahmoud			+	
K. arambourgi Basse	+			
K. attenuatum Hyatt	+			
K. collignoni Mahmoud			+	
K. compressum Hyatt			+	
K. deserti Mahmoud			+	
K. dubertreti Basse	+	+		
K. flexiloculosum Basse	+			
K. pinax Krause	+			
K. rittmani Mahmoud			+	
K. spathi orientalis Mahmoud			+	
K. spathi spathi Mahmoud			+	
K. subcomplicatum Basse	+			
K. syriacum (von Bluch)	+	+	+	+
K. uhligi Choffat	+	+	+	+
Engonoceras gracile (Douvillé)	+		+	
E. jezzinense Basse	+			
E. aff. *E. complicatum* Hyatt	+		+	
E. julieni Basse	+			
E. Khenchelaense (Basse)	+			
E. zumoffeni (Basse)	+			
E. vicorpense (Basse)	+			
Engonoceras sp.		+		
Hypengonoceras sp.			+	
Mortoniceras sp.			+	

Table 2 : CENOMANIAN AMMONITES

After : Avnimelech and Shoresh, 1962 ; Basse, 1937, 1940 ; Douvillé, 1928 ; Eck, 1915 ; Fourtau, 1904 ; Greco, 1915 ; Taubenhaus, 1920.

			Lebanon & Syria	Israel	Sinai	Egypt
UPPER CENOMANIAN	CE 4	*Turrilites acutus* Passy		+		
		T. costatus Lamarck		+		
		Neolobites vibrayeanus (d'Orbigny)	+	+	+	+
		N. fourtaui Pervinquière	+	+		+
		N. schweinfurthi Eck		+		+
		N. brancai Eck				+
		N. peroni Staff and Eck				+
		N. isidis Greco				+
		Forbesiceras cf. *F. conlini* Stephenson		+		
		Eucalycoceras judaicum (Taubenhaus)		+		
		Pseudocalycoceras harpax (Staoliczka)		+		
		P. hajoulense Basse	+			
		P. angolaense (Spath)	+	+		
		P. haugi (Pervinquière)		+		
		Calycoceras newboldi (Kossmat)		+		
		C. newboldi spinosum (Kossmat)	+	+		
		Acanthoceras cenomanense (d'Archiac)		+		
		A. sussexiense (Mantell)	+			
		Euomphaloceras meridionale (Stoliczka)		+		
		E. africanum Pervinquière		+		+
		E. multicostatum Basse	+			
		E. cunningtoni (Sharpe)		+		
LOWER CENOMANIAN	CE 3	*Anisoceras plicatile* (J. Sowerby)		+		
		Idiohamites ellipticus (Mantell)		+		
		I. alternatus (Mantell)		+		
		Hypoturrilites mantelli (Sharpe)		+		
		H. carcitanensis (Matheron)		+		
		Ostlingoceras bechii (Sharpe)		+		
		Mariella cf. *M. lewesiensis* (Spath)		+		
		Turrilites costatus Lamarck		+		
		T. scheuchzerianus (Schlüter)		+		
		Puzosia cf. *P. subplanulata* (Schlüter)		+		
		Forbesiceras cf. *F. sculptum* Crick		+		
		Mantelliceras cf. *M. mantelli* (J. Sowerby)	+	+		
		M. costatum (Mantell)		+		
		M. ex gr. *M. dixoni* Spath		+		
		Utaturiceras vicinale (Stoliczka)	?	+		
		Sharpeiceras laticlavium (Sharpe)		+		
		Acompsoceras renevieri (Sharpe) → CE 4	+		+	
		A. spathi Basse	+			
		A. sarthense (Guéranger)		+		
		Paracalycoceras alaouitense (Basse)	+			
		P. paralaouitense Basse	+			
	CE 2	*Mariella bergeri* (Brongniart)		+		
		Hyphoplites falcatus (Mantell)		+		
		Forbesiceras cf. *F. largilliertianum* (d'Orbigny)		+		
		cf. *Mantelliceras heynense* Thomel		+		
		Metoicoceras besairiei Collignon		+	+	
	CE 1	*Stoliczkaia amanoi* Matsumoto and Inoma		+		
		Mantelliceras saxbii (Sharpe)		+		
		M. couloni (d'Orbigny)	?	+		
		Graysonites wooldridgei Young		+		
		G. cf. *G. lozoi* Young		+	+	
		Utaturiceras bethlehemense Avnimelech & Shoresh		+		
		Utaturiceras sp.			+	

Table 3 : TURONIAN AMMONITES
After : Basse, 1937, 1940, 1954; Douvillé, 1928; Eck, 1915; Freund and Raab, 1969; Greco, 1915; Lewy, 1975.

TURONIAN														
LATE		EARLY												
T 9	T 8	T 7	T 6	T 5	T 4	T 3	T 2	T 1		Lebanon & Syria	Transjordan	Israel	Sinai	Egypt
+									*Baculites* sp.				+	
+									*B.* cf. *B. undulatus* d'Orbigny				+	
				+					*Parapuzosia (Austiniceras)* sp.			+		
									Pachydiscus sp.	+				
		+							*Romaniceras deverianum* (d'Orbigny)			+		
		+							*R. deverioide* (de Grossouvre)			+		
+									*Romaniceras* sp.				+	
		+							*Romaniceras (?) inermis* (de Grossouvre)	+		+		
								+	*Kanabiceras* sp.			+	+	
					+				*Metoicoceras* cf. *M. whitei* Hyatt			+		
			+						*Mammites nodosoides* (Schlotheim)	?		+	+	
									M. tischeri Laube and Bruder	+				
									M. incertus Douvillé					+
									M. cf. *M. pervinquierei* de Grossouvre	+				
							+		*Pseudaspidoceras footeanum* (Stoliczka)	+			+	+
							+		*P.* cf. *P. paganum* Reyment	+		+		
					+	+	+		*P.* cf. *P. pseudonodosoides* (Choffat)			+		
		+							*Paramammites* cf. *P. polymorphum* (Perv.)	+		+		
								+	*Nigericeras* sp.			+		
							+		*Paravascoceras cauvini* (Chudeau)			+		
							+		*P. rumeaui* Collignon			+		
							+		*P. tavense* (Faraud)			+		
						+	+		*P. crassum* (Furon)		+	+		
							+		*P. obessum* (Taubenhaus)			+		
								+	*P.* cf. *P. evolutum* Schneegans			+		
									P. baroicense (Choffat)					+
							+		*Gombeoceras* cf. *G. gongilense* (Woods)	+		+		?
								+	*Vascoceras depressum* Barber			+		
						+			*V. pioti* (Peron and Fourtau)		+	+		+
				+		+			*V. durandi* (Thomas and Peron)	+		+		+
				+					*V. harttiforme* Choffat			+		
				+		+			*V.* cf. *V. amieirense* Choffat		+	+		?
				+		+			*V.* cf. *V. adonense* Choffat			+		+
									V. kossmati Choffat					+
									V. gamai Choffat					+
									V. munda Choffat					+
									V. niloticum Douvillé					+
									V. ex. gr. *V. globosum* Reyment	+				
									V. aff. *V. ellipticum* Barber	+				
									V. nigeriense Woods	+				
									V. cf. *V. robustum* Barber	+				

Table 3 : TURONIAN AMMONITES
(continued)

TURONIAN														
LATE		EARLY								Lebanon & Syria	Transjordan	Israel	Sinai	Egypt
T 9	T 8	T 7	T 6	T 5	T 4	T 3	T 2	T 1						
			+	+					*Fagesia* cf. *F. superstes* (Kossmat)	+		+		
			+						*F. thevestensis* (Peron)			+		+
									F. bomba Eck					+
			+						*F. lenticularis elliptica* Freund & Raab			+	+	
			+						*F. lenticularis asymmetrica* Freund & Raab			+		
			+						*F. lenticularis lenticularis* Freund & Raab			+	+	
			+	+	+	+			*Thomasites rollandi rollandi* (Thom. & Perv.)	+	+	+	+	+
			+						*T. rollandi globosum* Pervinquière			+		
			+	+					*T. rollandi complanatus* Pervinquière	+		+		
			+						*T. jordani jordani* Pervinquière	?		+	+	
			+						*T. jordani laevis* Pervinquière			+		
									T. jordani sinaitica Douvillé				+	
		+	+	+					*Neoptychites cephalotus* (Courtiller)	+		+	+	
			+						*N. xetriformis* Pervinquière	?		+		
		+	+						*N.* cf. *N. xetra* (Stoliczka)			+		
				+					*Neoptychites* sp. 2			+		
						+			*Pseudotissotia (Bauchioceras) tricarinata* (Reyment)			+		
						+			*Choffaticeras meslei* (Peron)		+		+	
			+	+	+				*Ch. segne* (Solger)	+		+	+	+
			+	+	+				*Ch. quaasi* (Peron)	+	+	+		+
				+	+				*Ch. pavillieri* Pervinquière			+		+
			+	+					*Ch. sinaiticum* (Douvillé)		+	+		+
			+						*Ch. luciae trisellatum* Freund & Raab	?	+	+	+	
									Ch. securiforme (Eck)	+		+		
			+						*Ch. mokattanicum* Greco			+		+
									Ch. destefani Greco					+
			+	+					*Choffaticeras* sp.		+	+		
+									*Masiaposites carinatus* Collignon			?	+	
			+						*Hoplitoides* cf. *H. mirabilis* Perv.			+		
									H. ingens van Koenen	+				
+									*H. baalbekensis* Basse	+				
									Hoplitoides sp.					+
	+								*Coilopoceras* sp.			+		
+									*C. zihoricum* Parnes		+	+	+	
+									*C. requienianum* (d'Orbigny)				+	
+									*C. multicostatum* Lewy				+	+
+									*C. sinaiense* Lewy				+	
+									*C.* aff. *C. newelli* Benavides-Cáceras				+	
+									*C.* cf. *C. novimexicanum* Hyatt				+	
									C. lesseli Brüggen	+				
									Selwynoceras douvillei (Pervinquière)	+				
			+						*Subprionocyclus* sp.			+		
									Prionocycloceras (?) *dubertreti* (Basse)	+		+		
	+	+	+						*Protexanites salmuriensis* (Courtiller)	+		+		

Table 4 : CONIACIAN AMMONITES
After : Douvillé, 1928; Eck, 1915; Greco, 1915; Lewy, 1975; Parnes, 1964; Ponikarov, 1966.

CONIACIAN									
LATE		EARLY							
CA 5	CA 4	CA 3	CA 2	CA 1		Syria	Israel	Sinai	Egypt
				+	*Proplacenticeras eboroense* Collignon			+	
				+	*Placenticeras tamulicum* (Blanford)			+	
			+		*Plesiotissotia sinaitica* Lewy			+	
		+			*Allotissotia galeppei* (Pervinquière)		+	+	
			?		*Hemitissotia morreni* (Coquand)		+		+
			?		*H. morreni praecipha* Peron	+			
			?		*H. cazini* Pervinquière				+
	+				*Heterotissotia neoceratites* Peron		+	+	
	+				*H.* aff. *H. semmamensis* Pervinquière			+	
	?				*H. aegyptica* Greco				+
	?				*H. neolobitoides* Greco				+
	?				*H. osiridis* Greco				+
+					*Tissotia* sp.			+	
+					*Metatissotia fourneli* (Bayle)			+	+
+					*M. ewaldi* (von Buch)		+	+	
+					*M.* cf. *M. steinmanni* Lisson	.		+	
					Gauthiericeras cf. *G. bajuvaricum* Redt.	+			
					Peroniceras cf. *P. czornigi* Redt.	+			
					P. ex gr. *P. moureti* de Grossouvre	+			
					Peroniceratinae indet.		+		
+					*Protexanites* sp.		+	+	
		+	?		*Barroisiceras onilahyense* Basse	?	+	+	
		?			*B. neqarotense* Parnes		+		
			?		*Subbaroisiceras* cf. *S. mahafalense* Basse	+			
			+		*Roemeroceras parnesi* Lewy		+	+	
	+				*R. tunisiense* (Hyatt)		+	+	
	+				*Buchiceras bilobatum* Hyatt		+	+	
					Reesideoceras cf. *R. gallicum* Basse	+			
+					*Reesideoceras* sp.			+	
		+	+		*Harleites bentori* Parnes		+	+	
		?			*Forresteria* cf. *F. allaudi* (B.L.T.)		+		

Table 5 : DISTRIBUTION OF MID-CRETACEOUS PECTINIDS IN THE MIDDLE-EAST

AGE / ZONE / SPECIES	ALBIAN	CENOMANIAN				TU-RON-IAN	Lebanon	Israel	Jordan	Sinai	Egypt
		LOWER			UPPER						
	Knemiceras Zone	CE 1	CE 2	CE 3	CE 4						
Neithea syriaca (Conrad)	x——x						+	+	+	+	+
N. dutrugei (Coquand)		x——	——x	?		?	+	+	+	+	+
N. alpina (d'Orbigny)			x						+		
N. coquandi (Peron)*		x——	——x——	——xxx——	——xxxxxx——	——x	+	+	+	+	?
Neithea sp.*					x			+		+	
N. quinquecostata (J. Sowerby)						?			+		
N. aequicostata (Lamarck)						x		+	+		
N. gibbosa (R. Pulteney)			--	----	----?----	·		+			
N. striatocostata (Goldfuss)			x					+			
N. fleuriausiana (d'Orbigny)	x					?		+			
"*Pecten*" *karmeliticus* Blanck.				?——	——---			+		+	

* Figured in Plate 2
x : occurrence
____ : range
? : uncertain position
--- : uncertain range

PLATE 1

(All figures except 13 in natural size)

Fig. 1. — *Stoliczkaia amanoi* Matsumoto and Inoma

CE 1 : Lower Cenomanian ; Makhtesh Hathira (Hamakhtesh Hagadol), Northern Negev ; top Hevyon Member of the Hazera Formation.

Figs. 2-3. — *Mantelliceras couloni* (d'Orbigny)

Same stratigraphic level and location as Figure 1.

Fig. 4. — *Turrilites acutus* Passy

CE 4 ; Upper Cenomanian ; Jerusalem ; Kefar Shaul Formation.

Fig. 5. — *Hypoturrilites mantelli* (Sharpe)

CE 3 ; Lower Cenomanian ; Mount Carmel ; Khureibe Chalk.

Figs. 6-7. — *Ostlingoceras bechii* (Sharpe)

Stratigraphic level and location as in Figure 5.

Figs. 8-9. — *Subprionocyclus* sp.

T 6(?) Upper Turonian ; Northern Negev, (Mishor Haruhot), north of Mahktesh Ramon ; Ora Shale Formation.

Fig. 10. — *Metoicoceras bessiriei* Collignon

CE 2 ; Lower Cenomanian ; Gebel Halal ; Northern Sinai, upper En-Yorqe'am Member of the Hazera Formation.

Figs. 11-12. — *Graysonites* cf. *G. lozoi* Young

CE 1 : Lower Cenomanian ; Jerusalem area ; base Beit-Me'ir Formation

Fig. 13. — *Graysonites wooldridgei* Young

x 1/2 ; CE 1 ; Lower Cenomanian ; Har Rahama ; Northern Negev ; top Hevyon Member of the Hazera Formation.

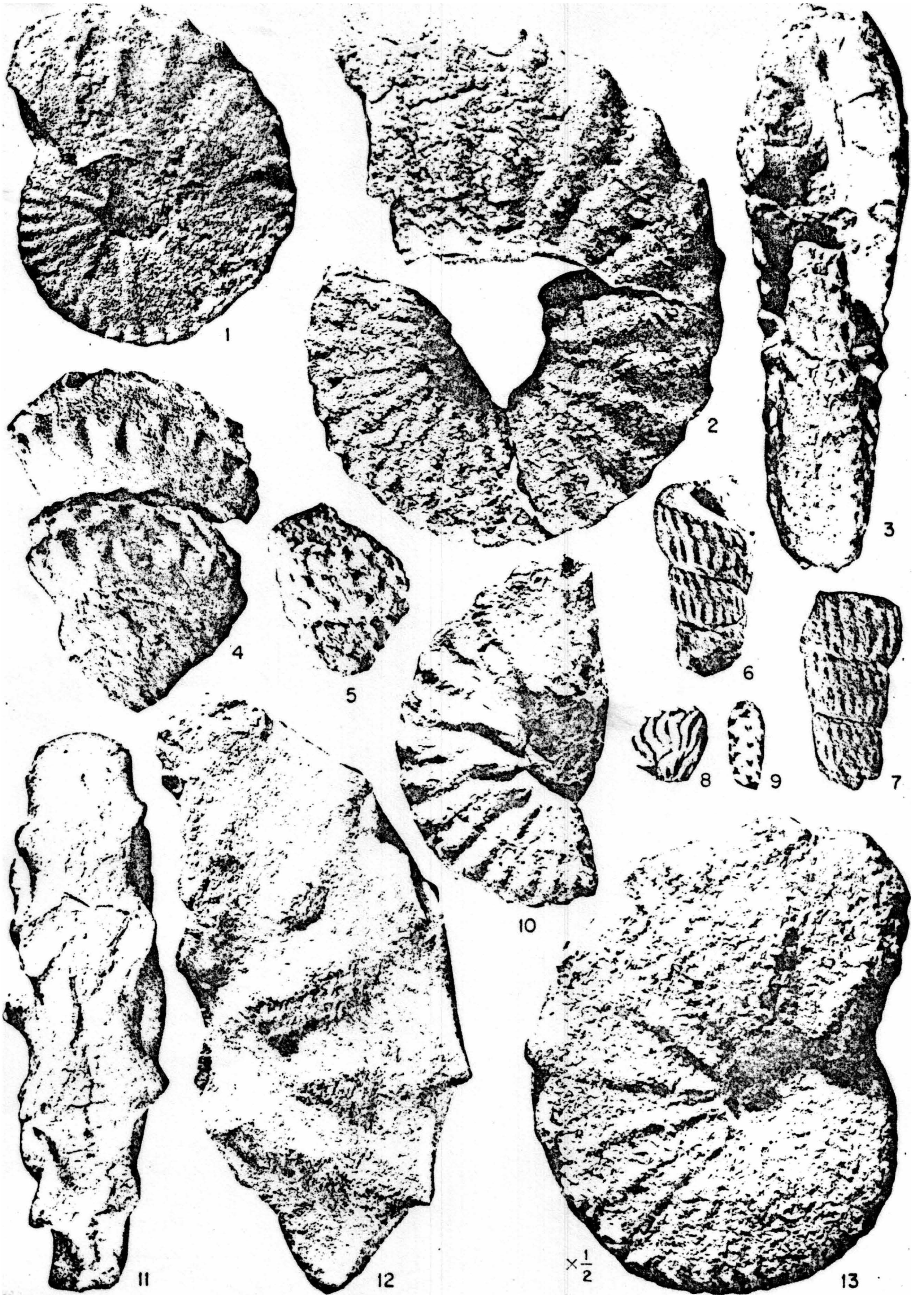

Plate 1

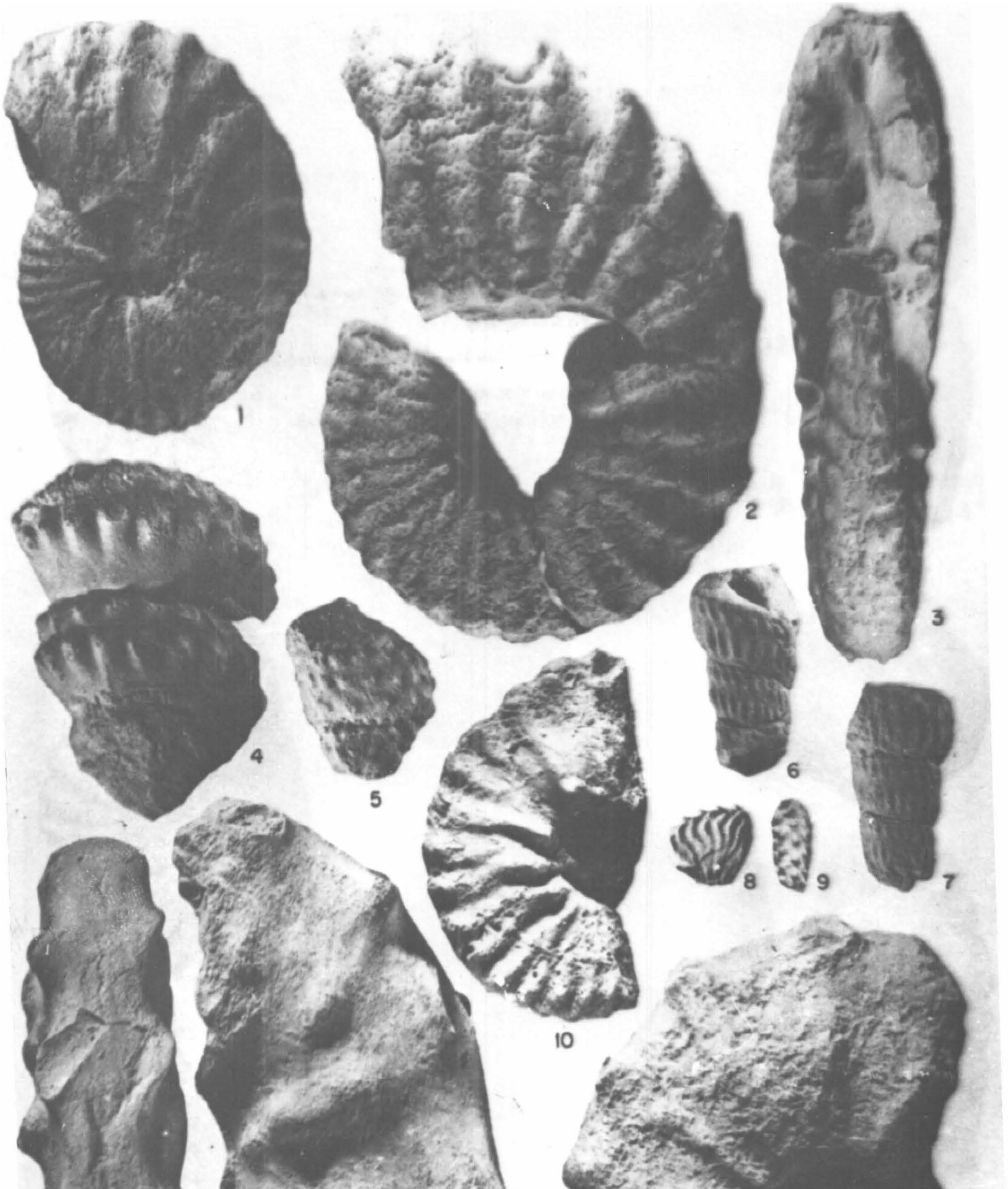

Plate 1

PLATE 2

(All figures except 4, 8, 9 in natural size)

Fig. 1. — Neithea coquandi Peron

CE 1 ; *Lower Cenomanian* (ranges into CE 4) ; Makhtesh Hathira (Hamakhtesh Hagadol) ; Northern Negev ; top Hevyon Member of the Hazera Formation.

Figs. 2, 8, 9. — Sharpeiceras laticlavium (Sharpe)

CE 3 ; *Lower Cenomanian* ; Mount Carmel ; lower part of Khreibe Chalk. 8-9 : x 1/2.

Fig. 3. — Hypoturrilites carcitanensis (Matheron)

Same stratigraphic level and location as Figs. 2, 8, 9.

Fig. 4. — Puzosia cf. P. subplanata (Schlüter)

x 2/3 ; CE 3 - CE 4 ; Lower to Upper Cenomanian ; Mount Carmel ; Khureibe Chalk.

5. — *Neithea* sp.

Base CE 4 ; Upper Cenomanian : Har Rahama : base Avnon Member of the Hazera Formation.

Figs. 6-7. — Mantelliceras cf. M. mantelli (J. Sowerby)

CE 3 ; *Lower Cenomanian* ; Mount Carmel ; lower part of the Khureibe Chalk.

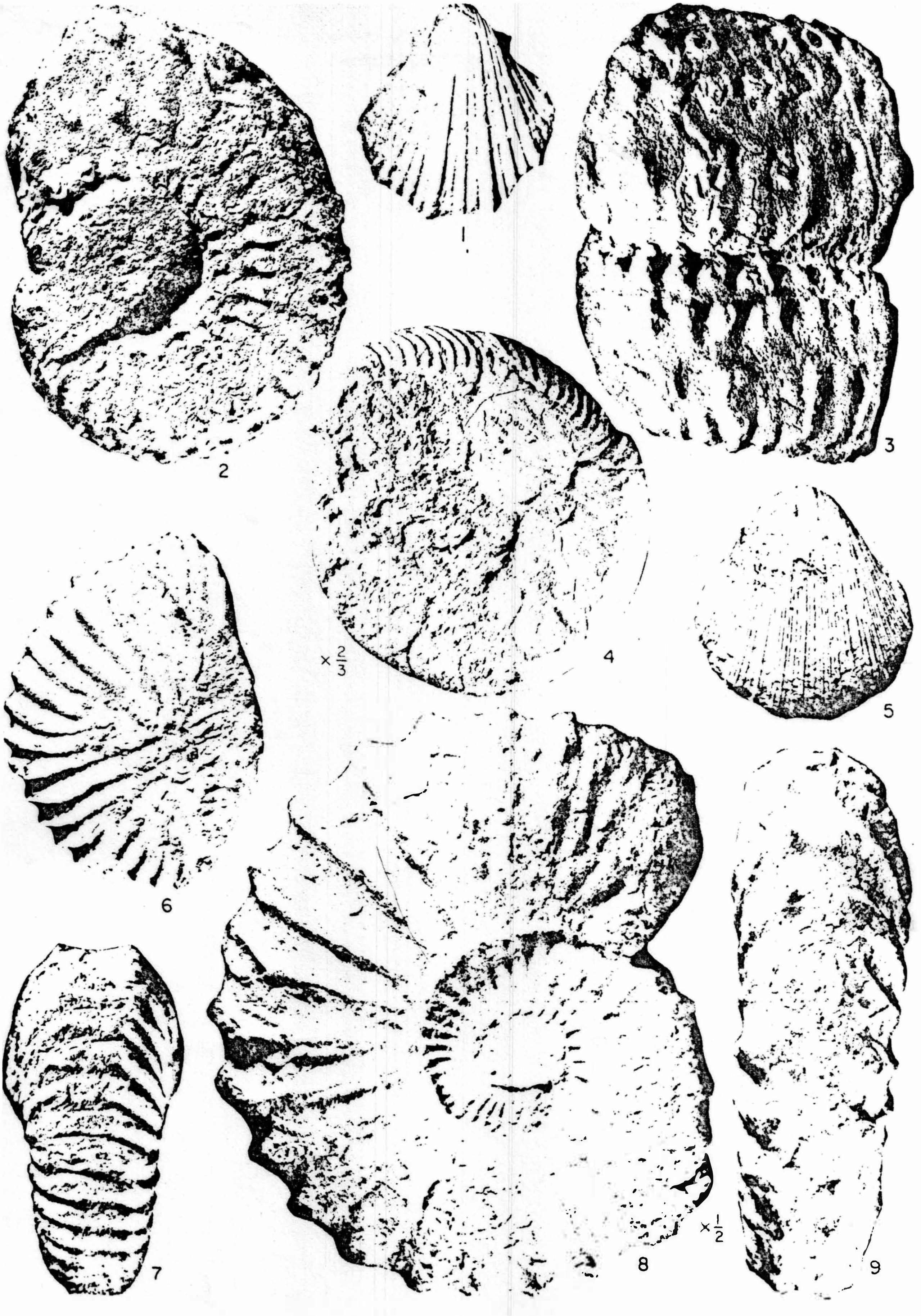

Plate 2

Plate 2

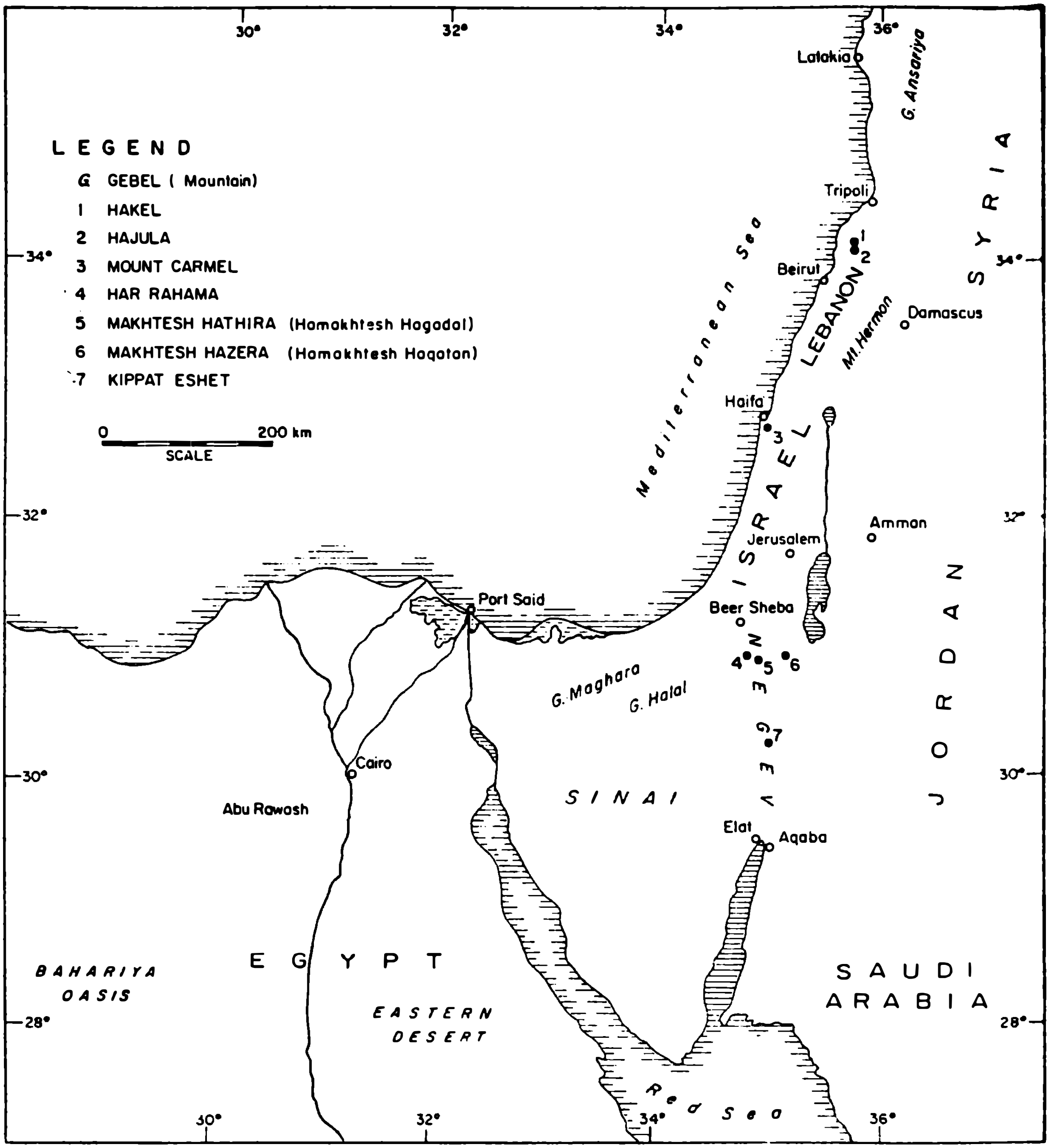

Figure 1 : Location map

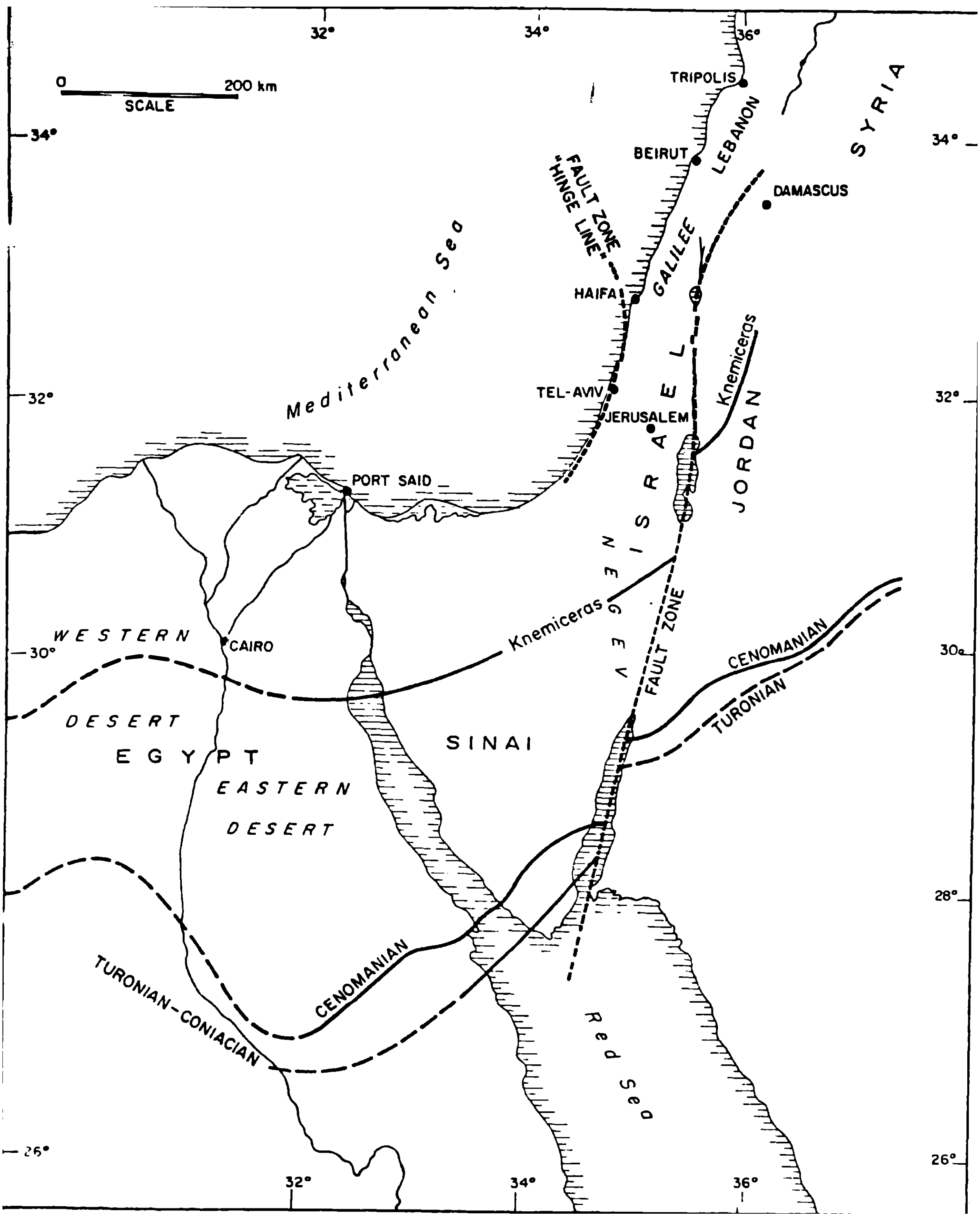

Figure 2 : Tentative Albian to Coniacian Tethyan shore lines in the Middle East.