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The approximate position of the Middle–Upper Cenomanian substage boundary in Israel

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ABSTRACT

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The Upper Cenomanian ammonite *Thomelites sornayi* (Thomel) was recently discovered in Jerusalem in the Laminated Limestone Member at the upper part of the Kefar Sha'ul Formation. Lateral correlations 2–4 km away from the *T. sornayi* locality suggest that this species occurs between *Cunningtoniceras meridionale* (Stoliczka) below and *Neolobites vibrayeanus* (d'Orbigny) above. *N. vibrayeanus* occurs in southern Israel in two successive formations in two levels nearly 40 m apart. The single level of this species in Jerusalem, which overlies the Upper Cenomanian *T. sornayi*, correlates to the lower level in southern Israel. Accordingly, the first appearance of *N. vibrayeanus* in Israel can now be dated as of Late Cenomanian age, suggesting that the species is confined to the Upper Cenomanian substage only. The Middle–Upper Cenomanian boundary should be placed just below this earliest *N. vibrayeanus*. No ammonite species restricted to the Upper Cenomanian has been discovered in northern Israel to enable the placement of the boundary between the Middle and the Upper Cenomanian substages. Alternatively, this boundary can be tentatively placed above the last occurrence of the benthic foraminifer genus *Orbitolina*, which is known to range to the top of the Middle Cenomanian. This genus is found in isolated limestone and dolostone lenses in the upper part of the Junediya Formation in the Mount Carmel region.

INTRODUCTION

The mixed record of Middle and Upper Cenomanian ammonite species in Israel allowed recognition of two-fold division only of the Cenomanian Stage, with the Upper Cenomanian comprising species of the Middle and Upper Cenomanian substages recognized elsewhere (Lewy and Raab, 1978). A narrow unit with the Upper Cenomanian ammonites *Metoicoceras geslinianum* (d'Orbigny) and *Eumphaloceras septemseriatum* (Cragin), as well as a fragment of *Eucalycoceras rowei* (Spath) found loose below the former species, was later recognized in southern Israel in the lower part of the Derorim and the Ora formations (Lewy et al., 1984). This unit overlies two levels of *Neolobites vibrayeanus* (d'Orbigny). The upper level is nearly at the base of the Derorim and Ora formations, and the lower level lies in the underlying Hazera Formation in the upper part of the Avnon Member in the Makhtesh Ramon region (southern Israel; Figs. 1, 2; Lewy, 1988). This latter member is overlain by the dolomitic Tamar Member that forms the uppermost part of the Hazera Formation.

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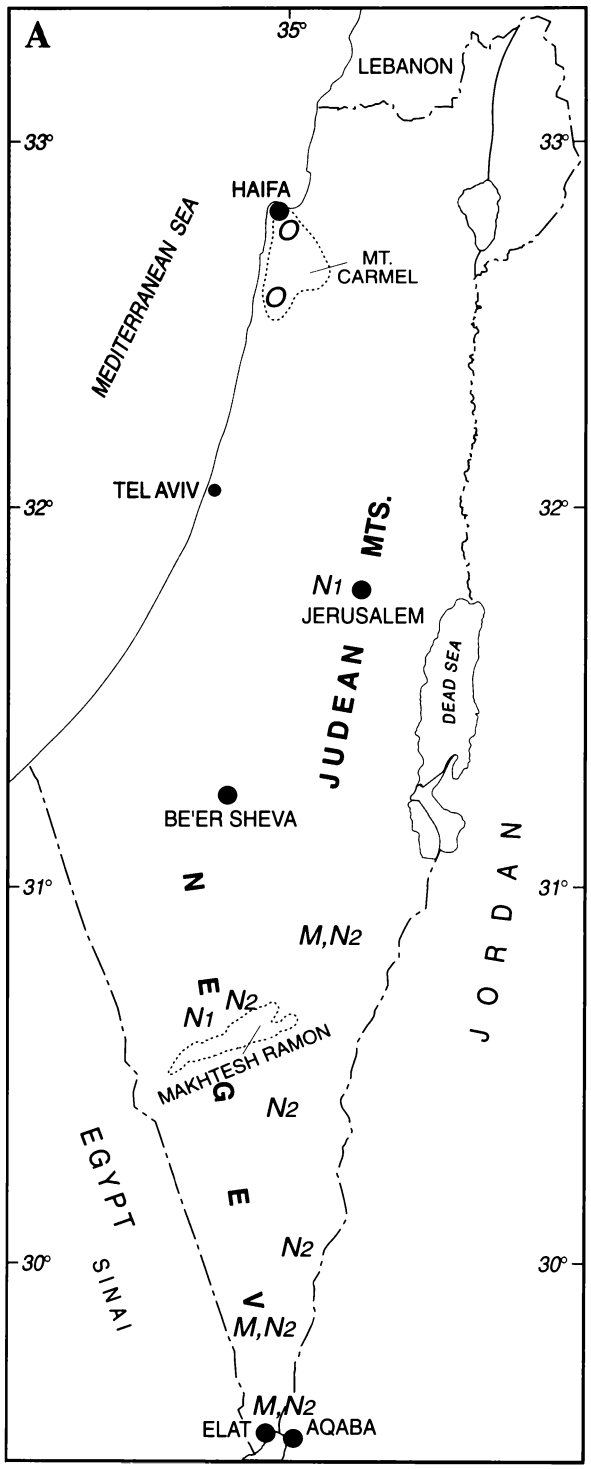

N. vibrayeanus is recorded from a narrow interval in its type region in west-central France, from where other Upper Cenomanian ammonites were described (Kennedy and Juignet, 1981). "Elsewhere, the species marks a level high in the Cenomanian, just below that of *Metoicoceras geslinianum/Sciponoceras gracile* Zone of authors" (ibid. p. 28). This dating could be applied to the upper level of *N. vibrayeanus* that closely underlies *M. geslinianum* in Israel, but was questionable concerning the much lower level. Middle and Upper Cenomanian ammonites found in Jerusalem in a narrow interval in the upper part of the Kefar Sha'ul Formation, that yielded *N. vibrayeanus*, enable dating the lower level of the species as Upper Cenomanian. For the first time the Middle and Upper Cenomanian substage boundary, as defined by ammonite biozones in Europe, is recognized in central Israel and tentatively correlated northward and southward.

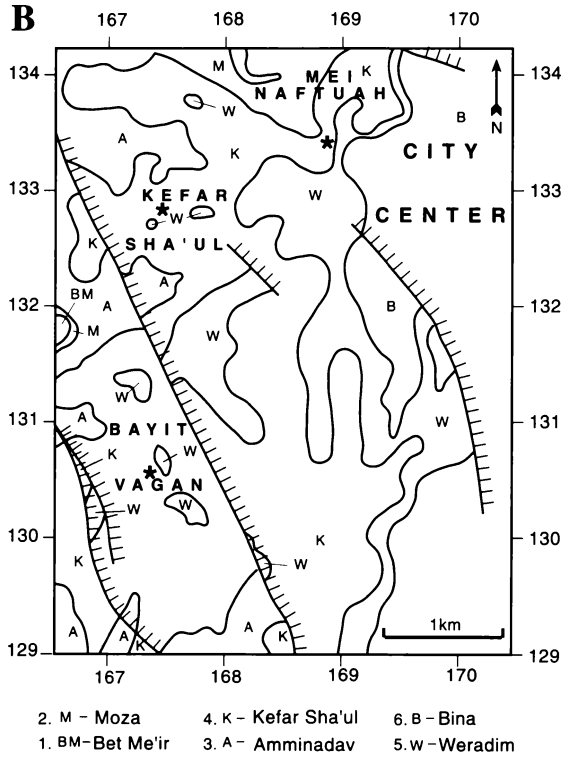

Fig. 1. A: Map of Israel with the locations of the ammonites *Metoicoceras geslinanum* (M), *Neolobites vibrayeanus* in the lower (N_1), and upper level (N_2), and the foraminifer *Orbitolina* (O). B: Simplified geological map of the western part of the city of Jerusalem showing the ammonite collecting sites (Israeli coordinates; modified after Arkin, 1976). The succession of the formations is graphically shown in Fig.2.

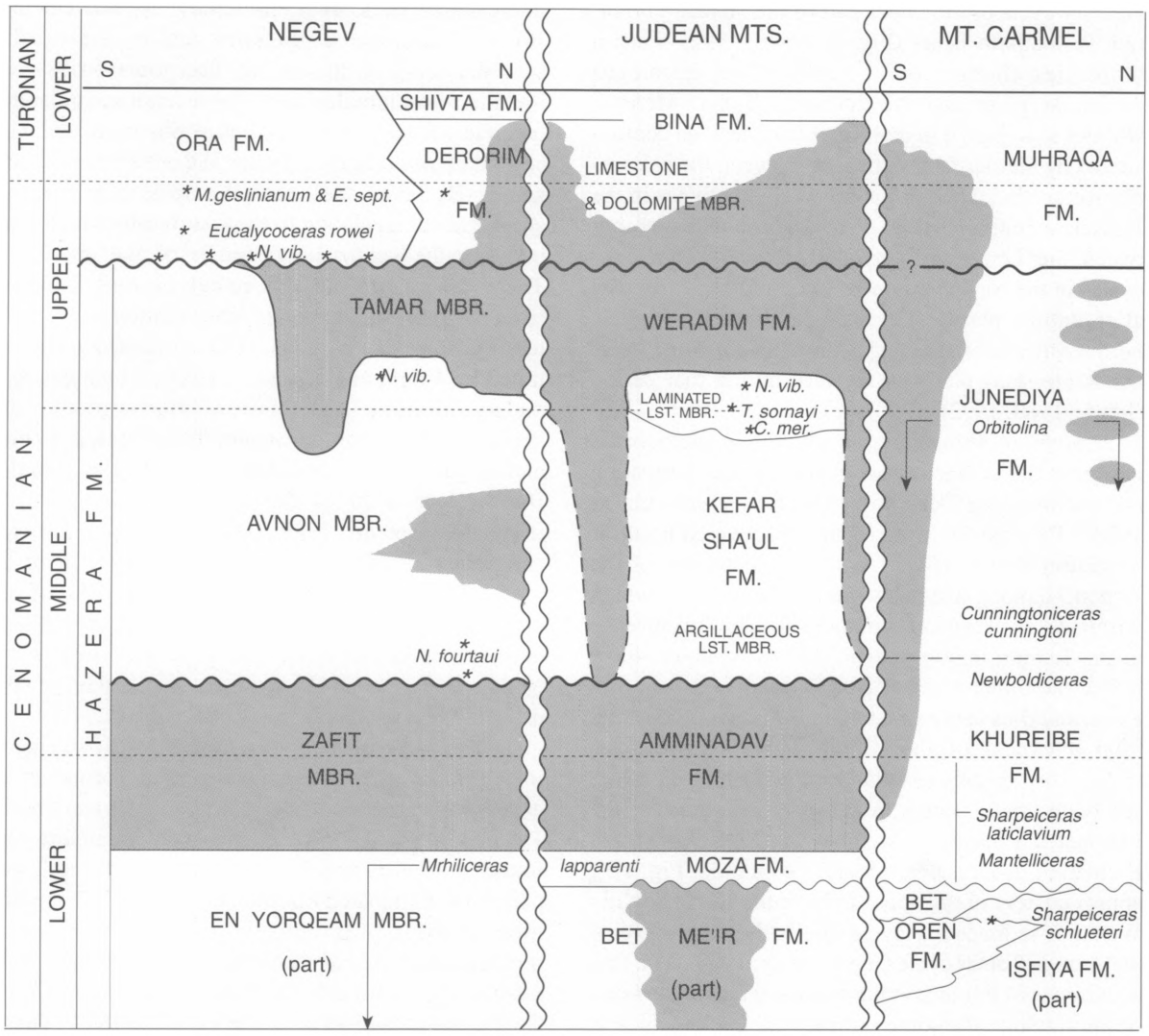

Fig. 2. Schematic bio- and lithostratigraphic correlation of some Mid-Cretaceous sequences in Israel, with the main dolomitic lithofacies as separate rock units, or as lateral facies changes (shaded areas), and the boundaries of the major sedimentary cycles (thick lines). Asterisks mark position of taxa (abbrevated names recorded in the text).

BIO- AND LITHOSTRATIGRAPHY

The Kefar Sha'ul Formation in Jerusalem (Arkin et al., 1965) consists of a lower, rather massive, yellowish, Argillaceous Limestone Member that yields acanthoceratid ammonites (ca. 60 m thick; Fig. 1A,B), and an upper, Laminated Limestone Member (20–30 m thick). The Kefar Sha'ul Formation is overlain by dolostone of the Weradim Formation (Fig. 2; about 25 m thick in Jerusalem; Arkin et al., 1965). The contact between these formations is quite sharp in the Jerusalem area. However, lateral lithofacies changes occur between the Kefar Sha'ul limestone and the Weradim dolomite (Fig. 2), whereby mainly the lower calcareous Kefar Sha'ul Formation is dolomitized into the Weradim rock-type while the thickness of both lithofacies remains rather constant (e.g., Lewy, 1989). In addition to these regional changes the upper part of the Kefar Sha'ul Formation in the Jerusalem area shows local variations in bedding thickness, as well as in the total thickness of the Laminated Limestone Member. Both the Kefar Sha'ul and the Weradim formations form an upward-shallowing sedimentary cycle that is the correlative of the Avnon–Tamar sedi-

mentary cycle of the upper part of the Hazera Formation in southern Israel (Fig. 2; Lewy, 1992). Lateral lithofacies changes occur between the calcareous Avnon Member and the dolomitic Tamar Member without any change in their total thickness, as demonstrated by similar facies changes between the calcareous Kefar Sha'ul and dolomitic Weradim facies in the Jerusalem region (Lewy, 1988). The boundaries between the Upper Albian to Turonian sedimentary cycles in the Negev (southern Israel) form nearly parallel datum plains. Each cycle thickens slightly northwestwards, indicating a more rapid subsidence of the stable shelf platform seaward during that period (Lewy, 1988, 1992).

Neolobites vibrayeanus is common in southern Israel near the contact between the Hazera Formation and the ovelying Derorim or Ora formations (Lewy, 1988). This species was recently discovered north of Makhtesh Ramon (Fig. 1A) in the upper part of the Avnon Member, just below the Tamar Member which terminates the Hazera Formation. This low occurrence in the Ramon region is estimated to be about 40 m below the upper level of *N. vibrayeanus* in adjacent areas, and thus approximately in the upper third of the total thickness of the Avnon–Tamar sedimentary cycle. This species (Avnimelech and Shoresh, 1962; see Plate I.3–4) occurs in the platy limestone of the Laminated Limestone Member of the Kefar Sha'ul Formation in Jerusalem (coord. 1674/1328, Fig. 1B), approximately in the upper third of the Kefar Sha'ul–Weradim sedimentary cycle that is the correlative of the Avnon–Tamar cycle (fig. 2; Lewy, 1992). The first occurrence of this ammonite species at nearly the same position within the same sedimentary cycle, which is traceable throughout southern and central Israel, may represent the evolutionary, global first appearance of this species.

A single ammonite resembling *Cunningtoniceras meridionale* (Stoliczka) was found in pinkish-grey limestone beds in the basal part of the Laminated Limestone Member in the Bayit Vagan quarter in western Jerusalem (Plate I. 5–6; coll. Z. Lewy, 9.1964; coord. 1674/1306, Fig. 1B). Wright and Kennedy (1987) regarded *C. meridionale* (Stoliczka, 1864) a junior synonym of *C. cunningtoni* (Sharpe, 1855). However, Japanese specimens identical to the Indian lectotype of *C. meridionale* suggest that their morphological affinities differ considerably from those of *C. cunningtoni* (Matsumoto et al., 1989). The ornament of the single *Cunningtoniceras* from Jerusalem (Plate I. 5–6) resembles that of *C. meridionale* by the intercalation of a weak secondary rib between the strongly tuberculated primaries, and by the equally spaced ribbing on the venter. The primary ribs bear umbilico-lateral bullae and spinose outer ventrolateral tubercles, from which the ventral ribs bifurcate. The secondary ribs lack these bullae and outer ventrolateral spines. However, their ventral extension is equal in shape and tuberculation to the ventral ribs which loop between the ventrolateral spines of the primaries. These ventral ribs are also equally spaced, differing from the uneven ribbing and tuberculation on the venter of *C. lonsdalei* (Adkins, 1928; discussed and illustrated in Wright and Kennedy, 1987), which has secondary ribs as well. The narrow whorl section of the single specimen from Jerusalem (breadth, B, is 44 mm and height, H, is 42 mm; B/H=1.05) compared to the B/H = 1.40–1.50 of the typical *C. meridionale* (Matsumoto et al., 1989, p. 42) seems of a lower taxonomic significance than the similarity in ornament. The precise stratigraphic position of *C. meridionale* in the Cenomanian of India is not well defined, but in Japan the species is attributed to the Middle Cenomanian (Matsumoto et al., 1989, p. 43), probably of a similar range as of *C. cunningtoni.*

During road construction a fresh road-cut was made in the upper part of the Kefar Sha'ul Formation in northwest Jerusalem (Mei Naftu'ah quarter; coord. 1688/1334; Fig. 1B). A well preserved ammonite was found in greyish-pink bedded limestone of the lower part of the Laminated Limestone Member. The ammonite (Plate I, 1–2) closely resembles Thomel's morphotypes *Eucalycoceras harpax* (Stol.) var. *tulearensis* (Coll.) and var. *lattensis* Thomel of Late Cenomanian age (Porthault et al., 1966). These morphotypes were included by Wright and Kennedy (1990) as weakly tuberculated intrapopulational varieties of *Thomelites sornayi* (Thomel), which normally posesses strong umbilical, spinose tubercles on the primary ribs. This assemblage co-occurs in southwest France in the *Calycoceras guerangeri* Zone of early Late Cenomanian age that underlies the *Metoicoceras geslinianum* Zone (Porthault et al., 1966). This low position within the Upper Cenomanian is in agreement with the occurrence of the Israeli *T. sornayi* in alternating beds of limestone and marl at the lower coarser-bedded part of the Laminated Limestone Member, in which the Middle Cenomanian *C. meridionale* was also found some 4 km south of the site of *T. sornayi.* However, they were most probably found in successive zones and hence substages (Fig. 2).

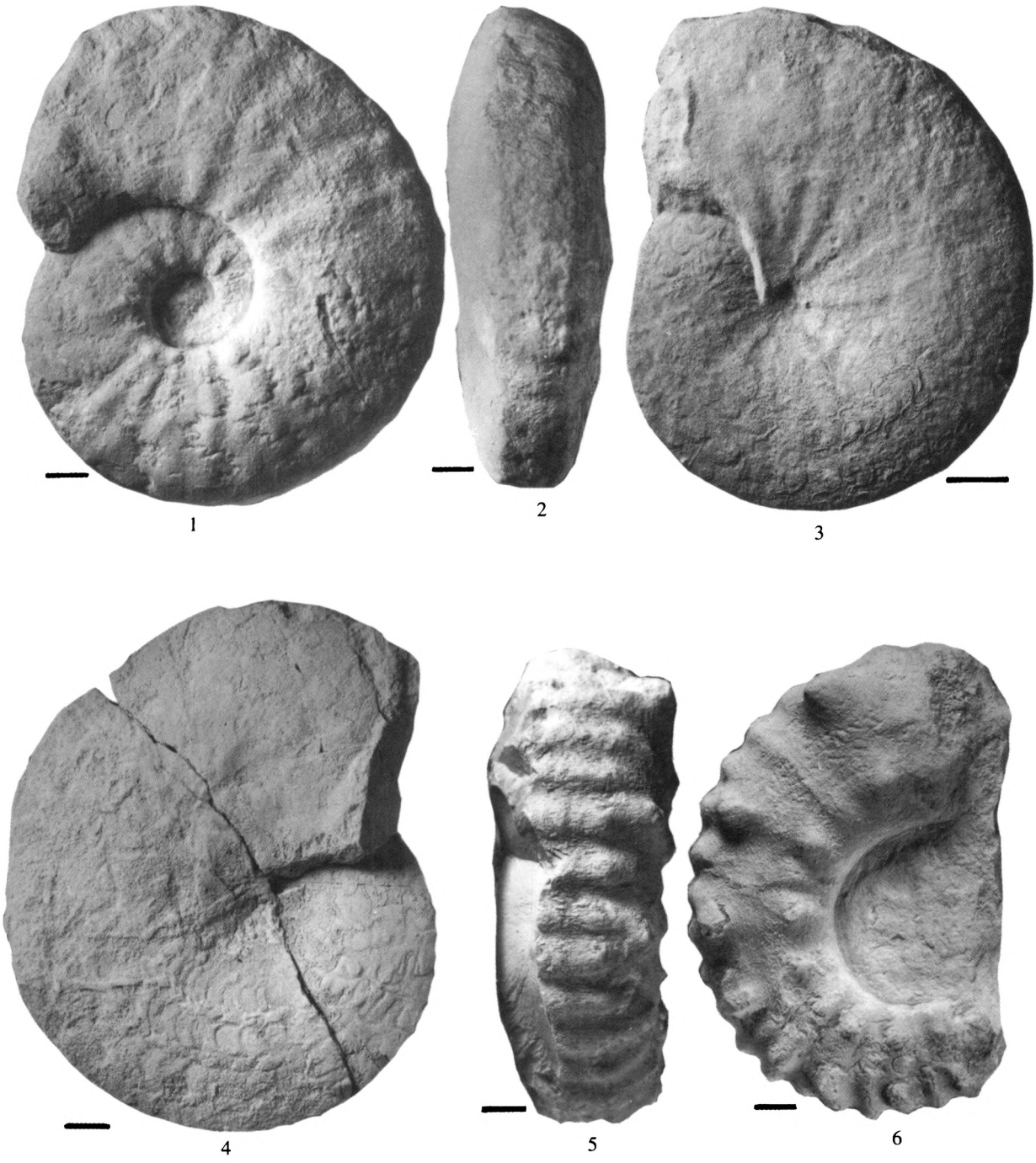

Plate I. Cenomanian ammonites from the Laminated Limestone Mbr., upper part of the Kefar Sha'ul Fm., western part of the city of Jerusalem (Fig. 1B). 1–2. *Thomelites sornayi* (Thomel); lowermost Upper Cenomanian; Mei Naftu'ah quarter, coord. 1688/1342; GSI M-8112, coll. Z. Lewy. 3–4. *Neolobites vibrayeanus* (d'Orbigny), lower Upper Cenomanian; Kefar Sha'ul quarter, coord. 1674/1328; 3. specimen HU-21387; 4. specimen HU-11720 (coll. L. Picard). 5–6. *Cunningtoniceras meridionale* (Stoliczka); uppermost Middle Cenomanian; Bayit Vagan quarter, coord. 1674/1305; HU-37738, coll. Z. Lewy. Scale bar 1 cm. HU-numbered specimens are deposited in the collections of the Hebrew University of Jerusalem; the specimen with the GSI M-number is deposited in the collections of the Geological Survey of Israel.

RECOGNITION OF THE MIDDLE–UPPER CENOMANIAN BOUNDARY IN ISRAEL

The presence of *C. meridionale* and *T. sornayi* enables one to define for the first time the approximate position of the Middle–Upper Cenomanian boundary in the region of Jerusalem. The closely overlying occurrence of the first *N. vibrayeanus* is thus of earliest Late Cenomanian age. This age can be ascribed to the lower level of *N.vibrayeanus* north of Makhtesh Ramon (Figs. 1A, 2), approximately in the same position within both correlative sedimentary cycles. The relative position of the Middle–Upper Cenomanian boundary can be traced within this cycle. Laterally from Jerusalem and the Makhtesh Ramon region one should look for additional specimens of the earliest occurring *N.vibrayeanus* (lower level) to improve the recognition of the underlying Middle–Upper Cenomanian boundary in other places in southern Israel.

Ammonites that may help to trace this substage boundary were not found in northern Israel. The benthic foraminifer genus *Orbitolina,* which disappears at the end of the Middle Cenomanian, was recently discovered in limestone and dolostone lenses in the upper part of the Junediya Formation (ca. 20–40 m below its top) in the north and south of Mount Carmel (Fig. 2; Lewy, 1995). Accordingly, the Middle–Upper Cenomanian substage boundary is tentatively placed above the last appearance of *Orbitolina* in these few lenses, and traced laterally within its relative level of occurrence in the upper part of the Junediya Formation (Fig. 2). The recognition of the overlying Muhraqa Formation is in places questionable due to profound lithofacies changes. The lack of age-indicative fossils in the lower part of this formation (as locally defined) does not enable one to trace the precise position of the Cenomanian–Turonian boundary, which is, therefore, drawn tentatively in Fig. 2. In some regions the detection of the Middle–Upper Cenomanian boundary is impossible because of the erosive truncation of the upper part of the Cenomanian sequence (Bein, 1974; Lipson-Benitah, 1994).

A tripartite division of the subsurface Cenomanian succession of western Israel was applied on the basis of planktic foraminifera to emplace the Middle–Upper Cenomanian substage boundary without, however, being able to differentiate a well defined Upper Cenomanian sequence (Lipson-Benitah, 1994; Lipson-Benitah and Almogi-Labin, in press).

CONCLUSIONS

Thomelites sornayi (Thomel) recently found in Jerusalem enables the dating as early Late Cenomanian of the single (lower) level of *Neolobites vibrayeanus* in Jerusalem. Both overlie the level with the Middle Cenomanian *Cunningtoniceras meridionale,* which was found in a similar lithofacies 2–4 km away. This enables the division of the Cenomanian Stage in Israel into three substages. The early Late Cenomanian age of the lowermost occurrence of *N. vibrayeanus* in Jerusalem seems to restrict the range of this species to the Upper Cenomanian. The approximate position of the Middle–Upper Cenomanian boundary in the upper part of the Kefar Sha'ul Formation in Jerusalem is traced to the Makhtesh Ramon region (upper part of Avnon Mbr., Hazera Fm.), just below the lower of two levels of *N. vibrayeanus*. Thereby the sequence attributed to the Upper Cenomanian in a tripartite division is extended from a single *M. geslinianum* level (Lewy et al., 1984) to about 40 m of dolostone and some limestone and marl (Fig. 2).

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REFERENCES

Arkin, Y. 1976. Jerusalem and vicinity. Geological map, sheet 11-II, 1:50,000. Survey of Israel.

Arkin, Y., Braun, M., Starinsky, A., Hamaoui, M., Raab, M. 1965. Type sections of Cretaceous formations in the Jerusalem-Bet Shemesh area. Geol. Surv. Isr. Strat. Sec. 1: 1–42.

Avnimelech, M.A., Shoresh, R. 1962. Les céphalopodes cénomaniens des environs de Jerusalem. Bull. Soc. Geol. Fr. (7), 4: 528–535.

Bein, A. 1974. Reef development in the Judea Group from the Carmel and the coastal plain, Israel. Ph.D. thesis, Hebrew Univ., Jerusalem, 169 pp. (in Hebrew, English abstr.).

Kennedy, W.J., Juignet, P. 1981. Upper Cenomanian ammonites from the environs of Samur, and the provenance of the types of *Ammonites vibrayeanus* and *Ammonites geslinianus*. Cretac. Res. 2: 19–49.

Lewy, Z. 1988. Lithostratigraphic subdivision of the Hazera Formation (Late Albian–Late Cenomanian) in the Negev, southern Israel. Isr. J. Earth Sci. 37: 205–210.

Lewy, Z. 1989. Correlation of lithostratigraphic units in the upper Judea Group (Late Cenomanian–Late Coniacian) in Israel. Isr. J. Earth Sci. 38: 37–43.

Lewy, Z. 1992. Periodicity of Cretaceous epeirogenic pulses and the disappearance of the carbonate platform facies in Late Cretaceous times (Israel). Isr. J. Earth Sci. 40: 51–58.

Lewy, Z. 1995. Resources of building materials within the mapping sheets of Haifa (3-I) and Atlit (3-III). Geol. Surv. Isr. Rep. GSI/22/95: 1–13 (in Hebrew).

Lewy, Z., Raab, M. 1978. Mid-Cretaceous stratigraphy of the Middle East. Ann. Mus. Hist. Nat. Nice. 4 [for 1976]: XXXII 1–XXXII 20.

Lewy, Z., Kennedy, W.J., Chancellor, G. 1984. Co-occurrence of *Metoicoceras geslinianum* (d'Orbigny) and *Vascoceras cauvini* Chudeau (Cretaceous Ammonoidea) in the southern Negev (Israel) and its stratigraphic implications. Newsl. Stratigr. 13: 67–76.

Lipson-Benitah, S. 1994. Cenomanian stratigraphical micropaleontology of shelf deposits — Israel. Rev. Esp. Micropaleontol. 26: 83–100.

Lipson-Benitah, S., Almogi-Labin, A. Cenomanian biostratigraphy and palaeoenvironments in the northwest Carmel region, northern Israel. Cretac. Res., in press.

Matsumoto, T., Suekane, T., Kawashita, Y. 1989. Some acanthoceratid ammonites from the Yubari Mountains, Hokkaido. Part 2. Sci. Rep. Yokosuka City Mus. 37: 29–44.

Porthault, B., Thomel, G., de Villoutreys, O., 1966. Étude biostratigraphique du Cénomanien du bassin supérieur de l'Estéron (Alpes-Maritimes). Le problème de la limite Cénomanien–Turonien dans le Sud-Est de la France. Bull. Soc. Geol. Fr. (7), 8: 423–439.

Wright, C.W., Kennedy, W.J. 1987, 1990. The Ammonoidea of the Lower Chalk. Parts 2, 3. Palaeontological Society, London: pp. 127–294.