

MICROBIOSTRATIGRAPHICAL (FORAMINIFERA) DIVISION OF THE TURONIAN TO SANTONIAN IN TUNISIA (EL KEF AND DJ. FGUIRA SALAH AREA)



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Abstract: The profile through the Turonian in the area of Hammam Mellègue together with perfectly exposed Coniacian and Santonian formations is one of the best in Tunisia. It was proposed by the author as the stratotype profile for the Tethyan realm (Salaj 1986). We stress that planktonic and benthonic foraminifers are perfectly preserved here. The Lower Turonian is characterized by the upper part of the *Whiteinella gigantea* Zone (*W. archaeocretacea* Pessagno 1967 which is a synonym of *Whiteinella inornata* Bolli is not present in the uppermost Cenomanian to the Lower Turonian) with the *Dicarinella imbricata* and *Dicarinella hagni* Zones with abundant species of the genus *Whiteinella* Pessagno 1967. The *Helvetoglobotruncana helvetica* Zone of the Middle Turonian is characterized by the *Dicarinella oraviensis trigona*, *Dicarinella biconvexa* and *Sigalitruncana turona* Subzones (Salaj 1976; Salaj & Bellier 1978). The appearance and explosive development of the species *Whiteinella inornata* (Bolli) and *Whiteinella repanda* (Bolli) in the uppermost part of the *Sigalitruncana turona* Subzone together with various representatives of the genus "*Gabonella*" de Klasz, Marie & Meijer 1960, which are also abundant in the Upper Turonian is interesting. The uppermost Turonian is characterized by *Dicarinella primitiva* (Dalbiez) and *Dicarinella paraconcavata* (Hofker). The Lower Coniacian is defined by the *Dicarinella concavata*-*Helvetoglobotruncana cachensis* Zone, whilst the Middle-Upper Coniacian is determined by the *Globotruncanella praehavanensis* Zone. The uppermost Coniacian is determined by *Sigalia deflaensis* (Sigal) and the base of the Santonian is determined by *Sigalia carpathica* Salaj & Samuel (Salaj & Maamouri 1995).

Key words: Tunisia, Dj. Fguira Salah, El Kef, Turonian-Santonian, standard zonation, planktonic foraminifers.

Introduction

The aim of this note is to point to the significance of the Turonian-Santonian hypostratotypes of Tunisia (loc.: Dj Fguira Salah, El Fahs and Hammam Mellegue, El Kef; Fig. 1) in function of stratotypes for the Tethyan realm.

The subdivision of these stages in Tunisia is based above all on the macrofauna and foraminifers. The relationship with the foraminiferal zones is shown on Fig. 3.

Turonian

As standard profiles for the Turonian, three were chosen: a profile in the area of El Fahs (Salaj 1986, p. 486) a further profile in the area of Enfidaville (Dj. Abid - Dj. Bayada, Salaj 1973, 1980) and especially the profile in the area of El Kef (Hammam Mellègue) (Salaj 1980, 1986, p. 490-491, 1987a, 1989).

The uppermost Cenomanian-Lower Turonian is characterized by the Bahloul Formation (17 m thick). A new detailed subdivision of this formation was carried out by Maamouri et al. (1994). The base of the Lower Turonian is determined and proved by appearance of *Dicarinella imbricata* (Mornod) (Salaj & Maamouri 1995). The middle and upper part of the Bahloul Formation (Lower Turonian) is defined by the microfauna of the *Dicarinella hagni* Zone. In some places (Hammam Mellègue, Burollet & Sainfeld 1956) the Lower

Turonian is documented by the presence of the *Inoceramus labiatus* Schloth. The top of the Bahloul Formation and Bireno Formation correspond to the *Helvetoglobotruncana helvetica* Zone (thickness 57 m, Salaj 1986) with the *Dicarinella oraviensis trigona*, *Dicarinella biconvexa* (definition of these

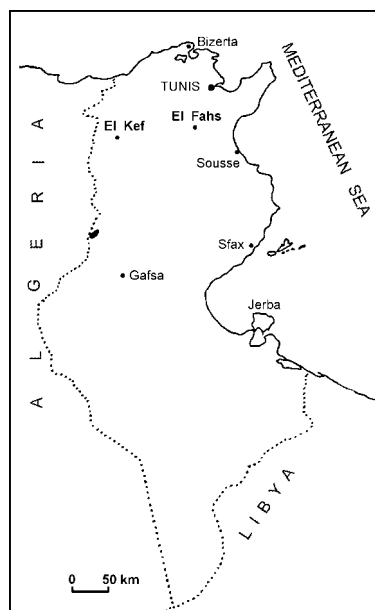


Fig. 1. Localization of the studied sections (see Salaj 1995).

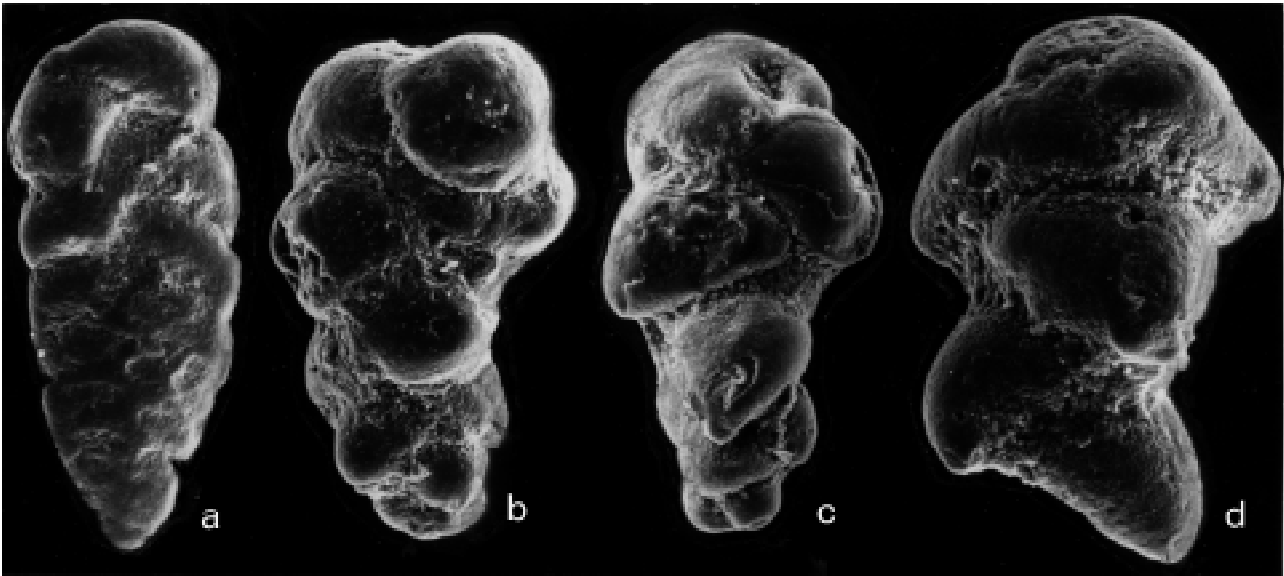


Fig. 2. a — *Gabonella laevis* de Klasz, Marie & Rerat, $\times 420$. b — "*Gabonella*" *discorta irregularis* de Klasz, Marie & Rerat, $\times 380$. c — "*Gabonella*" *parva* de Klasz & Meijer, $\times 375$. d — "*Gabonella*" *spinosa* de Klasz & Meijer, $\times 400$. Sample 2-33. Loc.: Hammam Mellègue (El Kef area). The Sigalitruuncana turona Subzone of the Middle Turonian.

zones see Salaj & Samuel 1966) and Sigalitruuncana (syn. Caronita — Salaj & Gašpariková 1983) turona Subzones.

The Upper Turonian corresponding to the Falsomarginotruuncana schneegansi Zone (see Salaj 1987b) is characterized by the *Whiteinella inornata*-*Falsotruuncana maslakovae*, *Dicarinella renzi* and *Dicarinella primitiva* Intervale Subzones or Zones (Fig. 3).

The profile through the Turonian in the area of Hammam Mellègue together with the perfectly exposed Coniacian and Santonian formations is one of the best in Tunisia. It was proposed by the author as the stratotype profile for the Tethyan realm (Salaj 1980, 1986). The knowledge of Turonian stratigraphy from this and other profiles is summarized in other works by the author (Salaj 1973, 1975, 1976, 1980, 1986, 1987a, b, c, 1989, 1995), to which we also refer. In this place we stress that benthonic and planktonic foraminifers are perfectly preserved here. The samples, either taken from the profile of Hammam Mellègue or from the profile of Dj. Fguira Salah, not only for the Turonian, but for all stages of the Upper Cretaceous (Salaj 1973, 1984, 1986), have made detailed studies of foraminifers, from the individual zones, the study of their phylogeny (Salaj 1987b), and of detailed taxonomic problems possible.

Interesting explosive development of the species *Whiteinella inornata* (Bolli), *Whiteinella repanda* (Bolli) and representatives of the genus *Falsotruuncana* Caron 1981 was found (Pl. I: Fig. 6) in the uppermost part of the *Helvetoglobotruncana helvetica* Zone (Salaj 1996, p. 252-253), in the upper part of the Sigalitruuncana turona Subzone defined by Salaj (1975). At the same time explosive development of various representatives of the genus "*Gabonella*" de Klasz, Marie & Meijer (1960) was also taking place (Fig. 2), proved by the author (Salaj 1996) at the profile of Hammam Mellègue. They are also abundant in the *Whiteinella inornata*-*Falsotruuncana maslakovae* Subzone defined by Salaj & Gaš-

pariková (1983, p. 598). The oldest occurrence of this genus *Gabonella laevis* de Klasz, Marie & Rerat is mentioned by de Klasz & Rerat (1963) from the Cenomanian of Gabon.

Turonian-Coniacian boundary (Fig. 3)

The uppermost Turonian with *Dicarinella primitiva* (Dalbiez) (Salaj 1986, p. 495) and *Dicarinella paraventricosa* (Hofker) is documented in the Dj. Fguira Salah area mainly by the presence of *Hemiasper verneuilli* Desor and *Hippurites requieni* Matheron (Castany 1951; Jauzein 1967; Salaj 1976, 1996). The Coniacian base is documented by the presence of the species *Dicarinella concavata* (Brotzen), *Helvetoglobotruncana cachensis* (Douglas) (Pl. I: Figs. 9-11), *Dicarinella asymetrica* (Sigal) (Pl. I: Figs. 14-15) and *Falsomarginotruuncana angusticarinata* (Gandolfi). At this locality the lowermost Coniacian from the faunistic point of view is documented by the presence of abundant rudists and *Holaster desloiseauxi* Coquand.

The same planktonic foraminifers at the base of the Coniacian are present in the Hammam Mellègue area. Here the author found some specimens of the *Ammonites* (?= *Forresteria* sp.). The author noted that the appearance of the *Dicarinella concavata* (Brotzen) in the Upper Turonian (Robaszynski & Caron 1995, p. 686) is not confirmed.

The Coniacian Working Group led by Kauffman in Brussels (Kauffman 1955, p. 154, Kauffman et al. 1996, p. 84-94) proposed the definition of the Turonian-Coniacian stratotype boundary on the bases of the first occurrence (FO) of *Forresteria* (*Harleites*) *petrocariensis* (Coquand) (= *Barroisicerias habelfellneri*, see Kennedy 1984a,b, cf. Kauffman et al. 1996) at the locality Wagon Mound (New Mexico, U.S.A.) or the Salzgitter-Salder Quarry Section, Lower Saxony, Germany (Kauffman et al. 1996, p. 90). The Tunisian El Kef sec-

ESTIMATES TIME IN MY (SALAJ 1986, 1989)	STAGES	PLANKTONIC FORAMINIFERAL ZONES AND SUBZONES	AGE OF THE ZONES (SALAJ 1986, 1989)	EL KEF/THICKNESS	DJ. FGUIRA SALAH/THICKNESS	MACROFAUNE Localities: 1-El Kef area 2-Dj. Fguira Salah area
84.700	UPPER TURONIAN	Contusotruncana manauensis Radotruncana elevata	2.880	144 m	140 m	2 - ammonites (WIEDMANN in SALAJ 1980, p. 92)
87.600	MIDDLE SANTONIAN	Dicarinella asymetrica Ventilabrella decoratissima	0.870	43 m	40 m	1 - Texanites olivetti
88.450	LOWER SANTONIAN	Sigalia carpathica	0.770	38 m	37 m	1 - Plesiaster peini 2 - Texanites collignoni 1,2- I. (Platyceramus) siccensis
89.200	UPPER CONIACIAN	Sigalia deflaensis	0.200	4.5 m	4 m	2 - Protexanites
89.400	MIDDLE CONIACIAN	Dicarinella concavata Globotruncanella praeHAVANENSIS	2.300	66.5 m	68 m	1 - Paratexanites serratomarginatus 1- Peroniceras subtricarinarium Inoceramus cf. broghniarti
91.700	LOWER CONIACIAN	Dicarinella concavata Helvetoglobotruncana cachensis Falsomarginotruncana angusticarinata	1.500	42.5 m	45 m	2 - rudistes, echinids 1- ?Forresteria sp.
93.200	UPPER TURONIAN	F. schneegansi Dicarinella primitiva Dicarinella renzi	1.050 1.150	15m 105	7m 19m	2 - Holaster (Holasteropsis) aff. latissimus Hemiaster verneuilli Hemiaster aff. latigrunda
95.320	MIDDLE TURONIAN	W. gigantea Falsotr. maslakovae Sigalit truncana turona	0.820	82 m	38 m	2 - Hippurites requieni M. fiegei mytiloidiformis
95.790	LOWER TURONIAN	H. helvetica Dicarinella biconvexa Dicarinella oraviensis trigona Dicarinella hagni Dicarinella imbricata	0.210 0.200 0.160 0.210 0.200	21 m 20 m 16 m 21 m 20 m	0.5 m 2.1 m 2.2 m 0.6 m 0.6 m	2 - Mytiloides fiegei mytiloidiformis Explanations: W. = Whiteinella H. = Helvetoglobotruncana F. = Falsomarginotruncana
96.200						

Fig. 3. Biozonal division of the Turonian-Santonian in the Hammam Mellègue and Dj. Fguira Salah areas (El Kef, El Fahs), after Salaj 1995, modified.

tion was not recommended by the Working Group at the Brussels Meeting for consideration as a viable candidate for the Stratotype Turonian-Coniacian boundary (see Birkelund et al. 1984; Salaj 1984). The main reason, as some colleagues not correctly mentioned at the session is that the political situation in Tunisia is not stable. As a matter of fact, from the point of view of macrofauna this boundary is not sufficiently dated, but this macrofauna is found at this place.

We stress that the disadvantage of the Wagon Mound locality, as was shown in the lecture by Kauffman, is that not far below the Turonian-Coniacian boundary in the uppermost Turonian there is a stratigraphic hiatus. The occurrence of *Durania texana* 2 m above the Coniacian base is also interesting. There is obviously the same stratigraphic rudist horizon as at the locality Dj. Fguira Salah Tunisia, however, this is about 15 m above the Coniacian base (Salaj 1986, p. 495). So the question arises, whether the Lower Coniacian at the locality Wagon Mound is represented by condensed sediments or accompanied by hardground.

Another stratotype Turonian-Coniacian boundary, as proposed by Cobban (in Kauffman 1995, p. 155) could be defined at the locality Pueblo (Colorado) where at the base of the Coniacian representatives of the genus *Forresteria* are much more abundant than at the locality Wagon Mound and so this locality becomes more important.

Coniacian

The Lower Coniacian is defined by the *Dicarinella concavata*-*Helvetoglobotruncana cachensis* Zone while the Middle-Upper Coniacian is determined by the *Globotruncanella praehavanensis* Zone, which was defined by Salaj & Gašpariková (1983).

The author verified its Middle Coniacian age at the locality El Baiada (1 km NNW of elev. p. 506, NW area on map sheet El Kef 1:50,000, near the road leading to Souk-Ahras). There is alternation of marly limestones and marls, from macrofauna representatives of the genera *Inoceramus* sp. and *Peroniceras* are found here. Burrollet & Sainfeld (1956, p. 12) mention from there *Inoceramus* cf. *broghniarti* Airachi and *Peroniceras subtricaratum* d'Orbigny, a typical representative of the Middle Coniacian zone (Kennedy 1984a, p. 153) of the same name.

The Upper Coniacian age of this species at map sheet El Kef is also unambiguously documented by the localities with macrofauna at the Coniacian-Santonian boundary. They are the localities Kat es Sekouma (by the road) and Oued Chella. The Upper Coniacian (lower part) is proved here by occurrences of specimens of the species *Paratexanites seratomarginatus* (Redt.). The uppermost Coniacian is determined microfaunistically by the *Sigalia deflaensis* Zone, in which at the locality Dj. Fguira Salah scarcely representatives of the genus *Protexanites* are found (Salaj 1984, p. 200). It is necessary to mention that mainly at the localities Dj. Fguira Salah besides echinoids, benthonic foraminifers, ostracods and, of course, also nannoplankton are uncommonly abundant.

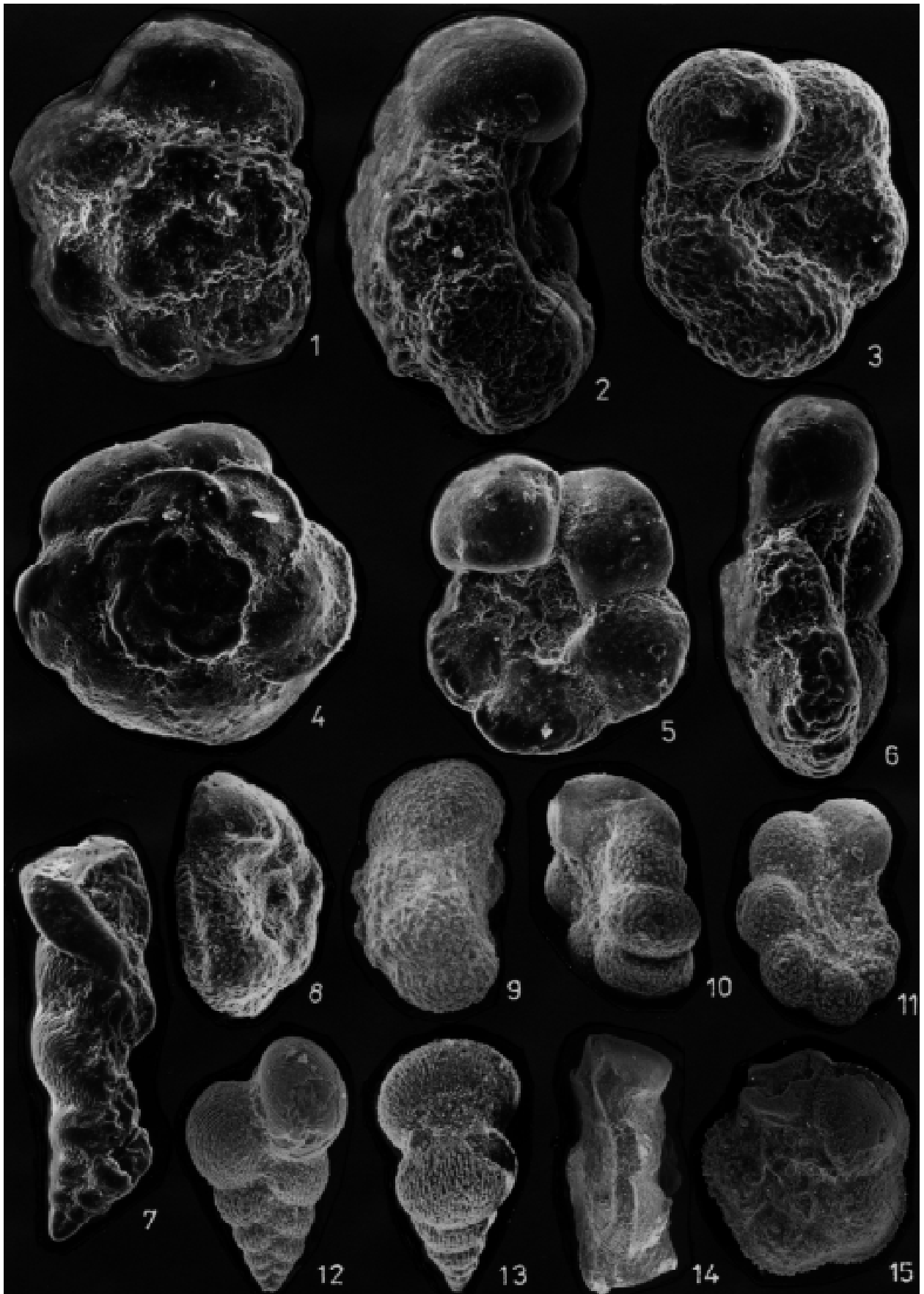
Coniacian-Santonian boundary (Fig. 3)

In Tunisia as well as in Algeria the base of the Santonian is determined on the basis of appearance of the species *Inoceramus (Platyceramus) siccensis* Pervinquiere. It is found at the profile Dj. Fguira Salah (Salaj 1980, 1984) as well as in the area of Hammam Mellègue and at many other localities on the map sheet El Kef (1:50,000). In addition at the former locality (Dj. Fguira Salah) 5 m higher up from the Santonian the species *Texanites olivetti* (Blanckenhorn) was found. In fact it corresponds to the species *Texanites collignoni* (Lamolda 1995, p. 156). From the index species, which unambiguously determines the Santonian base, is *Sigalia carpathica* Salaj & Samuel (Pl. II: Figs. 4-7), as it was proved at many localities in Tunisia (Maamouri & Maamouri 1969; Salaj & Maamouri 1971; Salaj 1970, 1980; Sigal 1977). It should also be mentioned that in the upper part of the *Sigalia carpathica* and *Ventilabrella decoratissima* (Middle Santonian) Zones at the locality Dj. Fguira Salah rudists (*Vaccinites* div. sp.) are abundant. The *Ventilabrella decoratissima* Zone in the Hammam Mellègue area is documented by the *Texanites olivetti* (Blanckenhorn). The Upper Santonian with ammonites (Wiedmann in Salaj 1980, p. 92) is defined by foraminifers of the *Contusotruncana manaurensis*-*Radotruncana elevata* Zone.

Similar stratigraphical conditions to those of the locality Dj. Fguira Salah are also at the locality 1 km NWW of Hammam Mellègue and at the locality Chabet et Bagrat as well as at the already above mentioned localities on map sheet El Kef: Oued Chella, Koudiat es Sekouma and in the synclinal structure formed by Upper Coniacian to Lower Campanian sediments, at the localities Draa Sebatache, Kat Kassar (along the road) and Oued Felja three up to 1 m thick layers of micrite limestones are found within the range of about 15 m, separated by layers of grey marls. The uppermost of them contain extraordinarily abundant specimens of the species *Inoceramus (Platyceramus) siccensis* Pervinquiere. In this layer, as described by Burrollet & Sainfeld (1956) at the localities Koudiat Sekouma and Chabet et Bagrat (map sheet El Kef 1:50,000, Burrollet & Sainfeld 1956), well preserved specimens of the *Texanites texanum* Roemer are found and, moreover, at the localities: Oued Chella, Oued Felja, Draa Sebatache, echinoids, represented by the species *Plesiaster peini* Coquand, are extraordinarily abundant in this uppermost layer.

As far as the index fossil for establishing the Coniacian-Santonian stratotype boundary is concerned the Santonian Working Group led by Lamolda (1995, p. 156) in the first

Plate I: Figs. 1-3 — *Helvetoglobotruncana helvetica* (Bolli); $\times 200$, $\times 240$, $\times 200$. Sample 2-33. Loc.: Hammam Mellègue. Upper part of the *Helvetoglobotruncana helvetica* Zone (*Sigalitruncana turona* Subzone). **Figs. 4, 5** — *Sigalitruncana turona* (Olbertz); $\times 200$, $\times 175$. Sample 2-33. Loc.: Hammam Mellègue (El Kef area). Uppermost part of the Middle Turonian. **Fig. 6** — *Falsotruncana maslakovae* Caron; $\times 275$. **Fig. 7** — *Heterohelix americana* (Cushman); $\times 280$. Sample 2-33. **Figs. 9-11** — *Helvetoglobotruncana cachensis* (Douglas); $\times 130$. Sample Z-38. Loc.: Dj. Fguira Salah. *Helvetoglobotruncana cachensis*-*Falsotruncana angusticarinata* Zone of the Lower Coniacian. **Figs. 12, 13** — *Heterohelix striata* (Ehrenberg); $\times 110$, $\times 120$. **Figs. 14, 15** — *Dicarinella asymetrica* (Sigal); $\times 150$. Sample Z-38.



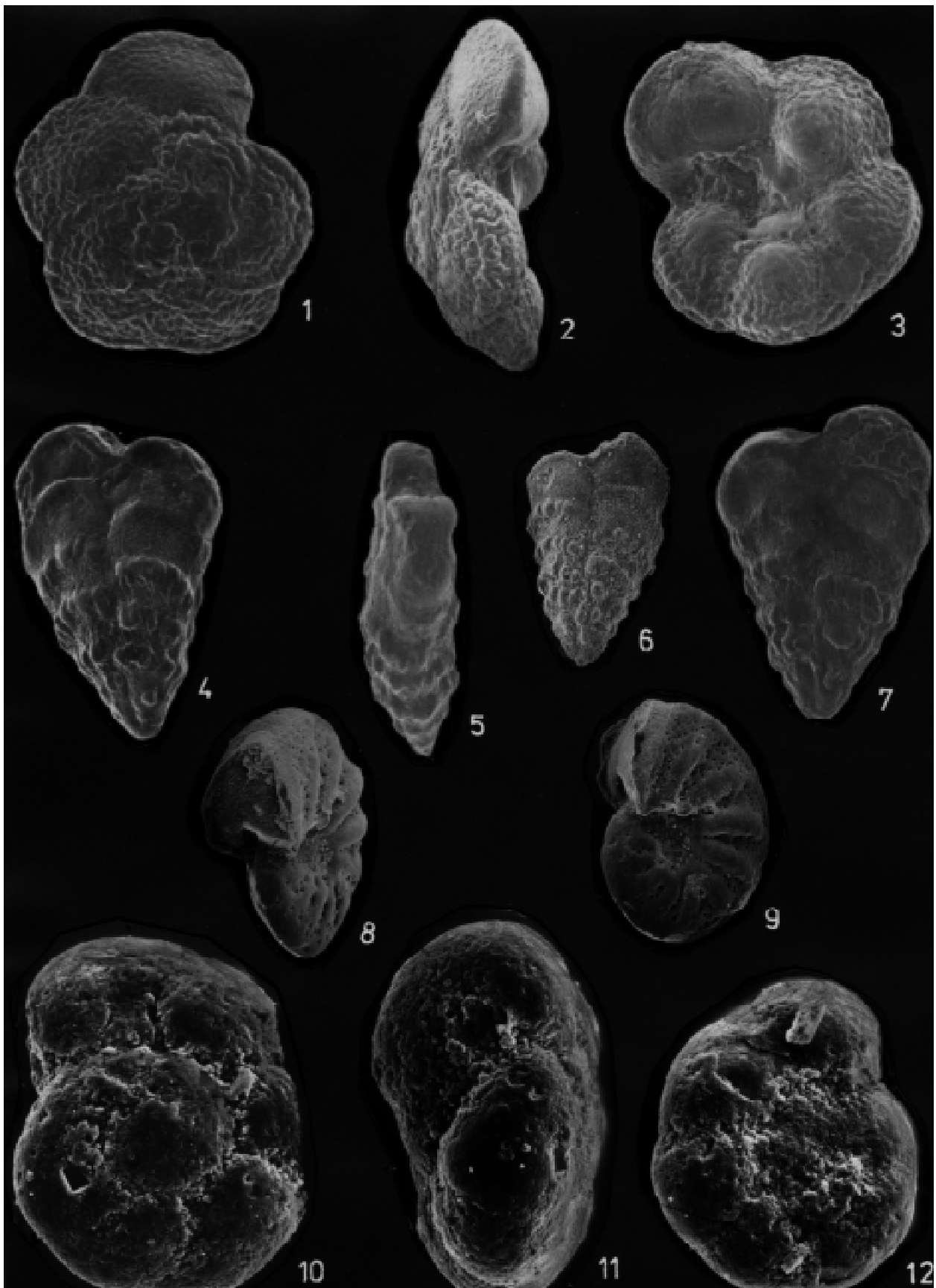


Plate II: Figs. 1-3 — *Globotruncanella praehavanensis* Salaj & Gašpariková; ×120. Sample Z-1861. Loc.: Dj. Fguira Salah. *Globotruncanella praehavanensis* Zone of the Middle Coniacian. **Figs. 4-7** — *Sigalia carpathica* Salaj & Samuel; ×140, ×140, ×80, ×140. Sample Z-1193/30. Loc.: Dj. Fguira Salah. Zone of the *Sigalia carpathica* of the Lower Santonian. **Figs. 8, 9** — *Gavelinella costulata* (Marie); ×80. Sample Z-1193/30. **Figs. 10-12** — *Gavelinella moniliformis* (Reuss); ×450, ×450, ×350. Sample 2-33. Loc.: Hammam Mellègue. *Sigalitrunca turona* Subzone.

place propose the appearance of representatives of the subgenus *Inoceramus* (*Cladoceramus*) *undulatoplicatus* and from foraminifers the species *Sigalia carpathica* Salaj & Samuel. The author notes the appearance of the species *Gavelinella costulata* (Marie) (Pl. II: Figs. 8-9) from the base of the Santonian as well. As further representatives of other groups for establishing the Coniacian-Santonian stratotype boundary, mainly *Inoceramus* (*Platyceramus*) *siccensis* (Lamolda 1995, p. 157) should be mentioned. The definitive locality for the Coniacian-Santonian stratotype boundary has not been chosen so far. The Santonian Working Group suggests (Santonian Working Group — Circular 5, Brussels 1995) three candidates for the Coniacian-Santonian boundary stratotype: Olazagulia Quarry (Navarra, Spain), Seaford Head (Sussex, England) and Ten Mile Creek (Dallas, Texas, U.S.A.).

We stress that another three localities for the Coniacian-Santonian boundary stratotype are proposed and are being taken into consideration (see Lamolda & Hancock et al. 1996, pp. 99-100): a) The El Kef area, b) The West-central Alberta, Canada (Cold Temperate Province), c) and The Mangyshlak area (Kazakhstan).

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