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# The late Aptian–early Albian transgressions in the Chott area, southern Central Tunisia

Etienne Jaillard [a, *], Jean-Louis Latil [b], Jean-Pierre Masse [c], Rabaa Hfaiedh [d]

[a] Université Grenoble Alpes, ISTerre, IRD UMR 219, Maison des Géosciences, CS 40700, 38058 Grenoble Cedex 9, France
[b] G.R.E.G.B., Le Maupas, 05300 Lazer, France
[c] Géologie des Systèmes Carbonates, Aix-Marseille Université-CEREGE-Centre Saint-Charles, 13331 Marseille Cedex 03, France
[d] Université de Gafsa, Faculté des Sciences, laboratoire Eau-Energie-Environnement (Sfax), Tunisia

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The detailed sedimentological and biostratigraphic study of the upper Aptian–Albian series in the Chott area, southern Central Tunisia, leads to the identification of several, well-dated depositional sequences. The upper Aptian sequences are marked by very shallow marine, first partly evaporitic, then mainly clastic deposits. The last sequence yielded latest Aptian ammonites (*H. jacobi* zone). The Aptian–Albian boundary is assumed to be marked by a long-lasting hiatus, and by the abrupt change from clastic to carbonate deposits. The overlying "*Knemiceras* Beds" express the Albian transgression, and comprise four depositional sequences. New findings of ammonites allow to date these beds to the lower Albian (*D. mammillatum* superzone), and to correlate the four sequences with those defined in Central Tunisia. Five distinct morphologies of *Knemiceras* sp. are recognized in the "*Knemiceras* beds". Because of their stratigraphic position, the overlying massive shelf carbonates (Radhouane Member) are ascribed to the uppermost lower Albian (*T. camatteanum* and *L. pseudolyelli* zones), and correlated with the Allam Limestone of Central Tunisia. This carbonate series is capped by a major discontinuity, correlated with the middle Albian discontinuity known in Central Tunisia. The ammonites and rudists fauna are presented and illustrated.



## 1. Introduction

Although the Cretaceous stratigraphy of Central Tunisia has been established since a long time (Pervinquière, 1907; Domergue et al., 1952; Burollet, 1956; M'Rabet et al., 1995), the uneven paleotopography of the margin, together with significant Mesozoic tectonic events obscured the lateral correlations of sedimentary deposits along the Tunisian margin. These difficulties are enhanced by the highly endemic character of the mid-Cretaceous ammonite fauna, which makes difficult biostratigraphic correlations between the various paleogeographic provinces of Tunisia, and with the well dated series of the northern Tethyan margin. For these reasons, we undertook a revision of the stratigraphy, ammonite biostratigraphy and sedimentary evolution of the upper Aptian–Albian succession of Central Tunisia, which led us to revise some stratigraphic assignments, and to refine the sedimentary history of this area (Chihaoui et al., 2010; Latil, 2011; Jaillard et al., 2021). In this paper, we present paleontological, stratigraphic and sedimentological results about the upper Aptian–Albian successions of the Chott Basin in southern Central Tunisia. These results allow us to refine the age of the sedimentary pile of the Chott area, to highlight the sedimentary evolution of the area, and to propose new correlations with northern Central Tunisia.

## 2. Geological setting and previous works

During the Cretaceous, Tunisia was part of the southern Tethyan margin, which was gently dipping northward. Central Tunisia is known to have been a positive area, that received a relatively reduced sedimentation during the Cretaceous (Burollet, 1956; M'Rabet, 1981). It was bounded to the north by a deep marine basin, which presently crops out in the Tell Chain, folded during the Alpine deformation, and to the South by an WNW-ESE trending intracontinental basin, known as the Chott Basin (Burollet, 1956; Hlaiem et al., 1997; El Amari et al., 2016). The latter is in turn bounded to the South by the Saharan platform, which received thin,

* Corresponding author.
*E-mail address:* Etienne.Jaillard@univ-grenoble-alpes.fr (E. Jaillard).

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mostly continental, clastic deposits during the Mesozoic (Busson, 1972; Tlig, 2015; Khila et al., 2016) (Fig. 1).

The Chott Basin is bounded to the North by a major, NW-SE trending fault (Gafsa Fault, Saïd et al., 2011), which separates the Atlasic domain marked by NE-trending massifs, folded during the Neogene, from the Chott depression characterized by roughly E-W trending open folds (Fig. 2). The Chott Basin recorded a first extensional crisis of Triassic—Lower Jurassic age, ascribed to the Tethyan rifting, and a second extensional crisis of Early Cretaceous age, interpreted as the result of the opening of the Eastern Mediterranean oceanic domain (Barrier et al., 1993; Hlaiem et al., 1997; Bouaziz et al., 2002). The structure of the Chott basin is marked by a complex, large-scale, E-W trending anticline (Masrouhi et al., 2019), which allows the Cretaceous series to crop out in the northern (northern Chott Chain) and southern (southern Chott Chain, or Tebaga de Kebili) parts of the basin (Fig. 2).

The stratigraphy of the Chott area has been first established in the fifties during campaigns for oil exploration (Domergue et al., 1952; Arnoult-Saget, 1956). Since then, the age of the Aptian series and the deposition environment of the Aptian—Albian successions have been refined by local works (M'Rabet et al., 1979; Ben Youssef et al., 1985a; Ben Youssef and Peybernès, 1986; Chaabani et al., 1992; Abdallah and Memmi, 1994; Abdallah et al., 1995; Marzouk and Ben Youssef, 2008; Hfaiedh et al., 2013; Godet et al., 2014; Ben Ali et al., 2018). Meanwhile, the Mesozoic tectonic evolution of the basin has been studied by Abbes and Tlig (1991), Louhaichi and Tlig (1993), Hlaiem (1999), Lazzez et al. (2008) and Amamria et al. (2021). These authors gave evidences of diapiric movements in the Jurassic-Early Cretaceous, significant Albian tectonic movements, and a major unconformity of Coniacian age.

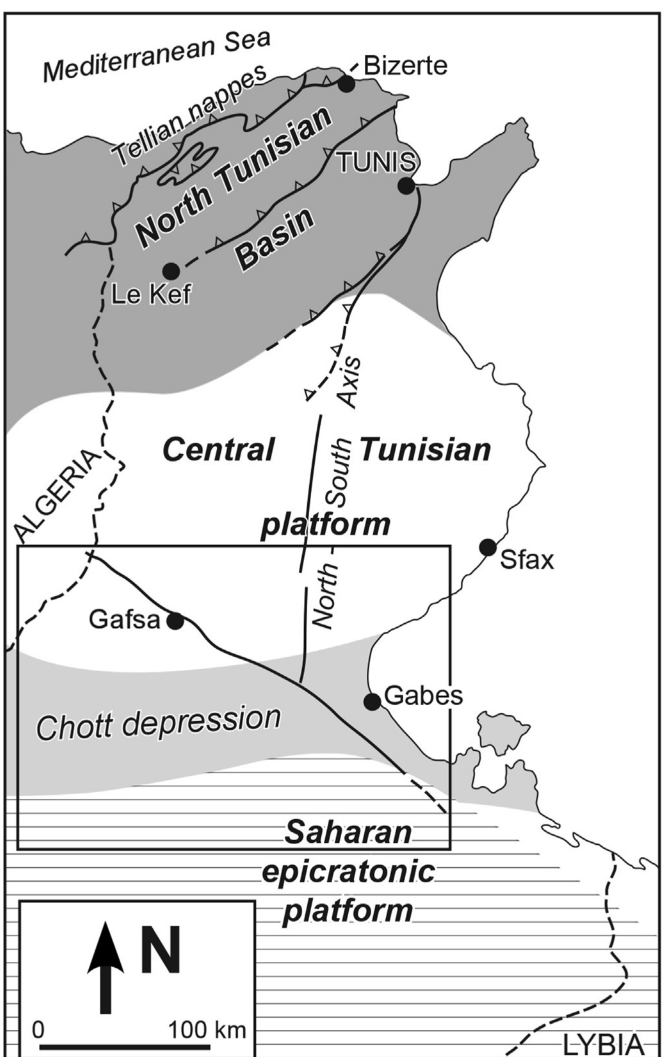


**Fig. 1.** Structural sketch of Tunisia, showing the main paleogeographic domains.

Farther Southeast, in the Medenine area (Fig. 2), correlative layers received significant attention, from sedimentological (Busson, 1972; Ben Youssef et al., 1985b; Ben Youssef and Peybernès, 1986; Ouaja et al., 2002; Bodin et al., 2010; Tlig, 2015) and paleontological points of view (vertebrates, floras; *e.g.* Barale et al., 1998; Benton et al., 2000; Cuny et al., 2010a; Ouaja et al., 2011; Fanti et al., 2012; Krimi et al., 2017). According to these works, the Aptian—Cenomanian interval comprises two formations.

The Orbata Formation (Fm) comprises three members (Fig. 3):

- The Berrani Member (Mb) (5—30 m) is made of massive limestone and dolomite, rich in rudists, orbitolinids, corals and algae, which indicate a shallow shelf environment. The microfauna suggests a latest Barremian to earliest Aptian age (Ben Youssef and Peybernès, 1986; Hfaiedh et al., 2013).
- The Arguib Mb (50—100 m) comprises alternating limestones and marls, locally overlain by evaporites. This unit contains microfaunas of early Aptian age (Ben Youssef and Peybernès, 1986; Hfaiedh et al., 2013).
- The Foum el Argoub Mb (30—40 m) is made of sandstones and scarce limestone beds. In Bir Oum Ali, this unit yielded scarce ammonites, the determination of which points to an early Aptian (Ben Youssef et al., 1985a; Abdallah et al., 1995), or late Aptian age (Hfaiedh et al., 2013), respectively.

The Zebbag Fm comprises four units (Fig. 3).

- The basal part ("Knemiceras Beds", 50 m) locally overlies two successive massive, orbitolinid-rich limestone beds, of late Aptian, and late Aptian or early Albian age, respectively (Hfaiedh et al., 2013). The rest of the unit is composed of alternating, fossiliferous marl and limestone beds, which yielded ammonites (several species of *Knemiceras*) ascribed to the middle to late Albian (Domergue et al., 1952; Arnoult-Saget, 1956; M'Rabet et al., 1979; Ben Youssef and Peybernès, 1986; Abdallah and Memmi, 1994), revised as early to middle Albian in age (Moreno-Bedmar et al., 2008).
- The lower part of the Zebbag Fm (Radhouane Mb, 30—80 m) forms prominent cliffs all along the Chott chains. It is made of massive, commonly laminated limestone and dolostone. Abdallah et al. (1995) ascribed this unit to the early to middle Cenomanian, whereas Bodin et al. (2010) consider it as late Albian in age.
- The overlying thick shales, evaporites and dolostones (Kerker Mb, 100—150 m) are poorly dated. Benthic foraminifers suggest a Cenomanian age (Abdallah et al., 1995).
- The Zebbag Fm ends up with alternations of marls and limestones, overlain by massive dolostones (Gattar Mb, 40—60 m). The lower part yielded latest Cenomanian ammonites, while the Gattar Mb is of Turonian age (Abdallah et al., 1995, 2000; Meister and Abdallah, 2005).

Our study focused on the upper part of the Orbata Fm (Arguib and Foum el Argoub Mbs) and the lower part of the Zebbag Fm ("*Knemiceras* beds" and Radhouane Mb; Fig. 3). These lithologic units were studied North and South of the Bir Oum Ali anticline (1 and 2 on Fig. 2), and in the middle part of the Tebaga de Kebili chain, where two sections were studied at Foum el Argoub (3 and 4 on

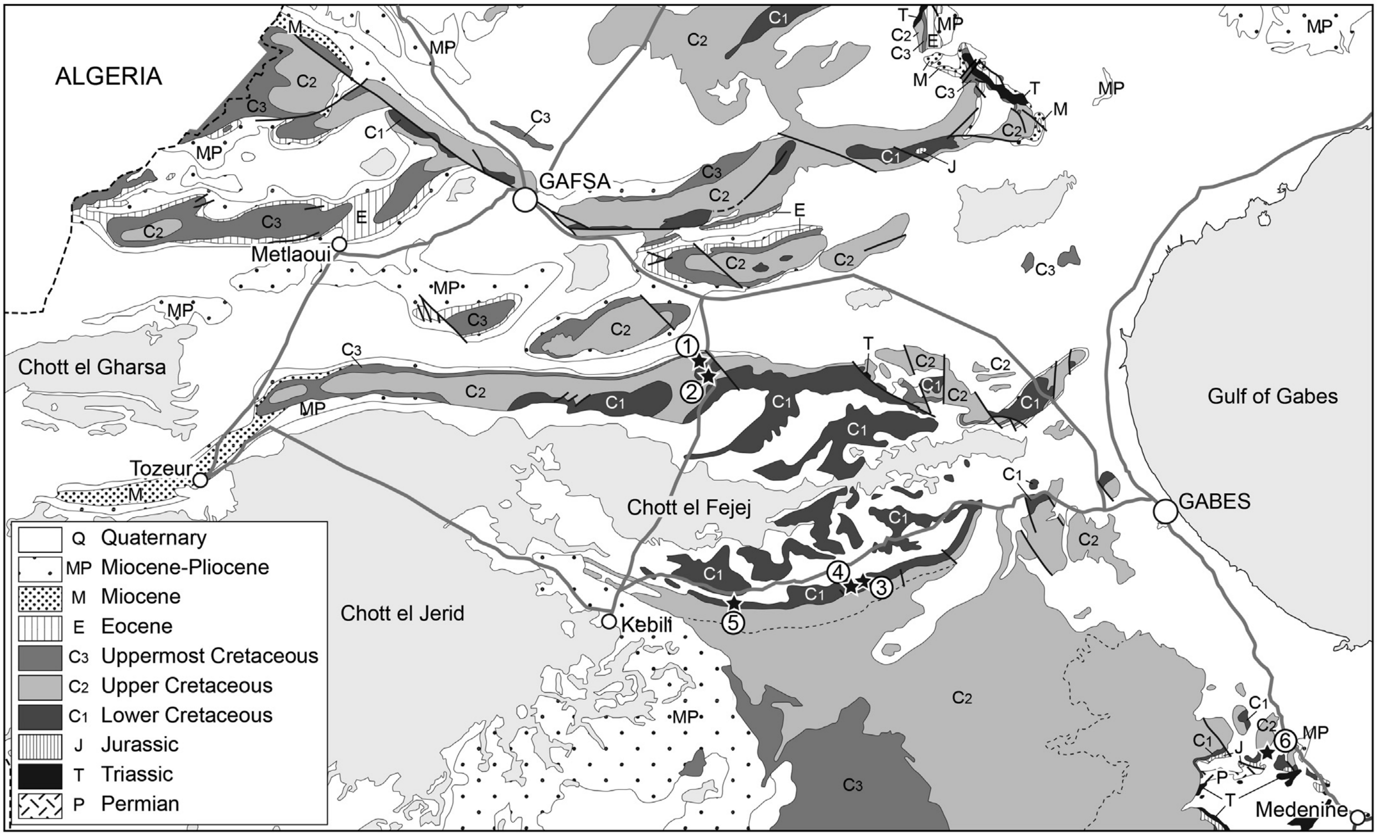


**Fig. 2.** Location geological map of the Chott area, showing the studied sections (location of Fig. 1). 1. Bir Oum Ali North, 2. Bir Oum Ali South, 3. Foum el Argoub, 4. Foum el Argoub West, 5. Limagues.

Fig. 2). Additionally, other outcrops have been visited West of the Tebaga de Kebili (5 on Fig. 2), and in the Tebaga de Médenine (6 on Fig. 2). In the Foum el Argoub area, the evaporites of the Arguib Mb acted as a decollement layer for present-day, large-scale gravity slidings, and the stratigraphic succession is disturbed in many places.

## 3. Facies, sedimentary evolution and sequence stratigraphy

The Arguib Mb comprises two lithologic units. The lower unit is mainly calcareous and includes high energy calcarenites (Unit 2 of Ben Youssef and Peybernès, 1986; Hfaiedh et al., 2013), while the upper one mostly includes marl and evaporites (Unit 3 of Ben Youssef and Peybernès, 1986; Units 3 and 4 of Hfaiedh et al., 2013). Here, we only deal with the upper unit of the Arguib Mb.

### 3.1. 1st Sequence (SX, upper part of Arguib Mb)

The upper part of the Arguib Mb comprises marls and locally evaporites (SX in Figs. 4 and 6). Shales and marls are usually silty, and the clastic amount increases upward. The base of the “evaporitic unit” is interpreted as the basal sequence boundary of SX. As a matter of fact, on one hand, it represents a sharp environmental change between the underlying, low energy, open marine carbonates and the very shallow marine, evaporitic deposits; and on the other hand, it is marked by emergence features at the top of shallow marine limestone or dolostone dated as late early Aptian (Hfaiedh et al., 2013). Additionally, in Bir Oum Ali South, the discontinuity underlines a calcareous breccia that reworks the underlying deposits, and is overlain by storm deposits and phosphate-rich beds. Unfortunately, due to gravity slidings, the basal contact is poorly exposed in the Foum el Argoub section, and does not allow to refine this interpretation.

The lower part of the sequence is dominated by marls containing open marine fauna (echinoids, annelids, oysters and other bivalves), with subordinate sandstone and dolomite beds. Current ripples in sandstones were only observed at the base of the succession. The middle part of the succession is marked by microbial, stromatolitic laminations, and teepee structures in dolomite, indicating very shallow marine to intertidal environments. The associated fauna comprises mainly oysters, trigonids and unidentified broken bivalves, with subordinate annelids and gastropods. This fauna suggests a shallow, open marine environment. Where present (Bir Oum Ali South), evaporites mostly exhibit chicken wire or laminar textures, and are interbedded with thin beds of limestone and dolostone (Fig. 5B). The latter exhibit oolites, microbial laminations, convolute structures and desiccation breccias (Fig. 5A), and may contain ostracods and small bivalves, and fragments of crinoids, echinoids, oysters, pectinids, rudists, corals, orbitolinids and red algae (Fig. 4). This suggests that there, evaporites were deposited in backshore sabkha, isolated from the open sea by high energy, bioclastic barrier-islands.

The upper part of the sequence exhibits marl, which become sandy upward and include channels filled with sandstone and micro-conglomerates (*e.g.* Bir Oum Ali South, Fig. 4). The latter contain rounded lithoclasts, fish remains, selachian teeth, bone and wood fragments, and scarce echinoid spines and bivalves. The

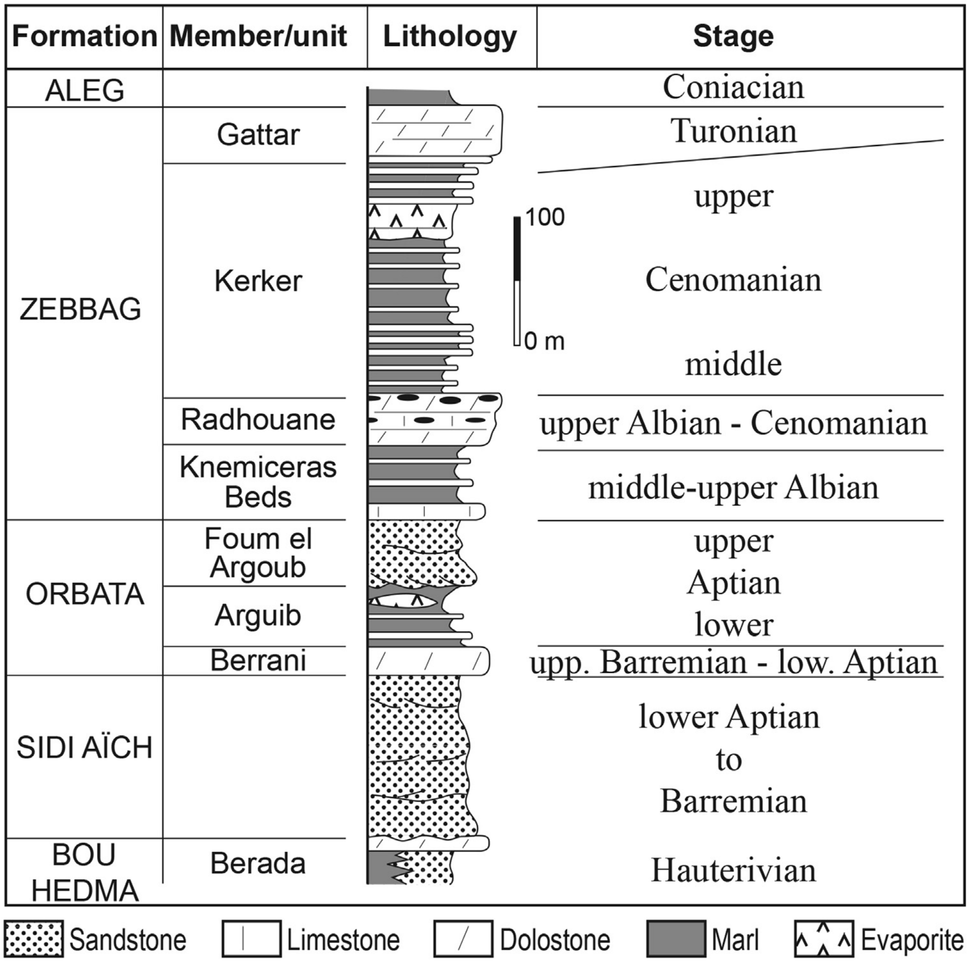


**Fig. 3.** Synthetic stratigraphic column of the Barremian–Turonian succession of the Chotts area, after Domergue et al. (1952) and Abbes and Tlig (1991).

upper part of the sequence shows an increasing amount of siliciclastics that marks the transition with the overlying Foum el Argoub Mb, and express an increasing terrigenous supply and a shallowing-upward trend (Figs. 4 and 6).

### 3.2. 2nd Depositional sequence (SY, lower part of Foum el Argoub Mb)

The Foum el Argoub Mb (30–60 m) is mostly made of poorly consolidated, fine-grained sandstones, intercalated with few limestone beds and with thicker and coarser beds, some of which are channels filled with conglomerate (Fig. 5D).

The basal discontinuity of the second sequence (SY, Figs. 4 and 6) is an erosional surface overlain by coarse-grained sandstones, which commonly exhibit steep, sigmoidal cross laminations, which locally present herring-bone structures (Figs. 4 and 6). In Foum el Argoub, a channel is filled with sands and pebbles, and fragments of both terrestrial and fresh water (dinosaurs, wood fragments, crocodiles …), and marine (fish teeth, oysters …) organisms. Thick beds of medium to coarse sandstone exhibit steep, sigmoidal cross laminations, which locally present herring-bone structures. Other beds display low-angle cross stratifications interpreted as foreshore structures.

Sandstones are usually very clean and well sorted, except in channels, and contain rounded eolian quartz grains. Locally, gently dipping cross stratifications suggest a foreshore environment. Sandstone beds are locally bioturbated and show common root traces. Dominant fossils are wood fragments, among which most of them grew in low energy intertidal zones (*Alstaettia* sp.), while some others were component of continental dry forests (*Metapodocarboxylon* sp.) (M. Philippe, written comm.). The middle part of the sequence contains shallow marine fauna (rudistids, trigonids, oysters, nerineids). In Bir Oum Ali South, a limestone intercalation is very rich in nerineids (also mentioned by Hfaiedh et al., 2013), and its top is deeply karstified (Fig. 5E).

The presence of thick, channels infilled with coarse-grained deposits at the base of the series in the Bir Oum Ali sections (Fig. 5C) suggests that a sea level drop occurred at the beginning of the deposition of the Foum el Argoub Mb. These observations point to a low energy, very shallow marine environment, submitted to significant clastic supply, and commonly crosscut by high energy tidal channels. Low energy embayments and/or high frequency sea level rises allowed the sporadic deposition of calcareous mud containing marine fauna.

### 3.3. 3rd Depositional sequence (SZ, upper part of Foum el Argoub Mb)

The base of this sequence is marked by a massive, medium to coarse sandstone bed that exhibits sigmoidal cross laminations and

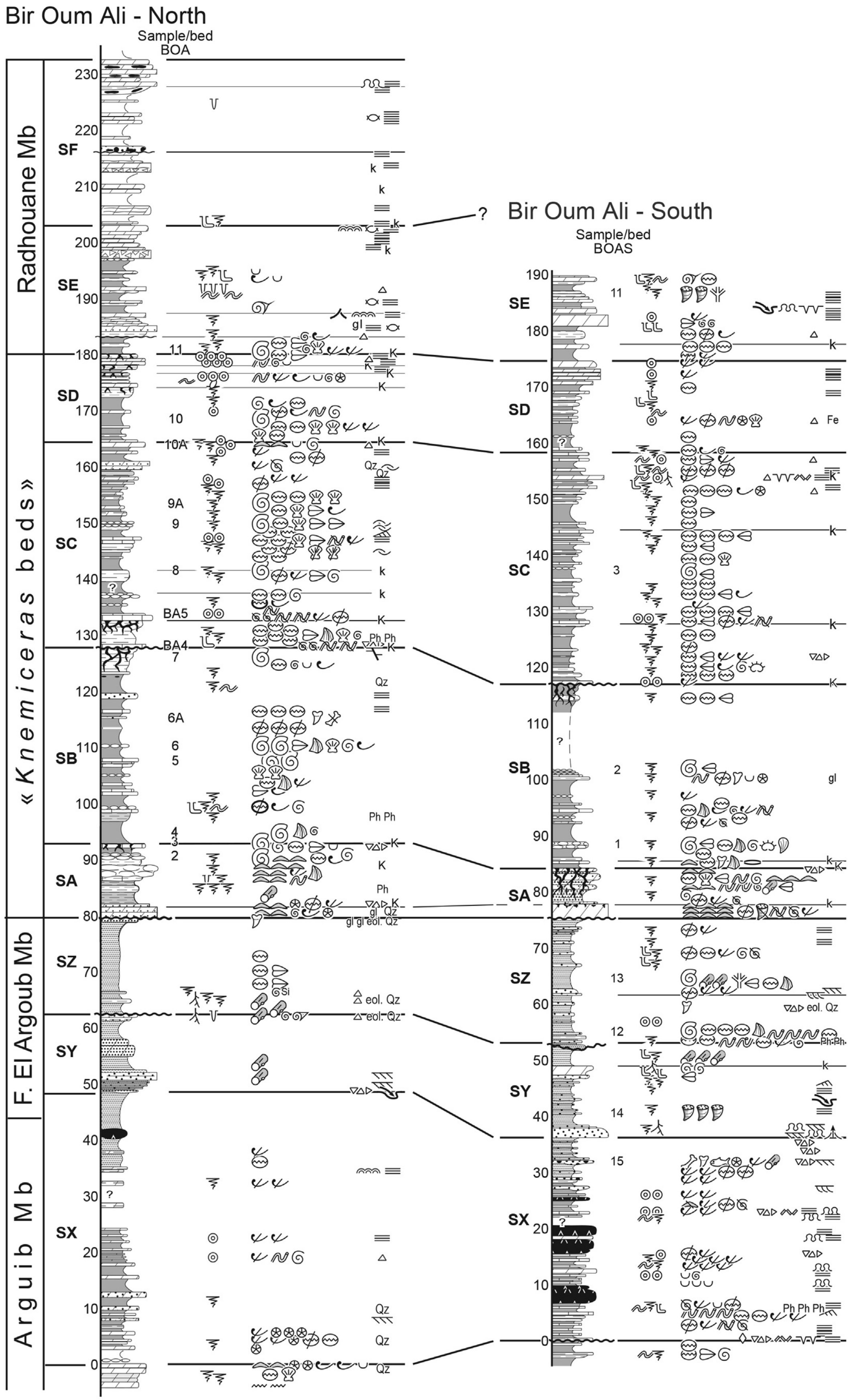


**Fig. 4.** Lithology and sedimentology of the Bir Oum Ali sections. Caption on Fig. 6.

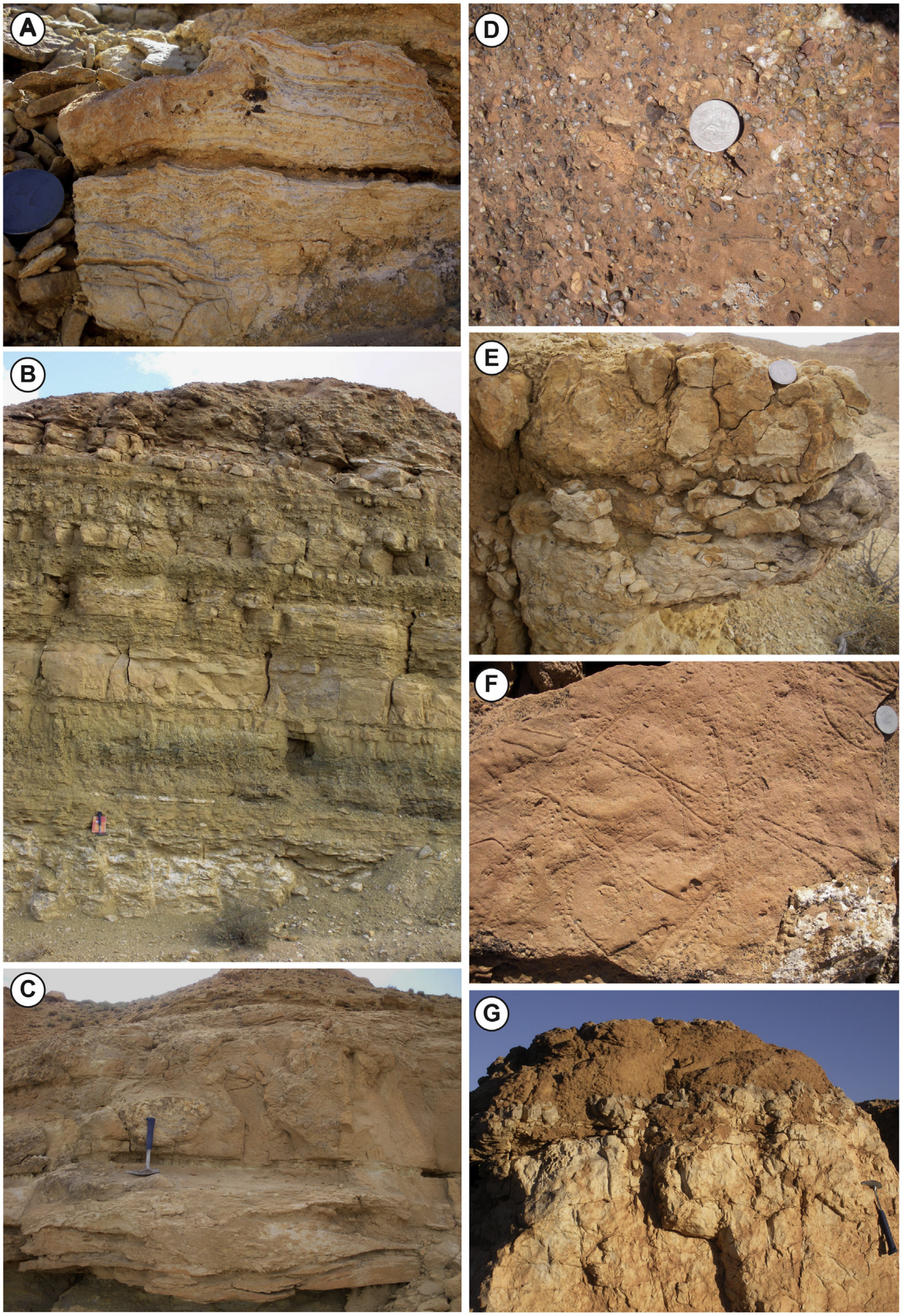


**Fig. 5.** Aspects of the sedimentation of the Arguib and Foum el Argoub members. (A) Teepee structure in a thin calcareous bed at the base of the evaporite unit (Bir Oum Ali South section, m 1 (SX)). (B) Evaporites alternating with marls and thin limestone beds (Bir Oum Ali South section, m 8-15 (SX)). (C) Channel at the base of the Foum el Argoub Member (Bir Oum Ali South section, m 36 (base SY)). (D) Microconglomerate in a channel of the Foum el Argoub Member (Foum el Argoub section, m 43 (base SY)). (E) Limestone bed rich in nerineids, deeply karstified (Bir Oum Ali South section, m 49 (S2)). (F) Arthropod trackways near the top of the Foum el Argoub Member (Foum el Argoub section, m 77 (SZ)). (G) Top of the massive orbitolinid-rich limestone (Bir Oum Ali South section, m 78 (SA)).

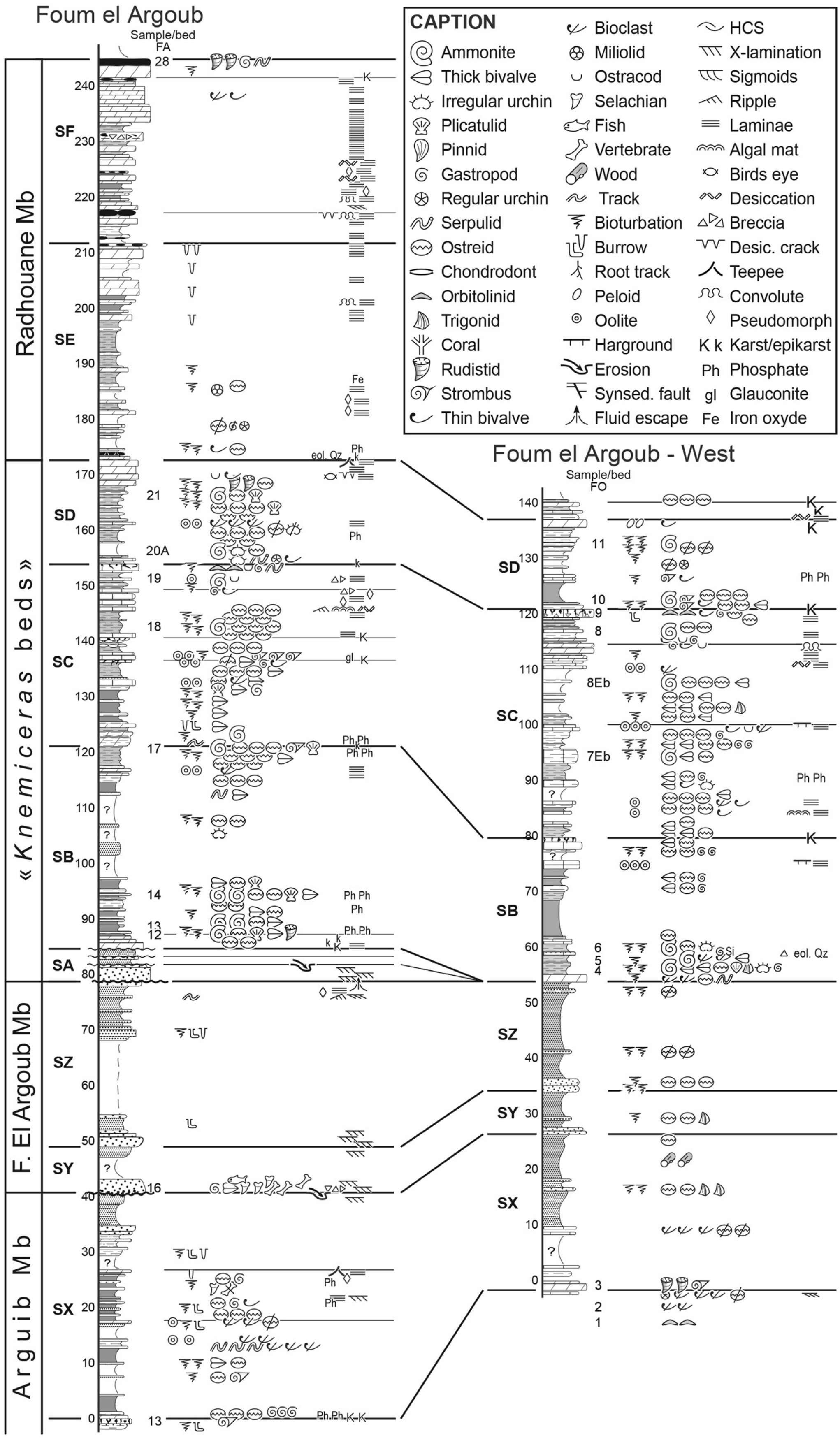


**Fig. 6.** Lithology and sedimentology of the Foum el Argoub sections.

herring-bone features (SZ, Figs. 4 and 6). In Bir Oum Ali South, a channel is infilled by phosphate-rich sand containing oysters, trigonids, ammonites, and numerous annelids that locally forms bioherms. Above, the faunal content includes oysters, trigonids and scarce other bivalves. In Bir Oum Ali South, some beds contain corals, fish teeth, gastropods and ammonites (Fig. 4). Bioturbation includes burrows and arthropod trackways (Fig. 5F).

With respect to the previous one, the 3rd sequence indicates a lower energy regime, a more distal environment and a more open, although shallow, marine environment. The ammonite-bearing beds in the middle part of the sequence (BOAS 13, Fig. 4) is interpreted as the maximum flooding of this depositional sequence.

### 3.4. 4th Depositional sequence (SA, base of "Knemiceras *Beds")*

In Bir Oum Ali, the fourth sequence begins with a 3 m-thick, massive bed of fossiliferous sandy limestone or dolostone (SA, Fig. 4). This bed contains numerous orbitolinids, annelids, echinoids, rudists, oysters and other bivalves. Lithoclasts and glauconite are common. The top is a deeply karstified surface, locally infilled by red, sandy, dolomitic marls with small rounded quartz pebbles (Bir Oum Ali South; Fig. 5G). It is overlain by bioturbated, fossiliferous marls locally rich in phosphate, which grade upward into nodular or massive limestone beds (5–10 m; Fig. 4). The latter contains small- and large-sized gastropods, orbitolinids and bivalves, associated with annelid bioherms and fossil wood fragments. The overlying massive, orbitolinid-rich nodular limestone beds are intensely bioturbated and contain annelids, oysters, pectinids, trigonids and other bivalves. The top of each upper bed of the sequence is deeply karstified.

In Foum el Argoub, the fourth sequence begins with a bed of coarse bioclastic calcarenite, which disappears to the West and displays very high energy structures indicating two opposite current directions (SA, Fig. 6). It is overlain by a massive dolostone bed that likely correlates with the upper, massive nodular bed of Bir Oum Ali (Fig. 6). In both localities, the sharp erosional basal contact locally overlies a mottled paleosol or a karstified surface (Fig. 7A), which expresses a long-lasting hiatus (Hfaiedh et al., 2013). This sequence begins with a transgressive bed, deposited in a very shallow, open marine environment, locally dominated by tides (Foum el Argoub). In Bir Oum Ali, this massive bed has been included in the Foum el Argoub Mb by Ben Youssef et al. (1985a) and Ben Youssef and Peybernès (1986), and has been interpreted as a distinct depositional sequence by Hfaiedh et al. (2013). Because the major facies change is observed at the base of this massive bed, we interpret it as a parasequence of the fourth sequence. Both interpretations, however, are likely. The rest of the sequence was deposited in a shallow marine environment, far from the clastic source, and marks the incipient development of a carbonate shelf sedimentation. With respect to the underlying sequences, it marks a significant transgressive trend.

### 3.5. 5th Depositional sequence (SB, lower part of "Knemiceras *Beds")*

Overlying a deeply karstified surface, is a 25–35 m-thick series of bioturbated marls and thin limestone beds that exhibits a diversified fauna with oysters, trigonids, pinnids, pectinids and other bivalves, gastropods, annelids, ammonites, fish teeth and scarce echinoids (SB, Figs. 4 and 6). Rudists and chondrodonts occur in the lower part. Some sandstone beds are observed in the middle part, and the upper part shows a slight thickening upward trend, especially in the Foum el Argoub area. In Bir Oum Ali, the top of the sequence is a deeply karstified surface, which expresses a subaerial exposure (Fig. 7B).

The transgressive interval shows numerous emergence surfaces (karsts, desiccation breccias). The maximum flooding is placed in a shaly, ammonite-rich interval located in the middle part of the sequence. The presence of trigonids, fish teeth, bone fragments and sandstones indicate a low energy, shallow marine environment, submitted to low continental supply. The lack of echinoids and corals points to a stressed, possibly hypersaline or restricted environment.

### 3.6. 6th Depositional sequence (SC, middle part of "Knemiceras *Beds")*

The sixth depositional sequence (30–50 m) is made of alternating marls and fossiliferous limestone or dolostone (SC, Figs. 4 and 6). No sandstones have been observed, but marls and limestones are locally sandy. The basal sequence boundary is usually a karstified surface that affects the top of the underlying sequence. The whole succession is intensely bioturbated, and comprises common oolitic limestone beds (grainstone). The faunal content is dominated by oysters, which may form coquinas (Fig. 7C), and are associated with gastropods, annelids, ostracods, pectinids, trigonids and other bivalves, and very scarce echinoids. Ammonites are present in the whole succession. Bioturbation and oolitic beds occur in the lower and middle parts of the sequence, whereas karstified surfaces, microbial laminations, stromatolites, desiccation breccias, convolute laminations, gypsum pseudomorphs, oscillation ripples and small-scale hummocky cross stratifications occur in the upper part of the sequence.

This sequence is interpreted as deposited in a very shallow marine, subtidal to intertidal platform. It exhibits a slight shallowing upward trend. The scarcity of detrital influx suggests that the coastline was located far landward. The top of the sequence is placed at the top of an orbitolinid-rich limestone bed already noticed by Ben Youssef et al. (1985a) and Ben Youssef and Peybernès (1986). This bed is intensely karstified, so that the volume of karst infilling is locally higher that the initial bed (Bir Oum Ali, Fig. 7D). The maximum depositional depth is reached in the middle part of the sequence.

### 3.7. 7th Depositional sequence (SD, upper part of "Knemiceras *Beds")*

The base of the seventh sequence (10–20 m; SD on Figs. 4 and 6) is marked by alternating beds of marl and limestone; phosphate occurs in Foum el Argoub sections. Oolitic limestone beds are present in the middle and upper part of the sequence. This interval is rich in oysters, plicatulids and other bivalves, as well as gastropods, scarce echinoids, numerous ammonites (Fig. 7E). Rudists appear locally in the upper part. Sedimentary structures include bioturbation in the lower part and microbial laminations and desiccation breccia in the upper part. The upper part of the sequence is made of thick beds of dolostone, locally deeply karstified, indicating an emergence period.

The depositional environment of this sequence was comparable to that of the previous one, although the presence of rudists and echinoids may indicate more open marine conditions. The 6th and 7th sequences probably represent the deepest, most open marine depositional environments in the studied interval.

### 3.8. 8th Depositional sequences (SE, lower part of Radhouane Mb)

The eighth sequence is represented by a 20-40 m-thick, thickening upward alternation of marls and laminated dolostone (SE, Figs. 4 and 6). In the marly lower part, the fauna comprises oysters, rudists, scarce corals and large gastropods (*Strombus* sp.). In the

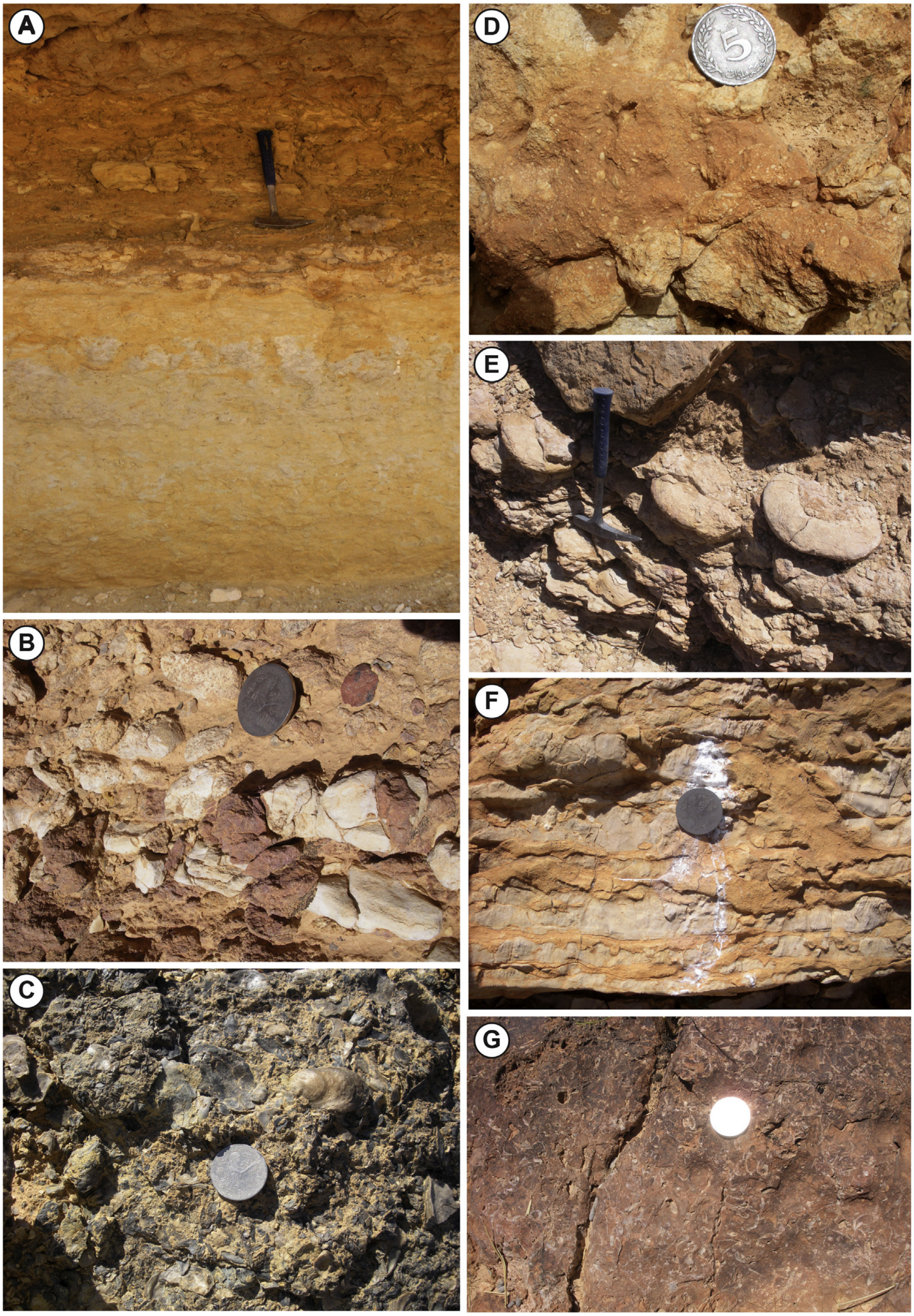


**Fig. 7.** Aspects of the sedimentation of the "*Knemiceras* beds" and Radhouane Member. (A) Alteration and pedogenesis below the massive orbitolinid-rich limestone bed (top SZ) (Foum el Argoub section, m 78). (B) Intense karstification, interpreted as a sequence boundary (Bir Oum Ali North section, m 128 (top SB)). (C) Oyster coquina (Bir Oum Ali North section, m 145 (SC)). (D) Karstified, orbitolinid-rich limestone, interpreted as a sequence boundary (Bir Oum Ali North section, m 164 (top SC). (E) Layer rich in *Parengonoceras bussoni* (Foum el Argoub West section, m 117 (SC)). (F) Laminated dolomitic limestone with tidal laminations (Foum el Argoub section, m 183 (SE)). (G) Silicified dolostone bearing numerous rudists (Foum el Argoub section, m 246 (top SF)).

dolomite beds of the upper part, sedimentary structures include microbial laminations (Fig. 7F), desiccation cracks and breccias, convolute lamination and epikarsts. They are capped by a karstified surface, locally silicified, interpreted as the upper boundary of the sequence.

The eighth sequence is interpreted as deposited in a shallow, low energy subtidal to intertidal flat sheltered from terrigenous supply. The maximum flooding surface is located in the lower, marly part of the sequence.

### *3.9. 9th Depositional sequences (SF, upper part of Radhouane Mb)*

The ninth sequence is represented by a 30–35 m-thick, thickening upward alternation of marls and laminated dolostone (SF, Figs. 4 and 6). Macrofauna is virtually absent, except at the uppermost bed. Dolomite beds show microbial lamination, desiccation breccia, convolute lamination and pseudomorphs of evaporite and their upper surfaces frequently show desiccation cracks or dissolution (epikarst). This sequence is marked frequent flint nodules and by a thick bed of breccia, which suggests tectonic instability. In Foum el Argoub, the top of the sequence is a thick, deeply silicified, rudist-bearing dolomitic bed (Fig. 7G). In Bir Oum Ali North, a major erosional surface locally removed the upper part (≈20 m) of the Radhouane Mb.

The ninth sequence was deposited in a very shallow, low energy intertidal to supratidal flat, submitted to frequent emersion periods.

## 4. Overview on other outcrops

### *4.1. Radhouane section*

The Radhouane outcrop is located 18.5 km ENE of the town of Kebili, and 6.5 km WSW of the settlement of Radhouane (9.5 km ESE of Limagues village; 5 on Fig. 2). Because the southern flank of the Chott anticline dips westward, only the upper part of the Albian section is exposed. Nevertheless, the sequences identified in Foum el Argoub are easily recognized (Fig. 8), and the upper part of the "*Knemiceras* beds" are well-exposed and can be followed for hundreds of meters. There, well-preserved specimens of ammonites have been collected (see below, section 7).

### *4.2. Chabet el Ouargli (Tebaga de Médenine)*

The short section of Chabet el Ouargli is located 23 km NW of Médenine, and 9 km NE of Dkhilet Toujane (6 on Fig. 2). A nearby section has been described by Ben Youssef and Peybernès (1986; see also Ben Youssef et al., 1985b). The section begins with undated and poorly exposed clastic deposits (Fig. 9). They are overlain by a 2 m-thick alternation of fossiliferous phosphatic conglomerate and breccia, dolomite beds and marls. Three phosphatic beds yielded ammonites, associated with shallow marine (oysters) to outer shelf fauna (bivalves, bryozoans, plicatulids), suggesting reworking and mixing of fauna. The occurrence of reworked clasts and fauna, and of karstified phosphatic beds strongly suggests that only the maximum flooding deposits of depositional sequences are recorded. These layers are correlated with the "*Knemiceras* beds" of the Chott area (Ben Youssef and Peybernès, 1986). Overlying a last phosphatic bed, massive dolomite beds present tidal lamination and karstified surfaces, and contain shallow marine fauna (Fig. 9). They are interpreted as carbonate shelf deposits, and correlated with the Radhouane Mb of the Chott area.

## 5. Biostratigraphy

The discovery of scarce ammonite species already known from Central Tunisia (Chihaoui et al., 2010; Latil, 2011), together with the finding of rudists and the revision of few orbitolinid faunas, allows us to specify the age assignments of the successions studied in the Chott area, and to propose correlations of the latter with the classical series of Central Tunisia (Burollet, 1956; M'Rabet et al., 1995; Chihaoui et al., 2010; Ben Chaabane et al., 2019, 2021). A detailed study of the ammonite fauna will be published elsewhere.

### *5.1. Upper part of the Arguib Mb (sequence SX)*

In Foum el Argoub, the very top of the underlying sequence yielded *Polyconites* cf. *verneuili* (FO 3, Fig. 10), which is known as a late Aptian to Albian *p.p.* species in the Mediterranean domain. In Bir Oum Ali, Hfaiedh et al. (2013) mention a deshayesitid ammonite (Barremian-Aptian) below the evaporite layers, which, together with benthic foraminifers, indicates the "uppermost part of the Early Aptian". In the overlying sandstones (BOAS 15, Fig. 10), we collected vertebrate remains (*Lepidotes* sp., *Cretodus semiplicatus*, *Onchopristis dunklei*, *Tribodus tunisiensis*, *Cretalamna appendiculata*, crocodilian teeth), which indicate a late Aptian or early Albian age (Cuny et al., 2010b). Because it overlies late early Aptian beds, this unit is ascribed to the early (?) late Aptian.

### *5.2. Foum el Argoub Mb (sequences SY and SZ)*

The Foum el Argoub Mb yielded several fossils. Ben Youssef et al. (1985a) mention *Deshayesites callidiscus*, *D.* cf. *planus*, *D. weissi*, *Dufrenoyia furcata*, *Valdedorsella* sp. and a Cheloniceratidae, which would indicate an earliest Aptian age (Ben Youssef et al., 1985a; Ben Youssef and Peybernès, 1986; see also Abdallah et al., 1995, their Fig. 22).

In Foum el Argoub, the base of the sequence (FA 16, Fig. 10) yielded several fish remains identified as *Lepidotes* sp., *Cretodus semiplicatus* and *Scapanorhynchus* sp., as well as teeth of spinosaurid and non-spinosaurid theropods, which suggest a late Aptian or early Albian age (Cuny et al., 2010b). Near the base, in Bir Oum Ali South, we collected unidentified rudists. Higher up in the section, an association of wood fragments was determined as *Alstaettia* sp. and *Metapodocarboxylon* sp. (det. M. Philippe), which indicates a Middle Jurassic–Albian age. Finally, the base of depositional sequence SZ yielded two levels of ammonites (BOAS 12 and 13, Fig. 10). Layer BOAS 12 (Figs. 4 and 10) is equivalent to bed SOA 29 of Hfaiedh et al. (2013), that yielded a *Mellegueiceras* ammonite, interpreted as a likely ancestor of *M. chihaouiae* (Hfaiedh et al., 2013: p. 192). Among our samples, the occurrence of *Hypacanthoplites* aff. *H. plesiotypicus* (Fritel, 1906) *sensu* Casey (1965) (BOAS 12) and *Mellegueiceras chihaouiae* Latil, 2011 (BOAS 13), indicates the upper Aptian, more precisely the local *Mellegueiceras chihaouiae* zone, equivalent to the standard *Hypacanthoplites jacobi* Zone of Reboulet et al. (2018) (Latil, 2011) (Fig. 10).

### *5.3. Base of the* Knemiceras *beds (sequence SA)*

In Bir Oum Ali, the lower massive limestone bed contains numerous orbitolinids and other benthic foraminifers. Ben Youssef and Peybernès (1986) identified *Orbitolina (Mesorbitolina) parva*, *O. (M.) minuta*, *Charentia cuvillieri* and *Sabaudia minuta* in Bir Oum Ali North, and *O. (M.) minuta*, *O. (M.) texana*, *C. cuvillieri*, *Mayncina bulgarica*, *Paracoskinolina tunesiana*, *Colomiella tunesiana*, *Pseudochoffatella cuvillieri*, *Everticyclaminna hedbergi* and *Sabaudia* gr. *minuta* in the Bir Oum Ali South section. This association suggests a late Aptian age. From this lower bed, Hfaiedh et al. (2013) quoted

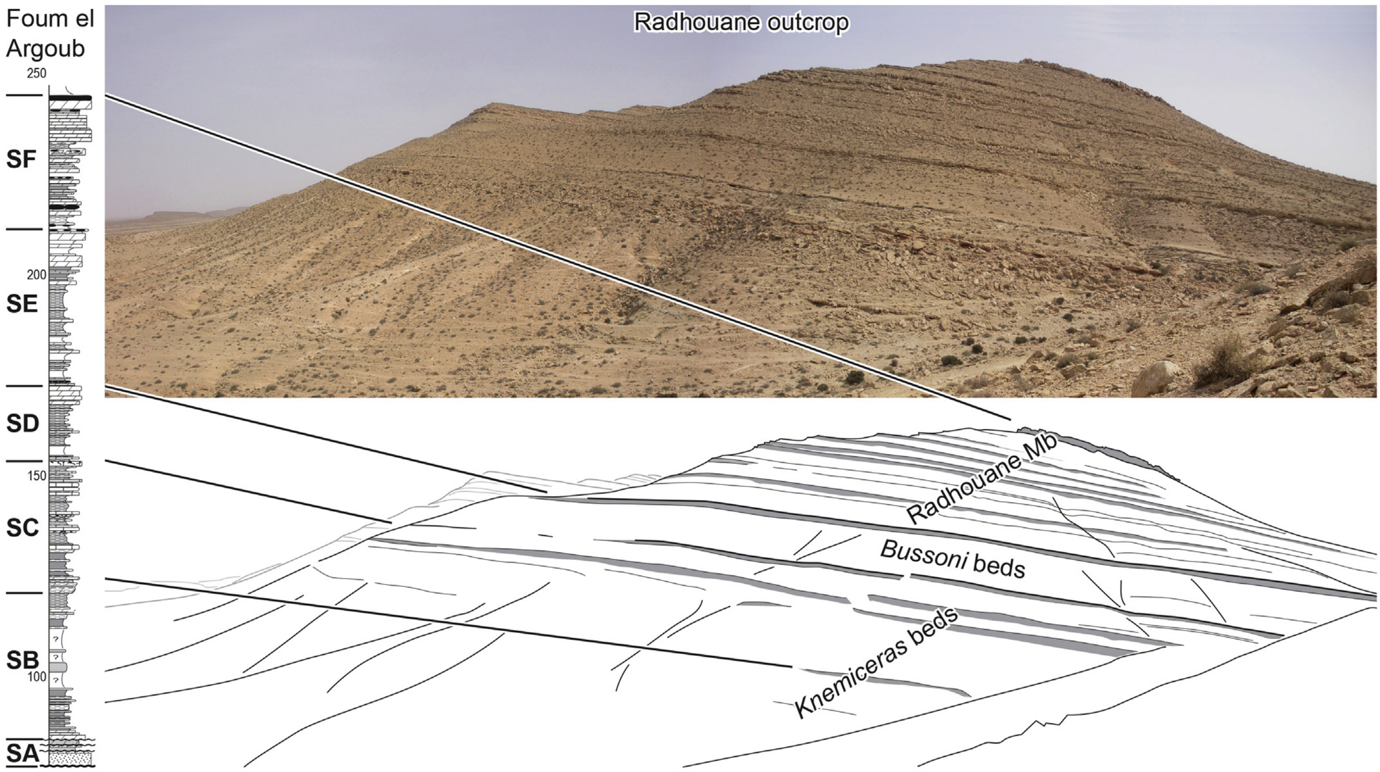


**Fig. 8.** Radhouane outcrop, and correlations with the Foum el Argoub section.

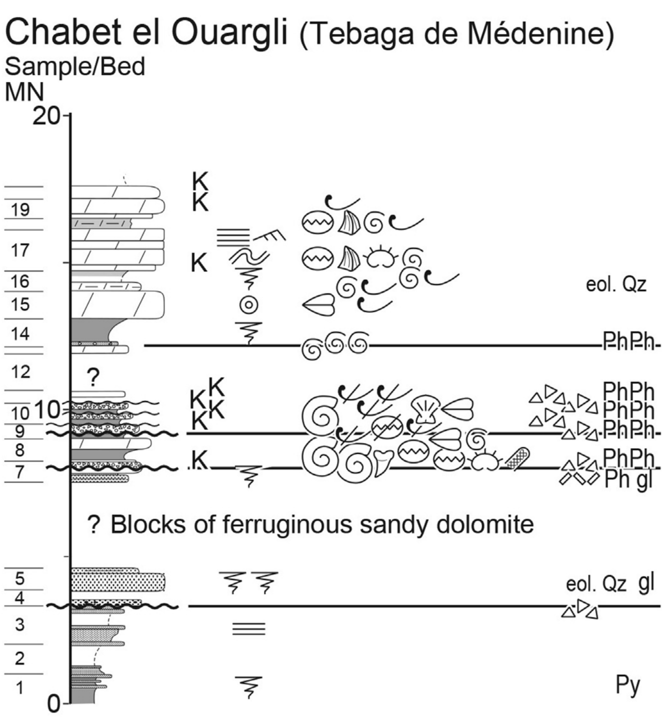


**Fig. 9.** Lithology and sedimentology of the Chabet el Ouargli section.

*Paracoskinolina tunesiana* and *Mesorbitolina pervia*, an association assigned to the late Aptian, whereas the upper massive limestone bed yielded *Mesorbitolina parva* and *Mersorbitolina texana*. According to Hfaiedh et al. (2013), this association indicates a late Aptian or early Albian age.

Although the orbitolinid fauna suggests a late Aptian age (Ben Youssef and Peybernès, 1986; Hfaiedh et al., 2013), an earliest Albian age for this interval is likely. As a matter of fact, on one hand, the major basal discontinuity of SA seems to encompass a long-lasting hiatus (see also Hfaiedh et al., 2013) that may correspond to the major sea-level drop known near the Aptian–Albian boundary (Haq, 2014; Bover-Arnal et al., 2014). On the other hand, in the Tajerouine area, a major transgressive pulse occurred at the top of the Hameima Fm (SE of Tajerouine) or at the base of the Fahdene Fm (NW of Tajerouine) during the *Mellegueiceras ouenzaensis* zone of Latil (2011), *i.e.* in the upper part of the *Leymeriella tardefurcata* zone (Chihaoui et al., 2010; Latil, 2011). This transgressive pulse may correlate with the transgression expressed by sequence SA of the present work. Finally, the presence of *"Hypacanthoplites"* aff. *"H." buloti* Latil, 2011 (Fig. 10) and a poorly preserved engonoceratid (BOA 2, Figs. 4 and 10) immediately above the fourth sequence unequivocally indicates an early (not earliest) Albian age (top of the *Leymeriella tardefurcata* standard zone, Latil, 2011).

### 5.4. *Lower part of the* Knemiceras *beds (sequence SB)*

From this sequence, Abdallah et al. (1995) quoted *Knemiceras syriacum*, *K. compressum*, *K.* cf. *gracile*, *Knemiceras* sp. and *Eopachydiscus* aff. *marcianus*. According to these authors, this assemblage indicates a late Albian age (*Mortoniceras inflatum* zone, Abdallah et al., 1995; p. 492–493). However, the occurrence of *"H"*. aff. *buloti* in the underlying sequence makes this assignment unlikely.

In the lower half of this sequence (BOA 3-5; BOAS 1-2; FA 12-14; FO 4-6; Fig. 10), we collected the main, endemic *Knemiceras* fauna of the Chotts with three distinct morphologies (work in progress) that we shall name herein *Knemiceras* sp. 1 to 3 (Fig. 10). In the

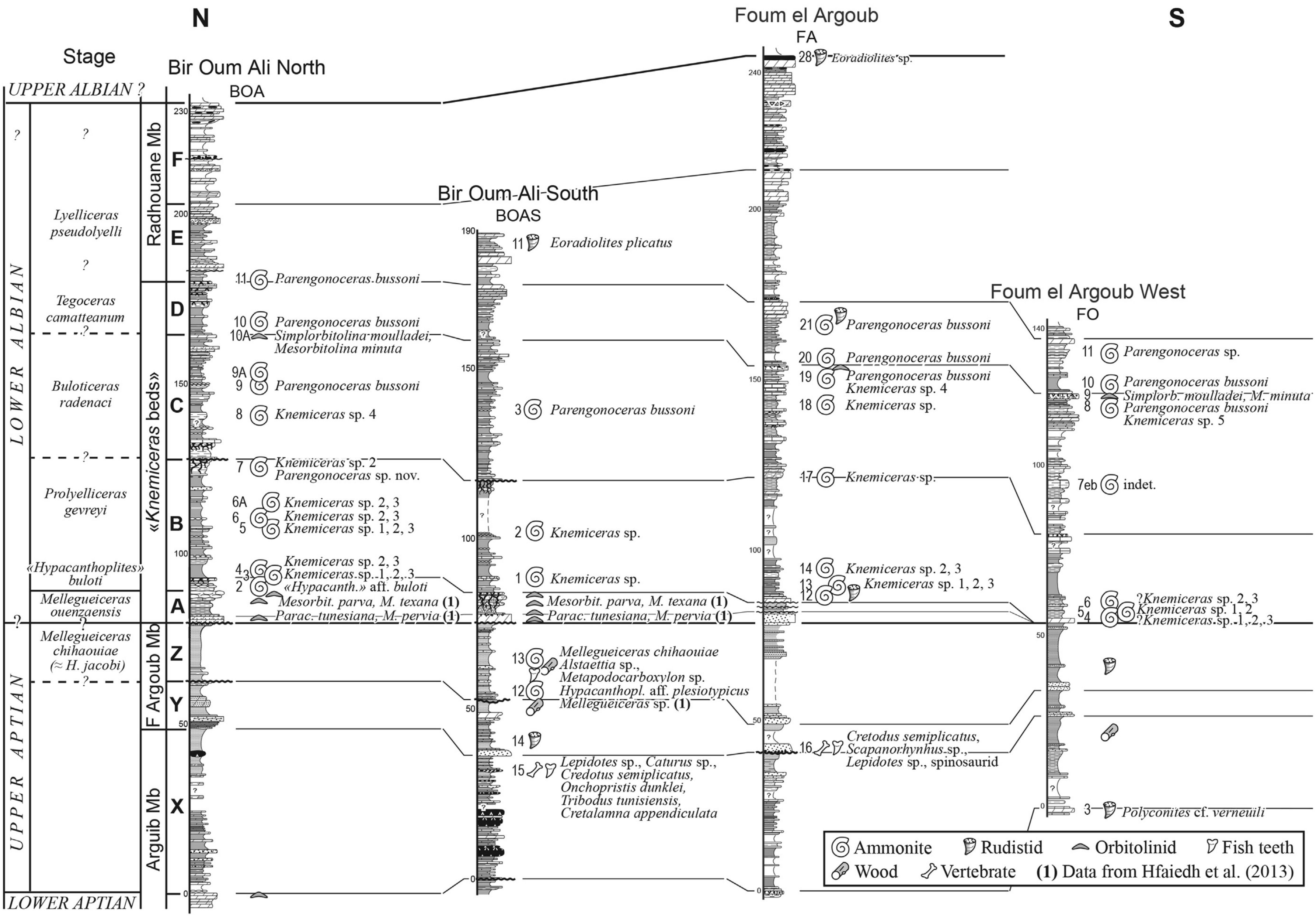


**Fig. 10.** Diagnostic faunas and correlation of the Bir Oum Ali and Foum el Argoub sections.

upper half of the sequence, the morphology *Knemiceras* sp. 1 has disappeared (under the control of ecology?), the morphology *Knemiceras* sp. 2 is rare, and the morphology *Knemiceras* sp. 3 becomes dominant. At the top of the sequence (BOA 7), a single *Parengonoceras*, a probable ancestor of *P. bussoni* is appearing (Fig. 10).

The fifth depositional sequence is correlatable with the ammonite-rich horizon of the Lower Shales (Fahdene Fm) of Chihaoui et al. (2010), the base of which is marked by the occurrence of *"Hypacanthoplites" buloti*. In this interpretation, the association of *Knemiceras* sp. 1 to 3, would correlate with part of the *"Hypacanthoplites" buloti* and more probably with the *Prolyelliceras gevreyi* zone of Latil (2011).

### 5.5. Middle part of the Knemiceras beds (sequence SC)

In the upper part of the "*Knemiceras* Beds", Abdallah et al. (1995) collected *Knemiceras syriacum*, *K. compressum*, *K. aegypticum*, *Knemiceras* sp., *Engonoceras toussainti*, *E.* aff. *saadense*, and *Parengonoceras* sp. According to these authors, the association of *Knemiceras* and *E. saadense* would indicate the latest Albian (Abdallah et al., 1995: p. 493).

The upper part of sequence SC (BOA 8-10A; BOAS 3; FA 17-19; FO 7Eb-8; Fig. 10) is characterized by a change in the *Knemiceras* fauna with the emergence of new morphologies, *Knemiceras* sp. 4, and *Knemiceras* sp. 5, and the presence of poorly preserved *Parengonoceras bussoni*. In Jebel El Hamra (Kasserine area), *P. bussoni* has been collected from upper lower Albian beds (top of the *Buloticeras radenaci* zone of Latil, 2011). Therefore, the assemblage of *Knemiceras* sp. 4 and 5, and *Parengonoceras bussoni* would be coeval with part of the *Buloticeras radenaci* zone of Latil (2011).

As mentioned before, the top of the sequence SC is marked by an orbitolinid-rich limestone bed. From this bed, Ben Youssef and Peybernès (1986) determined *"Coskinolina" (Simplorbitolina?) bronnimanni* (currently assigned to *Cribellopsis dercourti*), *Neoiraqia convexa*, *Orbitolina (Mesorbitolina) minuta*, *O. (M.) texana* and *O. (M.) leymeriei*, which would indicate the late Albian *s.l.* However, *O. (M.) minuta* is not known after the middle part of the middle Albian, whereas the first occurrence of *"C." (S.?) bronnimanni* is reported in the late Albian, and *N. convexa* is restricted to the latest Albian and Cenomanian. Because of this inconsistency, we collected several samples of this bed in the Bir Oum Ali and Foum el Argoub sections (BOA 10A and FO 9; Fig. 10). In these thin sections, one of us (M. M.) determined *O. (M.) minuta* and *"Simplorbitolina" moulladei*. The former species indicates a late Aptian to early middle Albian age, while the latter has been mentioned in Lebanon from strata ascribed to the middle Albian (Saint-Marc, 1974; Moullade and Saint-Marc, 1975; Moullade et al., 1980). Therefore, accounting for the age of the overlying sequence and the occurrence of *P. bussoni*, we assume that the determinations by Ben Youssef and Peybernès (1986) resulted from a mistake, and we propose that this unit is of late early Albian age (upper part of the *Douvilleiceras mammillatum* superzone).

### 5.6. Upper part of the Knemiceras beds (sequence SD)

From a bed probably correlative to this interval, Pons et al. (2010), mentions numerous *Eoradiolites plicatus*, they ascribed to the middle Albian, according to an updated stratigraphic framework by Moreno-Bedmar et al. (2008).

The base of the seventh sequence (top of the "*Knemiceras* Beds"; BOA 10-11; FA 20-21; FO 10-11; Fig. 10) is characterized by the occurrence of *Parengonoceras bussoni* (Figs. 7E and 10). The occurrence of *P. bussoni* allows to correlate this time interval with the top of the *Buloticeras radenaci* zone or the base of the *Tegoceras cammatteanum* zone of Latil (2011), *i.e.* a late early Albian age. *Knemiceras saharae* (Collignon, 1965) has been found by Busson (1965) at Foum el Argoub, about ten meters above the holotype of *Parengonoceras bussoni*. The enigmatic morphology of *K. saharae*, which is not a member of the genus *Knemiceras*, has not been found again.

### 5.7. Radhouane Mb (sequences SE and SF)

In the lower part of the Radhouane Mb of Jebel Torrich (50 km West of Bir Oum Ali), Abdallah et al. (1995) mentioned "three fragments of an ammonite ascribed to *Acompsoceras* sp." of early to middle Cenomanian age. However, on one hand, immediately below the Radhouane Mb, we collected *P. bussoni* of late early Albian age (BOA11, Fig. 10). On the other hand, in the lower part of this unit (BOAS 11, Fig. 10), we collected the rudist *Eoradiolites plicatus*, also known from the nearby Jebel Naïmia, the age of which has been revised as Albian *s.l.* (Pons et al., 2010). Finally, the deeply silicified top of the Radhouane Mb (FA28, Fig. 10) yielded silicified and poorly preserved *Eoradiolites* sp., which does not allow to specify the age of the Radhouane Mb.

Because in Jebel El Hamra (Kasserine area), *P. bussoni* has been collected near the boundary between *Buloticeras radenaci* and *Tegoceras camatteanum* zones of Latil (2011: Fig. 11, p. 333; uppermost part of the *Douvilleiceras mammillatum* superzone), sequences SE and SF can be ascribed to the *Tegoceras camatteanum* and *Lyelliceras pseudolyelli* standard zones, *i.e.* to the latest early Albian. Nevertheless, since no diagnostic fauna has been found in the massive limestone beds, an early middle Albian age cannot be totally ruled out for the top of Radhouane Mb.

### 5.8. Chabet el Ouargli (Tebaga de Médenine)

In this area, Ben Youssef et al. (1985b; Ben Youssef and Peybernès, 1986) quoted *Knemiceras syriacum* and *K. gracile*, which would indicate a middle (?) to late Albian age.

In the Chabet el Ouargli section, two karstified layers of phosphatic breccia yielded poorly preserved ammonites. In the lower one (MN 8, Fig. 9), poorly preserved specimens of *Knemiceras* sp. 1, 2 and 3 are associated with a probably reworked Acanthoplitinae. This association suggests a correlation with the fifth sequence of the Chott area (lower Albian, base of the *Douvilleiceras mammillatum* standard superzone). In the upper fossiliferous phosphatic bed (MN 10, Fig. 9), corroded specimens of *Knemiceras* sp. suggest a correlation with sequence SD of the Chott area (upper lower Albian). Therefore, the overlying carbonate succession correlates with the Rhadouane Mb, of probable latest early Albian age.

### 5.9. Correlations with other areas

Hfaiedh et al. (2013) proposed a sequence stratigraphy of the Aptian deposits in the Bir Oum Ali section. They distinguish two sequences within our sequence SX. Because of poor outcrops in the studied sections (Figs. 4 and 6), their interpretation is likely. Conversely, in their sequence named Unit IV, they interpreted the ammonite level as a Maximum Flooding deposit. However, our observations show that the ammonites (BOAS 12, Fig. 10) have been found in an erosional channel, interpreted here as an incised valley. As a consequence, their Unit IV can be correlated with our SX and SY sequences. In our sequence SA, Hfaiedh et al. (2013) considered the lower massive bed as a depositional sequence, since its top is locally karstified. Although this interpretation is likely, we interpret this lower bed as a transgressive minor sequence belonging to the transgressive interval of our sequence SA (see above).

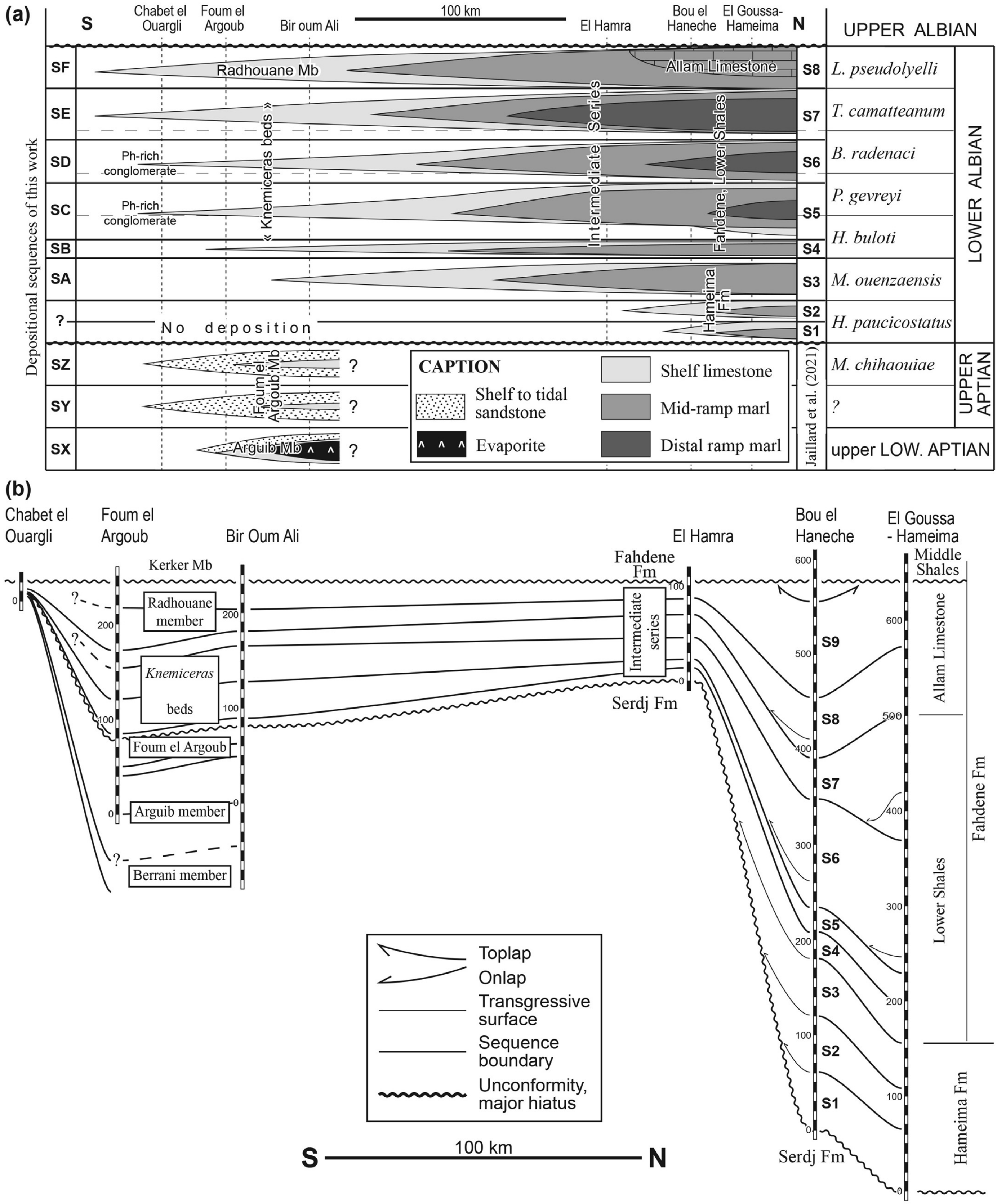


**Fig. 11.** Correlation of the Chotts area with Central Tunisia sections. (above) Chronostratigraphic correlations; (below) Correlation of sequences and sedimentary units.

In northern Central Tunisia, Ben Chaabane et al. (2019, 2021) revised the biostratigraphy and sequence stratigraphy of the mainly Aptian Serdj Fm, previously studied by Tlatli (1980) and Heldt et al. (2010). In the uppermost, transgressive part of the Lower Serdj Fm, they mention *M. chihaouiae*, as well as Acanthoplitinae (Ben Chaabane et al., 2019). Thus, this sequence (TA of Ben Chaabane et al., 2021) can be correlated with our SZ (upper part of the Foum el Argoub Fm). Consequently, our sequences SX and SY may correlate with part of the lower part of the Lower Serdj Fm, possibly the sequences bounded by Sb3 and Sb4 in Ben Chaabane et al. (2021).

In Central Tunisia, Jaillard et al. (2021) proposed a sequence stratigraphic framework of the lower Albian deposits, based on ammonite biostratigraphy (Latil, 2011). Our biostratigraphic data on the Chott area allow to propose the following correlations for the Albian sequences (Fig. 11).

In the Tajerouine area, a major transgressive pulse occurred during the *Mellegueiceras ouenzaensis* zone of Latil (2011). We suggest that SA of the Chott area correlates with this transgression, *i.e.*, with sequence S3 of Jaillard et al. (2021). As a matter of fact, SA and S3 are both immediately overlain by *"H." buloti*. In Central Tunisia, these early transgressions are followed by the deposition of three sequences (S4 to S6 of Jaillard et al., 2021), which correlates with sequence SB to SD of the Chott area.

Because in Jebel El Hamara, the base of S6 yielded *P. bussoni*, we propose that the Radhouane Mb (sequences SE and SF) correlates with the Allam Limestone of the Tajerouine area (sequences S7 and S8 of Jaillard et al., 2021). As a matter of fact, the top of the Allam Mb of Central Tunisia (Burollet, 1956) is marked by a major discontinuity of middle Albian age (Chihaoui et al., 2010; Latil, 2011). Since no major unconformity has been observed in the Rhadouane Mb, we correlate the major discontinuity that caps the Rhadouane Mb with the middle Albian discontinuity of Central Tunisia. Nevertheless, as mentioned by Chihaoui et al. (2010), an early middle Albian age cannot be totally ruled out for the top of both the Allam and Radhouane Mbs.

In the Saharan Atlas of Central Algeria (Bou Saâda area), Emberger (1960) described the Albian succession as follows, from base to top: (1) variegated sands and shales, (2) marl and dolomite capped by massive limestone with *Coskinolina* sp., (3) marl, limestone and coquinas with *Knemiceras* sp., (4) massive limestone and dolomite beds with *Strombus* sp., *Nerinea* sp., *Ostrea* sp., capped by a corroded surface and a ferruginous hard-ground, and (5) a thick series of marl and thin bedded limestone, the base of which yielded, among others, *Dipoloceras cristatum*, *Venezoliceras* gr. *usminensis*, *"Knemiceras" uhligi*, *Deiradoceras cunningtoni*, which unequivocally indicate an earliest late Albian age.

Units (1) and (2) are difficult to correlate with the studied sections, and may be lacking in southern Tunisia. However, unit (3) most probably correlates with the "*Knemiceras* beds", and unit (4) with the Radhouane Mb of the Chott area, which presents the same carbonate shelf facies and fauna. Therefore, the corroded and ferruginous hardground at the top of unit (4) is correlated with the major discontinuity observed at the top of the Radhouane Mb, interpreted here as encompassing most of the middle Albian. The earliest late Albian fauna mentioned by Emberger (1960) above this surface supports this interpretation.

## 6. Evolution of the Chott area in late Aptian–early Albian times

### 6.1. Sedimentary evolution

The lower Aptian, oligotrophic carbonate platform (Berrani Mb), is followed (lower part of Arguib Mb) by algal- and orbitolinid-rich calcareous deposits (Ben Youssef and Peybernès, 1986), which suggests that the Late Aptian transgression was associated with an increased nutrient influx, as suggested by Heldt et al. (2010) in northern Central Tunisia. The upper part of the Arguib Mb is then marked by evaporitic and clastic, very shallow marine deposits, which suggest more arid conditions during the Late Aptian in this area (Godet et al., 2014), and possibly a warmer climate, as also proposed by Heldt et al. (2010). The latter authors proposed that a warmer climate would have accelerated the water cycle, thus explaining the increased terrigenous clastic influx. Note that the appearance of significant clastic supply is known in other Late Aptian series of Central Tunisia (*e.g.* Jebel Jediri, Raddadi, 2005; Jebel Serdj, Heldt et al., 2010; Ben Chaabane et al., 2019). Whatever the case, the Late Aptian interval (Upper Arguib and Foum el Argoub Mbs) seem to include at least three maximum flooding surfaces, at the base of the evaporites and in the lowermost and middle part of the Foum el Argoub Mb, respectively.

The "Albian transgression" began close to the Aptian–Albian boundary, with a first transgressive pulse, recorded by sequence SA, which illustrates the reinstallation of a carbonate platform environment. This sequence seems to have been only deposited or preserved in paleo-depressions, since it lacks in the Foum el Argoub West and Tebaga de Médenine sections (Figs. 6 and 9). Additionally, it overlies a thick alteration horizon, which suggests a long-lasting sedimentary hiatus that likely corresponds to the drastic sea level drop recorded close to the Aptian–Albian boundary (Haq, 2014; Bover-Arnal et al., 2014; Jaillard et al., 2019).

The Albian transgression reached its maximum with sequences SB and SC (*Douvilleiceras mammillatum* superzone), which represent the deepest depositional environments of the whole succession. Environment remained mesotrophic, but the clastic supply decreased notably, and energy of deposition remained low. During deposition of sequence SC, mesotrophic conditions prevailed, and clastic supply increased, allowing the development of large accumulations of filtering organisms (oysters, plicatulids). However, compared to sequence SB, depositional environments seem to have been slightly shallower, and storm deposits and oolitic limestone are more abundant, suggesting higher energy of deposition.

The depositional sequence SD is a classical transgressive-regressive sequence, marked by a noticeable decrease of terrigenous clastic supply. This allowed the development, in its upper part, of an oligotrophic, very shallow marine carbonate shelf, as indicated by oolites and algal mats.

In the Radhouane Mb (sequences SE and SF), the abundance of tidal microbialites and the scarcity of macrofauna suggest a restricted, confined, very shallow marine, and low energy environment. Note that the coeval Allam Limestones of northern Central Tunisia have been interpreted as dysoxic deposits and a potential source rock (Ben Fahdel et al., 2011; Khalifa et al., 2018; Jaillard et al., 2021). The top of sequence SF (top of Radhouane Mb) is marked by a major sedimentary hiatus, which most probably encompasses most of the middle Albian period, and probably part of the late Albian, if the Cenomanian age of the overlying marls (Abdallah et al., 1995) is confirmed. This hiatus is probably associated with significant erosions of the Radhouane Mb in the Bir Oum Ali area.

### 6.2. Synsedimentary tectonics

The depositional sequences SX and SY are usually poorly exposed, and no reliable observations could be made regarding synsedimentary tectonic activity. Note, however, that Abbes and Tlig (1991) and Hfaiedh et al. (2013) mentioned significant thickness variations in the Arguib and Foum el Argoub Mbs of the Tebaga de Kebili area, which is consistent with our observations, since the measured thickness of the Foum el Argoub Mb varies from 25 to 40 m, according to the sections (Figs. 4 and 6).

The first noticeable manifestation of tectonic activity is post-dated by the sequence SD. In Bir Oum Ali North, the latter sequence overlies either the top of the ammonite-bearing sequence SC to the West, or the base of the same sequence to the East, thus evidencing a fault offset of 20–30 m. This fault play occurred after deposition of sequence SC, and before deposition of sequence SD, *i.e.* during the early Albian (*Buloticeras radenaci* zone of Latil, 2011). Farther Northeast, in a more mobile zone, Louhaichi and Tlig (1993) mentioned intense tectonic activity during the deposition of the "*Knemiceras* beds", marked by unconformities, thick slumped intervals, sharp thickness variations and normal faulting.

The Radhouane Mb is marked by numerous features suggesting tectonic instability. As already observed by Abbes and Tlig (1991), synsedimentary monogenic breccias, erosional surfaces and small-scale unconformities are common. In Bir Oum Ali North, local unconformities related to slumps are observed, and a conglomerate includes clasts of cherts (Fig. 4), thus indicating that silicification occurred during early diagenesis. This tectonic activity may have culminated with the major hiatus that occurred at the end of the early Albian. The latter seems to be due to a large-scale, long lasting emergence of the area, as testified by significant erosions in the studied area, by unconformities between the Radhouane Mb and the overlying Kerker Mb (Abbes and Tlig, 1991), and by locally thick fluvial conglomerates and red paleosoils, which overly the Radhouane Mb, Northeast of the studied area (Louhaichi and Tlig, 1993).

## 7. Systematic paleontology

### 7.1. Ammonites

Dimensions are given in millimetres: D = diameter; Wb = whorl breadth; Wh = whorl height; U = umbilicus; dc = distance between two successive ventrolateral tubercles; dc/H = ventrolateral tubercles density. Figures in parentheses are dimensions as a percentage of the diameter.

The repository of all specimens is UJF-ID: ISTerre, Université Grenoble Alpes, ex Institut Dolomieu collections.

Order: Ammonoidea Zittel, 1884
Suborder: Ammonitina Hyatt, 1889
Superfamily Engonoceratoidea Hyatt, 1900
Family Knemiceratidae Hyatt, 1903

Genus *Knemiceras* Böhm, 1898
[= *Iranoknemiceras* Collignon, 1981 (p. 258, type species *Knemiceras uhligi* (Choffat) var. *douvillei* Basse, 1940, p. 431, by original designation]
Type species: *Ammonites syriacus* Buch, 1850, p. 20, by the original designation of Böhm, 1898, p. 200.

***Knemiceras* sp. 1**
Fig. 12G, H

*Description.* D. 90.0 – Wh: 43 (0.48) – Wb: 39 (0.43) – U: 19 (0.21) – Wb/Wh: 0.91 – dc/Wh; 0.30
UJF-ID.15104, from BOA.5, is a juvenile with a 180° sector of body chamber (Fig. 12G, H). It has a discoidal coiling, with narrow, deep, funnel shaped umbilicus. The whorl section is moderately depressed, subtrapezoidal, with a maximum of width slightly above the umbilical edge, feebly convex flanks, and a broad, flat venter. There are six strong, conical, peri-umbilical tubercles, from which arise low, coarse, broad, radial to feebly prorsiradiate primary ribs that are visible mainly on the inner third of the flanks. Almost inconspicuous, coarse intercalatory ribs occur, one or two between two primaries arising just above the umbilical edge or at mid-flanks. All the ribs end with strong, spirally elongated ventrolateral clavi (dc/Wh at about 0.30) that are opposite on the venter. Supplementary material is currently being investigated.
*Occurrence.* Beds BOA.3 et 5; FA.13; FO.4,5, most probably the *Prolyelliceras gevreyi* Zone, lower Albian.

***Knemiceras* sp. 2**
Fig. 13A-C

*Description.* D. 140.0 – Wh: 73 (0.52) – Wb: 40 (0.29) – U: 19.5 (0.14) – Wb/Wh: 0.55 – dc/Wh; 0.16
UJF-ID.15105, from BOA.5, is an adult with a 90° sector of body chamber (Fig. 13A-C). It has a discoidal, involute coiling (U/D = 0.14), with narrow, deep umbilicus. The whorl section is compressed, subtrapezoidal, with a maximum of width at the inner third of the flanks, feebly convex flanks, and a narrow, flat venter. There are ten small, peri-umbilical bullae that give rise to inconspicuous, coarse primary ribs. Rather strong, conical, inner lateral tubercles are visible. There are no visible intercalatories. Numerous, small, spirally elongated ventrolateral clavi (dc/Wh at about 0.14) are opposite on the venter. On the inner part of the body chamber, the venter becomes feebly convex, and the ventrolateral clavi tend to disappear. Supplementary material is currently being investigated.
*Occurrence.* BOA. 3-7; FA.13, 14; FO.5, ?6, most probably the *Prolyelliceras gevreyi* Zone, lower Albian.

***Knemiceras* sp. 3**
Fig. 14A-C

*Description.* D. 87.0 – Wh: 45 (0.52) – Wb: 26 (0.30) – U: 10 (0.12) – Wb/Wh: 0.58 – dc/Wh; 0.16
UJF-ID.15103, from BOA.5, is an adult with a 90° sector of body chamber (Fig. 14A-C). It has a discoidal, involute coiling (U/D = 0.12), with narrow, funnel-shaped deep umbilicus. The whorl section is compressed, subtrapezoidal, with a maximum width at about mid-flanks, convex flanks, and a narrow, flat venter. There are small, peri-umbilical bullae on the juvenile that disappear early. The flanks are smooth, and there are numerous, small, spirally elongated ventrolateral clavi (dc/Wh at about 0.16) that are opposite on the venter. The venter is flat and very narrow. On the inner part of the body chamber, the ventrolateral clavi tend to disappear. Supplementary material is currently being investigated.
*Occurrence.* BOA.3-6; FA.13, most probably from the *Prolyelliceras gevreyi* Zone, lower Albian.

***Knemiceras* sp. 4**
Fig. 15A, B

*Description.* D. 87.0 – Wh: 45 (0.52) – Wb: 26 (0.30) – U: 10 (0.12) – Wb/Wh: 0.58 – dc/Wh; 0.16
UJF-ID.15107, from BOA.8, is a fragment of a phragmocone (Fig. 15A, B), 56 mm in diameter. It has a discoidal, involute coiling, with narrow, deep umbilicus. The whorl section is compressed, subtrapezoidal, with a maximum of width at the inner third of the flanks, feebly convex flanks, and a relatively broad, flat venter. There are strong, radially elongated periumbilical tubercles that give rise to coarse primary ribs, bearing small conical outer lateral tubercles and strong club-shaped ventrolateral clavi, which are opposite on the venter. There are generally two intercalatories between two primaries, arising at about mid-flanks. The ventrolateral tubercles density is low (dc/Wh at about 0.36). The venter is flat to feebly convex and moderately broad.
*Occurrence.* BOA.8; FA.19, *Buloticeras radenaci* Zone, lower Albian.

***Knemiceras* sp. 5**
Fig. 15C-F

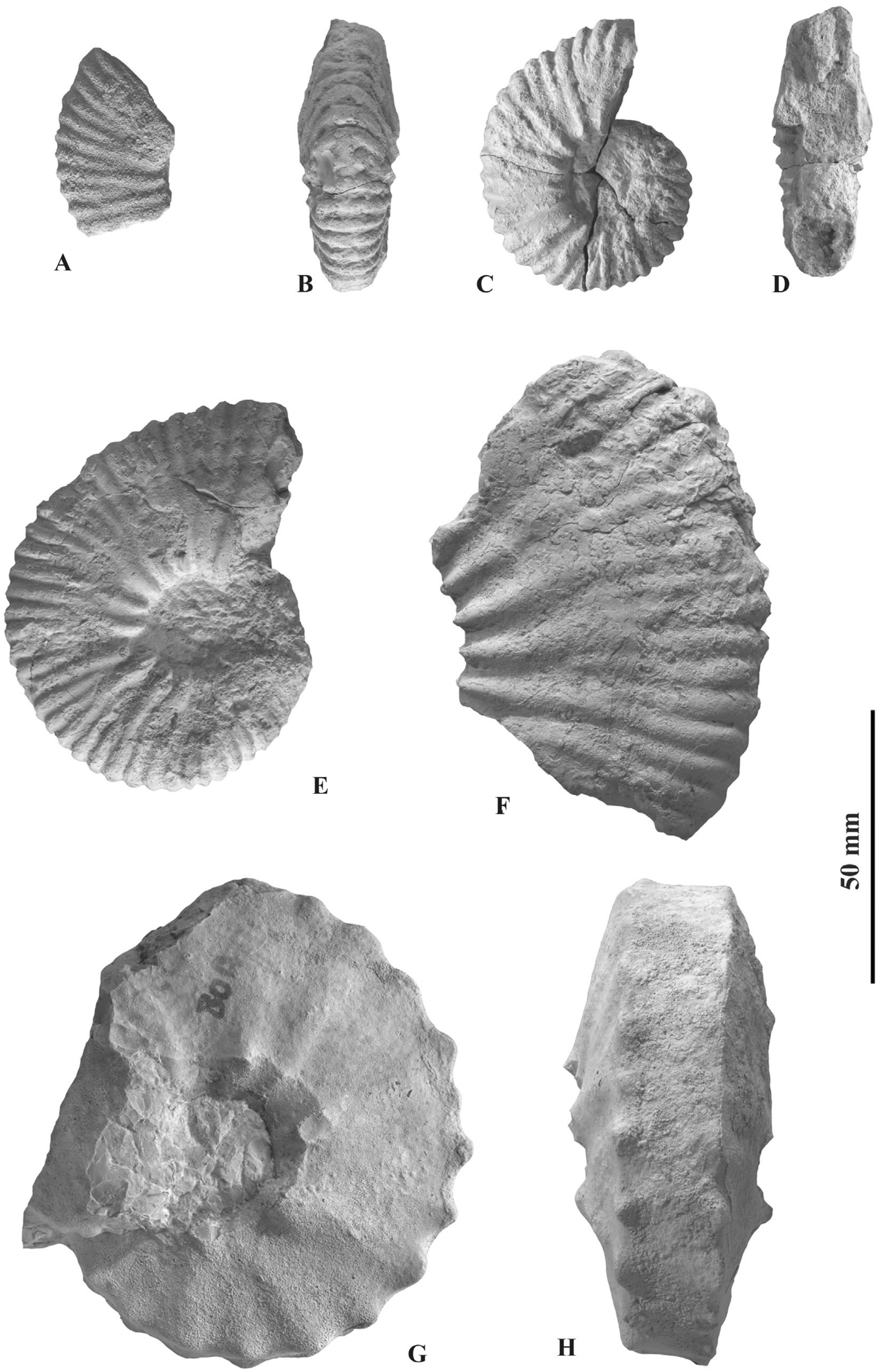


**Fig. 12.** (A) '*Hypacanthoplites*' sp. indet., UJF-ID.15100, from BOAS.12; (B–D) *Hypacanthoplites* aff. *H. plesiotypicus* (Fritel, 1906) *sensu* Casey (1965), non Fritel (1906), UJF-ID.15099, from BOAS.12; (E, F) *Mellegueiceras chihaouiae* Latil, 2011, (E) UJF-ID.15101, from BOAS.13; (F), UJF-ID.15102, from BOAS.13; (G, H) *Knemiceras* sp. 1, UJF-ID.15104, from BOA.5. Scale bar is 50 mm.

*Description.* D. 87.0 – Wh: 45 (0.52) – Wb: 26 (0.30) – U: 10 (0.12) – Wb/Wh: 0.58 – dc/Wh; 0.16
UJF-ID.15109, from F0.8 (Fig. 15C, D), and UJF-ID.15113, loose from the same section (Fig. 15E, F). These are juvenile phragmocones, 20 and 25 mm in diameter. The shell is discoidal, involute, with narrow umbilicus. The whorl section is compressed, subtrapezoidal, with a maximum of width at the inner third of the flanks, feebly convex flanks, and a moderately broad, flat venter. There are 5 strong, conical periumbilical tubercles that give rise to coarse, broad, prorsiradiate, convex, primary ribs, bearing strong, spirally elongated ventrolateral clavi, which are opposite on the venter. There is an intercalatory rib between two primaries, arising on the inner third of the flanks and tending to be branched to the primary. All ribs cross the venter without interruption. The ventrolateral tubercles density is low (dc/Wh at about 0.43).
*Occurrence.* FO.18 of Bir oum Ali, *Buloticeras radenaci* Zone, lower Albian.

Genus *Parengonoceras* Spath, 1924
[= *Platiknemiceras* Bataller, 1954. Type species, *Knemiceras* (*Platiknemiceras*) *bassei* Bataller, 1954, p. 175, by original designation; *Platyknemiceras* Bataller, 1959, p. 65, nom. null.]
Type species: *Amaltheus ebrayi* de Loriol, 1882, p. 7, by original designation by Spath, 1924, p. 508. Robert (2002, p. 100) selected the specimen figured by de Loriol (1882, pl. 1: MHNG.035492, Ebray collection) as lectotype (Pl. III, fig. 1-4). The species was revised by Latil (2008).

***Parengonoceras*** sp. indet.
Figs. 14D, E, 16A

*Description.* D. 120.0 – Wh: 61 (0.51) – Wb: 32 (0.27) – U: 15 (0.13) – Wb/Wh: 0.52
The specimen UJF-ID.15106, from BOA.7 (Figs. 14D, E, 16A), is an adult, about 140 mm in diameter, comprising a 180° sector of body chamber. The shell is discoidal, involute (U/D = 0.13), with shallow umbilicus, and convex umbilical wall. The whorl section is compressed, elliptical, with a maximum of width at about mid-flanks, convex flanks, and a narrow, flat venter, which becomes convex on the body chamber. There are 8, small, conical periumbilical tubercles that give rise to almost inconspicuous, low, coarse, radiate, primary ribs. Intercalatories may exist, arising at about mid-flanks. Numerous, spirally elongated ventrolateral clavi are alternating on the venter of the phragmocone and tend to disappear on the body chamber. There is an intercalatory rib between two primaries, arising on the inner third of the flanks and tending to be branched to the primary. All ribs cross the venter without interruption. The ventrolateral tubercles density is high on the phragmocone (dc/Wh at about 0.16).
*Occurrence.* Bed BOA.7 of Bir Oum Ali, most probably at the transition of the *Prolyelliceras gevreyi* and *Buloticeras radenaci* Zones, lower Albian.

***Parengonoceras bussoni*** Collignon, 1965
Figs 15G, H, 16C-E

1965. *Parengonocera bussoni* Collignon, p. 6, pl. A, fig. 1.
2011. *Parengonoceras bussoni* Collignon, Latil, p. 353, figs 27, 28; Pl. 6, figs 1, 2.

*Description.* UJF-ID.15111, from BOA.10 (Fig. 15H), UJF-ID.15110, from BOA.10 (Fig. 15G), and UJF-ID.15108, loose in FO.8 (Fig. 16C-E). The three fragments herein figured are characteristic of the species, as described by Latil (2011, p. 353). The smaller one (Fig. 16C-E) has been collected in the type locality and shows the juvenile growth stages. Supplementary material is currently being investigated and will allow a better knowledge of the ontogeny of the species.

*Occurrence.* Beds BOAS.3, BOA.9 to 11, FA.19-21, FA.8 and 10, and '*bussoni* beds' of Rhadouane outcrop, upper part of the *Buloticeras radenaci* Zone and *Tegoceras camatteanum* Zone, lower Albian.

Suborder Ancyloceratina Wiedmann, 1966
Superfamily: Acanthohoplitoidea Stoyanow, 1949
Family: Acantohoplitidae Stoyanow, 1949
Subfamily: Acantohoplitinae Stoyanow, 1949
See Latil and Robert (2019) for discussion.

Genus *Hypacanthoplites* Spath, 1923
Type species: *Acanthoceras milletianum* (Orbigny) var. *plesiotypica* Fritel, 1906, by the original designation of Spath, 1923, p. 64.

*Hypacanthoplites* aff. *H. plesiotypicus* (Fritel, 1906) *sensu* Casey (1965), non Fritel (1906)
Fig. 12B-D

**Comparison**
1965. *Hypacanthoplites plesiotypicus* (Fritel), Casey, p. 423, text-fig. 155.

*Material and description.* UJF-ID.15099: a juvenile phragmocone, 50 mm in diameter, preserved as a calcareous internal mould, from BOAS.12.
D. 45.0 – Wh: 20 (0.44) – Wb: 17 (0.38) – U: 14 (0.31) – Wb/Wh: 0.85 – dc/Wh; 0.14
The inner whorls, prior to a diameter of 20 mm, are not preserved. The coiling is moderately involute (U/D = 0.31). The umbilical wall is almost vertical and moderately deep, the umbilical edge is narrowly rounded. The whorl section is higher than broad, rectangular with a maximum of width at mid-flanks, becoming subtetragonal, with a maximum of width at the inner third of the flanks. The flanks are slightly convex, converging to a narrow, convex venter. The ribbing is moderately dense (dc/Wh = 0.14). The primary ribs are straight and radial, arising on the umbilical wall, strengthening at the periumbilical edge, developing tiny, but distinct, radially elongated tubercle. They bifurcate at mid-flank from a small, conical tubercle which tend to disappear at a diameter of 45 mm. Intercalatory ribs may occur, arising at about mid-flank. All the ribs cross the venter radially and are somewhat angular at the ventrolateral shoulders, due to an elevation of the ribs, without any trace of ventrolateral tubercles. The ribs are as wide as the intercostal spaces. The venter is slightly convex.
*Remarks.* Among the hundreds of acanthohoplitinids we collected from the uppermost Aptian and earliest Albian of Tunisia, this is the second specimen that can be assigned to the genus *Hypacanthoplites* as defined by Wright et al. (1996) (see Latil, 2011). Our specimen differs from *H. clavatus* (Fritel, 1906) by its less dense and more rigid ribbing, the lack of ventrolateral tubercles and by its less pronounced tuberculation at the same size. It differs from *H. plesiotypicus* (Fritel, 1906) = *H. jacobi* (Collet, 1907), by its persisting lateral tuberculation, the lack of ventrolateral tubercles and a less dense and more rigid ribbing.
*Occurrence.* Bed BOAS.12 of Bir oum Ali, Tunisia, *Hypacanthoplites jacobi* Zone.

**Genus '*Hypacanthoplites*'**
Acanthohoplitinae with regular ribbing, no tuberculation, convex venter excepted occasionally on the very young stages, lacking the juvenile *Hypacanthoplites* growth stages, and thus inconsistent with the diagnosis of the genus are herein provisionally placed within the genus '*Hypacanthoplites*'.

**'*Hypacanthoplites*' sp. indet.**
Fig. 12A

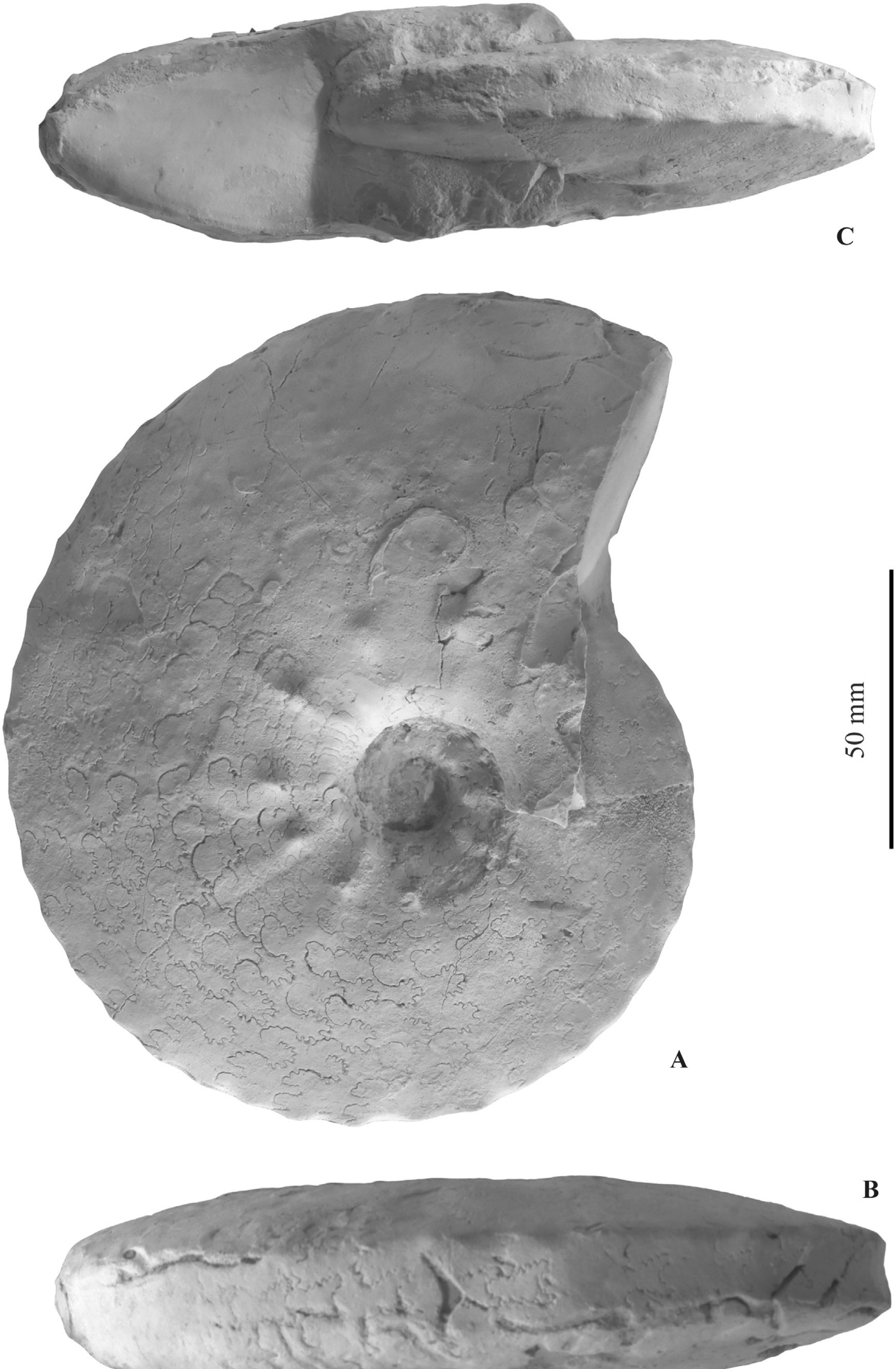


**Fig. 13.** (A–C) *Knemiceras* sp. 2, UJF-ID.15105, from BOA.5. Scale bar is 50 mm.

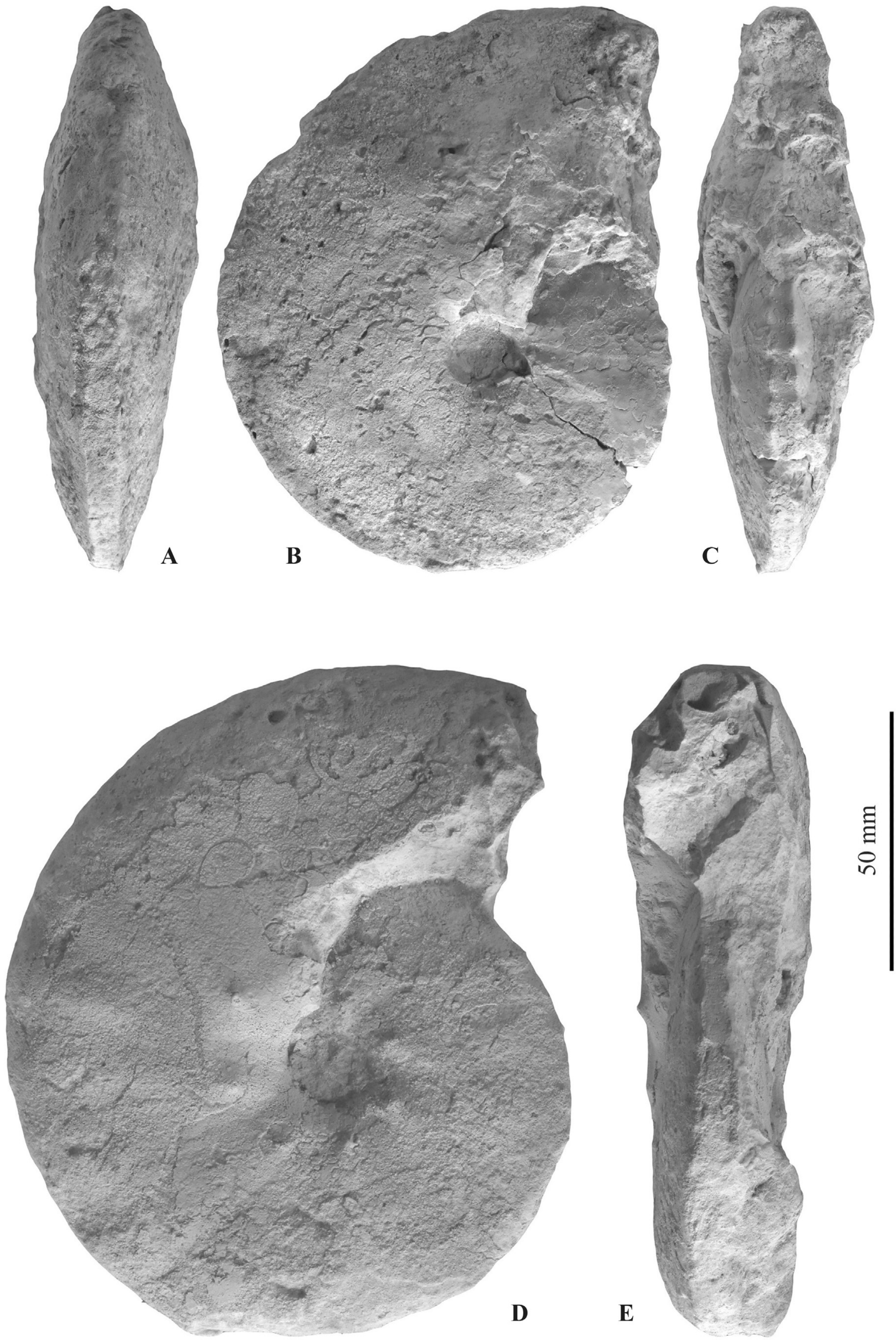


**Fig. 14.** (A–C) *Knemiceras* sp. 3, UJF-ID.15103, from BOA.5; (D, E) *Parengonoceras* sp. indet., UJF-ID.15106, from Bed BOA.7. Scale bar is 50 mm.

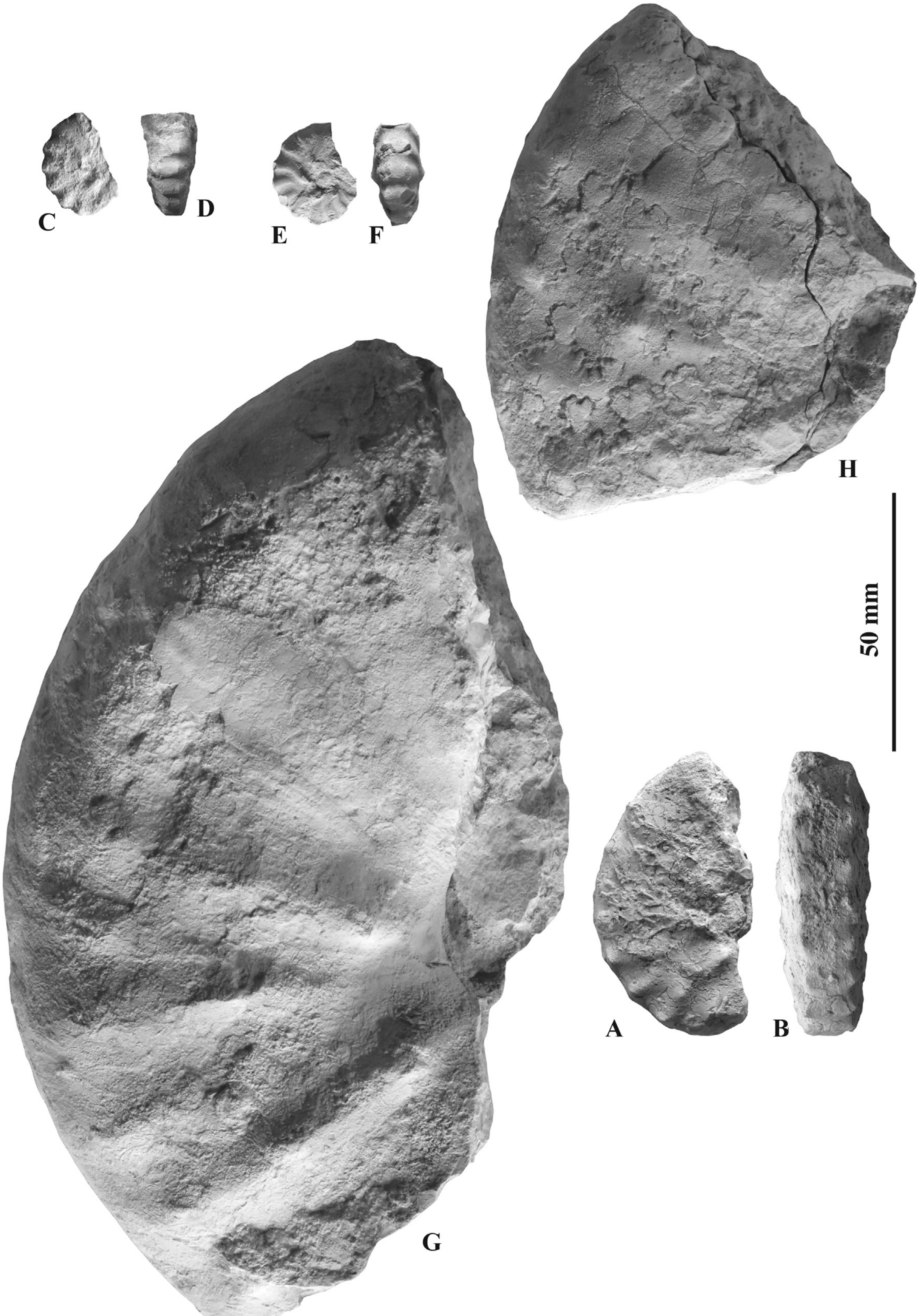


**Fig. 15.** (A, B) *Knemiceras* sp.4, UJF-ID.15107, from BOA.8; (C–F) *Knemiceras* sp.5, (C, D) UJF-ID.15113, loose from FO, (E, F) UJF-ID.15109, from F0.8; (G, H) *Parengonoceras bussoni* Collignon, 1965, (G) UJF-ID.15110, from BOA.10, (H) UJF-ID.15111, from BOA.10. Scale bar is 50 mm.

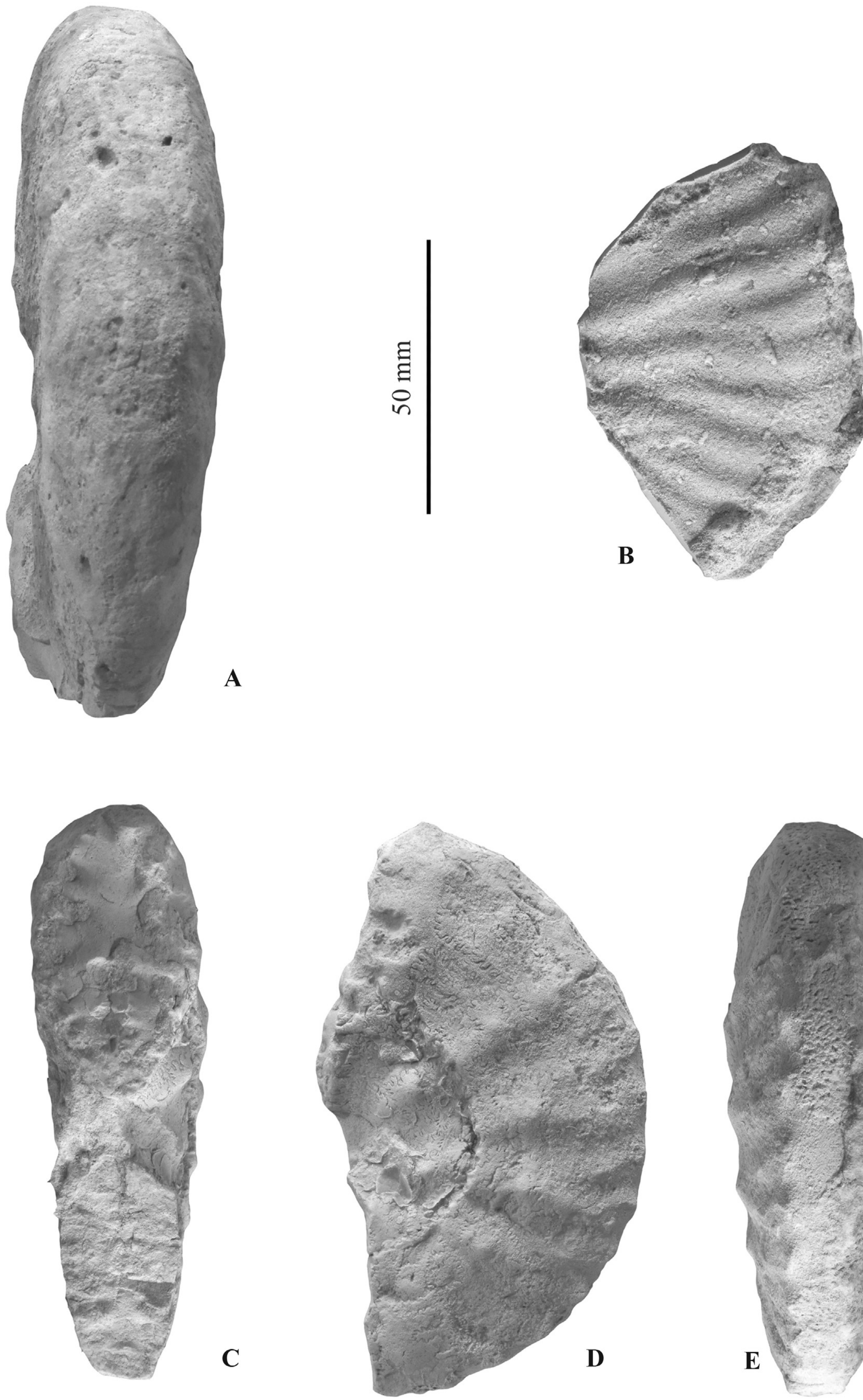


**Fig. 16.** (A) *Parengonoceras* sp. indet., UJF-ID.15106, from Bed BOA.7; (B) '*Hypacanthoplites*' aff. '*H.*' *buloti* Latil, 2011, UJF-ID.15112, from BOA.2; (C–E) *Parengonoceras bussoni* Collignon, 1965, UJF-ID.15108, loose in FO.8. Scale bar is 50 mm.

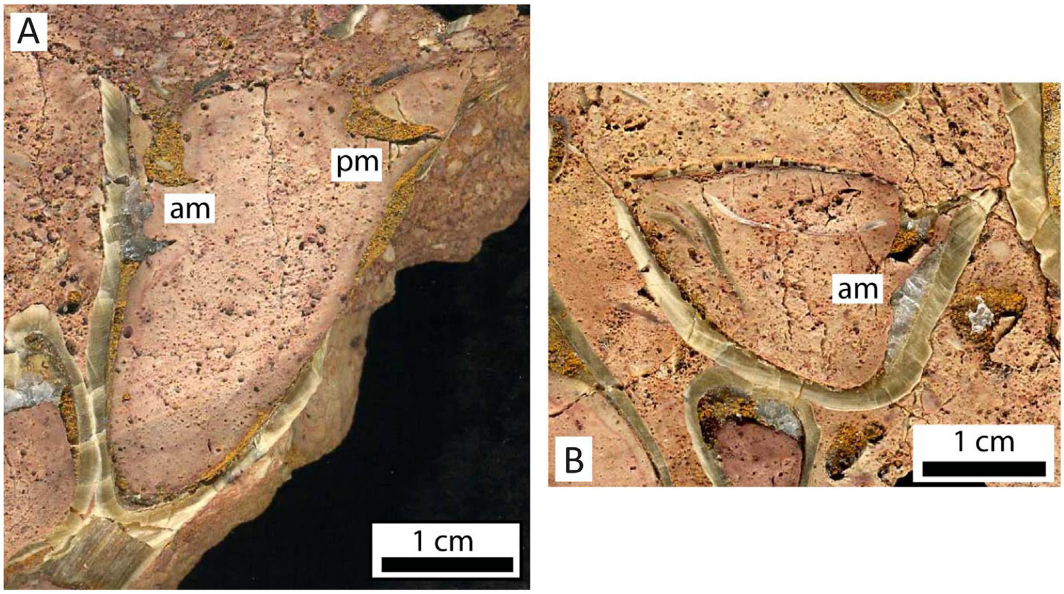


**Fig. 17.** *Polyconites* cf. *verneuili* (10 FO 3-2, Foum El Argoub). A- Antero-posterior section of a bivalve specimen showing the overall triangular shell habit and the myophores of the LV: am-anterior myophoral plate, pm-posterior myophoral plate with a L shape; notice the inward sloping myophores of the opposite valve; the inner shell layer has been leached and the corresponding cavity filled with a yellow brown matrix; B- antero-posterior oblique, mostly ventral, section of a bivalve specimen, showing the anterior myophoral plate (am) and the slightly convex shape of the LV. On both sections the outer shell layer is well preserved. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article).

*Material and description.* UJF-ID.15100: a fragment of a juvenile phragmocone, 38 mm long, preserved as a calcareous internal mould, from BOAS.12 (Fig. 12A).

The umbilical wall poorly preserved. The whorl section is subtetragonal, compressed (Wb/Wh = 0.80) with a maximum of width at the inner third of the flanks. The flanks are slightly convex, converging to a narrow, convex venter. The ribbing is moderately dense (dc/Wh = 0.18). The primary ribs arise at or below the periumbilical shoulder, and are straight and radial to slightly prorsiradiate. Between two primaries, there are generally one, sometimes two, intercalatory ribs, arising at about mid-flank or lower. All the ribs cross the venter radially.

*Remarks.* This specimen differs from *Hypacanthoplites* cf. *H. plesiotypicus* (Fritel, 1906), described above, by its more flattened flanks, broader venter, lack of tuberculation and less prominent ribs. It differs from *'H.' paucicostatus* (Breistroffer, 1953) by its straight ribs and the lack of any kind of swelling/raising of the ribs at periumbilical edge and at ventrolateral shoulders.

*Occurrence.* Bed BOAS.12 of Bir oum Ali, Tunisia, close to the Aptian–Albian transition, *Hypacanthoplites jacobi* Zone, upper Aptian.

**'*Hypacanthoplites*' aff. '*H.' buloti*** Latil, 2011
Fig. 16B

### Comparison

2011 '*Hypacanthoplites*' *buloti* Latil, p. 377, figs 41, 42; pl. 22, figs 1-26; pl. 23, figs. 1-5; pl. 23, fig. 1.

2013 *Hypacanthoplites? buloti* Latil; Klein and Bogdanova, p. 185.

*Material and description*. UJF-ID.15112: a poorly preserved fragment of an imprint, 75 mm long, with a maximum whorl-height of 55 mm, from BOA.2 (Fig. 16B).

The umbilical wall is not preserved. The flanks are weathered, showing only the basal part of the ribs, which are regularly alternating, one primary for one intercalatory. The ribs are coarse, broad, slightly flexuous, the intercalatories arising at about mid-flanks or lower. This specimen, with its broad ribs on the ventral area, is very close to *'H.' buloti*.

*Occurrence.* Bed BOA.2 of Bir oum Ali, Tunisia, '*Hypacanthoplites*' *buloti* Zone, lower Albian.

Genus *Mellegueiceras* Latil, 2011

Type species: *Mellegueiceras ouenzaensis* (Breistoffer in Dubourdieu, 1953, p.13, pl. 1 fig. 1-6), by the original designation of Latil, 2011, p. 371.

***Mellegueiceras chihaouiae*** Latil, 2011
Fig. 12F

2011 *Mellegueiceras chihaouiae* Latil, p. 371, pl. 10, fig. 1, pl. 11, figs 1-4, pl. 12, figs 1-5.

2013 *Mellegueiceras chihaouiae* Latil; Klein and Bogdanova, p. 209.

2019 *Mellegueiceras chihaouiae* Latil; Latil and Robert, p. 588, F6, Fig. 9B.

*Material and description.* UJF-ID.15102 from BOAS.13 (Fig. 12F), a single 90° sector of a phragmocone, with a maximum whorl height at about 60 mm, which is in all aspects, similar to the material described by Latil (2011) from Jebel Harraba: strong, coarse, straight to feebly flexuous, radiate to feebly prorsiradiate, irregularly alternating primary and intercalory ribs; primaries arising at the umbilical wall, developing a radially elongated swelling at the shoulder, bifurcating or trifurcating near mid-flank, while there are occasionally intercalated ribs that arise at mid-flank. Coarse ribs cross over the ventral area with intercoastal spaces narrower than ribs. Ribbing density (dc/Wh) is 0.11. Another specimen, UJF-ID.15101 (Fig. 12E), from the same bed, could represent the juvenile of the present species, problem that will be discussed in a forthcoming paper.

*Occurrence.* Bed BOAS.13 of Bir oum Ali, Tunisia, *Mellegueiceras chihaouiae* Horizon, top of the *Hypacanthoplites jacobi* Zone. The species has been found everywhere in Tunisia within the same stratigraphic interval.

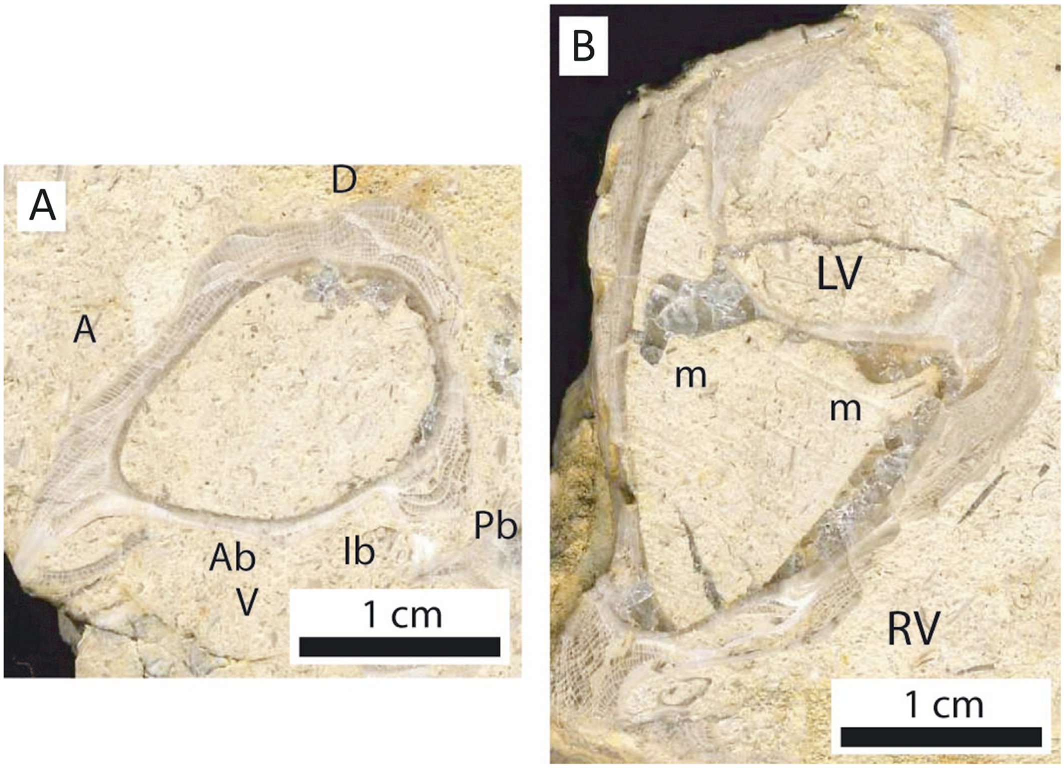


**Fig. 18.** *Eoradiolites plicatus* (BOA 11). A- transverse section of the LV showing the cellular habit of the dorsal (D)and anterior (A) sides, the compact ventral (V) side with an anterior band (Ab), inter-band (Ib) with the salient (mostly cellular) posterior band (Pb); B- longitudinal, oblique section of a bivalve specimen showing the depressed LV bearing two myophores (m), and the triangular habit of the RV.

### 7.2. Rudist bivalves

Rudist bearing rock samples were cut in order to reveal diagnostic longitudinal and/or transverse sections.

**Polyconitidae** MacGillavry
*Polyconites* cf. *verneuili* (Bayle) (Fig. 17)

Longitudinal antero-posterior sections show the conical shape of the right valve (RV) and the flattened low, convex habit of the left valve (LV), with a limited elevation above the commissure; transverse sections are subcircular to oval and lack evidence for ribs. The myophoral organisation is as follows:

-LV: projecting buttresses, the posterior with a L shape, that is reflexed posteriorily around an ectomyophoral cavity, the anterior a vertical plate projecting downward,

-RV: inward sloping thickenings of the inner shell layer.
The above myophoral attributes conform to the definition of *Polyconites* proposed by Douvillé (1889) and followed by subsequent workers (see discussion in Skelton et al., 2010). The anterio-posterior, commissural, dimensions of the shell is from 3 to 4 cm, the dorso-ventral ones are in the same range, the outer shell thickness varies from 1.5 to 2 mm. These measurements closely resemble those of *Polyconites hadriani* Skelton et al. (2010), a late Bedoulian form from Iberia. The main difference between the Tunisian specimens and the Iberian ones regards the shape of the myophores of the LV, the posterior more elongated posteriorily and with a flattened, nearly horizontal lower face, the anterior a well-defined vertical lamina. Our material also differs from *Polyconites subverneuili* Douvillé from Portugal, by the position of the anterior myophoral plate, in the Lusitanian form this plate is located far from the anterior shell margin (Douvillé, 1889). Our specimens also differ from *Polyconites operculatus* Douvillé by a smaller size and a simpler internal architecture (additional internal lobes associated with the myophoral apparatus of the LV and vertical conical cavities of the RV are missing in pre-Cenomanian species). In *Polyconites douvillei* Di Stefano, the RV is strongly ribbed and the myophores of the LV, vigorous and more bulbous.

The Tunisian specimens are therefore assigned to *Polyconites verneuili*, the range of which is late Aptian–Albian, its extent to the latest Albian being still poorly documented (Masse et al., 1998). The species has a wide biogeographical extent in the Mediterranean region, and is documented from Iberia-SW France, North Africa, Anatolia and the Middle East (Masse et al., 2002).

**Radiolitidae** d'Orbigny
*Eoradiolites plicatus* (Conrad) (Fig. 18)

This species has been reported by many workers from various locations from both the northern (European) and southern (African) Mediterranean margins. The recent revision provided by Pons et al. (2010) has demonstrated that most of the aforementioned quotations were based on a taxonomic misinterpretation of the species, especially for the European material. *Eoradiolites plicatus* is currently regarded as an African form, extending to the Middle East. The Tunisian specimens possess the diagnostic attributes of *Eoradiolites* Douvillé (1909), emended by Fenerci-Masse et al. (2006), focusing on both the shape of the ventral bands and the shell microstructure. The anterior band flattened, moderately salient, interband depressed, posterior band salient, more or less rounded; shell microstructure of the calcitic outer shell layer with a quadrangular, cellular network built after plates and walls (Fenerci-

Masse et al., 2006). The study of specimens of *Eoradiolites plicatus* from the type locality of Lebanon show that the two salient ventral bands are markedly dissymmetric, with a posterior band strongly projecting outward, and there is a continuous, relatively thick, compact, outer shell lamina (cortical layer), which tends to encase the cellular one. Moreover, the small amount of cellular versus compact portions of the shell (*e.g.* ventral side), usually considered as a significant specific attribute of *Eoradiolites plicatus* (Gallo-Maresca, 1994), applies to juvenile forms or apical sections of adults; in commissural sections of adults the cellular structure is well expressed.
Data from Levant (Douvillé, 1910) and Tunisia (Pons et al., 2010) suggest that *Eoradiolites plicatus* is restricted to the Albian.

## 8. Concluding remarks

Our data allowed us to refine the age, sedimentary evolution and geological significance of the upper Aptian–lower Albian series of the Chott area. The main results are as follows:

- At least three depositional sequences have been identified in the Late Aptian, and six depositional sequences were recognized in the early Albian. The latter can be correlated with sequences identified in Central Tunisia.
- The late Aptian period (upper Arguib and Foum el Argoub Mbs) is marked by the end of the lower Aptian carbonate shelf sedimentation in the area, by an increase of clastic and nutrient supply, and probably by a more arid and warmer climate expressed by local evaporite deposits (Heldt et al., 2010; Hfaiedh et al., 2013).
- The Aptian–Albian boundary is assumed to be expressed by a sedimentary hiatus at the base of the "*Knemiceras* beds". It is followed by the resumption of carbonate sedimentation in mesotrophic conditions, and by the beginning of the "Albian transgression".
- The "*Knemiceras* Beds" are of Early Albian age (*Douvilleiceras mammillatum* zone) and comprises three depositional sequences. The latter can be correlated with depositional sequences defined in Jebel El Hamra ("intermediate series") and in the Tajerouine area of Central Tunisia (Lower Shales of Fahdene Fm). The occurrence of *Parengonoceras busssoni* in the upper part of the "*Knemiceras* Beds" indicates the transition between the *Douvilleiceras mammillatum* and the *Lyelliceras pseudolyelli* zones.
- The Radhouane Mb is most probably of latest early Albian age (*Tegoceras camatteanum* and *Lyelliceras pseudolyelli* zones) and correlates with the Allam Limestones of Central Tunisia. Therefore, the definition of the Zebbag Fm of the Chott area must be revised, or this name should even be left out.
- As in northern Central Tunisia, the end of the lower Albian substage is marked by a major sedimentary hiatus, which comprises at least part of the middle Albian and probably part of late Albian times. This hiatus is locally marked by significant erosions.
- Tectonic movements are detected near the Aptian–Albian boundary (erosion of the Foum el Argoub Mb), in the early Albian (*Prolyelliceras gevreyi* zone), and in the late early Albian (*Tegoceras cammatteanum* and *Lyelliceras pseudolyelli* zones). However, variation in relative sea level seems to have mainly controlled deposition in late Aptian–early Albian times.
- A preliminary revision of the ammonite fauna leads to the identification of five species of the *Knemiceras* genus. Among specimens of Acanthohoplitinae and Engonoceratids, the presence of *Mellegueiceras chihaouiae*, *Hypacanthoplites* aff. *H. plesiotypicus*, "*Hypacanthoplites*" aff. *"H." buloti* and *Parengonoceras bussoni* leads to specify the age of the Chott succession, and allows correlations with other successions of Central Tunisia.

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