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Stratigraphic succession (Albian to lower? Cenomanian) and upper Albian ammonites and biozones from the Talerhza Basin (South Riffian Ridges, northern Morocco)

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ARTICLE INFO

Article history:
Received 23 May 2016
Received in revised form
18 January 2017
Accepted in revised form 23 January 2017
Available online 1 February 2017

Keywords:
Stratigraphy
Ammonites
Albian-lower Cenomaian
Talerhza Basin
South Riffian Ridges
Morocco

ABSTRACT

Lithostratigraphical analysis of more than ten sections of the El Mizab Formation (Talerhza Basin), previously assigned to the "Vraconnian" lead to distinguish a similar succession of five members, called from oldest to youngest: Silty marly limestones; Lower shelly marly limestones, Platy limestones, Upper shelly marly limestones and Marly limestones with *Rhynchostreon*. The lower and middle parts of the second member yielded a rich ammonite fauna of *Mortoniceras (Mortoniceras) pricei* and *Mortoniceras (M.) inflatum* zones, including: *Hypengonoceras faugeresi* sp. nov., *Mortoniceras (Deiradoceras)* aff. *albense* Spath, *Mortoniceras (D.) bipunctatum* Spath, *Mortoniceras (D.) cunningtoni* Spath, *Mortoniceras (Mortoniceras) pricei* (Spath), *Mortoniceras (M.) inflatum* (Sowerby) and *Oxytropidoceras (Tarfayites)* cf. *bituberculatum* Collignon. The upper part of the same member and the lower part of the fourth one yielded rare *Mortoniceras (M.) fallax* (Breistoffer) and *Mortoniceras (M.) pachys* (Seeley) of the *Mortoniceras (M.) fallax* Zone. The first member, having not yielded any ammonites, may have an early late Albian age, probably within the *Dipoloceras cristatum* Zone? The fifth member, rich in *Rhynchostreon suborbiculatum* (Lamarck), could be early? Cenomanian in age. The two underlying formations, El Heitouf and Bab Lkarma, previously assigned to the upper Albian (*Mortoniceras inflatum* Zone), could have an early to middle Albian age. The collected ammonites are studied and illustrated in the present contribution.

1. Introduction

Occurrence of Cretaceous deposits in the southeastern part of the South Riffian Ridges Domain, Talerhza area (Figs. 1–2) has been known since Abrard's (1921) and Daguin's (1927) seminal works. Daguin (1927, p. 148) distinguished two Cretaceous formations that he assigned to Cenomanian and "Senonian", and also mentioned the presence of the upper Albian substage based on a fragment of *Mortoniceras inflatum* Sowerby, collected from the area located « between the Liassic massif of Jebel Nosrani and the ledges of El Kelaa, in marlstones between the Bajocian and Cenomanian marlstones ». Bruderer et al. (1950) published the 1:100 000 geological map of western-Fez showing in its southwestern corner a small crescent-shaped basin with a Cretaceous-Paleocene infilling, overlying unconformably southwards and westwards on Bajocian marlstones. These authors distinguished three Cretaceous formations they attributed to the Cenomanian, Turonian and "Senonian". Collignon and Faure-Muret (1968) published a brief note on the late Albian ammonites from three outcrops of the Cretaceous basin: «El-Mizab, Douira track»; «El-Mizab, butte facing Douira» and «Valley of Wadi Daya» located to the north of Jebel Nesrani, facing the Sanhaja Douar. The first outcrop (collection 74 of Msougar) yielded: *Pervinquieria msougari* Collignon, *Deiradoceras cunningtoni* Spath, *Deiplasioceras douiraense* Collignon, *Pervinquieria* sp. indet., *Engonoceras* sp. indet. 2, and *Engonoceras* sp. indet. 3; the second outcrop (collection 76 of Msougar) yielded: *Pervinquieria pachys* Seeley and *Engonoceras* sp. indet. 3; the third one (collection 63 of Muylaert) yielded *Engonoceras* sp. indet. 1. According to Collignon and Faure-Muret (1968), this fauna characterizes the *Pervinquieria inflata* Zone of the upper Albian substage. Faugères (1978) published a synthetic stratigraphic log of the Cretaceous-Paleocene succession, more than 300 m-thick, in which

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http://dx.doi.org/10.1016/j.cretres.2017.01.005
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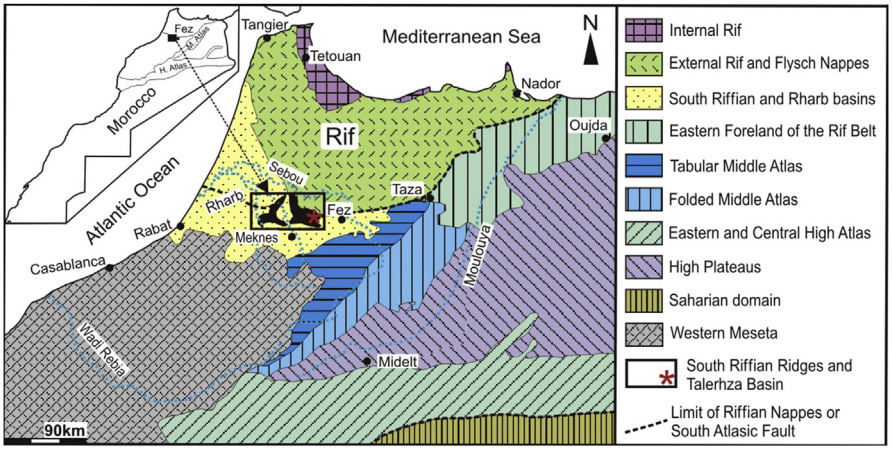


Fig. 1. Simplified structural map of northern Morocco (after Faugères, 1978) and location of the South Riffian Ridges.

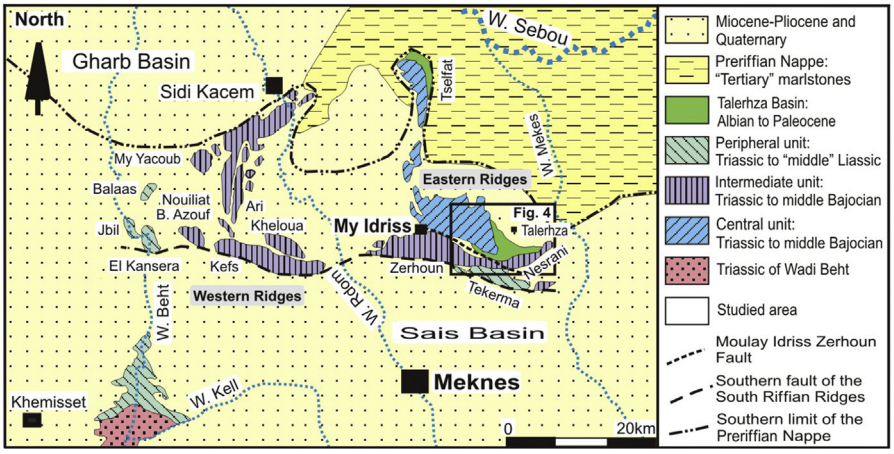


Fig. 2. Simplified structural map of the South Riffian Ridges (after Faugères, 1978) and location of the Talerhza Basin (slightly modified).

he defined ten formations. The fourth one, «Marnes et calcaires lumachelles à huîtres», that we call herein the El Mizab Formation, previously yielded for the author two fragments of *Mortoniceras* sp. (coordinates: x − 497.5, y − 384.5, p. 174); therefore, Faugères (1978) assigned a "Vraconnian" age for the whole «Marnes et calcaires lumachelles à huîtres» Formation.

Analysis of more than ten sections through the Cretaceous basin, that we call Talerhza Basin, lead to: precise the stratigraphic succession of the lower part of the Cretaceous succession; define a new formation named Bab Lkarma, and five members within the El Mizab Formation and characterize, in this latter formation, three upper Albian ammonite biozones: *Mortoniceras (Mortoniceras) pricei*, *Mortoniceras (Mortoniceras) inflatum* and *Mortoniceras (Mortoniceras) fallax*. In this contribution we present an integrated lithostratigraphic, biostratigraphic and paleontological study of the upper Albian from three selected sections: El Mizab 1, El Mizab 2 and south side of Jebel Nesrani.

2. Geological setting of the South Riffian Ridges

The South Riffian Ridges (or Preriffian Ridges) correspond to several hills of moderate altitude composed of Lower-Middle Jurassic rocks forming the southwestern Foreland of the Rif Belt (Fig. 1). These sedimentary rocks are wrapped towards the south and the west and are organized in two outcrop groups: Western and Eastern Ridges (Fig. 2) having an arc-like form and separated by a large depression filled with upper Miocene (Tortonian) marlstones. The first group displays several more-or-less isolated hills between Wadi Beht and Wadi Rdom; the second group corresponds to the Moulay Idriss Zerhoun Massif and its northern extension (the Tselfat Ridge). To the north and northeast, the South Riffian Ridges are thrusted by the "Tertiary" marlstones of the Preriffian Nappe. To the south, the Jurassic deposits of the South Riffian Ridges (Jebels Zerhoun, Tekerma and El Rherraf) are slightly overlapping on the Tortonian marlstones of the Sais Basin (Fig. 2).

The Meso- to Cenozoic successions of the South Riffian Ridges show the superposition of three stratigraphic sequences (Faugères, 1978) bounded by major unconformities which correspond to long periods of emersion and continental erosion (Fig. 2). The lower sequence corresponds to the Triassic-Bajocian substratum. The middle sequence is limited to the eastern (Talerhza area) and northeastern (Tselfat Ridge) edges of the South Riffian Ridges, and consists of Albian to Paleocene deposits unconformably lying on the Bajocian silty marlstones. The upper sequence is transgressive on the most part of the studied area and starts with a Molasse-type rocks of middle? to late Miocene age, unconformably lying on various Jurassic and Cretaceous formations. Within the Jurassic basement, Faugères (1978, 1982) distinguished three lithostratigraphic units, equivalent to three paleogeographic zones (Fig. 2):

- *Peripheral unit*, corresponds to the outer area of the Jurassic South Riffian Basin and displays a reduced and incomplete stratigraphic

sequence (Triassic - not younger than "middle" Liassic), composed of two formations: Triassic red shales and sandstones, and lower to "middle" Liassic dolomites and massive limestones;
- *Intermediate unit*, shows in addition of the two previous formations, a thick succession of marlstones and sandstones alternation with bioclastic and oolitic limestone interbeds of Toarcian to middle Bajocian age, especially the thick Bajocian «Grès et Calcaires du Jebel Zerhoun» Formation;
- *Central unit*, corresponds to the center of the Jurassic South Riffian Ridges Basin, is characterized by marine pelagic deposits from "middle" Liassic to middle Bajocian, similar to the Jurassic succession of the Folded Middle Atlas Belt. This unit forms all Jurassic mountains located north to the Moulay Idriss Zerhoun Fault (Fig. 2). At its eastern edge occurs the small-scaled Talerhza Basin.

3. Albian paleogeography of the South Riffian Ridges

The Talerhza Basin corresponds to a narrow N-S elongated basin from the Tselfat area, in the north, down to Jebel Nesrani, in the south (Fig. 2). This basin was formed during the early? Albian, due to a collapse of the northern and eastern margins of the South Riffian Ridges Domain (Fig. 3A). The stratigraphic sequence of this basin displays two different Cretaceous settings: in the south, Talerhza area, predominates a heterogeneous facies (Fig. 4) consisting of marlstones, marly limestones, silty marlstones, limestones, chalky limestones and shelly limestones rich in bivalves and occasionally in ammonites; in the north, Tselfat area, predominates a homogeneous facies constituted of bituminous shales with fish remains (Arambourg, 1954). The southern facies corresponds to a shallow-water platform, often influenced by terrigenous inputs. The northern facies corresponds to a narrow deep trough likely connected to the Atlantic Ocean with a narrow east-west sea branch (Fig. 3A), now hidden by the Neogene deposits of the Rharb Basin. This small-scaled Cretaceous basin of the South Riffian Ridges seems to be isolated from the Riffian Tethyan trough, in the northeast, probably by an emerged area of the External Preriffian Paleogeographic Zone (Fig. 3A).

4. Stratigraphic sequence of the lower part of the Talerhza Basin

The Albian-Paleocene sequence of the Talerhza Basin, crops out in a small triangular syncline (6 km-long/2.5 km-wide) widely opening northeastwards and extending northwestwards as a narrow corridor (3 km-long) along the Jebel Boujena (Fig. 4). The Cretaceous formations display low dips, from 15 to 30° to the northeast (Figs. 4–5), except along the Jebel Boujena where they are set upright. To the east and north, the Cretaceous deposits are unconformably overlain by middle? to upper Miocene Molasse-type rocks. The lower part of the Cretaceous stratigraphic

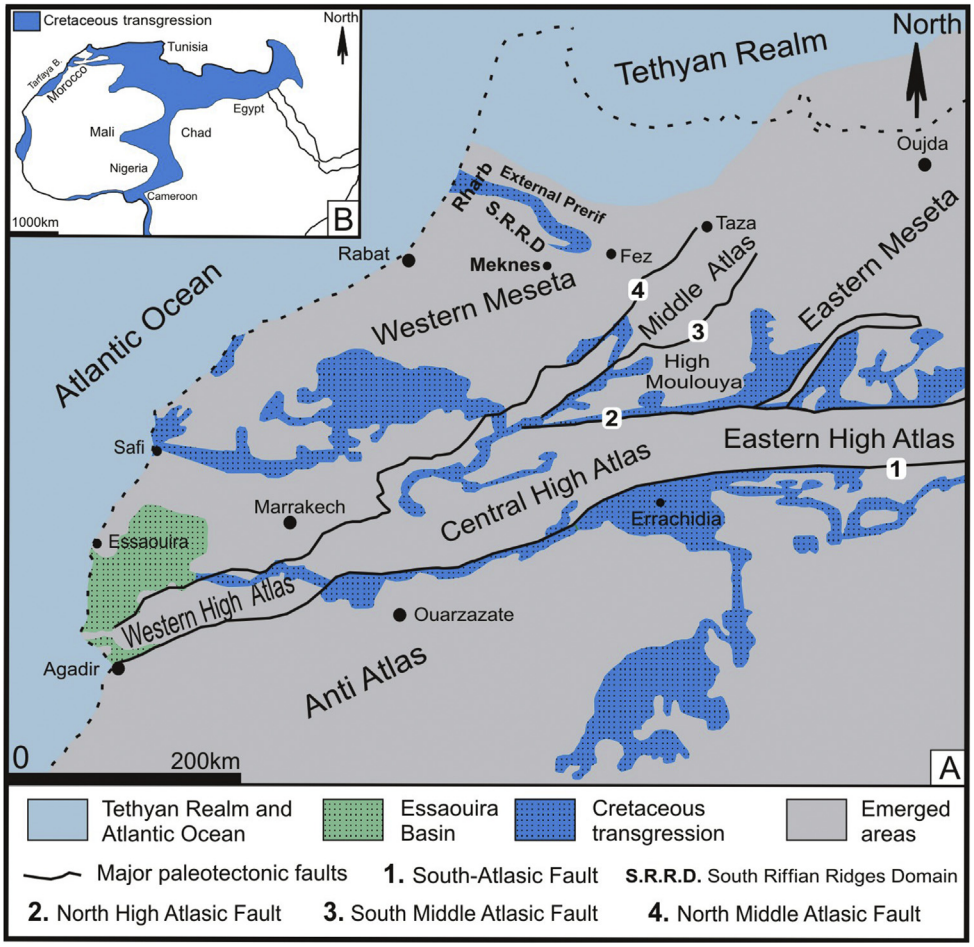


Fig. 3. A. Map showing the Aptian?-Albian transgression through smalls and shallow epicontinental basins of northern Morocco (after Ettachfini et al., 2005, slightly modified) and the Tethyan and Atlantic Oceans, the Essaouira Basin, with a complete marine succession from Triassic to Upper Cretaceous. This transgression seems to be caused by the normal faulting of the major paleo-faults of the Moroccan Alpine Domain. **B**. Cretaceous transgression through the north and central Africa (after Courville et al., 1998).

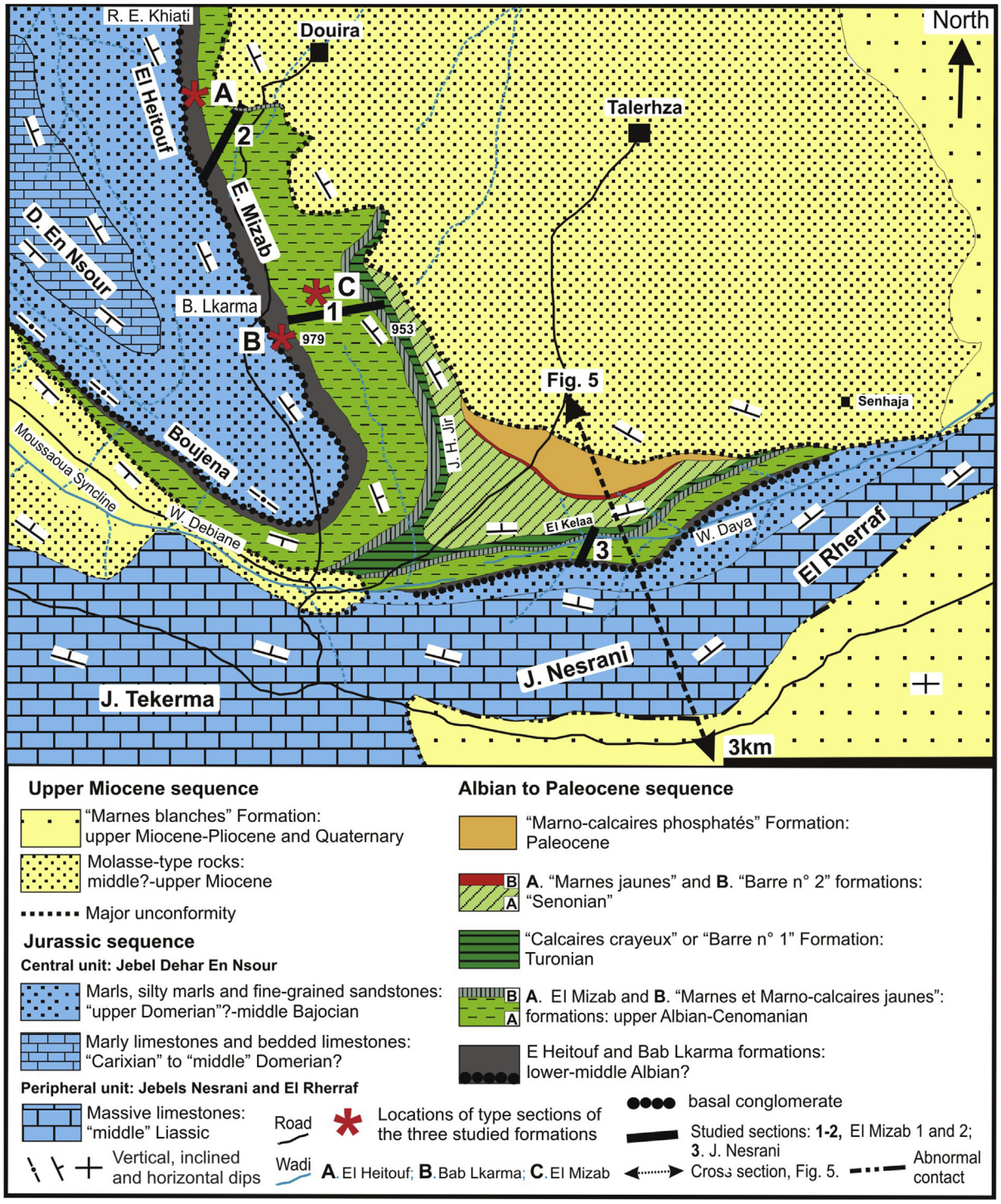


Fig. 4. Simplified geological map of the eastern part of the South Riffian Ridges, Talerhza area (from geological map of 1:50 000, sheet Beni Amar, Chenakeb and Bendkik, 2004, completed) and location of the three studied sections and the type sections of the three studied formations.

sequence consists of three formations, which are, from oldest to youngest (Figs. 6–7): El Heitouf, Bab Lkarma and El Mizab formations. The lithostratigraphic units (formations and members), defined in the present work are in accordance with the recommendations of the International Stratigraphic Guide (Salvador, 1994).

4.1. El Heitouf Formation

Derivation of name and type section. The name of this formation derives from Jebel El Heitouf (topographical map of 1:50 000, sheet Beni Ammar and Fig. 4). The type section, with coordinates: x – 497, y – 384.5, is situated one kilometer south-east of the Richa el

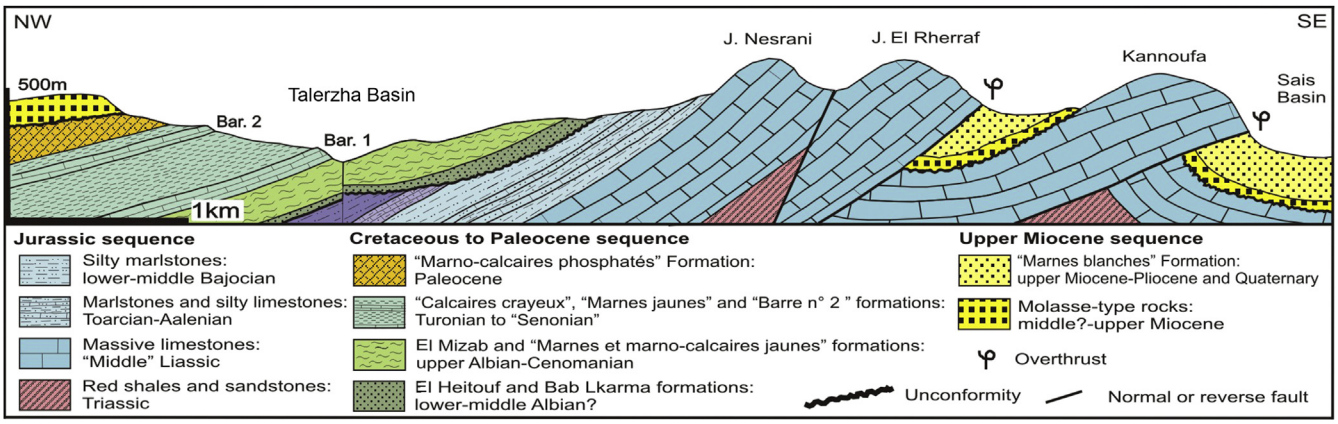


Fig. 5. Cross section through Jurassic calcareous massifs of Jebels Kannoufa and Nesrani and the Talerzha Basin (see location in Fig. 3).

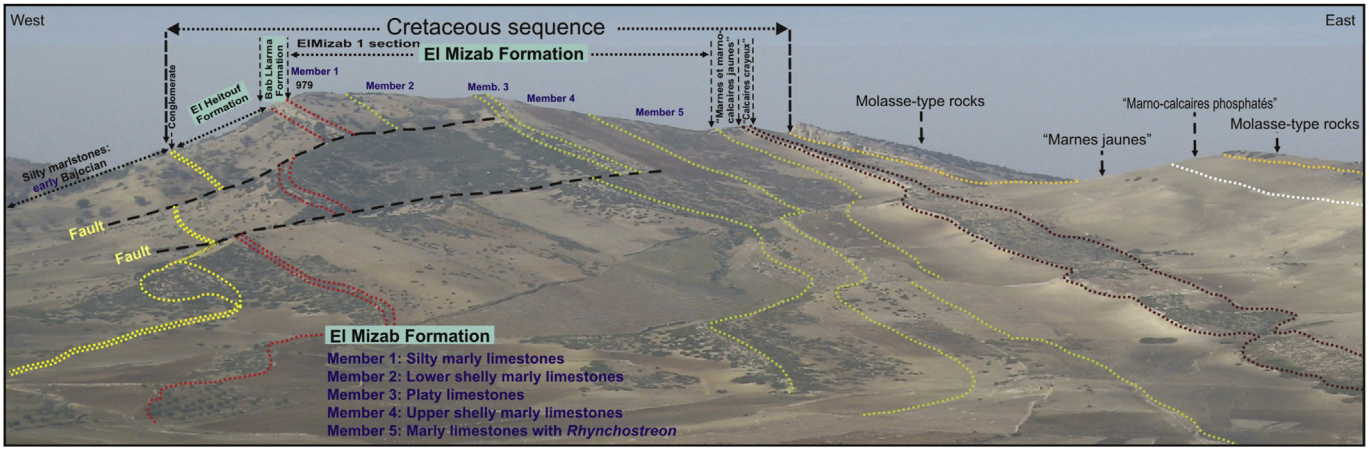


Fig. 6. Panoramic view of the Jurassic to Miocene succession of the South Riffian Ridges in El Mizab 1 section, showing the lower Bajocian silty marlstones, the Cretaceous-Paleocene sequence and the Molasse-type rocks of early? to late Miocene age.

Khiati site. This formation (15–40 m-thick) corresponds to the first « Conglomérat de base » and second « Marno-calcaires sableux blanchâtres » formations defined by Faugères (1978). It is better exposed along the western side of Jebel El Mizab (Fig. 4). The facies is siliciclastic-dominated and consists of marlstones and marly sandstones. This formation can be divided into four members, from bottom to top (Fig. 7B):

4.1.1. Polygenic conglomerate

This member (2–5 m-thick, Figs. 4, 7B) defines the base of the Cretaceous sequence and corresponds to a polygenic conglomerate consisting of commonly rounded limestones and sandstones pebbles, cemented or contained in a marly-sandstones matrix (Benzaggagh et al., 2016) and originated from various stratigraphic levels of Jurassic formations of the South Riffian Ridges and quartzite pebbles resulting from the erosion of the Paleozoic formations of the Western Moroccan Meseta.

4.1.2. Silty marlstones

This member (5–10 m-thick, Fig. 7B) consists of fine silty marlstones with one or two thin red marlstone layers (0.5 m-thick), most likely corresponding to two palaeosoil horizons.

4.1.3. Friable sandstones

It consists of one or several sandstone beds within a marlstone matrix (1–4 m-thick, Fig. 7B), locally containing fragments of bivalve shells (in Jebel El Heitouf) and rare *Nerinea* (gastropods), in Wadi Daya, south-west of Douar Senhaja.

4.1.4. Yellow marly limestones

This member (10–20 m-thick, Fig. 7B) consists of yellow marlstones and silty marly limestones with rare *Nerinea*, in the El Mizab outcrop.

4.2. Bab Lkarma Formation

Derivation of name and type section. The name of this formation derives from Bab Lkarma site (topographical map of 1:25 000, sheet Beni Ammar and Fig. 4). The type section is situated to the south of Bab Lkarma at elevation point 979. This formation (2–15 m-thick, Fig. 7A–C) which was not distinguished by Faugères (1978), is widely exposed along the Jebel El Mizab. It consists of massive sandy limestones beds of white or pink color, and contains rare *Nerinea*.

The two overlying formations, previously assigned to the upper Albian (*M. inflatum* Zone?), can have an early to middle Albian age.

4.3. El Mizab Formation

Derivation of name and type section. The name of this formation derives from Jebel El Mizab (topographical map of 1:50 000, sheet Beni Ammar and Fig. 4). The type section corresponds to the El

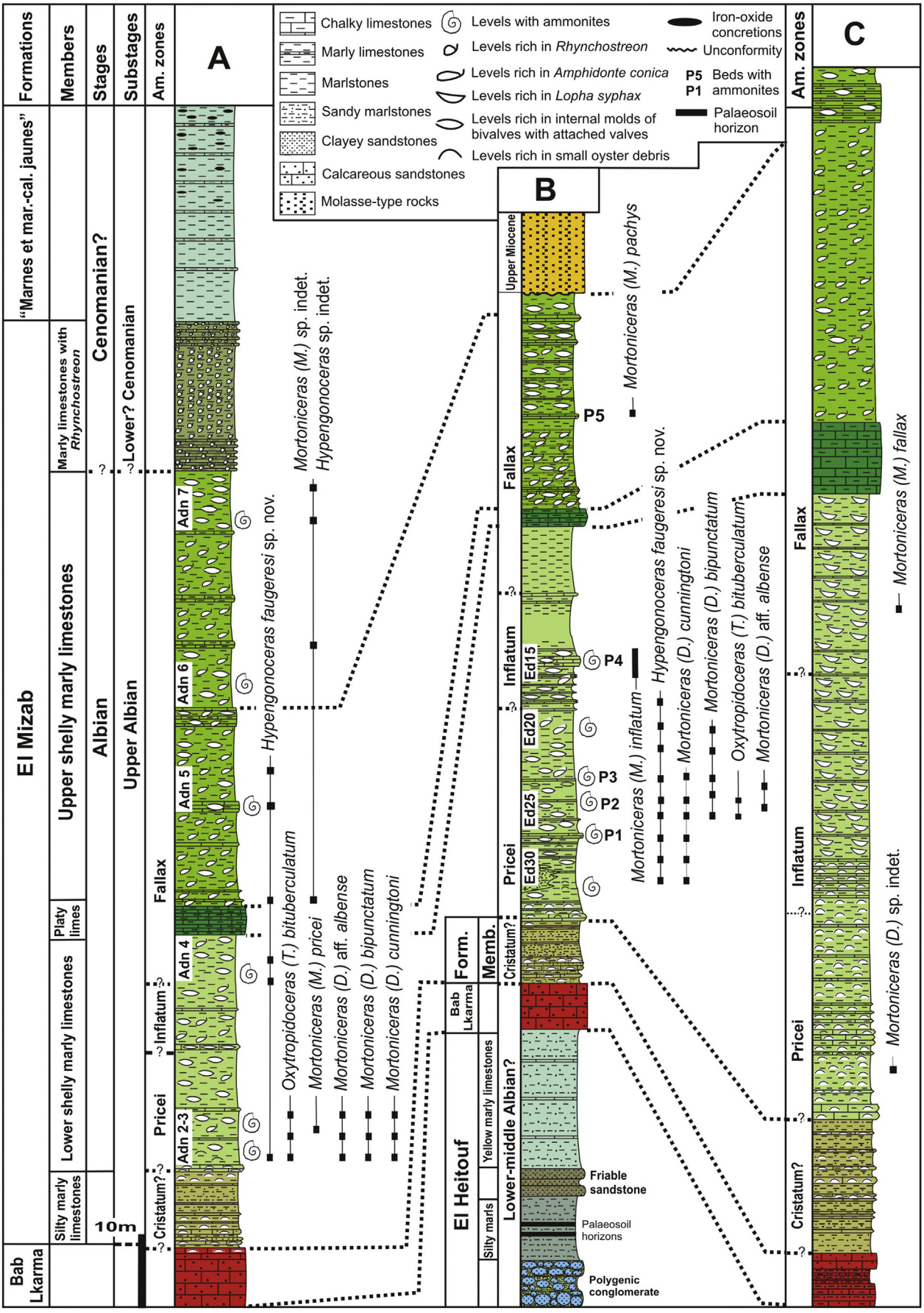


Fig. 7. Stratigraphic successions of the three studied formations (El Heitouf, Bab Lkarma and El Mizab), the upper Albian ammonites biozones and the distribution of the ammonite species in the three studied sections: **A**. El Mizab 1, **B**. El Mizab 2, **C**. South side of Jebel Nesrani (see locations in Fig. 4).

Mizab 1 section (Figs. 4, 6–7). Its base is located near Bab Lkarma, and extends eastwards to elevation point 953. This formation, corresponding to the « Marnes et calcaires lumachelles à huîtres » of Faugères (1978), is the thickest formation (70–120 m-thick) of the Cretaceous sequence. It consists of marlstones and shelly limestones alternation rich in oysters and shows a significant facies change and highly variable thickness. Despite these lateral variations, five fairly constant members can be distinguished through the Cretaceous basin, from bottom to top (Figs. 6–7):

4.3.1. Silty marly limestones

This member (10–20 m-thick, Figs. 6–7) consists of an alternation of marlstones, marly limestones and shelly limestones rich in small-size fragments of oyster shells and containing echinoids and gastropods, especially in the El Mizab 1 and 2 sections. Both sections also display local detrital influxes of fine sand grains and rare rounded lithoclasts derived from the erosion of the underlying conglomerate. This member, located below the stratigraphic levels dated by ammonites of the *M. pricei* Zone, can have an early late Albian age, probably *Dipoloceras cristatum* Zone?

4.3.2. Lower shelly marly limestones

This member (30–50 m-thick) consists of an alternation of shelly marlstones, marly limestones and thin limestone beds. Its base is characterized by two finely shelly limestone beds (0.5–2 m-thick) forming a lithological marker in the landscape, especially at El Mizab 1 section and on the northern side of Jebel Nesrani (Fig. 7). In El Mizab 1 and 2 sections, this member yields a rich bivalve fauna (Benzaggagh, 2016) with both articulated or disarticulated valves, especially *Cucullaea* (*Idonearca*) *thevestensis* (Coquand, 1862), *Cucullaea* (*Idonearca*) *trigona* (Seguenza, 1882), *Protocardia hillana* (Sowerby, 1813), *Aphrodina (Aphrodina) dutrugei* (Coquand, 1862) and *Amphidonte conica* (Sowerby, 1813), as well as rare gastropods and echinoids. In contrast, valves of *Lopha syphax* (Coquand, 1854) are abundant on the northern side of Jebel Nesrani. This member yielded several ammonite species of the *M. pricei* and *M. inflatum* zones (Fig. 7). Its upper part yielded rare ammonites of the *M. fallax* Zone.

4.3.3. Platy limestones

It consists of chalky limestones (2–5 m-thick) in 2–5 cm-thick beds, without any macrofossil, forming a reference level through the Cretaceous basin. This member might belong to the lower part of the *M. fallax* Zone.

4.3.4. Upper shelly marly limestones

This member (40–60 m-thick) consists of shelly marlstones and marly limestones with rare shelly limestone beds. Noteworthy is an alternation of levels rich in internal molds of bivalves with articulated valves and levels rich in *Amphidonte conica*. Its lower part yielded rare ammonites of *M. fallax* Zone.

4.3.5. Marly limestones with Rhynchostreon

It consists of shelly marlstones and marly limestones (10–20 m-thick) rich in *Rhynchostreon suborbiculatum* (Lamarck, 1801), and starts with 1–2 m-thick shelly limestone beds. This member, that has not yielded any ammonite, might have an early? Cenomanian age. According to Videt (2003), Videt and Néraudeau (2003) and Videt and Platel (2005), though *Rhynchostreon suborbiculatum* is widely present in the Upper Cretaceous, its abundance is mostly recorded in the Cenomanian in most Cretaceous epicontinental basins of the Tethyan Realm. The acme of the species is documented in the Cenomanian of the Tarfaya Basin, South Morocco (Freneix, 1972), the Bechar area, Algeria (Benyoucef et al., 2012), in Tunisia (Pervinquière, 1912), Sinai, Egypt (Kora et al., 2001; Ayoub-Hannaa, 2011), Jordan (Berndt, 2002), France (Videt, 2003; Videt and Néraudeau, 2003; Videt and Platel, 2005), Germany (Schneider et al., 2013), Spain (Berrocal-Casero et al., 2013), Brazil (Seeling and Bengtson, 1999), Central African Republic, Madagascar and Mexico.

5. Biostratigraphy and ammonite biozones

The second member of the El Mizab Formation yielded a rich ammonite fauna, especially in its lower part at the El Mizab 1 section, north and east of elevation point 979, and El Mizab 2 section, southwest of Douar Douira (Fig. 4). *Mortoniceras* and *Hypengonoceras* are the two commonest genera. Some specimens were collected *in situ*, but most of them originated from field-surfaces of shelly marly limestones. Despite this possible reworking fauna, the collected specimens allow to characterize three upper Albian ammonite biozones (Figs.7–8): *M. pricei*, *M. inflatum* and *M. fallax*.

5.1. Mortoniceras (M.) pricei *Zone*

The lower and middle parts of the Lower shelly marly limestones member yielded at El Mizab 1 and 2 sections (Fig. 7) several ammonite specimens of the *M. pricei* Zone, among which: *Hypengonoceras faugeresi* sp. nov. (Fig. 9A–H), El Mizab 1 section, Adn2-3 interval; El Mizab 2 section, Ed30, Ed25, Ed20 intervals; *Mortoniceras (Deiradoceras)* aff. *albense* Spath, 1933 (Fig. 10A, D), El Mizab 1 section, Adn2-3 interval; El Mizab 2 section, Ed25 interval; *Mortoniceras (D.) cunningtoni* Spath, 1933 (Fig. 10B in bed P1; Fig. 11A, C), El Mizab 1 section, Adn2-3 interval; El Mizab 2 section, Ed30, Ed25 intervals; *Mortoniceras (D.) bipunctatum* Spath, 1933 (Fig. 12A–B), El Mizab 1 section, Adn2-3 interval; El Mizab 2 section, Ed25, Ed20 intervals; *Mortoniceras (M.) pricei* (Spath, 1922) (Fig. 12C), El Mizab 1 section, Adn2-3 interval; *Mortoniceras (D.)* sp. indet. 1 (Fig. 11D), El Mizab 1 section, Adn2-3 interval; *Oxytropidoceras (Tarfayites)* cf. *bituberculatum* Collignon, 1966 (Fig. 10C, Fig. 11B), El Mizab 1 section, Adn2-3 interval; El Mizab 2 section, Ed25 interval, in addition to several partial or poorly preserved specimens of *Hypengonoceras* sp. indet., *Mortoniceras (D.)* sp. indet., *Mortoniceras (M.)* sp. indet. and *Oxytropidoceras* sp. indet.

5.2. Mortoniceras (M.) inflatum *Zone*

The middle part of the Lower shelly marly limestones member yielded several specimens of *Mortoniceras (M.) inflatum* (Sowerby, 1818) (Fig. 12D–G), especially at the El Mizab 2 section, Ed15 interval, in marlstones or in bed P4 (Fig. 7). In the El Mizab 1 section, the lower part of this member yielded several specimens of *Hypengonoceras* sp. indet., and *Mortoniceras (M.)* sp. indet.

5.3. Mortoniceras (M.) fallax *Zone*

This biozone is characterized in the upper part of the Lower shelly marly limestones member at Jebel Nesrani section (Fig. 7) by a single specimen of *Mortoniceras (M.) fallax* (Breistroffer, 1940) (Fig. 12H), and in the lower part of the Upper shelly marly limestones member in bed P5 of El Mizab 2 section, by one specimen of *Mortoniceras (M.) pachys* (Seeley, 1865) (Fig. 12I). Several specimens of *Hypengonoceras* sp. indet. and *Mortoniceras (M.)* sp. indet. were collected at the El Mizab 1 section (Adn5-7 intervals).

6. Stratigraphic range of previous ammonite specimens from the studied area

The two El Mizab sites with upper Albian ammonites mentioned by Collignon and Faure-Muret (1968) and Faugères (1978, outcrop

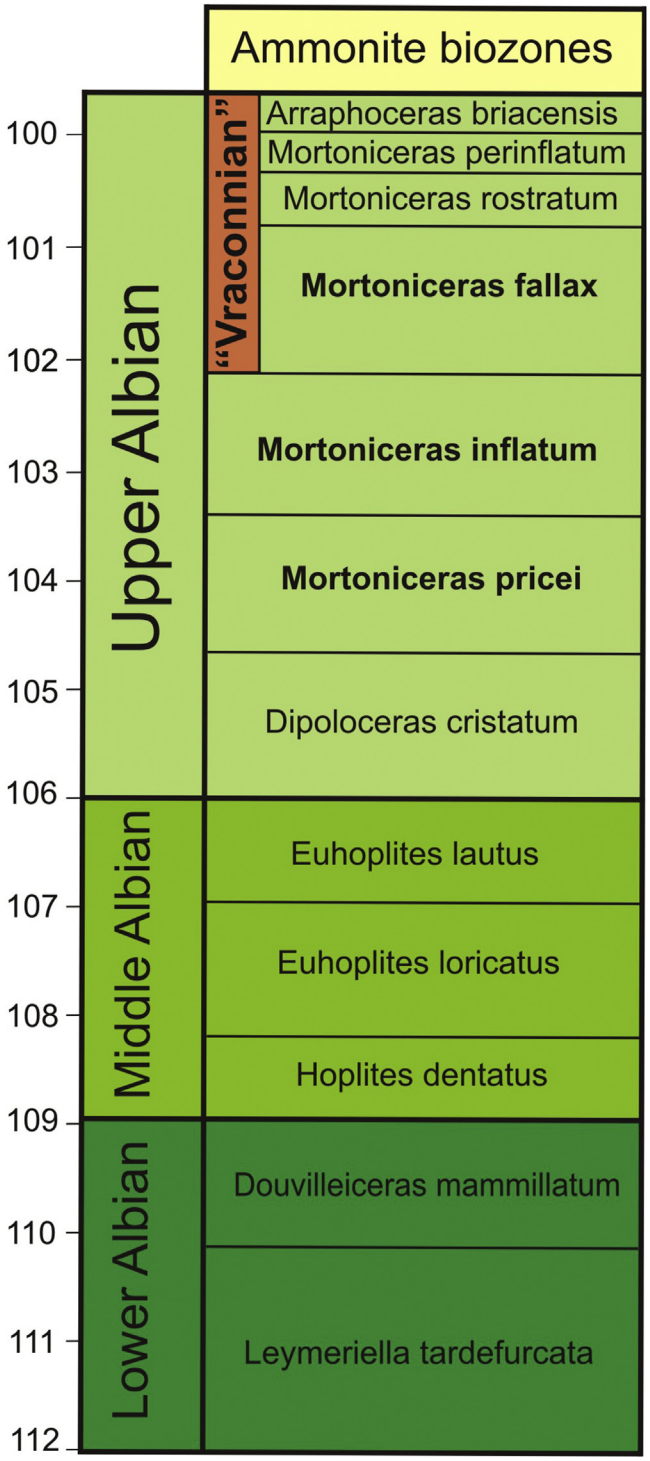


Fig. 8. Standard scale of Albian ammonite biozones (from Garcia et al., 2014).

of coordinates: x − 497.5, y − 384.5) correspond to our El Mizab 2 section. Consequently, ammonites of collection 74 from Msougar and the two specimens of *Mortoniceras* sp. mentioned by Faugères (1978) are from the second member of the El Mizab Formation, which is the richest member in ammonites. Those of collection 76 from Msougar likely originate from the fourth member of the same formation. Daguin's (1927) specimen of *Mortoniceras inflatum* (Sowerby) was found in coeval levels of the northern side of Jebel Nesrani, and not in the underlying « Marno-calcaires sableux blanchâtres » Formation as previously supposed by Faugères (1978, p. 124) who subsequently assigned a late Albian age (*M. inflatum* Zone) to the last formation. The detrital littoral facies of this formation is indeed unfavorable for the development of the pelagic ammonite fauna. Specimen of *Engonoceras* sp. indet. 1 from Muylaert's collection 63, probably came from the second or fourth member of the El Mizab Formation, but not from the « Calcaires crayeux » Formation (Fig. 6) as previously supposed by Faugères (1978, p. 125) who subsequently attributed this formation to the "Vraconnian". Actually, in Wadi Daya and at Jebel El Hajer El Jir (limestone in Arabic), these chalky limestones yielded some ammonite specimens of early to middle Turonian age (Benzaggagh et al., 2017).

7. Systematic palaeontology

Ammonite specimens studied in this contribution are housed in the Department of Geology, Faculty of Science of Meknes, Morocco, under numbers RD1-RD92. All measurements are given in millimeters. Abbreviations of measured parameters are: D. diameter, Wb. whorl breadth, Wh. whorl height, U. umbilical diameter. SMC, Sedgwick Museum, Cambridge, England; OUM, Oxford University Museum, England; BMNH, British Museum of Natural History, London, England.

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

Genus *Hypengonoceras* Spath, 1922
Type species: *Placenticeras warthi* Kossmat, 1895, by original designation of Spath (1922, p. 112).

Hypengonoceras faugeresi sp. nov.
Fig. 9A–H

1968 *Engonoceras* sp. indet., n° 1 Collignon & Faure-Muret, p. 22; pl. 2, fig. 1.
1968 *Engonoceras* sp. indet. n° 2 Collignon & Faure-Muret, p. 22; pl. 2, fig. 2.
1968 *Engonoceras* sp. indet. n° 3 Collignon & Faure-Muret, p. 22; pl. 2, fig. 3.

Derivation of name. This species is dedicated to Professor Jean-Claude Faugères as a tribute to his seminal work on the stratigraphy and sedimentology of the South Riffian Ridges.
Holotype. RD59 (Fig. 9A) is an almost complete specimen showing a phragmocone with visible suture lines, a body chamber of about a half whorl, and lateral and ventral ornamentation.
Type locality and stratigraphic horizon. El Mizab 1 section, Adn2-3 interval, *M. pricei* Zone.
Diagnosis. Discoidal shell of medium to large size; oval whorl section; narrow umbilicus; smooth flanks with six coarse radially elongated umbilicus bullae and broad inconspicuous ribs; narrow venter limited in the phragmocone by rows of spirally elongated opposite bullae; simple and regularly spaced suture lines (Fig. 9D1, F–H).
Additional material. Paratype, RD60 (Fig. 9C1–3), is a specimen showing lateral and ventral ornamentation and: RD31, RD33, RD73 from the El Mizab 1 section, Adn2-3 interval, *M. pricei* Zone; RD53, RD55, RD56 from the Ed30 interval; RD32, RD35 from the Ed25 interval; RD30, RD91, RD92 from the Ed20 interval, El Mizab 2 section, *M. pricei* Zone.
Description. Holotype RD59 (Fig. 9A) is a subadult specimen, with a maximum diameter of 55 mm; the discoidal shell shows an

involute coiling with a narrow umbilicus of 10 mm in diameter; the umbilical wall is shallow and convex; the whorl section is compressed, subelliptical (Wb/Wh = 0.50) with maximum width near the inner third of the flanks; the flanks are gently convex, converging to a very narrow venter of 5 mm width on the phragmocone, and 15 mm at the beginning of the body chamber; the lateral ornament is restricted to six coarse, radially elongated umbilical bullae, giving rise to two inconspicuous broad, coarse and flexuous ribs; the suture line with frilled lobes and pincer-like saddles; the ventral area is flat and smooth in the phragmocone, limited by rows of spirally elongated ventrolateral bullae alternating on the ventral area. From the beginning of the body chamber, the ventral area is smooth, rounded and without bullae.

RD60 (Fig. 9C1–3) is a juvenile specimen, slightly distorted of 80 mm in diameter; the phragmocone is poorly preserved; the discoidal shell shows an involute coiling with a very narrow umbilicus of 5 mm in diameter; the umbilical wall is shallow and convex; the whorl section is compressed, subelliptical (Wb/Wh between 0.35 and 0.40), with maximum width near the inner third of the flanks; the flanks are gently convex, converging to a very narrow venter of 3–4 mm in diameter; the lateral ornament is restricted to weak, radially elongated umbilical bullae, giving rise to two inconspicuous broad, coarse and flexuous ribs; the ventral area is flat and smooth, limited by rows of small spirally elongated ventrolateral bullae, alternating on the ventral area.

RD31 (Fig. 9D1–2) is a distorted and weathered subadult phragmocone with an estimated diameter of 115 mm; the discoidal shell shows an involute coiling with a very narrow umbilicus of 10 mm in diameter; the umbilical wall is shallow and convex; the whorl section is compressed, subelliptical (Wb/Wh = 0.40), with maximum width near the inner third of the flanks; the flanks are gently convex, converging to a very narrow venter; the suture line is strongly weathered, simple and regularly spaced, with bifid or entire saddle and trifid or entire lobes. Very narrow ventral area, with 5 mm in width at the end of the last whorl; it is flat and smooth and limited by rows of small spirally elongated ventrolateral bullae, alternating on ventral area; there is no visible lateral ornament.

RD73 (Fig. 9B1–2) is an adult, slightly distorted specimen, of 190 mm in diameter; the discoidal shell shows an involute coiling with a very narrow umbilicus, comprising 8% of the diameter; the umbilical wall is shallow and gently convex; the whorl section is compressed, subelliptical (Wb/Wh = 0.50), with maximum width near the inner third of the flanks; the flanks are gently convex, converging to a very narrow venter; the ventral area is flat and smooth on the phragmocone, limited by rows of spirally elongated ventrolateral bullae, alternating on ventral area; the ventral area becomes convex on the body chamber and the ventrolateral tubercles are disappearing; there is no visible lateral ornament.

RD92 (Fig. 9E1–3) is an adult specimen of 95 mm in diameter, with preserved body chamber on less than a quarter of the whorl; the shell is discoidal with a very narrow umbilicus of 10 mm in diameter; the umbilical wall is shallow and convex; the whorl section is compressed, subelliptical (Wb/Wh = 0.50), with maximum width near the inner third of the flanks; the flanks are smooth and gently convex, converging to a very narrow venter, of 4–5 mm width in diameter on the phragmocone and 10 mm to the beginning of the body chamber; the ventral area is flat and smooth on the phragmocone, limited by rows of small, spirally elongated ventrolateral bullae, alternating on the ventral area. From the beginning of the body chamber, the ventral area becomes convex and without bullae.

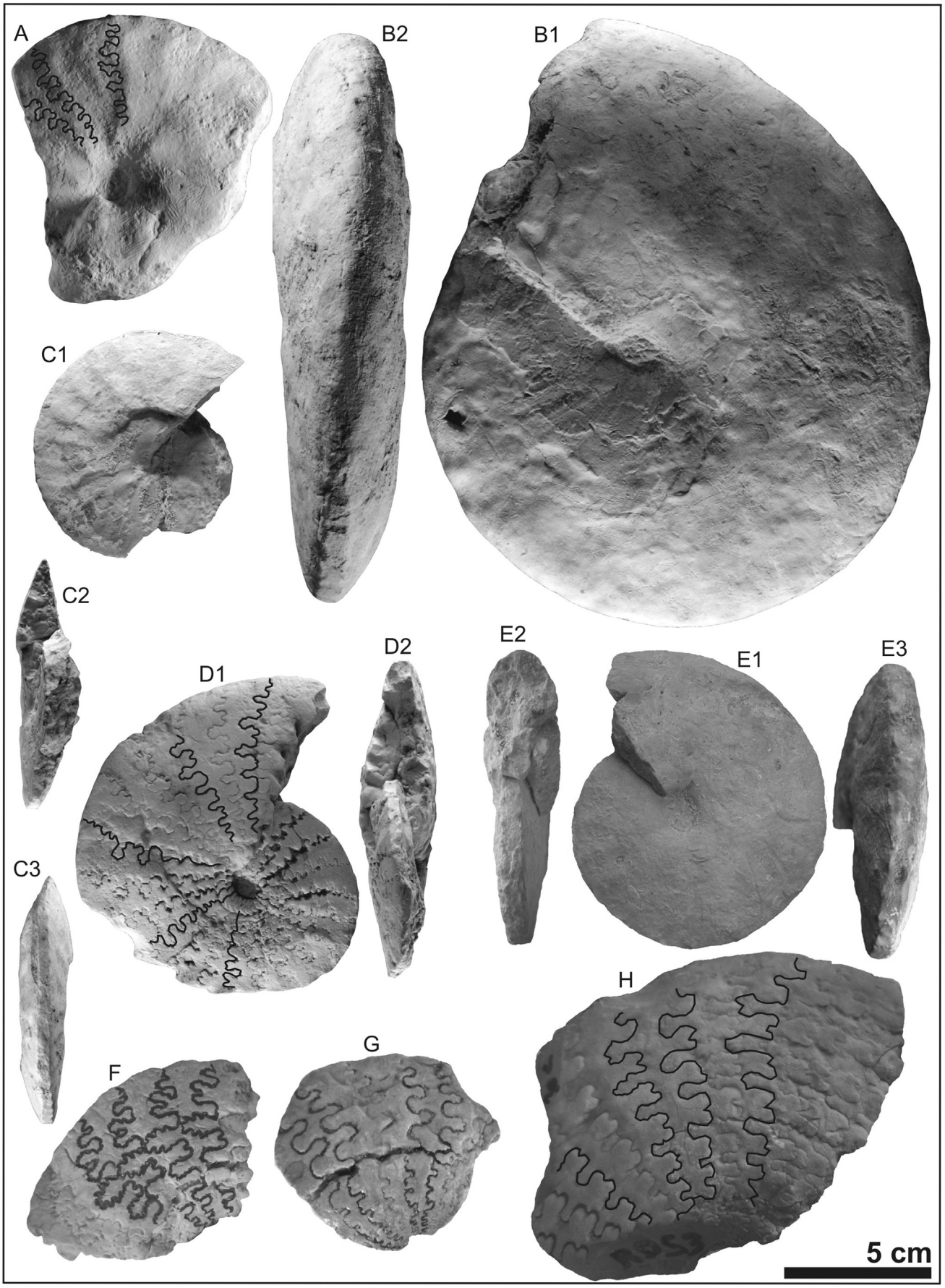
RD91, with 110 mm in diameter, is a subadult phragmocone, with a discoidal shell showing an involute coiling and a very narrow umbilicus of 6 mm in diameter; the umbilical wall is very shallow and convex; the whorl section is compressed, subelliptical (Wb/Wh = 0.40), with maximum width near the inner third of the flanks; the flanks are gently convex, converging to a very narrow venter of 3–5 mm width; the lateral ornament is restricted to six, coarse, radially elongated umbilical bullae, giving rise to two inconspicuous broad coarse and flexuous ribs; the ventral area is flat and smooth, limited by rows of spirally elongated ventrolateral bullae, alternating on the ventral area; the suture lines are not visible.

Discussion. *Engonoceras jullieni* Basse, 1940 (p. 439; pl. 4, fig. 4, text-fig. 11), from the Albian of Ras Acerdoun, Khenchela area, Algeria, shows superficial affinities with our specimen RD73 (Fig. 9B). It is a strongly worn adult specimen, with an estimated diameter of more than 200 mm, with a compressed section and slightly convex flanks, involute coiling and no visible lateral ornament; the ventral area is narrow and flat on the phragmocone and seems to be limited by rows of spirally elongated opposite bullae; the venter becomes convex on the body chamber. The presence of opposite bullae on venter suggesting an early Albian ornament of the genus. We think that this specimen could belong to the genus *Knemiceras* Böhm, 1898.

Engonhoplitoides khenchelaense Basse, 1940 (p. 442; pl. 4, figs. 5-6, text-fig. 12), type species of genus *Engonhoplitoides* Basse, 1940 (p. 441), is based on two specimens. The holotype, a poorly preserved fragment with strongly weathered suture, from the Albian of Bhamdoum, Lebanon, most likely belongs to some unidentified species of genus *Knemiceras*. The paratype, from the Albian of Ras Acerdoun, Khenchela area, Algeria, is a poorly preserved fragment, showing spirally elongated opposite bullae on venter and most likely an early Albian specimen of *Knemiceras*. Consequently, genus *Engonhoplitoides* is considered herein as a junior synonym of *Knemiceras* and species *Engonhoplitoides khenchelaense* and *Engonoceras jullieni* are regarded as *nomina dubia*.

Engonhoplitoides vicorpense Basse, 1940 (p. 443; pl. 5, figs. 2-3), from the upper Albian of La Muela de Vicorp, Valencia area, Spain, displays discoidal shells, with slightly convex flanks, narrow shallow umbilicus and a convex umbilical wall. The flat ventral area is limited by rows of spirally elongated clavi alternating on the ventral area. The lateral ornament is made of sharp, radially elongated umbilical bullae, giving rise to one or two broad coarse, proverse flexuous ribs. This species seems to be closely related to *Knemiceras uhligi* (Choffat, 1898, p. 77; pl. 2, figs. 3-5; pl. 4, fig. 2; pl. 22, figs. 44-46). Both *E. vicorpense* and *K. uhligi* are herein excluded from genus *Knemiceras* because of the presence of alternating clavi on venter and because of their stratigraphic position. Their respective generic position is still to be revised. They differ from our material by their strong ventrolateral clavi, broad venter and strong lateral ornament.

Collignon (1966) described three species from the upper Albian, *M. inflatum* Zone of Tarfaya, southern Morocco, co-occurring with trituberculated mortoniceratids. *Hypengonoceras chouberti* Collignon 1966 (p. 17; pl. 4, figs. 1-2; pl. 5, fig. 1) is a gigantic species with phragmocone reaching 500 mm in diameter. The juveniles differ from our specimens by their vertical umbilical wall, concave venter, strong clavi and coarsely ornamented inner whorls. *Hypengonoceras fauremuretae* Collignon 1966 (p. 18; pl. 6, figs. 1-4), virtually smooth throughout ontogeny, differs from our material by its concave venter and vertical umbilical wall. *Hypengonoceras tarfayense* Collignon 1966 (p. 19; pl. 7, fig. 1) is a phragmocone of 236 mm in diameter, with tiny ventrolateral clavi disappearing well


A
B2
B1
C1
C2
D2
D1
E2
E1
E3
C3
H
F
G
5 cm

before the end of the phragmocone, giving a smooth, rounded venter.

The poorly preserved specimens figured by López-Horgue et al. (2009) as *Knemiceras compressum* Hyatt (figs. 8A-C) and *Knemiceras* cf. *compressum* Hyatt (figs. 6K, L) from the upper Albian, *M. pricei* Zone, of the Karrantza and Trucios areas, northern Spain, only show superficial affinities with our material but seem to be closely related to *Knemiceras uhligi choffati* Geyer (1995, fig. 5) from the upper Albian of Arroyofrio, Teruel, Spain.

Occurrence. *M. pricei* and *M. inflatum* zones of northern Morocco (this work).

Superfamily Acanthoceratoidea de Grossouvre, 1894
Family Mojsisovicsiidae Hyatt, 1903
Subfamily Mojsisovicziinae Hyatt, 1903

Genus *Oxytropidoceras* Stieler, 1920 (=*Pseudophacoceras* Spath, 1921, p. 218, p. 218)
Subgenus *Tarfayites* Collignon, 1966
Type species: *Oxytropidoceras (Tarfayites) bituberculatum* Collignon 1966 (p. 19; pl. 8, figs. 1, 1a-b).

Remarks. The subgenus *Tarfayites* was erected by Collignon (1966, p. 19) for oxytropidoceratids with two rows of tubercles, lateral and ventrolateral. The type species figured by Collignon from the upper Albian, Oued Chebeika, south of Hassi Oum Esbed, Tarfaya Basin, southern Morocco, was supposed to be housed in the collections of the « Service de la Carte Géologique du Maroc », Rabat, Morocco, but so far we have failed to trace it. Consequently this species is not valid with respect to the ICZN rules. Our two specimens are incomplete fragments of phragmocones. A neotype can be designated pending a new collect of complete specimens.

Oxytropidoceras (Tarfayites)* cf. *bituberculatum Collignon, 1966
Fig. 10C1–2; Fig. 11B

1966 *Oxytropidoceras (Tarfayites) bituberculatum* Collignon, p. 19; pl. 8, fig. 1.
1968 *Oxytropidoceras (Venezoliceras) bituberculatum* Collignon: Renz, p. 643; taf. 8, fig. 1a-b. 8, text-fig. 51.

Material. Two specimens: RD69 is a small fragment, from Adn2-3 interval, El Mizab 1 section and RD68 a large fragment from Ed25 interval, El Mizab 2 section.
Description. Both of our specimens seem to be closely related to subgenus *Tarfayites* by the presence of two rows of tubercles: lateral and ventrolateral. RD69 (Fig. 10C1–2) is a high-keeled juvenile phragmocone, with a compressed section (Wb/Wh = 0.54) higher than broad, and maximum width on the inner third of the flanks; the umbilicus is narrow and shallow; the umbilical wall is gently rounded; primary ribs arise on the umbilical seam, are straight and radial on the inner part of the flanks and slightly projected forward on the outer part of the flanks; they broaden and strengthen towards ventrolateral shoulders and end at the keel; secondary ribs arise on the inner third of the flanks; there is one primary for one intercalatory rib; some primary ribs seem to bear a small tubercle on the inner third of the flanks; all ribs bear small ventrolateral tubercles; the ventral area is high and gently convex and bears a siphonal keel; very complicated suture lines.

RD68 (Fig. 11B) is a large adult phragmocone with an estimated diameter of 220 mm; the section is high and rather compressed (Wb/Wh = 0.60), with maximum whorl breadth on the lower third of the flanks; the coiling seems to be moderately involute with a shallow umbilicus and a rounded umbilical wall; the flanks are slightly convex, converging to a narrow, strongly weathered venter; the ribs are irregularly alternating with about one intercalatory for three primaries; the primary ribs arise on the umbilical seam, they are straight and slightly proverse on the inner part of the flanks, flexed forward on the outer part; they broaden and strengthen towards the ventrolateral shoulders; some primary ribs seem to bear a conical tubercle on the inner third of the flanks and all ribs bear a rather strong ventrolateral tubercle; very complicated suture lines.

Discussion. Specimen RD69 of small size, shows an ornamentation similar to that of the inner whorls of the holotype, with regular alternation of long and intercalatory ribs. RD68 of larger size, seems to show more intercalatory ribs compared to the outer whorl of the type species.
Occurrence. *M. pricei* Zone of northern Morocco (this work). Collignon (1966, 1967) reported that *Oxytropidoceras (Tarfayites) bituberculatum* Collignon, 1966 and *Oxytropidoceras (Venezoliceras) lecointrei* Collignon, 1966, co-occur in the upper part of the *D. cristatum* Zone of Tarfaya Basin, localities T481 to T484, with *Mortoniceras (Pervinquieria) inflatum* Sowerby, *M. (P.) rostratum* (Sowerby), *M. (P.)* cf. *equatoreale* Kossmat and *M. (P.) orientale* Kossmat. Even if these identifications have to be questioned, the co-occurrence of the two new species of Collignon (1966) with tuberculate mortoniceratids suggests that this assemblage may belong to the *M. inflatum* Zone.

Family Brancoceratidae Spath, 1934
Subfamily Mortoniceratinae Douvillé, 1912

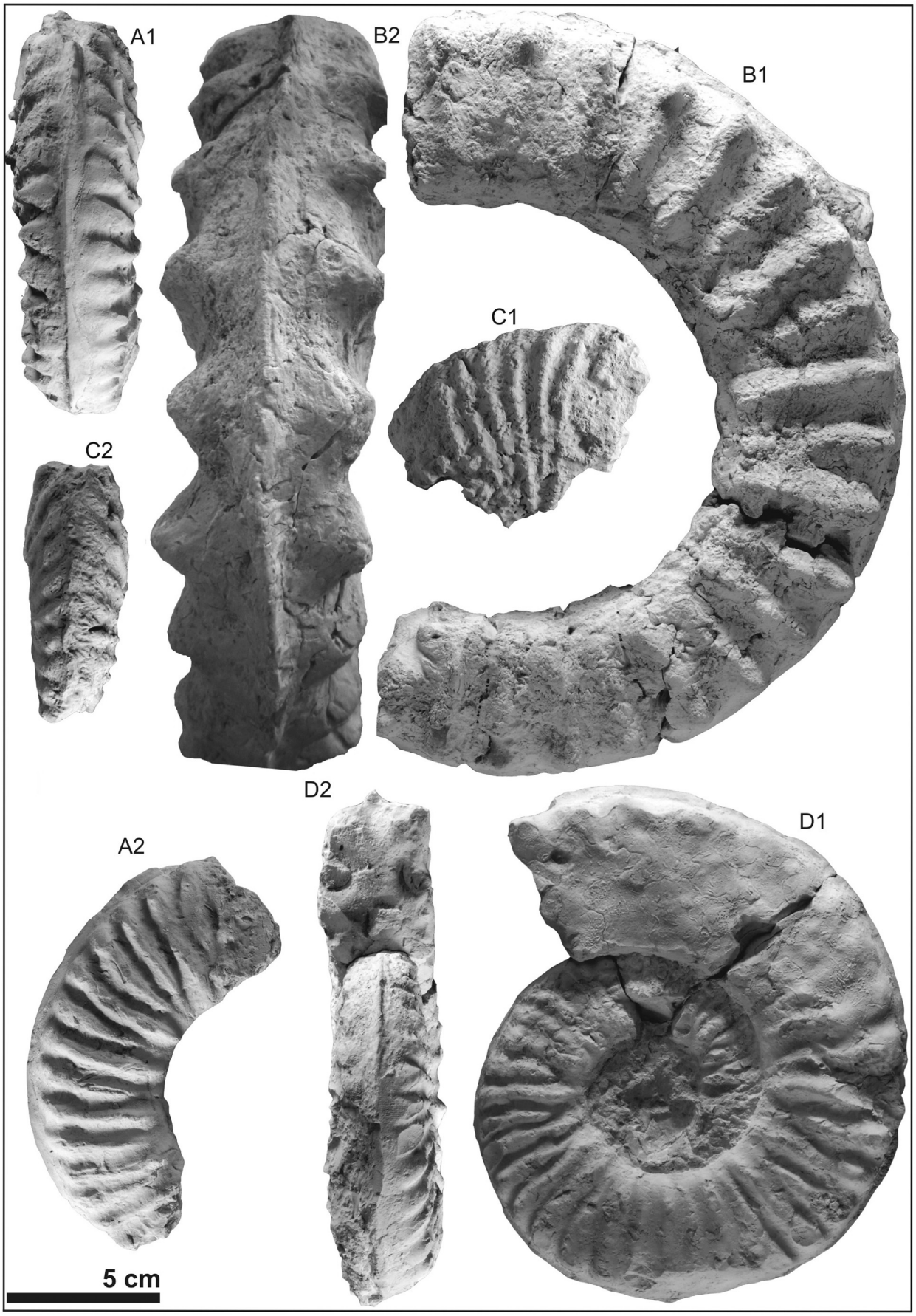
Genus *Mortoniceras* Meek, 1876
Subgenus *Deiradoceras* van Hoepen, 1931
Type species: *Inflaticeras prerostratum* Spath, 1921, by original designation of Van Hoepen (1931, p. 52).

Mortoniceras (Deiradoceras)* aff. *albense Spath, 1933
Fig. 10A1–2, D1–2

aff. 1933 *Mortoniceras (Deiradoceras) albense* Spath, p. 424; pl. 43, fig. 2; pl. 44, fig. 4, text-fig. 145b, 147, 149.
aff. 1975 *Mortoniceras (Mortoniceras) albense* Spath: Förster, p. 237; pl. 15, fig. 2 (with synonymy).
aff. 2008 *Mortoniceras (Deiradoceras) albense* Spath: Lehmann et al., p. 444; figs.2a-c, 3.
aff. 2011 *Mortoniceras (Deiradoceras) albense* Spath: Gale et al., figs. 14H, O.

Holotype. The specimen figured by Spath (1933, text-fig. 147).
Material. RD6, RD25, RD51, RD54, RD61, RD64 from Adn2-3 interval, El Mizab 1 section; RD65 from Ed25 interval, El Mizab 2 section.
Description. RD6 (Fig. 10D1–2) is probably a juvenile phragmocone of 170 mm in diameter; the coiling is evolute; the umbilicus comprising 39% of the diameter; the whorl section is rectangular, higher than wide (Wb/Wh = 0.80), with greatest thickness at the umbilical tubercle; the umbilical wall is shallow and vertical; the

Fig. 9. Upper Albian ammonites of the studied area (*M. pricei* Zone). **A**–**H.** *Hypengonoceras faugeresi* sp. nov. **A**. Holotype, RD59, lateral view, Adn2-3 interval, El Mizab 1 section; **B**. RD73, **B1**, lateral view, **B2**, ventral view, Adn2-3 interval, El Mizab 1 section; **C**. Paratype, RD60, **C1**, lateral view, **C2**, ventral view, **C3**, apertural view, Adn2-3 interval, El Mizab 1 section; **D**. RD31, **D1**, lateral view, **D2**, apertural view, Adn2-3 interval, El Mizab 1 section; **E**. RD92, **E1**, lateral view, **E2**, apertural view, **E3**, ventral view, Ed20 interval, El Mizab 2 section; **F**. RD35, lateral view, ED25 interval, El Mizab 2 section; **G**. RD30, lateral view, ED20 interval, El Mizab 2 section; **H**. RD53, lateral view, ED30 interval, El Mizab 2 section.


A1
B2
B1
C1
C2
D2
A2
D1
5 cm

umbilical shoulder is convex; the flanks are slightly convex; the ventrolateral shoulders are rounded; the inner whorls are poorly preserved, with ribs first bifurcating, with small umbilical and ventrolateral tubercles. On the last whorl, there is an alternation of primary and intercalatory ribs; the primaries arising at the umbilical shoulder and giving rise to a small, more or less radially elongated tubercle; the intercalatory ribs arise just above the umbilical shoulders; all ribs, 34 on the last whorl, are radial, straight or slightly concave and bear a small ventrolateral bulge; the venter is moderately broad, flat, with high and acute median keel, higher than tubercles; smooth flat surface separates the tubercles on the keel. RD61 (Fig. 10A1–2), RD54, RD51, RD64, and RD65 are incomplete phragmocones, and show an ornamentation rather similar to that of the specimen RD6.

Discussion. Our material differs from *Mortoniceras (D.) albense* Spath, 1933 by a more evolute coiling, a lower whorl section, and more delicate ribbing and tuberculation. They may represent a transitional morphology to *M. (M.) pricei*. RD61 (Fig. 10A1–2) is a fragment of a juvenile phragmocone, with its delicate ribbing, long intercalatories and small umbilical bullae and ventrolateral bulge, represent an extreme morphology.

Occurrence. *M. pricei* Zone, England (Spath, 1933), France (Gale et al., 2011), Germany (Lehmann et al., 2008), Morocco (this work), South Africa, Madagascar and Mozambique (Förster, 1975).

Mortoniceras (Deiradoceras) bipunctatum Spath, 1933
Fig. 12A–B

1933 *Mortoniceras (Deiradoceras) bipunctatum* Spath, p. 422; pl. 45, fig. 2, text-fig.145c, 146.
1995 *Mortoniceras (Deiradoceras) cunningtoni* Spath, var. *bipunctatum* Spath: Amédro et al., pl. 2, fig. 5.
1999 *Mortoniceras (Deiradoceras) bipunctatum* Spath: Kennedy et al., p. 111; figs. 10.8, 12/1-6.
2007 *Mortoniceras (Deiradoceras) bipunctatum* Spath: Lehmann et al., p. 738; fig. 11E.
2007 *Mortoniceras (Deiradoceras) bipunctatum* Spath: Mosavinia et al., pl. 91, figs. 6A-C.
2011 *Mortoniceras (Deiradoceras) bipunctatum* Spath: Gale et al., fig. 25F.

Holotype. BMNH C35930, by original designation of Spath, 1933, text-figure 146, from Bed 9 of the Gault Clay at Folkestone, Kent, lower upper Albian, *Hysteroceras orbignyi* subzone of the *M. inflatum* Zone.

Material. RD19 and RD20 from Ed20 and Ed25 intervals, El Mizab 2 section; RD44-RD46 and RD70 from Adn2-3 interval, El Mizab 1 section.

Description. Several fragments of phragmocone with medium size, evolute coiling; slightly convex flanks; subquadrate whorl section, slightly higher than wide; simple robust and prominent distant ribs, showing an alternation between primary ribs arising on the umbilical shoulder and forming strong and prominent umbilical tubercles, and radially elongated and intercalated ribs which arise at the mid-flank. Each rib ends in a strong, prominent ventrolateral tubercle, rounded, RD19 (Fig. 12A) and RD45, radially elongated, RD20 (Fig. 12B), RD44 and RD46, or slightly inflected forwardly, RD16. On the specimen RD19, the intercalated ribs are sometimes limited to ventrolateral tubercles; the venter is moderately broad and slightly convex; it bears a sharpened keel, RD16 and RD45, which separated from the ventrolateral tubercles by two smooth grooves. Specimens RD20, RD19, RD44 and RD46, despite a poor preservation, the ventral area bear traces of a prominent keel.

Discussion. Our material differs from the holotype figured by Kennedy et al. (1999, fig. 12/1) by a more evolute coiling and a lower whorl section, and resembles to the specimens figured by Mosavinia et al. (2007, figs 6A-C) and Kennedy et al. (1999, figs. 12/2-6) by robust spaced ribs, and strong umbilical and ventro-lateral tubercles.

Occurrence. *Mortonicers (D.) bipunctatum* Spath is reported in the lower part of the upper Albian of Texas (Kennedy et al., 1999) and in the *M. pricei* Zone in England (Spath, 1933), France (Gale et al., 2011), Germany (Lehmann et al., 2007), Morocco (this work) and Iran (Mosavinia et al., 2007).

Mortoniceras (Deiradoceras) cunningtoni Spath, 1933
Fig. 10B1–2; Fig. 11A1–2, C1–2

1933 *Mortoniceras (Deiradoceras) cunningtoni* Spath, p. 416; pl. 37, fig. 2; pl. 39, fig. 5; pl. 41, fig. 6; pl. 42, fig. 7; pl. 43, fig. 3; pl. 48, fig. 1; text-fig. 143, 144a, e.
1979 *Pervinquieria (Deiradoceras) cunningtoni* (Spath): Wiedmann, pl. 3, fig. 4.
1995 *Mortoniceras (Deiradoceras) cunningtoni* Spath: Amédro et al., pl. 2, figs. 1, 5.
1997 *Mortoniceras (Deiradoceras) cunningtoni* Spath: Kennedy et al., p. 466; pl. 9, figs. 6-7 (with synonymy).
2007 *Mortoniceras (Deiradoceras) cunningtoni* Spath: Mosavinia et al., pl. 93, figs. 7A-B (with synonymy).
2009 *Mortoniceras (Deiradoceras) cunningtoni* Spath: López-Horgue et al., figs. 9A-B.

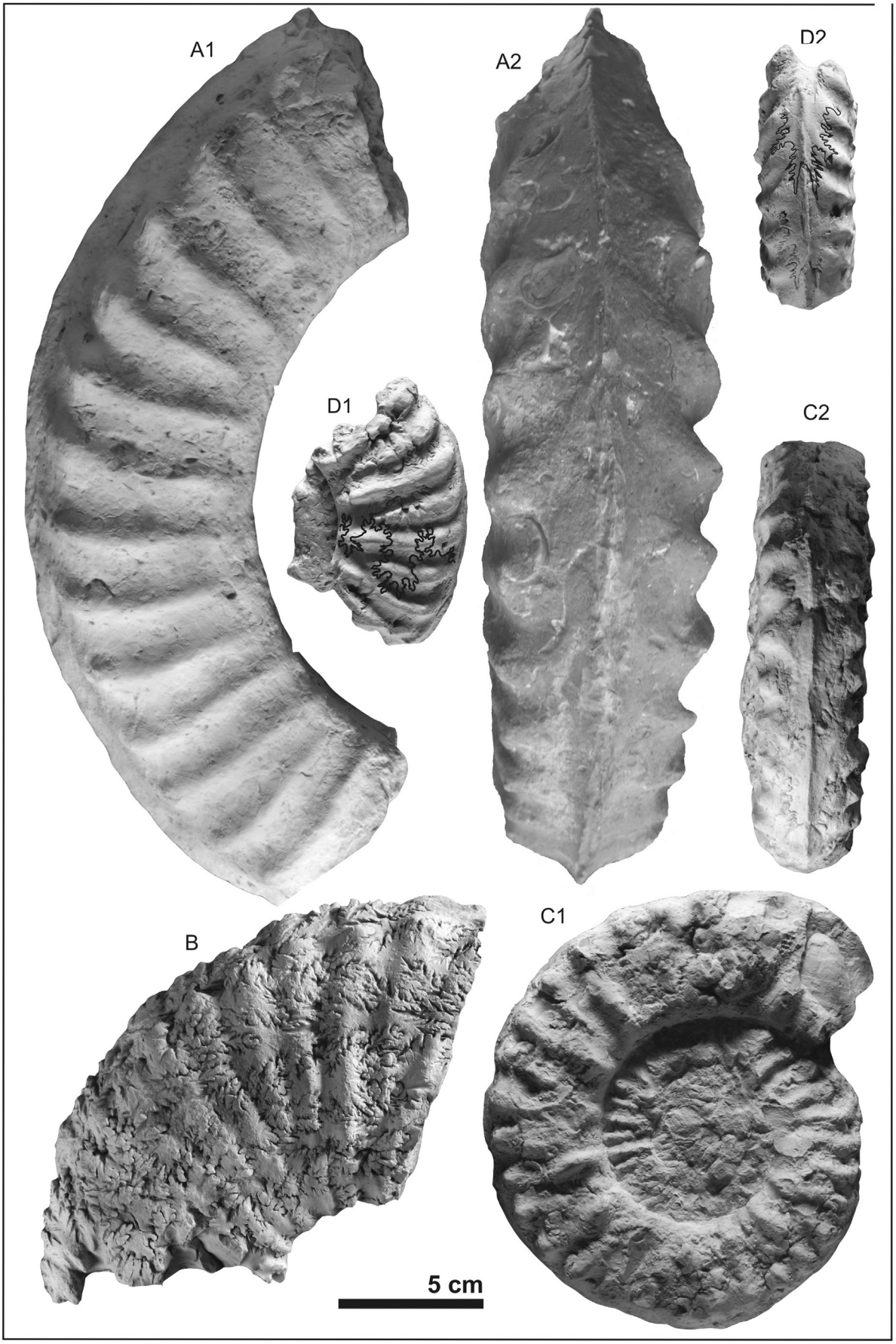
Holotype. BMNH C31709, figured by Spath (1933, pl. 41, fig. 6).

Material. Several specimens of medium to large size, among others: RD5, RD11, RD62, RD63 from Adn2-3 interval, El Mizab 1; RD16, from Ed25 interval, El Mizab 2 section and RD52, from bed P1, El Mizab 2 section.

Description. RD5 (Fig. 11C1–2) is probably a complete juvenile phragmocone of 160 mm in diameter; the coiling is evolute; the umbilicus comprising 43% of the diameter; the flanks are almost flat; the whorl section is rectangular, slightly higher than wide (Wb/Wh = 0.82), with greatest thickness at the umbilical tubercle; the umbilical wall is shallow and vertical, the umbilical shoulder is convex; the ventrolateral shoulders are rounded; the inner whorls are poorly preserved, with ribs first bifurcating, with rather small umbilical and ventrolateral tubercles. On the last whorl, the ribs (20 internal and 33 external) are strong, radial and regularly spaced; there is an alternation of long and short ribs; the primaries arise at the umbilical shoulder, giving rise to a strong radially elongated tubercle; the intercalatories arise on the inner third of the flanks; all ribs are bearing a strong rounded ventrolateral bulge; the moderately broad venter is flat to slightly convex and bears a high and strong siphonal keel elevating above the tubercles and separated from these by two smooth flat grooves.

RD52 (Fig. 10B1–2) is a large fragment of 250 mm in diameter, including the end of the adult phragmocone and the beginning of the body chamber; the coiling is very evolute (U/D = 0.54); the

Fig. 10. Upper Albian ammonites of the studied area (*M. pricei* Zone). **A**. *Mortoniceras (Deiradoceras)* aff. *albense*, Spath, 1933, RD61, **A1**, lateral view, **A2**, ventral view, Adn2-3 interval, El Mizab 1 section; **B**. *Mortoniceras (D.) cunningtoni* Spath, 1933, RD52, **B1**, lateral view, **B2**, ventral view, Ed30 interval, bed P1, El Mizab 2 section; **C**. *Oxytropidoceras (Tarfayites)* cf. *bituberculatum* Collignon, 1966, RD69, **C1**, lateral view, **C2**, ventral view, Adn2-3 interval, El Mizab 1 section; **D**. *Mortoniceras (D.)* aff. *albense*, Spath, 1933, RD6, **D1**, lateral view, **D2**, apertural view, Adn2-3 interval, El Mizab 1 section.


A1
A2
D2
D1
C2
B
C1
5 cm

umbilical wall is shallow and steep; the umbilical shoulder is convex; the whorl section is low, subquadrate, higher than wide (Wb/Wh = 0.78), with greatest thickness at the umbilical tubercle; the flanks are slightly convex; the ventrolateral shoulders are rounded; there is an alternation of long and short ribs; the primaries arise at the umbilical shoulder and give rise to a strong radially elongated tubercle; the intercalatories arise on the inner third of the flanks; all ribs are straight and radial and bearing a strong ventrolateral bulge. On the adapical end of the specimen, the intercalatory ribs arise on the umbilical shoulder, and the strength of umbilical clavi is decreasing on the primary ribs; the venter is slightly convex with two smooth flat grooves separating a high and strong siphonal keel.

RD11 (Fig. 11A1–2) is a fragment of an adult body chamber with an estimated diameter of 330 mm; the whorl section is subquadrate, higher than wide (Wb/Wh = 0.83); the umbilical clavi are inconspicuous; the ribs become slightly concave on the flanks and the ventrolateral bulges are persistent. At the end of the body chamber, the ribs are strongly projected forward on the venter.

Discussion. Our material differs in no significant respects from the material described by Spath (1933) from England, even if RD52 has a very low whorl section (Wh/D = 0.19). Amédro (1992, p. 112) suggested that *Prohysteroceras (Goodhallites) goodhalli* (Sowerby, 1820), *Prohysteroceras (G.) delabechei* Spath, 1934, *M. (D.) albense* Spath, 1933, *M. (D.) cunningtoni* Spath, 1933, *M. (D.) devonense* Spath, 1933, *M. (D.) bipunctatum* Spath, 1933, and *M.* (*M.*) *pricei* (Spath, 1922) are all conspecific. Pending a revision of this ammonite complex, we shall use Spath's narrow species concept. However, our specimen RD5 is similar by its size, ornamentation and rectangular section to the specimen figured by Wiedmann (1979, pl. 3, fig. 4) and Amédro et al. (1995, pl. 2, fig. 1a–b), but it differs from these by a slightly greater number of intercalatory ribs. Specimens RD11 and RD52 are of a large size.

Occurrence. *Mortoniceras (D.) cunningtoni* Spath, 1933 is reported from the *M. pricei* Zone of the Anglo-Paris Basin (Amédro et al., 1995; Amédro and Robaszynski, 2005); northern Morocco (this work), upper Albian of Iran (Mosavinia et al., 2007), northern Spain (Wiedmann, 1979; López-Horgue et al., 2009), South Africa (Kennedy et al., 1997) and England (Spath, 1933).

Mortoniceras (Deiradoceras) sp. indet. 1

Fig. 11D1–2

Material. RD22 from Adn2-3 interval, El Mizab 1 section.

Description. Specimen RD22 (Fig. 11D1–2) is a fragment of a juvenile phragmocone, with flat flanks, and showing an alternation of long and short ribs; the long ribs bear a weak umbilical clavus; all ribs are strongly projected forward across the ventrolateral shoulder; the ventral area is flat and shows a siphonal keel, separated from the ribs by two smooth flat grooves.

Discussion. This specimen differs from the other species of subgenus *Mortoniceras (Deiradoceras)* by a weak development of the umbilical and ventrolateral tubercles and a strong forward projection of the ribs on the ventrolateral shoulder.

Occurrence. *M. pricei* Zone of northern Morocco (this work).

Subgenus *Mortoniceras* Meek, 1876

Type species: *Ammonites vespertinus* Morton, 1834, by original designation of Meek (1876, p. 448).

Mortoniceras (Mortoniceras) pricei (Spath, 1922)

Fig. 12C1–2

1922 *Subschloenbachia pricei* Spath, p. 101.
1932 *Mortoniceras (Pervinquieria) pricei* (Spath), p. 391, pl. 36, figs. 11-12; pl. 37, fig. 3; pl. 38, fig. 5, text-fig. 130c, 131-132, 137c (with synonymy).
1966 *Mortoniceras (Pervinquieria) pricei* (Spath): Collignon, p. 20; pl. 9, fig. 5.
1976 *Mortoniceras (Pervinquieria) pricei* (Spath): Marcinowski & Naidin, p. 106; pl. 2, figs. 8-9 (with synonymy).
1990 *Mortoniceras (Mortoniceras?) pricei* (Spath): Marcinowski & Wiedmann, p. 87; pl. 8, fig. 7 (with additional synonymy).
1995 *Mortoniceras (Mortoniceras) pricei* (Spath): Amédro et al., pl. 2, fig. 4.
1997 *Mortoniceras pricei* (Spath): Delamette et al., pl. 34, fig. 3.
1999 *Mortoniceras (Mortoniceras) pricei* (Spath): Kennedy et al., p. 1109; figs. 8-9.
2002 *Mortoniceras (Mortoniceras) pricei* (Spath): Immel & Guoxiong, p. 92; pl. 2, fig. 2.
2007 *Mortoniceras (Mortoniceras) pricei* (Spath): Mosavinia et al., p. 91; figs. 5C-E.
2011 *Mortoniceras (Mortoniceras) pricei* (Spath): Gale et al., figs. 18B, 21A, 23A-E.

Holotype. *Mortoniceras (Pervinquieria) pricei* Spath, 1922, by monotypy, is BMNH C12488, the original of Spath, 1932, text-fig. 131, from the lower upper Albian *M. inflatum* Zone, *Hysteroceras varicosum* Subzone, Gault Clay at Folkestone, Kent.

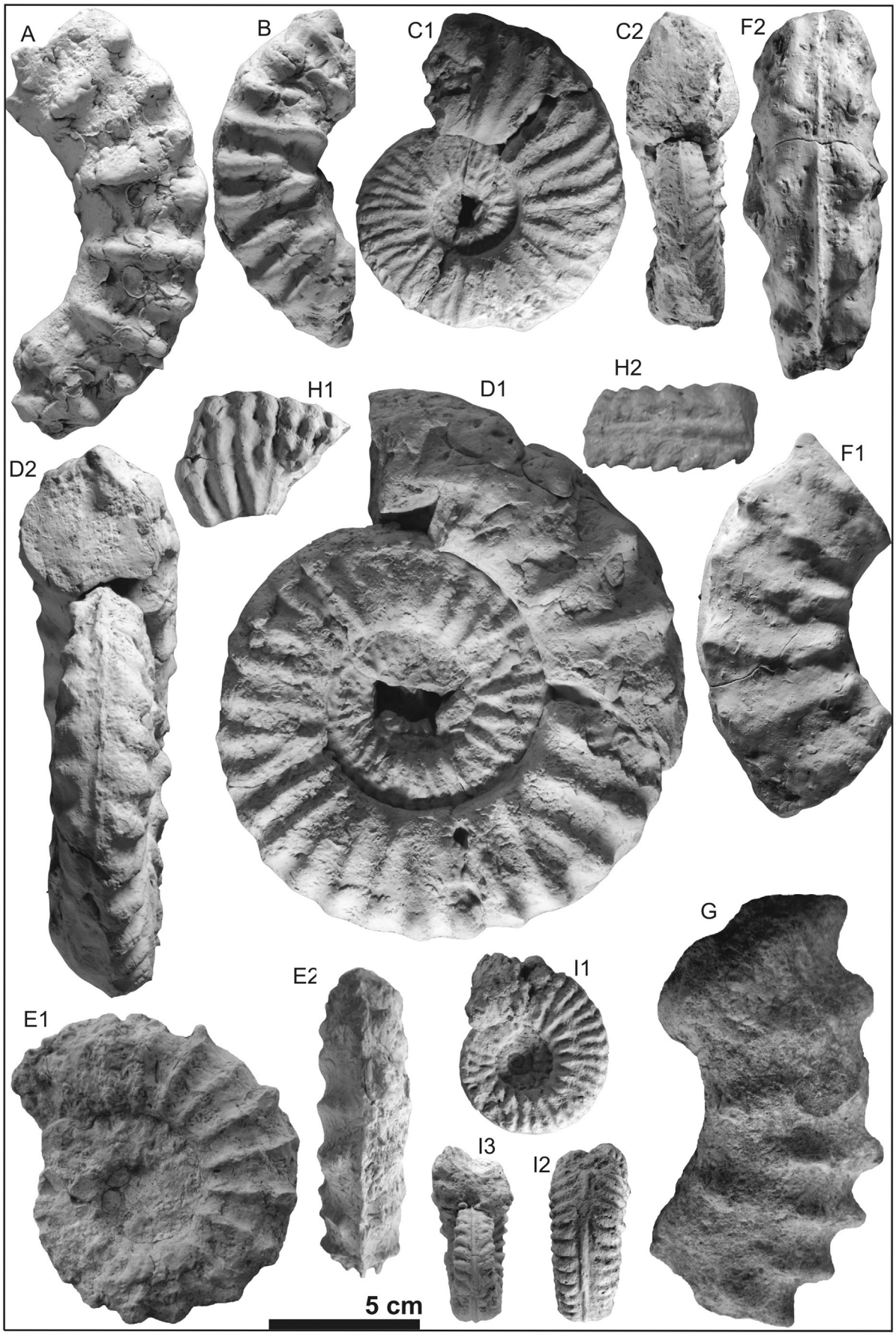
Material. RD21, from Adn2-3 interval, El Mizab 1 section.

Description. To this species, we assign the specimen RD21 (Fig. 12C1–2), with a discoidal shell, 100 mm in diameter, showing a small part of the body chamber; oval whorl section; broad and slightly convex flanks; medium umbilicus and short umbilical wall; radial and narrow ribs on inner whorls, getting progressively thicker and widely spaced on the last whorl; all ribs end a broad and blunt ventrolateral tubercle and are projected forwards; primary ribs arise on the umbilical wall, in form of a radially elongated tubercle, giving rise to two secondary ribs, rarely one, which are slightly concave forward; they are simple on the last whorl, and showing an alternation between the ribs which start at the umbilical shoulder and the intercalated arising near the lower third of the flanks; the venter is smooth, narrow and convex, with an acute siphonal keel.

Discussion. Our specimen differs from the two specimens of *M. (M.) pricei* (Spath), figured by Kennedy et al. (1999, figs. 8-9) by a small size, a slightly narrow umbilicus on the inner whorls, and slightly flexuous ribs. It is similar to the specimen figured by Amédro et al. (1995, pl. 2, 4a-b) by its size and ornamentation, and differs from the specimen figured by Renz (1982, p.13, figs. 2a-b) by a slightly more delicate ribs on the outer whorl.

Occurrence. *Mortoniceras (M.) pricei* (Spath) is widely distributed and known from the lower part of the upper Albian of Crimea (Marcinowski and Naidin, 1976), Texas (Kennedy et al., 1999), Poland (Marcinowski and Wiedmann, 1990), Iran (Mosavinia et al., 2007), Morocco (Collignon, 1966 and this work), Tibet (Immel and Guoxiong, 2002), Anglo-Paris Basin (Amédro, 1992; Amédro et al., 1995), SE France (Gale et al., 2011) and Haute-Savoie (Delamette et al., 1997), England (Spath, 1932), and Venezuela (Renz, 1982).

Fig. 11. Upper Albian ammonites of the studied area (*M. pricei* Zone). **A**. *Mortoniceras (D.) cunningtoni* Spath, 1933, RD11, **A1**, lateral view, **A2**, ventral view, Adn2-3 interval, El Mizab 1 section; **B**. *Oxytropidoceras (Tarfayites)* cf. *bituberculatum* Collignon, 1966, RD68, lateral view, Adn2-3 interval, El Mizab 1 section; **C**. *Mortoniceras (D.) cunningtoni* Spath, 1933, RD5, **C1**, lateral view, **C2**, ventral view, Adn2-3 interval, El Mizab 1 section; **D**. *Mortoniceras (D.)* sp. indet. 1, RD22, **D1**, lateral view, **D2**, ventral view, Adn2-3 interval, El Mizab 1 section.


A
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C1
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5 cm

Mortoniceras (Mortoniceras) inflatum (Sowerby, 1818)
Fig. 12D1–2, E1–2, F1–2, G

1818 *Ammonites inflatus* Sowerby, p. 170; pl. 178.
?1966 *Mortoniceras (Pervinquieria) inflatum* (Sowerby): Collignon, p. 21; pl. 9, fig. 2.
1968 *Pervinquieria msougari* Collignon & Faure-Muret, p. 20; pl. 1, fig. 1.
1995 *Mortoniceras inflatum* (Sowerby): Latil, pl. 1, fig. 1.
2004 *Mortoniceras* (*Mortoniceras*) *inflatum* (Sowerby): Amédro et al., p. 16; pl. 1, figs. 1, 4; pl. 2, figs. 1-2; pls. 3- 8 (with synonymy).
?2005 *Mortoniceras* (*Mortoniceras*) *inflatum* (Sowerby): Aly et al., p. 365; pl. 5, fig. 1.
2007 *Mortoniceras* (*Mortoniceras*) *inflatum* (Sowerby): Mosavinia et al., p. 85; figs. 4A-B, 5A-B, 7C-D.
2008 *Mortoniceras inflatum* (Sowerby): Abu-Zied, figs. 7Q-S.
2011 *Mortoniceras (Mortoniceras) inflatum* (Sowerby): Gale et al., figs. 24 A, C-F.

Holotype. OUM Buckland collection, original specimen of Sowerby (1818, pl. 178) from the upper Albian (Sandstone and Rag Series) of the Isle of Wight, England.
Material. RD1, RD3, RD18, RD43, RD66, RD90 from bed P4 and Ed15 interval, El Mizab 2 section.
Description. Our best preserved specimens are RD1 (Fig. 12D1–2) and RD90 (Fig. 12E1–2). RD1 is a probable juvenile specimen with 170 mm in diameter; the body chamber is preserved on almost a half whorl; the coiling is evolute (U/D = 0.47); the umbilical wall is shallow and rounded, with broadly rounded shoulder; the whorl section is moderately compressed (Wb/Wh = 0.88 on the phragmocone and 1 on the body chamber), rounded-trapezoidal with a broad fastigiate-carinate venter and slightly convex flanks; there are 20 primary ribs on the last preserved whorl, which are low on the umbilical shoulder, giving rise to a coarse umbilical tubercle; most of the primary ribs tend to be bifurcated from the umbilical tubercle on the phragmocone; the outer whorls show regularly alternating primary and intercalatory ribs, the latter arising on the inner third of the flanks; all ribs (27 on the last preserved whorl) are straight radial or weakly concave, bearing a small lateral tubercle at the mid-flank and a strong, coarse, rounded ventrolateral tubercle; these latter give rise to a coarse rib that sweeps forwards across the ventrolateral shoulder and the venter, and declines markedly and ends before the low siphonal keel.
RD90, is a phragmocone of 100 mm in diameter, shows a similar ornamentation to that of the specimen RD1, with a rectangular whorl section, higher than wide and well-developed elongated mid-lateral tubercles. RD43 (Fig. 12G) and RD18 (Fig. 12F1–2) are fragments of large specimens showing a sub-quadratic whorl section and well-developed mid-lateral tubercles.
Discussion. Our material falls within the range of variability as described by Amédro et al. (2004). Despite the low number of our specimens, three varieties of *M. (M.) inflatum* can be distinguished:

Variety a (Fig. 12D1–2), is identical to the holotype figured by Amédro et al. (2004, pl. 1, figs. 1a-c), associated specimens (Ibid., pl. 1, figs. 4a-b; pls. 3-4), and specimens figured by Mosavinia et al. (2007, figs. 5a-b), i.e. characterized by a medium size, simple or bifurcate ribs of rounded relief; both slightly broad and spaced, with weakly developed umbilical and lateral tubercles, and a rectangular to slightly oval, higher than wide section;

Variety b (Fig. 12E1-2, F1-2), is also of medium size, with acute, mostly simple and spaced ribs, well-developed umbilical and ventrolateral tubercles, and a compressed rectangular, higher than wide section. This variety is close to the specimens figured by Amédro et al. (2004, pl. 8, figs. 1-2), Collignon (1966), Collignon and Faure-Muret (1968), and Mosavinia et al. (2007, figs. 7c-d);

Variety c (Fig. 12G), is of larger size, displaying well-developed lateral tubercles, and a sub-quadratic, quite as high as wide section. This variety is close to the specimens figured by Marcinowski and Naidin (1976, pl. 3, figs. 1a-c), Amédro et al. (1995, pl. 3, fig. 3), Mosavinia et al. (2007, figs. 4a-b), and Marcinowski and Wiedmann (1990).

Occurrence. *Mortonicera (M.) inflatum* (Sowerby, 1818) has a wide paleogeographical distribution, being reported from the *M. inflatum* Zone of Anglo-Paris Basin (Amédro et al., 1995; Amédro et al., 2004), SE France (Latil, 1995; Gale et al., 2011), Spain (López-Horgue et al., 2009), Crimea (Marcinowski and Naidin, 1976), Iran (Mosavinia et al., 2007), Egypt (Aly et al., 2005; Abu-Zied, 2008), Poland (Marcinowski and Wiedmann, 1990), Morocco (Collignon, 1966, Collignon and Faure-Muret, 1968, and this work), Tunisia and Germany (Lehmann et al., 2008).

Mortoniceras (Mortoniceras) fallax (Breistroffer, 1940)
Fig. 12H1–2

1932 *Mortoniceras* (*Pervinquieria*) *rostratum* (Sowerby): Spath, p. 400 (pars); pl. 40, fig. 1.
1932 *Mortoniceras* (*Pervinquieria*) *kiliani* (Lasswitz): Spath, p. 408; pl. 38, fig. 1.
1940 *Pervinquieria fallax* Breistroffer, p. 137.
?1979 *Pervinquieria (Pervinquieria) fallax* (Breistroffer): Wiedmann, pl. 3, fig. 1.
2008 *Mortoniceras (Mortoniceras) fallax* (Breistroffer): Kennedy et al., p. 42; pl. 6, figs. 1-3; pl. 7, figs. 1-2; pl. 10, figs. 8-11, 16 (with synonymy).
2008 *Mortoniceras (Mortoniceras) fallax* (Breistroffer): Amédro, pl. 1, fig. 1; pl. 2, figs. 2-3; pl. 7.
2008 *Mortoniceras* (*Mortoniceras*) aff. *fallax* (Breistroffer): Amédro, pl. 8.
2008 *Mortoniceras (Mortoniceras) pachys* (Seeley): Amédro, pl. 9, fig. 1.
2011. *Mortoniceras (Mortoniceras) fallax* (Breistroffer): Gale et al., fig. 25E.
2014 *Mortoniceras* (*Mortoniceras*) *pachys* (Seeley): Amédro & Matrion, fig. 20.

Holotype. SMC B56, original specimen of Spath (1932, pl. 40, fig. 1) from the phosphatized upper Albian fauna at the base of the lower Cenomanian Cambridge Greensand of Cambridgeshire, England.
Material. A single fragment, RD8, from the upper part of the Lower shelly marly limestones member, El Mizab Formation, north side of Jebel Nesrani.
Description. RD8 (Fig. 12H1–2) is a fragment with a whorl height of 40 mm, showing flat flanks and a trapezoidal whorl section; strong radially elongated umbilical bullae giving rise to one or two coarse, straight radial ribs; there is a lateral elongated tubercle, just above

Fig. 12. Uper Albian ammonites of the studied area. **A**–**B**. *Mortoniceras (D.) bipunctatum* Spath, 1933, *M. pricei* Zone; **A**. RD19, lateral view, Ed20 interval, El Mizab 2 section; **B**. RD20, lateral view, Ed25 interval, El Mizab 2 section; **C**. *Mortoniceras (M.) pricei* (Spath, 1922), RD21, *M. pricei* Zone, **C1**, lateral view, **C2**, ventral view, Adn2-3 interval, EL Mizab 1 section; **D**–**G**. *Mortoniceras (M.) inflatum* (Sowerby, 1818), *M. inflatum* Zone; **D**. RD1, **D1**, lateral view, **D2**, apertural view, bed P4, El Mizab 2 section; **E**, RD90, **E1**, lateral view, **E2**, ventral view, Ed15 interval, El Mizab 2 section; **F**. RD18, **F1**, lateral view, **F2**, ventral view, Ed15 interval, El Mizab 2 section; **G**. RD43, lateral view, Ed15 interval, El Mizab 2 section; **H**. *Mortoniceras (M.) fallax* (Breistroffer, 1940), RD8, *M. fallax* Zone, **H1**, lateral view, **H2**, ventral view, Jebel Nesrani section; **I**. *Mortoniceras (M.) pachys* (Seeley, 1865), RD7, *M. fallax* Zone, **I1**, lateral view, **I2**, ventral view, **I3**, apertural view, bed P5, El Mizab 2 section.

the mid-flank; all ribs bear a coarse conical tubercle; the flank bears weak spiral depressions, flat venter shows thick ribs that are strongly inflected forward, forming a chevron; the blunt siphonal keel is of the same height as the ribs and separated of these by two smalls and smooth flat grooves.
Occurrence. This species occurs in the *M. fallax* Zone of Belgium (Kennedy et al., 2008), the Anglo-Paris Basin (Amédro, 2008; Amédro and Matrion, 2014), SE France (Breistroffer, 1940; Gale et al., 2011), northern Spain (Wiedmann, 1979), Morocco (this work), England (Spath, 1932) and Armenia (Atabekian, 1992).

Mortoniceras (Mortoniceras) pachys (Seeley, 1865)
Fig. 12I1–3

1865 *Ammonites pachys* Seeley, p. 227; pl. 9, fig. 4.
1932 *Mortoniceras* (*Pervinquieria*) *pachys* (Seeley): Spath, p. 405; text-fig. 130d, 138-139.
?1968 *Pervinquieria pachys* Seeley: Collignon & Faure-Muret, p. 21; pl. 1, fig. 2.
?1992 *Mortoniceras pachys* Seeley: Atabekian, p. 211; pl. 127, fig. 5; pl. 128, fig. 1.
2008 *Mortoniceras (Mortoniceras) pachys* (Seeley): Kennedy et al., p. 43.

Holotype. SMC B54 from the reworked upper Albian phosphates at the base of the Cenomanian Cambridge Greensand in eastern England (Seeley, 1865; Spath, 1932), redescribed by Kennedy et al. (2008, p. 42; pl. 10, figs. 9-11).
Material. RD7 is a juvenile specimen from bed P5, El Mizab 2 section.
Description. RD7 (Fig. 12I1–3) is a well-preserved phragmocone, 57 mm in diameter, without any visible suture line; the coiling is moderately evolute, and the umbilicus shallow, becoming deeper with age and comprising 36% of the diameter; the umbilical shoulder is broadly rounded; the whorl section is slightly depressed (Wb/Wh = 1.22), with flattened and subparallel flanks; the ventrolateral shoulders are rounded; the ribs are delicate and straight, broadening and strengthening across the ventrolateral shoulder; there are 20 primary ribs on the last whorl arising on the umbilical wall and strengthen into strong radially elongated umbilical bullae; they almost always bifurcate on the inner third of the flanks, giving rise, on the last whorl, to 36 secondary ribs; there is a shallow depression between the inner third and middle part of the flank and a bullae above mid-flank, tending to be attenuated with age, and a small conical ventrolateral tubercle; the venter is broad and slightly convex, with rapid development, and a smooth rounded siphonal keel of similar height as the ribs; these are thick broad and crescentic, concave forward; they are separated from the keel by two narrow grooves.
Discussion. *Mortoniceras (M.) pachys* (Seeley, 1865) differs from *Mortoniceras (M.) fallax* (Breistroffer, 1940), by the presence of a spiral depression between the periumbilical and lateral tubercles, the position of the lateral tubercle above the mid-flank even on the juvenile and its broad venter. The specimen figured by Collignon (1966, p. 21; pl. 1, fig. 2) as *Pervinquieria pachys* Seeley differs from our specimen by the presence of inconspicuous lateral tubercles. The specimen from Armenia figured by Atabekian (1992, pl. 127, fig. 5; pl. 128, fig. 1), differs from *M. (M.) pachys* by the position of lateral bullae at the mid-flank and the presence of a spiral depression between lateral and ventrolateral bullae. Amédro (1992, p. 212) suggested that *M. (M.) fallax* (Breistroffer, 1940) could represent a depressed form of *M. (M.) pachys* (Seeley, 1865). This is not supported by our material.
Occurrence. *M. fallax* Zone, France (Amédro and Matrion, 2014), Belgium (Kennedy et al., 2008), Poland (Marcinowski and Wiedmann, 1990), England (Spath, 1932), Armenia (Atabekian, 1992) and Morocco (Collignon and Faure-Muret, 1968, and this work).

8. Conclusion

Lithostratigraphical analysis of more than ten sections of the El Mizab Formation from the Talerhza Basin of the South Riffian Ridges, previously assigned to “Vraconnian”, allowed to distinguish a constant succession of five members. The second member and the base of the fourth one yielded a rich ammonite fauna including: *Hypengonoceras faugeresi* sp. nov, *Mortoniceras (M.) pricei* (Spath, 1922), *Mortoniceras (D.) cunningtoni* Spath, 1933, *Mortoniceras (D.)* aff. *albense* Spath, 1933, *Mortoniceras (D.)* sp., *Mortoniceras (M.) inflatum* (Sowerby, 1818), *Mortoniceras (M.) pachys* (Seeley, 1865), *Mortoniceras (M.) fallax* (Breistroffer, 1940) and *Oxytropidoceras (T.)* cf. *bituberculatum* Collignon, 1966. These species characterize three ammonite biozones of the upper Albian substage: *M. pricei*, *M. inflatum* and *M. fallax*. The *M. inflatum* Zone was the only one previously identified by Collignon and Faure-Muret (1968). The first member, which has not yielded any ammonites, may belong to the *D. cristatum* Zone? The fifth one, very rich in *Rhynchostreon suborbiculatum* (Lamarck, 1801), could be early? Cenomanian age. The two underlying formations: El Heitouf and Bab Lkarma, previously assigned to the upper Albian (*M. inflatum* Zone), may have an early to middle Albian age. The late Albian ammonites (and bivalves) from the Talerzha Basin are characteristic of a shallow outer-shelf environment and they are similar in terms of their size and specific association to some upper Albian ammonite assemblages from other marginal or epicontinental basins of the Atlantic Ocean (Tarfaya Basin, Anglo-Paris Basin, Texas,…) and the Tethyan Realm (Tunisia, Egypt, Iran,…). This faunal similitude can be explained by comparable prevailing palaeo-ecologique and palaeo-bathymetric environments that were favorable to the development of these marine faunas.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Acknowledgments

The authors wish to express their most sincere thanks to Dr Eduardo Koutsoukos, Editor-in-Chief of Cretaceous Research, for submitting the manuscript to the experts' judgments, and to Dr Elena Yazykova, Associated Editor, for her remarks and advice. They are also grateful to Dr. Luc G. Bulot (Aix-Marseille) and an anonymous reviewer for their valuable advice, highlighted comments and constructive suggestions. M. B. sincerely appreciate the preliminary discussions with Luc G. Bulot who provided literature and opinions that helped improving the taxonomic study and overall quality of this work.

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