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Revision of "Falaise de BLANCHE" (Lower Cretaceous) in Lebanon, with the definition of a Jezzinian Regional Stage

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Abstract: The "Falaise de BLANCHE" is a prominent cliff, consisting mostly of Lower Cretaceous limestones that extends as linear outcrops over most of the Lebanese territory and provides geologists a remarkable reference for stratigraphic studies. However, until now, this unit was lacking a clear definition. We introduce herein the Jezzinian Regional Stage, the type-locality of which is at Jezzine. It equates as an unconformity-bounded unit and, per definition, it is framed by two discontinuities. Because we identified an additional, median sequence-boundary, poorly-expressed in the type-section but better at Aazour, only 4.5 km westward of Jezzine, the new regional stage implicitly spans two sequences. The lithostratigraphic framework being properly redefined, we were able to investigate time-constrained micropaleontological assemblages, consisting mostly of benthic foraminifers and calcareous algae. Typically Southern Tethysian, these assemblages contribute to high-resolution, holostratigraphic correlations with the Persian Gulf area, on the eastern part of the Arabian Plate. The Jezzinian interval correlates with the upper part of the Kharaibian Regional Stage (also known as "Thamama II" reservoir unit in the oil industry). In turn, the Jezzinian is indirectly correlated with the Northern Tethysian Urgonian stratigraphic units where it corresponds to a rather short interval encompassing the standard Barremian - Bedoulian stage boundary. Locally the upper discontinuity is associated to a significant intra-Bedoulian hiatus. The macrofossil assemblages found in the Jezzinian (echinids) and above it (ammonites) support, or at least do not contradict, our micropaleontological dating.

Key Words: Lebanon; Lower Cretaceous; Barremian; Bedoulian; Aptian *auct.*; Falaise de BLANCHE; Jezzinian Regional Stage; rudists; echinids; ammonites; foraminifers; Dasycladales.

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Résumé : ***Révision de la "Falaise de BLANCHE" (Crétacé inférieur) au Liban et définition de l'Étage Régional Jezzinien.-*** Les calcaires du Crétacé inférieur de la "Falaise de BLANCHE" affleurent sur une grande partie du territoire libanais. Ils apparaissent dans le paysage sous forme d'escarpements linéaires saillants constituant autant de points d'ancrage remarquables pour tout recalage stratigraphique. Toutefois, jusqu'à très récemment, cette unité était piètrement caractérisée : il lui manquait notamment une définition rigoureuse. Nous introduisons ici l'Étage Régional Jezzinien, dont la localité-type est sise à Jezzine. Il s'agit d'une unité stratigraphique particulière, aussi appelée U.B.U. (pour "unconformity-bounded unit"), une unité qui, par définition, est encadrée par deux discontinuités. Parce que nous avons identifié une limite de séquence supplémentaire, en position médiane, peu exprimée dans la section-type, mais beaucoup mieux à Aazour, à 4,5 km à peine à l'ouest de Jezzine, le nouvel étage régional devrait implicitement couvrir deux séquences. Le canevas lithostratigraphique étant clairement redéfini, nous avons pu étudier les associations micropaléontologiques, constituées essentiellement de foraminifères benthiques et d'algues calcaires, associations dorénavant relativement bien contraintes du point de vue de leur âge. Typiquement sud-téthysiennes, elles facilitent les corrélations holostratigraphiques à haute résolution avec la région du Golfe persique, sur le côté oriental de la Plaque arabique. L'intervalle Jezzinien correspond ainsi à la partie supérieure de l'Étage Régional

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Kharaibien (aussi connu comme unité réservoir "Thamama II" dans l'industrie pétrolière). À son tour, le Jezzinien est indirectement corrélé avec les unités stratigraphiques urgoniennes nord-téthysiennes où il correspond à un intervalle relativement court comprenant la limite des étages standards (internationaux) Barrémien et Bédoulien. Localement la discontinuité sommitale est associée à un hiatus intra-Bédoulien significatif. Les associations macropaléontologiques reconnues dans le Jezzinien (échinides) et au-dessus de cette unité (ammonites) viennent à l'appui de notre datation micropaléontologique ou tout au moins ne la contredisent pas.

Mots-clefs : Liban ; Crétacé inférieur ; Barrémien ; Bédoulien ; Aptien *auct.* ; Falaise de BLANCHE ; Étage Régional Jezzinien ; rudistes ; échinides ; ammonites ; foraminifères ; Dasycladales.

1. Introduction

The "Falaise de BLANCHE" is a sheer-sided limestone cliff of alleged Aptian *sensu lato* (Bedoulian - "Gargasian") age that trends throughout the chains of Mount Lebanon, Anti-Lebanon (Lebanon: Fig. 1), Southern Alawite Mountains (Syria) and northern Galilee. This distinctive geomorphological unit forms the natural bridge of Fakra-Kfardebiane (Fig. 2) and the background of the waterfalls at Jezzine (Fig. 3), where it is some 70 meters in height. Actually DUBERTRET (1955: p. 20) was the first to attempt - unsuccessfully - to re-label it as "Falaise de Djezzine" after the name of this last locality. This stratigraphical unit required a full re-evaluation as, for instance, HEYBROEK (1942) and later DUBERTRET (1947) stated that it consists of a "calcaire récifal blanc" [a white reefal limestone], an assumption that is not consistent with our field observations and the scarcity of corals. Furthermore, it was lacking a type-locality and clear definitions of its lower and upper boundaries. Finally, there are also many interpretations regarding its dating: DUBERTRET (1963) claimed a late Aptian (= "Gargasian") age for his unit "c2b" (*op. cit.*: p. 43: "depuis la muraille de BLANCHE jusqu'à la base des bancs à *Cardium*") while the fossiliferous strata below it, *i.e.*, his unit c2a, should be early Aptian (= Bedoulian) in age; on the other hand, SAINT-MARC (1970), without excluding a late Aptian age for the uppermost layers, assumed its mainly early Aptian age. However due partly to the recent updates in the definitions and our understanding of the Barremian [1], Bedoulian and Aptian [2] stages and substages in their historical stratotypic areas these old datings should be fully reconsidered.

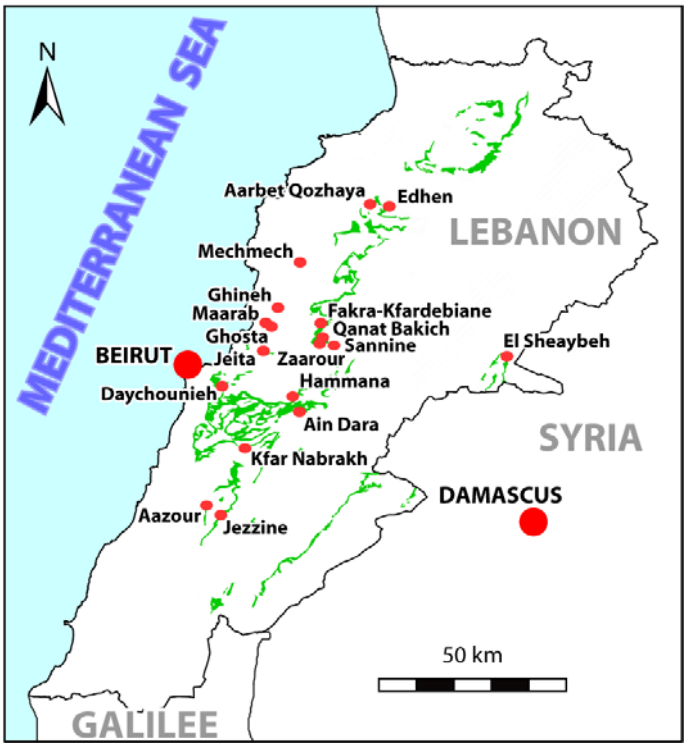


Figure 1: A simplified map of Lebanon showing the Jezzinian Regional Stage in green. Localities cited in the publication:

- South Governorate: Aazour, Jezzine and Wadi Jezzine, Jezzine District;
- Beirut Governorate: Beirut, Beirut District;
- Bekaa Governorate: El Sheaybeh, Baalbeck District;
- North Governorate: Aarbet Qozhaya and Ehden, Zgharta District;
- Mount Lebanon Governorate:
  - Ain Dara, Aley District;
  - Hammana, Baabda District;
  - Kfar Nabrakh, Chouf District;
  - Fakra-Kfardebiane, Ghineh, Ghosta, Jeita, Kanat Bakich and Maarab, Keserwan District;
  - Mechmech Jbeil, Jbeil District;
  - Daychounieh and Sannine, Matn District.

[1] *In 1998, the Barremian-Bedoulian boundary was moved upward from bed 45 to bed 60 in the historical stratotypic section of the Bedoulian (*MOULLADE et al., *1998).*

[2] MOULLADE et al. *(2011) recommended a new status for the Aptian substages, raising them to the rank of genuine stages. Accordingly the lower Aptian* sensu anglico et gallico *would equate with the historical Bedoulian; the Gargasian (middle Aptian* sensu gallico*) should be treated as a junior synonym of the historical Aptian* auct. *[there are no Bedoulian strata in Apt, nor in Gargas]. At La Bédoule, in the historical stratotypic section of the Bedoulian, the boundary between the Bedoulian and the Aptian* auct. *is located on top of bed 170 (*MOULLADE et al., *2011).*

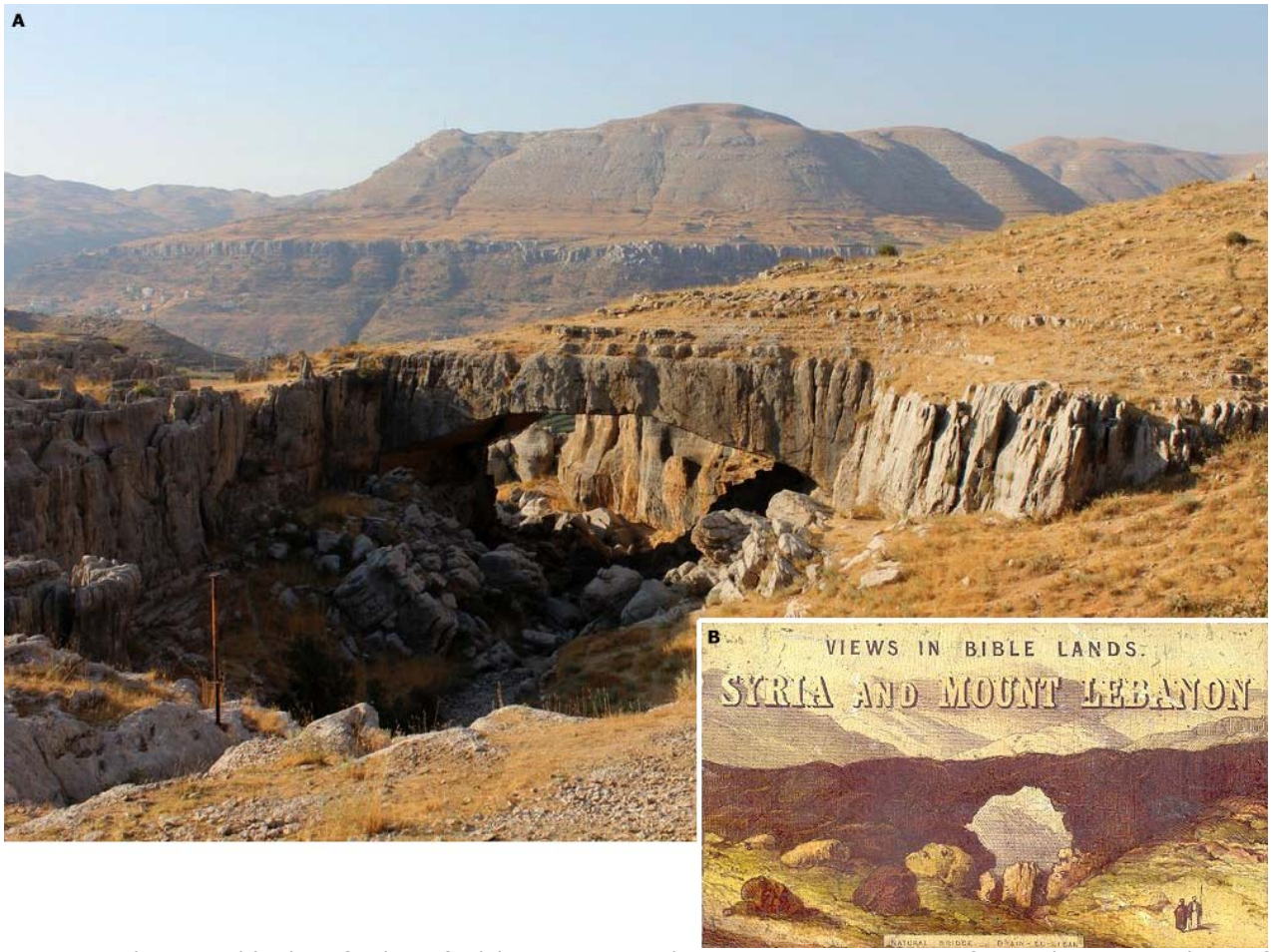


Figure 2: The natural bridge of Fakra-Kfardebiane. **A:** Nowadays view; **B:** Front cover of a XIXth Century edition of the book "*Views in Bible lands. Syria and Mount Lebanon*".

After summing up the notes of earlier authors (BLANCHE, 1847; FRAAS, 1878; DIENER, 1886; DOUVILLÉ, 1910, 1913; ZUMOFFEN, 1926; DUBERTRET, 1934, 1947, 1955, 1963; DUBERTRET & VAUTRIN, 1937; SAINT-MARC, 1970, 1972), we propose herein a new holostratigraphic definition for this unit, *i.e.*, a definition based on our faciological, lithostratigraphical, sequential, and paleontological analyses. The microfossil assemblages are compared with those of the Persian Gulf, because both areas belong to the same tectonic plate, *i.e.*, the Arabian Plate.

2. Review of past lithostratigraphic information and new definition

The discrete geological/morphological unit corresponding to "Falaise de BLANCHE" was named by DOUVILLÉ (1910) after Charles-Isidore BLANCHE (1823-1887). According to BLANCHE (1847, p. 14-15), it consists of "8º Un calcaire jaunâtre, terreux, à texture parfaitement oolithique" [8th) A yellowish limestone, earthy, with a purely oolitic texture], below, and "7º (...) un calcaire blanc, très dur, très compacte, à grain extrêmement fin et presque cristallin" [7th) a very hard and compact, white micritic limestone], above (Table 1) [Note that BLANCHE described the section from top to bottom]. This unit represents the "Gastropodenzone von Abeih" of FRAAS (1878), sandwiched between his "Sandsteinzone des Libanon" below and his "Braune Kreide (Cardiumbänke)" above. In 1963, for the edition of the "Lexique Stratigraphique International", DUBERTRET re-labelled the Gastropodenzone as "Falaise de Mdairej" and the Sandsteinzone as "Grès de Base". Unfortunately, for the neighborhoods of Beirut, he introduced an unnamed transitional zone (*op. cit.*: p. 56) consisting of "170 m de terrains argilo-sableux et calcaires fossilifères" [170 m of shaley to sandy and fossiliferous calcareous strata] between "Falaise de Mdairej" and "Grès de Base". WALLEY's "revision" (1983) merely introduced new names for the old units (from base to top "Chouf Sandstone Formation", "Mdairej Formation", and "Hammana Formation"). However, he failed to give clear definitions for most of these newly re-labelled lithostratigraphic units and he even added more confusion as, for instance, he ascribed a formal name to DUBERTRET's transitional unit (*i.e.*, "Abeih Formation") without providing any data supporting its distinctiveness among the Lebanese Cretaceous formations (Table 1).

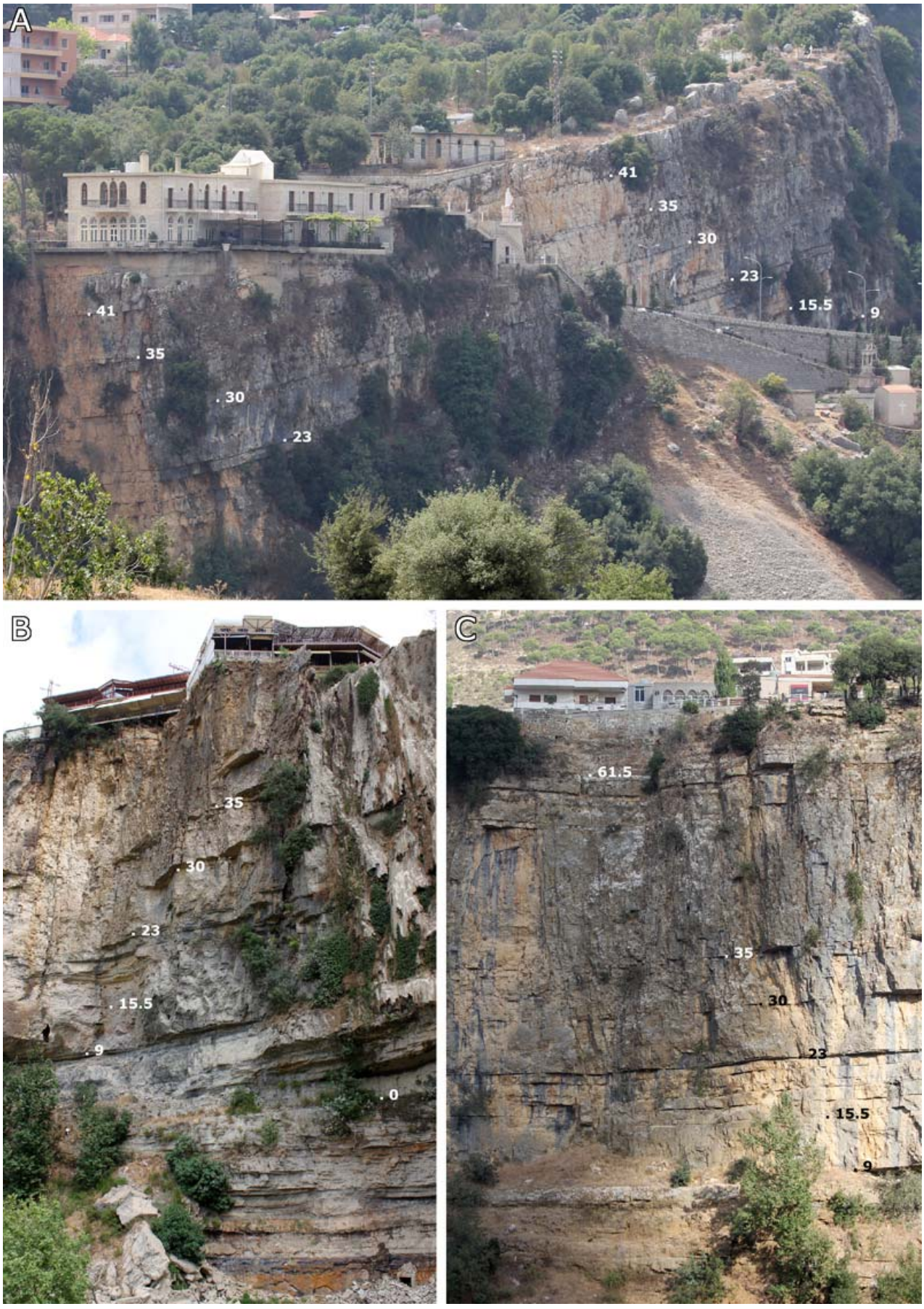


Figure 3: The cliff at Jezzine and Wadi Jezzine. **A:** The eastern side with the road section (see Log); **B:** The waterfall and the lower boundary at 0 m; **C:** The western side and the upper boundary at 61.5 m. Number labels refer to the metrics from the road section.

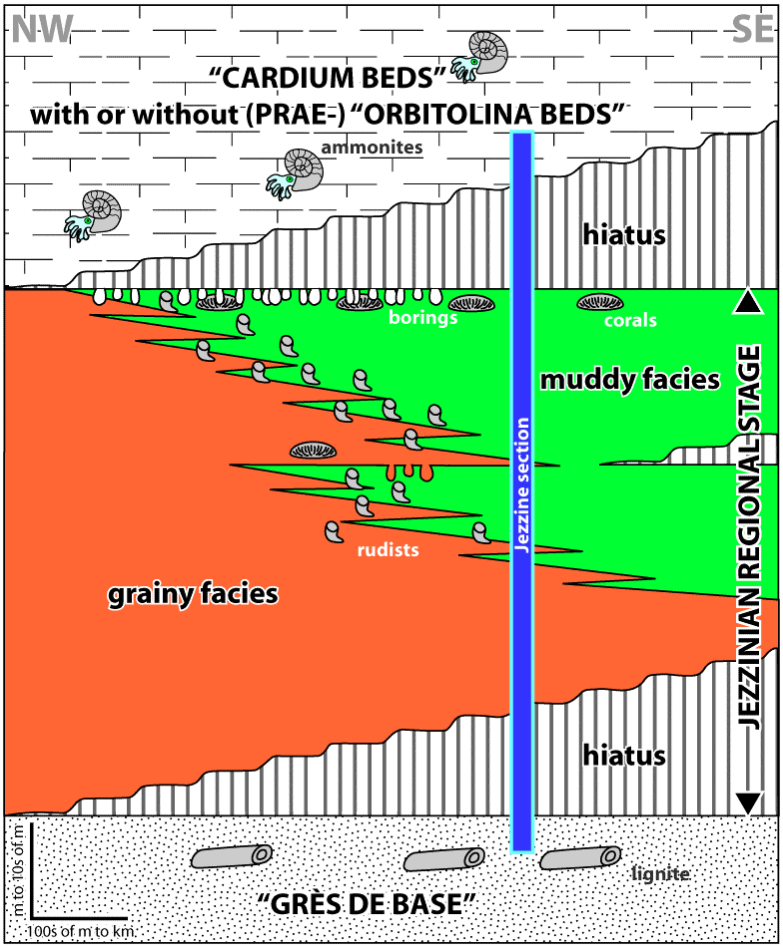


Figure 4: Lithostratigraphic scheme of the Jezzinian Regional Stage showing the two bounding sequence boundaries (SB) - transgressive surfaces (TS). For a simplification purpose, each hiatus does not take erosion in consideration, but only non-deposition. Similarly, the median boundary and the associated hiatus are not illustrated.

The lithostratigraphic approach of DUBERTRET (as that of WALLEY) is essentially facies-driven:

1) grain-dominated, shoal facies (oolitic and bioclastic wackestones and grainstones) are referred to the Abeih Formation;

2) mud-dominated, lagoonal facies (mudstones and bioclastic wackestones, with some gastropod floatstones) to the "Falaise de BLANCHE" or Mdairej Formation (Table 1). DUBERTRET (1947) described it as "calcaire blanc récifal" [white reef limestone] (DUBERTRET, 1963: p. 44), but there is no evidence of a reef environment. DUBERTRET (1963) named it "Falaise de Mdairej" after he established its type-section in this locality. Nowadays, the section is no longer available because of recent urbanization.

The micritic facies ("Mdairej") are commonly found in the upper part of most sections, above the calcarenitic facies ("Abeih"). They may locally be missing or interfinger with the later, suggesting that these areas represent transition zones between a shoal barrier and a protected lagoon behind it. This geometrical relationship is merely the signature of regular lateral changes in facies within a single time-unit. In addition, the orbitolinid and algal assemblages are very similar in both of these units. Rather than using the obsolete and meaningless facies-driven units, we have adopted the concepts of "Unconformity Bounded Unit", *i.e.*, UBU, or Alloformation (MURPHY & SALVADOR, 1999; see GRANIER, 2000, for application in the Middle East), or "Regional Stage" (see GRANIER *et al.*, 2011).

The term "Falaise de BLANCHE" is obviously ambiguous; first because some authors confused this unit with the "*Cardium* Beds" and others ignored the grainy facies that should be included, second because the term describes a geomorphological feature rather than a stratigraphic unit. Hence, we selected Jezzine (Jezzine District, South Governorate, Lebanon) as the most representative locality to define the Jezzine UBU, Jezzine Alloformation and Jezzinian Regional Stage, all of these terms being synonymous in our understanding (Fig. 4), as the interval having:

1) the lower boundary corresponding to the sequence boundary at the top of the siliciclastic coastal and estuarine deposits of the "Grès de Base". This paleoenvironmental interpretation is suggested by the occurrence of marine bivalves in bioturbated sands and shales, in association with lignite. At the Jezzine waterfall, the boundary, which is amalgamated with a transgressive surface at the top of the underlying siliciclastic unit, occurs directly above a lignite-rich horizon (Figs. 3.A-B : 0, and 5). "Floated" amber clasts found in such lignite-rich levels yield numerous biological inclusions, mostly Early Cretaceous arthropod remains (AZAR, 1997; AZAR *et al.*, 2010), previously thought to be Bedoulian-Aptian in age (AZAR *et al.*, 2003). Not far from Jezzine, outcrops have charophyte remains (GRAMBAST & LORCH, 1968; TIXIER, 1972; note: the material was originally collected by TIXIER, 1965), which in places are associated with the Triploporellacean alga *Salpingoporella dinarica* (RADOIČIĆ, 1959) and the foraminifer *Choffatella* gr. *decipiens* SCHLUMBERGER, 1905 (GRANIER *et al.*, work in progress);

<table>
<tr><th>Blanche (1847)</th><th>Fraas (1878)</th><th>Zumoffen (1926)
Dubertret (1934)</th><th>Dubertret & Vautrin (1937)</th><th>Heybroek (1942)</th></tr>
<tr><td rowspan="2">6th) yellowish limestone, earthy or crystalline [6e calcaire jaunâtre, terreux ou cristallin] with ammonites</td><td>5. Zone des Ammonites syriacus</td><td>"Vraconien"</td><td rowspan="2">"Albien"</td><td>Couches à Knemiceras</td></tr>
<tr><td rowspan="2">4. Cardiumbänke, braune Kreide</td><td rowspan="2">Banc à Cardium

"Albien"</td><td>Banc de Zumoffen</td></tr>
<tr><td>7th) very hard and compact, white limestone [7e calcaire blanc, très dur, très compacte]</td><td rowspan="2">"Aptien supérieur"</td><td>Couches à Orbitolines</td></tr>
<tr><td>8th) yellowish limestone, earthy, with a purely oolitic texture [8e calcaire jaunâtre, terreux, à texture parfaitement oolithique]</td><td rowspan="2">3. Gastropodenzone von Abeih</td><td rowspan="2">"Aptien"</td><td>Muraille de Blanche</td></tr>
<tr><td rowspan="2">9th) Sands and clays with lignite [9e sables et argiles à lignite]</td><td rowspan="2">"Aptien inférieur"</td><td>Couches à Gastéropodes

Banc de Mréjatt</td></tr>
<tr><td>2. Sandsteinformation des Libanon</td><td>"Néocomien"</td><td>"Néocomien"</td><td>Calcaires à pisolithes
Grès lignitifères</td></tr>
</table>

Table 1: Summary of the attributed terminology to the Jezzinian and its surrounding units over the period 1847 to date.



Figure 5: Lignite horizon below the transgressive surface on the main road section at the entrance of Jezzine (hammer for scale).

2) the upper boundary corresponding to another sequence boundary at the top of the muddy facies. In Jezzine, it is also amalgamated with a transgressive surface; the next sequence starts with a bioclastic orbitolinid-rich limestone (Fig. 3.C : 61.5). In other localities, these bioclastic limestones may be missing and a marly facies with orbitolinids and eventually scattered ammonites is found lying directly above the micritic limestones. In some places coral colonies are concentrated in strata lying below this upper boundary and locally emersion evidences (fenestrae, casts or molds of former aragonitic bioclasts filled with sediment) are found there too. The surface itself may be encrusted by oysters and bored by worms and pholadids (Fig. 6.A-B, D & G-F), indicative of an early lithification of the muddy sediment.

At Jezzine, we measured the type-section on the side of the main road at the entrance to the town (Fig. 3.A). There it is more than 48 m thick (Log) because it reaches some 61.5 m (estimated) in the nearby cliff section at Wadi Jezzine (Fig. 3.B-C). The detail of the section will be the main topic of a forthcoming publication. It is worth mentioning that in Jezzine area muddy facies dominates over grainy facies. On the opposite, in other localities (for instance, in Aazour, only 4.5 km WNW of Jezzine, or at Aarbet Qozhaya: Fig. 1), grainy facies dominates over muddy facies. In these localities the occurrence of a muddy "tongue" in the grainy facies led us to identify a median unconformity on top of the muddy "tongue": at Aarbet Qozhaya, it consists of a burrowed and bored surface (Figs. 6.C&E and 7), and therefore to discriminate two Jezzinian subunits/sequences.

<table>
<tr><th>Dubertret (1963)</th><th>Saint-Marc (1970)</th><th>Walley (1983)</th><th>This work</th></tr>
<tr><td rowspan="2">C3</td><td>Couches à Knemiceras</td><td rowspan="3">Hammana Fm</td><td>Knemiceras beds</td></tr>
<tr><td>Banc à Cardium</td><td>Cardium beds</td></tr>
<tr><td rowspan="2">C2b</td><td>Couches à orbitolines</td><td>Praeorbitolina beds</td></tr>
<tr><td>Falaise de Blanche</td><td>Mdairej Fm</td><td rowspan="2">Jezzinian Regional Stage
with both muddy
and grainy facies</td></tr>
<tr><td>C2a</td><td rowspan="2"></td><td>Abeih Fm</td></tr>
<tr><td>C1</td><td>Chouf Fm</td><td>"Grès de base"</td></tr>
</table>

Having identified the key facies and defined the lithostratigraphical and sequential framework, we can review the fossil contents and biostratigraphic interpretations.

3. Biostratigraphic review

On the basis of macrofossil finds, FRAAS (1878) proposed the first chronostratigraphic framework for the "Late Cretaceous" Lebanese units. According to DIENER (1886), FRAAS' succession consisting from base to top of the *Sandsteinzonze*, the *Gastropodenzone* and the *Cardiumbanke* is respectively Cenomanian in age for the first unit and Turonian for the last two.

According to DOUVILLÉ (1910) and DUBERTRET (1934), the mud-dominated facies of "Falaise de BLANCHE" should be referred to the Albian. However actually, some age-diagnostic fossils were collected by a third person from a discrete cliff located above the "Falaise de BLANCHE", *i.e.*, "Falaise de ZUMOFFEN" [see discussion below]. In his later publications, DUBERTRET (DUBERTRET & VAUTRIN, 1937; DUBERTRET, 1955, 1963) ascribed this facies to the "Aptien supérieur" (*i.e.*, Aptian *auct.*). He mentioned some macrofossils (echinids, rudists and pelecypods) and few microfossils (orbitolinids). SAINT-MARC (1970) was the first to base his dating mainly on micropaleontological data. He identified several benthic foraminifers and calcareous algae that led him to ascribe the "Falaise de BLANCHE" an Aptian age: both "inférieur" (early, *i.e.*, Bedoulian), most of it actually, and "supérieur" (late, *i.e.*, Aptian *auct.*), as he did not exclude this dating at least for the uppermost strata. The overlying "couches à Orbitolines" (*Orbitolina* Beds), an unformal unit he introduced (SAINT-MARC, 1970), can be treated either as part of the *Cardium* Beds of previous authors or as a junior synonym.

4. Review of paleontological data

Since 1910 many fossil finds have been reported in the Lebanese literature.

4.1) Macrofossils

4.1.a) Rudists

DOUVILLÉ (1910, 1913) identified some rudists from Lebanon but he did not collect the materiel himself. For instance, he identified *Polyconites verneuili* BAYLE, 1860 (1913: Pl. IX, figs. 1-3) and *Eoradiolites plicatus* CONRAD, 1852 (DOUVILLÉ, 1910: Figs. 71-75; DOUVILLÉ, 1913: Pl. IX, fig. 5) among the specimens collected by ZUMOFFEN (DOUVILLÉ, 1913: p. 409; ZUMOFFEN, 1926) from a small cliff consisting of a compact limestone and misinterpreted as "Falaise de BLANCHE" (DUBERTRET, 1963). In fact, this cliff is located above "Falaise de BLANCHE". Both species, *Polyconites verneuili* and *Eoradiolites plicatus*, are known from the Aptian *auct.* - Albian interval (MASSE, 1995; SKELTON & MASSE, 2000).

DOUVILLÉ (1913) also identified *Agria marticensis* ORBIGNY, 1847 (*op. cit.*: Pl. IX, fig. 4), in material collected by ZUMOFFEN (*op. cit.*: p. 409) probably from the base of the "Falaise de BLANCHE" and ascribed to the Aptian. Actually, it is not a genuine *Agriopleura marticensis* as it was re-labelled *Agriopleura libanica* by ASTRE (1930; MASSE & FENERCI-MASSE, 2014).

HEYBROEK (1942, p. 44) reported the find of "*Toucasia* sp." at the "sommet de Muraille de BLANCHE" in Kfer Matta [= Kfarmatta], near Abeih. This record was forgotten by subsequent authors.

The identification and the age of these rudists require revision. In addition new rudistid finds are under evaluation (J.-P. MASSE *et al.*, in preparation).

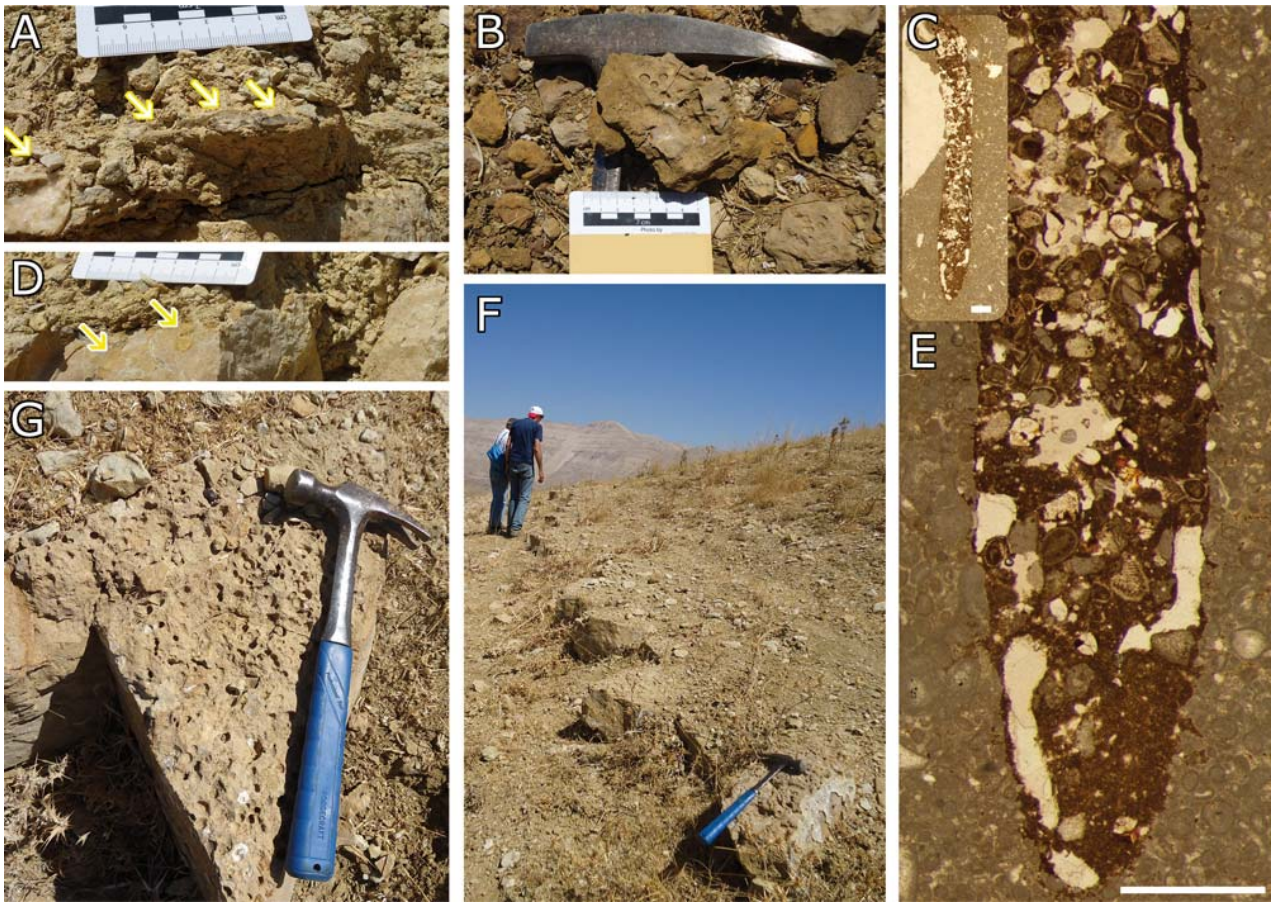


Figure 6: Perforations from different localities. **A:** Ghineh, Oysters (arrows); **B:** Sannine; **C & E:** Aarbet Qozhaya, thin-section AAR18.3 (graphic scale = 1 mm); **D:** Ghineh, borings (arrows); **F-G:** Zaarour (hammer for scale).

4.1.b) Echinids

Fraas (1878: p. 331) reported *Heteraster oblongus* (Brongniart, 1821) in his Cardium-bänke, which was then erroneously ascribed to the Cenomanian. These specimens were described as "*Enallaster syriacus*" by P. de Loriol (1887: Pl. VII, figs. 2-3; Pl. XVI, figs. 2-3). Later Keller and Vautrin (1937) illustrated this echinid under the name of "*Heteraster oblongus* Brongniart race *syriaca*" (*op. cit.*: Pl. VI, figs. 5-12; Pl. VII, figs. 1-19) from the "Aptien inférieur". Heybroek (1942), Dubertret (1947, 1955, 1963), and Saint-Marc (1970) also reported it without illustrating it contrary to the "visual guide" of the "fossils of Lebanon" (Arslan *et al.*, 1995: Pl. XX, figs. 87-88; 1997) where it appears as "*Heteraster* sp.".

Keller and Vautrin (1937) illustrated from the "Aptien supérieur" *Trochodiadema libanoticum* Loriol, 1887 (*op. cit.*: p. 140, Pl. V, figs. 2-3), *Salenia scutigera* Gray, 1835 (*op. cit.*: p. 144, Pl. V, figs. 4-5), *Holectypus portentosus* Coquand, 1879 (*op. cit.*: p. 147, Pl. V, fig. 6), *Clitopygus* (*Echinobrissus*) *goybeti* Cotteau, 1885 (*op. cit.*: p. 152, Pl. V, fig. 13), and *Toxaster dieneri* Loriol, 1887 (*op. cit.*: p. 154, Pl. V, figs. 17-20).

Dubertret (1955) reported from the "Falaise de Blanche" *Clitopygus* (*Echinobrissus*) *goybeti* Cotteau [now considered as a junior synonym of *Nucleopygus roberti* (A. Gras, 1848)], and *Diplopodia hermonensis* Loriol without illustrating them.

The nomenclature and the age of these echinids require revision too because either identifications are inaccurate or the location of the studied outcrops are uncertain.

In a preliminary evaluation of our own finds (*legit* D.A., R.G., B.G., S.M.), B. Clavel accurately identified four species:

i) First, the irregular urchin, *Heteraster oblongus*, is commonly found in most Jezzinian outcrops: Kanat Bakich (Pl. 3, figs. C & E; MHNUL 22797/0001-0007), Kfardebiane (Pl. 3, figs. D & I; MHNUL 25439/0001-0003), Ehden (MHNUL 33211/0001). In southeastern Europe, this species is characteristic of the Urgonian sequences Ba5 to Bd2 of Clavel *et al.* (2007), *i.e.*, the uppermost Barremian (top Giraudi ammonite Zone) and the lower Bedoulian (basal Forbesi ammonite Zone).

ii) Another irregular urchin, *Heteraster delgadoi* (Loriol, 1888), is found above the cliff in the *Cardium* Beds at Kanat Bakich (Pl. 3, fig. F, MHNUL 22797/0001). It is a very long-ranging species, commonly found in Albian and Cenomanian strata



Figure 7: A: Top of the lowest of the two Jezzinian sequences at Aarbet Qozhaya. One of the two massive beds contains numerous shells of "geant" nerinid gastropods; **B:** Detail of the burrowed and bored surface (Fig. 6.C&E) at the top of the micritic interval (hammer for scale).

iii) The third irregular urchin, *Nucleopygus roberti* (A. GRAS, 1848), is from the uppermost strata of "Grès de Base" (Pl. 3, fig. G-H; Qanater Zoubeyde, MHNUL 37321/0001-0002) and the lower part of the Jezzinian (Jeita, MHNUL 25261/0001). It is a long-ranging form, known in the whole Barremian - Bedoulian interval.

iv) A regular urchin, *Tetragramma malbosi* (AGASSIZ & DESOR, 1846), which was actually found in the *Cardium* Beds (Pl. 3, figs. A-B, Zaarour, MHNUL 22733/0001). It first appears in upper Bedoulian strata.

4.1.c) Ammonites

DUBERTRET (1955) reported a specimen of *Douveilleiceras* from the basal part of the Jezzinian section in a quarry at Mkalles, E Beyrouth. So far, it is the only ammonite record from this stratigraphic unit; unfortunately the specimem, was never illustrated and is lost.

In a preliminary evaluation of our own finds in the basal *Cardium* Beds, above the Jezzinian interval (*legit* R.G., B.G., S.M.), one of us (J.A.M-B.) identified a few questionable Deshayesitidae from "Mechmech" Jbeil (MHNUL 26218/0001-0002), a *Dufrenoyia* ? sp. from Kfar Nabrakh (MHNUL 23655/0007), and *Cheloniceras cornuelianum* (ORBIGNY, 1841) from Kfar Nabrakh (MHNUL 23655/0001 and 0011: Pl. 2, fig. E) and from Kanat Bakich (MHNUL 22797/0001: Pl. 2, figs. C-D). Also a number of *Cheloniceras* sp. are from Kanat Bakich (MHNUL 22797/0001 to 0006: Pl. 1, figs. A-B ; Pl. 2, figs. A-B), including a questionable one from Kfar Nabrakh (MHNUL 23655/0005). *Cheloniceras cornuelianum* spans both the Deshayesi and Furcata ammonite zones, suggesting that the Jezzinian is not younger than the Bedoulian. In addition to the ammonites, some large nautiloids, *Cymatoceras* ? sp., were collected at Kfar Nabrakh (MHNUL 23655/0002 to 0003).

4.2) Microfossils

4.2.a) Calcareous algae

SAINT-MARC (1970) illustrated and identified *Hensonella cylindrica* ELLIOTT, 1960 (*op. cit.*: Pl. 2, figs. 1-2), from the "Falaise de BLANCHE", and BASSON and EDGELL (1971) reported *Pianella dinarica* (RADOIČIĆ, 1959) from the Jezzine limestone (*op. cit.*: p. 418, Pl. 3, figs. 5-8). However both names are synonymized with *Salpingoporella dinarica* (RADOIČIĆ, 1959) according to BASSOULLET *et al*. (1978).

In addition, BASSON and EDGELL (1971) reported a number of forms from the "Jezzine limestone" on Mount Lebanon. However several incorrect identifications, taxonomic changes and problems of synonymy are listed below.

i) Incorrect identifications:

Montiella elitzae (BAKALOVA, 1971) was erroneously identified as *Cylindroporella sugdeni* ELLIOTT, 1957 (*op. cit.*: p. 417, Pl. 2, figs. 1-3). Note that the figured specimen in their Pl. 2, fig. 4 (*op. cit.*) does correspond to a genuine *Cylindroporella sugdeni*.

ii) Taxonomic changes:

Three specimens of *Macroporella pygmaea* (GÜMBEL, 1982) are correctly identified (*op. cit.*: p. 417-418, Pl. 5, figs. 1-3), but the species was transferred to the genus *Salpingoporella* (BASSOULLET *et al.*, 1971). Actually, we should refer them to *Salpingoporella* gr. *pygmaea - johnsoni*.

iii) Problem of synonymy:

Salpingoporella carpathica DRAGASTAN, 1969 (*op. cit.*: p. 420, Pl. 4, fig. 1), is a junior synonym *S. muehlbergii* LORENZ, 1902, according to BASSOULLET *et al.* (1978).

BASSON and EDGELL (1971) also gave two discrete names for a single (?) algal specimen: *Carpathoporella occidentalis* DRAGASTAN, 1995, non 1969 (*op. cit.*: p. 420, Pl. 4, figs. 7-8), and "*Coptocampylodon lineolatus* ELLIOTT, 1963" (*op. cit.*: p. 420, 422, Pl. 4, fig. 9-11). The type of the second species is a coprolite (see GRANIER & DELOFFRE, 1993).

4.2.b) Orbitolinids

According to DOUVILLÉ (1913: p. 411), "un échantillon d'*Orbitolina conoidea* GRAS, 1852 adhère à la valve supérieure" [a specimen of *Orbitolina conoidea* is adhering on the upper valve surface] of the *Agria marticensis* he was studying. This foraminifer is also reported by DUBERTRET (1955) as *Orbitolina conoidea-discoidea.* HENSON (1948) described *Orbitolina discoidea* GRAS var. *libanica* var. nov. (*op. cit.*: p. 55-56, Pl. II, figs. 10, 12) from Mdairej, above "Muraille de BLANCHE" but, according to SCHROEDER and NEUMANN (1985), it is a synonym of *Mesorbitolina texana* (ROEMER, 1852).

Both DOUVILLÉ (1910) and DUBERTRET (1955) reported the occurrence of *Orbitolina lenticularis* (BLUMENBACH, 1805). HEYBROEK (1942: Pl. 5, fig. 2) illustrated *Orbitolina lenticularis* from Kfer Matta [= Kfarmatta], near Abeih. HENSON (1948) illustrated *Orbitolina* cf. *lenticularis* (*op. cit.*: Pl. III, figs. 6-11), as well as *Orbitolina* cf. *bulgarica* (BOUÉ) (*op. cit.*: Pl. III, figs. 1-4).

HENSON (1948: p. 56-60) assumed that both *Orbitolina* cf. *lenticularis* and *Orbitolina discoidea* GRAS var. *libanica* have "previously been included under the names of *O. lenticularis* BLUM. and *O. conoidea-discoidea"* by DUBERTRET and VAUTRIN (1937).

SIMMONS *et al.* (2000) revised the HENSON's material (1948). It was an uneasy task due to the loss of specimens and petrographic thin-sections for any further review; and also due to the scarcity or lack of sections cut through the embryonic apparatus in the thin-section material. They prepared new petrographic thin-sections from the material that was used to describe *Orbitolina discoidea* GRAS var. *libanica* (SIMMONS *et al.*, 2000: p. 416) and *Orbitolina* cf. *lenticularis* (BLUMENBACH) (*op.cit.*: p. 416) from topotype material. They demonstrated that *Orbitolina discoidea* GRAS var. *libanica* is a junior synonym of *Mesorbitolina texana.*

In his 1970 publication, SAINT-MARC cited and illustrated several orbitolinids. However since this work was published there have been several taxonomic changes and problems of synonymy or incorrect identifications have been evidenced.

i) Incorrect identifications:

According to SCHROEDER *et al.* (2010), a specimen of *Paleodictyoconus arabicus* (HENSON) figured by SAINT-MARC (1970: Pl. 1, fig. 14) is actually a *Palorbitolina* sp.; another specimen (*op. cit.*: Pl. 1, fig. 13) is probably a *Rectodictyoconus giganteus* SCHROEDER, 1964.

ii) Taxonomic changes:

Only two specimens of *Paleodictyoconus arabicus* (HENSON, 1948) are correctly identified (SAINT-MARC, 1970: Pl. 1, figs. 12, 15) according to SCHROEDER *et al.* (2010), but the species was transferred to the genus *Montseciella* by CHERCHI and SCHROEDER (1999);

Mesorbitolina texana (ROEMER, 1849) *parva* DOUGLASS, 1960, is figured in his paper (SAINT-MARC, 1970: Pl. 1, fig. 6) and again in MOULLADE and SAINT-MARC (1975: Pl. XII, fig. 10) as *Orbitolina* (*Mesorbitolina*) *parva* DOUGLASS, 1960, but the variety is now given a species status.

iii) Problems of synonymy:

Mesorbitolina libanica (HENSON) is also figured by SAINT-MARC (1970: Pl. 3, figs. 1-3). It was described by HENSON (1948) as *Orbitolina discoidea* var. *libanica* and later again by MOULLADE and SAINT-MARC (1975) as *Orbitolina* (*Mesorbitolina*) *libanica*, but it is a junior synonym of *Mesorbitolina texana* (ROEMER, 1849) according to SCHROEDER and NEUMANN (1985: p. 79) as well as to SIMMONS *et al.* (2000).

Finally, the specimens of *Mesorbitolina lotzei* SCHROEDER, 1964, figured by SAINT-MARC (1970: Pl. 1, figs. 7-9), were ascribed to *Praeorbitolina cormyi* SCHROEDER, 1964, by MOULLADE and SAINT-MARC (1975: Pl. XII, fig. 5) and later to *Praeorbitolina wienandsi* SCHROEDER, 1964, by SCHROEDER (1979).

5. New microfossil data

During a first field work campaign in summer 2012, we sampled and logged several sections in discrete localities of Lebanon (Fig. 1). Thin section analyses of the material collected prove to bear rather rich micropaleontological assemblages consisting of calcareous algae (mostly Dasycladales) and benthic foraminifers (with representatives of the Charentiidae, Cyclamminidae, Orbitolinidae, Nezzazatidae, and Miliolidae families). These benthic microfossils are not usually given enough attention, though some proved to be efficient biostratigraphic tools to date rocks where, until recently, the classical markers (ammonites, planktonic foraminifers) were not found.

5.1) Dasycladalean algae

Some long-ranging species cannot give a precise dating.

- According to GRANIER (1994), *Actinoporella* gr. *podolica* (ALTH, 1878) (Pl. 4, figs. L & P) spans at least the Tithonian - Barremian interval. Two poor random sections ascribed to *Actinoporella podolica* by BASSON and EDGELL (1971: Pl. 3, figs. 1-2) from the Upper Jurassic of Mount Lebanon cannot be ascribed to this taxon.
- *Montiella elitzae* (BAKALOVA, 1971) (Pl. 4, figs. C-D) spans the Barremian-Ap-

tian *auct.* interval according to GRANIER and DELOFFRE (1993).

- *Salpingoporella dinarica* (RADOIČIĆ, 1959) (Pl. 4, figs. R & V) probably starts in the Tithonian Stage because it was found by GRANIER (2002) in association with *Anchispirocyclina lusitanica* (EGGER) and ranges up to the Albian (SOKAČ, 1996).
- *S. muehlbergii* (LORENZ, 1902) (Pl. 4, figs. G, K & O) ranges from the Upper Hauterivian to the Bedoulian according to GRANIER and DELOFFRE (1993).
- *S. hasi* (CONRAD *et al.*, 1977) (Pl. 4, figs. A-B) spans the Albian-Cenomanian interval according to GRANIER and DELOFFRE (1993) but its first occurrence might well be Bedoulian in age (CARRAS *et al.,* 2006) or even Barremian.
- *Suppiluliumaella polyreme* ELLIOTT, 1968 (Pl. 4, fig. I), spans the Barremian-Aptian *auct.* interval according to GRANIER and DELOFFRE (1993).

Other, poorly-known species cannot give an accurate dating.

- *Harlanjohnsonella annulata* ELLIOTT, 1968 (Pl. 4, fig. J), was, until now, known only from its type-region, including its type locality, Zlatibor, Serbia (ELLIOTT, 1968; RADOIČIĆ, 1995; RADOIČIĆ & SCHLAGINTWEIT, 2010), where it is Cenomanian in age. The form illustrated and labelled "*Harlanjhonsonella* cf. *annulata*" in JAFFREZZO *et al.* (1980: Pl. II, fig. 9) from the Aptian of Bey Dağlari in SW Turkey cannot specifically be referred to the species (MAKSOUD *et al.*, 2014).
- According to GRANIER and DELOFFRE (1993), *Genotella pfenderae* (KONISHI & EPIS, 1962) (Pl. 4, fig. E) spans the Albian - Turonian interval. The *Neomeris pfenderae* reported by BASSON and EDGELL (1971, Pl. 5, fig. 6) from the Cenomanian of Mount Lebanon is not referable to this taxon.

Finally we also identified some new species that, per definition, lack of stratigraphic relevance as, for instance, a new Triploporellacean species (Pl. 4, fig. H).

5.2) Benthic foraminifers

The most abundant foraminifera in our material are *Choffatella* and *Palorbitolina*. *Choffatella* preferred calm environments, either in back-shoal settings with Dasycladales or in fore-shoal settings in deeper, slightly clayey environments, in contrast to *Palorbitolina*, which preferred high energy, oxygenated and shallower areas (CUGNY, 1975; see discussion in GRANIER & BUSNARDO, 2013). Therefore they are rarely found together, the abundance of one explains the scarcity or even the absence of the other. They may eventually co-occur in transgressive facies, due to reworking (see discussion in GRANIER & BUSNARDO, 2013). In the Ain Dara section, for instance, *Choffatella* is abundant in the lowermost strata before its almost complete disappearance and its replacement by orbitolinids higher in the section.

More generally, when dealing with the benthic foraminifers, we faced the same difficulties as for the algae. The stratigraphic ranges of several species found in the interval ("Early Cretaceous"): *Buccicrenata hedbergi* (MAYNC, 1953) (Pl. 4, fig. Q), *Pseudotextulariella scarsellai* (DE CASTRO, 1964) (Pl. 4, fig. W), *Praechrysalidina infracretacea* LUPERTO SINNI, 1979 (Pl. 4, fig. F), and *Lituola* cf. *inflata* LOZO, 1944 (Pl. 4, fig. N), are too poorly constrained. Among them, *Involutina hungarica* (SIDÓ, 1952) (Pl. 4, figs. S-T), appears many times in the literature as "*Hensonina*", or "*Trocholina*", "*lenticularis*" or even "*lenticularis* var. *minima* HENSON, 1947" (SCHLAGINTWEIT & PILLER, 1990; CONSORTI *et al.*, 2014; RIGAUD *et al.*, 2014); originally described from the Lower Cenomanian of Dukhan (Qatar) and quite common in Albian strata, this form was also reported from Lower Barremian strata (GRANIER *et al.*, 2003), which qualifies it as long-ranging species. However, according to one of us (B.G.), there might be multiple species belonging to the same phylogenetic branch.

Furthermore many species have rather long ranges, encompassing two or more stages. For instance, *Choffatella* gr. *decipiens* (Pl. 4, figs. M & U), a morphospecies already reported from Lebanon by SAINT-MARC (1970: Pl. 1, figs. 4-5), ranges up to the Aptian *auct.* (Martini ammonite Zone) according to GRANIER and BUSNARDO (2013). It probably starts in the Valanginian because it may derive from *Choffatella pyrenaica* PEYBERNÈS, 1976.

Fortunately, some species may have rather short ranges and help ascribing ages:

i) *Palorbitolina lenticularis* (BLUMENBACH, 1805) (Fig. 8.C-F) is as a zonal marker of the Upper Barremian - lower Bedoulian for SCHROEDER *et al.* (2010), although it first occurs in the Lower --not lowermost-- Barremian strata (Nicklesi ammonite Zone) and last occurs in lowermost Aptian *auct.* strata (Furcata ammonite Zone) according to CLAVEL *et al.* (2013; GRANIER *et al.*, 2013, 2014). It has been previously identified in Lebanon by SAINT-MARC (1970), which led him later to distinguish an "Aptien inférieur" in "Falaise de BLANCHE" (SAINT-MARC, 1972);

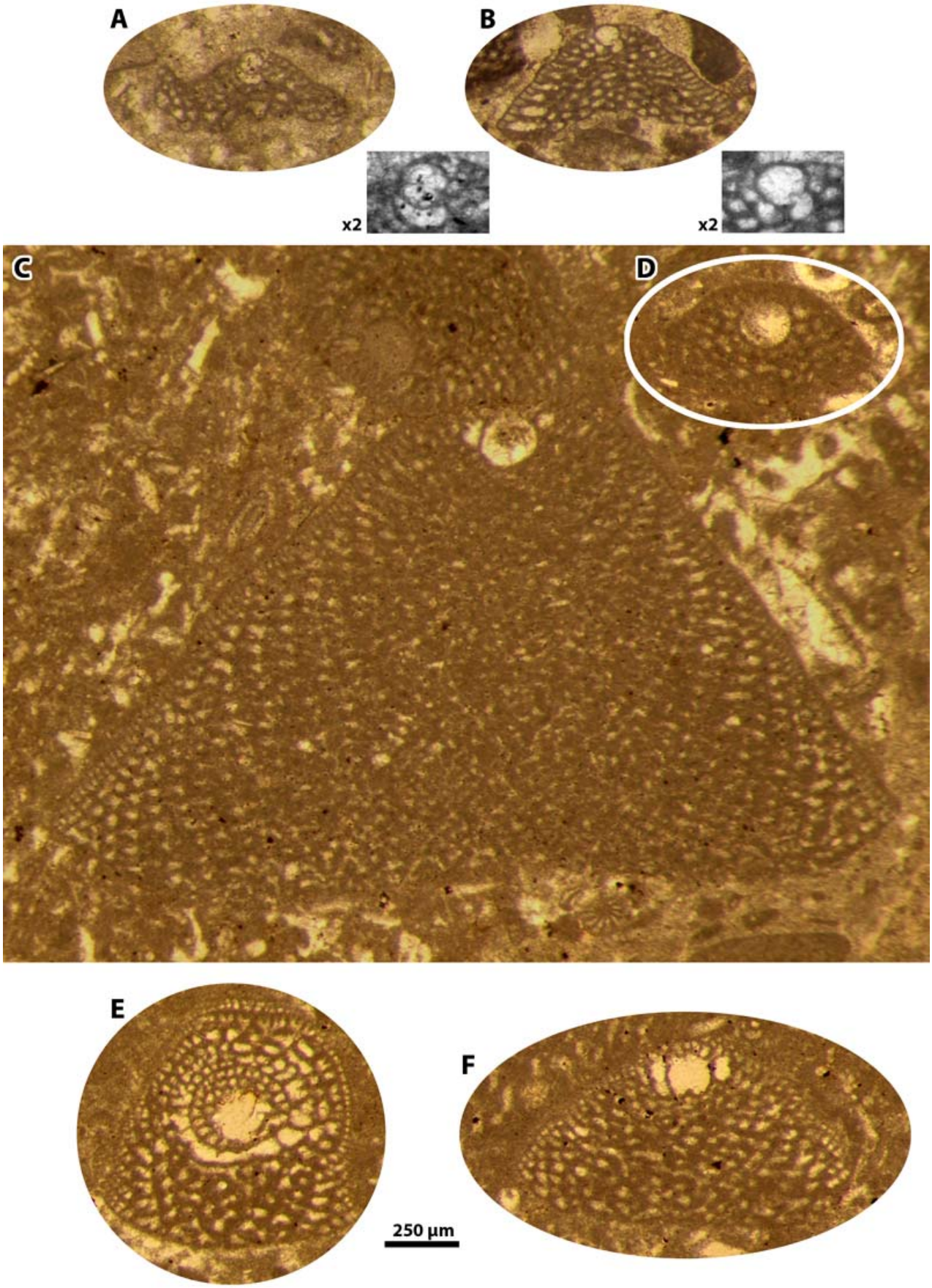


Figure 8: A-B: Slightly oblique and axial sections of *Praeorbitolina cormyi* SCHROEDER, 1964, from the "Orbitolina Beds", directly above the Jezzinian section at Jezzine, thin-section JEZh; **C-D:** Axial and slightly oblique sections of *Palorbitolina lenticularis* (BLUMENBACH, 1805) from Jezzinian strata, East Ain Dara, thin-section EAD38; **E-F:** Tangential and axial sections of *Palorbitolina lenticularis* (BLUMENBACH, 1805) from Jezzinian strata, East Ain Dara, thin-section EAD 68; scale bar = 250 µm (or 500 µm for "x2").

ii) *Montseciella arabica* (HENSON, 1948) is as a subzonal marker of the Late Barremian ranging from the Sartousiana to the base of the Oglanlensis ammonite zones (CLAVEL *et al.*, 2013) and in the *Palorbitolina lenticularis* Zone (SCHROEDER *et al.*, 2010). In Lebanon it is apparently restricted to the lowermost part of "Falaise de BLANCHE" as indicated by SAINT-MARC (1970: Pl. 1, figs. 12-13, 15). In July 2014, we collected new material from the same area (Pl. 5);

iii) *Rectodictyoconus giganteus* SCHROEDER, 1964, is an early Bedoulian marker (*Deshayesites oglanlensis* Zone, see SCHROEDER *et al.*, 2010). SAINT-MARC (1970: Pl. 1, fig. 13) found it in Lebanon but he erroneously ascribed this microspheric form to "*Paleodictyoconus arabicus* (HENSON)". So far, we have not identified new specimens in our material;

iv) *Praeorbitolina cormyi* SCHROEDER, 1964, is a zonal marker of the uppermost Bedoulian-lowermost Aptian *auct.* (*i.e.*, Deshayesi-Furcata ammonite zones) (SCHROEDER *et al.*, 2010). In Iran, it was found in Bedoulian strata too (SCHLAGINTWEIT *et al.*, 2013). In Lebanon it was first reported by MOULLADE and SAINT-MARC (1975: Pl. XI, figs. 1-7, 10). Actually, we did find it (Fig. 8.A-B) in outcrops at the top of the cliff in Jezzine, not in the Jezzinian interval but in grainy limestones directly overlying it.

Our micropaleontological inventory is still ongoing.

6. Correlations

6.1) The Jezzinian Regional Stage at the scale of the Arabian Plate (Southern Tethyan association)

Lebanese fossil assemblages and those of the Persian Gulf share microfossils in common, among which are:

i) *Salpingoporella dinarica*, only known from the Southern Tethys,

ii) *Montseciella arabica*, rare or missing outside this domain,

iii) *Choffatella decipiens* and iv) *Palorbitolina lenticularis*, which are cosmopolitan,

v) *Rectodictyoconus giganteus* SCHROEDER, 1964, the occurrence of which is poorly documented everywhere.

Salpingoporella dinarica and *Choffatella decipiens* have long ranges. *Palorbitolina lenticularis*, which spans most of Barremian – Bedoulian, has a medium range. Only two of these species have short ranges: *Montseciella arabica*, which characterizes the Late Barremian and extends into the earliest Bedoulian, and *Rectodictyoconus giganteus*, which is mostly early Bedoulian in age (*Deshayesites oglanlensis* Zone, see SCHROEDER *et al.*, 2010 [3]). In conclusion, based on the microfossil contents, the Jezzinian Alloformation/Regional Stage spans a rather short time interval corresponding to the transition of the Barremian to the Bedoulian.

vi) *Praeorbitolina cormyi* is found in the first layers above the Jezzinian section at Jezzine. According to CHERCHI and SCHROEDER (2013), this species is not reported from strata younger than the Deshayesi ammonite Zone, *i.e.*, not younger than the late Bedoulian, a datum which again is consistent with our interpretation.

The micropaleontological associations in Lebanon can be compared with those of the Persian Gulf, on the eastern side of the Arabian plate. According to the synthetic stratigraphic schema for Abu Dhabi (GRANIER, 2000, 2008; GRANIER *et al.*, 2003, 2011; BUSNARDO & GRANIER, 2011; GRANIER & BUSNARDO, 2013), which is also valid for Oman and Qatar, biostratigraphically significant species range throughout lithostratigraphic units:

i) *Montseciella arabica* occurs in the Kharaib Formation from Kharaib 1 to Kharaib 3 intervals;

ii) *Rectodictyoconus giganteus* is restricted to the Kharaib 3 interval;

iii) *Choffatella decipiens* spans the interval from the Lekhwair to the Bab formations (encompassing the Kharaib Formation);

iv) *Palorbitolina lenticularis* spans the whole Kharaib - Shu'aiba formations interval;

v) *Salpingoporella dinarica* was found in the uppermost part of the Lekhwair Formation and most of the Kharaib (except for Kharaib 2), the Hawar and the Shu'aiba formations. It is also known much lower in the series, *i.e.*, from the Bu Haseer Formation (Tithonian-Berriasian transition according to GRANIER, 2002);

vi) *Involutina hungarica* is reported as "*Hensonina lenticularis*" in the uppermost part of the Lekhwair Formation and most of the Kharaib (except for Kharaib 2) (GRANIER *et al.*, 2003);

vii) and, in Oman, *Praeorbitolina cormyi* first occurs in the Shu'aiba (WITT & GÖKDAĞ, 1994: Pl. 10.1, fig. 5; Pl. 10.1, fig. 6 under "*Orbitolina* (*Mesorbitolina*) *lotzei*").

[3] SCHROEDER et al. *(2010: fig. 18, "Bab Basin" column) present selected data from a well offshore Abu Dhabi (GRANIER, 2000, 2008; GRANIER* et al., *2003): the ranges of two species only,* Eopalorbitolina transiens *and* Montseciella arabica, *remain whereas those of three more species,* Palorbitolina lenticularis, P. *cf.* ultima *and* Rectodictyoconus giganteus, *were omitted. In the same figure, the Kharaib is ascribed a Barremian age, excluding a Bedoulian age for its upper part, in blatant contradiction of the ranges of the fossil contents reported in the referenced papers.*

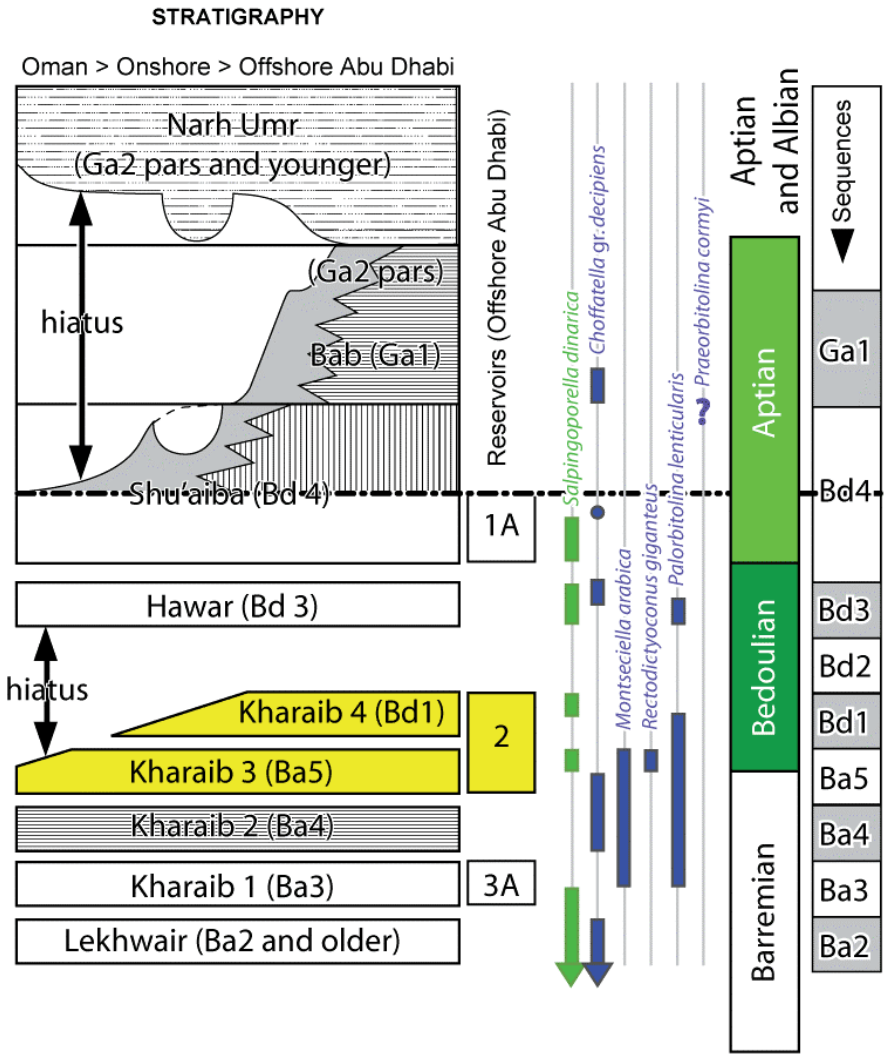


Figure 9: Stratigraphic log of Abu Dhabi with the Southern and Northern Tethyan correlations (modified from GRANIER & BUSNARDO, 2013) and the stratigraphic distribution of some microfossils. The yellow highlighted zone represents the Jezzinian correlating with the Kharaib 3 and Kharaib 4, and equating with the Ba5 and Bd1 of CLAVEL *et al.* (2007).

The distribution of *Montseciella arabica* led us to correlate the Jezzine type-section (Log) in Lebanon with the Kharaibian Regional Stage of the Persian Gulf (Fig. 9) and to exclude both the Hawarian and the Shuaibaian: the Jezzinian "falls" into the Kharaib interval .

The Kharaib in Abu Dhabi was first mentioned by SUGDEN (1953, unpublished report), then published by SUGDEN & STANDRING (1975) and changed in 'status' to the "Kharaibian Regional Stage" by GRANIER (2008). The occurrence of *Rectodictyoconus giganteus*, which needs to be better documented, would even narrow the interval to solely the Kharaib 3 sequence but because there are two sequences in the Jezzinian we shall assume that it is equivalent to the upper Kharaibian of Abu Dhabi (*i.e.*, Kharaib 3-4).

6.2) Correlation of the Jezzinian Regional Stage with the Urgonian of SE France (Northern Tethyan association)

The Kharaibian Regional Stage was correlated with a North-Tethyan scale in SW Europe (GRANIER, 2000; GRANIER *et al.*, 2003). The time range corresponding to this South-Tethyan unit is equivalent to sequences Ba3 to Bd1 of CLAVEL *et al.* (2007) as in GRANIER *et al.* (2003), not Ba1-Ba4 as in GRANIER (2000), *i.e.*, Late Barremian-early Bedoulian interval. Accordingly, it can be indirectly correlated with the Moutoniannum-Oglanlensis ammonite zones.

If we take into consideration the occurrence of *Rectodictyoconus giganteus* in the Jezzinian itself, we can narrow the correlation to the sequences Kharaib 3 and Kharaib 4, or its North-Tethyan equivalent Ba5 and Bd1 of CLAVEL *et al.* (2007).

On another side, our macrofossil finds, more specifically that of the irregular echinoid *Heteraster oblongus*, a marker of the latest Barremian - early Bedoulian in southeastern Europe, below and inside the cliff (*i.e.*, in the Jezzinian), and that of the ammonite *Cheloniceras cornuelianum*, above the cliff (in the basal *Cardium* Beds), confirm our age ascription for the newly defined Jezzinian Regional Stage.

6.3) Estimation of the duration of the hiatus at the top of the Jezzinian Regional Stage

In Lebanon, the occurrence of *Praeorbitolina cormyi* in the first strata above the Jezzinian, *i.e.*, at the base of the *Cardium* Beds, and those of *Montseciella arabica* and *Rectodictyoconus giganteus* in the Jezzinian itself suggest that the

upper discontinuity of the regional stage might correspond to a hiatus (Fig. 9) equivalent at least to the duration of the Hawarian (and possibly that of the "ghost" sequence Kharaib 5). With respect to CLAVEL *et al.* (2007), the hiatus would then encompass at least the sequence Bd3 (and possibly that of the "ghost" sequence equivalent, Bd2), *i.e.*, parts of the Weissi and Deshayesi ammonite zones (and possibly the whole Weissi Zone with parts of both the Oglanlensis and the Deshayesi zones).

7. Conclusion

An holostratigraphic re-evaluation of the "Falaise de BLANCHE" led us to redefine it, not as in DUBERTRET's times as a facies-driven "Formation" but, as a 'time-constrained' stratigraphic unit, *i.e.*, an unit bounded by two discontinuities: the Jezzinian Regional Stage, UBU or Alloformation (in our understanding these three terms represent slightly similar concepts). On the basis of biostratigraphic information (mostly derived from micropaleontological data, but duly supplemented by some macropaleontological data) and through a holostratigraphic approach, the newly defined Jezzinian should fall in a time interval corresponding to the latest Barremian - early Bedoulian. The upper boundary may locally correspond to a significant intra-Bedoulian hiatus (*i.e.*, spanning at least parts of the Weissi and Deshayesi ammonite zones). As currently understood, the lower boundary is probably intra-latest Barremian. Consequently the underlying strata, which yield charophyte remains (GRAMBAST & LORCH, 1968) or amber with biological inclusions, mostly insects (AZAR, 1997, 2000, 2007, 2012; AZAR *et al.*, 2010), are slightly older than previously thought (GRAMBAST & LORCH, 1968; AZAR *et al.*, 2003), *i.e.*, Barremian, not Bedoulian nor Aptian *auct.*

Forthcoming investigations on this unit and on both its underlying (*e.g.*, "Mréjatt Cliff") and overlying (*e.g.*, "ZUMOFFEN Cliff") units will probably help to confirm and refine these preliminary results.

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A part of the studied material (ammonites and echinoids) is registered with MHNUL numbers in the collections of the Muséum d'Histoire naturelle, Université Libanaise, Fanar - El-Matn (Lebanon); another part, consisting of the thin sections, is deposited with LPB numbers in the collections the Département des Sciences de la Terre et de l'Univers, Université de Bretagne Occidentale, Brest (France).

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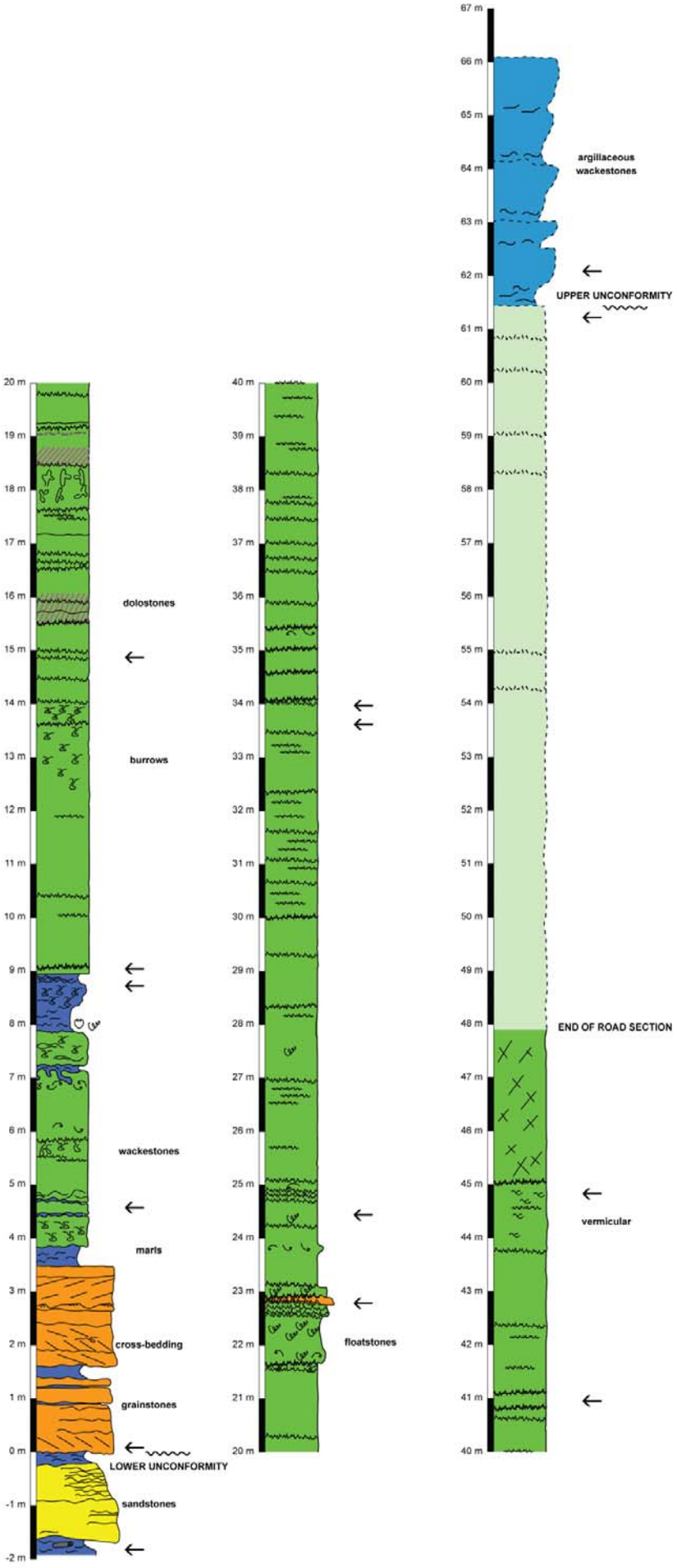
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◀ **Log:** The type-section at Jezzine, on the side of the main road at the entrance to the town. It was measured using a JACOB's staff. There it is more than 48 m thick but it reaches some 61.5 m (estimated) in the nearby cliff section at Wadi Jezzine (Fig. 3).

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Plates

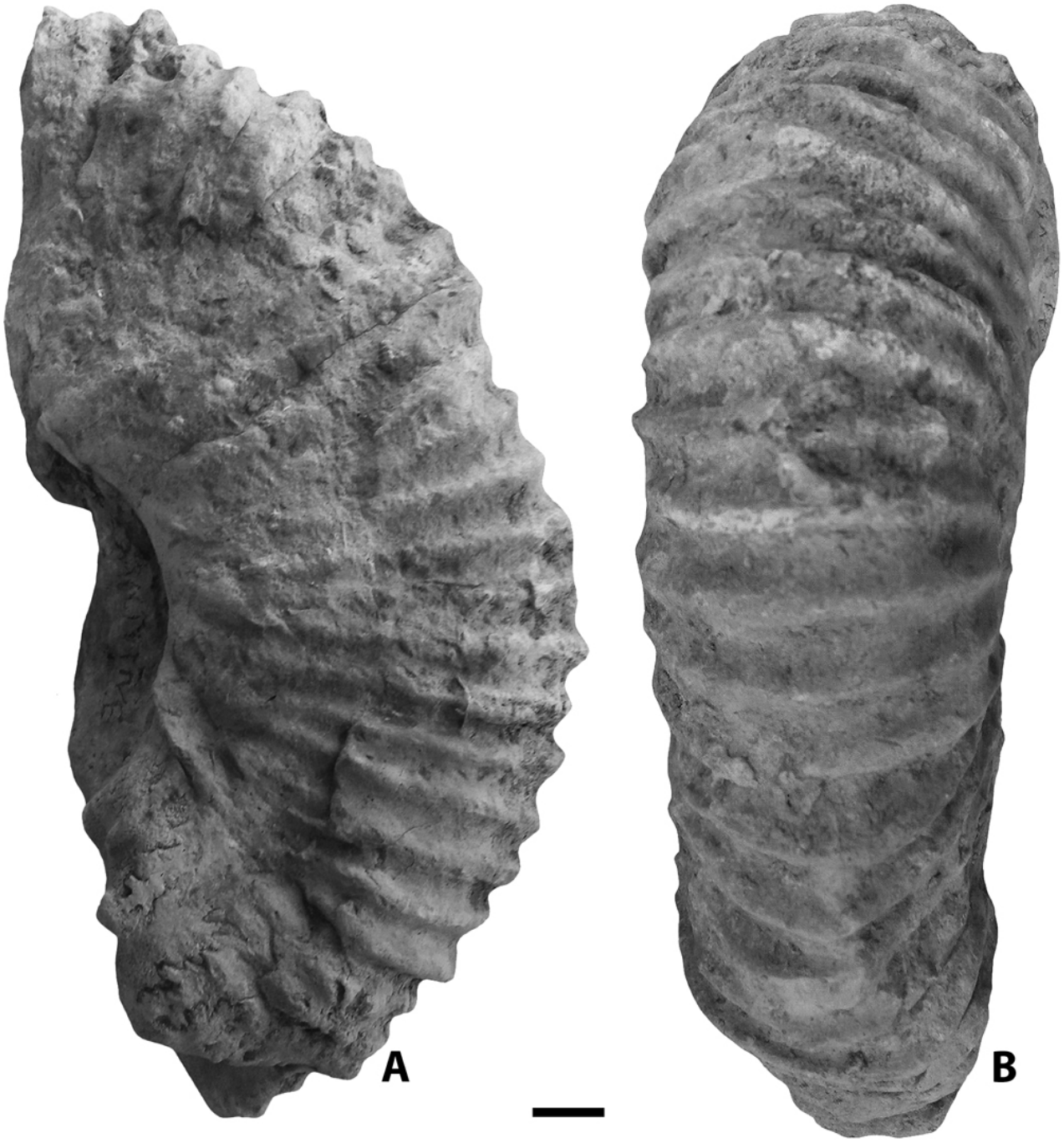
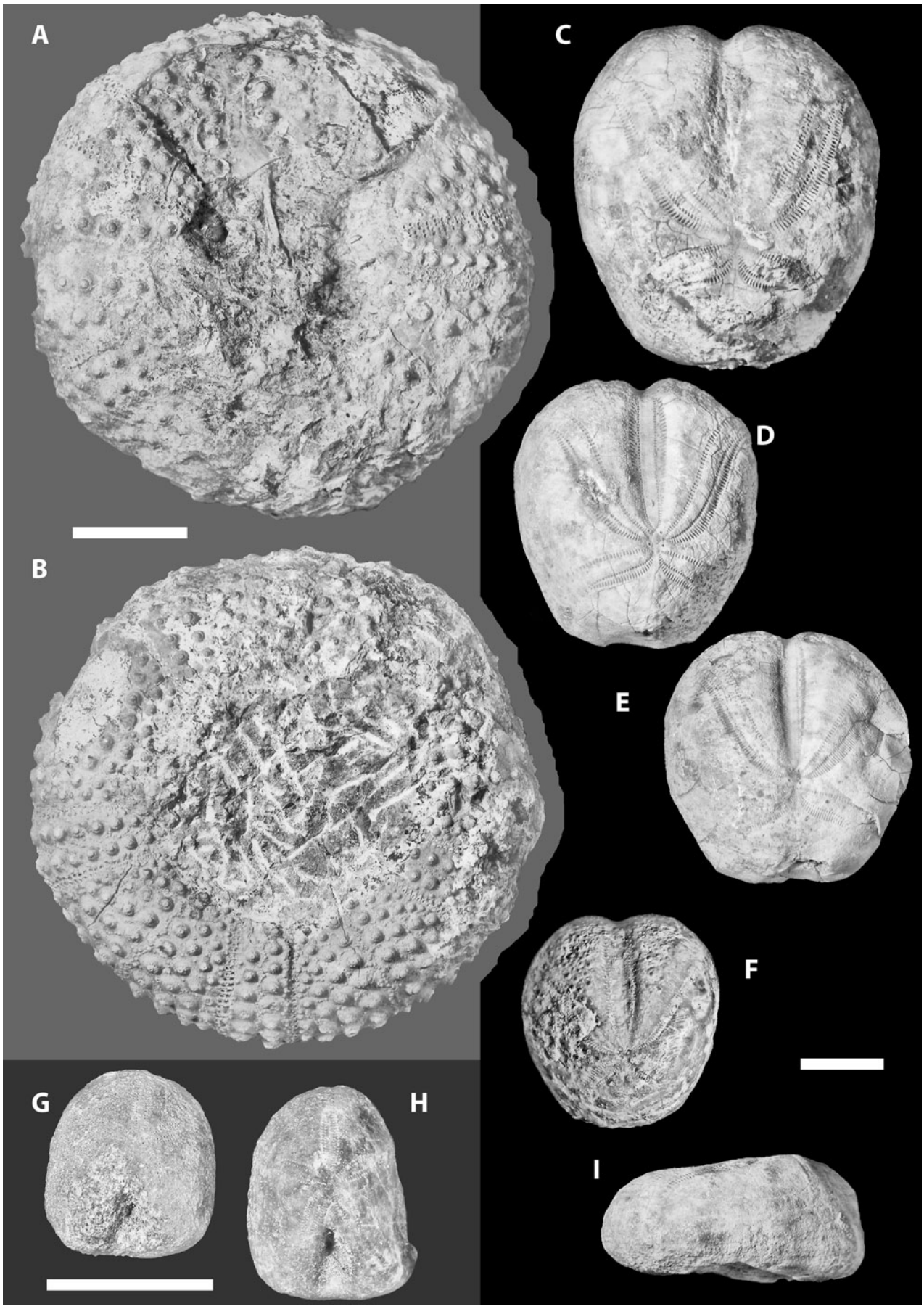


Plate 1: Lateral view (A) and ventral view (B) of *Cheloniceras* sp. (MHNUL 22797/0006), lowermost *Cardium* Beds, Kanat Bakich. Scale bar = 1 cm.

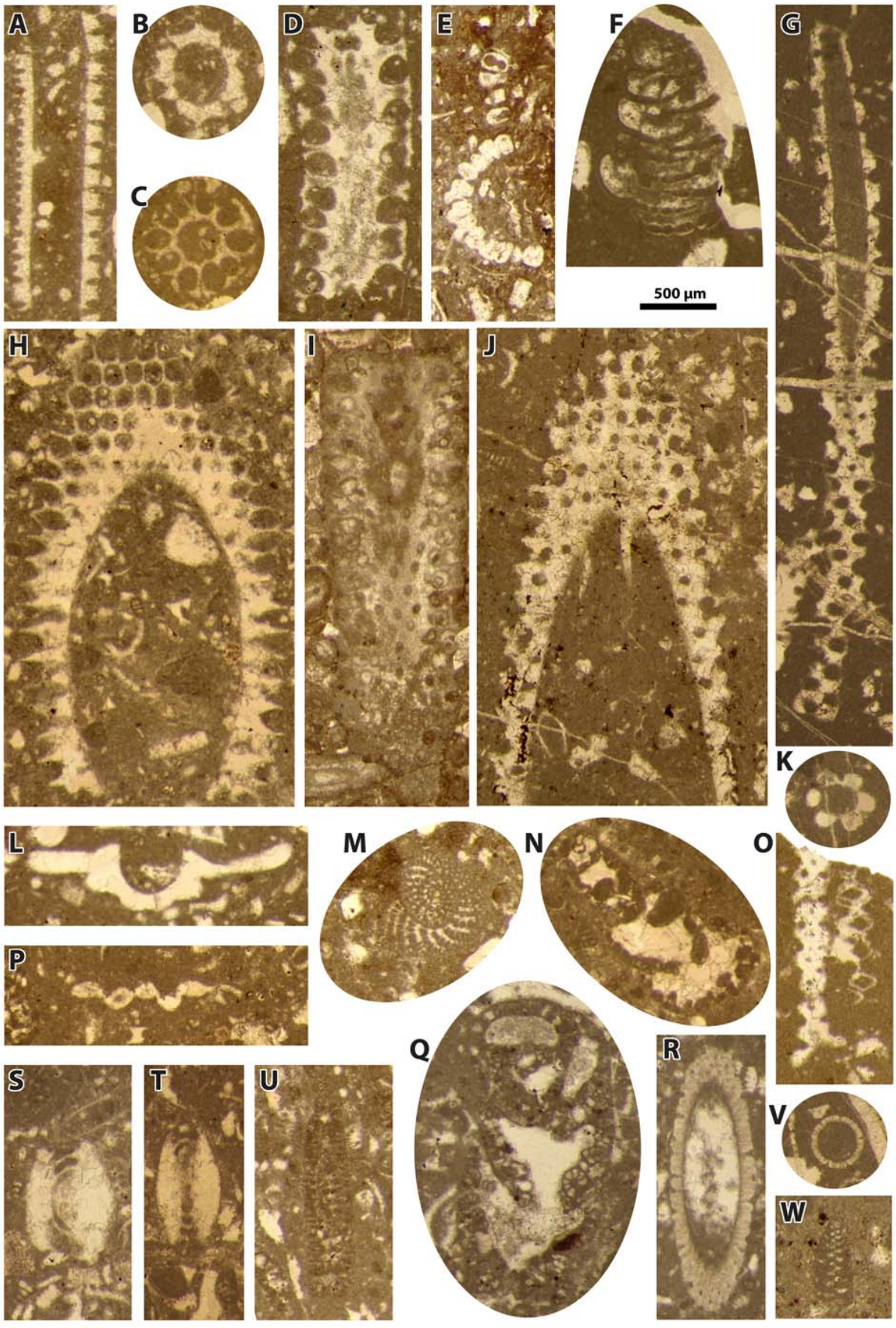
▶ **Plate 2: A-B:** Lateral view (A) and ventral view (B) of *Cheloniceras* sp. (MHNUL 22797/0002), lowermost *Cardium* Beds, Kanat Bakich; **C-D:** Lateral view (C) and ventral view (B) of *Cheloniceras cornuelianum* (ORBIGNY, 1841) (MHNUL 22797/0001), lowermost *Cardium* Beds, Kanat Bakich; **E:** Lateral view of a *Cheloniceras cornuelianum* (ORBIGNY, 1841) (MHNUL 23655/0001), lowermost *Cardium* Beds, Kfar Nabrakh. Scale bar = 1 cm.


A
B
C
D
E

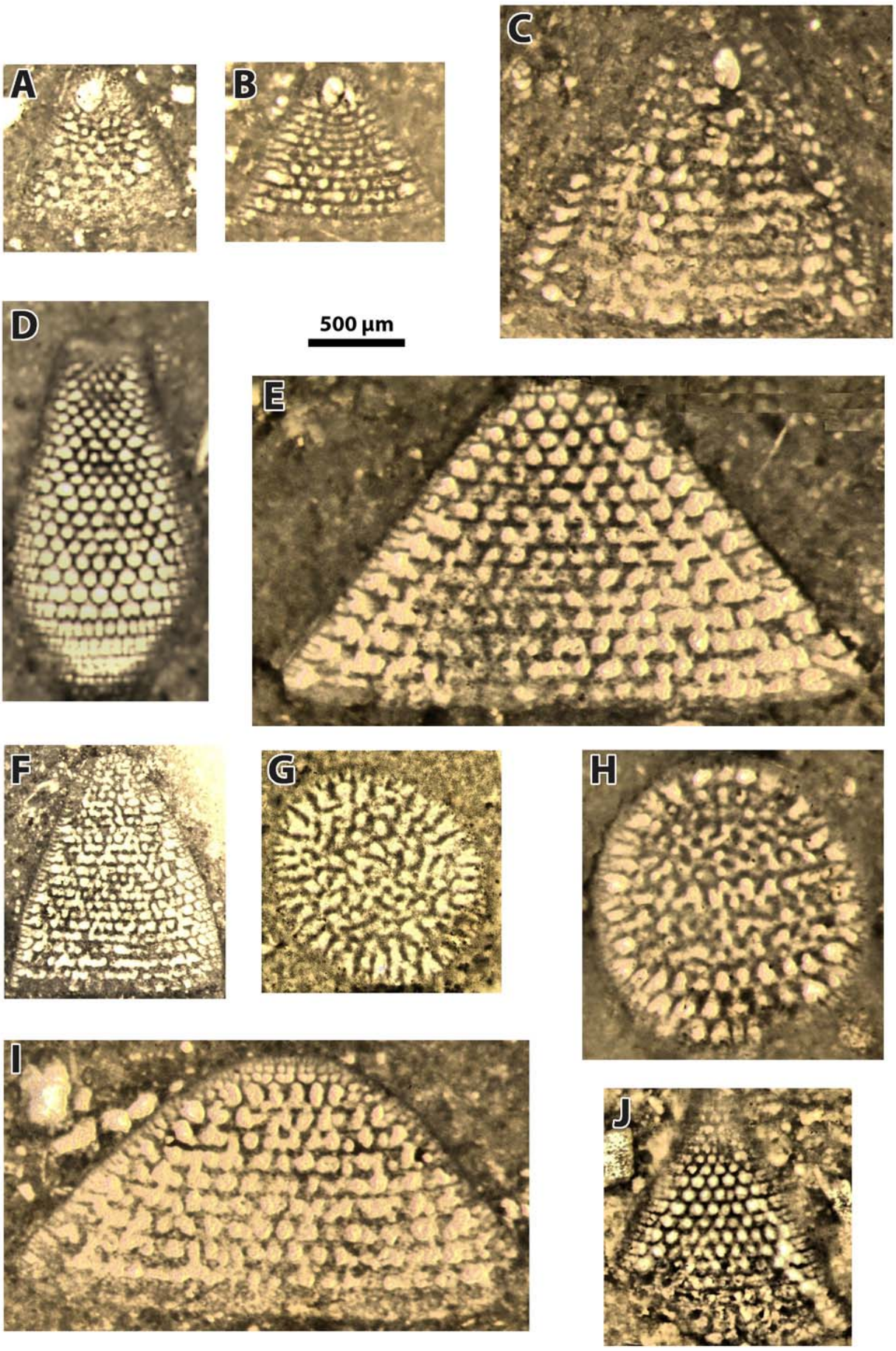
▶ **Plate 3: A-B:** Apical view (A) and oral view (B) of *Tetragramma malbosi* (AGASSIZ & DESOR, 1846), *Cardium* Beds, Zaarour (MHNUL 22733/0001), Leg. 12/09/2013; **C-E:** Apical views and **I:** Left side view of *Heteraster oblongus* (BRONGNIART, 1821), lower Jezzinian; C and E: Kanat Bakich; C (MHNUL 22797/0002) and E (MHNUL 22797/0003); D and I: Kfardebiane (MHNUL 25439/0001); **F:** Apical view of *Heteraster delgadoi* (LORIOL, 1888), *Cardium* Beds, Kanat Bakich (MHNUL 22797/0001). **G-H:** Apical views of *Nucleopygus roberti* (A. GRAS, 1848), uppermost strata of "Grès de Base", Daychounieh; G (MHNUL 37321/0001) and H (MHNUL 37321/0002). Material identification by B. CLAVEL. All scale bars = 1 cm.


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G
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▶ **Plate 4:** Microfossils, calcareous algae and benthic foraminifers, from the Jezzinian interval. **A:** Axial section of *Salpingoporella hasi* CONRAD *et al.*, 1977, Maarab, thin-section MEB44; **B:** Transverse section of *Salpingoporella hasi* CONRAD *et al.*, 1977, Maarab, thin-section MEB44; **C:** Transverse section of *Montiella elitzae* (BAKALOVA, 1971), East Ain Dara, thin-section EAD18; **D:** Subaxial section of *Montiella elitzae* (BAKALOVA, 1971), East Ain Dara, thin-section EAD19; **E:** Oblique sections of *Genotella pfenderae* (KONISHI & EPIS, 1962), Ain-El-Bnaya, thin section VO4; **F:** Subaxial section of *Praechrysalidina infracretacea* LUPERTO SINNI, 1979, Maarab, thin-section MEB74; **G:** Longitudinal section of *Salpingoporella muehlbergii* (LORENZ, 1902), Maarab, thin-section MEB73; **H:** Oblique section of a new species of Triploporellaceae, East Ain Dara, thin-section EAD18; **I:** Longitudinal section of *Suppiluliumaella polyreme* ELLIOTT, 1968, Aarbet Kozhaya, thin section AAR 16.4; **J:** Oblique section of *Harlanjohnsonella annulata* ELLIOTT, 1968, El Sheaybeh, thin-section VO15; **K:** Transverse section of *Salpingoporella muehlbergii* (LORENZ, 1902), Maarab, thin-section MEB73; **L:** Oblique section of a verticil of *Actinoporella* gr. *podolica* (ALTH, 1878), East Ain Dara, thin-section EAD19; **M:** Equatorial section of *Choffatella decipiens* SCHLUMBERGER, 1905, Maarab, thin-section MEB44; **N:** Longitudinal-subaxial section of *Lituola* cf. *inflata* LOZO, 1944, Ain-El-Bnaya, thin-section VO36; **O:** Tangential sections of *Salpingoporella muehlbergii* (LORENZ, 1902), Maarab, thin-section MEB73; **P:** Tangential section of a verticil of *Actinoporella* gr. *podolica* (ALTH, 1878), East Ain Dara, thin-section EAD20; **Q:** Longitudinal-subaxial section of *Buccicrenata hedbergi* (MAYNC, 1953), East Ain Dara, thin-section EAD20; **R:** Oblique section of *Salpingoporella dinarica* (RADOIČIĆ, 1959), East Ain Dara, thin-section EAD19; **S:** Oblique section of *Involutina hungarica* (SIDÓ, 1952), East Ain Dara, thin-section EAD38; **T:** Axial section of *Involutina hungarica* (SIDÓ, 1952), East Ain Dara, thin-section EAD38; **U:** Subaxial section of *Choffatella decipiens* SCHLUMBERGER, 1905, East Ain Dara, thin-section EAD18; **V:** Transverse section of *Salpingoporella dinarica* (RADOIČIĆ, 1959), Maarab, thin-section MEB73; **W:** *Pseudotextulariella scarsellai* (DE CASTRO, 1964), Ain-El-Bnaya, VO74. Scale bar = 500 µm.


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500 µm
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▶ **Plate 5:** *Montseciella arabica*. Deir Kreim, Ghosta. **A:** Axial section, thin section Krim-4a; **B:** Axial section, thin section Krim-6a; **C:** Axial section, thin section Krim-2b; **D:** Oblique section, thin section Krim-3b; **E:** Subaxial section, thin section Krim-3a; **F:** Subaxial section, thin section Krim-2a; **G:** Subtransverse section, thin section Krim-4c; **H:** Subtransverse section, thin section Krim-1b; **I:** Oblique section, thin section Krim-2c; **J:** Subaxial section, thin section Krim-6b. Thin sections prepared by B. CLAVEL. Scale bar = 500 µm.


A
B
C
D
500 µm
E
F
G
H
I
J