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Caprinula and *Sauvagesia* rudist faunas (Bivalvia) from the Cenomanian of NW Jordan. Stratigraphy and taxonomy

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A B S T R A C T

Three species of a canaliculated rudist *Caprinula* d'Orbigny, 1847, *C. sharpei* (Choffat, 1885), *C. cedrorum* (Blanckenhorn, 1890) and *C.* cf. *boissyi* d'Orbigny, 1840 and a radiolitid *Sauvagesia sharpei* (Bayle, 1857) are described from the Hummar Formation (upper Cenomanian) in NW Jordan, in the vicinity of Ajlun. *Caprinula sharpei*, *C. cedrorum* and *S. sharpei* are described for the first time from Jordan. Many specimens of *S. sharpei* are characterized by the presence of cavities flanking the lamellar myophores in the left valve and the apparence of the dorsal cavity and teeth/socket system moulds in the inner part of the outer shell layer of the right valve. A hiatus (or erosional unconformity) between Hummar Formation and upper Turonian Wadi As Sir Limestone Formation is suggested by the presence of karstic structures, reworked limestone clasts, and rudist fragments and a sharp boundary. Early diagenetic processes such as dissolution and silicification present in the loose rudist material is described.

1. Introduction

Cenomanian canaliculate and radiolitid rudists are distributed in Tethyan deposits along the northern side of the Mediterranean in Portugal, France, Italy, Croatia, Bosnia-Herzegovina, Bulgaria, Greece and Turkey (Accordi, Carbone, & Pignatti, 1998; Accordi, Carbone, & Sirna, 1989; Berthou, Ferreira Soares, & Lauverjat, 1979; Bilotte, 1985; Carbone, Praturlon, & Sirna, 1971; Combes, Fourcade, Masse, & Philip, 1981; Douvillé, 1888; d'Orbigny, 1847, 1850; Mermigis, 1993; Mermigis, Philip, & Tronchetti, 1991; Özer, 1988, 1998; Özer & Sarı, 2008; Pamouktchiev, 1974; Parona, 1926; Philip, 1978; Pleničar, 1961, 1963; Pleničar & Jurkovšek, 2000; Polšak, 1967; Pons, Vicens, & Tarlao, 2011; Sarı & Özer, 2009; Sharpe, 1850; Sirna & Paris, 1999; Slišković, 1966, 1982, 1983; Steuber, 1999a,b, 2002; Swinburne & Noacco, 1993; Tentor, 2007). Studies on the Arabian-African plate show that our knowledge is very limited regarding Cenomanian canaliculate rudists compared to radiolitids. Faunas from Tunisia, Libya, Morocco, Oman, Egypt, Lebanon, Jordan, Iraq and Iran (Steuber, 2002) are mostly described from older publications and are poorly described. Faunas are better known from Algeria (Chikhi-Aouimeur, 1996, 1998, 2002, 2004, 2010; Fliert, 1952; Parona, 1921). There are, nevertheless, good modern records from Oman (Philip, Borgomano, & Al-Maskiry, 1995) and Sinai, Egypt (Bauer, Steuber, Kuss, & Heimhofer, 2004).

The presence of rudists has been documented in stratigraphic and sedimentologic studies from the northern, central and southern parts of Jordan (Abed, 1982; Baaske, 2005; Kuss et al., 2003; Makhlouf, Abu-Azzam, & Al-Hiyari, 1996; Powell, 1989; Powell & Moh'd, 2011; Schulze, Lewy, Kuss, & Gharaibeh, 2003; Schulze, Marzouk, Bassiouni, & Kuss, 2004; Schulze, Kuss, & Marzouk, 2005), but there are no published studies on their systematic palaeontology. Bandel and Mustafa (1996) identified some rudists, including *Caprinula boissyi* d'Orbigny, 1847 and *Sauvagesia* sp. from limestones of Cenomanian age and *Hippurites requieni* Matheron, 1842 of Turonian age near the city of Ajlun in north Jordan. They did not give precise locality or stratigraphic data nor any information about the silicification of the rudists. New rudist material from the Ajlun-Kitim area (this study) confirms the presence of abundant canaliculate rudists with accompanying radiolitids from the upper Cenomanian limestones. This new material makes it possible to resolve some of the taxonomic problems associated with the rudist identifications of Bandel and Mustafa (1996). In addition, two controversial rudist identifications of *Toucasia matheroni* (Coquand, 1862) and *Radiolites*? sp. were determined to be requieniids in Berndt's (2002) study of the palaeoecology and

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taxonomy of the macrobenthic fauna of the Cenomanian of southern Jordan.

The rudists are a source of important data regarding the diagenetic history of the rudist reefs, rudist-bearing limestones and dolomitic limestones. The diagenetic processes affecting rudists are mainly revealed by the microfacies, geochemical, isotopic and luminescent analysis of the rudist shells, and also by lithologic reports from the viewpoint of reef diagenesis in previous studies (Al-Aasm & Veizer, 1986a,b; Al-Mohammad, 2012; Alsharhan, 1995; Aqrawi, Tehni, Sherwani, & Kareem, 1998; Asghari & Adabi, 2014; Braun & Hirsch, 1994; Enos, 1986; García-Garmilla, 2003; García-Garmilla, Özer, & Sarı, 2004; Garcia-Hidalgo et al., 2012; Ghanem & Kuss, 2013; Mansour, 2004; M'Rabet, Negra, Purser, Sassi, & Ben Ayed, 1986; Negra, 1984; Negra, Purser, & M'Rabet, 2009; Opdyke, Wilson, & Enos, 1995; Regidor-Higuera & García-Garmilla, 2005, 2006; Regidor-Higuera, García-Garmilla, & Elorza, 2002; Regidor-Higuera, García-Garmilla, & Skelton, 2007; Sadooni, 2005; Sanders, 1998, 1999, 2001; Steuber, 1999a; Touir & Soussi, 2003). There is remarkably less attention given to the diagenetic effects of loose rudist specimens. Reports of these effects are substantially based on dissolution of the valves from thin sections or valves embedded within the limestones (Burla, Heimhofer, Hochuli, Weissert, & Skelton, 2008; Cestari & Sartorio, 1995; Ross & Skelton, 1993; Sanders, 1998, 1999, 2001; Schlüter, Steuber, & Parente, 2008). The Jordanian rudist material allows us to describe the diagenetic processes affecting loose specimens that formed part of the mobile substrate.

The present study describes canaliculate and radiolitid rudists based on material recently collected from the upper Cenomanian limestones of the Hummar Formation between Ajlun city and Kitim town, NW Jordan (Fig. 1). New stratigraphic data on the upper boundary of the Hummar Formation is discussed and the diagenetic processes of the rudist valves are also described.

2. Material and methods

The rudist specimens were extracted from the following measured stratigraphic sections in the area between the Ajlun city and Kitim town in the NW of Jordan (Figs. 1–4):

1-Ishtafina section: NE of Ajlun city, 2 km W of Ishtafina town at the intersection of latitude (32°21´24.699 N) and longitude (35°44´16.884 E).
2-An Nuaymah section: SE of Kitim town, 3 km SE of Shayaha town at the intersection of latitude (32°23´ 20.717 N) and longitude (35°51´04.663 E).
3-Samta section: Between Ajlun city and Kitim town, 3 km SE of Rihaba town at the intersection of latitude (32°24´ 09.731 N) and longitude (35°48´26.204 E).

Thin sections from loose rudist specimens were made to better understand the diagenetic effects such as dissolution and silicification of the calcitic outer shell layer, the originally aragonitic internal shell layer and the body cavity. An XRD analysis was made to determine of the mineralogic composition of reddish-deposits filling the body cavity of *Caprinula* specimens.

Many of the studied rudist fossils are held in the first author's collection in Dokuz Eylul University, İzmir, Turkey, and the others in the collections of the Hashemite University, Faculty of Natural Resources and Environment, Department of Earth and Environmental Sciences, Jordan. The explanation of the identifying numbers (e.g., EESH 2013 V 6) is as follows: EESH – Earth and Environmental Sciences Department at Hashemite University, 2013 – the year of collection, V – refer to the rank of the collection during the year, and 6 – the number of each individual specimen within the collection.

3. Geological setting and stratigraphy

Jordan is located on the northern part of the Arabian Plate and comprises Precambrian, Mesozoic and Cenozoic rocks (Alsharhan & Nairn, 1997; Baaske, 2005; Powell, 1989). Palaeogeographic studies (Philip et al., 2000; Stampfli, Borel, Cavazza, Mosar, & Ziegler, 2001) show that, during late Albian and Turonian times, Jordan was part the Levant platform (Kuss et al., 2003; Schulze, Kuss, & Marzouk, 2005). The marine Cretaceous sequences of Jordan were deposited along the western and northern margin of the Levant platform, connected to the Mediterranean Neo-Tethys and located on the passive margin of the Arabian-Nubian Shield (Kuss et al., 2003; Philip et al., 2000; Powell, 1989; Stampfli et al., 2001; Schulze, Kuss, & Marzouk, 2005). The depositional system during the Cenomanian and Turonian was characterized by shallow marine carbonates including rudist-bearing limestones and dolomitic limestones, which largely covered the Jordanian shelf (Powell & Moh'd, 2011).

The Cretaceous succession of Jordan is divided into the three major lithostratigraphic groups: Kurnub Sandstone Group (Berriasian to Albian), Ajlun Group (Cenomanian to Turonian) and Belga Group (Coniacian to Eocene) (Fig. 1), all of which are observed around Ajlun city (Abed, 1982; Abdelhamid, 1995; Abu Qudaira, 2005; Bender, 1974; Burdon, 1959; Masri, 1963; Powell, 1989; Quennell, 1951).

Ajlun Group carbonates unconformably overlie siliciclastics of the Kurnub Sandstone Group and are in turn overlain unconformably by the limestones and marls of the Belga Group (Powell, 1989; Quennell, 1951). The Ajlun Group is composed of five formations, from bottom to top, the Naur (fossiliferous limestones, calcaerous mudstones, gypsiferous clays, ?upper Albian-lower Cenomanian), Fuheis (marls, marly nodular fossiliferous limestones, calcaerous mudstones, Cenomanian), Hummar (pink to yellowish grey fossiliferous limestones, dolomitic limestones, upper Cenomanian), Shuayb (yellow to yellowish grey fossiliferous marls and nodular limestones, upper Cenomanian to lower Turonian) and Wadi As Sir Limestone formations (dolomitic-marly-fossiliferous cherty limestones, upper Turonian) (Basha, 1978; Dilley, 1985; Wetzel & Morton, 1959) (Fig. 1).

The contacts between these formations are generally accepted as conformable in the Ajlun area. However, a subaerial unconformity marked by a calcrete and paleokarstic horizon separating the Fuheis and Hummar formations has been recently described from an area southeast of Amman (Abed, Hamad, Khair, & Kraishan, 2013). The lower boundary of the Wadi As Sir Limestone Formation may also be unconformable, as explained below.

The presence of rudists is documented only by limited taxonomic determinations in the Wadi As Sir Limestone Formation in the Ajlun area (Abdelhamid, 1995; Bandel & Mustafa, 1996; Masri, 1963; Powell, 1989). Rudist reefs have been reported in the Kitim area (Parker, 1970) and in the area south of the Amman (Powell, 1989) in the upper part of the Hummar Formation. The taxonomic determinations of known rudist species from the upper Cenomanian and upper Turonian of the Hummar and Wadi As Sir Limestone formations, respectively, collected from the five measured-stratigraphic sections in the Ajlun-Kitim area, will be presented in a separate study.

The Hummar and Wadi As Sir Limestone Formations are observed in the Ishtafina and Samta measured-stratigraphic sections, but the An Nuaymah section contains only the Hummar Formation (Figs. 2–4). The lower boundary of the Hummar Formation can not be observed in the sections, but the top is marked by an erosional unconformity and is directly overlain by the Wadi As Sir Limestone Formation. The karstic structures, reworked limestones and rudist fragments, sharp boundary, and the absence of Shuayb Formation or any palaeontologic indications of the lower

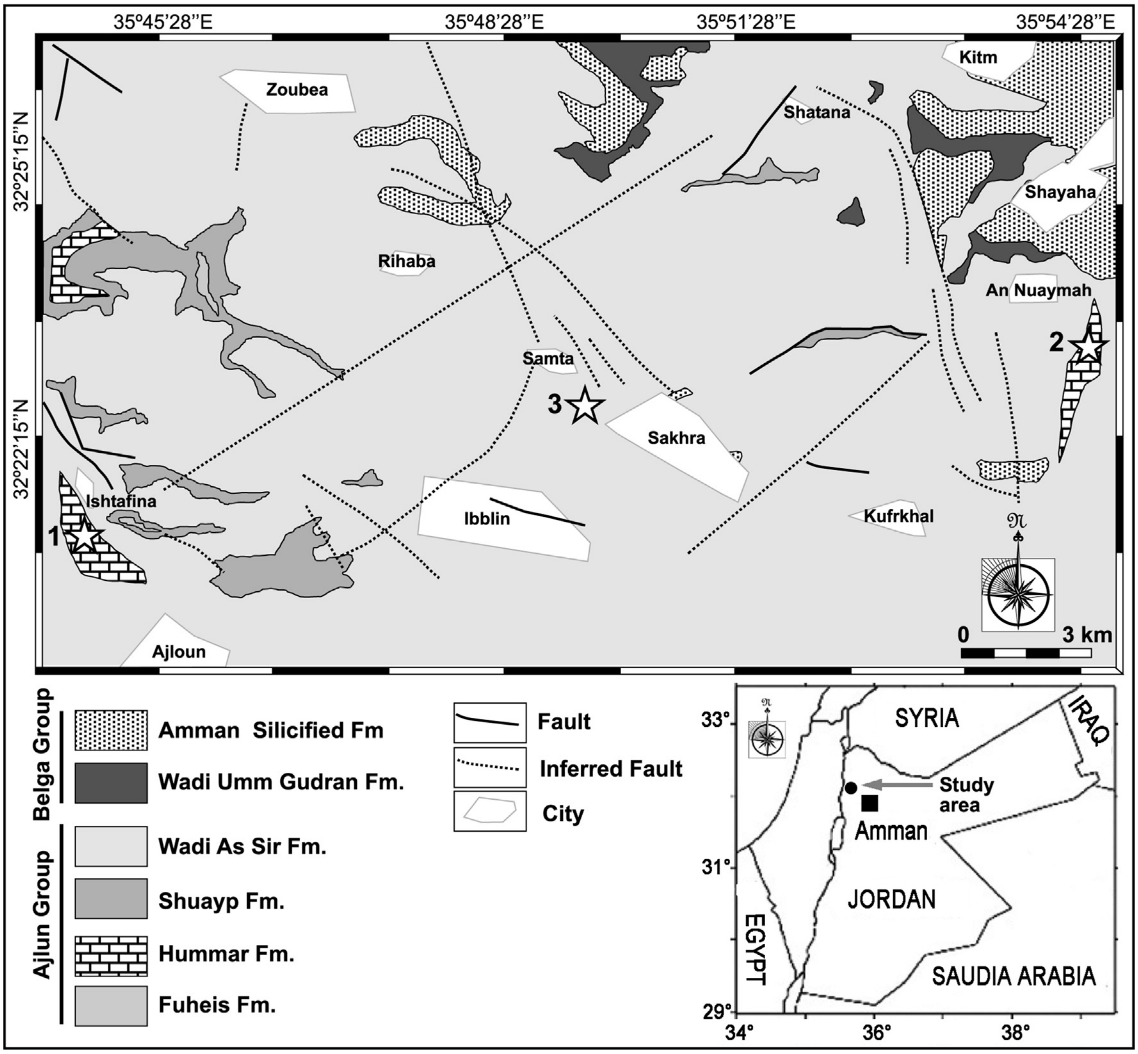


Fig. 1. Location map of the study area (inset bottom right) and geological map (modified from Abu Qudaira, 2005) showing the measured-stratigraphic sections (asterisks: 1-Ishtafina, 2-An Nuaymah, 3-Samta).

or middle Turonian indicate a hiatus between these two formations in this area. Evidence of emergence such as palaeosols and caliches were not observed on the erosional surface, but the discontinuity may be a result of Oceanic Anoxic Event (OAE) 2, which has been reported from the Cenomanian/Turonian boundary in Jordan (Bandel & Salameh, 2013; Powell, 1989; Powell & Moh'd, 2011; Schulze, Marzouk, Bassiouni, & Kuss, 2004; Wendler, Wendler, & Kuss, 2009) and on the Arabian-African platform (Abdallah, 2003; Bauer, Marzouk, Steuber, & Kuss, 2001; El-Sabbag et al., 2011; Frank, Buchbinder, & Benjamini, 2010; Hajikazemi, Al-Aasm, & Coniglio, 2010; Lewy, 1990; Saber, Salama, Scott, Abdel-Gawad, & Aly, 2009). The intensely silicified rudist material indicates early diagenesis of the shells, which developed during the subaerial exposure of the studied area.

The Hummar Formation consists mainly of limestones, but interbedded clayey marls with ammonites and marls are observed in the An Nuaymah section. The thickness of the formation varies from 8 m to 30 m. Monospecific clusters of canaliculate rudists are observed in three stratigraphic sections. Gastropod-bearing limestones are characteristically present above the levels of rudist-bearing limestones. The Ishtafina section is significant because of the greater abundance of canaliculated rudists compared to other sections. The rudist fauna consists of *Caprinula sharpei* (Choffat, 1885), *Caprinula cedrorum* (Blanckenhorn, 1890), *Caprinula* cf. *boissyi* d'Orbigny, 1840, *Caprina* cf. *schiosensis* Böhm, 1892, *Neocaprina nanosi* Pleničar, 1961, *Sauvagesia sharpei* (Bayle, 1857), *Apricardia* sp. and also includes requieniids (Özer & Ahmad, 2014).

The rudist fauna indicates a late Cenomanian age. The determined three species of *Caprinula* are recognized as mostly upper Cenomanian rudists (Steuber, 2002; Steuber & Löser, 2000), and have also been recorded from the upper Cenomanian of France (Bilotte, 1985; d'Orbigny, 1850; Philip, 1978), Portugal (Berthou et al., 1979), Italy (Swinburne & Noacco, 1993) and Algeria (Chikhi-Aouimeur, 2010). *Caprina schiosensis* has been recorded from Cenomanian strata of Algeria, Tunisia, Croatia, Bulgaria, Libya (Steuber, 2002) and the upper Cenomanian of Italy, Bosnia-Herzegovina, Slovenia and Turkey (Özer, 1998; Pleničar, Jurkovšek, & Kolar-Jurkovšek, 1999; Praturlon & Sirna, 1976; Sarı & Özer, 2009; Slišković, 1983). *Neocaprina nanosi* is a middle–late Cenomanian rudist and has been recognized in the central Mediterranean Tethys (Italy, Croatia, Slovenia, Bosnia-Herzegovina, Greece) by many authors (see Steuber, 2002). *Sauvagesia sharpei* was first described from the upper Cenomanian of Portugal, and shows a wide distribution in the upper Cenomanian of the northern and southern sides of the Mediterranean Tethys (see for detail Pons et al., 2011), but there are some records also from Turonian rocks (Steuber, 2002).

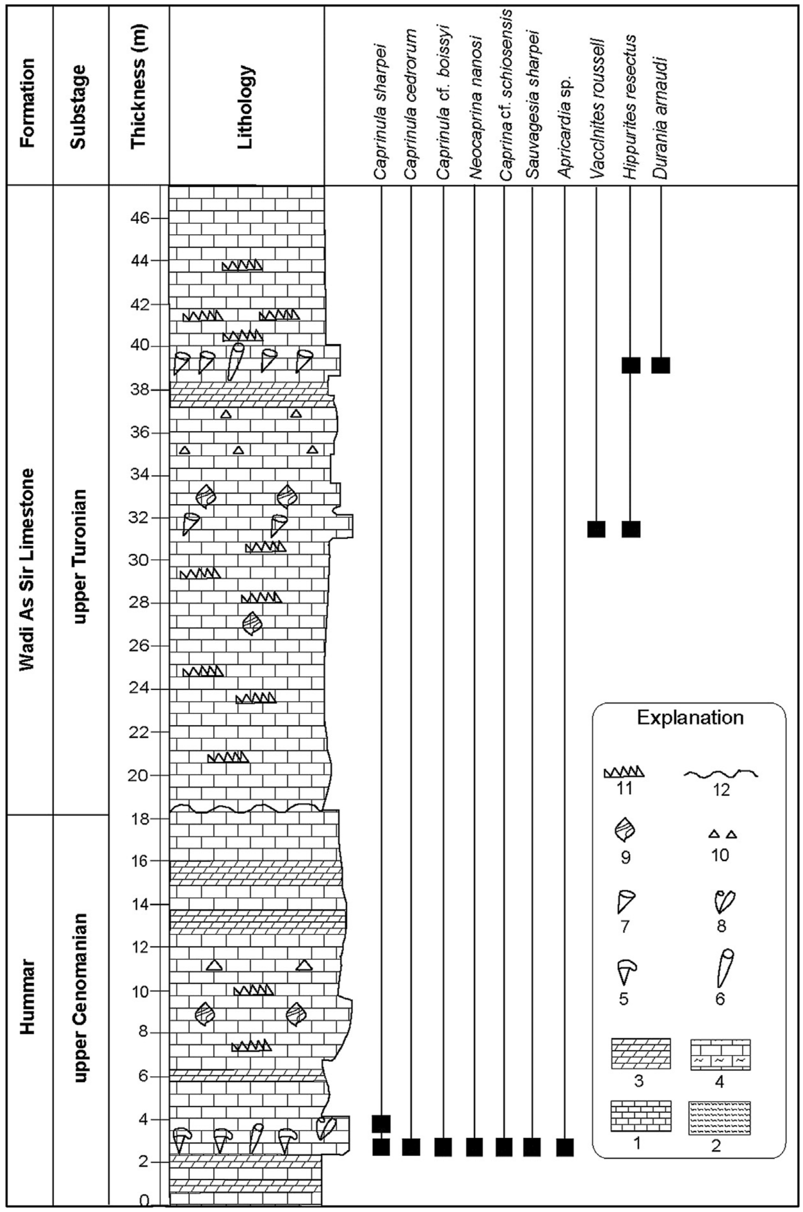


Fig. 2. Ishtafina measured-stratigraphic section (see Fig. 1 for location) showing the distributions of the described canaliculate and radiolitid rudists in this study and also other identified rudists. Explanation: 1-limestones, 2-clayey marlstones, 3-dolomitic limestones, 4-marlstones, 5-caprinids, 6-radiolitids, 7-hippuritids, 8-*Apricardia*, 9-gastropods, 10-cherts, 11-stylolite, 12-subaerial unconformity/hiatus.

Previous studies support the same age interpretation for the Hummar Formation. Benthic foraminifers from a study of the biostratigraphy of the Ajlun Group in the east of Jordan indicate a late Cenomanian age for the Hummar Formation (Basha, 1978). The late Cenomanian age of the formation is also supported by the presence of the ammonite, *Neobilites vibrayeanus* (d'Orbigny, 1841) in the *Calycoceras guarangeri* Zone, which further indicates a shallow marine shelf setting in the northern and central of Jordan (Schulze et al., 2005). Aly, Smadi, and Abu Azzam (2008) used the same ammonite as an index fossil for the upper Cenomanian in the Hummar Formation and Wiese and Schulze (2005) used it for Jordan and Egypt. Other studies based on ammonites, calcareous nannofossils and benthic and planktic foraminifers in the west-central-north of Jordan, also support a late Cenomanian age for the Hummar Formation (Schulze, Lewy, Kuss, & Gharaibeh, 2003; Schulze, Marzouk, Bassiouni, & Kuss, 2004; Schulze, Kuss, & Marzouk, 2005). We also found some ammonites in the marls of the formation just below the rudist-bearing limestones in the An Nuaymah section, but they have not yet been identified. Additional studies based on the foraminifera also support a late Cenomanian age for the formation (Abdelhamid, 1995; Dilley, 1985; Olexcon Int., 1967).

The Wadi As Sir Limestone Formation represents the uppermost formation of the Ajlun Group (Powell, 1989) and is comprised of well-bedded massive limestone, dolomitic limestones and dolomites, locally with intercalated beds of gypsum and chert nodules and especially characterized by the abundance of *in situ* rudists. Monospecific biostromes constructed mainly by *Hippurites resectus* Defrance, 1821 are observed in the Ishtafina and Samta measured-stratigraphic sections (Figs. 2 and 3). *Vaccinites rousseli* Douvillé, 1894 and *Durania arnaudi* (Choffat, 1891) are also found (Özer & Ahmad, 2014). The rudist fauna indicates a late Turonian age for the formation (see Steuber, 2002). The same age is also suggested for the formation in northern and southern Jordan (Abdelhamid,

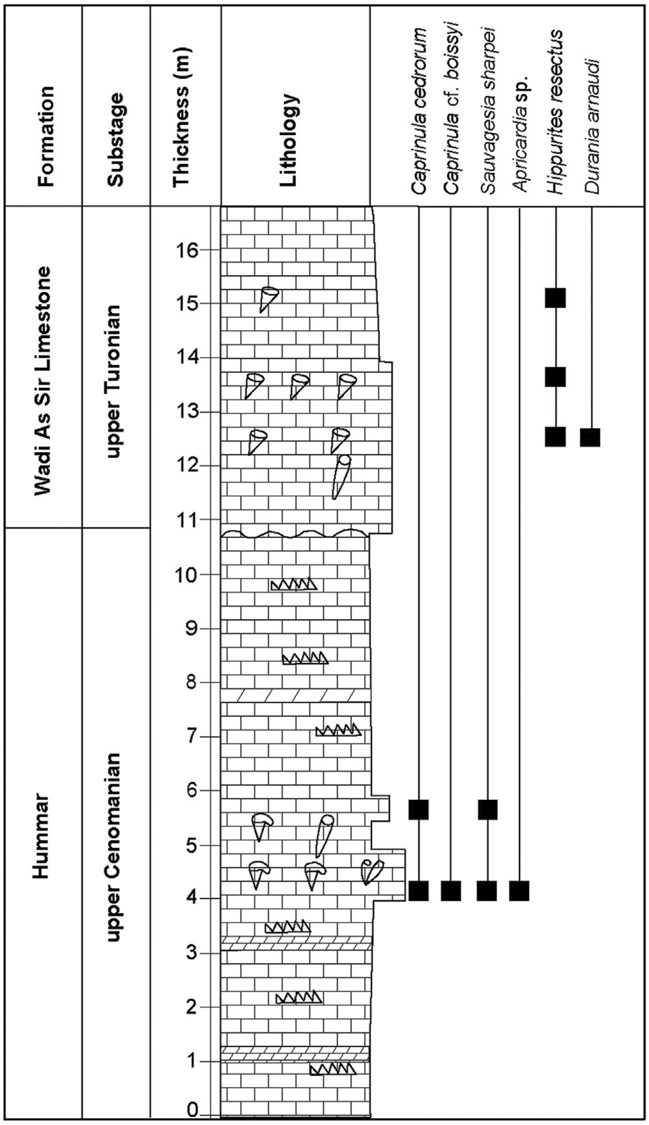


Fig. 3. Samta measured-stratigraphic section (see Fig. 1 for location and Fig. 2 for symbols) showing the distributions of the described canaliculate and radiolitid rudists in this study and also other identified rudists.

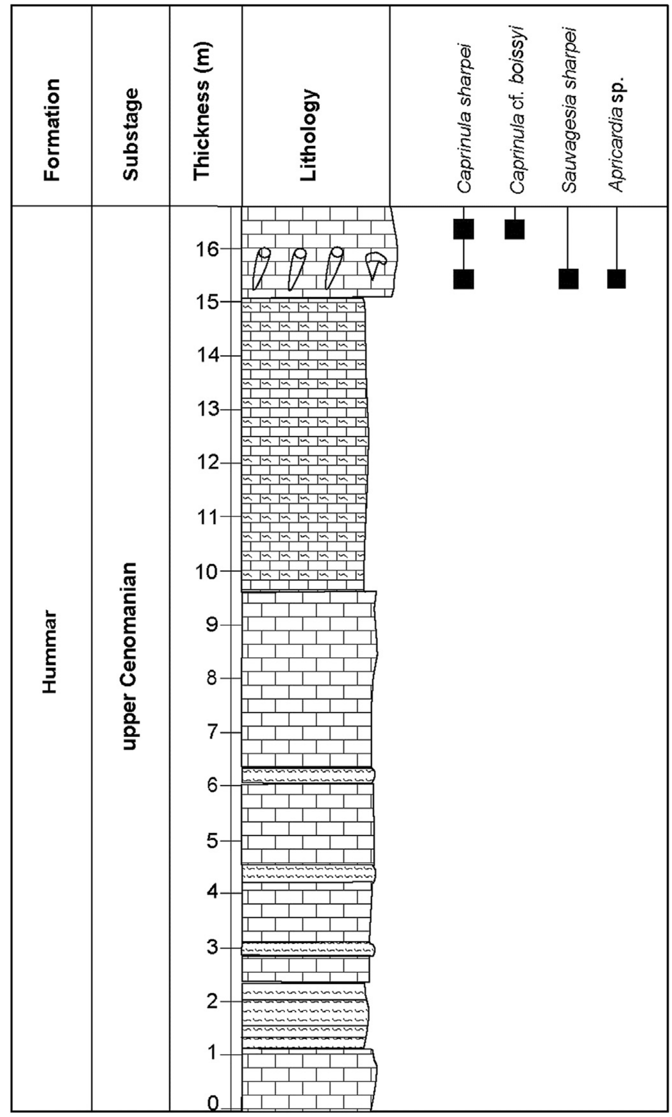


Fig. 4. An Nuaymah measured-stratigraphic section (see Fig. 1 for location and Fig. 2 for symbols) showing the distributions of the described canaliculate and radiolitid rudists in this study and also other identified rudists.

1995; Baaske, 2005; Bender, 1974; Dilley, 1985; Kuss et al., 2003; Powell, 1989; Schulze et al., 2003).

4. Systematic palaeontology

We follow the classification scheme and terminology for rudist taxa presented by Skelton (2013a,b).

Abbreviations: LV, left valve; RV, right valve; Ab, anterior radial band; Pb, posterior radial band; Ib, interband; L, ligament ridge; am, anterior myophore; pm, posterior myophore; at and ats, anterior tooth and socket; pt and pts, posterior tooth and socket; ct, central tooth; pc, posterior accessory cavity; ec, ectomyophoral cavity/canals; bc, body cavity; ol, outer (calcitic) shell layer; il, inner (originally aragonitic) shell layer.

Class BIVALVIA Linnaeus, 1758
Order Hippuritida Newell, 1965
Suborder Hippuritidina Newell, 1965
Superfamily: Radiolitoidea! d'Orbigny, 1847
Family: Caprinulidae Yanin, 1990
Genus *Caprinula* d'Orbigny, 1847
Type species. Caprina boissyi d'Orbigny, 1840
Caprinula sharpei (Choffat, 1885)
Fig. 5A–E

1885 *Ichthyosarcolites Sharpei*, Choffat, p. 63.
1888 *Caprinula Sharpei*, Douvillé, p. 712, pl. 12, Fig. 4, pl. 23, Figs. 5–6.
1961 *Caprinula sharpei*, Pleničar, p. 48, pl. 6, Fig. b, pl. 9, Fig. a, text-fig. 7.
1981 *Caprinula sharpei*, Pamouktchiev, p. 154, pl. 75, Fig. 4.

Material and occurrence. One specimen with both valves but RV is partially preserved (No. EESH 2013 V 40), one RV specimen (No. EESH 2013 V 42) from Ishtafina, Ajlun, Jordan and one specimen of LV (No EESH 2013 V 46) from An Nuaymah, Ajlun, Jordan (Fig. 1).

Description. The LV is conical with beak curved towards the posterior part and its length varies from 60 mm to 90 mm in well-preserved specimens (Fig. 5A–B). The calcitic ol is very thin

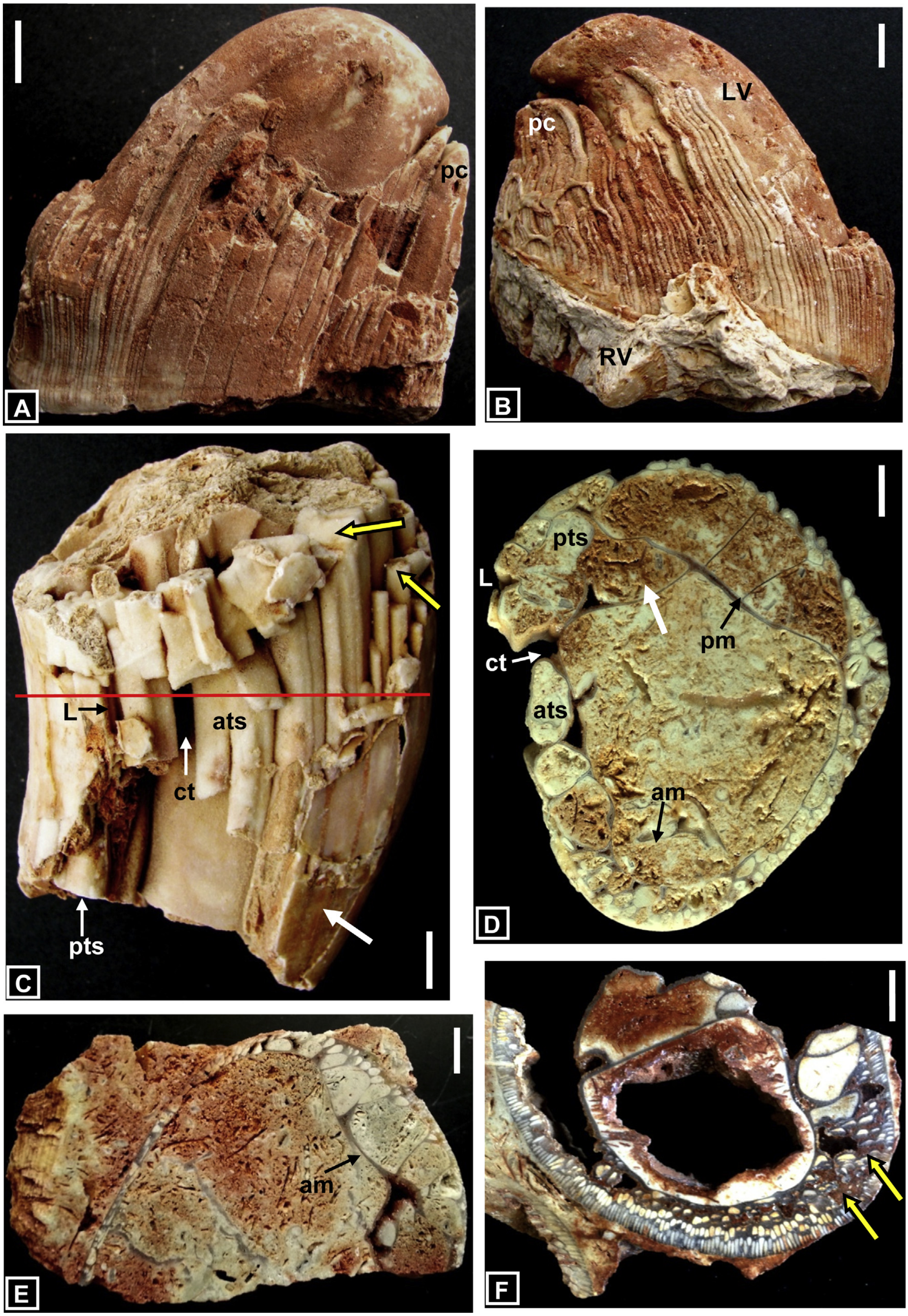


Fig. 5. A–E. *Caprinula sharpei* (Choffat, 1885). A–B – Both valves, but RV is partly preserved. The LV is conical and its beak curved towards the posterior part. The elongate pallial canals of the aragonitic il can be clearly observed in the eroded parts of the thin calcitic ol. Note thin aragonitic il. Ishtafina, Ajlun, Jordan. No. EESH 2013 V 40. C–D – Ishtafina, Ajlun, Jordan. No. EESH 2013 V 42. C – the RV, ventral part showing the L, the myocardinal apparatus, the thin ol (thick white arrow), the accessory cavities/canals and longitudinal pallial canals (yellow arrows). The thin furrows can be seen in the cavities along its length. The horizontal red line indicates the location of the transverse section given in the next figure. D – the adumbonal view, the transverse section of the same specimen showing the thin il with one or two rows of canals, the well-preserved large accessory cavities, the ct (dissolved out) in its characteristic position in front of the L, flanked by the internal moulds for the ats and pts. It looks quite similar to the RV of *C. sharpei*, as illustrated by Douvillé (1888, Pl

(0. 5 mm), badly preserved and the elongate pallial canals of the aragonitic il can be observed in its eroded part. The aragonitic il is very thin, 1 mm–2 mm is represented generally by a single row of polygonal or suboval very small pallial canals. A single specimen shows the second row containing very small rounded pallial canals in the antero-ventral part of the valve. An oblique lamina separates the bc from the pc, and the latter is much smaller than other. The transverse section of the LV is suboval, slightly flattened in the dorso-ventral sense and its diameter, very close to the commissure, varies from 70 × 60 mm to 90 × 75 mm.

The RV is broken out, it seems to be conical, gently curved and its present length varies from 20 mm to 70 mm (Fig. 5A–D). The calcitic ol is thin (1 mm) and almost preserved. The longitudinal thin pallial canals are seen in its eroded part. The transverse section of the RV is suboval and it has a maximum diameter 80 × 60 mm. The aragonitic il is thin (2–3 mm) in the antero-ventral part and consists of two rows of pallial canals showing elongated polygonal in the interior and following very small rounded canals (Fig. 5D). The il is very thin (1 mm) in the posterior part and consists of a single row of small rounded pallial canals. One row of accessory cavities/canals separated by thin laminae, are observed in the anterior and posterior parts of the valve, and present a remarkable aspect due to the small size of the pallial canals. The posterior part contains three large 10–13 mm sub-rectangular elongated cavities. The anterior part consists of two or three, sub-rectangular or ovaloid cavities, which are thinner (5 mm–8 mm) than those of posterior. In the middle of the each cavity there is a very thin furrow along its length (Fig. 5C). A large cavity is also seen between the pts and bc (Fig. 5D), which is labelled as '*Of*' by Douvillé (1888, pl. XXII, 4 b, pl. XXIII, 5 b). The L is invaginated. The LV teeth sockets are unequal; the anterior one is bigger than other. The ct is situated in front of the L and flanked by the internal moulds for the ats and pts. The myophores represented by thin plates.

Discussion and remarks. C. sharpei is characterized as poorly canaliculated, with one or two rows of pallial canals, differing from other species of the genus. RVs transverse sections of our specimens a show clear resemblance to that of Douvillé (1888, pl. XXIII, Fig. 5 b). The shape of the LV of our specimens is identical to *Caprinula brevis* Sharpe (1850, pl. 17, Fig. 1), but, the internal features of the latter species are less known. The thin LVs il consisting of one or two rows of pallial canals of a specimen determined as *Caprinula boissyi* by Sharpe (1850, pl. 16, Fig. 3), is similar to our specimens. It is likely that this is the first record of this species from Arabian platform carbonates.

Caprinula cedrorum (Blanckenhorn, 1890)

Figs. 5F, 6A–D

1890 *Hippurites cedrorum*, Blanckenhorn, p. 86.

1910 *Caprinula cedrorum*, Douvillé, p. 63, pl. 6, Fig. 1, text-figs. 59–61.

1933 *Caprinula cedrorum*, Keller, p. 46, pl. 6, Figs. 1 and 2, text-fig. 12.

1943 *Caprinula cedrorum*, Dechaseaux, p. 37, text-figs. 1–7.

1996 *Caprinula* aff. *cedrorum*, Chikhi-Aouimeur, p. 179–184, text-fig. 2, pl. 1, Figs. 1 and 2, pl. 2, Figs. 1–5.

Material and occurrence. One specimen with both valves, but RV is partially preserved (No. EESH 2013 V 41), one specimen of LV (No EESH 2013 V 43), three RV specimens (Nos EESH 2013 V 47, EESH 2013 V 50, EESH 2013 V 53) from Ishtafina, Ajlun, Jordan and one specimen of RV (No EESH 2013 V 51) from Samta, Ajlun, Jordan (Fig. 1).

Description. The LV is loosely coiled towards the posterior part and it is about 110 mm long. The canals of the aragonitic il and a thin lamina separating the pc from the bc can be observed in the eroded parts of the valve (Fig. 6A, B). The transverse section of the LV is suboval, its diameter varies from 50 × 40 mm to 70 × 60 mm. The L is invaginated, the ats is larger than the pts, the ct is situated in front of the L, the myophores are represented by thin plates. A thin lamina separating the bc from the pc and connected the at is preserved (Fig. 6D). The pc is much smaller than the bc. The aragonitic il consists of pallial canals decreasing in canal size from the inner part to outer of the il and covering around of the valve. It is thick, varies from 8 mm to 10 mm in the postero-ventral and antero-ventral flank part where it consists of six or seven rows of canals. Its inner part consists of two or three rows of large (2 mm–4 mm), polygonal or suboval pallial canals, outer rows very small (1 mm), fine and rounded and the outermost part comprises very small, piriform pallial canals. Four or five large accessory cavities are present on the other side of the pm.

The RV is conical and its length varies from 40 mm to 70 mm. The calcitic ol is thin (1 mm) and the longitudinal thin pallial canals are seen in its eroded part (Fig. 6C). The transverse section of the RV is suboval and it has a maximum diameter 60 × 50 mm. The aragonitic il is thick, varies from 8 mm to 10 mm in the anterior part and thin, 1 mm–4 mm in the other parts of the valve, consisting of pallial canals covering all around of the valve (Fig. 5F). The il consists of a single row of large, polygonal with 2 mm–4 mm diameter canals in the interior following one or three rows of small, round with 1 mm–2 mm diameter and piriform pallial canals. One row of accessory cavities/canals is separated by thin laminae, observed in the anterior and posterior parts of the valve. The L is invaginated. The myophores are represented by thin plates but the myophoral apparatus is partly preserved.

Discussion and remarks. Caprinula cedrorum (Blanckenhorn, 1890) and *Caprinula boissyi* d'Orbigny, 1840 show clear similarities as indicated by Douvillé (1910) and Chikhi-Aouimeur (1996), except the first differs from the type-species by the relatively small size of the pc, more oblique ats of the LV and may be the reduced size of the ec of the RV. Our specimens differ from *Caprinula boissyi* and we assign them to *Caprinula cedrorum.* The LV shows clear similarities with that of Douvillé (1910, Fig. 60), but the anterior part of our specimens is more canaliculated and so they approach the determination of Keller (1933, Fig. 12 a, b). *Caprinula distefanoi* Boehm, 1897 closely resembles some of the sections of *C. cedrorum* determined by Douvillé (1910, Fig. 60) and also our specimens.

Caprinula cf. *boissyi* d'Orbigny, 1840

Fig. 6E, F

1840 *Caprina boissyi*, d'Orbigny, p. 169.

1847 *Caprinula boissyi*, d'Orbigny, pl. 7, Fig. 52.

1888 *Caprinula boissyi*, Douvillé, p. 707, pl. XXII, Figs. 1 a, b.

2002 *Caprinula boissyi*, Steuber, (see Web Catalogue of the Hippuritoidea (rudist bivalves) for complete synonym list).

XXII, Fig. 4 b, pl. XXIII, 5 b), even to the detail of the cavity labelled '*Of*' by Douvillé in his figure, which can be seen in this specimen (thick white arrow). E – transverse section of the LV, but partially preserved, abumbonal view. Note the thin il and the similarity between the form of the large canals on the right of this image and those outside the am in the LV of *C. sharpei* figured by Douvillé (1888, Pl. XXII, Fig. 4a and Pl. XXIII, Fig. 5a and 6a). An Nuaymah, Ajlun, Jordan, No. EESH 2013 V 46. F – *Caprinula cedrorum* (Blanckenhorn, 1890), the abumbonal view, the transverse section of the RV showing the dissolution of the il, the bc and the myocardinal apparatus (thin black arrows). Note the bc collapsed with reddish-deposits. No. EESH 2013 V 53. Scales indicate 10 mm. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

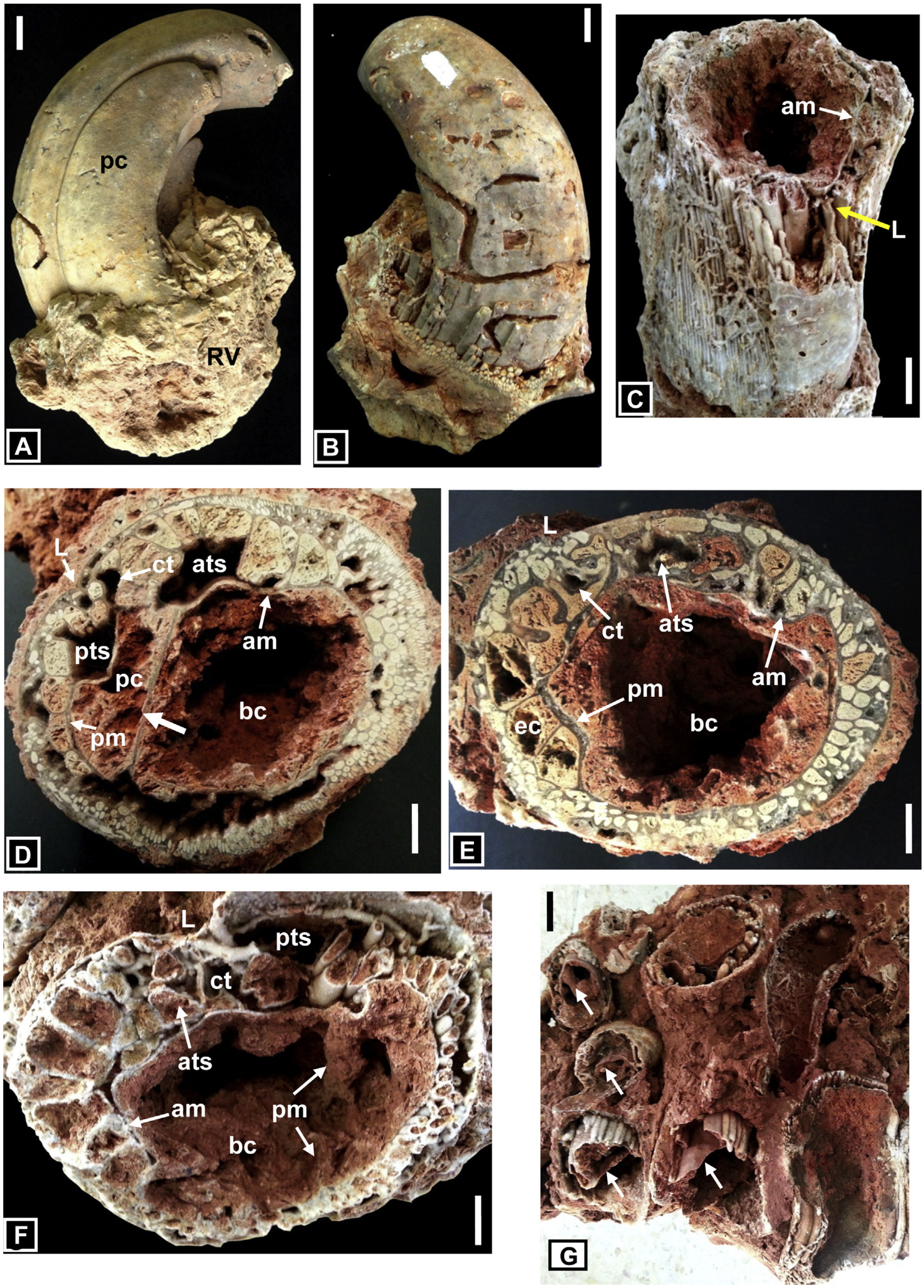


Fig. 6. A–D — *Caprinula cedrorum* (Blanckenhorn, 1890), Ishtafina, Ajlun, Jordan. A–B — Both valves, but RV is partly preserved. No. EESH 2013 V 41. A — the LV is loosely coiled towards the posterior part. The oblique lamina separating the pc from bc is clearly observed. B — the antero-ventral part of the valve showing the pallial canals decreasing in canal size from the inner part to outer in the il. C — RV, dorsal part, showing the thin ol, the longitudinal pallial canals of the il, the partly dissolved myocardinal apparatus and the large accessory cavities/canals. Compare the dissolution and deposits filling features of the bc with those of next figures. No. EESH 2013 V 51. D — transverse section of the LV showing the pallial canal decreases in canal size from the inner part to outer in the il, thin lamina separating the bc from the pc connected with ats (white thick arrow) and myocardinal apparatus, adumbonal view. Note the partial dissolution of the il and myocardinal apparatus, with the bc and the pc collapsed with sediment-fill (otherwise partly eroded out) after the dissolution of the valve. No. EESH 2013 V 43. E–F — *Caprinula* cf. *boissyi* d'Orbigny, the transverse section of the RV, E — the abumbonal view, showing the L, the myocardinal apparatus, the large cavities, the ec and the il. The aragonitic il covers approximately all around of the valve and its pallial canals preserved. Note the partially dissolution of the myocardinal apparatus and the large cavities, but almost all of the bc collapsed with deposits-filled after the dissolution of the valve, No. EESH 2013 V 45. F — adumbonal view. Note

2007 *Caprinula boissyi,* Tentor, p. 6, Figs. 4 and 5.
2010 *Caprinula boissyi,* Chikhi-Aouimeur, p. 92, 93, Figs. 83, 1–3, Figs. 84, 1–4.

Material and occurrence. Three RV specimens (Nos EESH 2013 V 45, EESH 2013 V 49, EESH 2013 V 48) from Ishtafina, Ajlun, Jordan and one specimen with both valves (No EESH 2013 V 44) from An Nuaymah, Ajlun, Jordan (Fig. 1).

Description. The LV is badly preserved and it is impossible to observe the internal characters. The RV is broken out, it seems to be conical with thin (1 mm) calcitic ol and its present length varies from 20 mm to 70 mm. The transverse section of the RV is suboval and it has a maximum diameter 80 × 60 mm (Fig. 6E, F). The aragonitic il covers all of the valve, its thickness is variable and it consists of a single row of suboval or polygonal canals in the interior following one or three rows of small, round and very sparse piriform pallial canals. One row of accessory cavities/canals separating by thin laminae was observed in the anterior and posterior parts of the valve. The ec separating the pm from the shell wall is visible in some specimens. The L is invaginated. The LV teeth sockets are unequal, the ct is situated in front of the L. The myophores are represented by thin plates (Fig. 6E, F).

Discussions and remarks. The LV features of our specimens are not preserved, however our RV specimens resemble *Caprinula boissyi* based on the horizontal cardinal apparatus and the presence of the ec. The large accessory cavities/canals of our specimens are comparable to those of *Neocaprina*? sp. determined by Steuber and Bachmann (2002) from the upper Albian of Sinai.

Family Radiolitoidae d'Orbigny, 1847
Genus *Sauvagesia* Choffat, 1886
Type species Sphaerulites sharpei Bayle, 1857
Sauvagesia sharpei (Bayle, 1857)
Figs. 7 and 8

1857 *Sphaerulites sharpei*, Bayle, 690.
1886 *Sphaerulites sharpei*, Choffat, p. 29, pls.2–3, pl.4, Fig. 1.
1891 *Sauvagesia sharpei*, Douvillé, p. 669, text-fig. 1
2002 *Sauvagesia sharpei*, Steuber (see Web Catalogue of the Hippuritoidea (rudist bivalves) for complete synonym list).
2010 *Sauvagesia sharpei*, Chikhi-Aouimeur, p. 129–131, Figs. 120–122.
2011 *Sauvagesia sharpei*, Pons et al., p. 656, 657, Fig. 8 A–D.

Material and occurrence. Nineteen specimens with two valves (Nos EESH 2013 V 1, EESH 2013 V 3, EESH 2013 V 4, EESH 2013 V 6 to EESH 2013 V 14, EESH 2013 V 15 B, C, EESH 2013 V 16, EESH 2013 V 17, EESH 2013 V 18, EESH 2013 V 34, EESH 2013 V 35), twelve specimens of RV (Nos EESH 2013 V 15 A, EESH 2013 V 16, EESH 2013 V 17, EESH 2013 V 19, EESH 2013 V 20, EESH 2013 V 22, EESH 2013 V 25, EESH 2013 V 26, EESH 2013 V 27, EESH 2013 V 28, EESH 2013 V 36, EESH 2013 V 39) selected from abundant material from Ishtafina, Ajlun, Jordan. Four specimens with both valves (Nos EESH 2013 V 2, EESH 2013 V 5, EESH 2013 V 31, EESH 2013 V 37), four RV specimens (Nos EESH 2013 V 21, EESH 2013 V 29, EESH 2013 V 30, EESH 2013 V 32) and one LV specimen with partially preserved RV (EESH 2013 V 29) from Samta, Ajlun, Jordan. Two specimens with both valves, their LV is partially preserved (Nos EESH 2013 V 15 D, EESH 2013 V 38) and two RV specimens (No EESH 2013 V 22, EESH 2013 V 24) from An Nuaymah, Ajlun, Jordan (Fig. 1).

Description. The RV is habitually straight, elongated conical, but in some specimens it is cylindro-conical and slightly curved towards the ventral part. The present length varies from 50 mm to 70 mm, ornamented with finely longitudinal ribs, 0.5 mm width, crossed by growth lamellae (Figs. 7F, 8A–D). The radial bands are preserved in some specimens, the Ab and Pb are slightly indented with fine riblets showing the same ornamentation as that of the valve. The Ab is wide and flat, Pb is narrow and salient and Ib is slightly furrow (Fig. 7A, C). The transverse section of the RV is circular to semi-circular and has maximal diameter of 58 mm and 70 × 80 mm, respectively (Table 1). The radiolitiform myocardinal apparatus can be observed in only some specimens because diagenetic processes obliterated the il and bc features and it is situated very close to the L and the internal dorsal margin of the shell. The at appears wider than pt, myophores are very close to inner margin (Fig. 8E–G). The L is small, triangular and represented by a V- or U-shaped longitudinal furrow, 3 mm wide along the external surface of the inner margin of the ol (Fig. 8A, B). The dorsal cavity consists of two small cavities in il either side of the ligamentary infolding represented by simple canal-like longitudinal internal moulds along the valve. A remarkable thick mould with subrectangular section showing a width varying from 4 mm to 9 mm is situated at the anterior of the L, its posterior part also contains a longitudinal mould with a 2 mm wide suboval section (Fig. 8A, B, E–G). The latter is always thinner than former. The moulds of the teeth/socket system also follow the dorsal cavity moulds and they are situated between the aragonitic il and calcitic ol. This structure is almost preserved in all specimens and can be clearly observed in the eroded parts of the ol (Table 1). The calcitic ol of the RV is thick, about 25–30 mm, and consists of cellular mesostructures showing mostly a polygonal cross sectional shape (Fig. 7A–E). However, some specimens show three or four rows of rectangular cell sections around the ventral part of the valve (Fig. 7E). The diameter of the polygons is about 2 mm–3 mm in the very close area to the inner margin of the ol, but it reaches 5 mm–7 mm in the middle part of the layer and sometimes towards the margin of the valve. The cell layers are habitually continuous, but the rare discontinuity is also present. The polygonal network is sometimes progressively developed and seems to be covered the L groove (Fig. 7C). This polygonal network shows a columnar structure reminiscent of the longitudinal canals due to the silicification of the eroded part of the ol in most of the specimens (Fig. 7). The remnants of these structures can be clearly observed when the ol intensely eroded.

The LV is preserved in some specimens; it is almost hemispherically convex, always shorter than RV, cap-like in shape with eccentric apex to the dorsal margin. Its height is variable and some of them are salient with rounded shape (Fig. 8C). The calcitic lamellar ol is 2–4 mm thick. The prong-like at and pt and plate-like am and pm can be observed projecting down into inner wall of the RV (Fig. 8H, I).

Discussion and remarks. Our specimens with small and triangular L, unequal, flat and finely ribbed radial structures separated by a slightly concave Ib and cellular structure with large cells of the ol resemble *Sauvagesia sharpei* (Bayle, 1857; Caffau,

the myocardinal apparatus, the pallial canals of the il, the large posterior cavities, the bc which were filled by the reddish-deposits after the dissolution of the valve, No. EESH 2013 V 49. G – the transverse, longitudinal and oblique sections of many *Caprinula* RV specimens extracted from life position in the area, showing dissolved out canal structure of the il. Compare the dissolution and deposits filling features of the bc with those of previous figures C, D, E. Notice that the laminae (white arrows) are just the preserved silicified tops of geopetal fills in the bc of the shells (otherwise eroded out), so they have nothing to do with the original shell structure, and are parallel from one specimen to another (=the original geopetal horizontal). Note also the original intraparticle (intraskeletal) porosity of the valves. No. EESH 2013 V 52. Scales indicate 10 mm.

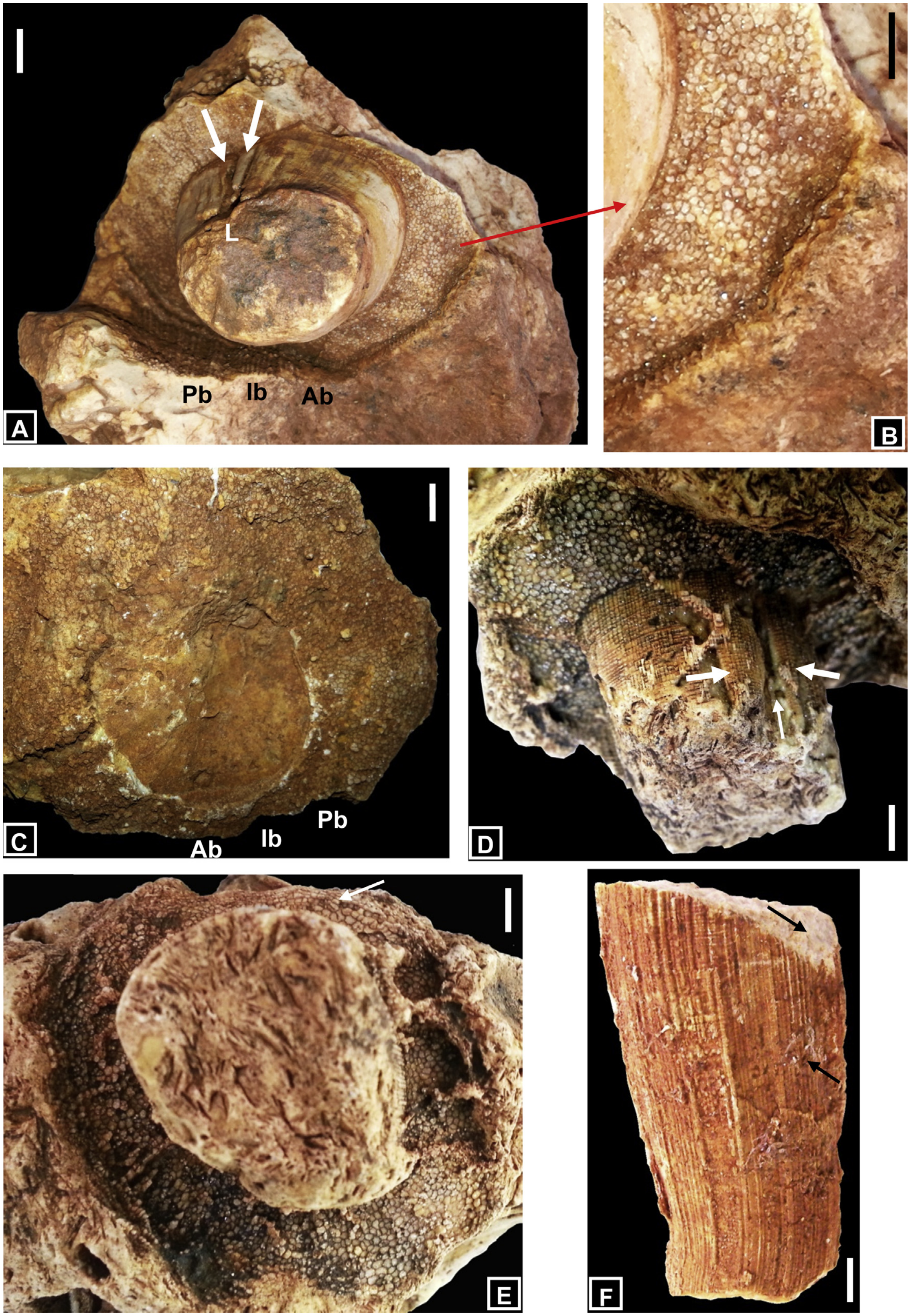


Fig. 7. A–F – *Sauvagesia sharpei* (Bayle, 1857). A–D – Ishtafina, Ajlun, Jordan, E–F – Samta, Ajlun, Jordan. A – bottom view of the RV showing the cellular structure of the ol. Note the longitudinal canal-like moulds of the dorsal cavity (thick white arrows) observed on the each side of L groove and the structure of the radial bands. No. EESH 2013 V 34. B – partial enlargement of the ol of the previous specimen showing the silicified polygonal network. C – top view of the RV showing the silicified polygonal network of the thick ol. Note the progressively developed covering of the cells of the L groove and dorsal cavity moulds. The Ab and Ib are preserved, but Pb is partially fragmented. D – bottom view of the RV showing the silicified cellular mesostructure of the polygonal network of the ol. Compare the longitudinal moulds of the dorsal cavity (thick white arrows), the L groove (thin white arrow) and feature of the bc with those of figure A and E. No. EESH 2013 V 36. E – bottom view of the RV showing the polygonal cross sectional shape of the cells, but the rectangular

Pugliese, & Pleničar, 1996; Chikhi-Aouimeur, 2010; Polšak, 1967; Pons et al., 2011).

The cellular habit with a large polygonal network of our specimens shows a remarkable analogy with that of *Tekirdagia* Özdikmen (pro *Favus*) described by Laviano and Skelton (1992, Figs. 7 and 8). The latter genus also shows the rare discontinuities of cell floors (e.g., see Fig. 7 and text on p. 67 in Laviano & Skelton, 1992) found in some of our specimens, which are possible in radiolitids (Amico, 1977, 1978; Pons & Vicens, 2008). But it is a biradiolitid, so it differs from the Jordanian specimens. The internal shell structure of the radial bands of *S. sharpei* specimens from the Cenomanian of Italy show the microscopic features resembling pseudopillars, a common feature in radiolitids even in primitive forms (e.g. *Eoradiolites davidsoni* (Hill), see Douvillé, 1909) provided by Pons et al. (2011, Fig. 8 C, D). Although, the il in the ventral part of our specimens show similarities with that of latter, they do not have this peculiar microstructure. The cellular structure of our specimens represents a columnar structure similar to the canaliculated inner shell layer of the rudists (Alencáster, 1990; Iba, Sano, Skelton, Kagi, & Tanab, 2009; Mitchell, 2013; Schlüter et al., 2008; Skelton, 2013a). However, the peculiar aspect of this structure in the Jordanian specimens may be due to the silicified mode of preservation as explained below in the "Diagenesis".

The structure of the LVs teeth as prong-like and flanking the lamellar myophores is a feature unknown for the genus *Sauvagesia* and allied forms (e.g. *Durania*) of Cenomanian age. This character may be useful for the emendation of *Sauvagesia*.

The dorsal cavity of the radiolitids was only reported as small, sub-oval, sub-cylindric, triangular or round "cavities" or "accessory cavities" by some studies (Karacabey-Öztemür, 1976, 1980; Milovanović, 1937; Mitchell, 2003; Özer, 1982, 1983; Pleničar, 1977; Pons, Schroeder, Höfling, & Moussavian, 1992; Sladič-Trifunovič, 1983). Publications, to date, on rudists have little information about the dorsal cavity of *Sauvagesia*, for example in *S. meneghiniana* (Pirona, 1869) and *S. tenuicostata* Polšak, 1967 from the Boeotia, central Greece (Steuber, 1999b, p. 113, 116). The moulds of the dorsal cavity and the teeth/socket system can be preserved in all specimens without any changes, but this peculiar shell structure has not been mentioned and figured until now either in radiolitids or *Sauvagesia* specimens. This feature may be compared with that of a monopleurid, *Mathesia* (pro *Agria*) *darderi* (Astre, 1933), which was recently described by Masse and Fenerci-Masse (2010).

The cellular mesostructures of the RVs ol, especially the presence of the cavities flanking the lamellar myophores in the LV and the apparence of the dorsal cavity and teeth/socket system moulds in the inner part of the ol provide features exclusive to our specimens, but they are not here accepted as a basis for creating a new species.

5. Diagenesis

The presence of dolomitic limestones, limestones with stylolites, and cherts in the Hummar Formation along with the topmost erosional surface features indicate that the formation has been subjected to diagenetic processes during subaerial exposure. This is result of intra-plate stress and fault tectonics related to the northwards movement of the Afro–Arabian Plate and its collision with the Eurasian Plate during the latest Cenomanian-Turonian, as documented by many studies of the Syrian Arc Fold-belt (Bartov, Lewy, & Steinitz, 1980; Bauer, Kuss, & Steuber, 2003; Brew, Barazangi, Al-Maleh, & Sawaf, 2001; Kuss et al., 2003; Sass & Bein, 1982). The tectonics resulted in favourable conditions for mixing of fresh water-sea water and a major sea-level fall which provided the early diagenetic conditions that simultaneously affected the rudist material.

The rudist material of this study shows diagenetic effects that include two major consecutive processes as follow:

5.1. Dissolution

Dissolution is one of the main diagenetic processes to affect the external and internal features of the studied material (Figs. 5–8). The ol, the il, and especially the bc of the valves collapsed partially or entirely after this intense dissolution, and were filled with reddish-deposits which are clearly observed in loose specimens and also in thin sections (Figs. 5C–F, 6–8, 9). The deposits filling the voids formed by the dissolution are comparable to those described in the following studies: "red internal argillaceous sediments then partially to completely filled rudist shells" have been described from the Lower Cretaceous rudist-bearing limestones of the Vercors carbonate platform (SE France) by Fouke et al. (1996, p. 304); radiolitid shells showing the dissolution and collapse with "internal sediments" have been described from the Upper Cretaceous rudist biostromes of Aurisina, Italy by Sanders (2001, Fig. 20); and dissolution and filling with "darker orange sediment" of caprinid shells have been described from the Lower Cretaceous of Portugal by Skelton in Burla et al. (2008, Fig. 8).

Some of the bc of the canaliculate rudist specimens show internal geopetal fabric (sensu, Flügel, 2010) that developed after dissolution (Fig. 6G). Internal geopetal fabrics are normally characterized by micritic fillings at the base and sparry calcite at the top (Bathurst, 1975; Flügel, 2010), the latter indicating that the carbonate development conditions were probably, but occasionally, associated with the increasing of the pH in the area (Bathurst, 1975; Flügel, 2010). Although they are eroded out in our canaliculated specimens, the thin oblique laminae are just the preserved silicified tops of geopetal fills and are parallel from one specimen to another, indicating the original geopetal horizon. Some geopetal fabrics in rudist shells have been reported, but not figured, from the Cretaceous of Mexico, Jamaica, Italy, Austria and Germany (Di Stefano & Ruberti, 2000; Mitchell, 1999; Steuber, 2001; Zimmerle, 1995). A geopetal fabric was described in the longitudinal section of a radiolitid from the Nabresina, Karst, Italy by Sanders (1998). It is probable that a *Sauvagesia sharpei* specimen from the Morocco has a geopetal fabric (Chikhi-Aouimeur, 2010, p. 131, Figs. 122, 3), although not recognized as such by this author.

Dissolution generates types of porosity including vuggy, moldic and enlarged intergranular porosity (Flügel, 2010; Moore, 1997; Selley, 2000). The vuggy and moldic porosity seems to be the main dissolution type in the rudist-bearing limestones (Cestari & Sartorio, 1995; Ross & Skelton, 1993). They are developed in all components (matrix, cement and grains) of the limestones and may have enhanced the porosity capacity of the Hummar Formation in the meteoric fresh water zone and occasionally in the mixed marine-fresh water zone (Moore, 1997; Moss & Tucker, 1995; Tucker & Wright, 1990). Confirmation requires detailed microfacies analysis, which is outside the scope of the present study. However, the eroded part of the valves indicate an original

cells can be also observed in the top of the specimen (white arrow). Note the obliterated preservation of the ol within the cells that resembles a canal-like columnar structure. Samta, Ajlun, Jordan, No. EESH 2013 V 37. F – the RV showing the canal-like thin columnar structures of the ols cells. The silicification both of the bc and the valve are seen (black arrows). An Nuaymah, Ajlun, Jordan, No. EESH 2013 V 22. Scales indicate 10 mm.

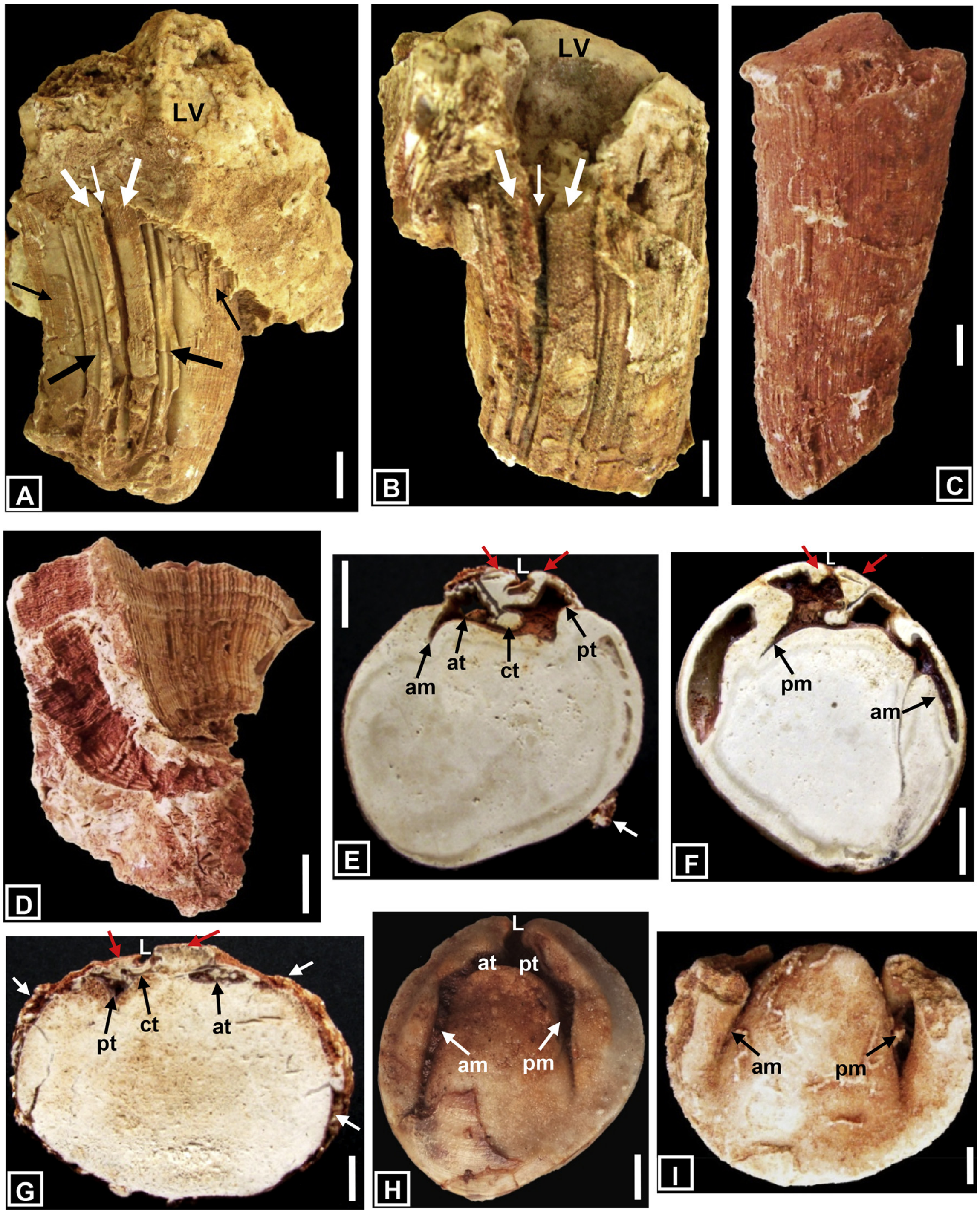
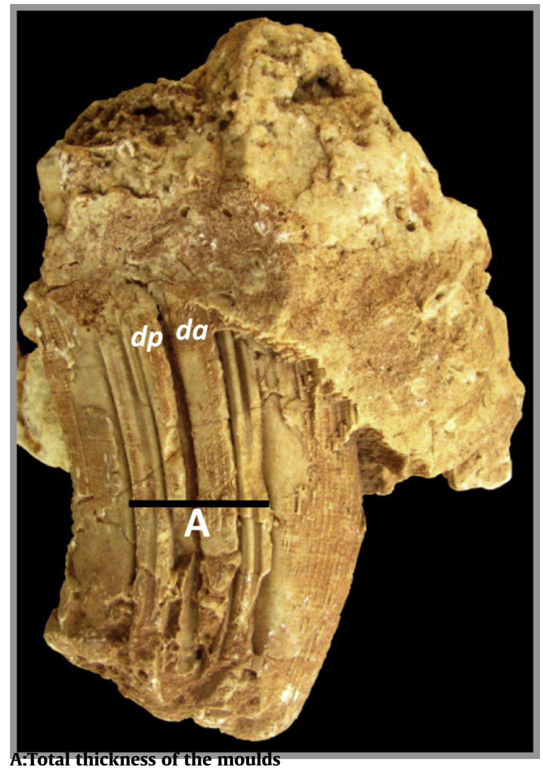


Fig. 8. A–I – *Sauvagesia sharpei* (Bayle, 1857). A–B – both valves, the RV is elongated conical to cylindro-conical, the L is represented by an V- or U-shaped longitudinal furrow (thin white arrow), two canal-like longitudinal moulds of the dorsal cavity (thick white arrows) situated on each side of the Ls furrow and following longitudinal suboval thin moulds of the teeth/socket system (thick black arrows). Note a remarkable subrectangular mould of the dorsal cavity in the anterior of Ls furrow and partially preserved ol showing the canal-like columnar structure of the cells (thin black arrows) caused by the silicification of the valve. The LV is partially preserved, almost hemispherically convex, always shorter than right valve, cap-like in shape with eccentric apex to the dorsal margin. Ishtafina, Ajlun, Jordan. Nos. EESH 2013 V 3, EESH 2013 V 1. C – both valves. Note the eccentric apex of the LV and the apparence as canal-like thin longitudinal structures of the cells of the RVs ol. Samta, Ajlun, Jordan, No. EESH 2013 V 5. D – the RV of conjoined to another shell shows the ornamentation with fine longitudinal ribs separated by thin grooves and crossed by growth lamellae, anterior side, Samta, Ajlun, Jordan, No. EESH 2013 V 32. E–G – the transverse sections of the RV close to the commissure showing the radiolitiform myocardinal apparatus. The subrectangular and suboval sections (red arrows) of the dorsal cavity longitudinal moulds observed along the valve, can be seen at the anterior and posterior of the L, respectively. The anterior one is always much large than the other. Compare with figure A and B. The remnants of the ol are partially preserved (white arrows). The intense silicification in the il and the bc after the dissolution of the valve represented. The myocardinal apparatus is also dissolved and filled by the reddish-sediments. E and F from Ishtafina, Ajlun, Jordan. No. EESH 2013 V 15 B and G from An Nuaymah, Ajlun, Jordan, No. EESH 2013 V 15 D. H–I – the top view of the LV presenting the prong-like at and pt and plate-like am and pm projecting down into inner wall of the RV. Nos. EESH 2013 V 15 B and EESH 2013 V 15 C from Ishtafina, Ajlun, Jordan. Scales indicate 10 mm. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
The RVs and LVs characters of *Sauvagesia sharpei* specimens. The dimensions is in mm. The nos 16 to 28, except 18, show the available length of the RV because of the absence of LV. The diameter of the partly preserved RV specimens is indicated by italic. The prefix of samples is EESH.

Sample no	RV's length	Diameter	LV's height	A	dp	da
2013 V 1	90	41 × 50	10	23	3	8
2013 V 2	95	30 × 40	14	22	3	8
2013 V 3	105	45 × 55	18	22	3	6
2013 V 4	100	45 × 55	10	23	4	7
2013 V 5	90	40 × 50	13	20	3	6
2013 V 6	95	45	10	22	3	8
2013 V 7	110	52	8	23	3	8
2013 V 8	145	58	35	28	4	9
2013 V 9	95	43	22	20	3	6
2013 V 10	110	55	15	22	3	7
2013 V 11	90	40	10	20	3	5
2013 V 12	100	45	24	24	3	7
2013 V 13	120	35	22	20	2	5
2013 V 14	110	51	10	23	2	6
2013 V 15A	130	40	10	25	3	6
2013 V 15B	85	35 × 40	11	23	3	7
2013 V 15C	50	27 × 35	8	14	3	6
2013 V 15D	110	35 × 42	12	25	4	8
2013 V 16	135	50	–	26	3	6
2013 V 17	110	45	–	24	3	8
2013 V 18	120	40 × 50	5	24	3	8
2013 V 19	120	34	–	22	3	7
2013 V 20	155	55	–	28	4	9
2013 V 21	80	32	–	18	3	7
2013 V 22	80	25	–	16	3	6
2013 V 23	90	40	–	18	3	7
2013 V 24	80	28	–	–	–	–
2013 V 25	82	30	–	–	–	–
2013 V 26	80	29	–	–	–	–
2013 V 27	81	30	–	–	–	–
2013 V 28	82	30	–	–	–	–
2013 V 29	60	65 × 75	12	17	3	6
2013 V 31	65	65 × 76	11	17	3	7
2013 V 32	70	66 × 78	12	20	3	7
2013 V 34	70	70 × 80	15	22	3	7
2013 V 35	55	65 × 74	13	18	3	6
2013 V 36	60	67 × 75	13	17	3	6
2013 V 37	62	68 × 80	10	18	3	7
2013 V 38	50	45 × 55	8	14	3	6
2013 V 39	78	66 × 74	13	18	3	7



A:Total thickness of the moulds
***dp*: posterior dorsal cavity mould**
***da*: anterior dorsal cavity mould**
Specimen No. EESH 2013 V 3
A indicates 22 mm

intraparticle (intraskeletal) porosity, in the studied rudist material (Fig. 6G).

5.2. *Silicification*

Silicification is another of the more important diagenetic features affected in the loose rudist material. Our specimens are silicified as a result of the precipitation of silica in the solution within the voids formed by the dissolution of the calcitic ol, the aragonitic il and by the volumetric dissolution of the bc and pc in the valves. It indicates that the presence of silica saturated waters and low pH conditions in the environment as explained in many studies (Cuif, Dauphin, & Sorauf, 2011; Holdaway & Clayton, 1982; Jacka, 1974; Lawrence, 1994; Maliva & Siever, 1988). There are many studies concerning the development of dissolution and subsequent silicification (Holdaway & Clayton, 1982; Knauth, 1979; Schmitt & Boyd, 1981). Maliva and Siever (1988) proposed that the force of crystallization of silica increases the free energy and solubility of carbonate material and replacement by silica.

Our *Sauvagesia* specimens have columnar structures that look like longitudinal canals in the thick calcitic ol (Figs. 7, 8A–C). However, a careful study of this structure shows that they are not canals, but instead a misleading superficial appearance of canals caused by silicification. It is probable that the internal cement within the stacked cells created vertically continuous canal-like structures as a result of silicification. Similar structures can also be observed in *Sauvagesia sharpei* (Bayle, 1857) specimens from the upper Cenomanian of Morocco, which were described as “Ils montrent une certain variabilité morphologique” by Chikhi-Aouimeur (2010, p. 131, Figs. 122, 1, 2). The same explanation was also proposed for the diagenetic quartz fabrics of the Lower Cretaceous requieniids and toucasids from the eastern Pontides, Turkey by Kırmacı (1995). The internal features of *Sauvagesia* specimens have been totally erased as a result of the precipitation of silica in spaces formed by the volumetric dissolution of the valves. Only the myocardinal apparatus can be observed in some small-sized specimens (Fig. 8E–G). Some gastropod sections and bivalve fragments showing the shell wall have been replaced by quartz in the silicified matrix of the RVs bc of *Sauvagesia sharpei* (Fig. 9G, H). The silicification also affected the internal features of *Caprinula* specimens. The original wall of the pallial canals of the il have been replaced by quartz, and the infilling material of these canals has been silicified, but with the original texture retained, revealing pellets, intraclasts, foraminifera, bivalve and gastropod sections in the pelloidal matrix (Fig. 9A–D, F). The destruction of the canals by quartz growth is commonly present in the il of *Caprinula* specimens (Fig. 9A–D). The oxidation, quartz and crystallization are present in the body filling reddish-deposits (Fig. 9E). XRD analysis of the reddish-deposits shows that quartz is dominant (about 98%) according to the intensity of the peaks of 2θ in different

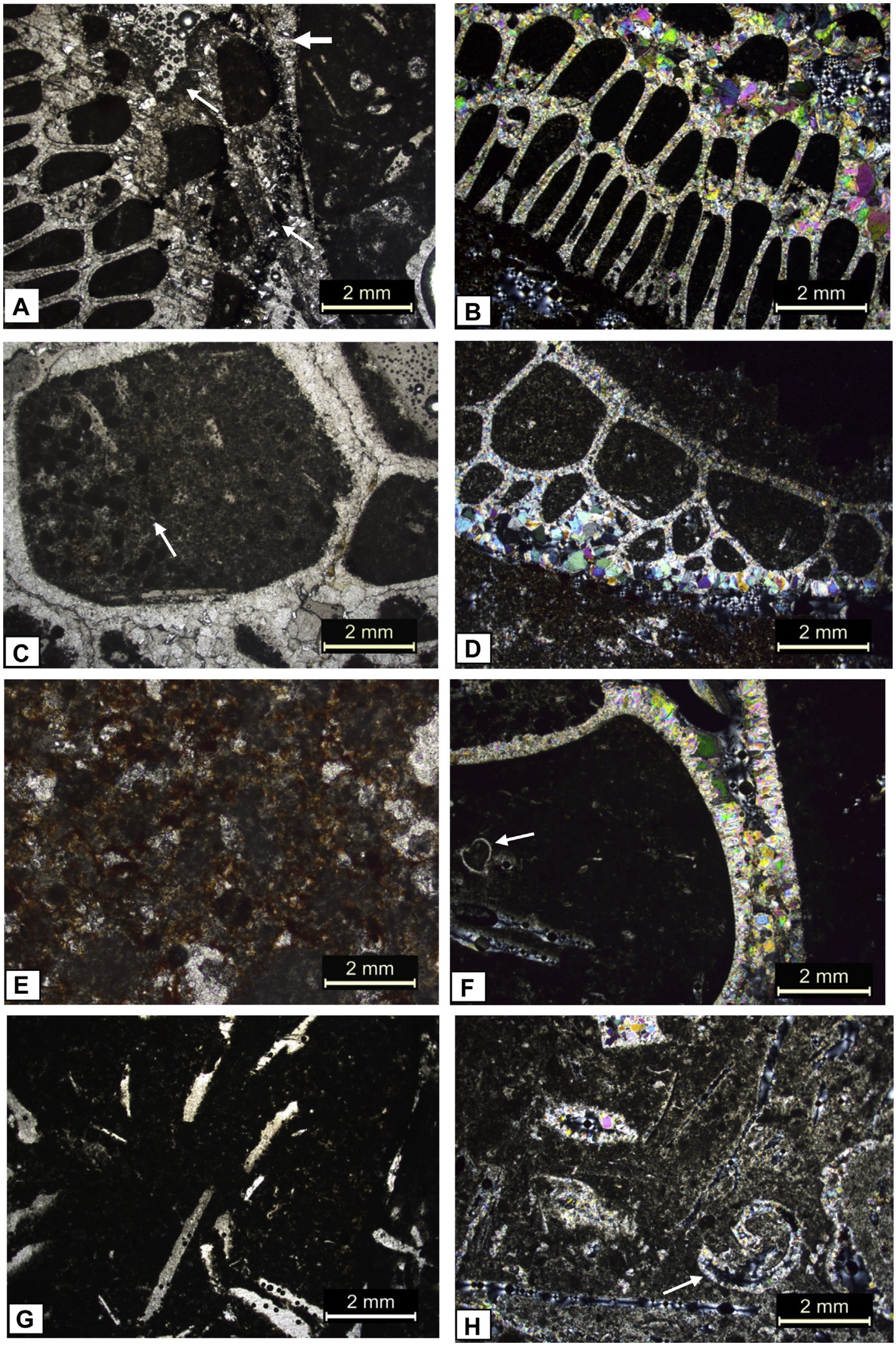


Fig. 9. Microphotographs of loose specimens. A, C, E, G – parallel polarized light, B, D, F, H – cross polarized light. A–F – *Caprinula cedrorum* (Blanckenhorn, 1890), Ishtafina, Ajlun, Jordan, A – the original wall of the pallial canals of the il has been replaced by quartz. Note the quartz growth destroying the canals and the diffusion of the reddish-deposits in to the fissure of the il (thin white arrows). The thick white arrow indicate the limit between the bc and the il, No. EESH 2013 V 47. B – the pallial canals, note the intense quartz growth destroying the canals, No. EESH 2013 V 47. C – the pallial canals, the walls of the canals have been replaced by quartz, the interior of the canals has also been silicified but the pellets

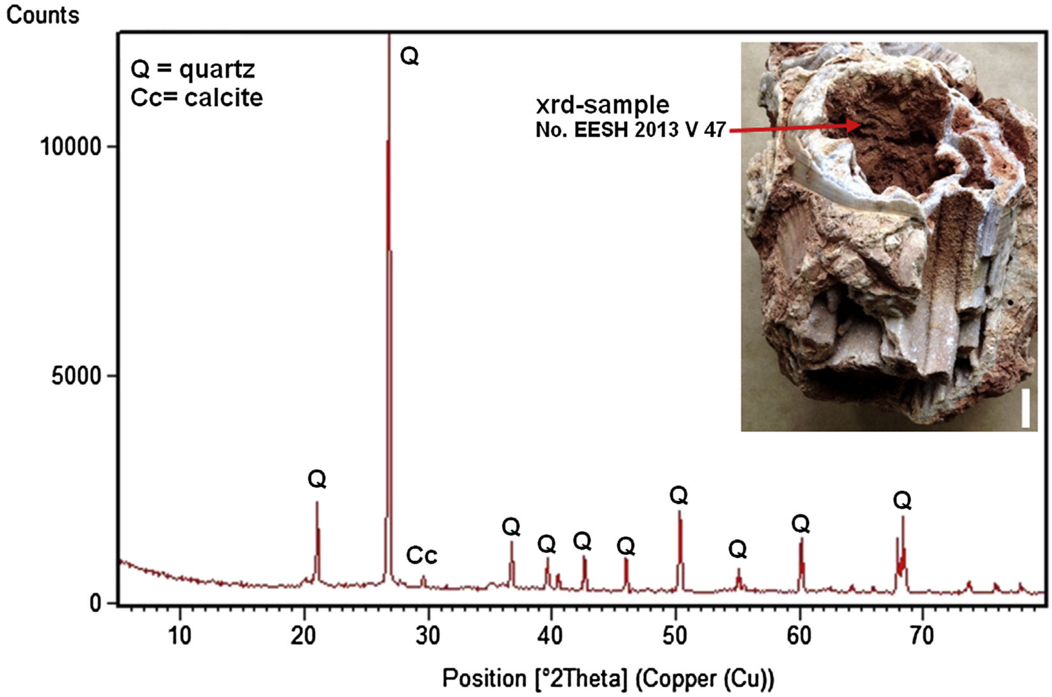


Fig. 10. XRD pattern of the sample from the reddish-deposits of bc of *Caprinula cedrorum* (Blanckenhorn, 1890) specimen, No. EESH 2013 V 47 (top right, the dorsal view, scale bar is 10 mm), Ishtafina, Ajlun, Jordan.

angles (Fig. 10). It is also distributed fairly homogeneously. The main peak over the 10,000 countun also indicates the intensity of the development of the silicification conditions.

The studied rudist material is mostly reddish-pink colour, but pale red or orange specimens are also present and they are commonly coated with iron-oxide. This gives them with the same colour appearance, after silicification as described for the reddish-pink silicified microgastropods from the Lower Triassic of Italy (Assereto & Rizzini, 1975) and for the reddish silicified trilobite exoskeleton from the Devonian of Morocco by Klug, Schulz, and De Baets (2009).

There is some information about silicified rudists in previous studies (Braun & Hirsch, 1994; Mansour, 2004; Molineux, Scott, Ketcham, & Maisano, 2007; Philip & Platel, 1995; Sanders, 1998). These were mainly based on fragments in microfacies data, instead of the loose specimens as described in this study. A number of possibilities have been suggested regarding the source of the silica, such as derivation from a silica-rich solution generated from the dolomites; dissolution of silica-producing organisms (silicieous diatoms, radiolarians, sponge spicules); silica released by transformation of montmorillinite to illite or mica; dissolution of sand and silt quartz grains or feldspar, chert nodules in the limestones, volcanic ash; silica derived from local hydrothermal activity; organic acids acting on siliceous diatoms, radiolarians, and sponge spicules. These mechanisms are explained and discussed in many studies (Aitken, Colom, Henderson, & Johnston, 2002; Belka, 1998; Hesse, 1987; Jacka, 1974; Knauth, 1979; Lawrence, 1994; Maliva & Siever, 1988). The presence of the dolomitic limestones and cherty limestones may be related to the silicification process of our rudist specimens, after the uplift and during the later erosion of the Cenomanian deposits, but the source of the silica is yet unclear.

Although, microfacies analysis is not aim of this study, some thin sections from the rudist-bearing limestones of the Hummar Formation display other diagenetic processes such as micritization, compaction and cementation, which are the subject of another study.

6. Conclusions

Three specimens of *Caprinula* d'Orbigny, 1847 and a single species of *Sauvagesia* Choffat, 1886 are described from three measured-stratigraphic sections (Ishtafina, Samta and An Nuaymah) of the upper Cenomanian limestones of the Hummar Formation around Ajlun city, NW of Jordan.

The presence of a stratigraphic gap in the study area between upper Cenomanian Hummar Formation and overlying upper Turonian Wadi As Sir Limestone Formation, which belong to Ajlun Group, is suggested for the first time. The karstic structures, reworked limestones and rudist fragments, sharp contact, and absence of the Shuayb Formation are the main indicators of an erosional surface, but its origin remain unclear and needs a detailed study.

Many canaliculate specimens show characters identical to those found in *Caprinula* d'Orbigny such as the invaginated L, a thin oblique plate separating the pc from bc connected with at, the decrease in canal size of the pallial canal from the inner part to outer in the il, the unequal teeth and sockets and the large accessory cavities/canals. Two different canaliculated il are identified in

(thin white arrow) and bivalve fragments can be seen, No. EESH 2013 V 53. D – the pallial canals, the pellets and the intraclasts can be seen in the canals. Note the intense quartz growth destroying the canals, No. EESH 2013 V 53. E – reddish body filling deposits showing the oxidation, quartz and crystallization, No. EESH 2013 V 47. F – the pallial canal within the bivalve (thin white arrow), pellets and the intraclasts are present. The wall of the canal has been replaced by quartz. No. EESH 2013 V 53. G and H – *Sauvagesia sharpei* (Bayle, 1857). G – the silicified bc consists of bivalve fragments, which have been replaced by quartz. Ishtafina, Ajlun, Jordan, No. EESH 2013 V 3. H – the silicified bc showing quartz and some gastropod sections (white arrow) and bivalve fragments in the matrix. Note the wall of gastropod has been replaced by quartz. An Nuaymah, Ajlun, Jordan, No. EESH 2013 V 15 D. Scales indicate 10 mm.

the many specimens of *Caprinula* d'Orbigny, 1847. The first is characterized by the poor canaliculation with 1 or 2 rows of pallial canals showing the features of *Caprinula sharpei* (Choffat, 1885) and the second by more than two rows of pallial canals characterizing those of *Caprinula cedrorum* (Blanckenhorn, 1890) and *Caprinula* cf. *boissyi* d'Orbigny, 1840. C. *cedrorum* is distinguished from *C. boissyi* by the pc being smaller than bc, a more oblique ats of the LV and the reduced size of the ec of the RV.

Many radiolitid specimens are characterized by a polygonal cellular structure and the presence of an L, both traits which are found in the genus *Sauvagesia* Choffat, 1886. The specimens have the small and triangular L, the cellular structure with large cells of the ol and the unequal, finely ribbed and slightly protruding Ab and Pb separated by a concave Ib corresponding to the features of *Sauvagesia sharpei* (Bayle, 1857). All RV specimens of this species show the canal-like longitudinal moulds of the dorsal cavity and the teeth/socket system along the valve situated between the aragonitic il and calcitic ol. Some of the LV have the prong-like at and pt and plate-like am and pm projecting down into inner wall of the RV, which are for the first time observed in the Cenomanian Sauvagesias and may leading to an emendation of the genus.

Two type of diagenetic processes, dissolution and silicification affect the calcitic ol, the aragonitic il, the myocardinal apparatus, the accessory cavities/canals, the pc and the bc of described canaliculate and radiolitid rudists. There are indications that silicification caused the misleading superficial longitudinal canal-like structures observed in the ol of *Sauvagesia* specimens.

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References

Abdallah, H. (2003). Genesis and diagenesis of the Gattar Carbonate Platform, Lower Turonian, northern southern Tunisia. In E. Gili, H. Negra, & P. W. Skelton (Eds.), *Nato Sci Ser: 28. North African Cretaceous carbonate platform systems* (pp. 31–51).

Abdelhamid, G. (1995). *The geology of Jarash area, map sheet (3154-1), 30* pp. 1–51. NRA, Geology Directorate, Bulletin.

Abed, A. M. (1982). Microfacies and Paleoenvironment of the Wadi Sir Formation (Upper Cretaceous), North Jordan. *Facies, 7*, 229–236.

Abed, A. M., Hamad, A. A., Khair, H. A., & Kraishan, G. (2013). Development of calcrete and clinoforms during emergence and flooding of the Late Cenomanian carbonate platform, Jordan. *Facies, 59*(4), 829–842.

Abu Qudaira, M. (2005). *Geological map of Dayr Abu Sa'id*. Map sheet No. 3154 IV. Amman, Jordan: Natural Resources Authority.

Accordi, G., Carbone, F., & Pignatti, J. (1998). Depositional history of a Paleogene carbonate ramp (Western Cephalonia, Ionian Islands, Greece). *Geologica romana, 34*, 131–205.

Accordi, G., Carbone, F., & Sirna, G. (1989). Some affinities between the Ionian Islands and the Apulian Upper Cretaceous rudist facies. In G. Battista Carulli (Ed.), *Memorie della Società geologica italiana: 40. Evolution of the Karstic carbonate platform: Relation with other periadriatic carbonate platforms* (pp. 163–173).

Aitken, S. A., Colom, J. C., Henderson, C. M., & Johnston, P. A. (2002). Stratigraphy, paleoecology, and origin of Lower Devonian (Emsian) carbonate mud buildups, Hamar Laghdad, eastern Anti-Atlas, Morocco, Africa. *Bulletin of Canadian Petroleum Geology, 50*, 217–243.

Al-Aasm, I. S., & Veizer, J. (1986a). Diagenetic stabilization of aragonite and low-Mg calcite; I, stable isotops in rudists. *Journal of Sedimentary Petrology, 56*, 138–152.

Al-Aasm, I. S., & Veizer, J. (1986b). Diagenetic stabilization of aragonite and low-Mg calcite; II, trace elements in rudists. *Journal of Sedimentary Petrology, 56*, 763–770.

Alencáster, G. (1990). Los rudistas. Origen, diversification, provoncialismo en Eurasia y en América y extinción. *Revista de la Sociedad mexicana de Paleontologia, 3*(1), 47–65.

Al-Mohammad, R. A. H. (2012). Depositional environment and petrophysical properties Study of Mishrif Formation in Tuba Oilfield, Southern Iraq. *Journal of Basrah Researches (Sciences), 38*(1. A), 25–50.

Alsharhan, A. S. (1995). Facies variation, diagenesis, and exploration potential of the Cretaceous rudist-bearing carbonates of the Arabian Gulf. *AAPG Bulletin, 79*(4), 531–550.

Alsharhan, A. S., & Nairn, A. E. M. (1997). *Sedimentary basins and petroleum geology of the Middle East*. Amsterdam: Elsevier, 843+99 p.

Aly, M. F., Smadi, A., & Abu Azzam, H. (2008). Late Cenomanian-Early Turonian ammonites of Jordan. *Revue de Paléobiologie Genève, 27*(1), 43–71.

Amico, S. (1977). *Etude de la structure du test des rudistes. Applications à la systematique à la paléobiologie et à la paléoécologie de ce groupe*. Unpublished PhD thesis, Université de Provence (Aix-Marseille I), 90 p.

Amico, S. (1978). Recherches sur la structure du test des Radiolitidae. *Travaux du Laboratoire de Géologie Historique et de Paléontologie, 8*, 131 p.

Aqrawi, A. A. M., Tehni, G. A., Sherwani, G. H., & Kareem, B. M. A. (1998). Mid-Cretaceous rudist-bearing carbonates of the Mishrif Formation; an important reservoir sequence in the Mesopotamian Basin, Iraq. *Journal of Petroleum Geology, 21*(1), 57–82.

Asghari, M., & Adabi, M. H. (2014). Diagenesis and geochemistry of the Sarvak Formation in Ahvaz oil field-Iran. *Geochemistry Journal, 1*(1), 1–7.

Assereto, R. L., & Rizzini, A. (1975). Reworked Ferroan Dolomite grains in the Triassic "oolite a gasteropi" of Camoniche Alps(Italy) as indicators of early diagenesis. *Neues Jahrbuch Geol. Palaontol Abhandlungen, 148*(2), 215–232.

Astre, G. (1933). Sur les petits *Agria* tubuleux de l'Urgo-Aptien. *Compte rendu sommaire et Bulletin de la Société géologique de France, 5*(3), 99–105.

Baaske, U. P. (2005). *Sequence stratigraphy, sedimentology and provenance of the Upper Cretaceous siliciclastic sediments of South Jordan*. Phd thesis. Institut für Geologie und Paläontologie der Universität Stuttgart, 135 p.

Bandel, K., & Mustafa, H. (1996). Constructional morphology of some Upper Cretaceous rudists of the Ajlun (Jordan). In C. Spaeth (Ed.), *Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg 77Proceedings of the 4th International Cretaceous Symposium, Hamburg 1992* (pp. 603–635).

Bandel, K., & Salameh, E. (2013). *Geologic development of Jordan. Evolution of its rocks and life*. The University of Jordan Press, 278 p.

Bartov, Y., Lewy, Z., & Steinitz, G. (1980). Mesozoic and Tertiary stratigraphy, paleogeography and structural history of the Jebel Areif en Naqa area, eastern Sinai. *Israel Journal of Earth Science, 29*, 114–130.

Basha, W. (1978). Foraminifera from the Ajlun Group of east Jordan. *Journal of the Geological Society of Iraq, 11*, 67–91.

Bathurst, R. G. C. (1975). *Carbonate sediments and their diagenesis*. New York: Elsevier Science, 658 p.

Bauer, J., Kuss, J., & Steuber, T. (2003). Sequence architecture and carbonate platform configuration (upper Cenomanian–Santonian), Sinai, Egypt. *Sedimentology, 50*, 387–404.

Bauer, J. M., Marzouk, A., Steuber, T., & Kuss, J. (2001). Lithostratigraphy and biostratigraphy of the Cenomanian–Santonian strata of Sinai, Egypt. *Cretaceous Research, 22*, 497–526.

Bauer, J., Steuber, T., Kuss, J., & Heimhofer, U. (2004). Distribution of shallow-water benthics (rudists, calcareous algae, benthic foraminifers) in the Cenomanian-Turonian carbonate platform sequences of Sinai, Egypt. In R. Höfling (Ed.), *Contribution to the 5th International Congress on Rudists, Erlangen, Germany 1999, 247* pp. 207–231). Courier Forschungsinstitut Senckenberg.

Bayle, E. (1857). Nouvelles observations sur quelques espèces de rudistes. *Bulletin de la Société géologique de France, 2*(14), 647–719.

Belka, Z. (1998). Early Devonain Kess–Kess carbonate mud mounds of the eastern Anti–Atlas (Morocco), and their relation to submarine hydro-thermal venting. *Journal of Sedimentary Research, 68*, 368–377.

Bender, F. (1974). *Geology of Jordan*. Berlin: Borntraeger, 196 p.

Berndt, R. (2002). *Palaeoecology and taxonomy of the macrobenthic fauna from the Upper Cretaceous Ajlun Group, southern Jordan*. Dissertation, Würzburg 222 p.

Berthou, P. Y., Ferreira Soares, A., & Lauverjat, J. (1979). Mid Cretaceous events, Iberian field conference 77, Guide I, Partie Portugal. *Cuadernos Geología Ibérica, 5*, 31–124.

Bilotte, M. (1985). Le Crétacé supérieur des plates-formes est-pyrénéenes. *Strata, 2*(5), 438 p.

Blanckenhorn, M. (1890). *Beiträge zur Geologie Syriens: Die Entwicklung des Kreidesystems in Mittel- und Nord-Syrien*, 135 p.

Boehm, G. (1897). Beitrag zur Gliederung der Kreide in den Venetianer Alpen. *Zeitschrift der deutschen geologischen Gesellschaft, 49*, 160–181.

Braun, M., & Hirsch, F. (1994). Mid Cretaceous (Albian-Cenomanian) carbonate platforms in Israel. *Cuadernos de Geologia Ibérica, 18*, 59–81.

Brew, G., Barazangi, M., Al-Maleh, A., & Sawaf, T. (2001). Tectonics and geologic evolution of Syria. *GeoArabia, 6*, 573–616.

Burdon, D. J. (1959). *Handbook pf the geology of Jordan; to accompany and explain the three sheets of 1:250,000 Geological Map*. Kingdom of Jordan, 82 p., Benham, Golchester.

Burla, S., Heimhofer, U., Hochuli, P. A., Weissert, H., & Skelton, P. (2008). Changes in sedimentary patterns of coastal and deep-sea successions from the North

Atlantic (Portugal) linked to Early Cretaceous environmental change. *Palaeogeography, Palaeoclimatology, Palaeoecology, 257*, 38–57.

Caffau, M., Pugliese, N., & Pleničar, M. (1996). The development of the mollusc fauna in the Cenomanian of the stratigraphic sequence of Visogliano (Karst of Triest, Italy). *Geologija, 37–38*, 87–121.

Carbone, F., Praturlon, A., & Sirna, G. (1971). The Cenomanian shelf edge facies of Rocca di Cave. *Geologica romana, 10*, 131–197.

Cestari, R., & Sartorio, D. (1995). *Rudists and facies of the periadriatic domain*. Agip, 207 p.

Chikhi-Aouimeur, F. (1996). *Caprinula* aff. *cedrorum* (Blanckenhorn, 1890) from the Upper Cenomanian of western Algeria. In G. Alencáster, & B. E. Buitrón-Sánchez (Eds.), *Revista mexicana de Ciencias geológicas 12, 2Number devoted to the Third international Conference on Rudists, 1995* (pp. 179–184).

Chikhi-Aouimeur, F. (1998). Sauvagesiinae du Cénomanien supérieur de la région de Berrouaguia (Sud d'Alger, Algérie). In J.-P. Masse, & P. W. Skelton (Eds.), *Geobios, Mémoire spécial 22Quatrième Congrès international sur les Rudistes* (pp. 101–109).

Chikhi-Aouimeur, F. (2002). *Etude quelques Radiolitides du Crétacé Superieur de l'Algerie Orientale*. Procedings 1st International Conference on Rudists (Beograd, 1988), "Rudists" (pp. 61–79). UGYS, Mem. Publ..

Chikhi-Aouimeur, F. (2004). Description of some rudists collected by J. Savornin in the Cenomanian-Turonian of northeastern Algeria (Sétif and Hodna region). In R. Höfling (Ed.), *Courier Forschungsinstitut Senckenberg 247Contribution to the 5th International Congress on Rudists, Erlangen, Germany 1999* (pp. 49–61).

Chikhi-Aouimeur, F. (2010). *L'Algérie à travers son Patrimoine paléontologique, Les Rudistes*, 269 p. Sarl Baosem.

Choffat, P. (1885). *Recueil des monographies stratigraphiques sur la système crétacique du Portugal. 1. Etude*. Contrées de Cintra, de Bellas et de Lisbonne 68 p.

Choffat, P. (1886). *Recueil d'études paléontologiques sur la faune crétacique du Portugal. Espèces nouvelles ou peu connues*. Comunicaçoes dos Serviços geologicos de Portuga 40 p.

Choffat, P. (1891). *Crétacique de Torres-Vedras. Recueil d'études paléontologiques sur la faune crétacique du Portugal: I*. Espéces nouvelles ou peu connues, Comunicaçoes dos Serviços geologicos de Portugal (pp. 203–211).

Combes, P.-J., Fourcade, E., Masse, J.-P., & Philip, J. (1981). Observations stratigraphiques et paléontologiques sur la Crétacé de la zone du Parnasse. In *Académie yougoslave des Sciences et des Arts, Travaux du Comité international pour l'Etude des Bauxites, de l'Alumine et de Aluminium 11/16* (pp. 347–365).

Coquand, H. (1862). Géologie et paléontologie de la région sud de la province de Constantine. *Mémoires de la Société d'Emulation de la Provence, 2*, 5–342.

Cuif, J.-P., Dauphin, Y., & Sorauf, J. E. (2011). *Biominerals and fossils through time*. Cambridge University Press, 480 p.

Dechaseaux, C. (1943). Nouvelles observations sur *Caprinula cedrorum* Blanckenhorn. *Bulletin de la Société géologique de France, 5*(13), 37–41.

Defrance, J. L. M. (1821). *Hippurites*. In J. L. M. Defrance (Ed.), *Dictionnaire des sciences naturelles, 21* pp. 195–197).

Dilley, F. C. (1985). *Cretaceous correlations in the Hamza Wells 1-5*. NRA Palaeontological Report, 6.

Di Stefano, P., & Ruberti, D. (2000). Cenomanian rudist-dominated shelf-margin limestones from the panormide carbonate platform (Sicily, Italy): facies analysis and sequence stratigraphy. *Facies, 42*, 133–160.

d'Orbigny, A. (1840). Note sur le genre Caprine. *Revue zoologique/par la Société Cuvierienne, 1839*, 168–170.

d'Orbigny, A. (1847). Considérations zoologiques et géologiques sur les brachiopodes. *Annales des Sciences naturelles Zoologie, 3*(8), 241–270.

d'Orbigny, A. (1850). Paléontologie française, Terrains crétacés. 4. *Brachiopodes*, 105–328.

Douvillé, H. (1888). Etudes sur les caprines. *Bulletin de la Société géologique de France, 3*(16), 699–730.

Douvillé, H. (1891). Sur les charactéres internes des Sauvagesia. *Bulletin de la Société géologique de France, 3*(19), 669–672.

Douvillé, H. (1894). Etudes sur les rudistes. Révision des principales espèces d'*Hippurites* (quatrième partie). *Mémoires de la Société géologique de France, Paléontologie, 6*(4), 95–138.

Douvillé, H. (1909). Sur le genre *Eoradiolites* nov. *Bulletin de la Société géologique de France, 4*(9), 77.

Douvillé, H. (1910). Etudes sur les rudistes. Rudistes de Sicile, d'Algérie, d'Egypte, du Liban et de la Perse. In *Mémoires de la Société géologique de France Paléontologie, 41*, 83 p.

El-Sabbag, A. M., Tantawy, A. A., Keller, G., Khozyemd, H., Spangenberg, J., Adatte, T., et al. (2011). Stratigraphy of the CenomanianeTuronian Oceanic Anoxic Event OAE2 in shallow shelf sequences of NE Egypt. *Cretaceous Research*, 1–18.

Enos, P. (1986). Diagenesis of mid-Cretaceous rudist reefs, valled Platform, Mexico. In J. H. Schroreder, & B. H. Purser (Eds.), *Reef diagenesis* (pp. 160–185). Berlin: Springer–Verlag.

Fliert, J. van de (1952). *Liste de rudistes du Crétacé du Constantinois. XIXème Congrès géologique international, Monographies régionales*. Deleau, P.: Le pays constantinois, 1, 13 (pp. 47–52).

Flügel, E. (2010). *Microfacies of carbonate rocks: Analysis, interpretation and application*. Berlin, Heidelberg: Springer-Verlag, 929 p.

Fouke, B. W., Everst, A.-J. W., Zwart, E. W., Schlager, W., Smalley, P. C., & Weissert, H. (1996). Subarerial exposure unconformities on the Verccors carbonate platform (SE France) and their sequence stratigraphic significance. In J. A. Howell, & J. F. Aitken (Eds.), *Geological Society special publication no. 104High resolution sequence stratigraphy: Innovations and applications* (pp. 295–320).

Frank, R., Buchbinder, B., & Benjamini, C. (2010). The mid-Cretaceous carbonate system of northern Israel: facies evolution, tectono-stratigraphy configuration and global control on the central Levant margin of the Arabian plate. In C. Homberg, & M. Bachmann (Eds.), *Geological society, special publication 341Evolution of the Levant margin and western Arabia platform since the Mesozoic* (pp. 133–170).

García-Garmilla, T. (2003). Rudists: growth strategies, life span and diagenetic response. *Geogaceta*, 211–218.

García-Garmilla, F., Özer, S., & Sarı, B. (2004). Cathodoluminescence and metamorphism in rudist shells from the Upper Cretaceous marbles of Menderes Massif (Western Turkey). *Geogaceta*, 36–40.

Garcia-Hidalgo, J. F., Barroso-Barcenilla, F., Gil-Gil, J., Martínez, R., Pons, J. M., & Segura, M. (2012). Stratal, sedimentary and faunal relationships in the Coniacian 3rd-order sequence of the Iberian Basin, Spain. *Cretaceous Research, 34*, 268–283.

Ghanem, H., & Kuss, J. (2013). Stratigraphic control of the Aptian–Early Turonian sequences of the Levant Platform, Coastal Range, northwest Syria. *GeoArabia, 18*(4), 85–132.

Hajikazemi, E., Al-Aasm, I. S., & Coniglio, M. (2010). Subaerial exposure and meteoric diagenesis of the Cenomanian-Turonian Upper Sarvak Formation, southwestern Iran. In P. Leturmy, & C. Robin (Eds.), *Tectonic and stratigraphic Evolution of Zagros and Makran during the Mesozoic-Senozoic geological Society, London, special publication No 330* (pp. 253–272).

Hesse, R. (1987). Selective and reversible carbonate–silica replacements in Lower Cretaceous carbonate-bearing turbidites of the Eastern Alps. *Sedimentology, 34*, 1055–1077.

Holdaway, H. K., & Clayton, C. J. (1982). Preservation of shell microstructure in silicified brachiopods from the Upper Cretaceous Wilmington Sands of Devon. *Geological Magazine, 119*, 371–382.

Iba, Y., Sano, S., Skelton, P. W., Kagi, H., & Tanab, K. (2009). First record of Late Albian canaliculate rudist from northern California and re-assessment of *Durania? Californica* Anderson, 1958. *Cretaceous Research, 30*(3), 540–546.

Jacka, A. D. (1974). Replacement of fossils by length-slow chalcedony and associated dolomitization. *Journal of Sedimentology and Petrology, 44*, 421–427.

Karacabey-Öztemür, N. (1976). Un nouveau genre de Radiolitidae: *Darendeella* n. gen. *Bulletin of the Mineral Research and Exploration, 86*, 69–76.

Karacabey-Öztemür, N. (1980). Two new genera of Radiolitidae (*Balabania* n. gen., *Kurtinia* n. gen.) from Turkey. *Geological Bulletin of Turkey, 23*, 79–86.

Keller, A. (1933). Sur quelques rudistes du Djebel Ansaryeh et de l'Amanus. Haut-Commissariat de la République Française en Syrie et au Liban, Service des Traveaux Publics, Section d'Etudes géologiques. *Notes et Mémoires, 1*, 45–52.

Klug, C., Schulz, H., & De Baets, K. (2009). Red Devonian trilobites with green eyes from Morocco and the silicification of the trilobite exoskeleton. *Acta Palaeontologica Polonica, 54*(1), 117–123.

Knauth, L. P. (1979). A model for the origin of chert in lime-stone. *Geology, 7*, 274–277.

Kuss, J., Bassiouni, A., Bauer, J., Bachmann, M., Marzouk, A., Scheibner, C., et al. (2003). Cretaceous-Paleogene sequence stratigraphy of the Levant Platform (Egypt, Sinai, Jordan). In E. Gili, H. Negra, & P. W. Skelton (Eds.), *Nato sciences Series: 28. North African Cretaceous carbonate platform systems* (pp. 171–187).

Kırmacı, Z. (1995). Diagenetic quartz fabrics and their occurrence conditions in Upper Jurassic-Lower Cretaceous Berdiga limestone (Eastern Pontids, NE Turkey). *Geological Bulletin of Turkey, 38*(1), 81–93.

Laviano, A., & Skelton, P. W. (1992). *Favus antei*, a new genus and species of a bizarre "big cell" radiolitid from the Upper Cretaceous of eastern Tethys. *Geologica romana, 28*, 61–77.

Lawrence, M. J. F. (1994). Conceptual model for early diagenetic chert and dolomite, Amuri Limestone Group, north-eastern South Island, New Zealand. *Sedimentology, 41*, 479–498.

Lewy, Z. (1990). Transgressions, regressions and relative sea level changes on the Cretaceous shelf of Israel and adjacent countries. A critical evaluation of Cretaceous global sea-level correlations. *Paleoceanography, 5*, 619–637.

Linnaeus, C. (1758). Systema Naturae. In *Holmiae (Salvius)* (10th ed.,, *1* 824 p.

Makhlouf, I., Abu-Azzam, H., & Al-Hiyari, A. (1996). *Surface and subsurface lithostratigraphic relationships of the Cretaceous Ajlun Group in Jordan*. Subsurface Geology Bulletin, No. 8. Amman: The Hashemite Kingdom of Jordan, Ministry of Energy and Mineral Resources, Natural Resources Authority, 95 p.

Maliva, R. G., & Siever, R. (1988). Mechanism and controls of silification of fossils in limestone. *Journal of Geology, 96*(4), 387–398.

Mansour, A. S. M. (2004). Diagenesis of Upper Cretaceous Rudist Bivalves, Abu Roash Area, Egypt: a petrographic study. *Geologia Croatica, 57*(1), 55–66.

Masri, M. (1963). *Report on the geology of the Amman-Zegra area* (unpublished). Amman, Jordan: Central Water Authority, 70 p.

Masse, J.-P., & Fenerci-Masse, M. (2010). *Mathesia mainelli* (Hippuritoidea, Monopleuridae) from the Late Aptian-Albian of the Mediterranean Region: a revision. In S. Özer, B. Sarı, & P. W. Skelton (Eds.), *Jurassic-Cretaceous Rudists and Carbonate Platforms, Part (A), 8th International Rudist Congress. Turkish Journal of Earth Sciences 19, 5* (pp. 543–556).

Matheron, P. (1842). *Catalogue méthodique et descriptif des corps organisés fossiles du Département des Bouches-du-Rhône et lieux circonvoisins*, 269 p.

Mermigis, A. (1993). Données nouvelles sur le genre *Neoradiolites* Milovanović du Cénomanien des Hellénides internes (Argolide septentrionale, Péloponnèse N.E.). *Revue de Paléobiologie, 12*, 243–263.

Mermigis, A., Philip, J., & Tronchetti, G. (1991). Séquences et cortèges de dépôts de plate-forme carbonatée au passage Cénomanien-Turonien dans les Hellénides

internes (Péloponnèse, Grèce). *Bulletin de la Société géologique de France, 162*, 547–552.
Milovanović, B. (1937). Les nouveaux rudistes de la Serbie. Académie royale Serbe. *Bulletin de l'Académie des Sciences mathématiques et naturelles B, 3*, 1–42.
Mitchell, S. F. (1999). Stratigraphy of the Guinea Corn Formation (Upper Cretaceous) at its type locality in the Rio Minho between Grantham and Guinea Corn, northern Clarendon, Jamaica. *The Journal of the Geological Society of Jamaica, 33*, 1–12.
Mitchell, S. F. (2003). Morphology, microstructure and stratigraphy of some Late Cretaceous Radiolitid rudists from Jamaica. *Geologia Croatica, 56*(2), 149–171.
Mitchell, S. F. (2013). A revision of selected Lower Cretaceous American caprinoid rudists: implications for phylogeny and biostratigraphy. *Caribbean Journal of Earth Science, 45*, 47–75.
Molineux, A., Scott, R. W., Ketcham, R. A., & Maisano, J. A. (2007). Rudist taxonomy using X-Ray computed tomography. *Palaeontologia Electronica, 10*(3), 1–6.
Moore, C. H. (1997). Carbonate diagenesis and porosity. In *Developments in sedimentology, 46*. Elsevier Science, 317 p.
Moss, S., & Tucker, M. E. (1995). Diagenesis of Barremian-Aptian platform carbonates (the Urgonian Limestone Formation of SE France): near-surface and shallow-burial diagenesis. *Sedimentology, 42*, 853–874.
M'Rabet, A., Negra, M. H., Purser, B. H., Sassi, S., & Ben Ayed, N. (1986). Micrite Diagenesis in Senonian Rudist Build-ups in Central Tunisia. *Reef Diagenesis*, 210–223.
Negra, M. E. (1984). *Paléoenvironnement et diagenèse des faciès récifaux à Rudistes au Jebel el Kebar, Tunisie central*. Thèse de 3 Cycle. Orsay: Univ. Paris-Sud.
Negra, M. E., Purser, B. H., & M'Rabet, A. (2009). Sedimentation, diagenesis and syntectonic erosion of Upper Cretaceous rudist mounds in Central Tunisia. In C. L. V. Monty, D. W. J. Bosence, P. H. Bridges, & B. R. Pratt (Eds.), *Carbonate mud-mounds: Their origin and evolution* (pp. 401–417). Blackwell Science.
Newell, N. D. (1965). Classification of the Bivalvia. *American Museum Novitates, 2206*, 1–25.
Olexcon Int.. (1967). *Micropalaeontology, palynology, stratigraphy and oil source rock identification, various wells and sections*. Unpublished report. Amman: NRA.
Opdyke, B. N., Wilson, P. A., & Enos, P. (1995). Geochemistry, diagenesis, and petrology of an Upper Cretaceous rudist reef from site 877, Wodejebato Guyot. In J. A. Haggerty, I. Premoli Silva, F. Rack, & M. K. McNutt (Eds.), *Proceedings of the ocean Drilling Program, Scientific results, 144* pp. 439–446).
Özer, S. (1982). Three new species of the genus *Gorjanovicia* Polšak from Kocaeli region (northwestern Anatolia). *Geologija, 25*, 229–236.
Özer, S. (1983). Les formations à rudistes du Sénonien supérieur d'Anatolie centrale (Turquie). *Travaux du Laboratoire de Stratigraphie et de Paleoécologie N.S., 1*, 32.
Özer, S. (1988). Description de quelques rudistes à canaux dans le Cénomanien de Turquie. *Géologie méditerranéenne, 15*, 159–167.
Özer, S. (1998). Rudist-bearing Upper Cretaceous metamorphic sequences of the Menderes Massif (western Turkey). In J.-P. Masse, & P. W. Skelton (Eds.), *Quatrième Congrès International sur les Rudistes. Geobios, Mémoire spécial, 22* pp. 235–249).
Özer, S., & Ahmad, F. (2014). *Cenomanian-Turonian rudists from NW Jordan*. Tenth International Congress on Rudists Bivalve, Rudists 2014, Bellaterra June 22–27, Scientific Program and Abstracts (pp. 20–21).
Özer, S., & Sarı, B. (2008). *Rudist-bearing marbles of the metamorphic Menderes Massif and the Upper Cretaceous rudistid limestones of the Bey Dağları (western Taurides) carbonate platform*. Eighth International Congress on Rudists. Cretaceous Rudists and Carbonate Platforms, İzmir-Turkey, Post-meeting Field Trip (2) Excursion Guide, June 26–28, 2008, 35 p.
Pamouktchiev, A. (1974). Sur quelques espèces de la famille Caprinidae du Balkan central et du Srednogorié occidental. In *Annuaire de l'Université de Sofia, Faculté de Géologie et Géographie, Livre 1, Géologie, 66* pp. 15–23.
Pamouktchiev, A. (1981). Bivalvia. II. In V. Tzankov (Ed.), *Les fossiles de Bulgarie, V. Crétacé supérieur* (pp. 152–206).
Parker, D. H. (1970). *The hydrogeology of the Mesozoic-Cainozoic aquifers of the western highlands and plateau of East Jordan (4 vols.)*. UNDP/FAO 212, no. 2, 424 p., Rome (unpublished technical report).
Parona, C. F. (1921). Fauna del neocretacico della Tripolitania. *Memorie per servire alla Descrizione della Carta geologica d'Italia, 8*, 1–21.
Parona, C. F. (1926). Richerche sulle rudiste e su altri fossili del Cretacico superiore del Carso Goriziano e dell'Istria. *Memorie del Istituto geologico, 7*, 1–56.
Philip, J. (1978). Stratigraphie et paléoécologie des formations à rudistes du Cénomanien; l'exemple de la Province. *Géologie Méditérranéene, 5*(1), 155–168.
Philip, J., Babinot, J.-F., Tronchetti, G., Fourcade, E., Ricou, L.-E., Guiraud, R., et al. (2000). Late Cenomanian. In J. Dercourt, M. Gaetani, B. Vrielynck, E. Barrier, B. Biju-Duval, M. F. Brunet, et al. (Eds.), *Atlas peri-Tethys palaeogeographical maps, Map 14*. Paris: CCGM/CGMW.
Philip, J., Borgomano, J., & Al-Maskiry, S. (1995). Cenomanian-Early Turonian carbonate platform of Northern Oman: stratigraphy and palaeoenvironments. *Palaeogeography, Palaeoclimatology, Palaeoecology, 119*, 77–92.
Philip, J. M., & Platel, J.-P. (1995). Stratigraphy and rudist biozonation of the Campanian and Maastrichtian of Eastern Oman. *Revista mexicana de Ciencias geológicas, 12*(2), 257–266 (for 1995).
Pirona, A. G. (1869). Le ippuritidi del Colle di Medea del Friuli. *Memorie del Reale Istituto veneto di Scienze, Lettere ed Arti, 14*, 397–435.
Pleničar, M. (1961). The stratigraphic development of Cretaceous beds in southern Primorska (Slovene littoral) and Notranjska (inner Carniola). *Geologija, 6*, 22–145.
Pleničar, M. (1963). Caprinidae and the genus *Radiolitella* from the Upper Cretaceous strata of southwestern Slovenia. Slovenska Akademija Znanosti in Umetnosti, Razred za prirodoslovne in medicinske Vede. *Razprave, 7*, 559–587.
Pleničar, M. (1977). Rudists from the Cretaceous beds of Slovenia. *Geologija, 20*, 5–31.
Pleničar, M., & Jurkovšek, B. (2000). Rudists from the Cenomanian bioherms of Hrusice and Nanos, Slovenia. *Geologija, 42*, 69–116.
Pleničar, M., Jurkovšek, B., & Kolar-Jurkovšek, T. (1999). Stop 1: Cenomanian-Turonian bioherm on Hrusica. In R. Höfling, & T. Steuber (Eds.), *Erlangener geologische abhandlungen: 3. Fifth International Congress on Rudists – Abstracts and field trip guides* (pp. 118–121).
Polšak, A. (1967). Macrofaune crétacée de l'Istrie méridionale (Yougoslavie). *Palaeontologica jugoslavica, 8*, 1–219.
Pons, J. M., Schroeder, J. H., Höfling, R., & Moussavian, E. (1992). Upper Cretaceous rudist assemblages in northern Somalia. *Geologica romana, 28*, 219–241.
Pons, J. M., & Vicens, E. (2008). The structure of the outer shell layer in radiolitid rudists, a morphoconstructional approach. *Lethaia, 41*, 219–234.
Pons, J. M., Vicens, E., & Tarlao, A. (2011). Cenomanian radiolitid bivalves from Malchina, Karst of Trieste, Italy. *Cretaceous Research, 32*, 647–658.
Powell, J. H. (1989). *Stratigraphy and Sedimentation of the Phanerozoic Rocks in Central and South Jordan – Part B: Kurnub, Ajlun and Belqa Groups*. Geological Bulletin No. 11. Amman: The Hashemite Kingdom of Jordan, Ministry of Energy and Mineral Resources, Natural Resources Authority, 130 p.
Powell, J. H., & Moh'd, B. K. (2011). Evolution of Cretaceous to Eocene alluvial and carbonate platform sequences in central and south Jordan. *GeoArabia, 16*(4), 29–82.
Praturlon, A., & Sirna, G. (1976). Ulteriori dati sul margine Cenomaniano della piattaforma carbonatica laziale – abruzzese. *Geologica romana, 40*, 83–111.
Quennell, A. M. (1951). The geology and mineral resources of (former) transjordan. *Colon geol Mia Resource, 2*, 85–115. London.
Regidor-Higuera, I., & García-Garmilla, F. (2005). Radiolitid growth patterns and tidal cyclicity, Upper Cretaceous of Northern Burgos (Spain): microstructural and geochemical clues. In H. F. Filkorn, C. C. Johnson, A. Molineux, & R. W. Scott (Eds.), *Seventh Internatıonal Congress on Rudısts 5 – 11 June 2005 Austin, Texas, USA Abstracts and Post-congress Field Guide* (pp. 74–76).
Regidor-Higuera, I., & García-Garmilla, F. (2006). Diagenetic alteration in caprotinid rudist shells from the Urgonian Complex of El Castillo Cape (Lower Albian, Gorliz, Bizkaia). *Geogaceta, 39*, 155–158.
Regidor-Higuera, I., García-Garmilla, F., & Elorza, J. (2002). Catodoluminiscencia y diagénesis en conchas de rudistas (Bivalvia) del Cretácico Superior de Gredilla de Sedano (Norte de Burgos, España). *Geogaceta, 32*, 285–288.
Regidor-Higuera, I., García-Garmilla, F., & Skelton, P. W. (2007). Sclerochronology and diagenesis of Late Cretaceous radiolitids (Bivalvia, Hippuritoidea) Spain. In R. W. Scott (Ed.), *Cretaceous Rudists and Carbonate Platforms: Environmental Feedback, SEPM Special Publication 87* (pp. 115–140).
Ross, D. J., & Skelton, P. W. (1993). Rudist formations of the Cretaceous: a palaeoecological, sedimentological and stratigraphical review. In V. P. Wright (Ed.), *Sedimentology review 1* (pp. 73–91). Blackwell Scientific Publications.
Saber, G. S., Salama, Y. F., Scott, R. W., Abdel-Gawad, G. I., & Aly, M. F. (2009). Cenomanian-Turonian rudist assemblages and sequence stratigraphy on the North Sinai carbonate shelf, Egypt. *GeoArabia, 14*(4), 113–134.
Sadooni, F. N. (2005). The nature and origin of Upper Cretaceous basin-margin rudist buildups of the Mesopotamian Basin, southern Iraq, with consideration of possible hydrocarbon stratigraphic entrapment. *Cretaceous Research, 26*(2), 213–224.
Sanders, D. (1998). Upper Cretaceous 'Rudist Formations'. In *Geol. Paläont. Mitt. Innsburck, 23* pp. 37–59.
Sanders, D. (1999). Shell disintegration and taphonomic loss in radiolitid biostromes. *Lethaia, 32*, 101–112.
Sanders, D. (2001). Burrow-mediated carbonate dissolution in rudist biostromes (Aurisina, Italy): implications for taphonomy in tropical, shallow subtidal carbonate environments. *Palaeogeography, Palaeoclimatology, Palaeoecology, 168*, 39–74.
Sarı, B., & Özer, S. (2009). Upper Cretaceous rudist biostratigraphy of the Bey Dağları Carbonate Platform, Western Taurides; SW Turkey. *Geobios, 42*, 359–380.
Sass, E., & Bein, A. (1982). The Cretaceous carbonate platform in Israel. *Cretaceous Research, 3*, 135–144.
Schlüter, M., Steuber, T., & Parente, M. (2008). Chronostratigraphy of Campanian-Maastrichtian platform carbonates and rudist associations of Salento (Apulia, Italy). *Cretaceous Research, 29*, 100–114.
Schmitt, J. G., & Boyd, D. W. (1981). Patterns of silicification in Permian pelecypods and brachiopods from Wyoming. *Journal of Sedimetary Petrology, 51*, 1297–1308.
Schulze, F., Kuss, J., & Marzouk, A. (2005). Platform configuration, microfacies and cyclicities of the upper Albian to Turonian of west-central Jordan. *Facies, 50*, 505–527.
Schulze, F., Lewy, Z., Kuss, J., & Gharaibeh, A. (2003). Cenomanian–Turonian carbonate platform deposits in west central Jordan. *Int. J. Earth Sci. (Geol Rundsch), 92*, 641–660.
Schulze, F., Marzouk, A., Bassiouni, M. A. A., & Kuss, J. (2004). The upper Albian to Turonian carbonate platform succession of west central Jordan-stratigraphy and crisis. *Cretaceous Research, 25*(5), 709–737.
Selley, R. C. (2000). *Applied sedimentology*. Academic Press, 523 p.
Sharpe, D. (1850). On the Secondary district of Portugal which lies on the north of the Tagus. *Quarterly Journal of the Geological Society of London, 6*, 135–201.
Sirna, G., & Paris, A. (1999). Le rudiste del Museo di paleontologia del dipertimento di Scienze della terra dell'Università "La Spienza" di Roma. *Geologica romana*,

35, 45–87.

Skelton, P. W. (2013a). Rudist classification for the revised Bivalvia volumes of the 'Treatise on Invertebrate Paleontology'. *Carribean Journal of Earth Science, 45*, 9–33.

Skelton, P. W. (2013b). Rudist classification: nomenclatural correction of 'Suborder Radiolitidina Skelton, 2013' to 'Suborder Hippuritidina Newell, 1965'. *Carribean Journal of Earth Science, 45*, 34.

Sladič-Trifunovič, M. (1983). Paleontological characteristics and biostratigraphic significance of *Pseudopolyconites*. *Geološki anali Balkanskog poluostrva (Beograd), 47*, 217–309.

Slišković, T. (1966). Zwei neue Arten der Gattung Ichthyosarcolites aus der Oberkreide (Ablagerungen der Südherzegowina), Conseil des Académies des Sciences et des Arts de la RSF de Yougoslavie. *Bulletin scientifique (A), 12*, 177–178.

Slišković, T. (1982). New Radiolitidae from the Cretaceous deposits of Bosnia and Herzegovina. *Bulletin du Musée de la République Socialiste de Bosnie-Herzégovine à Sarajevo, Sciences naturelles (N.S.), 21*, 1–19.

Slišković, T. (1983). *Ichthyosarcolites monocarinatus major* n. subsp. from Cenomanian deposits on Mt. Velez (Herzegovina). *Zemaljski Muzej Bosne i Hercegovine, Glasnik, prirodne Nauke (N. S.), 22*, 19–26.

Stampfli, G. M., Borel, G., Cavazza, W., Mosar, J., & Ziegler, P. A. (2001). *The paleotectonic Atlas of the Peritethyan domain*. Berlin: European Geophysical Society, CD-ROM, Electronic Publishing and Consulting.

Steuber, T. (1999a). Isotopic and chemical intra-shell variations in low-Mg calcite of rudist bivalves (Mollusca-Hippuritacea): disequilibrium fractionations and Late Cretaceous seasonality. *International Journal of Earth Science, 88*, 551–570.

Steuber, T. (1999b). Cretaceous rudists of Boeotia, central Greece. In *Special Papers in Palaeontology 61* (pp. 1–229).

Steuber, T. (2001). Strontium isotope stratigraphy of Turonian–Campanian Gosau-type rudist formations in the Northern Calcareous and Central Alps (Austria and Germany). *Cretaceous Research, 22*(4), 429–441.

Steuber, T. (2002). *A palaeontological database of Rudist Bivalves (Mollusca: Hippuritoidea, Gray1848)*. http://www.ruhr-uni-bochum.de/sediment/rudinet/intro.htm.

Steuber, T., & Bachmann, M. (2002). Upper Aptian-Albian rudist bivalves from northern Sinai, Egypt. *Palaeontology, 45*(4), 725–749.

Steuber, T., & Löser, H. (2000). Species richness and abundance patterns of Tethyan Cretaceous rudist bivalves (Mollusca: Hippuritacea) in the central-eastern Mediterranean and Middle East. *Palaeogeography, Palaeoclimatology, Palaeoecology, 162*, 75–104.

Swinburne, N. H. M., & Noacco, A. (1993). The platform carbonates of Monte Jouf, Maniago, and the Cretaceous stratigraphy of the Italian Carnic Prealps. *Geologica croatica, 46*, 25–40.

Tentor, A. (2007). Osservazioni stratigrafiche sul Monte Brestovi (Carso Gorıziano). Stratigraphic observations on Mount Brestovi (Karst of Gorizia, Italy). *Natura Nascosta, 35*, 1–23.

Touir, J., & Soussi, M. (2003). The growth and migration of two Turonian rudist-bearing carbonate platforms in Central Tunisia. Eustatic and tectonic controls. In E. Gili, M. El Hédi Negra, & P. W. Skelton (Eds.), *Earth and environmental sciences: 28. North African Cretaceous Carbonate Platform Systems, Nato Science Series, IV* (pp. 53–81).

Tucker, M. E., & Wright, V. P. (1990). *Carbonate sedimentology*. Blackwell Science, 468 p.

Wendler, J., Wendler, I., & Kuss, J. (2009). Early Turonian shallow marine red beds on the Levant carbonate platform (Jordan), Southern Tethys. In X. Hu (Ed.), *Cretaceous Oceanic Red Beds: Stratigraphy, Composition, Origins, and Paleoceanographic and Paleoclimatic Significance SEPM Special Publication No. 91* (pp. 171–179).

Wetzel, R., & Morton, D. M. (1959). Contribution à la Géologie de la Transjordanie. In L. Dubertret (Ed.), *Notes et Memoires sur le Moyen Orient VII* (pp. 95–191).

Wiese, F., & Schulze, F. (2005). The upper Cenomanian (Cretaceous) ammonite *Neolobites vibrayeanus* (d'Orbigny, 1841) in the Middle East: taxonomic and palaeoecologic remarks. *Cretaceous Research, 26*, 930–946.

Yanin, B. T. (1990). Kriterii sistematiki rudistov. In V. V. Menner (Ed.), *Sistematika i Filogeniia Bespozvonochikh. Kriterii Vydeleniia Vyschikh Taksonov* (pp. 57–69). Moscow: Nauka [In Russian].

Zimmerle, W. (1995). *Petroleum sedimentology*. Kluwer Academic Publisher, 407 p.