Cretaceous Research 58 (2016) 141–159

Contents lists available at ScienceDirect

Cretaceous Research

journal homepage: www.elsevier.com/locate/CretRes

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

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ARTICLE INFO

Article history:
Received 30 October 2014
Accepted in revised form 6 May 2015
Available online xxx

Keywords:
Rudist bivalves
Upper Cenomanian
Description
Stratigraphy
Diagenesis
Jordan

ABSTRACT

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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http://dx.doi.org/10.1016/j.cretres.2015.05.002
0195-6671/

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