Journal of African Earth Sciences 103 (2015) 128–139

Contents lists available at ScienceDirect

Journal of African Earth Sciences

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

Gastropods from the Campanian–Maastrichtian Aruma Formation, Central Saudi Arabia

Mohamed Gameil [a,b], Abdelbaset S. El-Sorogy [c,d,*]

[a] Department of Petroleum Geology and Sedimentology, Faculty of Earth Sciences, King Abdulaziz University, Jeddah, Saudi Arabia
[b] Department of Geology, Faculty of Science, Cairo University, Giza, Egypt
[c] Department of Geology and Geophysics, College of Science, King Saud University, Saudi Arabia
[d] Department of Geology, Faculty of Science, Zagazig University, Egypt

ARTICLE INFO

Article history:
Received 6 September 2014
Received in revised form 20 November 2014
Accepted 21 November 2014
Available online 24 December 2014

Keywords:
Gastropods
Upper Cretaceous
Aruma Formation
Central Saudi Arabia

ABSTRACT

The gastropod fauna of the Upper Cretaceous Aruma Formation in central Saudi Arabia comprises fifteen species belonging to fifteen genera, fourteen families, and five clades. The species are not abundant at any individual stratigraphic level but are equally and irregularly scattered in the formation. The studied species come mainly from the Hajajah Member of Upper Cretaceous Aruma Formation in central Saudi Arabia. *Calliomphalus orientalis* (Douvillé, 1916); *Coelobolma corbarica* Cossmann, 1918; *Turritella* (*Torquesia*) *figarii* Quaas, 1902; *Neoptyxis olisiponensis* (Sharpe, 1850) and *Otostoma* (*Otostoma*) *divaricatum* (d'Orbigny, 1847) are recorded from the Upper Cretaceous of central Arabia for the first time. The identified species have a close affinity to the Tethyan fauna known from other parts in Asia, Africa and Europe. Herbivores and predators are the dominant trophic groups which may indicate shallow marine lagoonal and relatively open marine environment.

1. Introduction

The Aruma Formation has got its name due to its occurrence in the Al 'Aramah plateau, a broad upland surface related to the easternmost of the Najd escarpments (Powers et al., 1966). Rocks of the Aruma Formation crop out from Wadi ad Dawasir in southern Saudi Arabia to beyond the Iraq–Saudi Arabia borders, a distance of more than 1600 km. Width of the Aruma outcrop band is somewhat erratic, but from a regional point of view it persistently increases from south to north. About 20 km wide at Wadi ad Dawasir, the formation is spread out over nearly 200 km where it passes into Iraq.

The Aruma Formation diconformably overlies continental siliciclastic sediments of the Cenomanian Wasia Formation (Steineke et al., 1958). The upper boundary is taken at the change from yellow–brown dolomitic shale below to gray crystalline *Lockhartia-bearing* dolomite of the Umm er Radhuma Formation (Steineke and Bramkamp, 1952) above. The first formal references to the Aruma Formation appeared in Steineke and Bramkamp (1952). The type locality was described by Steineke et al. (1958). Later, many studies have been carried out on the Upper Cretaceous stratigraphy and faunal distribution of the Aruma Formation such as algae and rudists (e.g., El Asa'ad, 1977, 1983a,b; Okla, 1991, 1992, 1994, 1995).

Since El Asa'ad (1977) carried out a taxonomic study on the Upper Cretaceous gastropods of central Saudi Arabia, nothing has been done on the taxonomy of this fauna. In this work an up-to-date taxonomic analysis and a revision is carried out on the Upper Cretaceous (Maastrichtian) gastropods of the Hajajah Member (Aruma Formation) from some exposed sections in Riyadh, Central Saudi Arabia.

The aims of the present study are (1) to describe and identify the gastropod fossil content of the Hajajah Member of the Upper Cretaceous Aruma Formation in Central Saudi Arabia and (2) to study the paleogeographic distribution of the identified taxa.

2. Materials and methods

275 Gastropod specimens were collected during two field trips from the Hajajah Member of the Aruma Formation at Khashm Bowaibiyat, Khashm Tawqi and Khashm Khanasir areas, Northeast Riyadh (Fig. 1). Most of the materials are preserved as internal molds or steinkerns, in rare specimens the remnants of the original skeleton can be preserved although highly calcitized.

* Corresponding author at: Department of Geology and Geophysics, College of Science, King Saud University, P.O. Box: 2455, Riyadh 11451, Saudi Arabia. Mobile: +966 540325046; fax: +966 14676214.

http://dx.doi.org/10.1016/j.jafrearsci.2014.11.015
1464-343X/

The specimens were prepared mechanically, cleaned carefully, and photographed. They are compared with other gastropods from neighboring countries especially the United Arab Emirates and Egypt where much works have been carried out on the Upper Cretaceous gastropods.

The taxonomic study carried out in this work follows the classification done by Bouchet and Rocroi (2005). Moreover the terminologies of the different parts of gastropod shell morphology that are used here follow Cox (1960). The specimens representing each species were measured and the mean value was used in this work, this is carried out for the different shell parameters as shell height, shell width, height of body whorl, apertural height and apertural width.

The materials are deposited in the Museum of the Geology Department, Faculty of Science, King Saud University under numbers MGD-FSc-KSU-1:15. Abbreviations used in the work are: HS: height of shell, WS: width of shell, HL: height of body whorl, HA: height of aperture, WA: width of aperture. All measurements are given in millimeters.

3. Stratigraphic setting

In the type locality, the Aruma Formation attains 140 m thick and is composed of limestone, shale and dolomite (Powers, 1968). Previously, the formation was divided into four lithological units that were grouped into two members namely, the Atj and Lina members. Later, the formation was subdivided into three members (El Asa'ad, 1984; Vaslet et al., 1988; Skelton and El Asa'ad, 1992). These members are, in ascending order, The Khanasir Member, the Hajajah Member and the Lina Member (Fig. 2).

The Khanasir Member is the lowermost member (up to ~65 m), it comprises shale at the base followed by slightly dolomitized, burrow and nodular limestone and capped with about 12 m of local rudist biostrome (Fig. 3A). It diconformably overlies the continental Cenomanian siliciclastics of the Wasia Formation with a sharp contact and is overlain by the Hajajah Member with very low angle unconformity. This member ranges in age from Coniacian at its base to Campanian at its uppermost few meters (El-Asa'ad, 1983a,b).

This Hajajah Member diconformably overlies the Khanasir Member. It comprises shale and marl at the base followed by limestone (up to ~75 m). The lower shale and marl rocks contain abundant scleractinian corals (solitary and colonial), stromatoporoids, gastropods (Figs. 3D–F, 4, and 5) and few bivalves. Corals are predominantly domal, platy and rarely branching. The limestone bed in the upper part includes abundant benthic larger foraminifera [including *Omphalocuclus macroporous* (Lamarck) and *Quenqueloculina* sp.] and dasycladacian algae (*Griphoporella* sp.).

The Hajajah Member is located below the level of the lowermost definitely Maastrichtian Foraminifera and above the level of the uppermost definitely Campanian Foraminifera. Skelton and El Asa'ad (1992) assigned the Hajajah Member to the Late Campanian according to the ammonites *Manambolites amardi* Collignon and

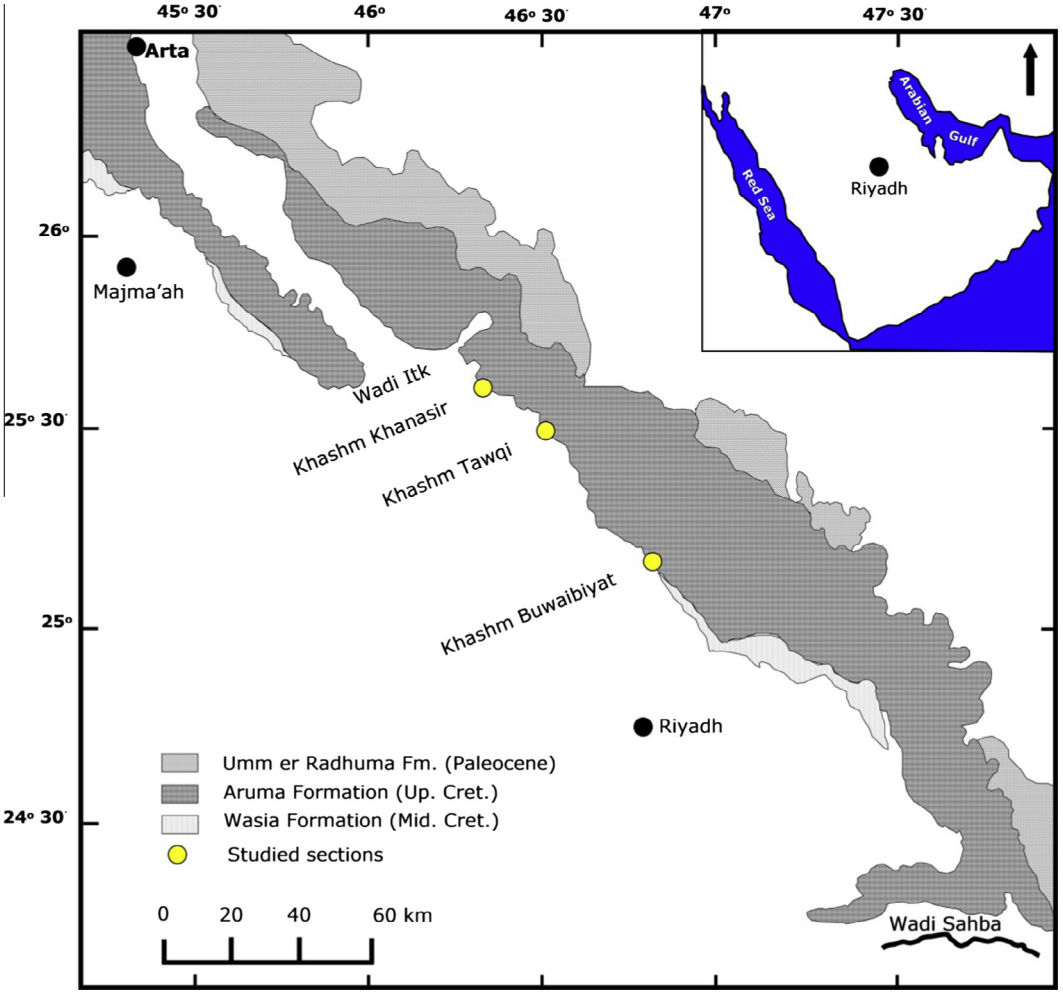

Fig. 1. Location map of the studied areas.

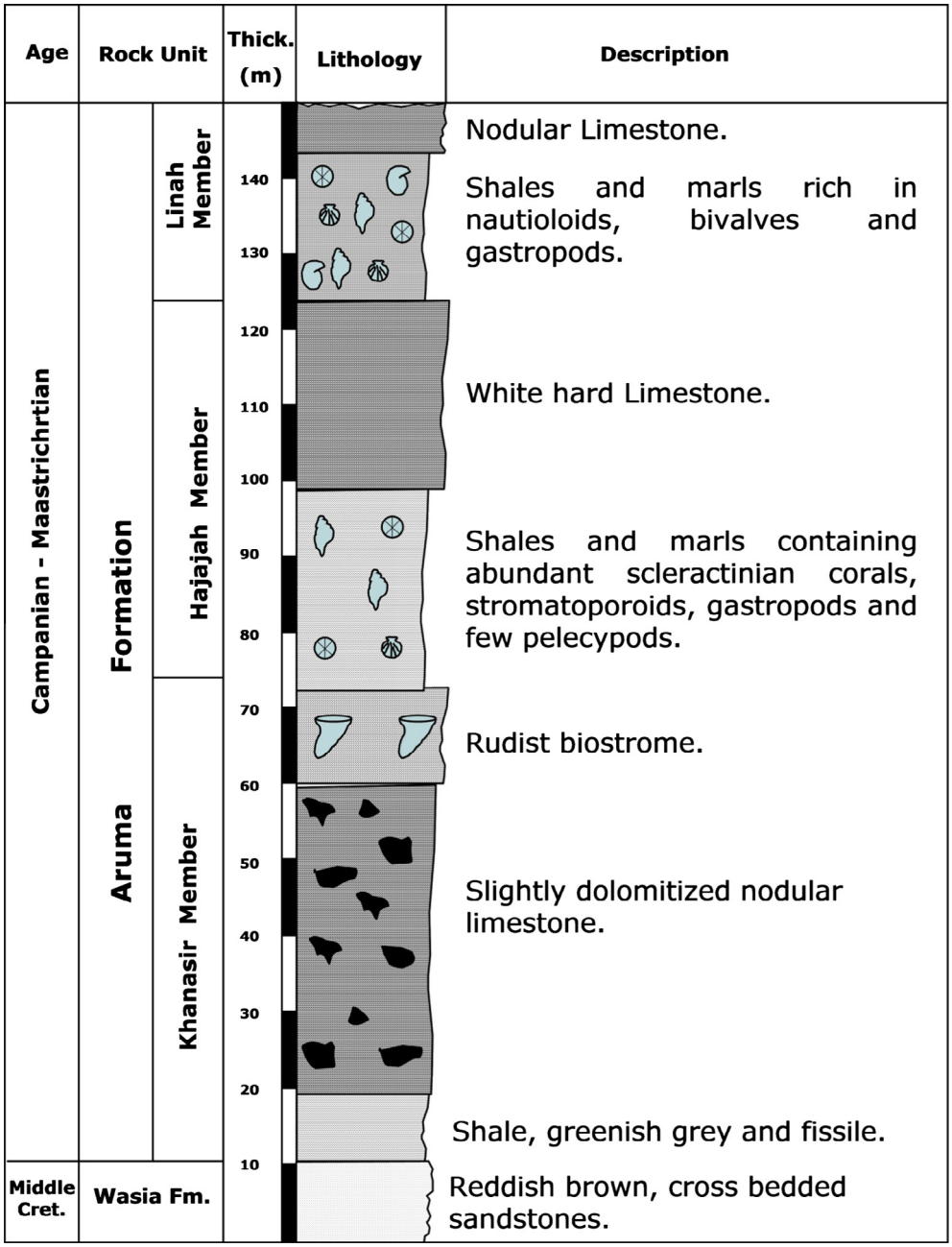

Fig. 2. Composite section of the Aruma Formation in the studied areas.

Roman, *Libycoseras chargense* Blanckenhorn and *pachydiscus* (*P.*) *launayi* (De Grossouvre) in the calcareous part of the member.

The Hajajah limestone Member passes gradationally upwards into the Lina Shale Member (over 40 m) which consists of shales and marly nodular limestones, and rich in nautioloids, burrowing bivalves and gastropods. Ammonites and foraminifera from this member suggest a late Maastrichtian age (El Asa'ad, 1983b).

4. Results and discussion

4.1. Taxonomy

Class Gastropoda Cuvier, 1797
Clade Vetigastropoda Salvini-Plawen, 1980
Superfamily Trochoidea Rafinesque, 1815
Family Trochidae Rafinesque, 1815
Subfamily Trochinae Rafinesque, 1815
Genus *Calliomphalus* Cossmann, 1888
Calliomphalus orientalis (Douvillé, 1916)
(Fig. 4A and B)
1916 *Metriomphalus orientalis* Douvillé: 145, pl. 18, fig. 31.
1991 *Metriomphalus orientalis* Douvillé – Aboul Ela et al.: pl. 2, fig. 1.
1992 *Calliomphalus* (*Calliomphalus*) *orientalis* (Douvillé) – Abdel-Gawad and Gameil: 71, fig. 2/1.
2006 *Calliomphalus* (*Calliomphalus*) *orientalis* (Douvillé) – El Qot: 93, pl. 19, fig. 1.
2008 *Calliomphalus* (*Calliomphalus*) *orientalis* (Douvillé) – Mekawy and Abu Zied: 317, pl. 4, fig. 3.
2011 *Calliomphalus*? *orientalis* (Douvillé) – Ayoub-Hannaa and Fürsich: 118, fig. 3.

Fig. 3. Field photographs of the Aruma Formation. (A) The Khanasir Member diconformably overlies siliciclastics of Wasia Formation. (B) General view of the Hajajah Member. (C) Close up view of the Hajajah Member with colonial and solitary corals and other invertebrates. (D) General view of the Lina Member.

Material: 20 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.

Measurements: HS: 15, WS: 20, HL: 11, HA: 13, WA: 13.

Remarks: The shell is trochoid with a conical spire consisting of two whorls. The suture is depressed and the body whorl occupies more than two-thirds of shell height. The aperture is small and circular. Ornamentation is in the form of tuberculated spiral lines. The spiral lines and the tubercles vary in number and generally increase with increasing the size of the whorl. Umbilicus is narrow and deep.

Calliomphalus dichotomous (Alth, 1850) differs from the present species in having more convex whorls and no tubercles, *C. biomstrofenesis* (Griepenkerl, 1889) also differs in having more spiral cords (see Abdel-Gawad and Gameil, 1992).

Distribution: Albian–Cenomanian of Egypt.

Superfamily Turbinoidea Rafinesque, 1815
Family: Turbinidae Rafinesque, 1815
Genus *Coelobolma* Cossmann, 1918
?*Coelobolma corbarica* Cossmann, 1918
(Fig. 4C and D)
1918 *Coelobolma corbarica* Cossmann: 150, pl. 5, figs. 4 and 5.
1985 *Coelobolma corbarica* Cossmann – Kollmann: 93, fig. 3e–i.
1993 *Coelobolma corbarica* Cossmann – Metwally: 336, pl. 1, fig. 3a, b.

Material: 10 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.

Measurements: HS: 20, WS: 16, HL: 16, HA: 14, WA: 10.

Remarks: The present species has a turbiniform shell with a depressed spire and an obtuse spiral angle (93°). The suture is

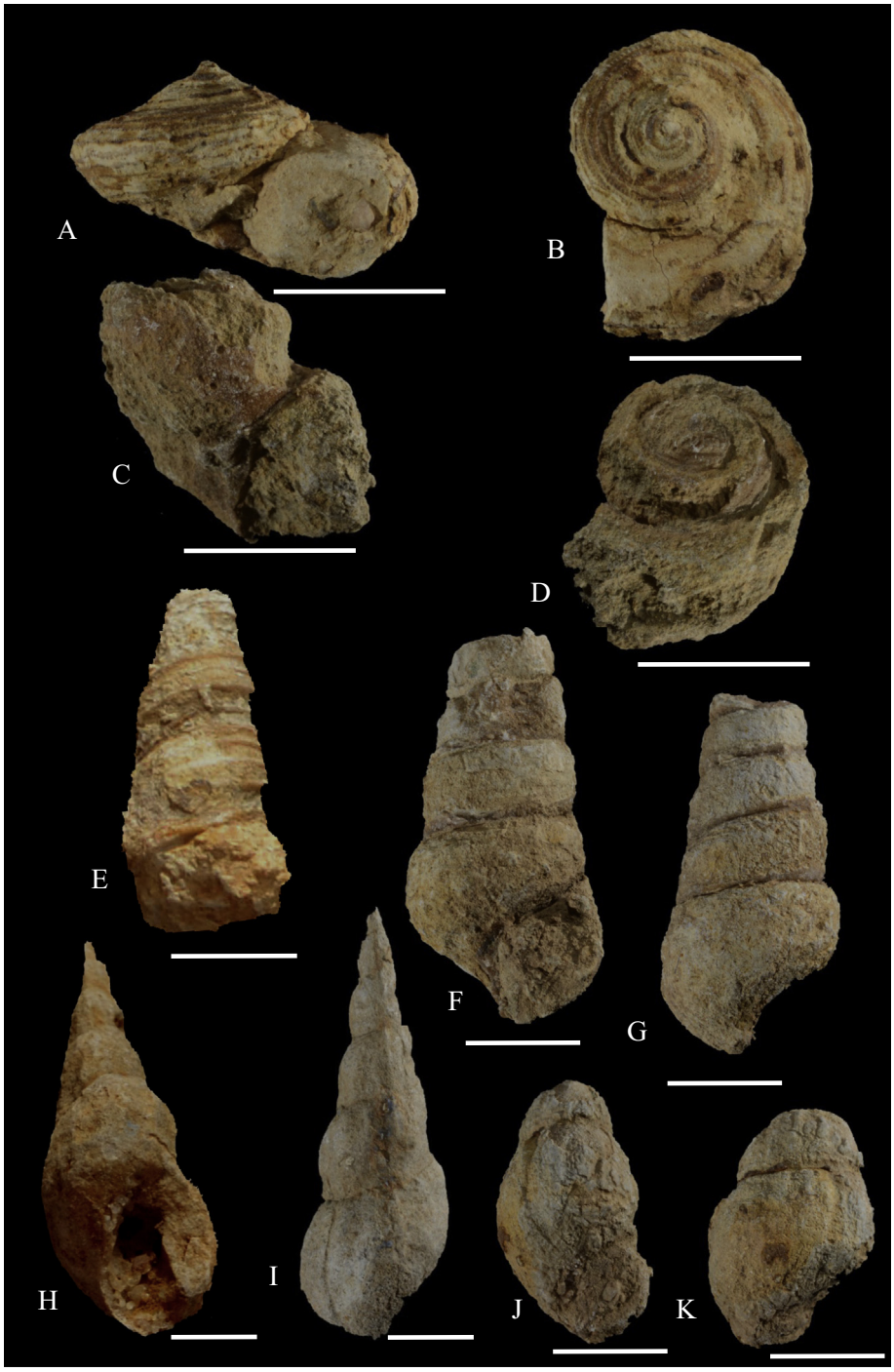

Fig. 4. (A) and (B) Apertural and top views of *Calliomphalus orientalis* (Douvillé). (C) and (D) Apertural and abapertural views of *Coelobolma corbarica* Cossmann. (E) Apertural view of *Turritella* (*Torquesia*) *figarii* Quaas. (F) and (G) Apertural and abapertural views of *Cerithium buddha* Noetling. (H) and (I) Apertural and abapertural views of *Pyrazus valeriae* (de Verneuil and de Lorière). (J) and (K) Apertural and abapertural views of *Aporrhais* sp. Scale bar = 1 cm.

depressed and the body whorl constitutes more than two thirds of shell height. The base is slightly convex. The studied specimens are attributed to *Coelobolma corbarica* Cossmann although the bad preservation of specimens renders the identification more or less doubtful.

Distribution: Upper Santonian of France and Maastrichtian of the Oman Mountains.

Clade Caenogastropoda Cox, 1960
Superfamily Cerithioidea Fleming, 1822
Family: Turritellidae Clark, 1851

Genus: *Turritella* Lamarck, 1799
Turritella (*Torquesia*) *figarii* Quaas, 1902
(Fig. 4E)
1902 *Turritella* (*Zaria*) *figarii* n. sp. Quaas: 255, pl. 26, figs. 15–16.
1963 *Turritella* (*Torquesia*) *figarii* Quaas – Abbass: 32, pl. 2, figs. 1–2.

Material: 30 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.
Measurement: HS: 17, WS: 8, HA: 8, WA: 5.

Description: Molds small, tightly coiled and turreted with a long spire. Spiral angle is narrow (15°). The whorls are convex and ornamented with four spiral lines. Spiral lines are thin and smooth. The interspaces between thick spiral lines are depressed and contain 1–2 thinner intercalatory spiral threads. The suture is depressed and the aperture is small and ovoid.

Remarks: The present species closely resembles *Turritella* (*Torquesia*) *figarii* Quaas, 1902 from the Campanian–Maastrichtian of the Egyptian Western Desert in having convex whorls and with four spiral lines and 1–2 faint spiral threads in-between.

Distribution: Campanian–Maastrichtian of Egypt.

Family Cerithiidae Fleming, 1822
Genus *Cerithium* Bruguie're, 1789
?*Cerithium buddha* Noetling, 1897
(Fig. 4F and G)
1897 *Cerithium buddha*n. sp. nov. Noetling: 60, pl. 15, fig. 4–5.
1993 *Cerithium buddha* Noetling – Metwally: 339, pl. 2, fig. 4.

Material: 35 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.

Measurements: HS: 52, WS: 18, HL: 13, HA: 13, WA: 10.

Remarks: The species is characterized by longitudinal spire with strongly rounded whorls and narrow spiral angle (19°). Noetling, 1897 first identified this species from the Upper Cretaceous (Maastrichtian) of Baluchistan (Pakistan) as having longitudinal spiny ribs crossed by fine spirals cords in the well preserved specimens. This ornamentation could not be observed in the Saudi specimens due to absence of original shell material.

Distribution: Maastrichtian of Baluchistan and the United Arab Emirates. Maastrichtian of Saudi Arabia.

Family Batillariidae Thiele, 1929
(=Pyrazidae Hacobjan, 1972 = Tiaracerithiinae Bouniol, 1981)
Genus *Pyrazus* Montfort, 1810
Pyrazus valeriae (de Verneuil and Lorière, 1868)
(Fig. 4H and I)
1868 *Cerithium Valeriae* sp. nov. de Verneuil and de Lorière: 11, pl. 2, fig. 1.
1916 *Pyrazus Valeriae* de Verneuil and de Lorière – Douvillé: 136, pl. 18, figs. 6–8.
?1927 *Cerithium* (?*Pyrazus*) *magnicostatum* Conrad – Blanckenhorn: 161, pl. 8 (4), fig. 75.
?1927 *Cerithium* (*Pyrazus*) *zumoffeni* sp. nov. Blanckenhorn: 160, pl. 8, fig. 73.
1992 *Pyrazus valeriae* (de Verneuil and de Lorière) – Abdel-Gawad and Gameil: 74, fig. 2/11, 2/11–12.
1986 *Pyrazus* (*Echinobathra*) *valeriae* (de Verneuil and de Lorière) – Buitrón: 25, figs. 14, 15.
1995 *Pyrazus* (*Echinobathra*) *valeriae* (de Verneuil and de Lorière) – Sánchez and Tinajero: 162, pl. 1, Figs. 7–9.
2004 *Pyrazus valeriae* (de Verneuil and de Lorière) – Abdel-Gawad et al.: pl. 5, fig. 1.
2006 *Pyrazus* (*Pyrazus*) *valeriae* (de Verneuil and de Lorière) – El Qot: 97, pl. 19, Figs. 9–11.
2007 *Pyrazus* (*Pyrazus*) *valeriae* (de Verneuil and de Lorière) – Mekawy: 158, pl. 1, fig. 7.
2008 *Pyrazus* (*Pyrazus*) *valeriae* (de Verneuil and de Lorière) – Mekawy and Abu Zied: 322, pl. 4, fig. 14.
2011 *Pyrazus valeriae* (de Verneuil and de Lorière): Ayoub-Hannaa and Fürsich, 120, fig. 5.

Material: 7 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.

Measurements: HS: 60, WS: 15, HL: 15, HA: 16, WA: 12.

Description: The present specimens have an acute spire with spiral angle about 12°. The spire consists of 5 whorls that constitute about 75% of the total height of shell. Ornament consisting of about 8–10 axial ribs, the spiral ribs are thin and weak. The suture is impressed and the aperture is ovate in outline.

Remarks: The present species differs from *Pyrazus* (*Echinobathra*) *magharensis* Abbass (1963) which has more axial (11–15) and spiral ribs (20–25). *P. themedensis* (Abbass, 1963) has deeper sutures with fewer spiral ribs (six).

Distribution: Early Cretaceous of Spain, Albian–Turonian of Egypt. Maastrichtian of Saudi Arabia.

Superfamily Stromboidea Rafinesque, 1815
Family Aporrhaidae Gray, 1850
Subfamily Aporrhainae Gray, 1850
Genus *Aporrhais* Da Costa, 1778
?*Aporrhais* sp.
(Fig. 4J and K)

Material: 18 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.

Measurements: HS: 30, WS: 15, HL: 27, HA: 10, WA: 9

Description: The collected specimens are badly preserved and only one or two spire whorls are preserved. The spiral angle is narrow (26°). The surface is ornamented with thick axial ribs, the ribs are smooth and curved. The interspaces between ribs are shallow and wide, they are twice the width of the axial ribs. The suture is impressed and the aperture is suboval.

Remarks: The bad preservation especially the wing-shaped aperture outer lip with two finger-like extensions makes generic and specific identification doubtful.

Family Colombellinidae Fischer, 1884
(=Columbellariidae Zittel, 1895 = Zitteliidae, Schilder, 1936)
Genus *Pterodonta* d'Orbigny, 1842
Pterodonta deffisi Thomas and Peron, 1889
(Fig. 5A and B)
1889 *Pterodonta Deffisi* Thomas and Peron in Peron: 1889: 83, pl. 20, figs. 17, 18.
1916 *Pterodonta Deffisi* Thomas and Peron – Greco: 158 (100), pl. 19 (11), figs. 6–9.
1934 *Pterodonta deffisi* Thomas and Peron – Blanckenhorn: 272.
1961 *Pterodonta deffisi* Thomas and Peron – Faris and Abbass: 55, pl. 2, fig. 12.
1963 *Pterodonta deffisi* Thomas and Peron – Fawzi: 98, pl. 7, fig. 7.
1963 *Pterodonta gigantica* Abbass: 83, pl. 7, figs. 1–2, 3, non figs. 4–5, 7.
1977 *Pterodonta deffisi* Thomas and Peron – El Asa'ad, 273, pl. 16, fig. 1.
1992 *Pterodonta deffisi* Thomas and Peron – Abdel Gawad and Gameil: 80, fig. 3: 14–16.
1993 *Pterodonta deffisi* Thomas and Peron – Metwally, 341, pl. 2, fig. 8a, b.
2006 *Pterodonta deffisi* Thomas and Peron – El Qot: 105, pl. 21, Figs. 9 and 10.
2011 *Pterodonta*? cf. *deffisi* Thomas and Peron – Ayoub-Hannaa and Fürsich: 136, fig. 13B

Material: 23 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.

Measurements: HS: 80, WS: 50, HL: 70, HA: 60, WA: 43.

Description: The shell is fusiform with a conical spire consisting of 2–3 slightly convex whorls. The body whorl is inflated and its size is double the spire whorls. The spiral angle is acute (30°),

the sutures are impressed, the aperture is ovate to elongate in outline with a a curved outer lip.

Remarks: The present species can be distinguished from *Pterodonta ovata* which has narrow and flat whorls. Due to the similarity in shell shape and apertural outline Abdel-Gawad and Gameil (1992) and El Qot (2006) considered *Pterodonta gigantic* Abbass (p. 7, figs. 1–3) as varieties of *Pterodonta deffisi* Thomas and Peron.

Distribution: Cenomanian–Turonian of Tunisia, Egypt, Syria, United Arab Emirates, Saudi Arabia and Portugal.

Family Ampullinidae Cossmann, 1919

Genus *Pseudamaura* Fischer, 1885

Pseudamaura subbulbiformis (d'Orbigny, 1850)
(Fig. 5C and D)
2005 *Pseudamaura subbulbiformis* (d'Orbigny), Kollmann, 63, pl. 8, figs. 12–15.

Material: 6 Specimens from the Hajajah Member (Aruma Formation).

Measurements: HS: 30, WS: 16, HL: 24, HA: 17, WA: 5.

Description: Medium sized, moderately high-spired, the spire consists of three whorls with slightly convex sides. The body whorl is large and egg-shaped, accounting nearly half of total height. The spiral angle is narrow (30°). The sutures are impressed and canali-

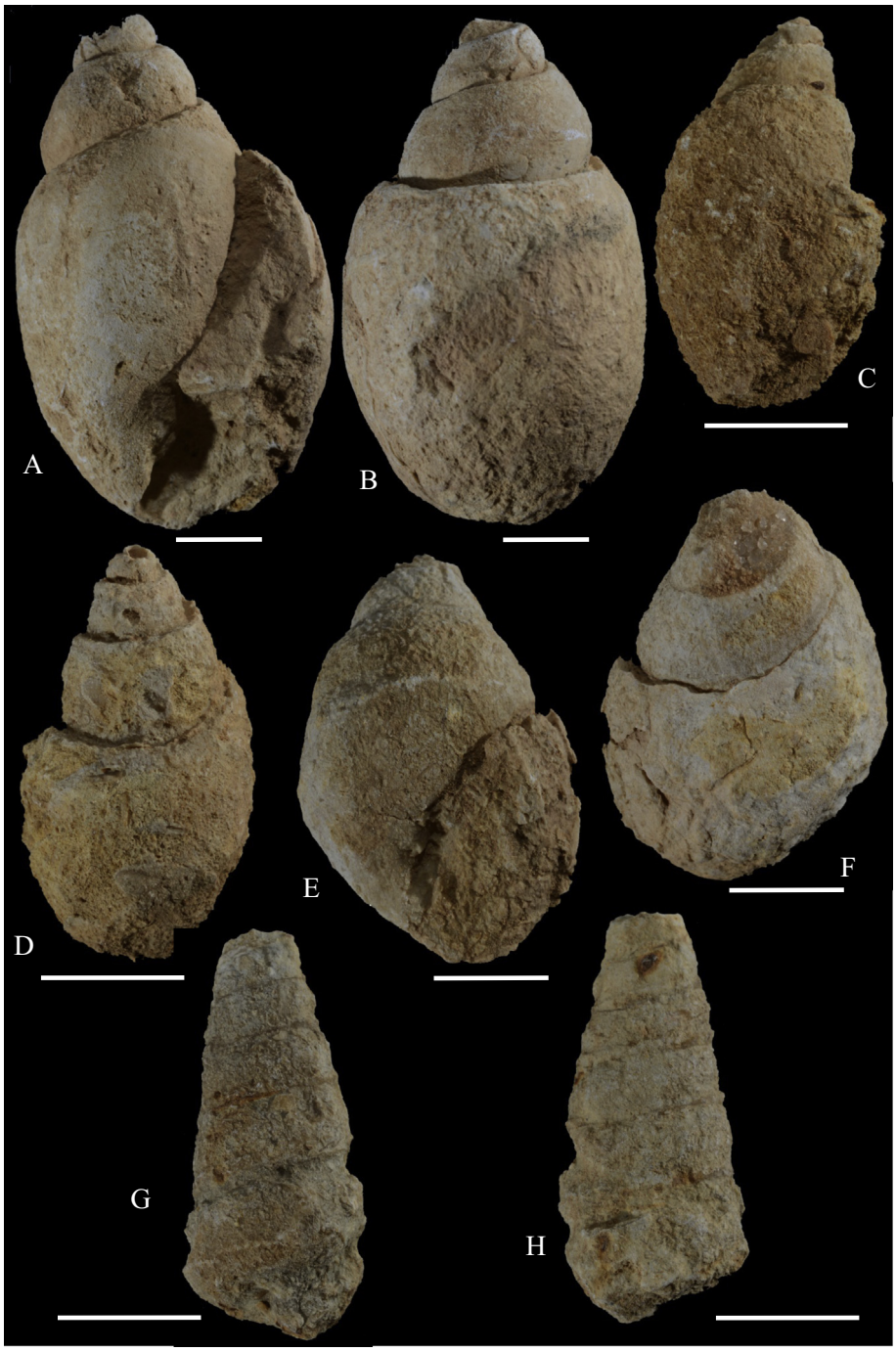

Fig. 5. (A) and (B) Apertural and abapertural views of *Pterodonta deffisi* Thomas and Peron. (C) and (D) Apertural and abapertural views of *Pseudamaura subbulbiformis* (d'Orbigny). (E) and (F) Apertural and abapertural views of *Tylostoma pallaryi* Peron. (G) and (H) Apertural and abapertural views of *Neoptyxis olisiponensis* (Sharpe). Scale bar = 1 cm.

culated. The aperture is ovate, a small umbilicus (a small slit, occasionally lacking).

Remarks: The studied specimens agree in the morphological characters of the shell with those characteristic of genus *Pseudamaura*.

Distribution: Turonian of France.

Family Tylostomatidae Stoliczka, 1868
Genus *Tylostoma* Sharpe, 1849
Tylostoma pallaryi (Peron and Fourtau, 1904)
(Fig. 5E and F)
1904 *Pseudomelania Pallaryi* sp. nov. – Peron and Fourtau in Fourtau: 270, pl. 1, fig. 22.
1916 *Tylostoma pallaryi* Peron and Forteau – Greco: 151, pl. 18, fig. 2–4.
1963 *Tylostoma pallaryi* Peron and Forteau – Fawzi: 91, pl. 7, fig. 1, 1a.
1974 *Tylostoma* (*Tylostoma*) *pallaryi* (Peron and Fourtau) – Albanesi and Busson: 310, pl. 24, fig. 6.
1977 *Tylostoma pallaryi* Peron and Forteau – El Asa'ad: 281, pl. 17, fig. 1.
1985 *Tylostoma* cf. *pallaryi* (Peron and Fourtau) – Dominik: pl. 15, fig. 7.
1993 *Tylostoma pallaryi* Peron and Forteau – Metwally: 345, pl. 4, fig. 3a, b.
2001 *Tylostoma pallaryi* (Peron and Fourtau) – Zakhera: pl. 3, fig. 9.
2002 *Tylostoma pallaryi* (Peron and Fourtau) – Zakhera: 320, fig. 2/12–14.
2004b *Tylostoma pallaryi* (Peron and Fourtau) – Abdel-Gawad et al.: pl. 5, fig. 13.
2006 *Tylostoma* (*Tylostoma*) *pallaryi* (Peron and Fourtau) – El Qot: 109, pl. 22, fig. 10.
2007 *Tylostoma* (*Tylostoma*) *pallaryi* (Peron and Fourtau) – Mekawy: 167, pl. 3, fig. 5.
2011 *Tylostoma* (*Tylostoma*) *pallaryi* (Peron and Fourtau) – Ayoub-Hannaa and Fürsich: 138, fig. 14D, E.

Material: 26 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.

Measurements: HS: 38, WS: 26, HL: 28, HA: 20, WA: 16.

Description: The present species is characterized by globular medium-sized shell, the spire is short and acute with spiral angle about 70°. The spire constitutes about one-third of shell height, the body whorl is short and about half of total height of the shell. The suture is slightly deep.

Remarks: The present species is distinguished from *Tylostoma athleticum* Greco (1916) described from the Cenomanian of the United Arab Emirates (Metwally, 1993) and Egypt (Greco, 1916) in having an inflated body whorl and a broad aperture.

The species shows some similarities to *T. globosum* (Sharpe, 1849) described from the Cenomanian of Egypt (Greco, 1916) but the later has a more globular shell. *T. cossoni* Thomas and Péron (1889), described by Greco (1916) from the Cretaceous of Egypt differs also in having a moderately high spire.

Distribution: Cenomanian of the United Arab Emirates, Cenomanian – Turonian of Egypt and Maastrichtian of Saudi Arabia.

Clade Neogastropoda Wenz, 1938
Superfamily Nerineoidea Zittel, 1873
Family Nerineidae Zittel, 1873
(=Triptyxisidae Pchelintsev, 1965 = Fibuloptygmatididae Hacobjan, 1973)
Genus *Neoptyxis* Pchelintsev, 1934
Neoptyxis olisiponensis (Sharpe, 1850)
(Fig. 5G and H)
1850 *Ptygmatis olisiponensis* sp. nov. Sharpe: 114, pl. 13, fig. 3.
1902 *Nerinea* (*Ptygmatis*) *olisiponensis* (Sharpe) – Choffat: 118, pl. 5, figs. 20–23.
1916 *Nerinea* (*Ptygmatis*) *olisiponensis* Sharpe – Greco: 145 (87), pl. 17 (9), figs. 14, 15.
1939 *Nerinea olisiponensis* Sharpe – Delpey: 196, pl. 11, figs. 1–4.
1952 *Nerinea olisiponensis* (Sharpe) – Awad: 28, pl. 1, fig. 6.
1982 *Neoptyxis olisiponensis* (Sharpe) – Accordi et al.: 776, fig. 12a.
1987 *Neoptyxis olisiponensis* (Sharpe) – Kollmann: 45, pl. 2, figs. 26, 27.
1992 *Nerinea olisiponensis* (Sharpe) – Abdel-Gawad and Gameil: 76, fig. 2/15–18; fig. 3/1–2.
1993 *Multiptyxis olisiponensis* (Sharpe) – Sirna and Mastroianni: pl. 2, fig. 3; pl. 3, fig. 1.
1995 *Multiptyxis olisiponensis* (Sharpe) – Sirna: pl. 2, fig. 1; pl. 3, fig. 1.
2006 *Nerinea olisiponensis* (Sharpe) – El Qot: 98, pl. 20, fig. 1.
2007 *Nerinea olisiponensis* (Sharpe) – Mekawy: 158, pl. 1, Figs. 9 and 10.
2011 *Neoptyxis olisiponensis* (Sharpe) – Ayoub-Hannaa and Fürsich: 144, fig. 18.

Material: 39 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.

Measurements: HS: 46, WS: 13, HL: 8, HA: 9, WA: 10.

Description: Specimens are turreted in shape with a high spire, spiral angle is acute (17°), the sutures are prominent and the whorls are flat. The aperture is small and ovate, the base is flat. The surface is ornamented with fine spiral threads.

Remarks: N. olisiponensis (Sharpe) resembles *N. requieniana* d'Orbigny, 1842 in having nearly flat whorls and shallow sutures but differs in having a larger number of whorls. Internal sections of both species shows that *N. requieniana* differs in lacking a deep sickle-shaped parietal fold with slight principal columellar fold (Ayoub-Hannaa and Fürsich, 2011).

Distribution: Cenomanian–Turonian of Portugal, Lebanon, Italy, and Egypt. Upper Cenomanian of Austria, Syria and Italy (Accordi et al., 1982).

Clade Cephalaspida Fischer, 1883.
Superfamily Philinoidea Gray, 1850
Family Cylichnidae Adams and Adams, 1854
(=Scaphandridae Sars, 1878 = Tornatinidae Fischer, 1883 = Acteocinidae Dall, 1913 = Triclidae Winckworth, 1932)
Genus *Cylichna* Lovén, 1846
Cylichna costata (Stewart, 1850)
(Fig. 6A and B)
1850 *Cypraea costata* Stewart, 32: pl. 39, fig.10.
1977 *Cypraea costacensis* Stewart – El Asa'ad: 178, pl. 17, fig. 6.
1993 *Cypraea costacensis* Stewart – Metwally: 343, pl. 3, fig. 5.

Material: 4 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.

Measurements: HS: 30, WS: 22, HL: 22, HA: 30, WA: 9.

Description: The shell is small and cypriform. The spiral angle is obtuse (105°). The body whorl overlaps all earlier whorls. The aperture is narrow and elongate with a curved outer lip.

Remarks: The specific name used by Stewart as *costacensis* does not follow the code of Zoological nomenclature as the first half of the name refers to costa which is a type of ornamentation not a place, so the suffix "ensis" should be replaced by "tata" and hence the full specific name becomes *costata*. Ayoub-Hannaa and Fürsich (2011) described some similar badly preserved steinkerns from the Upper Cenomanian of Egypt and identified them as *Cylichna*? sp. The Cypraeidae apparently have not changed much since their first appearance in the Cenomanian (Anderson, 1958).

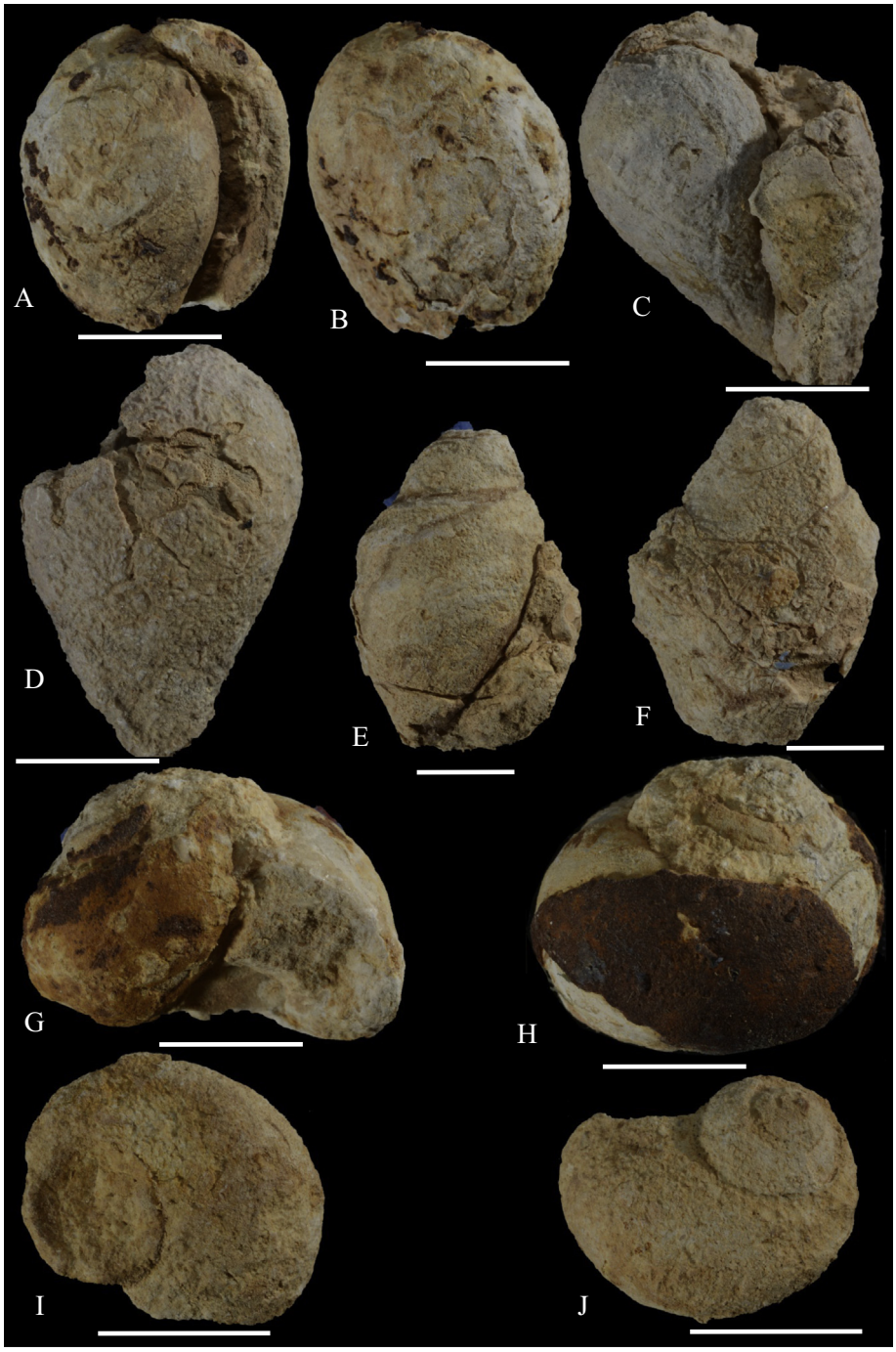

Fig. 6. (A) and (B) Apertural and abapertural views of *Cylichna costata* (Stewart). (C) and (D) Apertural and abapertural views of *Sycostoma pervinquiri* (Boelenev). (E) and (F) Apertural and abapertural views of *Rostellinda pergaensis* Boelenev. (G) and (H) Apertural and abapertural views of *Gyrodes* (*Gyrodes*) *cenomenensis* Abbass. (I) and (J) Top and abapertural views of *Otostoma* (*Otostoma*) *divaricatum* (d'Orbigny). Scale bar = 1 cm.

Distribution: Maastrichtian of the United Arab Emirates (Simsima Formation) and Saudi Arabia (Aruma Formation).

Clade Neogastropoda Wenz, 1938
Superfamily: Buccinoidea Rafinesque, 1815
Family: Melongenidae Gill, 1871
Genus *Sycostoma* Cox, 1931
Sycostoma pervinquiri (Boelenev, 1941)
(Fig. 6C and D)
1977 *Sycostoma pervinquiri* (Boelenev) – El Asa'ad: 248, pl. 18, fig. 10.
1993 *Sycostoma pervinquiri* (Boelenev) – Metwally: 346, pl. 4, fig. 4.

Material: 3 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.

Measurements: HS: 25, WS: 15, HL: 23, HA: 21, WA: 9.

Description: The shell is small and cypriform. The spiral angle is obtuse (105°). The spire is convolute and the body whorl is elongate and overlaps all earlier whorls. The aperture is narrow and elongate.

Remarks: The studied specimens agree in the morphological characters with those described by El Asa'ad (1977) and Metwally (1993).

Distribution: Cenomanian of the United Arab Emirates and Saudi Arabia.

Superfamily Muricoidea Rafinesque, 1815
Family Volutidae Rafinesque, 1815
Genus *Rostellinda* Dall, 1907
Rostellinda pergaensis Boelenev, 1941
(Fig. 6E and F)
1977 *Rostellinda pergaensis* Boelenev – El Asa'ad: 288, pl. 19, fig. 1.
1993 *Rostellinda pergaensis* Boelenev – Metwally: 347, pl. 4, fig. 6a,b.

Material: 32 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.
Measurements: HS: 36, WS: 20, HL: 22, HA: 28, WA: 7.
Description: The shell is medium and biconical. The spire is low spire consisting of two to three whorls with the body whorls occupying more than two thirds of shell height. The spiral angle is acute (45°). The suture is impressed. The aperture is narrow and elongate with a curved outer lip.
Remarks: The Saudi specimens are strongly similar to those described by Metwally, 1993 from the Maastrichtian of the United Arab Emirates but they have small dimensions compared with the large specimens of the United Arab Emirates.
Distribution: Maastrichtian of the United Arab Emirates and Saudi Arabia.

Superfamily Naticoidea Guilding, 1834
Family Naticidae Guilding, 1834
Genus *Gyrodes* Conrad, 1860
Gyrodes (*Gyrodes*) *cenomenensis* Abbass, 1963
(Fig. 6G and H)
1963 *Gyrodes* (*Gyrodes*) *cenomenensis* Abbass: 89, pl. 4, fig. 15.
1993 *Gyrodes* (*Gyrodes*) *cenomenensis* Abbass – Metwally: 344, pl. 4, fig. 1.

Material: 21 Specimens from the Hajajah Member (Aruma Formation), central Saudi Arabia.
Measurements: HS: 20, WS: 22, HL: 13, HA: 12, WA: 15.
Description: The shell is small and subglobose. The spira is low and consists of four whorls, spiral angle is obtuse (120°). The body whorl is inflated and constitutes about two thirds of shell height. The aperture is small and subround with a curved outer lip.
Remarks: The present species is common in the Cenomanian deposits of Egypt, in the gulf countries it is recorded from the Maastrichtian of both the United Arab Emirates (Metwally, 1993) and Saudi Arabia (present work).
Distribution: Cenomanian of Egypt and Maastrichtian of the United Arab Emirates and Saudi Arabia.

Superfamily Neritoidea Rafinesque, 1815
Family Neritidae Rafinesque, 1815
Genus *Otostoma* D'Archiac, 1859
Otostoma (*Otostoma*) aff. *divaricatum* (d'Orbigny, 1847)
(Fig. 6I and J)
1974 *Otostoma* (*Otostoma*) *divaricatum* (d'Orbigny) – Albanesi and Busson: 291, pl. 21, Figs. 1 and 2.
1992 *Otostoma* (*Otostoma*) *divaricatum* (d'Orbigny) – Abdel Gawad and Gameil: 72, Fig. 2: 9.

Material: One specimen from the Hajajah Member (Aruma Formation), central Saudi Arabia.
Measurements: HS: 5, WS: 22, HA: 4, WA: 4.
Description: The shell is very small, and with a low spire. The whorls are rapidly expanding, the body whorl is more than two thirds of shell size. The spiral angle is obtuse (135°), the suture is impressed. The ornamentations are very weak and may consist of fine spiral threads. The aperture is small and subrounded.
Remarks: Due to poor preservation of the studied specimens they are doubtfully attributed to *Otostoma varicatum* based on the general shape of the shell. It has a great similarity to the Egyptian specimens although the later has clearer spiral ornamenting threads.
Distribution: Maastrichtian of Algeria and Tunisia, Turonian–Maastrichtian of India and Madagascar, Cenomanian of Egypt.

4.2. Paleoecologic remarks

The lithological sequence of the Hajajah Member consists of shales and marls at the base followed by limestones. These rocks contain abundant fossils belonging to corals, stromatoporoids and mollusks (gastropods and bivalves). Gastropods in the studied area display different trophic structures, six families are herbivorous, feeding mainly on algae. These families include Trochidae, Turbinidae, Cerithiidae, Neritidae, Nerineidae and Tylostomatidae. Five families belong to predators, including Colombellinidae, Cylichnidae, Volutidae, Naticidae and Melongenidae. Two families belong to deposit feeders which are Batillariidae and Aporrhaidae. One family includes suspension feeders which is family Turritellidae (Table 1).

It is clear that herbivorous gastropods are the most common in the area and this indicates the presence of algae and/or sea grasses among their biotope (Abdel-Gawad, 1986). Okla (1995) identified a new species of dasycladacian algae from the studied section,

Table 1
Relationship between trophic modes and taxonomic levels of the identified gastropods.

Family	Trophic modes	No. of genera	No. of species	No. of specimens
Trochidae	Herbivores	1	1	20
Turbinidae	Herbivores	1	1	10
Turritellidae	Suspension feeders	1	1	30
Cerithiidae	Herbivores	1	1	35
Batillariidae	Deposit feeders	1	1	7
Aporrhaidae	Deposit feeders	1	1	18
Colombellinidae	Predators	2	1	29
Tylostomatidae	Herbivores	1	1	26
Nerineidae	Herbivores	1	1	39
Cylichnidae	Predators	1	1	4
Melongenidae	Predators	1	1	3
Volutidae	Predators	1	1	32
Naticidae	Predators	1	1	21
Neritidae	Herbivores	1	1	1

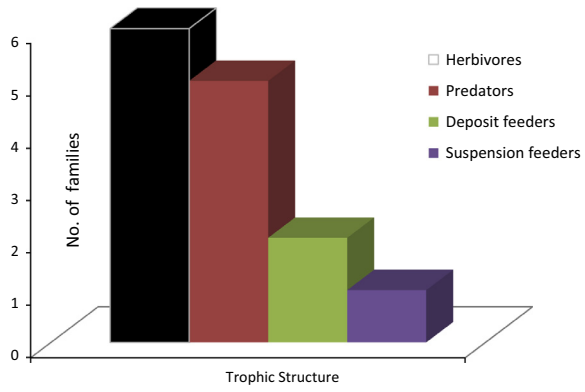

Fig. 7. Trophic modes of the identified gastropods.

named *Salpingoporella arumaensis* Okla. He interpreted this algal flora as an indication for the dominance of a shallow marine lagoonal depositional environment. Generally, the dominance of gastropods, most of them probably herbivores and deposit feeders suggests the presence of widespread algal films or plant debris, or both (Fürsich and Kirkland, 1986). Predators are also abundant like herbivores whereas suspension feeding gastropods are the least abundant (Fig. 7). The studied gastropods as well as the associated fauna of corals, bivalves (including rudists) suggest a shallow marine environment.

5. Conclusions

1. Fifteen gastropod species have been identified and illustrated from the Upper Cretaceous Hahajah Member of the Aruma Formation in central Saudi Arabia. *Calliomphalus orientalis* (Douvillé), *Coelobolma corbarica* Cossmann, *Turritella* (*Torquesia*) *figarii* Quaas, *Neoptyxis olisiponensis* (Sharpe) and *Otostoma* (*Otostoma*) *divaricatum* (d'Orbigny) are believed to be recorded for the first time from the Cretaceous rocks of central Saudi Arabia.
2. The identified species were previously recorded from the Cretaceous rocks of Oman Mountains, United Arab Emirates, Lebanon, Syria, India, Egypt, Algeria, Tunisia, Madagascar, Portugal, Italy, Austria, Spain and France.
3. The studied gastropods are dominated by herbivorous feeders and predators which together with the associated scleractinian corals, rudists, algae and stromatoporoids, suggest a shallow marine lagoonal and relatively open marine environment.

Acknowledgement

This work was funded by the Deanship of Scientific Research, College of Science Research Center, King Saud University, to whom the authors are greatly thankful.

References

Abbass, H.L., 1963. A Monograph on the Egyptian Cretaceous Gastropods. Geological Survey and Mineral Research Department, Monographs of the Geological Museum, Palaeontological Series 2, p. 146 p.
Abdel-Gawad, G.I., 1986. Maastrichtian non-cephalopod mollusks (Scaphopoda, Gastropoda and Bivalvia) of the Middle Vistula Valley, central Poland. Acta Geol. Pol. 36 (1–3), 69–224.
Abdel-Gawad, G.I., Gameil, M., 1992. Cenomanian gastropods from the Gebel Nezzazat area, west central Sinai, Egypt. Middle East Research Center, Ain Shams University, Earth Sci. Ser. 6, 69–85.
Abdel-Gawad, G.I., Orabi, O.H., Ayoub-Hannaa, W.S., 2004. Macrofauna and biostratigraphy of the Cretaceous section of Gebel El-Fallig area, northwest Sinai, Egypt. Egypt. J. Paleontol. 4, 305–333.
Aboul Ela, N.M., Abdel-Gawad, G.I., Aly, M.F., 1991. Albian fauna of Gebel Manzour, Maghara area, north Sinai, Egypt. J. Afr. Earth Sci. 13, 201–221.
Accordi, G., Carbone, F., Sirna, G., 1982. Relationships among tectonic setting, substratum and benthonic communities in the Upper Cretaceous of northeastern Matese (Molise, Italy). Geol. Romana 21, 755–793.
Albanesi, C., Busson, G., 1974. Gastéropodes du Crétacé Supérieur de l'extrême-sud tunisien et de la région du Tinrhert (Sahara Algérien). Riv. Ital. Paleontol. Stratigr. 80, 251–342.
Alth, A., 1850. Geognostisch - Palaeontologische Beschreibung der nächsten Umgebung von Lemberg. Haidingers Naturwis. Abh., 3/2:1–116.
Anderson, F.M., 1958. Upper Cretaceous of the Pacific coast. Geol. Soc. Am. Mem. 71, 1–378.
Awad, G.H., 1952. The Nerineas of Sinai (with a note on the mode of these extinct gastropods). Bull. Inst. Désert d'Egypte 2, 23–29.
Ayoub-Hannaa, W., Fürsich, F.T., 2011. Revision of Cenomanian–Turonian (Upper Cretaceous) gastropods from Egypt. Zitteliana 51, 115–152 (München).
Buitrón, B.E., 1986. Gasteropods del Cretacico (Aptiano: Tardio- Albiano Temprano) del Cerro de Tuxpan, Jalisco. Bol. Soc. Geol. Mex. 67, 17–31.
Blanckenhorn, M., 1927. Die fossilen Gastropoden und Scaphopoden der Kreide von Syrien-Palästina. Palaeontographica 69, 111–186.
Blanckenhorn, M., 1934. Die Bivalven der Kreideformation von Syrien-Palästina nebst einem ergänzenden Anhang über Brachiopoden, Gastropoden und Pteropoden und einem Überblick über die gesamte Molluskenfauna. Palaeontographica 81, 161–296.
Bouchet, P., Rocroi, J.P., 2005. Classification nomenclator of gastropod families. Malacologia 47, 1–397.
Choffat, P., 1902. Recueil d'études paléontologiques sur la faune crétacique du Portugal. Comun. Serv. geol. Portugal 1, 1–171.
Cossmann, M., 1918. Les coquilles des calcaires dOrgon. Bull. Soc. Géol. Fr. 4 (16), 336–431 (Paris).
Cox, L.R., 1960. General characteristics of gastropods. In: Moore, R.C. (Ed.), Treatise on Invertebrate Paleontology, Part I (Mollusca 1). Geological Society of America and University of Kansas Press, Boulder and Lawrence, KS, pp. I.249–I.251.
Delpey, G., 1939. Les gastéropodes mésozoiques de la région libanaise. Notes et Mem., Sect. Geol. Ht.-Comm. Syrie et Liban 3, 5–292, Paris.
de Verneuil, E. de., Lorière, G.de., 1868. Déscriptions des fossiles du Néocomien supérieur d'Utrillas et ses environs (Province de Teruel). Le Mans, Monnoyer, p. 30 p.
Dominik, W., 1985. Stratigraphie und Sedimentologie (Geochemie, Schwermineralanalyse) der Oberkreide von Bahariya und ihre Korrelation zum Dakhla-Becken (Western Desert, Ägypten). Berliner geowiss. Abh. A 62, 1–173.
Douvillé, M.H., 1916. Les terrains secondaires dans le massif du Moghara, à l'est de l'isthme de Sues, d'après les explorations de Couyat-Barthoux. Mém. Acad. Sci. Inst. Fr. 55, 1–184.
El Asa'ad, G.M.A., 1977. A Contribution to the Geology of the Aruma Formation in Central Saudi Arabia. Unpubl. Ph.D. Thesis, Mansoura University, 384 p.
El Asa'ad, G.M.A., 1983a. Lithostratigraphy of the Aruma Formation in Central Saudi Arabia. In: Proceeding of the 1st Jordanian Geological Conference, Special Publication, vol. 1, Amman, pp. 72–86.
El Asa'ad, G.M.A., 1983b. Bio- and chronostratigraphy of the Aruma Formation in Central Saudi Arabia. In: Proceeding of the 1st Jordanian Geological Conference, Special Publication, vol. 1, Amman, pp. 87–111.
El Asa'ad, G.M.A., 1984. The Paleobiogeographic distribution of the Late Cretaceous fauna of Arabia and surrounding area. Arab Gulf J. Sci. Res. 2, 105–121.
El Qot, G.M., 2006. Late Cretaceous macrofossils from Sinai, Egypt. Beringeria 36, 3–163.
Faris, M.I., Abbass, H.L., 1961. The geology of Shabraweet area. Fac. Sci. Bull. Ain Shams Univ. 6, 33–59.
Fawzi, M.A., 1963. La faune Cénomanienne d' Egypte. Geol. Surv. Egypt Monogr. 2, 1–133.
Fourtau, R., 1904. Contribution à l'étude de la faune Crétacique d'Egypte. Bull. Inst. Egypt. 4, 231–249.
Fürsich, F.T., Kirkland, J.I., 1986. Biostratinomy and Paleoecology of a Cretaceous Brackish Lagoon. Palaios 1 (6), 543–560.
Griepenkerl, O., 1889. Die Versteinerungen der senonen Kreide von Königslutter im Herzogthum Braunschweig. Paläont. Abh. 4, 1–117.
Greco, B., 1916. Fauna cretacea dell'Egitto raccolta dal Figari Bey. Parte seconda. Gasteropoda. Palaeontographica Italica. Mem. Palaeont. 22, 103–170.
Kollmann, H.A., 1985. Upper Cretaceous gastropods from excavations for the highways A10 (Charente, France). Cretac. Res. 6, 85–111.
Kollmann, H.A., 1987. Eine cenomane Gastropodenfauna aus Nea Nikopolis bei Kozani (Mazedonien, Griechenland). Ann. Naturhistor. Mus. 89, 37–56.
Kollmann, H.A., 2005. Gastropodes Crétacés. In: Fischer, J.C. (Ed.), Révision critique de la Paléontologie Française d'Alcide d'Orbigny, vol. 3. Backhuys Publishers, Leiden, pp. 1–239.
Mekkawy, M.S., 2007. Gastropods of the Cenomanian–Santonian sequence from North Eastern Desert, Egypt. Egypt. J. Geol. 51, 149–176.
Mekkawy, M.S., Abu Zied, H., 2008. Lower Cretaceous molluscan fauna from North Sinai, Maghara area, Egypt. Egypt. J. Paleontol. 8, 291–334.
Metwally, M.H., 1993. Cretaceous gastropods from the Northwestern flank of the Oman Mountains, United Arab Emirates. Bull. Fac. Sci. Zagazig Univ. 15, 333–359.
Noetling, F., 1897. Fauna of Baluchistan: The fauna of the Upper Cretaceous (Maastrichtian) beds of the Mari. Palaeontol. Indica Ser. 16 (3), 1–79.
Okla, S.M., 1991. Dasycldacean algae from Jurassic and Cretaceous of central Saudi Arabia. Micropaleontology 37, 183–190.
Okla, S.M., 1992. Further record of Jurassic and Cretaceous fossil algae from central Saudi Arabia. Rev. Paléobiol. 11, 373–383.
Okla, S.M., 1994. Fossil algae from Saudi Arabia revisited. Riv. Ital. Paleontol. S. 99, 441–460.
Okla, S.M., 1995. Late Cretaceous dasycladales from the Aruma Formation in central Saudi Arabia. Neues Jahrb. Geol. Paläontol. 8, 475–487.
Orbigny, A.De, 1842–1843. Paléontologie francaise. Déscription des mollusques et rayonnés fossiles. Terrains Crétacés. 2. Gastéropodes. Paris, Masson, pp. 5–456.
Orbigny, A.De, 1843–1847. Paléontologie francaise. Description des mollusques et rayonnés fossils de France – Terrains Crétacés. 3. Lamellibranches, Paris, 807 pp.
Peron, A., 1889. Déscription des mollusques fossiles des terrains crétacés de la région sud des Hauts-Plateaux de la Tunisie recueillis en 1885 et 1886 par Thomas, M. P. In: Exploration Scientifique de la Tunisie. Imprimerie Nationale, Paris, p. 405 pp.
Powers, R.W., 1968. Lexique stratigraphie international 3, Asie, fasc. 10bl. Centre National de la Recherche Scientifiq, Saudi Arabia, 177 pp.
Powers, R.W., Ramirez, L.F., Redmond C.D., Elberg Jr., E.L., 1966. Geology of the Arabian Peninsula, Sedimentary Geology of Saudi Arabia. Geological Survey Professional Paper, 560, 147 pp.
Quaas, A., 1902. Beitrag zur Kenntniss der Fauna der obersten Kreidebildungen in der libyschen Wüste (Overwegischichten und Blätterthon). Palaeontographica 30, 153–336.

Sánchez, B.E.B., Tinajero, Y.L., 1995. Mollusk gastropods in a Lower Cretaceous rudist-bearing formation of Jalisco, west central Mexico. Rev. Mex. Cien. Geol. 12, 157–168.
Sharpe, D., 1849. On Tylostoma, a proposed genus of gasteropodous mollusks. Quart. J. Geol. Soc. 5, 376–380.
Sharpe, D., 1850. On the secondary district of Portugal which lies on the North of the Tagus. Quart. J. Geol. Soc. 6, 135–195.
Sirna, G., 1995. The nerineids: taxonomy, stratigraphy and palaeoecology with particular references to Italian examples. Geol. Romana 31, 285–305.
Sirna, G., Mastroianni, F., 1993. Jurassic–Cretaceous nerineids of Campoli Appennino (Latium). Geol. Romana 29, 139–153.
Skelton, P.W., El Asa'ad, G.M.A., 1992. A new canaliculated rudist bivalve from the Aruma Formation of cental Saudi Arabia. Geol. Romana 27, 105–117.
Steineke, M., Bramkamp, R.A., 1952. Stratigraphic introduction. In: Arkell, W.J. (Ed.), Jurassic Ammonites from Jebel Tuwaiq, Central Arabia, vol. 236. Philosophical Transactions, the Royal Society, pp. 241–313.
Steineke, M., Bramkamp, R.A., Sanders, N.J., 1958. Stratigraphic relations of Arabian Jurassic oil. In: Weeks, L.G. (Ed.), Habitat of Oil. American Association of Petroleum Geologists, Tulsa, OK, USA, pp. 1294–1329.
Stewart, R.B., 1850. Gabb's California fossil type gastropods. Acad. Nat. Sci. Phila. Proc. 78, 287–447.
Vaslet, D., Brosse, J., Breton, J.P., Manivit, J., Le Strat, P., Fourniquet, J., Shorbaji, H., 1988. Explanatory Notes to the Geologic Map of the Shagra Quadrangle, Sheet 25 H. Ministry of Petroleum, Mineral Research, Jeddah, Kingdom of Saudi Arabia, 29 p.
Zakhera, M.S., 2001. Cenomanian–Turonian mollusks (bivalves, gastropods and ammonites) from Gebel Musabaa Salama, west central Sinai, Egypt. In: 2nd International Conference on the Geology of Africa, vol. 2, pp. 445–466.