First Record of Aptian- Cenomanian Brachiopods from the Vezk Section (South of Yasuj, Iran)

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Abstract

Brachiopod faunas from the Aptian- Cenomanian Vezk section in southwestern Iran comprise ten species in six genera, namely *Sellithyris cenomanensis*, *Sellithyris tornacensis*, *Sellithyris phaseolina*, *Phaseolina phaseolina*, *Tropeothyris* sp., *Concinnithyris subundata*, *Kingena arenosa*, *Cyclothyris difformis*, *Cyclothyris* sp. and *Cyclothyris compressa*. All species are recorded for the first time from the lower Cretaceous of Vezk section (South of Yasuj). These deposits are composed of an alternation of green marls and thin layers of yellow shaly or sandy limestone, which overlain by thick bedded black limestone. The thickness of these deposits are 74 meters, which covers the Jurassic sediments, while its upper boundary ends with erosion surface that covered by Neogene deposits. These deposits consist of different fossil groups such as brachiopods, echinoids, corals, gastropods and orbitolinids that confirm the Aptian-Cenomanian ages for these sediments. The fauna assemblages suggest at shallow and suitable environment prevailed during the deposition of the strata.

Keywords: Brachiopods; Aptian; Cenomanian; Yasuj; Iran.

Introduction

Brachiopods are marine organisms which have two shells or valves of different sizes, shape and ornamentation. Brachiopods are benthic organisms, their distribution depends on bathymetry, light, intensity of currents, distance from the shoreline, and the nature of suitable substrates [9]. Brachiopods are marine animals, living on or near the sea bed. Some brachiopods live in burrows but most are attached to rocks or the ocean floor by the pedicle which they use to adjust their position. Other brachiopod species developed spines to stabilise themselves in mud [7]. Brachiopod shell is an organo-mineral structure, mainly comprising low magnesium calcite enclosing a small amount of organic matrix [8]. Brachiopods, also known as 'lamp shells', are marine metazoans that elaborate a bivalved shell, similar to the molluscs of the class Bivalvia [12]. They are adapted to mesoeutrophic environments in shallow- to deep-water settings and occur in heterotrophic, sciophilous assemblages [11]. Brachiopods have a low metabolic rate, low nutrient demands [1] and are able to assimilate dissolved substances during times of low influx of particulate food [14]. Brachiopod dominance may be enhanced by reduced oxygen levels and a low nutrient supply [14]. Although brachiopods are among the most conspicuous and diverse constituents of marine invertebrate faunal elements of the Aptian-Cenomanian sediments in Vezk section, very few

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studies have been published on this subject (May be no study). Arab et al. (2015) reported five species of the Late Albian- Early Cenomanian brachiopods from Baghin region, west of Kerman. Foladi & Dastanpour (2015) reported ten species of the Middle Cretaceous brachiopods from Estakhrooyeh region. The brachiopods fauna of Vezk section comprises Sellithyris cenomanensis, Sellithyris tornacensis, Sellithyris phaseolina, Phaseolina phaseolina,

Tropeothyris sp., Concinnithyris subundata, Kingena arenosa, Cyclothyris difformis, Cyclothyris sp. and Cyclothyris compressa. The brachiopods generally confirm the Albian– Cenomanian age suggested by the other fossils, associated with these brachiopods, such as foraminifers. The present paper continues this work and deals with assemblages from the Albian-Cenomanian Yasuj strata, as exposed near the village of Vezk (southwest of Iran; Fig. 1).



Figure 1. Location map and studied sections of the Albian– Cenomanian strata in Southwestern Iran.

Geological Setting and Stratigraphy

The brachiopods described here have been collected from Albian– Cenomanian strata that crop out at Vezk section, southwest of Yasuj, Iran (Fig. 1). This section is situated about 17 km south of Yasuj city (N 30°32'53", E 51°38'43"). The Albian– Cenomanian sediments of Vezk section consist mainly of an alternation of green marls and thin layers of yellow shaly or sandy limestone (Fig. 2) which overlain by thick bedded black limestone, with an abundant benthic foraminifera (*Orbitolina*), echinoids, bivalves, gastropods and corals, most of which confirm an Albian– Cenomanian age for the sediments. The thickness of these deposits are 74 meters, which covers



Figure 2. Schematic lithological succession of Albian- Cenomanian strata in Vezk section.

the Jurassic sediments, while its upper boundary ends with erosion surface that covered by Neogene deposits. The Vezk section is a part of the Zagros sedimentary basin which is located in southwestern Yasuj city. The Cretaceous sediments are well-exposed in the studied area.

Materials and Methods

The present material was collected by T. Binazadeh during different field work in Vezk locality. To study the brachiopod fauna of Vezk section, 104 specimens of brachiopods has been collected from marls and thin layers of yellow shaly limestone of this section which belonging to two taxonomical classes were included in this study. About half of the specimens were crushed, distorted, imperfect, or weathered. Well preserved specimens were cleaned, using a mild detergent and whenever necessary by using an ultrasonic vibrator and a preparation needle.

Systematic paleontology

In total, 104 brachiopod specimens have been collected from this section. This biostratigraphic research resulted in to examine 6 genera 10 species of brachiopoda for the first time from this section.

Class Articulata Huxley, 1869

Order **Terebratulida** Waagen, 1883 Suborder **Terebratulidina** Waagen, 1883 Superfamily **Terebratuloidea** Gray, 1840 Family **Sellithyrididae** Muir-Wood, 1965 Subfamily **Sellithyridinae** Muir-Wood, 1965 Genus *Sellithyris* Middlemiss, 1959

Type species: *Terebratula sella* J. de C. Sowerby, 1823

Sellithyris cenomanensis (Gaspard, 1997) (Pl. 2, figs. D- F)

1997 Sellithyris cenomanensis (Gaspard); Gaspard pl. 1, fig. 9

2010 Sellithyris cenomanensis (Gaspard); Arab; Pl. 17, figs. A-J

Material: Nineteen complete specimens and eight five incomplete specimens were recovered.

Description: This species was previously identified by Gaspard (1988) and has been described later by Arab (2010- Pl. 17, figs. A-J). The shell is medium to large in size and pentagonal, biconvex, both valves are equally convex or pedicle valve more convex, with a round, medium to large and circular and mesothyridid foramen. The shell surface is smooth. Lateral margins are inclined antero-ventrally, the surface is marked by major growth lines, and the anterior margin is biplicate.The maximum width and thickness of the shell is to the middle of shell. The lateral commissure is ventrally curved. The beak is suberect. The beak ridges are distinct. The anterior commissure is uniplicate to sulciplicate.

Remarks: The recovered species are similar to those described by Arab (2010). This species differs from other *Sellithyris* species by its pentagonal outline, medium to large in sized, equal convex valves or pedicle valve more convex and suberect foramen. The species described by Arab (2010), have a pentagonalto subcircular outline, permesothyridid foramen in adult, my specimens are pentagonal to subcircular in outline and having mesothyridid foramen.

Age and distribution: This species occurs in the Albian? –lower Cenomanian sediments of Baghinand Basab regions, Kerman, Iran (Arab, 2010). This species is recovered from lower cenomanian sediment of Vezk section, Yasuj, Iran.

Sellithyris tornacensis (diArchiac, 1847)

(Pl. 2, figs. J- L)

1988 Sellithyris tornacensis (diArchiac): Owen, p. 104, pl. 6, figs 1-3

1997 Sellithyris tornacensis (diArchiac, 1847): Gaspard, pl. 2, fig. 1

2010 Sellithyris tornacensis (diArchiac, 1847): Arab, Pl. 16, figs. A-O

Material: Eleven complete specimens and four incomplete specimens were recovered.

Description: This species was previously identified by Owen (1988- p. 104, pl. 6, figs 1-3), Gaspard (1997pl. 2, fig. 1), and has been described later by Arab (2010- Pl. 16, figs. A-O). Shell is medium to large in size, biconvex and pedicle valve more convex and Pentagonal to oval in outline. The maximum width and thickness are situated at about mid length. The beak is is suberect. Foramen medium, circular and permesothyridid. The beak ridges are poorly developed. The lateral commissure ventrally curved. The Shell surface is smooth. The anterior commissure is uniplicate to sulciplicate.

Remarks: This is a distinctive species. The outline and beak characters of this section species are approximately similar to those from Baghin and Basab, which are described by Arab (2010). The species described by Arab (2010), have a pentagonal to elongate- oval outline, large size, large foramen and erect to suberect beak, my specimens are pentagonal to oval in outline, medium to large in size, medium foramen and having suberect beak.

Age and distribution: This species described from lower Cenomanian in Britain and northen Europe [18] and also, occurs in the Baghin and Basab regions (Albian? – lower Cenomanian). In the Vezk section, this species determine the lower Cenomanian age for the sediments.

Sellithyris phaseolina (Valenciennes in Lamarck, 1819)

(Pl. 2, figs. G- I)

1988 *Sellithyris phaseolina* (Valenciennes in Lamarck); Owen, pl. 6, figs 7-9

2010 Sellithyris phaseolina (Lamarck, 1819); Arab,

Pl. 18, figs. A-L

Material: Four complete specimens of various sizes and seven incomplete specimens are found.

Description: This species was previously identified by Owen (1988– pl. 6, figs 7-9), Gaspard (1997- p. 149, pl. 1, fig. 5) and has been described later by Arab (2010- Pl. 18, figs. A-L). Shell medium-sized to large. The outline is subcircular to oval. The shell is biconvex, both valves are more or less equally



Plate 1 Fig. A- C: Concinnithyris subundata Fig. D- F: Cyclothyris compressa Fig. G- I: Cyclothyris difformis Fig. J- L: Cyclothyris sp. Fig. M- O: Kingena arenosa

biconvex or pedicle valve more convex. The maximum thickness is at about mid-length. Lateral commissure is ventrally curved. The beak is erect to suberect. Foramen large, circular and mesothyridid. Beak ridges are poorly developed. Shell surface is smooth. Anterior commissure is usually uniplicate to sulciplicate. **Remarks:** The species illustrated by Owen (1988) are smaller than my specimens. The species described by Arab (2010) has a subpentagonal, subcircular to oval outline, both valve subequivalve and equally biconvex. The species described by Arab (2010) have a variable shapes in outline, medium to large and



Plate 2 Fig. A- C: Phaseolina phaseolina Fig. D- F: Sellithyris cenomanensis Fig. G- I: Sellithyris phaseolina Fig. J- L: Sellithyris tornacensis Fig. M, N: Trepeothyris sp.

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permesothyridid foramen and suberec beak, my specimens are subcircular to oval in outline, large and mesothyridid foramen and erect to suberect beak.

Age and distribution: This species occurs in the Albian?– lower Cenomanian age for the sediments of Baghin and Basab regions [2]. In the Vezk section, this species determine the lower Cenomanian age for the sediments.

Genus *Phaseolina* Gaspard, 1988

Phaseolina phaseolina (Lamarck, 1819)

(Pl. 2, figs. A- C)

1988. *Phaseolina phaseolina* (Lamarck) – Gaspard, p. 163, pl. 18. Fig. 9

2006. *Phaseolina phaseolina* (Lamarck) – Lee & Smirnova in Kaesler, H. 2065, fig. 1364(4a–d)

Material and occurrence: Two complete specimens and six incomplete specimens are found.

Description: The shell is Medium to large sized, biconvex and subcircular to oval in outline. Beak is suberect. The ventral beak is variably curved, influencing the foramen shape. The foramen is medium-sized to large mesothyrid, and small deltidium. There is a sulciplicate anterior commissure. The shell is smooth with fine radial capillae near the margins. Dorsal valve with a small bilobate cardinal process, a short and narrow loop.

Remark: In this species, the lateral margins are slightly inclined and the anterior margin less deeply biplicate than in *S. cenomanensis*. The species described by Gaspard (2014), have a medium size, pentagonal to subcircular outline, meso- to permesothyrid and large foramen, my specimens are Medium to large sized, subcircular to oval in outline and having mesothyridid, medium foramen.

Age and distribution: Gaspard (2014) has recorded this species from Cenomanian under the name *phaseolina phaseolina* (Lamarck). This species is recovered from upper cenomanian sediments of Vezk section, Yasuj, Iran.

Genus Tropeothyris Smirnova, 1972

Type species: Trepeothyris kugusemi Smirnova, 1972

Tropeothyris sp.

(Pl. 2, figs. M- N)

Material: Three complete specimens and five nearly complete specimens were recovered.

Description: The shell is medium-sized and subcircular to oval in outline. The shell is biconvex, ventral valve more convex and dorsal valve gently convex. The maximum width and thickness is situated at mid-length. The lateral commissure is straight

toward pedicle valve. The beak is suberect. Pedicle foramen is medium, circular and permesothyridid. Beak ridges are poorly developed. Shell surface is smooth. Anterior commissure is uniplicate.

Remarks: The specimens are very similar to those figured by Arab (2010). *Tropeothyris vectis* is pentagonal to broadly oval in outline, beak suberect, foramen large and a shallow sulcus starts at about midlength. *Tropeothyris* sp. is large-sized and subcircular to oval in outline, beak issuberect, foramen is medium, circular, permesothyridid and the anterior commissure is uniplicate. Both species are ventri-biconvex and the dorsal valve gently curved.

Age and distribution: This species recovered from Albian? – lower Cenomanian of Baghin and Basab sediments of Kerman, Iran.In the Vezk section, this species determine the upper Albian? age for the sediments.

Family **Gibbithyrididae** Muir-Wood, 1965 Subfamily **Gibbithyridinae** Muir-Wood, 1965 Genus *Concinnithyris* Sahni, 1929

Type species: *Terebratulaobesa* J. de C. Sowerby 1823

Concinnithyris subundata (J. Sowerby, 1813)

(Pl. 1, figs. A- C)

1988 *Concinnithyris subundata* (J. Sowerby); Owen, p. 132, pl. 6, figs 16- 18; pl. 15, figs 1- 18; pl. 16, figs 1- 15

1997 Concinnithyris subundata (J. Sowerby, 1813); Gaspard, p. 150, pl. 1, fig. 19

2005 *Concinnithyris subundata* (J. Sowerby, 1813); Bitner & Motchurova-Dekova, p. 527, figs 3 A- H, 4, 5

2010 Concinnithyris subundata (J. Sowerby, 1813); Arab, Pl. 21, figs A- L

Material: Seven complete and two incomplete specimens were recovered.

Description. This species was previously identified by Owen (1988- pl. 6, figs 7-9), Gaspard (1997- p. 150, pl. 1, fig. 19), Bitner & Motchurova- Dekova (2005, p. 527, figs 3 A-H, 4, 5) and has been described later by Arab (2010- Pl. 21, figs A-L). Medium-sized ventri-biconvex. Outline variable, shell. from subcircular to subpentagonal. Maximum width at about mid-length; maximum thickness in posterior third. Beak ridges short, rounded, distinct only posteriorly. Umbo suberect to incurved with an epithyrid, subcircular foramen of large size. Symphytium not exposed. Anterior commissure rectimarginate to slightly uniplicate. Shell surface is smooth.

Remarks. In outline and umbonal characters, the Bulgarian material matches well that assigned to *Concinnithyris subundata* by Owen (1988).This species differs from *Concinnithyris obesa*, by its

uniplicate anterior commissure, less biconvexity of the shell and subpentagonal, elongated oval to subcircular in outline. The outline and beak characters of this section species are similar to those from Baghin and Basab, which are described by Arab (2010).

Occurrence

This species described from the Cenomanian of Great England and France (Gaspard, 1997) and also, occurs in the Albian?– lower Cenomanian Baghin and Basab regions (Arab, 2010).In the Vezk section, this species determine the lower Cenomanian age for the sediments.

Superfamily Kingenoidae Elliott, 1948 Family Kingenidae Elliott, 1948 Subfamily Kingeninae Elliott, 1948 Genus *Kingena* Davidson, 1852 *Kingena arenosa* (d'Archiac, 1846)

(Pl. 1, figs. M- O)

1970 Kingena arenosa (d'Archiac) – Owen, p. 55, pl. 4, figs. 1–7

1972 *Kingena arenosa* (d'Archiac) – Popiel-Barczyk, p. 121, pl. 2, figs. 1–3; fig. 1a–c

Material: Three complete and two incomplete specimens are found.

Description: This species was previously identified by Owen (1970- p. 55, pl. 4, figs. 1–7). The shell is large sized, biconvex and triangular-pentagonal in outline. The maximum thickness of the shell are situated at the middle of the length. The short suberect umbo is truncated by the medium circular foramen. The anterior margin is rectimarginate to sulcate or faintly uniplicate. The surface is granular, even "finely spiky" in some shells, ornamented with numerous small nodules. The shell has straight lateral margins and a rectimarginate to faintly uniplicate anterior margin. Distinct growth lines mark the anterior half of the shell.

Remarks: The recovered species are similar to those described by Gaspard (2014). The species described by Gaspard (2014), have a Medium to large size, oval-pentagonal outline and large circular foramen, my specimens are large- sized, triangular-Pentagonal in outline and medium foramen

Age and distribution: This species occurs in the middle Cenomanian sediments of the North Germany [17]. This species is recovered from lower Cenomanian sediment of Vezk section, Yasuj, Iran.

Order **Rhynchonellida** Kuhn, 1949

Superfamily **Hemithiridoidea** Rzhonsnitskaya, 1956

Family Cyclothyrididae Makridin, 1955

Subfamily **Cyclothyridinae** Makridin, 1955 Genus **Cyclothyris** MCoy, 1844

Type species: *Terebratulala tissima* J. de C. Sowerby, 1840

Cyclothyris difformis (Valenciennes in Lamarck, 1819)

(Pl. 1, figs. G- I)

1988 Cyclothyris difformis (Valenciennes in Lamarck); Owen, p. 84, pl. 1, figs 13- 15, pl. 2, figs 4-6, figs 10- 15

1997 Cyclothyris difformis (Valenciennes in Lamarck); Gaspard, p. 146, pl. 1, fig. 15

2010 Cyclothyris difformis (Valenciennes in Lamarck); Arab, Pl. 23, figs. A- O

Material: Four complete specimens and seven crashed specimens were recovered.

Description: This species was previously identified by Owen (1988- p. 84, pl. 1, figs 13-15, pl. 2, figs 4-6, figs 10-15), Gaspard (1997-p. 146, pl.1, fig. 15), and has been described later by Arab (2010- Pl. 23, figs. A-O).Shell large-sized, Pentagonal to oval in outline and moderately to strongly biconvex, both valves equally convex. The maximum thickness of the shell are situated at the middle of the length and the maximum width is nearly to the anterior margin at the middle of the length. The lateral commissure of most specimens apparently straight and in some specimens is slightly curved toward the pedicle valve (bent). The ventral valve may not show any folding. The beak is straight to suberect. The foramen is large, circular and hypothyridid. The beak ridges are distinct and sharp. The shell surface is ornaments with 20-25 costae on either valve and growth lines are invisible. The anterior commissure is asymmetrical.

Remarks: The recovered species are similar to those described by Arab (2010). *Cyclothyris difformis* obtained from Baghin, Iran [2] and in this section confirms considerable variability than other regions the species were known *Cyclothyris difformis* has different number of ribs on either valve in different area. The species illustrated by Owen (1988) has slightly incurved beak, well-marked uniplicate anterior commissure and about 40-45 costae on either valve. The species described by Arab (2010), have a medium to large-sized, variable outline and medium to large foramen, my specimens are large-sized, Pentagonal to oval in outline and large foramen.

Age and distribution: This species occurs in the Lower Chalk (Cenomanian) from the Glauconitic Marls of Compton Bay (Isle of Wight) the Snowdon Hill, Chard, Somerset, England [18]. It has also recovered from Albian? - lower Cenomanian of the Baghin and Basab regions in Iran. This species show a lower Cenomanian age in Vezk section, Yasuj, Iran.

Cyclothyris compressa (Valenciennes in Lamarck, 1819)

(Pl. 1, figs. D- F)

1988. Cyclothyris compressa (Valenciennes in Lamarck); Owen, p. 86, pl. 3, figs 16-21

1997 Cyclothyris compressa (Lamarck, 1819); Gaspard, p. 147, pl.1, fig. 11

2010 Cyclothyris compressa (Lamarck, 1819); Arab, Pl. 24, figs. D- I

Material: Three complete specimens and two crashed specimens were recovered.

Description: Large Cyclothyris. The shell is subtriangular in outline and biconvex, brachial valve is more convex and pedicle valve is convex only in its posterior part. The maximum width and thickness are situated in the mid of the length. The lateral commissure is straight. There is no fold on the brachial valve and the shallow sulcus is developing nearly on the pedicle valve. The beak is short, slender and slightly suberect. Beak ridges are sharply defined, leaving a flattened space between them and the hinge The foramen is medium, circular line. and hypothyridid. The ornaments of the shells are about 22-26 costae on the either valve and the growth lines are invisible. The anterior commissure is asymmetrical.

Remarks: Gaspard (2014) illustrated that the species has been sometimes misidentified, it's represents have a winged shell, somewhat flat and transverse, ornamented by 32 to 38 strong angular costae and the beak is suberect. Arab (2010) described that the shell of *Cyclothyris compressa* (Baghain & Basab) is subtriangular to subpentagonal in outline, the valve ornaments by about 24- 26 costae and the beak is suberect to erect.

Age and distribution: This species also occurs in the lower to middle Cenomanian sediments of the Dobrevacuka locality near Beloslav in Bulgaria [4] and from Albian? – lower Cenomanian sediments of Baghin region, Iran [2]. This species is recovered from cenomanian sediment of Vezk section, Yasuj, Iran.

Cyclothyris sp.

(Pl. 1, figs. J-L)

Material. Five crushed specimens.

Description: Small to medium-sized, oval to subpentagonal *Cyclothyris*, with 45 relatively sharp ribs on each valve. The shell is transversely oval in outline. The shell is gently biconvex, brachial valve is more convex. There is not folding on the brachial valve and the sulcus is poorly developed on the pedicle

valve. The beak is straight. The Beak- ridges are distinct. Deltidial plates, visible in a single specimen, form wing-like extension around small to mediumsized foramen. The foramen is circular and hypothyridid. The lateral commissure is straight to curve toward the pedicle valve. Anterior commissure is asymmetrical.

Remarks: The ornament suggests some similarity to members of the group of *Cyclothyris latissima*. This species differs from other *Cyclothyris* species by having transversely oval to subpentagonal outline, gently biconvex shell, straight beak, and about 45 costellae on either valve. The Baghin specimens [2] are similar to my species by their outline, the size and the gently convexity of the valves, but number of ribs of Baghin species are smaller than ones Vezk (Yasuj, Iran) species.

Age and distribution: This species recovered from Albian?– lower Cenomanian sediments of Baghin and Basab regions, Kerman, Iran, from Late Jurassic- Early Cretaceous sediments of Spitsbergen [15]. In the Vezk section, this species determine the Aptian age for the sediments.

Results

The Albian- Cenomanian brachiopod fauna from the Vezk section (Yasuj, southwestern Iran) comprises four families, members of of which the Cyclothyrididae and Sellithyrididae constitutes the main group. All taxa, with the exception of Cyclothyris, are here recorded for the first time from Bulgaria, although all have been described previously from western and central Europe. The Cenomanian transgression, documented from across the globe, provided relatively stable, shallow-water conditions and low facies diversity [13], which explains why the taxonomic composition of brachiopod faunas is closely similar. Brachiopods are facies sensitive and their distribution is controlled by facies change. Rhynchonelloids are rare or absent in marly facies, while terebratuloids prefer marly sediments, of which the present paper provides another example [4]. The Early Cenomanian was a period during which numerous species originated; among these are such taxa as Concinnithyris subundata and Kingena arenosa described herein. The abundance of C. compressa indicates the basal upper Cenomanian, while the association of Ph. phaseolina is indicative of the upper Cenomanian. Brachiopods (and other fossils such as echinoids, corals and orbitolinids) indisate the Aptian-Cenomanian ages for these sediments. The fauna assemblages suggest at shallow and suitable environment prevailed during the deposition of the strata.

Discussion

Brachiopods are mainly of Boreal and/or Tethyan origin, with some being cosmopolitan [9]. A biochronological scheme for brachiopods does not yet exist. However, as a result of their palaeogeographical distribution, some brachiopod species or associations are potentially reliable markers in some neritic facies [9]. S. cenomanensis, because of their abundance, are good markers in the detrital facies of the middle Cenomanian while K. arenosa is present in more limestone facies. Similarly, C. compressa indicates the basal upper Cenomanian, while Ph. Phaseolina -with its abundance and wide distribution- indicates the Cenomanian. The lower Cenomanian upper lithostratigraphical units appear less fossiliferous than those of the middle and upper Cenomanian. Brachiopods also provide data on palaeoenvironmental conditions and ecosystem evolution by their adaptability to changes within the environment [9].

The large costate rhynchonellids (C. compressa) indicate agitated waters, even in deltaic conditions (C. compressa), with coarse detrital sediments. The association with corals, echinoids and orbitolinids, indicate a shallow marine even littoral environment. Rhynchonellid brachiopods (genus Cyclothyris) are reported from the Late Aptian- Early Cenomanian time interval deposits in Kerman region [2 & 5]. This genus has previously been reported from the other parts of the world (e.g. Europe). The identified rhynchonellids are found in the shaly limestone layers and they indicate a shallow environment and suitable conditions during the deposition of these strata. According to Owen (1962), various species of Cyclothyris begin with the appearance of Cyclothyris antidicotoma (Sowerby), Cyclothyris latissima (Sowerby) and Cyclothyris depressa (Sowerby) in late Aptian and terminated with Cyclothyris compressa (Valenciennes in Lamarck) in late Cenomanian. The bulk of the brachiopods fauna belongs to the order Terebratulida (80 %), with only few representive of the Rhynchonellida (20 %). The relative abundances at the family are: Sellithyrididae (66%), Gibbithyrididae (9%), Kingenidae (5%) and Cyclothyrididae (20%). The Sellithyris genus alone accounts for about 77% of the Sellithyrididae family.

References

- Abdelhady A. and Fürsich F. Macroinvertebrate palaeo communities from the Jurassic succession of Gebel Maghara (Sinai, Egypt). J. Afr. Earth .Sci, 97: 173–193 (2014).
- 2. Arab A. Systematic paleontology, Paleoecology and

Chemostratigraphy of Mid– Cretaceous Marls in West and North-west of Kerman. Ph.D. thesis, University of Shahid Bahonar, 362 pp. (2010).

- Arab A., Vaziri M.R. and Soheili S. Introducing of Rhynchonellid brachiopods (genus *Cyclothyris* and some its species) from Late Aptian-Early Cenomanian sediments of Baghin area (west of Kerman, Iran). *Paleontology*, 2 (2): 244- 258 (2015).
- Bitner M.A. and Motchurova Dekova N. Brachiopods from the Sanadinovo Formation (lower Cenomanian) in northern Bulgaria: *Cretaceous Res.*, 26: 525-539 (2005).
- Foladi F., and Dastanpour M. Systematic and Paleoecology of middle- Cretaceous Brachiopods of Family Sellithyrididae from Estakhrooyeh Section, West of Kerman. *Geoscinces*, 24: 73- 80 (2015).
- 6. Gaspard D. Sellithyridinae Terebratulidae du Cretace d'Europe occidentale. Dynamique des populations, systematique et evolution. Cahiers de Paleontologie. *CNRS*, *Paris*, 242 pp. (1988a).
- 7. Gaspard D. Distribution and recognition of phases in the AptianeTuronian (Cretaceous) brachiopod development in NW Europe. *Geol. Carpatica*, **48**: 145-161 (1997).
- Gaspard D. Microstructure de Tere bratules biplissees (Brachiopodes) du Cenomanien de la Sarthe (France). Affinite des formes avec le genre Sellithyris middlemiss. *Ann. Paleontol.*, (Invertebres), 68: 1–143 pls. (1982a).
- 9. Gaspard D. Noteworthy brachiopods of the Cenomanian stratotype: A synthesis of the biochronological, palaeoenvironmental and palaeoecological implications. *Geobios*, **47**: 347–370 (2014).
- Gaspard D. Types de brachidium chez des brachiopodes (craniiformes et rhynchonelliformes) du Crétacé– structures équivalentes à l'Holocène. *Fossiles, hors-serie.* 5: 55-70 (2015).
- Graziano R. and Taddei Ruggiero E. Cenomanian (Cretaceous) Brachiopod-Rich Facies of the Carbonate Platform-to-Basin Transition in the Matese Mountains (Central-Southern Italy): Stratigraphic and Paleoenvironmental Meaning. *GRA*, 9: 59-72 (2007).
- Immel F., Gaspard D., Marie A., Guichard N., Cusack M. and Marin F. Shell proteome of Rhynchonelliform brachiopods. J. Struct. Biol., 190: 360–366 (2015).
- Lee D.E., Smirnova T.N. and Sun D.L. Cancellothyridoidea. In: R.L. Kaesler (ed.), Treatise on Invertebrate Paleontology. Part H. Brachiopoda revised. *Geol. Soc. America & Univ. Kansas*, 5: 2145–2162 (2006).
- 14. Matyszkiewicz J., Krajewski M., Kochman A., Kozłowski A. and Dulinski M. Oxfordian neptunian dykes with brachiopods from the southern part of the Kraków-Cze_stochowa Upland (southern Poland) and their links to hydrothermal vents. *Facies*, **62** (2):1- 28 (2016).
- Sandy M.R., Hryniewicz K., Hammer O., Nakrem H.A. and Little C.T.S. Brachiopods from Late Jurassic- Early Cretaceous hydrocarbon seep deposits, central Spitsbergen, Svalbard. *Zootaxa*, 6: 501–532 (2014).
- Owen E.F. The brachiopod genus *Cyclothyris*. Bulletin of the British Museum (Natural History), *Geol.*, 7: 37-63 (1962).
- 17. Owen E.F. Cenomanian brachiopods from the Lower

Chalk of Britain and northern Europe. Bulletin of the British Museum (Natural History), *Geol.*, **44**: 65-175 (1988).

 Owen E.F. A revision of the brachiopod subfamily Kingeninae Elliott. Bulletin of the British Museum (Natural History). *Geol.*, 19: (2), 29–83 (1970).