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Tournaisian (Mississippian) brachiopods from the Mobarak Formation, North Iran

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ABSTRACT

Following detailed stratigraphic work on the Mississippian marlstone and bioclastic limestone of the Mobarak Formation of the Alborz Mountains in North Iran, forty-eight of the most important brachiopod taxa are here systematically described and illustrated. The ranges of the taxa are given along the Abrendan and Simeh Kuh stratigraphic sections, located north of Damgham. The examined brachiopod species date the base of the Mobarak Formation to the Tournaisian, in absence of age-diagnostic foraminifers. Change in brachiopod settling preferences indicates a shift from high energy, shallow-water settings with high nutrient supply in the lower part of the formation to quieter, soft, but not soppy substrates, with lower nutrient supply in the middle part of the Mobarak Formation. Brachiopod occurrence is instead scanty at its top. The palaeobiogeographic affinity of the Tournaisian brachiopods from North Iran indicates a closer relationship to North America, Western Europe and the Russian Platform than to cold-water Australian faunas, confirming the affinity of the other biota of the Alborz Mountains. This can be explained by the occurrence of warm surface-current gyres widely distributing brachiopod larvae across the Palaeotethys Ocean, where North Iran as other peri-Gondwanan blocks acted as staging-posts.

INTRODUCTION

The Mississippian Mobarak Formation of the Alborz Mountains (North Iran) has been recently revised by Brenckle et al. (2009) who focused mainly on its calcareous microfossil biota and refined its biostratigraphy, chronostratigraphy and paleogeography. The authors showed that the top of the Mobarak Formation is Tournaisian in the southeastern Alborz and becomes progressively younger towards northwest, due to a regional upper Pennsylvanian unconformity. However, the age of the base of the Mobarak Formation lacks age-diagnostic foraminers and has been assigned to the Tournaisian by Brenckle at al. (2009) based on the brachiopod assemblages which are now described in the present paper.

Macrofossils from the Mobarak Formation have been described mainly in the sixties (Gaetani, 1968; Ahmadzadeh Heravi, 1971; Stepanov, 1971; see also review in Vachard, 1996). For the brachiopods however, the collections were never so rich as the ones now available from the Abrendan and Simeh Kuh measured sections (eastern Alborz) (Figure 1).

The aim of this paper is to systematically describe the rich brachiopod fauna of the Mobarak Formation bed-by-bed collected along the Abrendan and Simeh Kuh sections and to discuss their biostratigraphic and palaeobiogeographic implications.

GEOLOGICAL SETTING

The brachiopods described in the present paper have been collected in the Mississippian Mobarak Formation, a mixed carbonate-siliciclastic marine unit that crops out along the flanks of the east-west trending Alborz Mountains of North Iran (Figure 1). The present Alborz Mountain Chain has developed in recent times on a Late Triassic collisional orogen (Zanchi et al., 2009a); during Late Palaeozoic it formed the North Iran block, whose boundary with Central Iran is located south of the southern foothills of the Alborz belt and is represented by minor facies changes in the Palaeozoic to Triassic successions (Zanchi et al., 2009b).

The Mobarak Formation has been established by Assereto in 1963. However, in the definition recently suggested by Gaetani et al. (2009) and Brenckle et al. (2009) it includes not only the Tournaisian and Visean rocks that Assereto (1963, 1966) placed in the Mobarak Formation, but also the marly limestones and bioclastic limestones previously referred to as the Geirud Formation. The lithology of the revised Mobarak Formation comprises marlstone, bioclastic packstone, wackestone and mustone with subordinate siltstone and arenite, capped by ooidal packstone and grainstone in the northwestern Alborz Mountains.

Brenckle et al. (2009) have shown that age-diagnostic foraminifers at Abrendan, mostly from the upper part of the Morabak Formation, are late Tournaisian in age. The occurrence of the brachiopod species *Tomiproductus elegantulus*, *Marginatia vaughani*, *Hemiplethorhynchus crassus*, *Rossirhynchus adamantinus*, *Cleiothyridina kusbassica*, *Composita megala*, and *Syringothyris skinderi* and the genera *Tolmatchoffia*, *Gerankalasiella*, *Atylephorus*, *Iniathyris*, and *Kisilia*, confirms a Tournaisian age also for the lower part of the Mobarak Formation, which contains only sparse calcareous microfossils. According to Brenckle et al. (2009), the top of the Mobarak Formation is early Visean in the northwest Alborz Mountains and it becomes increasingly older towards the southeast. This was caused by exposure and erosion in the south during the Pennsylvanian, followed by a latest Pennsylvanian – Early Permian transgression from the north.

The brachiopods here described have been collected by Maurizio Gaetani and Lucia Angiolini along the Abrendan section (coord. 36°21'47.6" N - 54°18'59.9" E, WGS84), and by Babak Aghababalou along the Simeh Kuh section (coord. 36°12'26.96" N - 54°13' 6.43" E, WGS84), which are located in eastern Alborz near the town of Damghan (Figures 1–3).

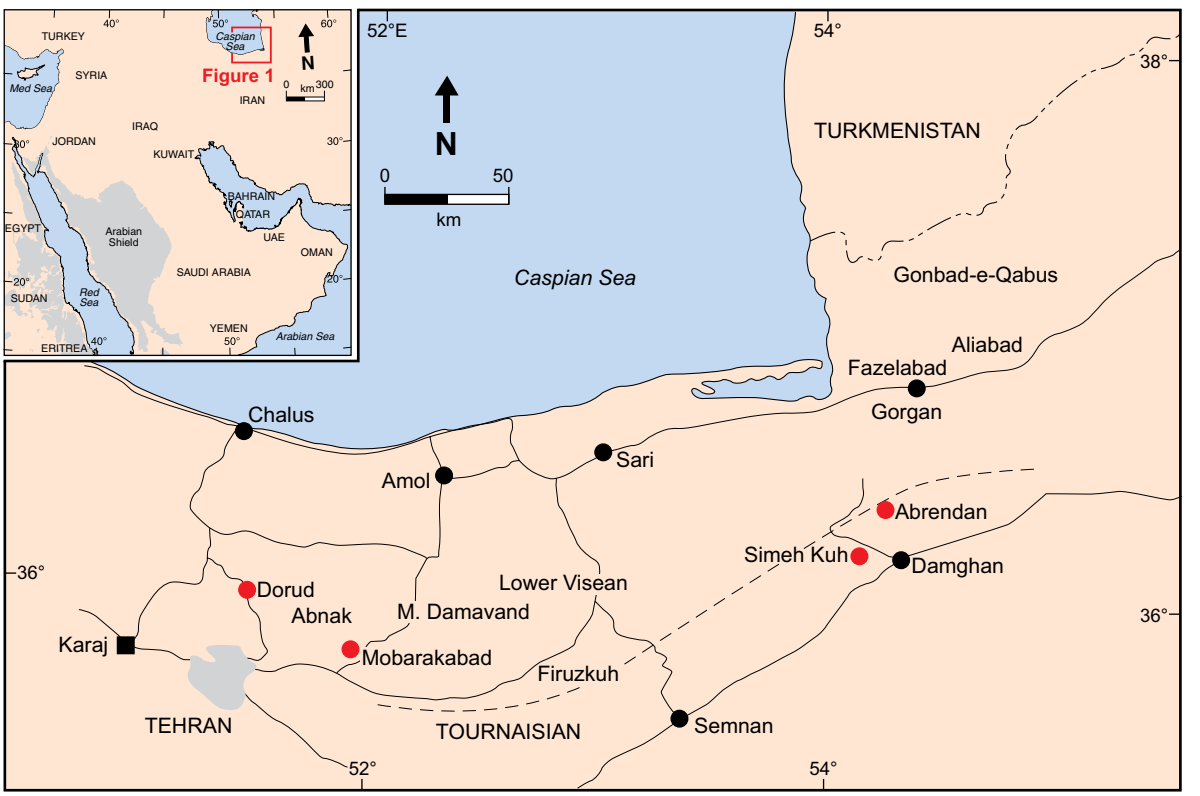

Figure 1: Geographic sketch map of North Iran, showing the location of the Abrendan and Simeh Kuh sections. The position of the main sections collected by Gaetani (1965, 1968) in the Dorud (Geirud) and Mobarakabad areas has been also indicated.

THE BRACHIOPOD FAUNA

A very rich brachiopod fauna comprising forty-eight taxa based on 855 specimens (Table 1) has been found in the Tournaisian (Mississippian) Mobarak Formation, Alborz Mountains, North Iran. A single species of the molluscan order Conocardioida, *Hippocardia alborza* Hoare and Aghababalu, 2001, has been also found in the lower part of the section (specimens MPUM10682-10685) (Figure 21, i–l).

The brachiopod distribution along the Abrendan section (Figure 2) is controlled in part by the facies change from bioclastic packstone in the lower part of the section, to fossiliferous marlstone with mudstone and fine packstone intercalations in its middle part.

Brachiopods from the lower one hundred metres of the formation are less diversified than the assemblages found higher in the section, between 140 and 160 metres from the bases (Figure 2). The lower assemblages comprise a maximum co-occurrence of 15 taxa, whereas samples IR988 to IR998 (Figure 2) comprise up to 22 co-occurring species. Also in the lower part of the Mobarak Formation, brachiopods are dominated by pedicle attached species (e.g. *Rossirhynchus*, *Hemiplethorhynchus*, *Cleiothyridina*, *Composita*, *Lamellosathyris*, *Ectochoristites*, *Parallelora*, *Unispirifer*, *Voiseyella*) with very rare free-living spiriferinids (*Syringothyris*, *Pseudosyrinx*) and a few seminfaunal strophomenates (*Leptagonia*, *Pustula*, *Geniculifera*, *Marginatia*, *Tomiproductus*). This indicates high energy, shallow-water settings, also recorded by the lithofacies being dominated by bioclastic packstone, where nutrient supply was high, favouring pedicle attached spire-bearers and rhynchonellids (Perez Huerta and Sheldon, 2006).

Table 1
List of brachiopod taxa described in the present paper.

Leptagonia cf. *L. analoga* (Phillips, 1836)
Caenanoplia cf. *C. burlingtonensis* (Carter, 1968)
Geniculifera sp. ind.
?Rhytiophora sp. ind.
Tolmatchoffia sp. ind.
Promarginifera sp. ind.
Buxtonia sp. ind.
Marginatia vaughani (Muir-Wood, 1928)
Marginatia aff. *M. deruptoides* Sarytcheva in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963
Tomiproductus elegantulus (Tolmatchoff, 1924)
Pustula cf. P. altaica Tolmatchoff, 1924
Pustula sp. ind.
Brochocarina sp. ind.
Schellwienella sp. ind.
Rhipidomella michelini (Léveillé, 1835)
Schizophoria (Schizophoria) resupinata (Martin, 1809)
Hemiplethorhynchus crassus Gaetani, 1968
Rossirhynchus adamantinus Gaetani, 1964
Paraphorhynchus aff. *P. elongatum* Weller, 1905
?Athyris sp. ind.
Lamellosathyris lamellosus (Léveillé, 1835)
Cleiothyridina kusbassica Beznosova in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963
?Cleiothyridina sp. ind.
Gerankalasiella sp. ind.

Carteridina sp. ind.
Composita megala (Tolmatchoff, 1924)
Composita subquadrata (Hall, 1858)
Composita aff. *C. pentagonia* (Weller, 1914)
Composita cf. *C. caimaensis* Chen, Tazawa, Shi and Matsuda, 2005
Composita sp. ind.
?Densalvus sp. ind.
?Iniathyris sp. ind.
Kisilia sp. ind.
?Tenisia sp. ind.
Ectochoristites sp. ind.
Parallelora sp. ind.
Unispirifer (Unispirifer) striatoconvolutus (Benson and Dun in Benson, Dun and Browne, 1920)
Unispirifer cf. *U. (Septimispirifer) septimus* (Thomas, 1971)
Unispirifer sp. ind.
Atylephorus sp. ind.
Prospirinae gen. et sp. ind.
Voiseyella aff. *V. texana* (Carter, 1967)
Latibrachythyris sp. ind.
Kitakamithyris sp. ind.
Torynifer sp. ind.
Syringothyris carteri (Hall, 1857)
Syringothyris skinderi Sokolskaya in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963
Pseudosyrinx sp. ind.

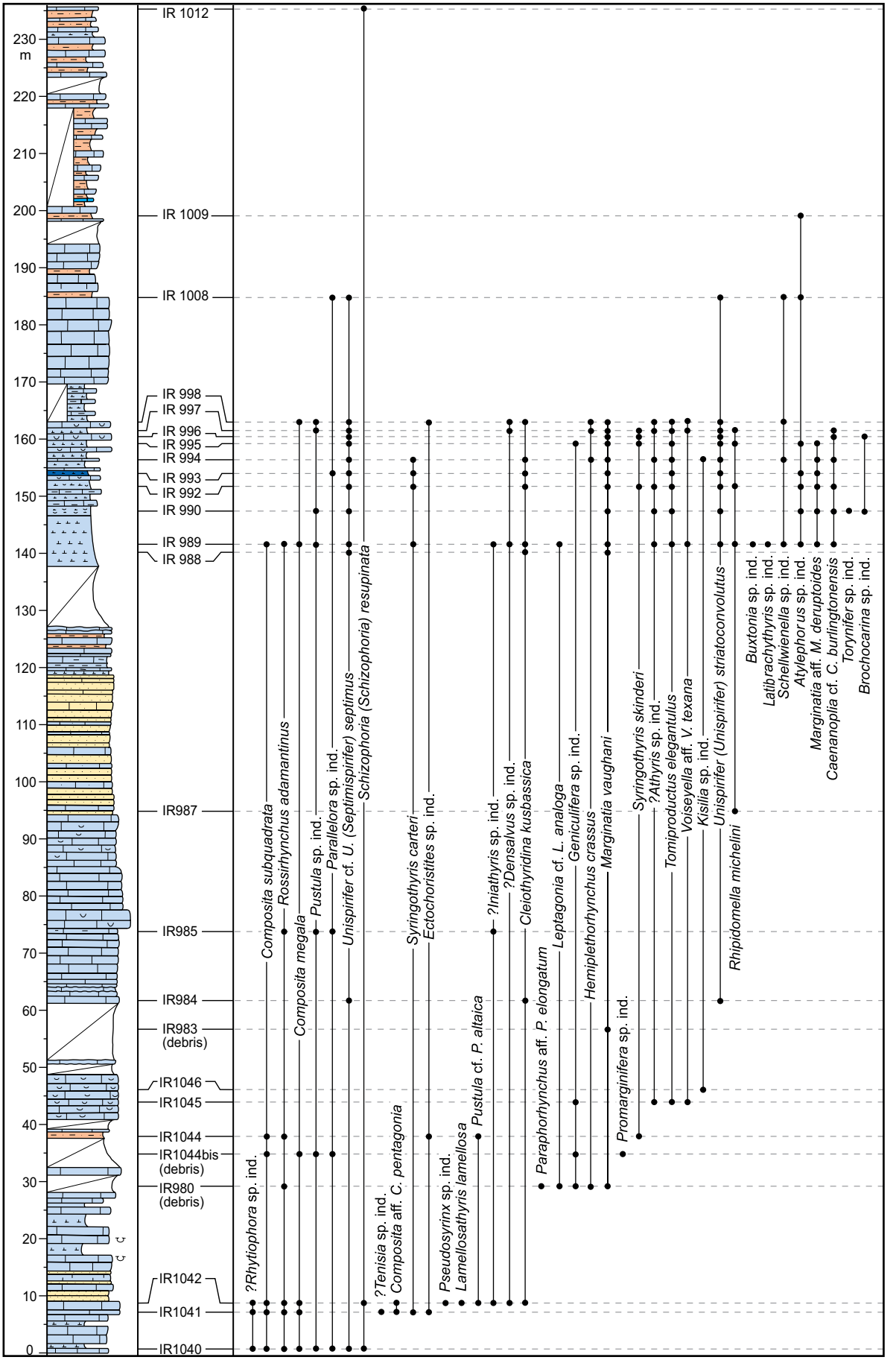

Figure 2: Stratigraphic log of the Abrendan section (coord. 36°21′47.6″ N - 54°18′59.9″ E, WGS84), showing the distribution of the brachiopod taxa.

The more abundant and more diversified assemblages which occur in the marlstone of the middle part of the formation are characterized by an increased proportion of concavo-convex seminfaunal productids (mainly species of *Marginatia* and *Tomiproductus*, *Buxtonia*, *Caenanoplia*, *Brochocarina*) indicating quieter settings than previously and probably lower nutrient supply. However, pedicle attached species are still dominant, indicating that the substrate was not soppy and there where at least hard substrates of limited extent on which they could have attached.

In the upper part of the Mobarak Formation cropping out along the Abrendan section the same lithofacies recorded at its base and in its middle part occur again, but brachiopods are very rare and include only a few species which range from below, such as *Parallelora* sp. ind., *Unispirifer* cf. *U. (S.) septimus*, *U. (U.) striatoconvolutus*, *S. (S.) resupinata*, *Atylephorus* sp. ind., and *Schellwienella* sp. ind. In the topmost part of the Abrendan section, for which Brenckle et al. (2009) have given a late Ivorian age, no brachiopods have been found. Therefore this part is not discussed in the paper.

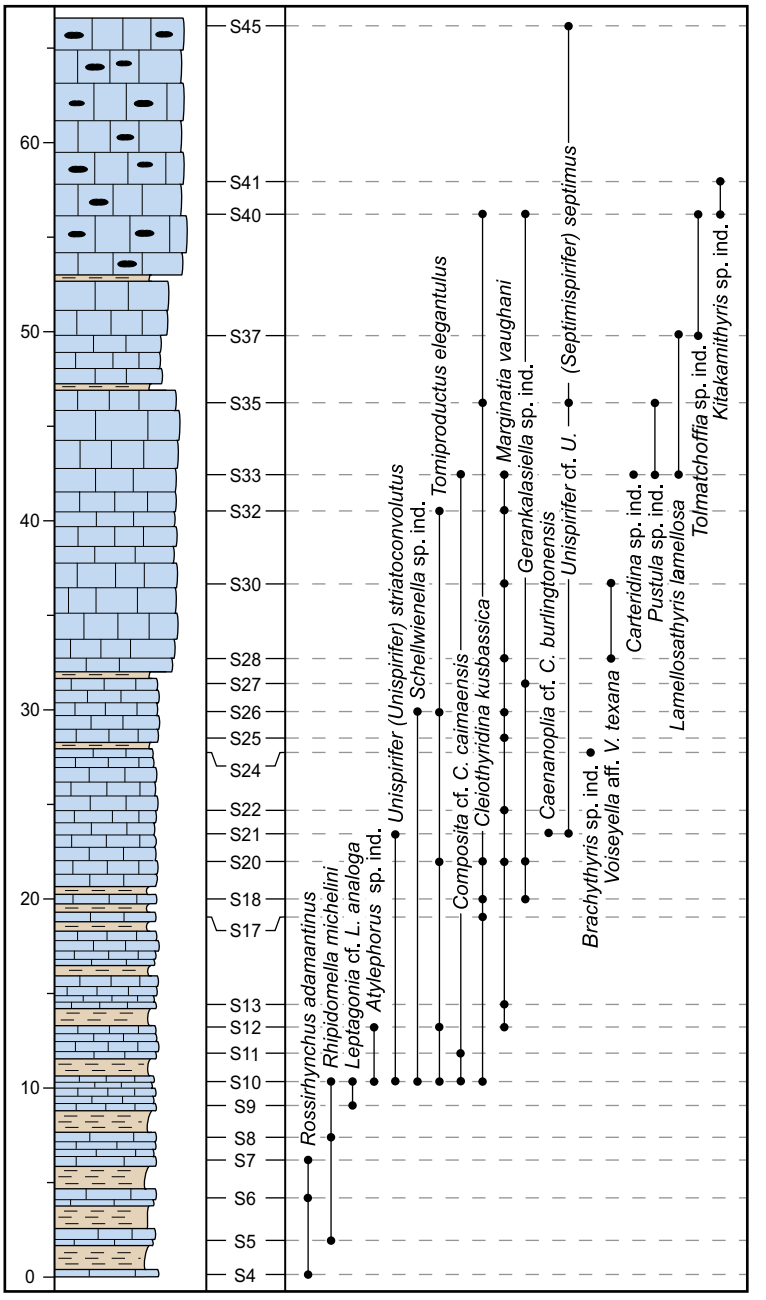

Figure 3: Stratigraphic log of the Simeh Kuh section (coord. 36°12′26.96″ N - 54°13′6.43″ E, WGS84), showing the distribution of the brachiopod taxa.

Brachiopods from the Simeh Kuh section (Figure 3) (Aghababalou, 1999) are less diversified than those from Abrendan, but occasionally they show a remarkably better preservation. They mostly comprise pedicle attached species with rare seminfaunal productids. Except for four species restricted to the lower part of the section (*R. adamantinus*, *R. michelini*, *L. analoga* and *Atylephorus* sp. ind.), most taxa range from the marlstone and marly limestone at the base of the section to the bioclastic limestone and cherty limestone at 50–60 metres from the base.

PALAEOBIOGEOGRAPHIC IMPLICATIONS

Brenckle et al. (2009) reported that the palaeogeographic position of the Alborz is controversial in literature; however, palaeomagnetic data from Alborz (e.g. Muttoni et al., 2009) indicate an apparent polar wandering (APW) compatible with that of West Gondwana, with a paleolatitude of about 45–50° South for the Alborz Mountains in the early Tournaisian. North Iran should have been thus located close to the Gondwanan margin, north of Arabia and northeast of Sanandaj-Sirjan along the southern

shore of the Paleotethys Ocean (Brenckle et al., 2009, fig. 9). This is supported by the subsequent Permian palaeogeographic evolution of the Alborz region which has been discussed by Angiolini et al. (2007), Gaetani et al. (2009) and Muttoni et al. (2009) and which shows North Iran progressively detatching from the Gondwanan margin and drifting north towards Eurasia in the course of the Permian.

However, Brenckle et al. (2009) presented evidence based both on their own data and on the available literature that the Mississippian biota from the Alborz is typical of waters warmer than should be expected at 45–50° South. They explained this apparent contradiction considering an expansion of the temperate to semitropical climate belts and the occurrence of a warm counter-clockwise surface current bathing the peri-Gondwanan fringe (Kiessling et al. 1999; Brenckle et al., 2009, fig. 9). This reconstruction could have been possible in the absence of ice-sheets in Gondwana, the interval of deposition of this part of the Mobarak Formation being a warm climate period, bracketed between the first two discrete glacial events of the late Palaeozoic ice age, one at the Late Devonian/Tournaisian boundary and the other in the late Visean (Fielding et al., 2008).

The brachiopods here described are mostly cosmopolitan, with only two species endemic to Iran (*R. adamantinus* and *H. crassus*). A good proportion of the determined species have been mostly found in the Russian platform (*Marginatia* aff. *M. deruptoides*, *T. elegantulus*, *P.* cf. *P. altaica*, *C. kusbassica*, *C. megala*, *S. skinderi*) or in the USA (*C.* cf. C. *burlingtonensis, P.* aff. *P. elongatus, C. subquadrata*, *C.* aff. *C. pentagonia*, *V.* aff. *V. texana*, *S. carteri*) and only *Unispirifer* cf. *U. (Septimispirifer) septimus* has been known exclusively from Australia. The Iranian fauna is also similar, especially at the generic level, to the Tournaisian brachiopods described by Mottequin (2010) from Ireland.

Similarity with North African Tournaisian fossils localities (e.g. Legrand Blain, 1974; Brice et al., 2005; Mottequin and Legrand Blain, 2010) is rather broad and mainly consists in the common occurrence of cosmopolitan genera as *Leptagonia*, *Marginatia*, *Buxtonia*, *Pustula*, *Schellwienella*, *Rhipidomella, Schizophoria*, *Hemiplethorhynchus*, *Cleiothyridina*, *Composita*, *Voiseyella*, *Unispirifer* and *Syringothyris*, besides the eurasiatic genus *Tomiproductus*.

As already reported in Brenckle et al. (2009) the brachiopods show a closer affinity to North America, Western Europe, the Russian Platform and North Africa than to cold-water Australian faunas, in agreement with the affinity of the other biota of the Tournaisian of the Alborz Mountains.

The very low degree of endemism of the North Iran fauna seems to support the interpretation of the presence of extensive warm surface-current gyres widely distributing brachiopod larvae across the Palaeotethys Ocean, where peri-Gondwanan blocks acted as staging-posts, favoring the circulation of mobile larval populations, the recruitment and successively the dispersion of taxa coming mostly from the north and the east. This pattern could have been generated by the palaeogeography during the Tournaisian, characterized by oceans extending E-W at the tropics up to intermediate latitudes and by the absence of ice caps in Gondwana.

SYSTEMATIC PALAEONTOLOGY

All of the described specimens are housed in the Palaeontological Museum of the Department of Earth Sciences "A. Desio", University of Milan, Italy. Specimens are registered with a prefix MPUM followed by a five digit number; the field number is indicated between parentheses. The systematic study follows the classifications of Cocks and Rong in Williams et al. (2000a) for the strophomenids, Brunton et al. in Williams et al. (2000b) for the productidines and strophalosiidines, Williams and Brunton in Williams et al. (2000b) for the orthotetidines, Williams and Harper in Williams et al. (2000b) for the orthids, Savage et al. in Williams et al. (2002) for the rhynchonellids, Alvarez and Rong in Williams et al. (2002) and Alvarez in Williams et al. (2007) for the athyridids, Johnson et al. in Williams et al. (2006) for the theodossioids, Carter in Williams et al. (2006) for the spiriferoids, packelmanelloids and brachythyridoids, Carter and Gourvennec in Williams et al. (2006) for the reticularioids and Carter in Williams et al. (2006) for the spiriferinidines.

We have followed the revised Treatise on Invertebrate Paleontology (Part H, 1997–2007) and the tradition for Palaeozoic brachiopods in illustrating the transverse serial sections with the ventral valve below. For a recent discussion on this matter we refer to Alvarez et al. (2008).

Subphylum RHYNCHONELLIFORMEA Williams, Carlson, Brunton, Holmer and Popov, 1996
Class STROPHOMENATA Williams, Carlson, Brunton, Holmer and Popov, 1996
Order STROPHOMENIDA Öpik, 1934
Superfamily STROPHOMENOIDEA King, 1846
Family RAFINESQUINIDAE Schuchert, 1893
Subfamily LEPTAENINAE Hall and Clarke, 1894a

Genus *Leptagonia* McCoy, 1844

Type species: *Producta analoga* Phillips, 1836 from the Visean of UK (Yorkshire).

Remarks: Brunton (1968) revised the original diagnosis and defined *Leptagonia* McCoy, 1844 as having a biconvex disk, sharp geniculation, variably disposed trails, and complex muscle platforms. Brand (1972) added that adults of *Leptagonia* can have a concavo-convex or plano-convex shape. *Leptaenopyxis* Havlíček, 1963, is externally similar to *Leptagonia*, but differs for a ventral sulcus which also occurs on the visceral disk.

Leptagonia cf. *L. analoga* (Phillips, 1836) (Figure 4, a–d)

1968 *Leptagonia analoga* – Gaetani: p. 688; pl. 47, figs 3a–3c.

Material: Six articulated specimens: MPUM10473(IR989-353); MPUM10474(S9A; S9B; IR989-354); MPUM10476(S10Q); MPUM10477(S10R); two dorsal valves: MPUM10475(IR980-14; IR989-355).

Description: Concavo-convex to plano-convex shape with sub-trapezoidal outline; maximum width at the hinge: 42.4–52.3 mm, corresponding length: 25.5–30.7 mm; cardinal extremities forming an angle of 60°. Ventral disk slightly convex, trail sharply geniculated; umbo with apical foramen; interarea apsacline, narrow and flat. Trail rather deeply sulcate. Dorsal disk flat; dorsal trail sharply geniculated with low but wide median fold. Ornamentation of strong, irregular rugae on the disks; thin costellae developed on the rugae, numbering 14–16 per 5 mm at 10 mm from the umbo; rugae and costellae fading on the trails. Interior of dorsal valve with robust cardinal process lobes projecting ventrally.

Dimensions (in mm):

	Width	Length	Thickness
IR989-353	52.3	30.7	18.4
S10Q	42.4	25.5	22.1
S10R	48.1	21.4	26.2

Remarks: The specimens under examination are very similar to *Leptagonia analoga* (Phillips, 1836), based on their dimensions, outline and ornamention, but differ slightly for a deeper ventral sulcus. According to Bassett and Bryant (2006), *L. analoga* has been reported from many regions of the world and most records need an accurate revision under modern palaentological aspects, based on the study of several morphological characters and particularly of the muscle fields. Of the other species occurring in the the Tournaisian – Serpukhovian of Great Britain, *Leptagonia caledonica* Brand, 1972 shows a different pattern of rugae and a more extended sulcus; *Leptagonia distorta* (Sowerby, 1840) is smaller and has a subquadrate outline; *Leptagonia smithi* Brand, 1972 has a stronger reticulation and a ventral sulcus on the visceral disk.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section.

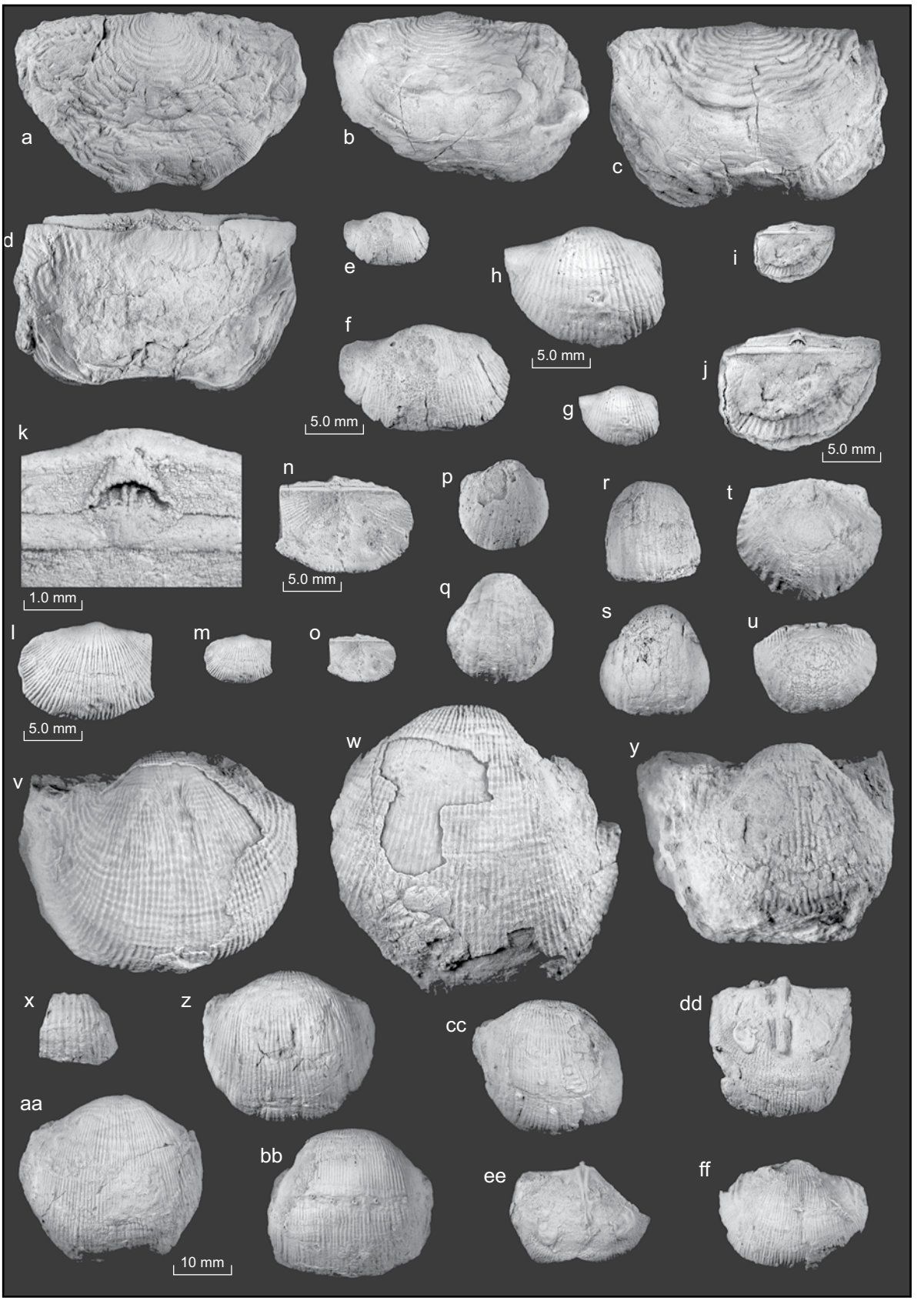

Figure 4: (a–d) ***Leptagonia*** **cf.** ***L. analoga*** **(Phillips, 1836). Abrendan section. (a) MPUM10473 (IR989-353), articulate specimen, ventral view, Simeh Kuh section. (b) MPUM10476(S10Q), articulate specimen, ventral view. (c–d) MPUM10477(S10R), articulate specimen. (c) ventral view. (d) dorsal view. (e–o)** ***Caenanoplia*** **cf. C.** ***burlingtonensis*** **(Carter, 1968). Abrendan section. (e–f) MPUM10478 (IR997-319), articulate specimen. (e) ventral view. (f) ventral view, X2. Simeh Kuh section.** *See facing page for continuation.*

Selected previous records: *L. analoga* has been recorded widely in Lower Carboniferous successions; Tournaisian, North Iran (Gaetani, 1968); Tournaisian – Serpukhovian, Great Britain and Ireland (Brand, 1972; Cocks and Rong in Williams et al., 2000a; Mottequin, 2010); Tournaisian, Belgium (Demanet, 1934); Mississippian, USA (Weller, 1914; Carter, 1999); Mississippian, Siberia (Sokolskaya in Sarytcheva et al., 1963; Gretchischnikova, 1966); Tournaisian – Visean, NW Australia (Thomas, 1971); Mississippian, SW China (Shi et al., 2005).

Order PRODUCTIDA Sarytcheva and Sokolskaya, 1959
Suborder CHONETIDINA Muir-Wood, 1955
Superfamily CHONETOIDEA Bronn, 1862
Family ANOPLIIDAE Muir-Wood, 1962
Subfamily CAENANOPLIINAE Archbold, 1980

Genus *Caenanoplia* Carter, 1968

Type species: *Caenanoplia burlingtonensis* Carter, 1968 from the Mississippian of the USA (Missouri).

Remarks: Similar to *Caenanoplia* Carter, 1968 is *Subglobosochonetes* Afanas'eva, 1976, which however has a smaller size, an orthocline interarea, less divergent anderidia (40–50°), and a coarser ribbing. *Globosochonetes* Brunton, 1968 is very close to *Subglobosochonetes*, but has more divergent anderidia (90°) and accessory septa.

Caenanoplia cf. *C. burlingtonensis* (Carter, 1968) (Figure 4, e–o)

Material: Three articulated specimens: MPUM10508(IR989-429); MPUM10479(S21A); MPUM10480(S21B); eight ventral valves: MPUM10481 (IR989-425B; IR990-335; IR992-317; IR994-332B; IR995-68; IR995-333A; IR995-333B; MPUM10478(IR997-319).

Description: Small sized, concavo-convex shell with semicircular, variably transverse outline; maximum width at the hinge: 6.2–14.8 mm; corresponding length: 4.1–9.6 mm; a few specimens slightly asymmetric. Ventral valve very convex with swollen umbo; ears flat, triangular, and well defined; interarea low, apsacline, with delthyrium closed by a convex pseudodeltidium; flanks rather steep. Dorsal valve concave, geniculated; notothyrium closed by a trapezoidal chilidium. Ornamentation of rounded costellae increasing by bifurcation and intercalation, numbering about 26–28; concentric filae; weak rugae only posteriorly; four spine bases along the cardinal margin. Interior of dorsal valve with high, narrow, bilobed, quadrifid cardinal process.

Figure 4 (continued): (g–k) MPUM10479-(S21A), articulate specimen. (g) ventral view. (h) ventral view, X2. (i) dorsal view. (j), dorsal view, X2. (k) X10, cardinal region. (l–o) MPUM10480-(S21B), articulate specimen. (l) ventral view, X2. (m) ventral view. (n) dorsal view, X2. (o) dorsal view. (p–s) *Geniculifera* sp. ind. Abrendan section. (p) MPUM10482(IR980-13), ventral valve, ventral view. (q) MPUM10484(IR1044B-25), ventral valve, ventral view. (r) MPUM10483(IR1045-303), ventral valve, ventral view. (s) MPUM10485(IR1045-310), ventral valve, ventral view. (t–u) *?Rhytiophora* sp. ind. Abrendan section. (t) MPUM10487(IR1040-300), ventral valve, ventral view. (u) MPUM10488(IR1041-300), ventral valve, ventral view. (v–w) *Tolmatchoffia* sp. ind. Simeh Kuh section. (v) MPUM10491(S37H), ventral valve, ventral view. (w) MPUM10490(S40G), articulate specimen, ventral view. (x) *Promarginifera* sp. ind. Abrendan section. MPUM10493(IR1044B-305), ventral valve, ventral view. (y) *Buxtonia* sp. ind. Abrendan section. MPUM10494(IR989-20), ventral valve, ventral view. (z–ff) *Marginatia vaughani* (Muir-Wood, 1928). Abrendan section. (z) MPUM10496(IR990-307), ventral valve, ventral view. (aa) MPUM10497(IR990-345), ventral valve, ventral view. (bb) MPUM10499(IR994-11), ventral valve, ventral view. (cc) MPUM10498(IR994-23), ventral valve, ventral view. (dd) MPUM10500(IR994-307), dorsal valve interior. (ee) MPUM10501-(IR994-358), dorsal valve interior. (ff) MPUM10495(IR996-10A), articulate specimen, ventral view. All figures X 1, unless otherwise stated. Scale bar 10 mm for the natural size.

Dimensions (in mm):

	Width	Length	Thickness
IR992-317	8.6	6.6	
IR994-50	13.3	8.3	
IR994-332B	10.1	5.2	
IR995-68	10.6	5.7	
IR995-333A	10.7	7.4	

	Width	Length	Thickness
IR995-333B	6.2	4.1	
IR997-319	14.8	9.6	
S21A	13.5	10.4	5.8
S21B	11.7	8.5	4.8

Remarks: The specimens from Iran are very similar to *Caenanoplia burlingtonensis* Carter, 1968 except for a slightly stronger radial ornamentation.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section.

Selected previous records: Mississippian, USA (Missouri) (Carter, 1968).

Suborder PRODUCTIDINA Waagen, 1883
Superfamily PRODUCTOIDEA Gray, 1840
Family PRODUCTELLIDAE Schuchert in Schuchert and LeVene, 1929
Subfamily PLICATIFERINAE Muir-Wood and Cooper, 1960
Tribe LEVITUSIINI Muir-Wood and Cooper, 1960

Genus *Geniculifera* Muir-Wood and Cooper, 1960

Type species: *Avonia boonensis* Branson, 1938 from the Tournaisian of the USA (New Mexico).

Geniculifera sp. ind. (Figure 4, p–s)

Material: 12 ventral valves: MPUM10482(IR980-13); MPUM10483(IR1045-303); MPUM10484(IR1044B-25); MPUM10485(IR1045-310); MPUM10486(IR995-330; IR1044B-19; IR1044B-306; IR1044B-307; IR1045-301; IR1045-304; IR1045-307; IR1045-309).

Description: Very convex valve with subrectangular outline; maximum width: 15.4–20.7 mm, corresponding length 14.5–20.3 mm. Umbo rather flat, visceral disc convex; trail sharply geniculated, with steep flanks; sulcus absent. Poorly preserved ornamentation of rugae on the visceral disk and weak ribs on the trail, numbering 4–5 per 5 mm; small, irregularly dispersed spine bases.

Dimensions (in mm):

	Width	Length	Thickness
IR995-330	15.4	14.5	13.3
IR1044B-306	17.6	22.3	15.0
IR1044B-307	19.4	18.7	

	Width	Length	Thickness
IR1045-301	20.7	20.3	20.7
IR1045-309	19.3	15.2	13.4
IR1045-310	20.3	15.8	

Remarks: *Geniculifera boonensis* (Branson, 1938), type species of the genus, has stronger rugae and larger spine bases. Due to the poor state of preservation the specific determination is left open.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Tribe SEMICOSTELLINI Nalivkin, 1979

Genus *Rhytiophora* Muir-Wood and Cooper, 1960

Type species: *Productus blairi* Miller, 1891 from the Tournaisian of the USA (Missouri).

?*Rhytiophora* sp. ind. (Figure 4, t–u)

Material: Five ventral valves: MPUM10487(IR1040-300); MPUM10488(IR1041-300); MPUM10489(IR1040-309; IR1042-306; IR1041-312).

Description: Regularly convex ventral valve with subrectangular outline; maximum width: 20.7–29.1 mm, corresponding length: 15.3–21.3 mm; visceral disk convex; ears flat, well defined. Sulcus absent. Ornamentation of elongate spine bases, irregularly arranged on visceral disk, forming ribs on the trail, numbering 2–3 per 5 mm at the anterior margin; weak, thin, crenulated rugae posteriorly.

Dimensions (in mm):

	Width	Length	Thickness
IR1040-300	29.1	21.3	14.7
IR1040-309	28.8	25.5	
IR1041-300	20.7	15.3	10.1
IR1042-306	22.6	18.1	9.8
IR1042-312	20.6	16.8	10.1

Remarks: These poorly preserved specimens are dubitatively included in *Rhytiophora*, based on their shape and ornamentation.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Family PRODUCTIDAE Gray, 1840
Subfamily PRODUCTINAE Gray, 1840
Tribe RETARIINI Muir-Wood and Cooper, 1960

Genus *Promarginifera* Shiells, 1966

Type species: *Promarginifera trearnensis* Shiells, 1966 from the late Visean of UK (Ayrshire).

Promarginifera sp. ind. (Figure 4, x)

Material: One ventral valve: MPUM10493(IR1044B-305).

Description: Very convex valve, 16 mm long. Visceral disc convex; trail geniculated, long, with steep flanks. Ornamentation of strong costae, numbering 4 per 5 mm at the beginning of the trail; spine bases on the costae, with diameter < 0.5 mm, forming a transverse row near the anterior margin.

Remarks: The present specimen is similar to *Promarginifera trearnensis* Shiells, 1966 based on its shape, radial ornamentation and the arrangement of the ventral spines, but it shows a stronger geniculation. Being based on one single specimen which is not very well preserved, the specific determination is left open.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Subfamily BUXTONIINAE Muir-Wood and Cooper, 1960
Tribe BUXTONIINI Muir-Wood and Cooper, 1960

Genus *Buxtonia* Thomas, 1914

Type species: *Anomites scabriculus* Martin, 1809 from the Mississippian of UK (Derbyshire).

Buxtonia sp. ind. (Figure 4, y)

1968 *Buxtonia* sp. ind. – Gaetani: p. 695.

Material: One ventral valve: MPUM10494(IR989-20).

Description: Very convex ventral valve with subrectangular outline; umbo prominent raised above the small ears. Maximum width: 35.6 mm, corresponding length: 33.0 mm. Median region flattened, without sulcus; trail strongly geniculated. Ornamentation of spine bases forming discontinuous ribs, numbering 7 per 5 mm at 5 mm from the umbo; weak rugae on the ears.

Remarks: The present specimen shows the main features of the genus, but the state of preservation precludes a specific determination. It is rather similar *Buxtonia scabricula* (Sowerby, 1814), but it has less evident spine bases and no sulcus.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Tribe TOLMATCHOFFIINI Sarytcheva in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963

Genus *Tolmatchoffia* Fredericks, 1933

Type species: *Productus robustus* Tolmatchoff, 1924 from the Tournaisian of Siberia.

Tolmatchoffia sp. ind. (Figure 4, v–w)

Material: One articulated specimen: MPUM10490(S40G); two ventral valves: MPUM10491(S37H); MPUM10492(S40H).

Description: Concavo-convex shell with subrectangular outline; maximum width: 49 mm, corresponding length: > 38 mm; corpus cavity deep. Ventral valve strongly convex with prominent umbo and flat ears; ventral sulcus variably developed. Dorsal valve concave. Ornamentation of costae numbering 7 per 5 mm at 5 mm from the umbo, increasing in width anteriorly; strong rugae posteriorly on flanks and ears, becoming less evident on the median part of the disk; they intersect the costae imparting a reticulate ornamentation to the disk; rare halteroid spine bases with diameter of about 2 mm occur on the trail. Interior of ventral valve with narrow, elongated, raised adductor scars and dendritic diductors.

Remarks: The present specimens show the main features of the genus *Tolmatchoffia*, having strong rugae posteriorly which become weak on the median part of the disk.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Simeh Kuh section.

Genus *Marginatia* Muir-Wood and Cooper, 1960

Type species: *Productus fernglenensis* Weller, 1909 from the Visean of the USA (Missouri).

Remarks: *Marginatia* Muir-Wood and Cooper, 1960 is very similar to *Marginoproductus* Tan, 1986, but *Marginatia* has a stronger reticulation on the visceral disk, dorsal spines, no cluster of spines on the ears, a shorter median septum, and an oval, dendritic muscle field. According to Bassett and Bryant (2006) *Marginatia* is also characterized by the absence of costellae at the umbo and an irregularly arranged pattern of spine bases.

Antiquatonia differs by its larger size and different ribbing. *Tolmatchoffia* Fredericks, 1933 and *Dictyoclostus* Muir-Wood, 1930 differ by their larger size and deeper ventral sulcus.

Marginatia vaughani **(Muir-Wood, 1928)** (Figure 4, z–ff; Figure 5, a–g; Figure 6)

1905a *Productus* cf. *P. martini* – Vaughan: p. 288; pl. 25, figs 2–2a.
1905b *Productus* cf. *P. martini* – Vaughan: p. 54; pl. 1.
1906 *Productus* cf. *P. burlingtonensis* – Vaughan: p. 128; pl. 2.
1911 *Productus burlingtonensis* – Delépine: p. 392; pl. 13, figs 3–3b.
1915 *Productus burlingtonensis* – Vaughan: p. 7.
1917 *Productus* cf. *P. martini* – Jarosz: p. 71; pl. 10, figs 20–20a.
1928 *Productus vaughani* Muir-Wood: p. 65; pl. 2, figs 12a–13c; text-fig. 15.
1931 *Productus (Dictyoclostus) vaughani* – Paeckelmann: p. 275; pl. 33, fig. 5.
1963 *Marginatia vaughani* – Sarytcheva in Sarytcheva et al.: p. 193; pl. 29, figs 1–4; text-fig. 83.
1968 *Tomiproductus vaughani* – Gaetani: p. 699; pl. 48, figs 1–7; pl. 49, fig. 1; text-fig. 5.
2010 *Marginatia vaughani* – Mottequin: p. 254; pl.1, figs 12–21; text-fig. 13.

Material: 51 articulated specimens: MPUM10495(IR996-10A); MPUM10502(S30D); MPUM10503(S25A); MPUM10506(IR989-316; IR989-322; IR990-17; IR990-32; IR990-50; IR990-303; IR990-308; IR990-343; IR994-24; IR994-34; IR994-68; IR994-303; IR994-308; IR994-363; IR994-364; IR995-9A; IR995-24; IR996-16; S12D; S13A; S13B; S13C; S20A; S20B; S20C; S22B; S25B; S25C; S26B; S28D; S28E; S30C; S32A; S32B; S32C; S32D; S33F; S33G; S33H; S33L; S33N; IR989-43; IR989-307A; IR989-307B; IR989-315; IR989-439; IR990-22; IR990-77); 105 ventral valves: MPUM10496 (IR990-307); MPUM10497 (IR990-345); MPUM10498(IR994-23); MPUM10499(IR994-11); MPUM10505(AB3; IR983-300; IR988-163; IR989-114; IR989-300; IR989-302; IR989-303; IR989-304; IR989-305; IR989-312; IR989-313; IR989-317; IR989-323; IR989-324; IR989-326; IR989-330; IR989-331; IR989-361; IR989-440; IR990-11; IR990-29; IR990-45; IR990-302; IR990-305; IR990-313; IR990-315; IR990-344; IR990-349; IR990-350; IR992-86; IR992-300; IR992-301; IR992-305; IR993-9; IR993-13; IR993-23; IR993-301; IR993-302A; IR993-302B; IR993-303; IR993-305; IR993-306; IR993-344; IR993-347; IR993-350; IR993-351; IR993-354; IR994-17; IR994-33; IR994-40; IR994-45; IR994-300; IR994-304; IR994-305; IR994-315; IR994-367; IR995-16; IR995-56; IR995-300A; IR995-302; IR995-310; IR995-312; IR995-317; IR995-325; IR995-328A; IR995-329; IR995-332; IR995-334; IR995-336; IR997-20; IR998-40; IR998-300; IR998-301; IR998-302; IR998-309; IR998-311; IR998-313; IR998-335; IR998-350; IR998-353; IR998-354; AB2; IR989-63; IR989-137; IR989-308; IR989-311; IR989-350; IR989-430; IR990-36; IR990-39; IR990-60; IR990-321; IR990-342; IR993-348; IR994-35; IR994-76; IR994-78; IR994-301; IR994-302; IR994-316; IR995-311); 11 dorsal valves: MPUM10500(IR994-307); MPUM10501(IR994-358); MPUM10504 (IR996-10B); MPUM10507(IR990-21; IR992-7; IR993-343; IR994-61; IR995-13; IR995-328B; IR997-37; IR997-301).

Description: Concavo-convex shell with subquadrate to subrectangular outline (Figure 6); maximum width: 16.0–32.0 mm, corresponding length 14.8–26.9. Ears well defined, flat; cardinal extremities angular. Ventral valve very convex, with prominent umbo; visceral disk convex; sulcus shallow; trail recurved with steep flanks. Dorsal valve flat or slightly concave; median fold evident at the geniculation. Ornamentation of ventral valve of regularly arranged, fine costellae increasing by bifurcation, numbering 10–11 per 5 mm at 10 mm from the umbo and 6 per 5 mm at the anterior margin; in most specimens the costellae are absent at the umbo; spine bases 0.4–1.1 mm in diameter, irregularly arranged except for a row near the cardinal margin and a second one inclined at 30° from the cardinal margin; occasionally they cause the interruption of the costellae or their local deviation; posteriorly, the rugae intersect the costellae imparting a strongly reticulate ornamentation to the visceral disk. Ornamentation of dorsal valve of fine costellae and rugae imparting a reticulation to the visceral disk. Interior of dorsal valve with bilobed cardinal process, antron, median septum extending to the end of the visceral disk, "D" shaped brachial ridges; lateral ridges curving at the cardinal extremities and extending for about half the length of the visceral disk; muscle fields raised, dendritic.

Intraspecific variability: Some specimens show the tendency to form weak fascicles of costellae at the anterior margin; others have a deeper sulcus.

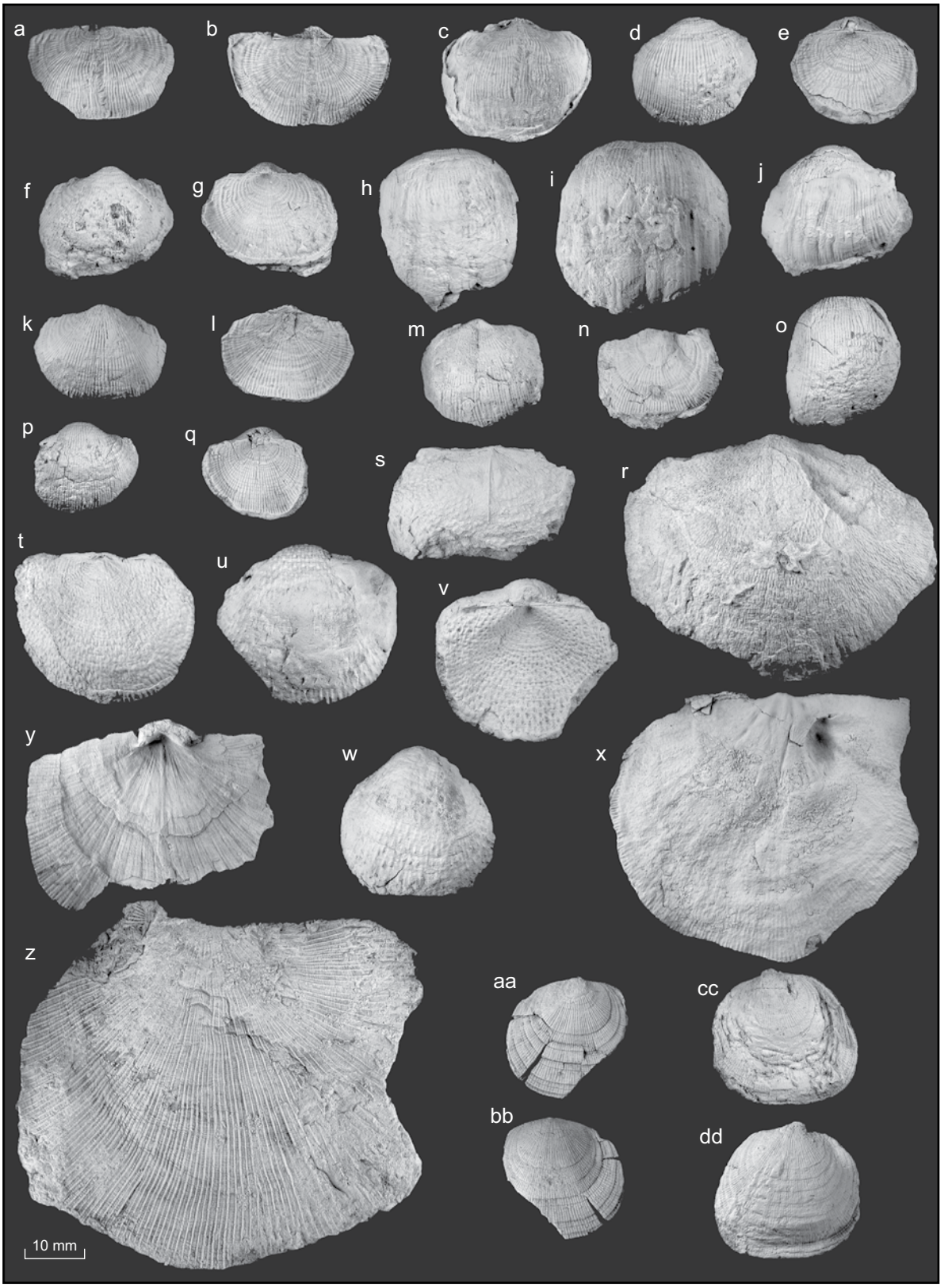

Figure 5*:* (a–g) *Marginatia vaughani* (Muir-Wood, 1928). Abrendan section. (a) MPUM10495(IR996-10A), articulate specimen, dorsal view. (b–c) MPUM10504(IR996-10B), external cast of a dorsal valve. (b) ventral view. (c) anterior view. Simeh Kuh section. (d–e) MPUM10503(S25A), articulate specimen. (d) ventral view. (e) dorsal view. (f–g) MPUM10502(S30D), articulate specimen (f) ventral view. (g) dorsal view. (h–j) *Marginatia* aff. *M. deruptoides* Sarytcheva in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963. Abrendan section.

See facing page for continuation.

Dimensions (in mm):

	Width	Length	Thickness
AB3	24.4	18.9	16.7
IR980-33	30.4	28.2	15.0
IR988-163	28.8	25.0	12.7
IR989-114	24.6	24	16.2
IR989-300	22.9	23.9	12.7
IR989-302	32.0	26.9	16.3
IR989-303	27.2	24.0	14.2
IR989-305	20.9	20.0	7.0
IR989-307B	20.4	19.2	9.8
IR989-316	22.0	18.6	8.8
IR989-317	21.3	23.2	12.3
IR989-322	25.1	18.5	7.9
IR989-323	25.6	23.0	12.2
IR989-324	22.7	18.8	6.5
IR989-326	23.2	19.0	13.5
IR989-331	23.2	22.3	12.0
IR989-361	26.2	22.2	16.0
IR989-440	25.0	20.2	13.8
IR990-29	21.3	20	12.1
IR990-45	26.3	23.7	17.3
IR990-307	30.2	27.0	18.3
IR990-308	25.4	24.2	13.5
IR990-313	24.1	19.2	7.3
IR990-318	21.1	17.8	8.6
IR990-344	28.0	27.8	
IR990-345	30.9	28.7	13.0
IR992-7	22.0	14.4	10.8
IR992-300	24.0	23.0	13.0
IR992-301	27.0	25.3	11.9
IR992-303	26.3	22.8	13.0
IR992-305	25.0	20.3	12.0

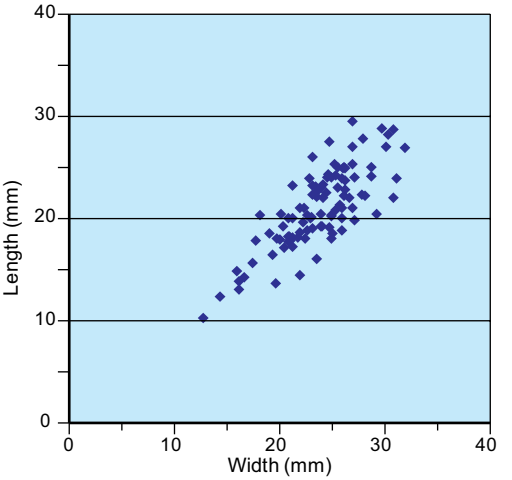

Figure 6: Width *versus* length diagram of *Marginatia vaughani*.

	Width	Length	Thickness
IR993-3	26.1	24.9	15.0
IR993-13	24.5	22.5	13.2
IR993-303	22.0	21.0	9.9
IR993-308	23.0	20.0	12.3
IR993-310	27.0	21.0	16.0
IR993-347	29.3	20.4	13.8
IR993-351	25.8	21.3	12.4
IR993-354	27.2	19.8	11.0
IR994-11	28.8	24.1	11.7
IR994-24	26.7	22.0	10.4
IR994-45	29.8	28.8	14.0
IR994-300	24.8	27.5	
IR994-303	30.9	22.0	16.8
IR994-304	27.0	29.5	15.0
IR994-305	26.0	23.9	12.3

Figure 5 (continued): (h) MPUM10513(IR989-309), ventral valve, anterior view. (i) MPUM10511-(IR990316), ventral valve, anterior view. (j) MPUM10514(IR995-316), ventral valve, anterior view. (k–q) *Tomiproductus elegantulus* (Tolmatchoff, 1924). Abrendan section. (k–l) MPUM10515(IR989-321), articulate specimen. (k) ventral view. (l) dorsal view. (m) MPUM10516(IR994-365), articulate specimen, ventral view. (n) MPUM10519(IR997-6), cast of a dorsal valve, dorsal view. Simeh Kuh section. (o) MPUM10517(S10N), articulate specimen, ventral view. (p–q) MPUM10518(S26C), articulate specimen. (p) ventral view. (q) dorsal view. (r) *Pustula* cf. *P. altaica* Tolmatchoff, 1924. Abrendan section. MPUM10523(IR1042-300), ventral valve, ventral view. (s–w) *Pustula* sp. ind. Abrendan section. (s) MPUM10526(IR990-317), dorsal valve interior. (t) MPUM10528(IR1044B-300B), dorsal valve, dorsal view. Simeh Kuh section. (u–v) MPUM10525(S33M), articulate specimen. (u) ventral view. (v) dorsal view. (w) MPUM10527(S35E), ventral valve, ventral view. (x) *Brochocarina* sp. ind. Abrendan section. MPUM10531(IR996-7), internal mould of a ventral valve. (y–z) *Schellwienella* sp. ind. Abrendan section. (y) MPUM10538(IR989-328), dorsal valve interior. (z) MPUM10535(IR1008-300), ventral valve, ventral view. (aa–dd) *Rhipidomella michelini* (Léveillé, 1835). Abrendan section. (aa–bb) MPUM10539(IR989-344), articulate specimen. (aa) ventral view. (bb) dorsal view. (cc–dd) MPUM10541(IR989-349), articulate specimen. (cc) ventral view. (dd) dorsal view. All figures X 1. Scale bar 10 mm.

	Width	Length	Thickness
IR994-307	24.7	24.3	9.4
IR994-308	24.2	22	12.4
IR994-315	21.3	17.2	11.8
IR994-363	26.0	18.8	14.0
IR995-9A	18.2	20.3	15.2
IR995-16	25.0	24.0	11.0
IR995-24	25.0	18.0	11.8
IR995-302	24.0	20.4	14.3
IR995-312	25.3	25.3	11.1
IR995-317	23.2	26.0	16.0
IR995-334	20.1	17.9	8.9
IR996-10A	24.8	19.1	8.8
IR996-10B	26.0	20.0	13.0
IR996-16	24.0	19.2	12.4
IR997-37	19.7	13.6	4.9
IR997-301	21.8	18.1	19.7
IR998-40	20.2	20.4	
IR998-302	23.5	23.1	11.0
IR998-335	25.6	25.0	
IR998-353	25.2	22.7	27.0
IR998-354	22.5	21.8	20.7
S12D	19.8	18.0	10.0

	Width	Length	Thickness
S13A	19.1	18.5	11.0
S13B	17.8	17.8	10.0
S13C	20.9	18.2	9.3
S20C	16.0	14.8	7.9
S22B	22.7	20.3	10.0
S25A	21.3	18.1	10.4
S25B	23.6	22.1	13.4
S25C	16.2	13.0	9.0
S26B	20.9	17.7	9.0
S28D	19.4	16.4	6.4
S28E	17.5	15.6	7.9
S30C	20.5	17.1	8.3
S30D	22.5	18.0	8.4
S32A	14.4	12.3	6.5
S32B	12.8	10.2	5.9
S32C	16.2	13.8	8.3
S32D	22.3	19.6	13.2
S33F	27.9	22.3	12.2
S33G	22.4	21.0	12.1
S33H	21.0	18.2	10.2
S33L	26.3	24.9	11.2
S33N	16.7	14.2	5.7

Remarks: *Marginatia vaughani* (Muir-Wood, 1928) differs from *Marginatia fernglenensis* (Weller, 1909) by its smaller size, weaker rugae, narrower umbo and fasciculation occurring only occasionally; it differs from *Marginatia quadrata* (Tolmatchoff, 1924) from the Tournaisian of Siberia (Sarytcheva in Sarytcheva et al., 1963), by its smaller size, the absence of fascicle of ribs on the flanks and the pattern of the spine bases; it differs from *Marginatia burlingtonensis* (Hall, 1858), from the Mississippian of the USA (Weller, 1914) and Japan (Tazawa, 2006), by its less extended reticulation and the smaller ears.

Marginatia minor Tan, 1986 and *Marginatia* (?) *regularis* Tan, 1986, from the Mississippian of China (Tan, 1986), differ by their stronger and more extended rugation. *Marginatia cylindrica* Shi, Chen and Zhan, 2005, from the Mississippian of China (Shi et al., 2005), has fewer and larger costellae. *Marginatia mimica* Roberts, 1971, from the Devonian – Carboniferous of Australia (Roberts, 1971), shows a wider disk and sinuous costellae on the ears.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section; AB-prefix specimens from scree of Abrendan section.

Selected previous records: Tournaisian, North Iran (Gaetani, 1968); Tournaisian, British Isles (Muir-Wood, 1928, Mottequin 2010); Tournaisian – early Visean, Belgium (Demanet, 1958); middle – upper Tournaisian of Siberia (Sokolskaya in Sarytcheva et al., 1963).

Marginatia aff. *M. deruptoides* Sarytcheva in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963 (Figure 5, h–j)

Material: Three articulated specimens: MPUM10509(IR990-300; IR994-318); MPUM10511(IR990-316); 10 ventral valves: MPUM10510(IR990-312; IR990-348; IR992-319; IR993-300; IR993-349; IR994-306; IR994-310; IR995-308); MPUM10513(IR989-309); MPUM10514(IR995-316); one ventral valve: MPUM10512(IR989-356A12).

Description: Concavo-convex shell with subquadrate outline; maximum width: 24.0–29.0 mm, corresponding length 17.0–28.8 mm; ears well defined. Ventral valve very convex with strong umbo; trail geniculated, not well preserved; median sulcus very shallow. Ornamentation of ventral valve reticulated on visceral disk, costellate on the trail with costellae (11 per 5 mm at 10 mm from the umbo) forming strong fascicles delimited by deep furrows, about 3 per 5 mm; rugae stronger on the ears and on the umbonal flanks; rare spine bases (diameter 1.0–1.5 mm), irregularly arranged, except for a row of 12–15 spine bases on the trail where the costellae start to form fascicles.

Dimensions (in mm):

	Width	Length	Thickness
IR989-309	24.0	25.9	
IR990-300	24.0	17.0	14.9
IR990-316	29.0	28.8	23.3

	Width	Length	Thickness
IR992-319	25.0	23.1	12.5
IR995-308	23.6	21.2	16.0
IR995-316	22.2	20.1	14.1

Remarks: The present specimens are very similar to *M. deruptoides,* but they are smaller in size and they have more regularly arranged fascicles of ribs. *M. deruptoides* differs from *M. vaughani* by its evident fascicles of ribs and the spine bases which are rarer and irregularly arranged except for one row of spines at the start of fasciculation. *Marginatia huaqiaoensis* Tan, 1986, from the Mississippian of China (Tan, 1986), has a more extended rugation and larger and pointed ears. *Marginatia magna* Carter, 1968, from the Mississippian of the USA (Carter, 1968, 1999), is larger, and it shows thicker rugae and coarser fascicles.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Selected previous records: Middle and late Tournaisian, Siberia (Sarytcheva in Sarytcheva et al., 1963).

Genus *Tomiproductus* Sarytcheva in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963

Type species: *Productus elegantulus* Tolmatchoff, 1924 from the Tournaisian of Siberia.

Remarks: The distinction between the genera *Marginatia* and *Tomiproductus* Sarytcheva in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963 is not always an easy task (Gaetani, 1968). As already commented above, *Tomiproductus* has a weaker reticulation which occurs only posteriorly on the visceral disk, cluster of spines on the ears, overall more numerous and more regularly arranged spines, and a breviseptum separated from the cardinal process shaft.

Tomiproductus elegantulus (Tolmatchoff, 1924) (Figure 5, k–q)

1924 *Productus elegantulus* Tolmatchoff: p. 244; pl. 14, figs 5–7.
1963 *Tomiproductus elegantulus* – Sarytcheva in Sarytcheva et al.: p. 202; pl. 31, fig. 11; pl. 32, figs 1–7; text-figs 88–89.
1968 *Tomiproductus elegantulus* – Gaetani: p. 697; pl. 48, figs 8–10; pl. 49, figs 2–3.

Material: 13 articulated specimens: MPUM10515(IR989-321); MPUM10516(IR994-365); MPUM10517-(S10N); MPUM10518(S26C); MPUM10520(IR989-319; IR995-28; IR998-308; S10M; S10P; S12C; S22A; S22C; S32E); 22 ventral valves: MPUM10521(IR989-318; IR989-320; IR989-441; IR990-310; IR990-311; IR992-23; IR992-50; IR992-55; IR992-304; IR993-307A; IR993-307B; IR995-21; IR995-25; IR995-306; IR995-307; IR995-327; IR997-50; IR997-51; IR998-7; IR998-19; IR998-307; IR998-351); 2 dorsal valves: MPUM10519(IR997-6); MPUM10522(IR989-325).

Description: Concavo-convex shell with subquadrate to slightly rubrectangular outline, longer than wider; maximum width: 18.2–24.8 mm, corresponding length: 17.8–23.2 mm; ears quite distinct; cardinal extremities angular. Ventral valve very convex with prominent umbo; flanks steep, slightly divergent; trail not sharply geniculated, recurved; shallow sulcus on the visceral disc which may

extend to the trail. Dorsal disk flat or slightly concave; trail sharply geniculated with fold becoming evident at the geniculation, fading anteriorly. Ornamentation of ventral valve with fine costellae, numbering 12 per 5 mm at 10 mm from the umbo and 8 per 5 mm at the anterior margin; spine bases aligned along the cardinal margin, 0.6–1 mm in diameter; weak rugae only posteriorly, near the ears. Dorsal valve with fine costellae, dimples and no spines; rugae intersect the costellae imparting a reticulation to the posterior part of the visceral disk. Interior of dorsal valve with lateral ridges, brachial ridges and median septum.

Dimensions (in mm):

	Width	Length	Thickness
IR989-318	24.7	18.2	7.9
IR989-320	23.0	21.1	15.7
IR989-321	22.3	16.3	6.8
IR990-310	21.6	17.0	10.2
IR990-311	21.8	18.1	19.7
IR992-23	21.7	19.0	11.2
IR992-55	23.1	13.8	
IR992-304	18.2	17.8	10.0
IR993-307A	24.4	21.0	20.8
IR994-365	19.3	17.4	8.8
IR995-21	24.8	23.2	15.0
IR995-25	24.4	21.3	14.4
IR995-306	26.0	22.0	12.9

	Width	Length	Thickness
IR995-307	22.0	21.7	15.9
IR997-50	24.3	21.8	14.7
IR997-51	22.4	21.9	15.0
IR998-7	23.5	21.1	15.5
IR998-19	22.3	19.8	25.1
IR998-308	22.3	20.0	10.1
S10M	19.2	20.0	13.5
S10N	19.5	21.5	12.4
S10P	19.9	14	
S12C	18.2	17.4	10.7
S22A	18.0	18.0	12.0
S22C	17.8	16.7	11.2
S32E	22.1	19.3	12.2

Remarks: *Tomiproductus elegantulus* (Tolmatchoff, 1924) differs from *Tomiproductus kollari* Carter, 1990, from the Mississippian of the USA (Carter, 1990), by its weaker rugae, less pointed ears, and the absence of fascicles of ribs; it differs from *Tomiproductus dukhovae* Sarytcheva in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963, from the middle to late Tournaisian of Siberia (Sarytcheva in Sarytcheva et al., 1963), by its fewer spine bases and more numerous costellae.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section; AB-prefix specimens from scree of Abrendan section.

Selected previous records: Tournaisian, North Iran (Gaetani, 1968); middle – upper Tournaisian, Siberia (Sarytcheva in Sarytcheva et al., 1963).

Superfamily ECHINOCONCHOIDEA Stehli, 1954
Family ECHINOCONCHIDAE Stehli, 1954
Subfamily PUSTULINAE Waterhouse, 1981

Genus *Pustula* Thomas, 1914

Type species: *Producta pustulosa* Phillips, 1836 from the late Visean of UK.

Pustula cf. *P. altaica* Tolmatchoff, 1924 (Figure 5, r)

Material: one ventral valve: MPUM10523(IR1042-300); one dorsal valve and one dorsal internal mould: MPUM10524(IR1044-3B; IR1044-3A).

Description: Concavo-convex shell with ovate outline; maximum width: 41.2–53.5 mm, corresponding length: 30.1–41.0 mm, thickness: 10.5–19.2 mm. Ventral valve convex with low umbo; sulcus absent. Dorsal valve concave with flat ears. Ornamentation of both valves with small, elongated spine bases, 0.6–1.8 mm long arranged in quincunx or concentrically; in the umbonal region they are subcircular

and more densely dispersed; cardinal spines aligned along the margin; weak longitudinal plicae towards the anterior margin.

Remarks: The present specimens are similar to *Pustula altaica* Tolmatchoff, 1924 because of their size, the anterior plicae and the ornamentation. However, they differ slightly by having spreading flanks and a more transverse outline and lacking a ventral sulcus. They differ from *Pustula pustulosa* (Thomas, 1914) by their much weaker and less extended rugae and the arrangement of spine bases.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Selected previous records: Tournaisian, Siberia (Sarytcheva in Sarytcheva et al., 1963; Gretchischnikova, 1966).

Pustula sp. ind. (Figure 5, s–w)

1968 *Pustula* aff. *P. altaica* – Gaetani: p. 694; pl. 47, figs 7–8.

Material: two articulated specimens: MPUM10525(S33M); MPUM10528bis(IR985-300); seven ventral valves: MPUM10527(S35E); MPUM10529(IR997-62; IR997-302; IR997-304; IR998-312; IR989-327; IR1044B-302); five dorsal valves: MPUM10526(IR990-317); MPUM10528(IR1044B-300B); MPUM10530(IR997-303; IR1040-1; IR1044B-300°).

Description: Concavo-convex shell with subquadrate to subrectangular outline; maximum width: 20.2–30.4 mm, corresponding length: 18.8–27.2 mm. Ventral valve convex with prominent umbo; umbonal flanks steep; visceral disc convex with median flattening; ears flat. Dorsal valve concave with flat ears and angular cardinal extremities. Ornamentation of ventral valve of widely spaced, irregularly arranged, elongated, spine bases, about 0.8 mm in width and 1.3–2.8 mm in length; posteriorly they are shorter and more densely dispersed; rugae on the umbonal flanks and on the ears. Occasionally the beak of the umbo is not ornamented. Ornamentation of dorsal valve similar, with denser spine bases which are radially arranged. Interior of dorsal valve with median septum extending to the geniculation; lateral ridges at 10° from the cardinal margin.

Dimensions (in mm):

	Width	Length	Thickness
IR985-300	20.2	18.8	9.2
IR997-62	29.2	24.0	12.7
IR997-304	28.7	25.8	12.2
IR998-312	26	23.8	
IR1040-1	27.2	19.3	

	Width	Length	Thickness
IR1044B-300A	29.6	24.8	6.2
IR1044B-300B	29.6	24.8	6.2
S33M	30.4	27.2	12.4
S35E	26.1	25.0	12.2

Remarks: The present specimens differ from most other species of *Pustula* by the more widely spaced spine bases and by the absence of a sulcus; they differ from *Pustula* cf. *P. altaica* by their smaller size, the absence of longitudinal plicae, and the coarser and more widely spaced spine bases.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Order ORTHOTETIDA Waagen, 1884
Suborder ORTHOTETIDINA Waagen, 1884
Superfamily ORTHOTETOIDEA Waagen, 1884
Family ORTHOTETIDAE Waagen, 1884

Genus *Brochocarina* Brunton, 1968

Type species: *Schuchertella wexfordensis* Smyth, 1930 from the late Visean on North Ireland.

Brochocarina sp. ind. (Figure 5, x)

Material: one ventral valve: MPUM10532(IR990-340); one ventral internal mould: MPUM10531(IR996-7).

Description: Large sized ventral valve, nearly planar with irregular shape and straight cardinal margin. Apsacline to orthocline interarea, striated; delthyrium closed by a pseudodeltidium. Interior of ventral valve with posteriorly lanceolate muscle scars, delimited by two lateral ridges and bisected by a median ridge, which are posteriorly fused and diverge anteriorly; lateral and anterior margins crenulated.

Remarks: The present specimens show the characteristic internal features of the genus *Brochocarina*, which consist of three internal ridges posteriorly fused and then surrounding the muscle field. However they are not sufficiently preserved to allow a specific determination.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Family PULSIIDAE Cooper and Grant, 1974

Genus *Schellwienella* Thomas, 1910

Type species: *Spirifera crenistria* Phillips, 1836 from the Visean of UK.

Schellwienella sp. ind. (Figure 5, y–z)

1968 *Schellwienella (Schellwienella)* sp. A – Gaetani: p. 689; pl. 47, fig. 4–6.

Material: four articulated specimens: MPUM10533(S10F; S10G; S26A); MPUM10688(S10H); three ventral valves: MPUM10534(IR989-47; IR994-317); MPUM10535(IR1008-300); two dorsal valves: MPUM10536(IR989-329); MPUM10538(IR989-328); one dorsal internal mould: MPUM10537(IR998-75).

Description: Concavo-convex shell with subrectangular outline; anterior commissure weakly uniplicate; maximum width: 17.8–42.9, corresponding length: 14.2–34.8 mm. Ventral valve flat to slightly concave, resupinate; umbo projecting posteriorly; interarea apsacline, wide, striated; delthyrium closed by a convex pseudodeltitium. Dorsal valve convex, with low fold. Ornamentation parvicostellate with 13–14 costellae per 5 mm at 10 mm from the umbo, becoming coarser anteriorly; filae and growth lamellae anteriorly. Interior of ventral valve with teeth supported by short dental plates. Interior of dorsal valve with sessile, bilobed cardinal process with lobes separated by a deep furrow; raised median septum, extending anteriorly to the cardinal process up to half the length of the valve; socket ridges short.

Dimensions (in mm):

	Width	Length	Thickness
IR994-317	23.9	18.2	3.2
IR998-75	42.9	34.8	15.0
S10F	17.9	14.4	4.9
S10G	14.3	11.9	3.7

Remarks: The present specimens resemble *Schellwienella cheuma* Bassett and Bryant, 2006, from the Tournaisian of UK (Bassett and Bryant, 2006), from which they differ by a lower number of costellae and longer dental plates.

Juvenile specimens are more similar to *Schellwienella crenulicostata* Weller, 1914 and to *Schellwienella inaequalis* (Hall, 1858), from the Mississippian of the USA (Weller, 1914); however, *S. crenulicostata* shows a lower number of costellae and *S. inaequalis* has a more prominent umbo. *Schellwienella rotundata* Thomas, 1910 differs by a more resupinate ventral valve, its higher interarea and the more numerous costellae. *Schellwienella australis* Thomas, 1971, from the Tournaisian – Visean from NE Australia (Thomas, 1971), differs by its coarser costellae and thinner and longer socket plates.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section.

Selected previous records: Tournaisian, North Iran (Gaetani, 1968).

Class RHYNCHONELLATA Williams, Carlson, Brunton, Holmer and Popov, 1996
Order ORTHIDA Schuchert and Cooper, 1932
Suborder DALMANELLIDINA Moore in Moore, Lalicker and Fischer, 1952
Superfamily DALMANELLOIDEA Schuchert, 1913a
Family RHIPIDOMELLIDAE Schuchert, 1913a
Subfamily RHIPIDOMELLINAE Schuchert, 1913a

Genus *Rhipidomella* Oehlert, 1890

Type species: *Terebratula michelini* Léveillé, 1835 from the Tournaisian of Belgium.

***Rhipidomella michelini* (Léveillé, 1835)** (Figure 5, aa–dd; Figure 7, a–e; Figure 8; Figure 9, a–f)

1835 *Terebratula michelini* Léveillé: p. 39; pl. 2, figs 14–17.
1861 *Orthis michelini* – Davidson: p. 132; pl. 30, figs 6–11.
1900 *Dalmanella michelini* – Frech in Frech and Arthaber: p. 201; pl. 16, figs 15a–15d.
1916 *Dalmanella michelini* – Frech: p. 238.
1923 *Rhipidomella michelini* – Demanet: p. 123; pl. 5, fig. 6.
1934 *Rhipidomella michelini* – Demanet: p. 37; pl. 2, figs 1–9.
1952 *Rhipidomella michelini* – Sarytcheva and Sokolskaya: p. 26; pl. 1, fig. 7.
1962 *Rhipidomella michelini* – Litvinovich: p. 177; pl. 1, fig. 1.
1965 *Rhipidomella michelini* – Wright in Williams et al., p. H 341; fig. 217, 2a–2f.
1968 *Rhipidomella michelini* – Brunton: p. 17; pl. 3, figs1–25, text-fig. 5.
1968 *Rhipidomella michelini* – Gaetani: p. 687; pl. 47, figs 1–2.
1971 *Rhipidomella michelini* – Ahmadzadeh Heravi: p. 49; pl. 1, figs 1–5.
1989 *Rhipidomella michelini* – Żakowa: p. 115; pl. 3, figs 5a–5b; pl. 7, figs 7a–7e; tab. 12.
2006 *Rhipidomella michelini* – Bassett and Bryant: p. 502; pl. 1, figs 1–4; pl. 6, figs 11–17.
2008 *Rhipidomella michelini* – Sun and Baliński: p. 519; fig. 26, A1–H4.
2010 *Rhipidomella michelini* – Mottequin: p. 259; pl. 2, figs 3–11; text-fig. 13.

Material: 34 articulated specimens: MPUM10539(IR989-344); MPUM10540(IR989-405); MPUM10541-(IR989-349); MPUM10542(S10D); MPUM10544(IR987-7; IR989-53; IR989-77; IR989-78; IR989-81; IR989-87; IR989-95; IR989-336; IR989-340; IR989-347; IR989-348; IR989-351; IR989-443; IR992-22; IR992-307; S5A; S5B; S8A; S8B; S8C; S10C; S10E; IR989-71; IR989-84; IR989-91; IR989-333; IR989-338; IR989-343); MPUM10667(IR989-342); MPUM10668(IR989-345); nine ventral valves: MPUM10545(IR989-334A; IR989-334B; IR989-339; IR995-315; IR997-315; IR989-335; IR989-337; IR989-341; IR995-55); four dorsal valves: MPUM10543(IR989-126); MPUM10546(IR989-67; IR989-125; IR997-16).

Description: Small to medium sized, biconvex shell with subcircular outline; maximum width: 11.3–24.9 mm; corresponding length 9.8–19.8 mm. The outline is transversally oval in the juvelines, but becomes more orbicular in the adults. Anterior commissure weakly unisulcate, rarely rectimarginate; cardinal margin straight but short. Ventral valve convex with pointed unbo, projected posteriorly; interarea apsacline, concave, triangular, striated with open delthyrium. Dorsal valve more convex than the ventral one; interarea small, orthocline. Ornamentation of fine costellae increasing by bifurcation and intercalation, numbering 18–21 per 5 mm at 5 mm from the umbo and 11–14 per 5 mm at the anterior margin; growth lamellae. Interior of ventral valve with long median septum extending to mid-length; muscle field elongated, depressed with small adductor scars closely set to the median septum; diductor scars large, flabellate, separated from the adductors by a thin ridge. Interior of dorsal valve with brachiophores set at 90°; bilobed, cardinal process trifid, with swollen base; lateral and anterior margins crenulated.

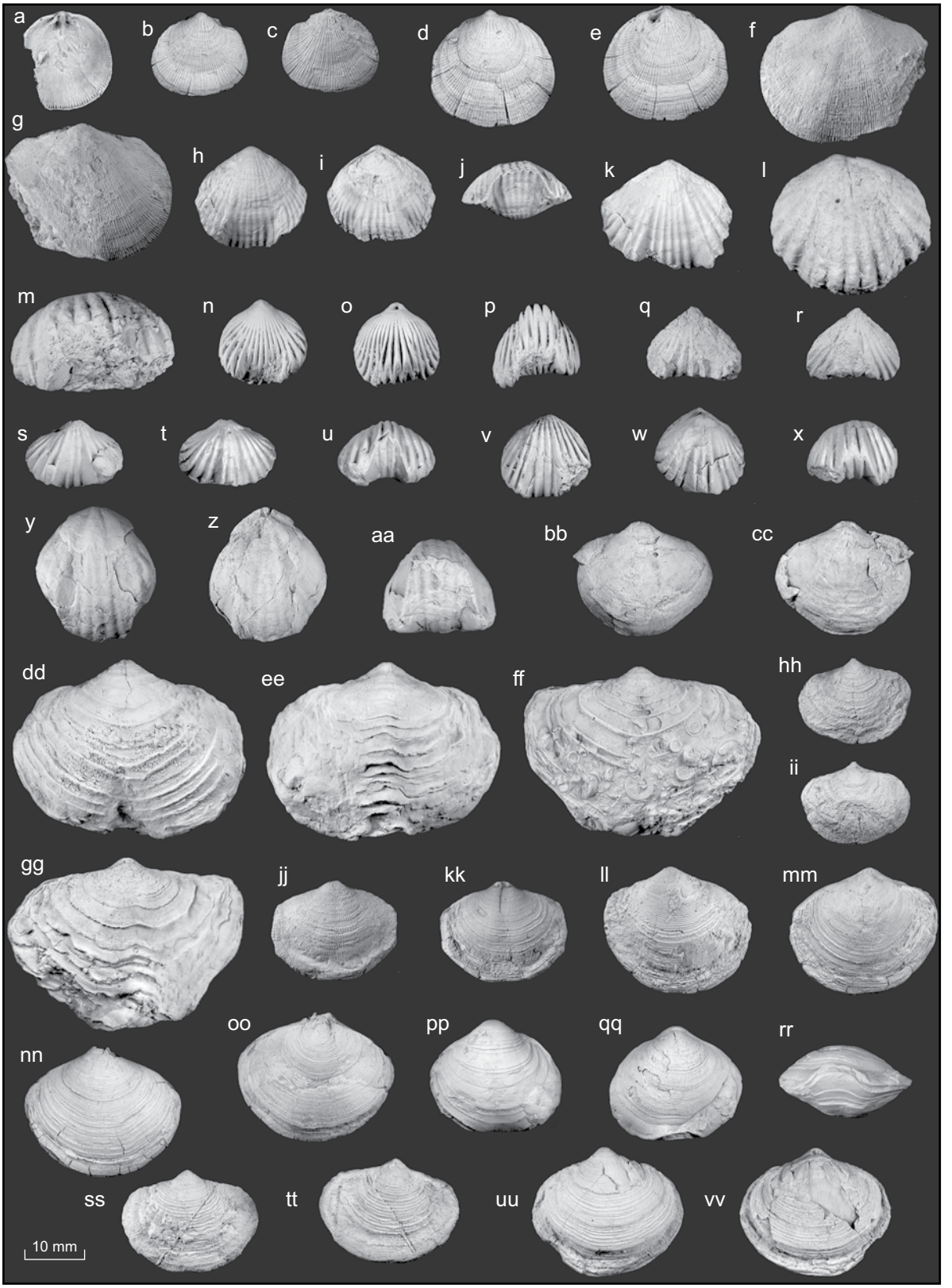

Figure 7: (a–e) ***Rhipidomella michelini*** **(Léveillé, 1835). Abrendan section. (a) MPUM10543 (IR989-126), dorsal valve interior. (b–c) MPUM10540(IR989-405), articulate specimen. (b) ventral view. (c) dorsal view. Simeh Kuh section. (d–e) MPUM10542(S10D), articulate specimen. (d) ventral view. (e) dorsal view. (f–g)** ***Schizophoria (Schizophoria) resupinata*** **(Martin, 1809). Abrendan section. MPUM10548(IR1042-26), articulate specimen. (f) ventral view. (g) dorsal view. (h–k)** ***Hemiplethorhynchus crassus*** **Gaetani, 1968. Abrendan section.**

See facing page for continuation.

Dimensions (in mm):

	Width	Length	Thickness
IR987-7	20.9	15.9	3.9
IR989-53	17.2	15.5	6.2
IR989-78	14.2	11.4	4.7
IR989-87	17.0	16.0	5.9
IR989-95	21.6	19.3	7.9
IR989-126	15.6	16.3	
IR989-336	11.3	9.8	2.7
IR989-340	21.0	19.3	
IR989-343	24.9	19.8	7.1
IR989-345	23.4	21.8	6.0
IR989-347	12.9	11.1	3.9
IR989-349	24.3	23.1	7.2
IR989-351	11.8	9.2	4.3
IR989-405	16.0	14.0	4.2
IR989-443	13.7	11.5	2.9
IR992-22	22.3	18.7	4.8
IR992-307	23.1	20.7	6.1
IR997-315	20.3	19.8	
S5A	19.8	18.7	5.8
S5B	21.8	19.9	5.2
S8A	20.9	16.9	5.5
S8B	21.0	20.9	6.9
S8C	24.2	20.1	2.9
S10C	21.8	19.0	4.5
S10D	20.7	19.5	5.8
S10E	19.6	17.9	8.9

Remarks: The present specimens show the diagnostic characters of *Rhipidomella michelini* (Léveillé, 1835) as illustrated by Demanet (1934) and Brunton (1968). *Rhipidomella australis* (McCoy, 1847), from the Mississippian of Australia (Campbell, 1957), is similar, but differs only for a higher number of costellae at the anterior margin and for its raised muscle field.

Among the several species described from the Mississippian of the USA by Weller (1914), *R. michelini* is similar to *Rhipidomella missouriensis* (Shallow, 1860), which differs by its more extended muscle field and the dorsal interarea;

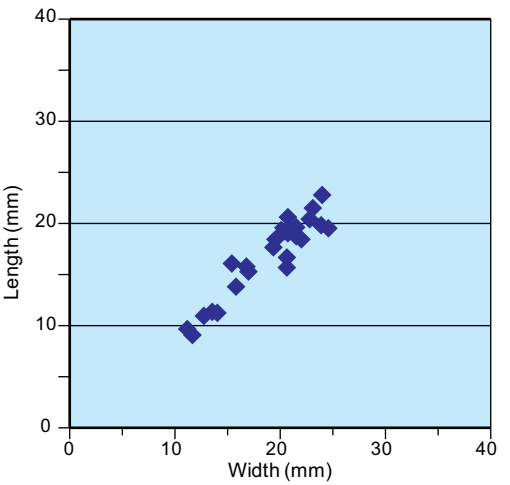

Figure 8: Width *versus* length diagram of *Rhipidomella michelini*.

Figure 7 (continued): (h–j) MPUM10550(IR980-3), articulate specimen. (h) ventral view. (i) dorsal view. (j) anterior view. (k) MPUM10551(IR997-40), ventral valve, ventral view. (l–x) *Rossirhynchus adamantinus* Gaetani, 1964. Abrendan section. (l–m) MPUM10558(IR989-352), dorsal valve. (l) dorsal view. (m) anterior view. (n–p) MPUM10556(IR1041-2), articulate specimen. (n) ventral view. (o) dorsal view. (p) anterior view. (q–r) MPUM10557(IR1042-315), articulate specimen. (q) ventral view. (r) dorsal view. Simeh Kuh section. (s–u) MPUM10555(S7A), articulate specimen. (s) ventral view. (t) dorsal view. (u) anterior view. (v–x) MPUM10573(S7D), articulate specimen. (v) ventral view. (w) dorsal view. (x) anterior view.(y–aa) *Paraphorhynchus* aff. *P. elongatum* Weller, 1905. Abrendan section. MPUM10562(IR980-8), articulate specimen. (y) ventral view. (z) dorsal view. (aa) anterior view. (bb–cc) *?Athyris* sp. ind. Abrendan section. MPUM10574(IR998-314), articulate specimen. (bb) ventral view. (cc) dorsal view. (dd–gg) *Lamellosathyris lamellosa* (Léveillé, 1835). Simeh Kuh section. (dd–ee) MPUM10579(S37F), articulate specimen. (dd) ventral view. (ee) dorsal view. (ff–gg) MPUM10580(S37G), articulate specimen. (ff) ventral view. (gg) dorsal view. (hh–oo) *Cleiothyridina kusbassica* Beznosova in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963. Abrendan section. (hh–ii) MPUM10563(IR984-150), articulate specimen. (hh) ventral view. (ii) dorsal view. (jj–kk) MPUM10564(IR989-366), articulate specimen. (jj) ventral view. (kk) dorsal view. (ll–mm) MPUM10565(IR998-1), articulate specimen. (ll) ventral view. (mm) dorsal view. Simeh Kuh section. (nn–oo) MPUM10566(S17A), articulate specimen. (nn) ventral view. (oo) dorsal view. (pp–rr) *?Cleiothyridina* sp. ind. Simeh Kuh section. MPUM10581(S11A), articulate specimen. (pp) ventral view. (qq) dorsal view. (rr) anterior view. (ss–vv) *Gerankalasiella* sp. ind. Simeh Kuh section. (ss–tt) MPUM10570(S18C), articulate specimen. (ss) ventral view. (tt) dorsal view. (uu–vv) MPUM10571(S20D), articulate specimen. (uu) ventral view. (vv) dorsal view. All figures X 1. Scale bar 10 mm.

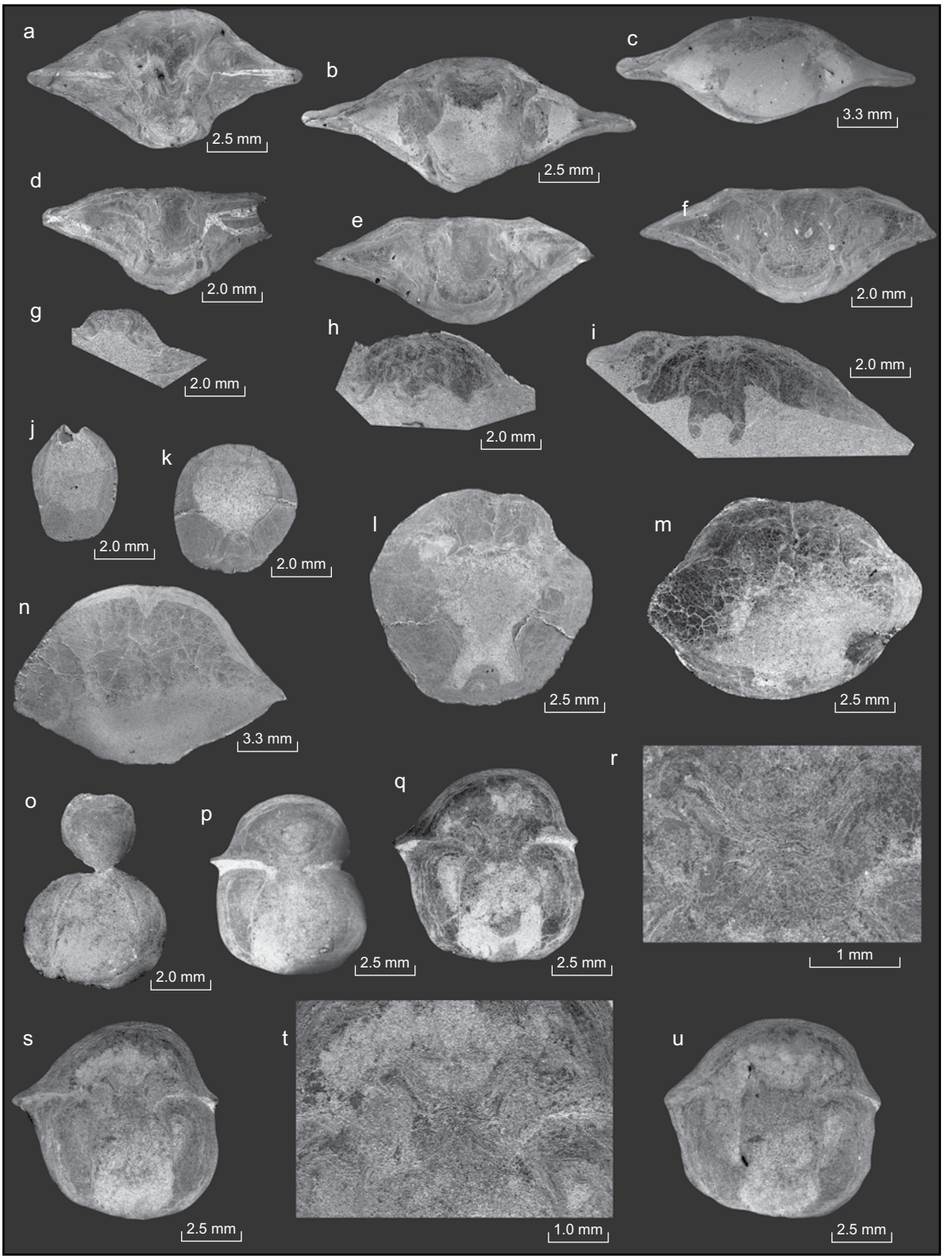

Figure 9: (a–f) *Rhipidomella michelini* (Léveillé, 1835). Abrendan section. (a–c) MPUM10667(IR989-342), transverse sections of an articulate specimen at (a) 3.2 mm, X4, (b) 3.9 mm, X4, (c) 5.6 mm, X3, from the umbo. (d–f) MPUM10668(IR989-345), transverse sections of an articulate specimen at (d) 2.4 mm, X5, (e) 3.1 mm, X5, (f) 6.7 mm, X5, from the umbo. (g–n) *Hemiplethorhynchus crassus* Gaetani, 1968. Abrendan section. (g–i) MPUM10669(IR994-2), transverse sections of an articulate specimen at (g) 0.6 mm, X5, (h) 1.2 mm, X5, (i) 2.7 mm, X5, from the umbo. (j–n) MPUM10670(IR997-307), transverse sections of an articulate specimen at (j) 0.6 mm, X5, (k) 0.9 mm, X5, (l) 1.7 mm, X5, (m) 6.7 mm, X4, (n) 8.1 mm, X3, from the umbo.

See facing page for continuation.

Rhipidomella tenuicostata Weller, 1914, which is smaller, has a weaker radial ornamentation and a robust median ridge extending anteriorly from the cardinal process; *Rhipidomella burlingtonensis* (Hall, 1858), which is larger and has a ventral sulcus.

Rhipidomella kusbassica Beznosova, 1963 in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963, from the Tournaisian – Visean of Siberia (Beznosova in Sarytcheva et al., 1963; Gretchischnikova, 1966), differs by its angular cardinal extremities and the lower number of costellae.

Rhipidomella prolifica Legrand-Blain in Mottequin and Legrand Blain, 2010, from the Tournaisian of Mouydir (Algeria) is a very characteristic minute species with a small muscle field and a thick and broad dorsal median ridge. *R. michelini*? from the Early Carboniferous of Australia (Roberts, 1971), and *R. michelini*? from the early Carboniferous of SW China (Shi et al., 2005), have different internal characters and a different number of costellae than the typical *R. michelini*.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section.

Selected previous records: Tournaisian, North Iran (Gaetani, 1968; Ahmadzadeh Heravi, 1971); Tournaisian, Belgium (Demanet, 1923, 1934); Tournaisian – Visean, British Isles (Brunton, 1968; Bassett and Bryant, 2006; Mottequin, 2010); late Visean, Poland (Żakowa, 1989); Tournaisian, Russia (Sarytcheva and Sokolskaya, 1952); Mississippian, South China (Sun and Baliński, 2008).

Superfamily ENTELETOIDEA Waagen, 1884
Family SCHIZOPHORIIDAE Schuchert and LeVene, 1929

Genus *Schizophoria* King, 1850
Subgenus *Schizophoria* (*Schizophoria*) King, 1850

Type species: *Conchyliolithus (Anonimites) resupinatus* Martin, 1809 from the Visean of UK.

Schizophoria (Schizophoria) resupinata (Martin, 1809) (Figure 7, f–g)

1809 *Conchyliolithus (Anomites) resupinatus* Martin: pl. 49; figs 13–14.
1850 *Schizophoria resupinata* – King: p. 106.
1952 *Schizophoria resupinata* – Sarytcheva and Sokolskaya: p. 29; pl. 2, fig. 12.
1963 *Schizophoria resupinata* – Beznosova in Sarytcheva et al.: p. 77; pl. 3, figs 5–8, text-fig. 24.
1968 *Schizophoria resupinata* – Pocock: p. 80; pl. 18, fig. 7, text-figs 13–15.
1976 *Schizophoria (Schizophoria) resupinata* – Lazarev: p. 102; pl. 2, figs 3–4, pl. 3, figs 1–5, text-fig. 58.
2000b *Schizophoria (Schizophoria) resupinata* – Harper in Williams et al.: p. 840; figs 612a–f.
2006 *Schizophoria resupinata* – Bassett and Bryant: p. 504; pl. 6, figs 1–10, pl. 7, figs 1–16, text-figs 6–7.
2008 *Schizophoria (Schizophoria) resupinata* – Sun and Baliński: p. 521; fig. 27, F–L.
2010 *Schizophoria resupinata* – Mottequin: p. 259; pl. 2, figs 12–13; text-fig. 13.

Material: four articulated specimens: MPUM10547(IR1012-37; IR1040-303; IR1042-311); MPUM10548(IR1042-26); one internal mould of an articulated specimen: MPUM10549(IR1040-4).

Description: Medium to large sized shell, dorsibiconvex with transverse oval outline; maximum width: 25.3–36.9 mm, corresponding length: 19.3–28.2 mm; anterior commissure uniplicate. Ventral valve resupinate, convex posteriorly, flate to concave anteriorly; interarea, narrow apsacline; sulcus absent. Dorsal valve very convex, flattened in its median part. Ornamentation of costellae increasing by intercalation, numbering 25 per 5 mm at 5 mm from the umbo and 13 per 5 mm at the anterior margin; rare growth lamellae. Interior of ventral valve with long, petaloid diductor scars, delimited by a narrow ridge and widening anteriorly.

Figure 9 (continued): (o–u) *?Athyris* sp. ind. Abrendan section. MPUM10671(IR989-357), transverse sections of an articulate specimen at (o) 1.2 mm, X5, (p) 2.5 mm, X4, (q) 3.1 mm, X4, (r) 3.1 mm, X15, (s) 4.2 mm, X4, (t) 4.2 mm, X10, (u) 5.4 mm, X4, from the umbo.

Dimensions (in mm):

	Width	Length	Thickness
IR1040-4	33.2	28.2	
IR1040-303	36.9	26.0	17.2
IR1042-26		22.3	13.0
IR1042-311	25.3	19.3	11.1

Remarks: The present specimens fit with the description of *Schizophoria (Schizophoria) resupinata* (Martin, 1809) given by Bassett and Bryant (2006). This species differs from *Schizophoria resupinata* var. *dorsosinuata* Demanet, 1934 by the absence of a dorsal sulcus and by the less numerous costellae. Several species have been described from the Mississippian of the United States by Weller (1914); of these similar to *S. resupinata* are *Schizophoria swallovi* (Hall, 1858), which however is larger and has wider muscle scars, and *Schizophoria sedaliensis* Weller, 1914, which has a uniformly convex ventral valve and a less transverse outline. *Schizophoria connivens* (Phillips, 1836), from the Early Carboniferous of UK is smaller, has a stronger ornamentation and a biplicate or uniplicate anterior commissure with subquadrate fold (Pocock 1968).

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Selected previous records: Tournaisian – Visean, UK (Brunton, 1968; Bassett and Bryant, 2006; Harper in Williams et al., 2000b); Tournaisian, Russia (Sarytcheva and Sokolskaya, 1952); Tournaisian – Visean, Siberia (Kusnetsk Basin) (Beznosova in Sarytcheva et al., 1963); Mississippian, South China (Sun and Baliński, 2008).

Order RHYNCHONELLIDA Kuhn, 1949
Superfamily RHYNCHOTREMATOIDEA Schuchert, 1913b
Family TRIGONIRHYNCHIIDAE Schmidt, 1965
Subfamily RIPIDIORHYNCHINAE Savage, 1996

Genus *Hemiplethorhynchus* von Peetz, 1898

Type species: *Hemiplethorhynchus fallax* von Peetz, 1898 from the late Tournaisian of Kusnetsk Basin.

Hemiplethorhynchus crassus Gaetani, 1968 (Figure 7, h–k; Figure 9, g–n)

1968 "*Hemiplethorhynchus" crassus* Gaetani: p. 702; pl. 50, figs 1–7, text-figs 6–8.

Material: seven articulated specimens: MPUM10550(IR980-3); MPUM10552(IR997-29; IR997-306; IR997-317; IR997-322); MPUM10669(IR994-2); MPUM10670(IR997-307); two ventral valves: MPUM10551(IR997-40); MPUM10553(IR998-61); one dorsal valve: MPUM10554(IR980-28).

Description: Small to medium sized, biconvex shell with subpentagonal outline, geniculated anteriorly; maximum width 18.2–23.9 mm, corresponding length 16.7–19.7 mm; anterior commissure strongly uniplicate. Ventral valve convex with swollen umbo; median sulcus starting at mid-length, quite deep anteriorly where it is sharply bent towards the dorsal valve; sulcal flanks at 45°. Dorsal valve thick as the ventral one; fold starting at mid-length with steep flanks. Ornamentation of rounded costae with wide interspaces starting at the umbo and becoming higher and wider anteriorly; they number 4–5 in the sulcus, 4–6 on the fold and 6–8 on each flank; accessory costae may originate on the sulcal flanks. Interior of ventral valve with deeply impressed muscle scars and bulbous myophragm. Interior of dorsal valve with a deep septalium and a long median septum extending to 2/3 of the length of the valve.

Ontogenetic variation: Juveniles show a more equidimensional profile and the absence of fold/sulcus which are instead quite strong anteriorly on the adults.

Dimensions (in mm):

	Width	Length	Thickness
IR980-3	18.2	16.7	9.5
IR994-2	23.9	19.7	7.9
IR997-40	21.4	18.3	

Remarks: *Hemiplethorhynchus crassus* Gaetani, 1968 is characterized by a strong intraspecific variability, which concerns the number of costae, the curvature of the umbo, the valve thickness, and by a marked ontogenetic variation with changes in the outline and in the depth of the fold and the sulcus.

Hemiplethorhynchus subovatum Carter, 1972, from the Mississippian of the USA is smaller, less biconvex and has more numerous lateral costae. *Hemiplethorhynchus fallax* von Peetz, 1898, from the Tournaisian of Siberia (Kusnetsk Basin) (Sokolskaya in Sarytcheva et al,. 1963), has a flatter ventral valve, a hook-like umbo and denser and more closely spaced costae.

Some incomplete specimens from the Tournaisian of Mouydir (Algeria) have been attributed to ? *Hemiplethorhynchus* sp. by Mottequin in Mottequin and Legrand Blain (2010).

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Selected previous records: Tournaisian, North Iran (Gaetani, 1968).

Superfamily CAMAROTOECHIOIDEA Schuchert in Schuchert and LeVene, 1929
Family LEIORHYNCHIDAE Stainbrook, 1945
Subfamily LEIORHYNCHINAE Stainbrook, 1945

Genus *Rossirhynchus* Gaetani, 1964

Type species: *Rossirhynchus adamantinus* Gaetani, 1964 from the Tournaisian of North Iran.

Rossirhynchus adamantinus Gaetani, 1964 (Figure 7, l-x; Figure 10)

1963 "*Camaratoechia*" ex gr. *C. baitalensis* – Gaetani in Assereto: p. 526.
1964 *Rossirhynchus adamantinus* Gaetani, p. 639, pl. 47, figs 1–6, text-figs 1–3.

Material: 18 articulated specimens: MPUM10555(S7A); MPUM10556(IR1041-2); MPUM10557(IR1042-315); MPUM10559(S4A; S4B; S4C; S6A; S6B; S6C; S6D; S6E; S6F; S6G; S7B; S7C; S7E; IR985-301); MPUM10573(S7D); five ventral valves: MPUM10560(IR980-309; IR980-18; IR1040-302; IR1040-306; IR1041-16); 11 dorsal valves: MPUM10558(IR989-352); MPUM10561(IR980-304; IR985-302A; IR985-302B; IR985-302C; IR980-303; IR989-426; IR1041-13; IR1041-301; IR1041-323; IR1044-304).

Description: Small sized, dorsi-biconvex shell with subpentagonal to oval outline; maximum width: 8.0–17.8 mm, corresponding length: 9.0–14.5 mm (Figure 10); anterior commissure strongly uniplicate; palintrope forming lanceolate areas at each side of the umbo. Ventral valve convex with recurved umbo projecting over the cardinal margin; ventral sulcus starting at 2/3 of the length, rapidly deepening anteriorly and sharply geniculated at the anterior margin forming a sulcal tongue; sulcal flanks inclined at 40° to the floor of the

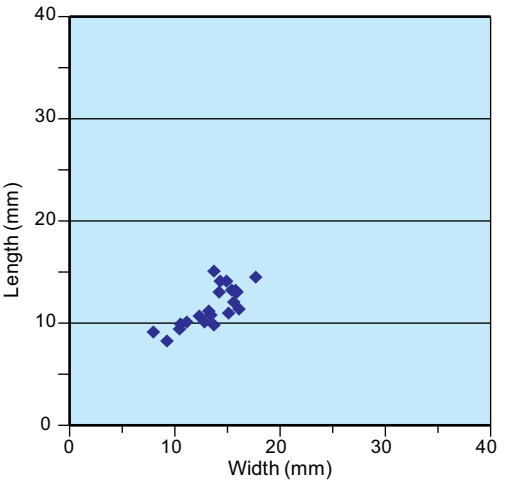

Figure 10: Width *versus* length diagram of *Rossirhynchus adamantinus*.

sulcus. Dorsal valve very convex with fold starting at 2/3 of the length of the valve, with steep flanks. Ornamentation of strong, rounded costae with narrow "V" shaped interspaces, starting at the umbo and numbering 2–3 in the sulcus, 3–4 on the fold, 5–9 on each flank; at 5 mm from the umbo the costae number 7–9 per 5 mm, whereas at 10 mm from the umbo the costae number 2.5 per 5 mm. Interior of ventral valve with thick dental plates; interior of dorsal valve with thin median septum and narrow, striated, and depressed adductor scars.

Ontogenetic variation: Juveniles are characterized by a more transverse subtriangular outline (Figure 10) and by finer costae. This is the character which shows the greatest variation during ontogeny, with costae rapidly increasing in width and height when the specimens attain a length of about 7 mm.

Dimensions (in mm):

	Width	Length	Thickness
IR980-304	17.8	14.5	
IR985-301	8.0	9.0	5.1
IR985-302B	10.5	9.3	
IR985-302C	9.3	8.1	
IR1041-2	14.4	14.1	12.7
IR1042-315	15.7	12.0	7.5
S4A	10.6	9.8	5.0
S4B	15.2	10.9	5.4
S4C	11.2	10.0	5.5
S6A	13.8	15.1	13.1
S6B	16.0	13.0	11.7

	Width	Length	Thickness
S6C	15.5	13.2	9.7
S6D	15.8	13.1	7.6
S6E	13.5	10.7	6.0
S6F	13.3	11.1	8.9
S6G	12.9	10.0	9.5
S7A	16.2	11.3	10.5
S7B	12.4	10.6	8.7
S7C	13.8	9.7	7.4
S7D	15.0	14.1	10.5
S7E	14.3	13.0	10.9

Remarks: The present specimens fit with the description and variability of *Rossirhynchus adamantinus* Gaetani, 1964.

Septemirostellum septimum (Veever, 1959), from the Devonian and Carboniferous of Bonaparte Basin, Australia (Roberts, 1971), is similar to *R. adamantinus*, but it has a less deep sulcus and a less projected sulcal tongue. From the same beds are *Septemirostellum amnicum* (Veever, 1959), which differs by its larger size, more elongated outline, wider costae, less convex dorsal valve and *Septemirostellum simplex* Roberts, 1971, which differs by its narrower and more elongated umbo and its less marked ornamentation.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section; AB-prefix specimens from scree of Abrendan section.

Selected previous records: Tournaisian, North Iran (Gaetani, 1964; Kebria-ee, 2005).

Superfamily RHYNCHOTETRADOIDEA Licharew in Rzhonsnitskaia, 1956
Family RHYNCHOTETRADIDAE Licharew in Rzhonsnitskaia, 1956
Subfamily AXIODEANEIINAE Savage, 1996

Genus *Paraphorhynchus* Weller, 1905

Type species: *Paraphorhynchus elongatum* Weller, 1905 from the Mississippian of the USA.

Paraphorhynchus aff. *P. elongatum* Weller, 1905 (Figure 7, y–aa)

Material: 1 articulated specimen with internal mould: MPUM10562(IR980-8).

Description: Medium size, biconvex shell with ovato-triangular outline; anterior commissure uniplicate and zig-zag; maximum width: 19.7 mm, corresponding length: 22.2 mm, thickness: 15.4 mm. Ventral valve convex with swollen umbo, projecting over the cardinal margin; umbonal flanks flat; ventral sulcus barely visible posteriorly, becoming deep and geniculated anteriorly; sulcal flanks inclined at 35° to the valve floor, which is raised posteriorly; sulcal tongue long, wide, rounded. Dorsal valve very convex, much more convex that the ventral one; dorsal fold high with steep flanks. Ornamentation poorly preserved of costae numbering 5 in the sulcus, 6 on the fold and 6 on each flank. Interior of ventral valve with long, divergent dental plates, extending along the sides of the sulcus.

Remarks: The present specimen fits with the diagnosis of *Paraphorhynchus elongatum* Weller, 1905, but it is smaller in size and it has a slightly greater number of costae in the sulcus/fold.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Selected previous records: Mississippian, USA (Missouri) (Weller, 1914).

Order ATHYRIDIDA Boucot, Johnson and Staton, 1964
Suborder ATHYRIDIDINA Boucot, Johnson and Staton, 1964
Superfamily ATHYRIDOIDEA Davidson, 1881
Family ATHYRIDIDAE Davidson, 1881
Subfamily ATHYRIDINAE Davidson, 1881

Genus *Athyris* McCoy, 1844

Type species: *Terebratula concentrica* von Buch, 1834 from the Middle Devonian of Germany.

?*Athyris* sp. ind. (Figure 7, bb–cc; Figure, 9o–u)

Material: seven articulated specimens: MPUM10574(IR998-314); MPUM10575(IR992-32; IR994-373; IR998-315; IR1045-32; IR989-359); MPUM10671(IR989-357); one fragment of ventral valve: MPUM10576(IR990-320); two dorsal valves: MPUM10577(IR997-55; IR998-316).

Description: Small to medium size, biconvex shell with subcircular to ovato-transverse outline; maximum width: 14.9–26.0 mm, corresponding length: 16.3–19.3 mm; anterior commissure rectimarginate, occasionally slightly uniplicate. Ventral valve very convex, without sulcus. Dorsal valve convex as the ventral one; median fold present only anteriorly. Poorly preserved ornamentation of growth lines and lamellae. Interior of ventral valve with dental plates and striated muscle field. Interior of dorsal valve with cardinal plate and narrow muscle field with an elongated, thin myophragm.

Dimensions (in mm):

	Width	Length	Thickness
IR1045-32	19.8	18.2	11.8
IR989-357	21.4	20.1	10.2
IR994-373	14.9	16.3	6.5
IR998-314	26.0	19.3	11.1
IR998-316	21.1	19.7	

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Genus *Lamellosathyris* Jin and Fang, 1983

Type species: *Spirifer lamellosus* Léveillé, 1835 from the late Tournaisian of Belgium.

Lamellosathyris lamellosa **(Léveillé, 1835)** (Figure 7, dd–gg; Figure 11, a–e)

1835 *Spirifer lamellosus* Léveillé: p. 39; pl. 2, figs 21–23.
1836 *Spirifer squamosa* – Phillips: p. 220; pl. 10, fig. 21.
1859 *Athyris lamellosa* – Davidson: p. 79; pl. 16, figs 1–1b.
1863 *Athyris lamellosa* – Davidson: p. 217; pl. 51, figs 14.
1887 *Athyris lamellosa* – de Koninck: p. 79; pl. 21, figs 1–5, ?figs 6–8, figs 11–12.
1914 *Athyris lamellosa* – Weller: p. 465; pl. 78, figs 1–5, figs 15–20.
1916 *Athyris lamellosa* – Frech: p. 236; pl. 3, fig. 2.
1937 *Athyris lamellosa* – Nalivkin: p. 124; pl. 39, figs 5–7.
1952 *Athyris lamellosa* – Sarytcheva and Sokolskaya: p. 233; pl. 69, fig. 404.
1965 *Athyris lamellosa* – Boucot, Johnson and Staton in Williams et al.: p. 662; fig. 537, 4 b–d.
1965 *Athyris lamellosa* – Wolfart: p. 301; pl. 41, fig. 1.
1968 *Athyris* ? *lamellosa* – Gaetani: p. 708; pl. 51, figs 1–3, text-fig. 9.
1971 *Athyris lamellosa* – Ahmadzadeh Heravi: p. 61; pl. 3, figs 5–7.
1980 *Actinoconchus lamellosus* – Brunton: p. 225; figs 15a–17.
1999 *Lamellosathyris lamellosa* – Carter: p. 121; figs 13 A–H, 14.
2002 *Lamellosathyris lamellosa* – Alvarez and Rong in Williams et al.: p. 1502; figs 1019.2a–2e; p. 1477, fig. 1002.4; p. 1485, fig. 1008.1.
2010 *Lamellosathyris lamellosa* – Mottequin: p. 262; pl. 3, figs 7–9, text-fig. 13.

Material: six articulated specimens: MPUM10633(S33D); MPUM10578(IR1042-313; S33C; S33E); MPUM10579(S37F); MPUM10580(S37G).

Description: Medium to large size, biconvex with transverse subpentagonal to semicircular outline; maximum width at the hinge or at mid-length: 22.8–52.0 mm, corresponding length: 18.6–41.3 mm; anterior commissure uniplicate. Ventral valve posteriorly convex, with stout, moderately recurved umbo; apical foramen subcircular; ventral sulcus starting at 3–4 mm from the umbo, deepening gradually until mid-length, then strongly deeper anteriorly. Dorsal valve thicker that the ventral one, uniformly convex, with anteriorly high fold. Ornamentation of coarse growth lamellae, with a thick rim at their anterior margin; weak rugae posteriorly. Interior of ventral valve with straight dental plates, slightly convergent to the valve floor; diductor scars more depressed than adductors. Interior of dorsal valve with strong and raised socket ridges, thick cardinal plate, thin myophragm.

Dimensions (in mm):

	Width	Length	Thickness
IR1042-313	52.0	41.3	17.8
S33C	22.8	18.6	9.8
S33E	32.6	22.6	8.5
S37F	38.7	28.5	21.8
S37G	39.4	29.0	16.0

Remarks: The present specimens fit with the description of *Lamellosathyris lamellosa* (Léveillé, 1835) given by Brunton (1980). The specimens described as *L. lamellosa* by Jin and Fang (1983) from the Mississippian of China (Yunnan) have not been placed in synonymy because they have no dental plates.

Lamellosathyris qaidamensis Chen, Shi and Zhan, 2003 from the Mississippian of NW China (Qaidam Basin) differs from *L. lamellosa* by its larger size, the less numerous growth lamellae, its wider and shallower sulcal tongue, the absence of a shallow dorsal sulcus, which is occasionally present in *L. lamellosa*.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section.

Selected previous records: Tournaisian, North Iran (Gaetani, 1968; Ahmadzadeh Heravi, 1971); late Tournaisian, Belgium (Brunton, 1980); Visean, British Isles (Davidson, 1859, Mottequin, 2010); late Tournaisian, Russia (Moscow Basin) (Sarytcheva and Sokolskaya,1952); Tournaisian, USA (Oklahoma, Louisiana, Missouri) (Carter, 1999).

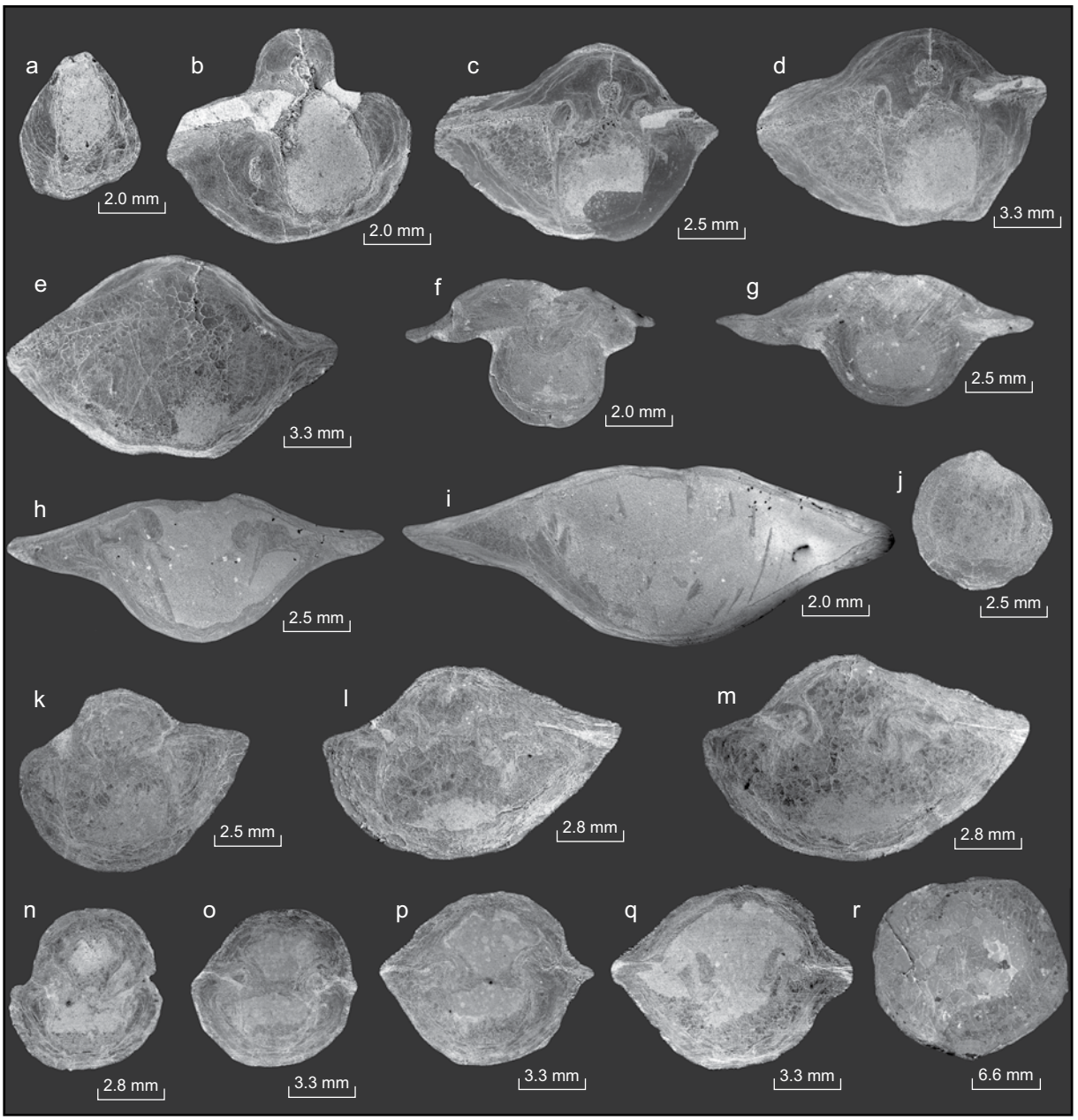

Figure 11: (a–e) *Lamellosathyris lamellosa* (Léveillé, 1835). Simeh Kuh section. MPUM10633(S33D), transverse sections of an articulate specimen at (a) 1.1 mm, X5, (b) 2.4 mm, X5, (c) 4.2 mm, X4, (d) 5.4 mm, X3, (e) 7.7 mm, X2.5, from the umbo. (f–o) *Cleiothyridina kusbassica* Beznosova in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963. Abrendan section. (f–i) MPUM10673(IR989-363), transverse sections of an articulate specimen at (f) 1.6 mm, X5, (g) 3.4 mm, X4, (h) 4.8 mm, X4, (i) 7.2 mm, X5, from the umbo. (j–m) Simeh Kuh section. MPUM10674(S20E), transverse sections of an articulate specimen at (j) 0.3 mm, X4, (k) 3.8 mm, X4, (l) 4.8 mm, X3.5, (m) 5.8 mm, X3.5, from the umbo. (n–r) *Gerankalasiella* sp. ind. Simeh Kuh section. (n–q) MPUM10675(S27B), transverse sections of an articulate specimen at (n) 2.1 mm, X3.5, (o) 2.7 mm, X3, (p) 3.3 mm, X3, (q) 4.1 mm, X3, from the umbo. (r) MPUM10679(S27A), transverse section of an articulate specimen, X1.5.

Subfamily CLEIOTHYRIDININAE Alvarez, Rong and Boucot, 1998

Genus *Cleiothyridina* Buckman, 1906

Type species: *Atrypa pectinifera* Sowerby, 1840 in 1840–1846, from the Guadalupian of UK.

Cleiothyridina kusbassica Beznosova in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963 (Figure 7, hh–oo; Figure 11, f–m)

1924 *Cliothyris royssi* – Tolmatchoff: p. 143; pl. 7, figs 14–15.
1963 *Cleiothyridina kusbassica* Beznosova in Sarytcheva et al.: p. 319; pl. 60, figs 5–7.
1965 *Cleiothyridina kusbassica* – Gaetani: p. 745; pl. 74, figs 5–6.
1968 *Cleiothyridina kusbassica* – Gaetani: p. 711; pl. 49, figs 6–7.
1971 *Cleiothyridina deroissyi* – Ahmadzadeh Heravi: p. 62; pl. 2, figs ?18-?19-20-21-?22.

Material: 20 articulated specimens: MPUM10563(IR984-150); MPUM10564(IR989-366); MPUM10565-(IR998-1); MPUM10566(S17A); MPUM10567(IR984-36; IR989-37; IR989-82; IR989-362; IR989-364; IR989-365; IR989-406; IR994-368; IR1042-301; S10B; S17B; S18A; S35A; S35B; S40B); MPUM10673(IR989-363); MPUM10674(S20E); four ventral valves: MPUM10568(IR988-2; IR989-434A; IR992-318; IR993-15); four dorsal valves: MPUM10569(IR989-46; IR989-436; IR989-437B; IR994-49).

Description: Small to medium size, biconvex, with subcircular to transversally oval outline; maximum width: 13.0–26.1 mm, corresponding length: 10.4–22.0 mm; anterior commissure rectimarginate. Ventral valve only slightly convex with pointed umbo; sulcus absent. Ornamentation of dense growth lamellae forming wide, flat, solid spines, which can reach a length of 3.5 mm. Interior of ventral valve with arcuate dental plates and low myophragm dividing weakly impressed muscle scars. Interior of dorsal valve with prominent socket ridges, cardinal plate medianly depressed with reduced cardinal flanges; low myophragm; narrow muscle field; laterally directed spiralia with about 11 whorls.

Intraspecific variability: There is a considerable variability for what concerns the angle of divergence of the umbonal flanks (from 90° to 170°), the outline, and the width of the cardinal margin.

Dimensions (in mm):

	Width	Length	Thickness
IR984-150	18.0	14.0	6.8
IR988-2	23.0	21.3	
IR989-37	12.6	13.1	2.6
IR989-46	20.9	16.3	
IR989-82	14.2	11.1	5.0
IR989-362	14.4	11.2	5.1
IR989-363	21.0	16.3	6.0
IR989-364	22.9	18.4	
IR989-366	20.8	16.9	7.0
IR989-406	14.6	12.7	7.6
IR989-436	22.7	20.0	4.9

	Width	Length	Thickness
IR989-437B	23.0	15.0	
IR993-15	20.0	20.0	
IR998-1	24.5	21.2	10.3
IR1042-301	13.0	10.4	5.7
S10B	19.4	19.2	
S17A	26.1	22.0	7.5
S17B	24.6	21.0	9.9
S18A	19.1	16.0	5.6
S20E	26.0	21.6	12.2
S35A	20.6	17.4	9.3
S35B	27.0	21.9	14.6

Remarks: The present specimens belong to *Cleiothyridina kusbassica* Beznosova in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963.

Cleiothyridina deroissyi (Léveillé, 1835), from the late Tournaisian of Belgium (Tournai) differs by its larger size, deep sulcus and evident sulcal tongue. The specimens described as *Cleiothyridina deroissyi* from the Tournaisian of North Iran by Ahmadzadeh Heravi (1971) are better placed in *C. kusbassica*.

Cleiothyridina tomiensis Beznosova in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963, from the Tournaisian of Siberia (Kusnetsk basin) (Beznosova in Sarytcheva et al., 1963) differs by its weak sulcus and the rare growth lamellae. *Cleiothyridina fimbriata* (Phillips, 1836), from the late

Visean of County Fermanagh (Ireland) (Brunton, 1980), is smaller and has a more recurved ventral umbo. *Cleiothyridina glenparkensis* Weller, 1914, from Missouri, is similar but differs by its weak ventral sulcus. *Cleiothyridina gloveri* Thomas, 1971, from the early Tournaisian of Australia has a much stronger convexity. *Cleiothyridina minilya* Thomas, 1971, from the Tournaisian – Visean of Australia differs by its larger size, subpentagonal outline and a deep sulcus.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section.

Selected previous records: Tournaisian, North Iran (Gaetani, 1965; 1968); Tournaisian, Siberia (Kuzbass and Kusnetsk Basins) (Beznosova in Sarytcheva et al., 1963).

?*Cleiothyridina* sp. ind. (Figure 7, pp–rr)

Material: one articulated specimen: MPUM10581(S11A).

Description: Small sized, ventri-biconvex shell with suboval outline, posteriorly rounded; maximum width: 21.9 mm, length: 18.8 mm, thickness: 12.9 mm; anterior commissure uniplicate; cardinal margin straight corresponding to half the width of the shell. Ventral valve convex, with swollen umbonal region; umbo short, stout with apical foramen; ventral sulcus shallow, wide occurring only anteriorly and forming a short sulcal tongue with subrectangular section. Dorsal valve less convex; dorsal fold only anteriorly. Ornamentation of distinct growth lamellae, regularly arranged forming concentric bands with denser lamellae at their anterior edge.

Remarks: The specimen is well preserved and has been dubitatively placed in the genus *Cleiothyridina* based on its ornamentation. It differs from *C. kusbassica* by the occurrence of a ventral sulcus, its uniplicate anterior commissure and its greater convexity.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Simeh Kuh section.

Genus *Gerankalasiella* Gretchischnikova, 1996

Type species: *Gerankalasiella gerankalasiensis* Gretchischnikova, 1996 from the Tournaisian of Transcaucasia.

Remarks: Alvarez and Rong in Williams et al. (2002) consider *Gerankalasiella* a synonym of *Cleiothyridina*, together with *Cleiothyridellina* Waterhouse, 1978 and *Kjarkiella* Gretchischnikova, 1996, as in fact these genera share several external characters. However, *Cleiothyridellina* has a much more inflated shell, a flat cardinal plate and a short and low median septum; *Kjarkiella* has a large size, very convex valves and dense growth lamellae divided along their edges; *Gerankalasiella* has longer growth lamellae and spiralia with a greater number of coils.

Gerankalasiella sp. ind. (Figure 7, ss–vv; Figure 11, n–r)

Material: six articulated specimens: MPUM10570(S18C); MPUM10571(S20D); MPUM10572(S18B; S40A); MPUM10675(S27B); MPUM10679(S27A).

Description: Medium sized, biconvex shell with transverse ovoidal to semicircular outline; maximum width: 21.3–25.3 mm, corresponding length: 19.6–21.5 mm; anterior commissure rectimarginate. Ventral valve with swollen umbo, recurved on the cardinal margin; ventral sulcus absent. Dorsal valve similar to the ventral one. Ornamentation of dense and long growth lamellae, with coarser ones occurring at regular intervals, bearing flat spines along their anterior edge. Interior of ventral valve with bow-like dental plates and a low myophragm dividing large, depressed muscle fields. Interior of dorsal valve with prominent socket ridges, cardinal plate depressed dorsally, robust cardinal flanges, low myophragm, narrow muscle field, spiralia with about 14 coils.

Dimensions (in mm):

	Width	Length	Thickness
S18B	22.1	18.2	5.6
S18C	23.0	17.3	6.8
S20D	25.3	21.5	10.5
S27A	22.0	18.4	11.7
S27B	21.3	19.6	10.5

Remarks: These specimens have been placed in *Gerankalasiella* and not in *Cleiothyridina* because of the distinct and long growth lamellae of which some are coarser and regularly spaced, their transverse outline, and their spiralia with numerous coils.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Simeh Kuh section.

Genus *Carteridina* Alvarez, Rong and Boucot, 1998

Type species: *Spirigera prouti* Swallow, 1860 from the Tournaisian of the USA.

Remarks: *Carteridina* differs from *Cleiothyridina* by its strongly uniplicate anterior commissure, its larger size, and the absence of dental plates and myophragm.

Carteridina sp. ind. (Figure 12, a–c)

Material: one articulated specimen with internal mould partially preserved: MPUM10582 (S33B).

Description: Large sized, ventribiconvex shell with transverse subpentagonal outline; maximum width at mid-length: 40.4 mm, corresponding length: 34.7 mm, thickness: 21.6 mm; anterior commissure uniplicate; cardinal extremities rounded. Ventral valve very convex, with swollen, recurved umbo; ventral sulcus shallow, deep anteriorly. Dorsal valve less convex than the ventral one; dorsal fold, higher anteriorly. Ornamentation of dense and thin growth lamellae bearing fine and flat spines set at low angle to the external surface. Interior of ventral valve with no plates.

Remarks: The present specimen has been placed in the genus *Carteridina* because of its large size, transverse outline and the absence of dental plates and myophragm in the ventral valve. *Carteridina prouti* (Swallow, 1860) is smaller and it has a more strongly uniplicate anterior commissure.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Simeh Kuh section.

Subfamily SPIRIGERELLINAE Grunt, 1965

Genus *Composita* Brown, 1845

Type species: *Spirifer ambiguus* Sowerby, 1822 in 1821–1822 from the Visean of UK.

Remarks: Three genera of the subfamily Spirigerellinae are similar to *Composita* Brown, 1845: *Iniathyris* Beznosova in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963, which differs by the stronger sulcal tongue, the more swollen umbo, the thicker dental plates and the more impressed muscle fields; *Posicomta* Grunt, 1986, which however is much smaller and has no sulcus or fold; *Tulathyris* Grunt, 1976 which is significantly smaller, has a thinner shell substance and a subtriangular cardinal plate.

Composita megala (Tolmatchoff, 1924) (Figure 12, d–l; Figure 13, a–h)

1924 *Seminula megala* Tolmatchoff: p. 137; pl. 6, figs 27–32.
1962 *Composita megala* – Beznosova in Beznosova et al.: p. 181; pl. C-23, fig. 3.
1963 *Composita megala* – Beznosova in Sarytcheva et al.: p. 322; pl. 61, figs 5–9, text-figs 144–145.
1968 *Composita megala* – Gaetani: p. 713; pl. 51, figs 4–6, text-fig. 11.

Material: 16 articulated specimens: MPUM10583(IR1042-24); MPUM10584(IR1042-302); MPUM10585(IR1042-303); MPUM10586(IR989-35; IR989-113; IR1041-17; IR1042-25; IR1042-27; IR1042-30; IR1042-304; IR1040-310; IR1041-46; IR1041-302; IR1041-313; IR1041-314; IR1041-316); three ventral valves: MPUM10587(IR998-359; IR1041-40; IR1041-318).

Description: Medium to large sized, biconvex to ventri-biconvex shell with subpentagonal to ovatotriangular outline; maximum width: 20.0–28.7 mm, corresponding length: 22.3–34.8 mm; anterior commissure uniplicate. Ventral valve very thick and convex with swollen umbo with large epithyrid foramen; ventral sulcus wide, starting at 1/3 of the length, rapidly deepening anteriorly to form a prominent sulcal tongue, anteriorly projecting with an "U" shaped cross section; the sulcus is delimited by two anteriorly diverging folds. Dorsal valve slightly less convex than the ventral valve; median fold starting from the umbo, becoming very high at the anterior commissure. Ornamentation of dense growth lamellae. Interior of ventral valve with anteriorly diverging dental plates. Interior of dorsal valve with cardinal plate and an elongated oval muscle fields separated by a thin myophragm.

Dimensions (in mm):

	Width	Length	Thickness
IR1042-24	23.0	24.6	17.9
IR1042-25	28.8	34.8	24.2
IR1042-27	20.0	22.3	16.0
IR1042-302	25.3	31.2	20.9
IR1042-303	21.7	24.5	15.8

Remarks: *Composita megala* (Tolmatchoff, 1924) differs from *Composita oblonga* (Tolmatchoff, 1924), from the Tournaisian of Siberia (Beznosova in Sarytcheva et al., 1963), because of its thick shell substance and deeper sulcus forming a prominent sulcal tongue.

Among the Australian species described by Thomas (1971), *Composita hendersoni* Thomas, 1971 has a ventral sulcus starting from the umbo, whereas *Composita carnarvonensis* Thomas, 1971 and *Composita bonapartensis* Thomas, 1971 have poorly expressed fold and sulcus and no sulcal tongue.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. Abrendan section.

Selected previous records: Tournaisian, North Iran (Gaetani, 1968); Tournaisian, Siberia (Beznosova in Sarytcheva et al., 1963).

Composita subquadrata **(Hall, 1858)** (Figure 12, m–x; Figure 13, i–m)

1858 *Athyris subquadrata* Hall: p. 703; pl. 27, figs 2a–2d, text-fig. 118.
1894 *Athyris subquadrata* – Keyes: p. 92.
1914 *Composita subquadrata* – Weller: p. 489; pl. 81, figs 1–15.

Material: 16 articulated specimens: MPUM10588(IR989-367; IR1042-3; IR1042-43; IR1042-317; IR1044B-23; IR1044B-27; IR1041-319; IR1042-49; IR1042-305); MPUM10588bis(IR1042-316); MPUM10591(IR1041-4); MPUM10592(IR1041-47); MPUM10593(IR1044-33); MPUM10594(IR1042-35); MPUM10676(IR1044-305); MPUM10595(IR1044B-12); one ventral valve: MPUM10589(R1041-32); one dorsal valve: MPUM10590(IR1041-53).

Description: Medium to large sized, ventri-biconvex shell with subpentagonal outline; maximum width: 19.8–31.2 mm, corresponding length: 20.1–28.4 mm; anterior commissure uniplicate. Ventral valve very thick and convex with swollen umbo, projecting posteriorly and perforated by a large epithyrid foramen; ventral sulcus wide, starting from 1/3 of the length, deepening only slightly anteriorly and forming a wide sulcal tongue, which is not very deep nor projecting much anteriorly, with subrectangular cross section; anteriorly the sulcus is bounded by two low folds. Dorsal valve less convex than the ventral one, with low fold, becoming higher anteriorly. Ornamentation of dense growth lamellae. Interior of ventral valve with long, divergent dental plates. Interior of dorsal valve with deeply impressed, narrow and elongated muscle fields, divided by a myophragm and delimited by ridges.

Figure 12: (a–c) ***Carteridina*** **sp. ind. Simeh Kuh section. MPUM10582(S33B), articulate specimen. (a) ventral view. (b) dorsal view. (c) anterior view. (d–l)** ***Composita megala*** **(Tolmatchoff, 1924). Abrendan section. (d–f) MPUM10583(IR1042-24), articulate specimen. (d) ventral view. (e) dorsal view. (f) anterior view. (g–i) MPUM10584(IR1042-302), articulate specimen. (g) ventral view. (h) dorsal view. (i) anterior view. (j–l) MPUM10585(IR1042-303), articulate specimen. (j) anterior view. (k) ventral view.**

See facing page for continuation.

Dimensions (in mm):

	Width	Length	Thickness
IR989-367	26.4	24.2	
IR1041-4	29.2	29.1	19.2
IR1041-47	30.0	31.2	20.4
IR1042-3	26.2	24.0	15.4
IR1042-35	31.2	28.4	
IR1042-43	27.3	29.5	
IR1042-316	19.8	20.1	10.6

	Width	Length	Thickness
IR1042-317	26.3	25.7	17.9
IR1044-33	29.8	31.3	
IR1044-305	26.3	24.8	14.0
IR1044B-12	22.7	23.2	15.0
IR1044B-23	21.8	23.5	
IR1044B-27	20.8	20.1	13.5

Remarks: *Composita subquadrata* (Hall, 1858) differs from *C. megala* by its more convex ventral valve, its equidimensional outline, a shallower sulcus, a less prominent sulcal tongue with a subrectangular cross section, and lower plicae bounding the sulcus.

Composita ambigua (Sowerby, 1822), from the Tournaisian – Visean of UK, Belgium, China and Russia (Chen et al., 2003), has an equidimensional shape similar to *C. subquadrata*, but differs by the occurrence of a narrow furrow in the ventral sulcus and more divergent ventral plicae. *Composita sulcata* Weller, 1914, from the Mississippian of the USA, has also a similar outline, but it differs by its high and prominent dorsal fold and its "U" shaped sulcal tongue.

Among the Australian species, *Composita hendersoni* Thomas, 1971 has a ventral sulcus and a dorsal fold which start from the umbo, whereas *Composita carnarvonensis* Thomas, 1971 and *Composita bonapartensis* Thomas, 1971 have a different outline and poorly expressed fold and sulcus.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Selected previous records: Mississippian, USA (Illinois).

Composita cf. *C. caimaensis* Chen, Tazawa, Shi and Matsuda, 2005 (Figure 12, y–dd)

Material: 3 articulated specimens: MPUM10596(S10A); MPUM10597(S11B); MPUM10598(S33A).

Description: Medium to large sized, biconvex shell with subcircular to transverse oval outline; maximum width: 22.7–27.1 mm, corresponding length: 21.2–27.2 mm; anterior commissure uniplicate. Ventral valve uniformly convex with swollen and recurved umbo; permesothyrid foramen; ventral sulcus only in the anterior third of the valve, forming a wide sulcal tongue with an "U" shaped cross section. Dorsal valve slightly less convex than the ventral one; median fold present only at the anterior margin. Ornamentation of growth lamellae and rare and weak radial striae.

Figure 12 (continued): (l) dorsal view. (m–x) *Composita subquadrata* (Hall, 1858). Abrendan section. (m–n) MPUM10591(IR1041-4), articulate specimen. (m) ventral view. (n) dorsal view. (o–p) MPUM10592(IR1041-47), articulate specimen. (o) ventral view. (p) dorsal view. (q–r) MPUM10594(IR1042-35), articulate specimen. (q) ventral view. (r) dorsal view. (s–t) MPUM10588bis(IR1042-316), articulate specimen. (s) ventral view. (t) dorsal view. (u–v) MPUM10593(IR1044-33), articulate specimen. (u) ventral view. (v) dorsal view. (w–x) MPUM10595(IR1044B-12), articulate specimen. (w) ventral view. (x) dorsal view. (y–dd) *Composita* cf. *C. caimaensis* Chen, Tazawa, Shi and Matsuda, 2005. Simeh Kuh section. (y–aa) MPUM10597(S11B), articulate specimen. (y) ventral view. (z) dorsal view. (aa) anterior view. (bb–dd) MPUM10598(S33A), articulate specimen. (bb) ventral view. (cc) dorsal view. (dd) anterior view. (ee–hh) *Composita* aff. *C. pentagonia* (Weller, 1914). Abrendan section. (ee–gg) MPUM10600(IR1041-49), articulate specimen. (ee) ventral view. (ff) dorsal view. (gg) anterior view. (hh) MPUM10601(IR1041-304), incomplete articulate specimen, anterior view. All figures X 1. Scale bar 10 mm.

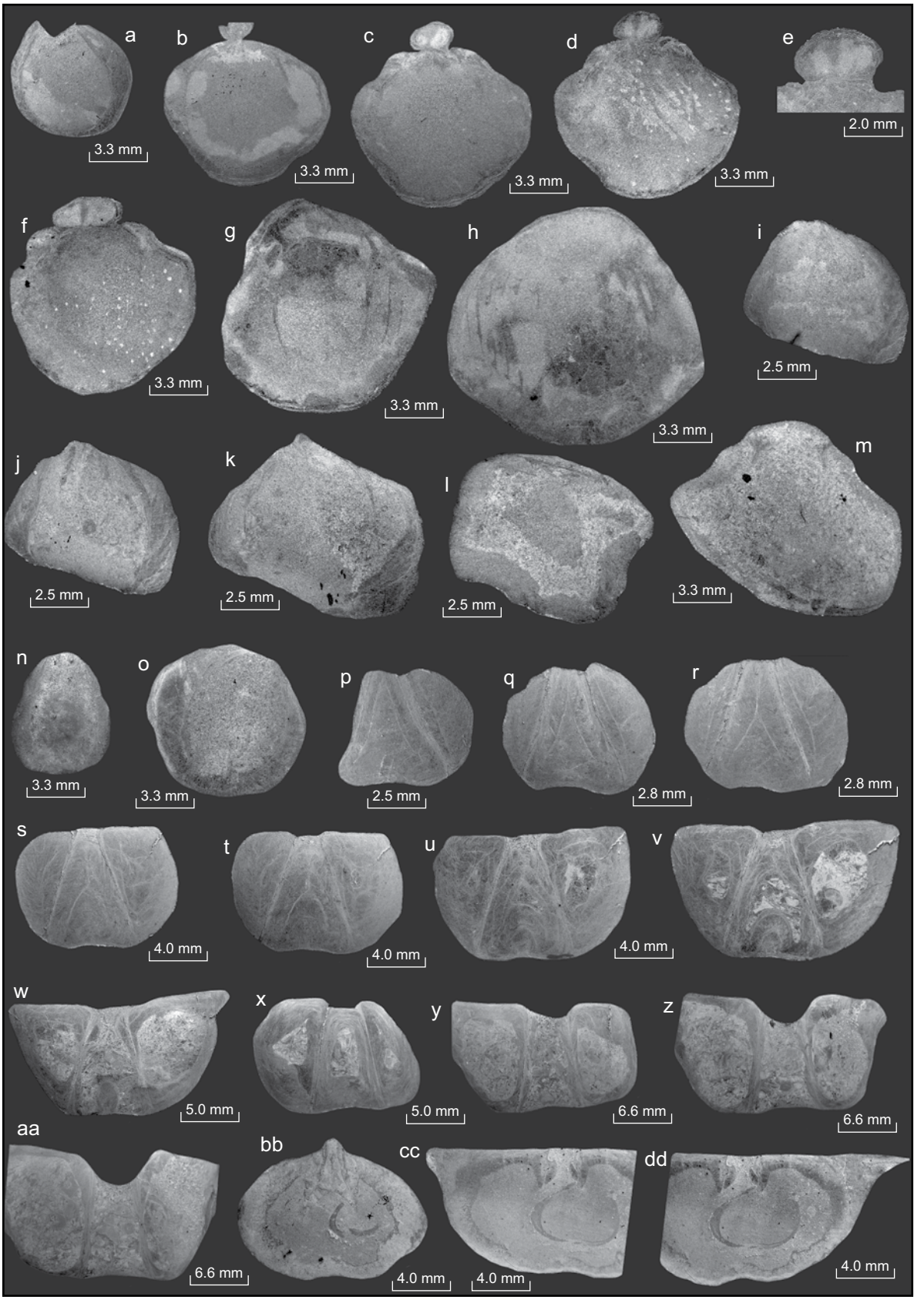

Figure 13: *See facing page for caption.*

Dimensions (in mm):

	Width	Length	Thickness
S10A	22.7	21.2	14.8
S11B	22.6	22.3	
S33A	27.1	27.2	16.2

Remarks: The present specimens are very similar to *Composita caimaensis* Chen, Tazawa, Shi and Matsuda, 2005 for their outline, the fold and sulcus restricted to the anterior region, and the depth of the sulcal tongue, but they differ slightly being larger and having a sulcal tongue with a characteristic "U" shaped section.

Composita matutina (Carter, 1988), from the Early Mississippian of the USA, is also similar, but it shows a sulcus and fold even more restricted anteriorly. *Composita athabaskensis* Warren, 1932, from the Mississippian of Canada (Carter, 1987), has a different outline and a shallower sulcal tongue. *Composita hendersoni* Thomas, 1971, from the Carboniferous of Australia shows a smaller size, a more variable outline and sulcus and fold starting more posteriorly.
The above described *C. subquadrata* and *C. megala* have a different outline and and more extended and pronounced fold and sulcus.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Simeh Kuh section.

Selected previous record: Late Mississippian, Brazil (Amazon basin) (Chen et al., 2005).

Composita aff. *C. pentagonia* (Weller, 1914) (Figure 12, ee–hh; Figure 13, n–o; Figure 14, a–c)

Material: eight articulated specimens: MPUM10599(IR1041-42; IR1042-19; IR1041-48; IR1041-111; IR1041-303); MPUM10600(IR1041-49); MPUM10601(IR1041-304); MPUM10602(IR1041-306).
Description: Medium to large sized, biconvex shell with subpentagonal outline; maximum width: 25.5–26.5 mm, corresponding length: 26.5–27.8 mm, thickness: 21.1 mm; anterior commissure strongly uniplicate. Ventral valve very thick and convex with swollen umbo, projecting posteriorly; large sulcus starting at mid-length, rapidly deepening anteriorly and forming a prominent and wide sulcal tongue, with "U" shaped cross section; sulcus delimited by two prominent plicae very high anteriorly. Dorsal valve as convex as the ventral valve; fold starting from the umbo and increasing in height anteriorly; lateral plicae very evident. Ornamentation of growth lamellae. Interior of ventral valve with long, slightly divergent dental plates; muscle field narrow, very impressed, with thin myophragm. Interior of dorsal valve with a low myophragm.

Remarks: The present specimens are very similar to *Composita pentagonia* (Weller, 1914), in all of the external features, but they differ by the absence of a median furrow along the fold and the sulcus.

Figure 13 (facing page): (a–h) *Composita megala* (Tolmatchoff, 1924). Abrendan section. MPUM10585(IR1042-303), transverse sections of an articulate specimen at (a) 1.1 mm, X3, (b) 2.1 mm, X3, (c) 3.5 mm, X3, (d) 4.2 mm, X3, (e) 4.2 mm, X5, (f) 4.9 mm, X3, (g) 6.1 mm, X3, (h) 6.8 mm, X3, from the umbo. (i–m) *Composita subquadrata* (Hall, 1858). Abrendan section. MPUM10676(IR1044-305), transverse sections of an articulate specimen at (i) 2.1 mm, X4, (j) 2.9 mm, X4, (k) 3.7 mm, X4, (l) 5.2 mm, X3, (m) 6.4 mm, X3, from the umbo. (n–o) *Composita* aff. *C. pentagonia* (Weller, 1914). Abrendan section. MPUM10600(IR1041-49), transverse sections of an articulate specimen at (n) 1.2 mm, X3, (o) 2.4 mm, X3, from the umbo. (p–aa) *Ectochoristites* sp. ind. Abrendan section. (p–w) MPUM10677(IR1041-24), transverse sections of a ventral valve at (p) 0.9 mm, X4, (q) 1.3 mm, X3.5, (r) 1.8 mm, X3.5, (s) 3.2 mm, X2.5, (t) 3.8 mm, X2.5, (u) 4.9 mm, X2.5, (v) 5.6 mm, X2.5, (w) 6.3 mm, X2, from the umbo. (x–aa) MPUM10678(IR1044-37), transverse sections of a ventral valve at (x) 1.2 mm, X2, (y) 2.5 mm, X1.5, (z) 5.0 mm, X1.5, (aa) 5.9 mm, X1.5, from the umbo. (bb–dd) *Unispirifer (Unispirifer) striatoconvolutus* (Benson and Dun in Benson, Dun and Browne, 1920). Abrendan section. MPUM10681(IR994-335), transverse sections of a ventral valve at (bb) 2.3 mm, X2.5, (cc) 4.6 mm, X2.5, (dd) 4.5 mm, X2.5, from the umbo.

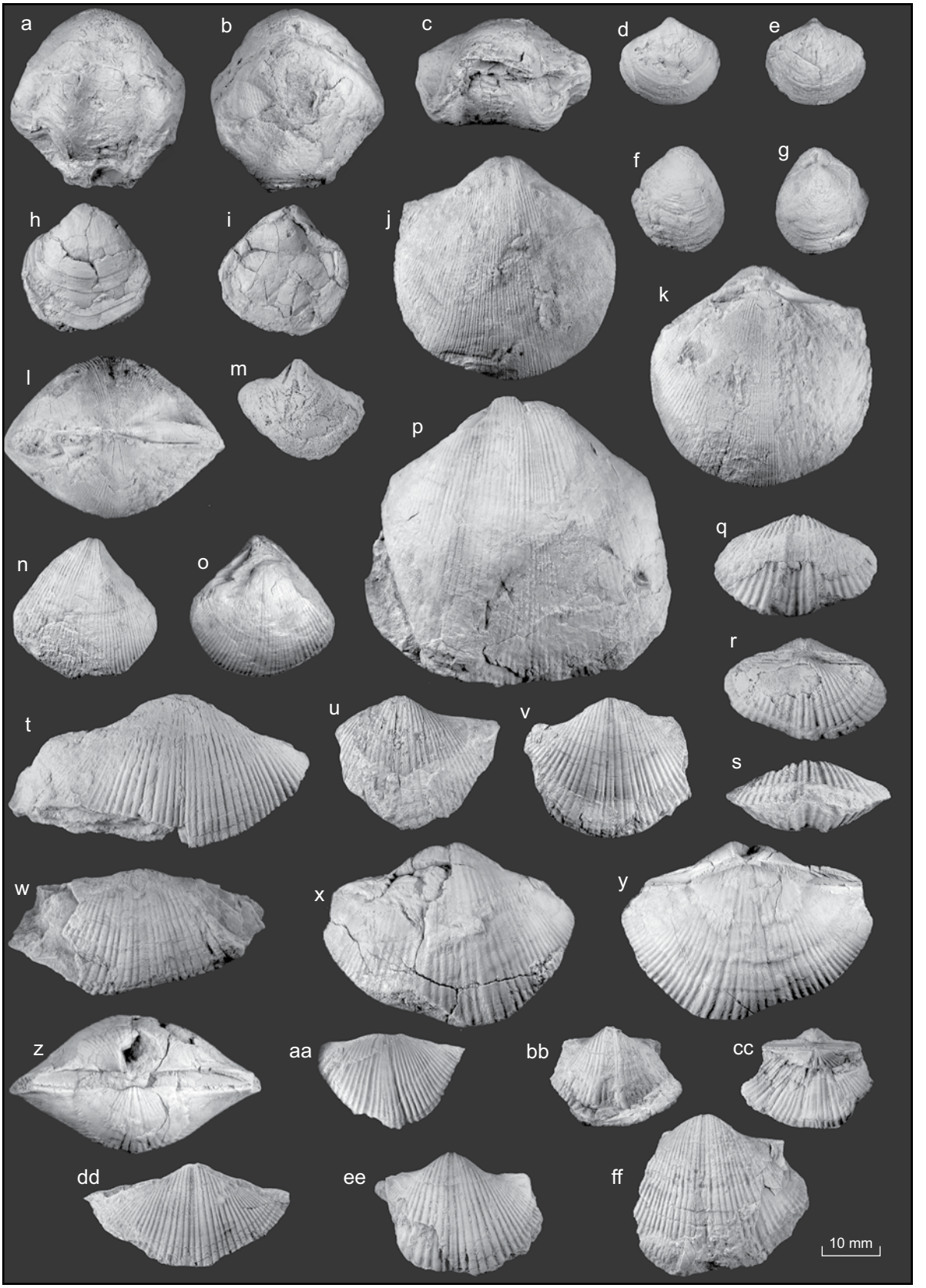

Figure 14: (a–c) *Composita* aff. *C. pentagonia* (Weller, 1914). Abrendan section. MPUM10602(IR1041-306), articulate specimen. (a) ventral view. (b) dorsal view. (c) anterior view. (d–e) *?Densalvus* sp. ind. Abrendan section. MPUM10604(IR998-4), articulate specimen. (d) ventral view. (e) dorsal view. (f–i) *?Iniathyris* sp. ind. Abrendan section. (f–g) MPUM10606(IR985-17), articulate specimen. (f) ventral view. (g) dorsal view. (h–i) MPUM10607(IR989-420), articulate specimen.

See facing page for continuation.

C. aff. *C. pentagonia* differ from *C. megala* by the greater depth and extension of the sulcal tongue and its very coarse lateral plicae. More specifically they have a deeper and more anteriorly extended sulcal tongue and lateral plicae which start more posteriorly and are more divergent than in *C. megala*. The same stronger features separate *Composita* aff. *C. pentagonia* from *C. subquadrata.*

Composita oblonga (Tolmatchoff, 1924), from the Tournaisian of Siberia (Kuzbass and Kusnetsk basins) (Beznosova in Sarytcheva et al., 1963), is less thick and has less evident sulcus, sulcal tongue and plicae. *Composita trinuclea* (Hall, 1856), from the Mississippian of the USA, shows a great variability and some specimens (Weller, 1914, pl. 81, figs. 21–23) are rather similar to the specimens under exam, except for a different outline and a less prominent sulcal tongue.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Selected previous record: Mississippian, USA (Missouri) (Weller, 1914).

Genus *Densalvus* Carter, 1991

Type species: *Athyris crassicardinalis* White, 1860 from the early Tournaisian of the USA (Iowa).

?*Densalvus* sp. ind. (Figure 14, d–e)

Material: seven articulated specimens: MPUM10603(IR989-48; IR997-31; IR997-36; IR997-308; IR1042-2; IR1042-7); MPUM10604(IR998-4).

Description: Small sized, biconvex shell with transverse oval outline; maximum width 12.1–17.2 mm, corresponding length: 11.8–15.0 mm; anterior commissure rectimarginate or slightly uniplicate; shell substance thick. Ventral valve slightly convex with swollen umbo, projecting posteriorly; a median flattening occurs instead of a sulcus. Dorsal valves less thick and convex than the ventral one. Shell surface smooth with only rare growth lines and few capillae. Interior of dorsal and ventral valves with myophragms.

Dimensions (in mm):

	Width	Length	Thickness
IR989-48	14.9	14.0	8.0
IR997-36	14.0	12.4	7.7
IR997-308	13.0	12.0	

	Width	Length	Thickness
IR998-4	17.2	15.0	7.7
IR1042-2	12.1	11.8	5.6
IR1042-7	15.5	15.8	8.4

Figure 14 (continued): (h) ventral view. (i) dorsal view. (j–l) *?Tenisia* sp. ind. Abrendan section. MPUM10608(IR1041-36), articulate specimen. (j) ventral view. (k) dorsal view. (l) posterior view. (m) *Kisilia* sp. ind. Abrendan section. MPUM10615(IR1046-28), ventral valve, ventral view. (n–p) *Ectochoristites* sp. ind. Abrendan section. (n–o) MPUM10610(IR1041-3), articulate specimen. (n) ventral view. (o) dorsal view. (p) MPUM10611(IR1041-35), articulate specimen, ventral view. (q–s) *Parallelora* sp. ind. Abrendan section. MPUM10616(IR985-6), articulate specimen. (q) ventral view. (r) dorsal view. (s) anterior view. (t–z) *Unispirifer (Unispirifer) striatoconvolutus* (Benson and Dun in Benson, Dun and Browne, 1920). Abrendan section. (t) MPUM10620(IR989-377), ventral valve, ventral view. (u) MPUM10621(IR990-333), ventral valve, ventral view. (v) MPUM10622(IR992-311), ventral valve, ventral view. (w) MPUM10672(IR993-339), dorsal valve, dorsal view. Simeh Kuh section. (x–z) MPUM10619(S10I), articulate specimen. (x) ventral view. (y) dorsal view. (z) posterior view. (aa–ff) *Unispirifer* cf. *U. (Septimispirifer) septimus* (Thomas, 1971). Abrendan section. (aa) MPUM10636(IR980-4A), dorsal valve, dorsal view. (bb–cc) MPUM10627(IR989-404), articulate specimen. (bb) ventral view. (cc) dorsal view. (dd) MPUM10631(IR990-48), ventral valve, ventral view. (ee) MPUM10632(IR993-313), ventral valve, ventral view. (ff) MPUM10634(IR994-77), ventral valve, ventral view. All figures X 1. Scale bar 10 mm.

Remarks: The present specimens are dubitatively placed in the genus *Densalvus* as the state of preservation is poor and the internal characters not preserved. However, they share some of the features of the genus *Densalvus* as the smooth valves, the thickness of the shell substance and the absence of the fold and sulcus.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Genus *Iniathyris* Beznosova in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963

Type species: *Iniathyris topkensis* Beznosova in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963 from the Tournaisian of Siberia (Kusnetsk basin).

?*Iniathyris* sp. ind. (Figure 14, f–i)

Material: four articulated specimens: MPUM10605(IR985-4; IR1042-34); MPUM10606(IR985-17); MPUM10607(IR989-420).

Description: Small sized, biconvex shell with rounded to longitudinally oval outline; maximum width at mid-length: 11.2–22.0 mm, corresponding length: 12.0–21.8 mm; anterior commissure rectimarginate or variably uniplicate. Ventral valve very convex with recurved umbo perforated by a large foramen; ventral sulcus of variable depth, starting from mid-length. Dorsal valve less convex than the ventral one; median fold only at the anterior margin. Ornamentation of thin and dense growth lamellae, occasionally with stronger relief. Interior of ventral valve with slightly divergent dental plates and lanceolate muscle field. Interior of dorsal valve with a myophragm.

Dimensions (in mm):

	Width	Length	Thickness
IR985-4	11.2	12.0	7.3
IR985-17	16.3	18.1	11.4
IR989-420	22.0	21.8	8.9
IR1042-34	17.4	20.6	11.0

Remarks: These specimens have been dubitatively included in the genus *Iniathyris* based on their similarity to *Iniathyris topkensis* Beznosova in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963. However, the state of preservation and rarity of the material do not allow a more precise identification.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Order SPIRIFERIDA Waagen, 1883
Suborder SPIRIFERIDINA Waagen, 1883
Superfamily THEODOSSIOIDEA Ivanova, 1959
Family ULBOSPIRIFERIDAE Johnson and Carter in Carter, Johnson, Gourvennec and Hou, 1994
Subfamily ULBOSPIRIFERINAE Johnson and Carter in Carter, Johnson, Gourvennec and Hou, 1994

Genus *Tenisia* Martynova, 1970

Type species: *Spirifer (Cyrtospirifer) dada* Nalivkin, 1937 from the Late Devonian of Kazakhstan.

?*Tenisia* sp. ind. (Figure 14, j–l)

Material: one articulated specimen: MPUM10608(IR1041-36); one ventral valvee: MPUM10609-(IR1041-28).

Description: Large sized, biconvex shell with equidimensional, subtriangular outline; maximum width at mid-length: 37.3–38.2 mm, corresponding length: 34.2–38.1 mm, thickness: 14.2–27.6 mm; anterior commissure slightly uniplicate. Ventral valve convex with wide, recurved umbo; interarea concave, apsacline, rather high and striated. Dorsal valve slightly less convex than the ventral valve with low dorsal fold. Ornamentation of fine ribs with narrow interspaces, numbering 9 per 5 mm at 15 mm from the umbo and 6 per 5 mm at the anterior margin; rare growth lines and capillae.

Remarks: These two specimens probably belong to the genus *Tenisia* based on their external characters. However, the determination is left open as the material comprises only two specimens of which the internal characters are not available.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Superfamily MARTINIOIDEA Waagen, 1883
Family MARTINIIDAE Waagen, 1883
Subfamily EOMARTINIOPSINAE Carter, in Carter, Johnson, Gourvennec and Hou, 1994

Genus *Kisilia* Nalivkin, 1979

Type species: *Kisilia linguata* Nalivkin, 1979 from the Tournaisian of Russia (Urals).

Remarks: *Kisilia* Nalivkin, 1979 is characterized by the occurrence of ventral adminicula which differentiate it from similar genera such as *Martinia* McCoy, 1844 and *Implexina*, Poletaev, 1971.

Kisilia sp. ind. (Figure 14, m)

Material: two ventral valves: MPUM10614(IR994-372); MPUM10615(IR1046-28).

Description: Small sized, convex ventral valve with ovatotriangular outline; maximum width: 13.1–22.1 mm, corresponding length: 15.0–1.7 mm, thickness: 5.8–9.1 mm; umbo pointed and projecting posteriorly; interarea apsacline, triangular, high and concave with wide delthyrium; weak median sulcus anteriorly. Shell surface smooth with rare growth lines. Interior of ventral valve with dental plates diverging anteriorly and a myophragm.

Remarks: The present specimens have been placed in the genus *Kisilia* based on the combination of internal and external characters. However, the state of preservation prevents any specific determination.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Superfamily SPIRIFEROIDEA King, 1846
Family SPIRIFERIDAE King, 1846
Subfamily SPIRIFERINAE King, 1846

Genus *Ectochoristites* Campbell, 1957

Type species: *Ectochoristites wattsi* Campbell, 1957 from the Tournaisian of Australia.

Ectochoristites sp. ind. (Figure 13, p–aa; Figure 14, n–p)

Material: one articulated specimen: MPUM10610(IR1041-3); 18 ventral valves: MPUM10611(IR1041-35); MPUM10612(IR998-334; IR1041-8; IR1041-11; IR1041-19; IR1041-21; IR1041-23; IR1041-26; IR1041-29; IR1041-309; IR998-346; IR1041-33; IR1041-38; IR1041-311; IR1041-325A; IR1041-325B); MPUM10677(IR1041-24); MPUM10678(IR1044-37); four dorsal valves: MPUM10613(IR998-317; IR1041-308; IR1041-310; IR1041-324).

Description: Large sized, biconvex shell with ovatotriangular outline; maximum width at mid-length: 27.9–49.3 mm, corresponding length: 24.6–48.2 mm; anterior commissure slightly uniplicate. Ventral valve with wide, recurved umbo; interarea apsacline, concave, high and striated; ventral sulcus wide, deeper anteriorly and delimited by large plicae. Dorsal valve slightly less convex than the ventral one with orthocline interarea; median fold evident only anteriorly. Ornamentation of thin ribs with fine intercostal sulci; ribs number 18 in the sulcus and 28 on each flank at the anterior margin; capillae and growth lines. Interior of ventral valve with robust, divergent dental plates.

Dimensions (in mm):

	Width	Length	Thickness
IR1041-3	27.9	24.6	17.3
IR1041-8	31.2	29.3	16.8
IR1041-19	48.1	37.4	21.6
IR1041-23	39.5	26.7	14.7
IR1041-24	47.2	38.8	21.1
IR1041-26	34.4	28.3	15.2

	Width	Length	Thickness
IR1041-35	49.3	48.2	38.3
IR1041-308	46.2	34.0	15.2
IR1041-324	37.8	27.4	13.6
IR1041-325A	43.1	36.2	15.7
IR1044-37	48.2	37.6	24.7

Remarks: The present specimen are similar to *Ectochoristites wattsi* Campbell, 1957, from the Tournaisian of Australia (New South Wales) (Campbell, 1957), from which they differ by their equidimensional outline and the shallower sulcus.

Ectochoristites inflatus Carter, 1967, from the Mississippian of Texas has a more pronounced sulcal tongue and larger and less numerous ribs.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Subfamily PROSPIRINAE Carter, 1974

Genus *Parallelora* Carter, 1974

Type species: *Spirifer marionensis* Shumard, 1855 from the Late Devonian of the USA.

Remarks: In the subfamily Prospirinae, *Parallelora* (Carter, 1974) is mostly similar to *Prospira* Maxwell, 1954. The distinction between the two genera is based on the shape of the interarea, which is subrectangular in *Parallelora*, and on the ribs, which are more numerous and bifurcating in *Parallelora*.

Parallelora sp. ind. (Figure 14, q–s)

Material: one articulated specimen: MPUM10616(IR985-6); eight ventral valves: MPUM10617(IR985-2A; IR985-7; IR985-18; IR985-305; IR993-337; IR1008-3; IR1040-10; IR1044B-21; three dorsal valves: MPUM10618(IR985-303A; IR985-303B; IR985-306A).

Description: Small to medium, ventribiconvex with transverse, semicircular to subtrapezoidal outline; maximum width at the hinge: 20.4–36.5 mm, corresponding length: 11.7–24.8 mm; thickness 13 mm; ventribiconvex; anterior commissure uniplicate; cardinal extremities mucronate. Ventral valve convex posteriorly with recurved, hook-like umbo; interarea subrectangular, apsacline, low

and striated; hinge denticulate; delthyrium trapezoidal. Ventral sulcus deep, starting from the umbo. Dorsal valve less convex than the ventral one; median fold low, evident only at the anterior margin. Ornamentation of ventral valve of coarse ribs, with interspaces of similar width; ribs number 3 inside the sulcus, with the median one arising at 3–6 mm from the umbo; 1 larger rib is also present higher on each sulcal flank; ribs number 14 on each lateral flank of the valve; growth lines. Ornamentation of dorsal valve similar, but with 4 ribs on the fold starting from the umbo. Interior of ventral valve with a thick apical callus, dental plates and myophragm.

Dimensions (in mm):

	Width	Length	Thickness
IR985-2A	24.8	17.6	
IR985-6	27.9	17.3	12.8
IR985-7	27.7	21.1	
IR985-303A	31.7	17.4	
IR985-305	26.8	16.3	

	Width	Length	Thickness
IR985-306A	20.4	11.7	
IR993-337	25.0	16.5	
IR1008-3	36.5	24.8	
IR1044B-21	27.4	19.8	

Remarks: The present specimens are easily placed in the genus *Parallelora* for their subrectangular interarea, their sulcal rib pattern and the mucronate cardinal extremities. However, they are left in open nomenclature because of their preservation and because they do not fit with any of the known *Parallelora* species.

Parallelora marionensis (Shumard, 1855), as described by Carter (1974), differs by its swollen umbo, higher interarea, denser growth lamellae and more numerous ribs on the fold. *Parallelora nupera* Carter, 1988, from the Mississippian of the USA (Illinois and Missouri) has a more equidimensional outline and denser growth lamellae.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Genus *Unispirifer* Campbell, 1957

Type species: *Spirifer striatoconvolutus* Benson and Dun in Benson, Dun and Browne, 1920 from the Tournaisian of Australia.

Remarks: *Unispirifer* Campbell, 1957 is characterized by a very transverse outline with alate, but generally not mucronate cardinal extremities, which distinguish the genus from allied ones. *Finospirifer* Yin, 1981 differs by its mucronate cardinal extremities and very pronounced fold and sulcus. *Prospira* Maxwell, 1954 differs by its mucronate cardinal extremities and by the subquadrate to subpentagonal outline which characterizes the adults. *Andreaspira* Abramov and Grigor'eva 1986, has a median costa which do not bifurcate and an apical callus well developed in the adults.

Austrochoristites Roberts, 1971 shows wide intercostal troughs bounding the sulcus and longer ventral adminicula.

Shi et al. (2005) subdivided the genus into three subgenera:
- *Unispirifer (Unispirifer)* Campbell, 1957, which includes species which are wider than long and have alate cardinal extremities;
- *Unispirifer (Septimispirifer)* Shi, Chen and Zhan, 2005, which includes species with slightly transverse to semicircular outline and angular cardinal extremities;
- *Unispirifer (Atylephorus)* Sartenaer and Plodowski, 1996, which includes only the genus *Atylephorus* of Sartenaer and Plodowski, 1996.

In this paper, only the first two subgenera are considered valid, whereas *Atylephorus* is considered a distinct genus (see below the discussion of *Atylephorus*).

Unispirifer (Unispirifer) striatoconvolutus (Benson and Dun in Benson, Dun and Browne, 1920) (Figure 13, bb–dd; Figure 14, t–z; Figure 15)

1920 *Spirifer striato-convoluta* Benson and Dun in Benson, Dun and Browne: p. 350; pl. 20, figs 7–8.
1957 *Unispirifer striatoconvolutus* – Campbell: p. 68; pl. 14, figs 1–9, text-figs 10–12.
1968 *Spirifer missouriensis* – Gaetani: p. 723; pl. 52, figs 6–7.
2005 *Unispirifer (Unispirifer) striatoconvolutus* – Shi et al.: p. 55; figs 12G–12K.

Material: nine articulated specimens: MPUM10619(S10I); MPUM10620(IR989-377); MPUM10621(IR990-333); MPUM10622(IR992-311); MPUM10623(IR989-130; IR989-151; IR989-229; IR989-379; IR989-401; IR989-414; IR992-309; S21C); 56 ventral valves: MPUM10624(AB8; IR989-33; IR989-44; IR989-131; IR989-376; IR989-387; IR989-388; IR989-391; IR989-410; IR989-411; IR989-412; IR989-415; IR989-416; IR989-417; IR990-1; IR990-324; IR990-326; IR990-329; IR990-336; IR992-9; IR992-12; IR992-13; IR992-60; IR993-334; IR993-335; IR994-19; IR994-320; IR994-324; IR994-327; IR994-333; IR994-334; IR995-20; IR995-318; IR995-319; IR1008-305; IR1008-306; IR989-136; IR989-385; IR989-394; IR989-397; IR989-399; IR990-55; IR992-1; IR992-26; IR994-323; IR994-329; IR994-338; IR998-56; IR998-321; IR998-329; IR998-330; IR998-333); MPUM10681(IR994-335); 29 dorsal valves: MPUM10625(AB6; IR989-23; IR990-61; IR993-30; IR994-12; IR994-340; IR996-21; IR997-45; IR997-309; IR998-24; IR998-59; IR984-54; IR989-55; IR989-92; IR989-106; IR989-396; IR989-402; IR990-327; IR992-312; IR993-50; IR993-55; IR993-336; IR994-54; IR994-344; IR994-345; IR998-319; IR998-328; IR998-332); MPUM10672(IR993-339).

Description: Large, biconvex shell with variably transverse sub-trapezoidal to semicircular outline; maximum width at the hinge: 29.7–57.2 mm, corresponding length: 17.8–27.5 mm; anterior commissure uniplicate; cardinal extremities mucronate in juveniles, alate in the adult specimens. Ventral valve convex with swollen umbonal region; umbo erect, high and hook-shaped; interarea apsacline, concave only below the umbo, then flat; ventral sulcus extending for the entire length of the valve with an apertural angle of 15°. Dorsal valve slightly less convex; interarea orthocline; dorsal fold extending for for all the length of the valve, high only at the anterior commissure. Ornamentation of 25 rounded ribs on each flank, with interspaces slightly narrower than the ribs; ribs originate at the umbo and increase in height and width anteriorly, being about 1 mm wide at the anterior margin; in the ventral sulcus there are 3 ribs of which the two lateral ones bifurcate twice at 10–15 mm from the umbo, whereas the median one bifurcates between 15 mm and 25 mm from the umbo (Figure 15); dorsal fold ornamented by 4 ribs and bounded by two deep intercostal furrows; capillae in the intercostal troughs and growth lamellae. Interior of ventral valve with stout dental plates, a small adductor field separated from the large diductor scars by a narrow ridge, and a myophragm. Dorsal valve with convergent socket ridges delimiting wide sockets.

Dimensions (in mm):

	Width	Length	Thickness
IR989-23	42.6	23.0	
IR989-130	38.0	17.5	12.7
IR989-376	41.0	28.5	
IR989-377	47.0	27.0	
IR989-387	36.0	22.2	
IR989-391	29.7	17.8	
IR989-415	35.0	26.1	
IR990-326	35.4	21.0	

	Width	Length	Thickness
IR990-329	45.0	26.0	
IR992-13	47.6	24.4	
IR994-320	53.5	31.0	
IR994-334	40.5	24.8	
IR994-340	57.2	27.5	
IR995-20	42.0	22.2	
IR995-318	56.0	30.0	
IR1008-306	54.4	29.5	

Remarks: The present specimens fit with the description of *Unispirifer (Unispirifer) striatoconvolutus* (Benson and Dun in Benson, Dun and Browne, 1920) given by Campbell (1957) having the same hook-shaped umbo, a rather high interarea, the same number and pattern of ribs in the sulcus and on the flanks, and two furrows bounding the dorsal fold.

The specimens decribed as *Spirifer missouriensis* (Swallow, 1860) from Gaetani (1968) have been placed in the synonymy of *Unispirifer (Unispirifer) striatoconvolutus*. They differ from *S. missouriensis* by the alate cardinal extremities, the lower dorsal fold and the less numerous ribs in the sulcus and on the fold.

Unispirifer (Unispirifer) senex Carter, 1988, from the Early Mississippian of the USA, has weaker but more numerous ribs. *Unispirifer (Unispirifer) fluctuosus* (Glenister, 1955), from the Tournaisian of northern Australia (Thomas, 1971), has more ribs in the sulcus/fold, but fewer ribs on the flank. *Unispirifer (Unispirifer) minnewankensis* (Shimer, 1926), from the Mississippian of Canada (Carter, 1987), has more outdistanced umbos and a different ornamentation. *Unispirifer (Unispirifer) unicus* Havlíček, 1984, from the Tournaisian of Libya, Morocco and Algeria (Brice et al., 2005), differs by its ornamentation of wide ribs with very narrow intercostals furrows, which converge in the sulcus.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; AB-prefix specimens from loose blocks of Abrendan section; S-prefix specimens from Simeh Kuh section.

Selected previous records: Mississippian, Australia (New South Wales) (Campbell, 1957); Mississippian SW China (Yunnan) (Shi et al., 2005); Tournaisian, North Iran (Gaetani, 1968).

Unispirifer cf. *U. (Septimispirifer) septimus* (Thomas, 1971) (Figure 14, aa–ff; Figure 16, Figure 17; Figure 18, a–d; Figure 19, a–g)

Material: 13 articulated specimens: MPUM10626(IR989-66; IR989-74; IR994-330; IR994-352; S21D; S35C; S40E; S40F; S45B); MPUM10627(IR989-404); MPUM10628(S40D); MPUM10629(S45A); MPUM10680(IR992-4); 57 ventral valves: MPUM10630(IR989-45; IR989-117; IR989-380; IR989-382; IR989-393; IR989-395; IR989-408; IR990-51B; IR990-72; IR990-334; IR992-19; IR994-15; IR994-55; IR994-319; IR994-342; IR995-7; IR995-42; IR997-10; IR997-18; IR997-33; IR997-318; IR998-326; IR998-343; IR998-348; IR998-349; IR1044-300; IR989-51; IR989-102; IR989-115; IR989-378; IR989-381; IR989-383; IR989-403; IR989-423; IR990-37; IR990-337; IR992-39; IR992-45; IR993-33; IR994-9; IR994-73; IR994-137; IR994-321; IR994-326; IR998-9; IR998-48; IR998-322; IR1008-139); MPUM10631(IR990-48); MPUM10632(IR993-313); MPUM10634 (IR994-77); 43 dorsal valves: MPUM10635(IR989-22; IR989-122; IR989-384; IR989-386; IR989-409; IR989-413; IR990-23; IR990-51A; IR990-328; IR990-332; IR994-13; IR994-339; IR994-354; IR995-40; IR995-331; IR997-316; IR998-45; IR998-323; IR984-3; IR988-300; IR989-34; IR989-374; IR989-375; IR989-390; IR989-392; IR990-40; IR990-41; IR990-325; IR990-330; IR993-338; IR993-342; IR994-59; IR994-63; IR994-328; IR994-331; IR994-347; IR994-355; IR995-322; IR995-323; IR996-1; IR998-331); MPUM10636(IR980-4A).

Description: Medium to large sized, biconvex shell with sub-trapezoidal outline; maximum width at the hinge: 14.0–57.0 mm, length 6.4–32.4 mm (Figure 17); anterior commissure slightly uniplicate. Ventral valve convex with high, pointed and strongly hooked umbo; interarea apsacline, denticulated;

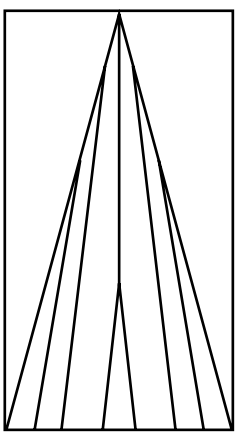

Figure 15: Costal pattern in the sulcus of *Unispirifer (Unispirifer) striatoconvolutus*.

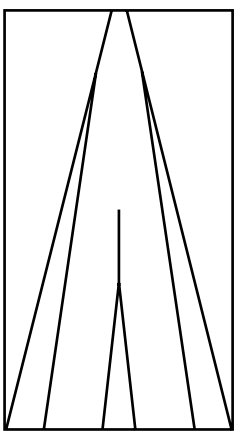

Figure 16: Costal pattern in the sulcus of *Unispirifer (Septimispirifer) septimus*.

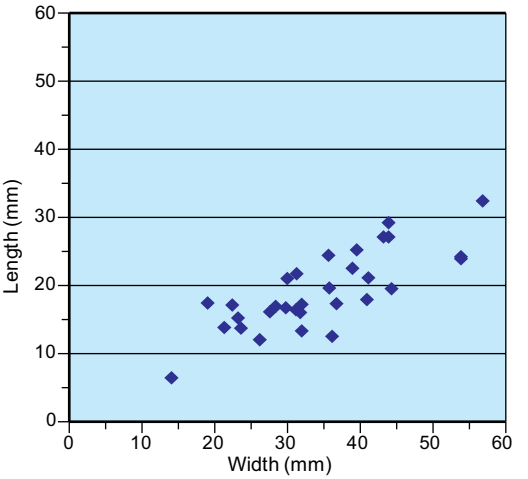

Figure 17: Width vs. length diagram of *Unispirifer (Septimispirifer) septimus*.

delthyrium closed by stegidial plates; ventral sulcus extending through the whole valve with an apertural angle of 15°. Dorsal valve slightly less convex than the ventral one; interarea orthocline, low; dorsal fold extending through the whole valve, becoming higher at the anterior margin, where it has a marked "U" shaped section. Ornamentation of 20 rounded ribs on each flank, with interspaces slightly narrower than the ribs; ribs originate at the umbo and increase in height and width anteriorly, with the lateral ribs weaker, finer and more closely set; sulcus delimited by 2 wide and marked ribs which are 1 mm wide at 10 mm from the umbo and which bifurcates forming 2 ribs each on the sulcal slopes; 1 median costa in the sulcus, initially very flat, bifurcating anteriorly (Figure 16); fold ornamented by 4 ribs and delimited by wide intercostal furrows; widespread capillae and growth lines. Interior of ventral valve with teeth supported by stout dental plates, a small apical callus and a small adductor field separated from the large diductor scars by a narrow ridge.

Dimensions (in mm):

	Width	Length	Thickness
IR980-4A	29.8	16.7	
IR989-22	21.3	13.8	
IR989-382	31.2	16.4	
IR989-384	44.0	27.1	
IR989-386	36.2	12.5	
IR990-23	43.3	27.1	
IR990-48	41.0	17.9	
IR990-51B	26.2	12.0	
IR990-72	35.7	24.4	
IR990-328	39.6	25.2	
IR992-19	57.0	32.4	
IR993-313	30.0	21.0	

	Width	Length	Thickness
IR994-13	14.0	6.4	
IR994-330	28.4	16.9	12.6
IR994-339	32.0	13.3	
IR994-347	23.6	13.7	
IR994-352	19.0	17.4	11.2
IR995-40	41.2	21.1	
IR998-45	44.4	19.5	
IR998-339	22.4	17.1	
S21D	44.0	29.2	20.9
S40D	31.3	21.7	14.8
S45A	36.8	17.3	20.0
S45B	27.6	16.1	13.4

Remarks: The present specimens fit well with the description of *Unispirifer (Septimispirifer) septimus* Thomas, 1971; however, there is a difference concerning the pattern of the median sulcal rib which in the material illustrated by Thomas (1971, p. 79, fig. 25e) seems to be evident since the umbo, whereas in the Iranian material is initially flat and inconspicuous.

U. (U.) striatoconvolutus differs by the sulcal ribs pattern (Figures 15–16) and the higher ventral interarea. *Unispirifer (U.) xiangshanensis* Shi, Chen and Zhan, 2005, from the Mississippian of SW China (Shi et al., 2005), has similar dimensions and outline, but has a different ribs pattern both in the sulcus and on the flanks. *U. (U.) fluctuosus*, from the Tournaisian of northern Australia (Thomas, 1971), differs by the median sulcal rib which immediately bifurcated and by having more numerous ribs on the fold.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section.

Selected previous records: Tournaisian, Australia (Carnarvon Basin) (Thomas, 1971); Mississippian, SW China (Yunnan) (Shi et al., 2005).

Genus *Atylephorus* Sartenaer and Plodowski, 1996

Type species: *Spirifer tornacensis* de Koninck, 1883 from the late Tournaisian of Belgium.

Remarks: *Atylephorus* differs from *Unispirifer* by its larger size, subquadrate outline, mucronate cardinal extremities, lower and less defined fold and sulcus, and flatter and more numerous ribs which bifurcate in a more complex and asymmetrical pattern.

Atylephorus is also similar to *Fusella* McCoy, 1844, *Cyrtospirifer* Nalivkin in Fredericks, 1924, *Imbrexia* Nalivkin, 1937, from which it can be distinguished based on the ribs pattern, the shape of the interarea and the height of fold and the depth of the sulcus.

Atylephorus sp. ind. (Figure 18, e–j; Figure 19, h–j; Figure 20)

Material: four articulated specimens: MPUM10637(S10L); MPUM10638(S12A); MPUM10639(S12B); MPUM10640(IR989-372); 17 ventral valves: MPUM10641(IR989-371; IR989-373; IR989-407A; IR990-352; IR993-26; IR993-27; IR1008-6; IR989-370; IR989-432; IR990-323; IR992-310; IR992-315; IR995-5; IR1009-1); MPUM10689(IR992-322); one dorsal valve: MPUM10642(IR992-308).

Description: Large to very large, biconvex with transverse semicircular outline; maximum width at the hinge: 41.4–65.4 mm, corresponding length: 28.0–37.4 mm; anterior commissure uniplicate; cardinal extremities mucronate along most growth stages. Ventral valve with swollen umbonal region and hook-like, recurved umbo; interarea apsacline, flat, rather high, striated; ventral sulcus shallow, extending for all the length of the valve with an apertural angle of 25°. Dorsal valve slightly less convex; interarea orthocline, low, flat; median fold low, evident only at the anterior commissure. Ornamentation of low, rounded ribs separated by narrow intercostal furrows; sulcus ornamented by 6–9 ribs, increasing from 3 initial costae by successive bifurcation of the lateral ones (Figure 20); lateral flanks ornamented by about 30 ribs; capillae in the intercostal troughs and growth lines. Interior of ventral valve with divergent dental plates apically embedded in the umbonal callus and a small delthyrial plate.

Dimensions (in mm):

	Width	Length	Thickness
S10L	46.3	32.8	26.2
S12A	58.4	38.4	30.3
S12B	65.4	37.4	32.3
IR989-371	51.3	36.4	
IR989-407A	47.9	32.8	

	Width	Length	Thickness
IR992-308	41.8	25.9	
IR992-315	43.4	35.6	
IR993-27	41.4	28.0	
IR1008-6	63.1	45.0	

Remarks: Two species are known in the genus *Atylephorus*: the type species *A. tornacensis* and *Atylephorus nalivkini* Poletaev, 2006, from the Late Devonian of the southern Urals. However, the present specimens show morphological features which distinguish them from both species. The Iranian specimens differ from *A. tornacensis* by their less convex ventral valve and the cardinal extremities which loose the characteristic mucronation in some of the gerontic specimens. *A. nalivkini* is more similar to the Iranian specimens, but it shows a narrower sulcus and fewer ribs at the anterior margin.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section.

Prospirinae gen. et sp. ind. (Figure 19, k–p)

Material: one articulate specimen: MPUM10686(IR990-322); 13 ventral valves: MPUM10687(IR989-369; IR989-398; IR990-331; IR993-333; IR994-27; IR994-70; IR994-80; IR997-85; IR997-313; IR998-34; IR998-57; IR998-320; IR998-352).

Description and discussion: The present specimens are externally similar to the species of genus *Unispirifer*, however they differ from it by their higher ventral interarea and peculiar internal characters of the ventral valve, which shows fused ventral adminicula forming an obtuse angle to the dental lamellae (Figure 19, l–o).

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

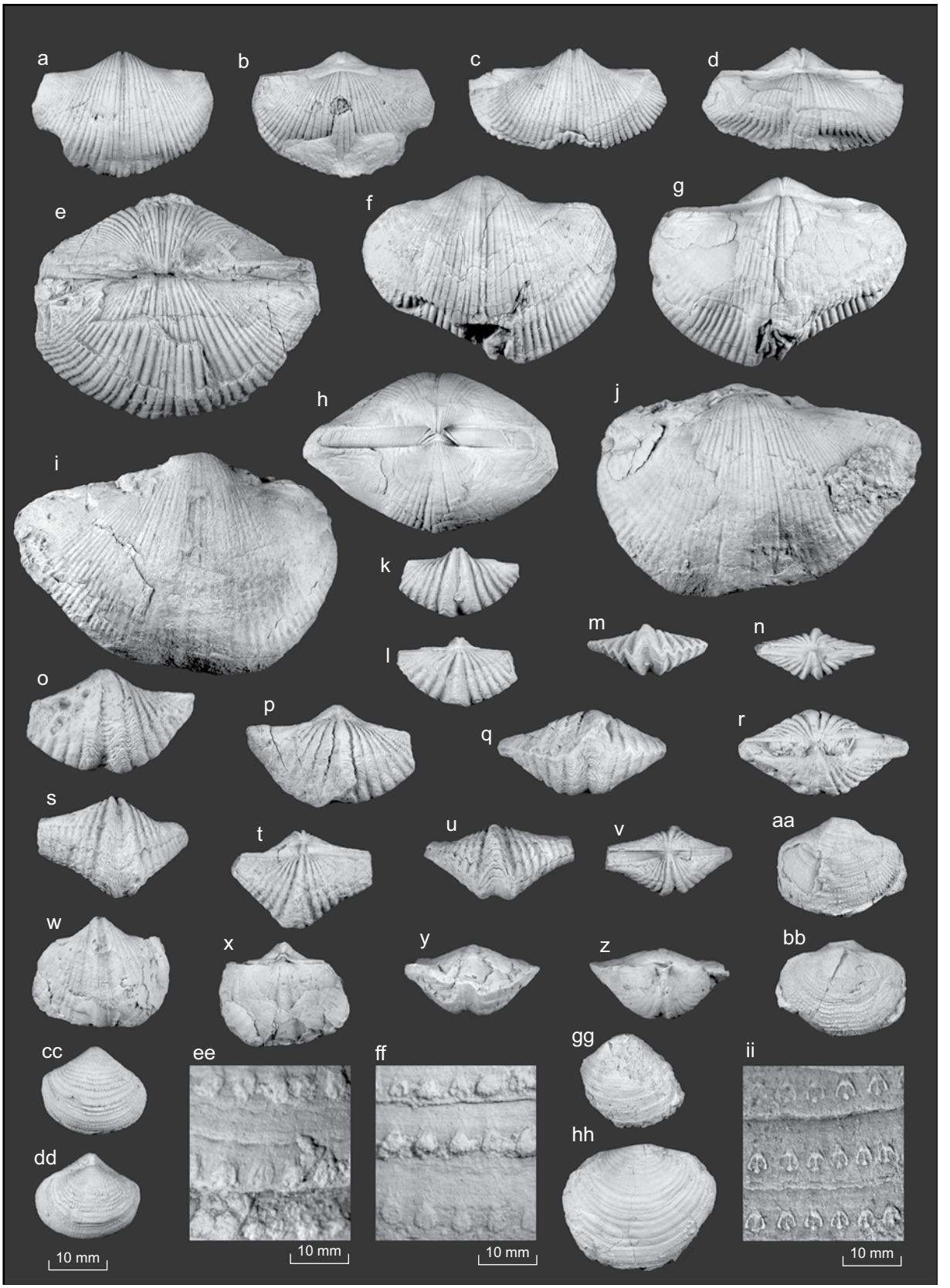

Figure 18: (a–d) *Unispirifer* cf. *U. (Septimispirifer) septimus* (Thomas, 1971). Simeh Kuh section. (a–b) MPUM10628(S40D), articulate specimen, (a) ventral view. (b) dorsal view. (c–d) MPUM10629(S45A), articulate specimen, (c) ventral view. (d) dorsal view. (e–j) *Atylephorus* sp. ind. Abrendan section. (e) MPUM10640(IR989-372), articulate specimen, posterior view. Simeh Kuh section. (f–h) MPUM10637(S10L), articulate specimen. (f) ventral view. (g) dorsal view, (h) posterior view.
See facing page for continuation.

Superfamily PAECKELMANELLOIDEA Ivanova, 1972
Family STROPHOPLEURIDAE Carter, 1974
Subfamily STROPHOPLEURINAE Carter, 1974

Genus *Voiseyella* Roberts, 1964

Type species: *Strophopleura anterosa* Campbell, 1957 from the Tournaisian – Visean of Australia.

Remarks: *Voiseyella* Roberts, 1964 is similar to *Cantabriella* Martínez-Chacón and Rio-Garcia, 1987 because of its tranverse outline, ornamentation of robust costae and evident, but smooth, fold and sulcus; however *Voiseyella* differs from it by its higher ventral interarea. It is also similar to *Punctospirifer* North, 1920, which has a densely endopunctate shell substance, a spinose micrornamentation and alate cardinal extremities.

Voiseyella aff. *V. texana* (Carter, 1967) (Figure 18, k–v)

Material: four articulated specimens: MPUM10643(S28A); MPUM10644(S28B); MPUM10645(S30A); MPUM10646(S30B); two ventral valves: MPUM10647(IR998-347; IR997-314); three dorsal valves: MPUM10648(IR1045-305; IR998-336; IR989-421).

Description: Small to medium sized, biconvex shell with very transverse outline; maximum width at the hinge: 11.5–31.6 mm, corresponding length: 6.3–17.9 mm; cardinal extremities mucronate across all growth stages; anterior commissure uniplicate. Ventral valve very convex, with pointed, recurved umbo; interarea apsacline, rather high, flat, trapezoidal; delthyrium with narrow deltidial plates; ventral sulcus deep, with "V" shaped cross section; sulcal tongue "U" shaped, projecting anteriorly. Dorsal valve less convex than the ventral valve, with high, narrow, flat-topped fold, delimited by two deep furrows. Ornamentation of coarse, rounded costae numbering 6–8 on each flank and decreasing in width and height laterally; very evident sulcus-bordering costae which are 2.2 mm wide at 10 mm from the umbo; growth lamellae.

Dimensions (in mm):

	Width	Length	Thickness
IR989-421	11.5	6.3	
IR998-347	30.0	15.6	
S28A	23.0	15.2	10.8

	Width	Length	Thickness
S28B	21.0	11.7	10.1
S30A	31.6	17.9	15.0
S30B	13.2	17.1	15.2

Remarks: The present specimens are very similar to *Voiseyella texana* (Carter, 1967), except for their greater length, flatter interarea and more convex umbo. However, due to the state of preservation the specific determination is left open.

Voiseyella novamexicana (Miller, 1881), from the Mississippian of the USA (Carter, 1967, 1999), differs by its subtriangular, transverse outline and its very convex valves.

Figure 18 (continued): (i–j) MPUM10639(S12B), articulate specimen. (i) ventral view. (j) dorsal view. (k–v) *Voiseyella* aff. *V. texana* (Carter, 1967). Simeh Kuh section. (k–n) MPUM10644(S28B), articulate specimen. (k) ventral view. (l) dorsal view. (m) anterior view. (n) posterior view. (o–r) MPUM10643(S30A), articulate specimen. (o) ventral view. (p) dorsal view. (q) anterior view. (r) posterior view. (s–v) MPUM10646(S30B), articulate specimen. (s) ventral view. (t) dorsal view. (u) anterior view. (v) posterior view. (w–z) *Latibrachythyris* sp. ind. Simeh Kuh section. MPUM10650(S24C), articulate specimen. (w) ventral view. (x) dorsal view. (y) anterior view. (z) posterior view. (aa–ff) *Kitakamithyris* sp. ind. Simeh Kuh section. (aa–bb) MPUM10652(S40C), articulate specimen. (aa) ventral view. (bb) dorsal view. (cc–ff) MPUM10654(S41B), articulate specimen. (cc) ventral view. (dd) dorsal view. (ee–ff) spine bases, X10. (gg–ii) *Torynifer* sp. ind. Abrendan section. (gg) MPUM10655(IR990-3), ventral valve, ventral view. (hh–ii) MPUM10656(IR990-341), dorsal valve. (hh) dorsal view. (ii) spine bases, X10. All figures X 1, unless otherwise stated. Scale bar 10 mm for the natural size.

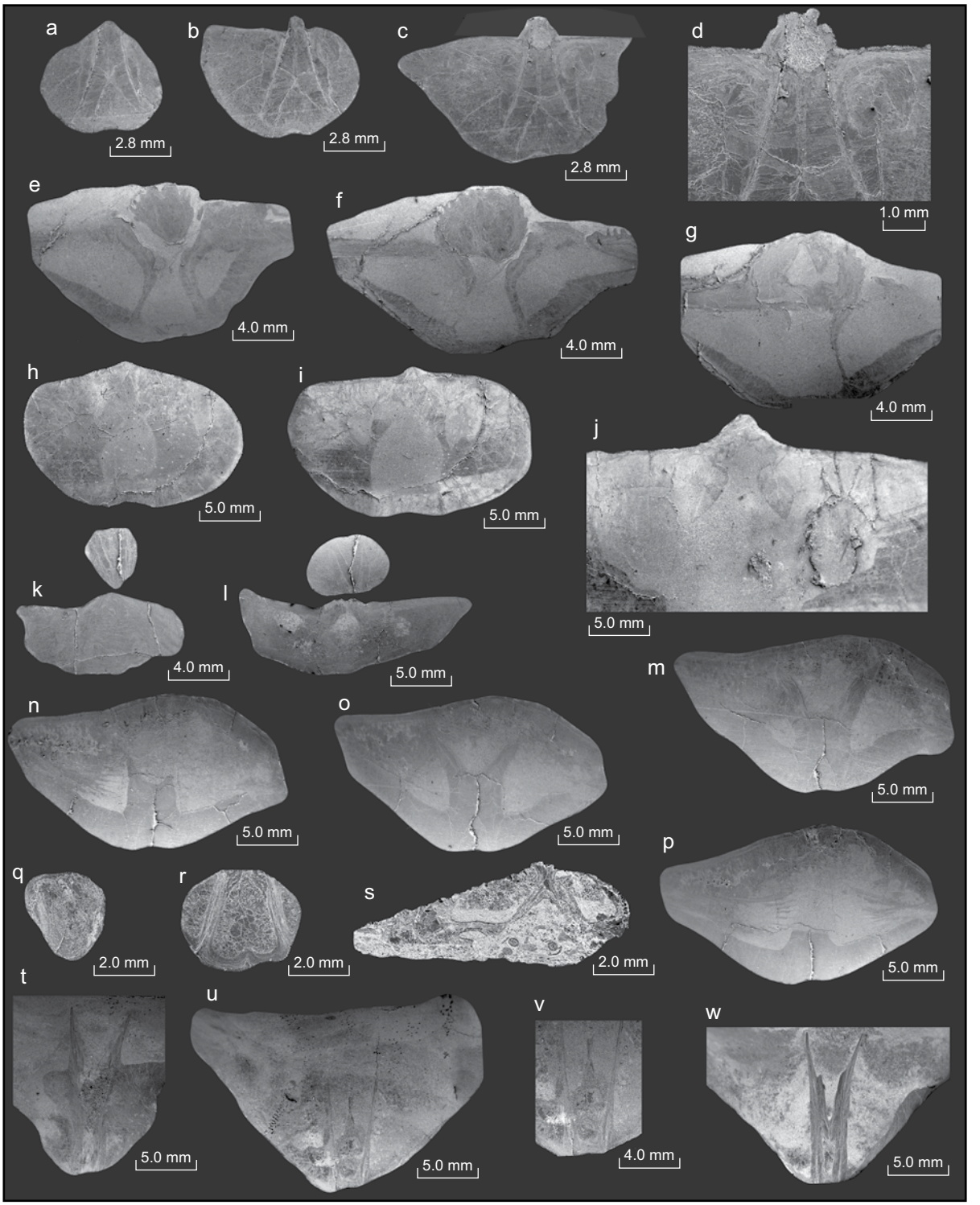

Figure 19: (a–g) *Unispirifer* cf. *U. (Septimispirifer) septimus* (Thomas, 1971). Abrendan section. MPUM10680(IR992-4), transverse sections of an articulate specimen at (a) 0.7 mm, X3.5, (b) 1.6 mm, X3.5, (c) 2.8 mm, X3.5, (d) 2.8 mm, X7, (e) 4.9 mm, X2.5, (f) 5.3 mm, X2.5, (g) 6.1 mm, X2.5, from the umbo. (h–j) *Atylephorus* sp. ind. Abrendan section. MPUM10689(IR992-322), transverse sections of a ventral valve at (h) 1.7 mm, X2, (i) 3.1 mm, X2, (j) 4.3 mm, X3, from the umbo. (k–p) Prospirinae gen. et sp. ind. Abrendan section. MPUM10686(IR990-322), transverse sections of an articulate specimen at (k) 2.2 mm, X2.5, (l) 3.4 mm, X2, (m) 5.2 mm, X2, (n) 5.9 mm, X2, (o) 6.7 mm, X2, (p) 7.9 mm, X2, from the umbo. (q–r) *Kitakamithyris* sp. ind. Simeh Kuh section. MPUM10652(S40C), transverse sections of an articulate specimen at (q) 0.9 mm, X5, (r) 1.7 mm, X5, from the umbo. (s) *Torynifer* sp. ind. Abrendan section. MPUM10656(IR990-341), transverse section of a dorsal valve at 1.0 mm from the umbo, X5.(t–w) *Syringothyris carteri* (Hall, 1857). Abrendan section. MPUM10660(IR99242), transverse sections of a ventral valve at (t) 5.6 mm, X2, (u) 7.2 mm, X2, (v) 7.2 mm, X2.5, (w) 8.8 mm, X2, from the umbo.

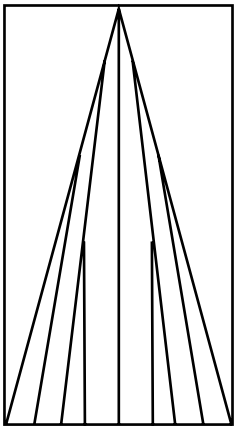

Figure 20: Costal pattern in the sulcus of *Atylephorus* sp. ind.

Voiseyella bruntoni Baliński and Sun, 2010 from the middle Tournaisian of South China has a much more transverse, mucronate outline, a narrower sulcus, a grooved fold and a flatter ventral interarea.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section.

Selected previous records: Mississippian, USA (Texas) (Carter, 1967); Mississippian, Canada (West Alberta) (Carter, 1987).

Superfamily BRACHYTHYRIDOIDEA Fredericks, 1924
Family BRACHYTHYRIDIDAE Fredericks, 1924

Genus *Latibrachythyris* Angiolini, Long and Davies 2011

Type species: *Spirifer pinguis* Sowerby, 1821 from the late Tournaisian – Visean of Ireland and England.

Remarks: *Latibrachythyris* differs from *Brachythyris* McCoy, 1844 by its wider cardinal margin, rounded to angular cardinal extremities, larger size, coarser ornamentation and more evident fold and sulcus. It differs from *Meristorygma* Carter, 1974 by its less transverse outline, less evident ribbing in the sulcus, and the absence of three distinct, wide costae on the fold.

Latibrachythyris sp. ind. (Figure 18, w–z)

Material: three articulated specimens: MPUM10649(S24A; S24B); MPUM10650(S24C); one ventral valve: MPUM10651(IR989-435C).

Description: Small to medium sized, biconvex shell with ovato-triangular to variably transverse outline. Maximum width at mid-length: 9.6–32.1 mm, corresponding length: 11.1–28.3 mm; hinge is ¾ of the maximum width; cardinal extremities rounded, slightly auriculated; anterior commissure uniplicate. Ventral valve convex with stout, recurved umbo; interarea high, relatively narrow, with a small delthyrium closed by a convex, striated stegidium with a concave anterior edge; ventral sulcus evident but shallow, wide, with an "U" shaped cross section. Dorsal valve less convex with rounded fold. Ornamentation of wide, flat costae, numbering 5 per 5 mm at 10 mm from the umbo and 2–3 per 5 mm at the anterior margin; ventral sulcus smooth with faint traces of ribs; dorsal fold smooth.

Dimensions (in mm):

	Width	Length	Thickness
S24A	32.1	28.3	14.7
S24C	23.2	19.9	12.1
S989C	9.6	11.1	

Remarks: The present specimens are left in open nomenclature due to their state of preservation.

Angiolini et al. (2011) placed *Brachythyris chouteauensis* Weller, 1909, from the Tournaisian of Missouri (Weller, 1914), Texas (Carter, 1967) and Oklahoma (Carter, 1999), in the genus *Latibrachythyris*; the Iranian specimens resemble in size and outline to the specimens from Missouri, but *L. chouteauensis* has a coarser ornamentation and more evident fold and sulcus. Other species with a wide hinge which may be worth to include in *Latibrachythyris*, but differ in details of ornamentation and outline from the Iranian specimens, are: *Brachythyris hortonensis* Carter, 1988, from the Early Mississippian of the USA; *Brachythyris gurleyi* Weller, 1914, from the Mississippian of the USA; *Brachythyris latecardinalis* Thomas, 1971, from the Tournaisian of Australia; *Brachythyris planulata* Roberts, 1971, from the Devonian – Carboniferous of Australia; *Brachythyris krapivnensis* Beznosova, 1959, from the middle – late Tournaisian of Siberia (Kusnetsk Basin) (Beznosova in Sarytcheva et al., 1963).

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran. IR-prefix specimens from Abrendan section; S-prefix specimens from Simeh Kuh section.

Superfamily RETICULARIOIDEA Waagen, 1883
Family ELYTHIDAE Fredericks, 1924
Subfamily ELYTHINAE Fredericks, 1924

Genus *Kitakamithyris* Minato, 1951

Type species: *Torynifer (Kitakamithyris) tyoanjiensis* Minato, 1951 from the Tournaisian of Japan.

Remarks: *Kitakamithyris* Minato, 1951 is externally similar to *Martinothyris* Minato, 1953, which differs by its elaborate spines, the absence of a ctenophoridium and of internal furrows on the internal surface of the valves. *Kitakamithyris* is similar to *Phricodothyris* George, 1932, which however differs by its rectimarginate commissure, the reduced dental lamellae and the very minute ctenophoridium. *Kitakamithyris* is similar to *Torynifer* Hall and Clarke, 1894b, which differs by its elaborate spines, the absence of spinules on the spines, the occurrence of a variably deep sulcus and of a cardinal plate supported by a robust septum.

Kitakamithyris sp. ind. (Figure 18, aa–ff; Figure 19, q–r)

Material: three articulated specimens: MPUM10652(S40C); MPUM10653(S41A); MPUM10654(S41B).

Description: Small to medium, biconvex shell with suboval transverse to elongated outline. Maximum width: 15.7–20.8 mm, corresponding length: 16.0–18.1 mm; anterior commissure uniplicate. Ventral valve very convex, with high, swollen umbo, recurved at its beak; interarea apsacline, high, concave at the umbo, then flat with wide delthyrium; ventral sulcus absent. Dorsal valve slightly convex with very low fold anteriorly. Ornamentation of dense growth lamellae bearing at their anterior margin regularly arranged ogival, double-barreled spine bases, numbering 10–11 per 5 mm; spinules along the spines. Interior of ventral valve with dental plates and a median ridge starting from the umbo.

Dimensions (in mm):

	Width	Length	Thickness
S40C	20.8	18.0	13.2
S41A	15.7	18.1	10.5
S41B	18.0	15.0	12.4

Remarks: The present specimens are similar to *Kitakamithyris merensis* Martínez-Chacón and Winkler Prins, 1977, from the Namurian of Spain, but they are smaller in size. They are similar to *Kitakamithyris cooperensis* (Swallow, 1860), from the Early Mississippian of the USA (Carter, 1988), but the latter has larger spines and a deeper ventral sulcus. *Kitakamithyris karatagensis* Chen and Archbold, 2000, from the Tournaisian – Visean of SW China is also similar, but has an inequilateral umbo and denser spine bases.

The species of *Kitakamithyris* from Australia (Thomas, 1971; Roberts, 1971) and from the Namurian of Argentina (Taboada and Cisterna, 1996) are very different in size, outline and depth of sulcus.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Simeh Kuh section.

Subfamily TORYNIFERINAE Carter in Carter, Johnson, Gourvennec and Hou, 1994

Genus *Torynifer* Hall and Clarke, 1894b

Type species: *Spirifer pseudolineatus* Hall, 1858 from the late Tournaisian of the USA.

Torynifer sp. ind. (Figure 18, gg–ii; Figure 19, s)

1968 *Torynifer* sp. A – Gaetani, p. 724, pl. 51, figs 7–9, text-fig. 15.

Material: one ventral valve: MPUM10655(IR 990-3); one dorsal valve: MPUM10656(IR990-341).

Description: Small to medium sized, biconvex shell with transverse, semicircular outline; maximum width: 26.4 mm, corresponding length: 22.5 mm, thickness: 6.5 mm. Anterior commissure rectimarginate. Ventral valve convex with slender umbo; ventral sulcus absent. Dorsal valve slightly convex; dorsal fold absent. Ornamentation of regularly spaced growth lamellae bearing double-barreled spines at their anterior margin, numbering 10 per 5 mm. Interior of dorsal valve with cardinal plate supported by a robust septum.

Remarks: The two available specimens are poorly preserved but the combination of the double-barreled spines with the internal cardinal plate and robust septum justifies to include them in the genus *Torynifer.*

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section. Also reported by Gaetani (1968) from the same formation of North Iran.

Order SPIRIFERINIDA Ivanova, 1972
Suborder SPIRIFERINIDINA Ivanova, 1972
Superfamily SYRINGOTHYRIDOIDEA Fredericks, 1926
Family SYRINGOTHYRIDIDAE Fredericks, 1926
Subfamily SYRINGOTHYRIDINAE Fredericks, 1926

Genus *Syringothyris* Winchell, 1863

Type species: *Spirifer carteri* Hall, 1857 (=*Syringothyris typa* Winchell, 1863) from the late Tournaisian of the USA.

Syringothyris carteri (Hall, 1857) (Figure 19, t–w; Figure 21, a–e; Figure 22, a–b)

1857 *Spirifer carteri* Hall: p. 398.
1914 *Syringothyris typus* – Weller: p. 395; pl. 69, figs 1–5.
2006 *Syringothyris carteri* – Carter in Williams et al.: p. 1898; figs 1862a–1862d.

Material: two articulated specimens: MPUM10657(IR989-418); MPUM10658(IR993-340); four ventral valves: MPUM10659(IR1041-312; IR1045-13); MPUM10660(IR992-42); MPUM10661(IR994-351); one dorsal valve: MPUM10662(IR989-424).

Description: Large sized, biconvex shell with transverse outline; maximum width at the hinge: 41.6–47.6 mm, corresponding length: 20.1–32.2 mm; cardinal extremities mucronate in juveniles, alate in adult forms; anterior commissure strongly uniplicate. Ventral valve convex, subpyramidal with wide umbo, projecting posteriorly; interarea apsacline, high (9.0–12.0 mm in height), striated, triangular, concave posteriorly then flat towards the cardinal margin; ventral sulcus evident on the entire valve, with an "U" shaped cross-section forming a "V" shaped sulcal tongue, only slightly projecting anteriorly. Dorsal valve uniformly convex; interarea orthocline, quite low; dorsal fold narrow, low posteriorly, increasing in height anteriorly, with "U" shaped cross section. Ornamentation of wide ribs with rounded tops numbering 5 per 10 mm on the lateral flanks at the anterior commissure; sulcus smooth except for growth lamellae; fold with two ribs. Interior of ventral valve with thick adminicula and thin dental lamellae joining to form dental plates which are parallel and closely set near the floor of the valve but diverge, dorsally towards the delthyrium; syrinx initially fused to the delthyrial plate then free; low myophragm.

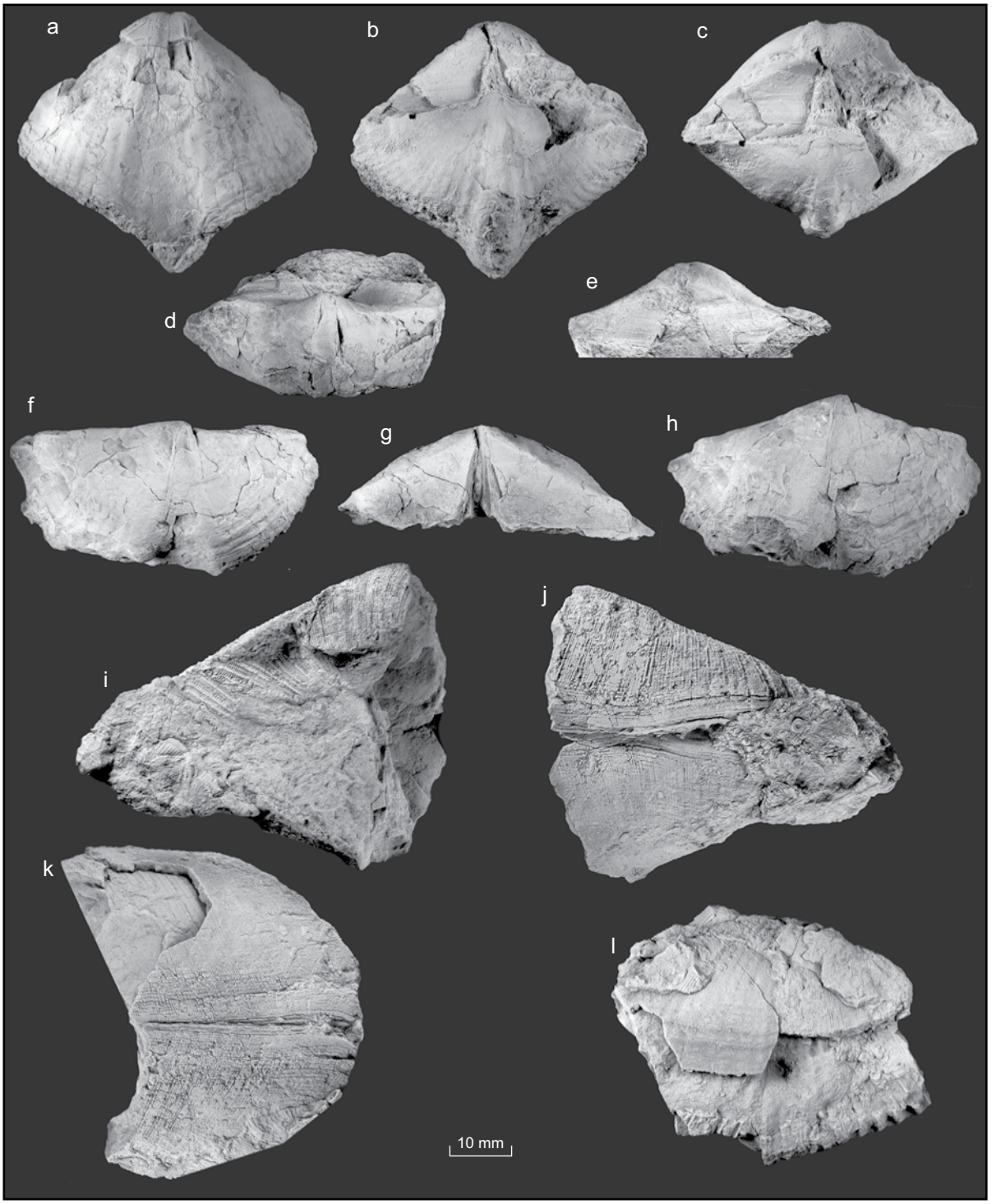

Figure 21: (a–e) ***Syringothyris carteri*** **(Hall, 1857). Abrendan section. (a–c) MPUM10657(IR989-418), articulate specimen. (a) ventral view. (b) postero-dorsal view. (c) posterior view. (d–e) MPUM10661(IR994-351), ventral valve. (d) postero-ventral view. (e) dorsal view of ventral interarea. (f–h)** ***Syringothyris skinderi*** **Sokolskaya in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963. Abrendan section. MPUM10665(IR997-61), ventral valve. (f) postero-ventral view. (g) ventral view. (h) dorsal view of ventral interarea. (i–l)** ***Hippocardia alborza*** **Hoare and Aghababalu, 2001. Abrendan section. (i–j) MPUM10682(IR989-49), articulate specimen. (i) dorsal view. (j) ventral view. (k) MPUM10683(IR994-350), articulate specimen ventral view. (l) MPUM10684(IR990-338), articulate specimen, lateral view. All figures X 1. Scale bar 10 mm.**

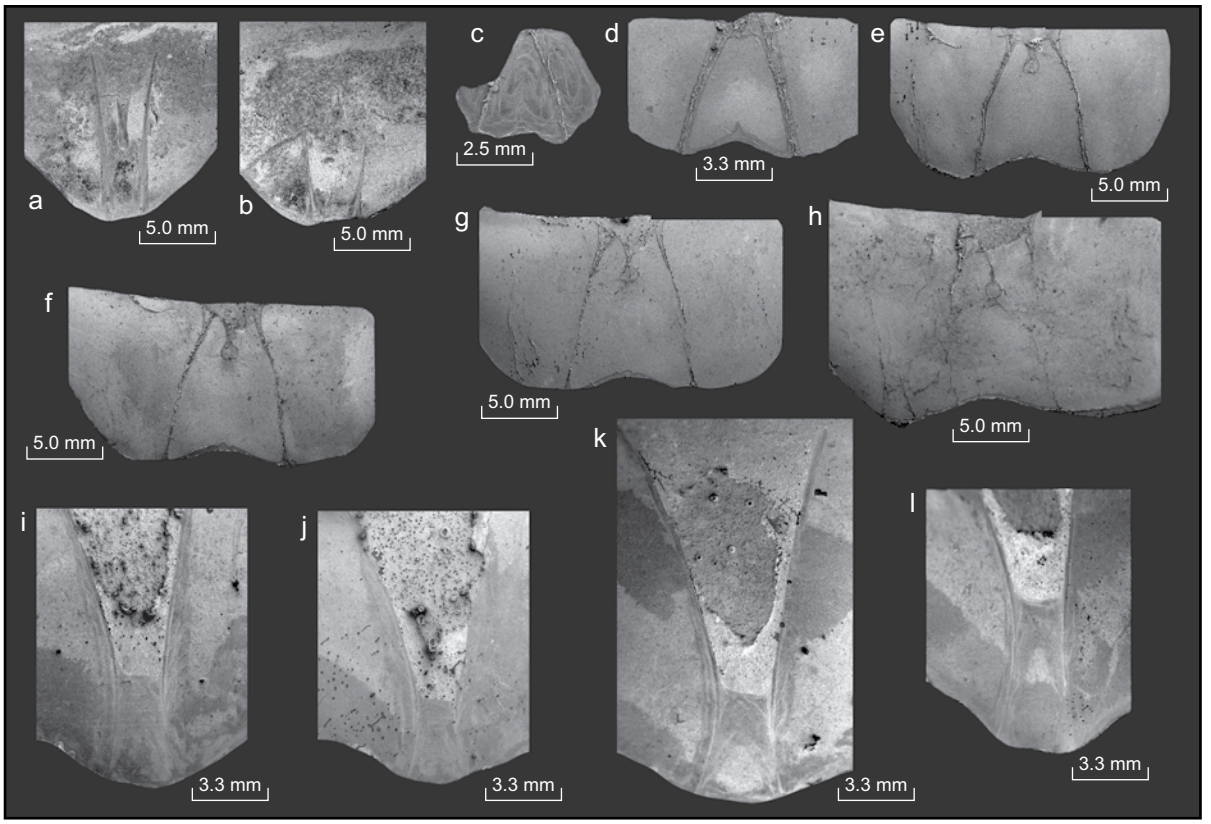

Figure 22: (a–b) *Syringothyris carteri* (Hall, 1857). Abrendan section. MPUM10660(IR992-42), transverse sections of a ventral valve at (a) 10.2 mm, X2, (b) 12.5 mm, X2, from the umbo. (c–h) *Syringothyris skinderi* Sokolskaya in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963. Abrendan section. MPUM10664(IR992-313), transverse sections of a ventral valve at (c) 1.2 mm, X4, (d) 5.8 mm, X3, (e) 7.2 mm, X2, (f) 8.3 mm, X2, (g) 9.5 mm, X2, (h) 10.2 mm, X2, from the umbo. (i–l) *Pseudosyrinx* sp. ind. Abrendan section. MPUM10666(IR1042-29), articulate specimen, tangential sections, (i) 2.4 mm, X3, (j) 3.0 mm, X3, (k) 4.1 mm, X3, (l) 5.5 mm, X3, from the umbo.

Dimensions (in mm):

	Width	Length	Thickness
IR989-418	47.6	32.2	35.1
IR992-42	41.6	20.1	16.9
IR994-351	47.6	20.1	

Discussion: The examined specimens fit with the description of *Syringothyris carteri* (Hall, 1857) based on their swollen lateral flanks and concave ventral interarea, the latter feature clearly distinguishing this species from the others in the genus.

The specimens described as *S. carteri* from the middle – late Tournaisian of Siberia (Kusnetsk Basin) by Sokolskaya in Sarytcheva et al. (1963) should be excluded from *S. carteri* because of their flat interarea.

Syringothyris textus (Hall, 1857), from the Mississippian of the USA (Weller, 1914), is similar to *S. carteri*, but differs by its flatter interarea, less recurved umbo and lower dorsal fold.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Selected previous records: Mississippian, USA (Illinois) (Weller, 1914).

Syringothyris skinderi Sokolskaya in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963 (Figure 21, f–h; Figure 22, c–h)

1963 *Syringothyris skinderi* – Sokolskaya in Sarytcheva et al.: p. 275; pl. 47, figs 3–7.

Material: nine ventral valves: MPUM10663(IR992-8; IR992-314; IR995-324; IR996-19; IR997-60; IR997-67; IR1044-5); MPUM10664(IR992-313); MPUM10665(IR997-61).

Description: Large, convex, subpyramidal valve with very transverse outline. Maximum width at the hinge: 20.4–50.1 mm, length 10.7–24.3 mm; cardinal extremities mucronate to alate; anterior commissure uniplicate. Ventral umbo wide, not swollen or recurved; interarea apsacline, very high (15.0–21.0 mm in height), triangular, flat; ventral sulcus extended for all the length of the valve with an "U" shaped cross-section. Ornamentation of costae on the lateral flanks; sulcus smooth except for growth lamellae. Interior of ventral valve with thin dental plates, divergent toward the floor of the valve; syrinx fused to the delthyrial plate; myophragm low.

Dimensions (in mm):

	Width	Length	Thickness
IR992-313	44.5	24.7	20.4
IR992-314	44.4	14.2	
IR995-324	42.6	20.1	22
IR997-60	20.4	10.7	8.0
IR997-61	50.1	24.3	22.0

Discussion: The examined specimens can be referred to *Syringothyris skinderi* Sokolskaya in Sarytcheva, Sokolskaya, Beznosova and Maksimova, 1963 based on their external characters.

S. skinderi is easily distinguishable from *S. carteri* by its flat interarea, which is very different from the concave one of *S. carteri*. Furthermore, *S. skinderi* has thinner dental plates and a syrinx fused to the delthyrial plate for most of its development.

S. skinderi differs from *S. textus,* from the Mississippian of the USA (Weller, 1914), by its less transverse outline, the lower ventral interarea and the longer dental plates; from *Syringothyris subcuspidatus* (Hall, 1858), from the Mississippian of the USA, by its more transverse outline, higher and flatter interarea and the different convexity of the two valves.

Syringothyris principalis North, 1920, from the Late Devonian – Tournaisian of UK, is similar, but differs for a more marked separation between the sulcus and the flanks enhanced by strong ribs delimiting the sulcus, which has a "V" shaped section.

Syringothyris afghanica (Plodowski, 1968) and *Syringothyris subcuspidatoides* (Plodowski, 1968), from the Visean – Namurian of Afghanistan, differ by their recurved and very pronounced umbos. *Syringothyris folloti* (Legrand Blain, 1974), from the Tournaisian of Sahara, differs by the presence of sulcal ribs and its lower ventral interarea.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

Selected previous records: Middle to late Tournaisian, Siberia (Kusnetsk Basin) (Sokolskaya in Sarytcheva et al., 1963).

Subfamily PERMASYRINXINAE Waterhouse, 1986

Genus *Pseudosyrinx* Weller, 1914

Type species: *Pseudosyrinx missouriensis* Weller, 1914 from the late Tournaisian of the USA (Missouri).

Pseudosyrinx sp. ind. (Figure 22, i–l)

Material: one articulated specimen: MPUM10666(IR1042-29).

Description: Large sized, biconvex shell with transverse semicircular outline; maximum width at the hinge: 36.4 mm, length: 22.2 mm, thickness: 24.4 mm; cardinal extremities mucronate in the juvenile stages later becoming angular. Anterior commissure uniplicate. Ventral valve subpyramidal; interarea orthocline, generally flat, concave only below the umbo, triangular, very high, striated; delthyrium triangular, high and narrow; ventral sulcus rather shallow but present on the entire valve; sulcal tongue not developed. Dorsal valve slightly but uniformly convex; umbo slightly swollen and overhanging; dorsal fold low, evident only anteriorly with an "U" shaped cross section. Ornamentation of fine, low, rounded ribs on the lateral flanks, numbering 9 per 10 mm at the side of the sulcus at the anterior margin; sulcus and fold smooth; rare growth lamellae. Interior of ventral valve with high and thin dental plates, diverging dorsally; delthyrial plate depressed with respect to the interarea; syrinx absent.

Discussion: Weller (1914) described several species of *Pseudosyrinx* from the Mississippian of the USA.

The examined specimen differs from *Pseudosyrinx missouriensis* Weller, 1914 and *Pseudosyrinx gigas* Weller, 1914, by its smaller size, less transverse outline and the absence of a sulcal tongue; from *Pseudosyrinx keokuk* Weller, 1914, by its smaller size, its flatter ventral interarea, and its smaller dorsal umbo.

Occurrence: Mobarak Formation, Damghan, Alborz, North Iran, Abrendan section.

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