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BIOSTRATIGRAPHY OF THE UPPER DEVONIAN TRIGONIRHYNCHIID BRACHIOPODS (RHYNCHONELLIDA) FROM ARMENIA

SEROBYAN V. [1,2], GRIGORYAN A.[1], MOTTEQUIN B.[3], MAYILYAN R.[4], CRÔNIER C.[2], DANELIAN T.[2]

[1]Institute of Geological Sciences of the National Academy of Sciences of the Republic of Armenia–Yerevan, Armenia (vahramserobyan@gmail.com)
[2]UMR 8198 Evo-Eco-Paleo du CNRS–University of Lille, France
[3]Royal Belgian Institute of Natural Sciences–Brussels, Belgium
[4]Yerevan State University–Yerevan, Armenia
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A review of the eight trigonirhynchiid brachiopod species known from Armenia is here conducted with respect to modern taxonomic assignments and updated stratigraphic correlations. The earliest diversity of the family recorded in Armenia is two species known from the Upper Frasnian; the diversity is highest during the late Famennian, but drops drastically in the Devonian–Carboniferous boundary. Our review highlights the biochronological potential of several trigonirhynchiid species in dating accurately the Late Frasnian and parts of the early and late Famennian intervals.

Keywords: Upper Palaeozoic; Devonian; Armenia; Taxonomy; Brachiopods; Rhynchonellides; Trigonirhynchiidae; Biostratigraphy.

INTRODUCTION

Armenia offers exceptional outcrops of Upper Palaeozoic sedimentary sequences, which still remain largely under–explored regarding the insights they may provide to understand Late Devonian mass extinction events. These sequences are encountered mainly in the southern part of Central Armenia (fig.1.) and belong to the South–Armenian block which was at the time part of Gondwana (Sosson *et al.*, 2010). Brachiopods are relatively rich in these sequences and are very useful for biostratigraphic correlations. This is especially true for rhynchonellides, which are particularly important for dating Upper Devonian–Lower Carboniferous sequences thanks to their short stratigraphic ranges and great diversity. In Armenia, Palaeozoic brachiopods were systematically studied by Abrahamian (Abrahamian 1954, 1957, 1959, 1974a, 1974b), but their fossil record deserves to be revisited in the light of taxonomical progress achieved since the seventies; this is particularly true for the rhynchonellide species, which were initially assigned by Abrahamian to the Givetian genus *Camarotoechia* Hall & Clarke, 1893. A review of Abrahamian's papers establishes the occurrence of 14 rhynchonellide species in Armenia,

eight of which belong to the family Trigonirhynchiidae; five of these species were described for the first time by Abrahamian in 1957 and 1959. The main purpose of this study is to update the taxonomic and biostratigraphic understanding of all eight trigonirhynchiid species known from Armenia, especially in the light of recent taxonomic and biostratigraphic revisions made based on material from Nakhichevan (see Alekseeva *et al*., 2018 and other references therein). We here provide English translations (from Russian) for the original diagnoses of all five new species introduced by Abrahamian and discuss the occurrence of all eight trigonirhynchiid species studied by her in the 12 sections cropping out in Armenia (Abrahamian 1957, 1959). Their age range and worldwide occurrence are also discussed. This review clarifies their biostratigraphic value as some of them are very valuable for the biostratigraphy of the Devonian sequences in Armenia and may be useful for correlations with sequences preserved in nearby Nakhichevan, but also in other regions which were situated during the Devonian along the northern margin of Gondwana (i.e. Iran, Afghanistan, Turkey and Morocco).

STRATIGRAPHIC FRAMEWORK

An up to 1500m–thick pile of Middle Devonian–Lower Carboniferous deposits covers the southern part of Central Armenia. These thick platform carbonate sequences represent the earliest depositional history of Palaeozoic sediments in the area, accumulated on the Gondwanan passive margin that was facing the Palaeotethys; this part was later individualized as the South–Armenian block, following its northward migration and opening of Neotethys further in the south (Sosson *et al*., 2010). The Palaeozoic of Armenia consists of mixed carbonate-siliciclastic deposits including sequences of limestones, shales, sandstones and quartzites. They have been studied since the 1850s by several important authors: Abich (1858), Frech & Arthaber (1900) Lisitsyn (1913), Bonnet (1947) etc. In Armenia, the Upper Devonian to Lower Carboniferous biostratigraphy was studied systematically by Arakelian (1964a, b) and Abrahamian (1957). In the Lesser Caucasus, a rudimentary Devonian biostratigraphical zonal scheme based on brachiopods was established by Rzhonsnitskaya (1948), which simply subdivided the Lower from the Upper Devonian. In her groundbreaking monography, Abrahamian (1957) discussed also the occurrence and stratigraphic distribution of 34 brachiopod species and 2 subspecies; she thus developed a new continuous biostratigraphic scheme characterized by marker species or species assemblages (fig.2).

As the Upper Palaeozoic sedimentary sequences of Armenia continue into Nakhichevan, brachiopod biostratigraphy was subsequently revised by Mamedov & Rzhonsnitskaya (1985); their zonal scheme was more recently updated by Mamedov & Rzhonsnitskaya (2000) and based on the conodont study of Aristov (1994) from Nakhichevan, it was correlated with the international conodont biozonation. Finally Ginter *et al.*, (2011) reported chondrichthyan remains from Armenia.

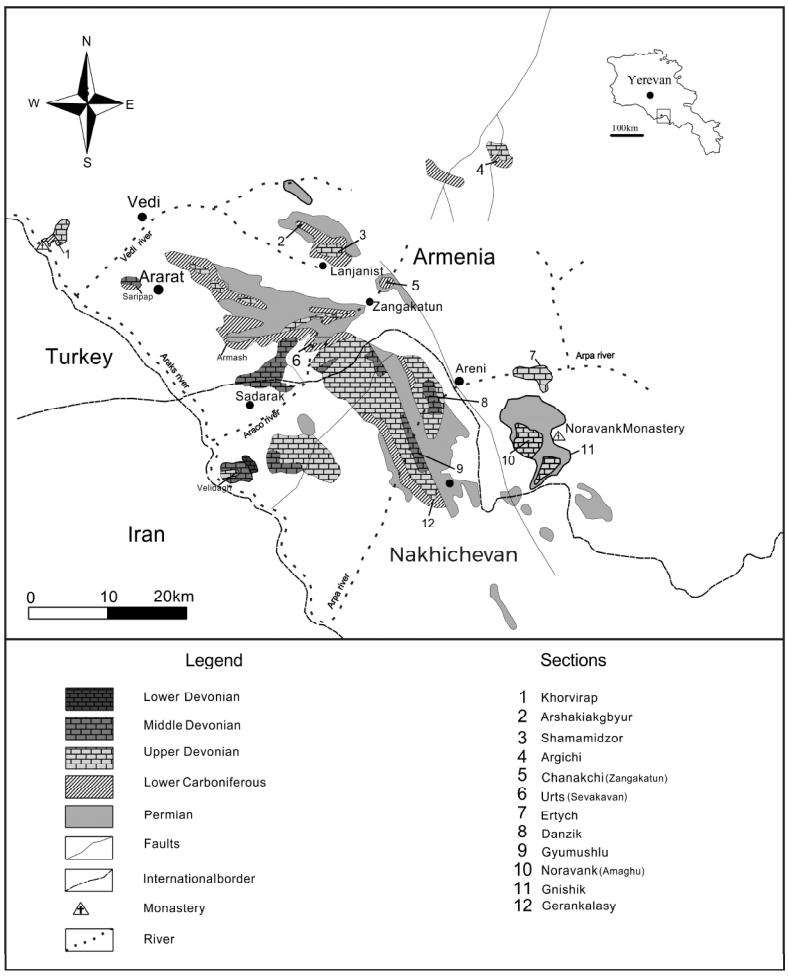

Figure1. Schematic geological map of South Armenian block; distribution of the Upper Devonian–Lower Carboniferous deposits with localization of trigonirhynchiidspecies (compiled by A.Grigoryan, V.Serobyan, R.Mayilyan, T.Danelian).

The Middle Devonian (Eifelian to Givetian) has a restricted distribution in Armenia; it is only detected along the boundary with Nakhichevan. The Eifelian stage is represented by limestones, sandstones and shales, while the Givetian is composed mainly of thick bedded coral limestones, sandy limestones and calcareous sandstones. The Upper Devonian sequences in Armenia were subdivided by Arakelian (1964a, b) into nine 'formations'; however, these successive units, although described based on a type locality, they were mainly characterized by their fossil record, rather than distinct lithological differences. In practice, most of the formations have very similar lithological characteristics and they cannot be recognized on the field without knowledge of their brachiopod assemblages. That is why they appear to correspond to horizons with different brachiopod assemblages; thus, they bear a biostratigraphic rather than lithostratigraphic significance (see Murphy & Salvador 1999). The Frasnian stage is composed mainly of limestones and shales with some intercalations of quartzites. The Famennian has a wider distribution than the Frasnian in Armenia. It is characterized by the absence of corals and by the abundance of brachiopods. It is represented by limestones,

sandy limestones, shales, quartzites and sandstone beds. The Lower Carboniferous consists mostly of carbonate rocks, which accumulated in slightly deeper marine environments. In the upper part of the sequence, corals predominate in the carbonates, whereas brachiopods are only locally abundant.

SYSTEMATIC PALAEONTOLOGY

The classification followed in this study is the one presented in the Treatise on Invertebrate Paleontology (Savage *et al*., 2002a).

Order Rhynchonellida Kuhn, 1949

Superfamily Rhynchotrematoidea Schuchert, 1913

Remarks — This superfamily is characterized internally by dental plates that are sometimes fused to the valve walls; it also bears a long dorsal median septum, which may be absent in some rare occasions, and a variably developed septalium (Savage *et al*., 2002b).

Family Trigonirhynchiidae Schmidt, 1965

Remarks — This is one of the most diverse rhynchonellide clades; it is characterized by strongly ribbed, wedge–shaped or nut–like shells, narrow and short hinge lines with functional pedicle. Internally, it is characterized by the presence of dental plates and a median septum; its septalium may be covered or uncovered (Savage *et al*., 2002b). The stratigraphic range of the family spans the Middle Ordovician to Early Carboniferous interval; only two genera within this family crossed the Devonian–Carboniferous boundary. No new genera appeared during the Tournaisian and the entire family became extinct during the Viséan (Savage *et al*., 2002b).

Subfamily Ripidiorhynchinae Savage, 1996

Genus *Cyphoterorhynchus* Sartenaer, 1965

Type species: *Uncinulus* (*Uncinulina*) *koraghensis* Reed, 1922

Cyphoterorhynchus arpaensis (Abrahamian, 1957)

1957 *Camarotoechia radiata* Nal, (in litt.) var. *arpaensis* n. var.; Abrahamian, p. 55, pl. 5, fig. 6; text–fig. 11.

1964a *Camarotoechia radiata* Nal, var. *arpaensis* Abrahamian, 1957; Arakelian, pp. 67 and 70.

1965 *Cyphoterorhynchus arpaensis* (Abrahamian, 1957); Sartenaer, p. 51.

1966 *Cyphoterorhynchus arpaensis* (Abrahamian, 1957); Sartenaer, p. 29, pl. 1, figs. 2a–2b, 3a–3e, 4a–4e; pl. 2, figs. 1a–1e; text–fig. 1.

1971 *Cyphoterorhynchus arpaensis* (Abrahamian, 1957); Brice, p. 52, pl. 3, fig. 2a–e, fig. 4a–e, fig. text 14A.

1974 *Camarotoechia radiata arpaensis* Abrahamian, 1957; Abrahamian p. 53, pl 17, fig. 5.

2006 *Cyphoterorhynchus arpaensis* (Abrahamian, 1957); Gourvennec, p. 5, pl. 1, figs. 24–28; table 1.

2018 *Cyphoterorhynchus arpaensis* (Abrahamian, 1957); Alekseeva *et al*., p. 910, pl. 7, figs. 3 and 4; pl. 14, figs. 7 and 15; text–fig. 53.

Diagnosis (English translation from Russian in Abrahamian 1957, p. 55).— Shell large, wider than long, oval in outline and dorsibiconvex; thickest at midlength; beak large and suberect; hingle line atrophic; sulcus and fold more or less well developed; tongue usually high and rounded; lateral commissures straight; median costae larger than costae on flanks (9–10 costae in sulcus, 10–12 on fold and 20–25 on each flank).

Remarks — Although initially introduced by Abrahamian (1957) as a variety of *Camaratoechia radiata* Nalivkin, 1960, it was raised by Sartenaer (1965) at the species level; in this occasion Sartenaer reassigned the species to the newly introduced genus *Cyphoterorhynchus*.

Occurrence and age — C. arpaensis was first reported in Armenia by Abrahamian (1957), in the *orbelianus* Zone of the Ertych, Noravank and Gnishik sections, later it was reported by Arakelyan (1964a) in the Baghrsagh Formation of the Danzik and Gyumushlu sections (Fig. 1). However, in 1974, Abrahamian specified that it actually occurs in the Baghrsagh Formation, which is considered as Late Frasnian in age based on the brachiopod fauna collected by Abrahamian it is correlated with the *Uchtospirifer subarchiaci–Cyphoterorhynchus arpaensis* brachiopod Zone of Rzhonsnitskaya & Mamedov (2000), for which *C. arpaensis* is amongst the species characterizing the assemblage zone (Alekseeva *et al*., 2018). This species is also reported from Nakhichevan (Alekseeva *et al.,* 2018), Iran (Sartenaer 1966), Turkey (Gourvennec 2006) and Afghanistan (Brice 1971) always from strata of Frasnian age.

Genus *Ripidiorhynchus* Sartenaer, 1966

Type species: *Terebratula livonica* Von Buch, 1834

Ripidiorhynchus gnishikensis (Abrahamian, 1959)

1959 *Camarotoechia strugi* Nal, subsp. *gnishikensis* n. subsp.; Abrahamian, p. 6, pl. 2, figs. 5-7.

1964a *Camarotoechia strugi* Nal, subsp. *gnishikensis* Abrahamian, 1959; Arakelian, pp. 67, 70, 74, 77.

2018 *Ripidiorhynchus gnishikensis* (Abrahamian, 1959); Alekseeva *et al*., p. 905, pl. 6, fig. 6; pl. 14, figs. 6 and 18; text–fig. 50.

Diagnosis (English translation from Russian in Abrahamian 1959, p. 6).— Shell medium–sized, rounded pentagonal in outline, moderately convex with straight lateral commissures; beak small, acute and inclined; hinge line astrophic; sinus and fold wide, originating at about midlength; costae numerous and fine thickened anteriorly, especially in sulcus and on fold; anterior margin widely trapezoidally curved.

Remarks — Abrahamian considered the species as a subspecies of *Camaratoechia strugi* Nalivkin, 1941 [=*Ripidiorhynchus livonicus* (Buch, 1834), according to Sokiran (2002), from the Lower Frasnian of northwestern Russia, Latvia, and Lithuania] based on some external differences observed

within the Armenian material such as the finer costae and a lower trapezoidal tongue. However Alekseeva *et al.,* (2018) have recently studied the internal structure of their material from Nakhichevan and they raised this morphotype to the species level assigning it at the same time to the new genus *Ripidiorhynchus* based on the shell shape, the external ornamentation, the massive teeth, the presence of short dental plates which are dorsally convergent and slightly curved, the short dorsal septum and covered septalium.

Occurrence and age - In Armenia, this species has been encountered in the Gyumushlu, Danzik sections from the Late Frasnian Baghrsagh Formation as well as in the Noravank, Ertich and Gnishik sections from the Baghrsagh Formation to the early Famennian Noravank Formation (Abrahamian 1959, Arakelian 1964; Fig. 1); these are correlated respectively with the *Uchtospirifer subarchiaci-Cyphoterorhynchus arpaensis* and *Cyrtospirifer asiaticus–Mesoplica meisteri* zones of Rzhonsnitskaya & Mamedov (2000). This species is also reported from Upper Frasnian in Nakhichevan (Alekseeva *et al.,* 2018).

Subfamily Trigonirhynchiinae Schmidt, 1965

Genus *Sinotectirostrum* Sartenaer, 1961

Type species: *Sinotectirostrum medicinale* Sartenaer, 1961

Sinotectirostrum delicatacostatum (Abrahamian, 1957)

1957 *Camarotoechia delicatacostata* n. sp.; Abrahamian, p. 53, pl. 6, figs. 5–6; text–fig. 10.

1964b *Camarotoechia delicatacostata* Abrahamian; Arakelian; pp. 106 and 109.

1974 *Camarotoechia delicatacostata* Abrahamian, 1957; Abrahamian, p. 54, pl. 31, fig. 7. 2018 Sinotectirostrum delicatacostatus (Abrahamian, 1957); Alekseeva et al., p. 895, pl. 5, fig. 2; text–fig. 41.

Diagnosis (English translation from Russian in Abrahamian 1957, p. 53).— Shell small–sized, convexoplane to weakly dorsibiconvex; hinge line strongly curved; beak pointed and suberect; anterior margin trapezoidally curved; sulcus and fold wide and distinct, originating at mid–length; costae uniform, fine and angular (5 costae in sulcus, 6 on fold, 10–12 costae on each lateral flank).

Remarks — This species is one of the most biostratigraphically valuable species of the uppermost Famennian (Strunian) of both Armenia and Nakhichevan. Initially described by Abrahamian (1957) it was incorrectly assigned to Camarotoechia. Further detailed study by Alekseeva et al., (2018), including observations on both external and internal structures, established that it should be assigned to Sinotectirostrum owing to the following characteristics: pentagonal outline, dorsibiconvex profile, simple costae arising near umbones, vertical dental plates and septalium with cover plate anteriorly.

Occurrence and age — Initially, Abrahamian (1957) reported this species from the Lower and Middle Etroeungt zones of the Arshakiaghbyur section. However, in 1974, she specified that it has a more restricted stratigraphic range and it only occurs in the uppermost Famennian Arshakiaghbyr Formation, which is correlated with the *Sphenospira julii-Spinocarinifera nigra* Zone of

Rzhonsnitskaya & Mamedov (2000). This species is found in Arshakiaghbyur and Chanakhchi (Zangakatun) sections (Abrahamian 1957, Arakelian 1964b; Fig. 1). Pakhnevich (2012) and Alekseeva et al., (2018) reported this species in their investigations dedicated to the Upper Devonian rhynchonelides in Nakhichevan, both considered it as one of the index species of the uppermost Famennian.

Subfamily Hemitoechiinae Savage, 1996

Genus *Sartenaerus* Özdikmen, 2008

Type species: *Camarotoechia baitalensis* Reed, 1922

Remarks: *Camarotoechia baitalensis* was selected by Sartenaer (1970) as the type species of his new genus *Centrorhynchus* but as pointed out by Özdikmen (2008), this name is preoccupied by *Centrorhynchus* Luehe, 1911 (Acanthocephala) with *Centrorhynchus aluconis* (Müller, 1780) as the type species. In order to solve this issue of junior homonymy, Özdikmen (2008) proposed the new name *Sartenaerus* for *Centrorhynchus* Sartenaer, 1970 (not *Centrorhynchus* Luehe, 1911).

Sartenaerus baitalensis (Reed, 1922)

1922 *Camarotoechia baitalensis* n. sp.; Reed, p. 94, pl. 14, figs. 11–21.

1957 *Camarotoechia baitalensis* Reed, 1922; Abrahamian, p. 41, pl. 4, figs. 1-2.

1964a *Camarotoechia baitalensis* Reed; Arakelian, pp. 74,79,80,82.

1970 *Centrorhynchus baitalensis* (Reed, 1922); Sartenaer, p. 11.

1974 *Camarotoechia baitalensis* Reed, 1922; Abrahamian, p. 52, pl. 18, figs. 7, pl. 19, fig. 2.

2010 *Centrorhynchus baitalensis* (Reed, 1922); Mirieva, p.75.

Remarks — This species is one of the most important rhynchonellide species of the lower Famennian strata of Armenia, which appeared in the Ertych Formation and was extremely abundant within a short stratigraphic interval.

Occurrence and age — Abrahamian (1957) reported initially this species in the *pamiricus* Zone of the Chanakhchi (Zangakatun), Arshakiaghbyur, Ertych, Noravank, Gnishik sections as well as in the *orbelianus* to *pamiricus* zones of the Ertych, Noravank, Gnishik and Arshakiaghbyur sections. Arakelian (1964a) also reported this species in the Gnishik, Noravank, Arshakiaghbyur, Khorvirap and Urts (Sevakavan) sections always from the lower Famennian Ertych Formation (fig.1). However, in 1974 Abrahamian specified that *S. baitalensis* is found in Armenia in the lower Famennian strata of the Ertych Formation (*orbelianus* Zone). This is consistent with the record of this species in Nakhichevan (Mirieva 2010), in the lower Famennian *Uchtospirifer orbelianus*–*Cyrtiopsis armenicus* Zone of Rzhonsnitskaya & Mamedov (2000).

Comparison — The specimens found in Armenia are identical to those introduced by Reed (1922) from the Famennian strata of Pamir, the only difference being that the specimens from Pamir are larger in shell size. *Sartenaerus baitalensis* (Reed, 1922) is very similar to *Sartenaerus letiensis*

(Gosselet, 1879), but the latter differs in the smaller and narrower shell and more pointed costae.

Sartenaerus letiensis (Gosselet, 1879)

1879 ***Rhynchonella letiensis*** n. sp.; Gosselet, p. 398.

1887 ***Rhynchonella letiensis*** Gosselet.; Gosselet, p. 106, pl. 1, figs. 9–19.

1957 ***Camarotoechia letiensis*** (Gosselet, 1887); Abrahamian, p. 38, pl. 5, figs. 4-5.

1964a ***Camarotoechia letiensis*** (Gosselet, 1887); Arakelian, pp. 67, 77, 80, 82-85.

1974 ***Camarotoechia letiensis*** (Gosselet, 1887); Abrahamian, p. 53, pl. 20, fig. 2. 1970 ***Centrorhynchus letiensis*** (Gosselet, 1887); Sartenaer, p. 11.

2016 ***Centrorhynchus letiensis*** (Gosselet, 1879); Mottequin & Brice p. 5, pl. 5, figs. A-G.

2018 ***Sartenaerus letiensis*** (Gosselet, 1887); Alekseeva ***et al.***, p. 899, pl. 5, fig. 7; text–fig. 45.

Remarks — This species is one of the typical Famennian species described by Gosselet (1879) in the middle–upper Famennian strata of the Franco–Belgian Basin and assigned to ***Rhynchonella***, later reassigned to ***Camarotoechia*** by Nalivkin (1930), subsequently allocated by Sartenaer (1970) to the newly proposed genus ***Centrorhynchus***, then the name ***Sartenaerus*** was erected as a replacement name for ***Centrorhynchus*** (Özdikmen, 2008). Although Mottequin & Brice in 2016 photographically illustrated two of Gosselet's specimens, the revision of the original is long overdue.

Comparison — The specimens found in Armenia are very close to the Gosselet's species illustrated in 1887, (p. 106, pl. 1, figs. 9–19), they also closely resemble to the forms described by Frech & Arthaber (1900) in the Famennian strata of Iran but, Iranian specimens are larger in shell size and having deeper sulcus.

Occurrence and age — ***Sartenaerus letiensis*** is found in a large area within the middle-upper Famennian of Franco–Belgian, in the Famennian of Morocco. In Armenia, according to Abrahamian (1957, 1974) ***S. letiensis*** is distributed within all the Famennian biozones, although Mirieva (2010) and Pakhnevich (2012) stated that in the sections of Nakhichevan this species dominated in the all Famennian zones, excluding the last zone (***Sphenospira julii-Spinocarinifera nigra*** Zone). ***S. letiensis*** is observed in the Gyumushlu, Noravank, Gnishik, Ertich, Argichi, Chanakhchi (Zangakatun), Arshakiaghbyur , Danzik and Urts (Sevakavan) sections (Abrahamian 1957, Arakelian 1964a; Fig. 1).

Genus *Ptychomaletoechia* Sartenaer, 1961

Type species: ***Rhynchonella omaliusi*** Gosselet, 1877

Ptychomaletoechia panderi (Semenov & Moeller, 1864)

1864 ***Rhynchonella panderi*** n. sp.; Semenov & Moeller, p. 213, pl. 2, fig. 7a

1937 ***Camarotoechia panderi*** (Semenov & Moeller); Nalivkin, p. 73, pl. 8, figs. 14–19.

1952 *Camarotoechia panderi* (Semenov & Moeller); Sarytcheva & Sokolskaya, p. 164, pl. 46, fig. 249.

1957 *Camarotoechia panderi* (Semenov & Moeller); Abrahamian, p. 50, pl. 6, fig. 1–2; text–fig. 9.

1964b *Camarotoechia panderi* (Semenov & Moeller); Arakelian, p. 111.

1976 *Ptychomaletoechia panderi panderi* (Semenov & Moeller); Bublichenko, p. 66, pl. 6, figs. 1a–1d, 2a–2d, 3a–3d, 4a–4d; text–figs. 4 and 5.

1995 *Macropotamorhynchus panderi* (Semenov & Moeller); Rzhonsnitskaya & Fedorova, pp. 102, 112, 123.

2000 *Macropotamorhynchus panderi* (Semenov & Moeller); Rzhonsnitskaya & Mamedov, p. 332.

2018 *Ptychomaletoechia panderi* (Semenov & Moeller, 1864); Alekseeva *et al.*, p. 903, pl.6, fig. 4; text–fig. 48.

Remarks — Biostratigraphically *P. panderi* is one of the most valuable species of the upper Famennian–lower Tournaisian interval owing to its restricted stratigraphic range and wide palaeobiogeographic distribution.

Occurrence and age — Described initially by Semenov & Moeller (1864) from the lowermost Tournaisian of the Moscow region, this species is widely distributed in the upper Famennian to lower Tournaisian successions of Russia and Kazakhstan. In Armenia it has been only found in the uppermost Famennian Arshakiaghbyur Formation of the Gyumushlu section (Abrahamian 1957, Arakelian 1964a; Fig. 1). However, in Nakhichevan Alekseeva *et al.*, (2018) reported it from both the uppermost Famennian *Sphenospira julii–Spinocarinifera nigra* and the lowermost Tournaisian *Unispirifer praeulbaenensis Rhytiophora curtirostris* zones.

Comparison — The Armenian material is identical to that illustrated by Semenov & Moeller, the difference is only in the ratio of the median costae, contrary to the specimens of Semenov & Moeller the Armenian specimens generally have 3 median costae in the sulcus and 4 costae on the fold and rarely 2 costae in the sulcus and 3 on the fold.

Genus *Paurogastroderhynchus* Sartenaer, 1970

Type species: *Camarotoechia* (?) *nalivkini* Abrahamian, 1957

Paurogastroderhynchus nalivkini (Abrahamian, 1957)

1957 *Camarotoechia* (?) *nalivkini* n. sp.; Abrahamian, p. 48–50, pl. 4, fig. 5; pl. 5, figs. 1–3; text-fig. 8.

1964a *Camarotoechia nalivkini* Abrahamian; Arakelian, pp. 81, 83–85.

1964b *Camarotoechia nalivkini* Abrahamian; Arakelian, pp. 99, 107.

1970 *Paurogastroderhynchus nalivkini* (Abrahamian, 1957); Sartenaer, p. 25-27.

1974 *Camarotoechia* (?) *nalivkini* Abrahamian 1957; Abrahamian, p. 53 pl. 19, fig. 3; pl. 20, fig. 1.

1971 *Camarotoechia* cf. *nalivkini* Abrahamian 1957; Brice, p. 75, pl. 5, figs. 3a–d.

2000 *Paurogastroderhynchus nalivkini* (Abrahamian 1957); Jafarian, p. 228, pl. 2, figs. 5a–c.

2018 *Paurogastroderhynchus nalivkini* (Abrahamian 1957); Alekseeva *et al*., (2018) p.902, pl. 6, figs. 2–3; pl. 14, figs. 9 and 13; text–fig. 47.

Diagnosis (English translation from Russian in Abrahamian 1957, p. 48)— Shell large, almost spherical in outline, strongly convex; beak large, conspicuous and slightly inclined; hinge line astrophic; sulcus and fold wide, poorly developed (sometimes not seeable); anterior margin highly trapezoidally curved; costae simple, rounded angular, closely spaced (6–7 costae in sulcus, 7–8 on fold, 11 on each flank); interspaces narrow.

Occurrence and age— This species defines the upper Famennian *Paurogastroderhynchus nalivkini* Zone of Abrahamian (1957) in Armenia and of Rzhonsnitskaya & Mamedov (2000) in Nakhichevan (see also Alekseeva *et al.*, 2018). In Armenia it occurs only in a very restricted stratigraphic interval which lithologically corresponds to the Gortun Formation and has been reported from nearly all sections studied by Abrahamian and Arakelian (Gyumushlu, Chanakhchi (Zangakatun), Arshakiaghbyur, Urts (Sevakavan) and Argichi; Fig. 1). It has been found also in Iran (Jafarian 2000) and in Afghanistan (Brice 1971), always in strata of late Famennian age.

Subfamily Greirinae Erlanger, 1993

Genus *Tchanakhtchirostrum* Sartenaer & Plodowski, 2003

Type species: *Camarotoechia* (?) *araratica* Abrahamian, 1957

Tchanakhtchirostrum araraticum (Abrahamian, 1957)

1957 *Camarotoechia* (?) *araratica* n. sp.; Abrahamian, p. 43, pl. 4, figs. 3–4; text–figs. 6 and 7.

1964a *Camarotoechia araratica* Abrahamian; Arakelian, p. 84.

1964b *Camarotoechia araratica* Abrahamian; Arakelian, pp. 102, 106, 110.

1974 *Liorhynchus* (*Araratella*) *araratica* (Abrahamian, 1957); Abrahamian, p. 55, pl. 31, fig. 7.

1986 *Araratella araratica* (Abrahamian, 1957); Erlanger, p. 57, pl. 6, figs. 1 and 2; text–fig. 3.

2003 *Tchanakhtchirostrum araraticum* (Abrahamian, 1957); Sartenaer & Plodowski, p. 342.

2018 *Tchanakhtchirostrum araraticum* (Abramian, 1957); Alekseeva *et al*., 2018 p. 919, pl. 8, fig. 6; pl. 14, fig. 1; text–fig. 60.

Diagnosis (English translation from Russian in Abrahamian 1957, p. 46)— Shell small, wider than long, rounded pentagonal in outline and moderately convex; thickest near anterior margin; sulcus and fold start near at midlength, well bordered by costae; tongue more or less high, anterior commissure zigzag; costae run almost from umbones, dichotomize in sulcus and on fold, costae on flanks simple; dental plates thin and short; septum thin with small septalium.

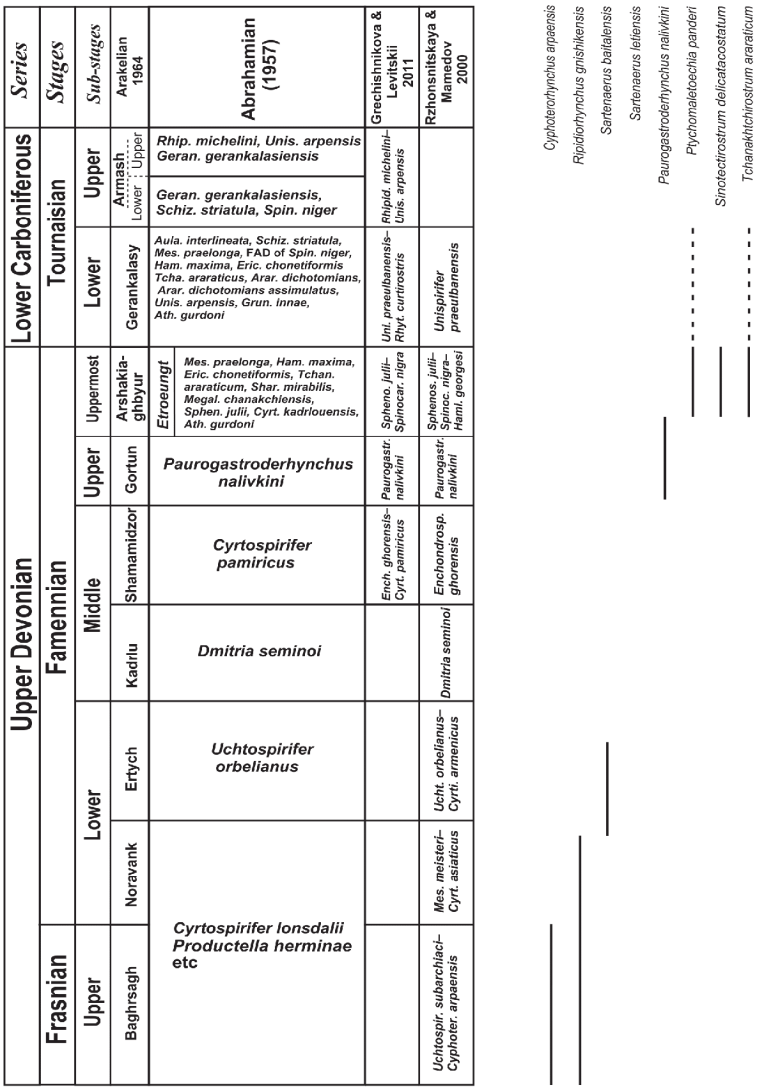

Figure2. Stratigraphic distribution of the Upper Devonian trigonirhynchiid species reported from Armenia (Biozones after Abrahamian 1957, Rzhonsnitskaya & Mamedov 2000, Gretchishnikova & Levitskii 2011, "Formations" after Arakelian 1964a, b). Dotted lines indicate the presence of a species in the fossiliferous record known from Nakhichevan. *Uchtospir.*:*Uchtospirifer*; *Mes.*: *Mesoplica*;*Enchondrosp.*: *Enchondrospirifer*; *Paurogastr.*: *Paurogastroderhynchus*; *Sphenos.*: *Sphenospira*; *Spinoc.*: *Spinocarinifera*; *Haml.*: *Hamlingella*; *Cyrt.*: *Cyrtospirifer*; *Uni.*: *Unispirifer*; *Rhyt.*: *Rhytiophora*; *Rhipid.*: *Rhipidomella*; *Eric.*: *Ericiata*; *Tchan.*: *Tchanakhtchirostrum*, *Shar.*: *Sharovaella*; *Megal.*: *Megalopterorhynchus*; *Ath.*:*Athyris*; *Aula.*: *Aulacella*; *Schiz.*: *Schizophoria*; *Arar.*: *Araratella, Grun.*; *Gruntathyris*; *Geran.*: *Gerankalasiella.*

Occurrence and age — Tchanakhtchirostrum araraticum is reported by Abrahamian (1957) and Arakelian (1964a, b) in the Chanakhchi (Zangakatun), Gyumushlu, Argichi,Urts (Sevakavan) Arshakiaghbyur and Gerankalasy sections (Fig. 1), from the upper Famennian *C. nalivkini* to the middle 'Etroeungt Zone'. This interval is correlated with the upper to uppermost Famennian (*Paurogastroderhynchus nalivkini* and *Sphenospira julii-Spinocarinifera nigra*

zones of Grechishnikova & Levitskii 2011). However, it appears that *T. araraticum* crossed the Upper Devonian–Lower Tournaisian boundary as Alekseeva *et al., 2018* found this species from the uppermost Famennian (*Sphenospira julii–Spinocarinifera nigra* Zone) to the lower Tournaisian (*Unispirifer praeulbanensis–Rhytiophora curtirostris* Zone of Grechishnikova & Levitskii 2011) in Nakhichevan.

CONCLUSIONS

The study of rhynchonellide brachiopods is essential for the dating of the Upper Devonian-Lower Carboniferous carbonate sedimentary sequences of Armenia. Although very fundamental for the stratigraphy of the Devonian and Lower Carboniferous sedimentary sequences of Armenia, the last comprehensive contribution dedicated to brachiopods dates back to the seventies (Abrahamian 1974), while important progress has been achieved since then in brachiopod taxonomy and biostratigraphy, as well as in correlation of brachiopod zonal schemes with the one established on conodonts, especially in Nakhichevan. In this literature review, we illustrate for the first time the biostratigraphic zonation established by Abrahamian (1957) and revised in 1974, with the sequences of "formations" established by Arakelian (1964a, b), but also most importantly with the brachiopod zonal schemes established in Nakhichevan. In Armenia, the earliest trigonirhynchiid species (*Cyphoterorhynchus arpaensis*) appeared during the Late Frasnian with two species known from the Upper Frasnian *Uchtospirifer subarchiaci–Cyphoterorhynchus arpaensis* brachiopod Zone. Close to the Devonian–Carboniferous boundary trigonirhynchiid diversity dropped sharply, although two species (*Ptychomaletoechia panderi* and *Tchanakhtchirostrum araraticum*) appear to have survived in the lower Tournaisian levels preserved in Nakhichevan (Alekseeva *et al.,* 2018).Our literature–based taxonomic and biostratigraphic review, displays an updated picture of the age range of the trigonirhynchiid brachiopod species known from Armenia (and elsewhere) and highlights the excellent biochronological potential of at least 4 species. Thus, *C. arpaensis* is characteristic of the Upper Frasnian, *S. baitalensis* of the upper part of the lower Famennian, *P. nalikini* of the upper Famennian and *S. delicatacostatum* of the uppermost Famennian.

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БИОСТРАТИГРАФИЯ ВЕРХНЕДЕВОНСКИХ TRIGONIRHYNCHIID БРАХИОПОД (RHYNCHONELLIDA) АРМЕНИИ

Серобян В., Григорян А., Моттекуин Б., Маилян Р., Кронье К., Данелиан Т.

Резюме

В статье приводится обзор известных в Армении восьми видов брахиопод из семейства trigonirhynchiid, с учетом современных таксономических переопределений и обновленных стратиграфических корреляций. Самые ранние представители этого семейства, определенные в Армении, представлены двумя видами известных из верхнего франа. Наибольшее разнообразие семейства наблюдается в конце фаменского периода и резко падает на границе девона и каменноугольного периода. Полученные результаты подчеркивают большой биостратиграфический и биохронологический потенциал некоторых видов trigonirhynchiid для точной датировки позднефранского, а также ранних и позднефаменских интервалов.

ՀԱՅԱՍՏԱՆԻ ՎԵՐԻՆ ԴԵՎՈՆԻ TRIGONIRHYNCHIID ԲՐԱԽԻՈՊՈԴՆԵՐԻ ԿԵՆՍԱՇԵՐՏԱԳՏԱԿԱՆ ԱՌԱՆՁՆԱՀԱՏԿՈՒԹՅՈՒՆՆԵՐԸ

Սերոբյան Վ., Գրիգորյան Ա., Մոտտեքուին Բ., Մայիլյան Ռ., Կրոնյե Ք., Դանելիան Տ.

Ամփոփում

Հոդվածում դիտարկվում են Հայաստանում հայտնի ութ trigonirhynchiid բրախիոպոդների տեսակները՝ հաշվի առնելով ժամանակակից տաքսոնոմիական վերանայումները և թարմացված շերտագրական համադրումները: Հայաստանում տվյալ ընտանիքի ամենահին բազմազանությունը ներկայացված է երկու տեսակով, որոնք հայտնի են վերին ֆրանից: Իրենց բազմազանության գագաթնակետին հասնում են ուշ ֆամենում և կտրուկ անկում ապրում ստորին քարածխայինի սահմանին: Trigonirhynchiid բրախիոպոդների դիտարկումները հնարավորություն են տալիս կարևորել դրանց կենսաշերտագրական և կենսաժամանակագրական նշանակությունը ճշգրիտ հասակային սահմանազատում կատարելու ուշ ֆրանի, ինչպես նաև վաղ և ուշ ֆամենի միջակայքերը: