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Devonian and Carboniferous Brachiopods and Biostratigraphy of Transcaucasia

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Abstract—The brachiopods of the orders Lingulida, Craniida, Orthida, Pentamerida, Rhynchonellida, Chonetida, Spiriferida, Spiriferinida, and Athyridida from the Middle–Upper Devonian and Lower Carboniferous of the Nakhchivan Autonomous Republic of the Republic of Azerbaijan and adjacent areas of Armenia are monographically described. The zonal scale for the Devonian and Carboniferous of Transcaucasia is elaborated based on the taxonomic composition and distribution of brachiopods and considering the data on the associated foraminifers, stromatoporoids, tabulate and rugose corals, tentaculites, bivalves, nautiloids, bryozoans, crinoids, conodonts, ostracods, trilobites, and flora. The history of regional biostratigraphic studies is reviewed. The results of work enrich and specify paleontological substantiation of the stratigraphic and correlation scales of Transcaucasia and, in addition, are useful for covering the Devonian and Carboniferous stages of brachiopod evolution and for resolving the general issues of Paleozoic biostratigraphy, particularly, for the compiling the faunal characteristic of the Devonian–Carboniferous boundary deposits.

For specialists on brachiopods and biostratigraphy of the Devonian and Carboniferous.

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Contents[1]

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INTRODUTION

This paper summarizes the results of the monographic study of brachiopods from the Middle–Upper Devonian and Lower Carboniferous deposits of Transcaucasia and elaboration of zonal stratigraphy of these deposits based on brachiopods.

The brachiopods are abundant, diverse, and widespread in the Devonian and Carboniferous deposits of Transcaucasia and are mainly satisfactory preserved. For a long time, they attracted attention of researchers and the data on their composition and distribution have traditionally been used for elaboration of regional stratigraphy. The Transcaucasian collections are particularly interesting for paleontologists and stratigraphers, as the Middle Devonian–Lower Carboniferous deposits in Transcaucasia constitute a continuous section in marine facies, which is a very rare case. The following researchers studied the Devonian and Carboniferous brachiopods of Transcaucasia: Abich (1858, 1878), Frech and Arthaber (1900), Lisitsyn (1913), Ržhonsnitskaja (1948), Abramian (1954, 1957, 1959, 1974a, 1974b), Mamedov (1961, 1966, 1974, 1976), Afanasjeva (1978), Grechishnikova (1986, 1996a, 1996b), Lazarev (1987), Erlanger (1993), Komarov (1997), and Pakhnevich (2012, 2017). However, up to recently, they remained insufficiently studied, as the data on the taxonomic position and stratigraphic occurrence of many genera and species of different orders were incomplete or needed to be specified. The monographic study of collections was required to specify the brachiopod composition and distribution, which are useful for paleontological substantiation of the stratigraphic units and addressing common problems of the phylum study.

This paper contains the results of the monographic study of brachiopods of the orders Lingulida, Craniida, Orthida, Pentamerida, Rhynchonellida, Chonetida, Spiriferida, Spiriferinida, and Athyridida from the Middle–Upper Devonian and Lower Carboniferous of the Nakhchivan Autonomous Republic of the Republic of Azerbaijan and adjacent regions of Armenia. The description of species and genera are provided and their taxonomy is given in correspondence with newly accepted brachiopod systematics.

The interiors of brachiopod shells were studied mainly by successive cross sectioning of the shells with subsequent sketching of the sections. In some cases, Pakhnevich produced photographs of cross sections with a digital binocular microscope and conducted a microtomographic study, providing virtual sections through the shells, which became the basis for tridimensional images of inner structures.

The present paper does not include descriptions of brachiopods of the order Atrypida, because they were relatively recently published as a separate monograph by Komarov (1997). The brachiopods of the orders Strophomenida, Productida, and Terebratulida are not described in the systematic part due to insufficiency of the collected material. However, the determinations of all of them are included in the faunal zonal lists to complete the faunal characteristics of the distinguished zones.

The material of the present study was collected by Grechishnikova in the 1970s and 1980s in the course of the Caucasian Expedition of the Ordzhonikidze Moscow Mining Institute (MGRI) (now the Russian State Geological Prospecting University (RGGRU)) with correspondence to agreement between the institute and Department of Geology of the Council of Ministers of Azerbaijan SSR. She also made initial generic and species determinations of all collected brachiopods.

The brachiopods are described by the employees of the Borissiak Paleontological Institute of the Russian Academy of Sciences (PIN) R.E. Alekseeva (orders Orthida and Pentamerida), G.A. Afanasjeva (orders Chonetida and Spiriferida: superfamilies Adolfioidea, Theodossioidea, Cyrtospiriferoidea, Spiriferoidea, Syringothyroidea), A.V. Pakhnevich (orders Lingulida, Craniida, and Rhynchonellida); the employee of the RGGRU I.A. Grechishnikova (order Athyridida); and the employee of All-Russian Research Geological Oil Institute N.V. Oleneva (order Spiriferida: superfamilies Ambocoelioidea, Delthyrioidea, Reticularioidea; order Spiriferinida: superfamilies Cyrtinoidea, Pennospiriferoidea).

Other fossil organisms were determined by E.A. Reitlinger (foraminifers), I.I. Chudinova (tabulate corals and heliolitids), L.M. Ulitina (rugose corals), L.N. Bol'shakova (stromatopores), E.S. Levitskii (trilobites), L.N. Egorova (Lower and Middle Devonian ostracods), V.A. Chizhova (Upper Devonian and Lower Carboniferous ostracods), I.G. Mironova (gastropods), V.F. Kulikova (bivalves), F.A. Zhuravleva (cephalopods), G.P. Ljaschenko (tentaculites), E.A. Myagkova (receptaculitids), V.D. Lavrent'eva (bryozoans), A.I. Polozhikhina (crinoids), O.P. Obrucheva, N.P. Krupinina, E. Mark-Kurik (fishes). In addition, V.A. Aristov monographically studied conodonts (1994) and N.A. Dorodnova (1993) studied tentaculites.

Grechishnikova elaborated the brachiopod zonal scale for the Middle–Upper Devonian and Lower Carboniferous of Transcaucasia based on specified data on the taxonomic composition, geographic and chronological distribution of Devonian and Carboniferous brachiopods of Transcaucasia derived from conducted study. She also used the data on associated foraminifers, stromatoporoids, rugose and tabulate corals, tentaculites, bivalves, nautiloids, bryozoans, crinoids, conodonts, ostracods, trilobites, and algae. In addition, the history of stratigraphic research of these deposits, the stratotypes, and lithologic composition of distinguished zones are described.

The material was obtained from a unique of its kind region, where the Upper Devonian Frasnian–Famen-

nian and Devonian–Carboniferous boundary deposits compose a continuous section of marine facies. Thus, the results obtained are useful both to address issues of brachiopod evolution at these stages of large changes in their diversity and rearrangement of assemblages and for developing solutions to the general problems of Paleozoic biostratigraphy.

The studied collection is stored in the Borissiak Paleontological Institute of the Russian Academy of Sciences, Moscow (PIN), collection no. 3744, and Russian State Geological Prospecting University (RGGRU), collection no. VI-184.

PART 1. BIOSTRATIGRAPHY OF THE DEVONIAN AND CARBONIFEROUS OF TRANSCAUCASIA (BRACHIOPOD ZONAL SCALE)

I. A. Grechishnikova

MIDDLE–UPPER DEVONIAN

In the 1970s and 1980s, the author of this article participated in a surveying geological study of the Caucasian Expedition of MGRI and studied stratigraphy of the Devonian deposits in southern Transcaucasia, Nakhchivan AR and neighboring areas of Armenia. During that period, over 50 Devonian and Lower Carboniferous sections were thoroughly studied with layer-by-layer sampling of all fossil remains. The most abundant and diverse fossils are brachiopods and corals.

The wealth of Devonian brachiopods of Transcaucasia has been acknowledged for a long time from the papers of Abich (1858), Frech and Arthaber (1900), Ržhonsnitskaja (1948), Abramian (1957, 1974a, 1974b), and Mamedov (1961, 1962a, 1962b); however, the lists and images of brachiopods provided do not cover the entire diversity of species. In some cases (especially for Middle Devonian deposits), brachiopods were inaccurately tied to stratigraphic levels that embarrassed the usage of these papers for elaboration of a detailed stratigraphic basis required for large-scale geological mapping. The only exception is papers of M.S. Abramian with descriptions and images of the Devonian brachiopods of Armenia and some districts of the Nakhchivan AR.

Based on the composition and distribution of the Devonian brachiopods of Transcaucasia derived from their monographic studies, the author elaborated a zonal biostratigraphic scale for the Devonian of the studied region. The brachiopod zonal assemblages were established. The description and depicture of these assemblages are important for overcoming some issues of Devonian stratigraphy, which are still controversial (Lower–Middle Devonian and Middle–Upper Devonian boundaries and also boundaries between the stages and systems).

The Middle Paleozoic sections of Transcaucasia are unique in their completeness, exposure, and richness in remains of many fossil invertebrates and vertebrates (fishes, conodonts) and suitable for international standards.

CHAPTER 1. BRIEF ACCOUNT OF THE STUDY OF THE DEVONIAN DEPOSITS OF TRANSCAUCASIA

Three stages are distinguished in the history of the study of the Devonian deposits of Transcaucasia.

The first prerevolutionary stage is associated with prominent researchers of the time, Abich (1858), Frech and Arthaber (1900), Bonnet (1947), and others.

Abich was the first to recognize in the vicinity of the village of Gnishik 122-m-thick Upper Devonian deposits with *Spirifer seminoi* Verneuil in Visquenel, 1850, *Spirifer orbelianus* Abich, *Orthis striatula* Schlotheim, and *Productus*.

Frech studied the section near Volch'i Vorota Gates and the village of Sadarak, Nakhchivan AR, and founded an extensive collection of corals, brachiopods, and mollusks, which appeared indicative of the Middle Devonian age of enclosing rocks. He developed the first stratigraphic scale of Devonian deposits (Table 1) with the lowermost Middle Devonian (limestones with *Calceola sandalina*), uppermost Middle Devonian (limestones with *Spirifer inflatus* and *Spirifer mediotextus*), and undivided Upper Devonian. He also published the first monographic description of some Devonian brachiopods from these regions.

The most complete results of longstanding investigations in Transcaucasia of Bonnet were published only in 1947. In Armenia (vicinity of the village of Gnishik) and Nakhchivan AR (between the villages of Yukhary and Ashaly Danzik), Bonnet recognized the Lower Devonian and incorrectly referred to it the Upper Devonian deposits, as it was subsequently noted by many researchers. He a elaborated stratigraphic scale of the Paleozoic (including the Devonian) and one of the first geological maps.

Therefore, the first stage culminated in distinguishing in Transcaucasia the series and stages of the Devonian System and elaboration of the first stratigraphic scales.

The second stage began after the establishment of Soviet authority in Transcaucasia. This stage was notable for orderly geological studies of the whole Transcaucasia. Azizbekov (1961) pointed out that there had been established many geological expeditions and exploration teams of the Academy of Sciences (AS) of the USSR, Azerbaijan and Armenian SSR, Karpinsky Russian Geological Research Institute (VSEGEI), All-Russian Scientific-Research Institute of Mineral Resources, geological councils of the USSR Ministry of Geology and Natural Resources Protection, and other organizations. These teams obtained new valuable data on the stratigraphy, tectonics, and mineral resources. The wide range of Paleozoic (including Devonian) deposits in Transcau-

Table 1. Stratigraphic division of the Devonian deposits of Transcaucasia by different researches from 1900 to 1962 (compiled by Grechishnikova in 1983)

System	Series	Stage	Substage	Frech, 1900 (Frech and Arthaber, 1900)	Ržonsnitskaja, 1948	Arakelyan, 1952, 1964	Mamedov, 1962a	
					beds	formation	formation, stage, substage	
Devonian	Upper	Famennian	2	Upper Devonian	Upper Famennian	Gortun	Famennian	Upper Famennian Substage
						Shamaa Midzor		
						Kadrlu		
			1		Lower Famennian	Erdichskaya		Lower Famennian Substage
						Noravan		
		Frasnian	2		Upper Frasnian	Bagarsykh-Deresi	Frasnian	Upper Frasnian Substage*
			1		Lower Frasnian	Chrakhana		Lower Frasnian Substage
						Danzik		
	Middle	Givetian	2	Uppermost Middle Devonian	Danzik	Gyumushlug	Danzik*	
			1		Sadarak	Sadarak	Sadarak	
		Eifelian	2	Lowermost Middle Devonian	Volch'i Vorota	Arazdayan	Volch'i Vorota*	
			1	Older beds along Araks River unknown				
	Lower	Emsian				Dagna		
						Velidag	Velidag	

(1) lower substage, (2) upper substage, (*) subdivisions including horizons and beds with fauna.

casia was established in the course of geological surveying and other studies in 1926–1946 (Paffenholtz, 1940).

The stratigraphic scale elaborated by Frech and Bonnet was the basis for geological mapping of the Devonian deposits at this stage.

The third stage began in 1945–1946, when large collectives of geologists almost simultaneously started complex studies of the geology of the Nakhchivan AR and Armenia, with compiling meso- and large-scale geological maps. This required more detailed stratigraphic scales, which were developed by Ržhonsnitskaja, Arakelyan, Abramian, Azizbekov, etc. (Tables 2–4).

Ržhonsnitskaja (1948) made a contribution to specification of the Devonian stratigraphy of Transcaucasia. She suggested a stratigraphic scale (Table 1), which certainly was a step forward towards understanding the stratigraphic sequence of beds constituting the Devonian System in the Nakhchivan AR but also had some drawbacks.

Within the Middle Devonian, Ržhonsnitskaja recognized the Volch'i Vorota Beds (Eifelian Stage), Sadarak Beds, which were subdivided into two parts (subsequently named the Lower Sadarak and Upper Sadarak beds), and Danzik Beds, which she referred to the Givetian Stage. The Frasnian and Famennian stages were divided into substages, which were also called the beds.

Unfortunately, the stratotype localities and their descriptions were not published, resulting in ambiguous interpretation of the volume of some of them by later researchers. An example to the above is the Volch'i Vorota Formation. Its volume, composition, and age proved to be extremely confused (Grechishnikova et al., 1983). The Volch'i Vorota Formation (initially the beds) was established by Ržhonsnitskaja in 1946 near Volch'i Vorota Gates, Nakhchivan AR. As it was mentioned above, the location of the type section was not specified. Ržhonsnitskaja (1948) mentioned that, in 1946, she studied four sections of the Devonian deposits in Transcaucasia, including one in the Araks River valley near Volch'i Vorota Gates (Dagna and Velidag Mountains). The last section should probably be considered as the stratotype of the Volch'i Vorota Formation, although the author did not focused on it. The section location is uncertain, as the Dagna and Velidag Mountains are large mountain ranges composed not only of rocks of the Volch'i Vorota Formation.

In 1973, Armenian researchers (Abramian et al., 1973) provided different information on the location of the Volch'i Vorota Formation type section, indicating the southeastern slope of Velidag Mountain; but in

Table 2. Correlation of the Middle Devonian zonation schemes of Transcaucasia (compiled by Grechishnikova in 1983)

Series	Stage		Formation	Brachiopod Zone		
	Ardennes	Eifelian	Mamedov, 1978–1983	Mamedov, 1978–1983	Grechishnikova, 1977–1983	
Upper	Frasnian		–	*Cyrtospirifer disjunctus*	Frasnian	Adolfia zickzack
					Givetian	*Indospirifer pseudowilliamsi*
Middle	Givetian	Givetian	Arpachai	*Emanuella pseudovolhynica*		*Stringocephalus burtini*
				Spinocyrtia transcaucasica–Crurithyris inflata		
			Sadarak	*Stringocephalus burtini*		
	Couvain	Eifelian	Volch'i Vorota	*Gruenewaldtia latilinguis*		*Mucrospirifer diluvianoides–Radiomena irregularis*
				Spinatrypa aspera aspera–Undispirifer ržhonsnitzkaja	Eifelian	*Alatiformia araxica–Dagnachonetes caucasius*
			Danzik	*Alatiformia araxica–Emanuella takwanensis*		
			Veligorskaya	*Euryspirifer intermedius*		*Arduspirifer speciosus*
		Emsian	Sharur	*Zdimir pseudobaschkiricus–Megastrophia uralensis*	Emsian	*Megastrophia uralensis–Zdimir pseudobaschkiricus*
Lower	Emsian		Saradzhlin	*Uncinulus keltibericus–Arduspirifer extensus*		*Arduspirifer extensus*

this case once again, only an area rather than particular section was specified.

According to the Stratigraphic Dictionary of the USSR (*Stratigraficheskii slovar' ...,* 1975), this stratotype is the section located between the Yeraskh (former Arazdayan) Station and village of Sadarak, which is situated beyond the initially established stratotype region. Finally, the guidebook prepared by Mamedov (1980b) for fieldtrips to the Middle Devonian type sections of the Nakhchivan AR reports that the Volch'i Vorota Formation was established on the southwestern slope of Velidag Mountain.

Published data on the location of the stratotype of the Volch'i Vorota Formation are highly contradictory and, thus, the researchers intended studying this formation face insurmountable difficulties.

The situation is not better for the characteristics of lithological and paleontological features of the formation. Ržhonsnitskaja (1948) in the original description mentioned that the Eifelian (Couvain) Stage is composed of coral limestones, dolomites, and variegated clayey sericitic shales with *Acrospirifer speciosus* (Buch), *Sieberella calceola* (Grabau), *Calceola sandalina* (Linnaeus), etc. 140 m of total thickness. In 1956, Ržhonsnitskaja added gray and reddish sandstones with interbeds of yellowish gray quartzites in the formation composition; simultaneously, she included into the faunal assemblage the new species *Pholidostrophia irregularis* Roemer, *Conchidiella* ex gr. *pseudobaschkirica* (Tschernyschew), and *Uncinulus* ex gr. *parallelepipedus* (Bronn). Thus, apart from the data on the stratotypical region, the characteristics of the Volch'i Vorota Beds (Formation) probably include the data on other regions (interbeds of sandstones, quartzites, *C.* ex gr. *pseudobaschkirica*, etc.), which had not previously been mentioned for the formation and expanded its stratigraphic volume.

This resulted in incorrectly identification of the formation in a number of areas of the Nakhchivan AR and Armenia.

According to current ideas concerning the stratigraphy of the Devonian of Transcaucasia, the deposits older than the Upper Emsian were included in the Upper Eifelian Volch'i Vorota Formation (Grechishnikova et al., 1980–1980d).

The situation is not better with the Danzik Beds. Ržhonsnitskaja supposed they were transitional from the Middle to Upper Devonian. The Danzik Beds were included in the Givetian Stage based on domination of Middle Devonian species in the faunal assemblage. The volume and age of the Danzik Beds were variously interpreted by later researchers, as will be described below. To ascertain the primary volume of the Danzik Beds, let us refer to the stratotype description by Ržhonsnitskaja in the unpublished (fund) paper (1947), which reads that "the rocks of the for-

mation are exposed opposite the village of Yukhary-Danzik east of the highway house on a mountain slope near the highway and composed of limestones, quartzites, sandstones, and sandy shales... The lower part of this formation is exposed 500 m below the village of Yukhary-Danzik and consists of indicative member, which I regarded as the Danzik Beds. It is composed of 50 m thick frequently alternating gray sandy shales and sandstones with thin plated dark gray sandy limestones overfilled with brachiopods and other fossils: *Schizophoria striatula* (Schlotheim), *Schuchertella umbraculum* (Schlotheim), *Strophe-odonta* cf. *concava* Hall, *Chonetes bretzii* Schnur, *Productella subaculeata* (Murchison), *Camarotoechia* aff. *prolifica* (Hall), *Atrypa reticularis* (Linnaeus), *Spirifer subattenuatus* Hall, *Cyrtospirifer* sp., *Emanuella inflata* (Schnur), *Athyris concentrica* (Buch), Rugosa, Tabulata, Pelecypoda, Gastropoda, *Orthoceras* (?), and crinoid columnals. Possibly, there is a fault at the end of this member 1 km below Yuzhno-Danzik, through which the Danzik Beds adjoin the Eifelian deposits."

Ržhonsnitskaja concluded that the Danzik Beds form there the sides of overturned anticline. As is evident from the description, contact is tectonic with the underlying rocks and conformable with the overlying rocks (Lower Frasnian). Analogues of the Danzik Beds were found on the other side of the mentioned anticline, where "... dark gray coral limestones alternating with rare quartzite interbeds are exposed after waterless ravine in front of a tight bend of the highway. The thickness is 50 m. There is a diabase dike, Rugosa, Tabulata. The poorly preserved brachiopods are *Schizophoria* sp. and *Spirifer* sp. Possibly, this is the uppermost Middle Devonian beds analogous to the Danzik Horizon." It is evident that the Danzik Beds on both sides of assumed overturned anticline are tentatively correlated by lithologic features rather than faunal data.

The analysis of brachiopods from the Danzik Beds provided by Ržhonsnitskaja in the afore-mentioned paper is also noteworthy; *Spirifer mediotextus* is exceptionally rare in the Danzik Beds, where it is replaced by the related species *Spirifer subattenuatus* (subsequently, Ržhonsnitskaja referred it to *Mucrospirifer araxicus* – I.G.), which externally differs from it in the shorter area, more sharply divided fold, and absence of plica in the sulcus." And later in the text, "*Spirifer subattenuatus* is common and abundant in the Danzik Beds. Some limestone interbeds are almost completely composed of its shells... *Chonetes bretzi* Schnur (species related to *Chonetes coronatus* Corn. from the Hamilton Group) and *Camarotoechia* aff. *prolifica* Hall are similarly wide-ranging... *Emanuella inflate* is typical for the Givetian Stage of Western Europe and is common in the Danzik Beds."

The author of the present paper found out that the Danzik Beds in the volume determined by the stratotype belong to the Eifelian Stage and are a part of the newly established *Alatiformia araxica–Dagnachonetes caucasius* Zone (Grechishnikova et al., 1983).

The incorrect assignment of the Danzik Beds to the uppermost Givetian Stage in the stratotype resulted, firstly, in wrong interpretation of the structure in Danzik and other regions and, secondly, in incorrect correlation: Eifelian deposits (Danzik Beds), true Upper Givetian, and possibly partly Lower Frasnian were taken for coeval. Thus, species that naturally do not co-occur were included in the faunal lists in the general characteristics of the "Danzik Beds."

In 1945–1956, the geology of the Nakhchivan AR was comprehensively studied by a large group of Azerbaijani geologists, including G.P. Kornev, A.M. Sadykov, N.V. Pashaly, A.A. Kadyrov, E.Kh. Madatov, K.O. Rostovtsev, A.E. Bagirov, N.A. Balashev, M.B. Zeinalov, T.G. Gadzhiev, and M.I. Rustamov. The overall scientific management was carried out by the Academician of the Azerbaijan SSR Azizbekov, who also summarized extensive data derived from the geological surveying studies during that time (Azizbekov, 1961). He focused on the study of Devonian deposits (Azizbekov, 1961, 1972), especially their lithographic composition. He was the first to describe the Velidag key hole (Azizbekov, 1961), where he tentatively distinguished the Lower Devonian and lowermost Eifelian Stage by the stratigraphic position. Contrary to the view of Ržhonsnitskaja, he correctly dated the deposits composing Dagna Mountain as Eifelian. Azizbekov described layer-by-layer many sections of Devonian deposits and defined the range of the latter. The value of his work is occasionally declined by many contradictions and sometimes simple mistakes in the provided lists of faunal assemblages from some beds, which leads to incorrect interpretation of the age and, hence, to wrong inferences concerning the history of geological development. For example, he mentioned for the Famennian Stage in section below the village of Yukhary-Danzik (Azizbekov, 1961) Visean *Productus* (*Echinoconchus*) ex gr. *punctatus* (Martin) and, for the same Famennian Stage in the section below the Dava-Olan ruins, Givetian *Camarotoechia* aff. *prolifica* and *Spirifer mediotextus* Archiac et Verneuil.

The systematic study of the Devonian deposits of Armenia and adjacent areas of the Nakhchivan AR was started in 1947 by the employees of the Academy of Sciences of the Armenian SSR Abramian and Arakelyan. Their longstanding studies resulted in a thoroughly elaborated and paleontologically substantiated stratigraphic scale of Devonian deposits (Arakelyan, 1952, 1964; Abramian, 1957; Abramian et al., 1973). The establishment of local stratigraphic units, the formations, for both Middle and Upper Devonian deposits was a novel relative to the scales of preceding researchers (Tables 1, 2).

Like Azizbekov, Arakelyan (1964) supposed that the oldest Paleozoic deposits in the Nakhchivan AR had been exposed by the Velidag key hole. He first dis-

tinguished two formations in the borehole section: the lower, Velidag, which he tentatively referred to the Upper Silurian–Lower Devonian, and the upper, Dagna, which he referred to the Lower Eifelian, Middle Devonian. The age of these formations was estimated almost without substantiation.

Apart from the Dagna Formation, Arakelyan recognized the Arazdayan Formation within the Eifelian Stage and referred it to the Upper Eifelian. He concluded that the Volch'i Vorota Beds correspond only to the uppermost newly established formation. The formation stratotype is located "near the highway from the village of Arazdayan to the village of Sadarak" (1964, p. 90). We found out that the Arazdayan Formation has a lower stratigraphic position in relation to Volch'i Vorota and consequently cannot be considered as at least part of its equivalent. The Arazdayan Formation in the stratotype section near the village of Yeraskh (former Arazdayan) is conformably overlain by the Eifelian beds of the *Alatiformia araxica–Dagnachonetes caucasius* Zone (approximately corresponding to the Danzik Formation) instead of the Sadarak Formation of the Givetian Stage, as was mentioned by Arakelyan (Grechishnikova et al., 1980a–1980d).

Arakelyan referred two formations to the Givetian Stage: Sadarak and newly established Gyumushlug. The Sadarak Formation corresponds to the Lower Sadarak Beds of Ržhonsnitskaja, although the Eifelian deposits were mistakenly referred to it in a number of sections (near the village of Yeraskh, on the southeastern slope of Velidag Mountain).

The stratotype of the Gyumushlug Formation is located "on the right bank of the Arpa River, on the southwestern side of the Gyumushlug Anticline" (Arakelyan, 1964, p. 61). Unfortunately, the precipice where the Gyumushlug Formation was originally established, was blown up in the course of the dyke construction. However, new outcrops appeared that clearly showed extremely complicated tectonics of this area near large Gyumushlug fault. Judging from the description of the lithologic composition and list of brachiopods, the Gyumushlug Formation combines a part of the Danzik Beds in their primary volume and a part of the Sadarak Formation, which are actually present in this region.

Like Ržhonsnitskaja, Arakelyan supposed that the Danzik Beds are transitional from the Middle to Upper Devonian, with a mixed Middle–Upper Devonian fauna. However, he referred them to the basal Frasnian Stage based on the appearance of the first species of *Cyrtospirifer*. This raised one of the most controversial issues of Transcaucasia stratigraphy. However, disagreement about the age of the Danzik Beds is based on a misunderstanding, incorrect, as mentioned above, correlation of the Danzik Beds, i.e., the Eifelian beds with *Alatiformia araxica–Dagnachonetes caucasius* and the beds overlying the Sadarak Beds, i.e., considerably younger beds. In the description of the section near the village of Danzik, Arakelyan (1964) described a member actually occurring at the base of Frasnian Stage as the Danzik Beds, since he provided such brachiopods as *Atrypa tubaecostata* Paeckelmann and *Cyrtospirifer* ex gr. *verneuili* (Murchison). The complexity of this problem aggravated, as Arakelyan selected this member as the stratotype of the Danzik Beds. In addition, in the description of other sections, Arakelyan referred to the Danzik Beds both the deposits corresponding to their original interpretation and the deposits of the lowermost Frasnian Stage.

Based on a monographic study of brachiopods, Abramian elaborated in 1957 a detailed stratigraphic scale for the Famennian Stage of southwestern Armenia.

Arakelyan (1964, p. 93) first distinguished a number of formations in the Upper Devonian (Table 1) "differing in their stratigraphic positions and faunal assemblages." The Frasnian–Famennian boundary was drawn at the base of algal limestones, which, according to Arakelyan, are a good marking horizon separating these stages. Biostratigraphic substantiation of this boundary was not provided. The main criterion is the convenience and ease of finding in-field of algal limestones.

Mamedov studied the Devonian deposits of the Nakhchivan AR for more than twenty years (1961, 1962a, 1962b, 1964, 1968, 1974, 1976, 1979, 1980b, 1983). His views on the stratigraphic sequence of Devonian deposits in the specified region changed considerably. Up to 1978, the stratigraphic scale of Mamedov differed insignificantly from the scale of Ržhonsnitskaja.

An undoubted achievement of Mamedov was an attempt to specify the stratigraphy of the Eifelian Stage, in which he distinguished four faunal levels: (1) horizon with *Euryspirifer speciosus*, (2) horizon with *Conchidiella* ex gr. *pseudobaschkirica* and *Megastrophia uralensis*, (3) horizon with *Spinatrypa kelusiana* and *Undispirifer ržhonsnitzkaja*, and (4) horizon with *Grunewaldtia latilinguis* and *Phacops latifrons*. The author mentioned that these horizons are spatially separated and their stratigraphic sequence is uncertain. However, after a faunal analysis, Mamedov concluded that all afore-mentioned horizons belong to the Upper Eifelian: the first, to the lowermost; second and third, to the middle; and the fourth, to the uppermost Upper Eifelian (the last was correlated with the Rommersheimer Beds of Western Europe, which are referred by some researchers to the basal Givetian). Mamedov correctly noted the presence of different faunal assemblages in the Eifelian deposits of the Nakhchivan AR (except the Danzik Beds); unfortunately, he supposed all of them to belong to the Volch'i Vorota Formation, while only the third and fourth horizons actually correspond to it, which we consider to be a single stratigraphic level. As discussed below, the oldest horizon of all listed above is the horizon

with *Conchidiella* ex gr. *preudobaschkirica–Megastrophia uralensis* of partly Emsian rather than Eifelian age. Hence, the stratigraphic sequence suggested by Mamedov is incorrect.

The ambiguity of the age and volume of the Danzik Formation promoted special studies of Mamedov. The results of these studies are summarized in his PhD theses (Mamedov, 1962b), where the Danzik Beds and the whole Devonian section of the Nakhchivan AR are described (as partly mentioned above).

Mamedov was the first to study monographically the brachiopods from the Danzik Beds. He described 57 species, of which 14 are new. The descriptions of new species were partly published (Mamedov, 1961, 1974). The Danzik Formation was studied in six regions: on the northeastern and southwestern sides of the Yukhary-Danzik Anticline, near the village of Damirchi, in the vicinity of Dagna Mountain, near the villages of Yeraskh and Gyumushlug. The lower boundary of the formation was recognized based on the lithology and appearance of *Mucrospirifer araxicus* (Ržonsnitskaja) and *Camarotoechia congregata* (Conrad). The upper boundary was established based only on the fauna, as according to this researcher, the lithology of the Lower Frasnian boundary beds remains the same. Mamedov mentioned that *Cyrtospirifer canaliferus* (Valenciennes) and *Eoreticularia pseudovolhynica* Mamedov disappear and the *Cyrtospirifer disjunctus* (Sowerby) group appears in the lowermost Lower Frasnian. In addition, he noticed that the transitional beds between the Danzik Beds and Frasnian Stage contain *Spinatrypa tubaecostata* (Paeckelmann), *Sp. bodini* (Mansuy), and rare fragments of *Cyrtospirifer* sp. (of the Upper Devonian appearance). The Danzik Formation is referred to the upper part of the Givetian Stage based on the prevalence of Givetian species in the faunal assemblage. In addition, Mamedov mentioned that, apart from typical Givetian taxa, the Danzik Formation contains Upper Devonian (Eifelian) and Lower Devonian species. The author explained such a mixture by two reasons: (1) poor preservation of fossil material and, hence, inaccuracy of determinations and (2) the older fossils were outwashed from the underlying rocks. In fact, the mixture of faunas in the Danzik Beds was caused only by referring to these beds of deposits from different parts of the section: Eifelian Stage (true Danzik Beds), uppermost Givetian Stage (beds with *Cyrtospirifer canaliferus*), and lowermost Frasnian Stage (Beds with *Emanuella pseudovolhynica* and *Spinatrypa tubaecostata*).

Thus, although the paper of Mamedov (1962b) was of undoubted paleontological value, it could not be used in stratigraphy.

Summarizing, it should be emphasized that, during the third stage, detailed stratigraphic scales were elaborated and well substantiated paleontologically and the local stratigraphic units (beds, formations, horizons) were recognized. They became the basis for geological mapping in the Nakhchivan AR and Armenia.

Detailed mapping of the Nakhchivan AR conducted by the employees of the Caucasian Expedition of the Department of Regional Geology and Paleontology of MGRI (the author started participation in 1969) revealed that these scales had serious shortcomings mentioned above. They are as follows: some stratigraphic units were established incorrectly (e.g., the Gyumushlug Formation); others have different stratigraphic position in the Devonian section than it was previously supposed, (e.g., the Danzik Beds, Beds with *Zdimir pseudobaschkiricus*); the third are larger than the stratotype (e.g., Volch'i Vorota Beds after Mamedov). Therefore, it became necessary to create a new stratigraphic scale of the Devonian deposits of Transcaucasia, which would consider new data and data of all preceding researchers. The author started this work in 1971. As there was strong confusion in the interpretation of volumes and stratigraphic positions of some previously established formations, the author decided to distinguish local complex (brachiopod) zones. Initially, the beds with fauna and members and, then, the local zones (lones) were established. Finally (Grechishnikova et al., 1980a–1980c), local brachiopod complex zones were approved, which became the basis for detailed geological maps of the Nakhchivan AR. The zonal scale of the Devonian deposits of Transcaucasia was reported by the author at the plenary session of the Devonian Committee of the International Commission on Stratigraphy (ICS) in 1977 and at the meeting of specialists on brachiopods in 1978. The sequence established based on the brachiopod zones was confirmed by the other groups of fossil organisms, especially the conodonts (Levitskii et al., 1980; Eichhorn et al., 1983; Aristov, 1994).

In preparation for the mobile session of the Devonian Committee of ICS to the Devonian type sections of Transcaucasia, joint traverses were taken in autumn 1978 by the employees of MGRI Grechishnikova and Levitskii, employees of the Paleontological Institute of the Academy of Sciences of the USSR Chudinova and Bukreeva, and the senior scientific researcher of the Academy of Sciences of Azerbaijan Mamedov. One of the most complete Devonian sections of Transcaucasia in the southern slope of Velidag Mountain was thoroughly studied to solve a number of contentious issues of the stratigraphic sequence and age of previously recognized units. Soon after that, Mamedov (1979) published his new stratigraphic scale, which almost completely coincides with the author's scale (Table 3). In addition to the existing formations, Mamedov newly distinguished the Saradzhlin and Sharur formations (Emsian Stage), Veligorskaya Formation (Eifelian Stage), and Arpachai Formation (Givetian Stage). Each formation corresponds to a brachiopod zone. He also published the most complete scale (Mamedov and Ržhonsnitskaja, 1985).

Table 3. Correlation of the stratigraphic schemes for Devonian deposits in the section of the southern slope of Velidag Mountain

<table>
<tr><th>Azizbe-kov</th><th colspan="2">Arakelyan</th><th colspan="9">Mamedov</th><th colspan="4">Grechishnikova</th></tr>
<tr><th>1961</th><th colspan="2">composed in 1964, 1973</th><th colspan="2">1962a</th><th colspan="3">1979, 1980</th><th colspan="4">1983</th><th colspan="2">composed in 1977, 1980, 1981, 1983</th><th colspan="2">present paper</th></tr>
<tr><th>stage</th><th>stage</th><th>formation</th><th>stage</th><th>formation</th><th>stage</th><th>forma-tion</th><th>zone</th><th>stage</th><th>forma-tion</th><th>zone</th><th>subzone</th><th>stage</th><th>zone</th><th>stage</th><th>zone</th></tr>
<tr><td rowspan="6">Eifelian (380 m)</td><td rowspan="2">Givetian</td><td>Gyumushlug (51 m)</td><td rowspan="2">Givetian</td><td rowspan="2">Sadarak</td><td rowspan="4">Eifelian</td><td>Danzik</td><td>Alatiformia araxica–Emanuella takwanensis</td><td rowspan="3">? Eifelian</td><td>Danzik</td><td>Alatiformia araxica–Emanuella takwanensis</td><td>–</td><td rowspan="3">Eifelian</td><td>Dagnachonetes caucasius–Alatiformia araxica</td><td rowspan="3">Eifelian</td><td>Dagnachonetes caucasius–Alatiformia araxica</td></tr>
<tr><td>Sadarak (212 m)</td><td>Veligorskaya</td><td>Euryspirifer intermedius</td><td>Veligorskaya</td><td>Euryspirifer intermedius</td><td>–</td><td>Euryspirifer speciosus</td><td>Euryspirifer speciosus</td></tr>
<tr><td rowspan="4">Eifelian</td><td rowspan="4">Arazdayan (87.5 m)</td><td rowspan="4">Eifelian</td><td rowspan="4">Volch'i Vorota (horizon with Conchidiella ex gr. pseudobaschkirica–Megastrophia uralensis)</td><td rowspan="2">Sharur</td><td rowspan="2">Zdimir pseudobaschkiricus–Megastrophia uralensis</td><td rowspan="2">Sharur</td><td rowspan="2">Zdimir pseudobaschkiricus–Megastrophia uralensis</td><td>Zdimir rossicus</td><td rowspan="3">Zdimir pseudobaschkiricus–Megastrophia uralensis</td><td rowspan="3">Zdimir pseudobaschkiricus–Megastrophia uralensis</td></tr>
<tr><td rowspan="3">Emsian</td><td>Zdimir pseudobaschkiricus</td><td rowspan="3">Emsian</td><td rowspan="3">Emsian</td></tr>
<tr><td rowspan="2">Emsian</td><td rowspan="2">Saradzhlin</td><td rowspan="2">Uncinulus keltibericus</td><td rowspan="2">Saradzhlin</td><td rowspan="2">Uncinulus keltibericus</td><td>Uncinulus keltibericus</td></tr>
<tr><td>Arduspirifer extensus</td><td>–</td><td>Arduspirifer extensus</td></tr>
</table>

Thus, at present, there are two stratigraphic scales of the Devonian of Transcaucasia, generally objectively reflecting the sequence of beds in the Devonian section.

The divergence concerns the number and volume of some units in the lower part of the section and, especially, the positions of the *Eoreticularia pseudovolhynica* and *Cyrtospirifer disjunctus* zones. We established by several sections that the Beds with *Eoreticularia pseudovolhynica* are positioned stratigraphically higher than the *Indospirifer pseudowilliamsi* Zone, i.e., higher than the part of the section which Mamedov referred to the lowermost *Cyrtospirifer disjunctus* Zone (Grechishnikova and Levitskii, 1981).

CHAPTER 2. BIOSTRATIGRAPHIC SUBDIVISION OF THE DEVONIAN OF TRANSCAUCASIA (BRACHIOPOD ZONAL SCALE)

The section of Devonian deposits in Transcaucasia is complete, sufficiently well exposed, and lacks breaks in sedimentation. It is composed of carbonate and terrigenous rocks formed in the coastal shallow-water environment and at moderate depth. The faunal remains are in places abundant, diverse, and well preserved. However, the assemblages of Devonian invertebrates listed below reflect our knowledge of the existing faunal assemblages rather than their true completeness. This is due to incompletely collected some groups of fossils (stromatoporates, ostracods, conodonts) and incompletely identified material (rugose and tabulate corals, bryozoans, etc.).

The brachiopods from the Devonian of Transcaucasia are the most widespread group of extinct invertebrates. This is best illustrated by the Famennian deposits of Transcaucasia. The abundance of brachiopods in rocks (separate beds are brachiopod shell deposits), their legible morphological features, and good preservation allow recognizing the most common species in-field in the course of mapping. Apart from the frequent occurrence, brachiopods are the best studied group in Transcaucasia in comparison with other fossils that certainly contributed to the usage of brachiopods in the elaboration of the local zonal scale.

Brachiopods, being benthic organisms, are closely connected with the facies and, hence, less suitable for wide correlations than conodonts, foraminifers, ostracods, and spores, although some representatives of these groups are also not absolute cosmopolitans and the data on their facial confinement have been increasingly published. For example, two conodont assemblages typical for the deepwater and shoal facies were recognized and shown to be hardly comparable with each other (Aristov, 1994). However, assemblages of benthic organisms, including brachiopods, are sustained for vast areas in the regions with low facies diversity, such as Transcaucasia, where a shallow sea continuously existed in the Devonian. Different basins of the same paleogeographic region or province become connected during vast transgressions and conditions become favorable for expansion of the ranges of certain benthic assemblages. This enables the usage of brachiopods and other benthic faunas for correlation of certain levels (e.g., Beds with *Stringocephalus burtini* in the Givetian, etc.).

When developing a new stratigraphic scale of the Devonian of Transcaucasia, the author considered the Devonian section of the Nakhchivan AR as a sequence of local complex brachiopod zones, i.e., certain rock masses, which were formed during simultaneous existence of characteristic taxa or the whole brachiopod assemblage.

The zonal boundaries are established by the appearance or disappearance of zonal taxa.

It should be noted that available data on the Devonian brachiopod assemblages of Transcaucasia in the published papers and fund writings do not reflect the whole taxonomic diversity of this group. Hence, a monographic study of all Devonian brachiopods will contribute to filling existing gaps. This is particularly important, as the Devonian sections of Transcaucasia on various bases may claim to the rank of the international standards.

Emsian Stage

Arduspirifer extensus Zone (Lower Part of the Saradzhlin Formation)

The zonal stratotype is located at the foot of the southern slope of Velidag Mountain (outcrop 48, Beds 1–4). The lower zonal boundary is not exposed; the upper boundary coincides with the erosion surface and is marked by a chemical weathering crust. The lower part of the zone is composed of 25-m-thick, dark gray, almost black, platy, strongly cleavaged, clayey and aleuritic limestones. The upper part of the zone is composed of black argillites, which were exposed in three trenches. The argillite color and petrographic composition relatively abruptly change near the upper border of argillites and overlapping sandy limestones of the basal part of the overlying *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone. The light altered argillites are 2–3 m thick; then, they are replaced by pinkish gray or purple–gray argillites, which transform in places into powdery substance, which is almost white in the dry condition. The newly formed clay is finely dispersed and relatively greasy to the touch. B.V. Il'in conducted thermal analysis and revealed the presence of alunite. Alunite and gypsum in the argillite roof indicate the preservation of the lower part of the chemical weathering crust. The argillites are 40 m thick.

The total thickness of the zone is 65 m.

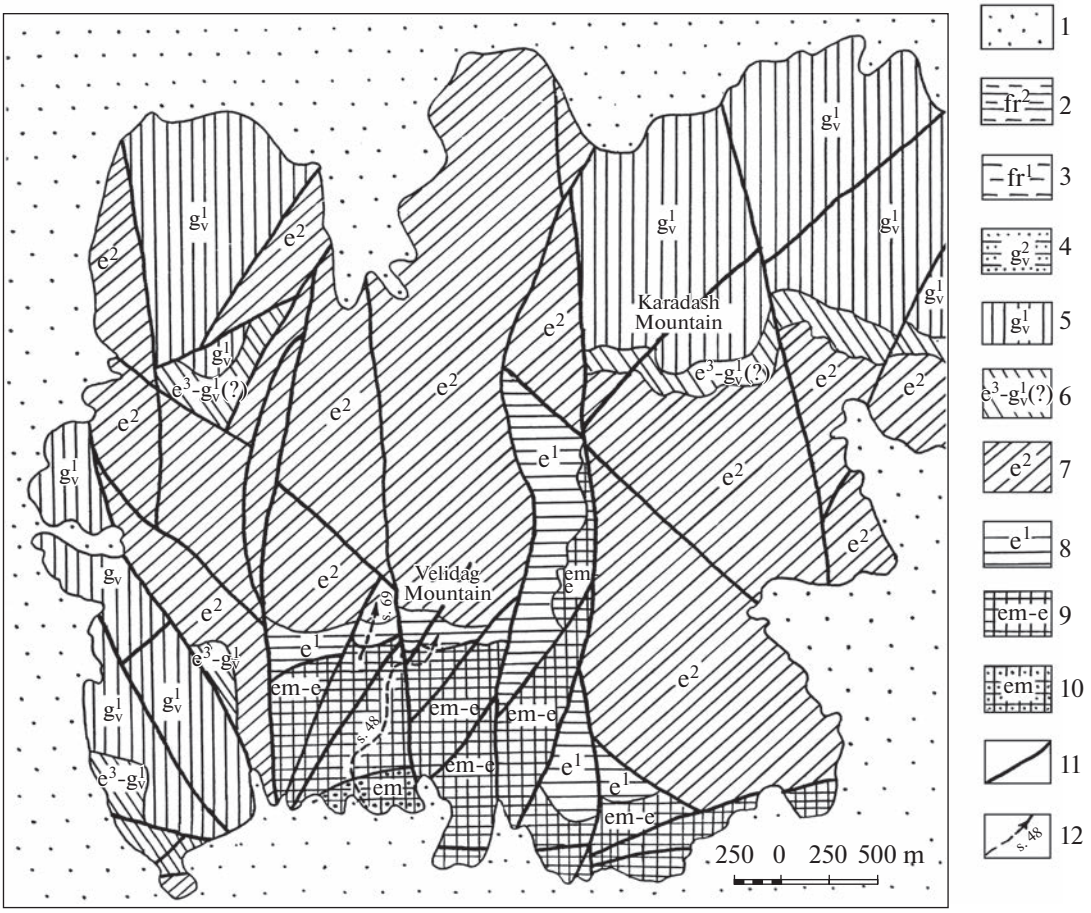


Fig. 1. Geological map in the vicinity of Velidag Mountain (composed by Grechishnikova, Levitskii, and Feliks in 1977): (1) Cenozoic deposits: conglomerates, gravels, sandstones, rarely limestones; (2–3) Frasnian Stage: (2) *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone, limestones; (3) *Adopfia zickzack* Zone: argillites, siltstones, sandstones, limestones; (4–5) Givetian Stage: (4) *Indospirifer pseudowilliamsi* Zone, argillites, limestones; (5) *Stringocephalus burtini* Zone, organogenic limestones; (6–8) Eifelian Stage: (6) *Mucrospirifer diluvianoides–Radiomena irregularis* Zone, lumpy clayey limestones and argillites; (7) *Alatiformia araxica–Dagnachonetes caucasius* Zone, clayey and sandy limestones and argillites; (8) *Arduspirifer intermedius* Zone, sandstones and limestones; (9) undivided Eifelian and Emsian stages: *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone, limestones, argillites, siltstones and sandstones; (10) Emsian Stage: *Arduspirifer extensus* Zone, limestones and argillites; (11) faults; (12) outcrops of the reference sections.

The limestones contain brachiopods (especially in the upper part of the limestone member) and few tabulate corals and tentaculites.

The brachiopod assemblage includes orthids, pentamerids, atrypids, rhynchonellids, and spiriferids; the most abundant spiriferid species is *Arduspirifer extensus* (Solle), which was chosen as a zonal index species. A new orthid species is *Schizophoria lata* Alekseeva et Gretchishnikova, sp. nov.

According to Eichhorn et al. (1983), limestones of the lower part of the zone (13 m from the section basement) contain the conodonts *Icriodus* ex gr. *beckmanni* Ziegler, *I. corniger ancestralis* Weddige, and *Ozarcodina cariothica* (Schulze), which characterize the Upper Emsian *serotinus* Conodont Zone.

It seems inappropriate (Grechishnikova and Levitskii, 1981) to unite the *Arduspirifer extensus* Zone and the overlying deposits separated from it by the erosion surface into a single *Uncinulus keltibericus–Arduspirifer extensus* Zone, as was done by Mamedov (Table 2).

Undivided Emsian and Eifelian Stages

Megastrophia uralensis–Zdimir pseudobaschkiricus Zone (Upper Part of the Saradzhlin Formation and Sharur Formation)

The outcrops of this zone are developed in the southern slopes of Dagna-Sarachludag, Velidag, and Saradag mountains. Its stratotype is the section in the southern slope of Velidag Mountain (reference section 48, Beds 2–31) (Grechishnikova and Levitskii, 1981), 1.5 km east of Volch'i Vorota Gates (Figs. 1, 2; Table 3).

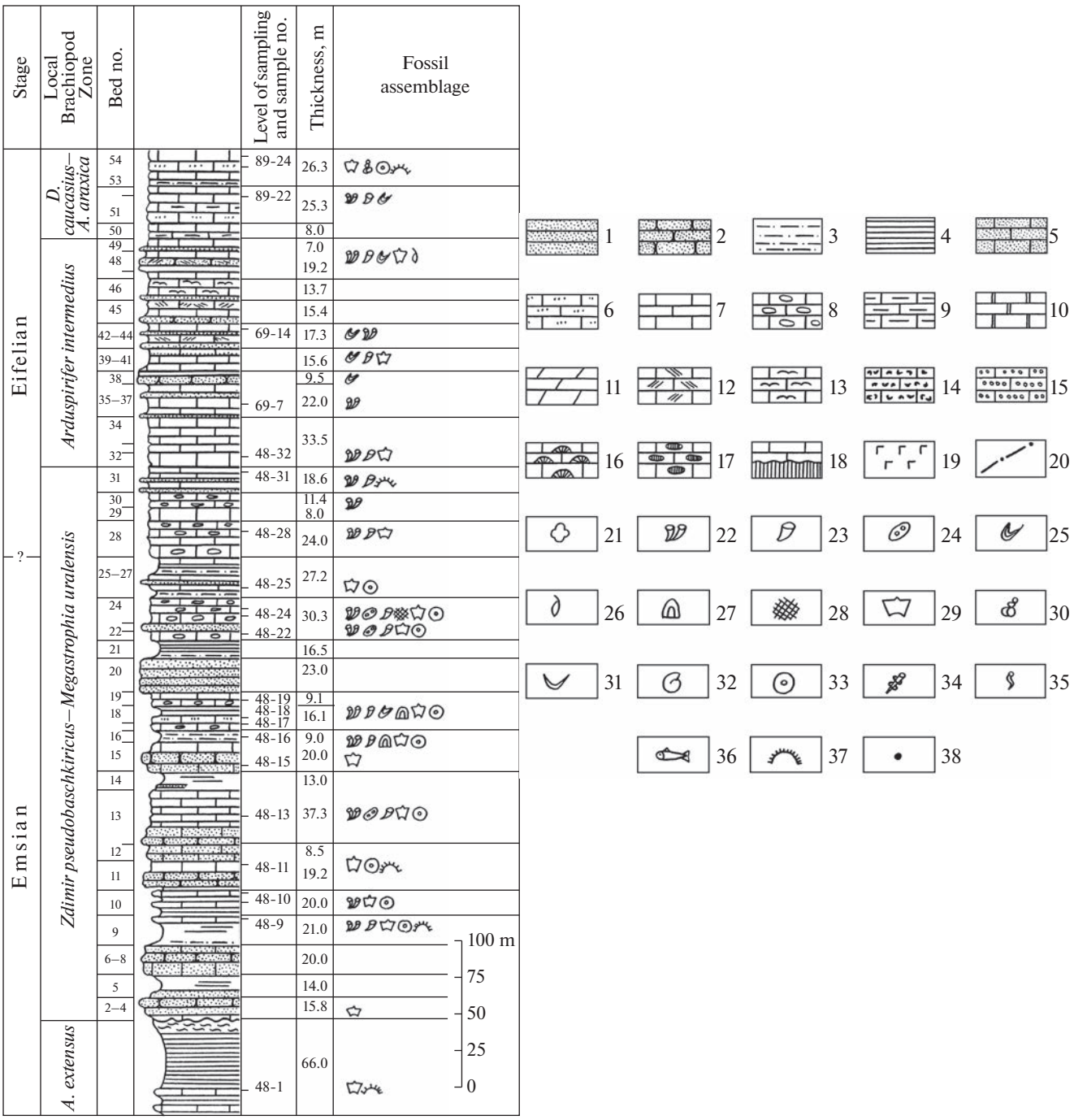


Fig. 2. Stratigraphic column of the Lower–Middle Devonian deposits in the southern slope of Velidag Mountain (reference section no. 48-69). Designations: (1) sandstones, (2) quartzites, (3) siltstones, (4) argillites, (5) calcareous sandstones, (6) sandy limestones, (7) limestones, (8) lumpy limestones, (9) clayey limestones, (10) dolomites, (11) marls, (12) limestones with oblique microlamination, (13) limestones with wavy microlamination, (14) oncolite limestones, (15) oolitic limestones, (16) limestones with rugose colonies, (17) calcarenites, (18) bauxite rocks, (19) mafic intrusive rocks, (20) faults, (21) foraminifers, (22) tabulate corals, (23) rugose corals, (24) heliolitids, (25) stromatoporoids, (26) ostracods, (27) trilobites, (28) bryozoans, (29) brachiopods, (30) gastropods, (31) bivalves, (32) cephalopods, (33) crinoids, (34) tentaculites, (35) algae, (36) fishes, (37) conodonts, (38) fossil occurrences.

The zone rests on the weathering crust developed in argillites of the underlying *Arduspirifer extensus* Zone. The zonal roof is recognized by the disappearance of *Zdimir* Barrande in the section.

The lower part of the zone is composed of argillites and siltstones, sandstones and quartzites, and also limestones; terrigenous rocks prevail. The upper part is composed mostly of organogenic limestones. Ter-

Table 4. Correlation of the stratigraphic schemes for Devonian deposits in the section of the western slope of the Karaburun Mountain (compiled by Grechishnikova in 1983)

Mamedov					Arakelyan		Grechishnikova			
1962a		1980, 1983			1964		compiled in 1977, 1980		present paper	
Stage	Formation	Stage	Formation	Zone	Stage	Formation	Stage	Zone	Stage	Zone
Givetian	Danzik	Eifelian	Danzik	*Alatiformia araxica – Emanuella takwanensis*	Frasnian	Danzik	Eifelian	*Dagnachonetes caucasius–Alatiformia araxica*	Eifelian	*Dagnachonetes caucasius–Alatiformia araxica*
					Givetian	Sadarak				
Eifelian	Volch'i Vorota (horizon with *Euryspirifer speciosus*)		Veligorskaya	*Euryspirifer intermedius*	Eifelian	Arazdayan (stratotype)		*Euryspirifer speciosus*		*Arduspirifer intermedius*

rigenous rocks prevail in the east course of the section (southeastern spur of the Velidag Mountain), that probably testifies to the closeness of the erosion area. The zone is 370 m thick.

This zone contains abundant remains of different invertebrate taxa, including stromatoporates, rugose and tabulate corals, trilobites, brachiopods: *Aulacella eifelensis* (Verneuil), *Resserella dagnensis* Alekseeva et Gretchishnikova, sp. nov., *Schizophoria lata* Alekseeva et Gretchishnikova, sp. nov., *Sieberella parva* Alekseeva et Gretchishnikova, sp. nov., *Zdimir pseudobaschkiricus* (Tschernyschew), *Z. triangulicostatus* (Khodalevich et Breivel), *Z. rossicus* (Karpinsky in Chernyshev), *Ivdelina pseudoararata* (Tjazheva), *Leviconchidiella vagranica* (Khodalevich), *Kransia* sp., *Beckmannia pentagona* (Kayser), *Schnurella transversa* (Reed), *Megastrophia uralensis* (Verneuil), *Punctatrypa* (*Punctatrypa*) *olgae* Nalivkin, *Spinatrypa* (*Spinatrypa*) *dorsata* Biernat, *Spinatrypina* (*Spinatrypina*) *subaspiroides* Komarov, *Undatrypa* (*Fossatrypa*) sp., *Atrypa* (*Atrypa*) *descrescens* Fenton et Fenton, *Atrypa menneri* Komarov, *Gretchispirifer dagnensis* Gretchishnikova et Oleneva, *Howellella subgregaria* (Ržonsnitskaja), *Arduspirifer mosellanus* (Solle), *Cyrtina indermedia* (Oehlert), *Eoreticularia aviceps* (Kayser), crinoids, chaetetids, heliolitids, gastropods, cephalopods, and bryozoans.

According to Aristov (1994), the *uralensis–pseudobaschkiricus* Zone contains two conodont assemblages; the first characterizes the lower part of the zone and contains *Ozarkodina carinthiaca* (Schulze), *Icriodus* ex gr. *beckmanni* Ziegler, and *Icriodus corniger ancestralis* Weddige. This assemblage corresponds to the *serotinus* Conodont Zone of the standard conodont scheme (Upper Emsian) based on the presence of latter species.

The second assemblage characterizes the middle part of the *uralensis–pseudobaschkiricus* Zone and contains *Icriodus culicellus* Bultynck, *I.* aff. *corniger rectirostratus* Bultynck, *I.* ex gr. *latericrescens* Branson et Mehl, *Ozarcodina cariathica* (Schulze), and *Polygnathus costatus patulus* Klapper. This assemblage corresponds to the *patulus–partitus* Zone of the standard conodont scheme (Eifelian Stage).

Polygnathus costatus costatus Klapper was found in the uppermost part of the *uralensis–pseudobaschkiricus* Zone. Thus, the *uralensis–pseudobaschkiricus* Brachiopod Zone is dated Upper Emsian–Lower Eifelian.

Eifelian Stage

Arduspirifer intermedius Zone (*Veligorskaya Formation*)

This zone is known in the slopes of Dagna-Sarachludag mountains, southern slope of Velidag Mountain, western part of the Saradag Range, northwestern slope of Karaburun Mountain near the village of Yeraskh, and the left bank of the Arpa River near the village of Danzik (Fig. 3; Table 4).

The complete sections of the zone are only known on Dagna-Sarachludag and Velidag mountains. The lower boundary is not exposed in the vicinity of Karaburun Mountain. The section in the southern slope of Velidag Mountain is regarded as the zonal stratotype (Grechishnikova et al., 1980b). The lower boundary is determined by the disappearance of *Zdimir* and appearance in the section of abundant corals, thamnoporids. The upper boundary is recognized by the appearance of the index species of the overlying *Alatiformia araxica–Dagnachonetes caucasius* Zone and the disappearance of sandstones.

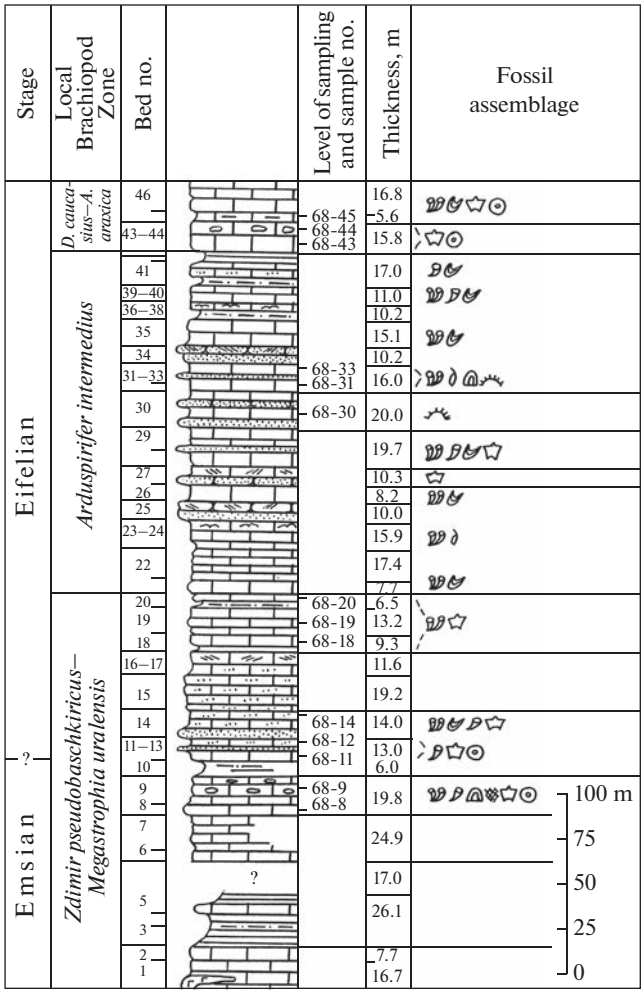


Fig. 3. Stratigraphic column of the Lower–Middle Devonian deposits in the southern slope of Dagna Mountain (reference section no. 68). For designations, see Fig. 2.

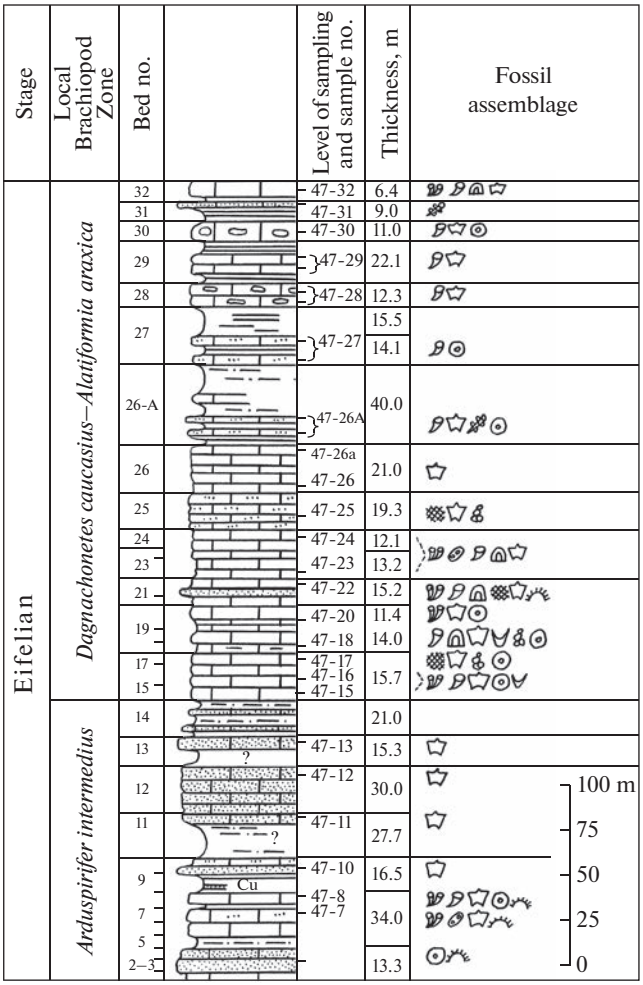


Fig. 4. Stratigraphic column of Eifelian deposits in the western slope of Karaburun Mountain (reference section no. 47). For designations, see Fig. 2.

The lithologic composition of the zone is facially variable. In the vicinity of the Velidag and Dagna-Sarachludag mountain ranges, the zone is composed of alternation of dolomitized or, in places, sandy limestones and varying from quartzitic to calcareous sandstones. The sandstone interbeds vary in thickness, as both local upswells and completely wedged out layers. Sandstones often show variously directed cross bedding; symmetric and asymmetric ripple marks are preserved in quartzites.

The lithologic composition of the zone on Karaburun Mountain is different (Fig. 4); sandstones are mostly fine-grained; sandy limestones compose the upper part of the section; and carbonate and clayey limestones prevail in the lower part. A significant role is played by argillites due to a decrease in carbonate rocks. The above-listed sections show that the lithologic composition of this zone regularly changes from the east to west, reflecting changes in sedimentation from the coastal- lagoon to shoal-marine types.

The zone is up to 150 m thick.

The zonal faunal assemblage includes stromatoporates, rugose and tabulate corals, and brachiopods: *Schizophoria lata* Alekseeva et Gretchishnikova, sp. nov., *Aulacella eifelensis* (Verneuil), *Zdimir triangulicostatus* (Khodalevich et Breivel), *Kayseria* aff. *nohnesis* Cooper, *Kransia parallelepipeda* (Bronn), *Arduspirifer intermedius* (Schlotheim), *Cyrtina heteroclita* (Defrance), *Howellella pseudoaculeata* (Rzhonsnitskaja), *Atrypa* (*Planotrypa*) *arazdayanensis* Komarov, crinoids, and conodonts. The conodont assemblage corresponds to the standard *costatus* Zone of the Eifelian Stage.

Generally, the faunal assemblage of the *intermedius* Zone is relatively poor, especially considering that most of the above-listed species were found in the section of Karaburun Mountain. This shows that, at the time of accumulation of the *intermedius* Zone, conditions within most of the studied territory were unfavorable for marine organisms.

Alatiformia araxica–Dagnachonetes caucasius Zone (Danzik Formation)

The deposits of this zone are widespread; they compose peaks and upper regions of the slopes of the Dagna-Sarachludag Mountain Range, vast spaces in the northwestern and eastern spurs of the Velidag-Karadash Mountain Range, eastern slopes and southeastern spurs of Saradag Mountain. Rocks of this age constitute most of Karaburun Mountain, the lower regions of the western slopes of Udzhubiz Mountain, and southern slopes of Adzhakyan Mountain. Isolated outcrops of this zone are known in the middle reaches of the Dzhaanam-Deresi River, in the upper reaches of the Bagarsykh-Deresi River, and on the Arpa River near the villages of Danzik and Gyumushlug.

The most complete section is located in the vicinity of the village of Danzik on the left bank of the Arpa River and was accepted as the stratotype (Grechishnikova et al., 1980a–180c; Grechishnikova and Levitskii, 1983). The lower boundary of the *araxica–caucasius* Zone is recognized by the appearance of the zonal index species; it is also well marked by the disappearance of quartzitic sandstones of the underlying zone in the section and can be distinguished in all other sections by this feature. Its upper boundary is recognized by the change in the fossil assemblage, while limestones of this zone are replaced by clayey rocks of the overlying zone.

The lower part of the section is composed mostly of limestones; sandstones and argillites appear in the middle; this terrigenous member is rich in fossil remains. The upper part of the zone is composed of massive, in places sandy, limestones and cross-bedded dolomitized limestones.

In the stratotype, the zone is 282 m thick and remains almost the same in the other sections.

The lithologic composition of the zone is rather uniform; the terrigenous member is well pronounced in all outcrops. There are only minor facial changes in the transition from the Danzik section to Karaburun: the proportion of silty–clayey and carbonate–clayey rocks increases in this direction, the number of argillite and siltstone interbeds increases in the middle and upper parts of the section of this zone on Karaburun Mountain.

Rocks of the *araxica–caucasius* Zone contain a rich assemblage of various fossils: chaetetids and heliolitids, stromatoporates, rugose and tabulate corals, trilobites, brachiopods: *Bicarinatina* sp., *Schizophoria lata* Alekseeva et Gretchishnikova, sp. nov., *Gypidula* cf. *biplicata* (Schnur), *Oligoptycherhyncus daleidensis* (Roemer), *Stropheodonta demissa* (Conrad), *Mesodouvillina birmanica* (Reed), *Leptodontella* cf. *caudate* (Schnur), *Dagnachonetes caucasius* Afanasjeva, *Productella mesodevonica* (Nalivkin), *Spinulicosta spinulicosta* Hall, *Alatiformia araxica* (Ržonsnitskaja), *Undispirifer ržhonsnitzkaja* Mamedov, *Emanuella takwanensis* (Kayser), *Atrypa* (*Planatrypa*) *karaburunensis* Komarov, *Desquamatia* (*Desquamatia*) *nemkovi* Komarov, *Athyris dansikensis* Mamedov, *A. ezquerraformis* Ržonsnitskaja, crinoids, tentaculites, and conodonts: the conodonts analogous to those of the underlying zone were found in the lower part of the *araxica–caucasius* Brachiopod Zone. The lower conodont assemblage corresponds to the *costatus* Conodont Zone and the upper corresponds to the *australis* Zone (Aristov, 1994).

In addition to the listed above, the gastropods, bivalves, trilobites, chaetetids, heliolitids, bryozoans also were found.

Mucrospirifer diluvianoides–Radiomena irregularis Zone (Volch'i Vorota Formation)

Rocks of this zone are exposed in many regions and stretch as a narrow stripe in the middle parts of the southern slopes of Karadash and Saradag mountains, on the southwestern spur of Kyzyl-Kaya Mountain, right bank of the Arpa River (vicinity of the village of Danzik), and on its left bank, where this zone forms a well-pronounced in relief upfold between protruding limestone ridges of the underlying *araxica–caucasius* Zone and overlying limestones of the *burtini* Zone. Small outcrops of the zone under consideration are known on the right bank of the Arpa River near the village of Gyumushlug and on the southwestern slope of Velidag Mountain. Finally, it is widespread in the Dzhaanam-Deresi River Basin, where it forms foothills of Kazma and Tezhgar mountains (Figs. 5–7).

The zonal stratotype is the section located on the left bank of the Dzhaanam-Deresi River valley; the section on the left bank of the Arpa River, in its middle reaches, near the village of Danzik was selected as a parastratotype (outcrop 19, Beds 38a, 38b, 38c, 39, 40; Grechishnikova and Levitskii, 1983) (Fig. 7).

The lower boundary of the *diluvianoides–irregularis* Zone is recognized by the disappearance from the section of most of the species of the older zonal assemblage and distinctly marked by clayey rocks of the considered zone replacing carbonate rocks of the underlying zone. The upper boundary of the *diluvianoides–irregularis* Zone is determined by the disappearance of species of the zonal assemblage and emphasized by the replacement in the section of bedded carbonate-clayey rocks by massive limestones of the *burtini* Zone.

The zone is divided into two parts based on lithological and partly paleontological features. The lower part is from 37 to 106 m thick and composed of black thinly-laminated argillites with interbeds of lumpy limestones and siltstones; the basement contains interbeds of concretionary siderites. The upper part varies in thickness from 60 to 142 m and is composed mostly of limestones with argillite interbeds. The limestones are black, organogenic (coral–brachiopod), fine-grained, and clayey, with indicative lumpy

Fig. 5. Geological map of the middle reaches of the Dzhaanam-Deresi River (composed by Levitskii in 1977). Designations: (1, 2) *Mucrospirifer diluvianoides–Radiomena irregularis* Zone: (1) lower part, argillites and siltstones, clayey and lumpy limestones; (2) upper part, clayey and organogenic limestones with argillite and siltstone interbeds; (3) marker limestone bed at bioherm basement. For other designations, see Fig. 1.

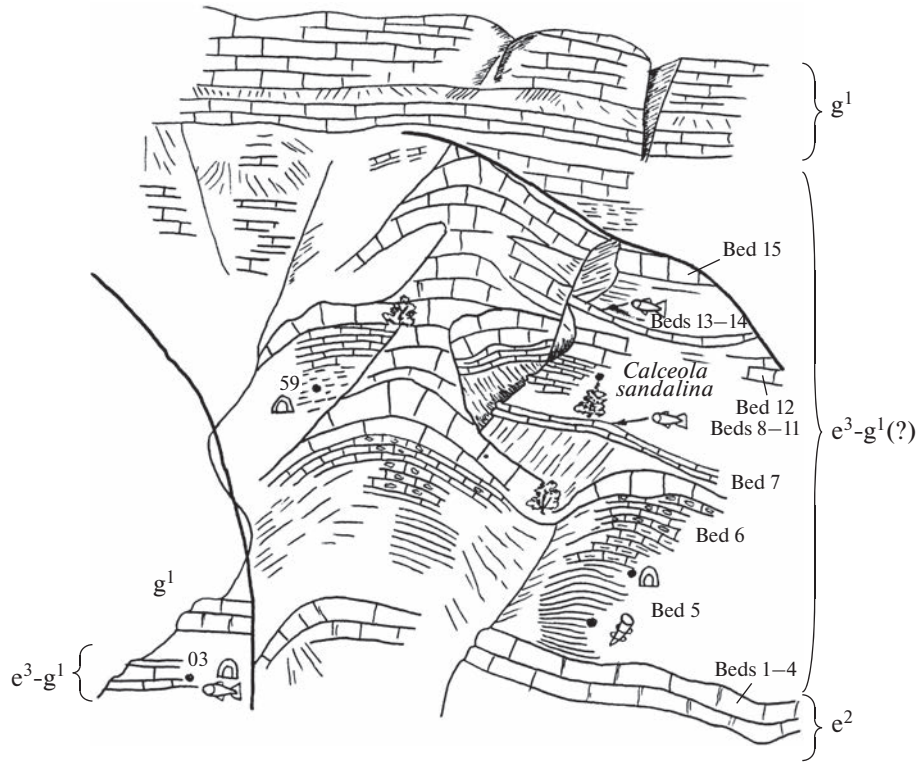


Fig. 6. Scheme of Eifelian bioherm on the left bank of the Dzhaanam-Deresi River valley (out of scale). Figures on the right correspond to the bed numbers in reference section no. 57 (composed by Grechishnikova in 1977). For designations, see Fig. 2.

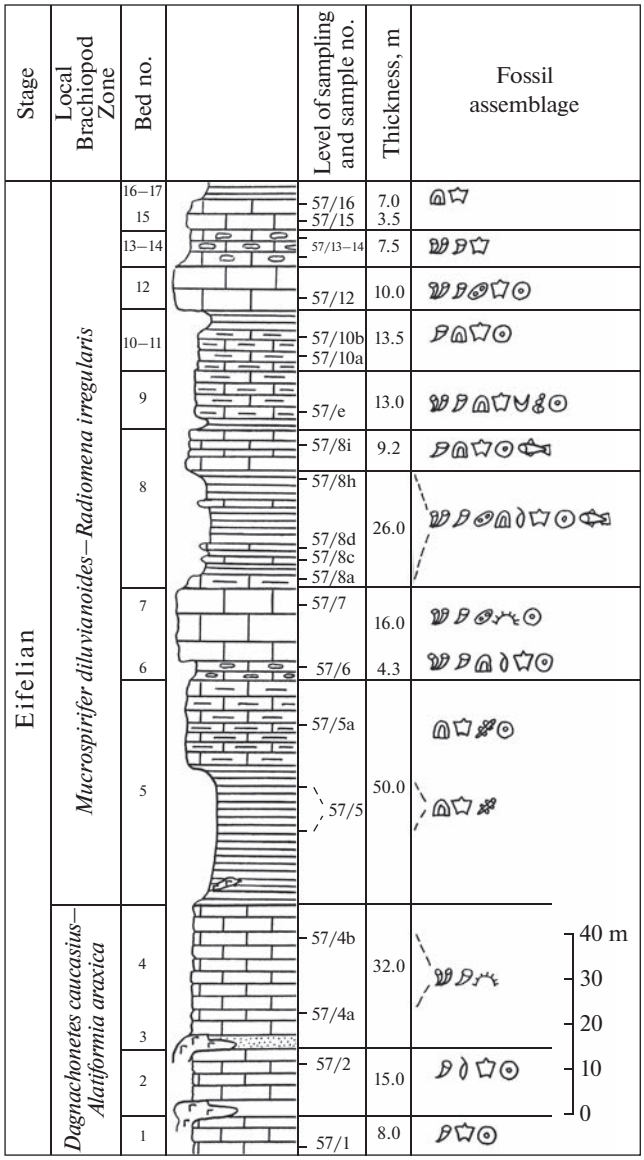


Fig. 7. Stratigraphic column of Eifelian deposits in the left bank of the Dzhaanam-Deresi River (reference section no. 57). For designations, see Fig. 2.

texture due to parastylolitization and many globular coral colonies.

The total zone is 248 m thick.

The bioherms in the upper part of the section in the middle reaches of the Dzhaanam-Deresi River are composed of gray, massive, nonbedded limestones. The main bioherm builders are algae and possibly tabulate corals. At certain levels, the bioherm transforms laterally into bedded limestones gradually decreasing in thick. Calcareous argillites and siltstones adjoin the bioherm through an abrupt facial boundary beds in the interspaces between bedded limestones. The region of the Dzhaanam-Deresi River at the time of the formation of the *diluvianoides–irregularis* Zone was probably situated on the outer margin of a shallow-water shelf spreading east of this region.

The zone strongly varies in thickness and facies within its range, which emphasizes the diversity of geographic environments of that time. In particular, near the village of Danzik, the zone decreases in thickness to 88 m; two members distinguished in the stratotype are preserved, but detrital limestones increase in volume in the upper part; bioherms are unknown.

Deposits of the *diluvianoides–irregularis* Zone contain a very rich and diverse fossil assemblage of rugose and tabulate corals, trilobites, ostracods, bryozoans, brachiopods: *Schizophoria lata* Alekseeva et Gretchishnikova, sp. nov., *Sch. bistriata* (Tschernyschew), *Leptagonia rhomboidalis* (Wilckens), *Aulacella finitiva* Alekseeva et Gretchishnikova, sp. nov., *Gypidula* sp., *Gypidulina grandis* Alekseeva et Gretchishnikova, sp. nov., *Devonogypa spinulosa* Havliček, *Douvillina interstrialis* (Phillips), *Radiomena irregularis* (Roemer), *Xystostrophia umbraculum* (Schlotheim), *Productella subaculeata* (Murchison), *Productella mesodevonica* Nalivkin, *P.* cf. *varians* Biernat, *Gypidula biplicata* (Schnur), *Devonogypa spinulosa* Havliček, *Leviconchidiella* sp., *Beckmannia pentagona* (Kayser), *Glosshypothyridina procuboides* (Kayser), *Kransia parallelepipeda* (Bronn), *Atrypa* (*Planatrypa*) *noraschensis* Mamedov, *A.* (*P.*) *collega* Struve, *Atryparia* (*Atryparia*) *dispersa* (Struve), *A.* (*A.*) *institа* Copper, *Altypa* (*Kyrtatrypa*) *culminigera* Struve, *Desquamatia* (*Variatrypa*) *zonata* (Schnur), *D.* (*Variatrypa*) *subditiva* Copper, *Spinatrypa* (*Isospinatrypa*) *aspera araxica* Komarov, *Desquamatia* (*Synatrypa*) *microzonata* Struve, *D.* (*Independatrypa*) *subditiva danzikesis* Komarov, *D.* (*In.*) *mikunovi* Komarov, *Spinatrypa* (*Isospinatrypa*) *muratovi* Komarov, *Carinatina arimaspa* (Eichwald), *Gruenewaldtia latilinguis* Schnur, *Eifelatrypa plana* (Kayser), *Mucrospirifer diluvianoides* Biernat, *Undispirifer rzhonsnitzkaja* Mamedov, *Nucleospira lens* (Schnur), *Eoreticularia aviceps* (Kayser), *Ambothyris* (?) *infima* (Whidbourne), *Cyrtina* ex gr. *heteroclita* Defrance, *Athyris concentrina* (Buch), *Merista* sp., *Schnurella transversa* (Reed), *Camerophorina pachyderma* Quenstedt, *Pugnax praevius* Schmidt, *Kayseria alvia* Copper, *Septalaria physomena* Torley, *Sieberella rectangularis* Torley, crinoids, chaetetids, heliolitids, stromatoporates, gastropods, cephalopods, bivalves, tentaculites, and conodonts.

Juvenile goniatitids (up to 0.5 cm in diameter) found in the Dzhaanam-Deresi River Basin are of great interest; unfortunately, according to B.I. Bogoslovsky, they cannot be determined. Remains of vertebrates found near the bioherm are also interesting; these are destroyed bones of placoderms, including a plate and imprints of plates of *Arthrodira* shield, and teeth of bradyodonts, dipterids, and elasmobranches.

The distribution of brachiopods and other organic remains in the section is irregular. The lower clayey member is relatively poor in fossil remains, while the

upper carbonate member is literally overfilled with fossils. The oryctocoenoses also differ in quality, which will possibly allow the *diluvianoides–irregularis* Zone to be subdivided into two separate units in the course of subsequent studies. This is particularly important, as Givetian taxa appear in the upper part of the zone in almost all invertebrate groups (stromatoporates, brachiopods, tabulate corals, bryozoans, crinoids) (Chudinova, 1983; Grechishnikova et al., 1983; Plamenskaya, 1983).

Although I adhere to the Eifelian dating of the considered zone in correspondence with the current correlation with the stratotypical sections of Western Europe, it seems plausible to lower the roof of the Eifelian Stage to the bottom of limestones in the middle part of the zone.

Based on the brachiopods, the *diluvianoides–irregularis* Zone is correlated with Beds XIV–XXIV of the Skala Horizon of Poland (Biernat, 1966), Beds 5–9 in Čelechovice of Czechoslovakia, Freilinger and Ahbach horizons of Eifelian troughs of Germany, and uppermost Couvain of Belgium (Coro). In the former USSR, this complex includes Pesterovo Limestones of Salair (Ržhonsnitskaja, 1968), which are supposed to be a facial analogue of the upper part of the Mamontovo Horizon; possibly the Langur Horizon of the eastern slope of the Urals, and also the strata described as analogue of the Chernaya Guba Horizon of the Tiesenhausen Peninsula of the Novaya Zemlya Archipelago (Cherkesova et al., 1978; Cherkesova, 1979). The wide distribution of this faunal assemblage reflects the onset of a new transgression and, consequently, a new historical developmental stage of Transcaucasia and other regions.

Based on conodont assemblages, the lower part of the *diluvianoides–irregularis* Zone is correlated with the *kockelianus* Conodont Zone (Levitskii et al., 1980) and its upper part is correlated to the lowermost *ensensis* Zone. Eichhorn et al. (1983, pp. 196–197) studied conodonts from the Danzik section and noted that "the *kockelianus* Zone was not recognized, since *Tortodus kockelianus kockelianus* Wittekindt was not found. However, the presence in the upper part of the section of such species as *Polygnathus linguiformis* ssp. *b* Weddige and a form transitional from *P. linguiformis pinguis* to *P. linguiformis* ssp. *a* Weddige, which simultaneously disappears throughout the section, suggests that this part of the section corresponds to the *ensensis* Zone. Unfortunately, the collection from this interval is still incompletely studied; however, there are some reasons for drawing the Eifelian–Givetian boundary 43–45 m below the boundary between the Volch'i Vorota and Sadarak formations (i.e., below the boundary between the *diluvianoides–irregularis* and *burtini* Zones: I.G.]." Hence, the conodonts do not contradict the author's conclusions on possible belonging of the upper part of the *diluvianoides–irregularis* Zone to the Givetian Stage.

Givetian Stage

Stringocephalus burtini Zone (Lower Part of the Sadarak Formation)

The deposits of this zone occur in the same regions as the deposits of underlying zone, but occupy considerably larger areas. They compose a part of several tectonic blocks north of the village of Sadarak, in which they are gently folded; in the Dzhaanam-Deresi River Basin, they compose a mountain range with Kazma Peak and a few separate hills at the foot of Tezhgar Mountain. The outcrops of this zone were found in the western and northern slopes of Velidag and Karadash mountains and both slopes of the Arpa River valley and the villages of Danzik and Gyumushlug.

The section on the left bank of the Arpa River, downstream from the village of Danzik (reference section 19, Beds 41–46) is suggested as one of possible zonal stratotypes (Grechishnikova et al., 1983) (Fig. 8). It is one of a few sections with exposed lower and upper boundaries (Fig. 2); however, its zonal assemblage is exceptionally poor in the index species. The lower boundary of the zone is recognized by the change in faunal assemblages, as near it, almost all species typical for the underlying zone, including *Calceola sandalina,* disappear and numerous representatives of *Hexagonaria* and *Stringocephalus burtini* (Defrance) appear. This boundary is also well lithologically pronounced and coincides with the bottom of massive limestones, which gradually replace lumpy clayey limestones of the upper part of the *diluvianoides–irregularis* Zone.

The upper boundary is recognized by the disappearance of index species in the section and the replacement of carbonate deposits of the *burtini* Zone by sandy-clayey rocks of the base of overlying zone.

The deposits of the *burtini* Zone are remarkably uniform over the whole range. The zone is totally carbonate and composed of different, essentially organogenic (stromatopore, coral, and brachiopod) limestones. The limestones are usually coarse-bedded and, therefore, form steep-sided slopes in relief. Near the villages of Danzik and Gyumushlug, the *burtini* Zone is lithologically distinctly divided into two parts; the lower part composed of massive coarse-bedded limestones and the upper part composed of the medium- and fine-bedded limestones with numerous remains of solitary and colonial rugosans, tabulate corals, and brachiopods (Fig. 2). However, in other places, this division is impossible.

Faunal remains include stromatoporates, rugose and tabulate corals, ostracods, bryozoans, conodonts, and brachiopods: *Areostrophia* sp., *Kransia parallelepipeda* (Bronn), *Glosshypothyridina procuboides* (Kayser), *Devonaria obtusa* Afanasjeva, *Spinatrypina* (*Spinatrypina*) *subnana* Komarov, *Spinocyrtia mediotexta*, *Cyrtospirifer* (?) *aperturatus* (Schlotheim), *Cyrtospirifer* (?) *canaliferus* (Valenciennes), *Indospirifer* sp., *Eoreticularia pseudovolhynica*, *Howellella angusti-*

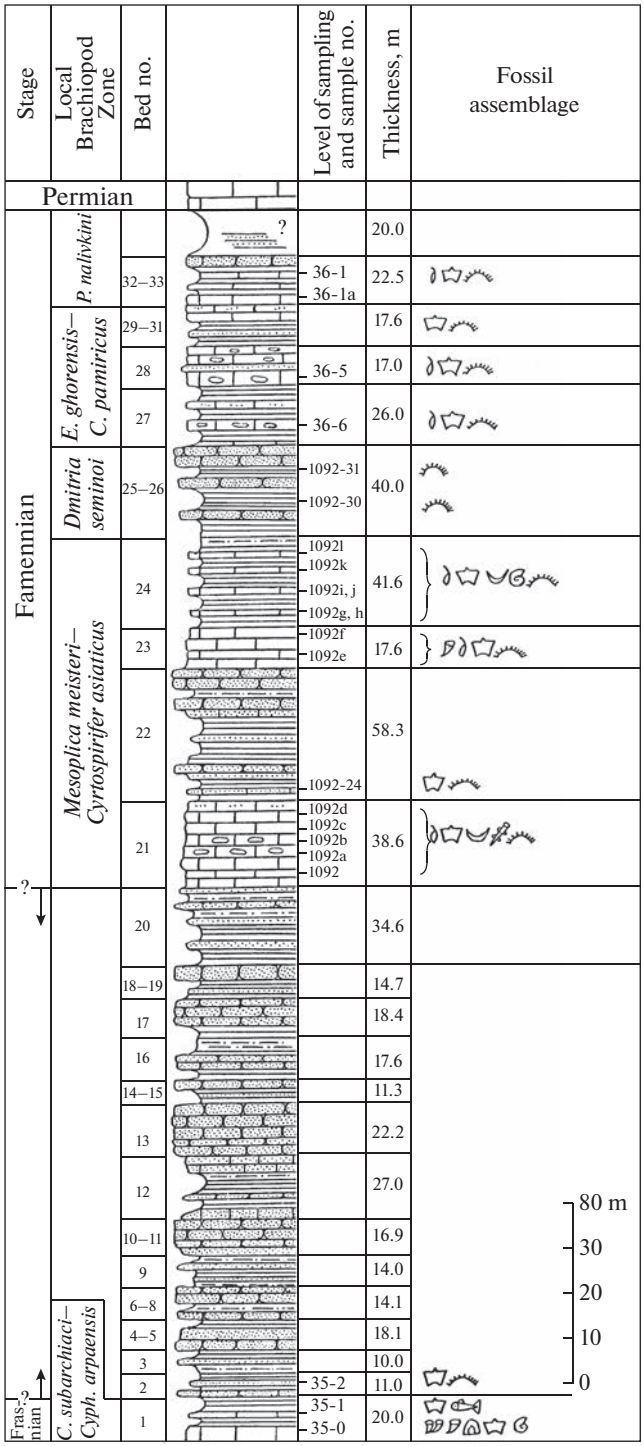


Fig. 8. Stratigraphic column of Upper Devonian deposits in the right bank of the Arpa River, near ruins of the village of Danzik (reference section no. 35-1092-36) (composed by Grechishnikova, Polozhikhina, and Aristov in 1977–1978). For designations, see Fig. 2.

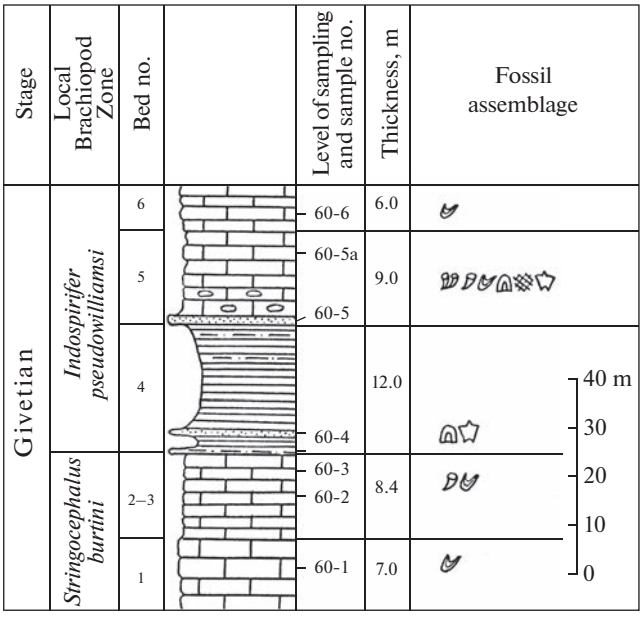


Fig. 9. Stratigraphic column of Givetian deposits in the left bank of the Dzhaanam-Deresi River, near levee (reference section no. 60). For designations, see Fig. 2.

plicata (Kozlowski), *Athyris* ex gr. *concentrica* (Buch), *Stringocephalus burtini*, *Crurithyris inflata* (Schnur), *Minatothyris torleyi* Struve. The presence of two last species sustains the belonging of the assemblage to the *varcus* Conodont Zone. However, the position of the *ensensis–varcus* boundary is uncertain, as a part of the section at this level lacks conodonts.

Egorova concluded (personal communication) that the ostracod assemblage strongly resembles that of the Staryi Oskol Horizon of the central East European Platform. In addition, the analysis of other faunal groups has revealed that the *burtini* Zone should be correlated with the *Stringocephalus* Beds of Belgium and Eifel and with the Cheslavka Horizon of the Urals.

Indospirifer pseudowilliamsi Zone (Upper Part of the Sadarak Formation)

The deposits of this zone are exposed along a very narrow stripe in the regions with the *burtini* Zone. It is laterally extended in the Gyumushlug Ore Field (Feliks et al., 1980).

The lithologic composition of this zone is uniform throughout its range. Its base is composed of brownish gray and reddish brown, quartzitic, calcareous, fine-grained sandstones with ferrous cement; the middle part consists of black thin plated argillites; and the upper part is composed of brownish gray, organogenic, sometimes slightly sandy limestones, becoming lumpy downward in the section (Fig. 9).

The lower boundary of the zone is well pronounced and runs at the bottom of calcareous sandstones, with a specific faunal assemblage or, which is the same, at the roof of limestones with *Stringocephalus burtini* and typical for the *burtini* Zone colonial rugose coral *Hexagonaria*. Limestones near the roof of the *burtini* Zone

usually contain abundant bun-shaped *Hexagonaria* colonies and stromatoporates; many colonies are overturned or declined, suggesting that, at the end of the formation of the *burtini* Zone, there were extremely shallow environments.

The upper boundary is also lithologically distinct and passes at the roof of the upper member of lumpy coral limestones, which is overlain by sandy–clayey rocks, which mark the onset of a new sedimentation stage. The lower boundary is well biostratigraphically substantiated, as the faunal assemblage characterizing the *pseudowilliamsi* Zone appears immediately above it; however, the upper boundary lacks such marker. The zone is 30 m thick.

The clayey part of the zone is usually poorly exposed in relief and has lift-offs, which provide contact between limestones of the *burtini* and *pseudowilliamsi* zones. This pattern was observed in the Gyumushlug Ore Field (Feliks et al., 1980).

The faunal composition is as follows: rugose and tabulate corals, trilobites, ostracods, brachiopods: *Xystostrophia umbraculum* (Schlotheim), *Cymostrophia* sp., *Rhipidomella arpensis* Alekseeva et Gretchishnikova, sp. nov., *A. finitima* Alekseeva et Gretchishnikova, sp. nov., *Schizophoria schnuri altera* Alekseeva et Gretchishnikova subsp. nov., *Aulacella eifaliensis* (Verneuil), *Leptagonia rhomboidalis* (Wilckens), *Megastrophia* sp., *Uncinulus korovini* Khalfin, *Beckmannia minor* (Kayser), *Schnurella transversa*, *Caucasiproductus gretchischnikovae* Lazarev, *C.* sp., *Spinatrypa* (*Invertrypa*) sp., *S.* (*Isospinatrypa*) *orthoclina* Copper, *Spinatrypina* (*Spinatrypina*) *kasangulubachensis* Komarov, *Desquamatia* (*Independstrypa*) *coenaubertorum* Godefroid et Jacobs, *Pseudoatrypa gjumuschlugensis* (Mamedov), *Gretchispirifer* sp., *Spinocyrtia irinae* Afanasjeva, sp. nov., *Sp. mediotexta*, *Nikospirifer praebisinus* Gretchishnikova, *Indospirifer pseudowilliamsi* Ržonsnitskaja, *Nordispirifer kasangulubachensis* Gretchishnikova, *Howellella angustiplicata* (Kozlowski), *Apousiella buchardi* (Murchison), *Reticulariopsis rotunda* Oleneva, sp. nov., *Undispirifer undiferus* (Roemer), *Cyrtina transcaucasica* Gretchishnikova, Oleneva, *Mucrospirifer* sp., *Gupidula* sp. 1, *Gypidula* sp. 2, *Devonogypa* sp., *Athyris acuminate* Khalfin, *Douvillina interstrialis* (Phillips), *Dicamara lacrima* (Sowerby), *Isopoma brachyptycta* (Schnur), *Crurithyris inflata* (Schnur), *Schnurella transversa*, tentaculites, and conodonts.

The above faunal assemblage of the *pseudowilliamsi* Zone allows its correlation with the lowermost Fromelennes beds of Belgium, Givetian deposits of Germany, and Safonovo beds of the Kuznetsk Basin. Based on conodonts, this zone is correlated to the *varcus* Conodont Zone of the standard scheme (Aristov, 1994).

Frasnian Stage

The Frasnian deposits are widespread, especially in the interfluve of the Dzhaanam-Deresi and Bagarsykh-Deresi rivers, and also in the Arpa River Basin. They strongly differ in lithology from the Middle Devonian (especially Givetian) rocks, which are mostly organogenic limestones. The lower part of the Frasnian Stage is composed mostly of terrigenous rocks, argillites, siltstones, and fine-grained sandstones; carbonate rocks prevail in the upper part. The last contain abundant and diverse remains of invertebrates, which became the basis for distinguishing two biostratigraphic zones within the Frasnian Stage, probably corresponding to the lower and upper substages and also tentatively a quartzite member (Figs. 8, 10–14).

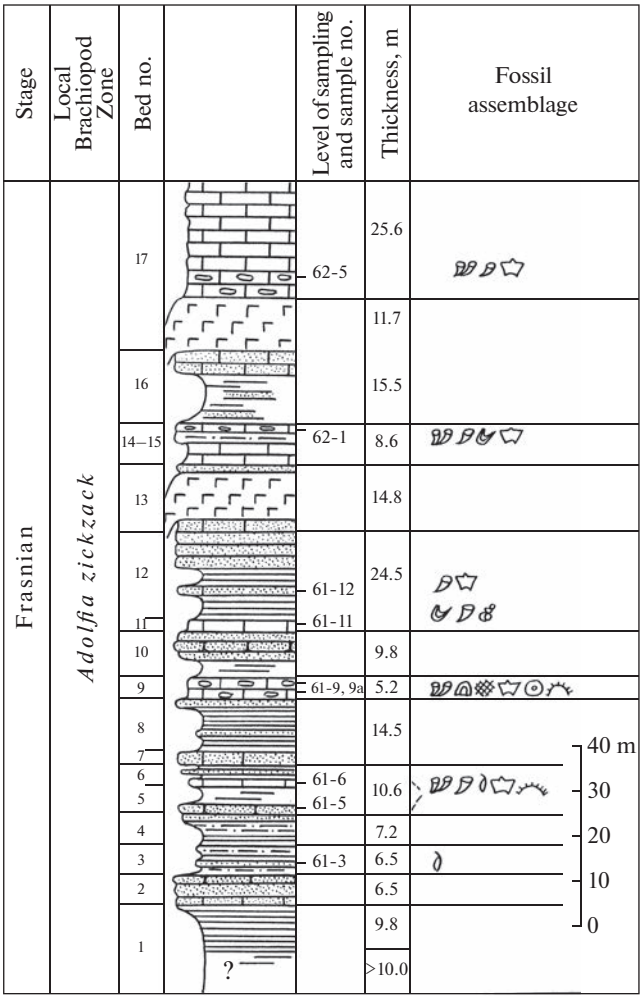


Fig. 10. Stratigraphic column of Frasnian deposits in the southwestern slope of a mountain with sea level 1103.8 (reference section no. 61–62). For designations, see Fig. 2.

Adolfia zickzack Zone (Chrakhana Formation)

The largest range of the *zickzack* Zone is in the interfluve of the Dzhaanam-Deresi and Bagarsykh-Deresi rivers, where it constitutes a row of ridges

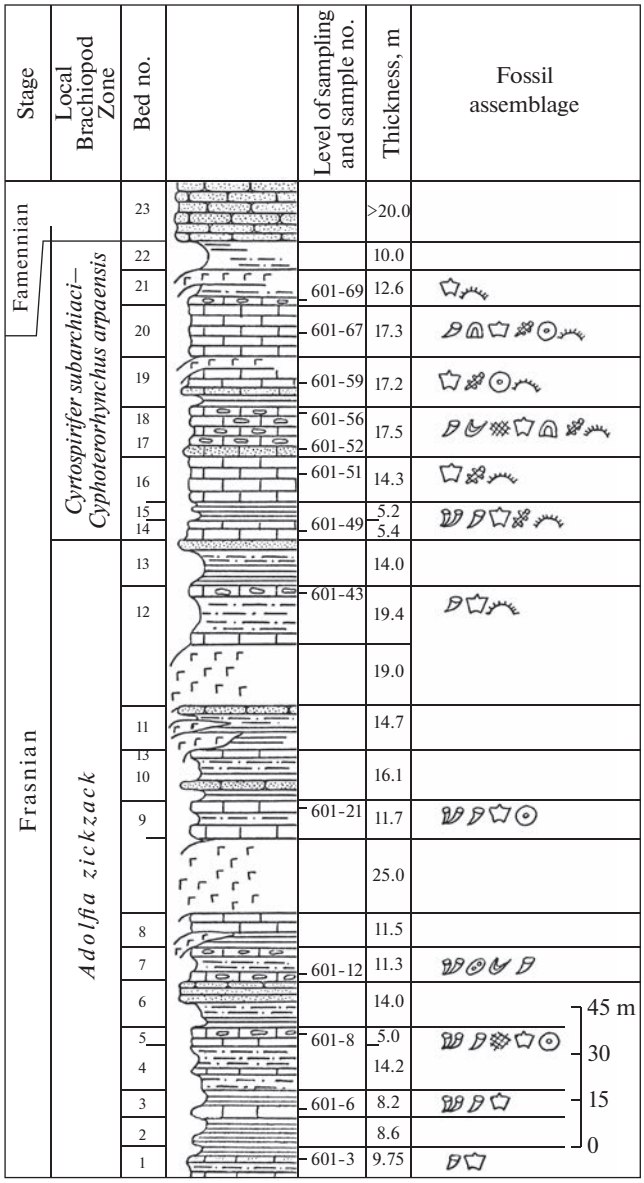


Fig. 11. Stratigraphic column of Frasnian deposits in the upper reaches of the Dzhaanam-Deresi River valley (reference section no. 601) (composed by G.M. Repnikova in 1978). For designations, see Fig. 2.

located near the western and eastern foothills of Bagarsykh Mountain. Large fields of the zone outcrops were found north of the village of Sadarak between Plakhpashi and Adzhakyan mountains and on both banks of the Arpa River, south and north of the villages of Danzik and Gyumushlug. Separate outcrops of the zone are recorded in the tectonic block in the upper reaches of the Paiya-dere gorge.

The lower boundary of the *zickzack* Zone is distinct and drawn at the bottom of the argillite member overlying coral limestones of the Upper Givetian *Indospirifer pseudowilliamsi* Zone (Fig. 8). It is distinct within the Gyumushlug Ore Field (Feliks et al., 1980) and on the left bank of the Arpa River, south of the village of Danzik.

The upper boundary is also well pronounced and determined by the appearance of the faunal assemblage of the overlying *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

The presence of relatively thick argillite and siltstone members provides two peculiar features of the *zickzack* Zone; firstly, their confinedness to Mesozoic mafic and intermediate intrusive rocks forming sills and, rarer, cross-cutting dikes and stocks; secondly, plasticity of these deposits, which caused their complex dislocations. In addition, the clayey members are usually poorly exposed. These peculiarities embarrass a thorough study of the section; although deposits of the *zickzack* Zone occupy large areas, it was difficult to select a stratotype, i.e., a continuous section of the zone from the bottom to roof (Fig. 10).

The section on the left bank of the Arpa River, south of the village of Danzik (reference section 19, beds 48–59) is designated as the stratotype.

Three members, lower, middle, and upper, are recognized within the zone based on lithologic peculiarities and faunal composition.

The lower member is composed of sandstones, siltstones, and argillites with limestone interbeds; its basement is composed of 0.5–1.0-m-thick brown slightly micaceous sandstone, which is replaced by variegated (crimson, brown, and gray) earthy argillites and siltstones with two interbeds of lumpy clayey limestones. The lower member terminates in the alternation of siltstones and calcareous sandstones with bony remains of fishes.

The member varies from 45 to 70 m of thickness.

The middle member is composed of limestones and argillites with siltstone, sandstone, and rare quartzite interbeds. The argillite and limestone interbeds are almost equally developed in the lower part of the member, but in the upper part, limestones prevail. The base of this member is composed of solid limestones filled with shells of *Eoreticularia pseudovolhynica* Mamedov. The member varies from 100 to 150 m of thickness.

The upper member is composed of black and bottle-green argillites and siltstones with interbeds of relatively thin limestones and rarer sandstones, which increase in number upward in the section. The member is 110–125 m thick (Fig. 11).

The total thickness of the *zickzack* Zone varies from 270 to 345 m.

The limestone beds of the zone considered contain rugose and tabulate corals, heliolitids, chaetetids, brachiopods, ostracods, and conodonts.

The fauna includes the following fossils: stromatoporates, rugose and tabulate corals, trilobites, ostracods, bryozoans, brachiopods: *Leptagonia* sp., *Xystostrophia* sp., *Schizophoria striatula* (Schlotheim),

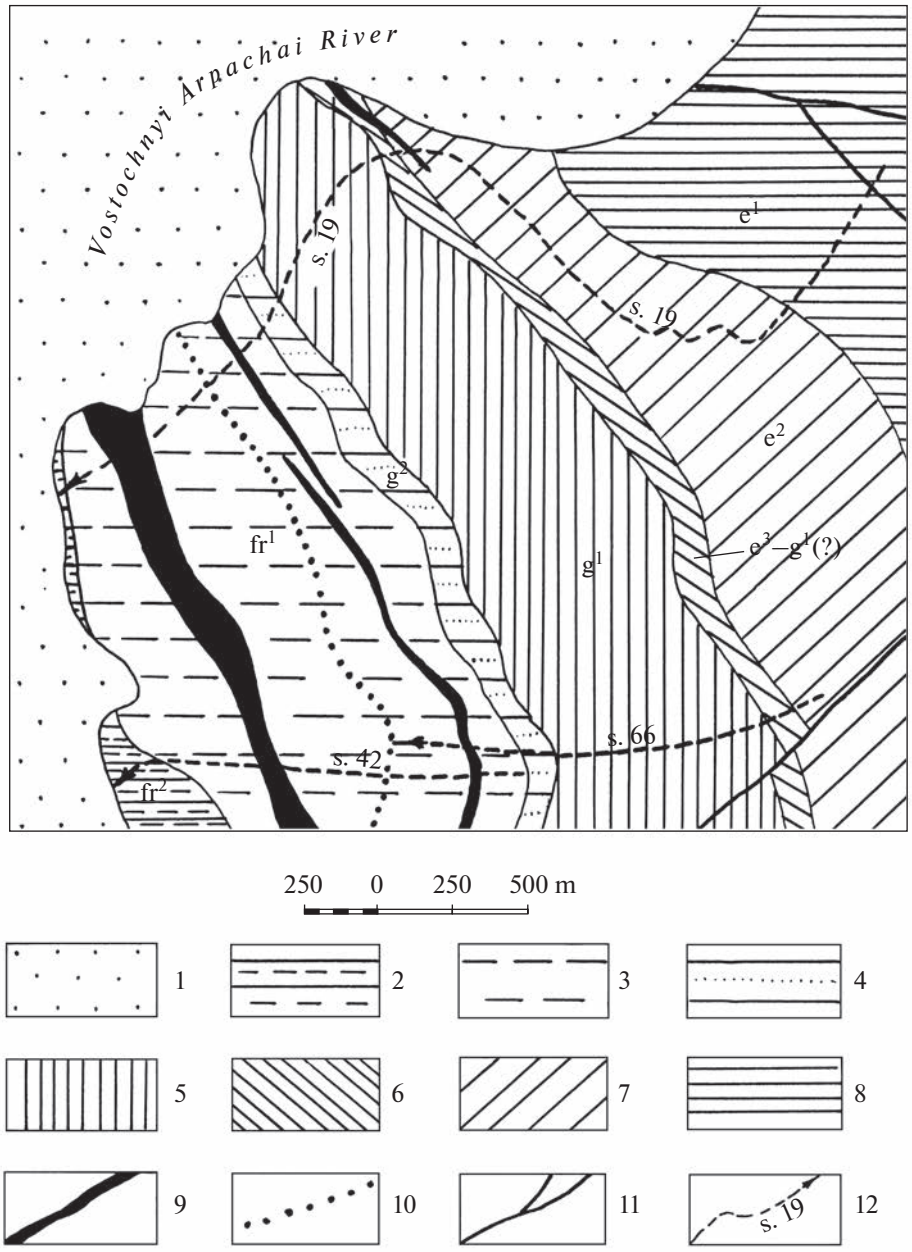


Fig. 12. Geological map of the left bank of the Arpa River near the former village of Danzik (composed by Feliks in 1977). For designations, see Fig. 1. Diabase bodies and dikes are shown in black.

Douvillina sp., *Devonoproductus sericeus* (Buch), *Productella* ex gr. *subaculeata* (Murchison), *Corbicularia dzhaanamensis* Afanasjeva, *Zezinia multicostata* Pakhnevich, *Pugnax acuminatus* (Martin), *Widbornella productoides* (Murchison), *Devonaria* sp., *Mucrospirifer vassinensis* Ržonsnitskaja, *Adolfia zickzack* (Roemer), *Cyrtina demarlii* Bouchard, *Pripyatispirifer caucusius* Afanasjeva, sp. nov., *Theodossia* sp., *Desquamatia* (*Independatrypa*) *subindependensis* Komarov, *Spinatrypina* (*Spinatrypina*) *comitata* Copper, *Sp.* (*Exatrypa*) *copperi* Komarov, *Sp.* (*Ex.*) *robusta* Copper, *Atrypa* (*Planatrypa*) *ertichensis* Abramian, *Eoreticularia pseudovolhynica*, *Merista* sp., crinoids, tentaculites, and conodonts.

The analysis of the faunal assemblage of the *zickzack* Zone revealed that, along with the Frasnian forms, all invertebrate groups include Givetian species in the lower part of the section. This is especially noticeable in the composition of rugose corals, which, according to L.M. Ulitina (personal communication), have a Givetian appearance. The high abundance of cystiphyllid corals is unusual, although they are supposed to become extinct globally in the Givetian. The presence of heliolitids in this zone is also unusual.

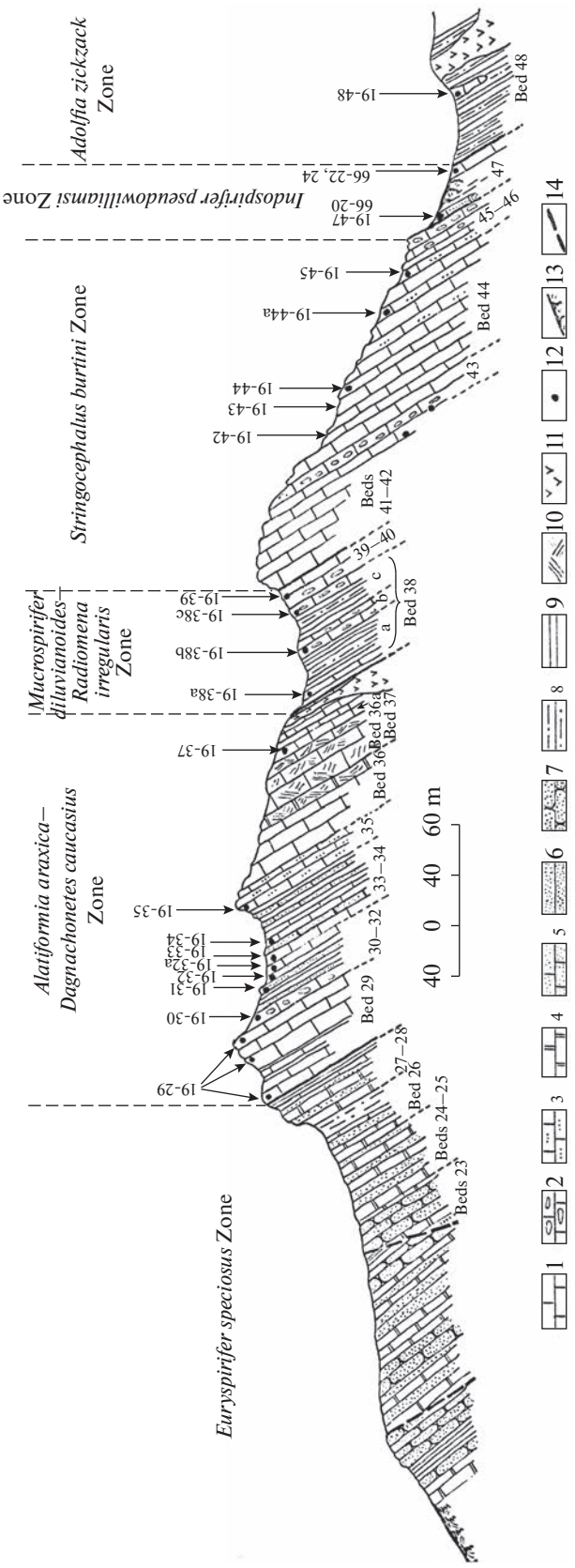


Fig. 13. Profile of the lower part of reference section no. 19 on the left bank of the Arpa River near the former village of Danzik (composed by Grechishnikova with contributions from Levitskii, Polozhikhina, and Feliks). For designations, see 2.

Aristov (personal communication) concluded that the conodont assemblage of the *zickzack* Zone is rather poor in species composition, which is mixed Givetian–Frasnian; all species of this assemblage are long-lived. The lower member contains especially many Givetian species. Final conclusions concerning the position of the Givetian–Frasnian boundary in Transcaucasia can only be drawn after a thorough study of remains of all invertebrate taxa. The brachiopod composition does not contradict the assignment of the *zickzack* Zone (at least its middle and upper members) to the Lower Frasnian.

Uchtospirifer subarchiaci–Cyphoterorhynchus arpaensis Zone (Bagarsykh Formation)

The deposits of this zone occur in the same regions as the underlying zone, i.e., in the interfluve of the Dzhaanam-Deresi and Bagarsykh-Deresi rivers and in the Arpa River Basin, vicinity of the villages of Danzik and Gyumushlug. In the former region, the outcrops of the *subarchiaci–arpaensis* Zone form a continuous stripe north of the range with Kazma Peak, on the western, southern, and eastern slopes of Bagarsykh Mountain, and constitute large fields in the middle reaches of the Bagarsykh-Deresi River.

The sections of this zone in the Dzhaanam-Deresi River Basin (reference section 601, Beds 49–74), (Fig. 11) and on the left bank of the Arpa River near the village of Ashaga-Yaidzhi are most complete and, therefore, are suggested as possible variants of the stratotype. The lower boundary is recognized at the bottom of limestones with the zonal faunal assemblage; the upper boundary is established by the disappearance of this assemblage and appearance of quartzites in the section.

Over its whole range, this zone is uniform in lithologic composition and indicative faunal assemblage (Fig. 14).

The lower, thicker part of the zone is composed of dark gray medium-bedded coral–brachiopod, clayey, and lumpy due to the parastylolitization limestones. The limestones include thin interbeds of bottle-green siltstones, black thinly laminated argillites, and green calcareous quartzitic sandstones (Fig. 15).

The upper part of the zone is composed of black argillites with thin interbeds of organogenic–detrital, slightly sandy limestones and sandstones with ferrous cement.

The zone is about 112 m thick.

The deposits of the *subarchiaci–arpaensis* Zone contain a faunal assemblage uniform in taxonomic composition, including rugose and tabulate corals, trilobites, ostracods, bryozoans, brachiopods: *Devonoproductus* sp., *Cyphoterorhynchus arpaensis* (Abramian), *Porthmorhynchus ferquensis* (Gosselet), *Rhipidorhynchus gnishikensis* (Abramian), *Desquama-*

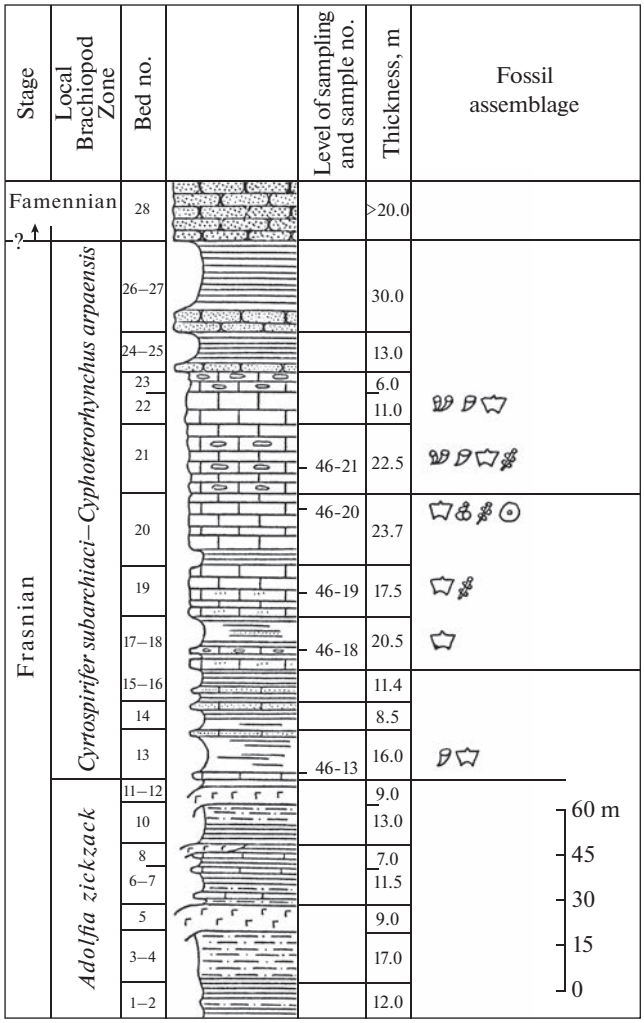


Fig. 14. Stratigraphic column of Upper Devonian deposits in the right bank of the Dzhaanam-Deresi River valley (reference section no. 46). For designations, see 2.

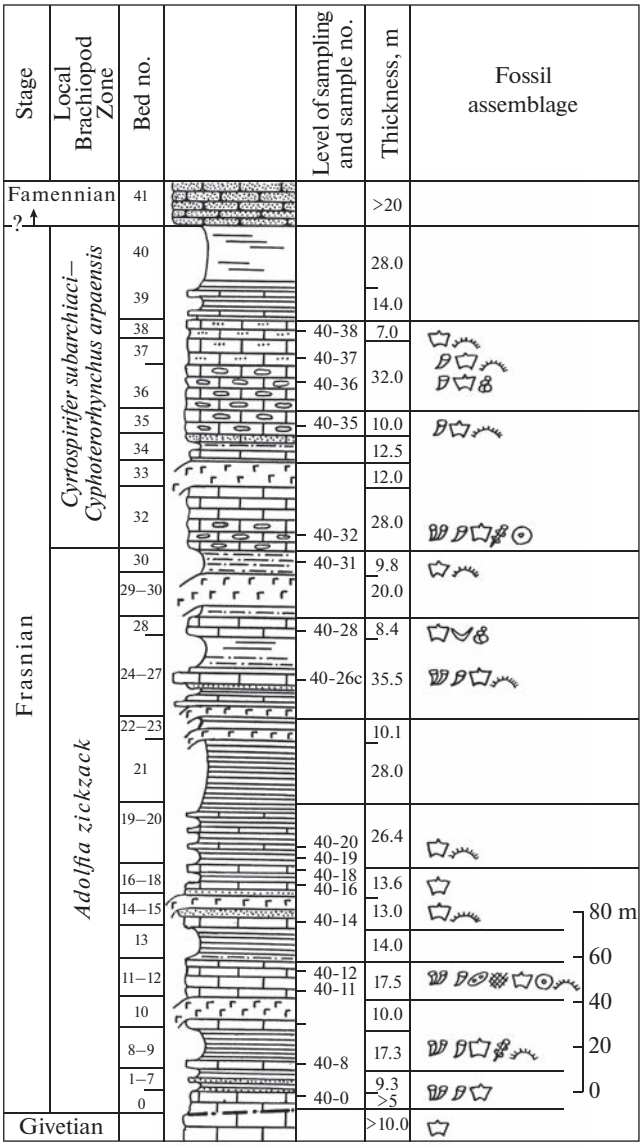


Fig. 15. Stratigraphic column of Upper Devonian deposits in the right bank of the Yaidzhi-Deresi River valley, south of the village of Gyumushlug (reference section no. 40). For designations, see Fig. 2.

tia (*Seratrypa*) *abramianae* Akekseeva et Komarov, *Spinatrypina* (*Exatrypa*) *robusta* Copper, *Spinatrypina* ex gr. *tubaecostata* (Paeckelmann), *Atrypa* (*Planatrypa*) *ertichensis*, *Uchtospirifer subarchiaci* (Martelli), *Theodossia nalivkini* Mamedov, *Cyrtospirifer tarbagataicus* (Vasilievsky), *Mucrospirifer bouchardi* (Murchison), *Douvillina* sp., crinoids, nautiloids, tentaculites, and conodonts.

The richest oryctocoenoses were found on the right bank of the Arpa River near the village of Danzik, where separate limestone interbeds are formed of brachiopod coquina with abundant tabulate coral colonies. Southerly and westerly, the faunal assemblage decreases in diversity; corals and atrypids become rarer, but spiriferids and rhynchonellids remain abundant.

Based on brachiopods, the *subarchiaci–arpaensis* Zone is correlated with the Middle and Upper Frasnian deposits of other districts of the former USSR and other countries. According to Aristov (personal communication), the lower part of the *subarchiaci–arpaensis* Zone is correlated with the Middle Frasnian of Belgium by the conodonts.

Later, Aristov (1994) reevaluated the age of the *subarchiaci–arpaensis* Brachiopod Zone. He supposed that the Givetian–Frasnian boundary is located within the *subarchiaci–arpaensis* Zone, i.e., it is recognized by the appearance of *Ancerodella rotundiloba* (Bryant). In outcrop 601 on the right bank of the Arpa River near the village of Danzik, this species was found in limestones at the base rather than in the middle of the zone. Aristov mentioned that the taxa most important for recognition on the Givetian–Frasnian

boundary are extremely rare in the studied sections and, therefore, their first appearance cannot be determined. Thus, he suggested to draw tentatively the Givetian–Frasnian boundary within the *subarchiaci–arpaensis* Zone.

Quartzite Member

The quartzite member forms isolated areas and stripes of outcrops north of Dolovan Mountain along both banks of the Arpa River downstream from the village of Danzik. However, this quartzite member is most developed in the stripe stretching northwest from the village of Gyumushlug to the Bagarsykh-Deresi River Basin and onward across Bagarsykh Mountain in the upper reaches of the Dzhaanam-Deresi River. The lower part of the quartzite member also forms a large area on the right bank of the Birali-Chai River west of Tezhgar Mountain.

The quartzite member in the lower part of the section is composed mostly of quartzites and quartzitic, rarely, quartz–feldspar sandstones, argillites, and siltstones. It rests conformably on limestones of the underlying *subarchiaci–arpaensis* Zone with gradual transitions (Fig. 8).

Quartzitic sandstones are white or pinkish, usually fine-grained, rarely, medium-grained. The quartz grains are well or angularly rounded and intermediately sorted. Cement is regenerative quartzitic, in places, ferrous–carbonate porous. The rocks often show oblique (both unidirectional and multidirectional) and parallel microlamination and dotty excretions of iron oxides.

Gray, greenish gray or brownish gray, unevenly grained, mostly fine-grained, quartzitic, rarely, feldspar–quartzitic sandstones. The grains are usually angular; larger grains are well rounded. Sandstones are often micaceous (muscovite and, rarer, biotite squama) and contain phosphorite grains (interbeds up to 30% of the total rock volume) and carbonaceous smears.

Dark gray and reddish brown siltstones usually contain admixture of sandy matter and are composed of nonrounded quartz grains and few muscovite squama.

Black or greenish black, thinly comminuted, sometimes micaceous argillites.

There is a definite regularity in the distribution of the above-listed rocks in the section. Fine-grained rocks and less abundant quartzitic sandstones prevail in the lower half of the strata (approximately 90 m). There occur fossil organic remains, such as fragments of brachiopod shells, ostracods, and phosphatized bony remains of fishes and conodonts. This part of the section is also micaceous and contains carbonaceous smears.

The upper half of the quartzite member is composed mostly of sandy rocks, although siltstone and argillite members are also observed here. Organic remains are very rare; they are small phosphatized bony remains and imprints of unidentifiable brachiopods in the upper part of the section. The quartzite member is 240–250 m thick.

Fossils are very rare and specific.

The conodont assemblage (Aristov et al., 1979; Ovnatanova and Aristov, 1984) is closely similar to that of the underlying Frasnian zone.

Famennian Stage

Rocks of this age are known along both banks of the Arpa River and widespread on its left bank south of the Yaidzhi-Deresi River valley and onward to the northwest along the right bank of the Arpa River up to the lower reaches of the Bagarsykh-Deresi River. The second area with Famennian deposits is in the vicinity of the village of Danzik. Famennian rocks are also exposed on the left bank of the Birali-Chai River southwest of Tezhgar Mountain and on the southern slope of Birali-Kuzei Mountain in the interfluve of the Dzhaanam-Deresi and Bagarsykh-Deresi rivers in the vicinity of Bagarsykh Mountain.

Five local complex brachiopod zones are recognized within the Famennian Stage. The lower zone corresponds to the Lower Famennian and the rest four, to the Upper Famennian.

Cyrtospirifer asiaticus–Mesoplica meisteri Zone (Presumably Noravan and Erdichskaya Formations)

The section of the zone on the right bank of the Arpa River near the village of Danzik (reference sections 36 and 1092) is most complete and was accepted as stratotype (Aristov et al., 1979). Rocks of this zone are developed in the same area as the deposits of the underlying zone. Most of the rocks are carbonate and clayey and uniformly distributed in the section. The *asiaticus–meisteri* Zone is subdivided into four members based on peculiarities of the lithologic composition and fauna (Fig. 8).

The first member (*asiaticus–meisteri*–I limestone) is composed of dark gray and black clayey and organogenic–detrital limestones, with interbeds of oncolite and shoreface calcarenite varieties. The member is 25 m thick. The bottom of oncolite limestones is the lower boundary of the *asiaticus–meisteri* Zone, where the index species appear.

The second member is composed of dark gray or black, often calcareous argillites. Argillites alternate with siltstones and brownish gray and greenish gray sandstones. The sandstones are quartzitic, with carbonate cement, relatively friable, irregularly grained, in places, ferruginated with carbonaceous smears, burrows of scrabbling organisms, rhizoids, and phosphatized bone remains. Along with these sandstones, the member contains interbeds of quartzitic sand-

stones. Several of such contiguous sandstone beds form an indicative interbed approximately in the middle part of the member. The member lacks well-preserved fossils. It is 60 m thick.

The third member (*asiaticus–meisteri*–II limestone) consists of limestones similar to that of the first member. They differ in the thin interbeds of black argillites and rarer quartzitic sandstones occurring in the lowermost third of the member. The thickness is up to 30 m.

The fourth member is composed of black argillites with siderite concretions and thin interbeds of often quartzitic sandstones and organogenic–detrital limestones. The member is up to 40 m thick.

The total thickness of the *asiaticus–meisteri* Zone is about 150 m.

The faunal assemblage of the *asiaticus–meisteri* Zone includes rugose corals, ostracods, bryozoans, the brachiopods *Sartenaerus letiensis* (Gosselet), *Gesoriacorostrum* cf. *boloniensis* (Orbigny), *Ptychomaletoechia* sp., *Paropamisorhynchus kotalensis* (Brice), *Greira transcaucasica* Erlanger, *Sharoviella mirabilis* Pakhnevich, *Stenaulacorhynchus* sp., *Mesoplica meisteri* (Peetz), *M.* ex gr. *subaculeata* (Murchison), *Hamlingella* ? *murchisoniana* (Koninck), *Productella herminae* (Frech), *Productella* sp., *Hunanospirifer arpaensis* Gretchishnikova, *Cyrtospirifer asiaticus* Brice, *C. verneuili* (Murchison), *C. quaddratus* (Nalivkin), *C. echinosus* Ljaschenko, *C. dansikensis* Afanasjeva, sp. nov., *Cyrtiopsis caucasia* Gretchishnikova, 1986, *C. armenica* Abramian., and *Uchtospirifer orbelianus* (Abich), bivalves, nautiloids, and conodonts.

Based on conodonts (Aristov, 1994), the *asiaticus–meisteri* Zone corresponds to two zones of the standard conodont scheme, the *triangularis* and *crepida* zones of the Famennian Stage.

The brachiopod assemblage of the *asiaticus–meisteri* Zone strongly differs from that of the underlying *subarchiaci–arpaensis* Zone, but is rather uniform within the zone. It should be noted, however, that, in the first limestone interbeds, brachiopods are numerous but poor in species composition. Based on brachiopods, the *asiaticus–meisteri* Zone is correlated with the Lower Famennian of Western Europe, Russia (Kuznetsk Basin), Kazakhstan, Iraq, and Afghanistan. Lavrent'eva (1985; personal communication) concluded that the bryozoan assemblage consists only of the Famennian species known from the Lower Famennian of Kyrgyzstan, Kazakhstan, and United States.

According to Chizhova (Aristov et al., 1979), the ostracod association "slightly resembles the ostracod association from the Lower Famennian of the French–Belgian Basin and Russian Platform."

Dmitria seminoi Zone (Kadrlu Formation)

This zone is known in the same regions as the *asiaticus–meisteri* Zone, but outcrops of the *seminoi* Zone occupy smaller areas. It conformably rests on the deposits of the underlying zone and is composed in the Nakhchivan District of terrigenous rocks with separate, relatively rare carbonate interbeds. Terrigenous rocks are quartzitic and clayey sandstones, argillites, and siltstones, which constitute alternating members of fine-grained to coarse-grained rocks with the predominance of sandstones. The zone contains separate thin interbeds of strongly sandy limestones with rare camarotechiids. The index species was not found.

In Armenia, this zone is composed mostly of lumpy limestones, which contain abundant shells of *Dmitria seminoi* (Abich), large camarotechiids, and productids, which are being studied.

The zone is at least 70–80 m thick. The lower boundary is recognized by the appearance of *Dmitria seminoi*; the upper boundary is established by its disappearance and appearance of the index species of the overlying *pamiricus–ghorensis* Zone.

The faunal assemblage is as follows: brachiopods were only found in Armenia (zone stratotype in the vicinity of the village of Kadrlu, section no. 6, Beds 20–26): *Schuchertella chemungensis transversa* Nalivkin, *Sartenaerus letiensis* (Gosselet), *Araratella dichotomians* Abramian, *Sharovaella mirabilis* Pakhnevich, *Widbornella capiratiformis* Abramian, *Dmitria seminoi* (Verneuil), *Cyrtospirifer* ex gr. *verneuili* (Murchison), *Dichospirifer cardiosinusoides* (Abramian), *Gruntathyris innae* Gretchishnikova, ostracods, and conodonts.

The brachiopod assemblage contains many endemic species, including the index species of the *Dmitria seminoi* (Verneuil) Zone and also species typical for the Famennian of Western Europe, Kazakhstan, and Pamir. According to Chizhova, the *seminoi* Zone is correlated with the lower part of the Dankov-Lebedyan Beds of the Russian Platform based on ostracods.

The conodont composition (Aristov, 1994) corresponds to two zones of the standard conodont scheme, *rhomboidales* and *marginifera* of the Famennian Stage. However, Aristov admitted that the species typical only for the *seminoi* Zone are absent.

Cyrtospirifer pamiricus–Enchondrospirifer ghorensis Zone (Shamaa Midzor Formation)

The deposits of the *pamiricus–ghorensis* Zone are developed only in the interfluve of the Yaidzhi-Deresi and Kabakhlychai rivers, enter the right bank of the Arpa River, and the Bagarsykh-Deresi River Basin. These deposits are widespread in the vicinity of the village of Danzik and in the Paiya-dere gorge. The out-

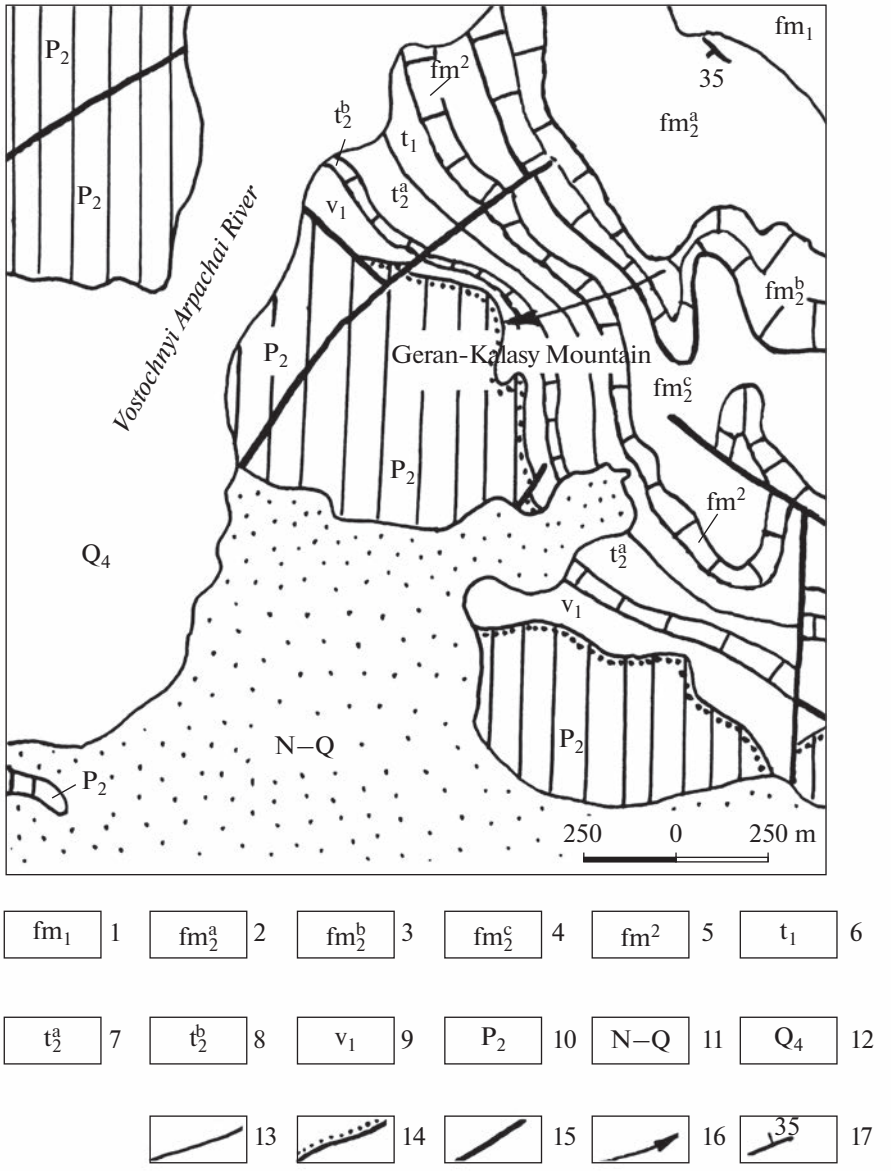


Fig. 16. Geological map of the vicinity of Geran-Kalasy Mountain (composed by Feliks in 1977). Designations: (1–5) Famennian Stage: (1) *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone, quartzites, sandstones, limestones; (2) *Dmitria seminoi* Zone, sandstones, argillites, limestones; (3) *Ehchondrospirifer ghorensis–Cyrtospirifer pamiricus* Zone, limestones; (4) *Paurogastroderhynchus nalivkini* Zone, limestones, argillites, sandstones, quartzites; (5) *Sphenospira julii–Spinocarinifera nigra* Zone, limestones; (6) *Unispirifer praeulbanensis–Rhytiophora curtirostris* Zone, sandstones, sandy limestones, argillites; (7) *Unispirifer tornacensis–Rhipidomella michelini* Zone, argillites with interbeds of sandy limestones; (8) *Spirifer baiani–Marginatia burlingtonensis* Zone, limestones; (*9*) Visean Stage, lower substage, limestones; (10) Upper Permian, limestones; (11) undivided Neogene and Quaternary deposits; (12) Recent alluvial gravels and sands; (13, 14) geological boundaries: (13) conformable; (14) unconformable; (15) faults; (16) location of reference section no. 11; (17) attitude.

crops of this zone are also known in the upper reaches of the Dzhaanam-Deresi River and the middle reaches of the Birali-Chai River.

The *pamiricus–ghorensis* Zone rests conformably on deposits of the underlying zone. Its most complete sections were studied on the northeastern slope of Geran-Kalasy Mountain (reference section 11, Bed 1) and on the right bank of the Arpa River, downstream from the village of Gyumushlug (reference section 5, Beds 12–26). The lower boundary is marked by the appearance of the zonal assemblage, including the index species *Enchondrospirifer ghorensis*. The upper boundary coincides with the roof of limestones with the index species and associated brachiopod species (Fig. 16).

The *pamiricus–ghorensis* Zone is composed mostly of limestones and argillites. The limestones at the zone base are gray, sandy, and solid and become more unal-

loyed in the upper part. Lumpy limestone varieties often occur and are usually rich in fossils (Fig. 17).

Black argillites prevail in the upper half of the section; they usually contain interbeds of quartzites, rarely gritstones, sometimes with phosphorite grains.

The *pamiricus–ghorensis* Zone is characterized by facial changes that are apparent even at a small distance.

The zone is 65 m thick.

Deposits of the *pamiricus–ghorensis* Zone contain the following brachiopods: *Schuchertella chemungesis* Condra, *Sch*. i*mpressa* Hall, *Hamlingella maxima* (Abramian), *Whidbornella caperatiformis* (Abramian), *Mesoplica* cf. *praelonga* (Sowerby), *Cyrtospirifer pamiricus* (Reed), *C. lonsdalii* (Grabau), *C. crassiplicatus crassiplicatus* Brice, *Arpaspirifer latus* (Abramian), *Enchondrospirifer ghorensis* Brice, *En*. aff. *ghorensis* Brice, *Sphenospira dansikensis* Gretchishnikova, sp. nov., *Dichospirifer thylakistoides* Brice, *D. cardiosinusoides* (Abramian), *D. felixi* Gretchishnikova sp. nov., *Sartenaerus charakensis* (Brice), *Araratella dichotomians*, *Sharovaella mirabilis*, *Sinotectirostrum delicatacostata* (Abramian), *Gruntathyris innae* Gretchishnikova, *G. pseudointermedia* Gretchishnikova, ostracods, conodonts, remains of cephalopods and fishes.

The above list shows that brachiopods and conodonts prevail in the fossil assemblage of the *pamiricus–ghorensis* Zone. The brachiopod assemblage includes abundant and diverse cyrtospiriferids (*Cyrtospirifer* Nalivkin, *Dichospirifer* Brice, *Enchondrospirifer* Brice, *Sphenospira* Cooper) and rhynchonellids (*Sartenaerus* Özdikmen, *Araratella* Abramian, Plodowski et Sartenaer, etc.). Based on the analysis of the species composition of the brachiopod zonal assemblage, this zone is confidently correlated with the Upper Famennian brachiopod assemblages of Afghanistan, Iran (Brice, 1970; Brice et al., 1973), Pamir, and, to a lesser extent, Kazakhstan.

Conodonts of the *pamiricus–ghorensis* Brachiopod Zone are also numerous and diverse in species composition. The *pamiricus–ghorensis* Zone is correlated with the *velifer* Conodont Zone, as its conodont assemblage contains *Scaphignathus velifer* Helms, which occurs from the bottom to roof along the whole section of the zone (Ziegler, 1962). This is the only case of verifiable correlation by conodonts of the coeval deposits of Transcaucasia with Western Europe and other regions (Grechishnikova et al., 1982).

According to Chizhova (Aristov et al., 1979; Grechishnikova et al., 1982), the ostracod association provides correlation of the *pamiricus–ghorensis* Zone with the upper part of the Famennian Stage, i.e., with Fa2b and Fa2cj (partly) of the French–Belgian Basin.

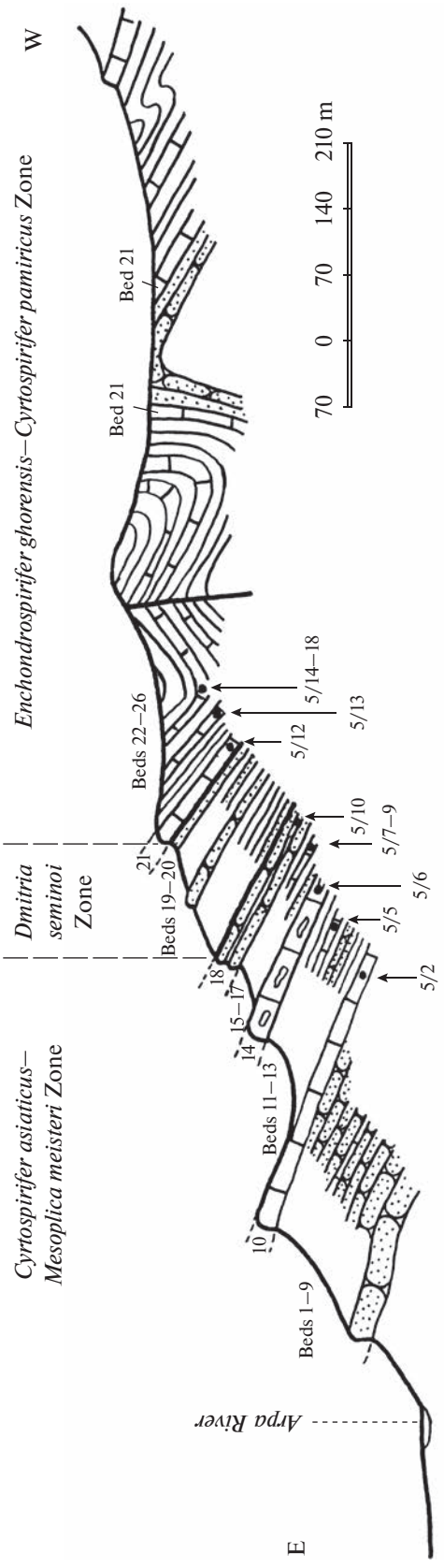


Fig. 17. Profile of reference section no. 11 on the northeastern slope of Geran-Kalasy Mountain (composed by Grechishnikova with contributions from Nikitina, Polozhikhina, and Golovatenko in 1970–1971). For designations, see Fig. 2.

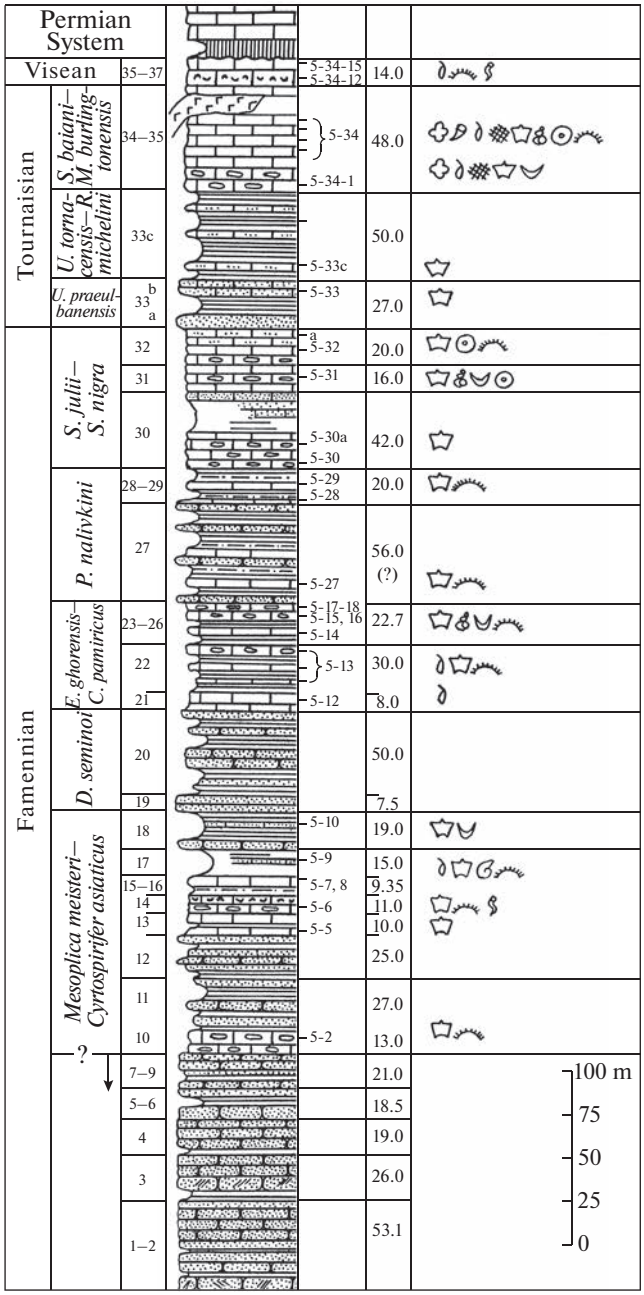


Fig. 18. Stratigraphic column of Famennian and Lower Carboniferous in the right bank of the Arpa River, opposite the village of Gyumushlug (reference section no. 5; composed by Grechishnikova with contributions from Uspenskaya, Nikitina, and Feliks in 1979). For designations, see Fig. 2.

Paurogastroderhynchus nalivkini Zone (Gortun Formation)

Of all Famennian deposits, this zone has the smallest range. Its outcrops were found in a relatively narrow stripe in the same areas where the underlying zone is exposed. Only in places (south of Kabakhdag Mountain and spurs of Birali-Kuzei Mountain), the of *nalivkini* Zone occupies a large area. It rests conformably on the underlying zone. The most complete section is located on the northeastern spur of Geran-Kalasy Mountain and selected as a stratotype (reference section 11, Beds 2–9) (Grechishnikova et al., 1982). The lower boundary is recognized at the top of limestones with the faunal assemblage of the *nalivkini* Zone and by the appearance of the index species of this zone. The upper boundary is well pronounced, it coincides with the roof of a terrigenous member that is overlain by limestones with the faunal assemblage of the younger *julii–nigra* Zone (Figs. 18, 19).

The *nalivkini* Zone is composed of argillites and siltstones. The argillites are dark gray, almost black, cherry red or reddish brown; they compose most of rocks of this zone and contain interbeds and seldom members of calcareous to quartzitic, in places, strongly micaceous sandstones, and rare interbeds of gray and yellowish brown, usually sandy limestones. These rocks contain interbeds of siderites and phosphorite concretions (the latter occur in the upper part of the section).

The *nalivkini* Zone is up to 85 m thick.

Deposits of this zone contain the following brachiopods: *Schellwinella* sp., *Paurogastroderhynchus nalivkini* (Abramian), *Sartenaerus charakensis* (Brice), *Araratella dichotomians*, *Sinotectirostrum delicatacostata*, *Cyrtospirifer kadrlouensis* Abramian, *Gruntathyris innae* Gretchishnikova, and also ostracods and conodonts.

Chizhova (Grechishnikova et al., 1982) correlated the *nalivkini* Zone with the Turgenev–Khovan beds of the central East European Platform and with Fa2c–Fa2d of the French–Belgian Basin based on its ostracod assemblage and appearance of *Shishaella* Sohn in the overlying deposits of the *julii–nigra* Zone.

The brachiopod assemblage of the *nalivkini* Zone is considerably poorer in taxonomic composition than the assemblage of the underlying *pamiricus–ghorensis* Zone. The most common brachiopods are camarotechiids, particularly the zonal species *Paurogastroderhynehus nalivkini*, which does not overpass the zonal boundaries. Shells of this species form coquina. The spiriferid *Arpaspirifer latus* is considerably rarer (Abramian).

The brachiopod assemblage of the *nalivkini* Zone is correlated with the Upper Famennian assemblage of Iran and Afghanistan (Brice, 1970; Brice et al., 1973).

According to Aristov (1994), all conodont species of the *nalivkini* Zone overpassed from the underlying beds and species typical only for this brachiopod zone are absent. Due to the absence of a zonal index species, this brachiopod zone cannot be correlated to the standard conodont scheme (Ziegler, 1962) and is tentatively correlated with the *styriacus* Zone.

Sphenospira julii–Spinocarinifers nigra Zone (Arshaki-Akbyur Formation, Lower Part)

The *julii–nigra* Brachiopod Zone forms a narrow stripe from the northeastern slope of Geran-Kalasy Mountain, along the right slope of the Myunkh-Bala-Ogly Mountain Range, vicinity of the village of Kyarki and adjacent areas of Armenia (vicinity of the village of Kadrlu). The most complete stratotypic section is located in the interfluve of the left bank of the Arpa River (Grechishnikova et al., 1982), which coincides with the northeastern slope of Geran-Kalasy Mountain (reference section 11, Beds 10–13) (Grechishnikova and Levitskii, 2011). The *julii–nigra* Zone forms there a gentle monocline. Some parts of the section typically composed of argillites and poorly exposed were exposed by trenches. This section is easily accessible for observation.

The *julii–nigra* Zone rests conformably on the underlying *nalivkini* Zone. Its lower boundary is well-defined at the bottom of the limestone bed with the zonal brachiopod assemblage, including the index species *Sphenospira julii* and *Spinocarinifera nigra*. The upper boundary is marked by the appearance of the zonal assemblage of the overlying *Parallelora praeulbanensis–Rhytiophora curtirostris* Zone and the change in lithologic composition. The *julii–nigra* Zone is composed mostly of gray and light gray, irregularly and slightly sandy, thin and medium-bedded, sometimes lumpy limestones. The upper part contains up to 5-m-thick argillite–aleuritic and sandy members. The zone is 40 m thick.

The faunal assemblage of the *julii–nigra* Zone includes foraminifers, trilobites, ostracods, bryozoans, the brachiopods *Petrocrania* sp., *Aulacella interlineate* (Sowerby), *Schuchertella radiate* Brice, *Schizophoria impressa* Nalivkin, *Schellwienella planumbona* (Weller), *Leptagonia analoga* (Phillips), *Plicochonetes glenparkensis* (Weller), *Sinotectirostrum delicatacostatus*, *Tchanakhtchirostrum araraticum* (Abramian), *Ptychomaletoechia panderi* (Semenov et Möller), *Araratella dichotomians*, *Mesoplica praelonga* (Sowerby), *Spinocarinifera nigra* (Gosselet), *S. inflata* (Sokolskaya), *Rhytiophora curtirostris* (Winchell), *Widbornella caperata* (Sowerby), *Hamlingella maxima* (Abramian), *Bagrasia chonetiformis* (Krestovnikov et Karpychev), *Arpaspirifer latus*, *Cyrtospirifer crassiplicatus* Brice, *C. kadrlouensis* Abramian, *Dichospirifer cardiosinussoides* (Abramian), *Sphenospira julii* (Deheé), *Ambocoelia unionensis* Weller, *Gruntathyris inna* Gretchishnikova, *G. pseudointermedia* Gretchishnikova, and *Athyris gurdoni* Reed, crinoids, gastropods, conodonts, and algae. As is clear from the above list, the faunal assemblage of the *julii–nigra* Zone is highly variable. The most abundant are foraminifers, algae, ostracods, brachiopods, and conodonts.

According to Reitlinger (Grechishnikova et al., 1982), the *julii–nigra* Brachiopod Zone corresponds

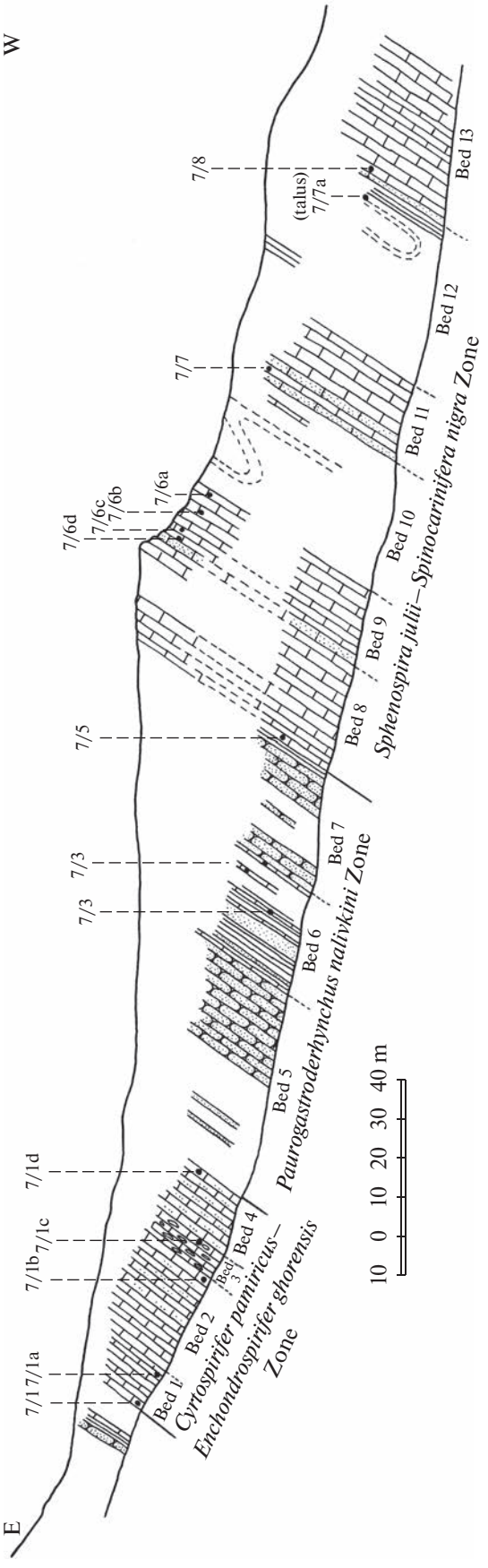


Fig. 19. Profile of the section of Devonian deposits (reference section no. 6) in the Shamaa Midzor gorge of Armenia (composed by Grechishnikova with contributions from Nikitina in 1970).

in foraminifers and calcareous algae to Fa2d, TnIa, and basaltic beds TnIb of the French–Belgian Basin.

Chizhova (Grechishnikova et al., 1982) correlated the *julii–nigra* Brachiopod Zone with the TnIa and possibly the lower part of TnIb of the French–Belgian Basin and Chekmagush Beds of the eastern Russian Plate based on its ostracod assemblage (appearance of *Shishaella ferox*, presence of beyrichiids becoming extinct, and species occurring in the Lower Tournaisian (European Etroeungt)).

The brachiopod assemblage of the *julii–nigra* Zone contains various productids, of which the following genera are widespread: *Mesoplica* Reed, *Spinocarinifera* Roberts, *Whidbornella* Reed, *Hamlingella* Reed, and *Bagrasia* Nalivkin. Most of the species of these genera do not occur in other brachiopod zones. The spiriferids are represented, on the one hand, by becoming extinct endemic *Arpaspirifer latus* and *Cyrtospirifer kadrlouensis* and, on the other hand, by *Sphenospira julii* typical for the Etroeungt Zone (s. str.) of Western Europe and many other regions. Along with these Devonian taxa, the sections of the Arshaki-Akbyur gorge and vicinity of the village of Kyarki have yielded a few *Parallelora* Carter, related to *P. praeulbanensis* (Bublitschenko) and widespread in the Carboniferous. The generic and partly species composition of the brachiopod assemblage of the *julii–nigra* Zone resembles that of the Etroeungt Zone of the French–Belgian Basin (Dehée, 1929) and the brachiopod association from the deposits of Iran (Brice et al., 1973) and Afghanistan (Brice, 1970) coeval with the Etroeungt Zone, and the basal and brachiopod beds of Rudnyi Altai (Grechishnikova, 1966). It is less similar to the associations from the Lytva Horizon of the Urals and the Abyshev Horizon of the Kuznetsk Basin (Sarytcheva et al., 1963).

According to Aristov (Grechishnikova et al., 1982; Aristov, 1994), the conodont assemblage of the *julii–nigra* Brachiopod Zone strongly differs from that of the underlying *nalivkini* Zone. On the one hand, it still contains Devonian species and, on the other hand, at the zone basement, many genera and species that only existed within in this zone or overpass into overlying Lower Carboniferous deposits appear. *Icriodus* Branson et Mehl, *Pelekysgnathus* Thomas, simply conical species, disappear. The *julii–nigra* Zone is presumably correlated with the *costatus* Conodont Zone. The boundary of the *julii–nigra* and overlying *praeulbanensis–curtirostris* zones probably coincides with the lower boundary of the *sulcata* Conodont Zone, that is, the boundary of two systems, the Devonian and Carboniferous (Table 5).

CARBONIFEROUS

This part is devoted to elaboration of brachiopod zonation of the Lower Carboniferous of the Nakhchivan AR of Transcaucasia.

One of the main challenges faced by the Caucasus Expedition of MGRI (with participation of the author) under a treaty with the Council of Ministers of Azerbaijan was elaboration of a detailed specialized geological map on a scale of 1 : 25000. This required a detailed stratigraphic basement. The stratigraphic scales elaborated by that time did not meet the above requirements. Several Lower Carboniferous formations were recognized based on lithologic and partly paleontological data and often confused due to their complicated tectonic structure. The author began the implementation of a new stratigraphic scale based on brachiopods, as it was the most abundant and diverse group of fossil remains of the Nakhchivan AR. Arakelyan (1964) recognized four Lower Carboniferous formations; only one of them (Geran-Kalasy) of the Tournaisian Stage was recorded in the Nakhchivan AR. The stratotypes of other formations are in Armenia. Unfortunately, it was impossible to explore them.

There is a great merit of Arakelyan (1964) in the elaboration of a well-substantiated stratigraphic scale of the Lower Carboniferous of Armenia and adjacent areas of the Nakhchivan AR and Abramian (1957, 1974b, etc.), who was the first to study monographically the brachiopods of this age. However, published data on Lower Carboniferous brachiopods provided by Abramian (see above), Grechishnikova (1996a), Lazarev (1987), and Erlanger (1986) do not reflect actual diversity of Lower Carboniferous brachiopod assemblages of the Nakhchivan AR and entire Transcaucasia.

Here, we introduce a novel determination of the age of the brachiopod zones based on the data on conodonts, which were collected layer-by-layer from the stratotype sections of these zones, allowing at least tentative correlation with the international conodont scale (Table 6).

The data of Reitlinger on the foraminifers and Chizhova on the ostracods were also important for correlation of the local brachiopod zones of the Nakhchivan AR (Grechishnikova et al., 1984) (Table 7).

From 1969 to 1980, the author and employees of the Caucasus Expedition of MGRI, Levitskii, E.A. Uspenskaya, V.P. Feliks, M.I. Nikitina, and others, thoroughly studied eight sections of the Lower Carboniferous and collected fossils in 200 outcrops.

Faunal remains were determined by Grechishnikova (brachiopods), Reitlinger (foraminifers and algae), A.S. Papoyan (rugose corals), N.V. Zernetskaya (gastropods), V.A. Muromtseva (bivalves), Lavrent'eva (bryozoans), A.I. Polozhikhina (crinoids), Chizhova (ostracods), and Aristov (conodonts).

Thin sections were described by P.I. Taraban'ko and A.D. Afanas'eva, with consultations of S.V. Maksimova.

Tables and figures were produced by Grechishnikova.

Table 5. Correlation of the stratigraphic schemes for the Devonian–Carboniferous boundary deposits of Transcaucasia (compiled by Grechishnikova in 1982)

Ržonsnitskaja, 1948	Stage	Substage	Abramyan, 1957			Arakelyan, 1964	Abramyan et al., 1975	Stage	Substage	Grechishnikova (Aristov et al., 1979)	Stage	Substage	Mamedov, 1980a
Beds with Rhipido mella michelini	Tournaisian	Lower	Lower Tournaisian beds with *Rhipidomella michelini*, *Spirifer tornacensis*			Geran-Kalasy Formation	Geran-Kalasy Horizon	Tournaisian	Upper	*Rhipidomella michelini–Unispirifer tornacensis* Zone	Tournaisian	Upper	*Rugosochonetes taidonensis–Imbrexia ussiensis* Zone
?			Etroeungt Zone	upper part	Sandy limestone with *Plicatifera niger*, *Athyris lamellosa* et al.	Arshaki-Akbyur Formation	Arshaki-Akbyur Horizon		Lower	*Unispirifer praeulbanensis–Rugauris curtirostris* Zone		Lower	*Paraphorhynchus striaticostatum–Hunanospirifer kureki* Zone
Upper Famennian beds				middle part	Sandy limestone with *Plicatifera praelonga*, *Cyrtospirifer julii* et al.					? *Sphenospira julii–Avonia* (?) *nigra* Zone			*Mesoplica praelonga–Hamlingella goergesi* Zone
				lower part	Sandy limestone with *Cyrtospirifer julii*, *Phacops bergicus* et al.								
	Famennian	Upper	Horizon with *Camarotoechia nalivkini*			Gortun Formation	Gortun Horizon	Famennian	upper	*Paurogastroderhyn chus nalivkini* Zone	Famennian		zonation absent
			Horizon with *Cyrtospirifer pamiricus*			Shamaa Midzor Formation	Shamaa Midzor Horizon			*Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone			

Table 6. Correlation of the Upper Devonian and Lower Carboniferous local brachiopod and conodont zones of Transcaucasia (compiled by Grechishnikova using the data of Aristov (1994))

Stage	Substage	Local brachiopod zones	Local conodont zones		Standard conodont zones
Visean	Middle	*moderatus*	Beds with *Cavusgnatus*		*bilineatus*
	Lower	Strata of algal limestones			*texanus*
Tournaisian	Upper	*baiani–burlingtonensis*	Beds with *P. lacinatus*	?	*anchoralis*
					typicus
		michelini	*P. inornatus– Siphonodella*		*isosticha–U. crenulata*
					J. crenulata
	Lower	*praeulbanensis–curtirostris*			*sandbergi*
					duplicata
					sulcata
Famennian	Upper	*julii–nigra*	*Pe. superstes* *P. inornatus*		*costatus*
			P. superstes–Pe. costatus		

BRIEF ACCOUNT OF THE STUDY OF THE LOWER CARBONIFEROUS DEPOSITS OF TRANSCAUCASIA

The history of the study of Carboniferous deposits of the Lesser Caucasus, including the Nakhchivan AR, was considered in detail in a number of works (Paffenholtz, 1940; Azizbekov, 1961; Arakelyan, 1964). Three trends outlined in the opinions of researchers on the Carboniferous stratigraphy at the first stages of studies. Some researchers (Frech and Arthaber, 1900) supposed that Transcaucasia contains the Tournaisian and Visean deposits of the Lower Carboniferous and Moscovian deposits of the Middle Carboniferous, to which they referred the beds with *Staffella sphaerica*. According to these researchers, the Upper Carboniferous and Lower Permian are absent in the sections. Sadykov (1954) shared this opinion, but he also supposed that the Carboniferous deposits of the Nakhchivan AR include the Tournaisian Stage of the Lower Carboniferous and the Kasimovian and Gzhelian stages of the Upper Carboniferous. He supposed that the Visean and Namurian stages of the Lower Carboniferous and the whole Middle Carboniferous are absent in the section and referred the beds with *Staffella sphaerica* to the Upper Carboniferous.

Other researchers (Yakovlev, 1931, 1941; Paffenholtz, 1940; Azizbekov, 1961) supposed the Carboniferous section of Transcaucasia to be complete and continuous. They referred the beds with *Staffella sphaerica* to the Middle Carboniferous and limestones with *Productus intermedius* to the Upper Carboniferous. Later, Azizbekov (1972) suggested that there is only Lower Carboniferous in the Nakhchivan AR.

Finally, the third group of researchers (Abich, 1878; Lisitsyn, 1913, 1923) referred all limestone strata overlying Devonian deposits to the Lower Carboniferous. In particular, Lisitsyn referred limestones including the beds with *Staffella sphaerica* exposed at the mouth of Vostochnyi Arpachai to the Lower Carboniferous and distinguished the Tournaisian and Visean stages with all coral–brachiopod zones of Western Europe. In his first paper, Lisitsyn (1913) cast doubt on the Lower Carboniferous age of limestones with *Staffella sphaerica*, but, later (Lisitsyn, 1923), he confidently referred them to the Lower Carboniferous and correlated them with the *Dibunophyllum* Zone.

Subsequently, based on the study of microfauna from the beds with *Staffella sphaerica* from different regions of Transcaucasia (collected by Abich and O.L. Einor), Miklouho-Maclay inferred that the Middle and Upper Carboniferous deposits are completely absent in the Lesser Caucasus. This conclusion was completely confirmed by other researchers (Arakelyan, 1952, 1964; Azizbekov, 1972).

The modern concepts of the stratigraphy of the Lower Carboniferous of Transcaucasia were developed by Abramian (1957, 1974b) and Arakelyan (1952, 1964).

Einor recognized the Tournaisian Stage, including the Lower, Middle, and Upper Tournaisian beds, and the Visean Stage in the Lower Carboniferous of the Zindzhirlu Range (Armenia). The Visean Stage was divided into the Lower and Middle Visean, with rich foraminifer and brachiopod assemblages. Einor also established that the Permian deposits rest unconformably with a stratigraphic break at different levels of the Lower Carboniferous. He also reasonably noted that the recognition of breaks in the limestone strata is highly problematic.

Abramian (1957, 1974b) performed great services in developing the biostratigraphy of the lower part of the Lower Carboniferous. She recognized the Tournaisian beds, which were subdivided in Armenia into the Lower and Upper Tournaisian. The Etroeungt Zone (recently referred to the Famennian Stage) and Lower Tournaisian beds were recognized in the Lower Tournaisian (Tables 8, 9). The Devonian–Carbonif-

Table 7. Biostratigraphic division of Devonian–Carboniferous boundary deposits based on brachiopods, foraminifers, ostracods, and conodonts (compiled by Grechishnikova, Reitlinger, Chizhova, and Aristov in 1984)

<table>
<tr><th>Stage</th><th>Substage</th><th>Grechishnikova (Aristov et al., 1979) brachiopod zones</th><th>Reitlinger foraminifers, beds</th><th>Chizhova (compiled in 1975–1982) ostracods, zones, assemblages</th><th>Aristov (Aristov et al., 1979) conodonts, zone</th><th>France–Belgium</th></tr>
<tr><td rowspan="4">Tournaisian</td><td>Upper</td><td>Rhipidomella michelini–Unispirifer tornacensis</td><td>----</td><td>Richterina aff. latior–Bairdia otscherensis Zone</td><td rowspan="3">Siphonodella</td><td>Tn2b-c</td></tr>
<tr><td rowspan="2">Lower</td><td rowspan="2">Unispirifer praeulbanensis–Rugauris curtirostris Zone</td><td>Beds with Bisphaera malevkensis, Earlandia minima, E. moderata</td><td>Richterina latior–Pseudoleperditia venulosa–Shivaella microphtalma Zone</td><td>Tn 2a</td></tr>
<tr><td></td><td rowspan="2">Richterina latior–Maternella hemisphaerica–Shivaella okeni–Cryptophyllus sp. Zone</td><td>Tn1b</td></tr>
<tr><td>Sphenospira julii–Avonia (?) nigra</td><td>Beds with florennensis Paracalligelloides</td><td>Bispatodus costatus</td><td>Tn1a</td></tr>
<tr><td rowspan="3">Famennian</td><td rowspan="3">Upper</td><td>Paurogastroderhynchus nalivkini</td><td rowspan="3">?

absent or are not characteristic</td><td>Maternella hemisphaerica–Tschizhovaella primula–Carboprimitia turgenevi Zone</td><td rowspan="2"></td><td>Fa2α – Fa2cβ</td></tr>
<tr><td rowspan="2">Cyrtospirifer pamiricus–Enchondrospirifer ghorensis</td><td rowspan="2">Upper Famennian assemblage</td><td rowspan="2">Fa2cα</td></tr>
<tr><td>Scaphignathus velifer</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>Fa2b</td></tr>
</table>

Table 8. Zonation scheme of the lower part of the Tournaisian Stage of Armenia (Abramyan, 1957)

Stage	Substage	Brachiopod zone
Namurian		---
Visean	Upper	*Rugosochonetes ischimicus tomilensis–Retzia radialis*
	Middle	*Gigantoproductus giganteus–Dielasma amoenum*
	Lower	*Spirifer trigonalis–Composita verkhotomica*
Tournaisian	Upper	*Marginatia deruptoides–Girtyella taidonensis*
	Middle	*Rugosochonetes taidonensis–Imbrexia ussiensis*
	Lower	*Paryphorhynchus striaticostatus–Hunanospirifer kureki*
		Mesoplica praelonga–Hamlingella goergesi

Table 9. Stratigraphic division of the Carboniferous of Armenia and adjacent regions of the Nakhchivan AR (Arakelyan, 1964)

System	Series	Stage	Substage		Formation (Horizon)
Carboniferous	Lower	Visean	Lower		Saripap
		Tournaisian	Upper		Armash
			Lower		Geran-Kalasy
				Etroeungt	Arshaki-Akbyur
Devonian	Upper	Famennian	Upper		Gortun

erous boundary is drawn at the bottom of the Etroeungt Zone. The beds with *Rhipidomella michelini* were dated Lower Tournaisian.

Table 9 shows that the Etroeungt Zone (now the Upper Devonian) is subdivided into three parts slightly differing in faunal assemblages. According to Abramian, "Carboniferous brachiopods and corals occur along with the Devonian brachiopods" in the Etroeungt Zone. She mentioned that faunas from the Etroeungt and Famennian beds of Armenia strongly resemble the fauna of Pamir, Iran, China, northern France, and England. There is some similarity to respective faunas of the Urals and Kazakhstan. Based on the recognized similarity, the existence of a large open marine basin is supposed in the Late Famennian and Etroeungt, and the territory of Armenia and possibly the whole Transcaucasia was located in the somewhat isolated coastal region.

Abramian suggested to divide the Etroeungt Zone into three parts; however, detailed studies revealed that this scheme cannot be applied in both Armenia and the Nakhchivan AR.

Over the years, Arakelyan (1964) fruitfully studied in detail the stratigraphy of the Lower Carboniferous of Armenia and neighboring areas of the Nakhchivan AR. He elaborated a stratigraphic scale based on a detailed description of the sections and layer-by-layer collected fossil assemblages (brachiopods, foraminifers, etc.). The scale suggested (Table 9) differed from the previous scales in the recognition of local stratigraphic units within the Lower Carboniferous, i.e., formations, which were subsequently ranked horizons.

This scale is most verified faunally and tested by the author in the study of many separate sections.

According to Arakelyan (1964), the same formation strongly differs in lithology in different regions of Transcaucasia, which was not confirmed by further studies. In fact, the deposits of different age were mistakenly referred to the established formations in other districts remote from the stratotypic region. The confusion was caused by the complicated rupturing tectonics, which was not considered in detail by this author.

Azizbekov (1961, 1972) studied Lower Carboniferous stratigraphy of the Nakhchivan AR. He described layer-by-layer the Lower Carboniferous sections in the vicinity of Myunkh-Bala-Ogly and Geran-Kalasy mountains and in the Paiya-dere gorge. In his last paper, Azizbekov (1972) recognized within the Tournaisian Stage the Etroeungt, Lower, and Upper Tournaisian beds. He supposed that Lower Visean deposits occur only within the Gyumushlug Anticline.

The author provided the faunal list for each stratigraphic unit; however, these lists contain many contradictions and species mentioned conjointly do not occur simultaneously in nature. The thickness of Lower Visean deposits provided in scale 3 (Azizbekov, 1961, p. 36) is obviously overestimated. According to Azizbekov, thick Lower Visean deposits (171 m) are observed in the vicinity of Paiya-dere gorge; however, this was not confirmed by further studies. The Lower Carboniferous is completely absent in this region and Permian limestones overlie directly Famennian deposits.

Table 10. Zonation scheme of the Lower Carboniferous of the Nakhchivan AR (Grechishnikova, 1982)

System	Series	Stage	Substage	Biostratigraphic Zone	Stratigraphic scheme of Arakelyan (composed in 1964–1973) formation (horizon)		
Carboniferous	Lower	Visean	Middle	*Moderatoproductus moderatus*	Visean	Lower	Saripap
			Lower	---			
		Tournaisian	Upper	*Marginatia burlingtonensis*	Tournaisian	Upper	Armash
				Rhipidomella michelini–Unispirifer tornacensis		Lower	Geran-Kalasy
			Lower	*Unispirifer praeulbanensis–Rhytiophora "curtirostris"*			Arshaki-Akbyur
1988 1974–1987		↓ ↑	↓ ↑	*Sphenospira julii–Spinocarinifera nigra*			
Devonian	Upper	Famennian	Upper	*Paurogastroderhynchus nalivkini*	Famennian	Upper	Gortun
				Cyrtospirifer pamiricus–Enchondrospirifer ghorensis			Shamaa Midzor

Table 11. Zonation scheme of the Lower Carboniferous of the Nakhchivan AR (Mamedov, 1980a, 1981)

Stage	Substage	Brachiopod Zone
Namurian		---
Visean	Upper	*Rugosochonetes ischimicus tomilensis–Retzia radialis*
	Middle	*Gigantoproductus giganteus–Dielasma amoenum*
	Lower	*Spirifer trigonalis–Composita verkhotomica*
Tournaisian	Upper	*Marginatia deruptoides–Girtyella taidonensis*
	Middle	*Rugosochonetes taidonensis–Imbrexia ussiensis*
	Lower	*Paryphorhynchus striaticostatus–Hunanospirifer kureki*
		Mesoplica praelonga–Hamlingella goergesi

Thus, by the beginning of our work, efforts made by many researchers had revealed that:

(1) Transcaucasia lacks Middle and Upper Carboniferous deposits;

(2) The Lower Carboniferous is represented by the Tournaisian and Visean stages;

(3) The Tournaisian Stage is subdivided into two or three substages; the lower substage includes the Etroeungt Zone;

(4) The Lower Carboniferous section terminates in Lower Visean deposits.

The author of this paper started a thorough study of the Lower Carboniferous deposits of the Nakhchivan AR in 1969. While composing a specialized geological map on a scale of 1 : 25000, some specifications were itemized in the stratigraphic scales elaborated by that time. Ostracod, conodont, and foraminifer assemblages were collected layer-by-layer and became the basis for interregional correlation of Lower Carboniferous deposits and boundary determinations of stratigraphic units and provided more accurate correlation of the Lower Carboniferous deposits of Transcaucasia with other regions, including the stratotypic regions. The author first elaborated a local brachiopod zonal scale (Table 10) (Grechishnikova and Levitskii, 2011) based on new data of the author and data of all preceding researchers. Therefore, species that were previously mentioned as common for the beds with fauna were added where possible in the zonal indexation, (e.g., the *Rhipidomella michelini* Zone corresponds to the beds with *Rhipidomella michelini* and *Spirifer tornacensis* (Abramian, 1957)).

Along with the author, Mamedov (1980a, 1981) studied the biostratigraphy of the Lower Carboniferous of the Nakhchivan AR and established two local zonal brachiopod scales for Tournaisian and Visean deposits (Table 11).

It is noteworthy that the zonal brachiopod scales of the Lower Carboniferous elaborated by the author and Mamedov lack common species accepted as index species. This contradiction was eliminated in the monographic study of the whole Lower Carboniferous brachiopod assemblage of the Nakhchivan AR, especially considering that the material was collected almost from the same sections.

BIOSTRATIGRAPHIC SUBDIVISION OF THE LOWER CARBONIFEROUS DEPOSITS OF TRANSCAUCASIA

LOCAL COMPLEX BRACHIOPOD ZONAL SCALE

Carboniferous System: Lower Series

The Carboniferous deposits on the studied territory of the Nakhchivan AR and adjacent areas of Armenia stretch as a relatively narrow stripe in the interfluve of the Yaidzhi-Deresi–Kabakhlychai rivers, along the northeastern slope of the mountain range with Myunkh-Bala-Ogly Peak and further into the basin in lower reaches of the Bagarsykh-Deresi River. This stripe occupies a relatively large area in the Birali-Chai River Basin and vicinity of Tezhgar and Birali-Kuzei mountains. The outcrops of Carboniferous deposits are also known in the upper reaches of the Dzhaanam-Deresi River and the western spur of Ardych Mountain. Finally, the deposits of this age compose Bazagl Mountain in Armenia.

As mentioned above, only Lower Carboniferous deposits are present in the Nakhchivan AR and Armenia.

Two stages, Tournaisian and Visean, are recognized in the lower series.

Tournaisian Stage

Three local complex brachiopod zones are recognized within the Tournaisian Stage based on changes in brachiopod assemblages containing species that do not overpass the zonal boundaries.

Lower Tournaisian Substage

Parallelora praeulbanensis–Rhytiophora curtirostris Zone

The distribution of deposits of this zone is given in the general characteristics of the Carboniferous System (see above). The most complete and continuous section is situated on the northeastern slope of Geran-Kalasy Mountain (Grechishnikova and Levitskii, 2011) (Fig. 20) and designated as the stratotype of the zone (outcrop 11, Beds 14–18) (Figs. 21, 22). Other complete sections are situated west of the village of Kyarki (outcrop 27, Beds 3–7) (Figs. 23, 24) and on the northeastern slope of the Myunkh-Bala-Ogly Mountain Range (outcrops 8–9, Beds 7–12). The lower boundary of the zone is marked by the disappearance of the zonal assemblage of the underlying zone and appearance of index species of this zone: *Parallelora praeulbanensis* and *Rhytiophora curtirostris*. The upper boundary is recognized by the disappearance of index species and associated brachiopod species of this zone.

The *praeulbanensis–curtirostris* Zone is composed of carbonate–terrigenous rocks (Fig. 21). Dark gray argillites with thin interbeds of siltstones and sandy limestones prevail in the lower part. The latter contain abundant fossils, including the index species *Parallelora praeulbanensis*. The middle part of the section consists of limestone strata, in places passing into calcareous, thin-bedded, irregularly ferruginated sandstones. Fossils are represented by numerous and diverse brachiopods, foraminifers, crinoids, and less abundant ostracods and conodonts (Fig. 22).

The upper part of the section is composed of terrigenous rocks with interbeds of strongly sandy limestones. The faunal composition remains the same.

The zone is about 38 m of thickness. The lithologic composition and zone thickness insignificantly vary in the studied area.

The faunal assemblage includes brachiopods: *Aulacella interlineata* (Sowerby), *Rhipidomella kusbassica* Besnossova, *Schuchertella planumbona* (Weller), *Leptagonia analoga* (Phillips), *Rugosochonetes multistriatus* Afanasjeva, sp. nov., *Rhytiophora curtirostris* (Winchell), *Sentosia retiformis* (Krestovnikov et Karpychev), *Avonia* sp., *Tchanakhtchirostrum araraticum*, *Ptychomaletoechia panderi*, *Hemiplethorhynchus* sp. 1, *Parallelora praeulbanensis*, *Syringothyris hannibalensis* (Swallow), *S.* sp., *Mucrospirifer* ex gr. *roemerianus* (Koninck), *Punctospirifer* sp., *P. gerankalasus* Oleneva, *Gruntathyris pseudointermedia* Gretchishnikova, *Gerankalasiella gerankalasiensis* Gretchishnikova, *Ambocoelia unionensis* Weller, and *Gyrtiella taidonensis* (Tolmatchow), as wee as foraminifers, tabulate corals, crinoids, ostracods, and conodonts.

Faunal Analysis and Correlation

The faunal assemblage of the *praeulbanensis–curtirostris* Zone is diverse, as evidenced by the above-listed species; however, its characteristic feature is the disappearance of Devonian species in many fossil groups.

The brachiopod species shared with the underlying zone are *Schuchertella planumbona*, *Tchanakhchirostrum araraticum*, *Ptychomaletoechia panderi*, and *Gruntathyris pseudointermedia* Gretchishnikova.

The most widespread and numerous species occurring only within the zone considered are *Parallelora praeulbanensis*, *Rhytiophora curtirostris*, *Leptagonia analoga* (Phillips), *Ambocoelia unionensis*, *Gerankalasiella gerankalasiensis*, *Gyrtiella taidonensis*, *Syringothyris hannibalensis* (Swallow), etc. Species of Devo-

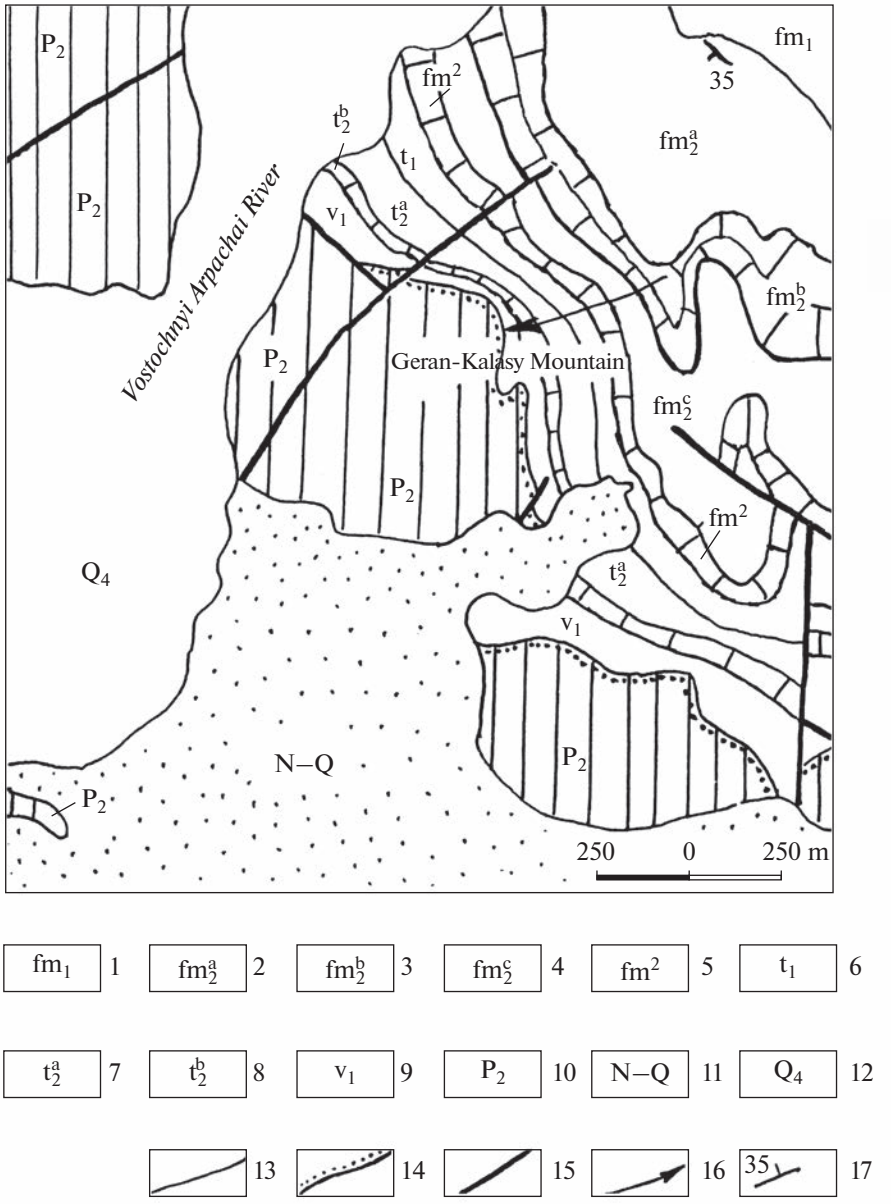


Fig. 20. Geological map of the lower reaches of the Vostochnyi Arpachai River (composed by Feliks in 1977). Designations: (1–5) Famennian Stage: (1) lower substage, *Cyrtospirifer asiaticus* Zone: quartzites, sandstones, limestones; (2–5) upper substage: (*2*) *Dmitria seminoi* Zone, sandstones, argillites, limestones; (3) *Enchondrospirifer ghorensis–Cyrtospirifer pamiricus* Zone, limestones; (4) *Paurogastroderhynchus nalivkini* Zone, limestones, argillites, sandstones, quartzites; (5) *Sphenospira julii–Spinocarinifera nigra* Zone, limestones; (6–8) Tournaisian Stage: (6) lower substage, *Unispirifer praeulbanensis–Rhytiophora curtirostris* Zone, sandstones, sandy limestones, argillites; (7, 8) upper substage: (7) *Rhipidomella michelini* Zone, argillites with interbeds of sandy limestones; (8) *Spirifer baiani–Marginatia burlingtonensis* Zone, limestones; (9) Visean Stage, lower substage, oncolite and organogenic–detrital limestones; (10) Upper Permian, coarsely stratified limestones; (11) Neogene and Quaternary systems undivided, gravels, sandstones, clays, tuffs; (12) Recent alluvial deposits, gravels, sands; (13, 14) geological boundaries: (13) conformable, (14) unconformable; (15) faults; (16) location of reference section no. 11; (17) attitude.

nian *Cyrtospirifer* and *Sphenospira* prevailing in the underlying zone are absent.

This zone can be more or less confidently correlated with the Kassin Horizon of Kazakhstan (Litvinovich, 1962), *Reteporina* beds of Rudnyi Altai (Grechishnikova, 1966), lower part of the Kyn Horizon of the Urals (*Atlas ...,* 1974), and the Malevo and Upino beds of the East European Platform (Sokolskaja, 1941) based on the wide distribution of *Parallelora*, appearance of *Syringothyris* Winchell and *Rhytiophora* Muir-Wood et Cooper, and the brachiopod species composition.

According to Reitlinger (Grechishnikova et al., 1984), the foraminiferal assemblage of this and pre-

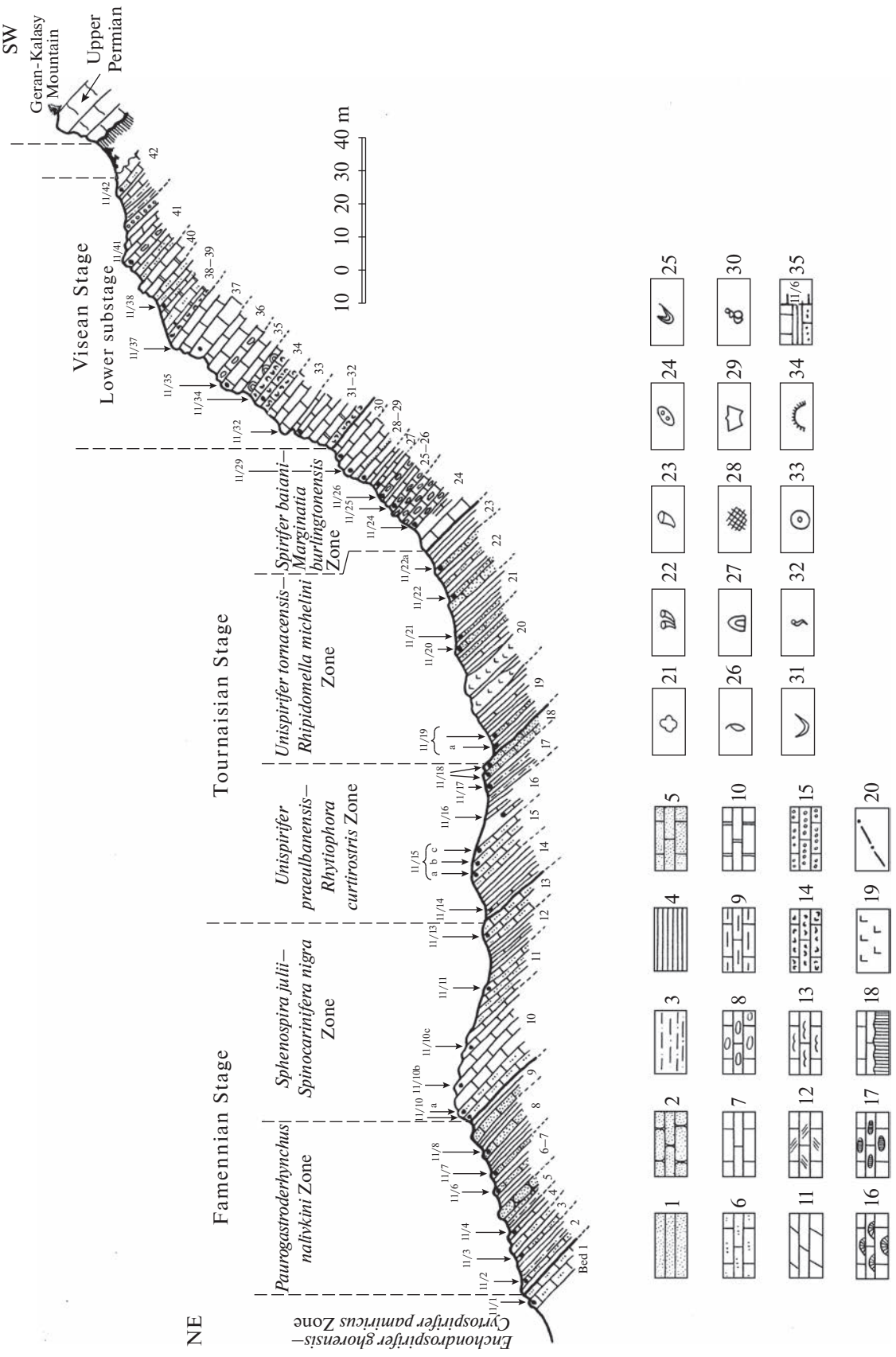


Fig. 21. Profile of reference section no. 11 on the northeastern slope of Geran-Kalasy Mountain (composed by Grechishnikova with contributions from Nikitina and Feliks in 1971). Designations: (1) sandstones, (2) quartzites, (3) siltstones, (4) argillites, (5) calcareous sandstones, (6) sandy limestones, (7) limestones, (8) lumpy limestones, (9) clayey limestones, (10) dolomites, (11) marls, (12) limestones with oblique microlamination, (13) limestones with wavy microlamination, (14) oncolite limestones, (15) oolitic limestones, (16) limestones with rugose colonies, (17) calcarenites, (18) bauxite rocks, (19) mafic intrusive rocks, (20) faults, (21) foraminifers, (22) tabulate corals, (23) rugose corals, (24) heliolitids, (25) stromatoporoids, (26) ostracods, (27) trilobites, (28) bryozoans, (29) brachiopods, (30) gastropods, (31) bivalves, (32) algae, (33) crinoids, (34) conodonts, (35) fossil occurrences.

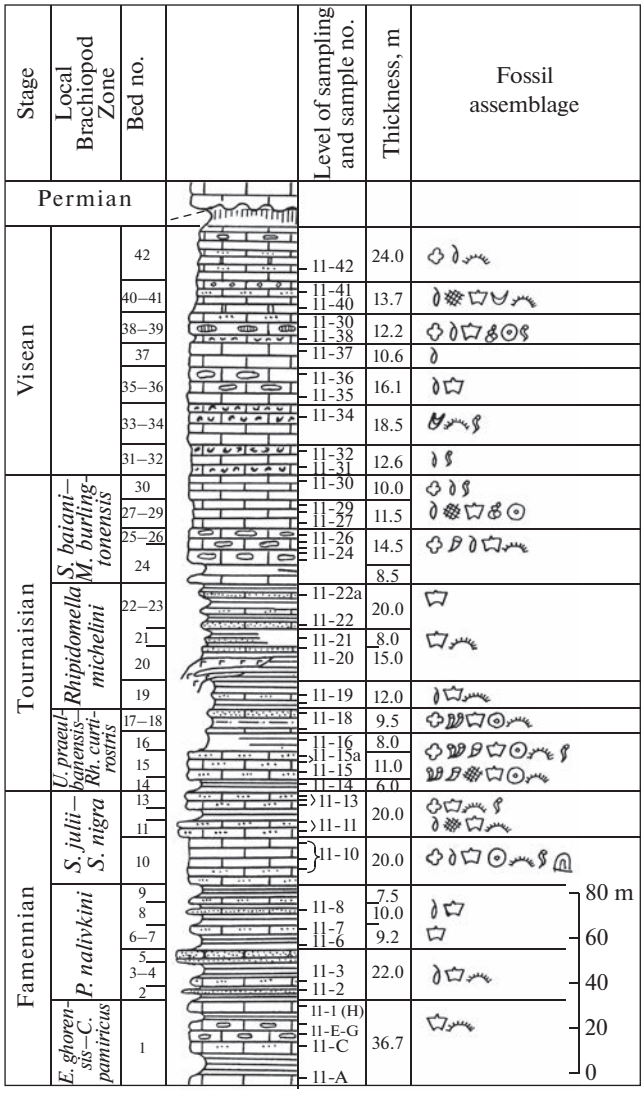


Fig. 22. Stratigraphic column of the uppermost Famennian and Lower Carboniferous of the northeastern slope of Geran-Kalasy Mountain (reference section no. 11). For designations, see Fig. 20.

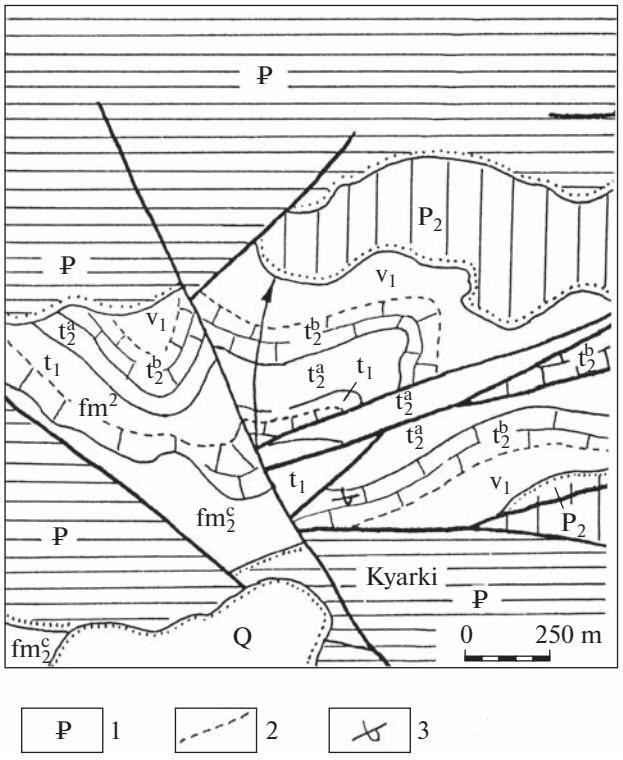


Fig. 23. Geological map of the vicinity of the village of Kyarki (composed by Feliks and Leven in 1977). Designations: (1) Paleogene System: conglomerates, sandstones, clays, limestones; (2) supposed geological boundary; (3) overturned bedding attitude. For designations, see Fig. 20.

ceding zones is impoverished in species diversity and contains earlandiids and tournayellids, which characterize the foraminiferal subzone CFla (=Tnlb) (Table 7) comprising deposits of the initial phase of the Early Tournaisian transgressive cycle of the French–Belgian Basin and the Malevo–Upino sedimentation cycle of the East European Platform.

According to Chizhova (Grechishnikova et al., 1984), numerous ostracods include many new species, apart from several already established species. The assemblage is dominated by *Shishaella* with large shells and a well-developed thorn. The ostracod assemblage of the *praeulbanensis–curtirostris* Brachiopod Zone is similar to the association of the *Richterina latior–Pseudoleperditia venulosa–Shivaella microphtalma* Zone (Table 7), but differs from it in the absence of glytopleurids, lichwiniids, etc. Therefore, the deposits with the considered assemblage are tentatively referred to the specified ostracod zone. The *praeulbanensis–curtirostris* Brachiopod Zone is preliminarily correlated with the Malevo–Upino deposits of the East European Platform and with Tnb2 Tn2a of the French–Belgian Basin (Table 7).

Conodonts are extremely rare in the *praeulbanensis–curtirostris* Zone. *Polygnathus communis communis* (Branson et Mehl), *Spathognathodus crassidentatus* (Branson et Mehl), *Bispathodus aculeatus aculeatus* (Branson et Mehl), and *B. aculeatus anteposicornis* (Scott) continue to exist. Aristov (1994) correlated (Table 6) this brachiopod zone with the *sulcata* and *duplicata* conodont zones and the lower part of the *sandbergi* Conodont Zone based on the appearance of *Polygnathus inornatus* Branson and *Siphonodella* sp.

Upper Tournaisian Substage

Rhipidomella michelini Zone

This zone is developed in the same regions of the Nakhchivan AR as the underlying zone. This is primarily the whole area of the lower reaches of the Arpa River (Geran-Kalasy Mountain (Fig. 21) and the

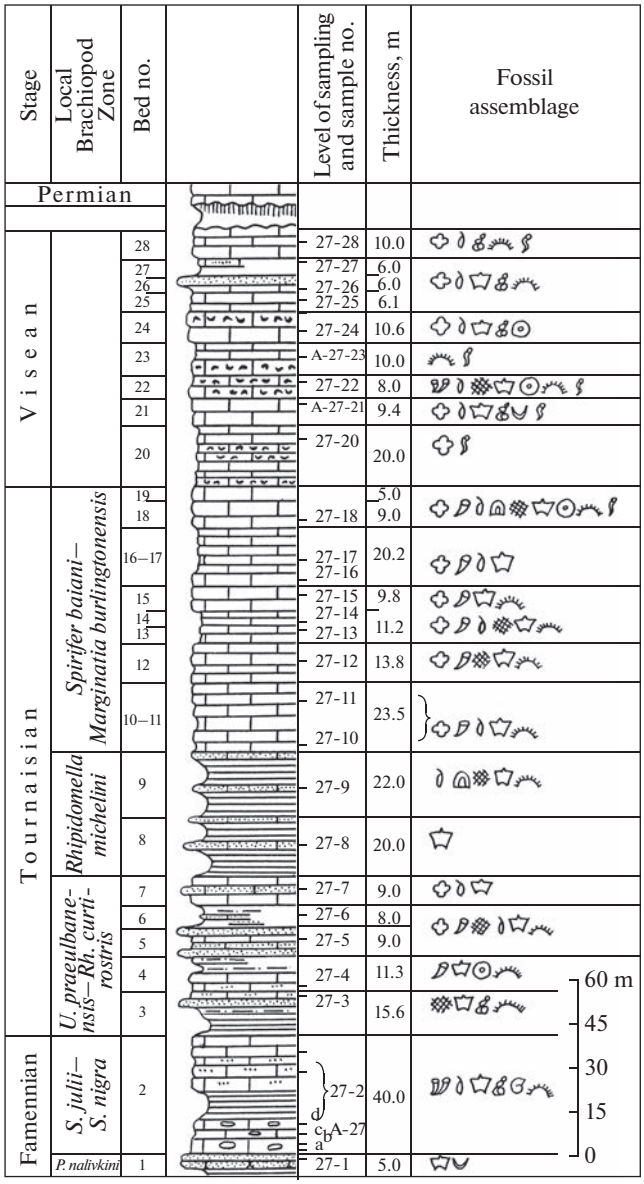


Fig. 24. Stratigraphic column of the uppermost Famennian and Lower Carboniferous in the vicinity of the village of Kyarki (reference section no. 27). For designations, see Fig. 22.

Myunkh-Bala-Ogly Mountain Range). Deposits of this zone are absent north of this area probably due to their erosion in the pre-Late Permian epoch, but are widespread in the vicinity of the village of Kyarki (Fig. 23) at the foot of Tezhgar Mountain and in Armenia.

The lower boundary of the zone is recognized at the bottom of the argillite member with the zonal species *Rhipidomella michelini* (Léveillé); the upper boundary is determined by the disappearance of zonal assemblage and appearance of index species of the overlying zone. The stratotype of the zone is located on the northeastern slope of Geran-Kalasy Mountain (reference section 11, Beds 19–23) (Figs. 21, 22).

The *Rhipidomella michelini* Zone (Fig. 22) is composed mostly of dark gray and greenish gray thin plated argillites with up to 1–m-thick interbeds of sandy limestones and quartzitic sandstones. The zone is up to 55 m (Figs. 21, 22) thick.

The study of the *michelini* Zone is sometimes difficult, as faults usually run at argillites and, moreover, they are penetrated by Mesozoic mafic and intermediate intrusions. Two interstrata intrusions are located in the argillite strata in the stratotype of the zone (Fig. 22).

This zone was initially established under the name of *Unispirifer tornacensis–Rhipidomella michelini*; however, a revision of spiriferid species based on the type material has revealed that specimens from the Carboniferous of Transcaucasia could not be referred to this species. More details are given about this in the description of *Unispirifer arpensis* Afanasjeva, sp. nov. In this respect, only the orthid species name was retained in the zonal name.

The faunal assemblage (Fig. 22) is dominated by brachiopods, whose remains occur mainly in the limestone interbeds; foraminifers, ostracods, conodonts, and other groups are less abundant.

The brachiopods are *Leptagonia analoga*, *Rhipidomella michelini*, *Rh. kusbassica* Besnossova, *Rh. burlingtonensis* (Hall), *Schuchertella lens* (White), *Sch. alternata* Weller, *Hemiplethorhynchus* sp. 2, *Tomiproductus elegantulus* (Tolmatchow), *Argentiproductus* cf. *praemarituceus* (Sergunkova), *Gerankalasiella gerankalasiensis*, *Syringothyris hannibalensis*, foraminifers, ostracods, and conodonts.

Faunal Analysis and Correlation

As is clear from the above-listed species, the *michelini* Zone contains a rich brachiopod assemblage. Some species overpassed from the preceding assemblage: *Leptagonia analoga*, *Syringothyris hannibalensis*, and *Gerankalasiella gerankalasiensis*. The dominating *Tomiproductus elegantulus*, *Rhipidomella michelini*, etc. are indicative of the Upper Tournaisian age of the zone considered.

The *michelini* Zone is correlated with the Kinderhook series (Louisiana Beds) and Burlington limestone of North America, the Upper Tournaisian deposits of Western Europe, the Donetsk Basin, Urals, Kazakhstan, and with the Taidon Horizon and lower part of the Lower Ters Horizon of the Kuznetsk Depression.

According to Chizhova (Grechishnikova et al., 1984), the ostracods are possibly most similar to the ostracod association of the *Richterina* aff. *latior–Bairdia otscherensis* Zone, although the determinations are preliminary and the composition of the assemblage is specific. Therefore, Chizhova tentatively correlated

the *michelini* Brachiopod Zone with the Cherepet Horizon of the East European Platform and Tn2b-c of the French–Belgian Basin (Table 7).

According to Aristov (Grechishnikova et al., 1984; Aristov, 1994), conodonts are rare in the *michelini* Brachiopod Zone. *Polygnathus communis communis*, *P. inornatus*, and *Spathognathodus crassidentatus* continue to occur; *Bispathodus aculeatus aculeatus*, *B. aculeatus anteposicornis*, *B. stabilis* (Branson et Mehl), and *Siphonodella* sp. are sporadically present. The local *Inornatus–Siphonodella* Ostracod Zone was established based on the simultaneous occurrence of *Polygnatus inornatus* and *Siphonodella* sp.; its upper part corresponds to the *michelini* Brachiopod Zone (Table 6) and, tentatively, to *sandbergi* (partly), *I. crenulata*, and *usosticha–U. crenulata* conodont zones of the standard conodont scale (Aristov, 1994).

Spirifer baiani–Marginatia burlingtonensis Zone

The deposits corresponding to the *baiani–burlingtonensis* Zone in the Nakhchivan AR occur in the region of the lower reaches of the Arpa River, where they constitute the northeastern slope of Geran-Kalasy Mountain (Figs. 20–22) and the Myunkh-Bala-Ogly Mountain Range. They are most widespread in the vicinity of the village of Kyarki (Fig. 23) and in Armenia and rest conformably on the underlying deposits of the *michelini* Zone. The stratotype of the zone is located in reference section 11, Beds 24–30 (Figs. 21, 22). The lower boundary is at the bottom of clayey lumpy limestones with the zonal assemblage. The upper boundary of the zone is at the bottom of algal limestones of the Visean Stage.

The *baiani–burlingtonensis* Zone is composed of various limestones and strikingly lithologically uniform throughout its range. The lower part of the zone is composed of black, lumpy due to parastylolithization, earthy limestones with thin argillite interbeds. Some limestone interbeds are filled with remains of rugose corals and brachiopods. The upper part of the section of the zone is composed mostly of massive, coarse-bedded, sometimes bituminous limestones with interbeds of dolomitized limestones. The macrofauna gradually disappears. The *baiani–burlingtonensis* Zone is from 45 to 90 m thick.

The faunal assemblage includes brachiopods: *Leptagonia analoga*, *Schellwienella crenistria* (Phillips), *Sch. burlingtonensis* Weller, *Sch.* sp., *Rugonochonetes* sp., *Tolmatcheffia* sp., *Marginatia vaughani* (Muir-Wood), *M. burlingtonensis* (Hall), *M.* sp., *Buxtonia* sp., *Tomiproductus elegantulus*, *Ovatia laevicosta* (White), *Pustula* sp., *Hemiplethorhynchus* sp. 2, *Kjarkiella kjarkiensis* Gretchishnikova, *Spirifer baiani* Nalivkin, *Unispirifer arpensis* Afanasjeva, sp. nov., *Syringothyris altaica* Tolmatchow, *S.* sp., *Torynifer* sp., *Punctospirifer* sp., *Cliothyridina* sp., *Verkhotomia verkhotomica* Sokolskaja, and also foraminifers, tabulate corals, and conodonts.

Faunal Analysis and Correlation

The brachiopod assemblage of the *baiani–burlingtonensis* Zone is taxonomically more diverse than the assemblage of the underlying zone. Species that do not overpass the zonal boundaries (*Marginatia burlingtonensis*, *M. vaughani*, *Spirifer baiani* Nalivkin, *Verkhotomia plenoides* Sokolskaja, *Kjarkiella kjarkiensis* Gretchishnikova, *Syringothyris altaica*, and some others) dominate in the assemblage, along with species with a wide vertical range (*Leptagonia analoga*, *Tomiproductus elegantulus*, *Ovatia laevicosta*, *Hemiplethorhynchus* sp. 2). The diversity of productid genera is noticeable: *Marginatia* Muir-Wood et Cooper, *Buxtonia* Thomas, *Tomiproductus* Sarytcheva, *Ovatia* Muir-Wood et Cooper, and *Pustula* Thomas, Tolmatchoffia Fredericks.

The brachiopod assemblage of the *baiani–burlingtonensis* Zone contains species typical for the Upper Tournaisian of other regions: Rusakovskoe Horizon of Kazakhstan, Taidon and Lower Ters horizons of the Kuznetsk Depression, Bukhtarma Formation of Rudnyi Altai, Burlington Beds of North America, and C Zone of Western Europe.

Foraminifers are numerous and diverse in the zone considered. A few species overpass its boundary: *Parathuramina* ex gr. *suleimanovi* Lipina and *Tournayella moelleri* Malakhova. The absolute majority of the listed foraminiferal species are known only from this zone. According to Reitlinger, they indicate the Upper Tournaisian age of the *baiani–burlingtonensis* Brachiopod Zone.

Conodonts are extremely rare in the considered brachiopod zone and occur mostly in the lower part of the zone section. *Polygnathus lacinatus* Huddle appears for the first time in the conodont assemblage, along with widely vertically distributed species, such as *Polygnathus communis communis*, *Bispathodus aculeatus aculeatus*, and *B. stabilis*. This allowed Aristov (1994) to establish the beds with *P. lacinatus* and correlate them with the *baiani–burlingtonensis* Brachiopod Zone. In addition, Aristov presumably correlated the *lacinatus* Zone with the *tipicus* and *anchoralis* zones of the standard conodont scale (Table 6).

Visean Stage

Lower Visean Substage

Algal and Organogenic–Detrital Limestones

The Lower Visean deposits of the Nakhchivan AR are restricted to the upper part of the mountains and mountain ranges in the lower reaches of the Arpa River: Geran-Kalasy Mountain (Figs. 20–22), Myunkh-Bala-Ogly Mountain Range, and further

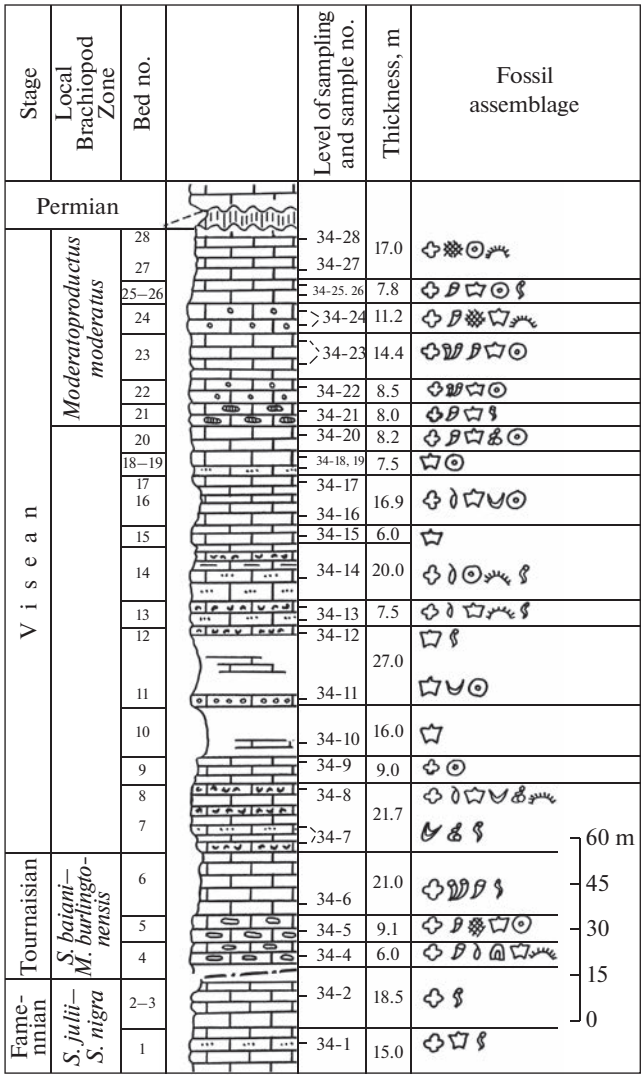


Fig. 25. Stratigraphic column of the uppermost Famennian and Lower Carboniferous of the southern slope of Bazagl Mountain (reference section no. 34). For designations, see Fig. 21.

northwesterly up to the vicinity of the village of Kyarki (Fig. 23) and Bazagl Mountain.

They rest conformably on the underlying Upper Tournaisian rocks with a similar lithologic composition. As brachiopods are absent or rare, Lower Visean deposits are distinguished as the oncolite and organogenic–detrital limestone strata. The stratotype of this rock is in outcrop 34 (Beds 7–20) located on the southern slope of Bazagl Mountain (Fig. 25).

The lower part of the section is composed mostly of oncolite limestones (Beds 7–14) alternating with interbeds of thin (up to 0.2 m) and medium-bedded (up to 0.5 m), organogenic–detrital, bituminous, dolomitized and slightly sandy limestones. The detritus may constitute up to 60% of rocks and is composed of fragments of bivalves, brachiopods, gastropods, crinoids, and foraminiferal and ostracod shells.

The upper part of the section (Beds 15–20) consists mostly of organogenic–detrital limestones with rare interbeds of sandy and oncolite limestones. The detritus composition is analogous to that described above. Some interbeds contain brachiopod shells. The total thickness of the oncolite and organogenic–detrital limestone strata is 140 m.

The faunal assemblage includes brachiopods (occur mainly in the upper part of the section): *Delepinea comoides* (Sowerby), *Punctospirifer* aff. *partitus* Portlock, *Composita puschiana* (Verneuil), *Macropotamorhynchus* ? *mutata* (Hall), *Streptorhynchus ruginosum* (Hall et Clarke), productids, foraminifers, ostracods, and conodonts.

Faunal Analysis and Correlation

Of all fossils found in the studied strata, brachiopod shells are exceptionally rare. Only five species are determined from the interbeds of organogenic–detrital, slightly sandy limestones in the middle and upper parts of outcrop 34, Beds 10, 15, 17, and 18 (Fig. 25). Thin sections from almost the whole section contain abundant fragments of brachiopod shells, which can be explained by the formation of enclosing rocks under conditions of outermost shoal environment and increased wave dynamics. *Macropotamorhynchus*? *mutata* and *Streptorhynchus ruginosum* indicate the Lower Visean age of enclosing rocks and allow their correlation with the Pod"yakovo and Verkhotomskoe horizons of the Lower Visean of the Kuznetsk Depression. According to Litvinovich (1962), the latter species also occurs in Middle Visean deposits.

The foraminiferal assemblage of the strata described is rich and diverse in species and generic composition. Some species, such as *Earlandia moderata* Mal., *Parathurammina* ex gr. *suleimanovi*, *Vicinesphaera squalida* Antropov, *Tournayella moelleri*, and *Earlandia vulgaris minor* Rauser et Reitlinger pass from the Upper Tournaisian underlying zone. Most of the above-listed species characterize only these strata. According to Reitlinger (Grechishnikova et al., 1982), the strata described are very well correlated with the Lower Visean of the Moscow Syneclise (Malinovo Subhorizon).

According to preliminary determinations of Chizhova, ostracods are also diverse in species and generic composition, but most of species are determined in open nomenclature. The ostracods from these strata strongly differ in composition from the Upper Tournaisian assemblage. Only two species, *Shemonaella* ex gr. *procera* N. Ivanova and *Shivaella longa* Tschigova, overpassed from the underlying *baiani–burlingtonensis* Zone. Other ostracod species do not cross the boundary of oncolite and organogenic–detrital limestone strata.

According to Aristov, the conodont assemblage strongly differs from that of the Upper Tournaisian. It is difficult to correlate it with other regions due to its unusual species composition of conodonts. However, based on the appearance of *Cavusgnathus* Harris et Hollingsworth, Aristov (1994) distinguished the beds with *Cavusgnathus*, whose lower part corresponds to the studied strata and is presumably correlated with the Visean *texanus* Zone of the standard conodont scheme (Table 6).

Middle Visean Substage

Moderatoproductus moderatus Zone

The deposits corresponding to the *Moderatoproductus moderatus* Brachiopod Zone were unknown in the Nakhchivan AR until the author's papers. They have a very limited range, rest conformably on the underlying strata, and are recognized only in the section of Bazagl Mountain, outcrop 34, Beds 21–28, which was accepted as the stratotype of the zone (Fig. 25). The lower boundary is at the bottom of limestones with the index species. The upper boundary is not determined due to the absence of younger Visean deposits caused by pre-Late Permian erosion (Fig. 25). The *moderatus* Zone is composed of various light gray, coarse-bedded limestones and, thus, strongly differs from dark gray limestones of underlying rocks. The lower part of the section (Beds 21–22) is composed of light coarse-bedded limestones (calcarenites) with interbeds of organogenic–detrital limestones containing small crinoid columnals, solitary rugosans, foraminifers, and brachiopods. This is the level, where the index species *Moderatoproductus moderatus* (Schwetzow) was first found. It is 16.5 m thick. The middle part of the section (Beds 23–26) is composed of alternation of gray and light gray oolitic and organogenic–detrital limestones. Some interbeds of oolitic limestones are "sandstone" composed of oolites and rounded fragments of echinoderms, bryozoans, foraminifers, and other organisms. Crinoid, coral, and brachiopod varieties were also recorded. Unfortunately, it is very difficult to extract fossils out of very solid limestones. The thickness is 33.4 m.

The upper part of the section (Beds 27–28) is composed of brownish gray, thin-bedded, fine-grained, organogenic–detrital, recrystallized limestones. The definable fauna of the uppermost bed includes foraminifers, algae, and a few conodonts. The thickness is 17 m.

The total thickness of *moderatus* Zone preserved in the studied section after pre-Late Permian erosion is 67 m.

The faunal assemblage includes brachiopods: *Schuchertella* sp., *Delepinea* cf. *comoides* (Sowerby), *Moderatoproductus moderatus* (Schwetzow), *Echinoconchus* ex gr. *elegans* (M'Coy), *E.* sp., *Gigantoproductus* sp., *Overtonia* sp., *Krotovia* sp., *Eomarginifera* sp., foraminifers, tabulate corals, and conodonts.

The above list shows that the faunal assemblage of the *Moderatoproductus moderatus* Zone is impoverished. The only exception is the foraminifers. The assemblage peculiar feature is a small number of species of all invertebrate taxa overpassing from underlying deposits. Although some productids and spiriferids were determined only to genus, the index species *Moderatoproductus moderatus* and *Echinoconchus* ex gr. *subelegans* (Thomas) were found, which confidently define the Middle Visean age of enclosing rocks. The deposits coeval with this zone are known in central Kazakhstan (Litvinovich, 1962). According to Reitlinger (personal communication), the only found foraminifer species is the widely vertically distributed *Mediocris mediocris* (Vissarionova). Other species do not overpass the zonal boundaries and are correlated with the Bobrikovo and Tula horizons of the East European Platform.

According to Aristov (1994), conodonts are very rare. They are absent in dolomitized limestones. The lower part of the zone contains *Gnathodus tipicus* Cooper and the upper part contains *Spathognathodus cristulus* Youngquist et Miller. Aristov correlates the *moderatus* Brachiopod Zone with the upper part of the local beds with *Cavusgnathus* and tentatively with the *bilineatus* Zone of the standard conodont scheme (Table 6).

PART 2. DEVONIAN AND CARBONIFEROUS BRACHIOPODS OF TRANSCAUCASIA

R.E. Alekseeva, G.A. Afanasjeva, I.A. Grechishnikova, N.V. Oleneva, and A.V. Pakhnevich

SYSTEMATIC PALEONTOLOGY

Order Lingulida Waagen, 1885

Family Pseudolingulidae Holmer, 1991

Genus *Bicarinatina* Batrukova, 1969

Bicarinatina: Batrukova, 1969, p. 59; Holmer and Popov, 2000, p. 39.

Liralingua: Graham, 1970, p. 153.

Type species. *Lingula bicarinata* Kutorga, 1837, p. 38; Devonian; Russian Platform.

Diagnosis. Shell medium-sized, flattened, and elongated. Ornamentation composed of concentric growth lines and radial capillae. Median depression on dorsal valve flanked by radial plicae. Imprint of visceral cavity oval and elongated.

Species composition. Five species; Middle Devonian–Lower Carboniferous; Lithuania, Latvia, Estonia, Scotland, United States, northwestern Russia; Middle Devonian, Eifelian of the Nakhchivan AR.

Comparison. This genus differs from *Tarutiglossa* Havliček, 1984 and *Wadiglossa* Havliček, 1984 in the more elongated shell, radial ornamentation, and median depression flanked by plicae.

***Bicarinatina* sp.**

Plate 1, fig. 1

Description. The shell is elongated and medium-sized, about 18.5 mm long and 6.4 mm wide. The valves are flattened. The maximum width is at the anterior margin. External ornamentation consists of concentric growth lines and radial capillae. The capilla interspaces are considerably wider than capillae. A sulcus-like median depression runs from the dorsal umbo to the anterior margin and is laterally bordered by plicae. At the anterior margin, the plicae are separated by a 6.2–mm-wide interspace, including ten capillae. The imprint of visceral cavity is oval and elongated.

Comparison. Available specimen cannot be identified to species due to insufficient material. *Bicarinatina* sp. is most similar to the type species of *B. bicarinata*.

Remarks. This specimen is referred to *Bicarinatina* based on the type of radial ornamentation, median depression, and lateral plicae. Its narrow shell is similar externally to that of some genera of the family Lingulidae.

Occurrence. Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone; Nakhchivan AR.

Material. One satisfactorily preserved dorsal valve; vicinity of the village of Danzik, outcrop 1301.

Order Craniida Waagen, 1885

Family Craniidae Menke, 1828

Genus *Petrocrania* Raymond, 1911

Craniella: Oehlert, 1888, p. 101.

Petrocrania: Raymond, 1911, p. 229; Goryanskii, 1960, pp. 176–177; Bassett, 2000, p. 181.

Philhedrella: Kozlowski, 1929, p. 28.

Lissocrania: Williams, 1943, p. 71.

Petrocraniella: Petrov, 1968, p. 74.

Type species. *Craniella meduanensis* Oehlert, 1888, p. 102; Devonian; northwestern France, Mayenne Department.

Diagnosis. Shell large and elongated. Dorsal valve conical, with high umbo located closer to valve margin. Ornamentation composed of concentric growth lines. Limbus present. Anterior adductor scars smaller than large posterior adductors and positioned close to each other.

Species composition. About 15 species; Lower Ordovician (Upper Arenig)–Lower Carboniferous; cosmopolitan, including the Devonian of the Nakhchivan AR.

Comparison. *Petrocrania* is similar externally to other Devonian craniids in the shell exterior and differs from *Acanthocrania* Williams, 1943 in the straight shell margin, the concentric ornamentation, and in the anterior and posterior adductors differing in the scar sizes.

***Petrocrania* sp.**

Plate 1, fig. 2

Description. The shell is large and elongated, 22.7 mm long, 21.5 mm wide, and 12.2 mm thick. The umbo of the dorsal valve is high and located closer to the posterior margin. External ornamentation consists of concentric growth lines. The posterior adductor scars are 6.5 mm wide and larger than 4.3-mm-wide anterior adductors, which are divided only by a 0.8-mm-wide interspace.

Comparison and remarks. These specimens cannot be determined to species due to the insufficient material; the arrangement of muscle scars is most similar to that of *Petrocrania*.

Occurrence. Upper Devonian, Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone; Nakhchivan AR.

Explanation of Plate 1

Fig. 1. *Bicarinatina* sp.: (1a) specimen PIN, no. 3744/868, rock fragment with shells of *Oligoptycherhynchus daleidensis* and *Bicarinatina* sp.; (1b) specimen PIN, no. 3744/869; ventral valve; Nakhchivan AR, vicinity of the village of Danzik, outcrop 1301; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone. Scale bar, 1 cm.

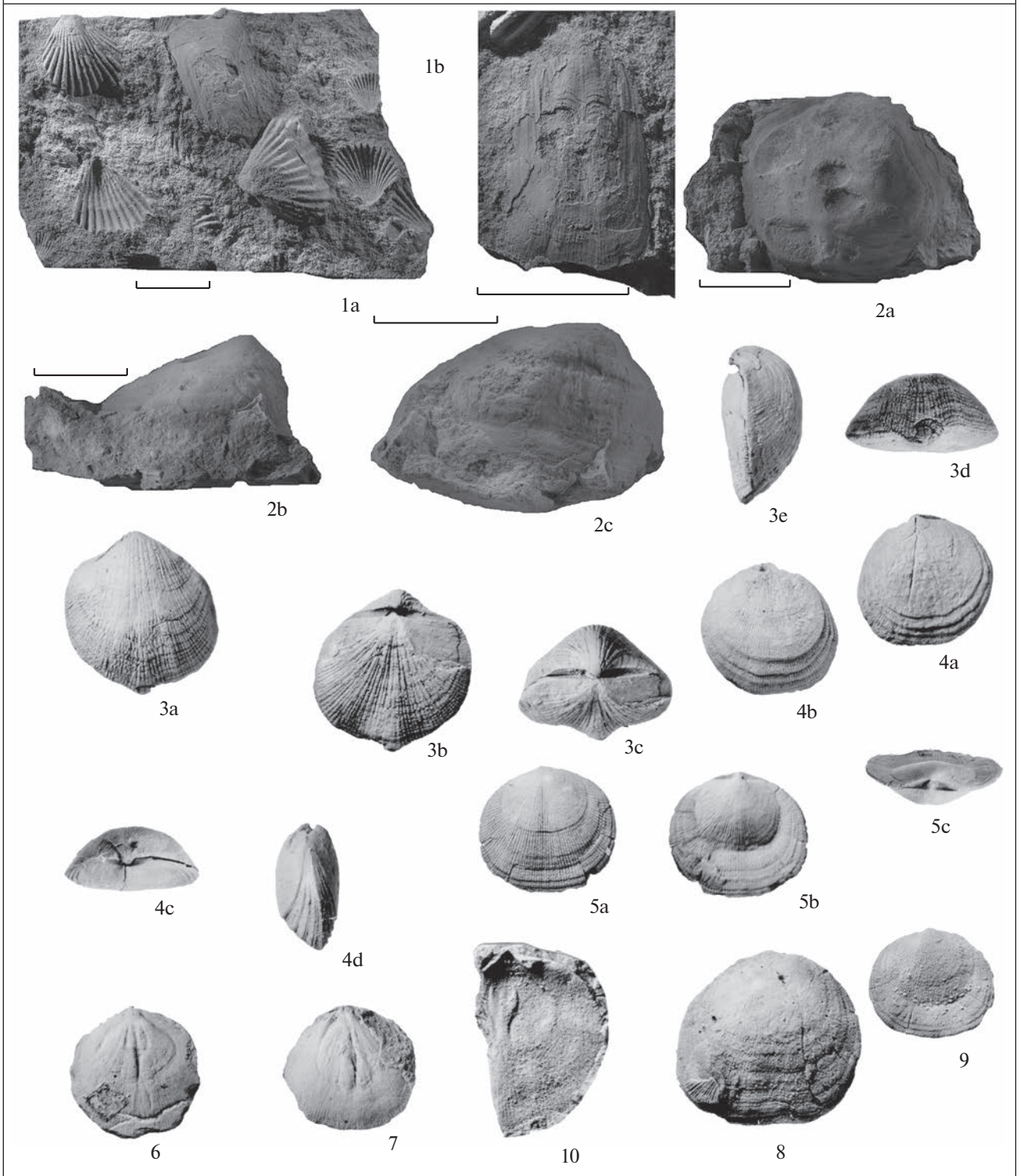
Fig. 2. *Petrocrania* sp., specimen PIN, no. 3744/870, inner mold of dorsal valve: (2a) upper, (2b) lateral, and (2c) posterior views; Nakhchivan AR, east of Geran-Kalasy Mountain, outcrop 10, Bed 5; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone. Scale bar, 1 cm.

Fig. 3. *Resserella dagnensis* Alekseeva et Gretchishnikova, sp. nov., holotype PIN, no. 3744/527, conjoined shell: (3a) ventral valve view; (3b) dorsal valve view; (3c) posterior view; (3d) anterior view; (3e) lateral view; southeastern slope of Dagna Mountain, outcrop 68, Bed 9; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

Figs. 4–7. *Rhipidomella arpaensis* Alekseeva et Gretchishnikova, sp. nov.: (4) holotype PIN, no. 3744/511, conjoined shell: (4a) ventral valve view; (4b) dorsal valve view; (4c) posterior view; (4d) lateral view; left bank of the Arpa River near the village of Gyumushlug, outcrop 65, Bed 16; (5) specimen PIN, no. 3744/517, conjoined shell: (5a) ventral valve view; (5b) dorsal valve view; (5c) posterior view; left bank of the Arpa River in the vicinity of the village of Danzik, outcrop 66, Bed 24; (6) specimen PIN, no. 3744/515, mold of ventral valve; (7) specimen PIN, no. 3744/516, mold of dorsal valve; left bank of the Arpa River near the village of Gyumushlug, outcrop 65, Bed 15; Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Figs. 8–10. *Rhipidomella kusbassica* Besnossova, 1963: (8) specimen PIN, no. 3744/540, dorsal valve; (9) specimen PIN, no. 3744/541, ventral valve with damaged anterior margin; (10) specimen PIN, no. 3744/539, inner surface of the ventral valve, ×1.5; eastern slope of Geran-Kalasy Mountain, outcrop 11, Bed 19a; Lower Carboniferous, Middle Tournaisian, *Rhipidomella michelini* Zone.

Plate 1



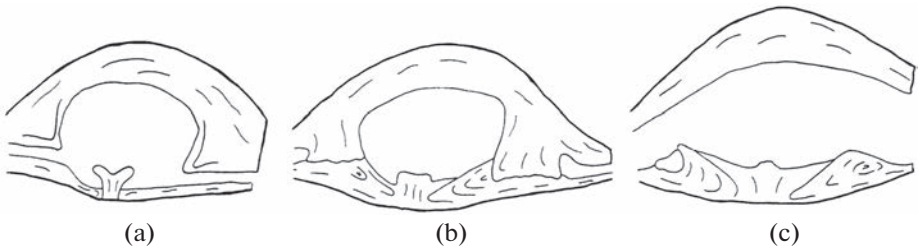


Fig. 26. *Resserella dagnensis* Alekseeva et Gretchishnikova, sp. nov., specimen PIN, no. 3744/529, serial cross sections through the shell; Nakhchivan AR, southern slope of Dagna Mountain, outcrop 68, Bed 9; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

M a t e r i a l. One inner mold of shell and fragmentary shell imprint; Nakhchivan AR, east of Geran-Kalasy Mountain, outcrop 10, Bed 5.

Order Orthida Schuchert et Cooper, 1932

Suborder Dalmanellidina Harper, 2002

Family Dalmanellidae Schuchert, 1913

Subfamily Resserellinae Walmsley et Boucot, 1971

Genus *Resserella* Bancroft, 1928

Resserella: Walmsley and Boucot, 1971, p. 494; Alikhova, 1960, p. 191; Harper, 2002, p. 793.

T y p e s p e c i e s. *Orthis canalis* Sowerby, 1839; Silurian, Wenlock, and Ludlow; Sweden, Island of Gotland.

D i a g n o s i s. Shell medium-sized and planoconvex. Ventral valve with apsacline area, massive curved umbo, and somewhat incurved beak. Dorsal valve with slightly convex umbo and anacline area. External radial ornamentation composed of medium-sized and small costae. In ventral valve, teeth massive; muscle field short, suboval, and located in posterior half of valve. In dorsal valve, cardinal process bifid; brachiophores broadly diverging, usually with fulcral plates; muscle field elongated oval.

S p e c i e s c o m p o s i t i o n. About twenty species; Silurian–Middle Devonian (Eifelian). Transcaucasia: *R. dagnensis* Alekseeva et Gretchishnikova, sp. nov. from the Lower Devonian (Emsian)–Middle Devonian (Eifelian), *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone.

C o m p a r i s o n. This genus is most similar to *Visbyella* Walmsley et al., (1968, p. 306) in the shell shape and external ornamentation and differs in the shell exterior and interior: *Visbyella* has dental plates and high myophragm in the ventral valve and a hypercline area and trifid cardinal process in the dorsal valve.

***Resserella dagnensis* Alekseeva et Gretchishnikova, sp. nov.**

Plate 1, fig. 3; Fig. 26

E t y m o l o g y. From Dagna Mountain.

H o l o t y p e. PIN, no. 3744/527, conjoined shell; Lower Devonian (Emsian)–Middle Devonian (Eifelian), *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone; Nakhchivan AR, southeastern slope of Dagna Mountain, outcrop 68, Bed 9 (Pl. 1, fig. 3).

D e s c r i p t i o n. The shell is 18–25 mm long and up to 22–28 mm wide, suboval to subtriangular, strongly unequally biconvex, with convex ventral and flattened dorsal valves. The maximum width is at the midlength; it is 1.1–1.2 times greater than the maximum length. The posterior margin is straight, up 20 mm long. The cardinal extremities are rounded. The ventral umbo is massive and slightly curved; the ventral area is apsacline, low, up to 3 mm high under the umbo. The delthyrium is wide; with the base one-third as long as the posterior margin. The dorsal umbo is poorly pronounced; the dorsal area is anacline. The notothyrium is covered with the cardinal process. The ventral valve is strongly convex, with relatively steep lateral slopes. The dorsal valve is flattened or slightly convex. The median sulcus is low and sometimes bear poorly developed plica in the middle, which terminates in a low, narrow, and dorsally tapering tongue at the anterior margin. External radial ornamentation consists of numerous costae rounded in cross section. The costae increase in number by dichotomy, rarely, by intercalation. A 5-mm-long segment of the anterior margin has 9–10 costae. The costae and interspaces are almost equally wide. In the ventral valve, there are massive teeth; the dorsal valve contains a bifid cardinal process.

V a r i a b i l i t y. The shell outline varies from suboval to subtriangular, depending on the width to length ratio. Relatively wider shells are widely subtriangular in outline.

A g e v a r i a b i l i t y. All young shells are subtriangular, with better pronounced sulcus on the dorsal valve.

C o m p a r i s o n. This species is most similar to *R. canalis* (Sowerby, 1839) (Walmsley and Boucot, 1971, p. 497, pl. 97, figs. 1, 4–7; pl. 100, fig. 4) from the Silurian (Wenlock–Ludlow) of Island of Gotland in the shell shape and external radial ornamentation, but differs from it in the considerably (almost twice) larger shell and the absence of thinner costae in the middle regions of both valves. It is similar to *R. pragensis*

(Havlíček, 1956, p. 497, pl. 10, figs. 3–6) from the Upper Emsian of the Czech Republic in the shell size and differs from it in the absence of thin costae in the middle part of the ventral valve. *R. dagnensis* is similar to *R. careyi* (Chatterton, 1973, p. 23, pl. 3, figs. 10, 16–27; pl. 35, figs. 1–3) from the Emsian of Australia in the shell exterior and differs from it mainly in the 1.5 times as large shell.

Occurrence. Transcaucasia, Lower Devonian (Emsian)–Middle Devonian (Eifelian), *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone.

Material. Nine complete moderately preserved conjoined shells from the Nakhchivan AR, southeastern slope of Dagna Mountain, outcrop 68, Bed 9; outcrop 1710.

Family Rhipidomellidae Schuchert, 1913

Subfamily Rhipidomellinae Schuchert, 1913

Genus *Rhipidomella* Oehlert, 1890

Rhipidomella: Beznosova et al., 1968, p. 51 (synonymy); Cooper and Dutro, 1982, p. 41; Harper, 2002, p. 818.

Type species. *Rhipidomella michelini* Léveillé, 1835; Lower Carboniferous; Belgium.

Diagnosis. Shell medium-sized, subround and subtriangular in outline, with more convex dorsal valve. Posterior margin considerably shorter than maximum width. Umbos of both valves small and poorly developed. External radial ornamentation composed of thin costae. Ventral valve containing short dental plates, broad suboval muscle field, and flabellate diductor scars; myophragm low, rarely extending anteriorly from muscle field. Dorsal valve with massive cardinal process and large suboval muscle field.

Species composition. Over 20 species; Middle Devonian (Eifelian)–Permian; cosmopolitan. Transcaucasia: *R. arpensis* Alekseeva et Gretchishnikova, sp. nov., *R. kusbassica* Besnossova, 1963, and *R. burlingtonensis* (Hall, 1892).

Comparison. This genus is similar to *Mendacella* Cooper, 1930 in external radial ornamentation, but differs in the shell shape (the shell of *Mendacella* is ventribiconvex) and outline of muscle fields in both valves (*Mendacella* has an elongated and bilobed ventral muscle field and poorly pronounced dorsal muscle field).

***Rhipidomella arpensis* Alekseeva et Gretchishnikova, sp. nov.**

Plate 1, figs. 4–7; Fig. 27

Etymology. From the Arpa River.

Holotype. PIN, no. 3744/511, complete conjoined shell; Middle Devonian, Givetian, *Indospirifer pseudowilliamsi* Zone; Nakhchivan AR, left bank of the Arpa River near the village of Gyumushlug, outcrop 65, Bed 16 (Pl. 1, fig. 4).

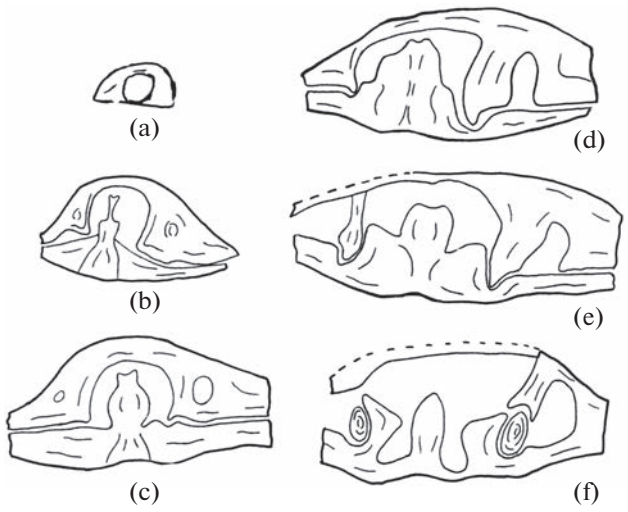


Fig. 27. *Rhipidomella arpaensis* Alekseeva et Gretchishnikova, sp. nov., specimen PIN, no. 3744/519, serial cross sections through the shell; Nakhchivan AR, left bank of the Arpa River near the village of Gyumushlug, outcrop 65, Bed 15; Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Description. The shell is 21–26 mm long and up to 23–29 mm wide, subrounded in outline, and dorsibiconvex. The maximum width is at the midlength; it is 1.1 times greater than the maximum length; rarely, the width and length are approximately equal. The posterior margin is short, up to 7–8 mm long. The cardinal extremities are rounded. The umbos of both valves are small and scarcely protruding beyond the posterior margin. The ventral area is low, apsacline, about 3 mm high under the umbo; the delthyrium is wide and open. The dorsal area is anacline. The ventral valve is slightly uniformly convex. The dorsal valve sometimes bears a narrow median longitudinal depression with corresponding low keel-shaped elevation on the ventral valve. External radial ornamentation consists of numerous low, thin, and branching costae. The costae are 1.5–2 times as wide as the interspaces, numbering 12–14 per 5 mm at the anterior margin. In the ventral valve, there are short dental plates and massive teeth. The ventral muscle field is broad, flabellate, and occupies one-third of the inner valve surface. The myophragm is low and reaches the anterior margin of the muscle field. In the dorsal valve, the cardinal process is high, massive, and enters the umbonal cavity of the ventral valve. The dorsal muscle field is subsquare in outline and occupies one-third of the inner valve surface. The anterior ends of brachiophores outline the posterior margins of the muscle field.

Comparison. The new species is similar to *R. burlingtonensis* (Hall, 1858) (Beznosova, 1963, p. 72, pl. 2, figs. 1–3) and *R. penniana* (Derby, 1874) (Beznosova et al., 1968, p. 51, pl. 1, figs. 6–8) in the shell size and external radial ornamentation and differs

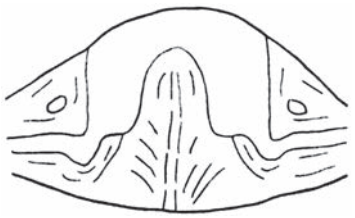


Fig. 28. *Rhipidomella kusbassica* Besnossova, 1963, specimen PIN, no. 3744/538, cross section through the umbo of a complete shell; Nakhchivan AR, northeastern slope of Geran-Kalasy Mountain, outcrop 11, Bed 19; Lower Carboniferous, Upper Tournaisian, *Rhipidomella michelini* Zone.

in the absence of a sulcus-like depression on the ventral valve. In addition, *R. burlingtonensis* differs in the subtriangular shell outline and maximum shell width located in the anterior half of the shell.

Occurrence. Middle Devonian, Givetian, *Indospirifer pseudowilliamsi* Zone; Transcaucasia.

Material. Fourteen moderately preserved specimens (12 conjoined shells, inner molds of 1 ventral and 1 dorsal valve) from the Nakhchivan AR: left bank of the Arpa River near the village of Gyumushlug, outcrop 19, Bed 47; outcrop 60, Bed 15; outcrop 63, Bed 5; outcrop 65, Beds 5, 15; outcrops 1419, 1420; left bank of the Arpa River in the vicinity of the village of Danzik, outcrop 66, Bed 24.

Rhipidomella kusbassica Besnossova, 1963

Plate 1, figs. 8–10; Fig. 28

Rhipidomella michelini: Tolmatchow, 1924, p. 212, pl. 13, fig. 4; Nalivkin, 1937, p. 36, pl. 3, figs. 6 and 7.

Rhipidomella kusbassica: Beznosova, 1963, p. 74, pl. 2, figs. 9–11; Grechishnikova, 1966, p. 91, pl. 1, figs. 5–10.

Holotype. PIN, no. 760/4467, ventral valve; Lower Carboniferous, Tournaisian, Lower Ters Horizon; Kuznetsk Depression, Tom River near the village of Fomikha (Beznosova, 1963, pl. 2, fig. 9).

Description. The shell is up to 29 mm long and up to 31 mm wide, subrounded in outline. The maximum width is in posterior half of the shell; it is on average 1.1 greater than the maximum length. The posterior margin is about 13 mm long, that is, slightly shorter than half of the maximum shell width. The cardinal extremities are rounded. The ventral umbo is small; the area is apsacline, 3–4 mm high under the umbo, with a wide delthyrium. The dorsal umbo scarcely protrudes beyond the posterior margin; the dorsal area is anacline. The ventral valve is slightly inflated, with the maximum convexity in the umbonal region. The anterior half of the ventral valve is flattened and bears a poorly pronounced wide sulcus-like depression in the middle. The dorsal valve is uniformly inflated and slightly more convex than the ventral valve. External radial ornamentation consists of numerous thin, low, and branching costae. The costae are slightly wider than interspaces, numbering 10 costae per 5 mm at the anterior margin. Thin concentric growth lines are better pronounced in the anterior half of the shell. In the ventral valve, there are short dental plates and massive teeth. The ventral muscle field is broad and flabellate. In the dorsal valve, the cardinal process is high, massive, and enters the umbonal cavity of the ventral valve.

Comparison. This species is similar to *R. altaica* Tolmatchow, 1924 (Tolmatchow, 1924, p. 213, pl. 13, figs. 5–7, 9, 10) from the Lower Carboniferous of the Kuznetsk Depression in the shell exterior and differs in the shell shape (more flattened ventral valve and less inflated dorsal valve). This species is similar to *R. michelini* (Léveillé) (Roberts, 1971, p. 41, pl. 1, figs. 1–5) from the Lower Carboniferous (Tournaisian and Visean) of Australia in the shell shape and size and differs in the relatively longer posterior margin, which in *R. michelini* is one-third of the maximum shell width.

Occurrence. Lower Carboniferous; Kuznetsk Depression and Rudnyi Altai. Transcaucasia: Lower Carboniferous, Lower Tournaisian, *Parallelora praeulbanensis–Rhytiophora curtirostris* Zone, Upper Tournaisian, *Rhipidomella michelini* Zone.

Material. Twelve moderately preserved, partly broken specimens (six complete conjoined shells and six separate valves) from the Nakhchivan AR: northeastern slope of Geran-Kalasy Mountain, outcrop 11, Bed 14 (*Parallelora praeulbanensis–Rhytiophoda curtirostris* Zone), Bed 19 (*Rhipidomella michelini* Zone).

Rhipidomella burlingtonensis (Hall, 1858)

Plate 2, figs. 1 and 2

Rhipidomella burlingtonensis: Tolmatchow, 1924, p. 214, pl. 13, fig. 11; Beznosova, 1963, p. 72, pl. 2, figs. 1–3; Grechishnikova, 1966, p. 92, pl. 1, fig. 11 (synonymy).

Description. The shell is up to 19 mm long and 21 mm wide, subrounded in outline, and dorsibiconvex. The maximum shell width is in the anterior half of the shell. The width to length ratio is about 1.1. The posterior margin is short; the cardinal extremities are rounded. The ventral umbo is small and protrudes beyond the posterior margin; the dorsal umbo scarcely protrudes beyond the posterior margin. The ventral valve is slightly uniformly inflated. The median region of the dorsal valve bears a poorly pronounced broad longitudinal depression. The anterior margin is straight. External radial ornamentation consists of numerous thin costae. The costae increase in number by dichotomy and intercalation in the course of shell growth and are 1.5–2 times as wide as the interspaces, numbering 12–13 costae per 5 mm at the anterior margin. The ventral muscle field extends to the valve midlength and is divided anteriorly into four lobes. The muscle field of the dorsal valve is of the same size and divided into four lobes.

Comparison. This species is similar to *R. altaica* Tolmatchow, 1924 (Tolmatchow, 1924, p. 213, pl. 13, figs. 5–7) from the Lower Carboniferous of the Kuznetsk Depression in the shell exterior and differs in the maximum shell width located in the anterior half of the shell, the uniformly convex ventral valve lacking a sulcus, very poorly pronounced median depression on the dorsal valve, which is well pronounced in *R. altaica*, and in the thinner costae; in *R. altaica,* the density of costae is 10 per 5 mm at the anterior margin.

Occurrence. Lower Carboniferous, Tournaisian; North America, Kuznetsk Depression, Rudnyi Altai. Transcaucasia: Middle Tournaisian, *Rhipidomella michelini* Zone.

Material. Two specimens (one moderately preserved complete conjoined shell and one inner mold of a complete shell) from the Nakhchivan AR, left bank of the Arpa River, eastern slope of Geran-Kalasy Mountain, outcrop 12, Bed 2.

Genus *Aulacella* Schuchert, Cooper, 1931

Aulacella: Schuchert and Cooper, 1931, p. 246; Harper, 2002, p. 818.

Type species. *Orthis eifeliensis* Verneuil, 1850; Middle Devonian, Eifelian; Poland, Germany.

Diagnosis. Shell small and dorsibiconvex. Ventral umbo and area well outlined. On ventral valve, saddle-shaped elevation near umbo passing into shallow depression in anterior half of valve. Dorsal valve with low saddle-shaped elevation along whole length. External radial ornamentation composed of thin angular costae. In ventral valve, muscle field elongated and bilobed to flabellate. In dorsal valve, cardinal process usually trifid; brachiophores slightly diverging.

Species composition. About ten species; Middle Devonian (Eifelian)–Lower Carboniferous (Tournaisian); Western Europe, Russia, Transcaucasia. Transcaucasia: *A. eifeliensis* (Verneuil, 1850) and *A. finitima* Alekseeva et Gretchishnikova, sp. nov.

Comparison. This genus is similar to *Rhipidomella* Oehlert, 1890 in the shell exterior and differs in the smaller shell, higher ventral umbo and area, and less flabellate ventral muscle field. It somewhat externally resembles *Thiemella* Williams, 1908, but differs in the smaller shell, less convex dorsal valve, worse developed saddle-shaped elevation on the ventral valve and sulcus-like depression on the dorsal valve, and in the type of the muscle field in the ventral valve (*Thiemella* has a cordate muscle field with a long myophragm stretching anteriorly from the muscle field.

Aulacella eifeliensis (Verneuil, 1850)

Plate 2, figs. 3–5; Fig. 29

Aulacella eifeliensis: Biernat, 1959, p. 26 (synonymy); Brice, 1970, p. 235 (synonymy).

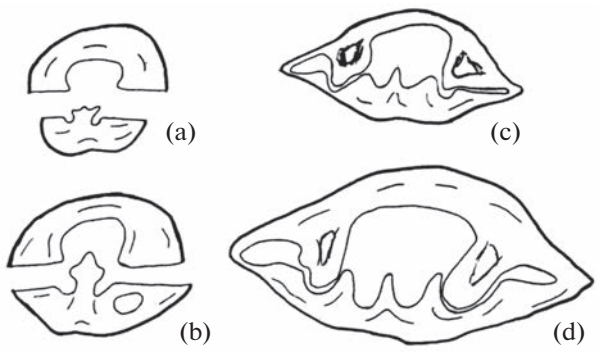


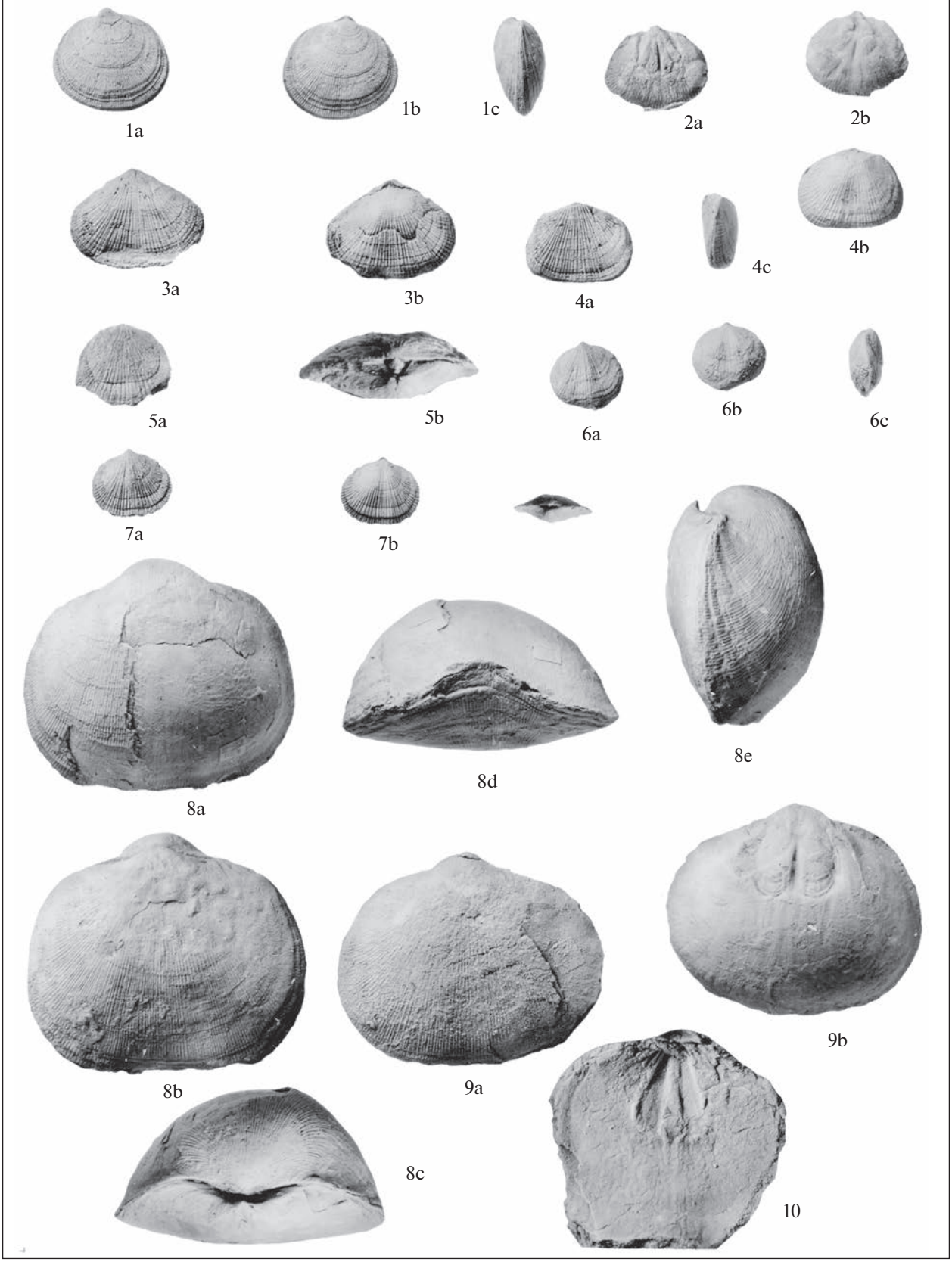
Fig. 29. *Aulacella eifeliensis* (Verneuil, 1850), specimen PIN, no. 3744/522, serial cross sections through the shell; Nakhchivan AR, southern slope of Velidag Mountain, outcrop 48, Bed 4; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

Description. The shell is 15–18 mm long and 17 to 23 mm wide, transversely elongated, suboval to subtriangular in outline, and slightly dorsibiconvex. The maximum shell width is at the midlength; it is 1.1–1.2 times greater than the maximum length. The posterior margin is straight and short (6–8 mm); its length is approximately one-third of the shell width. The cardinal extremities and lateral margins are rounded. The ventral umbo is small and well defined; the ventral area is low, apsacline, and up to 2 mm high under the umbo; the delthyrium is open. The dorsal umbo is small, low, and poorly pronounced. The dorsal area is anacline; the notothyrium is low, wide, and covered with cardinal process. The ventral valve is slightly inflated, most convex in the umbonal region, with a wide and shallow sulcus-like depression. The dorsal valve is flattened in the middle, and sometimes bear a shallow sulcus-like depression starting slightly anterior to the umbo. External radial ornamentation consists of numerous angular costae, which increase in number in the course of the shell growth by repeated dichotomy and intercalation and are most densely spaced at the anterior margin. The costae are two times as wide as interspaces, numbering 9–10 costae per 5 mm at the anterior margin. Concentric ornamentation is well pronounced. In the ventral valve, there are poorly developed dental plates and massive teeth. In the dorsal valve, the cardinal process is high and massive; the brachiophores are massive and border the sockets.

Variability. The shell varies in outline from suboval to subtriangular; the sulcus-like depression is variously pronounced on both ventral and dorsal valves.

Age variability. The keel-shaped elevation on the ventral valve and sulcus-like depression on the dorsal valve are well developed at early developmental stages.

Plate 2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1b
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8a
8d
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8b
9a
9b
8c
10

Comparison. This species is most similar to *A. interlineata* (Sowerby, 1840) (Abramyan, 1957, p. 17, pl. 1, figs. 1, 2) in the shell exterior, but differs in the shell outline (*A. interlineata* has elongated shell), the absence of keel-shaped elevation on the ventral valve, and the poorly developed sulcus-like depression on the dorsal valve.

Occurrence. Lower Devonian (Emsian)–Middle Devonian (Eifelian); Eurasia. Transcaucasia: Upper Emsian–Lower Eifelian (*Zdimir pseudobashkiricus–Megastrophia uralensis* Zone); Upper Eifelian (*Mucrospirifer diluvianoides–Radiomena irregularis* Zone).

Material. Twenty-nine moderately preserved complete conjoined shells from the Nakhchivan AR: *Zdimir pseudobashkiricus–Megastrophia uralensis* Zone: southern slope of Velidag Mountain, outcrop 48, Beds 18 and 24; southeastern slope of Dagna Mountain, outcrop 68, Bed 9; *Mucrospirifer diluvianoides–Radiomena irregularis* Zone: right bank of the Dzhaanam-Deresi River, outcrop 135, Bed 2.

***Aulacella finitima* Alekseeva et Gretchishnikova, sp. nov.**

Plate 2, figs. 6 and 7; Fig. 30

Etymology. From the Latin *finitimus* (neighboring).

Holotype. PIN, no. 3744/605, complete conjoined shell; Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone; Nakhchivan AR, eastern slope of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 5 (Pl. 2, fig. 6).

Description. The shell is small, 12 mm long and up to 13–14 mm wide, subsquare in outline, slightly transversely elongated, and dorsibiconvex. The maximum shell width is at the midlength; it is up to 1.1 times greater than the maximum length. The posterior margin is 6 mm long and straight. The cardinal extremities are rounded. The ventral umbo is small and low; the area is apsacline; the delthyrium is open. The dorsal umbo is poorly pronounced. The ventral valve is slightly convex; longitudinal median keel-shaped elevation is developed along its whole length and heightens anteriorly. The dorsal valve bears a median sulcus-like depression throughout its length. The anterior margin is straight. External radial ornamentation consists of numerous costae rounded in cross section, which increase in number by dichotomy and intercalation in the course of the shell growth. The costae are approximately twice as wide as the interspaces, numbering 12–13 costae per 5 mm at the anterior margin. Concentric ornamentation composed of growth ledges is well pronounced. In the ventral valve, there are low dental plates and massive teeth. The muscle field is bilobed, subtriangular, and extends to the valve midlength. In the dorsal valve, the cardinal process is high and massive; the brachiophores are massive and border the sockets.

Fig. 30. *Aulacella finitima* Alekseeva et Gretchishnikova, sp. nov., specimen PIN, no. 3744/607, cross section through the umbo of a complete shell; Nakhchivan AR, southern slope of Dagna Mountain, outcrop 63, Bed 5; Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Comparison. The new species somewhat resembles *A. eifeliensis* (Verneuil, 1850) in shell outline and differs in the smaller, slightly less transversely elongated shell, the presence of a well pronounced keel-shaped elevation on the ventral valve and sulcus-

Explanation of Plate 2

Figs. 1 and 2. *Rhipidomella burlingtonensis* (Hall, 1892): (1) specimen PIN, no. 3744/542, conjoined shell: (1a) ventral valve view; (1b) dorsal valve view; (1c) posterior view; (1d) anterior view; (1e) lateral view; (2) specimen PIN, no. 3744/543, mold of complete shell: (2a) ventral valve view; (2b) dorsal valve view; left bank of the Arpa River, eastern slope of Geran-Kalasy Mountain, outcrop 12, Bed 2; Lower Carboniferous, Middle Tournaisian, *Rhipidomella michelini* Zone.

Figs. 3–5. *Aulacella eifeliensis* (Verneuil, 1850): (3) specimen PIN, no. 3744/520, conjoined shell: (3a) ventral valve view; (3b) dorsal valve view; (4) specimen PIN, no. 3744/521, conjoined shell: (4a) ventral valve view; (4b) dorsal valve view; (4c) lateral view; southern slope of Velidag Mountain, outcrop 48, Bed 24; (5) specimen PIN, no. 3744/524, conjoined shell with damaged anterior margin: (5a) ventral valve view; (5b) posterior view, ×1.5; southeastern slope of Dagna Mountain, outcrop 68, Bed 9; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobashkiricus–Megastrophia uralensis* Zone.

Figs. 6 and 7. *Aulacella finitima* Alekseeva et Gretchishnikova, sp. nov.: (6) holotype PIN, no. 3744/605, conjoined shell: (6a) ventral valve view; (6b) dorsal valve view; (6c) lateral view; eastern slope of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 5; Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone; (7) specimen PIN, no. 3744/606, conjoined shell: (7a) ventral valve view; (7b) dorsal valve view; (7c) posterior view; right bank of the Dzhaanam-Deresi River, outcrop 135, Bed 2; Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Figs. 8–10. *Schizophoria* (*Schizophoria*) *schnuri altera* Alekseeva et Gretchishnikova, subsp. nov.: (8) holotype PIN, no. 3744/500, conjoined shell: (8a) ventral valve view; (8b) dorsal valve view; (8c) posterior view; (8d) anterior view; (8e) lateral view; (9) specimen PIN, no. 3744/501, damaged complete shell: (9a) dorsal valve view; (9b) mold of ventral valve; (10) specimen PIN, no. 3744/503, inner surface of ventral valve; upper reaches of the Bagarsykh-Deresi River, outcrop 33, Bed 78; Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Fig. 31. *Schizophoria* (*Schizophoria*) *schnuri altera* Alekseeva et Gretchishnikova, subsp. nov., specimen PIN, no. 3744/503, cross section through the umbo of a complete shell; Nakhchivan AR, upper reaches of the Bagarsykh-Deresi River, outcrop 33, Bed 78; Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

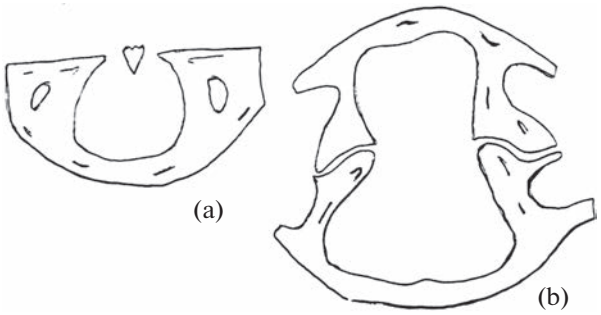


Fig. 32. *Schizophoria* (*Schizophoria*) *schnuri altera* Alekseeva et Gretchishnikova, subsp. nov., specimen PIN, no. 3744/505, serial cross sections through the shell; Nakhchivan AR, upper reaches of the Bagarsykh-Deresi River, outcrop 33, Bed 78; Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

like depression on the dorsal valve, and in the thinner costae.

Occurrence. Middle Devonian, *Mucrospirifer diluvianoides–Radiomena irregularis* (Upper Eifelian) and *Indospirifer pseudowilliamsi* (Upper Givetian) zones; Transcaucasia.

Material. Twenty moderately preserved conjoined shells from the Nakhchivan AR: *Mucrospirifer diluvianoides–Radiomena irregularis* Zone: right bank of the Dzhaanam-Deresi River, outcrop 135, Bed 2; Dzhaanam-Deresi River Basin, outcrop 3512/1; *Indospirifer pseudowilliamsi* Zone: eastern slope of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 5; left bank of the Dzhaanam-Deresi River, outcrop 60, Bed 5; right bank of the Dzhaanam-Deresi River, outcrop 132, Bed 2.

Superfamily Enteletoidea Waagen, 1884

Family Schizophoriidae Schuchert et Le Vene, 1929

Genus *Schizophoria* King, 1850

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

Schizophoria (*Schizophoria*): Lazarev, 1976, p. 100; Harper, 2002, p. 840.

Type species. *Conchiliolithus* (*Anomites*) *resupinatus* Martin, 1809; Lower Carboniferous; England.

Diagnosis. Shell large and strongly dorsibiconvex. Ventral valve slightly convex, flattened or resupinate. Dental plates well developed. Muscle fields of both valves broad, subtriangular or oval.

Species composition. Over 40 species; Devonian–Lower Carboniferous; cosmopolitan. Transcaucasia: *Sch.* (*Sch.*) *schnuri altera* Alekseeva et Gretchishnikova, subsp. nov., *Sch.* (*Sch.*) *lata* Alekseeva et Gretchishnikova, sp. nov.

Comparison. This subgenus differs from the subgenus *Paraschizophoria* Lazarev, 1976 in the slightly convex ventral valve (the shell of *Paraschizophoria* is subequally biconvex) and the wider ventral muscle field. It differs from the subgenus *Pokokia* Lazarev, 1976 in the shell shape (*Pokokia* has a globular shell with the ventral valve angularly curved at the anterior margin) and the broad muscle field in the dorsal valve (dorsal muscle field of *Pokokia* is narrow).

***Schizophoria* (*Schizophoria*) *schnuri altera* Alekseeva et Gretchishnikova, subsp. nov.**

Plate 2, figs. 8–10; Figs. 31 and 32

Etymology. From the Latin *alter* (another).

Holotype. PIN, no. 3744/500, complete conjoined shells; Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone; Nakhchivan AR, upper reaches of the Bagarsykh-Deresi River, outcrop 33, Bed 78 (Pl. 2, fig. 8).

Description. The shell is large, from 30 to 47 mm long and up to 39–49 mm wide, subrounded and slightly transversely elongated in outline. The maximum shell width is at the midlength; on average, it is 1.1 times greater than the maximum length. The posterior margin is from 16 to 21 mm long and almost half as long as the maximum width. The cardinal extremities and lateral margins are rounded. The ventral umbo is small and acute; the ventral area is low, apsacline, about 4 mm high under the umbo; the delthyrium is open. The dorsal umbo is low; the dorsal area is anacline. The shell is strongly unequally biconvex. The ventral valve is slightly convex, with a poorly pronounced median sulcus-like depression in the anterior half. The dorsal valve is considerably more convex (sometimes two times as convex) than the ventral valve, strongly inflated in the umbonal region, with steep lateral slopes. External radial ornamentation consists of numerous angular, strongly branching and intercalating costae. The costae are approximately twice as wide as the interspaces, numbering 8–9 costae per 5 mm at the anterior margin. In the ventral valve, the dental plates are low and massive; the teeth are massive. The muscle field is broad, subtriangular, and extends almost to the valve midlength; it is as wide as one-third of the valve width. The myophragm is low

and wide. In the dorsal valve, the cardinal process is multilobed; the brachiophores are massive; the sockets are with fulcral plates. The muscle field is elongated, suboval in outline, and extends for one-third of the valve length. The ridge dividing the anterior and posterior adductors is well pronounced and oblique relative to the myophragm.

Variability. The dorsal valve of rare widest specimens is less inflated than in most of the shells. The sulcus-like depression on the ventral valve is variously developed; it is usually shallow, widened anteriorly, and forms lowly and widely uniplicate anterior commissure. The depression of a few shells is narrower and terminates in a relatively high tongue at the anterior margin.

Comparison. The new subspecies is similar to *Sch.* (*Sch.*) *schnuri schnuri* Struve, 1965 (Struve, 1965, p. 203, pl. 20, fig. 5) in shell shape and size and differs in the shorter posterior margin, lower ventral umbo and area, and in the gentler sulcus-like depression on the ventral valve.

Occurrence. Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone; Transcaucasia.

Material. Seventeen specimens (14 complete conjoined shells, one incompletely preserved ventral valve, and two fragments) from the Nakhchivan AR: upper reaches of the Bagarsykh-Deresi River, outcrop 33, Bed 78; interfluve of the Dzheganzur and Yaidzhi-Deresi rivers, outcrops 1/77, 2/77; village of Gyumushlug, outcrop 80; left bank of the Arpa River in the vicinity of concentrating factory, outcrop 1073a; spurs of the Plakhpashi Mountain Range in the vicinity of the village of Sadarak, outcrop 1414a.

***Schizophoria* (*Schizophoria*) *lata* Alekseeva et Gretchishnikova, sp. nov.**

Plate 3, figs. 1–3; Plate 4, fig. 7; Fig. 33

Etymology. From the Latin *latus* (wide).

Holotype. PIN, no. 3744/506, damaged conjoined shell; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Megasrophia uralensis–Zdimir pseudobaschkiricus* Zone; Nakhchivan AR, southern slope of Velidag Mountain, outcrop 48, Bed 22 (Pl. 3, fig. 1).

Description. The shell is large, from 23 to 33 mm long and up to 25–42 mm wide, transversely elongated to isometric, suboval, and slightly dorsibiconvex. The maximum shell width is at the midlength; it is 1.1–1.2 times greater than the maximum length. The posterior margin is from 13 to 30 mm long and 0.5–0.7 times as wide as the shell. The ventral umbo is low; the ventral area is apsacline, low, up to 4 mm high under the umbo; the delthyrium is open. The dorsal umbo is low; the dorsal area is anacline. The median sulcus-like depression is shallow and usually developed near the anterior margin. External radial ornamentation consists of numerous low, thin, angular, branching, and intercalating costae. The costae are approximately twice as wide as the interspaces, numbering 10–12 per 5 mm at the anterior margin. In the ventral valve, the dental plates are low. The muscle field is narrow, subtriangular, and extends to one-third of the valve length. The myophragm on the valve mold is reflected as a well-pronounced narrow groove. In the dorsal valve, the cardinal process is multilobed; the brachiophores are massive; the sockets are with fulcral plates. The muscle field is subtriangular, well bordered posteriorly, extends to the valve midlength, and occupies almost one-third of the valve width.

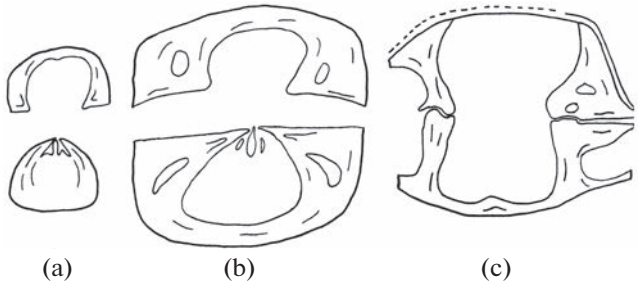


Fig. 33. *Schizophoria* (*Schizophoria*) *lata* Alekseeva et Gretchishnikova, sp. nov.; specimen PIN, no. 3744/510, serial cross sections through the shell; Nakhchivan AR, southern slope of Velidag Mountain, outcrop 48, Bed 22; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobaschkiricus–Megastrphia uralensis* Zone.

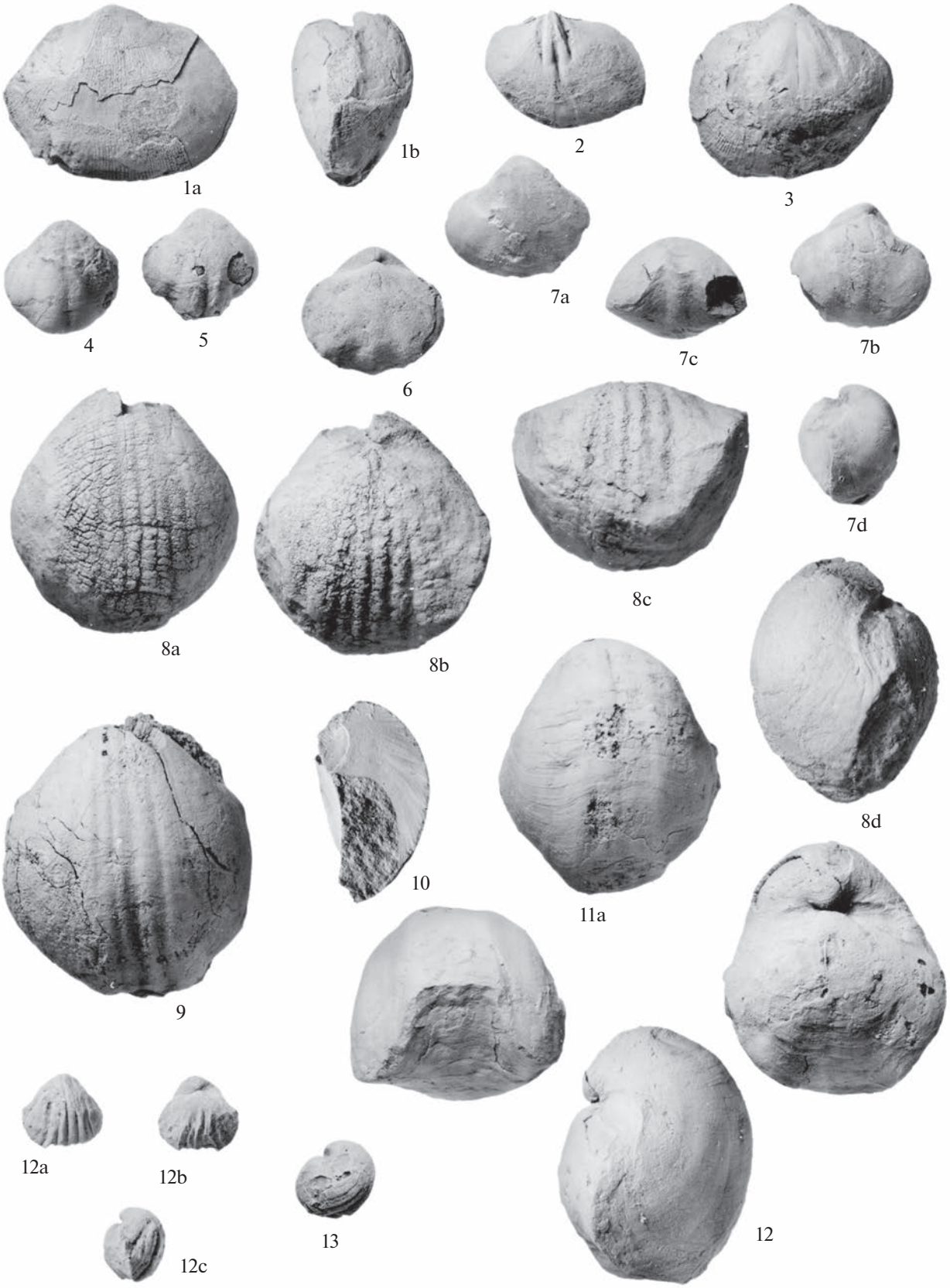
Variability. The shells are usually transversely elongated and 36–42 mm wide. Narrower shells have more convex valves than wider shells. The shells almost isometric in outline are singular.

Comparison. The new species differs from other species of subgenus in the slightly unequally biconvex shell, the thinner external radial ornamentation, small and narrow muscle field in the ventral valve, and large and wide muscle field in the dorsal valve.

Occurrence. Lower Devonian (Emsian)–Middle Devonian (Eifelian), *Megastrophia uralensis–Zdimir pseudobaschkiricus* (Upper Emsian–Lower Eifelian), *Arduspirifer intermedius* (Lower Eifelian), *Alatiformia araxica–Dagnachonetes caucusius* (Middle Eifelian), and *Mucrospirifer diluvianoides–Radiomena irregularis* (Upper Eifelian) zones; Transcaucasia.

Material. Twenty-six specimens (22 incompletely preserved conjoined shells and four fragments) from the Nakhchivan AR: *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone: southern slope of Velidag Mountain, outcrop 48, Beds 9, 10, 16, 22; outcrop 1710; *Arduspirifer intermedius* Zone: southern slope of Velidag Mountain, outcrop 48, Bed 32; *Alatiformia araxica–Dagnachonetes caucasius* Zone: left bank of the Dzhaanam-Deresi River, 1.5 km west of Kazma Mountain, outcrop 57, Bed 5a; *Mucrospirifer diluvianoides–Radiomena irregularis* Zone: southern slope of Velidag Mountain, outcrop 1410.

Plate 3



Order Pentamerida Schuchert et Cooper, 1931

Suborder Pentameridina

Superfamily Gypiduloidea Schuchert et Le Vene, 1929

Family Gypidulidae Schuchert et Le Vene, 1929

Subfamily Gypidulinae Schuchert et Le Vene, 1929

Genus *Gypidula* Hall, 1867

Gypidula: Sapelnikov, 1985, p. 100 (synonymy); Blodgett et al., 2002, p. 1006.

Type species. *Pentamerus occidentalis* Hall, 1858, p. 514; Upper Devonian, Frasnian; North America.

Diagnosis. Shell small to large, subpentagonal in outline, smooth or costate, and ventribiconvex. Ventral beak incurved. Median sulcus and fold well developed. In ventral valve, spondylium small and usually supported by short septum. In dorsal valve, inner hinge plates discrete.

Species composition. Over 40 species; Silurian–Upper Devonian (Frasnian); Eurasia, North America, North Africa, Australia. Transcaucasia: *G.* cf. *biblicata* (Schnur, 1854), *G.* sp.

Comparison. This genus is externally similar to *Sieberella* Oehlert, 1887 and differs in the discrete inner hinge plates, which in *Sieberella* are converging or slightly discrete.

***Gypidula* cf. *biblicata* (Schnur, 1854)**

Plate 3, figs. 4–7; Fig. 34

Gypidula cf. *biblicata*: Belanski, 1928, pl. 3, figs. 1–5; Nalivkin, 1941, p. 155, pl. 2, fig. 11; Khodalevich, 1951, p. 28, pl. 7, fig. 3; Andronov, 1961, p. 32, pl. A, figs. 1–12; Sapelnikov and Mizens, 1984, p. 9, pl. 1, figs. 4 and 6 (synonymy); 2000, p. 23, pl. 4, figs. 8–11.

Description. The shell is small, 20–22 mm long and up to 20–25 mm wide, subtriangular in outline, and strongly ventribiconvex. The maximum shell width is at the midlength; it is 1.1 times greater than the maximum length or they are approximately equal. The ventral umbo is small, gently curved, with incurved beak; the area is absent. The dorsal umbo is somewhat elevated. The ventral valve is relatively strongly inflated, with the maximum convexity in the valve midlength. The sulcus is shallow, narrow, with gentle margins, and developed mainly in the anterior half of valve. The maximum convexity of the dorsal valve is in the posterior half. The fold is developed in the anterior half of the valve and bears two low gentle plicae divided by a shallow groove. Beyond the limits of the median sulcus and fold, each lateral shell side bears two or three poorly pronounced gentle plicae developed mainly in the anterior half of shell. In the ventral valve, there are median septum and spondylium. In the dorsal valve, the inner hinge plates are

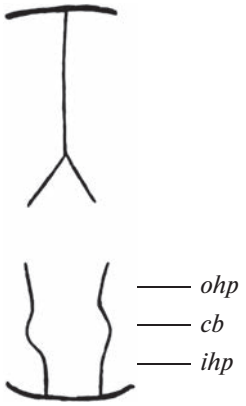


Fig. 34. *Gypidula* aff. *biblicata* (Schnur, 1954), specimen PIN, no. 3744/548, cross section through the shell: (*ihp*) inner hinge plates, (*cb*) crural bases, (*ohp*) outer hinge plates; Armenia, vicinity of the village of Yeraskh, outcrop 1182a; Middle Devonian, Upper Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

Explanation of Plate 3

Figs. 1–3. *Schizophoria* (*schizophoria*) *lata* Alekseeva et Gretchishnikova, sp. nov.: (1) holotype PIN, no. 3744/506, damaged conjoined shell: (1a) ventral valve view; (1b) lateral view; (2) specimen PIN, no. 3744/507, mold of ventral valve; (3) specimen PIN, no. 3744/508, mold of dorsal valve; southern slope of Velidag Mountain, outcrop 48, Bed 22; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobashkiricus–Megastrophia uralensis* Zone.

Figs. 4–7. *Gypidula* cf. *biblicata* (Schnur, 1854): (4) specimen PIN, no. 3744/547, ventral valve; (5) specimen PIN, no. 3744/545, ventral valve; (6) specimen PIN, no. 3744/546, conjoined shell, dorsal valve view; (7) specimen PIN, no. 3744/549, damaged conjoined shell: (7a) ventral valve view; (7b) dorsal valve view; (7c) anterior view; (7d) lateral view; southwestern slope of Karaburun Mountain, outcrop 47, Bed 24; Middle Devonian, Middle Eifelian, *Dagnachonetes caucasius–Alatiformia araxica* Zone.

Figs. 8–10. *Gypidula* sp.: (8) specimen PIN, no. 3744/575, damaged conjoined shell: (8a) ventral valve view; (8b) dorsal valve view; (8c) anterior view; (8d) lateral view; (9) specimen PIN, no. 3744/576, damaged ventral valve; (10) specimen PIN, no. 3744/577, lateral view of ventral median septum; left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 38; Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 11. *Gypidulina grandis* Alekseeva et Gretchishnikova, sp. nov., holotype PIN, no. 3744/563, conjoined shell: (11a) ventral valve view; (11b) dorsal valve view; (11c) anterior view; (11d) lateral view; left bank of the Arpa River near Danzik, outcrop 200, Bed 13; Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Figs. 12 and 13. *Sieberella parva* Alekseeva et Gretchishnikova, sp. nov.: (12) holotype PIN, no. 3744/550, conjoined shell: (12a) ventral valve view; (12b) dorsal valve view; (12c) lateral view; (13) specimen PIN, no. 3744/551, lateral view of damaged conjoined shell; Dagna Mountain, outcrop 68, Bed 9; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

Fig. 35. *Gypidula* sp. 1., specimen PIN, no. 3477/578, cross section through a shell; Nakhchivan AR, left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 38; Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

discrete and the outer hinge plates are directed laterally. The crural bases are moderately convex.

Comparison. This species is similar to *G. comis* (Owen, 1852) from the Upper Devonian of North America and Eurasia in the small shell with inflated valves, but differs in the smaller number and regularly arranged plicae. *G. comis* has up to four variously long and irregularly arranged plicae.

Occurrence. Middle Devonian; Western Europe, Urals. Transcaucasia: Middle Eifelian, *Dagnachonetes caucasius–Alatiformia araxica* Zone.

Material. Seven incompletely preserved conjoined shells from Armenia, southwestern slope of Karaburun Mountain, outcrop 47, Beds 16 and 24.

Gypidula sp.

Plate 3, figs. 8–10; Fig. 35

Description. The shell is large, subpentagonal in outline, somewhat elongated, and strongly unequally biconvex. The maximum shell width (40 mm) is at the midlength or slightly closer to the anterior margin; the maximum length is 43 mm. The posterior margin is slightly shorter than the maximum width, somewhat curved, and indistinctly bordered. The ventral umbo is massive, curved, with an incurved beak. The dorsal umbo is small and slightly elevated. The ventral valve is strongly convex. The fold is indistinctly pronounced, slightly elevated, and well developed only near the anterior margin. The lateral slopes are steep. The dorsal valve is slightly convex. The median sulcus is wide, with flattened bottom, and well pronounced only in the anterior half of the valve. The median sulcus and fold terminate at the anterior margin in a low tongue. External radial ornamentation consists of four or five low, wide costae rounded in cross section. The costae arise slightly anterior to the umbo and are developed only within the median sulcus and fold. The lateral slopes of both valves are smooth. The costae are 3–4 times as wide as the interspaces. In the ventral valve, there are median septum and spondylium. In the dorsal valve, hinge plates are discrete.

Comparison. This species is similar to *G. loweryi* Merriam, 1940, which was described in detail and figured by Johnson (1970, p. 98, pl. 14, fig. 20) from the Lower Devonian, Emsian of North America in shell size and shape and differs from it in the larger and rarer costae on low, poorly developed median sulcus and fold. It differs from the other known species of *Gypidula* in the large shell, strongly inflated ventral valve, and indistinctly pronounced median fold and sulcus.

Occurrence. Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone; Transcaucasia.

Material. Thirteen specimens (two conjoined shells: one without umbo, with damaged outer surface and another with deformed posterior half of the shell; eight ventral and three dorsal incompletely preserved valves) from the Nakhchivan AR, left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 38.

Genus *Gypidulina* Ržonsnitskaja, 1956

Gypidulina: Sapelnikov, 1985, p. 127 (synonymy); Blodgett et al., 2002, p. 1008.

Type species. *Pentamerus optatus* Barrande, 1847; Lower Devonian, Pragian, Koněprusy limestone; Czech Republic.

Diagnosis. Shell medium-sized and large, suboval in outline, and strongly ventribiconvex. Dorsal valve slightly convex. Ventral median fold and dorsal sulcus well to poorly developed. Tongue developed on anterior margin. External radial ornamentation absent. Ventral valve with short median septum and spondylium. Dorsal valve with inner hinge plates converging or fused at valve bottom.

Species composition. Three reliable species; Lower–Middle Devonian; Russia, Czech Republic, Canada, Transcaucasia. Several species were referred to this genus conditionally (Sapelnikov, 1985, p. 129). Transcaucasia: *Gypidulina grandis* Alekseeva et Gretchishnikova, sp. nov.

Comparison. This genus is similar to *Gashaomiaoia* Rong et al., 1985 and *Lysigypa* Havliček et Kukal, 1990 in shell exterior and differs in the presence of fold on the ventral valve and sulcus on the dorsal valve terminating in a tongue at the anterior margin. *Gashaomiaoia* and *Lysigypa* lack a fold and sulcus and their anterior margin is straight. In addition, the inner hinge plates of *Gashaomiaoia* are discrete. *Gypidulina* is similar to *Carinagypa* Johnson et Ludvigsen,

Fig. 36. *Gypidulina grandis* Alekseeva et Gretchishnikova, sp. nov., specimen PIN, no. 3744/564, cross section through the complete shell near dorsal umbo; Nakhchivan AR, left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 38; Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

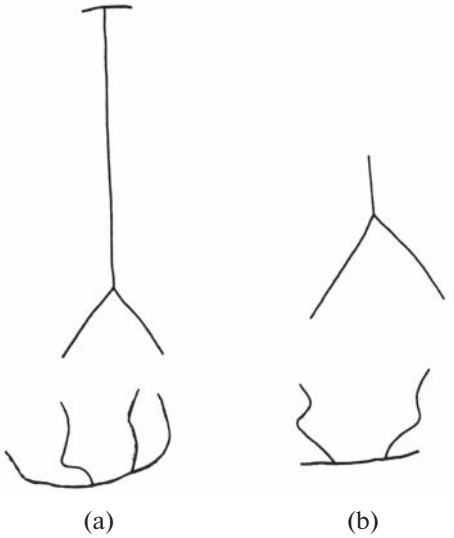


Fig. 37. *Gypidulina grandis* Alekseeva et Gretchishnikova, sp. nov., specimen PIN, no. 3744/565, serial cross sections through the shell; Nakhchivan AR, left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 38; Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

1972 in shell shape and differs in the presence of converging hinge plates in the dorsal valve (hinge plates of *Carinagypa* are discrete).

***Gypidulina grandis* Alekseeva et Gretchishnikova, sp. nov.**

Plate 3, fig. 11; Figs. 36 and 37

Etymology. From the Latin *grandis* (large).

Holotype. PIN, no. 3744/563, conjoined shell; Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone; Nakhchivan AR, outcrop 200, Bed 13 (Pl. 3, fig. 11).

Description. The shell is large, up to 44 mm long and up to 38 mm wide, suboval and elongated in outline, and strongly unequally biconvex. The maximum shell width is at the midlength or somewhat anterior to it. The length to width ratio is 1.15. The umbo of the ventral valve is massive, strongly curved, with the beak almost reaching the dorsal valve. The ventral valve is strongly inflated, with the maximum convexity in the valve midlength, and bears a relatively broad longitudinal flattening in the middle, which terminates near the anterior margin in an indistinctly pronounced fold. The ventral lateral slopes are steep. The dorsal valve is slightly inflated, with the maximum convexity in the posterior half, and bears a shallow and wide sulcus in the anterior half. The sulcus has a flattened bottom and terminates in a relatively high trapezoid tongue at the anterior margin. The shell surface is smooth, with thin concentric growth lines. In the ventral valve, there are short median septum and spondylium. In the dorsal valve, the inner hinge plates converge near the valve bottom in the umbonal region and gradually diverge anteriorly. The outer hinge plates are diverging. The crural bases are convex.

Comparison. The new species is similar to *G. globuliformis* Ivanova, 1962 (Ivanova, 1962, p. 65, pl. 10, figs. 1–5) from the Givetian of the Kuznetsk Depression in shell exterior and differs in the larger elongated shell.

Occurrence. Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone, Lower Givetian, *Stringocephalus burtini* Zone; Transcaucasia.

Material. Seven specimens (two conjoined shells and four incompletely preserved ventral valves) from the Nakhchivan AR: *Mucrospirifer diluvianoides–Radiomena irregularis* Zone: left bank of the Arpa River near the village of Danzik, outcrop 200, Bed 13; outcrop 66, Beds 3 and 6; *Stringocephalus burtini* Zone: left bank of the Arpa River near the village of Danzik, outcrop 19, Beds 38 and 39.

Genus *Sieberella* Oehlert, 1887

Sieberella: Sapelnikov, 1985, p. 125 (synonymy); Blodgett et al., 2002, p. 1013.

Type species. *Pentamerus sieberi* Buch in Barrande, 1847, p. 465, pl. 21, fig. 12; Lower Devonian, Koněprusy limestone; Czech Republic.

Diagnosis. Shell small to large. Posterior margin straight or slightly curved. Fold and sulcus vari-

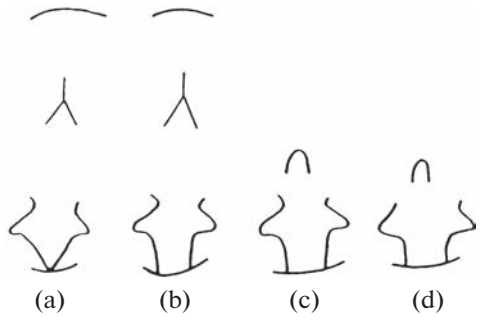


Fig. 38. *Sieberella parva* Alekseeva et Gretchishnikova, sp. nov., specimen PIN, no. 3744/552, serial cross sections through the shell; Nakhchivan AR, southern slope of Dagna Mountain, outcrop 68, Bed 9; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

ously developed. Costae or plicae covering entire shell surface. Ventral valve with median septum and spondylium. Dorsal valve with inner hinge plates slightly discrete to converging, sometimes forming low median septum. Crural bases wide and convex.

Species composition. Over 30 species; Lower–Middle Devonian; Eurasia, North America, North Africa, Transcaucasia. Transcaucasia: *Sieberella parva* Alekseeva et Gretchishnikova, sp. nov.

Comparison. This genus differs from *Gypidulina* Ržonsnitskaja, 1956 in the presence of external radial ornamentation.

***Sieberella parva* Alekseeva et Gretchishnikova, sp. nov.**

Plate 3, figs. 12 and 13; Fig. 38

Etymology. From the Latin *parva* (small).

Holotype. PIN, no. 3744/550, conjoined shell; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobashkiricus–Megastrophia uralensis* Zone; Nakhchivan AR, Dagna Mountain, outcrop 68, Bed 9 (Pl. 2, fig. 12).

Description. The shell is small, up to 13 mm long and 14 mm wide, suboval, transversely elongated in outline, and unequally biconvex. The maximum width is at the midlength; it is 1.07 times greater than the maximum length. The posterior margin is somewhat curved and slightly shorter than the maximum width. The ventral umbo is massive, strongly curved, and apposed to the dorsal umbo, with a small and indistinctly outlined area. The dorsal umbo is small and slightly curved. The ventral valve is relatively strongly inflated, with the maximum convexity in the umbonal region. The fold is low, flattened, and better outlined in the anterior half of the valve. The dorsal valve is less inflated than the ventral valve, with the maximum convexity at the valve midlength. The median sulcus is shallow, narrow, with a flattened bottom, and located anterior to the umbonal region. The anterior margin is ventrally curved, with a wide dentate tongue. External radial ornamentation consists of several angular costae. The costae arise anterior to the umbonal region of both valves and soon dichotomize only once, numbering 3 per 5 mm at the anterior margin. The costae and interspaces are approximately equally wide. The costae in the median fold, sulcus, and lateral slopes are equally sized. The median sulcus and fold bear four costae and each lateral side bears 3 or 4 costae. In the ventral valve, the median septum is short and relatively high; the spondylium is longer than the septum. In the dorsal valve, the inner hinge plates are fused in the umbonal region near the valve bottom and diverge anteriorly. The crural bases are distinctly defined, angular, and convex. The outer hinge plates are short.

Comparison. The new species is similar to *S. bascuscanica* Ržonsnitskaja, 1960 in shell shape and size and differs in the external ornamentation (costae of *S. bascuscanica* are developed only on the anterior half of shell). It is similar to *S. saepiplicata* Sapelnikov et Mizens, 2000 (Sapelnikov and Mizens, 2000, p. 37, pl. 14, figs. 1–5) in the shell exterior and differs in the more inflated shell, higher and massive ventral umbo, and in the fewer costae.

Occurrence. Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone; Transcaucasia.

Material. Six specimens (three complete conjoined shells and three incompletely preserved ventral valves) from the Nakhchivan AR, Dagna Mountain, outcrop 68, Bed 9.

Subfamily Ivdeliniinae Sapelnikov, 1985

Genus *Ivdelinia* Andronov, 1961

Subgenus *Ivdelinia* (*Ivdelinia*) Andronov, 1961

Ivdelinia: Sapelnikov, 1985, p. 119 (synonymy); Boldgett et al., 2002, p. 1013.

Type species. *Gypidula ivdelensis* Khodalevich (Khodalevich, 1951, p. 22, pl. 6, figs. 3, 4); Lower Devonian, Upper Emsian, Karpinsk Horizon, *Favosites regularissimus* Zone; eastern slope of the Urals.

Diagnosis. Shell medium-sized and large, subtriangular and subpentagonal in outline, and strongly ventribiconvex. Ventral valve relatively strongly convex; dorsal valve slightly convex. Ventral fold and dorsal sulcus well developed. External radial ornamentation composed of high costae or plicae angularly rounded in cross section. Ventral valve with median septum and spondylium. Dorsal valve with discrete inner hinge plates and moderately convex crural bases.

Species composition. Over ten species; Lower Devonian–Middle Devonian (Eifelian); Eurasia, North America. Transcaucasia: *I.* (*I.*) *pseudoarata* (Tjazheva, 1960).

Comparison. This subgenus resembles externally *I.* (*Ivdelinella*) Brice (1982a, p. 34) and differs in

the shell outline and shape and the pattern of ribbing. The shell of *Ivdelinella* is suboval and elongated; the fold and sulcus are poorly pronounced; the costae are low, flattened, and rounded in cross section. In addition, *Ivdelinella* lacks a median septum in the ventral valve.

***Ivdelinia* (*Ivdelinia*) *pseudoarata* (Tjazheva, 1960)**

Plate 4, fig. 1

Gypidula pseudoarata: Tjazheva, 1960, p. 308, pl. 77, fig. 6; 1962, p. 27, pl. 7, fig. 6.

Holotype. No. 255/216; Bashkir Republic Geological Fund (Ufa); Middle Devonian, Eifelian, upper part of the Biisk Horizon; western slope of the Urals.

Description. The shell is medium-sized, up to 18.5 mm long and 22 mm wide, transversely oval in outline, and unequally biconvex. The maximum shell width is at the midlength; the width to length ratio is about 1.02. The ventral umbo is massive and relatively strongly curved. The dorsal umbo is small and slightly elevated. The ventral valve is relatively strongly inflated, with the maximum convexity at the valve midlength, and most strongly arched near the posterior margin. The fold is wide, low, flattened, and arises anterior to the umbonal region. The lateral sides of the ventral valve are moderately steep. The dorsal valve is slightly convex and ventrally arched near the anterior margin, with the maximum convexity in the posterior half. The median sulcus is wide, shallow, and starts anterior to the umbonal region. The tongue at the anterior margin is low, wide, and well outlined. The lateral slopes of the dorsal valve are gentle. External radial ornamentation consists of relatively high, clearly defined costae somewhat rounded in cross section. The costae arise slightly anterior to the umbo, numbering approximately 5 on each lateral side, fold, and sulcus and 2.5–3 costae within 5 mm at the anterior margin. The costae are 2–2.5 times as wide as interspaces between them; the largest costae are located on the fold and sulcus and dichotomize at quarter of the valve length from the umbo. The costae on the lateral slopes are simple.

The shell interior is unknown.

Comparison. This species is similar to *I.* (*I.*) *uralensis* Andronov, 1961 (Andronov, 1961, p. 66, pl. 6, figs. 5–9) in shell size and shape and also the character of fold and median sulcus and differs from it in the larger and fewer costae on the lateral shell sides.

Occurrence. Middle Devonian, Eifelian, upper part of the Biisk Horizon; western slope of the Urals. Transcaucasia: Upper Emsian–Lower Eifelian, *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone.

Material. One moderately preserved conjoined shell from the Nakhchivan AR, Dagna Mountain, outcrop 1710.

Fig. 39. *Devonogypa spinulosa* Havliček, 1951, specimen PIN, no. 3744/573, cross section through the shell; Nakhchivan AR, Dzhaanam-Deresi River Basin, outcrop 51, Bed 8; Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Subfamily Devonogypinae I. Breivel et M. Breivel, 1977

Genus *Devonogypa* Havliček, 1951

Gypidula (*Devonogypa*): Havliček, 1951, p. 3; Jux, 1969, p. 77.

Devonogypa: Amsden, 1965, p. 550; Ržonsnitskaja, 1975, p. 39; Sapelnikov, 1985, p. 111; Bodgett et al., 2002, p. 1014.

Type species. *Gypidula* (*Devonogypa*) *spinulosa* Havliček, 1951; Middle Devonian, Givetian; Moravia.

Diagnosis. Shell small and medium-sized, subtriangular in outline, and strongly unequally biconvex. Ventral valve strongly convex, with massive and steeply curved umbo and incurved beak. Fold absent or poorly developed. Dorsal valve considerably less convex than ventral valve. Sulcus absent or poorly pronounced near anterior margin. External radial ornamentation absent. Microornamentation composed of tubercles. Ventral valve with short median septum and spondylium. Dorsal valve with discrete hinge plates.

Species composition. Three species; Middle Devonian; Czech Republic, Germany, Poland, Caucasus, Transcaucasia. Transcaucasia: *Devonogypa spinulosa* Havliček, 1951.

Comparison. This genus is similar to representatives of *Carinagypa* that lack external radial ornamentation and differs from them in the presence of tuberculate microornamentation; it differs from the subgenus *C.* (*Carinagypa*) Johnson et Ludvigsen, 1972 in the absence or poor development of fold and median sulcus; it differs from the subgenus *C.* (*Aseptata*) Brice, 1982 in the presence of a median septum in the ventral valve.

***Devonogypa spinulosa* Havliček, 1951**

Plate 3, figs. 2–4; Fig. 39

Pentamerus globosus Bronn, var. *a*: Gürich, 1896, p. 275, pl. 7, fig. 6.

Gypidula (*Devonogypa*) *spinula*: Havliček, 1951, p. 5, pl. 2, figs. 2, 3, and 5; Biernat, 1966, p. 28, pl. 1, figs. 1–5; pl. 2, fig. 10.

Holotype was not designated.

Description. The shell is large, up to 40 mm long and 38 mm wide, subpentagonal and elongated in

outline, and strongly unequally biconvex. The maximum width is in the anterior half of the shell; the length to width ratio is about 1.05. The posterior margin is shorter than the maximum shell width, slightly curved, and indistinctly outlined. The ventral umbo is massive, with an incurved beak and low area. The ventral valve is strongly and relatively uniformly inflated (uniformly arched in cross section), with the maximum convexity at the valve midlength. The dorsal valve is slightly inflated, with the maximum convexity in the posterior half. The anterior margin is straight. External radial ornamentation is absent. The microornamentation consists of small tubercles arranged in transverse or longitudinal rows. In the ventral valve, there are a short median septum and spondylium. In the dorsal valve, there are discrete inner hinge plates, diverging outer hinge plates, and convex crural bases.

Comparison. This species is most similar to *D. globa* (Bronn, 1853) in shell exterior and differs in the shorter and relatively less massive umbo of the ventral valve.

Occurrence. Middle Devonian; Czech Republic, Poland. Transcaucasia: Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irrgularis* Zone.

Material. Ten specimens (three complete conjoined shells and seven moderately and incompletely preserved ventral valves) from the Nakhchivan AR, Dzhaanam-Deresi River Basin, outcrop 51, Bed 8; outcrop 52, Bed 2; Dzhasy-Deresi River, outcrop 19, Bed 38.

Subfamily Conchidiellinae Ržonsnitskaja, 1961

Genus *Zdimir* Barrande, 1881

Zdimir: Sapelnikov, 1985, p. 132 (synonymy); Boucot et al., 2002, p. 1017.

Type species. *Zdimir solus* Barrande, 1881 (=*Porambonites robustus* Barrande, 1879); Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), Třebotov limestone; Czech Republic.

Diagnosis. Shell large and conchidium-like. Ventral fold and dorsal sulcus absent. External radial ornamentation composed of costae. Ventral valve with median septum and spondylium. Dorsal valve with discrete septal plates.

Species composition. About ten species; Lower Devonian (Upper Emsian)–Middle Devonian; Western Europe, Russia, Transcaucasia, Tien Shan, South China, Japan. Transcaucasia: *Z. triangulicostatus* (Khodalevich et M. Breivel, 1959).

Comparison. This genus is similar to *Zdimerella* Cherkesova, 1973 from the Middle Devonian of the Novaya Zemlya Archipelago and Canada in shell shape and external radial ornamentation and differs in the low and shorter median septum in the ventral valve (ventral septum of *Zdimerella* is high and long).

Zdimir triangulicostatus (Khodalevich et M. Breivel, 1959)

Plate 4, fig. 6

Zdimir triangulicostatus: Sapelnikov and Mizens, 2000, p. 40 (synonymy).

Holotype was not designated.

Description. The shell is large, up to 41 mm long and 51 mm wide, subtriangular and transversely elongated in outline. The maximum shell width is at the midlength; it is 1.2 times greater than the maximum length. The ventral umbo is low and slightly curved; the ventral valve is moderately uniformly inflated, with the maximum convexity at the midlength. The median sulcus and fold are absent. The dorsal and ventral valves are equally inflated; the maximum convexity of the dorsal valve is also at the midlength. The anterior margin is straight. External radial ornamentation is composed of large costae angularly rounded in cross section. The costae are uniform along the whole shell surface and rarely dichotomize, numbering 18–20 on each valve and 1–1.5 costae per

Explanation of Plate 4

Fig. 1. *Ivdelinia* (*Ivdelinia*) *pseudoarata* (Tjazheva, 1960), specimen PIN, no. 3744/560, conjoined shell: (1a) ventral valve view; (1b) dorsal valve view; (1c) lateral view; Dagna Mountain, outcrop 1710; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

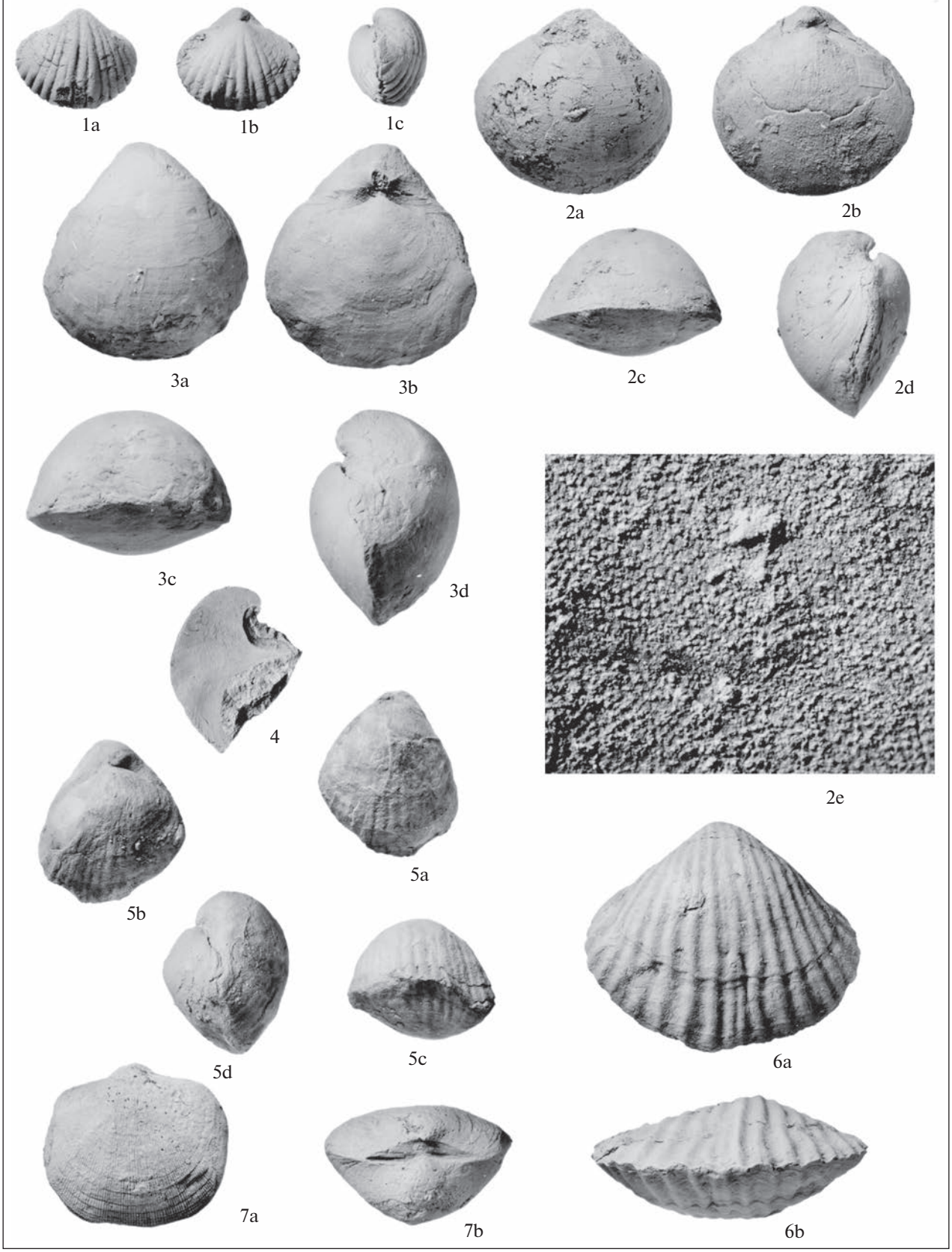
Figs. 2–4. *Devonogypa spinulosa* Havliček, 1951: (2) specimen PIN, no. 3744/570, damaged conjoined shell: (2a) ventral valve view; (2b) dorsal valve view; (2c) anterior view; (2d) lateral view; (2e) microornamentation, ×4; Dzhaanam-Deresi River Basin, outcrop 53, Bed 2; (3) specimen PIN, no. 3744/571, conjoined shell: (3a) ventral valve view; (3b) dorsal valve view; (3c) anterior view; (3d) lateral view; left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 38; (4) specimen PIN, no. 3744/572, lateral view of the ventral median septum; Dzhaanam-Deresi River Basin, outcrop 51, Bed 8; Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 5. *Leviconchidiella vagranica* (Khodalevich, 1951), specimen PIN, no. 3744/ 590, conjoined shell: (5a) ventral valve view; (5b) dorsal valve view; (5c) anterior view; (5d) lateral view; Velidag Mountain, outcrop 1717, Bed 2; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobashkiricus–Megastrophia uralensis* Zone.

Fig. 6. *Zdimir triangulicostatus* (Khodalevich et M. Breivel, 1959), specimen PIN, no. 3744/968, conjoined shell: (6a) ventral valve view; (6b) anterior view; southern slope of Dagna Mountain, outcrop 68, Bed 20; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

Fig. 7. *Schizophoria lata* Alekseeva et Gretchishnikova, sp. nov., specimen PIN, no. 3744/507, conjoined shell: (7a) ventral valve view; (7b) posterior view; southern slope of Velidag Mountain, outcrop 48, Bed 72, outcrop 1710; Lower Devonian (Upper Emsian)–Middle Devonian (Lower Eifelian), *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

Plate 4



5 mm at the anterior margin. The costae and interspaces are equally wide. The shell interior is unknown.

Comparison. This species is similar to *Z. tschumyshensis* (Rzhonsnitskaia, 1960) from the Lower and Middle Devonian of the Kuznetsk Depression and Mongolia in shell exterior and differs in the larger and relatively wider shell and the greater number of costae.

Occurrence. Lower Devonian (Upper Emsian)–Middle Devonian (Eifelian) of the Urals; Upper Emsian–Lower Eifelian, *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone, Lower Eifelian, *Arduspirifer intermedius* Zone of Transcaucasia.

Material. Six specimens (one complete conjoined shell and five incompletely preserved ventral valves) from the Nakhchivan AR: *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone: southern slope of Dagna Mountain, outcrop 68, Bed 20; *Arduspirifer intermedius* Zone: southern slope of Velidag Mountain, outcrop 69.

Genus *Leviconchidiella* Ržonsnitskaja, 1960

Leviconchidiella: Ržonsnitskaja, 1960, p. 301; 1961, p. 47; 1975, p. 17; Amsden, 1965, p. 551; Sapelnikov, 1985, p. 106; Blodgett et al., 2002, p. 1020.

Type species. *Sieberella vagranica* Khodalevich, 1951; Lower Devonian, Upper Emsian; eastern slope of the Urals.

Diagnosis. Shell medium-sized to large, elongated to transversely elongated. Ventral fold and dorsal sulcus indistinctly pronounced. Anterior margin straight or slightly ventrally arched. External radial ornamentation composed of costae roundly flattened in cross section, appearing anterior to smooth umbonal region. Dorsal valve with hinge plates discrete and closely positioned at valve bottom.

Species composition. About ten species; Lower Devonian (Emsian)–Middle Devonian (Eifelian); Urals, Kuznetsk Depression, Tien Shan, Transcaucasia. Transcaucasia: *L. vagranica* (Khodalevich, 1951).

Comparison. This genus differs from other genera of the subfamily in the poorly pronounced median fold and sulcus and in the absence of external radial ornamentation in the posterior region of the shell.

Leviconchidiella vagranica (Khodalevich, 1951)

Plate 4, fig. 5

Sieberella? vagranica: Khodalevich, 1951, p. 39, pl. 8, fig. 7.

Gypidula vagranica: Khodalevich et al., 1959, p. 23, pl. 5, fig. 23.

Conchidiella vagranica: Andronov, 1961, p. 95, pl. 15, figs. 1–11.

Leviconchidiella vagranica: Ržonsnitskaja, 1975, p. 18, pl. 7, figs. 5–9.

Holotype. UGGU (Ural State Mining University), no. 52/38; Lower Devonian, Upper Emsian, Karpinsk Horizon; Northern Urals.

Description. The shell is medium-sized, elongated, up to 30 mm long and 21 mm wide, and unequally biconvex. The maximum shell width is in its anterior half; the maximum length is 1.4 times greater than the maximum width. The ventral umbo is high, massive, and strongly curved. The ventral valve is relatively strongly inflated, with the maximum convexity in the umbonal region. The fold is poorly pronounced at the anterior margin. The dorsal valve is subpentagonal in outline and less inflated than the ventral valve, with a small and curved umbo. The median sulcus is absent. The anterior margin is slightly ventrally curved. External radial ornamentation consists of simple, low costae rounded in cross section, which appear anterior to smooth umbonal region, numbering 15–17 on each valve and 2 per 5 mm at the anterior margin. The costae on the lateral slopes are lower than in the median region.

Comparison. This species is most similar to *L. tenuiplicata* Khodalevich, 1951 (Khodalevich, 1951, p. 37, pl. 28, figs. 3, 4) in shell size and inflated valves and differs in the more elongated shell and larger costae. It is similar to *L. subvagranica* Sapelnikov et Mizens, 2000 (Sapelnikov and Mizens, 2000, p. 25, pl. 5, fig. 10) in shell exterior and differs in the larger and elongated shell, the longer costae, and, hence, the smaller area of smooth shell surface.

Occurrence. Lower Devonian (Emsian)–Middle Devonian (Eifelian); Urals, Kuznetsk Depression. Transcaucasia: Upper Emsian–Lower Eifelian, *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone.

Material. One incompletely preserved, slightly deformed conjoined shell from the Nakhchivan AR, Velidag Mountain, outcrop 1717/2.

Order Rhynchonellida Kuhn, 1949

Superfamily Rhynchotrematoidea Schuchert, 1913

Family Trigonirhynchiidae Schmidt, 1965

Subfamily Trigonirhynchiinae Schmidt, 1965

Genus *Oligoptycherhynchus* Sartenaer, 1970

Oligoptycherhynchus: Sartenaer, 1970, p. 20 (synonymy); Savage, 2002a, p. 1062.

Type species. *Terebratula hexatoma* Schnur, 1851, p. 3; Middle Devonian, Eifelian; Germany.

Diagnosis. Shell medium-sized, ovally pentagonal in outline, and dorsibiconvex. Ventral umbo low and somewhat curved. Median sulcus and fold well developed. External radial ornamentation composed of plicae covering whole shell surface. Median sulcus terminating in tongue at anterior margin. Lateral commissures straight. Ventral valve with dental plates and massive teeth. Dorsal valve with high median septum

dividing umbo into two cavities. Septalium open posteriorly and covered anteriorly. Septal plate with distinctive pit posteriorly. Hinge plates united. Crura crescentic.

Species composition. About ten species; Lower Devonian (Emsian) of Great Britain, Canada; Middle Devonian of Mauritania; Middle Devonian (Upper Eifelian) of Morocco, Europe; Middle Eifelian of Transcaucasia. Transcaucasia: *Oligoptycherhynchus daleidensis* (Roemer, 1844).

Comparison. This genus is externally similar to *Trigonirhynchia* Cooper, 1942 and *Cupularostrum* Sartenaer, 1961 and differs from them in the less convex valves, the fewer plicae, better pronounced tongue, and hinge plates united at the level of crus formation. It differs from *Cupularostrum* in the larger shell, better developed dental plates, sulcus and fold, and hinge plates united at the level of crus formation.

***Oligoptycherhynchus daleidensis* (Roemer, 1844)**

Plate 5, fig. 1; Plate 1, fig. 1a; Plate 14, fig. 12; Fig. 40

Terebratula daleidensis: Roemer, 1844, p. 65, pl. 1, figs. 7a–7c.

Camarotoechia daleidensis: Schmidt, 1941, p. 8, pl. 1, fig. 1.

"*Camarotoechia*" cf. *daleidensis*: Drot, 1964, p. 182, pl. 18, figs. 8a–8c; text-figs. 76 and 77.

Oligoptycherhynchus daleidensis: Sartenaer, 1970, pp. 20–21; 2010, p. 59, pl. 1, figs. 6–10 (synonymy).

Lectotype. No. IRScNBa, Royal Belgian Institute of Natural Sciences, Brussels (Sartenaer, 2010, pl. 1, figs. 6–10); Middle Devonian; Germany, near Daleiden.

Description. The shell is ovally pentagonal in outline, 11–18.8 mm long, 12.2–20.8 mm wide, and 6.6–16.1 mm thick. The maximum width is at the anterior margin; it is 1.1 times greater than the maximum length. The umbo is low and somewhat curved; the beak is not incurved. The posterior margin is ventrally curved. The ventral valve is slightly convex, with the maximum convexity in the anterior third, and flattened in posterior half. The median sulcus starts at the valve midlength, is deep, widened anteriorly, well bordered by the plicae, and terminates in a tongue at the anterior margin. The dorsal valve is strongly convex, with the maximum convexity in the anterior half of valve. The fold is well bordered by plical interspaces and is widened anteriorly. The lateral slopes are almost vertical; the lateral commissures are straight. External radial ornamentation is plicate. The plicae are large, triangular in cross section, and run from the valve umbos, numbering 3 in median sulcus, 4 on the fold, and 7–9 on the lateral sides. The plicae are 0.8–2.3 mm wide and wider than interspaces. In the ventral valve, there are long dental plates. In the dorsal valve, the septum is long and thickened. The septalium is open posteriorly and capped with a cover plate closer to the anterior margin. The hinge plates are united. The crura are crescentic in cross section and curved towards each other.

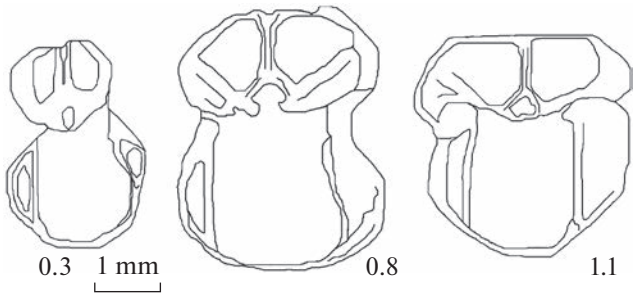


Fig. 40. *Oligoptycherhynchus daleidensis* (Roemer, 1844), specimen PIN, no. 3744/885, serial cross sections through the shell; Nakhchivan AR, left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 29; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone. Hereinafter figures indicate distances from the umbo.

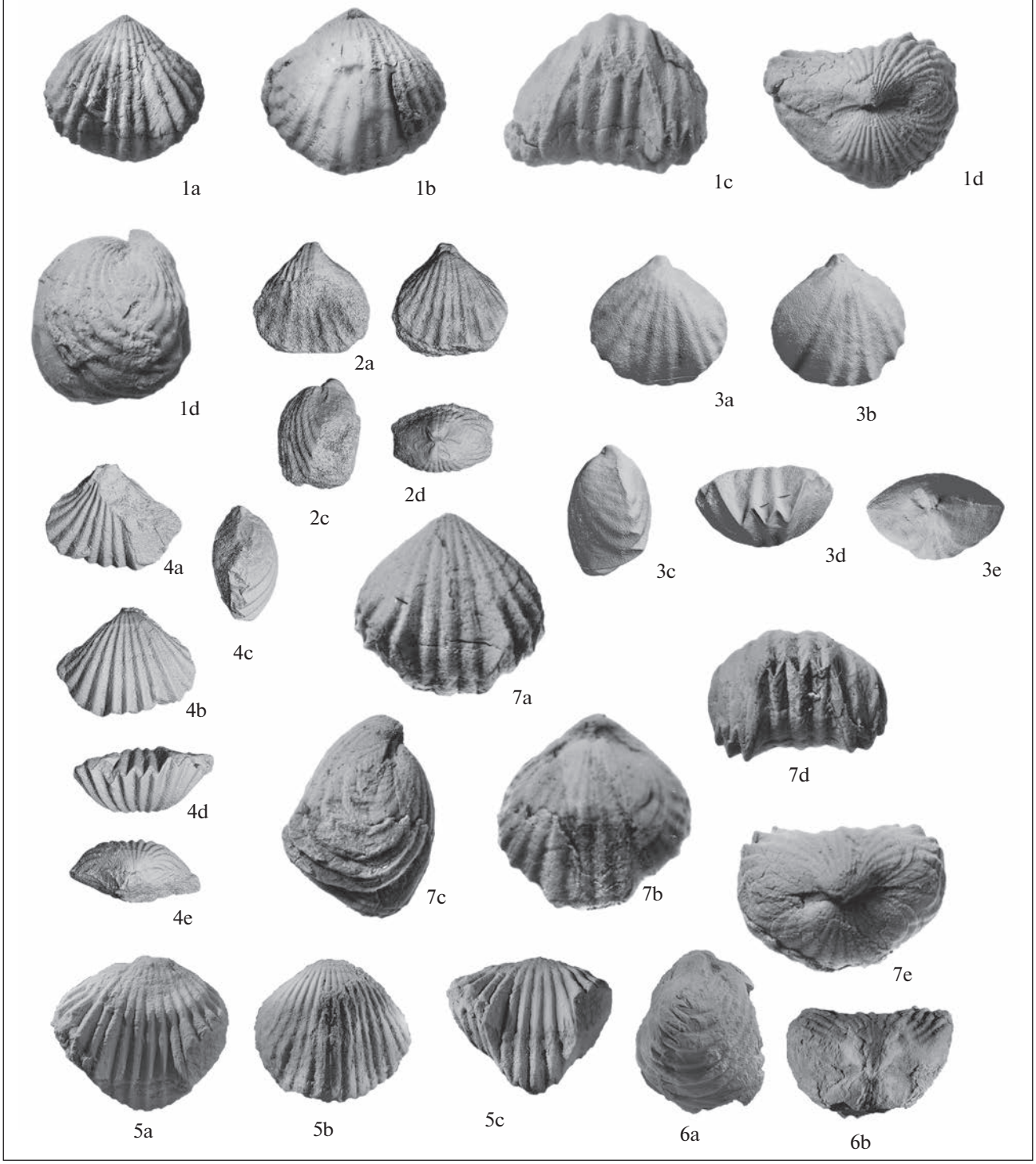
Comparison. This species is similar to the type species *Oligoptycherhynchus hexatoma* Schnur, 1851 and differs in the narrower shell with fewer plicae.

Remarks. *Oligoptycherhynchus daleidensiformis* was first mentioned from the Devonian deposits of Transcaucasia by Mamedov (1962a, 1984) under the name of *Camarotoechia daleidensiformis* sp. nov. He mentioned this species again in the extended abstract of his dissertation (Mamedov, 1962b), with the note "sp. nov." Thus, it remains uncertain when Mamedov established this species. The more so as he did not publish a description, photographs, or thin sections. Therefore, I referred all studied specimens to *O. daleidensis* instead of *O. daleidensiformis*, because it is uncertain, which distinctive features Mamedov ascribed to *O. daleidensiformis*.

Occurrence. Lower Devonian (Emsian) of Great Britain, Canada; Middle Devonian of Mauritania; Middle Devonian (Upper Eifelian) of Morocco, Europe. Transcaucasia: Middle Eifelian (*Alatiformia araxica–Dagnachonetes caucasius* Zone), possibly, Upper Emsian–Lower Eifelian (*Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone).

Material. Seventy-three complete shells, nine ventral, and five dorsal valves, all well preserved, from the Nakhchivan AR: left bank of the Arpa River near the village of Danzik, outcrop 19, Beds 29–30, 32a; right bank of the Arpa River near the village of Danzik, outcrop 603, Bed 18; Saradag Mountain, outcrop 1219b; southern slope of Dagna Mountain near frontier post, outcrop 68, Bed 43; southern slope of Velidag Mountain, outcrop 48, Bed 22; outcrop 69, Bed 24; outcrop 49, Bed 15; Karadash Mountain, 0.75 km southeast of the peak, outcrop 1180; Dagna Mountain, outcrop 1714; Dzhaanam-Deresi River Basin, outcrop 51; vicinity of the village of Danzik, outcrop 1301; Armenia: southwestern slope of Karaburun Mountain, outcrop 47, Bed 16; Karaburun Mountain near the village of Yeraskh, outcrop 1181.

Plate 5


1a
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5a
5b
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6a
6b

Genus *Sinotectirostrum* Sartenaer, 1961

Sinotectirostrum: Sartenaer, 1961, p. 3; Savage, 2002a, p. 1062.

Type species. *Sinotectirostrum medicinale* Sartenaer, 1961, p. 3; Upper Devonian, Famennian; Canada.

Diagnosis. Shell small, ovally pentagonal in outline, transversely elongated, and dorsibiconvex. Ventral umbo small, slightly curved, and covering delthyrium. Median sulcus, fold, and tongue well developed in adults and almost absent in juveniles. External radial ornamentation composed of simple low plicae or costae. Plicae run from valve umbos, widened anteriorly (variously in different species), completely covering shell surface, as wide as, or wider than interspaces. Dental plates short; teeth slightly curved. In dorsal valve, septum long; septalium open posteriorly and covered anteriorly; hinge plates united; crural bases triangular; crura brace-shaped.

Species composition. About ten species; Upper Devonian (Famennian) of Canada, China, the Novaya Zemlya Archipelago, Belarus, Transcaucasia. Transcaucasia: *S. delicatacostatus* (Abramian, 1957), *Sinotectirostrum zobeida* (Nalivkin, 1937), and *Sinotectirostrum* sp.

Comparison. Similar Famennian species within the subfamily Trigonirhynchinae are not known.

Remarks. This genus is externally similar to *Ptychomaletoechia* Sartenaer, 1961 (subfamily Hemitoechiinae), *Ripidiorhynchus* Sartenaer, 1966 (subfamily Ripidiorhynchinae), *Pseudosinotectirostrum* Yudina, 1991 (subfamily Ripidiorhynchinae), *Leptocaryorhynchus* Sartenaer, 1970 (family Leiorhynchidae), *Camarothyridina* Linnik, 1966 (family Ladogiidae), *Orophomesorhynchus* Sartenaer, 2001 (subfamily Ripidiorhynchinae), and *Piridiorhynchus* Sartenaer, 2001 (subfamily Ripidiorhynchinae). It differs from *Piridiorhynchus* in the shorter dental plates, the covered septalium, and united hinge plates. It differs from *Orophomesorhynchus* in the worse developed plicae in the median sulcus and fold, the long septum, presence of septalium, worse developed dental plates, and in the crural bases triangular in cross section. It differs from *Camarothyridina* and *Leptocaryorhynchus* in the nonthickened inner structures, high septum, covered septalium, united hinge plates, and in the shape of crura and crural bases. In addition, it differs from *Camarothyridina* in the presence of thin plicae rather than costae. *Sinotectirostrum* differs from *Pseudosinotectirostrum* in the fewer plicae, short dental plates, covered septalium, united hinge plates, and in the shape of crura and crural bases. It differs from *Ripidiorhynchus* in the less upturned median sulcus, the short dental plates, and in the crural bases triangular in cross section. It differs from *Ptychomaletoechia* in the short dental plates, covered septalium, and united hinge plates.

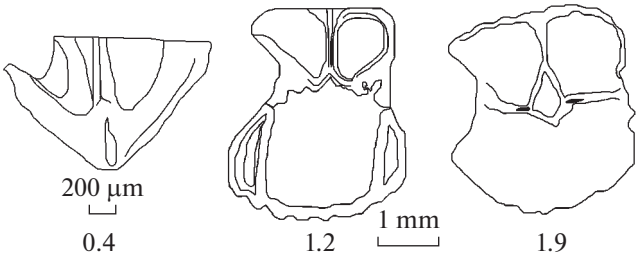


Fig. 41. *Sinotectirostrum delicatacostatus* (Abramian, 1957), specimen PIN, no. 3744/866, serial cross sections through the shell; Nakhchivan AR, vicinity of Kabakhdag Mountain, outcrop 1043a; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

Sinotectirostrum delicatacostatus (Abramian, 1957)

Plate 5, fig. 2; Fig. 41

Camarotoechia delicatacostata: Abramyan, 1957, pp. 53–55, pl. 6, figs. 5–6; Abramyan, 1974a, p. 54, pl. 31, fig. 5.

Explanation of Plate 5

All sizes are natural, except for specially mentioned. Hereinafter, the 3D models of shells were created by X-ray microtomograph from complete shells.

Fig. 1. *Oligoptycherhynchus daleidensis* (Roemer, 1844), specimen PIN, no. 3744/823, complete shell, ×2; Nakhchivan AR, left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 29; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

Fig. 2. *Sinotectirostrum delicatacostatus* (Abramian, 1957), specimen PIN, no. 3744/866, 3D model of complete shell: (2a) ventral valve view; (2b) dorsal valve view; (2c) lateral view; (2d) posterior view; Nakhchivan AR, vicinity of Kabakhdag Mountain, outcrop 1043a; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

Fig. 3. *Sinotectirostrum zobeida* (Nalivkin, 1937), specimen PIN, no. 3744/871; 3D model of complete shell: (3a) ventral valve view; (3b) dorsal valve view; (3c) lateral view; (3d) anterior view; (3e) posterior view; Nakhchivan AR, opposite Kyzyl-Kaya Mountain, outcrop 23, Bed 4; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Fig. 4. *Sinotectirostrum* sp., specimen PIN, no. 3744/853, 3D model of complete shell, ×2: (4a) ventral valve view; (4b) dorsal valve view; (4c) lateral view; (4d) anterior view; (4e) posterior view; Nakhchivan AR, western slope of Myunkh-Bala-Ogly Mountain (right bank of the Arpa River); Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Figs. 5 and 6. *Nymphorhynchia* sp., complete shells: (5) specimen PIN, no. 3744/934; (6) specimen PIN, no. 3744/935; Nakhchivan AR, Saradag Mountain, outcrop 1219; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

Fig. 7. *Sartenaerus letiensis* (Gosselet, 1887), specimen PIN, no. 3744/826, complete shell, ×2: (7a) ventral valve view; (7b) dorsal valve view; (7c) lateral view; (7d) anterior view; (7e) posterior view; Nakhchivan AR, right bank of the Arpa River, opposite the village of Danzik, outcrop 36, Bed 3; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

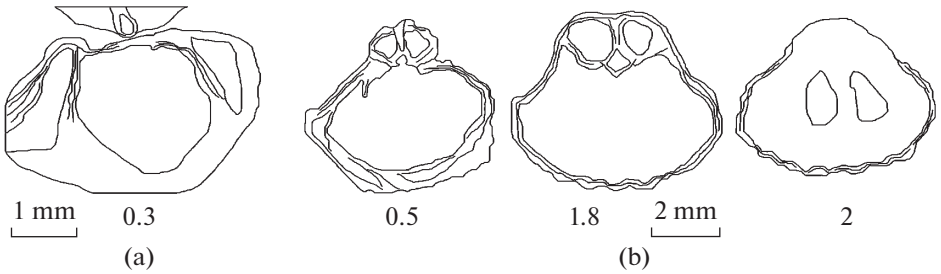


Fig. 42. *Sinotectirostrum zobeida* (Nalivkin, 1937), serial cross sections through the shell: (a) specimen PIN, no. 3744/897; (b) specimen PIN, no. 3744/933; Nakhchivan AR, opposite Kyzyl-Kaya Mountain, outcrop 23, Bed 4; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Holotype. No. f. 1/49, Institute of Geological Sciences, National Academy of Sciences of the Republic of Armenia (Abramyan, 1957, pl. 6, fig. 5); Upper Devonian; Armenia, vicinity of the village of Kadrlu.

Description. The shell is ovally pentagonal in outline, almost equally long and wide, small, 8.2 mm long, 8.3 mm wide, and 5.5 mm thick, and dorsibiconvex. The maximum width is at the anterior margin; the maximum thickness is in the middle of the shell. The median sulcus and fold are poorly pronounced and indistinctly bordered by costae and interspaces; respectively. The costae are simple, triangular in cross section, appear near the valve umbos, cover the whole shell surface, and are thickened anteriorly, numbering 2 in median sulcus, 3 on the fold, and 3–5 on the lateral shell sides. The costae and interspaces are equally wide. The ventral valve contains straight dental plates and long septum. The septalium is covered and medium wide. The hinge plates are united.

Comparison. This species differs from *S. zobeida*, *Sinotectirostrum* sp., and the type species *S. medicinale* in the worse developed radial ornamentation (above-listed species have well-developed plicae). In addition, it differs in the poorly pronounced sulcus and fold. *S. delicatacostatus* is most similar to *S. triangularum* Chen et Yang, 2011 in the poorly pronounced sulcus and fold.

Remarks. The specimen studied is most similar to *Sinotectirostrum delicatacostatus*. However, it is a juvenile shell and, thus, referred to this species tentatively. It differs from *Ptychomaletoechia panderi* (Sem. et Möl., 1864), *Sartenaerus letiensis* (Gosselet, 1887), and *S. charackensis* in the greater number of costae, covered septalium, and united hinge plates.

Occurrence. Upper Famennian, *Sphenospira julii–Spinocarinifera nigra*; Armenia.

Material. One satisfactorily preserved shell from the Nakhchivan AR, vicinity of Kabakhdag Mountain, outcrop 1043a.

***Sinotectirostrum zobeida* (Nalivkin, 1937)**

Plate 5, fig. 3; Fig. 42

Paryphorhynchus zobeida: Nalivkin, 1937, p. 80, pl. 1, figs. 19–21.

Holotype. TSNIGR Museum, no. 277/4261 (Nalivkin, 1937, pl. 11, fig. 21); Upper Devonian, Famennian, Meister Beds; northeastern Kazakhstan.

Description. The shell is medium-sized, dorsibiconvex, transversely elongated and ovally pentagonal in outline, 12.5–13.6 mm long, 13.3–14.5 mm wide, and 8.2–9.3 mm thick. The maximum width and thickness are at the shell midlength. The ventral umbo is slightly curved. The median sulcus and fold are low. The sulcus is well bordered by plicae and the fold is weakly bordered by interspaces. The plicae are simple, triangular in cross section, with smoothed crests, start near the umbos, widened anteriorly, and cover the whole shell surface, numbering 2–3 (usually 2) in the sulcus, 3 on the fold, and usually 5–6 on the lateral sides. The plicae on the fold and sulcus are thicker than on the lateral shell sides. The plicae and interspaces are approximately equally wide. In the ventral valve, dental plates are short and dorsally convergent. In the dorsal valve, the septum is long; the septalium is open posteriorly and covered anteriorly by a ventrally arched cover plate. The hinge plates are united. The crura are parallel to the plane of symmetry.

Comparison. This species differs from *Sinotectirostrum delicatacostatus* (Abramian, 1957) in the presence of plicae and better developed fold and median sulcus.

Remarks. The studied specimens are most similar to *Paryphorhynchus zobeida* and differ in the larger shell. They differ from *Sartenaerus letiensis* (Gosselet, 1887) in the fewer plicae, worse pronounced median sulcus and fold, less convex shells, poorly developed dental plates, covered septalium, and united hinge plates.

Occurrence. Famennian, Meister Beds of northeastern Kazakhstan; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* and *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* zones of the Nakhchivan AR.

Material. Sixteen well-preserved shells and one dorsal valve from the Nakhchivan AR, opposite Kyzyl-Kaya Mountain, outcrop 23, Beds 4, 7.

***Sinotectirostrum* sp.**

Plate 5, fig. 4; Fig. 43

Description. The shell is small, 6.2 mm long, 7.5 mm wide, 3.6 mm thick, ovally pentagonal and transversely elongated in outline, and dorsibiconvex. The maximum shell width and thickness are at the shell midlength. The ventral umbo is erect. The median sulcus and fold are poorly pronounced and indistinctly bordered by plicae and interspaces, respectively. The plicae are simple, triangular in cross section, start from the valve umbos, cover the whole shell surface, and are widened anteriorly, numbering 3 in median sulcus, 4 on the fold, and 7 on the lateral shell sides. The interspaces between plicae are slightly narrower than the plicae. The plicae on the fold, sulcus, and lateral sides are equally thick. The lateral slopes are gentle. In the ventral valve, the dental plates are moderately long and dorsally convergent. In the dorsal valve, the septum is long; the septalium is covered. The hinge plates are united. The crural bases are rodlike and inclined towards each other; the crura are laterally compressed.

Comparison. *Sinotectirostrum* sp. differs from *S. delicatacostatus* (Abramian, 1957) in the greater number of plicae on the median sulcus and fold. It differs from *S. zobeida* (Nalivkin, 1937) in the shell size, the poorly pronounced median sulcus and fold, and somewhat greater number of plicae.

Remarks. The collection includes only one juvenile specimen that is hard to assign to any known species.

Occurrence. Upper Devonian, Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone; Nakhchivan AR.

Material. One well-preserved shell from the Nakhchivan AR, western slope of Myunkh-Bala-Ogly Mountain, right bank of the Arpa River.

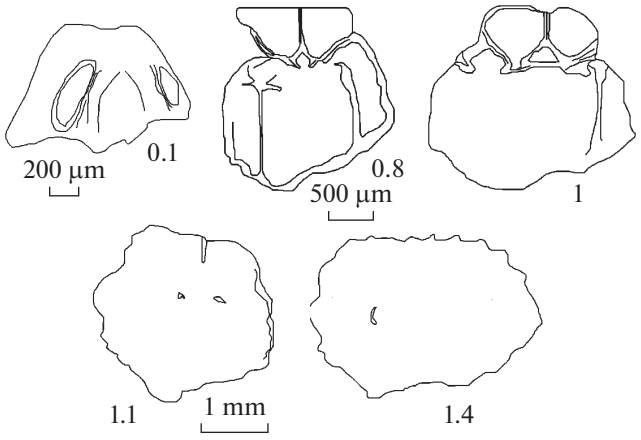


Fig. 43. *Sinotectirostrum* sp., specimen PIN, no. 3744/853, serial cross sections through the shell; Nakhchivan AR, western slope of Myunkh-Bala-Ogly Mountain (right bank of the Arpa River); Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Subfamily Hemitoechiinae Savage, 1996

Genus *Nymphorhynchia* Ržonsnitskaja, 1956

Nymphorhynchia: Ržonsnitskaja, 1956, p. 53; Ržonsnitskaja et al., 1960, p. 242; Savage, 2002a, p. 1070.

Wenxianirhynchus: Zhang Yan, 1983, p. 316.

Type species. *Nymphorhynchia bischofioides* Ržonsnitskaja, 1956, p. 53; Middle Devonian, Eifelian; Kuznetsk Depression.

Diagnosis. Shell large, ovally pentagonal and rhombic in outline, approximately equally long and wide, and dorsibiconvex. Maximum shell width and thickness in middle of shell. Ventral umbo large and curved. Median sulcus and fold well developed, widened anteriorly, well bordered by costae and interspaces, respectively, and terminating at anterior margin in tongue. Anterior margin uniplicate; lateral commissures slightly curved. Lateral slopes gentle. Radial ornamentation costate; costae triangular in cross section, starting from umbos and widened anteriorly. In ventral umbo, dental plates long. In dorsal valve, septum high and long; septalium wide, open, flattened; hinge plates connected to septalium.

Species composition. Over ten species; Upper Silurian (Pridolian)–Middle Devonian (Givetian); Kuznetsk Depression, the Urals, Altai, Mongolia, Canada, Bohemia, China, Middle Asia; Middle Eifelian of Armenia. Transcaucasia: *Nymphorhynchia* sp.

Comparison. Similar representatives of the subfamily Hemitoechinae in the Eifelian beds are not known.

Remarks. This genus is externally similar to *Trigonirhynchia* Cooper, 1942, *Oligoptycherhynchus* Sartenaer, 1970 (subfamily Trigonirhynchiinae), and *Ellesmerhynchia* Brice, 1990 (family Camarotoechiidae). It differs from *Trigonirhynchia* in the gentler lateral slopes, high and long septum, and shallow open septalium. *Nymphorhynchia* differs from *Oligoptycherhynchus* in the open septalium connected to hinge plates. *Nymphorhynchia* differs from *Ellesmerhynchia* in the rarer and more widely spaced costae, the shell shape (*Ellesmerhynchia* has elongated shell), long dental plates, and high septum.

***Nymphorhynchia* sp.**

Plate 5, figs. 5 and 6; Fig. 44

Description. The shell is large, equally long and wide, 15.6–28.4 mm long, 17–27.8 mm wide, and 18.8–24.4 mm thick, rhombic or ovally pentagonal in outline, and dorsibiconvex. The maximum shell width

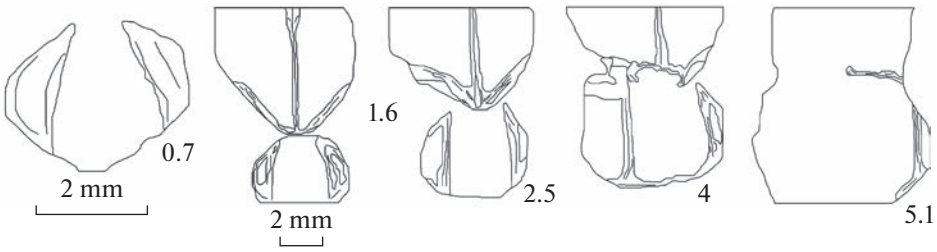


Fig. 44. *Nymphorhynchia* sp., specimen PIN, no. 3744/898, serial cross sections through the shell; Nakhchivan AR, Saradag Mountain, outcrop 1219; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

and thickness are in the middle. The ventral umbo is large, inflated, and curved. The ventral valve is most inflated in the umbonal region. The median sulcus and fold start in the shell midlength, are widened anteriorly, and well bordered by costae and interspaces, respectively. The tongue at the anterior margin is triangular. The dorsal valve is inflated, with the maximum convexity in the middle. The lateral commissures are slightly curved. The lateral slopes are gentle. The costae are wide, dense, triangular or angular in cross section, run from the valve umbos, and are widened anteriorly with the maximum width of 2.6 mm at the anterior margin in the median sulcus and numbering 5–6 in the sulcus, 5–7 on the fold, and 5–7 on the lateral sides. Near the umbos, costae and interspaces are equally wide, but anteriorly the interspaces become wider than costae. The dental plates are long and well separated from the ventral umbonal walls. The dorsal septum is high and long. The septalium is open, shallow, narrow posteriorly and widened and flattened anteriorly. The crural plates have curved margins and are connected to short hinge plates. Crural bases and crura are absent.

Remarks. Available specimens cannot be determined to species due to poor preservation. They are referred to *Nymphorhynchia* based on the shell interior.

Occurrence. Middle Devonian, Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone; Armenia.

Material. Eleven shells, two shell fragments, and four dorsal valves, all satisfactorily preserved, from the Nakhchivan AR, Saradag Mountain, outcrop 1219.

Genus *Sartenaerus* Özdikmen, 2008

Centrorhynchus: Sartenaer, 1970, p. 11; Savage, 2002a, p. 1067.
Sartenaerus nom. nov.: Özdikmen, 2008, p. 345.

Type species. *Camarotoechia baitalensis* Reed, 1922, p. 94; Upper Devonian; Pamir.

Diagnosis. Shell medium-sized, oval to rhombic and elongated to transversely elongated in outline, and dorsibiconvex. Ventral umbo from poorly developed to strongly curved. Delthyrium covered by curvature of dorsal beak. Sulcus, fold, and tongue well developed. Anterior margin uniplicate. External radial ornamentation composed of numerous simple plicae. Plicae running from umbo and covering whole shell surface. Lateral commissures straight. Umbonal walls thickened. Dental plates long, ventrally convergent, and close to walls of ventral umbo. Median septum long and stretching for about one-third of dorsal valve. Septalium open and connected to hinge plates; outside septalium, hinge plates discrete. Crural bases flattened; crura flattened somewhat laterally.

Species composition. About ten species; Upper Devonian (Famennian); Afghanistan, Iran, Turkey, Pamir, China, Morocco, Algeria, Western and Eastern Europe, Russia, Australia, North America, Transcaucasia. Transcaucasia: *Sartenaerus letiensis* (Gosselet, 1887) and *S. charakensis* (Brice, 1967).

Comparison. This genus externally resembles *Ptychomaletoechia* Sartenaer, 1961, *Ripidiorhynchus* Sartenaer, 1966, *Cyphotherorhynchus* Sartenaer, 1965, *Paropamisorhynchus* Sartenaer, 2001, *Orophomesorhynchus* Sartenaer, 2001, and *Piridiorhynchus* Sartenaer, 2001. It differs from *Ptychomaletoechia* in the dental plates inclined along the whole length (dental plates of *Ptychomaletoechia* are vertical and parallel posteriorly and become ventrally convergent only anteriorly) and in the thickened umbonal walls. The crura of *Sartenaerus* are laterally flattened and that of *Ptychomaletoechia* are triangular in cross section. The septalium of *Ptychomaletoechia* is narrower and deeper. However, these genera are similar in the majority of features. *Sartenaerus* differs from externally similar *Sinotectirostrum* in the wider plicae, open septalium, discrete hinge plates, and the crura triangular in cross section. It differs from *Ripidiorhynchus* and *Cyphotherorhynchus* in the wider plicae, open septalium, poorly developed dental plates, discrete hinge plates, and in the crura triangular in cross section. In addition, *Ripidiorhynchus* has a better developed median sulcus and fold. *Sartenaerus* differs from *Paropamisorhynchus* in the same features, but is similar in the triangular crural bases. It differs from *Orophomesorhynchus* in the wider plicae, well-developed and thickened septum, discrete hinge plates, presence of septalium, and in the crura triangular in cross section. It differs from *Piridiorhynchus* in the worse developed median sulcus and fold and the triangular crural bases.

Remarks. *Sartenaerus* is similar to genera of other families in the shell exterior. It differs from *Leptocaryorhynchus* (family Leiorhynchidae) in the presence of a high septum, shallow septalium, absence of outgrowths inclined towards each other along the septalium margins, and in the better developed dental plates. It differs from *Stenaulacorhynchus* (family Leiorhynchidae) in the more convex shell, well developed dental plates, presence of high septum, open septalium, absence of united hinge plates, and brace-shaped crura. It differs from *Gastrodetoechia* (family Leiorhynchidae) in the greater number of plicae on the shell and the shallow septalium. *Sartenaerus* differs from *Megalopterorhynchus* (family Petasmariidae) in the greater number of narrow plicae, shallower septalium, and brace-shaped crura.

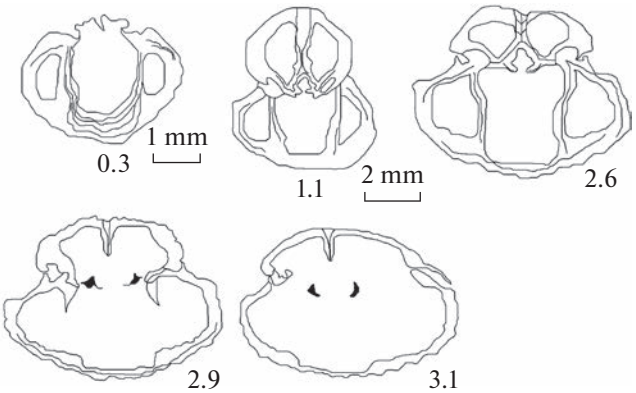


Fig. 45. *Sartenaerus letiensis* (Gosselet, 1887), specimen PIN, no. 3744/899, serial cross sections through the shell; Nakhchivan AR, mouth of the Bagarsykh-Deresi River, outcrop 1076; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Sartenaerus letiensis (Gosselet, 1887)

Plate 5, fig. 7; Fig. 45

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

Camarotoechia letiensis: Abramyan, 1957, pp. 38–41 (synonymy); Abramyan, 1974a, p. 53, pl. 20, fig. 2.

"*Camarotoechia*" *letiensis*: Drot, 1964, pp. 197–201, pl. 22, figs. 7a–7c; text-figs. 85 and 86. (synonymy).

Holotype was not designated.

Description. The shell is small, 13.5–17.7 mm long, 14.5–20.3 mm wide, and 10.5–13.1 mm thick, slightly elongated to transversely elongated and oval to rhombic in outline. The maximum width and thickness are in anterior third of the shell. The ventral umbo is low, curved or slightly curved. The delthyrium is covered by curvature of the dorsal beak. The ventral valve is slightly convex and flattened in the posterior half. The median sulcus is well developed, well bordered by costae, starts at the shell midlength, widened anteriorly, and terminates in trapezoid and anteriorly narrowing tongue. The dorsal valve is convex, with the maximum convexity in the anterior half. The fold is poorly pronounced, weakly bordered by interspaces, and starts at the shell midlength. The lateral slopes are gentle. The lateral commissures are straight. External ornamentation consists of simple, wide, and pointed costae. The costae start from the umbo, widened anteriorly, are up to 1.2–1.5 mm wide at the anterior margin and widest in the median sulcus and fold, numbering 3–5 in the median sulcus, 3–4 on the fold, and 8–11 on the lateral sides. The costae are wider than very narrow interspaces along the whole shell surface. In the ventral valve, the dental plates are ventrally convergent. The dorsal umbo is divided posteriorly by septum into two parts. The septalium is broad. The hinge plates are horizontal. The crural bases are horizontally flattened.

Variability. The number of costae sometimes varies in different regions of the shell.

Comparison. This species differs from *S. charakensis* (Brice, 1967) in the smaller and narrow shell and more pointed costae.

Occurrence. Upper Famennian of the French–Belgian Basin; Upper Devonian of Pamir, Indochina; Famennian, Zones III–IV, possibly Strunian of North Africa; Famennian of Transcaucasia.

Material. 105 shells, three inner molds, six ventral and four dorsal valves, all well preserved, from the Nakhchivan AR: vicinity of the village of Gyumushlug, outcrop 3; right bank of the Arpa River, opposite the village of Danzik, outcrop 36, Beds 1–6; vicinity of the village of Sovetashen, outcrop 2017/1; mouth of the Bagarsykh-Deresi River, outcrop 1076; right bank of the Bagarsykh-Deresi River, outcrop 1096a; lower part of Myunkh-Bala-Ogly Mountain, outcrop 1004a; east of Geran-Kalasy Mountain, outcrop 10, Bed 3; northern slope of Geran-Kalasy Mountain, outcrop 11; southern slope of Birali-Kuzei Mountain, outcrop 1437a; outcrop 1436, Bed b; outcrop 1433; 2.9 km south of Kabakhdag Mountain, outcrop 1045; 0.9 km west–northwest of mountain, with 1146.7 above sea level, outcrop 1042; 1.1 km south of Kabakhdag Mountain, outcrop1143a; left bank of the Arpa River near the village of Gyumushlug, outcrop 1242; Armenia: vicinity of the village of Kadrlu, Arshaki-Akbyur gorge, outcrop 7; Shamaa Midzor gorge, outcrop 6, Bed 30e; north of the village of Kyarki, outcrop 32, Beds 11–13.

Sartenaerus charakensis (Brice, 1967)

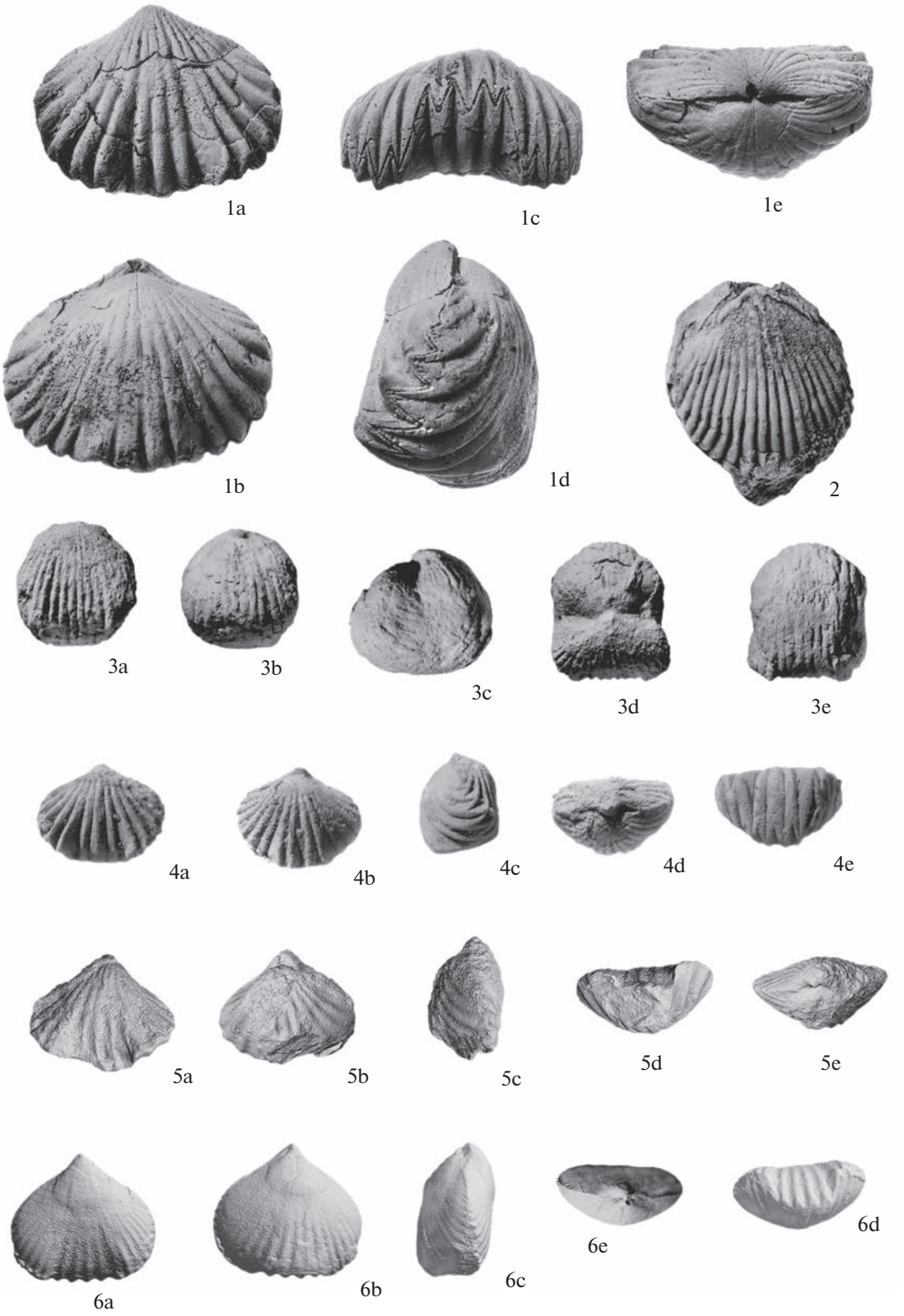
Plate 6, fig. 1; Fig. 46

"*Ptychomaletoechia*" *charakensis*: Brice, 1967, pp. 95–100, pl. 8, figs. 1–6; text-figs. 2–3.

Ptychomaletoechia (?) *charakensis*: Brice, 1970, pp. 22–24, pl. 1, figs. 4a–4e, 5a–5d, 6a–6e, 8; text-fig. 9A (synonymy).

Holotype. No. AF3GK40, Laboratoire de Paléontologie Stratigraphique; Faculté Libre des Sciences et Institut Supérieur d'Agriculture (Brice, 1967, pl. 8, figs. 1–6).

Plate 6


1a
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6d

D e s c r i p t i o n. The shell is small, 20.1 mm long, 23.4 mm wide, 13.5 mm thick, slightly transversely elongated and ovally pentagonal in outline. The maximum width and thickness are in the anterior third of the shell. The ventral valve is slightly convex and flattened in posterior half; the dorsal valve is slightly convex, with the maximum convexity in the anterior half. The median sulcus and fold start in the shell midlength and are well bordered by costae and interspaces, respectively. The sulcus is well developed and widened anteriorly; the tongue is trapezoid and narrows anteriorly. The lateral slopes are gentle. The lateral commissures are straight. External ornamentation is composed of simple, wide, and rounded costae. The costae run from the umbo, widened anteriorly, and only few dichotomize on the lateral sides, numbering 5 in sulcus, 4 on the fold, and 9–10 on the lateral sides. Along the whole shell surface, the costae are wider than extremely narrow interspaces. The costae are 2 mm wide at the anterior margin; the widest costae are located in the median sulcus and fold. The shell interior is similar to that of *S. letiensis* (Gosselet, 1887).

C o m p a r i s o n. This species differs from *S. letiensis* in the larger shell, better outlined median sulcus and fold, and rounded plicae.

O c c u r r e n c e. Upper Devonian of Afghanistan; Famennian of Transcaucasia.

M a t e r i a l. Thirty-four well preserved shells: Nakhchivan AR: vicinity of the village of Danzik, outcrop 15, Bed 17; right bank of the Arpa River, opposite the village of Danzik, outcrop 36, Bed 5; lower part of Myunkh-Bala-Ogly Mountain, outcrop 1004a; mouth of the Bagarsykh-Deresi River, outcrop 1076; right bank of the Bagarsykh-Deresi River, outcrop 1096a; southern slope of Birali-Kuzei Mountain, outcrops 1435, 1436 (Bed 6), 1437a; vicinity of the village of Gyumushlug, outcrop 3; left bank of the Arpa River near the village of Gyumushlug, outcrop 1242; east of Geran-Kalasy Mountain, outcrop 10; vicinity of the village of Kyarki, outcrop 27, Bed 2c; north of the village of Kyarki, outcrop 32, Bed 13; Armenia: Shamaa Midzor gorge, outcrop 6, Bed 30e.

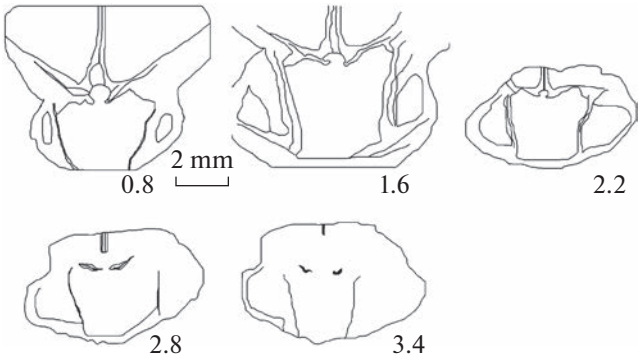


Fig. 46. *Sartenaerus charakensis* (Brice, 1967), specimen PIN, no. 3744/900, serial cross sections through the shell; Nakhchivan AR, southern slope of Birali-Kuzei Mountain, outcrop 1435; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Genus *Paurogastroderhynchus* Sartenaer, 1970

Paurogastroderhynchus: Sartenaer, 1970, p. 25; Savage, 2002a, p. 1073.

T y p e s p e c i e s. *Camarotoechia* (?) *nalivkini* Abramian, 1957, p. 48; Upper Devonian, Upper Famennian; southwestern Armenia.

D i a g n o s i s. Shell large or medium-sized, oval and elongated in outline, strongly inflated, dorsibiconvex, and laterally compressed. Ventral valve flattened, with small and almost erect umbo. Umbos of both valves strongly thickened. Delthyrium covered by curvature of dorsal beak. Median sulcus and fold poorly developed. External radial ornamentation composed of simple costae. Lateral commissures straight. Dental plates ventrally convergent and fused with walls of ventral umbo. Teeth well pronounced and massive; sockets deep. Dorsal median septum

E x p l a n a t i o n o f P l a t e 6

Fig. 1. *Sartenaerus charakensis* (Brice, 1967), specimen PIN, no. 3744/829, complete shell, ×1.5: (1a) ventral valve view; (1b) dorsal valve view; (1c) anterior view; (1d) lateral view; (1e) posterior view; Nakhchivan AR, mouth of the Bagarsykh-Deresi River, outcrop 1076a; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Fig. 2. *Paurogastroderhynchus nalivkini* (Abramian, 1957), specimen PIN, no. 3744/801, inner mold with preserved umbo, ×1.

Fig. 3. *Paurogastroderhynchus nalivkini* (Abramian, 1957), specimen PIN, no. 3744/800, complete shell, ×1: (3a) ventral valve view; (3b) dorsal valve view; (3c) lateral view; (3d) posterior view; (3e) anterior view; vicinity of the village of Danzik, outcrop 15, Bed 22; Upper Famennian, *Paurogastroderhynchus nalivkini* Zone.

Fig. 4. *Ptychomaletoechia panderi* (Sem. et Möl., 1864), specimen PIN, no. 3744/841, complete shell, ×2: (4a) ventral valve view; (4b) dorsal valve view; (4c) lateral view; (4d) posterior view; (4e) anterior view; Nakhchivan AR, Dzhaanam-Deresi River Basin, outcrop 1412b; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

Fig. 5. *Ptychomaletoechia* sp., specimen PIN, no. 3744/872, 3D model of complete shell, ×2: (5a) ventral valve view; (5b) dorsal valve view; (5c) lateral view; (5d) anterior view; (5e) posterior view; Nakhchivan AR, Paiya-dere gorge, Kyzyl-Kaya Mountain; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Fig. 6. *Ripidiorhynchus gnishikensis* (Abramian, 1959), specimen PIN, no. 3744/874, 3D model of complete shell, ×1.5: (6a) ventral valve view; (6b) dorsal valve view; (6c) lateral view; (6d) anterior view; (6e) posterior view; Nakhchivan AR, left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 59; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

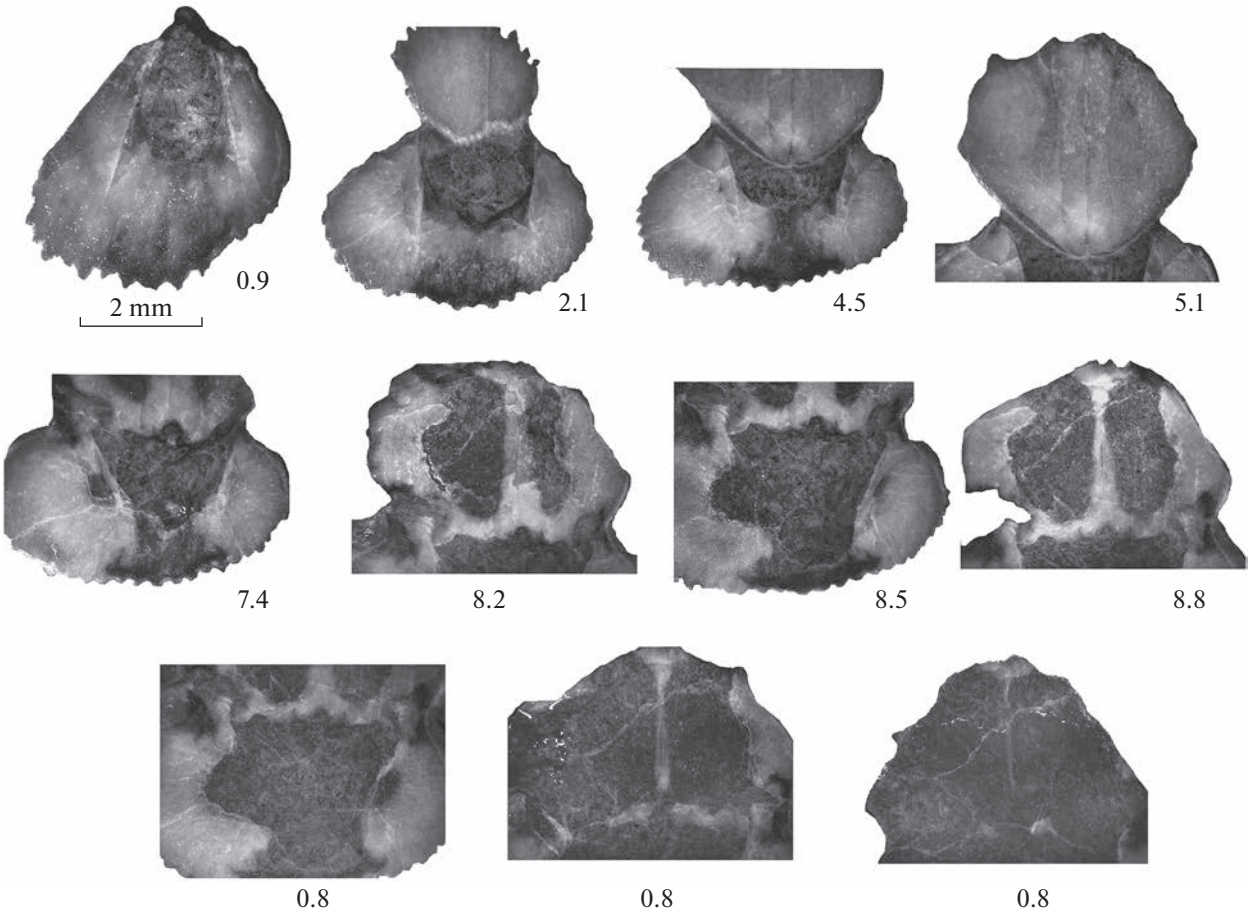


Fig. 47. *Paurogastroderhynchus nalivkini* (Abramian, 1957), specimen PIN, no. 3744/901, serial cross sections through the shell; Nakhchivan AR, right bank of the Arpa River, opposite the village of Danzik, outcrop 36, Bed 2; Upper Famennian, *Paurogastroderhynchus nalivkini* Zone.

fused with thickened umbonal walls posteriorly, strongly thickened, high, and long. Hinge plates discrete. Crura rodlike and oval in cross section. Cavity of ventral valve divided in middle by callus into three parts.

Species composition. Three species; Upper Famennian; Armenia, Nakhchivan AR (*Paurogastroderhynchus nalivkini* Zone), Algeria, Iran, Afghanistan. Transcaucasia: *Paurogastroderhynchus nalivkini* (Abramian, 1957).

Comparison. This genus is well distinguished from the other genera in the shell exterior, primarily in the very steep lateral slopes. It differs from *Pampoecilorhynchus* in the larger shell, strongly nonuniformly thickened valves, poorly developed dental plates, obtuse teeth, and in the crura oval in cross section.

Remarks. *Paurogastroderhynchus* differs from *Paraphorhynchus* Weller, 1905 (family Leiorhynchidae) in the thicker, convex, not elongated shells, strongly thickened shell wall, and very poorly developed dental plates.

***Paurogastroderhynchus nalivkini* (Abramian, 1957)**

Plate 6, figs. 2–3; Plate 14, figs. 9 and 13; Fig. 47

Camarotoechia (?) *nalivkini*: Abramyan, 1957, p. 48, pl. 4, fig. 5; pl. 5, figs. 1–3; Abramyan, 1974a, p. 53, pl. 19, fig. 3; pl. 20, fig. 1.

"*Camarotoechia*" cf. *nalivkini*: Gaetani, 1965, p. 727, pl. 72, figs. 1a–1c; Brice, 1970, p. 76, pl. 4, figs. 3a–3d.

Holotype. No. f 32/47, Institute of Geological Sciences, National Academy of Sciences, Armenia (Abramyan, 1957, pl. 4, fig. 5); Upper Devonian, Upper Famennian; Transcaucasia, Chanakhcha River valley.

Description. The shell is 20.9–30.8 mm long, 19.8–21.7 mm wide, 19.6–23 mm thick, and ovally elongated. The maximum width and thickness are at the shell midlength. The ventral umbo is low and slightly curved. The delthyrium is covered by curvature of the dorsal beak. The ventral valve is moderately convex and flattened, with a shallow sulcus. Shallow median sulcus and fold start in the valve midlength and are indistinctly bordered by costae and interspaces, respectively. The dorsal valve is strongly convex in the middle. The lateral slopes are steep; the lat-

eral commissures are straight. External radial ornamentation consists of 1–2-mm-wide simple costae. The costae run from the umbo, are semicircular in cross section, and widened anteriorly, numbering 5–6 in the sulcus, 6–7 on the fold, and 7–9 on the lateral sides. The costae are wider than interspaces. The valves are thickened along the whole length, including the umbos. The dental plates are fused with walls of the ventral umbo. The dorsal median septum is about one-third of the valve length. The cavity of the ventral valve is divided in the middle by callus into three parts.

Variability. The costae vary in size and number.

Comparison. This species differs from the other species of *Paurogastroderhynchus* in the steep lateral slopes and shell thickness.

Occurrence. Upper Famennian; Armenia, Nakhchivan AR (*Paurogastroderhynchus nalivkini* Zone), Algeria, Iran, Afghanistan.

Material. Forty-three well and satisfactorily preserved shells, 22 ventral and 8 dorsal valves, and 1 shell fragment from the Nakhchivan AR: vicinity of the village of Danzik, outcrop 15, Bed 22; vicinity of Kabakhal Mountain, outcrop 13, Bed 77; right bank of the Arpa River, opposite the village of Danzik, outcrop 36, Bed 2; vicinity of Kabakhdag Mountain, outcrop 1044a; east of Geran-Kalasy Mountain, outcrop 10; Armenia: Arshaki-Akbyur gorge, vicinity of the village of Kadrlu, outcrop 7, Bed 3.

Genus *Ptychomaletoechia* Sartenaer, 1961

Ptychomaletoechia: Sartenaer, 1961, p. 7; Bublichenko, 1976, p. 66; Savage, 2002a, p. 1073.

Type species. *Rhynchonella omaliusi* Gosselet, 1877, p. 314; Upper Devonian, Famennian; Belgium.

Diagnosis. Shell small or medium-sized, dorsibiconvex, and ovally pentagonal in outline. Ventral umbo small, slightly inflated, somewhat curved or almost erect. Posterior margin ventrally curved. Ventral valve with interarea; delthyrium covered by dorsal beak. Fold, sulcus, and tongue well developed. Anterior margin uniplicate. Lateral commissures straight. External radial ornamentation composed of plicae covering whole shell surface. Dental plates parallel or ventrally convergent and stretching along whole ventral umbo. Dorsal septum stretching for one-third of valve length. Septalium open; crural bases triangular in cross section; crura laterally flattened.

Species composition. Over 15 species; Upper Devonian (Famennian)–Lower Carboniferous (Tournaisian); Europe, Altai, Nakhchivan AR, China, Afghanistan, North America. Transcaucasia: *P. panderi* (Sem. et Möl., 1864), *Ptychomaletoechia* sp.

Comparison. This genus closely resembles *Pampoecilorhynchus* Sartenaer, 1968 in the shell exterior and differs in the less inflated shell, the better pronounced fold and sulcus, pointed plicae, and well-developed dental plates.

Remarks. *Ptychomaletoechia* is externally similar to a number of genera of different Famennian subfamilies of the family Trigonirhynchiidae and other rhynchonellid families: *Ripidiorhynchus* Sartenaer, 1966 (subfamily Ripidiorhynchinae), *Orophomesorhynchus* Sartenaer, 2001 (subfamily Ripidiorhynchinae), *Paropamisorhynchus* Sartenaer, 2001 (subfamily Ripidiorhynchinae), *Piridiorhynchus* Sartenaer, 2001 (subfamily Ripidiorhynchinae), *Macropotamorhynchus* Sartenaer, 1970 (subfamily Trigonirhynchiinae), *Sinotectirostrum* Sartenaer, 1961 (subfamily Trigonirhynchiinae), *Leptocaryorhynchus* Sartenaer, 1970 (family Leiorhynchidae), *Rossirhynchus* Gaetani, 1964 (family Leiorhynchidae), *Allorhynchus* Weller, 1910 (family Allorhynchidae). It differs from *Ripidiorhynchus* in the open septalium and the crus shape. It differs from *Sinotectirostrum* in the shell shape, open septalium, well-developed dental plates separated from the umbonal walls, and the tooth shape. It differs from *Orophomesorhynchus* in the presence of small plicae rather than costae on the shell surface, the wider fold and sulcus, the presence of well-developed dental plates, septum, and septalium, and in the laterally flattened crura. It differs from *Paropamisorhynchus* in the smaller shell, smaller plicae, open septalium, discrete hinge plates, and laterally flattened crura. *Ptychomaletoechia* closely resembles *Piridiorhynchus* in shell exterior and interior, but differs in the deeper and longer septalium and laterally flattened crura. It differs from *Macropotamorhynchus* in the well pronounced median sulcus and fold, the open septalium, and discrete hinge plates. It differs from *Leptocaryorhynchus* in the well-developed dental plates, the high septum, absence of outgrowths directed toward each other along the septalium margins, and in the laterally flattened crura. It differs from *Rossirhynchus* in the greater number of narrow plicae, the well-developed long dental plates, deeper septalium, and discrete hinge plates. *Ptychomaletoechia* differs from *Allorhynchus* in the presence of well-developed dental plates, septum, and septalium.

Ptychomaletoechia panderi (Semenov et Möller, 1864)

Plate 6, fig. 4; Fig. 48

Rhynchonella panderi: Semenov and Möller, 1864, p. 213, pl. 2, fig. 7a; Tolmatchow, 1924, p. 123, pl. 5, text-figs. 37–46.

Rhynchonella ponderi: Petts, 1893, p. 62.

Camarotoechia panderi: Nalivkin, 1937, p. 73, pl. 13, figs. 14–19; Rotai, 1941, p. 106, pl. 23, fig. 3; Sarytcheva and Sokolskaja, 1952, p. 164, pl. 46, fig. 249; Simorin, 1956, p. 234, pl. 25, figs. 20–27; Abramyan, 1957, p. 50, pl. 6, figs. 1 and 2; Gladchenko, 1960, p. 106, pl. 17, figs. 1–10; Rozman, 1962, p. 103, pl. 4, figs. 1–8; Aizenverg, 1966, p. 69, pl. 39, figs. 1 and 2; Bogunova, 1971, p. 97, pl. 24, fig. 17; Kalashnikov, 1974, p. 98, pl. 38, figs. 4 and 5; Fotieva, 1985, p. 44, pl. 4, figs. 5 and 6.

Camarotoechia aff. *panderi*: Nefedova, 1955, p. 435, pl. 3, figs. 2–4.

Ptychomaletoechia panderi panderi: Bublichenko, 1976, p. 66, pl. 6, figs. 1a–1d, 2a–2d, 3a–3d, 4a–4d; text-figs. 4 and 5.

Holotype was not designated.

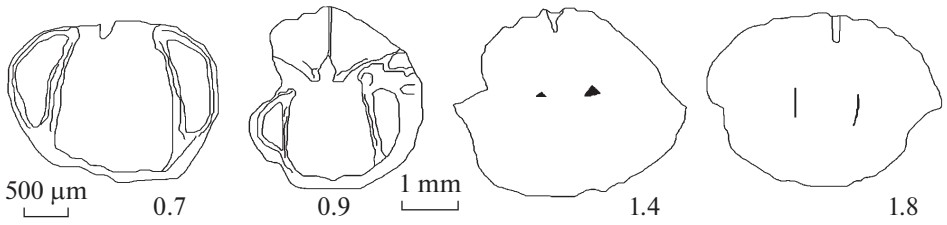


Fig. 48. *Ptychomaletoechia panderi* (Sem. et Möl., 1864), specimen PIN, no. 3744/902, serial cross sections through the shell; Nakhchivan AR, Dzhaanam-Deresi River Basin, outcrop 1412c; Lower Tournaisian, *Unispirifer praeulbanensis–Rhytiophora curtirostris* Zone.

D e s c r i p t i o n. The shell is small, 6.2–11 mm long, 7.3–13.5 mm wide, 4.2–7.5 mm thick, slightly transversely elongated and ovally pentagonal. The maximum width is at the shell midlength. The ventral umbo is small, somewhat inflated, and slightly curved. The posterior margin is ventrally curved. The ventral valve is slightly convex and flattened in posterior half, with the maximum convexity in its anterior third. The median sulcus and fold are well pronounced, well bordered by plicae and interspaces, respectively, widened anteriorly, and terminate at the anterior margin in a well-developed tongue. The dorsal valve is convex, with the maximum convexity in the anterior region. The lateral slopes are gentle; the lateral commissures are straight. External radial ornamentation is composed of medium-sized plicae, numbering 2 or 3 in the sulcus, 3 on the fold, and 4–5 on the lateral sides. The plicae are well developed, triangular in cross section, run from the valve umbos, and are 0.5–1 mm wide and wider than the interspaces. The dental plates are well developed, well separated from the walls of the ventral umbo, and inclined towards each other. The septum is short and runs up to one-third of the shell length.

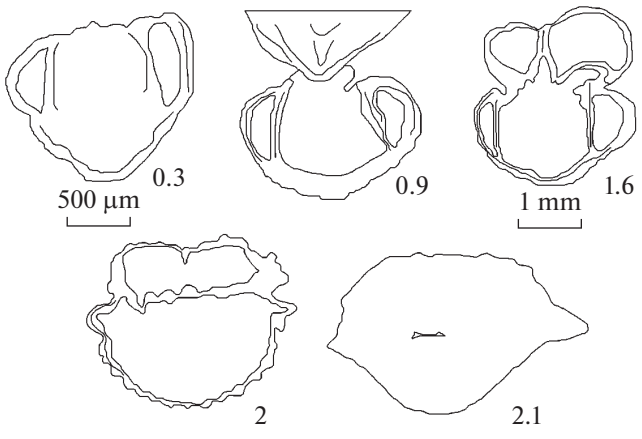


Fig. 49. *Ptychomaletoechia* sp., specimen PIN, no. 3744/872, serial cross sections through the shell; Nakhchivan AR, Paiya-dere gorge, Kyzyl-Kaya Mountain; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri*

C o m p a r i s o n. This species differs from similar *P. omaliusi* (Gosselet, 1877) in the smaller and more elongated shell, and the fewer plicae, including those in the median sulcus, fold, and lateral sides.

O c c u r r e n c e. Upper Famennian, Abyshev Horizon of the Kuznetsk Depression; lowermost Tournaisian of Kazakhstan, Donetsk Basin, Moscow Region, Pechora Urals, Karaganda Basin (Kassin Beds); Lower Tournaisian of the Verkhnyaya Pechora River (Nyamylgskii and Malevo horizons), Kyrgyzstan, Song Kol area (Song Kol Formation); southwestern slope of the Voronezh Anticline (Malevo and Upino horizons); Middle Tournaisian (Bukhtarma Formation) of Rudnyi Altai; Lower Carboniferous of the Kuznetsk Depression; Upper Famennian (*Sphenospira julii–Spinocarinifera nigra* Zone)–Tournaisian (*Unispirifer praeulbanensis–Rhytiophora curtirostris* Zone) of the Nakhchivan AR; probably Famennian of southern Timan.

M a t e r i a l. Forty-one variously preserved shells from the Nakhchivan AR: northeastern slope of Geran-Kalasy Mountain, outcrop 11, Beds 11, 13, 15, and 17; Dzhaanam-Deresi River Basin, outcrops 1412b, 1412c; northwestern end of Myunkh-Bala-Ogly Mountain, outcrop 22, Bed 8; village of Kyarki, outcrop 1431c; Armenia: Arshaki-Akbyur gorge, outcrop 7, Bed 6.

Ptychomaletoechia sp.

Plate 6, fig. 5; Fig. 49

D e s c r i p t i o n. The shell is small, dorsibiconvex, oval and transversely elongated, 8.4 mm long, 10.4 mm wide, and 5.4 mm thick. The maximum width is closer to the anterior margin. The maximum thickness is in the middle of the shell. The ventral umbo is almost erect; the ventral valve is slightly convex. The ventral sulcus and dorsal fold start at the valve midlength, are widened anteriorly, well bordered by plicae and interspaces, respectively, and terminate in a tongue at the anterior margin. The lateral sides are upturned over the tongue. The lateral commissures are straight; the lateral slopes are gentle. External ornamentation consists of simple plicae with obtuse apices in cross section. The plicae run from the umbos, covering the whole shell surface, and are widened anteri-

orly, numbering 3 in the sulcus, 3 on the fold, and 4–5 on the lateral sides. In the median sulcus, the plicae and interspaces are equally wide. The walls of the ventral umbo are thickened. The dental plates are fused with the umbonal walls posteriorly and become separate and parallel anteriorly. The dorsal septum is developed. The septalium is open; the crural bases are triangular in cross section; the crura are laterally flattened.

Comparison and remarks. This specimen is most similar to *Paryphorhynchus zuleika* Nalivkin, 1937 in shell exterior, i.e., ornamentation, shell shape and size; however, the material is insufficient to identify this specimen to species.

Occurrence. Lower Famennian (*Cyrtospirifer asiaticus–Mesoplica meisteri* Zone); Nakhchivan AR.

Material. One well-preserved specimen from the Nakhchivan AR, Paiya-dere gorge, Kyzyl-Kaya Mountain.

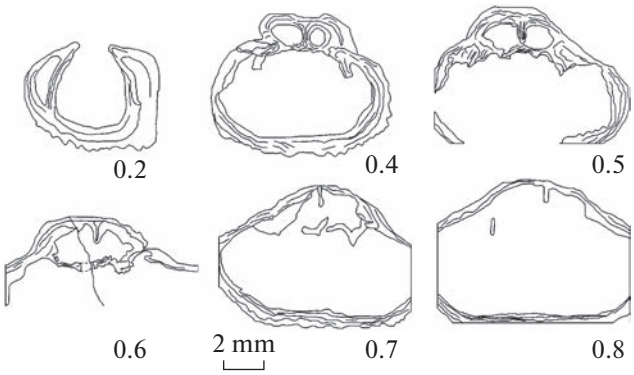


Fig. 50. *Ripidiorhynchus gnishikensis* (Abramian, 1959), specimen PIN, no. 3744/903, serial cross sections through the shell; Nakhchivan AR, left bank of the Arpa River, south of the village of Gyumushlug (interfluve of the Arpa and Yaidzhi-Deresi rivers), outcrop 40, Bed 32; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

Subfamily Ripidiorhynchinae Savage, 1996

Genus *Ripidiorhynchus* Sartenaer, 1966.

Ripidiorhynchus: Sartenaer, 1966b, p. 2; Savage, 2002a, p. 1075.

Type species. *Terebratula livonica* Buch, 1834, p. 57; Upper Devonian; Central Devonian Field.

Diagnosis. Shell medium-sized, dorsibiconvex, isometric or slightly transversely elongated, and ovally pentagonal. Ventral umbo somewhat curved. Median sulcus and fold strongly developed and forming tongue at anterior margin. External radial ornamentation costate. Costae running from umbos, covering whole shell surface, and widened anteriorly; largest costae located in median sulcus and fold. Lateral commissures straight. Anterior margin uniplicate. Ventral umbo with well-developed dental plates. Dorsal valve with low septum. Septalium open posteriorly and covered closer to anterior margin. Hinge plates united; crural bases and crura arched.

Species composition. About seven species; Middle Devonian (Upper Givetian)–Upper Devonian (Lower Famennian) of Asia, Europe, North America, North Africa; Upper Devonian (Frasnian) of the Nakhchivan AR and Armenia. Transcaucasia: *Ripidiorhynchus gnishikensis* (Abramian, 1959) and *Ripidiorhynchus* sp.

Comparison. This genus is externally similar to *Orophomesorhynchus* Sartenaer, 2001, *Poleomesorhynchus* Sartenaer, 2001, *Porthmorhynchus* Sartenaer, 2001, and *Piridiorhynchus* Sartenaer, 2001. It differs from *Piridiorhynchus* in the covered septalium, united hinge plates, the shape of the crura and crural bases. It differs from *Orophomesorhynchus* in the presence of septum, septalium, united hinge plates, and in the crus shape. *Ripidiorhynchus* differs from *Sinotectirostrum* in the better developed and longer dental plates, the shape of crura and crural bases. It differs from *Porthmorhynchus* in the united hinge plates and the shape of crural bases. It differs from *Poleomesorhynchus* in the shape of crura and crural bases.

Remarks. *Ripidiorhynchus* resembles *Leptocaryorhynchus* Sartenaer, 1970 (family Leiorhynchidae), *Cupularostrum* Sartenaer, 1961 (subfamily Trigonirhynchiinae), *Sinotectirostrum* Sartenaer, 1961 (subfamily Trigonirhynchiinae), *Ptychomaletoechia* Sartenaer, 1961 (subfamily Hemitoechiinae), and *Sartenaerus* Özdikmen, 2008 (subfamily Hemitoechiinae). It differs from *Leptocaryorhynchus* in the well-developed dental plates, the high septum, covered septalium, united hinge plates, and the shape of crura and crural bases. It differs from *Cupularostrum* in the better developed dental plates, well separated from the shell walls, the united hinge plates, and the shape of crural bases. It differs from *Sartenaerus* and *Ptychomaletoechia* in the united hinge plates, covered septalium, and in the shape of crura and crural bases. It is closely similar *Sinotectirostrum* in shell exterior and interior, but differs in the long dental plates and arched crural bases and crura.

***Ripidiorhynchus gnishikensis* (Abramian, 1959)**

Plate 6, fig. 6; Plate 14, figs. 6 and 18; Fig. 50

Camarotoechia strugi gnishikensis: Abramyan, 1959, p. 6, pl. 2, figs. 5–7.

Holotype. No. 210/1-54, Institute of Geological Sciences, National Academy of Sciences, Armenia; Upper Devonian; Armenia (Abramyan, 1959, pl. 2, fig. 5).

Description. The shell is medium-sized, almost equally long and wide (9–16.5 mm long, 10–17.3 mm wide, 5–10.7 mm thick), and ovally pentagonal in outline. The maximum width and thickness are near the anterior margin. The ventral umbo is small and somewhat curved. The delthyrium is covered by

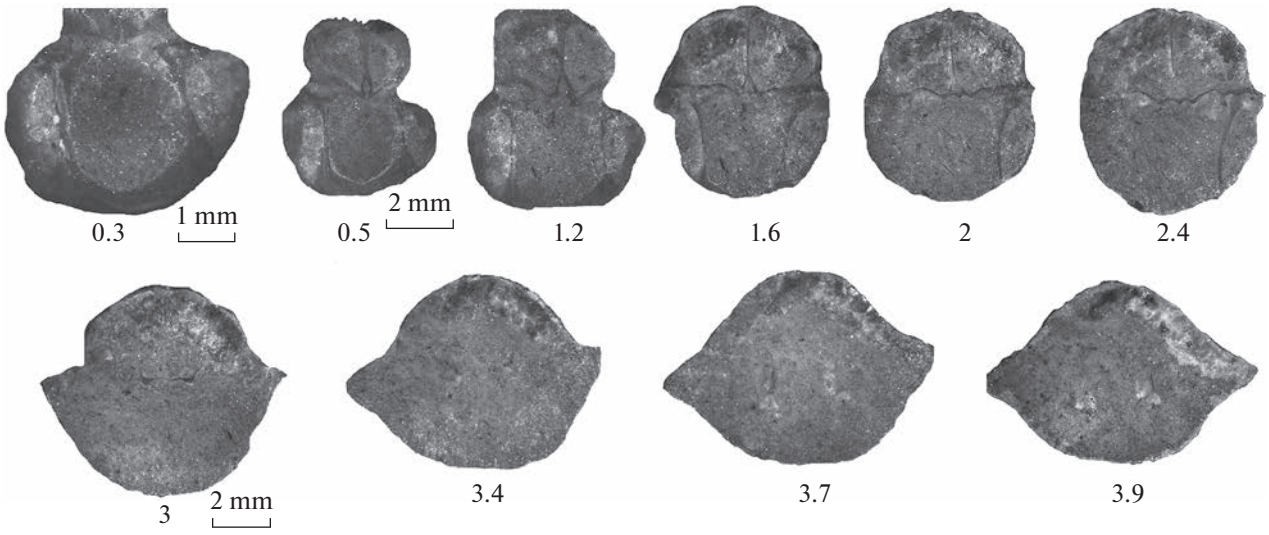


Fig. 51. *Ripidiorhynchus* sp., specimen PIN, no. 3744/904, serial cross sections through the shell; Nakhchivan AR, vicinity of concentrating factory, village of Gyumushlug, outcrop 1155; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

the dorsal beak. The ventral valve is slightly convex. The median sulcus and fold are well pronounced, start at the valve midlength, widened anteriorly, and well bordered by costae and interspaces, respectively. The tongue is low and trapezoid. The dorsal valve is convex, with the maximum convexity at the anterior margin. The lateral slopes are gentle. The lateral commissures are straight. External ornamentation consists of numerous narrow, simple, and triangular costae with acute apices in cross section. The costae run from the valve umbos, thicken anteriorly, especially in the median sulcus and fold, and are 1.2–1.5 mm wide at the anterior margin, numbering 5–6 in the sulcus, 4–7 on the fold, and 10–14 on the lateral sides. The costae and interspaces are equally wide near the umbos; at the anterior margin, the interspaces are wider than the costae. In the ventral valve, the dental plates are short, dorsally convergent, and slightly curved. The teeth are massive. The dorsal septum is short and low. The septalium is narrow, shallow, and covered; the hinge plates are united.

Comparison. All species of *Ripidiorhynchus* are very similar externally. Of Frasnian species, *R. gnishikensis* is most similar to *R. aldoga* (Nalivkin, 1941) and differs in the greater number of costae. It differs from the type species *R. livonicus* (Buch, 1834) and from *R. pskovensis* (Nalivkin, 1941) in the thicker shell and, especially, in the wide median sulcus. It differs from *R. strugi* (Nalivkin, 1941) in the wider median sulcus.

Occurrence. Upper Devonian, Frasnian; Nakhchivan AR, Armenia.

Material. 109 shells, two ventral and one dorsal valves, all well preserved, from the Nakhchivan AR: right bank of the Dzhaanam-Deresi River, 1.5 km east of Tezhgar Mountain, outcrop 601, Beds 53 and 59; left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 59; left bank of the Arpa River, south of the village of Gyumushlug (interfluve of the Arpa and Yaidzhi-Deresi rivers), outcrop 40, Beds 20, 32, 35, 37; right bank of the Arpa River near the village of Gyumushlug, outcrop 1107a; near the village of Gyumushlug, outcrop 250; opposite the village of Danzik, right bank of the Arpa River, outcrop 35, Beds 0 and 4; outcrop 101, Beds 11, 14, 16; Dagna Mountain, outcrop 3514; left bank of the Dzhaanam-Deresi River (lower reaches), near levee, outcrop 61, Beds 6 and 12; right bank of the Bagarsykh-Deresi River, outcrops 1094 and 1096a; upper reaches of the Bagarsykh-Deresi River, outcrops 133 and 134/1; left bank of the Yaidzhi-Deresi River, outcrops 1012, 1032b, and 1032c; left bank of the Arpa River, village of Yaidzhi, outcrop 28/77; vicinity of concentrating factory near the village of Gyumushlug, outcrop 1156; left bank of the Arpa River near the village of Gyumushlug, outcrop 1242.

***Ripidiorhynchus* sp.**

Plate 7, fig. 1; Fig. 51

Description. The shell is medium-sized, 14.3–15.2 mm long, 15.3–17.8 mm wide, 8.3–9.8 mm thick, ovally pentagonal, and slightly transversely elongated or as long as wide. The maximum width and thickness are at the middle of shell. The ventral umbo is low and curved. The posterior margin is curved ventrally. The ventral valve is slightly convex, with the maximum convexity in the umbonal region. The median sulcus is wide, shallow, and starts in the valve midlength. The tongue is moderately elongated and ovally rhombic. The dorsal valve is convex, with the maximum convexity in the middle. The fold starts in the valve midlength, is moderately broad and flat-

tened. The lateral slopes are gentle. The lateral commissures are straight. The anterior margin is uniplicate. Radial ornamentation consists of narrow costae roundly angular in cross section. The costae run from the umbos, cover both valves, are wider than the interspaces, and thickened anteriorly, numbering 5 in the sulcus (2 or 3 central costae are the largest), 4–5 on the fold, and 8–14 on the lateral sides. The largest costae are located in the median sulcus and fold. At the anterior margin, the costae are 1.1–1.4 mm wide in median sulcus and fold and 0.3–0.8 mm wide on the lateral sides. The median sulcus is well bordered by costae, although they are not strongly developed. The fold is bordered by interspaces. The dental plates are straight posteriorly and convergent anteriorly. The teeth are rounded. The septum is low and long. The septalium is open in the most posterior part and covered anteriorly along its whole length. The hinge plates are united and connected to the cover plate of the septalium. The crural bases are rodlike; the crura are laterally flattened.

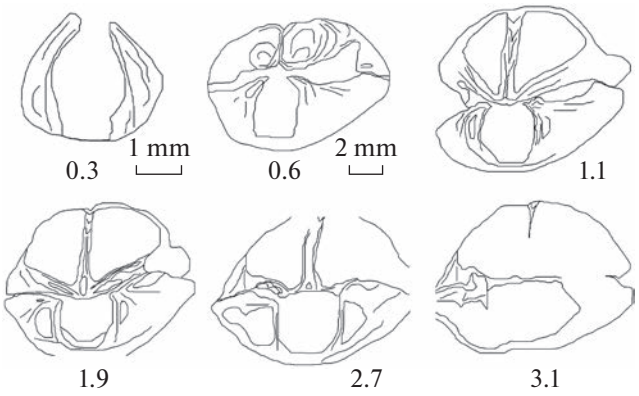


Fig. 52. *Paropamisorhynchus kotalensis* (Brice, 1970), specimen PIN, no. 3744/905, serial cross sections through the shell; Nakhchivan AR, right bank of the Arpa River, near the village of Gyumushlug, outcrop 5, Bed 7; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Comparison. These two specimens differ from the other species of the genus in the more elongated shell, while the shells of other species expand mostly transversely.

Occurrence. Middle Devonian, Upper Givetian, *Indospirifer pseudowilliamsi* Zone; Nakhchivan AR.

Material. Two satisfactorily preserved shells from the Nakhchivan AR, vicinity of concentrating factory in the village of Gyumushlug, outcrop 1155.

Genus *Paropamisorhynchus* Sartenaer, 2001

Paropamisorhynchus: Sartenaer, 2001, p. 201; Savage, 2007, p. 2705.

Type species. *Ripidiorhynchus* (?) *kotalensis*, Brice, 1970, p. 38; Upper Devonian, Frasnian; Afghanistan.

Diagnosis. Shell large and medium-sized, inflated, dorsibiconvex, ovally pentagonal in outline. Ventral umbo small, curved, and protruding beyond posterior margin. Delthyrium covered by dorsal beak. Median sulcus, fold, and tongue well developed. External radial ornamentation composed of numerous simple plicae. Plicae running from umbos and covering whole shell surface. Lateral commissures straight. Dental plates long, parallel, and fused with umbonal walls posteriorly. Teeth elongated. Dorsal median septum thickened. Septalium covered along its whole length. Hinge plates united.

Species composition. Type species; Middle Frasnian–Lower Famennian; Afghanistan, Transcaucasia.

Comparison. This genus differs from *Ripidiorhynchus* Sartenaer, 1966 in the more convex dorsal valve, the plicae triangular in cross section, the high septum, and in the arrangement of dental plates. It is similar to *Cyphoterorhynchus* Sartenaer, 1965, but differs in the larger plicae, the better developed dental plates, and the brace-shaped, nonflattened laterally crura. *Paropamisorhynchus* differs from *Poleomesorhynchus* Sartenaer, 2001 in the larger shell, the crural bases triangular in cross section, and brace-shaped crura. It differs from *Porthmorhynchus* Sartenaer, 2001 in the larger shell and large plicae, the shallower septalium, and absence of V-shaped hinge plate.

Remarks. *Paropamisorhynchus* differs from *Sartenaerus* Özdikmen, 2008 (subfamily Hemitoechiinae) in the covered septalium and united hinge plates. It differs from *Plionoptycherhynchus* Sartenaer, 1979 (family Leiorhynchidae) in the larger plicae, the presence of dental plates, covered septalium, united hinge plates, and brace-shaped crura. It differs from *Bergalaria* Schmidt, 1975 (family Septalariidae) in the higher plicae triangular in cross section, the deeper covered septalium, and in the absence of cardinal process.

Paropamisorhynchus kotalensis (Brice, 1970)

Plate 7, fig. 2; Fig. 52

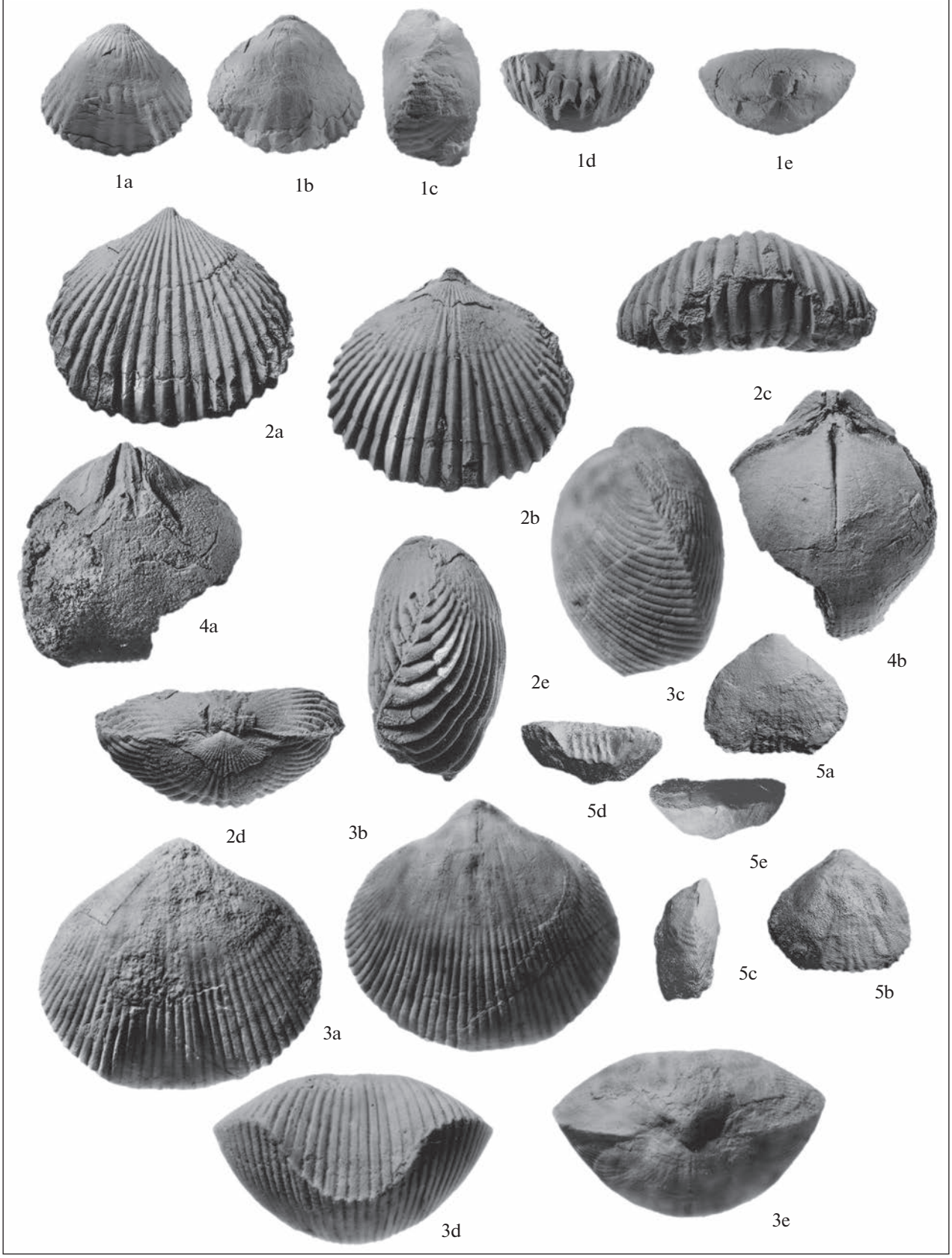
Ripidiorhynchus (?) *kotalensis*: Brice, 1970, p. 38, pl. 2, figs. 1a–1e, 2a–2e, 3a–3e, 4a–4e, 5a–5e; text-figs. 11 and 12.

Paropamisorhynchus kotalensis: Sartenaer, 2001, p. 201.

Holotype. No. AF3GK277, Laboratoire de Paléontologie Stratigraphique; Faculté Libre des Sciences et Institut Supérieur d'Agriculture (Brice, 1970, pl. 2, figs. 1a–1e); Upper Devonian, Frasnian; Afghanistan, Ghor Province.

Description. The shell is medium-sized or large, 20.3–25.7 mm long, 20.6–27.5 mm wide, 13.8–19.4 mm thick, and ovally pentagonal. The maximum shell width is closer to the anterior margin; the maximum thickness is in the shell midlength. The ventral umbo is small, curved, and protrudes beyond the posterior margin. The delthyrium is covered by the dorsal

Plate 7



beak. The ventral valve is slightly convex, with the maximum convexity in the middle. The median sulcus and fold are well pronounced, start from the umbos, are widened anteriorly, and well bordered by the plicae. The tongue is distinct, with a rounded anterior margin. The anterior margin is slightly uniplicate. The dorsal valve is convex, with the maximum convexity in the shell midlength. The fold is well pronounced, starts from the dorsal umbo, expands anteriorly, and is well bordered by plicae. The lateral slopes are gentle. The lateral commissures are straight. External radial ornamentation consists of numerous simple plicae. The plicae are 0.5–2.1 mm wide, start from the umbos, cover the whole shell surface, and are widened anteriorly, numbering 4–6 in the median sulcus and fold and 6–16 on the lateral sides. The widest plicae are located within the sulcus and fold. On the lateral shell sides, the plicae are narrow posterior to the median sulcus or fold. The interspaces are narrower than plicae near the posterior margin and widened anteriorly. The dental plates are well developed, parallel, and long. The dorsal median septum almost reaches the valve midlength. The septalium is covered; the hinge plates are united.

Variability. The plicae on the lateral shell sides vary in number.

Comparison and remarks. This is the only species of the genus. Similar species are also unknown among Frasnian and Lower Famennian rhynchonellids. *P. kotalensis* is similar to *Paurogastroderhynchus presaharensis* Brice in Brice, Legrand-Blain et Nicollin, 2005 in shell exterior and differs in the shell interior: nonthickened shell, well-developed dental plates, presence of septalium, and united hinge plates.

Occurrence. Middle–Upper Frasnian and lowermost Lower Famennian of Afghanistan; Lower Frasnian (*Adolfia zickzack* Zone)–Upper Famennian (*Paurogastroderhynchus nalivkini* Zone) of Transcaucasia.

Material. Thirty well and satisfactorily preserved shells, two ventral and two dorsal valves from the Nakhchivan AR: right bank of the Arpa River, near the village of Gyumushlug, outcrop 85, Beds 11–12, 5, 7, and 10; outcrop 1507/1; left bank of the Arpa River near the village of Gyumushlug, outcrop 1242; right bank of the Arpa River, opposite the village of Danzik, outcrop 36, Beds 1 and 2; right bank of the Dzhaanam-Deresi River, 1.5 km east of Tezhgar Mountain, outcrop 601, Bed 59; vicinity of Kasan-Gulu-Bakh Mountain, outcrop 1228; east of Geran-Kalasy Mountain, outcrop 10a; vicinity of Kabakhdag Mountain, outcrop 1044a; northwestern ending of Myunkh-Bala-Ogly Mountain, outcrop 22, Bed 12; Armenia: Arshaki-Akbyur gorge, vicinity of the village of Kadrlu, outcrop 7, Bed 7.

Genus *Cyphoterorhynchus* Sartenaer, 1965

Cyphoterorhynchus: Sartenaer, 1965, pp. 51–62; Savage, 2002a, p. 1076.

Type species. *Uncinulus* (*Uncinulus*) *koraghensis* Reed, 1922, p. 51. Upper Devonian, Frasnian; northwestern Pakistan, Chitral, Koragh Ridge.

Diagnosis. Shell large, oval, dorsibiconvex, and inflated. Dorsal umbo small and curved. Foramen small. Median sulcus and fold poorly developed and forming tongue at anterior margin. Anterior margin slightly uniplicate. External radial ornamentation composed of numerous closely spaced costae covering whole shell surface. Lateral commissures straight. Dental plates well separated from umbonal walls and occupying most of umbo. Teeth obtuse. Dorsal septum developed; septalium V-shaped, shallow, covered anteriorly. Crural bases triangular in cross section; crura flattened laterally.

Species composition. Thee species; Upper Devonian (Middle–Upper Frasnian); Transcaucasia, Pakistan, Iran, Afghanistan, Libya, Spain. Transcaucasia: *Cyphoterorhynchus arpaensis* (Abramian, 1957).

Explanation of Plate 7

Fig. 1. *Ripidiorhynchus* sp., specimen PIN, no. 3744/936: (1a) ventral valve view; (1b) dorsal valve view; (1c) lateral view; (1d) anterior view; (1e) posterior view; Nakhchivan AR, vicinity of concentrating factory village of Gyumushlug, outcrop 1155; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Fig. 2. *Paropamisorhynchus kotalensis* (Brice, 1970), specimen PIN, no. 3744/828, complete shell, ×2: (2a) ventral valve view; (2b) dorsal valve view; (2c) anterior view; (2d) posterior view; (2e) lateral view; Nakhchivan AR, vicinity of Kabakhdag Mountain, outcrop 1044a; Upper Famennian, *Paurogastroderhynchus nalivkini* Zone.

Fig. 3. *Cyphoterorhynchus arpaensis* (Abramian, 1957), specimen PIN, no. 3744/832, complete shell, ×2: (3a) ventral valve view; (3b) dorsal valve view; (3c) lateral view; (3d) posterior view; (3e) anterior view; Nakhchivan AR, vicinity of the village of Danzik, outcrop 101, Bed 14; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

Fig. 4. *Cyphoterorhynchus arpaensis* (Abramian, 1957), specimen PIN, no. 3744/829, inner shell mold, ×2: (4a) ventral valve view; (4b) dorsal valve view; Nakhchivan AR, south of the village of Gyumushlug (interfluve of the Arpa and Yaidzhi-Deresi rivers), outcrop 40, Bed 35; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

Fig. 5. *Porthmorhynchus ferquensis* (Gosselet, 1887), specimen PIN, no. 3744/875, 3D model of complete shell, ×1: (5a) ventral valve view; (5b) dorsal valve view; (5c) lateral view; (5d) anterior view; (5e) posterior view; Nakhchivan AR, right bank of the Arpa River, opposite the village of Danzik, outcrop 35, Bed 14; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

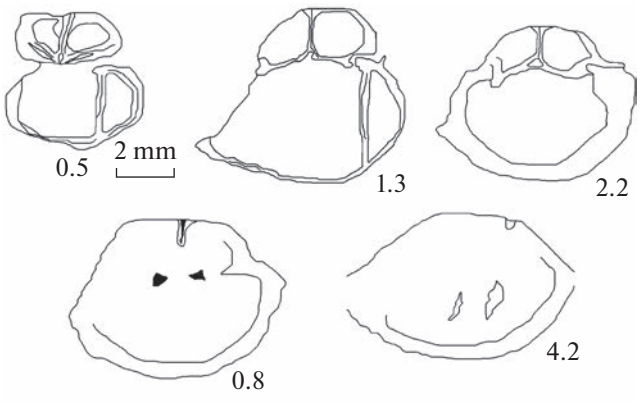


Fig. 53. *Cyphoterorhynchus arpaensis* (Abramian, 1957), specimen PIN, no. 3744/906, serial cross sections through the shell, figures indicate distances from the umbo; Nakhchivan AR, vicinity of the village of Danzik, outcrop 101, Bed 16; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

Comparison. This genus is similar in shell exterior to *Pseudosinotectirostrum* Yudina, 1991, but differs in the worse developed median sulcus and fold, thickened umbo of the ventral valve, and slightly curved dental plates.

Remarks. *Cyphoterorhynchus* differs from externally similar *Hadrotatorhynchus* Sartenaer, 1986 (family Leiorhynchidae) in the numerous distinct costae on the shell surface, the well-developed dental plates, presence of well-developed septalium, and the laterally flattened crura. It differs from *Orbiculatisinurostrum* Sartenaer, 1984 (family Leiorhynchidae) in the better pronounced costae, worse developed median sulcus and fold, well-developed dental plates, and in the covered septalium.

***Cyphoterorhynchus arpaensis* (Abramian, 1957)**

Plate 7, figs. 3 and 4; Plate 14, figs. 7 and 15; Fig. 53

Camarotoechia radiata Nal. (in litt.) var. *arpaensis*: Abramyan, 1957, p. 55, pl. 5, fig. 6.

Cyphoterorhynchus arpaensis: Sartenaer, 1966a, p. 29, pl. 1, figs. 2a–2b, 3a–3e, 4a–4e; pl. 2, figs. 1a–1e; text-fig. 1; (synonymy); Gourvennec, 2006, p. 5, pl. 1, figs. 24–28; Brice, 1970, p. 52, pl. 3, figs. 2a–2c, 4a–4d; text-fig. 14A.

Cyphoterorhynchus koraghensis interpositus: Sartenaer, 1966a, p. 37, pl. 1, fig. 1a–1e.

Camarotoechia radiata arpaensis: Abramyan, 1974a, p. 53, pl. 17, fig. 5.

Holotype. No. 10/46 (Abramyan, 1957, pl. 5, fig. 6); Upper Devonian, Upper Famennian; Transcaucasia, Arpa River Basin.

Description. The shell is dorsibiconvex, oval, slightly transversely elongated or equally wide and long (20.4–28.2 mm long, 21.2–28.2 mm wide, and 14.4–21.1 mm thick). The maximum width and thickness are in the middle of the shell. The ventral umbo is small and curved. The delthyrium is covered by the dorsal beak. The ventral valve is moderately convex and flattened anterior to the umbo. The median sulcus starts in the anterior one-third of the valve, is widened gradually anteriorly, and usually indistinctly bordered by costae. The tongue is medium high. The maximum convexity of the dorsal valve is its middle. The fold starts in the anterior one-third of the shell, is widened slightly anteriorly, and weakly bordered by the costal interspace interspaces. The lateral slopes are gentle. The lateral commissures are straight. External radial ornamentation consists of numerous simple, closely spaced costae rounded in cross section. The costae run from the umbos and expand anteriorly, numbering 10–14 in the sulcus, 10–12 on the fold, and from 16 to 25 on each lateral side. The costae are equally wide or wider than interspaces; from 0.6 to 1.6 mm wide in the median sulcus or fold; the costae on the lateral sides are thinner than in the median sulcus and especially on the fold. In the ventral valve, the umbonal walls are thickened; the dental plates are well separated from the lateral umbonal walls. The teeth are shaped as low obtuse nodes. In the dorsal valve, the median septum is thick posteriorly, thinners anteriorly, and runs for one-third of the dorsal valve. The septalium is covered by a plate closer to the anterior margin.

Variability. The shell varies in width. In the description of *C. koraghensis interpositus* Sartenaer, 1966, Sartenaer (1966a) noted that it is transitional between *C. arpaensis* and *C. koraghensis* (Reed, 1922), particularly since the subspecies occurs in the same deposits as both species. The specimens from our collection are similar to *C. koraghensis interpositus* in the number of costae in the median sulcus and fold and shell width, fall within the variation range of *C. arpaensis* and are referred to this species.

Only one specimen has single dichotomizing costa in the median sulcus and fold. The dental plates are variously remote from the walls of the ventral umbo.

Comparison. This species differs from *Cyphoterorhynchus koraghensis* in the larger shell, the shell shape, and the number of costae on the fold and median sulcus.

Occurrence. Upper Frasnian Substage, Bagarsykh Horizon, *Adolfia zickzack* and *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* zones of Transcaucasia; Famennian of Armenia; Upper Frasnian of Iran and Belgium.

Material. Well and satisfactorily preserved 444 shells, three ventral and 25 dorsal valves, and one shell fragment: Nakhchivan AR: vicinity of the Dzhaanam-Deresi River, outcrop 601, Beds 53, 59, 56, 67, 64, 69, and 72; village of Gyumushlug, outcrop 250; village of Danzik, outcrop 101, Beds 11, 14–16; Kabakhdag Mountain, upper reaches of Dava-Olan Creek, outcrop 1253a; Dagna Mountain, outcrop 3514; left bank of the Arpa River, south of the village of Gyumushlug, interfluve of the Arpa and Yaidzhi-Deresi rivers, outcrop 40, Beds 11, 16c, 20, 32–37; near the village of Gyumushlug, outcrop 42, Bed 11; right bank

of the Arpa River near the village of Gyumushlug, outcrop 35, Bed 0; outcrops 1107a, 1107b; left bank of the Arpa River near the village of Danzik, outcrop 19, Beds 54 and 57; right bank of the Bagarsykh-Deresi River, outcrops 1093a, 1094, 1096a, and 1418; left bank of the Arpa River, downstream from the village of Gyumushlug, outcrops 1067 and 1071; left bank of the Yaidzhi-Deresi River, outcrops 1012, 1032a, 1032b, 1032c, and 1034; left bank of the Arpa River, village of Yaidzhi, outcrop 28/77; interfluve of the Arpa and Yaidzhi-Deresi rivers, outcrop 30-6/77; north-northeast of the village of Yaidzhi, outcrop 1066c; upper reaches of the Bagarsykh-Deresi River, outcrops 133 and 134/1; vicinity of concentrating factory near the village of Gyumushlug, outcrops 1156 and 1157; left bank of the Arpa River near the village of Gyumushlug, outcrop 46, Bed 21; left bank of the Arpa River near the village of Gyumushlug, outcrop 1242.

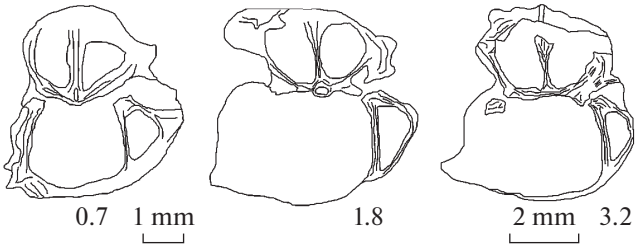


Fig. 54. *Porthmorhynchus ferquensis* (Gosselet, 1887), specimen PIN, no. 3744/907, serial cross sections through the shell; Nakhchivan AR, right bank of the Arpa River, opposite the village of Danzik, outcrop 35, Bed 14; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

Genus *Porthmorhynchus* Sartenaer, 2001

Porthmorhynchus: Sartenaer, 2001, p. 206; Savage, 2007, p. 2705.

Type species. *Rhynchonella ferquensis* Gosselet, 1887, p. 199; Upper Devonian, Middle Frasnian; northern France.

Diagnosis. Shell medium-sized, dorsibiconvex, and ovally pentagonal in outline. Ventral umbo small, low, and erect. Fold, sulcus, and tongue well developed. External radial ornamentation composed of smoothed and closely spaced costae covering whole shell surface. Lateral commissures straight. Dental plates short and located close to walls of ventral umbo. In dorsal valve, septum short; septalium open posteriorly and covered anteriorly. Hinge plates united posteriorly at level of covered septalium and then divided into two.

Species composition. Type species; Upper Devonian, Middle–Upper Frasnian; Europe, Altai, Afghanistan, Iran. Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone of the Nakhchivan AR.

Comparison. This genus is externally similar to various costate or covered with numerous small plicae Frasnian rhynchonellids. It is closely similar to *Cyphoterorhynchus* Sartenaer, 1970 and differs in the smaller shell, the better pronounced median sulcus and fold, and discrete hinge plates. *Porthmorhynchus* differs from *Ripidiorhynchus* Sartenaer, 1966 in the worse pronounced sulcus, fold, and tongue, closely spaced costae, and divided hinge plate. It differs from *Paropamisorhynchus* Sartenaer, 2001 in the smaller shell, small costae on the shell surface, and discrete hinge plate. *Porthmorhynchus* differs from *Poleomesorhynchus* Sartenaer, 2001 in the discrete hinge plate.

Remarks. *Porthmorhynchus* resembles *Comiotoechia* Ljaschenko, 1973 (family Ladogiidae) and *Semiotoechia* Ljaschenko, 1973 (family Ladogiidae) in ribbing pattern and differs in the nonthickened inner structures and long discrete hinge plates. In addition, it differs from *Comiotoechia* in the well-developed dental plates. This genus differs from *Cupularostrum* Sartenaer, 1961 (subfamily Trigonirhynchiinae) in the transversely elongated shell, the presence of costae rather than plicae, and the discrete hinge plate.

Porthmorhynchus ferquensis (Gosselet, 1887)

Plate 7, fig. 5; Fig. 54

Rhynchonella ferquensis: Gosselet, 1887, p. 199.

Ripidiorhynchus farsani: Brice in Brice and Farsan, 1977, p. 227.

Porthmorhynchus ferquensis: Sartenaer, 2001, p. 200.

Lectotype. Figured by Savage (2007 (text-fig. 1802d); Upper Devonian, Middle Frasnian; France, Boulogne.

Description. The shell is small, transversely elongated, 14.7–18.5 mm long, 17.4–20.7 mm wide, 9.3–20.8 mm thick, and ovally rhombic or ovally pentagonal in outline. The maximum width and thickness are in the middle of the shell. The ventral umbo is low and erect; the ventral valve is slightly convex. The median sulcus starts at the shell midlength, is widened anteriorly, well bordered by costae, and terminates in a trapezoid tongue. The dorsal valve is convex, with the maximum convexity in the umbonal region. The fold is well pronounced, bordered by costal interspace interspaces, starts in the shell midlength, and is obtuse at the anterior margin. The lateral slopes are gentle; the lateral commissures are straight. External ornamentation consists of numerous simple, closely spaced costae, oval and smoothed in cross section. The costae run from the umbo and expand anteriorly, numbering 7–8 in the sulcus, 6–8 on the fold, and 9–18 on the lateral sides. The costae are up to 1.3 mm wide at the anterior margin and along the whole shell surface wider than extremely narrow interspaces; the widest costae are located in the median sulcus and fold. In the ventral valve, the dental plates are arched. The dorsal septum divides the umbo into two parts posteriorly. The septalium is wide, open closer to the posterior margin and covered anteriorly. The hinge

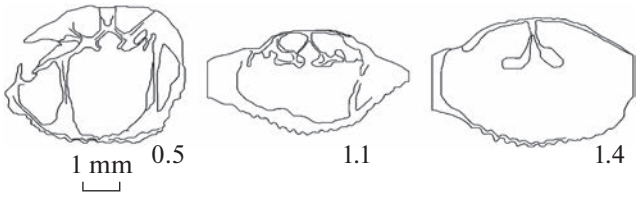


Fig. 55. *Gesoriacorostrum* cf. *boloniense* (Orbigny, 1850), specimen PIN, no. 3744/908, serial cross sections through the shell; Nakhchivan AR, right bank of the Arpa River opposite the village of Danzik, outcrop 36, Bed 1; *Paurogastroderhynchus nalivkini* Zone.

plates are connected by the cover plate of the septalium. The crura are absent.

Comparison and remarks. The genus includes the only species, which differs from *Ptychomaletoechia elburzensis* (Gaetani, 1965) in the larger shell, the greater number of costae on the shell surface, and the low tongue.

Occurrence. Middle–Upper Frasnian; northern France, Afghanistan, Iran; *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone of the Nakhchivan AR.

Material. Thirty-seven well-preserved shells, five inner molds, one ventral and two dorsal valves, and one shell fragment from the Nakhchivan AR: right bank of the Arpa River, opposite the village of Danzik, outcrop 101, Bed 11; outcrop 35, Bed 14; outcrop 43, Bed 6; left bank of the Arpa River, south of the village of Gyumushlug, interfluve of the Arpa and Yaidzhi-Deresi rivers, outcrop 40, Bed 32; right bank of the Arpa River near the village of Gyumushlug, outcrop 1107a; left bank of the Dzhaanam-Deresi River, lower reaches, near levee, outcrop 61, Beds 6 and 12; right bank of the Bagarsykh-Deresi River, outcrop 1093a; vicinity of concentrating factory near the village of Gyumushlug, outcrop 1157; left bank of the Arpa River near the village of Gyumushlug, outcrop 46, Bed 21.

Genus *Gesoriacorostrum* Sartenaer, 2003

Gesoriacorostrum: Sartenaer, 2003, p. 181 (synonymy).

Type species. *Atrypa boloniensis* Orbigny, 1850 in 1849–1852, p. LIX–LX; Upper Devonian, Frasnian; northern France, Bologna.

Diagnosis. Shell medium-sized, elongated oval or ovally pentagonal, slightly inflated, and subequally biconvex. Ventral umbo small and slightly curved. Median sulcus and fold poorly developed and indistinctly bordered by costae and interspaces, respectively. Anterior margin somewhat uniplicate. External radial ornamentation composed of numerous simple costae triangular in cross section with acute apices. Costae running from valve umbos, expanding toward shell margins, and covering whole shell surface. Lateral commissures straight. Dental plates long and ventrally convergent; teeth massive; sockets deep. Dorsal septum low. Septalium open near posterior margin and moderately deep. Hinge plates united anteriorly. Crura laterally flattened.

Species composition. One reliable species; Middle Frasnian of northern France and possibly Lower–Middle Famennian of Transcaucasia. Other species previously assigned to this genus require revision.

Comparison. This genus externally resembles Famennian costate ripidiorhynchinids, such as *Cyphoterorhynchus* Sartenaer, 1965, *Ripidiorhynchus* Sartenaer, 1966, *Orophomesorhynchus* Sartenaer, 2001, and *Piridiorhynchus* Sartenaer, 2001. *Gesoriacorostrum* differs from all above-listed genera in the poorly developed median sulcus and fold. It differs from *Cyphoterorhynchus* and *Ripidiorhynchus* in the open septalium. It differs from *Orophomesorhynchus* in the presence of septum and septalium. *Gesoriacorostrum* differs from *Piridiorhynchus* in the deep septalium and, according to Sartenaer (2003), in the united hinge plates.

Remarks. *Gesoriacorostrum* is similar to *Sinotectirostrum* Sartenaer, 1961 (subfamily Trigonirhynchiinae), *Ptychomaletoechia* Sartenaer, 1961 (subfamily Hemitoechiinae), and *Sartenaerus* Özdikmen, 2008 (subfamily Hemitoechiinae). However, *Gesoriacorostrum* has a poorly developed sulcus and fold. It differs from *Ptychomaletoechia* and *Sartenaerus* in the laterally flattened crura and, according to Sartenaer (2003), in the united hinge plates. This genus differs from *Sinotectirostrum* in the open septalium and laterally flattened crura.

Gesoriacorostrum cf. *boloniense* (Orbigny, 1850)

Plate 8, fig. 1; Plate 14, fig. 22; Fig. 55

Description. The shell is small and medium-sized, 8.5–12.4 mm long, 9–14.7 mm wide, 4.5–6.1 mm thick, flattened, subequally biconvex, and oval to ovally pentagonal. The maximum width is at the shell midlength. The ventral umbo is small and slightly curved. The delthyrium is covered by the dorsal beak. The median sulcus and fold are poorly pronounced near the anterior margin and indistinctly bordered by costae and interspaces, respectively. The dorsal valve is slightly inflated, with the maximum convexity in the middle. The lateral slopes are low and gentle. The lateral commissures are straight. External radial ornamentation consists of numerous simple costae triangular in cross section, with pointed apices. The costae start from the valve umbos, cover the whole shell surface, and widen anteriorly, numbering 3–4 in the sulcus, 4–5 on the fold, and 4–9 on the lateral sides. The widest, 1 mm wide, costae are located in the sulcus near the anterior margin. The costal interspace interspaces are narrower than costae. The dental plates are well separated from the umbonal walls. The septum is low; the septalium is open and moderately deep. The

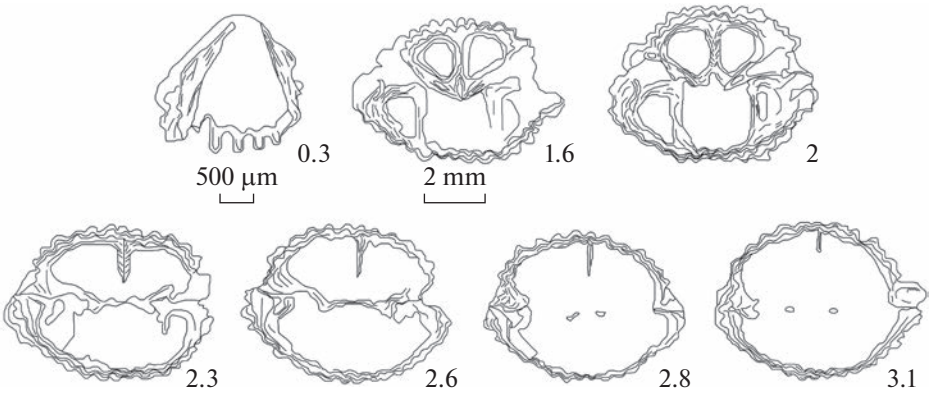


Fig. 56. *Hemiplethorhynchus* sp. 1, specimen PIN, no. 3744/851, serial cross sections through the shell; Nakhchivan AR, Geran-Kalasy Mountain, outcrop 10, Bed 6; Lower Tournaisian, *Unispirifer praeulbanensis–Rhytiophora curtirostris* Zone.

hinge plates are fused through a thin band. The crura are laterally flattened.

Age variability. The juveniles have a better pronounced median sulcus and fold and fewer costae on the lateral sides. The adult shells are more flattened and strongly ribbed.

Comparison and remarks. The genus includes one reliable species, which is strongly externally similar to some Famennian costate rhynchonellides. *Gesoriacorostrum* differs from *Sartenaerus letiensis* (Gosselet, 1887) and *Ptychomaletoechia panderi* (Sem. et Möl., 1864) in the flattened shell and poorly developed median sulcus and fold. It also differs from these species in the hinge plates connected to the septalium and to each other by a thin bar and in the crura, which are laterally flattened in *G.* cf. *boloniense*. Due to insufficient material, these specimens cannot be reliably assigned to *G. boloniense,* although they are most similar to this species.

Occurrence. Upper Devonian, Middle Frasnian of northern France; possibly, Lower–Middle Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* and *Paurogastroderhynchus nalivkini* zones of Transcaucasia.

Material. Three well-preserved shells, Nakhchivan AR: lower part of Myunkh-Bala-Ogly Mountain, outcrops 1004, 16; right bank of the Arpa River opposite the village of Danzik, outcrop 36, Bed 1.

Genus *Hemiplethorhynchus* Peetz, 1898

Hemiplethorhynchus: Peetz, 1898, p. 178; Savage, 2002a, p. 1076.

Type species. *Hemiplethorhynchus fallax*, Peetz, 1898, p. 178; Lower Carboniferous, Tournaisian; Altai.

Diagnosis. Shell small, ovally pentagonal, as long as wide, and dorsibiconvex. Ventral umbo low and slightly curved. Median sulcus and fold narrow and well bordered by costae and interspaces, respectively. Anterior margin uniplicate, with tongue. Lateral commissures straight. Radial costae starting from umbos and expanded anteriorly. Ventral umbo with dental plates. In dorsal valve, septum low; septalium open; hinge plates discrete after separating from septum, with thin inner margins and small bulbous thickenings at anterior tips, and united anteriorly. Crural bases narrow, flattened, and inclined towards each other. Crura brace-shaped.

Species composition. Five species; Lower Carboniferous, Tournaisian; Altai, China, Europe, Transcaucasia, North America (?). Transcaucasia: *Hemiplethorhynchus* sp. 1 and 2.

Comparison. There are no externally similar ripidiorhynchinids in the Lower Carboniferous.

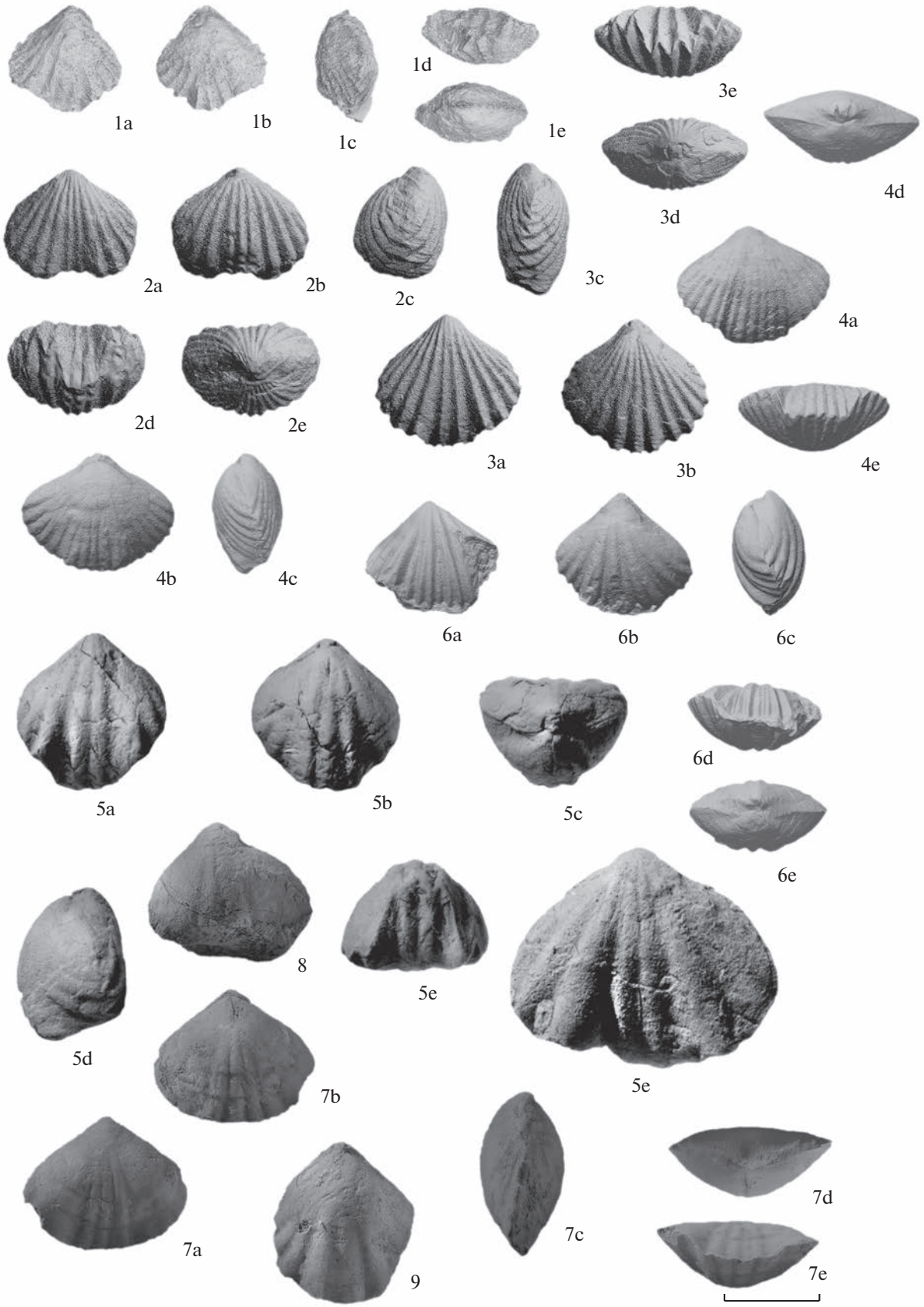
Remarks. This genus is externally similar to *Macropotamorhynchus* Sartenaer, 1970 (subfamily Trigonirhynchiinae), *Ptychomaletoechia* Sartenaer, 1961 (subfamily H5*Hemiplethorhynchus* differs from *Macropotamorhynchus* and *Ptychomaletoechia* in the open septalium (hinge plates of *Hemiplethorhynchus* are fused anterior into septalium) and in the fewer costae on the shell. The hinge plates of *Macropotamorhynchus* are united by the cover plate of septalium. It is most similar to *Rossirhynchus* and differs in the presence of costae rather than plicae.

Hemiplethorhynchus sp. 1

Plate 8, fig. 2; Fig. 56

Description. The shell is small, 9.8–11.4 mm long, 11.5–11.8 mm wide, 5.5–6.3 mm thick, ovally pentagonal in outline, and dorsibiconvex. The maximum shell width is at its midlength. The maximum convexity of the ventral valve is in the umbonal region. The umbo is slightly curved. Narrow sulcus and median fold start in the shell midlength and are well bordered by costae and interspaces, respectively. The anterior margin is uniplicate. The maximum convexity of the dorsal valve is at the fold in the anterior half of the valve. Radial ornamentation consists of simple

Plate 8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costae rounded in cross section. The costae run from the umbos, cover the whole shell, and widen anteriorly, numbering 2 in the sulcus, 3 on the fold, and 5–6 on the lateral shell sides. The costae are wider than interspaces; the widest costae (0.5–1.3) mm are in the median sulcus at the anterior margin. The lateral slopes are gentler in the ventral valve and steeper in the dorsal valve. The lateral commissures are straight. The dental plates are short and well separated from the umbonal walls. The dorsal septum is low and thick. The septalium is shallow and open; the hinge plates are united anterior to the septalium. The crural bases are dorsoventrally flattened; the crura are brace-shaped.

Comparison. The two specimens in our collection differ from the known species of *Hemiplethorhynchus*, *H. fallax* Peetz, 1898 and *H. peetzi* (Tolmachoff, 1924), in the less costate shell and slightly curved ventral umbo. Their shell interior corresponds to the generic diagnosis.

Remarks. Our specimens closely resemble the Upper Devonian–Lower Carboniferous small costate rhynchonellides *Ptychomaletoechia panderi* (Sem. et Möl., 1864), *C. acutirugata* (Koninck, 1887), and *C. biplex* (Tolmachoff, 1924) and strongly differ in the structure of hinge plates. They are referred to *Hemiplethorhynchus* based on features of the shell interior, but cannot be assigned to a certain species. Probably, these specimens represent a new species, but additional material is needed for further study.

Occurrence. Lower Carboniferous, Lower Tournaisian, *Unispirifer praeulbanensis–Rhytiophora curtirostris* and *Rhipidomella michelini* Zones; Transcaucasia.

Material. Three well-preserved shells: Nakhchivan AR: Geran-Kalasy Mountain, outcrop 10, Bed 6; southern slope of Bazagl Mountain, outcrop 34, Bed 1; northeastern slope of Geran-Kalasy Mountain, outcrop 11, Bed 19; vicinity of the village of Kyarki, outcrop 27, Bed 3.

Hemiplethorhynchus sp. 2

Plate 8, fig. 3; Plate 14, fig. 17; Fig. 57

Description. The shell is small, 11.8 mm long, 12.9 mm wide, 8.4 mm thick, ovally pentagonal, and dorsibiconvex. The maximum shell width is in the middle. The maximum convexity of the ventral valve is in the umbonal region. The umbo is slightly curved. The median sulcus is narrow. The sulcus and fold start at the shell midlength and are well bordered by costae and interspaces, respectively. The maximum convexity of the dorsal valve is at the fold. The anterior margin is uniplicate. The lateral slopes are gentle; the lateral commissures are straight. Radial ornamentation consists of simple costae angular in cross section. The costae run from the umbos and gradually widen anteriorly, numbering 2 in the sulcus, 3 on the fold, and 5–6 on the lateral shell sides. The costae in the median sulcus and fold are equally wide or wider than costae on the lateral shell sides. The costae are up to 0.5–

Explanation of Plate 8

Fig. 1. *Gesoriacorostrum* cf. *boloniense* (Orbigny, 1850), specimen PIN, no. 3744/873, 3D model of complete juvenile shell, ×2: (1a) ventral valve view; (1b) dorsal valve view; (1c) lateral view; (1d) anterior view; (1e) posterior view; Nakhchivan AR, lower part of Myunkh-Bala-Ogly Mountain, outcrop 16; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Fig. 2. *Hemiplethorhynchus* sp. 1, specimen PIN, no. 3744/851; 3D model of complete shell, ×2: (2a) ventral valve view; (2b) dorsal valve view; (2c) lateral view; (2d) anterior view; (2e) posterior view; Nakhchivan AR, Geran-Kalasy Mountain, outcrop 10, Bed 6; Lower Carboniferous, Lower Tournaisian, *Unispirifer praeulbanensis–Rhytiophora curtirostris* Zone.

Fig. 3. *Hemiplethorhynchus* sp. 2, specimen PIN, no. 3744/852, 3D model of complete shell, ×2: (3a) ventral valve view; (3b) dorsal valve view; (3c) lateral view; (3d) posterior view; (3e) anterior view; Nakhchivan AR, Geran-Kalasy Mountain, outcrop 1448; Lower Carboniferous, Upper Tournaisian, *Spirifer baiani–Marginatia burlingtonensis* Zone.

Fig. 4. *Greira transcaucasica* Erlanger, 1993, specimen PIN, no. 3744/856, 3D model of complete shell, ×1.7: (4a) ventral valve view; (4b) dorsal valve view; (4c) lateral view; (4d) posterior view; (4e) anterior view; Nakhchivan AR, Geran-Kalasy Mountain, outcrop 1241; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Fig. 5. *Sharovaella mirabilis* Pakhnevich, 2012, holotype PIN, no. 3744/804, complete shell, ×1: (5a) ventral valve view; (5b) dorsal valve view; (5c) posterior view; (5d) lateral view; (5e) anterior view; (5f) specimen PIN, no. 3744/805, complete shell of young brachiopod, ventral valve view, ×2; Nakhchivan AR, Geran-Kalasy Mountain, outcrop 1241; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Fig. 6. *Tchanakhtchirostrum araraticum* (Abramian, 1957), specimen PIN, no. 3744/855, 3D model of complete shell, ×1.5: (6a) ventral valve view; (6b) dorsal valve view; (6c) lateral view; (6d) anterior view; (6e) posterior view; Nakhchivan AR, vicinity of the village of Kyarki; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

Fig. 7. *Zaigunrostrum nakhichevanense* Pakhnevich, 2018, specimen PIN, no. 3744/861, complete shell, ×1.5: (7a) ventral valve view; (7b) dorsal valve view; (7c) lateral view; (7d) posterior view; (7e) anterior view; left bank of the Arpa River, outcrop 20, Bed 6.

Fig. 8. *Zaigunrostrum nakhichevanense* Pakhnevich, 2018, specimen PIN, no. 3744/862, complete shell, ×1.3, ventral valve view; Nakhchivan AR, right bank of the Arpa River near the village of Danzik, outcrop 36, Bed 2; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Fig. 9. *Zaigunrostrum nakhichevanense* Pakhnevich, 2018, specimen PIN, no. 3744/963, complete shell, ×2, dorsal valve view; Nakhchivan AR, east of Geran-Kalasy Mountain, outcrop 10, Bed 2; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

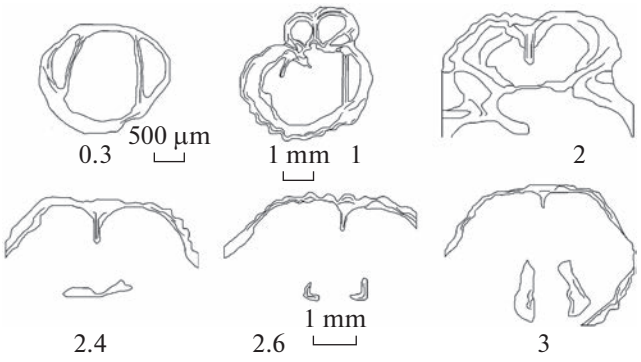


Fig. 57. *Hemiplethorhynchus* sp. 2, specimen PIN, no. 3744/852, serial cross sections through the shell; Nakhchivan AR, Geran-Kalasy Mountain, outcrop 1448; Upper Tournaisian, *Spirifer baiani–Marginatia burlingtonensis* Zone.

1.9 mm wide at the anterior margin in the median sulcus; the costal interspaces are narrower than, or as wide as, the costae. The dental plates are short and separated from the ventral umbonal walls. The dorsal septum is low, long, and slightly thickened. The septalium is shallow and open. The hinge plates are united anterior to the septalium. The crural bases are triangular and, anteriorly, dorsoventrally flattened in cross section. The crura are brace-shaped.

Comparison. These specimens are similar to *Hemiplethorhynchus* sp. 1, but differ in the flattened shell and equally wide costae covering the whole shell. As *Hemiplethorhynchus* sp. 1, *Hemiplethorhynchus* sp. 2 is probably also a new species, but not validly described due to insufficient material.

Remarks. *Hemiplethorhynchus* sp. 1 and 2 are similar to Lower Carboniferous *Ptychomaletoechia panderi* (Sem. et Möl., 1864), *C. acutirugata*, and *C. biplex* and differ in the shell interior.

Occurrence. Lower Carboniferous, Upper Tournaisian, *Spirifer baiani–Marginatia burlingtonensis* Zone.

Material. Two well-preserved shells from Transcaucasia: Arpa River Basin, outcrop 8, Bed 2k; vicinity of the village of Kyarki, outcrop 1448.

Subfamily Greirinae Erlanger, 1993.

Genus *Greira* O. Erlanger, 1993

Greira: O. Erlanger, 1993, p. 120.

Type species. *Greira transcaucasica* O. Erlanger, 1993, p. 120; Upper Devonian, Lower Famennian; Nakhchivan AR.

Diagnosis. Shell small, ovally pentagonal, transversely elongated, and dorsibiconvex. Umbo low and slightly curved. Median sulcus and fold well developed and well bordered by costae and interspaces, respectively. Fold flattened and broad. Anterior margin uniplicate; tongue developed. Lateral commissures straight. Radial ornamentation costate. Costae running from valve umbos and thickened anteriorly. In ventral umbo, dental plates developed. Dorsal valve with septum; septalium open posteriorly and covered anteriorly. Hinge plates united; crural bases triangular. Crura parallel to lateral margins and slightly curved, with ridge on outer side. Anteriorly ridge disappearing and crura becoming erect and inclined towards each other. Shell substance punctate.

Species composition. Type species; Lower, possibly, Upper Famennian; Nakhchivan AR.

Comparison. This genus is similar to punctate rhynchonellids of the subfamily Greirinae *Sharovaella* Pakhnevich, 2012, *Tchanakhtchirostrum* Sartenaer et Plodowski, 2003, and *Zaigunrostrum* Sartenaer et Plodowski, 2003 in the shell interior and differs in the presence of simple nondichotomizing costae. In addition, it differs from *Sharovaella* and *Zaigunrostrum* in the smaller shell.

Remarks. *Greira* is externally similar to the following Famennian small costate rhynchonellids: *Ripidiorhynchus* Sartenaer, 1966 (subfamily Ripidiorhynchinae), *Sinotectirostrum* Sartenaer, 1961 (subfamily Trigonirhynchiinae), *Ptychomaletoechia* Sartenaer, 1961 (subfamily Hemitoechiinae), *Orophomesorhynchus* Sartenaer, 2001 (subfamily Ripidiorhynchinae), and *Piridiorhynchus* Sartenaer, 2001 (subfamily Ripidiorhynchinae). It differs from all above-listed genera in the punctate shell and the wide flattened fold. It differs from *Ripidiorhynchus* in the pattern of crural bases and crura, which are slightly curved in *Ripidiorhynchus*. It differs from *Ptychomaletoechia* and *Piridiorhynchus* in the covered septalium, united hinge plates, and crura shape. It differs from *Sinotectirostrum* in the type of crura, which are brace-shaped in *Sinotectirostrum*. It differs from *Orophomesorhynchus* in the presence of long septum, well-developed septalium, and the shape of crural bases and crura.

Greira transcaucasica Erlanger, 1993

Plate 8, fig. 4; Fig. 58

Greira transcaucasica: O. Erlanger, 1993, p. 120, text-figs. 1 and 2.

Holotype. PIN, no. 4127/1042, conjoined shell; Upper Devonian, Famennian, *Mesoplica meisteri* Zone; Nakhchivan AR, left bank of the Arpa River between Geran-Kalasy and Kabakhal mountains.

Description. The shell is small, transversely elongated, 10.7–16.3 mm long, 12.3–22.9 mm wide, 6.4–13 mm thick, ovally pentagonal, and dorsibiconvex. The maximum width and thickness are at the shell midlength. The ventral umbo is low, curved or slightly curved. The delthyrium is covered by the dorsal beak. The median sulcus is well developed and wide; the fold is broad and flattened; the tongue is poorly pronounced, obtuse, and broad. The sulcus and fold start in the shell midlength and are distinctly bordered by costae and interspaces, respectively. The maximum

convexity of the dorsal valve is in the middle. The lateral slopes are gentle. The lateral commissures are straight. External ornamentation consists of simple, dense, low costae somewhat pointed in cross section. The costae run from the valve umbos, and expand to the anterior margin, reaching the width of 1.3 mm in the median sulcus and numbering 4–6 in the sulcus, 5–7 on the fold, and 5–9 on the lateral shell sides. The costae are slightly wider than interspaces in the umbonal region and equally wide at the anterior margin. The costae on the fold, median sulcus, and lateral sides are equally wide.

Variability. The number of costae and shell width vary.

Occurrence. Upper Devonian, Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone; Nakhchivan AR.

Material. Fourteen well-preserved shells: Nakhchivan AR: vicinity of Geran-Kalasy and Kabakhyal mountains, outcrop 1241; near the village of Tezhgar, outcrop 518; northwestern ending of Myunkh-Bala-Ogly Mountain, outcrop 22, Bed 8; left bank of the Arpa River near the village of Gyumushlug, outcrop 1242a, 1242c; Armenia: Arshaki-Akbyur gorge, vicinity of the village of Kadrlu, outcrop 7.

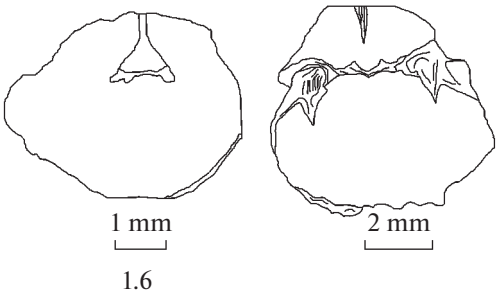


Fig. 58. *Greira transcaucasica* Erlanger, 1993, serial cross sections through the shell: (a) specimen PIN, no. 3744/909; (b) specimen PIN, no. 3744/930; Nakhchivan AR, vicinity of Geran-Kalasy and Kabakhal mountains, outcrop 1241; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Genus *Sharovaella* Pakhnevich, 2012

Sharovaella: Pakhnevich, 2012, p. 16.

Type species. *Sharovaella mirabilis* Pakhnevich, 2012, Upper Devonian, Lower (*Cyrtospirifer asiaticus–Mesoplica meisteri* Zone)–Upper (*Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone) Famennian; Transcaucasia.

Diagnosis. Shell medium-sized, dorsibiconvex, oval to ovally pentagonal and rhombic in outline. Ventral umbo large and somewhat curved. Delthyrium covered by dorsal umbo beak. Median sulcus, fold, and tongue well developed. External radial ornamentation composed of simple plicae. Plicae running from umbo in median sulcus and fold and starting in shell midlength on lateral shell sides. Lateral commissures from straight to somewhat curved. Walls of ventral umbo thickened. Dental plates short, ventrally convergent, and close to lateral umbonal walls. In dorsal valve, median septum developed; septalium covered; crural bases massive and flattened. Crura almost parallel to longitudinal shell axis, dorsoventrally elongated, slightly inclined towards each other, and calcariform. Crura with ridges in middle of their outer side. Shell substance punctate. Punctae irregularly arranged along whole shell, including umbos, plicae, and interspaces.

Species composition. Type species and, possibly, *Rhynchopora* (?) *morini* Drot; Famennian, Zone IV; Morocco.

Comparison. This genus is similar to *Zaigunrostrum* Sartenaer et Plodowski in the shell exterior and interior and differs in the better pronounced and higher plicae, the better developed median sulcus and fold, more convex shell, obtuse umbo, and strongly thickened umbonal walls and inner structures in the umbonal regions (dental plates are almost fused with lateral walls of the ventral umbo due to strongly developed callus). It is similar to *Greira* O. Erlanger, 1993 in the crura shape, but differs in the thickened walls of the ventral umbo, well-developed dental plates, ornamentation (few large plicae), flattened crural bases, larger shell, and in the shell shape. *Sharovaella* differs from *Tchanakhtchirostrum* Sartenaer et Plodowski, 2003 (we refer this genus to the subfamily Greirinae) in the absence of dichotomizing or intercalating plicae, well-developed dental plates, flattened crural bases, and absence of ridges on the crura.

Remarks. *Sharovaella mirabilis* was previously referred to different genera of different families: *Leiorhynchus* Hall, 1860, *Eoparaphorhynchus* Sartenaer, 1961 (family Leiorhynchidae), *Pugnax* Hall et Clarke, 1893 (family Pugnacidae), *Pugnoides* Weller, 1910 (family Petasmariidae), *Paraphorhynchus* Weller, 1905 (family Rhynchotetradidae). *Sharovaella* differs from all above-listed genera in the punctate shell. It differs from *Leiorhynchus* in the external ornamentation (plicae of *Sharovaella* are more numerous), the steeper lateral sides of the shell, the thickened walls of the ventral umbo, better developed septalium, nonthickened dental plates near walls of the ventral umbo, united hinge plates, the shape of crural bases and their location relative to the dorsal septum, absence of ridge on crura. It differs from *Eoparaphorhynchus* in the thinner septum, better developed dental plates, well-developed septalium, united hinge plates, shape of crural bases and crura. It differs from *Pugnax* in the shell shape, the better developed plicae, lower fold, shallower sulcus, better developed ventral umbo, thickened walls of the ventral umbo, presence of septum and septalium, shape and arrangement of crura. *Sharovaella* differs from *Pugnoides* in the shell shape, the smaller number of wider plicae, deeper septalium, shape of hinge plate, shape of crural bases and crura. It differs from *Paraphorhynchus* Sartenaer, 1961 in the

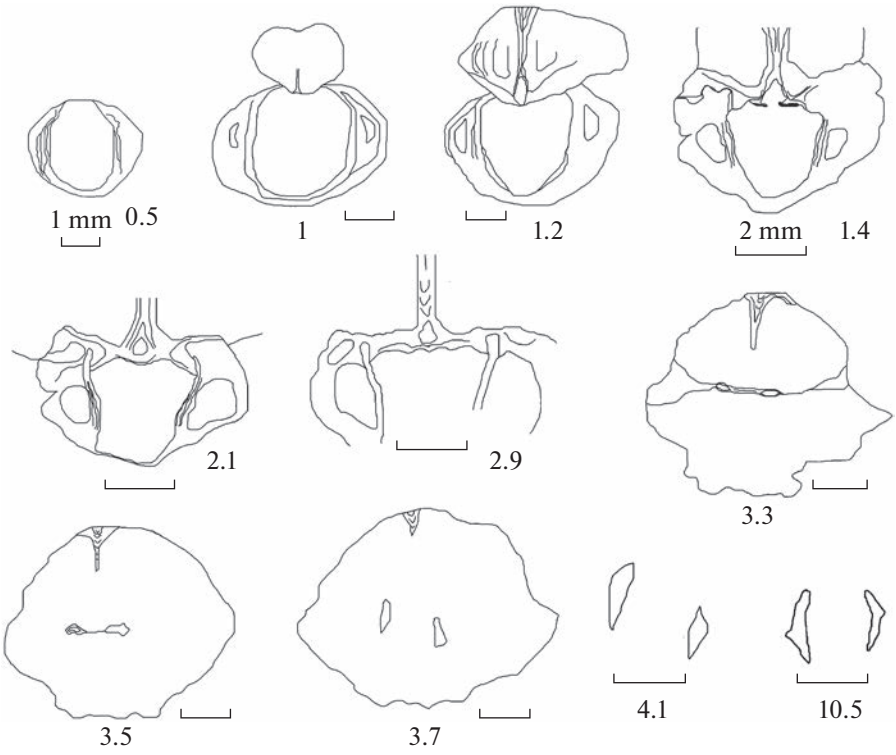


Fig. 59. *Sharovaella mirabilis* Pakhnevich, 2012, specimen PIN, no. 3744/807, serial cross sections through the shell; Armenia, vicinity of the village of Kadrlu, Arshaki-Akbyur gorge, outcrop 7; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

shell shape (shell of *Paraphorhynchus* Weller, 1905 is more elongated), thickened walls of the ventral umbo, worse developed dental plates, nonthickened dental plates near walls of the ventral umbo, covered septalium, the length and shape of crura. It differs from *Araratella* Abramian, Plodowski et Sartenaer, 1975 in the almost complete absence of intercalating and dichotomizing plicae, the inclined dental plates, and the shape of crura (*Araratella* has V-shaped crura). Septalium of *Araratella* is open and free posterior to the crural bases, with short hinge plates. *Sharovaella* differs from *Rhynchopora* King in the thickened walls of the ventral umbo, the pattern of ornamentation, the crus shape, and shell size and shape. The plicae of *Rhynchopora*, 1865 are narrower and more numerous than in *Sharovaella*. It is similar to *Tretorhynchia* Brunton, 1971 in the type of crura and differs in the shell shape, ornamentation, presence of median sulcus and fold, thickened walls of ventral umbo, developed dental plates, shape of ventral umbo, and covered septalium.

***Sharovaella mirabilis* Pakhnevich, 2012**

Plate 8, fig. 5; Plate 14, figs. 10 and 21; Plate 15, figs. 1 and 5; Plate 16, figs. 1 and 2; Fig. 59

Pugnoides triaequalis: Abramyan, 1957, p. 60, pl. 6, figs. 8 and 9.

Pugnoides (?) *triaequalis*: Abramyan, 1974a, p. 56, pl. 20, fig. 3.

Sharovaella mirabilis: Pakhnevich, 2012, p. 17, pls. 2–3; text-figs. 1–3.

H o l o t y p e. PIN, no. 3744/804, complete shell; Upper Devonian, Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone; Nakhchivan AR, Geran-Kalasy Mountain, outcrop 1241.

D e s c r i p t i o n. The shell is 14.7–23.6 mm long, 17.1–27.2 mm wide, and 8.5–19.9 mm thick, and oval to ovally pentagonal and rhombic. The shell width is almost 1.2 times greater than its length. The maximum width is at the shell midlength. The ventral umbo is large and somewhat curved. The delthyrium is covered by the dorsal beak. The ventral valve is slightly convex, with the maximum convexity in the umbonal region. The median sulcus is deep, with clearly defined margins, well bordered by plicae, starts at the valve midlength, expands anteriorly, and terminates at the anterior margin in a tongue. The dorsal valve is convex, with the maximum convexity in the middle. The fold is well pronounced and high. The lateral slopes are gentle in juveniles and steep in senescent specimens. The lateral commissures range from straight to somewhat curved. External radial ornamentation consists of simple plicae triangular in cross section, with rounded apices; some plicae are formed by intercalation. The plicae run from the umbo in the median sulcus and fold, and start at the shell midlength on the lateral shell sides, and expand anteriorly, numbering 2–3 in the sulcus, 3–4 on the fold, and 2–5 on the lateral shell sides. The plicae are 1.5–5.5 mm wide and wider

than the interspaces. The dental plates are short and thickened. The median septum is long. The septalium is covered and shallow. The crural bases are flattened and massive; the crura are laterally flattened and bear ridge on the outer side. The shell substance is punctate. The punctae are irregularly arranged in the secondary fibrous layer.

Age variability. The shell shape and number of plicae vary. Young shells are transversely elongated and adult shells are elongated or almost as long as wide. The sulcus and fold are poorly developed on young shells.

Individual variability. The fold bears 3–4 plicae and the median sulcus bears 2–3. The number of plicae widely varies from 2 to 5 on the lateral shell sides.

Comparison. This species differs from *Sharovaella* (?) *morini* (Drot, 1964), which is tentatively referred to this genus, in the more convex shell.

Remarks. *S. mirabilis* is externally similar to *Araratella dichotomians* (Abramian, 1954) and differs in the shell outline, the fewer nondichotomizing plicae, the larger umbo, usually simple plicae, the arrangement of dental plates, covered septalium, and in the crus shape.

Occurrence. Lower (*Cyrtospirifer asiaticus–Mesoplica meisteri* Zone)–Upper (*Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone) Famennian; Transcaucasia.

Material. Twenty complete shells, one well-preserved ventral valve, one satisfactorily preserved dorsal valve, and one valve fragment: Nakhchivan AR: vicinity of the village of Danzik, outcrop 15, Bed 17; vicinity of Geran-Kalasy Mountain, outcrop 1241; vicinity of Kyzyl-Kaya Mountain, outcrop 21, Bed 17; vicinity of the right bank of the Arpa River near the village of Danzik, outcrop 36, Beds 2 and 5; east of Geran-Kalasy Mountain, outcrop 10, Beds 1 and 2; lower part of Myunkh-Bala-Ogly Mountain, outcrop 1004a; mouth of the Bagarsykh-Deresi River, outcrop 1076; Armenia: vicinity of the village of Kadrlu, outcrop 7, Beds 1 and 5; Arshaki-Akbyur gorge.

Genus *Tchanakhtchirostrum* Sartenaer et Plodowski, 2003

Tchanakhtchirostrum: Sartenaer and Plodowski, 2003, p. 342.

Type species. *Camarotoechia* (?) *araratica* Abramyan, 1957, pp. 43–46; Upper Devonian, Upper Famennian; Transcaucasia.

Diagnosis. Shell ovally pentagonal, small, as long as wide or transversely elongated, moderately inflated, and dorsibiconvex. Umbo small and slightly curved. Ventral median sulcus and dorsal fold starting in shell midlength. External radial ornamentation costate. Costae dichotomizing or intercalary, running from umbos, expanded anteriorly, and covering whole shell. Anterior margin uniplicate. Lateral commissures straight; lateral margins gentle. Ventral umbo with dental plates separated from umbonal walls. Dorsal valve with low septum; septalium covered; hinge plates united; crural bases brace-shaped; crura laterally flattened. Shell substance punctate.

Species composition. Type species from the Upper Devonian (Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone)–Lower Carboniferous (Lower Tournaisian, *Unispirifer praeulbanensis–Rhytiophora curtirostris* Zone) of Transcaucasia and *Tchanakhtchirostrum centralis* (Sartenaer and Plodowski, 2003) from the Upper Devonian, Upper Famennian of central Morocco.

Comparison. The genera with radial ornamentation composed of dichotomizing or intercalating costae within the subfamily Greirinae are not known.

Remarks. *Tchanakhtchirostrum* resembles externally *Araratella* Abramian, Plodowski et Sartenaer, 1975 (subfamily Araratellinae) and differs in the details of the shell interior; in *Tchanakhtchirostrum,* the dental plates are separated from the walls of ventral umbo, the shell walls are nonthickened, the dorsal septum is low, the septalium is covered, the hinge plates are united, and the cardinal process is absent.

Tchanakhtchirostrum araraticum (Abramian, 1957)

Plate 8, fig. 6; Plate 14, fig. 1; Fig. 60

Camarotoechia (?) *araratica*: Abramyan, 1957, p. 43, pl. 6, figs. 3–4; text-figs. 6–7.

Liorhynchus (*Araratella*) *araratica*: Abramyan, 1974a, p. 55, pl. 31, fig. 7.

Araratella araratica: Erlanger, 1986, p. 57, pl. 6, figs. 1 and 2; text-fig. 3.

Tchanakhtchirostrum araraticum: Sartenaer and Plodowski, 2003, p. 342.

Holotype. No. F 14/47, Institute of Geological Sciences, National Academy of Sciences, Armenia (Abramyan, 1957, pl. 6, fig. 3); Upper Devonian, Upper Famennian; Transcaucasia, Chanakhcha River Basin.

Description. The shell is small, rarely medium-sized, 10.4–16.4 mm long, 12.2–20 mm wide, 6.3–13.1 mm thick, and ovally pentagonal. The maximum width and thickness are at the shell midlength. The ventral umbo is low and slightly curved; the ventral valve is slightly convex, with the maximum convexity in the flattened umbonal region. The posterior margin is ventrally arched. The anterior margin is uniplicate. The ventral sulcus is wide and shallow; the dorsal fold is wide and low. The sulcus and fold start at the shell midlength and well bordered by costae and interspaces, respectively. The tongue is wide and ovally trapezoid. The dorsal valve is convex, with the maximum convexity in the middle. The lateral slopes are gentle; the lateral commissures are straight. The radial ornamentation consists of narrow costae rounded angular in cross section. The costae run almost from the umbos, cover both valves, are thickened anteriorly, numbering at the anterior margin 11 in the sulcus, 6 on

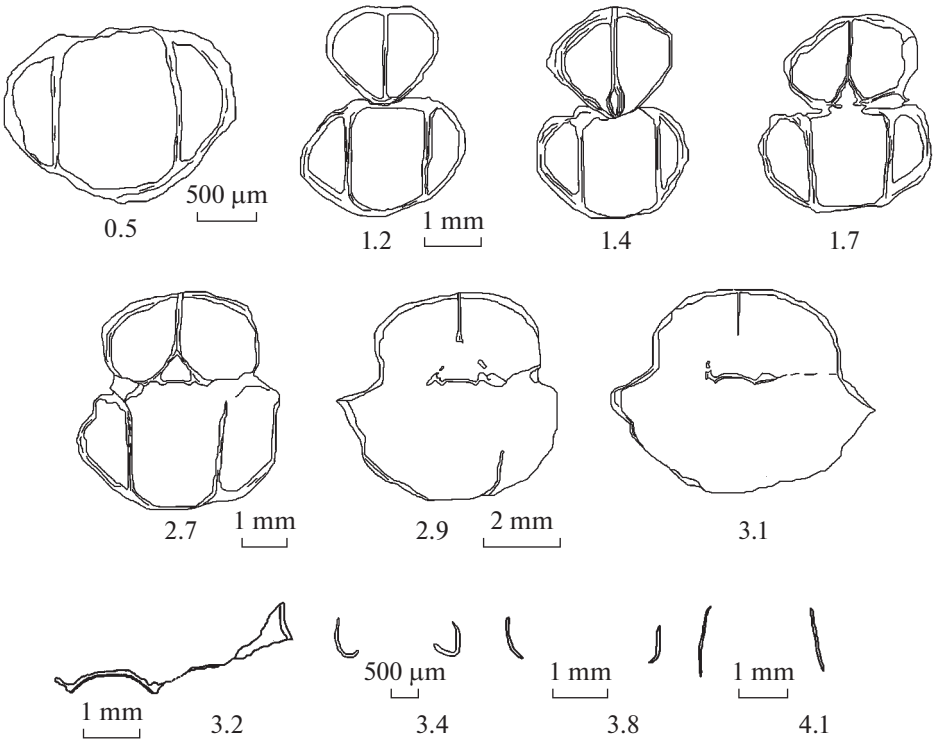


Fig. 60. *Tchanakhtchirostrum araraticum* (Abramian, 1957), specimen PIN, no. 3744/809, serial cross sections through the shell; Nakhchivan AR, western slope of Myunkh-Bala-Ogly Mountain (right bank of the Arpa River); Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

the fold, and 3–4 on the lateral shell sides. The costae dichotomize or intercalate (usually in the median sulcus and on the fold); small dichotomizing costae at the anterior margin are about 0.5–0.8 mm wide; nondichotomizing costae are about 1–1.5 mm wide. Simple costae are almost as wide as the interspaces; dichotomizing costae are wider than the interspaces. The dental plates are long and almost straight. The septum is low and long; the septalium is open posteriorly and covered anteriorly. The hinge plates are fused and connected to the cover plate of the septalium. The anterior margin of the fused hinge plates bear dorsally curved outgrowth. The crural bases are brace-shaped and formed laterally of this outgrowth. The crura are laterally flattened and dorsoventrally elongated. The shell substance is punctate.

C o m p a r i s o n. This species differs from similar *T. centralis* in the smaller shell.

R e m a r k s. *T. araraticum* is similar to species of the genus *Araratella* Abramian, Plodowski et Sartenaer, 1975 in shell exterior and differs in the absence of a cardinal process, the nonthickened umbos, the covered septalium, and united hinge plates.

O c c u r r e n c e. Upper Devonian (Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone)–Lower Carboniferous (Lower Tournaisian, *Unispirifer praeulbanensis–Rhytiophora curtirostris* Zone); Transcaucasia.

M a t e r i a l. Thirty-one shells, one dorsal valve, and one shell fragment from the *Sphenospira julii–Spinocarinifera nigra* Zone: Nakhchivan AR: northwestern end and lower part of Myunkh-Bala-Ogly Mountain, outcrop 22, Beds 8 and 9; outcrop 1005a; northwestern spurs of Geran-Kalasy Mountain, outcrop 11, Beds 4 and 10a; east of Geran-Kalasy Mountain, outcrop 10, Bed 3; right bank of the Arpa River near the village of Gyumushlug, outcrop 1501/78; vicinity of the village of Kyarki, outcrop 27, Bed 2; Armenia: Arshaki-Akbyur gorge, vicinity of the village of Kadrlu, outcrop 7, Beds 6 and 7; one shell from the *Unispirifer praeulbanensis–Rhytiophora curtirostris* Zone of the Nakhchivan AR, southeastern slope of Myunkh-Bala-Ogly Mountain, right bank of the Arpa River, outcrop 5, Bed 33.

Genus *Zaigunrostrum* Sartenaer et Plodowski, 2003

Zaigunrostrum: Sartenaer et Plodowski, 2003, p. 344.

T y p e s p e c i e s. *Gastrodetoechia iranica* Gaetani, 1965, p. 344; Upper Devonian, Lower Famennian; northern Iran, Zaigun valley.

D i a g n o s i s. Shell small or medium-sized, oval, transversely elongated, and dorsibiconvex. Maximum width in shell midlength or slightly anterior to it. Maximum thickness near posterior margin. Ventral umbo slightly incurved; delthyrium covered by dorsal beak.

Anterior margin somewhat uniplicate to almost rectimarginate. Median sulcus and fold poorly developed, wide, indistinctly bordered, and starting at shell midlength. Fold low. External radial ornamentation composed of wide, rounded, and smoothed plicae. Plicae starting in one-tenth of shell length from umbos, few in number, developed only in median sulcus and fold. Lateral commissures straight; lateral slopes gentle. Ventral valve with dental plates. Dorsal valve with low septum; septalium open posteriorly and covered anteriorly; hinge plates united; crural bases triangular, somewhat elongated in cross section; crura dorsoventrally elongated and cloven distally. Shell substance punctate.

Species composition. Two species: type species from the Upper Devonian, Lower Famennian of northern Iran and *Z. nakhichevanense* from the Upper Famennian of the Nakhchivan AR.

Comparison. There are no similar species within the subfamily Greirinae.

Remarks. This genus is externally similar to *Eoparaphorhynchus* Sartenaer, 1961, *Evanescirostrum* Sartenaer, 1965, *Iloerhynchus* Baliński, 1995, *Striatorhynchus* Pushkin, 1986, *Tenuisinurostrum* Sartenaer, 1967, *Rugaltarostrum* Sartenaer, 1961 (family Leiorhynchidae), and *Kindleina* Savage, Eberlein et Churkin, 1978 (family Plectorhynchellidae). It especially strongly resembles *Gastrodetoechia* Sartenaer, 1965 (family Leiorhynchidae), *Hadyrhyncha* Havliček, 1979, *Planovatirostrum* Sartenaer, 1970, *Novaplatirostrum* Sartenaer, 1997, and *Tetragonorhynchus* Sartenaer, 1999 (family Rozmanariidae) in shell exterior and differs from all above-listed genera in the punctate shell and almost from all of these genera in the crural bases triangular in cross section and elongated crura. *Zaigunrostrum* differs from *Eoparaphorhynchus* in the flattened shell, the absence of plicae on the lateral sides, well-developed dental plates, the low septum in the dorsal valve, presence of septalium, and united hinge plates. It differs from *Evanescirostrum* in the flattened shell, the low septum, covered septalium, and united hinge plates. It differs from *Iloerhynchus* in the flattened shell, well-developed deep septalium, and united hinge plates. It differs from *Striatorhynchus* in the flattened shell, well-pronounced plicae, covered septalium, and united hinge plates. It is similar to *Tenuisinurostrum* in crura shape and differs in the flattened shell, well-developed dental plates, the presence of dorsal septum and septalium, and in the united hinge plates. *Zaigunrostrum* differs from *Rugaltarostrum* in the flattened shell, the poorly developed fold and median sulcus, the covered septalium, and in the united hinge plates. It differs from *Kindleina* in the presence of septum and septalium and the united hinge plates. This genus is similar to *Gastrodetoechia* in the triangular in cross section crural bases, but differs in the flattened shell, the covered septalium, and the united hinge plates. It differs from *Hadyrhyncha* in the presence of plicae rather than costae on the shell surface, the presence of septum and septalium, in the and united hinge plates. It differs from *Planovatirostrum* in the absence of plicae on the lateral shell sides, well-developed dental plates, the presence of septum and septalium, and in the united hinge plates. It is similar to *Novaplatirostrum* in shell exterior and triangular in cross section crural bases and differs in the better developed plicae (only on the fold and sulcus), the presence of dental plates, septum, and septalium, the united hinge plates, and the absence of ventral septum. *Zaigunrostrum* differs from *Tetragonorhynchus* in the presence of dental plates, septum, and septalium, and in the united hinge plates.

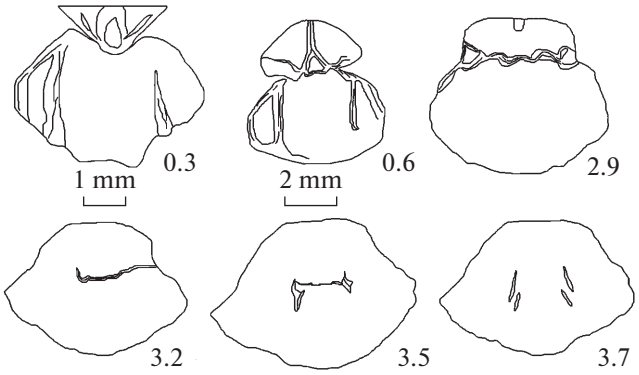


Fig. 61. *Zaigunrostrum nakhichevanense* Pakhnevich, 2018, specimen PIN, no. 3744/911, serial cross sections through the shell, figures indicate distances from the umbo; Nakhchivan AR, right bank of the Arpa River near the village of Danzik, outcrop 36, Bed 2; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

***Zaigunrostrum nakhichevanense* Pakhnevich, 2018**

Plate 8, figs. 7–9; Plate 15, figs. 4; Fig. 61

Zaigunrostrum nakhichevanense Pakhnevich, 2018, p. 27, text-figs. 1f–1m and 4.

Holotype. PIN, no. 3744/861; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone; Nakhchivan AR, left bank of the Arpa River, outcrop 20, Bed 6.

Description. The shell is small, 12.0–16.5 mm long, 17.0–17.3 mm wide, 6.5–9.3 mm thick, oval, transversely elongated, and dorsibiconvex. The maximum width is at the shell midlength or closer to the anterior margin. The maximum thickness is in the umbonal region. The ventral valve is slightly convex, with a small and slightly incurved umbo; the delthyrium is covered by the dorsal beak. The median sulcus is shallow and is not bordered by plicae; the fold is low and flattened. The sulcus and fold are wide, start at the shell midlength, and expand anteriorly. The dorsal valve is maximally thick in the umbonal region. The lateral commissures are straight; the lateral margins are gentle. External radial ornamentation consists of a few simple, low, flattened plicae rounded in cross

section. The plicae are 1.3–3.0 mm wide, wider than interspaces, usually developed in the sulcus and on the fold, and widen anteriorly, numbering 2–3 in the sulcus and 3–4 on the fold; two plicae are sometimes developed on each lateral side. Sometimes, plicae are almost fused. In the ventral valve, the dental plates are short, straight, and parallel to each other. The dorsal septum is low and short; the septalium is deep. The hinge plates are curved and united. The crural bases arise posteriorly as thickenings in the ventral ends of septalium plates and become triangular and slightly elongated in cross section anteriorly. The crura are long, dorsoventrally elongated, and anteriorly cloven at the distal ends. The shell substance is punctate.

Variability. Some specimens bear plicae on the lateral shell sides.

Comparison. This species differs from the similar Lower Famennian type species *Z. iranicum* (Gaetani, 1965) in the more flattened and transversely elongated shell, the more elongated ventral umbo, shallower median sulcus, and in the lower fold.

Occurrence. Upper Devonian, Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* and *Sphenospira julii–Spinocarinifera nigra* zones; Transcaucasia.

Material. Five well and satisfactorily preserved shells from the Nakhchivan AR: east of Geran-Kalasy Mountain, outcrop 10, Bed 2; left bank of the Arpa River, outcrop 20, Bed 6; right bank of the Arpa River near the village of Danzik, outcrop 36, Bed 2; Armenia: Arshaki-Akbyur gorge, outcrop 7, Bed 6.

Superfamily Uncinuloidea Ržonsnitskaja, 1956

Family Uncinulidae Ržonsnitskaja, 1956

Genus *Uncinulus* Bayle, 1878

Uncinulus: Bayle, 1878, pl. 11, figs. 11–16; Ržonsnitskaja et al., 1960, p. 243, pl. 46, figs. 1–4; text-figs. 260–261, 263–265.

Type species. *Hemithyris subwilsoni* Orbigny, 1850 in 1849–1852, pp. LIX–LX; Lower Devonian; France.

Diagnosis. Shell large, oval to ovally pentagonal in outline, strongly inflated and dorsibiconvex. Maximum thickness in anterior one-third of shell length at anterior margin. Ventral umbo medium-sized and incurved; foramen rounded; delthyrium covered by dorsal beak. Median sulcus, fold, and tongue well developed. External radial ornamentation composed of numerous simple costae terminating in marginal spines. Lateral commissures slightly curved. Squama and glotta developed. Walls of ventral umbo strongly thickened. Dental plates fused with umbonal walls. Ventral myophragm arising at same level as crura. Cardinal process bifid posteriorly and becoming multilobed anteriorly, brush-shaped, and, then, monolithic. Teeth massive and bulbous. In dorsal valve, median septum long, high, thickened posteriorly, and dividing dorsal umbo into two cavities. Septalium small; crura rodlike.

Species composition. About 50 species; Lower Devonian (Lochkovian)–Middle Devonian (Eifelian); cosmopolitan. Middle Eifelian–Upper Givetian of Transcaucasia: *Uncinulus korovini* Khalfin, 1937 and *Uncinulus subwilsoni* (Orbigny, 1850).

Comparison. This genus is most similar to *Plethorhyncha* Hall et Clarke, 1893 and differs in the wider and oval shell, the presence of a stage of the multilobed cardinal process, and ventral myophragm.

Remarks. *Uncinulus* is externally similar to *Kransia* Westbroek, 1868, *Glossinulina* Johnson, 1975, *Pseudoglossinotoechia* Tcherkesova, 1967 (family Hebetoechiidae). It differs from *Kransia* in the structure of umbo and dental plates, the presence of ventral myophragm, the long and well-developed dorsal septum, well-developed median sulcus and fold. It differs from *Glossinulina* in the pattern of the sulcus and fold lacking a bundle of costae in the middle, the dental plates fused with the shell walls, the massive cardinal process, thickened umbos, and the presence of ventral myophragm. It differs from *Pseudoglossinotoechia* in the absence of dichotomizing costae, the presence of massive cardinal process and ventral myophragm.

***Uncinulus korovini* Khalfin, 1937**

Plate 9, fig. 1; Plate 14, figs. 2, 4, and 14; Fig. 62

Uncinulus korovini: Khalfin, 1937, p. 101, pl. 3, figs. 31–34; Gratsianova, 1955, p. 258, pl. 58, fig. 7; Khodalevich and Breivel, 1972, p. 122, pl. 45, figs. 1, 2; text-fig. 24; Erlanger, 1994, p. 80, pl. 4, figs. 11–14, pl. 11, fig. 1b.

Holotype was not designated.

Description. The shell is large, 22–24.7 mm long, 23.3–26.9 mm wide, and 21.2 mm thick, and oval to ovally pentagonal. The maximum width is at the shell midlength. The ventral umbo is medium-sized and incurved; the foramen is rounded; the delthyrium is covered by the dorsal beak. The ventral valve is flattened. The ventral sulcus starts at the shell midlength and widens anteriorly; the tongue is large, high, obtuse, and rectangular. The dorsal fold is well developed, starts at the valve midlength, slightly widens anteriorly. The sulcus and fold are well bordered by costae and interspaces, respectively. The dorsal valve is strongly inflated, with the maximum convexity near the anterior margin. The lateral slopes are steep; the lateral commissures are curved. The squama and glotta are developed. External radial ornamentation consists of numerous simple costae rounded in cross section. The costae are absent on the lateral umbonal sides, run from the shell midlength, and widen anteriorly, numbering 6–7 in median sulcus and fold and 8–9 on each lateral side. The costae are 0.8–1.6 mm wide and considerably wider than interspaces. The walls of the ventral umbo are strongly thickened. The dental plates are fused with the ventral umbonal walls. The ventral myophragm is long and starts at the level

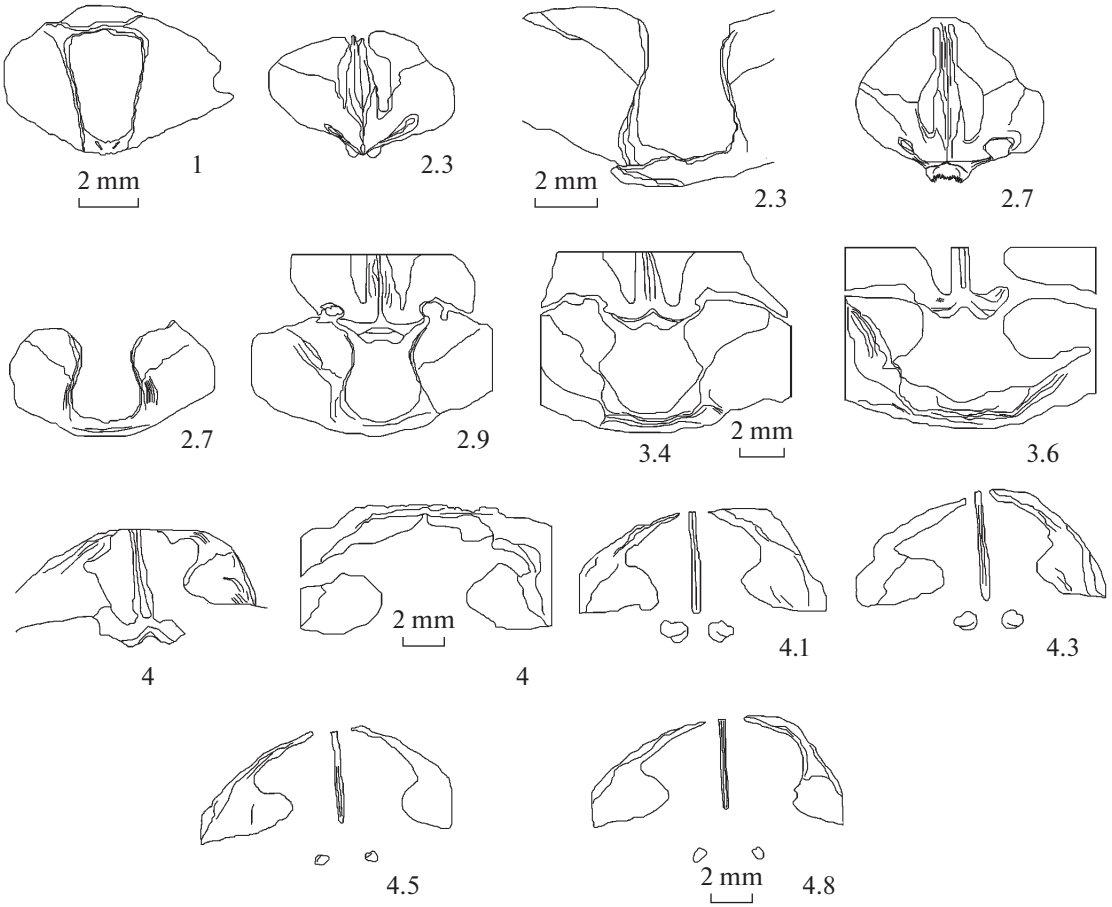


Fig. 62. *Uncinulus korovini* Khalfin, 1937, specimen PIN, no. 3744/912, serial cross sections through the shell; Nakhchivan AR, vicinity of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 3; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

of crus formation. The cardinal process changes from bifid to multilobed, then, monolithic. The dorsal median septum is long, high, thickened, and divides the dorsal umbo into two cavities. The septalium is small; the crura are rodlike in cross section.

Comparison. This species differs from *U. subwilsoni* (Orbigny, 1850) in the angular shell. It differs from *U. orbignyanus* (Verneuil, 1850) in the absence of a central costa in the median sulcus and the undivided fold.

Occurrence. Middle Devonian, Givetian; Gornyi Altai, Kuznetsk Depression; Upper Eifelian (*Mucrospirifer diluvianoides–Radiomena irregularis* Zone)–Upper Givetian (*Indospirifer pseudowilliamsi* Zone) of Transcaucasia.

Material. Fifty-nine shells and one ventral valve, all well preserved: Nakhchivan AR: vicinity of the village of Gyumushlug, outcrop 60, Beds 4 and 6; vicinity of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 3; left bank of the Dzhaanam-Deresi River, 1.5 km west of Kazma Mountain, outcrop 57, Bed 5; southeastern spur of the Plakhpashi Mountain Range, vicinity of the village of Sadarak, outcrops 1414a and 1419.

***Uncinulus subwilsoni* (Orbigny, 1850)**

Plate 9, fig. 2; Fig. 63

Hemithyris subwilsoni: Orbigny, 1850 in 1849–1852, pp. LIX–LX.

Holotype was not designated.

Description. The shell is medium-sized, 15.8–17.7 mm long, 15.2–17.1 mm wide, 13.8–16 mm thick, oval, almost circular in outline, inflated, and strongly dorsibiconvex. The maximum width is at the shell midlength. The ventral umbo is medium-sized and incurved; the foramen is small and rounded; the delthyrium is covered by the dorsal beak. The median sulcus starts from the umbo, becomes well pronounced only in the middle of the shell, and widens anteriorly. The tongue is trapezoid. The maximum thickness of the dorsal valve is at the anterior margin. The fold starts in the middle of the valve and widens slightly anteriorly. The median sulcus and fold are indistinctly bordered by costae and interspaces, respectively. The lateral slopes are steep; the lateral commissures are straight. The squama and glotta are

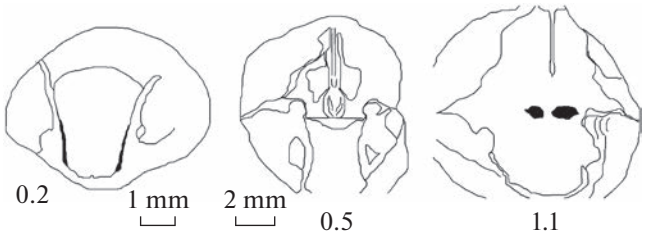


Fig. 63. *Uncinulus subwilsoni* (Orbigny, 1850), specimen PIN, no. 3744/913, serial cross sections through the shell; Nakhchivan AR, Dzhaanam-Deresi River, outcrop 81; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

developed. External radial ornamentation consists of almost always simple flattened costae rounded in cross section. The costae are 0.5–0.8 mm wide, wider than interspaces, run from the valve midlength along the whole shell surface, and sometimes dichotomize, numbering 9–12 in the sulcus, 9 on the fold, and 19–21 on the lateral sides. The costae in median sulcus and fold are wider than costae on the lateral sides. The umbonal walls are strongly, typically for *Uncinulus*, thickened. The dental plates are fused with the walls of the ventral umbo and become separated and arched anteriorly. The dorsal median septum is long, approximately half of the shell length, and covered by the callus posteriorly.

Comparison. This species differs from *U. korovini* Khalfin, 1937 in the almost globular shell, the more numerous and narrower costae, and in the arched dental plates. It differs from *U. orbignyanus* in the inflated globular shell, the undivided fold, and the absence of central costa in the median sulcus.

Occurrence. Lower Devonian of France; Middle Devonian, Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone of the Nakhchivan AR.

Material. Seven variously preserved shells from the Nakhchivan AR, Dzhaanam-Deresi River, outcrop 81.

Genus *Zezinia* Pakhnevich, 2018

Zezinia: Pakhnevich, 2018, p. 25.

Type species. *Zezinia multicostata* Pakhnevich, 2018; Upper Devonian, Lower Frasnian, *Adolfia zickzack* Zone; Nakhchivan AR.

Diagnosis. Shell medium-sized, oval, inflated, and dorsibiconvex; juvenile shells transversely elongated; adult shells almost as wide as long. Ventral umbo erect or slightly incurved; delthyrium covered by dorsal beak. Median sulcus and fold well developed, widening anteriorly, and terminating in tongue at anterior margin. External radial ornamentation composed of simple, wide, and flattened costae. Costae covering whole shell, but very poorly pronounced in umbonal region. Squama and glotta absent. Lateral commissures straight. Anterior margin with bases of marginal spines. Ventral umbo thickened. Dental plates absent or fused with umbonal walls. Teeth small. Dorsal median long and dividing umbo into two cavities. Cardinal process massive and multilobed. Septalium open posteriorly. Cardinal process having cavity at base, so that septalium looking covered. Hinge plates horizontal, fused with septalium. Crural bases rodlike; crura crescentic.

Species composition. Type species.

Comparison. This genus is externally similar to *Taimyrrhynx* from the Upper Emsian–Lower Eifelian of Bohemia and the Urals and differs in the shell shape, the presence of simple costae, the type of the cardinal process, the absence of separated dental plates, rodlike crural bases, and crescentic crura.

Remarks. *Zezinia* is externally similar to *Uchtella* Ljaschenko, 1973, *Glosshypothyridina* Rzhonsnitskaia, 1978 (family Hypothyridinidae), and *Hebetoechia* Havliček, 1959 (family Hebetoechiidae) and differs from *Uchtella* from the Frasnian of European Russia and the Urals in the septum, cardinal process, and horizontal hinge plates fused with the septalium. It differs from *Glosshypothyridina* from the Eifelian European Russia, the Urals, Belgium, and Germany in the presence of multilobed cardinal process, median septum, septalium, and thickened ventral umbo. It differs from *Hebetoechia* from the Pridolian–Lochkovian of Europe, North Africa, Asia, North America, and Australia in the presence of septalium closed by a massive multilobed cardinal process.

Zezinia multicostata Pakhnevich, 2018

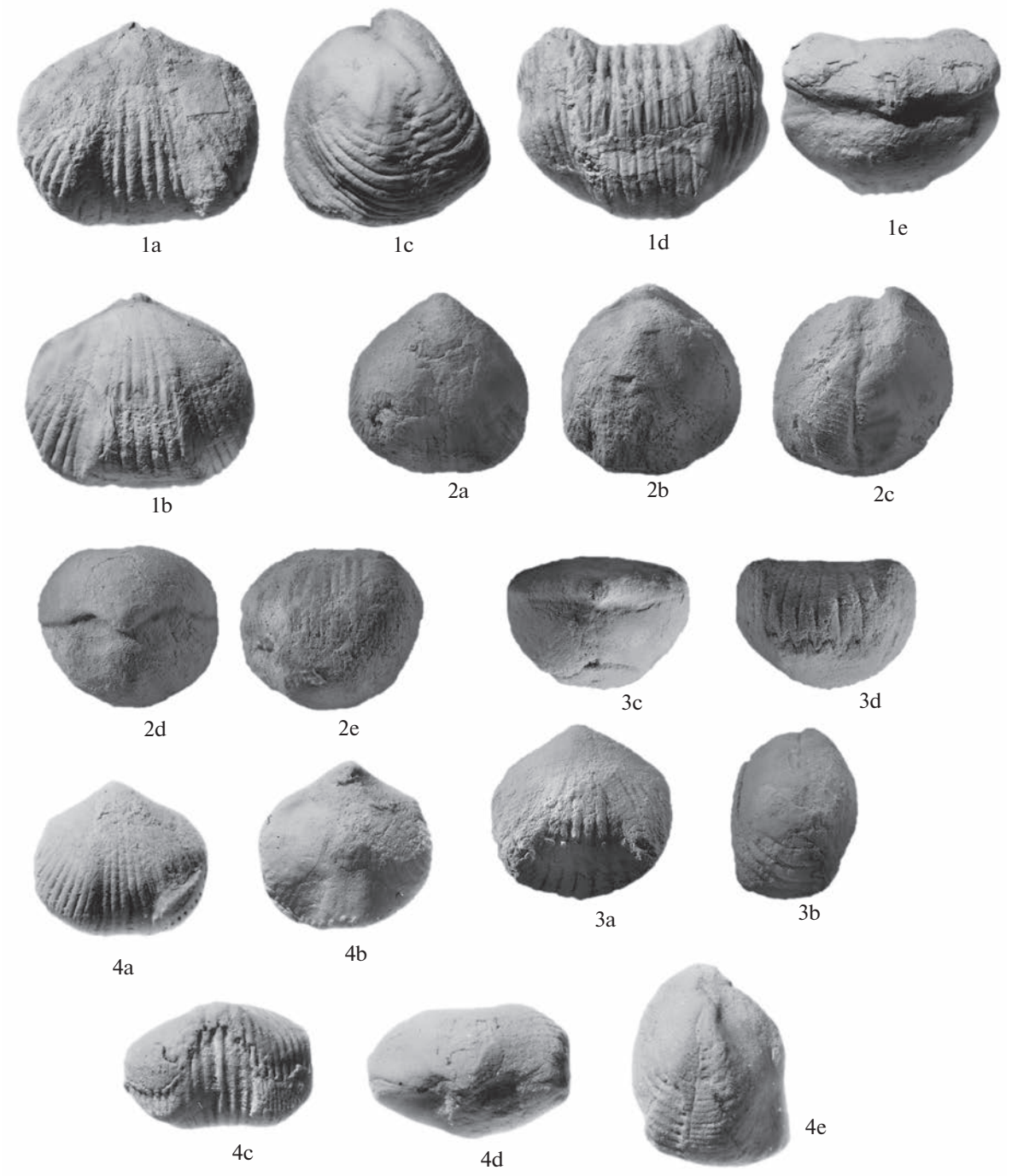
Plate 9, fig. 3; Plate 14, fig. 19; Fig. 64

Zezinia multicostata Pakhnevich, 2018, p. 25, text-figs. 1a–1e, 2, and 3.

Holotype. PIN, no. 3744/846; Upper Devonian, Lower Frasnian, *Adolfia zickzack* Zone; Nakhchivan AR, right bank of the Dzhaanam-Deresi River, 1.5 km east of Tezhgar Mountain, outcrop 601.

Description. The shell is 16.0–21.8 mm long, 17.8–21.6 mm wide, 12.1–15.3 mm thick, and oval; juvenile shells are transversely elongated. The maximum width and thickness are in the anterior one-third of the shell. The ventral umbo is erect or slightly curved; the delthyrium is covered by the dorsal beak. The ventral valve is slightly convex and flattened. The median sulcus is shallow, starts slightly anterior to the shell midlength, and widens anteriorly; the tongue is trapezoid. The dorsal valve is convex, with the maximum convexity near the anterior margin. The fold is flattened, well bordered by interspaces, and starts at the shell midlength. The lateral slopes are gentle. The lateral commissures are straight. The anterior margin bears bases of marginal spines. External radial ornamentation consists of simple, wide, and flattened costae bearing fine capillae. The costae cover the whole

Plate 9



Explanation of Plate 9

Fig. 1. *Uncinulus korovini* Khalfin, 1937, specimen PIN, no. 3744/833, complete shell, ×1: (1a) ventral valve view; (1b) dorsal valve view; (1c) lateral view; (1d) posterior view; (1e) anterior view; Nakhchivan AR, vicinity of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 3; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Fig. 2. *Uncinulus subwilsoni* (Orbigny, 1850), specimen PIN, no. 3744/876, complete shell, ×2: (2a) ventral valve view; (2b) dorsal valve view; (2c) lateral view; (2d) anterior view; (2e) posterior view; Nakhchivan AR, Dzhaanam-Deresi River, outcrop 81; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

Fig. 3. *Zezinia multicostata* Pakhnevich, 2018, specimen PIN, no. 3744/846, complete shell, ×1.5: (3a) ventral valve view; (3b) lateral view; (3c) posterior view; (3d) anterior view; Nakhchivan AR, right bank of the Dzhaanam-Deresi River, 1.5 km east of Tezhgar Mountain, outcrop 601; Lower Frasnian, *Adolfia zickzack* Zone.

Fig. 4. *Kransia parallelepipeda* (Bronn, 1837), specimen PIN, no. 3744/825, complete shell, ×2: (4a) ventral valve view; (4b) dorsal valve view; (4c) anterior view; (4d) posterior view; (4e) lateral view; Nakhchivan AR, eastern slope of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 6; Givetian, *Stringocephalus burtini* Zone.

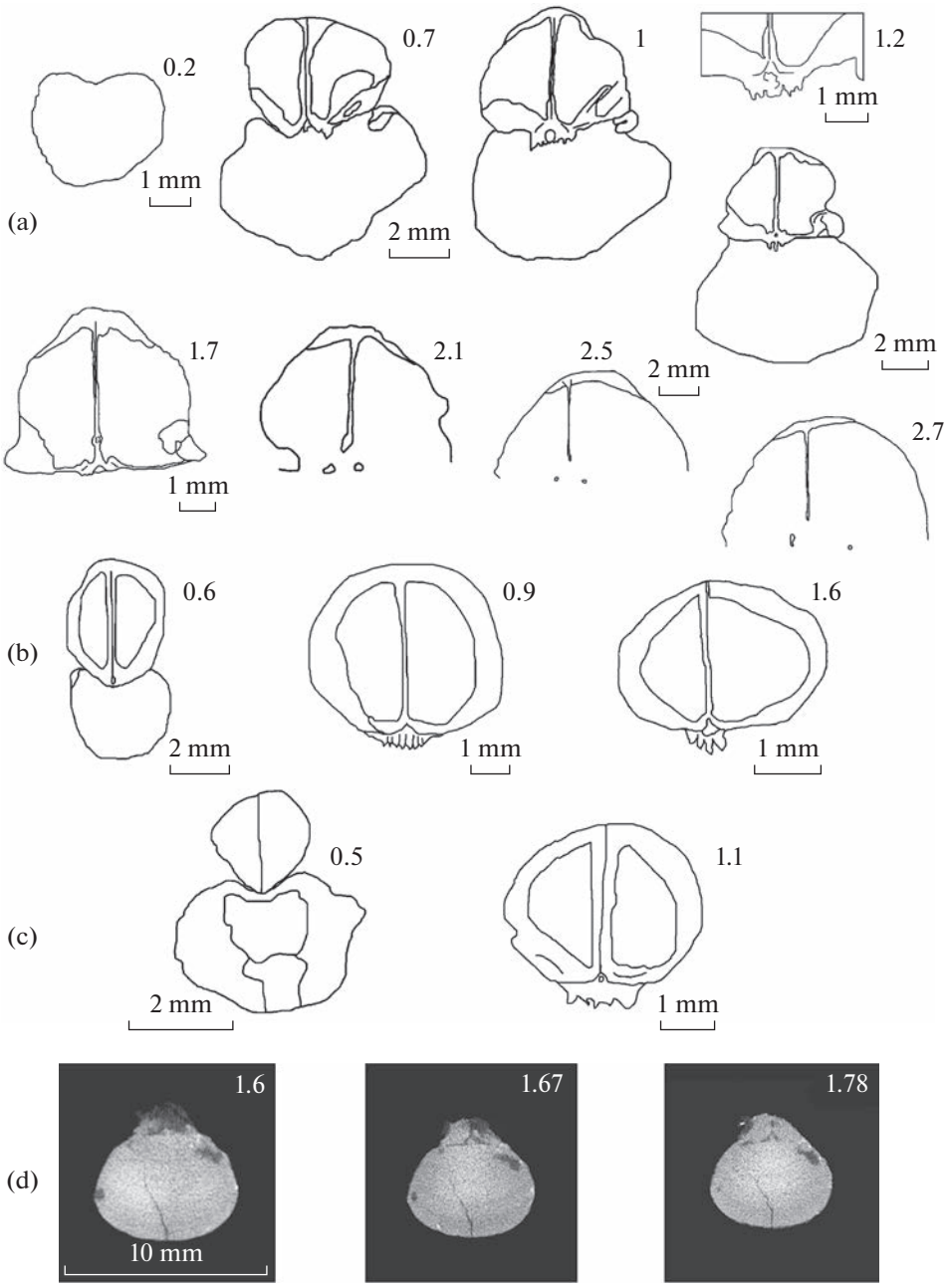


Fig. 64. *Zezinia multicostata* Pakhnevich, 2018, serial cross sections and virtual microtomographic slices through the shell: (a) specimen PIN, no. 3744/914; (b) specimen PIN, no. 3744/964; (c) specimen PIN, no. 3744/965; (d) specimen PIN, no. 3744/966; Nakhchivan AR, right bank of the Arpa River, upstream from village of Danzik, outcrop 43, Bed 10; Lower Frasnian, *Adolfia zickzack* Zone.

shell but are poorly pronounced in the umbonal region, and 0.9–2.4 mm wide at the anterior margin, numbering 6–7 in the sulcus, 5–7 on the fold, and 7–8 on the lateral sides. The costae are considerably wider than the extremely narrow interspaces. The ventral umbo is thickened. The dental plates are fused with walls of the ventral umbo. The teeth are small and rounded. The dorsal median septum is high, long, divides the dorsal umbo into two cavities. The cardinal process is massive, multilobed, and up to 1.44 mm wide. The septalium is narrow, shallow, and covered by the cardinal process. The hinge plates are horizontal and fused with the septalium. The crural bases are long and rodlike; the crura are thickened and crescentic.

O c c u r r e n c e. Lower Frasnian (*Adolfia zickzack* Zone); Nakhchivan AR.

M a t e r i a l. Twenty-two variously preserved shells and two ventral valves from the Nakhchivan AR: vicinity of the village of Gyumushlug, outcrop 42, Bed 6a; southern slope of Birali-Kuzei Mountain,

outcrop 1439; right bank of the Arpa River, upstream from the village of Danzik, outcrop 43, Bed 10; right bank of the Dzhaanam-Deresi River, 1.5 km east of Tezhgar Mountain, outcrop 601, Bed 3.

Family Hebetoechiidae Havliček, 1960

Subfamily Betterbergiinae Savage, 1996

Genus *Kransia* Westbroek, 1968

Kransia: Westbroek, 1968, p. 81; Baranov, 1996, p. 91; Savage, 2002b, p. 1111.

Type species. *Terebratula parallelepipeda* Bronn, 1837, p. 71; Middle Devonian, Givetian; Europe.

Diagnosis. Shell small or medium-sized, rounded and oval to rhombic in outline, slightly to strongly inflated, and ventribiconvex to dorsibiconvex. Ventral umbo small, high, and incurved; foramen small and rounded; deltidial plates conjunct. Median sulcus and fold starting at shell midlength, widened anteriorly, and forming tongue at anterior margin. Fold sometimes pronounced only at anterior margin. External radial ornamentation composed of numerous flattened costae covering whole shell surface. Costae usually simple, running from valve umbos, sometimes intercalating or dichotomizing, and terminating in marginal spines. Squama and glotta developed. Lateral commissures straight or somewhat curved near anterior margin. Umbonal walls of both valves thickened. Dental plates short, thin, and close to walls of ventral umbo. Teeth massive and columnar. Cardinal process multilobed, starting from valve bottom. Median septum long, reaching shell midlength, but not connected to hinge plates. Septalium absent. Hinge plates united only posteriorly and discrete anteriorly. Crura narrow, curved towards each other, and crescentic. Dorsal muscle field located in middle of valve. Muscle scars finger-shaped.

Species composition. About six species from Lower (Emsian)–Middle (Givetian) Devonian of Europe, the Urals, North Africa, China, Afghanistan; Eifelian of Kazakhstan; Eifelian (*Alatiformia araxica–Dagnachonetes caucasius*, *Mucrospirifer diluvianoides–Radiomena irregularis* Zones)–Givetian of the Nakhchivan AR. Transcaucasia: *Kransia parallelepipeda* (Bronn, 1837), *K. praecedens* (Kulkov, 1960), *K. subcordiformis* (Schnur, 1853).

Comparison. This genus is externally similar to *Mongolorhynx* Erlanger, 1992, *Glossinulina* Johnson, 1975, *Nordotoechia* Tcherkesova, 1965, *Pseudoglossinotoechia* Tcherkesova, 1967, *Betterbergia* Schmidt, 1981, *Primipilaria* Struve, 1992, and *Beckmannia* Mohanti, 1972. *Kransia* differs from *Mongolorhynx* in the worse developed costae on the shell surface, the more flattened ventral valve, the shell angular in outline, worse developed dental plates, and the low dorsal septum. It differs from *Glossinulina* in the absence of groove on the fold and bundle of costae in the median sulcus, the thickened valve umbos, the poorly developed dental plates and septum, and in the presence of more massive cardinal process. It differs from *Nordotoechia* in the smaller, less convex, rounded, not transversely elongated shell, the presence of small septum and cardinal process, and the absence of septalium. *Kransia* differs from *Pseudoglossinotoechia* in the less convex shell, the absence of numerous dichotomizing costae and upturned fold, and in the poorly developed septum. It differs from *Betterbergia* in the smaller shell, well pronounced narrower fold and median sulcus, the presence of cardinal process, and in the crus shape. It differs from *Primipilaria* in the few dichotomizing costae, not thickened low septum, the absence of septalium, and in the discrete hinge plates. It differs from *Beckmannia* in the larger shell, the better bordered median sulcus and fold, the thickened septum, and in the absence of a massive callus in the dorsal umbo.

Remarks. *Kransia* resembles *Aseptalium* Hou et Xian, 1975 (family Innaechiidae), *Eoglossinotoechia* Havliček, 1959 (family Glossinotoechiidae), and *Pseudouncinulus* Ržonsnitskaja, 1968 (family Hypothyridinidae). It differs from *Aseptalium* in the presence of septum and cardinal process, the poorly developed dental plates, the thickened umbos, and in the flattened crura. It differs from *Eoglossinotoechia* in the poorly developed low septum, the presence of multilobed cardinal process, the absence of stages of trifid and bifid cardinal process, and in the divided hinge plate. It differs from *Pseudouncinulus* in the narrower costae, the thickened umbos, and in the presence of septum.

Kransia parallelepipeda (Bronn, 1837)

Plate 9, fig. 4; Plate 14, fig. 3; Fig. 65

Terebratula parallelepipeda: Bronn, 1837, p. 71, figs. 46, 55, and 66; pl. 2, fig. 3; pl. 3, fig. 5; pl. 9, figs. 1, 2, and 6; pl. 10, fig. 3.

Hypothyris parallelepipeda: Nalivkin, 1930, p. 76, pl. 4, fig. 31 (synonymy)

Uncinulus parallelepipedus: Torley, 1934, p. 83, gruppe A, abb. 17, pl. 3, figs. 18–21; Schmidt, 1941, p. 18, pl. 1, figs. 17, 18; pl. 4, figs. 63–67, pl. 6, figs. 14–16 (synonymy); Khodalevich, 1951, p. 55, pl. 12, figs. 5 and 6; Khodalevich and Breivel, 1972, p. 122, pl. 45, figs. 7–10 and 12; text-fig. 23; Drot, 1964, p. 151, pl. 17, figs. 2a–2c, 3a–3c, 4a–4c.

Kransia aff. *parallelepipeda*: Brice, 1970, p. 30, pl. 3, figs. 7a–7d (synonymy).

Kransia cf. *parallelepipeda*: Sapelnikov et al., 1987, p. 97, pl. 8, figs. 1 and 2 (synonymy).

Kransia parallelepipeda: Jungheim, 2000, p. 53, pl. 8.

Holotype was not designated.

Description. The shell is 9.8–13.7 mm long, 10.7–14.8 mm wide, 6.4–9.3 mm thick, oval to rhombic, transversely elongated to elongated, and ventribiconvex. The ventral umbo is small, high, and incurved; the foramen is small and rounded; the deltidial plates are conjunct. The maximum convexity of the ventral valve is in its middle. The median sulcus starts at the shell midlength, widens anteriorly, is well bordered by costae, and terminates at the anterior

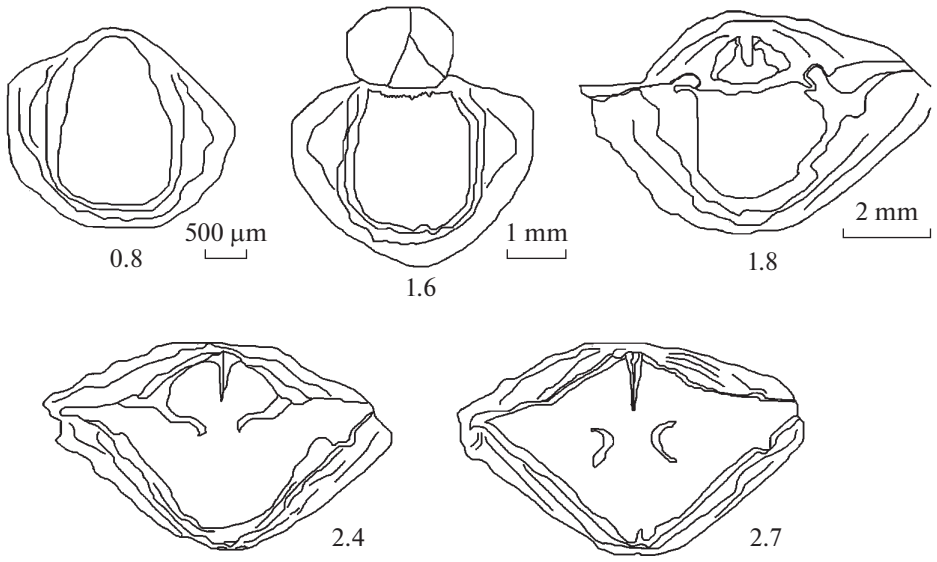


Fig. 65. *Kransia parallelepipeda* (Bronn, 1837), specimen PIN, no. 3744/915, serial cross sections through the shell; Nakhchivan AR, left bank of the Dzhaanam-Deresi River opposite bioherm, outcrop 56, Bed 7; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

margin into a trapezoid tongue. The dorsal valve is flattened, with the maximum convexity at the anterior margin. The fold starts at the anterior margin and is indistinctly bordered by costal interspaces. The lateral slopes are gentle. The squama and glotta are developed. The lateral commissures are straight or somewhat curved near the anterior margin. External radial ornamentation consists of numerous simple and flattened costae covering the whole shell surface. The costae are 0.3–0.6 mm wide, wider than interspaces, sometimes dichotomize or intercalate, and terminate into marginal spines, numbering 5–8 in the sulcus, 5–12 on the fold, and 8–12 on each lateral side. The dorsal muscle field is in the middle of valve; the muscle scars are finger-shaped. The walls of both umbos are thickened. The dental plates are short, thin, and located close to the walls of ventral umbo. The cardinal process is multilobed, starting from the bottom. The median septum is long, reaches shell midlength but is not connected to hinge plates. The septalium is absent. The crura are crescentic and curved inwards.

Variability. The shell shape and number of costae in the sulcus, fold and lateral sides vary.

Comparison. This species differs from *Kransia subcordiformis* (Schnur, 1853) in the elongated shell and narrow tongue.

Occurrence. Lower (Emsian)–Middle (Givetian) Devonian of Europe, the Urals, North Africa, China, Afghanistan; Eifelian of Kazakhstan; Eifelian (Lyaglyan and Akkapchigai horizons) of southern Tien Shan; Eifelian (*Mucrospirifer diluvianoides–Radiomena irregularis* Zone)–Givetian of Transcaucasia.

Material. 129 shells and one inner mold: Nakhchivan AR: left bank of the Dzhaanam-Deresi River, 1.5 km west of Kazma Mountain, outcrop 57, Bed 1–8b; left bank of the Dzhaanam-Deresi River, 1.5 km southwest of Kazma Mountain peak, outcrop 58, Beds 1–5; left bank of the Dzhaanam-Deresi River opposite bioherm, outcrop 56, Bed 7; right bank of the Dzhaanam-Deresi River, 0.5 km northwest of Kazma Mountain, outcrop 3510, Bed 8; left bank of the Dzhaanam-Deresi River, northwest of Kazma Mountain, outcrop 600, Bed 10; Dzhaanam-Deresi River Basin, outcrop 53, Bed 5; outcrop 104, Bed 3; outcrop 51, Bed 8; outcrops 1409 and 1222a; eastern slope of Kasan-Gulu-Bakh Mountain, outcrop 63, Beds 5 and 6; left bank of the Arpa River near the village of Danzik, outcrop 19, Bed 38; vicinity of Udzhubiz Mountain, outcrop 77, Bed 15; near the village of Gyumushlug, outcrop 1716/1; south spurs of the Plakhpashi Mountain Range, outcrop 1176; Velidag Mountain, outcrop 1422; interfluve of Dzheganzur-Dere and Yaidzhi-Deresi rivers, outcrop 2/77; Karadash Mountain, outcrop 50; left bank of the Dzhaanam-Deresi River (at reef basement), outcrop 03; southeastern spurs of the Plakhpashi Mountain Range, vicinity of the village of Sadarak, outcrop 1414a; 1 km southwest of Delanan Mountain, vicinity of the village of Sadarak, outcrop 1417, outcrop 75, Bed 4; Armenia: western slope of Adzhakyan Mountain, outcrop 64, Bed 4.

***Kransia praecedens* (Kulkov, 1960)**

Plate 10, figs. 1 and 2

Uncinulus parallelepipedus f. *praecedens*: Kulkov, 1960, p. 176, pl. 4, figs. 3a–3d.

Holotype. No. 285k-7, Tomsk Polytechnic University, Department of Geology and Land Man-

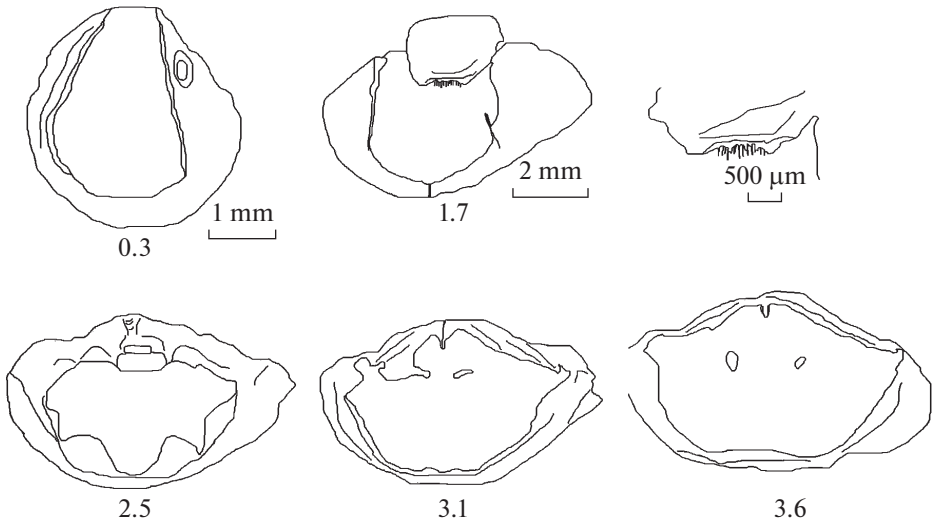


Fig. 66. *Kransia subcordiformis* (Schnur, 1853), specimen PIN, no. 3744/916, serial cross sections through the shell; Nakhchivan AR, vicinity of Kasan-Gulu-Bakh Mountain, outcrop 63, bed 5; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

agement; Kulkov, 1960, p. 176, pl. 4, figs. 3a–4d; 2 km southwest of Shanda Ulus, right bank of the Malyi Bachat River; Lower Devonian, Eifelian, Podshandinskie limestones.

D e s c r i p t i o n. The shell is 10.3–13.7 mm long, 10.1–13.8 mm wide, 6.2–9.5 mm thick, oval, somewhat pentagonal to triangular and elongated in outline. The ventral umbo is well pronounced, high, acute, and slightly inflated; the foramen is small and oval; the deltidial plates are conjunct. The ventral valve is convex, with the maximum convexity in the anterior one-third of the shell. The median sulcus starts at the shell midlength, widens anteriorly, is well bordered by costae, and terminates in a tongue at the anterior margin. The dorsal valve is flattened, with the maximum convexity at the anterior margin. The fold is low, indistinctly bordered by interspaces, and developed only at the anterior margin. The lateral slopes are gentle. External radial ornamentation consists of numerous simple and flattened costae covering the whole shell surface. The costae are 0.5–0.7 mm wide, wider than interspaces, and sometimes intercalate, numbering 3–4 in the sulcus, 3 on the fold, and 8–11 on the lateral shell sides. The marginal spines are developed. The muscle field is located in the middle of the dorsal valve; the muscle scars are elongated finger-shaped. The dental plates are separated from thickened walls of the ventral umbo and dorsally convergent. The median septum is long, reaches the shell midlength, and is not connected to hinge plates. The septalium is absent.

C o m p a r i s o n. This species differs from *K. subcordiformis* (Schnur, 1853) and *K. parallelepipeda* (Bronn, 1837) in the elongated shell, the larger elongated ventral umbo, and in the longer narrow tongue.

O c c u r r e n c e. Eifelian of Siberia; Upper Eifelian (*Mucrospirifer diluvianoides–Radiomena irregularis* Zone) of the Nakhchivan AR.

M a t e r i a l. Four satisfactorily preserved shells from the Nakhchivan AR, vicinity of the Dzhaanam-Deresi River, outcrop 1409, outcrop 57, Bed 9; outcrop 53, Bed 5.

***Kransia subcordiformis* (Schnur, 1853)**

Plate 10, fig. 3; Fig. 66

Terebratula subcordiformis: Schnur, 1853, p. 186, pl. 25, fig. 6.

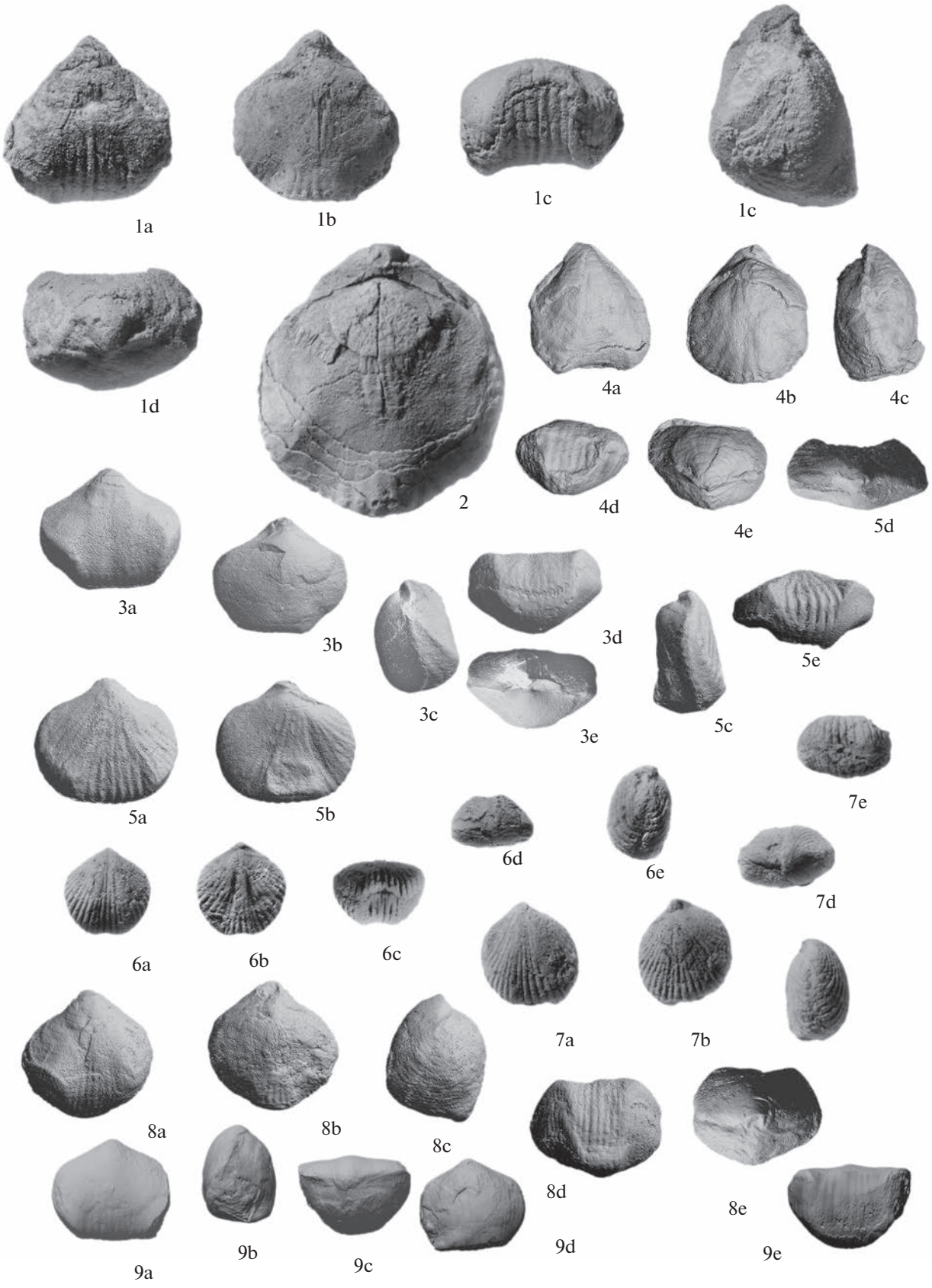
Uncinulus subcordiformis: Torley, 1934, p. 84, gruppe A, abb. 18, pl. 3, figs. 22 and 23; Schmidt, 1941, p. 19, pl. 2, fig. 20; pl. 4, fig. 71; Nalivkin, 1951, p. 12, pl. 3, figs. 8 and 9; Biernat, 1966, p. 88, pl. 20, figs. 5–21; Khodalevich and Breivel, 1972, p. 120, pl. 44, figs. 10 and 11; pl. 45, figs. 3 and 4 (synonymy); Sapelnikov and Mizens, 1981, p. 16, pl. 3, fig. 9; 1984, p. 21, pl. 4, figs. 5–7.

Kransia subcordiformis: Sapelnikov et al., 1987, p. 98, pl. 9, figs. 8–10; Jungheim, 2000, p. 53, pl. 8.

H o l o t y p e was not designated.

D e s c r i p t i o n. The shell is medium-sized, 12–14.3 mm long, 14–16.2 mm wide, 8.5–11.4 mm thick, oval, transversely elongated, and dorsibiconvex. The ventral valve is slightly convex, with small and somewhat curved umbo; the foramen is minute and rounded; the deltidial plates are conjunct; the interarea is small. The maximum convexity of the ventral valve is in its anterior one-third. The ventral sulcus starts at the valve midlength, but is well pronounced only at the anterior margin and indistinctly bordered by costae; the tongue is wide and almost rectangular. The maximum thickness of flattened dorsal valve is at the anterior margin. The fold is developed only at the anterior margin and indistinctly bordered by interspaces. The lateral slopes become steeper anteriorly and are vertical near the anterior margin. The lateral

Plate 10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commissures are straight or somewhat curved near the anterior margin. External radial ornamentation consists of numerous simple, flattened, wide costae covering the whole shell surface. The costae are 0.4–0.7 mm wide, wider than interspaces, and terminate in marginal spines, numbering 8–10 in the median sulcus, about 8 on the fold, and 8–12 on each lateral side. The costae in the median sulcus are wider than on the lateral sides. The umbonal walls are thickened. The cardinal process is multilobed. The dorsal septum is low, long, and reaches the middle of the valve. The septalium is absent.

Comparison. This species differs from *Kransia parallelipipeda* (Bronn, 1837) in the transversely elongated shell and wide rectangular tongue. It differs from *Kransia praecedens* (Kulkov, 1960) in the shell shape, the smaller ventral umbo, and wide short tongue.

Occurrence. Middle Devonian of Europe, the Urals and Salair; Givetian of the eastern slope of the Bashkir Urals; Upper Givetian of the Nakhchivan AR.

Material. Sixteen satisfactorily preserved shells from the Nakhchivan AR: vicinity of Kasan-Gulu-Bakh Mountain, outcrop 63, Beds 5, 6, and 58; left bank of the Arpa River near the village of Gyumushlug, above market, outcrop 65, Bed 15; left bank of the Dzhaanam-Deresi River, 1.5 km west of Kazma Mountain, outcrop 57, Beds 8–10.

***Kransia* sp.**

Plate 10, fig. 4; Fig. 67

Description. The shell is small, 6.6–11.5 mm long, 6.1–10.2 mm wide, 4.4–6.7 mm thick, oval, and elongated. The maximum shell width is at the anterior margin. The maximum thickness is in the umbonal region. The ventral valve is slightly convex, with a slightly incurved umbo. The median sulcus and fold start at the shell midlength, widen anteriorly, and are bordered by costae and interspaces, respectively. The tongue is small and narrow. The dorsal valve is convex, with the maximum convexity at the anterior margin. The lateral slopes are gentle, especially in the ventral valve; the lateral commissures are slightly curved. External ornamentation is costate. The costae are simple, flattened and rounded in cross section, wider than the interspaces, and up to 0.5 mm wide at the anterior margin, numbering 5 in the median sulcus, 6 on the fold, and 7 on the lateral sides. The costae probably run from the umbos; however, this is uncertain, as the shell is partly broken. The shell walls are thickened. In the ventral umbo, the dental plates are thin, short, and for most of their length fused with the umbonal walls. In the dorsal valve, the cardinal process is broad and multilobed, with the cavity at the base. The teeth are pointed. The septum is low, short, thickened, separated from the hinge plates, and passes into myophragm anteriorly. The hinge plates are thickened and divided, with strongly thickened inner margins. The crural bases are triangular in cross section; the crura are thickened and laterally flattened.

Comparison. *Kransia* sp. is most similar to representatives of *Kransia* in shell interior and differs from the other species of this genus in the shell shape. It differs from *K. parallelepipeda* (Bronn, 1837) and *K. subcordiformis* (Schnur, 1853) in the elongated shell. *Kransia* sp. is most similar to *K. praecedens* (Kulkov, 1960) in the elongated shell and differs in the

Explanation of Plate 10

Figs. 1 and 2. *Kransia praecedens* (Kulkov, 1960), specimen PIN, no. 3744/824, damaged shell, ×2: (1a) ventral valve view; (1b) dorsal valve view; (1c) anterior view; (1d) posterior view; (1e) lateral view; outcrop 1409; (2) specimen PIN, no. 3744/839, complete shell, dorsal valve view, muscle scars, ×4; Nakhchivan AR, vicinity of the Dzhaanam-Deresi River, outcrop 53, Bed 5; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 3. *Kransia subcordiformis* (Schnur, 1853), specimen PIN, no. 3744/877, 3D model of complete shell, ×1.5: (3a) ventral valve view; (3b) dorsal valve view; (3c) lateral view; (3d) anterior view; (3e) posterior view; Nakhchivan AR, vicinity of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 5; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Fig. 4. *Kransia* sp., specimen PIN, no. 3744/844, 3D model of complete shell, ×3: (4a) ventral valve view; (4b) dorsal valve view; (4c) lateral view; (4d) anterior view; (4e) posterior view; Nakhchivan AR, southern slope of Velidag Mountain, outcrop 48, Bed 2; Upper Emsian–Lower Eifelian, *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

Fig. 5. *Primipilaria primipilaris* (Buch, 1834), specimen PIN, no. 3744/831, 3 D model of complete shell, ×2: (5a) ventral valve view; (5b) dorsal valve view; (5c) lateral view; (5d) posterior view; (5e) anterior view; Nakhchivan AR, Dzhaanam-Deresi River Basin, outcrop 53, Bed 5a; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 6. *Beckmannia pentagona* (Kayser, 1871), specimen PIN, no. 3744/827, complete shell, ×2: (6a) ventral valve view; (6b) dorsal valve view; (6c) anterior view; (6d) posterior view; (6e) lateral view; Nakhchivan AR, left bank of the Dzhaanam-Deresi River, 1.5 km west of Kazma Mountain, outcrop 57, Bed 9; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 7. *Beckmannia minor* (Schnur, 1853), specimen PIN, no. 3744/838, complete shell, ×2: (7a) ventral valve view; (7b) dorsal valve view; (7c) lateral view; (7d) posterior view; (7e) anterior view; Nakhchivan AR, Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 5; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Fig. 8. *Beckmannia angularis* (Phillips, 1841), specimen PIN, no. 3744/845, 3D model of complete shell, ×1.5: (8a) ventral valve view; (8b) dorsal valve view; (8c) lateral view; (8d) anterior view; (8e) posterior view; Armenia, Karaburun Mountain, outcrop 47; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

Fig. 9. *Glosshypothyridina procuboides* (Kayser, 1871), specimen PIN, no. 3744/848, 3D model of complete shell, ×1: (9a) ventral valve view; (9b) lateral view; (9c) dorsal valve view; (9d) posterior view; (9e) anterior view; Nakhchivan AR, 1.75 km northwest of Kazma Mountain, Dzhaanam-Deresi River Basin; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

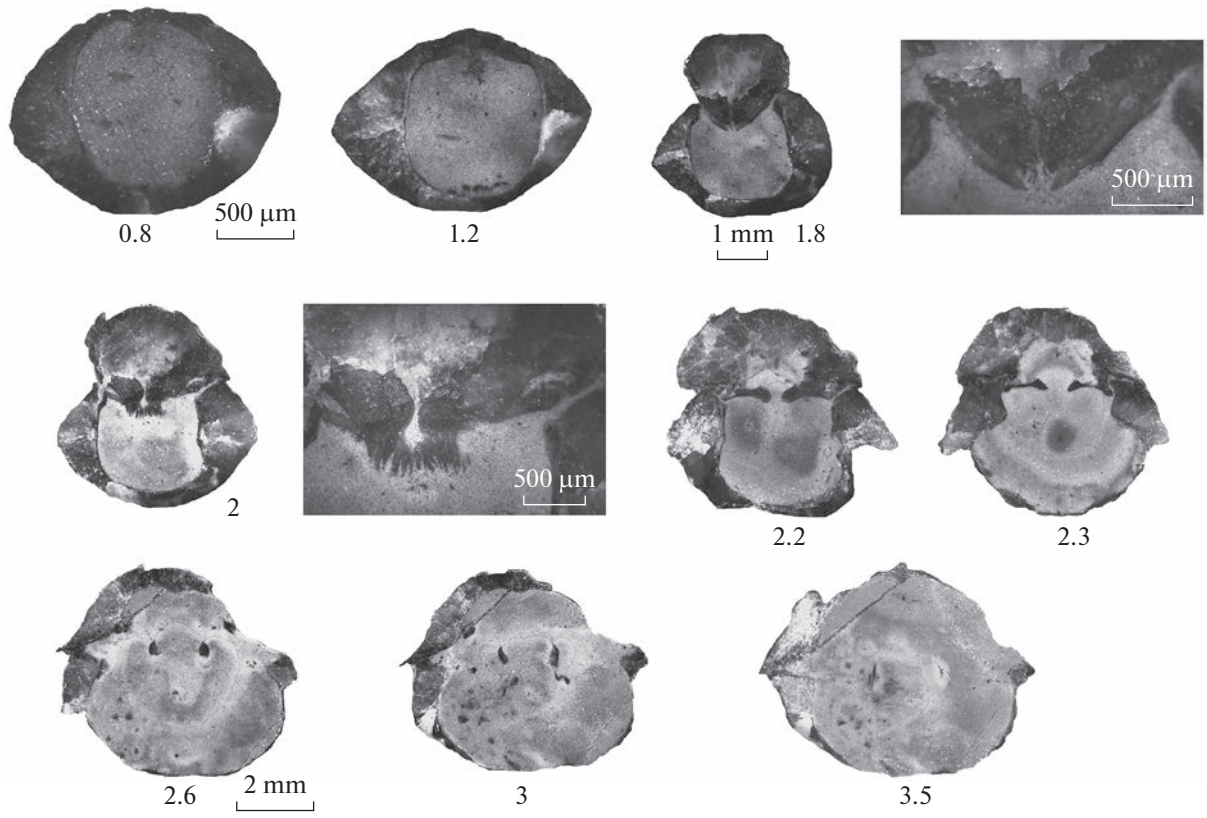


Fig. 67. *Kransia* sp., specimen PIN, no. 3744/844, serial cross sections through the shell; Nakhchivan AR, southern slope of Velidag Mountain, outcrop 48, Bed 2; Upper Emsian–Lower Eifelian, *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

narrower shell with smaller ventral umbo and smaller tongue.

Remarks. These specimens are similar to *Kransia,* but not assigned to any known species due to the poorly preserved insufficient material and some morphological peculiarities (elongated shell). The initial field determination, *Uncinulus keltibericus* Schumann, 1965, proved to be incorrect and occurrence of this species in Transcaucasia should be questioned. The studied specimens differ from *U. keltibericus* in the shell interior. Although the material is insufficient and poorly preserved; thus, they should be described taking into account the peculiarity of their shell exterior.

Occurrence. Upper Emsian–Lower Eifelian, *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone; Nakhchivan AR.

Material. Two poorly preserved shells from the Nakhchivan AR, southern slope of Velidag Mountain, outcrop 48, Bed 2.

Genus *Primipilaria* Struve, 1992

Primipilaria: Struve, 1992, p. 549; Jungheim, 2000, p. 54; Savage, 2002b, p. 1112.

Type species. *Terebratula primipilaris* Buch, 1834, p. 88; Middle Devonian; Europe.

Diagnosis. Shell medium-sized, ventribiconvex, ovally pentagonal, transversely elongated, and flattened. Ventral umbo small and somewhat incurved; foramen small and rounded; deltidial plates conjunct. Median sulcus and fold start almost from umbos and poorly pronounced; fold worse developed than median sulcus; tongue curved. External radial ornamentation composed of wide, flattened, intercalating and dichotomizing costae covering whole shell surface. Lateral commissures slightly curved. Anterior margin curved and parasulcate. Umbonal walls laterally thickened. Dental plates poorly pronounced and fused with walls of ventral umbo. Dorsal septum developed.

H5Europe; Eifelian–Lower Givetian of the western slope of the Urals; Upper Eifelian (*Mucrospirifer diluvianoides–Radiomena irregularis* Zone) of the Nakhchivan AR. Transcaucasia: *Primipilaria primipilaris* (Buch, 1834).

Comparison. This genus externally resembles *Beckmannia* Mohanti, 1972 and *Kransia* Westbroek, 1968 and differs in the numerous dichotomizing costae on the shell surface, the thickened septum, the presence of short septalium, and in the united hinge plates. In addition, it differs from *Beckmannia* in the larger shell.

Remarks. *Primipilaria* differs from similar Eifelian–Givetian Uncinuloidea in the dichotomizing costae.

***Primipilaria primipilaris* (Buch, 1834)**

Plate 10, fig. 5; Plate 14, fig. 5

Terebratula primipilaris: Buch, 1834, p. 68, pl. 2, figs. 29a–29c.

Rhynchonella primipilaris: Davidson, 1864–1871, p. 66, pl. 14, figs. 4–6; Tchernyshew, 1887, p. 95, pl. 11, figs. 7 and 10.

Uncinulus primipilaris: Schmidt, 1941, p. 23, pl. 2, fig. 21; pl. 6, fig. 17 (synonymy).

Primipilaria primipilaris: Jungheim, 2000, p. 54, pl. 8.

Holotype was not designated.

Description. The shell is medium-sized, 11.3–11.7 mm long, 12–13.5 mm wide, 5.6–7 mm thick, ovally pentagonal, and transversely elongated. The maximum width is at the shell midlength. The ventral valve is convex, with the maximum convexity in the umbonal region. The umbo is low and somewhat incurved, almost erect; the deltidial plates are conjunct. The posterior margin is straight. The median sulcus starts at the valve midlength, is well bordered by costae (the bordering costae run almost from the umbo), widens anteriorly, and terminates in a tongue. The dorsal valve is flattened, with the maximum convexity in the umbonal region. The fold is low and poorly developed only near the anterior margin. The lateral slopes are gentle. External radial ornamentation consists of flattened, sometimes dichotomizing or intercalating costae. The costae start from the umbos, thicken anteriorly, and terminate in marginal spines at denticulate anterior margin, numbering 6–9 in the median sulcus, about 5 on the fold, and 6–9 on each lateral side. The costae are 0.4–0.5 mm wide at the anterior margin and almost as wide as the interspaces. The dorsal septum is long and almost reaches the valve midlength. The shell interior is the same as in *P. primipilaris*.

Comparison. This species differs from *P. praeprimipilaris* Struve, 1992 in the fewer costae in the sulcus and on the fold. It differs from *P. fissicristata* Struve, 1992 and *P. primipilaroides* Struve, 1992 in the more transversely elongated shell.

Remarks. *P. primipilaris* differs from species of *Beckmannia* Mohanti, 1972 in the shell size and shape, the structure of the ventral umbo, the ornamentation, and in the well developed long septum. It differs from the species of *Kransia* Westbroek, 1968 in the shell shape, thickness, and ornamentation.

Occurrence. Middle Devonian (Eifelian–Givetian) of Europe; Eifelian–Lower Givetian of the western slope of the Urals; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone of the Nakhchivan AR.

Material. Three satisfactorily preserved shells from the Nakhchivan AR, vicinity of the Dzhaanam-Deresi River, outcrop 53, Bed 5a; outcrop 57, Bed 8h.

Subfamily Beckmanniinae Savage, 1996

Genus *Beckmannia* Mohanti, 1972

Beckmannia: Mohanti, 1972, p. 166; Savage, 2002b, p. 1113.

Type species. *Uncinulus minor beckmanni* Schmidt, 1951, p. 89; Middle Devonian, lowermost Givetian; Germany, Letmathe, near Dortmund.

Diagnosis. Shell small, pentagonal, and ventribiconvex. Ventral umbo small and somewhat incurved; foramen and deltidial plates covered by dorsal beak. Dorsal umbo strongly thickened. Median sulcus and fold well pronounced, starting from umbos, and terminating into tongue at anterior margin. External radial ornamentation composed of plicae covering whole shell surface. Lateral commissures straight. Ventral umbonal walls (especially lateral) thickened and convex towards each other. Dorsal umbo thickened, with small umbonal cavity. Dental plates absent. Septum low, thin, and long. Hinge plates separate. Crura wide, concave towards each other, and parallel to shell longitudinal axis.

Species composition. Four species; Middle Devonian (Givetian) of Europe, Tajikistan, the Urals; Eifelian (Akkapchigai Horizon) of the southern Tien Shan; Upper Eifelian of the Nakhchivan AR. Transcaucasia: *Beckmannia pentagona* (Kayser, 1871), *B. minor* (Schnur, 1853), *B. angularis* (Phillips, 1841).

Comparison. This genus differs from *Cassidirostrum* McLaren, 1961 in the more smoothed costae on the shell surface, the thin septum, worse developed dental plates, and the absence of septalium.

Remarks. *Beckmannia* is externally similar to the genera of the subfamily Betterbergiinae: *Kransia* Westbroek, 1968, *Betterbergia* Schmidt, 1981, and *Primipilaria* Struve, 1992. It differs from *Kransia* in the smaller shell, indistinctly bordered fold and sulcus, thin septum, and massive callus in the dorsal umbo. It differs from *Betterbergia* in the shell size and the absence of septalium. It differs from *Primipilaria* in the simple costae on the shell surface, the shell size, thin septum, and in the absence of septalium.

***Beckmannia pentagona* (Kayser, 1871)**

Plate 10, fig. 6; Plate 14, fig. 20; Fig. 68

Rhynchonella parallelipipeda var. *pentagona*: Kayser, 1871, p. 508, pl. 9, fig. 4.

Rhynchonella (*Hypothyris*) *pentagona*: Reed, 1908, p. 91, pl. 14, figs. 15, 15a, and 15b.

Uncinulus pentagonus: Torley, 1934, p. 85, pl. 3, figs. 32 and 33; Schmidt, 1941, p. 21, pl. 2, fig. 22.

Markitoechia cf. *pentagona*: Anderson et al., 1969, p. 139, pl. 6, figs. 1–4; text-fig. 4 (synonymy).

Kransia pentagona: Jungheim, 2000, p. 54, pl. 8.

Holotype was not designated.

Description. The shell is small and almost equally long and wide (6.2–8.8 mm long, 6.4–8.8 mm wide, 4.2–5.2 mm thick), and pentagonal. The maximum width is in the posterior one-third of the shell. The ventral valve is convex, with the maximum con-

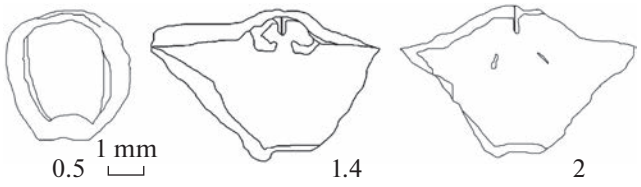


Fig. 68. *Beckmannia pentagona* (Kayser, 1871), specimen PIN, no. 3744/917, serial cross sections through the shell; Nakhchivan AR, left bank of the Dzhaanam-Deresi River, 1.5 km west of Kazma Mountain, outcrop 57, Beds 9–10; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

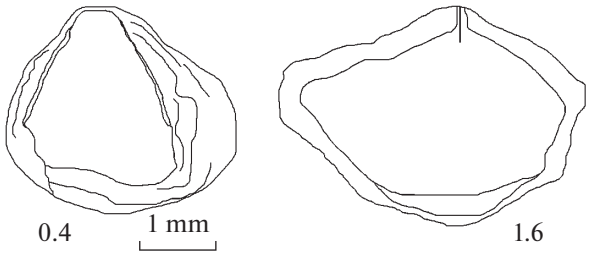


Fig. 69. *Beckmannia minor* (Schnur, 1853), specimen PIN, no. 3744/918, serial cross sections through the shell; Nakhchivan AR, Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 5; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

vexity in the anterior one-third. The ventral umbo is low and somewhat curved, almost erect; the delthyrium is covered by the dorsal beak. The posterior margin is wide, ventrally arched, and forms spiriferid-like area and ears. The median sulcus is developed in the anterior half of the ventral valve, medium wide, and terminates in a tongue. The dorsal valve is flattened, with the maximum convexity in the umbonal region. The fold is well developed, narrow, and divides the valve surface into three segments. The lateral slopes are gentle. External radial ornamentation consists of rounded in cross section plicae. The plicae are about 0.4 mm wide at denticulate anterior margin and wider than interspaces, numbering 3–5 in the sulcus, 4–5 on the fold, and 6–8, rarely, 10 on each lateral side. Two smaller plicae are sometimes developed in the interspaces bordering the fold. A few plicae dichotomize. The plicae bordering the median sulcus and interspaces bordering the fold are well pronounced.

Comparison. This species differs from similar *Beckmannia implexa* in the more convex pentagonal shell and well-developed median sulcus, fold, and tongue. It differs from *Beckmannia minor* in the pentagonal shell and more distinctly pronounced sulcus, fold, and costae.

Occurrence. Upper Emsian–Upper Givetian, *Zdimir pseudobaschkiricus–Megastrophia uralensis*, *Alatiformia araxica–Dagnachonetes caucasius*, *Mucrospirifer diluvianoides–Radiomena irregularis*, and *Indospirifer pseudowilliamsi* zones of Transcaucasia; Eifelian of Burma; Givetian of Germany, Spain.

Material. 358 well-preserved complete shells: Nakhchivan AR: left bank of the Dzhaanam-Deresi River 1.5 km southwest of Kazma Mountain peak, outcrop 58, Beds 1b and 55; left bank of the Dzhaanam-Deresi River opposite bioherm, outcrop 56, Beds 8 and 9; left bank of the Dzhaanam-Deresi River 1.5 km west of Kazma Mountain, outcrop 57, Beds 2, 8–11, and 34; right bank of the Dzhaanam-Deresi River, 0.5 km northwest of Kazma Mountain, outcrop 3510, Bed 8; left bank of the Dzhaanam-Deresi River (in the upper reaches), outcrop 3511; left bank of the Dzhaanam-Deresi River, northwest of Kazma Mountain, outcrop 600, Bed 10; Dzhaanam-Deresi River Basin, outcrop 1222h; interfluve of Birali-Chai and Dzhaanam-Deresi rivers, outcrop 1420; near the village of Gyumushlug, outcrop 1716/1; left bank of the Arpa River near the village of Gyumushlug, outcrop 1428a; left bank of the Arpa River in the vicinity of the village of Danzik, outcrop 66, Bed 3; outcrop 19, Bed 38b; southern slope of Plakhpashi Mountain, outcrop 1179; southern slope of Velidag Mountain, outcrop 48, Bed 18; outcrop 503a; Velidag Mountain, outcrop 1422; left bank of the Dzhaanam-Deresi River (at the reef basement), outcrop 03; 1 km southwest of Delanan Mountain, vicinity of the village of Sadarak, outcrop 1417.

***Beckmannia minor* (Schnur, 1853)**

Plate 10, fig. 7; Fig. 69

Terebratula angulosa var. *minor*: Schnur, 1853, p. 185.

Uncinulus minor: Schmidt, 1941, p. 20, abb. 1, pl. 2, figs. 25–26.

Kransia minor: Jungheim, 2000, p. 54, pl. 8.

Lectotype. No. 5/1, figured by Schmidt (1941, p. 20, abb. 1, pl. 2, fig. 25).

Description. The shell is small, 7.3–9.5 mm long, 6.9–19.1 mm wide, 3.7–5.9 mm thick, and almost isometric. The maximum width is in posterior one-third of the shell. The ventral valve is convex, with the maximum convexity in the anterior one-third. The ventral umbo is low and somewhat curved, almost erect; the delthyrium is covered by the dorsal beak. The posterior margin is ventrally arched; the dorsal and ventral interareas are well pronounced. The median sulcus is moderately wide, poorly developed near the anterior margin of the ventral valve, and terminates into a poorly pronounced tongue. The dorsal valve is flattened, with the maximum convexity in the posterior one-third. The fold is poorly pronounced. External radial ornamentation consists of low and flattened plicae. The plicae are about 0.4 mm wide at denticulate anterior margin and wider than interspaces, numbering 7–9 in the sulcus and 8 on each lateral side adjacent to the median sulcus. The plicae bordering the median sulcus are equally developed with other plicae.

Variability. The shell outline varies from isometric to transversely elongated.

Comparison. This species differs from similar *Beckmannia pentagona* (Kayser, 1871) in the oval and more flattened shell, the poorly developed median sulcus and tongue, and in the poorly pronounced fold. It differs from *Beckmannia implexa* (Sowerby, 1840) in the less elongated shell.

Occurrence. Givetian of Western Europe, the Urals, Middle Asia, western Bashkiria, eastern slope of the Bashkir Urals; Upper Givetian (*Indospirifer pseudowilliamsi* Zone) of the Nakhchivan AR.

Material. 168 variously preserved shells: Nakhchivan AR: Kasan-Gulu-Bakh Mountain, outcrop 63, Beds 5 and 6; south spurs of the Plakhpashi Mountain Range, outcrop 1176; west of Kazma Mountain, outcrop 1236a; near the village of Gyumushlug, outcrop 1716/1; interfluve of the Birali-Chai and Dzhaanam-Deresi rivers, outcrop 1420.

***Beckmannia angularis* (Phillips, 1841)**

Plate 10, fig. 8; Fig. 70

Uncinulus angularis: Leidhold, 1928, p. 34 (synonymy); Torley, 1934, p. 85, pl. 3, figs. 34–36; Kulkov, 1960, p. 177, pl. 4, fig. 5.

Beckmannia angularis: Sapelnikov et al., 1987, p. 96, pl. 8, fig. 3 (synonymy).

Holotype was not designated.

Description. The shell is medium-sized, 14.5–14.7 mm long, 14–16.4 mm wide, 10.4–11.3 mm thick, oval, isometric or transversely elongated, and dorsibiconvex. The maximum width is at the shell midlength. The ventral valve is convex, with the maximum convexity in the anterior one-third. The umbo is low, curved, with a somewhat incurved beak; the delthyrium is covered by the dorsal beak. The posterior margin is ventrally curved. The median sulcus is well developed, starts near the anterior margin of the ventral valve, and terminates into a trapezoid tongue. The maximum convexity of the dorsal valve is in its anterior one-third. The fold is low, flattened, and indistinctly bordered by interspaces. External radial ornamentation consists of flattened, rounded, and dense costae. The costae start from the umbos and form a zigzag anterior margin, numbering from 7 to 11 in the median sulcus, about 9 on the fold, and 15–22 on each lateral side. The costae are wider than interspaces, 0.7–0.8 mm wide in the median sulcus at the anterior margin; the costae in the median sulcus and fold are larger than the costae on the lateral sides. The umbonal walls are thickened. The dorsal septum is high, long, thickened, almost divides the umbo into two cavities, and reaches the valve midlength. The muscle scars are narrow and lanceolate.

Comparison. This species differs from similar *B. pentagona* (Kayser, 1871) in the more convex shell and especially in the convexity of the dorsal valve. It differs from *B. implexa* (Sowerby, 1840) in the incurved umbo and more convex shell. It differs from *B. minor* (Schnur, 1853) in the wider shell angular in outline.

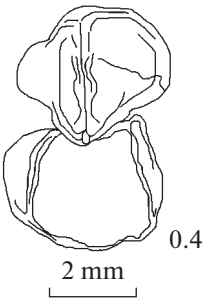


Fig. 70. *Beckmannia angularis* (Phillips, 1841), specimen PIN, no. 3744/919, serial cross sections through the shell; Armenia, Karaburun Mountain, outcrop 47, Bed 22; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

Remarks. A thickened, high septum is not typical for *Beckmannia* Mohanti, 1972 and *Kransia* Westbroek, 1968. This species should be revised with additional material in order to determine its generic belonging.

Occurrence. Middle Devonian of Europe, the Urals, Middle Asia and Salair; Eifelian (*Alatiformia araxica–Dagnachonetes caucasius* Zone) of Armenia.

Material. Three variously preserved shells from Armenia, Karaburun Mountain, outcrop 47.

Family Innaechiidae Baranov, 1980

Subfamily Corvinopugnacinae Savage, 1996

Genus *Corvinopugnax* Havlíček, 1961

Corvinopugnax: Havlíček, 1961, p. 36; Savage, 2002b, p. 1117.

Type species. *Rhynchonella corvina* Barrande, 1847, p. 70; Lower Devonian; Bohemia.

Diagnosis. Shell medium-sized, pentagonal, transversely elongated, slightly inflated, and dorsibiconvex. Ventral umbo small and slightly incurved. Median sulcus and fold poorly developed, broad, starting in anterior one-third of shell length, and weakly bordered by costae and interspaces, respectively. Anterior margin uniplicate. Lateral commissures slightly curved. External radial ornamentation composed of few plicae developed only along lateral and anterior margins. Plicae better developed in median sulcus and fold. Marginal spines small. Dental plates straight and short. Cardinal process, septum, and septalium absent. Dorsal valve with myophragm; hinge plates divided. Crural bases laterally flattened and inclined towards each other. Crura rodlike.

Species composition. About five species; Lower Devonian (Emsian)–Middle Devonian (Eifelian); North Africa, Europe, the Urals, Siberia, China; Middle Devonian, Upper Eifelian, *Mucrospirifer dilu-*

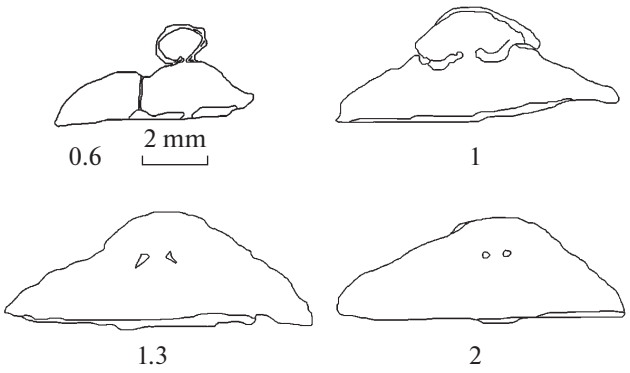


Fig. 71. *Corvinopugnax* sp., specimen PIN, no. 3744/920, serial cross sections through the shell; Nakhchivan AR, vicinity of the village of Danzik, outcrop 200, bed 11; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

vianoides–Radiomena irregularis Zone of the Nakhchivan AR: *Corvinopugnax* sp.

Comparison. There are no similar genera within the subfamily Corvinopugnacinae.

Remarks. This genus is similar to *Selennjachia* Baranov, 1982 (subfamily Vladimirirhynchinae) in some external and internal features. The plicae of *Selennjachia* are also developed along the shell margins. These two species are completely identical in shell interior. *Corvinopugnax* differs from *Selennjachia* in the more pointed plicae. The shell of *Selennjachia* is more convex, with smoothed margins. The shell of *Corvinopugnax* is transversely elongated, with better pronounced pentagonal outline. Our collection contains a single slightly constricted specimen of this genus, whose taxonomical position is somewhat uncertain. Its crura are rodlike in thin cross sections, while in the first description, they are considered to be laterally flattened.

Corvinopugnax sp.

Fig. 71

Description. The shell is small, 14.4 mm long, 16.5 mm wide, 7.3 mm thick, transversely elongated, pentagonal in outline, and triangular in cross section. The maximum shell width and thickness are in its middle. The umbo is small and slightly incurved. The ventral valve is slightly convex and flattened. The median sulcus is poorly developed at the anterior margin, broad, and weakly bordered by plicae. The dorsal valve is convex, with the maximum convexity in its middle. The fold is poorly pronounced, starts at the shell midlength, and is weakly bordered by plicae. The lateral slopes are gentle. The lateral commissures are straight. External ornamentation consists of small plicae developed near the anterior margin in the median sulcus and fold and along lateral margins. The plicae are better pronounced in the median sulcus and fold, are densely spaced, simple, and triangular in cross section, with rounded apices. The plicae are wider than plical interspaces and up to 1.1 mm wide at the anterior margin, numbering 7 in the sulcus, 8 on the fold, and 9–10 on each lateral side. In the ventral valve, there are straight and short dental plates. In the dorsal valve, the cardinal process and septalium are absent and the myophragm is developed. The hinge plates are divided, with dorsally curved distal ends. The crural bases are inclined towards each other and laterally flattened. The crura are rodlike and rounded in cross section.

Comparison and remarks. This specimen is not assigned to any species due to insufficient material. It is most similar to the type species *C. corvinus*.

Occurrence. Middle Devonian, Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone; Nakhchivan AR.

Material. One satisfactorily preserved shell from the Nakhchivan AR, vicinity of the village of Danzik, outcrop 200, Bed 11.

Family Hypothyridinidae Ržonsnitskaja, 1956

Genus *Glosshypothyridina* Ržonsnitskaja, 1978

Glosshypothyridina: Ržonsnitskaja, 1978, p. 180; Savage, 2002b, p. 1127.

Type species. *Rhynchonella procuboides* Kayser, 1871, p. 513; Middle Devonian, Eifelian; Germany.

Diagnosis. Shell small to medium-sized, oval to ovally pentagonal in outline, and dorsibiconvex. Ventral umbo small and incurved; foramen possibly present. Delthyrium covered by dorsal beak. Median sulcus, fold, and tongue developed. Anterior margin uniplicate. External radial ornamentation costate. Costae arising at shell midlength and terminating into marginal spines. Lateral commissures straight. Squama and glotta developed. Dental plates short and concave externally. Teeth fungaceous. Cardinal process massive. Hinge plates horizontal and connected to cardinal process. Dorsal septum low and long.

Species composition. Two or three species; Middle Devonian (Eifelian); European Russia, Belgium, Germany, the Urals, Nakhchivan AR. Transcaucasia: *Glosshypothyridina procuboides* (Kayser, 1871).

Comparison. This genus closely resembles *Hypothyridina* Buckman, 1906 and differs in the gentler lateral slopes, the presence of septum in the dorsal valve, and the bifid cardinal process. The genus *Hypothyridina* is composite and its differences from other Devonian genera vary.

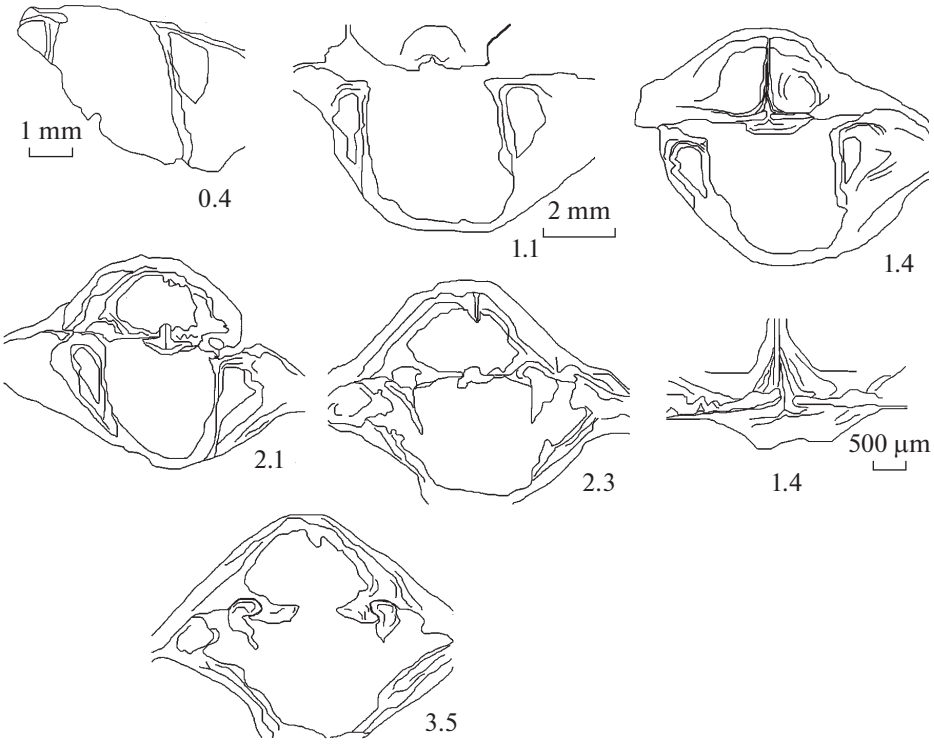


Fig. 72. *Glosshypothyridina procuboides* (Kayser, 1871), specimen PIN, no. 3744/921, serial cross sections through the shell; Nakhchivan AR, Dzhaanam-Deresi River, outcrop 51, Bed 8; Eifelian.

***Glosshypothyridina procuboides* (Kayser, 1871)**

Plate 10, fig. 9; Fig. 72

Rhynchonella procuboides: Kayser, 1871, p. 513, pl. 9, fig. 3; Tchernyshew, 1887, p. 94, pl. 11, fig. 11.

Hypothyris procuboides: Torley, 1934, p. 86, pl. 4, figs. 49–57.

Hypothyridina procuboides: Schmidt, 1941, p. 26, pl. 2, figs. 27 and 28; pl. 7, fig. 19; Khodalevich and Breivel, 1972, p. 125, pl. 54, figs. 7–9.

Glosshypothyridina procuboides: Ržonsnitskaja, 1978, p. 180; Jungheim, 2000, p. 56, pl. 9.

Holotype was not designated.

Description. The shell is small to medium-sized, 11.2–20.8 mm long, 12.5–25.1 mm wide, 9–15.6 mm thick, oval to ovally pentagonal, and dorsibiconvex. The maximum width is in the middle of the shell; it is 1.1-1.2 times greater than the maximum length. The umbo is low, small, and incurved. The delthyrium is covered by the dorsal beak. The posterior margin is ventrally curved. The ventral valve is slightly convex, with the maximum convexity at the valve midlength. The maximum convexity of the dorsal valve is in the anterior half. The lateral slopes of the dorsal valve are steep. The median sulcus is developed in the anterior half of the shell, widens anteriorly, and terminates into a tongue at the anterior margin. The fold is indistinctly pronounced. The median sulcus and fold are bordered by indistinct costae and interspaces, respectively. External radial ornamentation consists of somewhat flattened costae. The costae are 0.7–1 mm wide, wider than the interspaces, and show remains of marginal spines, numbering from 7 to 11 in the sulcus, 9–11 on the fold, and from 9 to 19 on each lateral side. The shell interior is the same as described in the genus.

Comparison. This species differs from *G. chernogubensis* Tcherkesova, 2002 in the slightly transversely elongated shell.

Occurrence. Eifelian of Germany; Eifelian–Lower Givetian of the western slope of the Urals; Upper Emsian–Lower Eifelian (*Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone)–Lower Givetian (*Stringocephalus burtini* Zone) of the Nakhchivan AR.

Material. Nineteen well-preserved shells from the Nakhchivan AR: left bank of the Dzhaanam-Deresi River, outcrop 51, Bed 8; 1.5 km west of Kazma Mountain, outcrop 53, Bed 2; outcrop 57, Bed 8; left bank of the Dzhaanam-Deresi River, outcrop 1221; 1.75 km northwest of Kazma Mountain, Dzhaanam-Deresi River Basin, outcrop 3512/2; left bank of the Dzhaanam-Deresi River southwest of Kazma Mountain, outcrop 58, Bed 5; left bank of the Dzhaanam-Deresi River, northwest of Kazma Mountain, outcrop 600, Bed 5, vicinity of the village of Danzik, outcrop 19, Bed 38; left bank of the Arpa River in the vicinity of the village of Danzik, outcrop 66, Bed 24; southern slope of Dagna Mountain near frontier post, outcrop 68, Bed 9–1.

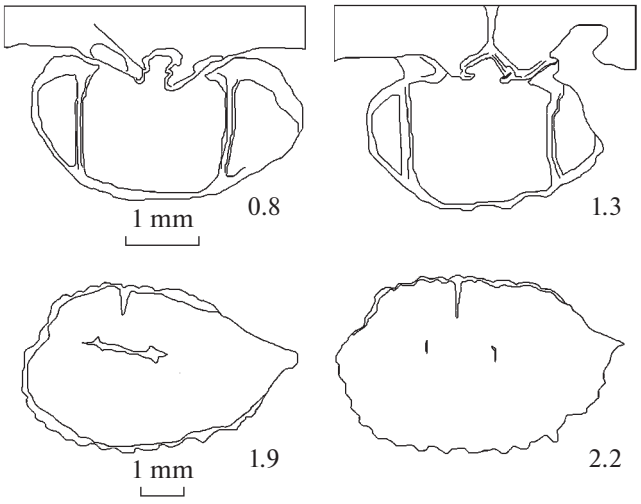


Fig. 73. *Stenaulacorhynchus* sp., specimen PIN, no. 3744/922, serial cross sections through the shell; Nakhchivan AR, vicinity of Geran-Kalasy Mountain, outcrop 1241; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Superfamily Camarotoechioidea Schuchert, 1929

Family Leiorhynchidae Stainbrook, 1945

Subfamily Platyterorhynchinae Savage, 1996

Genus *Stenaulacorhynchus* Sartenaer, 1968

Stenaulacorhynchus: Sartenaer, 1968, pp. 1–14; Savage, 2002c, p. 1156.

Type species. *Stenaulacorhynchus cheshmehshirensis*, Sartenaer, 1968; Upper Devonian, Lower Famennian; Iran, Ozbak-Kuh, Cheshmeh Shir.

Diagnosis. Shell medium-sized, flattened, oval to ovally pentagonal in outline, and dorsibiconvex. Ventral umbo small and erect; deltidial plates developed. Median sulcus and fold poorly pronounced. Anterior margin uniplicate. External radial ornamentation composed of numerous plicae covering whole shell surface. Lateral commissures straight. Posterior margin ventrally curved. Umbonal walls and teeth thickened. In dorsal valve, septum low; septalium open posteriorly and covered anteriorly. Crural bases oval in cross section. Crura laterally flattened.

Species composition. At most three species; Upper Devonian, Lower Famennian; Spain, northern Iran, Nakhchivan AR. Transcaucasia: *Stenaulacorhynchus* sp.

Comparison. This genus differs from *Insignitisinurostrum* Sartenaer, 1987 in the equally developed plicae, well-developed dental plates, covered septalium, and laterally flattened crura.

Remarks. Among Famennian rhynchonellid genera with flattened shell, *Stenaulacorhynchus* is most similar to *Hadyrhyncha* Havliček, 1979 (family Rozmanariidae), *Tenuisinurostrum* Sartenaer, 1967 (subfamily Leiorhynchinae), *Rugaltarostrum* Sartenaer, 1961 (subfamily Basilicorhynchinae), *Planovatirostrum* Sartenaer, 1970, *Novaplatirostrum* Sartenaer, 1997, *Phacoiderhynchus* Sartenaer, 2000, and *Tetragonorhynchus* Sartenaer, 1999 (family Rozmanariidae). *Stenaulacorhynchus* differs from *Hadyrhyncha* in the better pronounced plicae, the presence of septum, septalium, dental plates, and united hinge plates. It differs from *Tenuisinurostrum* in the greater number of plicae on the shell surface, the higher septum, the covered septalium, the presence of dental plates, and in the united hinge plates. It differs from *Rugaltarostrum* in the equally developed plicae, the covered septalium, united hinge plates, and laterally flattened crura. It differs from *Planovatirostrum* in the narrower plicae, the presence of septum, septalium, united hinge plates, and laterally flattened, noncurved, crura. *Stenaulacorhynchus* differs from *Novaplatirostrum*, *Phacoiderhynchus*, and *Tetragonorhynchus* in the plicae covering the whole shell, septum and septalium, and the laterally flattened crura. In addition, it differs from *Novaplatirostrum* and *Tetragonorhynchus* in the developed dental plates.

***Stenaulacorhynchus* sp.**

Plate 11, fig. 1; Fig. 73

Description. The shell is 10.5–11.2 mm long, 12.9–13.9 mm wide, 5.2–5.8 mm thick, oval to ovally pentagonal, dorsibiconvex, and flattened in posterior half. The maximum width is in the anterior one-third of the shell, near the anterior margin; it is 1.2 times greater than the maximum length. The posterior margin is ventrally arched. The ventral valve is slightly

Explanation of Plate 11

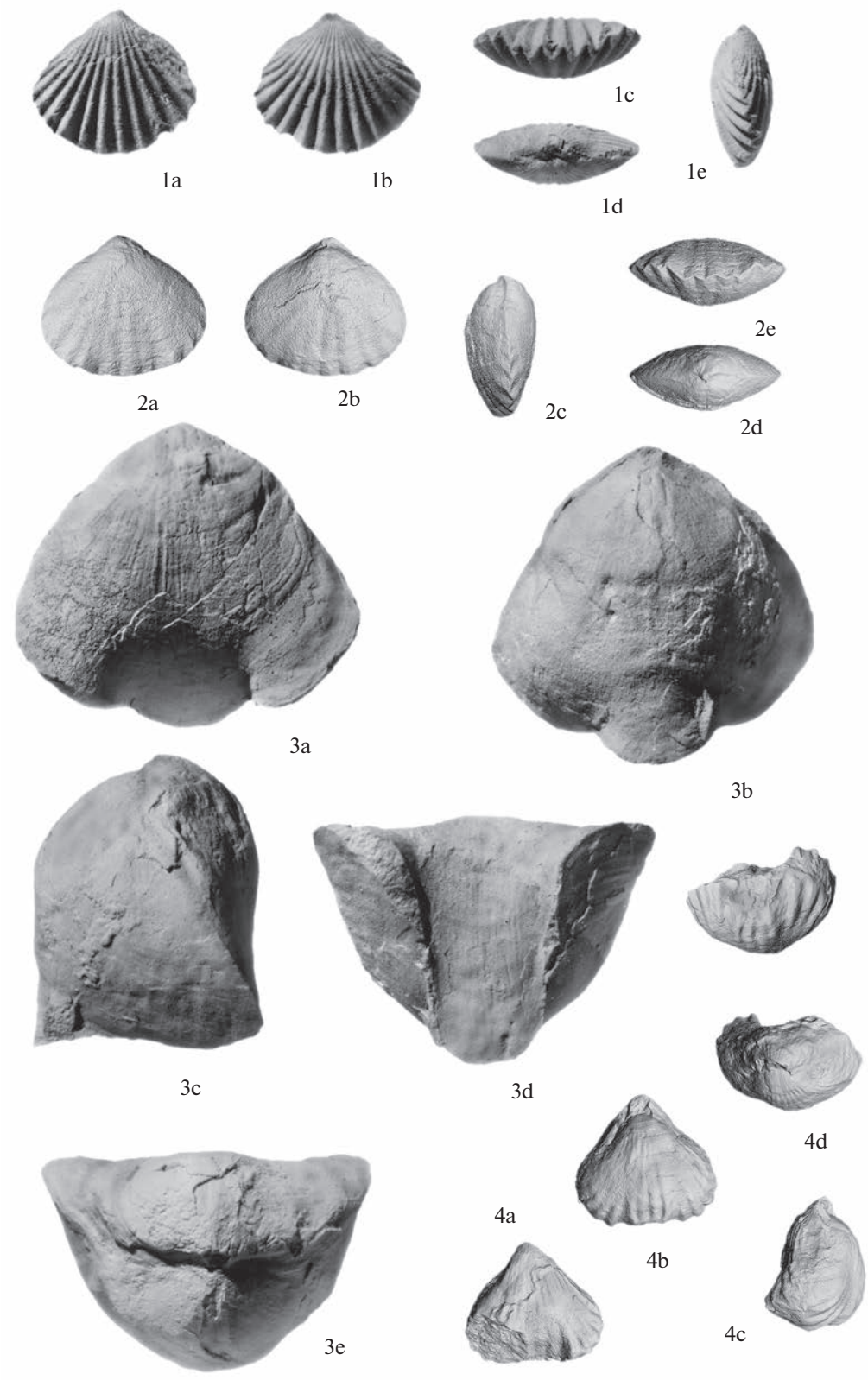
Fig. 1. *Stenaulacorhynchus* sp., specimen PIN, no. 3744/842, complete shell, ×1.7: (1a) ventral valve view; (1b) dorsal valve view; (1c) anterior view; (1d) posterior view; (1e) lateral view; Nakhchivan AR, vicinity of Geran-Kalasy Mountain, outcrop 1241; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Fig. 2. Platyterorhynchinae gen et sp. indet., specimen PIN, no. 3744/854, 3D model of complete shell, ×1.7: (2a) ventral valve view; (2b) dorsal valve view; (2c) lateral view; (2d) posterior view; (2e) anterior view; Nakhchivan AR, right bank of the Arpa River opposite the village of Danzik, outcrop 36, Bed 5; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Fig. 3. *Navalicria* sp., specimen PIN, no. 3744/835, complete shell, ×2: (3a) ventral valve view; (3b) dorsal valve view; (3c) lateral view; (3d) anterior view; (3e) posterior view; Nakhchivan AR, vicinity of the village of Danzik, outcrop 36; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Fig. 4. *Leptocaryorhynchus* sp., specimen PIN, no. 3744/849, 3D model of complete shell, ×2: (4a) ventral valve view; (4b) dorsal valve view; (4c) lateral view; (4d) anterior view; (4e) posterior view; Nakhchivan AR, east of Geran-Kalasy Mountain, outcrop 10, Bed 3; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

Plate 11



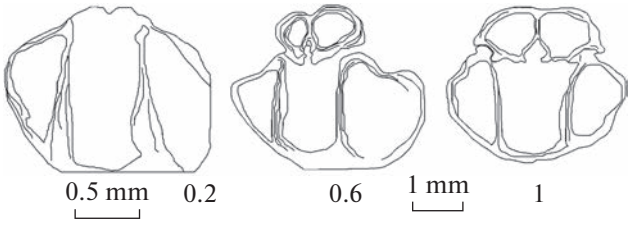


Fig. 74. *Platyterorhynchinae* gen. et sp. indet., specimen PIN, no. 3744/854, serial cross sections through the shell; Nakhchivan AR, right bank of the Arpa River opposite the village of Danzik, outcrop 36, Bed 5; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

convex, with the maximum convexity in its posterior half. The ventral umbo is low and erect. The deltidial plates are developed. The maximum convexity of the dorsal valve is in its middle. The median sulcus is shallow, medium wide, developed in the anterior half of the ventral valve, sometimes very poorly pronounced, and widens anteriorly. The fold is high in the anterior half of the shell, and widens anteriorly. The median sulcus and fold are bordered by sometimes indistinct plicae and interspaces, respectively. The lateral slopes and gentle. The lateral commissures are straight. External radial ornamentation consists of numerous plicae. The plicae are 0.9–1 mm wide at the anterior margin, numbering 3–4 in the sulcus, 4–5 on the fold, and 5–6 on each lateral side. The shell interior is the same as in the genus.

Comparison and remarks. These specimens cannot be referred to *S. cheshmehshirensis* Sartenaer, 1968 due to insufficient material.

Occurrence. Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone; Nakhchivan AR.

Material. Two well-preserved shells from the Nakhchivan AR, vicinity of Geran-Kalasy Mountain, outcrop 1241.

Platyterorhynchinae gen. et sp. indet

Plate 11, fig. 2; Fig. 74

Diagnosis. Shell small, 11.1 mm long, 12.9 mm wide, 5.7 mm thick, oval, transversely elongated, flattened, and ventribiconvex. Maximum shell thickness at midlength. Ventral umbo slightly incurved and flattened. Median sulcus and fold poorly pronounced, with indistinct borders. Tongue absent. Lateral margins gentle. External radial ornamentation composed of smoothed wide plicae covering both valves. Plicae wider than interspaces and arising at shell midlength, numbering 3 in median sulcus and fold and 4 on each lateral side. Dental plates short, running for one-tenth of shell length, ventrally convergent, and thickened posteriorly near valve bottom. Anteriorly, dental plates inwardly curved towards each other. Dorsal septum long, extending approximately for one-fifth of shell length, and increasing in height anteriorly. Septalium deep and open; outgrowths located along its margins not covering it. Hinge plates connected to septalium. Crura indistinct.

Remarks. Our collection contains the only specimen of this rhynchonellid, which is insufficient for determination. This specimen is similar to *Platyterorhynchus* Sartenaer, 1970 from the Upper Givetian–Lower Frasnian of Morocco, Turkey, Timan, the Russian Platform, Volga–Ural Region, China, Western Europe, western and eastern North America (Savage, 2002c) in the pattern of arrangement and the type of plicae, ventral umbo, long and high dorsal septum, and septalium with outgrowths.

Occurrence. Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Material. One well-preserved shell from the Nakhchivan AR, right bank of the Arpa River opposite the village of Danzik, outcrop 36, Bed 5.

Subfamily Calvinariinae Sartenaer, 1994

Genus *Navalicria* Sartenaer, 1989

Navalicria: Sartenaer, 1989, p. 66; Savage, 2002c, p. 1151.

Type species. *Navalicria compacta*, Sartenaer, 1989, p. 66; Upper Devonian, Middle–Upper Frasnian; Belgium.

Diagnosis. Shell large, triangular in outline, inflated, and dorsibiconvex. Ventral umbo small and curved; delthyrium covered by dorsal beak. Anterior margin uniplicate. Median sulcus and fold well developed. Tongue well developed, high, and dividing anterior margin into two parts. External radial ornamentation composed of numerous poorly pronounced capillae covering whole shell. Lateral commissures somewhat curved. Dental plates absent. Umbonal walls thickened. Dorsal septum long. Septalium small and covered posteriorly.

Species composition. Two or three species; Upper Devonian, Frasnian; Western Europe, China, western Canada, Nakhchivan AR. Transcaucasia: *Navalicria* sp.

Comparison. *Navalicria* is most similar to the following Frasnian camarotoechioids with a high tongue at the anterior margin: *Canavirilia* Sartenaer, 1994, *Vincalaria* Sartenaer, 1989, *Tomestenoporhynchus* Sartenaer, 1993, and *Lateralatirostrum* Sartenaer, 1979. It differs in the smooth median sulcus, the fold and lateral shell sides lacking plicae and flattened crura.

Remarks. This genus is most similar to *Pammegetherhynchus* Sartenaer, 1977 (family Pugnacidae) and differs in the presence of septum, septalium, laterally flattened crura and the absence of dental plates. It differs from *Orbiculatisinurostrum* Sartenaer, 1984 (subfamily Leiorhynchinae) in the absence of plicae and higher tongue. It differs from *Stenometoporhynchus* Sartenaer, 1987 (subfamily Stenometoporhynchinae) in the absence of plicae, the acute and

higher tongue. It differs from *Ladogia* Nalivkin, 1941 (family Ladogiidae) in the presence of capillae rather than costae on the shell surface, the more obtuse tongue, the absence of dental plates, the poorly developed septalium, and in the flattened crura. It differs from *Ladogilina* Ljaschenko, 1973 (family Ladogiidae) in the same features, except for the shell shape (shell of *Ladogilina* is rounded, including the tongue). *Navalicria* differs from *Parvaltissimarostrum* Sartenaer et Xu, 1991 (family Petasmariidae) in the absence of plicae, the lower tongue, the absence of dental plates, and in the flattened crura.

***Navalicria* sp.**

Plate 11, fig. 3

Description. The shell is triangular, 22.7 mm long, 27 mm wide, and 20.8 mm thick. The maximum width is in the anterior one-third of the shell. The ventral valve is slightly convex, with the maximum convexity in the umbonal region. The ventral umbo is low and incurved. The posterior margin is slightly dorsally arched. The delthyrium is covered by the dorsal beak. The median sulcus starts near the anterior margin, is not bordered by costae, and abruptly passes in a high, trapezoid, and distinctly pronounced tongue. The dorsal valve is strongly convex and inflated, with the maximum convexity in the anterior half. The fold is small, narrow, developed only near the anterior margin, and well bordered by interspaces. The lateral commissures are somewhat curved. External radial ornamentation is capillate. The capillae are narrower than interspaces, numbering 6 in the median sulcus. The dental plates are absent. The dorsal septum almost reaches the valve midlength. The septalium is closed at least posteriorly.

Comparison. The only specimen is most similar to the type species *N. compacta*. However, the shell of the type species is transversely elongated, while our specimen is triangular.

Remarks. A single poorly preserved specimen cannot be studied in detail. It closely resembles *Navalicria* and is referred to this genus based on a number of similar features: the shell shape, thickened umbonal walls, absence of dental plates, long septum, and presence of upturned tongue. However, some features do not fit the diagnosis of *Navalicria*, i.e., the triangular shell, numerous capillae, and stratigraphic position (this genus disappears in the Frasnian).

Occurrence. Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone; Nakhchivan AR.

Material. One satisfactorily preserved shell from the Nakhchivan AR, vicinity of the village of Danzik, outcrop 36.

Subfamily Leiorhynchinae Stainbrook, 1945

Genus *Leptocaryorhynchus* Sartenaer, 1970

Leptocaryorhynchus: Sartenaer, 1970, p. 14; Savage, 2002c, p. 1139.

Type species. "*Camarotoechia*" *jamensis* Brice, 1967, p. 100; Upper Devonian, Famennian; Afghanistan.

Diagnosis. Shell small, ovally triangular, and dorsibiconvex. Ventral valve flattened; ventral umbo small and somewhat incurved. Median sulcus and fold well developed, starting from shell midlength, and terminating in tongue at anterior margin. Median sulcus better pronounced than fold. Shell slopes steep laterally of median sulcus near straight margin. Lateral commissures straight. Lateral slopes steep in dorsal valve and gentle in ventral valve. Anterior margin uniplicate. External radial ornamentation composed of simple costae. Dental plates developed. Umbonal walls thickened. Dorsal septum developed. Septalium open. Hinge plates connected to septalium; their outgrowths not covering septalium completely. Crura brace-shaped posteriorly and laterally flattened anteriorly.

Species composition. Type species; Upper Devonian, Famennian; Afghanistan. Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone of the Nakhchivan AR: *Leptocaryorhynchus* sp.

Comparison. This small costate leiorhynchin genus is very unusual and dissimilar to any Famennian representative of the subfamily.

Remarks. *Leptocaryorhynchus* externally resembles genera of small Famennian costate rhynchonellids of the family Trigonirhynchiidae: *Sinotectirostrum* Sartenaer, 1961, *Ptychomaletoechia* Sartenaer, 1961, *Ripidiorhynchus* Sartenaer, 1966, and *Greira* O. Erlanger, 1993. It differs from the last in the impunctate shell, open septalium, the shape of the posterior parts of crura. It differs from *Sinotectirostrum* in the open septalium and the crus shape. It differs from *Ripidiorhynchus* in the high triangular fold and open septalium. It differs from *Ptychomaletoechia* in the presence of outgrowths on the hinge plates, which almost cover the septalium, and in the absence of crural bases triangular in cross section.

***Leptocaryorhynchus* sp.**

Plate 11, fig. 4; Fig. 75

Description. The shell is small, 9.9 mm long, 10.7 mm wide, 7.1 mm thick, slightly transversely elongated, ovally triangular, and dorsibiconvex. The maximum shell width is near the anterior margin. The umbo is low and somewhat curved. The ventral valve is flattened. The maximum convexity of the dorsal valve is near the anterior margin. The sulcus and fold start at the shell midlength, are well developed and bordered, and terminate into a tongue at the anterior margin. The sulcus is better pronounced than the fold.

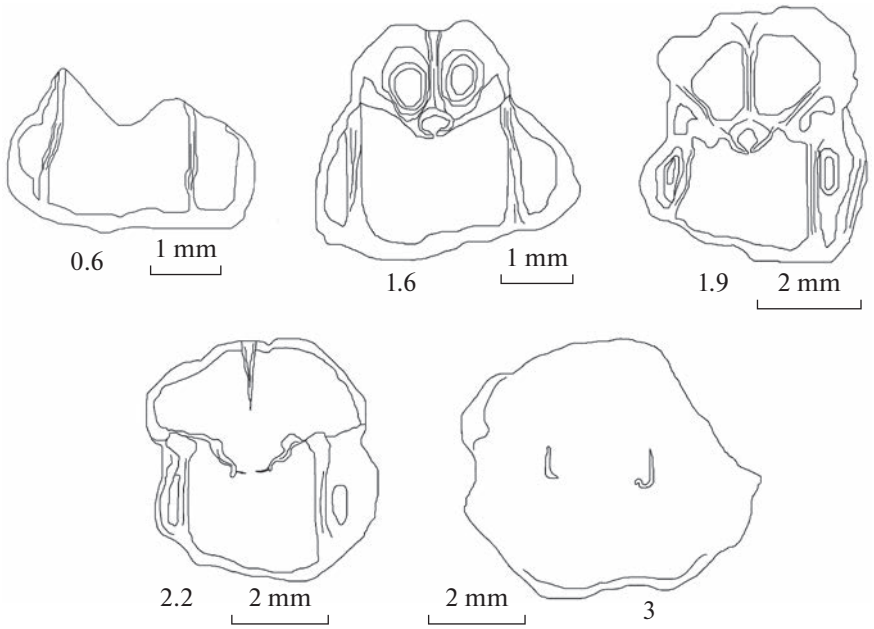


Fig. 75. *Leptocaryorhynchus* sp., specimen PIN, no. 3744/849, serial cross sections through the shell; Nakhchivan AR, east of Geran-Kalasy Mountain, outcrop 10, bed 3; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

The lateral slopes of the dorsal valve are steep. The lateral slopes of the ventral valve are gentle. The lateral commissures are straight. External radial ornamentation consists of simple costae rounded in cross section. The costae are 0.7–1 mm wide, slightly wider than interspaces, start from the umbos, cover the whole shell, and expand anteriorly, numbering 4 in median sulcus and fold, 7 on each dorsal lateral side, and 5 on each ventral lateral side. The dental plates are curved. The septum is low. The septalium is open. The hinge plates are connected to the septalium and bear outgrowths, which partly cover the septalium; the hinge plates are not connected by the cover plate. Anteriorly, the hinge plates are discrete. The crura are brace-shaped posteriorly and laterally flattened and parallel anteriorly.

Comparison and remarks. Although *Leptocaryorhynchus* includes the only species *L. jamensis*, the studied specimens cannot be assigned to this species due to insufficient material.

Occurrence. Upper Devonian, Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone; Nakhchivan AR.

Material. Four well-preserved shells from the Nakhchivan AR, east of Geran-Kalasy Mountain, outcrop 10, Bed 3; lower part of Myunkh-Bala-Ogly Mountain, outcrop 1005.

Family Septalariidae Havliček, 1960

Genus *Septalaria* Leidhold, 1928

Septalaria: Leidhold, 1928, p. 35; Savage, 2002c, p. 1158.

Type species. *Terebratula ascendens* Steininger, 1853, p. 61; Middle Devonian, Eifelian; Germany, Hauenborn.

Diagnosis. Shell medium-sized, ovally pentagonal, and dorsibiconvex. Ventral umbo low and somewhat incurved. Delthyrium covered by dorsal beak. Median sulcus, fold, and tongue well developed. Anterior margin uniplicate. External radial ornamentation composed of numerous plicae covering whole shell surface. Lateral commissures straight. Posterior margin ventrally curved. Short dental plates and flattened teeth poorly developed. Cardinal process well developed, massive, undivided into lobes. Dorsal septum long, high, thickened, reaching valve midlength, and connected to united hinge plates. Septalium open, wide, and shallow. Crura oval in cross section.

Species composition. About ten species; Lower Devonian (Upper Emsian)–Middle Devonian (Upper Givetian); the Urals, Europe, Altai, China, Australia. Upper Emsian–Lower Eifelian of the Nakhchivan AR: *Septalaria subtetragona* (Schnur, 1851).

Comparison. This genus is similar to *Onugorhynchia* Havliček, 1992 in shell exterior and differs in the poorly developed dental plates and large cardinal process.

Remarks. *Septalaria* externally resembles some Emsian–Givetian genera of Leiorhynchidae and Pugnacoidea and strongly differs in the presence of cardinal process, which is distinctly seen in cross sections.

***Septalaria subtetragona* (Schnur, 1851)**

Plate 12, fig. 1; Fig. 76

Terebratula subtetragona: Schnur, 1851, p. 3; Schnur, 1853, p. 177, pl. 23, fig. 4.

Septalaria subtetragona: Sapelnikov and Mizens, 2000 (synonymy).

Holotype was not designated.

Description. The shell is ovally pentagonal, 16–17.7 mm long, 19.9–23.2 mm wide, and 11.9–12.8 mm thick. The maximum width is in the middle of the shell; it is 1.3 times greater than the maximum length. The ventral umbo is low, somewhat curved, with erect beak. The posterior margin is ventrally arched. The delthyrium is covered by the dorsal beak. The ventral valve is slightly convex, flattened in posterior half, with the maximum convexity in the middle. The median sulcus is deep, with clearly defined margins, developed in the anterior half of the ventral valve, widens anteriorly, and terminates at the anterior margin in a tongue. The dorsal valve is strongly convex, with the maximum convexity in the anterior half. The fold is well bordered and widens anteriorly. The lateral slopes are almost vertical. The lateral commissures are straight. The anterior margin is zigzag and uniplicate. External radial ornamentation consists of large plicae rounded and flattened in cross section. The plicae are 0.4–1 mm wide, wider than the interspaces, and do not dichotomize, numbering 6–7 in median sulcus and fold and 15 on each lateral side. The median sulcus and fold are bordered by well-pronounced plicae and interspaces, respectively. The shell interior is the same as in the genus.

Comparison. This species differs from *S. struvei* in the plicae not covering the whole shell surface. It differs from *S. undulata* in the more convex shell and the numerous and narrower plicae.

Occurrence. Eifelian of Germany; Upper Emsian–Lower Eifelian (*Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone) of Transcaucasia.

Material. Twenty-seven variously preserved shells from the Nakhchivan AR: vicinity of Dagna Mountain, outcrop 1710; southern slope of Velidag Mountain, outcrop 48, Beds 24–25.

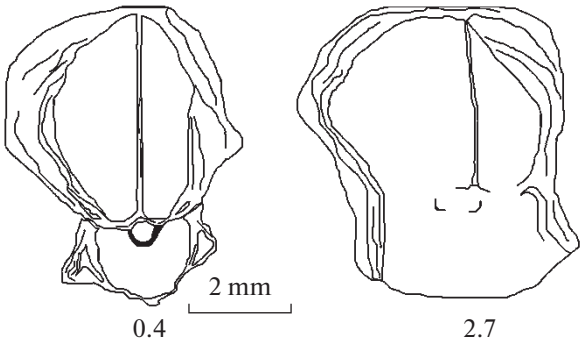


Fig. 76. *Septalaria subtetragona* (Schnur, 1851), specimen PIN, no. 3744/923, serial cross sections through the shell; Nakhchivan AR, vicinity of Dagna Mountain, outcrop 1710; Upper Emsian–Lower Eifelian, *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

Genus *Pseudocamarophoria* Wedekind, 1926

Pseudocamarophoria: Wedekind, 1926, p. 197; Biernat, 1966, p. 102 (synonymy); Savage, 2002p, p. 1164.

Type species. *Terebratula microrhyncha* Roemer, 1844, p. 65; Middle Devonian, Eifelian; Germany.

Diagnosis. Shell medium-sized, ovally pentagonal to longitudinally oval, inflated, and slightly dorsibiconvex. Ventral umbo small and incurved; foramen rounded; delthyrium covered by dorsal beak. Median sulcus and fold poorly developed. Anterior margin uniplicate. External radial ornamentation composed of large smoothed plicae. Plicae better developed at anterior margin; median plicae running from umbo; lateral plicae starting at shell midlength. Lateral commissures straight. Ventral umbonal walls strongly thickened. Dental plates developed. Median septum long and high. Septalium open and flattened. Hinge plates united. Crural bases apposed and oval in cross section.

Species composition. Two or three species; Lower Devonian (Emsian)–Middle Devonian (Givetian); Europe, China. Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone of the Nakhchivan AR: *Pseudocamarophoria undulataeformis* Biernat, 1966.

Comparison. This genus is similar to the septalariid genera *Septalaria* Leidhold, 1928 and *Nemesa* Schmidt, 1941 and differs from *Septalaria* in the absence of dental plates and cardinal process. It differs from *Nemesa* in the greater number of plicae and the united hinge plates.

Remarks. *Pseudocamarophoria* externally resembles *Calvinaria* Stainbrook, 1945 (family Leiorhynchidae), *Linguopugnoides* Havlíček, 1960, and *Camerophorina* Schmidt, 1941 (family Camerophorinidae) and differs from *Calvinaria* in the unpaired plicae and united hinge plates. It differs from *Linguopugnoides* in the same features and the presence of dental plates. It is externally similar to *Camerophorina* and differs in the absence of spondylium.

***Pseudocamarophoria undulataeformis* Biernat, 1966**

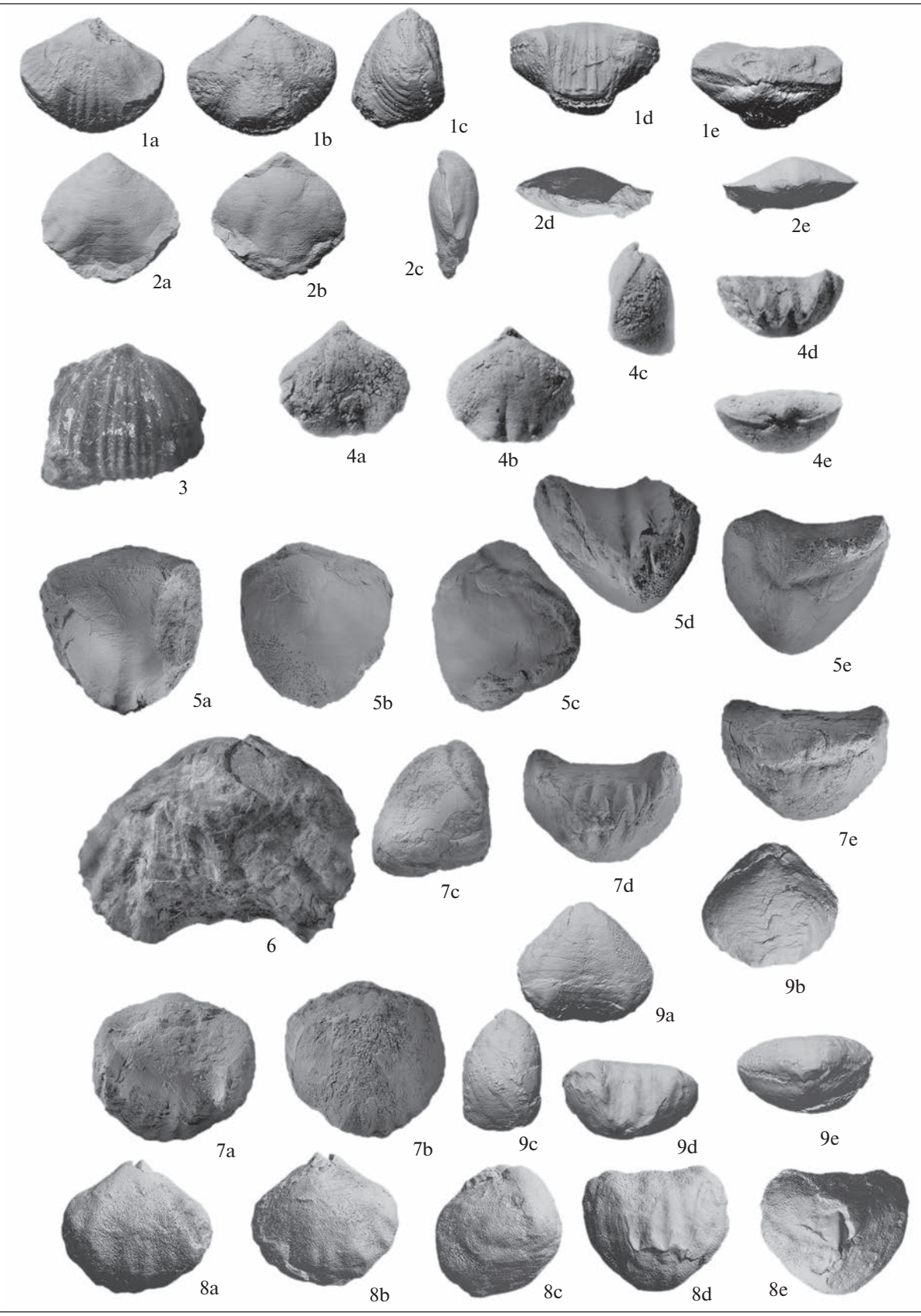
Plate 12, fig. 2; Fig. 77

Pseudocamarophoria undulataeformis: Biernat, 1966, pp. 102–104, pl. 19, figs. 1–22; text-fig. 34 (synonymy).

Holotype. No. Bc. VII/108 (Biernat, 1966, pl. 19, fig. 6); Middle Devonian; Poland, Świętokrzyskie Mountains.

Description. The shell is 14.6 mm long, 14–15.4 mm wide, 7.5–11.1 mm thick, ovally pentagonal to longitudinally oval, and dorsibiconvex. The maxi-

Plate 12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mum width is at the shell midlength. The ventral umbo is low, curved, with incurved beak; the delthyrium is covered by the dorsal beak. The ventral valve is convex, with the maximum convexity in the umbonal region, and flattened in the anterior half. The ventral sulcus is shallow, developed in the anterior half of the valve, and widens anteriorly. The dorsal valve is moderately convex, with the maximum convexity in the posterior region. The fold is weakly bordered by plical interspaces. The lateral slopes are gentle. The lateral commissures are straight. The anterior margin is uniplicate. External radial ornamentation consists of large, low, and smoothed plicae. The plicae are 1.6–2.4 mm wide, as wide as the interspaces, and do not dichotomize, numbering 1 in the sulcus, 2 on the fold, and 1 on each lateral side. The plicae bordering the median sulcus are better pronounced than interspaces bordering the fold. The walls of the ventral umbo are strongly thickened. The dental plates are short and located close to walls of the ventral umbo. The dorsal septum is high and anteriorly connected to short and broad septalium.

Comparison. This species differs from similar *C. microrhyncha* (Roemer, 1844) in the fewer plicae.

Occurrence. Middle Devonian of Poland; Eifelian (*Mucrospirifer diluvianoides–Radiomena irregularis* Zone) of the Nakhchivan AR.

Material. Nine poorly preserved shells from the Nakhchivan AR, vicinity of the Dzhaanam-Deresi River, outcrop 1739; 1.75 km northwest of Kazma Mountain, Dzhaanam-Deresi River Basin, outcrop 3512/2.

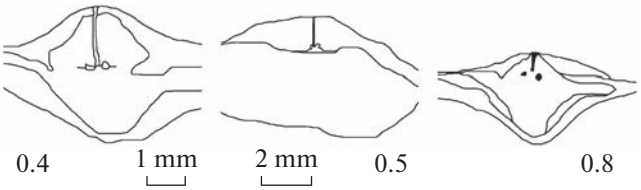


Fig. 77. *Pseudocamarophoria undulataeformis* Biernat, 1966, serial cross sections through the shell: (a) specimen PIN, no. 3744/924; (b) specimen PIN, no. 3744/931; (c) specimen PIN, no. 3744/932; Nakhchivan AR, vicinity of the Dzhaanam-Deresi River, outcrop 1739; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Subfamily Araratellinae Erlanger, 1986

Genus *Araratella* Abramian, Plodowski, Sartenaer, 1975

Araratella: Abramian et al., 1975 in Sartenaer and Plodowski, 1975, p. 5; Erlanger, 1986, p. 55; Savage, 2002d, p. 1233.

Type species. *Liorhynchus dichotomians* Abramian, 1954, p. 66; Upper Devonian, Upper Famennian; Armenia, vicinity of the village of Kadrlu.

Diagnosis. Shell medium-sized, from oval to ovally pentagonal, and dorsibiconvex, with maximum width in shell midlength. Ventral umbo small and slightly incurved; delthyrium covered by dorsal beak. Anterior margin uniplicate. Median sulcus and fold well developed, starting in quarter of shell length from umbo, and terminating at anterior margin in large, roundly trapezoid tongue. External radial ornamentation composed of roundly angular plicae covering whole shell surface. Plicae running from umbos, dichotomizing or intercalating, and better developed

Explanation of Plate 12

Fig. 1. *Septalaria subtetragona* (Schnur, 1851), specimen PIN, no. 3744/850, 3D model of complete shell, ×1.5: (1a) ventral valve view; (1b) lateral view; (1c) dorsal valve view; (1d) posterior view; (1e) anterior view; vicinity of Dagna Mountain, outcrop 1710; Upper Emsian–Lower Eifelian, *Zdimir pseudobaschkiricus–Megastrophia uralensis* Zone.

Fig. 2. *Pseudocamarophoria undulataeformis* Biernat, 1966, specimen PIN, no. 3744/857, 3D model of complete shell, ×1.5: (2a) ventral valve view; (2b) dorsal valve view; (2c) lateral view; (2d) anterior view; (2e) posterior view; Nakhchivan AR, Dzhaanam-Deresi River Basin, outcrop 1739; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 3. *Araratella dichotomians* (Abramian, 1954), specimen PIN, no. 3744/864, complete shell, ventral valve view, ×1; Nakhchivan AR, east of Geran-Kalasy Mountain, outcrop 10, Bed 3; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

Fig. 4. *Pugnax praevius* Schmidt, 1941, specimen PIN, no. 3744/840, complete shell, ×2: (4a) ventral valve view; (4b) dorsal valve view; (4c) lateral view; (4d) anterior view; (4e) posterior view; Nakhchivan AR, left bank of the Arpa River, vicinity of the village of Danzik, outcrop 1221; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 5. *Pugnax acuminatus* (Sowerby, 1822), specimen PIN, no. 3744/859, 3D model of complete shell, ×1.5: (5a) ventral valve view; (5b) dorsal valve view; (5c) lateral view; (5d) anterior view; (5e) posterior view; Nakhchivan AR, right bank of the Dzhaanam-Deresi River, 1.5 km east of Tezhgar Mountain, outcrop 601, Bed 6; Lower Frasnian, *Adolfia zickzack* Zone.

Fig. 6. *Hypseloterorhynchus* sp., specimen PIN, no. 3744/865, complete shell, ×1, ventral valve view; Armenia, Arshaki-Akbyur gorge, village of Kadrlu, outcrop 7, Bed 3; Upper Famennian, *Paurogastroderhynchus nalivkini* Zone.

Fig. 7. *Coeloterorhynchus* sp., specimen PIN, no. 3744/860, complete shell, ×1.2: (7a) ventral valve view; (7b) dorsal valve view; (7c) lateral view; (7d) anterior view; (7e) posterior view; southern slope of Birali-Kuzei Mountain, outcrop 1439; Lower Frasnian, *Adolfia zickzack* Zone.

Fig. 8. *Mirantesia* sp., specimen PIN, no. 3744/843, 3D model of complete shell, ×1.5: (8a) ventral valve view; (8b) dorsal valve view; (8c) lateral view; (8d) anterior view; (8e) posterior view; Nakhchivan AR, right bank of the Arpa River near the village of Danzik, outcrop 200, Beds 4–8; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 9. *Isopoma brachyptycta* (Schnur, 1853), specimen PIN, no. 3744/858, 3D model of complete shell, ×2.5: (9a) ventral valve view; (9b) dorsal valve view; (9c) lateral view; (9d) anterior view; (9e) posterior view; Nakhchivan AR, Kasan-Gulu-Bakh Mountain; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

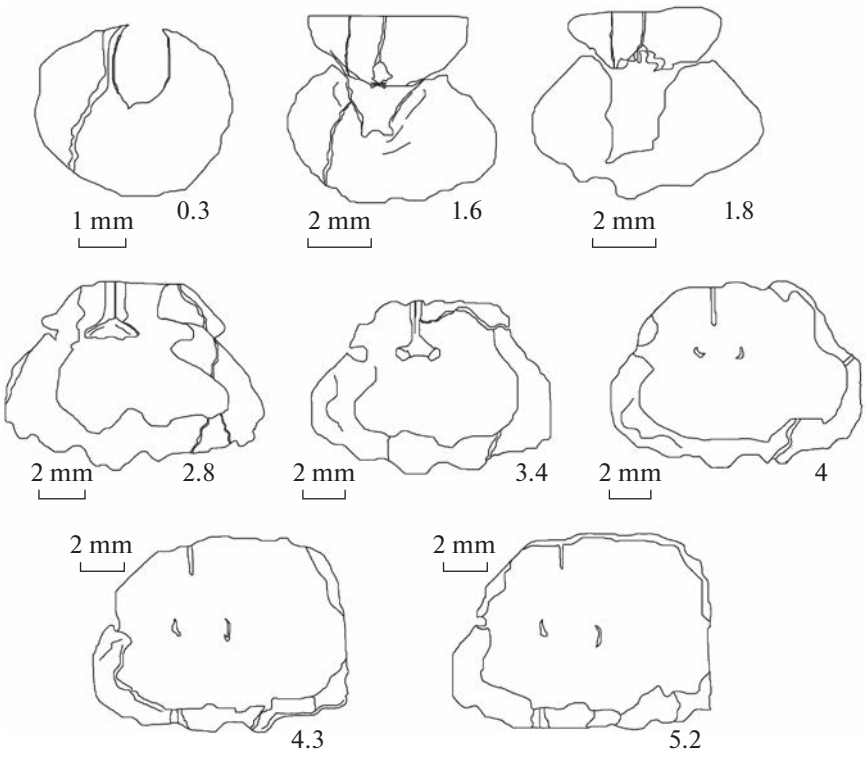


Fig. 78. *Araratella dichotomians* (Abramian, 1954), specimen PIN, no. 3744/830, serial cross sections through the shell; Armenia, vicinity of the village of Kadrlu, Arshaki-Akbyur gorge, outcrop 7, bed 5; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

in median sulcus and fold. Median sulcus near anterior margin with four plicae, of which two central larger than flanking plicae. Three or four plicae on sides of median sulcus. Fold with five plicae near anterior margin, of which one central larger than others. Lateral commissures straight. In ventral valve, dental plates short, somewhat thickened, and almost parallel and fused with umbonal walls. Walls of ventral umbo strongly thickened, especially laterally. In dorsal valve, umbonal walls thickened; cardinal process small and multilobed. Septum moderately long, low, and thickened. Septalium broad, Y-shaped, and open along its whole length. Cavity in septum arising in one-tenth of shell length under septalium forming falsely covered septalium. From this level anteriorly, lateral margins of septalium not fused with hinge plates. Hinge plates short. Cover plate of septalium with anterior outgrowth flanked laterally by dorsally open V-shaped crural bases. Crura elongated comma-shaped posteriorly and widened, crescentic to almost straight anteriorly. Shell three-layered and endopunctate. Endopunctae arranged in rows or irregularly in fibrous layer and sometimes dichotomizing. Punctae of *Araratella dichotomians* described in detail by Erlanger (1986).

Species composition. *A. dichotomians*, *A. anatolica*, and *A. moresnetensis*; Upper Devonian, Upper Famennian; Nakhchivan AR and Armenia, Iran, Afghanistan, Belgium, Germany, Spain. Upper Famennian of Transcaucasia: *A. dichotomians* (Abramian, 1954).

Comparison. There are no similar punctate rhynchonellids within the family Septalariidae.

Remarks. This genus previously included *Camarotoechia araratica* Abramian, 1957, which was later referred to *Tchanakhchirostrum* Sartenaer et Plodowski, 2003 (family Trigonirhynchiidae). *C. araratica* is similar to this genus in the radial ornamentation composed of dichotomizing plicae and differs in the presence of cardinal process and falsely covered septalium.

***Araratella dichotomians* (Abramian, 1954)**

Plate 10, fig. 3; Plate 15, fig. 3; Figs. 78 and 79

Liorhynchus dichotomians: Abramyan, 1954, p. 66, pl. 1, figs. 1–3; 1957, p. 63–64, pl. 7, figs. 3–4.

Araratella dichotomians: Erlanger, 1986, p. 55, pl. 4, figs. 3–5; text-figs. 1 and 2 (synonymy).

Holotype. Specimen of F-B; Abramyan, 1954, pl. 1, fig. 1; Upper Devonian, Upper Famennian; Armenia, vicinity of the village of Kadrlu.

Description. The shell is medium-sized, 18.8–21.5 mm long, 18.1–22.5 mm wide, 11.6–13 mm thick (Erlanger, 1986), elongated, oval to ovally pentagonal, dorsibiconvex, and inflated. The maximum shell width is in its midlength. The ventral umbo is

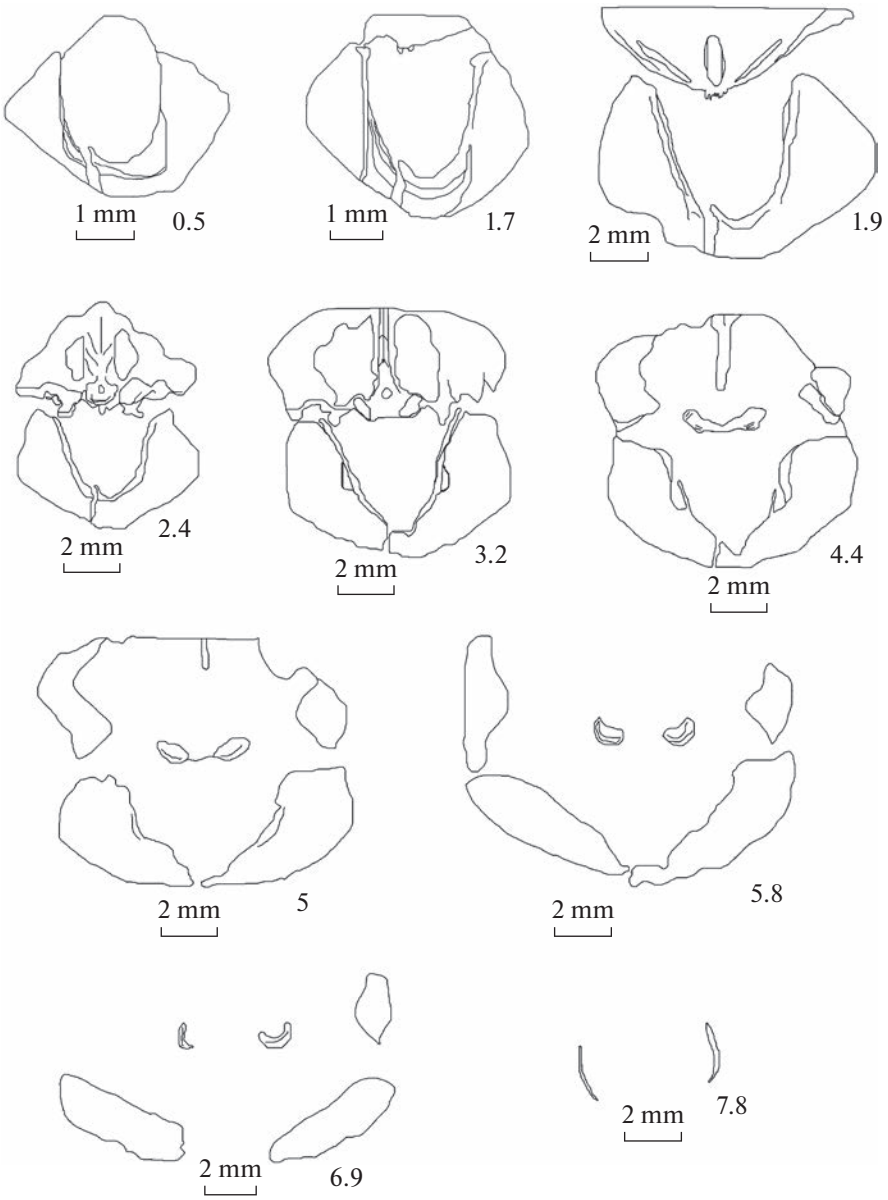


Fig. 79. *Araratella dichotomians* (Abramian, 1954), specimen PIN, no. 3744/810, serial cross sections through the shell; Armenia, 1.1 km south of Kabakhdag Mountain; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

slightly incurved. The ventral sulcus starts in one-forth of the valve length, widens anteriorly, and terminates into a roundly trapezoid tongue. The dorsal fold starts in quarter of the valve length from the umbo. The sulcus and fold are well bordered by plicae and interspaces, respectively. The anterior margin is uniplicate. External radial ornamentation consists of roundly angular plicae with pointed apices. The plicae cover the whole shell surface, run from the umbos, widen anteriorly, dichotomize and intercalate in the middle of the shell, numbering 4–6 in the sulcus, 5 on the fold, and 5–6 on the lateral sides. The plicae and interspaces are equally wide near the umbos; at the anterior margin, the plicae are narrower than interspaces. The lateral commissures are straight. In the ventral valve, the dental plates are short, thin, located close to the umbonal walls, and fused with walls posteriorly. The umbonal walls are thickened. In the dorsal valve, the cardinal process is multilobed, with denticle-shaped lobes. The septalium is broad, Y-shaped, and open. The septum under septalium is thickened and contains a cavity forming falsely covered septalium. The hinge plates are short, fused with the septalium posteriorly, and separated from it at the level of cavity formation in the septum. The septalium continues as dorsally curved outgrowth with crural bases along its margins. The crural bases are V-shaped and dorsally open. The crura are elongated comma-

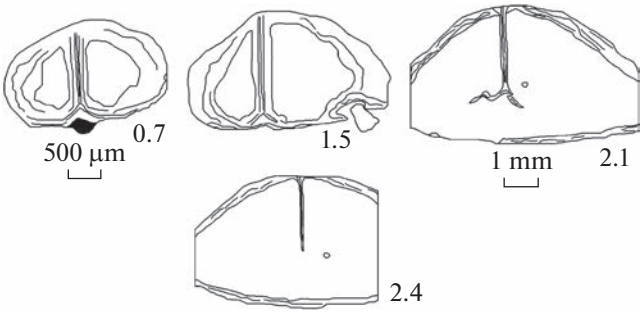


Fig. 80. *Septalariidae* gen. et sp. indet., specimen PIN, no. 3744/925, serial cross sections through the shell; Nakhchivan AR, right bank of the Arpa River upstream village of Danzik, outcrop 43, bed 2; Lower Frasnian, *Adolfia zickzack* Zone.

shaped posteriorly and, then, elongate parallel to lateral margins, become arched, and straighten anteriorly. The shell substance is endopunctate.

Variability. There are two variants of plica arrangement in the median sulcus and fold. In the first case, the plicae in the sulcus and on the fold are more numerous and narrower than on the lateral sides. In the second case, the plicae in the median sulcus and fold are fewer, but larger. This is one of criteria for the establishment of subspecies .

Comparison. This species is most similar to *A. moresnetensis* and differs in the greater number of radial plicae. It differs from *A. anatolica* in the less convex shell.

Remarks. *A. dichotomians* differs from *Tchanakhtchirostrum araraticum* (Abramian, 1957) in the larger shell, the presence of cardinal process, and the falsely covered septalium.

Occurrence. Upper Devonian, Famennian; northern and central Iran, central and western Afghanistan, Transcaucasia.

Material. Nineteen satisfactorily preserved shells from the Nakhchivan AR: east of Geran-Kalasy Mountain, outcrop 10, Bed 3; 2.9 km south of Kabakhdag Mountain, outcrop 1045b; lower part of Myunkh-Bala-Ogly Mountain, 1.1 km south of Kabakhdag Mountain, outcrop 1143; mouth of the Bagarsykh-Deresi River, outcrop 1076; northern slope of Geran-Kalasy Mountain, outcrop 11, Bed E-e; Armenia: Arshaki-Akbyur gorge, near the village of Kadrlu, outcrop 7, Beds 1 and 5.

***Septalariidae* gen. et sp. indet.**

Fig. 80

Diagnosis. Shell medium-sized, 12.5 mm long, 20.3 mm wide, 7.4 mm thick, transversely elongated, flattened, slightly inflated, and dorsibiconvex. Shell maximum thickness in its anterior half; maximum width at shell midlength. Median sulcus and fold poorly developed; fold weakly bordered by costal interspaces. Anterior margin uniplicate. External radial ornamentation composed of simple rounded costae. Costae from 0.7 to 1.6 mm wide, wider than interspaces, starting from umbos, and rarely dichotomizing, numbering 3 in sulcus, 5 on fold, and 8–9 on each lateral side. Lateral slopes low and gentle. Lateral commissures straight. Dental plates absent. Dorsal septum high, long, thin, and running up to one-third of shell length. Cardinal process unifid and massive. Septalium open and shallow, with outgrowths on its inner surface, at site of fusion of hinge and crural plates, typical for rhynchonellids of family Septalariidae. Hinge plates along their whole length fused with septalium. Crural bases somewhat laterally flattened. Crura triangular in cross section and positioned lateral to apex of septum.

Comparison and remarks. Of the Frasnian septalariids *Bergalaria* Schmidt, 1975, *Phlogoiderhynchus* Sartenaer, 1970, and *Septalariopsis* Chen, 1978, this specimen is most similar to *Phlogoiderhynchus* and *Septalariopsis* in shell exterior and differs in the shell interior. It differs from *Phlogoiderhynchus* in the presence of a well-developed septalium, the crura located close to the septum, the absence of ventral myophragm, and in the well-developed hinge plates. It differs from *Septalariopsis* in the thicker costae, the presence of unifid cardinal process, and the presence of outgrowths at the site of fusion of the hinge and crural plates. This specimen possesses all features characterizing the family Septalariidae: long high septum, cardinal process, outgrowths at site of fusion of hinge and crural plates, ornamentation typical for septalariids, crura located close to septum. The studied specimen is most similar to *Septalariopsis*; probably, it belongs to a new genus and species.

Occurrence. Lower Frasnian (*Adolfia zickzack* Zone); Nakhchivan AR.

Material. One incomplete satisfactory preserved shell from the Nakhchivan AR, right bank of the Arpa River upstream from the village of Danzik, outcrop 43, Bed 2.

Superfamily Pugnacoidea Ržonsnitskaja, 1956

Family Pugnacidae Ržonsnitskaja, 1956

Genus *Pugnax* Hall et Clarke, 1893

Pugnax: Hall et Clarke, 1893, p. 202; Ržonsnitskaja et al., 1960, pp. 246–247; Savage et al., 2002, p. 1165.

Type species. *Terebratula acuminata* Sowerby, 1822 in 1821–1822, p. 23; Lower Carboniferous; England.

Diagnosis. Shell small, oval, transversely elongated, moderately inflated, and dorsibiconvex. Ventral umbo erect or slightly incurved. Deltidial plates conjunct. Median sulcus, fold, and tongue developed. Anterior margin uniplicate. External radial ornamentation composed of rare simple plicae in median sulcus, fold, and lateral sides near anterior margin. Lat-

eral commissures straight. Dental plates short and located close to lateral umbonal walls. Septalium and median septum in dorsal valve absent. Hinge plates separate. Crural bases oval. Crura wide, vertical, and laterally flattened.

Species composition. About 35 species; cosmopolitan; Middle Devonian (Givetian)–Upper Permian (Tatarian). Transcaucasia: *Pugnax praevius* Schmidt, 1941 and *P. acuminatus* (Sowerby, 1822).

Comparison. This genus externally resembles *Dimensionaequalirostrum* Sartenaer, 1980, *Cavatisinurostrum* Sartenaer, 1972, *Evanidisinurostrum* Sartenaer, 1987, *Pammegetherhynchus* Sartenaer, 1977, *Parapugnax* Schmidt, 1964, and *Solidipontirostrum* Sartenaer, 1970. *Pugnax* differs from *Dimensionaequalirostrum* in the narrow pointed tongue and laterally flattened crura. It differs from *Cavatisinurostrum* in the presence of plicae in the median sulcus and fold, the poorly developed dental plates, and the laterally flattened crura. It differs from *Evanidisinurostrum* in the crural shape and the presence of small dental plates. It differs from *Pammegetherhynchus* in the lower and less pointed tongue, the crural shape, and the presence of hinge plates. *Pugnax* closely resembles *Parapugnax,* but differs in the tongue, which is not divided by three plicae. In *Pugnax*, on the contrary, these plicae are fused in the sulcus. It differs from *Solidipontirostrum* in the fewer plicae in the median sulcus and the absence of septalium.

Remarks. *Pugnax* is externally similar to *Ladogia* Nalivkin, 1941, *Ladogifornix* Schmidt, 1964 (family Ladogiidae), *Yunnanella* Grabau, 1923 in 1923–1924 (family Yunnanellidae), *Ovlatchania* Abramov et Grigorjewa, 1986, and *Parvaltissimarostrum* Sartenaer et Xu, 1991 (family Petasmariidae). It differs from *Ladogia*, *Yunnanella*, and *Ladogifornix* in the absence of costae on the shell, the short dental plates, the absence of septum and septalium, and the flattened crura. It differs from *Ovlatchania* in the above-listed features, except for the ornamentation and crura shape. It resembles *Parvaltissimarostrum* in the shell exterior and differs in the absence of septum and septalium and flattened crura.

***Pugnax praevius* Schmidt, 1941**

Plate 12, fig. 4; Fig. 81

Pugnax pugnus praevius: Schmidt, 1941, p. 31, pl. 2, figs. 34–36.
Pugnax pugnus praevius: Jungheim, 2000, p. 56, pl. 9.

Holotype was not designated.

Description. The shell is small, 9.8–10.4 mm long, 11.7–13.6 mm wide, 5.4–7 mm thick, oval, and transversely elongated. The maximum width is at the shell midlength or anterior one-third of the shell. The maximum thickness is in anterior one-third of the shell. The ventral valve is slightly convex, with the maximum convexity in the umbonal region. The ventral umbo is erect or slightly incurved; the deltidial plates are conjunct. The median sulcus starts from the shell midlength, widens anteriorly, is indistinctly bordered by plicae, and terminates into a trapezoid tongue at the anterior margin. The dorsal valve is moderately convex, with the maximum thickness in its anterior one-third. The fold is developed near the anterior margin and indistinctly bordered by plical interspaces. The lateral slopes are gentle. The lateral commissures are straight. External radial ornamentation consists of obscure, simple, and rounded plicae. The plicae are 1.2–2 mm wide, wider than interspaces, and developed only near the anterior margin, numbering 2–4 in the sulcus, 4 on the fold, and 1–2 on each lateral side. The dental plates are developed; the teeth are elongated typically for *Pugnax*. The crura are wide and vertical.

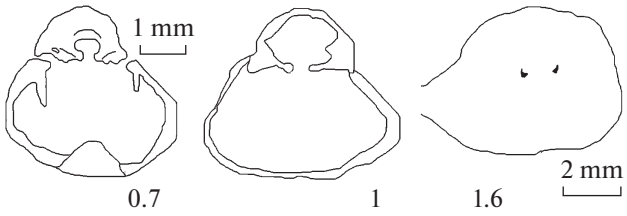


Fig. 81. *Pugnax praevius* Schmidt, 1941, specimen PIN, no. 3744/925, serial cross sections through the shell; Nakhchivan AR, vicinity of the village of Danzik, outcrop 19, Bed 38b; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Comparison. This species differs from *C. acuminatus* in the low median sulcus and few plicae dividing the tongue.

Occurrence. Eifelian of Germany; Eifelian (*Mucrospirifer diluvianoides–Radiomena irregularis*)–Lower Givetian (*Stringocephalus burtini* Zone) of the Nakhchivan AR.

Material. Four well-preserved shells from the Nakhchivan AR, village of Danzik, outcrop 19, Bed 38b; outcrop 1221, left bank of the Dzhaanam-Deresi River (at the reef basement), outcrop 03.

***Pugnax acuminatus* (Sowerby, 1822)**

Plate 12, fig. 5

Terebratula acuminata: Sowerby, 1822 in 1821–1822, p. 23, pl. 324, fig. 1; Buch, 1834, pp. 33–34; Phillips, 1836, p. 222, pl. 12, fig. 4.
Rhynchonella acuminata: Tchernyshew, 1887, p. 86.

Holotype was not designated.

Description. The shell is medium-sized, 18.5 mm long, 14.7 mm thick, and slightly transversely elongated. The maximum width is at the shell midlength. The maximum thickness is in anterior one-third of the shell. The ventral umbo is incurved and flattened. The ventral valve is slightly convex, with the maximum convexity near the umbo. The median sulcus and fold are well developed, start at the shell midlength, and terminate at the anterior margin into a

rounded tongue. The median sulcus narrows anteriorly, is not bordered by plicae, but is well outlined by high lateral slopes. The dorsal valve is strongly convex, with the maximum convexity in its anterior one-third. The fold is not bordered by interspaces. The ventral lateral slopes are lower than high and steep dorsal lateral slopes. The lateral commissures are straight. External radial ornamentation consists of plicae rounded in cross section. The plicae start near the anterior margin, are as wide as the interspaces, located only within the median sulcus and fold and absent on the lateral sides and numbering 3 in the median sulcus and fold. The central 3.1-mm-wide plica on both valves is larger than the lateral plicae. The dental plates are absent. The hinge plates are discrete.

Comparison. This species differs from *C. praevius* in the well developed fold and sulcus and in the steep lateral slopes of inflated dorsal valve.

Remarks. Thin sections of the specimen were not produced because of scanty material. All data on the shell interior were obtained with X-ray microtomography. The only available specimen in our collections externally resembles *Pugnax acuminatus* and is referred to this species.

Occurrence. Lower Frasnian (*Adolfia zickzack* Zone) of the Nakhchivan AR; Lower Carboniferous, Visean, Subzone D2 of Derbyshire, Great Britain.

Material. One satisfactorily preserved shell from the Nakhchivan AR, right bank of the Dzhaanam-Deresi River, 1.5 km east of Tezhgar Mountain, outcrop 601, Bed 6.

Genus *Hypseloterorhynchus* Sartenaer, 1971

Hypseloterorhynchus: Sartenaer, 1971, p. 2; Savage et al., 2002, p. 1171.

Type species. *Hypseloterorhynchus pennatus* Sartenaer, 1971, p. 2; Upper Devonian, Famennian; western Australia.

Diagnosis. Shell large, oval, transversely elongated, flattened, and equally biconvex. Maximum shell width in its middle. Median sulcus and fold well developed, starting near anterior margin, and terminating in tongue. Anterior margin uniplicate. Lateral commissures slightly curved. Lateral slopes gentle. Radial ornamentation plicate. Plicae wide, smoothed, simple, and running from shell midlength. Ventral umbo with dental plates.

Species composition. Type species; Upper Devonian, Upper Famennian; western Australia, Armenia.

Comparison. Famennian genera similar in shell exterior and interior are not known.

***Hypseloterorhynchus* sp.**

Plate 12, fig. 6

Description. The shell is large, 29.6 mm long and 42.9 mm wide, oval, flattened, and elongated. The maximum width is in the middle of the shell. The broad median sulcus and fold start near the anterior margin, are well bordered by plicae and interspaces, respectively, and terminate in a tongue. The anterior margin is uniplicate. The lateral commissures are slightly curved due to wide plicae. The lateral slopes are gentle. The radial ornamentation consists of simple, high plicae with obtuse apices. The plicae are up to 4.5 mm wide at the anterior margin, usually narrower than interspaces, and start at the shell midlength, numbering 2 in the sulcus, 1 on the fold, and 4 on each lateral side. The plicae cover the whole shell surface, but are lower and smoother in the sulcus and fold. Some plicae on the lateral sides of the ventral valve (closer to the sulcus) are paired. Possibly, they dichotomized. The dental plates in the ventral umbo are long.

Comparison and remarks. The only specimen in our collection resembles Australian *H. pennatus* Sartenaer, 1971 in shell exterior, but cannot be assigned to this species due to insufficient material and poorly known shell interior.

Occurrence. Upper Devonian, Upper Famennian, *Paurogastroderhynchus nalivkini* Zone; Armenia.

Material. One well-preserved shell from Armenia, Arshaki-Akbyur gorge, village of Kadrlu, outcrop 7, Bed 3.

Genus *Coeloterorhynchus* Sartenaer, 1966

Coeloterorhynchus: Sartenaer, 1966a, p. 41; Brice, 1970, p. 59; Savage et al., 2002, p. 1168.

Type species. *Coeloterorhynchus tabasensis*, Sartenaer, 1966a; Upper Devonian, Frasnian; Iran, Sardar valley.

Diagnosis. Shell ovally pentagonal, somewhat elongated, and strongly dorsibiconvex. Median sulcus, fold, and tongue developed. Anterior margin uniplicate. External radial ornamentation composed of few large simple plicae in median sulcus, fold, and, fewer, on lateral shell sides and dense strongly flattened costae. Lateral commissures curved. Septalium and median septum in dorsal valve absent.

Species composition. Five species; Middle Devonian (Givetian)–Upper Devonian (Frasnian); Europe, Afghanistan, Iran, North Africa, China. Upper Devonian; Frasnian of the Nakhchivan AR: *Coeloterorhynchus* sp.

Comparison. This genus is externally similar to *Pugnax* Hall et Clarke, 1893, *Globulirhynchia* Brice, 1981, *Parapugnax* Schmidt, 1964, and *Solidipontirostrum* Sartenaer, 1970. *Coeloterorhynchus* differs from *Pugnax* in the lower obtuse tongue and brace-shaped crura. It differs from *Globulirhynchia* in the less

inflated shell and the crus shape. It differs from *Parapugnax* in the lower tongue, the absence of septum and septalium, and the brace-shaped crura. It differs from *Solidipontirostrum* in the fewer plicae in the median sulcus and fold and the absence of the septalium.

Remarks. Of the Givetian–Frasnian rhynchonellids, which do not belong to the family Pugnacidae, *Coeloterorhynchus* is similar to *Isopoma* Torley, 1934 (family Aseptirhynchiidae) and *Athabaschia* Crickmay, 1963 (family Petasmariidae). It differs from *Isopoma* in the wider shell and the brace-shaped crura. It differs from *Athabaschia* in the absence of dental plates, septum, and septalium.

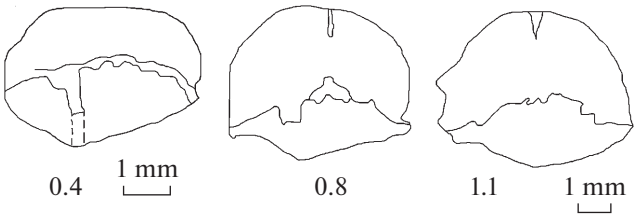


Fig. 82. *Solidipontirostrum* sp., specimen PIN, no. 3744/926, serial cross sections through the shell; Nakhchivan AR, left bank of the Dzhaanam-Deresi River, 1.5 km west of Kazma Mountain, outcrop 57, bed 2; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

Coeloterorhynchus sp.

Plate 12, fig. 7

Description. The shell is large, 19.8 mm long, 21.5 mm wide, 15.1 mm thick, and ovally pentagonal. The maximum shell width is at the midlength; the maximum thickness is in anterior one-third of the shell. The ventral valve is slightly convex, with the maximum convexity in its middle in a broad median sulcus. The tongue is trapezoid and strongly upturned. The dorsal valve is inflated, with the maximum thickness in its anterior one-third. The fold is developed near the anterior margin and indistinctly bordered by plical interspaces. The lateral slopes are steep. The lateral commissures are curved. External radial ornamentation consists of simple, large, and rounded plicae. The plicae are about 2.5 mm wide, wider than interspaces, and developed only near the anterior margin, numbering 5 in the median sulcus and fold and singular plicae on the lateral sides near the median sulcus and fold. The costae are about 0.3 mm wide, dense, and strongly flattened. The septalium and median septum in the dorsal valve are absent.

Comparison and remarks. This specimen is most similar to the type species *C. tabasensis,* but cannot be assigned to it due to insufficient material.

Occurrence. Lower Frasnian, *Adolfia zickzack* Zone; Nakhchivan AR.

Material. One satisfactorily preserved shell from the Nakhchivan AR, southern slope of Birali-Kuzei Mountain, outcrop 1439.

Genus *Solidipontirostrum* Sartenaer, 1970

Solidipontirostrum: Sartenaer, 1970, p. 21; Savage et al., 2002, p. 1174.

Type species. *Terebratula pugnoides*, Schnur, 1851, p. 3; Middle Devonian, Upper Eifelian; Germany.

Diagnosis. Shell small, triangular or pentagonal in outline, inflated, and dorsibiconvex. Ventral umbo erect. Fold, sulcus, and tongue well developed. External radial ornamentation composed of few plicae on fold, sulcus, and lateral sides near shell margins of both valves. Lateral commissures straight. Anterior margin uniplicate. Dental plates short and straight. Septum in dorsal valve "sessile." Septalium shallow, small, and open. Hinge plates fused with septalium.

Species composition. Two or three species; Middle Devonian, Eifelian–Givetian; Western Siberia, Europe; Eifelian of the Nakhchivan AR. Transcaucasia: *Solidipontirostrum* sp.

Comparison. This genus closely resembles the pugnacids *Pugnax* Hall et Clarke, 1893 and *Coeloterorhynchus* Sartenaer, 1966 in shell exterior and differs in the presence of septum, shallow septalium, and hinge plates fused with septalium.

Remarks. *Solidipontirostrum* resembles externally *Isopoma* Torley, 1934 (family Aseptirhynchiidae) and *Eurycolporhynchus* Sartenaer, 1968 (family Petasmariidae) and differs from the former in the shell shape (shell of *Solidipontirostrum* is less elongated) and in the shell interior: presence of low septum and septalium. Hinge plates of *Solidipontirostrum* are fused with septalium. It differs from *Eurycolporhynchus* in the straight dental plates, the low septum, and the presence of septalium.

Solidipontirostrum sp.

Fig. 82

Description. The shell is small, 7 mm long, 9.3 mm wide, 7.5 mm thick, ovally pentagonal, and dorsibiconvex. The maximum width is at the shell midlength. The ventral valve is slightly convex. The median sulcus is wide at the shell midlength and narrows anteriorly to form a tongue. The maximum convexity of the ventral valve is near the umbo. The dental plates are short, straight, and not fused with the umbonal walls. The maximum convexity of the dorsal valve is in its anterior half, on the fold. The fold is well developed, widens in the middle of the shell, and narrows anteriorly. The lateral slopes are gentle. The lateral commissures are straight. External radial ornamentation consists of small, low, smoothed plicae with rounded apices. The plicae are wider than interspaces and developed only near the anterior margin in the sulcus and fold and along the lateral margins of both valves. The number of plicae in the median sulcus

and fold is unknown due to the disrupted anterior shell margin; each lateral side bears three plicae. The median sulcus and fold are not bordered by plicae and interspaces, respectively. The dorsal septum is low, "sessile," and fused ventrally with open, short, and shallow septalium. The hinge plates are separated from each other and fused with the septalium.

Comparison and remarks. This specimen probably belongs to *Solidipontirostrum* based on the shell interior. However, it cannot be referred to any known species of this genus or established as a new species due to the poorly preserved median fold and sulcus and insufficient number of specimens.

Occurrence. Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone; Nakhchivan AR.

Material. One satisfactorily preserved shell from the Nakhchivan AR, left bank of the Dzhaanam-Deresi River, 1.5 km west of Kazma Mountain, outcrop 57, Bed 2.

Family Petasmariidae Savage, 1996

Genus *Mirantesia* Mohanti, 1972

Mirantesia: Mohanti, 1972, p. 176; Savage et al., 2002, p. 1192.

Type species. *Mirantesia mirantana* Mohanti, 1972, p. 176; Middle Devonian, Eifelian; Spain.

Diagnosis. Shell medium-sized, oval, transversely elongated, strongly inflated, and dorsibiconvex. Ventral umbo incurved. Median sulcus, fold, and tongue developed. Anterior margin uniplicate. External radial ornamentation composed of simple and wide plicae covering lateral sides, sulcus, and fold starting from shell midlength. Lateral commissures slightly curved. Lateral slopes steep. Dorsal valve with septum and septalium.

Species composition. Type species and *Mirantesia* sp.; Eifelian; Nakhchivan AR.

Comparison and remarks. This genus resembles *Sagueresia* Mohanti, 1972 (family Septalariidae) in shell exterior and differs in the greater number of plicae on the shell and the deeper septalium.

Mirantesia sp.

Plate 12, fig. 8

Description. The shell is 15.6 mm long, 18.9 mm wide, 16.2 mm thick, oval, transversely elongated, and dorsibiconvex. The maximum width is located closer to the anterior margin; it is 1.2 times greater than the maximum length. The ventral valve is slightly inflated, with the maximum convexity near the umbo. The ventral umbo is medium-sized, curved, and protrudes beyond the posterior margin. The median sulcus starts near the anterior margin. The tongue is long, broad, narrowly trapezoid, and strongly curved. The maximum convexity of the dorsal valve is in its middle. The fold starts at the valve midlength. The median sulcus and fold are indistinctly bordered by plicae and interspaces, respectively. The anterior margin is zigzag and uniplicate. The lateral slopes are steep. The lateral commissures are slightly curved. External radial ornamentation consists of a few simple, rounded, and smoothed plicae in cross section. The plicae are up to 1.8 mm wide at the anterior margin, wider than interspaces, and run from the shell midlength, numbering 2 in the sulcus, 3 on the fold, and 2 on each lateral side. The plicae are higher near the anterior margin and on the fold and better pronounced on the dorsal valve. The plicae on the lateral sides are hardly discernible and located closer to the median sulcus and fold. The dorsal valve has a septum and moderately deep septalium.

Comparison and remarks. This specimen cannot be referred to any known species due to insufficient material and poorly known shell interior.

Occurrence. Middle Devonian, Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone; Nakhchivan AR.

Material. One well-preserved shell from the Nakhchivan AR, right bank of the Arpa River near the village of Danzik, outcrop 200, Beds 4–8.

Family Aseptirhynchiidae Savage, 1996

Genus *Isopoma* Torley, 1934

Isopoma: Torley, 1934, p. 81; Ržonsnitskaja et al., 1960, p. 247; Savage et al., 2002, p. 1189.

Type species. *Terebratula brachyptycta* Schnur, 1853, p. 178; Middle Devonian, Eifelian; Germany.

Diagnosis. Shell small, oval, slightly transversely elongated, moderately inflated, and almost subequally biconvex. Ventral umbo large, slightly incurved, and protruding beyond posterior margin; foramen small and rounded. Median sulcus, fold, and tongue developed. Lateral commissures straight. Anterior margin uniplicate. External radial ornamentation composed of few simple plicae at anterior margin. Shell walls thickened. Dental plates absent. Ventral and dorsal myophragms developed. Hinge plates discrete. Crura wide, laterally flattened, and concave toward each other.

Species composition. Several species; Givetian; the Urals, Europe, Altai, China; Middle Emsian–Upper Givetian of the Nakhchivan AR (including the species, whose generic belonging to *Isopoma* is questionable). Transcaucasia: *Isopoma brachyptycta* (Schnur, 1853).

Comparison. In the Givetian, genera of the family Aseptirhynchiidae similar to *Isopoma* have not been recorded.

Remarks. *Isopoma* is externally similar to *Coeloterorhynchus* Sartenaer, 1966 (family Pugnacidae) and *Schnurella* Schmidt, 1964 (family Yunnanellidae) and

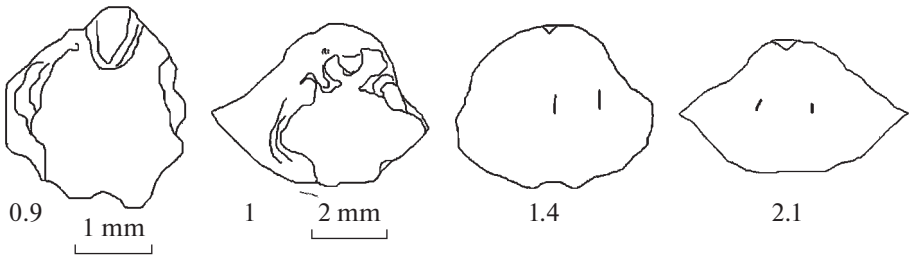


Fig. 83. *Isopoma brachyptycta* (Schnur, 1853), specimen PIN, no. 3744/883, serial cross sections through the shell; Nakhchivan AR, left bank of the Dzhaanam-Deresi River in its lower reaches near levee, outcrop 60, Bed 5; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

differs from *Coeloterorhynchus* in the narrower shell and laterally flattened crura. It differs from *Schnurella* in the absence of thin costae, septum, and septalium.

***Isopoma brachyptycta* (Schnur, 1853)**

Plate 12, fig. 9; Plate 14, fig. 8; Fig. 83

Terebratula brachyptycta: Schnur, 1853, p. 178, pl. 23, fig. 6.

Camarophoria cf. *brachyptycta*: Reed, 1908, p. 87, pl. 14, figs. 11 and 11a.

Isopoma brachyptycta: Torley, 1934, p. 81, gr. A, abb. 16, pl. 3, figs. 12–15.

Isopoma brachyptyctum: Schmidt, 1941, p. 45, pl. 3, fig. 53; pl. 4, fig. 88.

Septalaria brachyptycta: Nalivkin, 1951, p. 15, pl. 2, fig. 8.

Holotype was not designated.

Description. The shell is small, 6.5–11 mm long, 7.9–13 mm wide, 4.2–7.6 mm thick, oval, transversely elongated, and slightly dorsibiconvex. The maximum width is in the anterior one-third of the shell or in its middle; it is 1.2 times greater than the maximum length. The ventral valve is slightly inflated, with the maximum convexity in the umbonal region. The ventral umbo is large, slightly incurved, and protrudes beyond the posterior margin. The foramen is small and rounded. The ventral sulcus and dorsal fold are developed at the anterior margin, indistinctly bordered by plicae and interspaces, respectively, and terminate into a trapezoid tongue. The fold is flattened. The maximum convexity of the dorsal valve is in its anterior one-third of the length. The lateral slopes are gentle. The lateral commissures are straight. External radial ornamentation consists of a few simple rounded plicae. The plicae are 0.6–1.3 mm wide, wider than the interspaces, better pronounced in the sulcus and fold, and developed only at the anterior margin, numbering 3 in the sulcus, 4 on the fold, and 3–4 on the lateral sides. The valves are thickened. The dental plates are absent. The teeth are oval. The myophragms in both valves are long. The hinge plates are discrete. The crura are wide, laterally flattened, and concave towards each other.

Comparison. This species differs from *I. alecto* (Barrande, 1847) in the number of plicae in the median sulcus.

Occurrence. Middle Devonian of Germany, Poland, Moravia; Middle Devonian, Middle Eifelian (*Alatiformia araxica–Dagnachonetes caucasius* Zone)–Upper Givetian (*Indospirifer pseudowilliamsi* Zone) of the Nakhchivan AR.

Material. Twenty-one well and satisfactorily preserved shells from the Nakhchivan AR: vicinity of northwestern Kazma Mountain, Dzhaanam-Deresi River Basin, outcrop 1749; vicinity of Kasan-Gulu-Bakh Mountain, outcrop 63; left bank of the Dzhaanam-Deresi River, lower reaches, near levee, outcrop 60, Bed 5; left bank of the Arpa River near the village of Gyumushlug, outcrop 1423; southern slope of Dagna Mountain near frontier post, outcrop 68, Bed 9.

Family Camerophorinidae Ržonsnitskaja, 1958

Genus *Camerophorina* Schmidt, 1941

Camerophorina: Schmidt, 1941, p. 43; Ržonsnitskaja et al., 1960, p. 250; Savage et al., 2002, p. 1194.

Type species. *Terebratula pachyderma* Quenstedt, 1871 in 1868–1871, p. 200; Middle Devonian; Germany.

Diagnosis. Shell small, rhombic and ovally pentagonal to oval in outline, moderately inflated, and dorsibiconvex. Ventral umbo small, erect or slightly curved; delthyrium covered by dorsal beak. Median sulcus and fold poorly developed. Anterior margin uniplicate. External radial ornamentation composed of few simple plicae. Lateral commissures straight. Dental plates and ventral septum fused forming spondylium. Dorsal median septum absent. Hinge plates almost horizontal.

Species composition. Two or three species; Middle Devonian, Eifelian–Givetian; Moravia, the Urals, Germany, Spain; Eifelian of the Nakhchivan AR. Transcaucasia: *Camerophorina pachyderma* (Quenstedt, 1871).

Comparison and remarks. *Camerophorina* differs from other genera of the superfamily Pugnacoidea in the presence of spondylium.

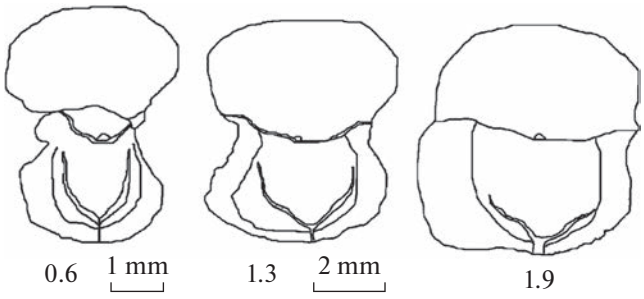


Fig. 84. *Camerophorina pachyderma* (Quenstedt, 1871), specimen PIN, no. 3744/927, serial cross sections through the shell; Nakhchivan AR, vicinity of the village of Danzik, outcrop 66, Bed 3; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

***Camerophorina pachyderma* (Quenstedt, 1871)**

Plate 13, figs. 1 and 2; Fig. 84

Terebratula pachyderma: Quenstedt, 1871 in 1868–1871, p. 200, pl. 42, fig. 49.

Camarophorina pachyderma: Schmidt, 1941, p. 43, pl. 3, fig. 54; pl. 4, fig. 85; pl. 7, fig. 28; Jungheim, 2000, p. 60, pl. 11.

Holotype was not designated.

Description. The shell is 9.2–18.9 mm long, 15.4–18.9 mm wide, 8–12.6 mm thick, rhombic and ovally pentagonal to oval, transversely or longitudinally extended in case of strongly developed median sulcus, and dorsibiconvex. The maximum width is in the umbonal region or in the shell midlength. The maximum thickness is in posterior one-third of the shell. The ventral umbo is small, erect or slightly curved. The delthyrium is covered by the dorsal umbo. The ventral valve is slightly convex, with the maximum convexity in the umbonal region. The median sulcus is well pronounced, starts at the shell midlength, widens anteriorly, and sometimes terminates at the anterior margin into a tongue. The dorsal valve is moderately convex, with the maximum convexity in the umbonal region. The fold is well bordered by plical interspaces, starts at the valve midlength, and almost do not widen anteriorly. The lateral slopes are gentle. The lateral commissures are straight. External radial ornamentation consists of a few simple plicae. The plicae are from 1 to 5.9 mm wide, developed only near the anterior margin, and better developed in the median sulcus and fold, numbering 1–3 in the sulcus (unequally wide when there are three of them), 1–4 on the fold, and 1–3 on each lateral side. The plicae bordering the median sulcus and fold are moderately developed. The dental plates are fused with the ventral septum to form the spondylium. The dorsal median septum is absent. The hinge plates are almost horizontal. Walls of the dorsal valve are thickened in the umbonal region.

Variability. The shell shape and number of plicae on the fold, sulcus, and lateral shell sides vary.

Comparison. This species differs from *C. bijugata* (Schnur, 1851) in the shell size and the greater number of plicae in the sulcus and fold.

Occurrence. Middle Devonian, Eifelian–Givetian; Germany, the Urals, Spain, Moravia; Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone of the Nakhchivan AR.

Material. Three well and satisfactorily preserved inner molds, eight shells, and one incomplete ventral valve from the Nakhchivan AR, vicinity of the village of Danzik, outcrop 19, Bed 38b; outcrop 66, Bed 3; southern slope of the Plakhpashi Mountain Range, outcrop 1179.

Family Yunnanellidae Ržonsnitskaja, 1959

Genus *Schnurella* Schmidt, 1964

Schnurella: Schmidt, 1964, p. 505; Savage et al., 2002, p. 1195.

Type species. *Terebratula schnurii* Verneuil, 1840, p. 261; Middle Devonian; France.

Diagnosis. Shell medium-sized, biconvex, ovally triangular to ovally pentagonal in outline, and strongly dorsibiconvex. Ventral umbo small and slightly incurved; delthyrium covered by dorsal beak. Median sulcus, fold, and tongue well developed. Anterior margin uniplicate. External radial ornamentation composed of numerous costae covering whole shell surface and plicae developed only near anterior margin. Lateral commissures slightly curved. Posterior margin ventrally curved. Dental plates diverging, ventrally convergent, and located close to lateral umbonal walls. Teeth flattened and angular posteriorly and oval anteriorly. Dorsal septum high and thickened. Septalium open and broad. Muscle scars drop-shaped.

Species composition. Two or three species; Middle Devonian, Givetian; Kuznetsk Depression, Armenia, the Urals, Europe; Upper Eifelian–Upper Givetian of the Nakhchivan AR. Transcaucasia: *Schnurella transversa* (Reed, 1908).

Comparison. The family Yunnanellidae does not include genera similar to *Schnurella*.

Remarks. This genus is externally similar to *Isopoma* Torley, 1934 (family Aseptirhynchiidae) and differs in the small costae on the shell surface and the presence of septum and septalium.

***Schnurella transversa* (Reed, 1908)**

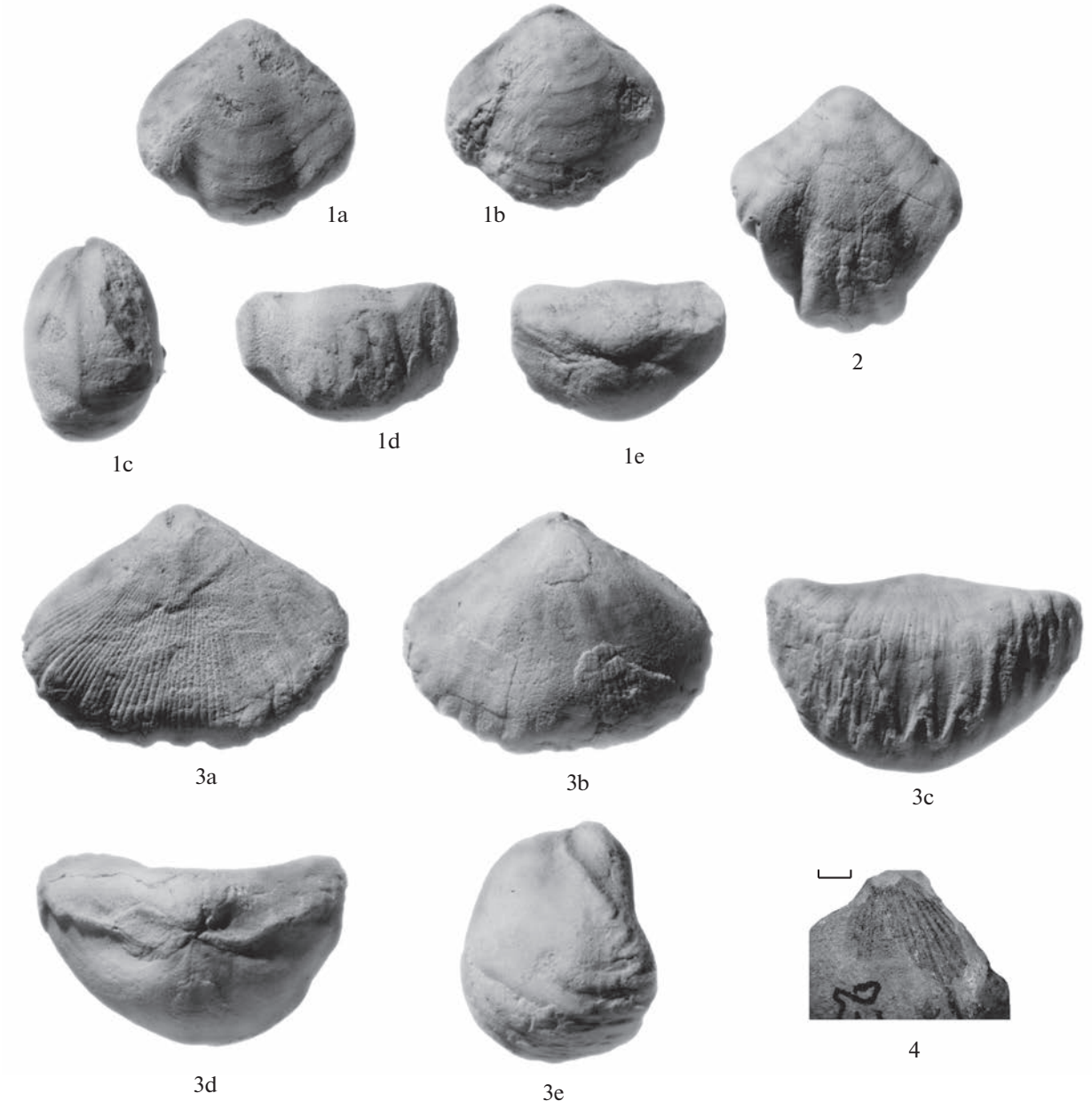
Plate 13, fig. 3; Fig. 85

Rhynchonella schnuri var. *transversa*: Reed, 1908, p. 92, pl. 14, figs. 17, 18–18c.

Holotype was not designated.

Description. The shell is 15.8–18.1 mm long, 20–24.3 mm wide, 12.3–14.7 mm thick, ovally triangular, and dorsibiconvex. The maximum shell width is in its anterior one-third; it is 1.3 times greater than the maximum length. The ventral valve is flattened along its whole length except for the umbonal region, where it is most convex. The ventral umbo is small and

Plate 13



Explanation of Plate 13

Fig. 1. *Camerophorina pachyderma* (Quenstedt, 1871), specimen PIN, no. 3744/836, complete shell, ×3: (1a) ventral valve view; (1b) dorsal valve view; (1c) lateral view; (1d) anterior view; (1e) posterior view;

Fig. 2. *Camerophorina pachyderma*, specimen PIN, no. 3744/837, complete shell, ventral valve view, ×2; Nakhchivan AR, left bank of the Arpa River, vicinity of the village of Danzik, outcrop 19, Bed 38; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 3. *Schnurella transversa* (Reed, 1908), specimen PIN, no. 3744/834, complete shell, ×2: (3a) ventral valve view; (3b) dorsal valve view; (3c) anterior view; (3d) posterior view; (3e) lateral view; Nakhchivan AR, left bank of the Arpa River, vicinity of the village of Danzik, outcrop 19, Bed 38; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 4. Wellerellinae gen et sp. indet., specimen PIN, no. 3744/867, complete shell, ventral valve view; Nakhchivan AR, near the village of Kyarki, outcrop 27, Bed 19; Lower Carboniferous, Upper Tournaisian, *Spirifer baiani–Marginatia burlingtonensis* Zone. Scale bar, 2 mm.

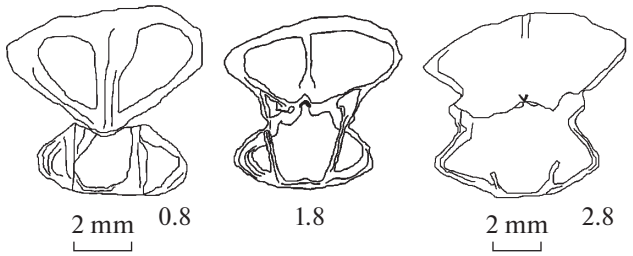


Fig. 85. *Schnurella transversa* (Reed, 1908), specimen PIN, no. 3744/928, serial cross sections through the shell; Nakhchivan AR, left bank of the Arpa River, vicinity of the village of Danzik, outcrop 19, Bed 38; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

slightly incurved. The posterior margin is ventrally curved. The ventral sulcus is broad, developed in the anterior half of the valve, sharply bends, and terminates into a tongue. The dorsal valve is strongly convex, with the maximum thickness in its anterior one-third. The fold is indistinctly bordered by costal interspaces. The lateral slopes are high and gentle. The lateral commissures are slightly curved. External radial ornamentation consists of costae and plicae. The costae are dense, flattened, wider than interspaces, and run from the umbos. The plicae are 1.1–1.7 mm wide, slightly narrower than the interspaces, and form a zigzag anterior margin. The sulcus bears 6 plicae and 25–26 costae; the data on the fold are absent. The dental plates are ventrally convergent and located close to the lateral walls of the umbo. The septum is developed. The muscle scars are drop-shaped and divided by myophragms.

Comparison. This species differs from *C. schnurii* Verneuil, 1840 in the larger and wider shell.

Occurrence. Eifelian of India; Upper Eifelian (*Mucrospirifer diluvianoides–Radiomena irregularis* Zone)–Upper Givetian (*Indospirifer pseudowilliamsi* Zone) of the Nakhchivan AR.

Material. Three well and satisfactorily preserved shells from the Nakhchivan AR: left bank of the Arpa River, vicinity of the village of Danzik, outcrop 19, Bed 38; vicinity of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 5.

Superfamily Wellerelloidea Licharew, 1956

Family Wellerellidae Licharew, 1956

Wellerellinae gen. et sp. indet

Plate 13, fig. 4; Fig. 86

Description. The shell is small, oval, elongated, and equally biconvex. The ventral umbo is large and slightly incurved. The maximum shell width is at the anterior margin. The median sulcus and fold are poorly developed near the anterior margin and indistinctly bordered by costae and interspaces, respectively. The radial ornamentation consists of numerous simple costae. The costae start from the umbos, cover the whole shell surface, and are thickened anteriorly, while their interspaces are narrow, numbering 5 in median sulcus. The dental plates are short and fused with lateral walls of the ventral umbo. The cardinal process is possibly developed. The dorsal septum is long, low, and does not reach the hinge plate. The hinge plates are united posteriorly and discrete anteriorly.

Comparison and remarks. These specimens are not referred to any genus due to the poor preservation and scanty material. However, they resemble rhynchonellides of the subfamily Wellerellinae in the pattern of radial ornamentation, shell interior (dental plates fused with the umbonal walls and the septum separated from the hinge plate).

Occurrence. Lower Carboniferous, Upper Tournaisian, *Spirifer baiani–Marginatia burlingtonensis* Zone; Armenia.

Material. Two poorly preserved shells from the Nakhchivan AR, near the village of Kyarki, outcrop 27, Bed 19.

Order Chonetida Nalivkin, 1979

Superfamily Chonetoidea Schrock et Twenhofel, 1953

Family Rugosochonetidae Muir-Wood, 1962

Subfamily Rugosochonitinae Muir-Wood, 1962

Genus *Rugosochonetes* Sokolskaja, 1950

Rugosochonetes: Sokolskaja, 1950, p. 23; Afanasjeva, 1976, p. 59 (synonymy); Afanasjeva et al., 2003, p. 102; Racheboeuf, 2000, p. 405.

Type species. *Orthis hardrensis* Phillips, 1841; Lower Carboniferous, Visean; England, Yorkshire.

Diagnosis. Shell small and semicircular in outline. Ventral valve slightly convex, dorsal valve slightly curved or flattened. Posterolateral regions somewhat flattened. Hinge spines inclined to posterior margin at 45°–50°. Median sulcus and fold absent. External ornamentation composed of numerous radial, frequently dichotomizing and intercalating capillae. Microornamentation composed of fine, regular, and dense concentric scars on radial capillae. In ventral valve, median septum narrow and high in umbonal region and stretching anteriorly as low ridge for two-thirds or three-quarters of valve length. Muscle field broad and weakly bordered. In dorsal valve, cardinal process bifid or quadrifid externally and bifid with alveolus at base internally. Median septum reaching valve midlength and gradually lowering. Lateral septa diverging from median septum at about 30°. Brachial ridges variously developed.

Species composition. About 45 species; Lower Carboniferous; cosmopolitan. Transcaucasia: *Rugosochonetes multistriatus* sp. nov.

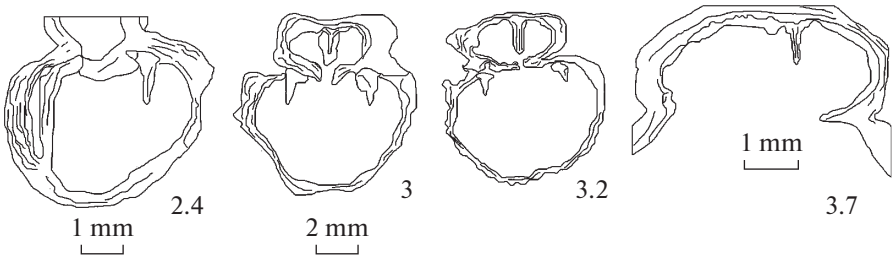


Fig. 86. Wellerellinae gen et sp. indet., specimen PIN, no. 3744/929, serial cross sections through the shell; Nakhchivan AR, near the village of Kyarki, outcrop 27, Bed 19; Upper Tournaisian, *Spirifer baiani–Marginatia burlingtonensis* Zone.

C o m p a r i s o n. This genus is most similar to cosmopolitan Middle–Late Carboniferous and Early Permian *Neochonetes* Muir-Wood, 1962 in shell outline and shape and pattern of external radial ornamentation and differs in the hinge spines inclined at a greater angle to the posterior margin, the presence of microornamentation composed of concentric scars on capillae, the absence of paired vascular ridges flanking the median septum in the ventral valve, and in the anteriorly lowering median septum in the dorsal valve (the septum of *Neochonetes* increases in height anteriorly). *Rugosochonetes* is similar to *Jakutochonetes* Afanasjeva, 1977 (Afanasjeva, 1977) from the Middle Carboniferous of the western Upper Yana region in the external radial ornamentation and shell interior of both valves and differs mainly in the smaller shell, the absence of a narrow groove on either valves in the plane of symmetry, and the presence of concentric scars on radial capillae.

***Rugosochonetes multistriatus* Afanasjeva, sp. nov.**

Plate 17, figs. 1–4

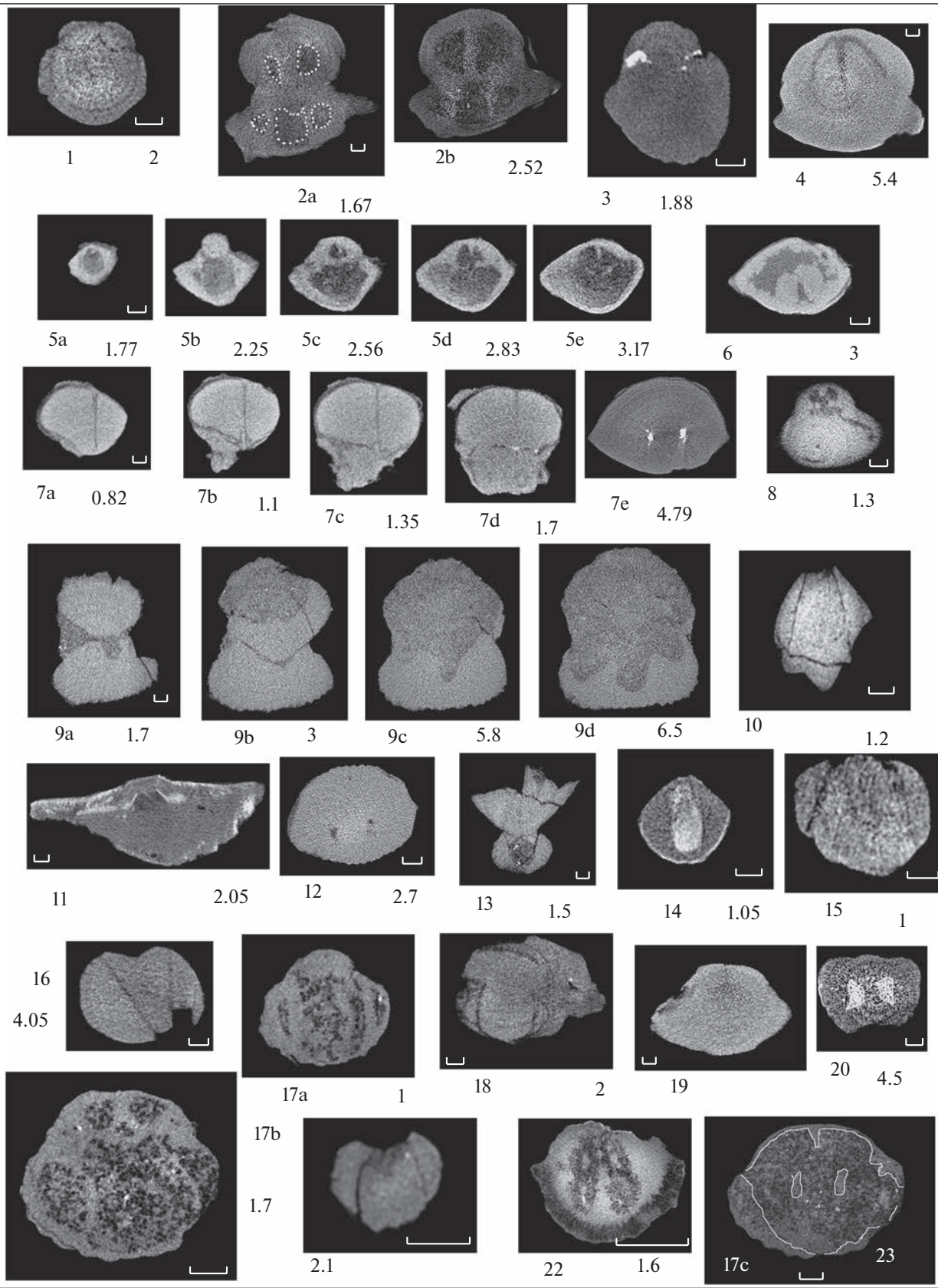
E t y m o l o g y. From the Latin *multus* (numerous) and *striatus* (striated).

H o l o t y p e. PIN, no. 3744/140, mold of ventral valve; Nakhchivan AR, left bank of the Arpa River, northeastern slope of Geran-Kalasy Mountain, outcrop 11, Bed 15; Lower Carboniferous, Lower Tournaisian, *Parallelora praeulbanensis–Rhytiophora curtirostris* Zone (Pl. 17, fig. 4).

D e s c r i p t i o n. The shell is semicircular in outline. The maximum shell width (12–15 mm) is at the valve midlength; it is 1.3–1.4 times greater than the maximum length. The posterior margin is shorter than the maximum width by 1–2 mm. The ears are rectangular, poorly pronounced or absent. The ventral umbo is small and slightly inflated, with an erect beak. The area is linear and anacline. The posterior margin bears 4–5 hinge spines on each side of the umbo inclined at about 60° to the posterior margin. The ventral valve is moderately uniformly inflated, with the maximum convexity in the posterior half of the valve. The median sulcus is absent; the median region of the valve bears a poorly pronounced and anteriorly widening depression. The posterolateral regions are somewhat flattened. The dorsal valve is uniformly slightly concave, with the maximum concavity in the middle. The fold is absent. The posterolateral regions are somewhat flattened. External radial ornamentation consists of numerous relatively sharp capillae rounded in cross section, which strongly increase in number anterior to the umbo by dichotomy and intercalation along the whole shell surface. The capillae are twice as wide as the interspaces, numbering on average 5 capillae per 1 mm in the middle of the anterior margin on each valve. Each valve bears up to 150 capillae near the anterior margin. The microornamentation consists of fine, dense, and regularly arranged concentric scars on the radial capillae. In the ventral valve, the median septum stretches for two-thirds of the valve length, is relatively high in the umbonal region, then, abruptly lowers, and is shaped anteriorly as a narrow and low ridge, gradually lowering towards the anterior margin. The muscle field is relatively broad and indistinct. The whole inner valve surface, including the posterolateral regions and excluding the muscle field, is covered with small rounded tubercles arranged in indistinct radial rows. In the dorsal valve, the cardinal process is divided into two by a groove on the inner side, with an alveolus at the base. The median septum is low and narrow, reaches the valve midlength, and lowers gradually anteriorly. The lateral septa diverge from the median septum at about 30°. The muscle field and brachial ridges are absent. Most of the inner valve surface, including the posterolateral regions, is covered with small, rounded, and irregularly arranged tubercles.

C o m p a r i s o n. The new species is generally similar to *R. burlingtonensis* (Weller, 1914) from the Lower Carboniferous (Upper Keokuk limestone) of the Mississippi River valley, United States, and differs in the maximum width located at the shell midlength and in the greater number of costae (*R. burlingtonensis* has up to 100). This species is similar to *R. annae* Afanasjeva, 1976 (Afanasjeva, 1976) from the Tula Horizon, Visean, Lower Carboniferous of the Russian Platform in shell size and number of radial capillae and differs

Plate 14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2b
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3
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5b
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5c
2.56
5d
2.83
5e
3.17
6
3
7a
0.82
7b
1.1
7c
1.35
7d
1.7
7e
4.79
8
1.3
9a
1.7
9b
3
9c
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9d
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10
1.2
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2.05
12
2.7
13
1.5
14
1.05
15
1
16
4.05
17a
1
18
2
19
20
4.5
17b
1.7
2.1
22
1.6
17c
23

Explanation of Plate 14

Virtual cross slices through complete shells produced based on X-ray microtomographs; dorsal valves at the top, ventral valves at the bottom. Figures are the distances from the ventral beak, mm. Scale bar, 1 mm.

Fig. 1. *Tchanakhtchirostrum araraticum* (Abramian, 1957), specimen PIN, no. 3744/878, section showing septum, septalium, and hinge plates; Nakhchivan AR, northwest ending of Myunkh-Bala-Ogly Mountain; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

Fig. 2. *Uncinulus korovini* Khalfin, 1937, specimen PIN, no. 3744/833, sections showing thickened shell walls, septum, septalium, cardinal process, and dental plates; Nakhchivan AR, vicinity of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 3; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Fig. 3. *Kransia parallelepipeda* (Bronn, 1837), specimen PIN, no. 3744/879, section through umbonal region showing the dental sockets filled with high-contrast mineral; Nakhchivan AR, left bank of the Dzhaanam-Deresi River, 1.5 km west of Kazma Mountain, outcrop 57; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 4. *Uncinulus korovini* Khalfin, 1937, specimen PIN, no. 3744/880, section showing septum; Nakhchivan AR, vicinity of Kasan-Gulu-Bakh Mountain, outcrop 63, Bed 3; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Fig. 5. *Primipilaria primipilaris* (Buch, 1834), specimen PIN, no. 3744/831, sections showing dental plates, septum, hinge plates, and crural bases; Nakhchivan AR, Dzhaanam-Deresi River Basin, outcrop 53, Bed 5a; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 6. *Ripidiorhynchus gnishikensis* (Abramian, 1959), specimen PIN, no. 3744/881, section showing the crus thickened by carbonate mineral; Nakhchivan AR, vicinity of the village of Gyumushlug, outcrop 250; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

Fig. 7. *Cyphoterorhynchus arpaensis* (Abramian, 1957), specimen PIN, no. 3744/882, sections showing the septum, septalium, hinge plates, and crus; Nakhchivan AR, vicinity of the village of Danzik, outcrop 101, Bed 14; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

Fig. 8. *Isopoma brachyptycta* (Schnur, 1853), specimen PIN, no. 3744/883, section showing the septum and hinge plates; Nakhchivan AR, vicinity of northwest Kazma Mountain, Dzhaanam-Deresi River Basin, outcrop 1749; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

Fig. 9. *Paurogastroderhynchus nalivkini* (Abramian, 1957), specimen PIN, no. 3744/884, sections showing different thickened shell regions; vicinity of the village of Danzik, outcrop 15, Bed 22; Upper Famennian, *Paurogastroderhynchus nalivkini* Zone.

Fig. 10. *Sharovaella mirabilis*, specimen PIN, no. 3744/806, section showing dental plates marked by fractures; Nakhchivan AR, vicinity of Kyzyl-Kaya Mountain, outcrop 21, Bed 17; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Fig. 11. *Vallomyonia* aff. *devonica* (Walcott, 1884), specimen PIN, no. 3744/967, virtual slice showing the brachiophores; Transcaucasia, Middle Devonian.

Fig. 12. *Oligoptycherhynchus daleidensis* (Roemer, 1844), specimen PIN, no. 3744/885, slice showing the crural bases; Nakhchivan AR, near the village of Danzik, outcrop 19, Bed 29; Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

Fig. 13. *Paurogastroderhynchus nalivkini* (Abramian, 1957), specimen PIN, no. 3744/886, slice showing umbonal thickenings; vicinity of the village of Danzik, outcrop 15, Bed 22; Upper Famennian, *Paurogastroderhynchus nalivkini* Zone.

Fig. 14. *Uncinulus korovini* Khalfin, 1937, specimen PIN, no. 3744/887, slice showing dental plates fused with umbonal walls and umbonal cavity filled with contrast mineral; Nakhchivan AR, village of Gyumushlug, outcrop 60, Bed 4; Upper Givetian, *Indospirifer pseudowilliamsi* Zone.

Fig. 15. *Cyphoterorhynchus arpaensis* (Abramian, 1957), specimen PIN, no. 3744/888, slice showing dental plates; Nakhchivan AR, vicinity of the village of Gyumushlug, outcrop 250; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

Fig. 16. *Tenticospirifer* sp., specimen PIN, no. 3744/378, slice showing dental plates; Armenia, Arshaki-Akbyur gorge, vicinity of the village of Kadrlu, outcrop 7, Bed 5; Upper Devonian, Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone.

Fig. 17. *Hemiplethorhynchus* sp. 2, specimen PIN, no. 3744/889, slices showing dental plates, septum, septalium, short hinge plates, and crura; Nakhchivan AR, vicinity of the village of Kyarki, outcrop 27, Bed 16; Lower Carboniferous, Upper Tournaisian, *Spirifer baiani–Marginatia burlingtonensis* Zone.

Fig. 18. *Ripidiorhynchus gnishikensis* (Abramian, 1959), specimen PIN, no. 3744/890, slice showing dental plates; Nakhchivan AR, right bank of the Dzhaanam-Deresi River, 1.5 km east of Tezhgar Mountain, outcrop 601, Bed 53; Upper Frasnian, *Cyrtospirifer subarchiaci–Cyphoterorhynchus arpaensis* Zone.

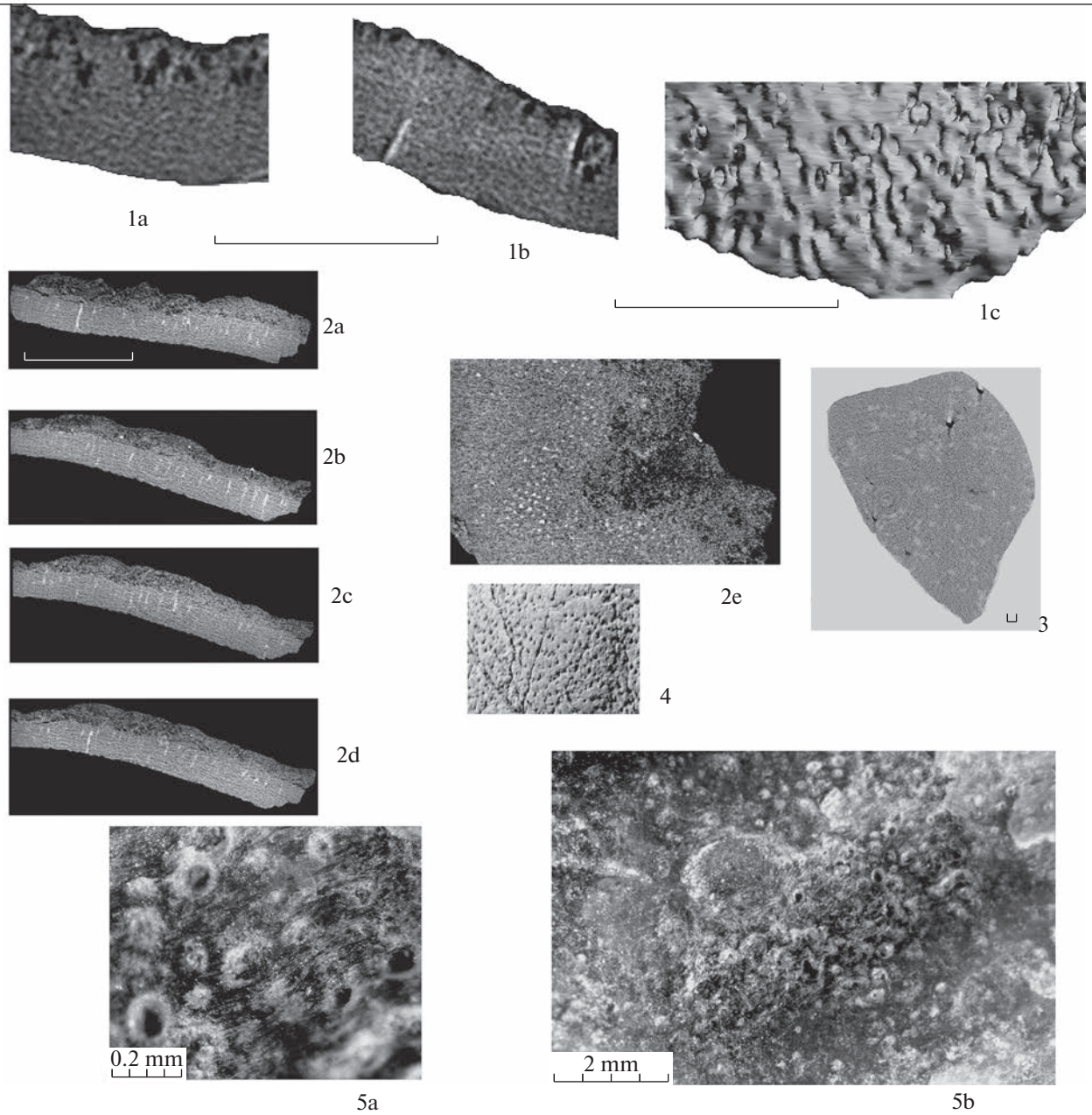
Fig. 19. *Zezinia multicostata* Pakhnevich, 2018, specimen PIN, no. 3744/891, slice showing the septalium; Nakhchivan AR, vicinity of Gyumushly, outcrop 42, Bed 6a; Lower Frasnian, *Adolfia zickzack* Zone.

Fig. 20. *Beckmannia pentagona* (Kayser, 1871), specimen PIN, no. 3744/892, slice showing the crura marked by contrast mineral; Nakhchivan AR, right bank of the Dzhaanam-Deresi River; Upper Eifelian, *Mucrospirifer diluvianoides–Radiomena irregularis* Zone.

Fig. 21. *Sharovaella mirabilis* Pakhnevich, 2012, specimen PIN, no. 3744/893, slice showing dental plates; Nakhchivan AR, mouth of the Bagarsykh-Deresi River, outcrop 1076; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Fig. 22. *Gesoriacorostrum* cf. *boloniense* (Orbigny, 1850), specimen PIN, no. 3744/894, slice showing the crura first overgrown with contrast mineral and then cilicified; Nakhchivan AR, lower part of Myunkh-Bala-Ogly Mountain; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Plate 15



Explanation of Plate 15

The punctae of punctate brachiopods photographed with different research implements: (1–3) X-ray microtomographs, (4) digital camera, (5) Leica MZ 16 digital stereomicroscope.

Fig. 1. *Sharovaella mirabilis* Pakhnevich, 2012, holotype PIN, no. 3744/804: (1a, 1b) virtual slices of a ventral valve fragment with (1a) dichotomizing punctae and (1b) punctae penetrating the whole shell wall; (1c) 3D reconstruction of ventral valve fragment; Nakhchivan AR, Geran-Kalasy Mountain, outcrop 1241; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone. Scale bar, 1 mm.

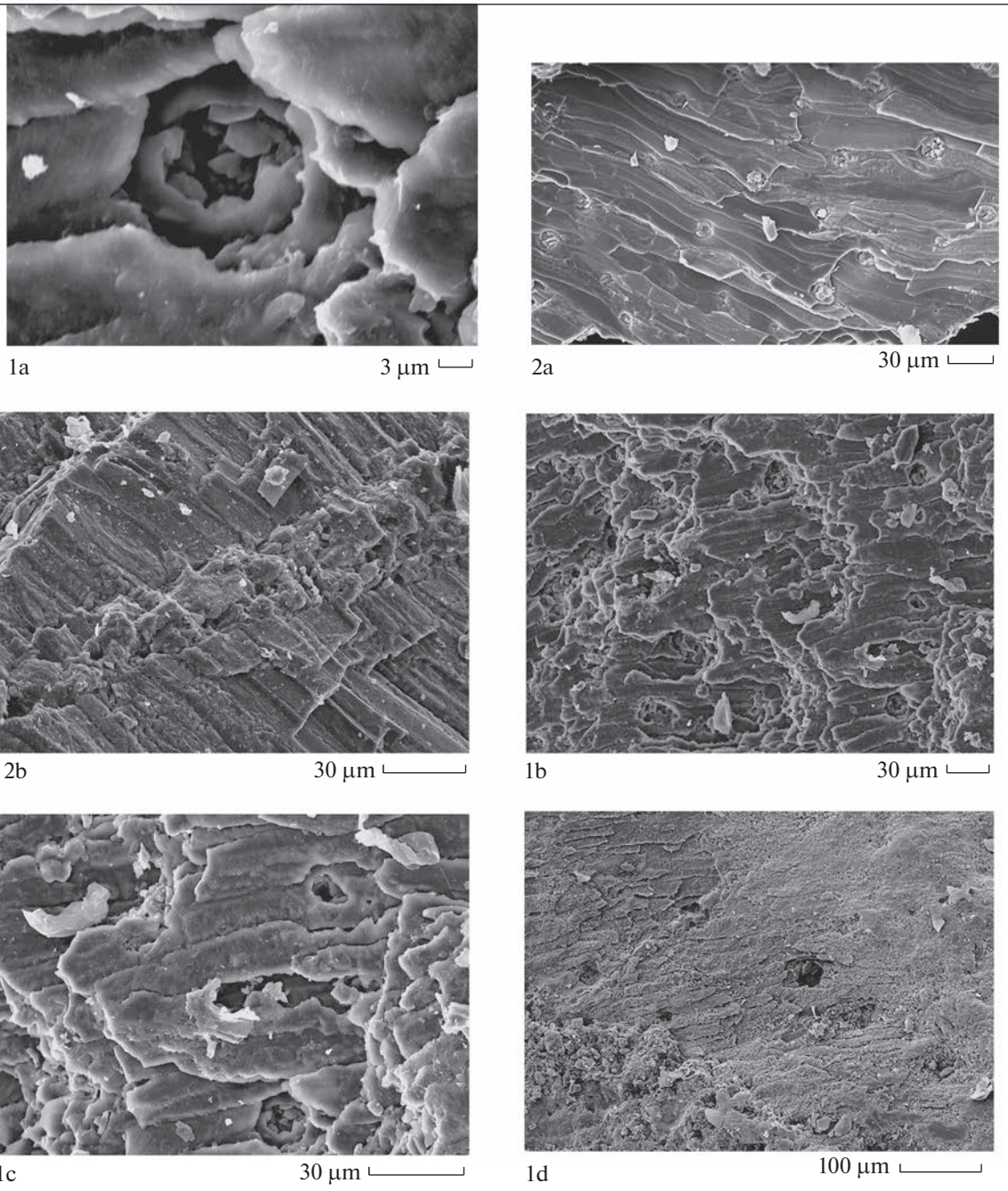
Fig. 2. *Cyrtina heteroclite*, specimen PIN, no. 3744/608: (2a–2d) serial cross sections through the shell fragment; (2e) coronal virtual slice of shell fragment; Nakhchivan AR, Dagna Mountain, outcrop 68, Bed 9; Lower (Emsian)–Middle (Eifelian) Devonian, *Megastrophia uralensis–Zdimir pseudobaschkiricus* Zone. Scale bar, 1 mm.

Fig. 3. *Araratella dichotomians* (Abramian, 1954), specimen PIN, no. 4127/1025, complete shell, coronal virtual slice of shell fragment showing light gray punctae; Nakhchivan AR, left bank of the Birali-Chai River, foot of Tezhgar Mountain; Upper Famennian, *Sphenospira julii–Spinocarinifera nigra* Zone. Scale bar, 100 μm.

Fig. 4. *Zaigunrostrum nakhichevanense* Pakhnevich, 2018, specimen PIN, no. 3744/862, complete shell, ventral valve surface of 1-mm-wide region; Nakhchivan AR, right bank of the Arpa River near the village of Danzik, outcrop 36, Bed 2; Upper Famennian, *Cyrtospirifer pamiricus–Enchondrospirifer ghorensis* Zone.

Fig. 5. *Sharovaella mirabilis* Pakhnevich, 2012, holotype PIN, no. 3744/804, smooth shell surface with black punctae, puncta margins white; Nakhchivan AR, Geran-Kalasy Mountain, outcrop 1241; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

Plate 16



Explanation of Plate 16

Fig. 1. *Sharovaella mirabilis* Pakhnevich, 2012, holotype PIN, no. 3744/804, outer surface of the ventral valve with punctae in the fibrous layer, SEM CamScan-4.

Fig. 2. *Sharovaella mirabilis* Pakhnevich, 2012, specimen PIN, no. 3744/806: (2a) outer surface of the ventral valve; (2b) wall of the ventral valve, SEM CamScan-4; Nakhchivan AR, Geran-Kalasy Mountain, outcrop 1241; Lower Famennian, *Cyrtospirifer asiaticus–Mesoplica meisteri* Zone.

in the relatively narrower shell, less curved valves, and in the location of the maximum width (the maximum width of *R. annae* is at the posterior margin).

Occurrence. Lower Carboniferous, Lower Tournaisian, *Paralleora praeulbanensis–Rhytiophora curtirostris* Zone; Nakhchivan AR.

Material. Six specimens (four ventral and two incompletely preserved dorsal valves) from the left bank of the Arpa River, southeastern slope of Geran-Kalasy Mountain, outcrop 11, Bed 15.

Genus *Dagnachonetes* Afanasjeva, 1978

Dagnachonetes: Afanasjeva, 1978, p. 66; 2003, p. 104; Racheboeuf, 1981, p. 154; 2000, p. 394.

Type species. *D. caucasius* Afanasjeva, 1978; Middle Devonian, Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone; Transcaucasia.

Diagnosis. Shell medium-sized, transversely elongated, and slightly concavo-convex. Median sulcus and fold absent or poorly developed. Ventral area apsacline; dorsal area catacline. Pseudodeltidium well developed. Hinge spines positioned at 40° to posterior margin. External radial ornamentation composed of numerous bifurcating capillae. In ventral valve, median septum stretching up to valve midlength. Teeth shaped as small oval tubercles stretching along posterior margin. In dorsal valve, cardinal process high, bifid on outer side and bulbous with alveolus at base on inner side. Median septum starting from alveolus, stretching for two-thirds of valve length, and lowering somewhat anteriorly. Lateral septa curved. Brachial ridges well pronounced. Anterolateral regions of inner surfaces of both valves (except for posterolateral regions) bearing small tubercles, which sometimes arranged in radial rows.

Species composition. At least eight species; Lower Devonian (Emsian) and Middle Devonian; Transcaucasia, Poland, France, Spain, Canadian Arctic Archipelago, Mongolia and China. Transcaucasia; Middle Devonian, Eifelian, *Araxiformia araxica–Dagnachonetes caucasius* Zone: *D. caucasius* Afanasjeva, 1978.

Comparison. *Dagnachonetes* is similar to *Neochonetes* Muir-Wood, 1962, which was cosmopolitan in the Middle–Upper Carboniferous and Permian, in the shell shape and pattern of external radial ornamentation. It differs in the absence of vascular ridges flanking the ventral median septum, which are characteristic of *Neochonetes*. In addition, the dorsal median septum of *Dagnachonetes* lowers anteriorly, while in *Neochonetes,* it increases in height. *Dagnachonetes* has curved lateral septa in the dorsal valve, which are absent in *Neochonetes*.

Remarks. Racheboeuf (1981, 2000) established the subfamily Dagnachonetinae in the family Chonetidae Bronn, 1862 and referred *Dagnachonetes* to this subfamily based on its concentric external ornamentation and absence of additional septa. However, these features characterize a number of genera of the subfamily Rugosochonetinae Muir-Wood, 1962, family Rugosochonetidae Muir-Wood, 1962, to which *Dagnachonetes* is also similar in typical for the whole family subdivided cardinal process and alveolus (Afanasjeva, 1988). Therefore, we retain *Dagnochonetes* in the subfamily Rugosochonetinae, as was done in the original description of this genus.

Dagnachonetes caucusius Afanasjeva, 1978

Plate 17, fig. 5; Plate 18, figs. 1–8

Dagnachonetes caucasius: Afanasjeva, 1978, p. 67, pl. 8, figs. 2–9.

Holotype. PIN, no. 3744/41, ventral valve; Nakhchivan AR, southeastern slope of Dagna Mountain, outcrop 68, Bed 45; Middle Devonian, Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone.

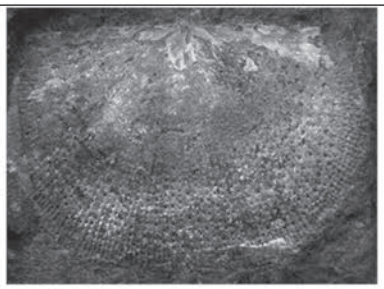
Description. The shell is semicircular in outline. The maximum shell width (22–26 mm) is at the posterior margin; it is 1.5–1.7 times greater than its length. The ears are small, rectangular or acute, and indistinctly defined. The ventral umbo is very slightly convex or flattened and does not protrude beyond the posterior margin. The posterior margin bears 7–8 hinge spines on each side of the umbo. The ventral area is low, flattened, elongated triangular, and about 1 mm high under the umbo. The umbonal margin of the area is stepped; the lateral margins are often cut. The apical angle of delthyrium is 60°. The pseudodeltidium is convex, triangular, and covers the delthyrium apex for one-third of its height. The dorsal area is linear and about 0.5 mm high under the umbo. The apical angle of the notothyrium is 110°. The maximum convexity of the ventral valve is in its posterior half. The median sulcus is absent. The maximum concavity of the dorsal valve is at its midlength. The fold is absent. The posterolateral regions of both valves are somewhat flattened. The radial capillae are numerous, clearly defined, rounded in cross section, and slightly wider than interspaces, numbering up to 200 on each valve near the anterior margin in the largest specimens. The capillae rarely branch within two-thirds of the shell

Explanation of Plate 17

Figs. 1–4. *Rugosochonetes multistriatus* Afanasjeva, sp. nov., exterior views of incompletely preserved ventral valves: (1) holotype PIN, no. 3744/140, ×3; (2) specimen PIN, no. 3744/145, ×3; (3) specimen PIN, no. 3744/148, dorsal valve: (3a) exterior view, ×3; (3b) microornamentation, ×10; (4) specimen PIN, no. 3744/150, mold of the ventral valve: (4a) general view, ×3; (4b) imprint of inner microornamentation, ×10; Nakhchivan AR, left bank of the Arpa River, southeastern slope of Geran-Kalasy Mountain, outcrop 11, Bed 15; Lower Carboniferous, Lower Tournaisian, *Parallelora praeulbanensis–Rhitiophora curtirostris* Zone.

Fig. 5. *Dagnachonetes caucasius* Afanasjeva, 1978, specimen PIN, no. 3744/645, slabstone with imprints and molds of the ventral and dorsal valves; southern slope of Dagna Mountain, outcrop 68, Bed 45; Middle Devonian, Middle Eifelian, *Dagnachonetes caucasius–Alatiformia araxica* Zone.

Plate 17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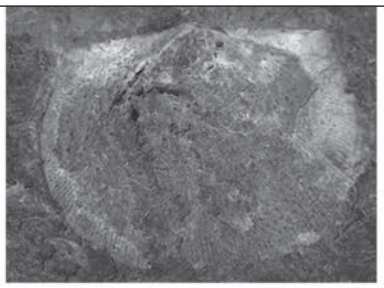
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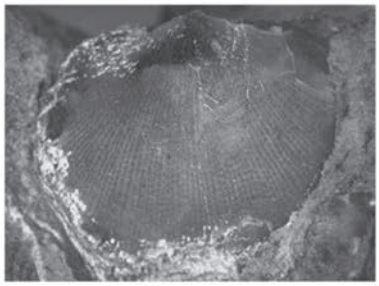
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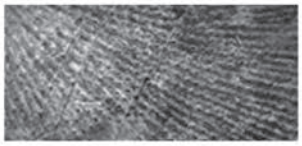
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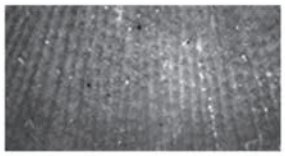
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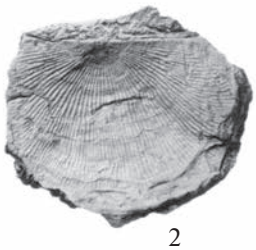
5

Plate 18


1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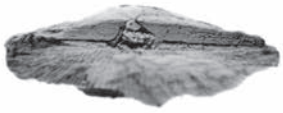
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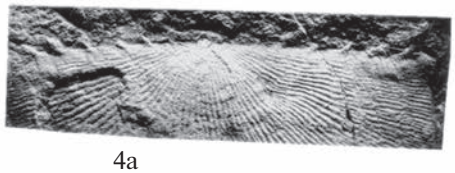
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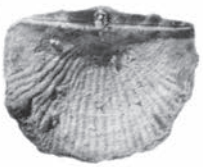
3b


9a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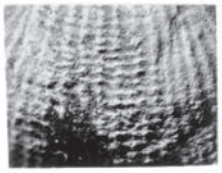

9e


9c


9d


4b

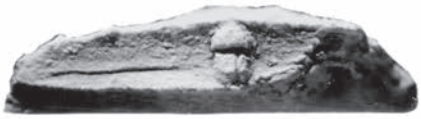

6


7

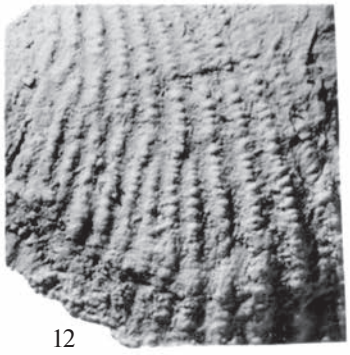

8a


10


11a


11c


11b


12


8b

length from the umbo and, then, almost all capillae bifurcate approximately at the same level. In doing so, the capillae considerably increase in total number and considerably decrease in width, numbering 4 capillae per 1 mm in the middle of the shell and 5–6 capillae per 1 mm at the anterior margin. In the ventral valve, the median septum is high and narrow in the umbonal region and continues anteriorly as a gradually lowering ridge. The muscle field is obscure. In the dorsal valve, the cardinal process is V-shaped externally, with two hooked lobes. The socket ridges are massive and almost parallel to the posterior margin. The median septum starts from the alveolus and lowers and narrows anteriorly. The lateral septa are wider than the median septum, start from socket ridges at 22°–25° to the median septum and, then, curve laterally, so that the angle of inclination becomes 40°. The brachial ridges are well pronounced, thin, and arched.

Comparison. This species is most similar to *D. dominicae* Racheboeuf (1981, p. 161, pl. 28, figs. 10–20) from the Eifelian (Formation de Kersadiou) of Armorican Massif in the shell exterior and differs in the larger and relatively less transversely elongated shell (the shell of *D. dominicae* is up to 15 mm wide, with the maximum width 1.8–2 times greater than the maximum length). *D. caucusius* resembles *D. morzadeci* Racheboeuf (1981, p. 164, pl. 29, figs. 1–10) from the Eifelian (Formation de Tibidy) and Givetian (Formation de Kerbelec, Formation de Lanvoy), Middle Devonian of the Armorican Massif in the pattern of external radial ornamentation and differs in the shell outline (the shell of *D. morzadeci* is subrectangular; its lateral commissures are directed perpendicular to the posterior margin). This species is similar to *D. quietus* Racheboeuf (1987, p. 13, pl. 4, figs. 7–14) from the Emsian, Lower Devonian (Blue Fiord Formation, Bird Fiord Formation) of the Canadian Arctic Archipelago in shell outline and strongly differs in the considerably better defined external radial capillae. It is similar to *D.* (?) *dundensis* Oleneva (Oleneva, 2000, p. 80, pl. 6, figs. 6–14) from the Middle Devonian, Givetian, (Khutugol Formation) of Mongolian Altai in the shell width to length ratio and differs in the larger shell (the shell of *D.* (?) *dundensis* is up to 17 mm wide) and the maximum shell width located at the posterior margin (the maximum width of *D.* (?) *dundensis* is usually located anterior to the posterior margin).

Occurrence. Middle Devonian, Middle Eifelian, *Alatiformia araxica–Dagnachonetes caucasius* Zone; Transcaucasia.

Material. Fifty-nine specimens: 43 ventral and 12 dorsal separate valves; four conjoined shells, inner molds of three ventral and two dorsal valves and one imprint of the outer surface of the dorsal valve from Armenia: vicinity of the village of Yeraskh, outcrop 47, Beds 11, 15, 16, 18, 20, 22, 23, 28, 29, and 32; outcrops 1182a, 1182b (32 specimens); Nakhchivan AR: southeastern slope of Dagna Mountain, outcrop 68, Bed 45; outcrop 603, Bed 22 (four specimens); left bank of the Arpa River near the village of Danzik, outcrop 19, Beds 29, 32, and 32a (17 specimens); southern slope of Velidag Mountain, outcrop 49, Beds 2, 4, 5, and 6a; outcrop 50, Bed 2 (11 specimens); Saradag Mountain, outcrop 1219a (one specimen).

Family Eodevonariidae Sokolskaja, 1960

Genus *Devonaria* Biernat, 1966

Eodevonaria (*Devonaria*): Biernat, 1966, p. 77.

Plicodevonaria: Boucot and Harper, 1968, p. 162.

Devonaria: Afanasjeva, 1978, p. 68; Racheboeuf, 1981, p. 103; 2000, p. 387.

Type species. *Chonetes zeuschneri* Sobolev, 1909; Middle Devonian, Givetian (Scaly beds); Poland, Świętokrzyskie Mountains.

Diagnosis. Shell small, semicircular in outline, and moderately concavo-convex. Median sulcus and fold absent. Ventral area apsacline; dorsal area catacline. Posterior margin of both valves denticulate. Pseudodeltidium and chilidium developed. Hinge spines positioned at low angle to posterior margin. External ornamentation composed of infrequently bifurcating and intercalating costellae covered with

Explanation of Plate 18

Figs. 1–8. *Dagnachonetes caucasius* Afanasjeva, 1978: (1) holotype PIN, no. 3744/41, ventral valve exterior, ×1.5; southern slope of Dagna Mountain, outcrop 68, Bed 45; (2) specimen PIN, no. 3744/99, dorsal valve exterior, ×2; vicinity of the village of Yeraskh, outcrop 47, Bed 28; (3) specimen PIN, no. 3744/34, conjoined shell, ×3: (3a) lateral view; (3b) area; (4) specimen PIN, no. 3744/1, ventral valve: (4a) posterior margin, ×3; (4b) microornamentation, ×5; vicinity of the village of Yeraskh, outcrop 1182a; (5) specimen PIN, no. 3744/46, inner mold of the ventral valve, ×1.5; vicinity of the village of Yeraskh, outcrop 47, Bed 18; (6) specimen PIN, no. 3744/77, interior of partly broken ventral valve, ×2; vicinity of the village of Yeraskh, outcrop 47, Bed 15; (7) specimen PIN, no. 3477/31, dorsal valve interior, ×1.5; (8) specimen PIN, no. 3744/32, dorsal valve: (8a) inner surface, ×1.5; (8b) cardinal process, ×5; vicinity of the village of Yeraskh, outcrop 1182a; Middle Devonian, Middle Eifelian, *Dagnachonetes caucasius–Alatiformia araxica* Zone.

Fig. 9. *Corbicularia dzhaanamensis* Afanasjeva, 1978, holotype PIN, no. 3744/106, conjoined shell: (9a) ventral valve view, ×5; (9b) dorsal valve view, ×5; (9c) lateral view, ×5; (9d) area, ×10; (9e) microornamentation, ×10; lower reaches of the Dzhaanam-Deresi River, outcrop 62, Bed 1; Upper Devonian, Lower Frasnian, *Adolfia zickzack* Zone.

Figs. 10–12. *Devonaria obtusa* Afanasjeva, 1978: (10) holotype PIN, no. 3744/117, ventral valve exterior, ×2; (11) specimen PIN, no. 3744/ 128, conjoined shell: (11a) dorsal valve view, ×3; (11b) lateral view, ×3; (11c) area, ×5; (12) specimen PIN, no. 3744/124, ventral valve, microornamentation, ×10; Armenia, western slope of Adzhakyan Mountain, outcrop 64, Bed 11; Middle Devonian, Lower Givetian, *Stringocephalus burtini* Zone.

concentric scars. In ventral valve, median septum low, narrow, and reaching valve midlength. Teeth shaped as small rounded nodes. In dorsal valve, cardinal process quadrifid on outer side and pineal on inner side; alveolus absent. Sockets shallow; socket ridges inclined to posterior margin. Dorsal median septum reaching valve midlength. Lateral septa very short. Brachial ridges absent. On both sides of median septum, 1–3 pairs of diverging or laterally curving ridges sometimes occurring. Anterolateral inner surfaces of both valves with relatively large rounded tubercles, which sometimes arranged in radial rows.

Species composition. Six species; Middle Devonian; Świętokrzyskie Mountains of Poland, Transcaucasia, the Armorican and Rhenish massifs of Germany. Transcaucasia, lower part of the Givetian, *Stringocephalus burtini* Zone: *D. obtusa* Afanasjeva, 1978.

Comparison. This genus is most similar in general appearance to *Eodevonaria* Breger, 1906 and differs primarily in the coarser external radial ornamentation (ornamentation of *Eodevonaria* consists of thin, frequently branching capillae). In addition, it differs in the shell interior: *Devonaria* has shorter lateral septa and longer paired ridges flanking the dorsal median septum.

Remarks. Racheboeuf (2000) referred *Devonaria* to the family Anopliidae. However, this genus has a well-developed median septum on the inner surface of the dorsal valve and, thus, cannot be assigned to Anopliidae, as this family is characterized by the absence or very poor development of the dorsal septum (Muir-Wood, 1962). *Devonaria* is related to the family Eodevonariidae Sokolskaja, 1960 based on the denticulate posterior margins of both valves.

Devonaria obtusa Afanasjeva, 1978

Plate 18, figs. 10–12

Devonaria obtusa: Afanasjeva, 1978, p. 69, pl. 8, figs. 10–12.

Holotype. PIN, no. 3744/117, ventral valve; Armenia, western slope of Adzhakyan Mountain, outcrop 64, Bed 11; Middle Devonian, Lower Givetian, *Stringocephalus burtini* Zone.

Description. The shell maximum width (11–12 mm) is at its midlength; it is 1.1–1.3 times greater than the maximum length. The posterior margin is shorter than the shell maximum width by 2–3 mm. The ears are minute, poorly defined, and obtuse. The umbo is flattened, with an obtuse beak, and does not protrude beyond the posterior margin. The posterior margin bears bases of 4–5 hinge spines on each side of the umbo. The ventral area is 1.2 mm high under the umbo, elongated triangular, and somewhat concave. The umbonal margin of the area is stepped; its lateral margins may be cut. The apical angle of the delthyrium is 65°. The pseudodeltidium is relatively massive, triangular, and covers the delthyrium up to the middle of its height. The dorsal area is 0.7 mm high under the umbo and elongated triangular. The apical angle of the notothyrium is 90°. The chilidium envelops the base of the cardinal process. The maximum convexity of the ventral valve and the maximum concavity of the dorsal valve are in their midlength. The posterolateral regions of both valves are somewhat flattened. The costellae are clearly defined, rounded in cross section, and twice as wide as the interspaces, numbering about 50 on each valve. The costellae widen somewhat anteriorly from the umbo, numbering 2–2.5 costellae per 1 mm. In the ventral valve, the median septum is uniformly high and wide along its whole length. In the dorsal valve, the cardinal process is relatively high. The median septum somewhat lowers anteriorly. The lateral septa are up to 1 mm long and inclined at about 20° to the median septum.

Comparison. This species is somewhat similar to *Devonaria* sp. (Racheboeuf, 1981, p. 103, pl. 35, figs. 7–9) from the Middle Devonian, Eifelian (Formation de Quélern) of the Armorican Massif in shell outline and differs in the considerably greater number of costellae (*D.* sp. has up to 22 costellae on each valve).

Occurrence. Middle Devonian, Givetian, *Stringocephalus burtini* Zone; Transcaucasia.

Material. Twenty-two specimens (two broken conjoined shells, 18 moderately preserved ventral valves, two broken dorsal valves) from Armenia, western slope of Adzhakyan Mountain, outcrop 64, Bed 11.

Superfamily Anoplioidea Muir-Wood, 1962

Family Anopliidae Muir-Wood, 1962

Subfamily Tornquistiinae Afanasjeva, 1984

Genus *Corbicularia* Ljaschenko, 1973

Corbicularia: Ljaschenko, 1973, p. 29; Afanasjeva, 1978, p. 64; Racheboeuf, 2000, p. 385.

Type species. *Chonetes menneri* Ljaschenko, 1973; Upper Devonian, Frasnian; East European Platform.

Diagnosis. Shell small, triangular, and moderately concavo-convex. Median sulcus and fold absent. Ventral area orthocline; dorsal area hypercline. Pseudodeltidium and chilidium developed. Hinge spines positioned at high angle to posterior margin. External ornamentation composed of radial, rarely bifurcating and intercalating capillae and fine concentric scars. In ventral valve, teeth oval and extending along posterior margin. Median septum reaching valve midlength. In dorsal valve, cardinal process trifid on outer side and bifid on inner side, with alveolus at base. Sockets extending along posterior margin; socket ridges almost parallel to posterior margin. Median septum and brachial ridges absent. Anterolateral regions of inner surfaces of both valves, except for posterolateral regions, having relatively large rounded tubercles.

Species composition. Type species; Transcaucasia, *Adolfia zickzack* Zone: *C. dzhaanamensis* Afanasjeva, 1978.

Comparison. *Corbicularia* is most similar to *Subglobosochonetes* Afanasjeva, 1976 from the Lower Carboniferous of the Russian Platform in shell shape and outline and pattern of external radial ornamentation and differs in the ornamentation composed of concentric scars and the absence of lateral septa in the dorsal valve.

Remarks. The author of the genus assigned it to the family Chonetidae Bronn, 1862 (Ljaschenko, 1973). Later, I assigned *Corbicularia* to the family Anopliidae Muir-Wood, 1962 based on the absence of median septum in the dorsal valve (Afanasjeva, 1978). Now, I refer *Corbicularia* to the anopliid subfamily Tornquistiinae Afanasjeva, 1983, which unites anopliid genera with tubercles on the inner surface of the dorsal valve arranged in radial rows to form poorly pronounced crests rather than ridges, as in the other subfamily Anopliinae Muir-Wood, 1962. Archbold (1980) and Racheboeuf (2000) placed this genus in the subfamily Caenanopliinae Archbold, 1980, which unites anopliid genera with external radial ornamentation and varying in the shell interior, which I consider unacceptable, as the chonetids are highly homeomorphic (Afanasjeva, 1988).

***Corbicularia dzhaanamensis* Afanasjeva, 1978**

Plate 18, fig. 9

Corbicularia dzhaanamensis: Afanasjeva, 1978, p. 65, pl. 8, fig. 1.

Holotype. PIN, no. 3744/106, conjoined shell; Nakhchivan AR, left bank of the Dzhaanam-Deresi River, lower reaches, outcrop 62, Bed 1; Upper Devonian, Lower Frasnian, *Adolfia zickzack* Zone.

Description. The shell maximum width (5 mm) is at the posterior margin or somewhat anterior to it; it is 1.2 times greater than the shell length. The ears are poorly defined, rectangular or obtuse. The umbo is small, moderately convex, and somewhat protruding beyond the posterior margin. The posterior margin bears 2–3 hinge spines on each side of the umbo. The ventral area is about 0.3 mm high under the umbo and elongated triangular; its surface is somewhat concave. The umbonal margin of the area is stepped; the lateral margins may be cut. The apical angle of the delthyrium is 100°. The pseudodeltidium is convex, triangular, and covers the delthyrium up to the middle of its height. The dorsal area is almost linear, with a very slightly concave surface, and about 0.15 mm high under the umbo. The apical angle of the notothyrium is 120°. The chilidium envelops the base of the cardinal process. The maximum convexity of the ventral valve and the maximum concavity of the dorsal valve are in the posterior half of the shell length. The posterolateral regions of both valves are flattened. External radial capillae are vague, rounded in cross section, rarely bifurcating and intercalating, and approximately two times as wide as the interspaces, numbering 25–30 capillae on each valve and 3 capillae per 5 mm of the anterior margin. In the ventral valve, the median septum is narrow and low along its whole length. In the dorsal valve, the cardinal process is relatively high. The largest tubercles in the middle of the valve are fused to form two pairs of low diverging radial ridges.

Comparison. This species closely resembles *C. menneri* Ljaschenko, 1973 from the Frasnian of the Russian Platform in general appearance and differs in the erecter ventral umbo and fewer and wider capillae. In *C. menneri*, each valve has 40 capillae, numbering 5–7 capillae per 1 mm of the anterior margin.

Occurrence. Upper Devonian, lower part of the Frasnian, *Adolfia zickzack* Zone; Transcaucasia.

Material. Twenty specimens (six moderately preserved conjoined shells, 12 ventral and two dorsal broken valves) from the Nakhchivan AR: left bank of the Dzhaanam-Deresi River, lower reaches, outcrop 62, Bed 1; right bank of the Arpa River upstream from the village of Danzik, outcrop 43, Bed 2.

(to be continued in the *Paleontological Journal,* 2018, vol. 52, no. 9).

Translated by A. Madison

SPELL: 1. ok