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Permian Gastropods from the Kulogory Formation of the Northern Moscow Syneclise

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Abstract—Permian gastropods from the Kulogory Formation (Sakmarian) were studied based on the author's material and the collection of Yakowlew (Central Research Geological Prospecting Museum (TsNIGR Museum), St. Petersburg). Lectotypes for *Arribazona tschernyschewi* (Yakowlew, 1899) and *Microdoma kulogorae* (Yakowlew, 1899) were designated. Six species are described; four of them are new and two are assigned to the new genera (*Biarmeaspira verideclinata* gen. et sp. nov., *Globodoma yakowlewi* gen. et sp. nov., *Glabrocingulum (Glabrocingulum) stankovskyi* sp. nov., and *Euconospira? pinegensis* sp. nov.). The high degree of polymorphism in the dominant species of uniform assemblages is probably the result of their development in "undersaturated" paleocommunities of closed lagoons with gradually increasing concentration of sulfate ions.

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INTRODUCTION

The taxonomic composition and stratigraphic range of the Permian gastropods of the northern Moscow Syneclise are known only from two papers (Yakowlew, 1899; Licharew, 1913). The fauna from the Kulogory Formation was described by Yakowlew based on a few specimens that he had received from F.N. Tschernyschew. In 1969, Kashik et al., (p. 399) in the paper on the stratigraphy of the Lower Permian of the northern Russian Platform pointed out that the assemblage of brachiopods, bivalves, and gastropods of the Kulogory Formation was described in the monograph of Nel'zina in 1965–1967. In the same paper, five gastropod species lacking descriptions and illustrations were listed. The same list, with illustrations, was published again in 1978 (Kalmykova et al., 1978). The type species from the Nel'zina collection (TsNIGR Museum, coll. no. 10344) are represented by molds. The study of gastropods from molds is undoubtedly a step backwards when compared with Yakowlew's study, where all descriptions and figures were based on the shell imprints. Therefore, it is not surprising that such species as *Wortheniopsis grandicarinata* Yakowlew and *Naticopsis tshernyschewi* Yakowlew were included in the list. The definitions of these species and that of *Tretospira* sp. I consider to be erroneous. The list of species from this formation that was published in the second volume of *Geology of the USSR* (Sidorenko, 1963, p. 470) contains even more mistakes.

This paper is devoted to the study of the taxonomic diversity of gastropods of the Kulogory Formation and their stratigraphic and geographic ranges. The material used for the study was collected by the author in July, 2002. The fauna collected from the Kulogory Formation is unique for this region and contributes to the detailed studies of one of the developmental periods of the Early Permian paleobasin in the northern wing of the Moscow Syneclise. The collection consists of 350 gastropod imprints (Paleontological Institute, Russian Academy of Sciences, coll. no. 4919). The imprints were studied by using latex casts, the quality of which sometimes made it possible to study the structure of the protoconchs. In the preparation of this paper, the collection of Yakowlew (TsNIGR Museum, coll. no. 325) was studied and lectotypes for some species were designated. The collections of Permian gastropods of the Geological Museum of the Kazan State University, including the Netchaev collection, were also studied.

THE STRATIGRAPHIC POSITION AND STRUCTURE OF THE KULOGORY FORMATION

The Kulogory Formation was distinguished by Bogachev in 1936. The sections under the village of Kulogory on the right bank of the Pinega River and on the eastern bank of the Kuloi Canal were selected for the stratotype. The formation is tentatively assigned to the Sakmarian, Sterlitamak Horizon (Kalmykova et al., 1978, p. 8).

The imprints of gastropod shells were collected from two stratigraphic levels in five localities nos. 4919/1, 4919/2, 4919/3, 4919/4, and 4919/5 on the right and left banks of the Pinega River (Fig. 1). In the sections studied, the Kulogory Formation consists of three transgressive and regressive cyclites, which are

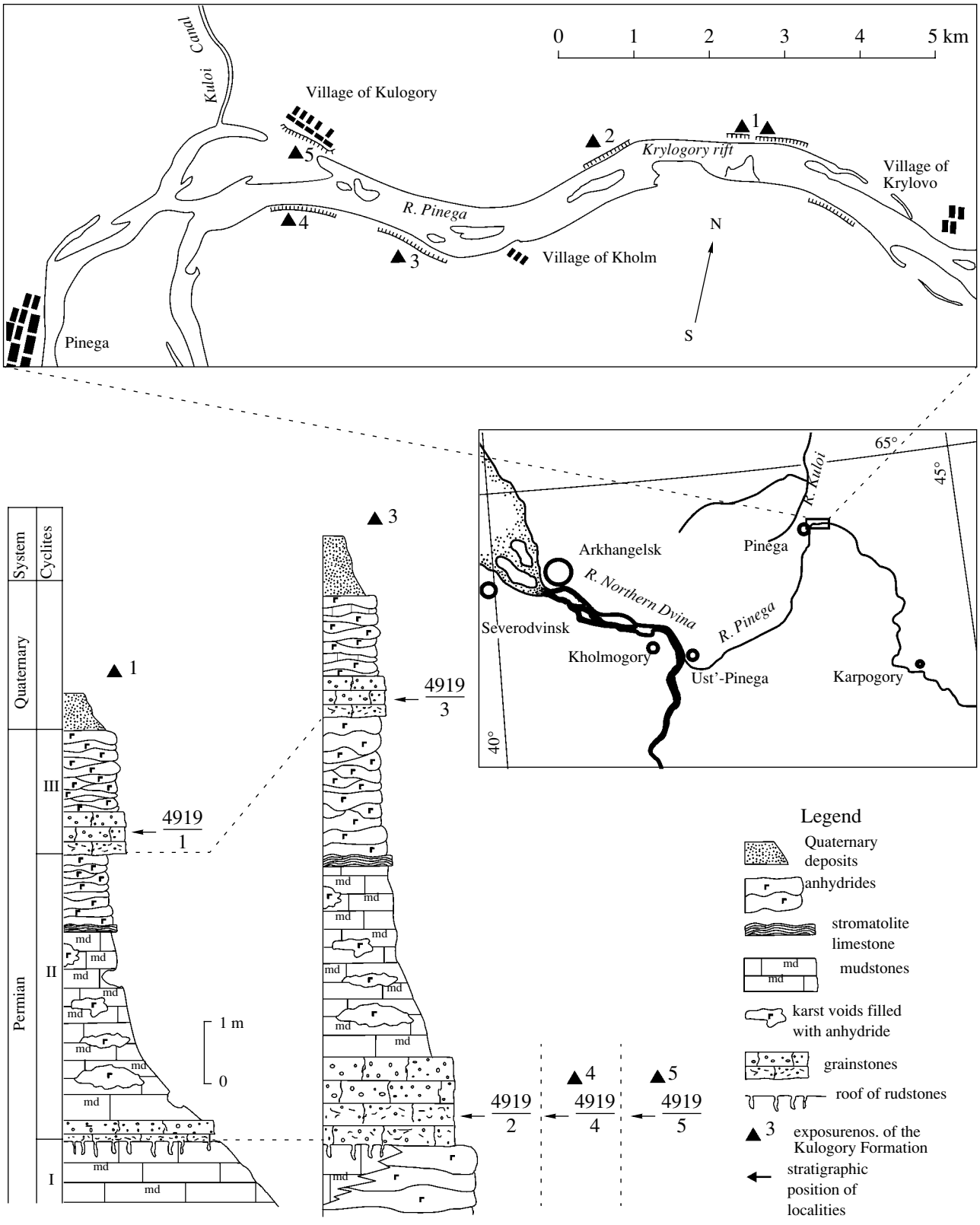


Fig. 1. Geographic and stratigraphic distribution of localities with gastropods in the Kulogory Formation.

probably similar in structure. Only the middle cyclite is completely represented. The first cyclite consists of regressive part that is composed of white barren mudstones with numerous caverns filled with anhydride. The roof of the mudstone member is topped by rudstone pierced with numerous long, thin rhyzolites. In the western part of exposures, the first cyclite is completely replaced with a thick anhydride member. In Exposure 5, its maximum apparent thickness is about 8 m. The base of the second cyclite is composed of the member of yellow grainstones. Their thickness increases considerably from east to west from 0.3 to 2 m. The grainstones are overlain by white barren mudstones with numerous karst voids filled with anhydride. The thickness of mudstones in Exposures 1, 2, 3, and 4 varies insignificantly. In all sections, the mudstones are overlain by 0.1–0.2 m thick stromatolite limestone. The top of the cyclite consists of a thick anhydride member. The third cyclite is incomplete; its upper part in the eastern part of Exposure 1 is truncated by red deposits of the Vikhtovo Formation and by Quaternary deposits in other exposures. In Exposure 5, the third cyclite is absent. The base of the third cyclite is composed of approximately 0.6-m-thick yellow grainstones, which are overlain by barren mudstones. The latter are highly karstified and often completely replaced with anhydrides.

ANALYSIS OF THE GASTROPOD ASSEMBLAGES OF THE KULOGORY FORMATION

All fossils of the Kulogory Formation came from two horizons of grainstones of the second and third cyclites. The faunistic assemblages of all fossil groups collected, including gastropods from these two stratigraphic levels, are sharply different in their diversity. The maximum diversity is in the grainstones of the second cyclite, where the increasing diversity of fossils correlates with the increasing thickness of grainstones from east to west and reaches its maximum in Exposures 4 and 5. *Arribazona tschernyschewi* (Yakowlew, 1899) and *Microdoma kulogorae* (Yakowlew, 1899) dominate among gastropods. Together with small bivalves, these two species form thin coquina layers, in which patchy accumulations of straight nautiloids occur sporadically. *Biarmeaspira verideclinata* gen. et sp. nov. occurs frequently but does not form vast accumulations. In Exposures 4 and 5, the sporadically distributed *Glabrocingulum (Glabrocingulum) stankovskyi* sp. nov., *Globodoma yakowlewi* sp. nov., and rare *Euconospira? pinegensis* sp. nov. occur. Various bryozoans, one brachiopod species (*Dielasma* sp.), and no less than two species of convolute nautiloids have also been encountered at this level.

In the grainstones of the third cyclite, the diversity sharply decreases. The fossils are represented by small bivalve or gastropod shells forming vast accumulations as thin coquina layers. Of other fossils, straight nautiloids occur sporadically in Exposure 1. *Arribazona tschernyschewi* (Yakowlew, 1899) and *Microdoma kulogorae* (Yakowlew, 1899) are absent in this level and, thus, *Biarmeaspira verideclinata* sp. nov. dominates. *Euconospira? pinegensis* is represented by a single specimen in the collection.

One of the characteristic features of the paleocommunity of the Kulogory Formation is the high degree of polymorphism in dominant species. The shells of *Biarmeaspira verideclinata* gen. et sp. nov. from Locality no. 4919/1 show an extreme degree of polymorphism. The following features combine freely: spiral angle, whorl profile, number and intensity of elements of the spiral ornamentation, and intensity of the growth lines. Each of the features varies widely. Arbitrary combinations of all variations of each feature resulted in paleopopulation in which similar shells are practically absent. Another specific feature of the paleocommunities of the Kulogory Formation is their obvious "undersaturation." Again, the "undersaturation" is expressed in the low numbers of taxa in the gastropod assemblage, absence of representatives of Bellerophontoidea and *Goniasma*, which are typical of the Permian, and representatives of other widely distributed groups.

In this basin, the penetration and the ensuing short-time development of the benthic and pelagic marine forms is stratigraphically restricted to the transgressive phase of cyclites. The subsequent impoverishment of the species composition and high degree of polymorphism of the dominant species are evidence of rapid isolation of these paleocommunities in the semi- or, more likely, completely closed paleobasins with the ion composition of the water displaced in the direction of increased concentrations of sulfate ions. The gradual increase in the concentration of sulfate ions is verified by the subsequent accumulation of barren (possibly lagoon) mudstones that are overlain by stromatolite limestones of extremely uniform thickness and then by anhydrides. The increasing concentration of sulfate ions led to the relatively quick death of the paleocommunities. Since data on Sakmarian gastropods from other regions of the eastern European Platform are absent, it is an open question whether or not the species described in this paper are endemic. It is only safe to say that there are no species common to the gastropod assemblage described and other known Permian assemblages.

SYSTEMATIC PALEONTOLOGY

Order Pleurotomariiformes Cox et Knight, 1960.

Suborder Pleurotomarioidei Cox et Knight, 1960

Family ?Raphistomatidae Koken, 1896

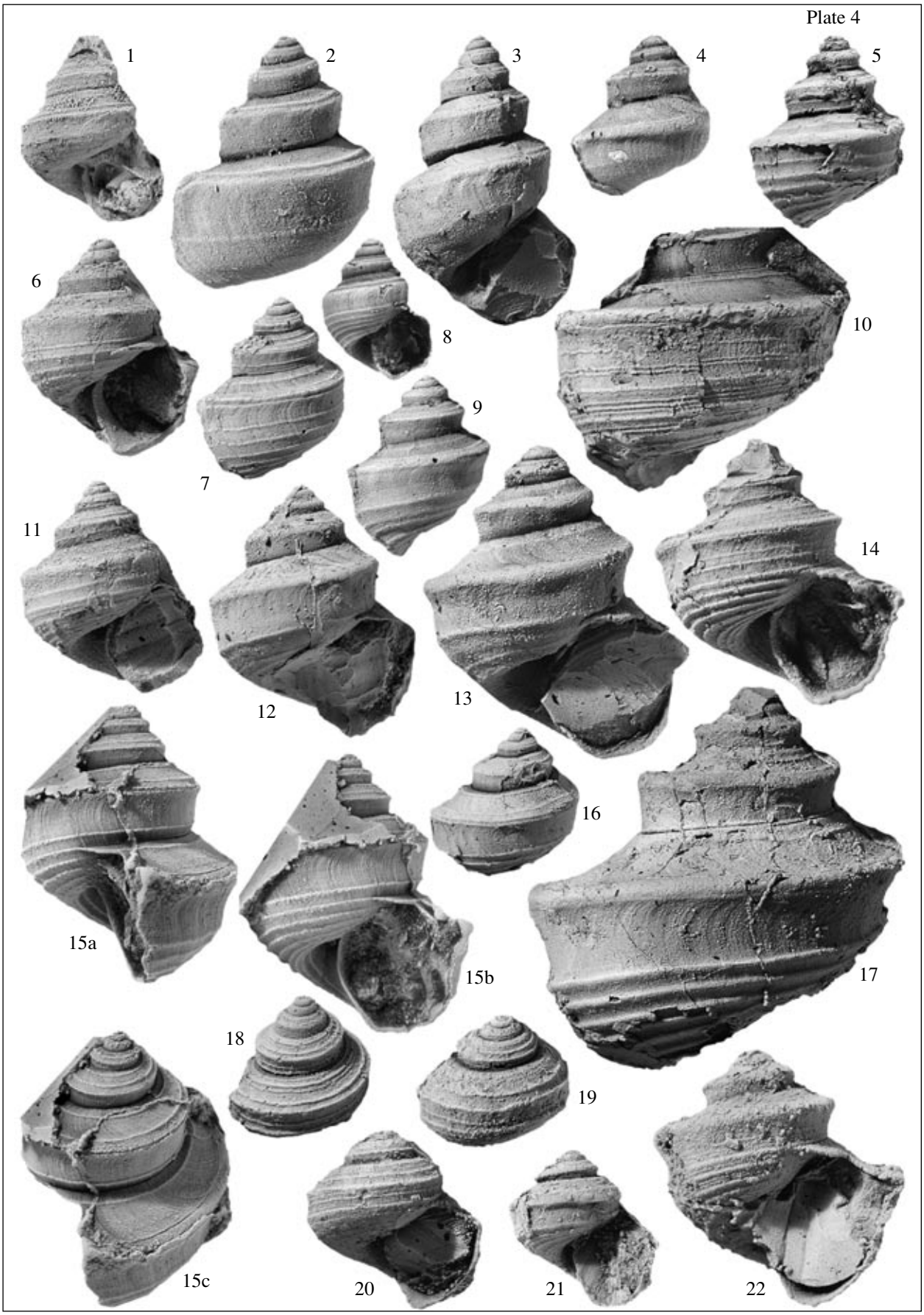
Genus *Biarmeaspira* Mazaev, gen. nov.

Etymology. From the Biarmia tribes and Latin *spira* (volute).

Type species. *Biarmeaspira verideclinata* sp. nov.

Diagnosis. Shell trochiform. Subsutural ramp separated from the lateral surface by a distinct keel shoulder with narrow selenizone. Lateral surface subvertical and separated from the basal surface by well

Plate 4



pronounced angulation. Suture located in the lower part of the lateral surface. Ornamentation consists of spiral ribs. On the early whorls, selenizone bordered by two spiral ribs. Shoulder keel marked by lower rib. Selenizone concave. On late whorls, upper part of selenizone remains on subsutural ramp and lower part of selenizone moves to lateral surface. Selenizone becomes convex. Spiral ribs bordering selenizone hold their thickness or become thinner. Selenizone smooth or covered by marked, sometimes cord-like lunulae.

Species composition. Besides the type species, *Turbo angulatus* Netchaev, 1894 (Netchaev, 1894, p. 348) from the Kazanian of the Volga–Kama region of Russia and *Worthenia multilineata* Batten, 1989 from the Wolfcampian and Guadalupian stages of the southwestern United States should be assigned to the genus. The last two species show close resemblance.

Comparison and remarks. This genus resembles *Baylea* Koninck, 1883 and *Manzanospira* Batten, 1989 in the specific structure of protoconch (discoid, larger than the teleoconch, and consists of no less than two whorls), whorl profile, and location and structure of the selenizone. The new genus differs in the location and profile of selenizone on the late whorls. Thus, *Baylea* is the probable ancestor of *Biarmeaspira*. Some abnormal specimens of *Biarmeaspira verideclinata* sp. nov. possess features characteristic of other genera, thus showing their genetic closeness. Some of them on the last whorl have the selenizone resembling the selenizone of *Worthenia*, others lack lateral keel and their profile resembles the profile of some *Manzanospira* species. In some specimens, the selenizone keeps the profile and the position near the edge of the subsutural ramp, a characteristic feature of *Baylea*. The new genus differs from *Worthenia* Koninck, 1883 in the structure and position of the selenizone on the early whorls.

***Biarmeaspira verideclinata* Mazaev, sp. nov.**

Plate 4, figs. 1–22

Wortheniopsis sp.: Yakowlew, 1899, p. 129; non *Wortheniopsis grandicarinata* Yakowlew, 1899; Nel'zina, 1978 (in Kalmykova et al., 1978), p. 22, pl. 1, figs. 26, 32.

Etymology. From the Latin *verus* (real) and *declinatus* (deviated).

Holotype. PIN, no. 4919/1-7, shell imprint; Russia, Arkhangelsk region, right bank of the Pinega River across the Krylogory rift, grainstone of the third cyclite; Lower Permian, Sakmarian, Kulogory Formation.

Description (Fig. 2). The shell is trochiform, medium-sized, with height equal to or slightly exceeding the maximum diameter, and with seven sharply angular whorls bearing variously developed shoulder, lateral and basal keels. Each whorl joins the preceding whorl in the lower part of the lateral surface. The suture is prominent, small and thin. The protoconch is large (up to 1.5 mm in diameter) and formed of approximately three smooth and rounded whorls. The first whorl and the first half of the second whorl of the protoconch are at the same level, the next whorl joins the preceding whorl noticeably below its periphery. The first whorl of teleoconch is slightly angular and ornamented with two spiral ribs bordering the selenizone. The next whorls have a sharp shoulder keel dividing the whorl surface into a subsutural ramp and lateral part. The subsutural ramp is wide, slightly convex, inclined to the horizontal line at an angle of 30°–45°, and ornamented with three spiral ribs with equal interspaces. The upper (subsutural) rib is located from the suture at the distance equal to the selenizone width. The lower rib coincides with the margin of the subsutural ramp and forms a keel. On the last two whorls, the profile of the subsutural ramp is almost straight or slightly concave between the selenizone and subsutural rib, and slightly convex near the suture. A weakly pronounced subsutural fold may be developed. The space between the upper rib of selenizone and subsutural rib increases gradually to become on the last whorl more than three times as wide as the selenizone. The space between the subsutural rib and suture remains equal to the selenizone width. With the shell growth, the selenizone width

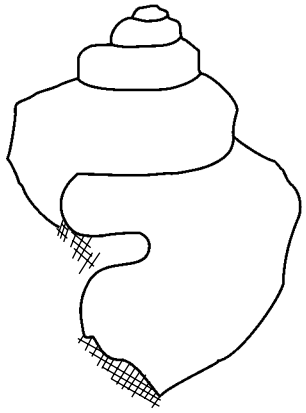


Fig. 2. The pleural slit in *Biarmeaspira verideclinata* gen. et sp. nov., the ratio of the slit depth to its width is clearly seen; specimen PIN, no. 4919/1-63; Arkhangelsk region, Pinega River, locality no. 4919/1; Sakmarian, grainstones of the third cyclite of the Kulogory Formation.

Explanation of Plate 4

Figs. 1–22. *Biarmeaspira verideclinata* sp. nov., ×4: (1) specimen PIN, no. 4919/4-7; (2) specimen PIN, no. 4919/1-25; (3) specimen PIN, no. 4919/1-11; (4) specimen PIN, no. 4919/1-26; (5) specimen PIN, no. 4919/1-86; (6) specimen PIN, no. 4919/1-68; (7) specimen PIN, no. 4919/1-32; (8) specimen PIN, no. 4919/1-124; (9) specimen PIN, no. 4919/1-92; (10) specimen PIN, no. 4919/1-152; (11) specimen PIN, no. 4919/1-76; (12) specimen PIN, no. 4919/1-2; (13) specimen PIN, no. 4919/1-60; (14) specimen PIN, no. 4919/1-4; (15) holotype PIN, no. 4919/1-7: (15a) lateral view; (15b) apertural view; (15c) oblique view from above; (16) specimen PIN, no. 4919/1-41; (17) specimen PIN, no. 4919/1-151; (18) specimen PIN, no. 4919/4-21; (19) specimen PIN, no. 4919/5-3; (20) specimen PIN, no. 4919/2-96; (21) specimen PIN, no. 4919/1-143; (22) specimen PIN, no. 4919/1-5; Arkhangelsk region, Pinega River, locality no. 4919/1; Sakmarian, grainstones of the third cyclite of the Kulogory Formation.

changes insignificantly, the upper rib of selenizone is always placed on the subsutural ramp, the lower rib of selenizone moves gradually from the periphery of the subsutural ramp to the lateral surface. Thus, the selenizone profile changes from concave to convex. In the lower part of the selenizone, an additional spiral thread may be formed. In the moving of the lower part of the selenizone to the lateral surface, this thread marks the shoulder keel on the last whorls. The lateral surface is almost vertical, or its lower part approaches the shell axis. The lateral surface profile is almost straight on the early whorls and concave on the last whorls. The lateral surface is smooth or bears one spiral rib one-third of the whorl lateral side away from the suture. The basal surface is slightly convex, ornamented with eight to ten spiral ribs with equal interspaces. The latter are approximately equal to the selenizone width. The upper rib may mark the weakly developed lateral keel that separates the lateral and basal surfaces. One more poorly pronounced keel may be developed between the sixth and eight ribs on the basal surface near the umbilicus. The umbilicus is deep, narrow, and passes through all the whorls. The aperture is rounded, but angular in the locations of keels. The aperture edges are thin. The slit depth is twice as much as its width; slit edges are parallel in the initial part and sharply diverging closer to the aperture. The growth lines are thin, well pronounced, sometimes sharp; smoothly curved and directed posteriorly from the suture; forming thin poorly pronounced or sharp lunulae in the selenizone; directed anteriorly under the selenizone; smoothly curved posteriorly in the middle of the lateral surface and below.

Measurements in mm and ratios:

Specimen PIN, no.	Maximum diameter	Shell height
4919/4-7	6.7	8.5
4919/1-25	10.0	12.1
4919/1-11	8.0	13.0
4919/1-26	6.3	7.8
4919/1-32	6.7	8.1
4919/1-68	7.7	9.5
4919/1-86	6.7	8.5
4919/1-124	5.2	6.4
4919/1-76	8.0	10.0
4919/1-7	≈11.0	12.5
4919/1-2	8.8	11.0
4919/1-92	7.0	8.6
4919/1-60	11.0	13.8
4919/1-41	6.1	7.0
4919/1-4	13.2	14.5
4919/1-3	6.3	6.0
4919/1-5	11.2	11.5
4919/1-96	7.5	8.5
4919/1-143	7.0	6.7
4919/1-151	17.0	17.0

Variability. The species is highly variable. The variations of the following features are freely combined: spiral angle, whorl profile, number of elements and intensity of spiral ornamentation, and intensity of growth lines. The spiral angle varies from 50° to 95° (Pl. 4, figs. 1, 3, 22). The whorl profile changes with the development of shoulder, lateral and basal keels. Each keel grows independently. Rare forms lack any of the keels (Pl. 4, figs. 19, 20). The shoulder keel is well developed in the majority of specimens; sometimes it is hypertrophied (Pl. 4, figs. 13, 14, 17, 21, 22). The basal keel is well developed in about half of the specimens studied (Pl. 4, figs. 3, 8, 9, 13, 21). The lateral keel occurs in a few specimens (Pl. 4, figs. 17, 18). The shells lacking the lateral keel but with a well developed basal keel have a specific profile, with steeply inclined and bowed down lateral and basal parts of the whorl (Pl. 4, figs. 3, 4, 5, 8, 9). Variability of ornamentation is connected with the development of additional spiral ribs or, rarely, with the intensification or partial or complete disappearance of the main spiral ribs. In specimens with poorly developed ornamentation, the ribs bordering the selenizone are always better pronounced than the other ribs. The ornamentation may develop independently in different parts of the whorl (subsutural ramp, lateral and basal surfaces). The most typical ornamentation consists of the following spiral ribs: one subsutural rib, two ribs bordering the selenizone, one rib on the lateral surface of the whorl one-third of the surface width away from the suture, and about eight ribs on the basal surface of the whorl. This type can be considered to be basal. In the subsutural ramp, the variability of the ornamentation is expressed either in the disappearance of the subsutural rib (Pl. 4, figs. 2, 3, 12) or in the development of additional ribs between the suture and subsutural rib, between the subsutural rib and selenizone (Pl. 4, figs. 14, 18). On the lateral surface, the variability of the ornamentation is expressed in the disappearance of the elements of the spiral ornamentation (Pl. 4, figs. 1, 2, 3, 4, 8, 9, 12, 13, 16, 17) or in the development of an additional rib between the selenizone and the rib located within one-third of the surface width from the suture (Pl. 4, figs. 10, 14, 20). On the basal surface, the variability of the ornamentation is expressed in the reduction in the number of spiral ribs from 10 (Pl. 4, fig. 14) to 0 (Pl. 4, figs. 2, 3, 4). In a few specimens, the variability of the ornamentation is extreme: the spiral ribs are absent (Pl. 4, fig. 4) or thickened and are divided by equal interspaces (Pl. 4, fig. 5); thinner additional ribs arranged in pairs may appear in the lateral and basal surfaces (Pl. 4, figs. 10, 22). Besides the variability, the poorly pronounced ornamentation in some specimens may be also connected with the state of preservation because these shells were most likely buried as rounded subfossil material (Pl. 4, figs. 2, 3, 4, 9, 12, 13). The variability of the growth lines is expressed in their intensity. Usually they look like thin grooves (Pl. 4, figs. 9, 12), but in some specimens their depth and width increase, and the grooves

and the interspaces become sharply pronounced (Pl. 4, figs. 15a–15c). In a few specimens, the growth lines are cordlike and their interspaces increase (Pl. 4, fig. 10).

Comparison. The new species closely resembles *Biarmeaspira angulata* (Netchaev, 1894) but differs from the latter in the absent or weakly developed subsutural fold and in the number of main spiral ribs on the basal surface (8–10 while *B. angulata* has more than ten ribs).

Remarks. In the *Treatise*... (Knight et al., 1960) and subsequent papers, the structure and depth of the pleural slit were ranked as family characters at least. But in the fossil shells, the pleural slits usually are not preserved. In the collection studied, two specimens, nos. 4919/1-63 and 4919/1-94, possess similar slits and similar bordering parts of the aperture (Fig. 2).

Occurrence. Sakmarian, grainstones of the second and third cyclites of the Kulogory Formation.

Material. One hundred and sixty-seven specimens: 146 imprints from locality no. 4919/1; 8 imprints from locality no. 4919/2; 5 imprints from locality no. 4919/3; 5 imprints from locality no. 4919/4; 3 imprints from locality no. 4919/5.

Family ?Eotomariidae Wenz, 1938

Genus *Glabrocingulum* Thomas, 1940

Subgenus *Glabrocingulum* Thomas, 1940

***Glabrocingulum (Glabrocingulum) stankovskyi* Mazaev, sp. nov.**

Plate 5, figs. 1 and 2

Tretospira sp.: Nel'zina, 1978 (in Kalmykova et al., 1978), pl. 1, fig. 25.

Etymology. In honor of the geologist A.F. Stankovskii.

Holotype. PIN, no. 4919/5-27; shell imprint; Russia, Arkhangelsk region, eastern part of the section under the village of Kulogory, grainstone of the second cyclite; Lower Permian, Sakmarian, Kulogory Formation.

Description. The shell is trochiform, medium-sized, with height approximately one-quarter of the maximum diameter, and consisting of six or seven shoulder whorls. The protoconch is very small and indistinguishable in the specimens studied. The subsutural ramp of the last whorl is approximately half as much as the width of the lateral surface and inclined to the horizontal line at an angle of 45°–50°. The shoulder is well pronounced, almost sharp, and marked by a narrow selenizone that is bordered by two thin prominent spiral ribs. The selenizone is concave. The line that connects the apices of the ribs bordering the selenizone is inclined to the shell axis at an angle of 40°. The suture is canal-like, well pronounced, thin, shallow, and located slightly below or above the lower rib of the selenizone. On the first whorls, the profile of the subsutural ramp is straight or slightly convex. The subsutural fold is prominent and located on the last two or three whorls. Its width is about one-third of the subsutural ramp. The surface between the fold and the selenizone is evenly concave. The subsutural fold is covered with numerous spiral threads and tubercles that are presumably placed on the last two whorls. The surface between the sutural fold and the selenizone bears no less than six thin, sharp, and spiral ribs with equal interspaces. The width of the spiral threads is approximately twice as narrow as the spiral ribs bordering the selenizone. The lateral surface is slightly convex, almost vertical, and separated from the basal surface by rounded angulation. The basal surface is slightly convex. Both lateral and basal surfaces are ornamented with large spiral ribs. These ribs and interspaces are also ornamented with numerous hardly distinguishable spiral threads. The number of large ribs in the lateral surface varies from four to seven. The ribs are thin near the selenizone and widen and flatten downwards; the width of the interspaces changes with rib thickness. The basal surface bears approximately seven large ribs (better pronounced than on the lateral surface). Their width increases insignificantly downwards. The outer lip is not preserved, the basal and inner lips are massive, the inner lip is very short, flared to form the umbonal callus that completely closes the umbonal part of the shell. The growth lines are thin, thread-like; in the basal surface of the shell, some of them are more prominent and canal-like. The growth lines in the subsutural ramp are slightly curved anteriorly and directed from the suture backwards to the selenizone. The growth lines located below the selenizone are smoothly curved anteriorly.

Measurements in mm and ratios:

Specimen PIN, no.	Maximum diameter	Shell height
4919/2-114	13.0	12.0
4919/2-117	>11.0	>9.5

Variability. The variability is mainly expressed in the number and intensity of the tubercles. The number of tubercles on the last whorl may be as great as 20. In some specimens, the tubercles are elongated along the growth lines. The number of large spiral ribs on the lateral surface varies from four to seven depending on the appearance and disappearance of thinner ribs near the selenizone. The ribs are well or poorly pronounced.

Comparison. The new species closely resembles *G. (Glabrocingulum) ferganicum* Licharew, 1967 but differs from the latter in the smaller ratio of the lateral surface to the subsutural ramp, in the number of tubercles reduced by almost half near the suture, in the presence of subsutural fold and umbonal callus. From *G. (Glabrocingulum) coronatum* Cronic, 1952, it differs in the poorly developed angulation between the lateral and basal surfaces, the inclination of the lateral surface, flaring inner lip, and umbonal callus.

Occurrence. Sakmarian, grainstones of the second cyclite of the Kulogory Formation.

Material. Six specimens: five imprints from locality no. 4919/2; one imprint from locality no. 4919/5.

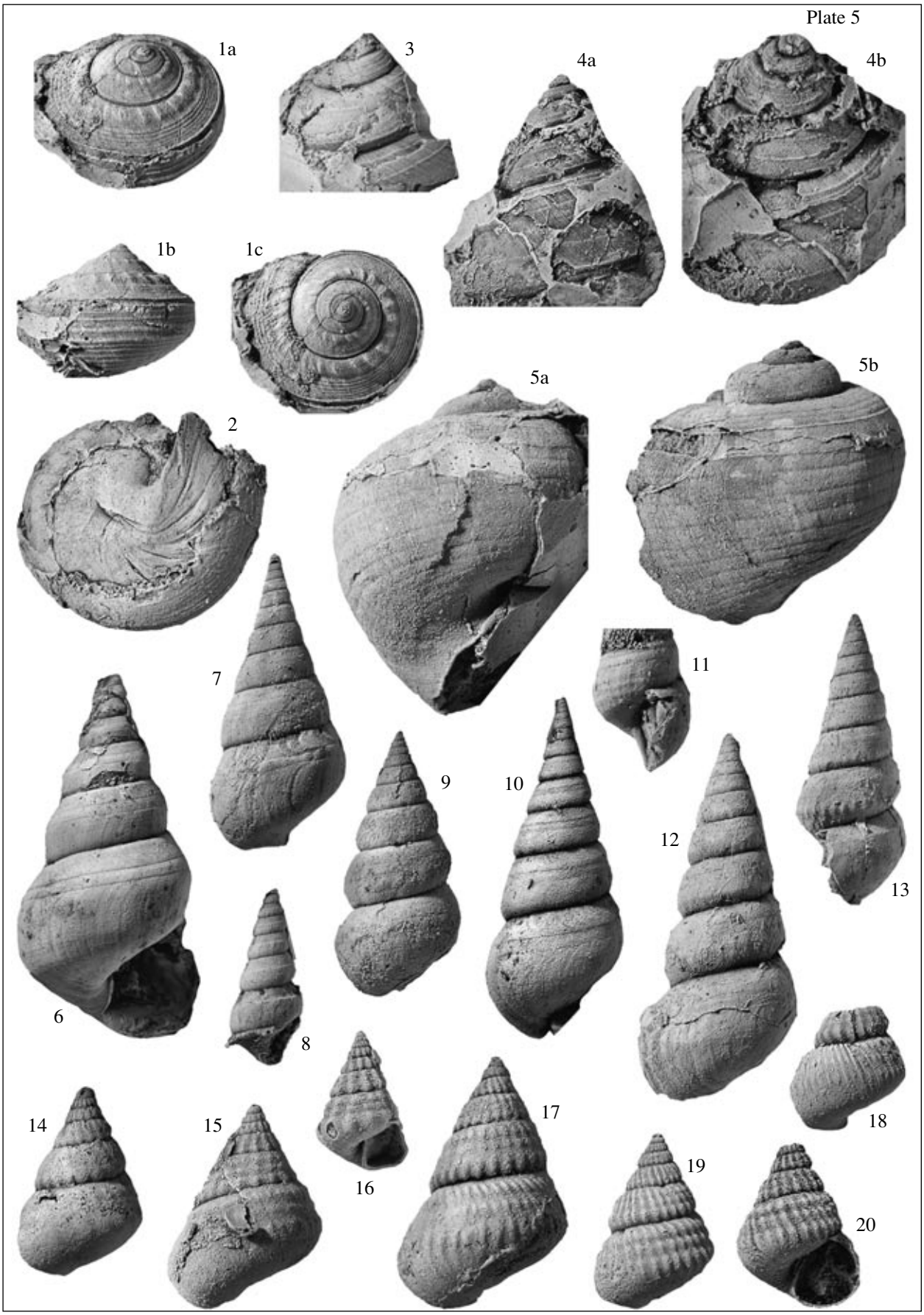


Plate 5
1a
3
4a
4b
1b
1c
5a
5b
2
7
11
9
10
12
13
6
8
14
15
16
17
18
19
20

Genus *Euconospira* Ulrich, in Ulrich et Scofield, 1897

***Euconospira? pinegensis* Mazaev, sp. nov.**

Plate 5, figs. 3, 4a, and 4b

Etymology. From the Pinega river.

Holotype. PIN, no. 4919/1-14, shell imprint; Russia, Arkhangelsk region, right bank of the Pinega River across the Krylogory rift, grainstone of the third cyclite; Lower Permian, Sakmarian, Kulogory Formation.

Description. The shell is trochiform and medium-sized. The teleoconch consists of six whorls that are probably sharply keeled. The keel is marked by the selenizone, which divides the whorl surfaces into lateral and basal parts. The selenizone is bordered by two spiral ribs. The selenizone surface is almost flat, parallel to the shell axis, and ornamented with well-pronounced lunulae. The suture is prominent, wide, and canal-like. The protoconch is not preserved. The first and second whorls of teleoconch are smooth and rounded. The lateral surface of the next whorls is almost straight in section, inclined to the shell axis at an angle of 30°–45°, and ornamented with five thin, spiral, and cord-like ribs. The lower rib of the lateral surface forms the keel and borders the upper part of selenizone. The lower rib of the selenizone is located either above or immediately under the suture. In the lateral surface, near the suture, the rounded angulation is developed as a narrow and weakly developed subsutural ramp. The upper spiral rib is located in the periphery of the angulation. All spiral ribs on the third and forth whorls are divided by almost equal interspaces. As the shell grows, the interspace between the upper two ribs remains practically the same. The interspaces between the suture and upper rib, between the second and third ribs, and the selenizone width change insignificantly. On the last whorl, the second rib moves upwards to the periphery of the subsutural ramp, and the upper rib moves closer to the suture; interspaces between the selenizone and forth rib and between the forth and fifth ribs increase significantly. The width of the former interspace is twice as much as the width of selenizone, and the width of the latter interspace is about three times as much as the selenizone width. The basal surface and the aperture are not preserved. The growth lines are thin, sharp, almost straight, and inclined posteriorly from the suture. The angle of inclination to the shell axis is about 35°–40°.

Measurements. The collected material consists of two fragmentary and deformed imprints. In the casts, the height and maximum diameter of the shell cannot be measured, but the height of the holotype was no less than 13 mm, and its maximum diameter was about 15 mm. The second cast is even more fragmentary.

Comparison. The new species differs from the other species of *Euconospira* in the thin, cord-like spiral ribs on the lateral surface above the selenizone and in the narrow rounded subsutural ramp.

Occurrence. Sakmarian, grainstones of the second and third cyclites of the Kulogory Formation.

Material. Holotype and one imprint from locality no. 4919/2.

Family Gosseletinidae Wenz, 1938

Genus *Globodoma* Mazaev, gen. nov.

Etymology. From the Latin *globosus* (rounded) and *domus* (house).

Type species. *Globodoma yakowlewi* sp. nov.

Diagnosis. Shell trochiform, medium-sized, consists of about five rapidly increasing, thin-walled, and evenly rounded in the profile whorls. Suture placed slightly above or below the whorl periphery. Selenizone wide and located above the whorl periphery. Selenizone surface smooth, almost straight or convex in profile; in species with spiral ornamentation, it may be concave and bordered by spiral ribs. Shell surface ornamented with variously developed spiral ribs or grooves; in some species, axial tubercles, folds, or, rarely, ribs present near the suture on the last whorl. Aperture rounded, the aperture edges thin, flaring inner lip forms tubular puncture-like umbilicus. Depth of the pleural slit equal or three times as much as the width of selenizone. Growth lines almost indistinguishable.

Explanation of Plate 5

Figs. 1 and 2. *Glabrocingulum (Glabrocingulum) stankovskyi* sp. nov., ×3.5: (1) holotype PIN, no. 4919/5-27: (1a) lateral view; (1b) apertural view; (1c) oblique view from above; (2) paratype PIN, no. 4919/2-114, bottom view; Arkhangelsk region, Pinega River, localities nos. 4919/2 and 4919/5; Sakmarian, grainstones of the second cyclite of the Kulogory Formation.

Figs. 3 and 4. *Euconospira? pinegensis* sp. nov., ×3.5: (3) specimen PIN, no. 4919/2-118; (4) holotype PIN, no. 4919/1-14; Arkhangelsk region, Pinega River, localities nos. 4919/1 and 4919/2; Sakmarian, grainstones of the second and third cyclites of the Kulogory Formation.

Fig. 5. *Globodoma yakowlewi* sp. nov., holotype PIN, no. 4919/4-6, ×3; Arkhangelsk region, Pinega River, locality no. 4919/4; Sakmarian, grainstones of the second cyclite of the Kulogory Formation.

Figs. 6–13. *Arribazona tschernyschewi* (Yakowlew, 1899), ×3: (6) specimen PIN, no. 4919/2-39; (7) specimen PIN, no. 4919/2-57; (8) specimen PIN, no. 4919/2-28; (9) specimen PIN, no. 4919/4-17; (10) specimen PIN, no. 4919/2-33; (11) specimen PIN, no. 4919/2-56; (12) specimen PIN, no. 4919/4-8; (13) specimen PIN, no. 4919/2-112; Arkhangelsk region, Pinega River, localities nos. 4919/2 and 4919/4; Sakmarian, grainstones of the second cyclite of the Kulogory Formation.

Figs. 14–20. *Microdoma kulogorae* (Yakowlew, 1899), ×3.5: (14) specimen PIN, no. 4919/5-13; (15) specimen PIN, no. 4919/2-76; (16) specimen PIN, no. 4919/2-79; (17) specimen PIN, no. 4919/2-65; (18) specimen PIN, no. 4919/4-31; (19) specimen PIN, no. 4919/5-25; (20) specimen PIN, no. 4919/5-19; Arkhangelsk region, Pinega River, localities nos. 4919/2, 4919/4, and 4919/5; Sakmarian, grainstones of the second cyclite of the Kulogory Formation.

Species composition. The species of the genus are sporadically distributed in the Middle–Upper Carboniferous and in the Permian of the Northern Hemisphere. Besides the type species, forms described as *Gosseletina spironema* (Meek et Worthen, 1866) (synonymy in Kues and Batten, 2001, p. 35), *Gosseletina permiana* Batten, 1989, and *Pleurotomaria divesouralica* Golovkinski, 1868 should be assigned to *Globodoma*. According to article 32.5.2.3 of the *International Code of Zoological Nomenclature*, the species name of the last taxon must be corrected and spelled without the hyphen: *Globodoma divesouralica* (Golovkinski, 1868).

Comparison. This genus differs from *Gosseletina* Fischer, 1885 in the ornamentation, thin inner lip forming a puncture-like umbilicus, and in the shell proportions. *Globodoma* has a more evolute last whorl, the ratio of the height of the aperture to the maximum diameter of the shell ranges from 1.23 to 1.25, while in the type species of *Gosseletina* this ratio is about 1.8.

***Globodoma yakowlewi* Mazaev, sp. nov.**

Plate 5, figs. 5a and 5b

Tretospira cf. *tumida* Meek et Worthen: Jakovlev, 1899, p. 55, pl. 5, fig. 10.

Naticopsis tschernyschewi Jakovlev: Nel'zina (in Kalmykova et al., 1978), p. 22, pl. 1, figs. 23, 24.

Etymology. In memory of the paleontologist N.N. Yakovlev.

Holotype. PIN, no. 4919/1-6, shell imprint; Russia, Arkhangelsk region, left bank of the Pinega River across the village of Kulogory, grainstone of the second cyclite; Lower Permian, Sakmarian, Kulogory Formation.

Description. The shell is medium-sized, globose, relatively thin, and consists of five rapidly growing whorls. The whorls are evenly rounded in section. The suture is well developed and canal-like. The selenizone is wide. If its surface is slightly concave or in a plane with the shell surface, the selenizone is bordered by thin spiral ribs. If it is situated slightly above the shell surface, the spiral ribs are absent. On the last whorl, the distance between the suture and the selenizone is almost three times as much as the selenizone width. The distance between the whorl periphery and the selenizone is approximately equal to the width of the latter. The selenizone surface is smooth or covered with very thin lunulae, flattened or convex in section. The ornamentation consists of spiral elements; axial ornamentation is absent or, rarely, developed as weak axial constrictions that follow the growth lines. The first whorls are smooth or covered with thin spiral grooves. Beginning with the third whorl, the spiral ornamentation is better pronounced and consists of evenly distributed thin grooves and wide spiral ribbons. Four or five spiral ribbons are developed between the suture and the selenizone. On the last whorl, two ribbons near the suture became considerably wider. Their width is comparable to that of the selenizone. The other two or three ribbons are about half as wide. The lateral and basal shell surfaces under the selenizone are covered with about 12 spiral ribbons of the same appearance. The upper ribbons are slightly narrower than the selenizone. The ribbons widen insignificantly downwards. In the cross section, the ribbons are flattened, slightly convex, and separated by distinct grooves. The growth lines are very thin; between the suture and the selenizone, they are slightly convex and inclined posteriorly at an angle up to 45°; in the selenizone, they form slightly developed lunulae; below the selenizone, they are smoothly convex and inclined anteriorly; at the distance approximately equal to the selenizone width, they smoothly curve posteriorly at a small angle. The aperture is rounded. The aperture edges are thin. The flaring inner lip forms thin puncture-like umbilicus. The ratio of the slit depth to its width ranges from 0.5 to 3. The edges of the slit are subparallel.

Measurements in mm and ratios:

Specimen PIN, no.	Shell height	Maximum diameter
4919/4-6 holotype	17.0	17.5
4919/4-3	11.0	10.5

Variability. The selenizone profile varies from flattened to evenly convex. The selenizone with flattened profile is in a plane with the shell surface or slightly below it and bordered by thin spiral ribs. The convex selenizone rises insignificantly above the shell surface; thin spiral ribs are absent.

Comparison. This species most closely resembles *G. divesouralica* (Golovkinski, 1868), differing in the smaller number of spiral ribs located above the selenizone and less convex profile of spiral ribs, which are shaped like wide ribbons.

Occurrence. Sakmarian, grainstone of the second cyclite of the Kulogory Formation.

Material. Seven imprints from the collection under study: three from locality no. 4919/2 and four from locality no. 4919/4; one imprint is a type specimen TsNIGR Museum, no. 123/325 (Yakowlew, 1899).

Suborder Murchisonioidei

Superfamily Murchisonioidea Koken, 1896

Family Orthonemidae Nützel et Bandel, 2000

Genus *Arribazona* Kues, 1990

***Arribazona tschernyschewi* (Yakowlew, 1899)**

Plate 5, figs. 6–13

Murchisonia (Glyphodeta?) tschernyschewi: Yakowlew, 1899, p. 39, pl. 5, fig. 1.

Murchisonia (Hormotoma?) tschernyschewi: non Licharew, 1967, p. 49, pl. 12, figs. 10–12; Nel'zina, 1978 (in Kalmykova et al., 1978), p. 22, pl. 1, figs. 29–31.

Arribazona tschernyschewi: Mazaev, 2003, p. 97.

Lectotype. TsNIGR Museum, no. 126/325, imprint; Arkhangelsk region, eastern part of the exposure under the village of Kulogory, grainstone of the

second cyclite; Lower Permian, Sakmarian, Kulogory Formation.

Description. The shell is turritelliform, medium-sized, up to 28 mm high, and consists of 12 to 14 gradually growing smooth whorls. The protoconch is unknown. The lateral surface of the first seven or eight whorls is almost straight and rounded near the upper and lower sutures. The lateral surface of the adult whorls is rounded and evenly transforms to the basal surface, which is slightly convex and bowed downward. As the shell grows, the ratio of whorl width to height increases approximately from 2.7 to 1.75. A few of the shells studied possess a weak keel on one or several whorls that coincides with the lower part of the selenizone. Some other shells have weekly developed angulation in the lower part of the lateral surface of one or three penultimate whorls. On the penultimate whorl, this angulation may be ornamented by collabrally elongated tubercles, up to 22 tubercles per whorl. The suture is pressed, moderately deep, and sometimes shallow. The selenizone is placed above the middle of the lateral surface of the whorl. The distance between the selenizone and the upper suture is half as much again the selenizone width. The selenizone is flattened or slightly convex, bordered by thin grooves, and is in a plane, or below, or slightly above the whorl surface. The aperture is trapezoidal; in the basal part, it is evenly rounded. The parietal-palatal canal is weakly developed. The mantle slit forms the selenizone. The width of the mantle slit is equal to the selenizone width and its depth slightly exceeds its width. The slit edges are almost parallel and widen insignificantly at the end. The outer, basal, and inner lips are thin. The inner lip is only slightly flaring and forms the columella and small puncture-like umbilicus. The columella is moderately long and almost straight. The growth lines are very thin; above the selenizone, they are curved and slightly inclined anteriorly; in the selenizone, they form lunulae; under the selenizone, they are inclined posteriorly and arc-like curved anteriorly.

Measurements in mm and ratios:

Specimen PIN, no.	Shell height	Maximum diameter
4919/2-46	9.50	4.40
4919/4-24	9.50	3.70
4919/2-110	11.00	4.20
4919/4-38	11.50	5.20
4919/2-44	13.00	7.00
4919/2-47	13.50	5.30
4919/4-28	15.70	6.20
4919/2-26	16.00	8.00
4919/2-34	18.40	9.00
4919/4-2	21.60	7.70
4919/2-39	22.50	12.50
4919/4-4	26.20	10.50
4919/5-26	27.40	10.40

Variability. The species is highly variable. In adult specimens, the spiral angle changes from 28° to 38°. The tangent to the whorl periphery is almost straight (Pl. 5, figs. 6, 10), slightly convex (Pl. 5, fig. 9, 13), or slightly concave (Pl. 5, fig. 7). In some specimens, the tangent to the whorl periphery is more complicated (Pl. 5, fig. 12). The whorl profile varies. In the majority of specimens, the lateral surface is slightly convex on the early whorls and more rounded on the last whorls. In a few specimens, a well pronounced rounded angulation, which may be ornamented by a spiral row of tubercles, forms on the last whorls between the lateral and basal surfaces (Pl. 5, fig. 13). Some specimens have a weak angulation above the selenizone on the first whorls or on the last whorl (Pl. 5, figs. 8, 13). One specimen possesses poorly developed, relatively wide spiral folds below the selenizone in the lateral and partly in the basal surfaces (Pl. 5, fig. 11).

Comparison. This species differs from *A. devispira* Mazaev, 2003 and *A. nodolira* Mazaev, 2003 in the wider strip between the upper suture and the selenizone. From *Arribazona hesperia* Kues, 1990, it differs in the rounder aperture and in the absence of the spiral threads below the selenizone.

Remarks. Licharew described three specimens from the Lower Permian of the Karachatyra Range (Fergana, Uzbekistan) as *Murchisonia (Gormotoma?) tschernyschewi* Yakowlew (Licharew, 1967, p. 49). These specimens sharply differ from the above material in the narrower and higher whorls, smaller number of whorls in the shell of the same height, and more elongated columella. These three specimens cannot be identified with Yakowlew's species and should be assigned to a new species.

Occurrence. Sakmarian, grainstones of the second cyclite of the Kulogory Formation.

Material. Ninety-three imprints: 67 from locality no. 4919/2; 22 from locality no. 4919/4; and 4 from locality no. 4919/5.

Family Microdomatidae Wenz, 1938

Genus *Microdoma* Meek et Worthen, 1867

***Microdoma kulogorae* (Yakowlew, 1899)**

Plate 5, figs. 14–18

Tuberculopleura kulogorae: Yakowlew, 1899, p. 59, pl. 5, fig. 24.

Microdoma kulogorae: Nel'zina, 1978 (in Kalmykova et al., 1978), p. 21, pl. 1, figs. 22, 27, 28.

Lectotype. TsNIGR Museum, no. 188/325, imprint; Arkhangelsk region, eastern part of the exposure under the village of Kulogory, grainstone of the second cyclite; Lower Permian, Sakmarian, Kulogory Formation.

Description. The shell is small, trochiform, up to 14 mm high, and consists of approximately seven whorls. The suture is pressed, shallow or moderately deep. The umbilicus is narrow and puncture-like. The

protoconch is unknown. Two first whorls are evenly convex and smooth. On the following whorls, axial ornamentation appears. The central part of the lateral surface of the whorls is almost flattened and slightly rounded near the suture. The collabral ribs are moderately massive and inclined posteriorly from the suture at an angle of 15°–20°. The interspaces and ribs are of equal width. Downwards and upwards, the ribs are bordered by the sutures. In the majority of the specimens, the ribs of the two last whorls are formed as three collabrally elongated tubercles divided by narrow constrictions. The lower row of tubercles forms a weakly developed keel that separates the lateral and basal shell surfaces. The basal shell surface is smooth and evenly rounded. The growth lines are thin, straight, and inclined posteriorly from the suture. The angle of inclination to the shell axis is 15°–20°. The aperture is suboval. The rounded angulation is present between the palatal and parietal edges and between the columellar and basal edges. The columellar edge is almost straight, inclined to the shell axis at an angle of 5°–20°, and flaring to form the columella with the false umbilicus. The inner and outer lips are about the same thickness.

Measurements in mm and ratios:

Specimen PIN, no.	Shell height	Maximum diameter
4919/2-76	10.6	8.4
4919/2-79	7.3	4.6
4919/2-83	8.0	5.4
4919/2-98	8.0	5.0
4919/5-13	9.8	7.0
4919/5-19	8.8	7.7
4919/5-25	9.1	6.3
4919/2-65	13.0	8.6
4919/5-2	14.0	>8.0

Variability. The species is highly variable. The apical angle ranges from 50° to 60°. The number of collabral ribs on the fifth and sixth whorls may vary from 12 to 26, while the ribs thickness is approximately equal to the interspaces width. Thus, with the change of the number of ribs, their thickness also changes. Many specimens lack ornamentation on the last whorl or, rarely, on the three last whorls, which become more or less smooth. The ribs may vary from the solid (with the same thickness along the whole length) to those subdivided into three parts in the form of three tubercles that are variously separated from each other.

Comparison. This species differs from *M. lashmensis* Mazaev, 1997 in the keel located lower and being more poorly developed. It differs from *M. simensis* (Yakowlew, 1899) in the collabral ribs dividing into three parts. From *M. anomalum* (Yakowlew, 1899), it differs in the more obtuse apical angle, and the keel more poorly developed and located lower.

Occurrence. Sakmarian, grainstones of the second cyclite of the Kulogory Formation.

Material. Thirty-eight imprints from locality no. 4919/2; 9 imprints from locality no. 4919/4; 19 imprints from locality no. 4919/5.

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