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A New Representative of the Petalonamae from the Upper Vendian of the Arkhangelsk Region

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Abstract-Ventogyrus chistyakovi gen. et sp. nov. is described here as a new representative of the enigmatic Late Vendian metazoan group the Petalonamae. Remains of *Ventogyrus* occur only in strata that were formed as a result of the infilling of erosional pots on the seafloor. It is shown that *Ventogyrus* was buried *in situ* in life position. *Ventogyrus* is preserved as an external cast of the upper side of the body that formed a deep depression. Occasional imprints of distributary ducts and the external covering of the lower side of the body are present. The corpus was boat-shaped, the depression on the upper side was compartmentalized into chambers by vertical baffles. *Ventogyrus* is reconstructed as an immobile unitary benthic organism. It is very similar to representatives of the Petalonamae *Pteridinium* Gurich,1933, especially to *Pteridinium nenoxa* Keller, 1974 in preservation, morphology, and mode of life. Unlike in *Pteridinium,* the sides of the corpus of *Ventogyrus* were supported by a median and two sternal baffles. A sternal chamber was located at the broader end, and additional baffles connected with the median baffle.

INTRODUCTION

In 1994 we examined natural outcrops of Upper Vendian rocks in the middle course of the Onega River, near the southeastern termination of the Vetrenyi Poyas Mountains between the village of Yarnema to the north and the mouth of the Somba Stream to the south.

Since the geological expedition of R. Murchison (Murchison *et al.,* 1849) the succession has long been referred to the Devonian. Sections were first described from the mouth of the Teksa Stream by N.I. Tolstikhin in 1923-1924 and by A.G. and O.A. Kondiain in 1951 as the Teksa Formation of Devonian age (Solontsov *et* a1.,1971). Later, a pre-Devonian age was established for the oldest deposits of sedimentary cover in the Moscow Basin as a result of deep drilling data obtained during the 1949-1950s. Accordingly, the age of the successions of the Mezen Basin was also revised.

Borehole sections (Iksa-2-g, Iksa-283, Shabenga-26, Pustinka-41) from the middle course of the Onega River were examined by Krivtsov (1958). Krivtsov recognized lithological rock members and correlated them with well spaced (more than 200 km) borehole sections (Nenoksa, Arkhangelsk, Ust-Pinega, etc.), where the age of the correlated rocks was considered Lower Cambrian. The scheme of the correlation of boreholes Nenoksa, Arkhangelsk, and Ust-Pinega subsequently underwent significant modifications. However, Krivtsov's scheme for the region northeast of the Vetrenyi Poyas Mountains were subsequently verified by the work Stankovskii et al. (1981). Krivtsov (1958) did not investigate outcrops in his correlation but, judging from his scheme presented, the rocks exposed in the river floodplain, are precisely the member that he referred to as "Blue Clays" of the Lower Cambrian Baltic Group. Rock sequence, that was earlier considered "Blue Clays," is currently viewed in the Nenoksa borehole as part of the Ust-Pinega Formation of the Upper Vendian and is correlated with the interval from the Upper Arkhangelsk Beds to the Lower Suzma Beds inclusive based on the scheme by Stankovskii *et al.* (1981, 1985) of the subdivision of the Upper Vendian deposits of Southeastern Belomorie.

Solontsov *et al.* (1971) suggested the name Teksa Subformation for the exposed sequences (of stratigraphic range more than one outcropped) as part of the Ust-Pinega Formation. They found tuffites with montmorillonite clay layers 1.5-4.0 cm thick at the mouth of the Teksa Stream, the stratotype section for the Subformation, and correlated them with the second tuffaceous marker horizon for the Ust-Pinega Formation. Outcrops were correlated with the Ust-Pinega borehole, with interval, juxtaposed with the Arkhangelsk and Verkhovka Beds by Stankovskii *et al.* (1981, 1985). Chistyakov *et al.* (1984) examined sections in the middle course of the Onega River, but in the description tuffites were not mentioned, in agreement with our findings.

Heavily altered ferriferous microfossils, found in heavily weathered unit of interbedded aleurolites and clays contribute to the dating of the sequences. The wider filaments may correspond to the pyritized remains of *Striatella* Assejeva,1982, narrow filaments are similar to the filamentous sulfur bacteria *Zinkovioides* Hermann, 1985. *Orbisiana* sp. are present as well (identified by M.B. Burzin). These genera of microfossils were recognized by M.B. Burzin and M.B. Gnilovskaya from the stratigraphic section between the Upper

Arkhangelsk and the Upper Zimnie Gori Beds according to the stratification scheme of Stankovskii *et al.* (1981, 1985) for the Upper Vendian of Southeastern Belomorie.

Interpretation of the sedimentary environment furnishes insights into both the agents responsible for preservation of *Ventogyrus chistyakovi gen. et* sp. nov., and a reconstruction of its mode of life.

Remains of soft-bodied organisms from the middle course of the Onega River were first found in 1976 on its left bank 1 km downstream from the mouth of the Somba Stream by Chistyakov. Further samplings were made there, as well as in outcrops near the mouth of the Teksa Stream in 1977, 1978, and 1983. The finds were referred to *lnkrylovia* cf. *I. lata* Fedonkin,1979, *Yarnemia ascidiformis* Nessov, 1984, cf. *Cyclomedusa* sp., cf. *Paleolina* sp., cf. *Arborea* sp., cf. *Dickinsonia* sp., *Neonereites uniseriales* Seilacher, 1960, etc. (Chistyakov *et al.,* 1984). The similarity between those finds and impressions of soft-bodied organisms from the Upper Vendian of the White Sea Winter Coast, the Onega Peninsula, Namibia and Australia was noted (Chistyakov *et* a1.,1984; Fedonkin,1985). In addition, our collected material contains numerous specimens of a new form *Ventogyrus chistyakovi* gen et. sp. nov., described herein. A single earlier discovered specimen has been mistaken for cf. *Arborea sp. by* previous investigators.

ENVIRONMENTAL AND TAPHONOMIC RECONSTRUCTION

The oldest sedimentary rocks exposed as small isolated outcrops in the middle course of the Onega River are built up of clays and terrigenous clastic deposits, dominated by the interbedding of aleurolite and clays typical for the Upper Vendian. Fine-grained turbiditelike sandstones and gutter and pot casts with flat clay pebbles on bedding surfaces appear in the aleuriliteclay interbedding sequence over a few kilometers south of the village of Yarnema. Hummocky stratification is widely-developed in the aleurolite-clay interbedding sequences as well. A section within a floodplain, 1 km downstream from the mouth of the Somba Stream was the only one studied in detail (Fig. 1). Fossil distribution was examined in the above mentioned section only. Impressons and casts of segmented tubes *Calyptrina* sp. (identified by M.B. Gnilovskaya), small circular impressions of a *Cyclomedusa-type* organism, and a few new undescribed forms were found along with *Ventogyrus chistyakovi gen. et* sp. nov.

Remains of *Ventogyrus chistyakovi gen. et* sp. nov. occurred within pot casts only. Pot casts are the sedimentary structures resulting from sediment infilling of rounded erosional depressions on sea bottoms. They reach 0.6-0.8 т in diameter and are up to 0.4 т thick. Casts have smooth sides, steeper on one side and more gentle on the other (Fig. 1). Remains of unclear affinities and a cast of *Calyprina* sp. tube fragment were found in a pot cast together with *Ventogyrus chistyak*ovi gen. et sp. nov.

Fine-grained sandstones and aleurolites with gradational bedding type, comprising isolated turbidite-like layers with erosional basal surfaces and wavy tops, can be interpreted as turbid flow deposits (similar to B, C, and E elements of the Bouma turbidite cycle, Walker, 1984b). Interbedded aleurolites and clays are attributable to distal parts of turbid flows. Clays with thin layers of aleurolite grade into aleurolites and clays and presumably resulted from turbid flow activity as well.

Isolated gutter and pot casts built of fine-grained sandstones and aleurolites are typical structures among groups of storm deposits or tempestites (5eilacher, 1982; Aigner,1985). It is believed that gutters and pots originate during storms and were produced by strong bottom flows (Myrow,1992,1994; Petrov,1993). Gutter and pot casts suggest strong hydrodynamic activity of a sedimentary environment and combined effect of horizontal and vertical turbulences within unidirectional bottom flows. Hummocky stratification of interbedded aleurolites and clays are also referred to as tempestite structure (Walker, 1980a; Seilacher, 1982; Aigner, 1985). The origin of hummocky bedding type remains enigmatic, but the majority of researchers consider the formation of this stratification type a result of sediment suspension and deposition by oscillatory flows, generated by storm waves (Dott and Bourgeois, 1982; Aigner,1985; Eyles and Clark, 1986; Prave and Duke, 1990). In such case the hummocks can be regarded as very large postvortex ripples, and individual laminations record pulses of liquefaction, suspension, and sedimentation of sand by single storm wave or wave train. Hummocky stratification serves as an indicator of storm wave base. The origin of basal surface structures-shrinkage cracks, flat clay pebbles-are explicable on the basis of event sedimentation (Kazmierczak and Goldring, 1978; Seilacher, 1982; Jensen,1993).

Tempestite structures (hummocky stratification, gutter and pot casts) in turbid flow facies are typical for shelf situations with wave-dominated sedimentation (Walker, 1980a). In such an event, interbedded aleurolites and clays meet distal tempestite scenarios: wave-suspended fine-grained sandy and silty material was transported by turbid flows below the storm wave base. Trend of the long axes of gutter casts, cross-lamination dip, and of the orientation of ripple-mark ridges indicate sediment transport in a southeasterly direction by storm flows.

Storms were presumably the major agent of transportation and sedimentation of sandy, silty, and clay material at the Yarnema part of the paleobasin: Storm waves stirred up large volumes of sand, storm-generated flows transported suspension material over large distances and into deeper water below the storm wave

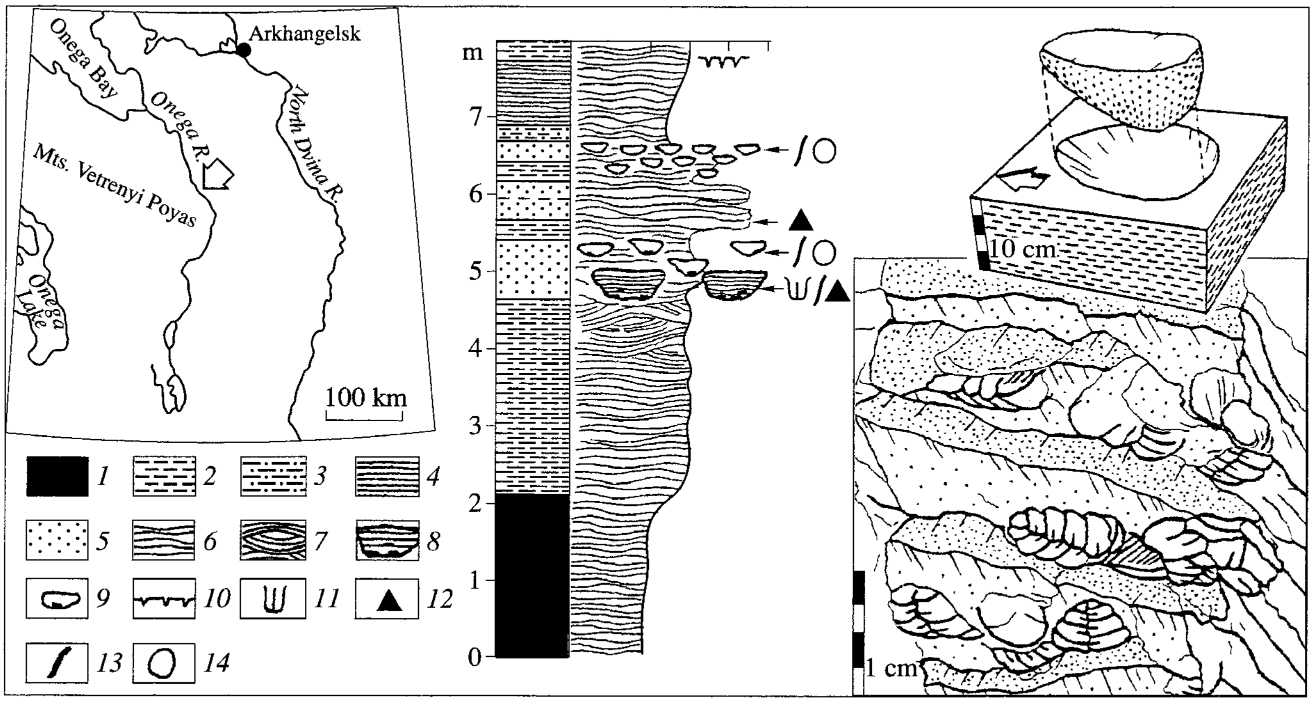


Fig. **1.** Geographical position of the fossil locality in the middle course of the Onega River (arrowed). The section of the Upper Vendian succession 1 km downstream from the mouth of the Somba Stream. The base of the section is in line with the water level, the sequence is overlain by calcareous-terrigenous deposits of the Middle Carboniferous Somba Formation. The shape and dimensions of the pat cast. The arrow indicates the reconstructed flow direction. The occurrence of *Ventogyrus* remains within the pot cast (drawing from the photograph of A.A. Bronnikov). Symbols:]-clays, 2-interbedded aleurolites and clays, the thickness of single flags does not exceed 10 mm, 3-interbedded aleurolites and clays, the thickness of single flags of aleurolites reaches 15 mm, 4-interbedded aleurolites and clays, the thickness of single flags of clays reaches 15 mm,5-finegrained sandstones, 6-planar lamination, 7-hummocky stratification, 8-pot casts with flat clay pebbles, 9-gutter casts with flat clay pebbles, 10-shrinkage cracks, 11--casts of *Ventogyrus, l2-new* undescribed forms, 13-casts and impressions of segmented tubes *Calyptrina* sp., 14-impressions of *Cyclomedusa-type.*

base. When the storms subsided, the deposition of sediment in the form of a cover took place over a sizable area. On the basin floor at the storm wave base hummocks formed, and the large erosional marks (gutters and pots) originated along the localized storm flows.

parts and erosional pots with oxygen and nutrients. However it should be noted that remains of *Ventogyrus chistyakovi gen. et* sp. nov. were not found within every pot cast.

The burial of organisms evidently resulted from a partial infill of pots with sand, transported as suspension by flows during episodes of increased storm activity. Event sedimentation of the suspension material without subsequent sediment transportation on the floor favored the burial of organisms *in situ,* commonly in life position. The following features testify to the above mentioned statement: forms of different sizes occur within the same bed, i.e., sorting of remains by size did not happen; a11 remains lie with downturned convex sides within the bed, both overturned remains and traces of their transportation over the sea floor were not found. Long axes of remains are always oriented in different directions. *Ventogyrus chistyakovi gen. et* sp. nov. was buried in groups within a few subsequent layers, with overlying casts distorting the underlying. It follows that the population of *Ventogyrus* inhabited a newly formed substrate at the end of the storm. One can suggest, that *Ventogyrus* lived on the sea floor along long-term bottom flows that could supply the deeper

PRESERVATION AND MORPHOLOGY OF REMAINS

Ventogyrus is preserved as casts within the sandstone layers. The impressions of soft tissues are preserved on the sole and side surfaces of the casts, in rare cases on the upper surface of the cast. Commonly the thin layer of sandstone covers the base of the casts and bears either folds and wrinkles, or rollers.

Casts are built of fine-grained silty, predominantly quartz sandstone. The textures and features are macroscopically identical to those of the cast-bearing rock. Commonly cast boundaries are marked with a yellowish-gray clay veneer. A11 casts occur in similar manner within individual layers: the lower surface, with characteristic pattern, is always aligned to the basal surface of the layer (Fig. 1). No traces of either material redistribution or concretion formation are observed. It suggests a synchronism of cast and cast-bearing layer formation.

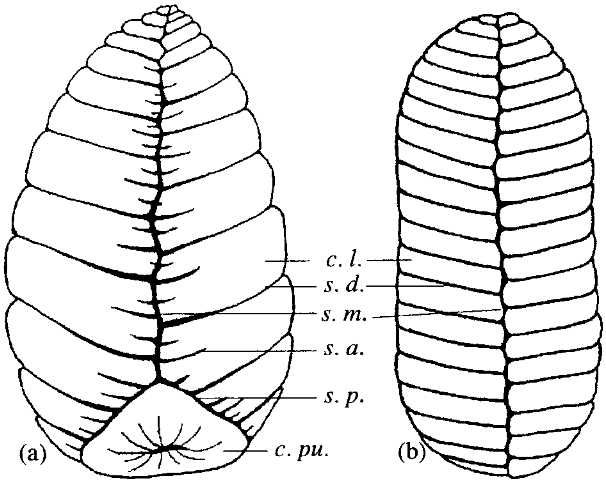


Fig. 2. The pattern of furrow arrangement on the lower surface of an ideal cast of two representatives of Petalonamae: (a) *Ventogyrus chistyakovi* sp. nov.; (b) *Pteridinium nenoxa* Keller, 1974. Abbreviations: s. m.-furrow corresponding to the median baffle *(saeptum medianum),* s. p.-furrows corresponding to sternal baffles *(saepta puppes), s.* d.-furrows corresponding to divisional baffles *(saepta dividensia), s.* a.-furrows corresponding to additional baffles *(saepta additicia), c.* l.--casts of lateral chambers *(camerae laterales),* c. pu.--cast of sternal chamber *(camera puppe).*

Casts of *Ventogyrus* have an ovoid shape viewed from the sole, with a wide and more narrow end. Casts lack a clear top surface, they are in their origin integral with the cast-bearing sandstone layer. Consequently, there was either a depression on the upper side of *Ven-togyrus* and sand easily infilled it, or there were cavities inside the body and the outer covering of the upper side could sag into the cavities under the sand weight. The highly narrow and deep furrows divide the convex or flatenned sole surface into elements (Fig. 2a). The zigzag medium furrow runs along the length of the cast. Furrows of different length link up with the median furrow almost perpendicular to it, slightly deviating toward the narrow end. The first order furrows reach the sides of the cast and divide the base into trapezoid-like elements. The second order furrows are located roughly halfway between the first order furrows and до not exceed 113 the length of the former. The third order furrows are positioned in the spaces between the first and second order furrows with length not exceeding 1/2 of that of the second order furrows. The shorter fourth and fifth order furrows may at times also be visible. The glide reflection symmetry is seen in furrow arrangement: the furrows of both halves of the cast are displaced at a half period relative to the plane, passing along the median furrow. The latter is bifurcated at the wide end of the cast into two furrows, that cut off the triangle-like element. The furrows inside the triangular element are not seen. The furrows of different length link up with them from the outside, similar to furrows that link up with the median one. The cast can be easily broken down into constituent elements. The inside of the cast surfaces reveals the impressions of inner structures (Fig. 3d; P1. 2, figs. 2-5). The shape of constituents may vary depending on the degree of preservation, however the ideal structure of the cast can be reconstructed from the whole studied sampled material.

The ideal cast resembles the shape of a barge, with a broad curved hull, high and broad stern, and narrower bow. The terms *stern* (for wider end), *bow* (for narrower end), and *sides* would be appropriate for use to denote ends and sides in a description of the shape of the cast. The following pattern can be observed in element arrangement. The sternal element with the triangular shaped sole is at the wider end, one of its sides forms the stern, while two others converge within (P1. 2, fig. 2). The rest of the cast is built up of elements with the trapezoid-shaped sole, the elements are disposed in two rows by the law of glide reflection relative to the plane, running along from inner rib of the sternal element to the narrow end. The internal construction of those elements of the cast in its turn is complicated by additional structures. Such structures form a characteristic pattern on the base of the cast (Fig. 2a). The gradual decrease of dimensions of the elements is observed toward the bow. The elements that adjoin the sternal one rapidly decrease in width and length toward the stern. The longest elements are therefore those that adjoin the inner rib of the sternal element.

There are casts with the bow that is bent upward (Figs. 3c, 3д; P1.1, figs. 1, 5; P1. 2, figs. 2, 4, 5). The curved part therein is preserved not as a cast, but in the form of an impression on the upper surface of the cast. In such curving one could expect an impression of the lower side of the curved bow, since it was in immediate contact with the upper surface of the cast (the differ-ences between upper and lower sides of the body will be discussed in the section "Reconstructed Organism"). However, this is not observed, while the impression of the upper side of the curved bow is preserved. The upper side of the curved bow could leave an impression on the sole of the overlying bed only. What is seen on the top surface is in fact the counterpart of the impression of the upper side of the curved bow. Consequently one can suggest the situation that the impression of the upper side of the buried body on the sole surface of overlying bed was the only preserved, and that during compac-tion it left the counterpart on the top of underlying bed.

The preservation of the bow in the form of an impres-sion but not of a cast implies that it was not infilled by the sand, that it could have been raised in life, and buried in a collapsed position on the surface of the sediment. Judging from nine casts, approximately the same eight to ten elements at the sternal part of the cast remain unbent, if counted from both sides (Figs. 3c, 3d; P1. 1, figs. 1, 5; P1. 2, figs. 2, 4, 5). These elements protrude on the basal surface of the bed, hence a quarter of the unbent part of the body was submerged in the sediment, while the bow was raised.

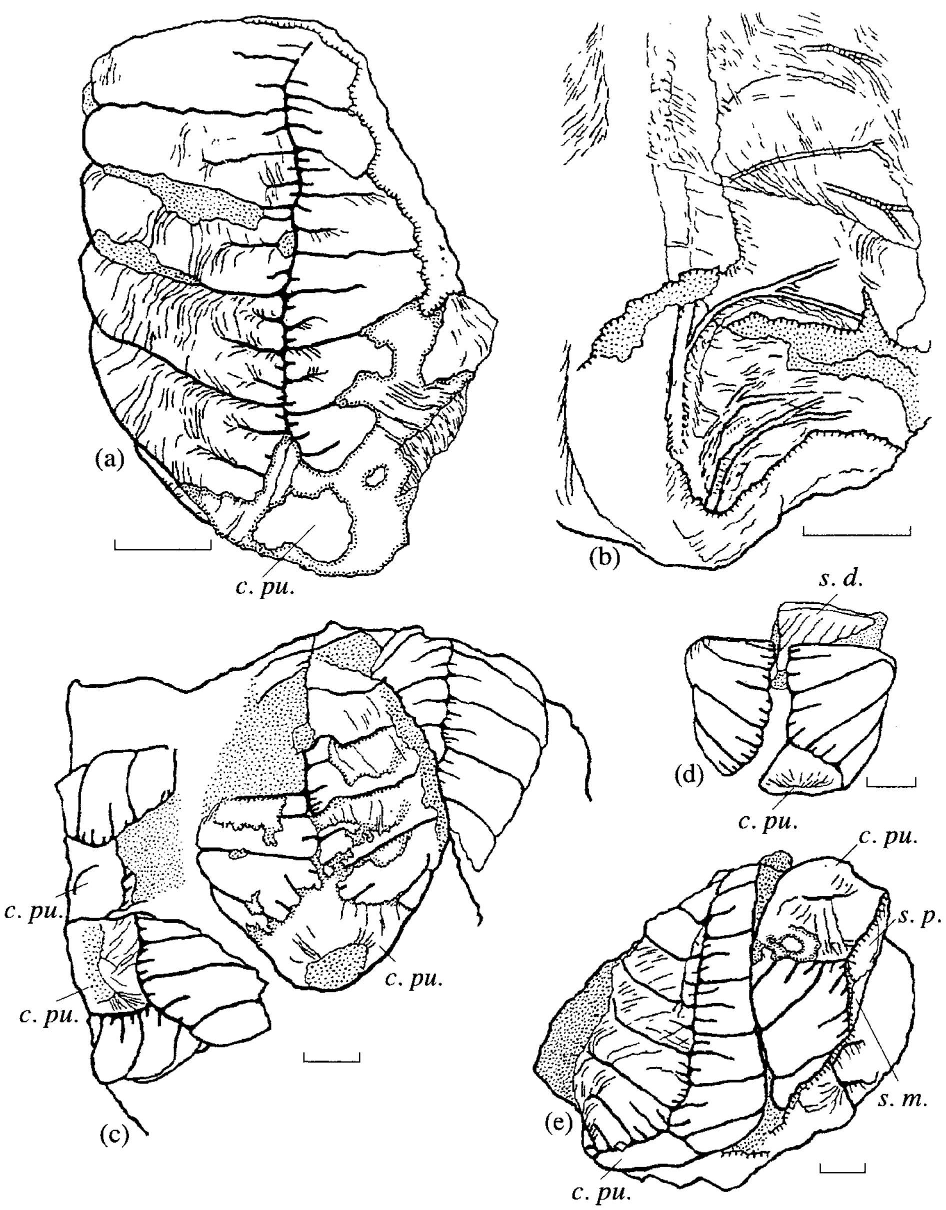
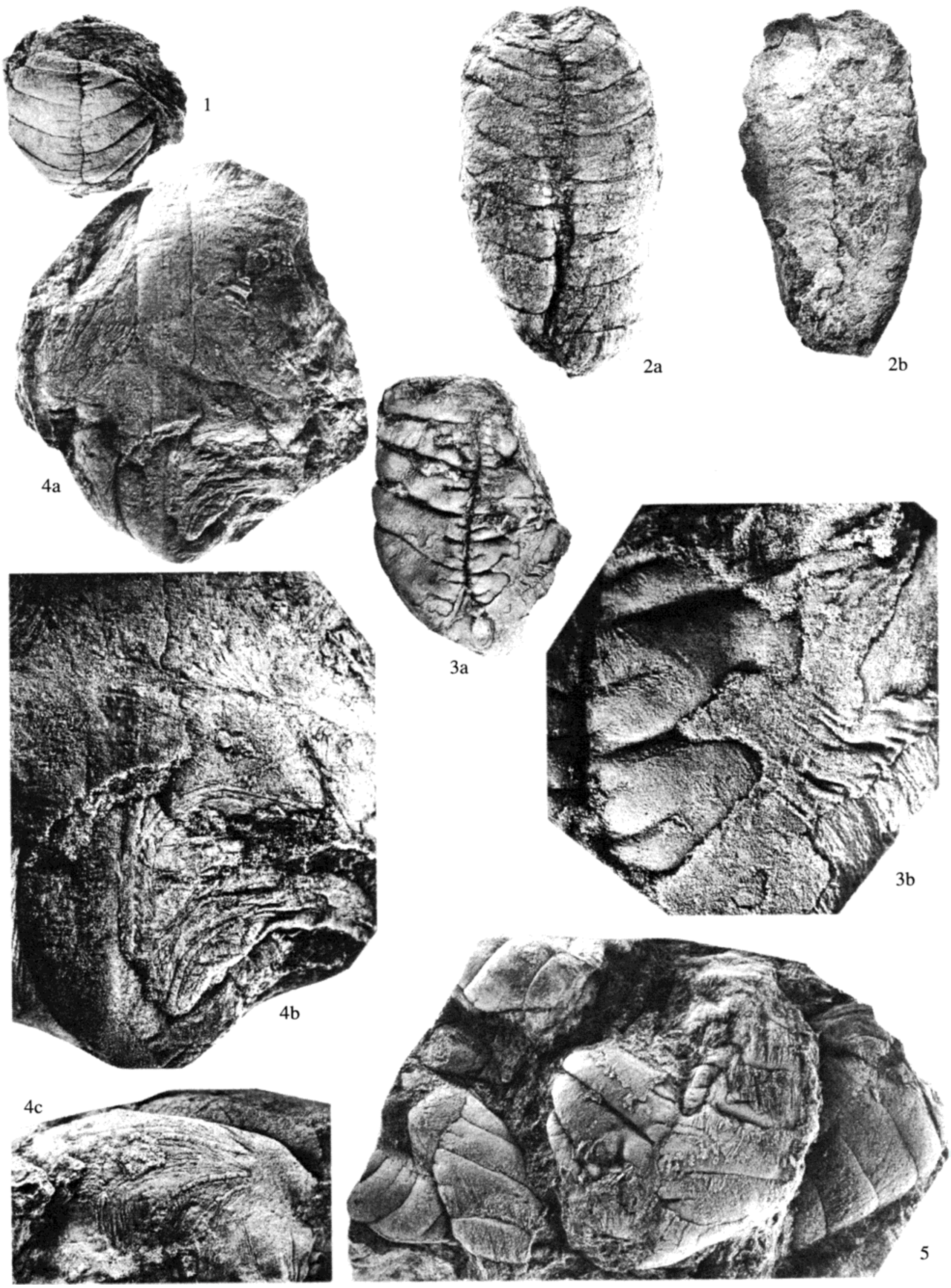


Fig. 3. Interpretational drawings of selected specimens of *Ventogyrus chistyakovi gen. et* sp. nov.: (a) holotype PIN, no. 4564-25 (P1.1, fig. 3a); (b) specimen PIN, no. 4564-23 (P1.1, fig. 4b); (c) specimen PIN, no. 4564-21(P1.1, fig. 5); (д) specimen PIN, no. 4564-35 (P1. 2, fig. 5); (e) specimen PIN, nos. 4564-27,4564-28, and 4564-29 (P1. 2, fig. 1). Line with dots denotes the fragments of the layer of sandstone with impression of covering. Abbreviations as in Fig. 2. The scale bar is 1 cm long.

There are also almost completely unbent casts with the bow infilled with sediment (Figs. 3c, 3e; P1. 1, figs. 2a, 3a, 5; P1. 2, fig. 1). However, deformed and incomplete casts are very common. The sternal element, for example, is not seen on every cast (P1.1, fig. 2). The deformations of the bow are observed in unbent casts. Commonly the folds are present at the place of the expected bend (Figs. 3a, 3c, 3e; P1. 1, figs. 2a, 3a, 5; P1. 2, fig. 1). One can suggest that such folds could have been formed when the originally curved body was straightened. This suggestion would confirm the assumption of a raised bow in the living organism.

The structure of very narrow and deep sole furrows is seen on the element surfaces that face inside the cast. The zigzag median furrow is deepest at the sternal part, then gradually shoals toward the bow. Since the bow is not preserved as a cast, it is impossible to determine whether the furrow levels out completely. The sides of the furrow are folded similarly in a zigzag pattern, and folds are traced to a depth depending on the adjoining lateral furrow (P1. II, fig. 4b). Sternal furrows have the same depth, equal to the median furrow at the juncture point. There are always folds at the interfaces between the median and sternal furrows and the lateral furrows. The first order lateral furrows extend to the sides of the cast, are deepest at the junctures with that median furrow, and as deep as the median furrow at this point. The depth of lateral furrows gradually decreases to zero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toward the sides of the cast (Fig. 3d; P1. 2, fig. 5). The deepest furrows are those that are adjacent to the interface between the sternal furrows and the median one. The depth of the first order furrows decreases toward the bow along the median furrow and toward the stern along the sternal furrows. Seven to nine folds were discovered on the sides of the first order furrows (Fig. 3d; P1. 2, figs. 3, 5). The depth of the second to fourth order furrows at the junctures with the median furrow is equal to their length; their depths gradually decrease to zero toward the sides of the cast. One or two folds were discovered on the sides of the furrow as well.

Thin sandstone lamina is not uncommonly preserved on the sole surface of the cast and bear folds and striations (Figs. 3a, 3c; P1. 1, figs. 3, 5), that can be interpreted as an impression of the outer covering of *Ventogyrus* We suggest that this is not an impression of the lower side of *Ventogyrus,* but the cast of the inner surface (that faces inside the body) of outer covering of an organism from its lower side. By our analogy with preservation of a bent bow at the upper part of the cast (see above) one can suppose that the impression of the lower side of *Ventogyrus* is not preserved. When sediment covers the body and either infills the depression or the external covering sags into the cavities, a break of the outer covering is possible and a small amount of sand may find its way into the organism. In such a case the inner surface of outer covering will give an impression.

Impressions are occasionally preserved on the upper surface of the cast (P1.1, fig. 2b). It is believed that the origin of these impressions can be explained in terms of the uneven or partial sediment infilling of the depression; the predominantly vertical sediment settling at some time could give way to a mainly horizontal action that tilted the sides of an organism protruding from the sediment on to the top of the partially infilled organism. Consequently, the assumption that sediment infilled the deep depression on the upper side of the body is the most likely to explain the cast formation.

Differences are observed between impressions of the outer cover of the lower side and the upper side: the former bears folds, while the latter lacks folds. They can be explained in terms of differences in conditions of preservation between the upper and lower sides. The upper side is preserved as an impression, but the lower side is preserved as the cast of its inner surface. After the covering breaks under the weight of the overlying sediment and sand penetrates inside, subsequent shrinkage and deformation of the outer covering of the lower side of the organism is possible.

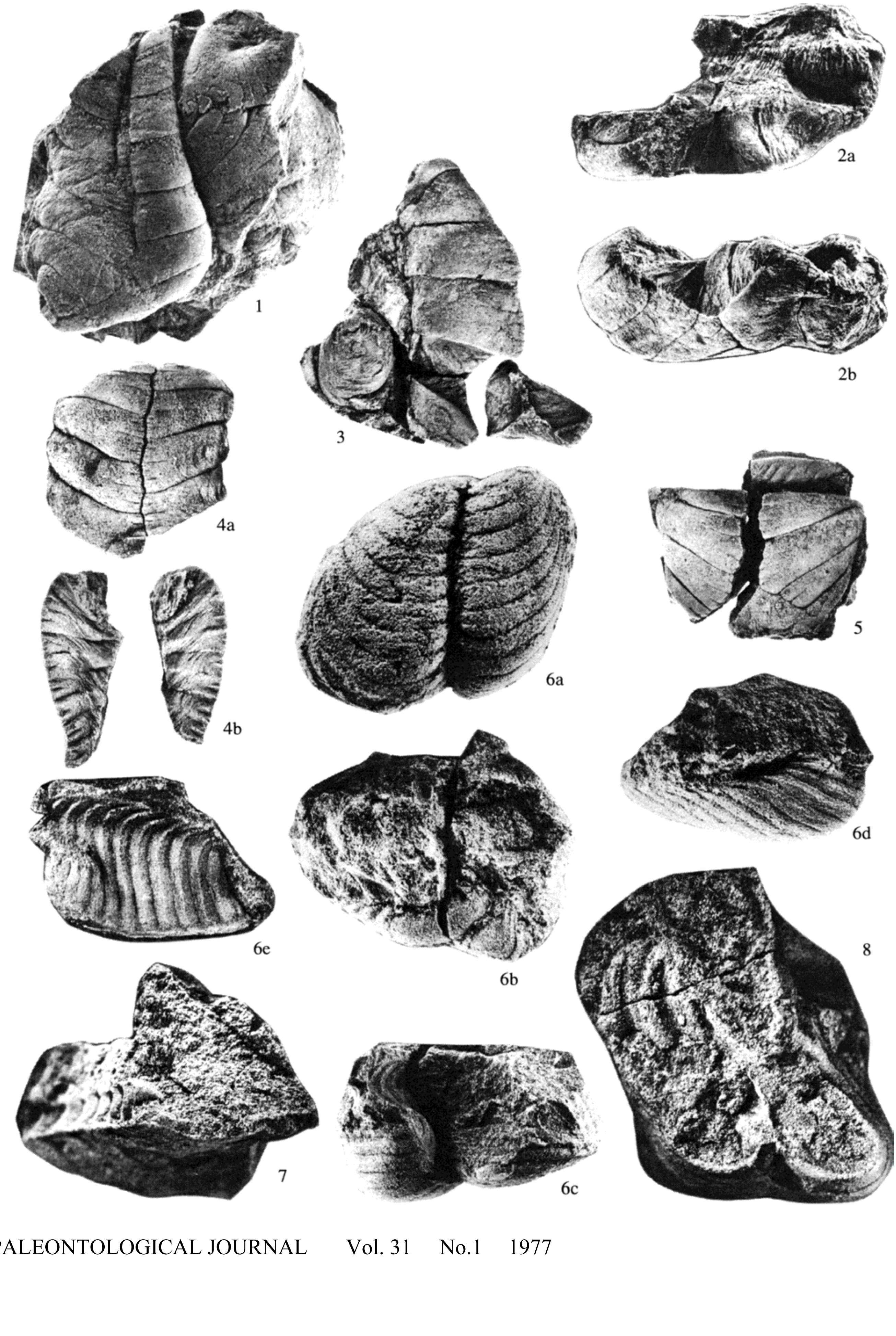
The striations are commonly observed on both casts and sides of the furrows (Figs. 3a, 3c-3e; P1.1, figs. 1-3, 5; P1. 2, figs. 1, 2, 4, 5). In rare cases the details of the enigmatic internal structures are very clearly preserved on the thin lamina of sandstone that covers the cast. They are rollers 0.1-1.3 mm wide. The most complete impression of the web of rollers is preserved on the surface of the sandstone lamina that entirely covers one of the casts (Fig. 3b; P1. 1, fig. 4). The roller with maximum width is aligned lengthwise. The narrow rollers branch off laterally and produce branches further. At the wider end a fanlike group of relatively narrow rollers is observed (P1.1, fig. 4c). The sandstone lamina with rollers covers the furrows on the base of the cast, and no exact arrangement of rollers relative to cast elements was possible without breaking the lamina.

One can suggest that the striations and rollers are the impressions of the internal organs that resemble tubes or ducts. The impressions of diverging and branching rollers can therefore be reconstructed as fragments of a distributary system of organs. The preservation of internal organs on the surface of thin lamina of sandstone can be explained in terms of sediment penetration of the organism as a result of the external covering breaking, similar to the case with preservation of impressions of the inside surface of the external covering. The striations on the cast surface, furrow sides, and the thin lamina are apparently evidence of a web of fine ducts covering the entire body below the skin.

Plate 1

A11 figures are approximately full scale, except for fig. 3b (x4), and figs. 4b, 4c (x2).

Figs. *1-5. Ventogyrus chistyakovi gen. et* sp. nov., Arkhangelsk District, the middle course of the Onega River, l km downstream from the mouth of the Somba Stream; Upper Vendian, the Ust-Pinega Formation, the Teksa Subformation (according to Solontsov *et* a1.,1971): (1) specimen PIN, no. 4564-33, the sole surface of the most complete cast of a bent specimen, the cast of c. *puppe).* (at the bottom) is bent, the bow is curved to the right and preserved as an impression within the layer, 15 c. *laterales* can be counted along the left side; (2) specimen PIN, no. 4564-22, relatively complete cast: (a) the sole surface, cast of c. *puppe).* was not found, 12 c. *laterales* can be counted from both sides, (Ь) top surface, the impression of the tilted side with finest ducts is preserved on the left half of the cast; (3) holotype, PIN, no. 4564-25: (a) the sole surface of the cast with fragments of the thin lamina of sandstone, the bow (at the top) is not preserved, the impressions of finest ducts are seen, the impression of outer covering is preserved on the surface of the thin layer (see Fig. 3a for interpretative drawing), (b) enlarged detail with the thin lamina of sandstone; (4) specimen PIN, no. 4564-23: (a) the sole surface of the cast covered by thin lamina of sandstone with the impression of ducts, (Ь) enlarged detail of the sternal part (see Fig. 3Ь for interpretative drawing), (c) lateral view, the stern is to the right, the impression of fanlike array of ducts is seen; (5) specimen PIN, no. 4564-21, the grouping of the casts on separate layers: specimen PIN, no. 4564-21-a (in the left bottom) is bent, the bow sinks into the rock, specimen PIN, no. 4564-21-b (in the left top) is incomplete, specimen PIN, no. 4564-21-c (in the center) is unbent, the bow is deformed, the fragments of thin sandstone lamina with impression of covering is preserved, specimen PIN, no, 4564-21-д (in the right) is unbent, overlies specimen PIN, no. 4564-21-c (see Fig. 3c for interpretative drawing).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The thin lamina of sandstone with impressions of a covering and of ducts is most common at the sternal part of the cast and along the furrows (Figs. 3a, 3c-3e; P1.1, figs. 3-5; P1. 2, figs. **1, 5).** The sternal element in such cases is covered by this lamina and not visible. The lamina covers the cast apparently spreading from the stern over the entire cast along the furrows (Figs. 3a, 3c; P1.1, figs. 3, 5). It is conceivable that the stern was where breaks in the covering occurred most frequently and were penetration of the sediment into the body was initiated. One can suggest that the sternal part was of primary functional importance for *Ventogyrus.* It is the place of maximal concentration of striations and where the rollers could diverge from over the entire cast. The depression with radiating striations is seen on the most completely preserved sternal element (Figs. 3c, 3d; Conceivably the depression might be the impression of some important body structures.

RECONSTRUCTED ORGANIZM

The cast described above is apparently left by a boat-shaped body (Fig. 4). The body width was roughly equal to the height of its sides, the body length from stern to bow was twice that of its width. The bow was raised and the length of the uncurved part was about the same as its width. The upper surface formed a deep depression, the baffles divided the depression into chambers. Each element of the cast represents a chamber, and the thin baffles correspond to very thin and deep furrows. The impressions on the element surfaces that face inside the cast provide the information on the

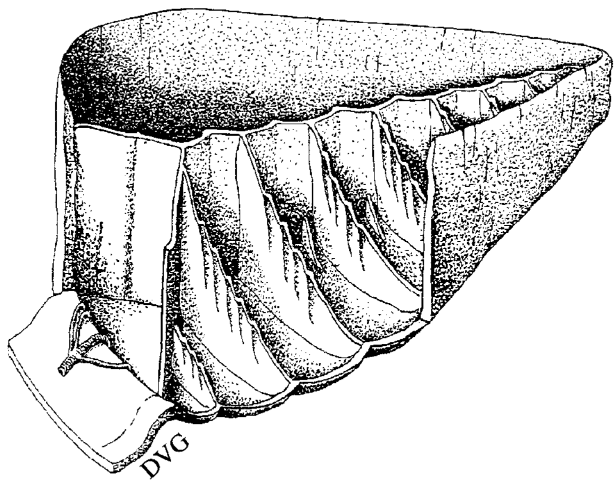

Fig. 4. Reconstruction of *Ventogyrus chistyakovi* sp. nov. The side is partly folded, partly removed. The bow was raised in life.

surface of the baffle. The body was slender, but the organism itself was tall due to raised sides. The preserved organs were located in its lower, lateral, and sternal sides and in the baffles.

The zigzag vertical baffle running along the body is designated as the *"median" (saeptum medianum).* One end of the s. *medianum* links up with the bow, the opposite end merges with the inner rib of the "sternal chamber" *(camera puppe).* The sternal chamber lacks baffles. The baffles that separate the sternal chamber are

Plate2

A11 figures are approximately full scale, except for figs. 7, 8 (x2).

Figs. *1-5. Ventogyrus chistyakovi gen. et* sp. nov., Arkhangelsk Region, the middle course of the Onega River, l km downstream from the mouth of the Somba Stream; Upper Vendian, Ust-Pinega Formation, Teksa Subformation (according to Solontsov *et* a1.,1971): (1) the grouping of casts on sole surfaces of separate layers (see Fig. 3e for interpretative drawing), specimen PIN, no. 4564-28 (in the left) is unbent, the bow is deformed, the impressions of finest ducts are seen, specimen PIN, no. 4564-29 (in the top right), fragment, the part of specimen PIN, no. 4564-27 (in bottom left) is seen on the overlying layer; (2) specimen PIN, no. 4564-34, unbent cast: (a) lateral view, the stern is to the right, the visually closest half of the cast is removed, the impression of s. *medianum* and *s. puppe).* is seen, the impressions of finest ducts are present, (b) sole surface, lateral oblique view, the visually closest half of the cast is removed, the impression of s. *medianum* and s, *puppe).* is seen, the depression is seen on the sole of c. *puppe). (3)* specimen PIN, no. 4564-36, fragment of the sole surface of unbent cast with six casts of c. *laterales, s. medianum* extends along the right edge, one of the elements c. *lateralis* is removed and is overturned to the right, the impressions of s. *dividensia* are seen on its surfaces facing inside the cast, the cast of new undescribed form is to the left; (4) specimen PIN, no. 4564-30, bent cast, the stern (at the bottom) is not preserved: (a) sole surface with furrows, corresponding to s. *additicia* of 1-4 orders, (b) cast is broken apart into two halves, the impression of s. *medianum* with sutures left from s. *dividensia* and s. *additicia* of 1-4 orders, the sternal part is at the bottom, the impressions of finest ducts are preserved; (5) specimen PIN, no. 4564-35, the sole surface of the bent cast is broken apart along the median, sternal, and along one of the lateral furrows, the impression of s. *dividens* with folds is seen on the fragment at the back (see Fig. 3d; for interpretative drawing).

Figs. *6-8. Pteridinium nenoxa* Upper Vendian, Ust-Pinega Formation; the Suzma River downstream: (б) PIN, no. 3992-2007: (a) the sole surface of the bent cast, (b) the raised bow of the cast, (c) the raised stern of the cast, (д) the side of the cast with furrows, corresponding to s. *dividensia, (e)* the impression of s. *medianum* on the surface of the half of cast broken apart along the median furrow, the sutures left from s. *dividensia* are seen, the bow to the right; (7) specimen PIN, no. 3992-2005, cast broken apart along the median and one of the lateral furrows, lateral oblique view on the sole surface, the impression of *s. medianum* (in the left) and s. *dividens* are seen (see Fig. 6b for interpretative drawing); (8) specimen PIN, no. 3992-2004, transversal break of the cast along lateral furrows, the sole is at the bottom, the impressions of s. *medianum* (in the left top) and two of s. *dividensia* with folds are seen (see Fig. бa for interpretative drawing).

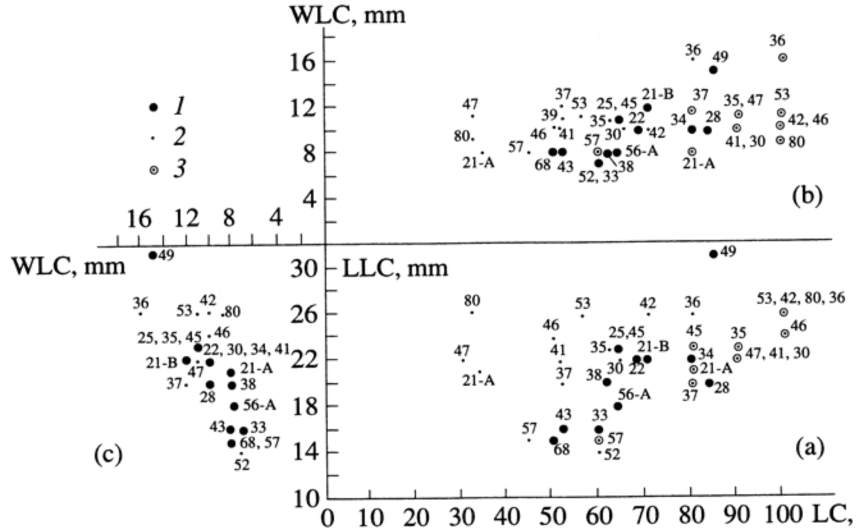

Fig. 5. The major parameters of relationship of *Ventogyrus* casts: (a) between length of the cast (LC) and maximum length of the cast of the lateral chamber (b) between length of the cast and maximum width of the cast of the lateral chamber (WLC), (c) between maximum width and length of the cast of the lateral chamber. Symbols: 1, 2-immediately estimated values:]-for complete specimens, 2-for incomplete specimens; 3-reconstructed values. The parameters were reconstructed in accordance with the proportions of dimensions for the most complete specimens. The numbers on plots are those for specimens.

designated as "sternal" *(saepta puppes).* The median baffle devides the upper surface of the body into two halves. The baffles of different length link up laterally, almost at a right angle slightly deviating toward the bow with the s. *medianum* and s. *puppes.* Baffles, that divide halves into "lateral chambers" *(camerae laterales)* are referred to as "divisional" *(saepta dividensia).* The baffles in chambers, that до not reach the sides of the depression are called "additional" *(saepta additicia).* Sutures are seen on the impression of the *s. mediana* at the interfaces between the median baffle and the divisional and additional baffles (P1. 2, fig. 4b).

The shape and dimensions of the baffles are reconstructed from impressions left on the casts of the chambers, as well as from suture lines left from the baffles on the s. *medianum* and from the length of the furrows on the sole of the cast. The s. *medianum* is tallest at the sternal part at the point of union with the baffles *s. puppes;* and is gradually reduced toward the bow. The height of the *s. puppes* is equal to that of the s. *medianum* at the interface with it, and remains constant. The s. *dividesia* reached the sides of the depression, the height was equal to that of the s. *medianum* at point of union and was reduced to zero at the sides. The s. *additicia* were shorter and lower (they were as tall as long) and similarly reduced toward the sides. The baffles s. *dividensia* and s. *additicia* had a shape reminiscent of a triangle (Fig. 3d; P1. 2, fig. 5). The s. *dividensia* that link up with the s. *puppe).* were reduced in height toward the stern. A11 the baffles were complicated by folds.

The term "sternal chamber" *(camera puppe).* was introduced purely by analogy with the lateral chambers. It is not homologous in the sense of the sternal and lateral chambers or in the similarity of function between the *c. puppe).* and c. *laterales.*

Features seen in baffles arrangement indicate their function of support in the organism. A11 the baffles were fixed relatively in position with the bottom and sides of the depression and with each other as judged from the approximate regularity in the mutual arrangement of both the furrows on the base and the sutures left from baffles on the impression of the median baffle. One can suggest that the s. *medianum* and *s. puppes* supported the sides of the thin body to maintain the boat-like shape. The s. *dividensia* and s. *additicia* presumably imparted stiffness to the upper side of the body and supported the s. *medianum* and *s. puppes.* Presumably, the folds on divisional and additional baffles could straighten, providing the s. *medianum* and upper side of the body with necessary elasticity and tension within certain limits. The glide reflection symmetry in the c. *laterales* arrangement could have provided resistance to possible shift deformations at flow pulses from the side. It would have been apparently difficult to lift and conversely to unroll the bow of such a construction without shape distortion. Consequently the living organism had a raised bow. Perhaps the entire construction lifted the bow and thus body above the sediment.

The study of *Ventogyrus* indicates an increase in both the width and length of the chambers at the same rate as body length increase (Fig. 5). Possibly, such an increase in the dimensions reflects body growth, and thus ontogenetic components may be recognized in the organism's variations. Since the body proportions remain relatively invariant, such a growth type can be considered isometric. We failed to determine unambiguously whether the new chambers were added at the bow as growth progressed or the entire set of chambers had been developed at early stages and remained unchanged over the rest of the organisms life. This is because of the poorly preserved bow, and mostly incomplete casts.

Perhaps the entire body of *Ventogyrus* was penetrated by ducts, presumably of a distributary system. Presumably the broadest duct ran under the median baffle. The narrower ducts leading off it may have extended beneath the divisional and additional baffles. These ducts in turn could have branched off into the chambers, the finest ducts could have formed a web under the covering. The following peculiarities in structure of the distributary system are noteworthy. The finest ducts run close to the external covering, they join within the body to form broad ducts, which in turn empty into the broadest duct, that leads to the stern. Supposedly the fluid flow was directed from the finest ducts into the broadest. The cilia at the terminations of the finest ducts would have been sufficient to create such a flow direction. The presence of strong muscles would be a necessary condition to create the flow in the opposite direction from the broadest duct into the finest. However, there are no obvious impressions on the cast that could be interpreted as traces of musculature.

Impressions on the lower side of the body are not preserved (except in the curved specimens). Hence, it is unclear whether it was smooth or bore some kind of appendages for anchoring in the sediment for example. Since the cast extends from the surface of the bed one can suggest a simple submergence of *Ventogyrus* into the sediment, thus necessitating no anchoring organs. Information on the external covering is very scant, but its deformation is rather typical for a relatively elastic integument.

Ventogyrus is reconstructed as an immobile benthic organism. This is indicated by its *in situ* burial in life position and by absence of traces of movement on the floor and in the sediment. It was not possible to determine from the sampled material whether *Ventogyrus* was a unitary organism, or colonial with each chamber representing a single individual. *Ventogyrus* was most probably a unitary organism, hence future study would presumably reveal that there is no relationship between the length of the body and the number of chambers. A constant chamber number for a11 specimens would be a likely feature of a unitary rather than colonial organism.

Accumulations of *Ventogyrus* casts preserved within a single layer are here interpreted as a settlement of unitary organisms. We discovered no real traces of colonial activity. For casts occurring over one another within different layers, and even deforming the underlying casts, it is unclear, whether they are connected. It is suggested that these may represent settlements and not colonies, until further study.

The casts of *Ventogyrus* lack any trace of a mouth and intestines, hence the mode of feeding is unclear.

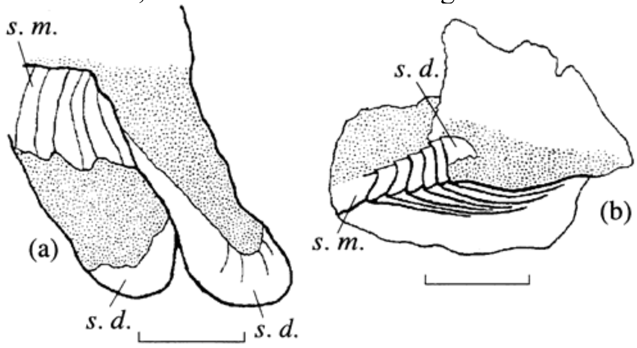

Fig. 6. Interpretational drawings of selected specimens of *Pteridinium nenoxa*: (a) specimen PIN, no. 3992-2004 (Pl. 2, fig. 8); (b) specimen no. 3992-2005 (Pl. 2, fig. 7). Abbreviations as in Figs. 2 and 3.

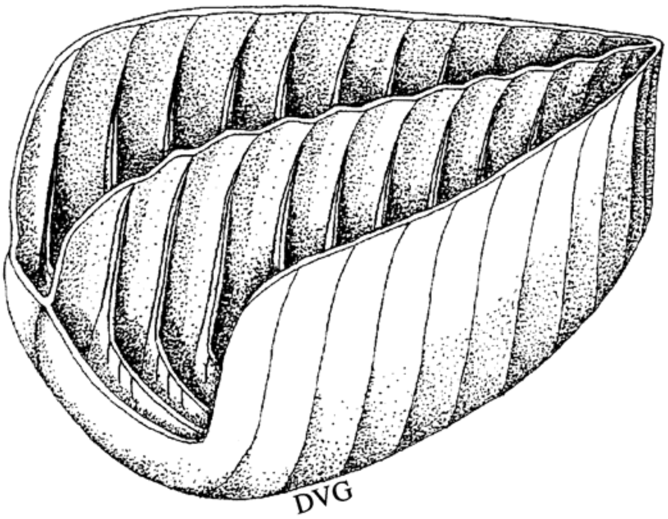

Fig. 7. Reconstruction of *Pteridinium nenoxa*

These organisms can be considered as suspension-feeders, since they are associated with a sedimentary environment with strong bottom set flow of water capable of supplying the depths with nutrients.

The biological affinities of *Ventogyrus* remain undetermined. *Ventogyrus chistyakovi gen. et* sp. nov. is most similar in structure, mode of life and preservation to representatives of *Pteridinium* Gurich,1933, particularly to those from the Ust-Pinega Formation, outcropped along the Syuzma River in the northwestern part of the Arkhangelsk Region Keller, *et al.,* 1974; Keller, and Fedonkin,1976; Palij *et* a1.,1979; Fedonkin, 1981, 1985).

Pteridinium nenoxa Keller, 1974, much like *Ventogyrus,* is preserved as casts, having an elongated ovoid shape in plan viewed from the sole, with the wider and narrower ends. The sole surface of the casts is divided into elements by very narrow and deep furrows (Fig. 2b; P1, 2, fig. 6a). A median zigzag furrow runs along the length of each cast. The casts of *Pteridinium* lack a sternal element at the wider end, as distinct from

Ventogyrus Very narrow and deep furrows vertically diverge from the median one, then gently curve toward the narrow end, and extend to the sides. Any other furrows, analogous to the furrows of second-fifth order of *Ventogyrus* casts, are absent. The plane of glide reflection symmetry runs along the median furrow, and furrows on either side are shifted at a half of a period. The narrow end is raised, a condition that may indicate a vertical orientation of the body in-life (P1. 2, fig. 6b; Fedonkin, 1981, p1. 29, fig. 2; 1985, p1. 11, fig. 1; Fedonkin,1992, fig. 26; Sokolov,1996). The broad end of the cast is raised as well (Pl. 2, fig. 6c). Fedonkin (1985, 1987) discovered that casts of *Pteridinium nenoxa* easily break down into two halves along the median furrow, and the impressions of soft tissues can be seen on the surfaces of the halves facing the inside of the cast (P1. 2, figs. 6e, 7; Fedonkin,1994, fig. 5c). Here is the first observation that casts break down similarly into elements along the furrows normal to the median one (Fig. 6; P1. 2, figs. 7, 8). The inside face of the cast of the elements reveals impressions as well. Furthermore, we discovered for the first time that casts of *Pteridinium nenoxa* occur in similar manner within the turbidite-like sandstones along the Syuzma River. The sandstones infill the broad erosional channel-like cut. The surface of the cast with a characteristic pattern of furrow arrangements always faces down.

One can suggest that the formation of the casts of *Pteridinium* occurred similar to that of *Ventogyrus,* as the sand infilled the depression formed by the upper side of the body. The cast structure therefore reflects the morphology of the upper side of the organism, and furrows that break down the cast into elements correspond to the baffles. Presumably the depression on the upper *flabellum,* consisted of few petaloids, connected by side was divided by the baffles into chambers (Fig. 7). The median baffle *(septum medianum)* ran along the length of the body from stern to bow, dividing the upper surface into two halves, and was as high as the sides of the depression. The two halves were compartmentalized into chambers *(camerae laterales)* by the divisional baffles *(saepta dividensia)*. The chambers lacked the s. *additicia.* Divisional baffles were relatively very low. Their height increased rapidly toward the s. *medianum* and at the junction point was as tall as the latter. The height of the s. *dividensia* increased toward the sides of the depression and reached the height of the latter. The upper edge of the baffles therefore resembled a parabola. The sutures left from the baffles can be seen on the impression of the s. *medianum* and on the sides (P1. 2, figs. бd, бe). The plane of glide reflection ran along the median baffle and the chambers of the two sides were shifted relative to one another at half of a period. The folds complicated the surface of the s. div*idensia.* The stern of *Pteridinium* lacked *c. puppe)*. unlike in *Ventogyrus* and the e. *laterales* alone formed the sternal side. The sides of the body were supported by the s. *medianum* and s. *dividensia,* unlike in *Vento-gyrus* where they were supported by the s. *medianum* and s. *puppe).*

The similarity to *Pteridinium* suggests the relationship of *Ventogyrus* to the family Pteridiniidae Richter, 1955 belonging to the enigmatic group of Precambrian organisms, the Petalonamae. The group Petalonamae was erected by H. Pflug during a study of the remains of soft-bodied organisms of Precambrian age from the Nama Group of Namibia (Southwest Africa). Originally Pflug used the name *Petalonamidae* to integrate of the forms *Velancorina* Pflug, 1966, *Pteridinium* Gurich,1933, and *Ernietta* Pflug,1966 (Pflug,1970a). The name *Petalonamae* was published in the same year (Pflug, 1970b), and *Rangea* Giirich, 1930, *Arborea* Glaessner et Wade, 1966, and *Chania* Ford, 1958 were placed in the list of taxa. In 1972 the name *Petalonamae* was used in the rank of phylum (Pfug,1972).

Pteridinium and *Rangea* were interpreted by preceding investigators as ctenophores (Giirich, 1933), gorgonaria (Richter, 1955), and sea pens (Glaessner and Daily, 1959; Glaessner and Wade, 1966), relying on the resemblances of appearance only. A11 reconstructions, however, did not explain the very important peculiarity of the fossilized material - its three-dimensional preservation. Namibian finds are sandstone-built casts, in which the sole surface is divided by furrows into elements. Casts were comprehensively studied including thin sections by Pflug *(1973).* Pflug mistakenly thought that the casts resulted from synsedimentary silification of the organisms. According to Pflug, the elements of the cast are the remains of single tubeshaped individuals[1] and were connected by a special fibrous tissue, thus forming a compact leaf-like body (petaloid) of high mechanic stability. As interpreted by Pflug, the corpus of Petalonamae called *petalodium, or flabellum* consisted of few petaloids, connected by fibrous tissue. Group burial or occurrences of casts in successive layers were considered as evidence of connection of the petalodiums. Petalodiums branch off the stalk anchored in the sediment and lie on the bottom surface in Pflug's reconstructions of Petalonamae.

It seems likely that an incorrect assessment of the burial mode of the Petalonamae led Pflug to misinterprete the fossils. Many workers subsequently pointed to discrepancies between drawings and plate illustrations, unconvincing interpretations, or excess speculations in Pflug's studies (Glaessner and Walter, 1975; Scrutton, 1979; Ford, 1979; Glaessner, 1979). Among critical comments was evidence of the incorrect orientation of the petalodium casts during studies (upside down) (Jenkins *et al.,* 1981). Arguments in favor of certain of Pflug's observations were proposed as well (Germs 1973; Jenkins,1985).

A new representative of the Petalonamae, *Ventogyrus chistyakovi gen. et* sp. nov., may change our con-

[1] The elements of the cast that were interpreted by Pflug as impressions of tubes, are regarded here as casts of chambers. The tubes in Pflug's reconstructions are not ducts of the distributary system as in our reconstruction of *Ventogyrus.*

cepts on the structure and mode of life of this enigmatic group of Precambrian organisms.

Ventogyrus chistyakovi gen. et sp. nov. is housed in the Paleontological Institute of the Russian Academy of Sciences (PIN), collection no. 4564.

SYSTEMATIC PALEONTOLOGY

Group PETALONAMAE

Family Pteridiniidae Richter, 1955

Genus *Ventogyrus* Ivantsov et Grazhdankin, gen. nov.

Etymology. From Latin *ventosus gyrus* (windy belt, for the Mountain name Vetrenyi Poyas).

Type species - *Ventogyrus chistyakovi* sp. nov.; Arkhangelsk Region, the Onega River, Upper Vendian, Ust-Pinega Formation.

Diagnosis. Lengthwise baffle s. *medianum* runs from the bow of the depression to inner rib of c. *puppe).* at the stern. *C. puppe).* has triangular base, one of its walls makes sternal side of the body, two others (s. *puppes)* converge within. The depression is compartmentalized into the chambers c. *laterales* by the baffles s. *dividensia* that normally extend from s. *medianum,* then slightly decline toward the bow in orientation relative to s. *medianum.* There are s. *additicia* of the first to fourth orders that extend from s. *medianum* inside the chambers. S. *dividensia* have triangular contour, they are as tall as s. *medianum* at the juncture point and decrease to zero toward the sides of the depression. Composition. Type species.

Comparison. Distinct from *Pteridinium* in the presence of c. *puppe).* at the stern, in triangular contour of the baffle, and in relatively larger dimensions of the chambers: Representatives of *Ventogyrus* additionally possess s. *additicia,* that are absent in *Pteridinium.*

We had no access to *Rangea* Giirich,1930 and *Phyllozoon* Jenkins et Gehling,1978, whereas, the material on *Inkrylovia* Fedonkin, 1979, *Archangelia* Fedonkin, 1979, *Podolimirus* Fedonkin, 1983, and *Valdainia* Fedonkin, 1983 is scanty and unambiguously interpreted. Discussions on similarities and distinctions of *Ventogyrus* and the above listed genera may be premature and are therefore not provided in the paper:

R e т a r k s. *Ventogyrus* can be compared favorably to many familiar representatives of Vendian soft-bodied biota: *Spriginna* Glaessner, 1958, *Marywadea* Glaessner, 1976, *Vendia* Keller, 1969, and *Vendomia* Keller, 1976. It most closely resembles the finds from South Australia as yet undescribed, but variously known as *metameric organisms* (Gehling, 1991; Gehling and Rigby,1996) and *soft-bodied trilobites* (Jenkins,1992). The similarity is in the contour of the impressions with wider and narrower ends, as well as in pattern of furrow arrangement. The listed representatives possess a triangular element and lengthwise furrow that extends from the inner angle of the triangular element to the narrow end. The transverse furrows diverge laterally off the lengthwise furrow. It is difficult to judge from pub

lished illustrations of those forms the presence of a glide reflection symmetry in the furrow arrangement.

Preceding researchers of outcrops in the middle course of the Onega River found a single specimen of *Ventogyrus chistyakovi* and misidentified it as cf. *Arborea* sp. The genus *Arborea* with *Rangea arborea* Glaessner, 1959 as the type species was introduced by Glaessner and Wade (1966) in the revision of the genus *Rangea* of specimens from South Australia. The new genus was distinct from *Rangea* in impressions of the first order branches that fell short of the edge of the foliate impression, and in spicule impressions occurring on the surface of the stalk impression. The name *Arborea* was used as a synonym of *Charniodiscus* Ford, 1958 by further revision of frondlike forms (Jenkins and Gehling, 1978) based on morphological similarity. In our view the lack of axial structure (stalk) and structures for anchoring in sediment distinguish *Ventogyrus* from frondlike organisms such as *Charniodiscus.*

Ventogyrus chistyakovi Ivantsov et Grazhdankin, sp. nov.

P1.1, figs. 1-5; P1. 2, figs. 1-5

cf. *Arborea* sp.: Chistyakov *et a1.,1984,* p.13, fig. 2h.

E t y т o l o g y. After V.G. Chistyakov.

H o l o t y p e. PIN, no. 4564-25; Arkhangelsk District, the middle course of the Onega River, l km downstream from the mouth of the Somba Stream; Upper Vendian, Ust-Pinega Formation, Teksa Subformation (according to Solontsov *et* a1.,1971).

Description. Immobile, unitary, benthic organisms up to 120 mm. long (the length of the organism was reconstructed from the largest incomplete specimen 85 mm long) and up to 62 mm wide, reaching 40 mm and over in height. The upper side of the body forms a deep depression. The body has an ovoid shape in plan, with wider and narrower ends. The thin body has vertically raised edges and resembles in shape a boat with a wide curved hull, tall and wide stern, and narrow raised bow. The rise starts roughly from the midlength, and the raised part is vertical. The sides of the body are supported by vertical baffles that compartmentalize the upper surface into chambers. The height of the sides remains constant over the entire length of the body. The preserved organs are located at the lower, lateral and sternal parts of the body. The body has a somewhat elastic covering.

The chamber *camera puppe).* with triangular base is at the wider end. One of its walls makes the sternal side of the body, two others *(saepta puppes)* converge within. The vertical zigzag baffle *saeptum medianum* runs from the inner rib of the *c. puppe).* to the bow. The body has maximum width at the junctures of s. *medianum* and s. *puppes.* The triangular baffles s. *dividensia* and s. *additicia* extend almost normally from s, *puppes* and s. *medianum.* At the junction point the baffles *s. medianum* and *s. puppes* bend in a zigzag pattern. The symmetry of glide reflection is observed in baffles

Dimensions of the major parameters of the casts of *Ventogyrus chistyakovi*, mm

specimen no.	LC	HC	NLC, L–R	LLC	WLC	LSC	preservation
4564-20							impression of the covering
4564-21-a	34	–	4–4	21	8	20	bent specimen
4564-21-b							fragment
4564-21-c	70	–	7–7	22	12	26	unbent specimen
4564-21-d	–	–	6–4	20	9	–	unbent specimen
4564-22	68	32	12–12	22	10	–	unbent specimen
4564-23							impression of the ducts
4564-24							fragment
holotype							
4564-25	64	–	8–7	23	11	20	unbent specimen
4564-26							impression of the ducts
4564-27							poor preservation
4564-28	84	–	9–9	20	10	24	unbent specimen
4564-29	–	20	–			36	fragment
4564-30	65	20	6–6	22	10	–	bent specimen, fragment
4564-33	60	–	15–7	16	7	16	bent specimen
4564-34	80	40	8–6	22	10	27	bent specimen
4564-35	63	22	6–7	23	11	20	bent specimen
4564-36	80	30	8–	26	16	–	unbent specimen, fragment
4564-37	52	–	6–5	20	12	30	bent specimen
4564-38	62	–	9–6	20	8	–	bent specimen
4564-39	52	–	6–4	20	11	26	unbent specimen
4564-41	52	–	5–5	22	10	–	unbent specimen, fragment
4564-42	70	18	8–6	26	10	–	unbent specimen
4564-43	52	–	8–7	16	8	–	unbent specimen, fragment
4564-45	64	–	6–4	23	11	–	unbent specimen
4564-46	50	10	4–7	24	10	–	unbent specimen
4564-47	32	16	–	22	11	20	poor preservation
4564-49	85	–	7–9	31	15	–	unbent specimen
4564-52	60	–	7–7	14	7	–	unbent specimen
4564-53	56	22	7–3	26	11	–	unbent specimen
4564-54							fragment
4564-56-a	64	–	8–7	18	8	14	unbent specimen
4564-56-b	56	40	5–	–	–	–	unbent specimen
4564-57	45	–	5–6	15	8	18	bent specimen
4564-59	–	–	–	–	–	26	poor preservation
4564-68	50	–	6–8	15	8	–	unbent specimen
4564-74	–	10	–	20	10	16	fragment
4564-76							fragment
4564-80	32	–	3–5	26	9	14	bent specimen

Note: Letter abbreviations: LC-length of cast, HC-height of cast, NLC-number of casts of lateral chambers along left (L) and right (R) sides if one looks on the sole surface of the cast positioned stern down, LLC-length of the lateral chambers, WLC-width of the lateral chambers, LSC-width of the sternal chamber. The following statements are adopted for row "preservation": "bent specimen" means that 8-10 chambers at sternal part have been infilled with sediment, and bow is not preserved, either bends and sinks into the rock, or is preserved as an impression; "unbent specimen" denotes those with more then 10 chambers preserved as casts at sternal part, and with bow preserved either as cast, or not preserved; "impression of the covering" - the thin layer of sandstone is preserved on the cast, it covers the furrows, and it is impossible to take measurements of major parameters without destroying the impression; "impression of the ducts" - the thin layer of sandstone covers surface of the cast and bears impressions of ducts of the distributary system, without destroying the impression it is impossible to take measurements of the major parameters; "poor preservation" implies that cast is incomplete; "fragment" refers to a fragment of cast. The bold font denotes the most complete specimens.

arrangement - the baffles of both sides are shifted at a half of a period relative to the plane that runs along the *s. medianum.* The chamber *c. puppe).* lacks baffles.

The baffle s. *medianum* is the tallest at the sternal part and gradually levels down toward the bow. The baffles *saepta dividensia* compartmentalize the upper side of the body into the chambers *camerae laterales* with a trapezoid base. The baffles s. *dividensia* are as tall as the s. *medianum* at the juncture point, and decrease to zero toward the sides. The upper edge of the *s. dividensia* is complicated by folds. The longest chambers the c. *laterales* adjoint to the *c. puppe).* The dimensions of the chambers gradually decrease toward the bow. The height of s. *dividensia* that diverge off the *c. puppes* rapidly decreases toward the stern.

The baffles *saepta additicia* in the chambers до not reach the sides of depression, have smaller dimensions, are as tall as long, and similarly decrease toward the bow and the stern. The first order s. *additicia* are between the *s. dividensia,* their length does not exceed 1/3 of that of the *s. dividensia.* The second order s. *additicia* are between the s. *dividensia* and first order s. *additicia,* their length reaches a half of those of the first order s. *additicia.* Sometimes the third and fourth order s. *additicia* are visible. The sutures left from the diverging baffles are seen on the impression of the s. *medianum.* A11 the baffles are relatively rigidly jointed with the floor and sides of the depression.

The preserved organs are the system of ducts. The finest ducts form the web beneath the external covering, but fuse together inside the body to form wider ducts less than 1 mm in diameter. The latter empty into the widest duct 1.3 mm in diameter, located under the *s. medianum* and leading toward the sternal part.

Dimensions: see table.

Remarks. The specimen of *Ventogyrus chistyakovi* found by Chistyakov *et al.,* (1984) was figured by Fedonkin (1985, p1.14, fig. 5) as "large frondlike form of uncertain systematic position".

Material. 39 specimens of varied preservation from the type locality.

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