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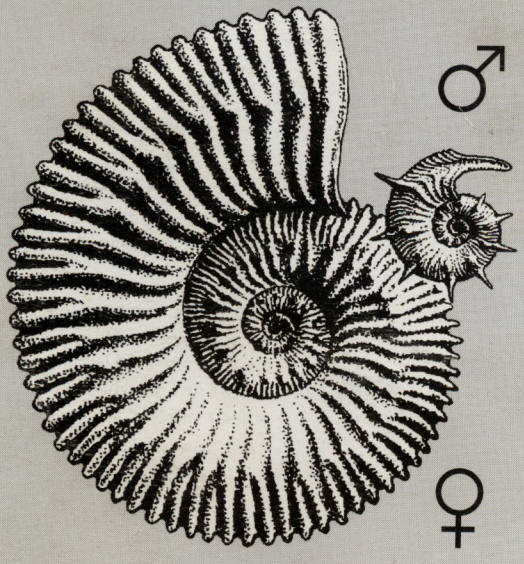
Trilobite-like arthropod from the Lower Cambrian of the Siberian Platform



Warszawa 1999

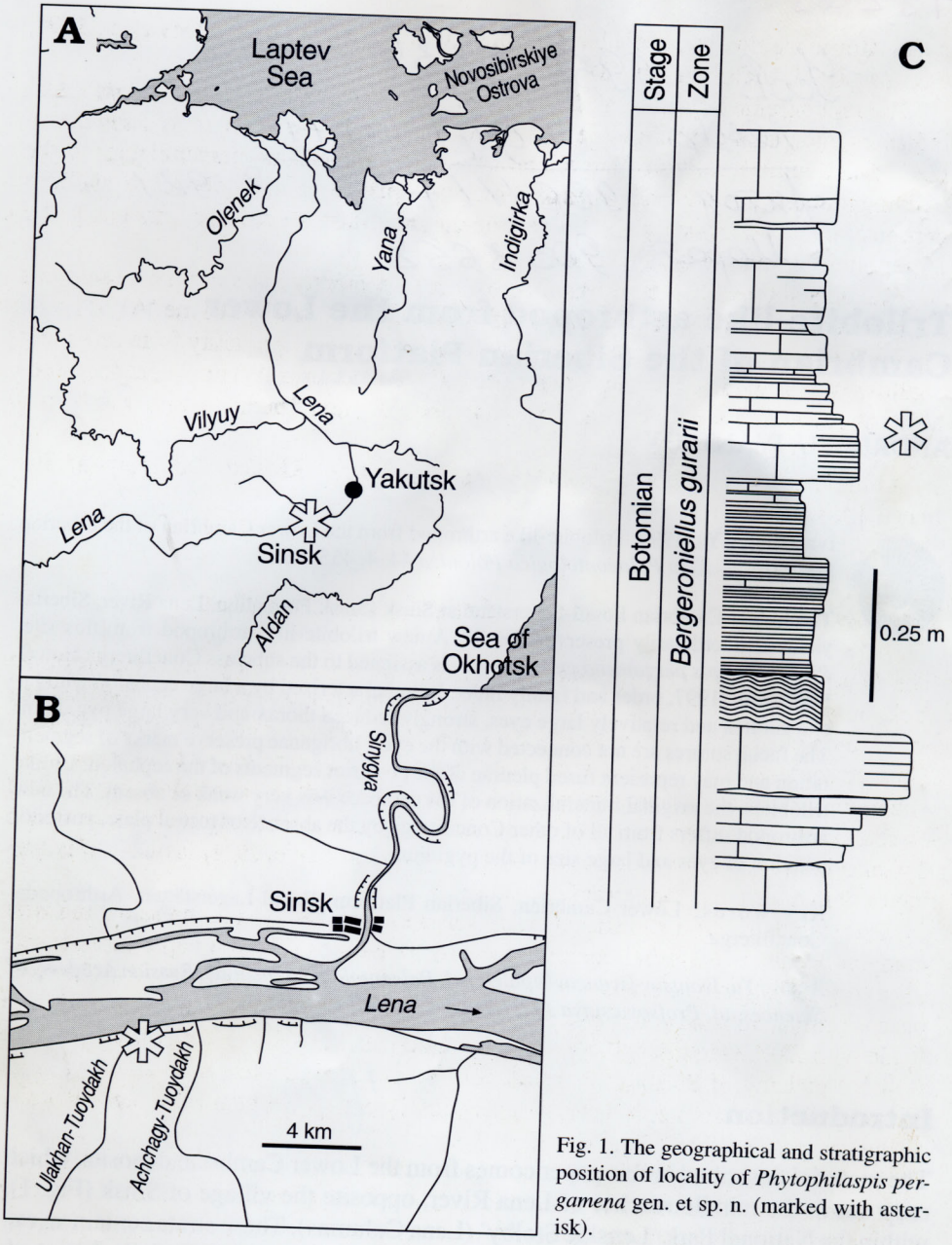


Fig. 1. The geographical and stratigraphic position of locality of *Phytophilaspis pergamena* gen. et sp. n. (marked with asterisk).

Sinsk Formation in the section of Achchagy-Tuoydakh on the right bank of Lena River, 2.5 km below the mouth of Achchagy-Tuoydakh stream (Zhuravlev & Repina 1990).

Besides the *Phytophilaspis* gen. n. and algal remains, the 'Algal Lens' contains also 'true' trilobites, bradoriids, lobopods, palaeoscolecids, undetermined arthropod-like and worm-like remains, articulated and inarticulated brachiopods, sponges,

chancelloriids, eldoniids, probable pterobranchs and acritarchs (Ivantsov *et al.* 1997; Ivantsov 1998; Melnikova 1998).

The taphonomic signature of the fossil assemblage contained in the 'Algal Lens' indicates transportation before the burial. The algal thalli are often broken and crumpled, disarticulated valves of large inarticulate brachiopods are perpendicular to the bedding plane, elongated carapaces of *Phytophilaspis* gen. n. and polymeran trilobites demonstrate approximately the same orientation. Most specimens, especially the larger ones, are turned upside down.

The deposition of Sinsk Formation took place apparently in deep-water conditions near the reef shoals (Bakhturov *et al.* 1988). The fossil assemblage of the 'Algal Lens' obviously formed as a result of transportation of the whole community from relatively shallow-water, photic environment (populated by the community) into a deeper, probably aphotic and anoxic zone, which was succeeded by rapid burial (Ivantsov & Wrona in preparation).

Abbreviation PIN denotes Paleontological Institute, Russian Academy of Sciences, Moscow.

Preparation technique and fossil preservation

The *Phytophilaspis* gen. n. remains (Figs 2, 3) were mechanically extracted from the rock, only in a single case acetic acid was used. If the rock is struck along the bedding plane, a crack usually forms easily along the outer (dorsal) surface of the carapace. Thus, the outer surface of the dorsal shield is almost fully exposed already in the field. The inner surface of the carapace adheres tightly to the rock and can hardly be prepared mechanically. The specimens of *Phytophilaspis* gen. n. occur originally as complete dorsal shields; the incompleteness of several specimens under study is due to weathering or damage during the extraction.

The shields show a significant post-mortem dorso-ventral compression and bear many concentric and radial contortion folds, sometimes giving a paper-like appearance (Fig. 2F). Some sclerites are separated from their neighbours laterally. The carapace is brown, thin and composed of the calcium phosphate (the chemical analysis was made with EDAX-equipped SEM Philips XL 20 in the Institute of Paleobiology of the Polish Academy of Sciences in Warsaw). The external surface of carapace is fairly smooth, while in cross sections it reveals densely packed vertical bars, perpendicular to the carapace surface (Fig. 3G, H).

The wrinkling of the carapace surface indicates that the cuticle was originally rather flexible and thus weakly mineralized. The complete replacement of the cuticular matter by calcium phosphate observed in the specimens is a secondary, post-mortem phenomenon. In contrast, the 'true' trilobites found in the same deposit (often in association with the *Phytophilaspis* gen. n. carapaces) show typical calcium carbonate mineralization.

The matrix beneath the axial carapace of all specimens of *Phytophilaspis* gen. n. and of the largest polymeran trilobites is altered (phosphatized?) to some extent. A narrow zone of strongest mineralization extends from the anterior edge of the glabella towards the end of the rhachis. The carapace of *Phytophilaspis* gen. n. is often deformed

sharply curved upwards above this zone, which presumably represents the mineralized digestive tract.

One of the specimens of *Phytophilaspis* gen. n. with exposed upper surface of the dorsal shield was coated with wax and than treated with 10% acetic acid. The procedure revealed a hypostoma and the basal parts of the anterior limbs (Fig. 3A, B). The remains of appendages are paired, and oval in cross-section. They are filled with rock lighter (after acid treatment) and slightly more resistant to dissolution than the surrounding matrix.

Interpretation of morphology

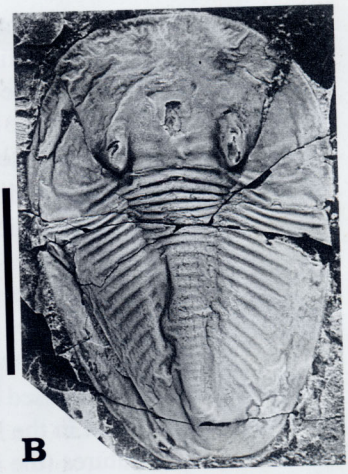
It is difficult to demarcate all the segments and carapace parts of *Phytophilaspis* gen. n. The sutural furrows, which originally separated the sclerotized areas, are masked by fractures formed after the deformation of the exoskeleton. It is obvious that even consolidated borders between the sclerites remained as weaker zones, prone to cracking. The frequency of fractures served as a criterion for distinguishing the originally open sutures from the secondary fractures. There is one limitation, though – the smaller specimens show smaller number and extent of fracturing than the larger ones. This may be explained by assuming that the carapace was tougher during earlier ontogenetic stages, or that the carapace of the larger animals was thicker and less elastic, and so cracked along the weaker zones. A third possibility is that a larger size with higher total convexity made the remains more suitable to compactional compression. Thus, it remains unknown, whether all individuals had fused pleurae of the first two thoracic segments, and whether all specimens, or only small ones, had their pleurae fused with the librigenae. In addition to the open sutures, the dorsal shield had areas with thin cuticle (not preserved) and others, with small sclerotized plates, not developed into prominent sclerites. Such zones connect the thoracic tergites, and the posterior margins of the librigenae with the anterior margin of the pygidium.

Several ways of division of the dorsal shield are possible. However, all of them are imperfect, as in all cases the supposed borders between the shield parts locally may run either along consolidated or along open sutures. The latter ones are secondary and cross the segments transversely.

The librigenae bear arched buttresses radiating from dorsal furrows on their surface. The buttresses are similar to those of the posterior pleural margins in most of the segments. Probably, they are traces of the original segmentation. The tergites corresponding to them are either reduced, or they may represent the posterior rings of the glabella. Thus, the facial sutures cross the four posterior segments of the cephalon transversely and divide them into three parts. The following nine segments, delineated →

Fig. 2. *Phytophilaspis pergamena* gen. et sp. n. **A**. Holotype, PIN 4349/830. **B**. PIN 4349/837. **C–E**. PIN 4349/832. **C**. General view. **D**. Magnified anterior part of the dorsal shield, paired narrow scleritized plates can be observed between the tergites of the thorax segments. **E**. Folding of the posterior margin of the pygidium. **F**. PIN 4349/834, strong deformation indicates for absence (or insignificant extent) of the original mineralization. All scale bars 2 cm.


A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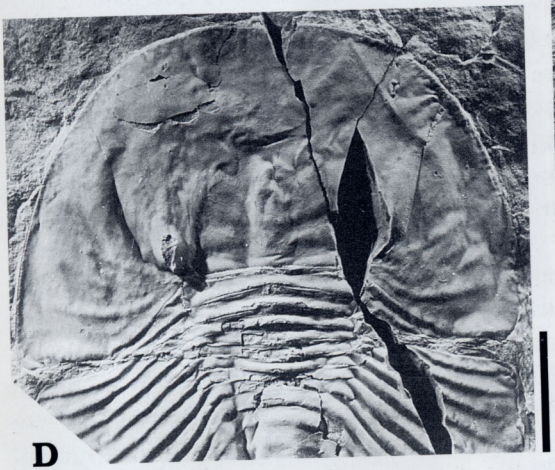
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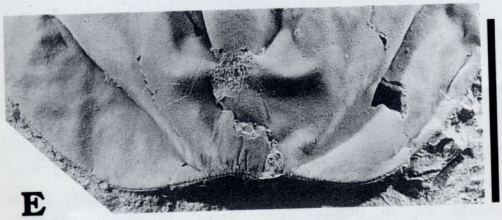

E


F

by open sutures along their entire outlines or only in the axial zone, may be regarded as thorax. The pleurae of two first ones are not fused with each other, but sometimes fused with the librigenae. The pleurae of other segments are completely or largely included into the pygidium. The thorax is thus either completely absent or represented by the tergites of only few segments.

The proposed scheme of division of the dorsal shield is shown in Fig. 4. The facial sutures divide the cephalon into three parts: cranidium (with the preglabellar field, glabella and eyes) and librigenae. The thorax is composed of four segments. Their tergites are articulated with the pleural fragments, although, as mentioned above, the pleurae of the first two tergites sometimes can be fused with the librigenae, while large pleural fragments of the last two tergites are incorporated into the pygidium.

The pygidium is composed of numerous segments. The tergites of the first two segments are still included in the thorax. The tergites of the five following segments are bordered by open sutures (the first two segments – completely, the following three – partially).

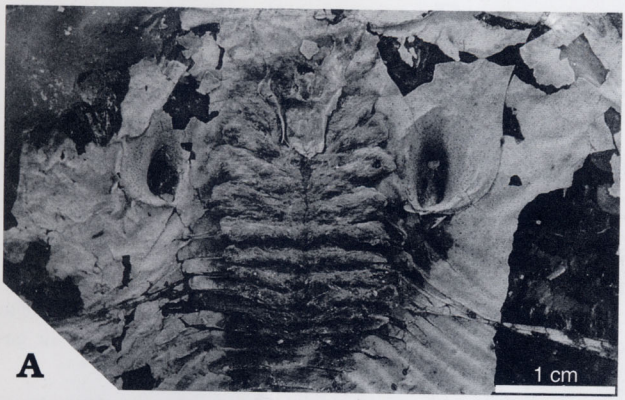
The remains of appendages, which were prepared in a single specimen, offer little information. One can only observe their general outlines and the differences in the sizes of their bases (Figs 3A, B, 4B). The bases of the anterior limbs, especially of the third and the fourth pairs, are the largest. Their size decrease gradually anteriorly and posteriorly, and the appendages could not be divided into distinct size groups.

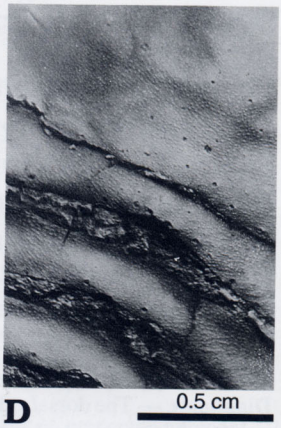
A single pair of appendages corresponds to each segment in the cephalon and thorax. But they do not match exactly: the segment borders on the ventral side are slightly displaced posteriorly with respect to the dorsal ones.

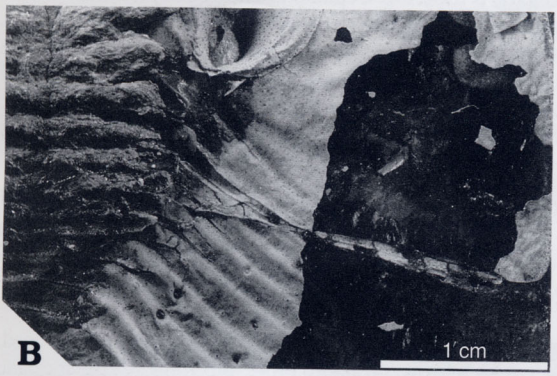
The first four pairs of appendages with the largest bases belong to the cranidium. Four lateral glabellar lobes on the dorsal side of the carapace correspond to the limbs. The hypostoma is elongated and bears extremities on its lateral margin, which are similar to the posterior wings of the hypostoma (Figs 3A, 5). A notch lying in front of the extremity is a place of the antenna insertion (not preserved in the specimens studied). Thus, the cephalon had a single pair of antennae and four pairs of cephalic limbs.

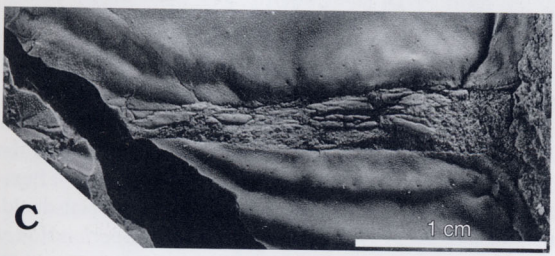
The presence of sharp deformation folds and significant unconformity of the sclerites along their articulation sutures indicate that the vertical compression was rather strong, and the dorsal shield was originally much deeper. In life, the cephalon and the pygidium were closer, and probably in contact through the zone of fine sclerotized plates. Due to this connection, the dorsal shield appears to be a rigid structure, not able to bend significantly. Moreover, the dorsal shield was possibly shed as a whole during moulting. The preservation of *Phytophilaspis* exclusively as complete dorsal shields indirectly confirms this speculation, especially because the polymeran trilobites from the same locality are usually preserved as isolated cephala, pygidia and isolated segments.

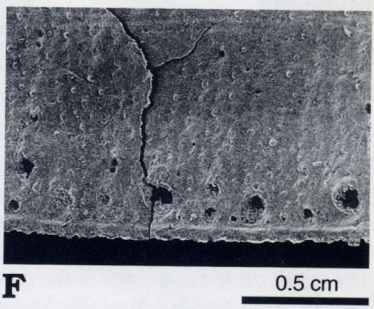
Fig. 3. *Phytophilaspis pergamena* gen. et sp. n. **A**, **B**, **F**–**H**. PIN 4349/841, after treatment with acetic acid. **A**, **B**. Bottom view. **A**. General view. **B**. Magnified fragment. **F**–**H**. Carapace fragments, SEM photos. **F**. Nodular ornament of the outer surface and pores of the cephalon margin, top view. **G**. Columnar structure of the internal side of the carapace, bottom view. **H**. The same area, cross section. **C**. Specimen PIN 4349/832, zone of fine sclerotized plates connecting lateral margins of the cephalon and pygidium.

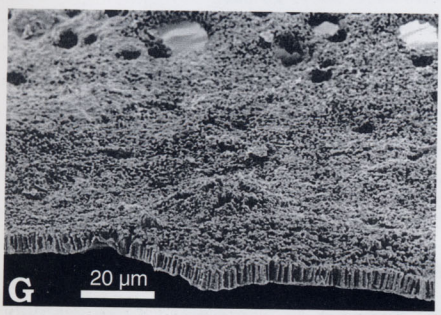


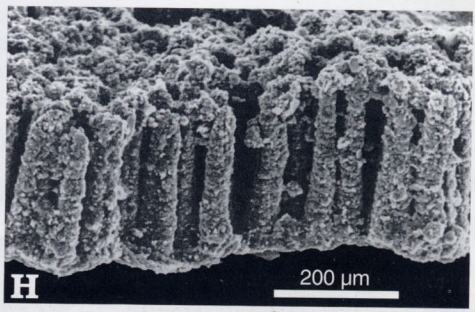












D, E. PIN 4349/830, Ornamentation of the outer carapace surface. **D**. Axial carapace zone, large pores concentrated along the posterior margin of the segments. **E**. The lateral margin of the cephalon.

Systematic description

Phylum Schizoramia Bergström, 1976
Class Artiopoda Hou & Bergström, 1997
Subclass Conciliterga Hou & Bergström, 1997
Order and family indet.
Genus *Phytophilaspis* n.

Type species: *Phytophilaspis pergamena* sp. n.

Derivation of the name: From the Greek: *phyton* – plant, *phileo* – to love, and *aspis* – shield (due to the occurrence of the specimens in an accumulation of algal remains). Grammatically, the generic name is feminine.

Diagnosis. — The dorsal side of the exoskeleton is tripartite. Cephalon bears large eyes, situated near its posterior margin, and segmented librigenae, facial sutures not connected with the eyes. Thorax is reduced and composed of four segments with incomplete pleurae. Pygidium is longer than the cephalon and thorax combined, and consists of at least 24 segments. The first two pygidial segments lack tergites, the tergites of the second to seventh segments are bordered by open sutures. *Phytophilaspis* differs from all of other Conciliterga Hou & Bergström, 1997 by the absence of rostral plate, posterior position of eyes and large size of the pygidium.

Remarks. — *Phytophilaspis* gen. n. shares several features with trilobites: (1) tripartite division of the dorsal shield, both transversely and longitudinally, and presence of prominent pygidium; (2) large eyes, situated on the pleural area of the cephalon; (3) facial sutures, separating the librigenae of the cephalon; (4) pattern of division of the axial zone of the cranidium; (5) shape of the hypostoma.

But the following features differentiate *Phytophilaspis* from trilobites: (1) the thorax is reduced, the cephalon and the pygidium are connected by narrow, probably inflexible zone; (2) the thoracic pleurae are fused with each other and with the pleurae of the cephalon and pygidium; (3) facial sutures do not cross the eyes, so the latter lie entirely within the cranidium; (4) the librigenae include the segments following the eye segment, and not the preceding one; (5) weak original mineralization of the cuticle of the dorsal exoskeleton.

Thus, *Phytophilaspis* fits within the subclass Conciliterga. However, it differs from all other Conciliterga in its absence of rostral plate, posterior position of the eyes and the large size of the pygidium. Probably, the appearance of zones composed of fine sclerotized plates in the areas of flexible articulation was a stage in the process of the segments' consolidation into a solid dorsal shield, similar to the shield of *Tegopelte* Simonetta & Delle Cave, 1975 (Whittington 1985), *Saperion* Hou *et al.*, 1991 and some other Conciliterga.

The optical surface of the eyes on non-deformed carapace took subvertical position, i.e. the surface was orientated laterally. The vertical orientation of the optical surface, mentioned in the diagnosis of subclass Conciliterga by Hou & Bergström (1997), could have been also based on specimens, which underwent severe post-mortem vertical compression.

Occurrence. — Outcrop in the middle reaches of Lena River, Siberia, Russia, opposite the village of Sinsk, within the National Park 'Lenskie Stolby' (Lena Columns), Sinsk Formation, Botomian Stage (*Bergeroniellus gurarii* Zone), Lower Cambrian.

Phytophilaspis pergamena sp. n.

Figs 2–5.

Holotype: PIN 4349/830 (Figs 2A, 3D, E), complete dorsal shield, compressed dorso-ventrally; length – 139.5 mm, width – 94.5 mm.

Type locality: The middle reaches of Lena River opposite the village of Sinsk, mouth of Ulakhan-Tuoydakh stream.

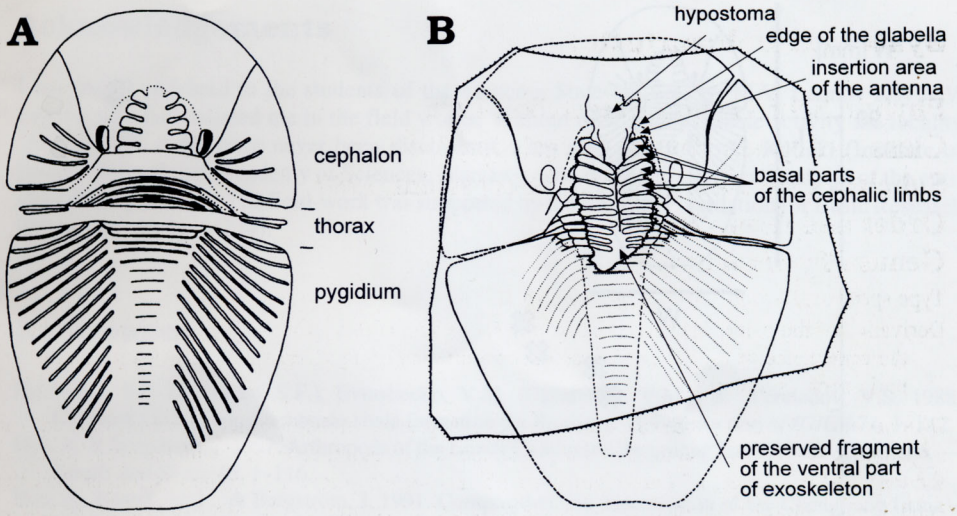


Fig. 4. *Phytophilaspis pergamena* gen. et sp. n. **A**. The scheme of dorsal shield division. **B**. Explanatory drawing to Fig. 3A (specimen PIN 4349/841 in ventral view).

Type horizon: Lower Cambrian, Botomian Stage, *Bergeroniellus gurarii* Zone, Sinsk Formation.

Derivation of the name: From Latin *pergamena* – parchment (due to the wrinkled appearance of carapace, resembling thin parchment or paper).

Diagnosis. — As for the genus.

Material. — Besides of the holotype there are PIN 4348/831-835 and 838-841 from the type locality; PIN 4348/836, downstream Lena River from the type locality, 2.5 km below the mouth of Achchagy-Tuoydakh stream; middle part of the Sinsk Formation.

Description. — The dorsal shield is oval in outline. The length of the specimens varies from 48.6 to 140.0 mm. Mean width to length ratio of almost fully flattened specimens is 0.68 (Fig. 5). The dorsal shield is tripartite. Cephalon is roughly trapezium-shaped, and about 2/5 of the carapace length. The length of its axial zone is 1/3 of the maximum width. The facial sutures divide the cephalon on three parts: cranidium and librigenae. The cranidium has wide preglabellar field, glabella and eyes. The glabella is prominently segmented into five lobes, probably the small unpaired lobe might be also present. The eyes are large, situated on the pleural areas of the cranidium near its posterior margin. Probably, the optical surface of the eyes was oriented vertically on the undeformed carapace. The librigena is roughly triangular in shape, composed of four fused pleurae. The hypostoma is large, elongated, with prominent posterior wings, its narrow posterior margin does not reach the posterior edge of the cranidium. The mode of articulation of the hypostoma with the carapace is unknown: as the single specimen (Fig. 3A) shows, the carapace does neither have doublure nor rostral plate. The single pair of antennae and four pairs of limbs correspond to the cephalon. The basal parts of these appendages are the largest.

Thorax is reduced, composed of four segments with shortened pleurae. The pleurae of the first two segments are usually fused with each other, and sometimes also with librigenae (Fig. 2B). On the margins of the carapace, they are replaced by a narrow zone, composed of two rows of fine scleritized plates. The zone connects the cephalon with pygidium. In the same manner, by means of the zones of fine scleritized plates, the tergites of the thoracic segments join each other, they also join the cephalon and pygidium.

The pygidium is parabolic in outline. Its length is 3/5 of the dorsal shield's length, the rhachis' width is 1/4 of the pygidium's width. Traces of the original segmentation are shown by elongated but-

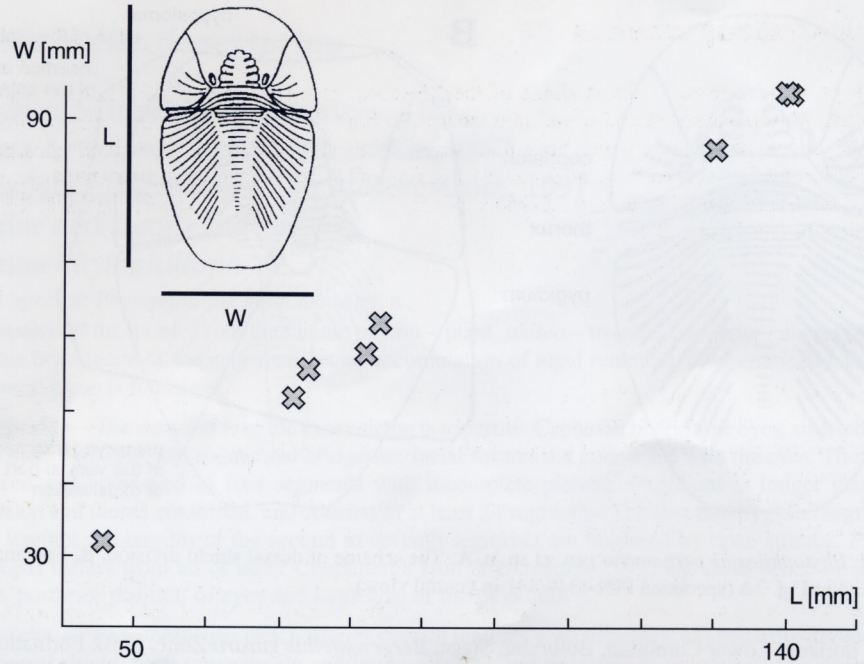


Fig. 5. Width (W) / Length (L) ratio of the compressed carapace of *Phytophilaspis pergamena* gen. et sp. n.

tresses. They are more numerous in the axial part than on pleurae (their number is no less than 24). The tergites of the first five segments are separated by open sutures, the first two – completely, the following three – only in its middle part. The pleurae have at least 18 remnant segments. The first two of them are shortened, while the corresponding tergites belong to the thorax.

The carapace is regularly ornamented by small tightly spaced nodules. Besides them, large, comparatively sparse pores can be observed along the lateral margin of the shield and on the posterior margins of the segments. Regular concentric and radial folds occur near the margins of the cephalon. Both these and irregular folds probably appeared as a result of synsedimentary deformation of the carapace. The cuticle mineralization was weak or absent *in vivo*.

Occurrence. — As for the genus.

Measurements. — Abbreviations: L, length of the carapace; LP, length of the pygidium; W, width of the carapace.

Specimen no.	L	LP	W	W / L	LP / L
PIN 4349/831	131.0	79.9	–	–	0.61
PIN 4349/832	131.0	77.9	85.5	0.65	0.59
PIN 4349/833	74.5	42.0	–	–	0.56
PIN 4349/830	139.5	85.3	94.5	0.68	0.61
PIN 4349/838	140.0	86.7	93.5	0.67	0.62
PIN 4349/837	48.6	27.4	32.0	0.66	0.56
PIN 4349/839	72.5	40.7	52.5	0.72	0.56
PIN 4349/840	82.5	47.0	57.5	0.70	0.57
PIN 4349/841	83.0	50.0	–	–	0.60

Acknowledgements

I am greatly indebted to the students of the Moscow State University: M.V. Leonov and A.V. Leguta, who had assisted me in the field works. Without their indispensable activity the locality 'Algal Lens', could have never been discovered. I am also grateful to C. Kulicki (Institute of Paleobiology, Polish Academy of Sciences, Warsaw), who made the chemical analysis of the cuticle of *Phytophilaspis*. The field-work was supported by the Russian Foundation for Basic Research (Project no. 96-05-64224).

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Трилобитовидная артропода из нижнего кембрия Сибирской платформы

АНДРЕЙ ЮРЬЕВИЧ ИВАНЦОВ

Содержание

В нижнекембрийской синской свите на р. Лене в Сибири открыто местонахождение ископаемых исключительной сохранности. Трилобитовидная артропода из этого местонахождения *Phytophilaspis pergamena* gen. et sp. n., помещена в подкласс Conciliterga Hou & Bergström, 1997 неопределенного отряда и семейства. Она характеризуется большим цефалоном с лицевыми швами и относительно большими глазами, сильно редуцированным тораксом и очень большим пигидием. Лицевые швы не соединяются с глазами. Подвижные щеки сохранют следы сегментации и, возможно, являются слившимися плеврами задних сегмен-

тов цефалона. Между центральными частями торакальных сегментов располагаются зоны мелких склеритизированных пластинок, плевральные же их части разделены швами или сливаются друг с другом и с подвижными щеками. Центральные части первых сегментов пигидия разделены швами, на плевры пигидия не продолжающимися. Цефалон и пигидий соединются на плеврах посредством зоны с мелкими склеритизированными пластинками и поэтому спинная часть панциря образует единый щит. В отличие от трилобитов, первоначальная минерализаци панциря была слабой или отсутствовала. От всех Conciliterga новая артропода отличаетс отсутствием ростральной пластинки, задним расположением глаз и большими размерами хвостового щита.

Trylobitopodobny stawonóg z dolnego kambru tarczy syberyjskiej

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Streszczenie

Dolnokambryjska formacja sinska znad rzeki Leny zawiera doskonale zachowane skamieniałości. Tamtejszy stawonóg *Phytophilaspis pergamena* gen. et sp. n. przypominający trylobita został zaliczony do podgromady Conciliterga Hou & Bergström, 1997, ordo et fam. indet. Nowy rodzaj charakteryzuje się dużą głową ze szwami policzkowymi i dużymi oczami, silnie zredukowanym tułowiem i bardzo dużym pygidium. Policzki ruchome zachowały ślady segmentacji, co wskazuje, że mogą one reprezentować zrośnięte pleury tylnych segmentów cefalonu. W odróżnieniu niż u trylobitów, u *Phytophilaspis pergamena* gen. et sp. n. mineralizacja pancerza była bardzo słaba. Nowy stawonóg różni się od pozostałych Conciliterga brakiem płytki rostralnej, położeniem oczu bardziej w tyle oraz bardzo dużym pygidium.

Trilobite-like arthropod from the Lower Cambrian of the Siberian Platform

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The Lower Cambrian Fossil-Lagerstätte at Sinsk (Sinsk Formation, Lena River, Siberia) yields extraordinarily preserved fossils. A new trilobite-like arthropod from this site, *Phytophilaspis pergamena* gen. et sp. n., is assigned to the subclass Conciliterga Hou & Bergström, 1997, order and family indet. It is characterized by a large cephalon with facial sutures and relatively large eyes, strongly reduced thorax and very large pygidium. The facial sutures are not connected with the eyes; librigenae preserve marks of segmentation and may represent fused pleurae of the posterior segments of the cephalon. Unlike trilobites, the original mineralization of the carapace was very weak or absent. The new arthropod differs from all of other Conciliterga by the absence of rostral plate, posterior position of eyes and large size of the pygidium.

Key words: Lower Cambrian, Siberian Platform, Fossil-Lagerstätten, Arthropoda, Conciliterga.

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Introduction

The material described in this paper comes from the Lower Cambrian deposits, which crop out in the middle reaches of Lena River, opposite the village of Sinsk (Fig. 1), within the National Park 'Lenskie Stolby' (Lena Columns). These strata contain an extraordinarily preserved fossil assemblage (a Fossil-Lagerstätte *sensu* Seilacher *et al.* 1985). They represent the Sinsk Formation, which belongs to the Botomian Stage (*Bergeroniellus gurarii* Zone, see Zhuravlev & Repina 1990).

Most of *Phytophilaspis* gen. n. remains come from a bed, informally named 'Algal Lens', which is typified by the mass occurrence of non-calcified algae. The bed crops out on the right bank of the Ulakhan-Tuoydakh stream, and is situated near the base of the Sinsk Formation (Fig. 1). An additional specimen was found in the middle part of the