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Pristiograptus (Graptoloidea) from the Upper Wenlock of the Baltic Countries

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Abstract—In the Baltic countries, the genus *Pristiograptus* is recognized throughout the *cyphus* to *parultimus–ultimus* zones. The highest diversity of pristiograptids is observed in the Upper Wenlockian *nassa–ludensis* Zone. Only *Pristiograptus* and Retiolitidae are recorded throughout this interval, whilst other characteristic Wenlockian graptolite species become extinct within the latter. Accordingly, only members of the genus *Pristiograptus* can be effectively used in detailed graptolite biostratigraphy of the *nassa–ludensis* interval. In the upper Homerian, *lundgreni*, *nassa, virbalensis*, and *ludensis* graptolite zones are distinguished. The *nassa* Zone can be divided in two parts: the lower one with *Pristiograptus parvus* Ulst and *Gothograptus nassa* (Holm) and the upper one with *G. nassa* and *P. dubius ludlowensis* (Bouček). The *virbalensis* Zone can is also subdivided in two parts: the lower one with *P. virbalensis* Paškevičius and *P. praedeubeli* (Jaeger), and the upper part with *P. virbalensis* and *P. deubeli* (Jaeger). The above biostratigraphic units can be used in the eastern Baltic areas. Extended descriptions of index taxa of the pristiograptids from the *virbalensis* Zone are presented.

Key words: *graptolites, Pristiograptus*, biostratigraphy, taxonomy, Silurian, Upper Wenlock, Baltic States.

INTRODUCTION

Representatives of the genus Pristiograptus are common nearly throughout the entire Silurian section in the East Baltic area. They are recorded from *cyphus* (Lower Llandovery) to *parultimus–ultimus* (lower part of the Pridoli) zones (Paškevičius, 1997). Ulst (Gailite *et al.*, 1967, Ulst, 1974, Gailite *et al.*, 1987) investigated the *Pristiograptus* species of the Wenlock–Ludlow boundary interval in the Baltic Syneclise. She revealed detailed distribution pattern of graptolites from an upper part of the *testis* Zone up to the lower part of the *nilssoni* Zone. Paškevičius (1974, 1997) improved the graptolite zonation (Table 1) and described distribution of graptolites in the *testis–nilssoni* interval. All species

Table 1. Correlation of Lithuanian and Latvian graptolite biozones with zonations of Central Asia, the Czech Republic (the boundary between the *gerchardi* and *ludensis* zones is placed higher since *C. gerchardi* disappear in the Lower Ludlow, Kozlowska-Dawidziuk *et al.*, 1998), and Arctic Canada (Lenz, 1994)

<table>
<tr><th rowspan="2">Series</th><th rowspan="2">Stage</th><th colspan="4">Graptolite zonation</th><th rowspan="2">Lithuanian regional stage</th><th rowspan="2">Formation (member)</th></tr>
<tr><th>Central Asia</th><th>Czech Republic</th><th>Arctic Canada</th><th>Lithuania Latvia</th></tr>
<tr><td>Ludlow</td><td>Horstian</td><td>nilssoni colonus</td><td>nilssoni</td><td>nilssoni colonus</td><td>nilssoni</td><td>Dubysa</td><td rowspan="4">Siesartis</td></tr>
<tr><td rowspan="5">Wenlock</td><td rowspan="4">Homerian</td><td>ludensis</td><td>gerchardi ludensis</td><td>ludensis</td><td>ludensis</td><td rowspan="3">Géluva</td></tr>
<tr><td>deubeli</td><td rowspan="2">deubeli praedeubeli</td><td rowspan="3">deubeli praedeubeli</td><td rowspan="2">virbalensi deubeli</td></tr>
<tr><td>sherrardae praedeubeli</td></tr>
<tr><td>nassa dubius</td><td>nassa dubius</td><td>nassa</td><td>Ančia (m)</td></tr>
<tr><td>lundgreni testis</td><td>lundgreni</td><td>lundgreni testis</td><td>lundgreni</td><td>Laagarahu</td><td>Ragainé</td></tr>
</table>

Note: (m) member.

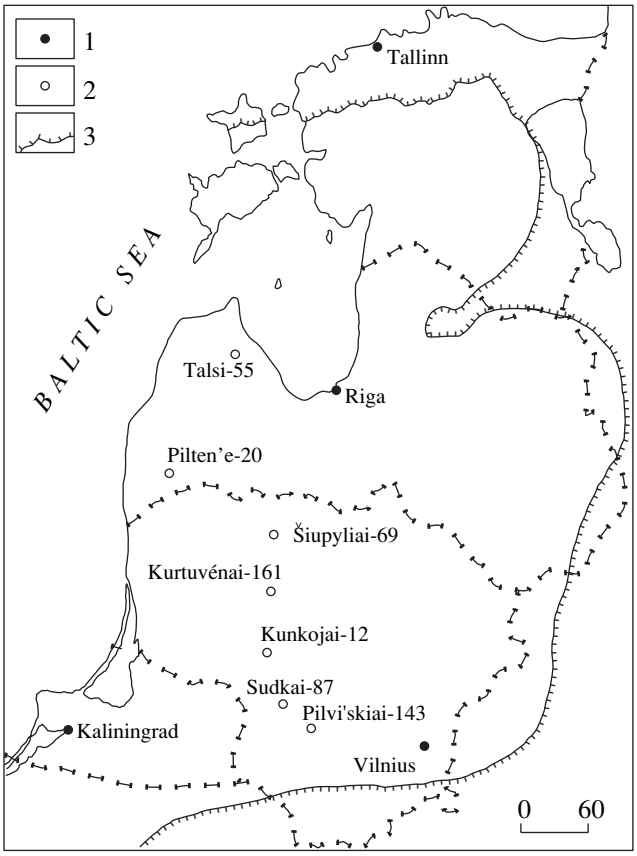

Fig. 1. Localities of examined boreholes and distribution of Silurian rocks in the Baltic region: (1) major cities; (2) boreholes, (3) boundary of Silurian rocks distribution area.

of the genera *Cyrtograptus, Monoclimacis*, and *Monograptus*, which are generally characteristic of the Wenlock in the East Baltic area, become extinct in the late Wenlock, at the end of the *lundgreni* time. Higher in the section, up to the Wenlock end (*nassa–ludensis* time), only *Pristiograptus* and Retiolitidae occur. New peculiar genera and species of monograptids appeared and became widespread only from the beginning of the Ludlow. Because of that, the genus *Pristiograptus* plays a very important role in biostratigraphy of the *nassa–ludensis* interval in the East Baltic region.

In Asia and Arctic Canada, monograptid species morphologically intermediate between the typical Wenlock and Ludlow taxa (*Lobograptus sherrardae* (Sherwin), *Pristiograptus idoneus* Koren) appear in the *praedeubeli–ludensis* zones (Koren and Suyarkova, 1994; Lenz, 1994b). The genus *Pristiograptus* is recorded in this region as well, but its species differ from those recognized in the East Baltic area.

The aim of this study is to describe and modify the upper Wenlockian graptolite zonation in the southern East Baltic region. The description of graptolites *P. deubeli* (Jaeger) and *P. paradeubeli* (Jaeger) from the *virbalensis* zone, which have been found in the East Baltic area, is given for the first time. *P. virbalensis* (Paškevičius) is described in more detail because this species is poorly known but abundant in the *nassa–ludensis* zones.

MATERIAL

Pristiograptids were studied in core sections of the boreholes Šiupyliai-69, Kurtuvénai-161, Kybartai-14, Sudkai-87 (Lithuania), Talsi-55, and Priekulé-22 (Latvia). All the boreholes are located in the northwestern part of the East European platform, in Lithuania and Latvia (Fig. 1). The maximum thickness of the Silurian in examined borehole sections is as high as 850 m. In the Boreholes Šiupyliai-69, Kurtuvénai-161, and Sudkai-87, graptolites were studied from the intervals of 966–1010 m (50 samples), 1274–1330 m (45 samples), and 760–805 m (25 samples), respectively. In the Borehole Kibartai-14, one sample was studied from the depth of 1071.8 m. Pristiograptids from the Borehole Talsi-55 were examined in the R. Ulst's collection in Riga, they originate from the interval of 603–640 m. Materials of the Borehole Priekulé-20 from the depths of 1156.6, 1046.4, and 1145.6 m were kindly donated for examination by D. Kaljo (Tallinn). All this material is from the interval of the *lundgreni–nilssoni* zones.

Photos of graptolites were made using a scanning electron microscope (SEM) in the Lund University (Sweden) and at the Laboratory of Material Research of the Tallinn Technical University (Estonia). Terminology used in this work is after Teller (1964) and Radzevičius and Paškevičius (2000).

BIOSTRATIGRAPHY

Based on available extensive data on upper Homerian graptolites, the range zones *lundgreni, nassa, virbalensis, ludensis*, and *nilssoni* are distinguished within this stratigraphic interval in the East Baltic region.

The appearance level of *Pristiograptus parvus* Ulst and *Gothograptus nassa* (Holm) corresponds to the lower boundary of the Upper Wenlockian *nassa* Zone (Fig. 2). The upper part of the *lundgreni* Zone is marked by extinction of many species and subspecies characteristics of the Wenlock, e.g., of *Monograptus testis testis* (Barrande), *M. testis inornatus* Elles, *M. flemingi flemingi* (Salter), *M. flemingi compactus* Elles et Wood, *Pristiograptus pseudodubius* (Bouček), *P. lodenicensis* Přibyl, and *Monoclimacis flumendosae* (Gortani). The genus *Cyrtograptus* becomes extinct at the same level as well. Taking this into consideration, we determine the lower boundary of the *nassa* Zone at the extinction level of the species mentioned above. In the East Baltic area, this event is confined to the base of microlaminated marls and clayey limestones of the Ančia Member. The member usually as thick as 1 or 2 m is distinguishable in western sections of the East Baltic area.

The lower part of the *nassa* Zone is marked by appearance of *P. parvus* and *G. nassa* (Paškevičius,

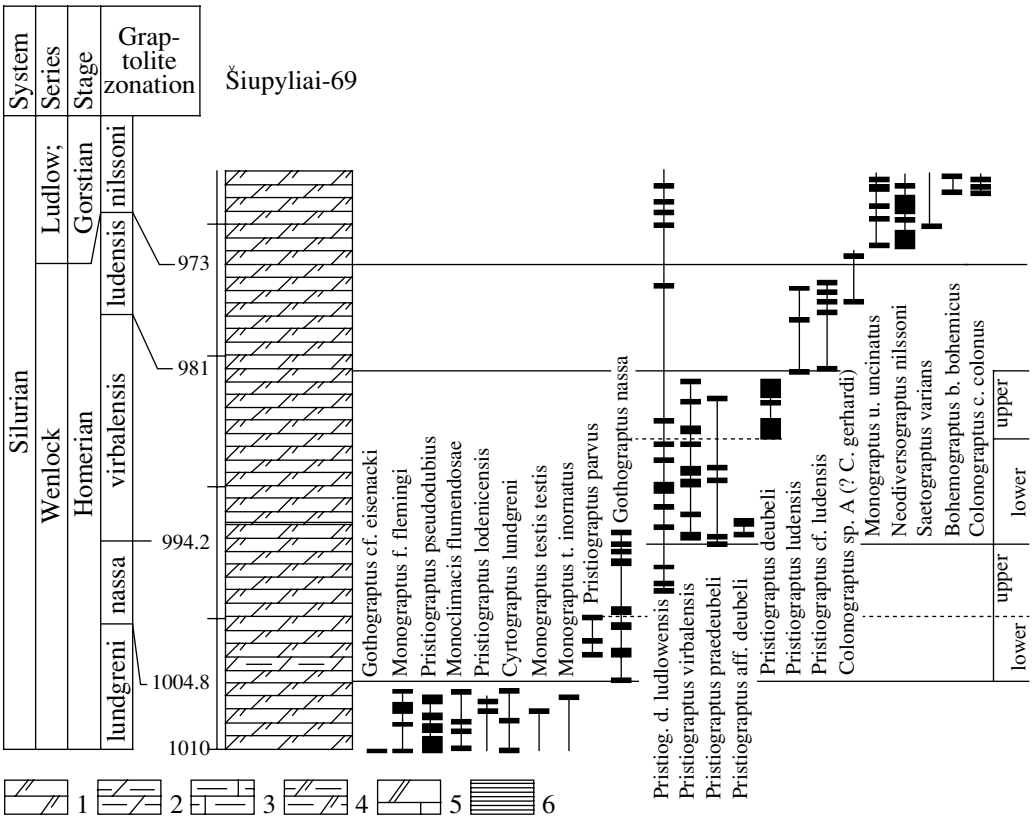

Fig. 2. Distribution of graptolites in the Wenlock–Ludlow boundary interval of the Šiupyliai-69 borehole: (1) dolomitic marl; (2) limy marl; (3) argillaceous limestone; (4) argillaceous dolomitic marl; (5) dolomitic marl with limestone interbeds; (6) argillite (proposed subzones are shown right of the distribution chart).

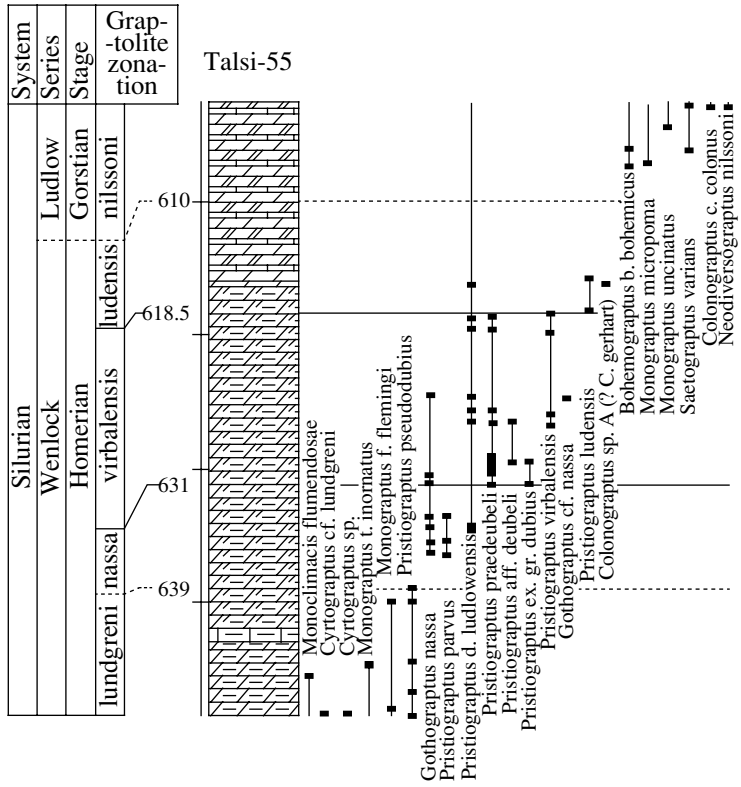

Fig. 3. Distribution of graptolites in the Wenlock-Ludlow boundary interval of the Talsi-55 borehole (proposed subzones are shown right of the distribution chart; symbols as in Fig. 2).

Table 2. Composite range chart of most widespread key graptolite species in the Wenlock–Ludlow boundary interval of the East Baltic region

Species \ Graptolite zones	*lundgreni* (upper part)	*nassa*		*virbalensis–deubeli*		*ludensis*	*nilssoni* (lower part)
		l.	u.	l.	u.		
Gothograptus eisenacki							
Monograptus t. *testis*							
Monograptus t. *inornatus*							
Monograptus f. *flemingi*							
Monograptus f. *compactus*							
Monoclimacis flumendosae							
Pristiograptus pseudodubius							
Pristiograptus lodenicensis							
Cyrtograptus lundgreni							
Gothograptus nassa							
Pristiograptus parvus							
Pristiograptus d. *ludlowensis*							
Pristiograptus virbalensis							
Pristiograptus praedeubeli							
Pristiograptus deubeli							
Colonograptus ludensis							
Colonograptus sp. A (*C. gerhardi* ?)							
Neodiversograptus nilssoni							
Monograptus uncinatus							
Saetograptus varians							
Bohemograptus b. *bohemicus*							
Colonograptus c. *colonus*							

Note: (l) lower; (u) upper.

1997). *P. parvus* is widespread only in a very narrow interval within the lower part of the *nassa* Zone. Vertical distribution range of this species is about 3 m in the examined section. New subspecies *P. dubius ludlowensis* (Bouček) appears above the disappearance level of *P. parvus.* The subspecies is of a wide stratigraphic range, getting up to the uppermost Ludlow. Based on distribution ranges of mentioned taxa, the *nassa* Zone can be divided in two parts, the lower one with *P. parvus* and *G. nassa* and the upper one with *P. dubius ludlowensis* and *G. nassa* (Table 2). The total thickness of the *nassa* zone varies from 8.5 to 10.6 m in the studied core sections.

The lower boundary of the *virbalensis* Zone coincides with the appearance level of *P. virbalensis* (Paškevičius) and *P. praedeubeli* (Jaeger). The zone is distinguishable in most graptolite-bearing sections of the eastern Baltic area. The species *P. deubeli*, that appears later, occurs in the upper part of the zone only and is scarce in the East Baltic area. The *virbalensis* Zone can also be divided in two parts, the lower one with *P. virbalensis* and *P. praedeubeli* and the upper part with *P. deubeli*. After obtaining additional evidence from other sections, these units could be ranked as subzones,

Pristiograptus forms *dubius, virbalensis*, and *deubeli* from the above zone of the adaptive type (Radzevičius and Paškevičius, 2000). *Pristiograptus ludensis* (Murchison), the index species of the next zone appears first in the upper part of the *virbalensis* Zone that ranges in thickness from 12.5 to 13.2 m in the studied borehole sections (Fig. 3).

Ulst (1974) described *P. talsiensis* from the same interval. This species is identified in specimens, which are classed with *P. virbalensis* and *P. praedeubeli* at present.

The *ludensis* Zone can be distinguished only in the central part of the Baltic Silurian basin, in shallow–water formations with rare graptolites. Its lower boundary coincides with the appearance level of *P. ludensis.* Subspecies *P. dubius ludensis* occurs in the zone as well. Appearance of *Colonograptus* sp. A. [?=*C. gerchardi* (Kuhne)] is recorded in the upper part of the zone (Fig. 4). This species transits into the Ludlow in

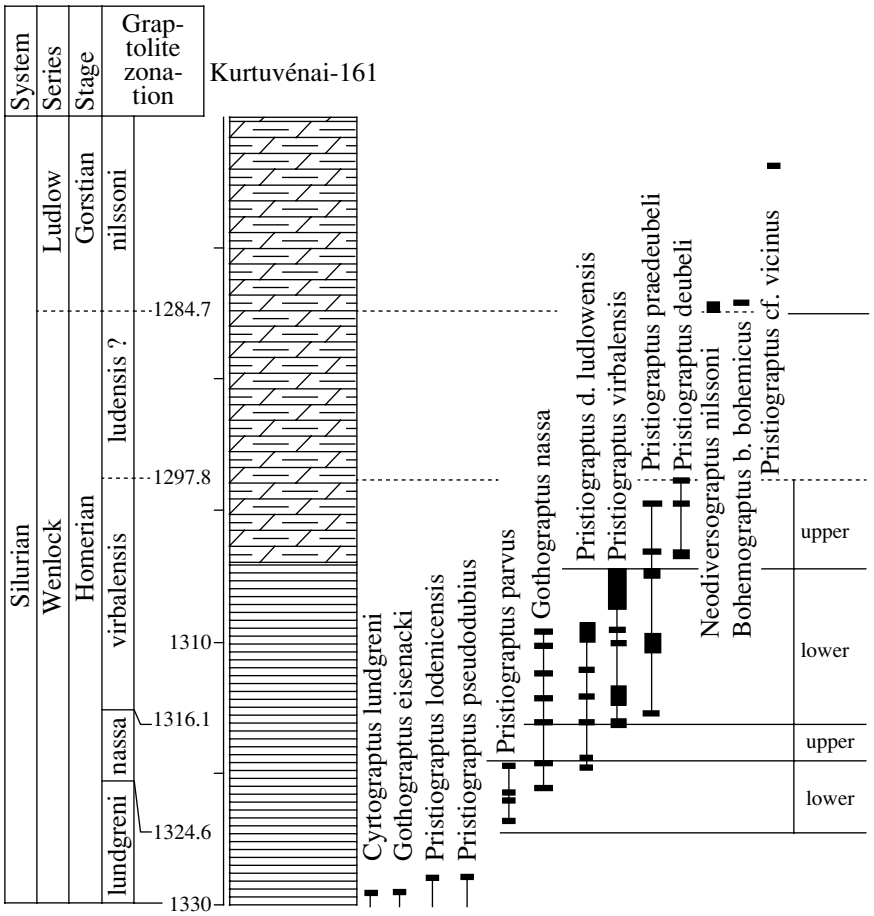

Fig. 4. Distribution of graptolites in the Wenlock-Ludlow boundary interval of the Kurtuvénai-161 borehole (proposed subzones are shown right of the distribution chart; symbols as in Fig. 3).

the East Baltic area. The upper boundary of the *ludensis* Zone marks the appearance of several new graptolite genera and species characteristic of the Ludlow.

SPECIES DESCRIPTION

Specimens described here are stored at the Department of Geology and Mineralogy of the Vilnius University. Their drawings are ours. Following symbols are used in description of pristiograptids: (L) length of rhabdosome with sicula; (W) rhabdosome width; ($T^{1, 2, 3...n}$) rhabdosome width near the first, second and subsequent thecae.

Family Monograptidae Lapworth, 1873

Genus *Pristiograptus* Jaekel, 1889

Pristiograptus virbalensis Paškevičius, 1974

Plate II, figure F

Pristiograptus virbalensis sp. nov.: Paškevičius 1974, p. 128, figs. 3–6, text-fig. 2;

Pristiograptus virbalensis Paškevičius: Paškevičius, 1979, p. 155–157b, pl. IX, figs. 1–2, pl. XXIV, figs. 3–6.

Pristiograptus virbalensis Paškevičius: Radzevičius and Paškevičius 2000, p. 96–97, pl. III, figs. 1–2, pl. VI, fig. G.

Holotype. *Pristiograptus virbalensis* Paškevičius, 1974, p. 128, Pl. 17, Figs. 3a, b; text-fig. 2a. Lithuania, Virbalis-5 core, depth 1026.75 m, specimen 920, Upper Wenlock, *virbalensis* Zone. Holotype is stored in the Geological Museum of the Department of Geology and Mineralogy of the Vilnius University.

Material. About 20 rhabdosomes and their fragments from the cores of Kurtuvénai-161, Šiupyliai-69, Virbalis-5 and Sudkai-87 boreholes.

Description. Rhabdosome is large, its proximal end is curved to ventral side against 5–8 thecae, L = 30–40 mm, W against T^1, T^2, T^3, T^4, T^5, and T^{10} is 0.8, 1, 1.1, 1.3, 1.4, and 1.8 mm, respectively. W_{max} up to 2–2.5 mm is observable against 10 to 15 thecae. W without aperture edge of theca against T^1, T^2, T^3, T^4, and T^5 is 0.7, 0.8, 1, 1.1, and 1.2 mm, respectively. Thecae are quadrangular and inconsiderably narrowing towards the mouth. Length of the first theca is 1.2 mm, its width up to 0.4–0.5 mm. The slightly concave nose of aperture edge is not as distinct as in *Pristiograptus* species

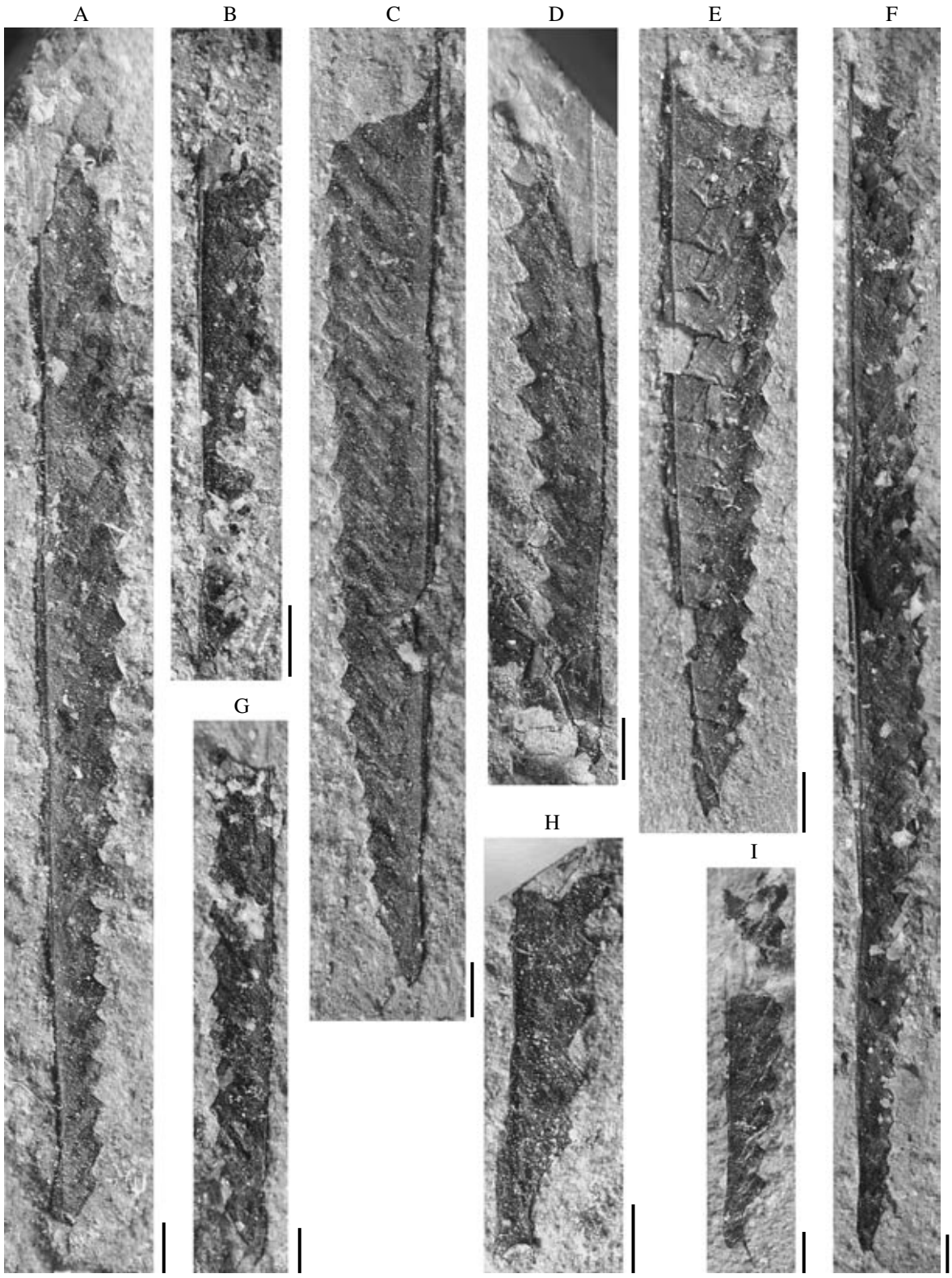

Plate I. Pristiograptids from the Wenlock–Ludlow boundary sediments of the Baltic region.
A. *Pristiograptus deubeli* (Jaeger), Šiupyliai-69, 988.3 m, 861; B. *Pristiograptus deubeli* (Jaeger), Šiupyliai-69, 983.9 m, 853; C. *Pristiograptus praedeubeli* (Jaeger), Šiupyliai-69, 991.9 m, 843; D. *Pristiograptus* aff. *praedeubeli* (Jaeger), Kurtuvėnai-161, 1310.4 m, 867; E. *Pristiograptus* cf. *ludensis* (Murchison), Piltené-20, 1156,6; F. *Pristiograptus praedeubeli* (Jaeger), Šiupyliai-69, 991.8 m, 851; G. *Pristiograptus praedeubeli* (Jaeger), Šiupyliai-69, 988.2 m, 821; H. *Pristiograptus deubeli* (Jaeger), Šiupyliai-69, 983.9 m, 854; I. *Pristiograptus praedeubeli* (Jaeger), Šiupyliai-69, 991.7 m, 839. Scale bar is 1 mm.

Plate II. Pristiograptids from the Wenlock–Ludlow boundary sediments of the Baltic region.
A. *Pristiograptus* cf. *deubeli* (Jaeger), Pilvi škiai-143, 779.5 m, S.P143–84; B. *Pristiograptus parvus* Ulst, Kybartai-14, 1071.7 m, P.K14-108; C. *Pristiograptus praedeubeli* (Jaeger), Sudkai-87, 776 m, P.S87–134; D. *Pristiograptus praedeubeli* (Jaeger), Pilvi škiai-143, 779.5 m, S.P143–148; E. *Pristiograptus virbalensis* Paškevičius, Sudkai-87, 768.9 m, P.S87–71; F. *Pristiograptus lodenicensis* Přibyl, Paroveja-9, 561.9 m, P.P9–1; G. *Pristiograptus deubeli* (Jaeger), Šiupyliai-69, 983 m, S.S69–61. Scale bar is 1 mm.

of the *dubius* type. The aperture edge of first thecae resembles those in thecae of the *dubius* type, but the medium and distal parts of the thecae have no distinctly concave thickened nose of aperture edge. The inclination angle between the nose of aperture edge and the thecal axis is also different. In the proximal part of the rhabdosome, the aperture edge forms an acute angle (63–68°) to the thecal axis (Fig. 3), whereas in the medial and distal parts the edge of thecal aperture is perpendicular to the thecal axis. The overlapping part of the theca equals 2/3 of the entire thecal length. Thecae are inclined to the rhabdosome axis at angle of 30–40°. In the interval of 10 mm, 10 to 11 thecae are counted. Sicula is narrow, conical, slightly bent to the ventral side of rhabdosome. Its length is 2.25–2.5 mm, width against the mouth is 0.4 mm. Sicula mouth is slightly concave. Mouth bend is asymmetrical and shifted toward virgella. The apex of sicula is positioned near the nose edge of the second thecae. The uncovered part of sicula equals 0,2 mm. Virgella is large, obtuse, 0.7–0.8 mm long and 0,1 mm wide. Virgula terminates with a small drop-like structure.

Comparison. *P. virbalensis* is very much similar to *P. auctus* found in England (Paškevičius, 1979). The virgella of *P. auctus* has a considerable bulge while the virgella of *P. virbalensis* is only slightly thickened. The first theca of *P. auctus* begins against the sicula mouth, whereas that in *P. virbalensis* begins at a distance of 0.2 mm from the sicula mouth. In addition, *P. auctus* is known from higher horizons of the lower Ludlow than *P. virbalensis.*

P. virbalensis differs in thecae morphology from *P. praedeubeli* and *P. deubeli.* Thecae in two last species are cylindrical, the first four to five thecae are of the colonograptid type (Radzevičius and Paškevičius, 2000), whereas thecae in *P. virbalensis* are quadrangular, and aperture margins of the first thecae are similar to those in the *Pristiograptus* species of the *dubius* type. In distinction from *P. virbalensis*, end of virgella of the *P. pradeubeli* and *P. deubeli* species is lacking droplike shape.

In contrast to *P. deubeli ludlowensis* (a species of the *dubius* type), *P. virbalensis* has different edges of thecal aperture. The aperture edge in *P. deubeli ludlowensis* is situated at an acute angle to the thecal axis in distinction from right angle characteristic of *P. virbalensis.*

Association. In the East Baltic region, *P. virbalensis* is found together with *P. piltenensis* Koren et Ulst, *P. deubeli ludlowensis* (Bouček), *P. praedeubeli* (Jaeger), *P. deubeli* (Jaeger) and *Gothograptus nassa* (Holm).

Age and geographic distribution. *P. virbalensis* is widespread in the entire territory of the East Baltic region. It is found in the *virbalensis* Zone of the Homerian Stage, (Géluva regional stage), Upper Wenlock. Outside the Baltic region, the zone interval corresponds to *praedeubeli-deubeli* zones of Arctic Canada, Gotland Island (Sweden), South Urals (Russia), northern Naratau and the Alai Ridge (Central Asia), and in eastern Poland (Fig. 1).

Pristiograptus praedeubeli (Jaeger, 1991)

Plate I, figs. C, F, G, I, Plate II, figs. C, D.

Monograptus ludensis (Murchison): Holland *et al.*, 1969, p. 670, fig. a;

Pristiograptus jaegeri: Holland *et al.*, 1969, p. 670, text-plate 120, fig. m (partim);

Pristiograptus praedeubeli (Jaeger): Jaeger, 1991, pp. 318–326, pl. 26, figs. 1–8; pl. 27, figs. 1–11, 14, pl. 29, fig. 11, text-figs. 4-18;

Pristiograptus praedeubeli (Jaeger): Koren and Suyarkova, 1992, pp. 95–97, pl. 8, figs. B–E, pl. 9, figs. A, B, D, E;

"Pristiograptus" praedeubeli (Jaeger): Lenz, 1994a, p. 1420, pl. 2, figs. 2 E–G, pl. 3, figs. 3A–E;

"Pristiograptus" ludensis (Murchison): Lenz 1994a, pl. 3, fig. G (partim);

Colonograptus ? praedeubeli (Jaeger): Gutierrez-Marco *et al.*, 1996, p. 660, pl. 1, figs. 4–6;

Colonograptus ? praedeubeli (Jaeger): Kozlowska-Dawidziuk, 1997, p. 394, text-fig. 2;

Colonograptus praedeubeli (Jaeger): Zhang and Lenz, 1997, p. 1227, pl. 4, figs. 4 A–D; pl. 5, figs. 5 T–W.

Pristiograptus praedeubeli (Jaeger): Radzevičius and Paškevičius, 2000, pp. 98–99, pl. V, figs 2–5; pl. VI, fig. E.

Holotype. Reproduction of the *Monograptus praedeubeli* Jaeger figure published by Jaeger (1991), Plate 27, Fig. 2 (proximal part) and Plate 20, Fig. 3 (whole rhabdosome of the holotype); g697.1.12 erratic boulders, near Rügen Island, Baltic Sea, the *pradeubeli* Zone.

Material. More than 50 rhabdosomes and their fragments from the cores of Kurtuvėnai-161, Sudkai-87 and Šiupyliai-69; specimens characterizing the last two sites are macerated in HCl.

Description. Rhabdosome is massive, long, inconsiderably curved to dorsal side in proximal part. The curvature is caused by sicula, which leans to dorsal side of the rhabdosome axis (virgula). The sicula is heavily bent to the ventral side against mouth and embraces the beginning of first theca. L is up to 25 mm, though longer rhabdosomes could perhaps be found too. The collection lacks complete rhabdosomes. W against T^1, T^2, T^3, T^4, and T^5 is 0.76–0.80, 0.8–0.9, 0.9-1.0, 1.0–1.15, and 1.11–1.25 mm, respectively. W at T^{10} is 1.25 mm. The rhabdosome is widening rapidly between the first and fourth to fifth thecae, while further on its width remains nearly constant. W_{max} is against thecae 18 to 20, being up to 1,8–2.0 mm wide. W without aperture edge of thecae against T^1, T^2, T^3, T^4, T^5, and T^{10} is 0.55–0.60, 0.6–0.7, 0.65–0.80, 0.7–0.9, 0.85–0.90, and 1.00–1.15 mm, respectively. Thecae are cylindrical. The first theca is 1.1 mm long and 0.35 mm wide. First four thecae differ from thecae located in the

medial and distal parts of the rhabdosome because of original zigzag-form edge nose of thecal aperture. In the middle and distal parts of rhabdosome, edge gets smoother. Apertural margins of medial and distal thecae are straight. The distal thecae are larger, 1.7–2.0 mm long and 0.6–0.8 mm wide. In the proximal end of rhabdosome, free parts of thecae are as long as 2/5 of their whole length, while in the distal part the proportion is 1/3. Thecae are inclined to the rhabdosome axis at angles of 30–35°. In the proximal part of rhabdosome, 12 to 13 thecae are counted in 10 mm interval, and this parameter in distal part is 10.0 to 11.5. Sicula is massive, 1.9–2.0 mm long and 0.25–0.30 mm wide, curved dorsally. The apertural part of sicula is strongly curved ventrally, resembling a horn in shape. The curvature begins in the free part of the sicula, which is 0.40–0.45 mm long. The apertural side of sicula is concave, deepening down to 0.15 mm. A massive acute virgella 0.8–1 mm long is embedded in the sicula wall. The sicula apex is approached to aperture of the second theca.

Comparison. *P. praedeubeli* and related *P. deubeli* (Jaeger) differs from each other in proximal parts. The horn-like sicula of *P. praedeubeli* is curved ventrally in its free part, whereas sicula of *P. deubeli* is conical, widening toward the aperture. The species also differ in thecae overlapping. The free part of a Thecae of *P. praedeubeli* are free for 2/5 or 1/3 of their length, whilst thecae of *P. deubeli* are half-overlapped.

There is much of similarity between the *P. praedeubeli* and *P. sigmoidalis* (Přibyl, 1943), although there are differences as well. Rhabdosome of *P. sigmoidalis* is curved dorsally in its proximal part, whereas that of *P. praedeubeli* it deprived of curvature. In addition, rhabdosome of the former is a little broader than that of the latter (2.2 versus 2 mm).

Association. In the East Baltic region, *P. praedeubeli* is found together with *P. virbalensis* Paškevičius, *P. deubeli ludlowensis* (Bouček), *P. deubeli* (Jaeger), *Gothograptus nassa* (Holm), and other retiolitids.

Age and geographic distribution. *P. praedeubeli* is widespread through the entire East Baltic region, where it occurs in the lower part of the *virbalensis* Zone of the Homerian Stage (Geluva regional stage), Upper Wenlock. The taxon is also known from Arctic Canada, Gotland (Sweden), Ireland, South Urals (Russia), northern Naratau Range and the Alai Range (Central Asia), and from eastern Poland.

Pristiograptus deubeli (Jaeger, 1959)

Plate I, figs. A, B, H, plate II, fig. G

Monograptus deubeli: Jaeger, 1959, pp. 126–127, pl. 10, figs. 4–8;

Monograptus deubeli: Holland *et al.*, 1969, p. 672–673, pl. 130, fig. 3;

Pristiograptus jaegeri: Holland *et al.*, 1969, p. 670, text-fig. 2, fig. k (partim);

Monograptus deubeli Jaeger: Koren and Suyarkova, 1994a, pp. 93–95, plates 6–7; pl. 8, figs. F–G, pl. 9, figs. C, F–K, pl. 10, figs. D–M;

"Pristiograptus" ludensis (Murchison): Lenz, 1994a, p. 1422, pl. 3, fig. F (partim).

Pristiograptus deubeli (Jaeger): Radzevičius and Paškevičius, 2000, pp. 99–100, pl. V, figs. 1a–c.

Holotype. *Monograptus deubeli* Jaeger, 1959, pl. 10, fig. 5. Upper Wenlock, former *Gothograptus nassa–Pristiograptus vulgaris* Zone in Germany, *Pristiograptus deubeli* zone at present.

Material. About 30 rhabdosomes and their fragments from cores of Kurtuvénai-161, Šiupyliai-69, Kunkojai-12, and Sudkai-87 boreholes; specimens from the last two boreholes are macerated after samples treatment in HCl.

Description. Rhabdosome is massive, dorsally curved a little in its proximal end. L > 30 mm. W near thecal aperture against T^1, T^2, T^3, T^4, T^5 and T^{10} is 0.8–1.0, 0.8–1.1, 1.1–1.15, 1.2–1.25, and 1.4 mm, respectively. W_{max} of 2 mm is against $T^{15–17}$. Thecae two types are cylindrical. The first three to four thecae are of the colonograptid type, whilst medial and distal thecae of the rhabdosome are of the pristiograptid type. The first theca is 1.0–1.15 mm long and 0.35–0.38 mm wide. Apertural margins of first three–four thecae have a thick nose. Apertural margins in proximal thecae are distinctly concave, particularly in the first theca. Cocavity disappears at the level of fifth theca, and further on thecae are of the pristiograptid type. The marginal bulge of thecal aperture in medial and distal parts of the rhabdosome is not so distinct like in the *Pristiograptus* species of the *dubius* type. It forms a poorly expressed arch, when it merges with the neighbouring theca. The apertural margins in these thecae are perpendicular to their axes. In the distal part, thecae are larger, 1.7–1.75 mm long and 0.55–0.6 mm wide. Thecae are half-overlapping each other. They are inclined to rhabdosome axis at an angle of 30–35°. In the proximal part of the rhabdosome, 13 thecae are counted in a 10-mm interval, whereas in medial and distal parts the corresponding number is 11 or 12. Sicula is 2 mm, less commonly 2.4 mm long. Its apertural part 0.15–0.2 mm across is conical, widened, and dorsally bent. The sicula apex reaches the end of apertural margin of the second theca. The free part of sicula is 0.26-0.35 mm long, and its apertural side is concave (0.15 mm). Sicula has massive virgella 1 mm long, oriented toward ventral side of rhabdosome.

Comparison. *P. deubeli* differs from the *dubius* type forms in its proximal part. First theca of *P. deubeli* is of the colonograptid type. Medial and distal thecae are of the pristiograptid type, but apertural edges of thecae are perpendicular to thecal axes, whereas those of the *dubius* type species are obliquely oriented.

P. deubeli is very similar to *P. sigmoidalis* described by Přibyl (1943). Only the thecae forms and the maximal width differ these species from each other. The

maximal length in the first one is 2 mm and in the second 2.2 mm. In *P. deubeli* thecae broaden upwards, whereas in *P. sigmoidalis* it becomes narrower in this direction. *P. sigmoidalis* is described from the *nilssoni* Zone, which is younger than the *virbalensis* Zone.

P. deubeli found in Lithuania slightly differs from the same species found in Germany in a more distinct dorsal curvature.

Note. Judging from the aperture structure in proximal thecae, *P. deubeli* and *P. praedeubeli* are apparently transitional between the *Pristiograptus* and *Colonograptus* genera.

Association. In the East Baltic region, *P. deubeli* occurs together with *P. virbalensis* (Paškevičius), *P. deubeli ludlovensis* (Bouček), *P. praedeubeli* (Jaeger), *Gothograptus nassa* (Holm), and other retiolids. Thin-walled brachiopods *Plagiorhyncha analoga* (Wenjukow), *P.* cf. *analoga* (Wenjukow), *Strophochonetes cingularis* (Lindstrom), and Orbiculoidea sp. (determinations by P. Musteikis) are found together with *P. deubeli* (Jaeger) as well.

Age and geographic distribution. *P. deubeli* is widespread throughout the East Baltic region, where it occurs in the upper part of the *virbalensis* Zone of the Homerian Stage (Geluva regional stage), Upper Wenlock. *P. pradeubeli* is known also from Arctic Canada, Gotland (Sweden), Ireland, South Urals (Russia), northern Naratau Range and the Alai Range (Central Asia), and from eastern Poland.

CONCLUSIONS

In the East Baltic region, the lower boundary of the *nassa* Zone is marked by the appearance of *P. parvus* and *G. nassa* and by disappearance of *Cyrtograptus, Monoclimacis*, and some *Monograptus* forms usually characteristic of the Wenlock. The *nassa* Zone can be divided into two parts, the lower one with *P. parvus* and *G. nassa* and the upper part with *G. nassa* and *P. deubeli ludlowensis.*

The *virbalensis* Zone can be also divided in two parts, the lower with *P. virbalensis* and *P. praedeubeli* and the upper with *P. deubeli* corresponding to the *praedeubeli* and *deubeli* zones, respectively, in other regions. The last species is rare in the East Baltic sections.

In the East Baltic region, the first finds of *Colonograptus* species are recorded in the *ludensis* Zone. *Colonograptus* sp. A. [?=*Colonograptus gerchardi* (Kuhne)] appearing in the upper part of this zone transits into the Ludlow.

Reviewers I.A. Basov and T.N. Koren

REFERENCES

1. L. Gailite, M. Rybnikova, and R. Ul'st, *Stratigraphy, Fauna, and Formation Conditions of Silurian Deposits in the Central Baltic States* (Zinatne, Riga, 1967) [in Russian].
2. L. Gailite, R. Ul'st, and V. Yakovleva, *Silurian Stratigraphy and Type Section in Latvia* (Soyuzmoringeologiya, Riga, 1987) [in Russian].
3. J. C. Gutierrez-Marco, A. C. Lenz, M. Robardet, and J. M. Picarra, "Wenlock-Ludlow Graptolite Biostratigraphy and Extinction: a Reassessment from the Southwestern Iberian Peninsula (Spain and Portugal)," Can. J. Earth Sci. **33**, 656–663 (1996).
4. C. H. Holland, R. B. Rickards, and P. T. Warren, "The Wenlock Graptolites of the Ludlow District, Shropshire, and Their Stratigraphical Significance," Palaeontology **12**, 663–683 (1969).
5. H. Jaeger, "Graptolithen und Stratigraphie des Jungsten Thuringer Silurs," in *Abhandlungen der Deutchen Akademie der Wissenschaften zu Berlin* (Berlin, 1959), pp. 126–127.
6. H. Jaeger, "Neue Standard-Graptolihenzonenfolge nach der 'Grossen Krise' an der Wenlock/Ludlow-Grenze (Silur)," Neues Jahrb. Paláeontol., Abh. **182** (3), 303–354 (1991).
7. T. N. Koren, "*Monograptus deubeli and praedeubeli (Wenlock, Silurian) in the Asian Part of the Former Soviet Union*," Alcheringa **18**, 85–101 (1994).
8. A. Kozlowska-Dawidziuk, "Retiolitid Graptolite Spinograptus from Poland and Membrane Structures," Acta Palaeontol. **42**, 391–412 (1997).
9. A. Kozlowska-Dawidziuk, A. C. Lenz, and P. Štorch, "Late Homerian-Early Ludlow Post-Extinction Graptolites, Všeradice, Czech Republic," in *Sixth International Graptolite Conference and 1998 Field Meeting of the IUGS Subcommission on Silurian Stratigraphy, Madrid, 1998*, pp. 97–100.
10. A. C. Lenz, "The Graptolites *"Pristiograptus" praedeubeli* (Jaeger) and *"Pristiograptus" ludensis* (Murchison) (Uppermost Wenlock, Silurian) from Arctic Canada: Taxonomy and Evolution," Can. J. Earth Sci. **31**, 1419–1426 (1994a).
11. A. C. Lenz, "New Upper Homerian (Uppermost Wenlock, Silurian) Monograptids from Arctic Canada," Can. J. Earth Sci. **31**, 1779–1784 (1994b).
12. A. C. Lenz and A. Kozlowska-Dawidziuk, "Upper Homerian (Upper Wenlock, Silurian) Graptolites from Arctic Canada," J. Paleontol. **76**, 321–346 (2002).
13. A. C. Lenz and M. J. Melchin, "Wenlock (Silurian) Graptolites, Cape Philips Formation, Canadian Arctic Island," Can. J. Earth Sci. **27**, 1–13 (1990).
14. A. C. Lenz and M. J. Melchin, "Wenlock (Silurian) Graptolites, Cape Philips Formation, Canadian Arctic Island," Trans. R. Soc. Edinburgh, Earth Sci. **82**, 211–237 (1991).
15. J. Paškevičius, "Graptolites and Zonal Subdivision of Ludlow Deposits in the East Baltic Region*,"* in *Graptolites of the USSR*, Ed. by A. Obut (Nauka, Novosibirsk, 1974), pp. 122–134 [in Russian].
16. J. Paškevičius, *Silurian Biostratigraphy and Graptolites of Lithuania* (Mokslas, Vilnus, 1979) [in Russian].

17. J. Paškevičius, *The Geology of the Baltic Republics* (Geol. Surv. Lithuania, Vilnius, 1997).

18. A. Přibyl, "Revise zastupcu rodu *Pristiograptus* ze skupiny *P. dubius* a *P. vulgaris* z českeho a ciziho siluru," Rozpravy II. Tridy České akademie **53** (4), 1–40 (1943).

19. S. Radzevičius and J. Paškevičius, "Pristiograptids (Graptolites) and Their Adaptive Types of the Wenlock (Silurian) in Lithuania," Geologija **32**, 88–109 (2000).

20. L. Telle, "Graptolite Fauna and Stratigraphy of the Ludlovian Deposits of the Chelm Borehole Eastern Poland," Studia geol. polonica **13**, 36–38 (1964).

21. R. Ul'st, "Succession of Pristiograptids in Wenlock–Ludlow Boundary Layers of the Central Baltic Region," in *Graptolites of the USSR*, Ed. by A. Obut (Nauka, Novosibirsk, 1974), pp. 105–122 [in Russian].

22. Y. Zhang and A. C. Lenz, "Uppermost Wenlock and Ludlow Graptolites from Southern Yunnan, China," Can. J. Earth Sci. **34**, 1220–1238 (1997).