The genus *Pestiograptus* (Graptoloidea) has been recorded from the Llandovery to the upper Přídolí, but is most common in the Wenlock–Ludlow interval and is one of the longest ranging monograptid genera. The genus is characterized by cylindrical thecae without distinct apertural processes and a slightly curved or straight, simple rhabdosome (after Urbanek 1958). This conservative monograptid group survived all of the Wenlock–Ludlow biotic crises and radiated and prospered while populations of other monograptids decreased. After those biotic crises new genera of monograptids developed from *Pestiograptus* via speciation and adaptive radiation. The extinction of the *Pestiograptus* lineage was the penultimate “nail in the coffin” of monograptid evolution. Jaekel (1889) erected the genus *Pestiograptus*. According to him, the rhabdosome of *Pestiograptus* is unbranched, is straight or a little curved, the thecae are cylindrical, inclined to rhabdosome axis, the thecal mouth opening free (the mouths of the thecae are not covered by any lid or hood) and, if present, apertural processes stand as spines at the lower edge of the mouth. Today, some of Jaekel’s *Pestiograptus* taxa are assigned to other genera [e.g. *Textograptus testis* (Barrande)]. Přibyl (1943) revised *Pestiograptus* based on material from Czechia and literature data, producing the first catalogue of the genus. Münch (1952) assembled his own summary of known graptolites, including *Pestiograptus*, and presented short descriptions and illustrations of all known taxa. This was later followed up by phylogenetic studies of *Pestiograptus* and related genera presented by Rickards & Wright (2003), Radzevičius (2003), Radzevičius et al. (2008), Urbanek et al. (2012) and Whittingham et al. (2020). In short, the taxa of *Pestiograptus* genera are well known and very important for graptolite evolution and palaeogeography.

Only one problematical species, *Pestiograptus frequens* Jaekel (described as having thecae of *colonus* type, as opposed to the unornamented thecae typical of *P. frequens*), has been recorded from the Zdanów outcrop (Malinowska 1955), although graptolites are common there. Surprisingly, there have been very few graptolite studies based on material from the Zdanów outcrop, despite graptolites from the lower Silurian to the lower Devonian in this section being very common in this section. The Zdanów outcrop is thus very important in the Sudetes region because of its considerable stratigraphical extent.

In this work two species of *Pestiograptus* are documented for the first time from the Sudetes Mountains. We
present detailed descriptions of flattened pristiograptids that enable a better understanding of the morphology of the taxa and expand our knowledge of the palaeogeographical range of these species of Pristiograptus.

**Geological setting and material**

The Bardo Mountains (Góry Bardzkie) are located in the Central Sudetes (Żelaźniewicz & Aleksandrowski 2008) and assigned to the European Variscides Belt, which runs from Central Poland in the East to southern Portugal in the West (Mazur et al. 2006). The Central European Variscides Belt is subdivided into several zones (Fig. 1A). The Silurian sections of the Bardo Mountains are assigned to the Saxothuringian zone (Porębska & Sawłowicz 1997), part of the Armorican Terrane Assemblage (Franke 2000). The Armorican Terrane Assemblage is considered to have been located in the southern part of the Rheic Ocean during the Silurian (Winchester et al. 2002).

There are several small Silurian outcrops in the Bardo Mountains. The most complete Silurian geological section is the Zdanów outcrop which is located on the road from Budzów to Wilcza (Fig. 1B) near Zdanów village (N 50° 33’ 43.2˝, E 16° 39’ 55.0˝).

Graptolites from the Zdanów outcrop have been known since the 19th century. Looking for resources of coal, Krug von Nidda (1853) described black shales with graptolites in the Zdanów area and documented Graptolithus priodon [= Monograptus priodon (Bronn)]. Frech (1897) described the new genus Monoclimacis and several other graptolites from Zdanów (in German Herzogswalde). Through graptolite biostratigraphy, Frech (1897) determined that the rocks of the Zdanów outcrop belonged to the Wenlock and Ludlow series. Dathe (1904) supposed that part of the Zdanów (the Zdanów
beds) outcrop was early Devonian in age. The first Silurian graptolite zonal scale for the Bardo Mountains was given by Dahlgren & Finckh (1924). Hundt (1924) also confirmed that Ludlow age rocks crop out in Zdanów. Malinowska (1955) later investigated graptolites from the Llandovery–Ludlow interval in the Zdanów outcrop. She described more than 50 graptolite species and provided a detailed graptolite biozonation. Jaeger (1959) described the new graptolite species Monograptus silesicus and Monograptus praehercynicus based on material from Zdanów. Teller (1959, 1960) investigated graptolites from the Silurian–Devonian boundary interval. The graptolite stratigraphy, especially that of the uppermost Silurian and lowermost Devonian, was investigated by Porębska (1980a, 1982; Porębska & Sawłowicz 1997), and a short report on the local graptolites was given by Kurałowicz (1976).

The thickness of Silurian strata is about 50 m in Zdanów (Porębska 1980b, Wyżga 1987) and represents pelagic sediments. These are distinguished as the Lower Graptolitic Shales, the Green Shales and the Upper Graptolitic Shales (Wyżga 1987). The Silurian shales overlie the light-coloured sandstone and clay shales of the Upper Ordovician Jadłownik Beds (Chorowska & Oberc 1980). The lithology of all units is represented by lydites (radiolarian cherts), clay shales with tephra interbeds, and phosphatic nodules (Porębska & Koszowska 2001).

Our new material comes from the Lower Graptolitic Shales (Fig. 2). The graptolite finds from the lundgreni Biozone are solely in our collection due to limited collecting. Monograptus flemingii (Salter) (Fig. 3A) and Testograptus testis (Barrande) (Fig. 3B) have been identified together with Pristiograptus dubius pseudo-dubius (Bouček) and Pristiograptus lodenicensis Přibyl. Testograptus testis indicates the mid–upper lundgreni Biozone of the lower Homerian. Monograptus flemingii ranges from the riccartonensis Biozone to the topmost lundgreni Biozone and is a typical Wenlock monograptid.

**Systematic palaeontology**

The classification and morphological terminology of pristiograptids is after Urbanek et al. (2012) and two

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**Figure 2.** Silurian cross section of the Zdanów outcrop (Porębska & Koszowska 2001). The star marks the approximate sampling position.
thecae repeat distance (2TRD after Howe 1983). Material is stored at the Department of Geology and Mineralogy of Vilnius University.

Order Graptoloidea Lapworth, 1873
Family Monograptidae Lapworth, 1873
Subfamily Pristiograptinae Gürich, 1908

Genus Pristiograptus Jaekel, 1889

Type species. — Pristiograptus frequens Jaekel, 1889, from erratic boulders from Świebodzice (Freiburg Schlesien) and Nowa Sol (Neusalz on Oder) Lower Silesia (Poland), Lobograptus scanicus Biozone, lower Ludlow.

Diagnosis. — Rhabdosome variable in length, straight or gently curved. Thecae are straight, simple cylindrical, generally uniform throughout the rhabdosome, varying in degrees of inclination to the rhabdosome axis and amount of overlap. Aperture is without any distinct structures. Ventral wall quite straight with a clear thecal apertural lip.

Remarks. — Widely used diagnosis of Pristiograptus genus is incomplete and mostly corresponding to Pristiograptus of Wenlock–Přídolí interval. There are some strongly differing species in the upper Aeronian and lower Telychian (Llandovery). The dorsally curved rhabdosome have P. xiushanensis NIGP (Loydell et al. 2015), P. renaudi (Philippot) (Štorch & Massa 2006). Loydell & Walasek (2020) describe Pristiograptus paradoxus with ventrally curved rhabdosome. Pristiograptus from Llandovery needed revision and perhaps will be placed in a separate genus in the future or the diagnosis of Pristiograptus will need to be revised. However, that problem will not be discussed herein.

Pristiograptus dubius pseudodubius (Bouček, 1932)

Figure 3C–E

1932 Monograptus pseudodubius; Bouček, pp. 1, 2, fig. 2e, f, pl. 8, fig. 3.
1943 Pristiograptus pseudodubius (Bouček). — Přibyl, pp. 8, 9, pl. 1, figs 1, 3.
1952 Pristiograptus pseudodubius (Bouček). — Münch, p. 86, pl. 18, fig. 7.
1965 Pristiograptus pseudodubius (Bouček). — Jaworowski, pl. 1, fig. 12, text-fig. 9.
1965 Pristiograptus pseudodubius (Bouček). — Obut et al., p. 72, pl. 13, fig. 2.
1965 Pristiograptus pseudodubius (Bouček). — Rickards, p. 260, pl. 29, fig. 10, text-fig. 2i.
1967 Pristiograptus pseudodubius (Bouček). — Gailite et al., pp. 243, 244, pl. 18, figs 8, 9, text-fig. 57.
1974 Pristiograptus pseudodubius (Bouček). — Ulst, pp. 108, 109, pl. 11, fig. 1, pl. 12, figs 1, 2.
1999 Pristiograptus dubius cf. pseudodubius (Bouček). — Zalasiewicz & Williams, fig. 9m.
2000 Pristiograptus pseudodubius (Bouček). – Radzevičius & Paškevičius, pp. 92–94, pl. 2, fig. 1.
2008 Pristiograptus pseudodubius (Bouček). – Sachanski et al., p. 389, fig. 4.7.
2012 Pristiograptus dubius pseudodubius (Bouček). – Sachanski et al., p. 872, pl. 2, fig. e.
2012 Pristiograptus dubius pseudodubius (Bouček). – Urbanek et al., p. 600, figs 5b, 6a, 7c, d.

Material. — Four asymmetrical flattened rhabdosomes from the Zdanów outcrop, Bardo Mountains, Lower Silesia, Poland, the Lundgreni Biozone, the Lower Graptolitic Shales, Homorian.

Description. — Rhabdosome is narrow and either straight or slightly ventrally curved. The width (W) of the rhabdosome gradually increases from 0.7 mm at th1, 0.75 mm at th2, 0.8 mm at th3, 1 mm at th4, 1.1 mm at th5. Value of Wmax is 1.5 mm. The interapertural width is 0.55 mm at th1, 0.65 mm at th2, 0.75 mm at th3, 0.85 mm at th4, 0.9 mm at th5. The 2TRD measurements are 1.6–1.9 mm (th2), 1.7–2 mm (th3), 1.6–2 mm (th4), 1.9–2 mm (th5) and 2–2.5 mm in medially and distally. Thecae are cylindrical; apertures possess a pronounced lip which extends half way up the outer wall of the succeeding theca. The angle (β angle) between the thecal apertural lip and the succeeding metathecal wall is obtuse (Fig. 3D2). No sicula are adequately preserved for measurement in any of the specimens.

Remarks. — Pristiograptus d. pseudodubius can be easily mistaken for other subspecies of P. dubius. Width of P. d. dubius (Suess) is 0.8 mm at th1, 1.0 mm at th2, 1.1 mm at th3, 1.25 mm at th4 and it is slightly greater than in P. d. pseudodubius. Pristiograptus d. parvus is smaller than P. d. pseudodubius. The rhabdosome of P. d. parvus widens from 0.6 mm at th1, 0.7 mm at th2, 0.8 mm at th3, 0.85 mm at th4. The rhabdosome of P. d. parvus is reduced in size as a result of so-called Lilliput effect (Urbanek et al. 2012).

The significant differences of P. dubius stem lineage subspecies are in the extension of the thecal apertural lip. The species sits directly above P. d. dubius stratigraphically, differing in morphology by the extension of the thecal apertural lip midway up the succeeding theca (Fig. 3C–E). Pristiograptus d. dubius has a thecal apertural lip ending at the beginning of the succeeding metathecal wall, and has a broader rhabdosome. The stratigraphically succeeding P. d. parvus Ulst bears even closer similarity to P. d. pseudodubius, also having a slender rhabdosome,
though generally even more so than \textit{P. d. pseudodubius}. \textit{P. d. parvus} lacks thecal lips extending onto the wall of the succeeding theca, further distinguishing the species. Despite these differences, the two have been treated as synonymous in the past \cite[e.g.][]{RickardsWright2003}.

The close morphological and stratigraphical relationship between the three above-mentioned taxa has resulted in the inference of their inclusion in the central \textit{P. dubius} stem lineage \cite{Urbaneketal2012,Whittinghametal2020}. The inclusion of \textit{P. d. dubius}, \textit{P. d. pseudodubius} and \textit{P. d. parvus} with that anagenic stem lineage supports their status as subspecies of \textit{Pristiograptus dubius} under a lineage species concept \cite[sans de Quieroz1998, 2007]{sensudeQuieroz}, as outlined and recommended by Whittingham \textit{et al}. \cite{Whittinghametal2020}.

**Occurrence.** – \textit{Monograptus belophorus}–\textit{Cyrtograptus lundgreni} biozones of the Wenlock. Range of geographical distribution is broad, spanning Arctic Canada \cite{LenzKozlowskaDawidziuk2001,Lenzetal2012}, Australia \cite{RickardsSandford1998}, Czech Republic \cite{Boucek1932,Pribyl1943}, England \cite{Rickards1965}, Ireland \cite{Rickardsetal1973,Doran1974}, Latvia \cite{Ul1974}, Libya \cite{StorchMassa2003}, Lithuania \cite{RadzevičiusPaškevičius2000}, Poland \cite{Jaworowski1965,Urbaneketal2012}, Romania \cite{Iordan1992,Coltioetal2016}, Sardinia (Italy) \cite{StorchPiras2009} Serbia \cite{Krsticetal2005}, South China \cite{Xu1984}, Turkey \cite{Sachanskietal2008,Sachanskietal2012}, Vietnam \cite{Thanhetal2013} and Wales \cite{Warrenetal1984}.

\textit{Pristiograptus lodenicensis} \textit{Přibyl}, 1943

**Figure 4**
The interapertural width is 0.5 mm at th1, 0.6 mm at th2, development of the lateral elevations increases with of cortical tissue and ventral incision (Fig. 4F). The e.g Pristiograptus sp. 1 of Holland & Paškevičius to place the previously unassigned P. praelodenicensis of the lateral elevations (Fig. 4C1, F) or “manta ray wings” e.g P. lodenicensis of the thecal apertural lip is narrow with symmetrical between the thecal apertural lips is right or acute (Fig. 4). The bilateral processes are more commonly found on the thecae of later Silurian monograptids, appearing with varying exaggeration in Colonograptus, Saetograptus and Pristiograptus labiatus Urbanek. In particular, the similarity between P. lodenicensis and P. labiatus has been used as an example of Rickards & Wright’s (2003) iterative speciation in the Pristiograptus dubius stem lineage (Urbanek et al. 2012). The possible origination of each of these lobate taxa from a central stem appears to challenge the notion of morphospace “progress” in graptolites put forth by Pearson (1998), at least in the case of the P. dubius stem lineage.

Also of interest in the morphology of P. lodenicensis is the shift seen in thecal morphology with progressing astogeny. This is a pattern not seen in other species of Pristiograptus, instead being more diagnostic of the thecae of Colonograptus colonus (Barrande) and Saetograptus chimaera (Barrande). The patterns seen herein are exemplary of the morphogenetic gradients outlined in Urbanek & Uchmanski (1990) and Urbanek (2003). This would indicate that the same process may be at work in P. lodenicensis, with a diluting morphogen resulting in two separate astogenetic phases in the species.

Occurrence. – Cyrtograptus lundgreni Biozone of the lower Homeric, upper Wenlock. Ulst (1988) proposed distinguishing a P. lodenicensis Subzone in the middle part of T. testis Biozone (= middle part of C. lundgreni Biozone). Pristiograptus lodenicensis is known from Latvia (Gailite et al. 1967, Ulst 1974), Lithuania (Paškevičius 1983, Radzevičius & Paškevičius 2005), the Polish part of the East Europe platform (Jaworowski 1965, Urbanek et al. 2012), the Polish part of the Sudetes Mountains (this paper), Thuringia (Jaeger 1959, 1991), Czech Republic (Přibyl 1943) and England (Holland et al. 1969) and Wales (Warren et al. 1984).
Pristiograptus d. pseudodubius is known from Czechia, often referred to the Perunica Terrane (Bouček 1932, Přibyl 1943), the Bardo Mountains part of the Saxo-Thuringia Terrane (this paper) and from Sardinia (Štorch & Piras 2009), which was a part of the Iberia massif during the Silurian (Torsvik & Cocks 2016). However, the Perunica and Saxo-Thuringia terranes, as well as Sardinia, are the part of Armorican terrane assemblage (Servais & Sintubin 2009) which was located near Central Gondwana (Torsvik & Cocks 2011) on the opposite side of the Rheic Palaeo-ocean with respect to Baltica during the Wenlock (Fig. 5). *Pristiograptus d. pseudodubius* is found in Romania (Iordan 1992, Colţoi et al. 2016) and Serbia (Krstić et al. 2005), localities in the Moesia Terrane (Torsvik & Cocks 2004). The Moesia Terrane is located between the Saxo-Thuringian Terrane and Moesia, Istanbul, Pontides (Ruban 1943), the Bardo Mountains part of the Saxo-Thuringia Terrane (this paper) and from Sardinia (Štorch & Piras 2009), which was a part of the Iberia massif during the Silurian (Torsvik & Cocks 2016). However, the Perunica and Saxo-Thuringia terranes, as well as Sardinia, are the part of Armorican terrane assemblage (Servais & Sintubin 2009) which was located near Central Gondwana (Torsvik & Cocks 2011) on the opposite side of the Rheic Palaeo-ocean with respect to Baltica during the Wenlock (Fig. 5). *Pristiograptus d. pseudodubius* is found in Romania (Iordan 1992, Colţoi et al. 2016) and Serbia (Krstić et al. 2005), localities in the Moesia Terrane (Torsvik & Cocks 2004). The Moesia Terrane is located between the Saxo-Thuringian Terrane and Moesia, Istanbul, Pontides (Ruban 1943), the Bardo Mountains part of the Saxo-Thuringia Terrane (this paper) and from Sardinia (Štorch & Piras 2009), which was a part of the Iberia massif during the Silurian (Torsvik & Cocks 2016). However, the Perunica and Saxo-Thuringia terranes, as well as Sardinia, are the part of Armorican terrane assemblage (Servais & Sintubin 2009) which was located near Central Gondwana (Torsvik & Cocks 2011) on the opposite side of the Rheic Palaeo-ocean with respect to Baltica during the Wenlock (Fig. 5). *Pristiograptus d. pseudodubius* is found in Romania (Iordan 1992, Colţoi et al. 2016) and Serbia (Krstić et al. 2005), localities in the Moesia Terrane (Torsvik & Cocks 2004). The Moesia Terrane is located between the Saxo-Thuringian Terrane and Moesia, Istanbul, Pontides (Ruban 1943), the Bardo Mountains part of the Saxo-Thuringia Terrane (this paper) and from Sardinia (Štorch & Piras 2009), which was a part of the Iberia massif during the Silurian (Torsvik & Cocks 2016). However, the Perunica and Saxo-Thuringia terranes, as well as Sardinia, are the part of Armorican terrane assemblage (Servais & Sintubin 2009) which was located near Central Gondwana (Torsvik & Cocks 2011) on the opposite side of the Rheic Palaeo-ocean with respect to Baltica during the Wenlock (Fig. 5). *Pristiograptus d. pseudodubius* is found in Romania (Iordan 1992, Colţoi et al. 2016) and Serbia (Krstić et al. 2005), localities in the Moesia Terrane (Torsvik & Cocks 2004). The Moesia Terrane is located between the Saxo-Thuringian Terrane and Moesia, Istanbul, Pontides (Ruban
et al. 2007) and was probably part of Armorican terrane assemblage. According to Sachanski et al. (2008, 2012), *P. d. pseudodubius* is known from north Turkey in part of the Pontides Unit (Torsvik & Cooks 2011). There is also a record of *P. d. pseudodubius* from Libya (Štorch & Massa 2003) which was part of central Gondwana (Fig. 5).

Pristiograptus *d. pseudodubius* is also recorded from the South and North China palaeocontinents (Xu 1984). Thanh et al. (2013) recorded *P. d. pseudodubius* from the Quang Ninh Zone of the Bac Bo Region in northeastern Vietnam, part of the South China Plate (Torsvik & Cooks 2013).

Pristiograptus *d. pseudodubius* has been described from central Victoria in East Australia (Rickards & Sandford 1998). East Australia makes up part of east Gondwana and was located near the equator during the middle Silurian (Torsvik & Cooks 2009).

There are very well documented graptolites including *P. dubius* (Lenz & Kozłowska-Dawidziuk 2001) and *P. dubius s.l.* (Lenz et al. 2012) from Wenlock of Arctic Canada, the part of Laurentia. Authors noted considerable variations in the collected specimens, albeit all the material is assigned to a single *P. dubius* species (Lenz & Kozłowska-Dawidziuk 2001). Accordingly, it can be assumed that *P. d. pseudodubius* might be present in the Arctic Canada.

Pristiograptus *lodenicensis*, however, is known from very few locations and only from the middle part of the *lundgreni* Biozone. It is known from Baltica (Latvia, Lithuania and Poland) (Fig. 5). Holland et al. (1969) figured *Pristiograptus* sp. 1 with cortical tissue (text-fig. 1d) typical of *P. lodenicensis* and illustrated some specimens (pl. 130, figs 5, 6) with the horizontal thecal aperture lips that are typical for *P. lodenicensis* (Fig. 4A). Based on those illustrations, we recognize the existence of *P. lodenicensis* from the Ludlow district, Shropshire and Denbighshire northeast Wales (Warren et al. 1984), expanding the species’ range to the Avalonia palaeocontinent.

There are also *P. lodenicensis* records from Thuringia (Jaeger 1959, 1991) and the Bardo Mountains of the Sudetes (this paper). Both locations are linked to the Saxo-Thuringian terrane which was located on the opposite side of the Rheic Palaeo-ocean during the Wenlock along with...
the Perunica terrane from which *P. lodenicensis* is also known (Bouček 1932, Přibyl 1943).

Graptolites of the *lundgreni* Biozone have been studied in Arctic Canada the part of Laurentia (Lenz & Kozlowska-Dawidziuk 2001, Lenz et al. 2012) but *P. lodenicensis* was not documented. Present all data indicates that *P. lodenicensis* is characteristic for the the Rheic Palaeo-ocean.

**Conclusion**

In summary, the long-ranging *Pristiograptus d. pseudo­dubius* is known from the *riccartonensis* to *parvus* biozones and is widespread, from Laurussia to Central Gondwana and East Gondwana. *Pristiograptus lode­nicensis* is known only from middle part of the *lundgreni* Biozone and is linked to the palaeogeographical province of the Rheic Palaeo-ocean. This difference in geographical range may be related to *P. lodenicensis*’ proposed position as a short-ranging iterative branch off of the *P. dubius* stem lineage (Urbanek et al. 2012), with little opportunity to spread widely after speciation.

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**References**

Belka, Z., Valverde-Vaquero, P., Dorr, W., Ahrendt, H., Wemmer, K., Franke, W. & Schäfer, J. 2002. Accretion of first Gondwana-derived terranes at the margin of Baltica, 19–36. In Winchester, J.A., Pharaoh, T.C. & Verniers, J. (eds) Palaeozoic amalgamation of Central Europe. Geological Society of London, Special Publication 201. DOI 10.1144/GSL.SP.2002.201.01.02

Bierreksov, M. & Jorgensen, K.Å. 1983. Late Wenlock graptolite bearing tuffaceous sandstone from Bornholm. Bulletin of the Geological Society of Denmark 31, 129–149.

Bouček, B. 1932. Předěbná zpráva o některých nových druzích graptolitů z českého gotlandienu. Věstník Státního geologického ústavu Československé republiky 7, 150–155.

Chew, D.M. & Stillman, C.J. 2009. Late Caledonian Orogeny and magmatism, 143–173. In Holland, C.H. & Sanders, I.S. (eds) The Geology of Ireland, 2nd ed. Dunedin Academic Press, Edinburgh.

Chorowska, M. & Oberc, J. 1980. The stratigraphy and tectonics of the uppermost Silurian and Lower Devonian of the Zdanów section (Bardo Mt, Sudetes) in the light of conodont studies. Geological Quarterly 24(2), 193–216.

Cocks, L.R.M., McKerrow, W.S. & Verniers, J. 2003. The Silurian of Avalonia, 35–53. In Landing, E. & Johnson, M.E. (eds) Silurian Lands and Seas, Paleogeography outside of Laurentia (Proceedings of the James Hall Symposium, Rochester, NY, USA, August 1996). New York State Museum Bulletin 493.

Coltof, O., Nicolas, G. & Safa, P. 2016. The assessment of the hydrocarbon potential and maturity of Silurian intervals from eastern part of Moesian Platform – Romanian sector. Marine and Petroleum Geology 77, 653–667. DOI 10.1016/j.marpetgeo.2016.06.024

Dahlgren, F. & Finckh, L. 1924. Ein Silurprofil aus dem Warthauer Schiefergebirge. Jahrbuch der Preußischen Geologischen Landesanstalt zu Berlin 44, 281–289.

Dathe, E. 1904. Erläuterungen zur Geologische Karte von Preußen und benachbarten Bundesstaaten 1: 25 000. Blatt Neurude, Lief 115. Berlin.

Doran, R. 1974. The Silurian rocks of the southern part of the Slieve Phelim inlier, Co. Tipperary. Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science 74, 193–202.

Frank, W. 2000. The mid-European segment of the Variscides: tectonostratigraphic units, terrane boundaries and plate tectonic evolution, 35–61. In Frank, W., Haak, V., Oncken, O. & Tanner, D. (eds) Orogenic Processes: Quantification and Modelling in the Variscan Belt. Geological Society London, Special Publication 179. DOI 10.1144/GSL.SP.2000.179.01.05

Frech, F. 1897. Lethaea geognostica oder Beschreibung und Abbildung für die Gebirgs-Formationen bezeichnendsten Versteinerungen. 1. Teil – Lethaea Palaeozoica. Schweizer­bartsche Verlagshandlung, Stuttgart.

Gailite, L. Rubinkova, M. & Ulst, R. 1967. Stratigrafia, fauna, i uslovia obrazovania silurijskich porod srednej Pribaltiki. 304pp. Izdatelstvo Zinatne, Riga.

Görgich, G. 1908. Die Leitfossilien. Ein Hilfsbuch zum Bestim­men von Versteinerungen bei geologischen Arbeiten in der Sammlung und im Felde. Erste Lieferung: Kambrium und Silur. 96 pp. Verlag von Gebrüder Borntraeger, Berlin. DOI 10.5962/bhl.title.29890

Holland, C.H., Rickards, R.B. & Warren, P.T. 1969. The Wenlock graptolites of the Ludlow district, Shropshire, and their stratigraphical significance. Palaeontology 12(4), 663–668.

Howe, M.P.A. 1983. Measurements of thecal spacing in graptoli­tes. Geological Magazine 120(6), 635–638. DOI 10.1017/S0016756800027795

Hundt, R. 1924. Die Graftoliten des deutschen Silur. 96 pp. Verlag Max Weg, Leipzig.

Iordan, M. 1992. Biostratigraphic age indicators in the Lower Palaeozoic successions of the Moesian Platform of Romania. Geologica Carpathica 43(4), 231–233.
Wyżga, B. 1987. Lower Palaeozoic of Bardo Mountains (Sudetes): a sequence of deep sea pelagic sediments. *Geologica Sudetica* 22, 119–145.

Xu, C. 1984. The Silurian graptolite zonation of China. *Canadian Journal of Earth Science* 21, 241–257. DOI 10.1139/e84-025

Zalasiewicz, J. & Williams, M. 1999. Graptolite biozonation of the Wenlock Series (Silurian) of the Builth Wells district, central Wales. *Geological Magazine* 136(3), 263–283. DOI 10.1017/S0016756899002599

Żelaźnie Wicz, A. & Aleksandrowski, P. 2008. Regionalizacja tektoniczna Polski – Polska południowo-zachodnia. *Przegląd Geologiczny* 56(10), 904–911.