sciendo

Geologos 30, 1 (2024): 45–56
https://doi.org/10.14746/logos.2024.30.1.04

GEOLOGOS

First record of trilobites (Arthropoda) from Carboniferous deposits of the Dnipro-Donets Depression, north-eastern Ukraine

Vitaly Dernov

Department of Palaeontology and Stratigraphy of the Palaeozoic Sediments, Institute of Geological Sciences of the NAS of Ukraine, Oles Honchar Street 55b, 01601 Kyiv, Ukraine.
e-mail address: vitalydernov@gmail.com

Abstract

A small trilobite faunule consisting of Weberides mucronatus (M'Coy, 1844) and Waribole sp. is described from Serpukhovian (Upper Mississippian) strata of the Sribne-Krasnograd Zone in the Dnipro-Donets Depression (north-eastern Ukraine). Weberides mucronatus has previously been recorded from Serpukhovian levels in the Donets Basin and in the Lviv Palaeozoic Trough in Ukraine, whereas species of Waribole are here recorded from Carboniferous deposits of Ukraine for the first time. This genus is typical of faunal assemblages of the Mississippian-aged Kulm facies, formed under relatively deep-water marine conditions and widely distributed across western and central Europe.

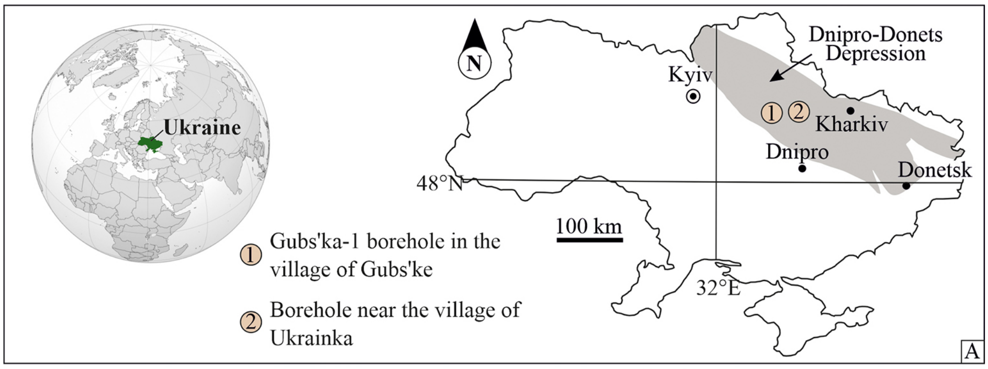
Keywords: Weberides, Waribole, Mississippian, East European Platform

1. Introduction

Trilobites, an incredibly diverse group of extinct arthropods, both taxonomically and ecologically, experienced a heyday between the Late Cambrian and Late Ordovician (Foote, 1993; Westrop & Adrain, 1998; Bault et al., 2022), but gradually began to decline during the Devonian and Carboniferous, to go extinct by the end of the Permian (Owens, 1990, 2003). Currently, approximately 80 trilobite genera are known from Mississippian (Lower Carboniferous) strata. Trilobite taxonomic diversity declined sharply near the Lower/Upper Carboniferous boundary, and only about 20 genera are known from Pennsylvanian levels (Bault et al., 2022).

Trilobites are highly significant for the stratigraphy of Lower Palaeozoic deposits (Tortello, 2003; Babcock et al., 2017), but their application in biostratigraphical schemes for Carboniferous and Permian strata is limited or even non-existent (see Brezinski, 1992, 2000, 2008). However, they do constitute a valuable tool for palaeogeographical and palaeoecological reconstructions (e.g., Brezinski, 1999, 2003, 2023).

The Carboniferous macrofauna of the Dnipro-Donets Depression (north-eastern Ukraine; Fig. 1A), inclusive of trilobites, is still poorly known, which may be explained by the multi-kilometre-thick Carboniferous succession occurring here at considerable depths (*c.* 3,000–6,000 m according to Bilyk et al., 2002 and Lukin, 2020). In Ukraine, Late Palaeozoic trilobites have been described from the Mississippian, Pennsylvanian and Lower Permian (Cisuralian) of the Donets Basin (Verneuil, *in* Murchison et al., 1845; Eichwald, 1861; Kargin, 1911; Chernyshev, 1922; Lebedev, 1927; V. Weber, 1933, 1937, 1939, 1941; Mychko & Dernov, 2019), the Serpukhovian and Bashkirian of the Lviv Palaeozoic Trough (Shul'ga et al., 1992; Shul'ga & Konstantynenko, 1993; Shul'ga et al., 2007), as well as from allochthonous blocks of Permian limestones within the Triassic–Jurassic flysch



Stage	Dnipro-Donets Depression			MH	Donets Basin
	Chernihiv-Valky Zone	Sribne-Krasnograd Zone	Lelyaky-Oril' Zone		
SERPUKHOVIAN	Abaziv Formation	Dyakove Group	Abaziv Formation	V-VIII	Kalmius Formation
	Lutsenky Formation		Novomykolayivka Formation	IX	Samara Formation

B

Fig. 1. Geographical location of the borehole cores which yielded the trilobite material (**A**) and stratigraphy and correlation of Serpukhovian deposits in the Dnipro-Donets Depression (**B**). Abbreviation: MH – microfaunal horizon (= foraminifer zone) *sensu* Brazhnikova et al. (1967). Stratigraphical scheme modified from Poletaev et al. (2013).

of the Crimean Mountains in southern Ukraine (G. Weber, 1915; Toumansky, 1930; Tumanskaya, 1935; Mychko, 2012). To date, trilobites from the Carboniferous of the Dnipro-Donets Depression have not yet been studied, although their presence has been recorded in some works (e.g., Brazhnikova et al., 1969).

Here, I describe two species of Serpukhovian (Late Mississippian) trilobites, *Weberides mucronatus* and *Waribole* sp., both from the Dnipro-Donets Depression. Despite the fact that the examined material is very sparse and poorly preserved, it consitutes the first record of Mississippian trilobites from the Dnipro-Donets Depression, broadens the known palaeontological characteristics of the Carboniferous sedimentary succession in this region and expands data on the palaeoecology and taphonomy of trilobites of this age.

2. Geological setting

Serpukhovian deposits of the Dnipro-Donets Depression are represented by four lithostratigraphical units: the Lutsenky and Abaziv formations in the Chernihiv-Valky Zone, the Dyakove Group in the axial part of the Sribne-Krasnograd Zone, and the Novomykolayivka and Abaziv formations in the Lelyaky-Oril' Zone (Fig. 1B).

The Lutsenky Formation has an indistinct cyclic character, with the transgressive part of the cycles composed of mudstones with limestone interlayers, while the regressive part consists of mudstones with siltstone and coal interlayers; cycles are capped by sandstone layers. Limestones are dark grey in colour and sometimes clayey and recrystallised and yield calcareous algae, foraminifera, bryozoans, brachiopods, bivalves, gastropods, ostracods, trilobites and crinoids (Vdovenko et al., 1988; Poletaev & Vdovenko, 2013). In the lower part of the formation, a fairly significant Serpukhovian brachiopod assemblage (*Tornquistia* cf. *subpolita* Aisenverg, 1985, *Buxtonia* sp., *Productus* cf. *dugnensis* Sarycheva, 1952, *Gigantoproductus* sp., ?*Undaria* cf. *plicatostriata* (Miloradovich, 1937), *Spirifer* cf. *botscharovensis* Semichatova, 1941, *Unispirifer* ex gr. *bisulcatus* (Sowerby, 1818), *Rugosochonetes* sp., *Krotovia* sp., *Schizophoria* sp., *Antiquatonia* sp. and *Phricodothyris* sp.), as well as foraminifera of microfaunal horizon IX and possibly the upper part of horizon X (*Earlandia vulgaris* (Rauzer-Chernousova & Reitlinger in Rauzer-Chernousova & Fursenko, 1937), *Betpakodiscus compressus* (Vdovenko, 1967) and *B. cornuspiroides* (Brazhnikova & Vdovenko in Brazhnikova et al., 1967)) have been identified (Poletaev et al., 1991). The thickness of the Lutsenky Formation varies significantly, from 55 m in the border parts of the Dnipro-Donets Depression up to 280 m in the south-east and in the axial part of the depression (Vdovenko et al., 1988; Poletaev & Vdovenko, 2013).

The Abaziv Formation is represented by a succession of mudstones with siltstone interlayers, sandstones and thin limestone strata. The limestone layers contain remains of brachiopods, gastropods, ostracods and foraminifera (Vdovenko et al., 1988; Poletaev & Vdovenko, 2013). The foraminifer assemblage of the lower and upper parts of the formation are quite significant and differ from each other. Foraminifera of microfaunal horizon VIII (e.g., *Earlandia vulgaris*, *Pseudoammodiscus volgensis* (Rauzer-Chernousova, 1948), *Omphalotis* sp., *Endothyranopsis crassa* (Brady in Brady & Robertson, 1870), *Palaeotextularia longiseptata* Lipina, 1948, *Archaediscus* ex gr. *krestovnikovi* Rauzer-Chernousova, 1948, *A. chernoussovensis* Mamet, *in* Mamet, Choubert & Hottinger, 1966, *A.* ex gr. *moelleri* Rauzer-Chernousova, 1948, *Euxinita efremovi* (Vdovenko & Rostovtseva, 1967), *Loeblichia minima* Brazhnikova, 1962, *Endostafella parva* (Möller, 1879), *Eostafella mirifica* Brazhnikova, 1948) are typical of the lower part of the formation, and foraminifera of microfaunal horizons VII to V (*Earlandia vulgaris*, *E. elegans* (Rauzer-Chernousova & Reitlinger in Rauzer-Chernousova, & Fursenko, 1937), *Haplophragmina beschevensis* (Brazhnikova in Brazhnikova et al., 1967), ?*Haplophragmoides horridus* (Grzybowski, 1901), *Archaediscus* ex gr. *krestovnikovi*, *Betpakodiscus cornuspiroides*, *Asteroarchaediscus baschkiricus* (Krestovnikov & Theodorovich, 1936), *Tetrataxis gigas* Brazhnikova, 1956, *T. media* Vissarionova, 1948, *Endotaxis brazhnikovae* (Bogush & Yuferev, 1966), *Planoendothyra spirilliniformis* Brazhnikova & Potievskaya, 1948, *Loeblichia minima* Brazhnikova, 1962 and *Eostaffella pseudostruvei* (Rauzer-Chernousova & Belyaev in Rauzer-Chernousova et al., 1936)) are typical of its upper part (Poletaev et al., 1991). The thickness of the formation ranges from 50 m in the border parts of the Dnipro-Donets Depression to 400 m in the south-east of that depression (Vdovenko et al., 1988; Poletaev & Vdovenko, 2013).

In the most submerged part of the Dnipro-Donets Depression, Serpukhovian deposits are represented by a shale-dominated sequence belonging to the Dyakove Group. The total thickness of this unit is not known, but it corresponds to several Visean–lower Bashkirian rock formations of the Donets Basin located to the south-east of the Dnipro-Donets Depression (Vdovenko et al., 1988; Poletaev & Vdovenko, 2013).

The Novomykolayivka Formation is represented by a succession of mudstones, siltstones, carbonaceous shales with coal beds and siderite interlayers. Mudstones are grey and greenish with imprints of non-marine bivalves and numerous plant remains, as well as an interlayer of carbonaceous clays and coals. Siltstones are also grey and greenish, clayey, with plant debris. This formation is widespread in the south-east of the Dnipro-Donets Depression, where it is laterally replaced by the coal-bearing Samara Formation of the western Donets Basin. In the Sribne-Krasnograd Zone, the Novomykolayivka Formation is replaced by the shale-dominated Dyakove Group, and further to the north-west by the Lutsenky Formation. The thickness of the Novomykolayivka Formation varies widely, from tens to thousands of metres (Vdovenko et al., 1988; Poletaev & Vdovenko, 2013).

3. Material and methods

The material studied is represented by six poorly preserved pygidia and a single glabella. These fossils were donated for study to the Department of Palaeontology and Stratigraphy of the Palaeozoic Sediments of the Institute of Geological Sciences (National Academy of Sciences of Ukraine, Kyiv) at different times by unknown geologists, but remained unstudied.

Thousands of boreholes were drilled in the Dnipro-Donets Depression between the 1950s and 1990s in a search for hydrocarbons, but data on the stratigraphy of sections of specific boreholes have been lost or are presented in very generalised form in unpublished technical reports. Therefore, it is possible to determine the age of the trilobites studied here only to the nearest stage (i.e., Serpukhovian), based mainly on views expressed by Bilyk et al. (2002).

The material examined comes from several Serpukhovian stratigraphical levels, penetrated in two boreholes, drilled within the peripheral parts of the Sribne-Krasnograd Zone (see Fig. 1A), as follows:

Gubs'ka-1 borehole (Poltava region, Lubny district, Ukraine), drilled in the village of Gubs'ke. The fossil-bearing rock is a black shale with exoskeleton fragments of *Waribole* sp. (specimens IGS NASU-21/04a, IGS NASU-21/04b, IGS NASU-21/05a and IGS NASU-21/05b), recovered from a depth of 4,167.0–4,180.0 m. Several poorly preserved thoraxes (e.g., Fig. 3D) and pygidia (e.g., Fig. 2E) were found in black shales penetrated by the Gubs'ka-1 borehole from a depth of 4,290.0–4,301.0 m, along with remains of brachiopods, bryozoans and crinoids.

Borehole near Ukrainka (Sumy region, Okhtyrka district, Ukraine), near the village of Ukrainka.

The fossil-bearing rock is a black shale, yielding a pygidium of *Weberides mucronatus* (specimen IGS NASU-21/07), recovered at a depth of 4,705.0–4,715.0 m.

The localities of two additional specimens, IGS NASU-21/09 (*Weberides mucronatus*) and IGS NASU-21/08 (an unidentified pygidium), with co-occurrring brachiopod and ?bromalite, are unknown.

Abbreviations used in the section 'Systematic palaeontology' below are as follows: L – length of pygidium, L* – length of pygidium without posterior process, W – width of pygidium, L_A – length of axis, W_A – maximal width of axis. The material studied (collection IGS NASU-21) is stored at the Department of Palaeontology and Stratigraphy of the Palaeozoic Sediments of the Institute of Geological Sciences, Kyiv.

4. Systematic palaeontology

Class Trilobita Walch, 1771
Order Proetida Fortey & Owens, 1975
Family Phillipsiidae Oehlert, 1886

Genus *Weberides* Reed, 1942

Weberides mucronatus (M'Coy, 1844)
Fig. 2A, B, E

*1844 *Phillipsia mucronata* M'Coy, p. 162, pl. 4, fig. 5.
1845 *Phillipsia Eichwaldi* Fischer; Verneuil, *in* Murchison et al., p. 376, pl. 27, fig. 14.
1861 *Phillipsia Eichwaldi* Fischer; Eichwald, pl. 54, fig. 10.
1871 *Griffithides mucronatus* M'Coy; Traquair, p. 213, figs 1–7.
1883 *Phillipsia Eichwaldi* var. *mucronata* M'Coy; Woodward, p. 23, pl. 4, figs 1, 3, 12, 15.
1912 *Griffithides* (?*Phillipsia*) *acuminatus* Roemer; Klebelsberg, p. 517, pl. 5, figs 10–12.
1912 *Phillipsia Eichwaldi* Fischer; Klebelsberg, p. 517, pl. 5, fig. 13.
1912 *Phillipsia* (?*Griffithides*) *mucronata* M'Coy; Klebelsberg, p. 517, pl. 5, fig. 14.
1933 *Phillipsia eichwaldi* var. *mucronata* M'Coy; V. Weber, p. 24, pl. 1, fig. 24.
1935 *Phillipsia mucronata* M'Coy; Schwarzbach, p. 432, pl. 27, fig. 1.

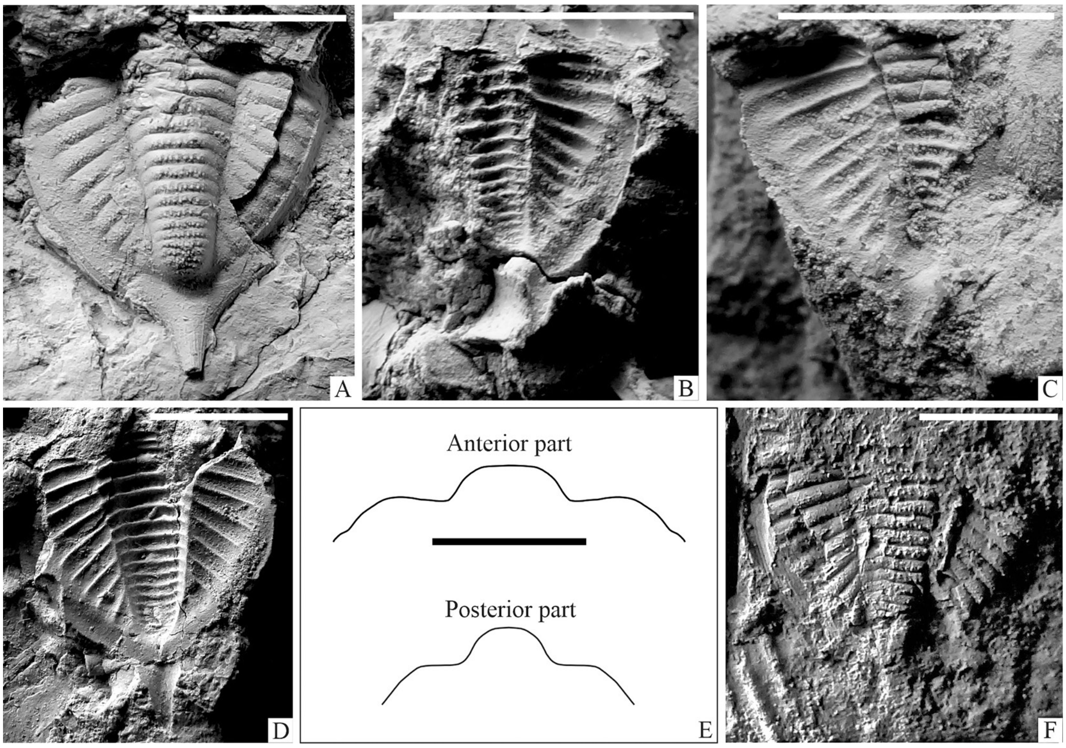


Fig. 2. *Weberides mucronatus* (M'Coy, 1844) from Mississippian strata in the Dnipro-Donets Depression (**A, B, E**) and from the Moscow Syneclise (**C, D, F**): A – IGS NASU-21/07; B – IGS NASU-21/09; E – Cross-section profiles of IGS NASU-21/07 from anterior and posterior (*c.* 2 mm from base of posterior process) parts; C, D, F – uncatalogued specimens stored at IGS NASU (Steshevian Horizon, Serpukhovian; River Shanya, ravine in the village of Bordukovo, Russia); E – indeterminate trilobite (Gubs'ka-1 borehole, stratigraphical interval 4,290.0-4,301.0 m, Serpukhovian). Scale bars equal 5 mm.

1935 *Phillipsia mucronata* var. *subcarinata* n. var. Schwarzbach, p. 434, pl. 27, fig. 2.
1935 *Phillipsia mucronata* var. *vasta* n. var. Schwarzbach, p. 434, pl. 27, fig. 3.
1937 *Phillipsia* (*Griff.*?) *eichwaldi* var. (?) *mucronata* M'Coy; V. Weber, p. 64, pl. 7, figs 18–24.
1941 *Phillipsia eichwaldi* var. *mucronata* M'Coy; V. Weber, pl. 42, figs 17, 18.
1942 *Weberides mucronatus* var. nov. *traquairi* Reed, p. 660, pl. 11, figs 1–4.
1942 *Weberides mucronatus* var. nov. *lata* Reed, p. 663, pl. 11, fig. 5.
1951 *Weberides mucronatus* (M'Coy); Přibyl, p. 11, pl. 1, fig. 8; pl. 2, figs 4–6.
1961 *Paladin mucronatus* (M'Coy); Bojkowski, p. 324, pl. 1, figs 1–3
1969 *Paladin mucronatus* (M'Coy); Korejwo, pl. 43, fig. 3.
1970 *Paladin mucronatus russicus* Osmólska, p. 135, pl. 14, figs 1, 7; pl. 18, fig. 13; pl. 19, figs 9, 13.
1970 *Paladin mucronatus mucronatus* (M'Coy, 1844); Osmólska, p. 133, pl. 19, figs 1–8, 10–12, 14;
1970 *Paladin mucronatus rotundatus* Osmólska, p. 136, pl. 20, figs 1, 9.
1970 *Paladin mucronatus latispinatus* Osmólska, p. 137, pl. 18, fig. 12.
1970 *Paladin mucronatus* subsp. Osmólska, p. 138, pl. 20, figs 2, 12.
1972 *Paladin mucronatus mucronatus* (M'Coy, 1844); Korejwo & Teller, pl. 15, fig. 5.
1974 *Paladin mucronatus mucronatus* (M'Coy, 1844); Korejwo, pl. 14, figs 7, 9.
1975 *Paladin mucronatus mucronatus* (M'Coy, 1844); Hahn & Hahn, pl. 11, fig. 8.
1986 *Paladin mucronatus* (M'Coy); Korejwo, pl. 36, figs 5–7.

Material. A single poorly preserved pygidium (IGS NASU-21/07) from the borehole near the village of Ukrainka (collector unknown) and a single poorly preserved imprint of a pygidium fragment (IGS NASU-21/09; collector and borehole unknown).

Description. IGS NASU-21/07 (Fig. 2A): medium-sized pygidium with subtriangular outline (L^* = 10.3 mm, W = 10.0 mm, L^*/W = 1.03) with pointed posterior process, 1.2 mm long and *c.* 0.8 mm wide at base. Axis narrow (W_A = 3.0 mm, L_A = 7.2 mm), long (70 percent of pygidial length, excluding posterior process), convex, rounded-trapezoidal in cross section, consisting of 15 rings separated by distinct furrows; axis in contact with marginal border. Lateral slopes of axis gentle in anterior part, and rather steep in median and posterior parts (Fig. 2E). Each axial ring bearing row of 6–8 tubercles, 0.3–0.5 mm in diameter. Pleural lobes slightly convex, relatively wide and consisting of 9 narrow (1–1.2 mm wide) pleural ribs. On parts of pleural ribs close to marginal border, a longitudinal row of very small rounded granules, about 0.15–0.20 mm in diameter, extending to rib. Maximum width of marginal border observed in posterior part of pygidium, and narrowing forwardly. Lateral sides of pygidium slowly moving away anteriorly from each other. Marginal border smooth, but longitudinal, very thin ridges occur on wedge-shaped, not completely preserved (no apex) posterior process.

Remarks. *Phillipsia mucronata* was described in 1844 by M'Coy from the so-called Mountain Limestone (Mississippian) of Ireland. According to V. Weber (1937), this species also includes the trilobite described by Verneuil, *in* Murchison et al. (1845) under the name of *Phillipsia Eichwaldi* Fischer von Waldheim, 1825. *Asaphus eichwaldi* Fischer von Waldheim in Eichwald, 1825 ranks amongst the earliest trilobites to have been described according to the rules of biological nomenclature (Mychko & Alekseev, 2012). Fischer de Waldheim (1830–1837) synonymised this species with *Asaphus brongniarti* Fischer von Waldheim, *in* Eichwald, 1825, another species described in the work of Eichwald (1825). It should be noted that later workers interpreted *Asaphus Eichwaldi* very broadly and that its stratigraphical distribution was unclear, because the type specimens had been lost (Mychko & Alekseev, 2012). However, subsequent studies have shown that specimens of *Asaphus Eichwaldi* described by Fischer de Waldheim originated from the Moscovian or the lower part of the Kasimovian (Mychko & Alekseev, 2017).

Following Woodward (1883), V. Weber (1933, 1937) considered *Phillipsia mucronata* to be a variety of '*Asaphus*' *eichwaldi*. Osmólska (1970) assigned *Asaphus Eichwaldi* to the genus *Paladin* Weller, 1936 and distinguished several subspecies. She also included *Phillipsia mucronata*, as described by M'Coy, in the same genus

V. Weber (1937) noted that *Paladin mucronatus* was the only Carboniferous trilobite species with a characteristic narrow pointed process in the posterior part of the pygidium. However, *Weberides longispiniferus* Kobayashi & Hamada, 1978 has an even longer process, reaching the entire length of the pygidium. This characteristic process allowed Reed (1942) to assign *Paladin mucronatus* to a new genus, *Weberides*. Later, Whittington (1954) considered this genus to be a junior synonym of *Paladin*, an opinion shared by Hahn and Hahn (1970) and Osmólska (1970).

To *Paladin mucronatus russicus* Osmólska (1970) assigned some forms described under the name *Griffithides eichwaldi* by Eichwald (1861), as well as *Phillipsia eichwaldi* var. *mucronata* M'Coy and *Ph.* (*Griffithides*) *eichwaldi* var. (?) *mucronata* M'Coy by V. Weber (1933, 1937, respectively). In addition, other specimens of *Ph.* (*Griffithides*) *eichwaldi* var. (?) *mucronata* were placed in a new species, *Paladin ailinensis*, by Osmólska (1970).

Brezinski (2003, 2005) showed on the basis of phylogenetic analysis that the genus *Weberides* constituted a sister group of *Paladin*, which should be considered as an independent genus with at least five European species, namely *W. cuspidatus* Reed, 1942, *W. czarnieckii* (Osmólska, 1970), *W. eichwaldi* (Fisher von Waldheim, *in* Eichwald, 1825), *W. maillieuxi* (Demanet, 1938) and *W. mucronatus* (M'Coy, 1844), as well as two North American forms (*W. chamberlaini* Brezinski, 2005 and *W. samwaysi* Brezinski, 2005). However, as noted by Brezinski (2005), two or even three subgroups of generic rank can probably be distinguished within this group of species.

It should be noted that Girty (1910) described *Griffithides mucronatus*, which was later assigned by Weller (1936) and Gordon (1969) to the new genus *Paladin*. Osmólska (1970) noted that in this case there would be homonymy of species names of trilobites described by M'Coy (1844) and Girty (1910). To avoid this problem, she proposed *Paladin girtyi* as a new name for *Griffithides mucronatus* Girty, 1910 (*non* M'Coy, 1844). In the same year (i.e., 1970), Hahn & Hahn (1970) proposed a new name for the species described by Girty, *P. girtyianus*, which then entered scientific use (Brezinski, 2005).

In the collections at the Institute of Geological Sciences of the NAS of Ukraine several trilobites from the Steshovian Horizon (Serpukhovian) of the Moscow Syneclise were found (Fig. 2C, D, F). One of these specimens (Fig. 2D) has a process in the posterior part of the pygidium and morphologically does not differ from *Weberides mucronatus* as described above. Thus, undoubtedly *Weberides mucronatus* is present in the Serpukhovian of the Moscow Syneclise, the type region of *Asaphus eichwaldi*.

Stratigraphical and geographical range. *Weberides mucronatus* is widely distributed in Visean and Serpukhovian (Middle and Upper Mississippian) deposits of Europe.

Family Proetidae Hawle & Corda, 1847
Genus *Waribole* Richter & Richter, 1926

Waribole sp.
Fig. 3A–C, E

Material. Three poorly preserved pygidia (IGS NASU-21/04a, IGS NASU-21/04b, IGS NASU-21/05a) and one poorly preserved glabella (IGS NASU-21/05b).

Description. IGS NASU-21/04a (Fig. 3C), a poorly preserved exoskeleton; pygidium subparabolic with low vaulting and relief, 7 mm long and 9.5 mm wide (L/W = 0.74). Axis sharply tapering posteriorly, 4 mm long and 3.7 mm wide, consisting of about 7 rings. Pleural areas gently convex, with 6 or 7 pairs of ribs with deep pleural and shallower interpleural furrows running parallel to each other, both extending close to broad border. Border *c.* 2 mm wide, slightly convex for most part, but becoming concave at margin. Poorly preserved cephalon and thorax cannot be described; however, genal spine long and pointed. Total length of exoskeleton about 15 mm.

IGS NASU-21/05a (Fig. 3B): subparabolic pygidium with low vaulting and relief, 5 mm long and 7.0 mm wide (L/W = 0.71). Axis sharply tapering posteriorly, 3.5 mm long and 3 mm wide, consisting of 7 or 8 rings. Pleural areas gently convex, with 6 or 7 pairs of ribs bearing deep pleural and shallower interpleural furrows running parallel to each other, both extending close to margin. Border about 2 mm wide, slightly convex, with thin longitudinal ribs.

IGS NASU-21/04b (Fig. 3A): not differing morphologically from IGS NASU-21/04 and with similar dimensions, but represented by poorly preserved internal mould of pygidium.

IGS NASU-21/05b (Fig. 3E): isolated, poorly preserved glabella, tapering forwardly, rounded anteriorly, *c.* 4.0 mm long and 3.0 mm in maximum width, with impressed, curved glabellar furrows S1, nearly extending to occipital furrow; glabellar furrows S2–S3 shorter than S1, shallow and extending approximately same distance towards sagittal line. Occipital furrow strongly curved, projecting forwards at axial line and curving back behind preoccipital glabellar lobes. Central part of occipital ring wider than lateral parts. Specimen found in close proximity to pygidium IGS NASU-21/05a (Fig. 3B).

Remarks. *Waribole* sp. can be distinguished from *Waribole* (*Angustibole*) *winterbergensis* Hahn, 1965, *W.* (*W.*) *aello* Hahn et al., 1998 and *W. conifera* (Richter & Richter, 1926) by its smooth glabella. Additionally, the genal spines in *W.* sp. are longer than in *Waribole* (*Waribole*) *aello*. *Waribole* sp. differs from *W. lobatus* Kobayashi & Hamada, 1980 by the rounded shape of the posterior margin of the pygidium, a much wider marginal border and probably fewer rings of the pygidium axis. The described form is morphologically quite similar to *W. warsteinensis* (Richter & Richter, 1926), but differs slightly by

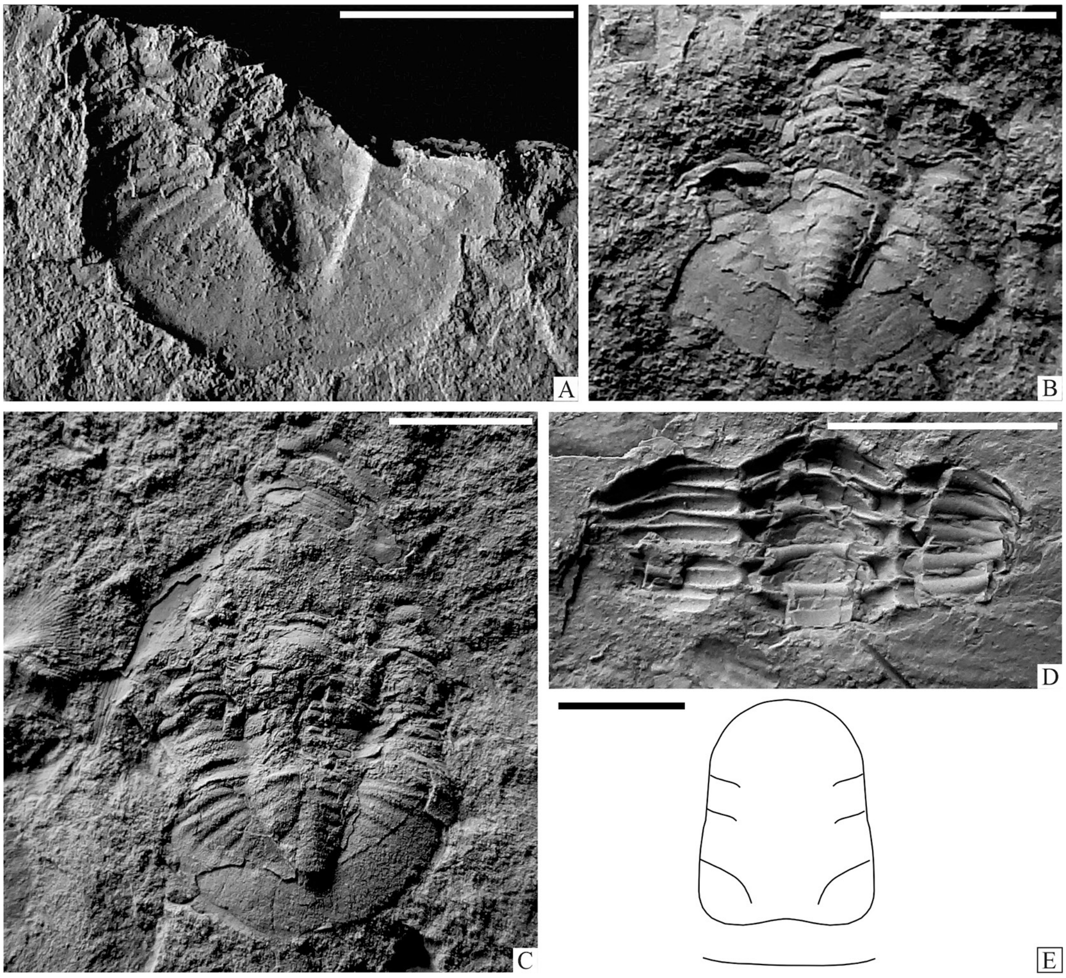


Fig. 3. *Waribole* sp. (**A–C, E**) and a thorax of an indeterminate trilobite from the Mississippian of the Dnipro-Donets Depression: A – IGS NASU-21/04b; B – IGS NASU-21/05a; C – IGS NASU-21/04a; **D –** unnumbered specimen (Gubs'ka-1 borehole, stratigraphical interval 4,290.0–4,301.0 m, Serpukhovian); E – schematic sketch of glabella IGS NASU-21/05b. Scale bars equal 5 mm (A–D) and 2.5 mm (E).

a narrower glabella. *Waribole* sp. is also morphologically close to *W. granulata* Osmólska, 1962, but the poor preservation of the available material does not allow a detailed comparison of these taxa. It should be noted that *W.* sp. reveals distinct morphological differences from *W. prima* Osmólska, 1962 and *W. secunda* Osmólska, 1962.

It is important to note that representatives of the genus *Waribole* have not been found in post-Visean deposits (Dr David K. Brezinski, pers. comm., March/2024). Therefore, the attribution of the available material to *Waribole* is probably best considered conditional.

5. Discussion

Weberides mucronatus, described above from the Dnipro-Donets Depression, has previously been recorded from Serpukhovian strata of the Lviv Palaeozoic Trough in western Ukraine (Shul'ga et al., 1992, fig. 373; Shul'ga & Konstantynenko, 1993; Shul'ga et al., 2007, fig. 156). The trilobite fauna of the Lviv Palaeozoic Trough is very similar in age and habitat conditions to the low-diversity faunule described in the present paper from the Dnipro-Donets Depression.

In the Donets Basin of Ukraine, the Serpukhovian deposits are represented by paralic coal-bearing strata that accumulated under relatively shallow-marine, coastal and continental conditions. Trilobites in these deposits are represented by species of the genera *Cummingella, Weberides*, *Phillipsia* and *Griffithides* (V. Weber, 1933, 1937, 1941). *Weberides mucronatus* had earlier been noted from lower Serpukhovian deposits of the Donets Basin by V. Weber (1933, 1937).

Representatives of the genus *Waribole* Richter & Richter, 1926 had not been previously recorded from Ukraine. This genus is typical of faunal assemblages of the Mississippian-aged Kulm facies in western and central Europe (e.g., Portugal, England, France, Germany, Czech Republic) (e.g., Hahn et al., 1989, 1996, 1998), which formed under relatively deep-water conditions and is represented by four lithofacies complexes including shallow-water carbonate platforms, starved basin facies with predominating pelites, calciturbidite-influenced basins filled with carbonate sediments derived from local platforms, and siliciclastic "Kulmgrauwacken" facies (Korn, 2010; Herbig, 2016).

Kulm trilobites were distributed globally in suitable deposits, for example in China (Hahn & Hahn, 2005), Kazakhstan (Balashova, 1956; Nikolaeva et al., 2022) and the USA (Hahn et al., 1980; Brezinski, 1998). Lithologically and in terms of depositional environments, the Mississippian sedimentary sequence of the Dnipro-Donets Depression resembles the Kulm facies, despite the fact that these deposits in the Dnipro-Donets Depression and European basins were formed under different geotectonic conditions. This issue requires further study, since only foraminifera (Brazhnikova et al., 1967; Poletaev et al., 1991) are relatively well studied from Mississippian deposits in the Dnipro-Donets Depression. Other biotic groups have been studied rather poorly, but it is known that these strata also contain corals (Klevtsovskiy & Ogar, 2013) and other cnidarians (Dernov, 2023), brachiopods (Vdovenko et al., 1988; Poletaev & Vdovenko, 2013) and cephalopods (Kuzina & Poletaev, 1991), which are quite similar in systematic composition to assemblages from the Kulm facies.

The typical Kulm trilobites have flattened exoskeletons and are athelopic (Hahn & Hahn, 2005), i.e., either blind, or with eyes reduced to a small number of lenses (Owens & Tilsley, 1995), since they lived in deep, almost aphotic habitats. However, Serpukhovian black shales of the Dnipro-Donets Depression formed in relatively low-energy dysaerobic marine environments with low sedimentation rates and within the photic zone (Vdovenko et al., 1993; Lukin, 2020).

6. Conclusions

Two trilobite species, *Weberides mucronatus* and *Waribole* sp., are described from Serpukhovian strata of the Sribne-Krasnograd Zone in the Dnipro-Donets Depression in north-eastern Ukraine. Species of the genus *Waribole* had not been previously recorded from Ukraine. *Waribole* is typical of faunal assemblages of the Mississippian-aged Kulm facies across western and central Europe, which formed under relatively deep-water conditions.

Acknowledgements

The author is sincerely grateful to Dr David K. Brezinski (Maryland Geological Survey, USA) and an anonymous reviewer, whose comments and suggestions improved the quality of the final version of the manuscript. The research was conducted within the framework of the programme "Strategic Mineral Resources for Economic Recovery of Ukraine: Analysis of Resources and Reserves, Development of Search Criteria for Increasing the Mineral Resource Base" (State Registration No. 0123U100855).

References

Babcock, L.E., Peng, S. & Ahlberg, P., 2017. Cambrian trilobite biostratigraphy and its role in developing an integrated history of the Earth system. *Lethaia* 50, 381–399.

Balashova, E.A., 1956. Turneyskiye trilobiti Ber-Chogura (Mugodzhary) [Tournaisian trilobites of the Berchogur (Mugodzhary)]. *Yearbook of the All-Union Palaeontological Society* 15 (for 1954 and 1955), 249–261.

Bault, V., Balseiro, D., Monnet, C. & Crónier, C., 2022. Post-Ordovician trilobite diversity and evolutionary faunas. *Earth-Science Reviews* 230, 104035.

Bilyk, A.O., Vakarchuk, G.I. & Ivanyshyn, V.A., 2002. *Stratyhrafiya, korelyatsiya ta vuhlevodnevyy potentsial turneys'kykh i vizeys'kykh vidkladiv Dniprovs'ko-Donets'koyi zapadyny* [*Stratigraphy, correlation and prospects of oil and gas bearing capacity of the Tournaisian and Visean deposits of the Dnipro-Donets Depression*]. Chernihivski Oberehy, Chernihiv, 111 pp.

Bogush, O.I. & Yuferev, O.V., 1966. Foraminifery karbona i permi Verkhoyan'ya [Carboniferous and Permian foraminifers from the Verkhoyansk Range area]. Nauka, Moscow, 209 p.

Bojkowski, K., 1961. Nowe stanowisko *Paladin mucronatus* McCoy w warstwach brzeżnych (namur A) [New locality of *Paladin mucronatus* McCoy in the Namurian A]. *Geological Quarterly* 5, 322–328.

Brady, G.S. & Robertson, D., 1870. The Ostracoda and Foraminifera of tidal rivers. With an analysis and descriptions of the Foraminifera, by Henry B. Brady, F.L.S. *Annals and Magazine of Natural History* 6, 273–309.

Brazhnikova, N.E., 1956. Foraminifery [Foraminifers]. [In:] Bondarchuk, V.G. (Ed.): Fauna i flora kamennougol'nykh otlozheniy Galitsiysko-Volynskoy vpadiny [Carboniferous fauna and flora of the Galychyna-Volyn Depression]. *Proceedings of the Institute of Geological Sciences. Series of stratigraphy and palaeontology* 10, 3–89.

Brazhnikova, N.E., 1962. *Quasiendothyra* i blizkiye k nim formy iz nizhnego karbona Donetskogo basseyna i drugikh rayonov Ukrainy [*Quasiendothyra* and similar forms from the Lower Carboniferous of the Donets Basin and other regions of Ukraine]. *Transactions of the Institute of Geological Sciences of the Academy of Sciences of the Ukrainian SSR* 44, 3–48.

Brazhnikova, N.E. & Potievskaya, P.D., 1948. Naslidky vyvchennya foraminifer za materialamy sverdlovyn zakhidnoyi okrayiny Donbasu [Results of the foraminiferal study on materials from wells of the western Donets Basin]. *Collection of works on palaeontology and stratigraphy* 1, 76–101.

Brazhnikova, N.E., Vakarchuk, H.Y., Vdovenko, M.V., Vinnichenko, L.V., Karpova, M.A., Kolomiets, Ya.Y., Potievskaya, P.D., Rostovtseva, L.F. & Shevchenko, H.D., 1967. *Mikrofaunisticheskiye markiruyushchiye gorizonty kamennougol'nykh i permskikh otlozheniy Dneprovsko-Donetskoy vpadiny* [*Microfaunistic marker horizons of the Carboniferous and Permian deposits of the Dnipro-Donets Depression*]. Naukova Dumka, Kyiv, 234 pp.

Brazhnikova, N.E., Zelenska, P.I., Kolomiets, Y.I., Potievska, P.I. & Sheviakova E.P., 1969. The eastern part of the Dnipro-Donets Depression and adjacent areas of the northern and northwestern margins of the Donets Basin. [In:] D.E. Aizenverg (Ed.): *Stratygraphiya URSR*. *Tom 5: Karbon* [*Stratigraphy of the Ukrainian SSR*. *Volume 5: Carboniferous*]. Naukova Dumka, Kyiv, 111–164.

Brezinski, D.K., 1992. Permian trilobites from west Texas. *Journal of Paleontology* 66, 924–943.

Brezinski, D.K., 1998. Trilobites from lower Mississippian starved basin facies of the Southern United States. *Journal of Paleontology* 72, 718–725.

Brezinski, D.K., 1999. The rise and fall of late Paleozoic trilobites of the United States. *Journal of Paleontology* 73, 164–175.

Brezinski, D.K., 2000. Lower Mississippian trilobites from southern New Mexico. *Journal of Paleontology* 74, 1043–1064.

Brezinski, D.K., 2003. Evolutionary and biogeographical implications of phylogenetic analysis of the late Paleozoic trilobite Paladin. [In:] P.D. Lane, D.J. Siveter & R.A. Fortey (Eds): *Trilobites and their relatives*. *Special Papers in Palaeontology* 70, 363–375.

Brezinski, D.K., 2005. Paleobiogeographic patterns in Late Mississippian trilobites of the United States with new species from Montana. *Annals of Carnegie Museum* 74, 77–89.

Brezinski, D.K., 2008. Phylogenetics, systematics, paleoecology, and evolution of the trilobite genera *Paladin* and *Kaskia* from the United States. *Journal of Paleontology* 82, 511–527.

Brezinski, D.K., 2023. Biogeographic patterns in Late Paleozoic trilobites. *Palaeogeography, Palaeoclimatology, Palaeoecology* 609, 11319.

Chernyshev, B.I., 1922. *O trilobitakh iz kamennougol'nykh otlozheniy Rossii* [*On the trilobites from the Carboniferous deposits of Russia*]. *Transactions of the Comrade Artem Donetsk technical school* 1, 84–104.

Demanet, F., 1938. La faune des Couches de passage du Dinantien au Namurien dans le synclinorium de Dinant [The fauna of the transition layers from the Dinantian to the Namurian in the Dinant synclinorium]. *Mémoires du Musée royal d'histoire mil rille de Belgique* 84, 1–202.

Dernov, V., 2023. First occurrence of the genus *Sphenothallus* Hall, 1847 (Cnidaria) in the Carboniferous of the Dnipro-Donets Depression, Ukraine. *Revista Brasileira de Paleontologia* 26, 13–20.

Eichwald, E., 1825. *Geognostico-zoologicae per ingriam marisque Baltici provincias nec non de trilobites observations*. Wyener, Kazan, 58 pp.

Eichwald, E., 1861. *Lethaea Rossica ou Paléontologie de la Russie. Ancienne Période. 3*. E. Schwiezerbart, Stuttgart, 1657 pp.

Fischer von Waldheim, G., 1825. Trilobiten. [In:] E. Eichwald, *Geognosticozoologicae peringriam marisque Baltice provincias nec non de trilobites obervationes*. Kazan, 1–58.

Foote, M.J., 1993. Contributions of individual taxa to overall morphological disparity. *Paleobiology* 19, 403–419.

Fortey, R.A. & Owens, R.M., 1975. Proetida – a new order of trilobites. *Fossils and Strata* 4, 227–239.

Girty, G.H., 1910. New genera and species of Carboniferous fossils from the Fayetteville Shale of Arkansas. *Annals of the New York Academy of Sciences* 20, 189–238.

Gordon, M., 1969. Revision of some of Girty's invertebrate fossils from the Fayetteville Shale (Mississippian) of Arkansas and Oklahoma – Trilobites. *Geological Survey professional paper* 606 (A–F), 35–39.

Hahn, G., 1965. Revision der Gattung *Archegonus* Burmeister 1843 (Trilobita). *Senckenbergiana lethaea* 46, 229–262.

Hahn, G. & Hahn, R., 1970. Trilobitae carbonici et permici II. (Proetidae: Griffithidinae). *Fossilium Catalogus. I: Animalia* 119, 163–331.

Hahn, G. & Hahn, R., 1975. Die Trilobiten des Ober-Devon, Karbon und Perm, I–VIII. [In:] K. Krömmelbein (Ed.): *Leitfossilien* 1. Gebrüder Borntraeger, Berlin & Stuttgart, 1–127.

Hahn, G. & Hahn, R., 2005. Kulm trilobites (Lower Carboniferous) from S-China. *Paläontologische Zeitschrift* 79, 371–375.

Hahn, G., Hahn, R., & Brauckmann, C., 1989. Neue Kulm-Trilobiten aus Wuppertal (Bundesrepublik Deutschland). 2. Eine Fauna aus dem Devon/Karbon-Grenzbereich. *Jahresberichte des Naturwissenschaftlichen Vereins in Wuppertal* 42, 183–200.

Hahn, G., Hahn, R. & Müller, P., 1996. 100 Jahre Trilobiten-Forschungin den Erdbacher Kalken (Unter-Karbon) – Zusammenstellung bisheriger Ergebnisse und Beschreibung neuer Taxa [100 years of trilobite research in the Erdbacher Kalken (Lower Carboniferous) - compilation of previous results and description of new taxa]. *Geologica et Palaeontologica* 30, 147–193.

Hahn, G., Hahn, R. & Müller, P., 1998. Trilobiten aus den Erdbacher Kalken (Unter-Karbon) von Steeden in Hessen. *Geologica et Palaeontologica* 32, 161–219.

Hahn, G., Paull, R.A. & Chamberlain, C.K., 1980. First recognition and stratigraphic significance of the early late Mississippian trilobite *Carbonocoryphe* (*Aprathia*) in North America. *Journal of Paleontology* 54, 371–380.

Hawle, I. & Corda, A.J.C., 1847. Prodrom einer Monographie der böhmischen Trilobiten. *Abhandlungen der Königlen Böhmischen Gessellschaft der Wissenschaften* 4, 120–292.

Herbig, H.-G., 2016. Mississippian (Early Carboniferous) sequence stratigraphy of the Rhenish Kulm Basin, Germany. *Geologica Belgica* 19, 81–110.

Kargin, A.K., 1911. O nekotorykh kamennougol'nykh trilobitakh Donetskogo basseyna [On some Carboniferous trilobites of the Donets Basin]. *Proceedings of the Yekaterinoslav Higher Mining School* 2, 1–16.

Klebelsberg, R. von., 1912. Die marine fauna der Ostrauer Schichten. *Jahrbuch der k. k. Geologischen Reichsanstalt* 63, 461–556.

Klevtsovskiy, A. & Ogar, V., 2013. Deyaki *Syringopora* z nyznyogo karbonu pivdennoi prybortovoi zony Dniprovs'ko-Donets'koi Depresii [Some *Syringopora* from the Lower Carboniferous of southern marginal zone of the Dnipro-Donets Depression]. *Paleontological Review* 45, 28–36.

Kobayashi, T. & Hamada, T., 1978. Advance reports on the Carboniferous trilobites of Japan. II. One new subgenus and three new species. *Proceedings of the Japan Academy, Series B: Physical and Biological Sciences* 54, 50–54.

Kobayashi, T. & Hamada, T., 1980. Carboniferous trilobites of Japan in comparison with Asian, Pacific and other faunas. *Palaeontological Society of Japan special papers* 23, 1–132.

Korejwo, K., 1969. Stratigraphy and paleogeography of the Namurian in the Polish Lowlands. *Acta Geologica Polonica*, 19, 609–709.

Korejwo, K., 1986. Biostratigraphy of the Carboniferous deposits of the Świdnik blocks (Lublin Coal Basin). *Acta Geologica Polonica* 36, 337–344.

Korejwo, K., 1986. Biostratigraphy of the Carboniferous deposits of the Świdnik blocks (Lublin Coal Basin). *Acta Geologica Polonica*, 36, 337–346.

Korejwo, K. & Teller, L., 1972. Karbon wyniesienia Kocka [Carboniferous deposits of the Kock Block]. *Acta Geologica Polonica* 22, 655-675.

Korn, D., 2010. Lithostratigraphy and biostratigraphy of the Kulm succession in the Rhenish Mountains. *Zeitschrift der Deutschen Gesellschaft für Geowissenschaften* 161, 431–453.

Krestovnikov, V.N. & Theodorovich, G.I., 1936. Novyy vid roda Archaediscus iz Karbona Yuzhnogo Urala [A new species of the genus *Archaediscus* from the Carboniferous of the Southern Urals]. *Bulletin de la Société des Naturalistes de Moscou* 44, 86–90.

Kuzina, L.F. & Poletaev, V.I., 1991. New Visean ammonoids of the Donets Basin and Dnipro-Donets Depression. *Paleontological Journal* 3, 35–45.

Lebedev, N.I., 1927. Materialy po geologii Donetskogo basseyna. 1. Paleontologicheskaya kharakteristika nekotorykh srednekamennougol'nykh gorizontov Donetskogo basseina [Materials on the geology of the Donets Basin. 1. Palaeontological characterization of some middle Carboniferous horizons of the Donets Basin]. *Scientific notes of the Dnipropetrovsk Research Department of Geology* 2, 1–104.

Lipina, O.A., 1948. Tekstulyariidy verkhney chasti nizhnego karbona yuzhnogo kryla Podmoskovnogo basseyna [Textulariids of the late Lower Carboniferous of the southern part of the Moscow Basin]. *Proceedings of the Institute of Geological Sciences of the Academy of Sciences of the USSR* 62, 196–215.

Lukin, A.E., 2020. Rannevizeyskiy evksinskiy basseyn v sisteme Paleotetisa (v svete sovremennykh dannykh) [The early Visean Euxine-type palaeobasin in the Paleotethys system (in the light of modern data)]. *Geology and Mineral Resources of the World Ocean* 16, 24–48.

Mamet, B., Choubert, B. & Hottinger, L., 1966. Notes sur le Carbonifère du Djebel Ouarkziz; étude du passage du Viséen au Namurien d'après les foraminifères [Notes on the Carboniferous of Djebel Ouarkziz; study of the transition from the Viséan to the Namurian according to foraminifera]. *Notes du Service Géologique du Maroc* 27, 6–21.

M'Coy, F., 1844. *A synopsis of the characters of the Carboniferous limestone fossils of Ireland*. Williams & Norgate, Dublin, 274 pp.

Miloradovich, B., 1937. Materialy k izucheniyu verkhnepaleozoyskikh brakhiopod severnogo ostrova Novoy Zemli [Materials on the Upper Palaeozoic brachiopods of the northern island of Novaya Zemlya]. *Proceedings of the Arctic Institute of the Academy of Sciences of the USSR* 19, 1–180.

Möller, V. von, 1879. Die Foraminiferen des russischen Kohlenkalks. *Mémoires de l'Académie impériale des sciences de St.-Pétersbourg*, 27, 1–132.

Murchison, R.I., Verneuil, É. & Keyserling, A., 1845. Géologie de la Russie d'Europe et des Montagnes de l'Oural. Partie II. Paléontologie [Geology of European Russia and the Ural Mountains. Part II. Paleontology]. John Murray, London and P. Bertrand, Paris, 512 pp.

Mychko, E.V., 2012. Revision of trilobites of the genus *Paraphillipsia* Tumanskaya from the Permian olistoliths of Crimea. *Paleontological Journal* 46, 575–582.

Mychko, E.V. & Alekseev, A.S., 2012. Trilobites from the Podolskian Horizon (Moscovian) exposed in the Priokskyi Quarry in Moscow Region. *Bulletin of the Moscow Society of Naturalists (Geological Section)* 87, 24–32.

Mychko, E.V. & Alekseev, A.S., 2017. Localities of the middle Carboniferous to Permian trilobites in Russia and neighbouring countries. *Bulletin of the Moscow Society of Naturalists (Geological Section)* 92, 40–83.

Mychko, E.V. & Dernov, V.S., 2019. New record of trilobites in the middle Carboniferous of the Donets Basin. *Bulletin of the Moscow Society of Naturalists (Geological Section)* 94, 52–63.

Nikolaeva, S.V., Kulagina, E.I., Mustapayeva, S.N., Alekseev, A.S., Gatovsky, Y.A., Denayer, J., Ohar, V., Kurilenko, A.V., Zhaimina, V.Ja. & Mychko, E.V., 2022.

Progress in the study of the Devonian–Carboniferous boundary sections in the Berchogur Depression (Mugodzhary Mountains, western Kazakhstan). *Paläontologische Zeitschr*ift 96, 415–447.

Oehlert, D.P., 1886. Étude sur quelques trilobites du groupe de Proetidae. *Bulletine Society Étude Scientifique d'Angers* 15, 121–143.

Osmolska, H., 1962. Famennian and Lower Carboniferous Cyrtosymbolinae (Trilobita) from the Holy Cross Mountains, Poland. *Acta Palaeontologica Polonica* 7, 53–204.

Osmolska, H., 1970. Revision of non-cyrtosymbolinid trilobites from the Tournaisian-Namurian of Eurasia. *Palaeontologica Polonica* 23, 1–165.

Owens, R.M., 1990. Carboniferous trilobites: the beginning of the end. *Geology Today* 6, 96–100.

Owens, R.M., 2003. The stratigraphical distribution and extinctions of Permian trilobites. *Special Papers of Palaeontology* 70, 377–397.

Owens, R.M. & Tilsley, J.W., 1995. An atheloptic trilobite assemblage from the Carboniferous of North Devon. *Geological Magazine* 132, 713–728.

Poletaev, V.I. & Vdovenko, M.V., 2013. Nyzhniy karbon (Missisipiy) [Lower Carboniferous (Mississippian)]. [In:] P.F. Gozhik (Ed.): *Stratygraphiya verkhnyogo proterozoyu i fanerozoyu Ukrainy. Tom 1. Stratygraphiya verkhnyogo proterozoyu, paleozoyu i mezozoyu* [*Stratigraphy of the Upper Proterozoic and Phanerozoic of Ukraine. Volume 1. Stratigraphy of the Upper Proterozoic, Paleozoic and Mesozoic*]. LAT&K, Kyiv, 250–283.

Poletaev, V.I., Vakarchuk, V.G., Vinnichenko, L.G., Kononenko, L.P., Lukin, A.Ye. & Reznikov, A.I., 1991. *Razchleneniye i korrelyatsiya nizhne- i srednekamennougol'nykh kamennougol'nykh otlozheniy Dneprovsko-Donetskogo avlakogena* [*Subdivision and correlation of the Lower and lower middle Carboniferous strata of the Dnipro-Donets Aulacogene*]. IGS AS USSR, Kyiv, 52 pp.

Přibyl, A. 1951., O moravskoslezských karbonských trilobitech [On the Moravian-Silesian Carboniferous trilobites]. *Rozpravy Ceské Akademie Ved a Umení* 60, 1–22.

Rauzer-Chernousova, D.M., 1948. Materialy k faune foraminifer kamennougol'nykh otlozheniy Tsentral'nogo Kazakhstana [Contributions to the Carboniferous foraminifer fauna of central Kazakhstan]. *Proceedings of the Institute of Geological Sciences of the Academy of Sciences of the USSR*, 66, 1–28.

Rauzer-Chernousova, D.M., Belyaev, G., Reitlinger, E., 1936. Verkhnepaleozoyskiye foraminifery Pechorskogo kraya [Upper Palaeozoic foraminifers of the Pechora region]. *Proceedings of the Polar Commission of the Academy of Sciences of the USSR* 28, 159–232.

Rauzer-Chernousova, D.M. & Fursenko, A.V., 1937. *Opredelitel' foraminifer neftenosnykh rayonov SSSR* [*The key book on foraminifers of oil-bearing regions of the USSR*]. ONTI, Leningrad and Moscow, 319 pp.

Reed, F.R.C., 1942. Some new Carboniferous Trilobites. *Annals and Magazine of Natural History (Series 11)* 57, 649–672.

Richter, R. & Richter, E., 1926. Die Trilobiten des Oberdevons. Beiträge zur Kenntnis devonischer Trilobiten. IV. *Abhandlungen der Preußischen Geologischen Landesanstalt, Neue Folge* 99, 1–314.

Schwarzbach, M., 1935. Trilobiten als Leitversteinerungen im Oberkarbon Oberschlesiens. *Geologische Verein Oberschlesiens Jahresber* 92, 92–96.

Semichatova, S.V., 1941. Brakhiopody bashkirskikh sloyev SSSR. 1. Rod *Choristites* Fischer [Bashkirian brachiopods of the USSR. 1. Genus *Choristites* Fischer]. *Proceedings of the Palaeontological Institute* 12, 1–152.

Shul'ga, V.F. & Konstantynenko, L.I., 1993. Rasprostraneniye fauny trilobitov v razreze karbonovoy uglenosnoy formatsii L'vovsko-Volynskogo basseyna [Distribution of the trilobite fauna in the Carboniferous coal-bearing of the Lviv-Volyn Basin]. *Proceedings of the National Academy of Sciences of Ukraine* 3, 95–99.

Shul'ga, V.F., Lelyk, B.I., Garun, V.I., Manichev, V.I., Stasiv, V.P., Savenok, S.S., Sedaeva, K.M. & Shwartzman, Ye.G., 1992. *Atlas of the lithological and genetic types and depositional conditions of the coal-bearing deposits of the Lviv-Volhyn Basin*. Naukova Dumka, Kyiv, 176 pp.

Shul'ga, V.F., Zdanovski, A., Zaytseva, L.B., Ivanova, A.V., Ivanina, A.V., Korol', M.D., Kotasova, A., Kostyk, I.O., Lelyk, B.I., Miger, T., Manichev, V.Yo., Matraphailo, M.M., Ptak, B., Savchuk, V.S., Sedaeva, G.M. & Stepanenko, Ya.G., 2007. Korrelyatsiya karbonovikh uglenosníkh formatsiy L'vovsko-Volynskogo i Lyublinskogo basseynov [Correlation of Carboniferous coal-bearing formations of the Lviv-Volhynian and Lublin basins. Varta, Kyiv, 427 pp.

Sowerby, J., 1818. The mineral conchology of Great Britain; or, Coloured figures and descriptions of those remains of testaceous animals or shells, which have been preserved at various times and depths in the earth. Vol. III. Privately published by the author, London, 194 pp.

Tortello, M.F., 2003. Biostratigraphic significance of the latest Cambrian-earliest Ordovician agnostoid trilobites from Northwestern Argentina. *Geologica Acta* 1, 61–72.

Toumansky, O., 1930. Permocarbonische Trilobiten der Krim. *Centrablatt fűr Mineralogie, Geologie und Paläontologie. Abteilung B,* 473–477.

Traquair, R.H., 1871. On *Griffithides mucronatus* (M'Coy). *Journal of the Royal Geological Society of Ireland, New Series* 12, 213–217.

Tumanskaya, O.G., 1935. *Kamennougol'nye i permskiye otlozheniya Kryma. Chast' 2. Kamennougol'nye i permskiye trilobity Kryma* [*Carboniferous and Permian deposits of Crimea. Part 2. Carboniferous and Permian trilobites of Crimea*]. Main Geological Exploration Department, Moscow, 63 pp.

Vdovenko, M.V., 1967. Nekotoryye predstaviteli Endothyridae, Tournayellidae i Lituolidae iz nizhnevizeyskikh otlozheniy Bol'shogo Donbassa [Some lower Visean representatives of Endothyridae, Tournayellidae and Lituolidae from the Great Donets Basin]. N.N. Dunaeva (Ed.): *Niznevizeyskaya fauna Donetskogo basseyna* [*Lower Visean fauna of the Donets Basin*]. Naukova Dumka, Kyiv, 18–29.

Vdovenko, M.V., Vinnichenko, L.G., Vinnichenko, L.V., Kononenko, L.P., Lunin, A.E., Onufrishin, S.V. & Ustinovskii, Yu.B. 1988., Nizhniy karbon [Lower Carboniferous]. [In:] E.F. Shnyukov (Ed.): *Geologiya i nefte-gazonoznost' Dneprovsko-Donetskoy depresii. Stratigraphiya* [*Geology and hydrocarbon potential of the Dnipro-Donets Depression. Stratigraphy*]. Naukova Dumka, Kyiv, 32–61.

Vdovenko, M.V., Vinnichenko, L.G., Lukin, A.E., Onufrishin, S.V., Pogrebnyak, V.A., Skovorodnikova, E.A., Neutrievskaya, N.V., Ryabchun, L.I. & Nyaga, V.I., 1993. Yelenovskiy etap razvitiya (ranniy vize–ranniy pozdniy vize) [The Yelenovkian stage of development (early Visean–early late Visean)]. [In:] Tsegelnyuk P.D. (Ed.): *Geologichna istoriya Ukrainy* [*Geological history of Ukraine*]. Naukova Dumka, Kyiv, 114–120.

Vissarionova, A.I., 1948. Stratigrafiya i foraminifery nizhnego karbona Russkoy platformy i Priural'ya [Stratigraphy and foraminifers of the Lower Carboniferous of the Russian Platform and Cisurals]. *Proceedings of the Institute of Geological Sciences of the Academy of Sciences of the USSR* 62, 190–195.

Walch, J.E.I., 1771. Die Naturgeschichte der Versteinerungen zur Erläuterung der Knorrischen Sammlung von Merkwürdigkeiten der Natur [The natural history of fossils to explain the Knorrisch collection of natural oddities]. P.J. Felstecker, Nürnberg, 235 pp.

Weber, G.F., 1915. Nakhodka verkhnekamennougol'nykh trilobitov v Krymu [Finds of Upper Carboniferous trilobites in Crimea]. *Proceedings of the Imperial Academy of Sciences, series 6* 14, 1657–1660.

Weber, V.N., 1933. Trilobity Donetskogo basseyna [Trilobites of the Donets Basin]. *Transactions of the All-Union Geological Exploration Department of NKTP of the USSR* 225, 1–95.

Weber, V.N., 1937. Trilobity kamennougol'nykh i permskikh otlozheniy SSSR. Chast' 1. Kamennougol'nye trilobity [Trilobites from the Carboniferous and Permian deposits of the USSR. Part 1. Carboniferous trilobites]. Main editorial office geological prospecting and geodesic literature, Leningrad and Moscow, 150 pp.

Weber, V.N., 1939. Trilobity [Trilobites]. [In:] I.I. Gorsky (Ed.): *Atlas rukovodyaschikh form iskopaemykh faun SSSR. Tom 5. Sredniy i verkhniy otdely kamennougol'noy sistemy* [*Atlas of index fossils of the USSR. Volume 5. Middle and Upper Carboniferous*]. GONTI, Moscow-Leningrad, 145–147.

Weber, V.N., 1941. Trilobity [Trilobites]. [In:] L.S. Librovitch (Ed.), *Atlas rukovodyaschikh form iskopaemykh faun SSSR. Tom 4. Nizhniy otdel kamennougol'noy sistemy* [*Atlas of index fossils of the USSR. Volume 4. Lower Carboniferous*]. State Publishing House of Geological Literature at the Council of People's Commissars of the USSR, Moscow-Leningrad, 157–164.

Weller, J.M., 1936. Carboniferous trilobite genera. *Journal of Paleontology* 10, 704–714.

Westrop, S.R. & Adrain, J.M., 1998. Trilobite alpha diversity and the reorganization of Ordovician benthic marine communities. *Paleobiology* 24, 1–16.

Whittington, H.B., 1954. Two silicified Carboniferous trilobites from West Texas. *Smithsonian Miscellaneous Collections* 122, 1–16.

Woodward, H., 1883. Synopsis of the genera and species of Carboniferous limestone trilobites. *Geological Magazine, new series* 10, 445–454, 481–487, 534–542.

Manuscript submitted: 22 January 2024
Revision accepted: 21 March 2024