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Lingulid brachiopods with probably preserved original shell colouration from the Kamensk Formation (Moscovian, Middle Pennsylvanian) of the Donets Basin, Ukraine

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ABSTRACT

Problems Statement and Purpose. The colouration (when pigment is distributed more or less uniformly within skeletal substance) and colour patterns (when pigment is concentrated or arranged in bands, lines, spots, patches, etc.) of fossil brachiopod shells is poorly understood, since its preservation in the fossil record requires the coincidence of several, sometimes random, taphonomic factors. However, the study of the original colouration of fossil invertebrates is of great palaeoecological and taphonomic importance (e.g., to study of the evolution of vision, the development of predator-prey relationships). Records of Palaeozoic brachiopod shells with preserved colouration are quite rare and the shell colouration and colour patterns are currently known for only 15 genera.

Data and Methods. Studied isolated valves of the lingulid brachiopods *Lingularia mytiloides* from the lower Moscovian Kamensk Formation of Luhansk Region (Ukraine) show a preserved colour pattern on the outer surface, represented mainly by light concentric bands. Studied remains are represented by small, 8–10 mm long and 6–7 mm wide, moderately convex ventral thin-shelled valves with elongate elliptical outlines, a rounded anterior margin, subparallel lateral margins and a small, pointed umbo. Valve surface is covered with thin concentric growth lines and weakly developed rugae.

Results and Discussion. The studied specimens were divided into two groups based on shell colouration features, which may reflect some details of the colouration and colour patterns. However, these differences may be taphonomic artefacts. It is quite possible that the colour bands on the surface of the valves are evidence of sulphide oxidation, but even so, they likely still reflect the original colour patterns. Environmental conditions were important factors for the preservation of the colouration on the shells of the studied lingulid brachiopods. Among these conditions, the most important were slow sedimentation, absence of agents of mechanical and chemical destruction, such as high-energy water activity, encrustation by epibionts, etc., dysaerobic conditions, and rapid burial apparently accompanied by the activity of bacterial communities.

The studied colour patterns on the shells of *Lingularia mytiloides* are similar to those on other fossil lingulids. The adaptive significance of this colouration for the studied lingulids, which lived infaunally, remains unclear and cannot be resolved with the available material.

Keywords*: colouration, inarticulate brachiopods, Carboniferous, taphonomy, Donets Basin, Ukraine.*

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Introduction. The original colouration (when pigment is distributed more or less uniformly within skeletal substance) or colour patterns (when pigment is concentrated or arranged in bands, lines, spots, patches, etc.) of skeletons of invertebrates are rarely preserved in the fossil record [4, 17, 37, 57], as aggressive environmental influences such as solar ultraviolet radiation, bacterial decomposition, etc. destroy some pigments (e.g., carotenoids and indigoids) [34, 57, 63].

In addition, taphonomic processes synchronous with the burial of remains (e.g., bioturbation, bioerosion, shell-crushing predation) and diagenesis processes such as dissolution, recrystallization, rock heating, etc., usually destroy the colouration formed by both pigments and structural features (i.e., interference patterns) of a skeleton [17, 37]. However, persistent compounds such as melanin and porphyrin can persist even after dissolution and recrystallization of the shell substance, and they are sometimes found even on steinkerns [57].

Pigments do preserve as molecular fossils [4, 10, 17], but they decay and no longer absorb light at particular wavelengths. Such a phenomenon would explain the survival of colour patterns, but not the original colouration. In turn, the colour patterns caused by the structural features of the skeletons are rarely preserved in the fossil record [37].

The study of the life-time colouration of fossil organisms is important for the palaeoecological, taxonomic and evolution research (e.g., to study of the evolution of vision, the development of the predator-prey dynamics in palaeoecosystems) [13, 37].

Brachiopods were an important component of Palaeozoic marine ecosystems, and their remains are present in marine rocks of different lithology formed under different sedimentary conditions. That is why these animals are quite well studied among many other groups of Palaeozoic marine biota. However, records of Palaeozoic brachiopod shells with preserved colouration are quite rare. So far, the largest number of such finds are known from the Devonian

[3, 4, 6, 8, 9, 11, 35, 40, 44] and Permian strata (see [62: Table 1]). There are much fewer records from the Carboniferous, and the shell colouration and colour patterns are currently known for only 15 genera, including *Petrocrania, Orbiculoidea, Schizophoria, Orthotetes, Mesolobus, Chonetinella, Striatifera, Semiplanus*, *Hustedia, Brachythyris*, *Athyris, Martinia, Acanthospirina, Composita*, and *Dielasma* (see Table 1 for details).

This paper presents the results of studying the colouration of shells of the lingulid brachiopods *Lingularia mytiloides* (Sowerby, 1812) from black shales of the Kamensk Formation (early Moscovian, Middle Pennsylvanian), exposed in the south part of Luhansk Region, Ukraine. So far, the only report on the colouration of fossil brachiopod shells from Ukraine is work of Baliński [4], which describes colour patterns on the shell surface of the Early Devonian strophomenids *Plectodonta* sp. from Podillia (western Ukraine). According to the author's own observations, some shells of the terebratulid brachiopod genus *Carneithyris* Sahni, 1925 from the upper Campanian (Upper Cretaceous) limestone succession exposed near the city of Luhansk (eastern Ukraine) also bear poorly preserved colour patterns that are visible in daylight (these fossils have not been studied under UV light). Other fossils with preserved colouration from Ukraine have been described or figured by Pchelintsev [50], Kolesnikov [38], Rogov and Perminov [54], Pacaud [49], Dernov [23], and Krokhmal et al. [41].

Geological setting. The studied material was collected at the Lutuhyns'ka-Pivnichna mine fossil site, which located near the town of Lutuhyne in Luhansk Region of Ukraine (coordinates: 48°25'25.8"N 39°12'26.9"E; Fig. 1A, B). The fossil-bearing rock is a dark grey, carbonaceous, sometimes pyritized siltstone with large carbonate nodules and interlayer or lenses of coquina (Fig. 1F), which composing the heap spoil of the Lutuhyns'ka-Pivnichna coal mine (Fig. 1E). This siltstone is a roof shale of the k_7^L coal layer (i.e., the lower interlayer of the k_7 coal bed of the Kamensk Formation; Fig. 1C, D).

Numerous fossils such as ?worm tubes, brachiopods (*Orbiculoidea nitida* (Phillips, 1836), *Lingularia mytiloides* (Sowerby, 1812), *Derbyia* sp., *Neochonetes donetzianus* (Aisenverg, 1950), *Densepustula* sp.), bivalves (species of the genera *Palaeoneilo, Phestia*, *Sanguinolites*, etc.), gastropods (species of the genera *Euphemites, Retispira, Bucaniopsis, Naticopsis, Soleniscus*), orthocerids, coiled nautiloids (species of the genera *Gzheloceras*, *Parametacoceras*, *Metacoceras, Temnocheilus, Peripetoceras*, *Coelogasteroceras*, *Ephippioceras*, etc.), ammonoids (*Wiedeyoceras clarum* Popov, 1979 and *Winslowoceras* sp.), trilobites (*Paladin* cf. *lutugini* (Weber, 1933)), fishes (species of the genera *Symmorium* and *Venustodus*), terrestrial plants (*Calamites* sp.), bromalites and some other trace fossils have been collected from this stratigraphic level [22, 23 and unpublished author's data]. Shells of some lingulids studied here, as well as bivalves and gastropods from this fossil site, have retained their colouration. Previously, coiled nautiloids *Parametacoceras jongmansi* Delépine, 1937, *Metacoceras* spp., and *Coelogasteroceras coxi* Gordon, 1960 with colour patterns were described from this locality by the present author [23].

The Kamensk Formation consists of a paralic sequence of sandstones, siltstones, mudstones, coals, and limestones (see Fig. 1D). These rocks contain remains of various marine and terrestrial organisms, e.g., foraminifers, chaetetids, corals, brachiopods, bryozoans, bivalves, gastropods, cephalopods, crinoids, echinoids, conchostracans, horseshoe crabs, fishes, macroflora, palynomorphs, calcareous algae, etc. The thickness of the Kamensk Formation varies from 300 m in the NW part of the Donets Basin to 1050 m in the SE part of the basin [45, 52].

The lower part of the Kamensk Formation (stratigraphic interval between the K_1 and K_3 limestone layers) can be ascribed to the uppermost part of the Bashkirian and corresponds to the Krasnodonian Horizon (uppermost part of the Kayalian Regional Stage) of the regional stratigraphic scheme of the Dnipro-Donets Downwarp; the middle and upper parts of the Kamensk Formation (stratigraphic interval between the K_3 and L_1 limestone layers) attributed to the lower Moscovian and corresponds to the Kamenskian Horizon (lower half of the Lozivkian Regional Stage) [45, 52].

The Kamenskian Horizon roughly corresponds to the Vereian Horizon of the stratotype section of the Moscovian Stage (Moscow Syneclise, Russia) [45, 52]. The base of the Moscovian in the Donets Basin is at the base of the K_3 limestone layer (lower part of the Kamensk Formation; see Fig. 1D) [45, 52]. The absolute age of the volcanic ash interlayer in the k_7 coal bed is 313.16±0.08 My [20].

Material and methods. Six specimens (IGS NASU-27/01 to IGS NASU-27/06) of the valves of *Lingularia mytiloides* (Sowerby, 1812) with colour patterns were examined in this study. This material (collection IGS NASU-27) is stored in the Department of Palaeontology and Stratigraphy of the Palaeozoic Sediments, Institute of Geological Sciences of the National Academy of Sciences of Ukraine, Kyiv. Several unnumbered specimens were photographed in the field and are currently stored in the Geological Museum of the Luhansk Taras Shevchenko National University (Poltava, Ukraine).

Studied fossils were collected from slightly weathered shales and small limonite nodules of the heap spoil of the Lutuhyns'ka-Pivnichna coal mine. All specimens were studied and photographed under daylight, because the technique of studying the colour patterns on the shells of Mesozoic and Cenozoic molluscs by treatment with sodium hypochlorite (NaClO) and observation under UV light [13, 16, 26, 66] is inadequate for the available material, because sodium hypochlorite (bleach) is a strong oxidant that reacts with the pyritized rock of the fossils rock matrix. Since the examined material is very rare, it was risky to process them in this way. Studies specimens immersed in water have not yielded outstanding results, and the wetting of pyritized fossils with water causes the development of pyrite decay, which leads to the destruction of the fossils [5, 12, 46].

Table 1

Carboniferous brachiopods with preserved shell colouration

Taxon	Locality	Age	Brief description	References
Petrocrania modesta (White & St. John, 1867)	Missouri, USA	Cherokee Group, Pennsylvanian	Dark blue or slate-colored	[30]
Orbiculoidea nitida (Phillips, 1836)	Boghead Quarry near Hamilton, Scotland	Carboniferous	Radial lines	[19]
Schizophoria resupinata (Martin, 1809)	Unknown	Carboniferous	Radial lines	[25]
Orthotetes kaskaskiensis (McChesney, 1860)	Preston, Illinois, USA	Chesterian, Mississippian	Concentric bands	[47]
Mesolobus mesolobus (Norwood & Pratten, 1854)	Muskingum County, Ohio, USA	Pottsville Formation, Lower Pennsylvanian	Concentric bands	[43]
Chonetinella jeffordsi Stevens, 1962	McCoy, Colorado, USA	Minturn Formation, Middle Pennsylvanian	Spots and concentric bands	[61]
Striatifera striata (Fischer, 1837)	Verkhnyaya Usa River, Pechora Basin, Russia	Upper Serpukhovian, Mississippian	The shells are colored pink	[36]
Striatifera striatoplicata (Miloradovich, 1947)	Verkhnyaya Usa River, Pechora Basin, Russia	Upper Serpukhovian, Mississippian	The shells are colored pink	[36]
Striatifera angusta (Janischewsky, 1910)	Orlovka-Yama, Pechora Basin, Russia	Visean	The shells are colored pink	[36]
Semiplanus semiplanus (Schwetzov, 1922)	Usa River, Pechora Basin, Russia	Mississippian	The shells are colored yellow	[36]
Hustedia mormoni (Marcou, 1858)	New Philadelphia, Ohio, USA	Putnam Hill Shale, Middle Pennsylvanian	Concentric bands	[33]
Brachythyris sp.	Zalaz-di-Bozh, Pechora Basin, Russia	Upper Visean, Mississippian	The shells are colored brown	[36]
Athyris sp.	Verkhnyaya Usa River, Pechora Basin, Russia	Upper Serpukhovian, Mississippian	The shells are colored pink	[36]
Martinia glabra (Sowerby, 1821)	Unknown	Carboniferous	Radial lines	[25]
Acanthospirina aciculifera (Rowley, 1893)	Louisiana, Missouri, USA	Louisiana Limestone, Tournaisian, Mississippian	Radial lines	[55]
Composita trinuclea (Hall, 1858)	Zalaz-di-Bozh, Pechora Basin, Russia	Upper Visean, Mississippian	The shells are colored brown	[36]
Composita globularis (Phillips, 1836)	Zalaz-di-Bozh, Pechora Basin, Russia	Upper Visean, Mississippian	The shells are colored brown	[36]
Dielasma hastata (Sowerby, 1828)	Settle, Yorkshire.	Carboniferous	Radial lines	[18]
Dielasma hastata (Sowerby, 1828)	Longnor, Derbyshire	Mississippian	Radial lines	[2]
Dielasma hastata (Sowerby, 1828)	Unknown	Carboniferous	Radial lines	[25]
Dielasma cf. *hastata* (Sowerby, 1828)	Morchanov-Kyrta, Pechora Basin, Russia	Carboniferous/Permian boundary interval	Radial lines	[36]
	Utlan and Sobinsk Rodnik rivers, Pechora Basin, Russia	Upper Pennsylvanian	Radial lines	[36]
Dielasma elongatum (von Schlotheim, 1816)	Unknown	Carboniferous	Radial lines	[25]

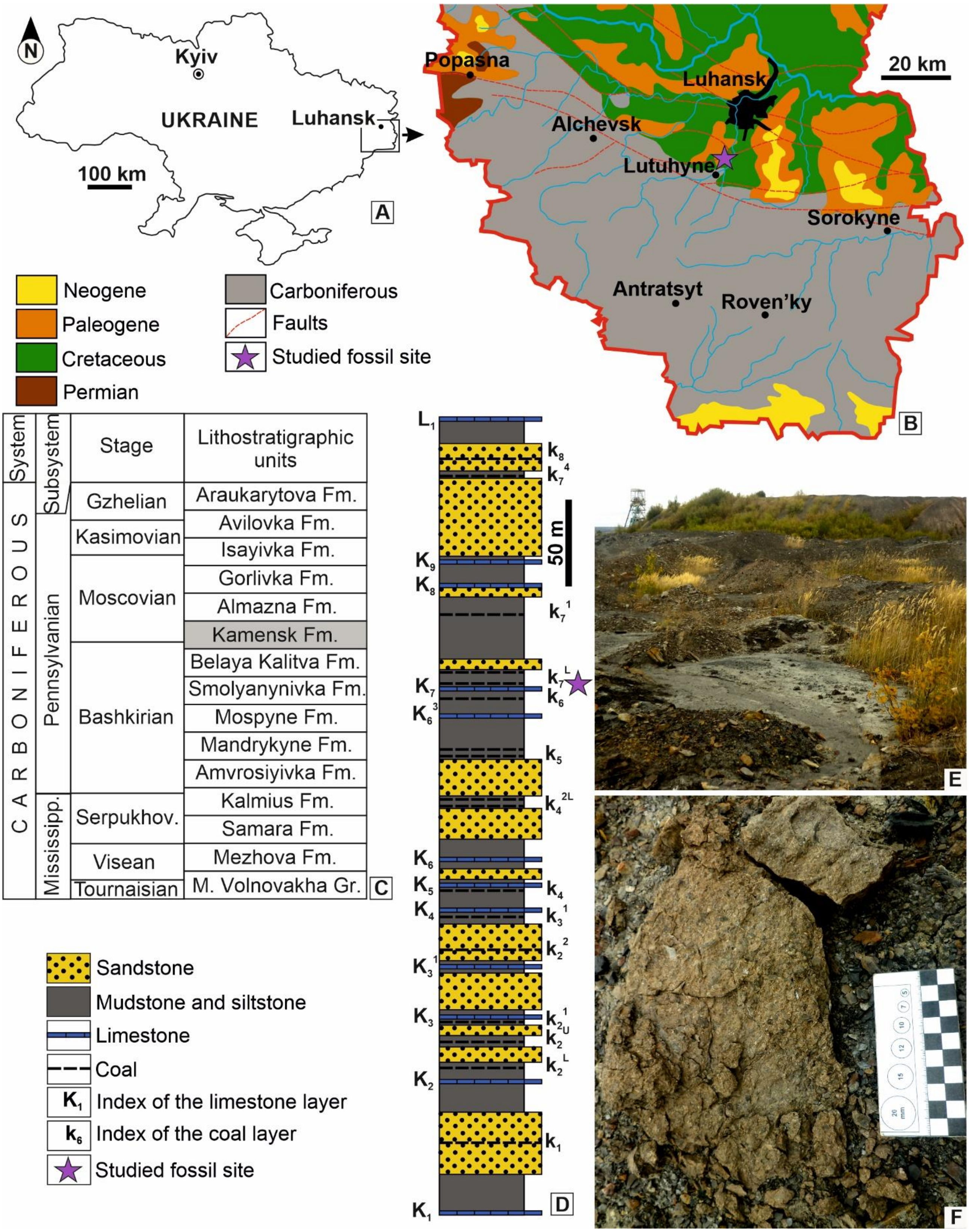

Fig. 1. Geographical and stratigraphic position of the studied fossil site.
A – study area; B – schematic geological map of the south part of Luhansk Region showing the geographic location of the studied fossil site (modified after [24]); C – stratigraphic position of the Kamensk Formation in the Carboniferous succession of the Donets Basin; D – stratigraphic position of the studied locality in the Kamensk Formation; E – general view of the dumps of the Lutuhynska-Pivnichna coal mine; F – coquina with remains of mollusks and brachiopods from the black shale of the Lutuhynska-Pivnichna fossil site.
Abbreviations: M. Volnovakha Gr. – Mokra Volnovakha Group,
Mississipp. – Mississippian, Serpukhov. – Serpukhovian

Morphology of lingulids with preserved colour bands. Studied remains of *Lingularia mytiloides* (Sowerby, 1812) (Fig. 2) are represented by small (8–10 mm long and 6–7 mm wide), moderately convex thin-shelled ventral valves with elongate elliptical outlines (valve length/valve width = 1.37–1.50), a rounded anterior margin, subparallel lateral margins, and a small, pointed umbo. Maximum valve width is located at about the mid-length. Valve surface is covered with thin concentric growth lines and weakly developed rugae. Internal structure of valves is not studied.

Description of colouration. The studied specimens can be divided into two groups based on the shell colouration features, which reflect some details of the colouration and colour patterns. However, these differences may be taphonomic artefacts.

The first group includes specimens IGS NASU-27/01, IGS NASU-27/03, and IGS NASU-27/04.

Specimen IGS NASU-27/01 (Fig. 2D). The colouration of the valve surface is represented by thin (*c*. 0.3–0.6 mm) concentric bands, two of which are quite visible. The light bands are quite clearly visible against the brownish-grey background of the main part of the valve.

Specimen IGS NASU-27/03 (Fig. 2B). The background colour of the main part of the valve is brown. White concentric bands, *c*. 0.7 mm thick, are clearly visible against the main background.

Specimen IGS NASU-27/04 (Fig. 2C). The colouration of this specimen is very similar to that of the specimens IGS NASU-27/01 and IGS NASU-27/03, but probably better preserved and represented by thin (*c*. 0.25–0.30 mm) concentric white bands on a brown background, which, unlike the bands on the mentioned above specimens, have clear and sharp borders.

The second group includes specimens IGS NASU-27/02 and IGS NASU-27/05 and two unnumbered specimens in the Geological Museum of the Luhansk Taras Shevchenko National University.

Specimen IGS NASU-27/02 (Fig. 2A). The valve is quite poorly preserved. There are poorly preserved concentric light bands on its surface; the main part of the valve surface is yellowish-brown in colour.

Unnumbered specimen (Fig. 2H). The colouration of this specimen is very similar to that of the specimen IGS NASU-27/02, but the concentric bands on a yellowish-grey and yellowish-brown back-

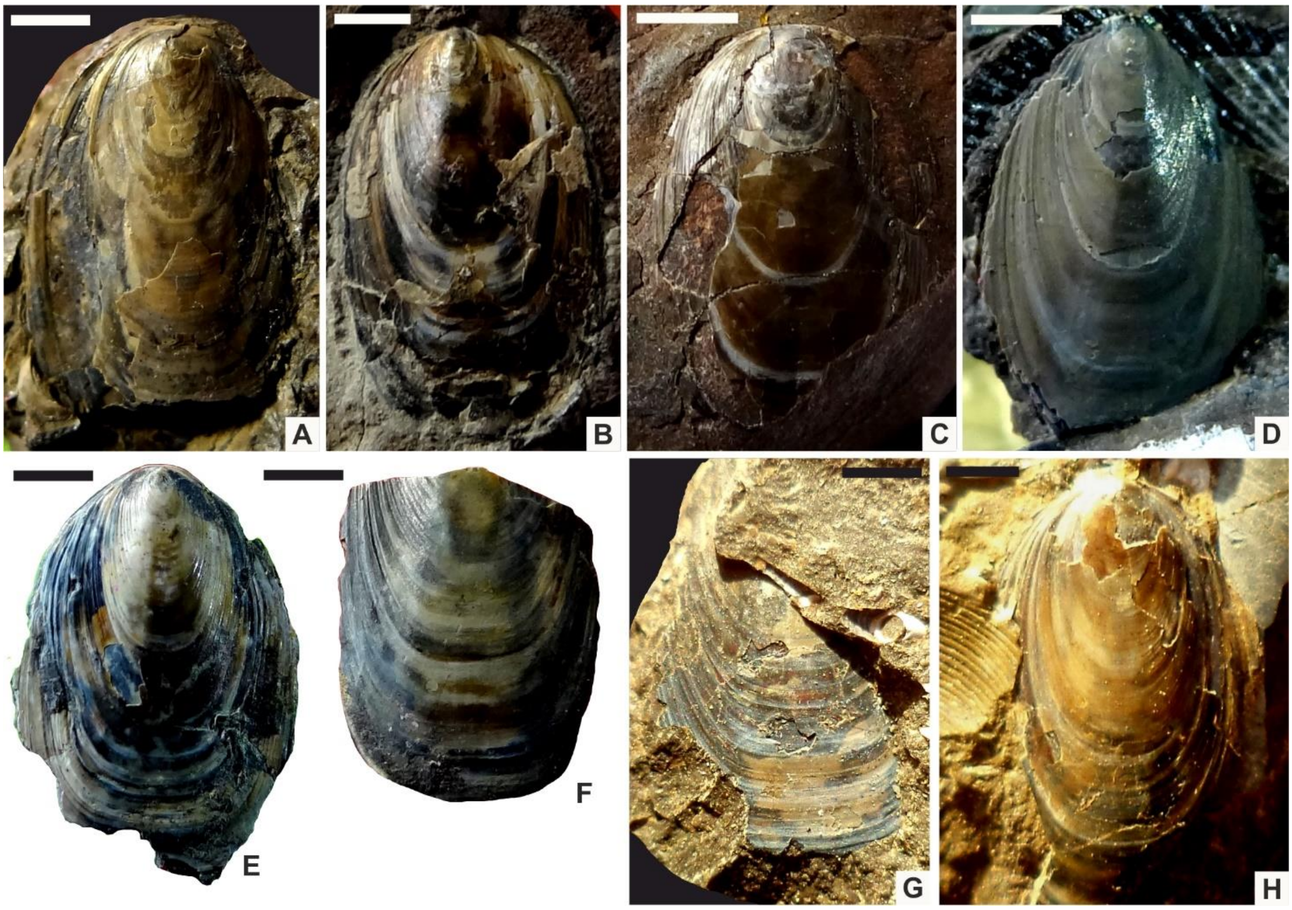

Fig. 2. Valves of *Lingularia mytiloides* (Sowerby, 1812) with probably preserved colour bands: A – IGS NASU-27/02; B – IGS NASU-27/03; C – IGS NASU-27/04; D – IGS NASU-27/01; E – IGS NASU-27/05; F – IGS NASU-27/06; G–H – unnumbered specimens (Geological Museum of the Luhansk Taras Shevchenko National University, Poltava). Scale bars = 2 mm.

ground are better observed than in the latter specimen, especially in the anterior part of the valve.

Unnumbered specimen (Fig. 2G) and the specimen IGS NASU-27/06 (Fig. 2F). The colouration of these specimens was studied only on a fragment of the anterior part of the valve, where it is represented by white and greyish concentric bands, *c*. 0.2–1.0 mm thick, with indistinct blurred borders on a grey background. In the specimen IGS NASU-27/06, the concentric bands are relatively thick and have indistinct boundaries and almost merge into a single spot.

Specimen IGS NASU-27/05 (Fig. 2E). The colouration of this specimen is similar to that of the two specimens described above (Fig. 2F, G) and is represented by thin concentric white and greyish bands, *c*. 0.3 mm thick on the grey-coloured anterior part of the valve and the umbonal part of the valve is evenly coloured white and greyish.

Discussion. ***Taphonomy.*** Pigments in fossil shells are very sensitive to light and oxygen, so it is desirable to isolate fossils with preserved colouration from the effects of these environmental agents [14, 17]. However, the specimens studied do not show such dependence, as they did not lose their colouration during prolonged exposure to the surface of rock dumps, where they were exposed not only to oxygen and sunlight, but also to precipitation and fluctuations in air temperature and the rock itself. It is possible that there are no pigments left in the fossils that could be destroyed by oxygen and light. A more dangerous process that can affect the preservation of the shells colour after they are removed from the rock is the development of the pyrite decay, since the rock matrix of the fossils is pyritized.

The key conditions for the preservation of the colour pattern of early Palaeozoic cephalopods of the Barrandian Area (Czech Republic) [64] and lower Moscovian nautiloids from the Lutuhyns'ka-Pivnichna fossil site [23] were low oxygen levels on and below the seafloor, rapid burial and lithification (especially in carbonate nodules), which are generally characteristic taphonomic features of Konservat-Lagerstättes [34]. In addition, probably, activity of bacterial communities and a very low water activity were also the reason for the preservation of the colouration on the nautiloid conchs from the Lutuhyns'ka-Pivnichna fossil site [23]. Probably, the same taphonomic conditions were decisive for preserving the colouration of the brachiopod shells after their burial in the bottom sediment. Kalashnikov [36] noted that the colour of some brachiopod shells from the late Visean algal bioherms in the Pechora Basin (Russia) was preserved due to the fact that these shells were enveloped in Cyanobacteria.

It should be noted that it is not possible to calculate what part of the brachiopod shells from the fossil site retained their original colouration, since most fossils are represented by small fragments of thin-shelled valves, but it should be noted that all collected *Lingularia mytiloides* have undeniable or probable traces of the lifetime colouration, but only the former were used in the study. Therefore, it should probably be acknowledged that coloured valves of *Lingularia mytiloides* from the studied locality are not uncommon.

Dr Leonid Popov (National Museum Wales; personal communication, September 2023) doubts the possibility of preserving the colour pattern on lingulid shells, as the shells of fossil lingulids do not preserve the organic matter with which the pigment is bound. He considers the colour pattern on the surface of the lingulid shells described here as traces of oxidation of pyrite, which replaced the organic matter. As demonstrated in the Introduction section, pigments can remain preserved even when shells are recrystallized and/or dissolved. Furthermore, it is not claimed that the original pigment has been preserved in the studied valves. It is quite possible that Dr Popov is right and the colour bands on the surface of the valves are evidence of sulphide oxidation, but even so, they likely still reflect the original colour patterns on the surface of the shells.

Comparison. Various authors have figured lingulid valves that may bear the original colouration or colour patterns. They are discussed in detail below, but it is not entirely certain that these patterns on the shell surface are actually colouration and not growth lines, taphonomic artefacts, artefacts of photography, etc.

Probably, the same colour pattern as in the studied brachiopods is present on the shells of *Lingula mytiloides* Sowerby, 1812, *L. squamiformis* Phillips, 1836, *L. straeleni* Demanet, 1934, *L.* sp., and *Liralingua wilsoni* Graham, 1970, as illustrated by Graham [29: pl. 14, figs 4–6, pl. 15, figs 3, 7, pl. 16, fig. 6, pl. 17, fig. 5]. These specimens come from the several Namurian-aged formations of the United Kingdom. Unfortunately, the low resolution of the black-and-white photographs of these brachiopods does not allow to confidently attributing the ornament figured to the original colouration of the shell.

Winkler-Prins and Martínez-Chacón [67] report white, grey and brown bands on the shells of *Lingula mytiloides* Sowerby, 1812 from black shales of the Tournaisian-aged Vegamián Formation of Spain, but do not provide detailed descriptions or images of this colour patterns. Probably, evidence of the original colouration are also present on the valves of *Lingula mytiloides* figured by Korejwo [39: pl. 1, figs 1–3] from the Tournaisian strata of Poland. These probable colour patterns are represented by weakly pronounced concentric bands, but the low resolution of the photographs does not allow to confidently interpreting their as the colour ornamentation rather than taphonomic or photographic artefacts.

Also, probable colour concentric bands is present on the surface of the valves of *Lingula carbonaria* Shumard & Swalow, 1858 from the Bashkirian-aged Pottsville Formation of Ohio [43: pl. 7, figs 1–3]. Very similar colour patterns in the form of concentric bands are present on the valves of *Lingularia* cf. *smirnovae* Biernat & Emig, 1993 from the Triassic of Spain [42: fig. 5].

There are several other reports on the original colouration of Palaeozoic and Mesozoic inarticulate brachiopods. Cleland [15: pl. 12, figs 3, 4, 5, pl. 13, figs 8, 9] illustrated two shells of *Lingula milwaukeensis* Cleland, 1911, as well as a shell of *Lingula* sp. bearing concentric colour bands. These fossils were found in the Devonian rocks of Wisconsin, USA. Kalashnikov [36] reported that the shells of *Lingula*, *Orbiculoidea*, *Lindstroemella*, and *Lingulipora* from the Carboniferous of the Pechora Basin are yellow and black in colour.

Greger [30] described several shells of the inarticulate brachiopods *Lingula* sp. (Upper Devonian Grassy Creek Shale of Missouri, USA) and *Orbiculoidea humilis* Hall, 1867 (Middle Devonian Hamilton Group of the New York State, USA). The colouration of *Lingula* sp. is represented by concentric dark blue bands, and the pattern on *Orbiculoidea humilis* is represented by concentric bands of light greenish and dark chestnut colours.

Singh [59] described a single specimen of the shell of *Lingula* (?*Pseudolingula*) *cincinnatiensis* Hall & Whitfield, 1875 from the Ordovician-aged Bullfork Formation in Kentucky, USA. Both valves of *Lingula* (?*Pseudolingula*) *cincinnatiensis* show the dark brown and bluish-grey colouration. A similar colouration is present on the surface of *Lingula rauliniana* d'Orbigny, 1847 figured by Gaspard [27: fig. 3E] from the upper Cenomanian (Upper Cretaceous) of France.

Conclusion. From the early Moscovian Kamensk Formation, the valves of the lingulid brachiopods *Lingularia mytiloides* (Sowerby, 1812) with probably preserved original colouration were studied. The specimens were divided into two groups based on shell colouration features, which may reflect some details of the colouration and colour patterns. However, these differences may be taphonomic artefacts. It is quite possible that the colour bands on the surface of the valves are evidence of sulphide oxidation, but even so, they likely still reflect the original colour patterns on the surface of the shell.

The key conditions for the preservation of the colour pattern of the studied lingulid brachiopods were low oxygen levels on and below the seafloor, rapid burial and lithification (especially in carbonate nodules). The studied colour patterns on the shells of *Lingularia mytiloides* are similar to those on other fossil lingulids. The adaptive significance of this colouration for the studied lingulids, which lived infaunally, remains unclear and cannot be resolved with the available material.

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Лінгуліди (брахіоподи) з ймовірно збереженим оригінальним забарвленням черепашки з кам’янської світи (московський ярус, середній пенсильваній) Донецького басейну (Україна)

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Забарвлення та кольорові візерунки на черепашках викопних брахіопод вивчені недостатньо, оскільки їх збереження у викопних рештках вимагає збігу декількох, іноді випадкових, тафономічних факторів. Однак, дослідження первинного (прижиттєвого) забарвлення викопних безхребетних має важливе палеоекологічне і тафономічне значення. З кам’янської світи (нижня частина московського ярусу, середній пенсильваній) Луганської області (відвали вугільної шахти Лутугинська-Північна поблизу м. Лутугине) вивчено рештки стулок лінгулід *Lingularia mytiloides* (Sowerby, 1812), на яких ймовірно збереглося прижиттєве забарвлення. Прижиттєве забарвлення палеозойських брахіопод вивчено слабко. Наразі, найповніші відомості ми маємо щодо забарвлення девонських брахіопод, а серед кам’яновугільних брахіопод прижиттєвий візерунок чи забарвлення відоме лише у 15 родів. Вивчені ізольовані стулки *Lingularia mytiloides* демонструють кольоровий малюнок, представлений переважно світлими концентричними смугами. Досліджені зразки були розділені на дві групи на основі особливостей забарвлення черепашок. Однак ці відмінності можуть бути тафономічними артефактами. Цілком можливо, що кольорові смуги на поверхні стулок є свідченням окислення сульфідів у піритизованих стулках, але навіть у цьому випадку вони, ймовірно, все ще відображають первісні кольорові візерунки на поверхні черепашки. Умови навколишнього середовища були важливими факторами для збереження забарвлення на стулках досліджених лінгулід. Серед цих умов найважливішими були низькі темпи седиментації, відсутність агентів механічної та хімічної деструкції, таких як висока активність водної товщі, інкрустація епібіонтами, дизаеробні умови та швидке поховання, що, очевидно, супроводжувалося діяльністю бактеріальних угруповань. На жаль, виявити адаптивне значення прижиттєвого візерунку на поверхні вивчених стулок брахіопод не вдалося.

Ключові слова*: забарвлення, беззамкові брахіоподи, кам’яновугільна система, тафономія, Україна*.

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