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***Hankoichnus* ichnogen. nov., a new arthropod (?) trace fossil from the Carboniferous of the Donets Basin (Ukraine)**

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*The flyschoid sediments of the Dyakove Group (Serpukhovian–Bashkirian) are exposed in the central part of the Donets Basin (Luhansk and Donetsk regions of Ukraine and Rostov Region of Russia). These sediments are important for studying the history of geological development of the Dnipro-Donets Downwarp. In addition, the sediments of the Dyakove Group contain deposits of a number of mineral resources (gold, ores of silver, lead, zinc, etc.). Nevertheless, the paleontological features of the Dyakove Group are poorly understood. This paper describes the phyllocarid (?) resting trace **Hankoichnus bandersnatchi** ichnogen and ichnosp. nov. from the early Bashkirian part of the Dyakove Group. Trace fossils of phyllocarids are poorly studied. Diagnosis of a new ichnogenus: a small phyllocarid (?) resting trace (*Cubichnia*), represented by a hexagon bounded on both sides by ridges (in fact, by grooves, since the described material is a convex hyporelief on the lower surface of a shale slab), with one small tubercle at one end. The ichnogenus **Hankoichnus** differs significantly from other resting traces of arthropods (e.g., *Alph*, *Arborichnus*, *Kingella*, *Rusophycus*, *Selenichnites*, *Tonganoxichnus*, etc.). The new ichnogenus has the greatest similarity with the trace fossils *Gluckstadtella* Savage, 1971. The difference between **Hankoichnus** and *Gluckstadtella* consists in the absence of imprints of producer's limbs in **Hankoichnus**. The most likely makers of traces **Hankoichnus** are phyllocarid crustaceans. This is confirmed by the morphology of the trace and the remains of the carapace valves of these crustaceans, found together with **Hankoichnus** in the black shales in the complete absence of remains of other biota. Phyllocarid remains are relatively common in Devonian and Carboniferous black shales formed in a dysaerobic marine environment.*

Keywords: arthropods; Carboniferous; Donets Basin; **Hankoichnus**; trace fossils.

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Introduction

Paleontological studies of the flyschoid deposits of the Dyakove Group (Serpukhovian–Bashkirian, see Fig. 1, c) revealed resting traces (Cubichnia), possibly phyllocarids, which are described below as a new ichnogenus *Hankoichnus* ichnogen. nov.

Trace fossils of phyllocarid crustaceans are rather poorly studied. Few works have been devoted to this question, perhaps the earliest being a brief report by Salter (1863), in which locomotion traces of *Peltocaris* were described. *Corpusculichnus caudatus* from the Middle Ordovician of Colorado (USA) is established and attributed by Fischer (1978) to either phyllocarids or horseshoe crabs.

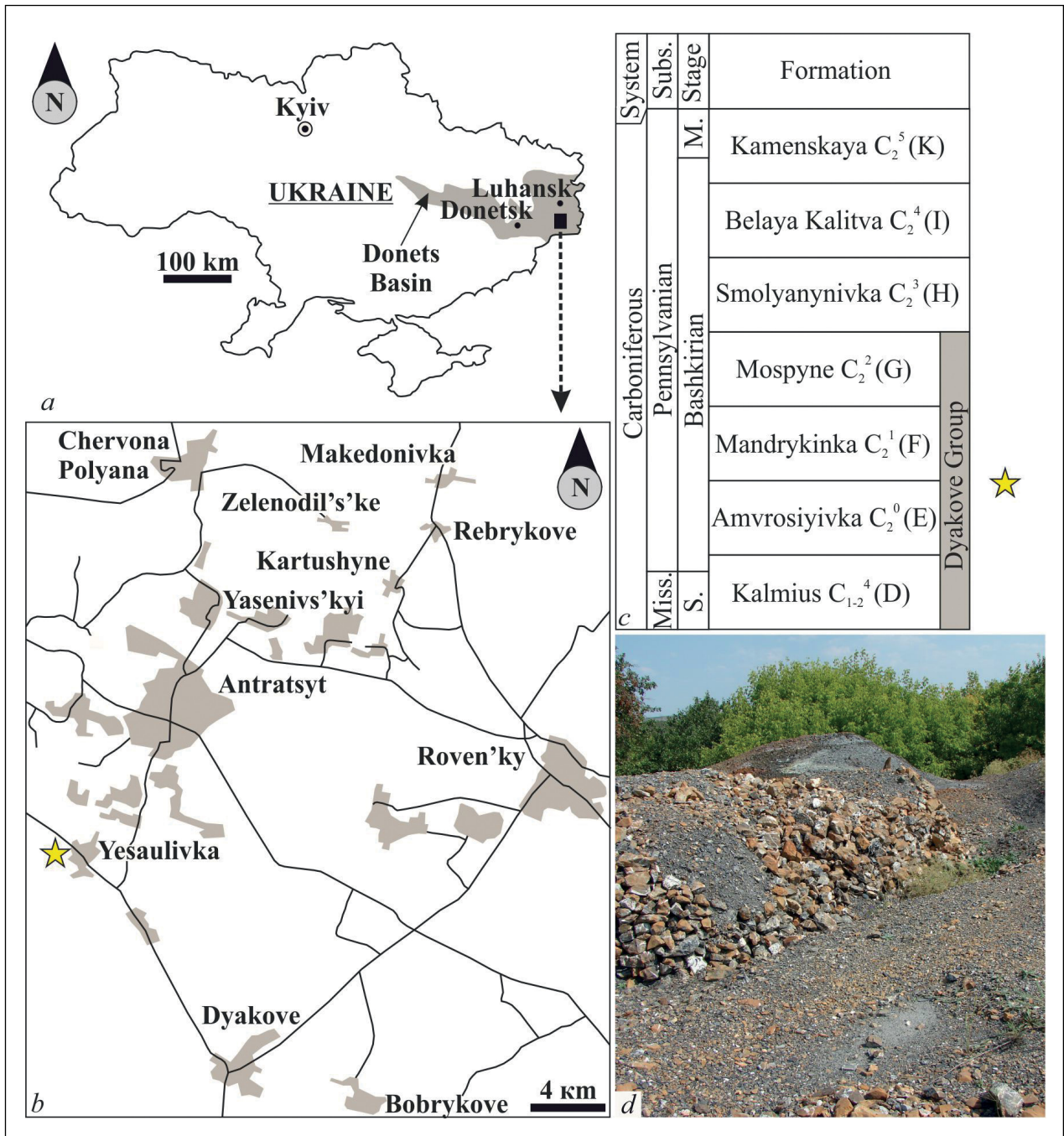


Fig. 1. Geological settings and location of the type locality of *Hankoichnus bandersnatchi* ichnogen nov. and ichnosp. nov.: a, b – geographic location of the type locality; c – stratigraphic position of the type locality; d – general view of the locality “Yesaulivka”. Locality “Yesaulivka” is shown by a yellow star. Abbreviations: M. – Moscovian, Miss. – Mississippian, S. – Serpukhovian, Subs. – Subsystem

Feldman et al. (1986) suggested that the “*Isopod-ichnus*-like” traces from the Late Devonian of the United States belong to *Tropidocaris salsiusculus* Feldmann et al., 1986. The phyllocarid trace fossils *Svalbardichnus trilobus* Wisshak et al., 2004 and *Chagriniichnites brooksi* Feldman et al., 1978 have been described from the Late Devonian of Spitsbergen (Wisshak et al., 2004) and the United States (Feldman et al., 1978; Weidner, Feldman, 1985), respectively.

Geological settings and material

A single specimen of the trace fossil *Hankoichnus bandersnatchi* isp. nov. was found in the tailings dump of an old polymetallic ore mine (Fig. 1, *d*) located near Yesaulivka, Roven'ky District, Luhansk Region, Ukraine (coordinates: 48°03'04.8"N 38°59'58.1"E) (Figs 1, *a*, *b*). The trace fossil *Hankoichnus bandersnatchi* isp. nov. was found in carbonaceous marine black shales (Fig. 1, *d*) overlying a layer of carbonate nodules laterally replaced by the F₁ limestone layer (early Bashkirian part of the Dyakove Group). In addition to the trace fossil *Hankoichnus bandersnatchi* isp. nov., the remains of poorly preserved phyllocarids were found in the black shale (Fig. 2, *b*); ammonoids *Retites* and *Cancelloceras* were found in the carbonate nodules below the black shale with *Hankoichnus bandersnatchi* isp. nov.

The sediments of the Dyakove Group are represented predominantly by black mudstones and siltstones (80–90% of the section thickness) with rare sandstone beds. The thickness of the Dyakove Group varies laterally from 1900 to 3310 m (Fis-sunenkeno, Reznikov, 1985; Reznikov, 1993).

The ichnoholotype of *Hankoichnus bandersnatchi* isp. nov. (GMLNU-12/1) is stored in the Geological Museum of Luhansk Taras Shevchenko National University (Poltava, Ukraine).

Systematic ichnology

Ichnogenus *Hankoichnus ichnogen. nov.*

Etymology. After *hanko*, a traditional Japanese seal.

Gender. Masculine.

Type ichnospecies. *Hankoichnus bandersnatchi* isp. nov.: early Bashkirian, Donets Basin (Ukraine); by monotypy.

Included ichnospecies. Only type ichnospecies is known to date.

Diagnosis. A bilaterally symmetrical trace with a width equal to its length, preserved as a convex hyporelief on the lower surface of the mudstone layer. The trace fossil is represented by a hexagon, bounded on both sides by ridges (actually grooves, since the single described specimen is represented by the convex hyporelief on the lower surface of the shale slab), with one small tubercle at one end.

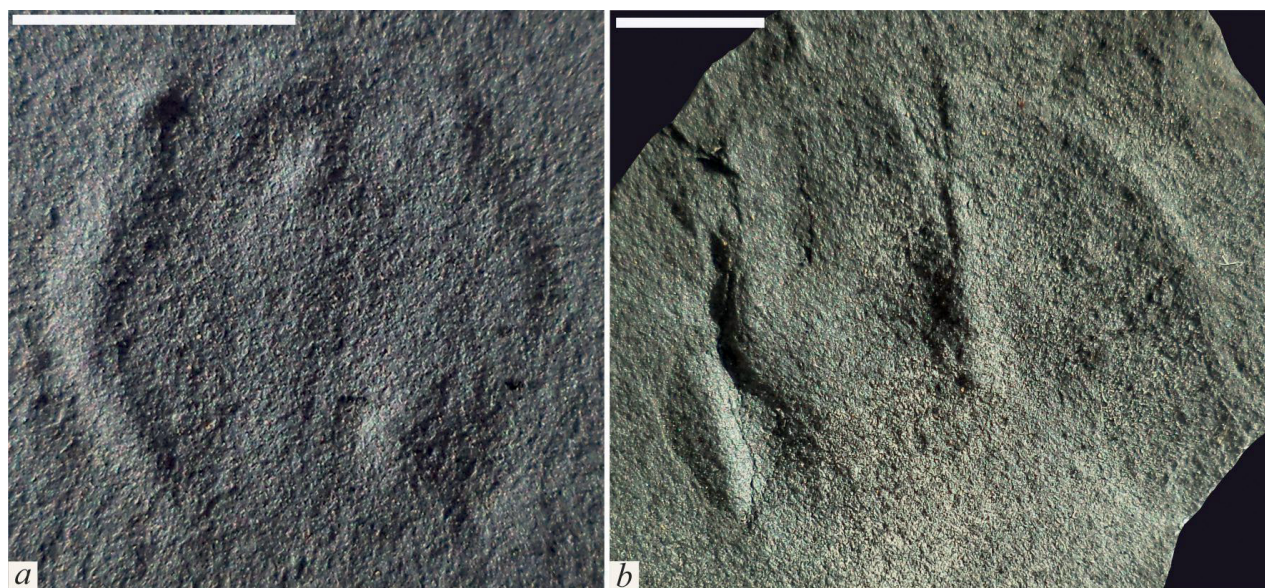


Fig. 2. Phyllocarid (?) resting trace *Hankoichnus bandersnatchi* ichnogen nov. and ichnosp. nov. and phyllocarid remains from Yesaulivka: *a* – *Hankoichnus bandersnatchi* ichnogen nov. and ichnosp. nov. (ichnoholotype), positive hyporelief; *b* – impression of the phyllocarid carapace valves (without number). Scale bars = 5 mm

Remarks. The producer of this trace is possibly phyllocarid crustaceans (see below). The ichnogenus *Hankoichnus* differs significantly from other arthropod resting traces (e.g., *Alph*, *Arborichnus*, *Kingella*, *Rusophycus*, *Selenichnites*, *Tonganoxichnus*, etc.). *Hankoichnus* ichnogen. nov. is similar to the trace fossils *Gluckstadtella* Savage, 1971; the difference between *Hankoichnus* and *Gluckstadtella* is the lack of the producer's limb impressions in *Hankoichnus*. *Hankoichnus* has some similarity in shape and size to the resting traces *Rusophycus furcosus* Gand, 1994 from the Permian of France (Gand, 1994). However, this similarity is not so great as to suggest that these trace fossils are identical.

Occurrence. Early Bashkirian of the Donets Basin, Ukraine.

***Hankoichnus bandersnatchi* ichnogen. and ichnosp. nov.**

Etymology. After *Bandersnatch*, a fictional animal from the literary works of Lewis Carroll (1832–1898).

Ichnoholotype. Specimen GMLNU-12/1 (see Fig. 2, *a*), represented by the positive hyporelief on the lower surface of the shale slab; stored in the Geological Museum of Luhansk Taras Shevchenko National University, Poltava.

Type locality. Ukraine, Luhansk Region, Roven'ky District, tailings dump of the old polymetallic ore mine near Yesaulivka.

Type stratigraphic level. The black shale above the F_1 limestone layer, Dyakove Group, early Bashkirian (*Cancelloceras*–*Bilinguites* ammonoid zone, *Pseudostafella praegorskyi*–*Ozawainella umbonata* foraminifer zone, *Idiognathoides sinuatus*–*Id. sulcatus sulcatus* conodont zone, and *Neuraethopteris* spp.–*Karinopteris acuta* macrofloristic zone).

Other material. Known only from the ichnoholotype.

Diagnosis. Same as for the ichnogenus.

Description. The trace is bilaterally symmetrical and preserved as a convex hyporelief on the lower surface of a slab of the black carbonaceous mudstone. The trace has the shape of a hexagon with rounded vertices. The sides of this hexagon are in the form of slightly protruding ridges up to 1 mm thick. At one end of these ridges are oval tubercles about 0.8 mm in diameter. An-

other rounded tubercle, somewhat larger (about 1 mm in diameter), is located between the tubercles of adjacent ridges.

Dimensions. Length is 9 mm, width at the widest part is 9 mm.

Remarks. As for ichnogenus.

Locality. Ukraine, Luhansk Region, Roven'ky District, tailings dump of the old polymetallic ore mine near Yesaulivka; black shale above the F_1 limestone layer, Dyakove Group, early Bashkirian.

Occurrence. Early Bashkirian of the Donets Basin, eastern Ukraine.

Discussion

The most likely makers of the traces *Hankoichnus* are phyllocarid crustaceans. This is confirmed by the morphology of this trace and the remains of the carapace valves of these crustaceans found together with *Hankoichnus* in the black shale (Fig. 2, *b*) in the complete absence of remains of other biota. Phyllocarid remains are relatively common in Devonian and Carboniferous black shales formed in a dysaerobic marine environment (Rolfe, Beckett 1984; Dernov, Udovichenko, 2019). Remains of the phyllocarids *Dithyrocaris* were reported by Dernov and Udovichenko (2019) in black shales in the middle part of the Mospyne Formation (Fig. 3). Representatives of the same genus have been found in the D_1^5 limestone layer of the Kalmius Formation (Serpukhovian) in the section on the Kalmius River (Aisenverg et al., 1987).

The interpretation of *Hankoichnus* as a resting trace of phyllocarid crustaceans is conditional and is based primarily on the absence of skeletal remains of other organisms in the black shales together with *Hankoichnus*. Therefore, this opinion may be disproved in the future.

Conclusions

A new phyllocarid (?) trace fossil *Hankoichnus bandersnatchi* ichnogen. and ichnosp. nov. is described from the early Bashkirian marine black shale of the Donets Basin. This ichnogenus differs from the most similar ichnogenus *Gluckstadtella* Savage, 1971, in the absent of the producer's limb impressions.

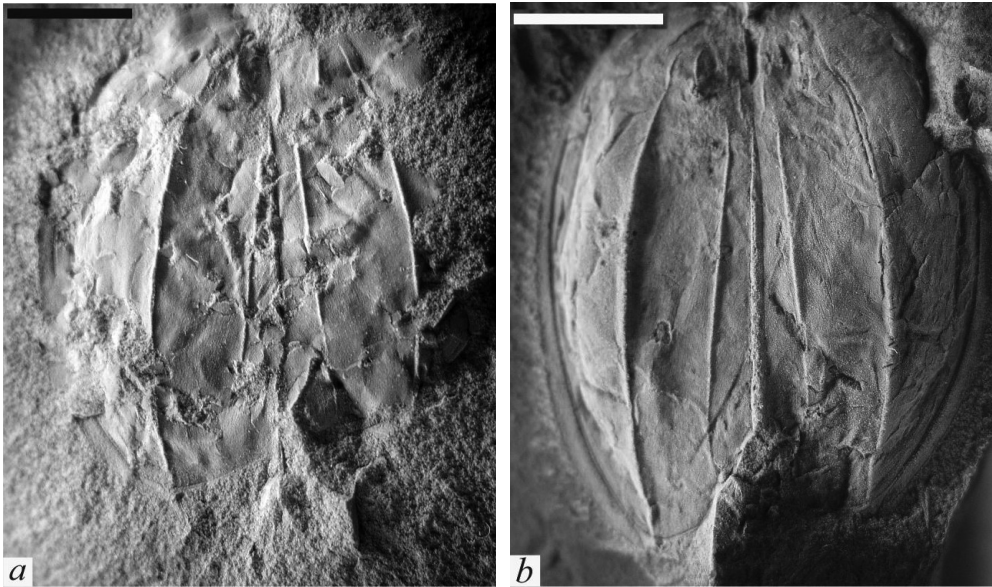


Fig. 3. Remains of the phyllocarid crustaceans *Dithyrocaris* from the black shale in the middle part of the Mospyne Formation (author's collection). Scale bars = 5 mm

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Hankoichnus ichnogen. nov. – нова іхнофосилія артроподи (?) з карбону Донецького басейну (Україна)

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Флішодні відклади дяковської серії (серпуховський та башкирський яруси), що представлені переважно чорними сланцями (аргілітами та алевролітами) з рідкісними товщами пісковиків, виходять на денну поверхню в Центральному Донбасі. Ці відклади утворилися в морському басейні евксинського типу. Вивчення зазначених відкладів має важливе значення для пізнання історії розвитку Доно-Дніпровського прогину. Крім того, відклади дяковської серії вміщують родовища цінних корисних копалин (золота, руд свинцю, цинку та срібла). Однак палеонтологічна характеристика дяковської серії недостатня. Ця обставина перешкоджає створенню обґрунтованої схеми біостратиграфічного розчленування потужного монотонного розрізу дяковської серії та реконструкції умов накопичення її відкладів. В цій статті з відкладів дяковської серії описано сліди спокою згодом філокарід *Hankoichnus bandersnatchi* ichnogen. et ichnospr. nov. Високі сліди життєдіяльності філокарід вивчені досить слабо. Новий іхнорід *Hankoichnus* представлений позитивним гіпорельєфом на нижній поверхні шару чорного сланцю у вигляді округленого шестикутника, обмеженого тонкими валиками з округлими горбками на одному з кінців. Новий іхнорід *Hankoichnus* істотно відрізняється від інших слідів спокою артропод (наприклад, *Alph*, *Arborichnus*, *Kingella*, *Rusophycus*, *Selenichnites*, *Tonganoxichnus* та ін.). Найбільшу подібність він має з іхнородом *Gluckstadtella* Savage, 1971. Відмінності між цими двома іхнородами полягають перш за все в тому, що у слідів *Gluckstadtella* присутні відбитки кінцівок продуцента сліду, чого не спостерігається у *Hankoichnus*. Іншою подібною до *Hankoichnus* іхнофосилією є *Rusophycus furcosus* Gand, 1994 з пермі Франції, проте морфологічна близькість цих слідів не настільки велика, аби стверджувати про їхню ідентичність. Продуцентом *Hankoichnus* є, вірогідно, філокаріди. Ця інтерпретація є дещо умовною і базується в основному на присутності у чорних аргілітах разом з цими іхнофосиліями решток філокарід поганої збереженості за повної відсутності фосилій інших груп фауни.

Ключові слова: артроподи; карбон; Донбас; *Hankoichnus*; іхнофосилії.