First finding of euconodont animals (Euconodontophylea) imprints on the territory of Russia

Первая находка отпечатков эуконодонтов (Euconodontophylea) на территории России

G.I. Buryi, A.P. Kasatkina, A.V. Zhuravlev & P.P. Safronov

Г.И. Бурий, А.П. Касаткина, А.В. Журавлев, П.П. Сафронов

G.I. Buryi, Far East Geological Institute, Far Eastern Branch, Russian Academy of Sciences, 159 Stoletiya Vladivostoka Pr., Vladivostok, 690022, Russia. E-mail: buryi@mail.ru

A.P. Kasatkina, Il'ichev Pacific Oceanological Institute, Far Eastern Branch, Russian Academy of Sciences, 43 Baltiiskaya St., Vladivostok, 690041, Russia. E-mail: poi@iasnet.ru

A.V. Zhuravlev, All-Russia Oil Scientific Geological-Surveying Institute, 39 Liteinyi Pr., St. Petersburg, 191014, Russia. E-mail: stratigr@mail.wplus.net

P.P. Safronov, Far East Geological Institute, Far Eastern Branch, Russian Academy of Sciences, 159 Stoletiya Vladivostoka Pr., Vladivostok, 690022, Russia. E-mail: psafronov@mail.ru

The paper presents data on first in Russia imprints of problematic euconodont animals found in the Lower Carboniferous deposits of the Kozhim River of the Northern Urals. In a thin interlayer of black carbonaceous mudstone, the first complete imprint of a euconodont animal and separated dental elements: "*Spathognathodus" crassidentatus* Branson & Mehl, *Polygnathodus communis* Branson & Mehl, *Bispathodus* sp. was found. The imprint is a long (about 4.8 mm), narrow (0.3–0.4 mm), worm-shaped body, exposed on one side, on which one can see a head, a trunk, and a tail. Behind the tail of the first imprint, there is a head of another younger specimen whose trunk appears to curve and pass into other plane. The first imprint of the euconodont animal was studied using a scanning electron microscope ZEISS EVO 50XVP without spraying its surface. A complete image of the euconodont animal trunk was obtained with low magnification (50×). With magnifications of 120× to 10000×, numerous details of its structure are observed. Complete data on the outer morphology of euconodont animals were thus obtained for the first time. These data support the hypothesis that the euconodonts belong to a distinct group of organisms established earlier, the phylum Euconodontophylea Kasatkina & Buryi, 1997.

Статья представляет данные о первой в России находке отпечатков эукондонтовых животных в отложениях нижнего карбона на реке Кожим на Северном Урале. В тонкой прослое черного углеродистого аргиллита был впервые обнаружен полный отпечаток эуконодонтового животного, а также отдельные зубные элементы, идентифицированные как "*Spathognathodus" crassidentatus* Branson & Mehl, *Polygnathodus communis* Branson & Mehl, *Bispathodus* sp. Отпечаток принадлежит длинному (около 4.8 мм), узкому (0.3–0.4 мм), червеобразному телу, видимому с одной стороны, на которой можно различить голову, туловище и хвост. Позади хвоста этого животного имеется голова другого, более молодого экземпляра, тело которого кажется изогнутым и переходящим в другую плоскость. Отпечаток большего по размеру эуконодонтного животного был исследован с помощью электронного сканирующего микроскопа ZEISS EVO 50XVP без напыления. При малом увеличении (50×) было получено полное изображение туловища животного, а при большем увеличении (120×–10000×) были исследованы многочисленные детали его строения. Таким образом, впервые в литературе получены полные данные о внешней морфологии эуконодонтных животных. Они подтверждают гипотезу о принадлежности этих животных к отдельному типу Euconodontophylea Kasatkina & Buryi, 1997.

Key words: tooth and H attaching elements, Lower Carboniferous, Scotland, Upper Ordovician, South Africa, Silurian, North America, Northern Urals, internal and external structures, muscular fibers, myomers, fishes, lower chordates, jawless craniates, transversal segments, fibrous structure, chaetognaths, isolated group of organisms

Ключевые слова: нижний карбон, Шотландия, верхний ордовик, Южная Африка, Северная Америка, северный Урал, внешняя и внутренняя морфология, мускульные волокна, миомеры, рыбы, низшие хордовые, бесчелюстные черепные, фиброзная структура, щетинкочелюстные, таксономически изолированные группы организмов

INTRODUCTION

The imprints of soft tissues of problematic euconodont animals are very rare met in the geological chronicle. Their separate microscopic phosphatic remains – tooth elements called conodonts by Pander (1856) and rounded attaching plates (H elements) (Müller et al., 1974; Buryi & Kasatkina, 2004) are reported more often. It was long unclear what these animals look like, although their conodont (euconodont) elements occur widely in all types of rocks of the sea genesis. It is not surprising that each finding of an imprint of a euconodont animal is the sensation like a finding of mammoth. The first findings, attributed to conodonts *Clydagnathus windsorensis* (Globensky), were found in 1983–1993 in the Lower Carboniferous bed in Granton near Edinburgh, Scotland (Briggs et al., 1983; Aldridge et al., 1993). In 1995, in the Upper Ordovician shales Soom, South Africa, an imprint with tooth elements *Promissum pulchrum* Kovács-Endrödy was found (Gabbott et al., 1995). In the fossil euconodont animals from Scotland and South Africa, the inner parts of the head, body, and tail divisions are mainly accessible for observations. So when studying these findings in the National Museum of Natural History in London, we gained an idea of their inner structure. In the forward parts of the head divisions in all known imprints there are paired rounded H attaching elements between which the mouth of a euconodont occurs (Buryi & Kasatkina, 2004). In the body division, the serially repeated transversal obliquely oriented (sometimes V-shaped) or perpendicular to the euconodont body axis muscular fibers are observed. In some cases they crosscut two longitudinal median lines (possibly the intestine walls) (Kasatkina & Buryi, 2007). The obliquely oriented muscular fibers have medial apexes of different directions: towards the head or oppositely. Such differently directed positions of the medial apexes of muscular fibers testify that the transverse body structures of euconodonts are not the myomers of fishes and lower chordates, which are always directed to the head (Carroll, 1988). This suggests radical difference of morphology of euconodont animals and that of lower chordates and fishes and makes it possible to attribute them to an isolated new group of organisms (Kasatkina & Buryi, 1997). R. Aldridge and other researchers who first found and studied the imprints of euconodont animals in Scotland and South Africa, hold the viewpoint of the great similarity of them to jawless craniates (hagfishes or heterostracans) (Donoghue et al., 1998). Not much is known about the external structure of euconodont animals. In the Silurian dolomites Waukesha in North America, the imprint of the euconodont forward part, broken in the outer side, was found. Nineteen obliquely oriented body segments are visible on it. In the head part of this imprint there are seven pairs of tooth elements attributed to *Panderodus* (Mikulic et al., 1985).

RESULTS

Finding of euconodont animals imprints in the Lower Carboniferous of the Northern Urals

This paper presents data on the imprints of problematic euconodont animals found first in Russia in the Lower Carboniferous deposits of the Northern Urals. They were found in the section along the Kozhim River (Sobolev et al., 2000) (Tournaisian stage, deep-sea facies of the continental slope) that is characterized by thin-laminated cherts and carbonaceous shales containing both euconodont tooth elements and apparatuses of spathognaths of different taphonomic types (Fig. 1). A.V. Zhuravlev found the first imprint of a euconodont animal in a thin interlayer of black carbonaceous mudstone (layer 59; sample T_2 – 59-1/95). Among separate elements he determined "*Spathognathodus" crassidentatus* Branson & Mehl, *Polygnathodus communis* Branson & Mehl, and *Bispathodus* sp. Apparatuses and their fragments belong mainly to the representatives of genera *Bispathodus* and

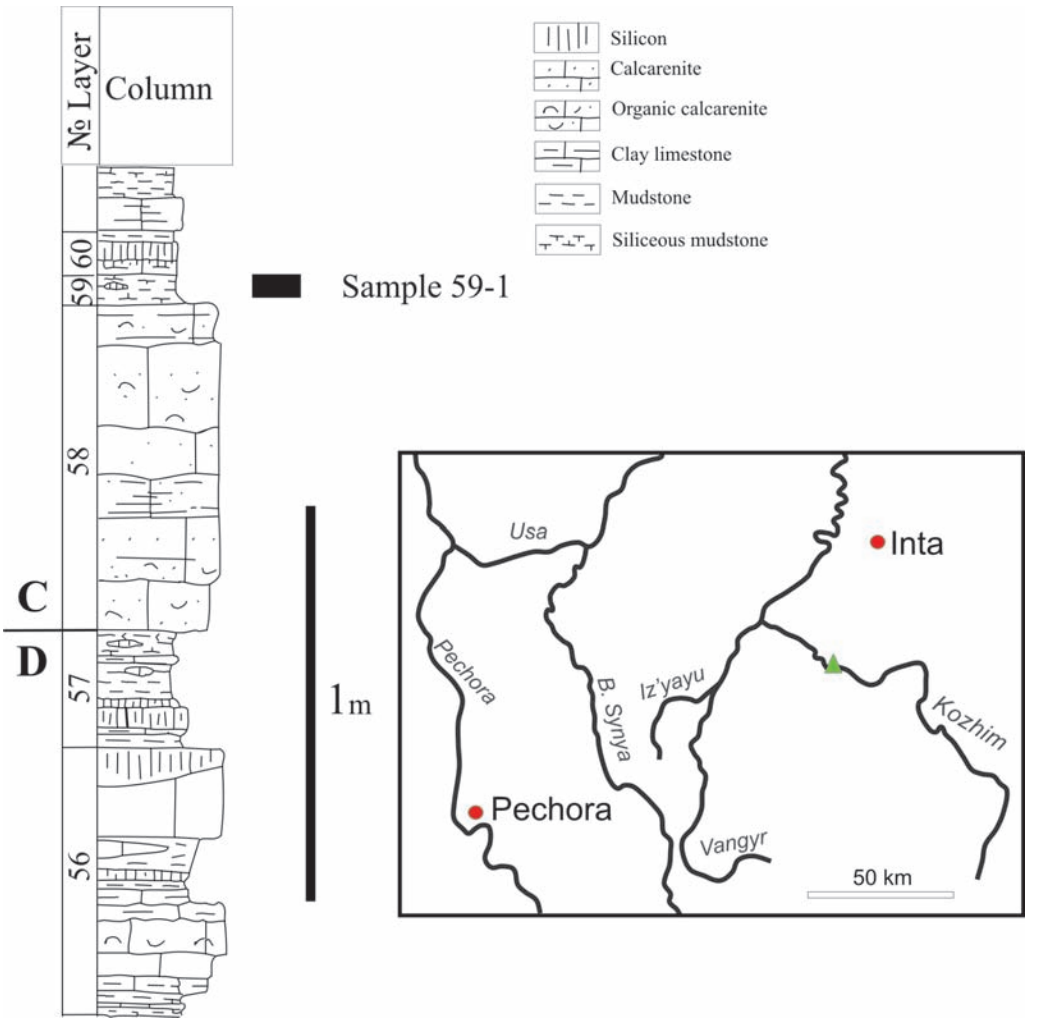

Fig. 1. Geological column and scheme of location of the Lower Carboniferous deposits section of the Kozhim River basin (Northern Urals).

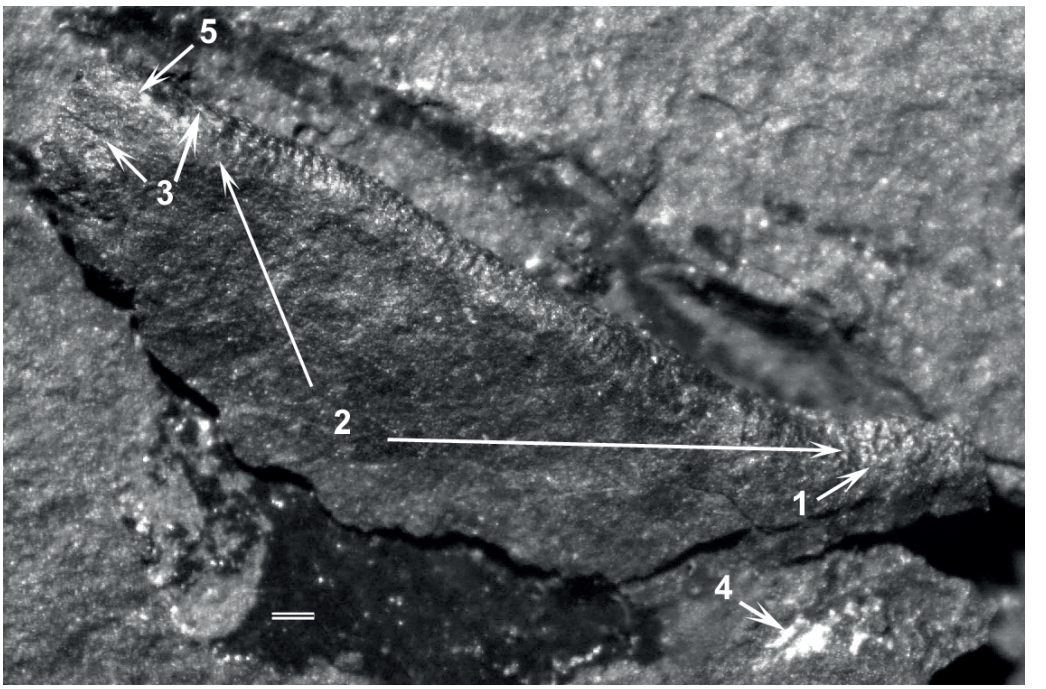

Fig. 2. Imprints of euconodont animals (specimen DVGI 2007 Tz-59-1/95). First imprint: **1**, head with a relief projection of the rounded structure (attachment H element); **2**, body with transversal segments; **3**, tail rays; **4**, a complex of dental S elements. Second imprint: **5**, head of finer imprint. Scale bars: 0.2 mm.

"Spathognathodus". Using these data a preliminary report was done (Zhuravlev, 1997). Later this sample of carbonaceous mudstone was studied in detail. Other several very fine imprints of young individuals and a counterpart of the first imprint were found. They differ in sizes, orientation, and preservation degree.

A study of euconodont animals imprints using a binocular microscope

The imprint of a euconodont animal, first found on the territory of Russia, was studied under MBC-10 microscope. It was established that it is a long (about 4.8 mm), narrow (0.3–0.4 mm), worm-like body with the exposed outer side, slightly curved in horizontal and vertical planes (Fig. 2). On the imprint, all main components of this animal – the head, body, and tail – are clearly seen. In the head part at a distance of 0.2 from its apical (anterior) end, a rounded H element (one of two skeletal attaching plates characteristic the euconodont animals) is strikingly seen under the soft connecting tissue. Immediately adjacent to the H element contour, but beyond the head there is an incomplete set of tooth S elements. Members of three tooth elements are observed with highly inclined crenations whose crenulation is characteristic of the representatives of the genus *Hindeodella*. The head is weakly differentiated from the body. In the trunk part, there are transversal muscular segments oriented most often perpendicularly and sometimes obliquely to the axis of the euconodont body. These muscular segments are suggested to be an external continuation of transversal muscle fibers which we studied on the inner shears of the imprints of euconodont animals from the Lower Carboniferous Shrimp bed in Scotland and the Upper Ordovician shales

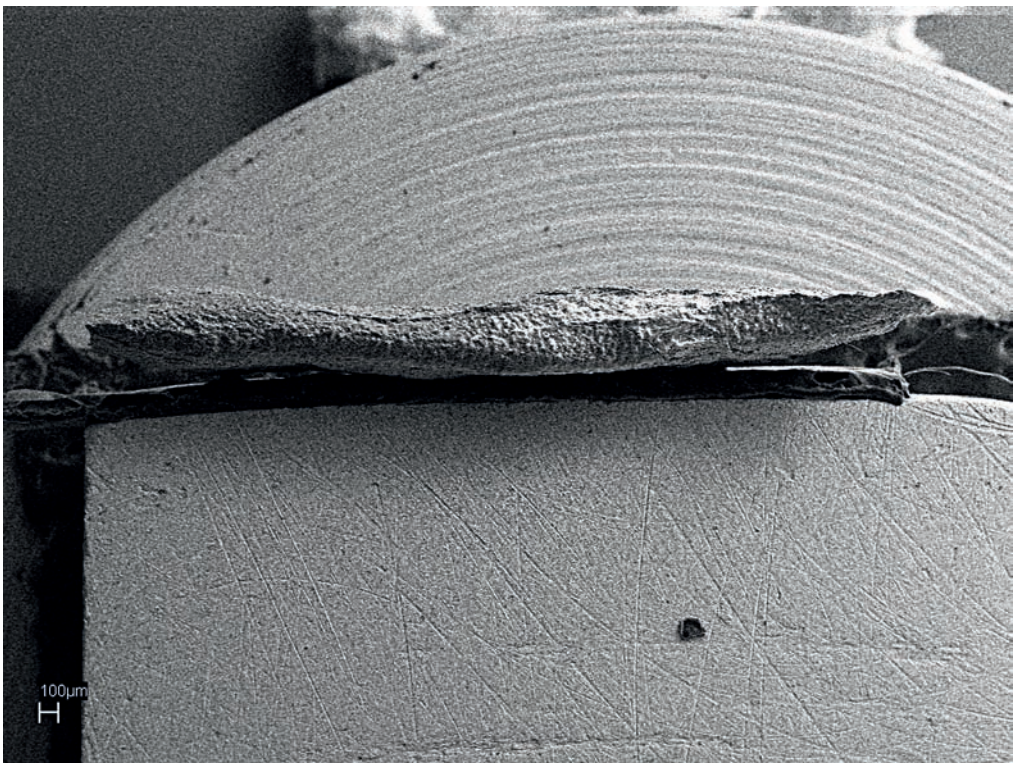

Fig. 3. Fibrous structures on the upper surface of the first imprint of euconodont animal, 5000×.

of Soom in South Africa (see above). Further backwards there is a tail tip on whose sides two long rays, characterized of all imprints of euconodont animals, are seen. Behind the tail of the first imprint, the head of another younger specimen is observed. Its body appears to curve and pass into other plane. Through the investigations, the practically whole core of the euconodont animal imprint was extracted from the rock with the exception of the very apex of its anterior end where, probably, an insignificant destruction took place.

First results of the ultramicroscopic study of the imprint

This imprint of the euconodont animal was studied using a scanning electron microscope ZEISS EVO 50XVP without spraying of its surface. Observations were carried out in the regime of the secondary electrons at accelerating voltage of 20 kV. With small magnifications (50×), a total image of the euconodont animal body was obtained. With magnifications of 120 to 10000 times, numerous details of its structure are visible. Most interesting are the fibrous structures, first found on the surface of the euconodont animal. They are isolated fiber-like formations about 0.3×10^{-5} m thick and 1×10^{-5} m to 0.7×10^{-4} m long arranged as a rule by diagonal or across the euconodont body (Fig. 3). Attentive viewing allows one to see that these fibers are not broken, with their ends they go inside the body. The fibrous formations almost ubiquitously penetrate the euconodont body and in some places go out of it. Attention is drawn to the granulose surface of the body division of the study imprint (Fig. 4). On the surface of the euconodont animal imprint, other puzzling microstructures of a funnel shape are found that yet invite their interpretation.

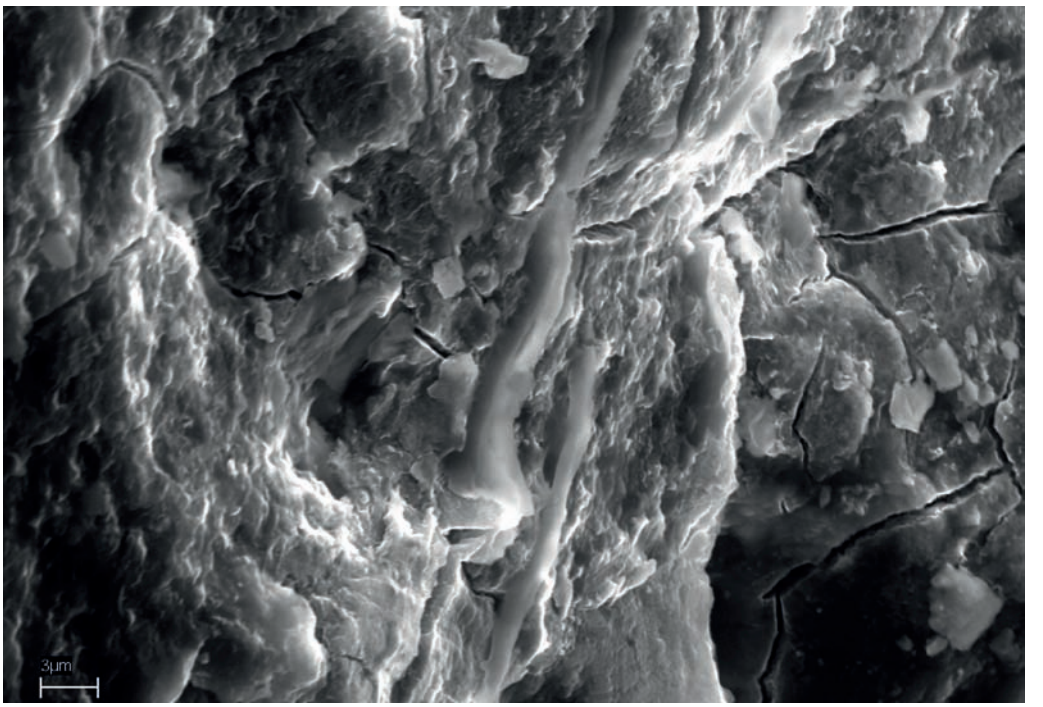

Fig. 4. Granulose surface of the trunk division of the euconodont animal imprint, 350×.

The funnel-shaped "pitted-foraminated" structures are suggested to be the vas deferens evacuating the secret onto the animal surface. They probably have a secretor function as in their morphology they are similar to glandular structures or endocrine glands of chaetognaths of the family Spadellidae (Kasatkina, 1982).

Thus, we first have obtained complete data on the external morphology of the euconodont animals that support the idea of their belonging to an isolated group of organisms – the phylum Euconodontophylea Kassatkina & Buryi, 1997 (Kasatkina & Buryi, 1997).

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