Palaeogeography, Palaeoclimatology, Palaeoecology 454 (2016) 113–124

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

A glimpse of a fish face — An exceptional fish feeding trace fossil from the Lower Devonian of the Holy Cross Mountains, Poland

Piotr Szrek [a,*], Sylwester Salwa [b], Grzegorz Niedźwiedzki [c], Marek Dec [d], Per E. Ahlberg [c], Alfred Uchman [e]

[a] Polish Geological Institute—National Research Institute, Rakowiecka 4 Street, 00-075 Warszawa, Poland
[b] Holy Cross Mountains Branch of the Polish Geological Institute—National Research Institute, Zgoda 21 Street, 00-075 Kielce, Poland
[c] Department of Organismal Biology, Uppsala University, Norbyvägen 18A, 752 36 Uppsala, Sweden
[d] Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland
[e] Institute of Geological Sciences, Jagiellonian University, Oleandry 2a, 30-063 Kraków, Poland

ARTICLE INFO

Article history:
Received 22 February 2016
Received in revised form 5 April 2016
Accepted 5 April 2016
Available online 13 April 2016

Keywords:
Osculichnus
Trace fossils
Predation
Lower Devonian
Holy Cross Mountains
Poland

ABSTRACT

An exceptionally well-preserved assemblage of numerous invertebrate and vertebrate trace fossils is described from the Lower Devonian of the Holy Cross Mountains, southern Poland. Two trace-bearing horizons occur in the shallow-marine sequence that is exposed in a small outcrop near Ujazd village. One of the trace fossils is preserved as a bilobate, generally elliptical, epichnial pit is described as *Osculichnus tarnowskae* isp. nov. and interpreted as a unique example of praedichnia. Neoichnologic experiments and observations indicate that the ichnogenus *Osculichnus* was produced by feeding fish. The fish producing *O. tarnowskae* probably hunted bivalves, polychaetes and arthropods, which are represented by invertebrate trace fossils in the same horizons. The overall shape and morphological details of *O. tarnowskae* suggest that it was made by a lungfish broadly similar to Dipnorhynchus. The trace provides the first direct evidence for Devonian lungfish feeding behaviour, as well as the first record of three-dimensional soft-tissue morphology of the snout area of an Emsian representative of this group. The trace fossils from Ujazd provide new insight into the palaeoecology and taphonomy of the Lower Devonian of the Holy Cross Mountains.

1. Introduction

Trace fossils not only express behaviour of their tracemakers, but in some cases, especially if very well preserved, they may record important information about the morphology of the trace maker's body. This information, called the "bioprint" (see Rindsberg and Kopaska-Merkel, 2005; Seilacher, 2007), is especially valuable if the soft body of the tracemaker is unknown.

During fieldwork conducted in the Holy Cross Mountains (southern Poland) in 2011–2014, an exceptionally well-preserved assemblage of numerous invertebrate and vertebrate trace fossils was discovered and investigated in a series of small outcrops of the Lower Devonian near Ujazd village. Among them are unusual depressions that occur at top of some beds in one of the outcrops. They are interpreted herein as fish feeding traces that reveal imprints of some anatomical details of the fish snout, in a manner comparable to recent fish traces. The aim of this paper is to present this peculiar trace fossil as a new ichnospecies of *Osculichnus* Demírcan and Uchman (2010). The trace fossils provide information about the snout anatomy and feeding behaviour of Early Devonian fishes. Associated invertebrate trace fossils that help to interpret the *Osculichnus* behaviour and palaeoenvironment, are briefly characterized as well.

The Lower Devonian of the Holy Cross Mountains is composed of siltstone and sandstone beds intercalated by mudstones. In contrast to the Middle or Upper Devonian rocks of this region, which are dominated by carbonate sediments, trace fossils are abundant in some Lower Devonian formations, where sandstone–mudstone interfaces provide favourable conditions for their preservation. Nevertheless, they have so far received very little attention (but see Tarnowska, 1976, 1997). An exception is the description of a very rich and exceptionally well preserved ichnoassemblage in the Bukowa Góra quarry (Szulczewski and Porębski, 2008). More than 20 invertebrate ichnogenera identified at this locality point to palaeoenvironments ranging from the shoreface-offshore shelf transition to lagoonal and marine depositional environments. The age of the section is well constrained as middle to upper Emsian (Malec, 1990; Fijałkowska-Mader and Malec, 2011), and generally corresponds with the age of the section from the locality presented herein.

2. Geological setting

The outcrop studied is located in the small village Ujazd near Iwaniska, near the NW–SE road from Iwaniska to Staszów, in the central part of the Holy Cross Mountains, about 190 km south of Warsaw

* Corresponding author.
E-mail address: piotr.szrek@pgi.gov.pl (P. Szrek).

http://dx.doi.org/10.1016/j.palaeo.2016.04.019
0031-0182/

(50°42′34.1″N; 21°19′26.1″E; Fig. 1). It is the small abandoned quarry mentioned by Szrek et al. (2012, 2015), where sandstone was exploited for local needs.

Preliminary data on the Lower Devonian of the Holy Cross Mountains were published by Gürich (1896); Czarnocki (1919, 1936) and Kowalczewski (1971). Some parts of the Lower Devonian stratigraphy and palaeoenvironment in the Iwaniska area were presented by Tarnowska (1976, 1981, 1997).

In the area studied, the Lower Devonian unconformably overlies the Cambrian clastic rocks. The succession is informally subdivided into the Haliszka and Winna formations, which are further divided into the Lower Sandstone Member, Mudstone Member and Upper Sandstone Member (Tarnowska, 1976, 1981, 1987; Fig. 2). In the Kielce facies area, the Lower Devonian siliciclastic deposits (Upper Sandstone Member) are overlain by the "pyrite-bearing and sideritic claystone" member, the "dolomite" member, the Dąbrowa Limestone Member and the "bioturbated dolomite" member (Gürich, 1896; Czarnocki, 1919; Tarnowska, 1976; Narkiewicz and Olkowicz-Paprocka, 1983; Malec, 1993), which represent either the uppermost Emsian or the lowermost Eifelian (Fijałkowska-Mader and Malec, 2011). The Lower Devonian/Middle Devonian transitional deposits (Emsian/Eifelian boundary interval) in the Kielce region yield conodonts of the *patulus* and *partitus* zones (Fijałkowska-Mader and Malec, 2011). The Lower Devonian of the Kielce facies region is subdivided into four miospore zones (*Verrucosisporites polygonalis–Dibolisporites wetteldorfensis*, *Emphanisporites annulatus–Brochotriletes bellatulus*, *Emphanisporites foveolatus–Verruciretusispora dubia* and *Acinosporites apiculatus–Grandispora protea* (Fijałkowska-Mader and Malec, 2011), which suggest the presence of the uppermost Pragian, Emsian and lowermost Eifelian in the Haliszka and Winna formations. The Winna formation is famous for its fossil fish (e.g., Tarlo, 1957, 1961, 1964, 1965; Kulczycki, 1960; Szrek et al., 2012, 2014, 2015) but relatively little work had been done previously on its trace fossils.

More detailed descriptions of the geological setting, biostratigraphic correlation, taphonomy and macrofossil content of the Lower Devonian formations of the Holy Cross Mountains have been published by Kowalczewski (1971); Łobanowski (1971); Tarnowska (1976, 1981, 1997); Malec (2005); Fijałkowska-Mader and Malec (2011); Filipiak (2011), and Wójcik (2015).

3. The Ujazd section

The Lower Devonian at Ujazd can be observed in a series of small exposures of white quartzite sandstones. These sandstones were last exploited by local residents more than 30 years ago. Recently, the exposures have become almost completely overgrown by plants, partly in a forest (Fig. 1B). One of those outcrops was re-investigated by the authors between 2011 and 2014.

The section studied in detail is about 4 m thick (Fig. 1A, B). It is composed of 1–2 m-thick sandstone beds interbedded with tuffaceous claystone layers that are up to 20 cm thick (Fig. 3). The strata dip about 20° to the north and maintain a strike of about 30°E. This section represents a very shallow water, low-energy marine environment. Preliminary petrographic and sedimentological investigations of the lower

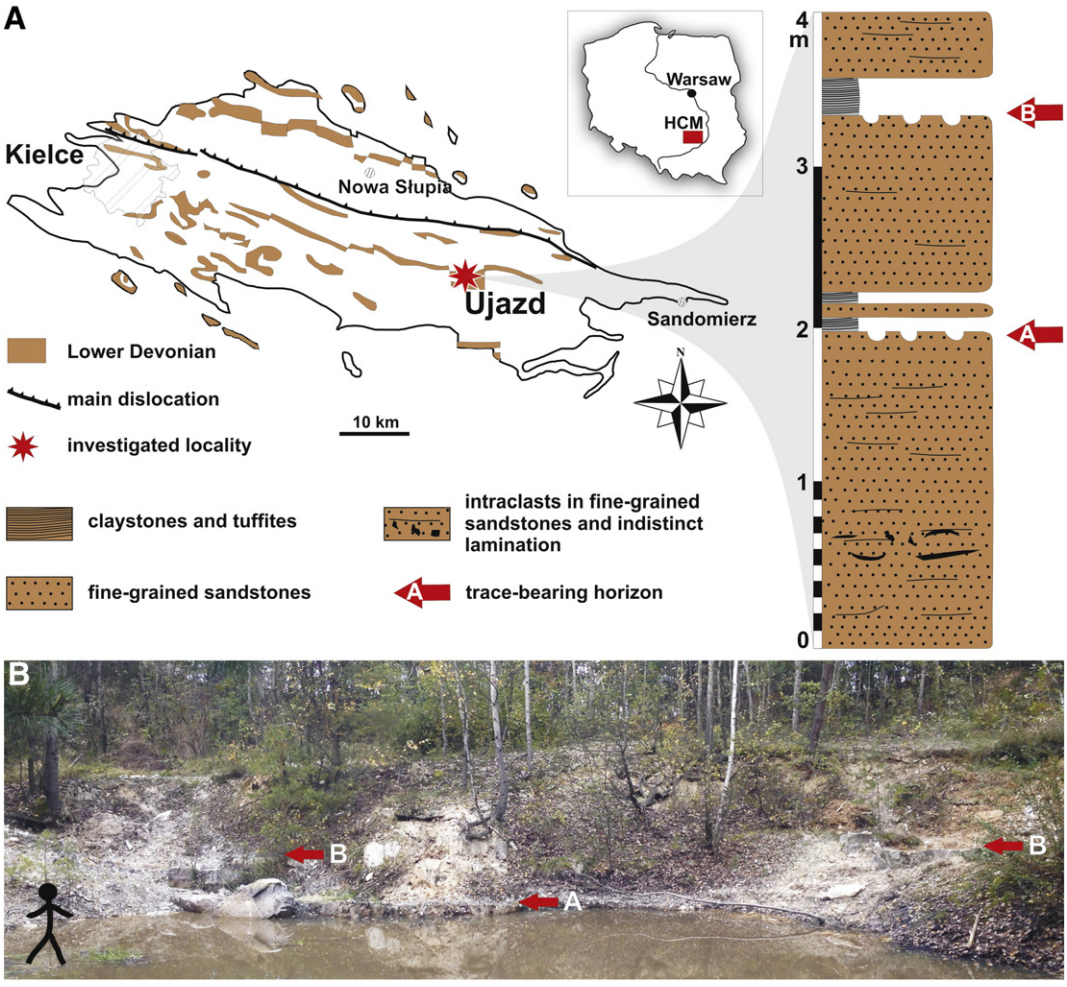

Fig. 1. Location and appearance of the investigated outcrop at Ujazd. A. Location map in the Holy Cross Mountains (HCM), Central Poland (modified from Kowalczewski, 1971). B. Studied section with trace fossil horizons. C. A photograph of the quarry with A and B trace-bearing horizons marked with arrows.