FRAGMENTA NATURAE VOL. 53: 17–26 (2020)
http://10.5281/zenodo.3745517
FORMERLY NATURE JOURNAL
Opole Scientific Society ISSN 2544-3941

# TRILOBITES AND ASSOCIATED FAUNA FROM BALTOSCANDIAN ERRATIC BOULDERS AT ORŁOWO CLIFF, NORTHERN POLAND

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**ABSTRACT:** At Orłowo Cliff, numerous erratic boulders of Palaeozoic sedimentary rocks, transported here by Pleistocene glaciers, are found. These contain a plethora of fossils, others trilobites and ostracods. So far, almost no studies have been done on these boulders that originate from Scandinavia, probably from Gotland, but also from other areas around the Baltic Sea. Most of these are of Silurian age, as a number of trilobite taxa (*Encrinurus punctatus* and *Calymene*sp.), as well as some ostracods belonging to the genus *Beyrichia* demonstrate.

**KEY WORDS:** Arthropoda, Ostracoda, Palaeozoic, Pomerania, Gdynia

## Introduction

Until now, the great majority of palaeontological studies in Poland have concentrated on the central and southern parts of the country, which is due mainly to historical aspects. The earliest palaeontological works appeared in Kraków and Wroclaw where the first Polish universities had been founded. However, the Pomeranian area also has significant palaeontological potential. For example, numerous fossils can be collected here from glacially derived erratic boulders. These have not yet been not studied in detail, but include many interesting palaeontological data.

Available literature sources date back to the twentieth century; for instance, studies of erratic Palaeozoic fossils by Neben and Krueger (1979) or descriptions of Silurian trilobites from Gotland by Ramskold (1985). An interesting example also is the introduction of new genera and species of polychaete worms from erratics in Poland and Estonia (Hints 1998).In 2017, a paper on erratic fossils from the south of Poland was published; this focused on trace fossils (Chrząstek and Pluta 2017).

In nearby countries, a diverse fauna of trilobites, brachiopods and hyoliths was described from erratic boulders found in Jylland, Denmark, by Weidner et al. (2015), while numerous faunal and floral elements were recorded from erratics in the northern Netherlands and in northern and north-eastern Germany (Keulen and Rhebergen 2017). Another example is a trilobite fauna, with even new species, from Germany and Denmark (Geyer et al. 2004).

The erratic boulders studied were transported here by Scandinavian ice sheets (glaciers) during the Pleistocene and embedded in glacial sediments far away from their original site of provenance.

A lot of erratic material is found in northern, central and even southern Poland, having originated from Scandinavia, other Baltic countries and the Baltic Basin itself (Chrząstek and Pluta 2017). Most of these probably originate from northern Sweden and Gotland, but during movement of ice sheets, also material from other areas could be incorporated. Among these boulders, there are so-called indicator erratic, such as the Tessini Sandstone, which can be traced to their exact area of origin (provenance), as well as erratics of lesser significance (e.g., Devonian dolomites), which are common over large areal extents or have more than one site of origin. Indicator erratics are helpful in determining the direction of ice sheet transgressions (Harasimiuk and Terpiłowski 2003).

## Locality

Orłowo Cliff (Fig. 1) is situated within the city area of Gdynia, along the southern coast of the Baltic Sea on a moraine plateau (Woźniak et al. 2018). The cliff measures over 0,5 km in length and attains a height of up to 60 metres. However, its size is constantly decreasing because of continuous abrasion at a rate of 1 m/year (Kaulbarsz 2005).

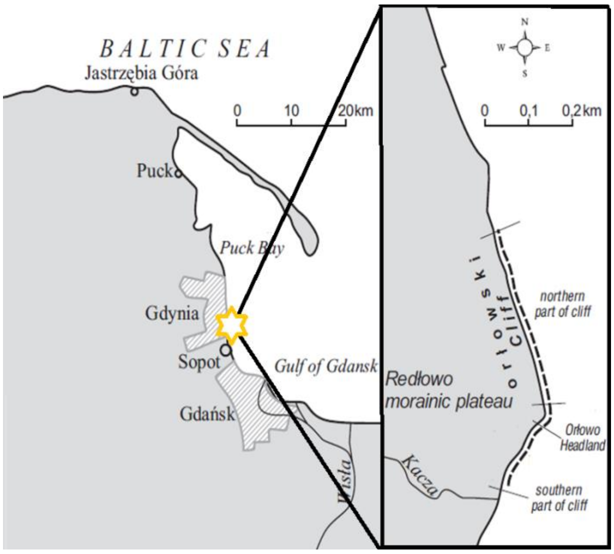


Fig. 1. Location of Orłowo Cliff at Gdynia (modified after Kaulbarsz 2005).


ISSN 2544-3941
http://10.5281/zenodo.3745517

The cliff (Fig. 2) comprises moraine clay and other fluvioglacial and glacial deposits (Kaulbarsz 2005) which probably reflect deposition during the Odranian, Warthanian as well as Vistulian glaciations. Three main parts of the cliff have been distinguished to date: the Orłowo Headland, the northern part and the southern part. The first-named probably is part of a fold; it comprises glacial tills. In the northern part there are sandy deposits of Miocene age between a layer of lignite (brown coal) and a moraine pavement. The southern part consists of tills, sands, silts and gravels. The cliff is characterised by glaciotectonic deformations and there are faults, overthrusts, folds and boudinage (Kaulbarsz 2005).

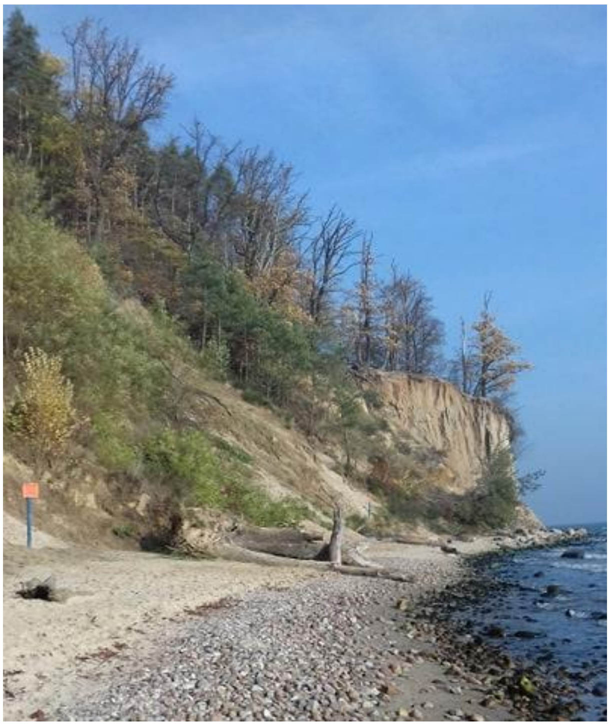

Fig. 2. Orłowo Cliff, view of the northern part (photo by the author).

**Material and methods**

On the beach underneath Orłowo Cliff, lots of erratic boulders are found (Fig. 3). These represent igneous (i.e., diorites, syenites, granitoids and porphyries), sedimentary (mainly limestones and sandstones) and also metamorphic (gneisses, quartzites) rocks. From the sedimentary erratic, numerous fossil remains of invertebrates (but not only, also fish skeletal parts are known), such as corals, sponges, brachiopods, bivalves, cephalopods and arthropods can be recovered. The present work is dedicated to Arthropoda, mainly trilobites, which represent the commonest group here and are comparatively well preserved in spite of their small size, ranging between a few milimetres to about five centimetres.

Rocks were crushing by hammer, then dissolving in hydrochloric acid. At the end fossils were preparing with chisels and needles. Photographs of fossils presented here were taken by the author with the help of an Digital microscope Xrec with 5x optical zoom.

Fig. 3. Erratic boulders on the beach underneath Orłowo Cliff (photo by the author).

**What are trilobites?**

Trilobites form a group of extinct marine arthropods belonging to the subphylum Trilobitomorpha. Most trilobites inhabited fairly shallow shelf seas and were benthic, endobenthic or nektobenthic; a few, like agnostids, may have been pelagic, floatingin


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the water column. Their first appearance is connected with the Cambrian Explosion; they died out during the Permian Mass Extinction Event (Radwańska 2007).

Trilobites had jointed legs and symmetrical bodies, divided into segments. Their exoskeleton, known as cuticle, was formed of mineral substances and chitin. These arthropods were often only a few centimetres long, but some of them were even smaller (just a few millimetres)or very much larger, up to several dozen centimetres. They grew via moulting. Trilobites probably fed on detritusor mainly small marine organisms and organic matter (Clarkson 2007).

The trilobite body (Fig. 4) was divided into three segmented sections: the cephalon, thorax and pygidium. In the centre of the cephalon is the glabella. In the thorax and pygidium, axial rings and pleura can be differentiated. A cephalon is constructed of a few conjoined segments and consists of the cranidium (glabella with furrows, fixigena) and librigena. There are also ventral and dorsal sutures. Many species had eyes with many lenses. The thorax comprised between two and forty-four segments. Between these there were joints and muscles; some species of trilobite (e.g., *Phacops*) could roll up in case of emergency (Clarkson 2007).

Trilobites had very well-developed appendages. Their number was not the same in every species. There were antennulae and four pairs of legs on a cephalon. On the thorax and pygidium there were only legs, consisting of three parts: the endopodite (internal, motion function), the exopodite with gills for breathing and the base of the leg. Some trilobites had also spines or claws (Witak et al. 2015).

About 15,000 species of trilobite have been described to date (Witak et al. 2015). The class Trilobita comprises eleven orders: Asaphida, Agnostida, Redlichiida, Ptychopariida, Phacopida, Corynexochida, Lichida, Harpetida, Trinucleida, Proetidaand Odontopleurida (Fortey 2001,Ebach et al. 2002,Bignon et al. 2020).

In addition, trilobites are excellent index fossils for the Cambrian and Ordovician. They are also good palaeoenvironmental indicators. Their fossil remains are common in Palaeozoic rocks across the entire world (Clarkson 2007).

## Preliminary results

The collection studied has been amassed by the author during field trips in 2017-2019. In total, 12 samples yielded 26 pieces of trilobites, 94 ostracods and 12 brachiopods. Some of these fossils have already been prepared, but others require further preparation and analysis under the microscope. The remains should also be compared with material illustrated in the literature, for instance, on fossils from Scandinavia (Neben and Krueger 1979) and on Silurian trilobites (Storey 2012). Literature items on the stratigraphy of Silurian rocks in northern Poland, based on data from boreholes, could also prove to be of importance (Tomczyk 1968). The next collecting trip is planned in 2020.

For the time being, four pygidia (Fig. 5) have been found, 16 trilobite segments, three other trilobite fragments, three fragments of *Encrinurus punctatus* (Wahlenberg 1821) (Figs. 6, 7), 94 ostracods, 12 brachiopods and four indeterminate specimens (Figs. 8, 9).

## Conclusions

Among specimens collected, three trilobite fragments belong to *Encrinurus punctatus* (Wahlenberg, 1821) have been recognised. This species belongs to the order Phacopida which ranged from the Middle Ordovician to the Lower Devonian. They were a few centimetres long and were characterised by tubercles on the cranidium, pygidium and some also on the thorax. Their thoraces had 11 segments (Tripp 1962). Fossils of *E. punctatus* were recorded from Estonia, Latvia, Sweden (especially Gotland) and Poland (fossiilid.info).

There are also three pygidia belonging probably to the genus *Calymene*. This genus is also assigned to the order Phacopida. These probably nektobenthic trilobites ranged from the Lower Ordovician to the Lower Devonian but were commonest in Silurian rocks; they are perfect index fossils for this period. They were about 2 cm long and often had 13 segments on the thorax. Specimens are found mostly in North America and Europe. They had a broad thorax and a small pygidium (Lehmann and Hillmer 1991). A few trilobite fragments are in need of further analysis.

Accompanying ostracods, mostly belonging to the genus *Beyrichia*, illustrate that most of these erratics are of Silurian age. In general, the erratic complex of fauna collected from the deposits at Orłowo Cliff in Gdynia could be compared with similar assemblages found in Gotland, southern Sweden and Estonia (fossiilid.info). Erratic faunal complexes recorded from those regions also include representatives of ostracods and brachiopods. Future research will certainly yield additional data.

**Acknowledgements**

I wish to express great appreciation to my supervisor dr hab. Elena Yazykova, prof. UO, for her help and constructive suggestions during this work, to prof. John Jagt for some advices, to Dawid Mazurek MSc for assistance in fossil identification and to my friends Mateusz Wróblewski, Adam Rytel and Grzegorz Gorczyński for help with data collection and to my parents for a new microscope.

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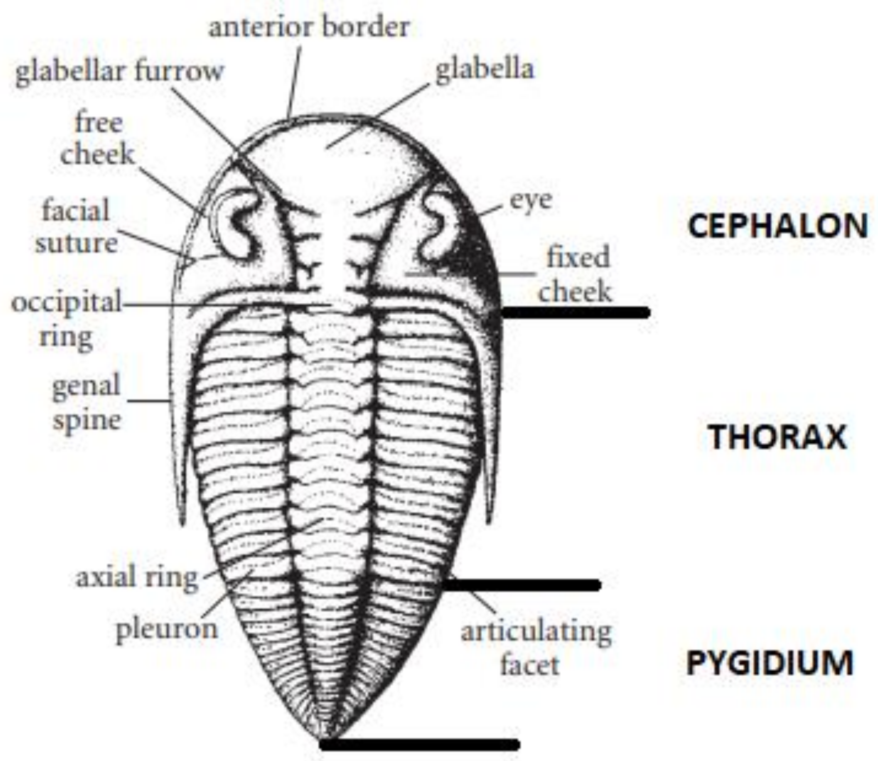


Fig. 4. Trilobite morphology (modified after Benton and Harper 2009).

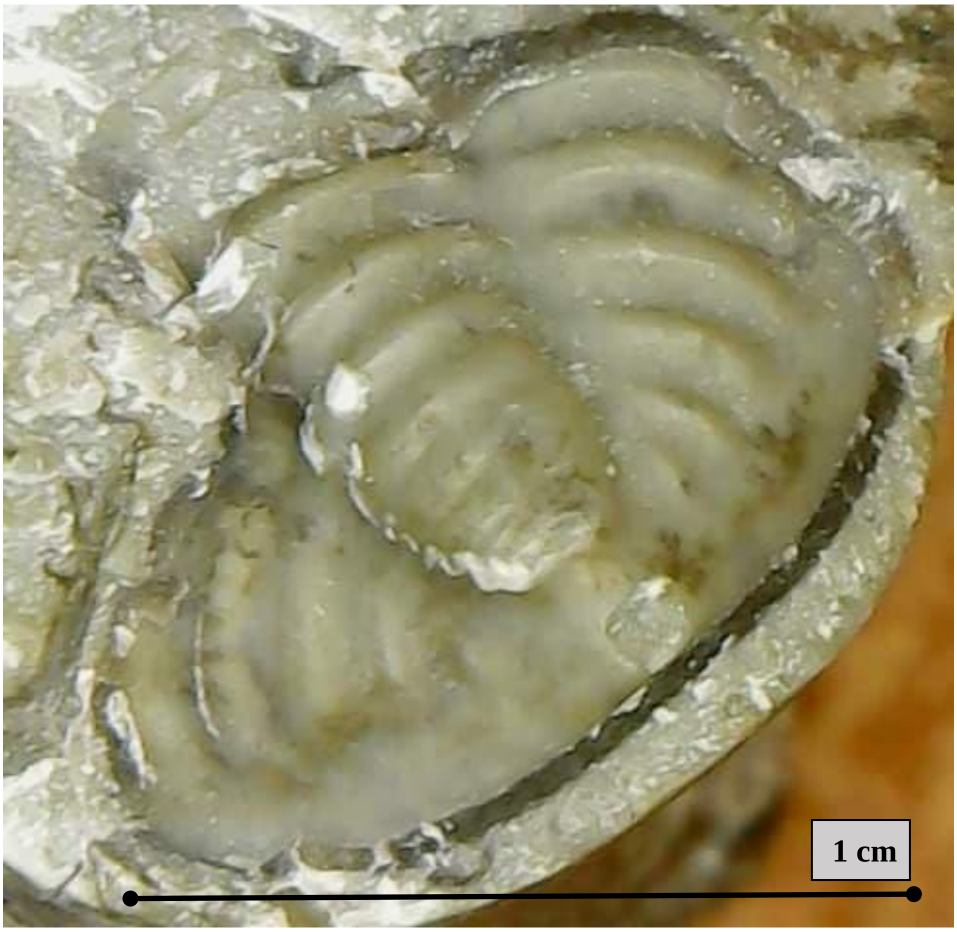


Fig. 5. Pygidium of ?*Calymene* sp.


ISSN 2544-3941
http://10.5281/zenodo.3745517

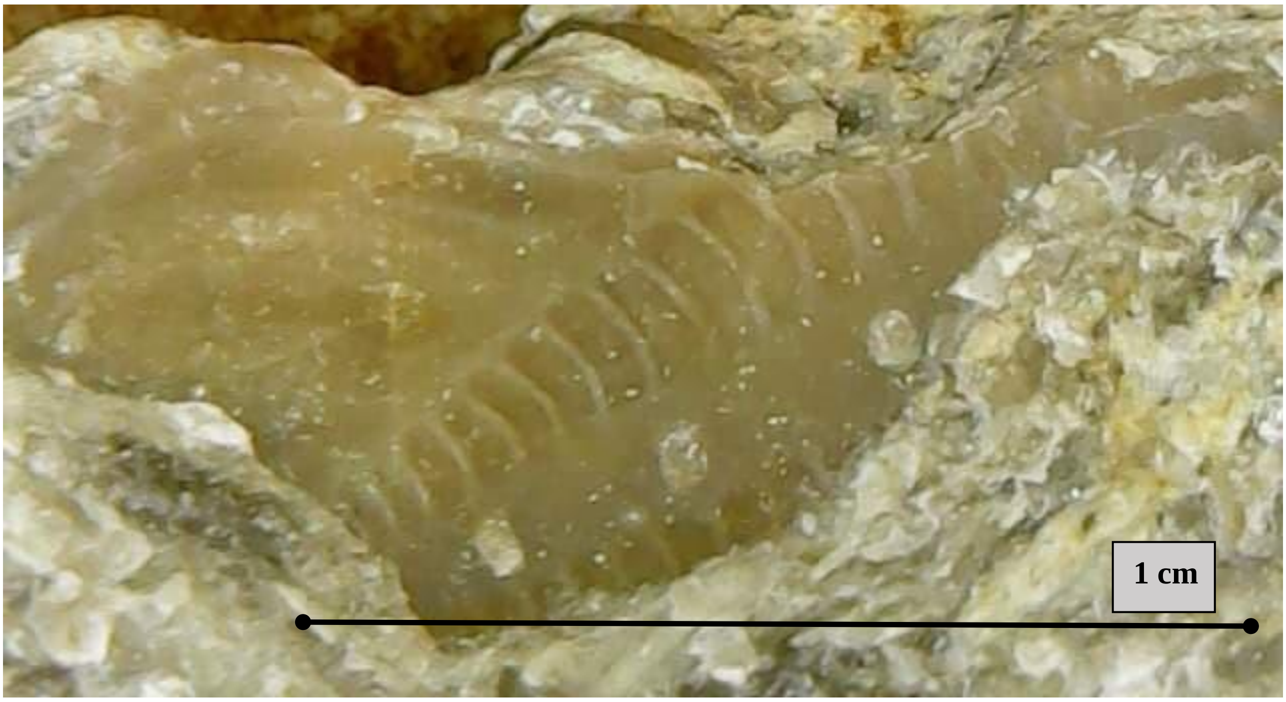


Fig. 6. *Encrinurus punctatus* (Wahlenberg 1821).


Fig. 7. *Encrinurus punctatus* (Wahlenberg 1821).


ISSN 2544-3941
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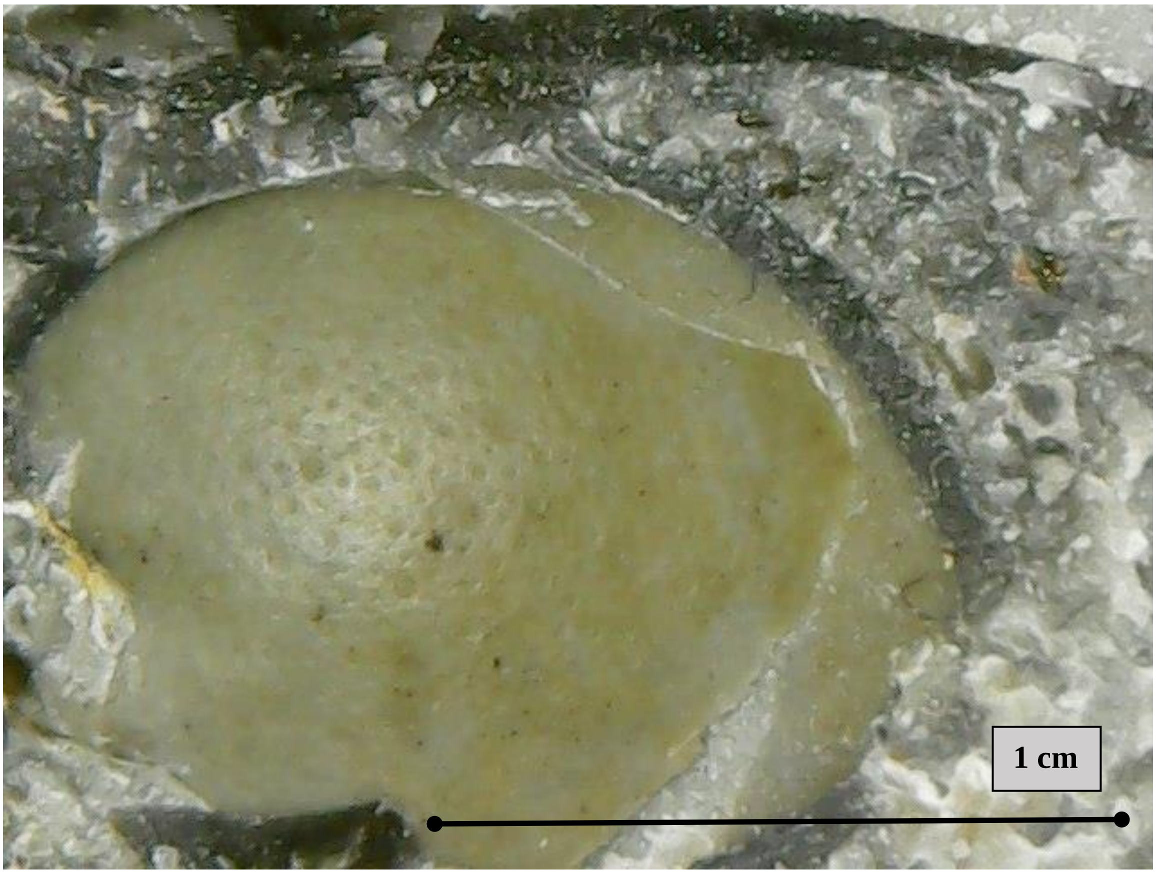

Fig. 8. Problematic sample; either a trilobite glabella or ostracod.

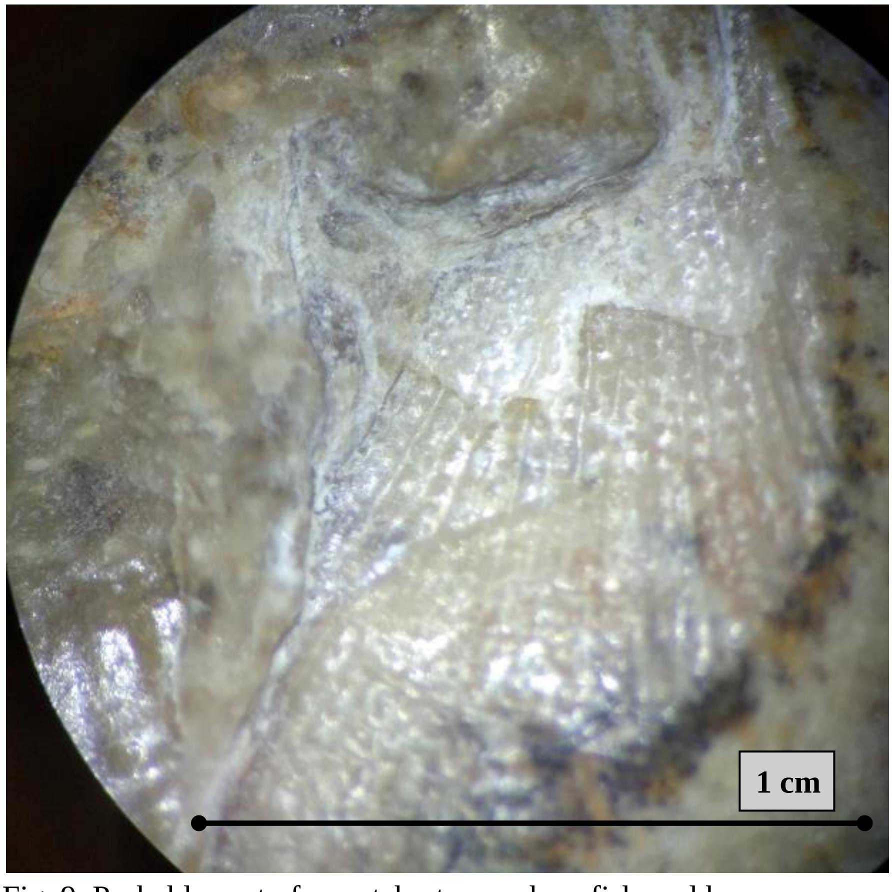

Fig. 9. Probably part of a vertebrate, maybe a fish scul bone.


ISSN 2544-3941
http://10.5281/zenodo.3745517

## Streszczenie


### *Trylobity i fauna towarzysząca ze skandynawskich i bałtyckich eratyków znalezionych w okolicy Klifu Orłowskiego, północna Polska*

Klif orłowski znajduje się w południowej części wybrzeża Morza Bałtyckiego. Administracyjnie należy do Gdyni, miasta w północnej Polsce. Na klifie stale zachodzi abrazja. Zbudowany jest on głównie z glin morenowych oraz innych osadów glacjalnych i fluwioglacjalnych. Na plaży w rejonie klifu orłowskiego znaleźć można liczne eratyki reprezentujące zarówno skały magmowe, metamorficzne, jak i osadowe. W tych ostatnich odnaleźć można wiele skamieniałości, przede wszystkim bezkręgowców (małżoraczki, małże, koralowce, gąbki, trylobity, głowonogi), ale nie tylko (np. ryby). Eratyki przyniesione były przez lądolód i pochodzą prawdopodobnie głównie ze Skandynawii (szczególnie Gotlandii), ale także innych rejonów Bałtyku. Większość z nich jest wieku sylurskiego, na co wskazuje obecność małżoraczków z rodzaju *Beyrichia*.

Niniejsze badania skupiają się głównie na skamieniałościach stawonogów, zwłaszcza trylobitów. W eratykach znalezionych na klifie orłowskim znajdują się skamieniałości trylobitów o wielkości od kilku mm do około 5 cm. W 12 zebranych fragmentach skał, znajduje się 26 fragmentów należących do trylobitów (cztery pygidia, z czego trzy należą prawdopodobnie do rodzaju *Calymene*, 16 pojedynczych segmentów, trzy inne fragmenty, trzy części należące do gatunku *Encrinurus punctatus* Wahlenberg, 1821). Oprócz tego znaleziono 94 małżoraczki, 12 ramienionogów i cztery fragmenty wymagające dalszej analizy.

Badania mają na celu pokazanie różnorodności fauny z eratyków wybrzeży bałtyckich i potencjału paleontologicznego Pomorza. Porównanie znalezionych skamieniałości z innymi kompleksami może pomóc w określeniu kierunków wędrówki lądolodu oraz być przydatne w innych analizach paleogeograficznych i paleoekologicznych.