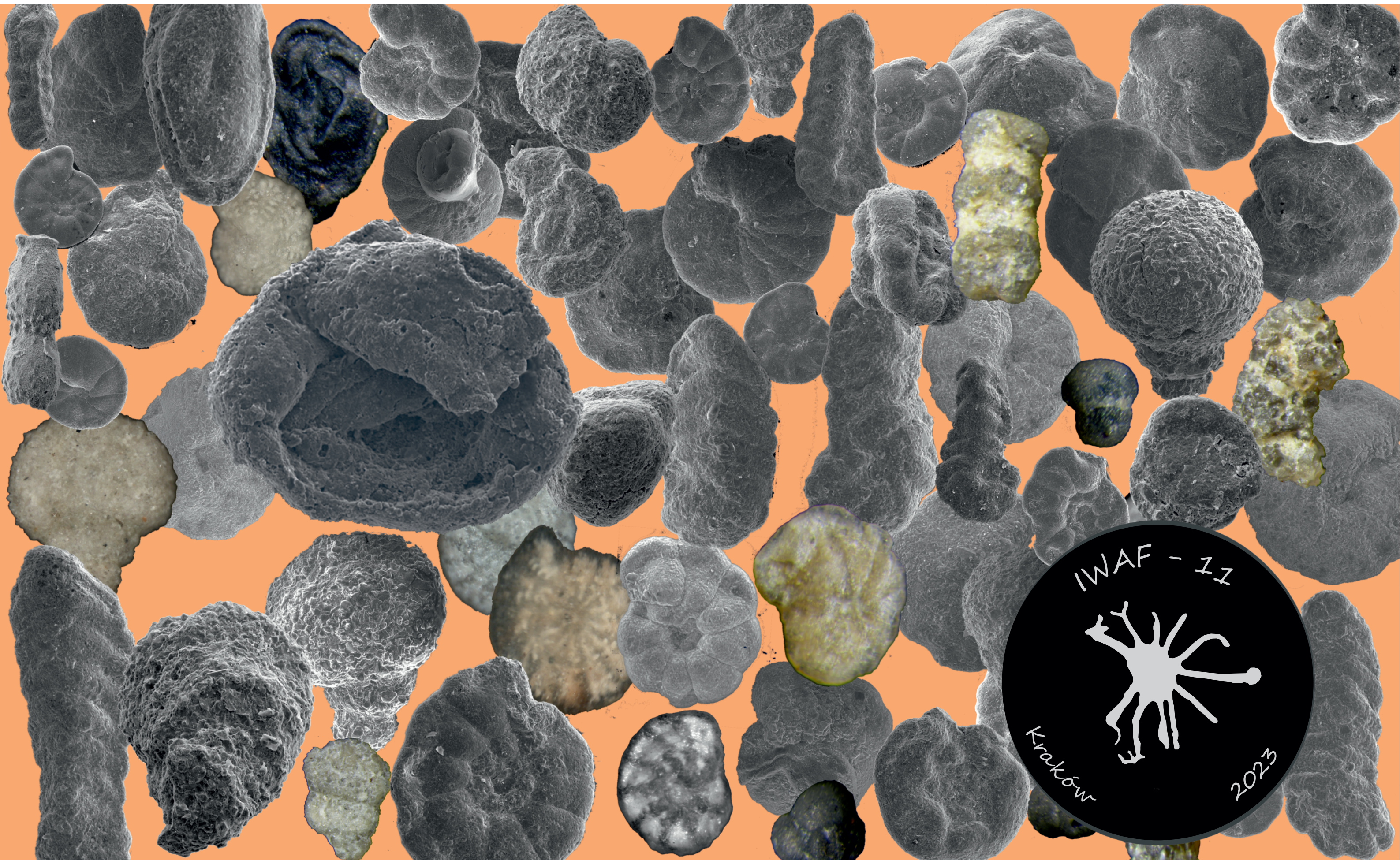
Eleventh International Workshop on Agglutinated Foraminifera

Abstract Volume



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Eleventh International Workshop on Agglutinated Foraminifera

Kraków, Poland, April 19–22, 2023

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Edited by:

S. Bębenek, A. Waśkowska,

& M.A. Kaminski

Grzybowski Foundation, 2023

Eleventh International Workshop on Agglutinated Foraminifera

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Preface

The Organizing committee of the Eleventh International Workshop on Agglutinated Foraminifera (IWAF-11) welcomes everyone to AGH University of Science and Technology in Kraków. We strongly believe that this event will provide an opportunity to discuss novel ideas and share the experience for specialists from all over the world after long break caused by Covid-19 pandemic.

We hope you enjoy your stay in Kraków, European capital of culture and former capital of Poland. The city, first mentioned in the diary of an Arab traveller, Ibrahim ibn Jacob in 965, is considered as one of the most famous in this part of Europe. It is the top tourist destination of Poland, famous for the XIII th century Old Town with Market Square and the Cloth Hall (Sukiennice), the Wawel Royal Castle as well as Kazimierz – The Old Jewish Quarter. Kraków is also called a centre of science and higher education because of the 7 universities located here, including the oldest in Poland – the Jagiellonian University and the largest technical university - AGH University of Science and Technology. Today, AGH University has more than 20,000 students, 16 departments, several didactic and scientific centres, student's associations and foundations. One of them is Micropaleontological Foundation Micropress Europe, whose headquarter is in the main building of AGH.

We are grateful to more than 30 scientists who registered for IWAF-11, and who submitted more than 35 papers that are included in this volume. These papers are fundamental to the IWAF-11, and they will certainly be the basis of numerous discussions and presentations of the latest investigations on agglutinated foraminifera. The programme of our meeting has been carefully planned and divided into two oral and poster sessions, a walking tour of Kraków and viewing the amazing collections in the European Micropaleontological Reference Centre housed in the office of Micropress Europe.

The committee enthusiastically supports the Workshop on Agglitunated Formaninfera to make it interesting and highly inspired for further research. We sincerely hope the IWAF-11 experience will be beneficial for every participant. In particular, we believe that young researchers taking a part in IWAF-11 will achieve satisfied results on the ground of agglutinated foraminifera.

We hope you enjoy the meeting.

The IWAF-11 Organizing Committee

Grzybowski Award for 2023 – Professor Barbara Olszewska

Justyna KOWAL-KASPRZYK[1] and Michael A. KAMINSKI[2]

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Figure 1. The research group of Loeblich and Tappan at UCLA in 1985. From left to right: Helen Tappan, Alfred R. Loeblich, Barbara Olszewska, Tim Patterson and two assistants.

Professor Barbara Olszewska is one of the leading figures in the field of Micropaleontology, especially in the area of foraminiferal biostratigraphy and paleoenvironmental interpretation. Her investigations have led to a deeper understanding of the diversity of Carpathian foraminifera as well as their usefulness as stratigraphic tools that form the basis for dating deep-sea sedimentary deposits. Professor Olszewska has spent the last 50 years investigating the deep-sea foraminiferal assemblages, and the agglutinated foraminifera in particular.

Barbara Olszewska began her career path in the late 1950s at the Geological Technical School in Krakow. Upon graduating in 1961, she was hired by the State Geological Institute, Carpathian Branch in Krakow where she spent the rest of her professional career. She earned her masters degree in 1969 at the AGH University of Science and Technology, and her PhD degree in 1975 at the Polish Academy of Sciences. In 1984 she was awarded her habilitation (=D.Sc.) at the State Geological Institute. On November 23, 2005 she received the title of Professor from the President of the Polish Republic.

Since 1984, Barbara Olszewska has held various administrative posts at the State Geological Institute, first as head of the Micropalaeontological Laboratory in the Department of Regional Geology (1984–1990), then as Deputy Director of the State Geological Institute, Carpathian Branch, as well as Director of the Division of Fundamental Research. Then until 2000 she was head of the Stratigraphy and Petrology

Laboratory of the Geology Division, and from 2001 to 2004 she was the Deputy Director of the Division or Cartography and Regional Geology of the State Geological Institute, Carpathian Branch. During her tenure she initiated new areas of research, such as calcareous nannoplankton biostratigraphy, microfacies, graphic correlation, as well as the application of microfossils to sequence stratigraphy. She made efforts to gather together (or retrain) experts from the various subdisciplines of Micropaleontology in order to build a multidisciplinary team that could carry out integrated research on the biostratigraphy and paleoenvironments. She also expanded the remit of the State Geological Institute, Carpathian Branch to include the area of the Carpathian Foredeep as well as the internal units of the Carpathians (e.g., Olszewska, 2008).

In her own research, Barbara Olszewska invested much effort into her micropalaeontological studies. It is important to point out the sheer breadth of her interests, expecially in this era of ever-increasing specialization within our field. She undertook studies of various groups of foraminifera, from planktonics to agglutinated benthics, to shallow-water calcareous benthics. In addition to studying whole specimens, she often undertook studies of carbonate rocks in thin section, and became one of the very few experts on this topic in the Carpathian area (e.g., Olszewska 2005, 2010). Her studies of carbonates in thin section lead her to work with other biostratigraphically important calcareous microfossils such as calcareous dinocysts, calpionellids, calcareous algae, and even *incertae sedis* microfossils, and microscopic fragments of larger fossils. She studies all areas of the Carpathians, with her main area of study being the Outer Carpathians and their foredeep. She also worked on exploratory boreholes that were drilled through the Carpathians in the search for hydrocarbon reservoirs (Olszewska, 2014).

Among Barbara Olszewska's greatest achievements are her biostratigraphical and paleoenvironmental studies of the Outer Carpathians (Morgiel & Olszewska, 1981, Olszewska 1997), and the Carpathian Foredeep (Olszewska 1999). She co-authored the "Stratigraphy and Correlation of Paleogene and Neogene Deposits of the Outer Carpathians and their Foredeep" and also contributed over 300 species to the "Atlas of Polish Characteristic and Index Fossils" (Olszewska et al., 1996; Odrzywolska-Bieńkowska & Olszewska, 1996). She also studies the Jurassic and Cretaceous microfossils of the European Platform sediments found beneath the Carpathian nappes (Olszewska 2001, 2004). Using an integrated microfossil approach, she arrived at a re-interpretation of the age of the Cieszyn Limestones (Olszewska, 2005; Olszewska et al., 2008). She also studies exotic rocks from the Carpathian flysch in an effort to understand their sources and provenance (e.g., Olszewska & Oszczypko, 2010; Olszewska et al., 2011).

Barbara Olszewska did not restrict herself to working on material from southern Poland or to collaborating with Polish scientists. In 1984–1985 she had a postdoctoral position funded by UCLA, during which she worked with an international team under the supervision of Alfred Loeblich and Helen Tappan. At the time, Loeblich and Tappan were working on their book "Foraminiferal Genera and their Classification" (Loeblich & Tappan, 1987). Barbara took on the task of revising the bolivinids and updating the classification and description of a large number of genera. She also collaborated with scientists who were investigating other areas of Europe, for example the Ukraine (Gutowski et al., 2005; Krajewski & Olszewska, 2007), Slovakia (Morycowa & Olszewska, 2013), and even Egypt (Welc et al., 2013). She took part in the team that studied the micropaleontology and chronostratigraphy of the flysch deposits of the

Morrocan Rif, and examined the faunal connections with the Carpathians (Morgiel & Olszewska, 1981b).

Professor Barbara Olszewska is the author of over 100 scientific publications and dozens of archived reports. She worked with leading scientists and research institutions as well as with national and international petroleum companies. However, her career was not limited to scientific reports – she also successfully supervised three Ph.D. students. She served as referee or external examiner for many other masters, Ph.D., and habilitation projects. She reviewed articles for Polish and International journals, as well as many research proposals. She played an active role in various geological committees and societies, such as the Scientific Committee of the Polish Geological Institute (from 1991), the Advisory Committee of the Centre for Research Excellence on the Abiotic Environment REA (from 2002). She served on the editorial boards of *Geologica Carpathica* and well as the publications of the Polish Geological Institute.

Although Professor Barbara Olszewska officially took her retirement, she remains active in scientific circles. She continues to advise and support her younger colleagues. Thanks to her knowledge of foreign languages, she remains in contact with scientists from a broad circle. For the younger generation she is not only a role model, but she is also a kind and generous person with broad interests – that are not restricted to Geology.

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Celebrating Fourty Years of IWAF

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In the late 1960s one of us (WAB) had the opportunity of visiting the paleontological laboratory of ESSO Oil company in Bordeaux, France as part of an extensive European tour designed on building a micropaleontology collection at the Woods Hole Oceanographic Institution. Knowing that we would soon be drilling in the Labrador Sea on DSDP Leg 12 (1970) WAB decided to visit the ESSO Oil Company in Bordeaux, which had been exploring in offshore Canada. He had an opportunity to visit their labs and obtain samples among which were some agglutinated benthic foraminifera about which little was known, but which we soon recognized as characteristic of the so-called deep-water flysch faunas found in the Carpathian and Caucasus Mountains. Sure enough, drilling the deep water Site 112 in the Labrador Sea on DSDP Leg 12 introduced us to those flysch faunas.

In June 1968, Phillips Petroleum announced the first commercial discovery of oil in the Norwegian sector of the North Sea. In fact the announcement was published by the Norwegian newspapers on the same day as they reported the assassination of Robert Kennedy. The Oil Rush in the North Sea was on. Phillips Petroleum gave us a couple of wells to study. In 1979, Felix Gradstein spent his sabbatical at Woods Hole, and we then realised that the Paleogene assemblages from the North Sea showed a great deal of similarity to Grzybowski's faunas from the deep-water flysch deposits of the Carpathians. We produced a paper published in *Marine Micropaleontology* that summarised the occurrence of the flysch-type faunas around the northern Atlantic, and formalised the term in the literature (Gradstein and Berggren, 1981).

Around this time, Felix Gradstein and WAB had the idea of holding a workshop in Amsterdam. We contacted our colleague Jan van Hinte in Utrecht, and the First IWAF meeting took place in September, 1981. One of the ideas we had was to invite some colleagues from Eastern Europe who had worked on the Carpathian faunas, as well as some colleagues from industry who were working on the agglutinated faunas of the North Sea. Stan Geroch, Irena Heller, and Krystyna and Wladislaw Pozaryski were among the people who were able to travel from Poland to Amsterdam to attend the meeting. One of the students who attended the meeting was Mike Kaminski, who at the time was doing his masters thesis with Stan Geroch at the Jagiellonian University, and acted as his travel companion and translator at the meeting.

For about 25 years one of us (WAB) managed a long-term project (1970–1995) on Cosmopolitan Cenozoic Deep Water Benthic Foraminifera (CCDWBF) centered at the Woods Hole Oceanographic Institution (WHOI) on Cape Cod, Massachusetts. With the support (at its acme) of 14 international oil companies the project produced numerous articles and a monograph which encompassed the taxonomy, biostratigraphy and paleoecology of 126 taxonomically significant Cenozoic taxa (Van Morkhoven et al. 1986). Mike Kaminski joined the CCDWBF project in 1982 as a Ph.D. student in the WHOI/MIT Joint Program. In the summer of 1985, Mike sailed as a shipboard micropaleontologist on board the *Joides Resolution* on ODP Leg 105, which after dodging icebergs in Baffin Bay revisited the Labrador Sea and recovered an excellent record of Paleogene agglutinated foraminifera. Around this time, we had the idea of producing a companion volume to the Van Morkhoven book that covers the Cenozoic Cosmopolitan

Aggutinated Foraminifera. The book *“Paleogene Cosmopolitan Deep-Water Agglutinated Foraminifera”* was published by Kaminski & Gradstein (with collaborators) in 2005. The publication of these two volumes represents the culmination of nearly five decades of investigations on the agglutinated and calcareous benthic foraminifera by our research groups.

Firstly, the Planktonic Foram people held two or three meetings that were called the "Planktonic conferences". These morphed into the Paleoceanography conferences, and the focus of the workshop was quickly lost. The Benthic Foram people had their "Benthos" meetings. After three meetings, this conference morphed into the "Forams" meeting. Again the focus was lost. The "miliolid people” never even started a workshop series.

In stark contrast, a working group on agglutinated foraminifera has been meeting for over 40 years now and continues to meet approximately every four years, with a minor haitus because of the recent pandemic. The "Working Group on Foraminiferal Classification", which meets at the IWAF meetings have managed to keep track of all the new genera that have appeared in the literature since the publication of Loeblich & Tappan’s (1987) book, and produce an update of Loeblich & Tappan's classification (Kaminski, 2014). This has been no small feat. By contrast the people who work on miliolids, calcareous benthic, or planktonic foraminifera have not been able to do anything similar. Among the highlights of the numerous studies by the agglutinated foram specialists was the publication of “*Cenozoic Cosmopolitan Deep-Water Agglutinated Foraminiifera”* (Kaminski & Gradstein, 2005), as well as a handsome series of conference proceedings volumes published by the Grzybowski Foundation, and now published as thematic issues of the journal *Micropaleontology*. These volumes have gathered together a significant proportion of all the papers published on the subject of Agglutinated Foraminifera over the past 25 years. Every serious micropaleontology laboratory, whether in academia or industry, keeps these handsome black volumes on a shelf within reach of the microscope.

It is our sincere wish that this series of workshops can be continued into the future under the leadership of a new generation of agglutinated foraminiferal specialists. We praise the efforts of our good colleagues at Micropress Europe for organising the current meeting venue, and we hope that the participants of the current meeting will forge new links that will lead to exciting new research on the subject of agglutinated foraminiferal.

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Agglutinated foraminifera during the Paleocene-Eocene climatic events – a case study from the Polish part of the Fore-Magura Thrust Sheet (Western Outer Carpathians)

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A sedimentary sequence of the Fore-Magura Thrust Sheet (F-MTS), due to the location of its deposition area on the slope of the basin, represents an environment that favoured hemipelagic/pelagic sedimentation above the local CCD, with sporadic intercalations of turbidites. Paleocene and Eocene sediments of the F-MTS are represented by variegated marls, inter-fingering with non-calcareous green and red shales rich in agglutinated, calcareous benthic and planktonic foraminifera. This study presents the results of a semi-quantitative analyses of the foraminiferal assemblages from the Paleogene (except Oligocene) marly, hemipelagic deposits recovered from four sections located south-west of Żywiec and west of the Soła River.

The Paleogene was a period of the global climate changes resulting in a number of extinctions, decimating various groups of organism, among others foraminifera (Molina, 2015). Agglutinated foraminifera suffered the most during the Benthic Extinction Event (BEE) at the end of the Paleocene which is connected with Paleocene - Eocene Thermal Maximum (PETM). Over 50% of these organisms became extinct and much-reduced diversity in the assemblages has been also noticed (Kaminski & Gradstein, 2005; Waśkowska, 2011). Other global events such as the Early Eocene Climatic Optimum (EECO), Middle Eocene Climatic Optimum (MECO) and Terminal Eocene Event (TEE) are also documented in a foraminiferal record (Molina, 2015), however most data concerns planktonic and calcareous benthic foraminifera. One of the characteristic feature of the Paleocene-Eocene agglutinated assemblages in the bathyal-abbysal settings is the presence of "acme" events, e.g., *Glomospira*, *Karrerulina*, *Reticulophragmium* and *Spiroplectammina* acmes (Kaminski and Gradstein, 2005).

The majority of studied material from F-MTS reveals mixed assemblages with all three groups of foraminifera i.e., agglutinated, calcareous benthic and planktonic. The agglutinated foraminifera represent a dominant component of the assemblages in the Paleocene deposits (up to 80%). At the Paleocene-Eocene transition, this proportion is rapidly reduced in favour of planktonic foraminifera. At BEE agglutinated foraminifera constitute only 5% on average. In 39 samples of the Eocene deposits, agglutinated foraminifera constitute from a few per cent up to 80% of the assemblages.

Agglutinated foraminifera are represented by the commonly known Carpathian species such as *Ammodiscus (Dolgenia) latus* (Grzybowski), *Annectina grzybowskii* (Jurkiewicz), *Glomospira charoides* (Jones and Parker), *Remesella varians* (Glaessner), *Rzehakina fissistomata* (Grzybowski) or *Spiroplectammina spectabilis* (Grzybowski) and rarely recorded *Ammoanita ingerlisae* Gradstein and Kaminski, *Conotrochammina whangaia* Finlay, *Dorothia beloides* Hillebrandt and *Saccaminoides carpathicus* Geroch.

Agglutinated foraminifera show an average 50% decrease in species diversity from mixed assemblages to planktic-dominated assemblages at the Paleocene-Eocene transition that can be correlated with the BEE. The early Eocene *Glomospira* acme, common in many settings of the flysch basins (e.g., Olszewska & Szydło, 2017) has not been noticed in the analysed deposits. The agglutinated assemblages reveal the changes along the slope from the sedimentation at the settings above local FL down to the depth below the local CCD and favour agglutinated species with calcareous cement such as *Arenobulimina d'orbigny* (Reuss), *Clavulinoides* div. sp. or *Gaudryina* div. sp. (Baliniak, 2018).

In the Eocene, major changes in the proportion of planktonic foraminifera are present in the mixed assemblages of the studied samples, such as the reduction of morozovellids and diversification in acarininids during and after EECO. Agglutinated foraminifera have not revealed the Eocene acme events, mentioned above (Kaminski and Gradstein, 2005), while their index taxa are present in the most studied samples. In the late Eocene samples, agglutinated foraminifera show a decline in diversity which is typical before TEE. Lack of the agglutinated foraminifera "acme" events may be connected with a F-MTS depositional environment located on a slope of the basin, above local CCD.

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Agglutinated foraminifera from the European boreal shelf sea during the Turonian nutrient crisis – preliminary results

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The Turonian stage in Europe is characterized by broadly flooded shelf areas which led to wide-distributed oligotrophic conditions in hemipelagic to pelagic settings – namely the Turonian nutrient crisis (Wiese et al. 2015). These conditions evolved due to changing paleoceanographical settings and/or drowning of the nearest nutrient source areas. Most paleoenvironmental information for this time interval were gathered by studies focused on planktic organisms such as calcareous nanoplankton (Linnert et al. 2010), or calcareous dinoflagellate cysts (Pearce et al. 2009, Wiese et al. 2015). Bottom-water conditions during this interval are otherwise just rarely studied. To fill this gap of knowledge, agglutinated foraminiferal assemblages are studied from the Turonian Oerlinghausen section from the Münsterland Cretaceous Basin (Germany), and compared to reported findings from the Lower Saxony Basin (Besen et al. 2021).

The studied Oerlinghausen section is composed of hemipelagic carbonate-rich deposits from marl-/limestone alternations. By removing all carbonate content with formic acid (10%), the remaining concentrated sample residues enabled a precise insight on early Late Cretaceous agglutinated foraminifera regarding biostratigraphy and paleoenvironmental changes.

The obtained diverse agglutinated foraminiferal assemblages from the Turonian of the Münsterland Cretaceous Basin mainly consist of deep infaunal taxa such as *Ammobaculites agglutinans,* and *Eobigenerina variabilis,* shallow infaunal taxa such as *Psammosphaera irregularis,* and epifaunal taxa such as *Ammolagena contorta, Glomospira charoides,* and *Trochamminoides* spp.. Especially, *A. contorta* and *G. charoides* occur in high relative abundances in the early Turonian just above the last black shale of the Cenomanian–Turonian Boundary Event which is congruent to observations made on Turonian assemblages from the Lower Saxony Basin (Besen et al. 2021). The calculated Shannon H index is relatively high for all recorded assemblages (2.5 to 3.6) while all agglutinated morphogroups continuously occur in Turonian deposits of the Münsterland Cretaceous Basin. Changes of relative abundances of agglutinated foraminiferal morphogroups reflect shifts of paleoenvironmental conditions most likely produced by sea level fluctuations.

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Konservat-lagerstätten of giant agglutinated foraminifera with the first fossil record of *Psammina* in the Cretaceous and Paleogene of the Carpathian Flysch

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Giant agglutinated foraminifera (GAF) of the genera *Bathysiphon*, *Nothia*, and *Arthrodendron* occur in places within Upper Cretaceous-Paleogene deep-sea sediments of the Carpathian Flysch. They are of importance for reconstruction of original test morphology and systematic placement of taxa that are known just in fragments from washing residues (e.g. Kaminski & Geroch 1992, Bubík 2019). There are two taphonomic settings favorable for the preservation of GAF. The first one is present on soles of sandstone turbidites. Traction carpets at the base of the turbidite current sometimes push the surface of the sea floor and protected them against the high-energy turbulent conditions within the turbidite current. Diagenesis of the sandstones provides the secondary cement that strengthens the foraminifer test. Another type of preservation can be seen in some hemipelagic sediments, where GAF are lying on the bedding planes or in more or less erect position.

Recently, an interesting fossil site of the first taphonomic type was found in Bystřice near Třinec in Silesia, Czech Republic. The Frýdek Formation of the Silesian Unit comprises slumps and submarine slides composed mostly of marls with exotic clasts and subordinate sandstone/conglomerate layers and lenses. Soles of some sandstone turbidites show, besides a characteristic ichnofossil assemblage (*Thalassinoides*, *Ophiomorpha*, *Scolicia*, *Palaeodictyon*, *Chondrites*), also tests of GAFs.

Nearly complete tubular branching form 10 cm in size may be perhaps assigned to *Nothia latissima* (Grzybowski). Thin-walled branches are 2 to 3 mm wide, flattened by compaction of sediment. Nine orders of branching are visible on the most complete specimen. Small fragments of more delicate branching form are close to *Nothia excelsa* (Grzybowski). Fragmented large tests of *Arthrodendron* spp. are concentrated along the lamination of traction carpet. At the first look they recall claystone intraclasts but they form a series of segments surrounded by a thin agglutinated wall. Two morphotypes can be distinguished: one with irregular elongated to pear-shaped segments (heart-shaped when branching), the other with subglobular chambers. The first one represents perhaps a new species, the later may be assigned to *A. grandis* (Grzybowski). The most surprising find was a 3 cm large flat form that recalls a bivalve shell. In fact it has thin agglutinated wall of a giant foraminifer from silty quartz and with fine growth lines. Among known taxa it recalls most closely the xenophyophorean genus *Psammina*.

Surrounding marls contained planktonic foraminifers of the Selandian (P4a Zone) and small benthic foraminifers that indicate outer shelf to bathyal environment (*Marssonella*, *Hagenowella*, *Spiroplectinella*, *Remesella*, *Tappanina*, *Bolivina*, *Pyramidina*, *Coryphostoma*, *Karreria*, *Alabaminoides*, *Gyroidinoides*, *Anomalina*, *Nonionella*, *Nonion*, *Cibicidoides*, etc.). No fragments of GAFs are present in the residue, so the turbidite sole keeps a unique record of these forms.

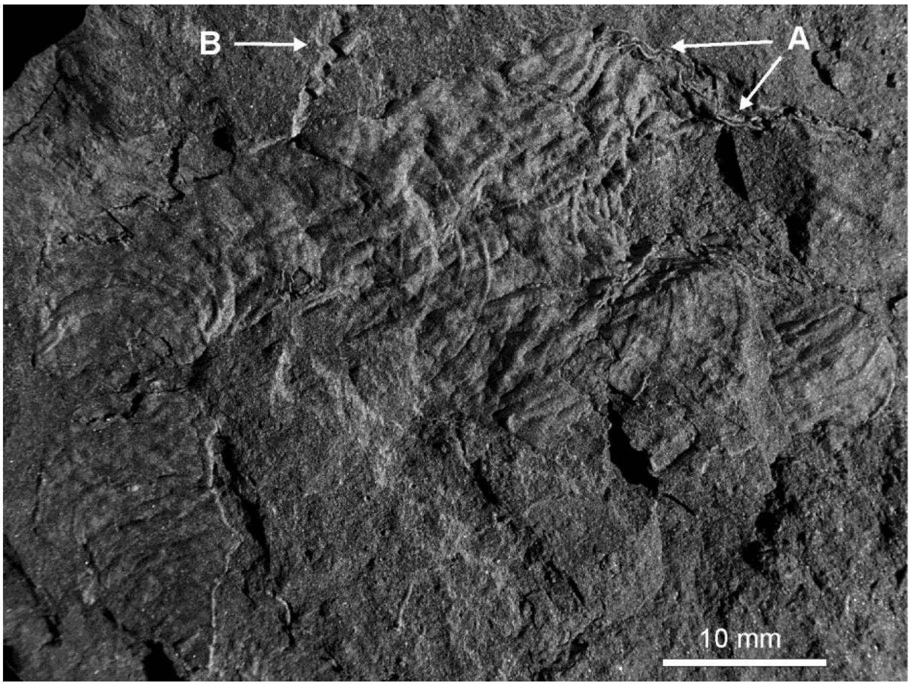

Figure 1. *Psammina* sp. in dark grey shale of the Istebna Formation, Bukovec. Note doubled agglutinated wall of the test at folded edge (A) and broken tube of *Bathysiphon* sp. (B)

Another fossil site with GAFs is situated at Oleška Stream section near Bukovec village near Jablunkov town. Black-grey silty shales of the Istebna Formation (Silesian Unit) represent the second taphonomic type (hemipelagites). The strata are late Maastrichtian or Danian in age. They contain horizons with frequent *Bathysiphon* spp. Several forms of this genus are locally abundant in the Istebna Formation (e.g. Bubík, 2007). The largest form from Bukovec reaches more than 23 cm in length and 5 mm in width (flattened stage of preservation). Also here, *Psammina* sp. was found in several specimens. The fan-shaped test up to 5 cm long has well visible growth lines. The agglutinated wall is 0.10 to 0.12 mm thick, composed of quartz silt. Test is apparently flat originally. Interior of the test between closely spaced walls is filled by dark clayey material. The finds represent the first fossil record of the xenophyophore *Psammina*, when not taking into consideration some problematic finds

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Agglutinated foraminifera record across the Jurassic-Cretaceous boundary in carbonate turbidites of Carpathian Flysch

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Jurassic-Cretaceous (JK) boundary was studied in two sections in the Silesian Unit of the Carpathian Flysch belt near Třinec town in Silesia, Czech Republic. Both sections comprise the Ropice Member of the Vendryně Formation (paraconglomerates and pebbly mudstones) and the overlying Cieszyn Formation (limestone turbidites and hemipelagic marlstones and shales). Based on calpionellids and calcareous dinocysts, the Karpentná section ranges within the upper Tithonian and the Ropice section from the Tithonian to lower Berriasian. The base of the Berriasian in Ropice was placed 4 m above the base of the Cieszyn Formation in biomicritic mudstone with packstone laminae, based on the Alpina Subzone of the Calpionella Zone (Reháková, personal communication).

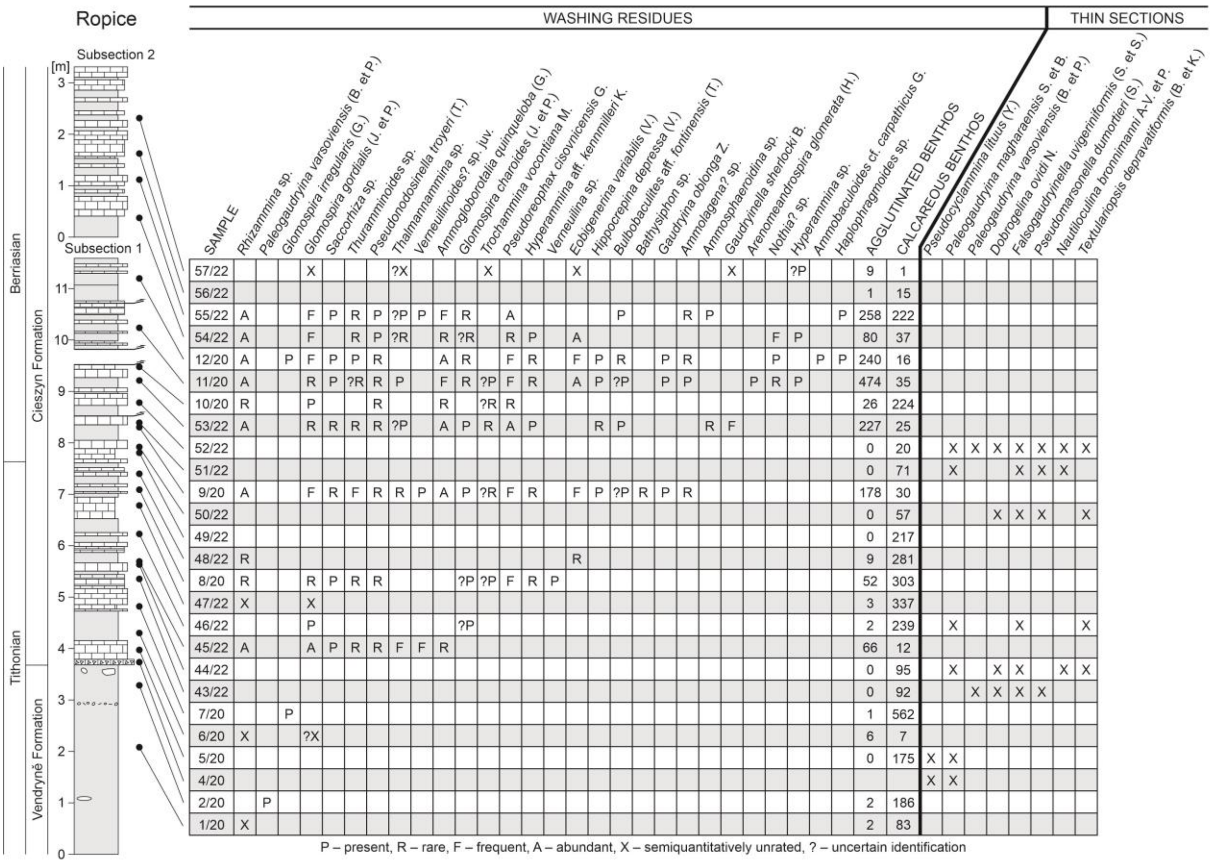
Foraminifera were extracted using standard methods: soft shales and marlstones disintegrated in sodium-bicarbonate solution, limestones dissolved were in 80% acetic acid (method of Lirer 2000), and washed on a 0.063 mm sieve. The acetolysis enable obtaining nodosariids and spirillinids, but the calcareous agglutinated taxa (*Nautiloculina, Falsogaudryinella*, *Dobrogelina* etc.) are dissolved. Therefore, thin sections of limestones were also studied. While the shales and marlstones of the Cieszyn Formation contain autochthonous flysch-type agglutinated fauna, the limestones contain calcareous-agglutinated taxa, reworked from carbonate platform and slope by turbidite currents.

Some agglutinated taxa demand further taxonomical study: e.g. *Thuramminoides* sp. – a form similar to *Saccammina placenta* (Grzybowski) but without apparent aperture, small species of *Ammosphaeroidina*, and *Ammolagena*? sp. – form similar to *Caudammina silesica* (Hanzlikova), but apparently attached to substrate, that is not preserved. The form tentatively identified as *Bulbobaculites* aff. *fontinensis* (Terquem) is close to *Ammobaculites fontinensis* (Terquem) figured by Geroch (1966) in shape and arrangement of chambers but lacks an uncoiled part.

Geroch and Nowak (1984) placed the J/K boundary to their *Pseudoreophax cisovnicensis* Zone below the lowest occurrence of *Verneuilinoides neocomiensis* (Myatlyuk) at the base of the Valanginian. Olszewska (1997) placed the boundary to her *Trochammina quinqueloba* Zone below the *Pseudoreophax cisovnicensis* acme at the base of the Valanginian. Both *A. quinqueloba* and *P. cisovnicensis* are abundant in the studied sections and do not help with correlation within the J–K transition. The assemblage of calcareous agglutinated foraminifers observed in thin sections of turbidite limestones is composed of taxa co-occurring in the upper Tithonian–lower Berriasian interval. Their appearance correlates with the onset of turbidites that transported reworked lime mud and microfauna from shallower habitats of the basin.

Although *Hippocrepina depressa* (Vašíček), *Bulbobaculites* aff. *fontinensis* (Terquem) and *Gaudryina oblonga* Zaspelova have their lowest occurrence 0.5 m above the J/K boundary at the Ropice section, they cannot serve as the J/K boundary markers, because they occur in the upper Tithonian of the Karpentná section. Early stratigraphical occurrences of *Thalmannammina* sp. and *Verneuilinoides*? sp. cannot be identified to species level with certainty because of poor preservation and juvenile status of specimens. The lowest occurrence of *Eobigenerina variabilis* (Vašíček) in the Tithonian part of the Cieszyn Formation is biostratigraphically more useful. Also, the lowest occurrence of

Gaudryinella sherlocki (Bettenstaedt), which is just 1.4 m above the J/K boundary, seems to be interesting.



WASHING RESIDUES																															THIN SECTIONS							
SAMPLE	*Rhizammina* sp.	*Paleogaudryina varsoviensis* (B. et P.)	*Glomospira irregularis* (G.)	*Glomospira gordialis* (J. et P.)	*Saccorhiza* sp.	*Thuramminoides* sp.	*Pseudonodosinella troyeri* (T.)	*Thalmannammina* sp.	*Verneuilinoides*? sp. juv.	*Ammogloborotalia quinqueloba* (G.)	*Glomospira charoides* (J. et P.)	*Trochammina vocontiana* M.	*Pseudoreophax cisovnicensis* G.	*Hyperammina* aff. *kennmilleri* K.	*Verneuilina* sp.	*Eobigenerina variabilis* (V.)	*Hippocrepina depressa* (V.)	*Bulbobaculites* aff. *fontinensis* (T.)	*Bathysiphon* sp.	*Gaudryina oblonga* Z.	*Ammolagena*? sp.	*Ammosphaeroidina* sp.	*Gaudryinella sherlocki* B.	*Arenomeandrospira glomerata* (H.)	*Nothia*? sp.	*Hyperammina* sp.	*Ammobaculoides* cf. *carpathicus* G.	*Haplophragmoides* sp.	AGGLUTINATED BENTHOS	CALCAREOUS BENTHOS	*Pseudocyclammina lituus* (Y.)	*Paleogaudryina magharaensis* S. et B.	*Paleogaudryina varsoviensis* (B. et P.)	*Dobrogelina ovidi* N.	*Falsogaudryinella uvigeriniformis* (S. et S.)	*Pseudomarsonella dumortieri* (S.)	*Nautiloculina bronnimanni* A-V. et P.	*Textulariopsis depravatiformis* (B. et K.)
57/22				X				?X				X				X							X			?P			9	1								
56/22																													1	15								
55/22	A			F	P	R	P	?P	P	F	R		A					P			R	P						P	258	222								
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11/20	A			R	P	?R	R	P		F	R	?P	F	R		A	P	?P		P	P			P	R	P			474	35								
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51/22																													0	71		X			X	X	X	
9/20	A			F	R	F	R	R	P	A	P	?R	F	R		F	P	?P	R	P	R								178	30								
50/22																													0	57				X	X	X		X
49/22																													0	217								
48/22	R															R													9	281								
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47/22	X			X																									3	337								
46/22				P							?P																		2	239		X			X			X
45/22	A			A	P	R	R	F	F	R																			66	12								
44/22																													0	95		X		X	X		X	X
43/22																													0	92			X	X	X	X		
7/20			P																										1	562								
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4/20																															X	X						
2/20		P																											2	186								
1/20	X																												2	83								

P – present, R – rare, F – frequent, A – abundant, X – semiquantitatively unrated, ? – uncertain identification

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Global Database of Foraminiferal Organic Linings: Where are the linings of agglutinated foraminifera?

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We would like to draw attention to the idea of creating a catalogue of all foraminiferal linings available in the scientific literature so far. The first version of Global Database of Foraminiferal Organic Linings (*ForamL* Version 1.2) has been based on 155 scientific publications that illustrated 614 linings (see Godos et al., 2021). The main problem is that organic linings of agglutinated foraminifera are not separated from the linings that come from calcareous foraminifera. This is because both types of shells produce nearly indistinguishable organic linings after palynological preparations. Therefore, this is not trivial to find characteristic features that help to identify organic linings left after dissolution of agglutinated foraminifera.

All foraminiferal organic linings have been grouped following the supraordinal classification proposed by Pawlowski et al. (2013) that includes monothalamean, globothalamean, tubothalameas, and lagenid foraminifera. These taxonomic groups of foraminifera are distinguished based on morphology of chambers. The database consists of three tables that cover the whole Phanerozoic, divided into the Cenozoic, Mesozoic, Paleozoic, and then to systems/periods. For each system, publications are referenced chronologically, according to a publication year. The purpose of gathering the data is to extend scientific knowledge on the origin, taphonomy, and phylogenetic patterns of these fossilizable organic foraminiferal structures. The ForamL database is also linked to the most recent review of the knowledge on foraminiferal organic linings is presented by Tyszka et al. (2021). The ForamL database will be further supplemented by available records of foraminiferal organic linings (Godos et al., 2021).

The database contains some examples of organic linings that most likely come from agglutinated foraminiferal shells. The oldest records of agglutinated foraminifera and their linings can be seen in the Cambrian of the Lontova Formation (Winchester-Seeto and Mcllroy, 2006). These authors mentioned that organic remains of foraminifera commonly occur in palynological samples, however, they are rarely reported and described. Bell and Winchester-Seeto (1999) documented organic linings from the Devonian that belong to several agglutinated foraminiferal taxa, including *Lagenammina* sp., *Psammosphaera sp*., *Saccammina wingarri*, *Thurammina sp*. and *Bathysiphon sp*. Other studies reported foraminiferal organic linings of agglutinated foraminifera extracted from shallow marine limestones, marls and mudstones in Australia, France, Siberia and Pakistan In the Triassic Haig et. al. (2015) presented the organic linings identified as *Trochammina sp*. and *Palustrella sp*. Mišik and Soták (1998) applied a complementary methodology based on intentional dissolution of complete agglutinated tests from the Jurassic of the Pieniny Klippen Belt. They found *Haplophragmoides concavus, Pseudobolivina variana*, and trochamminids. We believe that among the organic linings present in the database, there are abundant linings of agglutinated foraminifera. Unfortunately, currently there is no known method that can help to differentiate the linings of calcareous and agglutinated foraminifera. We plan to follow Mišik and Soták's (1998) approach to document well preserved agglutinated shells, then to dissolve them, and to identify microstructures of organic lining walls.

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Actualistic studies of cell ultrastructure and test morphogenesis in Foraminifera –implications for agglutinated Foraminifera

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The aim of the presentation is to present the results of new actualistic studies on ultrastructure and biomineralization in various species of calcareous Foraminifera and to compare them with results of previous studies on the test ultrastructure and composition, mechanism of test formation and biomineralization in agglutinated Foraminifera.

With the advent of the molecular phylogeny, our understanding of the evolution of foraminifera changed significantly (Pawlowski et al, 2013). The test wall composition is no longer considered the main taxonomically relevant feature. The multichambered foraminifera are now divided into at least two large clades on the basis of the chamber shape and arrangement: Globothalemea, having globular chambers and minimizing the distance between apertures of subsequent chambers, and Tubothalamea, typically possessing tubular chambers and maximizing the distance between apertures. Agglutinated Foraminifera do not form a clade, but rather are polyphyletic group representing numerous independent lineages placed both in Tubo- and Globothalamea, but also in the single-chambered Monothalamea. The evolution of the mechanisms of test formation must be considered in the broader context of evolution of Foraminifera as a whole. Moreover, many agglutinated species actually have the capacity to secrete calcium carbonate, e.g., *Valvulina oviedoiana* produce calcitic cement that in its ultrastructure resembles the calcite produced by miliolids, but in contrast to miliolids it has low magnesium content (Bender & Hemleben, 1988). It is still unclear how agglutinated Foraminifera fit into the boarder picture of the evolution of the mechanisms of calcification in Foraminifera in general.

Recently, thanks to application of new fluorescent probes, it has been demonstrated that F-actin in many species of Foraminifera has unique granular organization (Tyszka et al. 2019, Goleń et al. 2020, Goleń et al. 2022). Goleń et al. (2020) have proposed that this F-actin containing granules are counterpart of the fibrillar vesicles known form TEM observations (Angell, 1967, Le Kieffre et al. 2018) and play role in morphogenesis of a new chamber. Bender (1992) demonstrated that the same type of vesicles filled with fibrillar material occurs in numerous agglutinated species. These vesicles are especially abundant during the chamber formation, and Bender (1992) proposed that the fibrillar material are involved in the biomineralization process. It was, however, also observed that it covers the agglutinated particles. Assuming that the fibrillar substance is F-actin, this last function seems particularly plausible, as in many eukaryotic cells F-actin is often involved in adhesion to substrate.

Additionally, in their studies on chamber morphogenesis in *Amphistegina lessonii*, Tyszka et al. (2019) showed that the interior of new chamber is filled with frothy pseudopodia, specific sponge-like form of the ectoplasm. We conducted further observations of their 3D structure and dynamics on *A. lessonii* and *Ammonia conferitesta* (the results of these observations currently are being prepared for publication). The characteristic feature of frothy pseudopodia is the presence of numerous seawater-containing vacuoles and vesicles separated by cytoplasmic sheets. The SEM observations of Bender et al. (1988) showed that similar foam-like mass is present in agglutinated Foraminifera. It is unclear if this is homological to frothy pseudopodia in calcareous species.

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Extinction rates of deep-water agglutinated foraminifera across the Cretaceous/Paleogene boundary at Contessa, Umbria-Marche Basin, Italy: The Scaling Problem

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The record of deep-water agglutinated benthic foraminifera (DWAF) from the Cretaceous–Paleogene (K/Pg) boundary interval of the Scaglia Rossa Formation in the Umbria-Marche Basin has been studied in the Contessa Highway Section, near Gubbio, Italy. The section was sampled bed-by-bed in the lowermost 50 cm of the Paleocene, then at intervals of 10 cm to a stratigraphic height of 5 m above the K/Pg boundary. The DWAF were studied from acid residues. This study aims to quantify the extinction rate of the DWAF across the K/Pg boundary. The results of our study of Paleocene samples from Contessa were then compared with the Upper Cretaceous record of Cetean (2009) and Kaminski et al. (2011) to create a broader coverage of species distribution and abundance. The biostratigraphical resolution herein is considered robust enough to resolve the extinction rate of DWAF bioevents due to a suitable data gathering method, consistent sample preparation, and taxonomic investigation.

The total agglutinated foraminiferal record in the Paleocene at Contessa consists of 55 taxa from 44 samples, including the survivor taxa, Lazarus taxa, and the newly appearing taxa (those not found in the Maastrichtian). In a preliminary study of the lowermost meter of the Paleocene (Hikmahtiar et al., 2022), 49 Cretaceous species were listed as extinction taxa, 9 as survivor taxa, 19 as Lazarus taxa, and 17 taxa displayed first occurrences in the Paleocene. For the purpose of estimating the apparent extinction rate of the DWAF, we considered nine stratigraphic intervals with five samples in each bin: The first interval above the K/Pg boundary consists of five samples – with successive intervals adding multiples of five samples. In other words, interval 1 considers the first five Paleocene samples, interval 2 the first 10 samples, and so on, until interval 9 considers all 44 samples. This approach to calculating the extinction rate therefore takes into account the Signor-Lipps Effect (Signor and Lipps, 1982), and provides an estimate of the number of samples required in order to account for the presence of Lazarus taxa. As far as we are aware, no other study of benthic foraminifera has adopted such an approach to quantify mass extinction rates across the K/Pg boundary.

Our results show that apparent species extinction rate varies from 84% if only the lowermost five samples of Danian are considered, but decreases to 53% when all 44 Paleocene samples are taken into account (Fig. 1). The Lazarus taxa have the significant effect of lowering the apparent extinction rate, and creating a logarithmic model to represent its additive decrease as additional samples are added to the calculation: simply stated, the calculated extinction rate across the boundary is a function of height of the studied stratigraphic interval and the number of samples collected from the interval overlying the boundary. It is concluded that any benthic foraminiferal study of the K/Pg boundary should consider taking into account the Signor-Lipps effect and the number of samples required to account for the delayed appearance of Lazarus taxa.

The common occurrence of some infaunal forms, such as *Reophax* sp. and *Spiroplectinella israelskyi*, is regarded to be opportunistic, because they were rare in the Maastrichtian (Cetean, 2009), survived the K/Pg boundary, and then bloomed in the Early Paleocene (Hikmahtiar et al., 2022). Such samples have the effect of reducing species diversity and contribute to the Signor-Lipps effect and the delayed re-appearance of Lazarus taxa.

A more accurate prediction of the extinction rate based on high resolution sampling across the K/Pg boundary in Contessa will yield new insight into the true nature of the extinction rates and the behavior in the trophic structure across the K/Pg boundary in the western Tethys and elsewhere. These data, with details of recognition of foraminifera assemblages, a taxonomic study, and paleoenvironmental interpretation, can address the complex paleoecological problems associated with estimating faunal turnover rates across the K/Pg boundary.

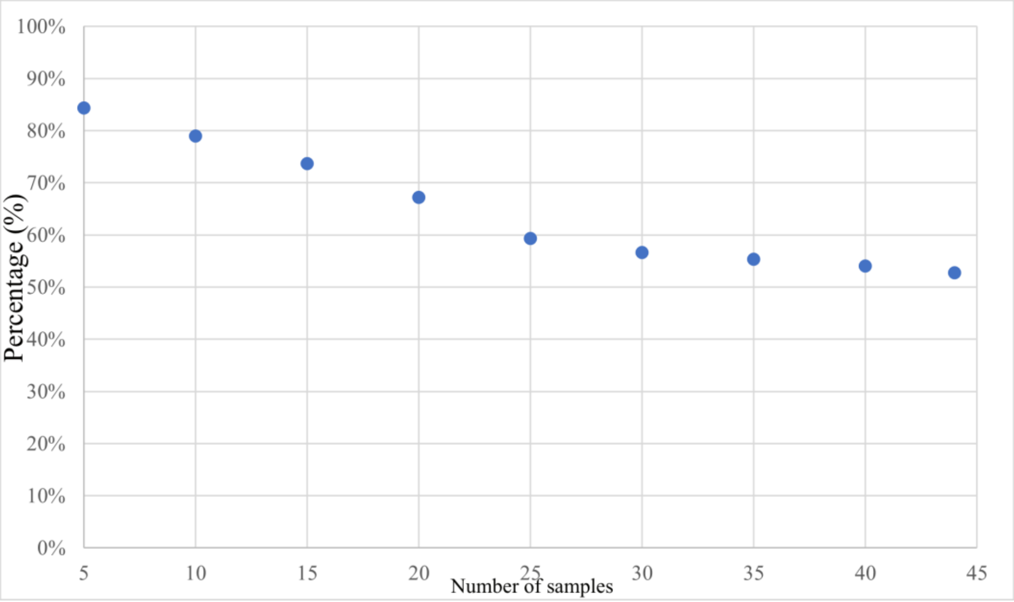

Figure 1. Apparent extinction rates of DWAF as a function of the number of Paleocene samples analysed.

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Distribution of Agglutinated Foraminifera in the Burkut Formation (Burkut Nappe, Ukrainian Outer Carpathians, Latorytsa River Basin)

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The Burkut Formation makes up most of the Eastern Carpathian Burkut Nappe (≈ Porkulets Nappe; probably prolongation of the Romanian Ceahleu Nappe Bodoc digitation after Kruglov, 1986). The Burkut Formation consists of thick (up to 1000 m) sandstone and gray sandy flysch strata of Albian-Cenomanian age (Byzova and Maslakova, 1974). In the Outer Eastern and Outer Western Carpathian nappe systems junction located at the Borzhava and Latorytsya river basins (Transcarpathian Region, Fig. 1), the distribution of the Burkut Formation is unclear. The age of the Burkut Formation located in this junction area has not been proven paleontologically, with the exception of the one locality, where along the Zalom Stream (left tributary of the Mala Pynya River) in the Latorytsa River basin, *Spiroplectinella gandolfi* (Carbonnier), *Haplophragmoides minor* Nauss, *Haplophragmoides platus* Loeblich, *Caudammina ovula* (Grzybowski) and *Thalmannammina sp.* were identified in the Burkut Formation by Byzova and Maslakova (1974).

The purpose of this work is to determine the age of the Burkut Formation in the study area located at the junction of the Eastern and Western Carpathians (Fig. 1), and to reconstruct the paleobathymetry of the sedimentary basin based on the study of agglutinated foraminifers.

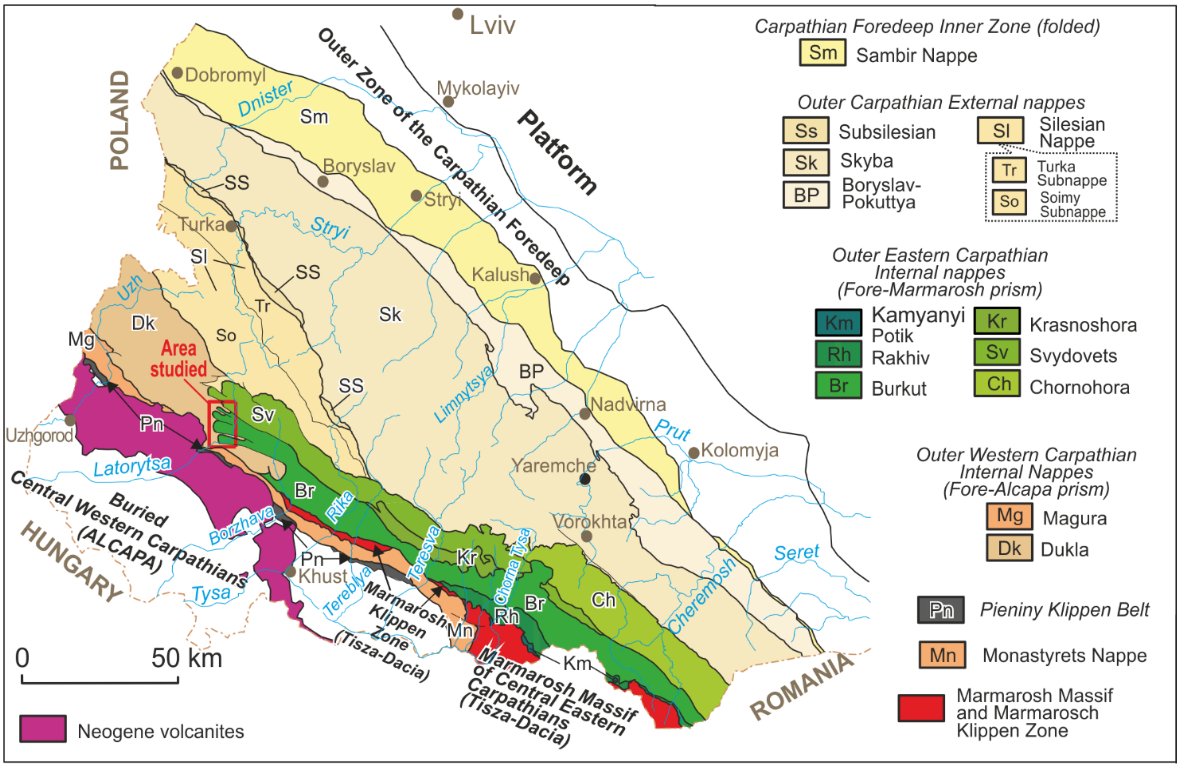

Figure 1. Main tectonic units of the Ukrainian Carpathians (Hnylko, 2012, modified) and area studied.

The Burkut Formation is represented by thick-bedded sandy turbidites and grain-flow deposits. A total of 47 samples from five exposed sections located at the Pynya River basin near the villages of Polyana and Holubyne and individual outcrops were studied. Mainly agglutinated foraminifers were found in the studied sediments of the Burkut Formation. Three main assemblages with characteristic foraminifera have been identified.

(1) Assemblage with *Haplophragmoides minor* Nauss and *Pseudonodosinella troyeri* (Tappan). The first species is typical for the Albian-Cenomanian of the Carpathians (Geroch and Novak, 1984), the second species – for the Lower Cretaceous of northwest Europe and the Carpathian Flysch (Geroch and Kaminski, 1995). Species *Glomospira irregularis* (Grzybowski), *Caudammina ovula* (Grzybowski), *Haplophragmoides* cf. *walteri* (Grzybowski), *Trochammina abrupta* Geroch, *Gerochammina stanislawi* Neagu and *Rhizammina* spp are presented in the assemblage.

(2) Assemblage with *Spiroplectinella gandolfi* (Carbonnier). This characteristic species recorded in the mid-Albian-Cenomanian of the northern Alps and in the upper Albian of the Papuan Basin and Indian Ocean (Holbourn and Kaminski, 1997 with references therein). The species *Caudammina crassa* (Geroch), *Haplophragmoides bulloides* (Beissel), *Haplophragmoides platus* Loeblich, *Haplophragmoides* cf. *walteri* (Grzybowski), *Bathysiphon* spp., *Rhizammina* spp. and *Ammodiscus* sp. are represented here.

(3) Assemblage with *Pseudonodosinella parvula* (Huss). This species recorded from upper Senomanian-Turonian and lower Senonian of the Subsilesian Unit of the Polish Carpathians (Geroch and Kaminski, 1995). Species *Gerochammina stanislawi* Neagu, *Bathysiphon* spp., *Rhizammina* spp., *Thalmannammina* sp. are present here.

Agglutinated foraminifera belonging mainly to the genera *Bathysiphon*, *Rhizammina*, *Pseudonodosinella, Haplophragmoides, Gerochammina,* make up to 100% of specimens in microfauna taphocenoses, and indicate deep-sea conditions below the local CCD.

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Free-living and pteropod-associated Agglutinated Foraminifera inhabiting deep-sea sediments in the Levantine Basin, southeastern Mediterranean Sea

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Benthic foraminifera (BF) constitute an important part of the meiofauna of deep water (> 200 m) environments, including the Mediterranean Sea (e.g. Danovaro et al., 2010). Parker (1958) was the first to identify 103 taxa (> 150 µm) in the Mediterranean bulk surface sediments (live and dead), with 38 species identified in the southeastern Levantine Basin (LB), including 5 agglutinated species. Jannink (2001) studied the living foraminiferal seasonality, biodiversity and microhabitats between 40-700 m water depth of the LB off the coast of Israel. She found 24 free-living agglutinated BF taxa such as *Eggerelloides*, *Textularia* and *Glomospira* in the 63-5 95µm size fraction inhabiting mainly the shallower sampling sites, 40 m (mid-shelf) and 120 m (upper continental slope), representing 40% of the total abundance. Due to the increasing activities of oil and gas companies in Israel's exclusive economic zone and the fact that the deep-sea fauna in this area is not well known, a thorough baseline study was urgently needed (Turkey, Greece, Cyprus and Egypt). Therefore, a multisurvey study was conducted in August 2013 to characterize and quantify living and dead benthic foraminiferal communities in the southeastern deep-sea LB and to analyze their relationship to environmental conditions (Hyams-Kaphzan et al., 2018). Benthic foraminiferal biotas (250-1000 µm and > 1000 µm) were sampled from the top 10 cm of the sediment at 50 sites. Samples were collected between 100 and 1900 m using a 0.0625 m^2 box corer and cover several locations in Israel's exclusive economic zone. During 2017 and 2018, two complementary surveys were conducted at 16 stations along two transects off Haifa and Tel-Aviv, at depth between 45-1900 m. Here, three Perspex-cores were sampled at each site and examined for the living BF (> 125µm) from the top 10 cm. Agglutinated species, especially those with organic-cement, are highly abundant in the deep water environments of the southeastern LB. The living assemblages consist of 35 agglutinated species and the dead assemblage consist of 56 species, both representing a third of the total foraminiferal species richness. Moreover, sampling the macroforaminiferal assemblages as compared to micro- and meio-faunal assemblages allowed us for the first time to identify a very unique environment at the deep southeastern Mediterranean seafloor. This unique habitat is formed by empty aragonitic shells of pteropods (mainly *Clio pyramidata*, *Styliola subula* and occasionally *Creseis acicula*, *Cavolinia gibbosa* and the heteropod *Atlanta* sp.). The pteropod shells provide a unique hard substrate on the sea floor, especially at bathyal depth, and is widely used by agglutinated taxa for attachment. The agglutinated BF comprise up to 50% of the living BF and 97% of the dead assemblage at water depth greater than 700 m. The attached species either encrust the pteropods outer shells (1st group) or are attached to the inner parts of the shells (Fig. 1, 2nd group). *Ammolagena clavata* is the most common species in the 1st group (Fig. 1-1), while *Ammolagena minuta* (Figs. 1-7, 1-8) and *Hemisphaerammina bradyi* (Fig. 1-9) are the most common in the 2nd group. In 2017 we discovered a 3rd group of BF that was living inside pteropod shells by burrowing into their hard tests (Fig. 1-16). The aragonitic shells of pteropods are particularly susceptible to ocean acidification and predicted near future increases in ocean acidity will threaten and potentially eliminate this BF-pteropoda association in deep-water environments.

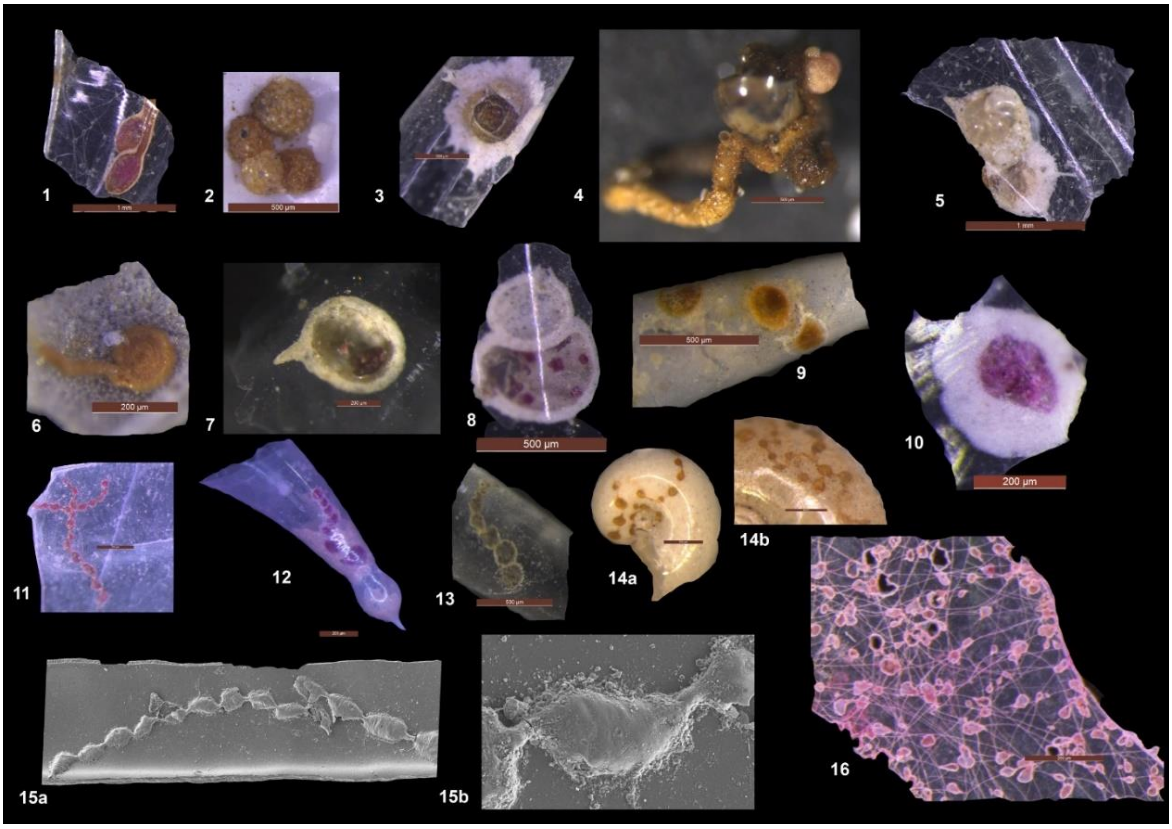

Figure 1. Selected agglutinated benthic foraminiferal species associated with pteropods shells:
1 - *Ammolagena clavata*; 2 - *Saccammina* sp.; 3- *Tritaxis fusca*; 4 - *Tolypammina vagans*; 5 - *Lobatula lobatula* attached to outer shell & *Hemisphaerammina marisalbi* attached to inner shell;
6 - *Ammodiscus tenuis*; 7-8 - *Ammolagena minuta;* 9 - *Hemisphaerammina bradyi*; 10 - *H. marisalbi*;
11, 15a-b - *Hospitella* ?; 12 - ? attached to *Clio cuspidata;* 13 - ? ; 14a,b - *Hormosinella* ? living inside the pteropod *Heliconoides inflatus* ; 16 - Borrowing species - *Thalamophaga ramosa* ? - living inside the wall of a pteropod shell.

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Pleistocene attached foraminifera from the Arctic Ocean: diversity, morphological types and substrate preferences

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Attached foraminifera (epilithic) are common in mid-Pleistocene deep-sea muds in the Lomonosov Ridge area. They settled the bigger bio- and lithoclasts found on the sea floor of the Central Arctic. The quantity and diversity of attached forms is relatively high, within 12 types of foraminifera were distinguished. They belong to the agglutinated foraminifera, only one species is organic-walled. Only primitive monothalamous or simple pseudomultichambered and multichambered forms were observed. The following genera were distinguished: *Rhizammina*, *Hemisphaerammina*, *Ammopemphix*, *Diffusilina*, *Iridia*, *Subreophax*, *Placopsilina*, *Placopsilinella*, *Hormosinelloides*, *Tholosina*, and forms with uncertain systematic affiliation, which, due to their morphological features, were specified as mat-like and ribbon-like forms.

Based on the living habitats, among the attached foraminifera from the cold Pleistocene waters two groups can be distinguished: 1) externally epilithic forms, which lived on the exposed surface of the substrate and build the tests forming elevations on the settled surface and 2) internally epilithic forms, settled into naturally-occurring dimples, depressions, and caverns within the substrate.

The externally epilithic forms build:

- convex tests, in form relatively high globular or hemispherical shape, usually solid and thick-walled that are in contact with the substrate at the periphery of their tests (e.g., *Hemisphaerammina*, *Tholosina*);
- flat tests, forming low elevations on the substrate surface, occurring as meandering tubes such as *Rhizammina*-like forms or uniserial to multiserial pseudomultichambered or multichambered forms including *Placopsilina*, *Placopsilinella*, as well as *Hormosinelloides*-like and *Subreophax*-like forms, cemented one side of the test to the substrate surface; a separate group consists of forms occurring as elongated or irregular mats, e.g., *Iridia* and ribbon-like forms.

Due to living-space limits, the internally epilithic forms are small-sized. To this group belong: forms building a flat roof being an extension of the substrate surface their cavern, e.g., *Diffusilina*-type forms and pseudocolonies of hemispherical chambers of *Ammopemphix*.

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New and renamed genera of agglutinated foraminifera published between 2017 and 2023

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At the level of generic taxonomy, there is a need to maintain an up-to-date catalogue of agglutinated foraminiferal genera. In the interval of time since the 10th International Workshop on Agglutinated Foraminifera in 2017, a total of 40 new genera of agglutinated foraminifera have appeared in the literature, and two pre-existing genera have been renamed. Most of the newly described forms are from the Upper Cretaceous of the Middle Eastern region. These new additions now bring the total number of valid agglutinated foraminiferal genera (including allogromids, xenophyophores, and fresh-water forms) to 910. This compares with the 624 valid agglutinated genera listed in the compilation of Loeblich & Tappan (1987). Below is a list of the newly published names, and examples of the newly described genera will be discussed.

Cantabriconus Schlagintweit, Rosales and Najarro, 2017
Lacogromia Siemensmaa, Perret-Gentil, Holzmann, Clauss, Völcker and Pawlowski, 2017
Limnogromia Siemensmaa, Perret-Gentil, Holzmann, Clauss, Völcker and Pawlowski, 2017
Suraqalatia Görmüs, Lawa and Al Nuaimy, 2017
Olgita Mikhalevich, 2017 nom.nov.
Tendalia Gooday and Holzmann, 2017
Bizarria Gooday and Holzmann, 2017
Banatia Schlagintweit and Bucur, 2017
Persiella Schlagintweit and Rashidi, 2017
Lepinoconus Cruz-Abad, Consorti and Caus, 2017
Flabelloperforata Schlagintweit and Rashidi, 2017
Persiacyclammina Schlagintweit and Rashidi, 2017
Zagrosella Schlagintweit and Rashidi 2017
Braciana Schlagintweit and Tesovic, 2017
Cyrea Holzmann and Pawlowski, 2018
Moulladella Bucur and Schlagintweit, 2018
Neodubrovnikella Schlagintweit and Rashidi, 2018
Neonavarella Giusberti, Kaminski and Mancin, 2018
Vanneauina Schlagintweit, 2019
Bispiraloconulus Schlagintweit, Bucur and Sudar, 2019
Pachycolumella Septfontaine, Schlagintweit and Rashidi, 2019
Pseudochablaisia Schlagintweit, Septfontaine and Rashidi, 2019
Calvezella Schlagintweit, 2020, nom.nov.
Schroedericonus Schlagintweit, 2020
Persiconus Yazdi-Moghadam and Schlagintweit, 2020
Carseyella Schlagintweit, 2020

Abyssalia Gooday and Holzmann
Moanammina Gooday and Holzmann
Bakhtiariella Schlagintweit and Rashidi, 2021
Septfontainella Schlagintweit, Bucur and Pleş, 2021
Srinivasania Kaushik and Ghosh, 2021
Ebrahimiella Yazdi-Moghadam and Schlagintweit, 2021
Pseudotrochamminita King, 2021
Gusicella Schlagintweit and Rashidi, 2021
Taanella Del Piero, Rigaud and Martini, 2022
Robinsoniella Schlagintweit, 2022
Hilla Holzmann, Gooday, Majewski and Pawlowski, 2022
Pseudoconqueria Holzmann, Gooday, Majewski and Pawlowski, 2022
Limaxia Holzmann, Gooday, Majewski and Pawlowski, 2022
Simplorabanitina Consorti, Schlagintweit and Yazdi-Moghadam, 2022
Nujappikia Gooday and Holzmann, 2022
Siphopfenderina Schlagintweit and Septfontiane, 2023

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Collections of Foraminifera Housed at the European Micropalaeontological Reference Centre in Kraków, Poland

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The European Micropalaeontological Reference Centre was established in 2014 in order to provide a permanent archive for published micropaleontological collections. Since its establishment, a number of Micropaleontologists have deposited their type slides or entire collections at the EMRC. The foraminiferal collection now consists of >20 wooden cabinets, each housing on average 1,000 microscope slides. The cabinets are housed in the office of Micropress Europe at the AGH University of Science & Technology in Krakow. As of spring 2023, we now have microfossil slide collections relating to the following publications:

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An *Entzia*-dominated marsh-type agglutinated foraminiferal assemblage from an *Arthrocnemum* salt marsh in Bahrain

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A living assemblage of agglutinated foraminifer was recovered from a salt marsh on the east side of Tubli Bay in eastern Bahrain. The sampled locality is adjacent to the VW/Porsche/Skoda dealership on the Shaikh Jaber Al-Subah Highway in Sitra, Bahrain, and is one of the last remaining patches of salt marsh on the east coast of Tubli Bay. The marsh is dominated by a single marsh plant species, *Arthrocnemum macrostachyum* (Mericand), which is formerly known as *Salicornia*. Samples were collected from beneath the *Arthrocnemum* canopy in two transects beginning at a tidal channel in the low marsh to the maximum extent of halophytic plants in the high marsh, and preserved in an ethanol/Rose Bengal solution.

A distinct elevation-related zonation in agglutinated foraminifera is observed from the low marsh to the high marsh. The tidal channel at the lower limit of the marsh contains an assemblage dominated by *Ammonia*, *Elphidium,* and miliolids, with *Clavulina* and *Agglutinella* as the only agglutinated taxa. In the middle part of the marsh, live *Trochammina inflata* is observed, while live *Entzia macrescens* is characteristic of the highest marsh in association with *Trochammina inflata*. Living specimens were observed during the winter 2019–2020 sampling season. Samples collected in Autumn 2019 only contained dead specimens.

The species *Entzia macrescens* has a worldwide distribution and is likely dispersed by birds along their migration pathways (Holzmann & Pawlowski, 2017). The island of Bahrain sits squarely within the East Africa – West Asia flyway. Tubli Bay is a well-known stopover point for migratory shore birds, and we have observed flamingos, egrets, and smaller shore birds at our sample locality. Based on the known migration pathway of oystercatchers and the great reed warbler, we might expect to find trochamminids at other salt marshes in the western Gulf region, but this remains to be verified by an expanded survey. This is the first report of a live *Entzia*-dominated agglutinated foraminiferal assemblage in the Arabian Gulf region.

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Selectivity in agglutinated foraminifera from Thermaikos Gulf, NW Aegean Sea

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Thermaikos Gulf is a semi-enclosed, shallow basin in the northwestern part of the Aegean Sea. The marine environmental conditions of the area are influenced by the several rivers and numerous ephemeral streams, that flow into the basin (Lykousis et al., 2005). They discharge tons of erosional sediments from metamorphic, igneous and sedimentary rocks that lie in the hinterland. As a result, the nature of sediment in the Gulf is controlled by distance from the rivers, resulting in sandy and shallow sediments to the west and fine sediment in deeper areas of the east.

Agglutinated foraminifers are a vital component in the living assemblages of Thermaikos Gulf, comprise up to 40% of the total living foraminferal fauna and reach a maximum of almost 50% in total assemblages (living+dead). During a continuous 12-month survey, a total of 17 living species were found, with highest percent occurrences recorded in late spring and summer. Among the agglutinated taxa, *Eggereloides scaber*, *Ammoglobigerina globigeriniformis*, *Textularia* spp., *Haplophragmoides canariensis, Leptohalysis scotii* and *Reophax* spp. were most common.

Previous studies have shown that the mineralogical composition of agglutinated tests is strongly influenced by the composition of the surrounding sediments (Armynot du Châtelet et al

., 2013). We have applied both light and Scanning Electron Microscopy coupled with an Energy Dispersive Spectrometer to identify and quantify the mineral diversity on agglutinated foraminiferal tests.

Here we report on the capability of agglutinated Foraminifera to actively select specific mineral grains as building materials for test construction, and document the main features accompanying their placement and arrangement in the test. From a total of 56 studied specimens, we determined more than 300 mineral grains.

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Type specimens of foraminifera housed in the collections of the European Micropalaeontological Reference Centre (EMRC)

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Over the frame of 8 years (2015–2023) the European Micropalaeontological Reference Centre (EMRC) collected over 18,000 faunal slides. The most important part of the collection is a separate microscope slide cabinet containing type specimens (mainly holotypes, paratypes and metatypes) of foraminifera, mainly agglutinated forms. The slides of type specimens are archived in cabinet drawers together with the reprints of papers in which the species were described. The EMRC currently houses type specimens of the following species:

Holotypes: *Agglutinella kaminskii* Garrison, 2019 (+ paratypes); *Ammobaculites fragmentarius* Cushman *agglutiniformis* Podobina, 1975 (+ paratypes, metatypes); *Ammobaculites originalis* Mjatliuk, 1970; *Ammobaculoides dhrumaensis* Kaminski, Malik & Setoyama, 2017 (+ paratypes); *Ammophemphix hemisphaericus* Waśkowska & Kaminski, 2018 (+ paratypes, metatypes); *Anomalinoides dividens* Łuczkowska, 1964 (+ paratypes); *Arenoturrispirillina waskowskae* Hikmahtiar & Kaminski, 2022 (+ paratypes); *Asterigerinata murraynhayesi* Wilson & Hayek, 2022 (+ paratypes); *Bulbobaculites gorlicensis* Waśkowska, 2014 (+ paratypes); *Buzasina antarctica* Kaminski, Wolfgring & Waśkowska, 2020 (+ paratypes); *Cadosinopsis rehakovii* Ciurej & Bąk, 2021 (+ paratypes); *Conoglobigerina grigelisi* Gradstein, 2017 (+ paratypes); (+ paratypes); *Cystamminella ancestralis* Mjatliuk, 1970 (+ paratypes); *Cystamminella bitkovensis* Mjatliuk, 1970 (+ paratypes); *Cystamminella elongata* Mjatliuk, 1970 (+ paratypes); *Cystamminella grzybowskii* Mjatliuk, 1970 (+ paratypes); *Eggerella stryensis* Mjatliuk, 1970 (+ paratypes); *Gaudryina spassensis* Mjatliuk, 1970 (+ paratypes); *Gavelinella mira* Podobina, 1975 (+ paratypes); *Globuligerina glinskikhae* Gradstein & Waśkowska, 2021 (+ paratypes); *Globuligerina tojeiraensis* Gradstein, 2017 (+ paratypes); *Globuligerina waskowskae* Gradstein, 2021 (+ paratypes); *Glomospira rostokiensis* Mjatliuk, 1970 (+ paratypes); *Grzybowskiella aquaea* Mjatliuk, 1970 (+ paratypes); *Grzybowskiella macilenta* Mjatliuk, 1970 (+ paratypes); *Grzybowskiella subangusta* Mjatliuk, 1970 (+ paratypes); *Hagenowina insueta Mjatliuk*, 1970 (+ paratypes); *Haplophragmoides arcticus* Kaminski, Waśkowska & Chan, 2016 (+ paratypes); *Hyperammina cylindrica* (Parr) crassa Mjatliuk, 1970; *Hyperammina primitiva* Mjatliuk, 1970; *Inaequalina jadwigae* Łuczkowska, 1971 (+ paratypes); *Kalamopsis dubia* White, 1928; *Karreriella indigena* Mjatliuk, 1970 (+ paratypes); *Karreriella pertenuis* Mjatliuk, 1970 (+ paratypes*);* *Karreriella pokornyi* Mjatliuk, 1970 (+ paratypes); *Marginulina torquata* Podobina & Orlov, 1995 (+ paratypes); *Petaloglobigerina simmonsi* Gradstein, 2021 (+ paratypes); *Protelphidium anglicum* Murray, 1965 (+ paratypes); *Pseudohastigerina naguewichiensis* (Mjatliuk, 1950); *Pseudonubeculina arabica* Amao & Kaminski, 2016 (+ paratypes); *Recurvoides anormis* Mjatliuk, 1970 (+ paratypes); *Recurvoides primus* Mjatliuk, 1970 (+ paratypes); *Recurvoides pseudoregularis* Mjatliuk, 1970 (+ paratypes); *Recurvoides smugarensis* Mjatliuk, 1970 (+ paratypes); *Recurvoides varius* Mjatliuk, 1970 (+ paratypes); *Recurvoides? nadvornensis* Mjatliuk, 1970; *Reophax dissonus* Mjatliuk, 1970 (+ paratypes); *Reophax paraduplex* Mjatliuk, 1970 (+ paratypes); *Saccammina scabrosa*

Mjatliuk, 1970 (+ paratypes); *Saccamminoides carpathicus* Geroch, 1955; *Sigmoilina canisdementis* n. sp. Kaminski & Garrison (+ paratypes); *Silicobathysiphon* cf. dubia Cushman & Renz longoloculus Mjatliuk, 1970; *Silicobathysiphon pseudoloculus* Mjatliuk, 1970; *Simobaculites saundersi* Wilson & Kaminski (+ paratypes); *Spiroplectammina denticulagera* Mjatliuk, 1970 (+ paratypes); *Textularia baudoniana* d'Orbigny incomperta Mjatliuk, 1970; *Thalmannammina necomiensis* Geroch, 1962 (+ paratypes, metatypes); *Tolypammina prava* Mjatliuk, 1970 (+ paratypes); *Trochammina abrupta* Geroch, 1966 (+ paratypes); *Trochammina erdutensis* Józsa, 2017 (+ paratypes); *Trochammoides irregularis* White, 1928; *Uvigerinammina mysaiosi* Neagu, 2011; *Verneuilina conica* White, 1928; *Verneuilinoides dnestrensis* Mjatliuk, 1970.

Paratypes: *Aaptotoichus challengeri* Holbourn & Kaminski, 1995; *Adercotryma agterbergi* Gradstein & Kaminski, 1989; *Ammobaculites areniferus* Nagy & Basov, 1998; *Ammobaculites bivarians* Nagy & Seidenkrantz, 2003; *Ammobaculites deflectus* Hjálmarsdóttir, Nakrem & Nagy, 2018; *Ammobaculites knorrigensis* Hjálmarsdóttir, Nakrem & Nagy, 2018; *Ammobaculites nanogyrus* Nagy & Seidenkrantz, 2003, *Ammobaculoides carpathicus* Geroch, 1966 (+ metatypess); *Ammodiscus kenderi* Cetean & Kaminski, 2011; *Ammodiscus nagyi* Kaminski, 1989; *Ammomarginulina spectata* Podobina, 1997; *Ammoscalaria antis* Podobina, 1975 (+ metatyps); *Andersenia rumana* Neagu, 1968; *Annectina biedai* Gradstein & Kaminski, 1997; *Annectina grzybowskii* (Jurkiewicz, 1960); *Anomalinoides ypresiensis* (ten Dam) ovatus Podobina, 1998*;Arenobulimina advea* (Cushman) *praeadvena* Barnard & Banner, 1980; *Arenobulimina bulletta* Barnard & Banner, 1980; *Arenobulimina macfadyeni* Cushman *elongata* Barnard & Banner, 1980; *Arenobulimina postchapmani s.s.* Barnard & Banner, 1980; *Arenobulimina postchapmani praecursor* Barnard & Banner, 1980; *Arenobulimina pseudoalbiana* Barnard & Banner, 1980; *Arenobulimina voloshinae s.s.* Barnard & Banner, 1980; *Arenobulimina voloshinae praevoloshinae* Barnard & Banner, 1980; *Arenogaudryina granosa* Podobina, 1975; *Arenoturispirillina cacumenensis* Neagu, 2004; *Astracolus fabaceus* Podobina & Orlov, 1995; *Astracolus impar* Podobina & Orlov, 1995; Astracolus mutabilis Podobina & Orlov, 1995; *Barkerina dobrogiaca* Neagu, 1999 (+ metatypes); *Bulbobaculites vermiculus* Nagy & Seidenkrantz, 2003; *Carasuella cylindrica* Neagu, 1999 (+ metatypes); *Cibicidoides eriksdalensis* (Brolzen) subsp. primus Podobina, 1975 (+ metatypes); *Colominella piriniae* Mancin & Kaminski, 2018; *Comaliamma dobrogiaca* Neagu, 1999 (+ metatypes); *Conotrochammina voeringensis* Gradstein & Kaminski, 1997; *Cribrostomoides carapitanus* Kaminski, Crespo de Cabrera & Gonzalez, 2011; *Cibrostomoides subretusus* Nagy & Basov, 1998; *Cribrostomoides vallatus* Nagy & Basov, 1998; *Cyclammina cyclops* McNeil, 1988; *Cyclogyra sibirica* Podobina, 1975 (+ metatypes); *Cystammina subgaleata* Vašíček, 1947; *Cystammina sveni* Gradstein & Kaminski, 1997 (+ metatypes); *Cystamminella pseudopauciloculata* Mjatliuk, 1966; *Danubina obtusa* Neagu, 1997; *Dentalina seliquformis* Podobina & Orlov, 1995; Dentalina tumidiscula Podobina & Orlov, 1995; *Discamminoides evolutus* Cetean & Kaminski, 2011; *Dobrogelina discorbiformis* Neagu, 1979*; Dobrogelina ovidi* Neagu, 1979; *Dorothia pupoides* (Orbigny) *ovata* Podobina, 1975 (+ metatypes); *Dorothia seigliei* Gradstein & Kaminski, 1989; *Eggerelloides camaraensis* Sousa, Kaminski & Yamashita, 2018; *Eponides proprius* Podobina, 1975; *Eratidus gerochi* Kaminski & Gradstein, 2005; *Falsogaudryinella praemoesiana* Kaminski, Neagu & Platon, 1995; *Falsogaudryinella xenogena* Kaminski, Neagu & Platon, 1995; *Fissurina globosa* Bornemann sibirica Podobina & Orlov, 1995; *Fissurina rotunda* Podobina & Orlov, 1995; *"Gaudryina" cuvierensis* Holbourn & Kaminski, 1995; *Gaudryinopsis subbotinae* Podobina, 1975 (+ metatypes); *"Gaudryinopsis" pseudobettenstaedti* Holbourn & Kaminski, 1995;

Gerochammina obesa Neagu, 1990 (+ metatypes); *Gerochammina stanislavi* Neagu, 1990; Gerochella *cylindrica* Neagu, 1997; *Globigerina linaperta tropicalis* Jenkins & Orr, published as *“Globigerina linaperta* n.spp.*”; Globigerina linaperita* Finlay var. *turgida* Finlay, 1939; *Globigerinoides trilobus bullatus* Chang & Chang, 1962; *Glomospirella biedai* Samuel, 1977; *Guembelitria samwelli* Jenkins, 1978 (+ metatypes); *Glomospira grzybowskii* Jurkiewicz, 1960; *Glomospirella bieda* Samuel, 1977; *Haplophragmoides deplexus* Podobina, 1998 (+ metatypes); *Haplophragmoides fastosus* Podobina, 1998 (+ metatypes); *Haplophragmoides falcatosuturalis* Neagu, 1990 (+ metatypes); *Haplophragmoides fastosus* Podobina, 1998*; Haplophragmoides nauticus* Kender, Kaminski & Jones, 2006; *Haplophragmoides perlobatus* Hjálmarsdóttir, Nakrem & Nagy, 2018*; Haplophragmoides propygmaeus* Nagy & Seidenkrantz, 2003; *Hinogammina danubiana* Neagu, 2000; *Hinogammina danubiana* Neagu, 2000;*Hippocrepina gracilis* Holbourn & Kaminski, 1995; *Histerolina pileiformae* Neagu, 2000; *Hormosinella fusiformis* Kaminski, Cetean, Balc & Coccioni, 2011; *Hyperamina intermedia* Mjatliuk, 1970; *Hyperammina kenmilleri* Kaminski, 1989; *Hyperammina mendena* Eickhoff, 1973; *Hyperammina nova* Mjatliuk, 1970; *Inordinatosphaera indica* Mohan & Soodan, 1967; *Kaminskia acuta* Neagu, 1999; *Kaminskia cuneata* Neagu, 1999; *Kaminskia flabellata* Neagu, 1999; *Karreriella poutica* Mjatliuk, 1970; *Karreriella seigliei* Gradstein & Kaminski, 1989; *Kutsevella spilota* Nagy & Seidenkrantz; *Labrospira macilenta* Setoyama, Kaminski & Tyszka, 2011; *Labrospira lenticulata* Hjálmarsdóttir, Nakrem & Nagy, 2018; *Marginulina elongata* Podobina & Orlov, 1995; *Marginulina recta* Podobina & Orlov, 1995; *Marginulina sibirica* Podobina & Orlov, 1995; *Marginulina sphaerica* Podobina & Orlov, 1995; *Marginulina tumefacta* Podobina & Orlov, 1995; *Moravammina? recta* Eickhoff (1973); *Neonavarella sudalpina* Guisberti, Kaminski & Mancin, 2018; *Nodosaria tchuzica* Podobina & Orlov, 1995 (+ metatypes); *Nonionammina elegans* Neagu, 1999; *Paratrochamminoides gorayskiformis* Kender, Kaminski & Jones, 2007; *Patelinella conica* Neagu & Cirnaru, 2001*; Patelinella heberti* Neagu & Cirnaru, 2001; *Patellovalvulina patruliusi* Neagu, 1975; *Pfenderina ammonoidea* Neagu, 1979; *Pfenderina conica* Neagu, 1979; *Phenacophragma beckmanni* Kaminski & Geroch, 1986 (+ metatypes); *Phenacophragma elegans* Kaminski, 1986 x; *Plectoverneuilinella angolaensis* Cetean & Kaminski, 2011; *Popovia johnrolandi* Preece, Kaminski & Dignes, 2000; *Portatrochammina profunda* Kender, Kaminski & Jones, 2007; *Psamminopelta gradsteini* Kaminski & Geroch, 1997; *Pseudotextulariella cretosa* Cushman, 1932; *Patellovalvulina patruliusi* Neagu, 1975; *Pseudotriloculina hottingeri* Amao & Kaminski, 2017; *Quinqueloculina longa* Podobina, 1975; *Rashnovammina carpathica* Neagu & Neagu, 1995; *Rectoglandulina acuminalata* Podobina & Orlov, 1995; *Rectoglandulina sibirica* Podobina & Orlov, 1995; *Rectogerochammina eugubina* Kaminski, Cetean & Neagu, 2010; *Recurvoides arctica* Setoyama, Kaminski & Tyszka, 2011; *Recurvoides trochoidalis* Setoyama, Kaminski & Tyszka, 2011; *Recurvoides recurvoidiformis* (Neagu & Tocorjescu, 1970); *Reophanus berggreni* Gradstein & Kaminski, 1997 (+ metatypes); *Reophax guttiformis* Podobina, 1975 (+ metatypes); *Reophax pyriformis* Yamashita, Sousa & Kaminski, 2018; *Reophax pyriloculus* Hjálmarsdóttir, Nakrem & Nagy, 2018; *Reticulophragmium mackenzieensis* McNeil, 1997; *Reticulophragmium projectus* Schröder-Adams & McNeil, 1994; *Reticulophragmium vidonioensis* Kaminski & Crespo de Cabrera, 1999; *Riyadhella persanensis* Neagu, 2004; *Saccammina basispiculata* Mikhalevich, Pronina & Nestell, 2000; *Scherochorella congoensis* Kender, Kaminski & Jones, 2007; *Scythiolina filiformis* Neagu, 2000; *Scythiolina flabellii* Neagu, 1997; *Siphogaudryina stephensoni* (Cushman) *distincta* Podobina, 1975 (+ metatypes); *Spiropsammina primitiva* Cetean & Kaminski, 2011; *Subreophax longicameratus* Kaminski, Cetean, Balc & Coccioni, 2011; *Tetragonostomina rhombiformis* Mikhalevich, 1975; *Tetrataxiella subtilissima* Cetean & Kaminski, 2011; *Textularia pernana* Hjálmarsdóttir, Nakrem & Nagy, 2018; *Textularia sibirica* Podobina, 1997; *"Textulariopsis" elegans* Holbourn & Kaminski, 1995; *Tipeammina* Neagu, 2004; *Trochammina alutensis* Neagu, 2004; *Trochammina globoconica* Tyszka & Kaminski, 1995; *Trochammina lomonosovensis* Evans & Kaminski, 1998; *Trochamminoides lamentabilis* Podobina, 1998; *Trochammina praerosacea* Nagy & Basov, 1998; *Trochammina priva* Podobina, 1975; *Trochammina quinqueloba* Geroch, 1959 (+ metatypes); *Trochammina rumana* Neagu & Neagu, 1995; *Trochamminoides lamentabilis* Podobina, 1998; *Trochamminoides lapilliformis* Nagy & Basov, 1998; *Uvigerammina una* Gradstein & Kaminski, 1999; *Uvigerinammina carpathica* Neagu, 2011; *Uvigerinammina moesiana* Neagu, 1965; *Uvigerinammina praejankoi* Neagu, 1990 (+ metatypes); *Valvulineria procera* Podobina, 1975; *Verneuilinella carpathica* Neagu & Neagu, 1995; *Verneuilinella pieninica* Tyszka & Kaminski, 1995; *Verneuilinoides alutensis* Neagu, 2004.

Metatypes: *Ammobaculites dignus* Podobina, 1964; *Ammogloborotaloides truncatulinoidiformis* Kaminski & Contreras, 2011; *Ammonia batava* (Hofker, 1951); *Ammosphaeroidina sphaerica* Podobina; *Asanospira grzybowskii* (Mjatliuk, 1950); *Cribrostomoides astrictus* Podobina, 1966; *Cribrostomoides cretaceous* Cushman & Goudkoff *exploratus* Podobina, 1966; *Cribrostomoides trinitatensis* Cushman & Jarvis *sibiricum* Podobina, 1966; *Cyclammina flexuosa* Podobina, 1966; *Dendrophyria gvidoensis* Mjatliuk, 1950; *Gaudryinopsis angustus* Podobina, 1975; *Glomospira gordialiformis* Podobina, 1967; *Glomospira straniki* Bubík, 1995; *Haplophragmium medium* Podobina, 1975; *Haplophragmoides idoneus* Podobina, 1974; *Haplophragmoides tumidus* Podobina, 1966; *Hormosina ovula* Grzybowski *gigantea* Geroch, 1960; *Hyperammina leariformis* Mjatliuk, 1960; *Hyperammina? exilis* (Mjatliuk, 1960); *Labrospira collyra* (Nauss) *senonica* Podobina, 1964; *Labrospira fraseri* (Wickenden) *stata* Podobina, 1966; *Labrospira honesta* Podobina, 1974; *Lenticulina tchizhapkensis* Podobnina & Orlov, 1995; *Pseudoclavulina hastata* (Cushman) *admota* Podobina, 1966; *Pseudoreophax cisovnicensis* Geroch, 1961; *Recurvoides magnificus* Podobina, 1966; *Recurvoides memornadus* Podobina, 1964; *Recurvoides optivus* Podobina, 1964; *Recurvoides pseudononioninoides* Neagu & Platon, 1994; *Recurvoides recurvoidiformis* (Neagu & Tocorj, 1970); *Reophax proprius* Podobina, 1975; *Reophax remotus* Podobina, 1975; *Silicobathysiphon gerochi* Mjatliuk, 1966; *Thalmannammina meandertornata* Neagu & Tocorjescu, 1970; *Thalmannammina simpla* Neagu & Platon, 1994; *Verneuilinoides concinnus* Podobina, 1975.

Jullienella foetida Schlumberger, 1890, the largest shallow-water agglutinated foraminifer in modern oceans

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In 1890, Schlumberger described a new and gigantic agglutinated foraminifer from the western coast of Africa (Liberia) and named it *Jullienella foetida* after its collector, the French bryozoan specialist Jules Jullien (Schlumberger, 1890). The species was initially considered to be a bryozoan, but Schlumberger recognized its true character and correctly described it as a single-chambered (monothalamous) agglutinated foraminifer with a large, flat or slightly undulating plate-like test, leaf-like, or fan-like in overall shape and with the chamber interior subdivided by longitudinal partitions.

Since it was first described by Schlumberger (1890), *J. foetida* has been widely reported from depths of 14 to 89 m across the West African continental shelf from Western Sahara to Ghana (Langer et al. 2022). It occurs on fine sandy and muddy substrates at densities of up to 200 individuals per m^2 and covering up to 10% of the sandy seafloor. Schlumberger (1890) reported that the largest specimens from off Liberia were 6 cm in maximum dimension, but more recent in situ images show leaf- and fan-like tests that reach a maximum dimension of 14 cm lying horizontally on the sediment surface with only the lower side partially buried (Tendal & Thiel, 2003). These large agglutinated structures often constitute the only available hard substrate on which sessile organisms can settle.

The test wall of *J. foetida* comprises a smooth, outer veneer of small (<10 µm) mineral grains that overlies the much thicker inner layer. Micro-CT scans suggest that much of the test interior is filled with cytoplasm, while X-ray micrographs reveal an elaborate system of radiating internal partitions. *Jullienella foetida* resembles some xenophyophores (giant deep-sea foraminifera) in terms of test size and morphology, but lacks their distinctive internal organization; the similarities are therefore likely to be convergent.

Based on micro-CT scan data, we calculated an individual cytoplasmic biomass of 3.65 mg wet weight for one specimen. When combined with literature records of seafloor coverage, this yielded an estimate of >7.0 g wet weight m^{-2} for the seafloor biomass of *J. foetida* in areas where it is particularly abundant. According to these calculations, our scanned *J. foetida* specimen had a biomass comparable to that of a slightly larger xenophyophore, and greater than that of three other xenophyophore specimens. The relatively restricted distribution of this species off the north-west African coast at depths above 100 m is probably related to the elevated, upwelling-related surface productivity along this margin, which provides enough food to sustain this high biomass. This remarkable species appears to play an important, perhaps keystone, role in benthic ecosystems where it is abundant, providing the only common hard substrate on which sessile organisms can settle.

Fig. 1

Fig. 2

Figure 1. Encrusted specimen of *Julliennella foetida* from the Abidjan (Ivory coast) collected at 80 meters depths.
Figure 2. Simplified model of *J. foetida* with surface partially taken off revealing an elaborate system of radiating internal partitions

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Agglutinated benthic foraminifera of the Cretaceus–Paleogene transition in the Skole Nappe, Polish Outer Carpathians

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The Outer Carpathians are dominated by Cretaceus–Paleogene (K-Pg) turbiditic deposits that accumulated the northern margin of the Tethys. Previously, the lack of the uppermost Cretaceous F2 and F1 biozones and the lowermost Paleogene Pα–P0 biozones have prevented the determination of the benthic assemblages and their relationship with the K–Pg event. Previous biostratigraphical studies (Machaniec et al. 2020) in the Hyżne section (Skole Nape, SE Poland) combined with the present study show a continuous record of the K–Pg transition foraminifers. The planktic foraminiferal zones characterizing the latest Maastrichtian to early Danian interval are present and recognized by the planktic index species. This complete record of events and changes is unique in the northern margin of Tethys. The Hyżne section offers a unique opportunity to study changes in taxonomic content, distribution, and diversity of benthic and planktic foraminifera, which were influenced by a series of environmental crises recognized worldwide.

In the studied section, the mass extinction at the K/Pg boundary is recorded below the dark-grey *marly mudstone* layer and is characterized by: (1) the standard Abathomphalus mayaroensis Zone which shows stratigraphically important changes, i.e., the interval with *A. mayaroensis* (Bolli) occurrence, the interval with the gradual disappearance of keeled and the large racemiguembelinid taxa, and the interval with the first bloom of *Guembelitria cretacea* Cushman. The coeval agglutinated foraminifers are relatively rare, but diverse. They include *Rhabdammina* sp., *Pasmmosiphonella* sp., *Ammodiscus cretaceus* (Reuss), *Glomospira* sp., *Caudammina ovula* (Grzybowski), *Rzehakina inclusa* (Grzybowski), *Reophax* sp., *Recurvoides* sp. *Trochamminoides* sp., *Saccammina* sp., some calcareous agglutinated taxa such as *Remesella varians* (Glaesner), *Rectoprotomarssonella rugosa* (Hanzlikova), *Arenobulimina* sp., *Gaudryina* sp., *Dorothia* sp., *Gerochammina* sp.; (2) the P0 Zone and Pa Zone, which indicate the lower Danian, despite the bloom of opportunistic planktic index taxon *Guembelitria cretacea* Cushman, the occurrence of *Parvularugoglobigerina eugubina* (Luterbacher and Premoli Silva) and a bloom of shallow infaunal, opportunistic, small-sized benthic calcareous *Brizalina* is observed. The assemblage is strongly dominated by calcareous epifaunal morphogroups represented by *Cibicides* sp,. *Anomalina* sp., and *Brotzenella* sp. and lenticulinids are also present. Small heterohelicids and hedbergellids occur in the clasts. They are considered Cretaceous survivors. All the other specimens (larger heterohelicids and hedbergellids) are potentially reworked and appear to be hydraulically selected. The agglutinated foraminifera are extremely rare. They include single, small and poorly preserved specimens of *Rhabdammina linearis* Brady, *Psammosiphonella cylindrica* (Glaesner), *Ammodiscus* sp., *Glomospira* sp., *Caudammina ovula* (Grzybowski), *C. excelsa* (Dylążanka), and *Hormosina velascoensis* (Cushman); (3) in the P1a Zone, the foraminifers are diverse and well preserved, with the characteristic simple tubular *Hyperammina*, *Bathysiphon*, *Rhabdammina*, branched tubular *Nothia*, and *Rhizammina*, *Ammodiscus* sp., *Subreophax scalaris* (Grzybowski), *Rzehakina fissistomata* (Grzybowski), *Rz. minuta* Cushman & Renz, *Rz. epigona* (Rzehak), *Caudammina excelsa* (Dylążanka), *C. ovula* (Grzybowski), *Hormosina velascoensis* (Cushman), *Recurvoides* sp., *Spiroplectammina* sp.; (4) the top of the lower Danian shows disappearance of planktic, benthic calcareous foraminifera, and calcareous-cemented agglutinated foraminifera. Only organically cemented deep-water agglutinated foraminifera (DWAF) occur, such as *Ammodiscus* sp., *Glomospira charoides* (Jones & Parker), *Rzehakina* sp., numerous *Caudammina excelsa*, the *C. ovula* group, *Hormosina velascoensis* (Cushman), *Recurvoides* sp., *Spiroplectammina navaroana* (Cushman). Other important taxa include *Paratrochaminoides* spp., *Trochammina* sp., *Trochamminoides* sp., *Saccammina* sp., and *Ammolagena clavata* (Jones & Parker). The relative abundance of each species fluctuates significantly in the studied interval, and the largest fluctuations are observed just above the K/Pg boundary.

The studied foraminiferal assemblages derive from different bathymetric zones. They can be referred to (1) above FL in the early late Maastrichtian, no deeper than the upper bathyal zone; (2), no deeper than the margin of the shelf during the latest Maastrichtian and in the earliest Danian; (3) the middle-lower bathyal depth, below LF and above CCD in the late early Danian; (4) the youngest sediments contain foraminifera from the bathyal depths below the CCD. The relative sea-level changes inferred for the section reveal a fall trend during Maastrichtian and earliest Danian and then a rise. As the foraminifera could have been redeposited by turbiditic currents, from shallower zones and the relative-sea level changes reflect the situation in the source area of the deposits, not necessarily in the place of deposition.

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Colonial Agglutinated Foraminifers from Late Silurian and Earliest Devonian strata of the Arbuckle Mountains area of South-Central Oklahoma, USA

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Strata of the Silurian (Ludlow and Pridoli) Henryhouse Formation and the Devonian (Lochkovian) Haragan Formation of the Hunton Group in the Arbuckle Mountains and Lawrence Uplift of south-central Oklahoma consist of argillaceous wackestone and mudstone with some beds of skeletal wackestone and packstone. Agglutinated foraminifers are common in most samples from these strata, except in a pyrite-rich interval of the lower member of the Henryhouse Formation. The foraminifers occur together with stratigraphically important conodonts at seven outcrop localities: Hickory Creek, Ca2, Highway 77, Dougherty West, Goddard Youth Camp, 9-10, and P1. The most complete lithological and faunal sequence is represented in the Highway 77 section, in which the Henryhouse Formation extends from the Gorstian (*Kockelella crassa* conodont Zone) into the late Pridoli and is overlain by the Lochkovian Haragan Formation (*Caudicriodus hesperius* conodont Zone).

There are two major oceanic events in the studied stratigraphic interval. Traces of the carbon excursion associated with the mid-Ludfordian Lau Event have previously been detected in the uppermost portion of the extremely argillaceous lower member and the lowermost portion of the upper member of the Henryhouse Formation. The second, the Klonk Event, crosses the Henryhouse - Haragan boundary.

Foraminifers of the Henryhouse and Haragan formations have never been systematically described. Ireland (1939) described only two species, *Bathysiphon rugosus* and *Psammosphaera gracilis*, from the Henryhouse Formation, and six species from the Haragan Formation, *B. rugosus*, *Psammophax bipartita*, *Stegnammina elongata*, *Ceratammina cornucopia*, *Webbinella bipartita*, and *Psammonyx maxwelli*. Earlier, Moreman (1933) described *Webbinella quadripartita*, also from the Haragan Formation.

The assemblage of agglutinated foraminifers from the Henryhouse Formation is rich and diverse. The unilocular genera include *Psammosphaera*, *Thurammina*, and *Thuramminoides*, but tests of bichambered genera are also common, such as *Tolypammina*, *Rectoammodiscus*, and *Hyperammina*. The present work studied colonial tests of monothalamid genera similar in morphology to “*Sorosphaera*” *multicella* (Dunn 1942), “*Sorosphaera*” *subconfusa* (Dunn 1942), and *Webbinelloidea* (Stewart and Lampe 1947).

Several new colonial species belonging to the genera *Sorostomasphaera?* (McClellan 1966) and *Webbinelloidea?* are present in all seven sections studied. A new genus of colonial foraminifers composed of sack-shaped individual chambers is present in the Ca2 and Dougherty West sections. In the extremely argillaceous lower member of the Henryhouse Formation, *Sorostomasphaera?* occurs, whereas *Webbinelloidea?* and *Thekammina* (Dunn 1942) are rare. In contrast, species of *Sorostomasphaera?*, *Webbinelloidea?*, and linear chains of rectangular-shaped chambers of the genus *Thekammina* are abundant and diverse in the moderately argillaceous upper Ludfordian and Pridoli interval of the Henryhouse Formation in the Highway 77 section, Units 16-20, samples 336A-349B. In the same section, a shift to a less diverse agglutinated foraminiferal fauna in the uppermost portion of Unit 20 and in the lower part of Unit 21 may correspond with the onset of the Klonk Event. In the Lochkovian Haragan Formation, *Sorostomasphaera?* and *Webbinelloidea?* remain present but in reduced numbers, and new species of *Thekammina* and *Webbinelloidea?* become prominent.

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Traditional and Molecular Methods of Investigation in the Foraminiferal Taxonomy

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I. Traditionally the morphological method of the shell study was the basic method in the foraminiferal taxonomy. Electronic microscopy gave it the new life. The second half of the 20th century is characterized by the rapid flowering of scanning electron microscopy (Reiss, 1957, 1959, 1960; Reiss, Merling, 1958; Towe, Cifelli, 1967; Hansen, Reiss, 1971 a, b; Bellemo, 1974 a, b, 1976; Hemleben et al., 1977; Spindler, 1978; Leutenegger, Hansen, 1979; Be et al., 1980; Debenay et al., 1996 b, 1998, 2000; Gooday, Smart, 2000, Krasheninnikov, 1956; Grigelis, Gorbatchick, 1980; Saidova,1980; Maslakova, 1983; Mikhalevich, 1986, ; Gubenko, 1989, Kaminski et al., 1995, 1996, 2008 and others).One of the main problems in the morphological systematics of foraminifera is the unevenness of the knowledge of their skeletons studied at different levels of microscopy (light and electron), which makes it difficult to compare their shells. Therefore, re-examination at a new EM level of type species of the genera is an overdue task. **II**. Due to the presence of a shell, cytologically foraminifera are much less studied than the other protozoa. The few data on the structure of their living cells obtained in the 19th and 20th centuries were first generalized and used to characterize large taxa (classes) (Mikhalevich, 1980, 1992). Currently, cytological methods that help to distinguish certain species and genera are used more widely in the study of primitive single-chambered forms with an agglutinated or organic shell (Gooday et al., 1996, 2008; Gooday, Kamenskaya, 2012; Bowser et al., 2002; Habura et al., 2004; Goldstein et al., 2010). **III**. Principally new stage in the taxonomy of foraminifera has begun with the introduction of molecular phylogenetic methods that allow obtaining of taxonomic criteria which are independent of the nature of morphology. The first steps in this direction were taken in the last decade of the 20th century. (Darling et al., 1996, 1997, 1999; Fahrni et al., 1997, Pawlowski et al, 1994, 1995,1997), in the 21st century the number of such studies has increased significantly (Darling et al., 2000, 2009; Pawlowski, 2000; Pawlowski et al., 2002, 2003; Pawlowski, Gooday, 2009; Pawlowski, Burki, 2009; Holzman et al., 2003, 2012; Habura et al., 2004; Flakowski et al., 2005; Bowser et al., 2006 and others). A fundamentally new type of collections has emerged - GenBank, which stores multi-genetic databases and counts at present more than 600 species. Molecular genetic studies of foraminifera began later than for the other unicellular eukaryotes because of significant difficulties, primarily due to the presence of a shell, as well as symbionts and various inclusions. The high rate of evolution of many of their groups makes it difficult to interpret the results. SSU rRNAs were most often used as molecular markers, nuclear DNA and protein-coding genes (e.g., actin-1, actin-2, betatubulin, RPB1) were also used. Standard procedures were PCR, sequencing and alignment. Interesting data of molecular studies were obtained for foraminiferal taxa of different taxonomic rank. **a**. The resolution of molecular methods was high in the field of species identification. Thus, it was shown that the diversity of the Antarctic allogromiid genotypes twice exceeds the amazing diversity of their morphological forms (Gooday et al. 1996; Bowser et al. 2002; Habura et al. 2004), that 2 new speciies of *Xiphophaga* differ only genetically (Goldstein et al., 2010). Different species level genotypes have been identified for representatives of Ammoniidae, Glabratellidae, Allogromiidae and some other groups. Molecular study of species genotypes in the genus *Ammonia* (Holzman, Pawlowski, 2000) showed that only one of them has distinct morphological differences.

However, a thorough morphometric analysis (Hayward et al., 2004) revealed morphological differences in each of these molecular genotypes, which once again demonstrates the need for joint studies of specialists in molecular and morphological methods. The study of intraspecific variability of planktonic forms (Darling et al., 1999, 2000; Varga et al., 1999, 2001) also revealed their high genetic variability and the clear confinement of many specific genotypes to the certain geographical areas and ecological niches; the number of forms previously considered as cosmopolitan has fallen sharply. The presence of the pelagic stage in the bottom species *Bolivina variabilis* (Darling et al., 2009; Darling, Leckie, 2010) was brilliantly proven. **b**. The genera *Brizalina*, *Cibicidoides*, *Fontbotia*, *Lobatula*, and *Jadammina* were shown not to be valid (Ertan et al., 2004; Scweizer et al., 2009, Holzmann et al., 2012). The separation of the majority of these genera was doubtful at the morphological level also. **c**. The results of molecular analysis of large taxonomic groups of foraminifera (families, orders) most often coincide with the data of morphological analysis (Mikhalevich, 1980-1998, Saidova, 1981). Thus, the homogeneity of such lines as miliolides, soritides, the parallel evolution of various nummulitid lines (Holzmann et al., 2003) is well documented, the polyphily of the former Lituolida was also revealed both in morpologic (Mikhalevich, 1992, 2004) and molecular studies (Fig. 1). These evolutionary advanced groups achieving a high complexity possess a lot of phylogenetically informative morphological features. **d**. The unity and monophily of Foraminifera as a separate type, adopted by a number of morphologists (Margulis, Schwartz, 1988, Mikhalevich, 1980, Saidova, 1981, Maslakova, 1990) was also confirmed at the molecular level (Pawlowski, 2000). Though in molecular variant Rotaliata and Nodosariata classes (clades) were united in one class, as well as Spirillinata and Miliolata clades, but main molecular clades (Pawlowski, 2012) and morphological classes practically coincide (Fig. 1), and both classifications unites agglutinated and calcareous forms of similar plane of structure in the single phyletic lines.

Conclusions.

1.Results obtained with morphological and molecular methods at the class level were rather close despite the difficulties in obtaining living material for molecular studies; 2. Molecular methods are the most important in the study of forms pure in morphological features, in specifying the boundaries of species and genera, in phylogeography, in monitoring of ecological conditions and pollution, as well as in the study of convergent forms of different groups hard to identify; 3. Morphological methods still preserve their actuality and even survive their renaissance owing to the E-microscopy; 4. The most reliable are the results obtained with an integrated approach and the use of various research methods.

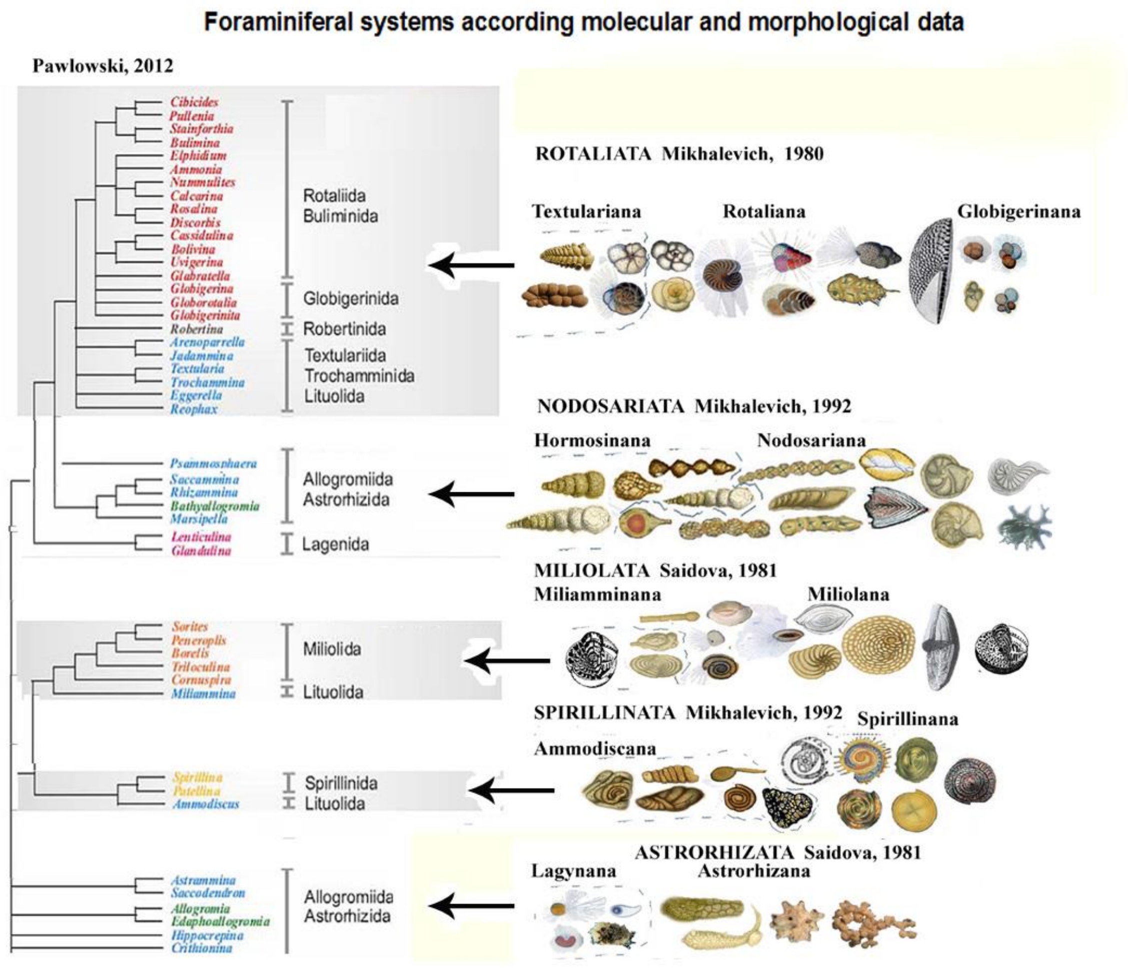

Figure 1. Foraminieral systems according to molecular and morphological data – scheme.

Acknowledgement:
The author is deeply thankful to J. Pawlowski for his kind permission to use his classification scheme.

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Turonian to Santonian Foraminiferal Biostratigraphy and Paleobathymetry of Non-calcareous Red Beds of the Vezhany Nappe (Ukrainian Inner Carpathians)

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The Vezhany Nappe (=Marmarosh Klippen Zone) is placed in the inner part of the Ukrainian Carpathians to the northwest of the Marmarosh Crystalline Massif and is filled with Cretaceous-Paleogene sediments. The Cretaceous stratigraphic succession of the Vezhany Nappe is composed of the Soymul Formation (Albian-Cenomanian) and the Puchov Formation (Turonian-Maastrichtian) (Vyalov et al., 1989). This succession is exposed along the Tereblya River (the village of Zabrid, Khust district, Transcarpathian region). Here, the age of these predominantly calcareous deposits was determined by previous researchers (Dabagyan et al, 1989) mainly on the basis of planktonic foraminifers. However, the non-carbonate deposits developed in the lower part of the Puchov Formation remained poorly studied.

The lower member (25 m of thickness) of the Puchov Formation in the section of the Tereblya River was studied by the authors of the presented work in 2019 and 12 samples of clay rocks were taken here at intervals of 2-3 m. An attempt was made to compare the studied section with the foraminiferal scales of Geroch and Nowak (1984) and Olszewska (1997) (Fig. 1).

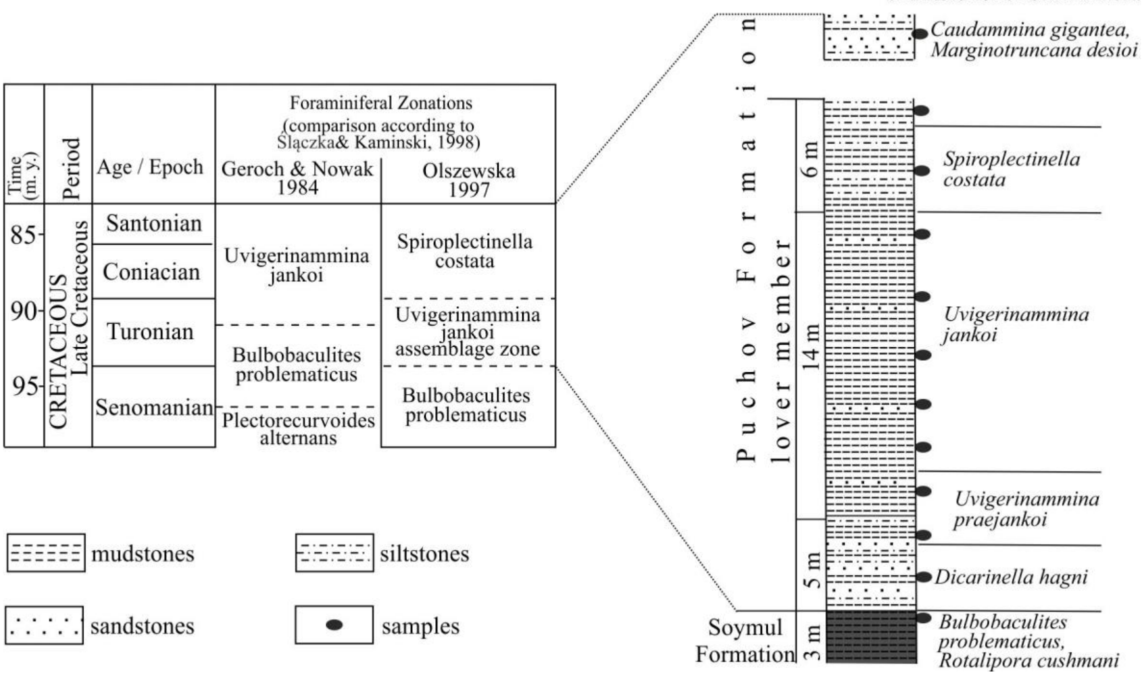

Figure 1. The studied section along the Tereblya River, compared with the foraminiferal zones of the Polish Carpathians

The beginning of the section is located on the left bank of the Tereblya River (48°16′31.4″N; 23°34′37.8″E). Here, downstream of the Tereblya River, the top of the Soymul Formation and the lower member of the Puchov Formation are exposed. The top of the Soymul Formation (3 m of thickness) is represented by dark gray to black, calcareous sandy mudstones. The lower member of the Puchov Formation consists of: alternation of the red sandy marls with cherry-red mudstones and gray sandstones (5 m of thickness); cherry-red mudstones with thin intercalations of bluish-gray sandstones (14 m of thickness) and red mudstones and siltstones (6 m of thickness).

After an unexposed interval (2 m), calcareous sandy siltstones and mudstones interbedded with bluish-gray sandstones are exposed. Small folds were observed here.

The Cenomanian/Turonian boundary corresponds to the boundary between the Soymul and Puchov formations. The planktonic species *Rotalipora cushmani* (Morrow) of late Senomanian age was identified in the top of the Soimul Formation with the benthic *Bulbobaculites problematicus* (Neagu). Planktonic species *Dicarinella hagni* (Scheibnerova), the first occurrence noted in the early Turonian, was found in gray mudstones at the base of the Puchov Formation.

Stratigraphically higher, only agglutinated foraminifers were found in the cherry-red and red mudstones of the lower member of the Puchov Formation. Three assemblages with characteristic foraminifera: (1) with *Uvigerinammina praejankoi* Neagu; (2) with *Uvigerinammina jankoi* Majzon and (3) with *Spiroplectinella costata* (Huss) are distinguished here (Fig. 1).

Species *Caudammina gigantea* (Geroch) and *Marginotruncana desioi* (Gandolfi) was found in the bottom of the upper member of the Puchov Formation and suggest the late Santonian age.

Species belonging to genera *Ammodiscus*, *Haplophragmoides*, *Labrospira*, *Pseudobolivina*, *Plectorecurvoides*, *Praecystammina*, *Uvigerinammina* and *Gerochammina* common in assemblages (1, 2) indicate deep-sea conditions below CCD. The occurrence of numerous *Marssonella oxycona* (Reuss) in the assemblages (3) suggests slope conditions close CCD.

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Middle Permian (Guadalupian) Agglutinated Foraminifera from the Delaware Basin, West Texas, USA

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Agglutinated foraminifers from the Middle Permian (Guadalupian) of the Delaware Basin in West Texas have never been mentioned in any studies although microfossils such as conodonts, fusulinids, radiolarians, and to a lesser degree calcareous small foraminifers (Nestell et al., 2019 with references), and fish microremains (Ivanov et al., 2015; 2018, with references), are very well known. The Delaware Basin represents a unique well-preserved Middle Permian Reef Complex with different paleoenvironments ranging from back reef to reef to fore reef to basinal. The Guadalupe Mountains area is the stratotype area for the Middle Permian worldwide where three GSSP's boundaries for the Roadian, Wordian and Capitanian Stages have been established. In the Guadalupe Mountains, the basinal lithofacies in ascending order are: Cutoff, Brushy Canyon, Cherry Canyon, and Bell Canyon Formations. Each formation is subdivided into several members (Nestell et al., 2019, fig. 1). In the Apache Mountains, to the south of the Guadalupe Mountains, these members cannot be recognized easily because of different lithofacies between the Guadalupe and Apache areas.

Agglutinated foraminifers discussed herein are present in the conodont residues from several basinal sections in the Guadalupe and Apache Mountains. Because of using formic acid for the extraction of conodonts, we assume that the recovered agglutinated foraminifers have organic cement, and not calcareous. In the Guadalupe Mountains, agglutinated foraminifers are present in the Roadian (Quarry section), upper Wordian (PI section), and upper Capitanian (Lamar section on US 62/180 and a Basinal Lamar section on US 1108). In the Apache Mountains area, agglutinated foraminifers are found in the uppermost Capitanian (EF section). Unfortunately, all species are identified in open nomenclature because they are new and will be described in a future paper.

In the Guadalupe Mountains area, agglutinated foraminifers are present in the Williams Ranch Member of the Cutoff Formation, and they are represented by rare specimens of the genera *Ammobaculites* Cushman (*A.* sp. C), and *Palustrella* Brönnimann, Whittaker and Zaninetti (*P.* sp. A). A rich assemblage of agglutinated foraminifers is present in the Hegler and a sparse assemblage in the Pinery, both members of the Bell Canyon Formation. The Hegler assemblage contains diverse species of the genera *Hemisphaerammina* Loeblich and Tappan (*H.* sp.), *Stomasphaera* Mound (*S.* sp. A), extremely rare *Lagenammina* Rhumbler (*L.* sp.), *Thurammina* Brady (*T.* sp. A, *T.* sp. B), *Psammosphaera* Schulze (*P.* sp. A, *P.* sp. B, *P.* sp. C), *Kechenotiske* Loeblich and Tappan (*K.* sp. A, *K.* sp. B), *Hyperammina* Brady (*H.* sp. A, *H.* sp. B, *H.* sp. C, *H.* sp. D, *H.* sp. E), *Ammodiscus* Reuss (*A.* sp. A, *A.* sp. B), *Ammodiscellites* Resig and Glenn (*Am.* sp. A, *Am.* sp. B), *Tolypammina* Rhumbler (*T.* sp. A, *T.* sp. B), *Scherochorella* Loeblich and Tappan (*S.* sp. A), *Ammobaculites* (*A.* sp. A, *A.* sp. B), and abundant *Palustrella* (*P.* sp. A) (Fig. 1). A poor assemblage of agglutinated foraminifers was found in the Lamar Limestone Member of the Bell Canyon Formation where it represented by species of the genera *Ammobaculites* (two species) and rare *Reophax* de Montfort (one species). In the Apache Mountains, agglutinated foraminifers are present in strata equivalent to the Reef Trail Member and are represented by species of the genera *Scherochorella* (*S.* sp. B), *Ammobaculites* (*A*. sp. D, *A*. sp. E, *A*. sp. F, *A*. sp. G), *Reophax* (*R*. sp. 1, *R*. sp. 2) and extremely rare *Haplophragmoides* Cushman (*H*. sp. A).

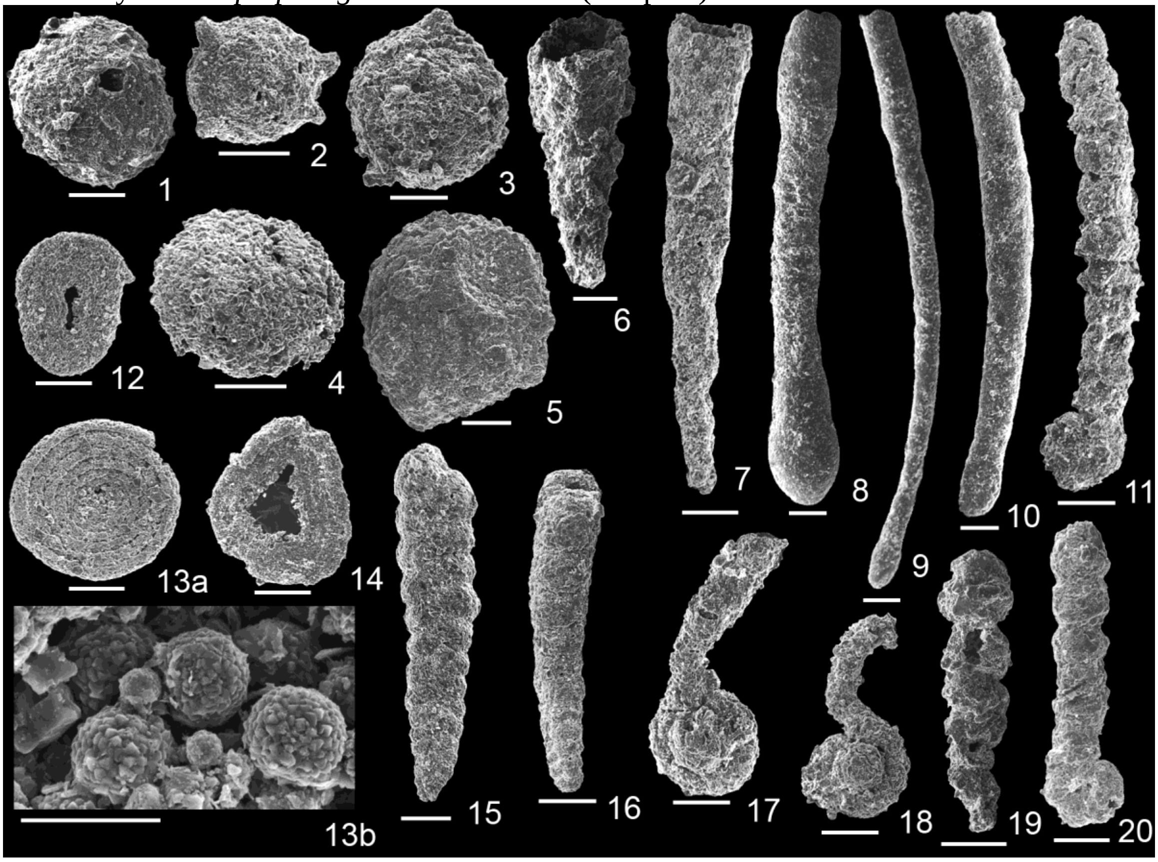

Figure 1. Agglutinated foraminifers from the PI section; Wordian, Guadalupian, Guadalupe Mountains, West Texas. 1. *Stomasphaera* sp. A, 2. *Thurammina* sp. A, 3. *Psammosphaera* sp. B, 4. *Psammosphaera* sp. A, 5. *Psammosphaera* sp. C, 6. *Kechenotiske* sp. B, 7. *Kechenotiske* sp. A, 8. *Hyperammina* sp. A, 9. *Hyperammina* sp. B, 10. *Hyperammina* sp. C, 11. *Ammobaculites* sp. B, 12. *Ammodiscus* sp. B, 13. *Ammodiscus* sp. A, b – framboids in the test wall, 14. *Tolypammina* sp. A, 15, 16. *Palustrella* sp. A, 17, 18. *Ammodiscellites* sp. A, 19. *Scherochorella* sp. A, 20. *Ammobaculites* sp. A. 1-6, 8-10, 15-20 – Hegler Member of the Bell Canyon Formation, 7, 11-14 – undivided Bell Canyon Formation. Scale bar – 100 µm, except 13b – 10 µm.

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Agglutinated monothalamous foraminifera: the challenges of higher-level classification integrating genetics and morphology

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There was time when morphology-based taxonomy ruled the foraminiferal world. However, times have changed and the development of genetic analyses has shed new light on the phylogenetic relationships of foraminifera, creating some conflicts with the traditional morphological approach. The divergence is particularly strong in the case of single chambered, monothalamous foraminifera (‘monothalamids’), which are traditionally divided into organic-walled and agglutinated classes. Phylogenetic studies show that representatives of both classes intermingle and that the agglutinated wall originated several times during early foram evolution. Several informal clades have therefore been introduced to classify monothalamids. Recently, we attempted to convert these clades into formal taxa, named after typical genera. However, this turned out to be more complicated than expected. In particular, several common genera, such as *Bathysiphon*, *Psammosphaera*, *Saccammina*, and *Crithionina*, are known to be polyphyletic. Genetic characterisation of the typical genera means that type species must be sequenced, which is often not feasible. Moreover, phylogenetic clades often comprise very different morphotypes, making their morphological definition practically impossible. Finally, it is unclear how to integrate genera known only from the fossil record in such classification? These and other challenges posed by the development of higher-level integrative systematics of monothalamids will be presented and discussed.

Wall Structure of Agglutinated Foraminifers from the Albian-Cenomanian (Cretaceous) Washita Group in North-Central Texas

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The agglutinated foraminiferal assemblage of the upper Albian-lower Cenomanian (mid-Cretaceous) Washita Group in North-Central Texas has been well documented in several studies in the mid-twentieth century. However, few agglutinated species identified in these early studies have been reevaluated since their initial descriptions. Loeblich and Tappan (1982) recognized that several agglutinated foraminiferal species described from the North-Central Texas area likely secreted calcareous cement to bind the grains that make up the test wall; however, supplementary illustrations to support this proposal were not published. Except for the species *Sculptobaculites goodlandensis* (Cushman and Alexander), a detailed analysis of the test walls of agglutinated foraminifers from the Washita Group has not been made (Rashall et al., 2019). The purpose of this study is to illustrate features of the test walls of Washita Group agglutinated foraminifers and characterize their grains and cements.

The Washita Group of North-Central Texas consists of nine formations (in ascending order): Kiamichi, Duck Creek, Fort Worth, Denton, Weno, Paw Paw, Main Street, Grayson, and Buda formations. The Buda Formation was excluded from this study as it rarely outcrops in the North-Central Texas area and was not observed at any sampling localities. Except for the shaley Kiamichi Formation, the Washita Group comprises alternating shallow marine marl and limestone units, indicative of the shallow epeiric sea that flooded the Gulf Coast region during the late Albian-early Cenomanian.

A total of 131 samples were studied from 21 outcrop localities at varying intervals within the Washita Group. Samples include those collected by the authors for the purpose of this study, as well as samples collected by Frank Lozo, Alfred Loeblich, and Helen Tappan, which were loaned to the authors by the Smithsonian National Museum of Natural History. Foraminiferal tests were studied using overhead LED light, thin sections and translucent slides (reflected light), scanning electron microscopy (SEM), and partial dissolution in acid to determine the chemical composition of the tests. Several polished half-specimens were also analyzed in SEM using energy dispersive X-ray (EDX) analysis to assess the internal compositional character of the test wall.

From the studied material, 24 species of agglutinated foraminifers were identified. Of these taxa, 13 were determined to have organic cement, including species of the genera *Glomospirella*, *Reophax*, *Scherochorella*, *Ammobaculites*, *Simobaculites*, *Flabellammina*, and *Aaptotoichus*. Eleven species were determined to possess a significant calcareous component that is interpreted to be secreted calcareous cement, including species of the genera *Sculptobaculites*, *Acruliammina*, *Textulariopsis*, *Quasispiroplectammina*, *Haimasiella*, *Gaudryina*, and *Gaudryinella*. Distribution of agglutinated quartz and calcareous grains was variable among the species. Elemental analysis of the internal structure of the test walls of *Textulariopsis washitensis* (Carsey) showed that despite the coarse agglutination of quartz grains along the exterior of the test, quartz grains were absent from the internal structure (Fig.1). Iron associated with diagenetic pyrite and iron oxides was also detected within the chambers of the test, as well as trace amount of aluminum. Additionally, canaliculi were identified along the attachment surface of *Acruliammina longa* (Tappan), similar to what has been previously described from the genus *Placopsilina* (Bender, 1995).

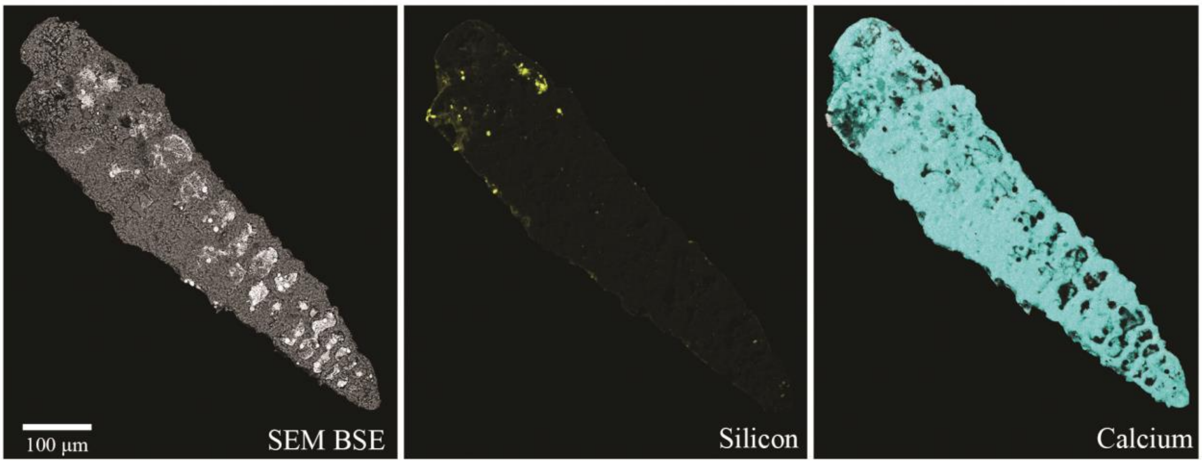

Figure 1. SEM images and corresponding elemental maps of a half-sectioned specimen of *Textulariopsis washitensis* (Carsey). On the elemental maps, illuminated areas denote the presence of the specified element. Elemental maps are shown in false color.

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Inosilicate grains in agglutinated foraminifera as possible indicators of nearby volcanic event - the Miocene Hámor site (Slovakia) case

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Specimen and species rich Lower Badenian deposits originated from of the Middle Miocene Hámor site (Langhian; Vinica Formation; Novohrad-Nógrad Basin; Central Paratethys; Čechovič and Seneš, 1950; Vass et al., 1979; Kováč et al., 2017, 2018; Hudáčková et al., 2020) yielded diversified associations of both micro and macrofossils. Nannofossils of the NN5 Zone were identified in the studied sample (*Coccolithus miopelagicus*, *Discoaster musicus*, *Helicosphaera waltrans*, *H. walbersdorfensis*, *Sphenolithus heteromorphus*) and the absence of *Helicosphaera ampliaperta* supports this age assignment. Nannoplankton associations document warm water paleoenvironments with lower nutrient (*Calcidiscus leptoporus*, *C. tropicus*, *Umbilicosphaera jafari* and *U. rotula*).

Foraminifera represent specific diversified epiphytic assemblages with dominance of *Amphistegina, Asterigerinata, Lobatula* and *Elphidium* genera. The planktic association consists of *Trilobatus trilobus* and rare *Globigerina* (Hudáčková et al. 2020). Locally, fossil composition differs when agglutinated taxa (*Textularia*, *Gaudryina austriaca* and *Pseudogaudriina*) together with miliolids become more abundant. Here, incorporation of the pyroxene grains into the wall by *Pseudogaudryina* sp., *Gaudryinopsis austriacus, Textularia laevigata* and *T. gramen* was observed. Miliolid taxa, e.g., *Quinqueloculina seminulum* also incorporate pyroxene grains into the wall during all ontogenic stages.

Although the agglutination patterns (size and nature of the cemented particles) are amongst the taxonomic attributes of the agglutinated foraminifera, its possible ad hoc formation should still be considered. Moreover, such shell development can reflect environmental heterogeneities and factors affecting the given area.

The aim of this study was to investigate implications of unusual mineral content of tests in *Pseudogaudryina* sp. (canaliculate agglutinated foraminifera), specifically sudden increase in inosilicate portion (number and size) in overall wall-grain content, possibly indicating nearby volcanic activity. Pyroxene grains, if present, are normally evenly distributed between the wall material of agglutinated foraminifera. With respect to the presence of this mineral content compared to normal, specimens from the studied locality can be divided into three clusters of general appearance: i) no difference, ii) high proportion, and iii) sudden appearance within a single test. Noteworthy to mention is that however some specimens with pyroxene grains builted-in to walls were also identified amongst the miliolid forms some genera of agglutinated foraminifera remain without any change in amount of this mineral.

The minerals that were enclosed in the foraminifera are identical to those found in the sands. The presence of glass shards, and the dominance of pyroxenes (enstatite, augite), plagioclase (An 48-68), amphiboles (pargasite, hastingsite, horblende), ilmenite + apatite document the significant influence of andesite volcanic activity. The non-volcanic admixture documents the presence of quartz, albite, K-feldspar and small foraminifers, which are also present in the shells.

If taken into consideration the pyroxene grains remain non-degraded only for a limited time in the environment and after a certain period become unavailable due to chemical and physical degradation. It should apply that if they are built-into the wall, they get an organic lining and thus also protection against pore water and corrosion respectively. Another attribute affecting the physical nature of the sediment particle is an increase in size as the foraminiferal test plays as a single "grain".

Since the Middle Miocene is the epoch of significant changes and events (e.g., volcanism) in the Central Paratethys, timing of particular short-term, local events can be crucial for further interpretation in regional context.

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End-Eocene decline of agglutinated foraminifera in the Istebné section (Central Western Carpathians): implications for climatic deterioration, sea-level fluctuations and bioproductivity changes

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The agglutinated foraminifera (DWAF) has been studied in the Istebné section due to their distribution across the Eocene/Oligocene transition (EOT). The microfauna of agglutinated foraminifera was significantly impoverished during the transition due to rapid climatic changes (Kaminski and Ortiz, 2014).

The Istebné section is about 220 m thick sequences of turbidites, hemipelagic marls and deep-water claystones. The lower sequence is formed by muddy turbidites, which higher-up developed thicker megabeds with submarine slumps and complete turbidite sequences. This trend reflects a thickening upward turbidite sequences towards the EOT, which indicate a global sea-level fall at that time (Miller et al. 2009). The lower Oligocene sequence became less clastic and more calcareous, composed mostly by hemipelagic marlstones with rare tuffite interbeds.

The Eocene/Oligocene boundary is marked by a topmost occurrence of planktonic foraminiferal species like *Hantkenina alabamensis*, *Globigerinatheka index* and *Turborotalia cerroazulensis* in upper third of the Istebné section. The Eocene sequence beneath this boundary contains a rich agglutinated foraminifera, whereas the sequences above EOT are significantly impoverished or barren in agglutinated microfauna. This implies a benthic foraminiferal turnover in response of the Oligocene climatic cooling (Ortiz and Kaminski 2012; Benedetti 2019).

The formations in lowermost part of the Istebné section contain a more abundant, robust and diversified agglutinated foraminifera. They reveal a predominance of epifaunal species like *Ammodiscus latus*, *A. cretaceus, A. peruvianus, Glomospira serpens*, etc. In addition to ammodiscid foraminifers, the assemblages also comprise species of *Reophax pilulifer*, *Rhabdammina cylindrica, Kalamopsis grzybowskii, Hormosina velascoensis, etc.*. The Middle Eocene age of these formations is constrained by the presence of *Ammodiscus latus*, which is a zonal species of the Bartonian assemblages (Waśkowska 2014, Waśkowska and Kaminski, 2014).

Prior to the Eocene/Oligocene boundary, the agglutinated foraminifers became rather monospeciffic, consisting of smaller infaunal species like *Reophax duplex*, *Supreophax splendidus*, *Psammosphaera* sp., *Repmanina charoides*, etc.

Above the Eocene/Oligocene boundary, the microfauna is significantly altered by dwarfing and the lack of planktonic foraminiferal species. They belong to opportunistic species like *Globigerina* (*bulloides - officinalis* plexus), *Tenuitella* and *Chiloguembelina*, which are associated with species of *Dentoglobigerina* (*D. tapuriensis, D. venezuelana, D. galavisi*), *Paragloborotalia* and *Turborotalia* (*P. nana, T. ampliapertura*), *Globoturborotalita* (*G. ouachitaensis, G. martini*), and others. Oligocene microfauna of agglutinated foraminifers is also reduced in test size and diversity. They persisted only by small tubular forms of species *Bathysiphon* sp., *Rhabdammina* sp., *Rhizammina indivisa*, etc. This trend led almost to complete disappearance of agglutinated foraminifers in uppermost part of the Istebne section.

Cyclic alteration of plankton-rich and DWAF-rich intervals in the Istebné section reflects a sea-level fluctuation, drop in the CCD and lysocline, which was induced by climatic cooling. This was also a reason of stress conditions for agglutinated microfauna under an increased bioproductivity, lowering of the CCD, eutrophication and/or upwelling activity in lower Oligocene carbonate-rich formations of the Istebné section. These boundary events were also associated with syngenetic volcanism, which correspond to "Tuff 25" dated around 32,8 – 34.6 Ma in the Carpathians (*sensu* Van Couvering et al. 1981).

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Agglutinated foraminifera as indicators of environmental crises in the flysch basin of the Polish Outer Carpathians (Cretaceous-early Paleogene)

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The research based on agglutinated foraminifera from the Polish Outer Carpathians was aimed at documenting environmental crises during the Cretaceous and Early Paleogene. They were analyzed in terms of their diversity, abundance and sensitivity to environmental parameters. The study used foraminifera morphogroups, which were discussed taking into account the available geochemical data and graphical correlation. Their relationship with external factors, in particular global oxygen deficiency, referred to as oceanic anoxic events (OAEs), has been also investigated.

During the Creatceous and early Paleogene the studied area was located on northern margins of the Tethys. Sedimentation strongly controlled by tectonic and geomorphological processes took place in several zones at different depth and distances from the land. Changes in the amount, density and granularity of the material transported to the basin by submarine currents have repeatedly led to facies changes within the formations (rock series). They are mainly represented by coarse-grained flysch interbedded with shales of various thicknesses, which also occur as independent complexes. The formation of these shales was associated with periods of decline in tectonic activity of varying frequency and duration. Some of them, characterized by a darker color, higher content of organic matter and Fe compounds (siderite, pyrite) or clay minerals (kaolinite), were formed in a low energy environment under the conditions of water stagnation and oxygen deficiency.

To document these conditions foraminiferal data collected from shale outcrops in the Western and Eastern Beskids and their foothills (Polish Outer Carpathians) were used. These deposits belong mainly to the Silesian tectonic unit, and partly also to the Sub-Silesian tectonic unit. The part of them constitutes independent lithostratigraphic formations of the Lower Cretaceous. They are represented by rocks traditionally known as the Upper Cieszyn Shales, which until recently are assign to the Cisownica Mb. of the Hradisce Fm., as well as others that are part of the Verovice Shales Fm. or Barnasiówka Radiolarian Shale Fm. Dark as well as red or brown shales with impoverished foraminiferal assemblages also occur as interbeds in coarse and thick-bedded turbidities, which respectively formed as the Albian-Cenomanian Lgota Fm. and the Campanian-Paleocene Istebna Fm.

The microfauna of these shales is characterized by low diversity and varying abundance. These foraminifers are represented by erect epifauna (*Rhizammina, Rhabdammina*), surface epifauna (*Ammodiscus, Rzehakina*), semi- and shallow infauna (*Glomospira, Haplophragmoides, Plectorecurvoides, Recurvoides*) as well as forms living deep in sediments and feeding on anaerobic bacteria (*Pseudoreophax*, *Verneuilinoides Reophax*, *Pseudonodosinella Spiroplectammina*, *Bolivinopsis*). They inhabited the bottom of the basin at various depths in conditions of low tectonic activity and oxygen deficiency. The presence of some infaunal species (*Arenobulimina, Bolvinopsis*) was probably related to both changes in oxygenation and the content of calcium carbonate in the sediments. This was facilitated by periodic changes in the rate and nature of deposition and the amount of terrigenous material supplied into the flysch basin.

Their diversity, distribution and behavior of foraminifera in flysch basins was strongly controlled by regional and local factors. For this reason, in various degree they reflect oceanic anoxic events (OAE's). The microfauna of the shale complex (Cisownica Mb, Verovice shales Fm., Barnasiówka Radiolarian Shales Fm.) indicates hypoxia related to the anoxic events of the Late Valanginian, Early Aptitian (OAE 1a), Early Albian (OAE 1b) and Cenomanian/Turonian (OAE 2), while those from the shales of turbidities (Lgota Fm, Istebna Fm) reflects the unfavorable conditions of the Albian, Campanian-Maastrichtian and Paleocene.

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Record of the shallow-water environment in the early basin of the Polish Outer Carpathians based on agglutinated foraminifera (Tithonian)

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Micropaleontological research was carried out on samples taken from the oldest sedimentary rocks of the Polish Outer Carpathians which outcrop near the Polish-Czech border. The examined rocks are represented by marls and organodetritic limestones with interbeddings of marly shales traditionally called lower Cieszyn shales and Cieszyn limestones. They constitute separate lithostratigraphic units co-occurring in the Tithonian as the Vendryne Fm. and the Cieszyn Limestones Fm. These carbonate rocks were formed in a narrow basin extending along the southern margins of the European Platform, which were disintegrated and fragmented during the rifting process initiated in the Oxfordian. Fragments of the platform have been incorporated into the basin structures or, as a result of the progressive destruction process, have become part of accumulated sediments, in which they occur both as carbonate blocks and displaced fossils or their fragments. Organic matter also came from reef structures forming around the basin's uplifts and on its shores.

Massive marly complexes, occurring partly in the form of submarine landslides and also as intercalation of organodetrital limestones, contain agglutinated foraminifera cemented with siliseous or calcareous material. They are represented by multi-chambered, elongated and conical forms with a cross-section similar to a cylindrical one, which include Verneulinidae (*Uvigerinammina uvigeriniformis, Paleogaudryina varsoviensis, Belorussiella taurica, B. textilarioides, B. wolinensis, Verneuilina subminuta*), Andercotrymidae (*Praedorothia hauteriviana, P. praehauteriviana, Protomarssonella hechti, P kummi, Pseudomarssonella dumortieri*) and Textulariopsidae (*Bicazammina jurassica, Hagimashella arcuata, Textulariopsis jurassica*). They were characteristic of the vast areas of the shelf and the adjacent deeper parts of the basin. Sometimes they were accompanied by very rare microfauna belonging to the following genera: *Melathrokerion, Buccicrenata, Alveosepta, Pseudocyclammina*, which can be associated with the shallow marine environment, including para-reef habitats. These foraminifera can be found mainly in the marly complex of the Vendryne Fm., as well as in the top of this unit, where the breccia level (Ropice horizon) was formed.

Foraminifera species occurring in the latest Jurassic of the Polish Outer Carpathians are cosmopolitan forms, characteristic of shallow Tethys environments, including shelf areas and carbonate platforms.

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Large aggutinated foraminifera from the Line Islands (Pacific Ocean): Architecture, preferential mineral selection and geochemical test composition

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The Line Islands are situated in the central Pacific Ocean and comprise a chain of 11 atolls and coral reefs. From the northwest to southeast, the chain stretches across 2,350 km, making it one of the longest island chains in the world. The islands rank among the most isolated in the tropical Pacific (Dahl, 1991, Barrott et al., 2012) and hold a biogeographic key position for the translocation of taxa across the Pacific. As such they constitute the ultimate stepping stone for the dispersal of species from east to west and vice versa.

Because of their isolated position, large-scale surveys on foraminifera are not yet available and the foraminiferal biotas from this area has remained largely unexplored. To date, only a single publication on modern foraminifera from the Line Island region (Kiritimati) has been published and reports on 5 genera of larger symbiont-bearing and 25 genera of smaller foraminifera (Carilli and Walsh, 2012). Our preliminary survey of the sample material shows that the foraminiferal fauna from the Line Islands comprises > 200 species. Among them are several, extremely large, agglutinated benthic taxa, that are particularly abundant in specific shallow-water habitats.

We have analyzed the mineralogical composition of individual tests using light microscope and Scanning Electron Microscopy (SEM), in addition to Energy-Dispersive X-ray (EDX), and Raman Spectroscopy Microscopy to provide structural fingerprints and signatures of the composition of agglutinated tests. SEM and light microscopy were employed to document the size-range, the position, and placement of mineral particles on the tests. The size-range and shape of the agglutinated minerals was determined from light microscope and SEM pictures.

The capability of agglutinated Foraminifera to preferentially select specific particles for the construction of their tests has long attracted the attention of scientists from many disciplines. To date, however, the exact mechanisms by which some unicellular Foraminifera accomplish selectivity, remains “a complete mystery” (Bowser and Bernhard, 1993). The process of selection is initiated at the contact site between foraminiferal cell and grain surface. This suggests that the “sensory” sites for grain type recognition are located within the reticulopodial surfaces of the Foraminifera. The glycoproteinaceous-rich surfaces of reticulopodia contain powerful functional groups (Langer and Bell, 1995) that have the ability to form electrostatic or hydrogen bonds with the mineral surfaces (Bowser et al., 1984; Langer, 1992; Allen et al., 1999). Makled and Langer (2010) suggested that the electron density of specific mineral types and the formation of electric dipoles create polarized charged ends that readily interact with the reticulopodial network and favour the adsorption of specific minerals to agglutinated tests.

Here we report on the capability of these agglutinated Foraminifera to actively select specific mineral grains as building materials for test construction and document the main features accompanying their placement and arrangement in the test. We also explore the possible mechanisms involved in their selective agglutination and compare them with previous observations.

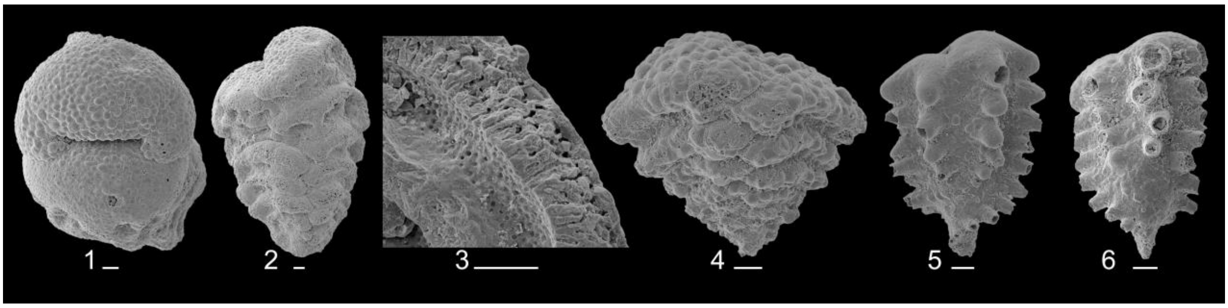

Figure 1. 1-3. *Septotextularia rugosa* Cheng and Zheng, 1978, 4. *Textularia* (?) sp., 5-6. *Siphoniferoides siphoniferus* (Brady, 1881).

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Assemblages of agglutinated foraminifera from Paleogene deposits of Western Siberia

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The West Siberian basin has formed after the Late-Carboniferous and Permian collision of the Siberian and Kazakhstan continents with the Russian craton. It is flanked by the Eastern Slope of the Ural Mountains to the west, the Kazakh highlands to the south, the Siberian platform to the east and extends north into the Kara Sea. The basins filling started in the Early Triassic when the newly formed collision structure underwent rifting, with the deposition of mainly basic and ultrabasic rocks. The rift structure, running north-south, shaped the basin's outline, a complicated elongated structure where oceanic water entered from both the north and south, and led to the deposition of marine sedimentary successions comprising Middle Triassic through Middle Paleogene clastic rocks (Akhmet'ev et al., 2010).

The Paleogene deposits are widespread in area of Western Siberia and correspond to the final stage of marine sedimentation (Iakovleva and Kulkova, 2003). Three marine main formations are distinguished in the Paleogene of central and southern part of Western Siberia. The Paleocene Talitsa Formation, the Lower and Middle Eocene Lulinovor Formation, and the Middle and Upper Eocene Tavda Foramtion. They comprise clays and mainly siliceous rocks such as diatomite, gaize, and tripolite (Smirnov and Konstantinov, 2017; Nesterov et al., 2021). Danian deposits in the Arctic region belong to the Tibeisale Formation and are represented by clay and siltstone (Bugrova, 2008; Trubin et al., 2022). The clay and biosiliceous rocks contain plenty agglutinated foraminifera, including stratigraphic markers for the Cretaceous and Paleogene deposits of the West Siberian Province. They also hold clues for palaeoecological reconstructions. We have studied agglutinated foraminiferal assemblages from four sites in the central and one site the arctic region of Western Siberia to provide a better understanding of the Paleogene depositional environment and biostratigraphy by analyzing the composition, structure, and diversity of widespread foraminiferal taxa. The material includes a total of 328 samples from the five sites in the southern Trans–Ural (near Chelyabinsk), middle Trans–Ural (Kyshtyrla quarry), northern Trans–Ural (near Uray village), and on the Yamal Peninsula (Kharasavey Oilfield). The analyzed sedimentary core materials are represented a mixture of clay, siltstone, and siliceous rocks.

A total of 40 species of agglutinated foraminifera were identified from 3570 picked specimens. The Danian Tibeisale Formation in the Arctic region contains just one infrequent species: *Ammodiscus glabratus*. The lower and middle Eocene Lulinovor Formation is represented by mainly silica rocks and houses three assemblages of Selandian, Thanetian and Ypresian age. The Selandian stage is characterized by a dominance of *Reophax inordinatus*. Assemblages of Thanetian stage are mainly composed of *Trochammina intacta*. The Ypresian stage includes rare *Technitella spiculitesta, Reophax difflugiformis, Glomospira gordialiformis, Haplophragmoides* cf. *stomatus*, *Ammomarginulina spectata*, and other taxa. The middle and upper Eocene Tavda Formation is dominated by a variety of perforate-hyaline and porcelaneous tests and agglutinated foraminifera are represented by a single species only (*Trochammina* (?) *gracilis*).

The Upper Paleocene and Lower-Middle Eocene benthic foraminiferal assemblages are dominated by «opportunistic» agglutinated taxa indicative for deep-water settings (see also Alegret et al., 2021). On the contrary, the Lower Paleocene and Middle to Upper Eocene formations contain a mixture of mainly perforate-hyaline and porcelaneous forms that are typical for more shallow-water environments.

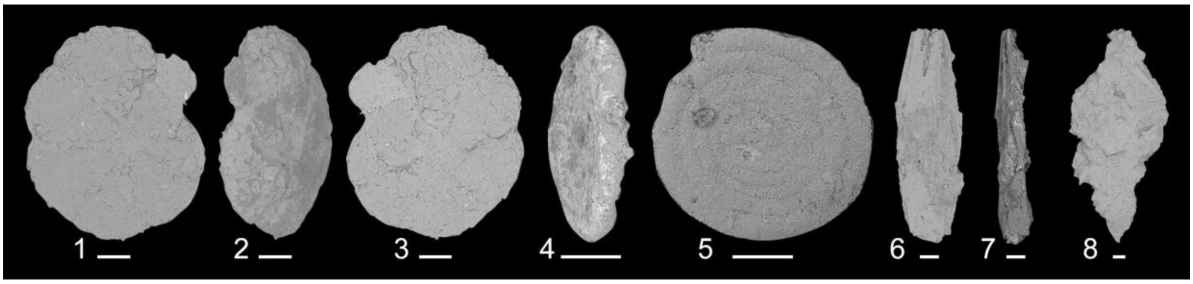

Figure 1. Paleogene agglutinated foraminifera from Western Siberia. 1-3. *Trochammina* (?) *gracilis* Lipman 1960, 4, 5. *Ammodiscus glabratus* Cushman & Jarvis, 1928, 6, 7. *Technitella spiculitesta* Bulatova, 1964, 8. *Reophax inordinatus* Young, 1951. Scale bar is 100 µm.

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Foraminiferal Organic Linings of agglutinated tests: Research challenges

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Foraminifera leave in the fossil records either mineralized tests (shells) or their organic linings. They should be treated complementary as they come from the same source of specimens represented by organo-mineral shells that just require different preparation techniques. However, the fossil archive of acid resistant organic linings is highly fragmentary, and in consequence, the overall foraminiferal record is highly biased towards mineral shells. We have made a meta-analysis of the overall published records of linings from the Paleozoic till today (Godos et al., 2021). This analysis indicates that nearly all foraminiferal linings show globular chambers with minimized distances between successive foramina (Tyszka et al., 2021). These morphologic features classify most of the multilocular organic linings into the Globothalamea class (sensu Pawlowski et al. 2013). *Tolypammina tantula* Bell assigned to the Suborder Ammodiscina is nearly the only exception identified so far in Tubothalamea (Bell and Winchester-Seeto, 1999). Its long uncoiled tubular test may suggest association with monothalamean astrorhizids, therefore, its tubothalamean assignment is still very uncertain.

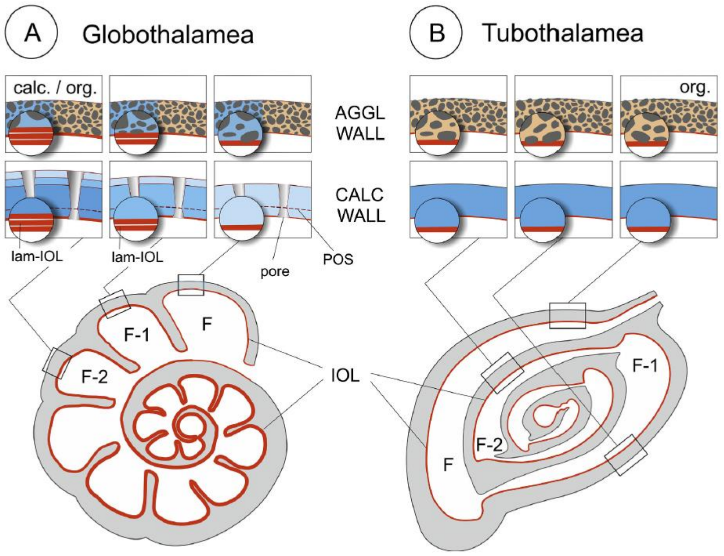

Figure 1. Inner Organic Lining (IOL) identified in cross-section of globothalamean and tubothalamean foraminiferal tests. Three final chambers are labelled from (F) to (F-2) to present schematic close-ups of their either agglutinated or calcareous walls. Globothalamean IOL tend to be thicker and more laminated in earlier chambers in contrast to tubothalamean one that is in general thinner and nonlamellar. Agglutinated globothalamean tests are composed of foreign mineral grains cemented by organic (org.) and/or calcareous (calc.) matter. Source: Tyszka et al., 2021, fig. 7 reproduced under the CC BY license.

Our question is why there is nearly no record of fossil linings that belong to Tubothalamea. Do all foraminifera produce organic linings? Are they compositionally and structurally similar? What is their taphonomic potential? All these questions encourage our interdisciplinary investigations and set crucial research targets we work on. Our overview of foraminiferal organic linings does not separate linings that come either from agglutinated or calcareous foraminiferal tests. We can assume that multichambered linings with globular chambers belong to the globothalamean foraminifera represented by the order Textulariida. This clade tends to show inner organic lining (IOL) structures analogous to calcareous tests of the same class. These linings are likely associated with the organic matrix that glue together agglutinated grains. According to Bender and Hemleben (1988) and Bender (1989), the IOL is recognized on the inner surface of the agglutinated wall and separates the wall from the cytoplasm. The IOL thickness in agglutinated foraminifera vary from 1 to 10 μm (Hedley, 1964). Bender (1992) based on observations of *Textularia* and *Valvulina* revealed that the inner organic lining was multi-layered (laminated) formed successively in association with every chamber formation .This lamination model follows the model known from calcareous globothamamean foraminifera (e.g. rotaliids) (Fig. 1).

The most intriguing is “the collagen nature” of the organic matrix identified in several species of agglutinated foraminifera. Hedley (1958), as well as Hedley and Wakefield (1967) reported a collagen-like sheath coating agglutinated tests of *Haliphysema*. Allen et al. (2000) supported these findings by comparison of glycoprotein reference standards with foraminiferal organic matrix and suggested that organic materials within the shells were similar to collagen rather than to chitin with slight variations from one species to another (Tyszka et al., 2021). *Astrammina rara* Rhumbler revealed infrared absorption spectra that was most similar to collagen (Allen et al., 2000).

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The age of the variegated Farony Shales within the Ropianka Formation (Magura Nappe, Outer Carpathians)

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A compact complex of variegated shales occurs in the lower part of the Ropianka Formation (Campanian–Paleocene) in the Magura Nappe (Bystrica Subunit). It is comprised of siliceous shales, with predominant red-coloured mudstones. The unit clearly stands out from the typical deposits of the Ropianka Formation, which are grey-green thin- and medium-bedded sandy dominated turbidites. The Farony Shales form a level several meters thick, which in the Gorce Mts. region (Szczawa-Lubomierz area) are exposed within Polish territory and extends for a distance of about 20 km. Our preliminary cartographic work indicates that its extent is in all probability much greater, and the Farony Shales can constitute a good correlation horizon in the Outer Carpathians.

The age of the Farony Shales was determined on the basis of foraminifers. Its exposures at four different locations were sampled (the total number of samples is 17 and they were collected from red and green mudstones), of which basically only a few yielded biostratigraphic results. Only agglutinated taxa were found, almost all classified as cosmopolitan long-ranging taxa. The age determinations were based on the presence *Rzehakina inclusa* Grzybowski co-occurring with numerous specimens of *Caudammina*, like *Caudammina gigantea* Geroch, *Caudammina ovula* (Grzybowski) and single *Caudammina excelsa* (Dylążanka). The share of *Caudammina* specimens, excluding tubular foraminifera was over 70%, of which *Caudammina ovula* (Grzybowski) amounting to 36.5% and *Caudammina gigantea* Geroch amounting to 34%. Such coincidences make it possible to estimate the age frame of the Farony Shales to the upper Campanian–lowermost Maastrichtian (lower part of the Rzehakina inclusa zone, zone after Olszewska, 1997). In other samples, where the taxonomic diversity was much smaller, assemblages with numerous *Placentammina placenta* (Grzybowski) and *Saccammina grzybowskii* (Schubert) specimens were found. Excluding tubular forms, the share of *Placentammina* and *Saccammina* was almost 50%. *Saccammina-Placentammina* acme assemblages in the Outer Carpathians occur in upper Campanian–Danian deposits (Waśkowska, 2021). In these assemblages, the large-sized (tentatively named) *Placentammina placenta* (Grzybowski) var. *gigantea* have a large share.

The exposures of the Farony Shales must have been known earlier. In the localities where we observed, the variegated shales were indicated on geological maps but they were included in the older strata - Malinowa Formation of Turonian–Coniacian age. The field work and detailed study of the Farony Shales were conducted by Marek Cieszkowski who was the first to identified their affiliation with the lower part of the Ropianka Formation, and the current biostratigraphic analysis confirms their late Campanian–earliest Maastrichtian age.

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Application of agglutinated foraminiferal acmes in Campanian-Eocene biostratigraphy in the Outer Carpathians

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The foraminiferal biostratigraphy is a main method used in determining the age the flysch deposits in deep water basins. Biozonations used in the Outer Carpathians (after Geroch & Nowak, 1984; Olszewska, 1997 and modifications) are based primarily on agglutinated foraminifera, as they are common, settled the floor of the flysch basin, also in conditions below the CCD. They form a durable tests that are preserved in sediments and they are easily accessible.

Parameters of the depth and other factors associated with turbidite deposition in the Outer Carpathian basins conditioned the development of benthic foraminiferal microfauna. In such environments, deep water agglutinated foraminifera developed, the vast majority of which were opportunistic and cosmopolitan. Among them short-ranging species occurred rarely and they constituted only an accessory component of assemblages, so they were not always revealed in samples. This causes difficulties in determining the age. At certain intervals there were conditions that favored the development of some species which caused their abundant occurrence, regarded to be acmes. An acme is an ecological phenomenon. Single acme zones have been applied in the biostratigraphic schemes for the Outer Carpathians, but an acme can be used much more widely and can support more biostratigraphy.

The analysis of the distribution of species abundance over time was carried out (supplementary data in Waśkowska, 2021). The foraminiferal assemblages with increased numbers of species were selected, a lower limit of abundance for an acme of a given species and its time frame of occurrence were determined. In Campanian–Eocene time interval, 19 species display significant increases in abundance within a certain time interval (see fig.). The following list specifies it in stratigraphic order with the range of the acme and their contribution to the assemblage (excluding specimens of tubular forms):

- *Caudammina gigantea* (Geroch) (upper Santonian–lowermost Maastrichtian), min. share 5%
- *Caudammina ovulum* (Grzybowski) (Campanian–Danian), min. share 3%
- *Placentammina placenta* (Grzybowski)–*Saccammina grzybowskii* (Schubert) (upper Campanian–Danian), min. share 10%
- *Caudammina excelsa* (Dylążanka) (lowermost Maastrichtian–Danian), min. share 3%
- *Caudammina ovuloides* (Grzybowski) (Danian–Selandian), min. share 3%
- *Hormosina velascoensis* (Cushman) (upper Danian–Selandian), min. share 3%
- *Praesphaerammina gerochi* (Hanzlíková) (Thanetian), min. share 5%
- *Glomospira charoides* (Jones & Parker)–*Glomospira gordialis* (Jones & Parker) (uppermost Thanetian–lowermost Ypresian), min. share 20%
- *Trochammina* spp. (upper Thanetian–lower Ypresian), min. share 20%
- *Reticulophragmium amplectens* (Grzybowski) (Lutetian–Bartonian), min. share 10%
- *Reophax duplex* (Grzybowski)–*Reophax "pilulifer"* Brady group of taxa (Lutetian–Priabonian), min. share 5%

- *Haplophragmoides walteri* (Grzybowski)–*Haplophragmoides nauticus* Kender, Kaminski & Jones (Lutetian–Bartonian), min. share 5%
- *Spiroplectammina spectabilis* (Grzybowski) (Lutetian–Priabonian), min. share 5%
- "*Ammodiscus" latus* Grzybowski (Bartonian–Priabonian), min. share 4%
  Praesphaerammina subgaleata (Vašícek) (Lutetian–Bartonian), min. share 20%.

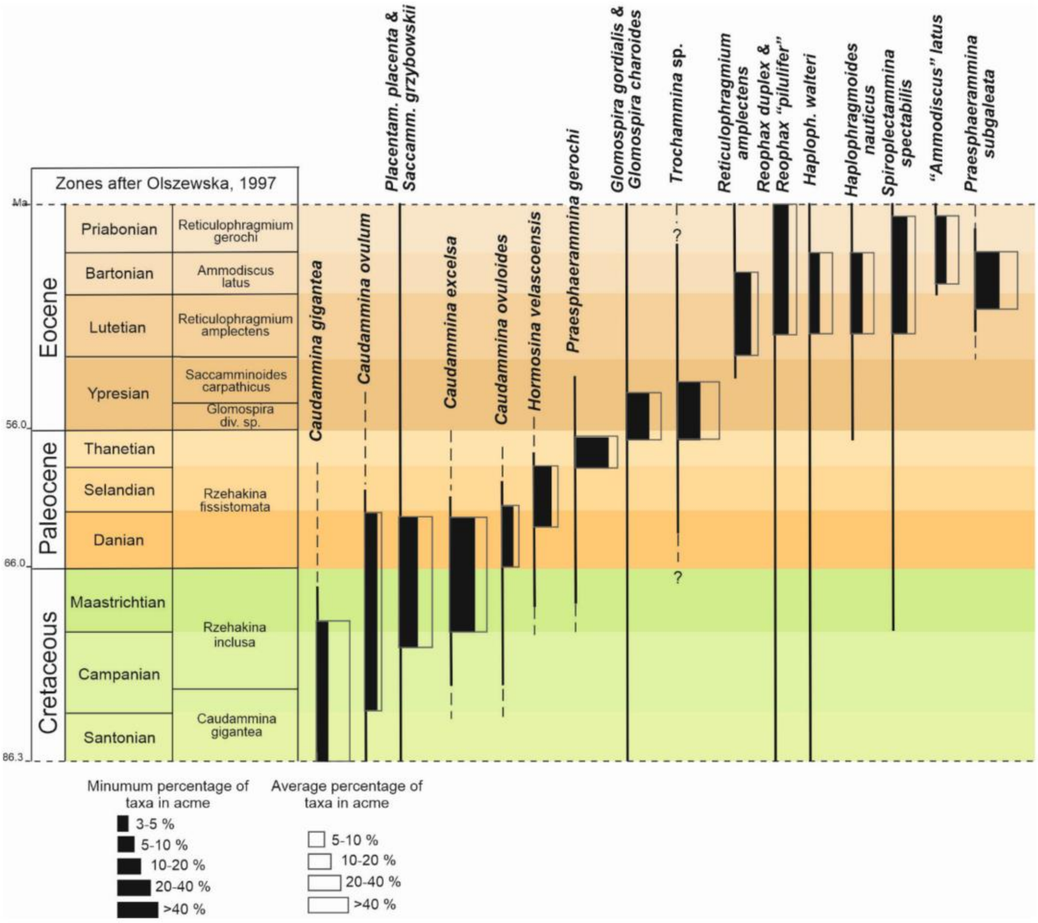

Figure 1. Biostratigraphical scheme of distribution of taxa acmes in the Outer Carpathians (after Waśkowska, 2021).

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Agglutinated Foraminifera, Where Dost Thou Go?

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Previous musings regarding the theoretical influence of foraminiferal habitat depths on abundances (Loubere, 1989) suggested that epifauna will have constant abundances in the sediment column, while infauna will increase in abundance down to their typical depth habitat and thereafter remain constant. This has not, however, been tested rigorously, studies typically collecting only single samples from horizons. Without the use of separate statistical replicates, the words ‘more’, ‘less’ and ‘constant’ are subjective observations that lack rigorous inferential meaning.

Some authors have suggested from non-replicated samples that there is a loss of agglutinated foraminifera with depth due to the decay of organically cemented individuals (Loubere and Gary, 1990; Schröder, 1986). Others have suggested that infaunal forms generally increase in relative abundance downcore (Kuhnt et al., 2000), *Karrerulina apicularis* being an important constituent at depths >10 cm. This latter suggestion implies that habitat preference is as important as wall type in the preservation of deep-sea agglutinated foraminifera. Here we compare the distributions of the supposedly epifaunal *Glomospira gordialis* and the suggested infaunal *K. apicularis* using replicates.

Ocean Drilling Program (ODP) Site 925 (Ceara Rise) lays beneath surficial North Equatorial Counter-Current (NECC), which seasonally extends from 3–10°N. The Site lays well above the carbonate lysocline. We collected four replicates of 4 g each from the uppermost Quaternary of ODP Hole 925E (4°12.257'N, 43°29.337'W; water depth 3040.5 m).

Sample slices 1.5 cm thick (half the 6 cm-diameter core) were taken from four horizons 3 cm apart, from 4–14.5 cm below the seafloor (cmbsf). The horizons were numbered 1–4 (shallowest to deepest). Each replicate was soaked in water, washed over a 63 µm sieve, and dried at ~80°C. The residue was picked clean of benthic foraminifera. All planktonic foraminiferal assemblages contained abundant *Menardella menardii*, and so are presumed to have come from Holocene Biozone Z.

Our use of replicates shed light on the following questions:

1. Does the total (agglutinated + calcareous) benthic foraminiferal assemblage decrease in absolute abundance with depth below the seafloor?
2. Does the proportional abundance of the total assemblage as agglutinated specimens change with distance below the seafloor?
3. Do the absolute abundances of *G. gordialis* and *K. apicularis* change with distance below the seafloor?

A total of 2512 benthic foraminifera were recovered from the 16 replicates (range = 51–257, $\bar{x}$ = 157). These were placed in 98 taxa (species), with 28 left in open nomenclature. Twenty-seven species had agglutinated walls. Almost half the taxa were rare, 20 being singletons and 46 represented by $\leq$4 specimens. Total recovery was dominated by *G. gordialis* (11.9%), with subdominant, calcareous *Ioanella tumidula* (10.4%). *Karrerulina apicularis* formed 3.2% of the total recovery, while agglutinated species together formed 29.2% of the entire recovery.

The mean proportion per horizon as agglutinated foraminifera (range = 0.26–0.33) was not significantly correlated with mean horizon depth (Spearman’s r = –0.8, P = .33), though the means for the uppermost horizon were almost equivalent (0.332 and 0.335) and that in the deepest horizon was lowest (0.209). The agglutinated:calcareous specimen ratio [range 0.266 (Horizon 4) – 0.521 (Horizon 1)] was negatively correlated with sample depth (r = –0.97, P = .0.04). For the totals of all forams, χ^2 = 12.01, P =.007, df = 3, indicating that the totals decrease with depth, but in two groups (Horizons 1 + 2 and Horizons 3 + 4). The agglutinated (χ^2 = 23.196, P = .004, df = 3) and calcareous (χ^2 = 8.91, P = .031, df = 3) groups showed the same pattern of paired horizons.

The mean abundance for *G. gordialis* decreased with depth from 26.50 specimens per replicate (spr) at Horizon 1 to 11.25 spr at Horizon 4, with 27.50 spr at Horizon 2. Analysis of variance indicated the means at two horizons at least differ significantly ($F_{3,12}$ = 10.806, P = .001). For this species only Horizons 1 and 4 are statistically significantly different, making it appear that, as with the agglutinated:calcareous ratio, there are two homogenous subsets (Horizons 1 + 2 and Horizons 3 + 4). There is thus not a simple linear decrease over depth. The mean abundance of *K. apicularis* decreased with depth from 8.5 spr at Horizon 1 to 1.75 spr Horizon 4 ($F_{3,12}$ = 6.218, P = .009). For this species Horizon 1 is significantly different from both 3 and 4.

Likelihood ratio tests show that, among the calcareous assemblage, there is no significant change in the absolute abundances of the commonest species (*I. tumidula*, *Globocassidulina subglobosa*, *Osangularielloides rugosa*, *Gyroidina subtenera*) between the grouped horizons 1+2 and 3+4. This suggests that there was no major palaeoenvironmental change throughout the section examined. We thus conclude that the change in the abundances of *G. gordialis* and *K. apicularis* are due to taphonomy and not to either palaeoenvironmental change or microhabitat.

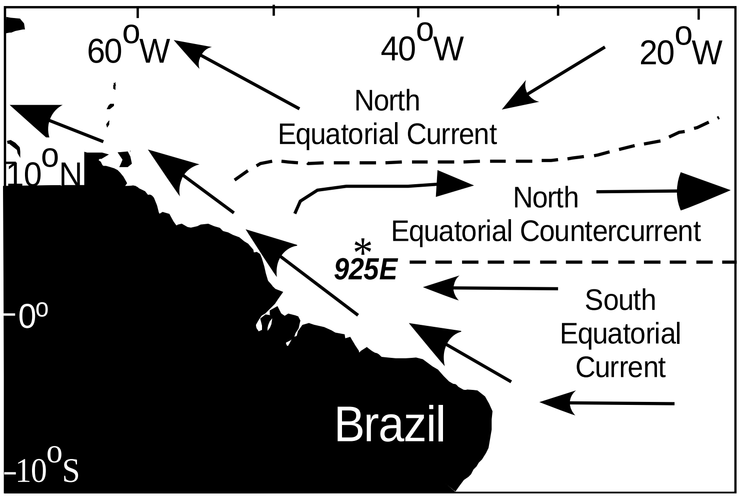

Figure 1. The location of ODP Hole 925E.

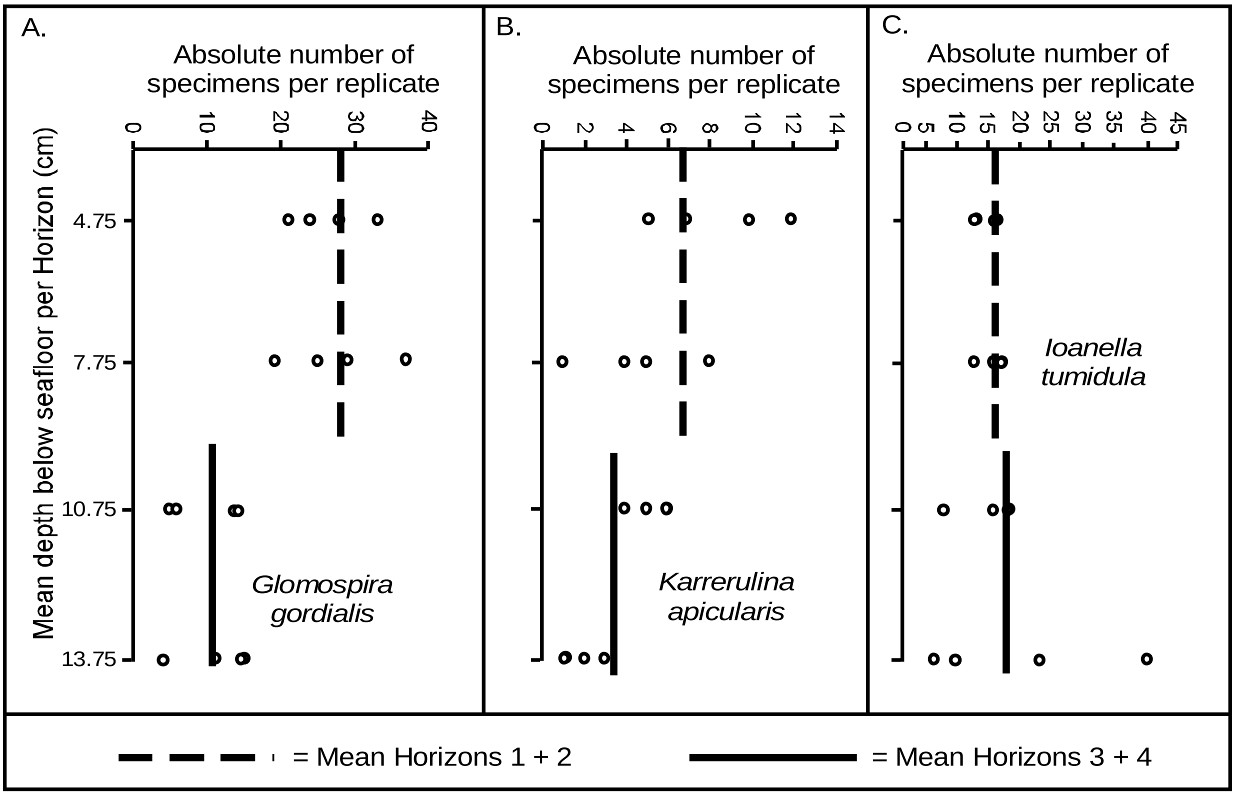

Figure 2. Absolute numbers of specimens per replicate (open circles) and means for horizons 1+2 and 3+4. *A. Glomospira gordialis. B. Karrerulina apicularis. C. Ioanella tumidula.*

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Thanks are due to the Ocean Drilling Program for providing the samples used in this study.

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Cretaceous agglutinated Foraminifera of the Australo-Antarctic Gulf, IODP Site U1512

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IODP Expedition 369 (Australia Cretaceous Climate and Tectonics) drilled an approximately 690 m thick Santonian to Turonian succession (nannofossil zones CC 17-CC 10) at Site U1512 in the Great Australian Bight. Site U1512 was drilled aiming at understanding the paleoceanographic evolution of the Southern Australian realm during the final stages of the breakup of Eastern Gondwana and to help document the Late Cretaceous climate evolution in the Southern High Latitudes (SHL) (Huber, 2019). The formation of the Australo-Antarctic Gulf was characterized by rapid subsidence from the Albian onwards. The data recovered at Site U1512 give valuable insight into the palaeoecological setting in the Australo-Antarcric Gulf during the early to intermediate stages of the Australia/Antarctica breakup and the gradual opening of the Australo-Antarctic Gulf (Wainman et al., 2019).

At Hole U1512A, 73 cores drilled to a depth of 3070.9 m were recovered (Huber et al., 2019). For this study, we analyzed one sample per core in every other core segment (i.e., 20 cc of core segment W1 every core). Core samples were taken at the IODP core repository at Texas A&M University (College Station, TX). The samples were disaggregated by boiling in soap solution and sieved over a 45 μm sieve. Microfossils were picked from the <125 μm fraction.

A unique, well-preserved record of benthic foraminifera of the Cretaceous southern high latitudes (predominantly composed by deep water agglutinated foraminifera, DWAF), offers insights into a complex and constantly changing marginal marine paleoenvironment. While agglutinated foraminifera are dominant throughout, calcareous benthic foraminifera are frequently recovered from the early to mid-Turonian as well as Santonian strata. Hole U1512A yields highly abundant radiolaria from the mid Turonian onwards – in the younger core segments, the share of radiolaria of the total microfossil assemblage often exceeds 50%. A benthic foraminiferal biostratigraphic framework of Site U1512 was correlated to nannofossil zones CC10c–CC16/17), planktonic foraminiferal biostratigraphy (identifying *Helvetotruncana helvetica*, the *Falsotruncana maslakovaa–H. helvetica*, and *Marginotruncana scheegansi–Planoheteroheli papula* zones) and identifies the calcareous benthic *Gavelinella eriksdalensis*-, *Pleurostomella*- and *Notoplanulina*- associations, as well as the agglutinated *Bulbobaculites problematicus* and *Uvigerinammina jankoi* zones. The latter can be correlated to Tethyan agglutinated foraminiferal zonations (Geroch and Nowak, 1984, Huber et al., 2019; Kaminski et al., 2020; MacLeod et al., 2020 Wolfgring et al., 2021).

Over 180 taxa were identified (126 agglutinated and 54 calcareous), the most common elements of the deep-water agglutinated foraminifera (DWAF) assemblage are tubular (i.e., *Kalamopsis grzybowskii*, *Bathysiphon* spp, *Ammodiscus* spp.) and planispiral forms (i.e., *Haplophragmoides* spp., *Buzasina* sp., *Labrospira* spp.).

The total abundance of tubular agglutinated taxa that show an epifaunal habitat preference in relation to the entire assemblage peaks just before we record an increase in the abundance of radiolaria in the mid Turonian. Generally, the abundance of tubular agglutinated foraminifera and radiolaria correlates negatively through Hole U1512A.

Another frequent element in the DWAF assemblage is the genus *Haplophragmoides* that represents between 20 and 40% of the benthic foraminiferal assemblage. The occurrence of this species seems particularly common in intervals with higher terrestrial influx. Like many agglutinated foraminifera, the agglutinated taxa at Site U1512 suffered from preservational issues. In addition to effects during early diagenesis, like the degradation of organic cement, especially delicate planispiral taxa, like *Haplophragmoides*, experienced intense deformation of chambers, sometimes affecting the correct identification of taxonomically relevant features.

The assessment of foraminiferal assemblages together with the evolution of other fossil groups (Radiolaria in particular) indicates unstable conditions at Site U1512 during the early Turonian-Santonian. A quantitative analysis of the benthic foraminiferal assemblage indicates changes in paleobathymetry and instable patterns in ocean circulation, creating a restricted paleoenvironment in the Australo-Antarctic Gulf during Late Cretaceous times that was influenced by the interplay of accelerated subsidence of the basin, variations in terrestrial runoff of the vast Ceduna river system to the north, thus illustrating a paleoenvironment with alternating dominant marine and terrestrial influences (Huber et al., 2019, Wolfgring et al., 2021).

Material recovered at IODP Site U1512 presents a unique record of a DWAF community from the Southern High Latitudes. The highly diverse DWAF assemblage yields many new taxa that are yet to be described. Agglutinated foraminiferal communities of Site U1512 can help learn about the paleoclimatic development of the Australo-Antarcric Gulf and the evolution of marginal marine basins during the Cretaceous hothouse.

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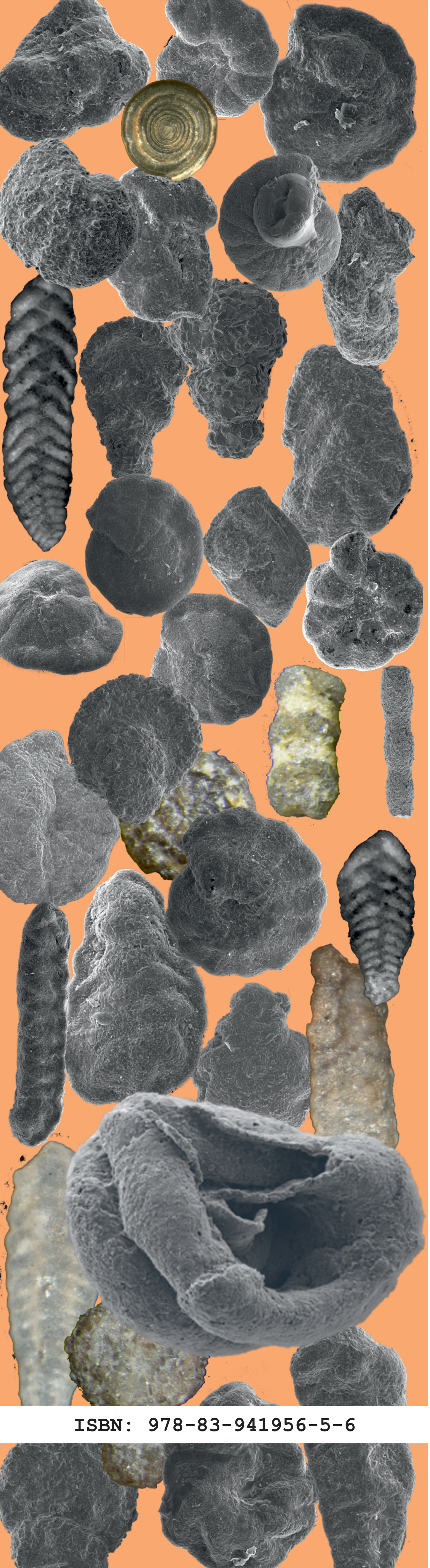

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