From normal marine to extreme environments: A Micropaleontological Perspective

The Micropalaeontological Society's
Joint Foraminifera and Nannofossil Meeting

University of Fribourg, Switzerland
1st – 4th July 2019

The Micropalaeontological Society

UNI FR
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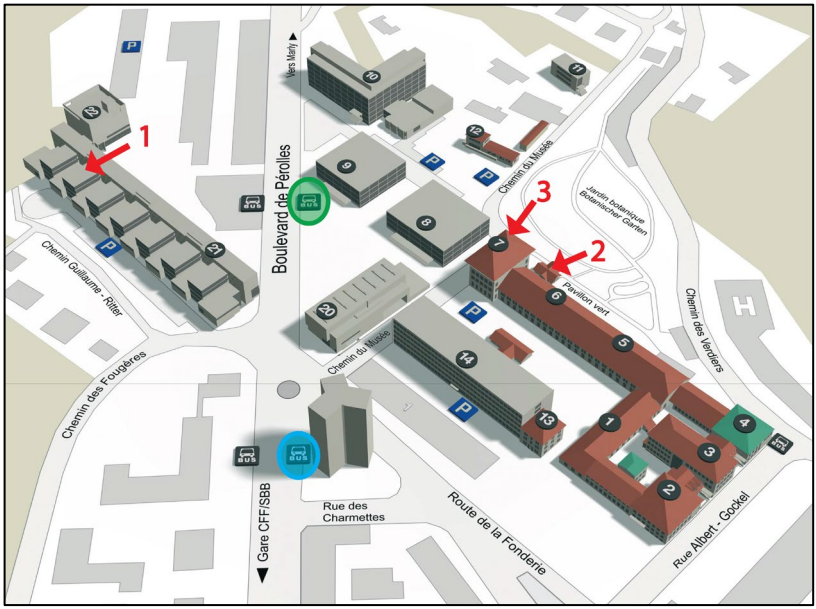
FNSNF
FONDS NATIONAL SUISSE
DE LA RECHERCHE SCIENTIFIQUE

Local Organising Committee
Dr. Silvia Spezzaferri
Stephanie Stainbank
Valentina Beccari

Scientific Committee
Dr. Silvia Spezzaferri
Prof. Martin Langer
Prof. Roberto Rettori

UNIVERSITY OF FRIBOURG PEROLLES CAMPUS MAP



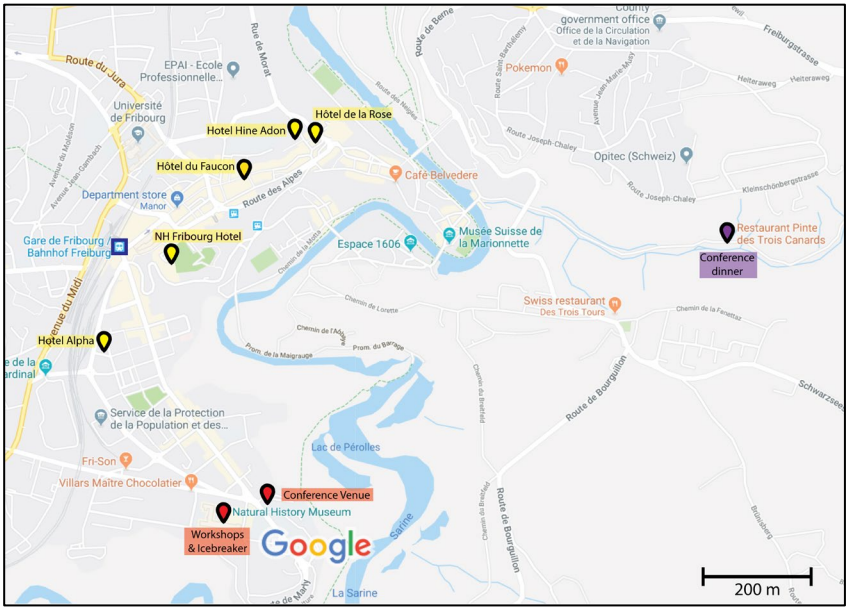
Location 1 (46.793784, 7.160430)
Conference Venue at Boulevard de Pérolles 90 (Building No. PER22), Auditorium G120, 1st floor.

Location 2 (46.792921, 7.156759)
Icebreaker party and early registration at the Pavillion Vert in the Botanical Gardens on the 1st of July at 17h30.

Location 3 (46.793111, 7.157101)
Workshop Venues at Department of Geosciences, University of Fribourg, Chemin du Musée 6 (Building No. PER07) on the 1st of July.

Bus stops from the city center main station (Fribourg Gare) are shown in blue **(Fribourg, Charmettes)** and green **(Fribourg, Plateau-de-Pérolles)**. Both can be reached using Bus lines 1 and 3 from the main station.

CONFERENCE DINNER AND HOTEL LOCATIONS



Date: Wednesday, 3rd July 2019
Time: 19:30 pm
Restaurant: Restaurant Pinte des Trois Canards, Chemin du Gottéron 102, 1700 Fribourg.

For those who wish to take the scenic walk to the restaurant, we will be meeting downstairs, outside the conference venue at 18h15. It is approximately a 3.6km walk and will take approximately 45 minutes.

Otherwise, you can take **Bus No 4 (Orange line_direction Auge Sous-Pont**) from the back of the main station (Fribourg, Gare), **platform 12.** Go for six stops to **Fribourg, Palme**, from where it is a 15min, 1km walk along the valley (Chemin du Gottéron) to the restaurant. Unfortunately, no buses go directly to the restaurant. If you want, however, there are taxis at the Fribourg Gare, which can take you directly there.

PROGRAM

TMS Workshops Program

Department of Geosciences, Earth Science, Chemin du Musée 6, 1700 Fribourg
Rooms: Auditorium 1.309 and room 1.311, 1st floor

Monday 1st July, 2019 - All Day Workshops

Workshop 1&2 **Biomonitoring: from FOBIMO protocols to microplastics**
Conveners: *Michael Martinez-Colon*, Florida A&M University
Hidetaka Nomaki, JAMSTEC, Japan

Session 1 **Biomonitoring with benthic foraminifera**
Organizers: *Michael Martinez-Colon*, Florida A&M University
Silvia Spezzaferri, University of Fribourg

This workshop aims to bring together researchers involved in environmental bio-monitoring using benthic foraminifera. This will provide state of the art knowledge exchange between participants and will also bring forward current findings in Eastern North Atlantic and European Arctic. The session will promote not only new ideas but will also address the Gulf of Mexico initiative for foraminiferal census data and species assignment criteria (Foram-AMBI). Invited talks will be given by participants engaged in ongoing research from other ocean basins (e.g., Mediterranean) in deep to coastal water environments.

8h20-8h25	Introduction and logistics
8h25-9h00	Activities in USA and potential FOBIMO Website (Martinez Colon M.)
9h00-9h40	Keynote Presentation - "Epiphytic foraminifers as a tool to assess the environmental health of seagrass meadows in the Mediterranean domain" ***Guillem Mateu Vicens****,* University of the Balearic Islands, Spain
9h40 -10h25	Keynote Presentation - "The Development and Implementation of the Foram-AMBI for the Gulf of Mexico" ***Patrick Schwing****,* University of South Florida, USA
10h25-11h00	*Coffee Break*
11h00-11h30	Comparison of four foraminiferal indices assessing the environmental quality of coastal Mediterranean soft bottom environments (Parent B., *Jorissen F.J.*)
11h30-12h30	Discussion
12h30-14h00	Lunch
14h00-15h00	Discussion

Session 2 **A new threat for marine environments and foraminifera: micro- and nano-plastics**
Organizers: *Hidetaka Nomaki*, JAMSTEC, Japan, *Fabrizio Frontalini*, Urbino University, Italy, *Vincent Bouchet*, University of Lille, France, *Dewi Langlet*, University of Lille, France, *Masashi Tsuchiya*, JAMSTEC, Japan

Microplastics and nanoplastics pollutions have affected many marine environments from coastal to pelagic settings, shallow water to deep trench, and tropic to polar regions. Micro- and nanoplastics have been also reported as serious threats for many marine organisms including foraminifera, though their effect is largely unknown. For instance, they can be integrated into the cell and generate measurable stresses at individual level. Lethal and sub-lethal effects of these small particles need however further experimental studies. Furthermore, the methods used to investigate microplastics in oceanic samples share a significant affinity to the conventional micropaleontological analyses: samplings of seawater or sediments, density separation if necessary, sieving with particular mesh sizes, and isolation/identification under binocular microscopes. Microplastics thus appears in our recent foraminiferal samples as well, and may be useful indicators for environmental pollutions, sedimentation age, and so on. Our archival samples of marine sediments and plankton nets may provide important historical record of pollutions. This workshop aims to share current knowledge on microplastics including the identification methods, and present a wide spectrum of researches (environmental, palaeo-environmental and experimental) on foraminifera and micro- and nanoplastics as well as the absorptions' pathways, and discuss future collaborations on this topic.

15h00 -15h15 General introduction on marine microplastics (*Nomaki H.)*

15h15 -15h35 Agglutinated foraminifera and micro plastics (*Tsuchiya M.*)

15h35-16h00 *Coffee Break*

16h00- 16h20 Physiological effects of nano-plastics on foraminifera (*Bouchet V.)*

16h20 - 16h40 Effects of microplastic leachates on the behavior of benthic foraminifera (*Langlet, D.)*

16h40 - 17h00 Transport of benthic foraminifera attached on plastics (*Jorissen, F.)*

17h00 - 17h35 General discussions and closing remarks

Workshop 3 **Neogene nannofossil taxonomy and biostratigraphic advancements**
Organizers: *T.M.S. Nannofossil Group*

The TMS Nannofossil Group are delighted to welcome Eric de Kaenel to present an overview of the BP Neogene Gulf of Mexico biostratigraphic framework, including taxonomic concepts and ranges of biostratigraphically important taxa from the Neogene Period. This workshop will provide a unique opportunity for participants to delve into and discuss the extensive framework, which has been developed through decades of detailed analysis and research, and was long-held internal by BP and its heritage companies.

The workshop aims to bring together those interested in understanding and advancing the application of Neogene nannofossil biostratigraphy, both within the Gulf of Mexico sections and beyond. There will be plenty of time for constructive and insightful discussion of the biostratigraphic framework presented, and of advancements and challenges of Neogene taxonomy and biostratigraphy more generally. This workshop is open to all nannofossil enthusiasts; academic, industrial and student.

14h00-15h00 Keynote Presenation - "Neogene nannofossil taxonomy and biostratigraphic advancements"
Eric de Kaenel*,* Switzerland

15h00-15h35 *Discussion*

15h35-16h00	*Coffee Break*
16h00-16h45	Nannotax *(Young J.)*
16h45-17h30	*General Discussion*
17h00	**Ice Breaker Party and Registration at the Pavillon Vert in the Botanic Garden.**

TMS Program
Tuesday, 2nd July 2019, TMS Meeting
Boulevard de Pérolles 90, Building PER22, Room G120, 1st floor

08h00	Registration for late arrivals
08h40–09h00	Opening remarks and logistics – S. Spezzaferri
Chair person:	**Joachim Schönfeld**
09h00–09h40	Keynote Presentation – Are methane seep sites "extreme environments" for foraminifera? Insights from the Arctic ***Giuliana Panieri*****,** University of Tromsø, Norway
09h40-10h00	Benthic foraminifera as tracers of brine production in the Storfjorden "sea-ice factory" *Fossile, E., Mojtahid, M., Howa, H., Lansard, B., Michel, E., Peron, O., Jouini, A, Demol, M.,* and *Nardelli, M.P.*
10:00–10:20	The impact of fish farming in an arctic fjord investigated using geochemical parameters and benthic foraminiferal assemblages *Klootwijk, A.T., Alve, E., Sørlie, C., and Hess, S.*
10h20-10h40	Unity makes strength: high contribution of intertidal benthic foraminifera to sediment reworking *Deldicq, N., Seuront, L.,* and *Bouchet, V.M.P.*
10:40-11:20	*Coffee break and Discussion at the Poster Session*
Chair person:	**Francesca Lozar**
11h20-11h40	Organic carbon rich sediments: benthic foraminifera as bio-indicators of depositional environments *Lo Giudice Cappelli, E., Clarke, J.L., Smeaton, C., Davidson, K.,* and *Austin, W.E.N.*
11h40-12h00	Microfossil analysis of cave sediments: Corbridge Cave, Berry Head, Devon *Hart, M.B., Proctor, C.J.,* and *Smart, C.W.*
12h00-12h20	The invasion of *Amphistegina lobifera* in Marsamxett harbour (Malta) - part II: an early invasion interrupted by a far-generated tsunami *Guastella, R. Marchini, A., Caruso, A., Cobianchi, M., Evans, J., Langone, N.,* and *Mancin N.*
12h20–14h00	*Lunch break*

Chair person: **Giovanni Coletti**

14h00–14h40 Keynote Presentation – Measuring the impact of extreme environments on Calcareous Nannofossil assemblages: the case of the Messinian salinity crisis
Francesca Lozar**,** University of Turin, Italy

14h40-15h00 Factors affecting planktonic foraminifera carbonate mass fluxes in the Cap Blanc upwelling area (Atlantic Ocean)
Kiss, P., Jonkers, L., Hudáčková, N., and *Kucera, M.*

15h00-15h20 Marine plankton response to the last deglaciation extracted from the fossil record
Strack, A., and *Kucera M.*

15h20-16h00 *Coffee break and Discussion at the Poster Session*

Chair person: **Martin Langer**

16:00-16:20 Calcareous Nannofossil assemblage highlight the differences between cyclicals and stochastics sapropels in the Sorbas basin
Mancini, A.M., Gennari, R., and *Lozar, F.*

16:20-16:40 Foraminifer, diatom and calcareous nannofossil multiproxy paleoceanography: an example from a Late Miocene diatomaceous deposit of the Northern Mediterranean
Gennari, R., Lozar, F., Pellegrino, L., Carnevale, G., and *Jordan, R.W.*

16:40-17:00 The Late Pliocene-Pleistocene foraminiferal and nannofossil stratigraphy of the Ioffe Drift, Western South Atlantic
Ivanova, E., Dmitrenko, O., Borisov, D., and *Ivar Murdmaa I.*

17h00-17h20 US Atlantic Coastal Plain ecosystems prior to and during the PETM
Doubrawa, M., Stassen, P., Robinson, M. M., Babila, T. L., Zachos, J. C., and Speijer, R. P.

17:20-18:30 *Guided Poster Session*

Wednesday, 3rd July 2019, TMS Meeting

Boulevard de Pérolles 90, Building PER22, Room G120, 1st floor

Chair person: **Hidetaka Nomaki**

08h40–09:20 Keynote Presentation – Sequencing biostratigraphy for transcribing past environments
Joachim Schönfeld, GEOMAR-Kiel, Germany

09:20-09:40 Marine Alien Foraminifera in Europe: The Current Status of the EU Marine Strategy Framework Directive
Langer, M., and *Stulpinaite, R.*

09:40–10:00 Modeling benthic foraminiferal microhabitats
Jorissen F., Meyers, S.R., and *Kelly-Gerreyn, B.A.*

10h00-10h20 Does coastal management affect salt-marsh resilience? A comparison of natural and anthropogenic impacts
Bunzel, D., Müller-Navarra, K., Milker, Y., Kathrin Hofman, L., and *Schmiedl G.*

10h20-11h20 Coffee break and Discussion at the Poster Session

Chair person: Giuliana Panieri

11h20-11h40 The Maldives coral reefs: are they under threat?
Beccari, V., Stainbank, S., Hallock, P., Basso, D., Fau, M., Spezzaferri, S., and the *CUSO ESPP Maldives Scientific Party.*

11h40-12h00 Symbiont-Bearing Foraminifera from the Agbada Formation in the Niger Delta: Paleoenvironmental and Paleobiogeographic Implications
Fajemila, O., and *Langer, M.*

12h00-12h20 High-diversity foraminiferal assemblages from coastal mangrove habitats in northern Brazil: Adaptive capacities and resilience under conditions of environmental stress
Sariaslan, N., and *Langer, M.*

12h20–14h00 Lunch break

Chair person: Ahuva Almogi Labin

14h00-14h20 The southernmost occurrence of lepidocyclinids from the Pacific coast of South America: the Los Choros Member (Paracas Formation, East Pisco Basin, southern Peru)
Coletti, G., Collareta, A., Bosio, G., Bracchi, V., Malinverno, E., Stainbank, S., Spezzaferri, S., Basso, D., Claudio Di Celma, C., and *Bianucci, G.*

14h20-14h40 Geochemistry of *Nummulites* as a proxy for Eocene paleotemperature evolution in the southern North Sea Basin
Martens, L., Stassen, P., Steurbaut, E., and *Speijer, R. P.*

14h40-15h00 Foraminifera as tool for biostratigraphic cross-correlation of major oilfields in the Vienna Basin
Kranner, M., Harzhauser, M., Mandic, O., Piller, W. E., Strauss, P., and *Siedl, W.*

15h20-16h00 *Coffee break and Discussion at the Poster Session*

Chair person: Michael Martinez-Colon

16h00-16h20 Modelling foraminiferal pore patterns: how to reconciliate gas exchanges and test robustness
Richirt, J., Champmartin, S., Schweizer, M., Mouret, A., Petersen, J., Ambari A., and *Jorissen F. J.*

16h20-16h40 Forecasting temperature-related extinctions
van Dijk, J., and *Steinbauer, M.*

16h40-17h00	Metabarcoding reveals putative interactions between sediment bacteria and deep-sea benthic foraminifera *Salonen, I., Chronopoulou, P.-M., Langlet, D., Nomaki, H., Tsuchiya, M.,* and *Koho. K.*
17h00-18h15	*Guided Poster Session*
19h30	**Conference Dinner** at the Pinte des trois Carnard in the Gotteron Valley, with explanation of the geology of Fribourg and the Gotteron Valley on the way there

Thursday, 4th July 2019, Excursion

8h30	Leaving Fribourg - Meeting point in front of the Department of Geosciences, Chemin du Musée 6. On the way an overview of the local geology and the suggestive Swiss Pre-Alps landscape will be given
9h00	Arrival at Jaun Pass and visit the pelagic Jurassic to Eocene session with analyses of hand samples.
12h00	Leaving to Gruyères, packed lunch, and visit of the town
13h45	Leaving Gruyères
14h30	Arrival at the Maison Cailler with chocolat degustation

Return to Fribourg

POSTERS

Benthic foraminifera and cold seep macrofauna associations
Beccari, V., Basso, D., Almogi-Labin, A., Hyams-Kaphzan, O., Weissman, A., Makovsky, Y., Rüggeberg A., and *Spezzaferri S.*

Heterotrophic foraminifera capable of inorganic nitrogen assimilation
Bird, C., LeKieffre, C., Jauffrais, T., Meibom, A., Geslin, E., Filipsson, H.L., Maire, O., and *Fehrenbacher, J.*

Recent agglutinated foraminifera from the North Adriatic Sea: What the agglutinated tests can tell"
Capotondi, L., Mancin, N., Cesari,V., Dinelli, E., Ravaioli, A., and *Riminucci, F.*

The evolution of Lower Cretaceous foraminifera in the North Sea basin and surrounding regions – Perspectives from the Central Graben [Danish sector]
Castañeda, J.P., Boomer, I., Edgar, K.M., and *Bailey, H.W.*

First record of foraminiferal faunas associated to *Haploops* settlements on the French Atlantic coast
Champilou, JB., Nardelli, M.P., Barras C. Jorissen, F., Mouret, A., Maillet, G.M. A. Baltzer, A., Rousset, JM. Reynaud, M., and *Metzger, E.*

The coral reef-dwelling *Peneroplis pertusus* brought to light: recalcification during culture experiments
Charrieau, L.M., Toyofuku, T., Nagai, Y., and *Fujita, K.*

Cyclicity in foraminifera assemblages and lithological variability, Upper Turonian, Bohemian Cretaceous Basin
Chroustová, M., Holcová, K., and *Hradecká, L.*

Distribution of benthic foraminifera in the allocated zone for aquaculture of Thermaikos Gulf (north Aegean Sea)
Delliou, A.-V., Antoniadou, C., and *Chintiroglou, C.-C.*

Impact of bottom currents on benthic foraminiferal assemblages in a cold-water coral environment: the Moira Mounds (North-east Atlantic)
Fentimen, R., Lim, A., Foubert, A., Rüggeberg, R.,Wheeler, A.J., and *Van Rooij, D.*

Ecological characterization of the Elbe Estuary (Northern Europe) and the applicability of foraminifera-based transfer functions for relative sea-level reconstructions
Francescangeli, F., Milker, Y., Bunzel, D., and *Schmiedl, G.*

Presence and distribution of non-indigenous foraminifera species on hard substrates on the Israeli shelf
Fröch, L., Enge,A.J., Heinz, P., and *Albano, P.G.*

Benthic foraminifera from the Peruvian oxygen minimum zone show a metabolic preference for nitrate over oxygen as an electron acceptor
Glock, N., Roy, A.-S., Romero, D., Wein,T., Weissenbach, J., Revsbech, N.P., Høgslund, S., Clemens, D., Stefan Sommer, S., and *Dagan T.*

Living on the edge: intertidal foraminifera at the 78°N, Central Spitsbergen
Golikova, E., Mikhailov, D., Voltsky, I., Varfolomeeva, M., and *Korsun, S.*

Glacial/interglacial CO_2 changes on coccolithophore physiology in the tropical Atlantic ODP 925 and 929 across the MIS 12 to MIS 10
González-Lanchas, A., Stoll, H.M., Flores, J.- A., Hernandez-Almeida, I., and *Sierro, F.J.*

Benthic foraminifera in Contourite Drift Systems
Grunert, P., Saupe, A., and Schmidt, J.

Sensitivity of coccolithophores and adaptation to selective pressures during the Oligocene - Early Miocene
Guitián, J., Dunkley-Jones, T., Loffel, T., and *Stoll, H.*

Developing micropaleontological proxy indicators of growth rates
Hernandez-Almeida, I., and *Stoll, H. M.*

Variations in dissolved bottom water oxygen concentrations of the intermediate equatorial Pacific over the last 140,000 years
Hoogakker, B., Day, C., and *Leng, M.*

Deep Sea benthic foraminifera define biohabitats in the southeastern Levantine Basin, eastern Mediterranean
Hyams-Kaphzan, O., Lubinevsky, H., Tom, M., Herut, B., and *Almogi-Labin, A.*

Micro- and nannofossils for provenance analysis of artworks – A new method of extraction and data cross-linking
Jaques, V., Holcová, K., Hradilová, J., and *Hradil, D.*

The long-term Miocene to Pliocene transition in calcareous nannofossil assemblages
Jones, A.P., and *Dunkley Jones, T.*

A 167 million-year record of ontogenetic disparity in planktic foraminifera
Kendall, S., Ball, A., Huber, B., Cunningham, J., and *Schmidt, D. N.*

Occurrence of bacterial biofilms on foraminifera tests from Serravalian Stage, Miocene of Slovakia
Kerkhoff, M.L.H., and *Holcová, K.*

Foraminiferal distribution, nitrogen metabolism and their contribution to biogeochemical cycles in the hypoxic Bering Sea
Langlet, D., Riso, R., Bouchet, V.M.P., Fujiwara, Y., and *Nomaki, N.,*

Ammonium and nitrate assimilation in benthic foraminiferal cells: NanoSIMS observations and enzymatic pathways
LeKieffre, C., Jauffrais, T., Lothier, J., Limami, A.M., Bernhard, J.M., Cukier, C., Roberge, H., Schmidt, C., Filipsson, H.L., Maire, O., Panieri, G., Meibom, A., and *Geslin, E.*

The invasion of *Amphistegina lobifera* in Marsamxett harbour (Malta) - part I: current invasion dynamic triggered by climate change
Mancin, N., Guastella, R., Caruso, A., Cobianchi, M., Evans, J., Langone, L., and *Marchini A.*

Implementation of the Foram Index in tropical coral reefs from Puerto Rico
Martinez-Colon, M., Rosa-Marin, A., Jagoe, C., Dieppa-Ayala, A., and *Woodley, C.*

Neogloboquadrina pachyderma distribution during the late Quaternary deglaciation phases of the western Ross Sea (Antarctica)
Melis, R., Colizza, E., Mezgec, K., Torricella, F., Di Roberto, A., and *Capotondi, L.*

New data for the biostratigraphy of the Late Cenomanian-Early Santonian (Late Cretaceous) deposits of the Chanis-Tkkhali River (Western Georgia) on planktonic foraminifera and nannoplankton
Mikadze, K., Lapachishvili, N., Ikoshvili, N., and *Onophrishvili, M.*

Sedimentology, geochemistry, and benthic foraminiferal ecology in the sediments under high primary production area off Aleutian Islands
Nomaki, H., Langlet, D., Seike, K., Suga, H., and *Fujiwara, Y.*

Benthic Foraminiferal Assemblages and Biotopes' Definition in a Coastal Lagoon: The Case Study of Sacca di Bellocchio (central Italy)
Paoloni, T., Frontalini, F., and *Barbieri, G.*

Exploring new high-resolution geochemical proxy calibration strategies for benthic foraminiferal tests
Petersen, J., and Grunert, P.

Foraminiferal community response to seasonal anoxia in Lake Grevelingen (Netherlands)
Richirt, J., Riedel, B., Mouret, A., Schweizer, M., Langlet, D., Meysman, F.J.R., Slomp, C.P. and *Jorissen, F.*

A modified method of calcisphere extraction and sample enrichment from consolidated Upper Triassic rocks in Southern Alps (Slovenia)
Rifl, M., and *Holcová, K.*

Planktonic Foraminifera Biostratigraphy and Microfacies Analysis of the Cenomanian-Campanian Succession in the Haymana-Polatli Basin (Ankara, Turkey): Implications for the Late Cretaceous Evolution of the Southern Pontides
Sariaslan, N., Altiner, S., and *Altiner, D.*

Feeding experiment offering methanotrophic bacteria to seep-associated Arctic benthic foraminifera
Schmidt, C., Geslin, E., Bernhard, J.M., LeKieffre, C., Roberge, H., Svenning, M., Hestnes, A.G., and *Panieri, G.*

Benthic foraminifera track the pollution history of Baltic and North Sea
Schmidt, S., Schönfeld, J., and *Hathorne, E.*

Establishing Environmental Baselines and Anthropogenic Influence on the Northern Cuban Continental Shelf and Slope using Benthic Foraminifera
Schwing, P.T., O'Malley, B.J., Martínez-Colón, M., Brooks, G.R., Larson, R.A., Armenteros, M., and *Hollander, D.J.*

Long-term Surface and Intermediate Water reconstructions: IODP359, northern equatorial Indian Ocean
Stainbank, S., Kroon, D., Zhang, M., Yu, S.M., Wright, J., Kunkelova, T., Rüggeberg, A., de Leau, E.S., De Boever, E., Chilcott, C., and *Spezzaferri, S.*

Ecological factors affecting the formation and persistence of genetic populations of rocky-shore benthic foraminifera
Tsuchiya, M., and *Fujikura, K.*

Shell structures of foraminiferal shells: A case study of *Ammonia tepida* species complex
van Dijk, I., Nehrke, G., Barras, C., Mouret, A., Richirt[2], Jorissen, J.F., and *Bijma, J.*

Extinctions in the marine plankton preceded by stabilizing selection
Weinkauf, M.F.G., Bonitz, F.G.W., Martini, R., and *Kučera M.*

Field observation of living planktic foraminifera from the Benguela Upwelling region
Winkelbauer, H.A., Poulton, A., and *Hoogakker, B.*

Larger foraminiferal biostratigraphy at the Eocene-Oligocene boundary in Southern Armenia
Zakrevskaya, E.Yu., Hayrapetyan, F.A., and *Grigoryan T.E.*

WORKSHOP KEYNOTE ABSTRACTS

Workshop 1&2 Keynote: Epiphytic foraminifers as a tool to assess the environmental health of seagrass meadows in the Mediterranean domain

Guillem Mateu-Vicens[1,2]

[1]*Càtedra Guillem Colom Casasnovas, Universitat de les Illes Balears (Spain)*
[2]*Càtedra de la Mar - Iberostar, Universitat de les Illes Balears (Spain)*
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One of the most endangered habitats in the Mediterranean Sea is the seagrass meadows dominated the endemic species *Posidonia oceanica*. This ecosystem covers up to 3% of the Mediterranean surface and provides essential ecosystemic services regarding the water quality (oxygen and transparency), sedimentary processes (carbonate factory, hydrodynamic buffer) and shelter for many littoral species (biodiversity hotspot). For their environmental values, *Posidonia oceanica* meadows have the maximum protection status in the EU (Habitats Directive EU 92/43 EEC 21/05/1992).
Several descriptors are used for monitoring this ecosystem (e.g. shoot density, cover, epiphytes biomass, occurrence of *Pinna nobilis*). However, despite their excellent role as bioindicators and their abundance and diversity (> 130 species) in the *P. oceanica* meadows, foraminifers are normally not considered in standard protocols. Initiatives such as FOBIMO are crucial to establish a standard methodology (Foram-AMBI) to sample and interpret the environmental significant of the foraminiferal assemblages.
Nevertheless, FOBIMO protocols are difficult to successfully apply in the *P. oceanica* meadows. First, two levels are distinguished in the plant: blades and rhizomes, each of them with species adapted to particular conditions of oxygen and organic matter concentrations, which, out of the context, might induce to misinterpretations. Second, dealing with living specimens may be counterproductive as the sampling of epiphytic forms encrusting the plant implies the breakup of abundant shoots to obtain a statistically significative number of individuals. This, indeed, is paradoxical as the monitoring might destroy the ecosystem to be protected. In consequence, alternatives such as analysing the pristine specimens of the thanatocoenosis according to their adscription to a given epiphytic foraminiferal morphotype are here proposed.

Workshop 1&2 Keynote: The Development and Implementation of the Foram-AMBI for the Gulf of Mexico

Schwing, P.T.[1,2], O'Malley, B.J.[1], Martínez-Colón[3], M., Spezzaferri, S.[4], Machain-Castillo, M.L.[5], Brooks, G.R.[2], Larson, R.A.[2], Armenteros, M.[6], and Hollander, D.J.[1]

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The Gulf of Mexico (GoM) is an economically important, ecologically diverse semi-enclosed basin bordered by the United States, Mexico and Cuba. The GoM is subjected to several natural (e.g. tropical cyclones, algal blooms) and anthropogenic (e.g. energy development, eutrophication, contaminant

loading) stressors. There are currently ongoing international cooperative research efforts developing baseline measurements throughout the GoM as a basis for future monitoring efforts. It is imperative that monitoring efforts of ecological quality status (EQS) are performed to fully characterize impact, response from future perturbations and to extricate their effects from ongoing stressors. There is a need in the GoM for an effective, economical EQS monitoring tool that can be implemented by managers. Benthic foraminifera are robust bioindicators of EQS for a broad range of marine environments. The benthic foraminifera AZTI Marine Biotic index (f-AMBI) has been successfully implemented in the Mediterranean and North Atlantic utilizing faunal composition and organic matter enrichment. Efforts are currently underway to calibrate, validate and implement the GoM f-AMBI, from coastal to abyssal settings. Initial calibrations are based on >100 sites throughout the GoM. These calibrations are currently being refined through comparison with other regional f-AMBI calibrations and ongoing interaction with FOBIMO group members. Implementation of the GoM f-AMBI is currently being negotiated with local, state and federal managers. GoM f-AMBI development provides a measure of benthic habitat suitability for economically important, benthic dependent fish and encourages collaborative partnerships between academic scientists and resource managers to operationalize, refine and implement f-AMBI as a decision support tool.

Workshop 3 Keynote: Neogene nannofossil taxonomy and biostratigraphic advancements

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A new Neogene time scale, the BP Gulf of Mexico Neogene Astronomically-Tuned Time Scale (BP GNATTS) has been published in May 2019 by Bergen, Truax, de Kaenel et al. This time scale is the first published industrial framework tuned to orbital periodicities and is the result of a research that started in 2002 on the Ocean Drilling Program's (ODP) Leg 154 sediments (offshore NE Brazil). This paper as well as the chart are in open access at https://pubs.geoscienceworld.org/gsabulletin/early-publication. Both calcareous nannofossils and planktonic foraminifera were analysed and included on this chart. The stratigraphic resolution is of 144 kyr. Both groups of microfossils are used to define a new Neogene stratigraphic scheme. Prior to this publication, five taxonomic papers on calcareous nannofossils were published in 2017 in the Journal of Nannoplankton Research by Bergen, de Kaenel, Blair, Boesiger and Browning. These papers introduced the taxonomic revision and the new species that are used to construct the BP GNATTS. This workshop will intoduce all these new improvements to the Neogene biostratigraphy as well as a revision of Pliocene and Quaternary calcareous nannofossils.

TMS KEYNOTE ABSTRACTS

TMS Keynote: Measuring the impact of extreme environments on Calcareous Nannofossil assemblages: the case of the Messinian salinity crisis

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The impact of the Messinian salinity crisis (MSC) on the upper Miocene geological record of the Mediterranean region is evident in the paleontological and in the sedimentary record, where a huge amount of evaporitic rocks deposited across the basin, starting from 5.97 Ma. The paleontological record is characterized by a progressive change towards more eutrophic and stressed conditions and culminates in the sudden disappearance of the calcareous plankton and benthos at the beginning of the MSC. This event has been interpreted since the seventies as mainly driven by the salinity increase ascribed to the restriction of hydrological connection with the Atlantic ocean, and responsible for evaporite deposition. Recently, calcareous nannofossils (CN), foraminfers and fish remains have been found in sediments interpreted as the lateral equivalent of gypsum beds, supporting the idea that the water column had a normal marine salinity during the first stage of the MSC. Calcareous nannofossil assemblages are mainly oligospecific and dominated by *Sphenolithus*, *Helicosphaera* and *Umbilicosphaera*, together with small *Reticulofenestra*. The biometric analyses of selected taxa (*Sphenolithus, Coccolithus, Helicosphaera*) reveal that some CN taxa are affected by a sharp and transient size decrease, coupled with dwarf and oligospecific foraminifer assemblages. These findings provide further insight on the conditions in the upper water column at the onset of the crisis. Furthermore, this study will shed light on the key factors responsible for size variations of the calcareous plankton, both transient, such as during Mesozoic Oceanic Anoxic Events, and permanent, as during the Cenozoic.

TMS Keynote: Are methane seep sites "extreme environments" for foraminifera? Insights from the Arctic

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Carbon dioxide is typically considered as one of the worse of greenhouse gases, but methane is roughly 30 times more potent as a heat-trapping gas. Recent research indicates that for each degree that Earth's temperature rises the amount of methane entering the atmosphere will increase. In the Arctic, vast amounts of methane are trapped at shallow depths below the seafloor as gas hydrates, ice-like frozen mixtures of gas and water. Current ocean warming makes these greenhouse gas reservoirs vulnerable to thawing.
In order to investigate methane emissions in the Arctic Ocean, with undergraduate students and international colleagues, we focus on micropaleontology, geochemistry, and foraminifer physiology. We investigate modern and fossil settings, from shallow to deep waters, trying to comprehend if foraminifers could be used to study methane emissions in the Arctic marine realm. Are there pronounced difference in the pattern of benthic foraminiferal attributes (e.g., diversity, density, presence/absence) between

methane seep and non-seep assemblages? Does foraminiferal calcite likely preserve geochemical information from which past methane events may be reconstructed?
This presentation illustrates and discusses case studies from Arctic methane seeps where we have conducted numerous collections using real-time visually-guided samplers and long coring systems over the last 6 years of CAGE scientific expeditions. The results obtained allow to provide useful information on foraminiferal primary biomineralization, secondary overgrowths, dietary selection (food preferences), cell biology, and biomarkers.

This work is funded by CAGE, through its Centres of Excellence funding scheme Grant 223259, and by NORCRUST (255150).

TMS Keynote: Sequencing biostratigraphy for transcribing past environments

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The response of extant marine organisms to environmental changes was investigated by numerous laboratory experiments at different scales and a few long-term monitoring studies. The linkage to species' evolution, diversity patterns and the biostratigraphic record has scarcely been drawn to date, leaving the fundamental questions unanswered: why, when and where has a species evolved, and which way has it spread? In a case study, the first appearance data of common benthic foraminiferal species from the Peruvian Oxygen Minimum Zone and *Globobulimina* species from Gullmar Fjord, Sweden, were compared with phylogenetic trees drawn from their gene sequences. The genetic and stratigraphic results were in reasonable agreement for several species, while the genes of others suggested much older radiation ages. First appearance ages vary from 16.3 to 1.41 million years ago (Ma). The majority of investigated taxa have evolved in the eastern Pacific Ocean. The first occurrences off Peru were with 5.67 to 0.75 Ma much younger, indicating that the species have migrated to the Peruvian Oxygen Minimum Zone during the late Neogene, after the coastal upwelling regime has established during the latest Miocene. The Swedish *Globobulimina auriculata* originated in the northeastern Pacific too and migrated to the northern Atlantic via the Arctic Ocean at 3.5 Ma, while the presumably related *Globobulimina turgida* originated at the same time in the northeastern Atlantic. Genetic trees and recent ecological observations depict both species as being fundamentally different and relate them to a common ancestor much further back in time.

ABSTRACTS

Benthic foraminifera and cold seep macrofauna associations

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In cold seep environments, hydrogen sulphide and methane are toxic to most sensitive species. However, in these environments, fluids enriched in dissolved reducing gas support microbial chemosynthetic processes and specialized methazoan communities, dominated by few adapted taxa. Cold seeps related fauna consist mostly of bivalves, gastropods, polychaets, decapods and benthic foraminifera. Seepage-related sediments were sampled along the Israeli continental slope, at the base of the Palmahim Disturbance, during the EU Eurofleets SEMSEEP Cruise in 2016. To identify potential bioindicator faunas for seep environments in the Eastern Mediterranean Sea, pockmark related samples were analysed for mollusks, living (rose Bengal stained) and dead benthic foraminifera. Chemosymbiotic mollusks were identified in the samples, including: *Taranis moerchii*, *Lurifax vitreus*, *Idas ghisottii*, *Lucinoma kazani*, *Thyasira biplicata*, *Isorropodon perplexum* and *Waisiuconcha* sp.. Together with these species, low oxygen foraminifera were identified e.g., *Chilostomella oolina, Globobulimina affinis* and *Globobulimina pseudospinescens*. Although the correlation of low oxygen tolerant foraminifera genus *Chilostomella* and *Globobulimina* to seep environments is not straightforward in the Eastern Mediterranean, their co-occurrence with the chemosymbiotic mollusks testify that they characterize seep environments in the Eastern Mediterranean.

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The Maldives coral reefs: are they under threat?

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Tropical environments host among the most fragile biodiversity hotspots in the world which are nowadays exposed to natural and human-induced stressors: coral reefs. A severe El Nino pulse in June 2015 caused a major coral-bleaching event worldwide. This bleaching particularly affected the Maldives.

In September 2018, during a Conférence Universitaire de Suisse Occidentale (CUSO ESPP doctoral programme) course and using Training Through Research a survey was conducted across three islands with different management regimes (community, resort and uninhabited). This allowed a comparison with pre-bleaching conditions documented during a similar survey carried out in April-May 2015, (IUCN REGENERATE Cruise).
Overall, three indices were used to evaluate the ecological status of the Maldivian reefs: the *Amphistegina* Bleaching Index (ABI), which denotes the degree of photic stress; the FORAM Index (FI), which is related to water quality and indicates if the environment can support calcifying organisms and the SEDiment CONstituents (SEDCON) Index, which provide an indication of processes affecting the macrobenthos and in particular bioerosion.
The three indices consistently evidence that environmental deterioration occurred from 2015 to 2018. However, although ecological conditions in community and resorts islands were more affected than in uninhabited islands, the entire ecosystem is slowly recovering.

Funding for the survey in 2018 was provided by the Conférence Universitaire de Suisse Occidentale (CUSO), Earth Surface Processes and Paleobiosphere (ESPP) doctoral school. The research is supported by the SNSF project 200021_175587.

Heterotrophic foraminifera capable of inorganic nitrogen assimilation

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Nitrogen often limits biological productivity in marine systems, where inorganic nitrogen is assimilated to the food web by heterotrophic and phototrophic bacteria and phytoplankton. Recently ammonium assimilation was observed in kleptoplast-containing protists of the phylum Foraminifera, possibly via the kleptoplast based GS-GOGAT (glutamine synthetase/glutamate synthase) assimilation pathway. However, an innate ability for ammonium assimilation in heterotrophic protists has never been reported. Using stable isotope incubations (^{15}N-ammonium and ^{13}C-bicarbonate) and combining transmission electron microscopy (TEM) with nanoscale secondary ion mass spectrometry (NanoSIMS) analyses, we investigated the uptake and assimilation of dissolved inorganic ammonium by heterotrophic protists (foraminifera) *Ammonia* sp. and *Globigerina bulloides*. Neither species assimilated ^{13}C-bicarbonate, available only to photosynthetic species, confirming their heterotrophic nature. However, both species assimilated dissolve ^{15}N-ammonium and incorporated it into organelles crucial to ontogenetic growth and development of the cell. Our results show that these heterotrophic protists have an innate cellular

mechanism for inorganic ammonium assimilation, highlighting a newly discovered pathway for dissolved inorganic nitrogen assimilation within the microbial loop and the marine food web.

Does coastal management affect salt-marsh resilience? A comparison of natural and anthropogenic impacts

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Active salt marshes are sensitive to environmental changes, and are considered of substantial importance in coastal resilience to present-day and future climate changes. In this context, the distinction between naturally and anthropogenically forced sediment deposition in coastal wetland areas is of critical importance to asses ongoing debates of coastal risk management and related adaptation strategies. We have investigated a sediment core from a formerly drained and semi-enclosed coastal salt marsh, and 20 surface samples from a recently drained and grazed salt marsh in the Bay of Tümlau, south-western North Sea. The salt-marsh sediment succession exhibited typical horizontal laminations, in which the single layers were alternately dominated by calcareous tidal-flat foraminifera (e.g., *Ammonia batava* s.l., *Elphidium excavatum*, *Elphidium williamsoni*, *Haynesina germanica*) and agglutinated salt-marsh taxa (i.a., *Entzia macrescens*). The results gained from the surface samples showed highest abundances of living *Elphidium* species within the drainage ditches, enabling the estimation and application of a 'reworking index' to the sediment-core data. This index was used for the estimation of changes in the down-core distribution of reworked calcareous foraminifera reflecting the re-deposition of particles from the surrounding tidal flats during storm tides or by human-induced dredging for land reclamation purposes.

Recent agglutinated foraminifera from the North Adriatic Sea: What the agglutinated tests can tell

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Agglutinated foraminifera from surface sediments of two sites (S1 and E1) in the North Adriatic Sea were investigated in order to detect their test composition and to explore possible links with the surrounding environment. Chemical-mineralogical analyses of the agglutinated tests by scanning Electron Microscopy and Energy Dispersive Spectroscopy, suggest that the chemical composition of the test surfaces generally mirrors the one of the sea-floor sediment. Only some species, as *Reophax nana* and *Leptohalysis scottii* exhibit a clear selectivity of the agglutinated grains. In detail, specimens of *R. nana* from site E1, which is mainly characterized by high hydrodynamic conditions at the sea-floor, show a

preferential selection of mineral grains containing high concentrations of Zircon (Zr) and Titanium (Ti) even if these elements occur in very low concentrations in the surrounding sediment. *L. scottii* exclusively picks mica flakes to build the test. We suggest that the compositional differences recorded in the considered agglutinated foraminiferal tests represent distinctive life strategies in order to live successfully in different environments.

The evolution of Lower Cretaceous foraminifera in the North Sea basin and surrounding regions – Perspectives from the Central Graben [Danish sector]

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This project investigates foraminiferal assemblages of the Lower Cretaceous in the North Sea and surrounding localities. An epoch of geological time that saw a progressive rise in overall sea level, global temperature, and an increase in diversity for some calcifying organisms – gastropods, bivalves, ostracods, calcareous nannoplankton, and foraminifera among them. Some stratigraphic sections are being studied for micropalaeontological analysis in this project. One of them provides core-borehole samples from the Danish North Sea, with ages ranging from Hauterivian to Aptian. This material was kindly provided by the Geological Survey of Denmark and Greenland (GEUS). The Danish Central Graben is dissected by N-S and NW-SE structures, which dominated the area during the Mesozoic, providing faulted blocks and half-grabens. The tectonic regime changed from Extensive in the Jurassic to Compressive in the Late Cretaceous, making the Lower Cretaceous a transitional period. A record of this structural complexity is found in Lower Cretaceous sedimentary deposits which far from the purely calcareous material from some Upper Cretaceous sections, display abundant siliciclastic content. Benthic and Planktonic communities of Foraminifera developed in these environments, and their micropalaeontological record is a testimony as much to the changing sedimentary environments as it is to the globally-observed evolutionary changes that affected the Foraminifera group in the Mesozoic. The Micropaleontological data shows a typical pelagic to hemipelagic assemblage. Abundance of Foraminifera is relatively low. Which is not unexpected for the area. Interesting changes in patterns of diversity and Abundance are correlated to local sea level changes and regional geological events.

First record of foraminiferal faunas associated to *Haploops* settlements on the French Atlantic coast

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On the inner continental shelf (depth < 50 m close to the shore) of South Brittany (France) dense settlements of *Haploops* spp., tube dwelling crustacean amphipods, have been reported over the last

decades. Their key-role as bio-engineer species, on the sediment dynamics and ecological niches is still poorly known. Recently, the perfect overlap of *Haploops* settlements on pockmarks field on three different sites along the French Atlantic coast arose the hypothesis that a link exists between the release of methane through active pockmarks and the presence of these organisms. The aim of the present study is to explore the foraminiferal faunas associated to these complex ecosystems and eventually the role of Haploops settlements as source of heterogeneity compared to the adjacent muddy substrates.
Foraminiferal assemblages (>125 µm) of three replicated cores collected inside the *Haploops* settlement in the adjacent muddy facies and inside a small pockmark chimney (where the *Haploops* are scarce), were analyzed.
The three facies have a common species pool, but display major differences in terms of absolute abundances and biodiversity. The *Haploops* facies shows less dense and highly diverse faunas, compared to the assemblages in the bare muddy facies, where the assemblages are largely dominated by the species *Elphidium selseyense*.
Compared to Haploops settlements, the pockmark facies exhibits similar abundances but a lower diversity. The main difference with Haploops facies concerns rare species, only present in the tube cover. Our results highlight a positive impact of Haploops ecosystems on the total diversity of the study area.

The coral reef-dwelling *Peneroplis pertusus* brought to light: recalcification during culture experiments

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Ocean acidification is a consequence of current global climate changes. The concomitant decrease in pH and carbonate ion concentration in sea water may have severe impacts on calcifying organisms. Coral reefs were among the first ecosystems to be recognized as vulnerable to ocean acidification. On coral reefs, large benthic foraminifera (LBF) are major calcium carbonate producers.
The aim of this study was to evaluate the effects of a lower pH and presence or absence of light on LBF. We performed culture experiments to study the resistance to ocean acidification conditions and resilience under dark or light treatments of the miliolid and symbiont-bearing species *Peneroplis pertusus*.
We found that after four days, no signs of test decalcification were observed on the specimens kept at pH 7.3, and severe test decalcification was observed on specimens kept at pH 6.9. All the specimens were alive, even the strongly decalcified ones, which demonstrates the resistance of *P. pertusus* to a lowered pH, at least on the short-term. After being partially decalcified, some of these living specimens were placed back at higher pH 7.8. After 10 days, test recalcification occurred, but only on individuals that were daily exposed to light. This result highlights the crucial role of the symbiont's photosynthesis, which provides the required energy for recalcification process. Moreover, the newly formed chambers were abnormal, and the ultrastructure of their walls was altered. We conclude that even if symbiont-bearing LBF show some resistance and resilience to lowered pH, they will stay strongly affected by ocean acidification conditions.

Cyclicity in foraminifera assemblages and lithological variability, Upper Turonian, Bohemian Cretaceous Basin

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Late Turonian hemipelagic deposits in central part of the Bohemian Cretaceous Basin (Czech Republic) show lithological cyclicity caused by rapidly changing depositional conditions. This cyclicity has been attributed to orbital control. Short-term palaeoenvironmental changes corresponding to these lithological variations are not well understood. Here we present foraminiferal assemlages performed on 68 samples from the Bch-1 drill core, study of foraminifera has not yet been applied to this reference section. Sampling was related with known lithology of the studied core, the samples were taken from interval: 109,75 – 253,5 m depths. In the samples studied, 42 benthic and 19 planktonic foraminifera species were determined and their abundances, diversity and P/B ratio were compared with the lithological proxies as well with previous interpretations of the longer-term depositional history.
The foraminifera data are compared to the following geochemical proxy parameters: CaCO3 content, Al, Si, Al/Si, Zr/Si ratios measured continuously over the entire drill core. Cyclicity in foraminifera assemblages seems to be different than cyclicity observed in geochemical parameters.
In the vast majority of samples, alternation in abundance is observed between *Heterohelix globulosa* on one side and genus *Whiteinella* and *Dicarinella* on the other side. Spearman correlation of foraminiferal species and geochemical data reveals two distinct groups in relation to the lithological proxies: Group 1, represented by *Cassidella tegulata*, *Praebulimina* sp., *Gaudrinella*, *Whiteinella paradubia* and *Dicarinella imbricata*, shows affinity to relatively carbonate-poor, and partly mud-enriched lithologies. Group 2, represented by species *Lenticulina* sp., and *Gyroidina nitida*, correlates to carbonate-enriched samples with higher Si/Al, Zr/Al ratios.

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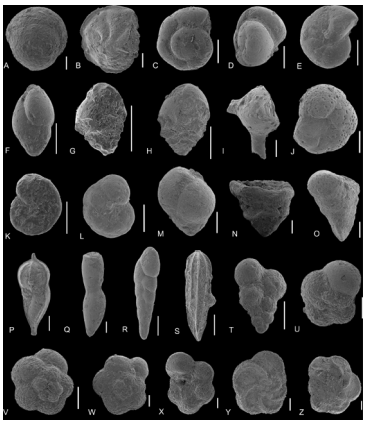

Fig. 1: A - *Ataxophragmium depressum* (Perner, 1892); B - *Lenticulina* sp.; C, D - *Gyroidinoides nitida* (Reuss, 1845); E - *Valvulineria lenticula* (Reuss, 1845); F - *Praebulimina* sp.; G, H - *Tappannina eouvigeriniformis* (Keler, 1935); I - *Ramulina globulifera* Brady, 1879; J - *Gavelinella polesica* (Akimec, 1961); K, L - *Cibicides* sp.; M - *Arenobulimina ?intermedia* (Reuss, 1845); N - *Marssonella oxycona* (Reuss, 1860); O – *Gaudryina* sp.; P – *Frondicularia* sp.; Q – *Dentalina* sp.; R - *Casidella tegulata* (Reuss, 1845); S – *Nodosaria* sp.; T - *Heterohelix globulosa* (Ehrengberg, 1840); U - *Whiteinella baltica* (Douglas & Rankin 1969); V - *Whiteinella brittonensis* (Loeblich and Tappan, 1961); W, X – *Dicarinella* sp.; Y, Z – *Marginotruncana* sp.

The southernmost occurrence of lepidocyclinids from the Pacific coast of South America: the Los Choros Member (Paracas Formation, East Pisco Basin, southern Peru)

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Large benthic foraminifera (LBF) of the family Lepidocyclinidae originated in the Americas during the Eocene and then spread worldwide, persisting until the Miocene. Like other clades of foraminifera, they are characterized by an evolutionary trend, the "nepionic acceleration", that favors their use in biostratigraphy. The East Pisco basin of southern Peru includes the Eocene Paracas Formation, whose basal Los Choros Member is characterized by shallow-water sediments rich in LBF. The Zamaca outcrop, investigated here, is located in the Ica desert and consists of mixed bioclastic-siliciclastic fine gravels of the Los Choros Member that nonconformably overlie the basement rocks. The bioclastic fraction is dominated by LBF with subordinate bivalves, echinoids, and barnacles. Lepidocyclinids are the most common group of LBF and to our knowledge they represent the southernmost occurrence of this family along the Pacific coast of America. Rare specimens of *Nummulites* and *Discocyclina* were also observed. Within lepidocyclinids, the primitive species *Lepidocyclina douvillei*, characterized by a small embryo and large and often slightly asymmetric principal auxiliary chambers, is the most common species, occurring together with *Lepidocylcina cf. trinitatis* and two different species of *Polylepidina*. The co-occurrence of *L. douvillei* and *Polylepidina*, coupled with the lack of *Helicolepidina* and *Helicostegina*, suggests a middle Eocene age (43.6–40.0 Ma), probably close to the Lutetian–Bartonian boundary. This interpretation is supported by the nannofossils assemblage (CNE14 biozone, 42.37–40.34 Ma) of the base of the overlying Yumaque Member. These results highlight the potential of lepidocyclinids for biostratigraphic analyses in the South American region.

Unity makes strength: high contribution of intertidal benthic foraminifera to sediment reworking

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Although benthic foraminifera are one of the most abundant components of the meiofauna, their role in intertidal ecosystems functioning has been overlooked. Specifically, benthic foraminifera may contribute to bioturbation process by sediment reworking. Whether this contribution is significant remains, however, to be assessed. The aim of this study was to quantify the sediment-reworking rate (SRR) of 5 foraminiferal species characteristic of European temperate mudflat: *Ammonia tepida, Haynesina germanica, Cribroelphidium williamsoni, Milliammina fusca and Quinqueloculina seminula.* Sediment surface was scrapped-off to collect living benthic foraminifera for the experiment. In the laboratory, individuals were sorted and spread over a thin layer of sediment in a beaker filled with seawater. Movements of all

individuals were recorded every 10 min using a camera for 24h. The volume of reworked sediment was calculated considering the distance travelled and the surface of the test for each species. For the 5 studied species, the SRRs ranged from 3x10-3 cm3.d-1 (*M. fusca*) to 16x10-3 cm3.d-1 (*Q. seminula*). Considering a community of those 5 species with an abundance of 60 ind.cm-2, the volume of sediment mixed per surface unit (1 m2) is 8.34x103 cm3.d-1. As a comparison, a population of *Heteromastus filiformis*, a polychaete inhabiting the same ecosystem, can mix up to 1.44x103 cm3.day-1. These results show that sediment reworking by benthic foraminifera is not to be neglected, and it stresses the need for further experimental work to understand the role of benthic foraminifera in bioturbation processes (i.e. particle reworking) but also the related biogeochemical fluxes at the water-sediment interface.

Distribution of benthic foraminifera in the allocated zone for aquaculture of Thermaikos Gulf (north Aegean Sea)

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Allocated zones for aquaculture (AZAs) are established under national maritime spatial planning, to ensure viability and safeguard, both, fisheries products and environmental quality. In Thermaikos Gulf, the main type of aquaculture is mussel-farming (*Mytilus galloprovincialis*). The relevant sector is expanding over the last years and an AZA to host and manage relevant units is currently under development. The present study aims to assess the structure of foraminiferan communities under the impact of mussel-farming, to explore their potential as indicators of environmental quality in biomonitoring. Sediment samples were collected with a Bowser corer in January 2019, by diving at depths ranging from 10 to 25m, from eight, randomly selected stations in Chalastra bay. Additional samples were collected for granulometric and organic content analyses. The standardized FOBIMO protocol was applied in both collection and processing of samples. The examination of the collected material revealed the presence of 74 species classified to 47 genera. The foraminiferan assemblages comprised a typical group of stress-tolerant taxa (*Bulimina aculeata, Bulimina elongata, Bolivina spathulata, Bolivina dilatata, Nonionoides turgidus, Rectuvigerina phlegeri, Ammonia tepida, Triloculina tricarinata, Quinqueloculina seminula*) and a remarkable presence of agglutinated taxa (*Eggerelloides scaber, Textularia earlandi, Lagenammina difflugiformis, Leptohyalis scotti, Nodulina dentaliniformis, Nouria polymorphinoides*) suggesting specific geochemical sediment conditions. The spatial distribution of foraminiferans was mainly determined by the combined effect of organic matter, topography and hydrodynamics.

US Atlantic Coastal Plain ecosystems prior to and during the PETM

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The early Paleogene long-term warming trend was punctuated by short-term global warming events, all marked by $\delta^{18}O$ and $\delta^{13}C$ excursions, with the Paleocene-Eocene Thermal Maximum (PETM) being the

most pronounced. Recent data show an additional minor, but distinct, $\delta^{13}C$ excursion prior to the PETM-onset, defined as the "pre-onset excursion" (POE). Its relation to the PETM is still unclear but may indicate pre-PETM climate instability with a more graduals change towards the PETM as previously assumed.
We studied the South Dover Bridge (SDB) core in Maryland, US Atlantic Coastal Plain, in which the Paleocene-Eocene transition is stratigraphically constrained by calcareous nannoplankton, and the POE and PETM are both marked by fine-grained sediments. The shallow marine SDB site is thought to have been situated near a major outflow of a paleo-river system and was thus highly susceptible to climate-related changes in the hydrological cycle.
We generated high-resolution foraminiferal assemblage and stable isotope records to better constrain environmental changes prior to and during the PETM. We detected a shift from well-oxygenated oligo- to mesotrophic bottom water conditions during the late Paleocene, to an episodic organic flux to the seafloor after the POE. During the peak warming phase of the PETM, mainly stress resistant benthic taxa could flourish in a river-dominated marine setting. The succession of foraminiferal assemblages indicates improved oxygen levels during the PETM recovery and decreased river influence. Based on these records, the completeness of the P-E transition is assessed, and a correlation along the depth transect of the shelf is proposed.

Symbiont-Bearing Foraminifera from the Agbada Formation in the Niger Delta, Nigeria: Paleoenvironmental and Paleobiogeographic Implications

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The Niger Delta is a major target for hydrocarbon reservoirs where high-resolution biostratigraphy has long been established as a successful tool for exploration. Biostratigraphic analysis was carried out on Well 'A' located within the onshore Western Niger Delta Basin of Nigeria. The materials for this study included digital gamma ray log data and ditch cutting samples. Seventy-six (76) ditch cuttings were prepared in the laboratory using standard micropaleontological procedures for the recovery of Foraminifera. Graphical plots of the stratigraphic distribution of benthic foraminifera were made for the well. The well log was used for lithological delineation.
The stratigraphy of individual units was dominated by the presence of *Amphistegina spp.* and *Operculina spp*., a group of taxa that normally flourish under oligotrophic conditions. These two symbiont-bearing genera were able to survive the turbulence and high energy regimes of the Messinian Niger Delta. Other foraminifera such as *Quinqueloculina* were also recorded in minimal numbers. The interval under study falls within the Agbada Formation, a paralic sequence of alternations between sandstone bodies and their shale counterparts. The presence of symbiont-bearing foraminifera within the Agbada Formation is not only of importance for dating the sediments but also for the reconstruction of paleoenvironmental conditions. Both *Amphistegina* and *Operculina* species have not been reported from modern Niger Delta sediments. Anthropogenic impacts and an increase of eutrophication processes at the delta mouth may possibly limit their distribution and occurrence in modern settings. This study compares modern and past Niger Delta conditions to assess the factors regulating the presence/absence pattern of symbiont–bearing foraminifera with emphasis on the Agbada Formation. It also completes the paleobiogeographic record of *Amphistegina* and *Operculina* in the fossil record.

Impact of bottom currents on benthic foraminiferal assemblages in a cold-water coral environment: the Moira Mounds (North-east Atlantic)

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Strong bottom currents play a key role in cold-water coral environments by shaping their morphology and providing the necessary food for the corals to thrive. This study investigates the considerable differences between living and dead benthic foraminiferal assemblages in such environments, more precisely in the Belgica Mound Province (NE Atlantic). A specific focus is to understand the role of currents and their influence on the taphonomy of benthic foraminiferal assemblages. Here, we analyze high-resolution sediment grain size distributions coupled with benthic foraminiferal assemblage composition to assess how strong deep-sea bottom currents affect benthic foraminiferal assemblages. We suggest that the dead benthic foraminiferal assemblage consists of a reworked glacial fauna associated with contemporary species. Reworked glacial species (e.g. *Cassidulina teretis*, *Elphidium excavatum*, *Sigmoilopsis schlumbergeri*) are the most abundant. Dominant species that are present almost exclusively in the living assemblage (*Alabaminella weddellensis*, *Nonionella iridea*, *Trifarina* spp.) are associated with high phytodetritus input, possibly as a response to the later phase of the North-east Atlantic bloom. Dead assemblages are further characterized by the scarcity of organic-walled agglutinated foraminifera in comparison to living assemblages. Sediment grain size distributions show that the downslope Moira Mounds consist of well-sorted fine sand, typical of contourite deposits in the area. Grain size distributions and the average Shannon diversity of living and dead foraminiferal assemblages indicate that the coral cover offers a sheltered environment, baffling eroded sediment and preventing post-mortem transport of dead foraminifera. We conclude that cold-water coral environments provide a valuable paleoenvironmental archive by trapping sediment in an otherwise non-depositional system.

Benthic foraminifera as tracers of brine production in the Storfjorden "sea-ice factory"

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The Storfjorden (Svalbard archipelago) is an area of intense sea-ice formation characterised by the production of Brine-enriched Shelf Waters (BSW) as a result of a recurrent latent-heat polynya. The rapid response of living benthic foraminifera to environmental factors (e.g. water salinity, oxygenation, nutrient concentrations), and their high fossilisation potential, make them promising bio-indicators for intensity and recurrence of brine formation. Additionally, the high sedimentation rate occurring in the fjord

(~3mm/yr) allows to trace recent changes in brine formation at high time resolution. Such approach requires to study the modern benthic foraminiferal ecology in different Arctic domains. To this aim, seven stations along a N-S transect across the Storfjorden have been sampled using an interface corer. In the top five centimetres of the sediment, living (Rose Bengal stained) foraminiferal assemblages were analysed together with geochemical and sedimentological parameters. Three major ecoregions were distinguished: i) an "inner-fjord" characterised by the dominance of calcareous species and fresh organic matter inputs; ii) a "deep-central-basin" dominated by agglutinated species potentially resulting from brine persistence that hampers the growth of calcareous species and/or causes their dissolution; iii) an "outer-fjord" characterised by typical North Atlantic species. Our results suggest the possible use of agglutinated/calcareous ratio (A/C) in the living foraminiferal faunas as a proxy for BSW intensity and persistence in the Storfjorden. Furthermore, thanks to the good sedimentary archives in the fjord, the A/C proxy will be tested on historical records in order to precisely follow the course of the quickly ongoing climate warming in the Arctic.

Ecological characterization of the Elbe Estuary (northern Europe) and the applicability of foraminifera-based transfer functions for relative sea-level reconstructions

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One of the main challenges of this century is to understand the recent global climatic changes. In this context benthic foraminifera play a prominent role as their variations reflect changes in environmental conditions. The presented project focuses on the understanding of modern ecological processes through the use of benthic foraminifera in the area of the Elbe Estuary (Northern Europe). In estuarine areas, the distribution of foraminifera is strongly influenced by elevation, hence benthic specimens could provide a suitable means of converting faunal data into an environmental signal, through the generation of a transfer function (TF). This TF is then applied to the fossil record to reconstruct the paleo-signal. Although elevation plays indisputably a primary control, strong environmental gradients can locally influence the distribution and density of benthic foraminifera. Hence, the site-specific ecological interactions between benthic foraminifera and environmental parameters have to be prior investigated to further develop a reliable TF. The aims of the presented project are two-folds: 1) to shed new light on benthic foraminiferal ecology and biodiversity, still imperfectly understood, of the Elbe Estuary; 2) to reconstruct the past millennium relative sea-level changes in the study area by using a foraminiferal-based TF. In particular the project will extend the intertidal modern data set to subtidal environments to improve TF reconstructions. This would strongly enhance the significance of foraminiferal-based TF's studies. As fluctuations of regional sea level can be directly connected to the climate regime, including the frequency of storm surges, the understanding of modern processes will serve to predict regional future climatic changes and environmental impacts in Northern Europe.

Presence and distribution of non-indigenous foraminifera species on hard substrates on the Israeli shelf

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The Levantine Basin in the eastern Mediterranean Sea has been strongly affected by the entrance of hundreds of tropical non-indigenous species after the opening of the Suez Canal in 1869. Several foraminiferal species of the Red Sea have been found in assemblages along the Mediterranean coast of Israel. Most information on non-indigenous foraminifera derives from investigations of soft-bottom assemblages, while studies dealing with the presence of non-indigenous species in hard-bottom assemblages are rare. Therefore, we aimed to assess the abundance and species composition of non-indigenous foraminifera on hard substrates in the eastern Mediterranean. We sampled rocky reefs along two transects in northern (Ahkziv) and southern (Ashqelon) Israel between 5 and 25 m depth in spring 2018. For the foraminiferal analysis we targeted two size fractions (125-500 µm, 500-1000 µm), and both the living and death assemblage. Preliminary results show the presence of non-indigenous species in all samples except the southern 25 m site. Their share in the total assemblage (living + dead) varies between localities, depths and size fractions, but typically ranges between 25 and 45% in the small fraction and up to 90% in the larger fraction. In total, we found at least ten non-indigenous species, of which *Amphistegina lobifera* and *Pararotalia calcariformata* were the most abundant. Our observations point to a transformation of the foraminiferal assemblages on hard substrates in the shallow Levantine Sea, similarly to what has been documented for other phyla.

Foraminifer, diatom and calcareous nannofossil multiproxy paleoceanography: an example from a Late Miocene diatomaceous deposit of the Northern Mediterranean

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The Upper Miocene diatomaceous deposits of the Piedmont Basin (NW Italy) record the paleoceanographic events preceding the onset of the Messinian Salinity Crisis in the northernmost Mediterranean. The 3.5 m-thick Pecetto di Valenza section is made up, from bottom to top, of homogenous marls, laminated Mn-rich and diatom-bearing marly sediments. The laminated facies are unevenly interrupted by coarse silty layers and speckled beds suggestive of gravity flows. Diatoms are best preserved in the upper finely laminated sediments; foraminifers and calcareous nannofossils are present in all lithologies, allowing a comparative approach useful in deciphering the bio-mediated processes occurring in the water column and at the sediment-water interface.
Regardless of the facies, the planktic micropaleontological assemblages indicate the prevalence of eutrophic conditions in surface waters (e.g., *Thalassionema nitzschioides*, *Globigerina bulloides*, *Coccolithus pelagicus, Reticulofenestra antarctica* and small Reticulofenestrids (<5µm)), but also the regular development of a Deep Chlorophyll Maximum under stratified waters (e.g., *Coscinodiscus* spp., Neogloboquadrinids). High export production is inferred from the dominance of *Uvigerina* spp. or *Bolivina* spp. among benthic foraminifera. Finally, a minor component is represented by displaced coastal taxa (e.g., *Actinoptychus senarius*, *Elphidium* spp. and epiphytic benthic foraminifers), highlighting a

continuous influence of inner shelf waters. The combined effect of gravity flows and *T. nitzschioides* densely-packed mats formation sinking toward the sea floor may had reduced the benthic foraminifer activity, as reflected by a low benthic productivity interval within the diatom-bearing sediments.

Benthic foraminifera from the Peruvian oxygen minimum zone show a metabolic preference for nitrate over oxygen as an electron acceptor

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Benthic foraminifera populate a wide and diverse range of marine habitats. Their ability to use alternative electron acceptors – nitrate or oxygen – makes them keyplayers within the benthic nitrogen cycle. Nevertheless, the metabolic scaling of the two alternative respiration pathways and the environmental determinants of foraminiferal denitrification rates are yet unknown. We measured the denitrification and oxygen respiration rates for ten benthic foraminiferal species sampled in the Peruvian oxygen minimum zone (OMZ). These species were able to use both nitrate and oxygen as an electron acceptor. Denitrification and oxygen respiration rates significantly scale with the cell volume. The scaling for oxygen respiration is lower than for denitrification, indicating that their nitrate metabolism during denitrification is more efficient than their oxygen metabolism during aerobic respiration in foraminifera from the Peruvian OMZ. The oxygen respiration rate is stronger correlated with the surface/volume ratio than the denitrification rate, most probably due to the presence of intracellular nitrate storage in denitrifying foraminifera. Oxygen can be toxic in higher intracellular concentrations and thus not be stored in vacuoles. Furthermore, we observe increasing cell volume in foraminifera from the Peruvian margin, under higher nitrate availability. This suggests that the cell size of denitrifying foraminifera is not limited by oxygen rather by nitrate availability. Our findings show that nitrate is the preferred electron acceptor in foraminifera from the OMZ, where the foraminiferal contribution to denitrification is governed by the ratio between nitrate and oxygen.

Living on the edge: intertidal foraminifera at the 78°N, Central Spitsbergen

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Both the standing stock and taxonomic diversity of marginal marine foraminifera tend to decrease polewards (Lübbers, Schönfeld, 2018). Data on living assemblages of intertidal and salt marsh foraminifera from the subarctic are scarce and are almost absent from higher latitudes. Thus, the distribution limits of the littoral foraminifera to the north remains unknown. Here, we described living

foraminiferal assemblages from the intertidal area of a non-glaciated Dicksonfjord in Central Spitsbergen (78°50´N, 15°24´E). Samples were collected along a 1.5 km transect on a mudflat towards the delta of glacio-fluvial river in the fjord head. The intertidal foraminiferal fauna of the Dicksonfjord was significantly depleted comparing to the temperate and subarctic latitudes; the absolute abundance of living foraminifera was extremely low (1–12 ind./10 cm^3). The living assemblage was represented only by 3 species of elphidiids, among which *Elphidium albiumbilicatum* was dominant. Agglutinated species were completely absent. Our data support the idea of latitudinal decrease in species richness and densities of intertidal foraminifera to the north. Taxonomically, only elphidiids withstand the harsh intertidal environment of the Arctic fjord. Among Arctic and subarctic intertidal foraminifera, only elphidiids have an elaborate system of channels in the shell wall, which serves to deploy and withdraw pseudopodia quickly. These agile protists are able to dig upwards through quickly depositing mineral fines delivered by the turbid river or to burrow quickly into the sediment escaping fresh-water pulses during low tide.

Glacial/interglacial CO2 changes on coccolithophore physiology in the tropical Atlantic ODP 925 and 929 across the MIS 12 to MIS 10

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Reconstruction of past stages based on multi-proxy analysis is a key to improve the understanding of paleoenvironment and the biogeochemical evolution of the ocean. Coccolithophores are important pelagic calcifying organisms, influencing pCO2 through the biological and carbonate pumps (Rickaby et al., 2007); a large array of carbon and oxygen stable isotope fractionation (vital effects) have been shown by coccoliths, allowing hypotheses about the varying active carbon acquisition strategies in correlation to cell size, and suggesting a link to changing paleoenvironment (Bolton et al., 2012).
The Pleistocene MIS 12 to MIS 10 interval stands out as a crucial climatic period of changing glacial-interglacial cyclicity (Candy et al., 2014), accompanied by changing paleoenvironmental and physicochemical-oceanographic conditions. Different paleorecords indicate that coccoliths were an important component of the carbonate fraction during this interval, with the worldwide dominance of the highly calcified coccolithophore *Gephyrocapsa caribbeanica* (Bordiga et al., 2014).
Collecting this background, this work aims to elucidate the interplay of CO2 and productivity effects on coccolith size and stable isotopes across the MIS 12 - MIS 11 - MIS 10 cycle in the tropical Atlantic (Sites ODP 925 and 929). For this purpose, this methodological procedure is currently being developed:

- Geochemical analyses over size-separated coccolith fractions dominated by *Gephyrocapsa* genus, including the *G. caribbeanica* domain (stable isotopes, Sr/Ca and trace elements measurements) and over planktic foraminifera species (stable isotopes).
- Measurement of carbon isotopic ratio of alkenones.
- Coccolith counting for estimation of % *F. profunda* vs small placoliths.
- Assessment of coccolith size and calcification features by using image analysis techniques (C-calcita).

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Benthic foraminifera in Contourite Drift Systems

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In the face of recent global warming, paleoceanography and paleoclimatology provide fundamental contributions to our understanding of ocean-climate dynamics. Well-calibrated proxy methods are at the core of these research efforts. Contourite drift systems (CDSs), depositional environments under persistent bottom current activity, provide formidable testing grounds for such proxy methods. In the Iberian Margin CDS, abundances of distinct benthic foraminifera (often referred to as “elevated epifauna”) are controlled by the strength and nutrient load of bottom currents. Abundances of the bottom current fauna (BCF) in sediment cores have thus been used to reconstruct variations in Mediterranean Outflow Water in the past. However, new faunal and geochemical data from Pliocene-Pleistocene contourites drilled during IODP Exp. 339 strongly indicate that the method is prone to be compromised by taphonomic processes, in particular downslope transport in areas with an unstable continental margin such as the southern Iberian Peninsula.
Here we present first results from an ongoing study that aims towards a better understanding and improvement of this potentially powerful proxy method. Through new faunal analyses from surface samples collected in high and low latitude CDSs, we evaluate biogeographic patterns of the BCF and test the applicability of the method beyond the Iberian Margin. Taphonomic biases and potential ways to minimize them are explored in surface and downcore samples along active and passive continental margins. The expected results will provide researchers with a reliable, well-calibrated and easily applicable proxy for bottom current reconstruction that will ultimately help to improve our understanding of the ocean-climate system.

The invasion of *Amphistegina lobifera* in Marsamxett harbour (Malta) - part II: an early invasion interrupted by a far-generated tsunami

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Information on early invasion stages, whether successful or not, is often lacking, because most invaders are discovered only once they have caused appreciable changes to the recipient environment or have

become abundant enough to be casually detected. Moreover, when newcomers fail to establish self-sustaining populations, they often are not even documented.
Here, we report for the first time a failed early invasion detected from a sediment core, radiometrically dated through ^{210}Pb chronology, collected at 16 m depth in the Marsamxett harbour, close to Manoel island, Malta.
The core, 41 cm long, records at least the last 110 years and contains, towards the bottom, the highly invasive *Amphistegina lobifera* Larsen 1976, a Lessepsian benthic foraminifera that today abundantly occurs in the Maltese islands (Central Mediterranean). Results thus show that *A. lobifera* was already present in Malta at the beginning of the 20th century but then it abruptly disappeared. We hypothesize that the disappearance was triggered by the 1908 Messina earthquake, with the following scenario: an anomalous tsunami wave reached the Marsamxett harbour and accumulated about 20 cm of sediment. This accumulation event suddenly buried the sea-bottom, destroying the benthic community and irremediably damaging the *Posidonia oceanica* meadow. The analysis of our core, in fact, shows that also *Posidonia oceanica* completely disappeared along with *A. lobifera* and other epiphytal foraminifera such as *Miniacina miniacea*.
This unsuccessful attempt by *A. lobifera* to colonize the area was successful replicated between 1940-1945 when the current invasion started.

Sensitivity of coccolithophores and adaptation to selective pressures during the Oligocene - Early Miocene

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It was hypostasized how atmospheric changes in carbon dioxide have a direct impact in the ocean carbon budget, where, the coccolithophore physiology appear to be especially sensitive to this changes. Main variations include changes in growth rate, degree of cellular calcification and coccolith size balance. Here we conduct a morphological study of coccolith size for the *Reticulofenestra* lineage, and specially the for alkenone main producer species *Cyclocargolithus floridanus* over the Oligocene-Miocene time interval using circular polarization microscopy methodology. IODP sediments selected for this study represent a latitudinal gradient over the Atlantic Ocean: mid-latitude Site 1406 (40°N) and tropical Site ODP 925 (2.5°N) as well as mid-latitude Indian Ocean Site 1168 (42°S). Results are compared with published data from the South Atlantic DSDP 516 (30°S). Our mid-latitude sites exhibit various steps decreasing in average size from 30 to 28 M.yr. and from 25 to 23 M.yr., however coccoliths larger than 8 microns are always present. Site 925 shows a constant trend while large coccoliths are rare. The lack of large coccoliths shown in DSDP 516 potentially may be related with a decrease in nutrient supply which appear to be scare after 24 M.yr.; and the two reducing size steps at mid-latitudes would be consequence of a global selective pressure, possibly including CO_2.

Microfossil analysis of cave sediments: Corbridge Cave, Berry Head, Devon

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The importance of the South Devon caves has been recognised since the early nineteenth century. Investigation of their archaeology and palaeontology was placed on a scientific footing by William Pengelly (1812–1894) in Brixham Cavern and Kent's Cavern. Continued exploration has shown that Quaternary deposits spanning at least the last 500,000 years exist in the region's caves. Long sediment records extending well back into the Middle Pleistocene preserve evidence of regional climate change at Kent's Cavern and sea level change at Berry Head. In the Berry Head Limestone Member of Berry Head (Torbay), there are a number of solution caves, of which Corbridge Cave is the largest known. Nearly twenty years' ago, Corbridge Cave and its cave sediments were described by Proctor and Smart (1991), and this included a series of preliminary comments on the foraminifera. All our new samples, collected in 2018, contain foraminifera, thin-valved ostracods and macrofaunal debris (e.g., echinoderm spines). The majority of the diverse assemblages of foraminifera are of small size (maximum 150–250 μm) and this suggests that they may have been transported into the cave system by storm or wave action. All of the species are well-known in Tor Bay, including the sea grass meadows, a large area of which is known from near Brixham Breakwater.The foraminifera can only provide limited stratigraphical information, except by using stable isotopes derived from a suite of closely-spaced samples and dates from adjacent speleothms.

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Developing micropaleontological proxy indicators of growth rates

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The carbon isotopic fractionation during photosynthesis (Ɛp) from sedimentary alkenone biomarkers produced by coccolithophores are a widely used proxy indicator for past concentrations of past dissolved CO_2 in seawater (CO_{2aq}). Phytoplankton growth rate is an essential parameter required to estimate pCO_2 from carbon isotopic fractionation in coccoliths. However, this factor has not been adequately accounted for in many published phytoplankton pCO_2 estimates. We use global-scale surface sediment datasets to estimate past growth rates based on several microfossils proxies and their modern relationship to changes in photic zone. The relative abundance of lower photic coccolithophorid *Florisphaera profunda* is proportional to water column stratification and nutricline depth. We hypothesize the %*F. profunda* will vary inversely with the growth rate/CO2 enhancement factor. We will evaluate a similar construction based on foraminiferal $\delta^{18}O$ gradients and planktonic foraminifera assemblages ratios between the upper mixed layer (e.g. *Globigerinoides sacculifer*) to thermocline (e.g. *Globorotalia menardii*) taxa. These proxies reflect the upper photic zone temperature and salinity gradients, which control stratification of the water column, and hence related to past phytoplankton growth rates.

Variations in dissolved bottom water oxygen concentrations of the intermediate equatorial Pacific over the last 140,000 years

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Intermediate waters (500 - 2000 m) from the equatorial- to North Pacific are currently hypoxic (oxygen concentrations below 120 µmol/kg), while deeper waters are well oxygenated. Some proxy compilations suggested that this trend was reversed during the last ice-age, with well-oxygenated Pacific intermediate waters, and lower oxygenated deeper waters associated with an increased deep carbon reservoir. Recently we challenged this concept, showing instead that there was an overall expansion of oxygen-depleted water during the last glacial (Hoogakker et al., 2018 Nature). Here we extend the bottom water oxygen record of ODP Site 1242 (1360 m depth) to 140,000 years, to further assess the natural variability in intermediate water dissolved oxygen concentrations over longer time-scales. We follow the approach of Hoogakker et al. (2015 Nat. Geosc.), which uses the carbon isotope gradient between bottom water (recorded by epifaunal benthic foraminifera *Cibicidoides wuellerstorfi*) and pore water at the anoxic boundary (recorded by infaunal *Globobulimina* spp.) as a quantitative bottom water oxygen proxy.

Deep Sea benthic foraminifera define biohabitats in the southeastern Levantine Basin, eastern Mediterranean

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The distribution of living and dead benthic foraminifera (BF) was investigated in the SE Levantine basin at water depths between 100-1900m. The research aim was to establish a reference baseline for studying possible future sea-floor changes that might arise due to increasing activity of gas/oil companies in this region. Macrofauna and benthic foraminifera were studied in the same size fraction (>250µm) in 50 stations distributed in the economic water off the Israeli coast. In total, 100 species of living foraminifera and 197 species of dead foraminifera were identified, many of them, for the first time in this region. Based on cluster analyses, six live and four dead foraminiferal assemblages were identified in the shelf margin (SM), upper continental slope (UCS), lower continental slope (LCS) and the bathyal. Species richness varied between 55 in the UCS and 16-22 in the bathyal. The highest abundance occurred in the UCS and the lowest in the bathyal. In water depths below ~1200m, agglutinated species made the majority of the BF. These agglutinated BF comprised up to 50% of the living foraminifera and 97% of the dead assemblage. Many of them were associated with the commonly occurring pteropods with aragonite shells, either encrusting their outer shell or being attached to the inner shell. *Ammolagena clavata* is the most common species in the 1st group, while *Ammolagena minuta* and *Hemisphaerammina bradyi* are the most common among the 2nd group. This foraminifera-pteropoda association is a unique phenomenon, and increasing ocean acidification might eliminate this distinct BF population.

The Late Pliocene-Pleistocene foraminiferal and nannofossil stratigraphy of the Ioffe Drift, Western South Atlantic

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The Ioffe contourite drift located in the Antarctic Bottom Water pathway from the Vema Channel to the Brazil Basin offers a unique opportunity to study past variations in bottom contour currents and their contribution to erosion and accumulation of deep-sea sediments applying a classical micropaleontological approach. Planktic foraminiferal and nannofossil zonation identified from three sediment cores collected above the foraminiferal lysocline provides a robust stratigraphic frame to define the gaps in the Late Pliocene – Quaternary records. In particular, we document the absence of foraminiferal zone *Globorotalia crassaformis hessi* (0.81–1.47 Ma) in two cores and of nannofossil zones *Gephyrocapsa* (0.92–1.22 Ma), *Helicosphaera sellii* (1.22–1.51 Ma) and *Calcidiscus macintyrei* (1.51–1.9 Ma) in one core. To get a deeper insight into the distribution of erosional hiatuses we applied some new techniques. As a result, integration of biostratigraphic data with the records of magnetic susceptibility, color reflectance and X-ray fluorescence permits a rather confident identification of long- and short-term hiatuses notably within the intervals from 1.51 to 0.81 Ma (roughly corresponding to the Mid-Pleistocene Transition), and 2.5/2.59 – 1.9 Ma (reorganization of deep-water circulation since the Pliocene/Pleistocene boundary) in all three sections. Comparison of the studied sediment records with the DSDP Site 516 reveals reduced thickness of all recovered biostratigraphic zones and more often occurrence of hiatuses in the Ioffe Drift than on the Rio Grande Rise suggesting more vigorous contour currents in the former area. The study was supported by the Russian Science Foundation (grant 18-17-00227).

Micro- and nannofossils for provenance analysis of artworks – A new metod of extraction and data cross-linking

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Nannofossils are rarely used in the cultural heritage field. These last years the interest for this field grow up and researchers (Hradil 2018; Kedzierski 2018) find out that it could be used for provenance determination. Paintings and statues between 15th and 18th century have preparatory layers made of chalk or clay (Antunes 2016). The aim of determining the assemblages in artworks is to found the material and therefore painting provenance or commercial paths.
There are two main problematic with artworks samples. The first one is the determination of nannofossils from samples in limited amount (unique), extremely small (micro-samples) and man-made (natural material mixed with organic binders). Non-destructive methods are preferred, like micro-/nanno-CTand SEM, but many informations won't be find by these methods. Smear slides stays the quickest, easiest and best way for assemblages determination. The extraction method for rocks cannot be used in this case and therefore a new method should be applied.

The extraction process was developped by empirical testing on mock-ups and pure materials at different temperatures, various ultrasonic times and with 8 chemicals like micro-emulsions.
The second problematic is the assemblage determination and its provenance. We want to process by cross-checking the data micro-/nannofossils assemblages, materials, historical quarries, cities and villages as well as painters travels.
For the beginning, seeding of datasets from speciallsts and connecting them in a geolocalised system is the priority. Then these datasets will be published in form of an open website to the scientific community.
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The long-term Miocene to Pliocene transition in calcareous nannofossil assemblages

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Integrated Ocean Drilling Program Expedition 363, (Site 1482; 15°3.32'S, 120°26.10'E, 1466 mbsf) was cored on the northwest Australian continental margin located on the Scott Plateau in late 2016. Recovered sediments from Site 1482 are clay-rich and yield diverse calcareous nannofossil assemblages that are well to moderately preserved. The late Miocene to late Pliocene (Tortonian-Piacenzian) interval is documented in this study, with 200kyr resolution between samples across a total of 6Ma. The quality of nannofossil preservation and this continuous late Miocene to Pliocene record allows for the detailed quantification of species diversity, assemblage composition and morphological disparity over macroevolutionary time scales. With these initial results we explore the competing effects of closure of the Indonesian Gateway, the development and dynamics of the Australian Monsoon, the long-term evolution of the Indo-Pacific Warm Pool, as well as global-scale cooling and declining atmospheric pCO2 on these tropical calcareous phytoplankton communities.

Modeling benthic foraminiferal microhabitats

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Since the pioneer work of Corliss and colleagues in the 1980's, we know that in open marine environments, benthic foraminifera show a vertical species succession in the superficial sediment layer. It is generally assumed that this vertical succession is controlled by the availability of oxygen and labile organic components. Since the discovery that not all foraminifera have a strictly aerobic metabolism, but that several species are facultative anaerobes, capable of respiring nitrate, our understanding of

foraminiferal microhabitats has become more complex. Even more than before, the quality of the available organic compounds seems to be the key parameter controlling foraminiferal microhabitats.
Here, we try to model the benthic foraminiferal habitat, using a large geochemical-foraminiferal dataset from the Bay of Biscay, collected between 1997 and 2001 at sites from 150 to 2000 m deep. After tuning the early diagenetic model (based on the OMEXDIA model of Soetaert et al., 1996) for each investigated site, theoretical foraminiferal taxa, with varying life cycle characteristics, have been introduced into the model, to simulate the observed faunal patterns as closely as possible.
The benefit of this model is that it allows us to evaluate theoretical foraminiferal taxa with various characteristics, and by observing which species life strategies best mirror the patterns observed in nature, we can gain new insights about the factors controlling foraminiferal microhabitats. The next step will be to formalize the approach as an inverse model, making it possible to reproduce the controlling factors on the basis of microhabitat successions observed in nature.

A 167 million-year record of ontogenetic disparity in planktic foraminifera

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Evolution prompts a variety of morphological designs in all species. Shape is a combination of biological and ecological constraints. However, much of the analysis of disparity in the fossil record focuses on the adult form as often ontogenetic stages are not preserved. In contrast, planktic foraminifera preserve their entire life cycle in their tests and are ideal to analyze rends in of ontogenetic disparity across time. By using computer tomography, 3D reconstructions of the ontogeny of 20 species of planktic foraminifera spanning the Middle Jurassic to recent have been created. 3D models are interrogated for size, surface area and volume comparison throughout development to determine the ontogenetic disparity between extinct and extant species. We postulate that the bauplan of planktic foraminifers is tightly constrained (Caromel et al., 2016) and follows the same trajectory through all main diversifications. Juvenile specimens of all species analysed show little variability in their shape with. Disparity during the Jurassic is low; species are simplistic and rounded. Adult disparity increases through time, but reduces to the Jurassic design in recovery from the K/Pg mass extinction, described by Luterbacher and Premoli Silva (1964). Chamber volume expansion differs greatly between Mesozoic and Cenozoic specimens: Jurassic species increase in size in smaller increments whereas in modern forms it is more extreme. Based on the changes of surface to volume area we propose that as a foraminifer grows, different metabolic processes dominate as sustaining higher metabolic demands requires a larger surface area per unit volume.

Occurrence of bacterial biofilms on foraminifera tests from Serravalian Stage, Miocene of Slovakia

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Microbial biofilms comprises all substances secreted by microorganisms for different pourposes from protection of the cells to substances wich enhance metabolic process. The presence of biofilms could contribute to the preservation of soft parts as they create a low oxygen microenvironment arround the dead bodies. In this work we present evidences of bacterial colonization of foraminífera tests in a carbonatic condition of precipitation. The interpreted paleoenviromnment shares similarity to actual sea-meadows which corresponds to a shallow and well illuminated area in the photic zone. The studied material consists of samples from strata relative to Langhian-Serravallian Stage, Miocene, Central Paratethys. Preliminary results correspond to bacterial biofilms identified by SEM imaging as patches and nets with irregular borders on the surface of the umbilical area of foraminifera tests and nannostructures corresponding in size and structure to actual and described fossil bacterial body cell polymorphs. The presence of biofilms could give indicatives of syndepositional conditions as well as of the diagenetic process hereafter. They can also increase the precipitation of minerals which will influence the diagenetic process and the fossilization process. This work owes acknowledgments to the project GAČR 242-201778.

Factors affecting planktonic foraminifera carbonate mass fluxes in the Cap Blanc upwelling area (Atlantic Ocean)

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The calcareous tests of planktonic foraminifera constitute a major component of the pelagic carbonate counter pump, transporting carbonate from the sea surface to the sea floor whilst simultaneously releasing CO_2. Globally, foraminifera are responsible for 20-40% of the global pelagic carbonate flux and in the Cap Blanc upwelling area (Atlantic Ocean) their contribution to the total carbonate flux is ~33%. Thus, foraminifera carbonate export flux plays a significant role in the atmospheric-oceanic CO_2 circulation on a timescale of 100-1,000 years. Understanding environmental factors affecting carbonate production by foraminifera is essential to model this process and predict its fate under future climate change. In theory, the foraminifera carbonate export flux can be modulated by changes in i) shell flux, ii) shell mass or iii) species composition of the settling foraminifera assemblage. Here we used time series of foraminifera flux from a sediment trap in the Cap Blanc area to quantify the contribution of these three candidate processes under natural conditions across two entire seasonal cycles. We determined the variations in test flux of 25 species, measured the average size and mass of their shells and calculated the contribution of the three processes to differences in mass flux of carbonate within a year and between the years. We show that the foraminifera carbonate flux varied by 34.32 mg m^{-2} d^{-1} within the years but only by 1.68 mg m^{-2} d^{-1} between the years. The largest contribution to the variability was individual flux and species composition, but we also document significant changes in size and weight, for example in *Globorotalia inflata* size can change by 80% and weight by 60% across the year.

The impact of fish farming in an arctic fjord investigated using geochemical parameters and benthic foraminiferal assemblages

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This study investigated geochemical parameters as well as fossil and living benthic foraminiferal assemblages in dated sediment cores from inner Øksfjord, Northern Norway. The aim was to establish reference conditions to identify the potential impact of fish-farming in the fjord. Currently, reference conditions cannot be determined using conventional methods as environmental monitoring studies started after the farms initiated. To assess the impact of fish-farming on the fjord, sediment cores were collected from the inner fjord's main and sub-basin. Traditionally used parameters like total organic carbon and certain trace metal concentrations in addition to C/N ratios and sediment stable carbon isotopes showed no temporal changes. Reference benthic foraminiferal assemblages indicated that natural conditions differed between the basins. The assemblages showed no temporal changes in the diversity indices (H'_{log2}, ES_{100}) traditionally used in the Norwegian classification system and indicated that good ecological conditions persisted. AMBI didn't change for the main basin but increased in the sub-basin signifying a larger abundance of organic matter tolerant species. Increasing relative abundancies of *Brizalina skagerrakensis* in the main basin and *Epistominella vitrea* in both basins indicated a larger phytodetritus input. In both basins *Cassidulina reniforme,* a species sensitive to increased organic matter declined. In the sub-basin opportunistic *Stainforthia* showed a rapid increase in relative abundance in the past decades. Temporal changes observed in the fossil fauna are confirmed by the living assemblages with even higher abundancies of living *Stainforthia*. This study shows that traditional monitoring techniques are not always adequate for determining the impact of fish-farming.

Foraminifera as tool for biostratigraphic cross-correlation of major oilfields in the Vienna Basin

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The Vienna Basin is an intra-alpine pull-apart basin, which originated during the early middle Miocene and is among Europe's largest onshore oil and gas fields. Due to the complex tectonic setting, an intra basin correlation of Miocene drillings remained difficult.
Our study aims at an updated biostratigraphic correlation of cores from four major oilfields (Rabensburg, Bad Pirawarth, Matzen and Aderklaa), which will be backed by north-south seismic cross-sections throughout the Vienna Basin
One of the main objectives is to obtain information about thickness and position of the supposed lower Miocene deposits and the stratigraphic content of middle Miocene deposits, that are varying considerably in thickness from well to well. The tectonic setting impedes with a straightforward correlation of single 3D seismic reflectors. To obtain a reliable correlation more than 500 samples of about 40 drillings are analysed and interpreted in respect of biostratigraphy and palaeoecology.

Especially the interpretation and correlation of thickness and distribution of the various Miocene formations is challenging due to major canyon structures and other erosive features. These have been unknown from surface outcrops and, therefore, the existing lithostratigraphic schemes need a re-evaluation.
The main analyses are based on benthic and planktonic foraminifera to assign the deposits to regional biostratigraphic zones and to allow a correlation with international stages. In addition, palaeoecological data will be used to describe the palaeoenvironmental conditions and their changes through time.
Combined with core-log data, such as spontaneous potential, resistivity as well as modern 3D seismic data, information about palaeotopography and palaeogeography during deposition are acquired. Furthermore, misinterpretations concerning the local stratigraphic setting should be resolved and a better intra-basin correlation in respect to lower Miocene - Ottnangian and Karpatian - and middle Miocene - Badenian and Sarmatian - units will be accomplished.
Therefore, the new biostratigraphic data and derived integrated stratigraphy will allow establishing a modern lithostratigraphic scheme for all seismic units. As such, this integrated approach will provide a framework for a modern sequence stratigraphy of the Vienna Basin.
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Marine Alien Foraminifera in Europe: The Current Status of the EU Marine Strategy Framework Directive

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The re-examination of marine alien foraminifera or Non-indigenous species (NIS) reported in Mediterranean waters by June 2019 is here provided, particularly focusing on establishment success, year of first record, origin, potential invasiveness, and likely pathways. Their distribution is assessed according to marine subregions outlined by the European Union (EU) Marine Strategy Framework Directive: Adriatic Sea (ADRIA), Ionian Sea and Central Mediterranean Sea (CMED), and Western Mediterranean Sea (WMED). Most of these species were recorded in more than one subregion. The NIS have established stable populations and some of them exhibit invasive traits.
Many NIS have most likely arrived through the transport-stowaway pathway related to shipping traffic (biofoulers, ballast waters, and hitchhikers) or unaided movement with currents. The Strait of Sicily represents a crossroad between the alien taxa from the Atlantic Ocean and the Indo-Pacific area.
This review can serve as an updated baseline for future coordination and harmonization of monitoring initiatives under international, EU and regional policies, for the compilation of new data from established monitoring programs, and for rapid assessment surveys.

Foraminiferal distribution, nitrogen metabolism and their contribution to biogeochemical cycles in the hypoxic Bering Sea

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South-east Bering Sea is one of the highest surface productivity area in the open ocean due to strong upwelling along the Bering canyon. However, the benthic geochemistry and organisms living in the area have been largely overlooked. From August 5th to 21st 2017 we sampled surface sediment in 5 stations along a 1536 to 103 meters depth transect in the Bering canyon with JAMSTEC R/V *Mirai*. Bottom-water hypoxia was observed in the two deeper stations (1536 and 536m). At these stations, the oxygen penetrates down to 5 mm in the sediment while oxygen penetration is 15 and 20 mm at the 103- and 197-meters deep stations respectively due to much siltier and organic-rich sediment in the deepest stations.
In the deeper stations, living foraminiferal communities (CellTracker Green labelled) were dominated by *Eggereloides advenus*, *Uvigerina peregrina* and *Bolivina spissa* while the shallow stations exhibited large densities of *Nonionella auricula*, *Portatrochammina pacifica*, *Bolivina pseudoplicata* and *Uvigerina peregrina*. Most of these species can accumulate nitrate in their cell (from 8 to 244 mmol/L; which is from 100 to 4000 times more concentrated than the higher concentration measured in pore-water). On-board denitrification measurements confirmed that *Bolivina spissa* and *Nonionella auricula* could reduce nitrate through denitrification and support their activity for up to 20 days under anoxic conditions.
Further analyses of foraminiferal shells pore size and distribution are under process to test if these parameters could be linked to oxygen and nitrate availability in the Northern pacific hypoxic zone.

Ammonium and nitrate assimilation in benthic foraminiferal cells: NanoSIMS observations and enzymatic pathways

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Nitrogen is a central element marine ecosystems. Yet, cell-specific ammonium or nitrate assimilation among benthic foraminifera is poorly understood. Ammonium assimilation in benthic foraminiferal cells has been shown for two kleptoplastic species only (*H. germanica* and *N. labradorica*). In these two species, the role of the kleptoplast in ammonium assimilation is not known, and it was suggested that a foraminiferal cytoplasmic pathway for ammonium assimilation exists. Some benthic foraminiferal species are known to maintain intracellular pools of nitrate, likely serving as nitrate source for the denitrification process. But whether nitrate-derived nitrogen can be assimilated into the foraminiferal biomass or not is unclear. By combining stable isotope incubations ($^{15}NH_4^+$ and $^{15}NO_3$) with NanoSIMS isotopic imaging we were able to follow the assimilation of inorganic nitrogen in biomass of different foraminiferal species from contrasted environments locations. While ammonium assimilation was recorded in all investigated species, no nitrate assimilation was observed, even in species known to performed denitrification,

indicating that the denitrifying foraminifera can store nitrate in their cell but do not use nitrate-derived nitrogen to build their biomass. Furthermore, GC-MS analysis of the amino acids produced during an incubation with $^{15}NH_4^+$ allowed us to study the metabolic pathways of ammonium assimilation in three benthic species. Those results revealed different enzymatic pathways between kleptoplastic and non-kleptoplastic species, shedding light on the role of kleptoplasts in foraminiferal ammonium assimilation.

Organic carbon rich sediments: benthic foraminifera as bio-indicators of depositional environments

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Carbon burial in coastal marine sediments acts as a climate regulator by reducing the remineralisation of organic carbon (OC) into the atmosphere and thus buffering the release of CO2. Fjords are known hotspots of carbon burial; however, little is known about the long-term fate of the carbon stored in these sediments. In this study, we evaluate the use of modern benthic foraminifera as bio-indicators of carbon content in six voes (fjords) on the west coast of Shetland. Benthic foraminifera are sensitive to changes in the amount of carbon reaching the seafloor, while they do not reflect in their assemblage composition carbon loss due to post depositional degradation. We identified four environments based on the relationship between benthic foraminiferal assemblages and carbon content in the sediments: 1) Land-locked regions influenced by riverine/freshwater inputs of organic matter, namely the head of fjords with a restricted geomorphology; 2) Stressed environments with a heavily stratified water column and sediments rich in organic matter of low nutritional value; 3) Depositional environments with moderate organic content and mild or episodic current activity; 4) Marginal to coastal settings with low organic content, such as fjords with an unrestricted geomorphology. We conclude that foraminifera potentially provide a qualitative tool to disentangle primary carbon signals from post-depositional degradation and carbon loss. This approach could be used down-core to support palaeoenvironmental reconstructions of OC burial and accumulation over different time scales and paired with statistical and spatial modelling to tease out post depositional OC degradation.

The invasion of *Amphistegina lobifera* in Marsamxett harbour (Malta) - part I: current invasion dynamic triggered by climate change

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Amphistegina lobifera is a benthic foraminifera native to the Red Sea which entered the Mediterranean through the Suez Canal. It is currently abundant in the Maltese islands (Central Mediterranean), where it was first observed in 2006. Here, we backdate its first arrival and reconstruct its invasion dynamics by

means of a sediment core collected in May 2018 in Marsamxett harbour (Malta) and radiometrically dated through ^{210}Pb chronology.
Results show that *A. lobifera* reached Malta approximately between 1940 and 1945, seventy years earlier than its first finding in 2006. During the first three decades (1940 to 1970), this non-indigenous species displayed very low abundances. We hypothesize that this is due to environmental conditions (in particular, sea surface temperature) not favourable for this tropical species. Since the 1970s, its abundance has started to increase, with accelerated population growth recorded since the 1990s.The maximum peak of abundance was recorded at cm 2-3 below sea floor, corresponding to A.D. 2006, the same year when the species was first observed in four different sites in Malta, Comino and Gozo. Its increased abundance perfectly mirrors the sea surface temperature increasing trend registered in the Western Mediterranean during the last 40 years, hence suggesting that the colonization process is following the current climate change.
This study applies for the first time a ^{210}Pb chronology to date a sediment record containing the invasive species *A. lobifera* and could be used as a replicable protocol to investigate the temporal dynamics of other small-size invaders with mineralized shells.

Calcareous Nannofossil assemblage highlight the differences between cyclicals and stochastics sapropels in the Sorbas basin

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Sorbas is one of the reference basin of the Messinian Salinity Crisis (MSC), an extreme event that affected the Mediterranean starting from 5.97 Ma, characterized by the huge deposition of evaporites. Before the MSC, the Mediterranean was affected by the progressive reduction of the water exchange with the Atlantic, recorded in the sedimentary record by precise steps. One of the major reduction step is dated at 6.7 Ma, and coincides with the onset of the cyclical sapropel deposition in the Sorbas basin. Here we focus on Calcareous Nannofossil associations of the last pre-evaporitic precessional cycles. Abundance fluctuations well correlate with precessional forcing, resulting in a cyclical peak in abundance of *Sphenolithus* spp. in the sapropel (precession minimum) and *Reticulofenestra pseudoumbilicus* and *Coccolithus pelagicus* in the marl/diatomite (precession maximum). Unexpectedly, the last pre-evaporitic cycle (UA34) is mainly composed by organic rich layers. Toward the MSC onset, the fossil assemblage is dominated by *Reticulofenestra pseudoumbilicus* and *Coccolithus pelagicus*, frequently recorded during precession maxima time. This fossil assemblage reveals that sapropels-like layers were deposited even during precession maximum, likely due to an increase in productivity which took place just before the MSC onset in a restricted and shallow basin.

Geochemistry of *Nummulites* as a proxy for Eocene paleotemperature evolution in the southern North Sea Basin

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The early Eocene witnessed a gradual warming towards the Early Eocene Climatic Optimum (EECO), enabling the northward migration of subtropical *Nummulites* into northwest Europe (King et al., 2016, The Geological Society). Our research assesses the application of these larger benthic foraminifera as a proxy for Eocene climate evolution in the southern North Sea Basin by Mg/Ca-paleothermometry, as developed by Evans et al. (2018, PNAS).
Our methodological study focused on the link between *Nummulite* geochemistry and (1) preservation state, (2) test size and (3) cleaning intensity. Different preservation states were compared through geochemical analyses (ICP-OES), combined with SEM observations. This indicates that increasing taphonomic alteration (dissolution and recrystallization) results in significantly lower Mg/Ca and Sr/Ca ratios. Smaller *Nummulite* specimens display a larger variability in test Mg/Ca, while the largest specimens only record the upper range. Intensive chemical cleaning (oxidation and reduction steps) effectively removes Fe- and Mn-bearing minerals, whereas the Mg/Ca ratio was not affected. This implies that Mg-contamination by sedimentary and diagenetic coatings is insignificant. Based on these results, we propose a simplified cleaning procedure of well-preserved specimens using a specific size range.
Lower Eocene (Ypresian) *Nummulites* from Belgium recorded a temperature rise towards the EECO of ± 7 °C (21-23 – 28 °C). These preliminary results are in accordance with other proxy data, indicating that *Nummulites* provide a powerful tool for paleotemperature estimates. Further research will include paleoenvironmental interpretations through comparison with the stable isotope data of smaller benthic foraminifera and sediment characteristics.

Implementation of the Foram Index in tropical coral reefs from Puerto Rico

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Coral reefs at Jobos Bay National Estuaries Research Reserve (JBNERR) have been impacted by anthropogenic inputs. A better understanding of reef health is needed to improve stakeholders' decisions for proper management actions in the reserve. The FORAM Index (FI) can be used as a tool to determine the water quality at the reefs using foraminifers as bioindicators. Four reefs; Cayo Caribe, Cayo Barcas, Cayo Pajaros and Cayo Morrillo, were sampled along transects in the front and back of each reef. Physicochemical parameters and nutrients were measured through the water column. Normal oligotrophic conditions permeate the reefs at with FI values >4 which is indicative of conditions “conducive for growth”. Of all the reefs, the Cayo Caribe has three stations with FI values between 2 and 4 as indicative of conditions of “environment marginal for reef growth and unsuitable for recovery”. Cayo Caribe is the eastern most and largest reef of the study area and is proximal to pharmaceutical and carbon processing plant. The predominance of sand-sized sediments and abraded specimens reflects the active hydrodynamic regime coupled with low foraminiferal density values. The FI is providing useful information about the current reef conditions and is expected to be incorporated as a biomonitoring tool at JBNERR.

Neogloboquadrina pachyderma distribution during the late Quaternary deglaciation phases of the western Ross Sea (Antarctica)

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Neogloboquadrina pachyderma (Ehrenberg) is the only planktic foraminifer able to live in polar areas, generally feeding on bacteria and diatoms. This species can also survive in brine channels within sea-ice under hyper-saline and low temperature conditions. In autumn, juvenile forms living in the upper part of the water column become incorporated into the forming frazil ice. With the onset of winter, some of the specimens may become trapped in brine pockets when lower temperatures cause further narrowing of brine channels. These individuals will die as juveniles due to low temperatures and/or lack of food, other individuals are released into the water column during spring ice melting and continue their life cycle. The distribution of *N. pachyderma* in the Antarctic continental margin allows one to constrain and test models of the ice sheet dynamic. We document the presence of intervals with abundant occurrence of juveniles (and adult forms) of well-preserved *N. pachyderma* from three piston cores from northern Drygalski Basin (cores TR17_03 and TR17_04PC, TRACERS PNRA-Project) and Hallett Ridge (core KI13_C2, ROSSLOPE PNRA-Project), Ross Sea, Antarctica. We discuss N. *pachyderma* habitat also considering data from benthic foraminifer and diatoms. We suggest that the co-occurrence of *N. pachyderma* with large tests and the abundant presence of juvenile forms in the sediment reflects the presence of seasonal open water conditions and/or variation in the length and intensity of seasonal sea ice. Our results can help reconstruct past glacial dynamics in the Ross Sea continental margin.

New data for the biostratinraphy of the Late Cenomanian- Early Santonian (Late Cretaceous) deposits of the Chanis-tkkhali River (Western Georgia) on planktonic foraminifera and nanoplankton

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Upper Cretaceous deposits in the Chanis-Tskali section (Western Georgia) are represented by carbonate rocks with multi-colored flints concretions. Various taxonomic assemblages of planktonic foraminifers and nannoplankton were distinguished for the Chanis-Tskali section firstly.
Rotalipora brotzeni: Muricohedbergella planispira, M. delrioensis (early Cenomanian). Author: Lehmann, 1966.
Rotalipora cushmani: Thalmanninella reicheli, Planoheterohelix globulosa (late Cenomanian (partially)). Author: Borsetti, 1962. *Chiastozygus amphipons* (nannoplankton).
Whiteinella archaeocretacea: Dicarinella imbricata, Helvetoglobotruncana praehelvetica. Author: Caron 1985 (late Cenomanian (partially) - early Turonian (partially)) and layer with *Chiastozygus amphipons* (nannoplankton).
Helvetoglobotruncana helvetica: Author: Sigali, 1977 (early Turonian), from nannoplankton: *Microrhabdulus decoratus*.

Marginotruncana schneegansi and *Marginotruncana pseudolinneiana*: *M. sinuosa, M. marginata. Eifellitus eximius* (nannoplankton). Author: Pessagno, 1967 (mid-late Turonian). Zone *Microrhabdulus decoratus* (early Turonian), which covers zones: *Whiteinella archaeocretacea* (partially), *Helvetoglobotruncana helvetica* and *Marginotruncana schneegansi - M. pseudolinneiana* (partially).
Marginotruncana coronata: M. pseudolinneiana, Planoheterohelix globulosa. Author: Moorkens, 1969 (the lower part of the early Coniacian). Allocated zone *Eifellithus eximius* (nannoplankton) (late Turonian - early Coniacian). It corresponds to – previous and *M. coronata* (partially).
Marginotruncana sigali and *Marginotruncana renzi: Marginotruncana pseudolinneiana, M. sinuosa* (the upper part of the early Coniacian-part of the late Coniacian). Author: Sliter, 1989, Bolli 1957.
Concavatotruncana concavata: M. angusticarinata (late Coniacian - early Santonian). Author: Sigal, 1977. *Marthasterites furcatus* (nannoplankton) (Coniacian), which correlates with the foraminifera zones: *Marginotruncana coronata* (upper part), *M. sigali-renzi* (fully embraced) and *Concavatotruncana concavata* (to the upper part of the zone).
Thus, a detailed study of the p. Chanis-Tskali allowed us to identify 8 zones by planktonic foraminifera and 4 zones and one layer by nanofossils.

Sedimentology, geochemistry, and benthic foraminiferal ecology in the sediments under high primary production area off Aleutian Islands

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South-east Bering Sea is one of the highest surface productivity area in the open ocean due to strong vertical mixing and upwelling along the Bering canyon. Here, we investigated the sediment biogeochemistry and benthic foraminiferal ecology based on surface sediment samples obtained by a multiple corer in August 2017, during the R/V Mirai MR17-04 cruise leg2. Sedimentary facies were different between sites depend on geological settings, and subsequently, organic matter contents and their qualities measured as phytopigment and their derivatives varied between different bottom topographies. Labile organic matters produced by phytoplankton were deposited in the deeper part (500 and 1500 m water depth) of the canyon and also in the 200 m water depth depression in the Unimak Channel which is c.a. 100 m deeper than surroundings. Porewater nutrient concentrations suggest high rate of organic matter mineralization at these phytoplankton-deposition sites. *Nonionella* spp. flourished at phytoplankton-deposition sites and possess abundant chloroplasts in their entire cells, inferring kleptoplasty. *Bolivina spissa,* a shallow infaunal species, showed abundant food vacuoles filled with sediment particles. The high primary production at this area allows high abundances of foraminiferal biomass and activities at particular site where phytoplankton biomass can be accumulated. Benthic foraminifera can degrade these phytodetritus by active grazing and by the retention of algal chloroplasts for certain foraminiferal species metabolisms, and subsequently contribute to the high nutrient concentrations in the sediments of these sites.

Benthic Foraminiferal Assemblages and Biotopes' Definition in a Coastal Lagoon: The Case Study of Sacca di Bellocchio (central Italy)

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The benthic foraminiferal and ostracod assemblages have been investigated in the Bellocchio lagoon (north-east coast of Italy) for the identification of biotopes. On the basis of the statistical analyses, three main biotopes that reflect different ecological and environmental conditions are here identified. These biotopes are characterized by specific assemblages of benthic foraminifera and ostracods that mirror the geographical distribution of the sample stations in the lagoon and are mainly influenced by the hydrological (namely salinity) and sediment conditions. The outer lagoon biotope is affected by marine influence and is dominated by a higher number of foraminiferal species, many of which are more common in open water environments, such as the *Quinqueloculina seminula*. The inner biotope is characterised by more restricted areas where the percentage of mud increases, the diversity indexes have lower values and resilience species, such as *Cyprideis torosa*, dominate. The last biotope is related to those stations located nearby the western border, farther away from the Adriatic Sea and significantly influenced by the nearby Comacchio wetlands.

Comparison of four foraminiferal indices assessing the environmental quality of coastal Mediterranean soft bottom environments

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Coastal environments are exposed to numerous pressures that potentially affect soft bottom faunas. Several indices based on living (Rose Bengal-stained) foraminiferal communities have recently been developed to assess the induced impact and determine the environmental quality of these environments. Here, we use a Mediterranean Sea data set to test four foraminiferal indices: 1) the effective number of species (exp(H'bc)), 2) the Foraminifera AMBI (Foram-AMBI), 3) the Tolerant Species Index for the Mediterranean (TSI-Med), and 4) the Foram Stress Index (FSI). These indices are all supposed to measure the response of the foraminiferal communities to organic matter enrichment, and therefore, their results should be very similar.
We found that the exp(H'bc) is not suitable to evaluate the environmental quality of our Mediterranean coastal setting, as it has a non-monotonic relationship with the organic matter enrichment gradient. The three indices based on groups of indicator species (TSI-Med, Foram-AMBI, and FSI) yield fairly similar results. For Foram-AMBI, the results are clearly improved if the total assemblage is used to calculate proportions of indicator species, and not only assigned species, as defined in the original methodology. In TSI-Med, a correction based on sediment grain size is applied to distinguish between natural and anthropogenic organic enrichment. Such a correction could also be added to Foram-AMBI and FSI. In future, it will be necessary to redefine the limits between the Ecological Quality Status classes for each index. This could not be realised here because of a lack of sites with a poor and bad environmental quality in the studied data set.

Exploring new high-resolution geochemical proxy calibration strategies for benthic foraminiferal tests

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Foraminiferal research contributing to our understanding of past climate variability relies increasingly on geochemical approaches. It is of utmost importance to define the (palaeo)ecological context of the studied species before the geochemical data from the foraminiferal test can be correctly interpreted. Moreover, biomineralisation models based on experimental studies with foraminifera predict species-specific elemental incorporation into the calcite lattice. In addition, it was proposed that diagenetic coatings could affect the geochemical composition of the benthic foraminiferal test leading to substantial bias in palaeoceanographic interpretations. Therefore, the development of new geochemical proxies from foraminiferal tests requires the combined use of various methodological approaches with contrasting resolution and sensitivity.
In this study, we explore the potential of benthic foraminiferal element-to-calcium ratios as palaeo-redox, -productivity as well as -river runoff proxies (e.g., Mn/Ca, V/Ca and Ba/Ca) in continental margin settings. We use sediment cores of contrasting study areas to study species from different microhabitats. To evaluate the potential bias from diagenetic coatings, we apply microanalytical techniques, i.e., Laser Ablation ICP-MS (LA-ICP-MS) and Secondary Ion Mass Spectrometry (SIMS) for the comparison of uncleaned and cleaned specimens. This will lay further groundwork for future proxy studies from environments with relatively rapid changes in e.g., productivity and ventilation.

Modelling foraminiferal pore patterns: how to reconciliate gas exchanges and test robustness

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Due to climate warming and increased anthropogenic impact, a decrease of ocean water oxygenation is expected in the near future, with major consequences for marine life. In this context, it is essential to develop reliable tools to assess past oxygen concentrations in the ocean, to better forecast these future changes. Recently, foraminiferal pore patterns have been proposed as a bottom water oxygenation proxy, but the parameters controlling foraminiferal pore patterns are still largely unknown. Here we use scaling laws to describe how both gas exchanges (metabolic needs) and mechanical constraints (shell robustness) control foraminiferal pore patterns. The derived mathematical model shows that only specific combinations of pore density and pore size are physically feasible. Maximum porosity, of about 30%, can only be obtained by simultaneously increasing pore size and decreasing pore density. A large empirical data set of pore data obtained for three pseudocryptic phylotypes of *Ammonia*, a common intertidal genus from the eastern Atlantic, strongly supports this conclusion. These new findings provide basic mechanistic understanding of the complex controls of foraminiferal pore patterns and give a solid starting point for the development of proxies of past oxygen concentrations based on these morphological features. Pore size

and pore density are largely interdependent, and both have to be considered when describing pore patterns.

Foraminiferal community response to seasonal anoxia in Lake Grevelingen (Netherlands)

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Oxygen depleted bottom waters are observed with increased frequency, intensity, extent and duration, and such events have very deleterious consequences for ecosystem functioning. Benthic foraminifera are fairly tolerant to low oxygen concentrations, which makes them ideal to develop environmental quality indices for these oxygen-stressed environments. Lake Grevelingen (Netherlands) is an artificial saltwater lake, experiencing seasonal anoxia/hypoxia in summer. At this location, two groups of bacteria (*Beggiatoaceae* and cable bacteria) have a profound impact on biogeochemical cycles and show contrasting population dynamics throughout the year. In 2012, two sites showing a variable duration of hypoxic/anoxic events during the year were sampled bimonthly in order to characterize the population dynamics of foraminifera over the seasonal cycle. We used CellTracker Green (CTG) to focus on living specimens in our investigations, as it is known that in low oxygen conditions, Rose Bengal does not efficiently discriminate living from dead individuals. Our results show that the benthic foraminiferal communities are strongly dominated by *Elphidium selseyense*, *Ammonia* T6, *Elphidium magellanicum* and *Trochammina inflata*. These dominant taxa exhibit different responses to the seasonal hypoxia/anoxia. Our data suggest that *Elphidium selseyense* is more resistant to oxic stress than *Ammonia* T6. The better understanding and characterization of the response of foraminiferal populations to seasonal hypoxia/anoxia, as obtained in this study, will help to design environmental quality indices using foraminifera.

A modified method of calcisphere extraction and sample enrichment from consolidated Upper Triassic rocks in Southern Alps (Slovenia)

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Calcispheres represent the remains of ancient calcareous dinoflagellates, a morphological group of calcareous nannofossils, smaller than 30 microns commonly found in Triassic microfossil assemblages. Extraction from indurated rocks is challenging, especially for calcareous nannofossil assemblages. These can be heavily modified by diagenesis in form of epitaxial overgrowth, which often completely engulfs the structure. Conventional methods of dissolution with acids and prolonged acoustic exposure can cause

further damage. The aim of this research was to develop a modified method of the calcisphere extraction, which enables multiple consistent measurements of their relative abundances in consolidated rocks. The method is tested on: marls, marly limestones and pure limestones. Bulk rock samples are crushed in mortar and dry-sieved over 0.02 mm sieve to reach 20 g. The crushed sediment is frozen and then boiled in water with dispersion agent, wet sieved under 0.0063 mm sieve and diluted to uniformed volume. We assembled a multi-staged apparatus (fig. 1) that enables a repeated wet vacuum powered acoustic microfiltration of particles smaller than 0.0010 mm and two decanting stages ending with collection vessel. Vacuum microfiltration enables constant filtrate flow, even though, thickness of the filtrate cake increases after repeated dosages of primary suspension. Primary suspension is for limited time exposed to ultrasonic cavitation with 60 W from which top layers of filtrate are transported to the sedimentation vessel via suction and finally to the vacuum filter flask. The sample is analysed under microscope using the Bürker-Türk chamber in pre–determined time intervals according to the Stokes' equation.

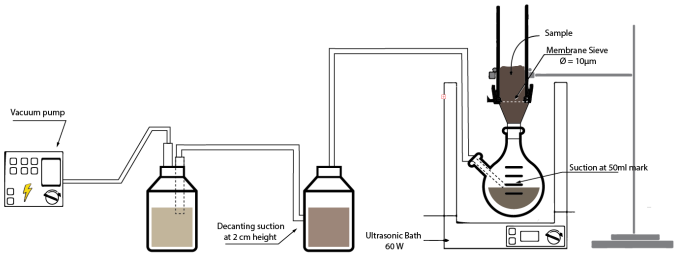

Figure 1: Technical sketch of the assembled multi-staged apparatus

Metabarcoding reveals putative interactions between sediment bacteria and deep-sea benthic foraminifera

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To date not much is known about the interactions between benthic foraminifera and sediment bacterial communities, although both are known to play a key role in benthic biogeochemical cycles of carbon and nitrogen. Here for the first time, we use a metabarcoding approach to shed light into potential links between sediment bacterial communities and the intracellular bacteria of various deep-sea benthic foraminiferal species.
Living foraminifera belonging to six species (*Bulimina subornata, Globobulimina* sp.*, Chilostomella ovoidea, Nonionella stella, Nonionella labradorica, Bulimina striata)* were collected from Sagami Bay, Japan, from 750 m water depth. Specimens were isolated from the top 5 cm, representing various foraminiferal microhabitats, and including both shallow- and deep-infaunal taxa. Altogether over 50 foraminiferal individuals were analysed and their intracellular bacterial assemblage was compared to bacterial communities living in the ambient sediment. In addition, foraminiferal intracellular nitrate pool and sediment pore water characteristics were assessed. Transmission electron microscopy was used to

further investigate the cellular structure of the foraminifera and link it to the intracellular bacterial communities.
The sediment bacterial community was dominated by Deltaproteobacteria, followed by Gammaproteobacteria and Bacteroidia. Compared to the sediment community, the intracellular bacterial assemblage of foraminifera was less diverse. Furthermore, it seems that foraminiferal bacterial assemblage is species-specific. For example, *C. ovoidea* was the only species that harboured an abundance of bacterial class Bacteroidia, whereas the intracellular assemblage of the denitrifying *B. subornata* was dominated by Alphaproteobacteria and chloroplasts. Species-specificity of the intracellular assemblages may be related to differing ecological strategies of foraminiferal species.

High-diversity foraminiferal assemblages from coastal mangrove habitats in northern Brazil: Adaptive capacities and resilience under conditions of environmental stress

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Mangrove forests are extremely productive ecosystems, sources and sinks of organic carbon and deliver essential ecosystem services both to the marine environment and people. We have studied the composition of modern benthic foraminiferal assemblages from mangrove swamps and mud flats along the Mamanguape River in Paraíba/Northern Brazil. Brazil is home to approximately 15% of the world's total mangal forest areas but the release of effluents and untreated wastewater is threatening these important ecosystems along the coastline. Sampling points for foraminifera were selected to acquire information on the foraminiferal assemblages associated with different environmental conditions, on the mud banks and in the estuary.
More than 100 species of benthic foraminifera were identified within the shallow mangrove habitats. The large number of identified mangrove taxa is the highest recorded so far for Brazilian mangrove habitats and rivals shallow-water assemblages recorded from nearby offshore and reef environments. The high diversity recorded indicates that a particularly large number of species is capable to grow and flourish under conditions of multiple stressors. Numerical analysis of the faunal assemblages shows that specific taxa, which were previously known to be uncommon in mangrove environments, are abundant in the Mamanguape River estuary. Distribution, diversity and species-specific analysis will provide guidance on the use of Brazilian mangrove foraminifera as indicators for the strength of tidal activity, pollution and anoxia in coastal waters and sea-level reconstructions.

Planktonic Foraminifera Biostratigraphy and Microfacies Analysis of the Cenomanian-Campanian Succession in the Haymana-Polatli Basin (Ankara, Turkey): Implications for the Late Cretaceous Evolution of the Southern Pontides

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During the Cretaceous, vast amounts of marine sediments were deposited along the south-facing active margin of the Eurasia. The Haymana Region of Central Anatolia (Turkey) is located in the southern part of the Pontides and preserves an almost complete record of the Cretaceous System.
With the aim of establishing a high-resolution biostratigraphy of the Cenomanian-Campanian deposits in the Haymana-Polatlı Basin, a stratigraphic section of 93.5 meters was analyzed for planktonic foraminifera (75 samples) and changes in microfacies. The section starts with limestones containing late Cenomanian aged rotaliporid and dicarinellid taxa and continues with early-middle Turonian aged clayey limestones with sporadic shale beds. These units are overlain by red colored Santonian limestones and shales containing abundant globotruncanids. It ends with monotonous grey-colored silty shales of the Campanian, whose silt content increases towards the upper part.
Based on detailed taxonomic studies performed on both washed material and thin section samples, the distribution of planktonic foraminifera throughout the stratigraphic section was determined. A biostratigraphic framework including nine biozones, one subzone and one concurrent range zone was established. In ascending order, the *Rotalipora cushmani* Zone and *Dicarinella algeriana* Subzone, *Whiteinella archaeocretacea* and *Helvetoglobotruncana helvetica* Zones were defined. The lack of late Turonian-Coniacian index markers suggests the existence of an unconformity for this interval. In the upper part of the section, *Dicarinella asymetrica*, *Globotruncanita elevata, Contusotruncana plummerae*, *Globotruncanella havanensis, Globotruncana aegyptiaca* and *Gansserina gansseri* Zones were identified.
The sedimentological investigation yielded eight microfacies types. The ordering of the microfacies reflected a continuous shallowing, although not dramatic, in the depositional environment.
The planktonic foraminifera biozonational framework established for the Late Cretaceous of the Haymana Basin, suggests further evidence for the timing and evolution of different phases of the subduction–accretion complex, which developed south of the Pontides. These phases are mainly the formation of olistostromes of pre-Santonian age, followed by the condensed carbonate deposition during the Santonian and lastly the switch from forearc deposition to the formation of a thick sequence of siliciclastic carbonates starting from the Campanian.

Feeding experiment offering methanotrophic bacteria to seep-associated Arctic benthic foraminifera

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Methane is the most potent greenhouse gas. Hence, it is important to unravel the complexity of methane-seep microbial life to better understand the efficiency of the benthic microbial filter regulating methane emissions from sediments to the water column. We collected living benthic foraminifera from sediment in the Barents Sea, at a gas hydrate site (Pingo 3, Storfjordrenna), ~10m away from active methane seepage at 382-m water depth. It is not yet known if benthic foraminifera in this habitat use seep bacteria as food and incorporate such bacterial carbon into their shells. Immediately following collection of the kleptoplast-bearing foraminifera *Nonionellina labradorica*, a feeding experiment was performed. After fixation of T0 specimens, incubations of 4, 8 and 20 h with the marine methanotroph Methyloprofundus sedimenitii were made. After glutaraldehyde fixation, the ultrastructure of four specimens per time-point

was studied using transmission electron microscopy. Images showing the exterior apertural region and cytoplasmic vacuoles will be presented and results will be placed in the context of methane-seep ecosystems with implications to geochemistry and palaeoceanography. Funded through CAGE (223259), NORCRUST (255150), US NSF (1634469), and by the French program “Make Our Planet Great Again”.

Benthic foraminifera track the pollution history of Baltic and North Sea

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Shallow marginal seas have been highly influenced by human activities since several hundred years. Especially near – shore environments were affected by the input of anthropogenic pollutants like heavy metals. Coastal cities rapidly expanded and greater shipyards were established during late 19th and early 20th century. This in turn, led to an elevated input of heavy metals into the coastal systems and to significant pollution of the environment. Heavy metals cause deleterious effects on biota because of their toxicity, persistence and bioaccumulation. Therefore, it is vitally important to assess past spatial and temporal distribution patterns and to compare those with recent pollution in order to evaluate contemporary emission reduction measures.
An emerging paleo-tool is the heavy metal incorporation into foraminiferal shells calcite, which offers monitoring of anthropogenic footprints on the environmental system. Heavy metal records in foraminiferal tests along two sediment cores from the Baltic and the North Sea track pollution events of local (e.g. shipyard, ironworks and metallurgy) and global (e.g. market cycles) origin. We analysed the heavy metal concentrations in tests of *Ammonia aomoriensis* or *Elphidium excavatum* (Mn, Zn, Cd Cu etc.) by laser ablation ICP – MS measurements. These metals reveal the pollution history of Baltic and North Sea during the last 500 years.

Establishing Environmental Baselines and Anthropogenic Influence on the Northern Cuban Continental Shelf and Slope using Benthic Foraminifera

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Benthic foraminifera (BF) are sensitive to environmental change and commonly used as indicators of pollution (e.g. petroleum, heavy metals). This study utilizes BF from surface sediments and sediment cores collected between 300-1500 m water depth from Habana (Eastern extent) to San Antonio Bank (Western extent) to assess pollution gradients along the northwestern Cuban continental shelf and slope. This assessment serves as a baseline in advance of future petroleum blowouts and existing anthropogenic influence from population centers. The northern Cuban continental shelf and slope are primarily narrow with deep water (>1500 m) typically within 15 km of the coastline. BF were extracted, stained and identified to species. Density, species richness, diversity indices (e.g. Shannon, Fisher's Alpha) and shell (test) stable isotope composition were determined. These measurements were paired

with short-lived radioisotope chronologies (e.g. $^{210}Pb_{xs}$) to determine variability over the past 100 years. Down-core (historical) trends are evident, including significant decreases in diversity over the past ~100 years north of Habana. Diversity remains relatively constant elsewhere over this period. Spatially, BF assemblages in surface samples collected north of Havana have the lowest diversity, which is consistent with increased anthropogenic influence. Records from the Northern Cuban shelf and slope will be compared with similar records from the Southern and Northern Gulf of Mexico to provide perspectives on environmental baselines throughout the Gulf of Mexico region. These environmental baseline measurements provide a means to quantitatively determine impact and resilience following future natural (e.g. weather related) or anthropogenic (e.g. oil spills) perturbations.

Long-term Surface and Intermediate Water reconstructions: IODP359, northern equatorial Indian Ocean

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Long-term foraminiferal geochemical records are fundamental in contributing to our understanding of ocean-climate interactions. As foraminifera live within discreet depths within the water column, planktonic and benthic records can be combined to disentangle surface and bottom water dynamics. Yet, foraminifera tests are susceptible to secondary, diagenetic processes altering their original geochemical composition. Understanding and constraining these affects is vital prior to undertaking paleo-reconstructions, particularly in carbonate platform environments where they are pronounced. In this regard, we reconstructed high resolution, low-latitude stable isotopic ($\delta^{18}O$ & $\delta^{13}C$) and Mg/Ca records for surface and upper thermocline dwelling (*Globigerinoides ruber*, *Globigerinita glutinata*, *Pulleniatina obliquiloculata*) and benthic (*Cibicides mabahethi/wuellerstorfi*) foraminifera spanning the last 1.8 million years. Samples were obtained from International Ocean Discovery Program (IODP) 359, Site U1467 from the Inner Sea of the Maldives in the northern, equatorial Indian Ocean. Notwithstanding the observed diagenetic controls, the top 1 Myr of our records are robust for paleo-oceanographic and –climatic reconstructions. Particularly, the first 0.5 Myr shows minimal to no diagenetic influences. Inferences can thus be made regarding the link between the seasonally reversing South Asian Monsoon (SAM) and its associated oceanographic influences. Of particular interest is the incursion of a low salinity 'tongue' into the northern Indian Ocean, from the Bay of Bengal, during glacial periods when the winter SAM is dominant.

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Marine plankton response to the last deglaciation extracted from the fossil record

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Over the last 600 ka, Earth's climate is dominated by changes in the orbital geometry (eccentricity) causing glacial-interglacial cycles with a frequency of approximately 100 ka. These cycles are asymmetrical meaning long glacial periods are followed by rapid warmings. During these transitions – also referred to as deglaciations – the global climate is rapidly changing on a multi-millennial-scale which makes these time periods ideal to study potential adaptation to environmental change.
Here, the biotic response of marine plankton to climate forcing during the last deglaciation which is the transition from the Last Glacial Maximum to the Holocene is investigated. A data set of Holocene to deglacial plankton records covering the Atlantic Ocean and marginal seas was compiled utilizing assemblage data that have been previously published at the environmental data archive PANGAEA. The assemblage data of marine plankton (i.e. planktic foraminifera, coccolithophores) used in this study cover the last 25 ka with a resolution of 1 ka. The comparability of the data is ensured by using either published age models or a combination of radiocarbon ages and correlated oxygen isotope data. Principal components analyses are then used to investigate the data and to identify and extract the first principal components that explain most of the variance in the data. These first PCs will then be examined in more detail and correlated to climate parameters (e.g. insolation, CO_2 and temperature) to look for specific patterns in the biotic response of the marine plankton and to better understand the variability in natural time scales.

Ecological factors affecting the formation and persistence of genetic populations of rocky-shore benthic foraminifera

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The Japan Sea experienced falling sea levels during the last glacial, when it was not connected with surrounding seas. The resulting low-temperature and low-salinity surface waters, coming from Asian continent, affected the biota. Around the last glacial maximum (LGM), diatom populations increased with sea ice and low salinity environment, but the status of rocky-shore benthic foraminifera is uncertain. We investigated how diatom endobionts influenced adaptation and genetic differentiation of foraminiferal hosts. We conducted molecular phylogeographic analyses of *Pararotalia nipponica* and *Elphidium "crispum"* using the internal transcribed spacers of rRNA, and used the plastid 16S rRNA gene to identify endobionts. We also estimated the trophic positions of the foraminifer species by nitrogen isotope analyses of amino acids. We found *E. "crispum*" into two phylogeographic groups, one on the Japan Sea side and the other on the Pacific side of Japan. The Japan Sea group persisted during the LGM despite the low-salinity surface waters. In contrast, *P. nipponica* displayed no genetic differentiation between both sides. *Elphidium "crispum"* retained kleptoplasts from diatoms inhabiting a wide environmental range and utilized their photosynthetic products, whereas *P. nipponica* maintained the tropical and subtropical marine diatoms as endobionts and prey diatoms as food source. The surface-water changes caused by the Japan Sea closure affected the survival of diatom species, and it is highly likely that they also affected

the survival of their foraminifer hosts. The persistence of local foraminifer populations and their genetic differentiation patterns are thus strongly influenced by endobiont ecology and host food resource usage.

Shell structures of foraminiferal shells: A case study of Ammonia tepida species complex

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Studying biomineralization of foraminifera has become more popular over the last decade and is increasingly directed towards its linkage with element incorporation and isotope fractionation. The next step forward, is to investigate the 'systematics' between structure (biomechanical constraints) and chemistry (biochemical constraints). We aim to catalogue species-specific variations in ultra-structures of foraminiferal shells, so-called cogwheels. These features, measuring in general 2-10 µm in diameter, are like puzzle pieces, together seemingly building blocks of the foraminiferal shell. The jigsaw structure becomes visible after gentle etching of the surface of the shell. By using SEM images and the software "ImageJ", we can select and measure different parameters of the shell, including these cogwheel structures as well as pores parameters. Here, we present our results from *Ammonia tepida* species complex, and show differences in shell ultrastructures of three phylotypes (T1, T2 and T6) commonly found on the European Atlantic coast. We compare specimens from both field samples and specimens from controlled (hyp)oxic conditions, to determine the variability between species, structural constrains and the effect of oxygen content on these shell features.

Forecasting temperature-related extinctions

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Human-induce climate change is expected to result in global temperatures exceeding those of the last million years. The response of species to climate change may depend on adaptation to previous long-term climate trends. A species' climate-related extinction risk likely depends on its evolutionary history. Here, we test the hypothesis that short-term temperature changes interact with the preceding long-term temperature trends in influencing the effect of climate change on intrinsic extinction risk of species. This crucial question can only be answered through analysis of deep-time data.
Here we investigated survival and extinction of microfossil groups as observed in their global occurrences throughout the Cenozoic documented in the NEPTUNE database. In a temporally continuous analysis, we implemented generalized linear mixed effects models with binomial family error to explain extinction by temperature changes interacting with long-term temperature trends. This approach is highly suitable for the imperfect nature of the deep-time fossil record and does not depend on inconclusive phylogenies. Our results suggest that extinction probabilities of microfossils are influenced by the magnitude of temperature change interacting with previous long-term temperature trend. These effects are more consistent for warming conditions when compared to climate cooling among the different groups.

Extinctions in the marine plankton preceded by stabilizing selection

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Populations facing persistent stress are threatened by extinction unless they adapt by either disruption or stabilization. Stabilization is more economical, because it quickly transfers a large part of the population closer to a new ecological optimum. However, canalization is deleterious in the face of persistently increasing stress, because it reduces variability and the populations' ability to react to further changes. Understanding how natural populations react to intensifying stress reaching terminal levels is key to assessing their resilience to environmental change such as that caused by global warming. Here, we make use of the glacial salinity rise in the Red Sea as a natural experiment allowing us to analyse the reaction of planktonic Foraminifera to stress escalation in the geological past. We analyse morphological trait state and variation in two species across a salinity rise leading to their local extinction. One species reacted by stabilization, detectable several thousand years prior to extinction. The second species reacted by trait divergence, but each of the two divergent populations remained stable or reacted by further stabilization. These observations indicate that the default reaction of the studied Foraminifera is canalization, and that stress escalation did not lead to the emergence of adapted forms. An inherent inability to breach the global adaptive threshold would explain why communities of Foraminifera reacted to Quaternary climate change by tracking their zonally shifting environments and means that plankton populations adapted to response by migration will be at risk of extinction when exposed to stress outside of their adaptive range.

Field observation of living planktic foraminifera from the Benguela Upwelling region

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We present results of a foraminifer abundance survey from the *RRS Discovery* cruise DY090 in the Benguela upwelling region from 23rd May to 28th June 2018. During this cruise a total of 33 plankton nets (100 µm mesh size) were deployed. The ship spent one week at station Benguela south (BS) offshore from the main upwelling area and three weeks at station Benguela north (BN) in close vicinity to the upwelling. Bongo nets were used to sample the upper 120 m of the water column and a multiple plankton sampler for the upper 750 m with four depths intervals. As expected, station BS is characterised by lower primary production (0.5–0.7 g C m^{-2} d^{-1}) and low foraminiferal abundance (0.6 per m^3), while station BN was generally characterized by higher productivity (0.7–2.6 g C m^{-2} d^{-1}) and higher abundance of foraminifera (> 8 per m^3). *Globorotalia menardii* was the dominant species in BS, while BN showed a mixture of *Globigerina* spp., *Globorotalia inflata* and *Neogloboquadrina pachyderma* (dextral and sinistral) with many other species in smaller numbers.
During the three weeks at station BN marked changes in nutrient concentration, primary production and abundance of foraminifera occurred. The interval characterized by a plankton bloom is likely linked to the passing of a high nutrient filament, originating from the high intensity upwelling. Details of planktonic foraminifera succession across this filament will be discussed.

Larger foraminiferal biostratigraphy at the Eocene-Oligocene boundary in Southern Armenia

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The Eocene - Oligocene boundary is marked by dramatic changes within the larger benthic and planktonic foraminiferal assemblages. The continuous upper Priabonian – Rupelian succession rich in larger foraminifera (LF) is outcropped in Shagap section, southern Armenia, where both foraminiferal zonations can be correlated.

The upper Priabonian of Shagap section corresponds to the shallow benthic SBZ20 zone and can be divided into two units. Lower unit is characterized by the FO of *Heterostegina gracilis* (zonal marker of the SBZ20 zone) and diverse LF assemblage, including 10 species of nummulitids, about 8 species of orthophragmines, *Pellatispira Fabiania, Chapmanina, Sphaerogypsina, Silvestriella, Calcarina, Neorotalia*. The upper unit is distinguished by the reduced LF diversity. The genera *Pellatispira, Fabiania*, *Silvestriella* disappear, but two *Nummulites* species (*N. vascus* and *N. bouillei*), more typical for Oligocene, first appear in this interval. The planktonic foraminiferal assemblage of P17 (E16) zone is found in the clay bed lying between these units. The rare *N. intermedius* and *N. vascus*, marking the SBZ21 zone, appear in sandy-clayey formation, covering the Eocene and corresponding to the planktonic foraminiferal O1-O2 zone.

According to the previous data (Grigorian, 1986) the Oligocene LF in Armenia are represented only by two species of Nummulites: *N. intermedius* and *N. vascus*. Our study of four Oligocene sections in Armenia revealed for the first time, alongside of these taxa, *N. striatus, Neorotalia* (Malishka), *Sphaerogypsina, Chapmanina* (Shagap), *Halkyardia, N. bouillei* (Lanjar), *N. cunialensis, Operculina complanata* (Mushavan). The Oligocene LF assemblages from Armenia are comparable with the Mediterranean ones.

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EMERGENCY NUMBERS

In Switzerland, as in the whole EU, the most important emergency number is 112. This number can be used in all the emergency situations.

MEDICAL

Ambulance
144

Clinique Générale
Rue Hans-Geiler 6
1700, Fribourg
(0041) 26 3500111

HFR Fribourg – Cantonal hospital
Case postale
1708 Fribourg
Chemin des Pensionnats 2-6
1752 Villars-sur-Glâne
(0041) 026 306 00 00

Daler hospital Fribourg
Route de Bertigny 34
1700, Fribourg
(0041) 26 4299111

POLICE

General number for police
117

Cantonal police
Chemin de la Madeleine 3
1763 Granges.Paccot
(0041) 263041717

Cantonal police – Fribourg city department
Route des Arsenaux 3D
1700 Fribourg
(0041) 26 3058820

FIRE SERVICE

Fire department
118

CAB SERVICE

Taxis Fribourg
Case postal 1513
1701, Fribourg
(0041) 26 4242424

ECO-TAXI Fribourg
Route de l'Aurore 2C
1700, Fribourg
(0041) 79 6909006

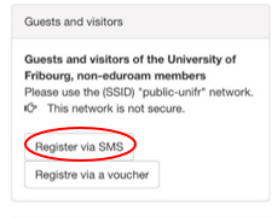
Taxis-Réunis ABC SA
Route-Neuve 41
1700 Fribourg
(0041) 26 4661010

WIFI CONNECTIONS

If you have access use **“eduroam”**. If you cannot access this network please use **“public-unifr.ch”** as per the directions below.

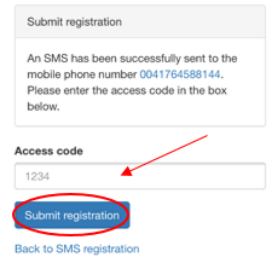
1) Go on your smartphone/tablet/personal computer turn on the WI-FI and select **“public-unifr”**

2) Scroll down and select **“register via SMS”**



3) Insert your mobile phone number and select **“request access code”**
NB. You can connect up to three devices per mobile phone number. however, every device needs a different code.

4) Insert your **access code** that you received by SMS and select “**submit registration**”



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