SILICAMICS 4

14-18 October 2024

Brest, France

The SILICAMICS interdisciplinary conferences series was launched in 2015 under initiative of the international Silica Group. These conferences series aim to develop an integrative approach that includes chemistry, biogeochemistry, biochemistry, physiology and genomics to better understand biosilicification and silicifiers in past, contemporary and future oceans. Among the outcomes of the three first SILICAMICS conferences are synthesis articles in Nature Geoscience (2018) and in Biogeosciences (2021) and two special issues of Frontiers in Marine sciences (2019 and 2022) that hosted more than 24 articles. The 4-day SILICAMICS 4 conference, to be held in Brest (France) in October 2024, focuses on:

- Biogeochemical Cycle of Silicon: Processes and Fluxes
- Paleo including the evolution of silicifiers
- Ecology and Biology of marine and terrestrial silicifiers
- Silicification processes and omics
- Siliceous plankton in the Open Ocean: Linking physics and biology
- Polar seas

Built around a “Gordon conferences” format, SILICAMICS 4 will bring together a small group of experts, young researchers and students in a secluded and beautiful location near Brest. The organizing committee has invited top-notch speakers, and the time for discussion and exchange between poster and presentation sessions, as well as working groups, will offer PhD students and young scientists the chance to debate with senior scientists in order to develop their own understanding of science in general, and more specifically of SILICAMICS’ flagship theme, the silicon cycle and the role of silicified organisms in the oceans.

SCIENTIFIC COMMITTEE

- Tristan Biard (LOG, Wimereux)
- Damien Cardinal (LOCEAN, Sorbonne Université)
- Lucie Cassarino (LEMAR)
- Matthieu Civel-Mazens (LEMAR)
- Xavier Crosta (EPOC, Univ Bordeaux)
- Taniel Danielan (Univ de Lille)
- Patricia Grasse (Center for Integrative Biodiversity, Leipzig, Germany)
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- Natalia Llopis-Monferrer (MBARI, California)
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- Su Mei Liu (UOC, China)
- Manuel Maldonado (CSIC, Spain)
- Brivaela Moriceau (LEMAR-IUEM)
- Fabrice Not (SBR-Sorbonne Univ)
- Jill Sutton (LEMAR-IUEM)
- Paul Tréguer (LEMAR-IUEM)
- Diana Varela (Univ Victoria, Canada)
- Dongdong Zhu (OUC, Qingdao)

ORGANISING COMMITTEE

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- Matthieu Civel-Mazens (LEMAR)
- France Floch (Geo-Ocean)
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- Sébastien Hervé (IUEM - LEMAR)
- Stefan Lalonde (Geo-Ocean)
- Johann Lavaud (LEMAR)
- Aude Leynaert (LEMAR)
- Brivaela Moriceau (LEMAR)
- Jill Sutton (LEMAR)
- Paul Tréguer (LEMAR)

PROGRAM

- Session 1: Biogeochemical cycle of silicon: processes and fluxes
  Chair: Damien Cardinal / Natalia Llopis Monferrer
- Session 2: Paleo including the evolution of silicifiers
  Chair: Xavier Crosta / Anna Isaia
- Session 3: Ecology and biology of marine and terrestrial silicifiers
  Chair: Diana Varela - Dongdong Zhu
- Session 4: Silicification processes and omics
  Chair: Manuel Maldonado - Alessandra Petrucciani
- Session 5: Silicifiers in the open ocean and upwelling systems
  Chair: Fabrice Not - Maria Lopez-Acosta
- Session 6: Polar seas
  Chair: Patricia Grasse - Maxence LePicard
- Syntheses of the conference and perspectives
  Chair: Jeffrey Krause

MONDAY 14 OCTOBER 2024

17:00	Welcome participants at the Centre Nautique de Moulin Mer and posters set up for the week
19:30	Icebreaker with cocktail and buffet

TUESDAY 15 OCTOBER 2024

08:30	Introduction of the conference (Paul Tréguer), practical points (Brivaëla Moriceau) and young researchers (Lucie Cassarino)
	Session 1: Biogeochemical Cycle of Silicon: Processes and Fluxes
09:00	**Shaily Rahman** - Probing mass balance, fluxes, and deep time implications of the surface Earth reactive silica cycle using Si isotopes.
09:45	**Dongdong Zhu** and **Su Mei Liu** - Monsoonal impacts on the Changjiang river discharges during the past thousand years as revealed by sediment phosphorus, nitrogen and silica speciation
10:05	**Manuel Maldonado** - Transport of silicic acid and production of silica in sponges: Where are we and where are we going?
10:25	coffee break
11:00	**Maria Lopez Acosta** - Exploring the variability of sponge silicon fluxes and stocks in coastal oceans
11:20	**Panagiotis Michalopoulos** - Microbial facilitation of rapid authigenic silica precipitation in marine sediments
11:40	**Paul Tréguer** - The silicon cycle at world ocean scale: facing new challenges
12:00	**Lucie Cassarino** - Insights on modern Si biogeochemical cycle in the Norwegian Sea combining new in-situ analytical methods with environmental and isotopic data (DRASTIC)
12:30	Lunch
	Session 2: Paleo including the evolution of silicifiers
14:00	**Giuseppe Cortese** - Radiolarians and diatoms as sources of past climate and environmental information in the Southern Ocean
14:45	**Vikki Lowe** - Silicate and carbonate phytoplankton community interactions during MIS 11 in the Indian Sector of the Southern Ocean
15:05	**Maxence Le Picard** - Silicon isotopes in Archean cherts: tracer of Si sources or precipitation kinetics?
15:25	Coffee break
16:00	**Fiorenza Torricella** - Resolving the Ross Sea response to continental climate change during the last two millennia
16:20	**Jill Sutton** - Diatom silicon isotopes in quaternary research: where do we stand?
16:40	**Matthieu Civel-Mazens** - Different interglacial circulation patterns in the Southern Ocean inferred from radiolarian assemblages & geochemistry
17:00	Aperitif / poster session
19:30	Diner
21:00	Students and early career scientists working group

WEDNESDAY 16 OCTOBER 2024

	Session 3: Ecology and Biology of marine and terrestrial silicifiers
09:00	**Julia Cooke** - Plant silicification by biome.
09:45	**Anna Isaia** - Phototobiology of a diatom inhabiting the subtidal sediments of the bay of Brest.
10:05	**Alessandra Petrucciani** - Si demand of diatoms in a changing ocean chemistry: an ecophysiological perspective.
10:25	coffee break
11:00	**Yelena Churakova** - Diverse non-diatom silicon transporters are active year-round in the silica-rich Baltic Sea
11:20	**Tristan Biard** - The role of Rhizaria in the silicon cycle : current knowledge and gaps
11:40	**Félix De Tombeur** - Why do plants silicify? Leveraging functional trait-based approaches to better understand plant silicon variation
12:30	Lunch
	Session 4: Silicification processes and omics
14:00	**Nils Kroeger** - The molecular basis for silica morphogenesis in diatoms
14:45	**Hanna Farnelid** - Patterns of silicon transporters of similar evolutionary origin evident among natural Baltic Sea diatom communities
15:05	**Tore Brembu** - A transcriptomic investigation into the biomineralization of *Coscinodiscus* girdle bands
15:25	Coffee break
16:00	**Natalia Llopis Monferrer** - Silicon transport in Phaeodaria
16:20	**Katariina Raassina** - Potential of imaging flow cytometry in determining diatom silicification kinetics
16:40	**Y. Chen, Lihua Ran** - The regulation of seawater silicate concentration on the growth and cell silicification of a cosmopolitan diatom species *Thalassionema nitzschioides*
17:00	**Annika Messemer** - Unraveling the SDV proteome of *Thalassiosira pseudonana* using proximity labeling
18:00	Aperitif / poster session
19:30	Gala Diner
21:00	Students and early career scientists working group

THURSDAY 17 OCTOBER 2024

	Session 5: Silicifiers in the Open Ocean and upwelling systems
09:00	**Ismaël Hernández-Carasco -** Highly-coherent oceanic structures and their impact on the diatom dynamics
09:45	**Marie Cueille** - Deciphering the impact of climate variability on siliceous plankton flux from sediment traps in the oligotrophic Ionian Sea (Eastern Mediterranean)
10:05	**Timor Katz** - The silica cycle in the eastern Levantine Basin (Eastern Mediterranean), new findings from the most diatom-inhospitable oceanic habitat
10:25	coffee break
11:00	**Su Mei Liu** - Nutrient regeneration in the Chinese marginal seas
11:20	**Patricia Grasse -** New insights into the Si cycle in an upwelling area: A modeling approach
11:40	**Michael Maniscalco** and **Kim Thamatrakoln** - Decoupling silicon metabolism from carbon and nitrogen assimilation poises diatoms to exploit episodic nutrient pulses in a coastal upwelling system
12:30	Lunch
	Session 6: Polar seas
14:00	**Karley Campbell** - Silica and the arctic sea ice biome
14:45	**Philipp Asmy** - Linking polar diatom ecology with carbon and silicon cycles
15:05	**Johann Lavaud** - Diatom ecophysiology in a brighter Arctic Ocean
15:25	Coffee break
16:00	**Sébastien Moreau** - Phytoplankton blooms and biological carbon and silica export in the Sea Ice Zone of the Southern Ocean
16:20	**Jeffrey Krause** - Cold storage: do sediment microbes facilitate silica sequestration Arctic sediments?
16:40	**Mathis Guyomard** - Evolution of dissolved and particulate silicon along a glacier-ocean continuum
17:00	**Antonia Thielecke** - Influence of light and silicic acid on the productivity of the Arctic phytoplankton community
17:20	**Diana Varela** - Siliceous plankton in the Pacific Sub-Arctic and Arctic Oceans: Rates, standing stocks and effects of a changing ocean
18:00	Aperitif / poster session
19:30	Diner
21:00	Students and early career scientists working group

FRIDAY 18 OCTOBER 2024

09:00	Synthetic conclusions of the themes, perspectives and cooperative projects (Jill Sutton)
10:00	Early career scientists and students' synthetic conclusions and projects (Lucie Cassarino & ECRs)
11:00	End of the SILICAMICS Conference ; Departure of the shuttle to the airport and railway station.

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SESSION
Biogeochemical cycle of silicon : processes and fluxes

Chair: Damien Cardinal / Natalia Llopis Monferrer

Probing mass balance, fluxes, and deep time implications of the surface Earth reactive silica cycle using Si isotopes

Shaily Rahman

Univ. Colorado Boulder, USA

The transport of reactive Si through various surface Earth reservoirs (e.g., global oceans, biosphere, rocks and sediment, and cryosphere) has applied critical controls on the evolution of the atmosphere and ocean chemistry through Earth's history. The Si cycle is intimately linked to that of C, alkalinity, macronutrients, and trace elements through several pathways like silicate mineral weathering, primary production, the biological portion of the ocean carbon pump, and reverse weathering. As an analogue for the mass balance on the surface Earth, examining the vectors or reactions through which dissolved Si enters, is processed, and exits the global ocean leads to a better understanding of the key drivers that couple Si to other cycles over short–term and geological time scales. Summaries of the marine silica cycle have undergone major revisions in the past decade, with an ~50% change in presumed sources and sinks. Some of these paradigm shifts have resulted from using stable and radiogenic Si isotopes to probe specific reaction pathways. For example, cosmogenic ^{32}Si activities in the proximal coastal zone revealed reverse weathering reactions were a major sink of silica in the ocean. To test whether budgets and summaries achieved mass balance, an inverse model was applied to compilations of stable Si isotope ratios in various surface Earth reactive Si reservoirs. Results revealed that silicate mineral weathering releases 19-21 teramoles of Si per year, of which ~10-18 teramoles are sequestered is silica sinks on land (e.g., freshwater diatoms, phytoliths, pedogenic clays). Though there remain gaps in our understanding, results of the modelling effort also revealed that the latest 2021 marine Si summary appears to be in isotopic mass balance and can only be so if reverse weathering reactions were included in the summary. Inverse modeling also led to more insight (and questions) regarding weathering congruency, fractionation factors, and reactions kinetics.

Monsoonal impacts on the Changjiang river discharges during the past thousand years as revealed by sediment phosphorus, nitrogen and silica speciation

Dongdong Zhu[1, 2], Su Mei Liu[1, 2]

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2 | Laboratory for Marine Ecology and Environmental Science, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China

The East China Sea (ECS) is a typical coastal and continental margin zone (CCMZ) that is under the effect of both riverine transported materials and nature climate change. To understand the effect of monsoon (Indian and East Asia Monsoon) on the Changjiang river (CJR) discharge during the past thousand years, this study conducted high resolution (1 cm) measurements of the sediment silica (e.g., biogenic Si (bSi), lithogenic Si (lSi)), phosphorous (e.g., loosely sorbed P, Fe bound P and soluble P (Fe-P), Authigenic P and $CaCO_3$ associated P (ACa-P), detrital P (DAP), organic P (OP), inorganic P (IP) and total P (TP)) and nitrogen speciation (e.g., fixed ammonium (N-fix), exchangeable NO_3^- and NH_4^+, organic N (ON), inorganic N (IN) and total N (TN)) of a 2.4 m long gravity core (core P4, 235 m water depth) which was obtained from the continental self-edge of the East China Sea. In addition, the organic carbon (TOC), inorganic carbon (IC) and total carbon (TC) were also determined. Chronology of P4 was based on the measurements of ^{210}Pb and ^{137}Cs activities of core top sediments (<30 cm). Our results showed the sediment IP, TP, DAP, ACa-P, N-fix, IN, NO_3^-, NH_4^+ and lSi decreased between ~1150 A.D to 1500 A.D and increased from 1500 A.D to 2002 A.D., indicating a decreased CJR discharge during 1150–1500 A.D and enhanced CJR discharge afterwards. These results were positively corelates to the strength of Indian Summer Monsoon (ISM). Further, the carbon (TOC, TIC and TC), Fe-P, OP, ON, TN and bSi continuously increased during ~1150 A.D to 1450 A.D, followed by a dramatic increase between 1450 A.D. to 1650 A.D, and a continuous increase until 2002 A.D, showing that the productivity of ECS shelf-edge (or outer shelf) is co-regulated by multiple nutrient sources (i.e., CJR and Kuroshio current).

Transport of silicic acid and production of silica in sponges: where are we and where are we going?

Manuel Maldonado[1], Laia Leria[1], Katsuhiko Shimizu[2]

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2 | Platform for Community-based Research and Education, Tottori University, Japan

The characterization of the first protein involved in silica production in sponges (silicatein) in 1999 established an initial milestone in understanding the molecular mechanisms underlying silica production by sponges. Since then, the deployment of molecular biology and proteomics has led to several reports on other proteins that also appear to be involved in sponge silicification (galectin, glassin, F-actin, hexaxilin, perisilin, sclerogen, etc.). The description of this additional set of proteins has progressively complicated the overall picture of the biological process to the point that it is difficult to follow for experts and non-experts alike. To complicate matters further, the systems through which silicic acid is transported from the ambient water to the sponge body for polymerization by silicifying proteins has remained unknown until recently and their characterization is still in an embryonic state. Here we review the molecular, proteomic and cytological bodies of information in an attempt to integrate them and provide a comprehensive hypothesis (to the level that is possible) on sponge silicification, explaining how silicic acid transporters and silicifying proteins operate and interact throughout the biological process. We also identify the most important gaps in knowledge and point to future directions for advancing the understanding of silica production by sponges.

Exploring the variability of sponge silicon fluxes and stocks in marine ecosystems

Maria Lopez Acosta[1,2], Corentin Le Goff[1], Aude Leynaert[3], Morgane Gallinari[3], Laura Moreno[1], Xosé Antonio Padin[1], Fiz F. Pérez[1]

1 | Institute of Marine Research (IIM-CSIC) – Spain
2 | Laboratoire des Sciences de l'Environnement Marin (LEMAR) – Université de Bretagne Occidentale (UBO) – France
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Sponges are abundant marine animals that constitute an important component of benthic communities in all oceans. They contribute to the benthic-pelagic coupling of nutrients such as silicon, connecting ecological and biogeochemical processes taking place at the seabed with those occurring in the water column. Sponges are considered major silicon sinks in marine ecosystems because they accumulate huge reserves of biogenic silica within their bodies and in sediments beneath them. These reserves were thought to change minimally on an intra-annual scale and to cycle slowly compare to those of diatoms. We investigated whether ecological and environmental factors such as predation and climate change can affect this silicon reservoir. The effect of predation was investigated over the course of a year in a coastal ecosystem using a combination of monitoring and in situ and lab experiments. Our findings revealed that predation triggers unprecedented intra-annual fluctuations in sponge silicon stocks associated with increased silicon utilization rates: sponge silicon deposition increased five-fold during predation, while consumption accelerated sixteen-fold during the recovery phase. In another experiment, sponges were exposed for 3 weeks to in situ conditions, moderate acidification (pCO_2=1500 ppm, pH=7.5, i.e., -0.4 pH units from today's scenario), warm waters (23°C, i.e., +8°C from today's conditions), and the combination of both stressors, with silicate concentrations gradually rising to 400 µM (i.e., when sponges saturated their consumption system). While moderate acidification had no discernible effect on sponge silicon consumption, warm waters significantly hastened their consumption rates. These results show how predators and environmental changes can shake up sponge communities and our understanding of the silicon cycleway of thinking, and underscore the need to delve deeper into sponge dynamics to accurately quantify silicon cycling in marine ecosystems

Microbial facilitation of rapid authigenic silica precipitation in marine sediments

Panagiotis Michalopoulos[1], Jeffrey W. Krause[2], Rebecca Pickering[3], Eleni Rousselaki[4], Kanchan Maiti[5], Martial Taillefert[6], Christophe Rabouille[7], Rudolph Corvaisier[8]

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Silicon is Earth's second most abundant element, cycling primarily through biological processes in terrestrial and oceanic water environments. The interface between marine sediment and water divides biological-dominated silica cycling in the oceanic water column from abiotic silica cycling during sediment burial. While recent studies indicate bacteria in extreme marine conditions induce silica precipitation, the quantitative importance of bacteria in sediment silicon cycling remains unexplored. Our experimental data support the hypothesis that microorganisms significantly influence early silica diagenesis, challenging the prevailing idea that abiotic factors exclusively govern bulk silica cycling rates in marine sediments. In incubation experiments, sediment microbes expedited silica sequestration within hours through rapid coupled dissolution/reprecipitation processes in Congo Deep Sea Fan and Mississippi River Plume sediments. Utilizing the radiotracer ^{32}Si, the study reveals that microbial mediation enhances silica uptake in Mississippi sediments, surpassing abiotic precipitation by 3.6 times in dilute suspensions with silica concentrations below 100 µM and 3.8 times higher in surface sediment porewater simulations. We purport that microorganisms drive significant diagenetic silica cycling, facilitating authigenic Si precipitation and reverse weathering through previously reported mechanisms. This unifies the critical role of microorganisms in the marine silica cycle to both pelagic waters and surface sediments.

The silicon cycle at world ocean scale : facing new challenges

Paul Tréguer[1]

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Because of the major role of diatoms and of other silicifiers in the control of the carbon cycle, to study the Si cycle in the ocean is of crucial importance. Major advanes have been made regarding the global balance of the Si cycle (Tréguer *et al*.., 2021), and processes that engender episodic diatom blooms (Hernandez-Carrasco *et al*., 2023).

Following Fabre *et al.* (2021), Aparicio *et al.* (submitted) suggest that the global Si budget should be reassessed, given the importance of dissolution of quartz from sandy beaches. From samples collected in eleven beaches of the NE Atlantic, we show that the temperature-dependent solubility limit of our samples at thermodynamical equilibrium, was 5-11 times less than Fabre *et al*.'s. Using a physical model we simulate the dispersion of a silicic acid flux generated by a sandy beach in the case of the Bay of Brest, and show that this flux is less than 0.2% of the river flux, annually. We discuss this process for the global silica cycle and how it contributes to the submarine groundwater flux at global scale (Cho *et al*., 2018). We need to better know about the contribution of different pelagic silicifiers to the production. To solve the Rhizaria antarctic paradox (Llopis-Monferrer *et al*., 2021) we can benefit from the circumpolar POLAR POD expeditions (2027-2029). We should also organise a Southern Ocean cruise dedicated to the pelagic Si cycle in the whole water column. Efforts have been made to better evaluate reverse weathering processes and silica burial rates (Rahman *et al.* 2016, 2017 ; Luo *et al*., 2022, Zhu *et al.* 2023) and to get rid of biases that affect the determination of the biogenic silica in sediments (Zhu, 2023). To conduct simultaneous determinations of reverse weathering rates and burial rates of silica in different environments is needed.

Insights on modern si biogeochemical cycle in the Norwegian Sea combining new in-situ analytical methods with environmetal and isotopic data (DRASTIC)

Lucie Cassarino[1], Matthieu Civel-Mazens[1], Natalia Llopis-Monferrer[2], Nicolas Djeghri[3], Jill Sutton[1], Aude Leynaert[1]

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2 | MBARI, USA
3 | Marine Biological Association (MBA), UK

Silicifying organisms, such as siliceous Rhizaria (Phaeodaria, polycystine Radiolarians) and diatoms have played a crucial role in the ocean by shaping the global cycling of silicon (Si), carbon (C), and other nutrients over time. While recent research has focused on diatoms, and their role in linking the marine silicon cycle to the export of carbon via the biological pump, siliceous rhizarias have been largely overlooked. Despite the extensive use of polycystines in marine sediment studies and paleo-reconstructions, their contribution and role to the modern silica and carbon cycle in the ocean remain poorly constrained.

The DRASTIC expedition (2023) had for scientific objective to determine the diversity and distribution of diatoms and rhizarians in the water column, and was designed to reduce carbon emissions as much as possible. During the expedition, we sampled microplankton communities in the Norwegian Coast along a North-South transect. Alongside traditional Niskin sampling for nutrients analysis and net tows for community composition, we deployed in-situ sensors including a new silicate sensor to evaluate its performance during cruise expeditions.

Preliminary results revealed striking differences in community compositions between the Northern and the Southern sections of the transect, with more rhizarians in the southern and warmer section, while the northern and colder part of the expedition was mainly composed of Calanus spp. copepods and tintinnids. The silicate sensor complemented traditional discreet sampling by providing additional data, but showed some limits for profiling measurements. Moreover, the expedition successfully aimed to be low-carbon by using a traditional sailboat, the Lun II, reducing carbon emissions by saving 100 tons of CO_2 and setting a new example for sustainable research practices.

SESSION 2
Paleo including the evolution of silicifiers

Chair: Xavier Crosta / Anna Isaia

Radiolarians and diatoms as sources of past climate and environmental information in the Southern Ocean

Giuseppe Cortese

GNS Science, Lower Hutt (New Zealand)

Biosiliceous micro-organisms have been the subject of intense scrutiny in recent years to clarify their autoecology, biodiversity and genomics. These efforts have contributed to improve their application in paleoceanography and paleoclimate research. In the latter fields, pioneering work by Jim Hays in the late 1970s led to fundamental scientific advances, such as the discovery of orbital controls on the pacing of ice ages, as well as the first temperature and sea ice reconstruction of the North Atlantic during the Last Glacial Maximum.
The original tool (transfer functions, linking species abundances to oceanographic variables) has evolved substantially since then, with increasingly sophisticated and more accurate techniques being employed. Their application has also targeted a much wider variety of oceanographic regions, including all the main ocean basins, as well as their marginal seas. A substantial focus on the Southern Ocean has contributed to a shift in thinking from a North Atlantic-centric view of paleoceanographic change to one that takes into account the large role the Southern Ocean plays in the global climate system.
In my talk, I will briefly touch upon the historic development of the field, as well as present a series of case studies highlighting how diatoms and radiolarians are being used to reconstruct complex aspects of oceanographic and climatic change in the Southern Ocean during the Late Pleistocene.

Silicate and carbonate phytoplankton community interactions during MIS 11 in the indian sector of the Southern Ocean

Vikki Lowe[1], Xavier Crosta[2], Elisabeth Michel[3], Yu Wang[4], Johan Etourneau [5], Sophie Sepulcre[4], Stephanie Duchamp-Alphonse[6]

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5 | École Pratique des Hautes Études, Universite de Bordeaux
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The Soft Tissue Pump (STP) and the Carbonate Counter Pump (CCP) are important components of the ocean's role in modulating atmospheric CO_2 by lowering surface ocean pCO_2 through organic carbon production and export (STP) or increasing surface ocean pCO_2 through CaCO3 production (CCP). However, few studies have focused on their respective impact on the carbon cycle during terminations and interglacials, particularly in the Southern Ocean. Here, we compare diatom and coccolith assemblages, and explore forcing factors on their communities using diatom- and foraminifera-based sea surface temperature estimates, XRF, organic carbon, and CaCO3 data, to examine phytoplankton community interactions in the Polar Frontal Zone west of Kerguelen Island (Indian Sector) during Termination V and Marine Isotope Stage 11 (MIS 11, ~425,000 to ~375,000 years before present). We show that during the extended and warmer-than-present MIS 11, when low eccentricity lengthened seasonal productivity, coccolithophores dominated the phytoplankton assemblages and outcompeted diatoms during summer blooms. This resulted in high carbonate production and a strengthened CCP in a region where silicate production and export normally dominate. An increase in the CCP would have significant implications for the region's contribution to atmospheric CO_2, and for nutrient transport out of the Southern Ocean. We hypothesise that the unique phytoplankton ecology of this interglacial, during the high carbonate production period of the Mid Brunhes Event (centred around ~420,000 years BP) that was even observable in the western Indian Sector of the Southern Ocean, may have contributed to the lengthening of MIS 11 interglacial.

Silicon isotopes in Archean cherts: tracer of Si sources or precipitation kinetics?

Maxence H. Le Picard[1], Mark Van Zuilen[2], Stefan V. Lalonde[1]

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2 | Naturalis Biodiversity Center [Leiden]

The Archean represents a critical phase of microbiological diversification in Earth's history that occurred under environmental conditions that were radically different from today. Cherts, by their chemical sedimentary nature, resistance to alteration, and abundance in Precambrian sedimentary sequences, represent precious geological archives that inform on environmental conditions and biogeochemical processes of the early Earth. However, the silicon (Si) stable isotope composition of Archean cherts remains understudied and the mechanisms driving isotopic variability are still poorly understood. Here we present new Si isotope data for 52 samples from two localities in the Pilbara craton (Western Australia), including the first $\delta^{30}Si$ data from the 3.46 Ga Apex Chert which is host to some of Earth's most ancient and controversial microfossils. In parallel, 18 modern silica sinter samples from the El Tatio geothermal system were analyzed in order to better understand the behavior of silicon isotopes during silica precipitation. The latter display a correlation between $\delta^{30}Si$ values, rare earth element compositions, and inferred depositional temperatures. These correlations reinforce previous suggestions that kinetic isotope fractionation represents the predominant control over the Si isotopic compositions of rapidly deposited Si chemical sediments. Back-of-the-envelope calculations indicate that such rapid precipitation rates also applied for Archean cherts, and that at the high deposition rates indicated by our calculations, the amorphous Si precursors to Archean cherts should have experienced minimal isotopic fractionation during precipitation. Our new data for Paleoarchean cherts of marine origin show mostly positive values that are remarkably homogenous, consistent with the above, and point toward a seawater source that was around +1.5 ‰ ca. 3.45 Ga. Finally, our data for the Apex Chert suggest that the entire deposit, including the cross-cutting vein hosting the controversial Schopf microfossils1, formed entirely from a contemporaneous seawater-derived Si source, which adds important nuance to the debate surrounding their biogenicity.

TUESDAY 15 OCTOBER

Cooling over the Victoria Land (GRETA): resolving the Ross Sea response to continental climate change during the last two millenia

Fiorenza Torricella[1], Francesca Battaglia[1], Simon Belt[2], Lucilla Capotondi[3], Ester Colizza[4], Florence Colleoni[5], Alessio Di Roberto[6], Leonardo Langone[1], Patrizia Giordano[1], Gesine Mollenhauer[7], Enrico Pochini[8], Tommaso Tesi[1]

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Ice core have largely improved our knowledge of short-term climate variability over the last 2ky in Antartica suggesting an abrupt cooling event along the Victoria Land (western Ross Sea, Antarctica). Still no information is available from the marine sedimentary record. GRETA proposes to fill this knowledge gap by investigating the ocean response to a cooling event recorded over the Victoria Land (ca 1.3-1.9 ky CE). We present new high-resolution sedimentary sequences collected in different sectors of the western Ross Sea (Granite Harbour and JOIDES Basin), comparing the new data with existing data collected in Wood Bay and Edisto Inlet (Tesi *et al.*, 2020; Mezgec *et al.*, 2017). We use a multidisciplinary approach that includes micropaleontological analyses (diatom assemblages), geochemical analyses (biomarkers such as IPSO25 and PIPSO25, organic carbon and stable isotope analyses, TEX86-L/RI-OH') and sedimentological analyses (grain size analyses and sortable silt determination). The final goal of our project is to reconstruct the sea ice dynamics and water mass properties (sea surface temperature, water mass circulation, upwelling) during the last 2,000 years in the western Ross Sea. We propose the first reconstruction of SST for the western Ross Sea covering the last 2,000 years and its relationship with the corresponding continental climate events. Finally, we will merge the information obtained from the marine domain with ice core and model data to provide new insights into the sub-millennial variability of atmosphere-ocean interactions.

Diatom silicon isotopes in quaternary research: where do we stand?

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Since the seminal work of De La Rocha *et al.* (1997, 1998), Si stable isotopes (expressed as δ^{30}Si) have been considered a proxy for past and present primary productivity. Observations in the modern ocean largely confirm the utility of δ^{30}Si for better understanding changes in the Si cycle, but others have simultaneously highlighted biases, caveats or complications involved in application of silicon isotope based approaches to the sediment record. These include the potential for Fe or other trace metals to influence silicon isotope fractionation, the demonstration of species-specific vital effects, the possibility of dissolution to alter initial isotope compositions, the necessity to account for whole-ocean and/or circulation changes before inferences of productivity, and the role of diagenesis in a broad sense. The result is that the application of silicon isotope approaches to Quaternary research seems to be stalling.
Recent reviews have summarised the principles behind silicon isotope geochemistry and the (marine) silicon cycle, and will not be restated in detail here. Instead, this synthesis piece will try to answer whether the fall-off in δ^{30}Si-based Quaternary research is warranted. We will provide not a simple regurgitation of previous work, but rather interrogate if each potential bias or complication is a tractable problem given the current state-of-the art, or what further knowledge is needed. We will address whether complementary geochemical proxies (e.g. Ge/Si) can be useful, whether previous palaeocenographic interpretations should be revisited, and what the next steps for the field should be.

Different interglacial circulation patterns in the Southern Ocean inferred from radiolarian assemblages & geochemistry

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With global warming, oceanography and the cycling of carbon and nutrients (including silicon) are subject to large scale reorganization in the Southern Ocean. These changes may be caused by frontal migrations of the Antarctic Circumpolar Current and/or changes in the overturning circulation, affecting siliceous productivity and, therefore, the biological carbon pump. As such, understanding variations in paleoproductivity and cycling of dissolved Silicon (dSi) related to past climate is pivotal. In sedimentary archives, previous interglacials of the late Quaternary remain the closest analogs to future climate conditions. Despite this, environmental reconstructions related to silicon cycling covering past the Late Glacial Maximum remain sparse in the Indian sector of the Southern Ocean and, most, are measurements on ocean-surface-dwelling-diatoms. Radiolarians are a siliceous microplankton group which live from the subsurface to the deep Southern Ocean. Here we investigate fossil radiolarian assemblages (census counts) and, for the first time, silicon isotopes (δ^{30}Si) and Ge/Si ratio measured on handpicked monospecific-radiolarian samples in cores from the Indian sector of the Southern Ocean (ISO). The δ^{30}Si is used as a tracer for water masses while Ge/Si reflects variations in dSi concentration within a water mass. Subsurface temperatures reconstructed from a transfer function applied to radiolarian assemblages suggest similar environmental settings during interglacials of the late Quaternary as expected when compared with Antarctica Ice core records. Geochemical proxies, however, show differences between the Holocene (ongoing interglacial) and the latter interglacials. We discuss potential changes in oceanography between the last and ongoing interglacials that may explain such differences.

3 SESSION
Ecology and Biology of marine and terrestrial silicifiers

Chair: Diana Varela - Dongdong Zhu

Plant silicification by biome

Julia Cooke, Ofir Katz, Ryosuke Nakamura, Jonas Schoelynck, Felix de Tombeur

Open University (School of Environment, Earth and Ecosystem Sciences), UK

All plants accumulate silicon, but there are strong phylogenetic patterns in accumulation across multiple plant parts. Previous studies and reviews have largely focused on the role of Si accumulation in plant functional types, functions of silicon in plants, or specific ecosystems. Here the role of plant silicon, in terms of quantity, dynamics and function, is considered from a biome perspective, with a focus on terrestrial systems, but also considering marine and freshwater biomes. Which biomes are best studied and where are the biggest gaps?

Photobiology of a diatom inhabiting the subtidal sediments of the bay of Brest.

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Motile benthic ('epipelic') diatoms thrive in intertidal and subtidal sediments (< 10 m) and constitute a significant part of microphytobenthos (MPB) communities. They contribute significantly to the estuarine and coastal primary productivity and play a major role in the biogeochemical cycles of essential elements (carbon, silicon, etc.). Given their ecological importance and their role in providing paramount coastal ecosystem services, it is necessary to understand how MPB diatoms adapt and respond to their environment.
Unlike intertidal diatoms, the photosynthetic productivity of subtidal diatoms has received less attention. Yet, their light environment is complex and characterized by low intensities and a spectrum shifted towards blue-green wavelengths. Noteworthy, recent studies have shown the crucial role of light quality, especially blue wavelengths, in essential diatom biological processes (cell division, photoacclimation, mobility in sediments, etc.). The present study aims to better understand how an epipelic diatom that inhabits the subtidal sediments of the bay of Brest, namely *Pleurosigma strigosum*, responds to its light climate.
To do so, *P. strigosum* was grown under different light conditions, including different light spectra and intensities: green-blue that reproduces the 10 m depth light climate, blue (445 nm) to decipher photophysiological responses to this wavelength, and compared these conditions to a usual 'white' light spectrum of two intensities. Growth, carbon and silicate content, pigments, photosynthesis and photoprotection performances were monitored to determine the light-response of *P. strigosum*. The talk will show how *P. strigosum* is particularly well-adapted to low intensity and blue light wavelengths.

Si demand of diatoms in a changing ocean chemistry: an ecophysiological perspective

Alessandra Petrucciani[1], Alessandra Norici[1]

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In the perspective of a changing ocean characterized by acidification and global warming, numerous efforts have been made to forecast the physiological response of diatoms, dominant and diverse group of marine phototrophs. Recent studies revealed that ocean acidification would also cause a lower $Si(OH)_4$ concentration in surface oceans, with the perspective of a dramatic decline of diatom population. Given the vast diversity and complexity of diatom response patterns to multiple stresses, the purpose of this study was to evaluate the Si demand of diatoms in future oceans. *Chaetoceros muelleri, Conticribra weissflogii* and *Cylindrotheca fusiformis* were acclimated to temperature (23°C), pCO_2 (1000 ppm) and pH (7.5) predicted for year 2200 and compared to cells acclimated to present conditions. Cultures were analysed in terms of growth performance, frustule and cell morphology, elemental and organic composition, silicic acid uptake. Main results showed that growth rates in year 2200 mimicking condition were higher as compared to those in control condition; a higher Si content per cell was detected and the stable isotopic $\delta^{13}C$ value was more negative. Data suggested that in Si replete grown diatoms, cells changed Ci source for fixation and switched off energy demanding CO_2 concentrating mechanisms; the saved energy might have been used to grow faster and to assimilate more Si per cell ($mgSi \cdot h^{-1}$).
C and Si metabolisms are strictly connected and forecasting the $Si(OH)_4$ concentration in surface oceans needs to consider not only the occurring abiotic changes (water chemistry) but also an altered biological usage by diatoms.

Diverse non-diatom silicon transporters are active year-round in the silica-rich Baltic Sea

Yelena Churakova[1], Evangelia Charalampous[2], Daniel Lundin[2], Anabella Aguilera[3], Benjamin Pontiller[4], Daniel J. Conley[5], Jarone Pinhassi[2], Hanna Farnelid[2]

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Biosilicification is a widespread phenomenon across eukaryotic supergroups. One of the most well-studied cellular mechanisms for biosilicification is the intracellular uptake of silica from the environment via silicon ion transporters (SITs). SITs were first discovered in diatoms, though a recent comprehensive search of genomic, metatranscriptomic, and proteomic datasets found SIT and SIT-like (SIT-L) variants widely distributed in both silicifying and non-silicifying eukaryotic supergroups. Many questions remain pertaining to the origin, distribution, function, and relevance of these SITs. We analyzed SIT expression dynamics over a two-year period in the silica-rich Baltic Sea, to better understand the role of non-diatom biosilicifiers in a natural seawater community. In addition to SIT expression of diatoms, SIT variants associated with *Choanoflagellatea, Chrysophyceae, Dictyochophyceae, Dinophyceae, Globothalamea, Litostomatea, Oxyrrhea, Prostomatea*, and *Prymnesiophyceae* were actively transcribed throughout the study, during every sampling occasion. The distribution of these 147 SITs within the classes was diverse; some classes expressed up to 35 variants, while others expressed two. Remarkably, the average transcripts per million (TPM) of Dictyochophyceae SITs were similar to or exceeding average TPM levels observed in diatoms, which highlights their active role in silica cycling in the Baltic Sea, and potentially other similar environments. This study is the first to shed light on the extent and dynamics of non-diatom SIT expression within natural communities, and stresses the importance of further exploring the contributions of these diverse and active players to silica cycling.

The role of rhizaria in the silicon cycle: current knowledge and gaps

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There is emerging recognition of silicified rhizarians (Radiolaria & Phaeodaria) as important players in the silicon cycle. While generally less abundant than diatoms in surface waters, silicified rhizarians can represent a significant, yet not fully quantified, pool of biogenic silica (bSi) in the deep mesopelagic ocean.
Recently (Laget *et al.*, 2024), using an unprecedent global in situ imaging dataset covering all major oceanic basins, we document the distribution of 109255 large single rhizarian specimen, in the epipelagic (0-200 m) and mesopelagic (200-800 m). Modelled bSi pools were generally higher in productive areas. Altogether, we estimated their mean pool of bSi to be 1.1 ± 3.3 mg Si m^{-2} (range: 0-204) in the epipelagic and 11.6 ± 12.1 (range 0-378.3) in the mesopelagic. These values, compared to previous estimates a smaller (<600 µm) rhizarian bSi pools (Monferrer *et al.*, 2020), only stress the substantial role of large rhizarians, but also as a whole, in mediating silicon production and fluxes in the global ocean (could contribute >15% of bsi bulk pool in the epipelagic considered alone).
Despite these newly-found estimates, the fate of these large biomasses is still unknown. There are only few records of rhizarian vertical fluxes including their full size-range. However, it is likely that their fluxes are counterbalanced by dissolution. Indeed, due to the porous nature of Phaeodaria skeletons, the skeleton of epipelagic populations might dissolve in the upper part of the ocean. In contrast, as mesopelagic Phaeodaria bSi production occurs at depths, we can expect that their carcasses reach great depths before undergoing total dissolution, exporting and spreading bSi more efficiently to the deep ocean. Here, I will review the current state of our knowledge while depicting some of the important gaps that we need to fill in order to better understand the role of Rhizaria in the Silicon cycle.

WEDNESDAY 16 OCTOBER

Why do plants silicify? Leveraging functional trait-based approaches to better understand plant silicon variation

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2 | University of Dundee
3 | University of Tartu
4 | The University of Western Australia
5 | The Open University [Milton Keynes]
6 | University of Sheffield [Sheffield]
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Biomineralization in plants has long fascinated plant physiologists and ecologists, and is gaining momentum in recent years through studies of silicon and silicification. Despite seminal papers that highlight the significance of Si as a beneficial element in plant biology, many aspects of Si in plant ecology remain puzzling. Why does the variation in foliar Si concentrations comprise several orders of magnitude in terrestrial plants, ranging from virtually none to very high concentrations that greatly exceed those of macronutrients (up to 10% dry weight)? Does silicification have adaptive value, and does it contribute, or has it contributed, to the success of clades and the expansion of specific biomes? What are the costs and benefits of Si, and can trade-offs with other functional traits be identified? In this talk, I will discuss (i) leaf [Si] variation among terrestrial plant species and its inclusion in trait-based ecology (ii) the links between leaf [Si] and plant ecological strategies, and (iii) the costs and benefits of leaf Si accumulation. The presentation will party rely on a recently built database with Si concentration in leaves of about 1800 species, crossed with larger databases to extract major ecophysiological traits. A better understanding of how plants use Si is a prerequisite to understand its variation, and to fully appreciate the influence of terrestrial ecosystems on the global Si and C biogeochemical cycles.

4 SESSION Silicification processes and omics

Chair: Manuel Maldonado - Alessandra Petrucciani

The molecular basis for silica morphogenesis in diatoms

Nils Kroeger[1]

1 | Technische Universitat Dresden

The silica cell walls of diatoms are paradigms for the remarkable ability of organisms to generate inorganic materials with complex nano- and micropatterns that exceed by far the capabilities of current materials synthesis. During the past two decades, numerous candidate genes have been implicated in bio-morphogenesis of diatom silica, yet hardly any of them have been functionally characterized. Furthermore, general mechanistic models are lacking that would be able to explain how the encoded proteins can control silica morphogenesis from the nanometer scale up to scale of hundreds of micrometers. Recently, we have performed the first proteomics analysis of silica deposition vesicles (SDVs) which has enhanced the ability to identify genes involved in silica biogenesis with high confidence [1]. Furthermore, we developed a method to visualize silica morphogenesis in diatoms with unprecedented detail [2]. Combining these advances with targeted gene knockout allowed us to establish an experimental pipeline for the functional characterization of SDV proteins, and has started to provide invaluable information to develop models for silica morphogenesis mechanisms [1,3].

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Patterns of silicon transporters of similar evolutionary origin evident among natural Baltic Sea diatom communities

Hanna Farnelid[1], Evangelia Charalampous[1], Yelena Churakova[1], Daniel Lundin[1], Anabella Aguilera[2], Benjamin Pontiller[3], Daniel Conley[4], Jarone Pinhassi[1]

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Diatoms form their most distinct characteristic, the silica frustule, using specialized ion proteins, the silicon transporters (SITs), to uptake silicic acid from the water. The SITs evolved and diversified together with the diatoms and their evolution is believed to have been affected by the changes in oceanic silica concentrations. In this study we explored the diversity of diatom SITs in the Baltic Sea using metatranscriptomic data from a total of 33 samples, spanning 22 months over 2016-2017, and studied characteristics of their functionality in association with their evolutionary history. In total, 224 diatom SIT sequences were identified. Diatom SIT expression levels agreed with diatom biomass shifts. Among the identified taxa, *Chaetoceros* and *Thalassiosira* were the genuses with the highest number of identified SIT variants, 30 and 21 SITs respectively. Phylogenetic analysis of the Baltic Sea diatom SITs grouped 47% in clade C and 22% of them in clade E. Further analysis of seasonal expression patterns showed that clade C SITs were most expressed during the transition from autumn to winter, while clade E SITs were mostly expressed in the period between winter and spring. The phylogenetic analysis of the diatom SITs in combination with the identification of common expression patterns through different environmental conditions in the Baltic Sea, a silica rich environment, contributes with important insights into the ecological understanding of silicic acid uptake across different environments.

A transcriptomic investigation into the biomineralization of *Coscinodiscus* girdle bands

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Photonic crystals (PhCs) are periodic nanoscale structures enabling the manipulation of light at the nanoscale that are used in a wide range of applications. However, the fabrication of high quality PhCs is time-consuming, expensive, and environmentally unsustainable. Species belonging to the genus *Coscinodiscus* are generally large-celled radial centric diatoms that are widespread in tropic to boreal oceans. A fascinating feature of *Coscinodiscus* girdle bands (the cell wall constituting the "side" of the cells) is the highly periodic pore lattice, which gives them their PhC properties. Two types of pore lattice have been found in the girdle bands of *Coscinodiscus* species: square and hexagonal. These lattices provide different PhC properties that are useful in different applications.
We aim to identify key genes involved in biomineralization of girdle bands in *Coscinodiscus*, and in particular genes involved in defining the PhC properties. To this end, we will characterize and compare the Si-responsive transcriptomes of *Coscinodiscus granii* and C. sp. H2, which have square and hexagonal girdle band lattices, respectively. Si-starved cultures will be resupplied with Si and harvested at selected time points for RNA sequencing. The results presented will be the first transcriptome investigation of cell wall biomineralization in the *Coscinodiscophyceae* class.

This work is supported by the Norwegian Research Council.

WEDNESDAY 16 OCTOBER

Silicon transport in Phaeodaria

Natalia Llopis Monferrer[1, 2], Sebastian Sudek[1], Lynne M Christianson[1], Steven H D Haddock[1], Erwan Corre[2], Charlotte Berthellier[2], Fabrice Not[2], Colleen Durkin[1]

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Phaeodaria, siliceous biomineralizing protists, inhabit diverse layers of the ocean, influencing plankton dynamics and the evolution of protists. Particularly abundant in the mesopelagic, the larger Phaeodaria species (>1 cm) pose a sampling challenge due to the delicate nature of their glass skeletons. Consequently, our understanding about the biology, ecology, and evolution of these captivating organisms remains scant. We use a remotely operated vehicle equipped with high-resolution imaging systems to observe giant phaeodarian colonies in their natural habitat and to gently collect to further study their cell biology, physiology and molecular evolution. Samples collected with the ROV were used to generate single-cell transcriptomes, from which we identified silicon transporter (SIT) gene sequences enabling us to elucidate the evolutionary diversification of silicifiers and their role in current biogeochemical cycles. Our research investigates how Phaeodaria developed silicon uptake capabilities through a unique form of this gene, while diatoms acquired their silicon uptake abilities through SIT duplication and fusion events. Furthermore, we analyze environmental data linked to these genes to contextualize the global distribution and abundance of these organisms.

The regulation of seawater silicate concentration on the growth and cell silicification of a cosmopolitan diatom species *Thalassionema nitzschioides*

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Thalassionema nitzschioides is a cosmopolitan diatom widely distributed in the world ocean, except in the polar waters. Moreover, it is normally in high abundance and sometimes dominant in some area, therefore contributes significantly to marine primary productivity, marine carbon and silicon cycle. Compared to most of the pelagic diatoms, *T. nitzschioides* is more easily preserved in the sediments, thus becomes even more important in the sediment diatom assemblage. The reason for the well preservation of *T. nitzschioides* may be related to its high degree of silicification, which also implies its important role in the marine silicon cycle, especially for the export and burial of biogenic silica. In this work, the possible effects of sea water silicate concentration changes on the growth of *T. nitzschioides* and its impact on the silicon, carbon and nitrogen contents in the cells were studied by means of laboratory culture experiments. The results showed that when other culture conditions, including temperature, salinity, light and other nutrient concentrations, remained constant, 1) silicate concentration had a significant effect on the maximum cell abundance of *T. nitzschioides*, which was significantly increased with the increase of silicate concentration. 2) The concentration of silicate also had significant effects on the content of silicon in the cells of *T. nitzschioides.* With the increase of silicate concentration, the silicon content in the cells increased significantly, however there was no significant change in the cell morphology, size, and volume. 3) The concentration of silicate further impacts the mole ratio of silicon-carbon (Si:C).and silicon-nitrogen (Si:N) in the cells, which increase significantly corresponding to increased silicon concentration in the culture environment. These results above indicated that the concentration of silicate in seawater not only affected the cell abundance of *T. nitzschioides*, but also impact the degree of cell silicification and the cell specific gravity, and further implies an important effect on the marine carbon and silicon export to the deep ocean and burial in the sediment.

Potential of imaging flow cytometry in determing diatom silicification kinetics

Katariina Raassina[1], Christopher Hulatt[1], Hirono Suzuki[1]

1 | Nord University

Analysing silicification kinetics using traditional methods is a time-consuming process. High-throughput methods, such as flow cytometry, offer an alternative way to analyse and visualise the formation of silica within individual diatom cells, which can be used to trace silicification kinetics over time. Not only does this offer a way of quickly phenotyping diatoms regarding their silica content, it also gives us insight into the metabolic incorporation and localization of silica inside cells.
We chose eleven different marine diatoms, four pennate and seven centric, to give us a comprehensive overview of differences in silicification between the species and strains. To study the silica content and silicification kinetics, we labelled the diatom cultures with a fluorescent probe, HCK-123, and took daily subsamples for imaging flow cytometry, capturing multispectral images of the cells for analysis. We analysed the biogenic silica content of the strains to see if bulk chemical measurements of diatom silica content were proportional to fluorescence measurements from the probe.
We determined the daily median intensity of each strain with IDEAS-program and fitted a pharmacokinetic model to the data. In our initial analysis we found that strains with known low silica content, such as *Phaodactylum tricornutum*, had low silicification rate and relative silica content, while high silicifiers, like *Cyclotella cryptica*, had high silicification rate and relative silica content. We will further analyse the data by correlating the fluorescence of the cells to the cell size and compare the results of the biogenic silica analysis with the fluorescence signals.
Our study shows that imaging flow cytometer can detect differences in the silica content and silicification rates between the studied diatom strains. Imaging flow cytometry offers many potential applications in the field of diatom phenotyping, such as determining how changes in the growth environment affect the silica content of diatoms.

Unraveling the SDV proteome of *Thalassiosira pseudonana* using proximity labeling

Annika Messemer[1], Per Winge[1], Tore Brembu[1]

1 | Norwegian University of Science and Technology

Thalassiosira pseudonana, a model centric diatom renowned for its intricate frustule pattern, is a key organism in understanding biosilicification. The process involves the formation of silica deposition vesicles (SDVs) where silica polymerization occurs. Investigating the molecular mechanisms within SDVs is crucial for comprehending silicification.
We genetically engineered *T. pseudonana* lines expressing under its native promotor a highly abundant silicanin Sin-2, which is localized to the SDV lumen, fused at the N-terminal with the labeling enzyme APEX2. This approach will allow proximity labeling of its closest interaction partners as well as surrounding proteins inside the SDV. APEX2 tagging of the C-terminal end of the silicanin, which is facing the cytosol, will serve as a control. One of the major drawbacks of this proximity labeling data is noise resulting from labeling during protein synthesis, processing and transport. This will be overcome by an experimental set up with a synchronized cell culture, and evaluation of highest APEX2 activity and thus protein abundance.
These results will offer unique insights into the spatial organization and interaction networks within the SVDs by identifying key proteins that are involved in the process of biomineralization.

5 SESSION Silicifiers in the Open Ocean and upwelling systems

Chair: Fabrice Not - Maria Lopez-Acosta

Highly-coherent oceanic structures and their impact on the diatom dynamics

Ismaël Hernández-Carrasco

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Diatoms are known to thrive in high nutrient-high turbulent systems (e.g. polar, upwelling and coastal areas). However, they are not exclusive to these systems, and recent observations revealed that short-living spatially-restricted diatoms blooms may occur in oligotrophic, nutrient limited waters fueled by transient meso- and submesoscale dynamical structures such as eddies, fronts or filaments, questioning future projections based on models that cannot properly resolve these circulation structures. In this talk, I will present a novel framework to identify flow coherence simultaneously in space and time, and how it can be used to study what dynamical conditions are conductive to episodic diatom blooms in oligotrophic waters. We combine remote-sensed data from different platforms (satellite observations of dominant phytoplankton functional types) with Lagrangian techniques, including finite-time Lagrangian eddy kinetic energy and finite-time Lagrangian vorticity calculated from altimetry derived surface currents. This methodology has been applied to classify the flow structures according to their Lagrangian coherent rate (LCR) (i.e. a new objective measure of the range of dynamical coherence scales of the underlying flow features), and to identify the mesoscale eddies that effectively promote diatoms blooms. In particular, we observe that turbulent mesoscale structures with high LCR (40 days or longer) favor the sustained growth of diatoms. The integration of Eulerian kinematic variables into a Lagrangian frame represents a significant step forward towards quantifying new dynamical scales of geophysical turbulence that modulate the phytoplankton community structure, and offer a new, robust test for Earth System Models.

Deciphering the impact of climate variability on siliceous plankton flux from sediment traps in the oligotrophic Ionian Sea (Eastern Mediterranean)

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Radiolarians (zooplankton) and diatoms (phytoplankton) are the main silicifying protists and major exporters of C and Si flux to the deep ocean. Although naturally nutrient-poor seas such as the Eastern Mediterranean (EMed) are expected to be highly sensitive to phenomena of global warming, the impact of climate variability on the biodiversity and vertical export of these siliceous plankton are still poorly understood. Therefore, this study presents the seasonal and interannual patterns of Polycystine radiolarians and diatoms from sediment traps moored at 700 m depth in the Ionian Sea and collected monthly/twice monthly throughout the years 2015, 2016 and 2017.

Regardless of the oligotrophic nature of the Ionian Sea, nutrient enrichment occurs intermittently through various mechanisms. Indeed, the vertical export of radiolarians and diatoms displays a periodicity that is controlled by climate and oceanographic changes. Their highest vertical export occurred synchronously in late winter and late summer, with a total flux reaching 93 000 and 95 000 specimens·m^{-2}·day^{-1}, respectively. Interestingly, the highest value was observed outside the usual seasonal peaks, in spring 2016, with 167 000 specimens·m^{-2}·day^{-1}. Otherwise, the average flux value (aside seasonal peaks) was ca. 24 000 specimens·m^{-2}·day^{-1}. The late winter peak was associated with seasonal water column mixing, low insolation, important precipitations, and phytoplankton blooms, while the second late summer peak was likely due to intermediate water upwelling, fluctuations in surface currents intensity and gyres, and atmospheric dust deposition from North African regions. Juvenile radiolarians were overall extremely abundant, with the juvenile/adult ratio remaining constant in all samples. It should be stressed that it is the first time that juveniles are counted with precision in a seasonal study.

The silica cycle in the eastern Levantine basin, new findings from the most diatom-inhospitable oceanic habitat.

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Owing to its anti-estuarine circulation, warm climate, and paucity of river inputs, the eastern Levantine basin (ELB) in the Mediterranean Sea is a stratified, hyper oligotrophic marine water body with extremely low concentrations of $NO_3^{+}NO_2$; PO_4 and $Si(OH)_4$ (DSI). The conditions in the ELB are harsh for primary producers in general and particularly for diatoms. A recent sediment-traps study offshore Israel (1500 m depth) showed exceptionally low annual biogenic silica (BSi) and diatom fluxes from the euphotic zone of 0.44 mg m^{-2} d^{-1} and 9.6×103 valves m^{-2} d^{-1}, respectively. These fluxes are the lowest reported in oceanic areas worldwide, marking the ELB as the most deficient endmember in the oceanic silica cycle. Our study also shows that much of the diatom frustules reaching the seafloor (~50 km offshore) are laterally transported from the shelf, highlighting the importance of this process. The harsh conditions for diatoms in the ELB were exacerbated following the completion of the Aswan High Dam over the Nile in 1965, that mitigated the discharge of silica (DSi)-rich water from the Nile to the Mediterranean Sea during autumn floods. We show that this event terminated the pre-dam seasonality in surface water DSi and decreased by 60-79% the accumulation rates of BSi in the far-field, deep-sea sediments (1100-1500 m depth) along the past trajectory of the Nile flood-plumes, offshore.

Nutrient regeneration in the Chinese marginal seas

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Nutrient regeneration and exchange at sediment and overlying seawater interface is an important source of nutrients for estuaries and coastal ecosystems. Nutrient concentrations in sediment pore waters were examined on the basis of observations in the Chinese marginal seas, i.e. the Bohai, Yellow Sea, East China Sea, and South China Sea. Nutrient diffusion fluxes at sediment and overlying seawater interface were calculated by diagenetic equations. Sediment represents a source for phosphate and dissolved silicate in the Chinese marginal seas, a source for ammonium in the Bohai and Yellow Sea in Aug 2015, and in the East China Sea in May and Aug 2011. While it is a source for nitrate in the South China Sea in Mar 2014. The diffusion of nutrients from sediment is an important source of nutrients for ecosystems of the Chinese marginal seas, which supports 2-8% of nitrogen, 2-3% of phosphorus, and 10-16% of silicon requested by primary production.

New insights into the Si cycle in an upwelling area: a modeling approach

Patricia Grasse[1, 2], Kristin Doering[3], Guillaume Fontorbe[4]

1 | German Centre for Integrative Biodiversity Research
2 | Helmholtz Centre for Ocean Research [Kiel]
3 | Lund University
4 | NaN

The Peruvian Upwelling is characterized by extremely high surface water productivity and one of the largest oxygen minimum zones in the world. Due to the upwelling of silicate-rich subsurface waters, primary productivity in this region is generally dominated by diatoms. However, warmer surface waters and subsequent changes in stratification and nutrient supply may cause a shift in plankton communities from diatoms to dinoflagellates and silicoflagellates, with implications for the silicon (Si) and carbon cycles.
In 2017, we investigated the Si cycle in a field experiment off the coast of Peru. Pelagic mesocosms (~55,000 L) were deployed for 50 days during the austral summer (February and April) to simulate upwelling conditions coinciding with a coastal El Niño. In this study, we combined stable silicon isotopes in seawater (δ^{30}SidSi) and biogenic silica (δ^{30}SibSi) in surface, subsurface, and sediment trap data with a modeling approach to better assess the processes controlling the Si cycle during different phases of the experiment (diatom-dominated vs. silicoflagellate-dominated).
The model simulation included the evolution of dissolved silica (dSi), biogenic silicate (bSi), and their stable isotopes. Isotopic simulations included a fractionation factor between seawater and diatoms (-1.1) and silicoflagellates (-3.7) during dSi uptake and were tested with and without fractionation during dissolution. In addition, bSi export efficiencies were investigated as a function of the dominant phytoplankton and their influence on carbon export. The modeling study provided new insights into the Si cycle in the equatorial upwelling off Peru.

Decoupling silicon metabolism from carbon and nitrogen assimilation poises diatoms to exploit episodic nutrient pulses in a coastal upwelling system

Michael Maniscalco[1], Mark Brzezinski[1], Jeffrey Krause[2], [3], Kim Thamatrakoln[4]

1 | University of California, Santa Barbara
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Diatoms serve as the major link between the marine carbon (C) and silicon (Si) biogeochemical cycles through their contributions to primary productivity and requirement for Si during cell wall formation. Although several culture-based studies have investigated the molecular response of diatoms to Si and nitrogen (N) starvation and replenishment, diatom silicon metabolism has been understudied in natural populations. A series of deckboard Si-amendment incubations were conducted using surface water collected in the California Upwelling Zone near Monterey Bay. Steep concentration gradients in macronutrients in the surface ocean coupled with substantial N and Si utilization led to communities with distinctly different macronutrient states: replete ('healthy'), low N ('N-stressed'), and low N and Si ('N- and Si-stressed'). Biogeochemical measurements of Si uptake combined with metatranscriptomic analysis of communities incubated with and without added Si were used to explore the underlying molecular response of diatom communities to different macronutrient availability. Metatranscriptomic analysis revealed that N-stressed communities exhibited dynamic shifts in N and C transcriptional patterns suggestive of compromised metabolism. Expression patterns in communities experiencing both N and Si stress imply that the presence of Si stress diminishes the impact of N stress on organic matter metabolism. That response is consistent with observations that the regulation of C and N metabolism is decoupled from Si limitation status, allowing optimization of the metabolic machinery necessary to respond to episodic pulses of nutrients. Several well-characterized Si-metabolism associated genes were found to be poor molecular markers of Si physiological status; however, several uncharacterized Si-responsive genes were revealed to be potential indicators of Si stress or silica production.

6 SESSION
Polar seas

Chair: Patricia Grasse - Maxence LePicard

Silica and the Arctic sea ice biome

Karley Campbell

UiT The Arctic University of Norway

The polar seas are characterized by the presence of a sea ice cover for some portion of the year. This frozen landscape is one of the largest biomes on the planet, which supports seasonally dense communities of diatoms that are vital contributors to ocean primary production and the biogeochemical conditions of the marine system. Drawing from several campaigns completed across the Arctic over the past decade, the role of silica within the sea ice biome will be discussed. This includes its function within ice algal communities in driving stoichiometric variability and differing states of nutrient limited growth between Arctic regions, as well as in supporting unique species of diatoms within several of the biome's microhabitats. This talk will also assess how the harsh growth conditions of sea ice help to promote a potentially net heterotrophic system, despite the prominence of diatom photosynthesis within the ice.

Linking polar diatom ecology with carbon and silicon cycles

Philipp Assmy[1], Karley Campbell[2] , Lucie Goraguer[1, 2], Hanna Kauko[1, 3], Christine Klaas[4], Jeffrey Krause[5, 6], Catherine Lalande[7], Megan Lenss[1, 2], Fanny Monteiro[8], Sébastien Moreau[1], Victor Smetacek[4]

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3 | Kongsberg Satellite Services
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Diatoms play an important role in the marine carbon and silicon cycles and dominate phytoplankton blooms in polar oceans. The fate of carbon and silicon in the deep ocean strongly depends on the ecological traits of the dominant diatom species. Here, we present results on phytoplankton blooms from several cruises to the polar oceans as well as biological carbon and silicon export obtained from moored long-term and short-term sediment traps deployed in the Atlantic sectors of the Arctic Ocean and Southern Ocean. The emphasis of the talk will be on diatom species composition and how it relates to elemental ratios. We show that fast-growing, weakly silicified diatoms enhance the Biological Carbon Pump along the iron-replete continental margins of the Arctic Ocean while the heavily silicified, grazer-protected diatoms of the iron-limited Antarctic Circumpolar Current drive the Southern Ocean silicon dump. We will also explore the impact of these diatom ecological differences on the carbon and silicon cycles using the global ocean model NEMO-PISCES representing plankton interactions with variable Fe:C and Si:C stoichiometry. We will place our findings into an ecological context to shed some light on the role of proximate environmental and ultimate evolutionary factors in shaping the interplay of diatom community composition and carbon and silicon cycles.

Diatom ecophysiology in a brighter Arctic Ocean

Johann Lavaud[1, 2]

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2 | Takuvik Joint International Laboratory ULAVAL-CNRS

Diatoms of the Arctic Ocean experience drastic light fluctuations due to extreme changes in the photoperiod and seasonal variations of the snow and sea-ice cover extent and thickness which attenuate light penetration in the water column. Arctic diatom communities exploit this complex seasonal dynamic through a well-documented species succession during spring, beginning in bottom sea-ice and culminating in massive phytoplankton blooms underneath sea-ice and in the marginal ice zone. The pattern of diatom taxa sequentially dominating this succession is relatively well conserved interannually, and taxonomic shifts seem to align with habitat transitions. To understand whether differential photoadaptation strategies among diatom taxa explain these recurring succession sequences, we coupled lab experiments with field data collected in Baffin Bay at 67.5°N (GreenEdge project campaigns). Based on field data, we selected diatom species typical of different ecological niches. We characterized their ca. 0°C growth and light-responses (photoacclimation, photoprotection) under light intensity ranges representative of their natural habitat. We furthermore investigated some specificities of the light-response in one of our selected species and model polar diatom, Fragilariopsis cylindrus: the circadian rhythmicity of photosynthesis modelled onto photoperiod, the light spectrum (in particular blue light) effect, and the survival to prolonged darkness. This talk will synthesise the major findings arising from these last years work performed between Takuvik (Canada) and LEMAR (France) labs.

Phytoplankton blooms and biological carbon and silica export in the Sea Ice Zone of the Southern Ocean

Sebastien Moreau[1, 2], Megan Lenss[3, 4], Lucie Goraguer[3, 4], Hanna Kauko[3, 5], Guillaume Liniger[6], Philipp Assmy[2, 3], Karley Campbell[4], Anette Wold[3], Jeffrey W. Krause[7, 8], Simon T. Belt[9], Lukas Smik[9, 10], Katrin Schmidt[11]

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Phytoplankton blooms in the Southern Ocean drive the Biological Carbon Pump (BCP) that plays a disproportionately important role in global climate on a range of timescales. Primary production in the sea ice zone (SIZ) of the Southern Ocean is mainly limited by the strong seasonal fluctuations in light and the availability of the micronutrient iron. In the SIZ, iron is mainly provided at the surface by melting sea ice, drifting icebergs, and deep sources (e.g. deep winter mixing, upwelling of iron-rich deep waters). Compared to the frontal regions of the Southern Ocean, the strength of the BCP in the SIZ is largely unresolved. However, our recent work using biogeochemical Argo floats suggests that this zone contributes equally to the BCP of the Southern Ocean when compared to open ocean frontal regions.
We present results from several research cruises (2019-2024) to the Kong Haakon VII Sea, in the eastern part of the Weddell Gyre, where the physical-biogeochemical mechanisms driving phytoplankton blooms are investigated. These include the upwelling of deep hydrothermal iron in an offshore frontal structure, the influence of sea ice melt in alleviating light- and iron limitation at the beginning of spring, and the role of ocean turbulence at the continental shelf break in supporting an actively exporting bloom dominated by the centric diatom Corethron pennatum and the haptophyte Phaeocystis antarctica. We also present results of biological carbon and silica export from long-term sediment traps deployed in the region from 2019 to 2023, deciphering the role played by ice algae in deep carbon and silica export.

“Cold storage” – do sediment microbes facilitate silica sequestration Arctic sediments?

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Early diagenetic processes produce authigenic clay in marine sediments, i.e. reverse weathering (RW) reactions, and are a major sink term in oceanic biogeochemical cycles. Due to the reaction byproduct of carbon dioxide, RW also affects oceanic pH on long temporal scales. Despite significant progress in our collective understanding of RW, the role of microbes has been overlooked. Sediment microbial activity facilitates changes to sediment porewater redox conditions and fundamentally alters the pathways in which organic matter can be processed. In collaboration with others, we have demonstrated that microbial activity can exert control on early diagenetic RW reactions on the order of hours to days in low-latitude marine deltaic sediments. However, whether the effect of microbes on this process extends to higher-latitude systems is unknown. There have been reports demonstrating the importance of RW reactions in colder environments (e.g. deep sea, polar regions) but unlike low-latitude systems, cold temperatures restrain the role of bacteria in water-column silica remineralization, and presumably this would extend to the sediments. Using fresh sediment collected in Svalbard during late winter, we present preliminary evidence that microbial activity facilitates increased sequestration monotonically in three separate experiments. Experiments were run at 3 °C and the effect from a lack of microbial activity increased over time (experiments lasted up to 120 hours) but differences were observed quickly (tens of minutes starting the incubation). While the mechanism of the effect is unknown (e.g. direct, indirect), and being explored, our results suggest that microbial processes should be considered when trying to understand and model RW in both low- and high-latitude systems.

Evolution of dissolved and particulate silicon along a glacier-ocean continuum

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Silicon (Si) is a key element for silicifying marine organisms. In the Southern Ocean, diatoms are the main phytoplanktonic group, in particular around the Kerguelen plateau with seasonal blooms, an area naturally enriched in iron. Diatoms plays a major role on the carbon cycle through the biological carbon pump (BCP) and Si cycle via their frustules made of biogenic silica (BSi). Silicic acid (DSi) supply from water below the surface generally controls the production of diatoms, but since few years, some studies report subglacial amorphous silica (ASi) as a potential source of DSi to the polar oceans. Since ASi can be both biogenic and non-biogenic, it is difficult to identify the Si source. In addition, clay particles can play a role in the DSi pool via Si adsorption - desorption along the salinity gradient in estuaries. The identification and nature of particles (primary, secondary mineral and ASi) is essential to assess the bioavailability of silicon. Different freshwater, estuarine, coastal and oceanic environments were sampled in late summer 2024 during the MARGO campaign around the Kerguelen plateau. Filtration at 3 µm and 0.2 µm was processed in order to study the coarse and fine particles. Different chemical leaching steps were tested with the aim of measuring Si isotopes. Chemical analysis will be combined by scanning electron microscopy (SEM) and X-Ray diffraction (XRD). We will discuss the evolution of the particulate fraction composition along the glacier-ocean continuum with samples collected from a melting glacier (glacial flour), glacial and non-glacial lakes, estuary and coast.

Influence of light and silicic acid on the productivity of the arctic phytoplankton community

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The Arctic phytoplankton community, which constitutes the base of the marine food web is dominated by two major functional types. Both depend on light and nutrients for their growth: silicifiers, dominated by diatoms, who additionally require silicic acid and non-silicifiers, mostly represented by the haptophyte Phaeocystis pouchetti. As the sea ice melts and increases light availability, primary productivity is supposed to increase, however the role of nutrient limitation is less understood. In recent decades the inflow of silicic acid into the Arctic Ocean has been declining due to increased stratification, and simultaneously the spring bloom composition has been observed to shift towards haptophytes. We hypothesised that the silicic acid decline at the surface will limit overall primary productivity, despite an increase in light availability, and favour a non-diatom dominated community. During two cruises to the Arctic in 2023, samples of the natural phytoplankton assemblage were collected from the Chla-max layer and incubated under an array of different light and silicic acid levels using stable isotopes (^{13}C, ^{15}N and ^{30}Si). The Photosynthesis vs. Irradiance vs. Nutrients (PIN) surfaces obtained were used to model carbon, nitrate and silicic acid uptake rates as a response to light and silicic acid concentrations. Preliminary results indicated that silicic acid uptake rates scaled with silicic acid availability, whereas there was little influence of light availability. These responses to light and nutrients for both silicifying and non-silicifying phytoplankton groups, will help improve our understanding of Arctic primary productivity as climate change advances.

Siliceous plankton in the Pacific Sub-Arctic and Arctic Oceans: rates, standing stocks and effects of a changing ocean

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Silicon is a fundamental element to marine biogeochemistry, ultimately linking the cycles of carbon and nitrogen through biological processes. Diatoms are the largest consumers of dissolved Si in marine surface waters and contribute to about 40% of annual marine carbon fixation. Therefore, diatoms have a large impact on surface ocean Si cycling, principally in coastal and shelf regions. In contrast, the role that other pelagic siliceous organisms, such as Rhizaria, have in marine Si cycling is less well known, despite sustained efforts in data collection and large advances in understanding the Si cycle. We investigated silicon, carbon and nitrogen dynamics (uptake rates and particulate matter) in plankton natural assemblages and those exposed to ocean acidified conditions in the NE Pacific Sub-Arctic (2019-2023) and Arctic (North Bering and Chukchi Seas, 2013-2023). On average, diatoms accounted for the majority of primary productivity (60-100%) and nitrate uptake (75-100%) when compared to the total phytoplankton assemblages in these regions. Ocean acidification experiments conducted in the Pacific Arctic in 2022 showed a decrease in diatom biomass at the lowest pH (7.77) treatment compared to intermediate pH (7.94) and control (8.25) conditions. Diatom nutrient physiology and elemental stoichiometry were not affected by ocean acidification. When compared to diatoms, Rhizaria contributed less than 0.12% to overall biogenic silica production in the Pacific Sub-Arctic, but can contribute significantly more to the export of biogenic silica to the deep sea. A 10-year record of Rhizaria community composition (2010-2020) and Si uptake rates (2022-2023) in the Sub-Arctic were used to update published estimates of global silica production by Rhizaria. This dataset that encompasses extensive spatiotemporal scales and compares two key siliceous players should significantly contribute to refining our understanding of the global marine Si cycle.

Posters Abstracts

Phytoplankton responses to Zinc and Copper toxicity: impact on the physiology and the elemental composition of *Pseudo-nitzschia*

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For the last decade, the pennate diatom *Pseudo-nitzschia australis* (*P. australis*) has received an increasing attention notably due to its major contribution to the high concentrations of the neurotoxin domoic acid (DA) recorded in the Eastern North Pacific during the 2015 warm blob. Furthermore, in HNLC regions, pelagic diatoms including others *Pseudo-nitzschia* species play a major role in the biogeochemical cycles of essential elements such as carbon, silicium and iron. The study of *Pseudo-nitzschia* physiology is therefore essential for a better understanding of the marine biogeochemistry with further environmental and societal implications. Among the different essentials elements for marine life, copper (Cu) and zinc (Zn) are indispensable for phytoplankton growth but become toxic at sub-nanomolar ionic concentration (i.e. Cu^{2+} and Zn^{2+}). Cu lower the cellular growth of some *Pseudo-nitzschia* species and Zn may alter the photosynthetic system efficiency. The aim of this study is to investigate the effects of Cu^{2+} and Zn^{2+} on the physiology, the elemental composition and the DA production of the toxic diatom *P. australis*. A regional strain of *P. australis* (isolated from the Baie d'Audierne, Britanny, France), was exposed for 10 days to different levels of Cu^{2+} and Zn^{2+}, during laboratory-controlled experiments (L1/Aquil medium). Cell growth rate, specific DA production, lipids content, C, Cu and Zn elemental composition were all modified by exposure to the toxic levels of Cu^{2+} and Zn^{2+} tested. This presentation will further present the links between the physiology of *P. australis* cells and DA production

Silicon isotopic contrast between Southern Ocean fertilized and HNLC (High Nutrients Low Chlorophyll) areas around Kerguelen and Heard islands

Edwin Cotard[1], Valentin Deteix[1], Arnaud Dapoigny[2], Sandrine Caquineau[3], Thomas Ryan-Keogh[4], Damien Cardinal[1]

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3 | IRD, LOCEAN - IPSL
4 | Council for Scientific and Industrial Research (CSIR)

Silicon (Si) is a key element for silicifying marine organisms. Silicic acid (DSi), controls the production of diatoms, predominant in the Southern Ocean. Diatoms are main contributors to the biological carbon pump, which is particularly active in the Southern Ocean and in areas naturally enriched in iron such as around the Kerguelen and Heard plateau.
The objective of this study is to better understand the factors controlling the biogeochemical cycle of Si and its dynamics in the Southern Ocean and how it might be impacted by island mass effect. We use Si isotopic signatures combined with several parameters: DSi, BSi, LSi concentrations and, SEM observations of suspended particles. Different oceanic environments were sampled in late summer 2021 during the SWINGS campaign. Here, we focus exclusively around the Kerguelen and Heard plateau.
Surface δ^{30}Si values are not homogeneous among stations likely resulting from different DSi water mass sources. Nevertheless, other significant variations are observed for areas under shelf influence. Around Heard the δ^{30}SiDSi data are homogeneous and lighter by 0.5 to 1‰, along with high LSi concentrations, suggesting a significant contribution of LSi to the DSi pool. This is consistent with SEM observations showing the presence of volcanic ashes. We also observe variations in the δ^{30}SiBSi signatures. The surface δ^{30}SiBSi vary strongly ranging from 2.5‰ to 1.0‰ coupled with high BSi concentrations above the shelf (>5 µM at Heard and at Kerguelen). We will discuss this data with the degree of Si utilization and its sources in the mixed layer.

Shifts in diatom assemblages over the two last centuries in the Bay of Brest

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The assemblages of siliceous microorganisms (diatoms) were studied in a sediment core collected in the Bay of Brest (BB), with a resolution of 5 to 10 years, between 1897 to 2013. This work is part of a larger study examining several taxonomical groups, such as dinocysts, pollen grains and foraminifera, studied for the same time-frame and sediment core. This larger study will allow a direct comparison between the evolution of landscapes, estuarine and marine ecology, and the influence of anthropogenic pressures on the BB. The principal objective of this study was to observe the potential changes in the diatom assemblages due to human activity within the BB watershed. The sediments were processed with different chemical reagents (HCl and H_2O_2) and sieved prior to microscopical observation of the diatom taxa. Roughly 300 individual diatom valves were morphologically characterized using microscopic analysis (optical and scanning electron). A baseline assemblage, prior to 1945, was established in order to compare the diatom taxa over time. Prior to 1945, the diatom assemblages are considered to be relatively stable, based on geochemical and palynological analyses from previous studies. In addition, the first 15 cm of the sediment core, which was influenced by bioturbation, is also considered as a stand-alone assemblage. Overall, the diatom taxa studied within the sediment core represent different assemblages associated with each time frame evaluated. A majority of pennate diatoms prevailed, notably the family *Cocconeidaceae* within the sub-order *Bacillariophycideae*, an ubiquitous taxa relatively abundant within benthic diatoms. These preliminary results agree with previous palynological studies, which is encouraging. However, a more detailed taxonomic evaluation is needed to confirm whether diatoms can be used as an environmental proxy in estuarine environments.

Silica determination assessment in seagrass leaves

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The biogeochemical cycle of silicon has been extensively studied in terrestrial plants, revealing three beneficial effects of biogenic silica accumulation for this vegetation: structural, physiological and protective. However, its importance in marine plants, particularly seagrasses, which are essential for biogeochemical coupling between terrestrial and coastal ecosystems, remains largely unexplored. Our research aims to fill this gap by assessing for the first time the wet-alkaline digestion and hydrofluoric-acid digestion methods to determine the silicon content in the leaves of a common seagrass species, *Zostera marina*. Leaves of *Z. marina* contained 0.26% silicon:dry-weight, consistent with the only two existent studies in seagrasses to date. Our results indicated that *Z. marina* incorporates silica in two forms: a labile form, digested by the alkaline method, and a more resistant form, digested only by acid digestion. These findings support chemical digestions for silicon quantification and provide insights into the impact of seagrasses on the marine silicon cycle: labile silica will be recycled, benefiting siliceous organisms upon leaf degradation, and the refractory form will contribute to the ecosystem's buried silica stock and coupled carbon sequestration. This study also provides a methodological basis for exploring silicon functionality in seagrass physiology and ecology.

Optical properties of benthic diatoms from the subtidal sediments of the Bay of Brest.

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The most distinctive feature of diatoms microalgae is a 3D silica exoskeleton called the frustule, whose micro- and nano-structures, with unique optical properties, form perfect biophotonic crystals that are very similar to those used in various advanced industrial applications (e.g., optical telecommunications). Optical characteristics could support benthic diatoms' photoregulation, as well as contribute to other photobiological processes such as phototaxis and karyostrophy (i.e., the movement of chloroplasts along cytoplasmic strands toward the nucleus during exposure to strong light).
Frustule centric diatom's capacity to collect and focus light like a lens has been studied before. Pennate diatoms, however, present a stronger focusing capability, thanks to their fusiform shape and their refractive index repartition. Also, pennate diatoms living in very low light subtidal environments could depend on their optical properties to collect light for optimal photosynthesis. The measurements of the structures of the silicon shell, and of the repartitions of the cell's organelles give us a way to understand the cell's optical parameters.
Our study has the particularity to aim at living diatoms' optical properties, particularly the pennate diatom *Pleurosigma strigosum* present in the subtidal sediments of the bay of Brest in the West of France.
We tried to find the right optical phenomenon for blue engineering purposes, i.e. the 3D micro impression of bio-inspired lenses. A first promising attempt will be shown.

Land-sea transport of dissolved and particulate silicon: fluxes from rivers and sewage to the ria of Vigo (nw Iberian peninsula)

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The second largest Galician Ria is that of Vigo with 156 km^2, and a fluvial granitic basin of 490 km^2, where 420,000 people live. The Ria receives continental supplies from the Oitavén river (16.3 m^3·s^{-1}) and five streams (Alvedosa, Lagares, Fraga, Maior, Ullo: 6.9 m^3·s^{-1}); also discharge six wastewater treatment plants (WWTPs): Vigo city (2.0 m^3·s^{-1}) and Teis, Arcade, Redondela, Cangas and Moaña towns (0.3 m^3·s^{-1}). In NW Iberian Peninsula, the silicon biogeochemical cycle is conditioned by spring-summer upwelling events, whereby land-sea fluxes of dissolved silicate (DSi) in the Ria of Vigo were considered unimportant. This study is undertaken to assess the inputs of silicon to a ria coastal system and to enrich the information about the land-sea Si-contributions. Water was monthly sampled in 2004, filtered the sampling day (0.45 mm Pall hydrophilic polypropylene) in a cleaned lab and DSi analysed following auto-analytical methodology. Filters were weighed, microwave digested (USEPA 3052 guideline) and particulate silicon (PSi) determined by ETAAS. In rivers, the annual average concentration of DSi ranged 92-179 mM (Oitavén-Lagares), while in WWTPs did 143-194 mM (Redondela-Teis). These concentrations are similar to the world river average. PSi was 14-163 mM (Oitavén-Lagares) and WWTP 19-187 mM (Redondela-Cangas). The main DSi flux to the Ria corresponded to the quasi-pristine Oitavén River with 1120 t·yr^{-1}, while the major PSi flux is due to the contaminated Lagares Stream with 890 t·yr-1. Overall Si-load to the ria of Vigo in 2004 was 3590 t·yr^{-1} (32% PSi), where WWTP discharges were only 11% of total. Regarding the world area weighted averages, in the ria DSi (5.1 t·km^{-2}·yr^{-1}) is the order of the mean land-ocean yield but PSi (2.5 t·km^{-2}·yr^{-1}) is 30-times lower.

Impact of viral infection and silicon limitation in *Chaetoceros socialis* on cellular silica content and exopolymer production

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Marine microbial dynamics are influenced by various important processes, including viral infection and nutrient availability. As one of the most abundant and diverse phytoplankton on Earth, diatoms facilitate carbon export due to the ballasted, silica-based cell wall and production of exoploymers (EPS), such as transparent exoploymers (TEP) and coomassie-stainable particles (CSP), that promote aggregation and sinking. Viral infection and lysis enhances upper ocean recycling of organic matter and associated elements through a process called the viral shunt, but recent evidence suggests viral infection may also stimulate export – the viral shuttle. Using laboratory cultures of *Chaetoceros socialis* grown under replete and silicon (Si)-limited conditions, we examined the impact of viral infection on cellular silica content and EPS production. Infected *C. socialis* had higher biogenic silica (bSi) concentrations per cell compared to uninfected cultures in both nutrient conditions, with Si-limited infected cultures having the highest bSi concentration per cell. However, neither TEP nor CSP production were enhanced in infected culture regardless of nutrient status. These data suggest that viral infection of *C. socialis* may stimulate sinking through increased ballast production, but not enhanced aggregation, highlighting a dynamic role of viruses in carbon cycling. Ongoing work is extending these observations to natural communities through analyses of nutrient-manipulated mesocosm experiments conducted in the Gulf of Naples, Italy during the annual Spring diatom bloom that has historically been dominated by *C. socialis*.

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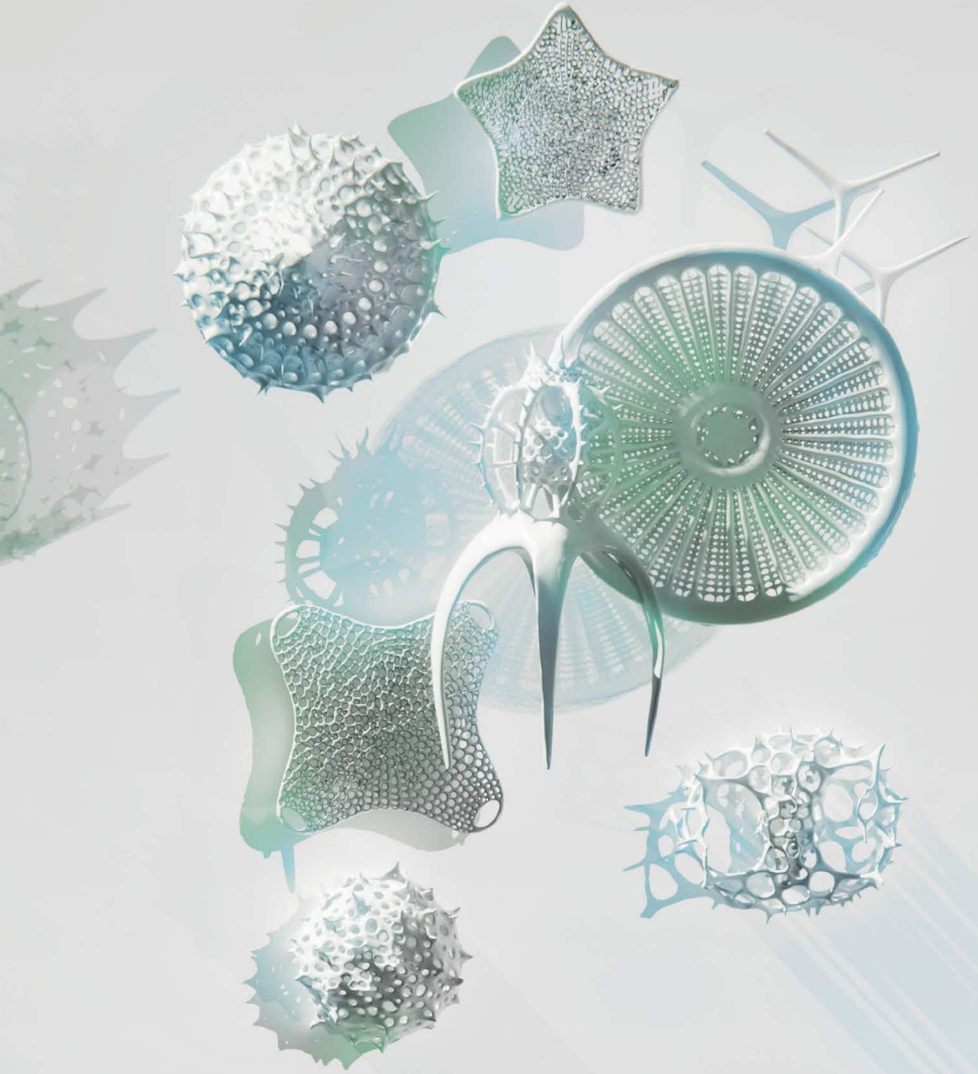

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