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***Proceedings: Students in Polar and Alpine Research Conference 2023***

MUNI SCI Department of Geography

CZECH ANTARCTIC RESEARCH PROGRAMME

**Students in Polar and Alpine Research Conference 2023 – preface**

Dear colleagues and young researchers,

It was our pleasure to meet you again at the international Students in Polar and Alpine Research Conference, which was being held for the 8th time at the Department of Geography, Faculty of Science, Masaryk University, Brno, Czechia. We are pleased that we met old colleagues and young scientists there interested in polar and alpine research and shared their geoscience and bioscience knowledge with us.

Furthermore, we would like to thank the four keynote speakers for their interesting talks and the experience they passed on to us. This year, we heard 12 contributions in the form of oral presentations, the abstracts of which can be found on the following pages.

We believe that you enjoyed the conference as much as we did and that it was beneficial for all of us and an opportunity to establish new friendships and scientific cooperations. All past and future conference-related information can be found your-round on the website: https://sparc-brno.webnode.cz/

We greatly appreciate your participation and hope to see some of you in the coming years.

Brno, 18 September 2023

Martin Kadlec, Jakub Holuša

**Proceedings**
Students in Polar and Alpine Research Conference 2023

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## Contents

**Buried but not dead: Microbiomes of Arctic Cryosols**

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Arctic permafrost soils contain about half of the global soil organic carbon (about 1300 Pg). One-third of this carbon is stored in subducted organic matter (cryoOM) due to cryoturbation processes.

Here, we present results from several Arctic projects aimed at identifying the role of microbial functioning in the decomposition of organic matter in cryoturbated soils (Siberia, Greenland, Canada) and assessing the potential vulnerability of this organic matter in a future climate.

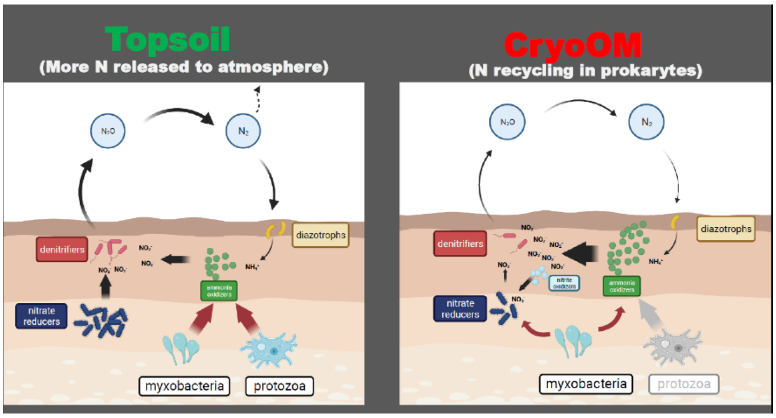
Our main findings were:

**Bacterial and fungal abundance is closely correlated with carbon loss.** A low fungal/bacterial ratio may be one of the reasons for the slow decomposition of cryoOM and can be used as a predictor of cryoOM vulnerability. The microbial community is distinctly different from the topsoil and more similar to the surrounding subsoil communities. Therefore, there is a mismatch between microbial community composition and OM quality, which contributed to the slow decomposition of cryoOM.

**OM availability is reduced and N cycling is slowed.** In several incubation experiments, including experiments with labelled substrates, we demonstrated different nutrient limitations of microbial communities in cryoOM. The N-containing substrates resulted in a significant priming effect, indicating a strong N limitation of the microbial community. A high proportion of cryoOM is bound to clay minerals, which may contribute to lower availability for microbial decomposition and lower vulnerability of cryoOM.

**Based on the metatranscriptomic results**, we predicted that N in cryoOM is likely to be recycled into microbial biomass through a microbial cycle in which **predatory bacteria (Myxococcota) play a crucial role.** This may lead to lower overall $N_2O$ emissions from the cryoOM.

In conclusion, we show that decomposition processes in cryoturbated Arctic soils are slowed by a combination of changes in microbial community composition, reduced OM availability and decelerated N cycling.



**Investigating small-scale drifting snow processes at the Poles with OpenFOAM**

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**Keywords:** snowdrifts, OpenFOAM, Arctic, Antarctica, Alps

Drifting snow is intrinsic to polar environments, at the North and South Poles but also in high mountain regions. The complex interaction between air, snow and obstacles leads to the formation of snowdrifts that have important consequences in these locations. In the Arctic, where the snow distribution is often modulated by pressure ridges, it impacts the surface energy balance and thus the formation and melt of the underlying sea ice. Snow also influences the sea ice in Antarctica, besides having an important impact on the ice shelf mass balance. In the mountains, snow transport and its interaction with terrain leads to snow cornices and other accumulations with consequences for avalanche danger, hydrology and ecology. Strong snow accumulation is further observed around (research) buildings and other artificial structures, which often complicates the logistics, especially in polar regions.

Despite their importance, the factors governing the formation of snowdrifts are not yet fully understood. Simulating snowdrifts with a highly detailed physics-based snow model can help to grasp the processes underlying their development and also develop engineering solutions to avoid undesirable drifts. In our study, we make use of the Eulerian-Lagrangian snow transport model snowBedFoam (Hames et al., 2021) to investigate snowdrift processes around both natural and man-made structures. The model was successively applied to a sea ice pressure ridge in the Arctic (Hames et al., 2022), a research station in Antarctica and solar photovoltaic panels in the Alps. The numerical results for snow distribution showed a good qualitative agreement with the measurements. However, our current modelling framework uses a fixed topography and is not yet suitable for a precise quantitative assessment of snowdrifts, which quickly evolve in time. Further developments such as mesh-surface adaptation or the inclusion of evolutive snowpack properties are therefore the next steps of our work.

**References:**

Hames O., Jafari M., Lehning M. (2021): snowbedfoam: an openfoam eulerian-lagrangian solver for modelling snow transport. https://www.envidat.ch/dataset/snow-accumulation-on-arctic-sea-ice-during-mosaic

Hames O., Jafari M., Wagner D.N., Raphael I., Clemens-Sewall D., Polashenski C., Shupe M.D., Schneebeli M., Lehning M. (2022): Modeling the small-scale deposition of snow onto structured arctic sea ice during a mosaic storm using snowbedfoam 1.0. Geoscientific Model Development, 15(16), pp. 6429–6449. doi.org/10.5194/gmd-15-6429-2022

## Exploring the Icy Treasures: Biosynthetic potential of Antarctic bacteria from James Ross Island

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**Background:** The growing problem of antimicrobial resistance motivated scientists to re-explore natural sources of bioactive secondary metabolites. Antarctica represents an extreme environment colonized by bacteria with unique adaptation mechanisms allowing them to thrive under harsh conditions. Such adaptations include the production of secondary metabolites to inhibit competitors or sustain abiotic stresses, which predestines these microbes as a source of natural products for biomedical use.

**Objectives:** This work aimed to recover novel bacterial taxa from Antarctic soils to access the biosynthetic potential hidden in yet uncultivated bacteria. The main objective is the activation and subsequent upregulation of silent biosynthetic gene clusters enabling the discovery of novel secondary metabolites, through diverse cultivation and co-cultivation strategies, as well as genetic manipulations.

**Methods:** Three isolation methods (pre-selection of spore-forming bacteria, modified low-nutrient and soil-extract based media) were applied to recover novel bacteria from Antarctic soils, predominantly targeting phyla with high biosynthetic potential such as *Actinomycetota*, *Pseudomonadota* and *Bacillota*. Activation of silent biosynthetic gene clusters was attempted through targeted cultivation and co-cultivation. Screening for bioactive molecules and evaluation of their novelty was achieved using genomics, metabolomics, and bioactivity testing.

**Results:** A collection of 1023 isolates was established. Recovered isolates were associated with four bacterial phyla including 123 isolates of novel species. *Pseudomonadota* and *Actinomycetota* represented the most abundant phyla. Specific media stimulated the biosynthesis of several unknown natural products. One of these unknown compounds showed strong antimicrobial activity against Gram-negative bacteria including multidrug-resistant clinical strains. This compound has been linked to the specific gene cluster responsible for its production. Plans for upregulation to obtain sufficient concentration for isolation involve cluster-specific genetic manipulations.

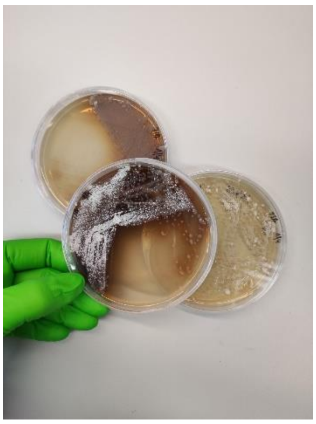

**Figure 1** Novel species of bioproductive Antarctic *Streptomyces* spp.

**Deglaciation of the last North American Ice Sheet Complex**

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The last North American Ice Sheet Complex covered extensive regions of northern North America at the peak of the last glacial period. This was the only time when the Cordilleran Ice Sheet in the mountainous west coalesced with the Laurentide Ice Sheet covering the vast regions east of the Canadian Cordillera all the way to the Atlantic coast. In the north, the Laurentide Ice Sheet coalesced with the Innuitian Ice Sheet, which in turn coalesced with the Greenland Ice Sheet. The quantitative chronology of the last North American Ice Sheet Complex consists of radiocarbon, cosmogenic exposure, and optically stimulated luminescence ages. While radiocarbon ages have been the backbone of quantitative glacial chronologies for decades, with several generations of published deglaciation chronologies being based on radiocarbon datasets, the other quantitative dating methods have only been added recently to quantitative deglacial chronologies at the ice sheet complex scale in North America. The maximum extent of the North American Ice Sheet Complex was reached at 22 ka, however, the local last glacial maxima were asynchronous across the ice sheet complex with some regions starting their retreat as early as 25 ka, or even earlier, while other regions reaching their maxima as late as ~17 ka. The amount and robustness of information on the chronology of ice retreat varies across the ice sheet complex with some regions having considerably higher uncertainty than others. Among the most loosely constrained regions belong most of the areas of the glaciated continental shelf and the northwestern sector of the Laurentide Ice Sheet that has high uncertainty on the ice margin positions during the rapid retreat from its late local last glacial maximum. Future work might attempt to narrow down the uncertainty of ice margin retreat chronology by building Bayesian transects perpendicular to the ice margin isochrones; an approach already tested for the British-Irish Ice Sheet. More attention might also be given to the period prior to the Last Glacial Maximum, given how scarce information is on both the last ice build-up and on earlier glaciations in North America.

**Growth and Decay phases of the Coastal Polynya in the Ross Sea sector of West Antarctica during 2002-2023**

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**Keywords:** Coastal Polynya, Antarctic sea-ice, SAR, Ross Sea, Passive Microwave

Insight into the distribution of sea ice is crucial to understanding ocean–atmosphere heat exchange and water-mass transformation in Polar Regions, and in understanding the future trajectory of sea ice in both hemispheres. Of particular interest in this context are polynyas, which are sites of intensive ocean–atmosphere heat exchange during winter, often regarded as "ice-production factories". With our study, we aim to communicate how dynamic the summer (November to April, considered as the decay period) and winter (May to October, considered as the growth period), coastal polynya behaviour for the Ross Sea sector is. In winter (growth phase), polynyas are low sea-ice concentration areas with Frazile ice and are influenced by local wind conditions, whereas in summers (decay phase), the same regions have less fragile ice types with more open water. In this study, we document the behavior of Ross Sea polynyas using 6.25 km spatial resolution at a daily scale. We see large changes in interannual variance with the time of year. Variance is very low from April until October but is large in March and increases through the summer months. Our data shows peak positive anomalies during the summers of 2003, 2008, 2010 (prior to 2012) and the highest negative summer anomalies in the Western Ross Sector were observed after the super El-Nino 2016. The highest negative anomaly years 2022, 2017, 2019, and 2017 (lowest first order) had some interesting behavior in the winter as well, whereas, in 2022, the winter anomalies were the lowest in the period chosen for the study, followed by 2010. This led us to investigate the polynya behavior separately for summers (decay mode) and winters (growth mode). We briefly present the circumstances and circulation patterns during the high and low anomalies of both phases causing drastic changes in polynya behavior in the Ross Sea sector of West Antarctica.

**Acknowledgements:**
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**Antarctic lichens survive in high-light environments: a case study of *Xanthoria elegans* from James Ross Island, Antarctica**

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**Keywords:** chlorophyll fluorescence, non-photochemical quenching, photoinhibition, photoprotective mechanisms, photosystem II

**Introduction:** In Antarctic terrestrial ecosystems, lichens may be exposed to high light doses (HL) in the austral summer season. Whilst a high light dose is not harmful to the photosynthetic apparatus of symbiotic algae (chlorolichens) or cyanobacteria (cyanolichens) when lichen thalli are in a dry (desiccated) state, exposure to HL in a wet state causes photoinhibition, i.e. HL-induced decrease in primary and secondary processes of photosynthesis. However, HL resistence is species-specific trait (Cao et al. 2015). In our study, we have used several chlorophyll fluorescence techniques to investigate the phenomenon of photoinhibition in an Antarctic lichen *Xanthoria elegans* which is considered to have a high constitutive resistance to photoinhibition thanks to several proteins and antioxidants present in a thallus (Pedišius, 2020).

**Experimental species:** The samples of *X. elegans* were collected from a deglaciated area of the northern part of James Ross Island during the Czech Antarctic expedition in the austral summer of 2021–2022. The sampling site was a slightly inclined plateau (50 m a.s.l.) located close to a coastal line located north of the Berry Hill mesa. In laboratory-based experiments, *X. elegans* thalli were exposed to HL of 2000 μmol $m^{-2} \cdot s^{-1}$ of photosynthetically active radiation (PAR) for 30 min. During the photoinhibitory treatment as well as the consequent recovery (180 min.) thallus temperature was maintained at 5 °C. FollowingHL treatment and during consequent recovery, the below-listed chlorophyll fluorescence parameters were measured at the Extreme Life Laboratory (Department of Experimental Biology, Masaryk University, Brno).

**Methods:** To evaluate the extent of photoinhibition and consequent recovery, the following chlorophyll fluorescence methods were used in fully-hydrated thalli of *X. elegans*: (1) Slow Kaustky kinetics with repetitive saturation pulses, (2) induction curves of non-photochemical quenching (NPQ), and (3) photosynthetic light-response curves of electron transport rate (ETR) through the systém of electron transport carriers in thylakoid membrane of a chloroplast. NPQ components related to photoinhibition-induced structural and functional changes in PSII were evaluated according to Tietz et al. (2017).

**Results and discussion:** Thalli of *X. elegans* responded to the above-specified HL treatment by a short-term decrease in potential (Fv/Fm) and effective quantum yields of PSII ($\Phi_{PSII}$) but the two parameters showed fast recovery. This was possibly due to an increase in NPQ values, which was more than two times higher than before HL treatment. The underlying mechanism was the activation of the non-photochemical quenching component related to photoinhibition (qIt). Similarly NPQ induction curves revealed increase in NPQ values and involvement into PSII protective mechanisms activated after HL treatment (see Barták et al., 2023).

The short-term changes in PSII photochemistry well documented low-to-medium photoinhibition and almost full recovery of PSII that was reached after 180 min. These findings support the idea of a high-degree of photoresistance in *X. elegans* in its wet state. In a broader sense the results reveal that the species is highly adapted to short-term photoinhibitory episodes. The underlying physiological mechanism is the species' ability to increase NPQ, and qIt rapidly after the HL stimulus, i.e. in tens of seconds after the start of photoinihibitory HL treatment.

**Acknowledgements:**
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**References:**

Barták M., Hájek J., Halıcı M. G., Bednaříková M., Casanova-Katny A., Váczi P., Puhovkin A., Mishra K. B., Giordano D. (2023): Resistance of Primary Photosynthesis to Photoinhibition in Antarctic Lichen Xanthoria elegans: Photoprotective Mechanisms Activated during a Short Period of High Light Stress. Plants, 12, 2259. doi.org/10.3390/plants12122259

Cao S., Zhang J., Zheng H.; Liu C., Zhou Q. (2015): Photosynthetic performance in Antarctic lichens with different growth forms reflect the diversity of lichenized algal adaptation to microhabitats. Polish Polar Research. 36(2), p. 175b–188. 10.1515/popore-2015-0012

Pedišius V. (2020): UV-B absorbing and bioactive secondary compounds in lichens Xanthoria elegans and Xanthoria parietina: A review. Czech Polar Reports. 10(2), p. 252-262. 10.5817/CPR2020-2-19

Tietz S., Hall C. C., Cruz J. A., Kramer D. M. (2017): NPQ(T) a chlorophyll fluorescence parameter for rapid estimation and imaging of non-photochemical quenching of excitons in photosystem-II-associated antenna complexes. Plant, Cell & Environment. 40(8), p. 1243-1255. 10.1111/pce.12924

**Aeolian abrasion on James Ross Island, Antarctica**

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**Figure 1 A)** Honeycombs on basalt boulder with the hammer to scale; **B)** Abrasion surface on granite boulder. Note the grinded red numbers

Glaciers almost exclusively form the Antarctic landscape. The action of other terrestrial exogenic processes is limited to only a few small deglaciated areas. One of these areas is located on the Ulu Peninsula, where most of the 250 km2 deglaciated land of James Ross Island is concentrated. Therefore, it represents one of the few places that has been modified by fluvial and aeolian processes. Much effort has been put into studying (niveo- ) aeolian accumulation forms in the area in the past. Furthermore, the research focused on wind-blown material quantification has been progressing. However, almost no attention has been paid to aeolian erosion/abrasion. A large quantity of fine-grained clastic material, snowflakes and firn carried by strong winds over the open-space area suggests a particular potential of these processes. Nevertheless, their effects can be relatively inconspicuous at first sight. First, we can observe a desert lag left after removing fine-grained material from the surface. Hyaloclastite breccia, basalt, and granite boulders typically have fewer surface features resulting from aeolian abrasion . Honeycombs appear to form on some basalt surfaces (Fig. 1A), whereas no aeolian erosion/abrasion markers are visible on hyaloclastite breccias or granites (Fig. 1B). However, despite the lack of forms on these rocks, there is likley to be a significant degree of abrasion occuring on these boulders. One indication of this is that a carving in a rock at the Johann Gregor Mendel Czech Antarctic Station from 2005 is now almost absent in 2023. To examine the aeolian erosion and abrasion in the studied area, several methods could be used, including: 1) analysis of thin sections made from wind-polished boulders, 2) laserscanning of the selected boulders, 3) honeycombs and wind-polished facets orientation measurements, and, 4) comparison the results with meteorological, climatological, and soil moisture data. Combining these materials and methods would enable us to study aeolian erosion and abrasion (and how rock properties influence it), quantify the processes on a temporal scale, and evaluate the availability of wind-transported material. First samples and measurements were conducted during a recent expedition, hopefully serving as a basis for further long-term project.

**Corynebacteria in penguins**

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Penguins represent a unique group of birds with a distinctive lifestyle, which makes their populations vulnerable to various ecological pressures, including infectious diseases. Recent studies have suggested that although corynebacteria can be found in typical penguin microbiomes, some strains may act as opportunistic pathogens and contribute to several penguin diseases, such as diphtheric stomatitis, bumblefoot infections, and other infectious lesions. In our long-term cultivation study of bacteria associated with the fauna of the Antarctic Peninsula region, we identified multiple strains of corynebacteria among the isolates from the mucosa and faeces of Adélie penguins (*Pygoscelis adeliae*).

The isolates obtained were sorted into clusters of closely related strains using rep-PCR fingerprinting. 16S rRNA gene was sequenced for selected representatives of these clusters, and the resulting sequences were compared to publicly available nucleotide databases for identification. The results showed that many of the studied isolates belong to the genus *Corynebacterium*, and a surprising number could not be assigned to any known species. Some of the isolates appear to be closely related to known corynebacteria originating from birds, such as *Corynebacterium aquilae*, *ciconiae* or *spheniscorum*, indicating existing adaptation for a bird host.

Thorough characterization of the novel *Corynebacterium* species may provide some insight into their adaptations to the host and their pathogenic potential. As corynebacteria are receiving increasing attention as emerging penguin pathogens, understanding their diversity and virulence potential is essential for developing strategies to prevent and treat those infections.

**Pore Structure Evolution in Andesite Rocks Induced by Freeze-Thaw Cycles Examined by Non-Destructive Methods**

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Mechanical or physical weathering (physical rock breakdown), or more specifically, frost weathering induced by repeated freeze-thaw cycles, is a key process that influences the appearance of geo-relief, especially at high altitudes or in polar periglacial regions. It is closely related to the regional and global climate (Grossi et al., 2007). Physical rock breakdown mainly stems from the propagation of cracks in the rock matrix (Eppes and Keanini, 2017). The sources of stresses which are induced by freezing and thawing (hencefort referred to as F-T cycling) and cause deterioration of rock material are still discussed (Deprez, et al., 2020). Frost damage may include a combination of several mechanisms and is currently attributed mainly to crystallization pressure (Powers, 1949; Everett, 1961; Walder and Hallet, 1985; Scherer, 1999; Steiger, 2005a,b; Steiger, 2014) subsequent hydraulic pressure (Powers, 1949), and volumetric expansion (Hirschwald, 1908) One or another usually predominates depending on material properties, moisture conditions, and thermal conditions (Hall, 1999).

In this work, we compare the values of petrophysical properties before and after 100 F-T cycles, as well as recorded length change behaviour and temperature development on a vacuum-saturated fractured andesite rock sample taken from the Babina Quarry in Slovakia using a specially-constructed thermodilatometer, VLAP 04, equipped with two HIRT- LVDT sensors. We also used non-destructive visualization of the rock pore network by μCT imaging in order to study the development of the pore structure and fracture network in pyroxene andesites during the freeze-thaw process.

Based on our results it can be stated that:

1) The tested andesite from Babiná is a rock with extremely low porosity and a specific pore size distribution pattern with a large number of small capillary pores and micropores, as well as a large number of macropores. This corresponds to the results from the indicative rock pore structure method. Based on those results, the rock pore structure of Babina andesite predominantly contains hard to access macropores, which are interconnected by micropores and mesopores. A part of this specimen’s matrix contains a large amount of blind and isolated pores. Pore interconnection determined by the imbibition curve slope C(I) is also extremely low, but with a significant increase after F-T cycling.

2) Non-destructive visualization by μCT showed only a slight increase in macroporosity of the sample after 100 F-T cycles. On the other hand, significant fracture opening corresponds to a 31 pp. increase in fracture volume. The largest dimensional changes of porous structures are also bound to the locations near the fracture (Figure 1 and Figure 2).

3) The physical breakdown of rock necessarily stems from the propagation of fractures. F-T induced cracking of a brittle-elastic solid like pyroxene-andesite is caused by ice crystallization and hydraulic pressure build-up which led to rock fatigue failure. Subcritical cracking of the tested andesite results in the total residual strain of $8 \cdot 10^{-5}$ recorded after 100 F-T cycles (Figure 3).

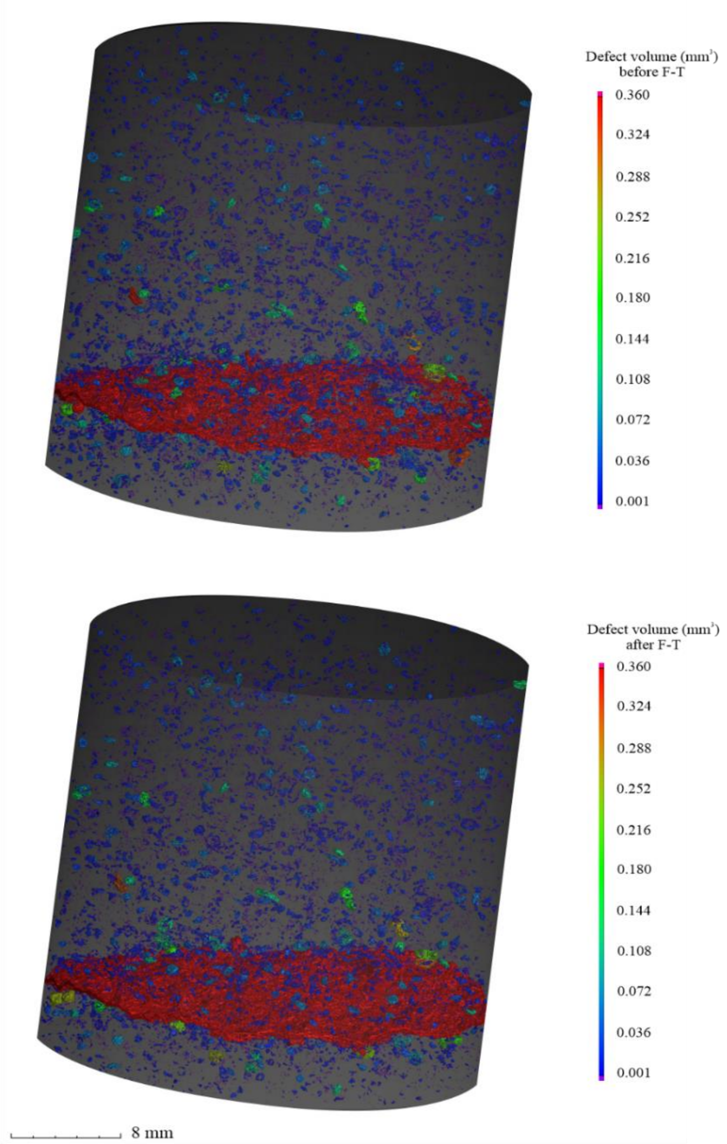


**Figure 1** Distribution of pores. The total volume of the detected pores was 127 $mm^3$, which represents a total porosity of 0.73%. After application of 100 F-T cycles, it increased to 153 $mm^3$ - porosity 0.89%.

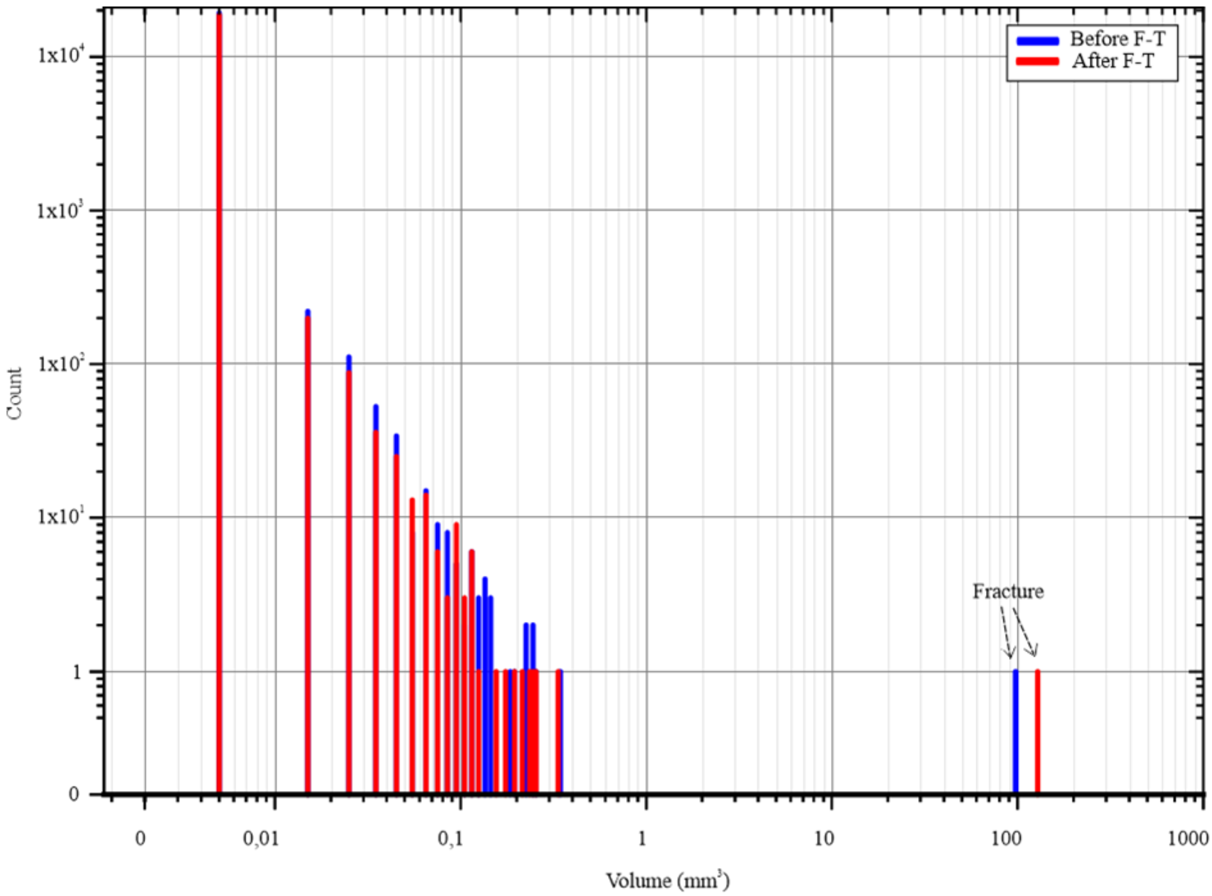


**Figure 2** Histogram showing pore size distribution of macropores (due to the used voxel size of 34 µm/voxel, we were able to scan only pores with an effective diameter larger than 136 µm.) in andesite determined by Micro X-ray tomography before and after 100 F-T

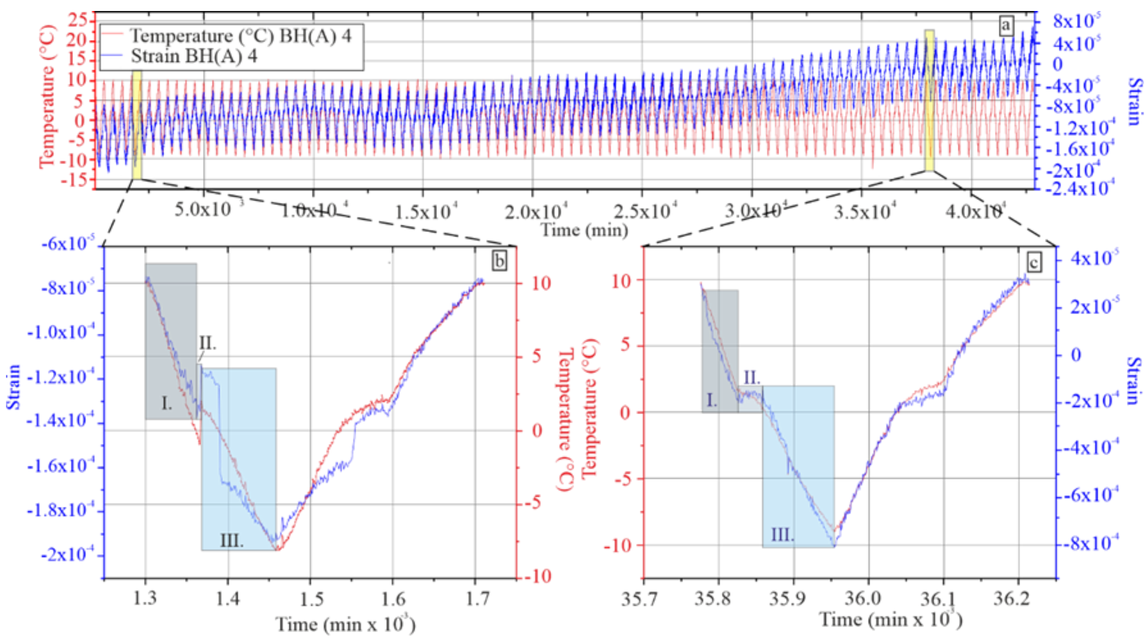


**Figure 3** Record of temperature and strain behaviour of BH(A) sample; a) Temperature and strain path during 100 F-T cycles, b),c) Detailed records of temperature and strain vs time during 4th and 83rd F-T cycle.

**References:**

Deprez M., De Kock T., De Schutter G., Cnudde V. (2020): A review on freeze-thaw action on weathering of rocks. Earth Science Reviews, 203, 103143.

Eppes M. C. and Keanini R (2017): Mechanical weathering and rock erosion by climate dependent subcritical cracking. Reviews of Geophysics, 55, p. 470–508.

Everett D.H. (1961): Thermodynamics of frost damage to porous solids. Transaction of the Faraday Society, 57(7), p. 1541–1551.

Grossi C. M., Brimblecombe P., Harris I. (2007): Predicting long term freeze-thaw risks on Europe built heritage and archaeological sites in a changing climate. Science of The Total Environment, 377, p. 273-281.

Hall K. (1999): The role of thermal stress fatigue in the breakdown of rock in cold regions. Geomorphology, 31, p. 47–63.

Hirschwald J. (1908): Die Prüfung der naturlichen Bausteineaufihre Verwitterungs beständigkeit, Verlag Wilhelm Ernst & Sohn, Berlin. [In German]

Powers T.C. (1949): The air requirements of frost-resistant concrete. Portland Cement Association, Chicago.

Scherer G.W. (1999): Crystallization in pores. Cement and Concrete Research, 29.

Steiger M. (2005a): Crystal growth in porous materials–I: the crystallization pressure of large crystals. Journal of Crystal Growth, 282, p. 455–469.

Steiger M. (2005b): Crystal growth in porous materials–II: Influence of crystal size on the crystallization pressure. Journal of Crystal Growth, 282, 470–481.

Steiger M., Charola A.E., Sterflinger K. (2014): Stone in Architecture. In: Siegesmund S., Snethlage R. (Eds.): Stone in Architecture: Properties, Durability. Springer-Verlag, p. 225–315.

Walder J. and Hallet B. (1985): A theoretical model of the fracture of rock during freezing. Geological Society of America Bulletin, 96 (3), p. 336–346.

**Numerical atmospheric model applications for operative weather forecasting in Antarctica**

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Antarctica is one of the most challenging environments to conduct fieldwork in. Freezing air temperature combined with strong winds can lead to frostbite and hypothermia. Heavy snowfall and blowing snow can reduce visibility and may be damaging for sensitive scientific instruments. The extreme and varying meteorological conditions in Antarctica thus emphasize the need for highly accurate weather prediction. However, weather forecasting is especially difficult in coastal areas, due to complex topography and variable land cover. These complexities may render output of global numerical weather prediction models less reliable. To overcome these limitations, the Antarctic Mesoscale Prediction System (AMPS) was designed. The system relies on the Weather Research and Forecasting (WRF) model and it modified for use in polar environments. Unfortunately, the system is spatially limited, with high-resolution only available around McMurdo Station. In the Antarctic Peninsula region, where many other bases are located, the AMPS output is only available in the 2.67 km or lower-resolution grids. The model performance in air temperature and wind speed simulation was assessed with in-situ observations from Johann Gregor Mendel Czech Antarctic Station and Davies Dome glacier, both located in the northern part of James Ross Island (JRI), northeastern Antarctic Peninsula region. Further, the WRF model was run in 0.5 km resolution using physical parameterisations which performed well during validation studies over northern JRI (Matějka et al., 2021; Matějka et al., 2022). The results show that the mean bias of simulated air temperature in the 10 – 120-hour lead time was reduced from -4.1 °C (AMPS) to -0.8 °C (WRF@0.5 km). The variability of difference between simulated and observed temperature was also reduced. A slight improvement was also found on the top of Davies Dome glacier. Wind speed accuracy was marginally improved when using WRF@0.5 km at JGM and very slightly worsened at Davies Dome. We suggest that the custom configurations of the WRF model might be beneficial for operative weather prediction in other coastal Antarctic regions.

**References:**

Matějka M., Láska K. (2022): Impact of the selected boundary layer schemes and enhanced horizontal resolution on the Weather Research and Forecasting model performance on James Ross Island, Antarctic Peninsula. Czech Polar Reports, 12, p. 15–30. https://doi.org/10.5817/CPR2022-1-2

Matějka M., Láska K., Jeklová K., Hošek J. (2021): High-Resolution Numerical Modelling of Near-Surface Atmospheric Fields in the Complex Terrain of James Ross Island, Antarctic Peninsula. Atmosphere, 12, 360. https://doi.org/10.3390/atmos12030360

**Glacio-hydrological behaviour of the Gasbreen, a debris-covered glacier in the high Arctic**

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**Keywords:** Glacier retreat, Glacio-hydrological discharge, Satellite Remote Sensing, Hornsund, Svalbard.

Global warming in the polar regions has led to widespread shrinkage of the cryosphere, resulting in a loss of mass from ice sheets and glaciers, a reduction in snow cover and Arctic sea ice extent, as well as an increase in permafrost temperature. Warming on Svalbard is two to six times faster than in the rest of the world and, consequently, this affects the terrestrial and marine environment. According to the RCP scenarios, Svalbard will be more vulnerable in the future. The shrinking cryosphere has significant impacts on marine ecosystems, and the hydrological regime of the Svalbard region. In addition, due to increasing physical weathering rock debris is deposited over the glaciers, and the number of glacial lakes and snow avalanches is also increasing in the region. Increasing debris cover over glaciated catchments has potential impacts on glacial ablation and hydrological runoff.

In this study, the Gasbreen Glacier from the Hornsund region was selected to analyse glaciological (variability in debris cover, vertical and horizontal thinning) and hydrological runoff from the catchment for the period 2003–2020. The high-resolution satellite imagery from the ASTER and Sentinel platforms were used to extract the debris cover, glacier outlines, and glacier ablation (dem differencing), while meteorological data from ERA 5 was used to estimate the hydrological runoff from the glaciated catchment. The observations showed that the debris thickness over the glacier ablation zone varied between 3 and 20 cm, and debris cover over Gasbreen Glacier has been increasing annually. The glacier has lost significant glacial mass (vertically and horizontally) during the period 2003-2020, resulting in increases in hydrological runoff.

This study shows that increased climate variability may have affected the glaciated catchment area by increasing debris cover and reducing the melt rate over the lower ablation zone. It has been observed that the hydrological properties of debris-covered glaciers differ between clean ice from land/marine terminal glaciers, although they are within the same climatological, geological, and geomorphological setting. Therefore, we communicate with this study that for the Spitsbergen region, it is particularly important to understand how these properties affect the timing and magnitude of meltwater runoff and further marine ecosystems.

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**Exceptional glacier changes on the James Ross Archipelago, Antarctica, since 2010**

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Here, we have brought together multiple datasets to highlight exceptional glacier changes on the James Ross Archipelago between 2010 and 2023. We present annual end-of-summer snow line altitudes (SLA), albedo, and area change for all 156 glaciers covering ~2200 $km^2$, in-situ measurements of ablation and accumulation on Davies Dome and Lookalike glaciers on James Ross Island, as well as previously published velocity and surface elevation data. We show that glacier area and surface elevation have decreased across the archipelago. Glacier thinning has prevailed since 2019/20, coincident with an increase in SLA. These increasing melt rates were driven by sustained exceptional temperature rises (0.2 $°C \cdot yr^{-1}$) and exacerbated by very low albedo, and we discuss the implications of these for glacier longevity in the region.

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Front cover photo: Weddell seal lying on the shore of Prince Gustav Channel, James Ross Island, Antarctica (© Jakub Holuša)

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