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Editorial: Processes controlling development of periglacial and paraglacial landscapes in rapidly changing polar regions: Part 1

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This special issue is a scientific tribute to the founders and researchers working at Stanislaw Baranowski Polar Station of the University of Wroclaw, which in 2021 celebrated the 50th anniversary (1971–2021). It was named after Stanisław Baranowski (1935–1978) its founder and renown glaciologist, who tragically died after an accident on King George Island in 1978. On this special occasion, we have invited researchers from throughout Poland to present case studies that document and analyze changes in recently deglaciated landscapes, where paraglacial and periglacial processes started to remove the effects of glaciation.

Stanislaw Baranowski Polar Station is located on Wedel Jarlsberg Land, on the west coast of Spitsbergen, the largest island in the Svalbard Archipelago (Fig. 1). The Station building is located on the bedrock outcrop, right under the embankment of the lateral moraine of the Werenskioldbreen, *ca.* 550 m away from the coast of Nottinghambukta and at *ca.* 15 m above the sea level. The Brattegg stream flows next to the building, where in a small river gorge, creates a 2.5-meter high waterfall. The Station is located in the Sør-Spitsbergen National Park, established in 1973. This unique location supports studies in a number of scientific disciplines, including geomorphology (including permafrost studies),

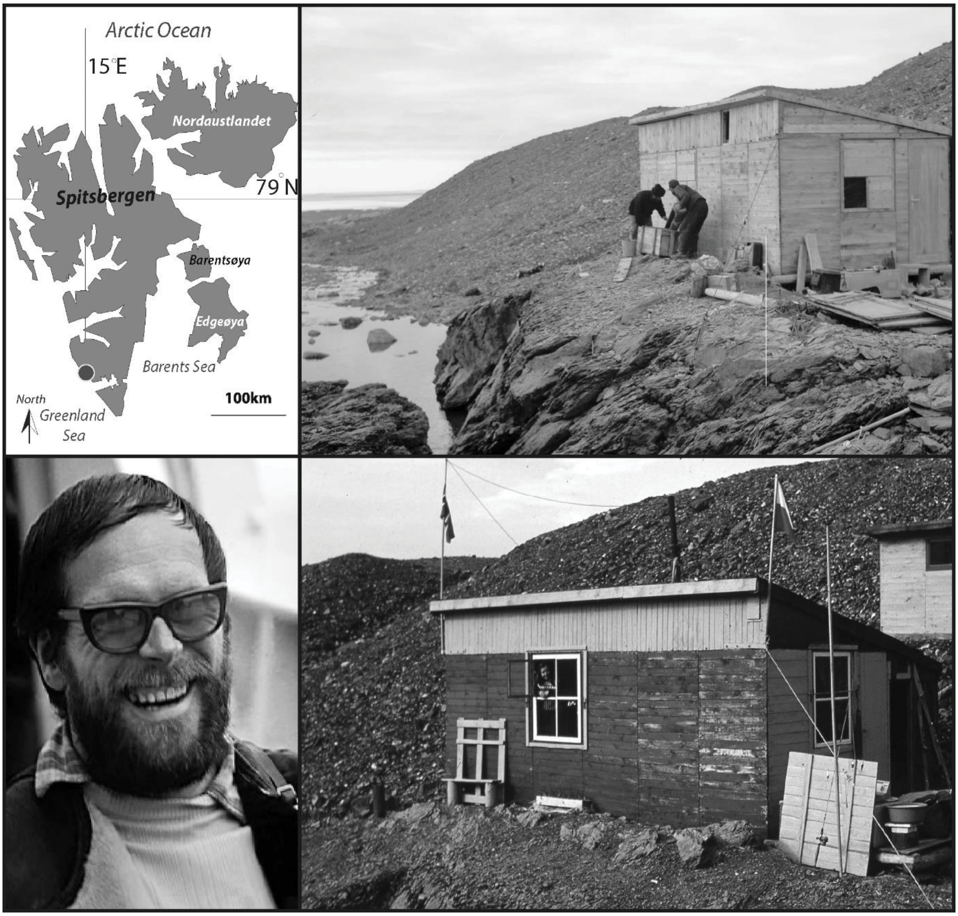

Fig. 1. Stanislaw Baranowski Polar Station in Spitsbergen during first years of operations in the 1971–1980 period. The concept and location of the station was the great achievement of its founder Stanisław Baranowski. Images from Janusz Kida collection.

glaciology, climatology, geology and ecology. Both, long term and short-term projects are carried out.

The first part of this special issue starts with an article by Migała *et al.* (2023) summarising the direction and rate of changes of climatic factors measured at the meteorological station of the Polish Polar Station in Hornsund (77° N) in 1979–2019, located *ca.* 12 km south-east from Stanislaw Baranowski Polar Station. Unlike similar summaries published earlier (Wawrzyniak and Osuch 2020), the authors of this synthesis point to factors strongly influencing the transformation of the natural environment, including extreme phenomena (intense precipitation, droughts) and weather anomalies. Based on the collected data, they comment on the impact of drastic temperature increase on deglaciation, permafrost degradation, changes in the hydrological cycle and vegetation growth.

It is important to note that climate inducted changes in water cycle, carbon, and other biogeochemical cycles are crucial to determine impact of cold region downstream aquatic geoecosystems. Glacier melting and permafrost thawing increase water discharge and solute fluxes (Brighenti *et al.* 2019). However, it is still unknown what would be consequences of these processes for water flow and solute export, including nutrients, from both glacierised and permafrost catchments. In glacierised basins, exposure of proglacial sediment enhances chemical and physical weathering and removal of their products, *e.g.*, solutes, colloids, suspended sediments, to glacier-fed streams (Stachnik *et al.* 2022). These products also include labile micro and macronutrients facilitating carbon metabolism in downstream aquatic ecosystems (Hawkings *et al.* 2014, 2020; Milner *et al.* 2017). As glaciers are absent in catchment, permafrost thaw and thickening of active layer affect biogeochemical processes via release of organic and inorganic macronutrients to surface waters such as lakes and rivers (Beel *et al.* 2020, 2021). However, there is still lack in knowledge on impact of future changes in both glaciers and permafrost covered catchments on chemical processes in ground and surface water.

Determination of glacier melt, being important part of water cycle in polar region, is crucial to determine changes in water supply to proglacial zone. Ignatiuk (2023) shows that energy balance model is a more precise and effective method to determine glacier melt as compared with simpler approaches, *e.g.*, temperature-index model. He demonstrates that radiation balance and sensible heat are major factor influencing surface melt of High Arctic glaciers, for Werenskioldbreen accounting for 58 and 42%, respectively. Amount of water sourced from ice and snow melt in glacierised basin affects chemical processes in proglacial groundwater.

Modelska and Buczyński (2023) found out that despite low groundwater discharge in proglacial zone of Werenskioldbreen, chemical processes are enhanced by a wide range of processes, from sulphides and carbonates dissolution occurring in early stage of deglaciation to precipitation and/or dissolution of secondary iron (oxy)hydroxide (highly bioavailable form of Fe) at the longer exposed proglacial zone. This leads to elevated concentration of macro ions, minor and trace elements, *e.g.*, Si and Zn, and change in physio-chemical water properties, e.g., rise in conductivity and acidity, in groundwater as compared with surface waters. Groundwater exhibits an important hotspot for chemical weathering and release of solute to proglacial glacier-fed rivers.

On contrary, chemical processes in groundwater in permafrost underlined basin of Steinvik River exhibit completely different pattern. Rysiukiewicz *et al.* (2023) showed that chemical processes in groundwater, as depicted from springs originating from permafrost active layer, have much slower rate. The major processes controlling water chemistry are circulation of meteoric water enriched with atmospheric and marine derived aerosols and macronutrients supply from birds colonies. High permeability and hydraulic conductivity of active layer result in a shorter residence time of water inhibiting chemical weathering processes.

The aim of the study by Wąsik *et al.* (2023) was to identify the hydrogeological characteristics of the active layer in the glacier ice-free area of the Brattegg Valley. The authors measured the hydraulic conductivity of weathered metamorphic rocks in different geomorphological situations in the period 2005–2010. The highly variable results were used to determine groundwater runoff. Assuming a unit thickness of the aquifer, the runoff was determined to be 130 L s^{-1} in the catchment, representing between 15% and 47% of the average surface runoff. These specific data will be useful for modelling the hydrological and hydrogeological processes of the Brattegg Valley, which has recently been subject to thermal monitoring and geophysical surveys in permafrost degradation studies (Kasprzak 2020), and other High Arctic areas with similar geological structure, including especially small mountain catchments.

References

Beel C.R., Lamoureux S.F., Orwin J.F., Pope M.A., Lafrenière M.J. and Scott N.A. 2020. Differential impact of thermal and physical permafrost disturbances on High Arctic dissolved and particulate fluvial fluxes. *Scientific Reports* 10: 11836. doi: 10.1038/s41598-020-68824-3

Beel C.R., Heslop J.K. Orwin J.F., Pope M.A, Schevers A.J., Hung J.K.Y., Lafrenière M.J. and Lamoureux S.F. 2021. Emerging dominance of summer rainfall driving High Arctic terrestrial-aquatic connectivity. *Nature Communication* 12: 1448. doi: 10.1038/s41467-021-21759-3

Brighenti S., Tolotti M., Bruno M.C., Wharton G., Pusch M.T. and Bertoldi W. 2019. Ecosystem shifts in Alpine streams under glacier retreat and rock glacier thaw: A review. *Science of the Total Environment* 675: 542–559. doi: 10.1016/j.scitotenv.2019.04.221

Hawkings J.R., Wadham J.L., Tranter M., Raiswell R., Benning L.G., Statham P.J., Tedstone A., Nienow P., Lee K. and Telling J. 2014. Ice sheets as a significant source of highly reactive nanoparticulate iron to the oceans. *Nature Communications* 5: 1–8. doi: 10.1038/ncomms4929

Hawkings J.R., Skidmore M.L., Wadham J.L., Priscu J.C., Morton P.L., Hatton J.E., Gardner C.B., Kohler T. J., Stibal M., Bagshaw E.A., Steigmeyer A., Barker J., Dore J.E., Lyons W.B., Tranter M., Spencer R.G.M., and the SALSA Science Team. 2020. Enhanced trace element mobilization by Earth's ice sheets, *Proceedings of the National Academy of Sciences* 117: 31648–31659. doi: 10.1073/pnas.201437811

Ignatiuk D. 2023 Energy mass balance and temperature-index melt modelling of Werenskioldbreen, Svalbard. *Polish Polar Research* 44: 127–152. doi: 10.24425/ppr.2022.143314

Kasprzak M. 2020. Seawater Intrusion on the Arctic Coast (Svalbard): The concept of onshore-permafrost wedge. *Geosciences* 10: 349. doi: 10.3390/geosciences10090349

Migała K., Łepkowska E., Osuch M., Stachnik Ł., Wawrzyniak T., Ignatiuk D. and Owczarek P. 2023. Climate indices of environmental change in the High Arctic: Study from Hornsund, SW Spitsbergen, 1979–2019. *Polish Polar Research* 44: 91–126. doi: 10.24425/ppr.2022.143316

Milner A.M., Khamis K., Battin T.J., Brittain J.E., Barrand N.E., Füreder L., Cauvy-Fraunié S., Gíslason G.M., Jacobsen D., Hannah D.M., Hodson A.J., Hood E., Lencioni V., Ólafsson J.S., Robinson C.T., Tranter M. and Brown L.E. 2017. Glacier shrinkage driving global changes in downstream systems. *Proceedings of the National Academy of Sciences* 114: 9770–9778. doi: 10.1073/pnas.161980711

Modelska M. and Buczyński S. 2023. Hydrodynamics and hydrogeochemistry of the Werenskiold glacier forefield (SW Spitsbergen). *Polish Polar Research* 44: 153–178. doi: 10.24425/ppr.2023.144540

Rysiukiewicz M., Marszałek H. and Wąsik M. 2023 Forming of water chemistry in active layer, Steinvik River catchment, SW Spitsbergen. *Polish Polar Research* 44: 179–196. doi: 10.24425/ppr.2022.143313

Stachnik Ł., Yde J.C., Krzemień K., Uzarowicz Ł., Sitek S. and Kenis P. 2022. SEM-EDS and water chemistry characteristics at the early stages of glacier recession reveal biogeochemical coupling between proglacial sediments and meltwater. *Science of the Total Environment* 835: 155383. doi: 10.1016/j.scitotenv.2022.155383

Wawrzyniak T. and Osuch M. 2020. A 40-year High Arctic climatological dataset of the Polish Polar Station Hornsund (SW Spitsbergen, Svalbard). *Earth System Science Data* 12: 805–815. doi: 10.5194/essd-12-805-2020

Wąsik M., Marszałek H. and Rysiukiewicz M. 2023. Permeability of active layer sediments and groundwater runoff in Brattegg River catchment, SW Spitsbergen. *Polish Polar Research* 44: 197–219. doi: 10.24425/ppr.2022.143315