John Muir Trust Report

Valkyrie Expedition 2024

Background

The Valkyrie Expedition was undertaken between 21 March and 15 April 2024 in areas around Scoresby Land and Liverpool Land, Eastern Greenland.

The aims of the expedition included:

1. Undertake winter exploration and surveyance of remote valleys and their associated peaks north of Constable Point/Nerlerit Inaat, Greenland to the northern edge of Liverpool Land. Peaks in the 3300-3400 ft region to the immediate north of the Passagen valley, Scoresby Land were identified as scarcely described previously and were a focus for winter exploration.
2. Undertake feasibility assessment of novel infection diagnostics for use in remote, resource-limited and cold climate settings.
3. Undertake exploratory environmental bacteriology and mycology work through use of modified whole genome sequencing technology.

Weather and climate challenges

While on the expedition ambient temperatures typically ranged between -15 and -33^{O}C, being colder than expected for this time of year. The most challenging days came on summits and on crossing the end of the Carlsberg Fjord as it opened onto the Greenland Sea-ice. In both circumstances we were exposed to the north wind with further drops in real-feel temperatures below -40^{O}C.

On most days, the sky was clear, with daylight/twilight hours reaching almost 22 hours of the day by the expedition. Of note, on the second day in the Passagen valley there was considerable cloud cover and fog, with visibility reduced to about 100m. The following day however was clear and provided good conditions for climbing. The days spent travelling down the Carlsberg Fjord were challenged by high winds with considerable snow drift onto the glacier, adding to the efforts required to move the pulks. On these days, the wind made communication difficult and at times considerably limited opportunities to pause for any food or water.

Energy expenditure during the expedition ranged from c.6000-10000 kcal/day, depending on the incline, prevailing wind and activity. Despite calculated energy intake, a clear deficit was evident with a loss of 6 and 7kg body mass across the expedition.




Exploratory travel

The expedition covered approximately 250 km of direct travel with full supplies and a further c.50km^2 while surveying within valleys or surrounding peaks including the Passagen, Liaselv, Lejrelv, Lepidopteriseh and Hareelv valleys as well as the approaches to Umingmakbjerg in the west and Triasdat through to Storefjord in the east. Travel was primarily by cross country skis each pulling a pulk ranging between 40-60 kg depending on the stage of the expedition. Kit was initially tested on climbing of modest peaks on the edge of the Hurry Fjord glacier. The narrow valleys here were filled with crystal blue frozen rivers, in places the ice was thin and moving water could still be

seen passing beneath. While the edges of the valley were often steep, opportunities to climb were identified. The peaks in this area are typically rounded, an effect brought about by the combination of soft-sandstone and the high-strength winds. To reach peaks, short areas of climbing of only 5-8 metres were required before being able to return to ascending on steep snow-covered slopes using skis or snowshoes. The crowns were typically swept clear of any deep snow.

Broadly, we travelled north from Constable Point along the western edge of the Hurry Fjord before climbing up into the Klitdal valley, continuing north to the base and then up the Carlsberg Fjord. The furthest point north from Constable Point reached was 71° 35' 5.532" N, 22° 45' 8.964" W. Once we were nearing the northern edge of Liverpool Land, we turned west, and skimobiles were used to travel as far up the east-west Passagen valley as possible where we were able to make camp and conduct several days of extensive surveying and scientific work.

Key peaks for climbing were identified through use of the Royal Geographical Society archives and advice provided by Greenland Explorations Logistics and Consultancy who have extensive experience travelling in East Greenland. The RGS archives hold a detailed report of the 1977 Joint Services Expedition to Liverpool Land and the Passagen valley was identified as a key area that had not been explored by the 1977 expedition nor was there any local knowledge of winter exploration in the last 30 years. Maps of the area did not contain any names for the individual peaks lining the valley except those that stood at the opening of the valley/edge of the Carlsberg Fjord and are called Wood Bjerg and Tait Bjerg. The site of the 1977 basecamp, at the bottom of the Carlsberg Fjord, was visited on the way past. The valley itself was filled with deep and soft snow, making passage by anything other than skis highly impractical. The north wind had consistently blown snow off and over the peaks running along the northern edge of the valley all winter. In many locations, our 3m snow probe was unable to find the base of the valley.

The north and south edges of the valley were intermittently cut with deep gorges in excess of 20m deep and partially covered by snow. For the most part these were avoidable although we had no choice but to cross two on one day climbing the northern side of the valley.

Climbing peaks around the Passagen valley

We had been unable to find any previous report of winter climbs along the northern edge of the valley and so opted to focus efforts here initially. In order to start climbing we were required to go

approximately 2km further up the valley from our camp before a suitable slope became available, with a sheer wall of soft snow providing an obstacle early after entering the valley. The deep and soft snow slowed progress initially. The clear skies and snow-covered hills also helped to hide several ridges during the first half of the day, resulting in the need to cut back and forth several times to gain modest altitude.

By midday we had made it on to a huge glacial plateau and explored both the longer outer circumference to the west and the shorter to the east, with loose sandstone rocks making passage along the eastern edge difficult on skis. Skis with full length climbing skins were however required for further ascent until the last 100m. At this point the north wind had left considerable portions of the peak clear from deep snow and the terrain was made up of loose sandstone rocks ranging from 1-2 metres wide to smaller c.5cm pieces. Here the skis and backpacks were cached, and the last portion of ascent was continued on foot with the aid of crampons and ice-axes to assist during the steeper parts of the approach.

Once the summit was reached there was clear visibility out over the Greenland Sea-ice to the north-east and to the ranges further north and west. The wind was severe limiting opportunity to remain on the rounded peak. On the south facing side, a family of Arctic hares had made burrows in the snow. They were tame and unafraid of our presence, with three coming within 1-2 metres. The first peak was linked by ridgelines to several others in a chain. Each were navigable with crampons and the occasional need for an ice-axe as the wind had scoured much of the ridges clear of any deep snow. The ridgeline peaked at 3380 feet.

Descent was hampered by the steep slopes, deep snow and need for long cross-country skis and skins on the flat portions. Following an attempt to take a gentler slope down from the higher glacier, a route down into the main valley was not identified and necessitated a trek back towards the initial point of ascent from the valley floor. By this time 10 hours had passed since leaving the camp and the sun had disappeared beyond the peaks of mountains further west. In the last hour of skiing

back across the valley the temperature dropped considerably further while the change in light made it difficult to discern changes in gradient.

Challenges

The most physically demanding portion of the expedition was experienced on return journey through the Klitdal valley. Near the southern end, the winds had cleared a significant portion of the top snow leaving an area of mixed glacial ice, frozen soil and broken rock. On the passage north this had stretched for about 5km, but with plenty of snow remaining along the edges of the valley to make good progress. Several days of fierce winds had left the area considerably bearer however with the scoured terrain now stretching c.18km. The route was no longer suitable for skis and the pulks intermittently dragged in the frozen soil or slid across emerging portion of the underlying glacier leaving no suitable location for setting up camp. Despite slow progress and after a long day of ferrying the pulks it was possible to cross through this area and set up camp on the northern edge of the Hurry Fjord.

Wildlife encountered

Throughout the expedition, no signs of human activity were seen after leaving Constable Point. Arctic hares were seen among the peaks surrounding the Passagen valley. An Arctic fox was a frequent night visitor to our tent while camped in the Passagen valley, with clear signs seen of another following parts of our trail in the snow when returning south. Polar bear tracks were seen when crossing the opening of the Carlsberg Fjord/on the sea-ice at the northern edge of Liverpool Land but thankfully no bear was encountered. Two ravens joined us for several hours across five days while travelling with the pulks.

Scientific assessment of novel diagnostic technologies

A range of diagnostic methods and kits for identification of bacterial and viral pathogens were assessed in extreme cold climates in the context of both climate change and potential value in areas of conflict, catastrophe and disaster. All kits required modifications. Methods for bacterial identification including culture, microscopy and biochemical phenotypic testing were evaluated using National Collection of Type Culture organisms.

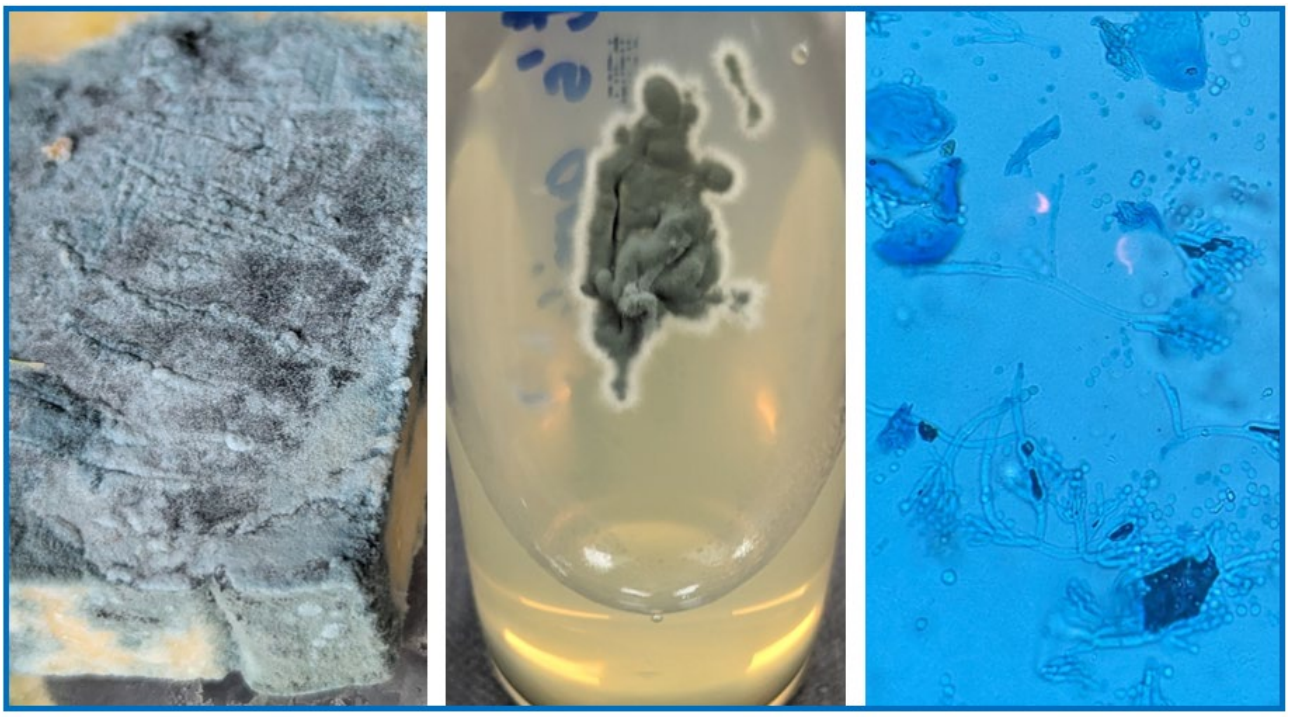
Bacterial culture was successfully enabled using both a water-bath heated by use of white gas and a small USB-powered incubator. To maintain temperatures the incubator was encased in polystyrene and wrapped in WoolCool® before being placed with a 20000mAh battery powered by a 120W solar panel inside a black dry bag. Target temperatures of 35-37^{O}C were obtainable for up to 18 hours with successful culture and identification of both Gram positive and negative organisms. Lateral flow devices for cost-effective and low-resource identification of antimicrobial resistance genes were shown to have high performance despite the extreme weather conditions.

Novel respiratory tract infection diagnostics, using a loop assisted isothermal amplification assay modified for the cold, demonstrated high performance including diagnosing two cases of influenza A. The assay was shown to be modifiable for use in an electricity free environment and to be operational up to 1000m altitude and at temperatures as cold as -40^{O}C for the first time, building on testing conducted with TeamGB at the downhill Winter Olympics ski event.

Exploratory environmental microbiome work

Antimicrobial resistance has been identified as one of the top 10 global public health threats by the World Health Organization. The Arctic/Antarctic regions offer unique environments for antimicrobial resistance research through discovery of novel mechanisms and threats, discovery of novel antimicrobial peptides and for evaluation of mechanism/development in a relatively pristine environment. The large research bases, for example at the South Pole, have been inhabited by humans for many years now comprising its value as a pristine research environment. The alternative may require sample acquisition and/or testing further afield.

In addition to testing of diagnostic platforms, the team modified equipment required to undertake remote DNA/RNA extraction and whole genome sequencing. Confirmatory work is ongoing with retesting of samples in the UK but key areas of work include identification and characterisation of a cryotolerant fungi found growing at -30^{O}C but with previous academic literature limiting known growth of similar species to temperatures above 0^{O}C. Phenotypically the mold has shown considerable growth at low temperatures of 0-4^{O}C, some slow growth at -20^{O}C and initially very slow growth at room temperature or 30^{O}C, with improvement after several generations. Images of initial growth in the cold, re-growth for laboratory identification and microscopy are shown below.



In addition to sequencing work in cold environments, we tested multiple extraction protocols for DNA/RNA and recovery potential using nucleic acid capture and storage devices. The devices are designed to maintain recoverability of DNA material down to -20^{O}C while protecting from freeze-thaw damage. The kits were tested down to -40^{O}C and further work is currently ongoing on results to confirm Arctic hare microbiome, hampered slightly by no full genome for the animal held within the international Genome bank.

Summary of scientific findings

Clear demonstration of modifications to diagnostic kits in enabling successful use in extreme cold environments for both bacterial and viral pathogens. Identification of cost-effective, low resource demanding diagnostic kit for antimicrobial resistance suitable for use in post-catastrophe or conflict settings in areas with cold climate.

First successful use of remote long-read whole genome sequencing equipment north of the Arctic circle. Demonstration of recoverability of DNA/RNA from extreme cold climates, increasing potential of kit use to previous limitations of -20^{O}C. Possible discovery of new fungal sub-species or discovery of new cryotolerant capability.

Future work

The Valkyrie Expedition 2024 was successful in undertaking winter exploration of previously poorly or undescribed regions of remote East Greenland, including modest peaks of 3300-3400 ft, adding to geographic data collected during the 1977 Joint Services Expedition. The Expedition also undertook successful assessment of modified or novel diagnostic tools for use in remote, cold environments. A full detailed Expedition report will be submitted to the archives of the Royal Geographical Society. Academic findings will be submitted for peer-reviewed publication and inform ongoing remote diagnostics work. It is possible that the Expedition has identified a new sub-species of microorganism as part of the exploratory work. Further confirmation and comparison with known submissions to international genome banks is underway and should be completed in the coming weeks.

The success of the Expedition would not have been possible without both financial and logistics support. As a key part of this, the team extend their sincere thanks to the John Muir Trust for their support. Additional support was provided by the Scientific Exploration Society, Chelsea Infectious

Diseases Research group and Greenland Logistic and Consultancy. Recognition of the invaluable support from the John Muir Trust will be included in all formal reports and academic manuscripts submitted for publication. We look forward to sharing our scientific work in detail following peer-review.

With warmest thanks,

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