Europlanet TA scientific report

Project leader:

Project number: 22-EPN3-105
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TA facility visited: Kangerlussuaq

Project title:

At the interface of ice and water on Mars: insights from Western Greenland

Scientific report summary
(plain text, no figures, maximum 250 words, to be included in database and published)

The aim of this project was to investigate elements of the glacial and periglacial system surrounding Kangerlussaq, Western Greenland, to then compare them to similar landforms on the surface of Mars. Our first target in the field focused on investigating former subglacial drainage pathways that would have transported and accumulated water under the western Greenland ice sheet (GIS). Preliminary field observations, consisting of field and UAV imagery, mapping of former ice flow directions and sediment analyses, identified sets of bedrock incised depressions, linked by shallow channels that often cross drainage divides, point at a former subglacial drainage setting consisting of interlinked subglacial cavities. These observations would be consistent with present day radar observations of drainage pathways under the western GIS margin near Kangerlussuaq. Beside their interest for understanding the geometry of current subglacial drainage under Greenland, interlinked subglacial cavities are also interesting analogues to the martian so-called fresh shallow valleys, which are suggested to have formed under former ice cover.
Our second field objective investigated polygonal terrain, its morphology, distribution, and the connection with the depth to the ice layer. We studied polygonised terrains around Kangerlussuaq, collecting image data, structure-from-motion, and depth to the ice layer. We also mapped the distribution of polygonal terrain as observed in the field and aerial imagery. Our results and interpretations will be applied to the study of Martian polygons, to propose a model of the buried ice conditions for Mars' permafrost, and the development of channel systems.

Full Scientific Report on the outcome of your TNA visit

We encourage you to add figures to your report, which should be approx. 1 page of text plus figures.

During this field campaign, we visited sites of interest both to understand the past organization of the subglacial drainage pathways and to constrain the distribution and morphology of polygonal terrain and its degradation, shown in Figure 1.

Interlinked subglacial cavities and former subglacial pathways of the GIS. Over the course of the field campaign, we visited four sites of interest located in proximity to the road from Kangerlussuaq to the Western Greenland ice sheet margin and obtained measurements of striation location and direction along the road as well as in each of the sites, for a total of 30 measurements. Each site was first identified using the ArcticDEM and imagery from Maxar, available in Google Earth for the region, by selecting those depressions that were perched on top of the ridges and hilltops, connected by pathways that appeared as dry, shallow valleys on imagery, but were crossing drainage divides on topography. Accessibility from the road and trails was a main consideration in the selection of sites, which are shown in figure 1.

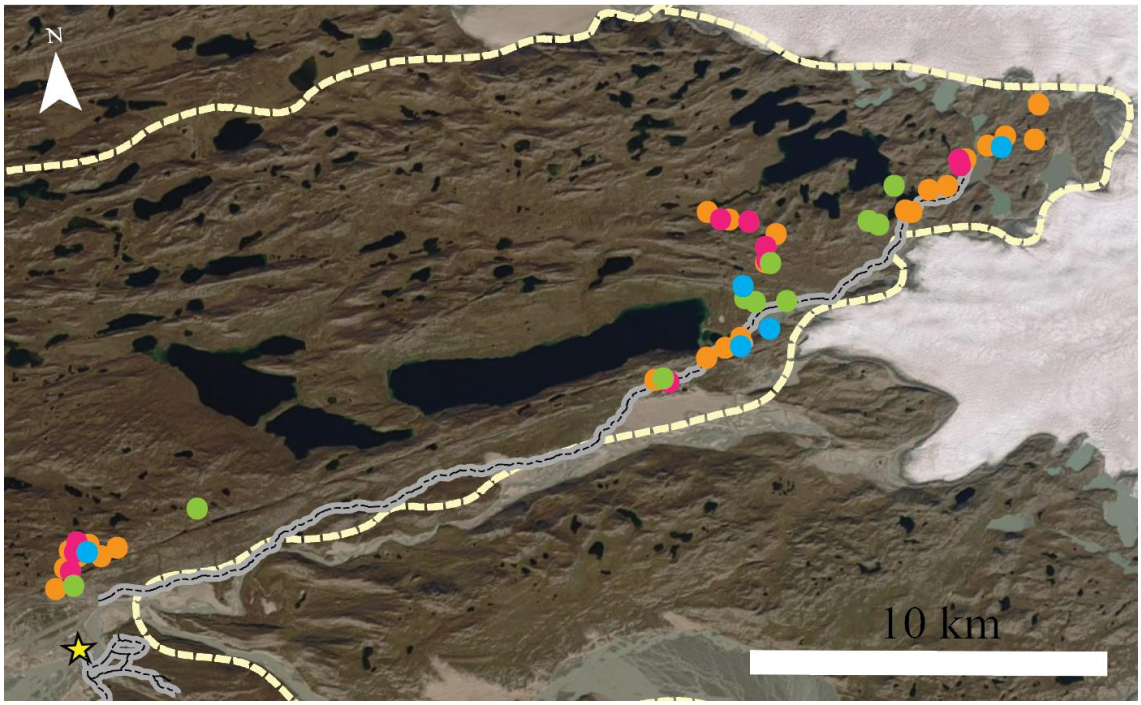

Figure 1. Satellite image overview of the sites visited in the field. Orange dots mark locations for glacial striation measurements, pink dots mark the location where cross-divide channels were visited, blue locations show polygonal terrain where UAV data and/or depth to ice estimations were acquired, and green dots mark the location of possible drumlins. Background image data credit: Airbus/ Maxar Technologies/ CNES/ USGS – Google Earth.

On three of the four sites of interest, as allowed by distance to the military airport in Kangerlussuaq, we obtained Uncrewed Aerial Vehicle (UAV) imagery to generate structure-from-motion topography and orthoimages. At each site, we obtained image data for cross-section shape, evidence for valley continuation across divide and assessed the origin of the valleys (i.e., discarding lake breach events by identifying lake shorelines and moraine ridge locations). We then identified in-situ exposures of polished bedrock where we mapped location and direction of glacial striations and chattermarks to map former ice motion direction, and identified the presence of bedrock P and S-forms (Figure 2, top right), corresponding to bedforms left behind by turbulent meltwater. Figure 2 shows examples of the data acquired.

Taken together, striations marking past flow direction (Figure 2, top panels), presence of currently dry, cross-divide valleys following former ice direction (Figure 2, bottom left), shallow depressions now filled with water, and presence of bedforms typical of turbulent flow on polished bedrock near the hilltops (Figure 2, top right) are evidence for past subglacial drainage pathways corresponding to former interconnected subglacial cavities. Mapping of two former subglacial bedforms was also accomplished by acquiring UAV image data with high precision geolocation. One of them was found to be a highly degraded drumlin, confirmed in the field by acquiring structure-from-motion photogrammetry and digging a trench to expose the internal sedimentary structure, from which a sediment sample was extracted for posterior characterization (Figure 2, bottom right).

Figure 2. Top left: glacial striations on a polished bedrock exposure. Top right: P-forms on polished bedrock exposures, displaying striations. Bottom left: Cross-divide channel linking local depressions, some of which were water-filled. Bottom right: Trench and sediment sizes obtained from the side slope of a highly degraded drumlin.

Polygonal terrain was identified in most north-facing slopes, some former lake floors, and virtually no south-facing slopes in the field region, in the sites shown in Figure 1. Polygonal terrain locations were identified both through field reconnaissance and by using aerial photography. Two sites were mapped in detail using UAV image data (Figure 3, top left), with precise positioning acquired from a differential GPS and reference station. Depth to the ground ice layer was recorded in five locations, including north and south facing slopes, by digging trenches across polygonal troughs (Figure 3, right) and by using a steel pole (Figure 3, bottom).

Figure 3. Polygonal sites. Top left: UAV-borne image of polygonal sites (each polygon is ~ 4m across). Right panel: trench excavated to the ice layer on a polygon site, with the polygonal trough on the middle. Bottom left: steel pole measurement of depth-to-ice on a polygonal trough.

Field data thus seems to confirm the presence of former subglacial interconnected cavities in the region, identifying examples of these systems and providing a description of their geometry, with implications for currently active systems under the western GIS. We also were able to map the distribution, morphology, and depth to ice layer of the polygonal terrain, contrasting its degradation by comparing N and S facing slopes in the region.

Publications arising/ planned.

3 publications are planned from this study, with the following preliminary titles.

- Geomorphology of the former interconnected subglacial cavities on the Kangerlussuaq region: studying the drainage pathways of the former Western Greenland Ice Sheet margin.
- Quaternary geomorphology and glacio-geology of the Kangerlussuaq region, Western Greenland (led by and in collaboration with E. Prof. Niels Knudsen).
- Distribution, morphology, and physical characteristics of polygonal terrain in the Kangerlussuaq region, Western Greenland.

Host confirmation

Please can hosts fill in/check this table confirming the breakdown of time for this TA project:

Dates for travel to accommodation for TA visit (if physical visit by applicant)	Start Date of TA project at facility	Number of lab/field days spent on TA Visit pre-analytical preparation	Number of days in lab/field site for TA Visit	Number of days spent in lab for TA Visit data analysis	End Date of TA project at facility	Dates for travel home (if physical visit by applicant)
Departed: 24-07-23 Arrived: 25-07-23	25-07-23	[]	8	[]	02-08-23	Departed: 02-08-23 Arrived: 04-08-23

The host is required to approve the report agreeing it is an accurate account of the research performed.

Host Name **Aarhus University**

Host Signature Aarhus 27 August, Keld Rømer Rasmussen

Date

Project Leader confirmation

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Project Leader Name Anna Grau Galofre
Project Leader Signature

Date 25-08-2023