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REMAINS of Greenland

Technical report

National Museum of Denmark report number: 20495

Authors:

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1 SUMMARY

REMAINS OF GREENLAND' - FIELD REPORT

1 Summary

Climate change is leading to the accelerated destruction of archaeological sites in Greenland. From 2016-2019 the research project REMAINS of Greenland has investigated the short and long-term net effects of climate change on the preservation of archaeological sites in Nuuk region. REMAINS of Greenland is financed by VELUX FONDEN and administered by the National Museum of Denmark in close collaboration with the Center for Permafrost (CENPERM) at the University of Copenhagen and the Greenland National Museum and Archives (NKA). The project has been based on 5 field campaigns that has included a multidisciplinary team of experienced and early career researchers and university students. Highlights of the field work include:

- Archaeological survey and sub-surface testing at fourteen sites.
- Broad spectrum soil and vegetation analysis at six sites.
- Installation of environmental monitoring stations at eight sites.
- Collection of soil, wood and bone samples from at seven sites.
- Replication of a number of historic photos throughout the Nuuk fjord to contrast observable changes to the landscape over the past century.
- dGPS and areal UAV surveys conducted at nine sites
- Development and refinement of a comprehensive site valuation protocol, to describe archaeological significance, state of preservation, and threats against preservation

This report describes the fieldwork carried out during REMAINS of Greenland.

2. Introduction

There is growing global concern about the accelerating impact of climate change on archaeological sites, especially in the Arctic where an increasing number of ancient sites and structures are at risk of being lost. In 2016 the research project REMAINS of Greenland was initiated as a direct response to the many climate change threats facing archaeological sites in Greenland. The overall aims of the project were:

- To advance the basic understanding of how climate change influences the preservation of archaeological sites and organic artefacts.
- To develop research based cultural resource management tools for locating sites at risk.
- To develop strategies for dealing with threatened sites in Greenland.

REMAINS of Greenland was built on the experiences of several previous collaborative projects and employed a team of leading and early career researchers and students. The project's research was focused on sites in the Nuuk region in southwest Greenland, a region with a high density and variety of archaeological sites and where the effects of climatic change are extremely visible.
During the project a total of 14 sites were investigated (Fig. 1 and Table 1). The greater project area included locations found dispersed throughout the Ameralik and Godthåbs fjord systems and comprised a variety of different coastal and inland locales. The sites were selected from following criteria:

- Sites located in different environmental/climatic landscape niches (i.e. site locations ranging from the inner parts of the fjord to the outer coastal region and island groups)
- Sites known or assumed to be rich in organic material, preferably confirmed by the presence of a midden feature adjacent to a documented settlement.
- Sites with available information from previous archaeological surveys,
- Sites that possessed opportunities for dissemination, i.e. both in terms of outreach to the local community and in terms of tourism potential.
- Sites where it was possible to retrieve multiple data with least impact/disturbance of the ruins and/or archaeological features.

2 INTRODUCTION

From 2016-2019 a total of five field trips were carried out of which two were major campaigns that included more than 15 participants each. In total more than 20 researchers and students were involved in the project (an overview of each field trip and participants is found appendix A).

The purpose of this report is to provide a combined overview of the field activities carried out in the Nuuk region, the methods that have been applied and the data collected. It is not the purpose of this report to show or discuss results, instead we refer to the published scientific arcticles that has come out of the project. In appendix B a detailed description of the activities carried out at each site can be found. The project has produced significant amount of data which can be obtained by contacting the Greenland National Museum and Archives or National Museum of Denmark.

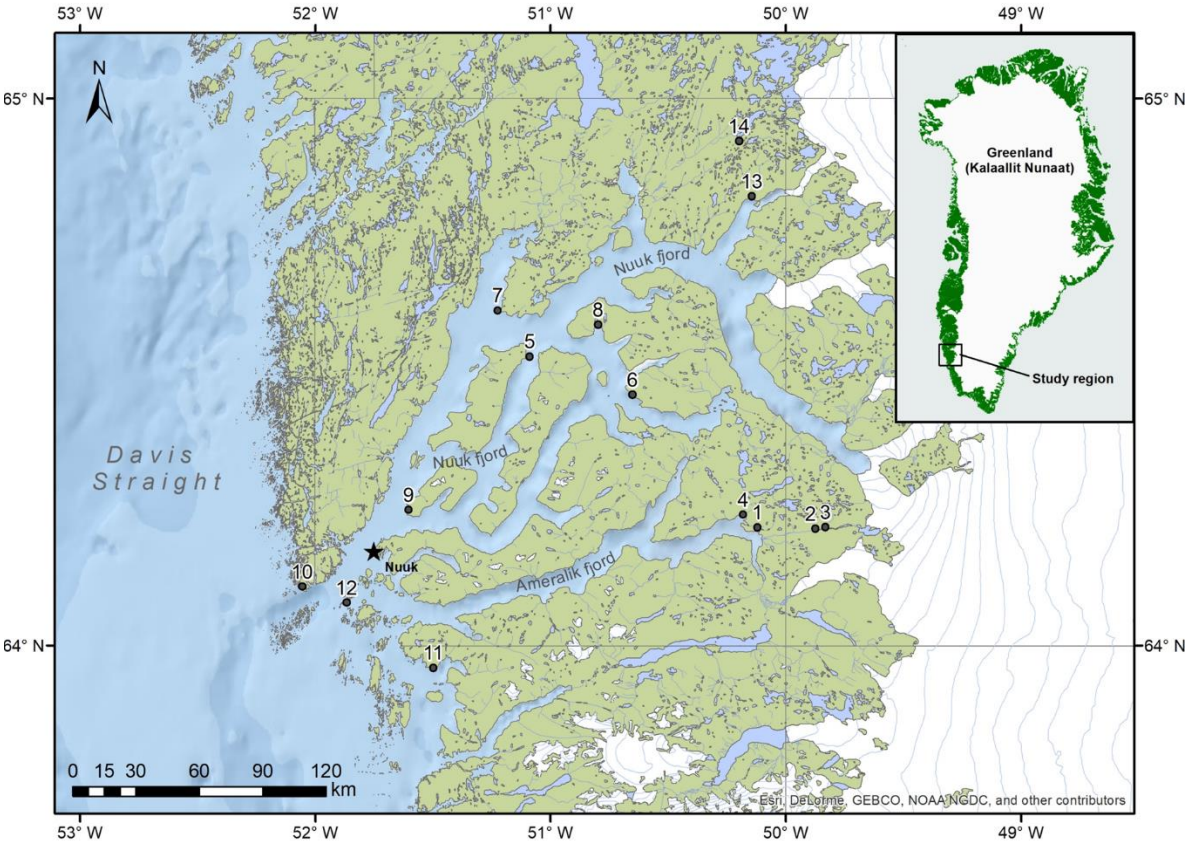

Fig. 1: The Nuuk fjord in Southwest Greenland. The capital city, Nuuk, is marked by a star. Fourteen sites were investigated by the REMAINS team between 2016-2019: (1) V52a; (2) V53c; (3) V53d; (4) Kilaarsarfik (V51, Sandnæs); (5) Qoornoq; (6) Iffiartarfik; (7) Nuugaarsuk; (8) Itivi; (9) Ersaa; (10) Kangeq; (11) Qarajat; (12) Tulugartalik; (13) Ujarassuit (V7, Anavik); (14) Tussap tasia.

2 INTRODUCTION

Map No.	Site	Latitude	Longitude	Locality	Cultural phases
1	**Austmannadal (V52a)**	64.21935°	-50.120628°	inland valley	Norse
2	**Austmannadal (V53c)**	64.21992°	-49.832758°	inland valley	Norse
3	**Austmannadal (V53d)**	64.216990°	-49.8740180°	Inland valley	Norse
4	**Kilaarsarfik (Sandnæs, V51)**	64.24264°	-50.182338°	coastal, inland fjord	Saqqaq, Dorset, Norse
5	**Qoornoq**	64.53314°	-51.089226°	island, inner fjord	Norse, Thule, Colonial, Saqqaq (at nearby Tuapagssuit)
6	**Iffiartarfik**	64.46319°	-50.651597°	coastal, inner fjord	Norse, Thule, Colonial (Hernnhut, Moravian)
7	**Nuugaarsuk**	64.61687°	-51.224355°	coastal, inner fjord	Thule, Colonial
8	**Itivi**	64.5912°	-50.798717°	coastal, inland fjord	Norse, Thule
9	**Ersaa**	64.25176°	-51.602684°	coastal, inner fjord	Thule, Colonial
10	**Kangeq**	64.10958°	-52.054651°	island, head of fjord	Saqqaq, Thule, Colonial
11	**Qarajat**	63.95893°	-51.498644°	coastal, inland fjord	Thule, Colonial (Hernnhut, Moravian)
12	**Tulugartalik**	64.08006°	-51.867362°	island, head of fjord	Thule, Colonial
13	**Ujarassuit (Anavik, V7)**	64.82379°	-50.144088°	inland valley	Norse
14	**Tussap tasia**	64.92353°	-50.198898°	inland mountain	Thule, Historic Inuit

Table 1: Archaeological sites investigated by the REMAINS team from 2016-2019.

3. Overview of field Investigations

The field investigation carried out in the project was based on reviews of previous archaeological surveys, relevant literature, and historic photographs. This information was also used to investigate long-terms patterns of landscape change at each study. Sites were documented based on dGPS and UAV surveys. Sub-surface testing was performed to evaluate the present-day integrity of the archaeological record and to collect soil and organic materials to be used in laboratory decomposition studies. The current state of preservation conditions was evaluated at each site through a protocol work-flow. Subjects explored included coastal processes, erosional forces, vegetation cover, root penetration, annual frost and permafrost, soil water content, soil oxygen content, soil porosity and soil chemistry. Environmental monitoring was carried out at nine sites (Austmananadal Valley (V52a, V53d), Kilaarsafik, Ujarassuit (Anavik), Tussaap Tasia, Iffiartarfik, Qoornoq, Ersaa and Kangeq).

The following section provides a combined overview of the field activities carried out in the Nuuk region, the methods that were applied and the data collected.

3.1 Documenting the history and recent degradation of sites

Site formation processes and recent changes at all field sites was identified based on literature search and compilation of existing published reports from previous archaeological surveys. A compilation of the information found for each site is found in the detailed description of field activities at each site found in appendix B. Old orthophotos were used to assess changes in vegetation, shoreline positions and erosion events at the sites. Furthermore, historic photos from the past century in the Nuuk fjord were replicated. Every effort was made to replicate photos in terms of both perspective and scale to highlight differences in vegetation, topography and to document any evidence of modern human disturbance at the sites. Examples of some of the comparative photo sets are shown in Fig. 2.

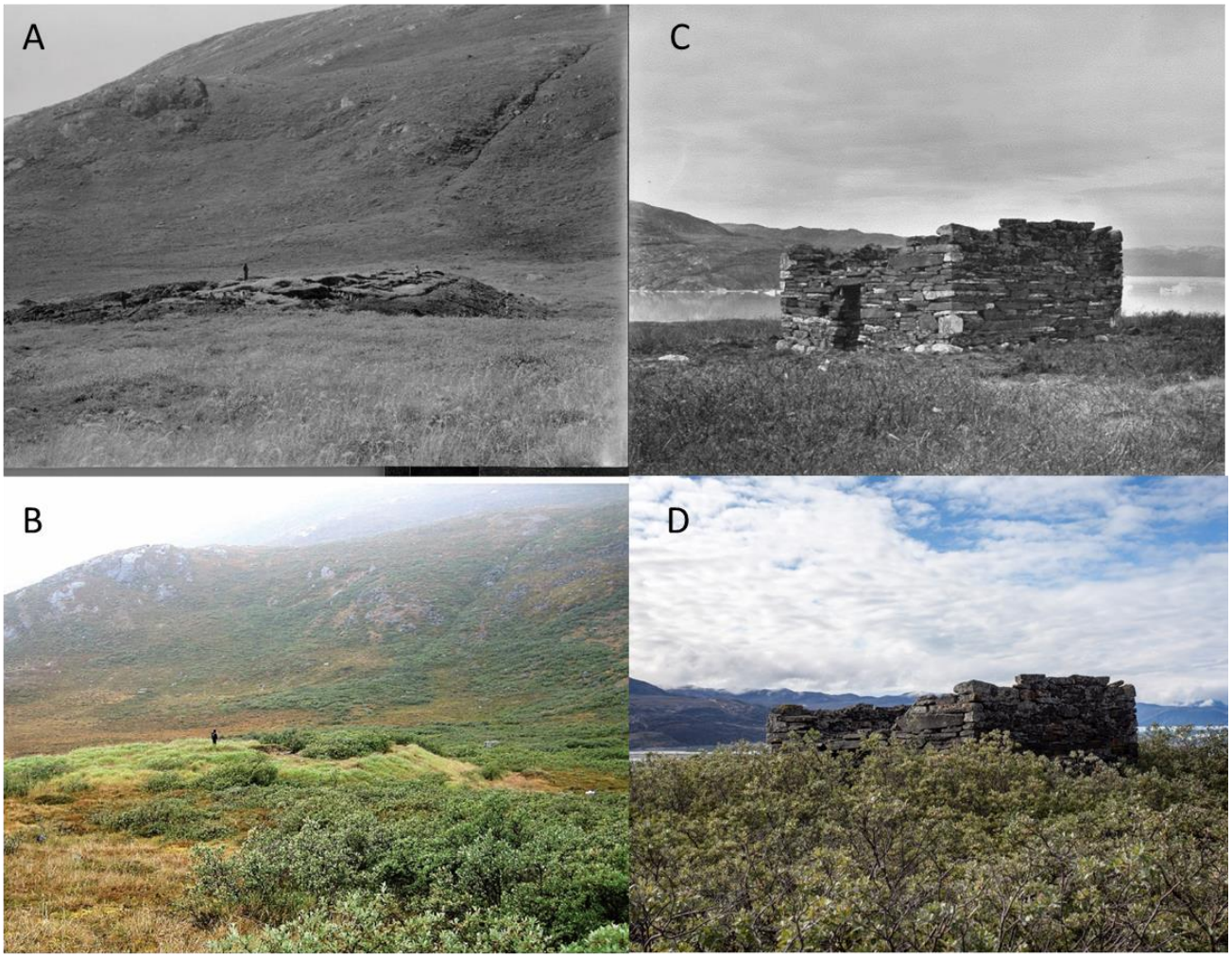

Fig. 2: (A&B) V53D 1937 (Photo Roussel) and 2016 (Photo Matthiesen), (C&D) Ujarassuit (Anavik) 1932 (Photo Roussel) and 2017 (Photo Fortuna))

3.2 Developing a protocol for site description and risk assessment

An evaluation protocol was developed and used at the 14 study sites. This was done to ensure: (1) data retrieved during and after the REMAINS project is consistent and (2) that the data can be summarized in a systematic manner for future integration into the Greenland National Museum's GIS database (Fig. 3).

3 OVERVIEW OF FIELD INVESTIGATIONS

Fig. 3: REMAINS team members discussing the goals of the protocol at Qoornoq near Ruin group 10. From left to right: Madsen, Johansen, Lyberth, Harmsen, Matthiesen and Pedersen. Photo Fortuna

Data recorded in the protocol includes both a quantitative evaluation of a site's relative level of integrity as well as a quantitative observation of a *site's value*. In addition, descriptions of present and future threats are included based on field observations. The protocol is supplemented by supporting material collected during the course of field work (e.g. photos, drawings, spreadsheets and field notes, etc.). All valuations are ranked accordingly 1 through 5 (1=very poor; 2=poor; 3=medium; 4=good; 5=excellent.) The protocol consists of two tables with different levels of detail: *Table A* provides a descriptive summary of the site and synthesizes much of the information notated in *Table B* which contains detailed valuations specific to the state of preservation of archaeological materials, specific environmental data and subjective archaeological/heritage observations. The REMAINS protocol has been published in Harmsen et al. (2018). The data collected at each site via the protocol can be seen in appendix B.

3.3 dGPS and UAV surveys

Documenting archaeological sites in Greenland presents considerable challenges. Vector maps (scale of 1:250000) exist but derive from raster maps compiled during post-WWII aerial photography campaigns. To address this discrepancy, fieldwork conducted in the project utilized UAVs for the high-precision data capture of areal images of sites and features (Figure 4). On the ground, a Trimble RTK-dGPS was used for: (1) capture the GPS positions of sampling and environmental monitoring sites; (2) anchor ground control points used in terrestrial mapping during drone fly overs; and (3) to waypoint important landscape features and Thule grave features encountered during site walkovers.

Two different UAVs were employed at various times and locations. The use of two different UAV systems insured a higher success rate for data capture in the event of a technical malfunction. The Tarot 650 and eBee systems employed during the study comprised a suite of pre- and post-flight data processing software (eMotion 2 and Postflight Terra 3D 3) as well as the ready-to-fly hardware capable of autonomous capture of high-resolution aerial photos. Digital photos captured during fly-overs was used for generating detailed orthomosaic maps of the sites.

Fig. 4: Left: Fenger-Nielsen piloting the Tarot 650-aport Quadcopter at Ersaa. Right: Myrup and Fenger-Nielsen programming the flight path of the eBee at Sandnæs (photos: Fortuna 2016, Danish National Museum).

Table 2 lists the various systems and the locations employed during the project. Three different cameras were used during these test flights: (1) a Sony RX100M3 digital camera (RGB), (2) a Seqoia

multi-spectral camera; and (3) a modified Canon NDVI camera. The purpose of this study was to investigate how flight altitude influenced data capture across three different camera types. Detailed flight information for each site is provided in appendix B. Orthomosaic maps of Kilaarsafik, Ujarassuit (Anavik), Iffiartarfik, Qoornoq, Ersaa and Kangeq were created.

System	Kilaarsafik	Ujarassuit	Iffiartarfik	Qoornoq	Ersaa	Kangeq	Qarajat	Tulugartalik
Trimble RTK-dGPS	x	x	x	x	x	x		x
Quadcopter Tarot 650-sport	x	x	x	x	x	x		
Ebee fixed-wing UAV	x	x		x	x	x	x	x

Table 2: dGPS and UAV systems and locations where they were utilized during the project.

3.4 Archaeological survey & testing

Archaeological survey in the form of site walk-overs of archaeological ruins and features was performed at all sites. At Kilaarsafik, Ujarassuit (Anavik), Qoornoq, Iffiartarfik, Ersa, and Kangeq, corners and contours of ruins and features were captured using the Trimble dGPS. At other sites, such as Nuugaarsuk, Itivi, Qarajat and Tulugartalik, limited time during site visits necessitated the use of hand-held Garmin GPS units for gathering waypoints, supplemented by photo documentation. In all cases, efforts were made to correlate, identify the presence of all extant features and ruin groups noted in earlier archaeological survey reports. Sub-surface testing was performed at Kilaarsafik, Ujarassuit (Anavik), Tussaap Tasia, Iffiartarfik Qoornoq, and Ersaa, with locations and profiles of test trenches shown provided in Appendix B. Specific locations for sub-surface testing were chosen in the field based on a combination of factors that balanced potential research value against minimal disturbance to the site and its component features. In places where sub-surface testing was deemed appropriate, the underlying goal of opening a test unit was always to: (1) determine the cultural phasing of the site; (2) measure soil conditions and install environmental sensors and data-logging equipment; and

(3) in some case, embed modern bone and wood samples into the walls of profiles for decomposition studies.

Trenches were excavated to a minimum of 20 cm of sterile subsoil when possible. Portions of units that exemplified distinctly different cultural horizons were notated and excavated as separate contexts. Excavated soils were screened through 16 mm2 mesh screen to capture artifacts and bulk organics (i.e. wood, charcoal and mussel shell) (Figure 5). Soils, features and inclusions were described by both color and texture. When possible, excavated soils were matched to Munsell color charts. When color-matching was not possible, soil color was generalized. A total of 108 diagnostic artifacts and 78 bulk samples (e.g. bone, charcoal, shells and wood) were collected between 2016-2017 with a total aggregate weight of 10.62 kg.

With the exception of some samples sent to Denmark for further destructive analysis, all samples and artifacts collected during the term of project are curated at the NKA in Nuuk. Artifacts and bulk samples were weighed and categorized by a generalized classification scheme of types category and listed throughout the accompanying appendices.

Location	Test Unit	artifacts (*n*)	bulk samples (*n*)	combined weight (g)
Kilaarsarfik (Sandnæs, V51)	T1	8	5	339.3
Kilaarsarfik (Sandnæs, V51)	P1	-	-	
Qoornoq	T1	44	16	472.6
Qornooq	T2	21	33	8132.7
Iffiartarfik	T1	19	17	1309.1
Ersaa	T1	-	5	217.8
Kangeq	Holes 6-9	4	-	10.6
Ujarassuit (Anavik, V7)	T1	12	2	136.8
Ujarassuit (Anavik, V7)	S1	-	-	
Tussap tasia	T1	-	-	
Tussap tasia	T2	-	-	
		108	78	10618.9

Table 3: Summary of artifacts and samples by location collected in the project.

Fig. 5: Madsen and Johansen sorting artifacts at Iffiartarfik (photo: Fortuna 2016).

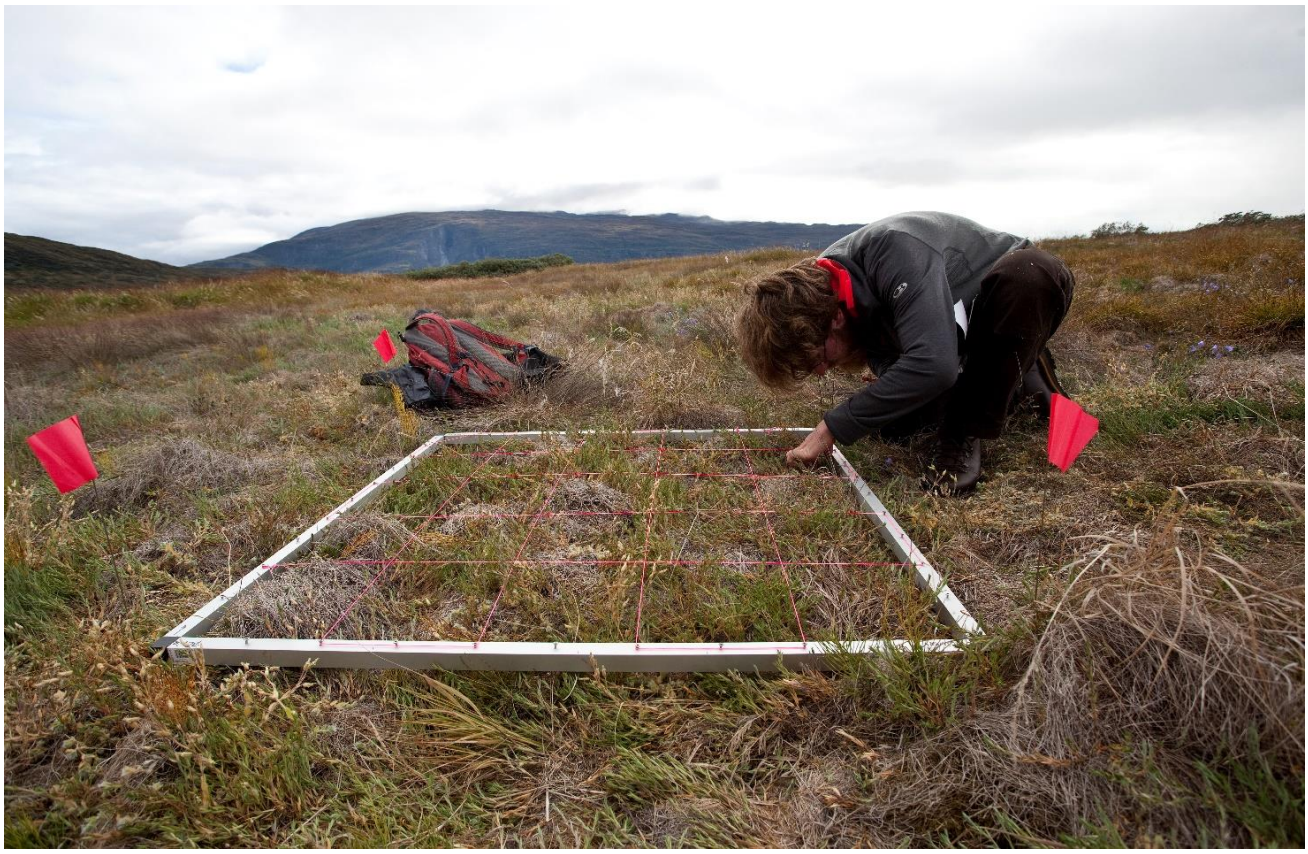

Fig. 6: Sherman-Andersen sampling vegetation using a 1x1 m grid at Kilaarsafik (photo: Fortuna 2016).

3.5 Investigations of vegetation

Broad spectrum vegetation sampling was performed at Kilaarsafik, Qoornoq, Iffiartarfik, Ersaa and Kangeq. Prior to sampling a distinction was made between *natural* and *cultural* soil areas; *cultural soils* would be described as those locations found within ruin groups versus *natural soils* areas found outside or on the periphery of ruin groups. Vegetation cover was quantified using a 1x1 meter frame divided in to 25 sectors by pinpoint analysis (Figure 6). A 20x20 cm area within each plot was harvested and green biomass collected. Each plot was photographed with a high-resolution camera (Hasselblad) and a multi-spectral camera (Sequia). The normalized difference vegetation index (NDVI) was measured using a Decagon NDVI sensor. The same 20x20 cm area was then removed by shovel to a maximum depth of 30 cm below the surface. Volume specific soil samples ($100cm^3$) were collected from four depths when possible (at 5 cm, 10 cm, 20 cm and 30 cm below the surface respectively). Afterwards the hole was backfilled and turf restored to minimize disturbance to the site and local biota. At each sample location 15-20 leaves were harvested from 1-3 species within or

adjacent to each sample plot. The results from pedological & vegetation sampling are published in Fenger-Nielsen et al. (2018).

Fig. 7: Eriksen collecting Northern willow (S. glauca) columns at Kilaarsafik.

To investigate recent and localized increases in Northern willow (*S. glauca*), 134 dendrochronological samples were collected from ruin groups in the Austmannadal Valley (V52c, V53c, V53d), Kilaarsafik, Qoornoq, Iffiartarfik, Nuugaarsuk, Ersaa, and Kangeq. Sample zones were segregated between the inside (i.e. "cultural") and outside (i.e. "natural") of ruin groups; samples collected from the outside of ruin groups provided local baselines for analysis. When a shrub was identified as suitable for sampling, 10-20 cm of the root column was cleared of soil and debris to provide coverage of approximately 10-20 cm of root stem and 10-20 cm of above ground stem. Samples were obtained by use of a handsaw and placed into paper bags. 15 leaves from each of the sampled trees were then harvested to conduct C/N + ^{15}N analyses. A total of 131 *S. glauca* samples were collected, locations and the type of sample collected are detailed in Table 4.

Site	"Cultural" sample	"Natural" sample
Austmannadal Valley, 52a	6	6
Austmannadal Valley, 53c	2	-
Austmannadal Valley, 53d	12	12
Qoornoq, Ruin group 13	12	12
Iffiartafik	12	12
Nuugaarsuk	6	6
Ersaa	12	12
Kangeq	12	-
Total	**74**	**60**

Table 4: Location and number of wood samples collected. "Cultural" indicates samples were taken within or in close proximity to an archaeological feature. "Natural" indicates samples were taken outside of a ruin group. All samples are currently stored at the National Museum of Denmark.

3.6 Environmental monitoring

Climate monitoring stations and dataloggers were installed at Kangeq, Kilaarsafik (V51), site V53d in the Austmannadal Valley in 2012. In 2016, data from these loggers was routinely collected during field work. Data collected from the loggers comprised multiple years of data on air and subsurface temperature, relative humidity, wind speed and direction, snow depth, precipitation, and soil moisture. All batteries were changed out in older equipment and loggers were re-programmed for continuous monitoring until 2018. New stations were installed at Qoornoq, Ersaa and Iffiartarfik in 2016 and at Anavik and Tussaap Tasia in 2017. In addition to environmental data, high-resolution automatic cameras were positioned to capture time-lapse sequences of sites every few hours at Kilaarsafik, Qoornoq and Kangeq. A list of the locations and the types of data collected are listed in Table 5.

3 OVERVIEW OF FIELD INVESTIGATIONS

Data logged	**V52a**	**V53d**	**Kilaarsafik**	Ujarassuit	**Tussaap Tasia**	**Qoornoq**	**Iffiartafik**	**Ersaa**	**Kangeq**
Air temperature			X	X	X	X			X
Atmospheric humidity			X			X			X
Wind speed, direction			X						
Snow depth			X						X
Precipitation			X	X		X	X		X
Soil oxygen content			X						X
Soil temperature	X	X	X	X	X	X	X	X	X
Soil moisture		X	X	X	X	X	X	X	X
Time lapse cameras			X			X			X

Table 5: Climate stations and datalogging equipment were installed at numerous locations in the Nuuk fjord region. The table denotes the type of location and type of data recorded at each site.

Fig. 8: Prior to installation into the walls of test trenches, bone samples were sewed into fishing net as triplicates or secured with a string attracted to the numbers.

3.7 Decomposition studies

Modern bone and wood (European Beech and Scots Pine) samples were installed in the walls of test trenches at Kilaarsafik, Qoornoq, Iffiartarfik, Ersaa and Kangeq (Table 6). The purpose of installing these samples was to observe the in-situ degradation rate at the different archaeological sites. These samples provide a necessary baseline for measuring natural and anthropogenic factors that may be accelerating the rate of decomposition occurring in archaeological contexts in the Nuuk fjord region. Bone samples were sewed into fishing nets in groups of three or in some cases (e.g. Ersaa and Kangeq) secured with a string attracted to a label number prior to being embedded in the walls of profiles (Fig. 8).

3 OVERVIEW OF FIELD INVESTIGATIONS

Site	Depth (cm)	Wood sample	Bone samples
Kilaarsafik	5	1 Beech and 1 Pine	3 bones
Kilaarsafik	20	1 Beech and 1 Pine	3 bones
Kilaarsafik	40	1 Beech and 1 Pine	3 bones
Kilaarsafik	60	1 Beech and 1 Pine	3 bones
Iffiartarfik	5	1 Beech and 1 Pine	3 bones
Iffiartarfik	10	1 Beech and 1 Pine	3 bones
Iffiartarfik	20	1 Beech and 1 Pine	3 bones
Iffiartarfik	35	1 Beech and 1 Pine	3 bones
Qoornoq	5	1 Beech and 1 Pine	3 bones
Qoornoq	10	1 Beech and 1 Pine	3 bones
Qoornoq	20	1 Beech and 1 Pine	3 bones
Qoornoq	35	1 Beech and 1 Pine	3 bones
Ersaa	5	1 Beech and 1 Pine	1 bone
Ersaa	10	1 Beech and 1 Pine	1 bone
Ersaa	20	1 Beech and 1 Pine	2 bones
Ersaa	35	1 Beech and 1 Pine	2 bones
Kangeq	10	1 Beech and 1 Pine	2 bones
Kangeq	20	1 Beech and 1 Pine	2 bones
Kangeq	40	1 Beech and 1 Pine	3 bones
Kangeq	60	1 Beech and 1 Pine	2 bones

Table 6: Samples of modern wood and bone installed in 2016 during REMAINS of Greenland. At the end of the project (ultimo 2019) all samples were still buried.

4. REMAINS Publications

Matthiesen, H., Fenger-Nielsen, R., Harmsen, H., Koch Madsen, C., Hollesen, J. 2019. The impact of vegetation on archaeological sites in the low Arctic. Accepted for publication in *Arctic* (December 2019).

Hollesen, J., Matthiesen, H., Fenger-Nielsen, R., Abermann, J., Westergaard-Nielsen, A., Elberling, B., 2019. Predicting the loss of organic archaeological deposits at a regional scale in Greenland, Scientific Reports 9, 9097.

Prendin, A.L., Carrer, M., Karami, M., Hollesen, J., Bjerregaard Pedersen, N., Pividori, M., Treier, U.A., Westergaard-Nielsen, A., Elberling, B., Normand, S., Immediate and carry-over effects of insect outbreaks on vegetation growth in West Greenland assessed from cells to satellite, Journal of Biogeography 0.

Fenger-Nielsen, R., Hollesen, J., Matthiesen, H., Sherman-Andersen, E.A., Westergaard-Nielsen, A., Harmsen, H., Michelsen, A., Elberling, B. 2018: Footprints from the past: The influence of past human activities on vegetation and soil across five archaeological sites in Greenland. *Science of the Total Environment* 654, 895-905.

Harmsen, H., Hollesen, J., Madsen, C.K., Albrechtsen, B., Myrup, M., Matthiesen, H. A Ticking Clock 2018. Preservation and Management of Greenland's Archaeological Heritage in the Twenty-First Century. *Conservation and Management of Archaeological Sites* 20, 175-198.

Hollesen, J., Callanan, M., Dawson T., Fenger-Nielsen, R., Friesen, T.M., Jensen, A.M., Markham, A., Vandrup Martens, V., Pitulko V.V., Rockman, M. 2018. Climate change and the deteriorating archaeological and environmental archives of the Arctic. *Antiquity* 92, 573-586.

Hollesen, J., Matthiesen, Elberling, B. 2017. The impact of climate change on an archaeological site in the Arctic. *Archaeometry* 59(6), 1175-1189.

Hollesen, J., Matthiesen, H., Madsen, C.K., Albrechtsen, B., Kroon, A., Elberling, B. 2017. Climate change and the preservation of archaeological sites in Greenland, in T. DAWSON, C. NIMURA, E. LÓPEZ-ROMERO & M.-Y. DAIRE (ed.) Public Archaeology and Climate Change: 90-99, Oxford, Oxbow.

Hollesen, J., Matthiesen, H., Møller, A. B., Westergaard-Nielsen, A. & Elberling, B., 2016. Climate change and the loss of organic archaeological deposits in the Arctic. *Nature Scientific Reports* 6, Article number: 28690.

APPENDIX A: FIELD TRIPS

REMAINS OF GREENLAND' - FIELD REPORT

Field trip 1: 4-29 August 2016

Sites visited:

Austmannadal (V52A, V53C and V53D); Kilaarsafik; Qoornoq; Iffiartafik; Nuugaarsuk; Itivi; Ersaa; Kangeq; Qajarat; Tulugartalik.

Main tasks:

- To study site formation processes, recent environmental changes and human impacts based on extant reports of previous archaeological surveys and historical photos
- Perform archaeological surveys and sub-surface testing to evaluate the current state of preservation and to collect samples of archaeological soil, wood and bone.
- Register the distribution, density and root depth of the vegetation found ant the archaeological sites and in the surrounding areas.
- Collect data on soil properties and vegetation
- Install environmental monitoring equipment
- Perform detailed mapping and documentation of the archaeological sites using high precision GPS and low altitude high-resolution aerial photography's through unmanned aerial vehicles (UAV/Drones)
- Test a new protocol for on-site risk assessment, identify immediate and long-term risks and mediate future options for the preservation and protection of Greenland's archaeological heritage

APPENDIX A: FIELD TRIPS

REMAINS OF GREENLAND' - FIELD REPORT

Participants:

Name	Affiliation
Jørgen Hollesen (JHO)	Senior Researcher, National Museum of Denmark
Henning Matthiesen (HMA)	Senior Researcher, National Museum of Denmark
Anne Marie Eriksen (AME)	Ph.D. Student, National Museum of Denmark & Centre for Geogenetics, University of Copenhagen
Nanna Bjerregaard Pedersen (NBP)	Post Doc, National Museum of Denmark
Roberto Fortuna (RFO)	Photographer, National Museum of Denmark
Rasmus Fenger-Nielsen (RFN)	Ph.D. Student, National Museum of Denmark & Department of Geosciences and Natural Resource Management, University of Copenhagen
Bo Elberling (BEL)	Professor, Department of Geosciences and Natural Resource Management, University of Copenhagen
Aart Kroon (AKR)	Associated Professor, Department of Geosciences and Natural Resource Management, University of Copenhagen
Andreas Westergaard-Nielsen (AWN)	Post Doc, Department of Geosciences and Natural Resource Management, University of Copenhagen
Emil Alexander Sherman Andersen (ESA)	Student, Department of Biology, University of Copenhagen
Bo Albrechtsen (BOA)	Deputy Director, Greenland National Museum and Archives
Christian Koch Madsen (CKM)	Archaeologist, Greenland National Museum and Archives
Mikkel Myrup (MMY)	UAV/GIS specialist, Greenland National Museum and Archives
Hans H. Harmsen (HHH)	Archaeologist, Greenland National Museum and Archives
Allan Lynge (ALY)	Logistics/Transportation Coordinator, Greenland National Museum and Archives
Randi Sørensen Johansen (RSJ)	Student, Ilisimatusarfik, University of Greenland
Ulunnguaq Nielsen Lyberth (UNL)	Student, Ilisimatusarfik, University of Greenland

Table 1: Personnel during field trip 1 and their institutional affiliations.

APPENDIX A: FIELD TRIPS

REMAINS OF GREENLAND' - FIELD REPORT

Management summary:

Day	Activities
04-08-2016	Packing of equipment
05-08-2016	Packing of equipment & food shopping
06-08-2016	Packing of equipment & food shopping
07-08-2016	Transfer Nuuk – Kilaarsafik of Group 1 (HMA, NBP and HHH); first day of investigation of Austmannadalen
08-08-2016	Transfer Nuuk - Kilaarsafik of Group 2 (JHO, AME, RFO, RFN, ESA, CKM) Day two of ivestigation into Austmannadalen (HMA, NBP and HHH)
09-08-2016	Fieldwork, Kilaarsafik (JHO, AME, RFO, RFN, ESA, CKM) Day three of investigation into Austmannadalen (HMA, NBP and HHH)
10-08-2016	Fieldwork, Kilaarsafik – MMY joins group 2 Day four of investigation into Austmannadalen (HMA, NBP and HHH)
‘11-08-2016	Fieldwork, Kilaarsafik (JHO, AME, RFO, RFN, ESA, CKM, MMY) Day five of investigation into Austmannadalen (HMA, NBP and HHH); team returned to Kilaarsafik in the afternoon
12-08-2016	Transfer Kilaarsafik – Qoornoq (JHO, HMA, NBP, AME, RFO, RFN, ESA, CKM, HHH), two students (RSJ and UNL) joined team in Nuuk
13-08-2016	Fieldwork, Qoornoq (JHO, HMA, NBP, AME, RFO, RFN, ESA, CKM, HHH, RSJ and UNL), BEL, AKR and AWN joined the Group
14-08-2016	Fieldwork, Qoornoq (JHO, NBP, AME, RFN, HHH, UNL, BEL, AWN, AKR) Daytrip to Iffiartarfik (HMA, RFO, ESA, CKM, RSJ)
15-08-2016	Fieldwork, Qoornoq (HMA, RFO, HHH, RSJ) Daytrip to Iffiartarfik (JHO, NBP, AME, RFN, ESA, CKM, UNL, BEL, AWN, AKR)
16-08-2016	Fieldwork, Qoornoq (RFN, ESA, AWN, HHH) Daytrip to Nuugaarsuk and Itivi (JHO, HMA, NBP, AME, RFO, HHH, UNL, RSJ, BEL, AKR)
17-08-2016	Fieldwork Qoornoq (JHO, HMA, NBP, AME, RFO, CKM, MMY, UNL, RSJ, AKR) Transfer 4 persons; Qoornoq – Ersaa (RFN, ESA, HHH, AWN) Transfer 1 person; Qoornoq – Nuuk (BEL) (returned to Denmark 18-08)
18-08-2016	Transfer Qoornoq – Ersaa (JHO, HMA, NBP, AME, RFO, CKM, UNL, RSJ, AKR) Fieldwork, Ersaa (JHO, HMA, NBP, AME, RFO, RFN, ESA, CKM, HHH, UNL, RSJ, AKR, AWN)
19-08-2016	Fieldwork, Ersaa (JHO, HMA, NBP, AME, RFO, RFN, ESA, CKM, HHH, MMY, UNL, RSJ, AKR, AWN) Transfer to Nuuk (JHO, HMA, NBP, AME, RFO, RFN, ESA, CKM, HHH, UNL, RSJ, AKR, AWN)

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20-08-2016	Personal day; no fieldwork performed
21-08-2016	Fieldwork, Kangeq (JHO, HMA, NBP, RFO, RFN, ESA, CKM, HHH, UNL, RSJ, AKR) Characterization & selection of samples (e.g. bones and wood) (HMA, NBP, AME)
22-08-2016	Fieldwork, Kangeq (JHO, HMA, NBP, AME, RFO, RFN, ESA, CKM, HHH, UNL, RSJ, AKR, AWN)
23-08-2016	Lab work, Nuuk (JHO, HMA, NBP, AME, RFO, RFN, ESA, AKR) AWN returned to Denmark
24-08-2016	Daytrip, Qarajat (JHO, HMA, NBP, AME, RFO, RFN, ESA, CKM, HHH, MM, UNL, RSJ, AKR)
25-08-2016	Daytrip, Tulugartalik (HMA, AME, RFO, ESA, CKM, HHH,MM, UNL, RSJ) Meeting with ASIAQ in Nuuk (AKR, RFN, JHO) End of fieldwork dinner
26-08-2016	Packing of equipment and shipment of samples (JHO, HMA, NBP, AME, RFO, RFN, ESA, AKR)
27-08-2016	Packing of equipment and shipment of samples (HMA, RFO, RFN, ESA) JHO, NBP, AME and AKR return to Denmark
28-08-2016	Packing of equipment and shipment of samples (HMA, RFO, RFN, ESA)
29-08-2016	HMA, RFN and ESA return to Denmark

Table 2: Summary of the day-to-day activities during the REMAINS field trip 1.

APPENDIX A: FIELD TRIPS

Field trip 2: 7-13 March 2017

Sites visited:

Kangeg and Qoornoq (Figure 1 and Table 1).

Main tasks:

- Collect data from monitoring equipment
- Change batteries and check the overall status of monitoring equipment
- Measure snow depths and collect samples of snow density
- Install a Diver water level logger at Qoornoq
- Shoot drone footage of winter conditions

Participants:

Name	Affiliation
Jørgen Hollesen (JHO)	Senior Researcher, National Museum of Denmark
Henning Matthiesen (HMA)	Senior Researcher, National Museum of Denmark
Mikkel Myrup (MMY)	UAV/GIS specialist, Greenland National Museum and Archives
Hans H. Harmsen (HHH)	Archaeologist, Greenland National Museum and Archives
Josephine Pedersen (JPE)	Student, University of Århus

Table 3: Participants during the REMAINS field trip 2 and their institutional affiliations.

APPENDIX A: FIELD TRIPS

REMAINS OF GREENLAND' - FIELD REPORT

Management summary:

Day	Activities
08-03-2017	Fieldwork Kangeq (JHO, HMA, MMY, HHH, JPE).
10-03-2017	Fieldwork Qoornoq (JHO, HMA, MMY, HHH, JPE).

Table 4: Summary of the day-to-day activities during the REMAINS field trip 2.

APPENDIX A: FIELD TRIPS

Field trip 3: 6-28 August 2017

Sites visited:

Austmannadal (V52A); Kilaarsafik (Sandnes); Ujarassuit (Anavik), Tussaap Tasia, Qoornoq; Iffiartafik; Ersaa; Kangeq (Figure 1 and Table 1).

Main tasks:

- Perform an archaeological survey and sub-surface testing at Ujarassuit (Anavik) and Tussaap Tasia
- Perform a broad spectrum soil and vegetation analysis at Ujarassuit (Anavik)
- Install environmental monitoring equipment at Ujarassuit (Anavik) and Tussaap Tasia
- Replication of a number of historic photos at Ujarassuit (Anavik)
- Collection of data from monitoring equipment at V52A, Kilaarsarfik, Iffiartarfik, Qoornoq, Ersaa and Kangeq
- Perform root studies at Kilaarsarfik

APPENDIX A: FIELD TRIPS

REMAINS OF GREENLAND' - FIELD REPORT

Participants:

Name	Affiliation
Jørgen Hollesen (JHO)	Senior Researcher, National Museum of Denmark
Henning Matthiesen (HMA)	Senior Researcher, National Museum of Denmark
David Gregory (DGR)	Senior Researcher, National Museum of Denmark
Bjarne Grønnow (BGR)	Professor, National Museum of Denmark
Roberto Fortuna (RFO)	Photographer, National Museum of Denmark
Bo Elberling (BEL)	Professor, Department of Geosciences and Natural Resource Management, University of Copenhagen
Rasmus Fenger-Nielsen (RFN)	Ph.D. Student, National Museum of Denmark & Department of Geosciences and Natural Resource Management, University of Copenhagen
Emil Sherman Andersen (ESA)	Student, Department of Biology, University of Copenhagen
Lærke Stewart (LST)	Post Doc, Department of Bioscience, Aarhus University
Laura Balslev (LBA)	Master student, Department of Bioscience, Aarhus University
Bo Albrechtsen (BOA)	Deputy Director, Greenland National Museum and Archives
Christian Koch Madsen (CKM)	Archaeologist, Greenland National Museum and Archives
Mikkel Myrup (MMY)	UAV/GIS specialist, Greenland National Museum and Archives
Hans H. Harmsen (HHH)	Archaeologist, Greenland National Museum and Archives
Allan Lynge (ALY)	Logistics/Transportation Coordinator, Greenland National Museum and Archives
Randi Sørensen Johansen (RSJ)	Student, Ilisimatusarfik, University of Greenland
Ulunnguaq Nielsen Lyberth (UNL)	Student, Ilisimatusarfik, University of Greenland
Jens Kanutsen (JKA)	Student, Ilisimatusarfik, University of Greenland

Table 5: Participants during the REMAINS field trip 3 and their institutional affiliations.

APPENDIX A: FIELD TRIPS

REMAINS OF GREENLAND' - FIELD REPORT

Management summary:

Day	Activities
06-08	Nuuk, packing of equipment and shopping of food (JHO, HMA, RFN, HHH).
07-08	Transfer Nuuk –‘ Kilaarsafik (JHO, HMA, RFN, CKM), first day of investigations at Kilaarsafik
08-08	Fieldwork Kilaarsafik (JHO, HMA, RFN, CKM)
09-08	Fieldwork Kilaarsafik (JHO, HMA, RFN, CKM)
10-08	Fieldwork Kilaarsafik, Short visit to V52A (JHO, HMA, RFN, CKM), Transfer Kilaarsafik - Nuuk
11-08	Nuuk, packing of equipment and shopping of food (JHO, HMA, RFN, HHH).
12-08	Day trip to Kangeq (JHO, HMA RFN, HHH, ALY).
13-08	Nuuk, packing of equipment and shopping of food (JHO, HMA, RFN, HHH).
14-08	Day trip to Ersaa (JHO, RFN, ALY), Packing equipment (HMA), Transfer Nuuk – Anavik (HHH, RSJ, UNL, JKA, LST, LBA), Setting up basecamp
15-08	Transfer Nuuk – Anavik (JHO, HMA, DGR, BJG, RFO, BEL, RFN, ESA, MMY, ALY), Setting up basecamp, inspecting the site
16-08	Fieldwork Anavik (All)
17-08	Fieldwork Anavik (JHO, DGR, RFO, HHH, RSJ, UNL, LST, LBA), Day trip Iffiartarfik (BEL, RFN, ESA, ALY), First day of trip to Tussaap Tasia (HMA, BJG, MMY, JKA).
18-08	Fieldwork Anavik (JHO, DGR, RFO, BEL, RFN, ESA, HHH, ALY, RSJ, UNL, LST, LBA), Second day of trip to Tussaap Tasia (HMA, BJG, MMY, JKA).
19-08	Fieldwork Anavik (JHO, DGR, RFO, BEL, RFN, ESA, HHH, ALY, RSJ, UNL, LST, LBA), Third day of trip to Tussaap Tasia (HMA, BJG, MMY, JKA).
20-08	Fieldwork Anavik (JHO, DGR, RFO, BEL, RFN, ESA, HHH, ALY, RSJ, UNL, LST, LBA), Fourth and final day of trip to Tussaap Tasia (HMA, BJG, MMY, JKA).
21-08	Fieldwork Anavik (HMA, RFO, BJG, ESA, HHH, RSJ, UNL, JKA, LST, LBA), Day trip Qoornoq (JHO, DGR, RFN, ALY), Returned to Nuuk (BEL, MMY).
22-08	Fieldwork Anavik (JHO, HMA, DGR, RFO, BJG, RFN, ESA, HHH, ALY, RSJ, UNL, JKA, LST, LBA)
23-08	Fieldwork Anavik (JHO, HMA, DGR, RFO, BJG, RFN, ESA, HHH, ALY, RSJ, UNL, JKA, LST, LBA)
24-08	Fieldwork Anavik (JHO, HMA, DGR, RFO, BJG, RFN, ESA, HHH, ALY, RSJ, UNL, JKA, LST, LBA)

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25-08	Transfer Anavik- Nuuk (RFO, BJG, HHH, RSJ, UNL, JKA, LST, LBA), Anavik – Iffiartarfik, Qoornoq – Nuuk (JHO, HMA, DJG, RFN, ESA, ALY).
26-08	Packing of equipment and shipment of samples, Project dinner, LST and LBA return home Denmark
27-08	Packing of equipment and shipment of samples
28-08	JHO, HMA, DGR, RFO, BGR, RFN and ESA return home to Denmark

Table 6: Summary of the day-to-day activities during the REMAINS field trip 3.

APPENDIX A: FIELD TRIPS

REMAINS OF GREENLAND' - FIELD REPORT

Field trip 4: 21 to 31 August 2018

Sites visited:

Kangeg, Kilaarsafik (Sandnes) and Qoornoq (Figure 1 and Table 1).

Main tasks:

- Collect data from monitoring equipment
- Dismounting of monitoring equipment

Participants:

Name	Affiliation
Jørgen Hollesen (JHO)	Senior Researcher, National Museum of Denmark
Henning Matthiesen (HMA)	Senior Researcher, National Museum of Denmark
Mikkel Myrup (MMY)	UAV/GIS specialist, Greenland National Museum and Archives
Laura Balslev (LBA)	Master student, Department of Bioscience, Aarhus University
Allan Lynge (ALY)	Logistics/Transportation Coordinator, Greenland National Museum and Archives

Table 7: Participants during the REMAINS field trip 4 and their institutional affiliations.

Management summary:

Day	Activities
23-08-2018	Fieldwork Qoornoq (JHO, HMA, ALY).
26 & 27-08-2018	Fieldwork Kilaarsarfik (Sandnes) (HMA, MMY, ALY).
28-08-2018	Fieldwork Kangeq (JHO, HMA, ALY, LBA).

Table 8: Summary of the day-to-day activities during the REMAINS field trip 4.

APPENDIX A: FIELD TRIPS

REMAINS OF GREENLAND' - FIELD REPORT

Field trip 5: 8 August 2019 (Helicopter trip)

Sites visited:

Austmannadal (V53D), Ujarassuit (Anavik), Tussaap Tasia Figure 1 and Table 1).

Main tasks:

- Collect data from monitoring equipment
- Dismounting of monitoring equipment

Participants:

Name	Affiliation
Jørgen Hollesen (JHO)	Senior Researcher, National Museum of Denmark
Henning Matthiesen (HMA)	Senior Researcher, National Museum of Denmark

Table 9: Participants during the REMAINS field trip 5 and their institutional affiliations.

APPENDIX B: SITE DESCSRIPTIONS

REMAINS OF GREENLAND' - FIELD REPORT

Contents

1. Austmannadalen (V52a, V53c, V53d)

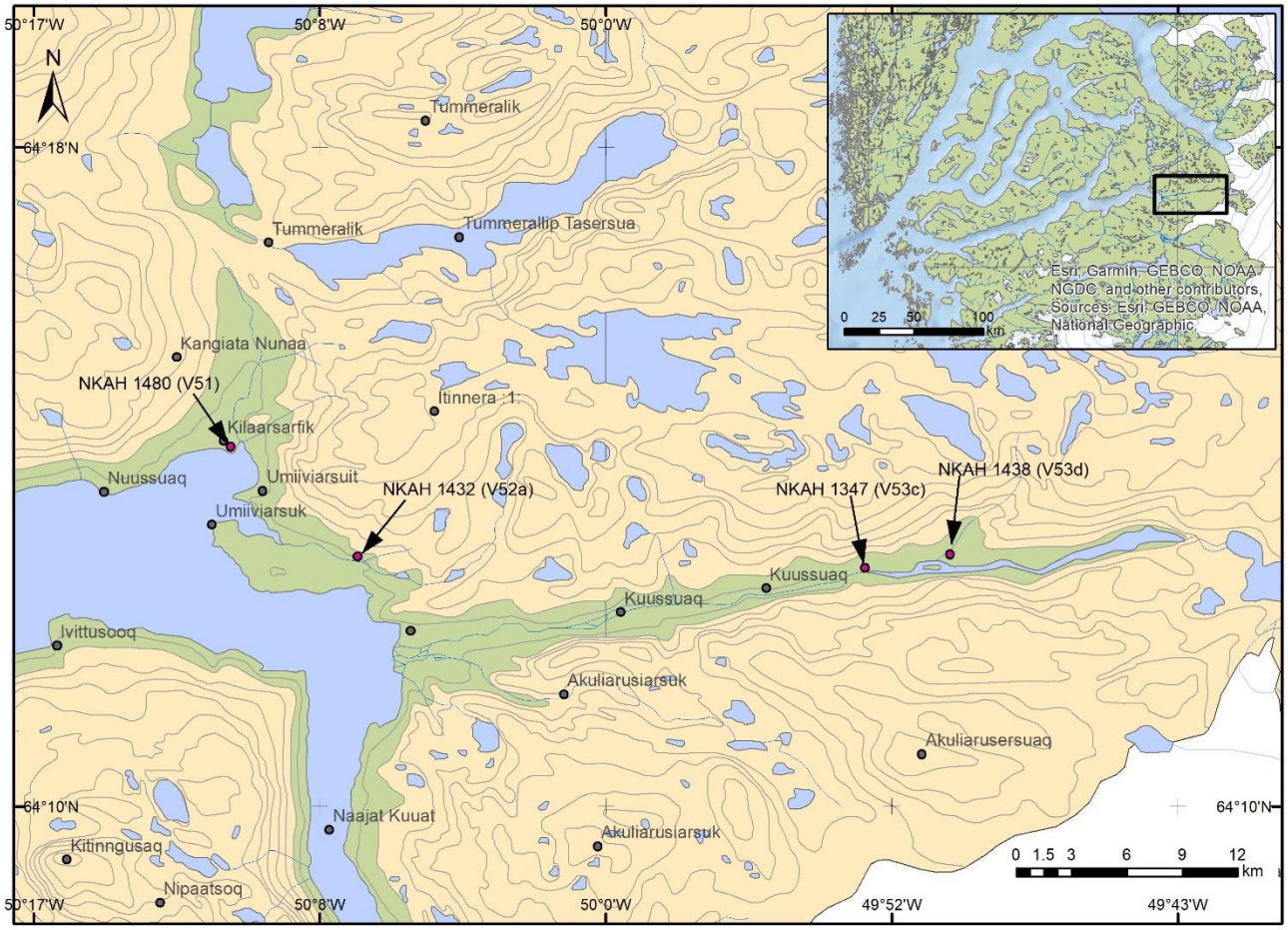

Fig. 1. Sites V52a, V53c and V53d were investigated to collect environmental data and assess vegetation growth. Kilaarsafik (V51 Sandnæs), is located to the northwest of the Austmannadal Valley.

Site description

The Austmannadalen (Fig. 1) is a wide river valley formed by the transport of meltwater from the Greenland Ice Sheet in the eastern head of the Ameralik fjord. Several ancient Norse features and farms are identified within the valley interior. A five-day field excursion to visit V52a, V53c and V53d was conducted by team members HMA, NBP and HHH from 7 August to 10 August, 2016. The trek inland from the interior coast to Austmannadalen is a difficult route with steep and uneven terrain and many areas covered by dense patches of willow and alder scrub. Settlement phases of the Norse farms found in the valley are consistent with the greater Western Settlement periodization of ca. AD 1000-1350 (Arneborg 2003).

The research objectives of the team included: (1) download data from temperature and water content-loggers installed in 2012 at V53d (see Knudsen et al. 2014); (2) perform vegetation sampling at the sites; (3) perform site assessments using the REMAINS protocol; (4) replicate historic photos; and (5) collect water/soil/vegetation samples for Sr-analysis for an affiliate project run by Karen Margarita Frei from the National Museum of Denmark; and (6) collect any gear left behind by the 2012 team.

V52a [NKAH 1432]

Fig. 2. Plan of the farmhouse at V52a. (1-5) dwelling rooms; (6) bathhouse; 7 and 12 transversal passages; (13) cow-byre; other rooms are presumed to be sheep-sheds and hay-barns (adapted from Roussell (1941:161, Fig.

Ruin group V52a (64.21935°, -50.120628°) is a centralized farm complex typical of later Norse settlements in Greenland where human dwelling and livestock enclosures were connected and combined into single, long block structures. The ruin comprises a large 17 room house with three satellite structures and a small enclosure to the north of the main ruin group. Fig. 2 shows a plan view of the farmhouse. It is worth noting that the two transversal passages (7 and 12) would have accommodated passage between the partitioned domestic (1-5) and cow-byre (13) and other livestock quarters. At the time of the visit by the team, a dense concentration of dwarf willow was present in portions of the main house previously excavated by Roussell in 1934 (Roussell 1936).

V53c [NKAH 1437]

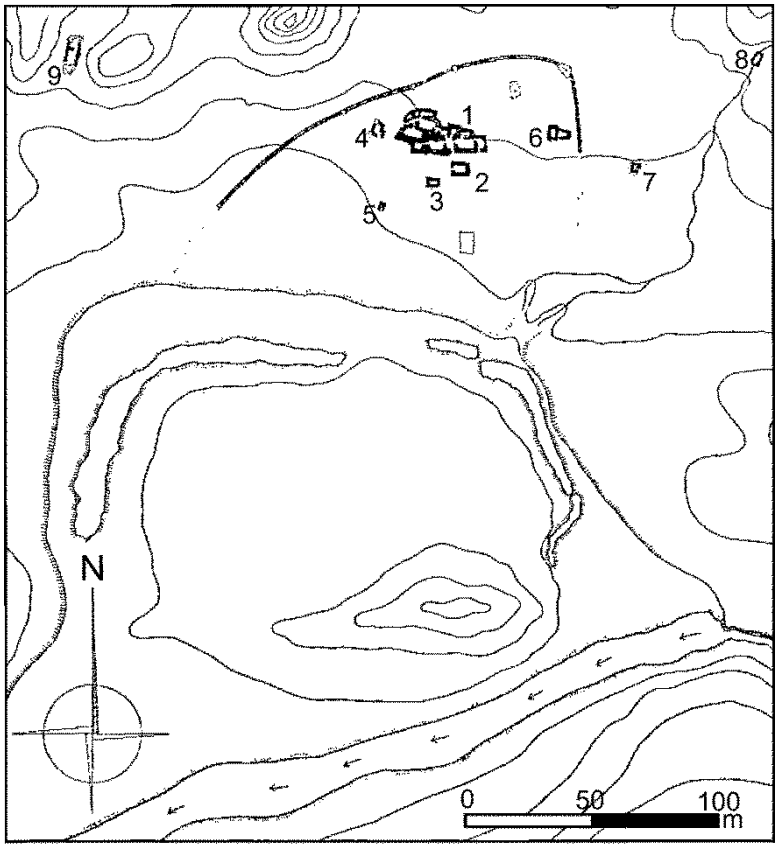

Fig. 3. Topographic map of ruin group V53c. (1) Farmhouse block; (2 & 3) sheep-shed & store-house; (4) smithy; (5) curing house?; (6) byre; (7) drying/store-house; (8) byre, (9) animal pen (modified from Roussell (1941:66, Fig. 42).

V53c (64.21699°, -49.874018°) is a large centralized farm located on the north side of the Austmannadalen. At some point in the past, the Kuussuaq river bent to the north directly below the site where a one hectare gravel field lies about 2-3 m below the farm's homefield (Fig. 3). A remnant stone wall demarcates the extent the homefield to the north. Adjacent structures are found scattered around the main building that include a smithy, byres, sheds and store houses.

V53d [NKAH 1438]

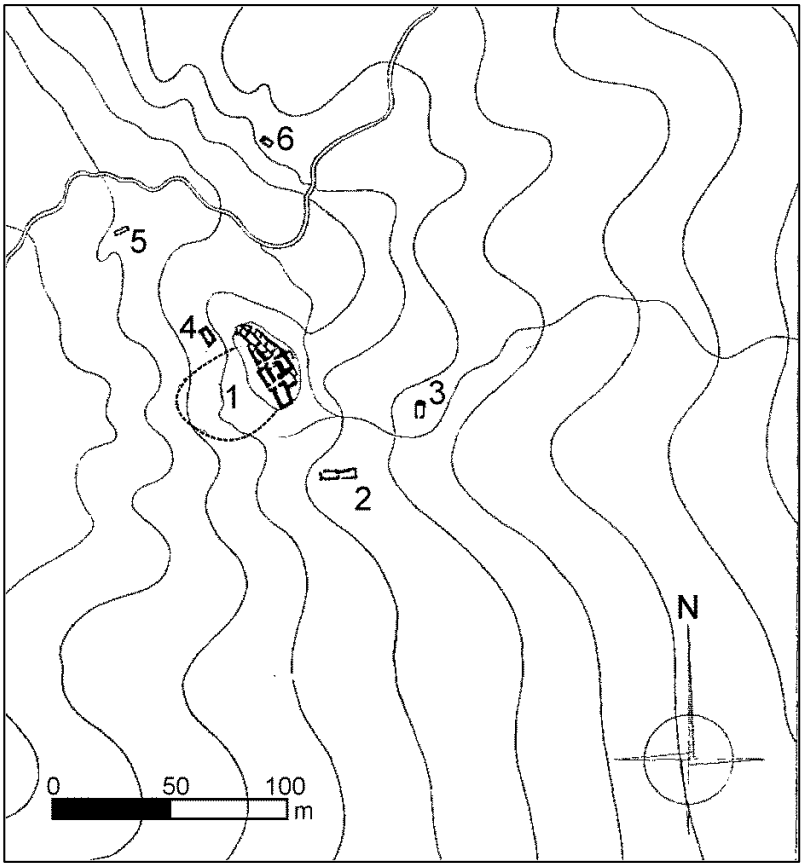

Fig. 4. Topographic map of ruin group V53d. (1) Farmhouse block, midden denoted by dashed line; (2) byre; (3) sheep-shed; (4-5) unknown structures; (6) small storehouse (modified from Roussell 1941:68, Fig. 44).

V53d (64.216990°, -49.8740180°) is the inner most Norse farm found in the Austmannadalen. The site's core is a centralized 17 room farmhouse located on the eastern side of a valley that opens to the Austmannadalen. Five small satellite structures are located adjacent to the main ruin group. V53d was first identified by E. Knuth in 1934 (Knuth 1944). Roussell excavated the ruin group in 1937.

Roussell published the first survey plan of the site in 1941 (Fig. 4). The site is highly visible from a distance because of the dense vegetation that has taken root in the un-backfilled rooms left by his 1937 excavation. As Knudsen, et al. (2014) notes, the site appears to not have a homefield except for what might have grown on the midden and patches of grass to the south of the main farmhouse.

Roussell excavated almost all the ruins at V53d, and at the time noted the high degree of organic preservation (e.g. bone, wood and dung pellets) at the site, attributing it to the well constrained permafrost. Knudsen, et al. (2014) reports that in 2012, the ruins of V53d appeared stable. With the

exception of ruin 6, all of the ruins at V53d have been completely covered with vegetation; ruins 1 and 4 with grass and the rest dominated by willow scrub.

Archaeological investigations and sampling

Sampling of archaeological deposits was carried out at V53d in 2012 and described in Knudsen, et al. (2014). No formal sub-surface testing was conducted during the 2016 investigation of the valley, apart from one small test pit opened on the east side of the house structure at V52a for the purpose of installing a data-logger and make in situ measurements of water content and conductivity (N64°13.385' W050°07.219'). Volume specific soil samples (100cm^3) were taken from this pit and a single wood sample (branch fragment) was collected in-situ from 40-50 cm below the surface. Wood reference samples were taken from a spade handle believed to have been left behind by Roussell. This sample was collected for the purpose of study the effects of fungi on wood. Three sterile samples of natural dead and decayed *Salix glauca* were also collected in the central farmhouse area at V53d.

Water, soil and vegetation were sampled at seven locations in the Austmannadal for Sr-analysis (Table 1). Water samples were taken from running water in small streams, and adjacent to these a few leaves or grasses were sampled, along with soil from a few cm below the surface.

Prøvenavn	Lat/Lon (WGS84)	Approx. Altitude
Frei S1	N64 13.638 W49 49.141	205 m
Frei2	N64 12.975 W49 53.363	142 m
Frei3	N64 12.614 W49 56.267	77 m
Frei4	N64 12.509 W50 02.667	112 m
Frei5	N64 13.003 W50 04.029	254 m
Frei6	N64 13.237 W50 06.719	119 m
Frei7	N64 14.661 W50 10.449	4 m

Table 1. Water, soil and vegetation were sampled at seven locations in the Austmannadal for Sr-analysis.

Vegetation Studies

In order to investigate changes in the distribution and density of *Salix glauca* (Northern willow), stem samples were collected at V53d, V53c, and V52a. At V53d, a total of twenty-four (*N*=24) *S. glauca* stems were collected in and around the main house ruins. Twelve (*n*=12) stems were sampled from the northern trenches originally dug by Rousell (N 64° 13.606', W 049° 49.127'). Twelve (*n*=12) additional stems were sampled from a reference area outside of the main house area consisting of two clusters east and west of the site (N 64° 13.610', W 049° 49.089' and N 64°

13.622', W 049° 49.173'). At V53c, only two (*N*=2) *S. glauca* stems were collected. The samples were taken from a willow visible in a photo from 1937 and an adjacent willow tree. At V52a, a total of twelve (*N*=12) *S. glauca* stems were collected. Six (n=6) stems were collected in trenches originally dug by Rousell; three (*n*=3) stems in the eastern section of the site and three (*n*=3) in the western section. Six (*n*=6) reference stems were collected outside of the main archaeological area.

Environmental monitoring

In 2012, TinyTags data-logger was installed in a test trench at V53d (trench PV), to measure subsurface temperatures at -0, -15, -30, -50, -90 and -110 cm below the surface and soil water content at -15, -30, -50 and -90 cm below the surface. Furthermore, temperature sensors were installed (room 17/trench P IV) on the ground surface and at -20 cm below the surface and in the wetland beneath the site at -20 and -40 cm below the surface. Hourly temperature data was measured between intervening years of 2012-2014 and water content data from 2012-2016 was collected during the investigations performed in 2016 by HMA, NBP and HHH. Batteries were replaced and loggers re-programmed, taking measurements every three hours until 8 August 2019 (when all equipment and buried sensors were removed from the site).

At V52a, the depth to the permafrost was checked at 20 points, giving values between 47 and 66 cm (11th August 2016) and between 38-60 cm (10th August 2017). A TinyTag was installed in a small pit, measuring the temperature at 0 and 50 cm depth every 3 hours from August 2016 until August 2017.

During the investigation efforts were made to replicate Roussell's historic photos from 1937.

1-3. APPENDIX B: SITE DESCSRIPTIONS

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Protocol

Table 2. Observations made in Austmannadalen in 2016 using the REMAINS field protocol.

Table A			
Site	**V53D**	**V53C**	**V52A**
NKAH no	1438	1437	1432
Serial no /FM number	64V2-III-519	64V2-III-518	64V2-III-513
Region	Austmannadalen	Austmannadalen	Austmannadalen
Site name			
Number of structures	Excavated houses, midden	9 excavated houses, midden, spectacular drying house	5 excavated houses, midden, well-preserved drying house
Location			
N/E (decimal degrees; WGS84)	64.216990°,, -49.8740180°	64.21992°, -49.832758°	64.21935°, -50.120628°
Height above sea level (lowest and highest point)	230 m	170 m	117 m
Setting/surroundings	Lying on small hill, ca 15 m above wetland	Lying beneath mountain slope	Placed in the middle of a wetland/bog of ca 300x150m
Site description			
Site type	Farm	Farm	Farm
Date culture	Norse	Norse	Norse
Finds			Wood, organic macrofauna
Dimensions/outline	30 x 50 m	30 x 100 m	not estimated
Thickness of deposits	100 cm	Rousell notes a thickness of at least 40 cm	not measured
Vegetation cover	Bluejoint, alpine meadow grass (rørhvene, rapgræs). Long on building remains, shorter on midden. Willow (gråblå pil) in old excavations. NB: not described systematically.	Bluejoint and shorter grasses (rørhvene og kortere græsser) on midden. Buildings completely overgrown by willow (gråblå pil). NB: not described systematically.	Mosses, short grass and horsetail on midden, long grass and villow in excavated buildings. NB: not described systematically.

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Photos (add numbers from other participants)	HMA no 4174-4201 (2016), HMA no 3434-3550 (2012). Rousell (1937)	HMA no 4150-4172; 4202-4204 (2016). HHA No 3563-3562; 3552-3555 (2012). Rousell (1937)	HMA 4214-4220 (2016); HMA 3598-3624 (2012)
Evaluation, summary			
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)			
Archaeological value (1-5 as above)	3	3	3
State of preservation (1-5 as above)	3	3	3
Preservation conditions (1-5 as above)	4		5
Ongoing degradation? (comparison to earlier site visits)	Some of Rousells photos from 1937 were re-taken in 2016, showing very distinct changes in vegetation, including a substantial invasion of willow	Some of Rousells photos from 1937 were re-taken in 2016, showing that willow-growth had increased substantially (from approx ½ m height to 1½ m height around the houses)	McGovern 1981 writes that the midden is very badly damaged from old excavatation. We couldn't observe that during the short visit.
Date visited	09/08/2016 and 21-24/8/2012	08-09/08/2016 and 24/8/2012	11/8/2016 and 26/08/2012 (few hours only)
Visited by	Hans Harmsen, Nanna Bjerregaard Pedersen, Henning Matthiesen	Hans Harmsen, Nanna Bjerregaard Pedersen, Henning Matthiesen	Hans Harmsen, Nanna Bjerregaard Pedersen, Henning Matthiesen

Table B			
Site	**V53D**	**V53C**	**V52A**
State of preservation			
Buildings/site structure and integrity	Excavated, stable	Excavated, overgrown by willow. Drying house nearby very well preserved	Well preserved, seemingly stable. 3 buildings not found.
Physical disturbance	Several trenches through midden	A few shallow trenches through midden	A few trenches and one test pit in midden
Volume excavated during visit	1x0.5x1m (in 2012)	none	20x20x50 cm for temperature sensors (2016); 20x30x50 cm for pollen samples

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REMAINS OF GREENLAND' - FIELD REPORT

			(2012)
Materials found (list)	Wood, bone, charcoal		Wood
Wood	Few wood chips, poorly preserved		Some pieces found, excellent preservation
Bone	Many found, well preserved, slightly dry/cracked in the upper layers (2012)		None found
Stratigraphy			Turf is very well preserved
Other			
State of preservation, in brief (1-5)	3		Not investigated in detail, but from the environment it is assumed to be good to excellent (4-5)
Measurements during visit (ranges)			
Documented by drone	No	No	No
Active layer thickness (range and date measured)	Midden completely thawed. Frost in the shade in room 17, and frost at 70 cm depth in wetland nearby (22/8/2012). However, logging 2012-2014 doesn't show permafrost at these places.	not measured	45-67 cm (11/8/2016); 45-64 cm (26/8/2012)
Soil temperature (range and date measured)	-10 to +10 C at 15 cm depth (logger 2012-2014)	not measured	0-12 °C (11/8/2016); 0-8 °C (26/8/2012)
Water content (range measured)	12-30% vol in midden (logger 2012-2016)	not measured	30-80% vol (waterlogged ca 20 cm down)
Conductivity (range measured)	Top midden 50-100 mS/m, bottom 5 mS/m (2012)	not measured	20-30 mS/m
pH (range measured)	6-7 (2012)	not measured	5.5 (7 in uppermost soil layer)

1-3. APPENDIX B: SITE DESCSRIPTIONS

REMAINS OF GREENLAND' - FIELD REPORT

Sea level (logged: yes/no)	no		Not relevant
Root depth	no		Horsetail to 30 cm depth, fine roots from grass go deeper
Other (ground water level,…			
Samples taken during visit			
Soil (list samples/number)	Soil samples taken in 2012		Ring samples (both in 2012 and 2016)
Artefacts (list materials)	Bone samples (in 2012)		Wood
Other materials (list)	Sterile wood samples (in 2016)		Pollen samples (in 2012, Paul Ledger)
Vegetation (leaves/biomass/dendro samples)	Dendro samples of willow taken in 2016	A few willow samples for dendrochronology (a.o. a willow visible on Roussell's photo from 1937)	
Evaluation of value			
Experience: beauty/monumentality	5	5 (drying house very visible in landscape)	5
Experience: memory/historic value	4	4	4
Physical integrity	3	3	2
Physical preservation	3	3	2
Archaeological rarity/representation	1	1	1
Archaeological information value	2	2	2
Archaeological assemblage value	2	2	2
Archaeological value, in brief (1-5)	**2.85 = "3"**	**2.85 = "3"**	**2.57 = "3"**
Evaluation of threats (ongoing/expected)			

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REMAINS OF GREENLAND' - FIELD REPORT

Erosion from water and ice	Very low risk of freshwater erosion, due to distance to stream	No erosion from water	No erosion from water observed
Other erosion (wind, animals, visitors)	Very low risk of wind erosion. Some ongoing erosions from animals, but not critical - no development from 2012-16. No damage from visitors.	Modest erosion observed, unknown origin (photo 3563 from 2012)	None observed
Damage from vegetation, roots	Mainly grass (bluejoint) on midden, that stabilizes it. In the ruin approx. half of the rooms were filled with willow and half were covered with bluejoint	Mainly willow, that grows up to 1½ m height. The excact effect on the ruins is unknown, but their roots may damage any remaining floor deposits	Horsetail may cause some damage on midden
Drainage	Probably on-going		Drainage is unlikely, but the damage from drainage would be big.
Melting, heating	Melting took place after Rousell removed the soil from the rooms		Some melting if the temperature increases but the risk is limited
Soil movement (including creeping, cryoturbation, slide)	Unlikely due to low water content. Possible some signs of cryoturbation		Unlikely as there is no slope
Decay of organic materials	Rate unknown		Estimated to be very low under present conditions (permafrozen or waterlogged)
Other threats			
Future threats?			
Preservation conditions, in brief (1-5)	4		5
Are earlier descriptions available for comparison (references)	Roussell 1936; 1941; photos from 1937,	Roussell 1938; 1941; photos from 1937,	Roussell 1936; 1941; McGovern 1981

Monitoring			
Already initiated (which parameters)	Monitoring of water content in midden since 2012, monitoring of temperature in midden, within house and in wetland since 2012		TinyTag temperature logger installed at 0 and 50 cm depth on the 11/8/2016
Suggested (which parameters)			
Important unknowns/research needed			Extent and content of midden

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4. Kilaarsafik (Sandnæs) V51 [NKAH 1480]

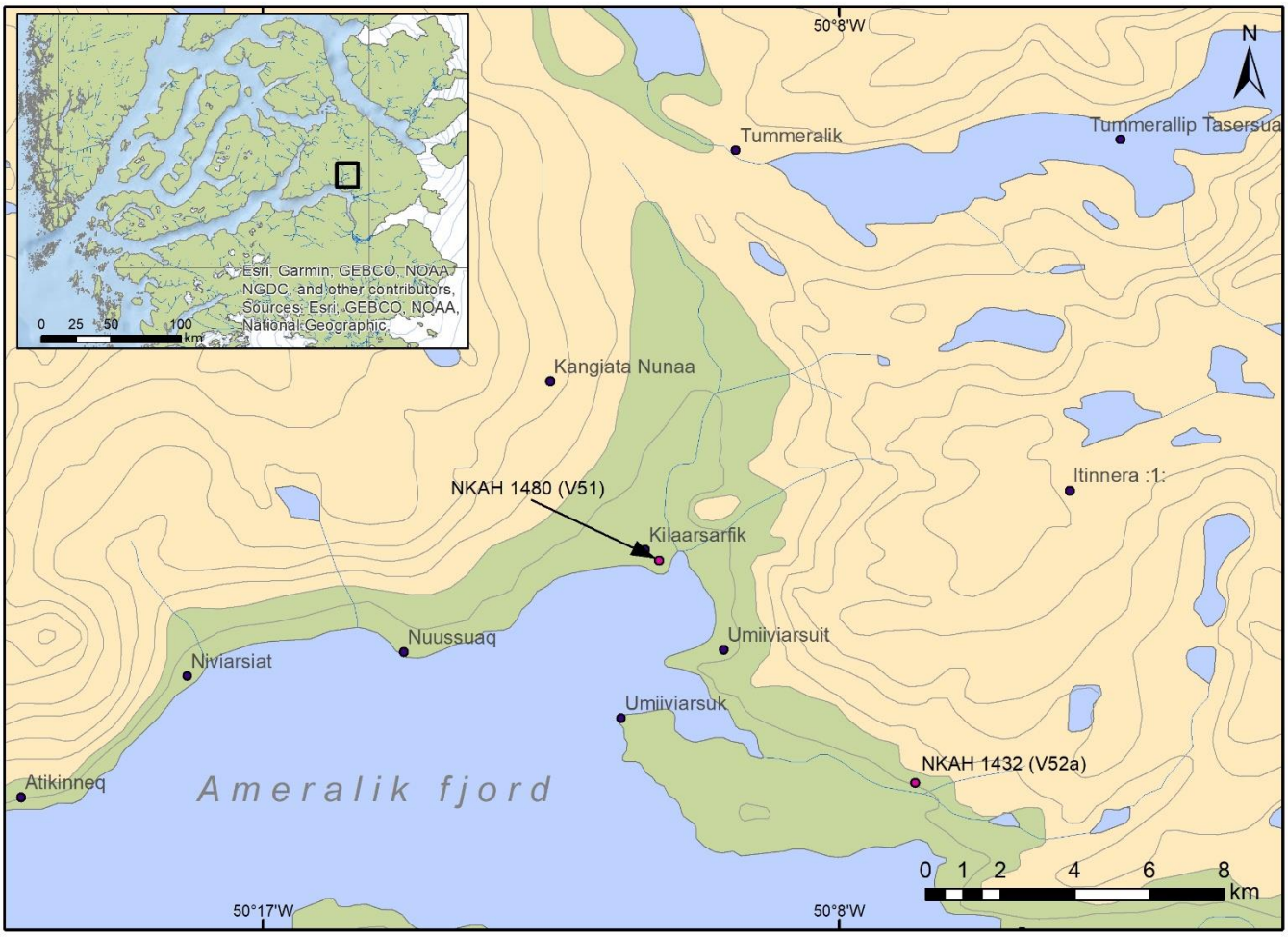

Fig. 1. Kilaarsafik (Sandnæs, V51), denoted by the arrow, is located at the juncture of three inland valleys systems that meet at the head of the Ameragdla fjord.

Site description

During the Middle Ages, the Ameralik fjord was occupied by several farmsteads that collectively constituted roughly one-third of the farms in the Norse Western Settlement (~25 of a total of approximately 70-75 farms). Sandnæs (64.24264°, -50.182338°) was one of the largest of these farms, located at the juncture of three inland valleys that meet at the head of the Ameralik fjord (Fig. 1). The

site possesses a homefield and an assortment of structural features that include a centralized farmhouse, church, byre complex, storage areas, iron smithy, stone wall and several other structures of unknown purpose. It is reasonable to assume that given its size, V51 was a focal point of social and economic activity, a fact supported by the presence of a large church an and mention in historic sources (Egede 1925, Thorhallesen 1776). In his survey in the mid-1980s, McGovern identified Saqqaq/Dorset occupations just south of the main Norse ruin group. Although little is visible on the surface, this area was well known by Greenlanders as a place inhabited by the *old Kablunæt* (i.e. Norse) (Thorhallesen, 1776).

The surrounding valley landscape of V51 is geomorphically dynamic with the fjord coastline constantly being reworked along the shore and fringes (Fig. 2). The area has experienced numerous episodes of localized sea level transgression attributable to isostatic subsidence due of its close proximity to the glacier front. During low tide, the small bay becomes exceedingly shallow making landing at the site exceedingly difficult by boat. The large shallow delta to the south of V51 is a result of massive sediment transport from the inner fjords. Fine sediment (e.g. silt) is transported with the tide and deposited to Kilaarsafik during slack water. Along the southern shore the, the fetch is large and southwest-westerly winds generate moderate wave action (sometimes upward of 1 m in height). The eastern shore where the settlement is located faces an embayment with a very short fetch that provides lee from direct wave action in the fjord.

The surrounding terrain of the ruin group is characterized as a low-relief (approximately 2-3 m above mean sea level) alluvial fan dominated by grass and willow scrub. An active river mouth lies ~100 m north of the settlement and appears stable. There are–clear signs of old riverbeds in the immediate vicinity suggesting the river has shifted over time. Travelling up into the valley, vegetation becomes patchy with tall grass and isolated shrub. These hinterlands would have made for poor pastureland during Norse times.

Due to the long-documented history of the site dating back to the 18th century, some broad assumptions can be made regarding the rate of erosion taking place at the site. Early descriptions suggest the church

and churchyard were already in the early stages of eroding into the bay in the late 18th and early 19th enturies (Breiðfjörð 1836, Magnússon and Rafn 1838, Pingel 1842, Giesecke 1910). During this period, the ruins of the church and its adjacent churchyard were still identifiable. By the time Bruun visited the site in 1903, the church was still visible, but no bones were observed on the surface and only in the erosion front (Bruun 1903, 1917). By the 1930s, the church had become completely submerged in the bay and graves were only preserved in the westernmost end of the churchyard. Little documentation is made of vegetation conditions in the old accounts, but by 1903 it appears that willow scrub had begun to proliferate within and around the ruin group (Bruun 1903). Historic and recent site descriptions, sketches, photographs, and site maps suggest some degree of geomorphic change in the form of coastal erosion taking place along the shoreline (Knudsen, et al. 2014).

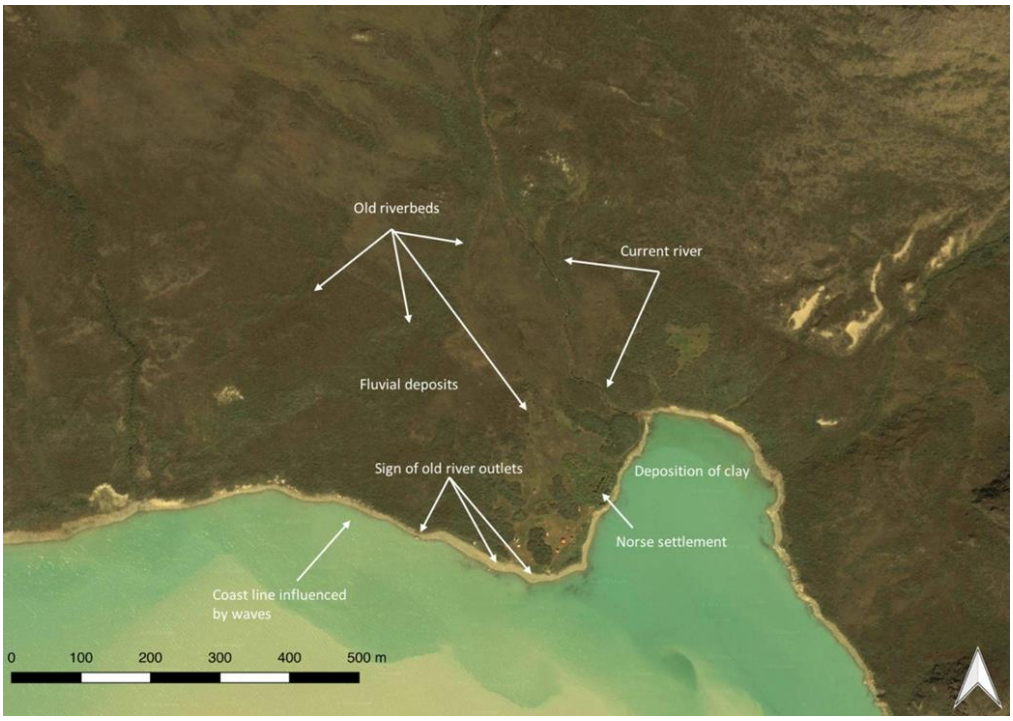

Fig. 2. Google Earth satellite image showing major geomorphology of Kilaarsafik (Kroon 2016).

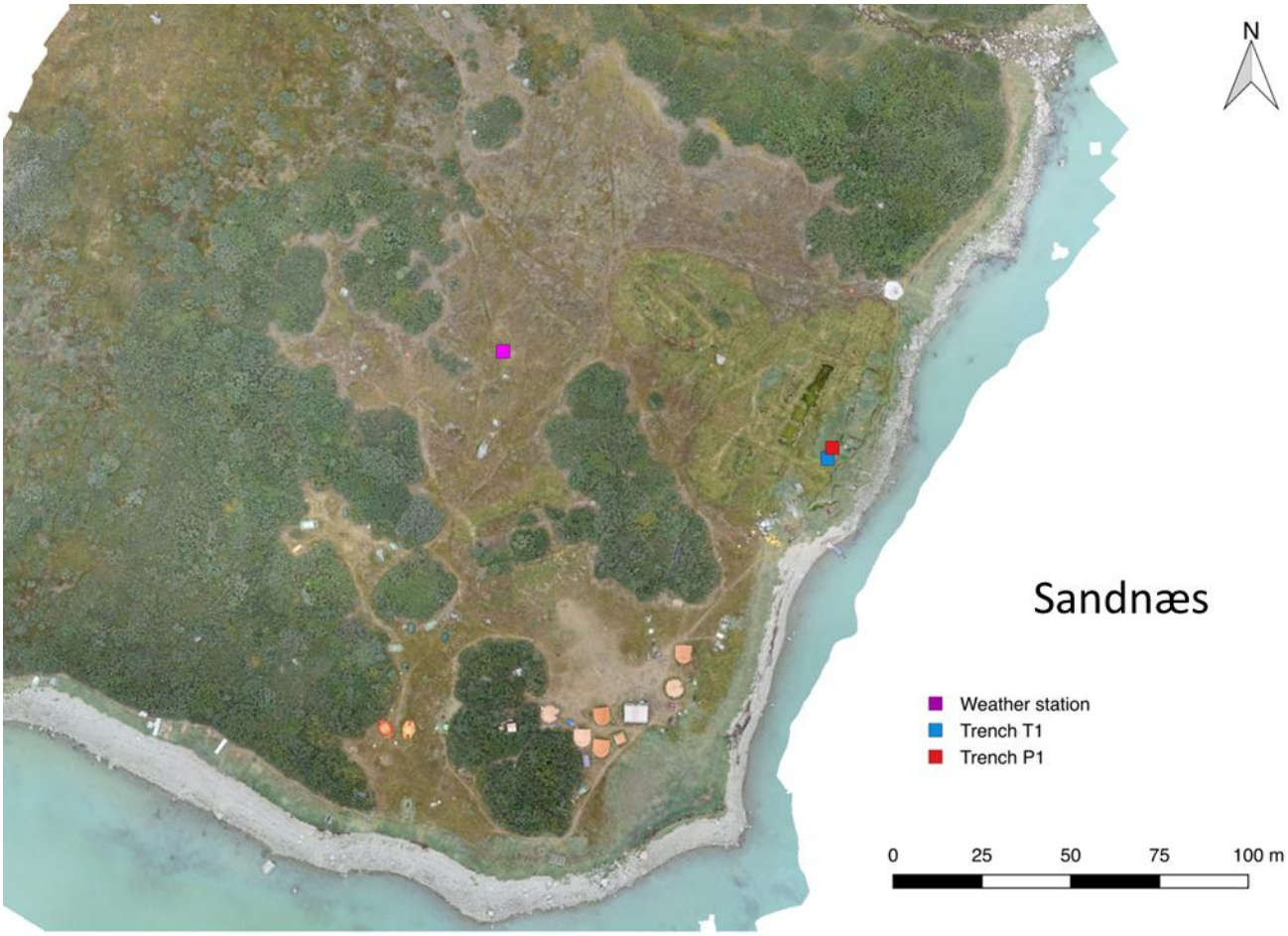

Fig. 3. Map of the archaeological site at Sandnæs (V51) showing the positions of the weather station and Trench T1 and Trench P1.

Archaeological investigations and sampling

Two test trenches were opened at V51 in 2016 (Fig. 3). This sub-surface testing was performed to: (1) examine preservation conditions of organic remains in the midden; (2) document local soil conditions and install environmental monitoring equipment; and (3) install modern bone and wood samples into the walls of the profile to study natural decomposition. Trench P1 was originally opened in 2012 (Knudsen, Larsen, and Ødegaard 2012). This 1x1 area was located in the corner of the midden of Unit F I previously excavated in 1984 (McGovern et al. 1996). A new trench (T1) was excavated approximately 4m west of trench P1. Environmental monitoring equipment and modern wood and bone samples were installed in the wall profile (Fig. 4).

Trench P1

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P1 was re-opened in 2016 to collect modern samples of wood and bone installed in the wall profile in 2012 (Fig. 5). During this investigation, one (*n*=1) ancient wood sample was collected in-situ from P1 at -120 cm below the surface. Six (*n*=6) modern bone samples were also collected from P1 at depths of -20, -40, -60, -80, -100 and -120 cm below the surface. Wood samples of maple (*Acer, Danish Ahorn*, hereafter "*A*") and pine (*Pinus, Danish Fyr*, hereafter "F") were collected at -20 (*A,F*), -40 (*A,F*), -60 (*F*), -80 (*F*) and -100 (*A,F*) cm below the surface. All remaining samples were numbered with new labels and affixed with a pink string (

Table 1).

Fig. 4. Profile of excavation trench drawn by McGovern during the Sandnæs Archaeological Rescue Project (1984). This area was re-opened in 2016 1x1 area was located in the corner of the midden of Unit F I previously excavated by McGovern in 1984. Trench T1 was excavated approximately 4m west of trench P1 to install environmental monitoring equipment and modern wood and bone samples in the wall profile.

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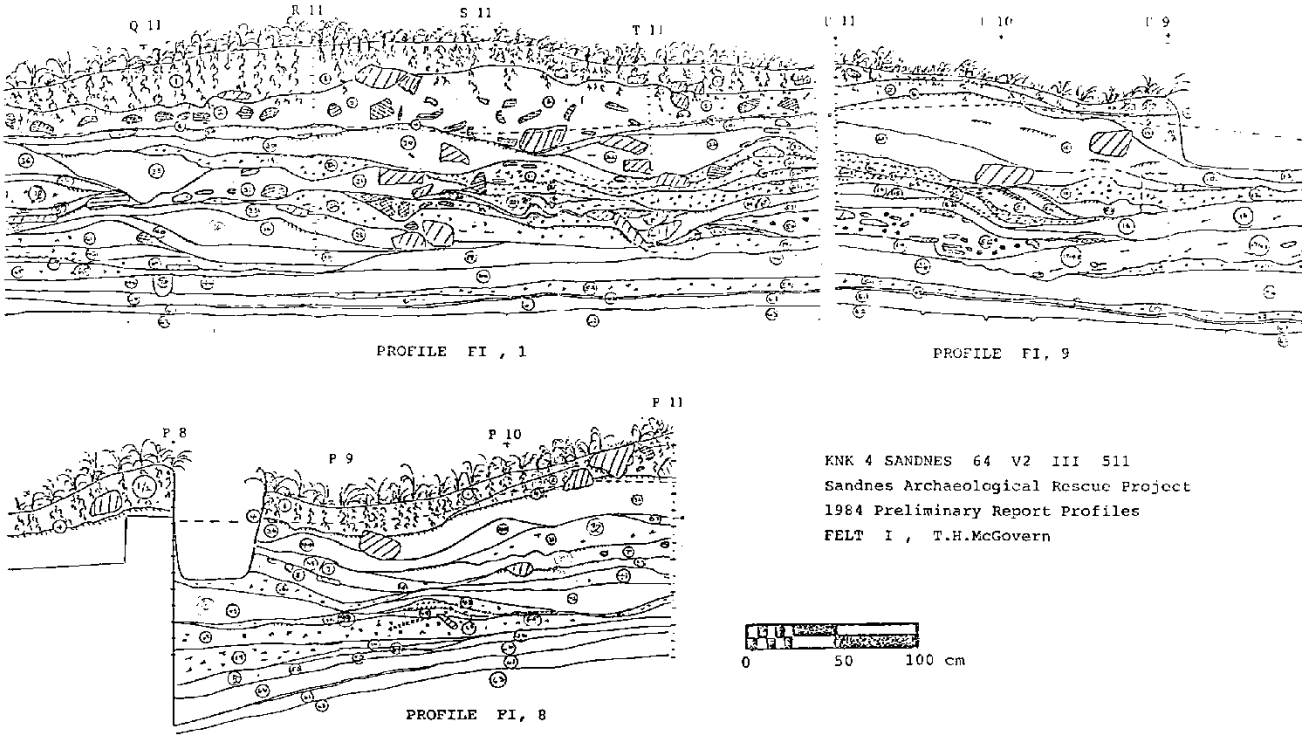

Depth below surface (cm)	Wood	Bone	Hair
-20	A2, F2 (only chip)	K1,2,3 (1 sample left)	H1
-40	A6, F6 (only chip)	K4,5,6 (1 sample left)	H2
-60	A4, F4 (only chip)	K7,8,9 (2 samples left)	H3
-80	A11, F11 (only chip)	K10,11,12 (1 sample left)	H4 (not located - status unknown)
-100	A14, F14 (both present), A15, F15 (only chip)	K13,14,15 (2 samples left)	H5
-120	None	K16,17,18 (2 samples left)	H6

Table 1. Status of the wood, bone and hair samples installed in Trench P1 at Kilaarsafik in 2012 after sampling in 2016.

Trench T1

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T1 was located approximately 4m west of trench P1 and produced 8 individual artefacts, detailed by type, quantity (n) and weight in Table 2. Bulk samples of bone were also collected and are listed by number of samples bags and aggregate weight in Table 3. All finds were collected in sterile sample bags and segregated based on provenience.

Artifact type	***n***	**wt. (g)**
metal	1	2.3
Slag, ferrous	3	7.6
steatite	2	58.4
worked bone	2	23.8
Total (*N*)	8	92.1

Table 2. Total T1 artifacts, detailed by type, quantity (n) and weight at V51.

Sample type	**# of sample bags**	**wt. (g)**
bone	5	274.2
Total	5	247.2

Table 3. Total T1 samples, detailed by type, number of sample bags taken and aggregate weight.

Fig. 5. Profile in trench P1 at Kilaarsafik showing the modern bone and wood samples installed embedded in the wall in 2012.

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Environmental monitoring equipment and modern wood and bone samples were installed in the wall profile of T1. One sample of *Fagus sylvatica* (European beech), one sample of *Pinus sylvestris* (Scots pine) and three unmacerated bone samples were buried at each depths of -5, -20, -40, and -60 cm below the surface. A vertical groove was made in the wall of the profile for the samples to rest in. Volume specific soil samples of 100cm^3 were collected at depths of -5, -20, -40, and -60 cm below the surface. T1 produced 62 artefacts (*N*=62) (Table 2.3). Ten (*n*=10) bone samples were collected in sterile plastic bags (by AME) and ten (*n*=10) bone samples in normal plastic sample bags (by HMA). Three (*n*=3) of these wood samples were selected for further analysis in the degradation study and sent to the National

Museum of Denmark, Conservation Department, for further analysis. These samples were stored in a cooler at the NKA and later transported frozen to the National Museum of Denmark.

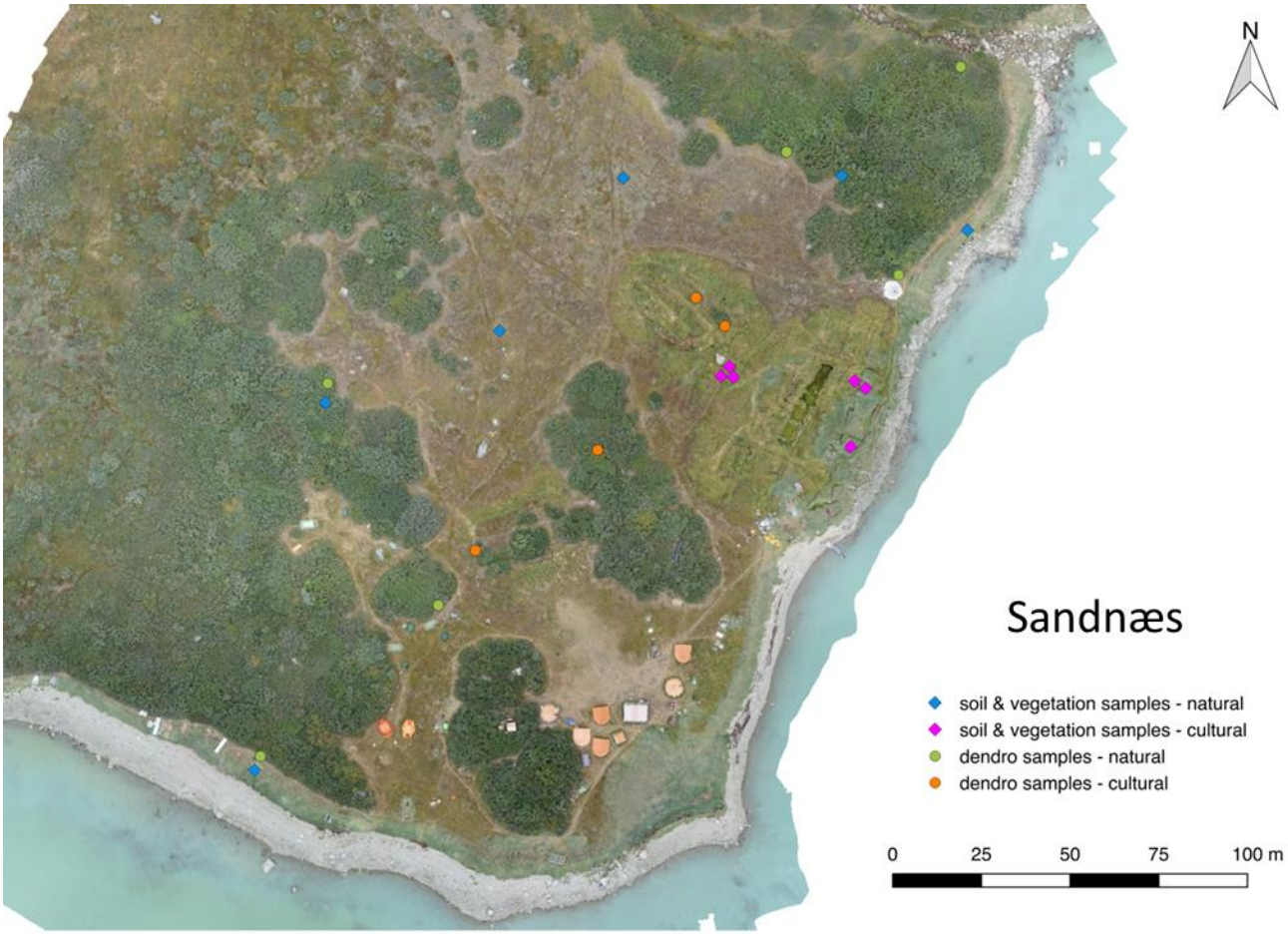

Fig. 6. Map of the archaeological site at V51 showing the positions of sampling sites.

Vegetation Studies

Detailed vegetation analyses were carried out on six (Fig. 6) 1x1 m plots at V51 (“cultural” 1-6) and on six 1x1 meter plots on the surrounding natural soil (“natural” 1-6). Each plot was photographed with a very high-resolution camera (Hasselblad) and a Sequia multi-spectral camera and NDVI was measured using a Decagon NDVI sensor. The vegetation cover was quantified using a 1x1 m frame divided in to 25 sectors by pinpoint analysis. A 20x20 cm area within each plot was harvested and the green biomass collected. The same 20x20 cm area was then dug out to a maximum depth of 30 cm below the surface. Volume specific soil samples of 100cm^3 were collected from depths of -5 cm, -10 cm, -20 cm and -30

cm below the surface. After sampling each hole was backfilled to minimize disturbance. Additionally, 15-20 leaves were harvested from 1-3 different species on top or immediately adjacent to each sample plot.

At nine locations (5 “cultural” and 4 “natural”) holes were extended down to 60-80 cm depth to study the root penetration depth of different plants. The maximum root depth for “Horsetail”, “Woody roots” and “Fine roots”, respectively, was registered. Volume specific samples of 100 cm^3 were collected for each 10 cm depth, to quantify the root mass. These soil samples were wet sieved (2 mm sieve) and the roots were sorted as above before they were dried and weighed.

To investigate any recent increase in growth of *S. glauca* (Northern willow), dendrochronology samples were collected the archaeological site and in the surrounding area (Fig. 6). First 10-20 cm of the root column was cleared from soil and litter and then a stem containing approximately 10-20 cm root and 10-20 cm above ground stem was cut or sawn off (Fig. 7). In addition, 15 (*n*=15) leaves from each of the sampled trees were harvested to conduct C/N + ^{15}N analyses. A total of 11 (*N*=11) *S. glauca* stems were collected at V51. Four stems (*n*=4) were sampled from the archaeological site and seven stems (*n*=7) sampled along a transect that paralleled the sample plots (Fig. 6).

4 APPENDIX B: SITE DESCSRIPTIONS

Fig. 7. Dendrochronology samples were collected at the archaeological site and in the surrounding natural area.

GPS and UAV Surveys

A high precision TRIMBLE RTK-dGPS was used to (1) map the archaeological site, (2) accurately determine the coordinates of ground control points that were used in the analyses of the drone flights, (3) map the positions of sampling sites and (4), map the location of the environmental monitoring sites (Fig. 3 and Fig. 6). Geomorphological data like high-tide shorelines were collected by dGPS in 2012. A quadcopter UAV (Tarot 650-sport) was also used to conduct a mapping survey of the site. Two flights were carried out using different cameras: a regular RGB camera (Sony RX100) and a multi-spectral camera (Seqoia). Detailed information on each flight is seen in Table 4.

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Date	Local time	Weather	Survey type	Camera	Altitude	Area (km2)	Photos
11/08/16	13:47-13:56	Overcast	Site survey	Sony RX100M3	100 m	0.09	172
11/08/16	15:13-15:22	Overcast	Site survey	Sequoia	100 m	0.09	99

Table 4. Detailed information on the flights carried out at Kilaarsafik using a quadcopter UAV (Tarot 650-sport).

Environmental monitoring

In 2012, a weather monitoring station was installed approximately 100 m west of the core area of the archaeological site (Fig. 3). From August 2012 to August 2018 a Campbell Scientific CR1000 datalogger collected data from measured hourly air temperature and relative humidity (MP100A Temperature & Relative Humidity probe), wind speed and direction (A100R Anemometer & W200P Windvane), snow depths (SR50A Sonic Ranging Sensor – stopped working in 2013) and precipitation rates (52202 Tipping Bucket Rain gauge). Next to the weather station, subsurface temperatures were measured every hour at depths of 0, -25, -50 and -75 cm below the surface using a Campbell Scientific 107. Four soil moisture sensors (Delta T, SM300) were installed at the same 0, -25, -50 and -75 cm depths. The sensors were connected to a dedicated datalogger (Delta T, DL6) programmed to log every 6 hours. Volume specific soil samples ($100cm^3$) were taken at the same depths as the sensors were installed to calibrate the sensors.

In 2012, equipment was also installed at Trench P1 in order to measure subsurface temperatures at 0, -25, -50, -75, -100, -125 and -150 cm below the surface and soil water content at -25, -50, -75 and -125 cm below the surface (Fig. 3). Furthermore, temperature sensors were installed in a nearby permafrost drilling (PF1) at -40 and -100 cm depths below the surface.

The new trench (T1) excavated in 2016, was instrumented with equipment to measure soil temperatures (Campbell Scientific 107), oxygen (Presense) and soil moisture content (Delta T, SM300) at -5, -20, -40 and -60 cm below the surface. The soil temperatures and oxygen contents were logged every 12 hours using a Campbel Cr300 datalogger and the soil moisture contents every 6 hours using a Delta T, DL6 logger. Volume specific soil samples ($100cm^3$) were taken in the same depths as the soil moisture sensors to calibrate the sensors.

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Measurement of *in situ* pH, water content and conductivity was carried out at P1 for every 5-10 cm depth in 2012, and repeated measurement were carried out in P1 and T1 in 2018 during retrieval of the monitoring equipment.

An automatic camera was also installed east of the site and programmed to take pictures every 6 hours (00:00, 06:00, 12:00 and 18:00, winter time). All monitoring equipment and sensors were removed from the site in August 2018.

During the investigation efforts were made to replicate Roussell's historic photos from 1937.

Protocol

Table 5. The observations made at V51 using the field protocol.

Table A	
Site	V51
NKAH no	1480
Serial no /FM number	64V2-III-511
Region	Ameralikfjorden
Site name	Kilarsafik, Sandnæs
Number of structures	8 excavated houses, flooded church and churchyard, midden, fences.
Location	
N/E (decimal degrees; WGS84)	64.24264°, -50.182338°
Height above sea level (lowest and highest point)	0-10 m (check GPS data) - sea reaches foot of midden at spring tide
Setting/surroundings	Placed at the shoreline in a brackish bay
Site description	
Site type	Farm with church
Date culture	Norse
Finds	
Dimensions/outline	100x100 m
Thickness of deposits	150 cm
Vegetation cover	Long grass on midden, Horsetail in wet areas, willow in some of the buildings. NB: not described systematically - Emil more?
Photos (add numbers from other participants)	HMA 3391-3416; 3645-3694; 3707-3737 (2012)
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5	

excellent)	
Archaeological value (1-5 as above)	
State of preservation (1-5 as above)	3
Preservation conditions (1-5 as above)	3
Ongoing degradation? (comparison to earlier site visits)	McGovern 1981 writes the site is strongly threatened by erosion and recommends rescue excavation. He presents a map of the changes in shoreline from 1903, 1936 and 1981. However, there doesn't seem to be large changes from 1981 to 2016 (need confimation from drone maps)
Date visited	8/8/-11/82016, 20/8/2012; 26-31/8/2012
Visited by	Christian Koch Madsen, Jørgen Hollesen, Roberto Fortuna, Annemarie Eriksen, Rasmus Fenger Nielsen, Emil Andersen
Table B	
Site	V51
State of preservation	
Buildings/site structure and integrity	Excavated, seem stable, difficult to see due to vegetation
Physical disturbance	Many trenches and testpits, site highly disturbed
Volume excavated during visit	2016: Trench T1, for oxygen and water content sensors, ca 50x50x60 cm. 2012: Profile P1, for water content and temperature, ca 0.5x1.5x0.1 m (cleaning of Profile B from 1984)
Materials found (list)	
Wood	Few wood chips, poorly preserved
Bone	2016, T1: Average state of preservation 2.71 (59 bones from T1). 2012, P1: Bones poorly preserved in the upper dry layers (crumbles), well preserved in lower layers
Stratigraphy	
Other	
State of preservation, in brief (1-5)	3
Measurements during visit (ranges)	
Documented by drone	Mikkel Myrup and Rasmus Fenger Nielsen
Active layer thickness (range and date measured)	In trenches: frost at 30-80 cm, in balks frost at 75-150 cm. Drilling was made in one trench where there was at least 70 cm of frozen midden.
Soil temperature (range and date measured)	0-8 °C for soil in the shade, up to 18 °C in the sun
Water content (range measured)	10-70 %, upper layers very dry
Conductivity (range measured)	30-2500 mS/m
pH (range measured)	5.5-7. Down to 5 in a few layers
Sea level (logged: yes/no)	No
Root depth	
Other (ground water level,…	
Samples taken during visit	
Soil (list samples/number)	Ring samples, bulk samples (in 2012 and 2016), drill samples

	of permafrozen soil (in 2012)
Artefacts (list materials)	Bone
Other materials (list)	
Vegetation (leaves/biomass/dendrosamples)	Dendrosamples (AME), vegetation (Emil)
Evaluation of value	
Experience: beauty/monumentality	3
Experience: memory/historic value	4
Physical integrity	2
Physical preservation	3
Archaeological rarity/representation	4
Archaeological information value	4
Archaeological assemblage value	5
Archaeological value, in brief (1-5)	
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	The sea water reaches the midden at springtide, but there is no wave action and very limited ongoing erosion. Some erosion from ice may be expected in winter (?).
Other erosion (wind, animals, visitors)	Some erosion from visitors as the site is a very popular summer camp
Damage from vegetation, roots	Horsetail may cause some damage on midden; willow may cause some damage on houses
Drainage	Drainage into open trenches and pits probably ongoing
Melting, heating	Most of the midden is already thawed, but some permafrozen layers were found
Soil movement (including creeping, cryoturbation, slide)	Some takes place, may increase if midden gets more wet
Decay of organic materials	Rate may increase if the midden gets more wet
Other threats	
Future threats?	
Preservation conditions, in brief (1-5)	3
Are earlier descriptions available for comparison (references)	McGovern et al 1986, McGovern 1981; Roussell 1936; Bruun 1903; Bruun 1918
Monitoring	
Already initiated (which parameters)	Climate station installed 2012. Temperature and water content measured in midden from 2012. Oxygen measured from 2016. Automatic camera installed 2016
Suggested (which parameters)	
Important unknowns/research needed	
Mitigation - summary of recommendations	
Refill trenches	Would improve moisture content on midden and probably raise the frost level if the trenches were backfilled

Backfill	Backfill in the open pits may raise the soil level with permafrost
Erosion protection	
Cut back vegetation	
Fencing	
Rescue excavation	

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5. Qoornoq

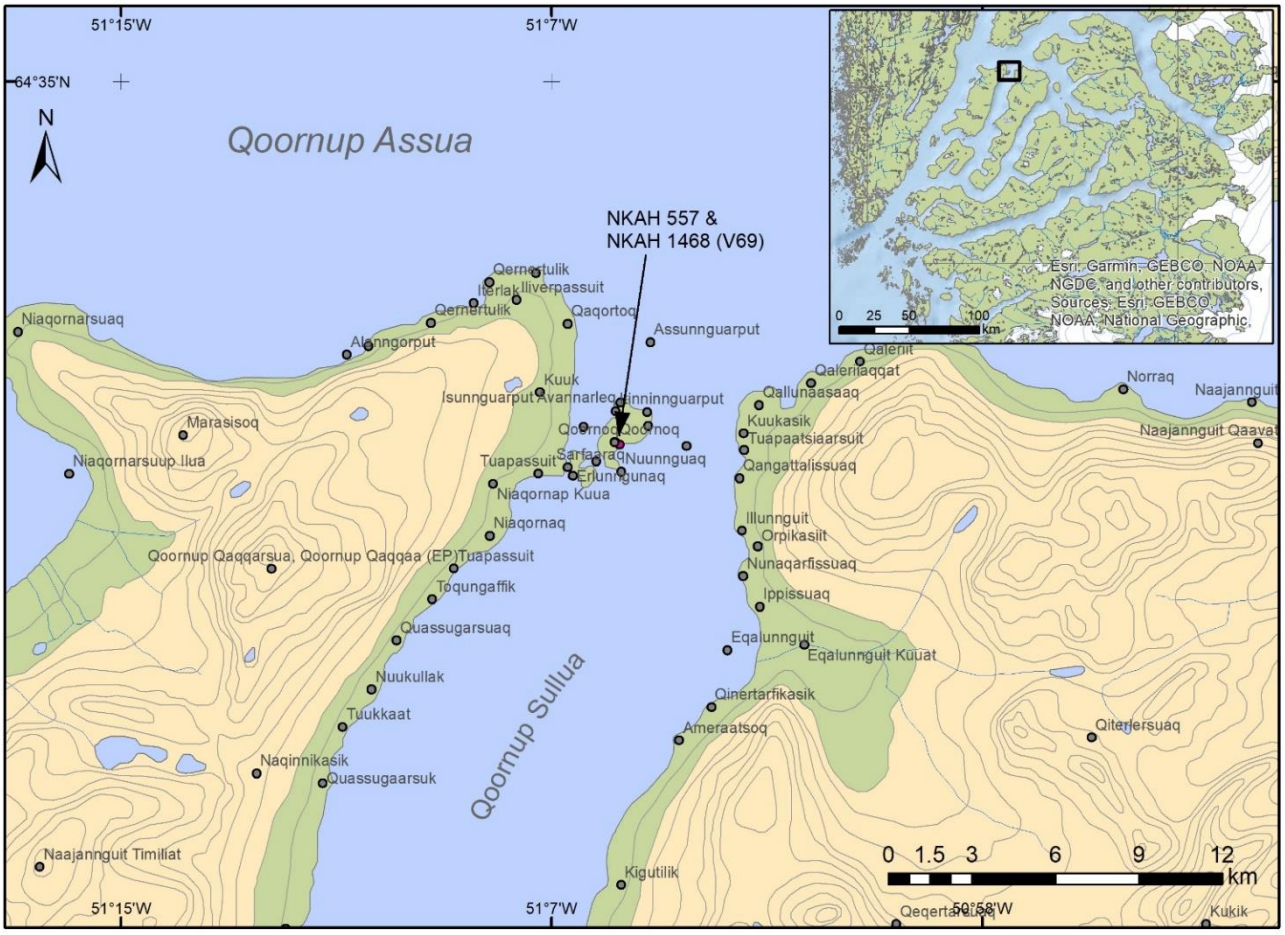

Fig. 1. The island of Qornooq is located at the confluence of Qoornup Assua and Qoornuup Sullua fjords. The location of two archaeological sites on the island, NKAH 557 and 1468 (V69), are denoted by the arrow.

Site description

Qoornoq (64.533140°, -51.0892260°) is a small island located at the confluence of the Qoornua Sullua and Qoornup Assua fjords (Fig. 1). At low tide, Qoornoq is connected to the northeastern coast of the larger adjacent island of Qoornuup Qeqqarsua. Qornoq's physiography is formed by sedimentary basement rock outcrops with tombolos and pocket beaches found along the island's eastern shore. The site is exposed to minor wave action from the south due to the limited fetch of the cove (Fig. 2). However, the beach has a meso-tidal range of between 2 and 4 m and water levels can reach the vegetation line during extreme tidal events. This is evidenced by active erosion fronts observed along the high-water line on the north shore of the cove.

5 APPENDIX B: SITE DESCSRIPTIONS

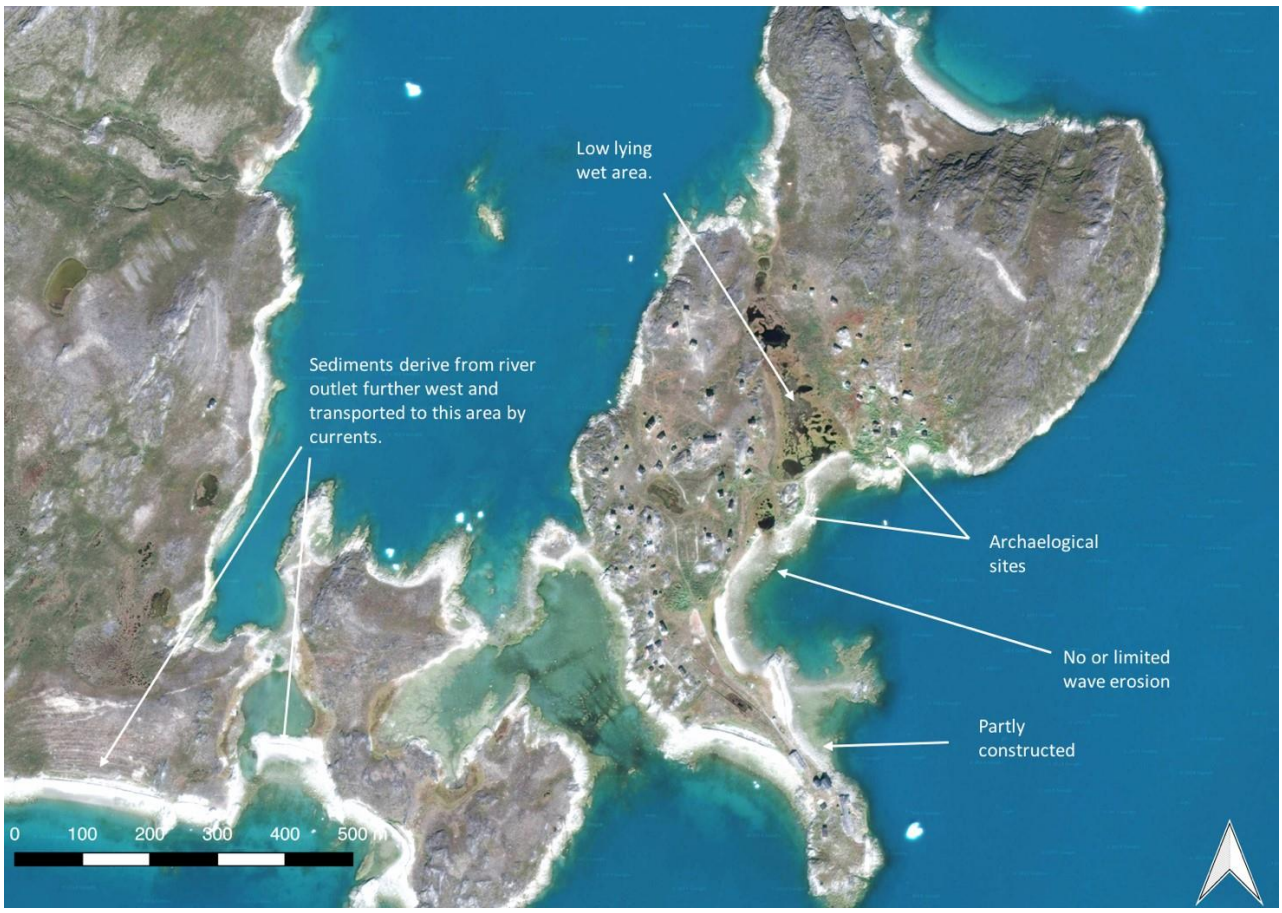

Fig. 2. Satellite view of Qoornoq with arrows showing geomorphic features.

A sand and gravel pocket beach runs along the eastern shore of the island. It is exposed to the southeast and possesses a more pronounced barrier structure. Waves during regular high-water levels are building up the berm of the barrier. Extreme water levels, probably caused by a combination of wind set-up and atmospheric set-up during storms, are causing washover fans. There is a low lying salt marsh fringed by a distinct berm and a pronounced cobble beach found in between the two main archaeological sites on the island. Normal high-water levels just reach the top of this barrier, protecting the major part of the salt marsh from flooding. However, during spring tides and extreme water levels, these salt marshes are flooded and fine sediments deposited.

5 APPENDIX B: SITE DESCSRIPTIONS

REMAINS OF GREENLAND' - FIELD REPORT

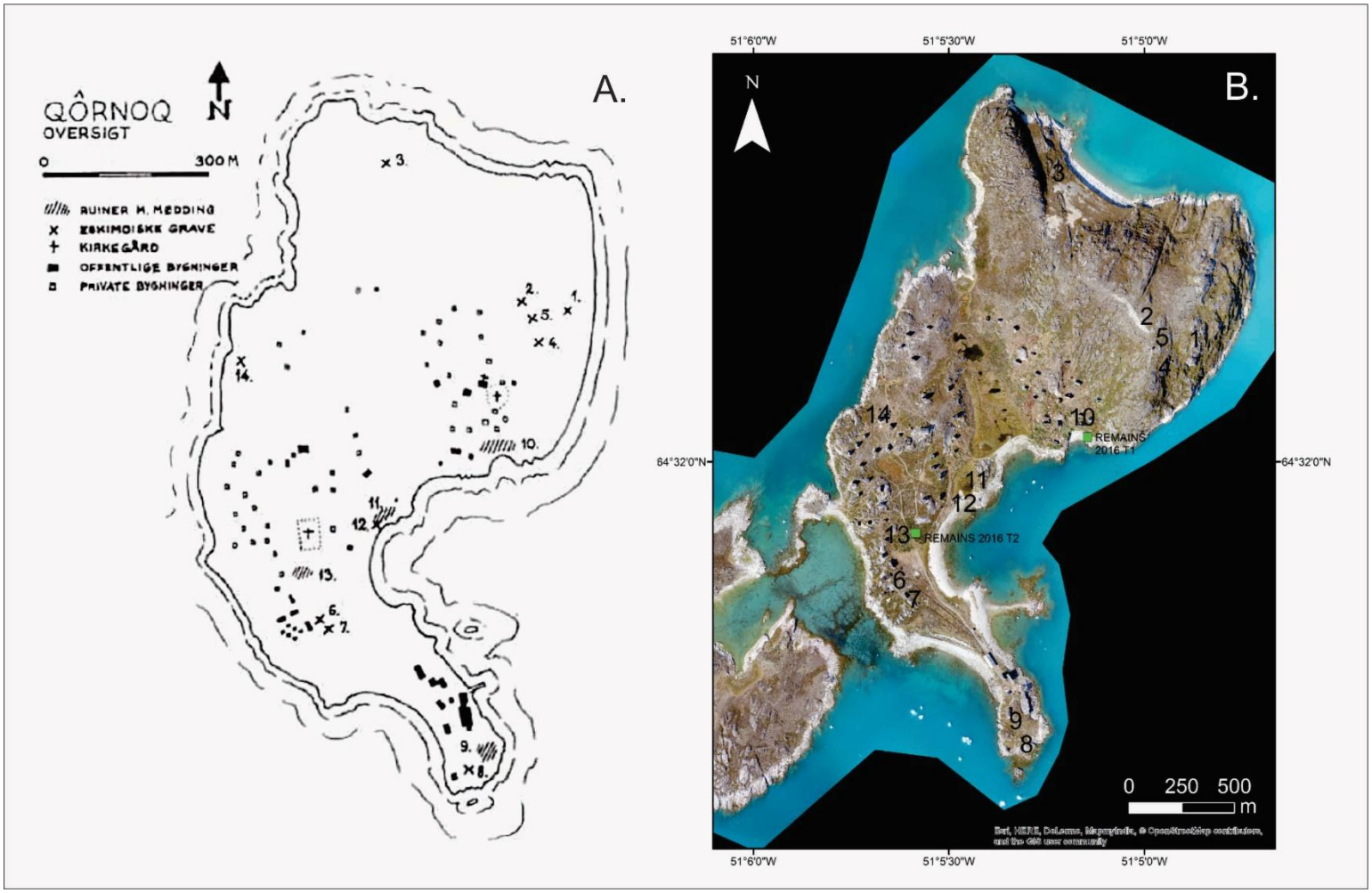

Fig. 3. (A.) The island of Qoornoq from Gulløv (1983:43) based on archaeological features identified by Melgård and Nelleman in early 1950s: (1-8) Thule burials; (9) (10) Thule-Inuit ruin group 1; (11) settlement features (Thule); (12) Thule burial; (13) ruin group 2, Norse farmhouse with overlaying Thule-Inuit winter houses; (14) Thule burial. (B.) Drone map of Qoornoq (Myrup 2016). Two test trenches were opened by the REMAINS team in 2016. Test trench 1 (T1) was placed in ruin group 1 (map no. 10), on the north shore of Qoornoq's small eastern bay. Test trench 2 (T2) was placed in the middle of ruin group 2 (map no. 13) where a concentration of 6 Thule winter houses were reported by Melgård to overlay a Norse farm.

5 APPENDIX B: SITE DESCSRIPTIONS

Archaeological investigations and sampling

The first formal archaeological investigations at Qoornoq were performed in the early 1950s by Meldgård and Nelleman. Their surveys identified several features and two major ruin groups: ruin group 1 (Fig. 3, map no. 10), a heavy degraded concentration of Thule winter houses found on the north shore of the island's eastern cove beach and ruin group 2 (Fig. 3, no. 13) a small concentration of approximately six Thule-Inuit turf houses built on the footprint of a Norse farmhouse (V69).

In 2016, two (2) test trenches measuring 0.5 x 1 m were opened at Qoornoq at the two ruin groups. These trenches were opened to: (1) examine preservation conditions of organic remains in the middens; (2) document local soil conditions and install environmental monitoring equipment; and (3) install modern bone and wood samples into the walls of the profile to study natural decomposition.

Trench T1 (ruin group 1, map no. 10)

Test trench 1 (T1) was located on a sloping (<45° grade) embankment situated on the north shore of Qoornoq's small eastern cove (Fig. 3). Visual inspection of the site confirmed the presence of an undetermined number of heavily disturbed Thule-Inuit winter house features; all heavily degraded and slowly moving downslope through a gradual process of solifluction. T1 was excavated by spade and trowel and dug to the maximum depth possible; approximately -65 to -70 cm below datum. The stratigraphy of T1 was extremely mixed due to both natural formation processes and human activity, presumably cutting into the remains of a turf wall (Fig. 4 and Fig. 5). T1 provenience was based on northwest coordinates with a datum placed 10 cm above the ground surface. All soil horizons and contexts of T1 are summarized below and in detail in Table 1.

0-25 cm below datum

Due to coastal erosion and human activity on the slope over the past few centuries, soil horizons were observed to be poorly constrained. Context [01] consisted of a dense turf layer (O-Horizon) with the transition to the underlying sub-soil occurring at approximately 20-30 cm below datum. Context [01a] consisted of a 10 YR 2/2 very dark brown turf and loam matrix, comprised mostly of a thick denigrated turf and root mass (~50% of layer). Context [01b] displayed a 10 YR 2/2–10 YR 2/3 very dark brown to very dark gray transition of the same turf and organic material, becoming lighter downward through what appeared to be natural illuviation and progressively thinning downslope.

25-70 cm below datum

Context [02] comprised a highly variegated but heterogeneous midden layer following the contours of a submerged turf and cobble wall. Soil in this level was observed as 10 YR 2/2 very dark brown silty soil. The layer contained a dense concentration of bone, decomposed mussel and organics (wood and denigrated turf wall). Context [03] forms a non-contiguous 10 YR 3/2 very dark grayish brown very fine aeolian silt band in the northern half of the trench between 45 and 55 cm below datum. Context [04] was observed as a greasy clay-like soil inclusion in the northeast corner of the trench at 60 cm below datum, possibly a floor layer.

Depth, cm below datum	Context no.	Description	Interpretation
0-30 cm	[01a]	10 YR 2/2 very dark brown turf and loam. Thick root mass ~50% of layer.	O/A Horizon
20-40 cm	[01b]	10 YR 2/2 – 10 YR 2/3 very dark brown to very dark gray thick turf mass and loam. Band becomes thinner down slope.	E-Horizon, eluvial horizon
30-70 cm	[02]	10 YR 2/2 very dark brown silty loam; dense bone, decomposed mussel and decomposed organics.	Midden layer
40-60 cm	[03]	10 YR 3/2 very dark grayish brown very fine silt band.	Aeolian deposit
55-65 cm	[04]	10 YR 5/3 brown clayish inclusion, compact and greasy to touch with 10 YR 2/1 black lenses.	Wetland in-wash, marine sediment?

Table 1. Soil strata identified in Test trench T1 at Qoornoq.

5 APPENDIX B: SITE DESCSRIPTIONS

REMAINS OF GREENLAND' - FIELD REPORT

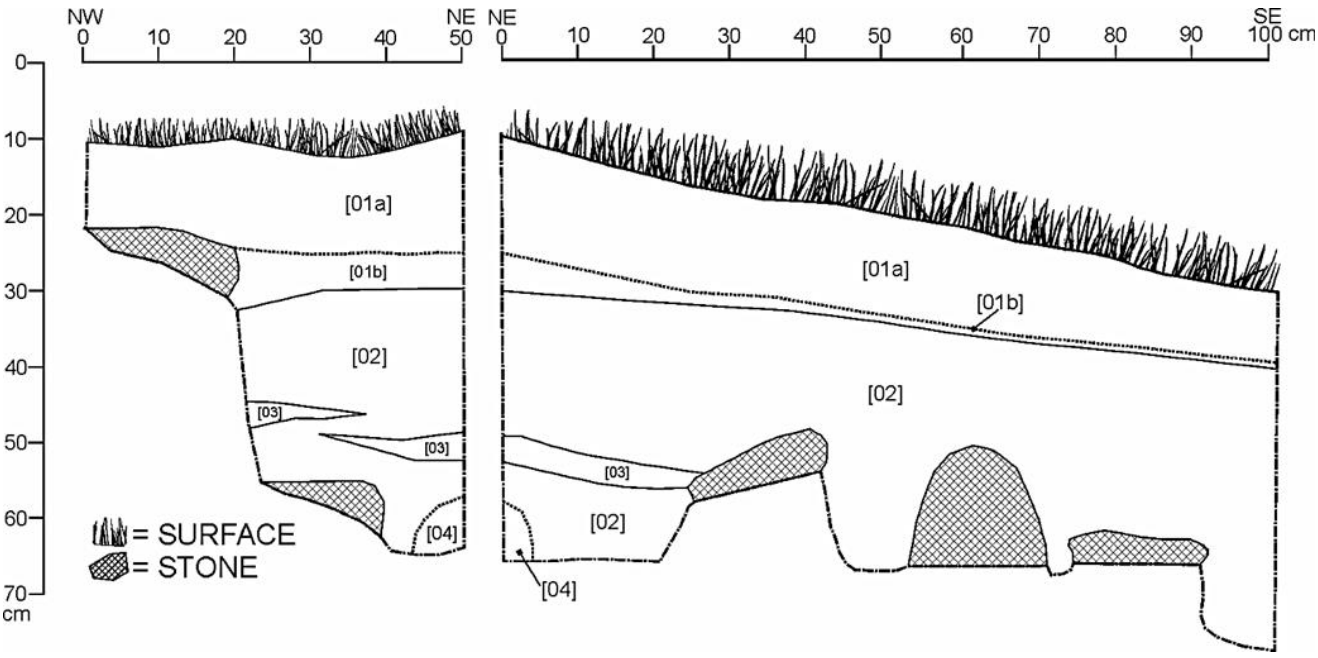

Fig. 4. Profile of North and East walls of Test trench T1 at Qoornoq.

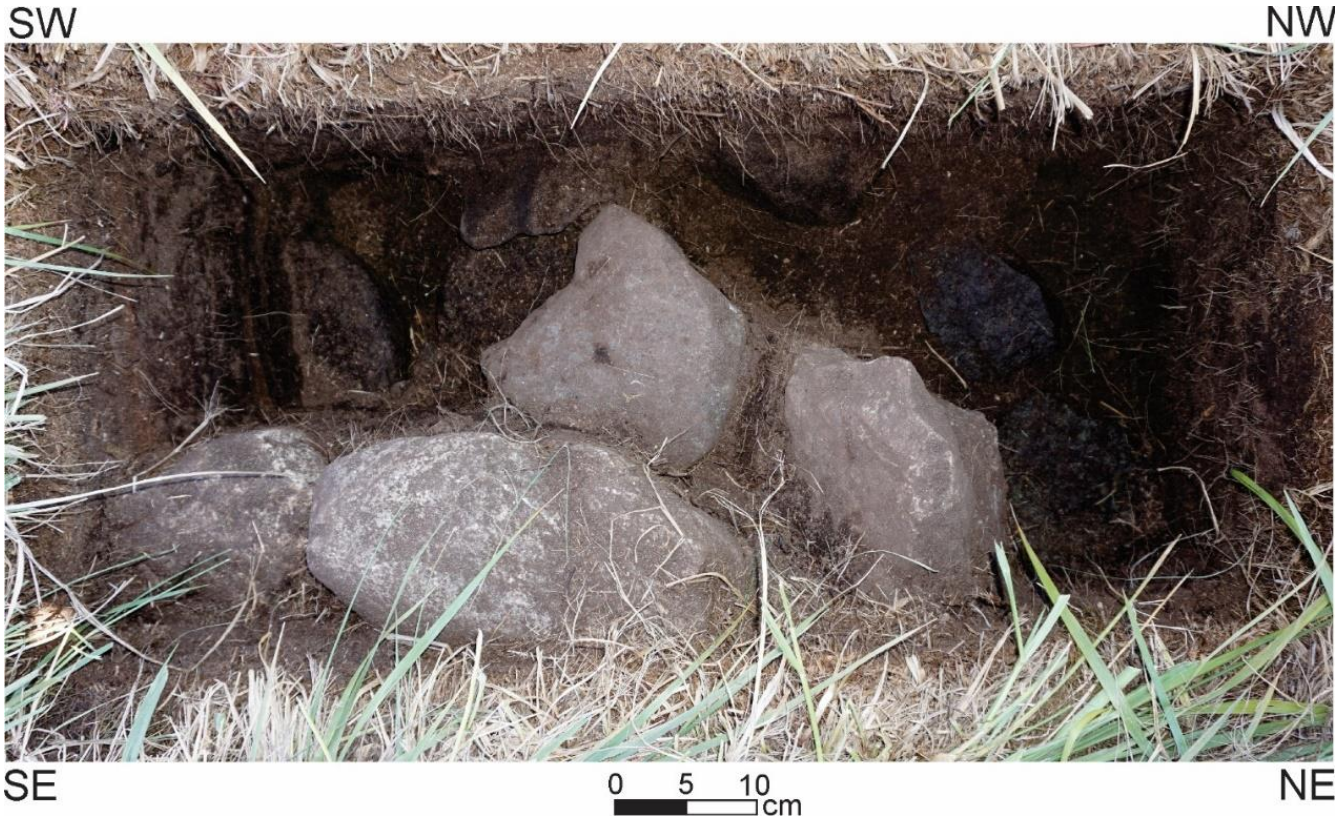

Fig. 5. Areal plan photo of T1.

5 APPENDIX B: SITE DESCSRIPTIONS

T1 produced 44 individual artefacts, detailed by type, quantity (*n*) and weight in Table 2. Bulk samples of charcoal, bone, shell and wood were also collected and are listed by number of samples bags and aggregate weight in Table 3. All finds were collected in sterile sample bags and segregated based on provenience. An additional 12 bone samples were collected in situ from T1 at depths of 0-20, 15-25, 26-35, 36-45 and 49 cm below the surface in sterile sample bags. Five wood samples were collected in situ in separate sterile bags at 0-30 cm below the surface. These specimens possessed varying degree of degradation and were selected from the different stratigraphic layers. Volume specific soil samples (100 cm^3) taken at -5, -10, -20 and -35 cm depths below the surface.

Table 2. Total T1 artifacts, detailed by type, quantity (*n*) and aggregate weight.

Artifact type	***n***	**wt. (g)**
ceramic	14	21.9
fur	1	.23
glass	13	37.7
lithic	3	146.9
metal	4	18.9
misc. modern	3	2
worked bone/antler	3	2.9
Total (*N*)	**44**	**358**

Table 3. Total T1 samples, detailed by type, number of sample bags taken and aggregate weight.

Sample type	**# of sample bags**	**wt. (g)**
charcoal	5	21.8
bone	5	101.2
blue mussel (*Mytilus edulis*)	4	3.2
wood	3	7
Total	**16**	**114.6**

In addition to archaeological sampling at T1, one sample of Fagus sylvatica (European beech), one sample of Pinus sylvestris (Scots pine) and three unmacerated bone samples were buried at the depths (-5, -10, -20 and -35 cm below the surface) to study decomposition processes (Fig. 6).

Fig. 6. Modern bone and wood samples installed in T1 at Qoornoq.

Trench T2

T2 was located in ruin group 2 (Fig. 3., map no. 13) where the remains of at least six Thule-Inuit winter houses are observed approximately 50 m from the present-day shoreline of the island's small eastern cove. T2 was strategically placed on a slightly elevated mound presumed to be at the entrance of the house on top of a midden feature. T2 was excavated by spade and trowel to a depth of approximately -105 cm, reaching its greatest depth at its northern-half. Trench provenience was based on northwest coordinates with a datum placed 10 cm above the ground surface.

All soil horizons and contexts are summarized below (Table 4). One of the most significant features of T2 is that the trench had–as hoped for–intruded into a previous excavation by H.C. Gulløv 1979. Soil in this context [02] is characterized as backfill comprised of mixed dark brown to gray silty sand.

0-20 cm below datum

Context [01a, b] consisted of a single contiguous O-Horizon observed occurring approximately 0-20 cm below datum. Toward the bottom of the layer the vegetation become more demonstrably degraded with an increased density of bone and blue mussel shells (*M. edulis*).

20-30 cm below datum

Between 20-30 cm, Context [03] is identified as a well-constrained midden deposit; heterogenous in nature and comprised of friable, mottled dark brown/gray with yellow silty sand with dissolved organics that include bones, blue mussel and some wood. Context [03] (and [18] in the west wall) appears as complimentary to context [05]. Although only observed in the east wall, [05] is a thin midden deposit comprised of dark brown/black mottled sand. In the west wall [03] and [05] are separated by context [04], a dark brown peat deposit mixed with sand and overlying sterile layers of fine gravel and coarse sand. This interruption suggests possibly either a marine in-wash event or a period when the site may have been abandoned, allowing for the undisturbed deposition of aeolian sands.

30-40 cm below datum

In the west wall between 30 and 40 cm, a naturally occurring yellow gravel deposit [06] of alluvial origin is observed. Context [07] appears to be a well-constrained midden deposit layer composed of a mottled, dark gray-brown friable sandy silt. Artefacts included degraded bone and wood, blue mussel and a few specks of charcoal.

40-60 cm below datum

Contexts [08] and [09] are observed as cultural deposits. Context [09] comprised a heterogeneous gray, friable silty sand midden deposit, densely layered with bones, mussel shell, dissolved wood and charcoal. Based on its composition, [08] appears to be an overlying or collapsed turf wall feature. This deposit appears as dark brown to gray, sandy silt. It is fairly compact relative to other layers, with a few dissolved bones and what may be a large degrading turf mass.

60-85 cm below datum

Contexts [10]-[15] and [19] are observed as a series of thin layers resting more or less horizontally against stones. As these layers were all sterile for cultural inclusions, they are most likely to be interpreted as a series of natural deposition events (peat formation, aolian and alluvial deposits). Alternatively, the layering could be from the cutting of turf/peat (on virgin soils) and represent wall or other building material, but the test unit was too small to provide any conclusion on this.

85-110 cm below datum

Contexts [16]-[17] are observed as natural deposits in the form of sorted aeolian sands of varying color.

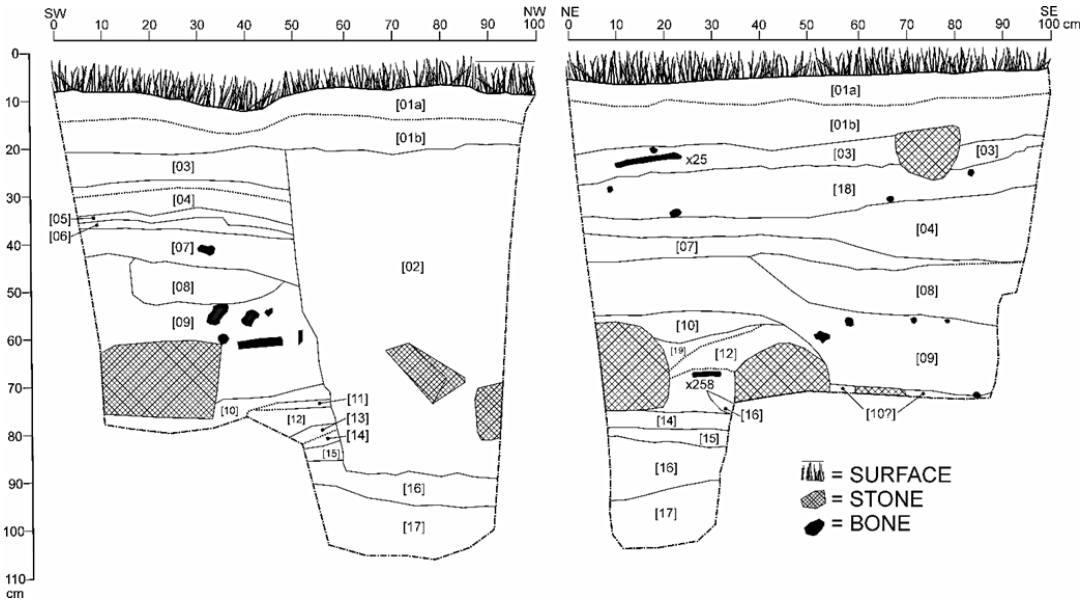

Fig. 7. Profile of West and East walls of Test trench 2 (T2), Ruin group 13 at Qoornoq.

Fig. 8. Areal view of the turf and stone wall feature observed in the southern half of T2 at Qoornoq.

5 APPENDIX B: SITE DESCSRIPTIONS

REMAINS OF GREENLAND' - FIELD REPORT

Depth	Context no.	Description	Interpretation
0-20 cm	[01a]	Vegetation layer with roots.	O Horizon
0-20 cm	[01b]	Partly decomposed vegetation layer with some bones and mussels.	O/A Horizon, mixed midden deposit
0-20 cm	[02]	Dark brown to gray mixed silty sand, cut with backfill.	Backfill from Gulløv 1979
20-30 cm	[03]	Heterogeneous, friable dark brown mottled with gray and yellow silty sand, dissolved organics, many bones and mussels and some wood.	Midden deposit
20-30 cm	[04]	Dark brown peaty deposit somewhat mixed, somewhat mixed sand(?) with inclusions of a few bones overlying sterile layers of fine gravel and coarse sand (aeolian) +	Peat formation with in-wash (?) on aaeolian deposit.
20-30 cm	[05]	Dark brown mottled with black sand with dissolved organics, some bones and dissolved wood.	Midden deposit
30-40 cm	[06]	Yellow sterile gravel, alluvial deposit, natural	Alluvial sediment
30-40 cm	[07]	Dark brown mottled with gray friable sandy silt with inclusions of many bones, dissolved wood, lenses of mussels and specks of charcoal.	Midden deposit
40-60 cm	[08]	Dark brown to gray sandy silt, fairly compact with a few dissolved bones and turf lump?	Turf wall?
40-60 cm	[09]	Dark brown to gray heterogeneous and friable silty sand with many bones, mussels and some specs of charcoal, dissolved wood, organics.	Midden deposit
55-65	[19]	Light gray, slightly sandy S/H with no cultural inclusions	Peat/turf deposit
70-80 cm	[10]	Dark brown sandy silt, sterile, peat from turf wall?	Natural peat (or turf wall?)
70-80 cm	[11]	Light gray, sorted fine sand and Aaeolian deposits.	Aeolian sands
70-80 cm	[12]	Similar to [10].	Natural peat (or turf wall?)
70-80 cm (west wall)	[13]	Dark gray coarse sand, sorted and sterile.	Alluvial sediment
70-80 cm	[14]	Yellow coarse sand, sorted and sterile.	Aeolian deposit

80-90 cm	[15]	Dark brown to black pure clayish silt	Wetland (peat) deposit
80-90 cm	[16]	Light gray sorted sand.	Aeolian sand
90-110 cm	[17]	Yellow to brown sorted sand.	Aeolian sand
30-40 cm (east wall) 90-110 cm (west wall)	[18]	Grayish brown silty sand, heterogeneous and highly friable with inclusions of many bones and mussels, some specs of charcoal and dissolved wood.	Midden deposit

Table 4. Soil strata identified in Test trench T2 at Qoornoq.

T1 produced 21 individual artefacts, detailed by type, quantity (*n*) and weight in Table 5. Bulk samples of charcoal, bone, shell and wood were also collected and are listed by number of samples bags collected and aggregate weight in Table 6. All finds were collected in sterile sample bags and segregated based on provenience. From the bulk material, thirty-six (*n*=36) bone samples with varying degree of degradation from the different stratigraphic layers were selected and sent to the National Museum of Denmark for further analysis. Additionally, six archaeological bone samples were collected sterile in T2 at -35 (*n*=1), -40 (*n*=2), and -55 (*n*=3) below the surface. Volume specific soil samples (100cm^3) and bulk samples were collected at -10, -20, -30, -40, -50, -60, -70 and -80 cm depths below the surface. Five (*n*=5) native pieces of wood, naturally decayed, were sampled in sterile bags from the foliage of *S. glauca* scrubs close to the excavation site. No modern bone or wood samples were installed in the walls of this trench.

Artifact type	***n***	**wt. (g)**
worked bone	12	380.6
worked tusk/ivory	1	18
Metal chain link/ornamental fitting	1	.2
round ball, unidentified material	1	6.3
lithic (chalcedony, opaque)	1	5.7
lithic (slate)	3	649
lithic (steatite, unworked)	1	33.2
lithic (steatite, worked)	1	12.2
Total (*N*)	**21**	**1105.2**

Table 5. Total T2 artifacts, detailed by type, quantity (*n*) and aggregate weight.

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Sample type	# of sample bags	wt. (g)
charcoal	6	23.4
bone	10	3766.20
blue mussel (*Mytilus edulis*)	8	3137.20
wood	9	100.7
Total	**33**	**7027.5**

Table 6. Total T2 samples, detailed by type, number of sample bags taken and aggregate weight.

Vegetation Studies

Detailed vegetation analyses were carried out on six 1x1 m plots on the archaeological site in the eastern part or Qornooq ("cultural" 1-6) and on six 1x1 m plots on the surrounding natural soil ("natural" 1-6). The location of each plot is shown in Fig. 9. Each plot was photographed with a high-resolution camera (Hasselblad) and a multi-spectral camera (Sequia) and NDVI was measured using a Decagon NDVI sensor. The vegetation cover was quantified using a 1x1 meter frame divided in to 25 sectors by pinpoint analysis. A 0.2 x 0.2 m area within each plot was harvested and green biomass collected. The same sample area was then dug to a maximum depth of -30 cm below the surface. Volume specific soil samples (100cm^3) were collected at -5 cm, -10 cm, -20 cm and -30 cm below the surface. After sampling, the hole was backfilled and vegetation cover replaced to minimize damage to the site. For each plot, fifteen to twenty leaves were harvested from one to three species on or close to each sample plot.

To investigate the recent increase in growth of *S. glauca* (Northern willow), dendrochronology samples were collected near T2 and in the surrounding reference ("natural") area. When a sample plant was identified, 10-20 cm of the root column was cleared from soil and debris. Then the stem (comprised of approximately 10-20 cm root and 10-20 cm above-ground stem) was sawn away and collected. Additionally, fifteen (n=15) leaves from each sample trees were harvested to conduct C/N + ^{15}N analyses.

5 APPENDIX B: SITE DESCSRIPTIONS

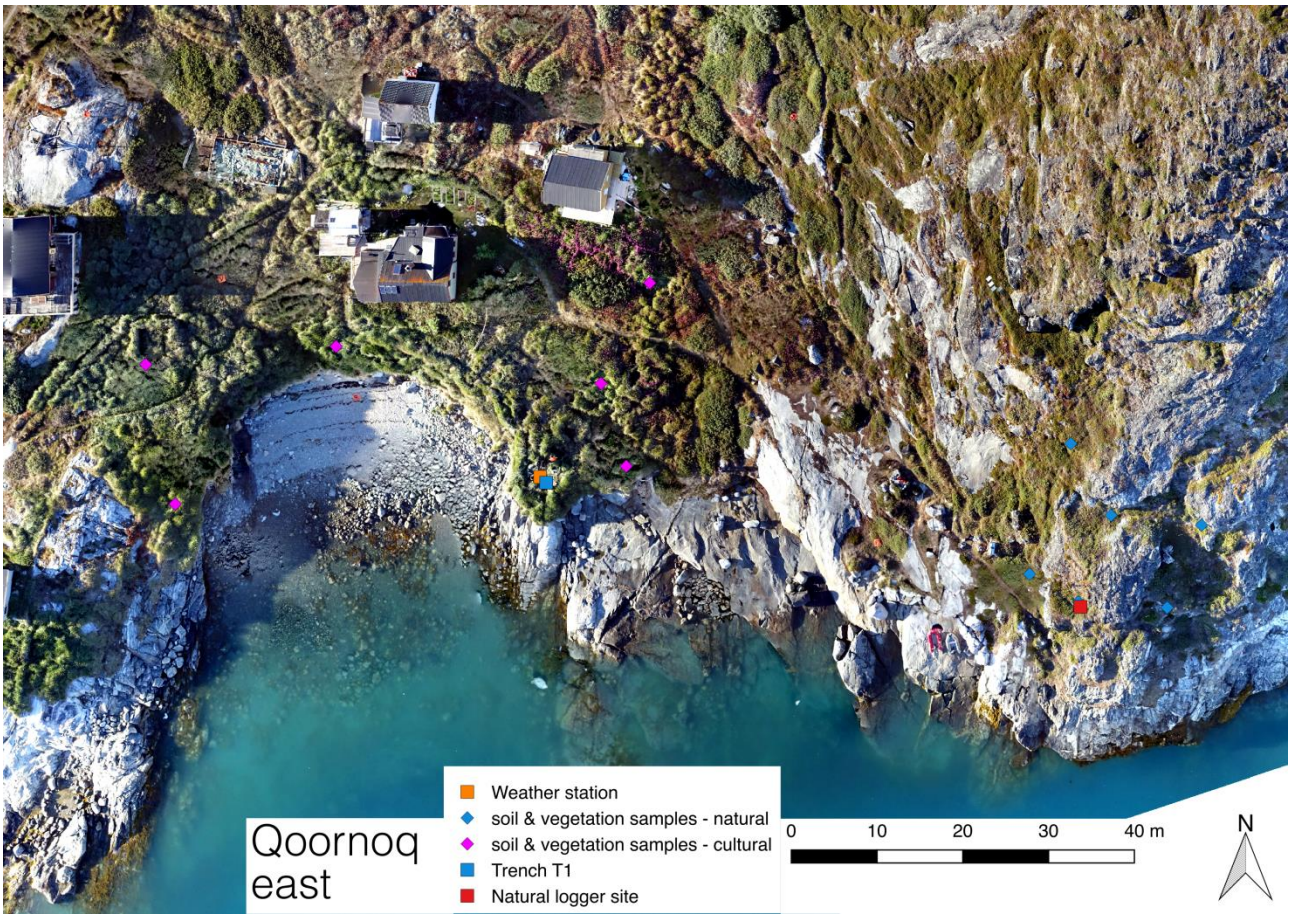

Fig. 9. Drone map of the Qoornoq east (ruin group 1, map no. 10) showing the positions of Trench 1 (T1) soil and vegetation sampling and installation of environmental monitoring equipment.

At Qoornoq, a total of twenty-four (*N*=24) *S. glauca* stems were collected. Twelve (*n*=12) stems were sampled from ruin group 2 (map no. 13). Six (*n*=6) stems were sampled in the house ruins south of T2 and six (*n*=6) stems sampled north of T2. Twelve (*n*=12) stems were also sampled from the "natural" surroundings: Four (n=4) stems were sampled north of T2 outside of the visible house remains. Additionally, four (*n*=4) stems were sampled to the south of the winter house ruins found on the southern tip of the island (see Fig. 3, map no. 9), and four (*n*=4) stems sampled east of ruin 9. All sample areas were documented with photos and GPS points. *S. glauca* stems were not sampled in and around ruin group 1 (T1). Modern cabins and gardens are clustered in this area, and *S. glauca* was not readily observed in any significant density. In the vicinity surrounding the ruin group 1, some *S. glauca* growth was observed but it was sparse and low in height (<50 cm).

At two locations holes were dug next to *S. Glauca* to study the root penetration depth. The roots penetrated only to 25 cm depth, even if the plants were 100 and 180 cm high.

GPS and UAV Surveys

A high precision TRIMBLE RTK-dGPS was used to (1) map archaeological features; (2) anchor ground control points; (3) map the positions of sampling locations and environmental monitoring sites and (5) collect geomorphologic data. The latter included mean high-tide shorelines, vegetation lines, cross-shore profiles at all pocket-beaches and open-embayment beaches and profiles over the salt marsh. The cross-shore profiles (beach topography) was correlated with local flooding statistics, using tidal curves and water level data.

A quadcopter UAV (Tarot 650-sport) was used to conduct a mapping survey of the site. A total of seven (*N*=7) flights were performed. Three of the flights were surveys with the purpose of mapping ruin group 1 and its surroundings with a regular RGB camera (Sony RX100). A GPS failure on the Tarot resulted in some uncertainty, which is the reason why the site survey was carried out several times.

The remaining four flights were carried out as a part of a methodological study along a transect at four different altitudes (100 m, 80 m, 60 m, 40 m). Three different cameras were used to collect ground data: (1) a regular RGB camera (Sony RX100): (2) a multi-spectral camera (Seqoia); and (3) a

modified NDVI camera (Canon). The purpose of this study was to investigate how the flight altitude influenced the data captured on the three different cameras. Detailed information on each flight is seen in Table 7.

Date	Local time	Weather	Survey type	Camera	Altitude (m)	Area (km^2)	# of photos
13/08/16	12:37-12:43	Sunny	Site survey	Sony RX100M3	90	0.032	108
13/08/16	19:06-19:10	Sunny	Site survey	Sony RX100M3	90	0.032	179
13/08/16	19:43-19:46	Sunny	Site survey	Sony RX100M3	90	0.032	86
14/08/16	12:44-12:48	Sunny	Transect	Sony RX100M3	100,80,60,40		64
14/08/16	13:02-13:08	Sunny	Transect	Canon	100,80,60,40		174
14/08/16	13:53-13:57	Sunny	Transect	Sequoia	100		38
14/08/16	14:54-14:57	Sunny	Transect	Sequoia	100,80,60		48

Table 7. Detailed information on the flights carried out at the site using a quadcopter UAV (Tarot 650-sport).

Environmental monitoring

Measurement of *in situ* pH, water content and conductivity was carried out in both T1 and T2 for every 5 cm depth during excavation. In 2016, a weather station was installed at T1. Until August 2018, the station (Campbell Scientific CR1000 data logger) measured air temperature and relative humidity (CS215 Temperature & RH Probe), precipitation rates (52202 Tipping Bucket Raingauge), soil temperatures at 0, -10, -20 and -35 cm (Campbell Scientific 107 probe) and soil water contents at -5, -10, -20, and -35 cm depths (Theta Probe). Volume specific soil samples (100cm^3) were taken in the same depths to calibrate sensors.

Soil temperature (Tinytags) and soil water content sensors (Theta Probes) were installed in the natural soil next to the midden. Soil temperatures were measured every hour at 0, -10, -20 and -35 cm depths. Volume specific soil samples (100cm^3) were taken in the same depths to calibrate sensors. An automatic camera was also installed on top of the weather station and programmed to take photos three times per day.

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During the investigation efforts were made to replicate historic photos.

All monitoring equipment and sensors were removed from the site in August 2018.

Protocol

Table 84. Observations made at Qornooq in 2016 using the REMAINS field protocol.

Table A	
Site	Qoornoq
NKAH no	577 (V69), 1468
Serial no /FM number	FM 64V1-001-009, 501
Region	Godthåbsfjorden
Number of structures	2 middens, large number of Thule and Norse houses, modern fish factory. Here focus is on middens in areas on map nos. 10 and 13 (Gulløv 1983, page 48)
Location	
N/W (decimal degrees; WGS84)	64.533140°, -51.0892260°
Height above sea level (lowest and highest point)	0-10 m (check GPS data) - sea reaches foot of midden at spring tide
Distance from reference point to erosion front	
Setting/surroundings	Placed between 40-50 summer cottages
Site description	
Site type	Winter dwelling, middens
Date culture	Norse, Thule, historic
Finds	
Dimensions/outline	2 middens, ca 10x20 and 20x30 m each.
Thickness of deposits	up to 50 cm
Vegetation cover	Lyme, horsetail, bluejoint, fireweed, chichweed (marehalm, padderok, rørhvene, gederams, fladstjerne). A few willows (gråblå pil) on midden.
Photos (add numbers from other participants)	RF has repeated historic photos. HMA photo no 4222-4236; 4244-4273; 4348-4398, including photography of the whole erosion front
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)	
Archaeological value (1-5 as above)	
State of preservation (1-5 as above)	2-3
Preservation conditions (1-5 as above)	2
Ongoing degradation? (comparison to earlier site visits)	Local residents report that 2 m of the midden were eroded during a storm ca 2 years ago. Lyme grass is now covering the erosion front.
Date visited	12-18/8/2016
Visited by	Christian Koch Madsen, Hans Harmsen, Randi Sørensen Johansen, Ulunnguaq Nielsen Lyberth, Allan, Jørgen Hollesen, Henning Matthiesen, Roberto Fortuna, Nanna Bjerregaard Pedersen, Annemarie Eriksen, Rasmus Fenger Nielsen, Emil Andersen, Bo

	Elberling, Aart Kroon, Andreas Westergaard-Nielsen

Table B	
Site	Qoornoq
State of preservation	
Buildings/site structure and integrity	
Physical disturbance	
Volume excavated during visit	2 trenches in Norse (T2) and Thule (T1) midden, 50x100x50 cm. 1 small trech in natural reference area
Materials found (list)	Wood, bone, mussel, iron (nail, cartridge), glass, porcelain
Wood	1
Bone	Average 2.1 in T1 (97 bones), and 3,2 in T2 (684 bones)
Stratigraphy	
Other	In Thule midden the mussels were completely decalcified; better preserved in Norse midden
State of preservation, in brief (1-5)	2
Measurements during visit (ranges)	
Documented by drone	Mikkel Myrup and Rasmus Fenger Nielsen
Active layer thickness (range and date measured)	Middens completely thawed
Soil temperature (range and date measured)	4-20 C (13-15/8/2016)
Water content (range measured)	10-30% vol in middens, 6-20% vol in natural soil
Conductivity (range measured)	30-80 mS/m (in excavation pits)
pH (range measured)	4.3-6 (T1, Thule midden), 5.2-7.8 (T2, Norse, with shells), 4.5-5.5 (natural soil)
Sea level (logged: yes/no)	March 2017-August 2017
Root depth	Root from Horsetail and Lyme down to at least 30 cm. Checked root depth of willow in natural soil - these only reached 20-25 cm, even though the soil depth was up to 60 cm.
Other (ground water level,…	Oxygen: soil in trench 1 is fully oxygenated (15/8/2016)
Samples taken during visit	
Soil (list samples/number)	Ring samples from trench 1 and reference trench (at loggers)
Artefacts (list materials)	Bones for decay studies
Other materials (list)	Vegetation (Emil)
Vegetation (leaves/biomass/dendrosamples)	Living willow samples for dendro (NBP/AME)
Evaluation of value	
Experience: beauty/monumentality	Ruins visible and contributes to landscape experience
Experience: memory/historic value	Local residents have strong connection and memories to site
Physical integrity	Poor for Thule midden (T1), good for Norse midden (T2)
Physical preservation	
Archaeological rarity/representation	
Archaeological information value	3-4
Archaeological assemblage value	2
Archaeological value, in brief (1-5)	Eroding Thule midden 1, central norse midden 4-5
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	High risk. Probably as single events during storms at spring tide.
Other erosion (wind, animals, visitors)	Some erosion from visitors/local residents
Damage from vegetation, roots	Horsetail roots down to approx 30 cm depth. Willow??

Drainage	Midden already dry during visit
Melting, heating	Middens south facing and warm.
Soil movement (including creeping, cryoturbation, slide)	
Decay of organic materials	High risk due to unsaturated, oxic conditions
Other threats	
Future threats?	
Preservation conditions, in brief (1-5)	2
Are earlier descriptions available for comparison (references)	Gulløv 1983, s.47p. Some old photos are available, but modern replica photos do not show loss in comparison
Monitoring	
Already initiated (which parameters)	Water content, temperature in trench 1 and natural reference. Precipitation. Automatic camera
Suggested (which parameters)	
Important unknowns/research needed	
Mitigation - summary of recommendations	
Refill trenches	
Backfill	
Erosion protection	
Cut back vegetation	
Fencing	
Rescue excavation	

References

Gulløv, Hans Christian. 1983. *Nuup kommuneam gangarnitsanik eqqaassutit inuit-kulturip nunaqarfii*. Nuuk: Kalaallit Nunaata Katersugaasivia (Nationalmuseet Grønland).

Iffiartarfik [NKAH 1457]

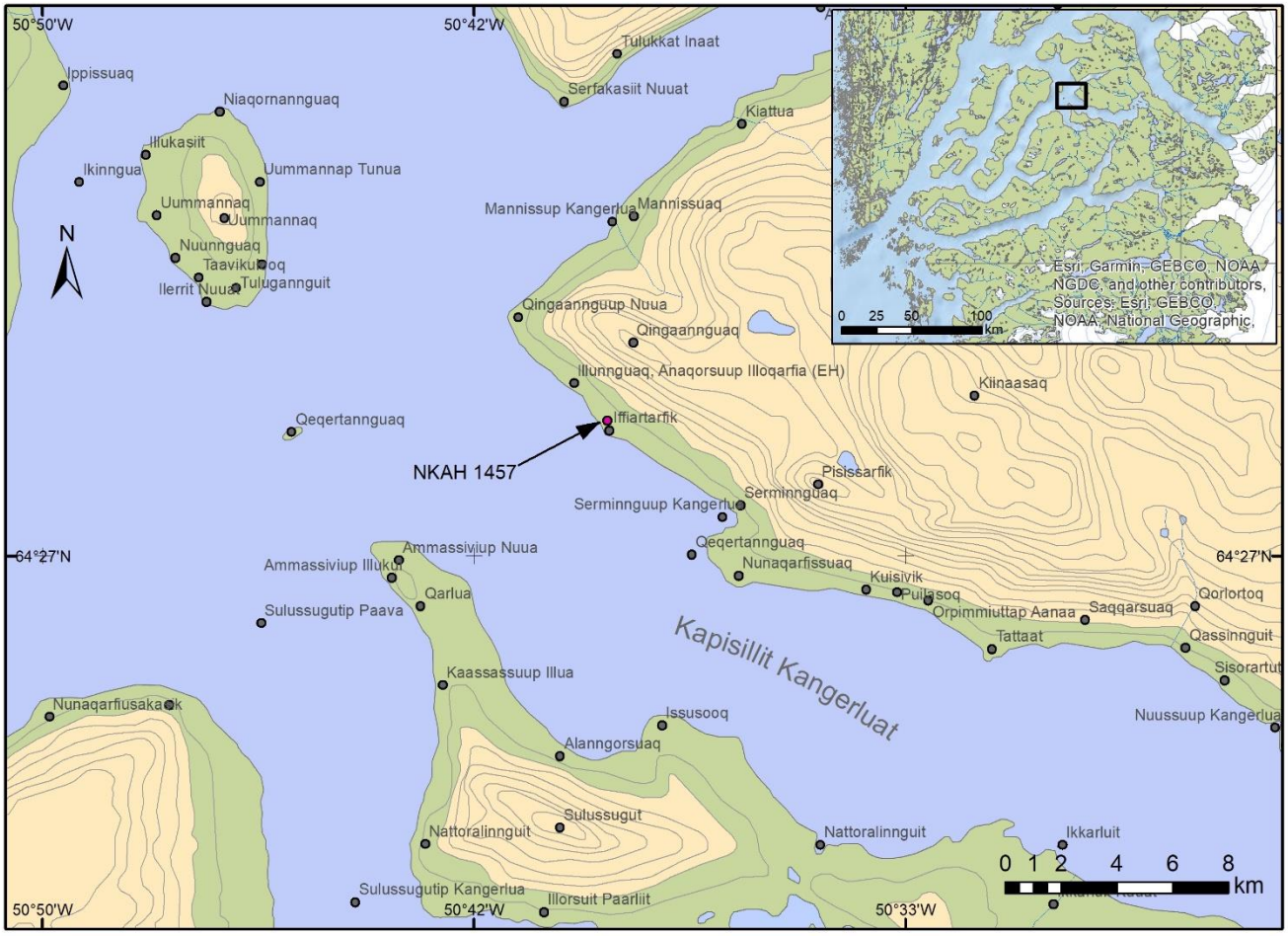

Fig. 1. Location of Iffiartarfik (NKAH 1457) in the Kapisillit Kangerluat.

Site description

The ruin group at Iffiartarfik (64.463190°, -50.6515970°) is located close to the modern shoreline in a relatively small coastal zone (ca. 200 m wide) in the Kapisillit Kangerluat (Fig. 1). The coastline of this part of the fjord consists of sand and gravel, with a very distinct barrier-berm system. Wash-over fans have been created intermittently, probably during extreme water levels with relatively large waves (large for this fjord environment with limited fetches of ca. 1 m). The upper level of the barrier is not flooded very often as evidenced by the dense vegetation cover at the site. The overall configuration of the geomorphology of the area is heavily determined by hard-rock outcrops that are sub-areal during low-tide. These outcrops create a sheltered sedimentary platform behind them and the possibility to form transverse intertidal bars (eg. high-tide tombolos, see Fig. 2). The coastline has probably been quite stable over the last few decades.

6 APPENDIX B: SITE DESCSRIPTIONS

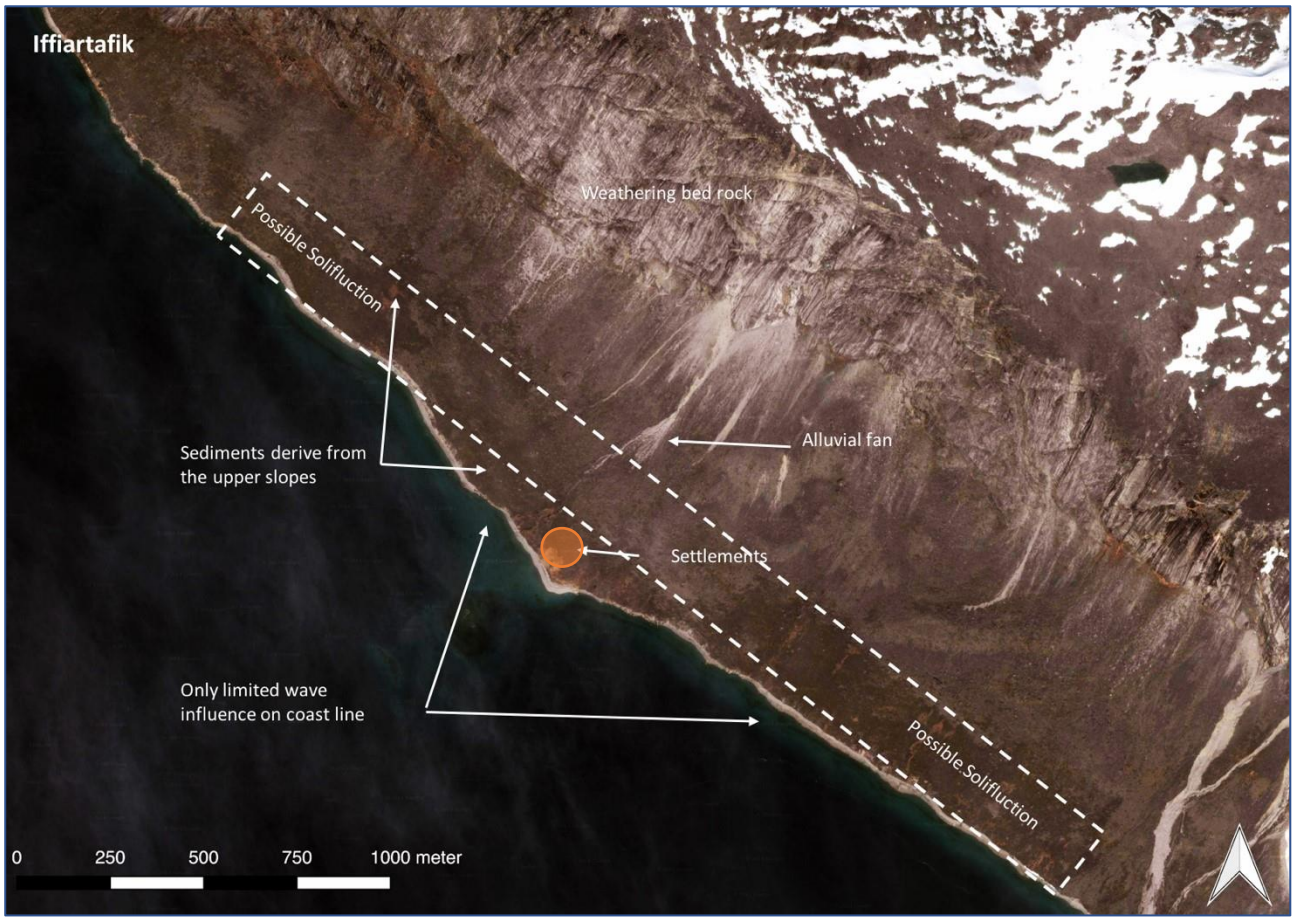

Fig. 2. Geomorphology of Iffiartarfik. The location of the ruin group NKAH 1457 is indicated by the orange circle.

The interior uplands of Iffiartarfik are characterized by steep slopes with debris flows, falls and slumps. Solifluction might be present on the lower slopes, but are definitely subordinate to the other hill-slope processes. These hillslope features often extend directly into the littoral zone. Most of the sediments derive from weathered bedrock originating from the top of the slope. Parallel debris flows are observed running down the hill. Alluvial fans are observed at the bottom of the hill where the slope flattens out. The main ruin group at Iffiartafik lies approximately 25 m from the modern shoreline (Fig. 3).

Archaeological investigations and sampling

One test trench measuring 0.5x1 m was opened at Iffiartarfik (Fig. 3) in 2016. This sub-surface testing was performed to: (1) examine preservation conditions of organic remains in the midden; (2) document local soil conditions and install environmental monitoring equipment; and (3) install modern bone and wood samples into the walls of the profile to study natural decomposition. The

6 APPENDIX B: SITE DESCSRIPTIONS

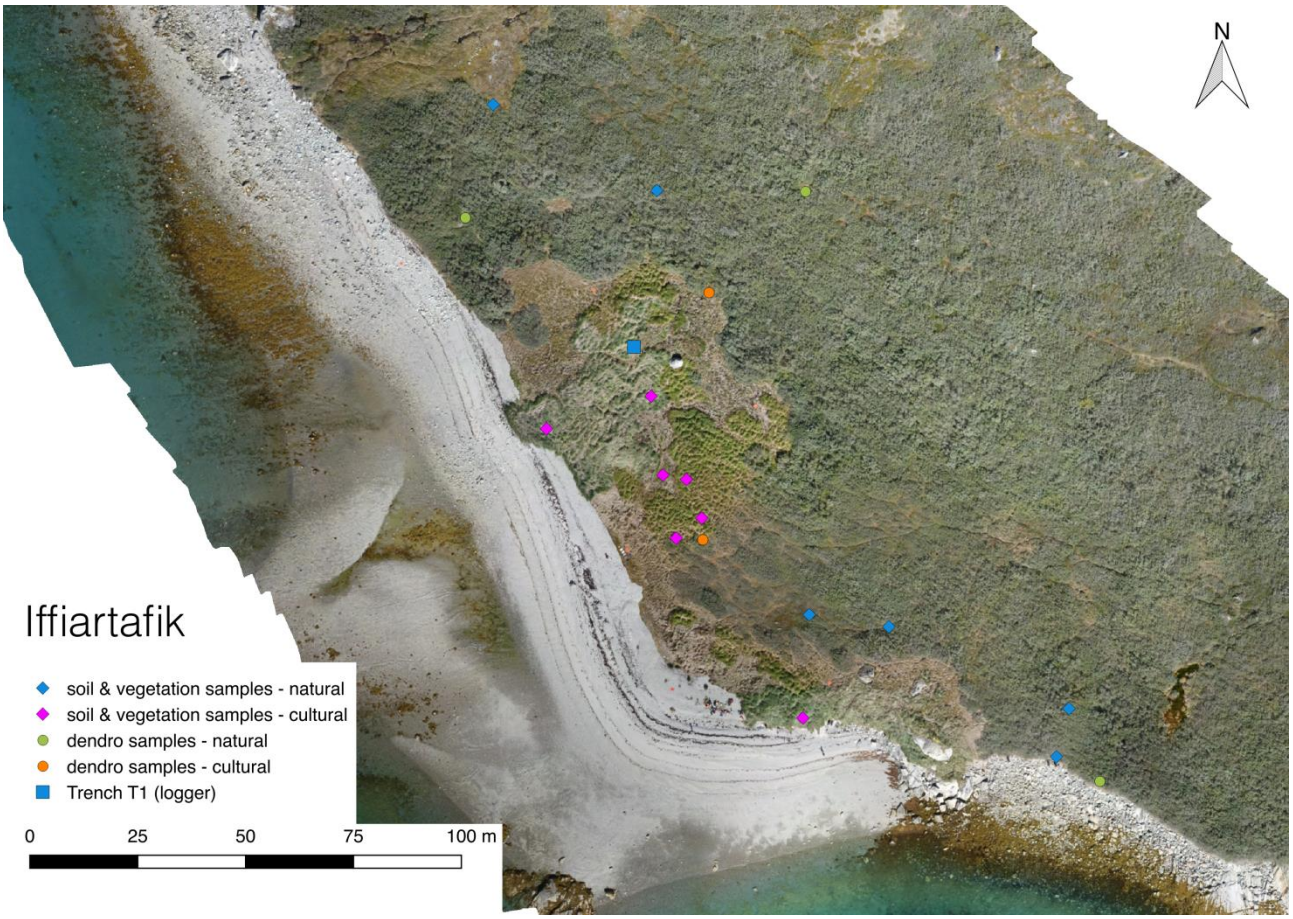

Fig. 3. Drone map of Iffiartafik showing the positions of Trench 1 (T1), soil and vegetation sampling and installation of environmental monitoring equipment.

ruin group at Iffiartarfik comprises a complex of five Thule-Inuit house features built on the footprint of a Norse farm with a tent ring located to the west of the main grouping (Fig. 4). Mummy caves ("mumiehulerne"), visited by Eigil Knuth in 1945 and Jørgen Meldgård 1952 were reported a short distance further inland from the site (Gulløv 1983), but were not identified by the survey team in 2016. Iffiartarfik was first described by the Hernnhut as *Pissigsarbik*. Documentary sources indicate burials by the Moravian church in 1754. Giesecke also mentions the location in 1808 and at that time it was reported that there were several graves at Iffiartarfik (Giesecke 1910).

Trench T1

Test trench 1 (T1) was a 0.5 x 0.5 m test unit located on just below the Norse feature between Thule culture features VIII and IX. The trench was excavated with trowel and dug to the sterile subsoil at approximately 50 cm below the surface (Fig. 5). Detailed observations on the strata identified during excavation of T1 are summarized below and in

6 APPENDIX B: SITE DESCSRIPTIONS

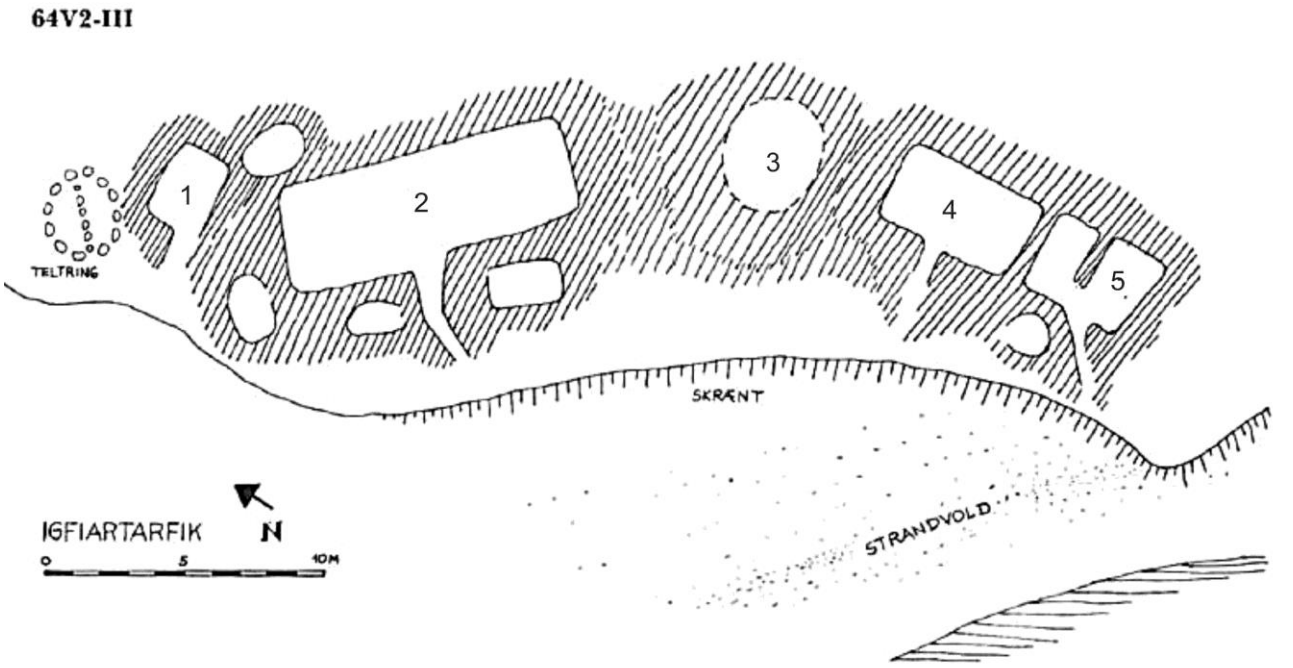

Fig. 4. Ruin group NKAH 1457 at Iffiartarfik. (1) Square house feature and tent ring; (2) nave with depot; (3) round depression; (4) less rectangular house feature; (5) house feature similar to 4 but with partition and depot. Adapted from Gulløv (1983:156).

0-20 cm below surface

Context [01] consisted of a single contiguous vegetation layer (1a and b, O-Horizon) with a distinct transition occurring at approximately 15-20 cm below the surface. [01a] consisted of thick vegetation mass with roots and a few bones and mussels. As depth increased, the layer [01b] became more degraded and the density of bone, blue mussel shell (*M. edulis*) and poorly preserved wood increased. Context [02] demonstrated a well-constrained midden deposit, dark brown and mottled with black sandy silt. This layer possessed many inclusions of decomposed organics (i.e. bones, pieces of poorly preserved wood, specks of charcoal and blue mussel shell).

20-30 cm below surface

Three contexts were observed between 20 and 30 cm below the surface. Context [03] comprised a midden deposit of reddish-brown soil, mottled with dark brown and grey silty sand and decomposed organic inclusions (i.e. turf, wood, etc.). Context [04] demonstrated a thin but well-constrained compact midden deposit containing a high density of mussel shell and few bones (those that were observed may have migrated downward from [03]. Context [05] demonstrated a compact 3-5 layer

grouping of brownish yellow to dark brown silt formed of dissolved turf with no inclusions of cultural material.

30-40 cm below surface

At approximately 30 cm below the surface, context [06] comprised a dark brown coloring mixed with grey, friable silty sand. This midden deposit contained numerous decomposed organics (i.e. mainly degraded wood, bones and a few blue mussel shells). Context [07] was observed as a sterile vegetation horizon; compact and dark brown in color with a texture of sandy silt. At approximately 35-45 cm below the surface, a constrained cultural layer, context [08], is observed to traverse the trench laterally, following the natural slope of the site from east to west. Soil in this layer comprises a black sandy silt, compact with many specks of charcoal.

40-50 cm below surface

From 40 to 50 cm below the surface, two contexts are observed: contexts [09] and [10]. Context [09] parallels the same color and textual characteristics of context [07]; a sterile vegetation horizon comprised, dark brown sandy silt. At approximately 45 cm below the surface, a light greyish brown sand was encountered, this subsoil contained a dense collection of fist-sized beach cobbles and no cultural material. Excavation was concluded at approximately 50 cm below the surface.

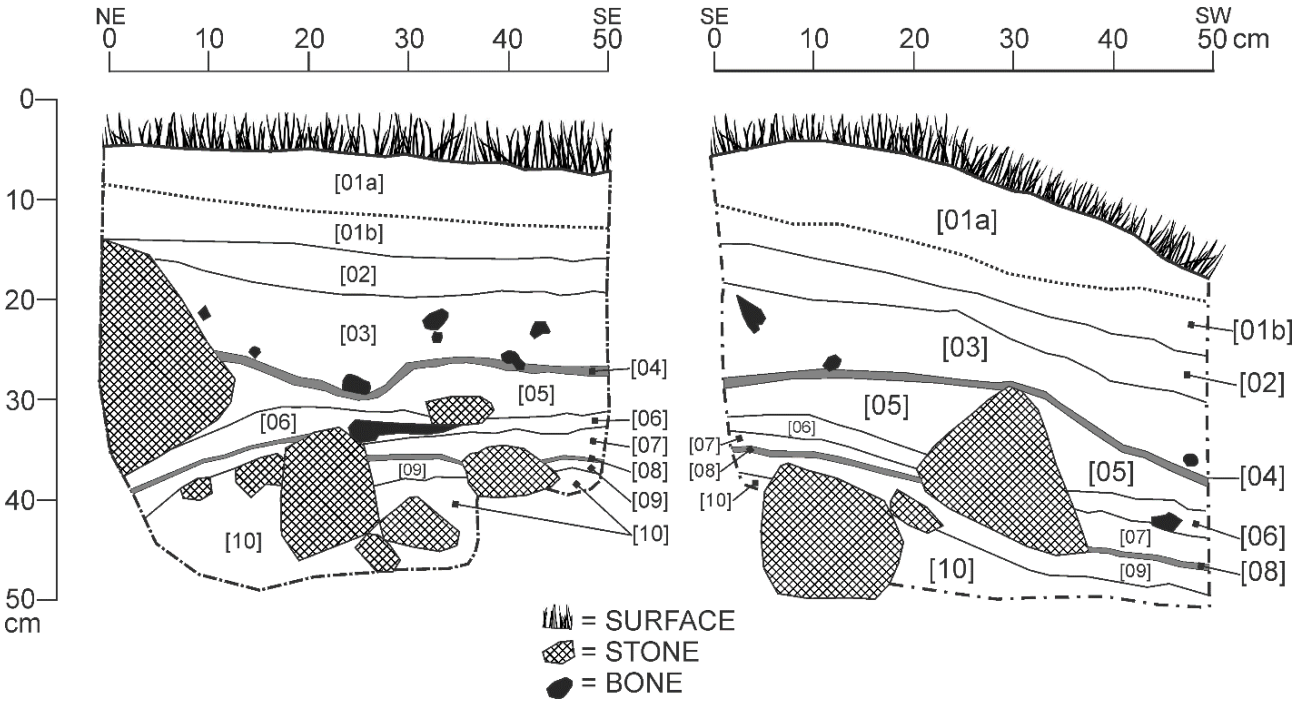

Fig. 4. Profile of East and South walls of T1 at Iffiartarfik.

6 APPENDIX B: SITE DESCSRIPTIONS

Table 1. Soil strata identified in T1 at Iffiartarfik.

Depth	Context no.	Description	Interpretation
0-20 cm	[01a]	Vegetation layer with roots and a few bones and mussels.	O Horizon
0-20 cm	[01b]	Partly decomposed vegetation layer with many bones, some mussels and small pieces of poorly preserved wood.	O/A Horizon, vegetation layer, mixing from top of midden deposit [02]
0-20 cm	[02]	Dark brown mottled with black sandy silt with inclusions of decomposed organics, many bones, pieces of poorly preserved wood, specks of charcoal and many mussels.	Midden deposit
20-30 cm	[03]	Reddish brown mottled with dark brown and grey silty sand with inclusions of decomposed organics (turf, wood, etc.). Some smaller pieces of wood, many bones and some mussels.	Midden deposit
20-30 cm	[04]	Thin compact mussel layer with a few bones, possibly from [03].	Midden deposit
20-30 cm	[05]	3-5 layers of brownish yellow to dark brown silt/dissolved turf with no inclusions of cultural material. 2-3 vegetation horizons, compact.	Sterile; non-cultural deposition
30-40 cm	[06]	Dark brown spotted with grey silty sand, friable inclusions of decomposed organics, decomposed wood, bones and a few mussels	Midden deposit
30-40 cm	[07]	Dark brown sand silt with no cultural inclusions, compact.	Submerged vegetation horizon
30-40 cm	[08]	Black sandy silt, compact with many specks of charcoal.	*Landnám* layer
40-50 cm	[09]	Similar to [07]. Vegetation horizon.	Submerged vegetation layer
40-50 cm	[10]	Light greyish brown sand with many fist sized stones, subsoil.	Sterile subsoil

T1 produced nineteen (*N*=19) individual artefacts, detailed by type, quantity (*n*) and weight in (Table 2)**Fejl! Henvisningskilde ikke fundet.**. Bulk samples of charcoal, bone, shell and wood were also collected and are listed by number of samples bags and aggregate weight in (Table 3). All finds were collected in sterile sample bags and segregated based on provenience. From the bulk material collected, forty-seven (*n*=47) bone samples with varying degree of degradation from the different stratigraphic layers were selected for analysis. Additionally, four (*N*=4) bone samples were collected in situ from T1 from the profile at 15 cm (*n*=2), 20 cm (*n*=1) and 25-30 cm (*n*=1) below the surface. Volume specific soil samples (100cm^3) were also taken at -5, -10, -20 and -35 cm

depths below the surface. Four (*n*=4) naturally decayed wood pieces were also sampled from *S. glauca* close to T1.

Table 2. Total T1 artifacts, detailed by type, quantity (n) and aggregate weight.

Material type	**artifacts (*n*)**	**wt. (g)**
lithic, chalcedony	2	3.1
lithic, steatite	1	23
lithic, sandstone	1	9.6
lithic, other	3	15.3
worked bone/antler	12	33
Total	**19**	**84**

Table 3. Total T1 samples, detailed by type, number of sample bags taken and aggregate weight.

Sample type	**# of sample bags**	**wt. (g)**
charcoal	3	7.9
bone	6	1076.1
blue mussel (*Mytilus edulis*)	4	109.3
wood	4	31.8
Total	**17**	**1225.1**

In addition to archaeological sampling at T1, one sample of Fagus sylvatica (European beech), one sample of Pinus sylvestris (Scots pine) and three unmacerated bone samples were buried at each depths of -5, -10, -20 and -35 cm below the to study degradation processes (Fig. 6).

Fig. 5. T1 at Iffiartarfik with the installed sensors and modern bone and wood samples.

Vegetation Studies

Detailed vegetation analyses were carried out on six (*n*=6) 1x1 meter in the immediate vicinity of the ruin group and on six (*n*=6) 1x1 meter plots (“cultural” in Fig. 3) on the surrounding reference area soil (“natural” in Fig. 3). Each plot was photographed with a high-resolution camera (Hasselblad) and a multi-spectral camera (Sequia) and NDVI was measured using a Decagon NDVI sensor. The vegetation cover was quantified using a 1x1 meter frame divided in to 25 sectors by pinpoint analysis. A .2 x .2 m area within each plot was harvested and green biomass collected. The same sample area was then dug to a maximum depth of -30 cm below the surface. Volume specific soil samples (100cm^3) were collected at -5 cm, -10 cm, -20 cm and -30 cm below the surface. After sampling, the hole was backfilled and vegetation cover replaced to minimize damage to the site. For each plot fifteen to twenty leaves were harvested from one to three species on or close to each sample plot.

To investigate the recent increase in growth of *S. glauca* (Northern willow), dendrochronology samples were collected near T1 and in the surrounding reference (“natural”) area. When a sample plant was identified, 10-20 cm of the root column was cleared from soil and debris. Then the stem (comprised of approximately 10-20 cm root and 10-20 cm above-ground stem) was sawn away and

collected. Additionally, fifteen (*n*=15) leaves from each sample trees was harvested to conduct C/N + ^{15}N analyses.

A total of twelve (*N*=12) stems were sampled from Iffiartarfik. Six (*n*=6) *S. glauca* were sampled in the south of the house ruins, close to the beach/sea and six (*n*=6) stems sampled in the eastern part of the house ruins. Twelve stems were also sampled from the "natural" surroundings; four (*n*=4) stems were sampled north of the site, four (*n*=4) stems were sampled south of the site, and four (*n*=4) stems were sampled east of the site. All sample areas were documented with photos and GPS points.

GPS and UAV Surveys

A high precision TRIMBLE RTK-dGPS was used to (1) map archaeological features; (2) anchor ground control points; (3) map the positions of sampling locations and environmental monitoring sites and (5) collect geomorphologic data.

A quadcopter UAV (Tarot 650-sport) was used to conduct a mapping survey of the site. A total of five (*N*=5) flights were performed. Two of the flights were surveys with the purpose of mapping the entire site with two different types of cameras: a regular RGB camera (Sony RX100) and a multi-spectral camera (Seqoia).

The remaining four flights were carried out as a part of a methodological study along a transect at four different altitudes (100 m, 80 m, 60 m, 40 m). Three different cameras were used to collect ground data: (1) a regular RGB camera (Sony RX100): (2) a multi-spectral camera (Seqoia); and (3) a modified NDVI camera (Canon). The purpose of this study was to investigate how the flight altitude influenced the data captured on the three different cameras. Detailed information on each flight is seen in Table 4.

Table 4. Detailed information on the flights carried out at the site using a quadcopter UAV (Tarot 650-sport).

Date	Local time	Weather	Survey type	Camera	Altitude (m)	Area (km^2)	# of photos
15/08/16	12:29-12:34	Sunny	Site survey	Sony RX100M3	100	0.085	133
15/08/16	14:03-14:06	Sunny	Transect	Sony RX100M3	100,80,60,40		43
15/08/16	14:30-14:39	Sunny	Site survey	Sequoia	100	0.085	135
15/08/16	15:06-15:18	Sunny	Transect	Sequoia	100,80,60,40		101
15/08/16	15:45-15:50	Sunny	Transect	Canon	100,80,60,40		73

Fig. 6. A quadcopter UAV (Tarot 650-sport) was used to conduct a mapping survey at Iffiartarfik.

Environmental monitoring

Measurement of *in situ* pH, water content and conductivity was carried out in T1 for every 5 cm depth during excavation. Temperature (Tinytags) and soil water content sensors (Sm300) were installed in the excavated trench of T1 in 2016. Air and soil temperatures were measured every three hours at depths of 0, -10, and -35 cm below the surface. Soil water content was measured every six hours at -5, -10, -20 and -35 cm depths below the surface. Volume specific soil samples ($100cm^3$) were taken in the same depths to calibrate sensors. Precipitation rates were recorded every hour using a Campbell 52202 Tipping Bucket Raingauge connected to a TinyTag pulse counter. All monitoring equipment and sensors were removed from Iffiartarfik in August 2017.

6 APPENDIX B: SITE DESCSRIPTIONS

Protocol

Table 5. Observations made at Iffiartarfik in 2016 using the REMAINS field protocol.

Table A	
Site	Iffiartarfik
NKAH no	1457
Serial no /FM number	FM no 64V2-III-009
Region	Kapisillit Kangerluat
Number of structures	2 middens, Large number of Thule and Norse houses, field
Location	
N/W (decimal degrees; WGS84)	64.463190°, -50.6515970°
Height above sea level (lowest and highest point)	0-10 m (check GPS data) - sea reaches foot of midden at spring tide
Distance from reference point to erosion front	
Setting/surroundings	Placed beneath steep mountain slope
Site description	
Site type	
Date culture	Norse, Thule, historic
Finds	
Dimensions/outline	2 middens, ca 20x30 m each (check GPS)
Thickness of deposits	up to 50 cm
Vegetation cover	Lyme, horsetail, bluejoint (marehalm, padderok, rørhvene). Willows (blågrå pil) mainly outside midden but in house trenches
Photos (add numbers from other participants)	RF Photos of erosion front. HMA 4237-4243
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)	
Archaeological value (1-5 as above)	3

State of preservation (1-5 as above)	3
Preservation conditions (1-5 as above)	3
Ongoing degradation? (comparison to earlier site visits)	Drone data indicates ongoing coastal erosion, but not yet critical for the archaeological deposits
Date visited	14-15/8/2016
Visited by	Christian Koch Madsen, Hans Harmsen, Randi Sørensen Johansen, Ulunnguaq Nielsen Lyberth, Allan, Jørgen Hollesen, Henning Matthiesen, Roberto Fortuna, Nanna Bjerregaard Pedersen, Annemarie Eriksen, Rasmus Fenger Nielsen, Emil Andersen, Bo Elberling, Aart Kroon, Andreas Westergaard-Nielsen

Table B	
Site	Iffiartarfik
State of preservation	
Buildings/site structure and integrity	
Physical disturbance	
Volume excavated during visit	Ca 50x50x50 cm including both Thule, Norse and landnam
Materials found (list)	Wood, bone, antler, mussels, charcoal, calcedon, soapstone
Wood	1 - very poor
Bone	Average state of preservation 3.1 (419 bones)
Stratigraphy	
Other	Mussels varied between well preserved and decalcified
State of preservation, in brief (1-5)	3
Measurements during visit (ranges)	
Documented by drone	Rasmus Fenger Nielsen
Active layer thickness (range and date measured)	Middens completely thawed
Soil temperature (range and date measured)	5-14 (14/8/2016)
Water content (range measured)	10-35%vol. Most of the soil was very dry.
Conductivity (range measured)	30-80 mS/m in excavation pit
pH (range measured)	5.2-7.8

Sea level (logged: yes/no)	No
Root depth	Root from Horsetail and Lyme down to at least 30 cm
Other (ground water level,…	
Samples taken during visit	
Soil (list samples/number)	Ring samples from logger installation
Artefacts (list materials)	Bones for decay studies
Other materials (list)	Vegetation (Emil)
Vegetation (leaves/biomass/dendrosamples)	Living willow samples for dendro (NBP/AME)
Evaluation of value	
Experience: beauty/monumentality	3
Experience: memory/historic value	2
Physical integrity	4
Physical preservation	4
Archaeological rarity/representation	2
Archaeological information value	3
Archaeological assemblage value	4
Archaeological value, in brief (1-5)	
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	Some risk. Probably as single events during storms at spring tide. Aart details?
Other erosion (wind, animals, visitors)	No erosion observed from wind/animals/visitors
Damage from vegetation, roots	Horsetail roots down to approx 30 cm depth. Willow??
Drainage	Midden already relatively dry during visit
Melting, heating	Midden south facing and warm.
Soil movement (including creeping, cryoturbation, slide)	
Decay of organic materials	Probably ongoing
Other threats	

Future threats?	
Preservation conditions, in brief (1-5)	3
Are earlier descriptions available for comparison (references)	Gulløv 1983 (p 156-157); Meldgaard 1952 (notebooks)
Monitoring	
Already initiated (which parameters)	Water content, temperature in trench 1
Suggested (which parameters)	
Important unknowns/research needed	
Mitigation - summary of recommendations	
Refill trenches	
Backfill	
Erosion protection	
Cut back vegetation	
Fencing	
Rescue excavation	

References

Giesecke, K.L. 1910. "Mineralogisches Reisejournal über Grönland." *Meddelelser om Grønland* 35:478.

Gulløv, Hans Christian. 1983. *Nuup kommuneam gangarnitsanik eqqaassutit inuit-kulturip nunaqarfii*. Nuuk: Kalaallit Nunaata Katersugaasivia (Nationalmuseet Grønland).

7. Nuugaarsuk

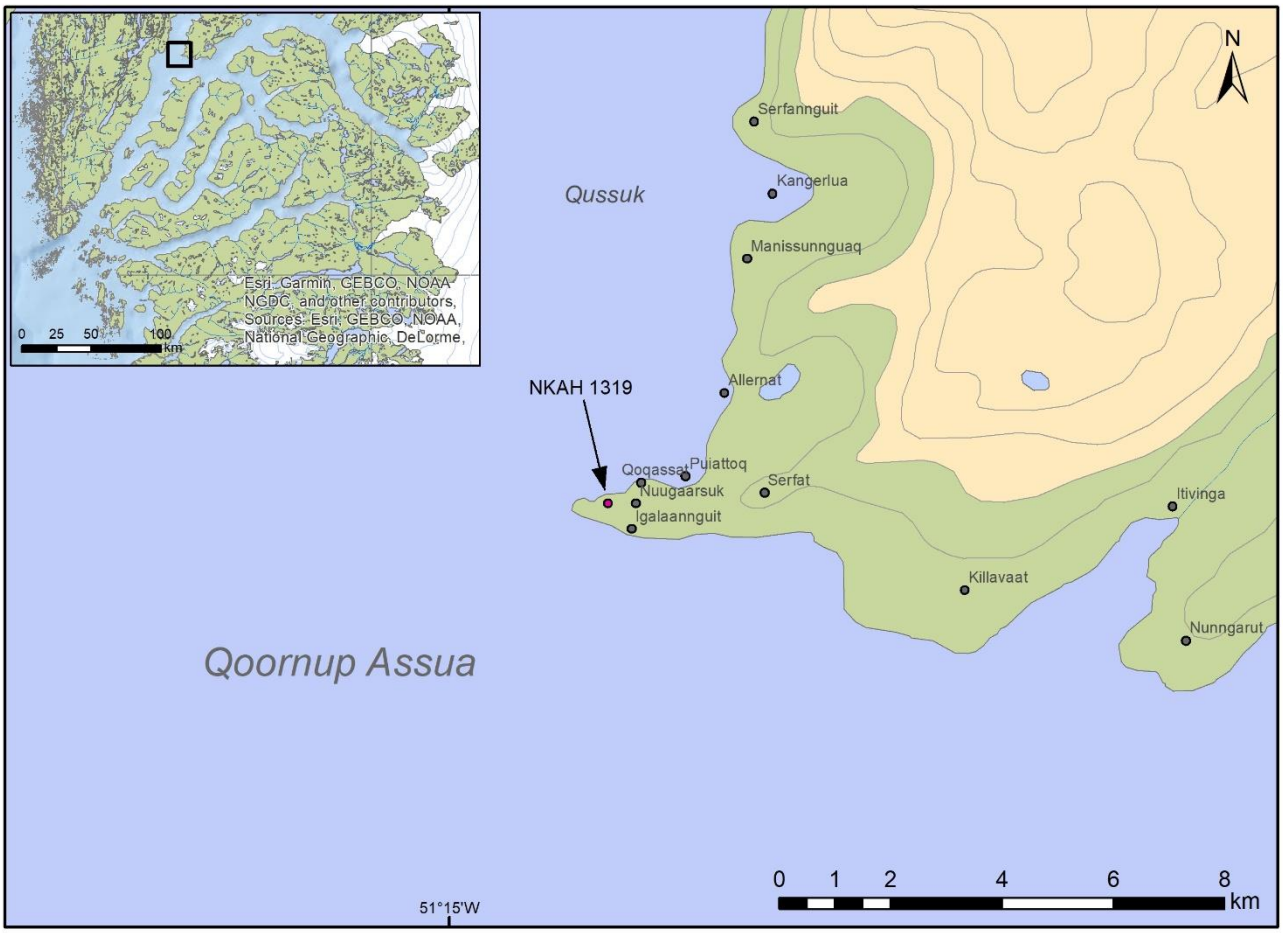

Fig. 1. Location of Nuugaarsuk [NKAH 1319] in the Nuuk Fjord.

Site description

Nuugaarsuk (64.616870°, -51.2243550°) is in the northern portion of the Nuuk fjord on a peninsula that extends to the west into the Qoornup Assua. The site lies on hard-rock and no sedimentary coastlines are observed in the area. During high tides, water levels appear to be reaching up to the vegetation on the southern cliff faces. These hard-rock cliffs are not eroding despite the exposure of the southern shores to large fetches.

The ruin groups at Nuugaarsuk are clustered in two locations. To the west, remains of several (min. of 3) Thule winter houses and midden features are observed on the southern shore and a second group of seven (*n*=7) of more defined and recent house ruins are found to the northwest (Fig. 2). To the east,

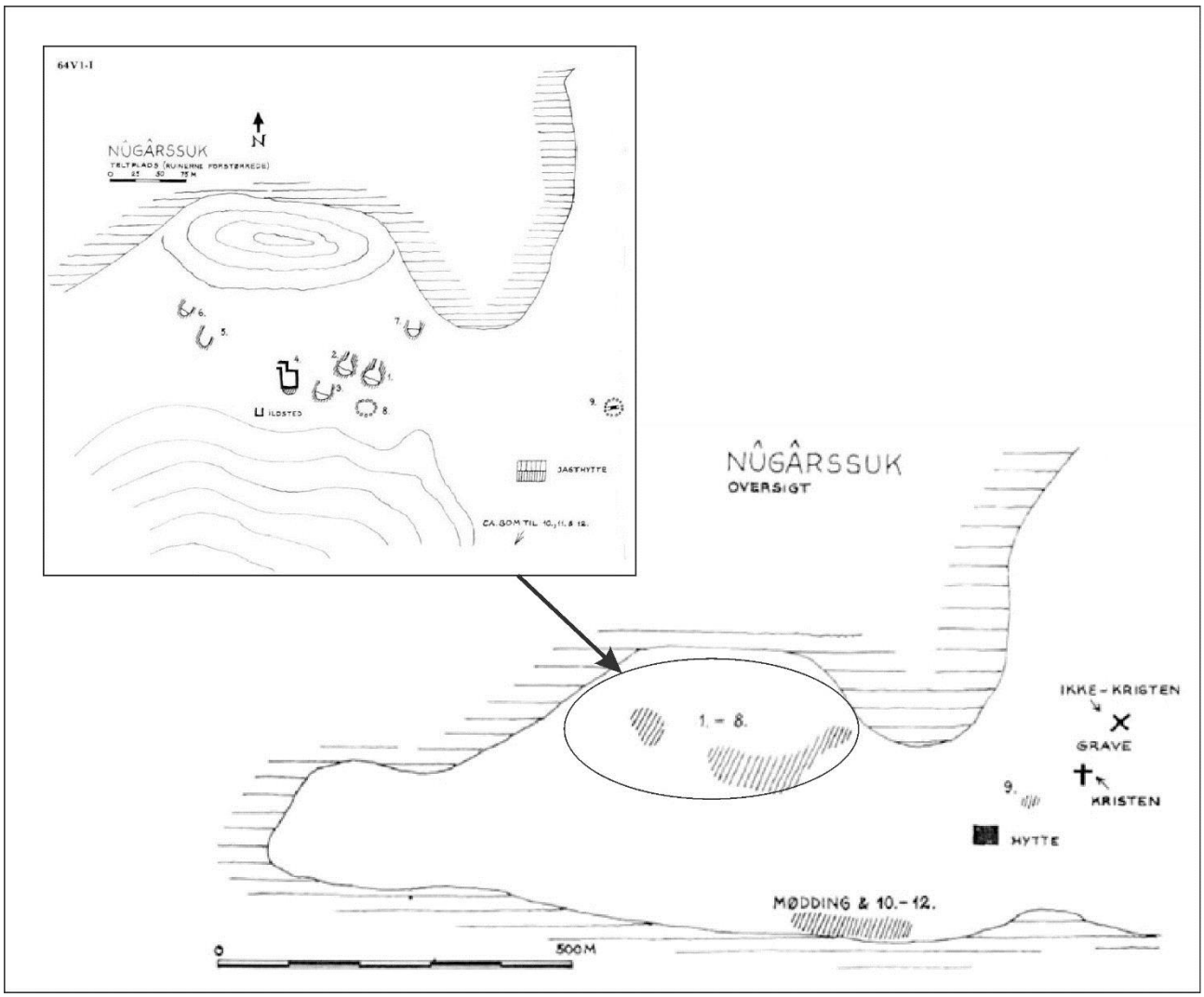

Fig. 2. Ruin features at Nuugaarsuk, (1-8.) house features; (9.) tent ring with medial hearth; (10-12.) midden features (after Gulløv 1983:52-53).

the remains of a tent ring are observed as well as a scattered grouping of Christian and Thule graves. In the 1770s, Thorhallesen mentions that the only unbaptized family in Godthåd district was residing at Nuugaarsuk (Nûgârssuk).

Archaeological investigations and sampling

Investigations in 2016 consisted of a site walkover and visual inspection of the current state of the ruin groups. No sub-surface archaeological testing was carried out at Nuugaarsuk. GPS waypoints and photos were taken of all present features (1-12) described in Gulløv (1983:52-53). Three (*n*=3) partly exposed archaeological wood samples were collected from the erosion front of the midden, lying in situ approximately 40-50 cm from below the modern soil surface. Additionally, three (*n*=3) native wood pieces, naturally decaying on the ground were also collected in sterile bags.

7 APPENDIX B: SITE DESCSRIPTIONS

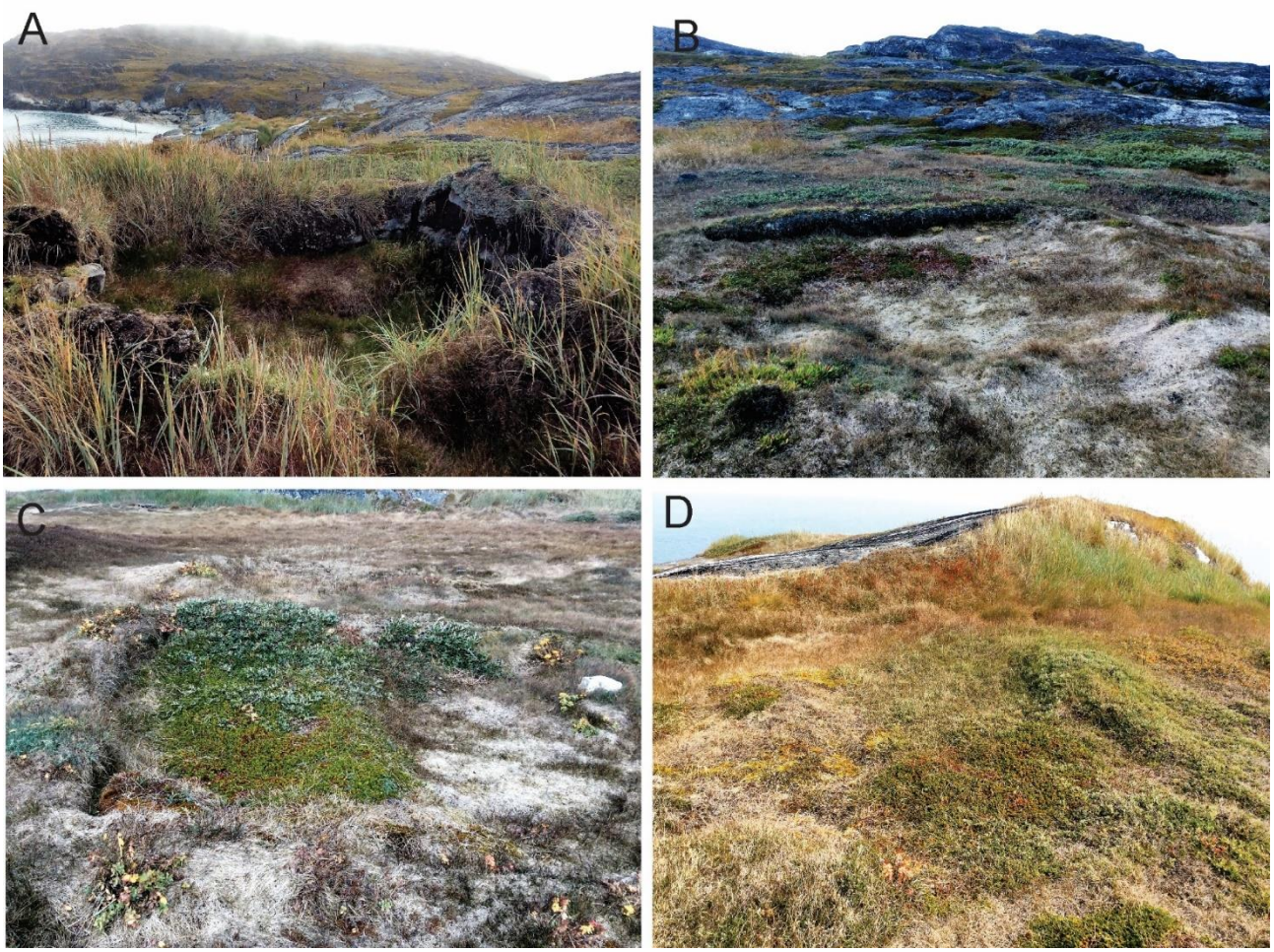

Fig. 3. Selected photos of ruins from Nuugaarsuk. (A) house 4, facing East; (B) house 6, facing South; (C) house 1, facing West; (D) house 7, facing North.

Vegetation Studies

To investigate any recent increase in growth of *S.glauca*, dendrochronology samples were collected at the archaeological site and in the surrounding areas. A total of twelve (*N*=12) *S. glauca* stems were collected. Six (*n*=6) stems were sampled from the archaeological site behind the ruins of House 2 behind the midden. Six (n=6) stems were also sampled from the natural surroundings east of the archaeological site. GPS waypoints for the sample areas were taken accordingly.

7 APPENDIX B: SITE DESCSRIPTIONS

REMAINS OF GREENLAND' - FIELD REPORT

Protocol

Table 1. Observations made at Nuugaarsuk in 2016 using the REMAINS field protocol.

Table A	
Site	Nuugaarsuk
NKAH no	1319
Serial no /FM number	64V1-001-026
Region	Nuuk fjord
Number of structures	Midden, three Thule houses, 8 tent rings, graves
Location	
N/E (decimal degrees; WGS84)	64.616870°, -51.2243550°
Height above sea level (lowest and highest point)	Sea reaches foot of midden and long houses at spring tide. Tent rings and graves placed high (approx. 10 m above high tide)
Distance from reference point to erosion front	No reference point
Setting/surroundings	Midden and houses on top of steep rock
Site description	
Site type	
Date culture	Thule, historic
Finds	
Dimensions/outline	Only small part of midden - few m2, up to approx 40 cm thick (estimated, no probe available)
Thickness of deposits	House walls up to 1.5 m, midden up to ca 40 cm
Vegetation cover	Lyme, horsetail, bluejoint, roseroot, low willow (marehalm, padderok, rørhvene, rosenrod, lav gråblå pil) on houses. Low grass on tent fundaments, low willow (gråblå pil) on no 5.
Photos (add numbers from other participants)	HMA no 4275-4305, including photography of the whole erosion front
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)	
Archaeological value (1-5 as above)	3
State of preservation (1-5 as above)	Tent fundaments and houses 4-5, midden 1-2
Preservation conditions (1-5 as above)	
Ongoing degradation? (comparison to earlier site visits)	Gulløw 1983 describes midden as heavily eroding, however, withiout historic photos it is difficult to evaluate if the process is still ongoing. The houses on the midden have lost their entrance, so a substantial erosion must taken place before 1979
Date visited	16-08-2016 (few hours)
Visited by	Hans Harmsen, Randi Sørensen Johansen, Ulunnguaq Nielsen Lyberth, Allan, Jørgen Hollesen, Henning Matthiesen, Roberto Fortuna, Nanna Bjerregaard Pedersen, Annemarie Eriksen, Bo Elberling, Aart Kroon

Table B	
Site	Nuugaarsuk
State of preservation	
Buildings/site structure and integrity	Buildings still stand out distinct with up to 1½ m high walls
Physical disturbance	Midden under erosion, long houses at risk of erosion
Volume excavated during visit	No excavation

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REMAINS OF GREENLAND' - FIELD REPORT

Materials found (list)	Observed exposed bone in midden
Wood	
Bone	
Stratigraphy	
Other	
State of preservation, in brief (1-5)	
Measurements during visit (ranges)	
Documented by drone	
Active layer thickness (range and date measured)	Not measured
Soil temperature (range and date measured)	Not measured
Water content (range measured)	Not measured
Conductivity (range measured)	Conductivity checked at a few point to evaluate maximum tide level - 100-300 mS/m
pH (range measured)	Not measured
Sea level (logged: yes/no)	Not measured
Root depth	Not measured
Other (ground water level,…	
Samples taken during visit	
Soil (list samples/number)	None
Artefacts (list materials)	None
Other materials (list)	
Vegetation (leaves/biomass/dendrosamples)	AME/NBP took a few willow samples for dendro. NBP took wood samples for fungi analysis
Evaluation of value	
Experience: beauty/monumentality	Visible in landscape - gives increased value
Experience: memory/historic value	
Physical integrity	Midden is almost gone. Long houses and tent fundaments well preserved and visible
Physical preservation	
Archaeological rarity/representation	Not very rare
Archaeological information value	
Archaeological assemblage value	
Archaeological value, in brief (1-5)	3 (midden 1)
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	High riskfor midden and long houses. Probably as single events during storms at spring tide
Other erosion (wind, animals, visitors)	No erosion observed from wind/animals. A little influence from visitors (removal of stones from tentring)
Damage from vegetation, roots	
Drainage	
Melting, heating	
Soil movement (including creeping, cryoturbation, slide)	
Decay of organic materials	Probably ongoing
Other threats	
Future threats?	
Preservation conditions, in brief (1-5)	
Are earlier descriptions available for comparison (references)	Gulløv 1983, s.52; NKA 1979 (report from site visit).

Monitoring	
Already initiated (which parameters)	
Suggested (which parameters)	
Important unknowns/research needed	
Mitigation - summary of recommendations	
Refill trenches	
Backfill	
Erosion protection	
Cut back vegetation	
Fencing	
Rescue excavation	

References

Gulløv, Hans Christian. 1983. *Nuup kommuneam gangarnitsanik eqqaassutit inuit-kulturip nunaqarfii*. Nuuk: Kalaallit Nunaata Katersugaasivia (Nationalmuseet Grønland).

Thorhallesen, Egill. 1776. *Efterretning om Rudera eller Levninger af de gamle Nordmænds og Islænderes Bygninger paa Grønlands Vester-Side, tilligemed et Anhang om deres Undergang sammesteds*. Copenhagen: August Friderich Stein.

8. Itivi, V18a [NKAH 1418]

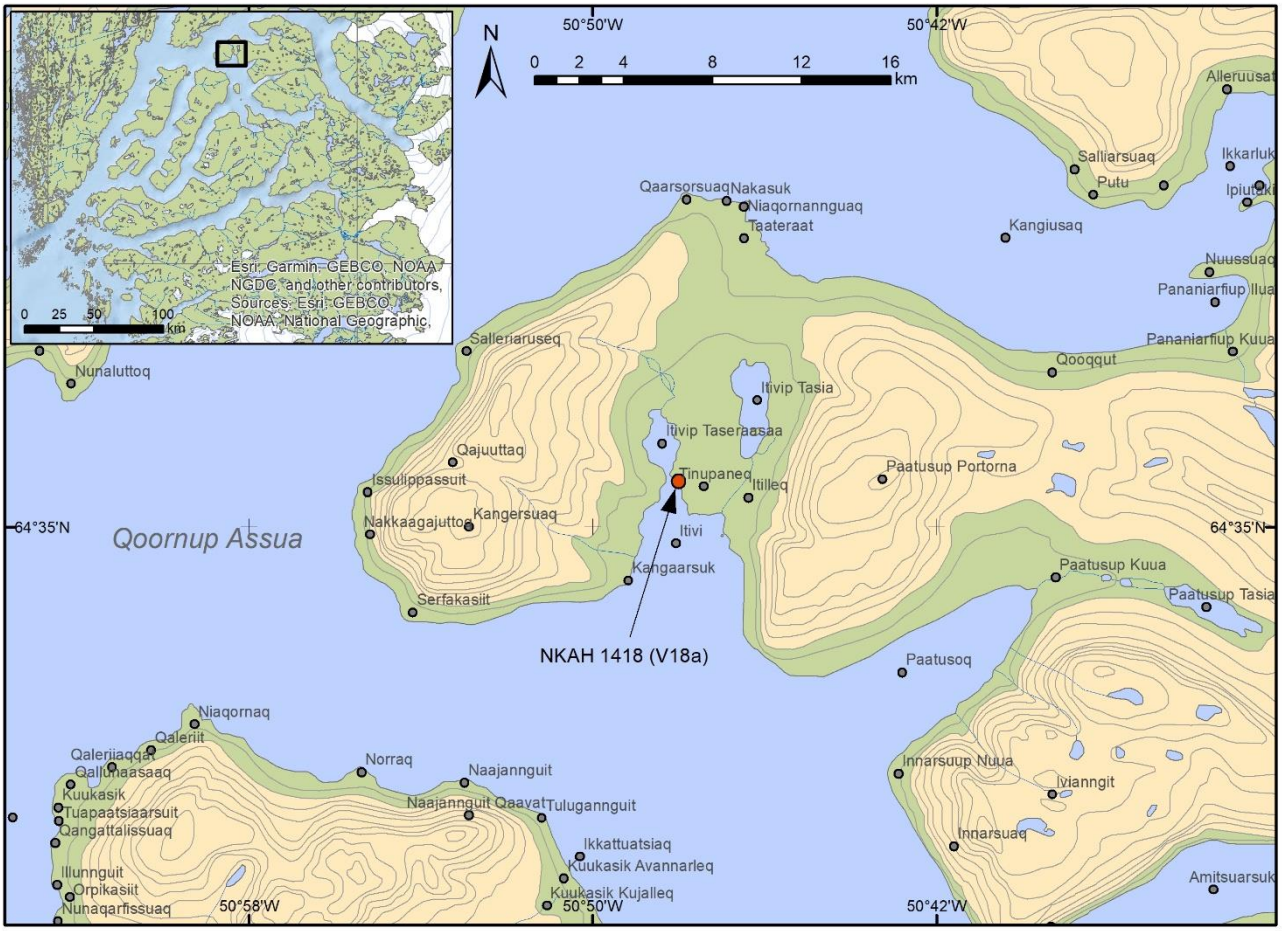

Fig. 1. Location of Itivi, V18a [NKAH 1319] in the Nuuk Fjord.

Sites description

Itivi, V18a (64.591200°, -50.7987170°) is located in a west-facing embayment with a relatively large fetch facing the Qoornup Assua. There is a pronounced sandy beach system in the central part of the embayment that stretches to the mouth of a channel that connects to the bay with Itivip Taseraasaa. This channel is migrating laterally resulting in the erosion of glacial cliffs at the northern part of the beach head. Heading west along the coast, berms are observed as well-developed and most of the back-beaches do not show any sign of erosion. A distinct dry channel out-lobe is visible on the northern beach suggesting the channel has moved over time. The velocities through the channel are still large (ca. 1 m/s during our visit) and are redistributing sediments along the beaches.

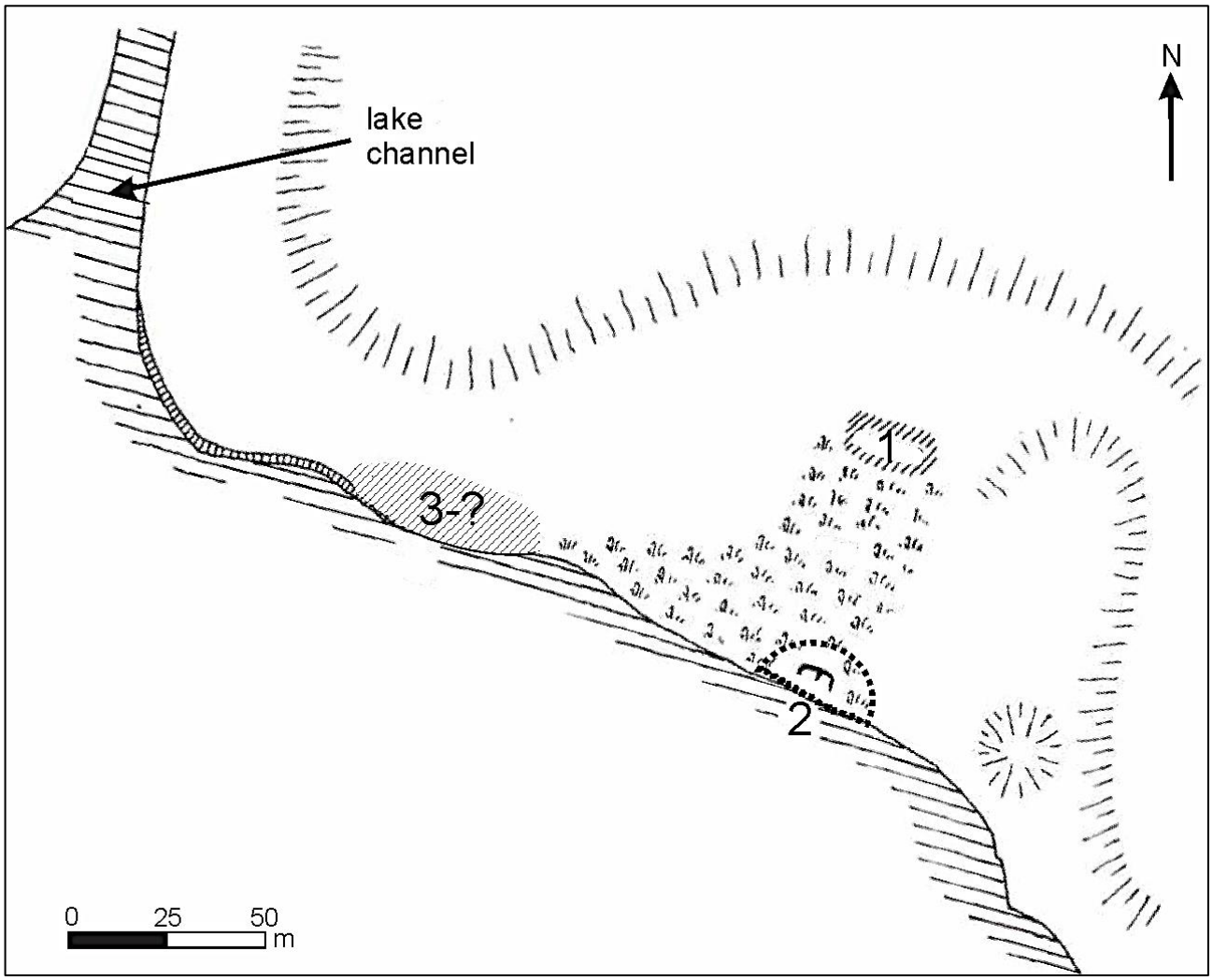

Fig. 2. Itivi, ruin features 1-3; illustration from Gulløv (1983:42) adapted from Meldgård 1952. (1) Norse house feature; (2) eroding Thule house, 2 rooms separated by central partition; ruin (3) was not identified at the time of the visit in 2016.

The main ruin group at Itive is a Norse farmstead located about 200-300 m to the southwest of the channel. The walls of a partitioned Thule house (2), heavily eroded, are also observed on the beachfront with a second Norse feature (1) located approximately 40-50 m inland to the north from the beach. A third Norse feature (3) was reportedly identified by Meldgård in 1952—however at the time of visit in 2016 no visible evidence of the feature was observed (Fig. 2).

Archaeological investigations and sampling

Investigations in 2016 consisted of a site walkover and visual inspection of the current state of the ruin groups. The presence of remaining archaeological features was compared against Meldgård's

1952 site map (Fig. 2). Ruin features 1 and 2 were photographed (Figs. 3 and 4) and GPS waypoints collected. No sub-surface testing or sampling was conducted at Itivi in 2016.

Fig. 4. Ruin 1, facing north.

Fig. 3. Ruin 2, facing north.

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REMAINS OF GREENLAND' - FIELD REPORT

Protocol

Table 1. Observations made at Itivi using the REMAINS field protocol.

Table A	
Site	Itive, V18a
NKAH no	1418
Serial no /FM number	64V1-001-002, 502
Region	Nuuk fjord
Number of structures	Thule longhouse built on Norse features?
Location	
N/E (decimal degrees; WGS84)	64.591200°, -50.7987170°
Height above sea level (lowest and highest point)	Upper midden 4-5 m above high tide line (check GPS). Long house is at spring tide line.
Distance from reference point to erosion front	Front wall of long house is eroded
Setting/surroundings	Next to an inlet to a lake/bay, with a very strong tidal current
Site description	
Site type	Midden (1 left), Norse building remains, 1 Thule longhouse
Date culture	Norse, Thule
Finds	
Dimensions/outline	Longhouse 8x3 m
Thickness of deposits	
Vegetation cover	Lyme, bluejoint, willow, dwarf birch (marehalm, rørhvene, gråblå pil, dværgbirk). No horsetail (padderok).
Photos (add numbers from other participants)	HMA 4317-4347, including photography of the whole erosion front
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)	
Archaeological value (1-5 as above)	1
State of preservation (1-5 as above)	
Preservation conditions (1-5 as above)	2
Ongoing degradation? (comparison to earlier site visits)	Degrading. Compared to old description from 1952, midden II has eroded away, and the Thule longhouse has become slightly smaller
Date visited	16-08-2016 (few hours)
Visited by	Hans Harmsen, Randi Sørensen Johansen, Ulunnguaq Nielsen Lyberth, Allan, Jørgen Hollesen, Henning Matthiesen, Roberto Fortuna, Nanna Bjerregaard Pedersen, Annemarie Eriksen, Bo Elberling, Aart Kroon,

Table B	
Site	Itive
State of preservation	
Buildings/site structure and integrity	
Physical disturbance	
Volume excavated during visit	
Materials found (list)	
Wood	
Bone	
Stratigraphy	
Other	
State of preservation, in brief (1-5)	

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Measurements during visit (ranges)	*no measurements*
Documented by drone	
Active layer thickness (range and date measured)	
Soil temperature (range and date measured)	
Water content (range measured)	
Conductivity (range measured)	
pH (range measured)	
Sea level (logged: yes/no)	
Root depth	
Other (ground water level,…	
Samples taken during visit	
Soil (list samples/number)	None
Artefacts (list materials)	None
Other materials (list)	None
Vegetation (leaves/biomass/dendrosamples)	None
Evaluation of value	
Experience: beauty/monumentality	Not very visible
Experience: memory/historic value	
Physical integrity	Most of the site is gone/eroded
Physical preservation	
Archaeological rarity/representation	
Archaeological information value	very low
Archaeological assemblage value	
Archaeological value, in brief (1-5)	1
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	High risk. May be continuously on-going due to strong tidal current
Other erosion (wind, animals, visitors)	No erosion observed from wind/animals/visitors
Damage from vegetation, roots	Limited damage
Drainage	
Melting, heating	
Soil movement (including creeping, cryoturbation, slide)	
Decay of organic materials	
Other threats	
Future threats?	
Preservation conditions, in brief (1-5)	2
Are earlier descriptions available for comparison (references)	Gulløv 1983, s.42. Includes drawings from a site visit by Meldgaard in 1952.
Monitoring	
Already initiated (which parameters)	
Suggested (which parameters)	
Important unknowns/research needed	
Mitigation - summary of recommendations	
Refill trenches	
Backfill	
Erosion protection	
Cut back vegetation	

Fencing	
Rescue excavation	

References

Gulløv, Hans Christian. 1983. *Nuup kommuneam gangarnitsanik eqqaassutit inuit-kulturip nunaqarfii*. Nuuk: Kalaallit Nunaata Katersugaasivia (Nationalmuseet Grønland).

9. Ersaa [NKAH 1150]

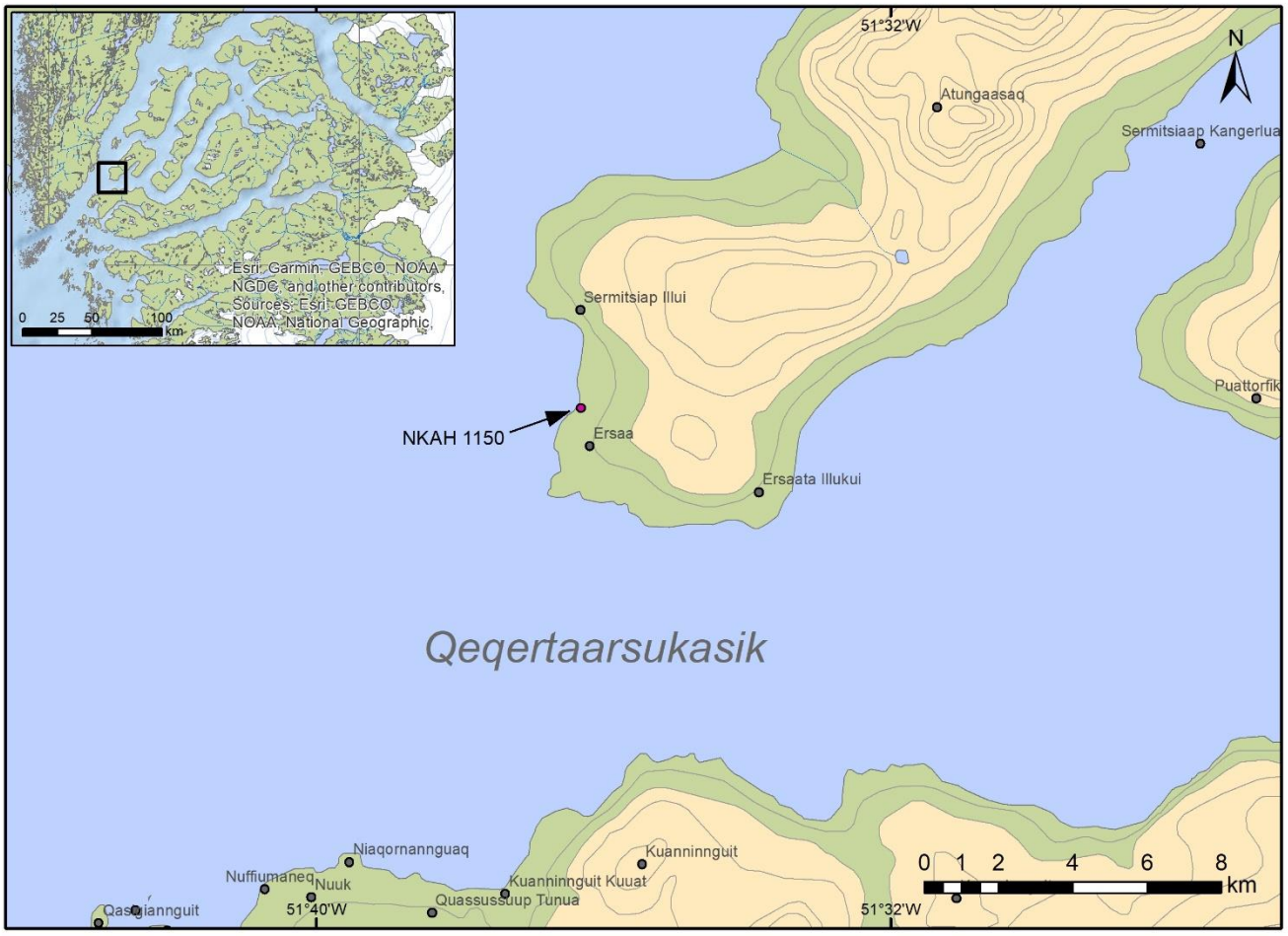

Fig. 1. Location of Ersaa on the island of Sermitsiaq in the Qeqertaarsukasik fjord.

Site description

Ersaa (64.251760°, -51.6026840°) is a coastal Thule-Inuit winter settlement located on the island of Sermitsiaq in the Qeqertaarsukasik fjord (Fig. 1). The settlement is nestled on a west facing rocky and stable elevated plateau overlooking a rocky pocket beach. The pocket beach faces southwest and the fetch and exposure to the winds can generate large waves, making the site vulnerable to high tides and storm surges. However, the sediments on the small beaches are very coarse (gravel and cobbles). Upper parts of the beachhead showed some signs of erosion. Small fluvial creeks were also observed close to the site, but they do not appear to be actively transporting sediment. In 2016, the creeks were dry. The hinterland is relatively flat with exposed outcrops of the sedimentary basement. This suggests little to no mass movement along the slope.

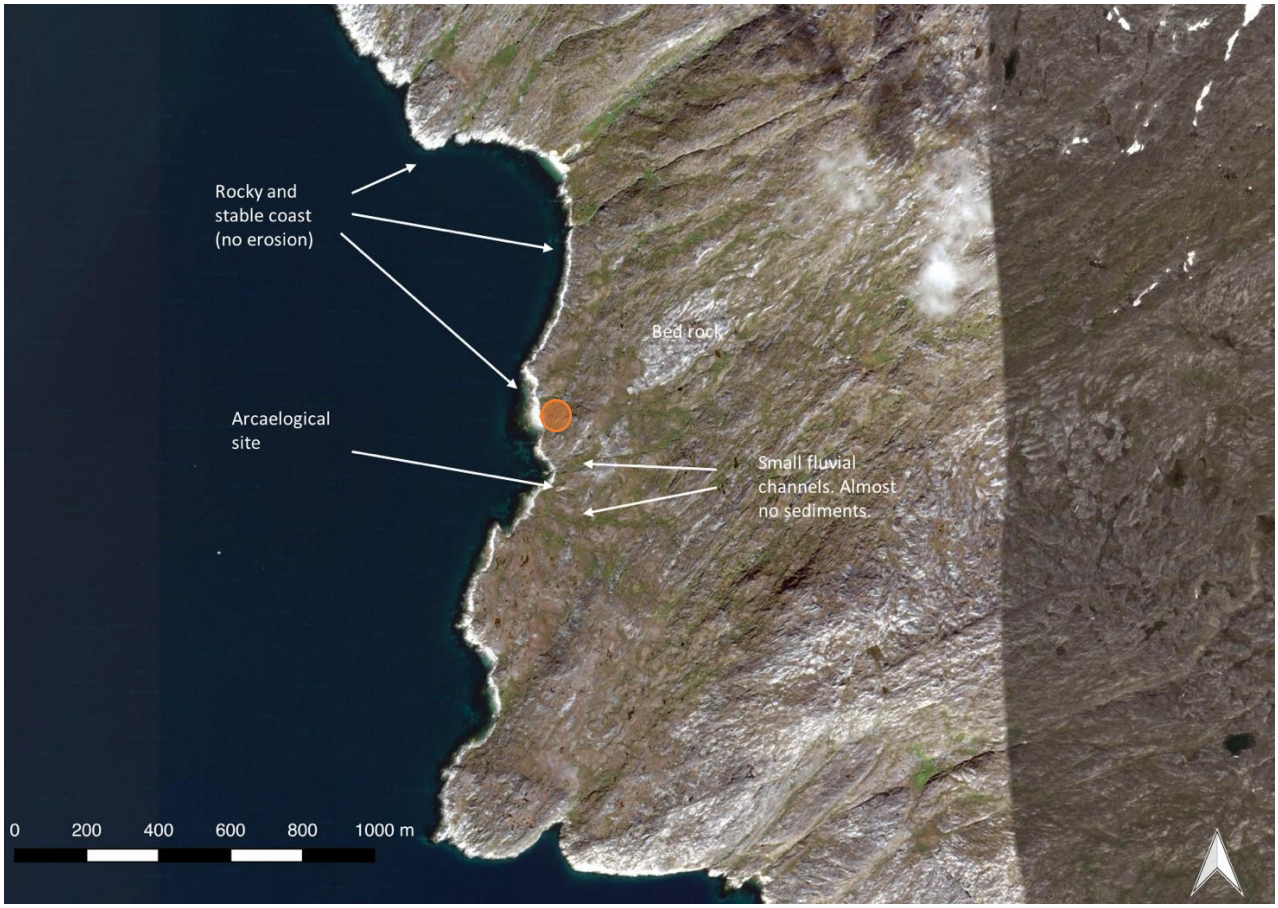

Fig. 2. Geomorphology of Ersaa. The location of the ruin group NKAH 1150 is indicated by the orange circle

Archaeological investigations and sampling

One test trench measuring .5 x 5. m was opened at Ersaa in 2016 (Fig. 3). This sub-surface testing was performed to: (1) examine preservation conditions of organic remains in the midden; (2) document local soil conditions and install environmental monitoring equipment; and (3) install modern bone and wood samples into the walls of the profile to study natural decomposition. The Thule-Inuit winter settlement at Erssa was probably in use up to through the late 18th century. In 1810, Giesecke reports a large ruin group comprised of several houses at the site (Giesecke 1910). In 1952, Meldgård and Nelleman identified twelve dwellings characteristic of both early and late Thule house types Gulløv (1983:60), with the younger longhouse features in varying states of collapse along the beach front (Fig. 4). Initial observations in 2016 suggest that the site is continuing to erode into the fjord as a result of coastal forcing events as major house features appeared to be sloughing down from the upper terrace onto the cobble beach and bare rock shoreline.

9 APPENDIX B: SITE DESCSRIPTIONS

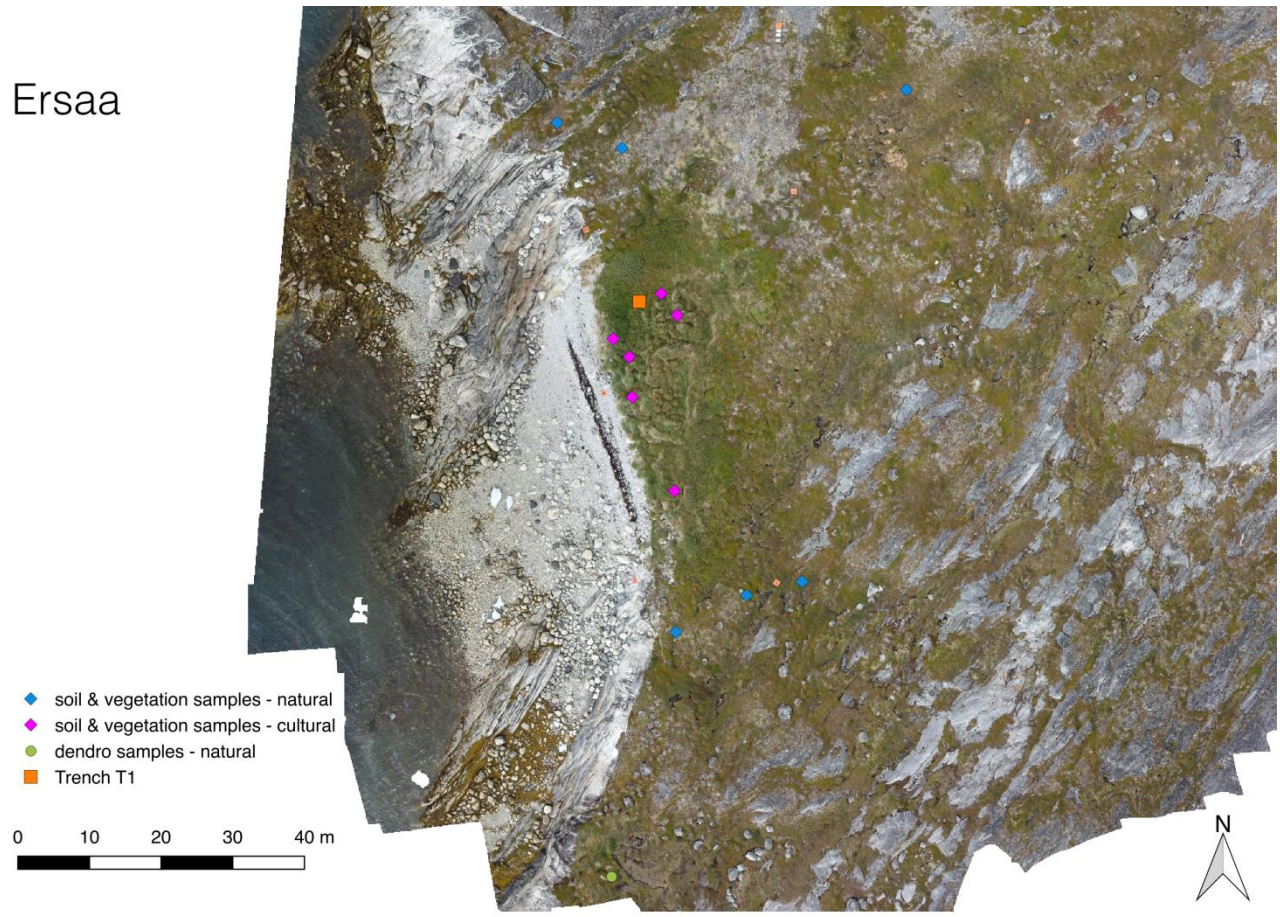

Fig. 3. Drone map of Ersaa showing the positions of Trench 1 (T1) soil and vegetation sampling.

Trench T1

Due to the advanced state of erosion observed at the site and extremely shallow soil, a small 0.5 x 0.5 m trench (T1) was opened on the lower northern edge of House 4. This area was chosen because it possessed the least gradient (<20%) and the highest probability of possessing a well-constrained midden layer due to its proximity to the entrance of the house feature. The trench was excavated by spade and trowel, and dug to the dense cobble sterile subsoil lying at approximately 70 cm below datum (Fig. 5). Trench provenience was based on southeast coordinates with a datum placed 10 cm above the ground surface. Detailed observations on the strata observed during excavation of T1 are summarized below and in Table 1.

9 APPENDIX B: SITE DESCSRIPTIONS

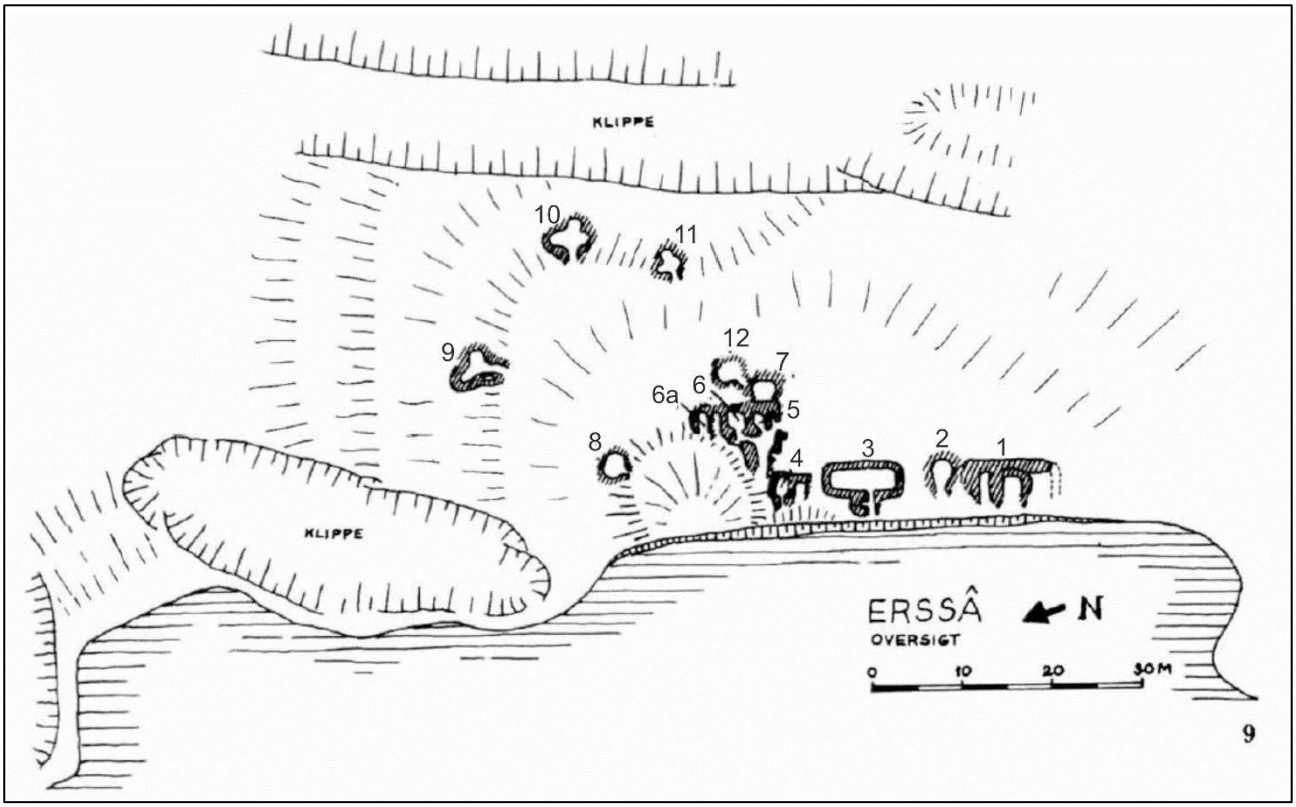

Fig. 4. Ruin group at Ersaa after Gulløv (1983:60). (1-2), (7) and (12),: clustered circular and square Thule-Inuit house types with later additions. (3): later Thule long-house; (9 -10) early Thule, clover-shaped houses excavated by Meldgård and Nelleman ca. 1952; (11): un-excavated early Thule house

0-20 cm below datum

Context [01] consisted of a single contiguous 5 YR 3/3 dark reddish brown turf & loam vegetation layer (O-Horizon) with a distinct transition occurring at approximately 20 cm below datum.

20-40 cm below datum

At 20 cm below the datum a midden layer was observed comprised of a 10 YR 2/1 black greasy clay-like soil with mammal bone and heavily decomposed organic materials. Pebbles and cobbles increased with depth. Several prominent and contrasting soil inclusions [s1-s4] were also observed in this midden layer. They included a mottled 10 YR 6/1 grey & 10 YR 5/3 brown coarse grain sand [s1], a 10 YR 7/3 very pale brown fine grain sand [s2], a 10 YR 4/4 dark yellowish-brown medium grain sand [s3] and a 10 YR 5/6 yellowish brown medium grain sand.

40-60 cm below datum

At approximately 40 cm below datum the midden layer transitions to context [03a], a 10 YR 3/2 very dark greyish brown coarse beach sand. The layer possesses a few bones, most likely migrating

downward from the midden layer, context [02]. Beach gravel and cobbles increase significantly at this horizon, comprising ~40-50% of the layer's matrix.

60-70 cm below datum

At roughly 50 cm below datum, the soil content subtly transitions to a wet marine sediment; 10 YR 2/1 black, wet clay and sand [context 03b]. Beach cobbles increase in both density (~50-60%) and size and observed to be generally larger than cobbles seen in [03a]. No cultural material observed below 55 cm.

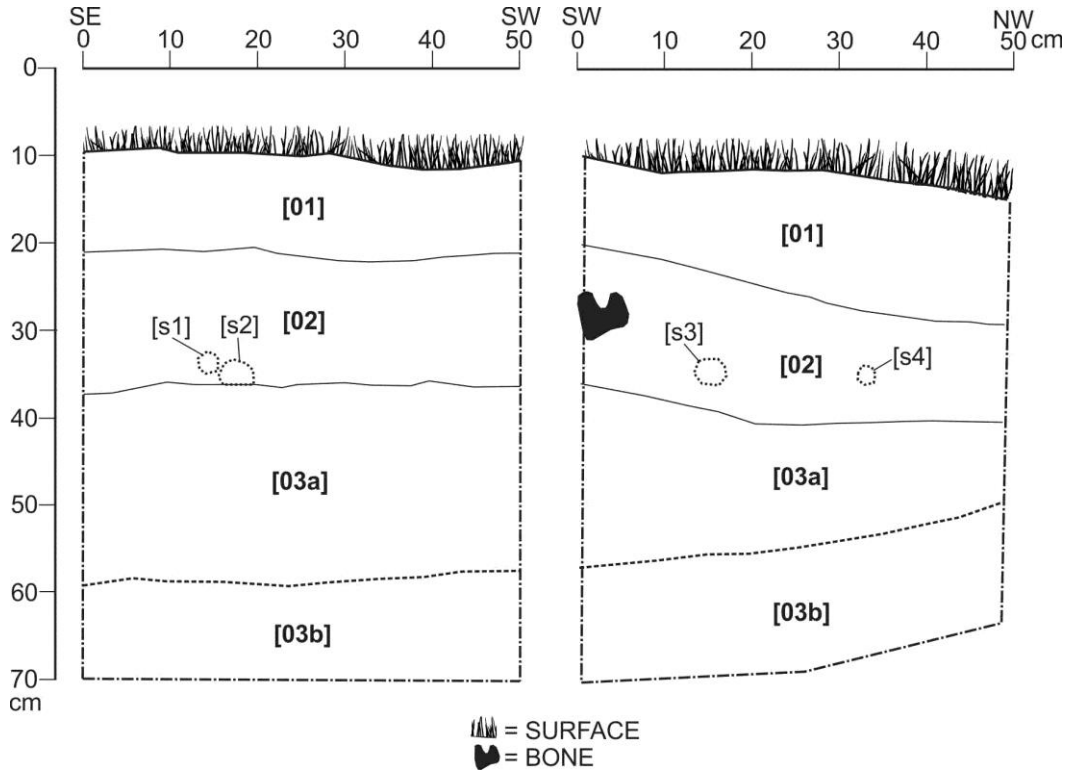

Fig. 5. Profile of South and West walls of T1 at Erssa.

9 APPENDIX B: SITE DESCSRIPTIONS

REMAINS OF GREENLAND' - FIELD REPORT

Table 1. Soil strata identified in T1 at Erssa.

Depth, cm below datum	Context no.	Description	Interpretation
0-20	[01]	5 YR 3/3 dark reddish brown turf & sandy soil	O-Horizon
20-40	[02]	10 YR 2/1 black greasy clay loam with mammal bone and heavily decomposed organics. <20% beach pebbles and cobbles.	Midden layer
35	[s1]	Mottled 10 YR 6/1 grey & 10 YR 5/3 brown coarse grain sand inclusion	Inclusion
35	[s2]	10 YR 7/3 very pale brown fine grain sand inclusion	Inclusion
35	[s3]	10 YR 4/4 dark yellowish-brown medium grain sand inclusion	Inclusion
35	[s4]	10 YR 5/6 yellowish brown medium grain sand inclusion	Inclusion
40-55	[03a]	10 YR 3/2 very dark greyish brown coarse sand; some bones migrated down from [02]. ~40-50% beach pebbles and cobbles.	Coarse beach sand and gravel, cobbles
55-70	[03b]	10 YR 2/1 black, wet clay-like fine grained sand mix. ~50-60% beach cobbles, generally larger than cobbles observed in [03a].	Buried marine sediment, sterile

No diagnostic artifacts were found in T1 at Ersaa, however, bulk samples of bone and charcoal were collected and are listed by number of samples bags and aggregate weight (Table 2). No wood was found in T1. All finds were collected in sterile sample bags and segregated based on provenience. Additionally, three (*N*=3) bone samples were collected in situ in T1 directly from the profile at 15 cm (*n*=1) and 30 cm (*n*=2). From the bulk sample material, ten (*n*=10) bone samples from different contexts with varying degree of degradation were selected for analysis. Volume specific soil samples (100cm^3) were taken at -5, -10, -20 and -35 cm depths below the surface. A total of four (*N*=4) naturally decayed wood pieces were also sampled from *S. glauca* found close to T1.

Table 2. Total T1 samples, detailed by type, number of sample bags taken and aggregate weight.

Sample type	# of sample bags	wt. (g)
charcoal	1	2.8
bone	4	215.8
Total	**5**	**217.8**

9 APPENDIX B: SITE DESCSRIPTIONS

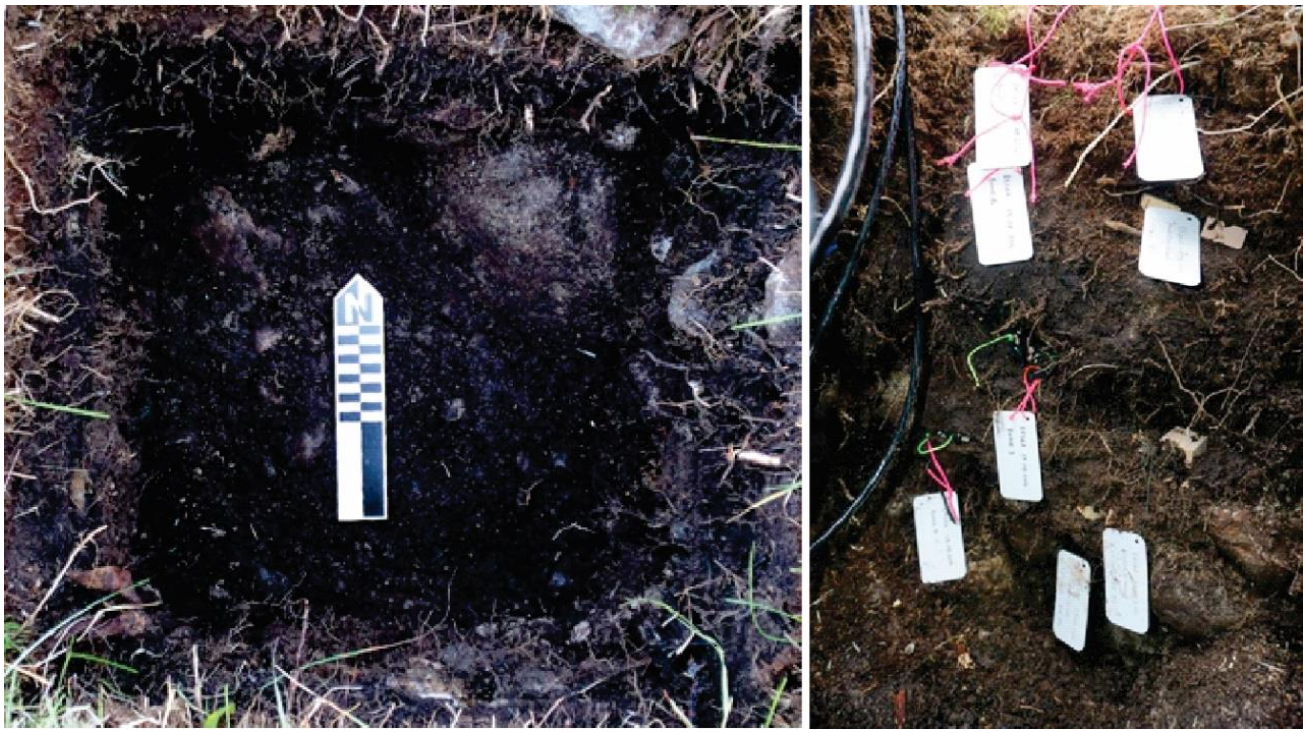

Fig. 6. Left: bottom of T1 at Erssa. Right: Modern wood and bone samples were installed in the wall of TU1 at -5, -10, -20 and -35 cm below the surface.

In addition to archaeological sampling at T1, one sample of Fagus sylvatica (European beech) and one sample of Pinus sylvestris (Scots pine) were installed in T1 next to the temperature and moisture content sensors at the depths of 5, 10, 20 and 35 cm. Furthermore, one sample of unmacerated bone was buried at 5 and 10 cm depth and two samples in 20 and 35 cm depth.

Vegetation Studies

Detailed vegetation analyses were carried out on six (*n*=6) 1x1 meter in the immediate vicinity of the ruin group and on six (*n*=6) 1x1 meter plots ("cultural" in Fig. 3) on the surrounding reference area soil ("natural" in Fig. 3). Each plot was photographed with a high-resolution camera (Hasselblad) and a multi-spectral camera (Sequia) and NDVI was measured using a Decagon NDVI sensor. The vegetation cover was quantified using a 1x1 meter frame divided in to 25 sectors by pinpoint analysis. A 0.2 x 0.2 m area within each plot was harvested and green biomass collected. The same sample area was then dug to a maximum depth of -30 cm below the surface. During the course of the subsurface investigation, a single piece of heavily decayed wood was found and collected in a depth of -10 cm below the soil surface at location of "culture 5". The wood sample was collected sterile. Volume specific soil samples (100cm^3) were collected at -5 cm, -10 cm, -20 cm and -30 cm below the surface. After sampling, the hole was backfilled and vegetation cover replaced to minimize

damage to the site. For each plot fifteen to twenty leaves were harvested from one to three species on or close to each sample plot.

To investigate the recent increase in growth of *S. glauca* (Northern willow), dendrochronology samples were collected near T1 and in the surrounding reference ("natural") area. When a sample plant was identified, 10-20 cm of the root column was cleared from soil and debris. Then the stem (comprised of approximately 10-20 cm root and 10-20 cm above-ground stem) was sawn away and collected. Additionally, fifteen (*n*=15) leaves from each sample trees was harvested to conduct C/N + ^{15}N analyses.

A total of twenty-four (*N*=24) stems were sampled from Ersaa. Twelve (*n*=12) *S. glauca* were sampled from within the ruin group ("cultural" in Fig. 3); six (*n*=6) were sampled in house 1 and six (*n*=6) sampled from the interior of houses 5 and 6. Twelve stems were also sampled from the surrounding reference area ("natural" in Fig. 3) surroundings; four (*n*=4) stems were sampled north of the site, four (*n*=4) stems were sampled south of the site, and four (n=4) stems were sampled east of the site. All sample areas were documented with photos and GPS points.

GPS and UAV Surveys

A high precision TRIMBLE RTK-dGPS was used to (1) map archaeological features; (2) anchor ground control points; (3) map the positions of sampling locations and environmental monitoring sites and (5) collect geomorphologic data. The latter includes mean high-tide shorelines, vegetation lines, cross-shore profiles at all pocket-beaches and open-embayment beaches. Cross-shore profiles (beach topography) was related to local flooding statistics, using tidal curves and water level data.

A quadcopter UAV (Tarot 650-sport) was employed to map the site. A total of five (*N*=5) flights were performed. Two of the flights were surveys with the purpose of mapping the entire site with two different types of cameras: a regular RGB camera (Sony RX100) and a multi-spectral camera (Seqoia).

The remaining three flights were carried out as a part of a methodological study along a transect at four different altitudes (100 m, 80 m, 60 m, 40 m). Three different cameras were used to collect ground data: (1) a regular RGB camera (Sony RX100): (2) a multi-spectral camera (Seqoia); and (3) a modified NDVI camera (Canon). The purpose of this study was to investigate how the flight altitude

influenced the data captured on the three different cameras. Detailed information on each flight is seen in Table 3.

Table 3. Detailed information on the flights carried out at the site using a quadcopter UAV (Tarot 650-sport).

Date	Local time	Weather	Survey type	Camera	Altitude	Area (km2)	Photos
17/08/16	14:51-15:03	Overcast	Site survey	Sony RX100M3	60 m	0.03	200
17/08/16	16:07-16:13	Overcast	Site survey	Sequoia	60 m	0.03	118
18/08/16	15:40-15:43	Overcast	Transect	Sony RX100M3	100,80,60,40		33
18/08/16	15:48-15:52	Overcast	Transect	Canon	100,80,60,40		63
18/08/16	16:11-16:16	Overcast	Transect	Sequoia	100,80,60,40		157

Environmental monitoring

Measurement of *in situ* pH, water content and conductivity was carried out in T1 for every 5 cm depth during excavation. Temperature (Tinytags) and soil water content sensors (Sm300) were installed in the excavated trench of T1 in 2016. Air and soil temperatures were measured every three hours at depths of 0, -10, and -35 cm below the surface. Soil water content was measured every six hours at -5, -10, -20 and -35 cm depths below the surface. Volume specific soil samples (100cm^3) were taken at the same depths to calibrate sensors. All monitoring equipment and sensors were removed from Ersaa in August 2018.

Protocol

Table 4. Observations made at Ersaa in 2016 using the REMAINS field protocol.

Table A	
Site	Ersaa
NKAH no	1150
Serial no /FM number	
Region	Qeqertaarsukasik fjord
Number of structures	12 Thule houses, 1 paleoeskimoic tentring
Location	
N/W (decimal degrees; WGS84)	64.251760°, -51.6026840°
Height above sea level (lowest and highest point)	Lowest part at high tide line, higher houses 5-10 m higher (check GPS)
Distance from reference point to erosion front	
Setting/surroundings	Lying at eroding coastline, maybe on previous beach terrace
Site description	

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Site type	Thule winter dwelling
Date culture	18th-19th century
Finds	Mammal bone, charcoal
Dimensions/outline	ca 60x40 m (tjek GPS)
Thickness of deposits	20-30 cm in trench1
Vegetation cover	Bluejoint, lyme, horsetail, willow, dandelion, mountain sorrel (rørhvene, marehalm, padderok, pil, mælkebøtte, fjeldsyre)
Photos (add numbers from other participants)	HMA 4399-4445, including photography of the whole erosion front
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)	
Archaeological value (1-5 as above)	3
State of preservation (1-5 as above)	
Preservation conditions (1-5 as above)	2-3
Ongoing degradation? (comparison to earlier site visits)	Probably. Compared to old drawings from 1952 there has been erosion of approximately 2x4 m of house number 1 (better estimate will be available from drone data). Some of the houses have lost their entrance, so a substantial erosion must have taken place before 1952. Vegetation pattern doesn't seem to have changed compared to registrations from 1952.
Date visited	18-19/8/16
Visited by	Hans Harmsen, Christian Koch Madsen, Mikkel Myrup, Randi Sørensen Johansen, Ulunnguaq Nielsen Lyberth, Jørgen Hollesen, Henning Matthiesen, Roberto Fortuna, Nanna Bjerregaard Pedersen, Annemarie Eriksen, Aart Kroon, Anders Westergaaard Nielsen, Rasmus Fenger Nielsen, Emil Andersen

Table B	
Site	Ersaa
State of preservation	
Buildings/site structure and integrity	3 houses excavated already, 1 is almost gone, 1 is maybe sliding into the sea, the rest are well defined
Physical disturbance	
Volume excavated during visit	T1, ca 50x50x50 cm, for water content and temperature sensors
Materials found (list)	Bone, charcoal
Wood	
Bone	Average 2.3 (55 bones from T1)
Stratigraphy	
Other	
State of preservation, in brief (1-5)	
Measurements during visit (ranges)	
Documented by drone	Mikkel Myrup and Rasmus Fenger Nielsen
Active layer thickness (range and date measured)	not measured (>50 cm)
Soil temperature (range and date measured)	6-12 C
Water content (range measured)	10-50 % vol (in loggerhole)
Conductivity (range measured)	20-40 mS/m
pH (range measured)	4.5-5.5
Sea level (logged: yes/no)	
Root depth	ca 40 cm
Other (ground water level,…	
Samples taken during visit	

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REMAINS OF GREENLAND' - FIELD REPORT

Soil (list samples/number)	Ring and bulk samples in T1, ring samples in vegetation holes
Artefacts (list materials)	Bone samples from T1
Other materials (list)	
Vegetation (leaves/biomass/dendrosamples)	Biomass and dendro
Evaluation of value	
Experience: beauty/monumentality	4
Experience: memory/historic value	5
Physical integrity	2
Physical preservation	2
Archaeological rarity/representation	2
Archaeological information value	1
Archaeological assemblage value	3
Archaeological value, in brief (1-5)	3
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	Erosion towards the sea. Some erosion from snowmelt
Other erosion (wind, animals, visitors)	Possibly erosion from visitors
Damage from vegetation, roots	Horsetail down to at least 40 cm below ground
Drainage	Drainage is good as the houses and middens are lying on well draining coarse material - this is bad for the preservation of organic material, but may be good for the stability of walls
Melting, heating	
Soil movement (including creeping, cryoturbation, slide)	Possibly slide in connection with erosion
Decay of organic materials	Already heavily decayed
Other threats	
Future threats?	
Preservation conditions, in brief (1-5)	2-3
Are earlier descriptions available for comparison (references)	Gulløv 1983, p 59-62, including drawings from Meldgaard 1952 (notebook) and Nellmann 1952 (report)
Monitoring	
Already initiated (which parameters)	Temperature, water content
Suggested (which parameters)	Repeated photos of erosion front to follow erosion
Important unknowns/research needed	
Mitigation - summary of recommendations	
Refill trenches	
Backfill	
Erosion protection	
Cut back vegetation	
Fencing	
Rescue excavation	

References

Giesecke, K.L. 1910. "Mineralogisches Reisejournal über Grönland." *Meddelelser om Grønland* 35:478.

Gulløv, Hans Christian. 1983. *Nuup kommuneam gangarnitsanik eqqaassutit inuit-kulturip nunaqarfii*. Nuuk: Kalaallit Nunaata Katersugaasivia (Nationalmuseet Grønland).

Kangeq [NKAH 1088]

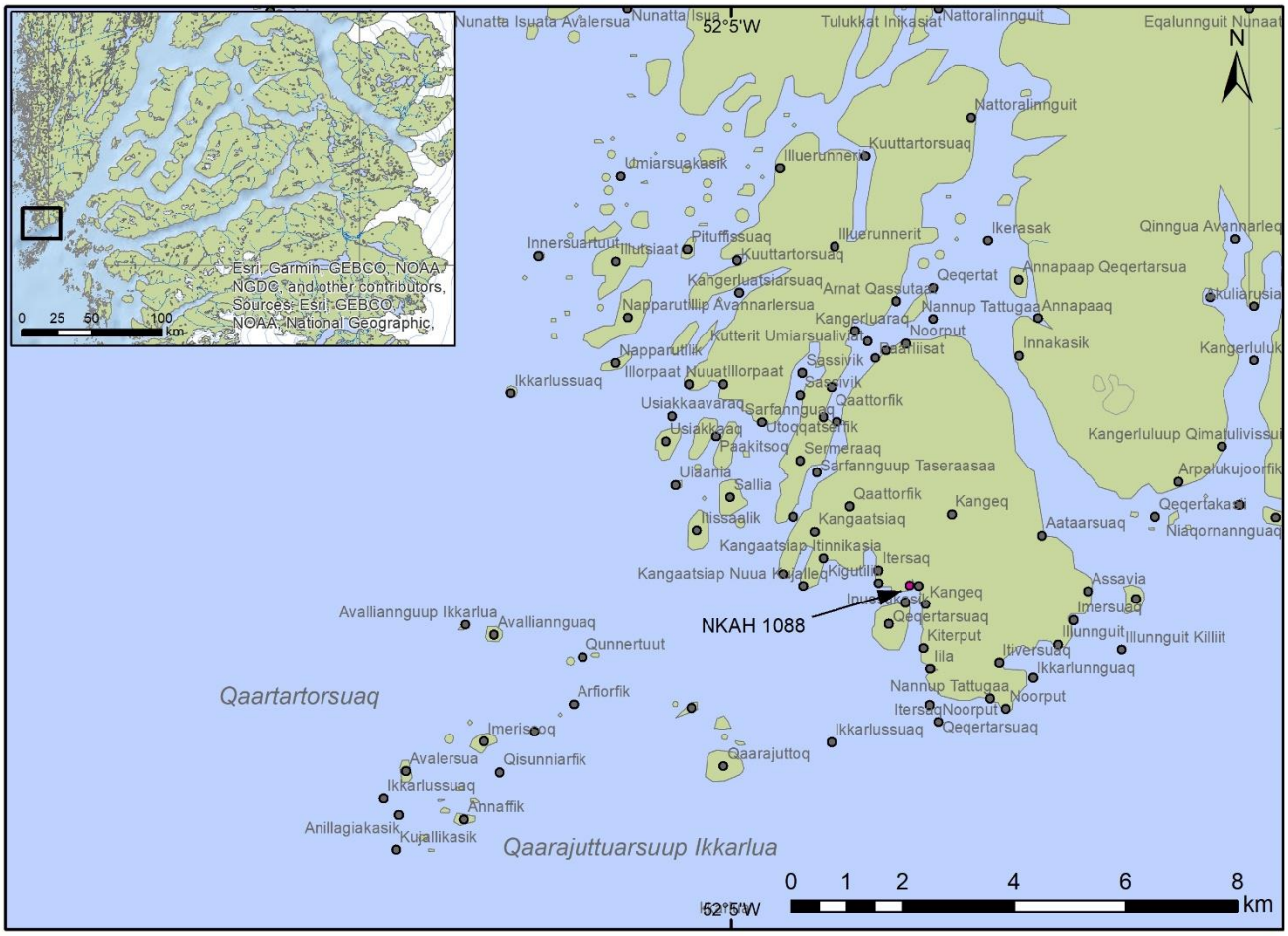

Fig. 1. Kangeq is located at the mouth of the Nuuk fjord, close to the open waters of the Davis Straight.

Site description

Kangeq (64.109580°, -52.0546510°) is a historic island settlement found at the mouth of the Nuuk fjord, close to the open waters of the Davis Straight, approximately 15 km west of Nuuk. Due to the steep surrounding terrain, Kangeq is well protected from wind, waves and ocean swells. Tidal influence at the inlet where the site is located is high, with fluctuations ranging between 4 to 5 m. At high tide there is a risk of wave erosion of the exposed middens that underlie the overhanging ground turf. The surrounding area of the inlet consists of bedrock with only few signs of geomorphological processes. The slope on the midden appears to be vulnerable to local erosional forces caused by overland and sub-surface run-off.

Fig. 2. Geomorphology of Kangeq. The location of NKAH 1088 is indicated by the orange circle

Archaeological investigations and sampling

The settlement of Kangeq was in almost continual use over the last 700 years, with evidence of an even earlier Saqqaq phase relatively dated to ca. 2398-1690 BC (Hinnerson-Berglund 2004). The settlement was officially closed in 1974 and possess a number of deteriorating historic structures in various states of decay. The site is still used by local residents as several summer cabins were being constructed at Kangeq in 2016.

Kangeq's ancient features include the remains of several Thule-Inuit winter house features and several well-constrained middens (in some locations over 2+ m in thickness) with bone, skin, baleen, feathers, and wood dating from ca. 14th through 19th AD. The three main midden sections are situated on the northern part of the inlet, with a fourth midden located along the southern shore.

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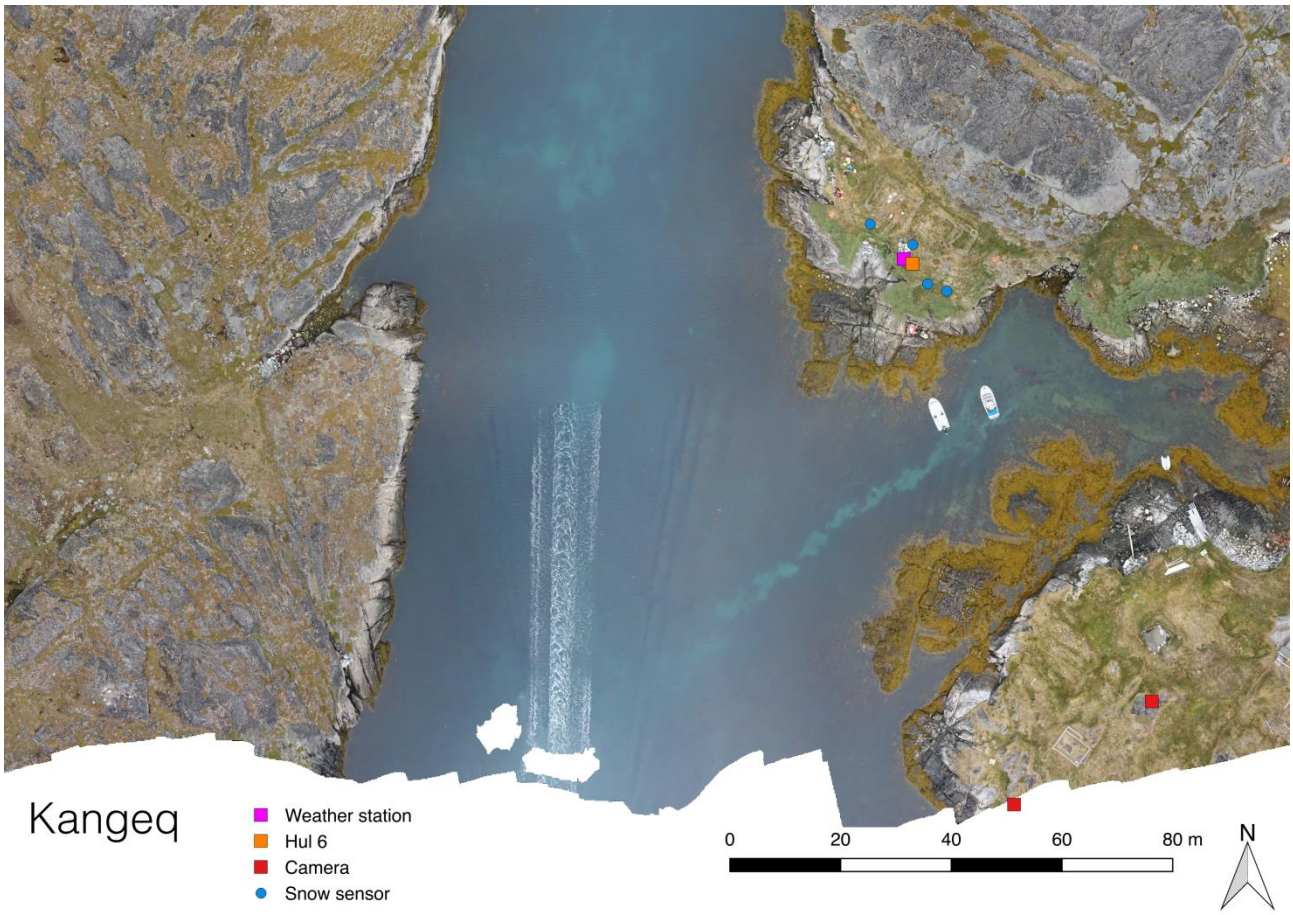

Fig. 3. Drone map of Kangeq showing the position of Hole 6 (Hul 6) and installation of environmental monitoring equipment.

In 2012, the REMAINS team cleared a 1 m wide profile of midden section on the north shore and installed a sub-surface monitoring equipment at a second location. Bone and wood samples was collected in situ. Data from the monitoring station was retrieved in 2013 (Knudsen et al. 2014). A total of four diagnostic artifacts were collected from the re-opening of holes 6-9 in 2016, detailed by type, provenience, quantity (n) and weight in Table1.

Artifact type	**Provenience**	***n***	**wt. (g)**
glass	Hole 6	1	1.3
ceramic	Hole 9	1	1.5
lithic, chalcedony	Hole 7	1	0.4
harpoon head	Hole 8	1	7.4
Total (*N*)		4	10.6

Table 1. Total artefacts, detailed by type, provenience, quantity *(n)* and weight from Kangeq in 2016.

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Hole 6

Hole 6 was originally excavated in 2012 (Knudsen et al. 2014), but re-opened and expanded in 2016 as part of the REMAINS fieldwork. Bulk wood and bone samples were collected for further analysis at the National Museum of Denmark. In total, two hundred and eighty-seven (*N*=287) bone samples and eighty (*N*=80) wood samples were collected from Hole 6. An additional five (*N*=5) bone and five wood samples (n=5) were collected sterile directly from hole 6. Volume specific soil samples (100cm^3) were taken at -5, -20, -40 and -60 cm depths below the surface.

Five sets of modern wood (one set: one *Pinus sylvestris* and one *Acer* spatula were buried on 6 September 2012 (Knudsen et al. 2014) just beneath the turf layer in separate hole close to Hole 6. In 2016, one maple (*n*=1) and one pine (*n*=1) sample were collected sterile whereas the rest of the samples were left in place.

In addition to archaeological sampling at hole 6, one sample of Fagus sylvatica (European beech) and one sample of Pinus sylvestris (Scots pine) were installed next to the temperature and moisture content sensors at the depths of 10, 20, 40 and 60 cm. Furthermore, two sample of unmacerated bone was buried at 10, 20, 60 cm and three samples were buried in 40 cm depth (Fig. 4).

Fig. 3. Modern wood and bone samples installed in the profile of hole 6 at Kangeq.

10 APPENDIX B: SITE DESCSRIPTIONS

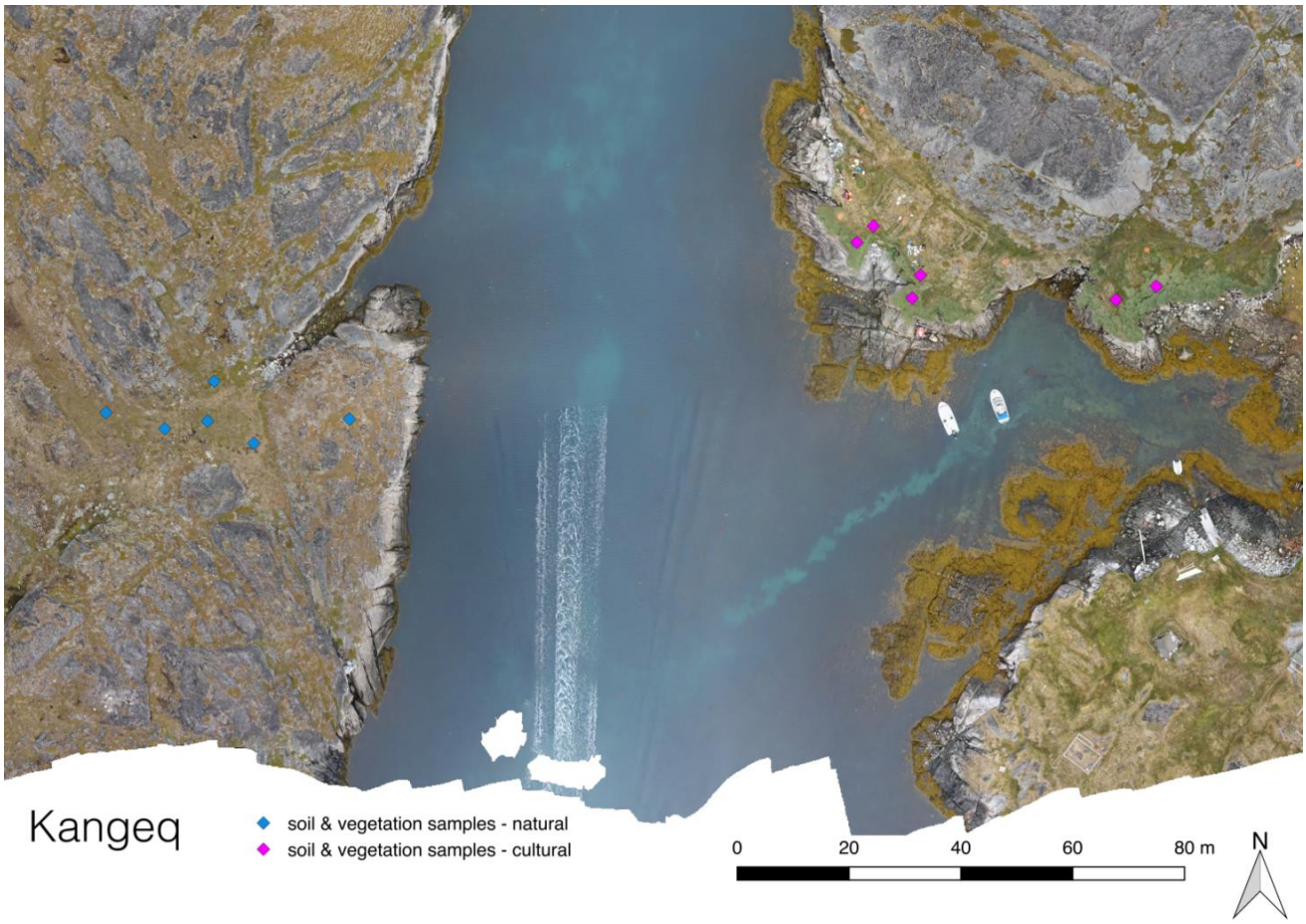

Fig. 5. Map of the archaeological site at Kangeq showing the positions of sampling sites.

Three (*n*=3) wood samples were sampled in situ from the midden profile excavated by Gulløv in 1968 at -50 cm, -65 cm, and -100 cm depths below the ground surface. The wood samples were partly exposed but embedded in the midden. Six (*n*=6) wood samples were sampled in situ from the same profile but in the section that had eroded after 2012 at -30, -40, -50, -80, -110, and -120 cm depths below the surface. Samples placed in 2012 in the profile dug by Gulløv in 1968 were not found as in their original positions in the part of the profile that eroded after 2012.

An additional five (*n*=5) wood samples were collected from a bridge construction and another unknown construction (ca. 1974 or earlier) prior to Kangeq's abandonment.

Vegetation Studies

Detailed vegetation analyses were carried out on six (Fig. 5) 1x1 m plots immediate to the ruins and midden ("cultural") and on six 1x1 meter plots on the surrounding reference area ("natural"). Each plot was photographed with a very high-resolution camera (Hasselblad) and a Sequia multi-spectral camera and NDVI was measured using a Decagon NDVI sensor. The vegetation cover was quantified using a 1x1 m frame divided in to 25 sectors by pinpoint analysis. A 20x20 cm area within each plot was harvested and the green biomass collected. The same 20x20 cm area was then dug out to a maximum depth of 30 cm below the surface. Volume specific soil samples of 100cm^3 were collected from depths of -5 cm, -10 cm, -20 cm and -30 cm below the surface. After sampling each hole was backfilled to minimize disturbance. Additionally, 15-20 leaves were harvested from 1-3 different species on top or immediately adjacent to each sample plot.

The *S. glauca* growth at Kangeq was generally low, possibly as a consequence of human over the last several centuries. A total of twelve (*n*=12) *S. glauca* stems were collected south of the midden and along a cliff east of the midden. When a sample plant was identified, 10-20 cm of the root column was cleared from soil and debris. Then the stem (comprised of approximately 10-20 cm root and 10-20 cm above-ground stem) was sawn away and collected. Additionally, fifteen (n=15) leaves from each sample trees were harvested to conduct C/N + 15N analyses.

GPS and UAV Surveys

A high precision TRIMBLE RTK-dGPS was used to (1) map archaeological features; (2) anchor ground control points; (3) map the positions of sampling locations and environmental monitoring sites and (5) collect geomorphologic data. The latter includes mean high-tide shorelines, vegetation lines, cross-shore profiles at all pocket-beaches and open-embayment beaches. Cross-shore profiles (beach topography) was related to local flooding statistics, using tidal curves and water level data.

A quadcopter UAV (Tarot 650-sport) was employed to map the site. flights were carried out using different cameras: a regular RGB camera (Sony RX100) and a multi-spectral camera (Seqoia). Detailed information on each flight is seen in Table 2.

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Date	Local time	Weather	Survey type	Camera	Altitude	Area (km2)	Photos
21/08/16	12:49-12:55	Overcast	Site survey	Sony RX100M3	80 m	0,062	152
21/08/16	13:25-13:32	Overcast	Site survey	Sequoia	80 m	0,062	103

Table 2. Detailed information on the flights carried out at the site using a quadcopter UAV (Tarot 650-sport)

Environmental monitoring

Measurement of *in situ* pH, water content, conductivity and thermal properties were carried out in hole 6 for every 5 cm depth during excavation. Monitoring equipment was installed in hole 6 in 2012 to measure sub-surface temperatures at -0, -10, -20, -30, -40, -60, -80 and -100 cm below the surface. Soil water content was measured at -10, -20, -30 and -40 cm below the surface. In 2016, time-series data was downloaded and the logger station expanded to also measures air temperature and relative humidity (CS215 Temperature & RH Probe). Precipitation rates (52202 Tipping Bucket Raingauge) and soil water content were also measured at -5, -20, -40, and -60 cm depths below the surface (Sm300). Volume specific soil samples ($100cm^3$) were taken at the same depths to calibrate sensors. Soil temperatures (Campbell Scientific 107) and oxygen content (Presense) were collected at -5, -20, -40, and -60 cm depths below the surface. Soil temperatures and oxygen contents were logged every 12 hours using a Campbel Cr300 data logger. All monitoring equipment and sensors were removed from Kangeq in August 2019.

In 2016 two automatic cameras were installed (facing North) to take photos of the midden three times per day. The cameras were removed from the site in August 2018.

10 APPENDIX B: SITE DESCSRIPTIONS

REMAINS OF GREENLAND' - FIELD REPORT

Protocol

Table 3. Observations made at Kangeq in 2016 using the REMAINS field protocol.

Table A	
Site	Kangeq
NKAH no	1088
Serial no /FM number	64V1-III-036
Region	Nuuk fjord
Number of structures	Paleo-Inuit and Thule Inuit site, several buildings up to modern times, and a large midden
Location	
N/W (decimal degrees; WGS84)	64.109580°, -52.0546510°
Height above sea level (lowest and highest point)	Midden from high tide line up to 2-3 m above. Thule houses 3-5 m above high tide line.
Distance from reference point to erosion front	Logger is approx. 3 m from erosion front (check GPS data)
Setting/surroundings	Situated on rocky coast where waves can only reach through a relatively narrow strait. Steep cliff behind main midden.
Site description	
Site type	Large midden (Thule, Saqqaq), Thule houses
Date culture	
Finds	
Dimensions/outline	*need GPS data*
Thickness of deposits	Thickness from 50 to 250 cm
Vegetation cover	Lyme, alpine meadow grass, dandelion, roseroot, mountain sorrell, alpine chickweek, common scurvy grass, low chichweed - no horsetail, only few willow (marehalm, rapgræs, mælkebøtte, rosenrod, fjeldsyre, fjeldhønsetarm, Grønlandsk Kokleare, Rank fladstjerne - ingen padderok, ganske få pil)
Photos (add numbers from other participants)	HMA 4448-4510, including photography of the whole erosion front
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)	
Archaeological value (1-5 as above)	4-5
State of preservation (1-5 as above)	3
Preservation conditions (1-5 as above)	3
Ongoing degradation? (comparison to earlier site visits)	Some ongoing degradation. Small changes seen in Gulløvs excavation pit, where the vertical wlls are leaning, and some material has erodet between 2012 and 2016.
Date visited	21-22/8/16
Visited by	Hans Harmsen, Christian Koch Madsen, Randi Sørensen Johansen, Ulunnguaq Nielsen Lyberth, Jørgen Hollesen, Henning Matthiesen, Roberto Fortuna, Nanna Bjerregaard Pedersen, Annemarie Eriksen, Aart Kroon, Anders Westergaaard Nielsen, Rasmus Fenger Nielsen, Emil Andersen

Table B

10 APPENDIX B: SITE DESCSRIPTIONS

REMAINS OF GREENLAND' - FIELD REPORT

Site	Kangeq
State of preservation	
Buildings/site structure and integrity	Thule houses stand out with 1-1½ m high walls.
Physical disturbance	
Volume excavated during visit	2016: Hole 6 expanded to ca 50x50x50 cm for installation of oxygen sensors. 2012: hole 6 ca 30x30x50 cm for installation of water content sensors
Materials found (list)	Bone, wood, porcelain, antler, leather
Wood	2
Bone	Average 2.7 (287 bones from hole 6)
Stratigraphy	no clear stratigraphy in Hole 6
Other	
State of preservation, in brief (1-5)	3
Measurements during visit (ranges)	
Documented by drone	Rasmus Fenger Nielsen
Active layer thickness (range and date measured)	60 cm (22/8/16)
Soil temperature (range and date measured)	0-5°C
Water content (range measured)	35-60% (in logger hole)
Conductivity (range measured)	25-30 mS/m (in logger hole)
pH (range measured)	4.5-5.8
Sea level (logged: yes/no)	
Root depth	ca 40 cm (thin roots)
Other (ground water level,…	
Samples taken during visit	
Soil (list samples/number)	Ring and bulk samples in logger hole, ring samples in vegetation holes
Artefacts (list materials)	Bone and wood
Other materials (list)	
Vegetation (leaves/biomass/dendrosamples)	Biomass and dendro
Evaluation of value	
Experience: beauty/monumentality	"Haunting beauty". Very visible archaeology at eroding midden
Experience: memory/historic value	Very important to Nuuk, high historic value
Physical integrity	
Physical preservation	Preservation of midden still good - frozen layers at 60 cm depth
Archaeological rarity/representation	
Archaeological information value	High (big volume of midden remaining, but relatively well documented already)
Archaeological assemblage value	
Archaeological value, in brief (1-5)	4-5
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	Previous and ongoing erosion from water, both from the sea (where the midden is already eroded to the spring tide level) and from behind, where freshwater running through the midden is undermining integrity in some places. Estimated erosion since 1972 is modest on northside of bay (based on comparison with photo), but at the A,B and C profiles from 1982 some material has disappeared. Erosion on southside of bay seems more severe, as a lot of

	material is found in front of midden - the exact cause is unclear (thawing of permafrost?)
Other erosion (wind, animals, visitors)	Limited erosion from visitors
Damage from vegetation, roots	Limited damage, roots in dense root mat may help protect against erosion
Drainage	
Melting, heating	Large part of the midden is still permafrozen
Soil movement (including creeping, cryoturbation, slide)	High risk at excavation profiles
Decay of organic materials	
Other threats	
Future threats?	
Preservation conditions, in brief (1-5)	3
Are earlier descriptions available for comparison (references)	Gulløv 1997; Gulløv 1983, s.115-119; NKA 1969 (report). Old photos from ca 1900 up to 1982 are available. Also photos from site visit in 2012
Monitoring	
Already initiated (which parameters)	Temperature, water content, oxygen
Suggested (which parameters)	
Important unknowns/research needed	
Mitigation - summary of recommendations	
Refill trenches	
Backfill	
Erosion protection	
Cut back vegetation	
Fencing	
Rescue excavation	

References

Gulløv, Hans Christian, and J. Ilkjær. 1969. Nationalmuseets Grønlandsundersøgelser, sommeren 1968. Unpublished report: NKA.

Hinnerson-Berglund, Maria. 2004. *Mobilitet och estetik. Nuukfjorden på Grönlands västkust som människornas livsvärld för 4000 år sedan*. Göteborg: Göteborg University.

Knudsen, Pauline, Christian K. Madsen, Peter A. Toft, Henning Matthiesen, Jørgen Hollesen, Aart Kroon, Anders B. Møller, Mikkel W. Pedersen, Morten Allentoft, Morten Meldgaard, Ann E. Lennert, Paul Ledger, Kirstine Møller, and Pipaluk Lynge. 2014. Field report 2012-2013 for the pilot project "People of All Times." Report from Conservation & Science, National Museum of Denmark, Copenhagen.

Qarajat [NKAH 647]

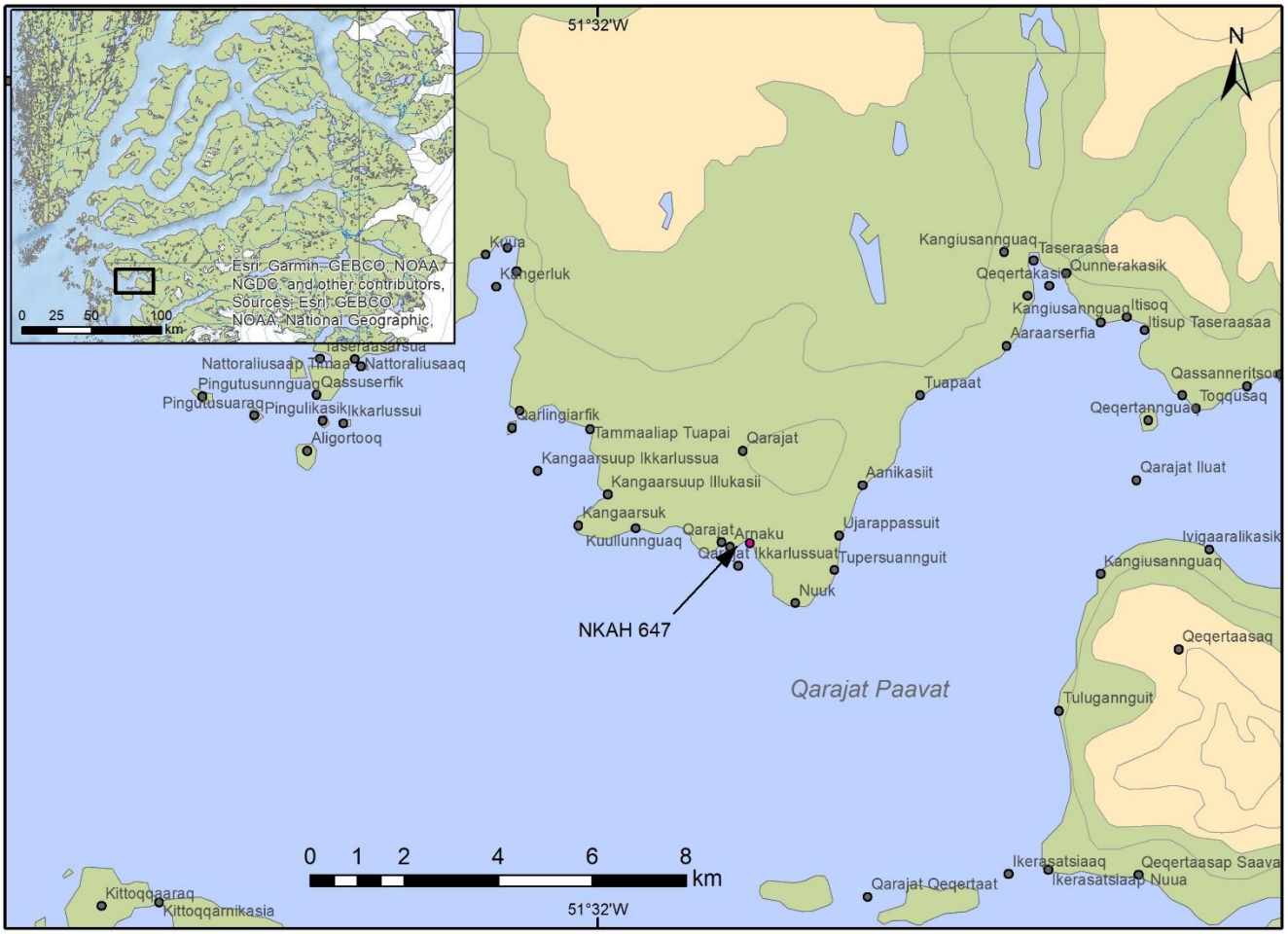

Fig. 1. Location of Qarajat [NKAH 647] in the Nuuk Fjord.

Site description

Qarajat (63.958930°, -51.4986440°) is located on the northern shore of Qarajat Paavat (Fig. 1). The site represents a late Thule-Inuit/Hernnhut settlement but is currently in use as a summer property with one modern structure built approximately 100 m to the southeast of the main ruin group close to the modern shoreline. Little documentation exists on the site's history. The main ruin group is located along a small brook running down from the north with a few isolated features scattered near the shore (**Fig. 2**). Egil Knuth visited Qarajat ca. 1945 and identified a complex ruin group of at least 17 houses. He reports that at the time of his visit that some of the houses had been in use as late as 1905 (e.g. houses

11 APPENDIX B: SITE DESCSRIPTIONS

REMAINS OF GREENLAND' - FIELD REPORT

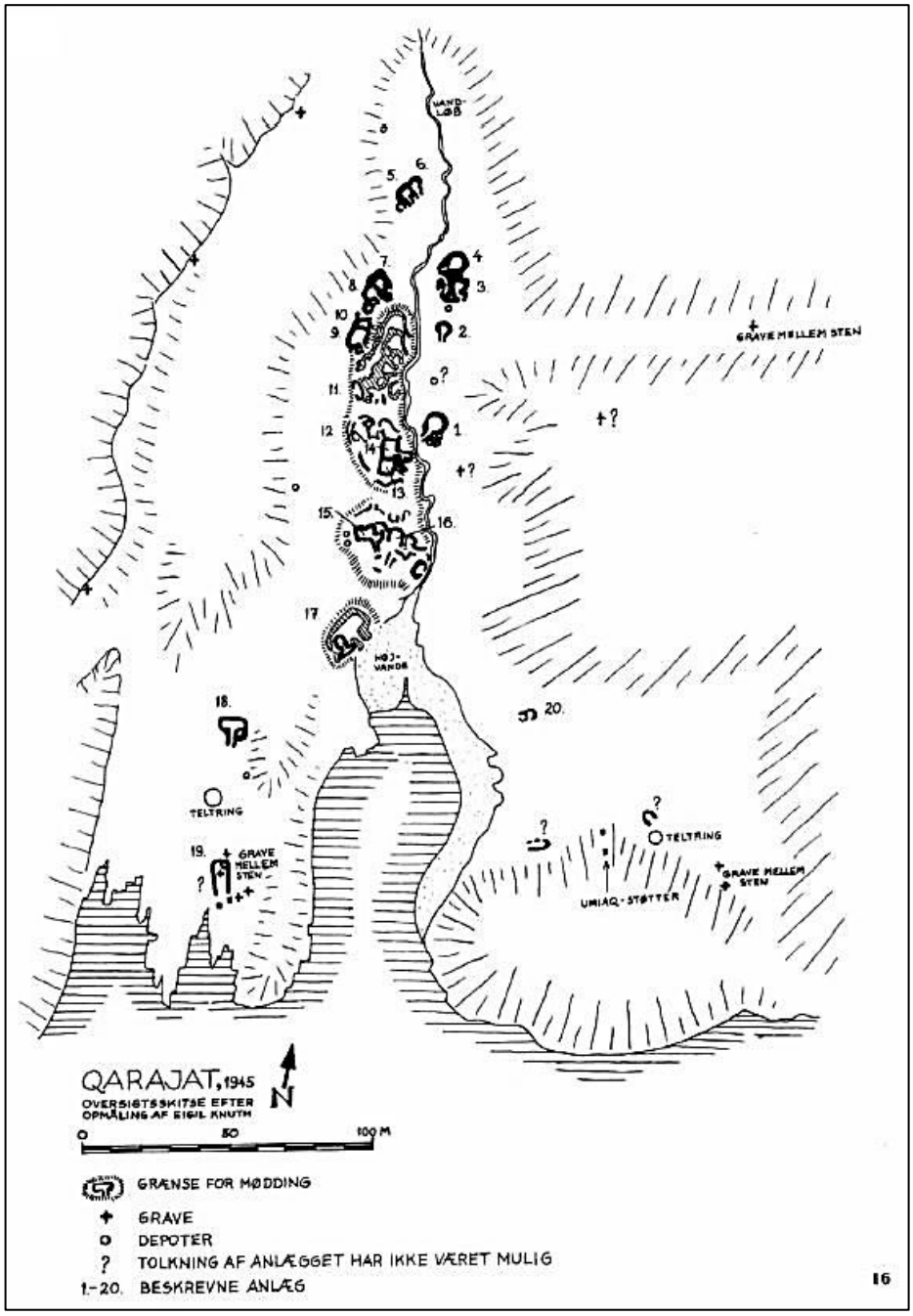

Fig. 2. The ruin group at Qarajat after Gulløv (1983:26). Features 1-6, 8, 10 and 18 excavated by Knuth ca. 1945. (1) Round house feature with five caches; (2) round house feature; (3) small, square house feature, possibly built on footprint of older round house; (4) round house feature; (5) rectangular house feature; (6) square house feature; (7) square house feature; (8) square house feature; (9) long house feature; (10) square house feature; (11) house feature; (13) square house feature, more recent; (14) square house feature; (15) square house feature, inhabited from 1900 to 1905; (16) square house feature, inhabited from 1900 to 1905; (17) nave ; (18) longhouse feature, adjoining room was added later and then used as a grave (excavated); (19) undetermined horseshoe-shaped feature; (20) washed-out house feature.

no. 15 and 16). It appears that Knuth excavated approximately nine areas within the main ruin group. Additionally, he identifies five undefined features, two tent rings, seven detached caches and three possible graves in the immediate vicinity (Gulløv 1983:25-29). In 2016, house no. 17 was observed to be actively undermined and sloughing into the bedrock of the supratidal zone.

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Archaeological investigations and sampling

Time at Qarajat was limited and consisted of a site walkover and visual inspection of the current state of the ruin groups. The presence of remaining archaeological features was compared against the site map in Gulløv (1983:26). Ruin features were photographed and GPS waypoints collected. No sub-surface testing or sampling was conducted at Qarajat in 2016.

Protocol

Table 1. Observations made at Qarajat in 2016 using the REMAINS field protocol.

Table A	
Site	Qarajat
NKAH no	1088
Serial no /FM number	63V1-00I-016
Region	
Number of structures	17 houses, tent rings, depots, graves, umiaq/kayak support posts. 11 features were excavated by Knuth in 1945
Location	
N/E (decimal degrees; WGS84)	63.958930°, -51.4986440°
Height above sea level (lowest and highest point)	Lowest point at high tide line, highest houses estimated 8 m above (needs to be checked when drone data are processed)
Distance from reference point to erosion front	
Setting/surroundings	Situated on rocky coast, small brook running down in between the houses
Site description	
Site type	Extensive Thule site, settlement up to modern times. Extensive middens under erosion
Date culture	ca 1300 to 1900
Finds	No excavation was carried out, but bone was visible in some of the house walls
Dimensions/outline	Ca 250x50 m (need validation from drone data)
Thickness of deposits	Thickness not measured (no corer available). House walls were up to ca. 1½ m high
Vegetation cover	Lyme, bluejoint, alpine meadow grass, dandelion, willow, some dwarf willow, common scurvygrass - no horsetail (marehalm, rørhvene, rapgræs, mælkebøtte, revling, pil, lidt dværgpil, Grønlands Kokleare - ingen padderok)
Photos (add numbers from other participants)	HMA 4517-4534. Roberto Fortuna has photos of the whole erosion front
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)	

Archaeological value (1-5 as above)	2-3
State of preservation (1-5 as above)	
Preservation conditions (1-5 as above)	4
Ongoing degradation? (comparison to earlier site visits)	Comparison to drawing from 1945 shows very limited changes (closer comparison awaits drone data). However, some of the houses have lost their entrance, so a substantial erosion must taken place before 1945. Description of vegetation is similar for all houses in 1945 and today (detailed description available from HMA)
Date visited	24-08-16
Visited by	Hans Harmsen, Mikkel Myrup, Christian Koch Madsen, Randi Sørensen Johansen, Ulunnguaq Nielsen Lyberth, Jørgen Hollesen, Henning Matthiesen, Roberto Fortuna, Nanna Bjerregaard Pedersen, Annemarie Eriksen, Aart Kroon, Rasmus Fenger Nielsen, Emil Andersen

Table B	
Site	Qarajat
State of preservation	
Buildings/site structure and integrity	Thulehouses stand out with 1-1½ m high walls.
Physical disturbance	11 of the houses have been "disturbed" through excavation
Volume excavated during visit	no excavation carried out
Materials found (list)	
Wood	
Bone	
Stratigraphy	
Other	
State of preservation, in brief (1-5)	
Measurements during visit (ranges)	
Documented by drone	Mikkel Myrup
Active layer thickness (range and date measured)	
Soil temperature (range and date measured)	
Water content (range measured)	
Conductivity (range measured)	
pH (range measured)	
Sea level (logged: yes/no)	
Root depth	
Other (ground water level,…	
Samples taken during visit	No samples
Soil (list samples/number)	
Artefacts (list materials)	
Other materials (list)	
Vegetation (leaves/biomass/dendrosamples)	
Evaluation of value	
Experience: beauty/monumentality	Clearly visible in landscape
Experience: memory/historic value	Known by local descendants. Probably many historical sources
Physical integrity	2 (11 of the houses are already excavated)

Physical preservation	
Archaeological rarity/representation	5 (many different Thule houseforms represented)
Archaeological information value	2-3 (check information value in middens - these were not excavated in 1945)
Archaeological assemblage value	
Archaeological value, in brief (1-5)	2-3
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	Modest erosion since excavation in 1945 (needs to be confirmed by Mikkels drone data), however, a significant erosion has taken place earlier as the entrances to some of the houses have disappeared. Local informant says that there has been limited changes since she starting visiting the site in 1970
Other erosion (wind, animals, visitors)	A little erosion (and garbage) from visitors. One fox grave.
Damage from vegetation, roots	Limited damage (no Horsetail). Roots in dense lyme mat may help protect against erosion
Drainage	Normally the area is quite wet, but very dry in this summer
Melting, heating	
Soil movement (including creeping, cryoturbation, slide)	Probably some risk near erosion front
Decay of organic materials	Probably high risk during dry summers, but havent checked the content of organic materials
Other threats	
Future threats?	
Preservation conditions, in brief (1-5)	4
Are earlier descriptions available for comparison (references)	Gulløv 1983, s.25; Knuth 1945.
Monitoring	
Already initiated (which parameters)	none
Suggested (which parameters)	
Important unknowns/research needed	
Mitigation - summary of recommendations	None are considered necessary
Refill trenches	
Backfill	
Erosion protection	
Cut back vegetation	
Fencing	
Rescue excavation	

References

Gulløv, Hans Christian. 1983. *Nuup kommuneam gangarnitsanik eqqaassutit inuit-kulturip nunaqarfii*. Nuuk: Kalaallit Nunaata Katersugaasivia (Nationalmuseet Grønland).

Tulugartalik [NKAH 1088]

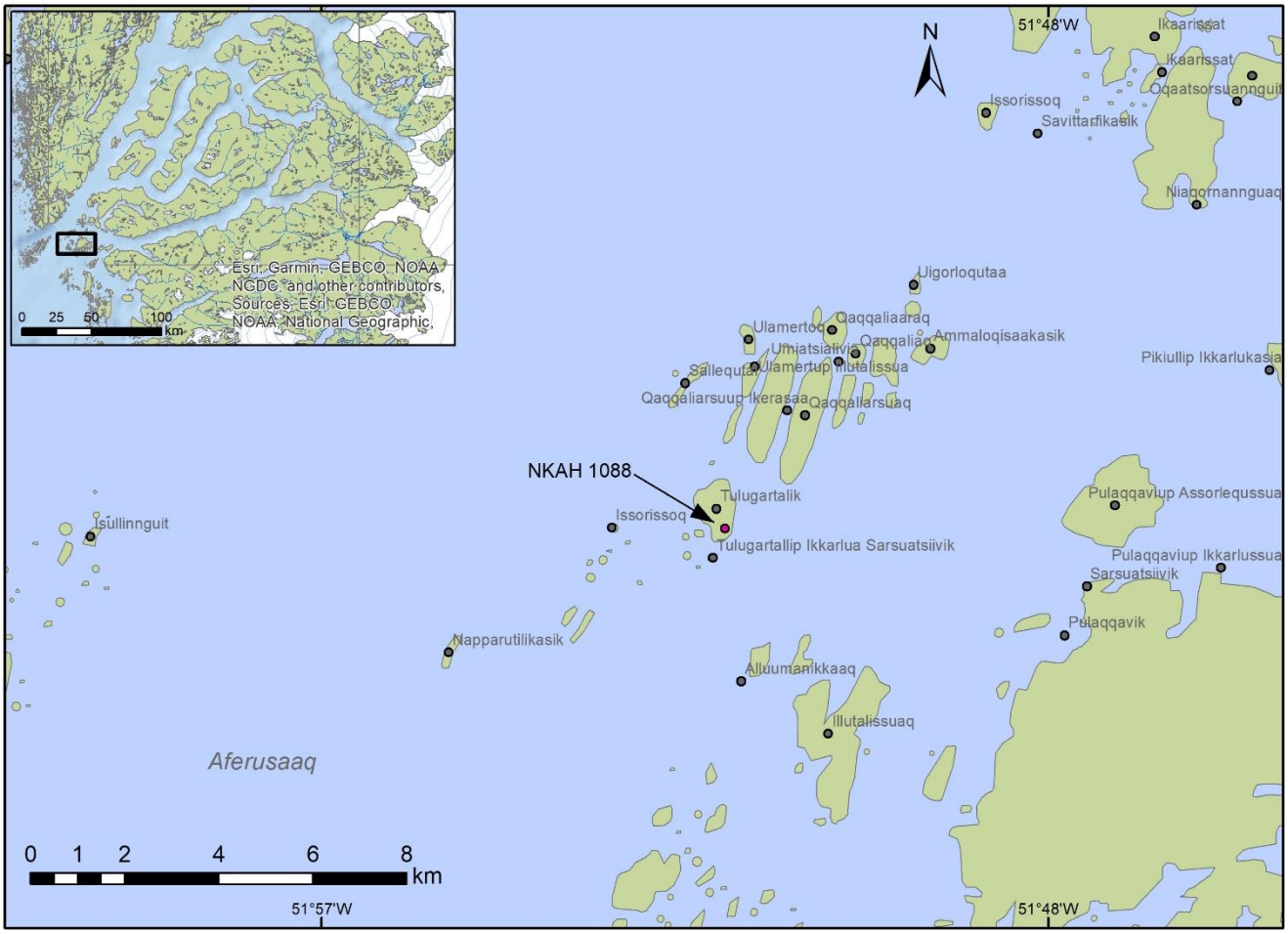

Fig. 1. Location of Tulugartalik site [NKAH 1088] in the Nuuk Fjord.

Site description

The small island of Tulugartalik, (64.080060°, -51.8673620°) is located a few kilometers southwest of Nuuk and hosts two Thule-Inuit winter house ruin groups (Fig. 1). Ruin group 1 is found on the northeast side of the island and comprises three house features a small cache to the south. Ruin group 2 is found on a small cobble beach to the south comprising four house features—house ruin 6 is believed to be the "death-house" related to the smallpox epidemic of 1733-34, excavated by Louis Bobé in the early 20th century (see Bobé and Egede 1952). Houses 5, 7 and 8 appear to be in the advanced stages of collapse and eroding into the fjord. A grave is also mentioned by Gulløv (1983:5) but was not

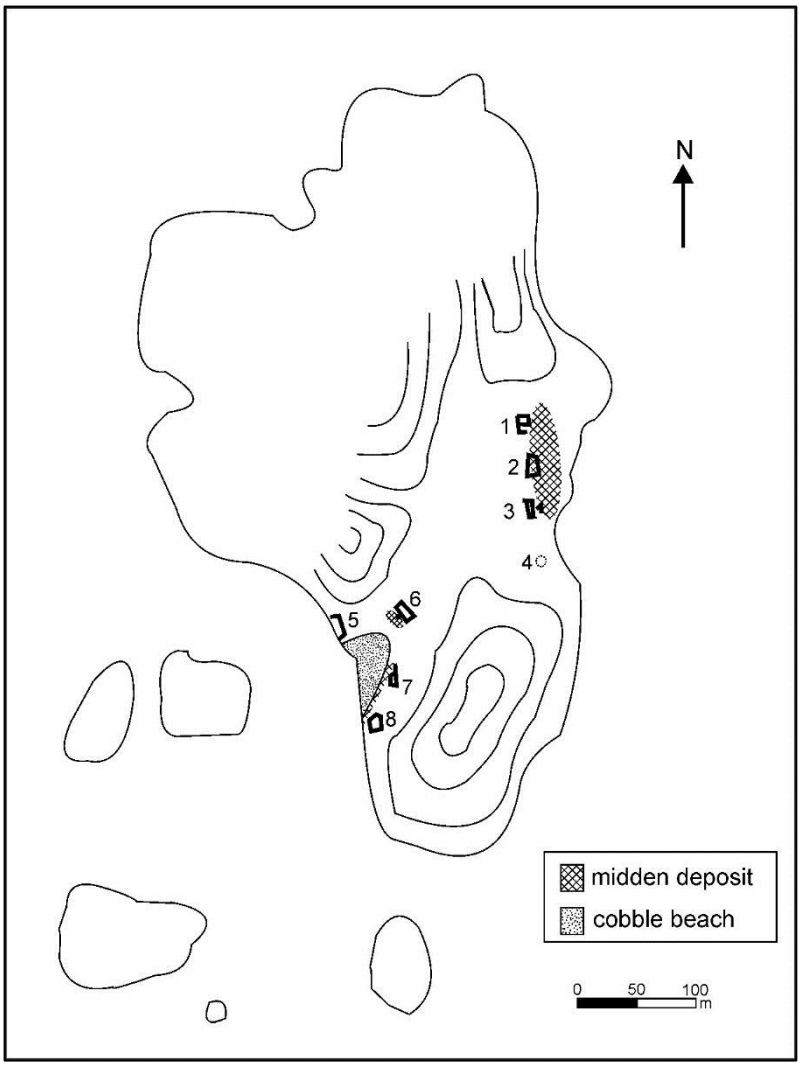

Fig. 2. Ruin groups at Tulugartalik. Winter house features 1-4 comprise Ruin group 1. Features 5-8, Ruin group 2. House 6 is observed as the sealed "death house," excavated by Bobé in early 20th century (after Gulløv 1983:84).

identified in 2016, however the remnants of what appeared to be a stone ring play "kayak" was observed to the west of the Ruin group 1 on the higher elevation escarpment.

Archaeological investigations and sampling

Time at Tulugartalik was limited due to inclement weather and was confined to a site walkover and visual inspection of the current state of the ruin groups. The presence of remaining archaeological features was compared against the site map in Gulløv (1983:84). Ruin features were photographed and GPS waypoints

collected. A small hole dug in the marshy area in front of house 6 showed very well-preserved wood but no samples were collected in 2016.

Protocol

Table 1. Observations made at Tulugartalik in 2016 using the REMAINS field protocol.

Table A	
Site	Tulugartarlik
NKAH no	1057
Serial no /FM number	64V1-III-No5
Region	
Number of structures	7 winter houses
Location	
N/E (decimal degrees; WGS84)	64.080060°, -51.8673620°
Height above sea level (lowest and highest point)	Houses 5,7 and 8 at spring tide line, 1-3 and 6 approx. 1-3 m above
Distance from reference point to erosion front	
Setting/surroundings	Situated on a skerry with rocky coast, 1-4 on the west side, 5-8 on the east side
Site description	
Site type	Thule winter settlement
Date culture	
Finds	No excavation was carried out, but bone and wood was visible in one of the house walls. A small hole dug in a wetland in front on house 1d showed very well preserved wood
Dimensions/outline	2 settlements, ca 50x50 m each
Thickness of deposits	walls up to 1 m high, deposits/midden >40 cm, turflayer in wetland 120 cm thick
Vegetation cover	Bluejoint, alpine meadowgrass, dandelion, willow, crowberry, cloudberry, horsetail, a little lyme (rørhvene, rapgræs, mælkebøtte, pil, revling, multebær, padderok, en smule marehalm)
Photos (add numbers from other participants)	HMA 4538-4556. Roberto Fortuna has some photos of the erosion
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)	
Archaeological value (1-5 as above)	
State of preservation (1-5 as above)	
Preservation conditions (1-5 as above)	
Ongoing degradation? (comparison to earlier site visits)	Sketch from 1972 is available, showing limited changes. However, some of the houses are heavily eroded, so heavy erosion has taken place prior to 1972.
Date visited	25-08-16
Visited by	Hans Harmsen, Christian Koch Madsen, Randi Sørensen Johansen, Ulunnguaq Nielsen Lyberth, Henning Matthiesen, Roberto Fortuna, Annemarie Eriksen, Emil Andersen

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REMAINS OF GREENLAND' - FIELD REPORT

Table B	
Site	Tulugartarlik
State of preservation	
Buildings/site structure and integrity	4 houses still complete/good integrity, 2 heavily eroded, 1 under erosion
Physical disturbance	1 of the houses has been "disturbed" through excavation
Volume excavated during visit	no excavation carried out
Materials found (list)	wood
Wood	Excellent preserved in wetland (NBP more)
Bone	
Stratigraphy	
Other	
State of preservation, in brief (1-5)	
Measurements during visit (ranges)	
Documented by drone	no
Active layer thickness (range and date measured)	
Soil temperature (range and date measured)	
Water content (range measured)	80-90 % in wetland in front of 1d
Conductivity (range measured)	25 mS/m in wetland in front of 1d
pH (range measured)	5.7 in wetland in front of 1d (1 measurement only)
Sea level (logged: yes/no)	
Root depth	
Other (ground water level,…	
Samples taken during visit	
Soil (list samples/number)	
Artefacts (list materials)	2 wood samples (for NBP)
Other materials (list)	
Vegetation (leaves/biomass/dendrosamples)	
Evaluation of value	
Experience: beauty/monumentality	2
Experience: memory/historic value	Historic sources mentions one of the houses as a deadhouse (smallpox epidemy)
Physical integrity	1-4 (1 for eroding houses, 4 for higher lying)
Physical preservation	
Archaeological rarity/representation	not unique
Archaeological information value	Middens not excavated - information value? Wetland in front of 1d has excellent preservation conditions
Archaeological assemblage value	
Archaeological value, in brief (1-5)	
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	Modest erosion since Gulløv and Kapels visit in 1972, however, a significant erosion has taken place earlier as parts of the houses have dissapeared.
Other erosion (wind, animals, visitors)	No erosion from visitor or animals. A lot of debris (driftwood and plastic) from the sea

Damage from vegetation, roots	Limited damage from Horsetail. Roots in dense bluejoint and grass mat may help protect against erosion
Drainage	Normally the area is quite wet, but very dry in this summer
Melting, heating	
Soil movement (including creeping, cryoturbation, slide)	
Decay of organic materials	
Other threats	
Future threats?	
Preservation conditions, in brief (1-5)	
Are earlier descriptions available for comparison (references)	Gulløv 1983, s.84p; NKA 1972, report.
Monitoring	
Already initiated (which parameters)	none
Suggested (which parameters)	
Important unknowns/research needed	
Mitigation - summary of recommendations	None are considered necessary
Refill trenches	
Backfill	
Erosion protection	
Cut back vegetation	
Fencing	
Rescue excavation	

References

Bobé, Louis, and Hans Egede. 1952. *Hans Egede, colonizer and missionary of Greenland*. Copenhagen: Rosenkilde and Bagger.

Gulløv, Hans Christian. 1983. *Nuup kommuneam gangarnitsanik eqqaassutit inuit-kulturip nunaqarfii*. Nuuk: Kalaallit Nunaata Katersugaasivia (Nationalmuseet Grønland).

Ujarassuit (Anavik), V7 [NKAH 1345]

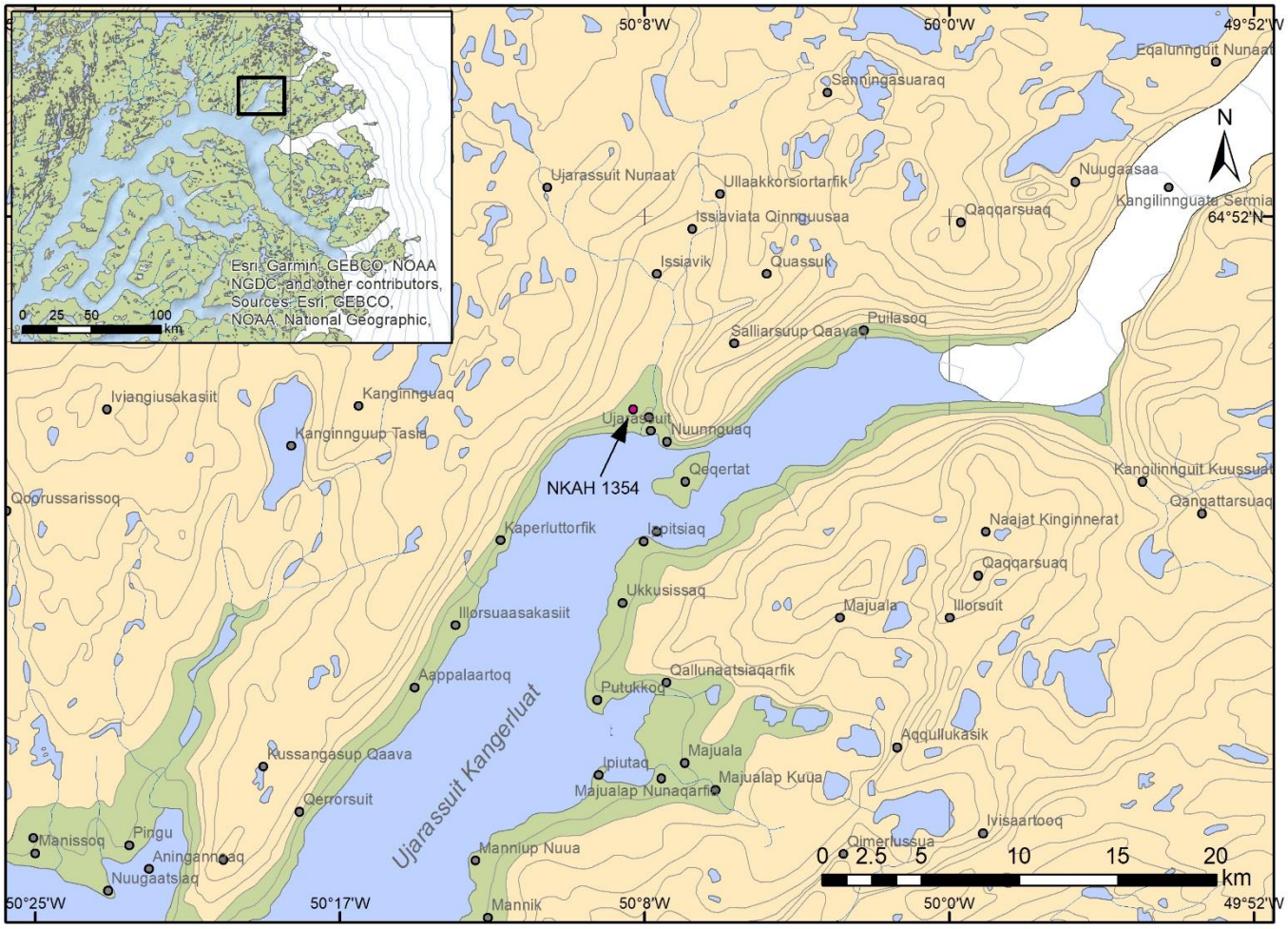

Fig. 1. Ujarassuit (Anavik) lies on an elevated escarpment overlooking the fjord in the Ujarassuit Kangerluat.

Site description

Ujarassuit (64.823790°, -50.1440880°) is a well-known Norse farm lying on an elevated valley floor near the head of the Ujarassuit Kangerluat. Ujarassuit was one of the early abandoned Norse settlements identified by the missionary Hans Egede in the Nuuk fjord (Egede 1925). Over the course of the 18th to 19th centuries, surveys of the site were frequent and included visits by several individuals that included: Pingel, J.A.D. Jensen, Ryder, Thorhallesen, Kleinschmidt and Bruun (Lynnerup 1998:23,

after Bruun 1917). Although a church was assumed to be present at Ujarassuit, it was not confirmed until archaeological excavations were performed by Roussell in 1932 (Roussell 1941:105). Outstanding preservation of archaeological remains was observed by Roussell during his investigations; outside the southeast corner of the church, Roussel noted the possibility of finding well-preserved bodies and even clothing due to the high state of preservation conditions. Further study of Ujarassuit was performed in 1982 by Kapel and Arneborg with excavations in the church and farmhouse block (ruin 2). At this time, preservation conditions outside the church yard were notes as similar to descriptions by Roussell in the same area in 1932. Roussell suggested that the church was probably in use after ca. AD 1300. Radiocarbon analyses by Kapel and Arneborg (1982) have indicated a burial period ca. 14th century.

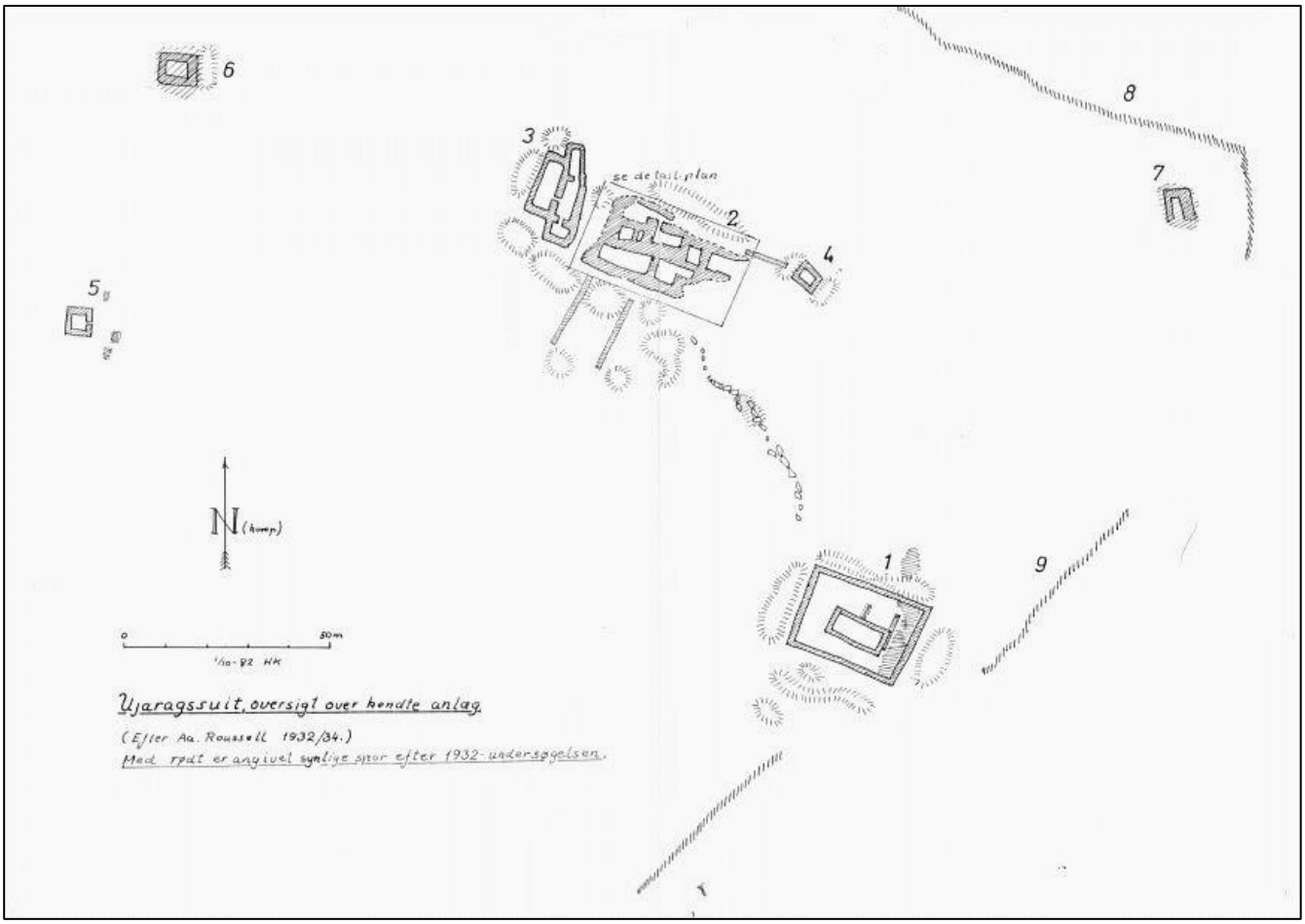

Fig. 2. Norse farm and features at Ujarassuit (Anavik). (1) Church; (2) farmhouse block; (3) byre-barn; (4) horse stable; (5) drying house: (6-7) sheep sheds; (8-9) infield stone wall (Kapel and Arneborg 1982:21)

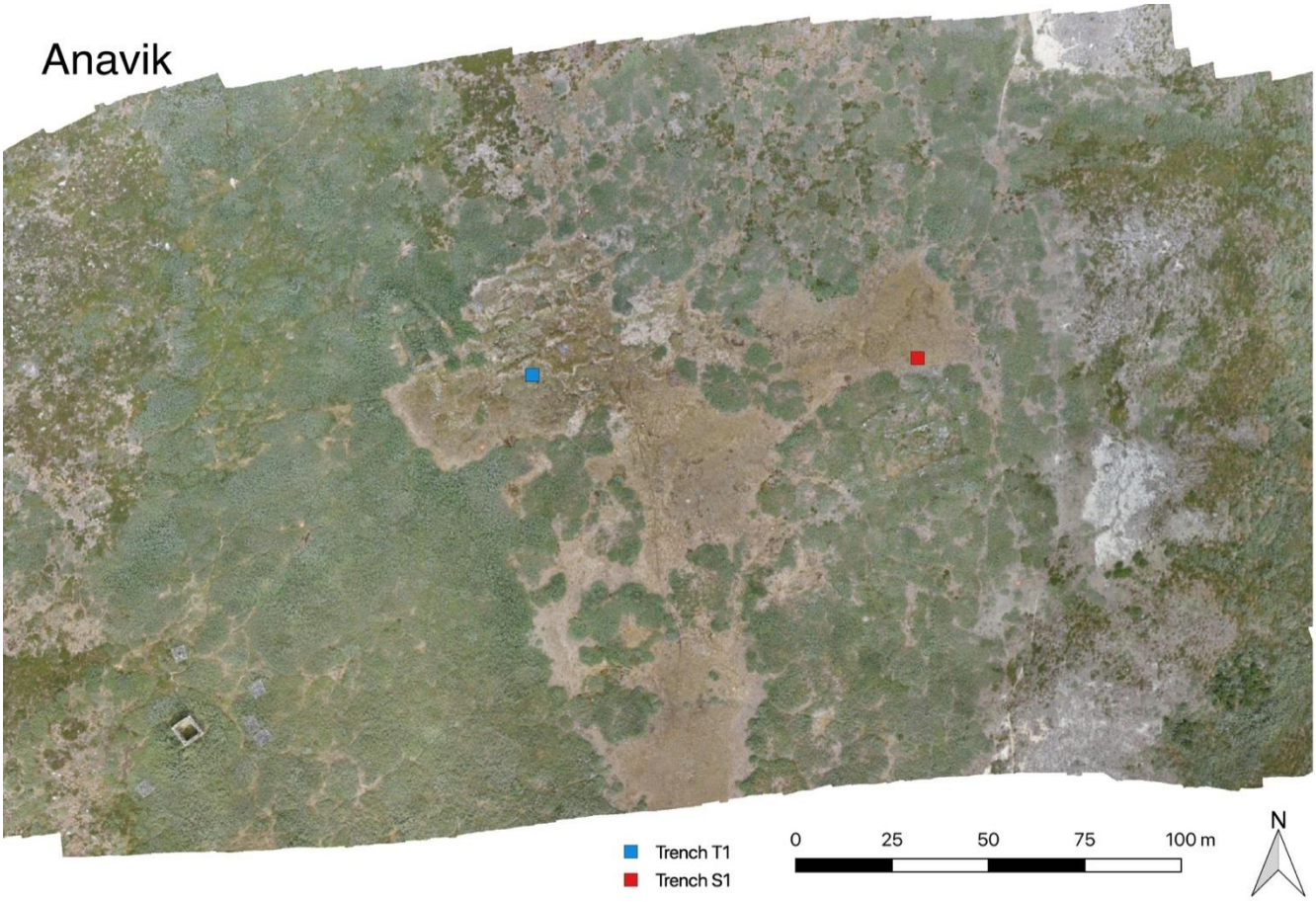

Fig. 3. Drone map of ruins at Ujarassuit (Anavik) showing the positions of trenches T1 and S1

Archaeological investigations and sampling

Trench 1 (T1)

A test trench profile (T1) measuring .5 x 1 m was opened at ruin 2 (farmhouse midden feature) at Ujarassuit in 2017 (Fig. 5 and 6). Clearance of this profile section of the midden was performed to: (1) examine preservation conditions of organic remains in the midden; (2) document local soil conditions and install environmental monitoring equipment; and (3) install modern bone and wood samples into the walls of the profile to study natural decomposition. The location of the profile expanded of a previous trench left exposed by Roussell in 1932, cutting laterally through a mound of backfill covering the house's southern midden deposit. Detailed observations on the strata identified during excavation of T1 are summarized below and in Table 1.

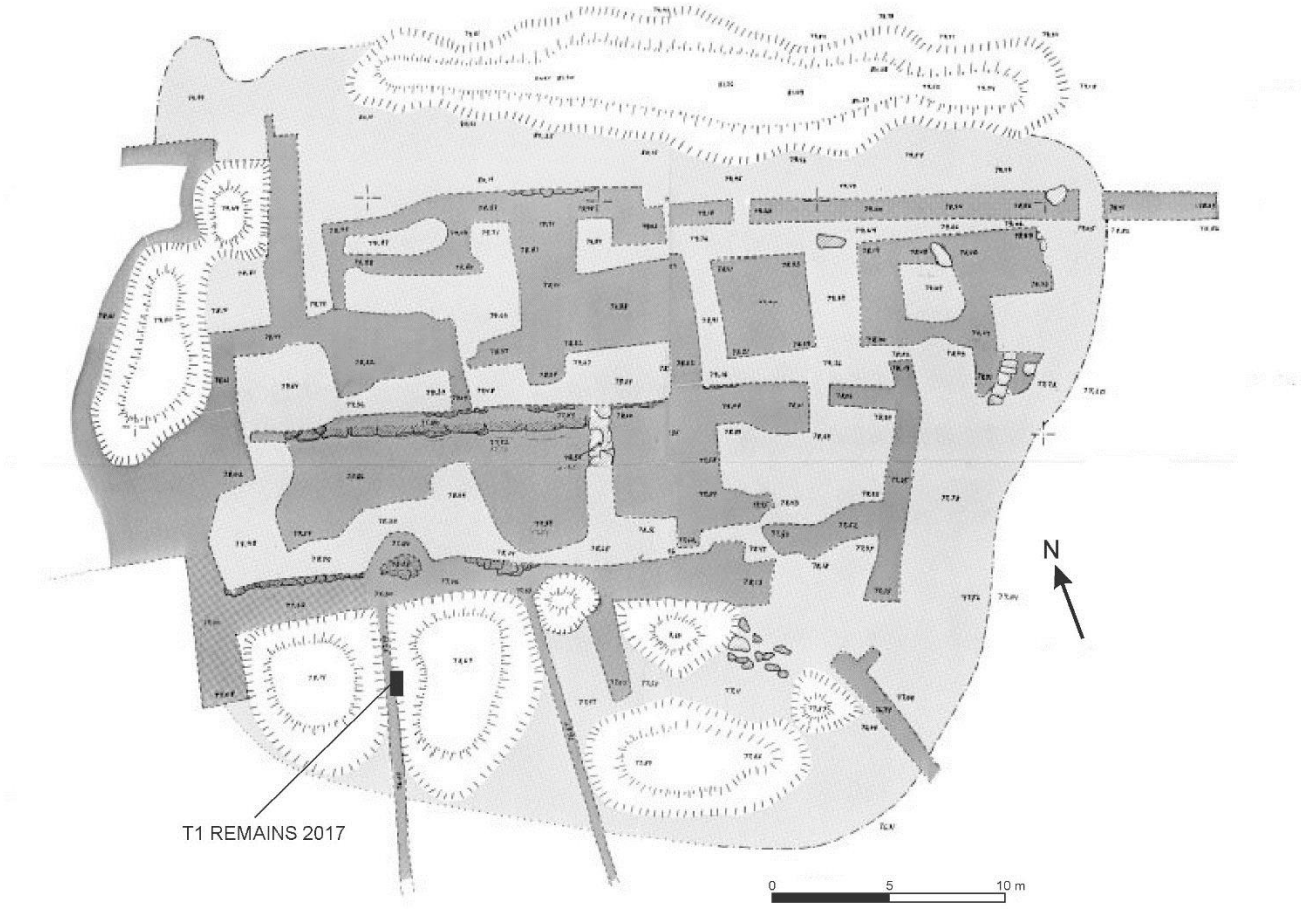

Fig. 4. Ruin 2, Norse centralized farmhouse at Ujarassuit. A .5x1 m trench profile was cleared in 2017 to examine sub-surface preservation conditions of the house's southern midden feature.

0-50 cm below datum

Sloping downward at a <25-35% grade, context [01] was comprised of fine 10 YR 2/1 black soil with small charcoal inclusions. The context was generally homogenous and identified as backfill from Roussel's 1932 excavation of the house (ruin 2). Between -30 and -35 cm below datum in the north half of T1, a thin 10 YR 2/2 very dark brown greasy soil, context [02] was observed as the uppermost midden layer. This context was constrained by several large cobbles that were probably found in situ and originating during some late phase of occupation at the site. Context [3], observed between to -35 to -55 cm below datum comprised a 10 YR 2/1 black, greasy midden layer with a prominent 10 YR 6/1

gray fine silt lens (a). No artefacts were collected, but a large flagstone was removed at -50 cm below datum.

50-80 cm below datum

Contexts [4-9] consisted of several heterogeneous midden layers, all possessing heavily degraded bone material with poor preservation. Context [4] through [6] ranged from a mottled 10 YR 2/2 to 3/2 very dark grayish brown to black fine silt to a 7.5 YR 2.5/1 black and 7.5 YR 3/2 dark brown greasy soil, all layers possessing charcoal and degraded bone ("butter bone") inclusions. Context [7] comprised a sandier 10 YR 2/1 black soil with charcoal and degraded bone inclusions. Context [8], only observed in the southern quadrant of the profile, was characterized as a 7.5 YR 2.5/2 very dark brown soil with demonstrable micro-bands of 10 YR 6/1 fine silt and charcoal. Context [9] was the single densest midden layer, heavily mottled but dominated by a 10 YR 3/2 very dark grayish brown greasy soil. The context possessed several degraded bones and 10 YR 5/1 gray silt inclusions. Contexts [10-11] formed the lowest levels of the midden sequence and were generally characterized by several mixed micro-bands <1 cm thickness, differentiated between 10 YR 2/1 black greasy soil; 10 YR 3/6 dark yellowish-brown sand; 10 YR 5/1 gray silt. Preservation quality in T1 was observed to be extremely poor and is believed to have been a consequence of the trench serving as a natural drainage feature for the midden over the past 80 years. Due to the poor preservation, very few organic artifacts were collected from the midden layers (contexts [4] through [11]), however two metal objects were recovered in the lower levels of the profile that included a needle and nail in context [10]. A whale bone was left embedded in the west wall of the trench at approximately -44 cm below datum.

80-110 cm below datum

Excavation was concluded at approximately -110 cm below the surface as a homogenous 10 YR 4/3 brown sand and gravel devoid of artefacts and charcoal emerged at approximately -95 cm below datum and comprising context [13].

Fig. 5. Profile of East wall of T1 at ruin 2, Ujarassuit.

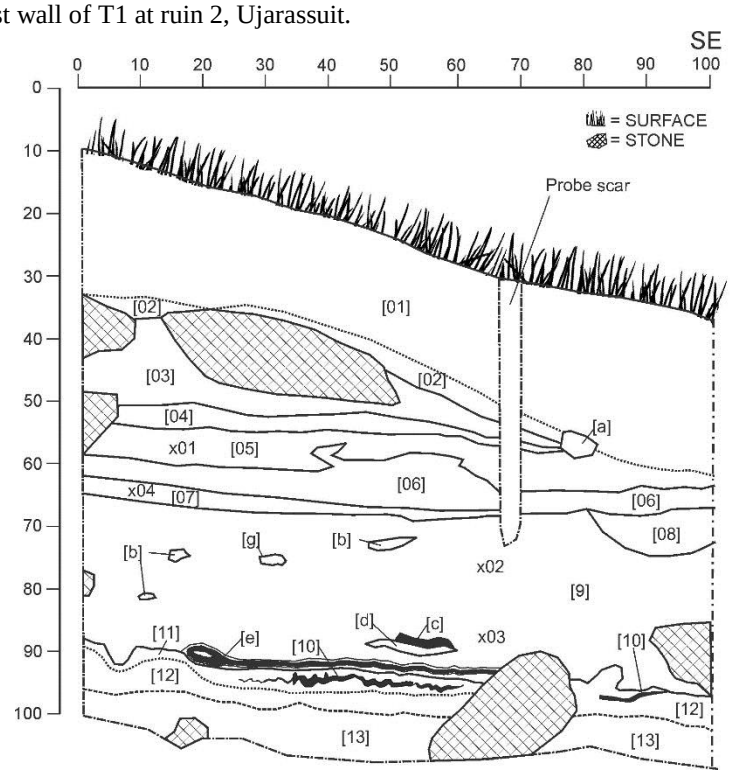

Fig. 6. Bottom of T1, ruin 2 at Ujarassuit.

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REMAINS OF GREENLAND' - FIELD REPORT

Table 1. Soil strata identified in T1 at Ujarassuit

Depth (below datum)	Context no.	Description	Interpretation
0-50 cm	[01]	10 YR 2/1 black with small charcoal inclusions, fine	Rousell 1932 backfill
30-50 cm	[02]	10 YR 2/2 very dark brown greasy soil	midden
35-55 cm	[03]	10 YR 2/1 black, greasy soil	midden
	(a)	10 YR 6/1 gray fine silt lens	aeolian deposit
55-60 cm	[04]	10 YR 3/2 very dark grayish brown, fine silt	aeolian deposit
55-65 cm	[05]	graded 7.5 YR 2.5/1 black & 7.5 YR 3/2 dark brown greasy soil; charcoal inclusions	midden
55-65 cm	[06]	mottled 10 YR 2/2 very dark brown soil; charcoal and degraded bone inclusions	midden
60-65 cm	[07]	10 YR 2/1 black sandy soil; charcoal and degraded bone inclusions	midden
65-75 cm	[08]	7.5 YR 2.5/2 very dark brown soil + micro bands of 10 YR 6/1 fine silt and charcoal	mixed midden and aeolian deposits
65-95 cm	[09]	Heavily mottled, dominated by 10 YR 3/2 very dark grayish brown greasy soil; degraded bone and 10 YR 5/1 gray silt inclusions	midden
	(b)	10 YR 5/1 gray silt inclusion	aeolian deposit
	(c)	10 YR 2/1 lens	charcoal stain
	(d)	10 YR 3/3 dark brown sandy sediment inclusion	natural
	(e)	10 YR 5/1 gray silt inclusion	aeolian deposit
	(g)	degraded bone inclusion	cultural
85-95 cm	[10]	several mixed micro-bands <I cm thickness: 10 YR 2/1 black greasy soil; 10 YR 3/6 dark yellowish brown sand; 10 YR 5/1 gray silt	midden deposit
~90 cm	[11]	10 YR 5/1 gray, fine powder silt	aeolian deposit
90-95 cm	[12]	10 YR 4/1 dark gray fine sand	natural
95-105 cm	[13]	10 YR 4/3 brown sand, emergent gravel	natural

T1 produced twelve (*N*=12) individual artefacts, detailed by type, quantity (*n*) and weight in Table 2. Bulk samples of bone and shell were also collected and are listed by number of samples bags and

aggregate weight in Table 3. No wood was found preserved in T1. All finds were collected in sterile sample bags and segregated based on provenience. Volume specific soil samples (100cm^3) were also taken at -5, -20, -40 and -60 cm depths below the surface.

Table 2. Total T1 artifacts, detailed by type, quantity (n) and aggregate weight.

Material type	**artifacts (*n*)**	**wt. (g)**
lithic, steatite	1	2
lithic, Igaliku sandstone	1	91.7
lithic, slate	2	28.8
lithic, other	4	4.6
metal	2	3.3
Total	**12**	**130.4**

Table 3. Total T1 samples, detailed by type, number of sample bags taken and aggregate weight.

Sample type	**# of sample bags**	**wt. (g)**
bone	1	6.1
mussel	1	.3
Total	**2**	**6.4**

One sample of *Fagus sylvatica* (European beech) and one sample of *Pinus sylvestris* (Scots pine) were buried at each of the four depths (10, 20, 40, and 60 cm) by digging a groove in the profile for the samples to rest in, and a pair of samples were left on the soil surface.

Trench S1

In order to get an impression of the preservation conditions at the graveyard a 1.0 m deep hole was dug into the natural soil just outside the graveyard wall (Fig. 3). The soil consisted of silt with distinct dark/light lamination (Fig. 7), and coarser sand from 0.84 m and downwards.

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Fig. 7. Corner of trench S1 outside the graveyard wall at Ujarassuit.

Vegetation Studies

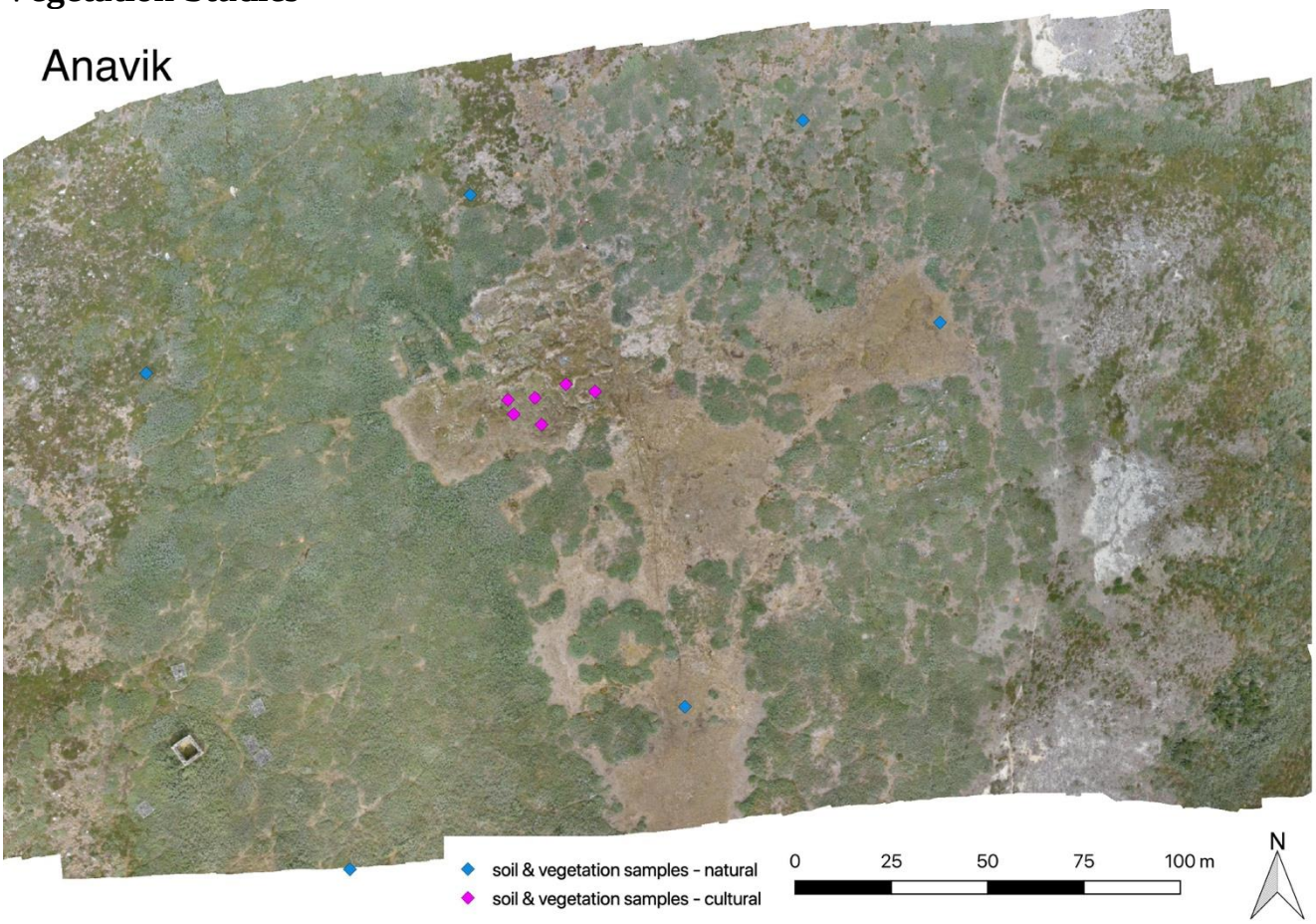

Fig. 8. Map of the archaeological site at Ujarassuit (Anavik) showing the positions of sampling sites.

Detailed vegetation analyses were carried out on six (*n*=6) 1x1 meter in the immediate vicinity of the ruin group and on six (*n*=6) 1x1 meter plots ("cultural" in Fig. 8) on the surrounding reference area soil ("natural" in Fig. 8). Each plot was photographed with a high-resolution camera (Hasselblad) and a multi-spectral camera (Sequia) and NDVI was measured using a Decagon NDVI sensor. The vegetation cover was quantified using a 1x1 meter frame divided in to 25 sectors by pinpoint analysis. A .2 x .2 m area within each plot was harvested and green biomass collected. The same sample area was then dug to a maximum depth of -30 cm below the surface. Volume specific soil samples ($100cm^3$) were collected at -5 cm, -10 cm, -20 cm and -30 cm below the surface. After sampling, the hole was backfilled and vegetation cover replaced to minimize damage to the site. For each plot fifteen to twenty leaves were harvested from one to three species on or close to each sample plot.

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Fig. 9. To investigate the spatial scale of lasting effect from historical human activities on the vegetation around Ujarassuit (Anavik) the species composition was investigated by measuring, C:N ratio, δ15N-values and shrub radial-growth within the settlement and along a one kilometre transect.

To investigate the recent increase in growth of *S. glauca* (Northern willow), dendrochronology samples were collected near T1 and in the surrounding reference ("natural") area. When a sample plant was identified, 10-20 cm of the root column was cleared from soil and debris. Then the stem (comprised of approximately 10-20 cm root and 10-20 cm above-ground stem) was sawn away and collected. Additionally, fifteen (n=15) leaves from each sample trees was harvested to conduct C/N + ^{15}N analyses.

A total of twenty-four (N=24) *S. glauca* stems were sampled from Ujarassuit. 12 samples were from "cultural" areas (with two samples from each of ruins 1, 2, 3, 5, 6 and the midden) and 12 samples were

from “natural” areas (with six samples from each of two plots). All sample areas were documented with photos and GPS points.

Lastly, a study in legacies of species composition was investigated by measuring: C:N ratio, δ^{15}N-values and shrub radial-growth along a one kilometer transect at Ujarassuit (Fig. 9). This was done to estimate the degree and extent at which human effects on thevegetation are detectable.

GPS and UAV Surveys

A high precision TRIMBLE RTK-dGPS was used to (1) map archaeological features; (2) anchor ground control points; (3) map the positions of sampling locations and environmental monitoring sites and (5) collect geomorphologic data.

A quadcopter UAV (Tarot 650-sport) was used to conduct a mapping survey of the site. A total of two (*N*=2) flights were performed. The flights mapped the entire site with two different types of cameras: a regular RGB camera (Sony RX100) and a multi-spectral camera (Seqoia). Detailed information on each flight is seen in.

Table 4. Detailed information on the flights carried out at Ujarassuit using a quadcopter UAV (Tarot 650-sport).

Date	Local time	Weather	Survey type	Camera	Altitude	Area (km2)	Photos
16/08/16	-	-	Site survey	Sony RX100M3	60 m	0.074	485
16/08/16	-	-	Site survey	Sequoia	60 m	0.074	245

Environmental monitoring

Measurement of *in situ* pH, water content and conductivity was carried out in T1 and S1 for every 5-10 cm depth during excavation. Temperature (Tinytags) and soil water content sensors (Sm300) were installed in the excavated Trench T1 in 2017. Soil temperatures (10, 20, 40 and 60 cm depth) were measured every hour. The soil water content was measured every 4 hours in 10, 20, 40 and 60 m depth. Volume specific soil samples (100cm^3) were taken in the same depths as the soil moisture sensors in order to calibrate the sensors.

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Trench S1 was instrumented to measure air temperature and soil temperatures in 10, 40 and 80 cm depth and soil water content in 10, 40, 80 and 100 cm depth. Volume specific soil samples (100cm^3) were taken in the same depths as the soil moisture sensors in order to calibrate the sensors. Precipitation rates were cumulated every hour using a Campbell 52202 Tipping Bucket Raingauge connected to a TinyTag pulse counter. Finally, a dipwell was installed to 1.5 m depth in which groundwater level was monitored using a Diver water-level logger that was barometric compensated using a Baro-Diver.

All monitoring equipment and sensors were removed from the site in August 2019.

Protocol

Table 5. The observations made at Ujarassuit (Anavik) using the field protocol in 2017.

Table A	
Site	Anavik
NKAH no	1354
Serial no /FM number	
Region	
Site name	
Number of structures	8 ruins, churchyard, stone quarry, pen
Location	
N/W (ddd.mm.mmm; WGS84)	N 64°49.344' W 050° 08.842'
Height above sea level (lowest and highest point)	50 m
Distance from reference point to erosion front	not relevant
Setting/surroundings	Fluvial plane ca 50 m asl, site placed under gentle hill slope, extensive willow shrubs
Site description	
Site type	Norse farm with church

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Date culture	Norse (1200-1400?)
Finds	Small testpit made in midden. Found bone, iron, and charcoal in 2017. Earlier excavations (1982 and 1932) have shown soapstone, hair, iron, bone, charcoal, wood. At the churchyard were earlier found bone, hair, skin, textile, wood
Dimensions/outline	ca 300x300 m
Cultural layers present? If Yes, maximum thickness?	Midden in front of houses. Thickness up to 70 cm
Vegetation cover	Details from Lærke?
Photos (add numbers from other participants)	HMA (2287-2460)
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)	
Archaeological value (1-5 as above)	
State of preservation (1-5 as above)	Buildings 4, midden 2, churchyard unknown
Preservation conditions (1-5 as above)	4 (no immediate threat)
Ongoing degradation? (comparison to earlier site visits)	
Date visited	15-24/8/2017; 8/8/2019
Visited by	Hans Harmsen, Randi Sørensen Johansen, Ulunnguaq Nielsen Lyberth, Jens Kanutsen, Allan Lynge, Mikkel Myrup, Jørgen Hollesen, Henning Matthiesen, Roberto Fortuna, David Gregory, Bo Elberling, Rasmus Fenger Nielsen, Emil Andersen, Bjarne Grønnow, Lærke, Laura
Table B	
Site	Anavik
State of preservation	
Buildings/site structure and integrity	
Physical disturbance	ruins excavated by Rousell, highly disturbed, not backfilled
Volume excavated during visit	In midden: 50x50 cm, 80 cm deep. Outside churchyard: 60x60 cm, 1 m deep.
Materials found (list)	bone, iron, charcoal
Wood	none
Bone	very poor to poor state of preservation (1-2)
Stratigraphy	stratigraphy OK

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Other	
State of preservation, in brief (1-5)	Buildings 4, midden 2, churchyard unknown
Measurements during visit (ranges)	
Documented by drone	yes
Active layer thickness (range and date measured)	No frost found (dug/drilled 150 cm deep hole)
Soil temperature (range and date measured)	8-15 C (in midden, 23/8/2017)
Water content (range measured)	13-30 % vol (in midden)
Conductivity (range measured)	1-40 mS/m (in midden)
pH (range measured)	4.4-5.6 (in midden)
Sea level (logged: yes/no)	-
Root depth	Thin roots (grasses) down to at least 80 cm, a few Horsetail down to at least 80 cm
Other (ground water level,…	>150 cm below soil surface at graveyard
Samples taken during visit	
Soil (list samples/number)	ringsamples and bulk samples in midden and in natural soil
Artefacts (list materials)	3 bone samples from midden
Other materials (list)	
Vegetation (leaves/biomass/dendrosamples)	Dendrosamples from cultural and natural area
Evaluation of value	
Experience: beauty/monumentality	
Experience: memory/historic value	Very high historic value
Physical integrity	
Physical preservation	
Archaeological rarity/representation	church is rare
Archaeological information value	
Archaeological assemblage value	
Archaeological value, in brief (1-5)	
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	freshwater ponds found in several ruins during heavy rain, but no signs of erosion were seen

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Other erosion (wind, animals, visitors)	Vind erosion observed, but not immediate threat. Some visitors to the site, but no damage observed
Damage from vegetation, roots	Massive willow shrub in some of the ruins, however only few willows on the midden
Drainage	Some drainage may take place, but organic material is already quite degraded
Melting, heating	not relevant
Soil movement (including creeping, cryoturbation, slide)	none observed
Decay of organic materials	probably ongoing in midden, but material is already very degraded
Other threats	
Future threats?	
Preservation conditions, in brief (1-5)	4 (no immediate threats observed)
Are earlier descriptions available for comparison (references)	
Monitoring	
Already initiated (which parameters)	temperature and water content sensors installed in midden and in natural reference next to churchyard. Ground water level logger installed near churcyard
Suggested (which parameters)	
Important unknowns/research needed	Conditions at churchyard unknown
Mitigation - summary of recommendations	
Refill trenches	
Backfill	
Erosion protection	
Cut back vegetation	Has been carried out in ruin 3 in 1982. seems efficient, as there are only few willows now
Fencing	
Rescue excavation	
Field worker	HMA

References

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Tussaap Tasia [NKAH 4997]

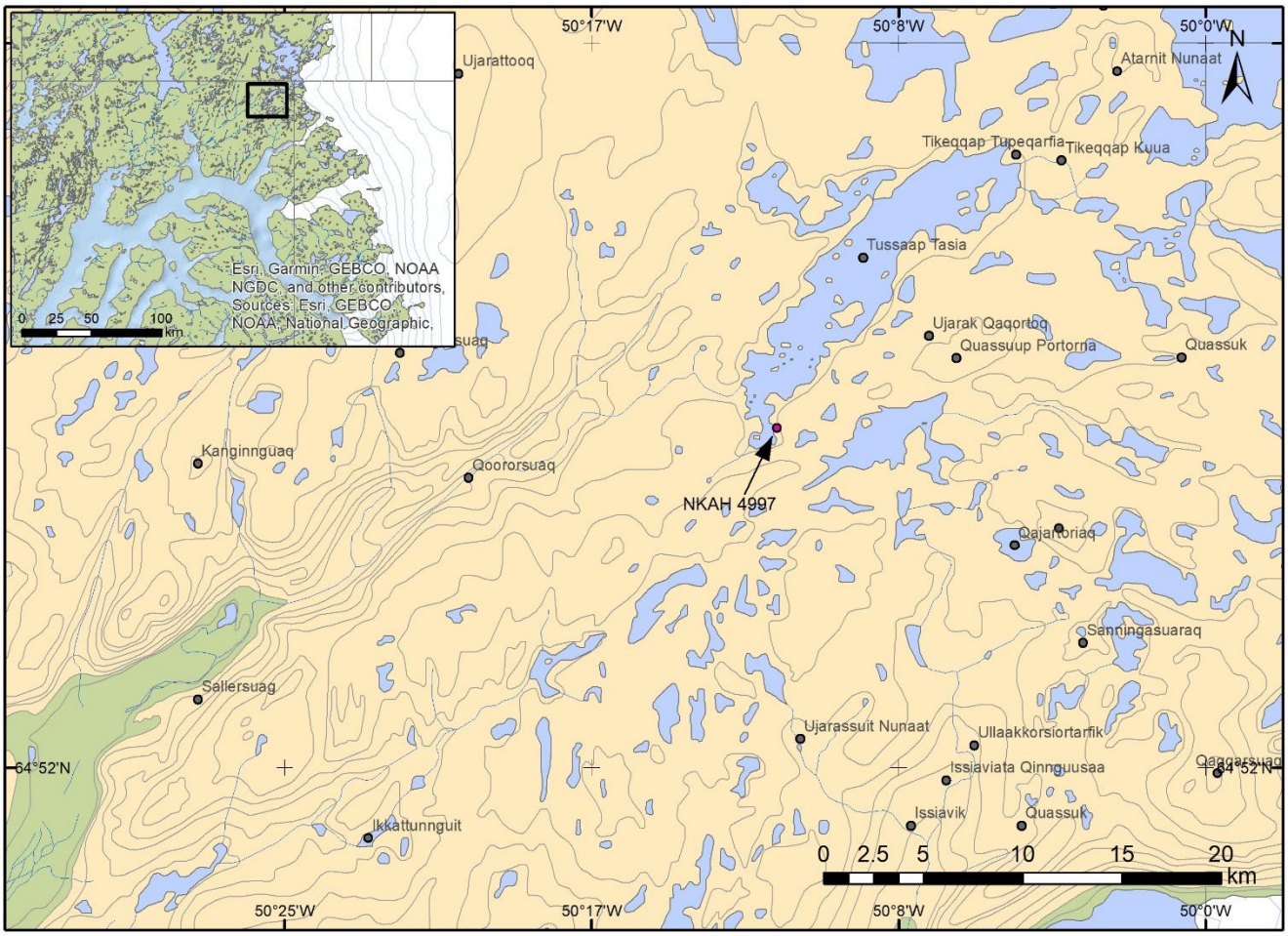

Fig. 1. Location of NKAH 4997 on the southeastern shore of Tussap Tasia.

Site description

NKAH 4997 (64.926530°, -50,1940200°) lies on the southeastern shore of Tussap Tasia. Located between 2 and 8 m above the lake shore, this later Thule-Inuit settlement is comprised of a large cluster large stone tent houses (*n*~9) and meat caches. Other features reported on and adjacent to the site include two ”playhouses”, a grave, and twelve tent rings (Odgaard et al. 2008).

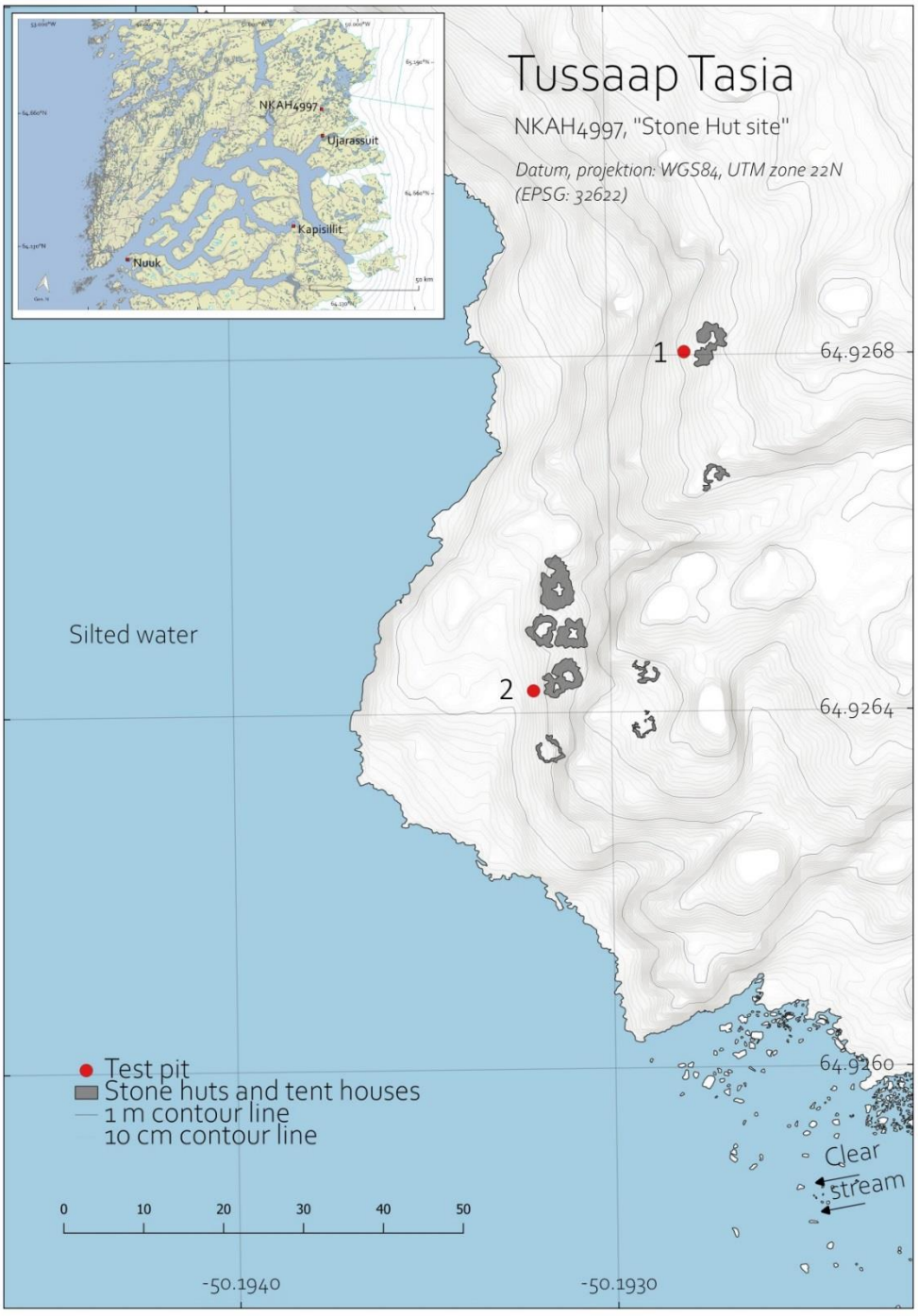

Fig. 2. Map of the site Tussaap Tasia with the location of the two test hole (T1 and T2).

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Archaeological investigations and sampling

Organic archaeological deposits were only found close to the stone houses at the site. Based on an initial probing two test hole were excavated (T1 and T2, Fig. 2). In both test holes, shallow cultural layers were found just below a layer of natural peat (O-horizons) approximately 10-15 cm below surface.

Test hole 1 (T1)

Test hole T1 (0.5 x 0.5 m hole) was excavated by spade and trowel, and dug to the maximum depth possible; approximately 25 cm (Fig. 3). Detailed observations on the strata identified during excavation of T1 are summarized in Table 2. In total, nine artefacts were collected from T1. This included six (*n*=6) bones (most likely caribou), two (*n*=2) fragments of processed soapstone and one (*n*=1) piece of asbestos.

Table 1. Soil strata identified in T1 at Tussaap Tasia.

Layer	Depth below surface	Description/interpretation
Layer 1	0-6 cm	Single contiguous vegetation layer (O-Horizon).
Layer 2	6-7 cm	Dark humus layer. Few seeds preserved, no charcoal. Few findings of soapstone and asbestos fragments.
Layer 3, upper horizon	7-17 cm	Silt layer with mixed clay, light grey to grey-brown.
Layer 3, lower horizon	17-25 cm	Yellow-brown sand. Silt with gravel. Cryoturbation.
Layer 4	25 cm	Silt with sand and gravel. Few roots. Is found just above the bedrock which is highly weathered.

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Fig. 3. Profile of T1 at Tussaap Tasia.

Test hole T2

Test hole T2 was excavated in the area in front of ruin A. This .5 x .5 cm hole was excavated by spade and trowel, and dug to the maximum depth possible; approximately -25 cm (Fig. 4). Detailed observations on the strata identified during excavation of T2 are summarized in Table 2. In total eighteen, (*N*=18) artifacts were collected that included: several fragments of bone, tooth and antler, one large bone (caribou), one fragment of soapstone, two fragments of asbestos. Eleven (*n*=11) pieces of charcoal were collected.

Table 2. Soil strata identified in T2 at Tussaap Tasia.

Layer	Depth below surface	Description/interpretation
Layer 1	0-4 cm	Single contiguous vegetation layer (O-Horizon).
Layer 2	4-15 cm	Cultural layer. Shifts between brown and light-brown and become dark-brown at the bottom. Abundance of charcoal and dissolved bones throughout the layer, increasing in concentration with depth. Few findings of soapstone and asbestos fragments. Silt with some sand (grey-brown). The bottom of the layer is peaty silt with more sand than above.
Layer 3	15-17 cm	Silt with sand, beige-colored.
Layer 4	17-25 cm	Upper part: light grey silt with sand with a black humus stripe at the top. Below: yellow sand with gravel.

Fig. 4. Profile of T2 at Tussaap Tasia.

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Environmental monitoring

Measurement of *in situ* pH, water content, conductivity and thermal properties were carried out in hole T2 for every 5 cm depth during excavation. Volume specific soil samples (100cm^3) were taken at 10, 20, 30 1nd 40 cm depth. From August 2017 to August 2019, air and soil temperatures were measured in T1 at depths of 10, 20 and 40 cm below the surface. All monitoring equipment was removed from Tussaap Tasia in August 2019.

Protocol

Table 3. The observations made at Tussaap Tassia using the field protocol in 2017.

Table A	
Site	Tussaap Tasia
NKAH no	
Serial no /FM number	5071 i Nunniffiit
Region	
Site name	
Number of structures	14 (12 tenthouses, 2 play houses). 4 of the houses are build entirely of stone. A grave inside one of the houses
Location	
N/W (ddd.mm.mmm; WGS84)	N 64°55.587' W 050° 11.590'
Height above sea level (lowest and highest point)	660 m above sea level. 2-8 m above lake level.
Distance from reference point to erosion front	Erosion front ca. 1 m from front of house F
Setting/surroundings	Highlands w. low vegetation
Site description	
Site type	Summer camp for reindeer hunting
Date culture	Thule/historic inuit
Finds	
Dimensions/outline	Approx. 50x50m
Cultural layers present? If Yes, maximum thickness?	Degraded midden in front of houses, ca 15 cm thick

Vegetation cover	Mosses, lichen, bluejoint, willow, no horsetail (mos, lav, rørhvene, pil)
Photos (add numbers from other participants)	HMA(4676-4730), BGR (203014-51)
Evaluation, summary	
(1: very poor, 2 poor, 3 medium, 4 good, 5 excellent)	
Archaeological value (1-5 as above)	
State of preservation (1-5 as above)	Buildings 4-5, midden 2
Preservation conditions (1-5 as above)	4-5 (no immediate threats)
Ongoing degradation? (comparison to earlier site visits)	
Date visited	17-20/8/2017
Visited by	Henning Matthiesen, Bjarne Grønnow, Mikkel Myrup, Jens Kanutson

Table B

Site	Tussaap Tasia
State of preservation	
Buildings/site structure and integrity	well preserved
Physical disturbance	roof of the stone houses is collapsed. A little cryoturbation in midden
Volume excavated during visit	2 holes (50x50 cm), 15-20 cm deep
Materials found (list)	Bone, soapstone, asbestos, some charcoal
Wood	
Bone	some bone, almost dissolved, very poor state of preservation (1)
Stratigraphy	Stratigraphy OK, but layers have collapsed and are very thin
Other	
State of preservation, in brief (1-5)	Buildings 4-5, midden 2
Measurements during visit (ranges)	
Documented by drone	yes
Active layer thickness (range and date measured)	No permafrost found (dug 50 cm deep hole in natural ground, and 40 cm deep hole next to house)
Soil temperature (range and date measured)	3-8 C (19/8/2017)
Water content (range measured)	10-25% vol in natural soil (hole 1) and 30-60% vol in cultural deposits
Conductivity (range measured)	- (problem with sensor)

pH (range measured)	4.5-5.0 in cultural deposits
Sea level (logged: yes/no)	
Root depth	Thick roots (willow/birch) down to 10 cm, thin roots (grasses) down to 50 cm at least
Other (ground water level,…	Only thin soil layer (max 50 cm), sand and gravel, probably aeolean sand in places
Samples taken during visit	
Soil (list samples/number)	Ring samples in midden and in natural soil
Artefacts (list materials)	BG sampled bones
Other materials (list)	none
Vegetation (leaves/biomass/dendrosamples)	Willow sample from house C. A few samples of dead wood for Nanna
Evaluation of value	
Experience: beauty/monumentality	Stone houses monumental (4)
Experience: memory/historic value	Houses probably painted by Aaron (4)
Physical integrity	
Physical preservation	Midden poorly preserved (1), houses (4)
Archaeological rarity/representation	House type rare (4-5)
Archaeological information value	
Archaeological assemblage value	
Archaeological value, in brief (1-5)	
Evaluation of threats (ongoing/expected)	
Erosion from water and ice	Lake erodes the brink, but still quite far to the houses (except structure F 1 m from the lake).
Other erosion (wind, animals, visitors)	none observed. Very few visitors.
Damage from vegetation, roots	Little damage. Only 1 willow observed inside house.
Drainage	not relevant as organic material is already degraded
Melting, heating	not relevant
Soil movement (including creeping, cryoturbation, slide)	A little cryoturbation is observed
Decay of organic materials	probaly ongoing, but material is already very degraded
Other threats	
Future threats?	Site may be flooded if lake-level is heightened for hydropower production
Preservation conditions, in brief (1-5)	4-5 (no immediate threats)
Are earlier descriptions available for comparison (references)	Site visited in 2007 and 2008 (Odgaard 2007, Knudsen et al 2009)

Monitoring	
Already initiated (which parameters)	Temperature-sensors installed in the ground (4 depths). There is a weatherstation at the end of the lake (Asiaq)
Suggested (which parameters)	
Important unknowns/research needed	
Mitigation - summary of recommendations	
Refill trenches	
Backfill	
Erosion protection	
Cut back vegetation	remove willow in house C?
Fencing	
Rescue excavation	
Field worker	Henning Matthiesen

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