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Nunatta Katersugaasivia
Allagaateqarfialu/The
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[THE CULTURAL HISTORY OF THE INNAANGANEQ METEORITE – TECHNICAL REPORT 2015]

This project was conducted in a collaborative effort by personnel affiliated with the University of Copenhagen, the Natural History Museum of Denmark, the National Museum of Denmark and the Greenland National Museum during the second half of 2014 and the first half of 2015.

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INTRODUCTION AND SUMMARY

The fieldwork 2014

Notwithstanding both serious logistic and weather trials during our fieldwork in Northern Melville Bay the 2014-field campaign must be characterised as highly productive. There are certainly good reasons why the retrieval of the meteoric pieces in the 19th and 20th centuries posed almost insurmountable challenges, and that no previous archaeological fieldwork has been done in the area. These experiences make us even more respectful of people of the area that has managed to create a rich life in the area across centuries.

During the fieldwork the archaeological site recordings were done at various levels of detail at the sites that once housed the meteoric fragments known as “Woman” and “Dog” (both at Saveruluup Itilliapalua), “Ahnighito” (eastern side of Meteorite Island), and “Savik 1” (at Saveqarfik).

Throughout the fieldwork the use of drone-based recordings was tested for the first time in Greenland. The results are very promising not only as a way to increase over-all precision of 2D site maps and increasing effectivity during fieldwork, but also as a way to produce 3D models that allow us to make quantitative analyses of features at the site. For example, the correspondance between on-ground calculations on the magnitude of the piles of hammer stones surrounding the find spot of “Woman” seem in precise correspondance with the calculations generated by drone measurements and software.

Geo-radar surveys were done at a site on the southern shore of Meteorite Island and on the eastern central part of the island. Previous fieldwork in 2012 (by Henning Haack) showed two well-defined magnetic anomalies that potentially could be evidence of two new large meteoric pieces. The work in 2014 demonstrated that magnetometers can be used to detect buried even deeply buried iron meteorites, and that the background noise is significantly less than the expected. The additional scannings done in 2014 indicate that the anomalies are more likely to be the result of terrestrial rather than extraterrestrial phenomena.

The fieldwork was performed in coordination with, and substantial logistical support from, the research team connected to the North Water Project headed by Professor Kirsten Hastrup, University of Copenhagen.

Following the 2014-fieldwork

Limited documentation on the retrieval of the Savik 1 meteoric piece in 1922-1925 has hitherto been known. In connection to the project we however had the good luck that chief archivist Lisbeth Valgreen at Arktisk Institut located an album with more than 100 photographs from the work done in Thule in 1922-23. The

photographs have now been scanned by members of the present project and are now made available at www.arktiskebilleder.dk

In prolongation of the fieldwork we tested the use of a handheld XRF-scanner (in collaboration with conservator Michelle Taube and ph.d.-student Eileen Colligan) in order to seclude Inuit tool- and weaponblades made from meteoric iron from those made of telluric and European iron. The results are very promising and not only document the productivity of the XRF-scannings, but also hint at an unexpected historical patterns both with regards to the distribution of telluric and meteoric iron. Thus, if the pattern seen from the limited number of samples we have XRF-scanned meteoric iron is almost exclusively traded/exchanged west of the Avanersuaq, i.e. into arctic Canada, while almost no meteoric iron seems to be traded south into west Greenland or north-east into northeast and east Greenland. In that sense the Avanersuaq area should be considered as the easternmost fringe of a large Canadian network rather than part of Greenland. In addition, we were surprised by the relatively extensive use of telluric iron as evidenced by the examined pieces.

While “Woman” and “Dog” today stand out with their smooth surface they may well have looked quite different when first encountered by humans some 1300 years ago. The present surface is likely to be the results of centuries of hammering on the meteoric pieces in order to extract iron. Preliminary studies of the surface structure of “Savik 1” (while at the National Museum) and of “Woman” and “Dog” (by Mikkel Myrup during a visit in April 2015 at the American Museum of Natural History, in New York City) clearly suggest that pieces of iron was extracted directly from the two meteoric pieces. Seemingly by hammering the uneven surface into ridges that could then be “cut” by using the sharp edges of hammer stones from which flakes have been struck (see figure 01).



Figure 01: Close-up of the surface of “Woman”. The hammered up ridges on the meteoric piece can clearly be seen.
Mikkel Myrup *del.*

Outputs – so far

The project has not only received considerable public attention through the printed media (i.e. articles in “Polarfronten”, “Politiken”, “Sermitiaq” (a Greenlandic newspaper)), but has also been an item in “P1-eftermiddag” and on “TV2-news”, as well as a substantial article web-based “Videnskab.dk/Science Nordic”.

Additional scientific dissemination have been completed through two papers presented (Appelt et al. 2015; Myrup 2015) at the international Canadian Archaeological Association Meeting (in St. Johns, Newfoundland), and will be published in peer-reviewed articles in *Nationalmuseets Arbejdsmark* (Jensen et al. 2015, *in press*), in Oxford University Press Handbook of Arctic Archaeology (Appelt et al. 2015, *in press*), and in *Arctic Anthropology* (Appelt et al. *in prep.*).

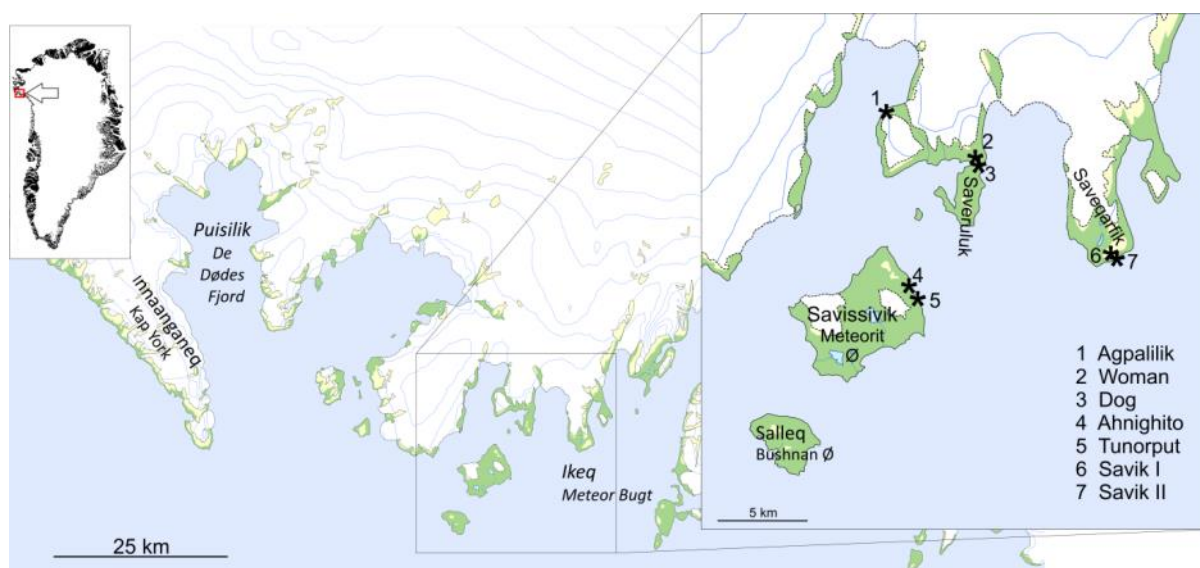


Figure 02: The research area. *Jens Fog Jensen del*

Future research

The promising results of the XRF-analyses indicate that similar and more systematic testing of large numbers of metal from all parts of Greenland and Eastern Arctic could result in great advances in our understanding of Thule culture trade network and interaction between Thule, Norse and Late Dorset.

Another aspect of Inuit iron use that deserves more systematic scrutiny is the transport of hammer stones from distant places to the extraction localities. Sources indicate that the hammer stones have been collected near Cape York but the actual locality or localities have not yet been identified. This very energy consuming characteristic of Inughuit’s ancient use of meteorite iron indicate that an archaeological survey of Cape York

and De Dødes Fjord could be highly rewarding in order to fully understand the complexity of Inughuit's iron extraction system.

Hopefully future fieldwork and laboratory studies will enable advances in these directions.

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We finally want to thank ph.d.-student Eileen Colligan, chief geologist emeritus Peter Dawes and docent emeritus Asger Ken Pedersen for their relentless interest in the intricacies of hammer stones, various sorts of iron, and the significans of various trace elements in XRF readings.

2014 FIELDWORK INTINERARY

- July 8th Martin leave Copenhagen for Nuuk to prepare equipment and provisions for the fieldwork with Mikkel M. and Bjarne Grønnow (from the NOW team).
- July 21st Mikkel M., Bjarne Grønnow, and Martin left Nuuk on board Minna Martek.
- July 23rd Departure from Ilulissat having taken Jens, Mikkel S. and the NOW crew aboard.
- July 26th Arrival to Savissivik, survey of bird cliffs and boulder terraces to the south and east of Savissivik.
- July 27th Survey of southern shore of Meteorite Island, documentation of the still used Qattannguaqarfik camp as well as surrounding recent and sub recent settlements.
- July 28th “Ahnighito survey” and documentation of human activities on eastern shore of Meteorite Island. Photo-documentation and description of the Ahnighito locality and traces of Robert Peary’s retrieval of the meteorite.



Figure 03: *Minna Martek* anchoring in Saveruluk. Jens Fog Jensen *del.*

- July 29th Mikkel S., Mikkel M., Bjarne Grønnow, Martin and Jens excursion to Saveruluk to survey the locations of Woman and Dog.
- July 30th Moved to new house in Savissivik thanks to Thomas Suersuaq

July 31 st	Repair of floor sockets in rubber boat and later continued work at Saveruluup Itilliapalua where Mikkel M. drone documented the site and features were numbered.
August 1 st	Martin and Mikkel continued work at Saveruluup Itilliapalua, Jens waited for Henning in Savissivik, but heavy fog prevented the helicopter from landing.
August 2 nd	Work at the site of Woman, description and photo documentation of all features.
August 3 rd	Retrieved fuel and provisions from Minna Martek. Bad weather but continued work at the locality of Woman, and sailed to Saveqarfik for the inspection of the original location of the Savik meteorite.
August 4 th	Henning Haack arrived to Savissivik around 12.30. Magnetometer was assembled, and the first anomaly (the one located near the shore of the lake to the south of Savissivik) was measured and disclaimed as a bedrock outcrop.
August 5 th	Mikkel M., Martin, Henning and Jens established camp in the cove to the Northeast of Savissivik. Sailed then to the north side of Savissivik and hiked to the western slopes of Signal Mountain where the most promising magnetic anomaly has been detected. After 6 hours work in a grid with the earth radar this anomaly was also disclaimed.
August 6 th	Camp blown over around 6 a.m. Minna Martek returned between 9 and 10 from visit to Salve Ø and the four of us (Mikkel M., Martin, Henning, and Jens went for the last time to the location of Woman.
August 7 th	Documented Kangillipaluk – the Thule settlement sitting on a little point below a bird cliff a few kilometres to the north of Savissivik. Five winter houses and several other features were recorded.
August 8 th	Landlocked in Savissivik due to heavy swell.
August 9 th	Still heavy swells and landlocked, but excursion to survey boulder terraces to the south and southeast of Savissivik graveyard.
August 10 th	Minna Martek moved to northern shore of Savissivik where she anchored in calm waters. We then abandoned all dispensable equipment in storage in Savissivik and hiked over the island to board the ship from the northern shore of Savissivik Island.

- August 11th Preparing provisions for ‘excavation camp’ to be set a shore. Weighed anchor 10.45 and coursed for Thule Air Base. Arrived at TAB around 22.30
- August 12th Unloading equipment and staff from Minna Martek after the hoist to the gangway had been repaired by electrician. Departure from Thule Air Base around 11.30 with course for Savissivik. Increasing gale made Captain Erik Petersen anchor in Saveruluk.
- August 13th Anchoring the whole day in Saveruluk, wind increasing to storm during evening and night. Two anchors were out.
- August 14th Nice weather excursion to Woman and documenting the spit jutting out towards northwest from the western shore of Saveruluk, where there is hunter’s cabin in the well protected cove. Some caches and tent rings were registered here. During the afternoon Martin, Mikkel M. Bjarne and Jens made excursion to Saveqarfik to document the shelters and tent rings in ‘telbugt’ at the southwestern side of the point. Heavy swell made it necessary to leave Bjarne in boat while we briefly documented features ashore. Returned to Minna Martek around 4 pm and Minna Martek coursed for Upernavik and eventually Nuuk.
- August 15th Heavy swell, arrived and anchored at Nuussuaq / Kraulshavn around 5 pm.
- August 16th Steering south. Getting a new storm while passing the cliffs of Karrat to the north of Upernavik. Anchoring in well-protected cove at northern side of Langø to the south of Upernavik. Two anchors out and anchor guards posted all night.
- August 17th Anchor chains entangled. Leaving after some hours work straightening out the anchor chains. Anchoring 15.15 in Kaffehavn at the northwest side of the island Qeqertaq where Sdr. Upernavik is located at the southern side.
- August 18th Net in anchor. Left Kaffehavn late in afternoon and sailed to Sdr. Upernavik to get radio contact and pick up a weather report, but had to return to Kaffehavn after having read the forecast.
- August 19th Departing from Kaffehavn between 8 and 9 am, passing Svartenhug around 1 pm.
- August 20th Arrival at Ilulissat Martin, and Mikkel S. left the company here.
- August 22nd Arrival and unloading the ship in Nuuk.

HISTORY OF THE INNAANGANEQ METEORITE

Following the end of the Napoleonic Wars the Admiralty of the British Navy decided to use its surplus ship capacity for other purposes. It among other equipped the ships *Isabella* and *Alexander* to search for the “Northwest Passage”, i.e. a sea-route that would shorten the sailing distance between Europe and the attractive markets in China and India. The expedition was headed by Captain John Ross (Buchwald 1992: 146). On August 8 1818, the ships, after several trying weeks with dense sea ice and heavy winds, reached the northern parts of the Melville Bay. They thus became the first Europeans in 500 years that encountered people living this far North. These people were the Inughuit, as they called themselves, or the Arctic Highlanders as they were called by John Ross (Gilberg 1995).



Figure 04: The first encounter between Inughuit and the crew of *Isabella* and *Alexander* on August 8th 1818. Painting by John Sakæus (Ross 1819).

The Ross-expedition had the good fortune to have had engaged the Greenlander Sakæus as an interpreter. In 1816 Sakæus had boarded a Scottish whaler as a stowaway, while moored in the Disco Bay. After arriving in Scotland he had learned English and had become an excellent painter (Frandsen 2010). Sakæus initially had some difficulties in communicating (both orally and on a wider cultural level) with the Inughuit, as there had been centuries with no contact between the Inughuit and inuit groups living further south, and there were distinct dialectical differences between the two parties. Sakæus, however, soon overcame these challenges and given the short time the two parties (on various occasions over ten days) interacted, and surprisingly detailed information was exchanged (Ross 1819).

With regard to the topic in question, Sakæus learned from Meigack, a member of the Inughuit group, that they had come to the area in order to procure iron for knife and harpoon blades. Meigack also told Sakæus that the iron was found in several masses at a location called Sowallick (probably this refers to *Savilik* which in Greenlandic means 'with knife'). It was furthermore related that one of these masses were harder than the others and that they would extract the iron by cutting off pieces with hard stones and hammer these pieces into small ovals to be mounted as blades. The hard hammer stones, which John Ross examined and suggested was of basalt, was related to have been collected at a place called Inmallick (Ross 1819: 103-104, 112). Weather and ice conditions prevented Ross and his crew from pursuing the location of the iron masses further, but all in all the so-called "Iron Mountain"/"Sowallick" marked on the expedition's map relatively accurately place the find-spot of the meteorite fragments.



Figure 05: Sakæus as portayed by Alexander Nasmyth in 1817 (?).
http://www.wikigallery.org/wiki/painting_240888/Alexander-Nasmyth/Portrait-of-the-Eskimo-Whaler-John-Sacheuse

During the meetings the expedition purchased among others two dog sledges, two harpoons, and two knives mounted with iron blades. In his final report (Ross, 1819) Ross correctly identified the knife's iron blades as of meteoric/extra-terrestrial origin, by referring to the iron's nickel content as revealed by chemical analysis. What is remarkable is that only 10-15 years prior to Ross' writings the extra-terrestrial origin, and thus the existence of meteorites, was still disputed among the British and French scientific communities. Also the chemical analysis within geology were also very much in their infancy. Ross' observations on the iron blades thus found their way into Ernst Florens Friedrich Chladni's book *Ueber Feuer-Meteore* (Chladni 1819: 344-345), a book that was crucial in the development of the late modern period scientific meteoric studies, and thus also the intense interest of major natural history museums in Europe and the USA (Buchwald, 1992, chapter 2).

In the following decades several unsuccessful attempts are made to find the meteoric pieces by expeditions from Britain, Sweden and Denmark (e.g., Laursen 1972: 33-34).

From 1886 the American explorer Robert E. Peary since 1886 had made several expeditions to Avanersuaq (i.e. the Thule area) using the area as a starting point for his quest to become the first man on the North Pole. During his years in the area he was in contact with most of the people living there. The relations built in May 1894 eventually led to a member of the Inughuit group Tellikotinah brought Peary to the northern Melville Bay and showed him the location of the pieces of the meteorite that would later be named "the Woman", "the Dog" (both located on the peninsula Saveruluup Itilliapalua) and "the Tent"/"Ahnighito" (located on the eastern shore of Savissivik Island) (Peary 1898, vol. II). As mentioned above major American museums had become very interested in meteorites, and Peary, having failed to reach the Pole (which he did not reach until 1909), was in dire need to produce results. He therefore took great effort in ensuring the meteoric pieces for an American museum (Meier 2013).



Figure 06: "Raising the Great Meteorite from the hold of the *Hope*". From Ahnighito's arrival to New York (Scientific American 1897: 241).

The following is extracted from volume 2 of Peary's *Northward across the Great Ice* (Peary 1898).

An unsuccessful attempt was made in August 1894 by Peary and his ship *Falcon* to collect the pieces (1898: 556). In 1895 Peary returned to the northern Melville Bay with his ship *Kite* and among others a group of seamen, a working crew of Inughuit, the American artist Albert Operti and the American engineer Emil Diebitsch to pick up the 3 tons heavy "Woman" and the approximately 400 kilogramme "Dog". The ship had to be anchored at some distance from the northern side of the Saveruluup Itilliapalua Peninsula. Both pieces were pulled from their original position with the aid of sledges down to the shore. To move "Woman" a ramp was levelled-out, a plank tram-way was built upon which rollers were placed and with the sledge on top of the whole construction. From the northern shore both pieces were then shipped on large ice-floes to the ship, and from there transported to St. John's, Newfoundland and further on to New York.

In 1896 an attempt was made to retrieve the largest of the three meteorite fragments, the 30 tons “Ahnighito”, but due to particularly difficult ice-conditions, heavy winds, and equipment failure the project had to be abandoned. The following year Peary returned with the ship *Hope* and during a few weeks of intense work by sea-men, five mason’s labourers, nine Inughuit and several others managed to transport the “Ahnighito” aboard the ship, which then departed for Boston and finally New York City. The curious name “Ahnighito” was given to the meteorite in 1897 by Peary’s daughter during a “baptizing” ceremony (Buchwald 1992: 151). Her middle name was Ahnighito, which is likely an anglophile version of the Inuit name Arnakitsoq (the name of the daughter’s nanny) .

It was later to be sold to the American Museum of Natural History for \$40,000 (Huntington 2002: 62). Even if somewhat outside the scope of the present writing, it should be mentioned that the 1897 journey to Boston and New York also was the journey on which Peary brought six Inughuit to the USA which subsequently turned out to become one of the darkest chapters in the history of the people of Avanersuaq (Meier 2013; Gilberg 1995).

In 1913 a fourth large piece of the meteorite came to the attention of the non-Inughuit community, when Qidlugtok told Knud Rasmussen that he had discovered “.....*the meteor we had been looking for for many years.*” (Freuchen, 1953 [1936]: 209) (Our translation). The suggested “*many years*” apparently refer to the three years that had gone by since Knud Rasmussen established the so-called Thule Station at the foot of the Dundas Mountain, close to where the present day Thule Air Base, home of the 821st Air Base Group, is located.

In 1913 a large American expedition had made head-quarters in the northern part of Avanersuaq. The head of the Crocker Land Expedition, Donald B. MacMillan, had also heard of the new find, and had sent expedition geologist W. Elmer Ekblaw to secure the new piece for the Museum of Natural History in New York. Knud Rasmussen however, managed to convince Ekblaw that he had already made arrangement on behalf of a Danish museum (even if this was not the case and that he yet had to see the meteoric piece himself), but also he would be happy to bring Ekblaw to the find site and help to ensure that an American museum would receive a “a slice” of the meteorite when it had arrived in Copenhagen (Freuchen 1953: 213).

Rasmussen’s actions should probably be seen in the light of the wider idea behind the establishing of the Thule Station, which according to his partner Peter Freuchen was a reaction not only to the American presence in the area, but also the famous Norwegian explorer Otto Sverdrup in 1909 seemingly had plans to establish a trading station in the area. Freuchen goes on to explain that at that time “Danish Greenland” only

reached the area south of the Melville Bay, and that a Norwegian presence would break the Danish Monopoly in Greenland resulting in the Thule area being lost for Denmark (Freuchen 1953: 29-30).

The two men and Qidlugtok did travel to the Saveqarfik Peninsula, and it was probably at this time the new meteoric piece was christened “Savik”. Due to the break-out of World War I it was however not until 1922 the money for an expedition was granted by the Danish Government to send a ship to Saveqarfik to attempt to collect Savik. The meteoric block was located 270 metres above sea-level and at a coastal stretch that is normally ice-bound through-out the year. During an expedition in 1922-23 a crew headed by engineer Ib M. Nyebo managed to bring the piece down from the hill-top and across the sea-ice to Salleg (Bushnan Island), *inter alia* with the aid of 14 dog sledges and 175 dogs. In 1925 it was collected at Salleg and transported to Copenhagen and later on brought to the Mineralogical Museum (the present-day Geological Museum) (Bøggild 1927).

Chief archivist Lisbeth Valgreen of the Arctic Institute has managed to locate the hitherto un-recorded photo-albums containing some 100 photographs from the 1922-23 expedition. The photographs have now been digitised and are accessible through “Arktiske Billeder”.



Figure 07: “Savik” being raised from its nest of hammer stones at some 270 metres above sea-level. The photograph is from 1922/23. The photographer is unknown. © Arktisk Institute

The last of the known larger pieces of the Innaanganeq meteorite was found in 1963 by engineer Vagn Buchwald after two years of searching during a tenure as Danish scientific liaison officer at Thule Air Base. The 20 tons piece was found on the Agpalilik peninsula less than 10 kilometres from where Peary collected Woman and Dog. After considerable difficulties the meteorite piece landed in Copenhagen in 1967, and is now one of the centrepieces in the exhibitions of the Geological Museum in Copenhagen. The piece was baptised “Agpalilik” and became the starting point of Buchwald’s long-standing research into the pre-history, history, geology and astronomy of the Innaanganeq meteorite that has defined the field until present-day (e.g. Buchwald 1992; 2008; Buchwald & Mosdal 1985; Haack 2012).



Figure 08: “Savik” being moved from the Geology Museum to a gallery at the National Museum for a one-year loan. An example of the very productive collaboration between the people involved in the present project.

It finally should be mentioned that important information on amongst other the later history of the meteorite were gathered by Holger Pedersen and Torben Risbo even if they did not have the good fortune to locate new pieces of the meteorite, which was their ambition (Pedersen & Risbo 1992; Risbo & Pedersen 1994).

PREHISTORY OF THE INNAANGANEQ METEORITE

The Tunit:

Having been abandoned for about 700 years the eastern High Arctic including Avanersuaq was re-settled by what archaeologists is known as the Dorset people in the 7th and 8th century CE. By Inuit these people are known as Tunit. They were the first to exploit the Innaanganeq meteorite. The following is an extract from Appelt et al. *in press*:

Far-reaching interaction networks were in existence within and between regions settled by Tunit communities. Visible and recognizable evidence of these networks is seen in the distribution of “exotic” raw materials, including iron, copper and various mineral raw materials. These materials were used primarily to produce blades for various tools and weapons, and all could have been substituted by other locally available raw materials if the imported material was not available. Their wide distribution highlights their importance, and it is likely that their value was based in large part on their aesthetic and exotic properties.

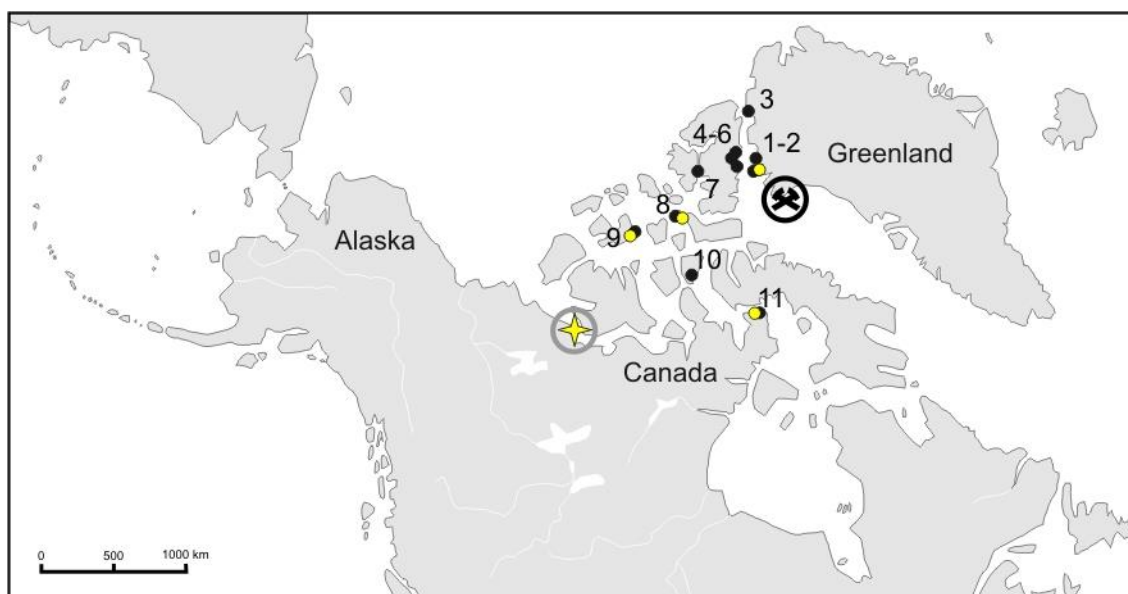


Figure 09: Late Dorset/Tunit sites with meteoric iron from the Avanersuaq area (black) or natural copper (yellow). Appelt et al *in press*.

Iron was recovered by Late Dorset people from eight meteorite fragments in northwest Greenland. This iron has a distinct trace element profile (Buchwald, 1992; Buchwald and Mosdal, 1985), allowing us to be certain that it was not found and used until Tunit groups arrived in the Avanersuaq area (Northwest Greenland). The meteoric iron from Avanersuaq has been found on Late Dorset sites across much of the Tunit range, from Smith Sound (Appelt et al. 1998; Buchwald 2001; Holtved 1944; LeMoine 2014; LeMoine & Darwent 2010;

Mathiassen 1928; McCullough & Schledermann 1996; Knuth 1984; Schledermann 1990) and Axel Heiberg Island (McGhee 1981) in the High Arctic To Devon Island (McGhee 1981), Little Cornwallis Island (Helmer et al. 1995a; 1995b), Somerset Island (Damkjar 2005), and the Igloolik area in Foxe Basin (this latter case based on rust stains in blade slots; Meldgaard cited in McCartney 1988: 62; Meldgaard personal communication, 2003). The high number of iron-bearing knife handles from the Igloolik area reveals that we cannot apply a standard distance to source fall-off curve to describe iron's distribution as a simple matter of distance from the sources in Avanersuaq. This is further confirmed by the high number of pieces found at the sites at Little Cornwallis Island (where some 45 pieces out of 98 metal objects are of meteoric iron) (Pringle 1997).

The distribution of native copper in Late Dorset is generally similar to that of meteoric iron, but in addition sites on Victoria Island, at the westernmost fringe of the Late Dorset area, are included, reflecting the presence of major copper sources in the Coronation Gulf region (Franklin et al. 1981; McCartney 1988; 1991). The finds from the Late Dorset period in the Iqaluktuuq region on Victoria Island include 13 pieces of copper (Friesen personal communication, 2006), and the Creswell Bay sites contain two pieces of copper (Damkjar personal communication, 2005). With the exception of the two pieces of copper from the Abverdjar site (Rowley, 1940), copper is only known in the Igloolik area as verdigris (green staining) in blade slots in knife-handles (Meldgaard personal communication, 2003). The artefact material from two sites in Northwest Greenland includes one copper harpoon end blade and one arrow-point-like piece (Appelt et al, 1998). With the exception of the Arvik and Tasiarulik sites at Little Cornwallis Island, which produced 53 pieces of copper (LeMoine 2005; Pringle 1997; Rast 1995), the limited amount of copper and iron is noteworthy. Part of the explanation for this pattern is the limited use of metal detectors at excavations on most Arctic excavations, Little Cornwallis being the only one at which large-scale and systematic survey was done (McCartney and Mack 1973; Pringle (citing McCartney) 1997). In addition, given the very large distances the metal objects were transported, they would have been curated, and reworked into very small pieces prior to being discarded.

With clear evidence that iron and copper were being exchanged over great distances, one wonders which "items" other regional areas brought into these large scale exchange systems. No doubt there were a multitude of smaller scale exchange-systems within regions and between neighbouring regional areas that may have included materials such as antler (LeMoine 2005), quartz crystal (Damkjar 2005) and other stone raw materials which cannot currently be sourced accurately. Soapstone for the production of lamps and other vessels would have been an item for exchange at least in regional networks, as areas with high quality soapstone are rare. Large parts of the High Arctic only receive limited amounts of driftwood, and it therefore seem likely that wood would have been in demand from groups settled in more southerly areas. The

driftwood was not only an important raw material for various tool and weapon shafts, but most likely was used as part of the support system for tents and cold season dwellings. In addition, exchange-systems are likely to have included a number of artifacts and raw materials that are rarely preserved in the archaeological context such as skin, fur, and blubber. We may also have difficulties in recognising the presence of some objects/raw materials as the result of exchange due to difficulties in determining provenience. Finally, walrus ivory is widely distributed and must have been an important item of exchange. Some Late Dorset sites include midden areas with very high concentrations of walrus cranial fragments, which are so numerous that it is likely that production of ivory was a major activity at the site. Some of this ivory may well have been included in the intra-regional, as well as inter-regional exchange networks (Appelt et al. 1998; Appelt and Gulløv 1999; Bendix 2000). In Foxe Basin, walrus seem to have been a major factor in the development of the area's importance throughout the entire Dorset period. The area is one of only a few in the Eastern Arctic with almost permanent intensive settlement from the beginning of Pre-Dorset until terminal Dorset, i.e. for more than 3000 years (Murray 1996; 1999). Given that metal from both northeast and northwest reached the area in some quantities, Foxe Basin must have contributed something to the exchange network, and ivory was likely one such export. In addition, it is possible that densely populated and relatively complex northern Foxe Basin groups provided something less tangible: a social and genetic safety net for their cousins occupying more risky, peripheral environments (cf., Murray 1999).

The Inuit/Inughuit:

Migrating into the Avanersuaq area (i.e. the Thule area) sometime in the second half of the 11th century AD or the early 12th century AD the pioneering Alaskan Inuit groups seem to have out-competed the Tunit, also in exploiting and trading in iron within a century or two (Appelt & Gulløv 2009).

With regards to the distribution of meteoric iron in **Greenland** our knowledge is limited as soon as we move beyond the Avanersuaq area. Thus the only recorded and chemically analysed piece of meteoric iron in Inuit context south of the northern Melville Bay is from the Sermermiut site situated in the vicinity of modern-day Ilulissat (central Disco Bay).

The small knife blade is mentioned in Buchwald's publication from 1985 (1985: table 4) with reference to Lorenzen's writings in 1882 (Lorenzen 1882: 26). Neither of the two sources provides the piece's museum inventory number or other information, outside the analyses made by Lorenzen was done at the request of professor Steenstrup. Going through the National Museum's protocols we managed to identify the artefact in question among the little more than 1000 artefacts that the son of professor Steenstrup donated to the National Museum in 1932. The piece is numbered L2.917 in the protocols and is a crudely made knife handle

of caribou antler (84 mm long with a 12-17 mm oval cross-section). The handle has a slot for an end blade, which is rectangular, and 10 x 4 mm, and perhaps 23 mm deep. The meteoric iron blade itself was sawed in two pieces in 1881 for the chemical analyses the tang with a small part of the knife blade proper. Inside the box that housed the knife is a small piece of cardboard with a pencil drawing of the intact knife blade, which is 58 mm long slightly irregular and with a rounded tip (the blade is 8-14 mm wide). The tang part of the blade is 23 mm long (3-9 mm wide and 2 mm thick). On the same cardboard we learn that the nickel content of the metal is 7.76% and cobalt 0.56%, i.e. within the range of the meteoric iron readings.

XRF-scanned metal artefacts from Greenland

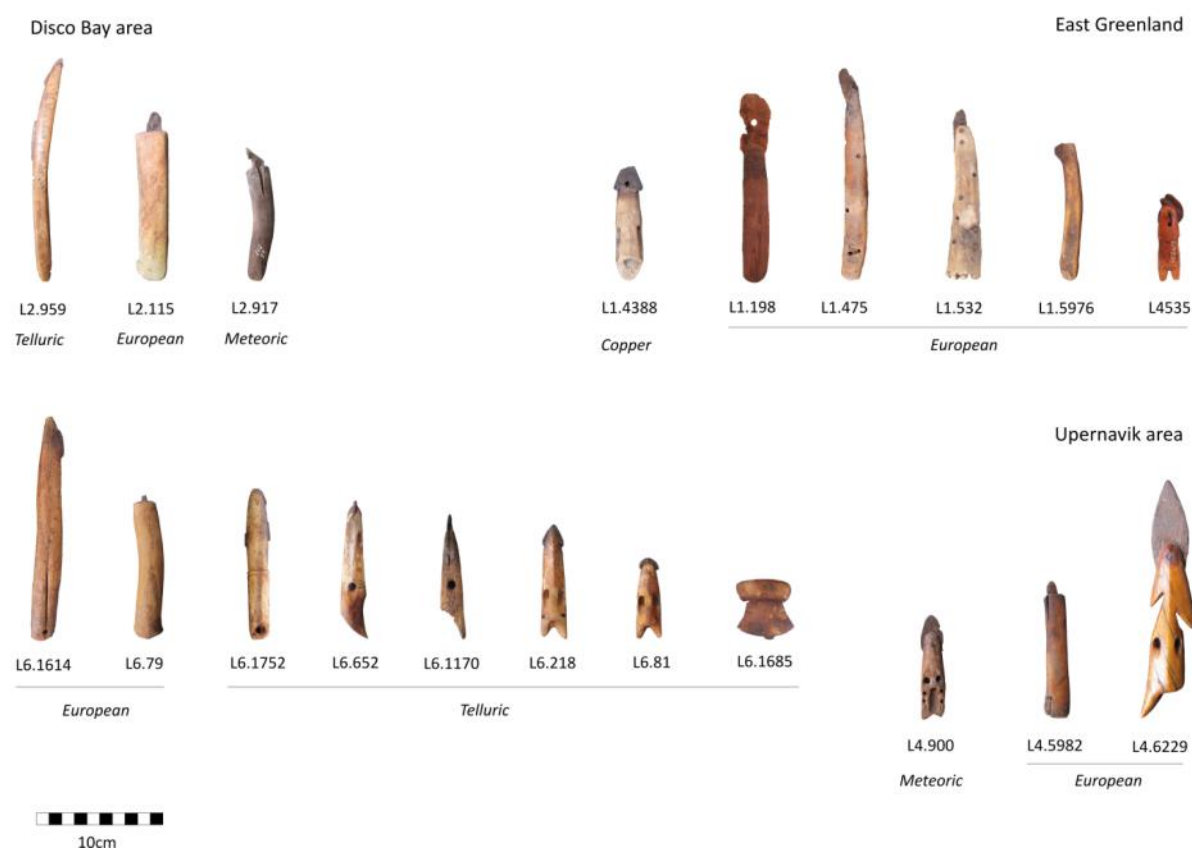


Figure 10: Objects XRF-scanned in connection with the present project.

In order to investigate if tools and weapon with meteoric iron in the archaeological records are truly restricted to the Avanersuaq area in Greenland a small pilot study was set up in collaboration with Michelle Taube (National Museum of Denmark) to XRF-scan some 25 items from East and West Greenland (see [appendix A](#)). The results of the analysis largely confirm the suggestion that every limited amounts of meteoric iron reaches West Greenland. Thus only one knife blade (inventory # L4.900) and one harpoon blade (inventory # L4.1348) from the Inussuk site (in the southern part of the Upernavik area) (Mathiassen, 1930) turned out to have been from meteoric iron. Both of these items were excavated from the deeper

layers at the site, likely dating to the 14th – 15th century AD. The analysis indicated that six of the seven examined items the Illutalik site (north-eastern Disco Bay) (Mathiasen 1934) were made from telluric iron from the source located at the site Uiffaq, on the south coast of Disco Island (for summary on the “discovery” of the telluric iron see Fundal 1972; Ulf-Møller 1986). With regards to the tested items from East Greenland all were made from locally collected native copper or European iron, the latter has probably either been brought into the area through trade or collected from ships timber found as driftwood.

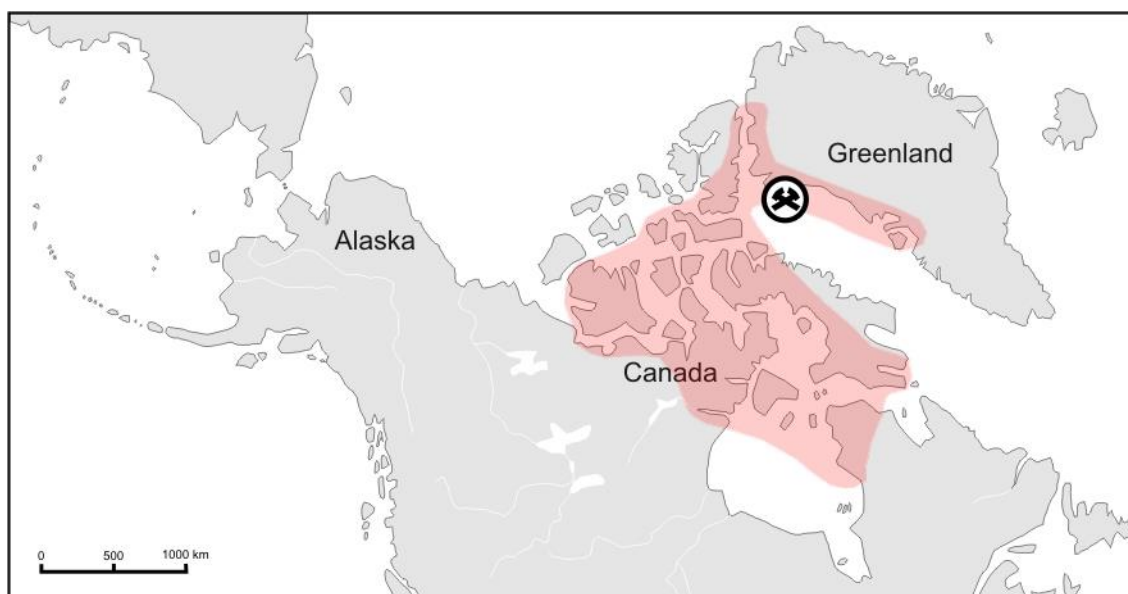


Figure 11: The trade in meteoric iron from the Avanersuaq area reached its maximum extension following the arrival of Inuit in the first half of the 11th century AD.

While the presented results certainly can only be taken as indications, and a more systematic and extensive testing is necessary, we do however feel that meteoric iron following the pioneering Inuit expansions in East Greenland and West Greenland became less important and substituted by local rawmaterials, i.e. in East Greenland native copper, various local types of slate and chert, and from the 17th century European metal, while the raw material needs in West Greenland were covered by a combination of telluric iron, Norse metals (iron, copper and bronze (see below)), and from the 17th century European trade metal.

A simple listing of metal pieces found on Inuit sites in the *Pikialasorsuaq region* on pre-18th century CE amount to at least 191 pieces, of which 24 pieces are likely to be of Norse origin; the remaining 155 pieces are most likely to be meteoric iron.

Site Name	Meteoric iron	Norse iron	Unidenti. (likely meteoric)	Relevant radio-carbon dates	Dating	Literature
Fossil Bay	-	1	-	AAR7473 (on antler)	14 th century calAD	Andreasen & Lange 1999
Cape Russell	-	1	-	-	13 th – 15 th century	Holtved 1944
Ruin Ø	-	2	5	-	13 th – 14 th century	Holtved 1944
Cape Grinnell	7	2	-	AA85146 and AA85148 (on caribou bone), AA85147 (on musk-ox bone)	14 th century calAD	LeMoine & Darwent 2010; LeMoine 2014
Inuarfissuaq	-	-	19	AAR7370 (on antler)	13 th – 15 th century calAD	Appelt 2003; - Holtved 1944
Qaqaitsut	4	-	-	AA90329-AA90332 (on caribou bone)	13 th – 17 th century calAD	Dussault et al. 2014; LeMoine & Darwent 2010; LeMoine 2014
Nuulliit	28	-	-	KIA16936 and KIA16941 (on Musk-ox)	13 th – 14 th century calAD	Appelt 2003; Buchwald & Mosdal 1985; Holtved 1954
Thule/Dundas	2	-	26	-	13 th – 17 th century	Holtved 1944; 1954; Buchwald & Mosdal 1985
Skrælling Isl.	-	17	74	GSC3038 (on cloth), GSC3156 (on heather), GSC 3003 (on heather)	13 th – 14 th century calAD	McCullough 1989
Eskimobyen	-	1	-	GSC3396 (on heather)	13 th – 15 th century calAD	McCullough 1989
Sum	41	24	124			

Table 01: Iron objects excavated at pre 17th century sites in the Pikialarsorsuaq region. Datings indicated is either arrived at suggested by the available radiocarbon dates and/or significant architectural features and stylistic attributes seen in the artefact inventories excavated.

The iron are from specimens excavated on seven dwelling sites in the Avanersuaq area and two on Ellesmere Island dating to 13th to 15th century calAD (see table 01). The time available within the frame of the present project did not permit a re-assessment of the archaeological material excavated by Erik Holtved, as most of the material is stored in the Greenland National Museum & Archives. In the present listing 73 pieces of non-

Norse iron has been included; a number arrived at by going through the tables, text and photographs published by Holtved (1944; 1954). An assessment of the material excavated by Holtved were done in 1982 by Allen McCartney (pers. comm. Hans Christian Gulløv) and published in 1988 (McCartney 1988, Table 2), according to which the finds included 125 pieces of iron. Thus some 52 pieces are not in in table 01, bringing the total number of non-Norse pieces to 207, or some 75% of the total amount of metal recorded by McCartney.

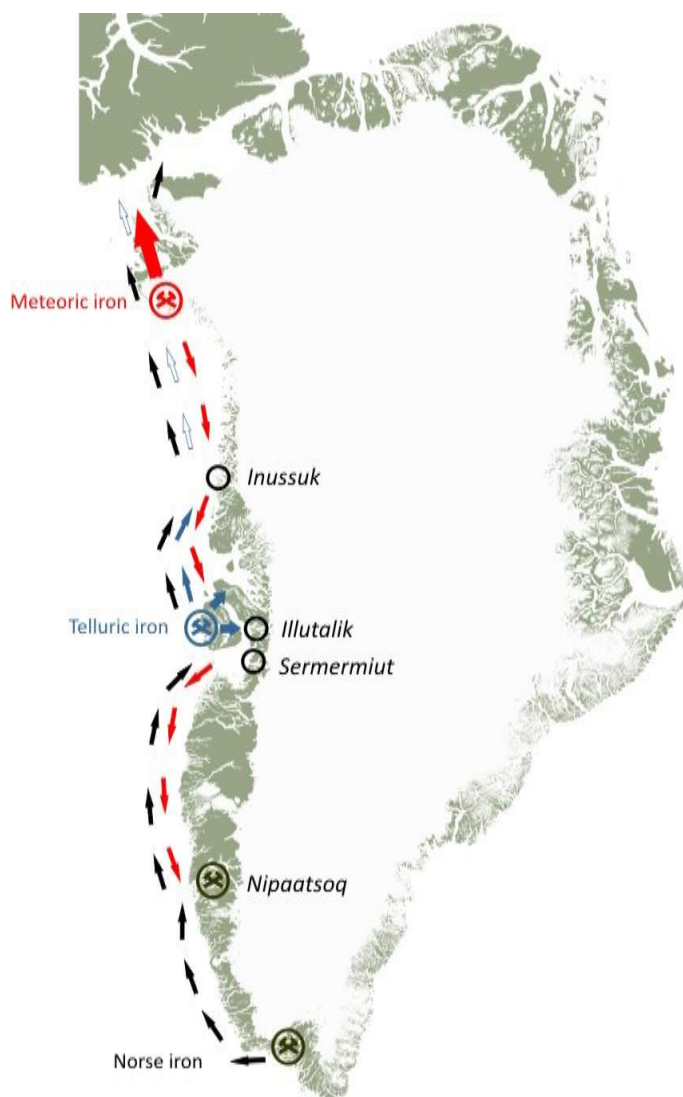


Figure 12: Norse iron (black), telluric iron (blue), and meteoric iron (red) been moved along the west coast of Greenland 11th to 17th century AD. Data from literature and from XRF-scans in connection to the present project

Extensive studies of metal (i.e. iron and natural copper) on pre-Contact Inuit sites in *Arctic Canada and Alaska* have been published by McCartney (overviews in McCartney, 1988; 1991; McCartney & Mack, 1973). He makes a convincing case for the existence of an epi-metallurgy age as well as that the social organisation of the pioneering centuries (i.e. approx. 11th/12th century to the 15th century CE) more comparable to the historically known societies in Alaska, than the egalitarian far-between and small societies encountered by

early European and American explorers in the eastern Arctic (1991). In prolongation McCartney demonstrates that well-developed trading networks ensured the distribution of the meteoric iron from Avanersuaq besides Greenland to areas as far away as the north-western shores of Hudson Bay, Frobisher Bay, and Victoria Island (1988) – within a geographical triangle with sides of about 1000 x 1200 x 800 kilometres. Taken his starting point in on the one hand side finds of metal on actual metal pieces on the prehistoric sites, and on the other indirect evidence in the shape of rust-stains/verdigris on tool handles as well as blade-slid width (i.e. slids of less than 2/1.5 mm were for metal blades, while slids for stone blades are more than 2 mm wide), that a substantial percentage of the tools would have had metal blades (1991). Somewhat more speculative and by including post-Contact ethnographic observations he goes on to suggest that the organisation of the metal distribution locally, regionally and inter-regionally, whether iron or natural copper, may have been centred around *Umialiks* (i.e. local/regional leaders) (ibid: 35-38).

Three Canadian pre-contact Inuit sites stands out as particularly rich iron, i.e. the Porden Point site, the Cape Garry site and Learmonth site (McCartney 1988: Table 2). This is certainly a reflection of several factors, such as preservation conditions. The most important factor may however be whether or not a metal detector was used when screening the excavated material or not, as McCartney was probably the first archaeologist to make systematic use of the metal detector on eastern Arctic prehistoric sites, namely the Cape Garry and Learmonth sites (Pringle 1997).

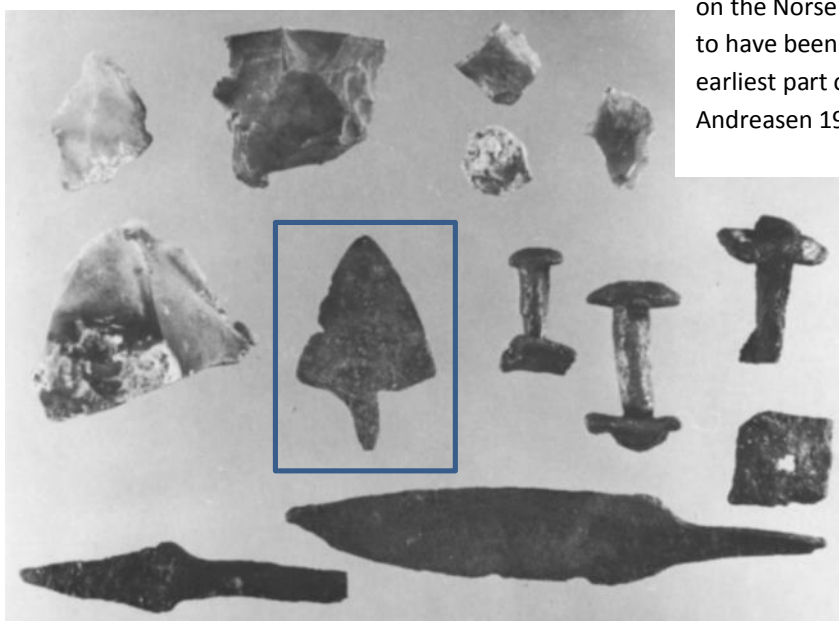
The Norse:

Excavations on a Norse farm 1976 revealed a number of unexpected finds (Andreasen 1980; 1982). The apparently modest highland farm Nipaatsaq is situated deep in the inland of the southern part of the so-called Western settlement (i.e. modern day Nuuk area). Among the intriguing finds was a tiny silver shields with ornaments that suggest some sort of connection to nobility in Scotland, as well as a few small “rings” of iron from a chain mail. The farm was settled from the early 11th century until the end of the 14th century AD. The finds furthermore included an arrow head made of iron from the Innaanganeq meteorite (Buchwald 2001).

The arrow head constitute the hitherto only find of meteoric iron in a Norse context and its presence is among the important direct evidence of the Norse journeys to Avanersuaq. While no other Norse farm has produced pieces of chain mail we know of three Inuit sites in the Pikialasorsuaq region (Skrælling Island (McCullough 1989), Ruin Ø (Holtved 1944), and Cape Grinnell (LeMoine & Darwent 2010)) and at one site in the northern Melville Bay (Kap Seddon (Grønnow 1981)) with findings of chain mail.

These pieces only constitute a small portion of the Norse items in the area, which taken as a whole attest to occasional visits by the Norsemen in the area (see Schledermann 1982; Appelt & Gulløv 2009; Gulløv 2004 with references). The total number of Norse objects found on Inuit sites in Greenland and on Ellesmere Island dating to the period ca. 1200 - 1400 calAD is 111, of which 89% is from the Píkiyasorsuaq area, i.e. furthest to the North of Greenland (Gulløv 2008: table 3). These archaeological findings are further substantiated by (a few) written medieval sources from Iceland (Arneborg 2004, with references).

Figure13: The arrowpoint made from meteoric iron. The arrowpoint was found on the Norse farm Nípaatsoq, which seems to have been settled from the 11th to the earliest part of the 15th century AD. Andreasen 1982: fig. 13.



THE SITES RECORDED DURING THE FIELDWORK

Saveruluup Itilliapalua

The locality

The site at which the "Woman" and "Dog" fragments of the Innaanganeq-meteor was located until 1895 is called Saveruluup Itilliapalua (in the following called "SI"), The meaning is likely *the good place to cross Saveruluk*, i.e. the easiest dog sledge passage from the ice-filled waters draining the Helland Glacier to the small bay due North of Meteorite Island. According to Qaerngaq Nielsen (whom visited us at the site on 31 July) the passage is normally used, when the sea ice is unstable further out in the Meteorite Bay, and thus people often also today come by this area. The passage is narrow, orienteered approximately East-West, and about 800 metres long. At its highest parts the passage is characterised by sparse vegetation (various lichens, and mainly black lichen) and unstable deposits of sediment in polygons and boulders. The terrain north of the passage rises to about 50 metres above sea level and has a view towards Saveqarfik peninsula (were the Savik fragments were found) and the Agapalilik peninsula and Meteorite Bay. Towards the western coast the terrain changes to a lightly coloured boulder field that seem to have been permanently covered by a snow patch until recent years. The land towards the eastern end of the passage is characterised by clay-like floating sediments.

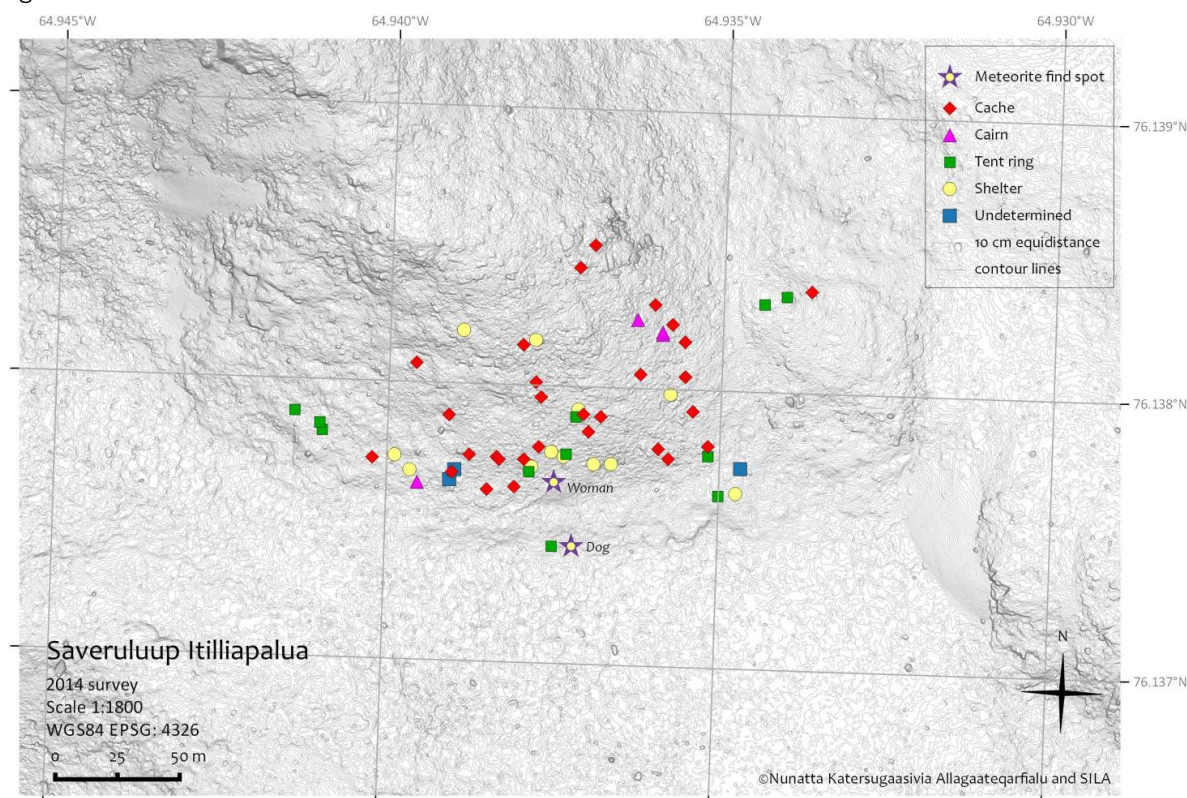


Figure 14: Map of Saveruluup Itilliapalua based on data generated by fixed-winged drone. Mikkel Myrup *del.*

The original resting place of the Woman fragment is on the central northern side of the passage in a steep and unstable layer of boulders – 0.5 – 1.5 metres across - overgrown by mainly by black lichen, but also moss and in a few places sedges. This is also the area in which all 62 archaeological features were recorded. The dense vegetation makes it very difficult to assess the age of the individual features, and thus the time-frame of the whole site collapses into one horizon. This situation is worsened by poor preservation conditions for organic materials, and that possible artefacts will diffuse downwards between the loose boulders. The loose boulders also mean that it was difficult to move around between the various archaeological features without causing damage.

In the eastern end of the steep boulder area one finds three about one metre high cairns (features labelled SI CH, SI CI and SI CJ, see below), built several courses and in bond. This type of building style is usually not seen in Greenland, and it has been suggested they were built by Peary's crew. The cairns are visible from the eastern coast of the passage.

Where the fragments of the meteorite were once located

SI AA (Woman)

N76,13767°/W064,93755°

The original position of Woman is notable as an approximately 220 x 300 x 40 centimetres sub-rectangular depression in the centre of a large heap of water rolled greenish to grey porphyry-basalt stones. The porphyry-basalt stones were used as hammer stones to extract small nuggets or flakes of the meteoric iron for tool and weapon blades.

According to Sakæus the local Inughuit related to him that the hammer stones were collected on Innaanganeq and brought to the site (Ross 1819). According to Peter Dawes – one of the geologist who in recent years have worked most in the area – it is likely that the hammer stones more precisely were collected on the southwestern side of Innaanganeq (Dawes, personal communication 2014), i.e. about 50 kilometres – as the crow flies - from Woman.



Figure 15: The depression in the hammer stone pile in the background marks the original resting place of "Woman". Bjarne Grønnow *del.*

The area excavated by Peary's crew extends further (180 x 140 x 30 centimetres) towards the southwest (i.e. towards a stone ramp). A 30 – 50 centimetre berm of sediment and boulders surround the excavated area and was deposited during the 1895-excavation.

The extension of the heap of hammer stones is 15.4 meters along the east-west axis and 12.6 meters in the north-south axis. It is estimated that the layer of the porphyry-basalt stones is between 100 – 200 centimetres deep, distributed across levels at about 250 centimetres. The smallest of the hammer stones is ca. 10 x 10 x 20 centimetres weighing about three to four kilograms, while the largest stones are ca. 40 x 25 x 20 centimetres and may weigh as much as 25 to 30 kilograms. An estimated 90% of the hammer stones in the stone heap are either large flakes or cores from which large flakes have been detached during their use.



Figure 16: Hammer stone pile at “Woman” seen from south. Jens Fog Jensen *del.*

In order to pull Woman from its resting place Peary had an approximately 200 centimetres wide ramp built established on the south-eastern side of the depression.

Based on our own estimates on the ground and calculations from the drone recordings (see below) we suggest that the stones heap proper (i.e. not including the hammer stones found around Dog, in the lower parts of the ramp and in connection to the dwelling structures) may be as much as $36\text{m}^3 \pm 10\text{m}^3$.

Furthermore estimating that the density of packing in the heap is 0.65, and the density of the stones is 2.9 we end up with the following calculation:

$36\text{m}^3 \times 0.65 \times 2.9 = \mathbf{67.86 \text{ ton}}$ of hammer stones were hauled to the site.

Several pieces of bones and wooden splinters were found distributed across the depressed area and the pile of hammer stones.



Figure 17: An example of one of the very large hammer stones at “Woman”. Even if its only half its original size the stone is estimated to weigh about 20 kilogram. Bjarne Grønnow *del.*

The stone ramp

The transport of the meteoric fragments in 1895 onto Peary's ship *Kite* were done through a boulderfield, across a large snow patch to the Saveruluk Bay, and on a large winter ice floe. The trans with the use of a large timber sledge rolling on iron pipes on top of rails made from heavy timber. To facilitate the transport through the boulder field the terrain had to be levelled out by filling up the lower parts with stones from the surrounding terrain. A two meter wide ramp was constructed from the foot of Woman down to the valley floor. A few splinters of the transport constructions can be seen the original position of Woman and along the ramp.

The following descriptions are made from positions taken approximately five metres apart (R1 to R15) with a hand-held GPS (Montana 600), and all measured on the southern (lower) side of the ramp.



Figure 18: “Woman” being transported on an ice-floe to the *Kite* in 1895 (Peary 1898).

R1

N76,13763°/W064,93757°

This first part of the ramp is made by levelling out the western side of the hammer stone pile.

R2

N76,13757°/W064,93776°

The western part is built from natural stones from the immediate surroundings. The edge of the ramp is built from relatively large boulders (50-75 centimetres across, 30 - 50 kilos). The floor of the ramp is made from head-size stones some of which are hammer stones.

R3

N76,13758°/W064,93784°

At this position the ramp is formed by three very large natural boulders.

R4

N76,13754°/W064,93816°

Large boulder of approximate two metres across is part of the construction.

R5

N76,13753°/W064,93838°

The ramp passes in between two very large boulders.

R6

N76,13750°/W064,93868°

This section of the ramp is grass and moss covered. The southern edge is made from fist- to head-sized stones.

R7

N76,13749°/W064,93894°

A large boulder forms the southern edge of the ramp that is otherwised filled in with from fist- to head-sized stones.

R8

N76,13751°/W064,93911°

The southern edge is formed by a large boulder. There is a sporadic filling in of the lower areas. The beginning of a moss covered area.

R9

N76,13751°/W064,93944°

A large boulder makes up the southern side of the ramp.

R10

N76,13750°/W064,93982°

Moss covered area in between two filled in large lowerings in the ramp.

R11

N76,13751°/W064,94018°

Boulder field with lower areas filled out with fist-sized or smaller stones.

R12

N76,13750°/W064,94041°

A large tringular boulder makes up the southern side of the ramp. A large part of the area is filled out with head-sized stones.

R13

N76,13748°/W064,94075°

Boulder field with some filling out among other some hammer stones.

R14

N76,13750°/W064,94096°

The beginning of the bottom of the valley floor characterised by large polygon dirt patches formed by cryoturbation. The sledge has been pulled across the level areas, that in some places have been filled up with fist- to head-sized stones. A few wooden and bone splinters are seen along the trail.

R15

N76,13752°/W064,94125°

The end of the ramp. The lack of vegetation on this part of the boulderfield suggests that a large and year-round snow patch covered most of the remaining stretch towards the coast. A few bones are seen at the beach, where the sledge was pulled out on a large ice floe.



Figure 19: A few pieces of wood found close to the original resting place of “Dog” are among the only direct physical evidence of Peary’s activities at the site. Jens Fog Jensen *del.*

SI AB (Dog)

N76,13743°/W064,93720°

The find spot, where Peary's crew extracted the *Dog* fragment, stands out as a low depression in the landscape in which the centre is covered by hammer stones. The activities of 1895 is visible only as a thin layer of wooden splinters, and to the South a planning of the terrain towards the sledge ramp established for pulling Woman. The activity area is about 530 centimetres long in an east/west axis and about 410 centimetres across in the north-south axis. The depression is at maximum 40 centimetres below the surrounding terrain. Hammer stones are of the same size and sort as seen at Woman.



Figure 20: The location from which Peary's crew hauled "Dog" in 1895

SI CP, Dog's original location

N76,13750°/W064,93728°/34 m.a.s.l.

The may be the original position at which Dog was left when deposited by the Ice. The place is about six metres northwest of SI AB and about one metre higher in the terrain. The find spot is seen as a shallow

depression (about 120 x 70-140 centimetres) surrounded by an up to two metre wide berm of hammer stones. We suggest that the movement of Dog between the two locations was done prior to Peary's presence in the area, and thus may have been done by Inughuit or their predecessors, perhaps turning the stone over to get access to a part of the block that was more workable.



Figure 21: "Dog" being hauled to the shore. Peary 1898.

Description of other features - introduction

The features have exclusively been found on the northern side Saveruluup Itilliapalua, i.e. in the vicinity to the location of the two meteoric blocks. The areas south, east and west were also surveyed, but no features were found in any of these areas.

The locating and recording of features were done under less than optimal circumstances, i.e. hastily and under poor weather conditions. As a result it was only possible to perform more extensive recording and drawings of four features.

The survey was done in four separate stages. The initial stage was done by walking in straight lines along an east-west axis, with 10 – 15 metres in between us, and marking each new feature found with a flag. During the second stage each of the new found features were re-visited and evaluated by all three members of the survey team. A cardboard with a feature label (approximately 20 centimetres in diameter) was placed in each of the features. During this stage a number of new features were found. In stage three each feature recorded with GPS, evaluated again, photographed and described in short texts. Several features were discarded during stage three. The height above sea-level was also recorded as suggested by the GPS-readings, but these can only be used as an estimated height above sea-level, as the instrument deviation may be as much as +/- metres in this x-axis.

The cardboard plates placed in the features had two functions, namely to ensure that we did not double-label any structures, and to help the identification of features on the overview photos produced by the

drone overfly (stage 4). As it turned out the cardboard plate were too small for the purpose as we could not make the labels large enough to be identifiable on the overview photos. Next time the plates should be at least 30 centimetres in diameter. See section below on drone overflies.

All in all 62 features were recorded of which there are six we cannot ascribe type on or the other type of feature with any certainty. The very unstable character of the scree, in which the features are located, means that clearings and constructions (stone in stone) easily cave in and thus become unrecognisable as made by humans. Following the final registration we realised that that a number of “depressions” in the scree were actually clearings (caches) as they were relatively standardised, i.e. circular to oval, 75 – 90 centimetres, and 30-50 centimetres deep. In light of this the 32 recorded caches may well only constitute about half of the actually number of caches.

Description of other features

SI AC, Tentring

N76,13762°/W064,93500°

A circular tentring of head-sized boulders in the lower southern part of the scree. The structure is about 4 metres across in on the outside of the wall line, and the northern half includes a platform area. The structure is covered by a dense layer of bog whortleberry, moss and lichen, and thus seem to be of considerable age.

SI AD, Shelter

N76,13763°/W064,93473°

The walls of this shelter ruin have caved in, but originally built in two-three courses, and 30 to 40 centimetres high. The inner measures are about 180 x 140 centimetres and the floor is covered in small round stones. The whole structure is covered by a dense layer of black lichen.

SI AE, Shelter

N76,13773°/W064,93471°

The shelter-like structure is constructed up against a large boulder. The caved in walls encompass an area of about 130 x 130 centimetres and originally would have been standing about 70-80 centimetres high, build in two courses of boulder 40-50 centimetres across. The interior is covered by a dense layer of moss, lichen and grass, while the walls are covered by black lichen. The structure is situated about four metres from structure SI AD.

SI AF, Cache

N76,13837°/W064,93370°

The rectangular cache is built up against a large boulder and is located on a low natural mount immediately east of Woman's original position. Its interior measures ca. 140 x 170 centimetres surrounded by building stones about 35 centimetres across. The cache is marked by an upright triangular boulder. Both the interior and exterior of the cache is covered by a dense layer of black lichen, moss and grass.

SI AG, Tentring

N76,13834°/W064,93407°

The oval tentring has a well-defined periphery of larger boulders encircling an area of about three times four metres. Several, likely secondary, linear stone arrangements are seen inside the structure. The interior is

covered by a dense layer of lichen, moss and grass, while the periphery stones are covered by black lichen. Situated on a ridge is of the original position of Woman, and about eight metres from structure SI AF.

SI AH, Tenring/shelter

N76,13832°/W064,93439°

Rectangular shelter/tenring built up against a low rock ridge and with a partly moss covered interior measuring 200 x 200 centimetres. The periphery is made of boulders, covered by black lichen, up to 40 centimetres across. The structure is situated on a low ridge immediately south of Woman and about five metres from structure SI AG.

SI AI, Platform

N76,13776°/W064,93516°

Pointed oval clearing in the scree, about 320 x 120 centimetres. The northwestern side of the structure is marked by a large boulder, while the rest of the periphery is marked by smaller and larger boulders pushed aside. The floor of the platform/working area is covered in fist-sized stones and covered in small patches of black lichen

SI AJ, Cache

N76,13779°/W064,93517°

Partly destroyed cache located up against the same large boulder as structure SI AI and likely connected to this. The interior of the structure is 30 x 30 x 50 centimetres.

SI AK, Cache

N76,13775°/W064,13579°

Circular opened cache built up against a large boulder. The interior of the cache is approximately 50 centimetres across, and the depth ca. 30 centimetres. The structure is overgrown by black lichen.

SI AL, Cache

N76,13763°/W064,93807°

Well-defined circular cache of a pile of boulders approximately two meters across. The interior is densely overgrown with moss and grass and ca. 83 x 83 centimetres.

SI AN, Cache

N76,13762°/W064,93851°

Opened oval cache made of large boulders. The interior of the structure is 135 x 95 centimetres densely vegetated with lichen and moss.

SI AO, Cache

N76,13765°/W064,93903°

Circular cache about 60 centimetres in diameter and 25 centimetres deep, with interior covered by black lichen.

SI AP, Cache

N76,13763°/W064,93900°

Rectangular cache constructed up against a large boulder. The interior is about 40 X 170 centimetres and in several places with the "roof"-stones still *in situ*. The cache is covered by a dense layer of moss, lichen and grass and located approximately 2.5 centimetres from structure AO.

SI AQ, Cache

N76,13769°/W064,93900°

Identical to structure AP and located on the opposite site of the large boulder.

SI AR, Cairn

N76,13764°/W064,93954°

The ca. 40 centimetre high cairn is built in three inter-locking courses on top of a large boulder. The structure is densely covered by black lichen.

SI AS, Shelter

N76,13769°/W064,93967°

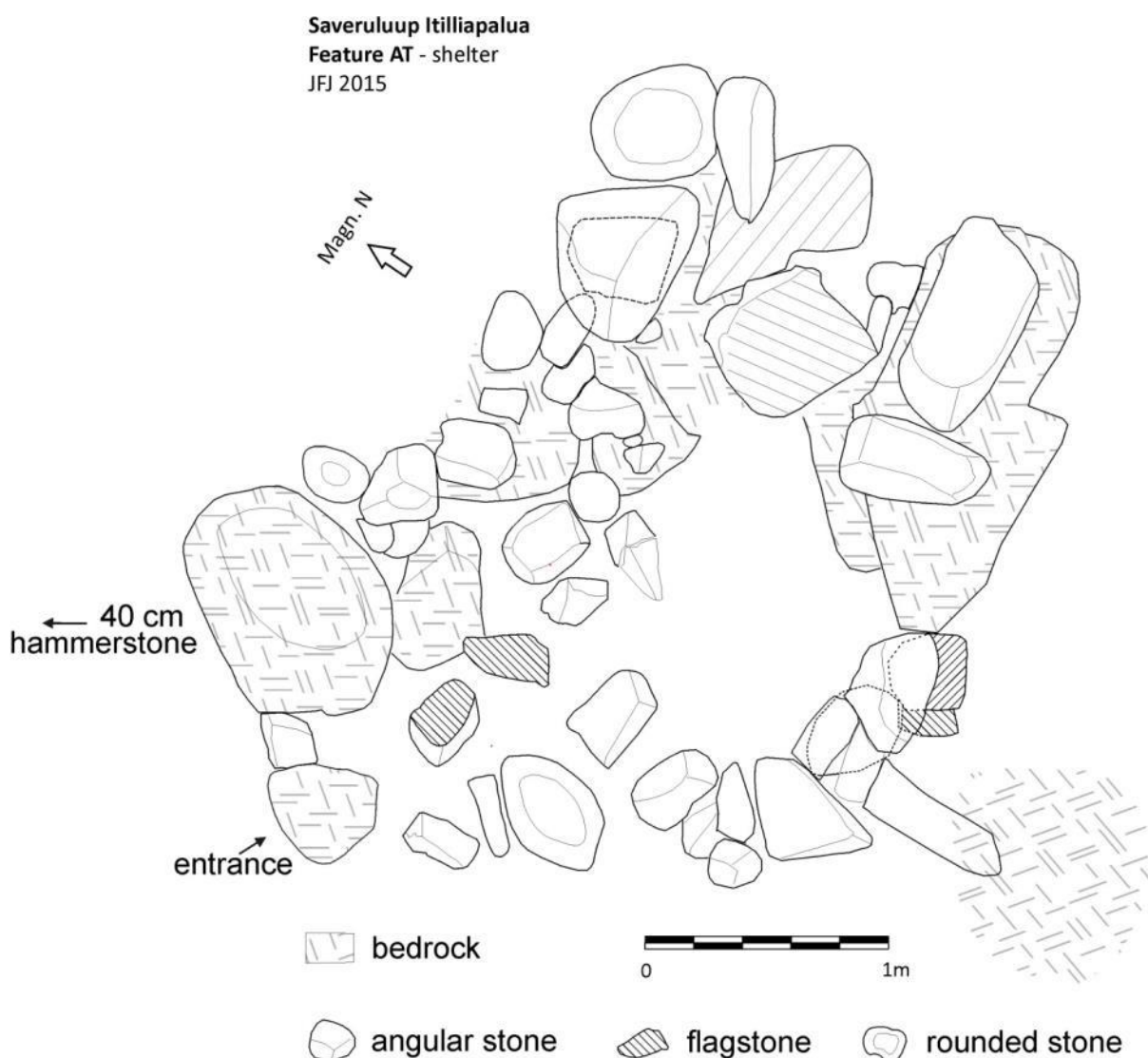
An oval platform area on 100 x 80 centimetres with a well-defined periphery on three sides of large stones. The inner part of the structure is covered by moss and lichen, while the periphery stones are over-grown with black lichen. The identification of the structure is somewhat uncertain.

SI AT, Shelter

N76,13773°/W064,93988°

A pear-shaped shelter structure with walls preserved in two-three courses on the southern side (up to 70 centimetres high), while the wall on the western side has caved in. The eastern side is constituted by a large

natural boulder. The 45 centimetres wide entrance area is seen in the northern wall. The maximum interior width of the structure is 105 centimetres, while the maximum length is 130 centimetres. The interior is densely overgrown by moss, lichen, and grass, while the walls are covered by black lichen. A hammer stone was found approximately 100 centimeters northeast of the entrance.



SI AU, Cache

Figure 22: Jens Fog Jensen *del.*

N76,13772°/W064,94021°

Well-preserved circular cache constructed of large boulders, approximately two metres across. The interior chamber is 120 x 70 centimetres in part still covered by “roof- stones”, and originally about 50 centimetres deep. The structure is entirely covered in black lichen, and is situated about three metres from structure SI AT and probably is built in connection to it.

SI AV, Tentring(?)

N76,13781°/W064,94099°

The structure is somewhat ill-defined. The interior is amorphous circular and two metres across surrounded by smaller and larger boulders. The interior is covered by moss and lichen, while the periphery stones are covered in black lichen.

SI AW, Tentring

N76,13785°/W064,94105°

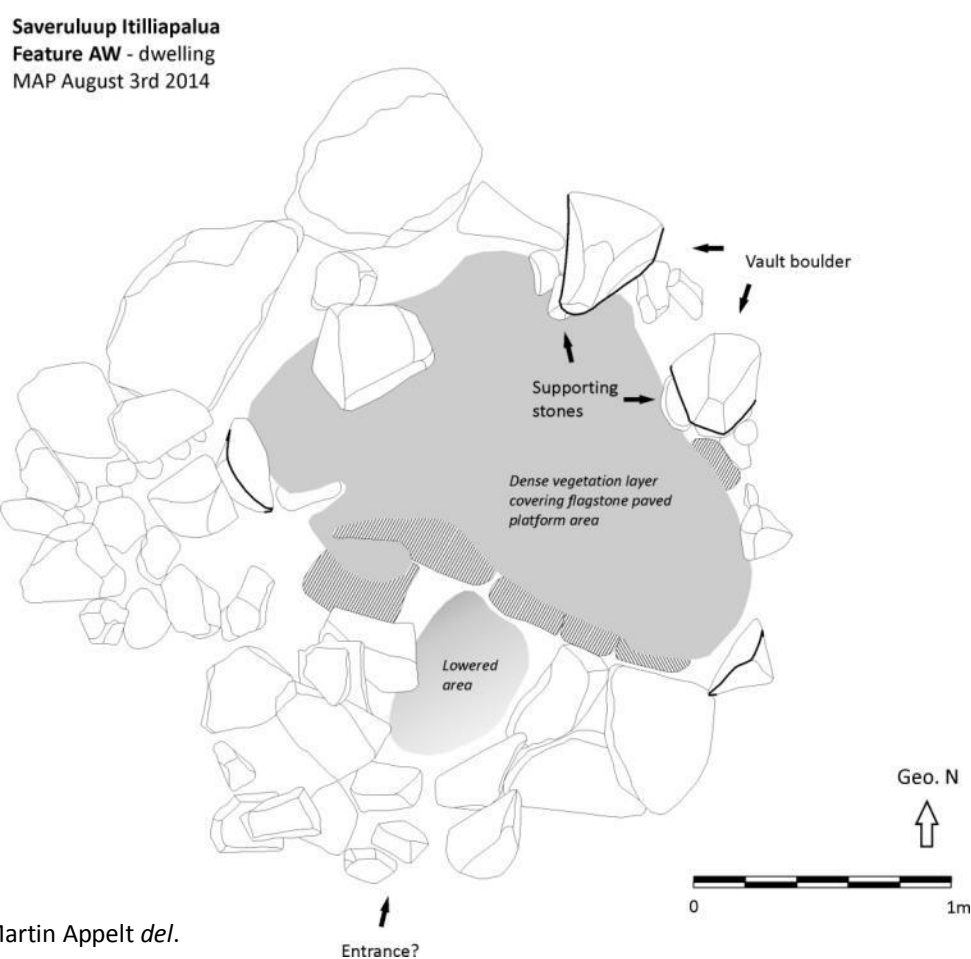


Figure 23: Martin Appelt *del.*

Sub-triangular dwelling structure. The dwellings interior groundplan is sub-triangular, about 220 centimetres wide and approximately 185 centimetres deep. The north back part and the western part of the dwelling is paved with flagstones covered by a dense layer of moss probably a platform area with a side bench (about 60 x 60 centimetres, possibly functioning as a lampstand) that occupy about $\frac{3}{4}$ of the interior space. A lowered area of about 50 x 50 centimetres is seen the structures south-eastern corner, which seem to have been the entrance area of the dwelling. The structures periphery is heterogeneous, i.e. the northwestern wall is constituted by two large natural boulders, while reminiscens of a false vault is seen in the northeastern

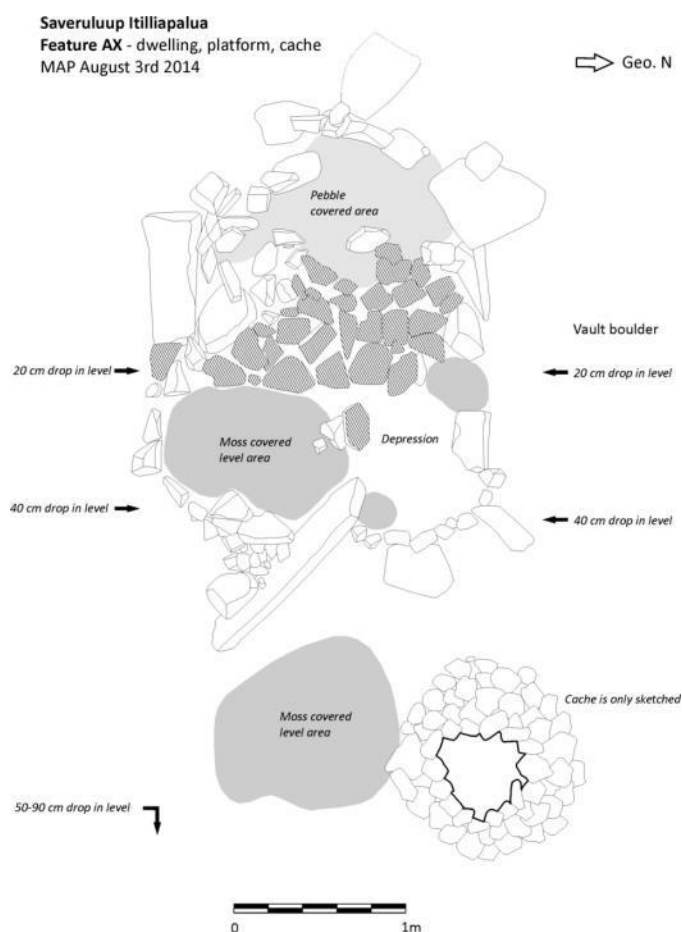
part of the wall in the shape of two about 50 centimetres long triangular boulders are raised on edge and supported by two-three small rocks on the inside of the wall. The eastern and southern parts of the wall are more less a jumble of various sizes of rocks tilted towards the lowerlying (southern) part of the scree. The wall boulders are covered by a very dense layer of black lichen and seem to be one of the oldest structures at the site. The structure is marked by a simple cairn that may have been raised in connection to Risbo and Pedersen's visit to the site (Risbo & Pedersen 1992).

SI AX, Tenthouse, platform and cache

N76,13789°/W064,94141°

SI AX is a small complex of features includes three separate units in the heavily sloping terrain (see figure 18). The central feature is a sub-rectangular dwelling structure, which stands out as a levelled out clearing in the scree about 190 centimetres wide and either 170 centimetres. The back half of the interior is paved with closely set flagstones raised some 20 centimetres above the floor area that faces the valley bottom. The floor area is again divided into two halves, i.e. a moss covered area and an area lowered an additional 20 centimeters below the platform level. The nature of the back wall is unclear as it is off set some 50 centimetres from what seem to be the original room. The area in between the platform and the back wall is level and covered by a layer of pebbles.

The terrain drops about 40 centimetres immediately outside the front wall of the dwelling towards the two other features in the complex, i.e. a levelled moss covered semi-circular area some 110 centimetres across and a well-preserved cache. The cache is circular with an interior groundplan 70 centimeters in diameter and a maximum height of 40 centimetres. The terrain drops 50 to 90 centimetres immditaely outside the moss covered plan and cache. The density of the vegetation cover (moss and black lichen) is uniform acroos all structures, making it likely that the three units were constructed and used simultaneously.



SI AY and AZ: Omitted!

SI BA, Cache

76,13789°/64,93909°/43 m.a.s.l.

Opened cache underneath a rock overhang built from 15 large rocks framing a rectangular chamber of 173 x 30 centimetres. Partly overgrown by black lichen.

SI BB, Cache

76,13775°/64,93875°/41 m.a.s.l.

Opened cache of head-sized stones. The interior groundplan is approximately 70 centimetres in diameter. Densely overgrown by lichen and moss.

SI BC, Cache

76,13774°/64,93835°/39 m.a.s.l.

Well-preserved cache with some "roof-stones" still in position. The exterior measures about 275 x 125 centimetres made of head-sized stones, while the interior is 186 x 45 x 35 centimetres.

SI BD, Cache

76,13773°/64,93830°/41 m.a.s.l.

The circular cache stand-out as a clearing in the scree, 70 centimetres across, surrounded by 15 head-sized stones. Densely overgrown by lichen.

SI BE, Cache or shelter (?) (fig 25)

76,13773°/64,93794°/39 m.a.s.l.

Well-preserved cache or shelter with an interior groundplan of 110 x 105 centimetres. The western wall is complete collapsed, while the southern wall is still standing 70 centimetres high, built in five courses of



Figure 25: Jens Fog Jensen *del.*

stones, including a number of hammer stones. Further hammer stones are found inside the structure and in and scattered in an area about one and half metre from the structure.

SI BF, Clearing (fig. 26)

76,13770°/64,93784°/39 m.a.s.l.

Levelled out rectangular clearing in the scree, 110 x 80 centimetres with a few head-sized stones forming a low wall towards the north and a large flat boulder placed on edge at the eastern periphery of the clearing. The whole feature is densely overgrown with lichen and some moss. The clearing is situated 125 centimetres southeast of SI BE and 150 south of SI BG.



Figure 26: Jens Fog Jensen *del.*

SI BG, Shelter (fig. 27)

76,13770°/64,93781°/41 m.a.s.l.

Solidly constructed shelter with a southern wall still standing 90 centimetres high towards the east and south, built in six courses. The entrance to the shelter is 50 centimetres wide and is found in the western wall. The interior groundplan is oval and about 130 x 90 centimetres.



Figure 27: Jens Fog Jensen *del.*

SI BH, Cache (fig. 28)

76,13.778°/64,93773°/42 m.a.s.l.

Solidly constructed cache, made of head-sized stones and with exterior measures of 150 x 100 centimetres. The interior chamber is 35 x 50 x 45 centimetres.



Figure 28: Jens Fog Jensen *del.*

SI BI, Shelter (fig 29a & 29b)

76,13776°/64,93752°/40 m.a.s.l.

Solidly constructed with only a few of the wall stones caved in, only some eight metres north of the original location of Woman. The shelters interior is about 160 x 110 centimetres and with walls up to 80 centimetres high built in four courses (on the northern side). A platform of flagstones covers the back half of the interior. The 60 centimetres wide entrance is facing Woman and the valley floor. Several fist-sized stones is found about one metre from the structure. A small cache (exterior measurements 30 x 60 centimetres) is built on the east side of the structure.



Figure29 a & 29b: Lower picture of hammer stone found inside structure BI. Jens Fog Jensen *del.*

SI BJ, Shelter (fig. 30)

76,13774°/64,93733°/40 m.a.s.l.

Well-preserved and well-constructed shelter with an oval interior groundplan of 80 x 70 centimetres, approximately five metres northeast of the original position of Woman. The walls are up to 70 centimetres high in five courses. A 50 centimetres wide entrance is facing southwest, towards Woman. The structure is depicted on one of Albert Operti's paintings from 1894.

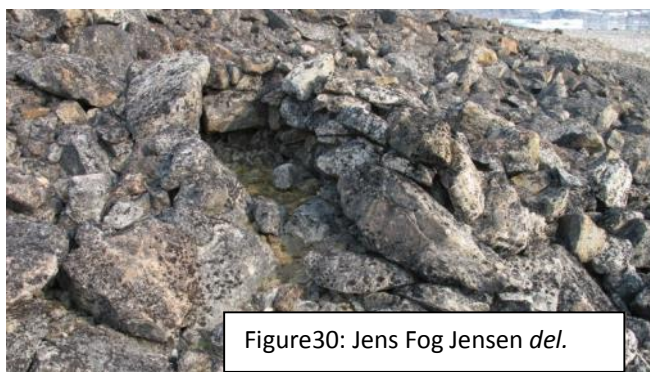


Figure30: Jens Fog Jensen *del.*



Figure 30a & 30b: Lower photo of hammer stone found inside structure BK. .Jens Fog Jensen *del.*

SI BK, Platform (fig. 30a & 30b)

76,13776°/64,93730°/39 m.a.s.l.

(inconsistent with the measurement of SI BJ)

Levelled cleared horseshoe-shaped, about 130 centimetres wide and 100 centimetres deep. A low lee wall is constructed from a few large boulders on the three sides. The platforms southeastern side is open and faces the valley bottom. The structure is overgrown with black lichen and reindeer lichen on the platform. Two very large hammer stones are seen about two metres southeast of the structure

SI BL, Shelter (fig. 31)

76,13773°/64,93,688°/38 m.a.s.l.

Shelter constructed up against a large natural boulder. The interior is 140 x 74 centimetres and have walls up to 50 centimetres high. Large flat boulders are found below a layer of moss, both covering most of the interior.



Figure 31: Jens Fog Jensen *del.*

SI BM, Shelter (fig. 32)

76,13773°/64,93663°/37 m.a.s.l.

Shelter ruin with a rectangular interior, 120 x 100 centimetres, with walls up to 50 centimetres high and built in two courses. A few of the wall stones are now found on the floor.

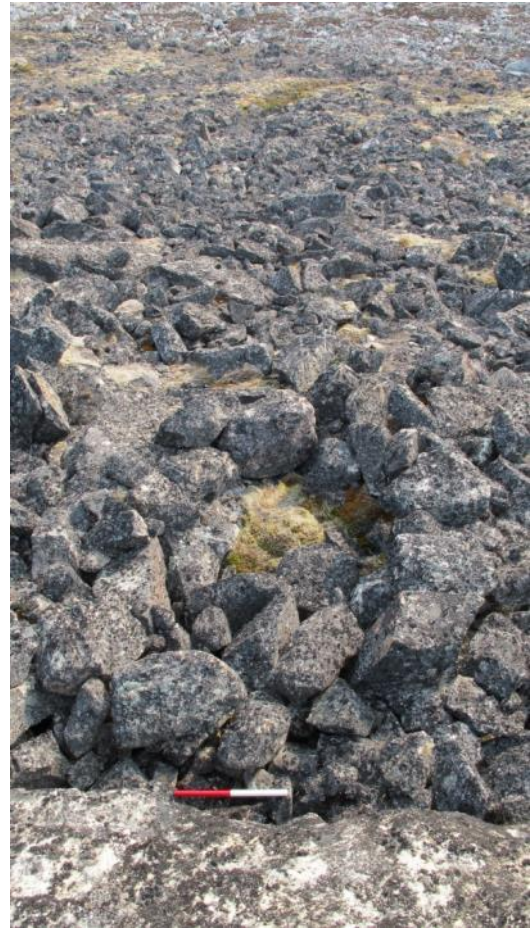


Figure 32: Jens Fog Jensen *del.*

SI BN, Cache (?) (fig. 33)

76,13779°/ 64,93591°/37 m.a.s.l.

A 130 x 40 centimetres cleared area in the scree that towards southeast is bordered by 12 head-sized stones in a crescent. The "floor" is covered by fist-sized stones and all of the structure is covered by a dense layer of black lichen.



Figure 33: Jens Fog Jensen

SI BO, Cache (?)

76,13792°/ 64,93542°/38 m.a.s.l.

Weakly defined cache with a sub-rectangular chamber of about 85 x 60 centimetres. Fist- to head-sized stones have been piled up around the possible chamber, probably from when the cache was opened.

SI BP, Shelter (fig. 34)

76,13799°/ 64,93578°/41 m.a.s.l.

Well-defined shelter ruin with an rectangular interior groundplan of 240 x 80 centimetres.

The walls are constructed of large, 50 -80 centimetres long, boulders placed on edge.

The interior is divided into two 120 centimetres long sections by a number of stones that may either constitute a platform edge or may be walls stones caved in? Fist-sized stones cover the floor, which raises slightly towards the supposed platform area.

The walls are covered by black lichen, while the floor is only sporadically covered by reindeer lichen.

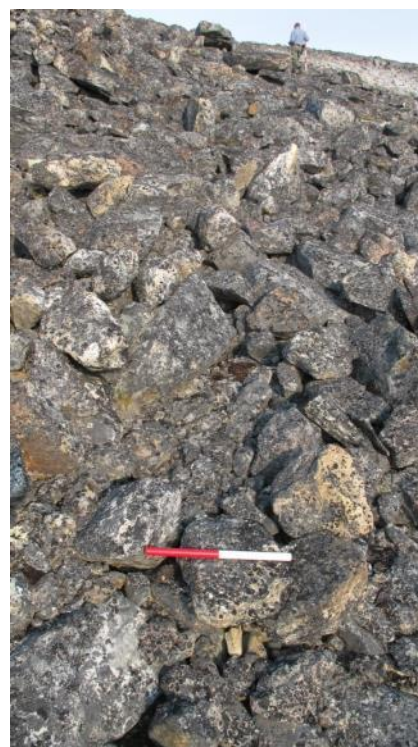


Figure 34: Jens Fog Jensen *del.*

SI BQ, Cache (?)

76,13789°/64,93679°/47 m.a.s.l.

The opened cache stand out as an oval area 90 x 120 centimetres with an uneven bottom of fist-sized stones.

SI BR, Cache (fig 35)

76,13784°/ 64,93700°/45
m.a.s.l.

The opened cache stands out as a circular clearing in the scee with a periphery of head-sized stones and a large natural boulder with a hollow below.



Figure 35: Jens Fog Jensen *del.*

SI BS, Cache (fig. 36)

76,13790°/64,93708°/48 m.a.s.l.

The meat grave is in a rock cleft between three large natural boulders with three large "roof-stones" still in situ. The chamber ia 120 x 35-50 x 55 centimetres. The cache is likely connected to SI BT and BU and is located only two metres northeast of these structures.



Figure 36: Jens Fog Jensen *del.*

SI BT, Shelter (fig. 37)

76,13792°/64,93714°/48
m.a.s.l.

Well-built and well-preserved shelter with a pear-shaped groundplan, 130 x 130 centimetres. The southwest facing wall is in three courses and 55 centimetres high. The entrance facing south is 65 centimetres wide and the interior of the structure covered by moss. a level area of about one m² is seen immediately in front of the entrance.

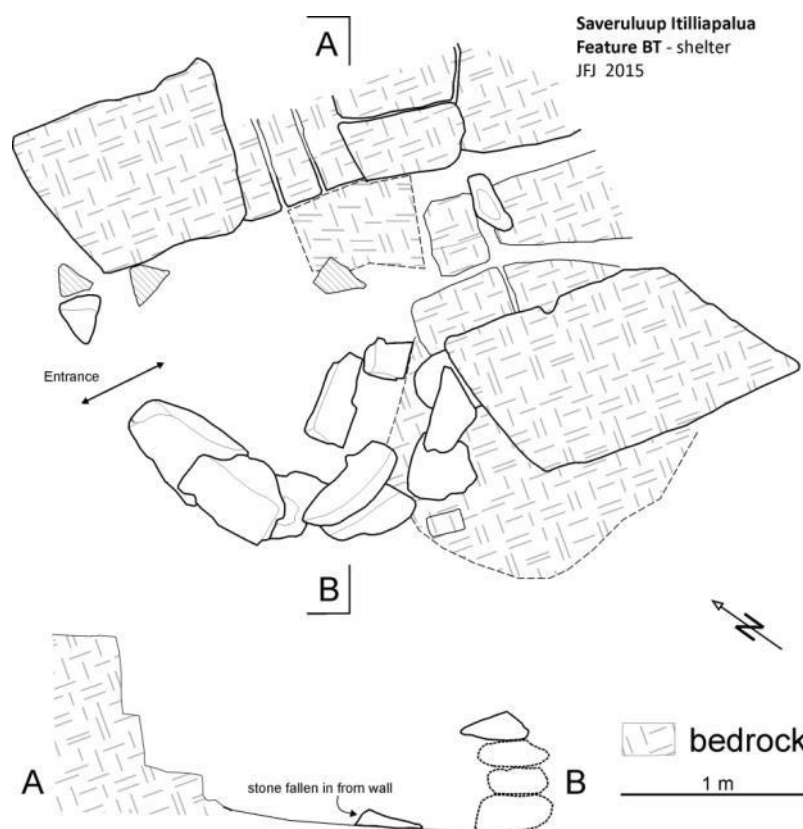


Figure 37

SI BU, Platform

76,13789°/64,93716°/47 m.a.s.l.

The 230 x 130 centimetres stone paved area is delimited towards the north by a 58 centimetres high wall built in three courses. The interior is covered by a dense layer of black lichen and in a few places some moss.

SI BV, Cache (fig. 38)

76,13795°/64,93771°/48 m.a.s.l.

Badly preserved cache located in the lower part of an area with several caches. A few weather worn seal bones are seen beside the structure. The chamber of the cache is approximately 110 x 56 centimetres.



Figure 38: Jens Fog Jensen *del.*

SI BW, Cache (fig. 39)

76,13801°/64,93777°/50 m.a.s.l.

The cache is a clearing in the scree, some 50 centimetres in diameter and 50 centimetres deep. The head-sized cleared stones are found at the edge of the clearing.



Figure 39: Jens Fog Jensen *del.*

SI BX, Shelter (fig. 40)

76,13795°/64,93813°/48 m.a.s.l.

Well-built and well-constructed shelter with a rectangular and moss grown groundplan, 140 x 130 centimetres. The walls are made of up to 45 centimetres long flat boulders on edge, on the western side supported by smaller boulders. Towards the north the structure is delimited by a large natural boulder upon which the remains of a false vault construction is seen. The floor of the structure is flagged with with large flat boulders, one of which is 45 x 65 centimetres.



Figure 40: Jens Fog Jensen *del.*

A number of green porphyric basalt hammer stones are seen on a plan area immediately south of the entrance area.

SI BZ, Cache

76,13807°/64,93961°/48 m.a.s.l.

A possible double chambered cache, 140 centimetre long and built with head-sized stones up against a large natural boulder. One of the chambers is somewhat asymmetrical rectangular and about 40 x 60 x 50 centimetres, the other chamber perhaps 25 x 40 x 55 centimetres.

SI CA, Shelter

76,13819°/64,93890°/54 m.a.s.l.

Shelter built up against a large natural boulder with a floor of fist-sized cobbles. The structures interior measures 200 x 100-120 centimetres, and has a front wall (towards the valley bottom) of very large boulders that may or may not be natural deposit in the scree. Several possible caches is seen in the vicinity of the structure. One of these has a groundplan of 100 x 60 centimetres.

SI CB, Shelter

76,13817°/64,93781°/53 m.a.s.l.

Shelter with a short southeast facing wall that delimits a rectangular area of 115 x 80 centimetres covered by moss and grass. The wall is 100 centimetres long and 50 centimetres high in two courses..

SI CC, Cache

76,13815°/64,93798°/53 m.a.s.l.

Circular clearing some 50 centimetres across and framed by head-sized boulders covered by black lichen.

SI CD, Omitted!

SI CE, Cache

76,13805°/64,93622°/43 m.a.s.l.

Ill-defined circular clearing some 75 centimetres across and framed by head-sized boulders.

SI CF, Cache

76,13805°/64,93556°/43 m.a.s.l.

Bell-shaped groundplan, 150 x 120 centimetres, surrounded of head-sized stones covered in black lichen.

SI CG, Cache

76,13818°/64,93559°/43 m.a.s.l.

Well-defined oval area of fist-sized stones covered with moss and 60 - 70 centimetres in diameter. The area is surrounded by head-sized stones.

SI CH, Cairn (Peary 1895?)

76,13820°/64,93590°/46 m.a.s.l.

The smallest and lowest of three cairns on the eastern end of the northern ridge bordering the valley. The cairn is about 75 centimetres high and 98 centimetres wide built in three courses in bond. Five or six flagstones found in between the present cairn and cairn SI CI has probably originally been part of SI CH, thus increasing its height to about 100 centimetres.

Foto: MMY 9156, seen from Southeast; MMY 9157, seen from Southwest; MMY 9158-9159, seen from Southwest (images of all three cairns).

SI CI, Cairn (Peary 1895?)

76,13821°/64,93590°/47 m.a.s.l.

The cairn is 115 centimetres high constructed in seven courses, and in two columns in bond (100 centimetres wide and 40 centimetres deep).

Foto: MMY 9160-9161, seen from Southeast; 9162-9163, seen from Southwest; 9169-9170 (black lichen growing on the structure).

SI CJ, Cairn (Peary 1895?)

76,13824°/64,93629°/48 m.a.s.l.

The cairn is constructed the same way as the two cairns described above. It is 50 centimetres high built in four courses in bond on top of a large natural boulder (the top of which is 165 centimetres above the surrounding terrain) and 100 centimetres wide.

Foto: MMY 9164, seen from Southwest; MMY 9165, seen from Southeast; 9166-9168 (black lichen growing on the structure).

SI CK, Cache

76,13830°/64,93603°/48 m.a.s.l.

Circular cache of rounded as well as flat boulders some 95 centimetres across. A few boulders are found on the floor of the cache, otherwise covered by moss and grass.

SI CL, Cache

76,13851°/64,93698°/58 m.a.s.l.

Large well-preserved cache with an oval chamber, ca. 120 x 40 with 50 centimetres high walls in several courses. The exterior measure is about 300 centimetres in diameter. Several large and flat "roof-stones" are seen fallen on the floor, that is made of fist-sized stones and covered by moss.

SI CM, Cache

76,13843°/64,93719°/59 m.a.s.l.

The partly covered oval cache has a chamber of 100 x 45 centimetres and with 45 centimetres high walls.

SI CN, Cache

76,13823°/64,93577°/47 m.a.s.l.

Cache with circular chamber surrounded by very large boulders (up to 110 centimetres high). Floor of fist-sized stones.

SI CO, Tentring

76,13743°/64,93748°/32 m.a.s.l.

Well-preserved levelled area, two metres across, and with a well-defined semi-circular periphery towards the southwest.

SAVEQARFIK

Savik

The following is an extract from the very sparse notes we have from the less than one hour visit to the site in heavy winds and rain.



Figure 41: At the site where “Savik” originally was located. Note the hammer stones in front. “Savik” was originally resting on an estimated 10 tons of hammer stones. The cairn in the background is likely built by either Peter Freuchen (in 1913) or Nyebo (in 1923). Martin Appelt *del.*

The original position of Savik is at a ridge about 270 metres above sea level at the south-western side of the Saveqarfik peninsula. It is located about 1500 metres, as the crow flies, from the coastal site we suspect it was brought into the sea ice from (here called Saveqarfik South). Its position is marked by an approximately one metre well-built cairn, probably built when Savik was brought down from the ridge in 1923. A heap of greenish porphyric-basalt hammer stones is seen immediately east of the cairn. The pile is six to seven metres across and estimated to be at average 50 centimetres thick. A depression at about one metre across is seen at the centre of the pile marking the original position of Savik. The flat terrain around Savik can

generally be characterised as a large boulder field overgrown in black and yellow lichen, and with small patches of moss and grass in between the stones. There is an excellent view south across the Melville Bay.



Figure 42: An example of the number of large and heavily built shelters and cache is seen found on the northern side of the “Savik” site. Martin Appelt *del.*

Saveqarfik South

As with the visit to the “Savik” site we only had a two hours at the site we preliminarily has named Saveqarfik South site, as heavy swells and difficult conditions for anchoring made the site almost inaccessible. Our impression is that the site holds several phases of settlement, but also that the most visible and substantial structures were built in connection at the time “Savik” was brought down from the mountain ridge and driven by sledge to Salve Ø, i.e. between 1923 and 1925.

SqS 18 – Cache (fig. 43)

N 76° 07,478'/W 64° 38,781'

This is a well-preserved cache, with “roof-stones” still *in situ*. Exterior measures are approximately 120 x 80 centimetres.

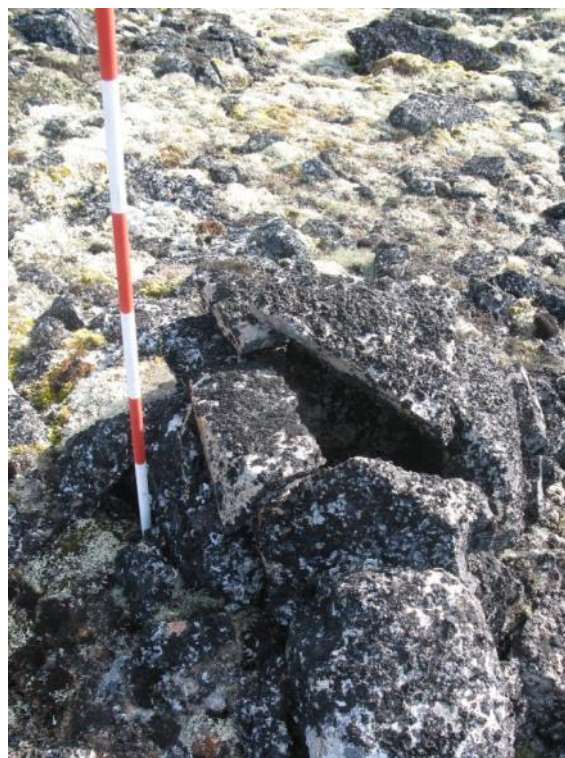


Figure 43: Martin Appelt *del.*

SqS 19 – Tentring (fig. 44)

N 76° 07,480'/W 64° 38,776'

The interior measurements of this rectangular tent ring is ca. 350 x 300 centimetres, with the periphery set in head-sized and larger boulders. The interior is covered by dense vegetation, but a flagging of the northern half of the structure indicates the presence of a platform area.



Figure 44: Martin Appelt *del.*

SqS 20 – Cache (fig. 45)

N 76° 07,472'/W 64° 38,773'

The cache has an oval chamber of ca. 70 x 60 x 45 centimetres.



Figure 45: Martin Appelt *del.*

SqS 21 – Cache or grave ? (fig. 46)

N 76° 07,468'/W 64° 38,785'

The massive cache or grave has exterior measurements of approximately 230 x 250 x 100 centimetres.



Figure 46: Martin Appelt *del.*

SqS 22 – Cache (fig. 47)

N 76° 07,464'/W 64° 38,772'

The massive cache or grave has exterior measurements of approximately 170 x 120 x 80 centimetres. A number of the “roof-stones” are still *in situ*. The chamber is at minimum 50 centimetres high.

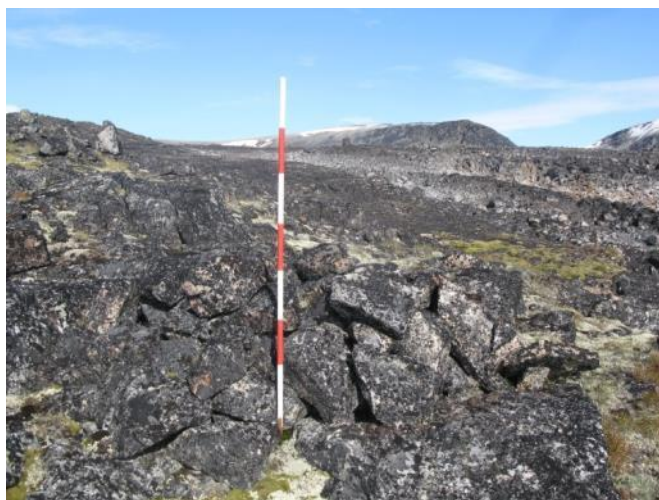


Figure 47: Martin Appelt *del.*

SqS 23 - Shelter

N 76° 07,464'/W 64° 38,878'

Shelter 180 X 150 cm internally, walls built of more than head sized angular and rounded stones set in set in three courses. A few of the angular stones are set on edge.



Figure 48: Martin Appelt *del.*

SqS 24 – Shelter (fig. 48)

N 76° 07,465'/W 64° 38,797'

The shelter is built up against an 80 centimetres high rock face and includes a cache feature. The overall exterior measurement of the shelter and cache is 340 x 180 centimetres. The walls are built in two courses and about 80 centimetres high. The outline of the cache is triangular and about 80 x 100 centimetres, and with an interior height of ca. 40 centimetres.

SqS 25 - Shelter

N 76° 07,468'/W 64° 38,799'

Shelter consisting of a stone wall built on a minor rock ledge just 'below' MRK 26. Towards south the angular wall stones are set in three courses, otherwise the walls are set with just one row of angular stones on edge. The opening is towards west.

SqS 26 – Shelter/"wall" cairns? (fig. 49a & 49b)

N 76° 07,469'/W 64° 38,793'

Feature of unknown function constituted by two parallel walls with 140 centimetres in between that are oriented approximately N-S, i.e. towards the coast. The walls are about 115 centimetres high and built in seven courses. The eastern wall is 140 centimetres long and 50 centimetres deep, while the western wall is 90 centimetres long and 40 centimetres deep.

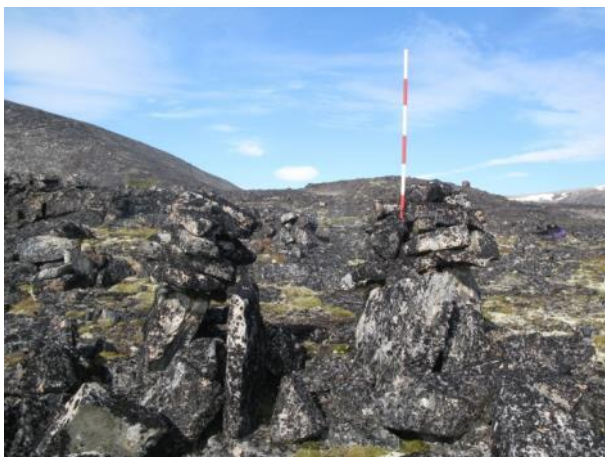


Figure 49a & 49b: Martin Appelt *del.*

SqS 27 - Shelter

N 76° 07,471'/W 64° 38,807'

Shelter with periphery of angular stones set in up to three courses encircling a 140 X 100 cm large floor. Towards east there is an extra wall in a distance of 50 cm from the rear wall, the 'front' wall towards west (and the sea) has fallen over. Moss covers the floor.



Figure 50: Martin Appelt *del.*

SqS 28 – Cache (fig. 50)

N 76° 07,473'/W 64° 38,801'

The massive cache has most of the "roof-stones" *in situ*, while the walls are partly collapsed. The two long sides of the cache are made of large boulders. The original size of the cache seems to have been about 125 x 100 centimetres, and in its present – collapsed – state it is 60 centimetres high.

SqS 29 – Cache (fig. 51)

N 76° 07,476'/W 64° 38,808'

An extremely well-preserved sub-rectangular cache built up against a rock face with exterior measures of 180 x 120 x 90 centimetres.

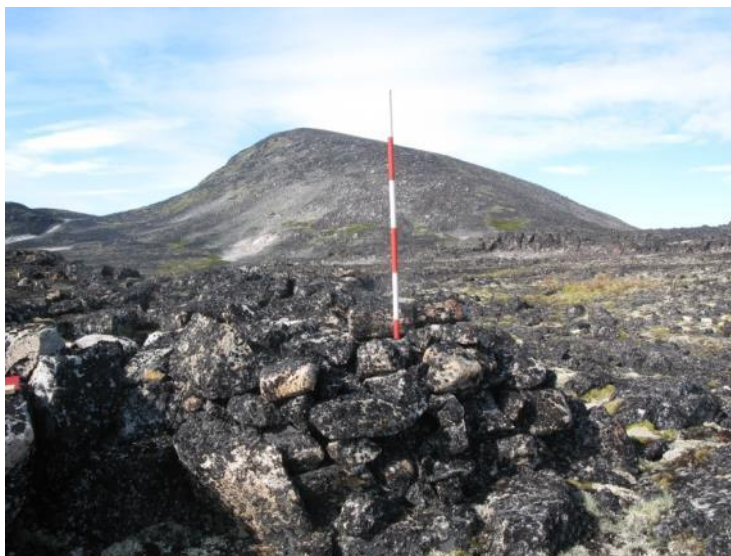


Figure 51: Martin Appelt *del.*

SqS 30 - Shelter

N 76° 07,475'/W 64° 38,812'

Shelter with lunar shaped wall of flat stones set on natural boulder on a high point. The wall encircles a 140 X 100 cm large floor covered by moss.

SqS 31 – Shelter (fig. 52)

N 76° 07,482'/W 64° 38,823'

The rectangular shelter ruin has heavy, but partly collapsed, walls that originally would have been in four courses. The interior measures are 150 x 160 x 75 centimetres.



Figure 52: Martin Appelt *del.*

SqS 32 – Tentring (fig. 53)

N 76° 07,486'/W 64° 38,837'

A sub-rectangular tentring with a periphery of head-sized stones. The interior is approximately 370 x 230 centimetres and a box-hearth is seen in the centre, which may be secondary.

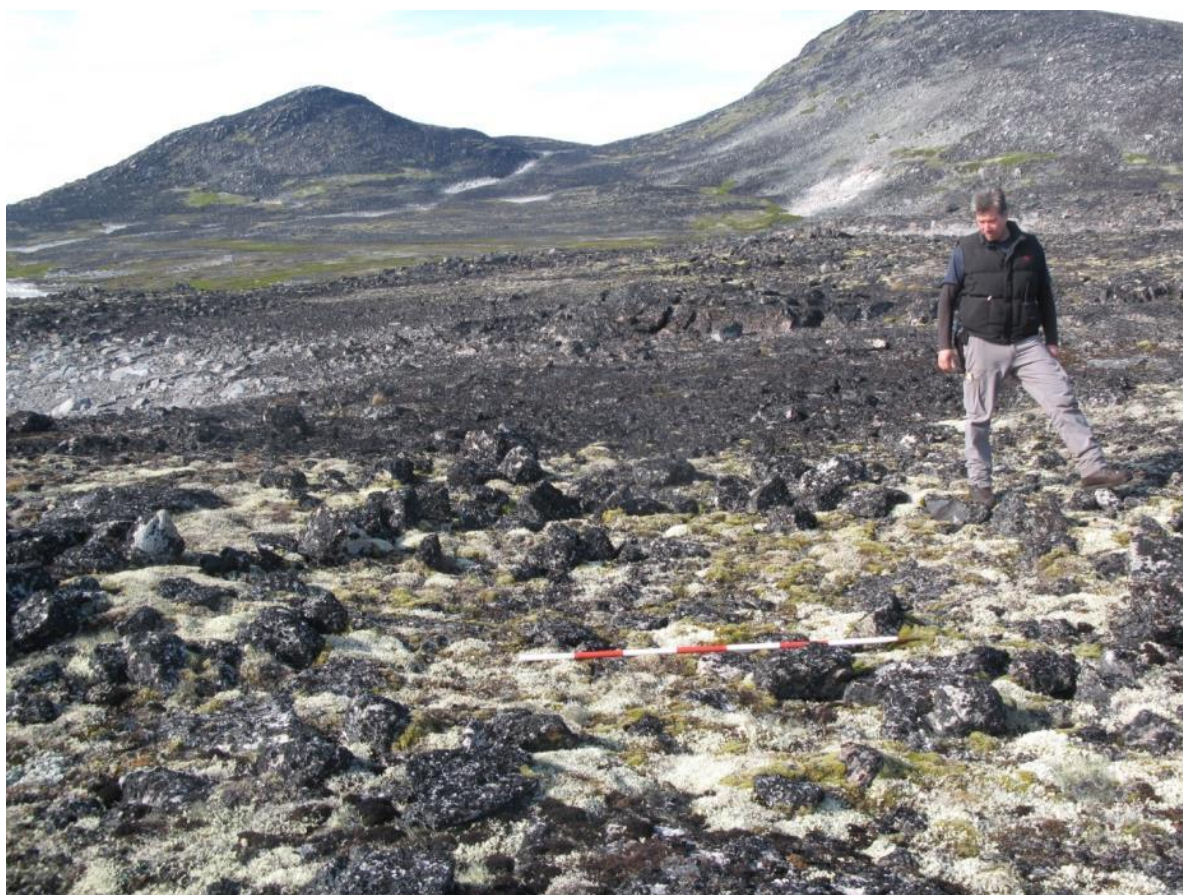


Figure 53: Martin Appelt *del.*

SqS 33 - Tentring

N 76° 07,490'/W 64° 38,830'

Circular tent ring built of up to more than head sized angular and round stones, 4 m in diameter. A few stones are seen inside in the floor space which otherwise is even and overgrown by moss.

METEORITE ISLAND EAST

76.05972°/64.92223°

On July 28th 2014 we spend most of the day trying to locate the position from where Peary removed “Ahnighito” in 1897. This was not an easy task as most of Meteorite Island’s east coast is barren and the landscape is “flowing”, i.e. with either gravel or clay-like sediments resting on top of a permafrozen layer. Judging by the photographs seen in Peary’s 1989 book and our own observations the formerly permanent ice-patches have melted, and large amounts of melt water sieve towards the coast thus creating a “flow-layer” for the upper layers of the sub-soil.

Having finally located the site we realised that the only evidence of Peary’s impressive enterprise was a one to two meter wide depression (“channel”) leading from approximately 10 metres above the sea-level to a narrow peninsula at the coast, three hammer stones found at the peninsula, a few splinters of wood and dislocated boulders immediately above the place where Peary had his ship anchored.



Figure 54a-f: The Ahnighito site – then and now.

SEARCH FOR ADDITIONAL CAPE YORK FRAGMENTS ON METEORITE ISLAND

The Cape York iron meteorites are fragments from one of the world's largest known meteorite falls. Several of the fragments recovered from the fall have been known and utilized by the local Inuit's for centuries, while others were only discovered recently. Ten fragments with a total mass of 58 tons have been recovered so far.

Like all other iron meteorites, the Cape York irons are fragments of the metal core of an asteroid. The original asteroid was destroyed in a catastrophic collisions between two asteroids 650 My ago. We have another approximately 300 iron meteorites from the same core and an additional 700 iron meteorites, which are fragments from the cores of some 100 other asteroids.

The Cape York meteoroid fragmented during atmospheric entry and scattered the fragments over a huge area. There is every reason to believe that there are many fragments from the Cape York fall that has never been found. In a joint project between the Natural History Museum of Denmark, The Danish National Museum, and the Greenland National Museum we have made an effort to locate more of these fragments.

In the spring of 2012 two large magnetic anomalies were found on Meteorite Island. The anomalies could indicate the presence of buried fragments of iron meteorite from the large prehistoric Cape York fall. In order to determine if the anomalies represented buried meteorites, GeoRadar surveys were carried out at both localities during the ongoing NOW project. Unfortunately, none of the two anomalies appear to be caused by meteorites.

The fall of the Cape York iron meteorite shower

The Cape York iron meteoroid entered the atmosphere above the Thule Area a few thousand years ago. The estimated minimum mass of the meteoroid prior to fragmentation in the atmosphere was 1000 t. The entry speed of the meteoroid was likely of the order of 20-25 km/s, which is sufficiently high that even solid metallic meteoroids fragment upon impact with the atmosphere. Fragmentation of meteoroids start approximately 100 km above the ground and the resulting fragments are therefore always scattered over a large area. The fragments of the Cape York shower, recovered so far, have mainly been found on Meteorite Island and some peninsulas to the north of the island (Fig. 55). A few, relative small fragments, have been found around Thule Air base, which is located 110 km to the NW of Meteorite Island. If the meteoroid entered the atmosphere on a south-easterly course it is possible that small fragments, which are slowed down faster, could fall in the area around the Thule Air base, whereas larger fragments would continue to

the area around Meteorite Island. However, it is also possible that the ice have transported some or all of the fragments to the place where they were found.



Figure 55: Map showing the locations where the Cape York iron meteorites have been found. Henning Haack *del.*

Most of the snow and ice free parts of the fall area are covered by glacial boulders. The meteorites found so far have been partially covered by boulders (Fig. 56), suggesting that the meteorites have been moved by the ice. It is therefore very likely that some of the fragments, which have not been found yet, are totally covered by boulders. Our survey is the first which attempts to find Cape York iron meteorites, which are totally covered by glacial boulders.

Figure 56: Vagn Buchwald and the Agpalilik meteorite shortly after he found it on July 31. 1963. Note that Agpalilik is almost covered in boulders and that there is no impact pit, as we would have expected if the meteorite fell where it was found.



Scientific significance of the Cape York iron meteorites

The Cape York iron meteorites are unique among the approximately 1000 known iron meteorites. Unlike all of the other iron meteorites that we know of, the Cape York irons are chemically inhomogeneous (Esbensen et al. 1982; 1982a). The variations in chemistry between the different Cape York fragments and within each fragment is important for two reasons: 1) the variations allow us to better understand the crystallization of the metal core from which the meteorites came. 2) The difference in chemistry may, under favorable conditions, allow us to trace meteoritic metal, found in archeological sites, back to the meteorite fragment, from which it was originally removed.

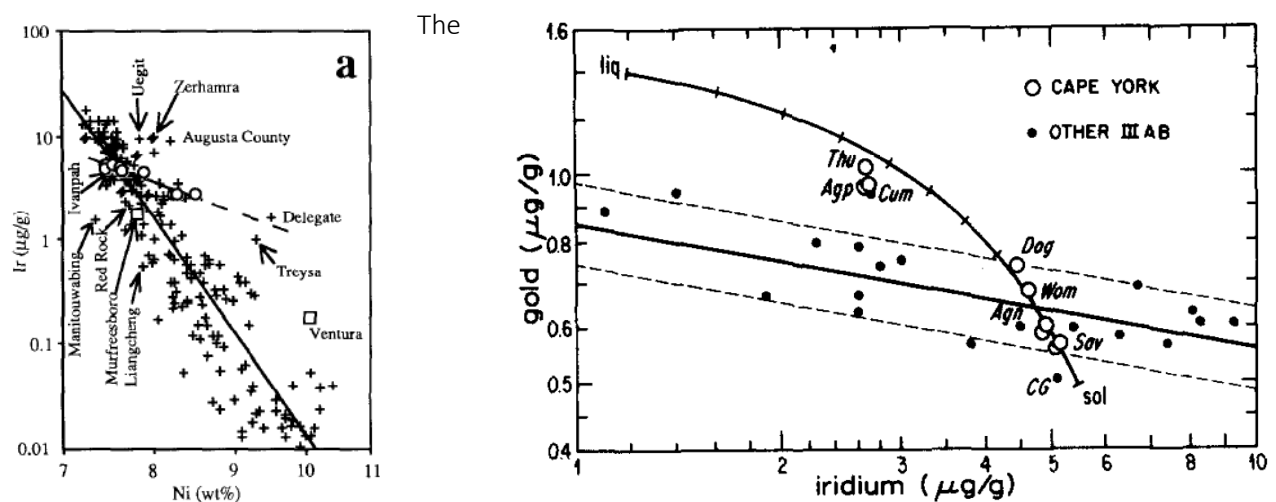


Figure 57: Chemical compositions of the Cape York irons and the other IIIAB iron meteorites. a) Iridium vs gold concentrations in IIIAB irons (plusses and squares) and Cape York irons (circles). From Haack and Scott, 1993 [4]. b) Gold vs Iridium concentrations in the Cape York irons and IIIAB irons in the same compositional range. Note that all of the Cape York irons have a unique chemical composition. From Esbensen et al. 1982.

The Cape York iron meteorites belong to the largest group of iron meteorites, known as group IIIAB iron meteorites. All group IIIAB iron meteorites are believed to originate from the same asteroid core. Fig. 57a shows the chemical composition of a suite of IIIAB irons. The large variation in chemistry between fragments from the same core is due to the crystallization process. During crystallization the different elements are fractionated between melt and solid. Some elements, like Iridium, are compatible with the crystallizing solid and therefore concentrate in the first solid. As crystallization proceeds iridium is depleted in the remaining melt and the last solid to crystallize is therefore significantly depleted in iridium (by a factor of 3500 for IIIAB irons). In contrast, nickel is incompatible and therefore displays the opposite behavior. The first solid to crystallize is depleted in nickel. As crystallization proceeds nickel is therefore concentrated in the remaining melt and the last solid to crystallize. The crystallization of the core can therefore be traced from the upper left toward the lower right in Fig. 57a. Each IIIAB iron meteorite, except Cape York, has a unique chemical

composition that tells us when it crystallized compared to the other IIIAB irons. However, we cannot say anything about where in the core the individual meteorites were when they crystallized. Cape York is the only piece of the core where we can follow the crystallization process across the surface of the larger pieces and also from one piece to the other. The Cape York irons therefore provide information about the physical evolution and structure of core crystallization process in asteroids. Did the core crystallize from the inside out (like the Earth), from the outside in, or in the form of a complex network of growing dendrites? The latter option is what the Cape York irons seem to be telling us (Haack & Scott 1992; 1993).

The observation that the Cape York irons are chemically diverse on a meter-scale thus gives us a unique opportunity to study the growth of solids in the asteroidal core (Haack & Scott *ibid.*). This process is similar to the ongoing crystallization of the Earth core and therefore also relevant for the understanding of our own planet.

Magnetic survey, spring 2012

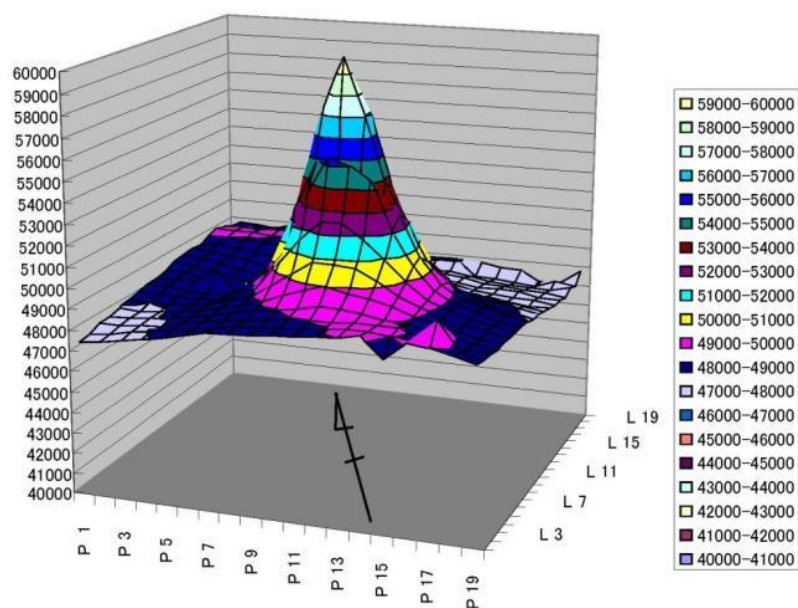


Figure 58: Magnetic field measurement measured over the Agpalilik meteorite in the courtyard in front of the Geological Museum in Copenhagen.

Buried iron masses produce anomalies in the total magnetic field, which can be measured on the surface above the masses. The fastest way to search for buried iron masses is to measure the total magnetic field along a profile on the surface. Figure 4 shows the total magnetic field measured over the Agpalilik meteorite, which is placed in the courtyard in front of the Geological Museum in Copenhagen. The anomaly caused by the 15 t mass was 10.000 nT above the ambient magnetic field, which measures 48.000 nT in Copenhagen.

Such a large anomaly is easily detected by a relatively simple instrument. Furthermore, the result shows that it should be possible to detect a similar sized meteorite to a depth of approximately 10 m.

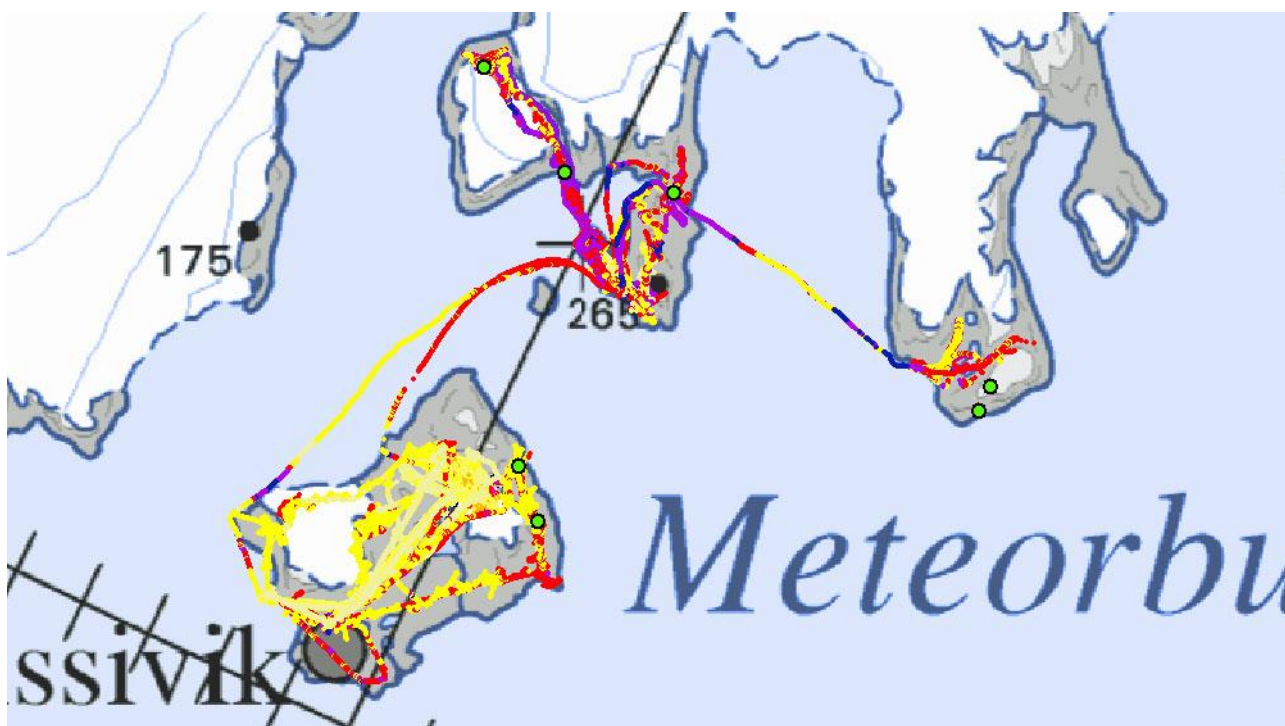


Figure 59: Map of the area around Meteorite Island. The coloured track shows profiles recorded during the magnetic mapping campaign in the spring of 2012. Different color codes illustrate variations in magnetic field strength.

In the spring of 2012 Henning Haack and Jeppe Möhl from the Natural History Museum of Denmark conducted a magnetic survey in the Cape York fall area, where we would expect to find buried iron meteorites. Dragging two magnetometers, mounted on sleds, across the snow covered terrain we mapped the magnetic field along a profile with a total length of 700 km.

We estimate that any iron meteorite with a weight of more than 5 t should be detectable up to 10 m below the surface and up to a horizontal distance of 5 m from the profile. This gives us a total area covered of approximately 7 km² - which is a very small fraction of the total area where fragments could be found.

The total magnetic field, as measured along the profile, was relatively constant. Variations of the magnetic field caused by magnetized erratic boulders could potentially have made it impossible to detect buried iron masses – but this was fortunately not the case. Typical magnetic field variations caused by erratic boulders were of the order of 100 nT whereas the anomalies caused by buried iron meteorites are typically several thousand nT. Fig. 60a shows that one of the promising anomalies is much stronger than the variations caused by the glacial boulders.

The survey did locate several large anomalies with properties that ruled out that they could be caused by iron meteorites. For example, volcanic dikes produce linear patterns of anomalies which can be followed over distances of hundreds of meters to kilometers. Volcanic dikes are common in the area and we found several examples of such linear anomalies. Other anomalies had very broad peaks, which is inconsistent with the anomaly caused by an iron meteorite buried at shallow depth.

The two most promising magnetic anomalies

Two of the anomalies found during the survey had properties which were consistent with anomalies caused by very large buried iron meteorites. Fig. 6a shows a magnetic profile from the day, where one of the anomalies were discovered. Note that the anomaly is much stronger than the background variation in magnetic field along the profile. The anomaly is symmetric and the magnitude of the anomaly is approximately 2/3 of the anomaly measured over the Agpalilik meteorite in Copenhagen (Fig. 60).

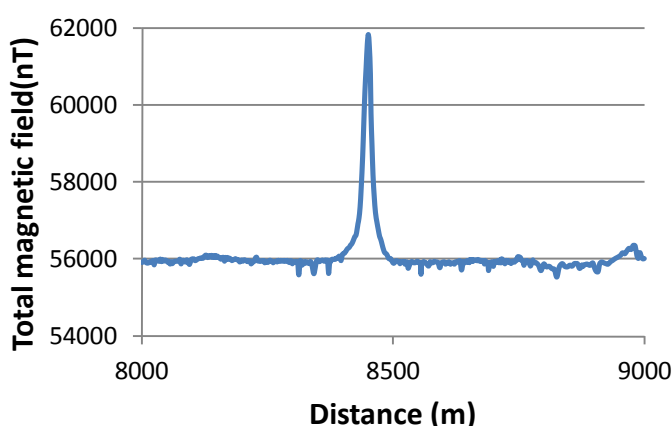


Figure 60: a) Profile showing the intensity of the magnetic field along a profile mapped at Site B on Meteorite Island. b) Color coded magnetic field measurements at the same location as a). The field strength increases from 56000 nt (Yellow) to 61000 (dark blue)

Following the initial discovery of the anomaly, magnetic profiles were made in a dense grid around the anomaly (Fig. 60b). The results of the detailed mapping show that the anomaly is approximately circular and narrow. This is consistent with the pattern expected from an iron meteorite and at the same time difficult to explain in terms of normal geological structures.

The magnetic anomaly peak is approximately 5 times wider than the peak measured 1 m above the Agpalilik meteorite in Copenhagen. The wider peak indicate that the object, causing the anomaly, is buried deeper - approximately 10-15 m below the surface. Given the burial depth, we can estimate the mass required to

cause a 6000 nT anomaly. The estimated mass turned out to more than 100 t – which would make the meteorite bigger than the largest iron meteorite ever recorded – the 60 t Hoba in Namibia.

There is an upper limit to the mass of iron meteorites which can land intact. If the mass is too high the object will impact the Earth surface at several km/s. Very massive meteoroids maintain supersonic speeds as they pass through the Earth atmosphere. If the impact velocity at the surface exceeds a few km/s the mass will simply vaporize upon impact. The upper mass, which can land intact on the ground, depend on the entry speed and angle as well as the material properties of the meteoroid and the target material. Since the inferred mass of the buried iron meteorite was larger than any other known iron meteorite we modelled the atmospheric entry of large iron masses. We found that, under favorable conditions (low entry velocity and low entry angle) it was possible that even meteoroids with a mass of several hundred t could land intact.

The purpose of the magnetic mapping project was to search for iron meteorites buried under glacial moraine. However, since the magnetic survey was conducted in April-May, where the snow cover over the two anomalies was at least 2 m, we were unable to study the nature of the surface geology at the sites where we found the magnetic anomalies. It could therefore not be ruled out that the anomalies were caused by terrestrial geology. Returning to the sites after the snow had melted would not help, either, since the results showed that the objects causing them were buried more than 10 m below the surface. The only feasible method to determine if the anomalies were caused by iron meteorites was to use a Georadar to detect them and measure their burial depth. A Georadar emits radar pulses into the ground and use the returned reflected signals to create an image of the sub-terrain. Objects with a high electric conductivity create strong reflections and the method is therefore ideal to detect and map iron meteorites.

GeoRadar profiling

We used a 50 MHz Georadar, equipped with two antennas – a transmitter and a receiver. The two antennas, which were 2 m long and identical, were mounted on a common frame with a separation of 2 m. The frame with the antennas was carried along the profiles and placed on the ground every 50 cm. Each time the frame was put on the ground a single pulse was transmitted and the returned echoes recorded. Figure 7 shows an example of one of the 8 profiles recorded.

We performed georadar profiling at both of the two locations where we had observed large magnetic anomalies in 2012 (Fig. 62).

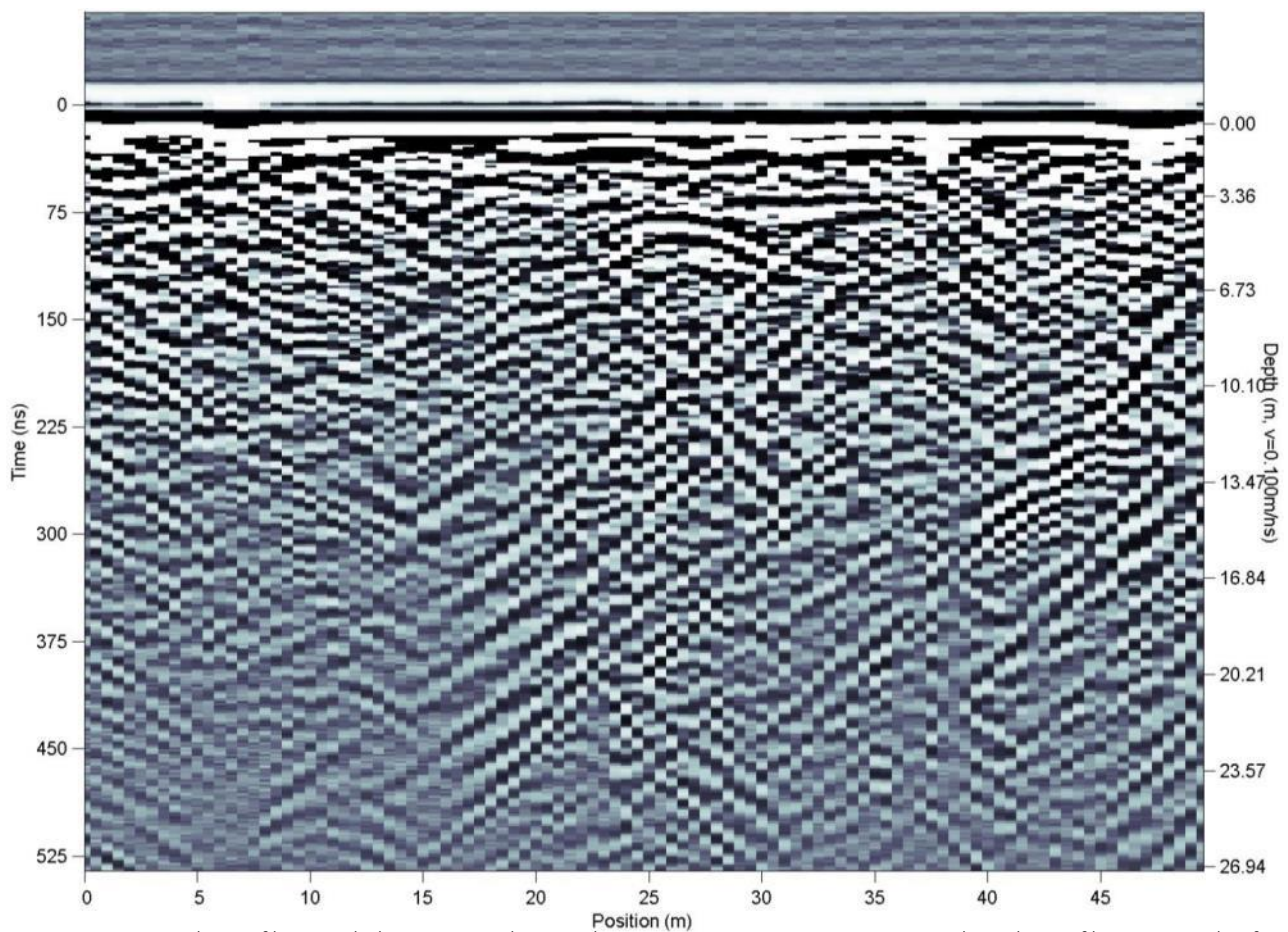


Figure 61: GeoRadar profile recorded at site B. Each vertical trace represents one measurement along the profile. An example of a reflection is seen 3.4 m below the surface and 25 m from the start of the profile. The magnetic anomaly was caused by something 10-15 below the surface. The reflection therefore cannot be the same object that caused the magnetic anomaly.



Figure 62: Map showing the locations of the two sites where magnetic anomalies were found on Meteorite Island during the 2012 survey.

Site A

The first site was a few km east of the small town Savissivik on meteorite island (Fig.62). The magnetic mapping was performed while the area was covered in snow and we did therefore not know anything about the surface geology. The anomaly was found at the shore of a large shallow lake in an area with virtually no surface relief (less than 2 m). Due to the absence of any significant topography we had expected that the surface was composed of glacial moraine without any bedrock exposures.

During the georadar mapping we discovered a long shallow bedrock exposure running straight through the magnetic anomaly. Since this effectively ruled out that there could be a meteorite buried under the surface we did not perform a detailed georadar mapping. Although the surface exposure did not display anything that could explain the presence of the magnetic anomaly the existence of the exposure shows that the anomaly must be caused by something within the bedrock.

Site B.

Site B was located on a slope on the northern part of Meteorite Island. The slope was covered in glacial boulders and there were no signs of bedrock exposures. Unlike the situation at site A, it was therefore possible that a large iron meteorite could be buried under the surface. The width of the magnetic anomaly suggests that it is caused by something buried 10-15 m below the surface. In order to test if that was the case, we made a series of parallel georadar profiles in the area where the magnetic anomaly was found. The profiles were 50 m long, parallel and with a spacing of 4 m. We made 8 profiles with the central profile running through the coordinates, where the magnetic anomaly was located. Figure 7 shows a georadar profile across the center of the magnetic anomaly at site B. The absence of any reflections below 6 m rule out that the anomaly is caused by anything with a high electric conductivity – such as an iron meteorite. We infer that the most likely explanation is that the anomaly is caused by a very large, strongly magnetized boulder – with a low electric conductivity. Alternatively, the anomaly is caused by a large, approximately spherical, volume of strongly magnetized material in the bedrock below the erratic glacial boulders.

The absence of small, strongly magnetized boulders seem to make the first option unlikely. However, it may also be argued that the second alternative is unlikely since magnetized materials usually are associated with dikes or sheets and rarely have spherical shapes. Whatever the cause of the anomaly, the absence of a strong reflection in the georadar survey shows that the magnetic anomaly cannot be due to a buried iron meteorite.

Conclusions

The magnetic survey performed in the spring of 2012 shows that magnetometers can be used to detect buried iron meteorites. The background noise is significantly less than the expected signal. If one of our profiles had passed over a large buried meteorite there is little doubt that we would have detected it.

Unfortunately, the georadar profiling done in the summer of 2014 showed that the two detected anomalies were caused by terrestrial geology rather than an extraterrestrial object.

MAPPING ARCHAEOLOGICAL SITES USING AERIAL PHOTOGRAPHY

Documenting archaeological sites in Greenland, and other places for that matter, has always been more or less challenging. Vectorised maps covering all of Greenland exist in the scale of 1:250000, but they derive from raster maps compiled from *inter alia* post-WWII aerial photography campaigns. Hence, detailed maps of the Greenlandic landmass are in short supply, and that has left archaeologists to produce their own site map sketches. This has resulted in great variation of the quality of topographical representations of sites containing cultural historical remains. Detailed documentation of archaeological sites have, alongside hand drawn sketches obviously, involved methods such as theodolite, total station (an electronic/optical instrument) and differential GPS surveying. While these instruments can effectively yield detailed spatial data regarding intra-site archaeological features, stratigraphic sequences etc., the gathering of accurate topographical data of the surrounding landscape requires alternative methods, especially if the expansion of the area in question is considerable. The advent of GIS (Geographic Information Systems) software, which one can operate without having obtained a degree in computer engineering, geodesy or surveying, has enabled a broader use of digitised topographical data (cf., Goodchild, 2009; Rana & Joliveau, 2009). Many archaeologists are now able to render digital representations of archaeological sites and their topographical contexts without greater effort. The lack of adequate and readily available base maps in a Greenlandic context in a more apt scale than 1:250000 still pose challenges though. The benefit of collecting spatial data with millimetre precision using differential GPS equipment loses a considerable part of its value if one is not able to place the data output in a larger topographic context. Although still in its infancy, the use of drone mapping technology, or UAS (Unmanned Aerial System), seem to be an applicable solution to the problem of producing accurate maps. This is why the Nunatta Katersugaasivia Allagaateqarfialu/Greenland National Museum & Archives (NKA) in collaboration with the Danish National Museum endeavoured to undertake the task of introducing this technology to Greenlandic archaeology on the July-August 2014 expedition to the Savissivik region.

Equipment Decision

A basis for decision concerning which UAS package to deem suitable for this project was not easy to reach. We invested considerable resources in the effort of creating an overview of the multiple options available. Should we strive for a rotor-driven drone or a fixed-winged drone as a sensor platform? What about software? Was it possible to get an integrated software package including flight planning and post-flight data processing abilities? What were our expectations to the output? Should the system be able to record both stills and video? In short, defining the requirements specification took quite an effort.

Eventually, we concluded that our basic needs could be satisfied with the ability to produce accurate maps via orthophotography and obliques. Aerial video recording was seen as useful, but more for the sake of public outreach purposes and not of immediate importance in a mapping context. Our choice fell on senseFly's UAS called eBee. This is a full package consisting of pre- and post-flight data processing software as well as the ready-to-fly hardware capable of autonomously capturing high-resolution aerial photos. The pre-flight planning software is called eMotion 2 and the post-flight data processing software Postflight Terra 3D 3. For further information regarding eBee specifications, please consult senseFly's website:

<https://www.sensefly.com/drones/ebee.html>



Figure 63: As seen on the photograph the UAS equipment does not take up much space. The fixed-wing Styrofoam drone itself weighs less than 700 grams. Terrain obviously has to be taken into consideration when planning landing spot. Mikkel Myrup *del.*

The Mapping

The eBee system basically makes maps out of jpeg-format photos which the software will transform into a orthophoto mosaic, i.e. the aerial photographs (up to several hundreds) are merged through pixel recognition. Spatial data attached to each individual photo (*inter alia* x-, y- and z-axis as well as photo angle

via accelerometer) enable the software to create a so-called point cloud. This means that you now have a 3D terrain model consisting of points. Each point have been assigned a colour extracted from the original jpeg-photo, resulting in a point cloud which in appearance is quite close to what the mapped landscape looks like in reality.

The point cloud created via the UAS comprises a basic data set that can be used for several different purposes. In this context, for example, we are interested in generating high-resolution conventional contour line maps. The software provide us with the possibility of converting the basic data consisting of the point cloud into a wide variety of common GIS-formats, such as vectorised shape-files, which is the format we generally use. Once the contour line map is generated and geo-referenced, you can import additional GIS-layers as you wish, such as archaeological features that have been GPS-recorded etc.

Another feature of the system, which is useful in situations where you need to illustrate or present an archaeological site, is the possibility of making fly-through videos of your 3D terrain model.

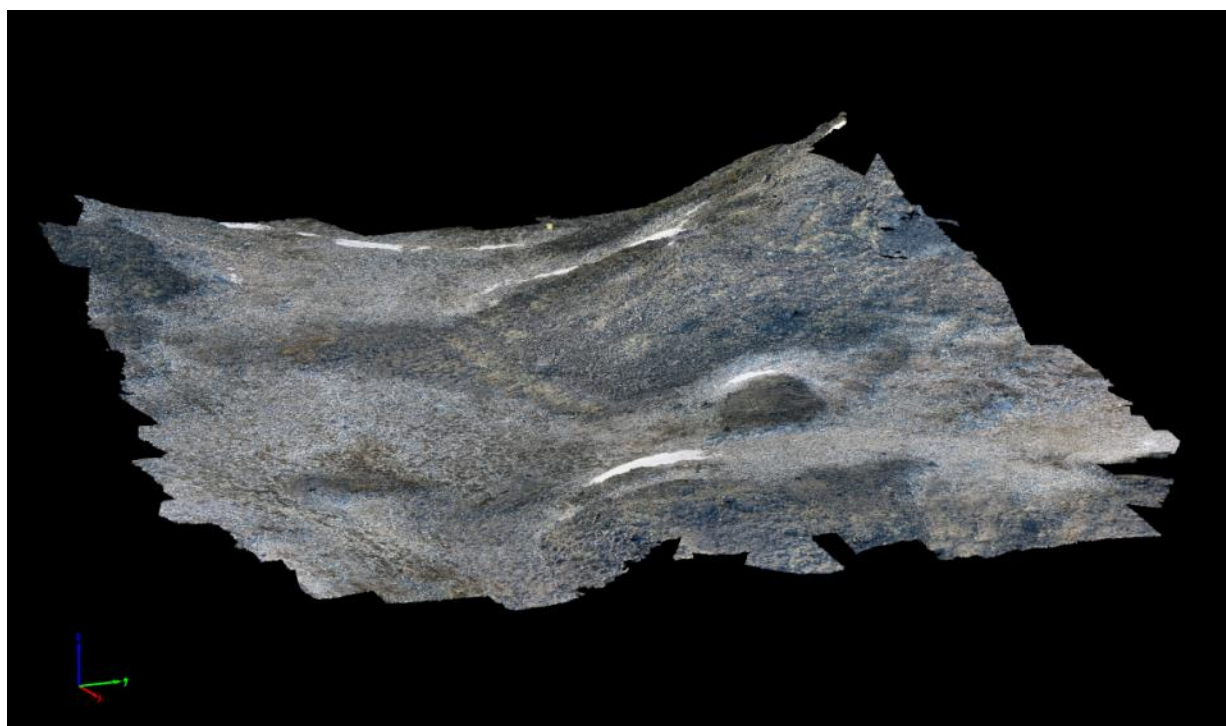


Figure 64a: A 3D terrain model of Saveruluup Itilliapalua based on the point cloud created from the orthophoto mosaic. The find spots of Woman and Dog are situated in the middle of the model. The model represents an area measuring approximately 400 X 600 metres. Below is seen a high-resolution contour line map (10 cm equidistance) showing the archaeological features recorded in 2014. Mikkel Myrup *del.*

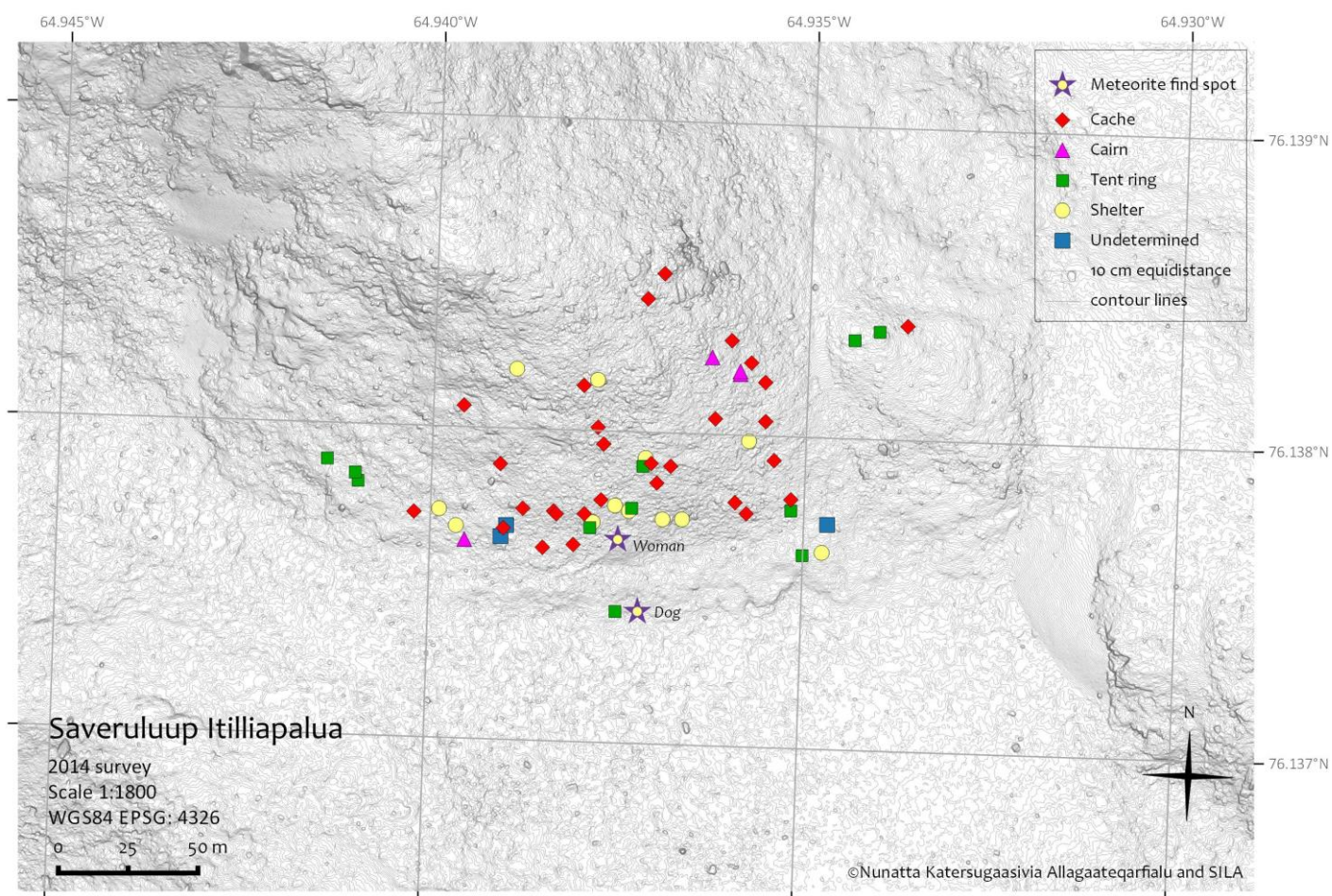


Figure 64b: Mikkel Myrup *del.*

The eBee UAS package software also gives us the possibility of making so-called stockpile measurements. This function was tested in trying to estimate the volume of the hammer stone pile, consisting of basalt-porphry, which has been built up around the three tonne meteor fragment Woman. As mentioned above, the point cloud basic data provide you with a three dimensional terrain surface. The software has been developed with the ability to calculate volume within a defined area. It is apparent though, that this function has been implemented with more well-defined and controlled environments in mind, such as modern industry quarries and the like. In our case the software estimates the hammer stone pile to have a total volume of 36,80 m³, but that is with a $\pm 10,46$ m³ margin.

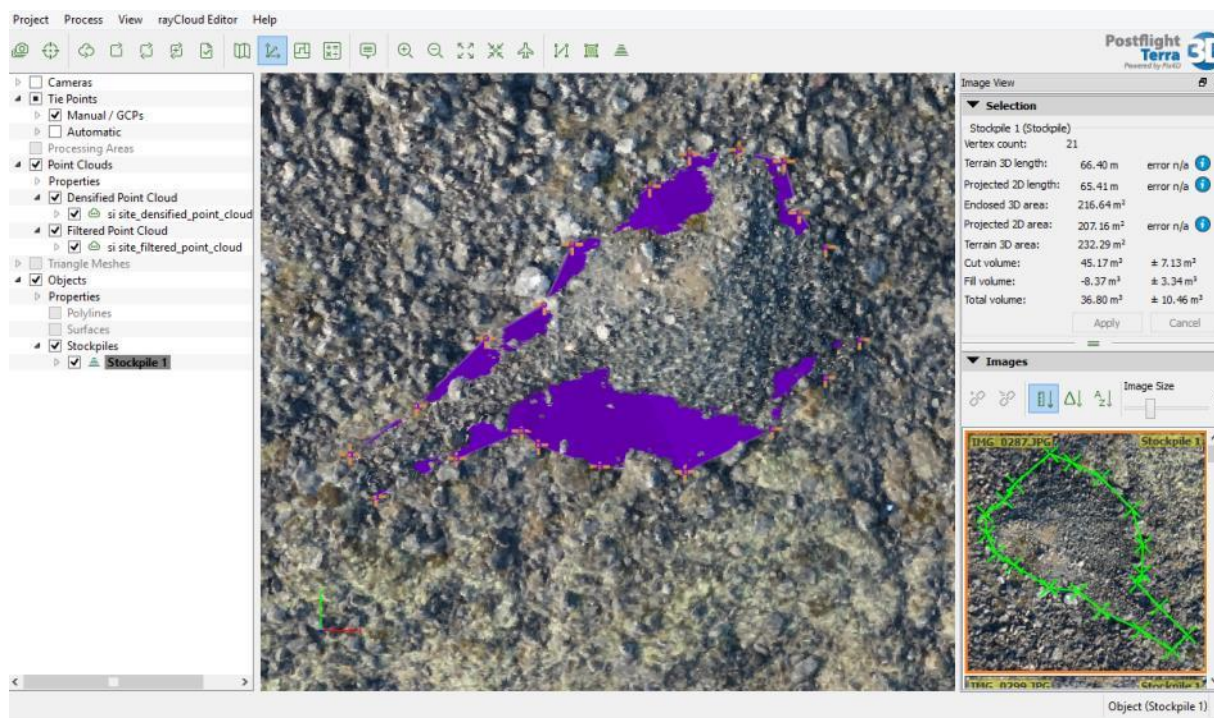


Figure 65: Screenshot of software stockpile calculation window. After definition of pile (smaller right hand window) the programme calculates volume. Mikkel Myrup *del.*

UAS - Conclusions and Future Perspectives

The field season spent in the Savissivik area yielded important experiences regarding the use of UAS in archaeology/heritage management. The system is a powerful tool for generating high-resolution maps, and this capacity alone justifies its price, which still does not surmount that of a new differential GPS-system. Adding the feature of generating fly-through videos of a three dimensional landscape just makes this system outstanding compared to its cost. The outputs made possible with this system will surely place it as essential standard field equipment in providing any future mapping solutions for the Greenland National Museum and its partners.

That being said, several factors have to be taken into account regarding the coming use of the system. Topographical challenges: The eBee is, as mentioned above, a very light aircraft and it has been designed to land unassisted in an area predefined in the flight planning software. Greenlandic terrain often tend to be quite rough, to put it mildly. Boulder fields or just rocky surfaces, does not

treat the styrofoam airframe well over time. It is therefore recommended that a system of retrieving the drone in mid-air, just before touchdown, is developed. It is possible to catch the aircraft before it hits the ground, but it is also risky for the catcher running around with his/hers eyes in the sky on an uneven surface.

The most obvious solution is to craft a barrier (i.e. two lightweight poles and a net), much similar to the system used as an emergency aircraft retriever on an aircraft carrier during arrestor hook failure incidents. Such a solution will prevent the aircraft from instant deceleration by head-on collision with hard ground obstacles and consequently prolong its lifetime significantly.

Another important lesson learned from the field campaign is to prepare every flight meticulously. Detailed checklists elaborating each procedural step before take-off should be compiled in advance and ideally a team consisting of minimum two should perform the flight operations at all times. This will decrease risk of omissions of minor and/or major importance due to personal error substantially.

LIST OF LITERATURE

Andreasen, Claus

1982: Nipaitsoq og Vesterbygden. *Tidsskriftet Grønland*, Vol 5-7: 177-188.

Andreasen, Claus & Hans Lange

2000: Arkæologiske undersøgelser, Washington Land, Vestlige Nordgrønland, sommeren 1999. Foreløbig rapport. Report # 33-374, on file at Nunatta Katersugaasivia Allagaateqarfialu: 59 pages

Appelt, Martin, Jensen, Jens F., Myrup, Mikkel & Haack, Henning

2015: Heavenly and Terrestrial Iron. Paper presented at Canadian Archaeological Association Meeting, St. Johns, Canada.

Appelt, Martin, Damkjar, Eric & Friesen, T. Max

In press: Late Dorset. In (eds. Friesen, T. Max & Owen Mason). *The Oxford Handbook of Arctic Archaeology*. Oxford University Press. 49 pages.

Appelt, Martin & Hans Christian Gulløv

1999 (eds.): *Late Dorset in High Arctic Greenland*. Danish Polar Center Publications, No. 7

2009: Tunit, Norsemen and Inuit in Thirteenth-Century Northwest Greenland – Dorset Between the Devil and the Deep Sea. In (eds. Maschner, Herbert D., Mason, Owen & McGhee, Robert) *The Northern World AD 900 – 1400*. The University of Utah Press: 300 - 320

Appelt, Martin, Gulløv, Hans Christian, Hanna, Don, Kapel, Hans, LeMoine, Genevieve & Møhl, Jeppe

1998: Appendix 1: Archaeology. In (eds. Arneborg & Hans Christian Gulløv) *Man, Culture and Environment in Ancient Greenland. Report on a Research Programme*. Danish Polar Center Publications, No. 4: 154 – 187.

Arneborg, Jette

2004: Det europæiske landnam – Nordboerne i Grønland: I (red. Gulløv, Hans Christian) *Grønlands forhistorie*. Gyldendal: 220-278.

Bendix, Bo

- 2000: Late Dorset Faunal Remains from Sites at Hatherton Bay, Thule District Greenland. In (eds. Appelt, Martin, Berglund, Joel & Gulløv, Hans Christian) *Identities and Cultural Contacts in the Arctic*. Danish Polar Center Publication, No. 8. Danish Polar Center: 77 – 81

Buchwald, Vagn F.

- 1992: *Meteoritter – nøglen til Jordens fortid*. Gyldendal: 247 pages
- 2001: *Ancient Iron and Slags in Greenland*. Meddelelser om Grønland, Man & Society, Vol. 26: 92 pages.
- 2008: *Iron, steel and cast iron before Bessemer*. Historisk-filosofiske Skrifter, nr. 32. Det Kongelige Videnskabernes Selskab: 596 pages.

Buchwald, Vagn F. & Gert Mosdal

- 1985: *Meteoritic iron, telluric iron and wrought iron in Greenland*. Meddelelser om Grønland, Man & Society, Vol. 9: 49 pages.

Bøggild, J. K.

- 1927: Memo on file at Geologisk Museum: 6 pages.

Chladni, Ernst F. F.

- 1819: *Ueber Feuer-meteore, und über die mit denselben herabgefallenen Massen*.
Wien.

Damkjar, Eric

- 2005: Late Dorset Longhouses: A Look Inside. In (ed. Sutherland, Patricia D.) *Contributions to the Study of Dorset Palaeo-Eskimos*. Mercury Series, Archaeology Paper 167. Canadian Museum of Civilization: 147 - 165

Dussault, Frédéric, Bain, Allison & LeMoine, Genevieve

- 2014: Early Thule Winter Houses: An Archaeoentomological Analysis. *Arctic Anthropology*, Vol. 51(1): 101-117.

Esbensen K.H. & V. F. Buchwald

- 1982: Planet(oid) core crystallization and fractionation. Evidence from the Agpalilik mass of the Cape York shower. *Physics of the Earth and Planetary Interiors* **29**, 218-232.

Esbensen K.H., Buchwald, V.F., Malvin D.J. & Wasson J.T.

1982a: Systematic compositional variations in the Cape York iron meteorites. *Geochimica et Cosmochimica Acta* **46**, 1913-1920.

Frandsen, Niels

2010: Hvem var John Sacheuse. *Tidsskriftet Grønland*, Nr. 4: 312-319.

Franklin, U.M., Gotthardt, R. & Yorga, B.

1981: *An Examination of Prehistoric Copper Technology and Copper Sources in Western Arctic and Subarctic North America*. National Museum of Man, Mercury series, Archaeological Survey of Canada Paper No. 101. Canadian Museum of Civilization.

Freuchen, Peter

1953: *Min grønlandske ungdom*. Forlaget Fremad: 301 pages.

Fundal, Erling

1972: Det vestgrønlandske jern – geologisk arbejdsfelt og eskimoens værktøj. *Tidsskriftet Grønland*, nr. 4: 97-110.

Gilberg, Rolf

1995: Det eneste folk i verden fik besøg fra månen. *Tidsskriftet Grønland*, Nr. 7: 279-301.

Goodchild, Michael F.

2009: Geographic information systems and science: today and tomorrow, *Annals of GIS*, 15:1, 3-9, DOI: [10.1080/19475680903250715](https://doi.org/10.1080/19475680903250715)

Grønnow, Bjarne

1981: Den store SlædevejTræk af Melvillebugtens forhistorie. De arkæologiske undersøgelser i forbindelse med "Knud Rasmussens Mindeekspedition". *Forskning i Grønland/Tusaat*, nr. 1-2: 2-9.

Gulløv, Hans Christian

2004: Kulturmøder i Nord. I (red. Gulløv, Hans Christian) *Grønlands forhistorie*. Gyldendal: 211-217

2008: The Nature of Contact between Native Greenlanders and Norse. *Journal of the North Atlantic*, No. 1: 16-24.

Haack, Henning

2012: *Meteoritter*. Gyldendal.

Haack, H. & E.R.D. Scott

1992: Asteroidal core crystallization by inward dendritic growth. *Journal of Geophysical Research* **97**, 14727-14434.

1993: Chemical fractionations in group IIIAB iron meteorites: Origin by dendritic crystallization of an asteroidal core. *Geochimica et Cosmochimica Acta* **57**, 3457-3472.

Helmer, James, LeMoine, Genevieve and Hanna, Don

1995: *Report on the 1994 excavations at Arvik (Qjlx-1), Little Cornwallis Island, Northwest Territories*.
University of Calgary

1995b: *Report on Excavations at Qjlx-10 (Tasiarulik); Little Cornwallis Island, Northwest Territories, 1993*.
Department of Archaeology, University of Calgary

Holtved, Erik

1944: *Archaeological Investigations in the Thule District, I-II*. Meddelelser om Grønland 141(1-2).

1954: *Archaeological Investigations in the Thule District, III*. Meddelelser om Grønland 146(3).

Huntington, Patricia A. M.

2002: Robert E. Peary and the Cape York Meteorites. In *Polar Geography*, No. 26(1): 53-65.

Laursen, Dan

1972: *The Place Names of North Greenland*. Meddelelser om Grønland, Vol 180(2): 443 pages.

Knuth, Eigil

1984: Reports from the Musk-Ox Way. Private print

LeMoine, Genevieve S.

2005: Understanding Dorset from a Different Perspective: Worked Antler, Bone, and Ivory. In (ed. Sutherland, Patricia D.) *Contributions to the Study of Dorset Palaeo-Eskimos*. Mercury Series, Archaeology Paper 167. Canadian Museum of Civilization: 133 – 146.

2014: Personal communication in mail to Martin Appelt of October 23th 2014. On file at the National Museum of Denmark.

LeMoine, Genevieve M. & Christyann M. Darwent

2010: The Inglefield Land Archaeological Project: Introduction and overview. In *Geografisk Tidsskrift/Danish Journal of Geography*, Vol. 110(2): 279-296.

Lorenzen, Johannes

1882: Kemisk undersøgelse af metallisk jern fra Grønland. *Meddelelser om Grønland*, Vol. 4: 1-40.

McCartney, Allen P.

1988: Late Prehistoric Metal Use in the New World Arctic. (eds. Shaw, R. D., Harritt, R. K. & Dumond, D. E.) *The Late Prehistoric Development of Alaska's Native People*. Aurora, Alaska Anthropological Association Monograph Series, No. 4: 57-79.

1991: Canadian Arctic Metal Trade Metal: Reflections of Prehistoric and Historic Social Networks. In (ed. Roberts, M.) *Metals in Society – Theory Beyond Analysis*. MASCA Research Papers in Science and Archaeology, Vol 8(II). Philadelphia.

McCartney, Allen P. & D. J. Mack

1973: Iron Utilization by Thule Eskimos of Central Canada. *American Antiquity*, Vol. 38(3): 328-339.

McCullough, Karen M.

1989: The Ruin Islanders: Early Thule Culture Pioneers in the Eastern High Arctic (Canadian Museum of Civilization Mercury Series)

McCullough, Karen M. & Peter Schledermann

1996: Ellesmere Island Archaeology Project. Report on the 1995 Field Season. The Arctic Institute of North America – Internal Report No. 38

McGhee, Robert

1981: *The Dorset Occupations in the vicinity of Port Refuge, High Arctic Canada*. National Museum of Man, Mercury Series. Archaeological Survey of Canada Paper 92. Ottawa: National Museums of Canada.

Mathiassen, Therkel

1928: Eskimo Relics from Washington Land and Hall Land. *Meddelelser om Grønland* 71: 183 – 216.

1934: *Contribution to the Archaeology of the Disco Bay*. Meddelelser om Grønland, Vol. 93(2).

Meier, Allison

2013: Minik and the Meteor. <http://narrative.ly/stories/minik-and-the-meteor/>. Posted on March 19th 2013 (latest accessed on September 26th 2014).

Murray, Maribeth S.

1996: *Economic change in Palaeoeskimo prehistory of the Foxe Basin*. Unpublished Ph.D.-dissertation from McMaster University, Hamilton.

1999: Local heroes. The Long-term effects of short-term prosperity – an example from the Canadian Arctic. In *Arctic Archaeology* edited by Rowley-Conway, Peter. World Archaeology 30(3): 466 – 487.

Myrup, Mikkel

2015: Neogeography and Remote Sensing in Greenlandic Archaeology: Experiences from a 2014 UAS Technology Pilot Project. Paper presented at Canadian Archaeological Association Meeting, St. Johns, Canada.

Peary, Robert E.

1898: *Northward across the Great Ice*.

Pedersen, Holger & Torben Risbo

1992: Rapport fra Kap Tork Meteoritekspeditionen 1992. 19 pages report.

Pringle, Heather

1997: New Respect for Metal's Role in Ancient Arctic Cultures. *Science*, Vol. 277 (No. 5327): 766-767.

Rana, Sanjay & Thierry Joliveau

2009: NeoGeography: an extension of mainstream geography for everyone made by everyone?, *Journal of Location Based Services*, 3:2,75-81, DOI: [10.1080/17489720903146824](https://doi.org/10.1080/17489720903146824)

Rast, Tim L.

1995: Appendix 2: 1994 Metal Scan Survey of the Arvik (QjJx-1), Tasiarulik (QjJx-10) and QiLa-3 sites, Little Cornwallis Island N.W.T. In *Report on the 1994 excavations at Arvik (QjJx-1), Little Cornwallis Island, Northwest Territories* edited by Helmer, James, Genevieve LeMoine and Don Hanna. University of Calgary: 122 – 139.

Risbo, Torben & Holger Pedersen.

1994: Kap York-meteoritekspeditionen. Carlbergfondet, Årsskrift 1994. Rhodos: 38-45.

Ross, John

1819: *A Voyage of Discovery*. London.

Rowley, Graham W.

1940: The Dorset Culture of Eastern Arctic. *American Anthropologist* 42(3): 490 - 499

Schledermann, Peter

1982: Nordbogenstande fra Arktisk Canada. *Tidsskriftet Grønland*, Vol 5-7: 218-225.

1990: *Crossroads to Greenland. 3000 Years of Prehistory in the Eastern High Arctic*. Arctic Institute of North America, Komatik Series No. 2. The Arctic Institute of North America.

Ulf-Møller, Finn

1986: Støbejernsblok på 10 tons fundet på Disko. *Tuussat/Forskning*, nr. 2: 20-25.