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The Thule black sand province, North-West Greenland: investigation status and potential

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Abstract

The Thule black sand province (76^{o}-78^{o}N) composes a coastline several hundred kilometres long that is navigable in summer. Both ilmenite-rich and magnetite-rich deposits are known.

The most economically promising heavy mineral sands occur on active and uplifted beaches of the Steensby Land ilmenite showing that is located immediately north-west of Thule Air Base. Here a flat uplifted plain up to 3 km wide, dominated by alluvial and littoral deposits, forms the outer coast for over 80 km; active sandy beaches are up to 10 m wide.

Mineralogical composition of the darkest sands show an opaque fraction of up to 95% with more than 75% absolute weight of ilmenite. Grade of the active beaches is high - up to 60% - with an average about 43% TiO_2; uplifted beaches have a larger tonnage potential but lower titanium values up to 23% TiO_2 with an average around 12%.

The uplifted beaches contain commercially viable tonnage if sufficient grade could be maintained. Results so far available are confined to surface sampling down to permafrost level (> 1 m). Potential of the titanium province would be increased by the discovery of black sands at depth or offshore.

Contents

Fig. 1. General location of the Thule black sand province, North-West Greenland, showing the position of the Steensby Land ilmenite showing (inset Fig. 2). Heavy mineral sands have been recorded in the region from Kap Edvard Holm in the south to Kap Alexander in the north.

1. Introduction

This report reviews the occurrences of heavy mineral (black) sands in the Thule district of North-West Greenland, gives some preliminary mineralogical and chemical data and summarises logistic conditions.

The Thule black sand province (76^{o}-78^{o}N) composes a coastline several hundred kilometres long that is navigable in summer. Both ilmenite-rich and magnetite-rich sands occur with the former appearing the most extensive. Proven ilmenite concentrations are recorded on both active and uplifted beaches. The main source of the ilmenite sands is a regional Precambrian basaltic sill and dyke complex that forms the immediate hinterland to the most economically promising (as yet) black sand occurrences in Steensby Land. Several sources may contribute to the magnetite-rich sands.

2. General geology

The regional geology of the Thule district (Fig. 1) is composed of a Precambrian gneiss-supracrustal rock complex overlain by the middle to late Proterozoic Thule Basin. The strata of the basin form a thick unmetamorphosed and undeformed sedimentary and volcanic succession that is cut by prominent basaltic rocks (sills and dykes) of two ages: Helikian (1200-1000 Ma) and Hadrynian (750-650 Ma). The Hadrynian rocks have an unusually high titanium content - up to 6% in whole-rock analysis. As a regional magmatic suite the rocks represent some of the most titanium-rich basalts in Greenland.

3. Regional extent of the province

The regional location of the black sand province is shown in Fig. 1. Heavy mineral sands have been recorded in the region bounded by Kap Edvard Holm in the south (76^{o}) to Kap Alexander in the north (78^{o}). Within this region the most conspicuous exposures of black sands occur along the south-western coast of Steensby Land, both at the present littoral zone and on the raised coastal plain. This region is referred to in the following as the Steensby Land showing (Fig. 2).

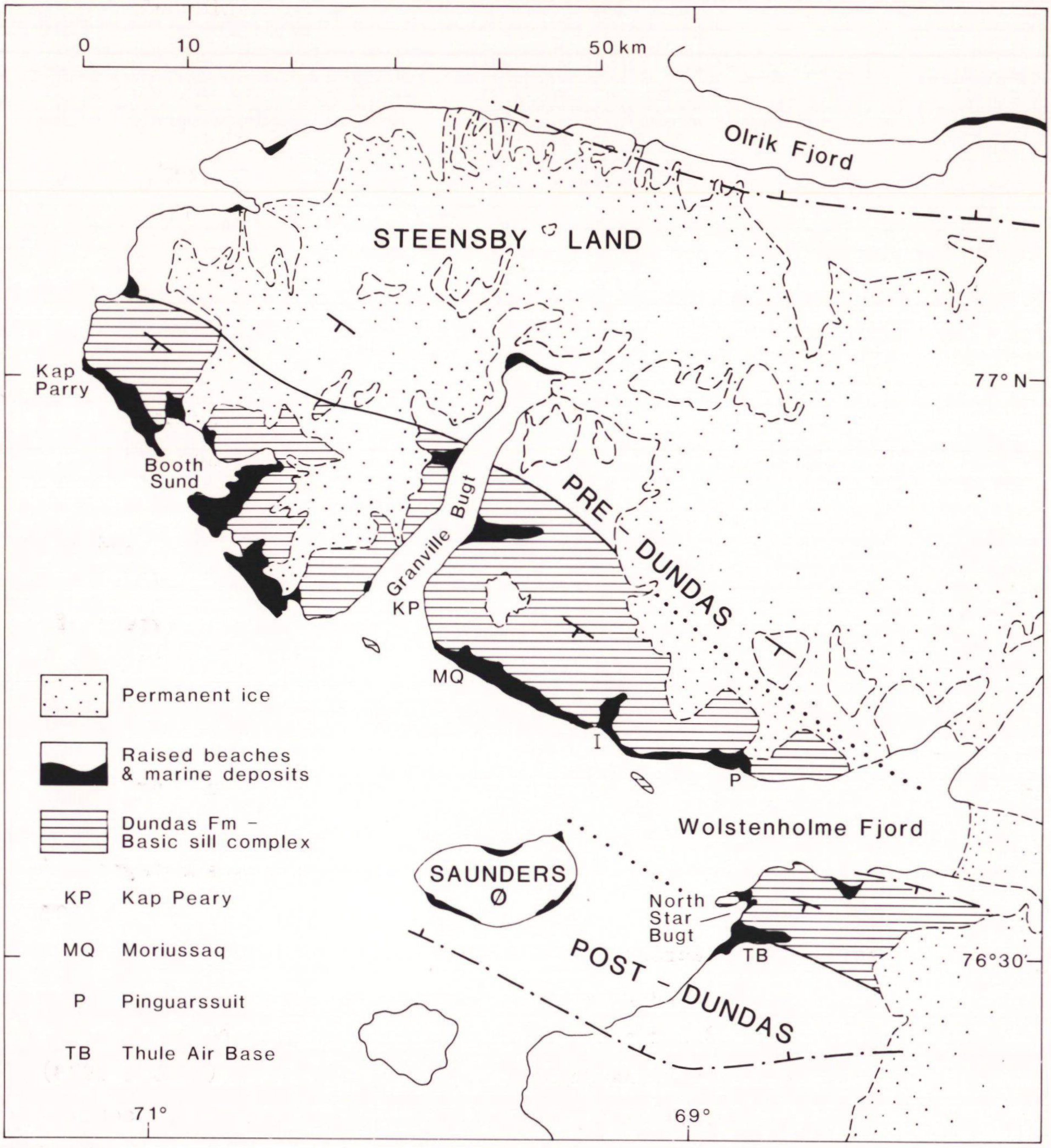

Fig. 2. Location map of the Steensby Land ilmenite showing illustrating the extent and size of the uplifted coastal plain and the outcrop area of the Dundas Formation with the titanium-rich Hadrynian basic sill complex. I = Iterdlak.

4. Discovery and field activity

The main stages in the discovery and field investigation of the black sand province are summarised below.

1916 Lauge Koch: reports "iron sand" on the north side of Wolstenholme Fjord, Steensby Land. His sample, investigated years later, was found to be ilmenite-rich (c.90% weight ilmenite, Ghisler & Thomsen (1973)).

1950 GGU: routine collection of sand samples during regional geological reconnaissance between Savigsivik and Olrik Fjord. Heavy fractions of sands reported on by Ghisler & Thomsen (1971) establish the presence of ilmenite-rich sands at North Star Bugt (present site of Thule Air Base). Occurrences of sands rich in magnetite noted elsewhere in the district.

1971 GGU: resampling of North Star Bugt locality confirms black sands with up to 75% weight ilmenite (Ghisler & Thomsen, 1973).

1974 GGU: reconnaissance mapping determined the regional extent of black sand occurrences along the coast of Steensby Land (Kap Parry - Wolstensholme Fjord); spot sampling of active beach at Moriussaq (Dawes, 1975).

1975: GGU: sampling programme of active beaches at North Star Bugt, Moriussaq and Granville Bugt (Dawes, 1976).

1977 GGU: traverse investigation, including sampling, and magnetic/ electromagnetic measurements of the Steensby Land showing from active beach across uplifted plain to bedrock scarp. Samples taken in hand-dug pits and limited to summer-thawed layer above permafrost (0.5 m - 1 m). The surface sampling showed no obvious correlation with the magnetic or EM observations (Cooke, 1978).

1978 GGU: Thule black sand province extended both north and south with discoveries of heavy mineral sands at 76°N and north of 78°N (Dawes, 1979).

1985 Greenex A/S: prospecting licence, granted 20.5.85. Summer 1985 spot sampling of sands around Moriussaq in rough pits to is permafrost. T confirmed GGU's results as far as ilmenite; assays for gold, platinium and palladium give low valves, <20 ppb. Licence relinquished 31.12.86.

1985-6 QIT-Fer et Titane Inc: prospecting licence granted 30.5.85. Field work planned 1985; force majeure closure of Thule Air Base prevented field work. Licence expired 31.12.86.

5. Steensby Land ilmenite showing

5.1. Bedrock geology

Southern Steensby Land and the area north of Thule Air Base is composed of middle Thule Group - Dundas Formation (mainly siltstones and shales) - that is characterised by a prominent basic sill complex, cut by an intense swarm of roughly coast-paralled (WNW-trending dolerite dykes (Fig. 3). About 15 master sills occur in the complex and sill rock composes between 30-40% of the stratigraphic section. In the outer coastal area basaltic rocks make up perhaps 50% of the total bedrock exposure. General dip of the sills and host strata is gentle (up to 10^{o}) to the south-west.

The thickest of the sills is over 100 m; the widest of the dykes about 150 m. Both sills and dykes have comparable chemistry and are exceptionally rich in TiO_2 (see section 5.5)

5.2. Surficial geology

The south-west coast of Steensby Land is dominated by an extensive, flat coastal plain with an elevation up to about 40 m. (Figs 4, 5). Beach deposits form a major component of this uplifted plain. The largest width of raised beaches is up to 3 km, around Booth Sound. To the south-east of Granville Bugt the plain is widest around Moriussaq where it is up to 1 km wide along a 10 km stretch (Fig. 2).

The uplifted beaches for the most part are in the form of flat-topped benches, often with distinct frontal scarps. The beaches are formed of graded and bedded deposits of cobbles, pebbles, sand, with some silt. In many places there has been reworking of material by fluviatile processes and several wide water courses across the plain (Fig. 7). Delta, fluvial and outwash deposits also occur, as well as areas of grey marine silts.

The undisturbed beaches support a sparce vegetation of low tufty grass, stunted willow and humus (Fig. 6).

The active beaches vary in width and extent; areas of sandy beach up to 10 m wide are broken by areas where basaltic rock outcrops forming a craggy coastline. Where well developed, the sandy beaches seem to extend someway seaward below tide level (Fig. 7).

Fig. 3. Coastal cliffs south of Kap Peary, Granville Bugt, showing three main basic sills and a younger dyke cutting shales of the Dundas Formation. Both sills and dykes are titanium rich. The cliffs are about 500 m high. 6th September, 1974.

Fig. 4. View to the south-east along southern Steensby Land illustrating the uplifted coastal plain that is about 1 km. wide. New snow fall, 14th September, 1975.

Fig. 5. View over Moriussaq across the coastal plain to the bedrock scarp. The beaches of the coastal spit are composed of black ilmenite sands (see Fig. 7). New snow fall, 14th September, 1975.

Fig. 6. Surface of the raised beaches behind Moriussaq showing low, grassy vegetation. 5th August, 1977.

Fig. 7. Aerial views of Moriussaq illustrating the black colouration of the active beach sands.
Upper: two areas of well-preserved raised beaches are separated by a wide braided water-course. Such streams have redistributed the littoral deposits and the heavy mineral concentrations. 4th August, 1978.
Lower: black sands of the active beach in Moriussaq harbour. 6th July, 1982.

5.3. Location and extent of ilmenite-rich sands

Black sands have been noted or sampled at localities along the entire coast between Kap Parry and Pinguarssuit, in Granville Bugt and on the south side of Wolstenholme Fjord at North Star Bugt; a total of coastline of over 150 km (Fig. 2). The most conspicuous exposures occur on the active beaches where in some localities, for example at Moriussaq, the overall black colour of the surface sand catches the eye at a distance (Fig. 7). The darkest sands are concentrated in diffuse 'layers' (up to 50 cm thick); lighter coloured sandy beaches can be streaked with concentrations of dense black sand.

The black sands noted on the uplifted beaches are associated with much coarser material and in general these deposits contain a smaller concentration of heavy minerals than the sands of active littoral zone. Black sands can peter out with depth into cobbles but some sands continue down into frozen ground.

Black sands have also been noted in the fluvial-dominated deposits making up the wide braided rivers that enter the sea at Iterdlak and Pinguarssuit. Iterdlak is most probably the sample location of the ilmenite sand reported on by Ghisler & Thomsen (1973, see section 4).

5.4. Grade

Mineralogical composition of some of the darkest sands indicates on opaque fraction of up to 95%, with more than 70% absolute weight of ilmenite (Table 1). The composition of the opaque fraction is notably constant and the ilmenite is 'clean' showing no exsolution or microscopic intergrowth. The values shown in Table 1 on samples from North Star Bugt compare well with black sands from Steensby Land.

Chemical compositions of analytical ilmenite separated from six sand samples from Steensby Land are shown in Table 2; these give an average TiO_2 value of about 46%, with total iron around 38.5%.

Chemical analysis of sand samples from Steensby Land confirm the general field assessment that the active beaches contain the higher concentrations of titanium. Average TiO_2 contents are as follows:

Active beach: TiO2 43%, range 41-44% (3 samples)

Raised beach: TiO_2 12%, range 6-23% (13 samples)

Table 1. Mineralogical composition of black sands from North Star Bugt

GGU sample no.	13842	141039	141040
Heavy fraction >2.9 (weight %)	95 %	84 %	54 %
opaque (number of grains) %	73 %	68 %	54 %
Heavy fraction percentages of transluscent minerals			
diopside	68 %	34 %	39 %
augite	+	7 %	3 %
hypersthene	22 %	10 %	6 %
hornblende	7 %	37 %	44 %
epidote	3 %	7 %	8 %
garnet		4 %	+
titanite	+	1 %	
zircon		+	
sillimanite		+	
Relative composition of the opaque fraction (number of grains)			
ilmenite	95 %	88 %	90 %
titanomagnetite	4 %	6 %	3 %
magnetite	+	6 %	6 %
pyrite	+	+	1 %
density of sand (calculated)	4.5	4.2	3.5
absolute weight % of ilmenite	74 %	60 %	37 %

+) present in amounts below 1 %

Data from Ghisler & Thomsen (1972)

Table 2. Chemical composition of ilmenite in black sands, Steensby Land

GGU Sample no.	1 139273	2 139288	3 139292	4 243624	5 243639	6 243649
Analytical ilmenite % in the sand	33.0	42.0	60.0	39.0	12.0	14.0
Chemical results	%	%	%	%	%	%
TiO_2	46.30	46.50	46.50	44.00	46.20	45.50
Fe_{total}	38.80	38.90	38.90	37.60	38.40	38.80
Al_2O_3	0.45	0.43	0.40	0.43	0.40	0.40
CaO	0.14	0.13	0.13	0.13	0.16	0.14
MgO	0.87	0.88	0.92	0.66	0.80	0.86
MnO	0.61	0.62	0.62	0.65	0.64	0.61
SiO_2	0.74	0.74	0.70	0.87	1.50	1.03
Cr_2O_3	0.06	0.06	0.06	0.02	0.03	0.06
V_2O_5	0.39	0.38	0.38	0.34	0.35	0.39

Location of samples:

1-3 Active beach, Moriussaq
4 Active beach, Pinguarssuit
5 Active beach, 5 km south-east Moriussaq
6 Uplifted beach Moriussaq, 200 m inland

Chemical data from Qit-Fer et Titane (unpubl. data)

5.5. Source of titanium

The source of the ilmenite concentrates in the beach and fluvial sands is undoubtedly the Hadrynian basaltic sill and dyke complex that dominates the landscape of southern Steensby Land and Wolstenholme Fjord. Both sills and dykes are rich in opaque minerals; ilmenite reaches up to 15% vol. Chemically the rocks are characterised by very constant and extremely high titanium values - up to 6% in whole rock analysis, with a total Fe up to 15%. One sill south of Kap Peary (Figs 2, 3) contains 6% titanium and 14.5% total iron.

Based on chemical analysis of 12 samples the average titanium contents of the basic material is as follows:

Sills: TiO_2 5.3%, range 4.7 - 6.0% (4 samples)

Dykes: TiO_2 4.9%, range 4.5-5.2% (8 samples)

6. Magnetite-rich sands

Heavy mineral sands in which magnetite and/or titanomagnetite form the dominant opaque fraction occur in the Thule district as beach and river deposits, e.g. Parker Snow Bugt, Kap York peninsula (Ghisler & Thomsen, 1971). Such sands have been sampled in a region bounded by Melville Bugt in the south (Kap Edvard Holm) and Kap Alexander in the north (Fig. 1).

The titanium/iron-rich WNW-trending Hadrynian dyke swarm that occurs throughout the Thule district, may contribute to the opaque fraction of these black sands (outside the Steensby Land showing). In addition another source might be the Helikian basaltic sills and volcanics that occur in the region north of Wolstenholme Fjord; the sills stretch as far north as south-western Inglefield Land (Fig. 1).

The high opaque fraction of the sands in the south could be derived from Precambrian basic dykes or from the Archaean basement in which the two most obvious possible sources are: the Kap York meta-igneous complex (gabbros, diorites) and the banded ironstone formation and magnetite-rich gneisses that form a belt traceable for 400 km from the region around Thule Air Base throughout Melville Bugt down to 75°N.

7. Access and climate

As with other regions in the High Arctic access, travel and operation can be difficult due to the harsh winters. On the plus side: Thule Air Base is situated in the region thus providing standard communication and travel facilities.

Average temperatures at Thule Air Base are: in summer 7.7°C (July), in winter -20°C (January). Minimum temperature can be as low as -40°C; in the height of summer temperatures can reach 15°C. Being over 1200 km north of the Arctic Circle the region experiences in summer 3 1/2 months of continuous sunlight, but in winter a corresponding period of darkness.

Average snow fall is about 80 cm per year. The coastal ground is free of snow for about 4 months of the year (June-September) - new snow can cover the coast by mid September (Figs 4, 5).

The sea is normally free of pan ice for 2 - 2 1/2 months and most years are navigable by local boat for at least 2 months (mid July - mid September). Navigation by larger ships is possible for 3 months and ice-strengthed vessels (class 1A) 4 months.

Small wooden motorboats up to about 30 feet (with small cabin) can be hired at Moriussaq or Thule (see Fig. 7). A commercially operated Bell 212 helicopter is presently stationed at Thule Air Base and is available for 'ad hoc' charter.

8. Conclusions and potential

The Thule black sand province contains both ilmenite-rich and magnetite-rich sands. Proven quantities of ilmenite-rich sands in the Steensby Land showing are extensive and occur on both active and uplifted beaches.

The available analytical results indicate the presence of a fairly high concentration of titanium on the active beaches (average 43% TiO_2) with lower values (average 12% TiO_2) on the older beaches. Potential tonnage of the active beaches is low but possibility of off-shore deposits considerably increases this potential. The uplifted beaches contain commercially viable tonnage if sufficient grade could be maintained.

It is stressed that the investigations so far carried out have been confined to 'surface' sampling down to the permafrost level (>1 m); no drilling has been undertaken. Sands within the permafrost could be exploited; thus the possibility of placer deposits at depth must be considered.

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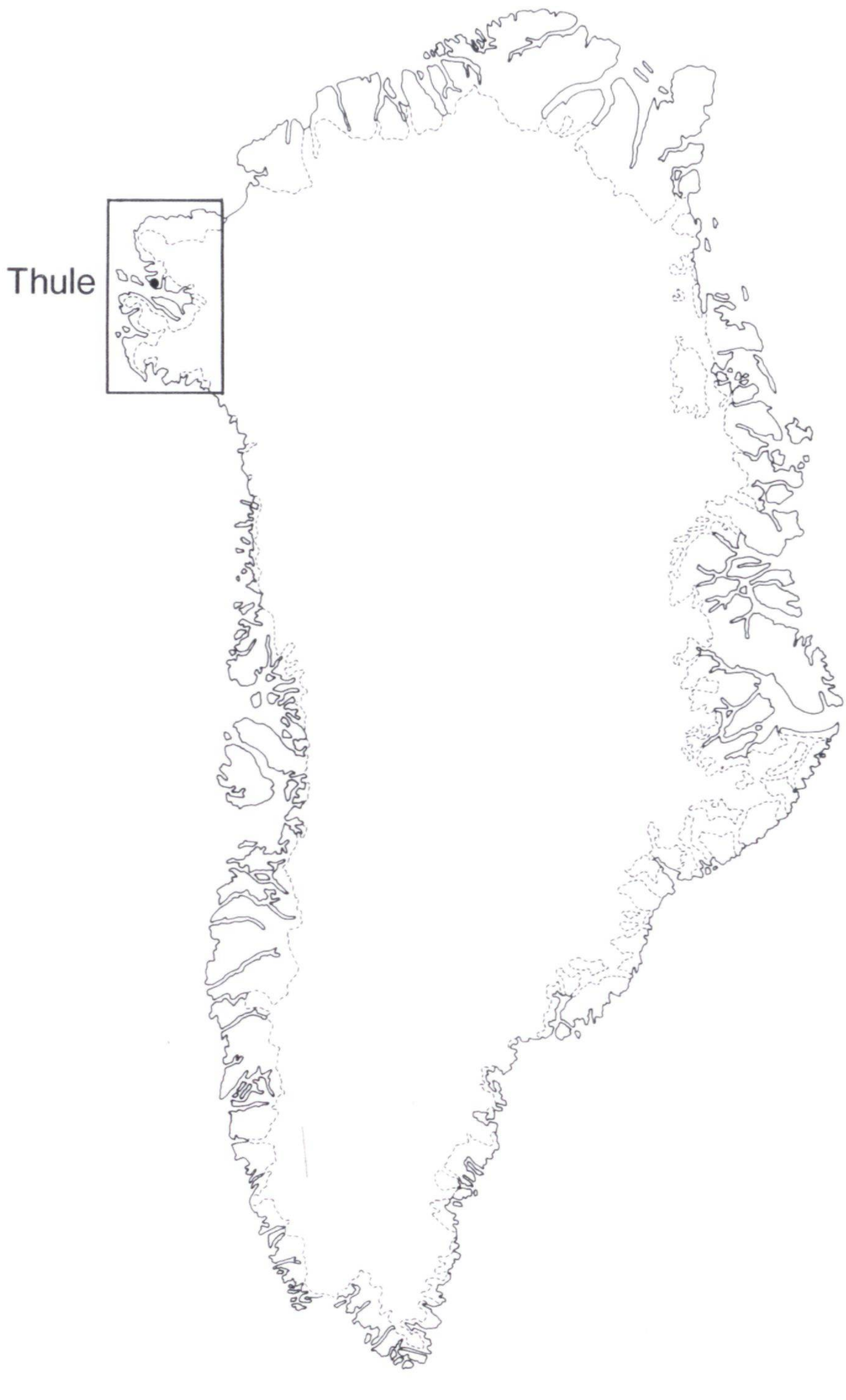

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