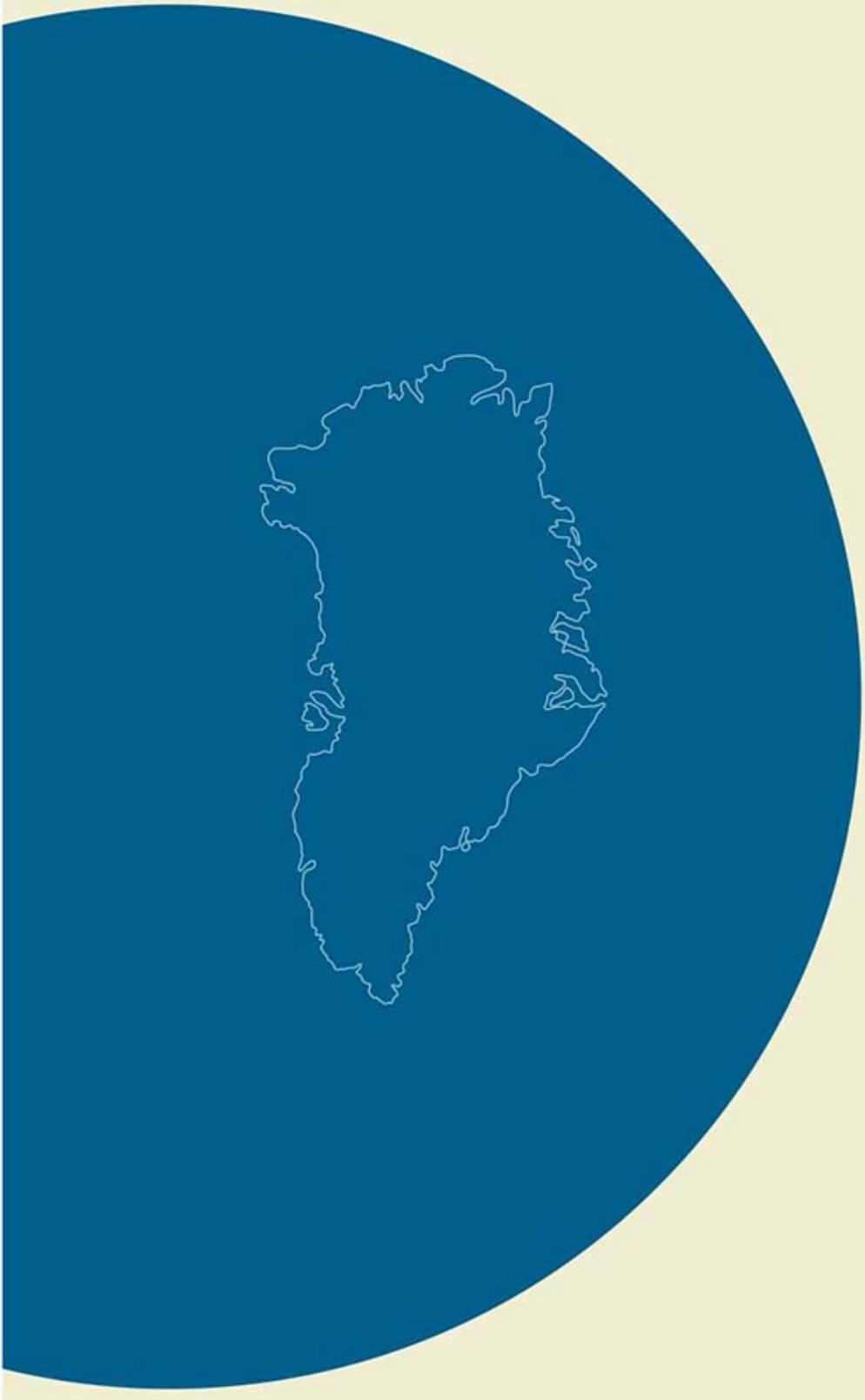
DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2015/74

Thule Black Sand offshore mapping

Sea floor bathymetry and boomer profiling and grab sampling

Jørn Bo Jensen & Lars Georg Rödel



GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF CLIMATE, ENERGY AND BUILDING

GEUS

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1. Summary

A combined echo sounding, C-boom and grab sample survey was conducted in august 2015 in the Moriusaq area of the Wolstenholme Fjord. The aim was to map offshore potential heavy mineral sand deposits.

A survey grid spacing between 150m and 250m formed the basis for the constructed bathymetric map. In general a narrow zone of shallow water and broader areas of medium to deep water were mapped. An exception is the south-easternmost area that is dominated by shallow to medium water depths.

On the basis of a general knowledge of the postglacial sea level evolution from a highstand at 13000 years BP to a lowstand 7000 years BP, followed by transgression to the present situation, it was possible to establish a geological model that has been used in the seismic interpretation.

Highstand, lowstand and transgressive units have been interpreted, and coastal plain as well as shallow water sand facies of lowstand and transgressive seismic units are potential heavy mineral black sand resources.

Sandy facies types are considered to be present offshore, down to a water depth of about 15m. In the depth interval 15m – 30m below present sea level, lowstand sand can be expected, covered by a thin muddy transgressive unit.

At water depths of more than about 20m, heavy disturbance by iceberg ploughing is observed and at water depths of more than 30m, sands could occur below a thicker deep water mud layer.

More detailed information on heavy sand distribution and volumes may be acquired as a follow up on the present survey results. It is suggested to conduct shallow coring at well-planned sites.

2. Introduction

The Thule black sand province in North-West Greenland (76°–78°N) is a potential ilmenite- and magnetite-rich sand resource, consisting of raised - and possibly also submerged beaches. The heavy sand in the beaches is characterised by a high concentration of ilmenite. The maximum concentration is 60 wt% and the average is 37 wt%. The main source of the ilmenite sand is a regional Precambrian basaltic sill and dyke complex that has intruded Precambrian sedimentary bedrock. The regional geology and mineral occurrences in the area are described in GEUS report 2015/XX.

The present report describes a combined offshore acoustic and grab sampling survey carried out in august 2015, in the near coastal area outside the deserted settlement Moriusaq northwest of Thule Air Base (Fig. 1)

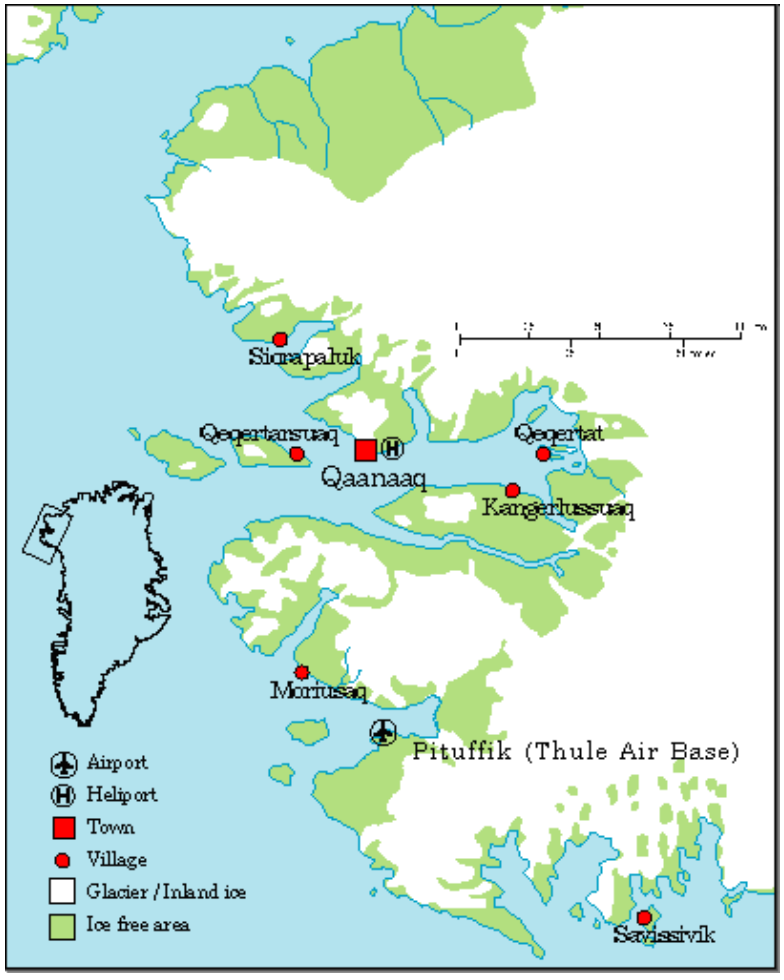


Figure 1 Location of Moriusaq northwest of Thule Air Base.

The survey area is located between Mourisaq in the west and the Pinguarsuit Sermiat glacier in the east. The area was sub-divided in the survey areas 1a, 1b, 2a and 2b (Fig. 2).

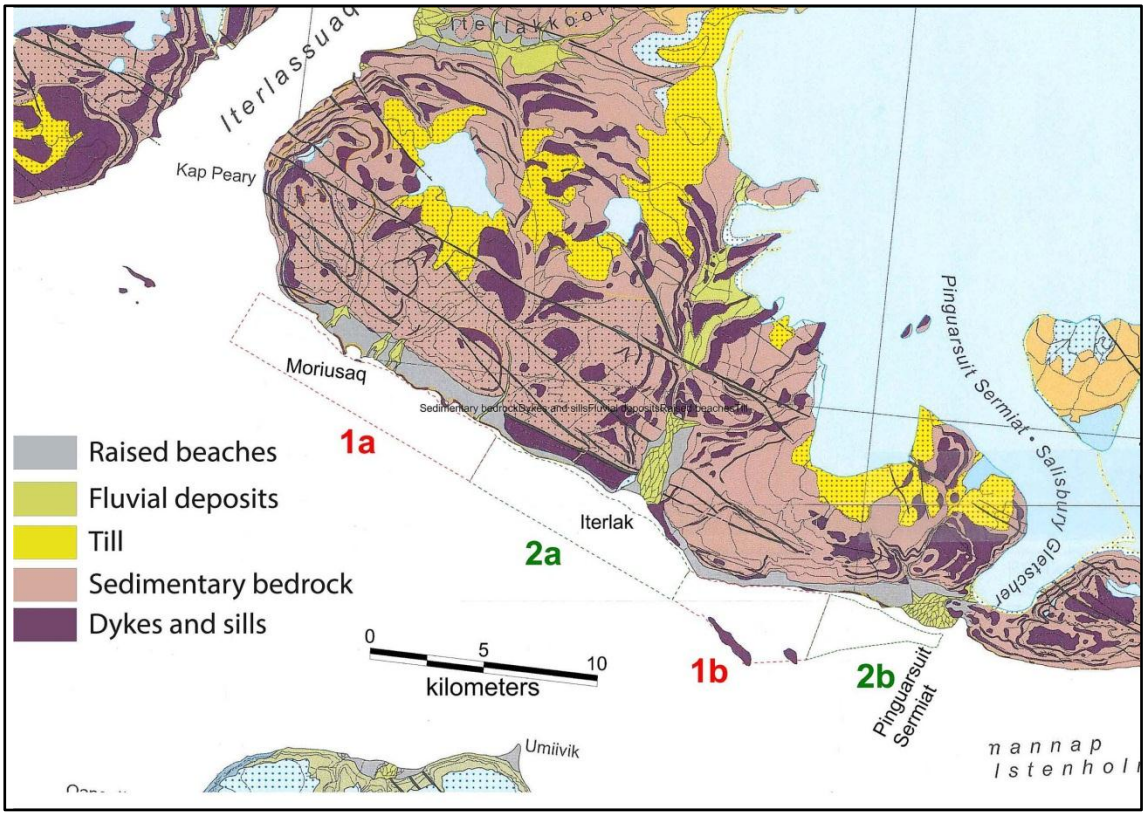


Figure 2. The survey areas 1a, 1b, 2a and 2b between Moriusaq and Pinguarsuit Sermiat. The light grey areas near the coast represent raised beaches.

2.1 Background

Black heavy mineral sands have been recorded in the Moriusaq region in uplifted beaches within extensive flat coastal plains at altitudes up to 40 m above sea level. The sands are enriched in ilmenite and/or magnetite, derived from Neoproterozoic titanium-rich dolerite sills and dykes in the immediate hinterland of the beaches. The uplifted beaches form flat-topped benches, often with distinct frontal scarps. The uplifted beaches are up to 1 km wide along a 20 km coastal stretch (Fig. 2).

The highest shell-bearing marine silt and sand in the Thule region are c. 60 m a.s.l. (Dawes 2006). The well-developed, raised terraced beach systems contain up to a dozen tiered low-gradient levels. Several of the beach deposits are continuous from the marine limit down to modern storm-wave beach ridges.

Several modelling studies of glacial rebound have been performed that cover North-West Greenland. Fleming & Lambeck (2004) published two curves that predict relative sea level changes, one labelled Thule (Fig. 3) and another labelled Iterlak. Both are from areas to the east of Moriusaq, and both show a rapid fall of the relative sea level from deglaciation until c. 7,000 years BP, followed by a rise in the relative sea level. At 7,000 years BP the relative sea level was 35 m below present sea level at Thule and 20 m at Iterlak.

Based on the areal extent of raised beaches and an assumed overall depth of 2 m to bedrock, Appel et al. (1991) estimated a total onshore sand volume of 40 million m^3, equal to

80 million tons. The possibility of offshore placers in the surf and nearshore zones (wave breaking and wave shoaling) to a water depth of 30 m below present day sea level (the minimum level of the paleo-sea surface) considerably increases the potential for larger tonnages.

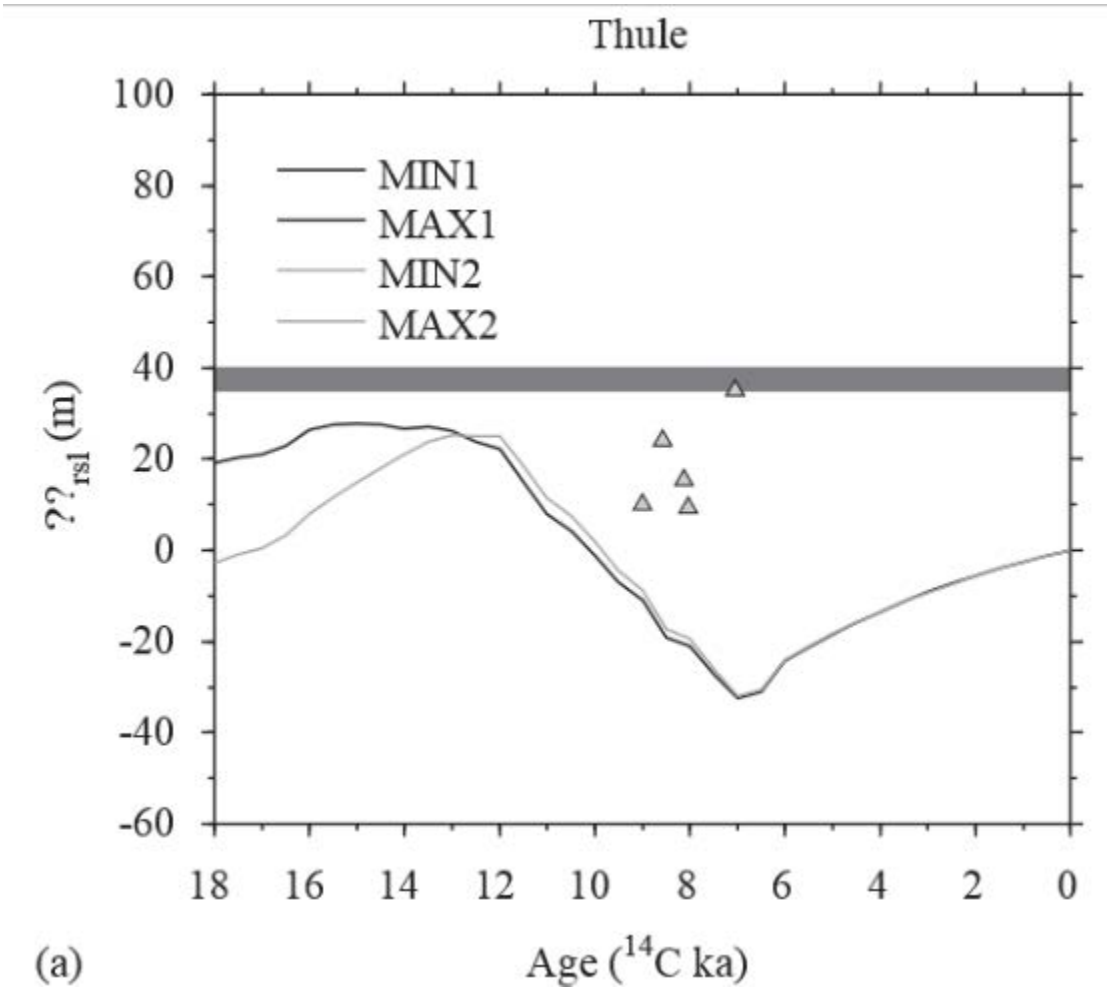


Figure 3. Observed and scaled-predicted relative sea-level curve for Thule presented by Fleming & Lambeck (2004) indicating a sea level fall from c. 13,000 years ago to minus 35 m below present sea level, followed by a transgression from 7,000 years ago to present day sea level. Dark-grey shading indicate the estimated local marine limit. Triangles indicate observed lower limits. Figure from Fleming & Lambeck (2004.

2.2 Aim

The aim of the survey was to map the seabed bathymetry and the potential thickness of submerged beach sand in the nearshore survey area (Fig. 2) defined by the borders of the survey areas 1a – 2b, or when the water depth exceeds about 40m. In addition to the acoustical mapping, the results of the sediment sampling are reported with sampling positions on the maps (Appendix A1 – A8) and summarised in a excel spread sheet (Appendix C1).

3. Survey

3.1 Acoustical mapping

The survey was carried out in the period 12/8 - 25/8 2015.

The acoustical GEUS survey team consisted of two persons: One technician (Lars Georg Rödel) that was responsible for mobilisation and instrument handling/repair, and one senior geologist (Jørn Bo Jensen) that was responsible for survey planning, data acquisition, processing and on site interpretation of acoustical data.

12/8 the survey started with loading of the GEUS equipment on M/S Kisaq in Qaanaaq and transfer to Mourisaq.
13/8 the speedboat GEUS II was unloaded from M/S Kisaq, mobilised with acoustic equipment and the first test survey was carried out.
14/8 was the first survey day. M/S Kisaq was replaced by M/S Duda.
15/8 – 24/8 continuous bathymetry and C-Boom survey was carried out with 10-hours acoustical survey days and a survey speed of about 3 knots using the small speed boat GEUS II. Nice survey weather dominated due to high air pressure. Resulted in sunshine and very weak wind during the entire survey period.
A total of about 300km survey lines was covered in the four areas (Table 1) including 38km of echo sounder infill in area 1a.

Area	Echo sounder and C-boom	Echo sounder
	km	km
1a	72	38
2a	107	0
1b	54	0
2b	26	0

Table 1. Overview of surveyed line km in the four survey areas.

A survey line spacing of 500m was originally planned, but due to the exclusion of two additionally planed areas 2C and 2D, it was possible to complete infill between the primary 500m spacing lines. The infill lines were focused in the nearshore 1km, in general at water depths shallower than 30m, with a line spacing of about 125m.

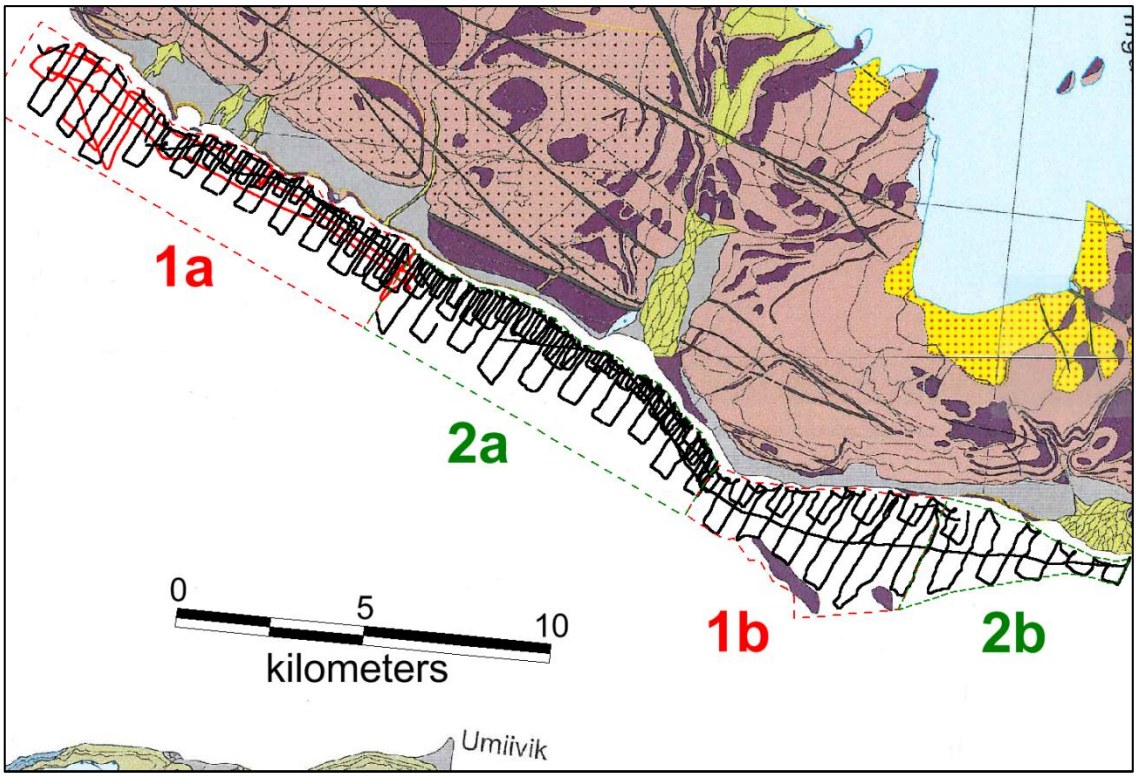


Figure 4. Survey track lines. Black lines: combined bathymetry and C-boom. Red lines: additional Garmin echo sounder data. UTM zone 19 wgs84.

3.2 Grab sampling

A total of 69 offshore grab samples (Fig. 9) have been taken in the nearshore shallow part of the survey area with a distribution of 53 sand samples at water depths less than 15m and 16 mud to sandy mud samples at water depths over 15m (Fig. 10).
The detailed results of the grab sampling campaign are reported in a separate report (Weatherley, S. 2015).

3.3 Survey ships and ship configuration

The survey was utilised M/S Kisaq (12 – 14/8 2015) and M/S Duda (15/8 - 24/8 2015) as floating basecamps, as well as platforms for taking bigger grab samples. The larger ships were supplemented by a small speed boat (GEUS II) designed for conducting shallow water acoustic surveys with echo sounder and C-boom as well as for some small grab samples.

3.3.1 Kisaq

Kisaq is a travel boat with accommodations for up to 12 people, storage capacity and two cranes, which make it ideal as a platform for smaller scale cruises. We only had few days on board, but it served our purpose well.

Figure 5. M/S Kisaq.

3.3.2 Duda

Duda replaced Kisaq because Kisaq had other duties.
Duda is an old police boat now owned by Lasø Upernavik Aps. Duda was the main ship during the survey, but ships performance and maintenance turned out to be questionable. After one day with grab sampling (10l Van Veen grab) it was therefore decided to use Duda solely as a basecamp for the onshore and the offshore geological survey teams.

Figure 6. M/S Duda.

3.3.3 GEUS II

The combined echo sounder and C-boom survey was conducted with a small speedboat GEUS II (Fig. 7) designed for the purpose

GEUS II was equipped with:

- C-Nav3050 GPS system that provides sub-meter, precise point positioning

- Navisound 620 and TC2170 Transducer echo sounder for the Bathymetric measurements. The system can measure the depth down to about 100m water depth and with an accuracy of few cm.

- C- Boom seismic source and Geo-Sense Ministreamer 24 elements, with a frequency band of 0.5 – 1.5 kHz (Fig. 8). A resolution in the range of 30cm can be expected, and the penetration in sand is 5 – 20m. The streamer was kept 4 m from the propeller wash by a glassfiber rod

- Chesapeake Technology 24 bit AD converter for acquisition of seismic data
Chesapeake Soranwiz6 software for recording and processing seismic data; the software was also used for navigation and runline management.

- Geosense 8 element, 1 channel streamer from GeoSurveySystems NL

- Combined power supply, bandpass filter and gain unit from GeoSurveySystems for the analogue input.

- Fujitsu Laptop with 4+1 serial ports, 1 on the board and 4 on a qualcomm pcmcia card.

- The entire system was powered by a Honda i30 generator via a 1kw UPS for protection. Grounding of all units was done to the polemounted transducer.

- Sonar Wiz 5 seismic acquisition software was used on a laptop, as well as Seisvision seismic interpretation software and MapInfo GIS for on location data processing and presentation.

- A Van Veen 4l grab sampler was used to collect surface sediment samples (Fig. 9). The small grab samples were taken on board GEUS II or the mob boat of Duda.

Figure 7. GEUS II with the seismic equipment.

Figure 8. C-boom and Geo-Sense Ministreamer in survey situation off Moriusaq.

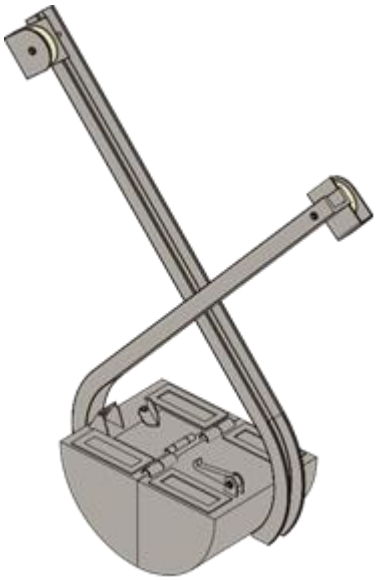


Figure 9. Van Veen grab sampler.

3.4 Positioning

For the positioning of GEUS II the GPS navigation system C-nav3050 was used, which provides sub-meter accuracy in UTM zone 19 wgs84.

4. Bathymetry

For bathymetrical measurements Navisound 620 and a TC2170 Transducer echo sounder, were used with the capacity to provide depth data to centimetres accuracy.
The echo sounder operates at 33/210 kHz. Editing of the echo sounder data was done with the NaviPac-software packet NaviEdit.
Corrections of tidal effects were carried out after the survey by using the tidal table for Greenlandic waters produced by the Danish Meteorological Institute (DMI) and adding values in relation to the lowest astronomical tidal level.
The results of the bathymetry mapping are illustrated in figure 10.

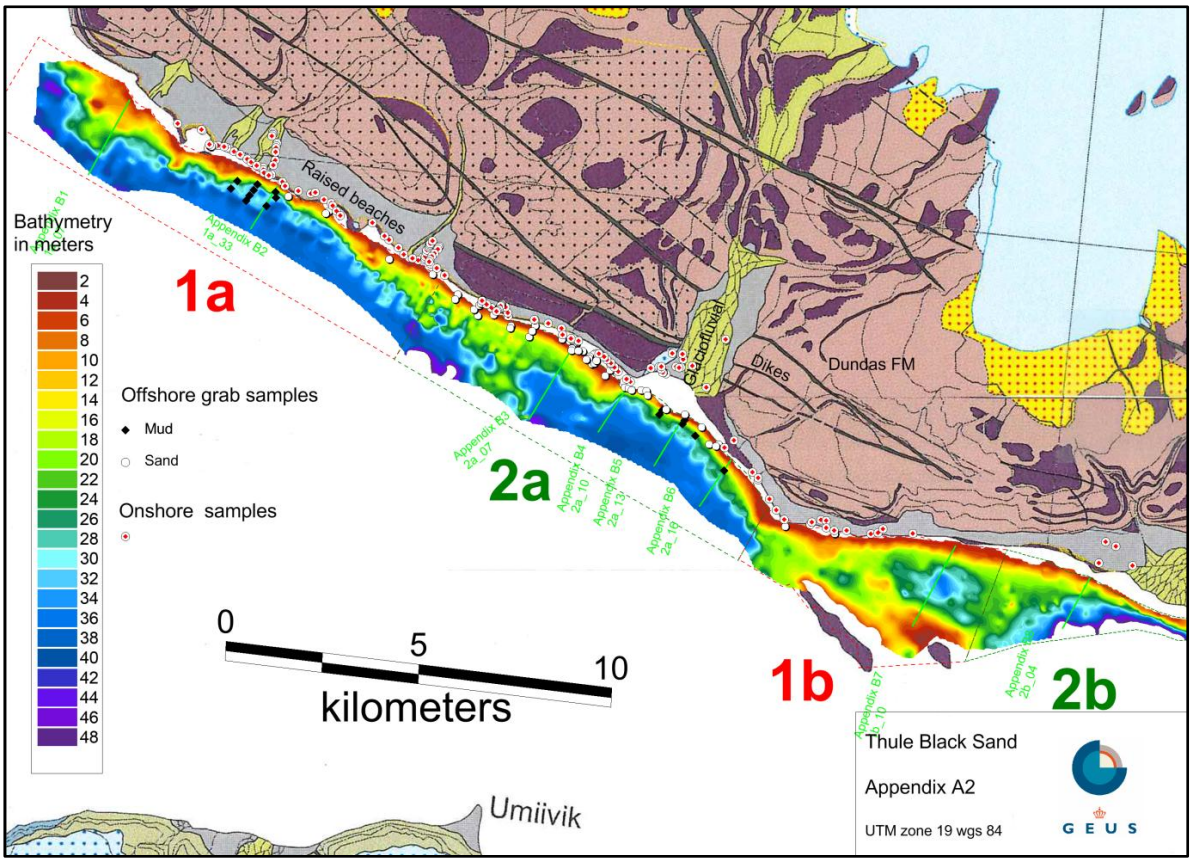


Figure 10. Bathymetrical map of the survey area corrected for tidal effects. The location of grab samples is indicated. For details see Appendix A2.

4.1 Bathymetry area 1a

In area 1a the central offshore area is dominated by a narrow zone with shallow water. Water depths of more than 30m are reached less than 1km from the present coast (Fig. 11). In

the westernmost part close to Moriusaq the shallow water zone with increases to more than 2km and water depths of only a few meters are found in some small areas. In the eastern-most part of area 1a the shallow water zone also increases but to a lesser extent.
The surface sediment was investigated by grab sampling. At water depths of less than 15m we found sand while grab samples from deeper water consisted of mud and sandy mud.

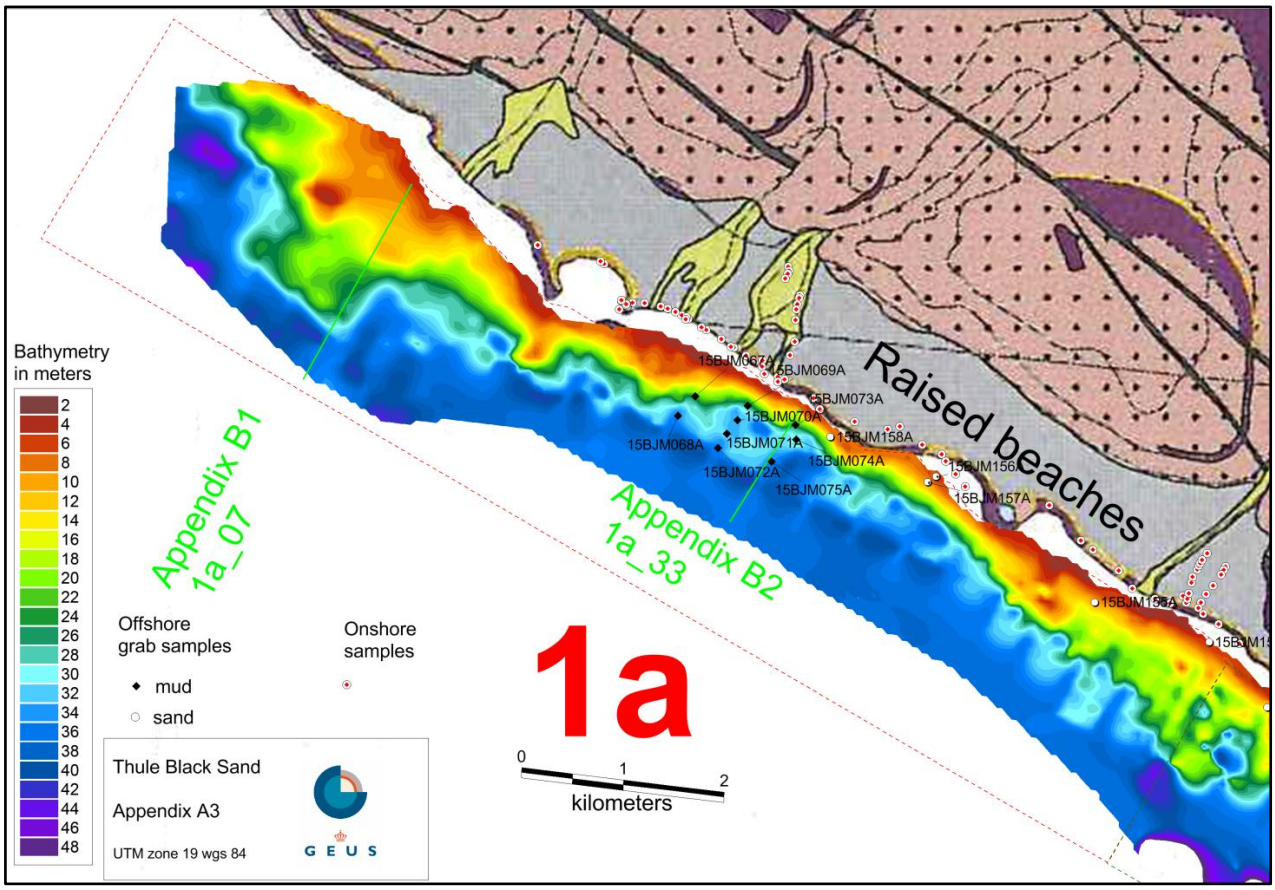


Figure 11. Bathymetry of area 1a. The locations of onshore samples and offshore grab samples as well as Appendix B1 and B2 profiles are indicated. For details see Appendix A3.

4.2 Bathymetry area 2a

The bathymetry in area 2a shows a rather diverse morphology with fairly shallow areas to the northwest and southeast, while the Iterlak bay mainly shows water depths of more than 30m.

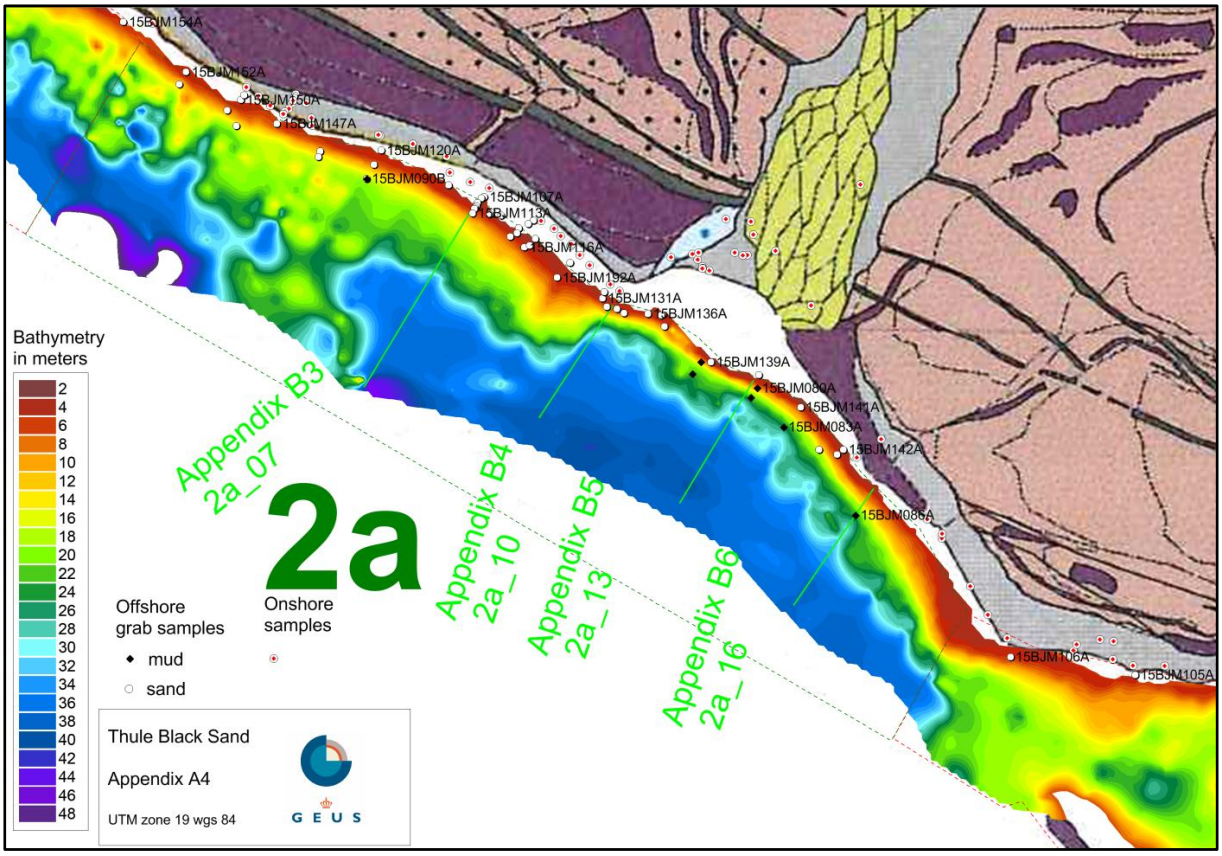


Figure 12. Bathymetry of area 2a. The locations of onshore samples and offshore grab samples as well as Appendix B3 – B6 profiles are indicated. For details see Appendix A4.

4.3 Bathymetry area 1b and 2b.

Areas 1b and 2b are in general shallow water areas of less than 25m. However in area 1b a central deeper area is observed (down to 40m) and in the south-eastern part of area 2b the basin deepens to water depths of more than 50m.

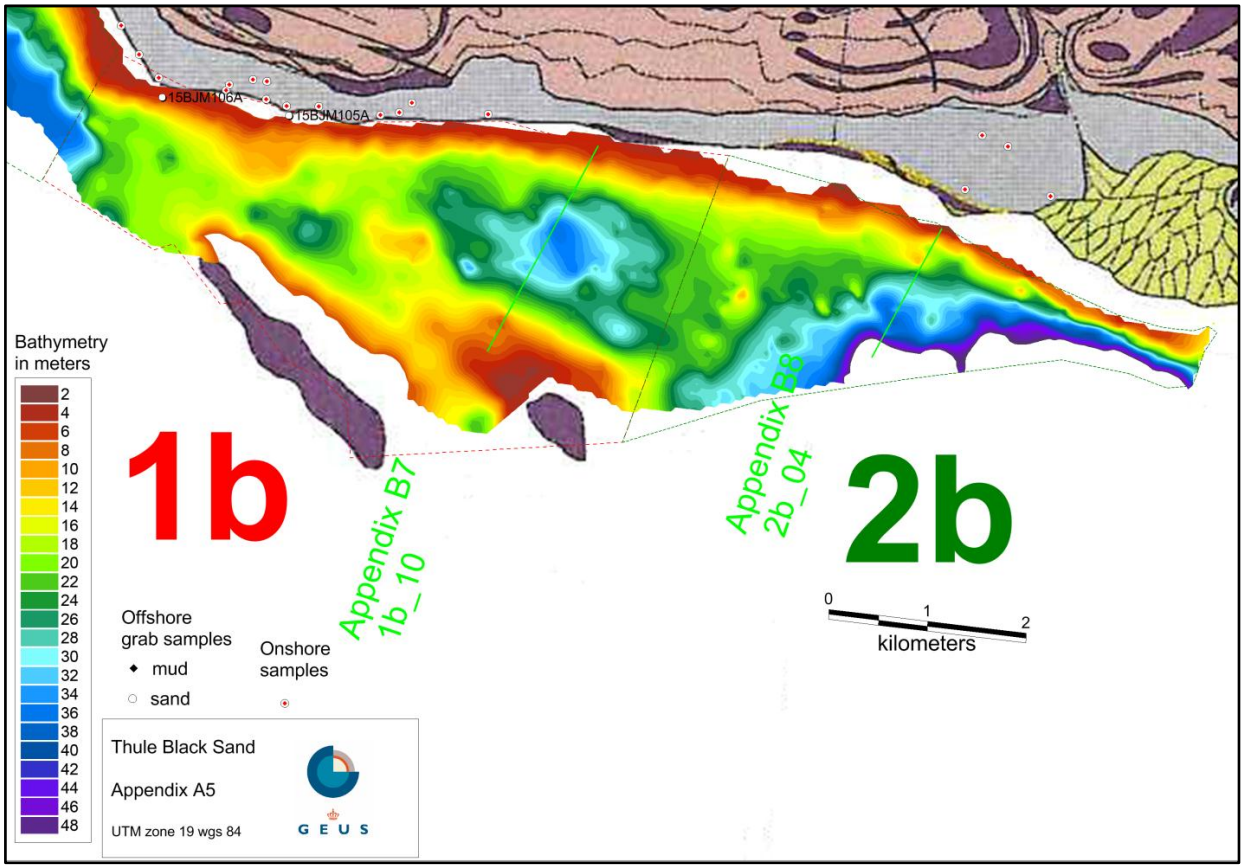


Figure 13. Bathymetry of area 1b and 2b. The location of onshore samples and offshore grab samples as well as Appendix B7 – B8 profiles are indicated. For details see Appendix A5.

5. Acoustic mapping with C- Boom

In order to map the thickness and distribution of potential offshore heavy mineral sand deposits a c-boom survey was carried out.

The C-boom system consists of a seismic source and a Geo-Sense Ministreamer of 24 elements (Fig. 8), with a frequency band of 0.5 – 1.5 kHz. A resolution in the range of 30cm can be expected, and a penetration in sand of 5 – 20m.

Sonar Wiz 5 seismic acquisition software was used, as well as Seisvision seismic interpretation software and MapInfo GIS for on location data processing and presentation.

5.1 C- Boom interpretation procedure and geological model

Post survey interpretation of the C-Boom data has been carried out using Seisvision seismic interpretation software and MapInfo GIS. The data were loaded and a general overview of the data set was established.

On the basis of the scaled-predicted relative sea-level curve for Thule published by Fleming & Lambeck (2004) (Fig. 3) a sequence stratigraphic interpretation approach was applied. The frame of the interpretation is an initial highstand HST at a level of about 30 meters above present sea level (about 13000 years BP) and a falling sea level to a lowstand about 30 meters below present sea level LST (about 7000 years BP), followed by a final transgressive phase TST to the present sea level.
The systems tract configuration in figure 14 illustrates the relationship of the depositional facies types: coastal plain, shallow marine sand and offshore mud. We may expect that potential black sand resources can be found in the coastal plain and in the shallow marine sand facies zones. This means that the zone from 30 meters above present sea level to 30m below present sea level is a potential target area.
With the presented sequence stratigraphical approach in mind, the seismic data were interpreted and it was possible to map the seismic units seen in the Thule Black Sand geological model (Figure 14):

Sedimentary bedrock
The lowermost seismic base level unit is in general defined as the lowest well defined seismic reflector. Occasionally it is possible to see internal inclined reflectors, cut by the upper boundary. The unit is believed to be the sedimentary bedrock represented in the region.

Highstand unit
At water depths of more than 30m, the sedimentary bedrock is in general covered by a seismic unit, bordered by sharp upper and lower boundaries and with internal reflector patterns ranging from basin infill to diffuse. The unit is believed to represent deep water glaciomarine sediments deposited during the early highstand period.

Lowstand unit

A sharp lower unconformity boundary is characteristic for the unit, whereas the upper boundary is more gradual. The unit is observed at water depths of more than 20m and the near coastal part of the unit shows onlapping internal reflectors in wedge structures. The unit is interpreted as the lowstand unit, developed when the water level was about 30m below present sea level, with sandy near-coastal deposits in wedge structures and muddy sediments in the deeper sheet deposits.

Transgressive unit

The uppermost unit covers most of the area, except for shallow areas, where sedimentary bedrock comes to the surface due to the block faulting and erosion. In the shallow areas from about 20m below sea level to the present sea level, internal reflector draping is present while deeper parts are dominated by disturbed internal reflectors and a rough surface, probably due to iceberg ploughing of the seabed. The unit is interpreted as the transgressive unit representing the last 7000 years.

Grab samples at the seabed shows that the seabed at water depths greater than 15 – 20m consists of mud, while the shallower part consists of sand.

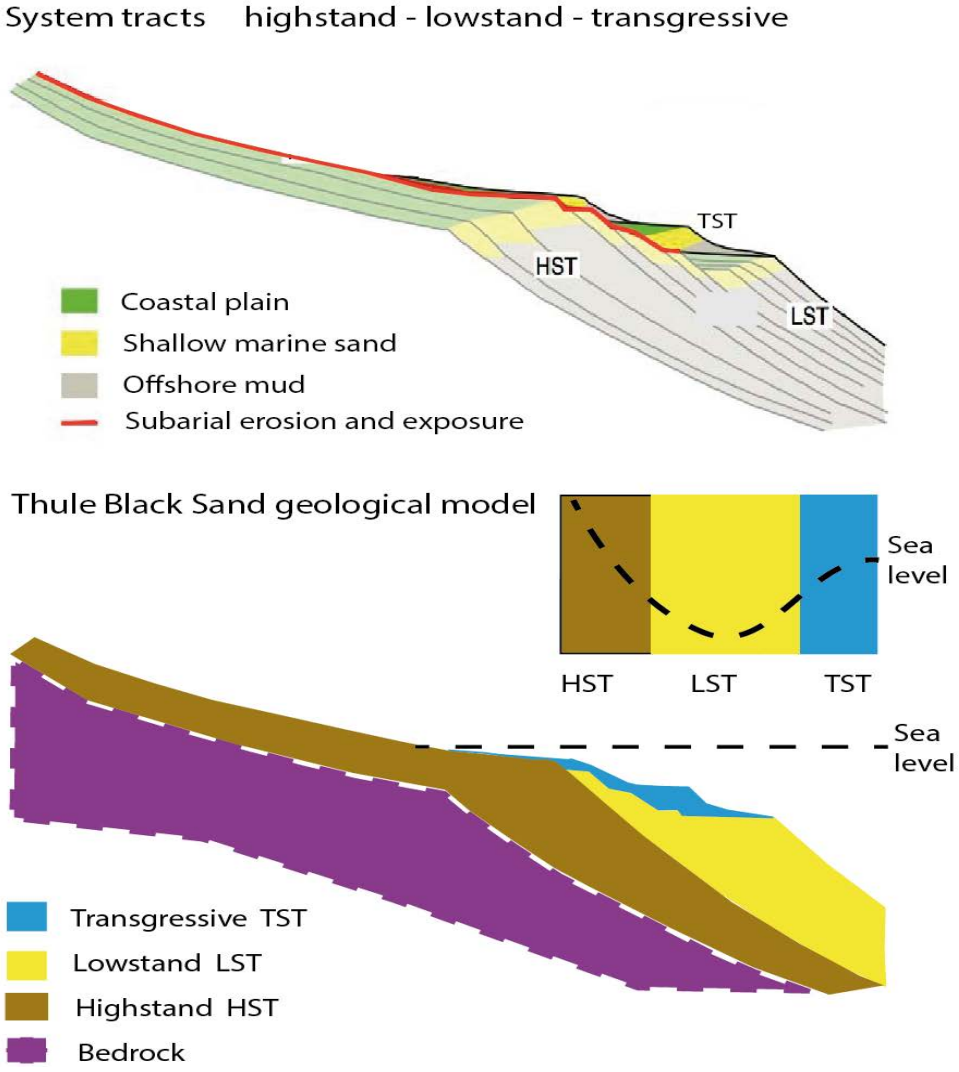


Figure 14. Systems tracts and principal geological model for the Thule Black Sand.

6. Potential black sand resources

Lowstand and transgressive seismic units combined thickness has been mapped and proven by grab sampling to contain heavy mineral sands.

- Shallow water transgressive sand unit up to 15m thick mapped in areas 1a and 2a, as well as the easternmost part of area 2b
- Medium depth transgressive and low stand deposits mapped along the headland bedrock margin in area 1a outside the Iterlak delta and in area 2b outside the Pinguarsuit Sermiat delta.
- In deeper waters greater than 30m deep water muddy sediments could overlie or predominate, with heavy disturbance by iceberg ploughing.

The overview thickness map presented in figure 15 shows a mosaic of areas with more than 5m of sediment thickness and a few areas with more than 10m of sediment thickness. In the following chapters the linkage between water depth and sand potential will be described for the individual survey areas 1a, 1b, 2a and 2b.

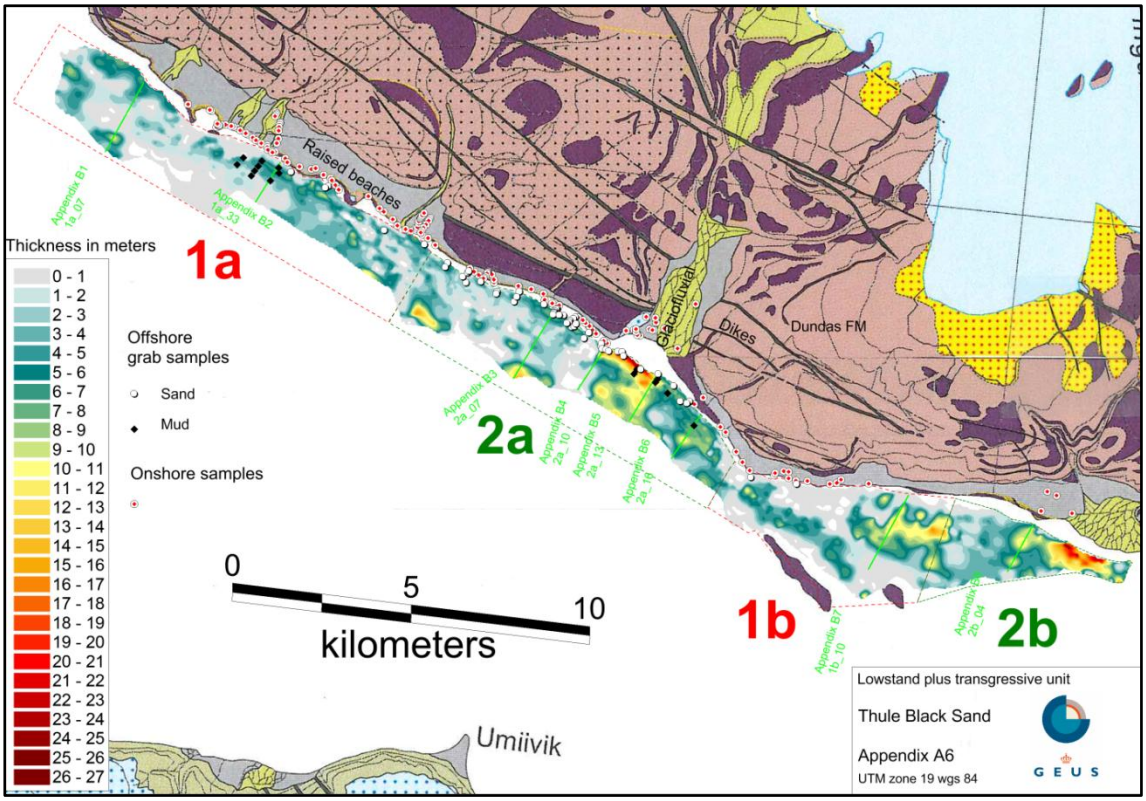


Figure 15. Thickness map of the combined lowstand- and transgressive units. For details see Appendix A6.

6.1 Potential black sand resources in area 1a

In survey area 1a the shallow nearshore zone with water depth down to about 15m (fig. 16) is characterised by transgressive sand deposits in the north-western and the south-eastern parts (Fig. 17), while sedimentary bedrock is found at the seabed in the central part. In the central area an up to 10m thick wedge is found at water depths of 20 to 40m. This represents a lowstand wedge, probably with sandy sediments, covered by a thin transgressive top unit that according to the grab samples consists of muddy sediments (Figure 18). The lowstand wedge is deposited at the margin of a bedrock ridge.
In the deeper parts, at water depths above 30m, we either find bedrock or transgressive unit, deep water, probably muddy sediments heavily influenced by iceberg ploughing (Figs. 17 and 18.

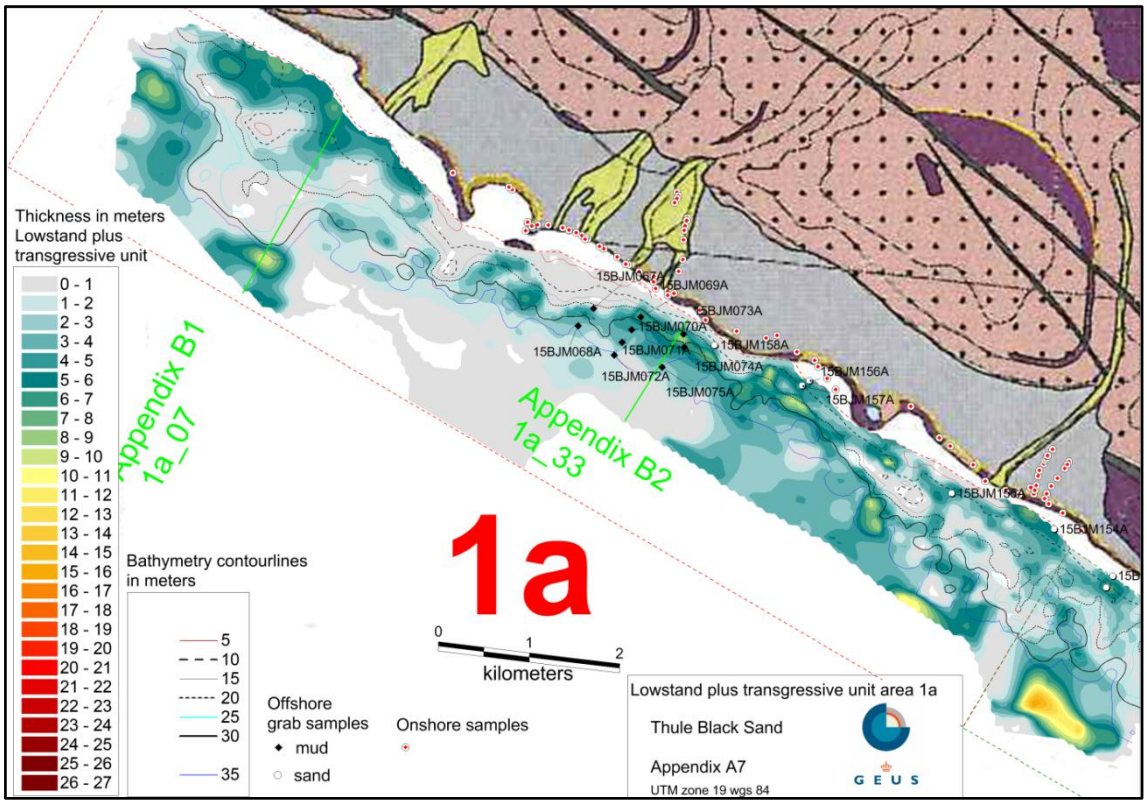


Figure 16. Potential resource thickness in area 1a combined with bathymetry contour lines. The location of onshore samples and offshore grab samples as well as Appendix B1 and B2 profiles are indicated. For details see Appendix A7.

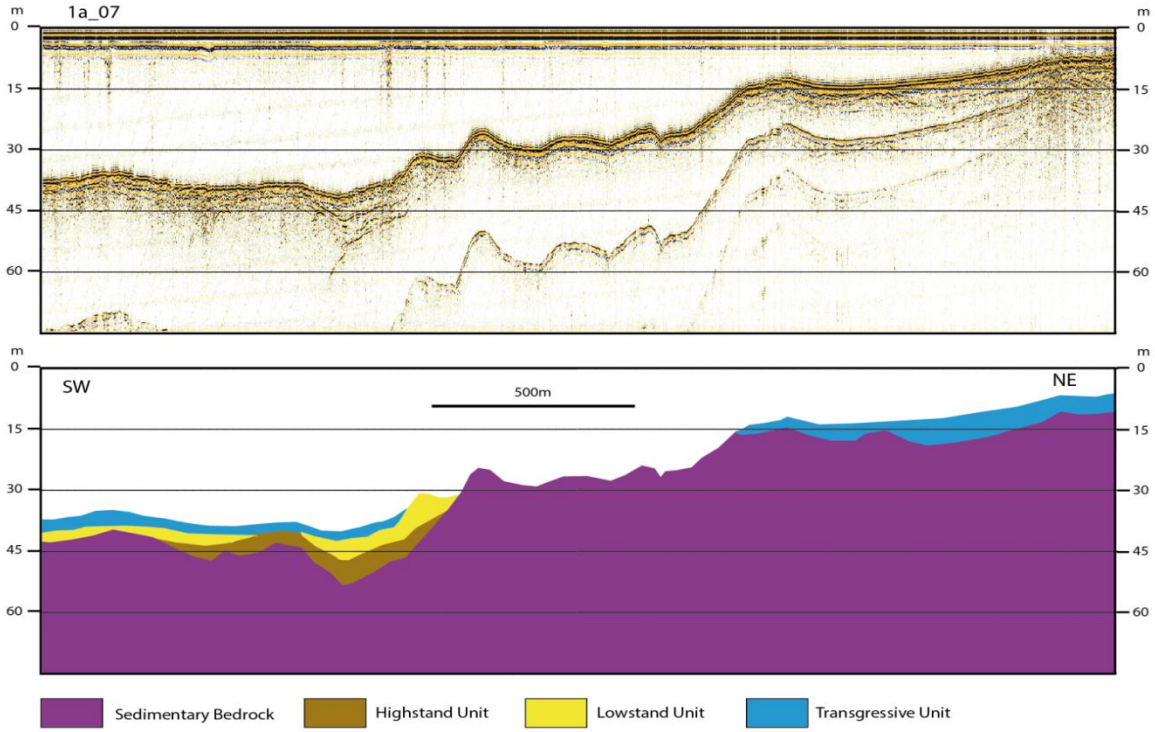


Figure 17. C-boom profile 1a_07 and interpretation of seismic units. For details see appendix B1 and for location Figure 16.

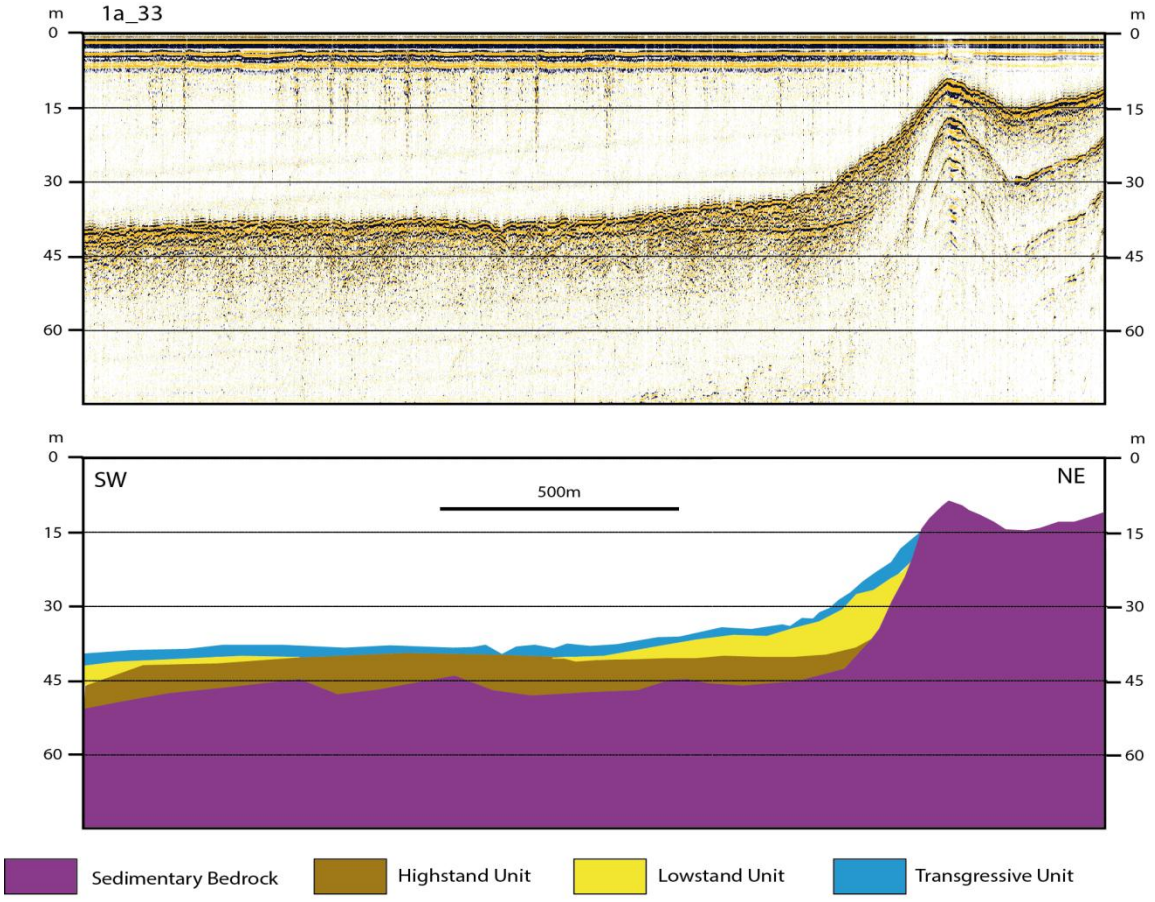


Figure 18. C-boom profile 1a_33 and interpretation of seismic units. For details see appendix B2 and for location Figure 16.

6.2 Potential black sand resources in area 2a

In survey area 2a northwest of the Iterlak delta (Fig. 2) the shallow nearshore zone with water depths down to about 20m (fig. 19) is by grab sampling characterised as transgressive sand (Fig. 20) with a thickness of more than 6m.

Outside the Iterlak delta at water depths of less than 20 to 25m a thick sand body (more than 15m) consists of lowstand- and transgressive unit pro-delta deposits (Figs. 21 and 22). Grab samples show sand at water depths of less than 15m and muddy sediments at water depths over 15m, probably due to transgressive unit mud sedimentation, coupled to stepwise fining upwards sedimentation, related to the sea level rise.

Southeast of the Iterlak delta the nearshore shallow water (less than 20 – 25m) transgressive unit sand body continues as demonstrated in the seismic profile 2a_16 (Fig. 23) with a direct link to the deeper water lowstand unit at water depths of more than 25m. The grab samples once more shows that the shallow seabed with water depths of less than 20m consist of sand, while the deeper parts has a top layer of muddy sediments.

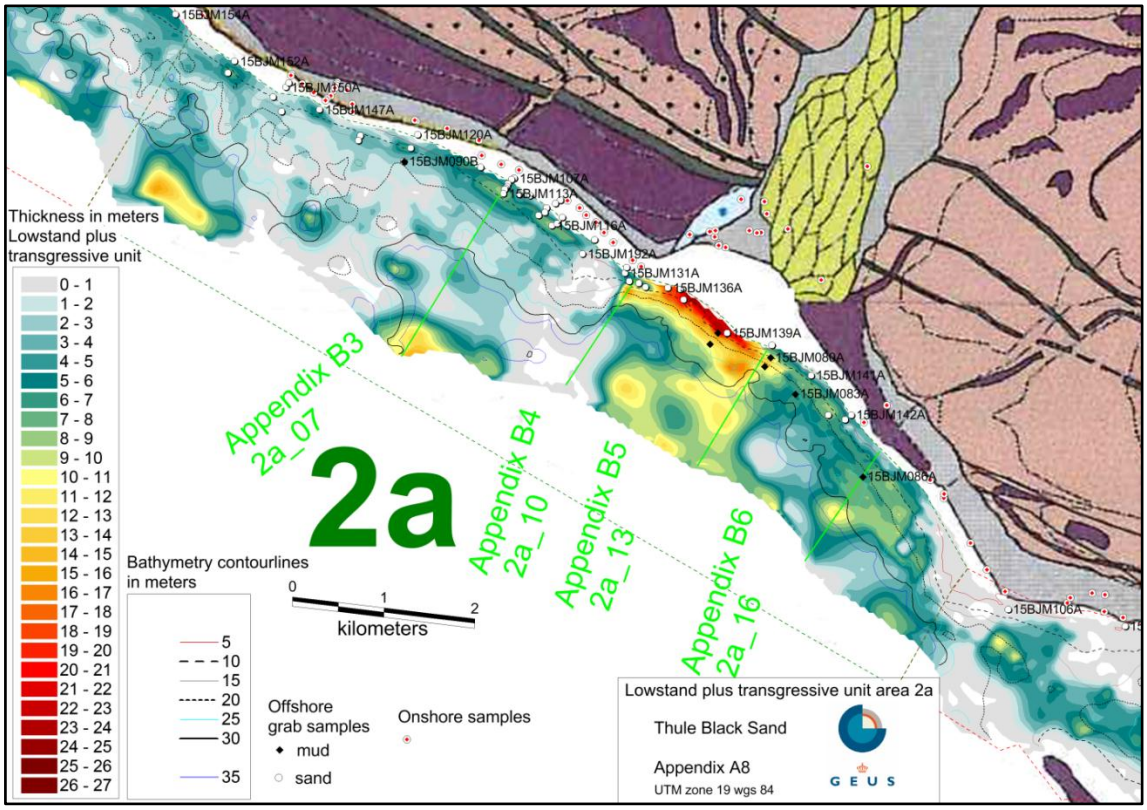


Figure 19. Potential resource thickness in area 2a combined with bathymetry contourlines. The location of onshore samples and offshore grab samples as well as Appendix B3 – b6 and B2 profiles are indicated. For details see Appendix A8.

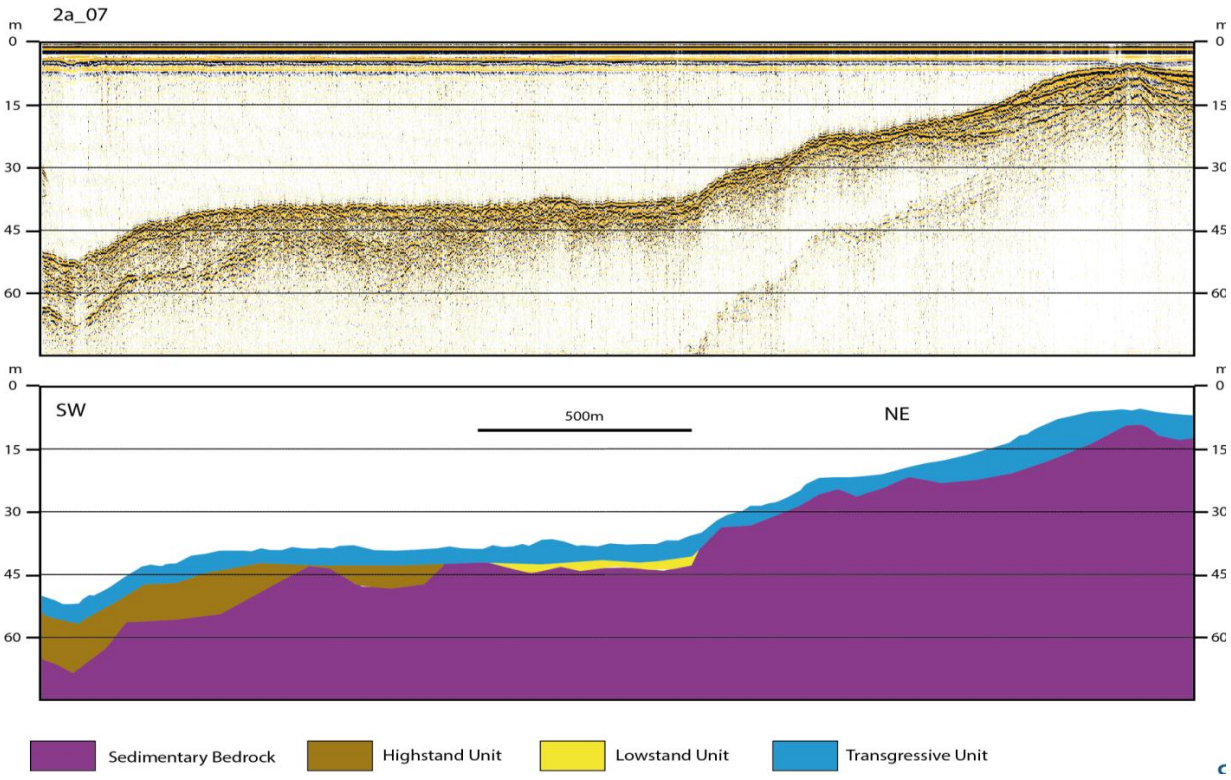


Figure 20. C-boom profile 2a_07 and interpretation of seismic units. For details see appendix B3 and for location Figure 19.

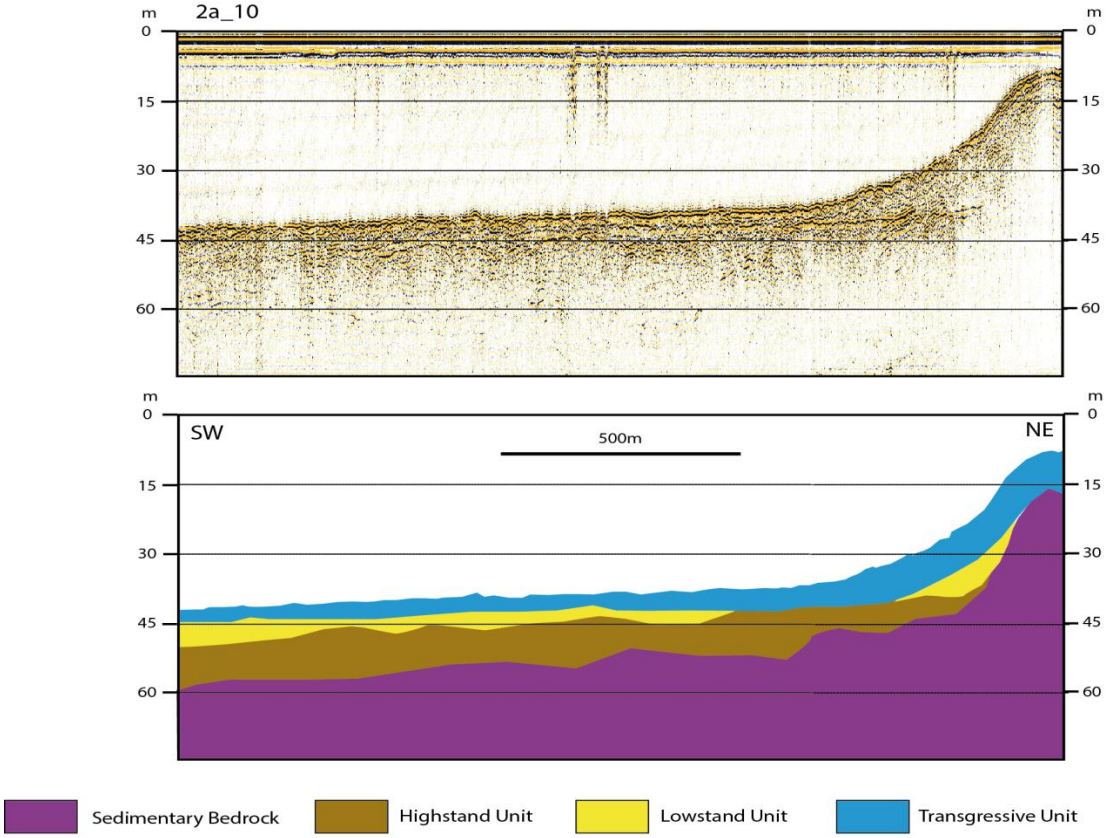


Figure 21. C-boom profile 2a_10 and interpretation of seismic units. For details see appendix B4 and for location Figure 19.

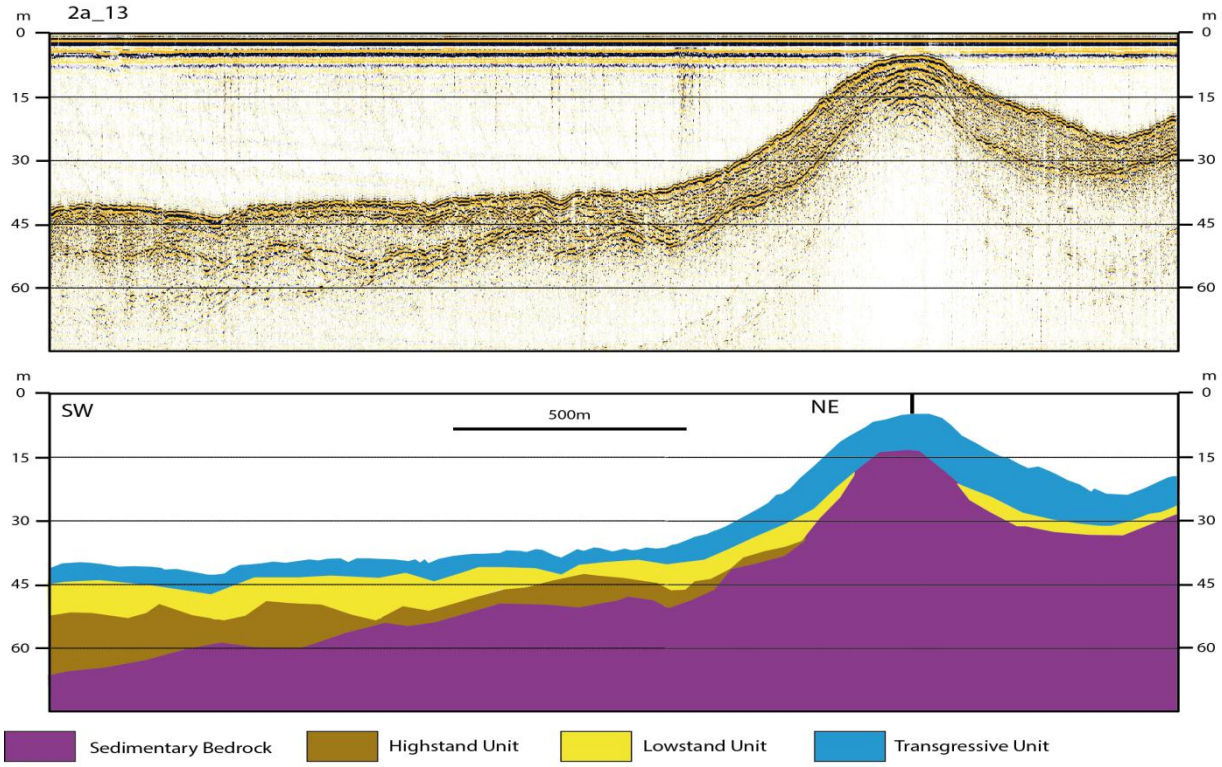


Figure 22. C-boom profile 2a_13 and interpretation of seismic units. For details see appendix B5 and for location Figure 19.

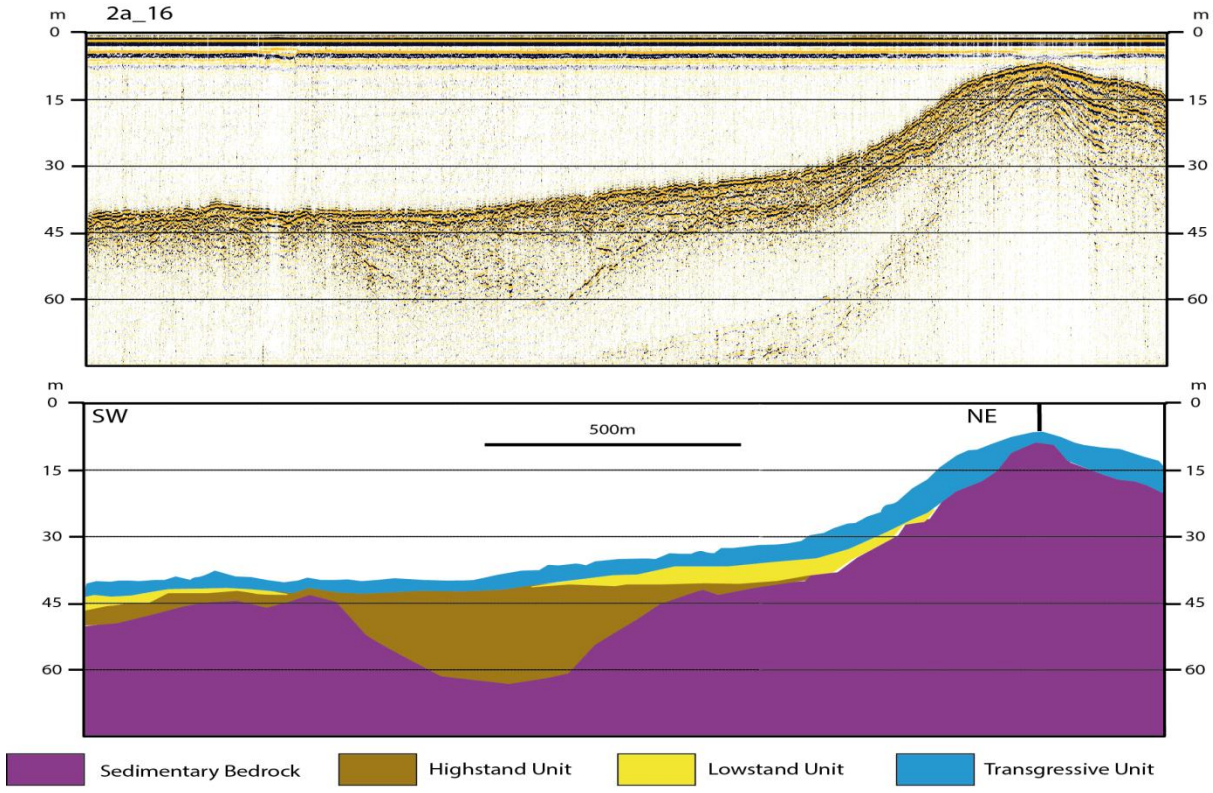


Figure 23. C-boom profile 2a_16 and interpretation of seismic units. For details see appendix B6 and for location Figure 19.

6.3 Potential black sand resources in area 1b and 2b

Survey area 1b and 2b are located west of the Pinguarsuit Sermiat delta (See fig. 2).

Area 1b is the westernmost area (Fig. 24). It is protected by two small islands and in general shallow water depths of less than 20m, except a smaller basin with water depths down to 35m. Seismic profile 1b_10 (Fig. 25) shows that the shallow areas to a large extent consist of bedrock at the seabed, while the basin contains the highstand-, lowstand- and transgressive units.
We have no samples from the basin, but the transparent seismic appearance indicates muddy deep water sediments, except a small wedge-like part of the lowstand unit at water depths of 20 – 30m, which could represent lowstand beach sand deposits. The undisturbed reflectors in the transgressive unit indicates that the basin is protected and not under influence of ploughing icebergs.

Area 2b western part is partly a shallow ridge consisting of bedrock, while the eastern part outside the Pinguarsuit Sermiat delta only has a narrow northern shallow zone of about 500m, before the water depths exceeds 35m. The seabed in the shallow northern rime contains up to about 15m of combined lowstand – and transgressive unit pro-delta deposits that can be expected to follow the pattern offshore the Iterlak delta. At water depths above 20m the seabed is heavily influenced by iceberg plough marks.

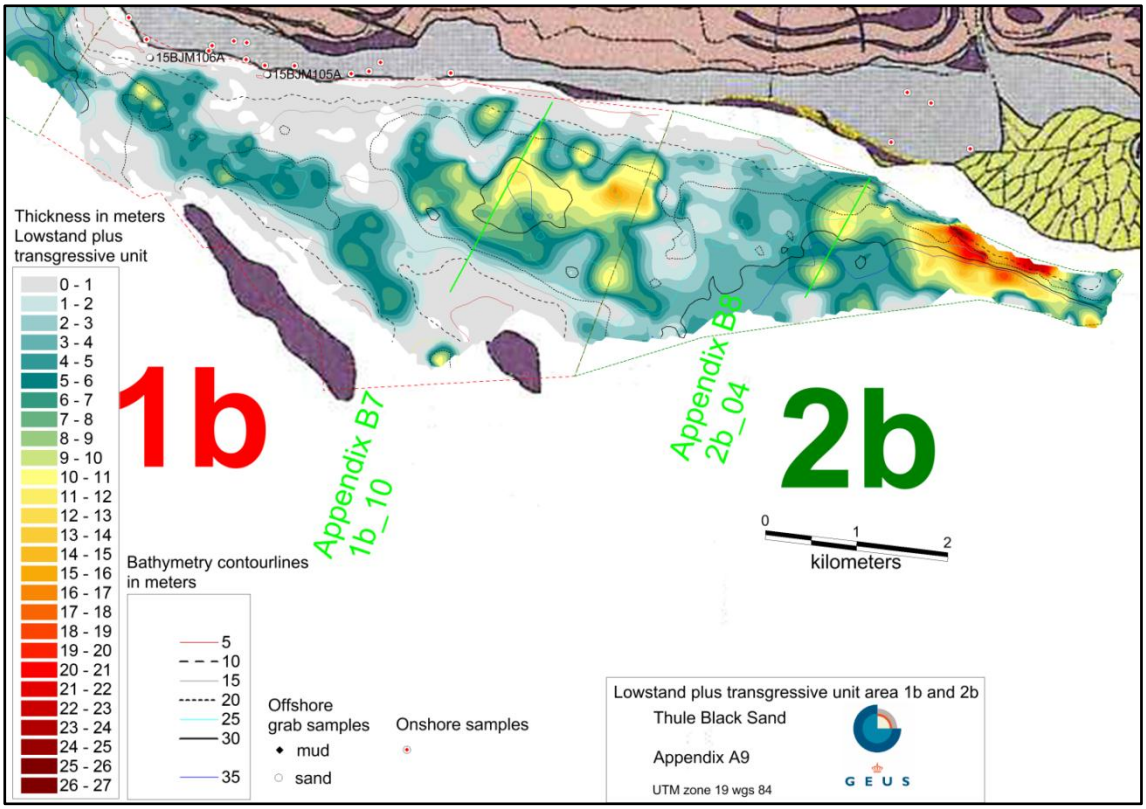


Figure 24. Potential resource thickness in area 1b and 2b combined with bathymetry contour lines. The locations of onshore samples and offshore grab samples as well as Appendix B7 and B8 profiles are indicated. For details see Appendix A9.

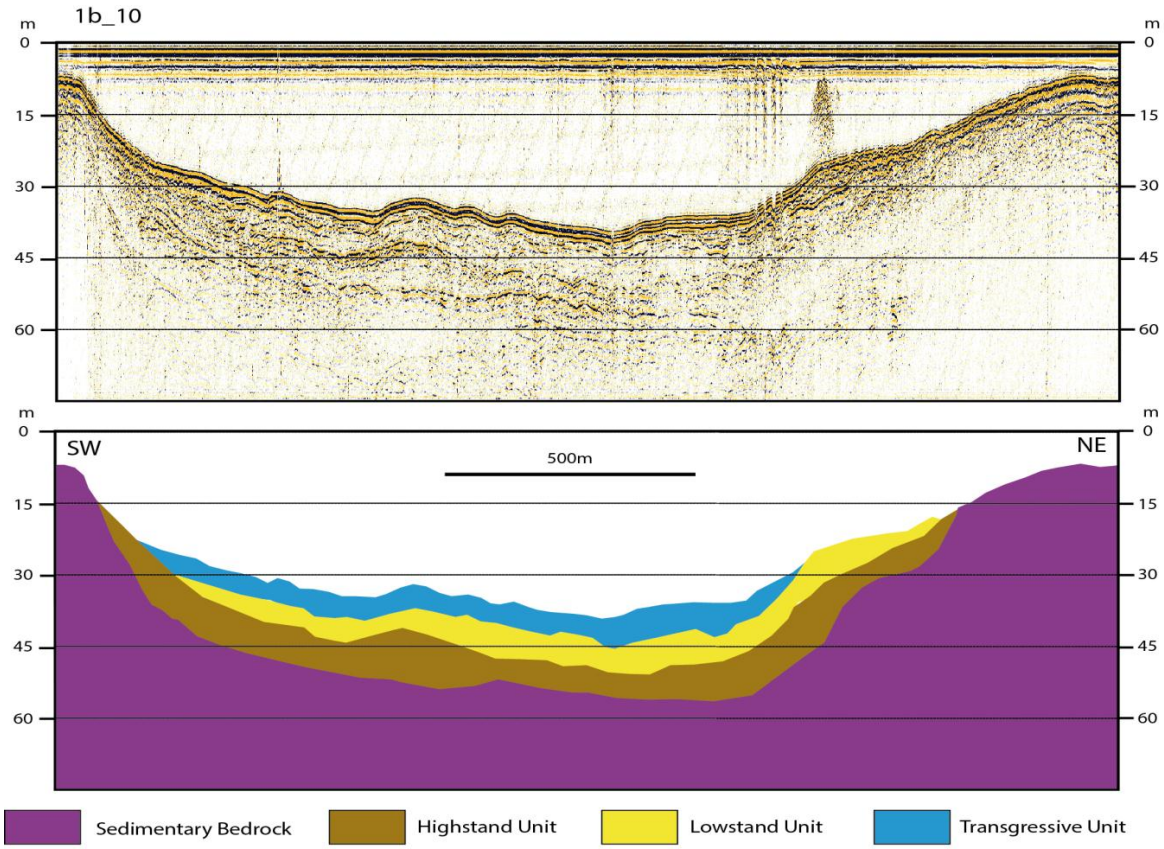


Figure 25. C-boom profile 1b_10 and interpretation of seismic units. For details see appendix B7 and for location Figure 24.

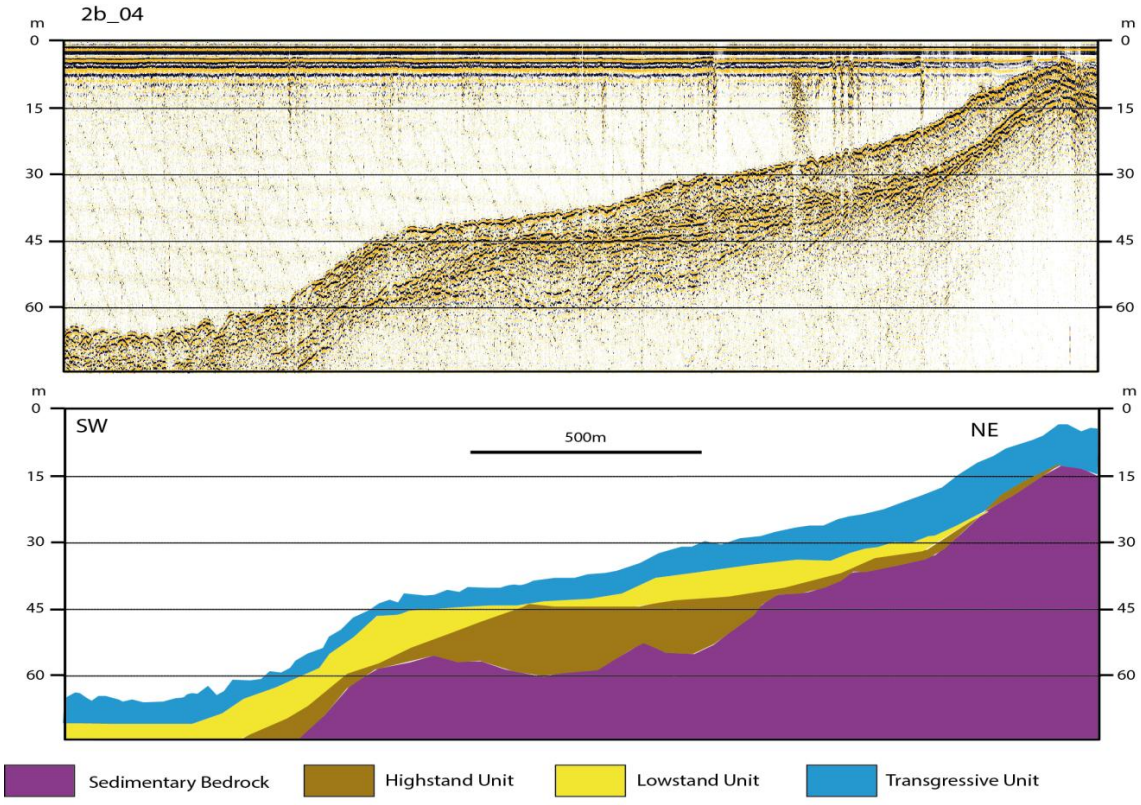


Figure 26. C-boom profile 2b_04 and interpretation of seismic units. For details see appendix B8 and for location Figure 24.

7. Conclusions

The overall conclusions of the combined bathymetric, C - boom and grab sampling survey are.

- The bathymetric survey reveals a shallow zone of water (<15m) up to approximately 500m from shore.

  Medium water depths (15-25m) comprise submerged headlands northeast of Moriusaq and Interlak delta, and south-eastern areas of 1b and 2b

  Water depths of more than 25m dominate areas 1a and 2a

- A geological model has been established, based on published information on the post glacial sea level history. From highstand 30m coastlines above present sea level (13000 years BP), followed by regression to a lowstand about 30m below present sea level (7000 years BP) and a final transgression to the present sea level.

- The geological model was used in the interpretation of the C – boom data and highstand-, lowstand- and transgressive units have been mapped.

- The lowstand- and transgressive seismic units are potential black sand resources and the combined thickness of the two units has been mapped.

- Discontinuous shallow water transgressive unit sand (proved by grab samples) has been mapped in areas 1a and 2a, as well as the easternmost part of area 2b with thickness between 5 and 15m in the most promising areas.

- At medium water depths, transgressive- and lowstand unit deposits have been mapped along the margin of headland bedrock, in area 1a outside the Iterlak delta and in area 2b outside the Pinguarsuit Sermiat delta.

- At deeper waters above 30m deep water muddy sediments can be expected, with heavy disturbance by iceberg ploughing.

- The shallow basin area 1b is a protected basin in general with little indication of possible resources.

8. Recommendations

On the basis of the detailed studies carried out in the Thule Black sand survey, we recommend to verify the findings in the seismic interpretation by conducting a follow up sampling survey.
With a coring devise that can penetrate about 6m into the seabed, it will be possible, in combination with the C-boom data, to map potential high grade sand deposits and calculate resource volumes.

9. References

Appel, P.W.U., Dawes, P.R.. Garde, A.A. Kalvig, P., Ghisler, M. & Schønwandt, H.K 1991: Potential small scale mining projects in West Greenland. Unpublished report produced by GGU and Mineral Development International A/S for Grønlands Baseselskab A/S, 62 pp.

Dawes, P.R. 2006: Explanatory notes to the geological map of Greenland, 1:500 000, Thule, Sheet 5. Geological Survey of Denmark and Greenland Map Series 2, 97 pp + map.

Fleming, K. & Lambeck, K. 2004: Constrains on the Greenland Ice Sheet since the Last Glacial Maximum from sea-level observations and glacial-rebound models. Quaternary Science Reviews 23, 1053–1077.

Weatherley, S. 2015: Summary of geological field data from the Black Sand Province collected in 2015. GEUS report 2015/83.

10. Appendices

10.1 A appendices

- Appendix A1 Survey tracklines.
- Appendix A2 total Bathymetry.
- Appendix A3 area 1a Bathymetry.
- Appendix A4 area 2a Bathymetry.
- Appendix A5 areas 1b and 2b Bathymetry.
- Appendix A6 total resource thickness.
- Appendix A7 area 1a resource thickness.
- Appendix A8 area 2a resource thickness.
- Appendix A9 area 1b and 2b resource thickness

10.2 B appendices

- Appendix B1 C-Boom line 1a_07
- Appendix B2 C-Boom line 1a_33
- Appendix B3 C-Boom line 2a_07
- Appendix B4 C-Boom line 2a_10
- Appendix B5 C-Boom line 2a_13
- Appendix B6 C-Boom line 2a_16
- Appendix B7 C-Boom line 1b_10
- Appendix B8 C-Boom line 2b_04

10.3 C appendices

- Appendix C1 Sample points page 1 of 3
- Appendix C1 Sample points page 2 of 3
- Appendix C1 Sample points page 3 of 3

11. Digital data delivery

In addition to the report the following will be delivered:

- Report as well as A,B and C appendix in PDF format
- Survey lines in MapInfo GIS format utm zone 19 wgs84
- Grab sample points sand, mud and onshore samples in MapInfo utm zone 19 wgs 84.
- Bathymetric X,Y, Z data in meters below sea level corrected for tidal effects. One file including Navisound 620 data and one file including additional Garmin echo sounder data. Both files are in ASC format.
- Bathymetric Grid in Vertical mapper GRD file format utm zone 19 wgs 84.
- Thickness X,Y, Z data in meters ASC format
- Resource thickness Grid in Vertical mapper GRD file format utm zone 19 wgs 84.
- Appendix A1 Survey tracklines MapInfo workspace plus tab files.
- Appendix A2 total Bathymetry MapInfo workspace plus tab files.
- Appendix A3 1a Bathymetry MapInfo workspace plus tab files.
- Appendix A4 2a Bathymetry MapInfo workspace plus tab files.
- Appendix A5 1b and 2b Bathymetry MapInfo workspace plus tab files.
- Appendix A6 total resource thickness MapInfo workspace plus tab files.
- Appendix A7 1a resource thickness MapInfo workspace plus tab files.
- Appendix A8 2a resource thickness MapInfo workspace plus tab files.
- Appendix A9 1b and 2b resource thickness MapInfo workspace plus tab files.
- Appendix C1 sample information in excel spreadsheet

Raised beaches

Glaciofluvial

Dikes

Dundas FM

Appendix B1
1a_07

Appendix B2
1a_33

1a

Appendix B3
2a_07

2a

Appendix B4
2a_10

Appendix B5
2a_13

Appendix B6
2a_16

1b

Appendix B7
1b_10

Appendix B8
2b_04

2b

Survey track lines

Bathymetry and C-boom

Additional echosounder data

0 5 10

kilometers

Umiivik

Thule Black Sand

Appendix A1

UTM zone 19 wgs 84

GEUS

Bathymetry
in meters

2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48

Offshore grab samples

- Mud
- Sand

Onshore samples

Raised beaches

Glaciofluvial

Dikes

Dundas FM

Appendix B1
1a_01

Appendix B2
1a_33

1a

Appendix B3
2a_07

2a

Appendix B4
2a_10

Appendix B5
2a_13

Appendix B6
2a_16

1b

Appendix B7
1b_10

Appendix B8
2b_04

2b

0 5 10
kilometers

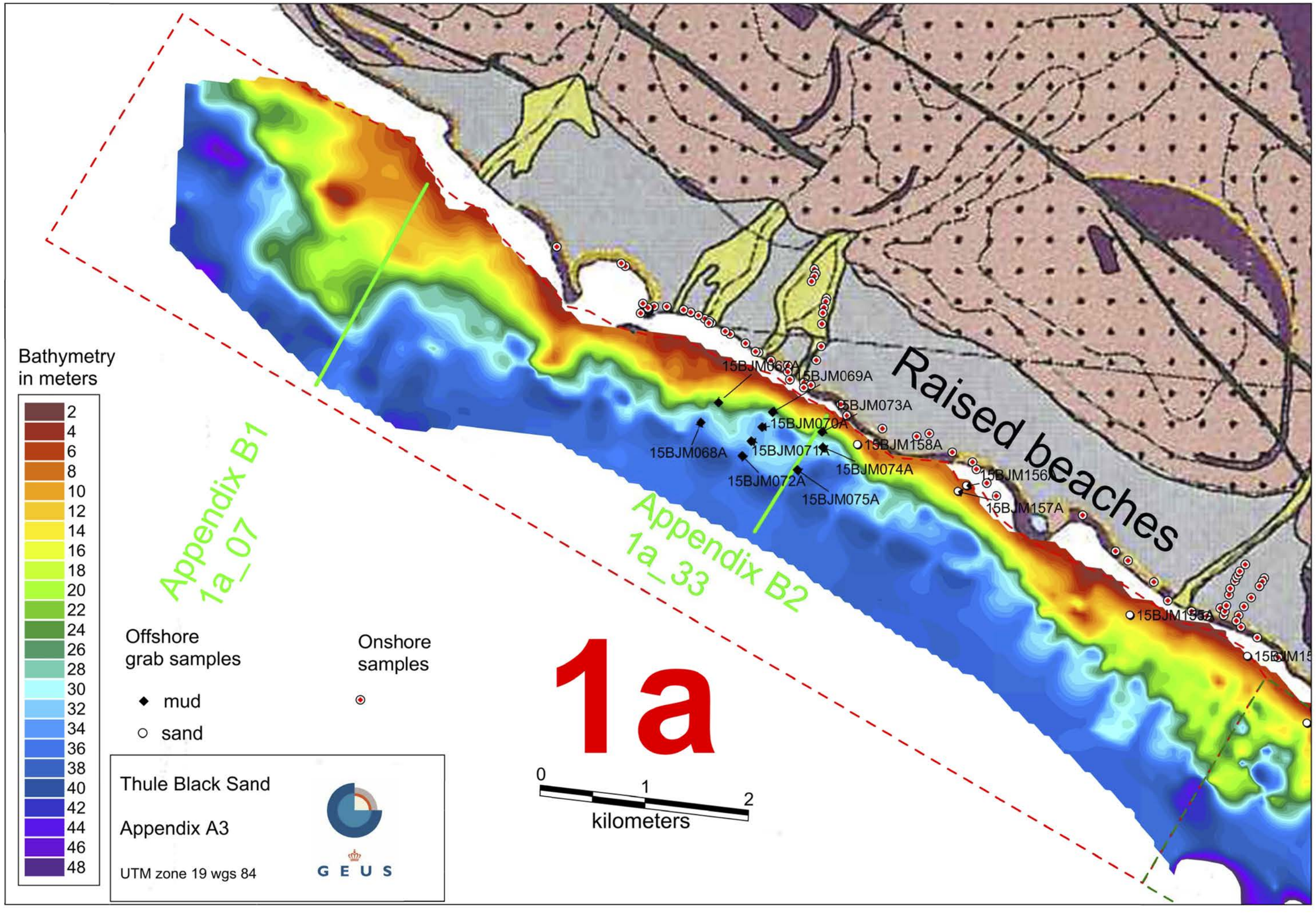
Umiivik

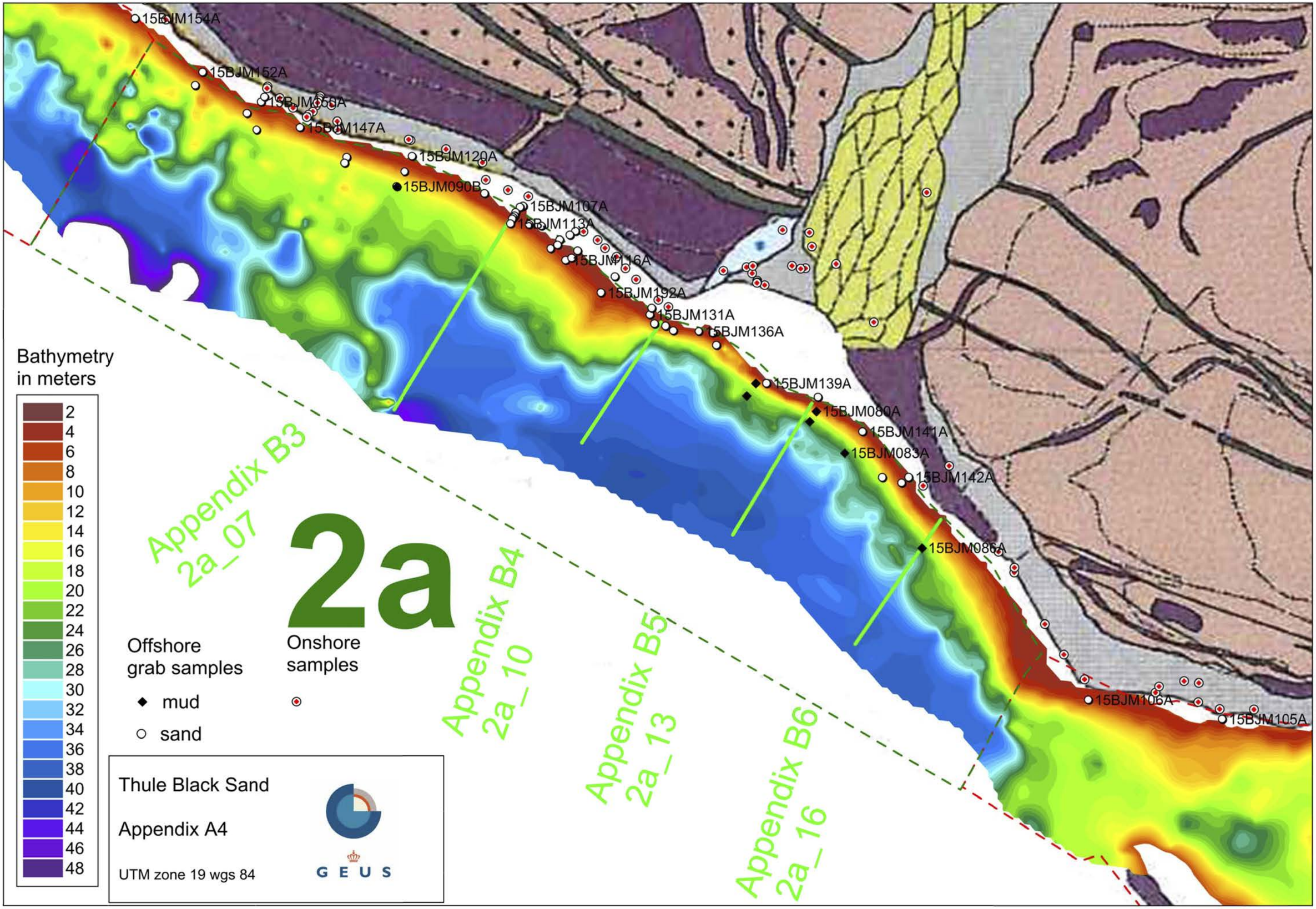
Thule Black Sand

Appendix A2

UTM zone 19 wgs 84

GEUS


Bathymetry
in meters
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Appendix B1
1a_07
Appendix B2
1a_33
Raised beaches
15BJM069A
15BJM073A
15BJM070A
15BJM158A
15BJM068A
15BJM071A
15BJM074A
15BJM072A
15BJM075A
15BJM156A
15BJM157A
15BJM15
Offshore
grab samples
mud
sand
Onshore
samples
1a
0
1
2
kilometers
Thule Black Sand
Appendix A3
UTM zone 19 wgs 84
GEUS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15BJM152A
15BJM147A
15BJM120A
15BJM090B
15BJM107A
15BJM113A
15BJM116A
15BJM192A
15BJM131A
15BJM136A
15BJM139A
15BJM080A
15BJM141A
15BJM083A
15BJM142A
15BJM086A
15BJM106A
15BJM105A
Bathymetry
in meters
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Appendix B3
2a_07
2a
Appendix B4
2a_10
Appendix B5
2a_13
Appendix B6
2a_16
Offshore
grab samples
mud
sand
Onshore
samples
Thule Black Sand
Appendix A4
UTM zone 19 wgs 84
GEUS

15BJM106A

15BJM105A

Bathymetry
in meters

2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48

1b

2b

Appendix B8

Appendix B7
1b_10

Appendix A4
2b_04

Offshore
grab samples

◆ mud

○ sand

Onshore
samples

0 1 2
kilometers

Thule Black Sand

Appendix A5

UTM zone 19 wgs 84

GEUS

Thickness in meters

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
10 - 11
11 - 12
12 - 13
13 - 14
14 - 15
15 - 16
16 - 17
17 - 18
18 - 19
19 - 20
20 - 21
21 - 22
22 - 23
23 - 24
24 - 25
25 - 26
26 - 27

Offshore grab samples

Sand

Mud

Onshore samples

0 5 10

kilometers

Raised beaches

Glaciofluvial

Dikes

Dundas FM

Umiivik

Appendix B1 1a_07

Appendix B2 1a_33

Appendix B3 2a_07

Appendix B4 2a_10

Appendix B5 2a_13

Appendix B6 2a_16

Appendix B7 1b_10

Appendix B8 2b_04

1a

2a

1b

2b

Lowstand plus transgressive unit

Thule Black Sand

Appendix A6

UTM zone 19 wgs 84

GEUS

Thickness in meters
Lowstand plus
transgressive unit

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- 11 - 12
- 12 - 13
- 13 - 14
- 14 - 15
- 15 - 16
- 16 - 17
- 17 - 18
- 18 - 19
- 19 - 20
- 20 - 21
- 21 - 22
- 22 - 23
- 23 - 24
- 24 - 25
- 25 - 26
- 26 - 27

Bathymetry contourlines
in meters

- 5
- 10
- 15
- 20
- 25
- 30
- 35

Offshore
grab samples

- mud
- sand

Onshore samples

15BJM069A
15BJM073A
15BJM070A
15BJM158A
15BJM068A
15BJM071A
15BJM074A
15BJM156A
15BJM072A
15BJM075A
15BJM157A
15BJM155A
15BJM154A
15B

Appendix B1
1a_07

Appendix B2
1a_33

1a

0 1 2
kilometers

Lowstand plus transgressive unit area 1a

Thule Black Sand

Appendix A7

UTM zone 19 wgs 84

GEUS

15BJM154A
15BJM152A
15BJM150A
15BJM147A
15BJM120A
15BJM090B
15BJM107A
15BJM113A
15BJM116A
15BJM192A
15BJM131A
15BJM136A
15BJM139A
15BJM080A
15BJM141A
15BJM083A
15BJM142A
15BJM086A
15BJM106A
15

Thickness in meters
Lowstand plus transgressive unit

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
10 - 11
11 - 12
12 - 13
13 - 14
14 - 15
15 - 16
16 - 17
17 - 18
18 - 19
19 - 20
20 - 21
21 - 22
22 - 23
23 - 24
24 - 25
25 - 26
26 - 27

Appendix B3 2a_07
Appendix B4 2a_10
Appendix B5 2a_13
Appendix B6 2a_16

2a

Bathymetry contourlines in meters

5
10
15
20
25
30
35

0 1 2
kilometers

Offshore grab samples
mud
sand

Onshore samples

Lowstand plus transgressive unit area 2a

Thule Black Sand

Appendix 8

UTM zone 19 wgs 84

GEUS

15BJM106A

15BJM105A

Thickness in meters
Lowstand plus
transgressive unit

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
10 - 11
11 - 12
12 - 13
13 - 14
14 - 15
15 - 16
16 - 17
17 - 18
18 - 19
19 - 20
20 - 21
21 - 22
22 - 23
23 - 24
24 - 25
25 - 26
26 - 27

1b

2b

Appendix B7
1b_10

Appendix B8
2b_04

0
1
2
kilometers

Bathymetry contourlines
in meters

5
10
15
20
25
30
35

Offshore
grab samples
◆ mud
○ sand

Onshore samples

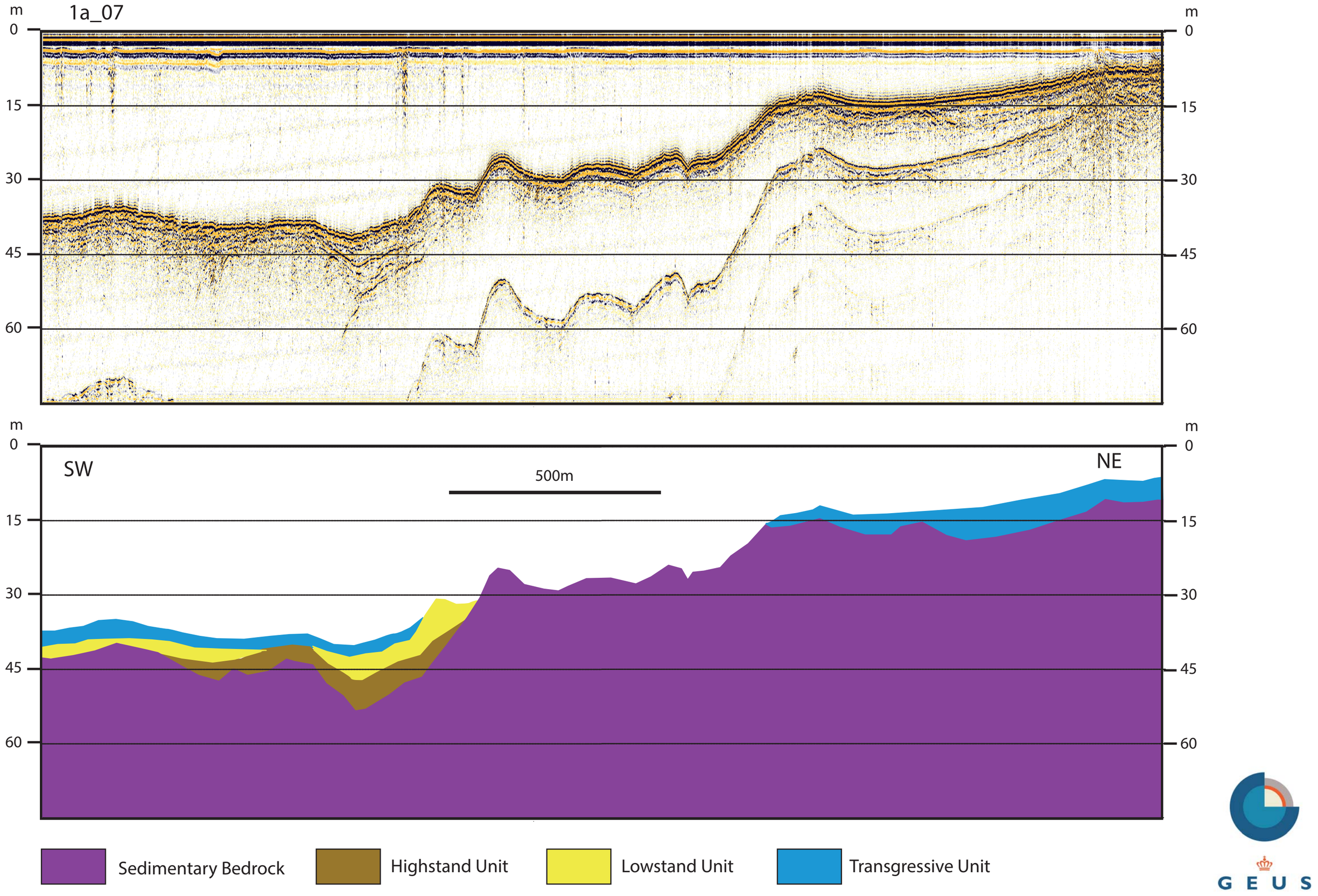
Lowstand plus transgressive unit area 1b and 2b

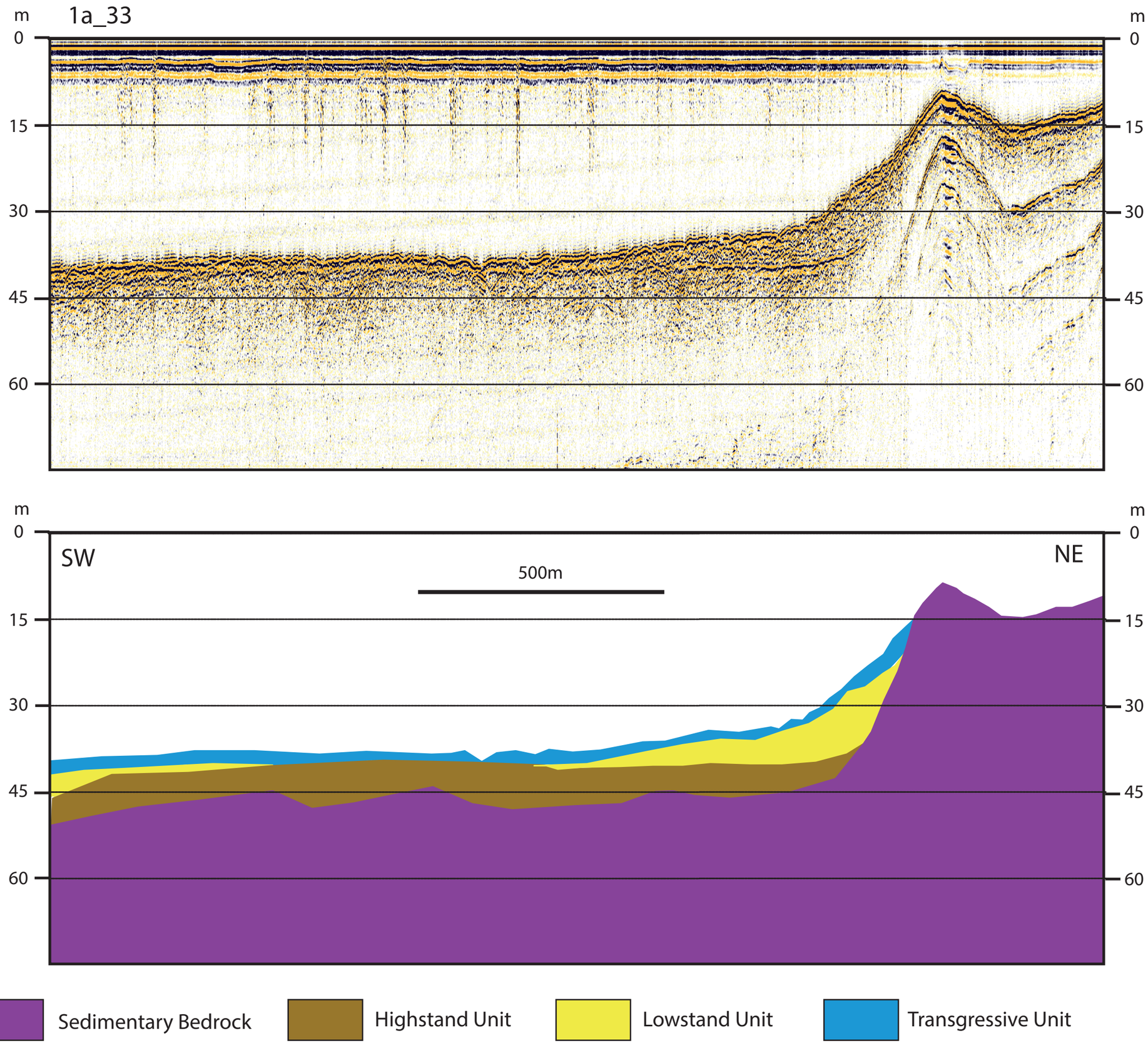
Thule Black Sand

Appendix A9

UTM zone 19 wgs 84

GEUS


m
0
15
30
45
60
1a_07
SW
500m
NE
Sedimentary Bedrock
Highstand Unit
Lowstand Unit
Transgressive Unit


m
1a_33
0
15
30
45
60
m
SW
NE
500m
Sedimentary Bedrock
Highstand Unit
Lowstand Unit
Transgressive Unit

GEUS

2a_07

m
0
15
30
45
60

SW

500m

NE

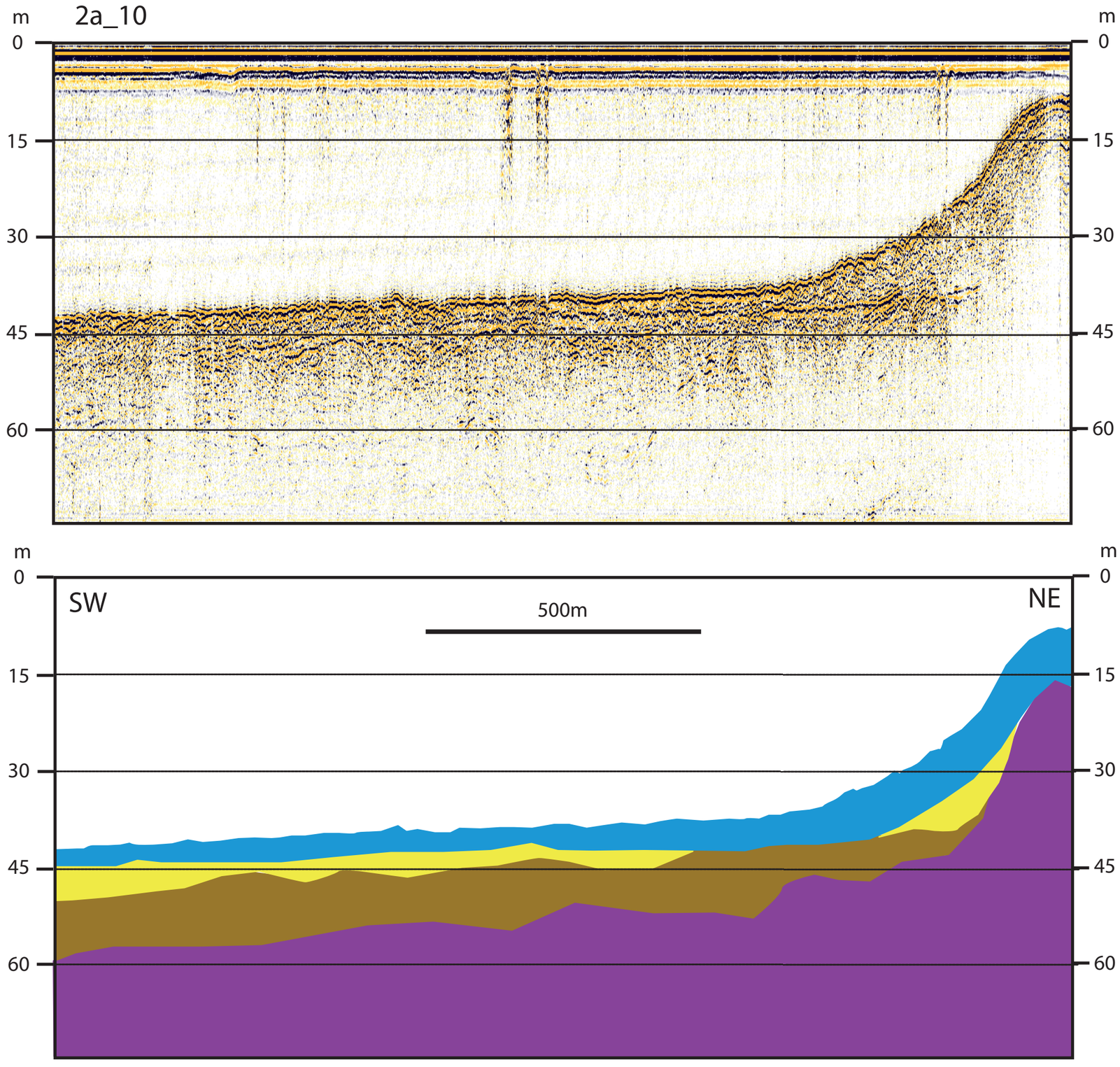
Sedimentary Bedrock

Highstand Unit

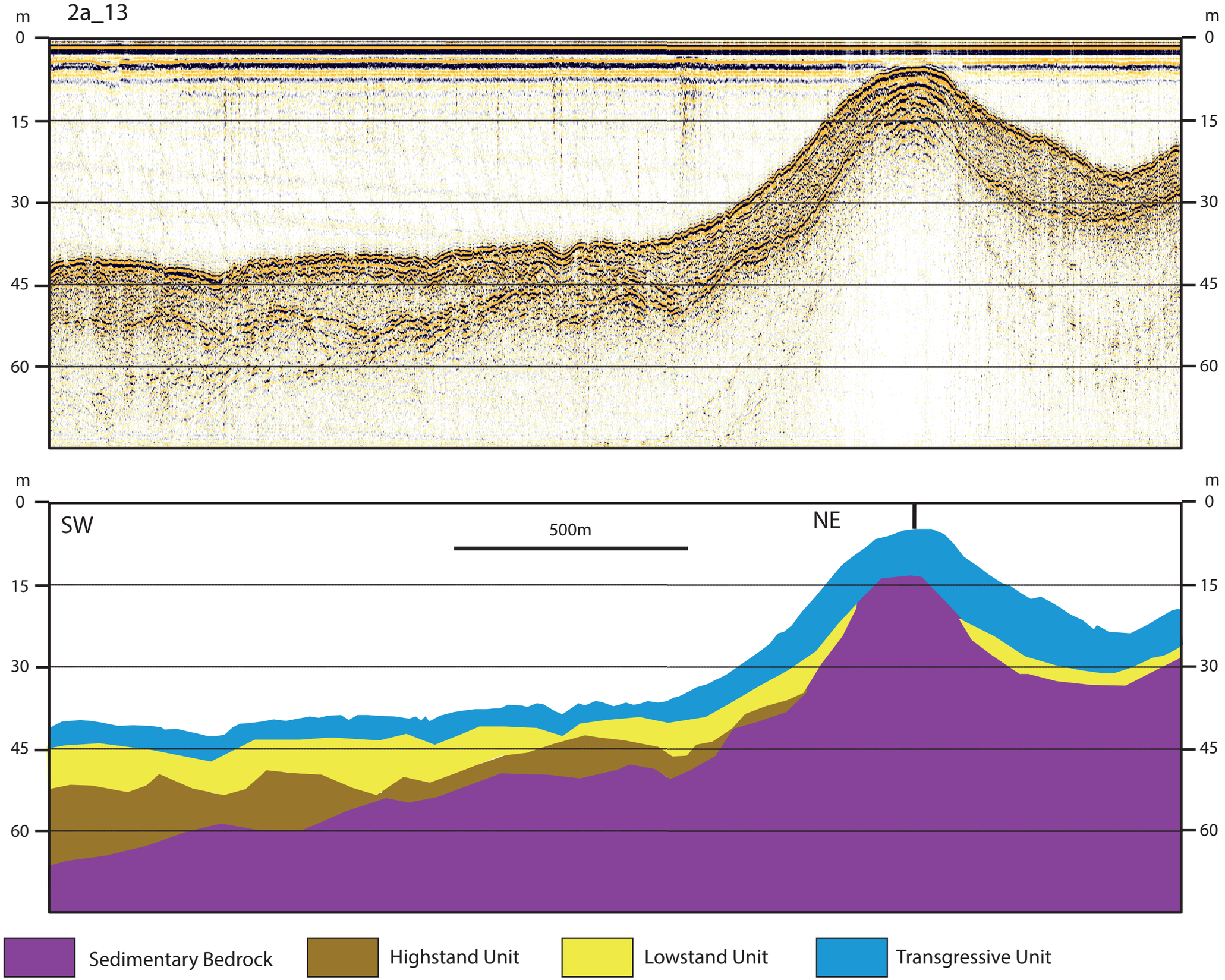
Lowstand Unit

Transgressive Unit

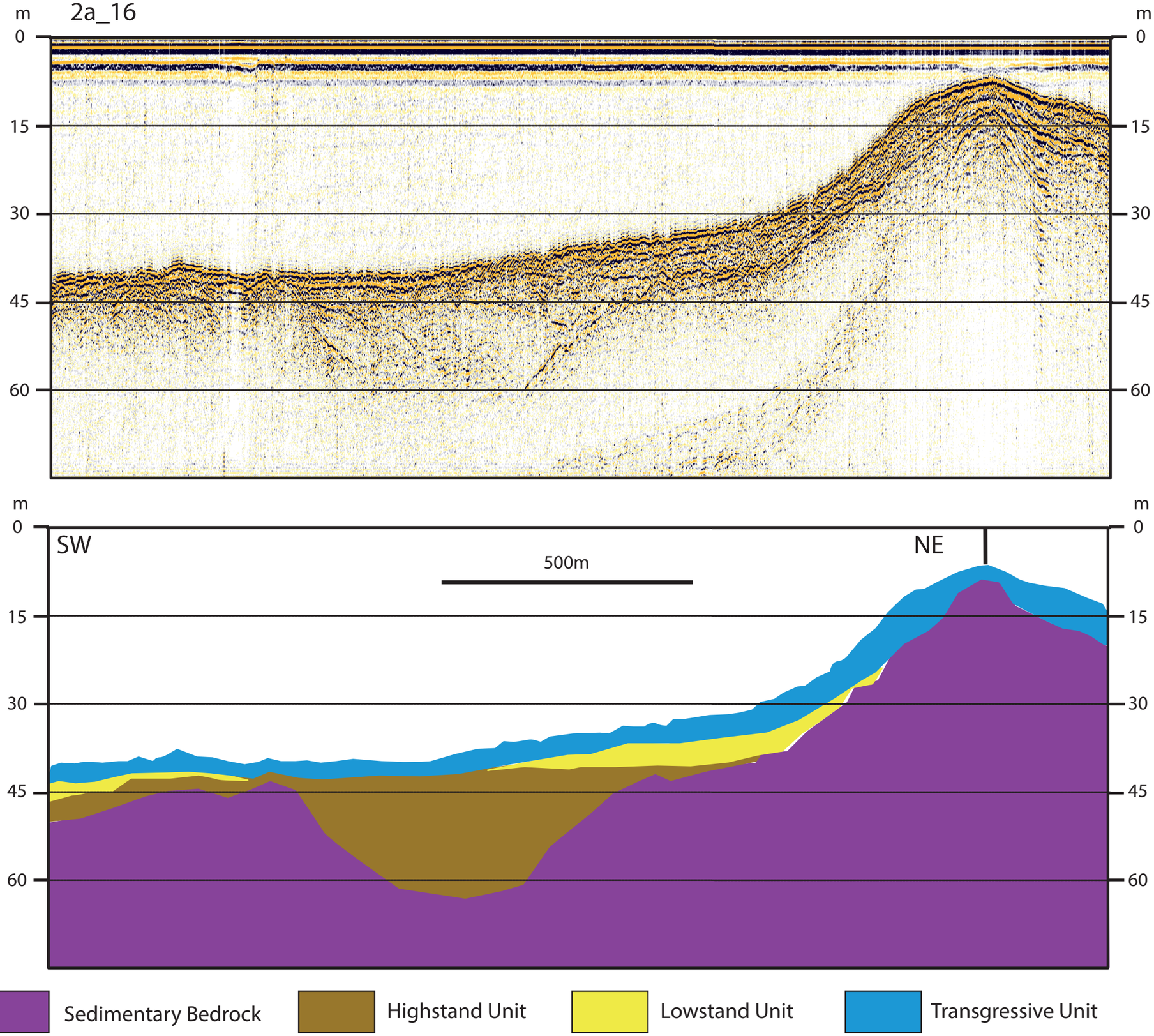
GEUS


m
2a_10
0
15
30
45
60
m
SW
500m
NE
Sedimentary Bedrock
Highstand Unit
Lowstand Unit
Transgressive Unit

GEUS

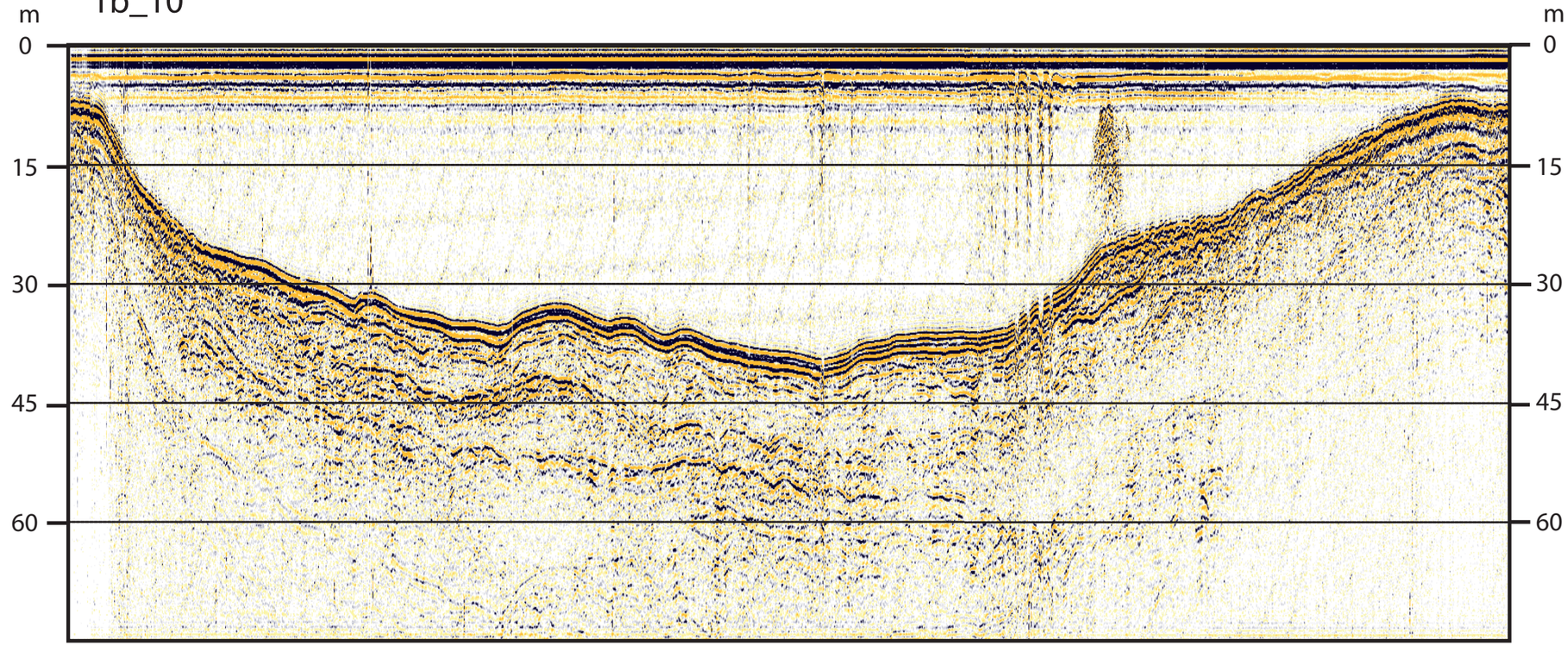

2a_13
m
0
15
30
45
60
SW
500m
NE
Sedimentary Bedrock
Highstand Unit
Lowstand Unit
Transgressive Unit

GEUS


m
2a_16
0
15
30
45
60
SW
NE
500m
Sedimentary Bedrock
Highstand Unit
Lowstand Unit
Transgressive Unit

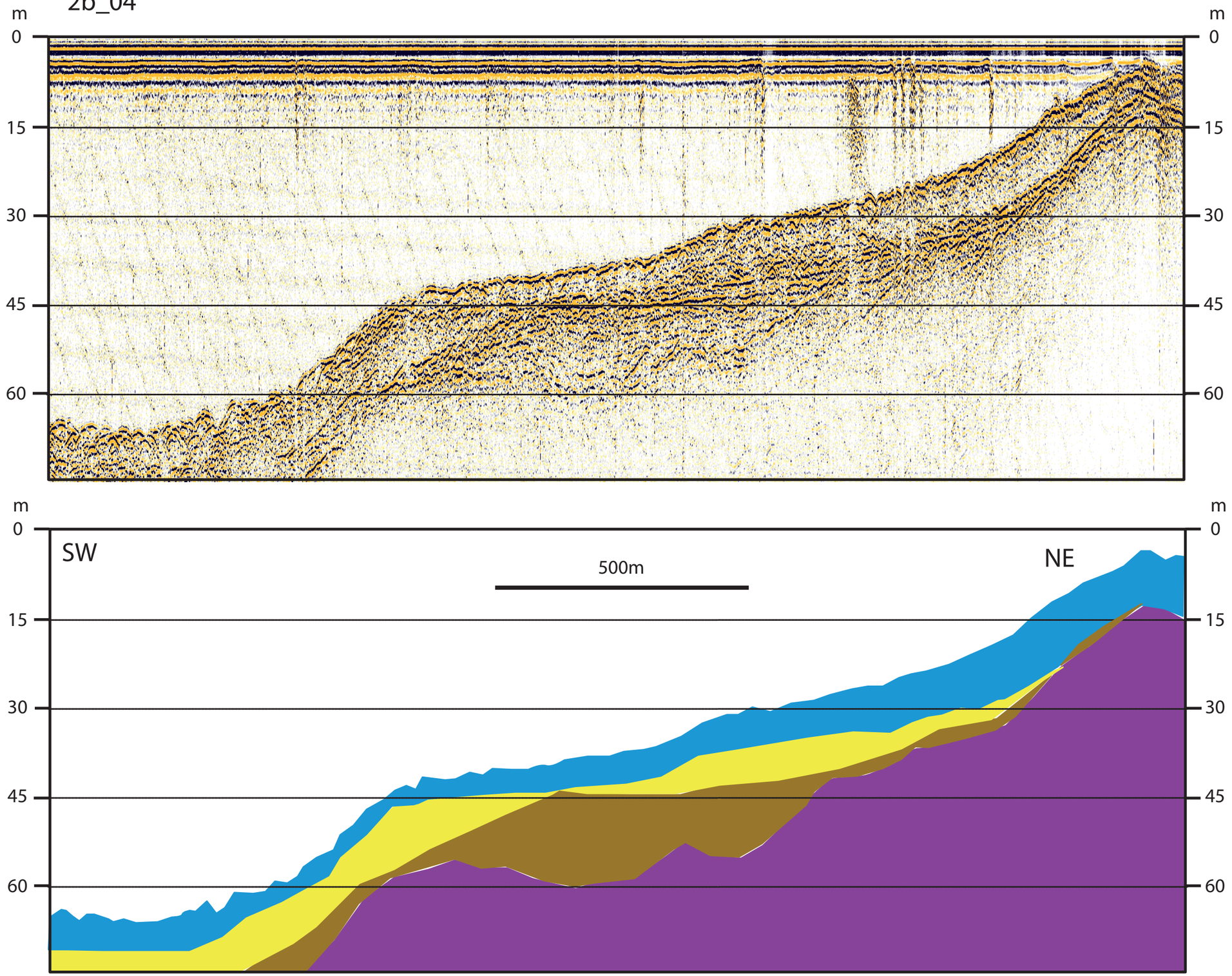
GEUS

1b_10


m
0
15
30
45
60
m
SW
NE
500m
Sedimentary Bedrock
Highstand Unit
Lowstand Unit
Transgressive Unit

GEUS

2b_04


m
0
15
30
45
60
SW
500m
NE
Sedimentary Bedrock
Highstand Unit
Lowstand Unit
Transgressive Unit

GEUS

Date	SampleNum	Easting mE	Northing mN	Zone UTM WGS 84	GEUS SampleNum	Shipment_Bag	Beach_area	Sample Depth (cm)	RL (m)	Active beach	Raised terace	Offshore	Description	Discarded?	metallics % (est.) / notes	pan/wash
06-08-2015	BJM_1000	453988	8537507	19 X	none	1	1	30	<2	1	0	0				
06-08-2015	BJM_1001	478242	8532230	19 X	none	1	1	30	<2	1	0	0				
06-08-2015	BJM_1002	476953	8531094	19 X	none	1	1	30	<2	1	0	0	2 samples 2nd taken from 476886 8530872			
07-08-2015	BJM_1003	477395	8519571	19 X	none	1	1	30	<2	1	0	0	sea shore			
07-08-2015	BJM_1004	478054	8519465	19 X	none	1	1	30	<2	1	0	0	sea shore 2 samples in one spot			
07-08-2015	BJM_1005	478054	8519465	19 X	none	RM	1	30	<2	1	0	0	sea shore 2 samples in one spot			
07-08-2015	BJM_1006	478234	8519119	19 X	none	1	1	30	<2	1	0	0	sea shore			
07-08-2015	BJM_1007	479355	8518791	19 X	none	1	1	30	<2	1	0	0	beach north of settlement			
07-08-2015	BJM_1008	479079	8518933	19 X	none	1	1	30	<2	1	0	0	beach north of settlement			
07-08-2015	BJM_1009	478898	8519020	19 X	none	1	1	30	<2	1	0	0	beach/runoff from stream			
07-08-2015	BJM_1010	478695	8519093	19 X	none	RM	1	30	<2	1	0	0	2 samples from 'boat hull'			
07-08-2015	BJM_1011	478695	8519093	19 X	none	RM	1	30	<2	1	0	0	2 samples from 'boat hull'			
08-08-2015	BJM_1012	490031	8514762	19 X	none	RM	3	30	<2	1	0	0	Near Thule on uplifted beach			
08-08-2015	BJM_1013	490209	8514611	19 X	none	RM	1	30	<2	1	0	0	Beach grab			
12-08-2015	15BJM001A	478691	8519096	19 X	560927	2	1	30	<2	1	0	0	Large bag to make concentrates		10	
12-08-2015	15BJM002A	478832	8519050	19 X	560928	2	1	30	<2	1	0	0	Spade depth		30	
12-08-2015	15BJM003A	478769	8519075	19 X	560929	2	1	30	<2	1	0	0	Spade depth		40	
12-08-2015	15BJM004A	478623	8519112	19 X	560930	2	1	5	<2	1	0	0	Surface 5cm		80	
12-08-2015	15BJM004B	478623	8519112	19 X	560930	2	1	30	<2	1	0	0	Spade depth		representative	
12-08-2015	15BJM005A	478462	8519123	19 X	560931	2	1	30	<2	1	0	0	Spade depth		80	
12-08-2015	15BJM006A	478342	8519111	19 X	560932	2	1	30	<2	1	0	0	Spade depth		30	
12-08-2015	15BJM007A	478289	8519087	19 X	560933	2	1	30	<2	1	0	0	Spade depth		20	
12-08-2015	15BJM008A	478214	8519030	19 X	560934	2	1	30	<2	1	0	0	Spade depth		30	
12-08-2015	15BJM009A	478293	8519066	19 X	560935	2	1	2	<2	1	0	0	Top 2cm		resasonable	
12-08-2015	15BJM009B	478289	8519072	19 X	560936	2	1	2	<2	1	0	0	Top 2cm		resasonable	
12-08-2015	15BJM009C	478283	8519080	19 X	560937	2	1	2	<2	1	0	0	Top 2cm		resasonable	
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12-08-2015	15BJM011A	478015	8519487	19 X	560940	3	1	15	<2	1	0	0	Top 15cm		40	
12-08-2015	15BJM012A	478878	8519034	19 X	560941	3	1	30	<2	1	0	0	Spade depth		20-30	
12-08-2015	15BJM012B	478878	8519034	19 X	none	3	1	30	<2	1	0	0	Spade depth		?	
12-08-2015	15BJM013A	478872	8519014	19 X	560942	3	1	30	<2	1	0	0	Spade depth in intertidal area		30	
12-08-2015	15BJM014A	479031	8518954	19 X	560943	3	1	30	<2	1	0	0	Spade depth		?	
12-08-2015	15BJM015A	479228	8518861	19 X	560944	3	3	30	15	1	0	0	Spade depth up stream 75m		?	pan to check
13-08-2015	15BJM016A	479326	8518794	19 X	560945	3	2	30	<5	1	0	0	5m above tide/ spade depth		15	
13-08-2015	15BJM018A	479476	8518727	19 X	560946	3	1	30	<2	1	0	0	Spade depth		<30	
13-08-2015	15BJM019A	479638	8518697	19 X	560947	3	3	30	20	0	1	0	Uplifted beach/ Spade depth/ 100m inland		hard to see	
13-08-2015	15BJM020A	479639	8518636	19 X	560948	3	3	5	20	1	1	0	Surface 5cm/ stream outlet/ 25m inland		40, lower beneath	
13-08-2015	15BJM021A	479662	8518564	19 X	560949	3				1	0	0	NO SAMPLE/ ROCK CHIP FOR GEUS			
13-08-2015	15BJM022A	479797	8518552	19 X	560950	3	1	30	<2	1	0	0	Spade depth		?	wash
13-08-2015	15BJM023A	479864	8518536	19 X	560951	3	1	5	<2	1	0	0	5cm deep		50	
13-08-2015	15BJM024A	479797	8518504	19 X	560952	4	1	5	<2	1	0	0	Intertidal/ 5cm		20	
13-08-2015	15BJM024B	479797	8518504	19 X	560953	4	1	30	<2	1	0	0	Spade depth			seive
13-08-2015	15BJM025A	480155	8518386	19 X	560954	4	1	5	<2	1	0	0	Surface 5cm/ mouth of stream		20?	
13-08-2015	15BJM026A	480218	8518285	19 X	560955	4	1	30	<2	1	0	0	Spade depth		?	pan to check
13-08-2015	15BJM027A	480564	8518201	19 X	560956	4	3	30	20	0	1	0	200m inland/ rocky sand on lake		tr	
13-08-2015	15BJM028A	480893	8518165	19 X	560957	4	3	30	25	0	1	0	200m inland/ rocky sand on lake		tr	
13-08-2015	15BJM029A	481012	8518208	19 X	560958	4	3	30	30	0	1	0	300m inland, vegetation area		?	
13-08-2015	15BJM030A	481237	8518054	19 X	560959	4	1	30	<2	1	0	0	Stream mouth		5	
13-08-2015	15BJM031A	481433	8517983	19 X	560960	4	3	30	15	1	0	0	20m inland above rocky coast/ Spade depth		15	
13-08-2015	15BJM032A	481472	8517919	19 X	560961	4	1	15	<2	1	0	0	Intertidal/ 15cm		30	
13-08-2015	15BJM033A	481575	8517801	19 X	560962	4	1	30	<2	1	0	0	Waterline/ Spade depth		30	
13-08-2015	15BJM033B	481575	8517801	19 X	none	n/a	1	30	<2	1	0	0	No GEUS sample/ for concentrate/no BJM sample			
13-08-2015	15BJM034A	481674	8517689	19 X	560963	4	2	30	<5	1	0	0	3m from high tide/ spade depth		plenty	
13-08-2015	15BJM035A	484415	8516464	19 X	560964	5	2	30	<5	1	0	0	5m above tide/ spade depth		min	pan
13-08-2015	15BJM036A	484209	8516630	19 X	560965	5	1	30	<2	1	0	0	Stream mouth/ 10m above tide/ spade depth		high	
13-08-2015	15BJM036B	484209	8516630	19 X	560966	5	1	30	<2	1	0	0	Intertidal/ spade depth		<10	
13-08-2015	15BJM037A	484051	8516713	19 X	560967	5	1	30	<2	1	0	0	Stream mouth/ Spade depth		20	
13-08-2015	15BJM038A	483848	8516869	19 X	560968	5	3	30	10	1	0	0	50m up uplifted beach/rl 10m		?	wash
13-08-2015	15BJM039A	483723	8516779	19 X	560969	5	1	30	<2	1	0	0	Intertidal/ spade depth		high	
13-08-2015	15BJM040A	483575	8516806	19 X	560970	5	2	30	<5	1	0	0	Beach/ spade depth		high	
13-08-2015	15BJM041A	483346	8516880	19 X	560971	5	1	30	<2	1	0	0	Intertidal/ spade depth		low	
13-08-2015	15BJM042A	483207	8517043	19 X	560972	5	2	30	<5	1	0	0	5m above tide/ spade depth		high	
13-08-2015	15BJM043A	482950	8517219	19 X	560973	5	2	30	<5	1	0	0	Beach/ spade depth		high	
13-08-2015	15BJM043B	482950	8517219	19 X	560974	5	1	30	<2	1	0	0	Intertidal/ spade depth		5-10	
13-08-2015	15BJM044A	482828	8517295	19 X	560975	5	2	30	<5	1	0	0	Beach/ spade depth		med	
13-08-2015	15BJM044B	482828	8517295	19 X	560976	5	1	5	<2	1	0	0	5cm deep		high	
13-08-2015	15BJM045A	482504	8517604	19 X	560977	5	2	30	<5	1	0	0	Top of tide mark		?	examine
14-08-2015	15BJM046A	489295	8514289	19 X	560978	6	1	30	<2	1	0	0	Spade depth		<15	
14-08-2015	15BJM047A	489197	8514345	19 X	560979	6	1	30	<2	1	0	0	Intertidal/ spade depth		<10	
14-08-2015	15BJM047B	489197	8514345	19 X	560980	6	2	30	<5	1	0	0	Beach/ spade depth		high	
14-08-2015	15BJM048A	488979	8514515	19 X	560981	6	2	30	<5	1	0	0	Beach/ spade depth		<15	
14-08-2015	15BJM049A	488875	8514610	19 X	560982	6	2	30	<5	1	0	0	Upper beach/ spade depth		10	
14-08-2015	15BJM050A	488777	8514692	19 X	560983	6	1	30	<2	1	0	0	Intertidal/ spade depth		10	
14-08-2015	15BJM050B	488777	8514692	19 X	560984	6	2	30	<5	1	0	0	Upper beach/ spade depth		30	
14-08-2015	15BJM050C	488787	8514712	19 X	560985	6	3	30	15	0	1	0	On tundra 30m from water		?	wash
14-08-2015	15BJM051A	488674	8514780	19 X	560986	6	1	20	<2	1	0	0	Intertidal/ top 20cm		med-high	
14-08-2015	15BJM052A	488602	8514850	19 X	560987	6	3	30	10	0	1	0	10m RL/ 30m inland/ tundra/ med sand, small pebbles		?	wash
14-08-2015	15BJM053A	488465	8514914	19 X	560988	6	1	3	<2	0	1	0	Top 3cm		30	
14-08-2015	15BJM053B	488465	8514914	19 X	560989	6	1	30	<2	0	1	0	Spade depth		10	
14-08-2015	15BJM054A	487924	8515188	19 X	560990	7	3	30	15	0	1	0	15m RL/ Tundra/ 30m from shore		10	
14-08-2015	15BJM055A	487729	8515225	19 X	560991	7	3	30	12	1	0	0	Upper beach/ spade depth/ 12m RL/ inland 25m		10	
14-08-2015	15BJM056A	487515	8515297	19 X	560992	7	2	30	<5	1	0	0	Beach/ spade depth		med	
14-08-2015	15BJM057A	487478	8515460	19 X	560993	7	3	30	34	0	1	0	Uplifted beach/ 50m in/ RL 34m/ highest point of raised area		10?	
14-08-2015	15BJM058A	487127	8515546	19 X	560994	7	3	30	25	0	1	0	RL 25m/ 100m inland		?	wash / pan
14-08-2015	15BJM059A	486787	8515591	19 X	560995	7	3	30	20	0	1	0	RL 20m/100m inland/ spade depth		5	
14-08-2015	15BJM060A	486769	8515596	19 X	560996	7	3	30	20	0	1	0	Stream sediment/ 20m RL		present	
14-08-2015	15BJM061A	486089	8515607	19 X	560997	7	3	30	10	0	1	0	10m RL/ 40m inland/ spade depth		tr	
14-08-2015	15BJM062A	486079	8515688	19 X	560998	7	3	30	18	0	1	0	18m RL/ 100m inland		5	
14-08-2015	15BJM063A	486019	8515835	19 X	560999	7	3	30	31	0	1	0	31m RL/ 150m inland/ new sample book started		10	
14-08-2015	15BJM064A	485654	8515765	19 X	569501	8	1	30	<2	1	0	0	Intertidal/ spade depth		high?	
14-08-2015	15BJM065A	485525	8515845	19 X	569502	8	1	30	<2	1	0	0	Intertidal/ spade depth		unsure	
14-08-2015	15BJM066A	485401	8515923	19 X	569503	8	1	30	<2	1	0	0	Intertidal/ spade depth		20	
14-08-2015	15BJM066B	485401	8515923	19 X	569504	8	2	30	<5	1	0	0	Above tidal zone/ Spade depth		conc	
15-08-2015	15BJM067A	478988	8518260	19 X	none	n/a				0	0	1	offshore/ Soft sediment collected at 51m	yes		
15-08-2015	15BJM068A	478825	8518049	19 X	none	n/a				0	0	1	offshore/ Depth 34m	yes		
15-08-2015	15BJM069A	479508	8518231	19 X	none	n/a				0	0	1	offshore	yes		
15-08-2015	15BJM070A	479412	8518075	19 X	none	n/a				0	0	1	offshore	yes		
15-08-2015	15BJM071A	479312	8517927	19 X	none	n/a				0	0	1	offshore	yes		
15-08-2015	15BJM072A	479230	8517776	19 X	none	n/a				0	0	1	offshore	yes		
15-08-2015	15BJM073A	479984	8518098	19 X	none	n/a				0	0	1	offshore	yes		
15-08-2015	15BJM074A	479996	8517952	19 X	none	n/a				0	0	1	offshore	yes		
15-08-2015	15BJM075A	479760	8517704	19 X	none	n/a				0	0	1	offshore	yes		
16-08-2015	15BJM078A	490155	8513656	19 X	none	9				0	0	1	offshore	yes		
16-08-2015	15BJM079A	490072	8513524	19 X	none	9				0	0	1	offshore	yes		
16-08-2015	15BJM080A	490739	8513456	19 X	none	9				0	0	1	offshore	yes		
16-08-2015	15BJM081A	490679	8513351	19 X	none	9				0	0	1	offshore	yes		
16-08-2015	15BJM082A	491131	8513205	19 X	none	9	4			1	0	0	offshore			
16-08-2015	15BJM083A	491023	8513088	19 X	none	9				0	0	1	offshore	yes		
16-08-2015	15BJM083B	492023	8513088	19 X	none	9	4			1	0	0				
16-08-2015	15BJM086A	491790	8512269	19 X	none	9				0	0	1	offshore	yes		
16-08-2015	15BJM086B	491790	8512269	19 X	none	9	4			1	0	0				
16-08-2015	15BJM088A	487749	8514752	19 X	none	9	4				0	1	offshore			
16-08-2015	15BJM090A	486668	8515126	19 X	none	10				0	0	1	offshore	yes		
16-08-2015	15BJM090B	486668	8515126	19 X	none	10	4			0	0	1				
17-08-2015	15BJM091A	492523	8512323	19 X	569505	10	1	30	<2	1	0	0	Spade depth/ Intertidal		20	pan
17-08-2015	15BJM092A	492678	8512143	19 X	569506	10	2	30	<5	1	0	0	Top of tide mark/ spade depth		conc	pan
17-08-2015	15BJM092B	492679	8512191	19 X	569507	10	1	30	<2	1	0	0	Intertidal/ spade depth		30	
17-08-2015	15BJM093A	492985	8511684	19 X	569508	10	1	30	<2	1	0	0	Intertidal/ spade depth		25	
17-08-2015	15BJM094A	493379	8511198	19 X	569509	10	1	30	<2	1	0	0	Intertidal/ spade depth		30	
17-08-2015	15BJM094B	493379	8511198	19 X	none	10	1	30	<2	1	0	0	Uppertidal/ spade depth/ NO GEUS SAMPLE		conc	pan
17-08-2015	15BJM095A	494063	8511154	19 X	569510	10	1	30	<2	1	0	0	Uppertidal/ spade depth		5	
17-08-2015	15BJM096A	494095	8511217	19 X	569511	10	3	30	28	0	1	0	Spade depth RL 28m		5	
17-08-2015	15BJM097A	494332	8511297	19 X	569512	10	3	30	34	0	1	0	200m inland/ raised terrace side sample/ spade depth/ RL 34m		? Unsure, 10-20% dk fraction	

Sample points

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GEUS

17-08-2015	15BJM097B	494472	8511297	19 X		569513	10	3	30	36	0	1	0	200m inland/ raised terrace side sample/ spade depth/ RL 36m		med-high?	
17-08-2015	15BJM098A	494472	8511112	19 X		569514	10	1	30	<2	1	0	0	Intertidal/ spade depth		tr	
17-08-2015	15BJM099A	494679	8511070	19 X		569515	11	1	30	<2	1	0	0	Intertidal/ spade depth		10	
17-08-2015	15BJM099B	494679	8511070	19 X		569516	11	1	30	<2	1	0	0	Intertidal/ spade depth		high / stream	
17-08-2015	15BJM100A	495005	8511105	19 X		569517	11	1	30	<2	1	0	0	Intertidal/ spade depth		10	
17-08-2015	15BJM101A	495627	8511093	19 X		569518	11	1	30	<2	1	0	0	Uppertidal/ spade depth		low	
17-08-2015	15BJM102A	495818	8511142	19 X		569519	11	1	30	<2	1	0	0	Intertidal/ spade depth		<10	
17-08-2015	15BJM103A	495942	8511256	19 X		569520	11	3	30	25	0	1	0	Raised beach/ 25m RL/ 100m inshore		10	
17-08-2015	15BJM104A	496713	8511235	19 X		569521	11	3	30	20	0	1	0	Raised beach		15	
17-08-2015	15BJM105A	494710	8510973	19 X	none		not sampled yet	4			0	0	1	50m offshore 6m		?	wash
17-08-2015	15BJM106A	493425	8511002	19 X	none		not sampled yet	4			0	0	1	100m offshore		?	wash / pan
18-08-2015	15BJM107A	487882	8515085	19 X	none		12	4			0	0	1	Tied to seismic L7A Area 2A		visible metallics	
18-08-2015	15BJM108A	487853	8515070	19 X	none		12	4			0	0	1	Tied to seismic L7A Area 2A		<15%	
18-08-2015	15BJM109A	487813	8515016	19 X	none		12	4			0	0	1	Tied to seismic L7A Area 2A/4m water		silty	
18-08-2015	15BJM110A	487804	8514982	19 X	none		12	4			0	0	1	Tied to seismic L7A Area 2A/5-6m water		?	
18-08-2015	15BJM111A	487791	8514964	19 X	none		12	4			0	0	1	Tied to seismic L7A Area 2A/6m water		?	
18-08-2015	15BJM112A	487782	8514949	19 X	none		12	4			0	0	1	Tied to seismic L7A Area 2A/6m			
18-08-2015	15BJM113A	487767	8514902	19 X	none		12	4			0	0	1	Tied to seismic L7A Area 2A/8m			
18-08-2015	15BJM114A	488393	8514905	19 X	none		12	4			0	0	1	Off sandy beach/2.5m		visible metallics	
18-08-2015	15BJM115A	488341	8514863	19 X	none		12	4			0	0	1	Off sandy beach/3m		silty, notable dk fraction	
18-08-2015	15BJM116A	488308	8514615	19 X	none		12	4			0	0	1	Off sandy beach/5m			
18-08-2015	15BJM117A	488245	8514805	19 X	none		12	4			0	0	1	Off sandy beach			
18-08-2015	15BJM118A	488227	8514752	19 X	none		12	4			0	0	1	Off sandy beach/5-6m		significant fine, angular, black fraction - metallics?	
18-08-2015	15BJM119A	488159	8514709	19 X	none		12	4			0	0	1	Off sandy beach/7m			
18-08-2015	15BJM120A	486811	8515436	19 X	none		12	4			0	0	1	Tied to seismic L5A/4m		10-15% black ?metallic fraction	
18-08-2015	15BJM121A	486742	8515278	19 X	none		12	4			0	0	1	Tied to seismic L5A/10m		silty w. v. fine black grains	
18-08-2015	15BJM122A	485406	8515940	19 X		569522	13	3	30	30	0	1	0	Uplifted terrace/ 30m RL		5-10% metallics	
18-08-2015	15BJM123A	485910	8515910	19 X		569523	13	3	30	42	0	1	0	Top terrace/ RL 42m/ spade depth		10-15%	
18-08-2015	15BJM124A	485904	8515888	19 X		569524	13	3	30	39	0	1	0	2nd top terrace/ RL 39m/ spade depth		30-50% in metallic layers, average 20%?	
18-08-2015	15BJM125A	485897	8515869	19 X		569525	13	3	30	36	0	1	0	3rd top terrace/ RL 36m/ spade depth		up to 25% metallics, spade depth	
18-08-2015	15BJM126A	485886	8515843	19 X		569526	13	3	30	32	0	1	0	4th top terrace/ RL 32m/ spade depth		c. 10%	
18-08-2015	15BJM127A	485872	8515813	19 X		569527	13	3	30	30	0	1	0	5th top terrace/ RL 30m/ spade depth		20% metallics	
18-08-2015	15BJM128A	485844	8515752	19 X		569528	13	3	30	20	0	1	0	6th top terrace/ RL 20m/ spade depth		c. 5%	
18-08-2015	15BJM129A	485804	8515718	19 X		569529	13	3	30	17	0	1	0	7th top terrace/ RL 17m/ spade depth		5-10%	
18-08-2015	15BJM130A	485787	8515693	19 X		569530	13	3	30	14	0	1	0	8th top terrace/ RL 14m/ spade depth		10-15%	
19-08-2015	15BJM131A	489125	8514189	19 X	none		14	4			0	0	1	4m depth		sandy mud w. dk fraction	
19-08-2015	15BJM132A	489141	8514255	19 X	none		14	4			0	0	1	3m depth		wet, silty slurry w. some sand	
19-08-2015	15BJM133A	489172	8514107	19 X	none		14	4			0	0	1	7m depth		moderately sandy, dk grey mud	
19-08-2015	15BJM134A	489278	8514098	19 X	none		14	4			0	0	1	4m depth		charcoal coloured, plentry of black particles ?metallics?	
19-08-2015	15BJM135A	489353	8514063	19 X	none		14	4			0	0	1	3m depth		silty sand, quite stiff, but wet and loose on top. Plenty of dk black grains	
19-08-2015	15BJM136A	489598	8514086	19 X	none		14	4			0	0	1	4m depth		Silt w. v. fine black fraction	
19-08-2015	15BJM137A	489734	8514088	19 X	none		14	4			0	0	1	1m depth		Fine sand, significant metallics, silvery white mineral too.	
19-08-2015	15BJM138A	489772	8513974	19 X	none		14	4			0	0	1			Fine sand. 10-15% metalliferous grains	
19-08-2015	15BJM139A	490260	8513666	19 X	none		14	4			0	0	1	3m		Dk brown - charcoal fine sand. Relatively little silt.	
19-08-2015	15BJM140A	490755	8513593	19 X	none		14	4			0	0	1	0.5m		Similar to 139, notable metallics	
19-08-2015	15BJM141A	491193	8513313	19 X	none		14	4			0	0	1			V. sandy, stiff, dk grey silt	
19-08-2015	15BJM142A	491646	8512931	19 X	none		15	4			0	0	1			Fine-med sand with obvious metallics, some lithic clasts	
19-08-2015	15BJM143A	491395	8512899	19 X	none		15	4			0	0	1	3m		Fine sand, metallics present	
19-08-2015	15BJM144A	491580	8512870	19 X	none		15	4			0	0	1	5m		Fine silty sand with metallic fraction	
19-08-2015	15BJM145A	486184	8515350	19 X	none		15	4			0	0	1	12m		Moderately stiff brown silt / v. fine sand with black metallic fraction	
19-08-2015	15BJM146A	486166	8515291	19 X	none		15	4			0	0	1	14m		Sandy mud, grey brown colour, shelly organisms.	
19-08-2015	15BJM147A	485731	8515581	19 X	none		15	4			0	0	1			Wet silt w. fine sand. Significant metallic fraction, smells organic.	
19-08-2015	15BJM148A	485316	8515508	19 X	none		15	4			0	0	1			Sandy silt w. fine black fraction	
19-08-2015	15BJM149A	485217	8515655	19 X	none		15	4			0	0	1			Sandy silt w. fine black fraction	
19-08-2015	15BJM150A	485354	8515782	19 X	none		15	4			0	0	1			Fine sand + metallics	
19-08-2015	15BJM151A	485384	8515834	19 X	none		15	4			0	0	1	3m		Fine sand, metallics present	
19-08-2015	15BJM152A	484783	8515999	19 X	none		15	4			0	0	1	6m		V. fine, dk brown - grey sand	
19-08-2015	15BJM153A	484717	8515863	19 X	none		15	4			0	0	1	14m		Bioturbated, sandy mud / silt/	
20-08-2015	15BJM076A	501549	8511058	19 X		569531	9	1	30	<2	1	0	0			V dk silt. Can't tell if metallics present	
20-08-2015	15BJM076B	501549	8511058	19 X		569532	9	1	30	<2	1	0	0	Sampled to 40 cm		15-20% dk fraction	
20-08-2015	15BJM077A	502417	8511092	19 X		569533	9	1	30	<2	1	0	0			Few metallics, if any	
20-08-2015	15BJM084A	501970	8511545	19 X		569534	9	1	30	<2	0	0	0			Mixed sand and clasts. Possibly some metallics. Unsure	
20-08-2015	15BJM085A	501707	8511626	19 X		569534	9	1	30	<2	0	1	0			V. stony dk brown sand.	
20-08-2015	15BJM087A	493175	8511413	19 X	none		9	1	30	<2	1	0	0			Top of active beach, natural ilmenite concentrate to >30cm along back wall of beach	
20-08-2015	15BJM089A	491781	8512871	19 X	none		9	1	30	<2	1	0	0			metallic+ ?cpx layers	
20-08-2015	15BJM154A	484125	8516437	19 X	none		16	4			0	0	1	7.1m	9.38am	Fine sand and silt, ?metallics	
20-08-2015	15BJM155A	482988	8516695	19 X	none		16	4			0	0	1	14.0m	10.18am	Sandy silt. Unsure if metallics within	
20-08-2015	15BJM156A	481386	8517750	19 X	none		16	4			0	0	1	5.9m	10.46am	Sand with fine dk fraction.	
20-08-2015	15BJM157A	481307	8517686	19 X	none		16	4			0	0	1	11.4m	10.53am	Silt w. v. fine black fraction	
20-08-2015	15BJM158A	480334	8518015	19 X	none		16	4			0	0	1	14.5m	11.03am	Silt w. v. fine black fraction	
20-08-2015	15BJM159A	483883	8516803	19 X		569536	16	3	30	8	0	1	0	rl 8m		1st terract. Sand, medium brown. ?metallics	
20-08-2015	15BJM160A	483893	8516844	19 X		569537	16	3	30	12	0	1	0	rl 12m		10% dark fraction, medium grained sand.	
20-08-2015	15BJM161A	483906	8516901	19 X		569538	16	3	30	17	0	1	0	rl 17m		Fine sand, possibly metallics <3% .	

Sample points

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20-08-2015	15BJM162A	483927	8517008	19 X		569539	16	3	30	26	0	1	0	rl 26m		Mixed medium-coarse sand with fine ?metallic fraction at c5%
20-08-2015	15BJM163A	483937	8517069	19 X		569540	16	3	30	31	0	1	0	rl 31m		>10% metalllics in mixed mineralogy sand
20-08-2015	15BJM164A	483981	8517147	19 X		569541	16	3	30	35	0	1	0	rl 35m		Soil bound by clayey lumps. Metallics present
20-08-2015	15BJM165A	483993	8517185	19 X		569542	16	3	30	40	0	1	0	rl 40m		Coarse white sand, finer black grains. <10% metallics
20-08-2015	15BJM166A	484010	8517211	19 X		569543	16	3	30	44	0	1	0	rl 44m		Similar to 166, c. 5% metallics
20-08-2015	15BJM167A	484024	8517246	19 X		569544	16	3	30	47	0	1	0	rl 47m		Similar to 165. c. 3-5% metallics
20-08-2015	15BJM168A	484074	8517319	19 X		569545	16	3	30	56	0	1	0	rl 56m		Mixed sand. 5-10% metallics
20-08-2015	15BJM169A	484259	8517209	19 X		569546	16	3	30	60	0	1	0	rl 60m		Unsure of metallic fraction
20-08-2015	15BJM170A	484242	8517174	19 X		569547	16	3	30	52	0	1	0	rl 52m		C.10% metallics
20-08-2015	15BJM171A	484216	8517126	19 X		569548	16	3	30	51	0	1	0	rl 51m		Trace metallics, I think.
20-08-2015	15BJM172A	484140	8517007	19 X		569549	16	3	30	35	0	1	0	rl 35m		V. fine and silty.
20-08-2015	15BJM173A	484074	8516913	19 X		569550	16	3	30	29	0	1	0	rl 29m		40-50% metallics. Good natural concentrate.
20-08-2015	15BJM174A	484026	8516823	19 X		569551	16	3	30	25	0	1	0	rl 25m		Fine sandy soil bound by clay. ?metallics
20-08-2015	15BJM175A	484005	8516767	19 X		569552	16	3	30	21	0	1	0	rl 21m		Silt / clay soil with pebble and sand fraction. Metallics <5%
21-08-2015	15BJM176A	479863	8519656	19 X		569553	17	3	30	70	0	1	0	rl 70m		Stony soil, trace metallics (verified by panning)
21-08-2015	15BJM177A	479878	8519617	19 X		569554	17	3	30	64	0	1	0	rl 64m		Few metallics in dk brown soil
21-08-2015	15BJM178A	479864	8519586	19 X		569555	17	3	30	61	0	1	0	rl 61m		20-30% metallic sand beneath soil top.
21-08-2015	15BJM179A	479840	8519535	19 X		569556	17	3	30	58	0	1	0	rl 58m		Dk brown to charcoal sand, mixed grains, some metallics
21-08-2015	15BJM180A	479988	8519387	19 X		569557	17	3	30	49	0	1	0	rl 49m		with metallifierous rich layer at 20cm depth
21-08-2015	15BJM181A	479981	8519358	19 X		569558	17	3	30	47	0	1	0	rl 47m		35% metallics in 40cm deep hole in pebble-free sand. Top 10 cm is pebbles.
21-08-2015	15BJM182A	479966	8519297	19 X		569559	17	3	30	42	0	1	0	rl 42m		Fine sand, 15% metallics
21-08-2015	15BJM183A	479957	8519244	19 X		569560	17	3	30	39	0	1	0	rl 39m		>10% metallics on average, with 10 cm thick concentrate layer (50% metallics)
21-08-2015	15BJM184A	479951	8519137	19 X		569561	17	3	30	33	0	1	0	rl 33m		5% metallics in brown, fine-med. Sandy soil.
21-08-2015	15BJM185A	479951	8518921	19 X		569562	17	3	30	29	0	1	0	rl 29m		Fine to medium mixed sand with 5% metallics
21-08-2015	15BJM186A	479908	8518783	19 X		569563	17	3	30	24	0	1	0	rl 24m		Fine to medium mixed sand with 5% metallics
21-08-2015	15BJM187A	488061	8514916	19 X	none		18	4			0	0	1	3.2m	10.11am	Fine, mid brown-grey sand, 15% black particles. ?metallic?
21-08-2015	15BJM188A	487945	8514916	19 X	none		18	4			0	0	1	4.5m	11.23am	V. fine sand in loose wet mud. Sand is dark coloured. Few metallics
21-08-2015	15BJM189A	488364	8514643	19 X	none		18	4			0	0	1	5.0m	11.44am	Fine sand, possible metallics
21-08-2015	15BJM190A	488419	8514719	19 X	none		18	4			0	0	1	3m	11.53am	Fine dk grey sand with some silt and clay, trace metallics
21-08-2015	15BJM191A	488782	8514515	19 X	none		18	4			0	0	1	2.5m	12.05pm	Fine dk grey sand with some silt and clay, trace metallics
21-08-2015	15BJM192A	488654	8514344	19 X	none		18	4			0	0	1	5.5m	12.20pm	Wet mud, medium sand fraction and some lithic fragments
21-08-2015	15BJM193A	487511	8515161	19 X	none		18	4			0	0	1	3.5m	12.50pm	Notable metallics. Definite assay, notably different from other offshore sites
22-08-2015	15BJM194A	489812	8514702	19 X		569564		3	30	40	1	1	0	rl 40m terrace/ 50m inside		40-50% metallics beneath pebble top layer
22-08-2015	15BJM195A	490137	8514645	19 X		569565		3	30	<2	1	0	0	rl 1m top of tide mark		25% metallics, on beach face in intertidal zone.
22-08-2015	15BJM195B	490139	8514629	19 X		569566		1	30	<2	1	0	0	rl 1m/ intertidal		5010% metallics, on ridge crest
22-08-2015	15BJM195C	490135	8514623	19 X		569567		1	30	<2	1	0	0	Intertidal/ spade depth		Mixed mineralogy, medium sand, small metallic fraction. Pebbles within
22-08-2015	15BJM196A	490464	8514828	19 X		569568		3	30	20	0	1	0	100m inland/ raised		Layers 5 cm thick. Metalliferous rich are about 50%, intervening layers are 5-10%
22-08-2015	15BJM197A	490648	8515036	19 X		569569		3	30	<2	0	1	0	in delta/ 300m from shore		Pebbly, valley floor. Unsure on metallic fraction
22-08-2015	15BJM198A	490883	8514897	19 X	none			3	30	<2	0	1	0	middle of delta/ 400m from coast		Clast rich sand, few metallics if any
22-08-2015	15BJM199A	491264	8514380	19 X	none			3	30	5	0	1	0	south east side/ 600m from coast near bank		Sand, few metallics if any
23-08-2015	15BJM200A	490087	8514710	19 X		569570		3	30	15	0	1	0	rl 15m side of a terrace		?
23-08-2015	15BJM201A	490593	8514820	19 X	none			3	30	12	0	1	0	taken lower on shoulder of terrace than 15BJM201B		Trace
23-08-2015	15BJM201B	490593	8514820	19 X	none			3	30	17	0	1	0	taken higher on shoulder of terrace than 15BJM201A		More metallics than 201A, 10 m above river, coarse sand
23-08-2015	15BJM202A	490547	8514810	19 X	none			3	30	3	0	1	0	top of terrace		5-10%
23-08-2015	15BJM203A	491730	8515688	19 X	none			3	30	15	0	1	0	1.5km S/E in delta/ contained shell layer		Few metallics
23-08-2015	15BJM204A	490620	8515167	19 X	none			3	30	15	0	1	0	N/E side of delta		No metallics seen in sample
23-08-2015	15BJM205A	490364	8515161	19 X	none			3	30	15	0	1	0	N/E of raised terrace		Shelly beach sand. Few metallics if any
23-08-2015	Con sample from Iterlak Delta	490091	8514781	19 X	none			3	30	30	0	1	0	large bag taken to make con		Concentrate from flat top of triangular terrace. Sample from 40cm.