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GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886

Seabed classification along selected sub-bottom profiler records in Baffin Bay

R. Bennett, D. C. Campbell, C. Theriault, E. MacLean, S. Poirier, J. Parkinson

2015

Canada

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2015

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Introduction

Significant hydrocarbon potential in the Baffin Bay region and the growing human population and economy in Nunavut will result in a need for new marine infrastructure. The development of such projects requires scientific understanding of regional geological constraints to exploration and infrastructure development. This involves knowledge of the regional geological framework of Baffin Bay including glacial erosion, post-glacial sedimentation, and seabed geological hazards. This study analyzes all available sub-bottom profiler data in order to generate a map of the distribution of seabed types and morphological features to be used as a tool to better understand this framework.

The physiography of the Canadian Baffin Bay margin is primarily a product of its rifting and glacial history. It is a passive continental margin that lies offshore of four large islands of the Canadian Arctic Archipelago: Baffin Island, Bylot Island, Devon Island, and Ellesmere Island (Figure 1). Baffin Bay is interpreted to represent the northwestern extension of the North Atlantic – Labrador Sea rift system (Skaarup et al., 2006). The modern seafloor morphology and shallow stratigraphy of Baffin Bay are strongly influenced by past glacial processes.

Methods

This study utilized sub-bottom profiler data in Baffin Bay and adjacent Lancaster Sound and Davis Strait. These data were collected with a 3.5 kHz sub-bottom profiler or a Huntec deep tow seismic system during Geological Survey of Canada (GSC) cruises 71032, 76023, 76029, 77027, 78029, 81045, 82034, 87033, 91039, and 2008029. Data from all GSC cruises in the study area were assessed for data quality and only the cruises listed above had sub-bottom profiles that were of suitable quality for this project. Only data of appropriate quality (shown on Figure 1) from these ten cruises were used for seabed classification.

The surface and near-surface geology was interpreted and classified based on criteria developed during similar previous GSC studies on the Grand Banks of Newfoundland (Cameron, 2000) and the Scotian Slope (Campbell, 2000). These criteria are listed and described in Table 1.

Digital navigation files containing a position (latitude and longitude) at one minute intervals from the ten cruises were loaded into a geographic information system (GIS) in ArcMap. Four additional columns were added to these navigation files so that classification codes for the surface geology (surface column), subsurface geology (subsurface column), seabed relief (relief column) and notes could be added by the interpreter. Digital versions of the reflection profiles were then analyzed and the surface, subsurface, and relief of the seabed was classified as per the criteria in Table 1. Codes for the classification were added to the appropriate column at each one minute interval that had interpretable data. Any additional information that the interpreter deemed important was added in the notes column.

Upon completion of the interpretation, each classification code was assigned a unique colour in the GIS. The colour-coded along-track interpretations were then plotted on top of a regional bathymetry layer (source: GEBCO) in ArcMap to display the geographical extent of each of the classifications.

Illustrative figures showing examples of each classification code are presented in this report. Twelve maps (1:2,050,000 scale) showing the distribution of surface geology (4 maps), sub-surface geology (4 maps), and geological features (4 maps) are included in Appendix 1. Digital GIS files of the along-track interpretation are included with this open file report.

Seabed classification

The classification criteria used in this report was employed to maximize the contrast between disturbed (i.e. modified by downslope sediment failure) and undisturbed sediment at the seabed as well as in the shallow sub-surface. The purpose of highlighting this contrast was to map areas in Baffin Bay that have experienced slope failure processes so that they could be investigated during future research.

Undisturbed sediment is typically well stratified with strong continuous internal reflectors while disturbed sediments have an irregular upper surface and incoherent internal structure. The distinction between disturbed and undisturbed sediment was difficult to make in some areas where the sediment type did not allow penetration of the acoustic signal (e.g. till, sand, bedrock) or where data quality was poor. Areas where it was not possible to determine if the lack of stratification was due to sediment failure or to sediment type were coded as stratified or poorly stratified. Most of the data analyzed in Baffin Bay shows the seabed and shallow sub-surface is poorly stratified (e.g. Figure 1, Figure 2). This is likely due to the influence of past glaciations that have deposited coarse sediments (e.g. till, sand) on the continental shelves on both sides of Baffin Bay. The limited deep-water data that were available for this report show that these areas are well stratified (e.g. Figure 1) as they would have experienced non-glacial or ice-distal sedimentation. A large portion of the seabed off Lancaster Sound is dominated by stacked debris flows (Figure 1, Figure 7). These features were formed when vast amounts of glacial sediment were being deposited on the Lancaster Sound Trough Mouth Fan. Other debris flows were observed on the continental slope off Clyde River, Nunavut, with two other localized locations on the Greenland margin (Figure 1).

There is evidence of shallow hydrocarbons in the form of acoustic wipe outs and diapirs observed in the data. Almost all of the hydrocarbon evidence was observed in the Cape Dyer area (see Appendix 1, Geological features map 3). Hydrocarbon indicators from other data sources such as satellite imagery (Budkewitsch et al., 2013) and multibeam bathymetry (Bennett et al., 2014) have been noted in this area but the source and migration mechanism for the hydrocarbons are not known at this time. The presence of other surface and sub-surface features such as channels, mounds, and bedrock have been mapped and included in the attribute tables of the GIS classification files.

GIS digital files

All of the GIS files used to generate the maps in this report are compatible with the software program ArcMap by ESRI. A free GIS data viewer is available from ESRI at http://www.esri.com/software/arcgis/explorer if required. The maps included with this open file are presented using the Universal Transverse Mercator projection (Zone 20N).

References

Bennett, R., Campbell, C., Furze, M., 2014. The shallow stratigraphy and geohazards of the Northeast Baffin Shelf and Lancaster Sound, Bulletin of Canadian Petroleum Geology, Vol. 62, No. 4, p. 217 – 231.

Budkewitsch, P., Pavlic, G., Oakey, G., Jauer, C. and Decker, V. 2013. Reconnaissance mapping of suspect oil seep occurrences in Baffin Bay and Davis Strait using satellite radar: preliminary results. Geological Survey of Canada Open File 7068.

Cameron, G.D.M., 2000. Acoustic evidence for shallow gas and seabed classification along selected ship tracks on the deep-water margin of the Grand Banks of Newfoundland. Geological Survey of Canada Open File 3762.

Campbell, D.C., 2000. 3.5 kHz sub-bottom profiler seabed classification on the Scotian Slope. Geological Survey of Canada Open File 3928.

Skaarup, N., Jackson, H.R., and Oakey, G., 2006. Margin segmentation of Baffin Bay/Davis Strait, eastern Canada based on seismic reflection and potential field data. Marine and Petroleum Geology, v. 23, p. 127-144.

Table 1

Code	Classification	Description	Example figure
df	debris flow	general term for disturbed incoherent seabed that includes debris flows, slumps, and slides	2
dfs	debris flow stacked	general identifier for a succession of overlapping debris flows	3
idf	intermediate debris flow	debris flow with an irregular upper surface that occasionally returns hyperbolic reflections; subsurface is transparent or incoherent	4
idfs	intermediate debris flow stacked	a succession of overlapping intermediate debris flows	5
sdf	smooth debris flow	debris flow with a smooth upper surface and transparent sub-surface	6
sdfs	smooth debris flow stacked	a succession of overlapping smooth debris flows	7
ws	well stratified	continuous parallel or sub-parallel reflectors	8, 9
wse	well stratified eroded	continuous parallel or sub-parallel reflectors, evidence of erosion or truncation of reflectors at the seabed	9
s	stratified	parallel or sub-parallel reflectors that are not continuous	2
se	stratified eroded	non-continuous parallel or sub-parallel reflectors, evidence of erosion or truncation of reflectors at the seabed	10
ps	poorly stratified	diffuse sub-parallel reflectors	2, 11, 16
pse	poorly stratified eroded	irregular seabed with diffuse sub-parallel reflectors but erosion not obvious in subsurface	11
psr	prolonged strong reflector	thick, dark reflector at the seabed that indicative or hard sediments such as till or sand	12
t	transparent surface reflector	thin transparent reflector at the seabed, indicative of Holocene mud	13
wo	acoustic wipe out	sub-surface geology wiped out or masked by the presence of hydrocarbons in the sediment that prevents penetration of the acoustic signal	14

h	hummocky seabed	Highly irregular seabed that is not a rough debris flow	2
ss	steep slope	sloping of the seabed due to a sudden change in water depth; these slopes can cause hyperbolic reflections and other acoustic artifacts that impair interpretation of the underlying geology	2
sf	scarp face	vertical or near-vertical slope likely caused by faulting, erosion or slope failure	15
b	bedrock	seabed or sub-surface interpreted to be comprised of bedrock; characterized by a highly reflective and rough upper surface with no acoustic penetration below	16
sm	stratified mound	seabed mount with internal parallel or sub-parallel reflectors; stratification can range from poorly stratified to well stratified	17
ch	channel	depression eroded into the seabed	18
d	diapir	mound on the seabed formed by sediment rising towards the surface due to sub-surface pressures (e.g. rising hydrocarbons or fluids); incoherent internal structure	19

Figures

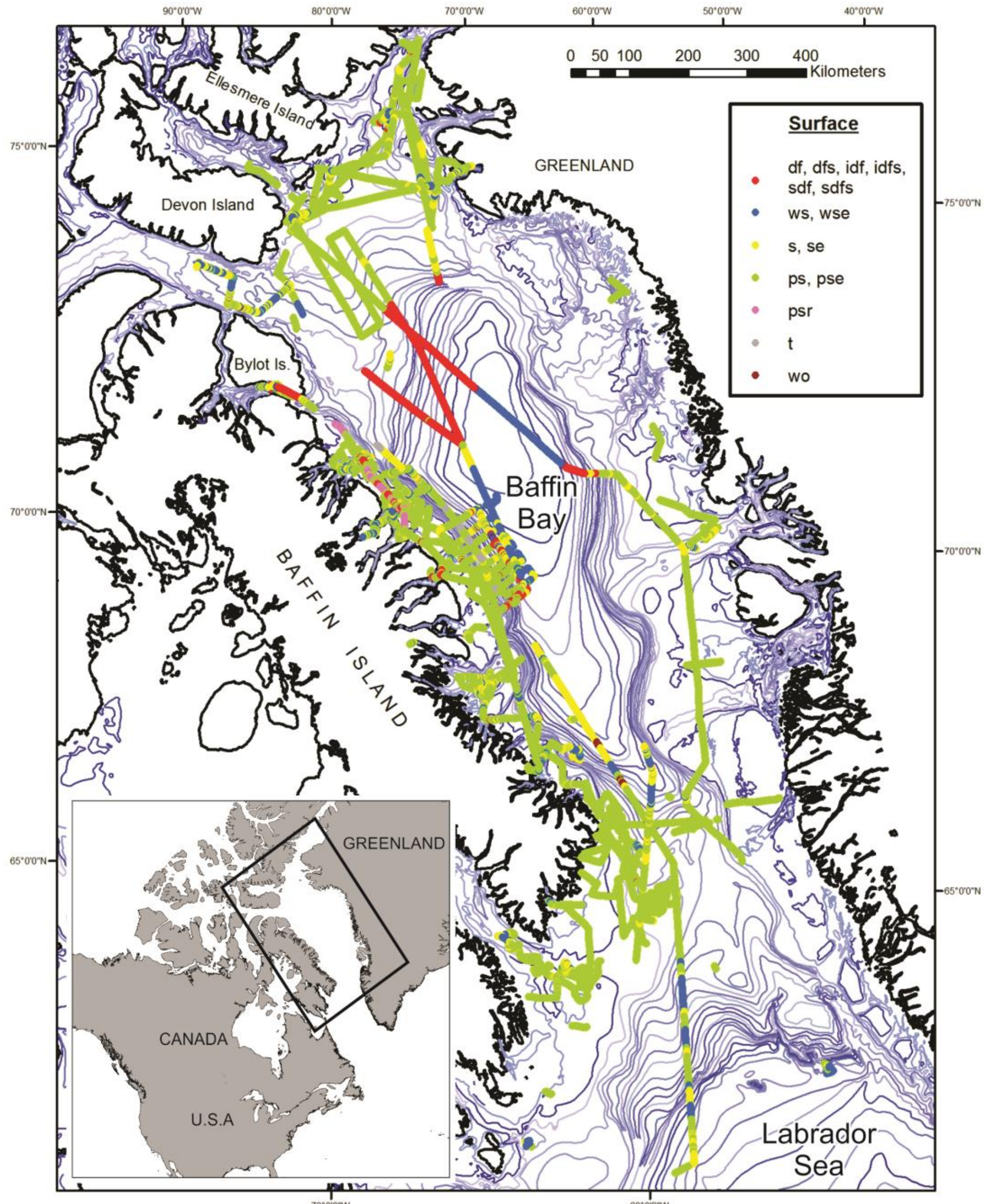


Figure 1: Overview map of surface classification of the seabed based on sub-bottom profiler data (See maps in Appendix 1 for more detail and figure locations).

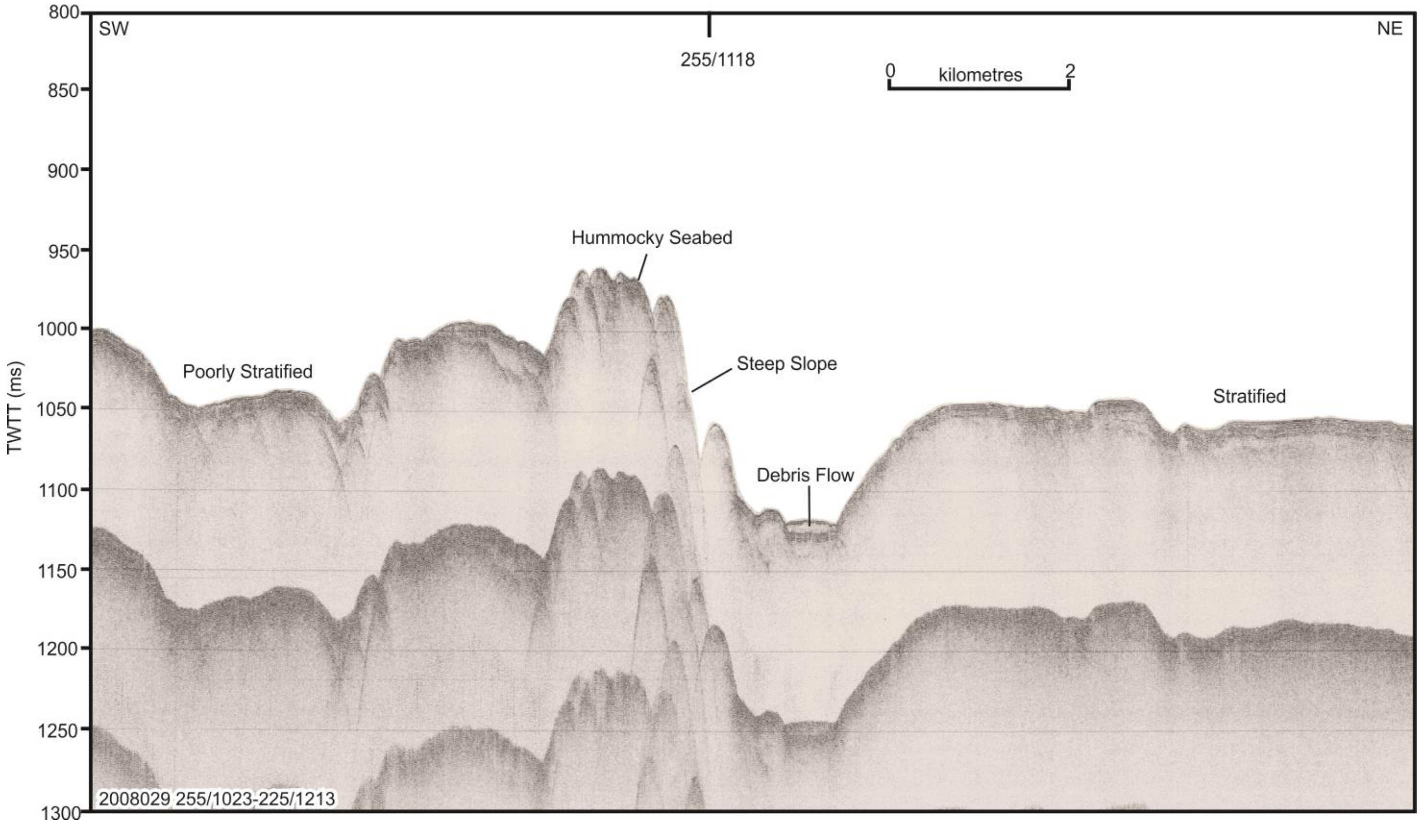


Figure 2: Huntec profile showing examples of a debris flow (df), stratified (s), and poorly stratified (ps) surface geology as well as steep slope (ss) and hummocky seabed (h) relief.

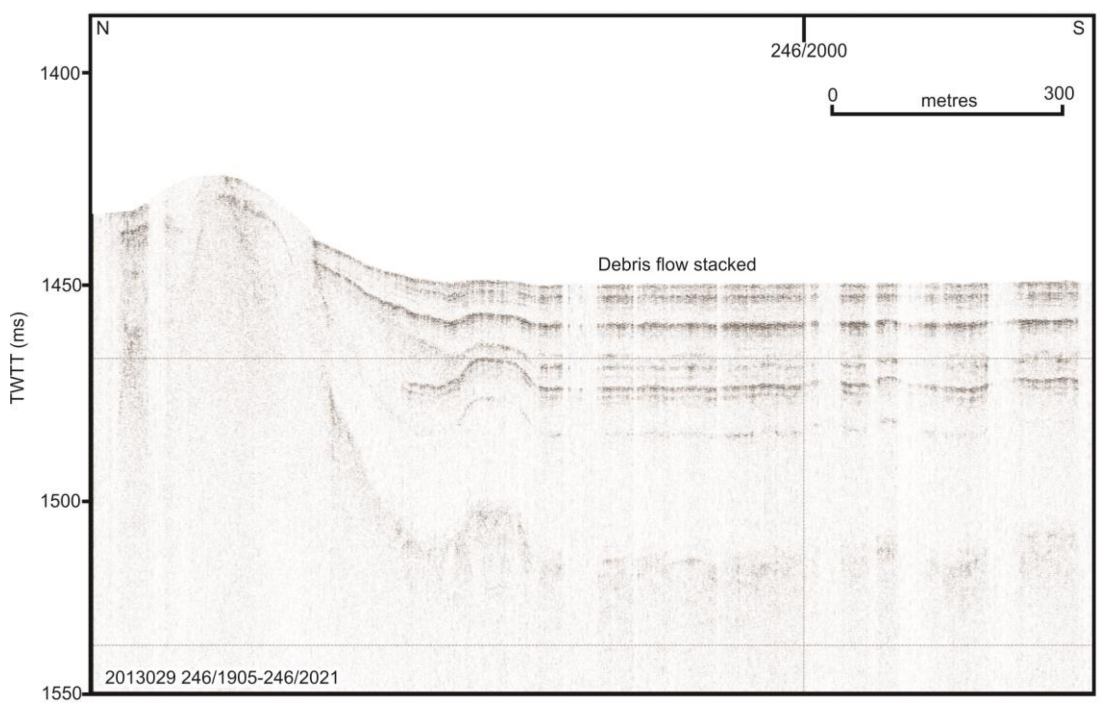


Figure 3: 3.5 kHz sub-bottom profiler record showing stacked debris flows (dfs).

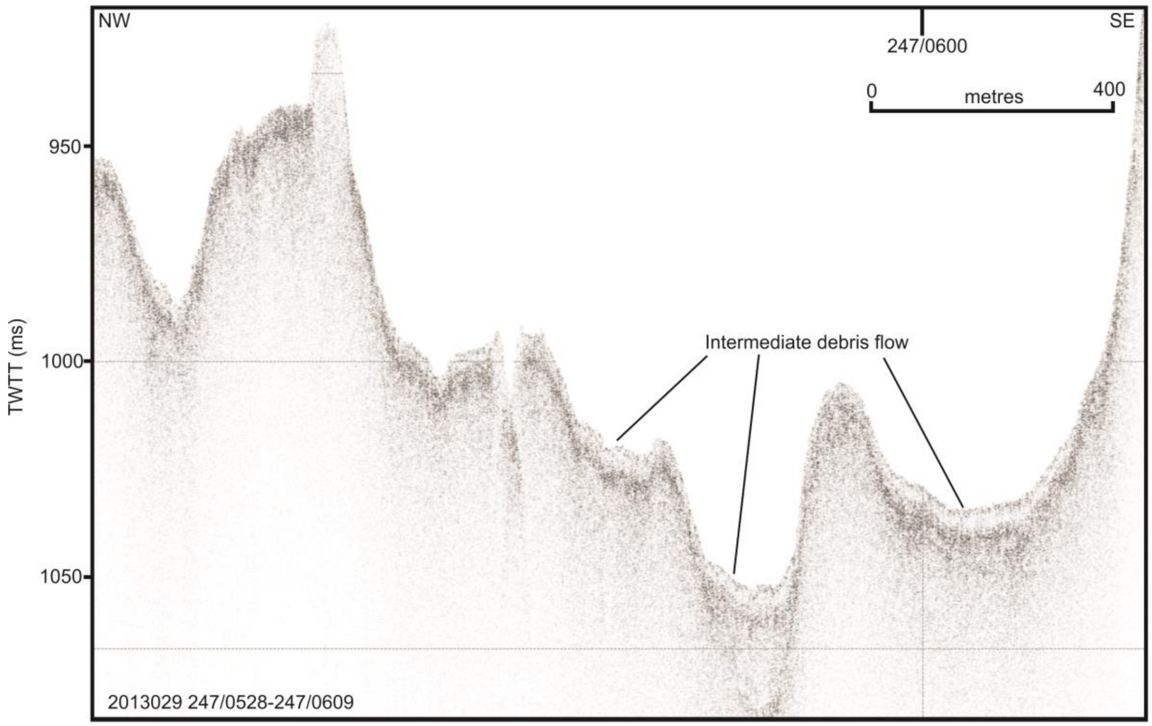


Figure 4: 3.5 kHz sub-bottom profiler record showing an example of an intermediate debris flow (idf).

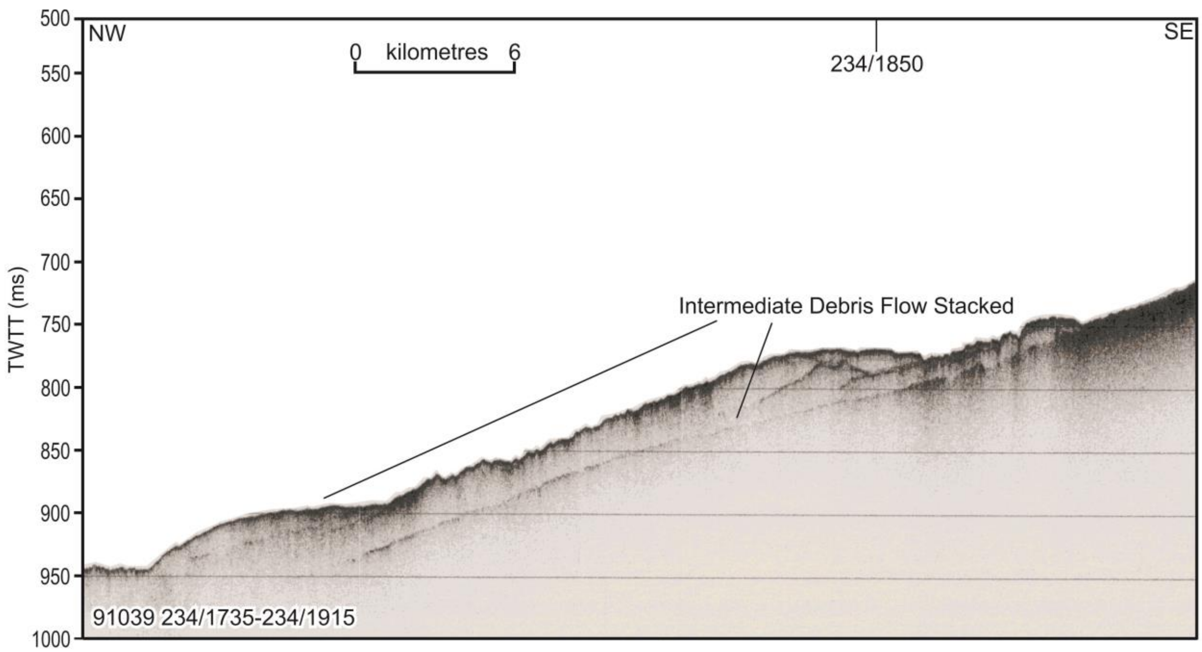


Figure 5: Huntec profile that shows an example of stacked intermediate debris flows (idfs).

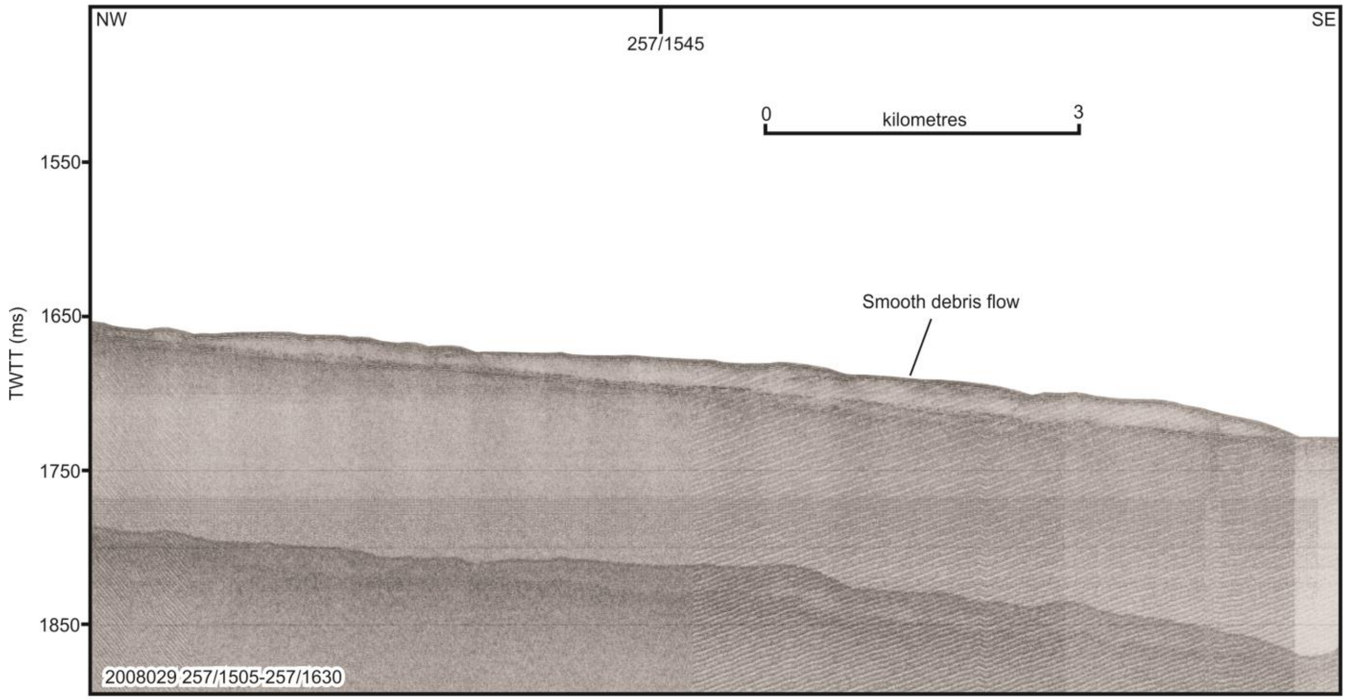


Figure 6: Huntec profile that shows an example of a smooth debris flow (sdf).

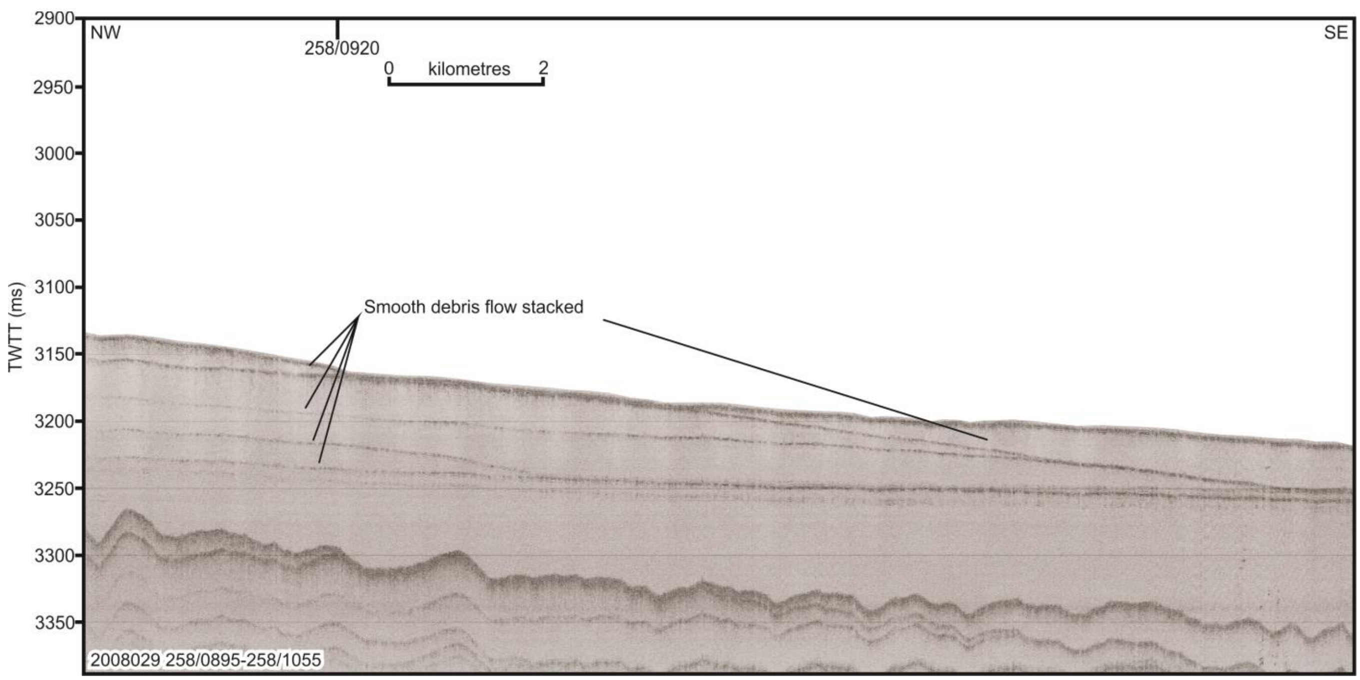


Figure 7: Huntec profile that shows an example of stacked smooth debris flows (sdfs).

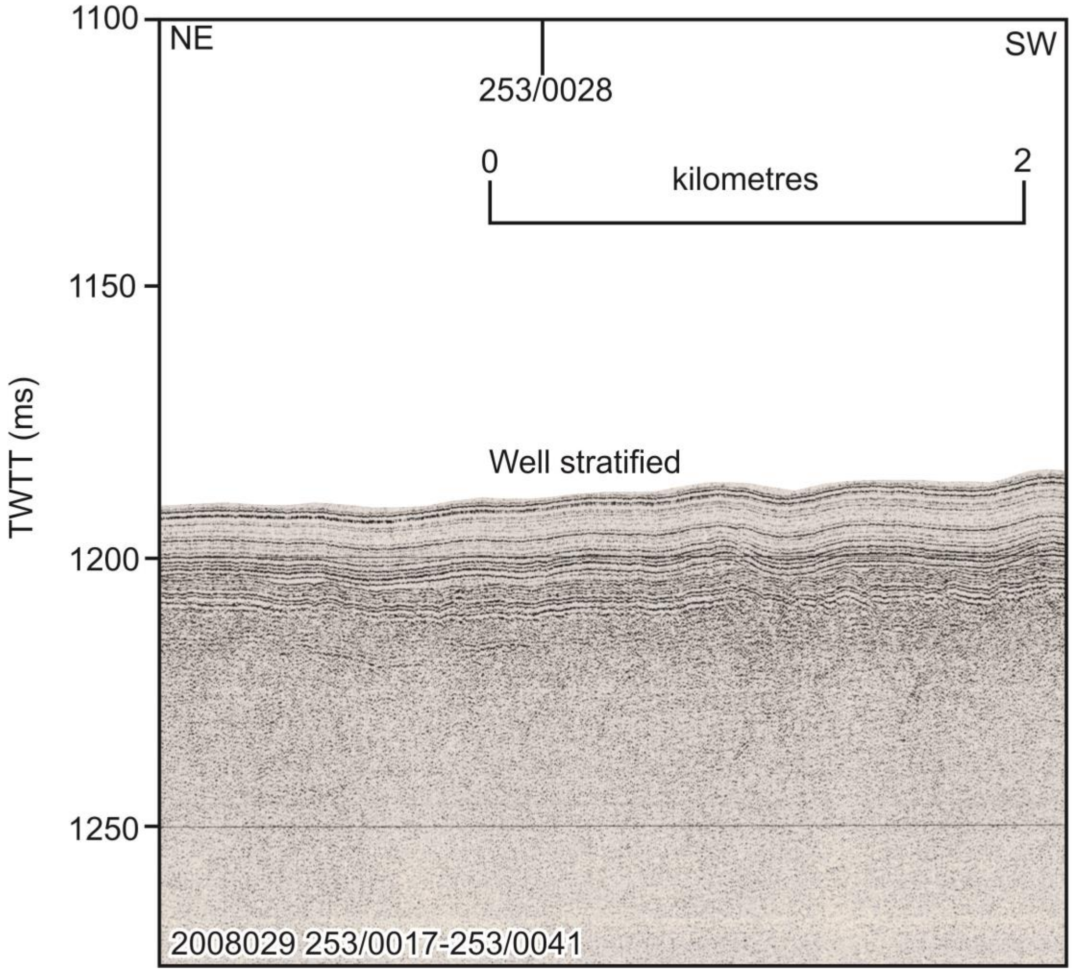


Figure 8: Huntec profile example of well stratified sediment (ws).

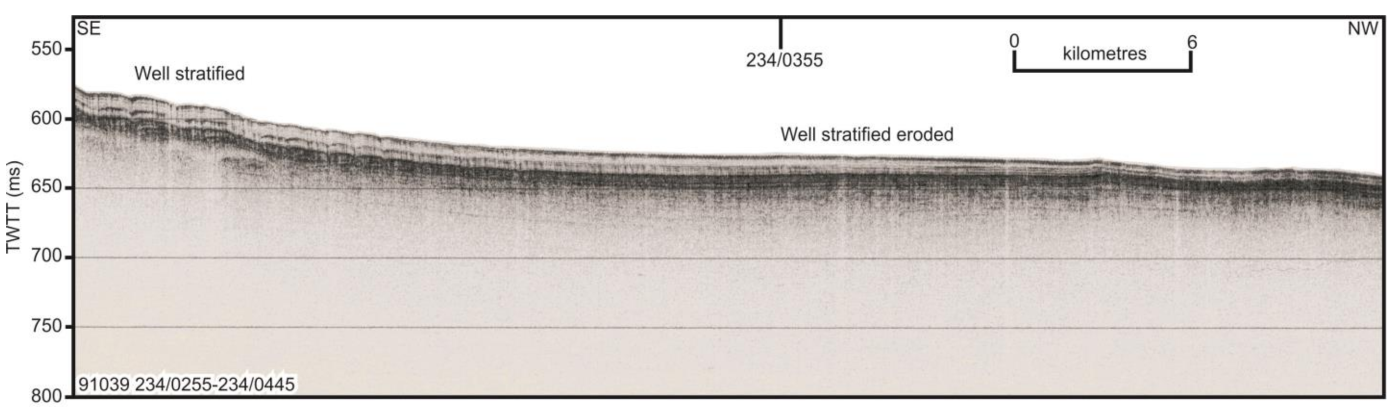


Figure 9: Huntec profile showing examples of eroded well stratified sediments (wse) as well as well stratified sediments (ws).

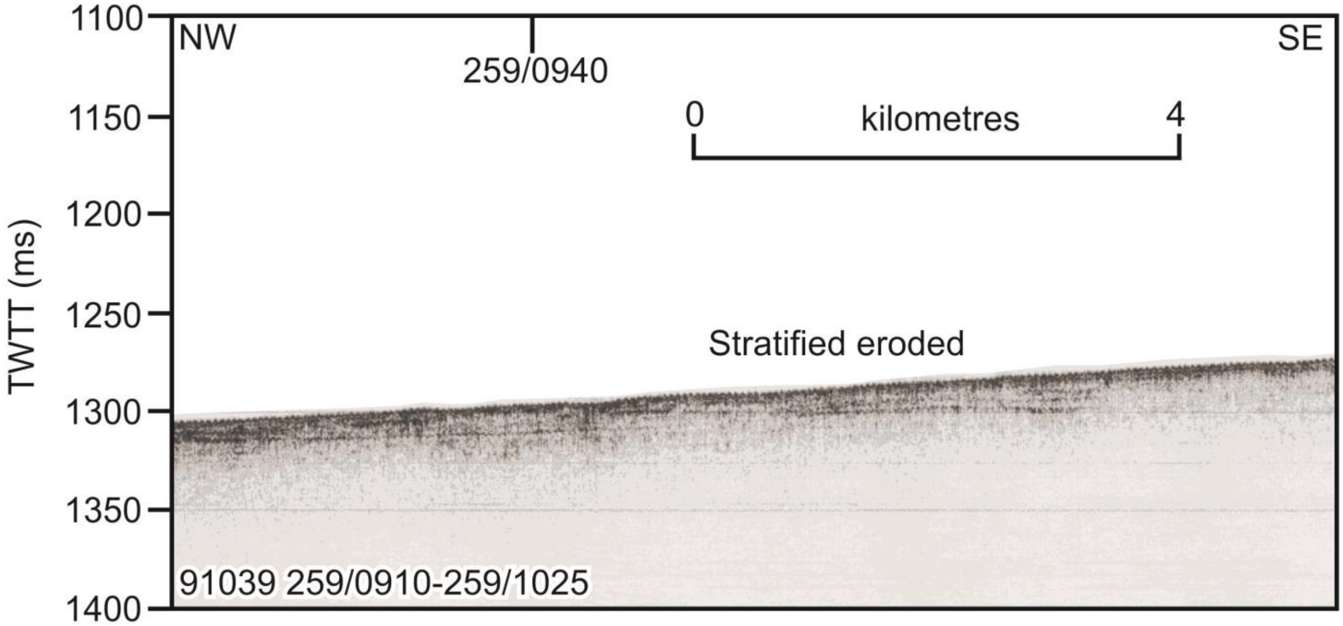


Figure 10: 3.5 kHz sub-bottom profiler record showing an example of eroded stratified sediments (se).

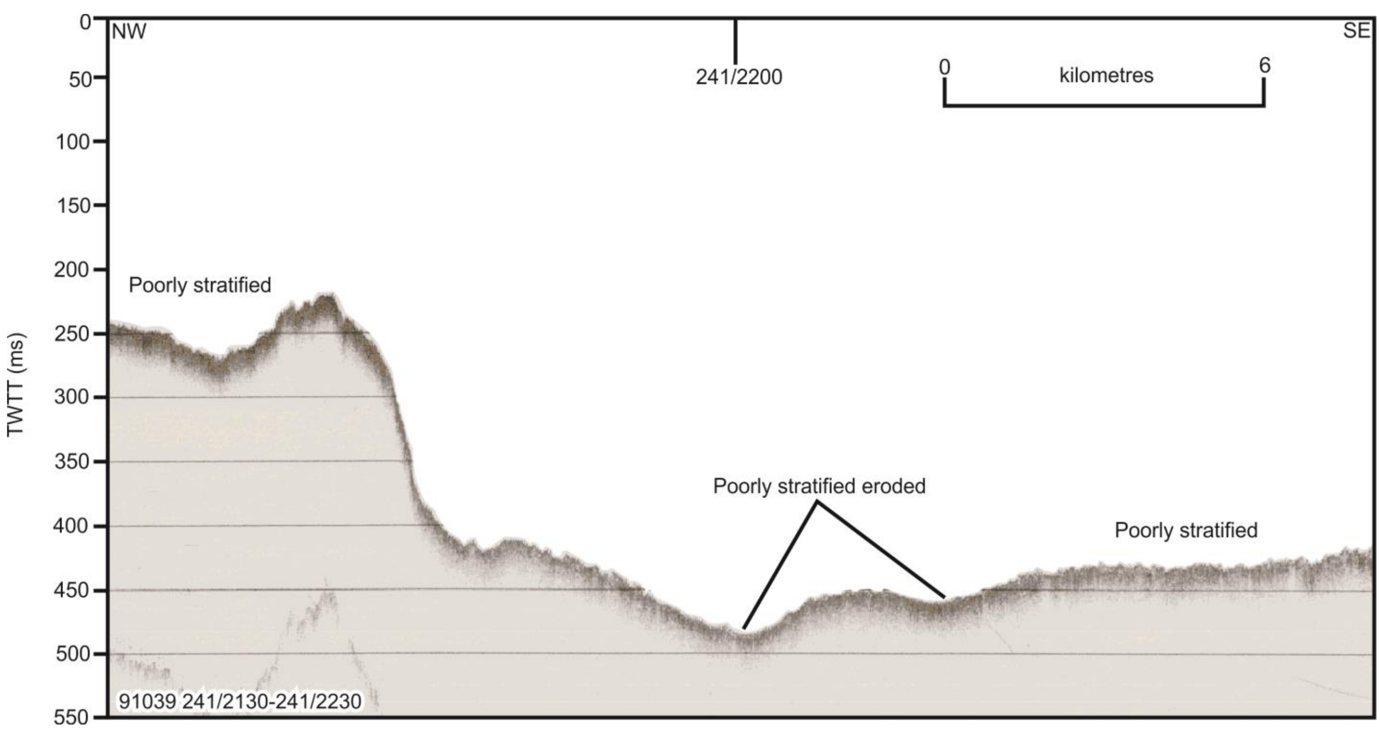


Figure 11: 3.5 kHz sub-bottom profiler record showing an example of eroded poorly stratified sediments (pse) and poorly stratified sediments (ps).

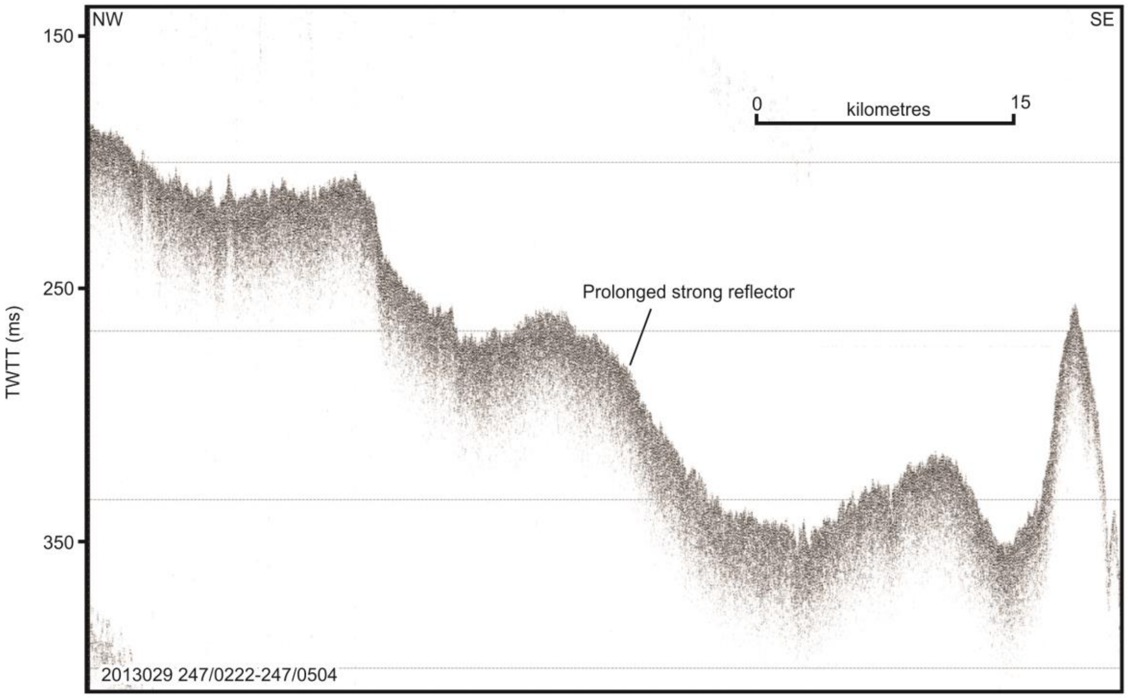


Figure 12: 3.5 kHz sub-bottom profiler record showing an example of a prolonged strong reflector (psr).

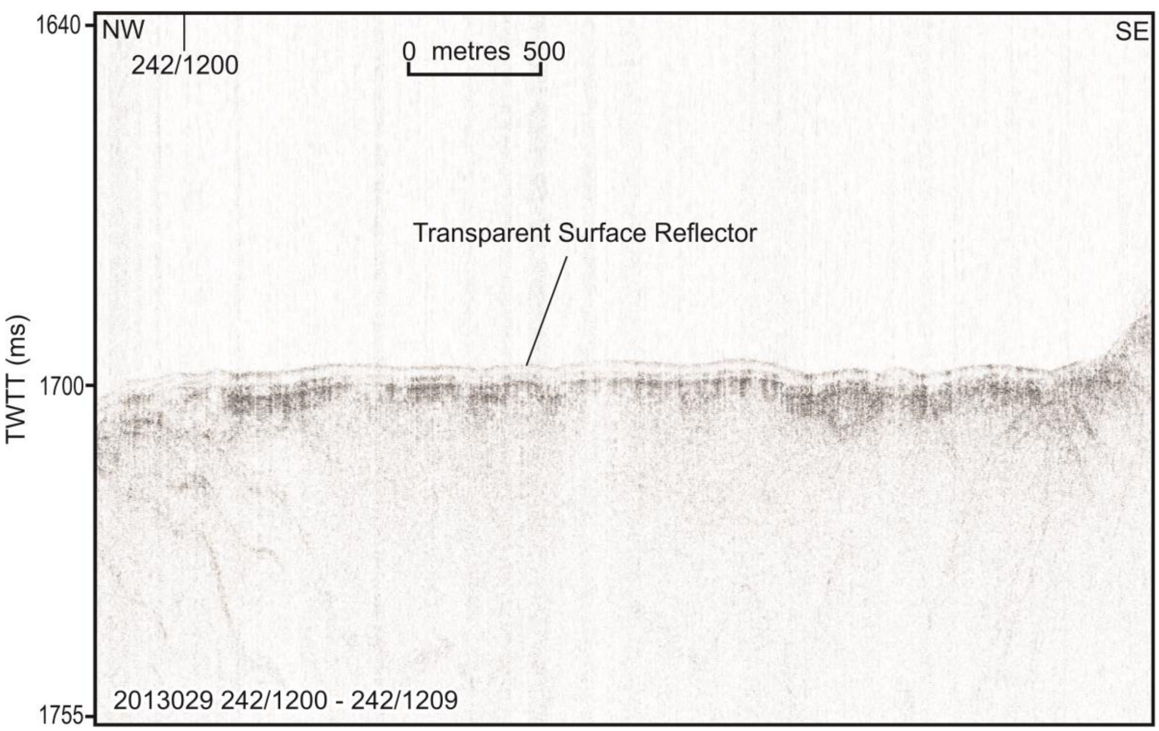


Figure 13: 3.5 kHz sub-bottom profiler record showing an example of a transparent surface reflector.

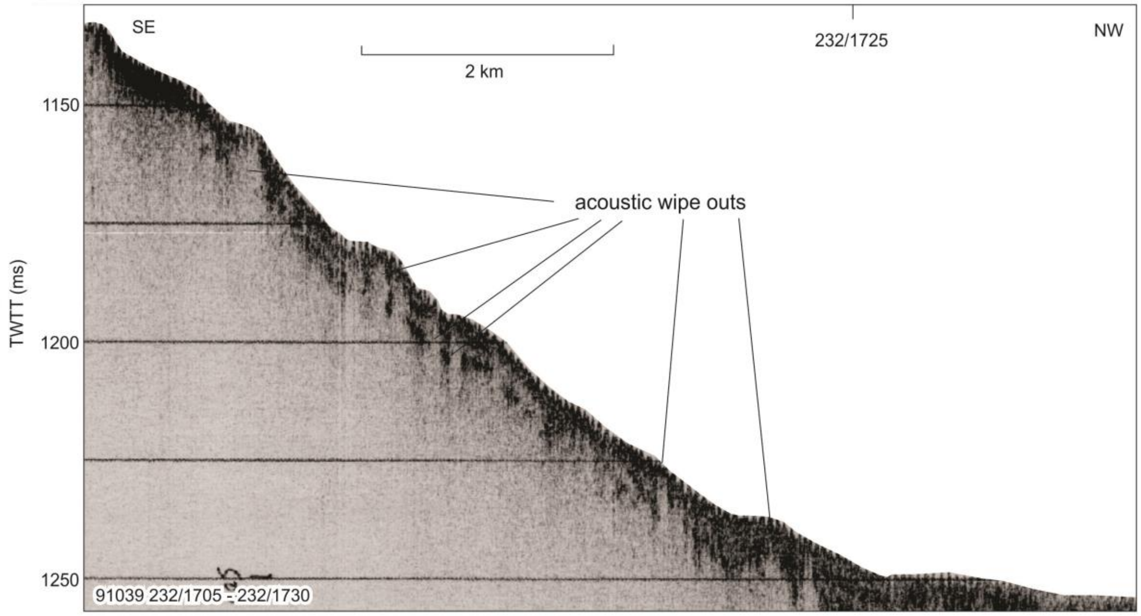


Figure 14: 3.5 kHz sub-bottom profiler record showing several examples of acoustic wipe out structures (wo) likely caused by the presence of gas in the near surface sediments.

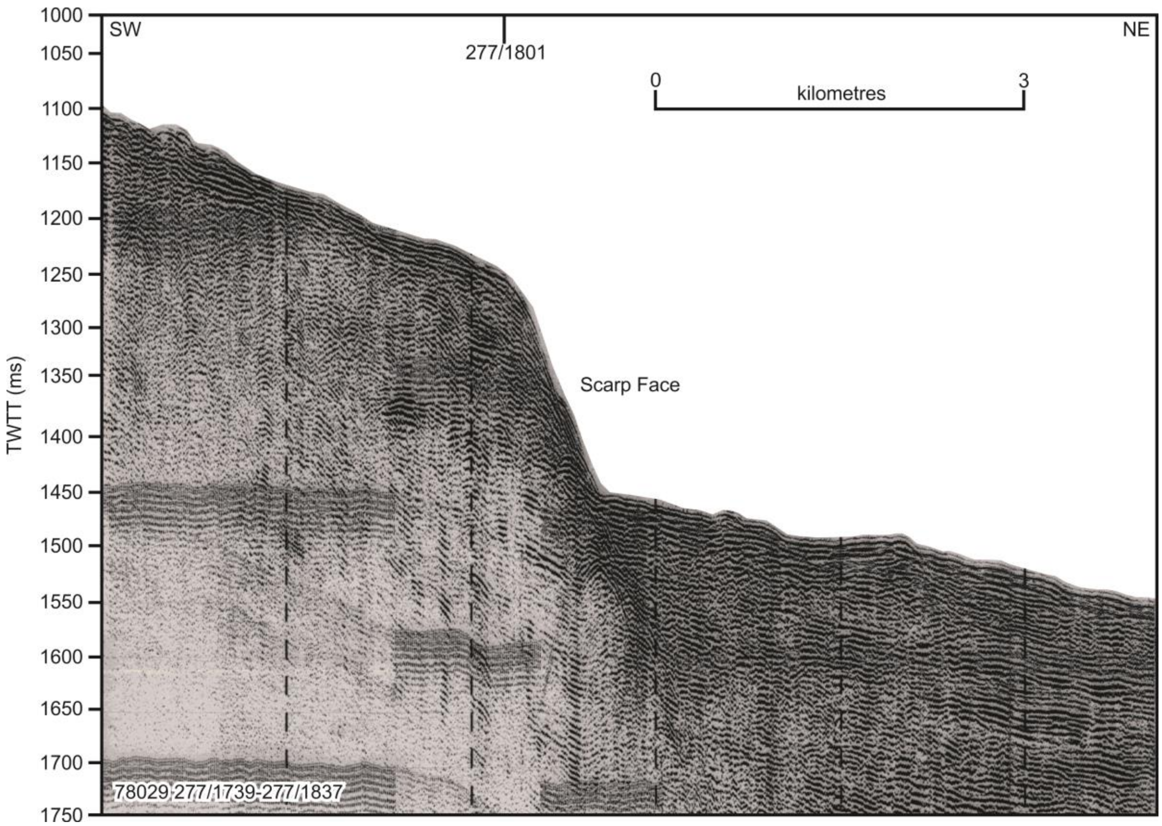


Figure 15: Seismic reflection profile showing an example of a large scarp face (sf).

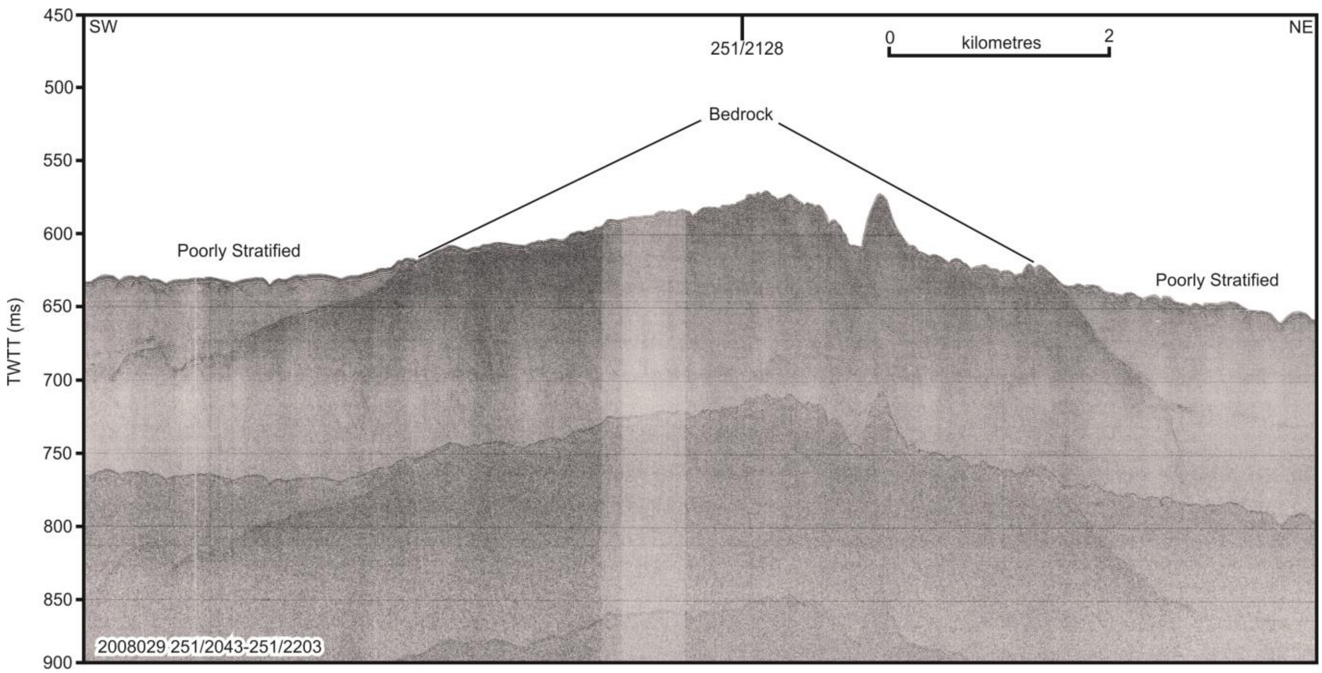


Figure 16: Huntec profile showing a hard surface interpreted to be bedrock (b) covered by a very thin veneer of sediment. Poorly stratified sediments (ps) lie on either side of the bedrock high.

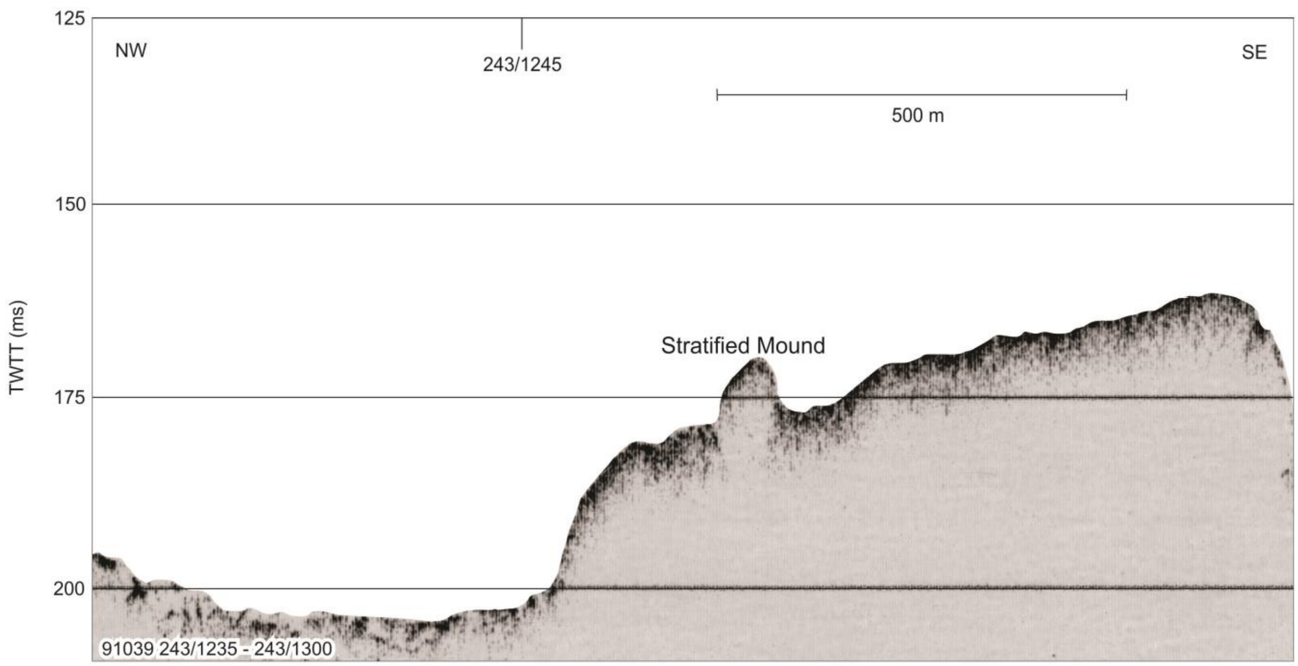


Figure 17: 3.5 kHz sub-bottom profiler record showing an example of a stratified mound (sm). This particular mound is poorly stratified.

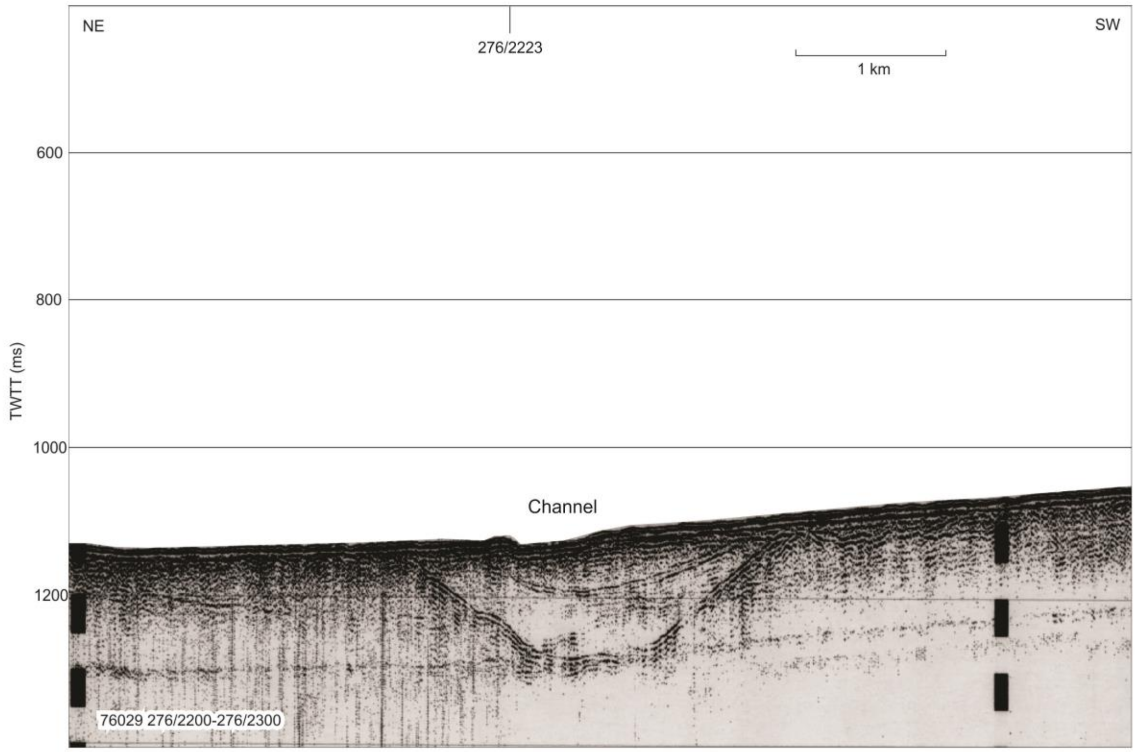


Figure 18: Seismic reflection profile showing an example of an infilled channel (ch).

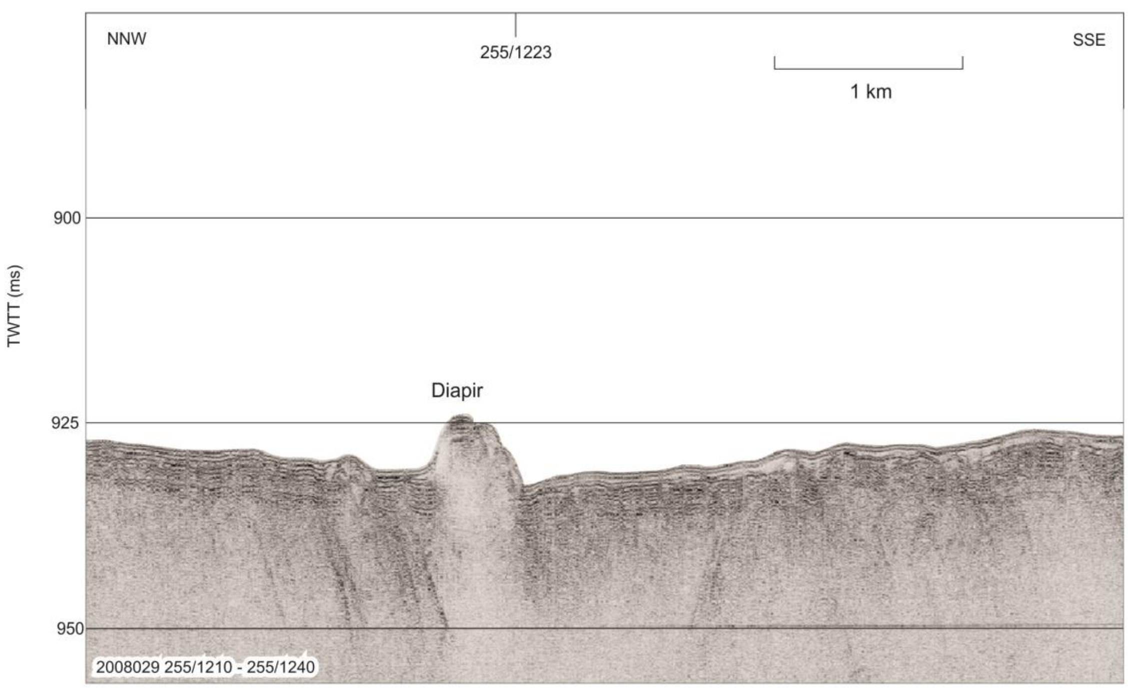
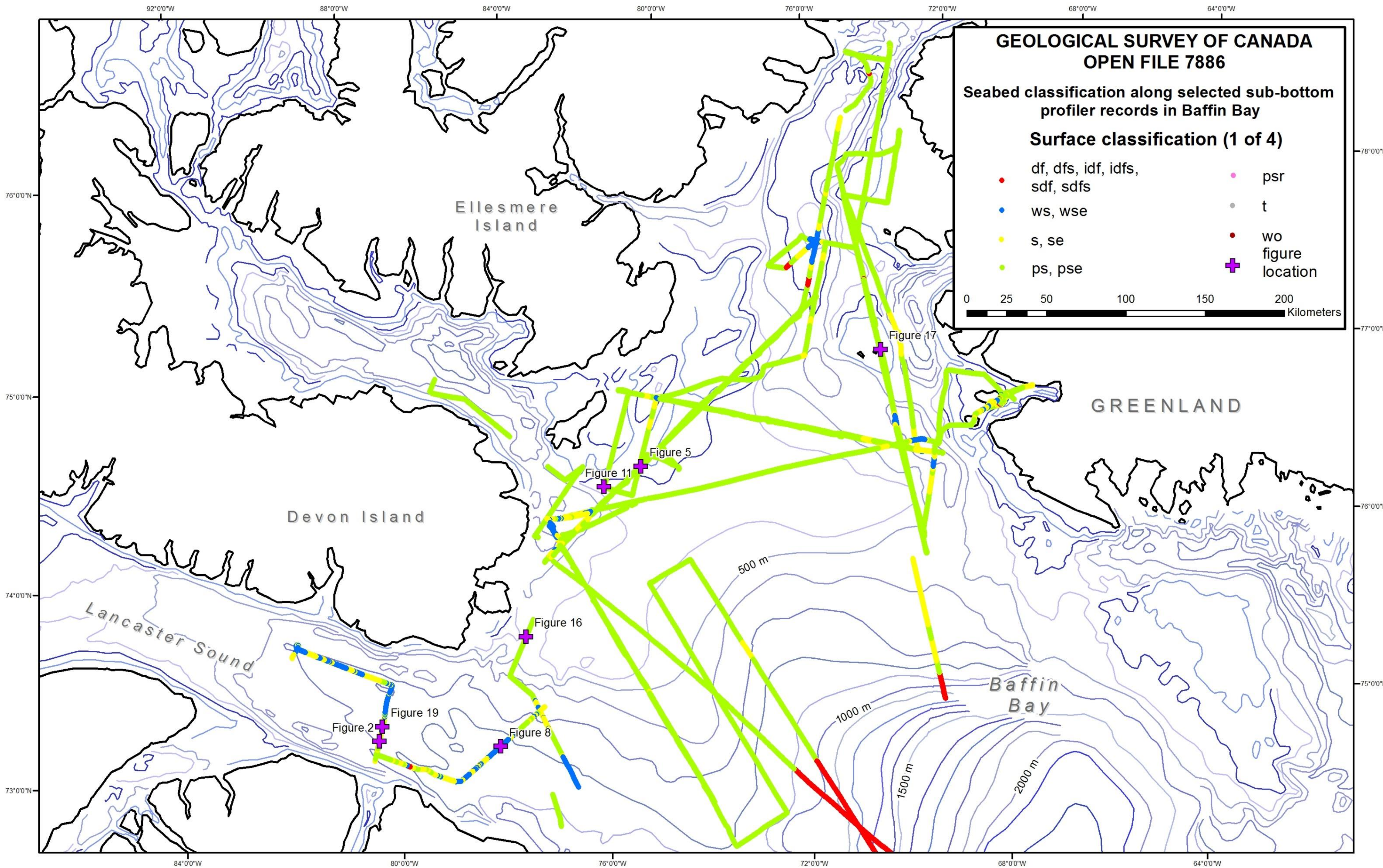


Figure 19: Huntec profile showing an example of a diapir (d). Internal structure of the feature is masked likely due to the presence of gas in the sediments.

Appendix 1 - Maps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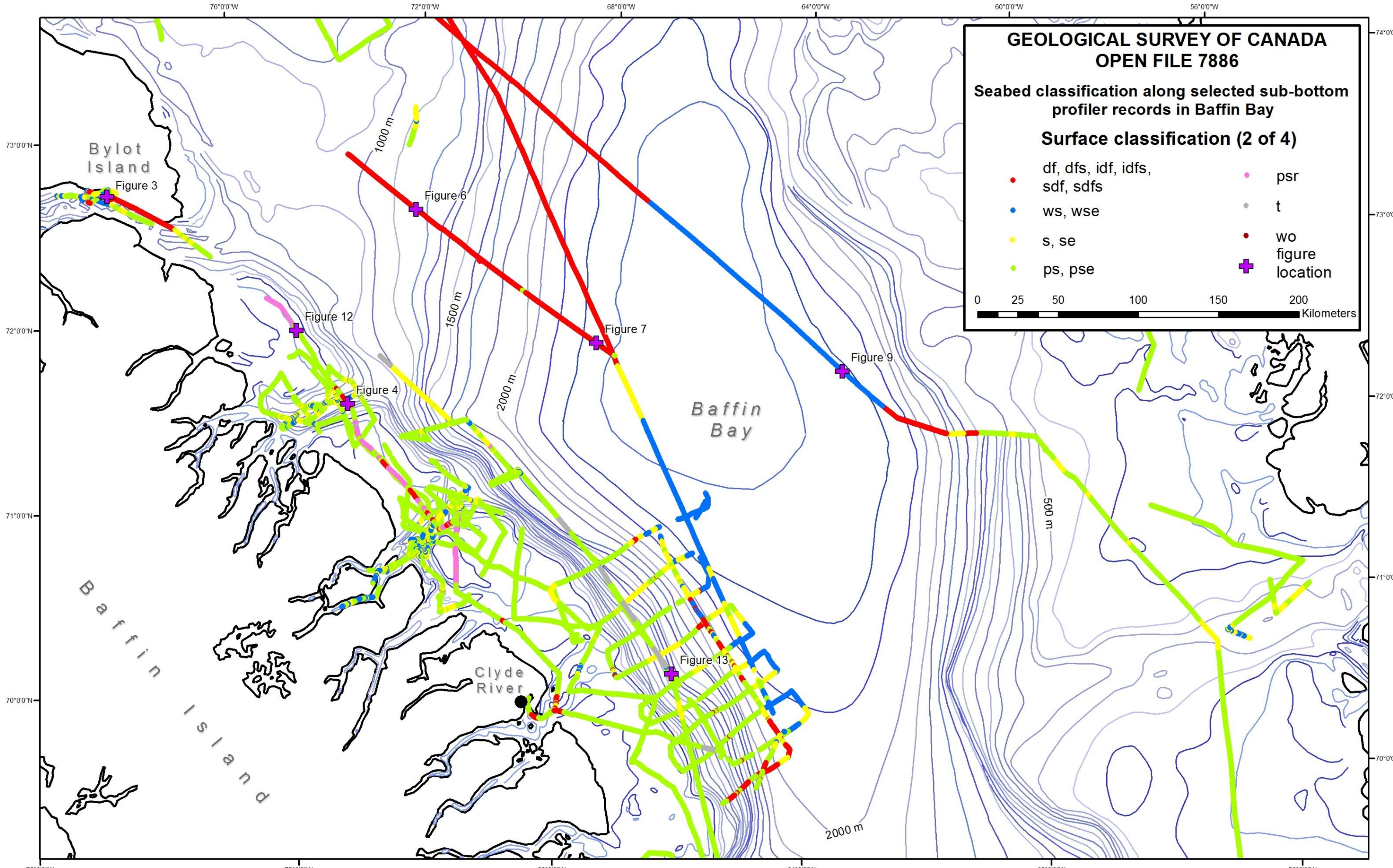
OPEN FILE 7886
Seabed classification along selected sub-bottom profiler records in Baffin Bay
Surface classification (1 of 4)
df, dfs, idf, idfs, sdf, sdfs
ws, wse
s, se
ps, pse
psr
t
wo
figure location
0 25 50 100 150 200 Kilometers
Ellesmere Island
Devon Island
GREENLAND
Lancaster Sound
Baffin Bay
Figure 2
Figure 5
Figure 8
Figure 11
Figure 16
Figure 17
Figure 19
500 m
1000 m
1500 m
2000 m


GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected sub-bottom profiler records in Baffin Bay
Surface classification (2 of 4)
df, dfs, idf, idfs, sdf, sdfs
ws, wse
s, se
ps, pse
psr
t
wo
figure location
0 25 50 100 150 200 Kilometers
Bylot Island
Baffin Island
Baffin Bay
Clyde River
Figure 3
Figure 4
Figure 6
Figure 7
Figure 9
Figure 12
Figure 13
1000 m
1500 m
2000 m
500 m
76°0'0"W
72°0'0"W
68°0'0"W
64°0'0"W
60°0'0"W
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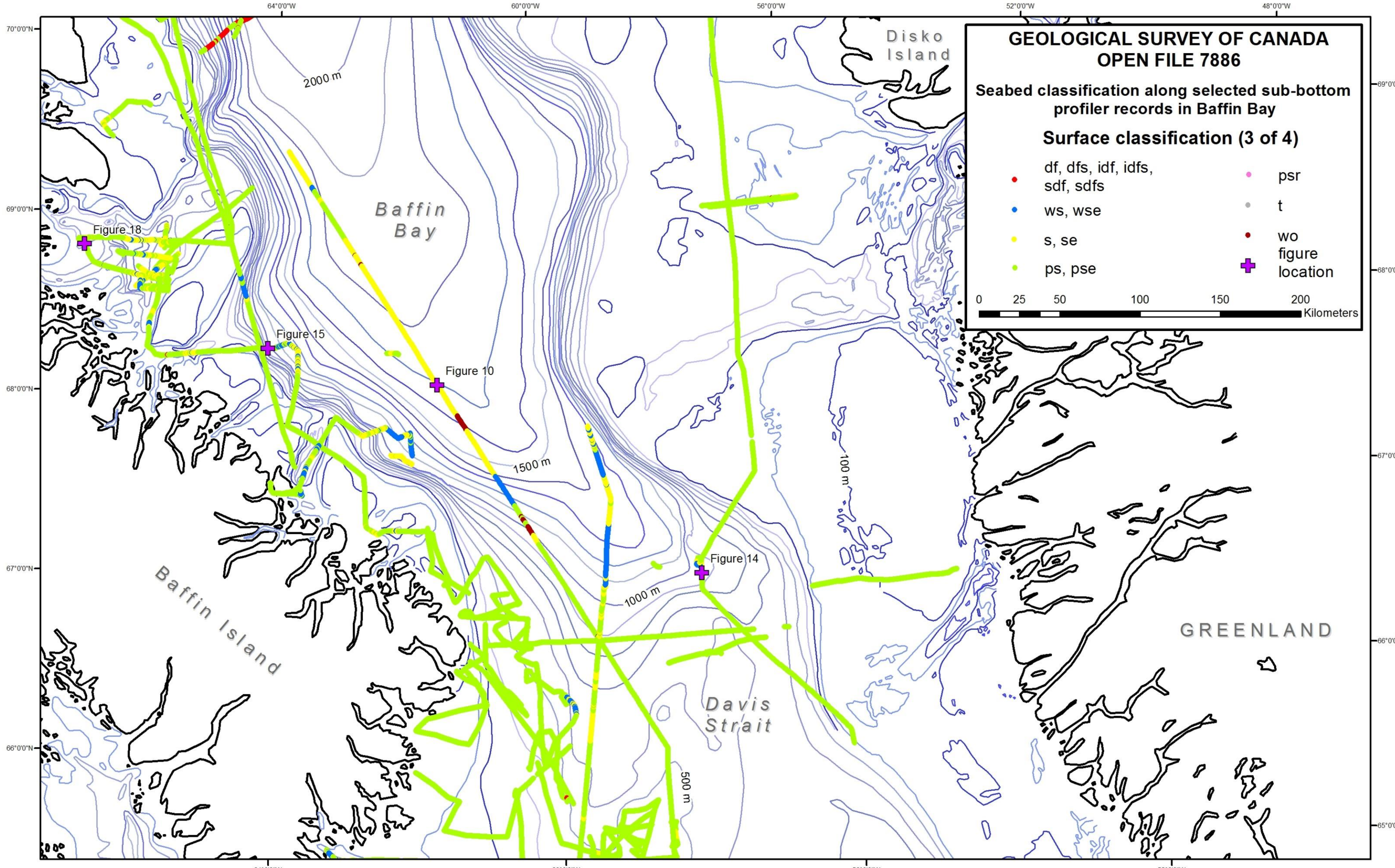
74°0'0"N


GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected sub-bottom profiler records in Baffin Bay
Surface classification (3 of 4)
df, dfs, idf, idfs, sdf, sdfs
ws, wse
s, se
ps, pse
psr
t
wo
figure location
0 25 50 100 150 200 Kilometers
Disko Island
Baffin Bay
Baffin Island
Davis Strait
GREENLAND
2000 m
1500 m
1000 m
500 m
100 m
Figure 18
Figure 15
Figure 10
Figure 14
64°0'0"W
60°0'0"W
56°0'0"W
52°0'0"W
48°0'0"W
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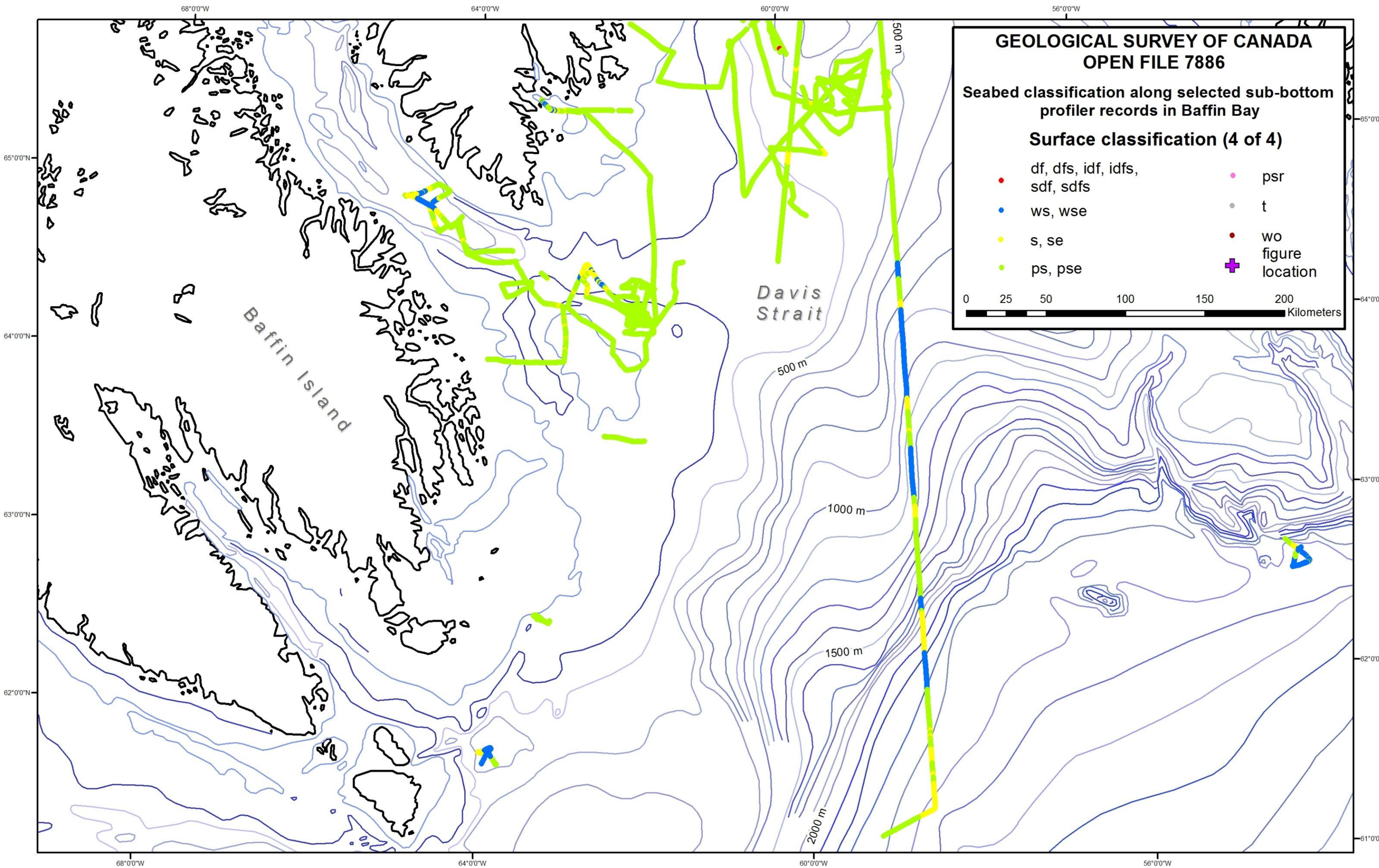
65°0'0"N



GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected sub-bottom profiler records in Baffin Bay
Surface classification (4 of 4)
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ws, wse
s, se
ps, pse
psr
t
wo
figure location
0 25 50 100 150 200 Kilometers
Baffin Island
Davis Strait
500 m
1000 m
1500 m
2000 m
68°0'0"W
64°0'0"W
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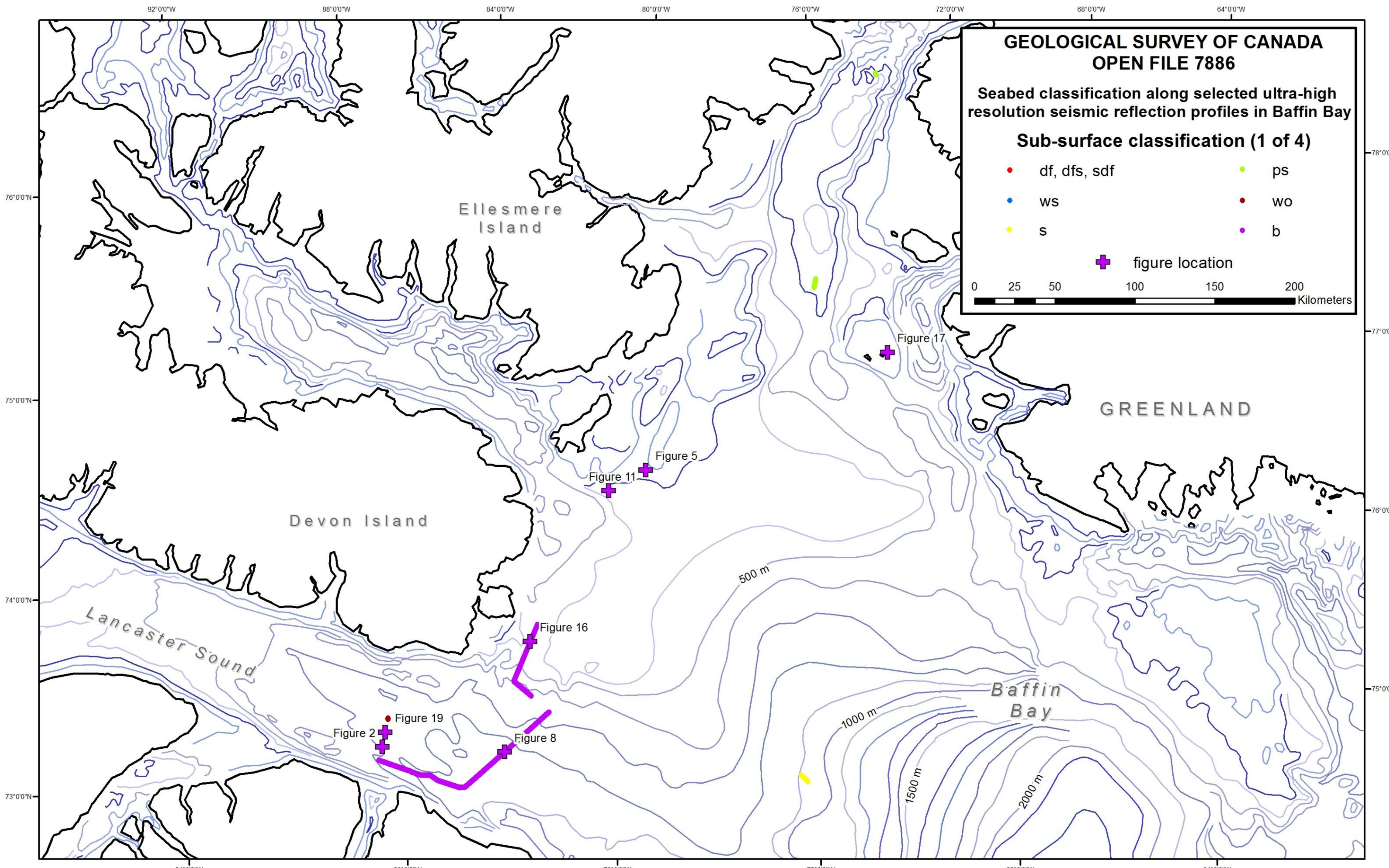
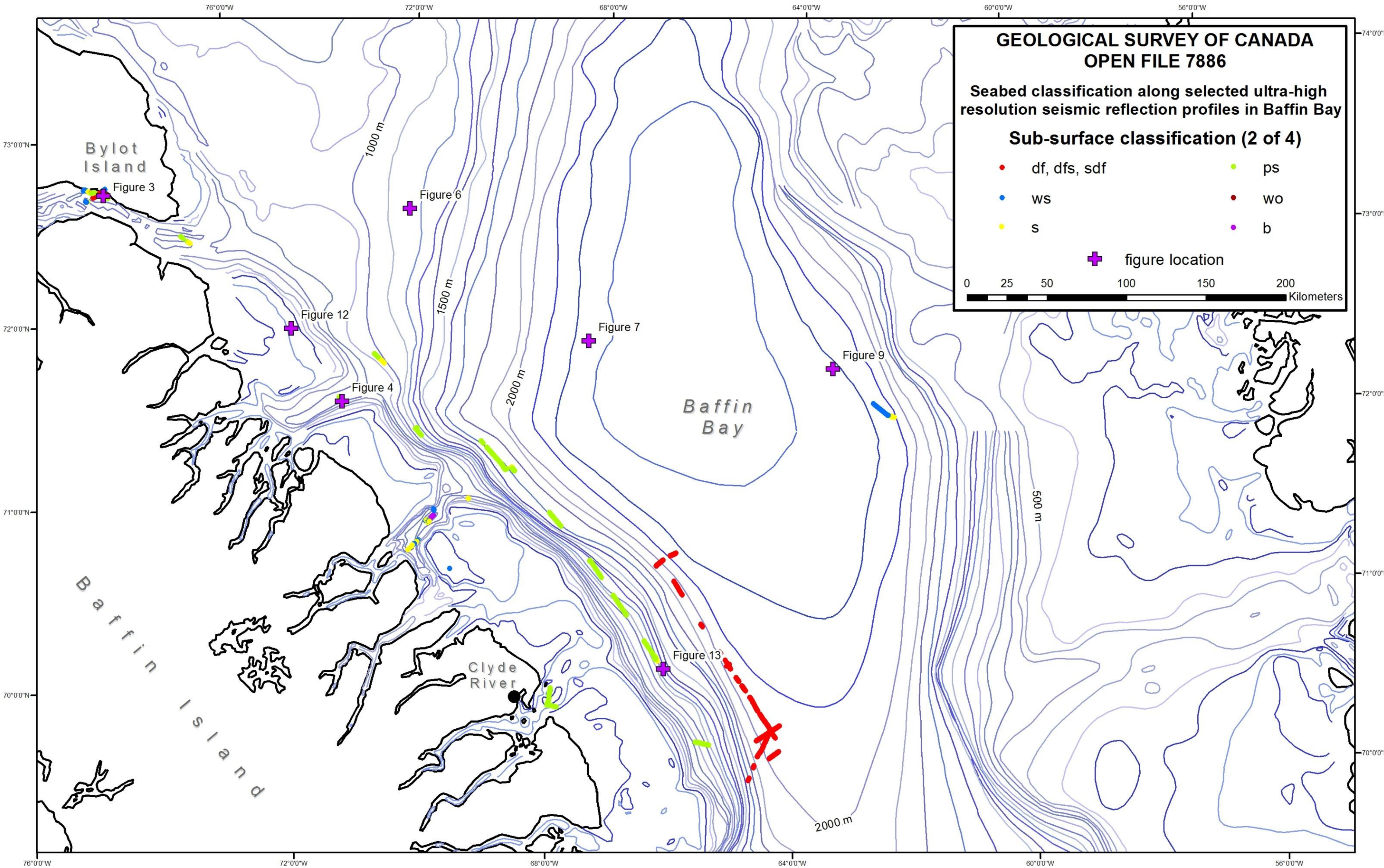


GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected ultra-high resolution seismic reflection profiles in Baffin Bay
Sub-surface classification (1 of 4)
df, dfs, sdf
ws
s
ps
wo
b
figure location
0 25 50 100 150 200 Kilometers
Ellesmere Island
Devon Island
Lancaster Sound
GREENLAND
Baffin Bay
500 m
1000 m
1500 m
2000 m
Figure 2
Figure 5
Figure 8
Figure 11
Figure 16
Figure 17
Figure 19


GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected ultra-high resolution seismic reflection profiles in Baffin Bay
Sub-surface classification (2 of 4)
df, dfs, sdf
ws
s
ps
wo
b
figure location
0 25 50 100 150 200
Kilometers
Bylot Island
Figure 3
Figure 6
Figure 12
Figure 7
Figure 9
Figure 4
Figure 13
Baffin Bay
Baffin Island
Clyde River
1000 m
1500 m
2000 m
500 m
76°0'0"W
72°0'0"W
68°0'0"W
64°0'0"W
60°0'0"W
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74°0'0"N
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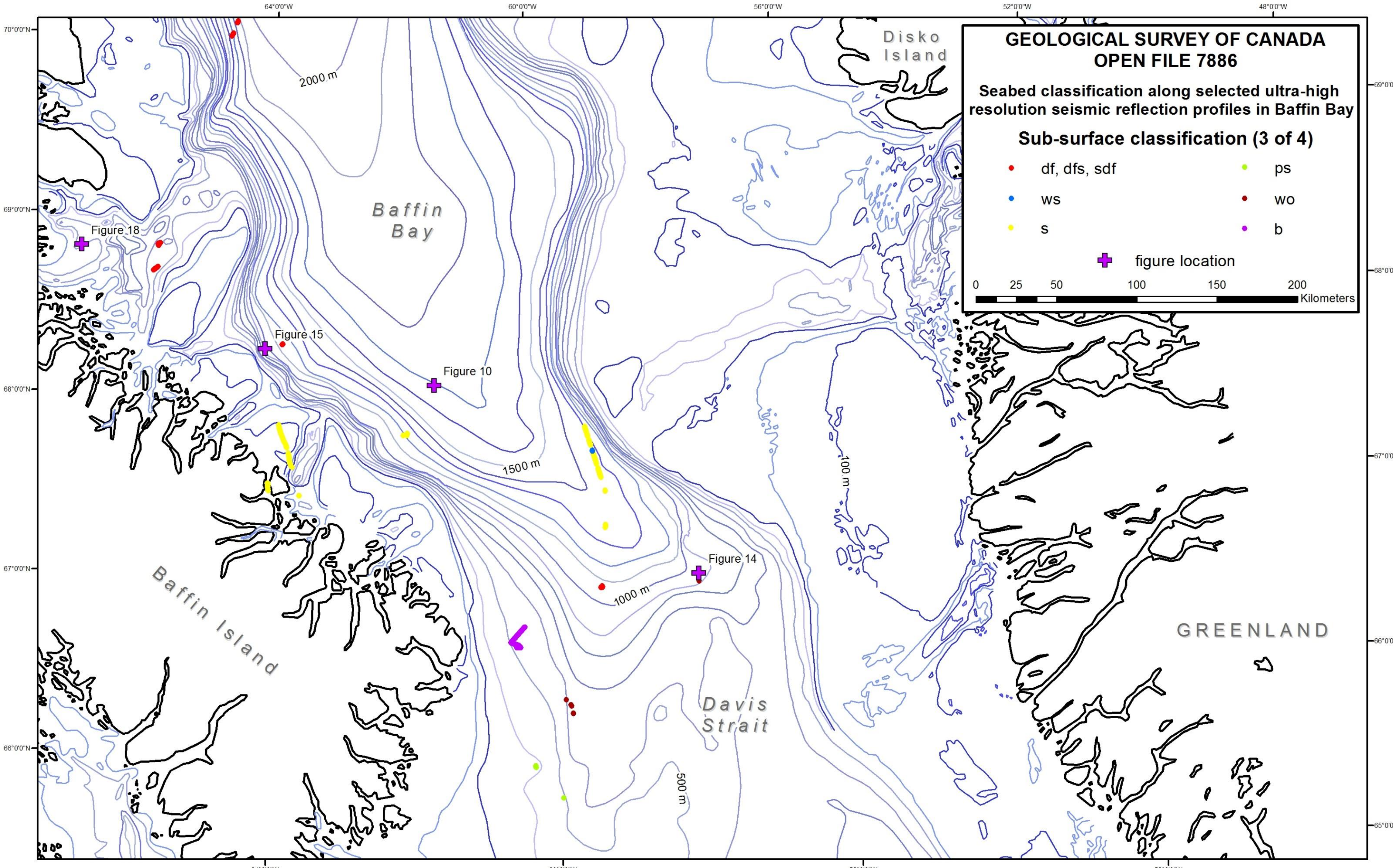
GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected ultra-high resolution seismic reflection profiles in Baffin Bay
Sub-surface classification (3 of 4)
df, dfs, sdf
ws
s
ps
wo
b
figure location
0 25 50 100 150 200 Kilometers
Disko Island
Baffin Bay
Baffin Island
Davis Strait
GREENLAND
Figure 18
Figure 15
Figure 10
Figure 14
2000 m
1500 m
1000 m
500 m
100 m
64°0'0"W
60°0'0"W
56°0'0"W
52°0'0"W
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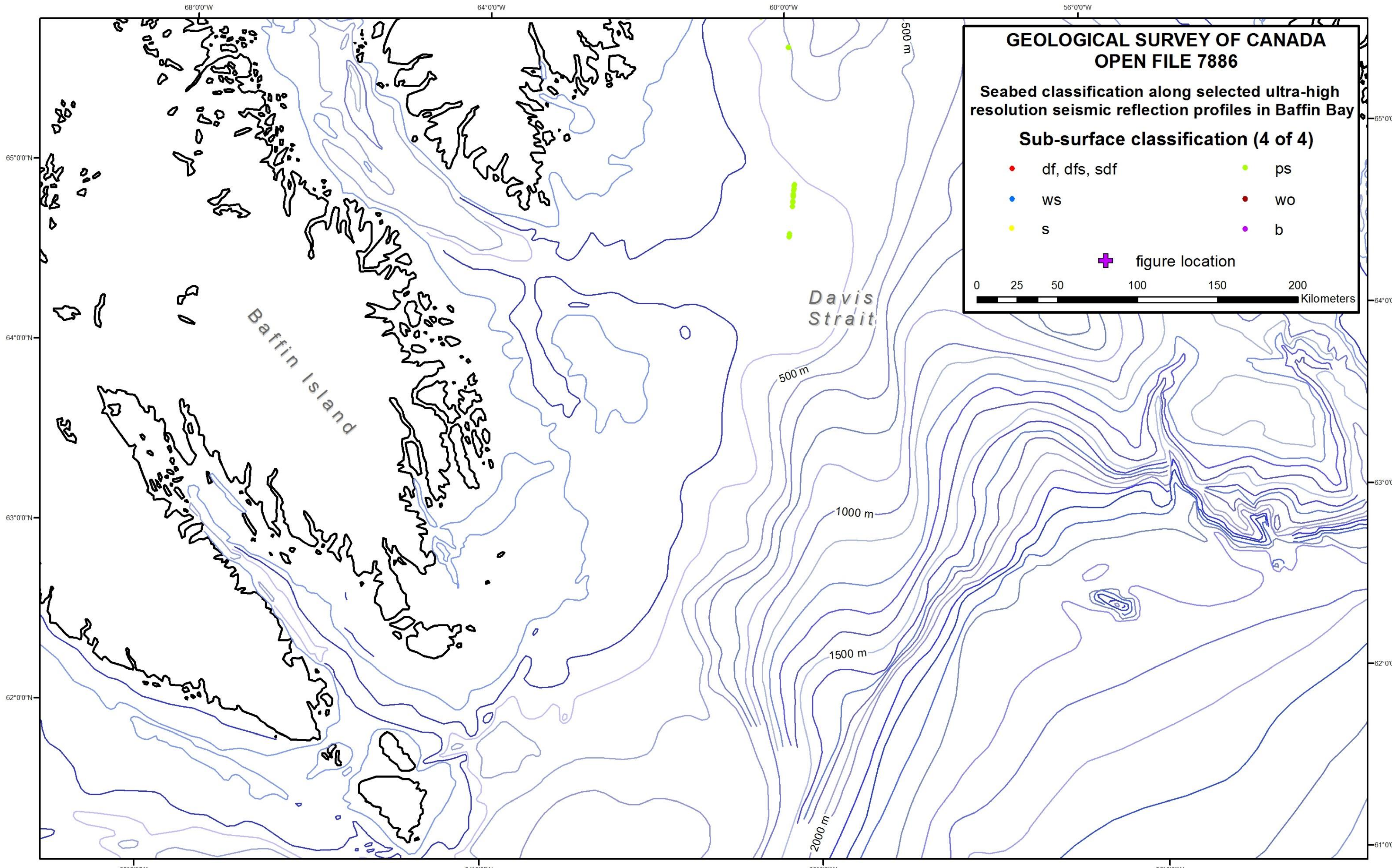
65°0'0"N



GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected ultra-high resolution seismic reflection profiles in Baffin Bay
Sub-surface classification (4 of 4)
df, dfs, sdf
ws
s
ps
wo
b
figure location
0 25 50 100 150 200
Kilometers
Baffin Island
Davis Strait
500 m
1000 m
1500 m
2000 m
68°0'0"W
64°0'0"W
60°0'0"W
56°0'0"W
65°0'0"N
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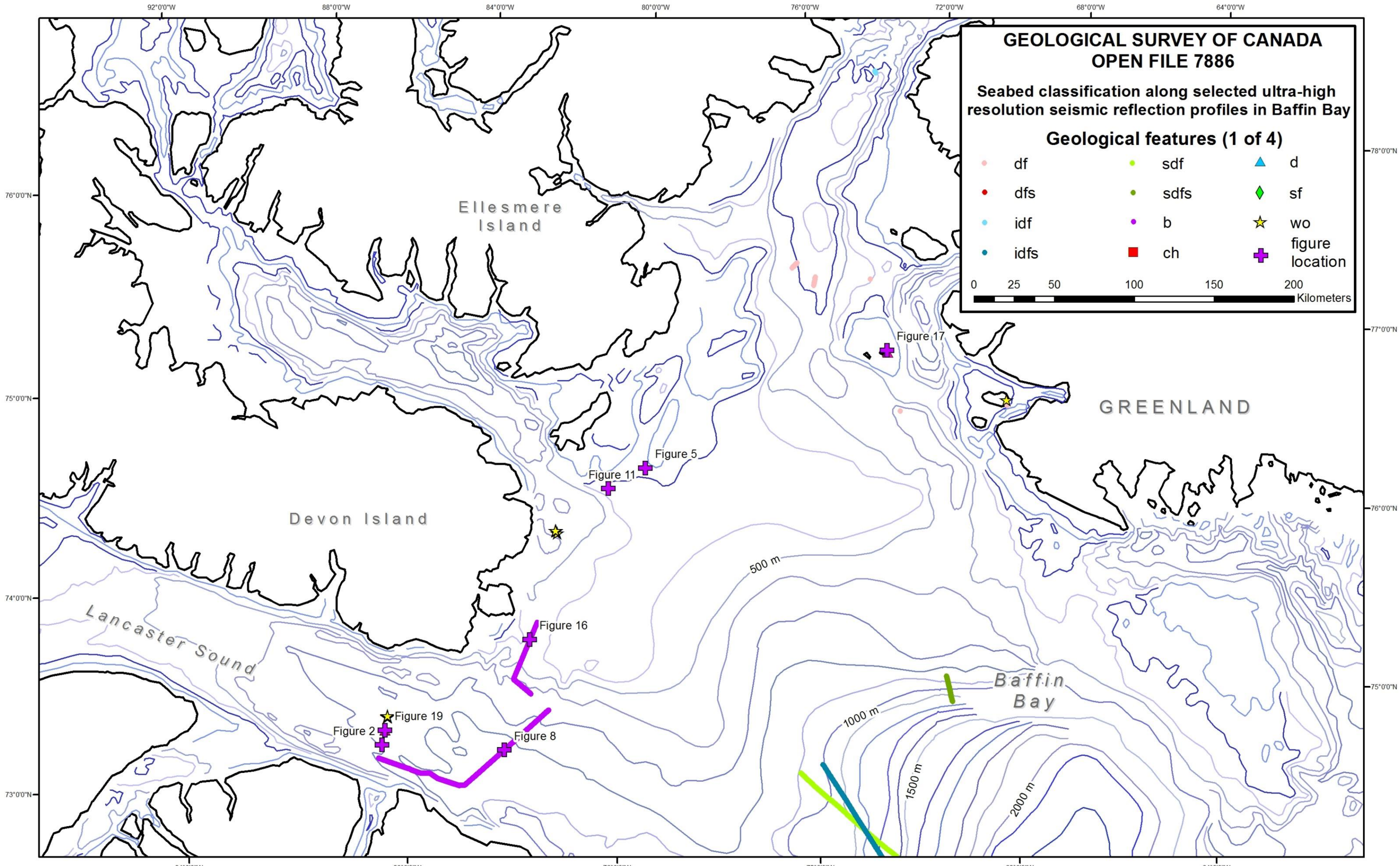
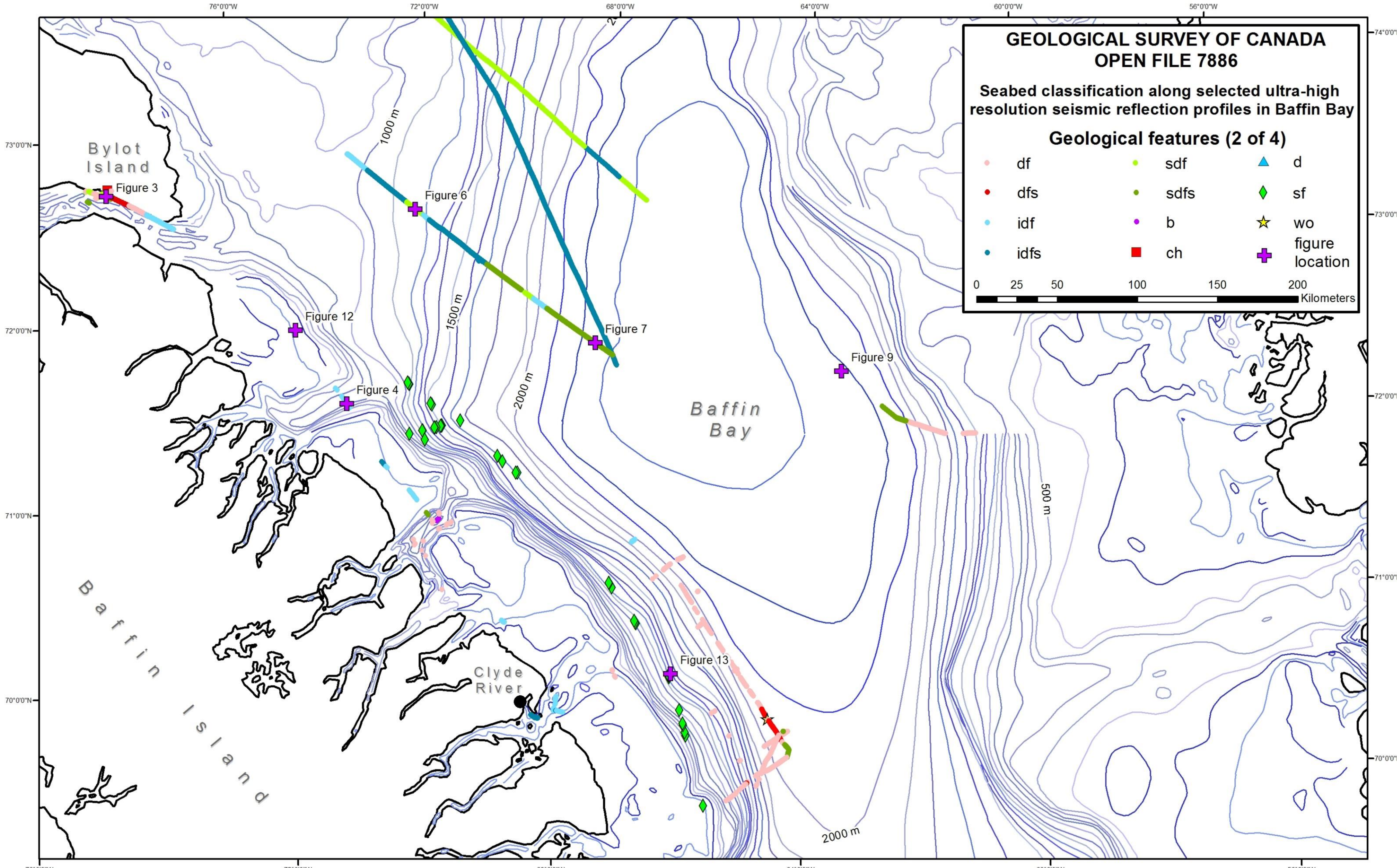
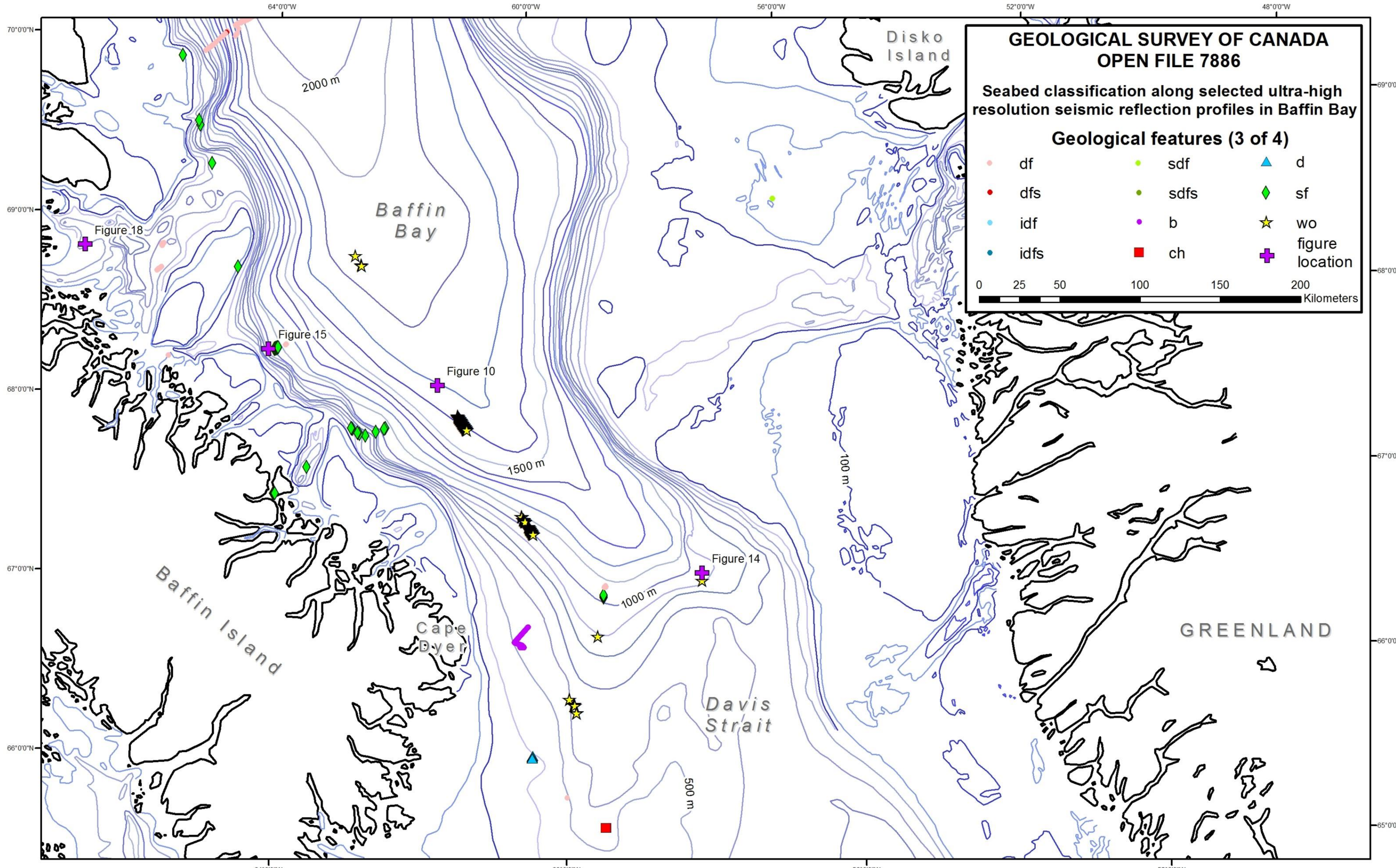
61°0'0"N

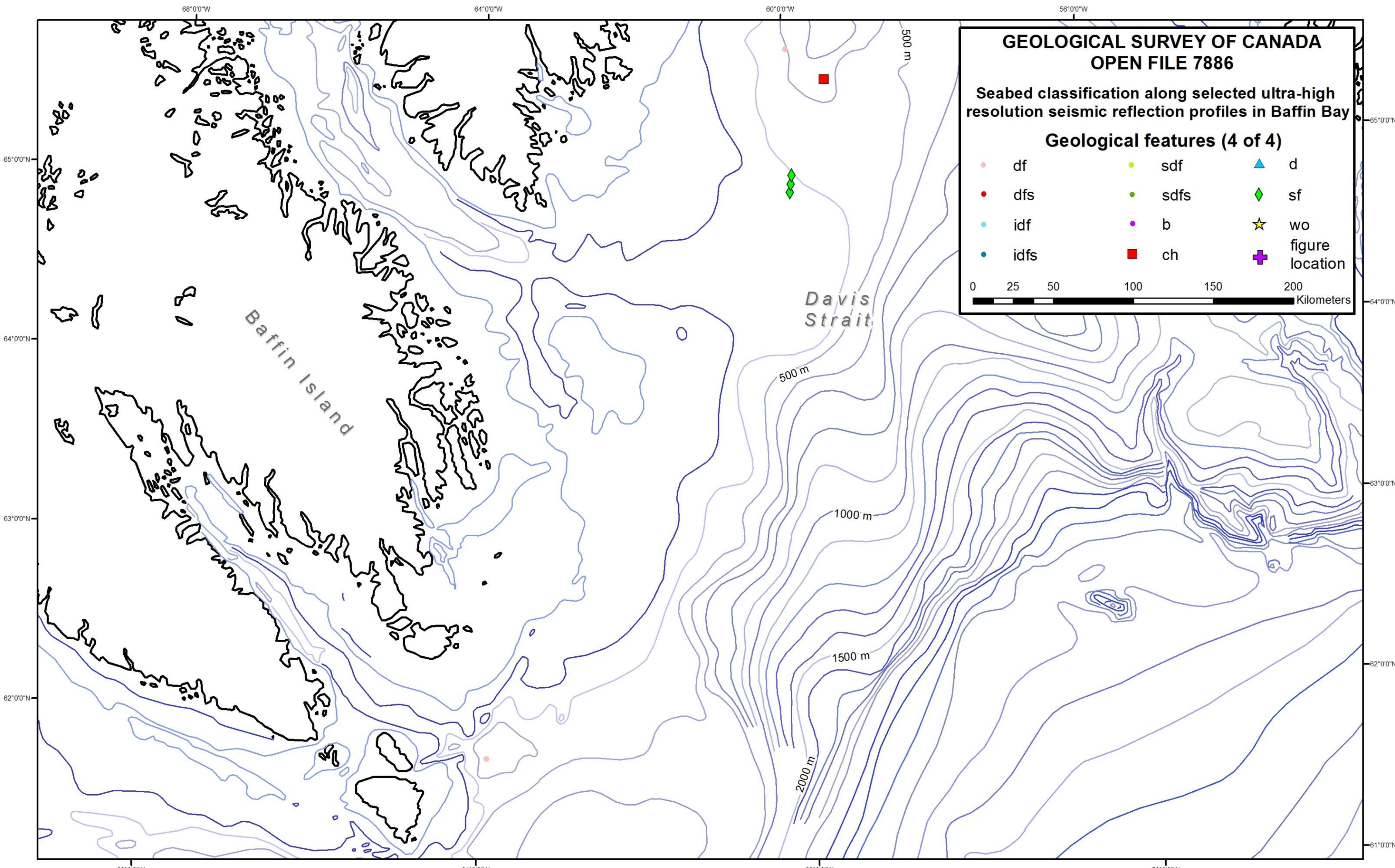


GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected ultra-high resolution seismic reflection profiles in Baffin Bay
Geological features (1 of 4)
df
dfs
idf
idfs
sdf
sdfs
b
ch
d
sf
wo
figure location
0 25 50 100 150 200 Kilometers
Ellesmere Island
Devon Island
Lancaster Sound
GREENLAND
Baffin Bay
Figure 2
Figure 5
Figure 8
Figure 11
Figure 16
Figure 17
Figure 19
500 m
1000 m
1500 m
2000 m
92°0'0"W
88°0'0"W
84°0'0"W
80°0'0"W
76°0'0"W
72°0'0"W
68°0'0"W
64°0'0"W
78°0'0"N
77°0'0"N
76°0'0"N
75°0'0"N
74°0'0"N
73°0'0"N



GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected ultra-high resolution seismic reflection profiles in Baffin Bay
Geological features (2 of 4)
df
dfs
idf
idfs
sdf
sdfs
b
ch
d
sf
wo
figure location
0 25 50 100 150 200
Kilometers
Bylot Island
Baffin Bay
Baffin Island
Clyde River
Figure 3
Figure 4
Figure 6
Figure 7
Figure 9
Figure 12
Figure 13
1000 m
1500 m
2000 m
500 m
2000 m


GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected ultra-high resolution seismic reflection profiles in Baffin Bay
Geological features (3 of 4)
df
dfs
idf
idfs
sdf
sdfs
b
ch
d
sf
wo
figure location
0 25 50 100 150 200 Kilometers
Disko Island
Baffin Bay
Baffin Island
Cape Dyer
Davis Strait
GREENLAND
Figure 18
Figure 15
Figure 10
Figure 14
2000 m
1500 m
1000 m
500 m
100 m
64°0'0"W
60°0'0"W
56°0'0"W
52°0'0"W
48°0'0"W
70°0'0"N
69°0'0"N
68°0'0"N
67°0'0"N
66°0'0"N
65°0'0"N


GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7886
Seabed classification along selected ultra-high resolution seismic reflection profiles in Baffin Bay
Geological features (4 of 4)
df
dfs
idf
idfs
sdf
sdfs
b
ch
d
sf
wo
figure location
0 25 50 100 150 200
Kilometers
Baffin Island
Davis Strait
500 m
1000 m
1500 m
2000 m
68°0'0"W
64°0'0"W
60°0'0"W
56°0'0"W
65°0'0"N
64°0'0"N
63°0'0"N
62°0'0"N
61°0'0"N