Submarine glacial geomorphology

Lecture 9

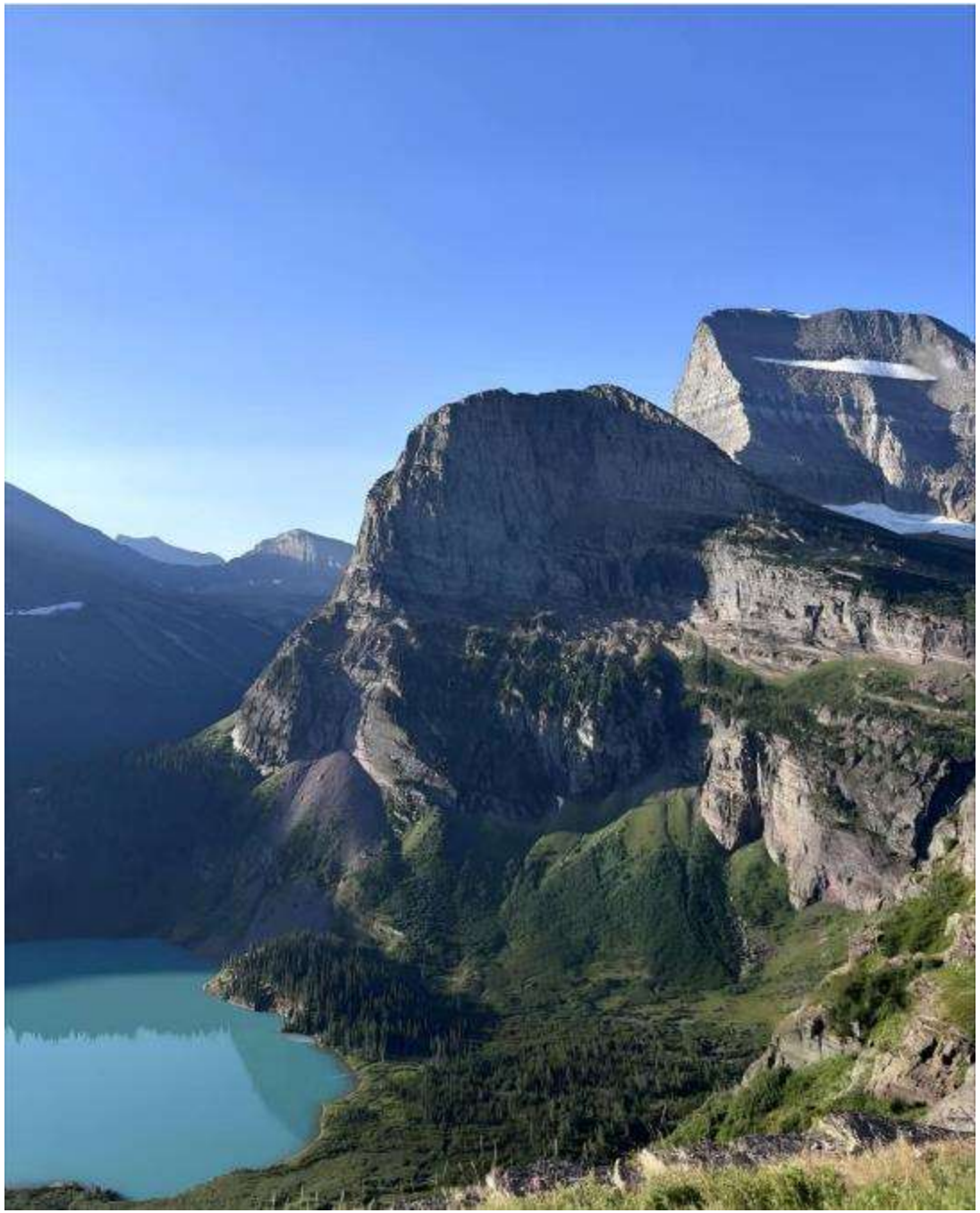
Skaftafelljokull (glacier)

My spring break trip to Iceland

2024 lava flow near Thorbjorn (hyaloclastite hill)

Part 0: Social Media

glacier, several terminal moraines, moraine lake, stream



upper right:

definitely cirques, aretes

lower left

probably cirque with cirque lake

background:

definitely glacier in cirque

aretes, horns

foreground

probably cirque with

moraine lake

background:

arete ?

foreground

cirque with moraine lake ?

plunge pool?

North Table Mountain, Golden, Colorado

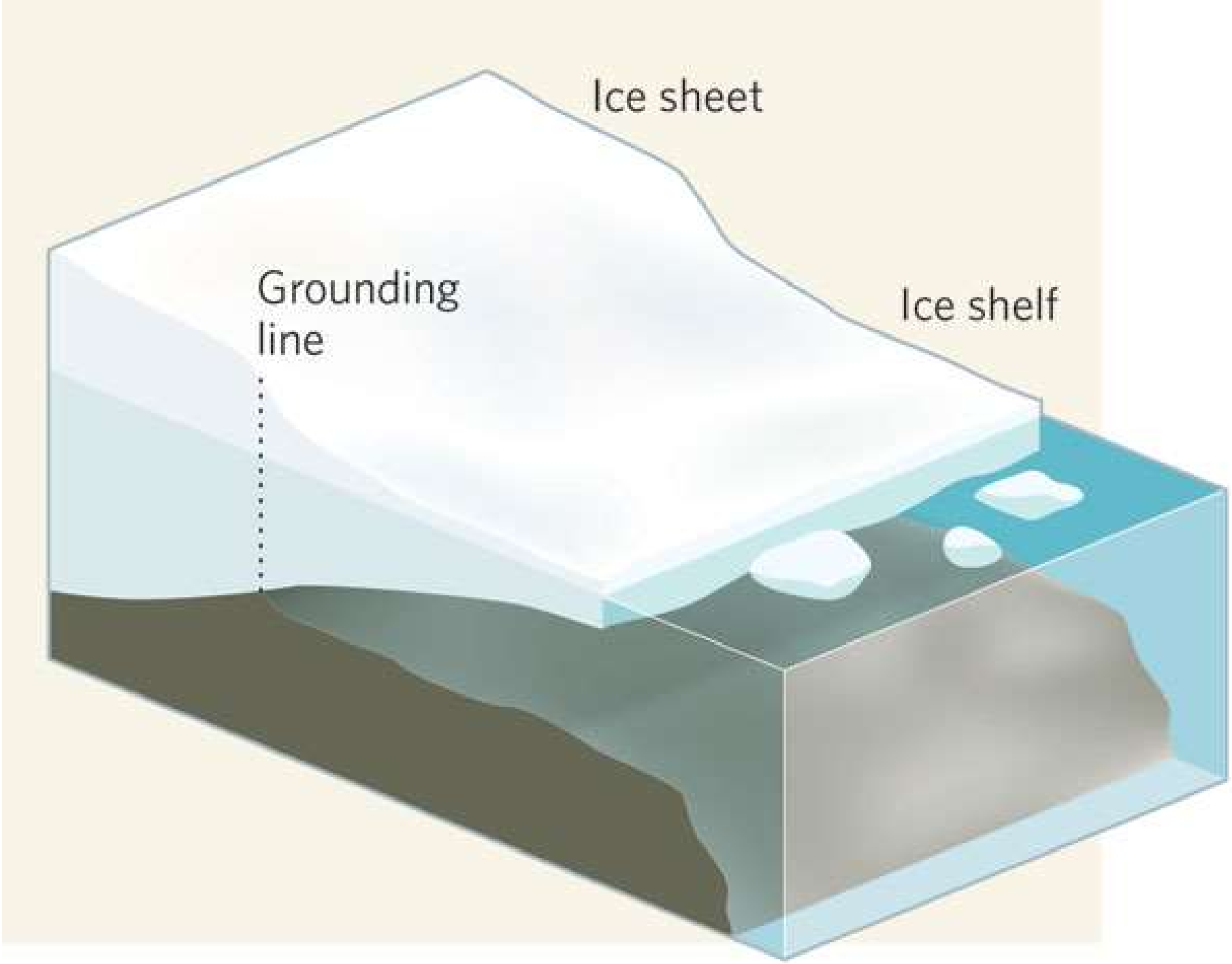
erosional “mesa”, not a table mountain

sediment sandstone, not hyaloclastite

Part 1: Icebergs

Filchner Ice Shelf

floating Ice


Ice sheet
Grounding line
Ice shelf

CNN Science Space Life Unearthed Watch Listen

World's biggest iceberg runs aground off South Georgia

By Jack Guy, CNN

3 minute read · Updated 12:27 AM EST, Wed March 5, 2025

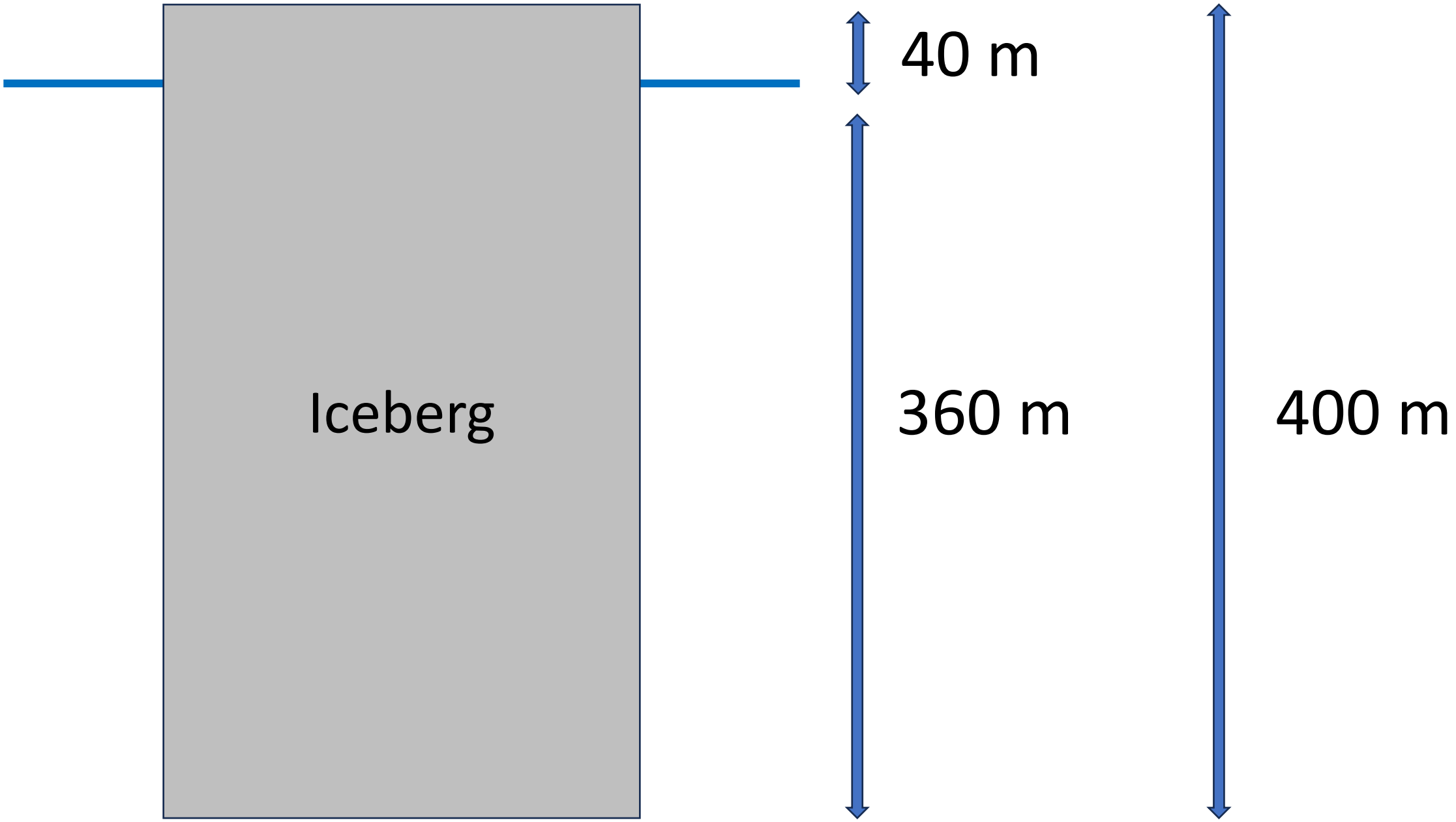
6 comments

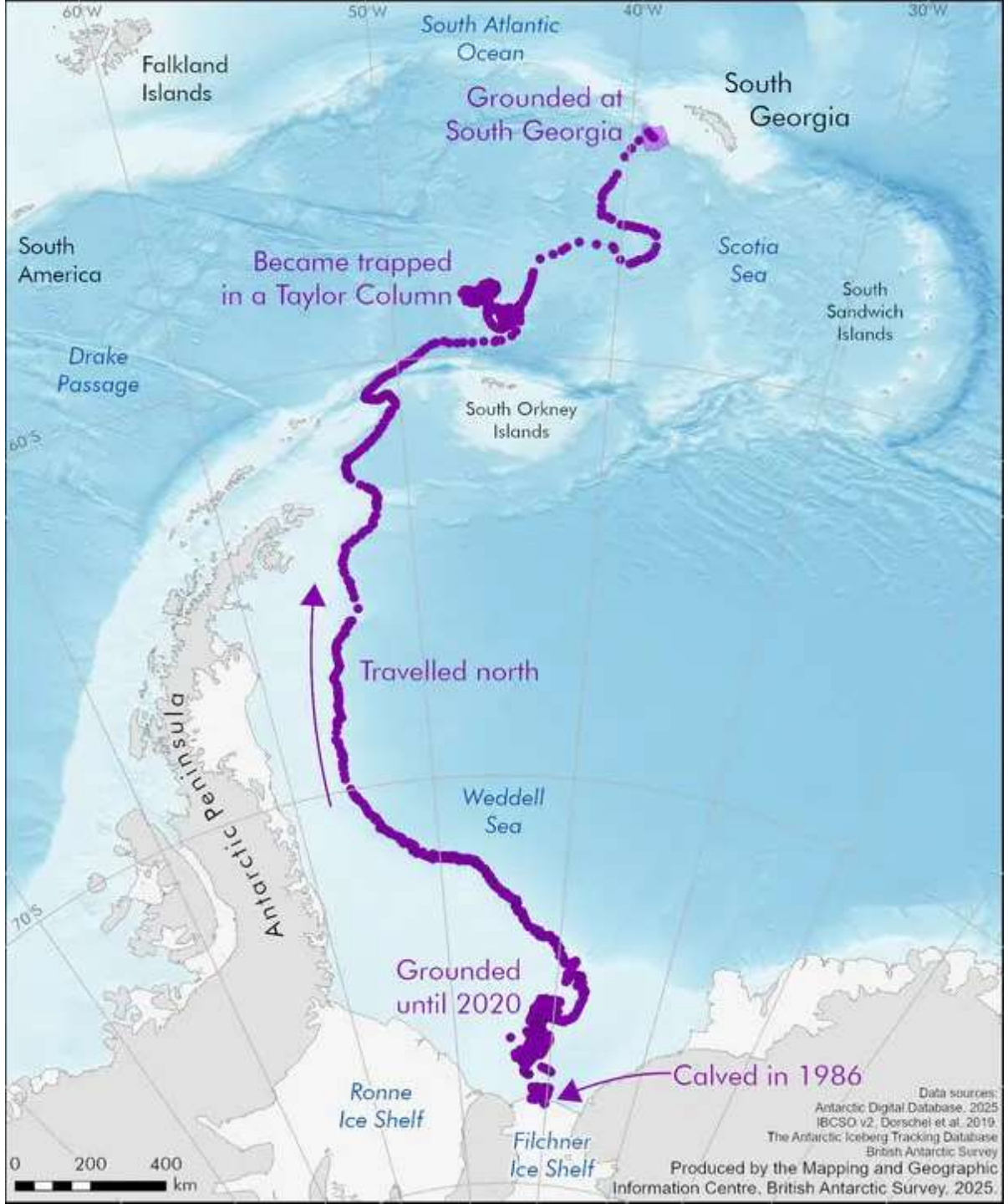
The world's largest iceberg pictured in Antarctica in January 2024. Rob Suisted/Reuters/File

A23a
broke off
Filchner
Ice Shelf

40 m

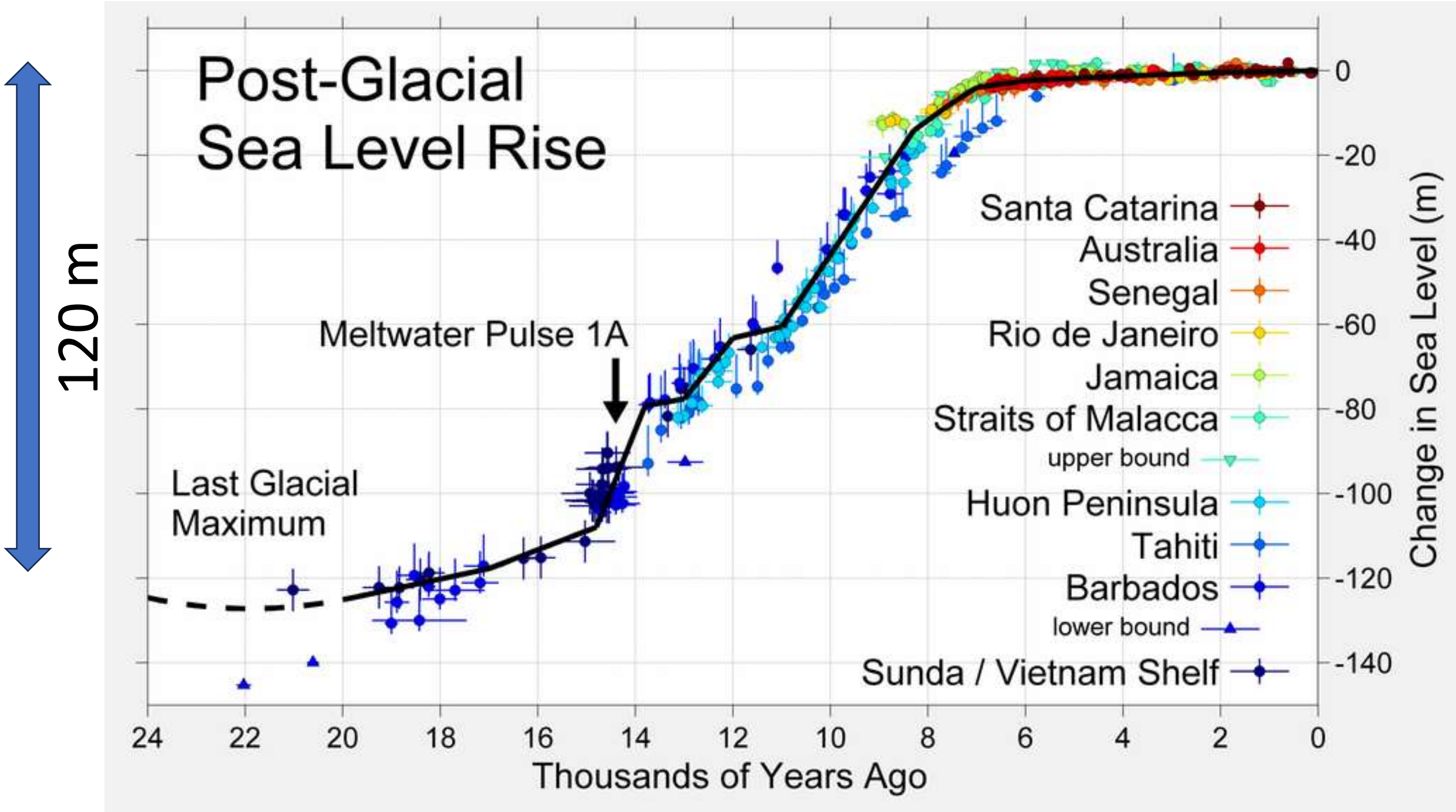
but only top
10% above
water


Iceberg
40 m
360 m
400 m


60°W
50°W
40°W
30°W
South Atlantic Ocean
Falkland Islands
Grounded at South Georgia
South Georgia
South America
Became trapped in a Taylor Column
Scotia Sea
South Sandwich Islands
Drake Passage
South Orkney Islands
60°S
Travelled north
Antarctic Peninsula
Weddell Sea
70°S
Grounded until 2020
Calved in 1986
Ronne Ice Shelf
Filchner Ice Shelf
0
200
400
km
Data sources:
Antarctic Digital Database, 2025
IBCSO v2, Dorschel et al. 2019
The Antarctic Iceberg Tracking Database
British Antarctic Survey
Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2025.

2025

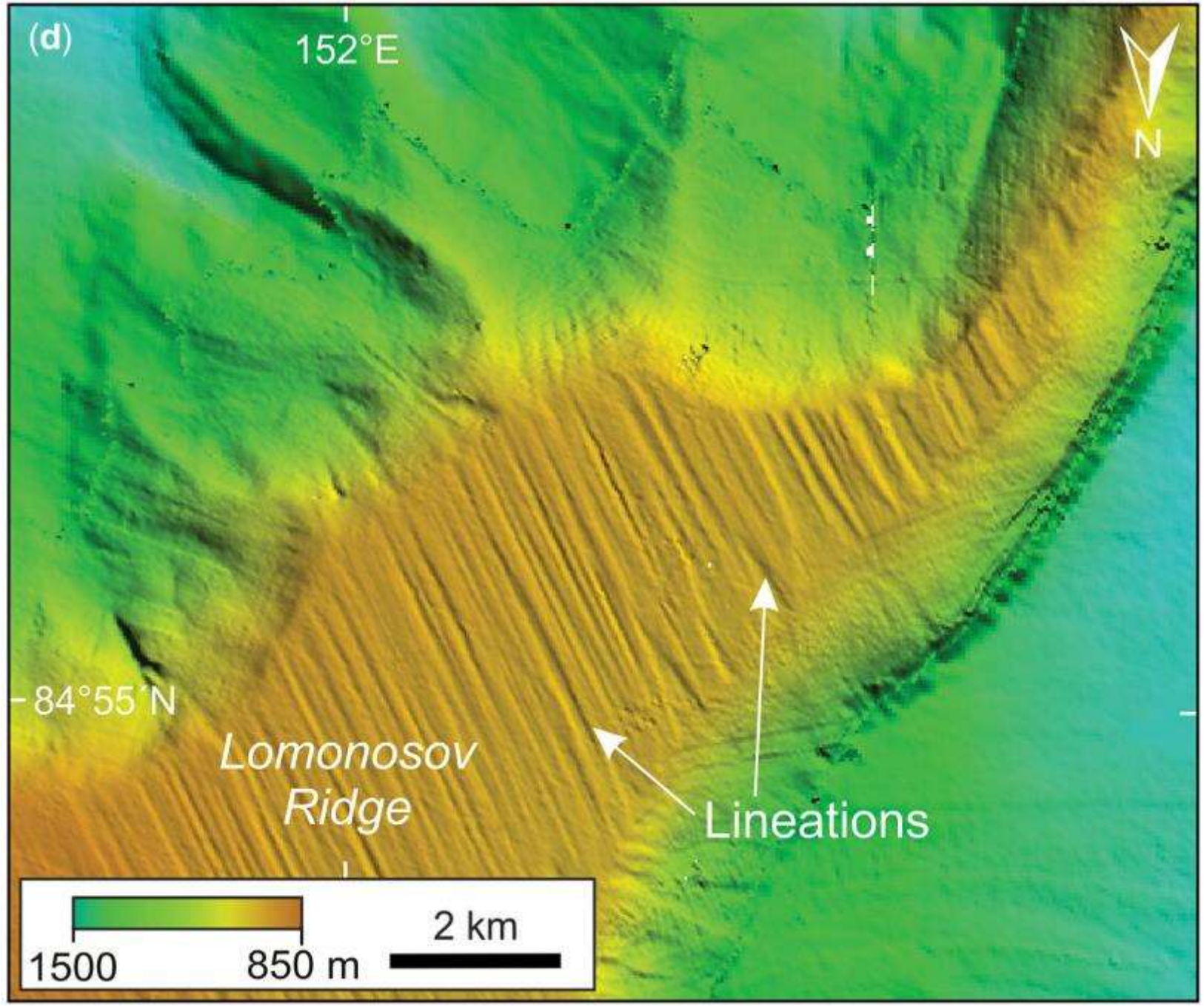
1986


Post-Glacial
Sea Level Rise
120 m
Meltwater Pulse 1A
Last Glacial
Maximum
Santa Catarina
Australia
Senegal
Rio de Janeiro
Jamaica
Straits of Malacca
upper bound
Huon Peninsula
Tahiti
Barbados
lower bound
Sunda / Vietnam Shelf
0
-20
-40
-60
-80
-100
-120
-140
Change in Sea Level (m)
24
22
20
18
16
14
12
10
8
6
4
2
0
Thousands of Years Ago

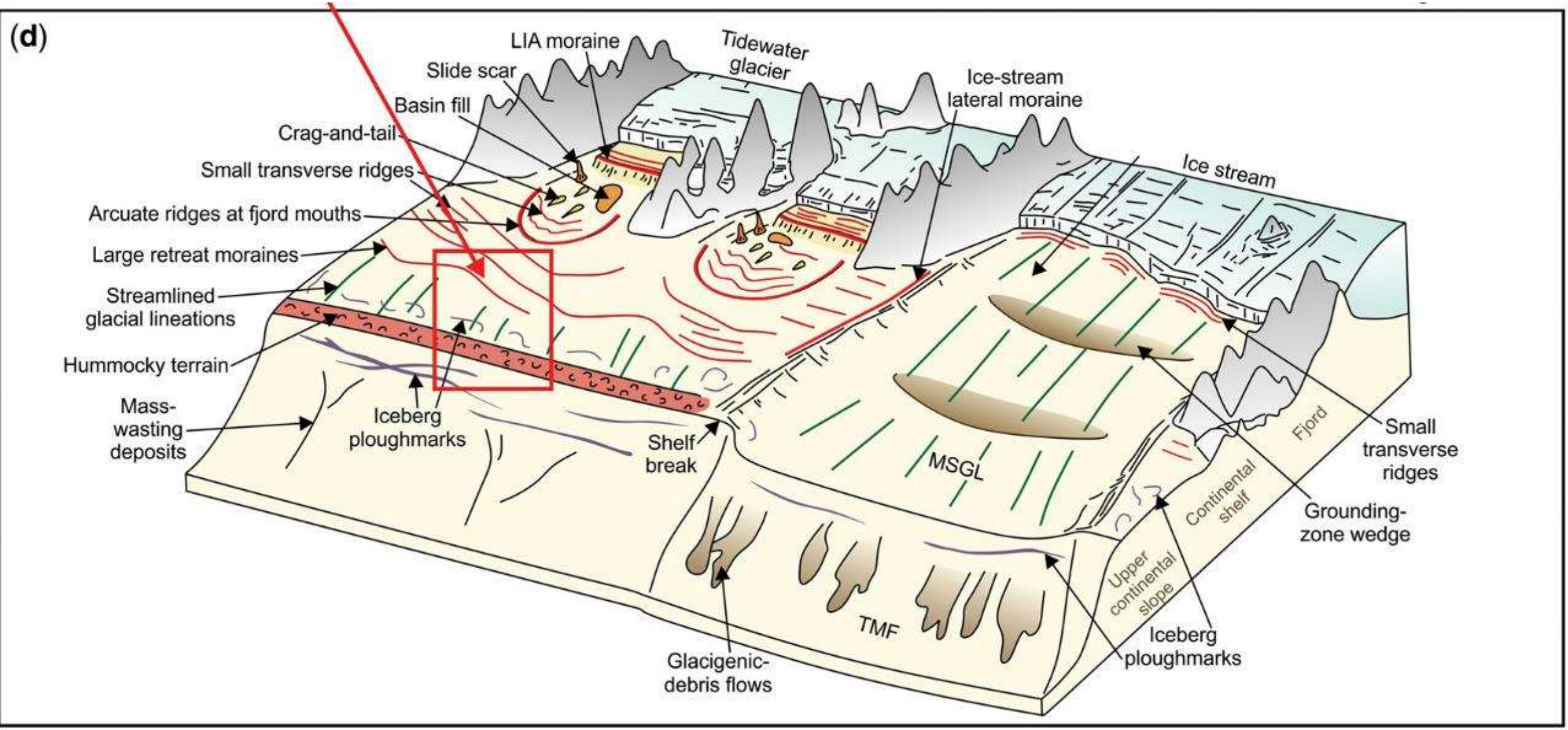
360 m + 120 m = 480 m

during the Ice Age
icebergs could run into the seafloor
to depths that are now 500 m deep

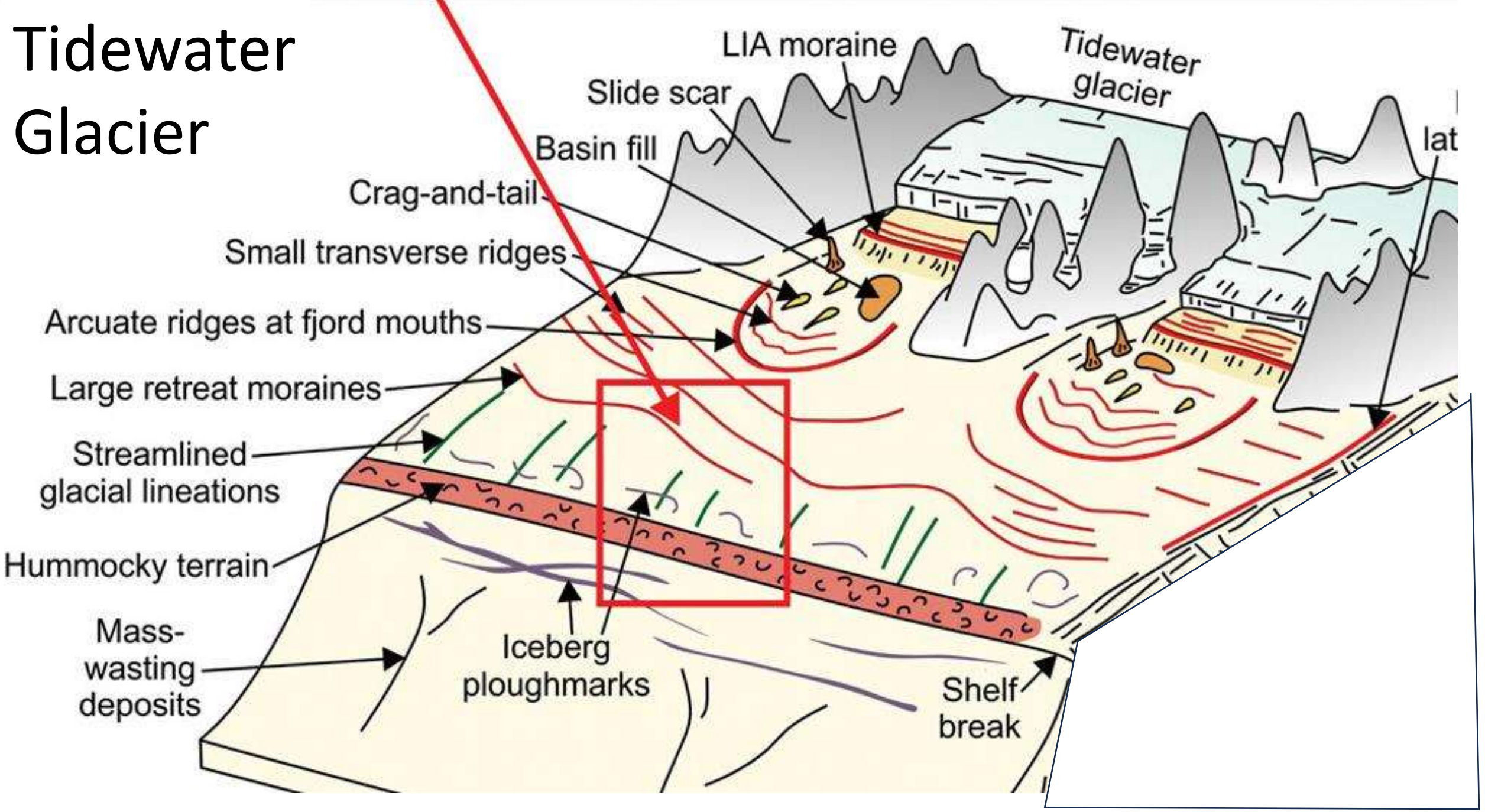

Lomonosov
Ridge


(d)
152°E
N
84°55´N
Lomonosov
Ridge
Lineations
1500
850 m
2 km

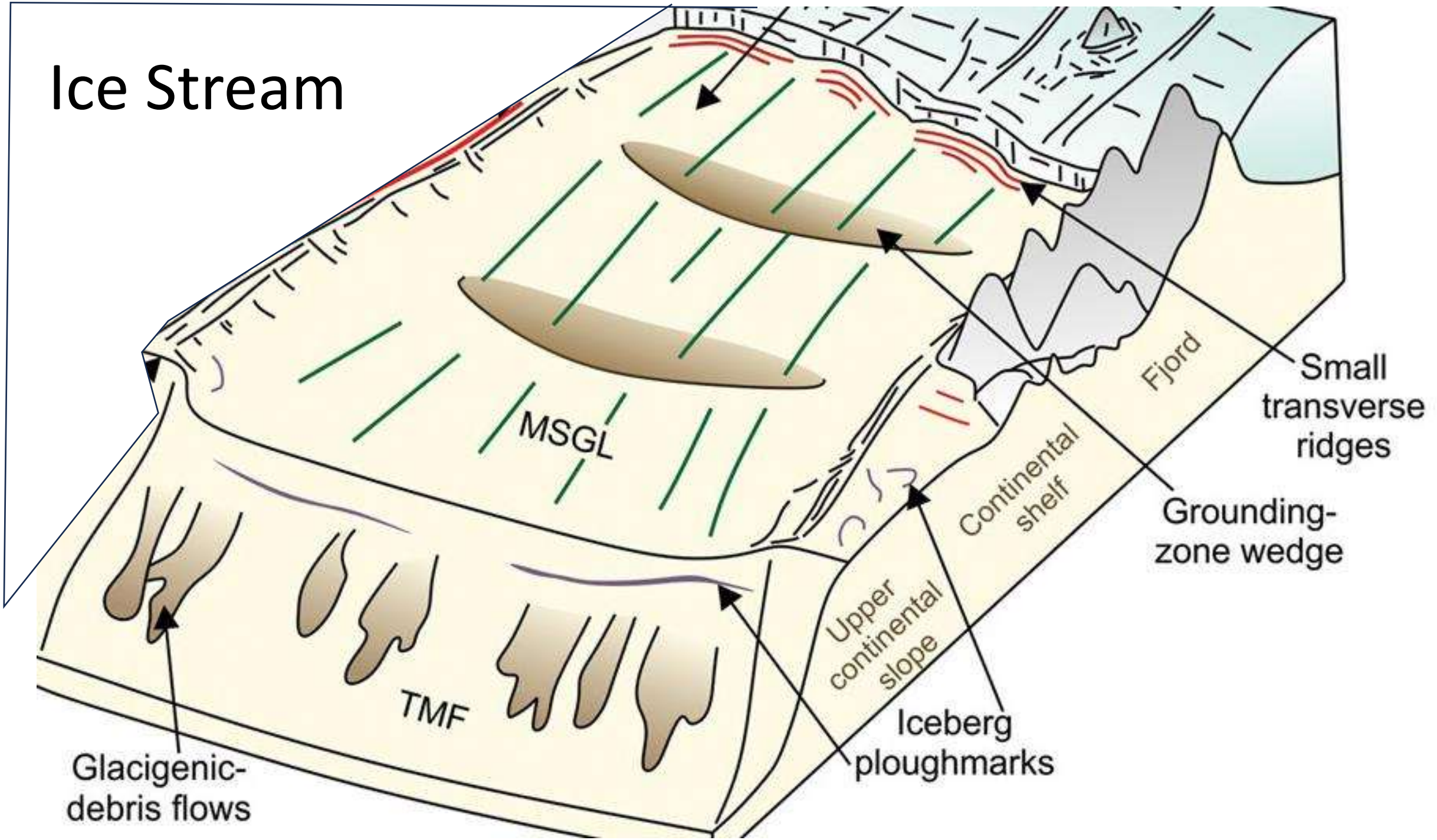
Part 2: Submarine glacial geomorphology

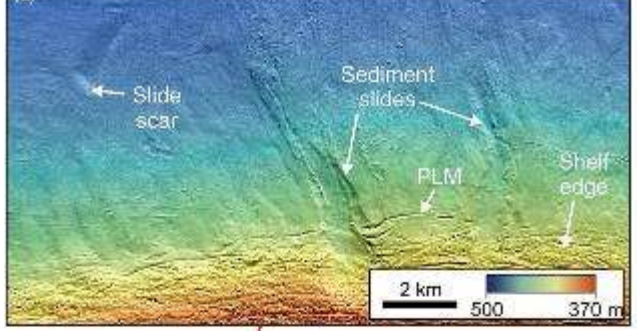

(d)
LIA moraine
Tidewater glacier
Slide scar
Basin fill
Crag-and-tail
Small transverse ridges
Arcuate ridges at fjord mouths
Large retreat moraines
Streamlined glacial lineations
Hummocky terrain
Mass-wasting deposits
Iceberg ploughmarks
Shelf break
Ice-stream lateral moraine
Ice stream
MSGL
Fjord
Small transverse ridges
Continental shelf
Grounding-zone wedge
Upper continental slope
Iceberg ploughmarks
TMF
Glacigenic-debris flows

Tidewater Glacier

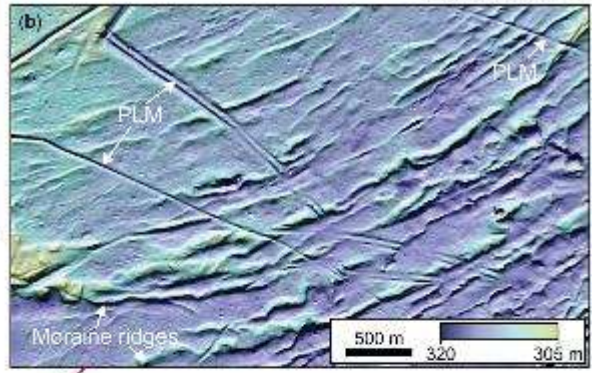


Ice Stream

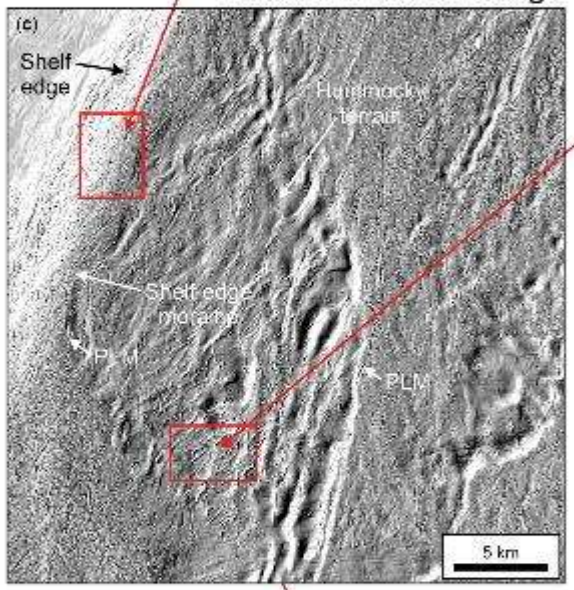

MSGL
TMF
Glacigenic-debris flows
Iceberg ploughmarks
Upper continental slope
Continental shelf
Grounding-zone wedge
Fjord
Small transverse ridges



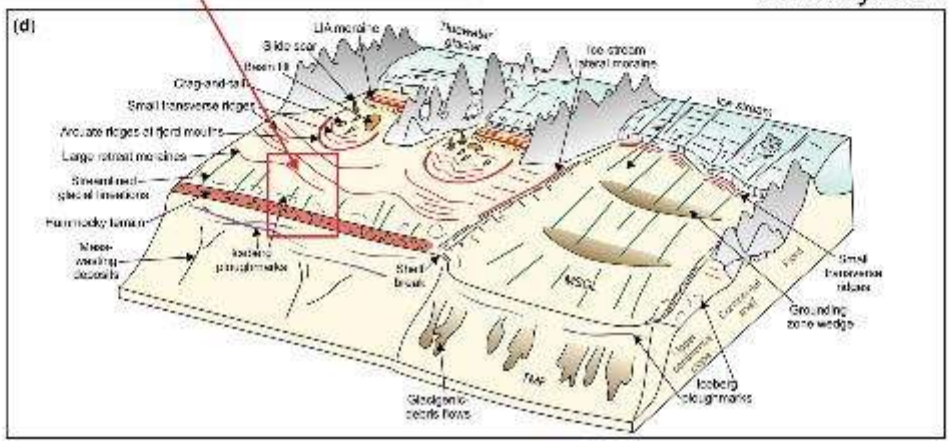
Landforms

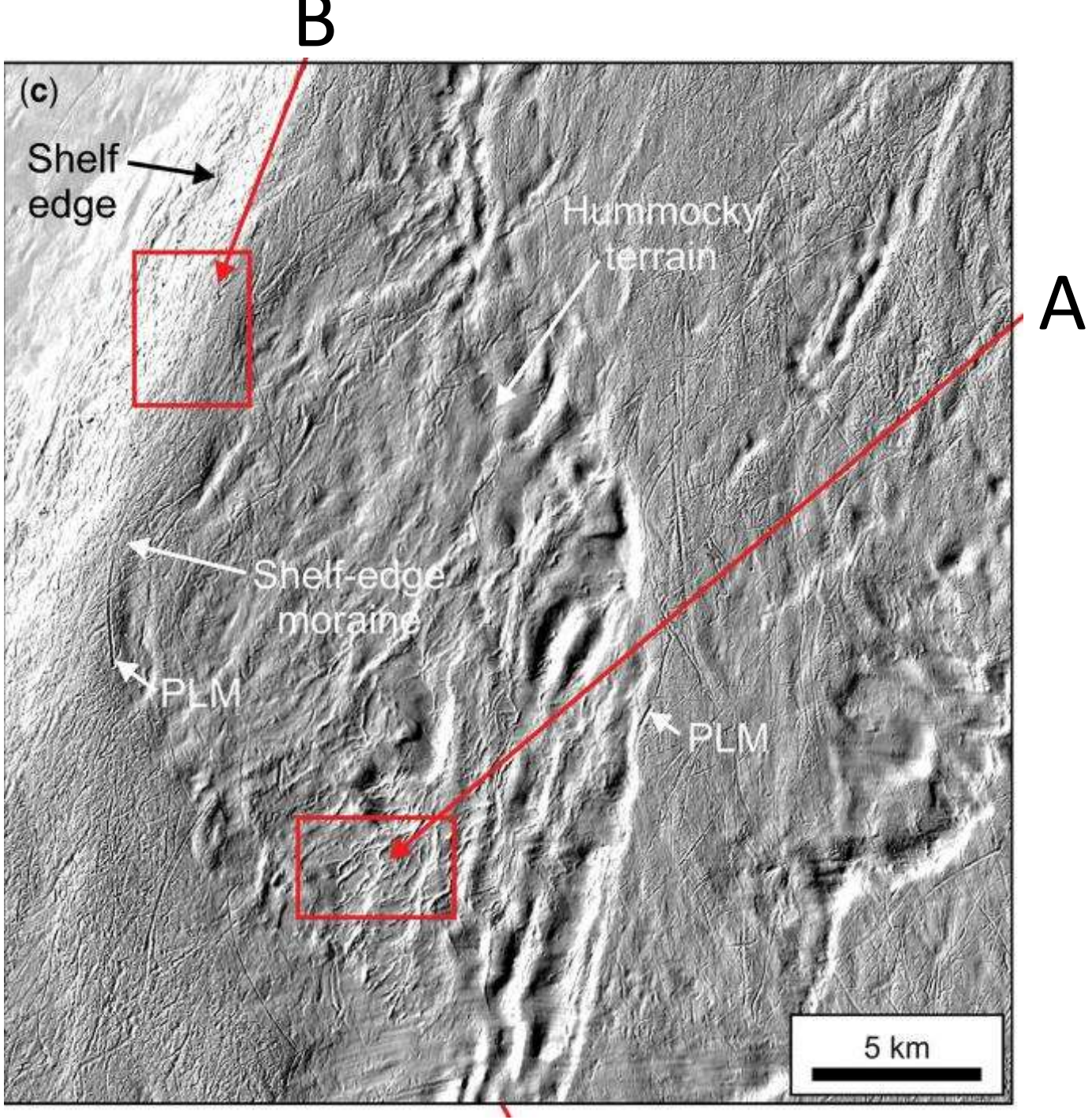


Landform assemblage

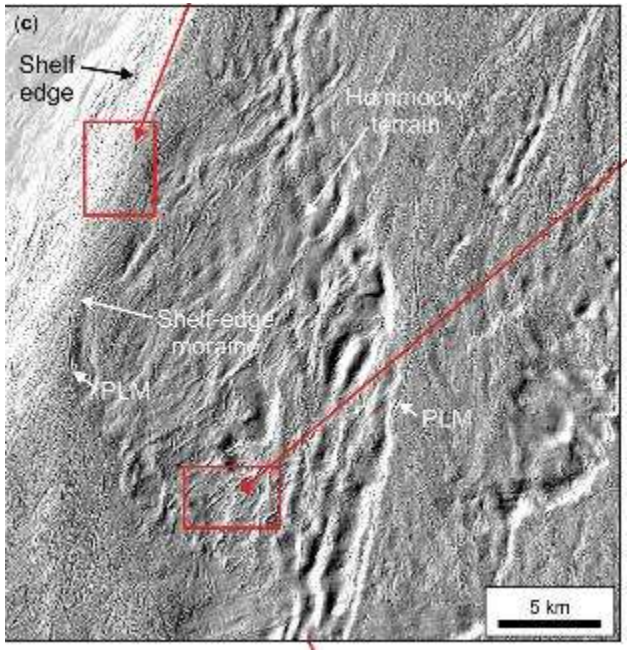


Landsystem

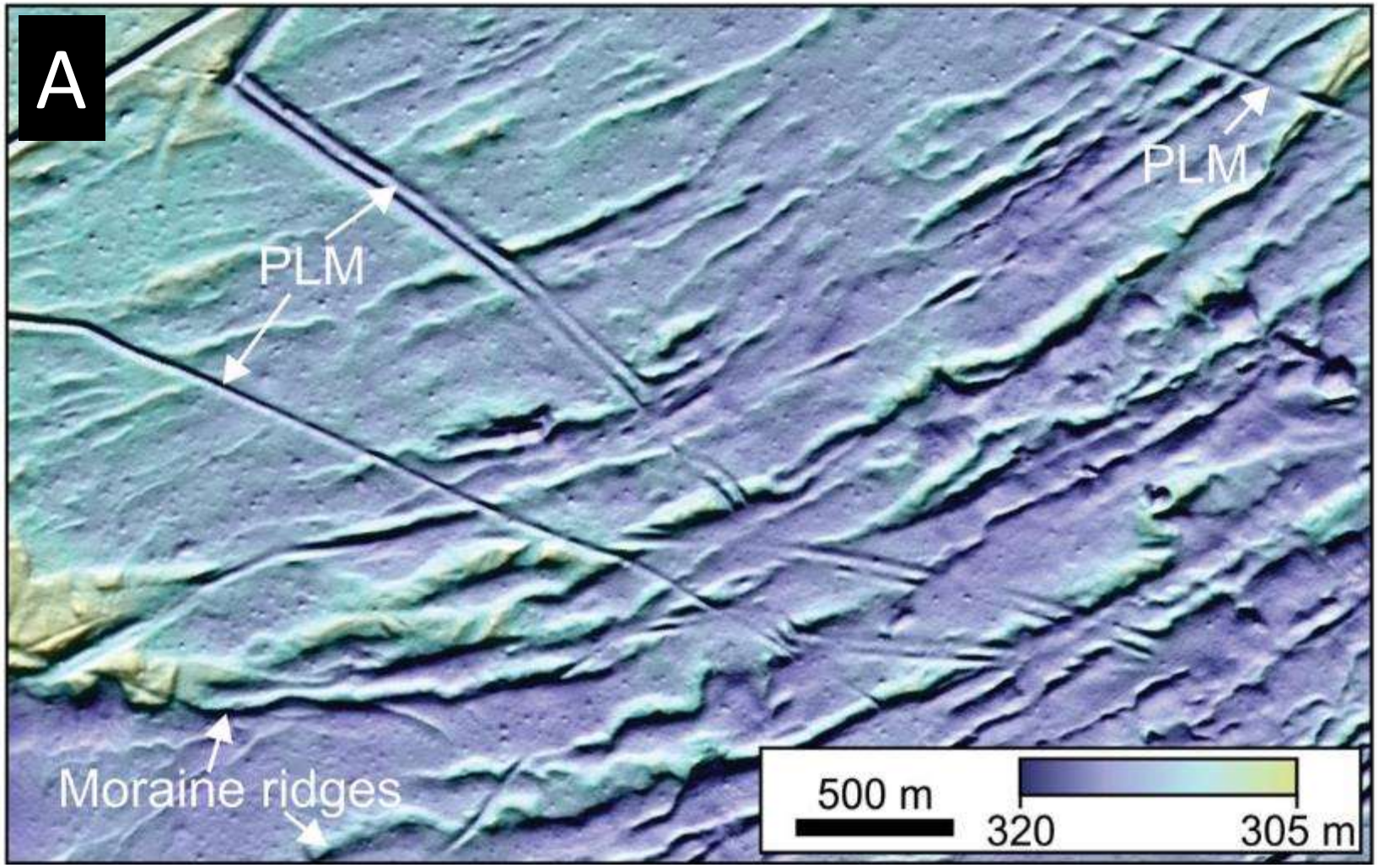



B
(c)
Shelf edge
Hummocky terrain
A
Shelf-edge moraine
PLM
PLM
5 km

PLM= iceberg ploughmarks

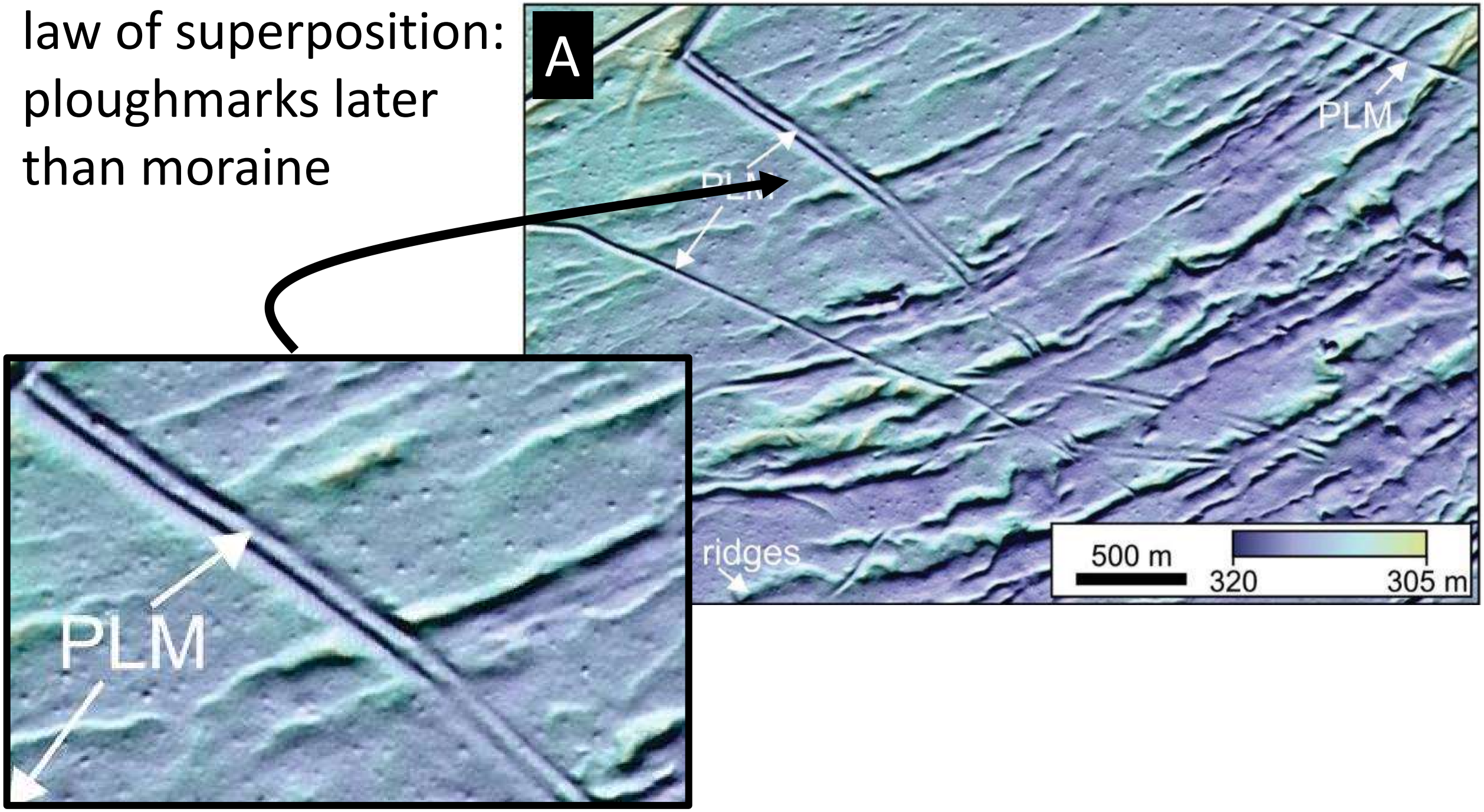


A

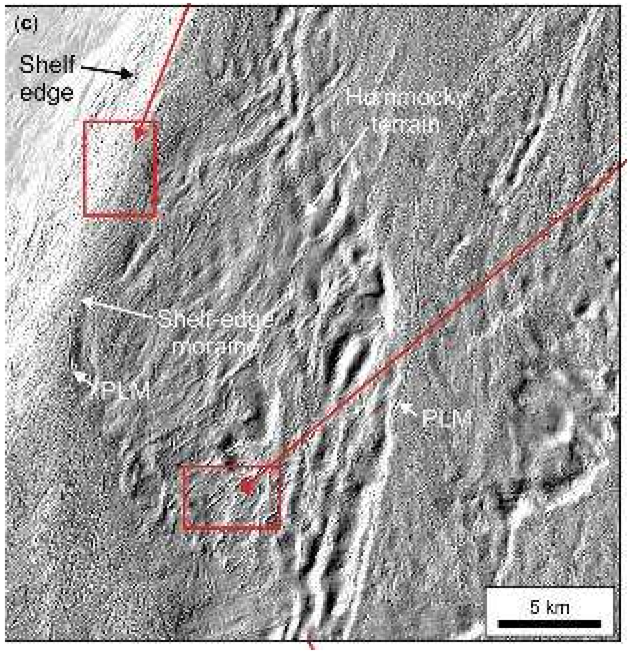


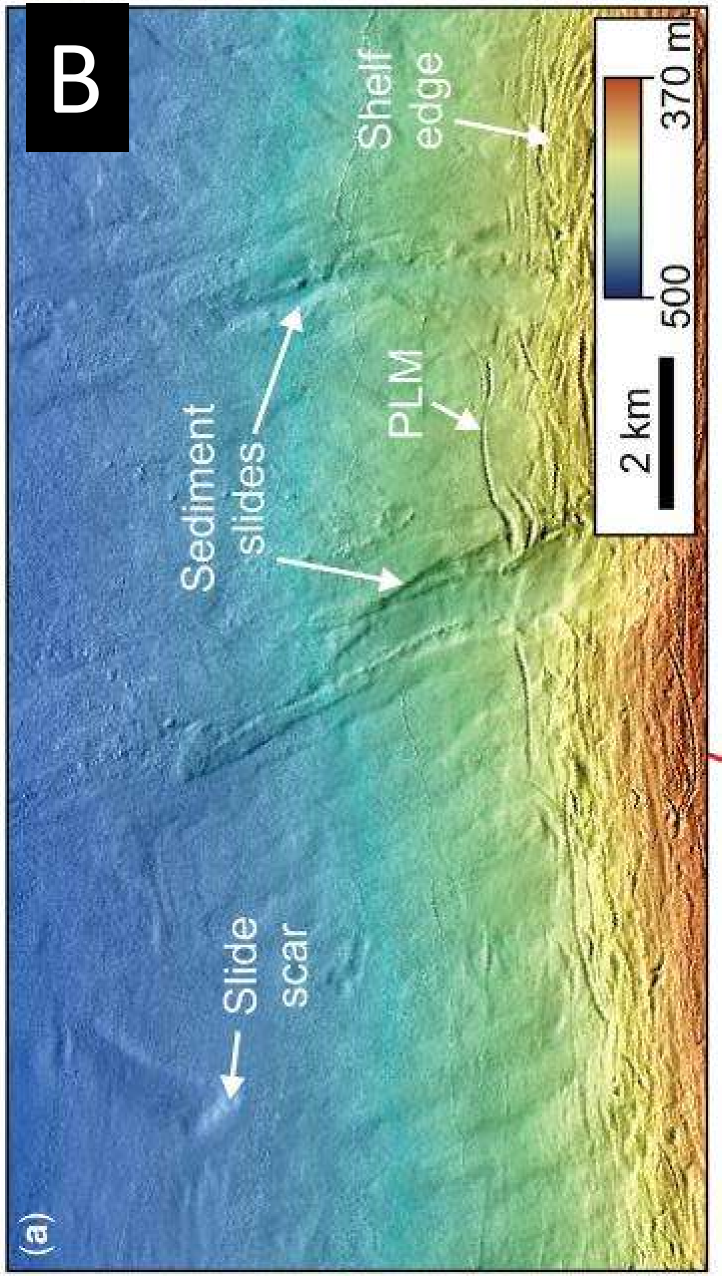
law of superposition:
ploughmarks later than moraine

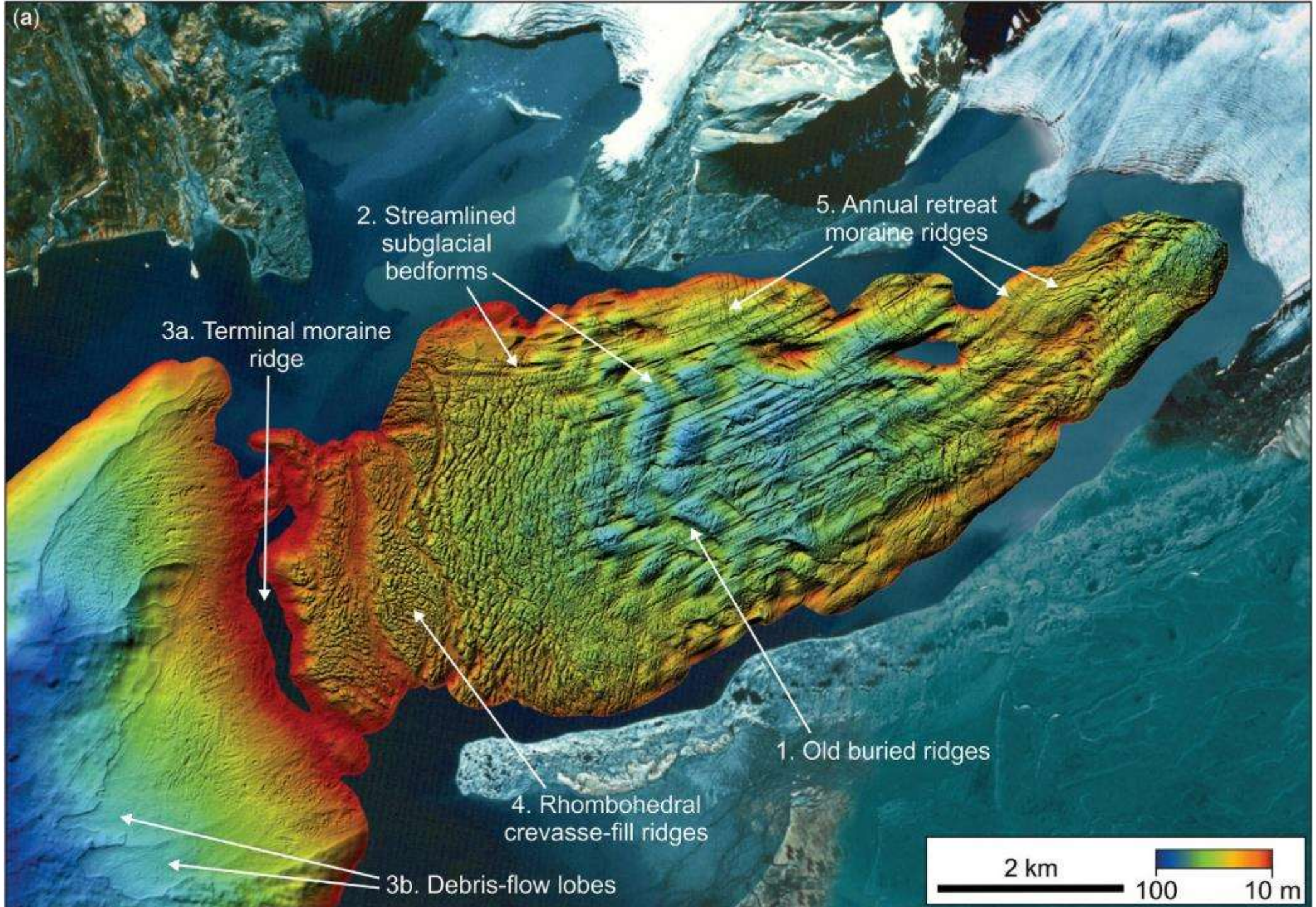
law of superposition: ploughmarks later than moraine

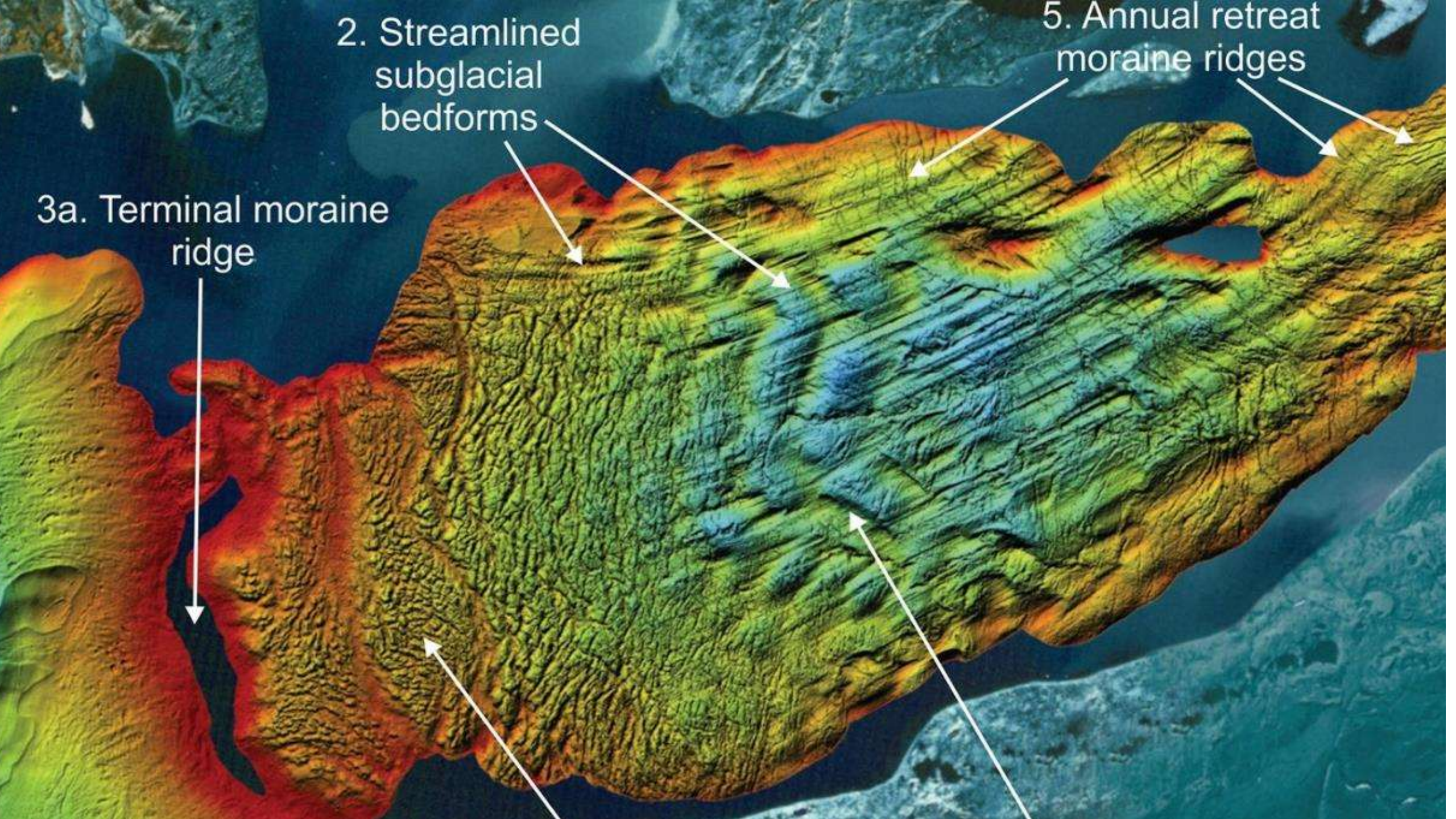


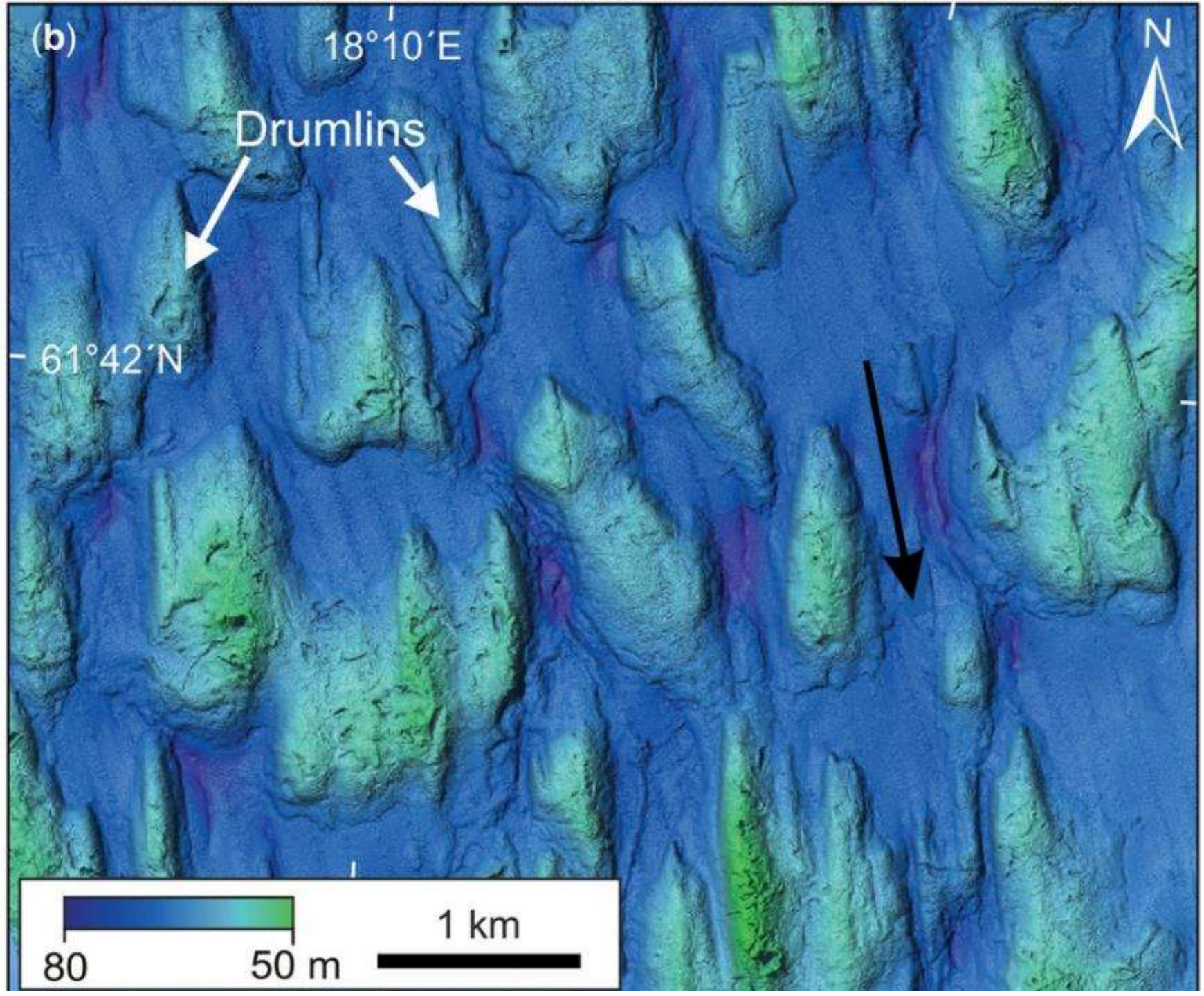
B


(c)
Shelf edge
Hummocky terrain
Shelf-edge moraine
PLM
PLM
5 km


B
Shelf edge
370 m
500
2 km
PLM
Sediment slides
Slide scar
(a)

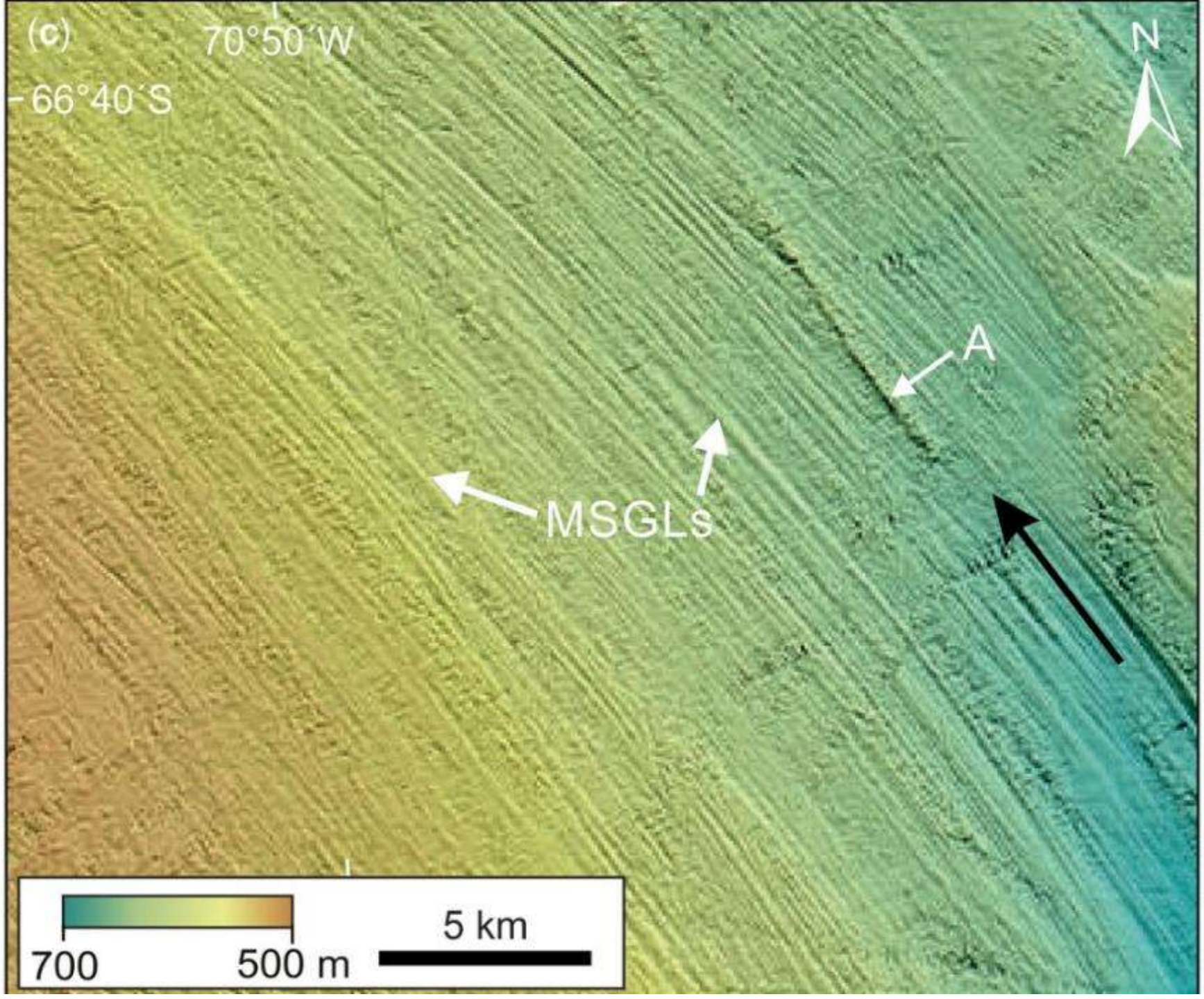

(a)
2. Streamlined subglacial bedforms
5. Annual retreat moraine ridges
3a. Terminal moraine ridge
1. Old buried ridges
4. Rhombohedral crevasse-fill ridges
3b. Debris-flow lobes
2 km
100
10 m


2. Streamlined subglacial bedforms
5. Annual retreat moraine ridges
3a. Terminal moraine ridge

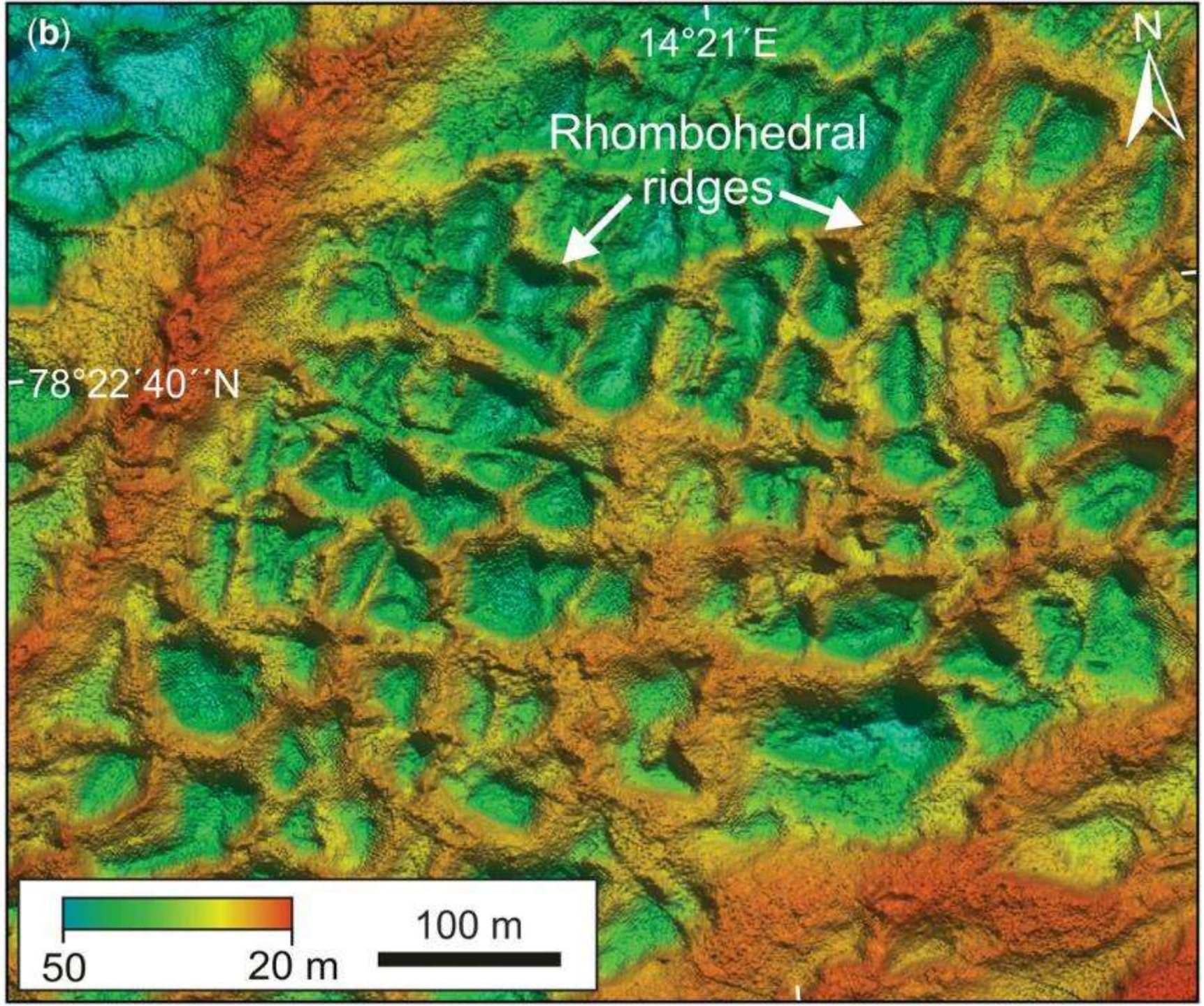

(b)
18°10´E
N
Drumlins
61°42´N
80
50 m
1 km

MSGL = mega-scale glacial lineations

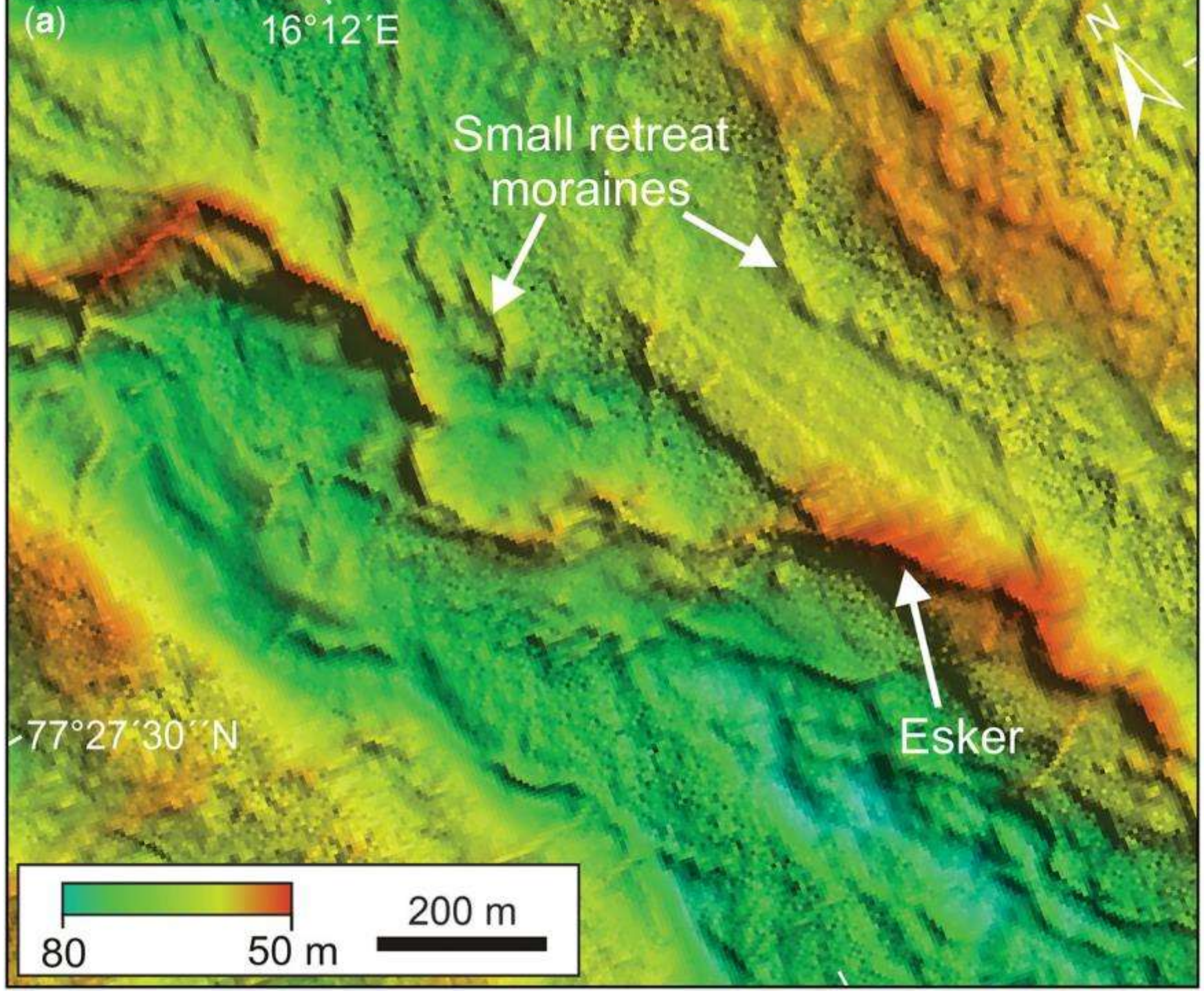
long, skinny drumlins



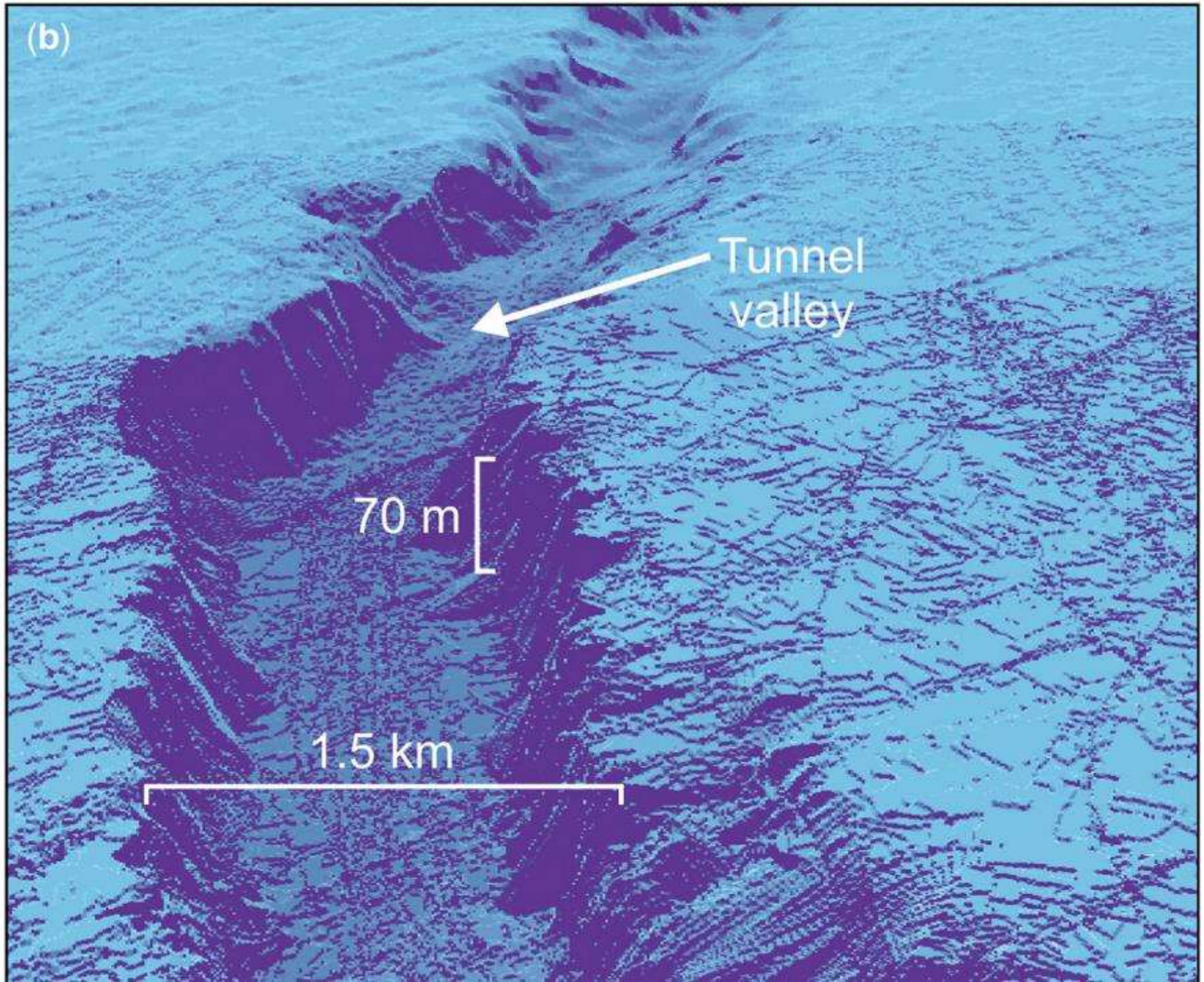
Rhombohedral ridges = from till in crevasses



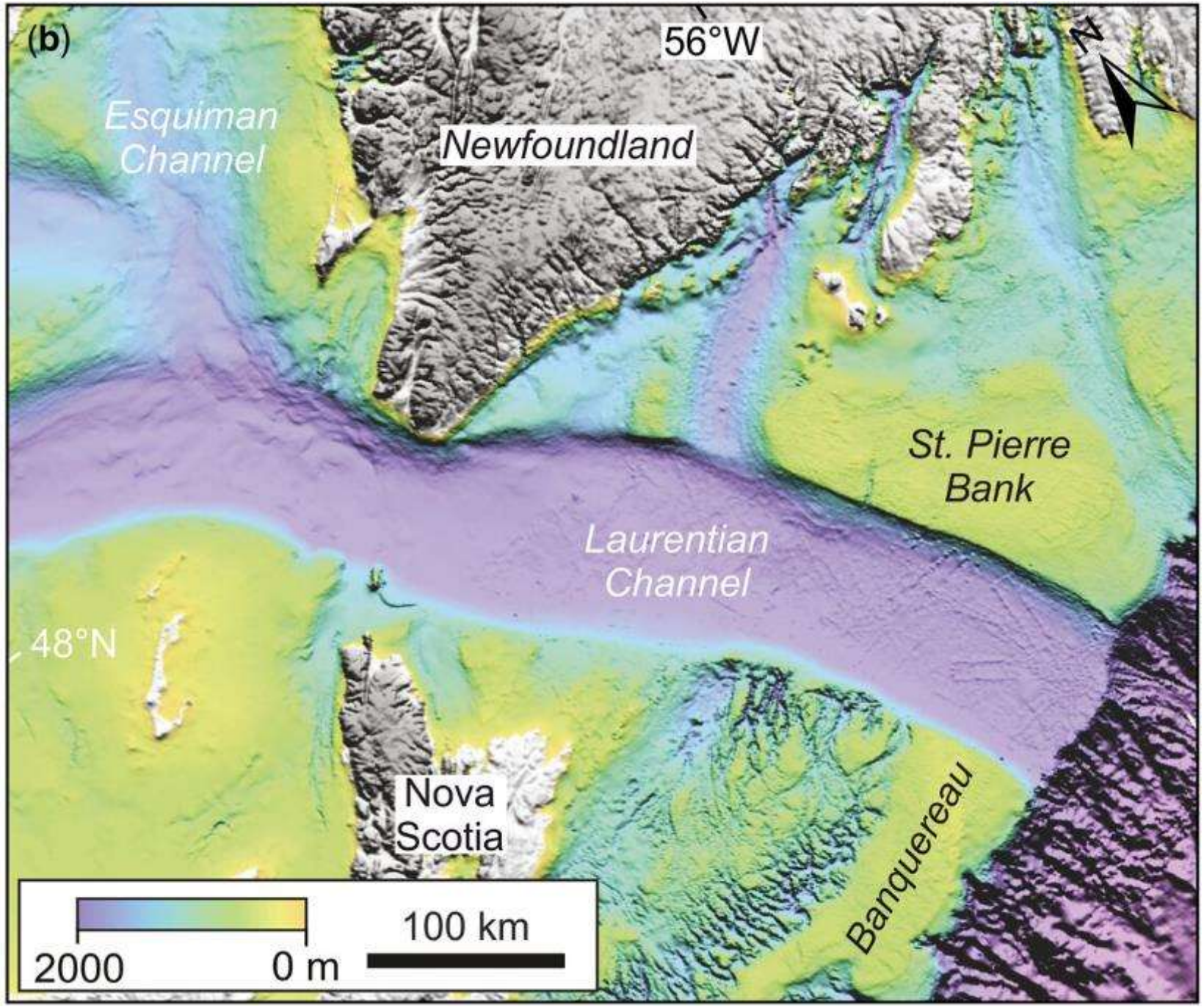
Esker



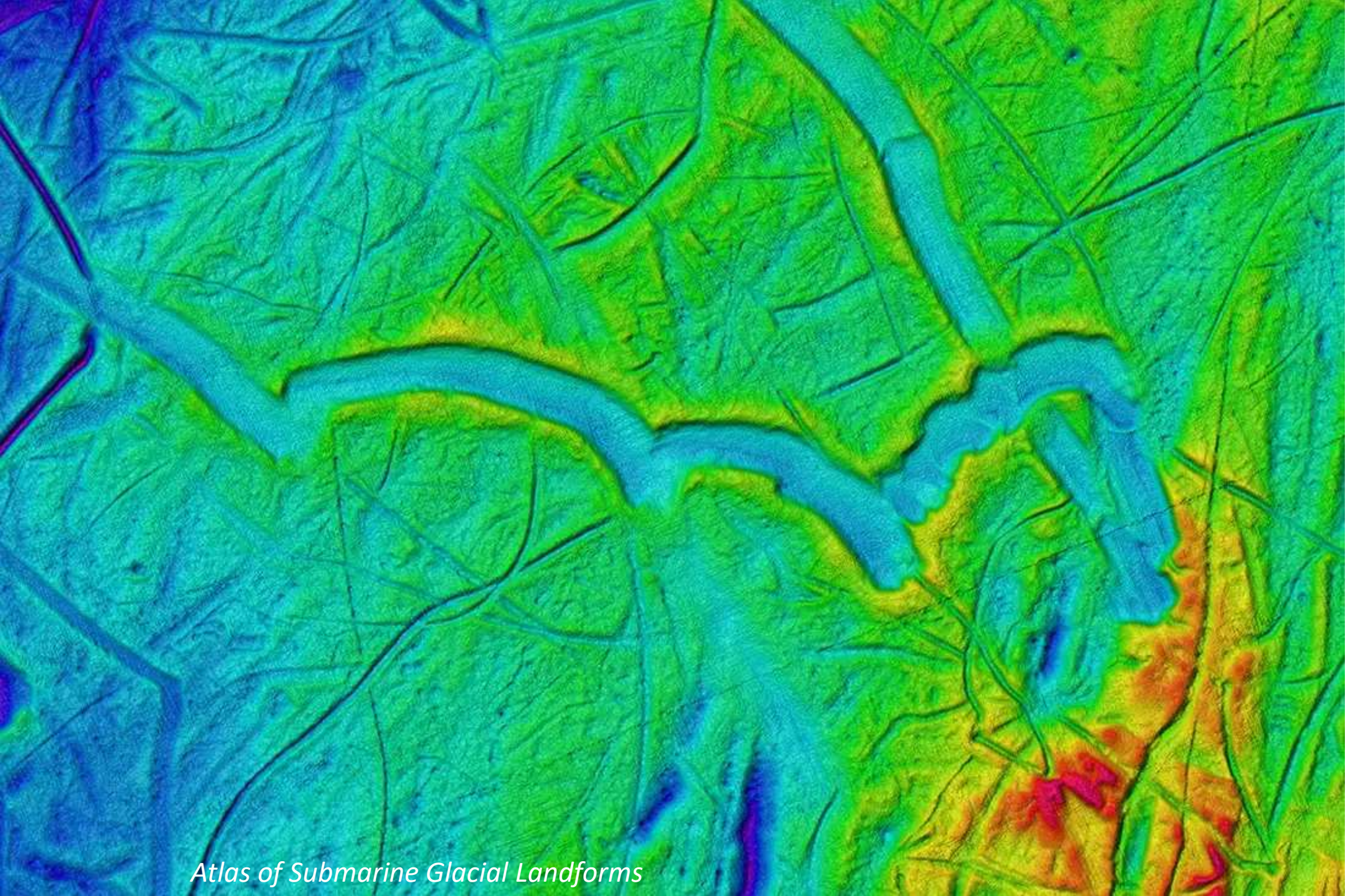
Tunnel Valley



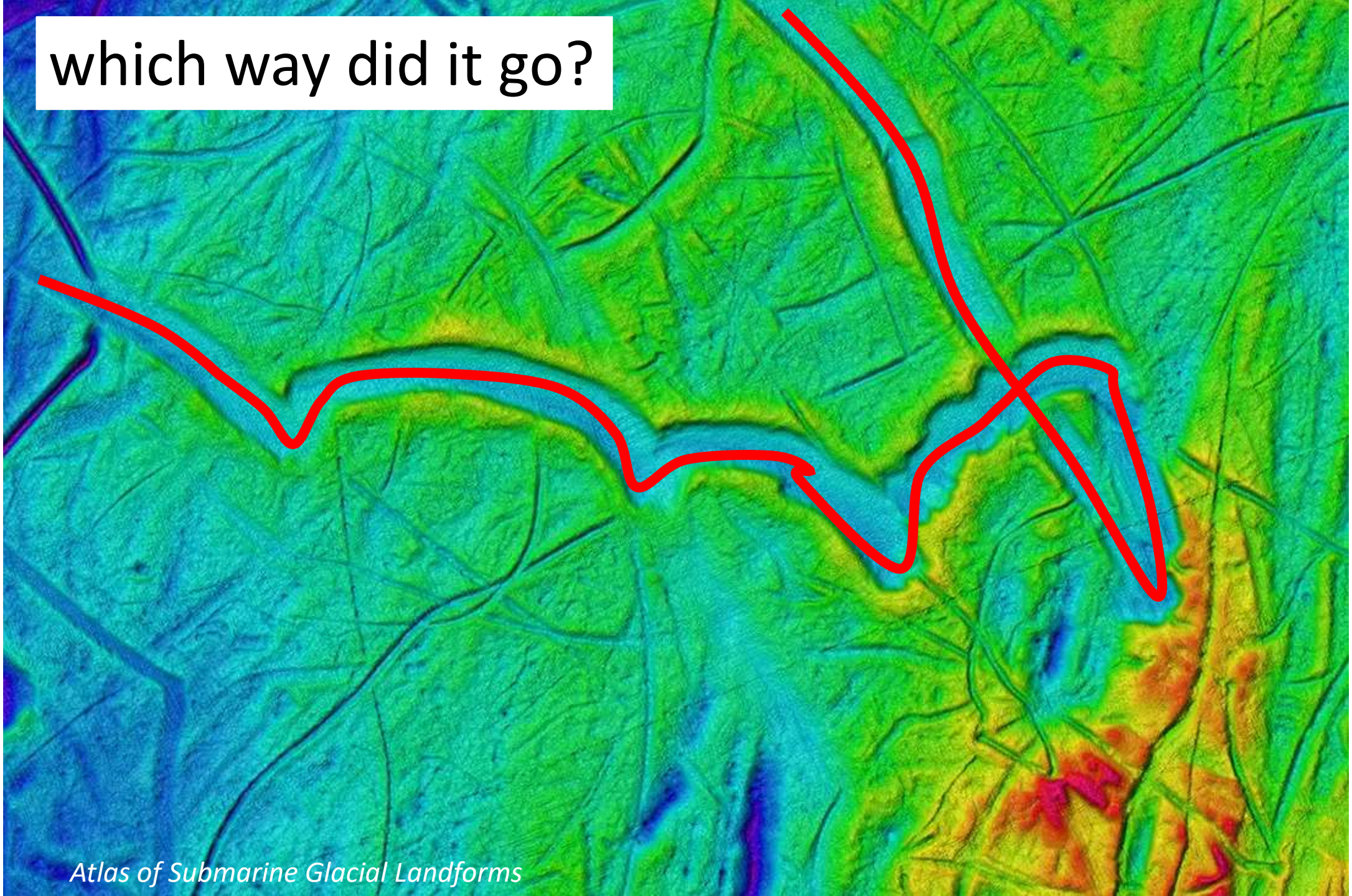
Fjord


(b)
56°W
N
Esquiman Channel
Newfoundland
St. Pierre Bank
Laurentian Channel
48°N
Nova Scotia
Banquereau
2000
0 m
100 km

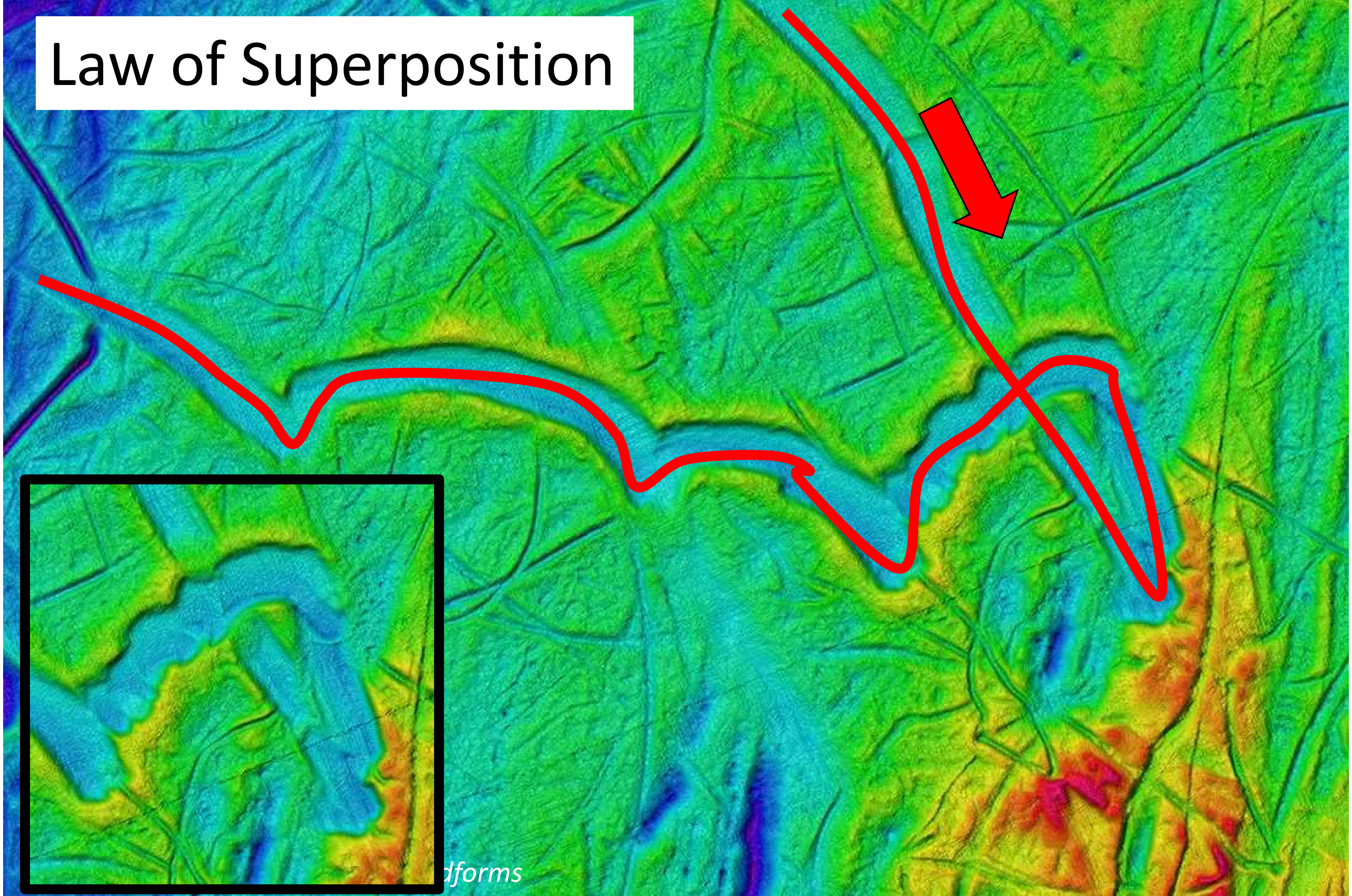
Part 3: Iceberg ploughmarks

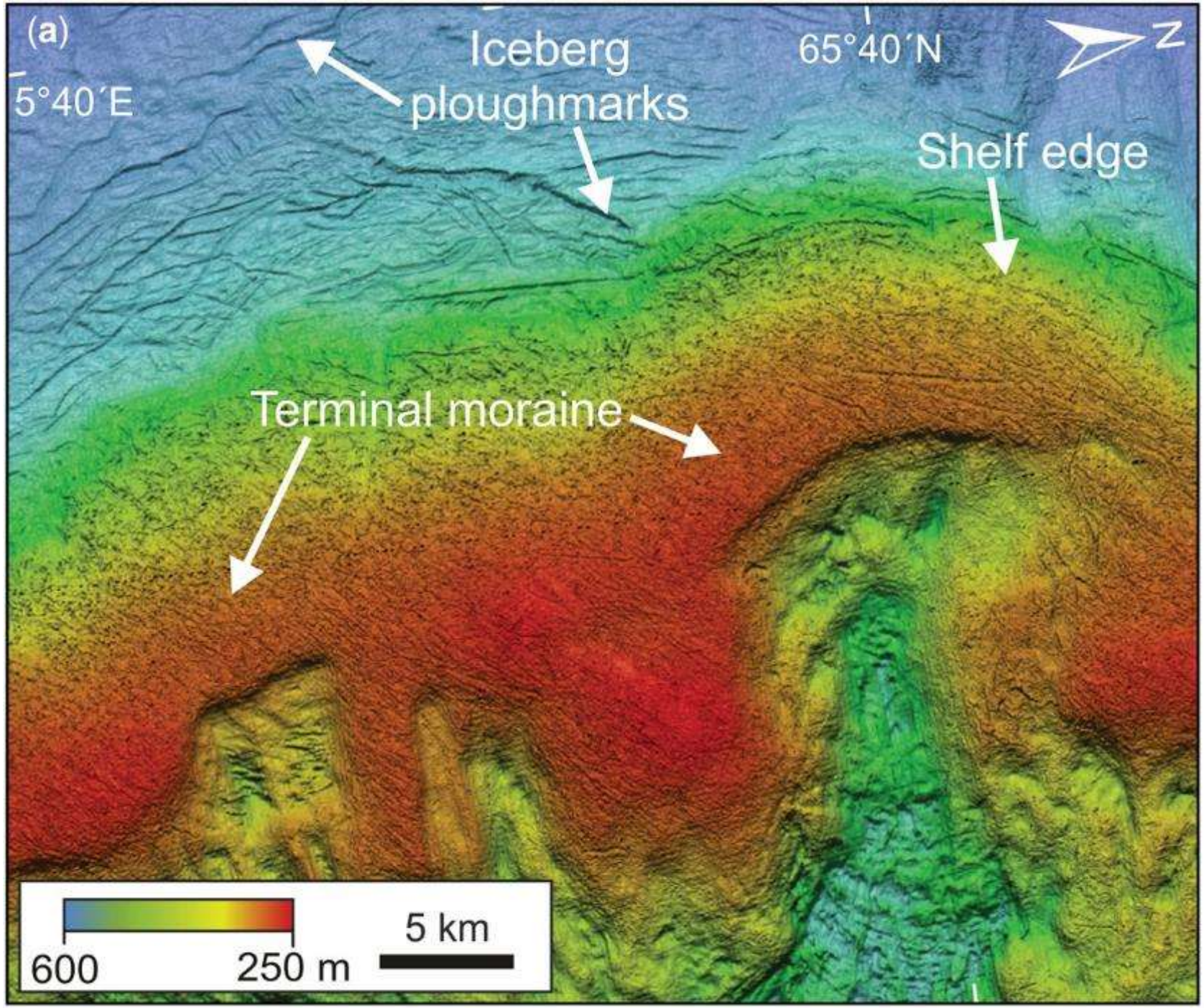


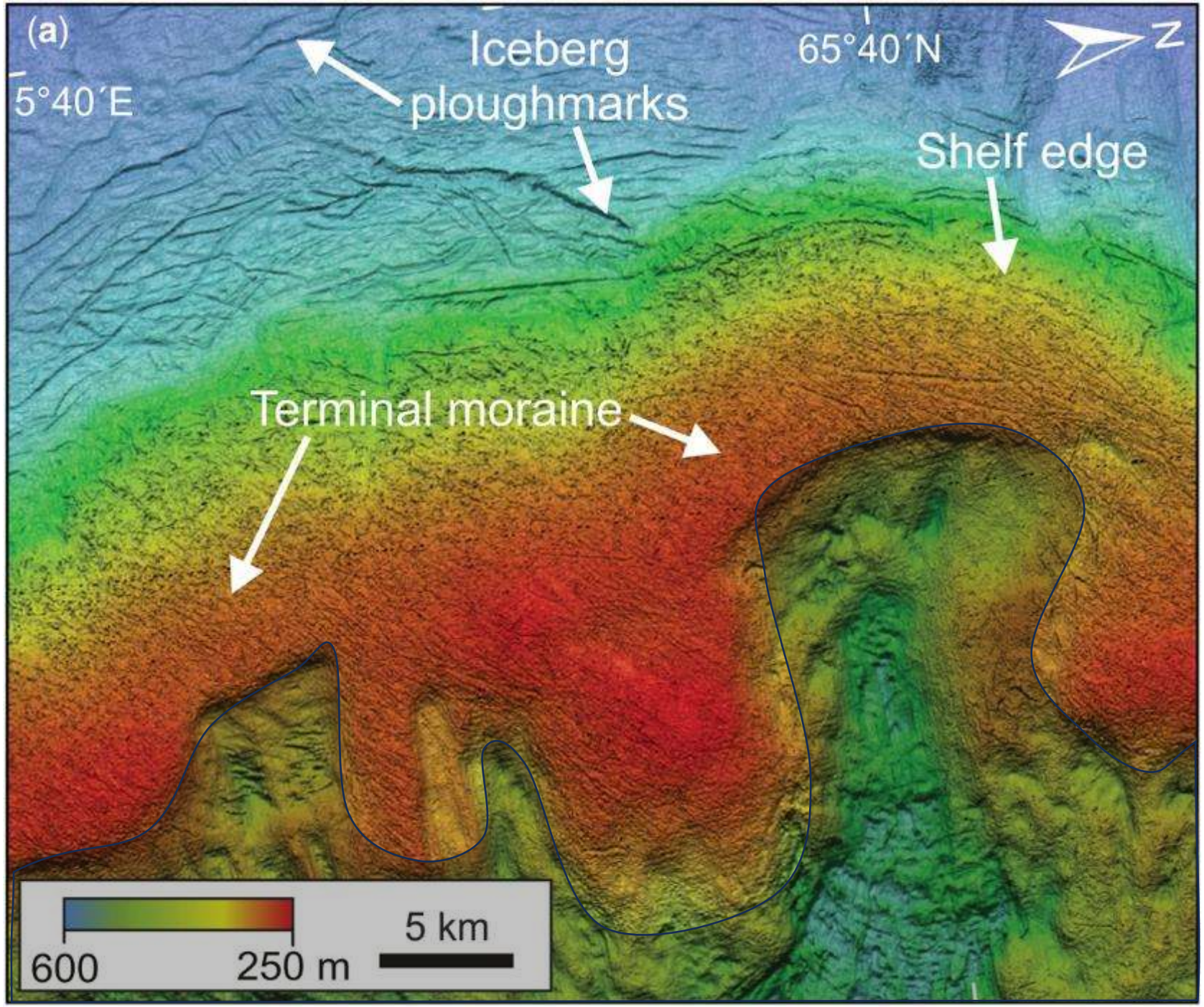
Atlas of Submarine Glacial Landforms


which way did it go?
Atlas of Submarine Glacial Landforms

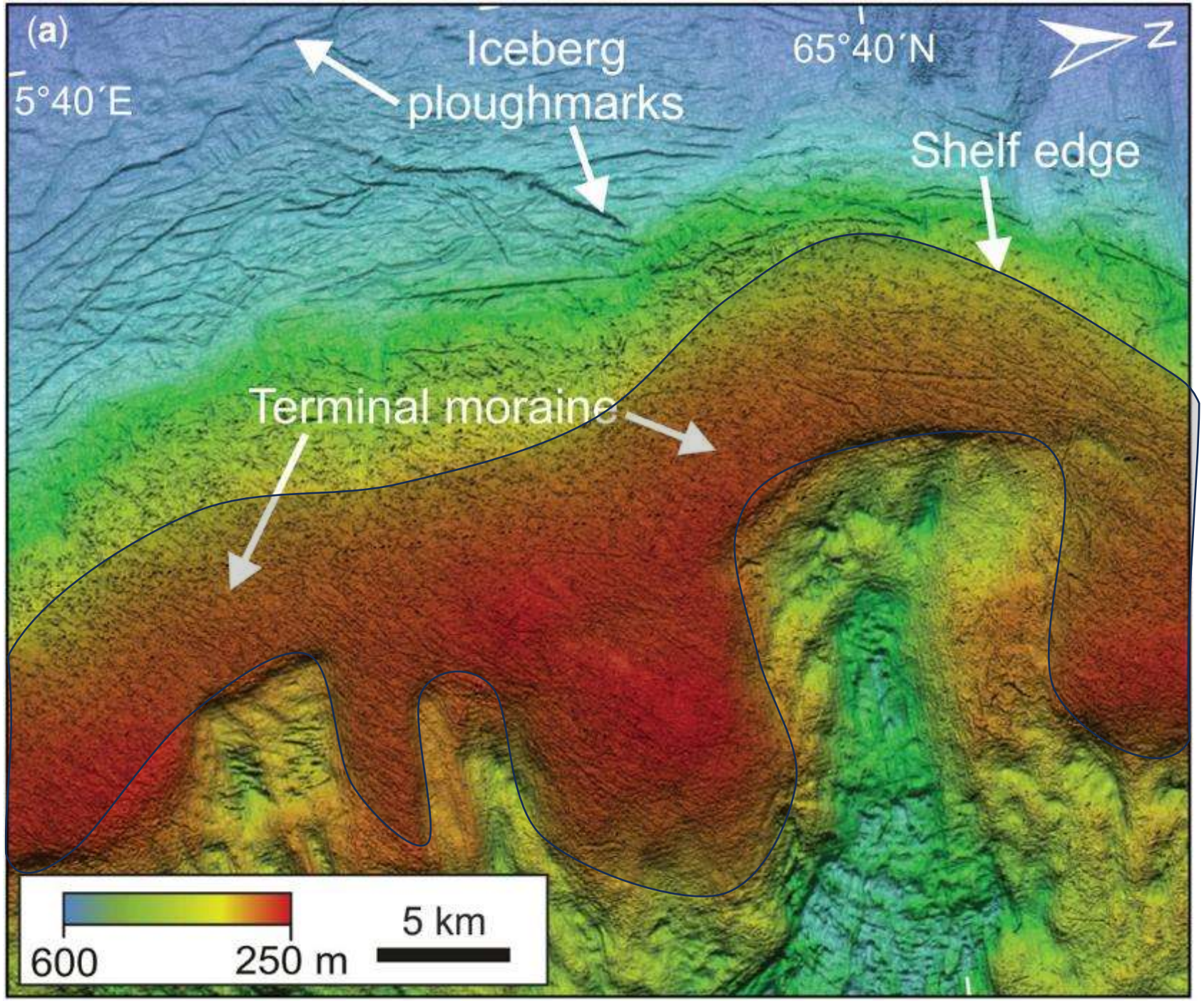
Law of Superposition



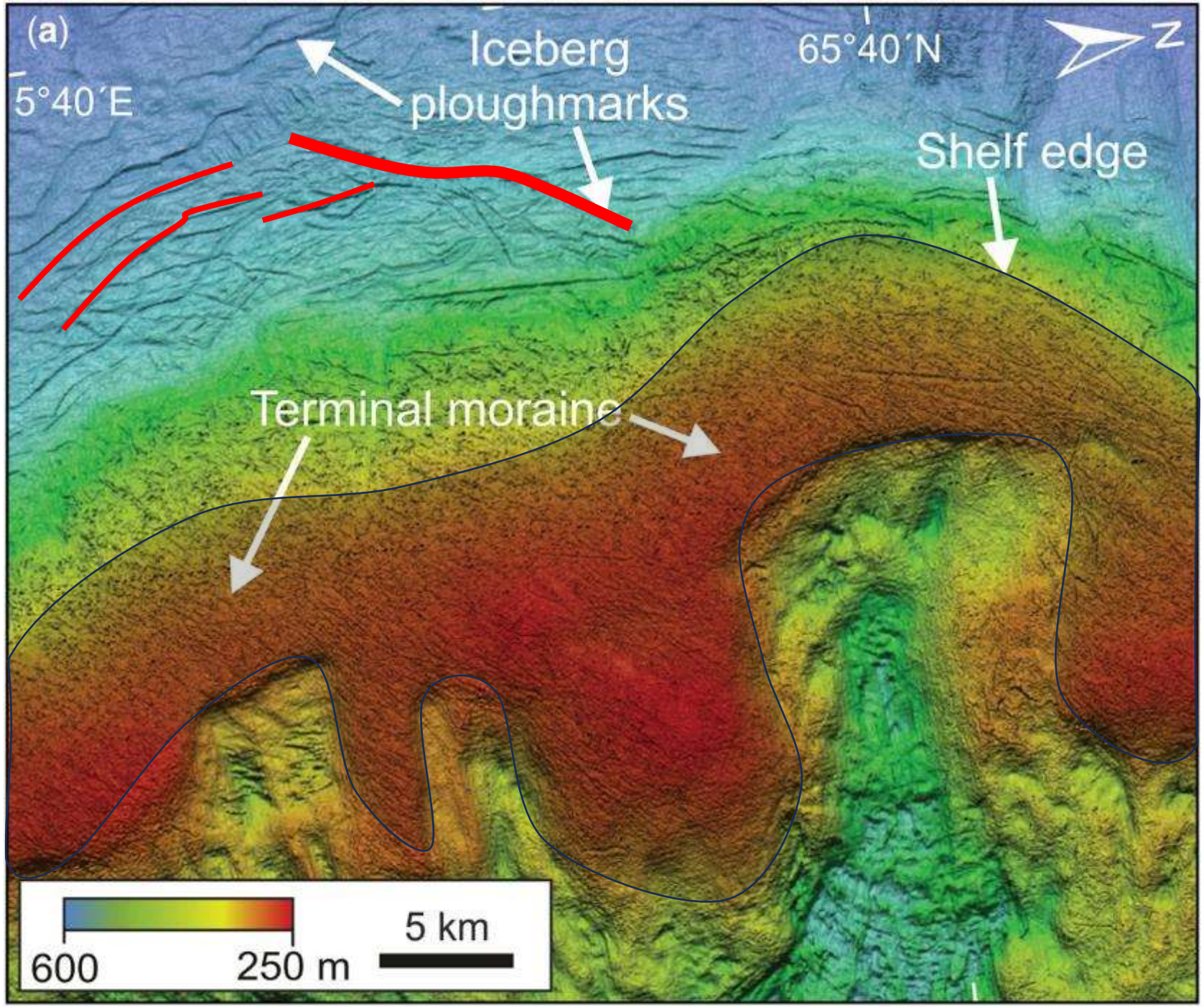

(a)
5°40´E
Iceberg ploughmarks
65°40´N
N
Shelf edge
Terminal moraine
600
250 m
5 km



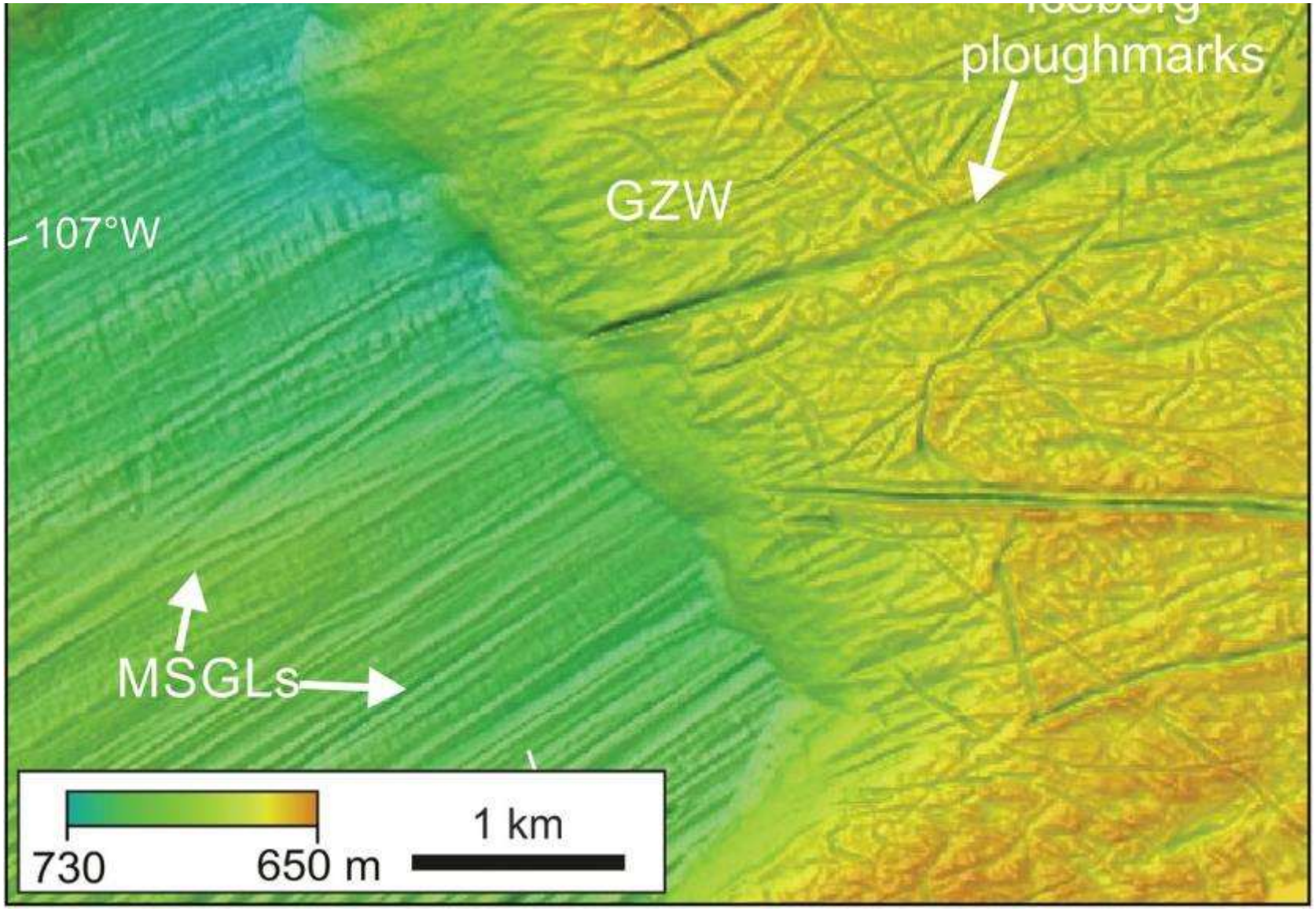
glacier was here

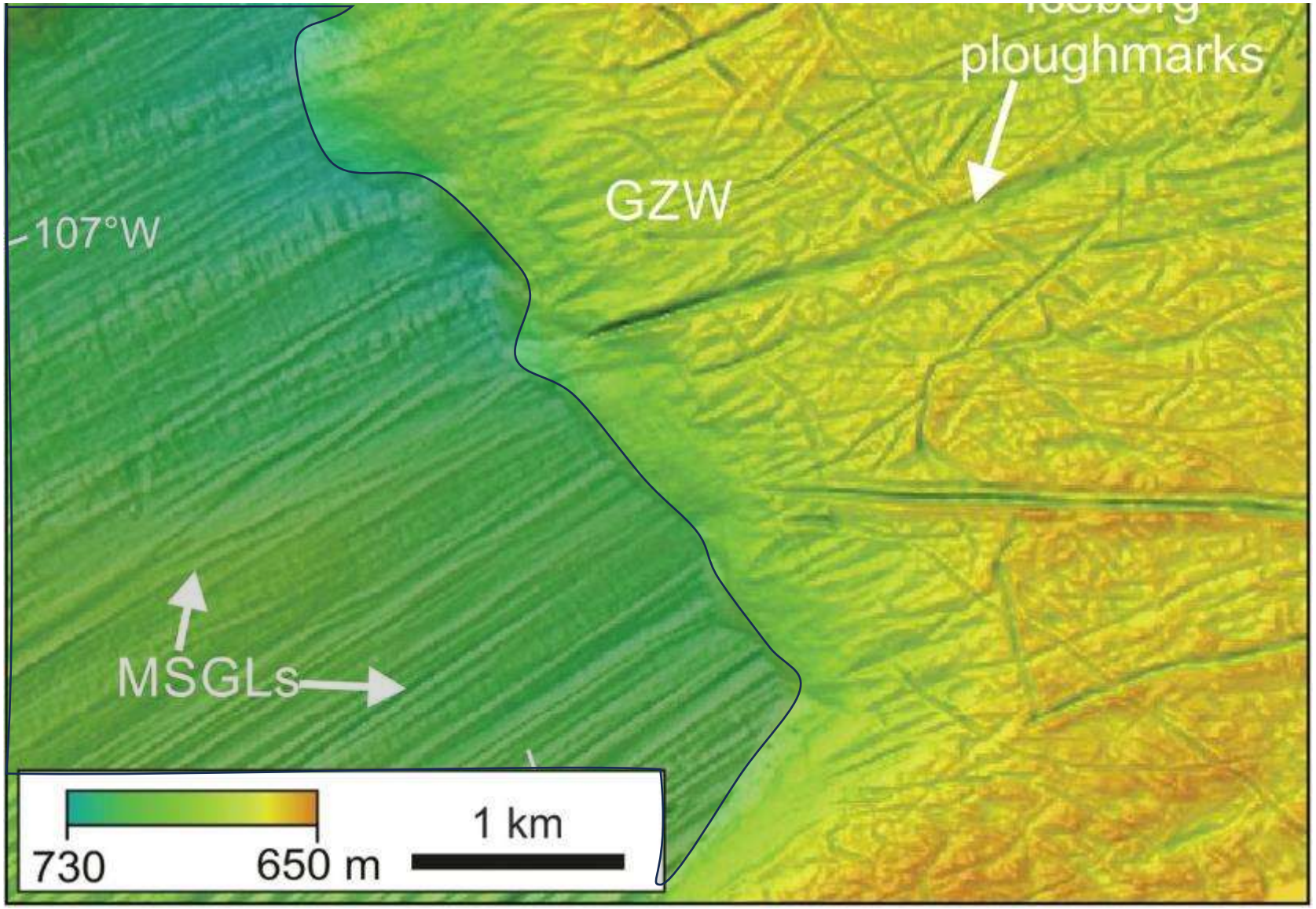

(a)
5°40´E
Iceberg ploughmarks
65°40´N
N
Shelf edge
Terminal moraine
600
250 m
5 km

Moraine



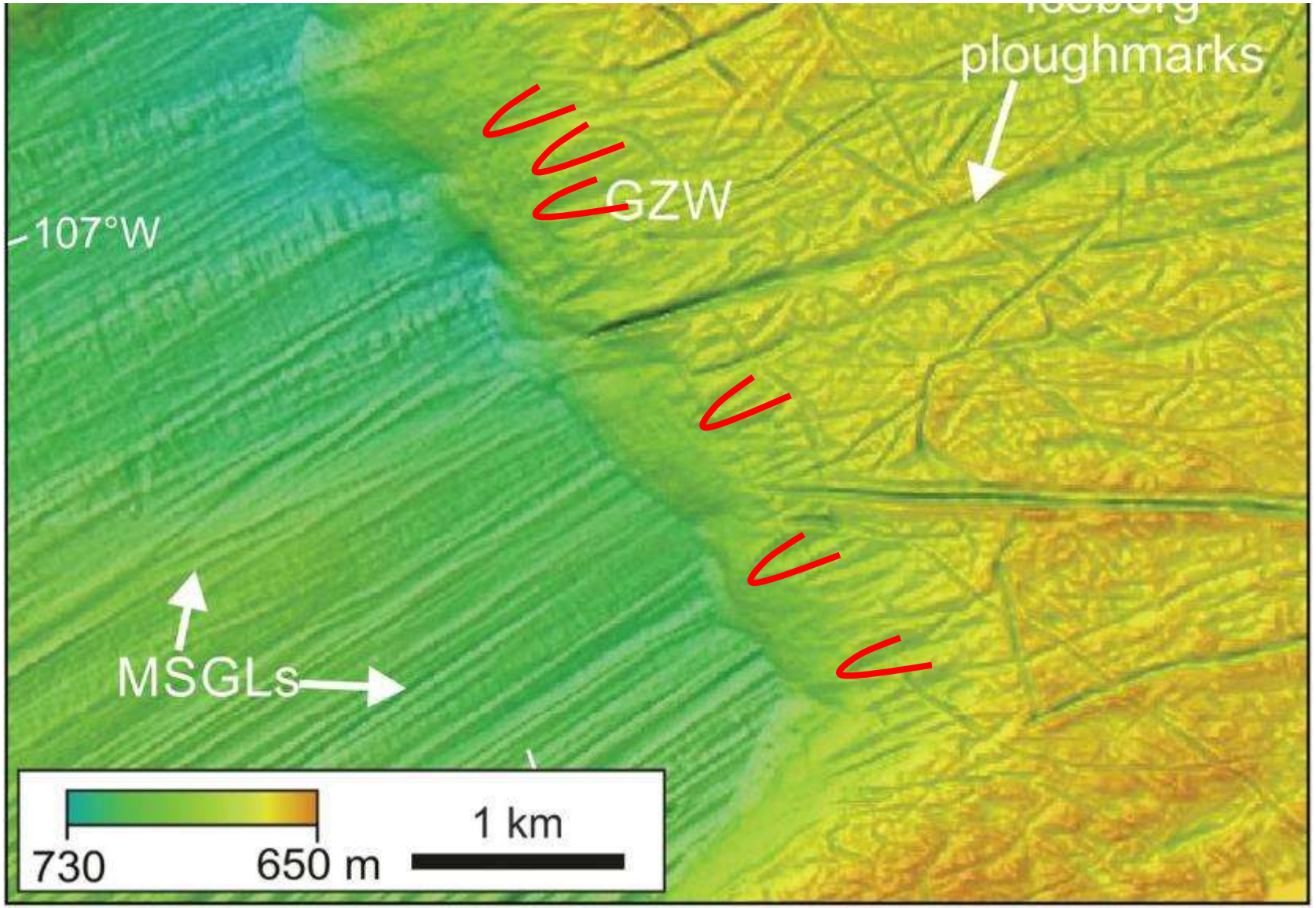
Iceberg Ploughmarks


iceberg
ploughmarks
GZW
107°W
MSGLs
730
650 m
1 km

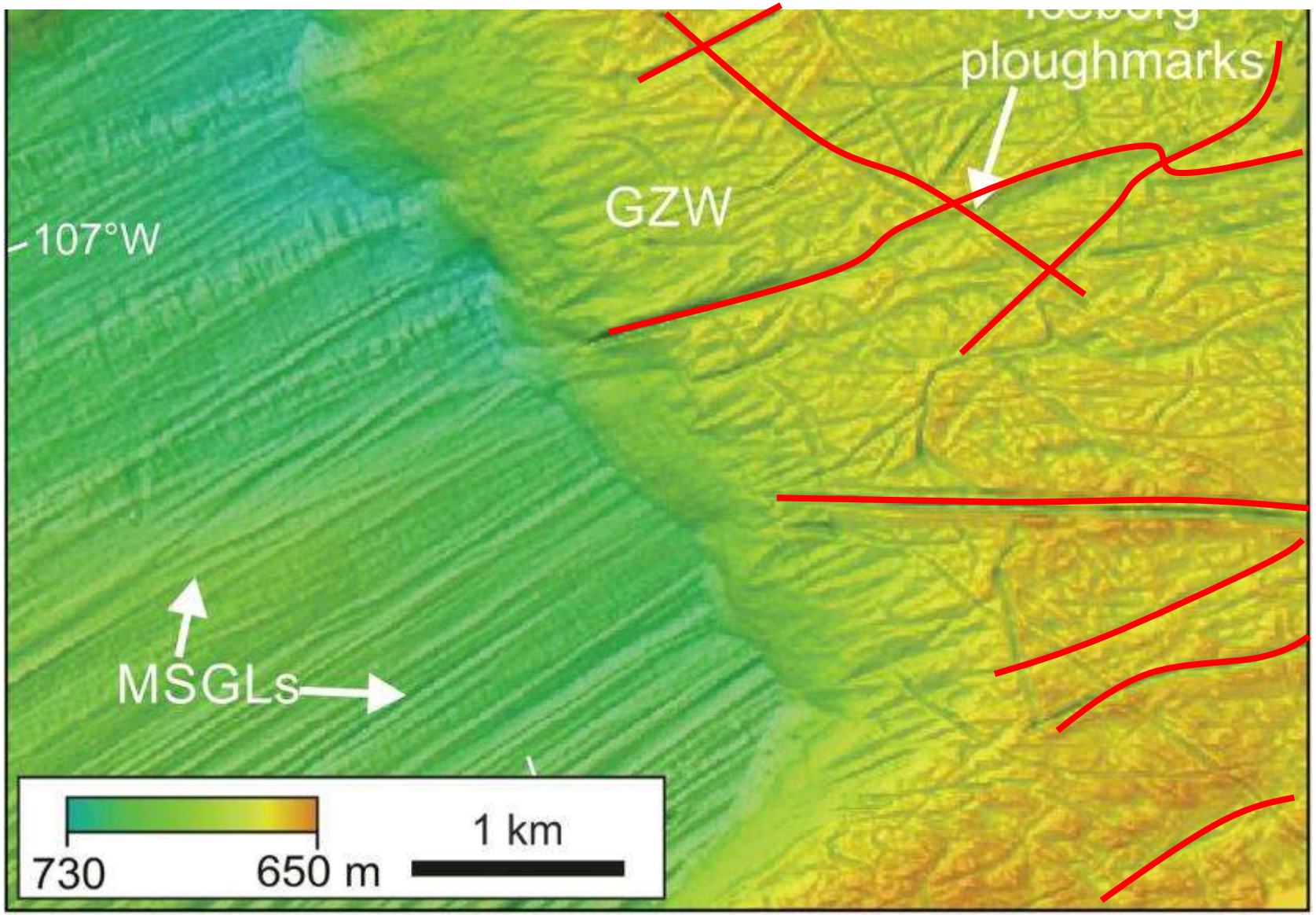


mega-scale glacial lineations

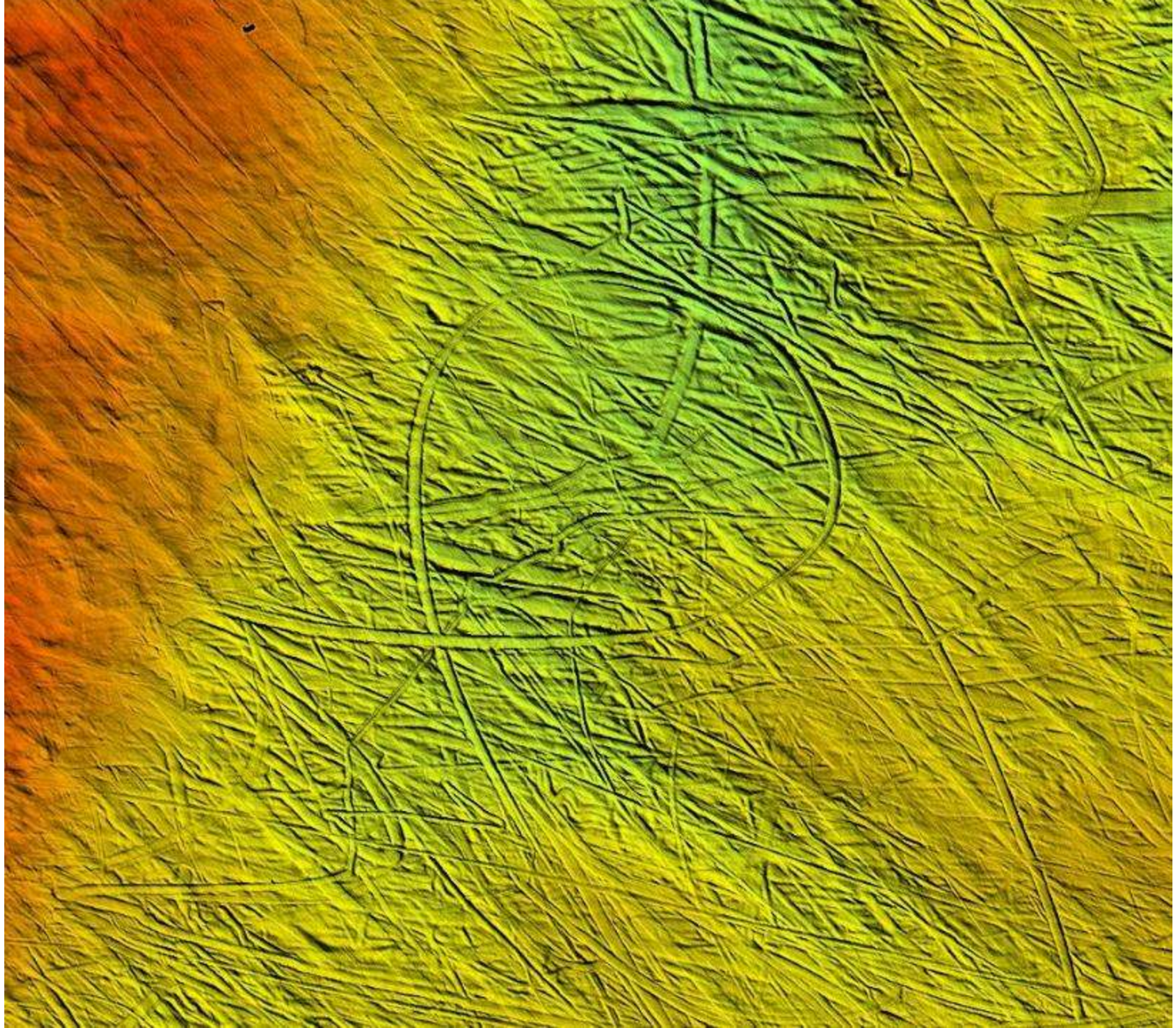
(long, skinny drumlins)

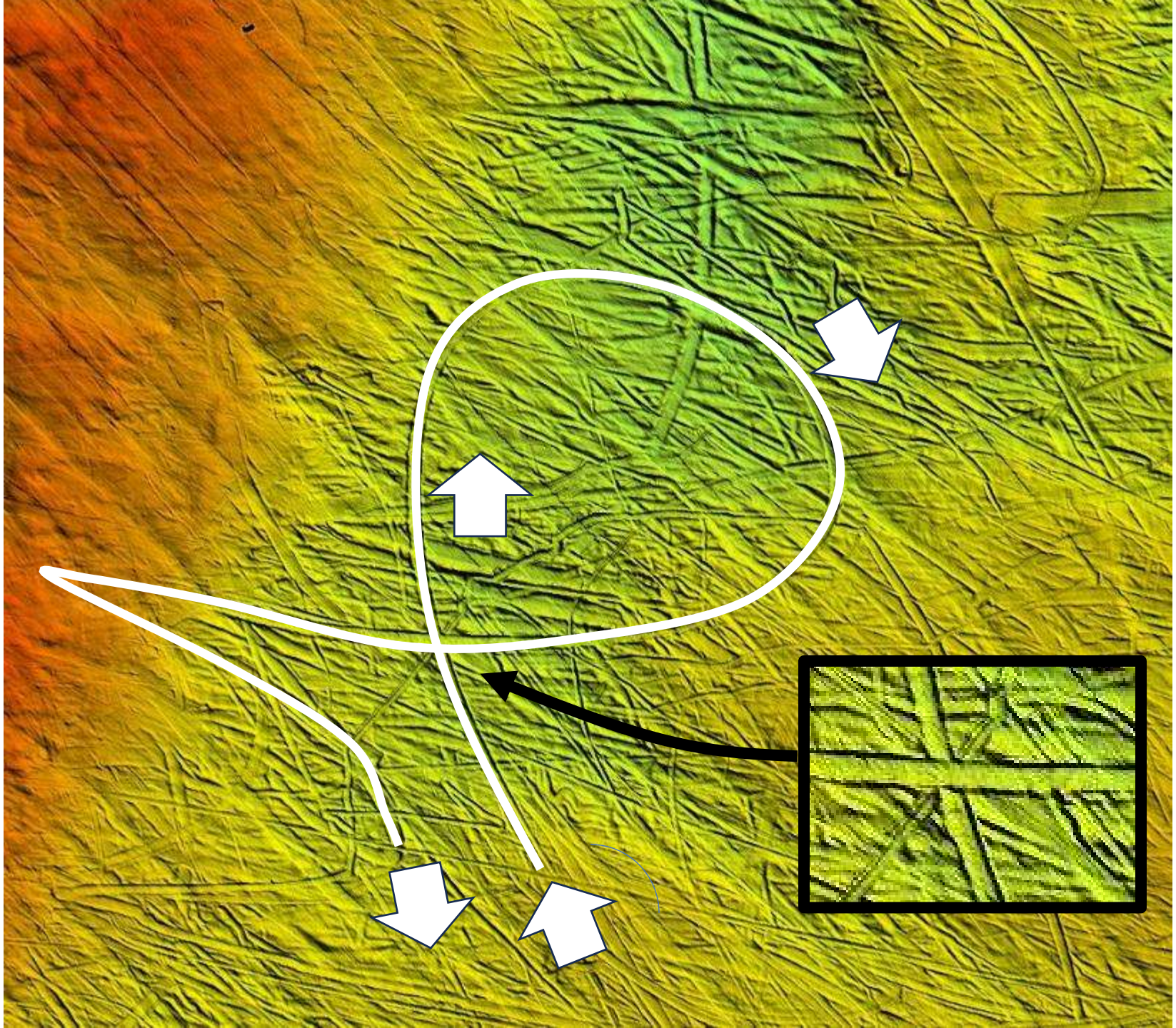


grounding-zone wedge



iceberg ploughmarks



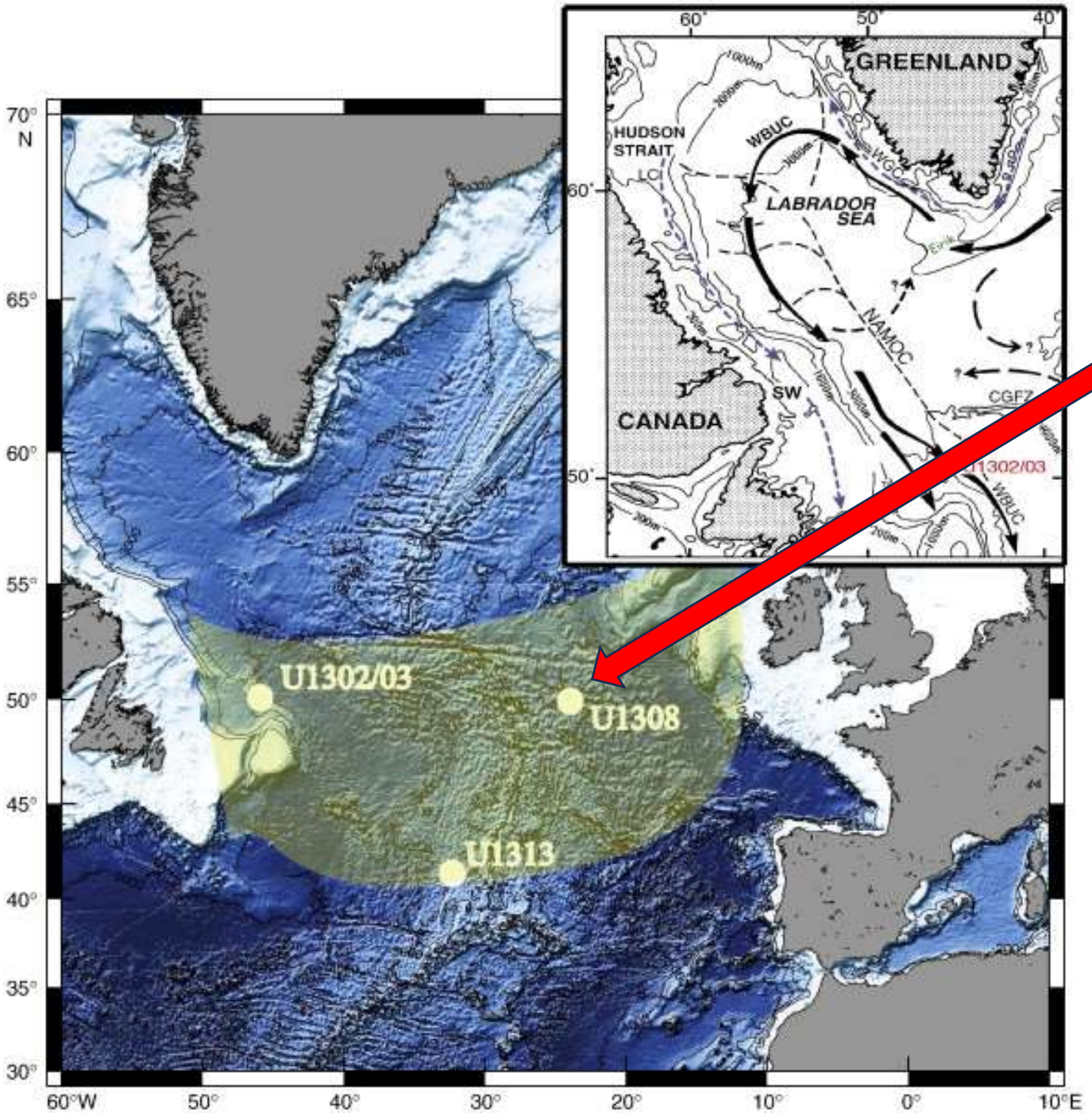


Part 4: Dropstones and Heinrich Layers

dropstone: melting iceberg dropped stone into otherwise well-stratified sediments

dropstone is not the same as a boulder in an outwash moraine, which could have been transported fluvially

Corner Rise Seamounts basaltic lithology, so easy to spot dropstones



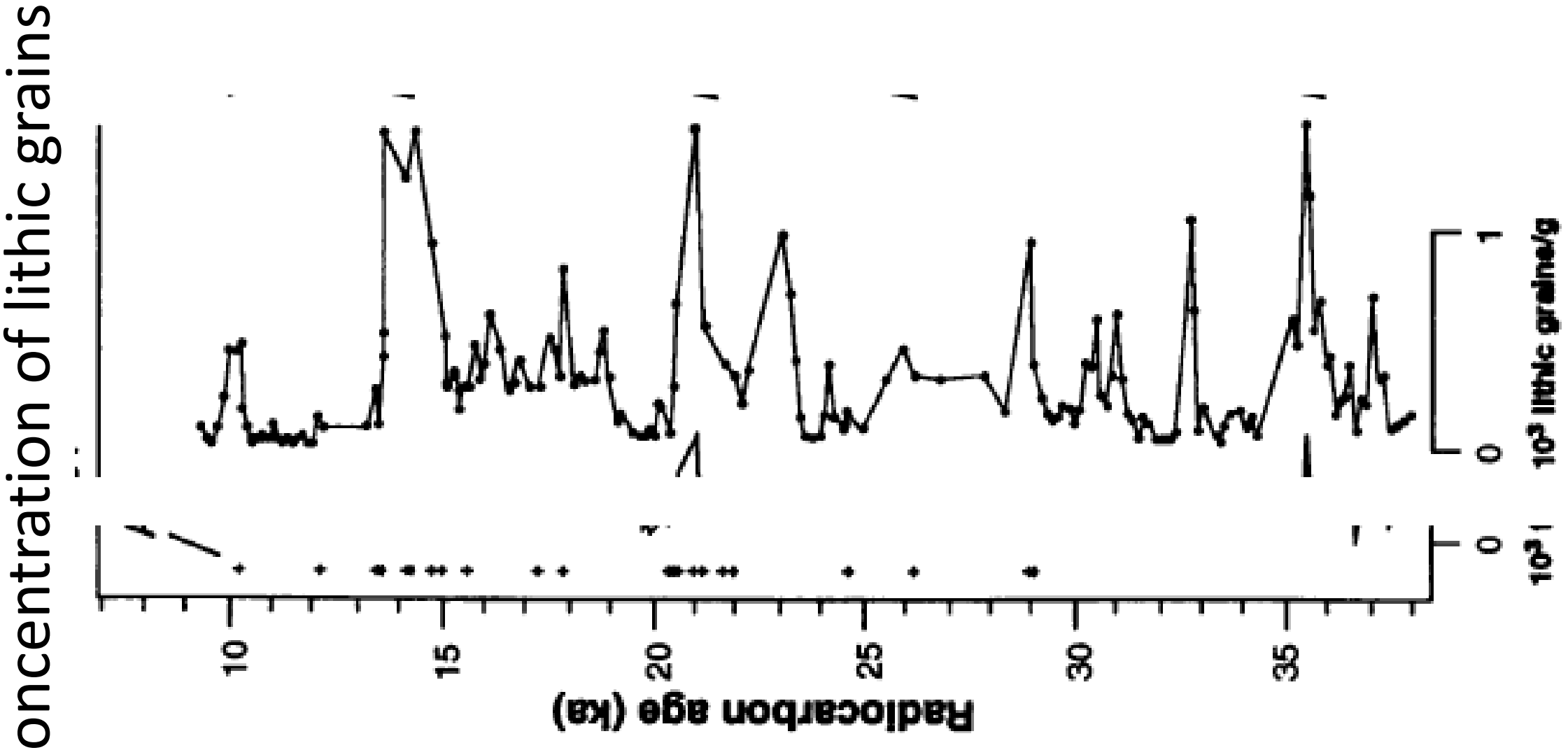
ODP Site U1308

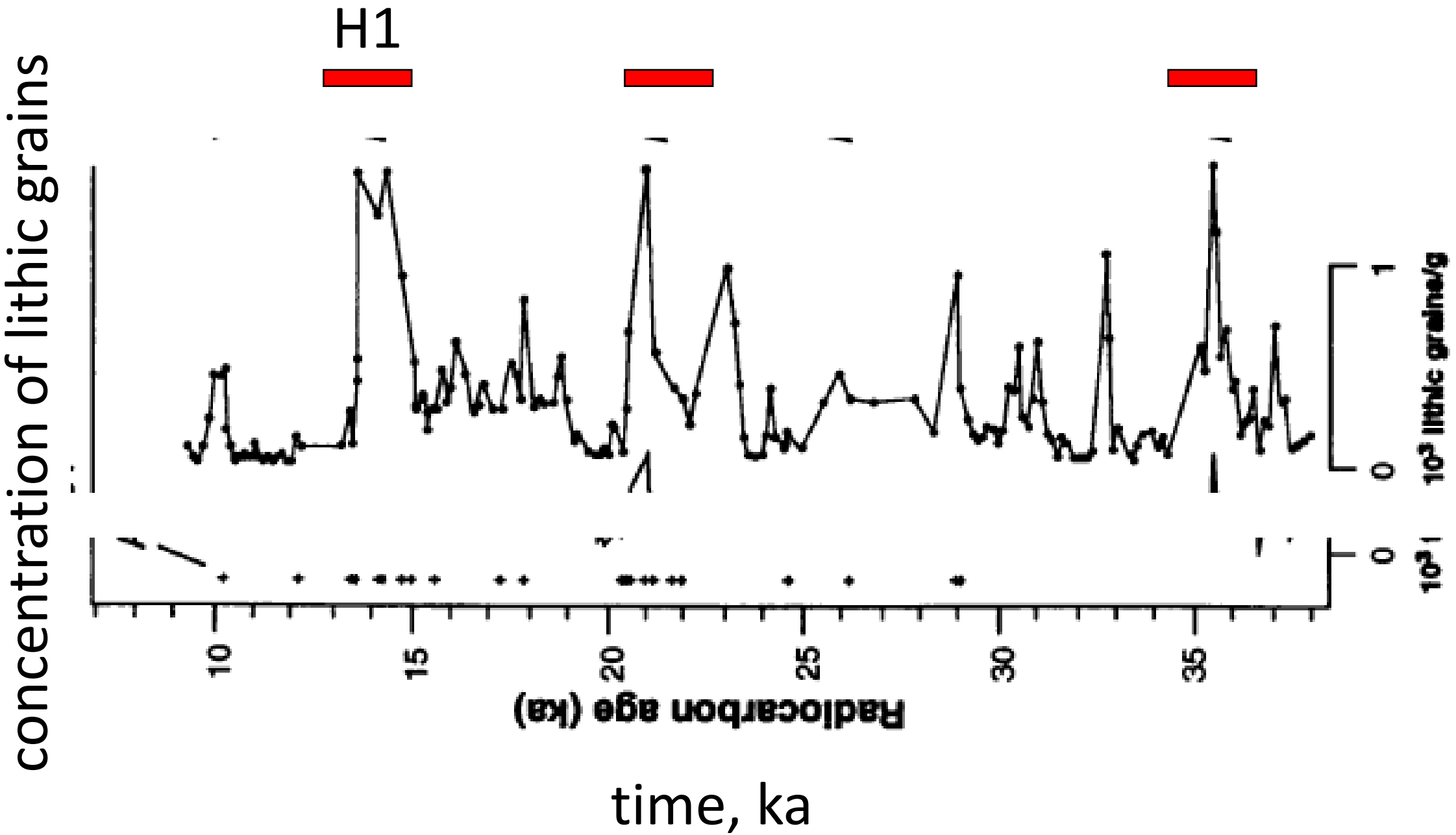
sediment mostly foraminifera

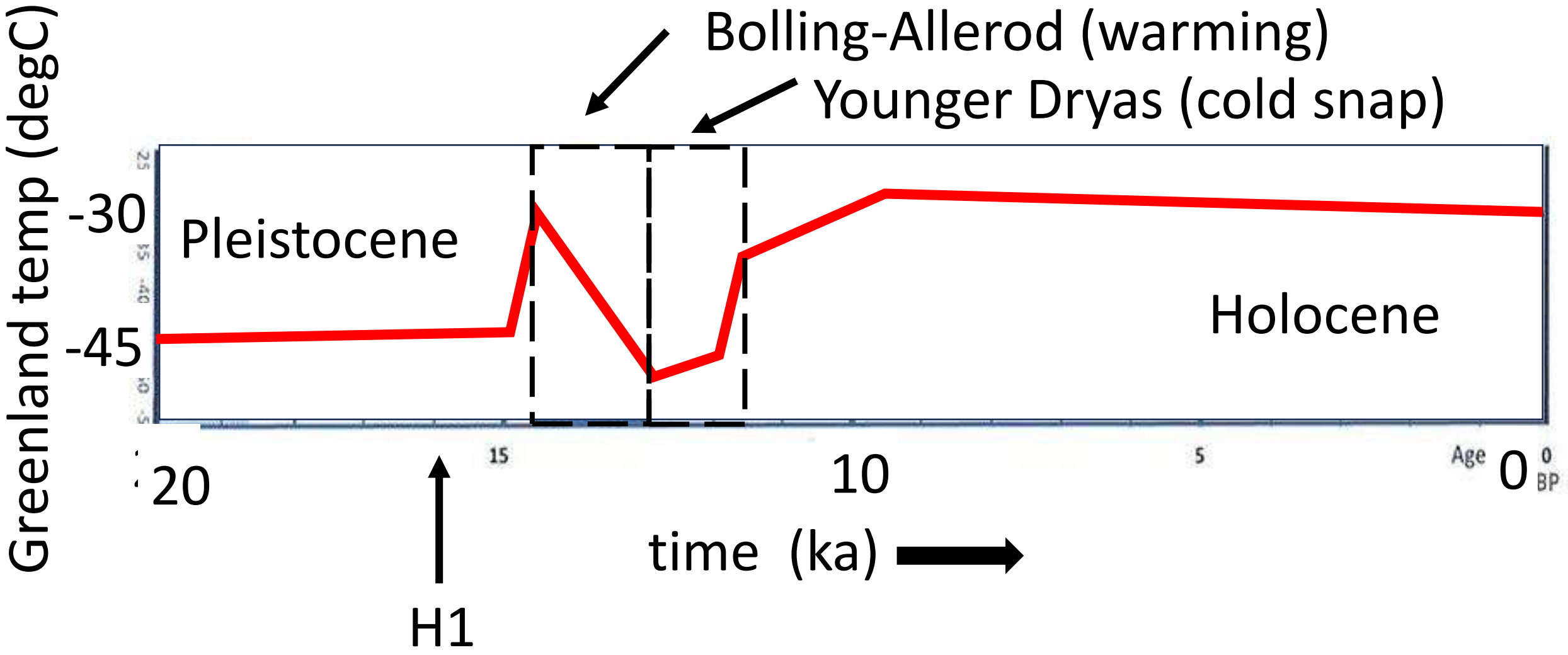
plankton with carbonate test (=shell)

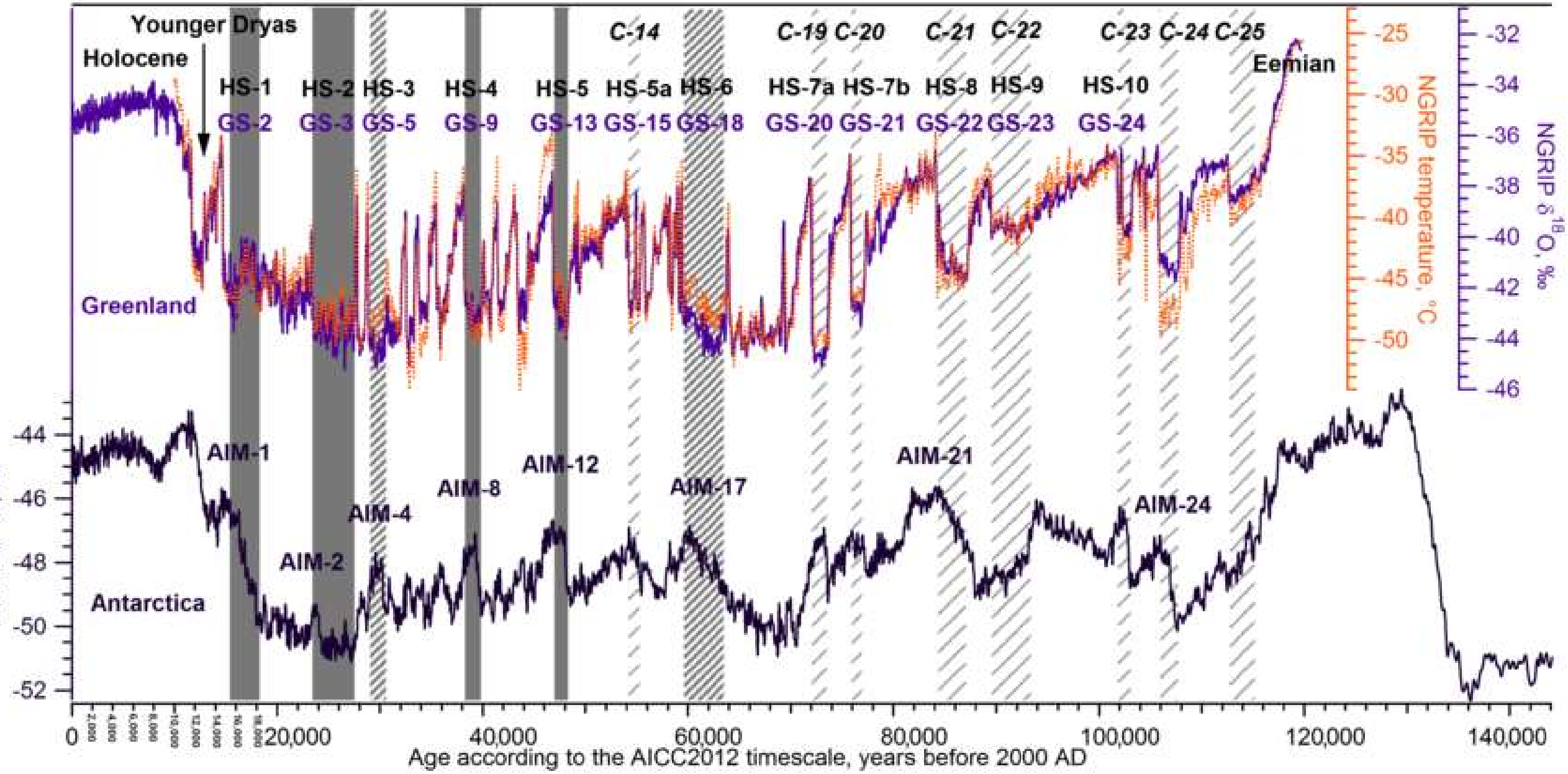
"lithic" sediment

(sand grains derived from the continent)

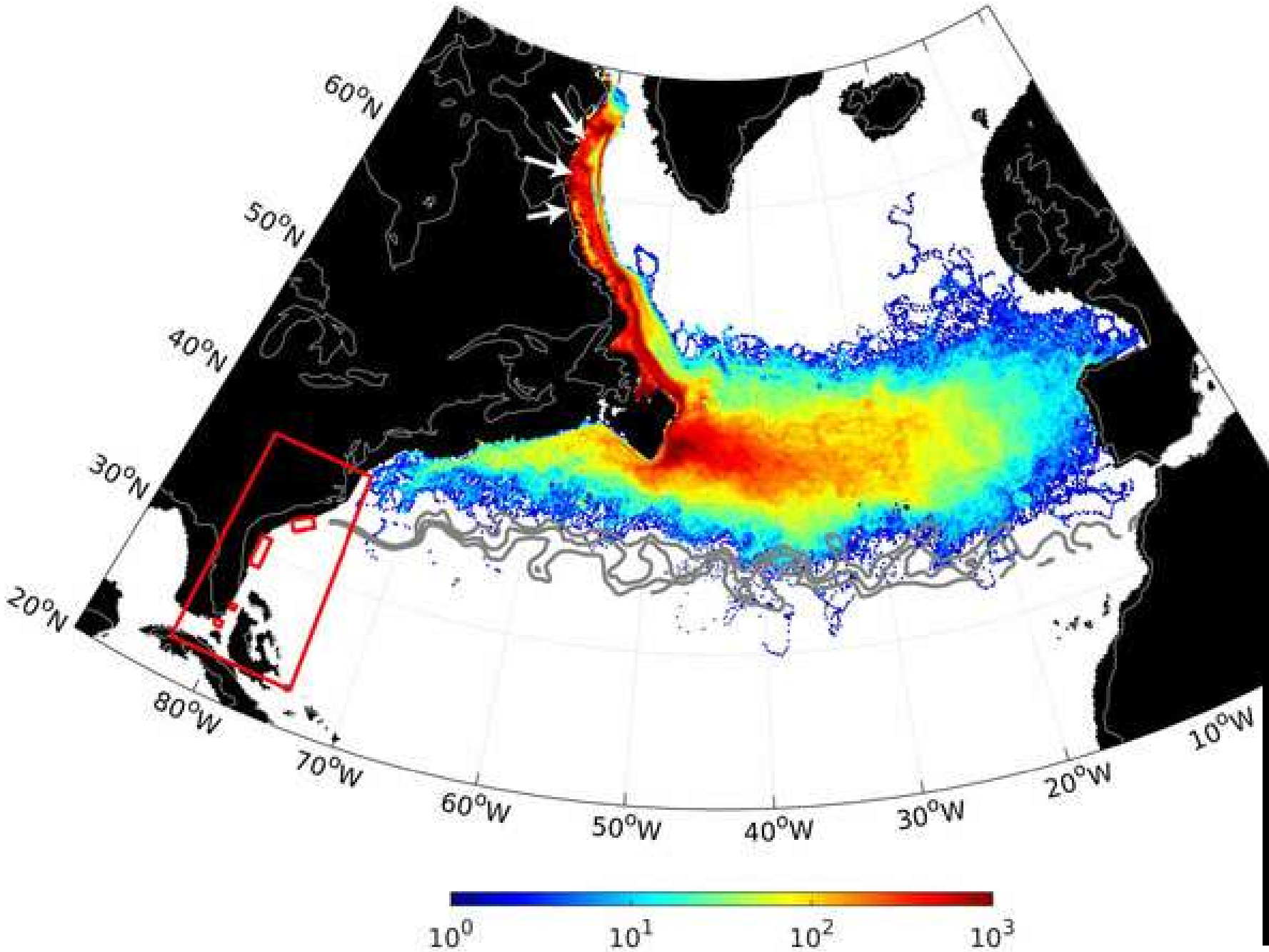

concentration of lithic grains
Radiocarbon age (ka)
10
15
20
25
30
35
0
1
0
time, ka


H1
concentration of lithic grains
Radiocarbon age (ka)
10
15
20
25
30
35
0
1
0
time, ka


Bolling-Allerod (warming)
Younger Dryas (cold snap)
Greenland temp (degC)
-30
-45
Pleistocene
Holocene
20
15
10
5
Age
0
BP
time (ka)
H1

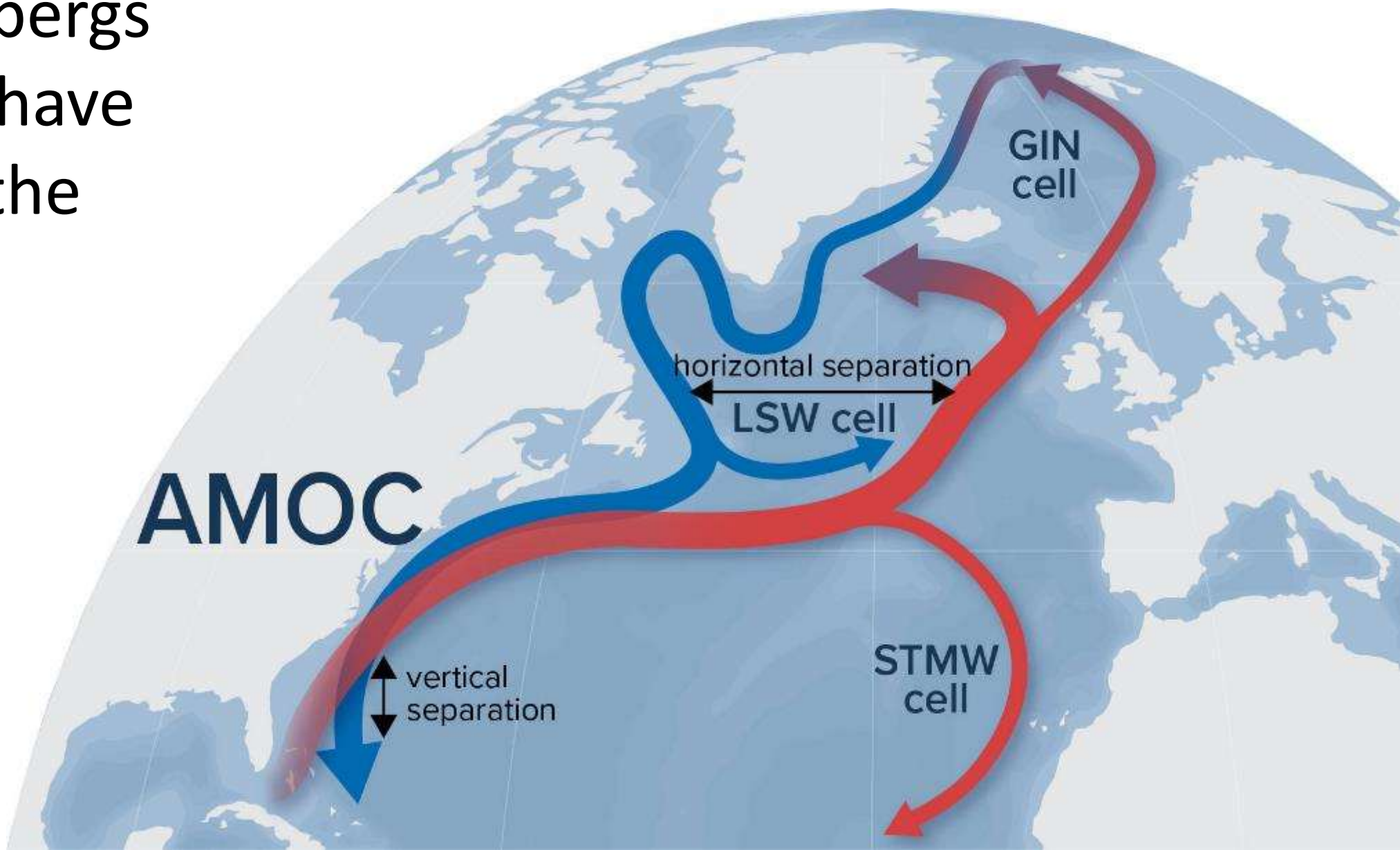

Younger Dryas
Holocene
HS-1
HS-2
HS-3
HS-4
HS-5
HS-5a
HS-6
HS-7a
HS-7b
HS-8
HS-9
HS-10
GS-2
GS-3
GS-5
GS-9
GS-13
GS-15
GS-18
GS-20
GS-21
GS-22
GS-23
GS-24
C-14
C-19
C-20
C-21
C-22
C-23
C-24
C-25
Eemian
Greenland
NGRIP temperature, °C
NGRIP δ18O, ‰
-25
-30
-35
-40
-45
-50
-32
-34
-36
-38
-40
-42
-44
-46
AIM-1
AIM-2
AIM-4
AIM-8
AIM-12
AIM-17
AIM-21
AIM-24
Antarctica
-44
-46
-48
-50
-52
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Age according to the AICC2012 timescale, years before 2000 AD

Modern surges of Icebergs



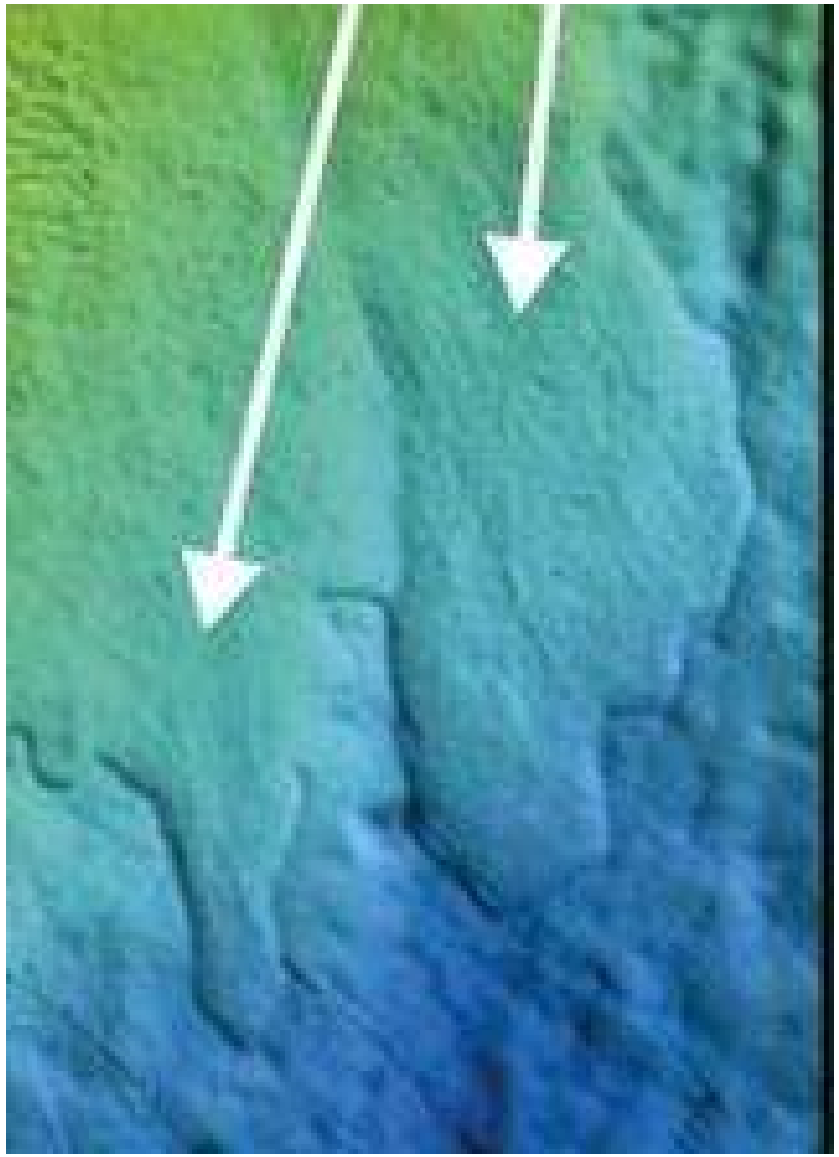
Simulation of Pleistocene Surge of Icebergs

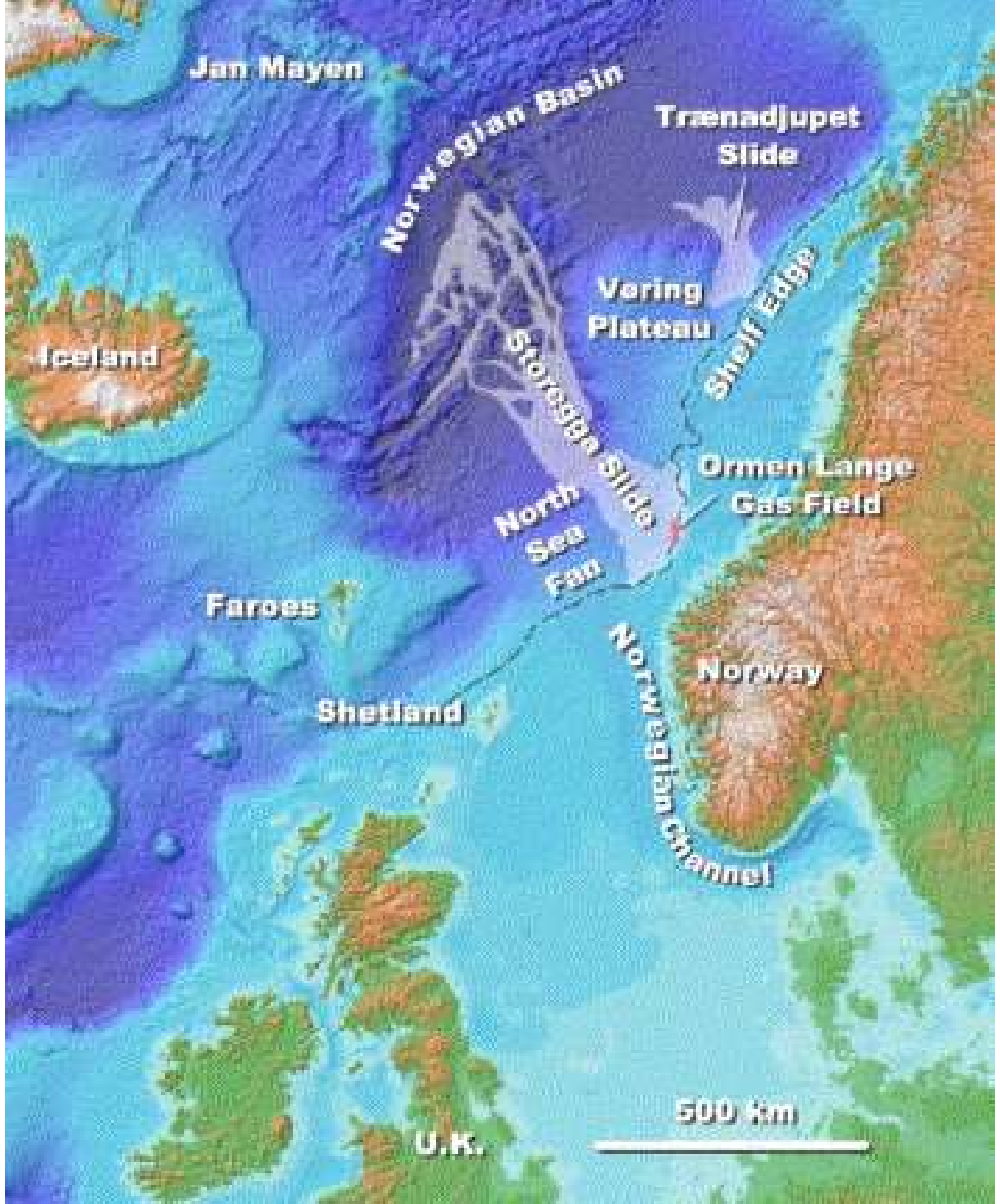
Low salinity of melting icebergs thought to have weakened the AMOC



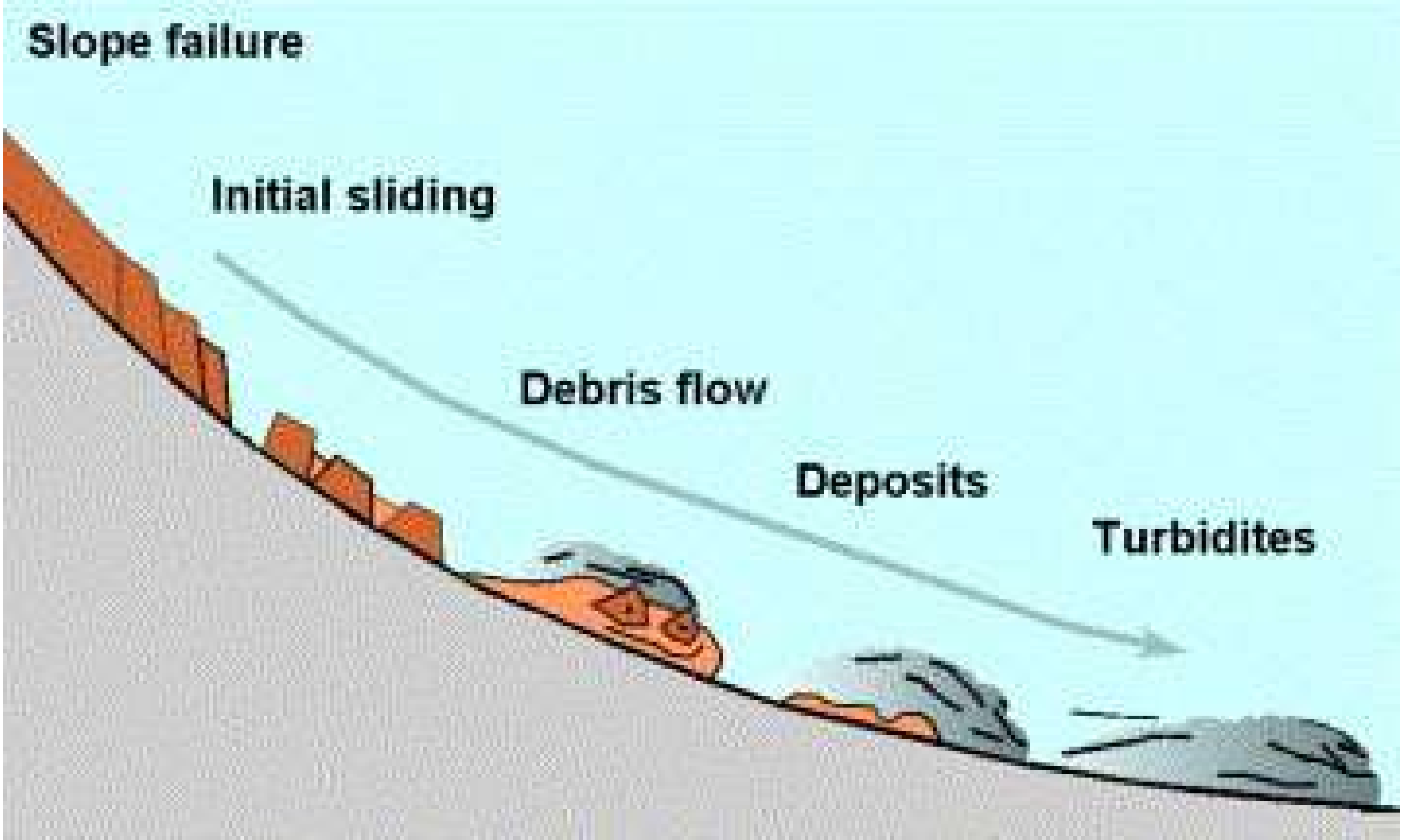
Part 5: Submarine debris flows

Debris Flows





The three Storegga Slides, approximately 6225–6170 BCE.


Slope failure
Initial sliding
Debris flow
Deposits
Turbidites

ANCIENT ARCHITECTS CHANNEL

THE STOREGGA SLIDE TSUNAMI AND THE DEATH OF DOGGERLAND