# High-resolution Geophysical Mapping of Submarine Glacial Landforms


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# ATLAS OF SUBMARINE GLACIAL LANDFORMS

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Edited by J.A. Dowdeswell, M. Canals, M. Jakobsson, B.J.Todd, E.K. DowdeswellL. K.A. Hogan

UNIVERSITY OF CAMBRIDGE

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The Geological Society

## *An Altas of Submarine Glacial Landforms: Modern Quaternary and Ancient*

In the past two decades there have been several advances that make the production of an atlas of submarine glacial landforms timely. First is the development of high-resolution imaging technologies; multi-beam echo-sounding or swath bathymetry that allows the detailed mapping of the sea floor at water depths of tens to thousands of metres across continental margins, and 3-D seismic methods that enable the visualisation of palaeo-continental shelves in Quaternary sediments and ancient palaeo-glacial rocks (e.g. Late Ordovician of Northern Africa). A second technological development is that of ice-breaking or ice-strengthened ships that can penetrate deep into the ice-infested waters of the Arctic and Antarctic, to deploy the multibeam systems. A third component is that of relevance – through both the recognition that the polar regions, and especially the Arctic, are particularly sensitive parts of the global environmental system and that these high-latitude margins (both modern and ancient) are likely to contain significant hydrocarbon resources. An enhanced understanding of the sediments and landforms of these fjord-shelf-slope systems is, therefore, of increasing importance to both academics and industry. We are editing an Atlas of Submarine Glacial Landforms that presents a series of individual contributions that describe, discuss and illustrate features on the high-latitude, glacier-influenced sea floor. Contributions are organised in two ways: first, by position on a continental margin – from fjords, through continental shelves to the continental slope and rise; secondly, by scale – as individual landforms and assemblages of landforms. A final section provides discussion of integrated fjord-shelf-slope systems. Over 100 contributions by scientists from many countries contain descriptions and interpretation of swath-bathymetric data from both Arctic and Antarctic margins and use 3D seismic data to investigate ancient glacial landforms. The Atlas will be published in late 2015 in the Memoir Series of the Geological Society of London.

*Overview maps showing the geographic distribution of the contributions to the Atlas of the Submarine Glacial Landforms*

Contributions will be organised in two ways: first, by position on the continental margin - from fjords, through continental shelves to the continental slope and rise; secondly, by scale - as individual landforms and assemblages of landforms. A final section will allow discussion of integrated fjord shelf-slope systems.

## *Editors*

J.A. Dowdeswell[1], M. Canals[2], M. Jakobsson[3], B.J. Todd[4], E.K. Dowdeswell[1], K.A. Hogan[5].

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## *Accepted papers (25 November 2014)*

*ANDERSON, J.B. & JAKOBSSON, M. Grounding-zone wedges on Antarctic continental shelves (820)*

*AMBLAS, D. & CANALS, M. Contourite drifts and canyon-channel systems on the Northern Antarctic Peninsula Pacific margin (844)*

*BARNES, P., PICKRILL, R. & BOSTOCK, H. Thompson and Bradshaw Sounds, Fiordland, New Zealand: a relict, mid-latitude, temperate glacier system (880)*

*BARNES, P. M., PICKRILL, R. A., BOSTOCK, H. C., DLABOLA, E. K., GORMAN, A. R. & WILSON, G. S. Relict proglacial deltas in Bradshaw and George Sounds, Fiordland, New Zealand (903)*

*BELLEC, V., PLASSEN, L., RISE, L. & DOWDESWELL, J. A. Malangsdjupet: a cross-shelf trough on the North Norwegian margin (860)*

*BELLEC, V., RISE, L., BØE, R. & DOWDESWELL, J. A. Glacially related gullies on the upper continental slope, SW Barents Sea margin (861)*

*BØE, R., BELLEC, V. K., DOLAN, M. F. J., RISE, L., BUHL-MORTENSEN, P. & BUHL-MORTENSEN, L. Cold-water coral reefs in the Hola glacial trough off Vesterålen, North Norway (821)*

*BROTHERS, L. L., LEGERE, C., HUGHES CLARKE, J. E., KELLEY, J. T, BARNHARDT, W. A., ANDREWS, B. D. & BELKNAP, D. F. Pockmarks in Passamaquoddy Bay, New Brunswick, Canada (904)*

*BURTON, D. J., DOWDESWELL, J. A., HOGAN, K. A. & NOORMETS, R. Little Ice Age terminal and retreat moraines in Kollerfjorden, northwest Spitsbergen (865)*

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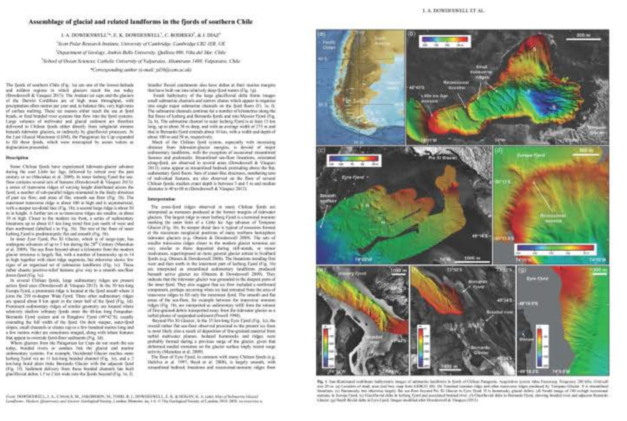
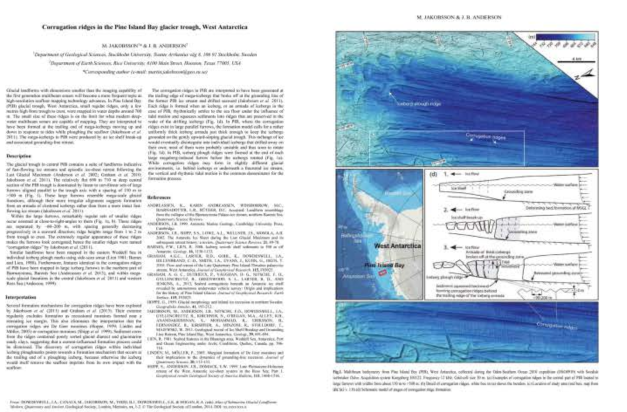
*TODD, B. J. De Geer moraines on German Bank, southern Scotian Shelf of Atlantic Canada (818)*

## *Example of a 4-page chapter describing an assemblage of glacial landforms*



## *Examples of 2-page chapters describing glacial landforms*



www.submarineglacialatlas.com/

# High-resolution Geophysical Mapping of Submarine Glacial Landforms

- Glacial landforms are generated from the activity of glaciers and display **spatial dimensions ranging from below one meter up to tens of kilometers**

- This presentation illustrates how the **evolution of marine geophysical mapping techniques** made it possible to study submarine glacial landforms in detail

# Three examples illustrating what higher resolution seafloor mapping revealed

# Spatial dimensions: from meters to kilometers

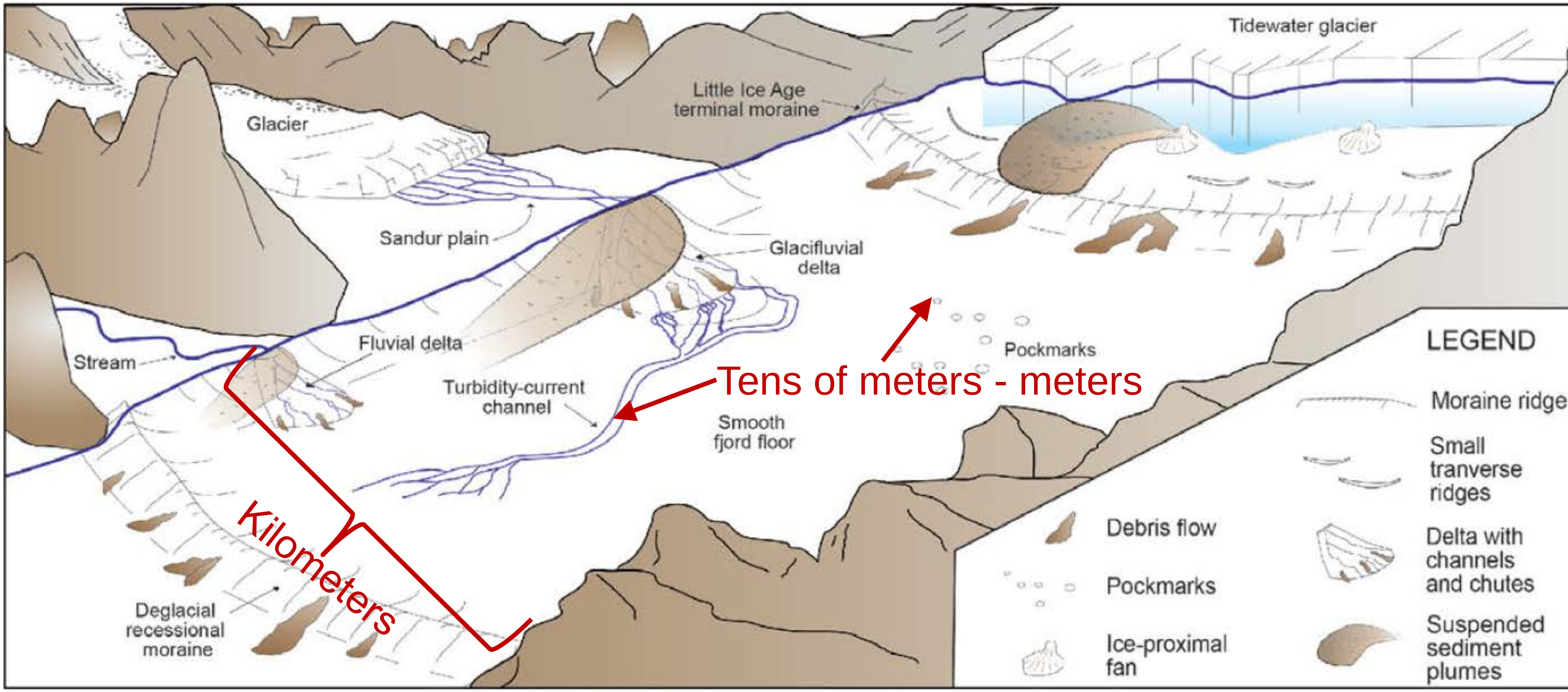
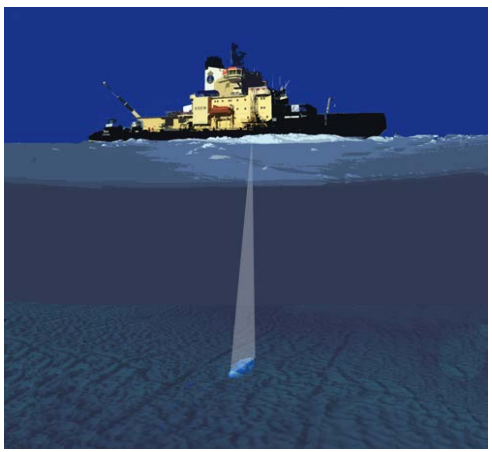
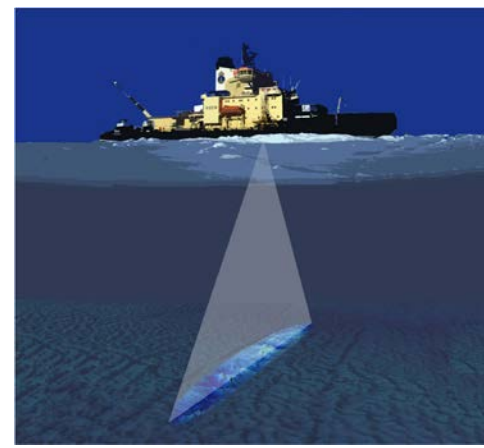


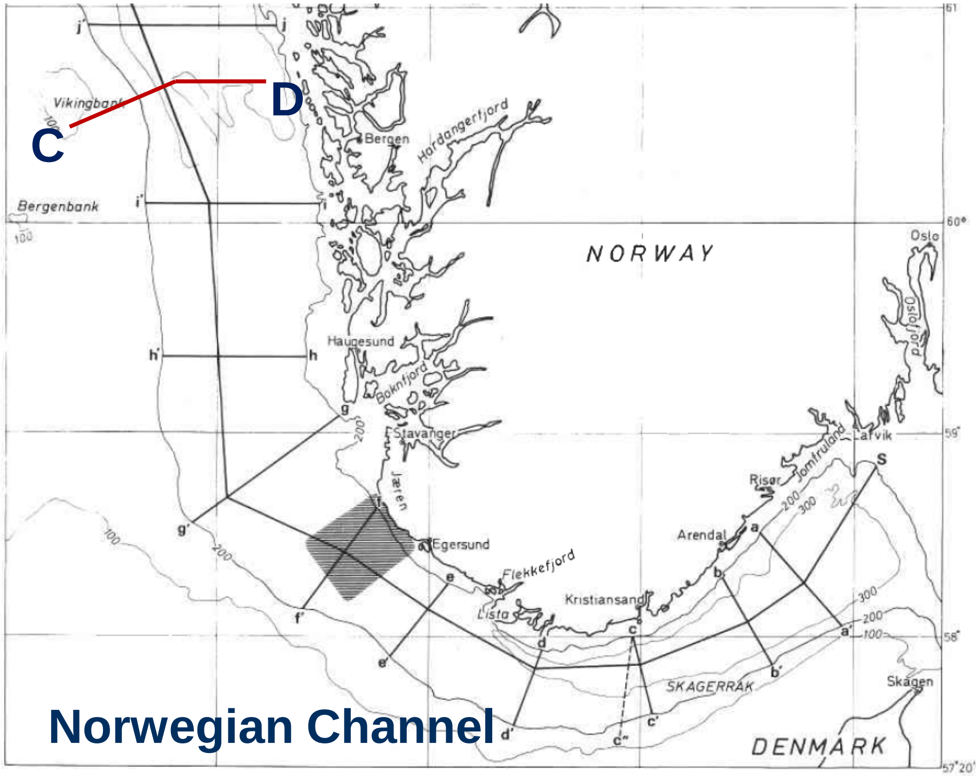

Image from: DOWDESWELL, J. A., DOWDESWELL, E. K., RODRIGO, C. & J. DIAZ. Assemblage of glacial and related landforms in the fjords of southern Chile (890)

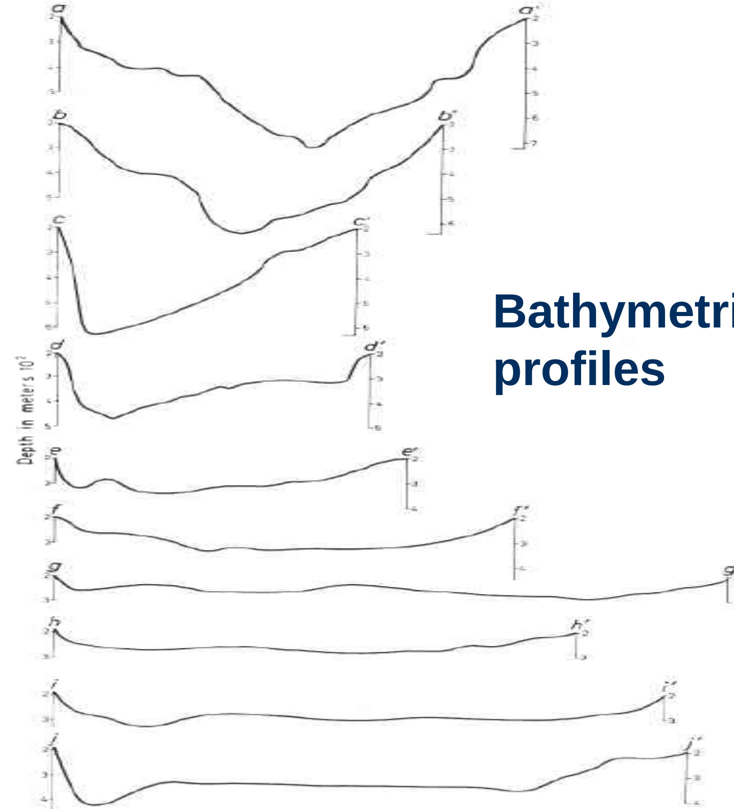
# From single beam to multibeam

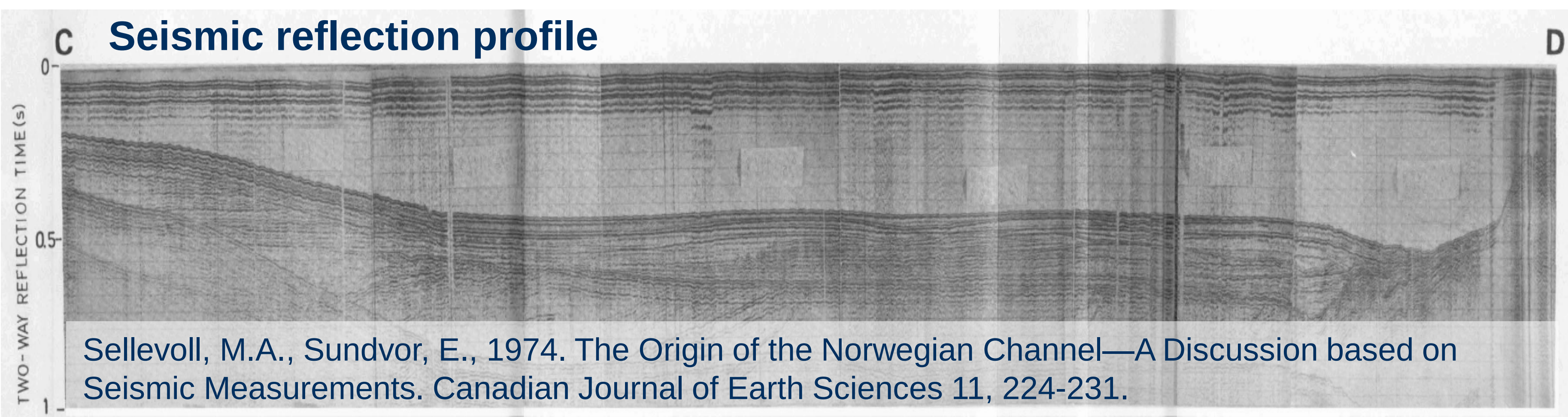




# Example 1: Norwegian Channel

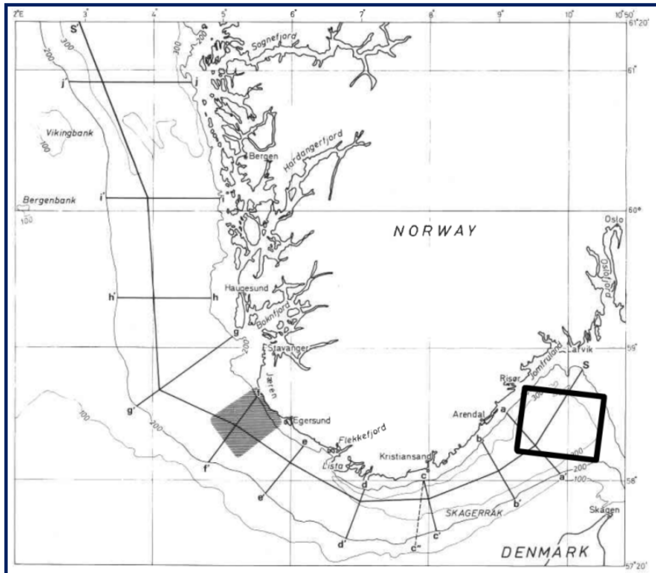


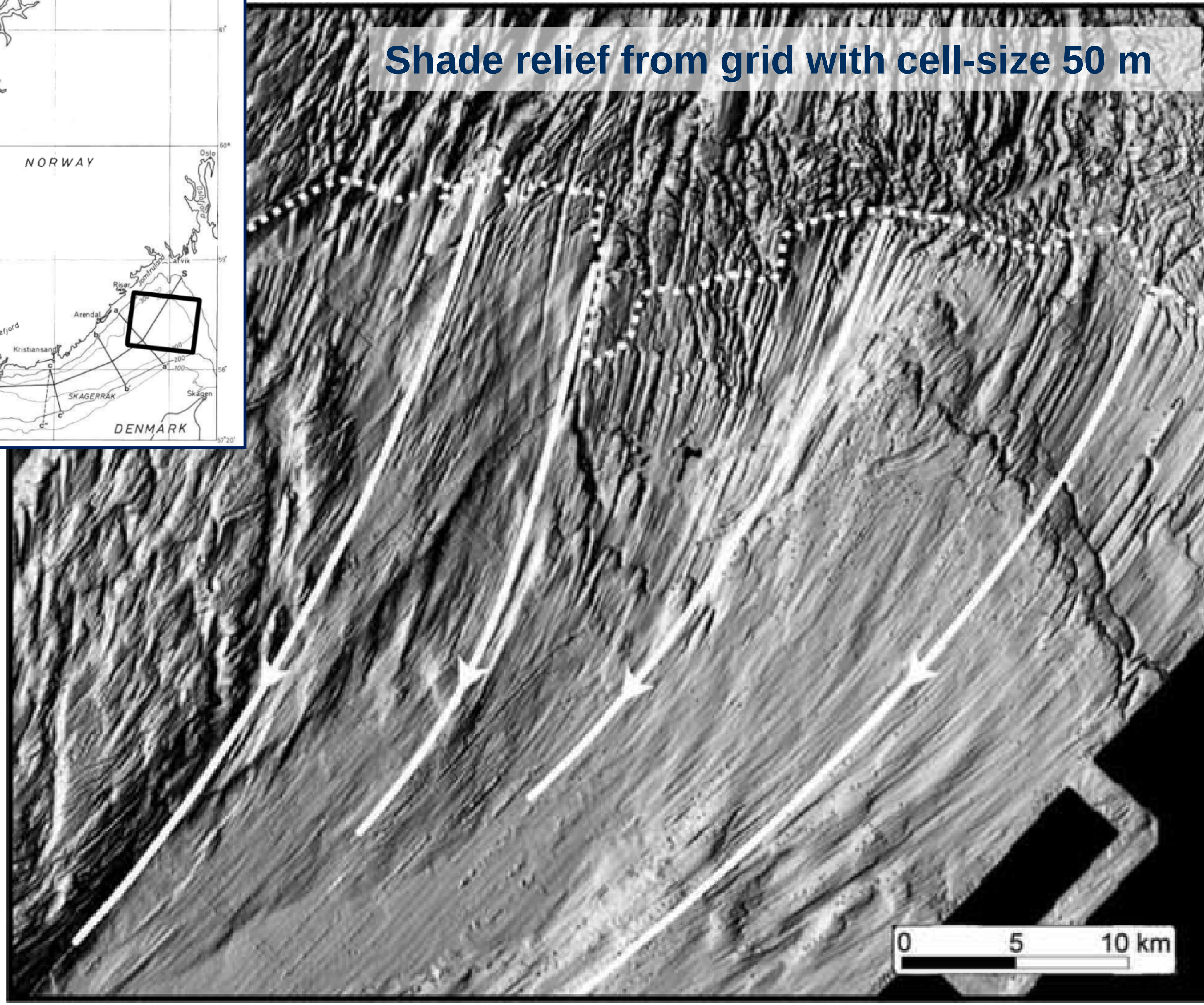





Sellevoll, M.A., Sundvor, E., 1974. The Origin of the Norwegian Channel—A Discussion based on Seismic Measurements. Canadian Journal of Earth Sciences 11, 224-231.



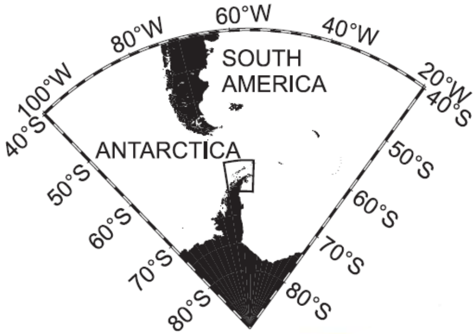




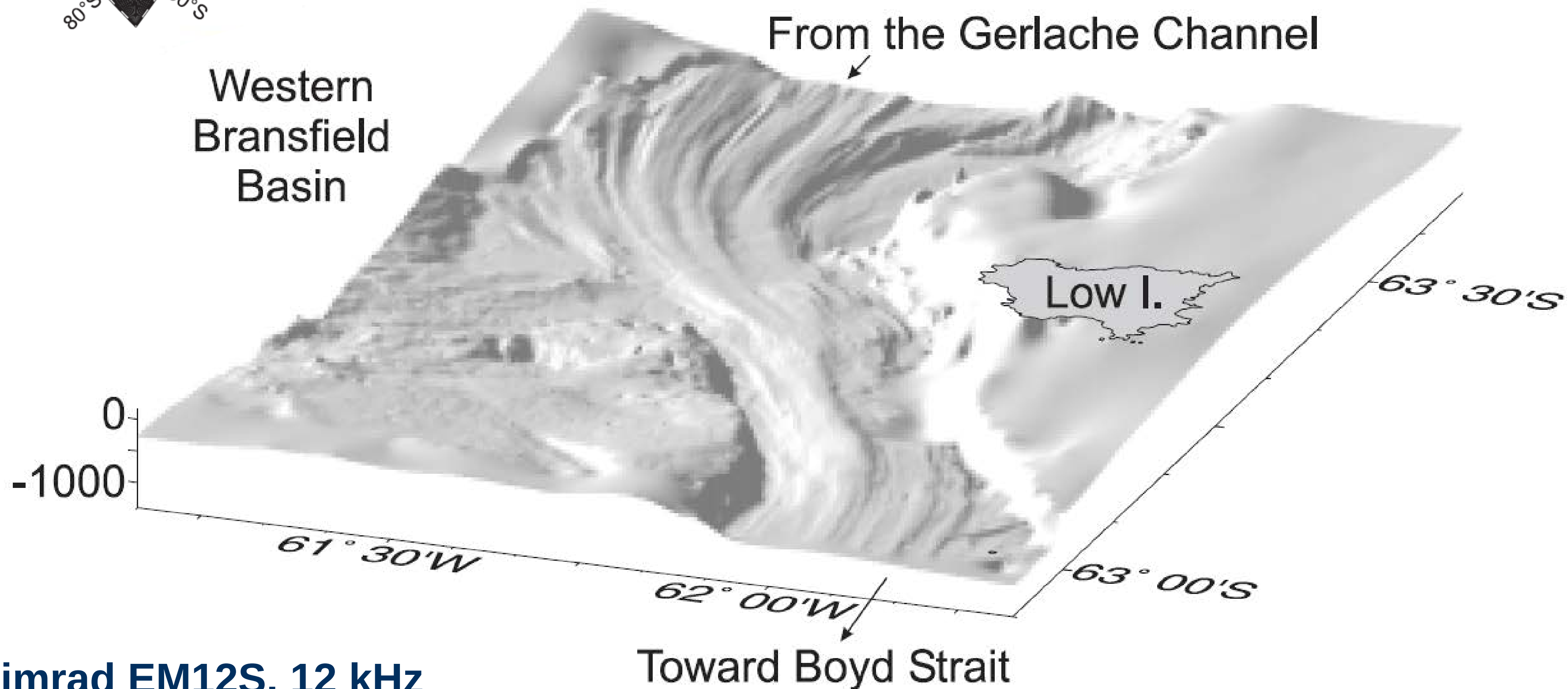


**Mapped with Simrad's first multibeam EM100, 95 kHz**

Ottesen, D., Dowdeswell, J.A., Rise, L., 2005. Submarine landforms and the reconstruction of fast-flowing ice streams within a large Quaternary ice sheet: The 2500-km-long Norwegian-Svalbard margin (57°–80°N). Geological Society of America Bulletin 117, 1033-1050.

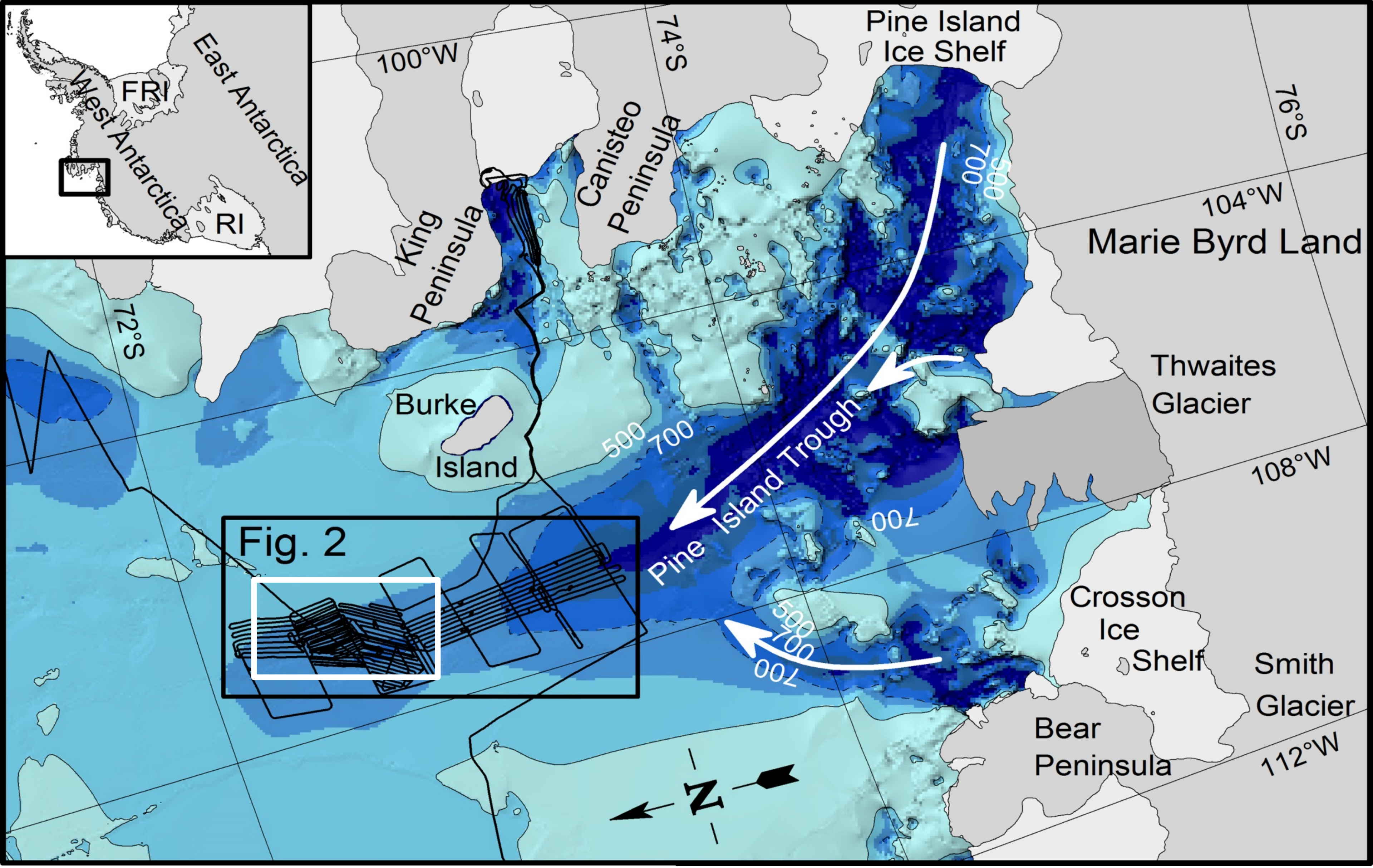



# The first(?) multibeam mapping of MSGLs




**Simrad EM12S, 12 kHz**

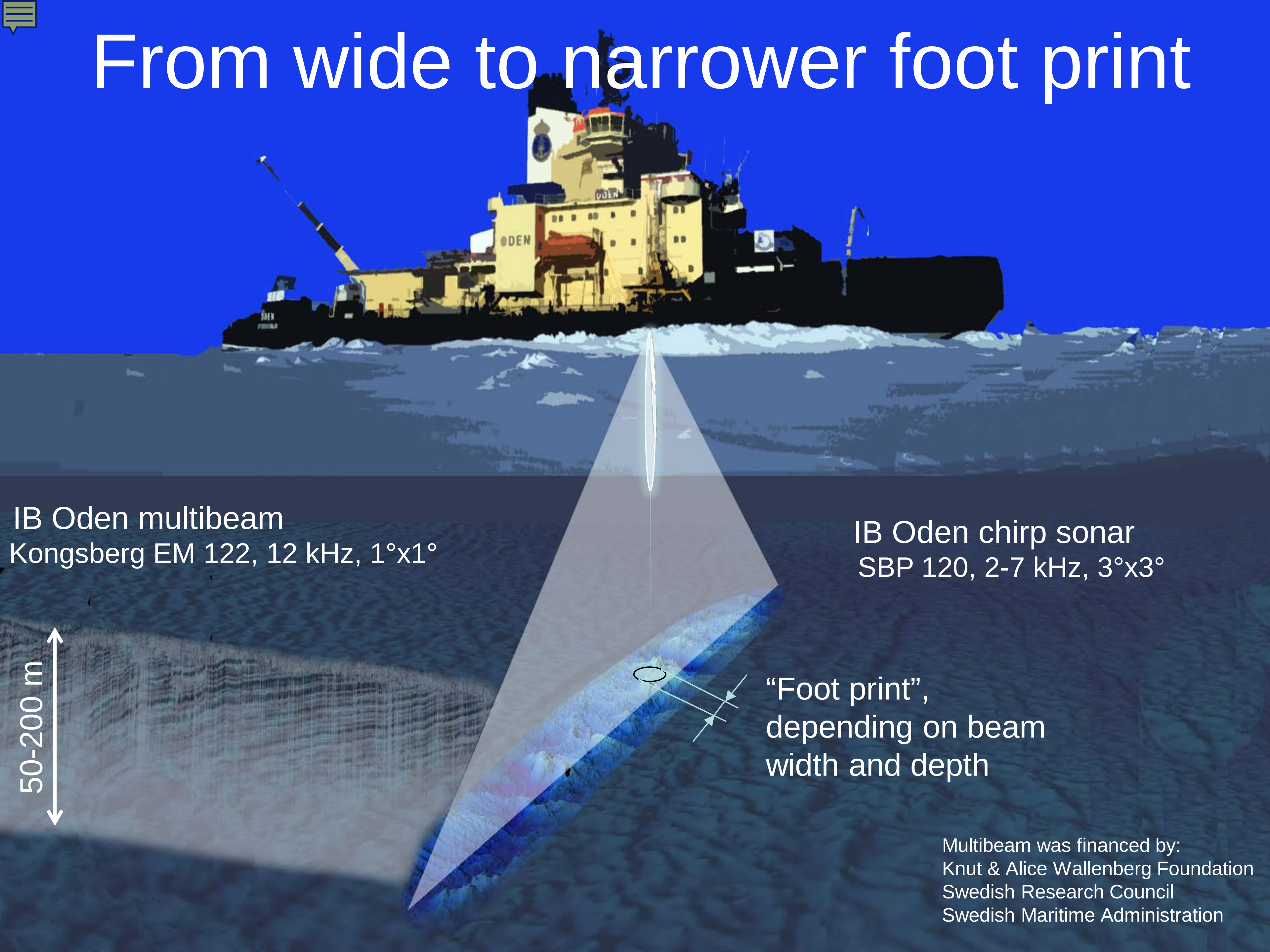
*Canals, M., Urgeles, R., Calafat, A.M., 2000. Deep sea-floor evidence of past ice streams off the Antarctic Peninsula. Geology 28, 31-34.*



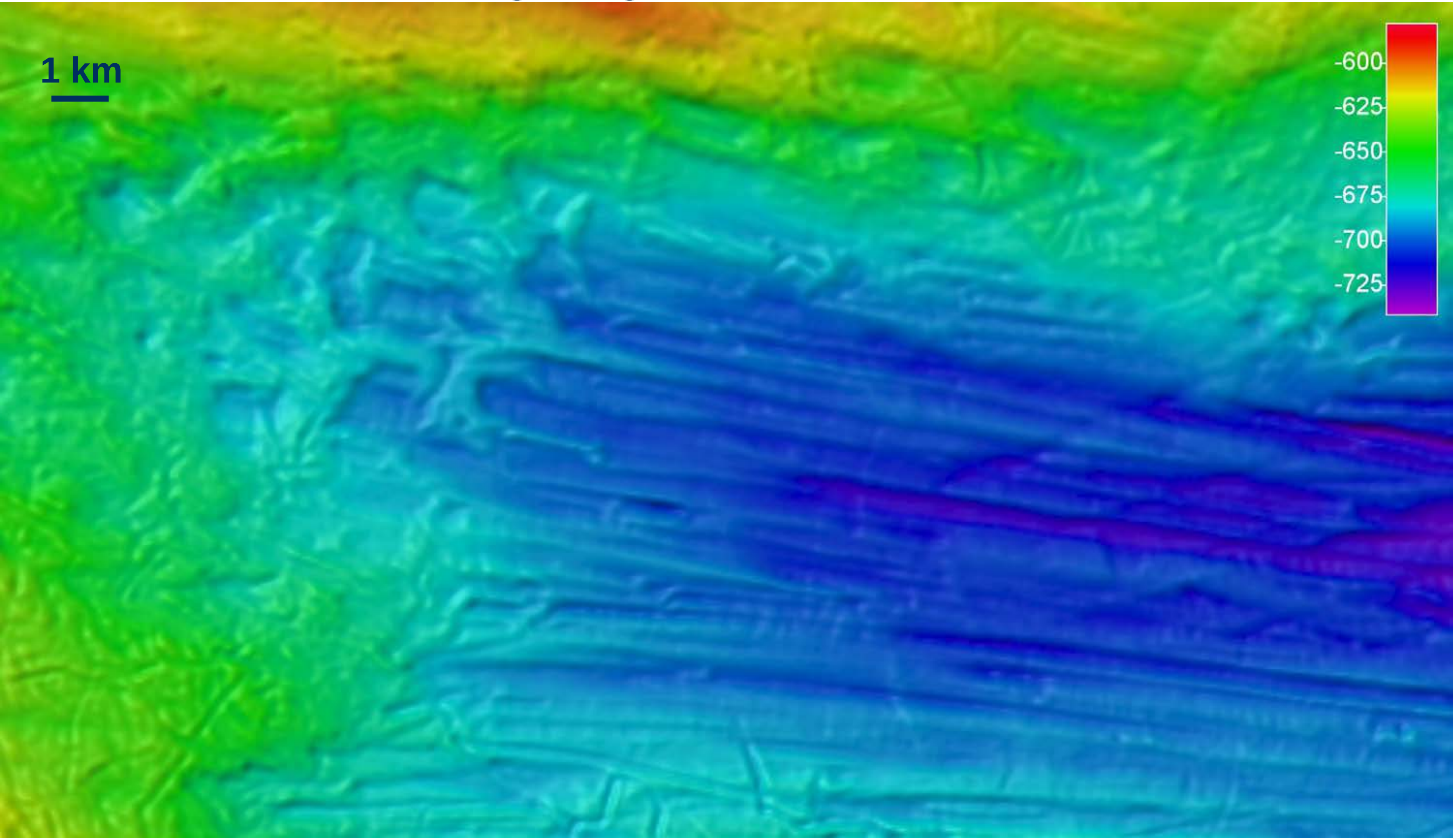

# Example 2: Pine Island Bay

*Jakobsson, M., Anderson, J. et al., 2011. Geological record of Ice Shelf Breakup and Grounding Line Retreat, Pine Island Bay, West Antarctica. Geology 39, 691-694.*

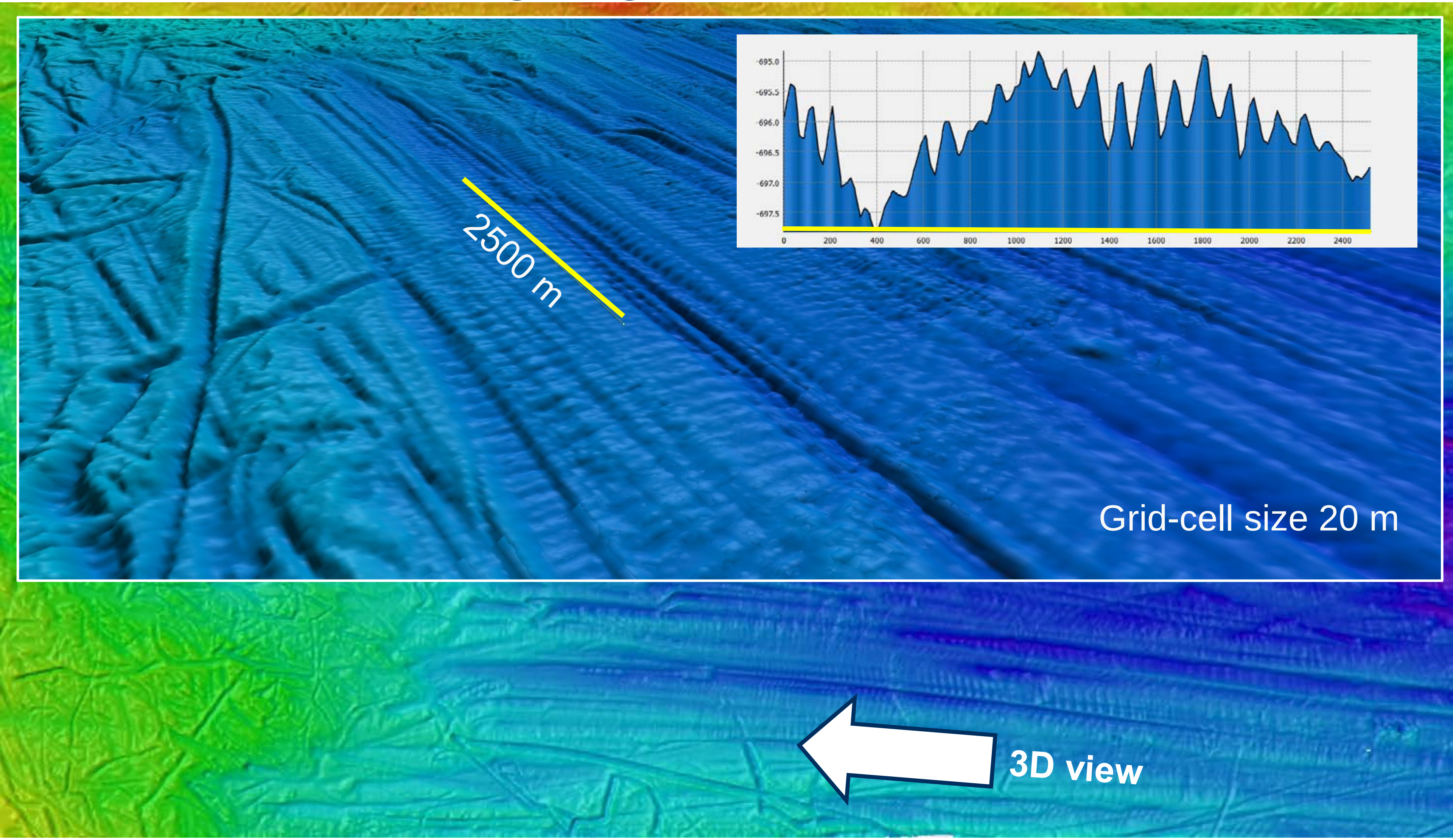
# From wide to narrower foot print

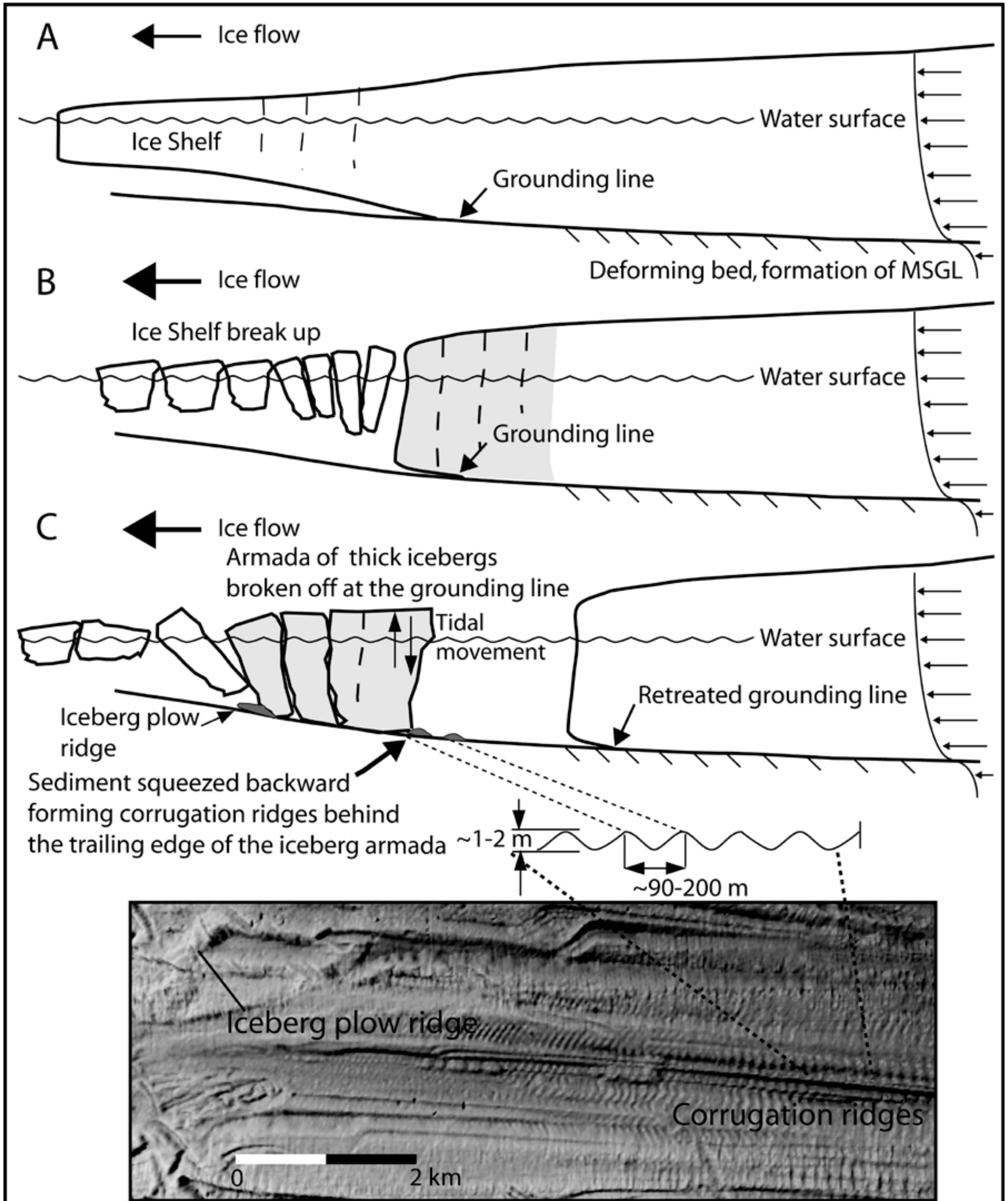


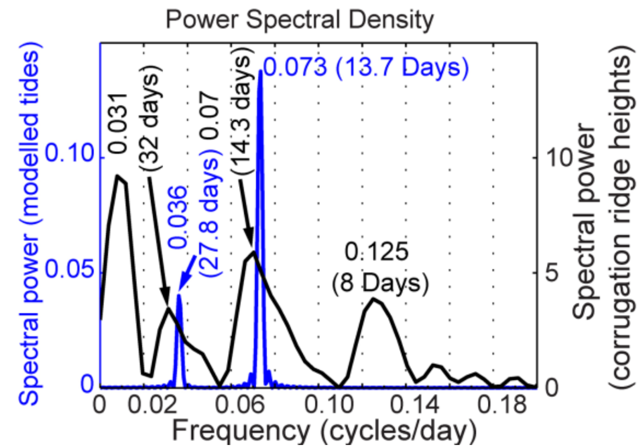
# Pine Island Trough: grid-cell size 50 m



# Pine Island Trough: grid-cell size 30 m



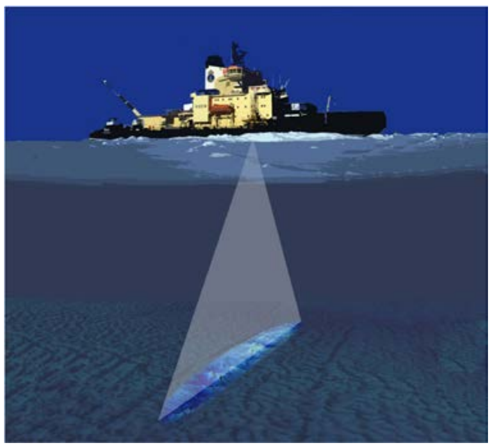


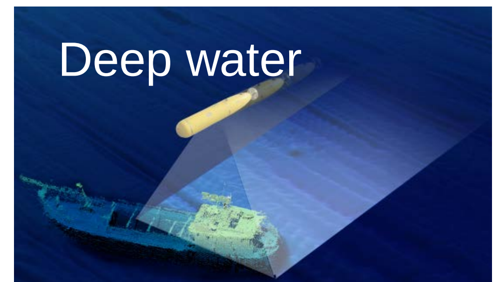




# Analyzed ridge height variation along bathymetric profile

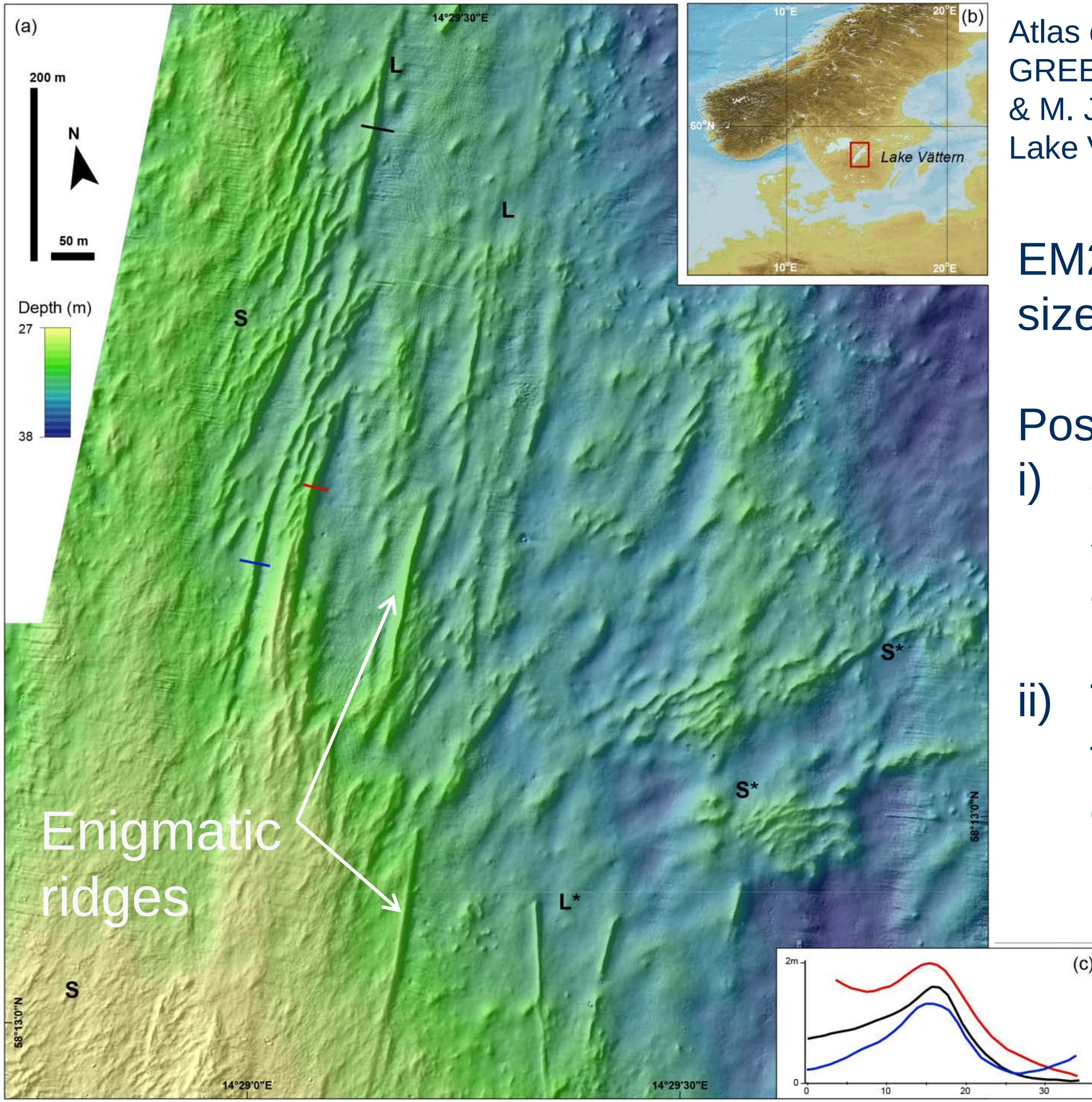
*Jakobsson, M., Anderson, J.B., et al., 2011. Geological record of Ice Shelf Breakup and Grounding Line Retreat, Pine Island Bay, West Antarctica. Geology 39, 691-694.*

# Getting closer to the seabed with higher resolution system






# Example 3: Enigmatic ridges in Lake Vättern, Sweden



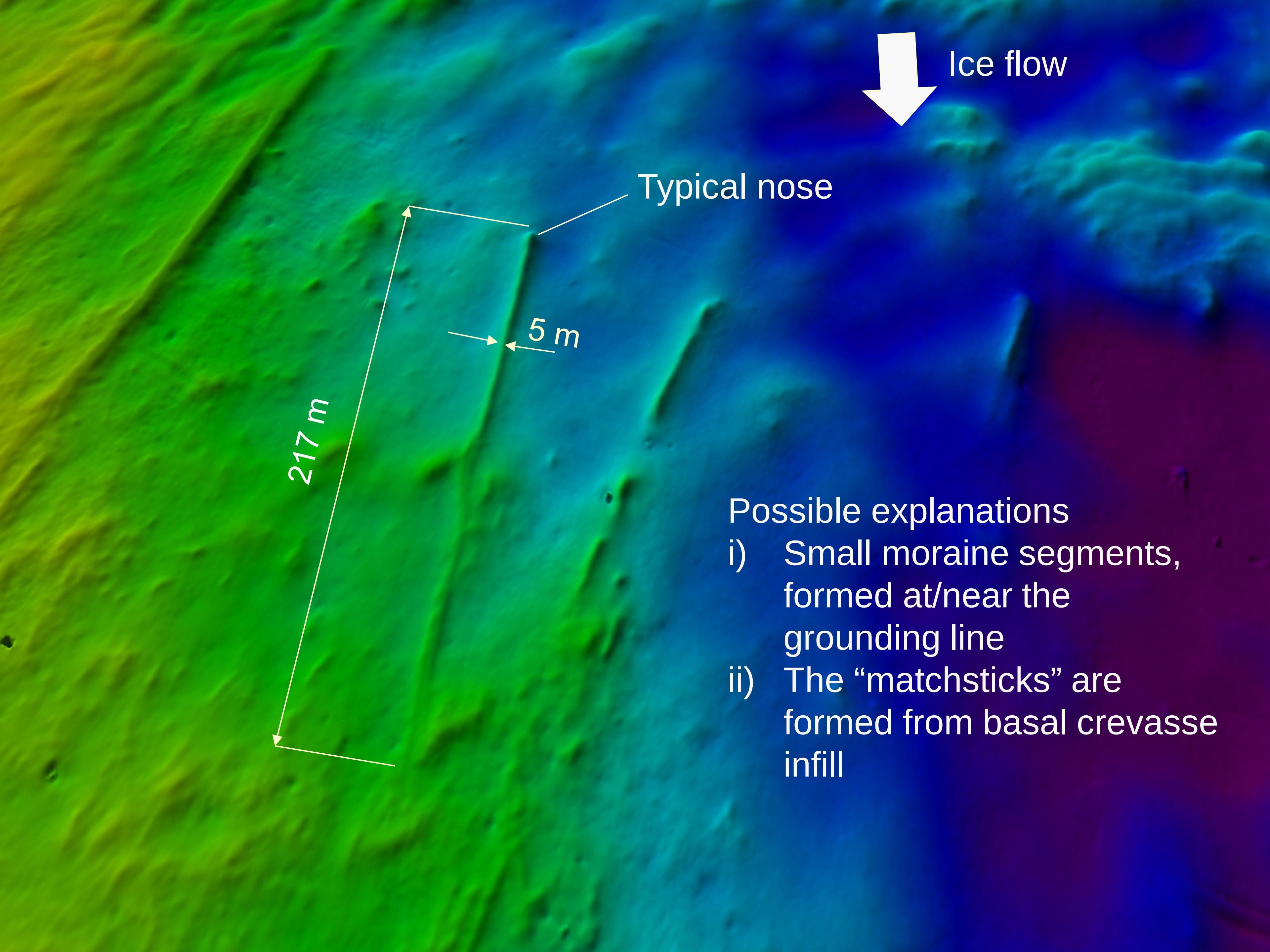

Atlas contribution:
GREENWOOD, S. L.
& M. JAKOBSSON. Enigmatic ridges in
Lake Vättern, Sweden (857)

EM2040, 300 kHz, grid-cell size 1 m.

Possible explanations

i) Small moraine segments, formed at/near the grounding line
ii) The “matchsticks” are formed from basal crevasse infill

Stockholm University


Ice flow
Typical nose
5 m
217 m
Possible explanations
i) Small moraine segments, formed at/near the grounding line
ii) The "matchsticks" are formed from basal crevasse infill

New global grid at 30 x 30 arc second resolution: GEBCO_2014

See poster: **OS31B-0990**

General Bathymetric Chart of the Oceans (GEBCO) – Mapping the Global Seafloor