A Re-Evaluation of the Late Pliocene - Pleistocene Behavior of the Scoresby Sund Sector of the Greenland Ice Sheet*

J. S. Laberg[1], M. Fwick[1], K. Husum[1], and T. Nielsen[1]

Search and Discovery Article #30309 (2013)**
Posted December 23, 2013

*Adapted from an oral presentation given at AAPG 3P Arctic Polar Petroleum Potential Conference & Exhibition, Stavanger, Norway, October 15-18, 2013

[1]Department of Geology, University of Tromso, Tromso, Norway (jan.laberg@uit.no)

Abstract

A major conclusion of Ocean Drilling Program Leg 162, drilling the western Svalbard and eastern Greenland continental margins, was that the Svalbard – Barents Sea Ice Sheet reached the shelf edge during peak glaciations much more frequently than the Greenland Ice Sheet during the late Pliocene – Pleistocene period. Both areas have a continental margin dominated by large, across-shelf-oriented troughs terminating at the shelf edge. In front of these troughs, large depocenters of glacigenic sediments, Trough-Mouth-Fans (TMFs), are located. Ice streams drained the ice sheets through these troughs during glacial, eroding and transporting large quantities of sediments to the shelf edge, from where they subsequently were remobilized as glacigenic debris flows. The deposits of the latter have a characteristic lens-formed morphology in cross-section. In order to tie the stratigraphy of ODP Site 987, located on the very distal part of the Scoresby Sund TMF on the east Greenland continental margin, to the more proximal parts where most of the glacigenic sediments have been deposited, a regional seismic line was acquired. The seismic line reveals that lithological unit IIA of site 987, interpreted to be debris-flow deposits, corresponds to an acoustically transparent unit. The overlying lithological unit I, found to be dominated by hemipelagic sediments comprising varying amounts of ice-rafted debris, is acoustically laminated. Tracing this unit south-westwards shows a transition from an acoustically laminated facies to stacked sub-units of transparent lenses of glacigenic debris flows, very similar to the signature of other TMFs. This shows that ODP Site 987 was located too distal to sample the glacigenic debris-flow deposits that dominate the deposits of the last ~2.58Ma on the more proximal part of the fan. From this we conclude that at least the Scoresby Sund sector of the East Greenland Ice Sheet had a much more dynamic behavior during the late Pliocene – Pleistocene period than previously realized, implying a more profound glacial erosion of this part of the shelf.

Selected References

Andreassen, K., C. Ødegaard, and B. Rafaelsen, 2007, Imprints of former ice streams, imaged and interpreted using industry 3D seismic data from the south-western Barents Sea, *in* R. Davis, H.W. Posamentier, L.J. Wood, and J.A. Cartwright, eds., Seismic Geomorphology: Application to Hydrocarbon Exploration and Production: Geological Society of London, Special Publications 277, p. 151-169.

Andreassen, K., E. Glad Nilsen, and C. Ødegard, 2007, Analysis of shallow gas and fluid migration within the Plio-Pleistocene sedimentary sucession of the SW Barents Sea using 3D-seismic data: Geomarine Letters, v. 27, p. 155-171.

Berger, D., and W. Jokat, 2008, A seismic study along the East Greenland margin from 72oN to 77oN: Geophysical Journal International, v. 174, p. 733-748.

Butt, F.A., A. Elverhøi, C.F. Forsberg, and A. Solheim, A., 2001: Evolution of the Scoresby Sund Fan, central East Greenland - evidence from ODP Site 987: Norwegian Journal of Geology, v. 81, p. 3-15.

Dahlgren, T., K.I.; T.O. Vorren, M.S. Stoker, T. Nielsen, A. Nygard, and P. Sejrup, 2005, Late Cenozoic prograding wedges on the NW European continental margin: their formation and relationship to tectonics and climate:. Marine and Petroleum Geology, v. 22, p. 1089-1110.

Dowdeswell, J.A., D. Ottesen, and L. Rise, 2010., Rates of sediment delivery from the Fennoscandian Ice Sheet through an Ice Age: Geology, v. 38, p. 3-6.

Dowdeswell, J.A., K.A. Hogan, J. Evans, R. Noormets, C.Ó Cofaigh, and D. Ottesen, 2010, Past ice-sheet flow east of Svalbard inferred from streamlined subglacial landforms: Geology, v. 38, p. 163-166.

Eldrett, J.S., I.C. Harding, P.A. Wilson, E. Butler, and A.P. Roberts, 2007, Continental ice in Greenland during the Eocene and Oligocene. Nature, v. 446, p.176-179.

Hiscott, R.N. and A.E. Aksu, Quaternary sedimentary processes and budgets in Orphan Basin, southwestern Labrador Sea: Quaternary Research, v. 45/2, p. 160-175.

Jamieson, S.S.R., N.R.J. Hulton, D.E. Sugden, A.J. Payne, and J. Taylor, 2005, Cenozoic landscape evolution of the Lambert basin, East Antarctica: the relative role of rivers and ice sheets: Global and Planetary Change, v. 45/1-3, p. 35-49.

Jansen, E. and J. Sjøhoim, 1991, Reconstruction of glaciation over the past 6 Myr from ice-borne deposits in the Norwegian Sea: Nature, v. 349, p. 600-603

Knies, J., J. Matthiessen, C. Vogt, J.S. Laberg, B.O. Hjelstuen, M. Smelror, E. Larsen, K. Andreassen, T. Eidvin, and T.O. Vorren, 2009, The Plio-Pleistocene glaciation of the Barents Sea–Svalbard region: a new model based on revised chronostratigraphy: Quaternary Science Reviews, v. 30, p. 1-18.

Laberg, J.S., K. Andreassen, and T.O. Vorren, in press, The late Cenozoic erosion of the high-latitude south-western Barents Sea shelf revisited: GSA Bulletin. doi:10.1130/B30340.1

Laberg, J.S., M. Forwick, K. Husum, and T. Nielsen, 2013, A re-evaluation of the Pleistocene behavior of the Scoresby Sund sector of the Greenland Ice Sheet: Geology, v. 41, p. 1231-1234.

Laberg, J.S., H.B. Johannessen, M. Forwick, M. Ivanov, and T.O. Vorren, 2012, Extensive erosion of the deep seafloor – implications for the behavior of flows resulting from continental slope instability: Advances in Natural and Technological Hazards Research, v. 31, p. 159-166.

Larsen, H.C., A. Saunders, L.M. Larsen, H. Lykke-Andersen, C. Marcussen, and L. Clausen, 1994, ODP activities on the South-east Greenland margin; Leg 152 drilling and continued site surveying, *in* A.K. Higgins and M. Sonderholm, eds., Report of Activities 1993: Rapport Gronlands Geologiske Undersogelse 1964, Report #160, p. 73-79.

Rise, L. S. Chand, H. Haflidason, J.S. L'Heureux, B.O. Hjelstuen, V. Bellec, O. Longva, J. Brendryen, M. Vanneste, and R. Bøe, 2012, Investigations of slides at the upper continental slope off Vesterålen, North Norway, *in* Y. Yamada et al., eds., Submarine Mass Movements and their Consequences: Advances in Natural and Technological Hazards Research 31, Springer Science and Business Media B.V., 167-176.

Sejrup, H.P., B.O. Hjelstuen, K.I.T. Dahlgren, H. Haflidason, A. Kuijpers, A. Nygård, D. Praeg, M.S. Stoker, and T.O. Vorren, 2005. Pleistocene glacial history of the NW European continental margin: Marine Petroleum Geology, v. 22, p.1111–1129.

Solgaard, A.M.; N. Reeh, P. Japsen, and T. Nielsen, 2011, Snapshots of the Greenland ice sheet configuration in the Pliocene to early Pleistocene: Journal of Glaciology, v. 57, no. 205, p. 871-880.

Solheim, A., J.I. Faleide, E.S. Andersen, A. Elverhoi, C.F. Forsbreg, K. Vanneste, G. Uenzelmann-Neben, and J.E.T. Channell, 1998, Late Cenozoic seismic stratigraphy and glacial geological development of the East Greenland and Svalbard-Barents Sea continental margins, *in* A. Elverhoi, ed., Glacial and Oceanic History of the Polar North Atlantic Margins: Quaternary Science Reviews, v. 17/1-3, p. 155-184.

STRATAGEM Partners, 2003, M.S. Stoker, compiler, Neogene evolution of the glaciated European margin: A product of the EC-supported STRATAGEM Project (Norfolk UK: Svitzer Limited).

UiT

THE ARCTIC
UNIVERSITY
OF NORWAY

A re-evaluation of the late Pliocene - Pleistocene behavior of the Scoresby Sund sector of the Greenland Ice Sheet

J. S. Laberg, M. Forwick, K. Husum, T. Nielsen

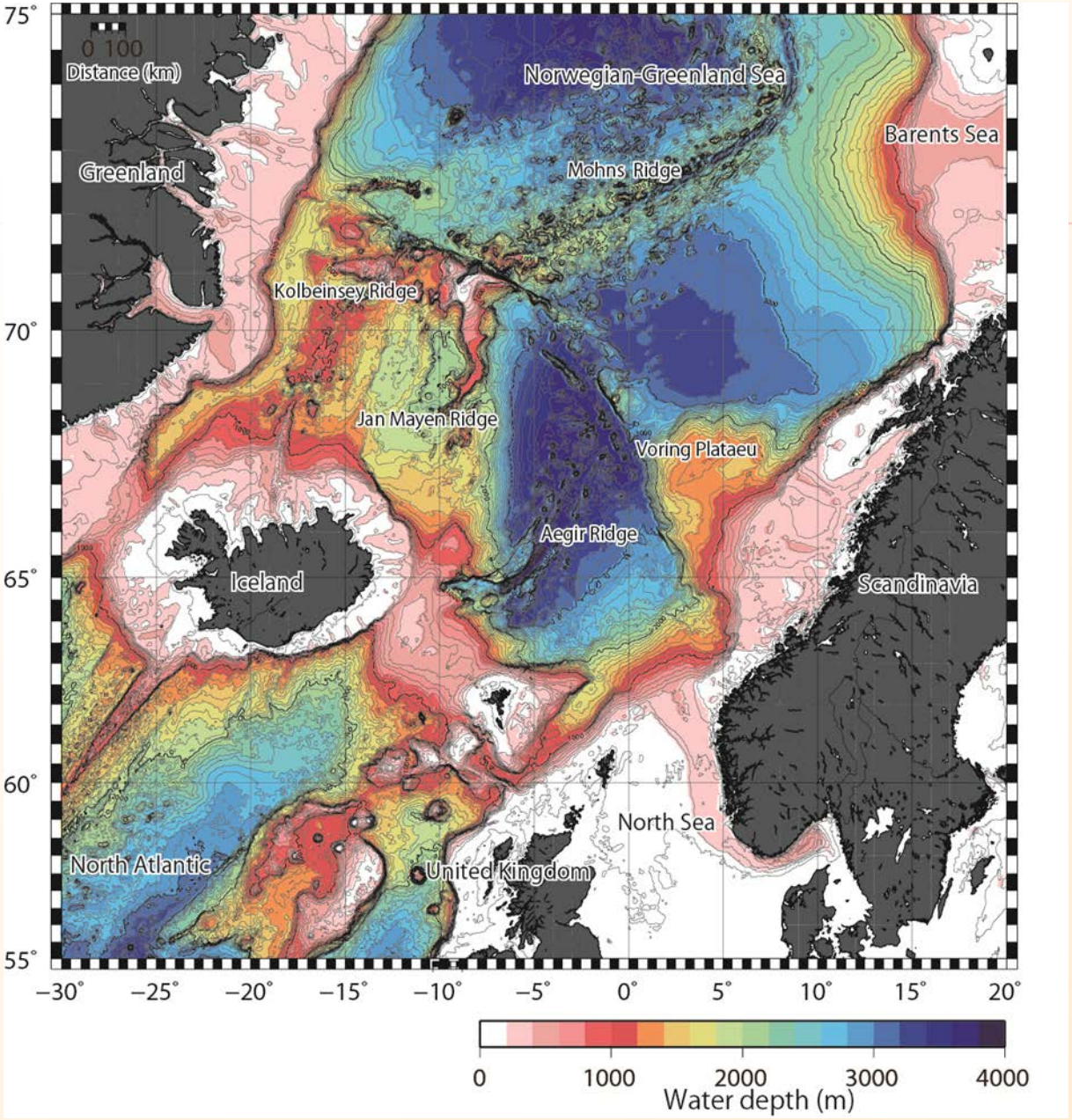
UNIVERSITY OF TROMSØ

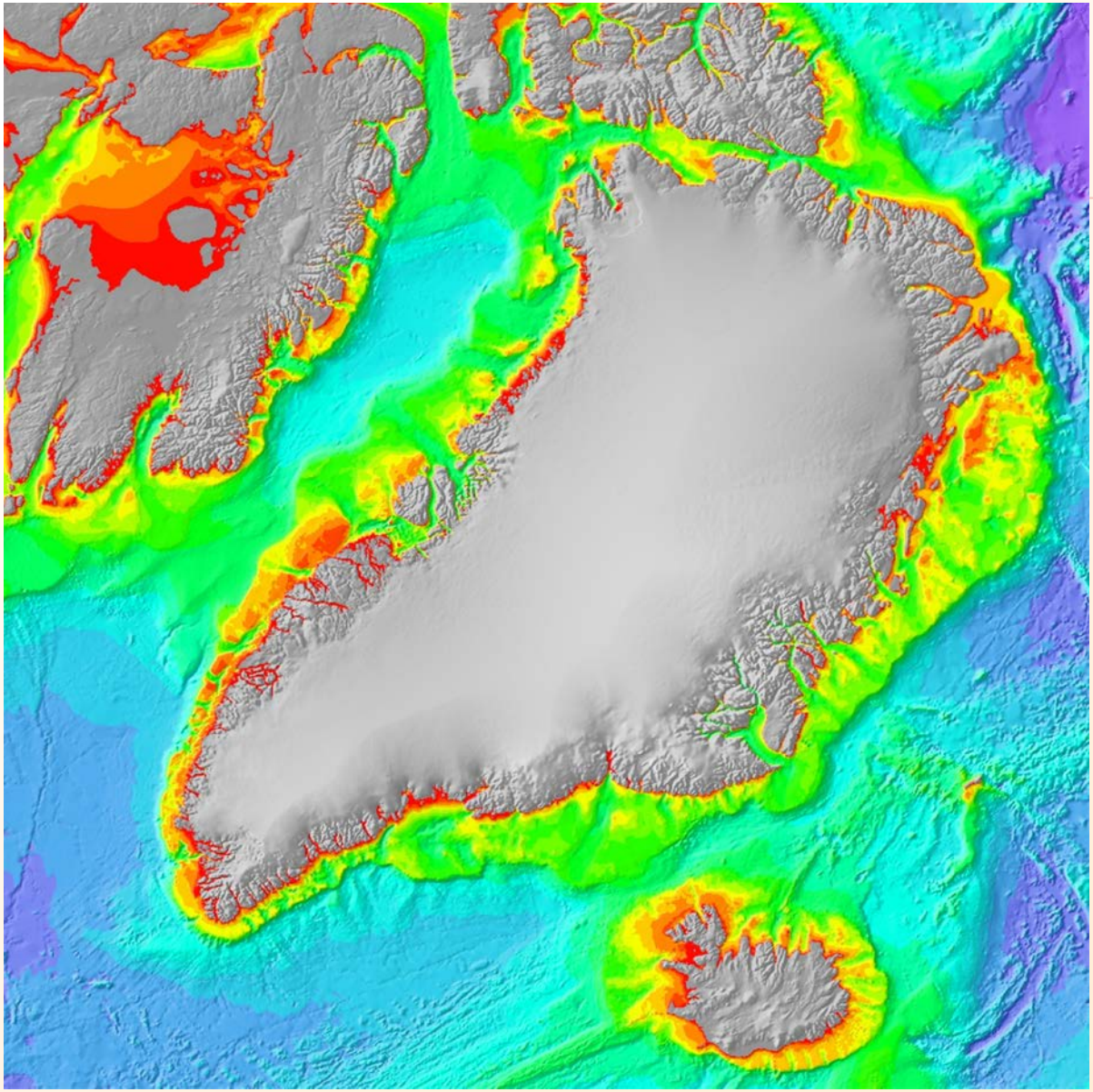
Aims of study

- Reconstruct the Neogene evolution of the northeastern Greenland continental margin
- Elucidate on the Neogene glacial history of the northeast Greenland
- Quatitify glacial erosion and sedimentation

Outline

- Study area
- The glacial history – a review
- Glacial sedimentation- and erosion rates
- The next step: what is needed for a better understanding of the Neogene evolution of the northeast Greenland continental margin?
- Summary


0 100
Distance (km)
Norwegian-Greenland Sea
Barents Sea
Greenland
Mohns Ridge
Kolbeinsey Ridge
Jan Mayen Ridge
Voring Plateau
Aegir Ridge
Iceland
Scandinavia
North Sea
North Atlantic
United Kingdom
75°
70°
65°
60°
55°
−30°
−25°
−20°
−15°
−10°
−5°
0°
5°
10°
15°
20°
0
1000
2000
3000
4000
Water depth (m)

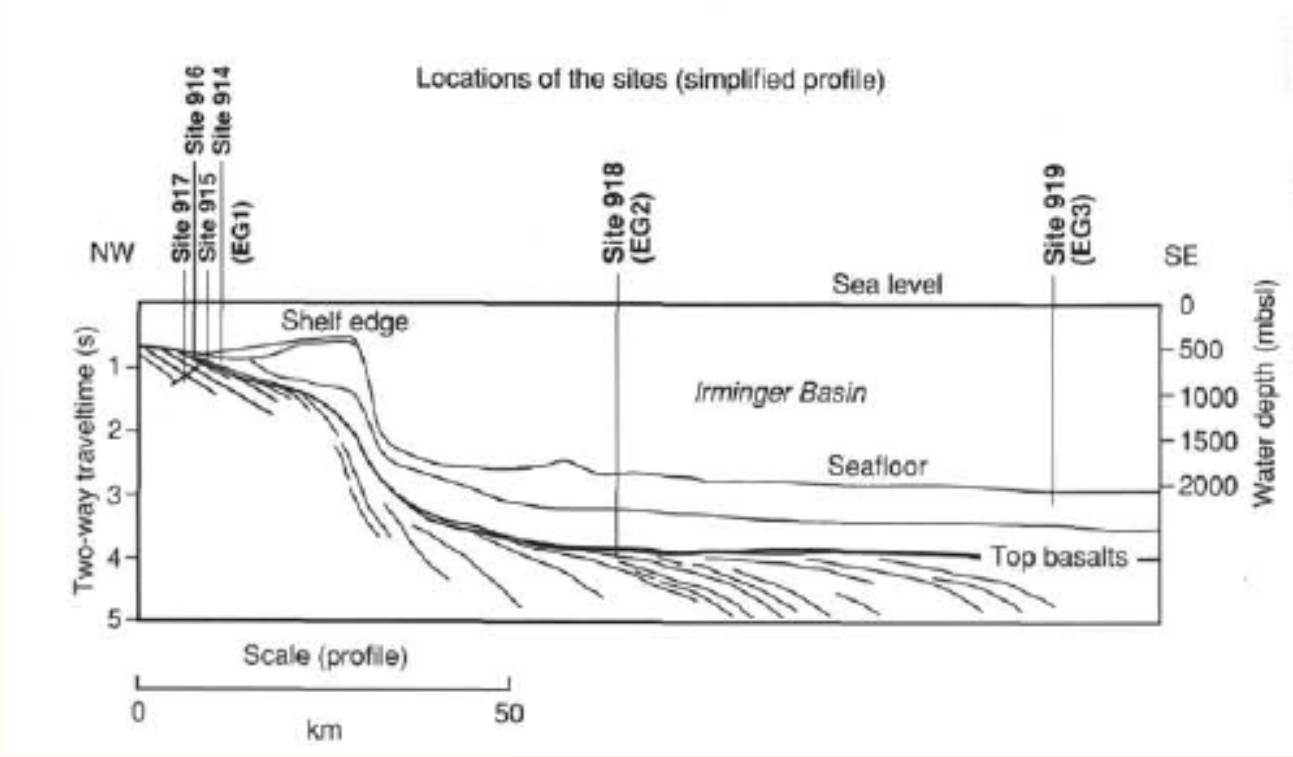


The glacial history – a review

- Based on results from Ocean Drilling Program Legs 152 (SE Greenland) and 162 (Scoresby Sund)

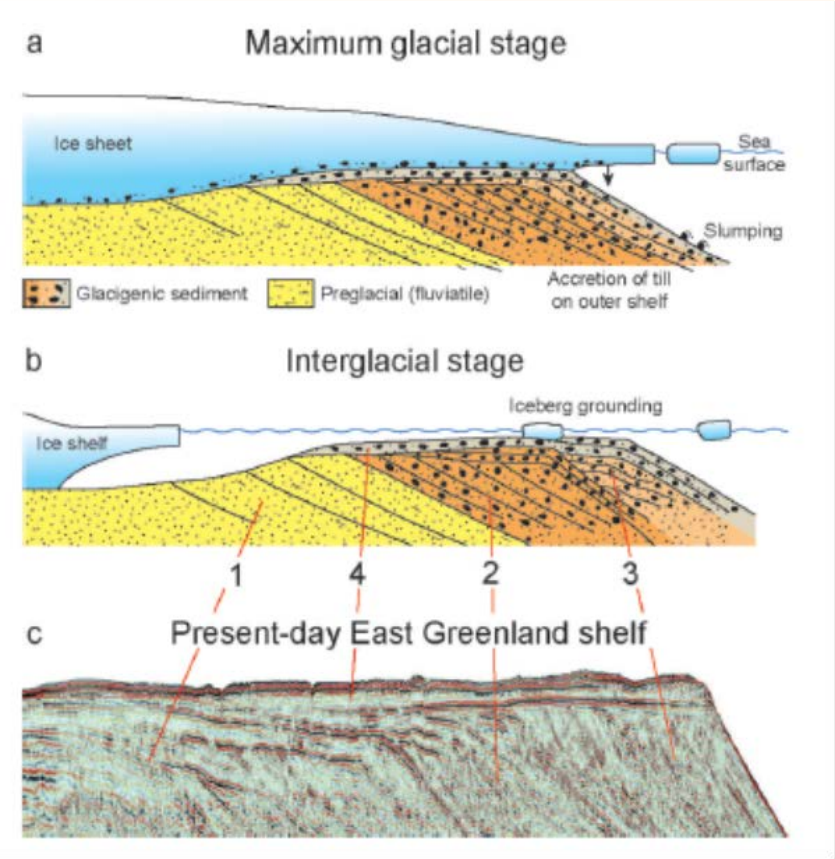
South-East Greenland

South-East Greenland



Larsen et al. (1994)

South-East Greenland

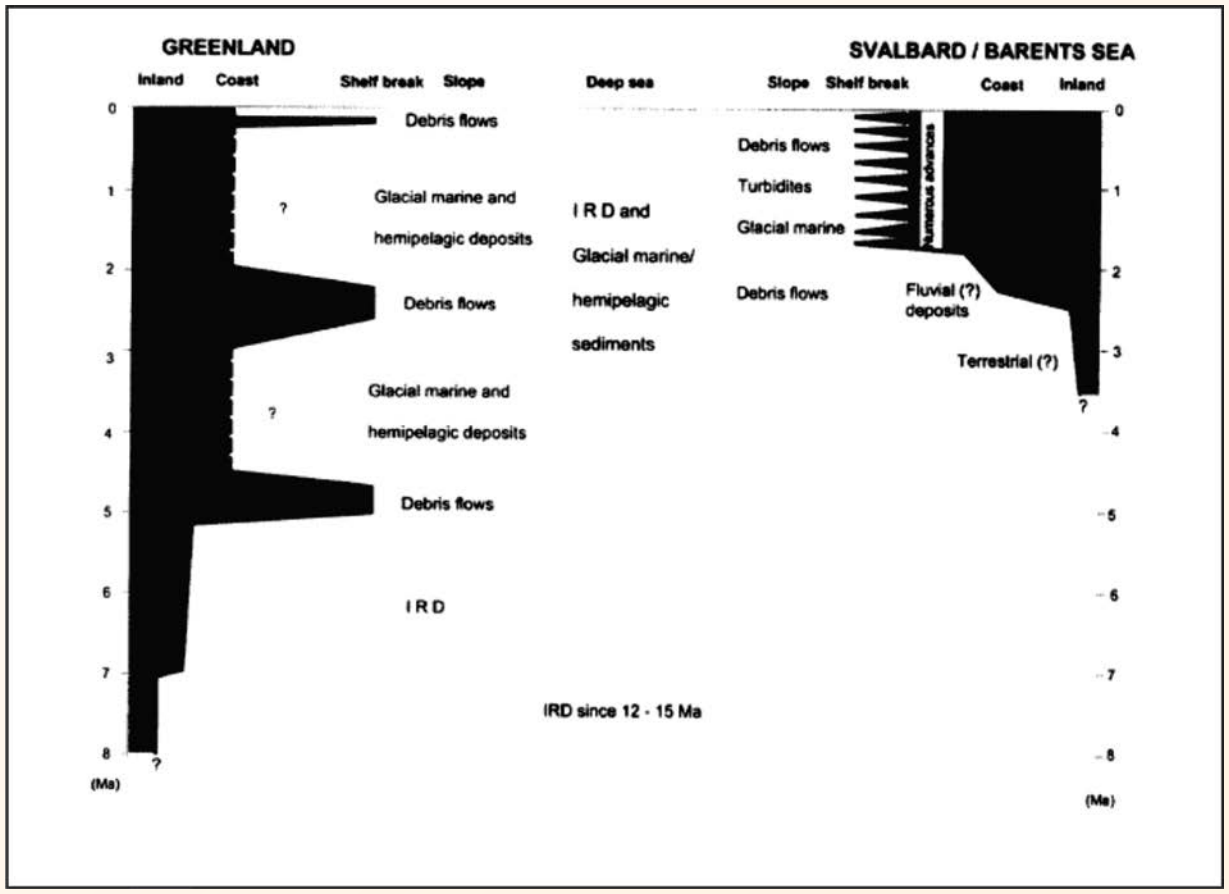


The SE Greenland Ice Sheet reached the continental shelf ~7 Ma ago and repeatedly thereafter

Solgaard et al. (2011)

Scoresby Sund

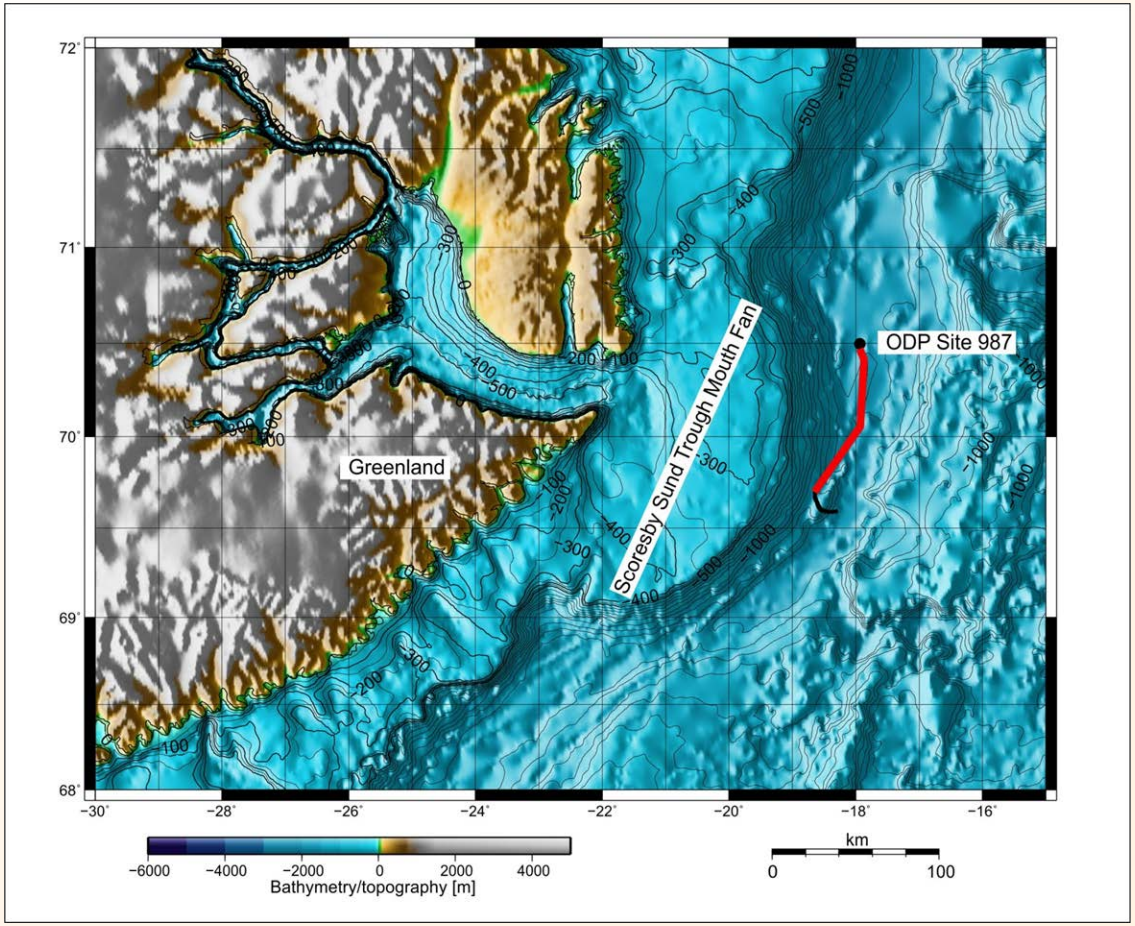
Scoresby Sund



Solheim et al. (1998)

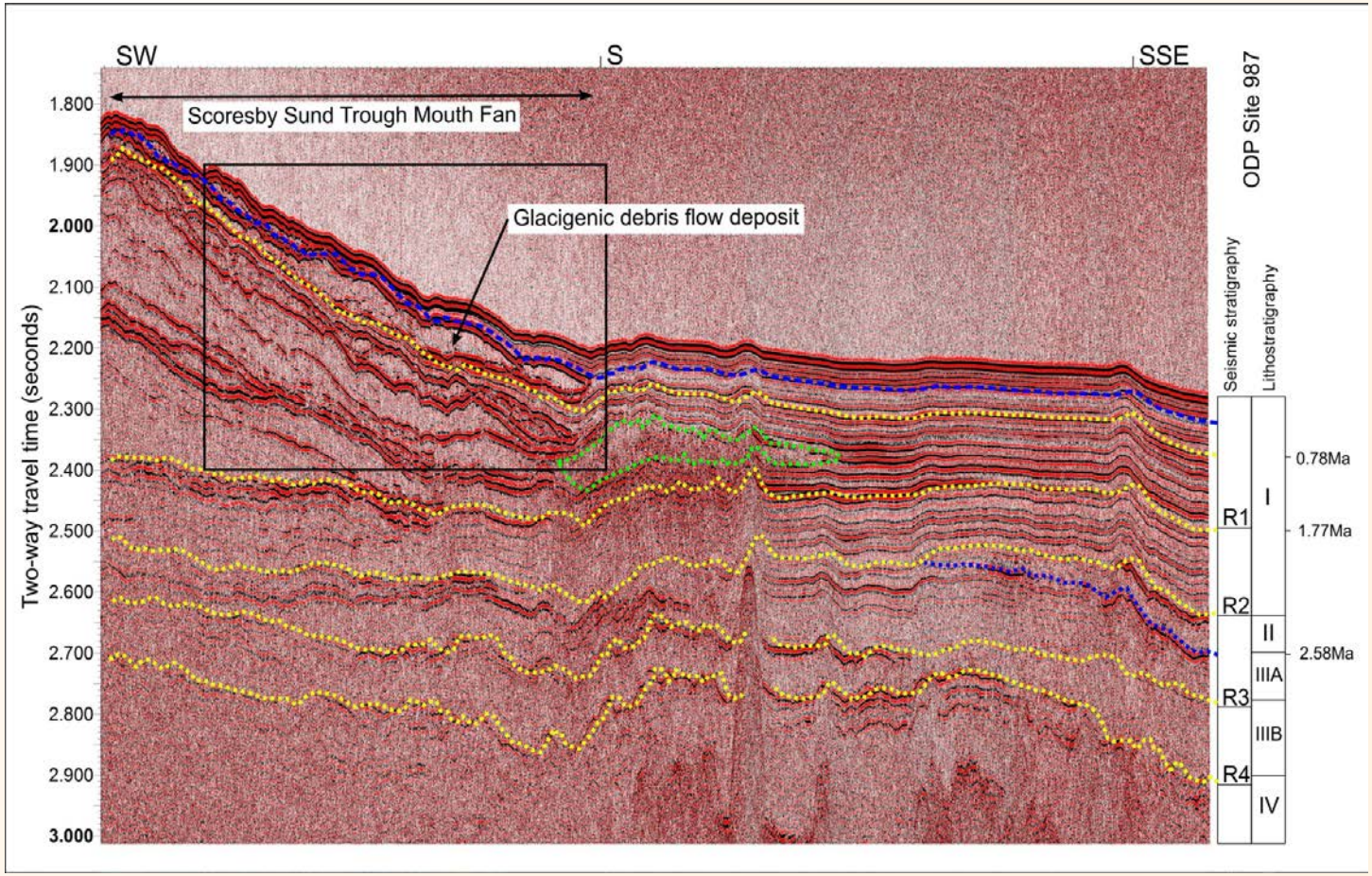
Scoresby Sund

Scoresby Sund



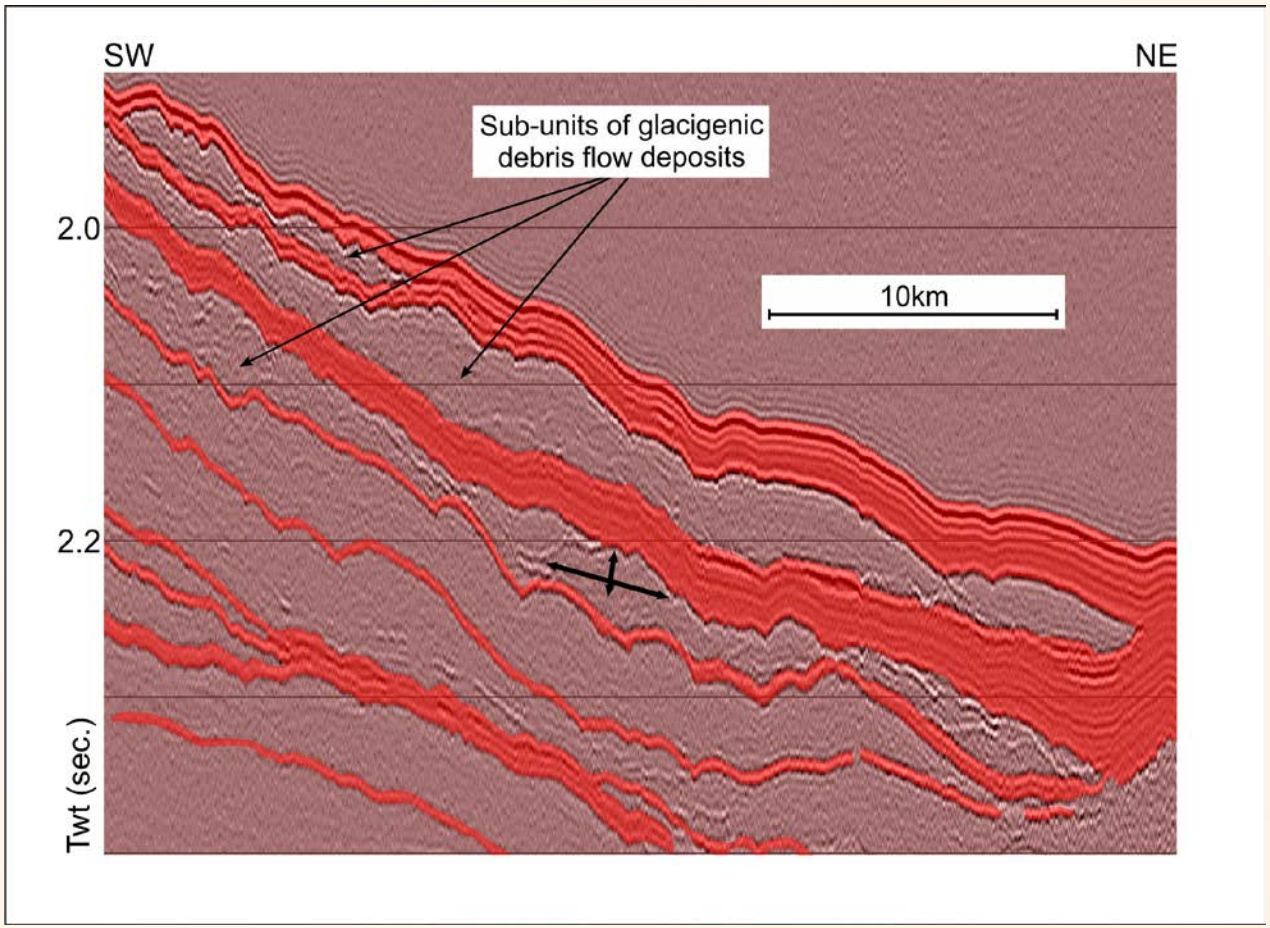
Laberg et al. (in press)

Scoresby Sund

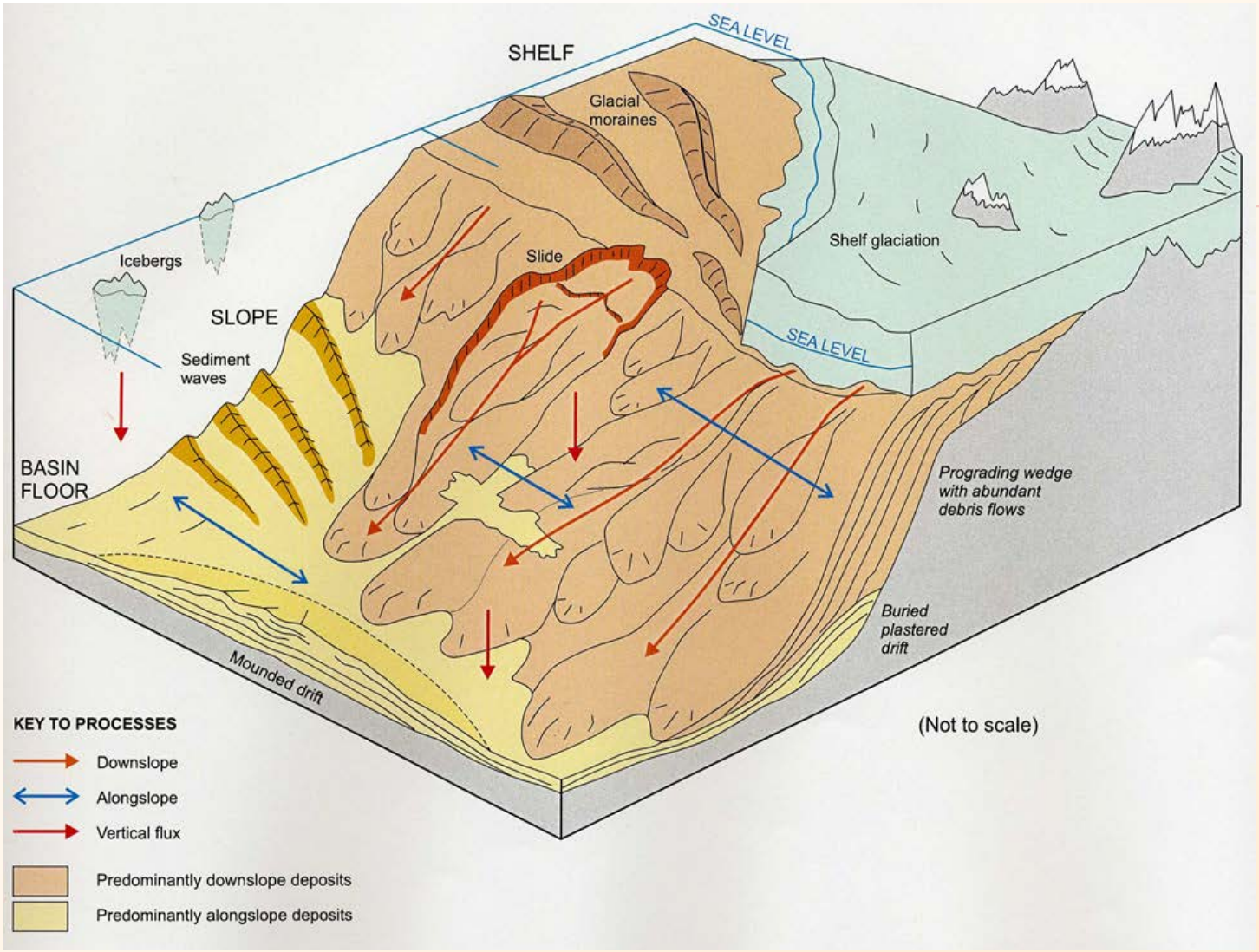


Laberg et al. (in press)

Scoresby Sund

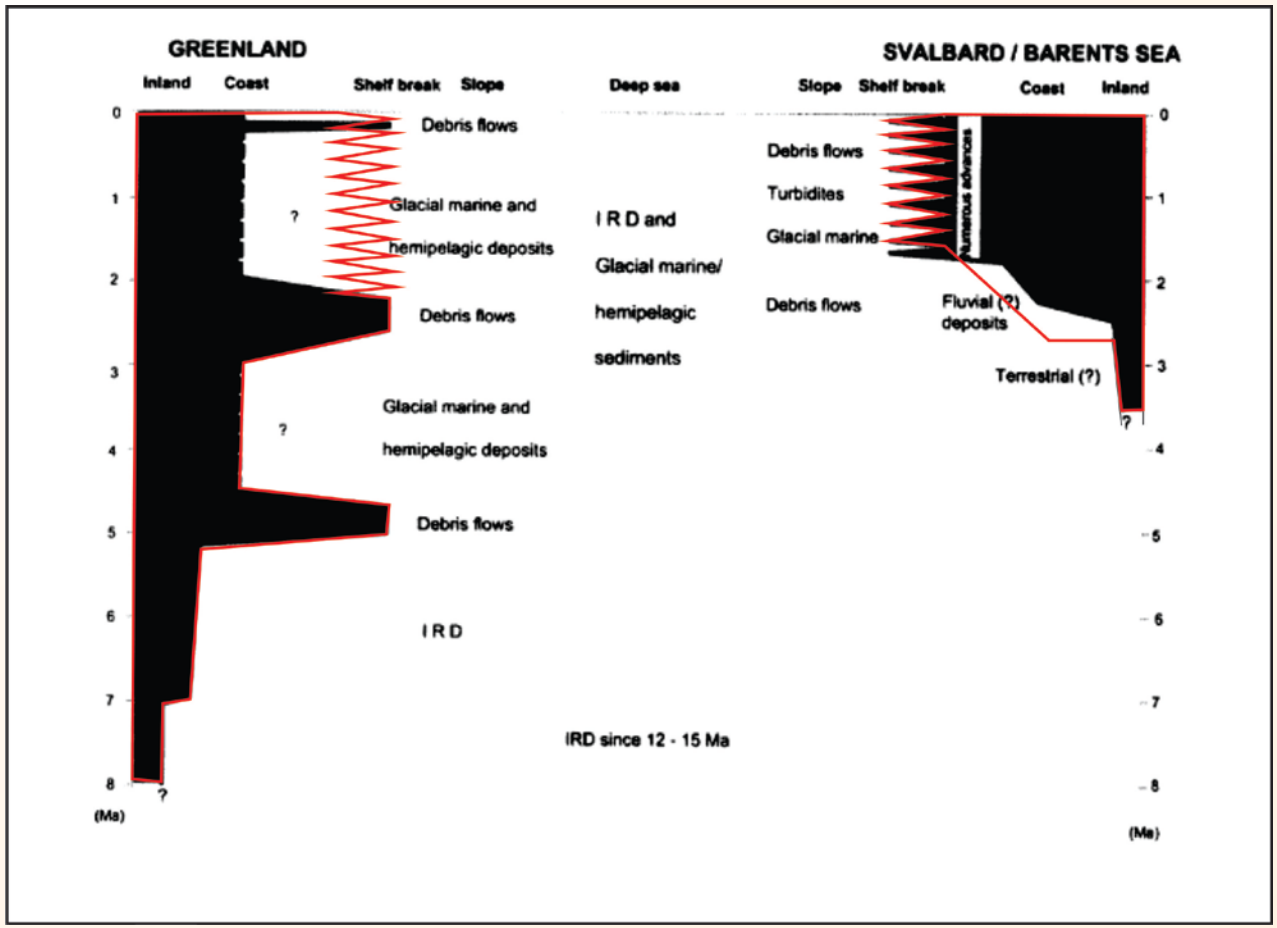


Laberg et al. (in press)

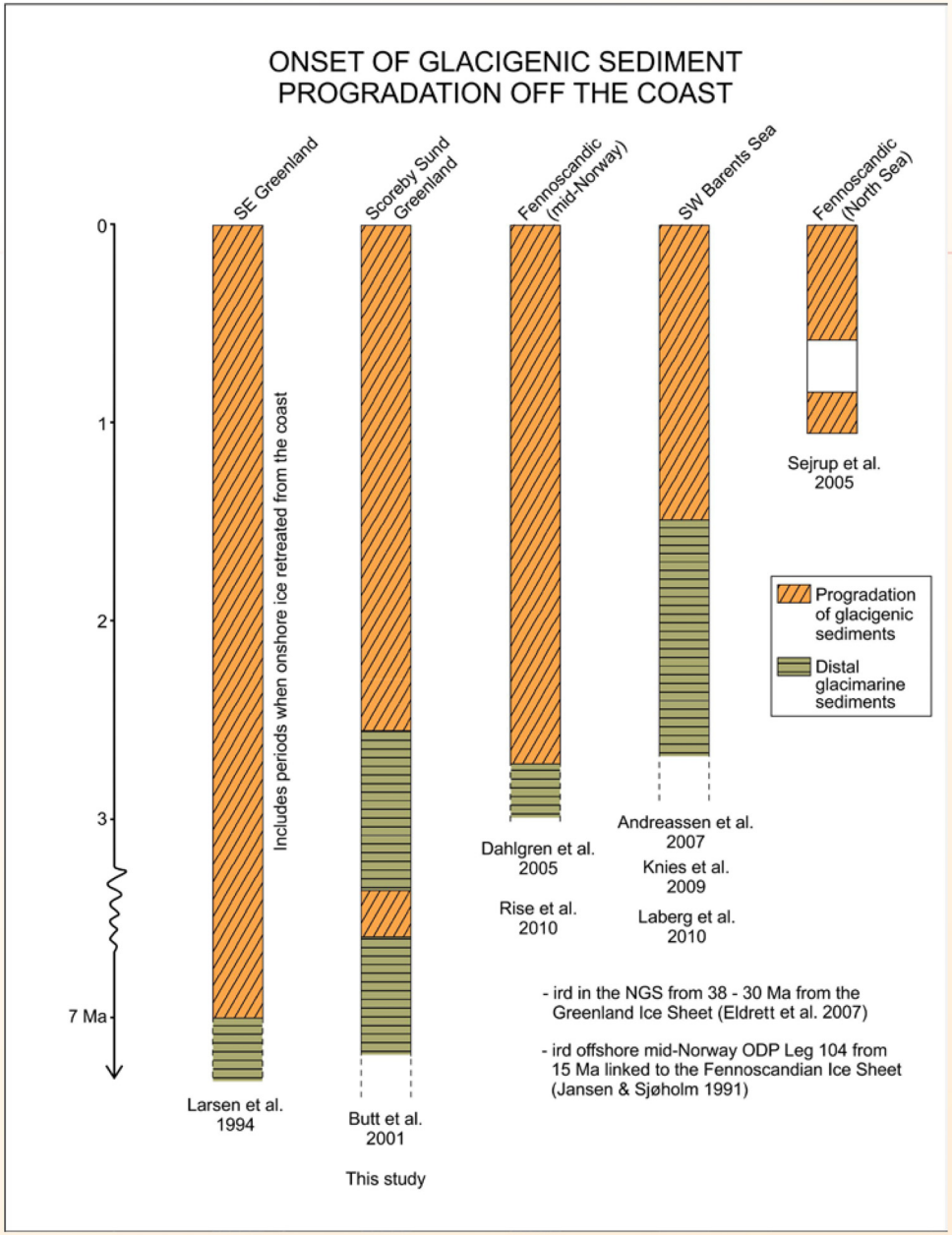


Stratagem partners (2002)

Scoresby Sund



Laberg et al. (in press)


ONSET OF GLACIGENIC SEDIMENT PROGRADATION OFF THE COAST
SE Greenland
Scoreby Sund Greenland
Fennoscandic (mid-Norway)
SW Barents Sea
Fennoscandic (North Sea)
0
1
2
3
7 Ma
Includes periods when onshore ice retreated from the coast
Sejrup et al. 2005
Progradation of glacigenic sediments
Distal glacimarine sediments
Andreassen et al. 2007
Knies et al. 2009
Laberg et al. 2010
Dahlgren et al. 2005
Rise et al. 2010
- ird in the NGS from 38 - 30 Ma from the Greenland Ice Sheet (Eldrett et al. 2007)
- ird offshore mid-Norway ODP Leg 104 from 15 Ma linked to the Fennoscandian Ice Sheet (Jansen & Sjøholm 1991)
Larsen et al. 1994
Butt et al. 2001
This study

Glacial sedimentation- and erosion rates

Glacial sedimentation and erosion rates

Area	Av. erosion rate	Av. sedimentation rate	Period	Reference
Southwestern Barents Sea	0.4 mm/yr	38 cm/kyr	0 – 2.7 Ma	This study
Western Fennoscandia	0.19 mm/yr	24 cm/kyr	0 – 2.7 Ma	Dowdeswell et al. (2010)
South-western Fennoscandia	0.12 mm/yr		0 – 1.1 Ma	Hjelstuen et al. (in review)
Eastern Canada	0.13 mm/yr		0 – 0.8 Ma	Hiscott and Aksu (1996)
East Greenland	?	2.8/4.8 cm/kyr	0 – 15 Ma	Berger and Jokat (2008)
East Antarctica	0.001 - 0.002 mm/yr		0 – 34 Ma	Jamieson et al. (2005)

Laberg et al. (2012)

The next step:

- More detailed seismic facies analyses of the glacigenic sediments – onset of shelf glaciations
- More detailed volume estimates of the glacigenic sediments
- Lithology/Chronology
- Estimates of sediment drainage area

Summary

- The SE Greenland Ice Sheet reached the continental shelf ~7 Ma ago and repeatedly thereafter

- During the Pleistocene the Scoresby Sund sector of the east Greenland Ice Sheet developed in line with other parts of the Ice Sheet, and was more dynamic and sensitive to past climatic changes than hitherto realized.

- Little is still known on the evolution of the Neogene (glacial) part of the east Greenland continental margin – due to the lack of data

- Estimates of glacial erosion and sedimentation rates are still tentative

Acknowledgement

- The Research Council of Norway
- Statoil ASA/Det norske oljeselskap ASA
- The captain and crew of R/V *Helmer Hanssen*


Thanks for your attention!