Grounding Zone Wedges, Kveithola Trough (NW Barents Sea)

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Abstract

Multibeam-bathymetric data from Kveithola Trough show a seafloor characterised by E-W trending mega-scale glacial lineations (MSGLs) overprinted by transverse grounding-zone wedges (GZWs). GZWs are thought to form by deposition of subglacial till at temporarily stable, grounded ice-sheet marine termini between successive episodic retreats (Batchelor & Dowdeswell, 2015). Sub-bottom profiles show that the present-day morphology of Kveithola Trough is largely inherited from the palaeo-seafloor topography of the GZWs, which is now draped by a deglacial to early Holocene glacimarine sediment about 15 m thick. The ice stream that produced such subglacial morphology was flowing from east to west towards the shelf edge in Kveithola Trough during the Last Glacial Maximum (LGM). Its rapid retreat was probably associated with progressive lift-off, and successive rapid melting of grounded ice, induced by eustatic sea-level rise.

Description

The E-W trending Kveithola Trough in the Barents Sea (Fig. 1) shows well-preserved subglacial morphologies (Rebesco et al. 2011; Bjarnadóttir et al. 2012; Fig. 1) including GZWs and MSGLs. The GZWs, up to 70 m high, and about 15 km apart from each other, result in the axial profile of the trough resembling a succession of stairs. The GZWs extend transversely across the entire width of the trough, except for the outermost wedge at the shelf edge which is fan-shaped. They have asymmetric axial profiles, with steeper, markedly lobate, west-facing outer slopes, and more gentle eastward-dipping inner sides.

The upper surface of the GZWs and the flanks of the trough have been impacted by the grounding of iceberg keels producing a vertical roughness of about 1 m. The iceberg ploughmarks are sinuous to linear in planform but can also include sharp corners or kinks along their paths. In general, the ploughmarks have trough-parallel orientations on the northern flank of the trough and along-slope beyond the shelf edge. The seafloor of the eastern (inner) side of each GZW is marked by MSGLs that are sub-parallel to the flanks of the trough and divergent in the region of the trough-mouth. The MSGLs comprise ridges and depressions 100-600 m wide, <15 m high and about 8 km long (length to width ratio >10:1). Sub-bottom profiler data (Fig. 1b) show that the transparent facies in which the GZWs and MSGLs have formed is capped by a stratified sedimentary drape. Although this drape attains a thickness of 20 ms two-way travel time (about 15 m when converted using a sound velocity of 1500 m s^{-1}), it does not obscure the morphologies inherited from the palaeo-subglacial landforms beneath it.

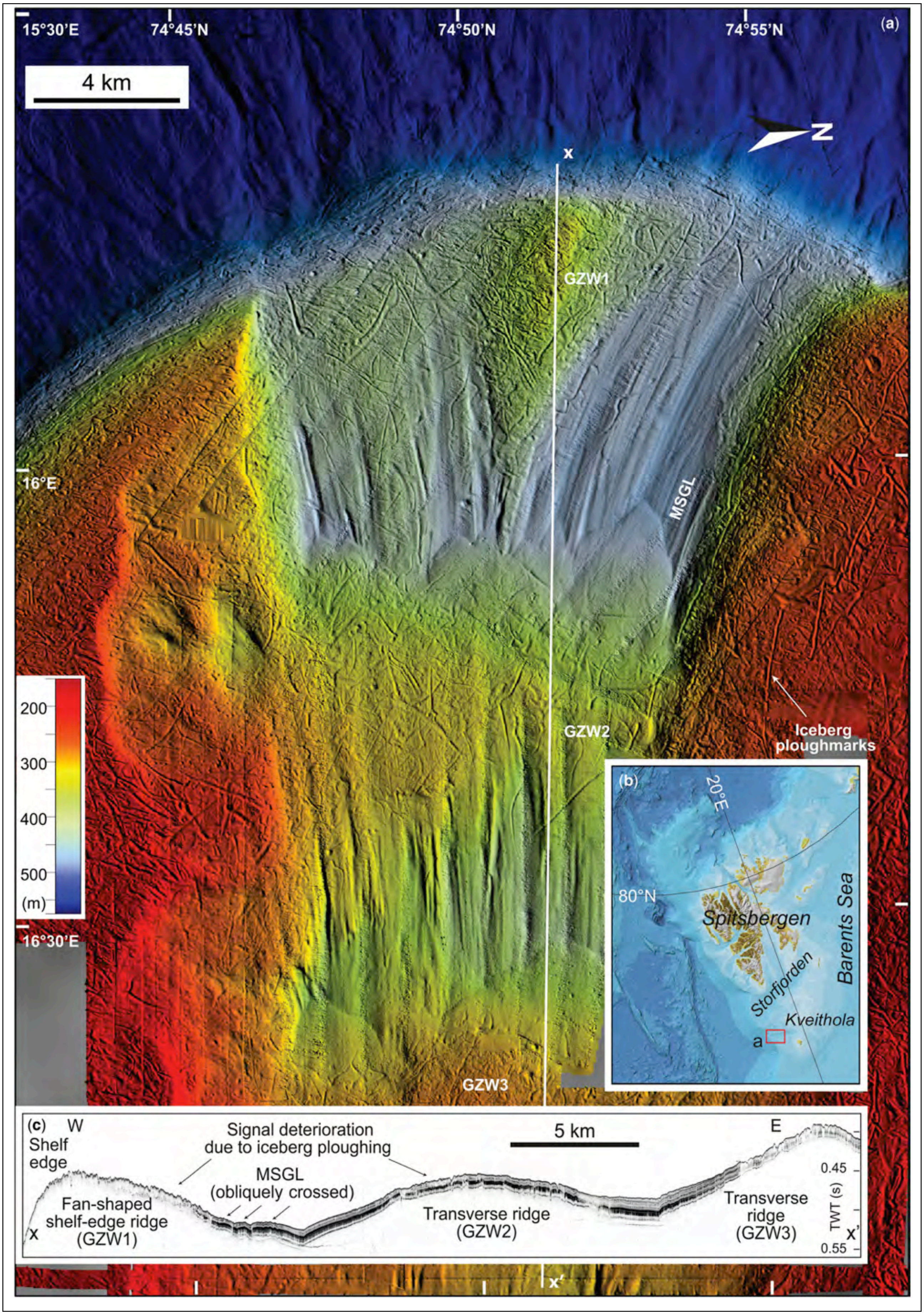
15°30'E
74°45'N
74°50'N
74°55'N
(a)
4 km
N
x
GZW1
MSGL
16°E
GZW2
Iceberg ploughmarks
200
300
400
500
(m)
16°30'E
GZW3
(b)
20°E
80°N
Spitsbergen
Barents Sea
Storfjorden
Kveithola
a
(c) W
Shelf edge
Signal deterioration due to iceberg ploughing
5 km
E
MSGL (obliquely crossed)
Fan-shaped shelf-edge ridge (GZW1)
Transverse ridge (GZW2)
Transverse ridge (GZW3)
0.45
TWT (s)
0.55
x
x'
x'

Figure 1: GZWs and associated MSGLs in Kveithola Trough. Sun-illuminated multibeam bathymetric image obtained by merging EGLACOM (Rebesco et al. 2011) and CORIBAR (Hanebuth et al. 2013) data from the outer part of Kveithola Trough, showing MSGLs overprinted by GZWs. EGLACOM acquisition Reson Seabat 8111. Frequency 100 kHz. CORIBAR acqusition Kongsberg EM1002. Frequency 95 kHz. Grid-cell size 10 m. (b) Location of study area (red box; map from IBCAO v. 3.0). (c) PARASOUND profile showing the sub-bottom characteristics of Kveithola Trough landforms. The laterally continuous, stratified, sedimentary drape (masked by iceberg ploughing on shallow areas) overlies a transparent unit, interpreted to correspond to the GZW. VE x 40.

Interpretation

The GZWs and MSGLs in the Kveithola Trough are similar to submarine glacial landforms identified elsewhere on the Norwegian-Svalbard margin (e.g. Ottesen et al. 2005). MSGLs are thought to be produced by deformation of a subglacial till layer of low shear strength under rapid ice-flow velocities beneath ice streams (e.g. Clark 1993). The ice stream that produced the subglacial morphologies in Kveithola Trough was flowing from east to west in the trough during the LGM (Rebesco et al. 2011). The morphological and acoustic character of the GZWs suggest that these features formed by deposition of unconsolidated, water-saturated subglacial till during temporary still-stands in the grounding-zone position of the ice-stream front (Batchelor & Dowdeswell, 2015). The wedges are clearly superimposed on the MSGL, testifying these landforms were produced mostly, but not exclusively (Bjarnadóttir et al. 2012), through a recessional trend during the deglaciation phase. Streamlining of the eastward (upstream) sides of the GZWs demonstrates that the ice stream remained grounded and active throughout its overall retreat, and that individual phases of sudden retreat were rapid enough to prevent the obliteration of the MSGLs. We speculate that the rapid-retreat phases were associated with lift-off of grounded ice induced by rapid global sea-level rise, as suggested by Lucchi et al. (2013).

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