Grounding-zone wedges and mega-scale glacial lineations in the Mertz Trough, East Antarctica

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Glacial erosion and deposition have shaped the Mertz Trough, East Antarctica, where seafloor grounding-zone wedges (GZWs) are associated with mega-scale glacial lineations (MSGLs) (McMullen *et al*. 2006). GZWs form along glacial margins at the transition to ice shelves during still-stands and consist of glacially transported sediment that is deposited on the ice-distal side of the wedge (Powell & Domack 2002). MSGLs are parallel elongated bedforms that typically form in soft sediments and beneath rapidly flowing ice streams (Clark 1993; Canals *et al.* 2000; Clark *et al*. 2003). They are found in glacial troughs where they run parallel to the trough axis. MSGLs are generally 6 to >100 km long, 200 to 1300 m wide, and spaced 0.3 to 5 km crest-to-crest (Clark *et al.* 2003; McMullen *et al.* 2006).

Description

The Mertz Trough is located perpendicular to the George V coast of Wilkes Land, East Antarctica (Fig. 1a, b). Multibeam-bathymetric imagery reveals a number of distinct features on the seafloor including several parallel elongated ridge and groove pairs, two sinuous sediment build-ups with streamlined bedforms at their surface, and depressions (Fig. 1c).

Five main parallel, elongated, straight ridge and groove pairs in the northern, seaward part of the study area are 14 to 20 km long, 500 m wide, and 20 m high. They are oriented north-south and have a lateral spacing of 1 to 1.5 km. South of these bedforms are two large, sinuous build-ups (GZW-A and GZW-B) oriented northwest-southeast. GZW-A and GZW-B are over 30 km long and up to 80 m high with steep downward steps facing northeast (seaward) and more gradually sloped southwest (landward) sides. A 2.5-m core in GZW-B (KC-2) shows that it is composed of diamicton capped by a diatom mud and ooze (Fig. 1c; McMullen *et al*. 2006). Smaller sediment build-ups with similar orientation and slope profiles to the larger GZWs are also visible (Fig. 1c). Parallel ridges and grooves that are several km long and 100 to 200 m wide, similar to, but smaller than, those in the northern part of the study area, appear to the south of GZW-A, where they are oriented north-northeast and are less conspicuous than those to the north. Centered within GZW-A and GZW-B are a breach point, scoured from a meltwater channel, and a depression, respectively, located where the relief of each build-up above the surrounding seafloor is about 40 m. The height of the large build-ups increases up to 80 m to the northwest of the depression and remains about 40 m to the east. The breach point in GZW-A is about 1 km wide, 15 m deep, and has an associated fan extending in a seaward direction, while the centered depression in GZW-B has a larger diameter of about 5 km and is not as well defined.

Interpretation

The parallel, elongated ridges and grooves to the north of the swath-mapped area are interpreted to be MSGLs, like similar structures in the Ross Sea and from the Gerlache Strait to Boyd Strait (Shipp *et al*. 1999; Canals *et al.* 2000). They indicate past ice streaming, flowing in a northerly direction, likely during the Last Glacial Maximum (LGM). This ice stream flowed out of the Mertz and Ninnis glacier systems from the south.

GZW-A and GZW-B, the large sinuous sediment build-ups oriented roughly perpendicular to the MSGLs are grounding-zone wedges marking areas where the ice sheet paused during its retreat. Their large size may reflect a sedimentary-basin source. Minor recession lines are marked by the smaller sediment build-ups, the development of which was possibly influenced by the occurrence of the MSGLs or shorter duration of still stands. The streamlined megaflute bedforms in the sediment inversely mirror the grooved ice base. As the ice lifts off the seafloor, the long keel of ice that forms a groove in the sediment reaches into deeper water than ice directly above a ridge of sediment, which could produce scalloped grounding zones. GZW-A marks the location where ice-flow directions changed from northerly to north-northeasterly during ice retreat, as evidenced by the orientations of MSGLs to the north and south of this feature. The breach point within GZW-A resulted from scouring of the GZW by channelized subglacial meltwater (McMullen *et al*. 2006; Le Brocq *et al*. 2013). The breach point has a small associated fan seaward of the breach, likely formed from sediment transported by glacial meltwater (Powell & Domack 2002). The centered depression within GZW-B marks the place where the grounding zone shifts southward, which is aligned with the breach point in GZW-A with respect to the ice-flow direction. The depression in GZW-B is larger in diameter and could have been formed by a greater volume of meltwater that dispersed its sediment load further or this feature could just be the backslope of an older, more northerly grounding zone.

The sea-floor features in the Mertz Trough illustrate the glacial history of the region, which was once covered by grounded ice. During the LGM, an ice stream flowed northward through the overdeepened trough, forming MSGLs. As the ice retreated southward, it paused in at least two places and deposited the main GZWs. Subglacial meltwater breached GZW-A, scoured a depression, and deposited a small sediment fan. After GZW-A was deposited, the ice-flow direction shifted towards the north-northeast as the ice sheet retreated further to the south, depositing sediment in small build-ups representing minor grounding zones. The parent ice stream became less prominent with recession, as the MSGLs are less conspicuous to the south. During another pause in recession, GZW-B was deposited and subglacial meltwater may have eroded a similar, though larger, depression. The ice sheet continued retreating and flow directions shifted towards the northeast.

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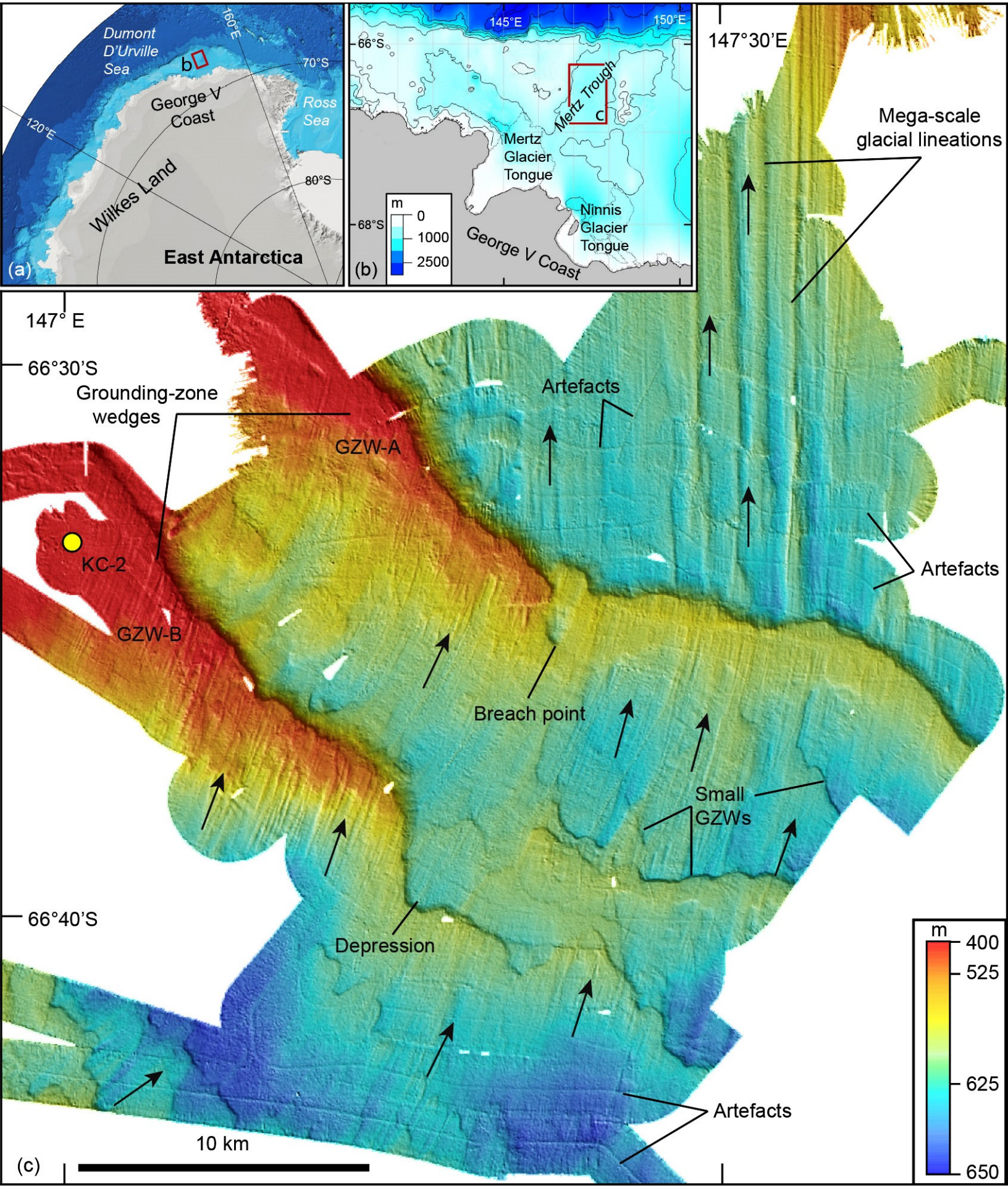
Dumont D'Urville Sea
160°E
b
70°S
George V Coast
Ross Sea
120°E
80°S
Wilkes Land
East Antarctica
(a)
145°E
150°E
66°S
Mertz Trough
c
Mertz Glacier Tongue
m
0
1000
2500
68°S
Ninnis Glacier Tongue
George V Coast
(b)
147°30'E
Mega-scale glacial lineations
147° E
66°30'S
Grounding-zone wedges
GZW-A
Artefacts
KC-2
Artefacts
GZW-B
Breach point
Small GZWs
66°40'S
Depression
Artefacts
10 km
(c)
m
400
525
625
650

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Fig. 1. Multibeam-bathymetric imagery of the central Mertz Trough, East Antarctica. (a) Location of study area (red box; map from IBCSO v. 1.0). (b) General bathymetry map of the Mertz Trough region. (c) Grounding-zone wedges (GZW-A and GZW-B) with streamlined megaflute bedforms at their surface and MSGLs in between and off GZWs. Black arrows indicate direction of ice flow, which is roughly opposed to ice retreat direction. Location of Kasten sediment core (KC-2) is shown by yellow circle. Nadir artefacts that could not be removed during processing are also shown. Acquisition system SeaBeam 2112. Frequency 12 kHz. Grid-cell size 35 m.