Submarine glacial-landform distribution across the West Greenland margin: a fjord-shelf-slope transect through the Uummannaq system (70° to 71°N)

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Today, the Greenland Ice Sheet reaches the sea via a number of fast-flowing outlet glaciers that are fed by ice drainage from huge interior basins (Rignot & Kanagaratnam 2006). At the Last Glacial Maximum (LGM), the ice sheet expanded to reach the continental shelf break around much of Greenland (Ó Cofaigh et al. 2013a). In the Uummannaq area, at about 70–71°N (Fig. 1a), there is now a 400 km distance between the terminus of Rink Glacier, which drains about 30,000 km² of the ice sheet, and the shelf edge. This provides a transect from the modern glacier front, through a deep fjord system and adjacent cross-shelf trough, to the continental slope in Baffin Bay. The seafloor is now exposed along this transect and the landforms produced by past glacial activity can be examined using marine-geophysical methods. Deglaciation from the LGM was underway at the shelf edge in Uummannaq Trough by 14.8 kyr ago and from the mid-shelf by 10.9 kyr, and ice had probably retreated back into the fjord system by 9.3 kyr ago (Ó Cofaigh et al. 2013a; Roberts et al. 2013).

The seismic stratigraphy of the continental shelf and upper slope in central West Greenland (Fig. 1b; Dowdeswell et al. 2014), together with the convex-outward shape of bathymetric contours at the mouth of Uummannaq Trough (Fig. 1a), demonstrate that a major sedimentary depocentre has built up there (Ó Cofaigh et al. 2013b). The prograding nature and seaward-dip of seismic reflections within the Pliocene-Pleistocene sediment package confirm the presence of a major trough-mouth fan that has progressively built-out the continental shelf into the deeper waters of Baffin Bay (Fig. 1b). In addition, a seismic section across Uummannaq Trough shows, through the truncation of sub-horizontal reflections at its margin (Fig. 1c), that there has been erosion as well as deposition from the likely past activity of ice streams flowing through the trough. The longer-term context is therefore of a margin where ice streams have advanced and retreated through the Uummannaq fjord-shelf system on a number of occasions over the past few million years. The submarine landforms that we describe and interpret below are the product of the latest cycle of ice-sheet growth and decay on Greenland since the LGM about 20,000 years ago.

Description of fjord-shelf-slope landforms

Inner fjords

The seafloor of Rink Fjord and Karrat Isfjord is relatively flat for the most part, with protruding bedrock pinnacles and ridges (Fig. 2a, b) (Dowdeswell et al. 2014). The basins in Rink Fjord reach over 1,000 m in depth. Karrat Isfjord is shallower, with water <600 m deep and appears, from its rougher appearance, to have more bedrock exposed at the seafloor. Both fjords have steep subaerial and submarine side-walls, giving the fjords a characteristic ‘u’-shape. This inner-fjord morphology is similar to that of the inner fjords of the Scoresby Sund and Kejser Franz Josef Fjord systems in East Greenland (Ó Cofaigh et al. 2001; Evans et al. 2002).

Within a few kilometres of the modern marine terminus of Rink Glacier there are two basins over 1,000 m deep, separated by a large transverse ridge that stretches across the fjord in about 650 m of water (Fig. 2a-c). The ridge is asymmetrical, with a steeper ice-distal slope of 22°. This ridge geometry is typical of many ice-contact sedimentary landforms (Benn and Evans, 2010). A well-defined submarine channel is also present on the otherwise fairly smooth basin floor and extends for about 4 km seaward from the distal side of the large transverse ridge (Fig. 2c). The channel is sinuous, up to 350 m wide and 25 m deep. Inshore of the transverse ridge, there is a deep trough within which two sedimentary lineations are present which are streamlined along the fjord axis (Fig. 2c).

Outer Uummannaq Fjord

Outer Uummannaq Fjord has the widest variety of submarine landforms anywhere within the Uummannaq system (Dowdeswell et al. 2014). Several sets of streamlined features are orientated approximately along fjord long-axes, although there is a clear curvilinear trend in the orientation of the landforms (Fig. 2d-g). In the inner 20 km or so of the fjord, streamlined lineations and bedrock-cored crag-and-tail features are found (Fig. 2e). It appears that the distally narrowing sedimentary tails of the crag-and-tails originate from bedrock ridges crossing the fjord. The streamlined features can be seen in TOPAS sub-bottom profiles in which a roughly 10 m-thick semi-transparent drape buries the strong reflection in which the streamlined features have formed (Fig. 2f).

Where Uummannaq Fjord narrows to about 25 km wide, between Ubekken Island and Nuussuaq Peninsula (Fig. 2d), the seafloor morphology is more complex, but remains streamlined in an east-west direction. Shorter linear features trending first WNW and then WSW are present (Fig. 2d, g). The less regular areas are probably bedrock at or near the seafloor, and there is a 20 km² area where small channels are imaged with bedrock highs between them (Fig. 2d, g).

Cross-shelf trough

Uummannaq Trough is almost 200 km long and about 20-25 km wide, with shallower banks generally <400 m deep to either side (Fig. 1) (Dowdeswell et al. 2014). The trough floor is relatively smooth (Fig. 3a, b, f) compared with the fjord further inshore (Fig. 2d). This, together with shallow sub-bottom profiles (Figs. 3d, e, c) indicates that the seafloor is sedimentary. TOPAS profiles show a strong, prolonged sub-bottom reflection (Fig. 3d), which is sometimes lинeated, overlain by an acoustically stratified drape up to about 20 m thick. Shallower banks have an irregular surface, with chaotic furrows (Fig. 3e, f). Seismic data also show that the shelf is composed of several hundred metres of prograding sediments (Fig. 1b, c).

Between about 54°30’ and 55°30’W, the inner-shelf is dominated by linear to curvilinear streamlined and apparently sedimentary landforms (Fig. 3a); some are blunt-nosed with streamlined tails, and have crescentic depressions around their heads (Fig. 3a). West of this, the seafloor is smoother, but several prominent scarpas, up to 40 m high (Fig. 3c-e), are imaged (Fig. 3a, b). These features have a wedge-like and asymmetrical shape with a deeper seaward face (Fig. 3c, e). Where their surface is undisturbed, the features are draped by acoustically semi-transparent or stratified sediment underlain by a strong, prolonged reflection and, sometimes, by less continuous weaker reflections (Fig. 3d, e).
Fig. 1. Regional bathymetry and shelf architecture of the Uummannaq fjord-shelf-slope system, West Greenland. The location of subsequent figures is also shown. (a) Multibeam-bathymetric coverage of the Uummannaq system. (a) is located as a red box on the inset location map of Greenland. UI is Ubekendt Island; RF is Rink Fjord. Regional bathymetry from IBCAO v. 3.0. (b) 130-km long dip seismic reflection profile showing West Greenland continental shelf architecture comprising prograding sedimentary units. (c) 110-km long strike profile showing a Late Quaternary glacial trough where erosion has truncated pre-existing reflections (black arrows). The reflections marked bPP represent the lower boundary of Plio-Pleistocene erosion and glacier-influenced sediments; (b) and (c) are located in (a). Note that the depth scales in (b) and (c) are approximate and are based on correlating the seafloor reflection with the bathymetric data.
Outernest shelf and slope

The continental slope and outermost Uummannaq shelf are shown in Figure 3f (Dowdeswell et al. 2014). The trough-mouth <600 m deep has streamlined sedimentary lineations with a strong sub-bottom reflection (Fig. 3f, g), buried under a drape of acoustically stratified sediment. There is also a 10 m-high ridge at about 60°W at about 600 m depth; the basal 12 cm of a 1.42 m-long core here is composed of stiff diamict overlain by glaciomarine mud (Ó Cofaigh et al., 2013a).

As water shallows on either side of the trough (Fig. 1a), irregular furrows a few metres deep dominate the seafloor in water < 570 m deep (Fig. 3f). A few irregular furrows occur down to about 850 m (Fig. 3f).

The continental slope reaches over 2,000 m in Baffin Bay, beyond the shelf break. In plan, the contours offsho of Uummannaq Trough bulge outwards, giving a fan-shaped appearance to the slope (Fig. 1a). On the slope, lobate sedimentary features are present in swath imagery (Fig. 3f). Sub-bottom profiles show stacking of lobes, particularly below 1,500 m depth, and individual semi-transparent units can be traced to the slope base (Fig. 3h). To the south of the trough-mouth, several slide scars have also been observed on the upper slope (Dowdeswell et al. 2014).

Interpretation of fjord-shelf-slope landforms

Inner fjord

A relatively smooth seafloor, broken by bedrock ridges and pinnacles that divide the fjord into several deep basins, is present over much of Rink Fjord and Karrat Isfjord (Fig. 2a, b). This is interpreted as fine-grained basin fill, supplied mainly by rain-out from sediment-rich meltwater derived from subglacial and glacial/fluvial sources. Turbid lateral meltwater streams were observed at the margins of Rink Glacier during marine-geophysical data collection in August 2009, and subglacial meltwater is also relatively abundant, especially given a basal melt rate of about 2.5 m d-1 close to the glacier terminus (Enderlin & Howat 2013). Suspended sediment plumes were also observed upwelling from the base of other tidewater glaciers in the Rink Fjord system (Powell 1990; Mugford & Dowdeswell 2011).

There are probably additional contributions to the inner-fjord basin fill from several other sources. Rink Glacier has an ice velocity of about 10 m d-1 close to its margin (Enderlin & Howat 2013), implying that many of the icebergs that drift through the fjord system are produced here (Fig. 1a). Icebergs are also sourced from several other tidewater glaciers entering the fjord. As the icebergs melt, debris rains out to the seafloor.

The large transverse ridge, asymmetrical in cross-section, extending across Rink Fjord about 2 km from the modern ice front, is likely to be sedimentary (Fig. 2a-c). Acoustic penetration is limited, suggesting that the ridge is composed of diamictic rather than sorted debris. Lateral moraine ridges are also clearly visible onshore. These subaerial and submarine ridges are interpreted to indicate the ice-front position of Rink Isbrae during the cool Little Ice Age (LIA), which took place in West Greenland from about 1500 to 1860 (Dahl-Jensen et al., 1998; Fischer et al., 1998). Many marine-terminating West Greenland glaciers show a similar LIA maximum. Similar transverse ridges in, for example, Svalbard and Chilean fjords, are also linked to LIA glacier growth (e.g. Ottesen & Dowdeswell, 2009; Dowdeswell & Vasquez, 2013). The remaining large transverse ridges in Karrat Isfjord are probably bedrock, sometimes with a thin drape of sediment (Fig. 2b). The floor of the inner fjords has a rougher appearance adjacent to steep fjord side-walls and where bedrock is also close to the sea-floor (Fig. 2a, c). In the relatively deep basin inshore of the moraine ridge, two streamlined landforms are interpreted as mega-scale glacial lineations (MSGL), formed subglacially before the retreat of Rink Glacier from this area over the past century (Fig. 2c).

A single 4 km-long sinuous submarine channel was also imaged in the 1,000 m-deep innermost sedimentary basin (Fig. 2c). It is interpreted as a turbidity-current channel, formed by underflows of dense and probably highly turbid water. Flow in this channel likely contributes intermittently to the build-up of acoustically laminated basin fill in the inner fjord system. Turbidity currents may be generated by occasional slope failures on the steep distal face of the moraine ridge close to the present terminus of Rink Glacier, with debris flows translating into turbidity currents downslope (Fig. 2c).

Outer fjord and Uummannaq shelf

The well-developed streamlined landforms, orientated parallel to outer-fjord and trough long axes, are interpreted as a product of deformational and depositional processes at the bed of a fast-flowing ice stream in the full-glacial and deglacial Greenland Ice Sheet (GIS) (Figs. 2e-g, 3a, f). Entirely sedimentary streamlined landforms, typically with an elongation ratio of >20:1, are interpreted as MSGLs (Clark 1993). The MSGLs are usually buried by a few metres of fine-grained glaciomarine sediment, deposited since ice retreat. MSGLs are observed frequently in cross-fjord troughs in both polar regions (e.g. Canals et al. 2000; Ó Cofaigh et al. 2002; Ottesen et al. 2005), and have also been observed forming beneath fast-flowing ice streams in modern Antarctica (King et al. 2009).

The presence of these subglacial landforms is clear evidence that the GIS advanced across Uummannaq Shelf to the shelf edge, probably at the LGM. Radiocarbon dates from the Uummannaq shelf and upper slope confirm that the MSGLs are linked to the presence of ice during the last full-glacial period (Jennings et al. 2012; Ó Cofaigh et al. 2013a). A 10 m-high moraine ridge on the outermost shelf yields a date of 14.8 cal. kyr from 5 cm above a stiff diamict, which is interpreted as subglacial till (Ó Cofaigh et al. 2013a); the date suggests that deglacial retreat from a full-glacial maximum limit on the outermost shelf was underway by this time.

Where streamlined subglacial landforms have an ice-proximal rock core and a sedimentary tail, they are interpreted as crag-and-tail features (Benn & Evans 2010). Some drumlins have crescentic depressions on their upstream sides. These depressions may be produced by subglacial water flow, especially given the presence of palaeo-channels on the inner shelf (Fig. 2g). Each of these types of streamlined sedimentary landform is an indicator of the presence of a former ice stream, together with its onset zone, in outer Uummannaq Fjord and Trough.

The sedimentary scars in Uummannaq Trough, between 55° and 56°W (Fig. 2a-d), and at about 58°W (Fig. 3e), are interpreted as the relatively steep ice-distal faces of three grounding-zone wedges (GZWs; Dowdeswell & Fugelli 2012). These depocentres appear asymmetrical in long-profile, typical of many similar buried features on the Greenland shelf (Dowdeswell & Fugelli 2012). GZWs are sedimentary wedges formed by delivery of deforming subglacial sediment to a marine ice margin that has been in a similar location for decades to centuries during more general regional deglaciation (e.g. Mosola & Anderson 2006; Dowdeswell & Fugelli 2012). Slight sub-bottom reflections suggest that the wedges are probably a few tens of metres thick (Fig. 3d, e). The presence of GZWs also implies that retreat in Uummannaq Trough was episodic, and punctuated by at least three still-stands, rather than a single catastrophic collapse (Dowdeswell et al., 2008a), although the duration of the still stands is still unknown.

Irregular to chaotic linear to curvilinear, V-shaped furrows are the characteristic landform on the relatively shallow banks to either side of Uummannaq Trough. There is a fairly sharp depth limit to the distribution of these features (Fig. 3e). The furrows are interpreted as ploughmarks produced by iceberg keels eroding the sedimentary seafloor (Woodworth-Lynas et al. 1991). Ploughmarks have been observed over very large areas of the Greenland shelf, especially where water is shallower than about 500 m (e.g. Brett & Zarudzki).
Fig. 2. Marine-geophysical data from Rink Fjord and inner Uummannaq Fjord-Trough system (modified in part from Dowdeswell et al. 2014). (a) Sun-illuminated multibeam-bathymetric image of Rink Fjord and Karrat Isfjord. (b) Seafloor depth profile along Rink Fjord showing flat-bottomed basins interrupted by bedrock highs. VE × 37. (c) 3D-view of inner Rink Fjord, looking up-fjord towards Rink Glacier, showing a sinuous channel system (white arrows) and cross-fjord moraine ridge; behind the ridge two lineations (black arrows) occur in front of Rink Glacier. (d) Multibeam image of submarine landforms in Uummannaq Fjord. Streamlined landforms indicate a confluence of palaeo-ice flow directions into Uummannaq Fjord and westwards onto the continental shelf (Dowdeswell et al., 2014); crag-and-tail landforms are arrowed in white. (e) Bathymetric image of the strait east of Ubekendt Island showing streamlined landforms (solid white) and a series of ridges (dashed and arrowed) at a topographic high that may indicate a former ice-marginal position. (f) 3.5 kHz sub-bottom profile across the crag-and-tail landforms shown in (d). VE × 25. (g) Multibeam image of streamlined landforms (white) and across-trough channels (arrowed) on the inner shelf; (a), (d) and (g) are located in Fig. 1a. Multibeam acquisition system: Kongsberg EM120. Frequency 12 kHz. Grid-cell size 30 m. Acoustic profile acquisition system: Kongsberg TOPAS PS 018 parametric sub-bottom profiler. Secondary beam frequency 0.5-6 kHz. Regional bathymetric contours from IBCAO v. 3.0.
and Kangerlussuaq Trough in East Greenland (Dowdeswell et al. 1992). An abrupt water-depth limit to iceberg-keel ploughing is typical of many high-latitude shelves (e.g. Barnes & Lien 1988; Dowdeswell et al. 1993), and is a result of the relatively uniform dimensions of the parent ice-sheet terminus from which the icebergs are derived (Dowdeswell & Bamber 2007). Icebergs with deeper keels, evidenced by ploughmarks at the mouth of Uummannaq Trough down to about 850 m (Fig. 3f), are present only where iceberg fragmentation and overturn have taken place, which may occasionally lead to iceberg geometries that result in particularly deep keels. Isolated slope-parallel depressions up to about 40 m deep in water depths of 850 to 1,085 m of water on the West Greenland upper slope have also been ascribed to ploughing by huge icebergs probably produced during break-up of the last full-glacial ice sheet (Kuijpers et al. 2007). Few icebergs with keels greater than 500 to 600 m are calved from the fast-flowing ice streams and outlet glaciers of the Greenland Ice Sheet today (Dowdeswell et al. 1992).

**Continental slope and Uummannaq Fan**

The outward-bulging contours of the continental slope at the mouth of Uummannaq Trough indicate the presence of a major submarine fan (Fig. 1a). Uummannaq Fan (Ó Cofaigh et al. 2013b), which is similar in geometry to trough-mouth fans reported at many locations on polar continental margins (e.g. Vorren et al. 1998). Prograding sediments on seismic records from Uummannaq Shelf support this interpretation (Fig. 1b). Offshore of Greenland, large fans have been mapped beyond the Disko shelf in West Greenland and Scoresby Sund and Kangerlussuaq Trough in East Greenland (Dowdeswell et al. 1992, 2010; Ó Cofaigh et al. 2013a; Laberg et al., 2015).

Such high-latitude, glacier-influenced fans are built up predominantly from the delivery of diamicton debris to the shelf edge and upper slope when ice sheets advanced to the shelf break during Quaternary full-glacial conditions (Vorren et al. 1998). The lobate landforms on Uummannaq slope (Fig. 3f, h) are interpreted as glaciogenic-debris flows, formed mainly from diamict delivered by the palaeo-ice stream that advanced through the adjacent trough at the last full-glacial about 20,000 years ago. The debris flows are stacked on the slope (Fig. 3b), and are the main building blocks of Uummannaq Fan (Ó Cofaigh et al. 2013b). Similar stacked glaciogenic-debris flows have been reported from many large trough-mouth fans on polar continental margins (e.g. Laberg & Vorren 1995; King et al. 1996; Vorren et al. 1998). Coring on the northern part of Uummannaq Fan has shown that turbidity currents, iceberg-rafting and hemipelagic rainout have also contributed to fan sedimentation (Ó Cofaigh et al. 2013b), although turbidity-current channel fills are absent from the area of the fan we have imaged using swath bathymetry (Fig. 11).

Finally, immediately south of the mouth of Uummannaq Trough, several small slide scars on the upper slope suggest that additional downslope mass wasting may take place through intermittent slope failures (Dowdeswell et al. 2014).

**Discussion: landform distribution and schematic model**

The landform distribution in the Uummannaq fjord-shelf-slope system is mapped in Figure 4a. The deep inner fjords are blanketed by fine-grained basin fill between rock pinnacles. The distribution of streamlined subglacial landforms, and a moraine ridge at the mouth of Uummannaq Trough, imply that a fast-flowing ice stream reached the shelf edge on this part of the West Greenland margin. Radiocarbon dates indicate that this advance took place at the LGM and that outer-shelf deglaciation had begun by about 14.8 cal. kyr ago (Ó Cofaigh et al. 2013a). The streamlined subglacial landforms vary in morphology from crag-and-tail features together with well-defined MSGLs in the outer fjord, to less well-defined lineations on the shelf. There is also an area of drumlins and crescentic depressions on the inner shelf, but the detailed role of meltwater in their formation is not clear. The set of streamlined landforms described above, and illustrated schematically in Figure 4b, indicates deformation of water-saturated sediments at a former ice-stream bed (Ó Cofaigh et al. 2005).

The distribution of subglacial landforms, with the fjords and inner shelf of the Uummannaq system containing a mix of sediments and bedrock at the seafloor, and the outer shelf being entirely sedimentary (Fig 4), is typical of many major ice-stream systems in both the Arctic and Antarctic (e.g. Wellner et al. 2001; Ó Cofaigh et al. 2002; Dowdeswell et al. 2010). Drumlins and crag-and-tail bedforms have been interpreted to indicate the onset-zone of fast ice-stream flow by some previous workers (e.g. Wellner et al. 2001). The association between form and flow is less clear in the Uummannaq system, given that drumlins are found at about 55°W at the wide mouth of outer Uummannaq Fjord (Fig. 4a). The presence of crescentic depressions on the stoss side of some drumlins, and limited development of channels nearby (Figs. 2g, 3a), certainly relates to subglacial processes, but whether to an onset zone or to full ice-stream flow remains unclear.

The fjords of the Uummannaq system show that acoustically laminated and presumably fine-grained sediments, derived predominantly from turbid meltwater sources and by rainout from icebergs, are typical of overdeepened basins within its fjords; similar to sediments reported from Kangerlussuaq and Nordvestfjord at 68° and 70°N in East Greenland (Syvitski et al. 1996; Ó Cofaigh et al. 2001). The rates of buildup of this material are, however, often slower than in the fjords of Alaska, Chile and Svalbard where air and water temperatures are warmer than in West Greenland (Powell & Molnia 1989). Subglacial and ice-contact landforms produced at the LGM and during regional deglaciation are often buried by a few to about 20 m of sediment on the West Greenland shelf, whereas tens of metres have built up over a similar period in milder fjord settings (e.g. Powell 1990; Dowdeswell & Vásquez 2013). More distal from modern sources of meltwater, the seafloor on the West Greenland shelf is dominated largely by streamlined and diamicton subglacial landforms, indicating the former presence of an ice stream in the Uummannaq cross-shelf trough, and GZW's that suggest episodic retreat across the shelf punctuated by still-stands of decades to centuries to build up substantial transverse-to-flow depositories.

In environments around Antarctica and North and Northeast Greenland, which are colder than the West Greenland margin, meltwater delivery of sediments is much more restricted. Here, especially in fjord and shelf areas traversed by large numbers of icebergs, sedimentation is much slower and debris deposited on the shelf is often diamicton in grain size (e.g. Dowdeswell et al. 1994; Anderson 1999).

The record of LGM and deglacial landforms is heavily reworked at water depths shallower than about 450-500 m by the ploughing action of deep-keeled icebergs. This is typical of many high-latitude shelves where high fluxes of large icebergs occurred during deglaciation and, in many cases, continued through the Holocene to the present, fed from huge (105 to 107 km²) interior ice-sheet drainage basins. The continuing release of such deep-keeled icebergs is not typical of the fjords of Alaska, Chile and Svalbard, where Holocene and modern iceberg production is restricted mainly to smaller and irregular-shaped icebergs with relatively shallow draughts derived from grounded tidewater glaciers with catchments of often only tens to a few hundred square kilometres (e.g. Dowdeswell & Forsberg 1992).

**References**


Fig. 3. Marine-geophysical data from the continental shelf and slope of Uummannaq Trough (modified in part from Dowdeswell et al. 2014). (a) Sun-illuminated multibeam-bathymetric image of drumlinised lineations (solid white) and two backstepping grounding-zone wedges (GZWs) the front of which are marked with dotted lines. (b) Multibeam-bathymetric image of a large GZW on the middle shelf. (c) Seafloor depth profile over the mid-shelf GZW in (b) showing rapid deepening of the trough in an offshore (westward) direction. VE × 156. (d) 3.5 kHz sub-bottom profile over the backstepping GZWs in (a). VE × 60. (e) 3.5 kHz sub-bottom profile over the large mid-shelf GZW in (b). VE × 53. In (d) and (e) faint reflections beneath the GZWs are arrowed. (f) Multibeam-bathymetric image of mega-scale glacial lineations (MSGL) on the outer shelf, and the Uummannaq trough-mouth fan; (a) and (f) are located in Fig. 1a. (g) Seafloor depth profile across Uummannaq Trough on the outer shelf showing MSGL (arrowed) and the 35-km wide glacial trough. VE × 42. (h) Down-slope 3.5 kHz sub-bottom profile on the lower slope of the Uummannaq trough-mouth fan showing stacked wedging units of sediment interpreted as glacigenic-debris flows. VE × 6. Multibeam acquisition system Kongsberg EM120. Frequency 12 kHz. Grid-cell size 30 m. Acoustic profile acquisition system Kongsberg TOPAS PS 018 parametric sub-bottom profiler. Secondary beam frequency 0.5-6 kHz. Regional bathymetric contours from IBCAO v.3.0.
Fig. 4. (a) Summary diagram of the distribution pattern of submarine landforms in Rink Fjord and in the Uummannaq Trough-Slope system, West Greenland (modified from Dowdeswell et al. 2014). (b) Schematic landform-assemblage model for the fjord-shelf-slope sedimentary system in central West Greenland. The model includes a schematic stratigraphy for the West Greenland continental shelf based on interpreted 2D seismic profiles like that shown in Fig. 1b. The legend for submarine landforms in (a) is also applicable to the schematic model in (b).


