Stratified glacimarine basin-fills in West Greenland fjords

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Acoustically stratified sediments that infill glacially eroded bedrock basins are common in fjords (Seramur *et al.* 1997; Gilbert *et al.* 1998; Hogan *et al.* 2012; Dowdeswell & Vasquez, 2013). Internally, such stratified sediments are often characterised by relatively smooth reflections that parallel the seafloor. Sills between basins usually comprise bedrock, sometimes covered by a thin veneer of glacimarine sediment and/or till. Fjords in West Greenland, including Rink Fjord and the Vaigat, contain bedrock basins infilled by acoustically stratified sediment (Fig. 1). The basin fills are a product of rain-out from turbid meltwater plumes, probably supplemented by iceberg-rafting and downslope resedimentation.

Description

The 85 km-long inner part of the northern Uummannaq Fjord System consists of Rink Fjord and Karrat Isfjord which, physiographically, are characterised by a series of relatively flat basins separated by bedrock highs (Fig. 1a, b). Rink Fjord is fed by Rink Glacier, a fast-flowing outlet glacier of the Greenland Ice Sheet. The fjord is less than 3.6 km wide and its side-walls are steep. The innermost fjord consists of two basins, reaching over 1000 m deep (Fig. 1a), separated by a large transverse moraine that shallows to about 600 m and is about 200 m high. Further south, the Vaigat is an 11 to 25 km wide strait, which separates Disko Island and the Greenland mainland (Fig. 1c, g); small basins also occur at the coast. Water depths reach 500 to 600 m in the main Vaigat trough, and 450 m in coastal basins.

Sediments within Rink Fjord comprise two distinct acoustic facies (Dowdeswell *et al.* 2014). Facies 1 is characterised by a strong and prolonged seafloor reflection that becomes rather diffuse on steep slopes. This is either bedrock and/or overconsolidated glacial till (Fig. 1b). Facies 2 infills basins between bedrock highs and is acoustically stratified. It is >50 m thick in deeper basins (Fig. 1b). In places Facies 2 overlies a strong and prolonged reflection with a semi-transparent facies sometimes imaged beneath. Occasionally a further thin, semi-continuous, reflection is visible beneath the semi-transparent unit. The stratified acoustic facies either infills the basins, or drapes areas of flatter sea-floor topography.

In the Vaigat, basins also contain the stratified Facies 2 (Fig. 1e). This comprises a stratified drape of parallel, low amplitude reflections which conformably infill the basins. The stratified sediments are up to 20 m thick in the northern Vaigat (typically 10 to 12 m thick) and are only present on slopes of less than ~10°. They form the uppermost acoustic unit in the basins and are underlain by Facies 3. The latter has an on-lapping geometry and is internally homogeneous to transparent with sub-parallel to moderate amplitude discontinuous to mounded reflections.

In a basin offshore of Rodebay, south of Arveprinsens Island (Fig. 1f), a >40-m thick package of stratified Facies 2 is overlain by acoustically homogenous strata with on-lapping to conformable geometries (Facies 3).

Interpretation

The smooth, acoustically stratified sediment that occurs in basins between bedrock highs in much of the inner part of Rink Fjord (Facies 2) is interpreted as a glacimarine basin-fill formed by the rain-out of fine-grained suspended sediment from turbid meltwater plumes (Mugford & Dowdeswell 2011), probably supplemented by sediment-gravity flows and also by the delivery of coarser debris from melting icebergs calved from outlet glaciers entering the fjord (Evans *et al.* 2002; Ó Cofaigh *et al.* 2001). Meltwater is delivered to the fjord from Rink Glacier at the fjord head as well as from subaerial meltwater streams and tidewater glaciers along the fjord sides. The strong and prolonged reflector buried beneath the stratified facies is consistent with the surface of a semi-transparent subglacial till.

In both the Vaigat and offshore of Rodebay, the mounded acoustically homogeneous to transparent Facies 3 is consistent with a retreating tidewater ice margin which pinned on local fjord bedrock highs or the coastline and delivered large volumes of sediment into the marine environment by sediment gravity flow processes including debris flows and turbidity currents probably supplemented by suspension settling from turbid meltwater plumes (Hogan *et al.* 2012). The conformable, drape-like geometry of the uppermost basin-fill Facies 2 in the Vaigat suggests that it is an ice-distal facies formed by meltwater sedimentation and iceberg-rafting. The variation in glacier-influenced basin fills in West Greenland fjords reflects the interplay between glacimarine processes through time, locally steep slopes leading to intermittent re-deposition and proximity to tidewater glacier margins (Hogan *et al.* 2012).

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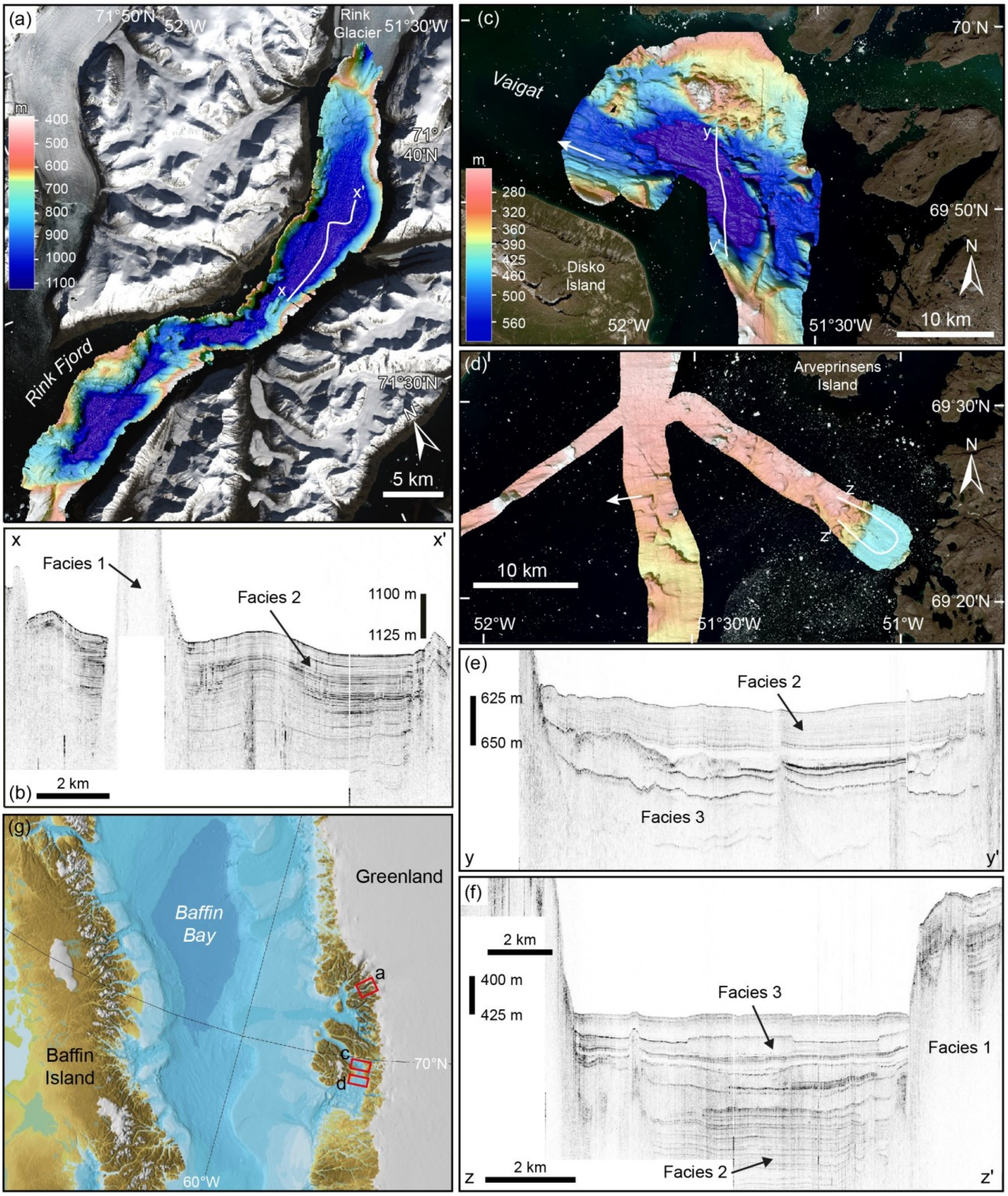

Fig. 1. Multibeam bathymetry and acoustic sub-bottom profiles of submarine basins close to the coast of West Greenland and their sediment infill. (a) Sun-illuminated image of multibeam bathymetry from Rink Fjord, West Greenland, with water depths >1000 m. (b) 3.5 kHz sub-bottom profile from Rink Fjord showing stratified, conformable basin fill (Facies 2) between basement pinnacles (Facies 1). VE × 96. (c) and (d) Multibeam bathymetry in Vaigat strait and a coastal basin, West Greenland, respectively; arrows indicate ice-flow directions during the last glacial based on the orientation of sculpted bedrock at the seafloor. (e) and (f) 3.5 kHz profiles of basins offshore West Greenland showing stratified sediment packages (Facies 2) and acoustically-transparent and mounded units (Facies 3); (e) the main basin in Vaigat (VE × 44) and (f) coastal basin offshore Rodebay and Kangersuneq, south of Arveprinsens Island (VE × 45). The acquisition parameters for panels (a), (c) and (d) are as follows. Kongsberg EM120. Frequency 12 kHz. Grid-cell size 30 m. The acquisition parameters for panels (b), (e) and (f) are: Kongsberg TOPAS PS 018 parametric sub-bottom profiler. Secondary beam frequency 0.5-6 kHz. (g) Location of study areas (red boxes; map from IBCAO v. 3.0).