High-resolution mapping of onshore-offshore glaciogenic features in Melville Bugt, northwestern Greenland

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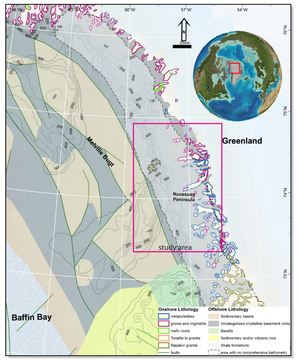
Background

Studies of glaciogenic landscapes help us understand the dynamics and variability of past glacial cycles. We present here the result of a high-resolution offshore geophysical mapping combined with onshore satellite imagery analysis to study the glaciogenic landscape in the coastal waters off Melville Bay, northwestern Greenland. The high resolution geophysical survey resulted in a spectacular overview of the seafloor in the region where we observe the interactions of glacial and perhaps glacial-fluvial processes within the complex bedrock structure. The landscape in both offshore and onshore study areas can be described as highly rugose, glacially eroded bedrock that resembles a 'cnoc-and-lochan' terrain. Different erosional features in both landscape are mapped and interpretation of their formation with regards to glacial processes is presented. The high-resolution dataset allowed us to study mesoscale (1-10's m) features of offshore bedrock erosional landforms, which we use in understanding palaeoglaciological processes in one of the least studied areas of the Arctic.

Study area



- Onshore and offshore geological map of western Greenland showing areas with little or no bathymetric dataset. (*data from www.data.geus.dk & www.geogratis.gc.ca*)

- View of the offshore landscape in the exposed rocks in the study area

-Deployment of AUV in the iceberg infested waters of the study area

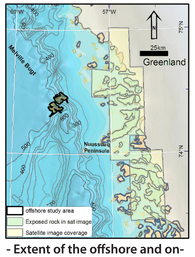
-Sailing ship *Explorer of Sweden* used in the offshore survey

Methods

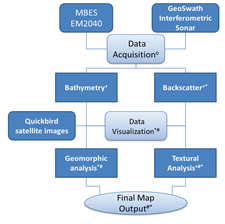
- **Quickbird Satellite Data**
  - Two sets of satellite images both panchromatic and multispectral acquired from DigitalGlobe Foundation *(http://www.digitalglobefoundation.org)*
  - 2D images were taken during late summer covered an area of approximately 1552 m^2
  - Pixel resolution of approximately <2m

- **Kongsberg EM2040**
  - Installed on the bow of the sailing ship *Explorer of Sweden*
  - operated @ 200-300 kHz for a max depth of ~500 m
  - total area covered is approximately 320 km^2 and produced bathymetric grids @ 4 m^2

- **Gavia Autonomous underwater vehicle (AUV)**
  - Package contains two acoustic systems: Geoswath Interferometric sonar and Marine Sonics sidescan sonar
  - mission lasts ~2 hours with survey speeds @ 4 knots covering approximately 2.2 $km^2$of seafloor
  - produced bathymetric grids @ 1.5 m^2 and side scan images @ 0.5 m^2

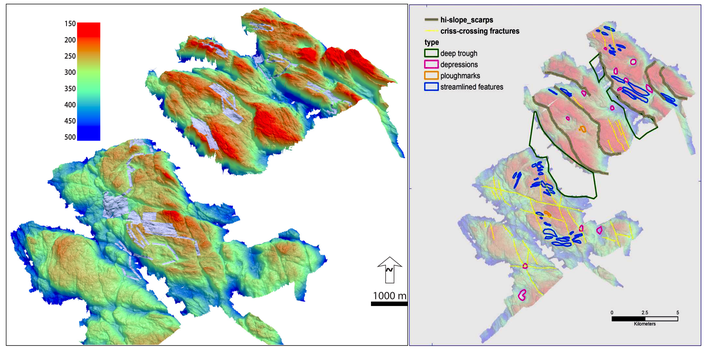


- Extent of the offshore and onshore study area

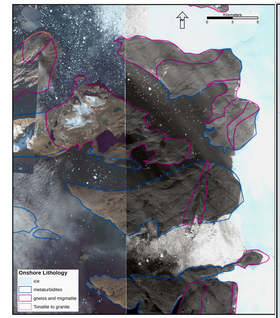


- Data processing pipeline. the softwares used; (o) - acquisition software; (+) Caris HIPS&SIPS; (*) Fledermaus suit; (#) ESRI-ArcGIS

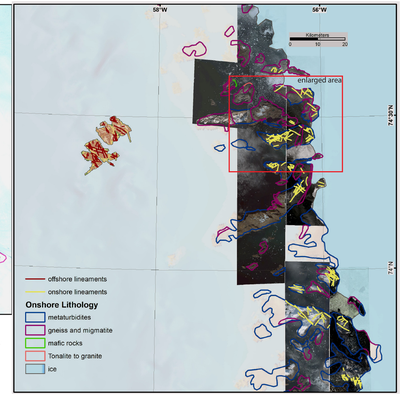
Results



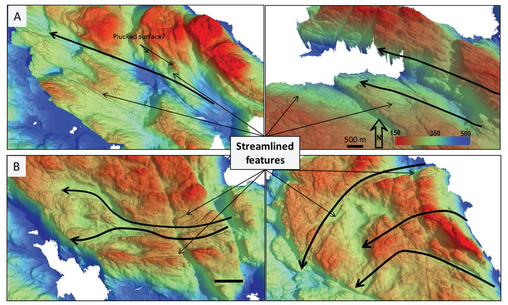
- Panel (A) shows the derived bathymetry (4m^2 grided) of the offshore study area collected by EM2040 multibeam system. Results show an areally scoured glacial erosional landscape landscape with little sediment cover. Colors in grey shows the extent of the data collected by AUV. In (B) are the geomorphological features identified from the offshore high-resolution bathymetry. The landscape is comprised of pre-glacial features that have been glacially modified during the past glaciations



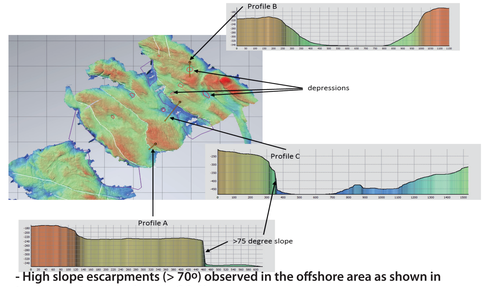
- Enlarged view of the 2D satellite image (*from right*) of the onshore, exposed rocks of northwestern Greenland. Two main types, metaturbites and gneiss, show slight variation in texture.



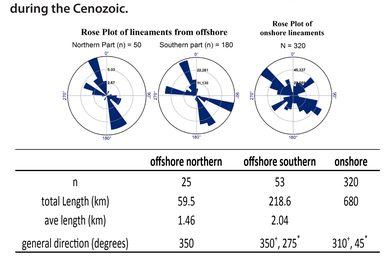
- Compilation of the satellite images from the study sites overlain with the results from the lineament mapping the glacialy scoured landscape. The main lineament pattern in both offshore and onshore follow the NW-SE direction, which is parallel to the coastline. Their formation is attributed to seafloor spreading processes during the Cenozoic.



- Streamlined landforms from the northern (A) and southern (B) part of the offshore bathymetric map. *Thin lines* point to the streamlined features that is suggested to be formed by glaci-fluvial processes. The features indicate that ice flowed in a NW-SE direction (***dark arrows***) towards the large x-section trough, the Melville Bugt.

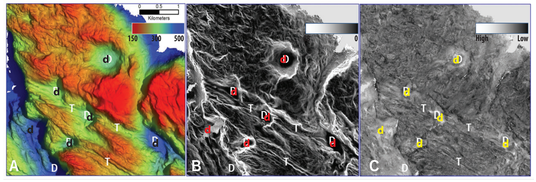


- High slope escarpments (> 70º) observed in the offshore area as shown in the transect profiles (*profile C & A*).

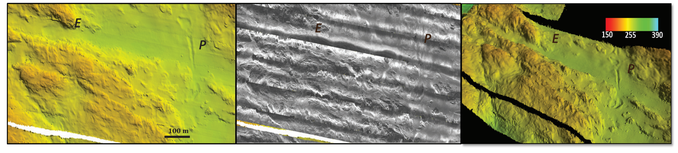


	offshore northern	offshore southern	onshore
n	25	53	320
total Length (km)	59.5	218.6	680
ave length (km)	1.46	2.04	
general direction (degrees)	350	350°, 275°	310°, 45°

°*main lineament direction,* **complimentary lineament direction*



- Enlarged view of prominently seen depression features (d) found in the northern part of the image. Displayed in three different views; bathymetry (A), slope map (B) and backscatter (C).



- The results from the Geoswath interferometric sonar showing the erosional terrain and the iceberg ploughmarks (P) and elongated geomorphological features (E). (A) bathymetry gridded at 1 m, (B) sidescan data gridded at 0.5 m, (C) slant-view of the bathymetry

Findings and Conclusion

- The high resolution dataset reveal an areally scoured landscape, which is a consequence of glacial activities acting on the tectonically modified bedrock. Pre-glacial tectonic processes served as important controls on the erosional potential of glacial processes, but the extent of glacial modification cannot be discerned.
- The offshore erosional landscape is suggested to be a consequence of a strong meltwater outflow pulse from the adjacent ice margin.
- Palaeo-iceflow analysis indicate that past ice flow direction was NW to SE towards the direction of the Melville Bugt, one of the biggest cross shelf troughs in western Greenland. Iceberg scourmarks in >300 m water show the presence of large icebergs in the study area.
- Landscape features in the offshore study area reveal differences in the spatial erosional pattern, because of differences in rock lithology or to some degree, differences in preglacial erosional processes. The spatial differences were also observed in the onshore satellite images where we see differences in appearance between various rock types.

Acknowledgement

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