Carbon mineralization rates in sediments of the Sherard Osborn and Petermann fjords – effects of subglacial meltwater runoff from the northern Greenland icesheet?

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Introduction

Subglacial runoff plays an important role for coastal marine ecosystems and future coastal Arctic ocean nutrient budgets. The Greenland icesheet has lost about 3600 Gigatons of ice since 1990, and up to 40 percent of this mass may have been transported by marine-terminating outlet glaciers such as the Sherard Osborn and Petermann fjords in northern Greenland. Subglacial discharge of meltwater into the fjords is an important component of the mass loss.

We present data on nutrient concentrations, dissolved inorganic carbon, sediment oxygen uptake, and sediment carbon mineralization rates in the Ryder and Petermann fjord waters and sediments to understand carbon and nutrient cycling in northern Greenland fjord systems. These are the first data on benthic nutrient and oxygen exchange reported for the Sherard Osborn fjord and provide important new constraints on the spatial extent of potential future melting-associated fertilization processes on the northern Greenland coast.

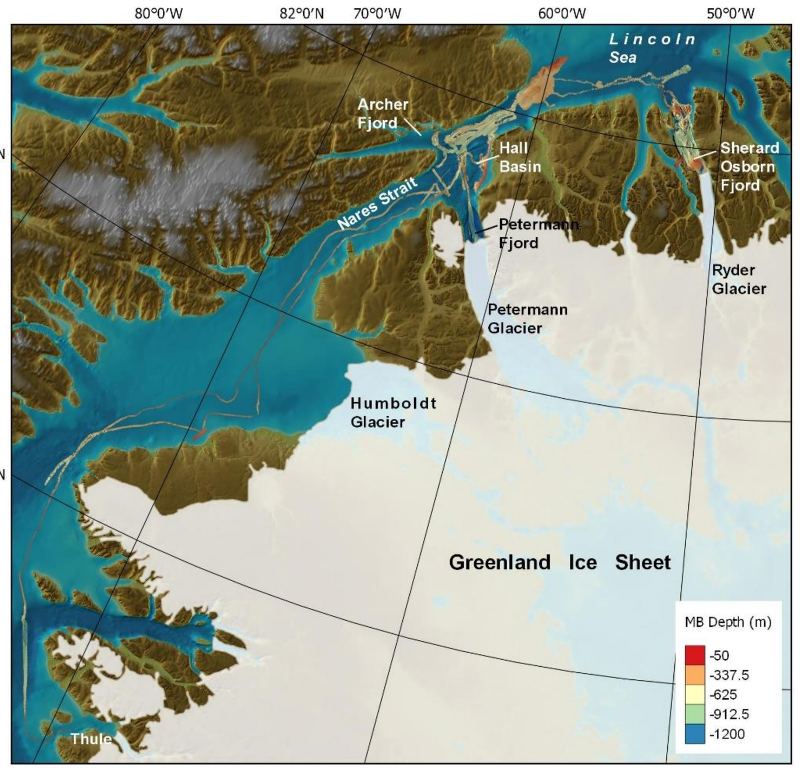
Results and discussion

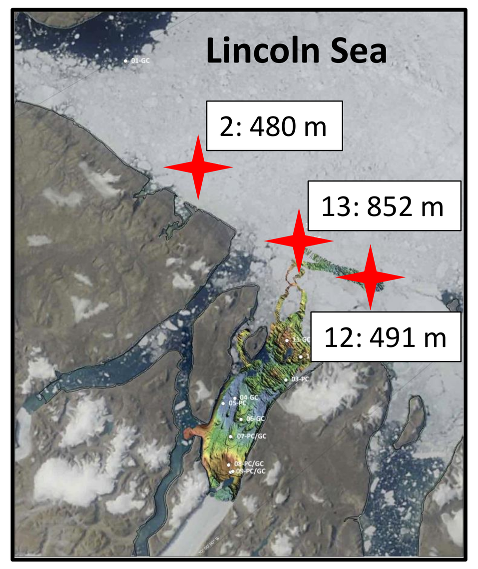
CTD profiles show a very warm surface layer with low salinity and a pronounced temperature minimum at 40 m depth with high O_2 concentrations. The water column was generally well mixed below 300 m depth, below which turbidity generally increased towards the bottom. A sharp fluorescence peak occurred at 35 m depth that was not associated with an increase in turbidity or with a change in O_2 concentrations.

An additional high-turbidity layer was also seen above and below 200 m depth. This turbidity was also not associated with enhanced fluorescence. A biological origin of this layer is uncertain. It is more likely of detrital origin.

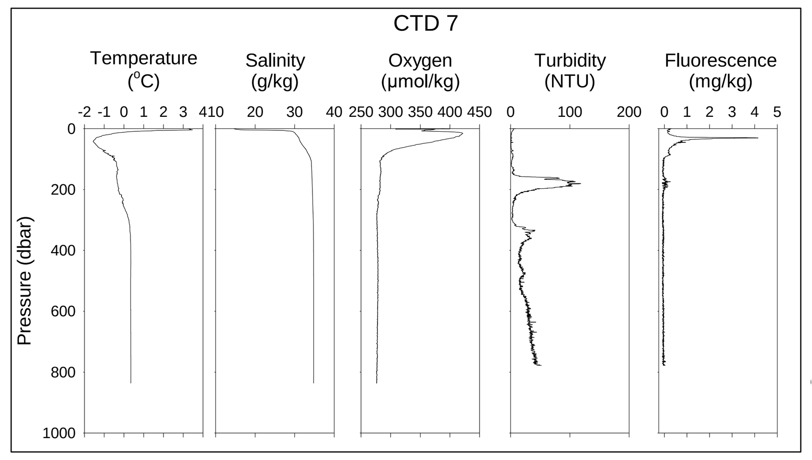
Possible sources of the bottom water turbidity may be erosion from topographic highs in the southern part of the fjord near the glacial tongue.

The origin of the distinct turbidity layer at 200 m depth is uncertain. Local sources descending the steep sides of the fjord are a possibility.

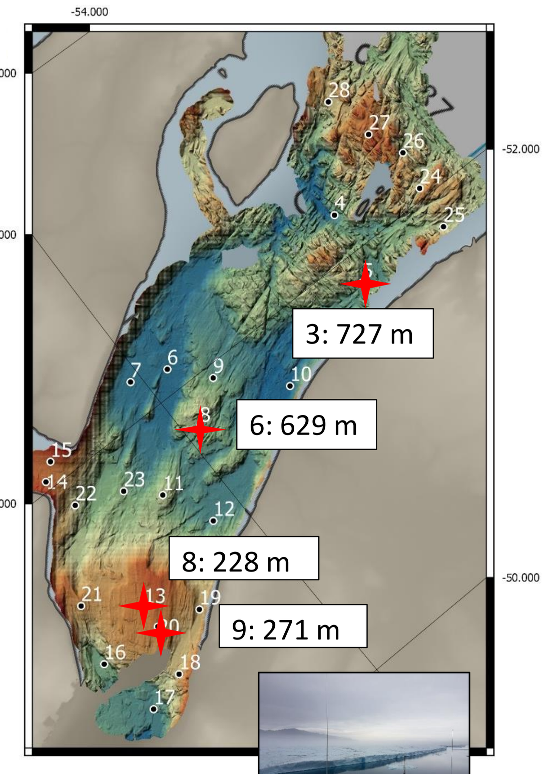




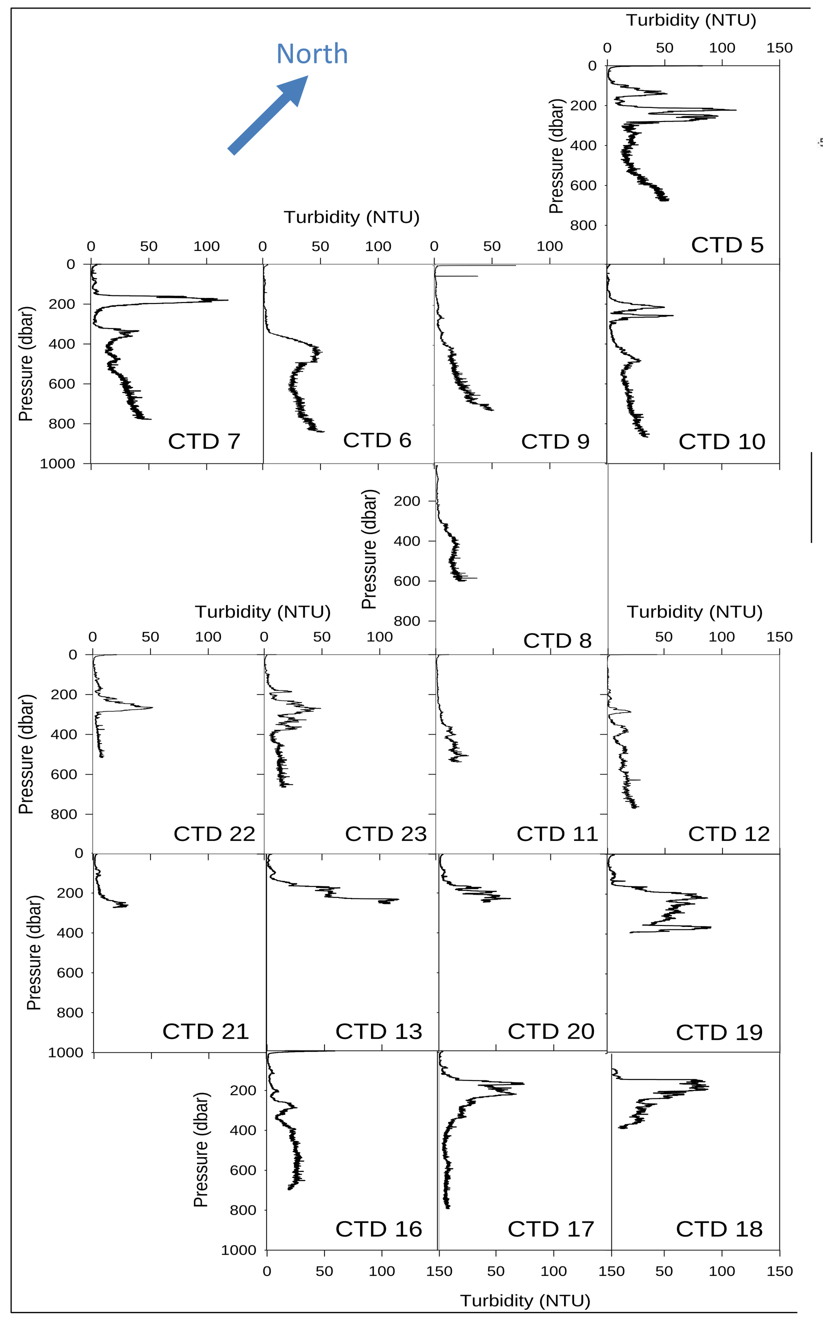
CTD profile 7 in central Sherard Osborn fjord



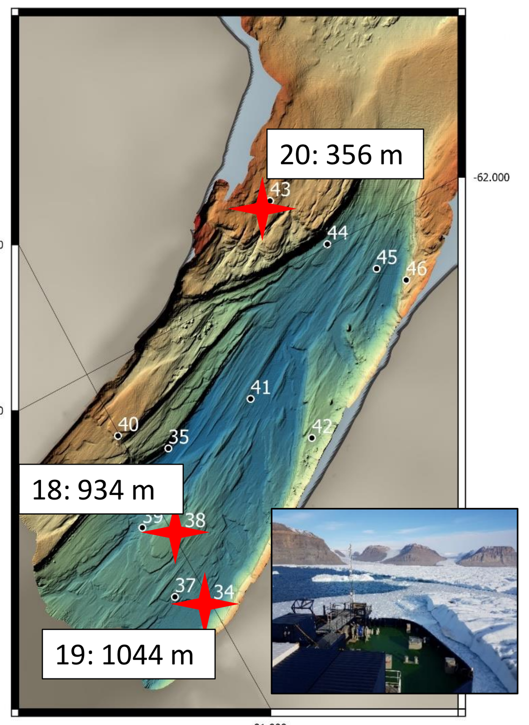
Sherard Osborn fjord



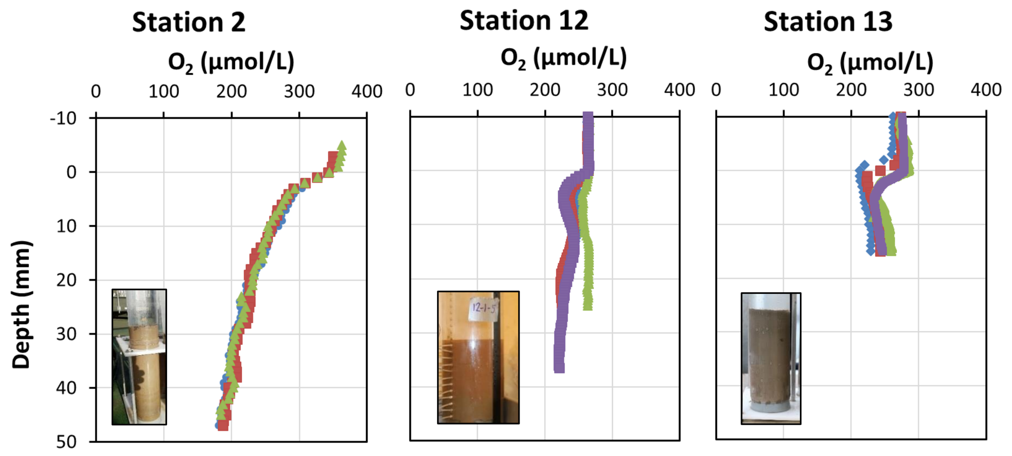
Turbidity profiles in Sherard Osborn fjord from N (top) to S (bottom)



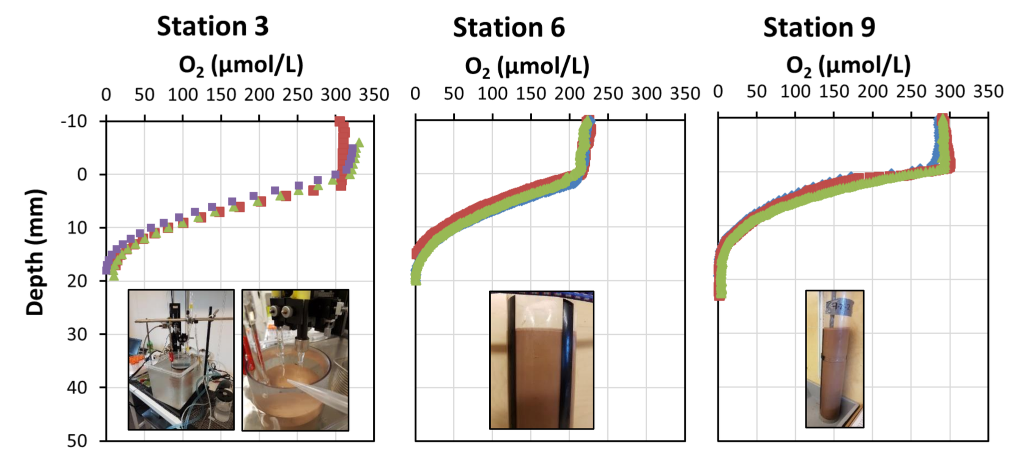
Petermann fjord



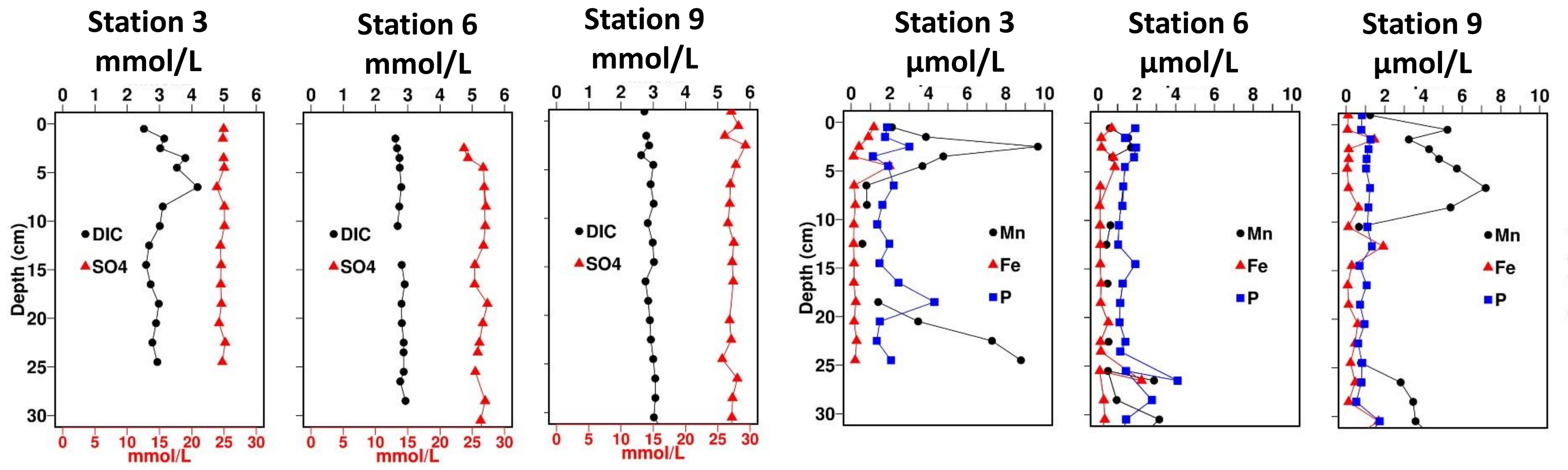
Lincoln Sea



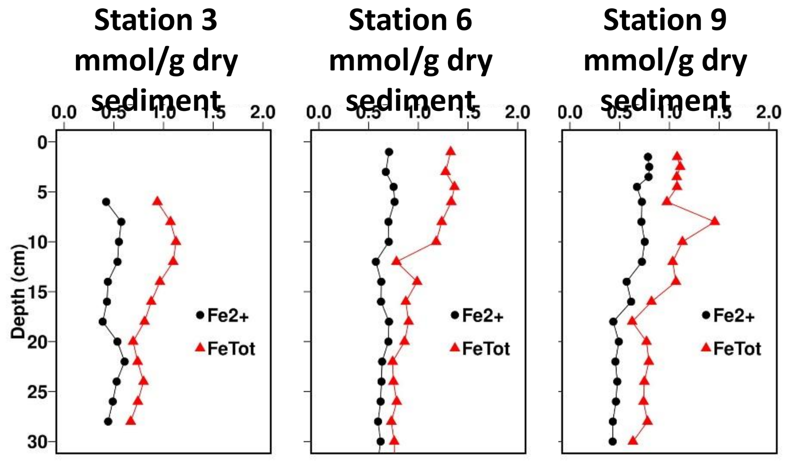
Sherard Osborn fjord



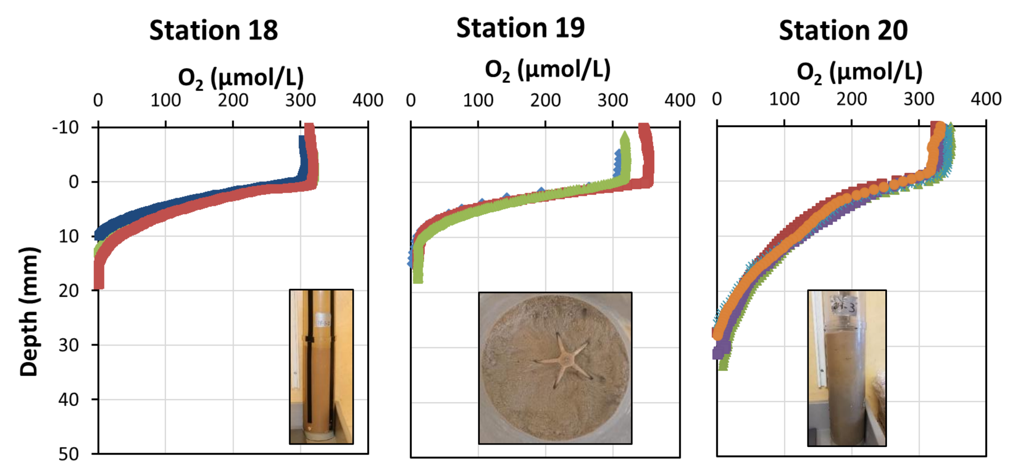
Porewater chemical composition



Reactive Fe



Petermann fjord



Petermann fjord sediment had slightly higher O_2 uptake rates compared to the Sharon Osborn fjord sediment. O_2 uptake rates increased towards the glacial tongue.

Table 1 Benthic exchange rates of O_2 and DIC from microelectrode and whole incubations

Station ID	Water depth (m)	Average oxygen penetration depth (mm)	Average diffusive oxygen uptake (mmol m^{-2} d^{-1})	Incubation intact core benthic oxygen uptake (mmol m^{-2} d^{-1})	Incubation intact core benthic DIC flux (mmol m^{-2} d^{-1})
Ryder19-2-MC	480	> 50	0.1		
Ryder19-3-MC	727	17	1.4	2.3	
Ryder19-6-MC	629	17	2.6	2.8	1.0
Ryder19-8-MC	228	15	4.3		
Ryder19-9-MC	271	12	5.7	3.1	4.5
Ryder19-12-MC	852	> 50	1.0	1.7	1.0
Ryder19-13-MC	491	> 50	0.8	1.8	1.0
Ryder19-18-MC	934	15	3.2	2.9	3.6
Ryder19-19-MC	1044	12	6.6	7.5	8.9
Ryder19-20-MC	356	35	2.2		

Conclusions

Sediments inside the silled fjord on perched basins and close to the glacial tongue had oxygen uptake rates that were up to four times higher when compared to sediments in the adjacent, near-perennially ice-covered Lincoln Sea (Table 1). These differences are attributed to the combined effects of lesser ice cover in the fjords, higher light availability, fertilization from glacial runoff, and sediment transport and redeposition within the fjord.

Conclusions

- Overall low concentrations of dissolved Fe, Mn, P: low rates of reduction; efficient P adsorption to abundant iron hydroxides
- Bacterial sulfate reduction at detection limit with ^{35}S-SO_4 method: No significant iron sulfide formation
  - Fe- and Mn- reduction dominated diagenesis
  - Low rates of anaerobic carbon mineralization
- Buried organic matter is unreactive except for the surface centimeter of sediment
- Little evidence for a distinct nutrient effect of the glacial runoff
- Sedimentation patterns in the fjords dominate the spatial distribution and the rates of carbon mineralization

Laboratory methods

- Porewater chemical analysis of dissolved iron, manganese, phosphate by ICP-OES, sulfate by IC, dissolved CO_2 by GC-FID obtained with rhizons
- pH and O_2 microprofiling of surface sediment in temperature controlled water bath using Unisense microelectrodes (50 µm tip)
- Benthic flux experiments using temperature- controlled stirred intact-core incubations using Firesting 2D optode spots
- Reactive iron extractions using 1M and 6M HCl under anoxic conditions followed by spectrophotometric analysis with Ferrozine

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