Modern Sedimentary Processes and Deposits at the Kronebreen-Kongsvegen Tidewater Glacier Front in Kongsfjorden, Svalbard, Norway

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Abstract

Part of the Svalbard Research Experience for Undergraduates (REU) project, was designed to quantify the modern sedimentary processes in the environment proximal to the Kronebreen-Kongsvegen subpolar tidewater glaciers that end in Kongsfjord, Svalbard, and relate those processes to sedimentary deposits. The purpose of this study is to first define the important processes that contribute to the stability of these glaciers relative to global warming. A second goal is to provide a geological template for interpreting sedimentary records of these polythermal glacimarine environments in order to assess responses of these glaciers to past global temperature changes. To achieve this goal a series of sediment gravity- and box-cores were collected from Kongsfjorden during the summer of 2014. Sedimentary facies were identified within these cores by describing color, particle size, primary and penecontemporaneous sedimentary structures, and contact types following standard sedimentological procedures. The lithofacies delineated using these data were related to the observed and quantitatively measured processes occurring in the fjord. The dominant depositional mechanisms in the fjord, included (i) turbidity currents and debris flows on the fjord floor as rapidly deposited sediment fails, (ii) settling of particles from suspension in sediment plumes flowing away from meltwater streams discharging from the glacier terminus, and (iii) iceberg rafting of coarse-grained sediment released from icebergs as they melt while floating away from the terminus after they are calved-off that ice face. We found that the processes and deposits are unique to these glacial systems and can be used to characterize them in older deposits to infer past glacier behavior. Furthermore, these sediments could potentially accumulate fast enough to help slow glacial retreat; however, they do not appear to be accomplishing that at present and the ice continues to be lost to global warming and contributes to rising sea levels.

Study Location

The Svalbard archipelago extends from 74° N - 81° N latitude and 10° E - 35° E longitude.

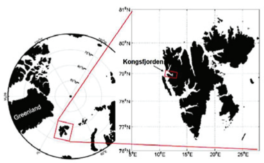


Figure 1. Global and regional setting of Kronebreen and Kongsvegen (Silyakova et al., 2013).

Recent Glacial History of Kongsfjorden

Since 1900 the glaciers have been undergoing continuous retreat from that last surge position (Svedsen et al., 2002).

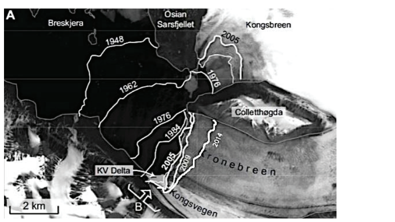
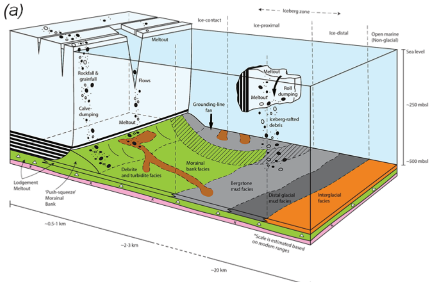


Figure 2. Retreat of Kronebreen-Kongsvegen since its most recent maximum extent achieved during a surge ending in 1948 (Trusel et al. 2009).

Glacimarine Depositional Mechanisms

The primary glacimarine sediment deposition mechanisms include suspension settling from meltwater plumes, sediment mass flows, and iceberg rafting (Cowan and Powell, 1991).

(a)



(b)

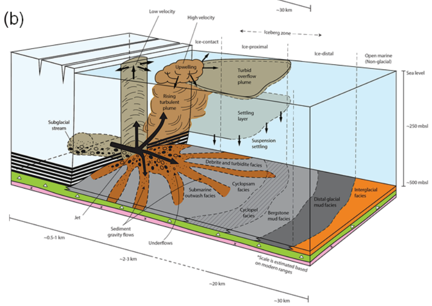


Figure 6. Modern Alaska tidewater cliff facies model for temperate glacial systems (modified from Powell and Molnia, 1989) used as a modern analog for interpreting the Kronebreen-Kongsvegen tidewater glacier environment. (a) Morainal bank model with facies deposited by rainout from melting of the ice face and calved icebergs, subglacial till deposition, and hemipelagic settling from meltwater stream plumes. (b) Grounding-line fan model with a subglacial stream conduit and jet that changes its position along the ice face in different melt seasons. Facies are formed by the deposition of subglacial stream outwash, suspension settling, and sediment gravity flows.

Field Work

Sediment core collection was conducted at the terminus of two confluent polythermal tidewater glaciers, Kronebreen and Kongsvegen, that flow into the head of Kongsfjorden.

Figure 3. Sample site map set on July 2014 image of Kongsfjorden (image courtesy of George Roth).

Sediment Coring

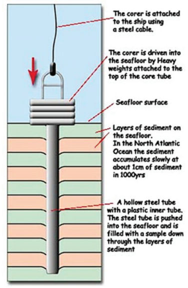
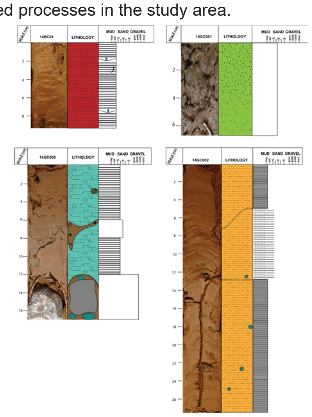


***Figure 4 (left).** Graphical depiction of the process of collecting a sediment core.*
***Figure 5 (right).** REU participants collecting a sediment core (image courtesy of Ross Powell).*

Laboratory Work, Results and Analysis

Following standard procedures, cores were cut in half, cleaned, and described sedimentologically. Core descriptions were then transferred into facies core logs that were used as a basis for interpretations relative to measured processes in the study area.



The following facies and their interpretations are defined using visual analysis of cores and core photographs, while considering their position relative to the meltwater discharge conduits and ice front.

Facies 1: Poorly sorted laminated very fine grained sandy mud with dispersed clasts.

Interpretation: (1) Suspension settling from meltwater plume; (2) Turbidity current deposit

Facies 2: Moderately sorted interlaminated fine sand, silt, and clayey units with dispersed clasts.

Interpretation: Supsension settling from meltwater plume

Facies 3: Clast-rich to clast-poor intermediate diamicton.

Interpretation: (1) Sediment gravity flows; (2) Iceberg rafting

Facies 4: Poorly sorted clast-rich lenses with a sandy matrix.

Interpretation: Iceberg rafting

Facies 5: Stratified clast-rich intermediate diamicton.

Interpretation: (1) Suspension settling from meltwater plume; (2) Iceberg rafting

Interpretations

__Facies 1:__ Suspension settling is distinguished by its parallel laminae. The gentle nature of deposition produces thin laminae that consist of fine sand or silt, which settle most rapidly as single particles, which can become deformed by dropstones (Ó Cofaigh and Dowdeswell, 2001). Finer particles are present in the background level of the water column and settle out with coarser particles, resulting in poorly sorted laminae (Cowen and Powell, 1990).

__Facies 2:__ Moderately sorted, planar interlaminated facies on the scale of millimeters with sharp to gradational upper and lower contacts, are commonly formed from suspension settling and turbidity currents (Ó Cofaigh and Dowdeswell, 2001). Both turbidity currents and suspension settling produce couplets of coarse- and fine- grained laminae, however, laminae that are <10mm are interpreted to have settled from suspension, while laminae >10mm are thought to have been settled from turbidity currents (Cowan et al., 1998).

__Facies 3:__ The irregular occurrence, coarse-grained homogenization, and the gradational upper contacts with sharp lower contacts suggests that Facies 3 units were deposited by sediment gravity flows (Cowan et al., 1998). The high concentrations of clasts and sand within Facies 3 may also be interpreted as iceberg-rafted deposits.

__Facies 4:__ Units are interpreted as iceberg-rafted deposits. Pebble- to -gravel-sized clasts and poorly sorted sediments accumulate on the upper surface of an iceberg. Due to melting, they become unstable and slump off the iceberg. They then settle on the fjord floor as diamicton lenses, commonly with coarse material dropped into muds accumulating on the fjord floor.

__Facies 5:__ The alternating couplets of stratified and poorly sorted sediments suggests that Facies 5 sediments were deposited by combined action of suspension settling from meltwater plumes and iceberg rafting.

Conclusions

(1) The processes and deposits are unique to these glacial systems and can be used to characterize them in older deposits to infer past glacier behavior.

(2) These sediments could potentially accumulate fast enough to help slow glacial retreat. However, from our measurements they do not appear to be accomplishing that at present and the ice continues to melt as warming continues and contributes to rising sea levels.

(3) This thesis provides an archive of the depositional environment proximal to the Kronebreen-Kongsvegen ice front, contributing to future assessments of the effects of climate change on this glacimarine system.

References

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