# Geomorphology and stratigraphy of fjord-lake basins of the eastern Canadian Shield

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## Introduction

Fjords are deep sedimentary basins located at the confluence of the terrestrial and marine environments that receive large volume of glacial, paraglacial and postglacial sediments. Fjords are connected to the sea, forming an open sedimentary environment in which oceanographic parameters such as water temperature, salinity and tides control the sedimentation patterns (Syvitski et al., 1986; Syvitski & Shaw, 1995).

Few studies have focused on documenting the impacts of forced regression on sediment architecture and processes as these basins become gradually isolated from the sea to form fjord-lakes. The passage from an open cold saline marine environment to enclose warmer freshwater lacustrine basin can influence the stratigraphic and geomorphological evolution of the fjord by modifying the sedimentary processes acting within them (Syvitski et al., 1986).

Here we analyse high resolution swath bathymetry imagery and acoustic stratigraphy data collected on three fjord-lakes of the eastern Canadian Shield (Lake Mekinac (Qc), Lake Walker (Qc) and Grand Lake (Lab)) in order to document their stratigraphic architecture and the sediment-landforms assemblages present on their bottom floor. The three lakes have a similar Quaternary context since they were all : 1) covered by the Laurentide Ice Sheet; 2) invaded by deglacial seas during the ice-retreat (Occhietti et al., 2011); and 3) glacio-isostically raised to form enclosed basins. However, these three lakes were not deglaciated at the same time and are located at different positions relative to marine limit.


Fig. 1- Location map of the three studied fjord-lakes: A) Lake Mekinac; B) Lake Walker; and C) Grand Lake. The same order of presentation are used for the figures in the results, from West to East.


## Methods

Hydroacoustic surveys took place in 2011 (Walker), 2014 (Mékinac) and 2016 (Grand) on the R/V Louis-Edmond-Hamelin survey launch. Depending on the water depth, different multibeam echosounders were used to do the high-resolution bathymetry of each lake. The following instruments were used for data acquisition:

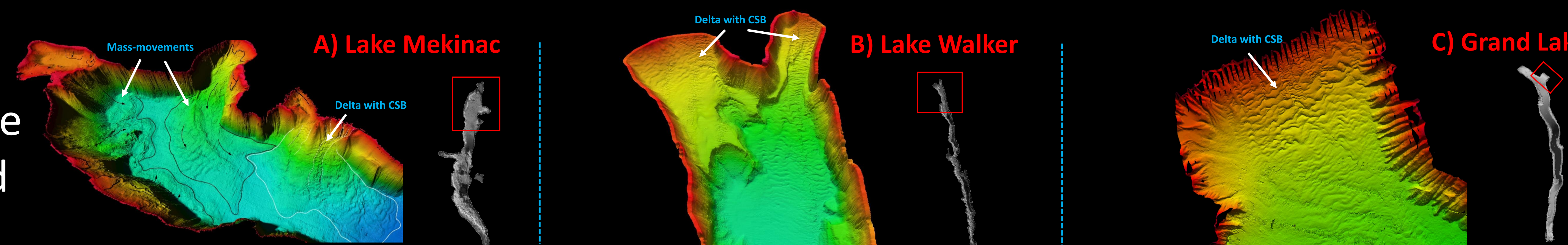
- *Reson Seabat 8101* multibeam echosounder (240 kHz)
- *GeoAcoustics Geoswath plus compact* interferometric sonar (250 kHz)
- *Kongsberg EM 2040* multibeam echosounder (200-400 kHz)
- *Knudsen 3212* subbottom profiler (3.5 & 12 kHz)

High-resolution swath batymetric imagery was post-processed using the Caris Hips & SIPS software. QPS Fledermaus and SegyJp2Viewer were used for visualization of the sub-bottom profiles and high-resolution swath batymetric imagery. ArcGIS was used for final map production.

## Results & Discussion

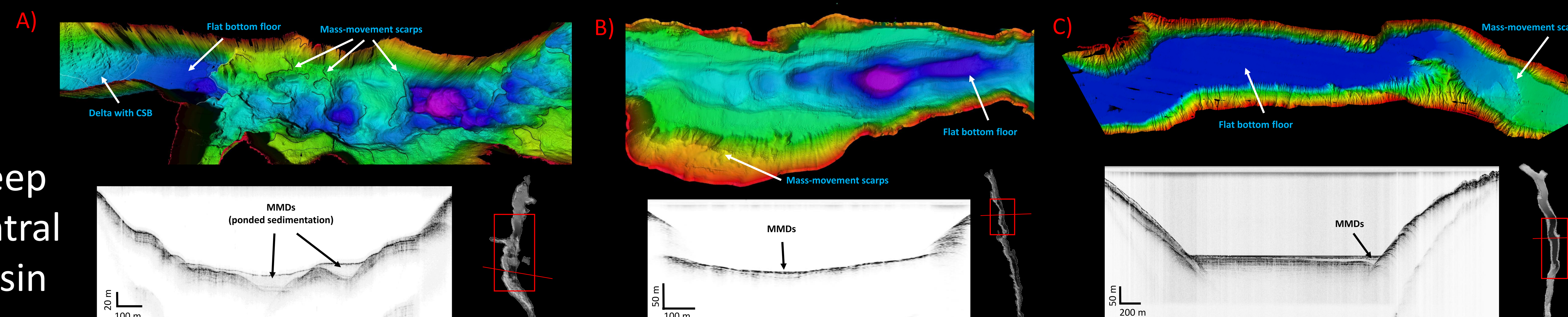
The swath bathymetry and acoustic stratigraphy data of the studied fjord-lakes show similar morpho-stratigraphy. According to their morphologies, the fjord-lakes can be divided in three distinct sectors, following their long axis :

### 1 Delta at the fjord head



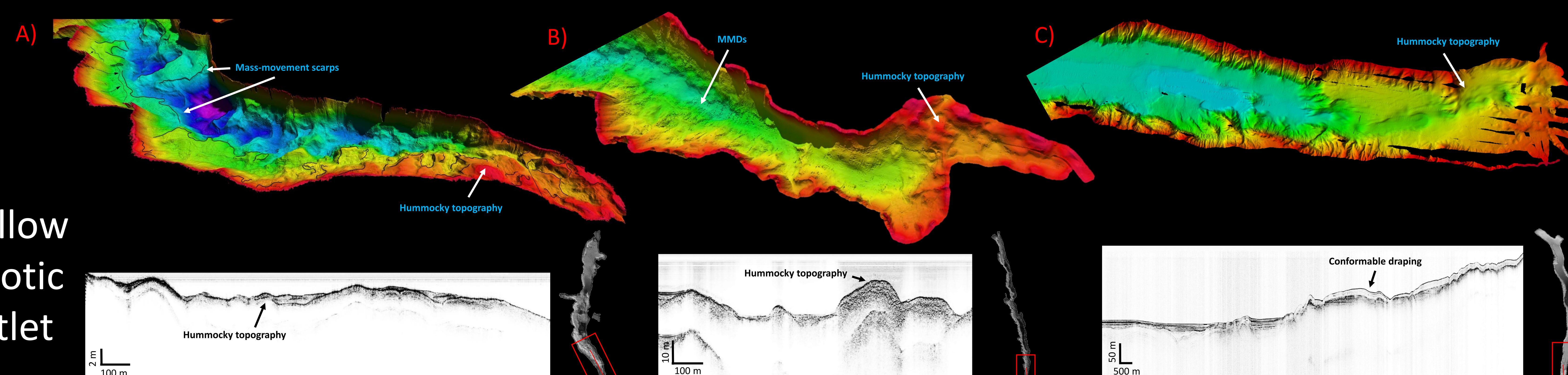

High-resolution bathymetry reveals crescent shaped bedforms (CSB) on the frontal slopes of the fjord-head deltas. The presence of CSB indicates that the delta are still active and that sediment supply is sufficient to generate density flows in the fresh lacustrine water (Hilbe & Anselmetti, 2014). It is well documented in the litterature that fjords are subject to gravity flows due to the high sedimentation rates and that their frequency decrease after an ice retreat (e.g. Syvitski & Shaw, 1995). However, the low density of the freshwater of fjord-lakes can increase the occurence of density flows at river mouths depending on their sediment load.

### 2 Deep central basin




The central basins of the fjord-lakes are characterized by a deep flat bottom floor, steep sidewalls and widespread mass-movement deposits (MMDs). Subbottom profiles show a thick stratigraphic sequence (> 50 m) composed of medium to high-amplitude parallel reflections that drape conformably the underlying topography, interspaced with transparent to semi-transparent layers. The transparent layers are thicker in the depressions which flattens the topography, indicating a ponded sedimentation resulting from rapidly deposited layers (RDL) or MMDs. Fjord-lakes can be submitted to high depositional rates since they occur in a force regressive setting which promotes river incision through pre-existing deposits. The absence of glacial landforms on lake bottom floors other than morainic ridges could be inferred from the burial of the ponded sedimentation of gravity driven processes.

### 3 Shallow chaotic outlet




The swath bathymetry data in the downstream section of the studied fjord-lakes show a shallow chaotic bottom floor characterized on the subbottom profiles by a thin laminated stratigraphic unit that drapes conformably the underlying topography. We interpret this shallow hummocky bottom floor to result from 1) the decrease of the erosive capacity of the glacier at the fjord outlet (Evans, 2003); and 2) the decrease of depositional rates away from the rivers input at the fjords head (Syvitski & Shaw, 1995). The ice margin was possibly less confined near the valley mouth and could extend laterally, decreasing its erosional potential. Adding to this, the low sedimentation rates and the few occurence of RDL away from the river mouths preserved the underlying chaotic topography, which is now still observed on the bottom floor.

## Summary & Conclusions

The morpho-stratigraphic similarities of the three studied fjord-lakes reveal a pattern in their deglacial and postglacial sedimentation processes. The results show that the isolation of these deep basins from the sea create a freshwater environment where gravity driven processes are frequent, which flattens the deep botton floor and bury glacial landforms and deposits. However, the decrease of depositional rates through the fjord axis preserved the underlying hummocky topography at the fjord outlet caused by the lower erosional potential of the former ice margin near the opening of the valley.

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