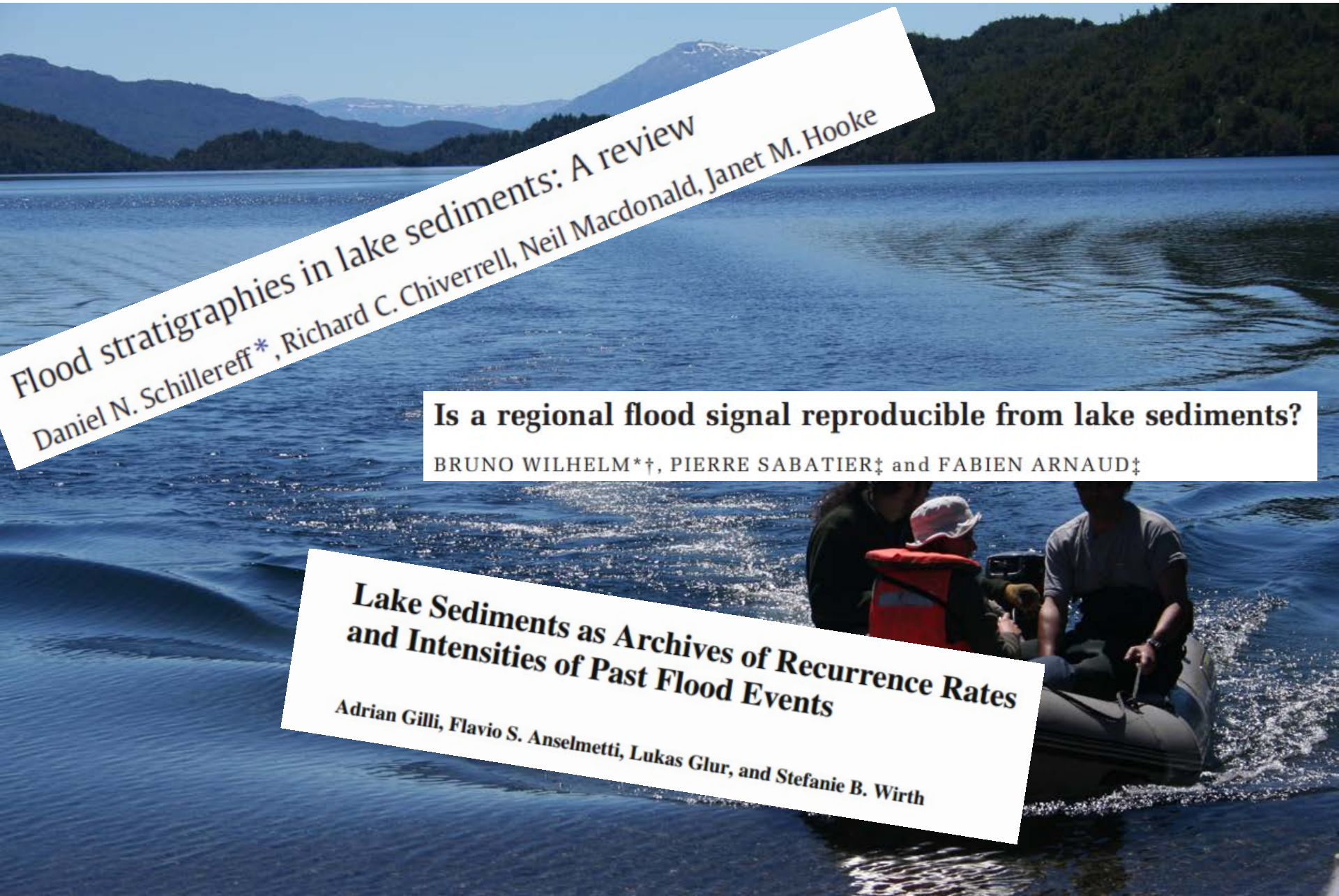
The potential of fjord sediment geochemistry for high-resolution paleohydrological reconstructions

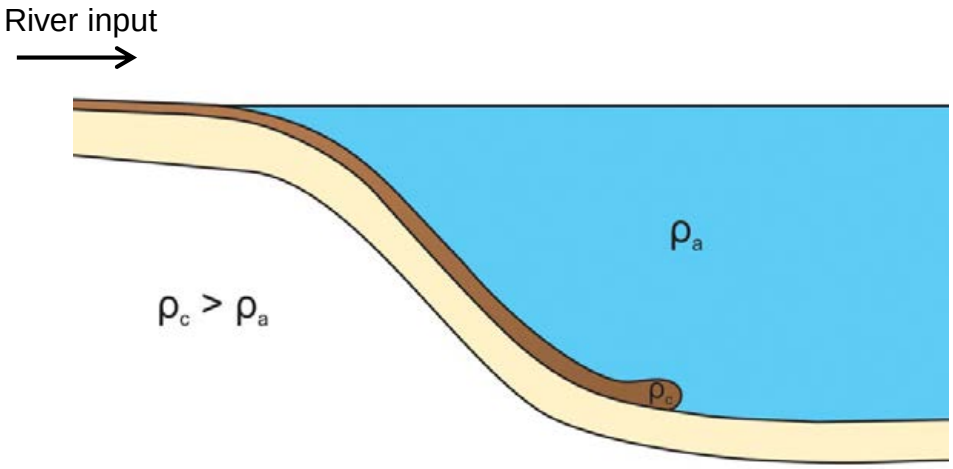
Sebastien Bertrand (UGent, Belgium)

In collaboration with: Silvio Pantoja (UdeC, Chile), Konrad Hughen (WHOI, USA), Gert Jan Weltje (KULeuven, Belgium)

Sediments as flood archives – mostly lakes



Sediments as flood archives – mostly lakes



Density of sediment-loaded river water >> lake water density

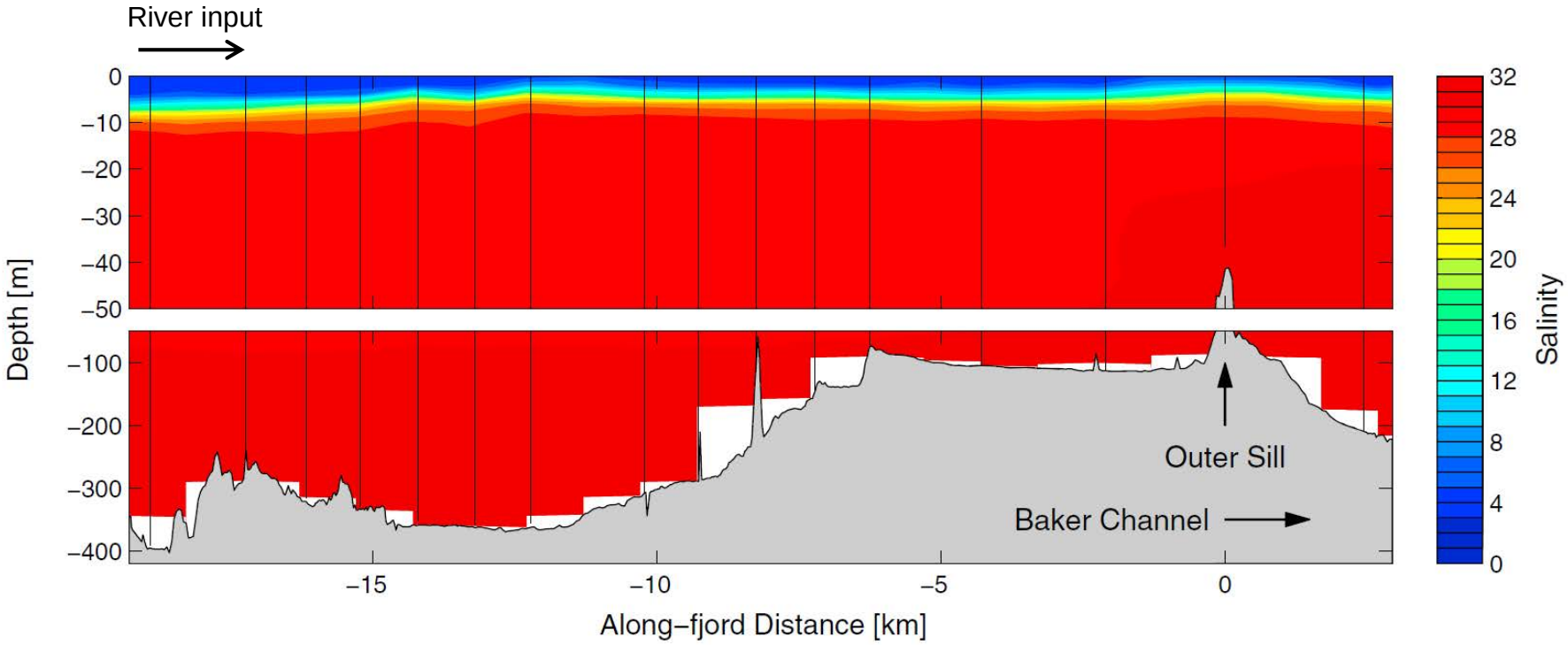
→ Floods are recorded as turbidites (underflows)

Difference between lake and fjord sediments

Fjords: Strongly stratified (salinity)

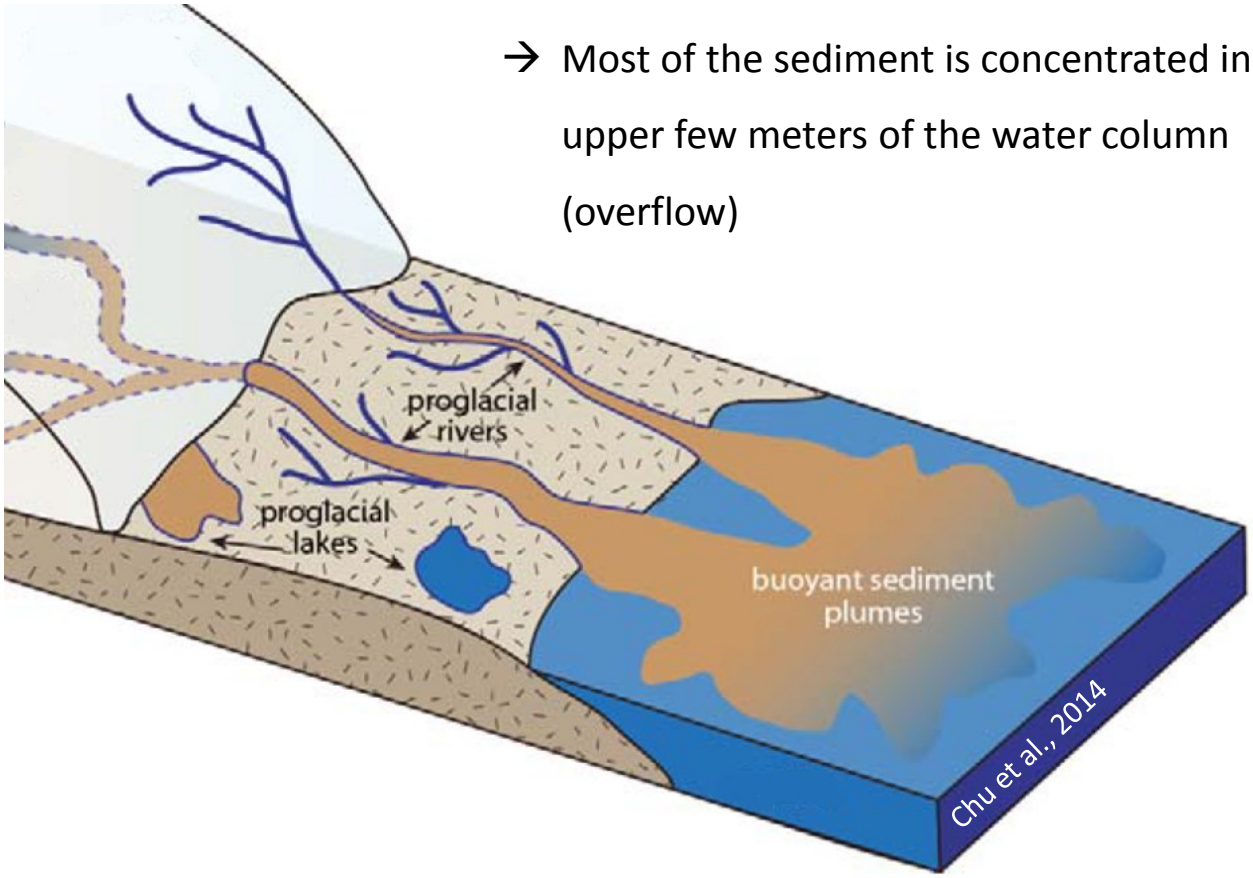
Generally 5–10m thick freshwater lens at the surface

Stratification has a strong control on sedimentary processes!



Moffat, 2014

Difference between lake and fjord sediments

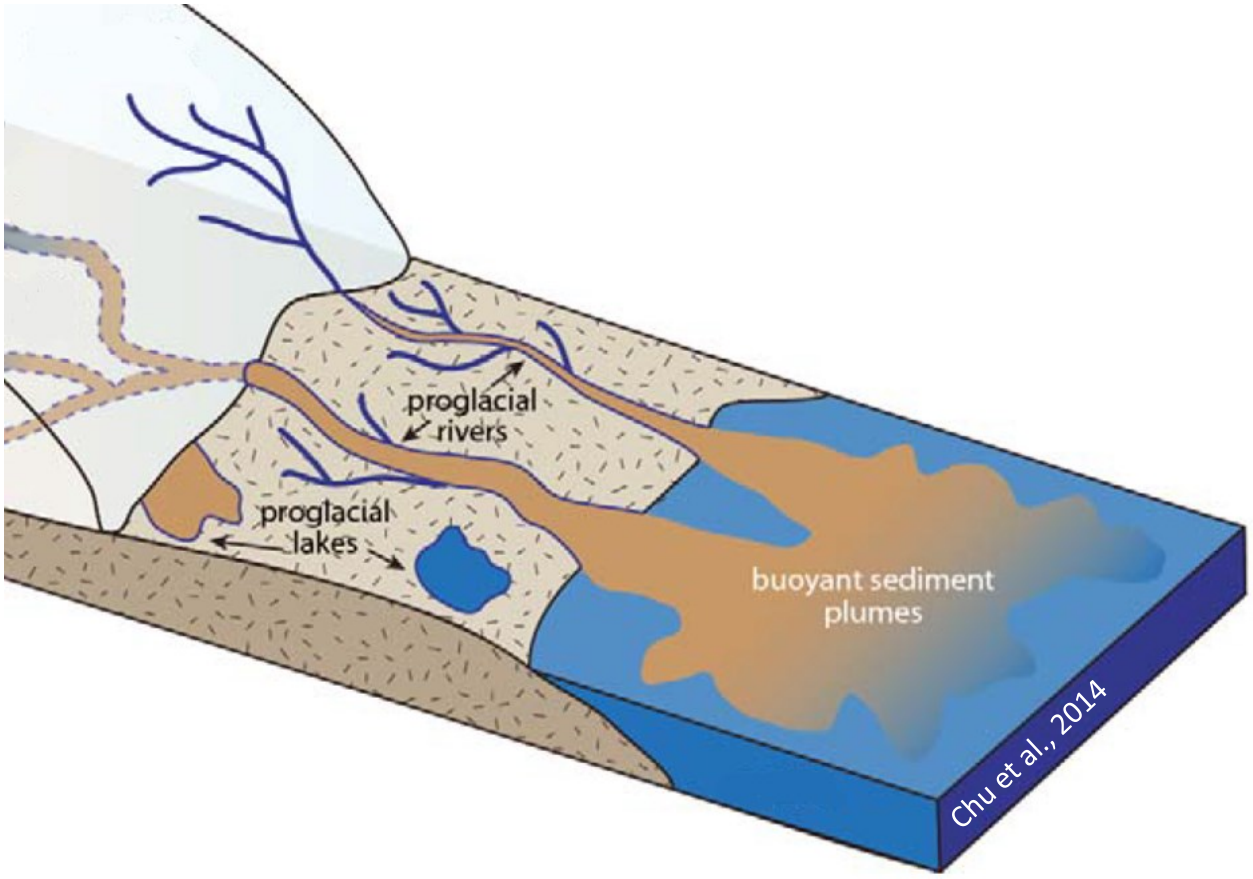


→ Most of the sediment is concentrated in the upper few meters of the water column (overflow)

Suspended sediment concentrations >> 1g/l are needed to overcome the density contrasts

→ Only large (glacial lake outburst) floods with high SPM concentrations are recorded.

Difference between lake and fjord sediments



→ Fjord sediments have the potential to record large floods (especially GLOFs)

… need indicators to identify flood deposits

Proxies of river discharge in fjord sediments

X

1.
Suspended particles transported in different hydrodynamic conditions

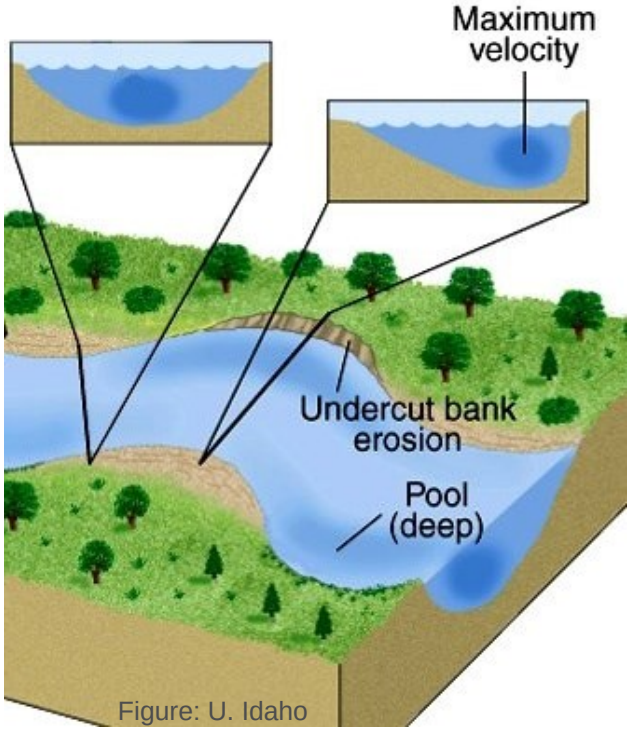
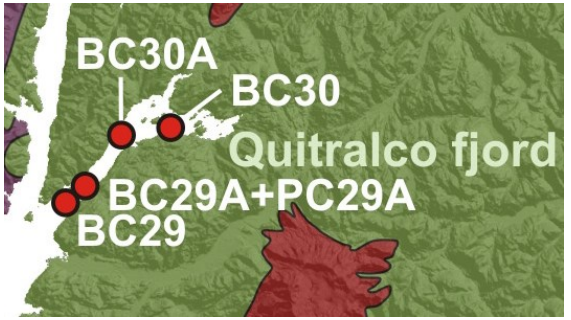


Figure: U. Idaho

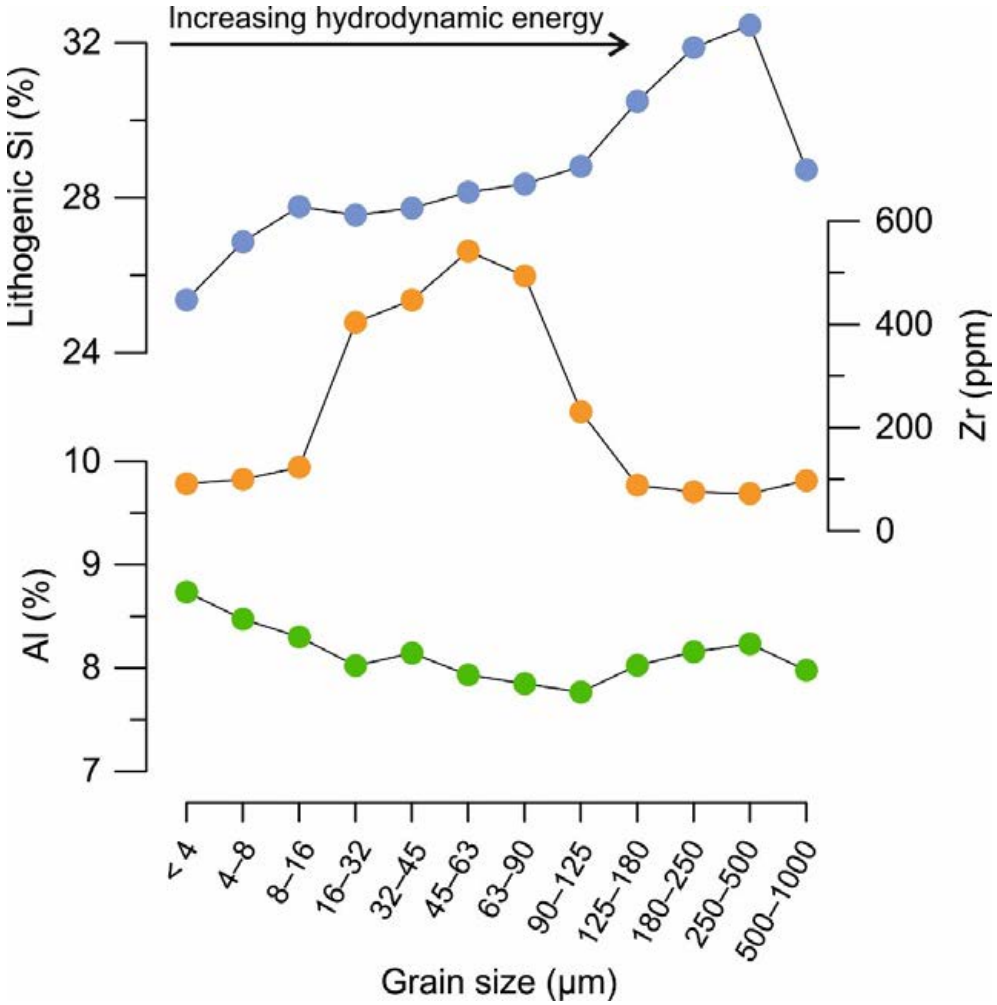
2.
Bulk river sediment sieved in different grain-size fractions

phi	um	
0	1000	Sieving
1	500	
2	250	
3	125	
3.5	88	
4	63	
4.5	44	
5	32	
5.5	22	Atterberg
6	16	
7	8	
8	4	
9	2	

3.
Surface (modern) fjord sediments - From river mouth to open ocean



Proxies of river discharge in fjord sediments



→ Clear influence of sediment grain-size on inorganic geochemistry.

Al is relatively constant with grain-size (hydrodynamics).

Other lithogenic elements are concentrated in a specific grain-size fractions

Proxies of river discharge in fjord sediments

1.
Suspended particles transported in different hydrodynamic conditions

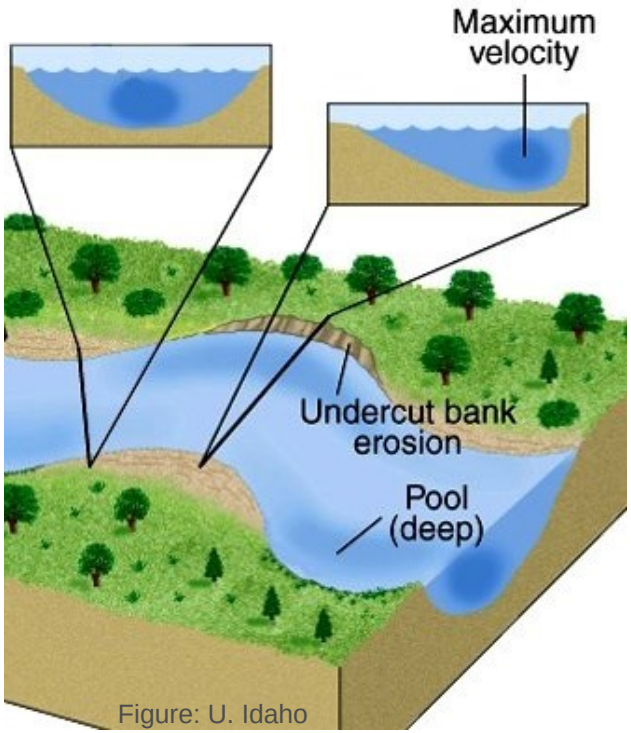
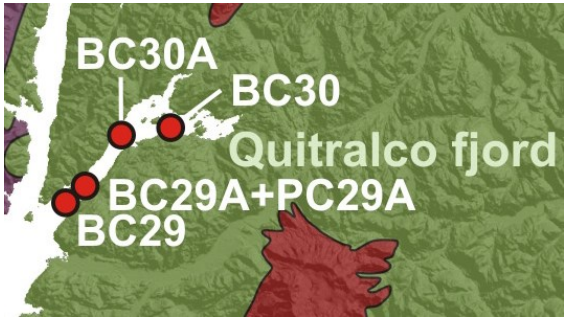


Figure: U. Idaho

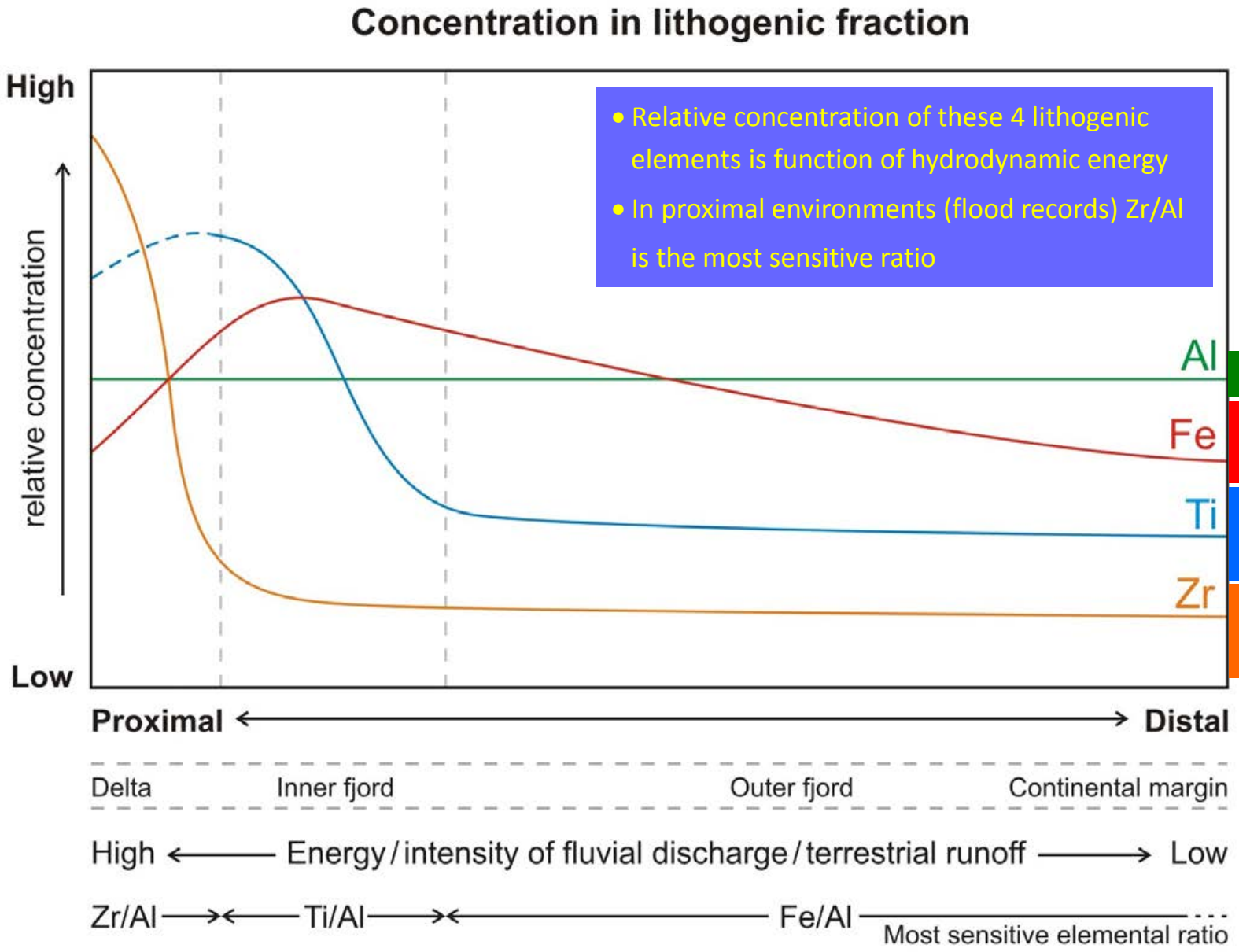
2.
Bulk river sediment sieved in different grain-size fractions

phi	um	
0	1000	Sieving
1	500	
2	250	
3	125	
3.5	88	
4	63	
4.5	44	
5	32	
5.5	22	Atterberg
6	16	
7	8	
8	4	
9	2	

3.
Surface (modern) fjord sediments - From river mouth to open ocean



Proxies of river discharge in fjord sediments



Bertrand et al., GCA 2012

Proxies of river discharge in fjord sediments

→ Sediment inorganic geochemistry (Zr/Al, Ti/Al) in fjords is well suited to estimate changes in river discharge through time

Advantage: can be measured at very high resolution (XRF core scanning)

Next step: modeling the relations between river discharge and fjord sediment geochemistry
→ reconstruct flood magnitude?

UNIVERSITEIT GENT

HYDROPROX

(UGent starting grant, 2016–2019)

Developing inorganic geochemical proxies for accurate paleohydrological reconstructions from fjord sediments

In collaboration with: Silvio Pantoja, Brian Reid, Carlos Moffat, Gert Jan Weltje

HYDROPROX

River discharge monitoring

Sequential sediment traps

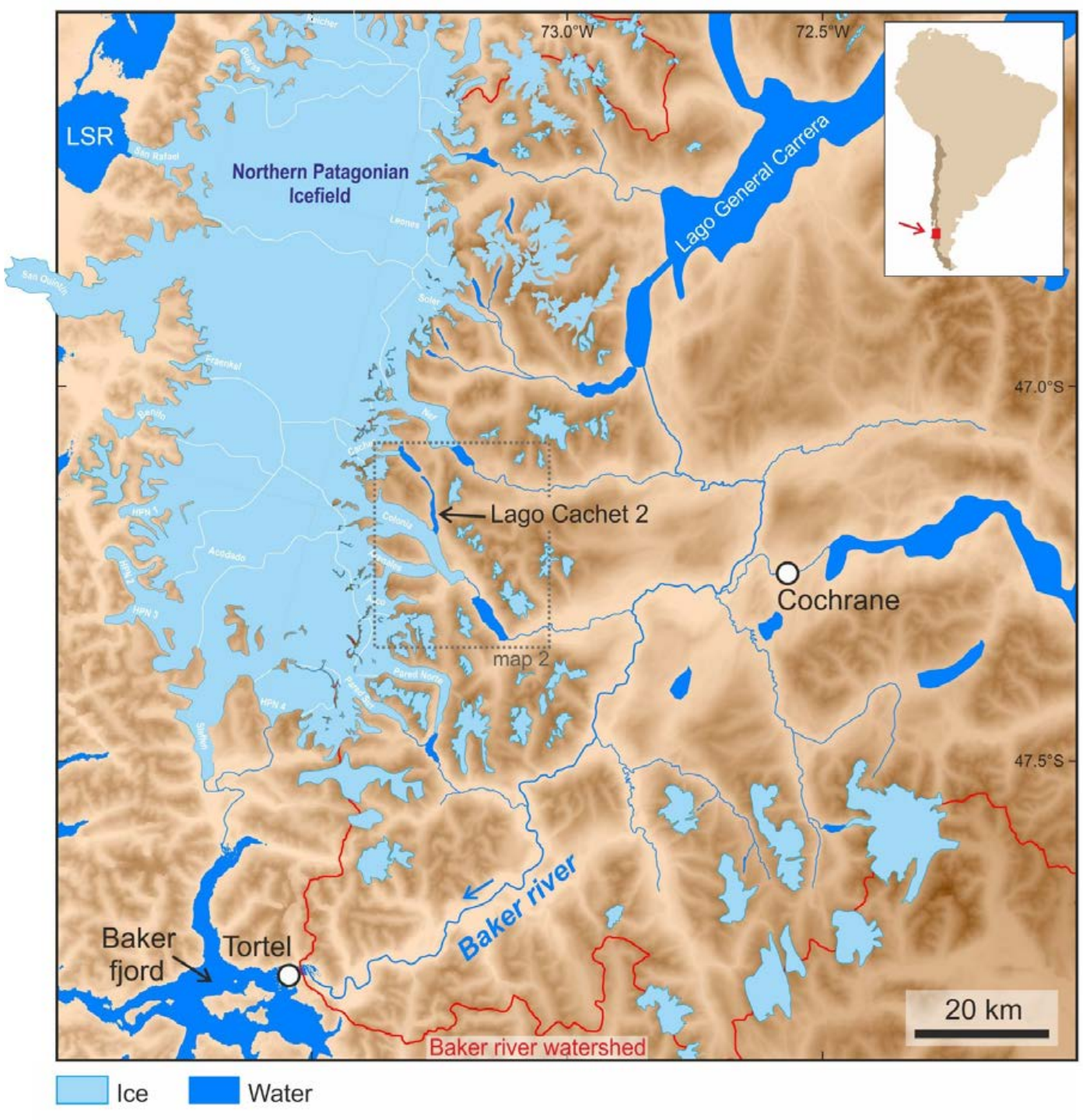
High-resolution surface sediment sampling

Paleo-GLOFs

(FWO Research project, 2016–2019)

Assessing the impact of climate change on the frequency of Glacial Lake Outburst Floods in Patagonia

In collaboration with: Silvio Pantoja, Brian Reid, Carlos Moffat, Gino Casassa, Francois De Vleeschouwer, Fernando Torrejón



15 GLOFs between 2008-2014

no GLOFs reported between 1968 and 2008

(Dussaillant et al., 2010)

Conclusions: Fjord sediments as paleo-flood archives

- Fjord sediments: continuous recorders of major floods (i.e., above a specific threshold)
  Advantage: less noise
  Limitation: may miss smaller events (with low sed. concentrations)

- Record flood occurrence, particularly GLOFs

- Potentially record flood magnitude (relations between discharge, grain-size, geochemistry)

- High accumulation rates (>1cm/yr) → successive events are clearly separated

- Resolution: ~decadal. Generally not varved

- Timescale: late Holocene

Thank you!