

# Impacts of asbestos mining activities on lake ecosystems: insights from a multi-proxy paleolimnological investigation (2017–2022)

Olivier Jacques, M.Sc. & Reinhard Pienitz, Ph.D.



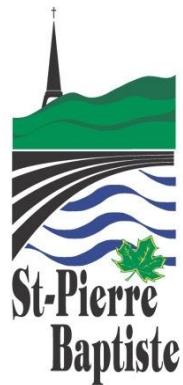
UNIVERSITÉ  
**LAVAL**

 **CentrEau**  
Centre québécois de recherche sur l'eau  
Quebec Water Research Centre

# Partner institutions and municipalities involved in this project



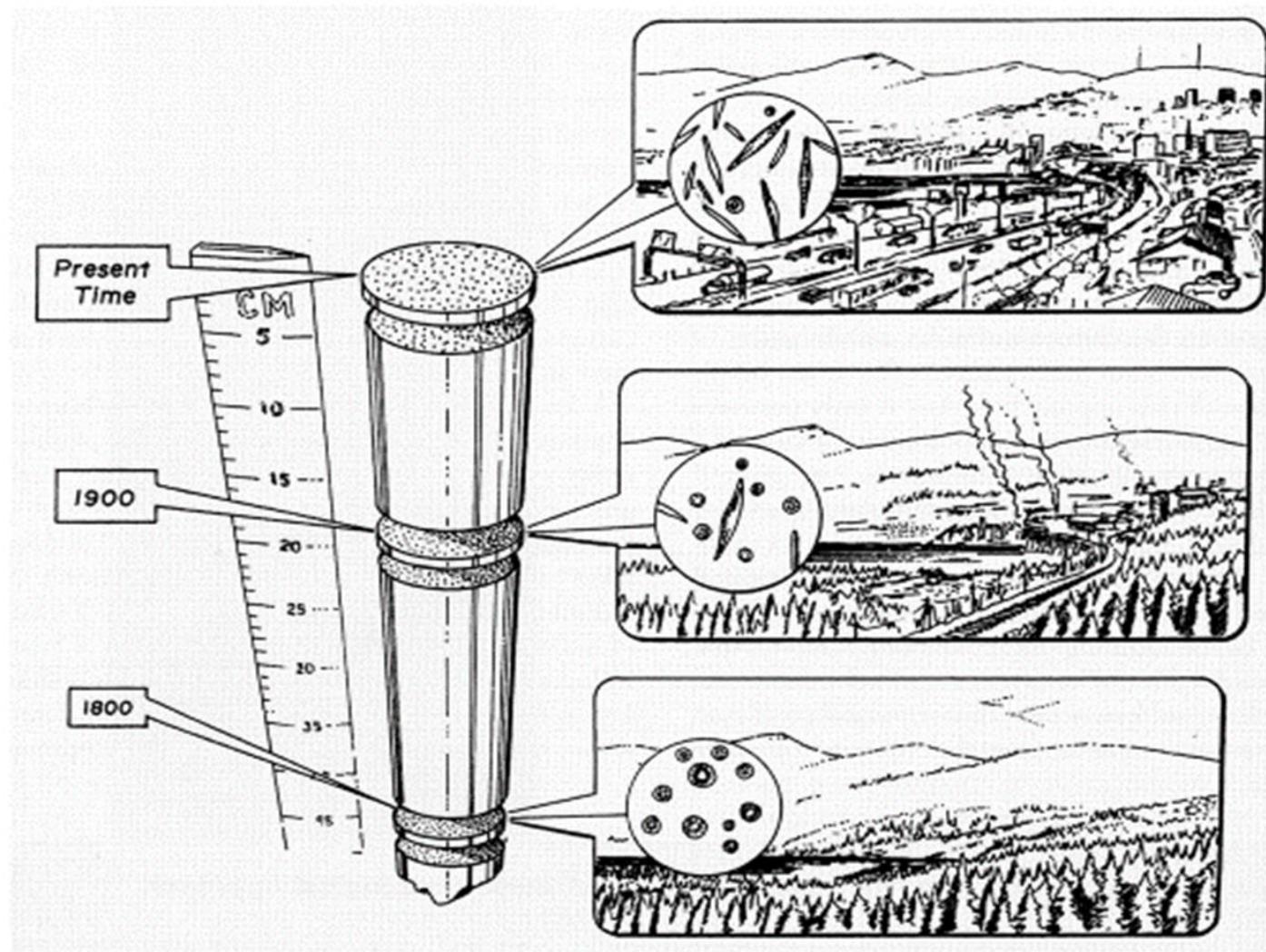
*Fonds de recherche  
Nature et  
technologies*



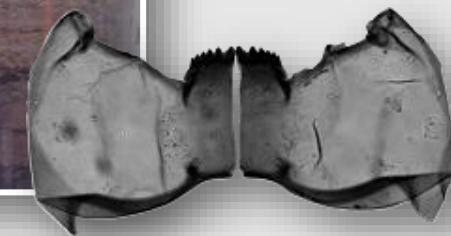
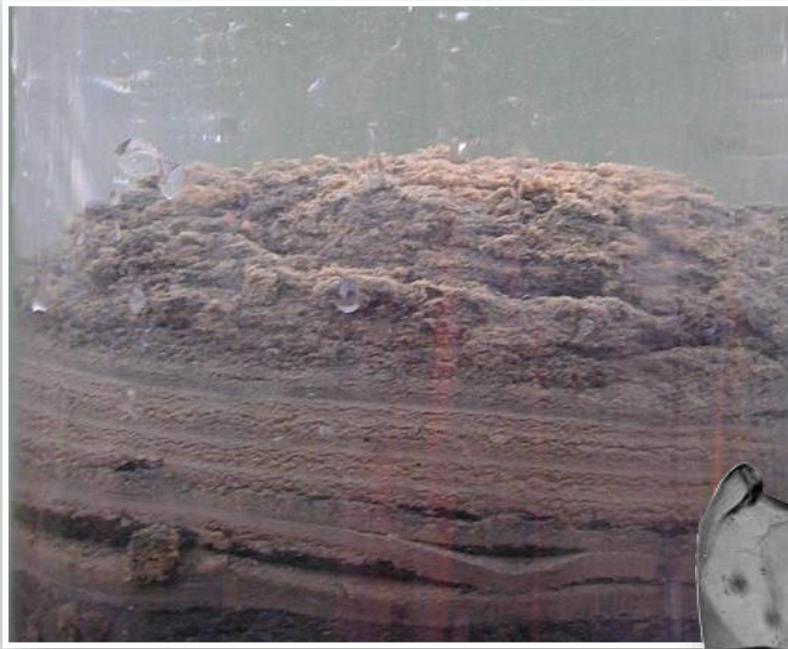
**INVERNESS**  
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# The paleolimnological approach: Insights into the history of lakes and rivers



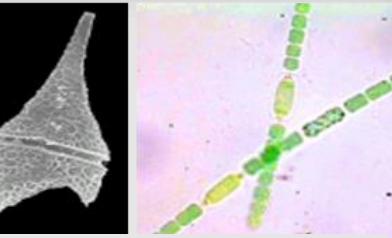
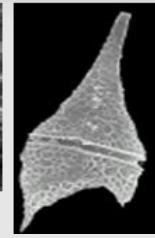
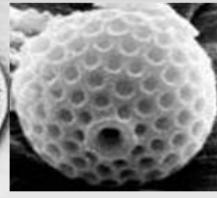
# Multiple indicators of changes in sediment archives



Isotopes

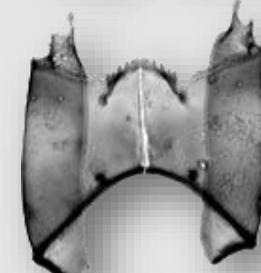
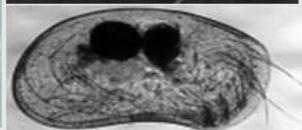
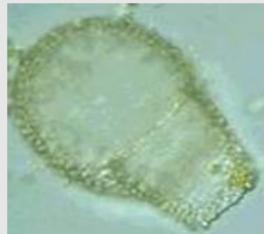
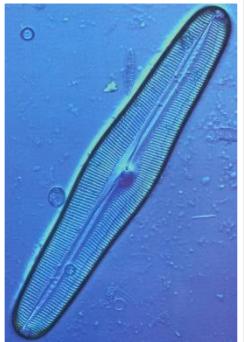
$\delta^{18}\text{O}$

$\delta^{13}\text{C}$   $\delta^{15}\text{N}$

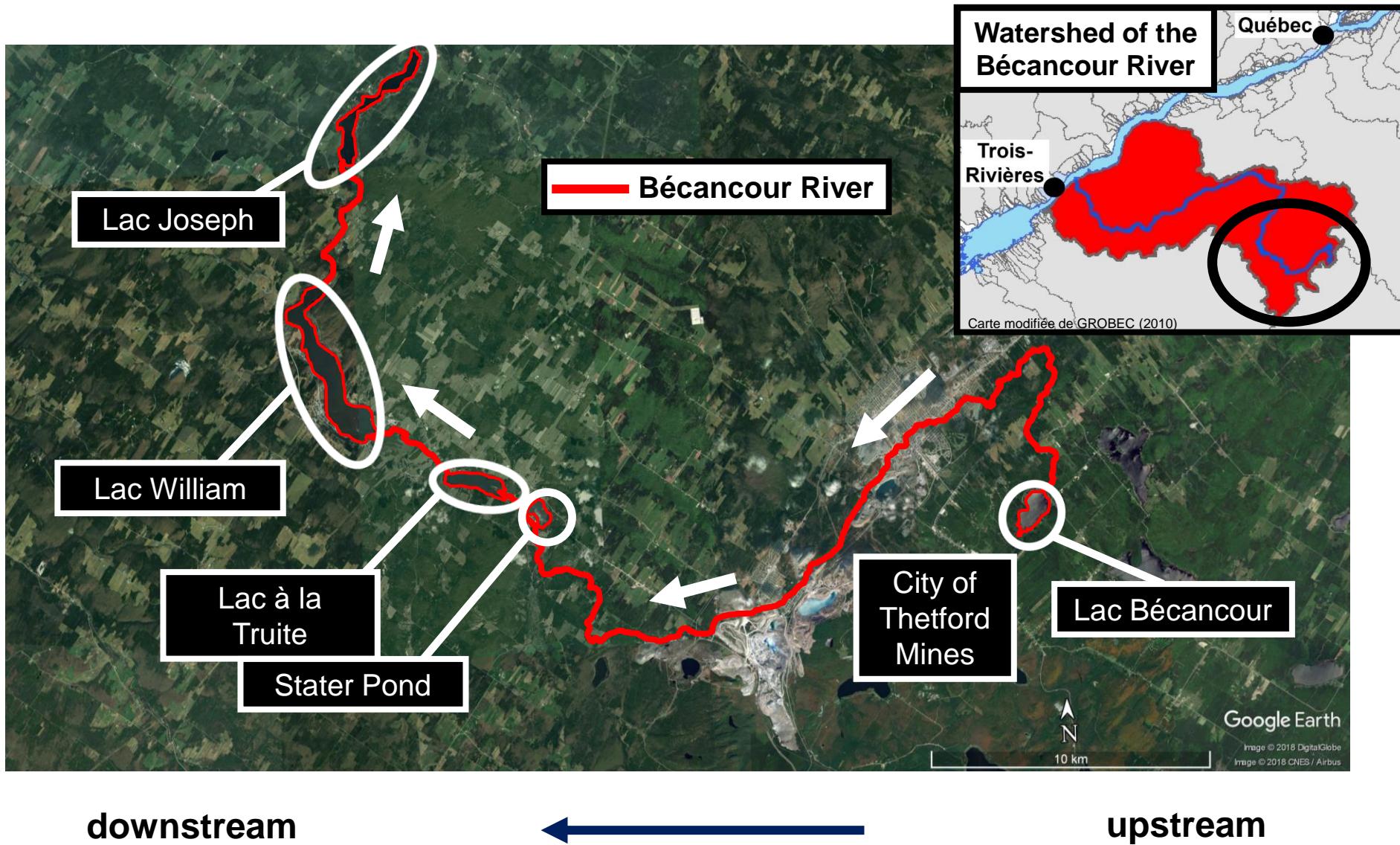


algues

invertébrés



# Chain of study sites (fluvial lakes)



# Main problems and challenges

## ❖ Eutrophication



Photo credit : APLTI



Photo credit : ALW

# Main problems and challenges

## ❖ Lake sediment infilling



Lac à la Truite



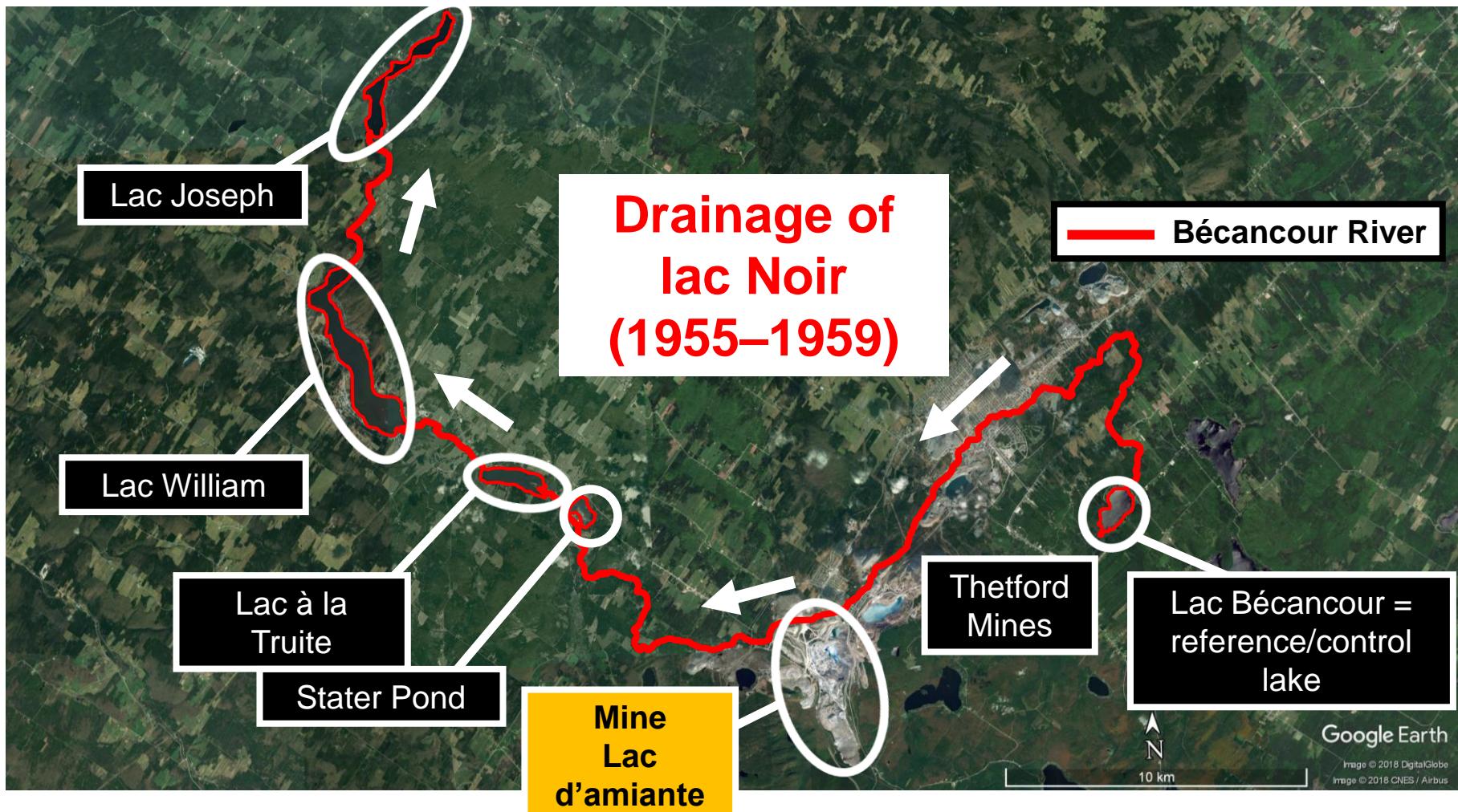
Lac William



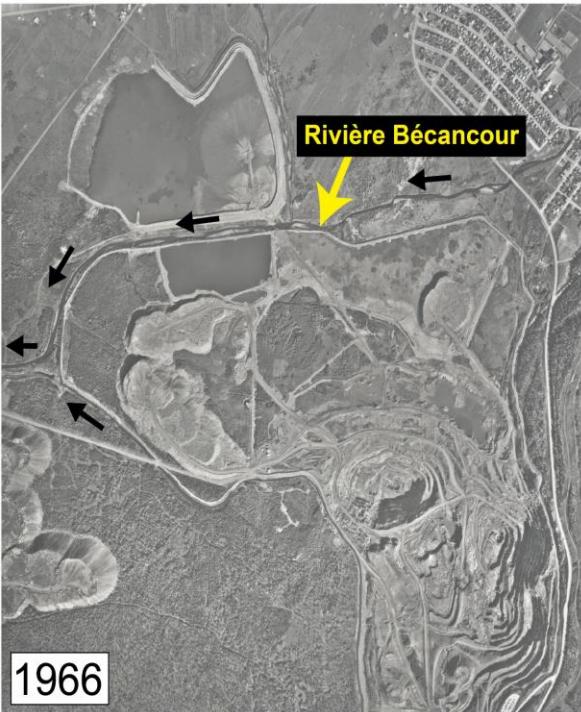
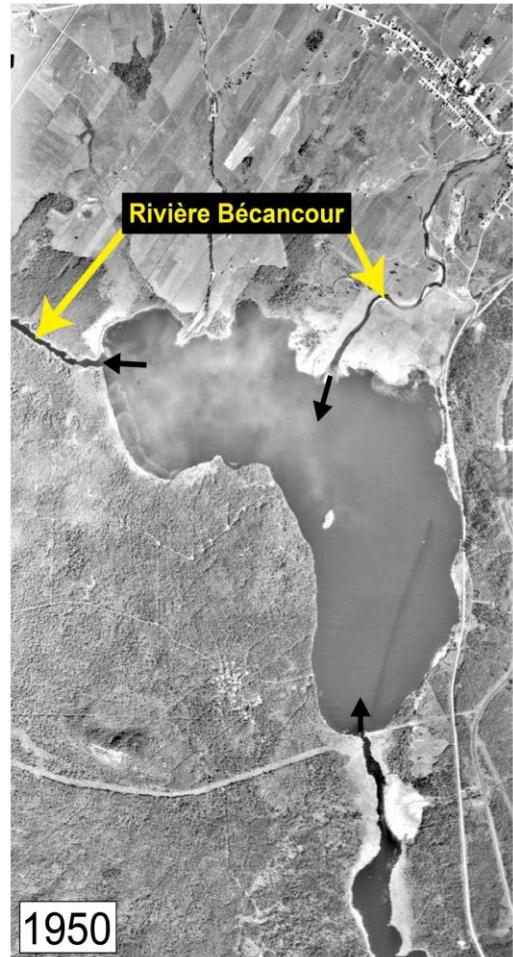
Source : Courier Frontenac (2016)

Photo credit : Laurier Larose

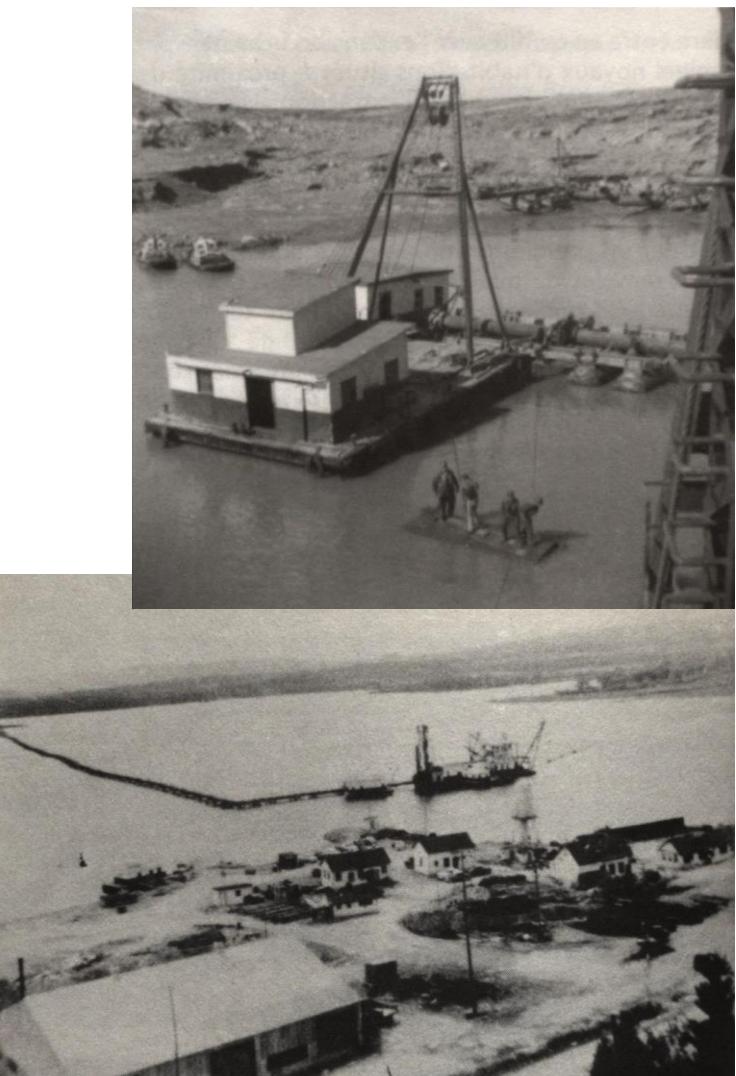
# Main problems and challenges



# Main problems and challenges

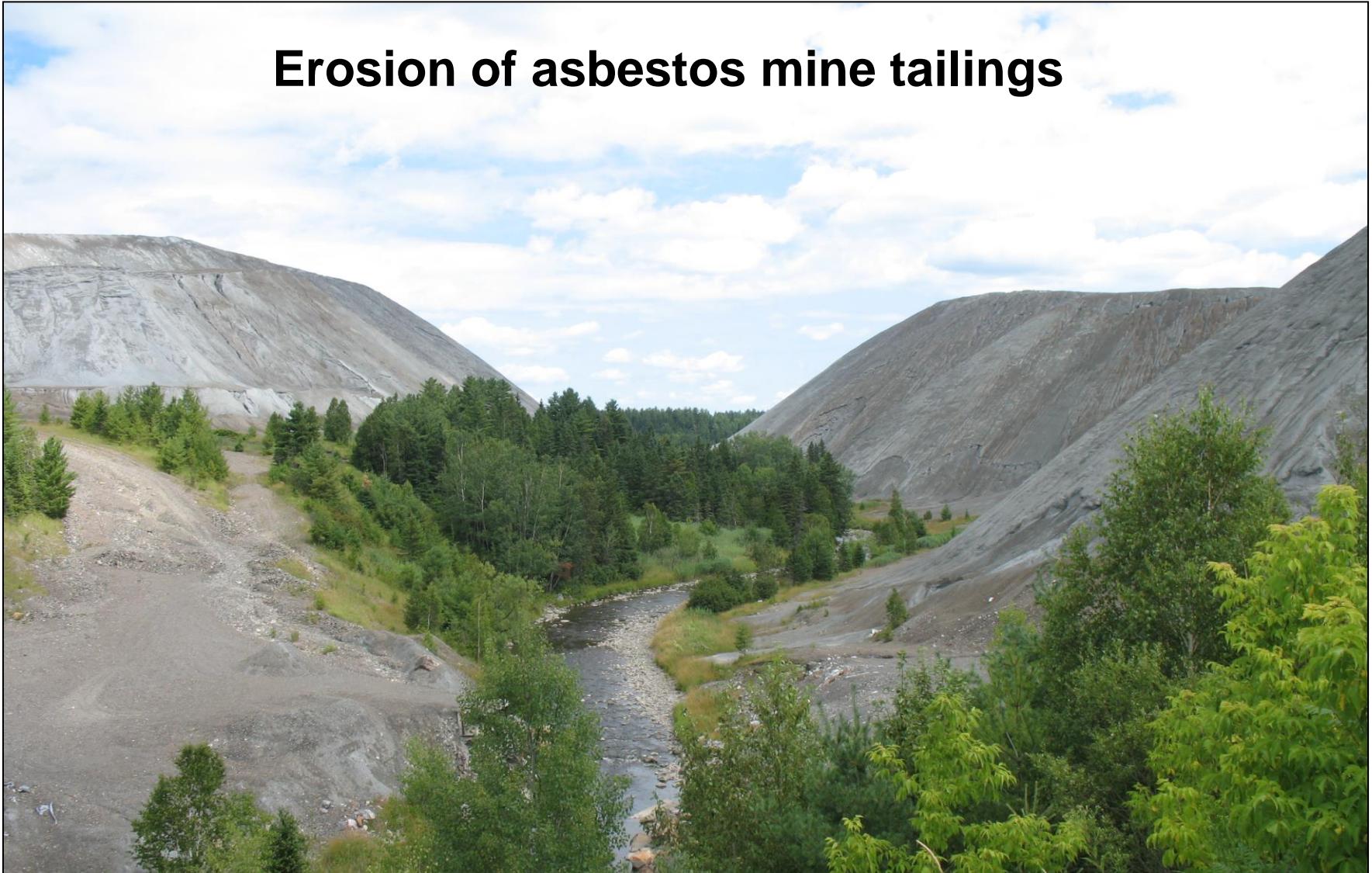


**Drainage of  
lac Noir  
(1955–1959)**



# Problem: Lake sediment infilling

Erosion of asbestos mine tailings



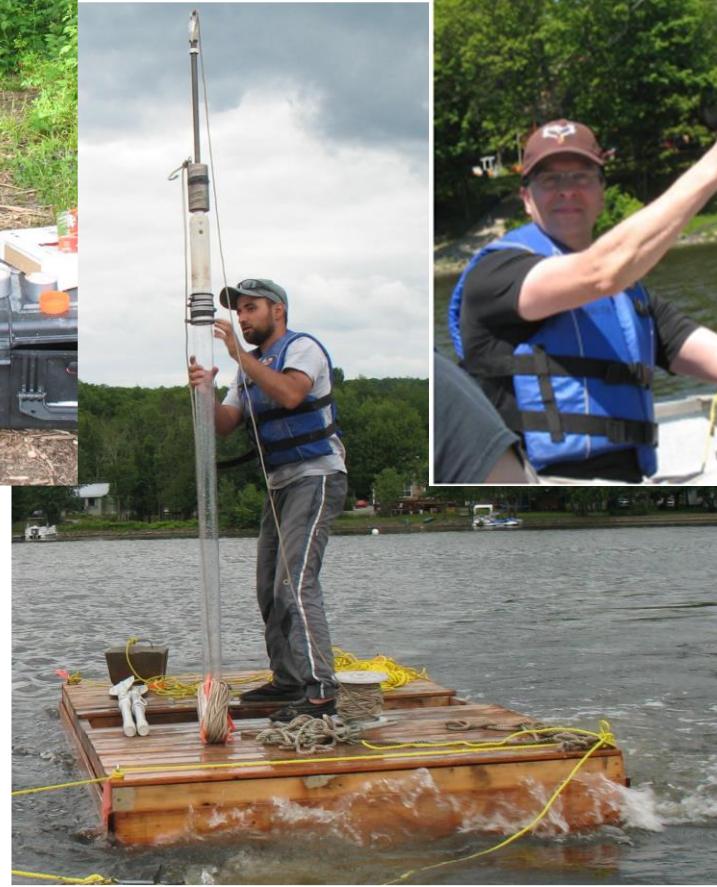
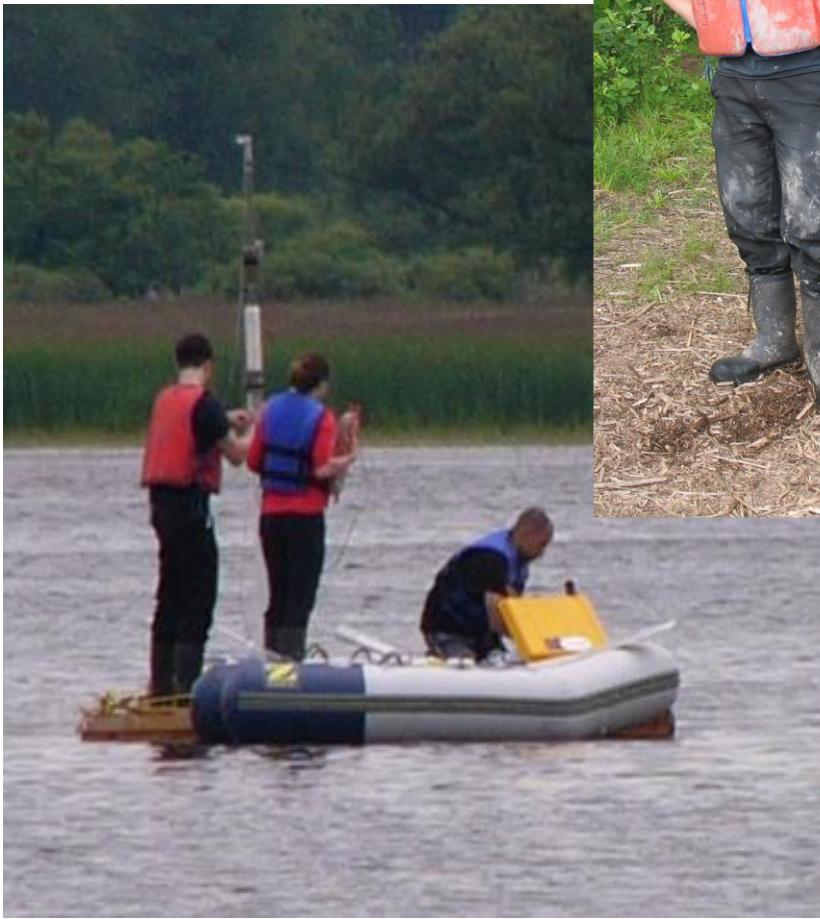
# Main research questions

- ❖ What are the origins of the lake infilling and eutrophication ?
- ❖ What are the natural background conditions of the lakes ?
- ❖ What is the level of ecosystem deterioration ?

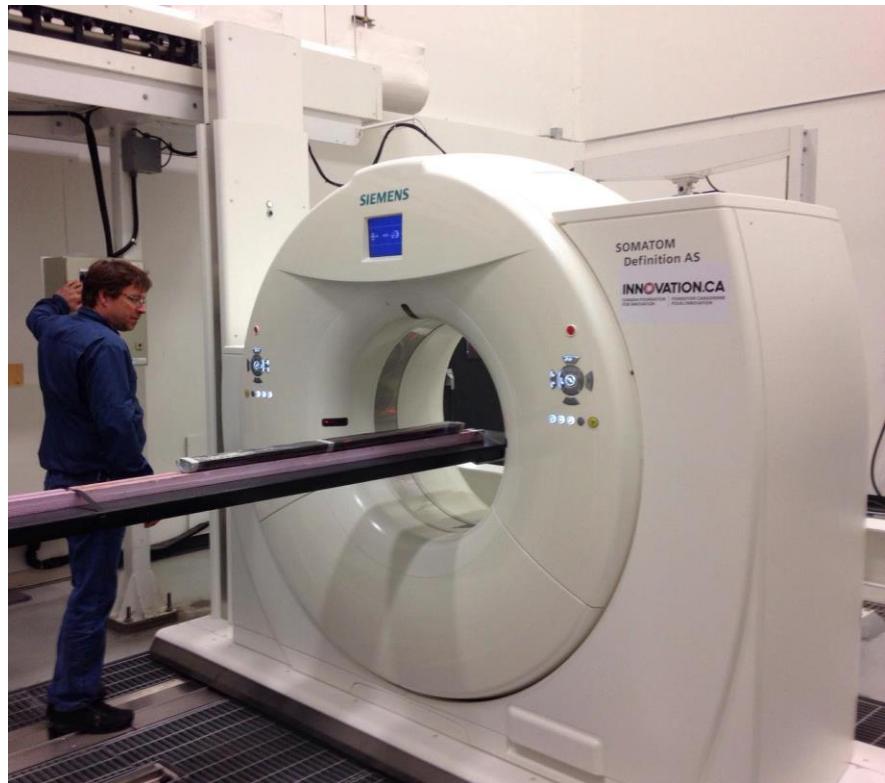
→ **Main objective : reconstruct the lake « health » evolution of the lakes in the Bécancour River basin over time.**

→ **Method : paleolimnology**

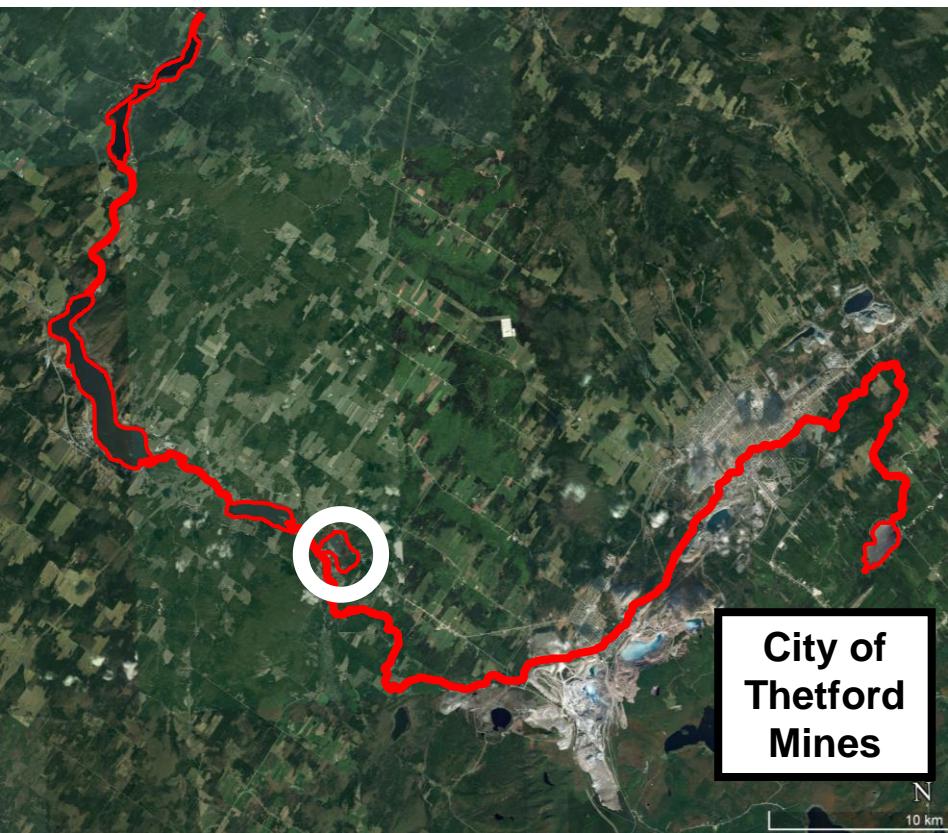
# Sediment sampling (summer 2017)



# Laboratory analyses

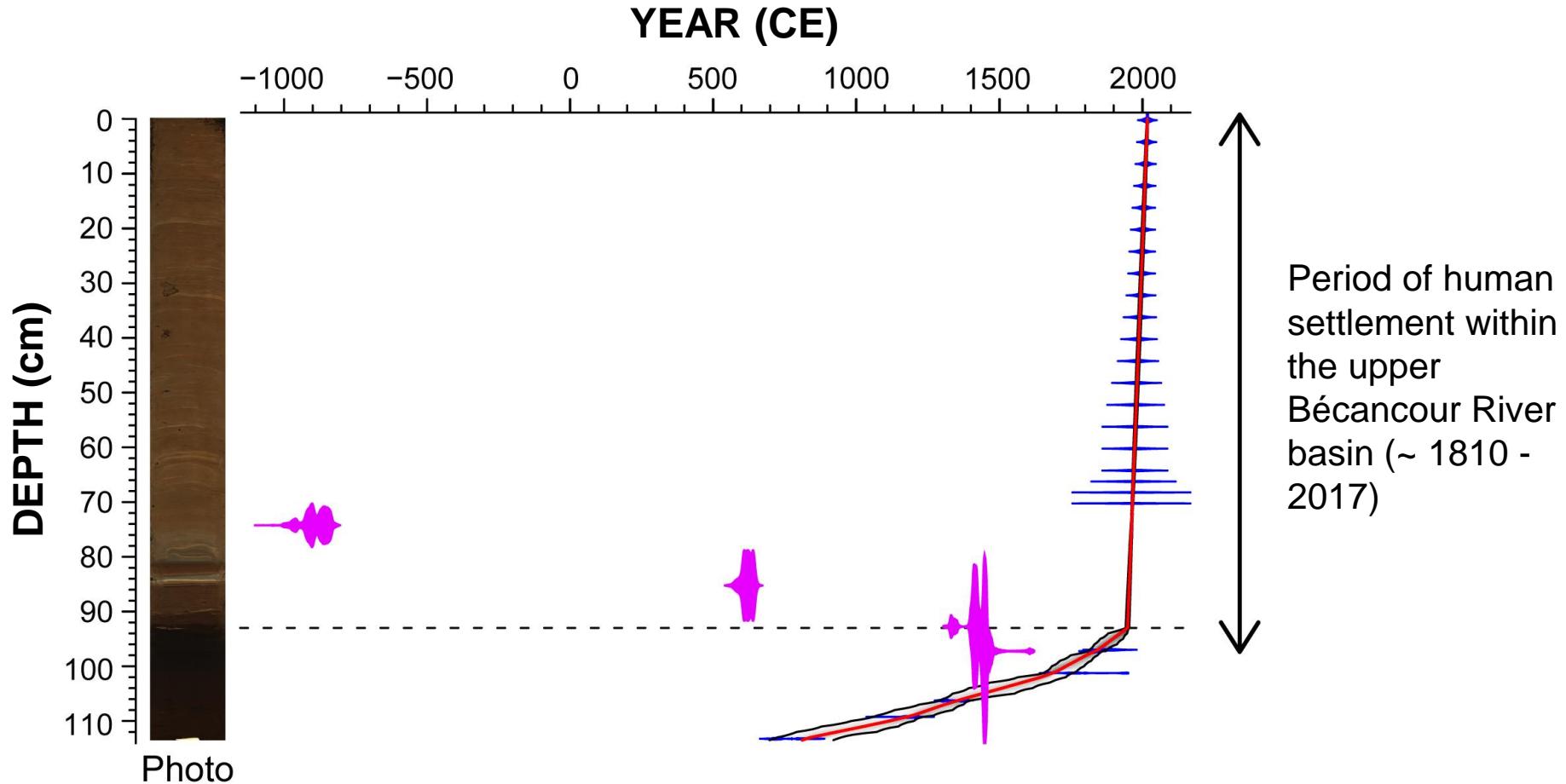


# Stater Pond

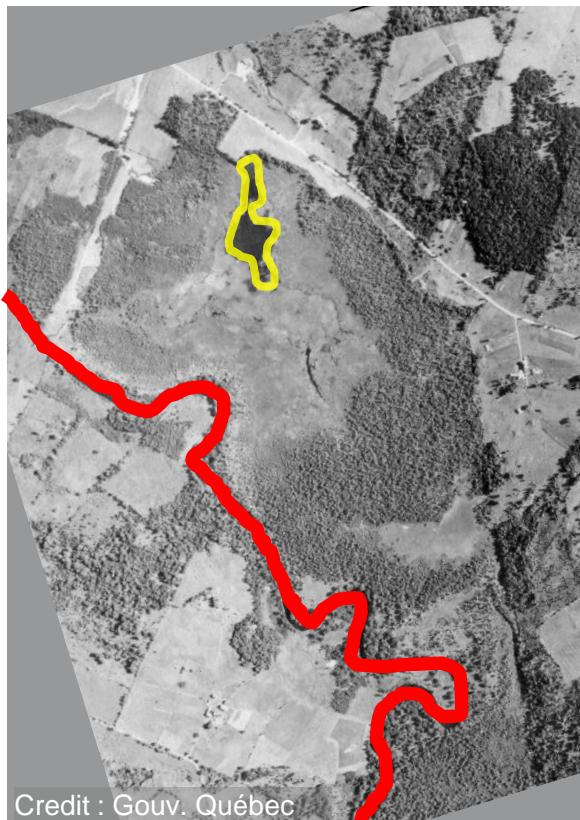


**1st water body  
located downstream  
from the mines**

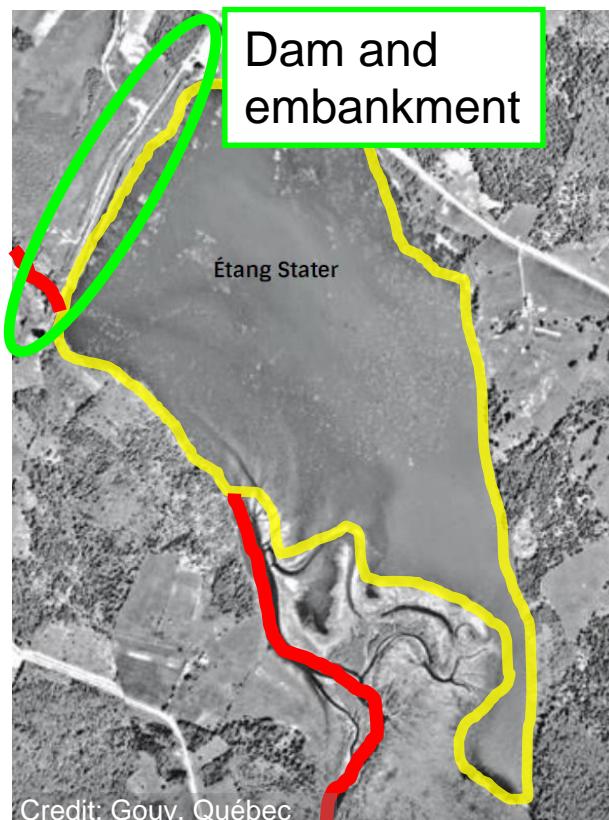
# Stater Pond – Core chronology



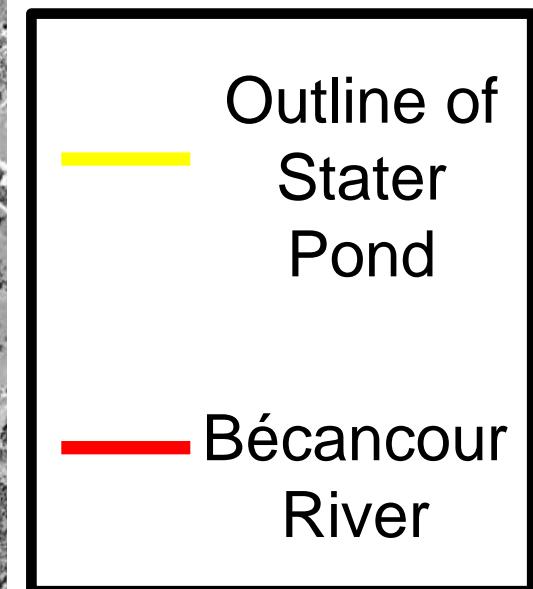
# Stater Pond – changes within the watershed



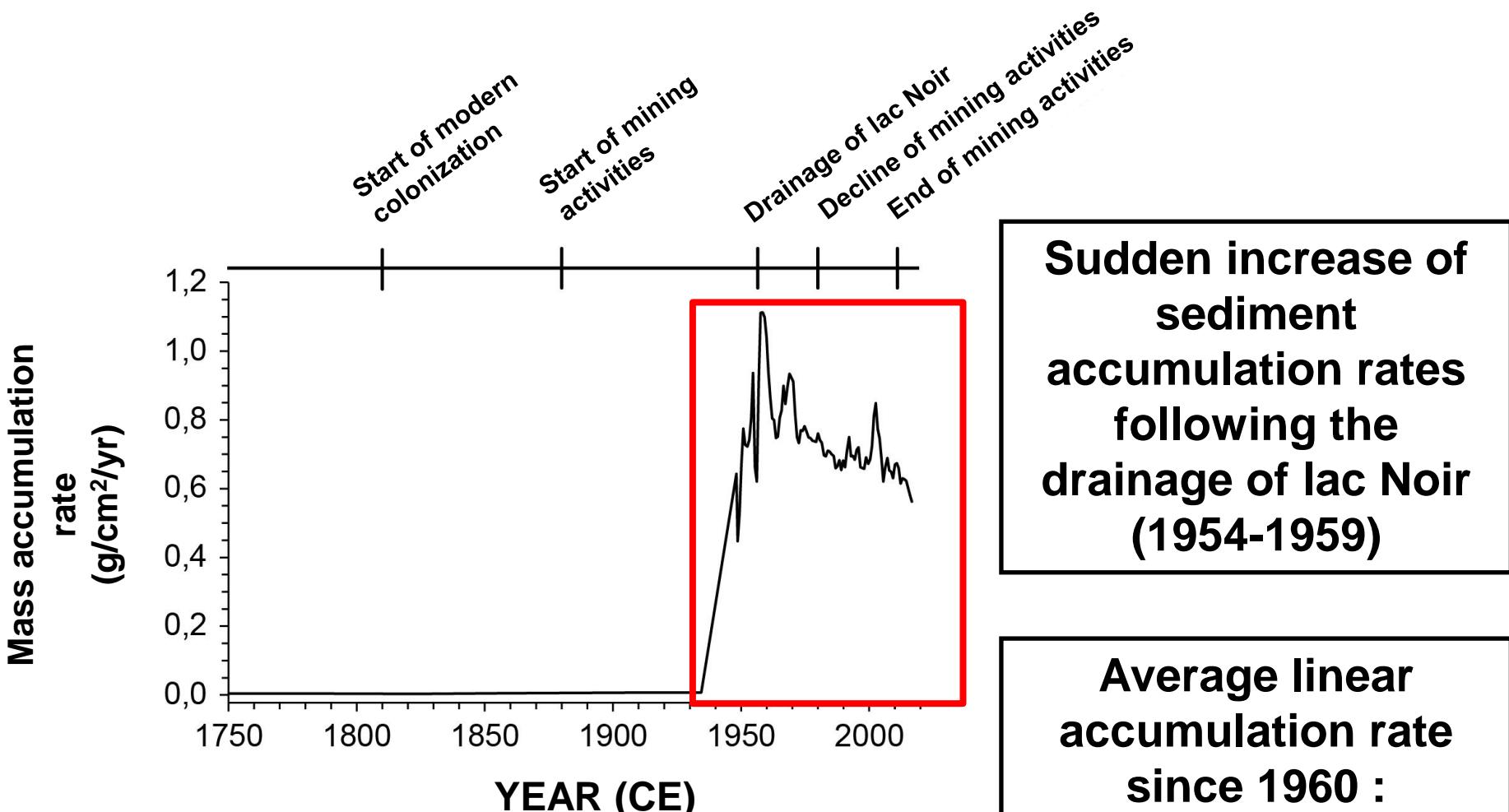
Before 1954



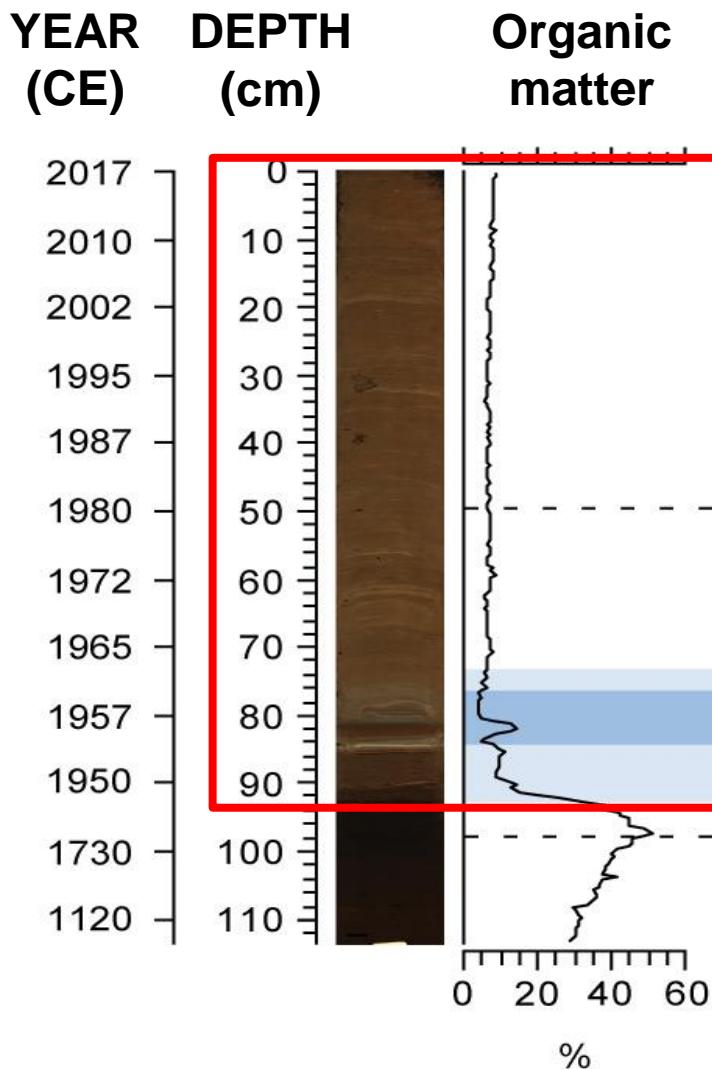
After 1959



# Stater Pond – sediment accumulation rates



# Stater Pond – organic matter content

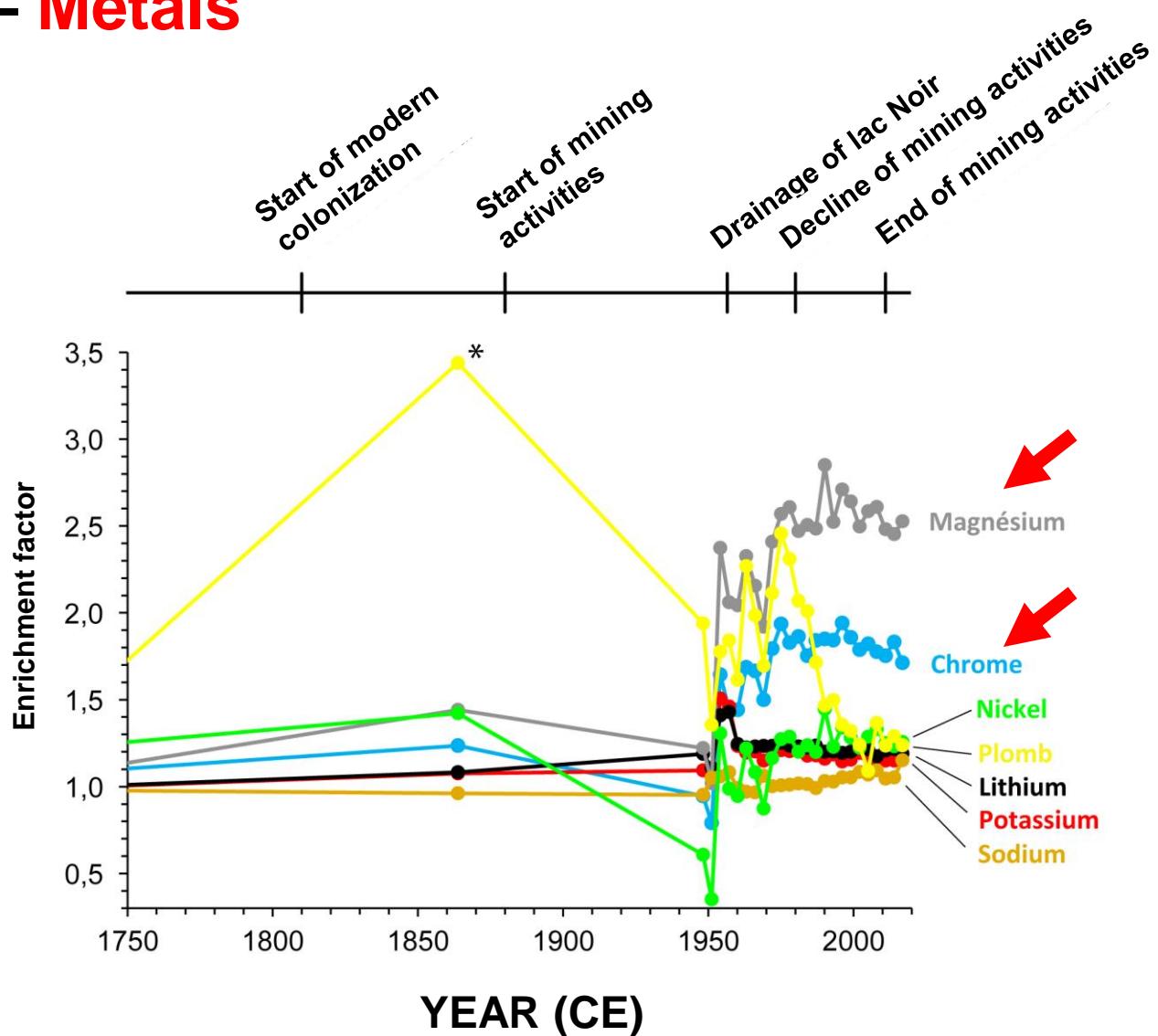


Sediments deposited since 1954 are very poor in organic matter (< 9 %)

→ important inputs of mineral matter

# Stater Pond – Metals

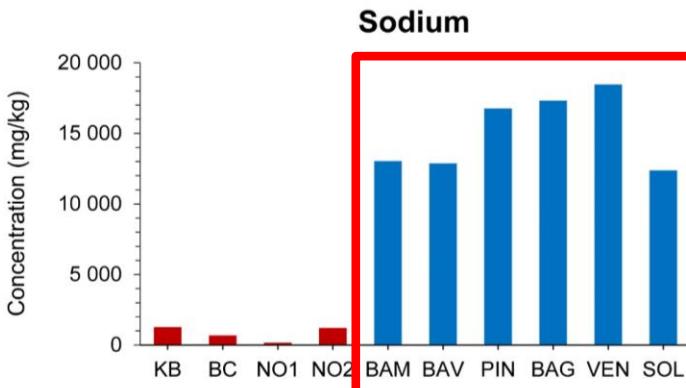
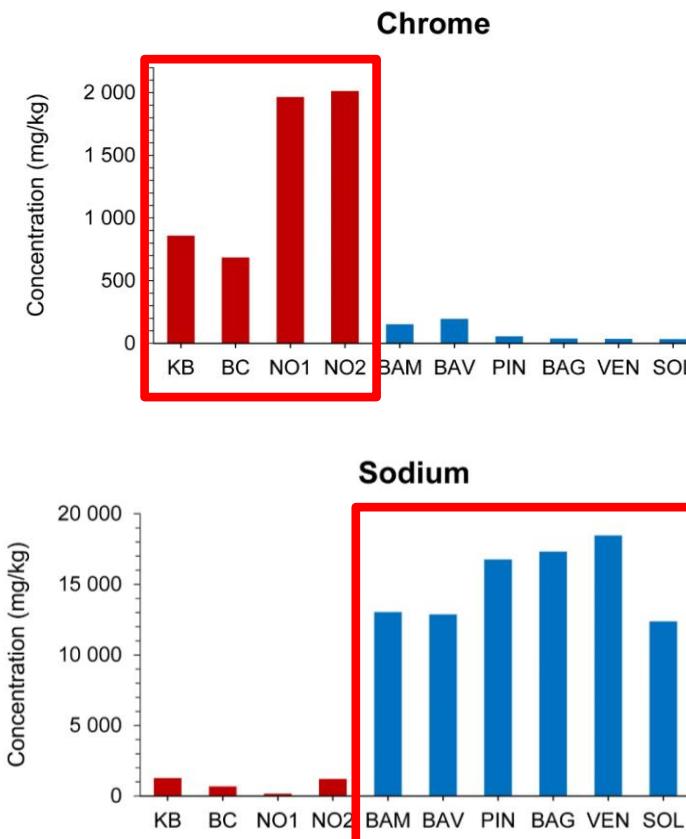
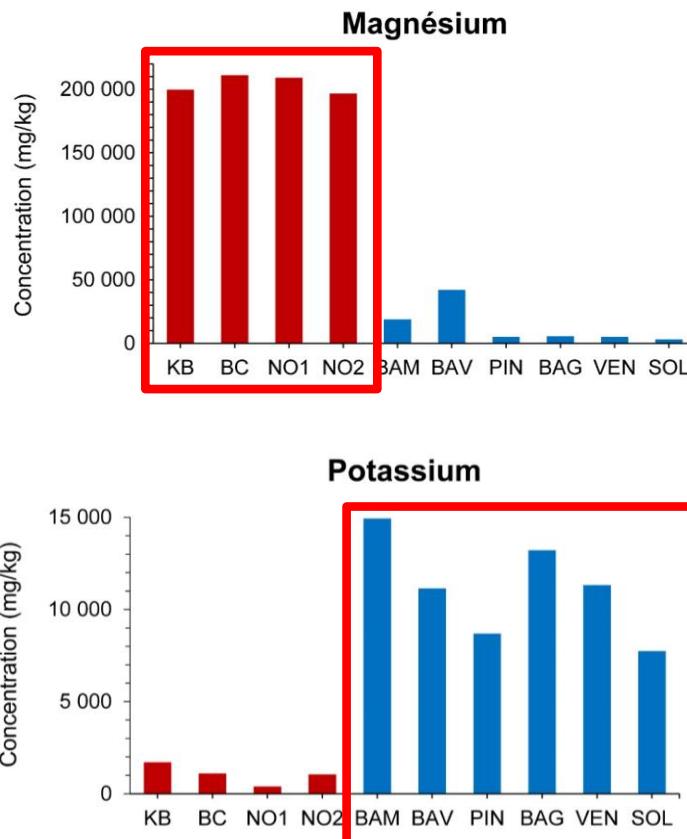
Sediments deposited since 1954 are abnormally enriched in magnesium and chromium





**Asbestos mining  
wastes contain  
high  
concentrations of  
magnesium and  
chromium**

# Sediment sources/origins



Asbestos  
mining  
residues

Riverine and  
soil  
sediments  
from tributary  
rivers

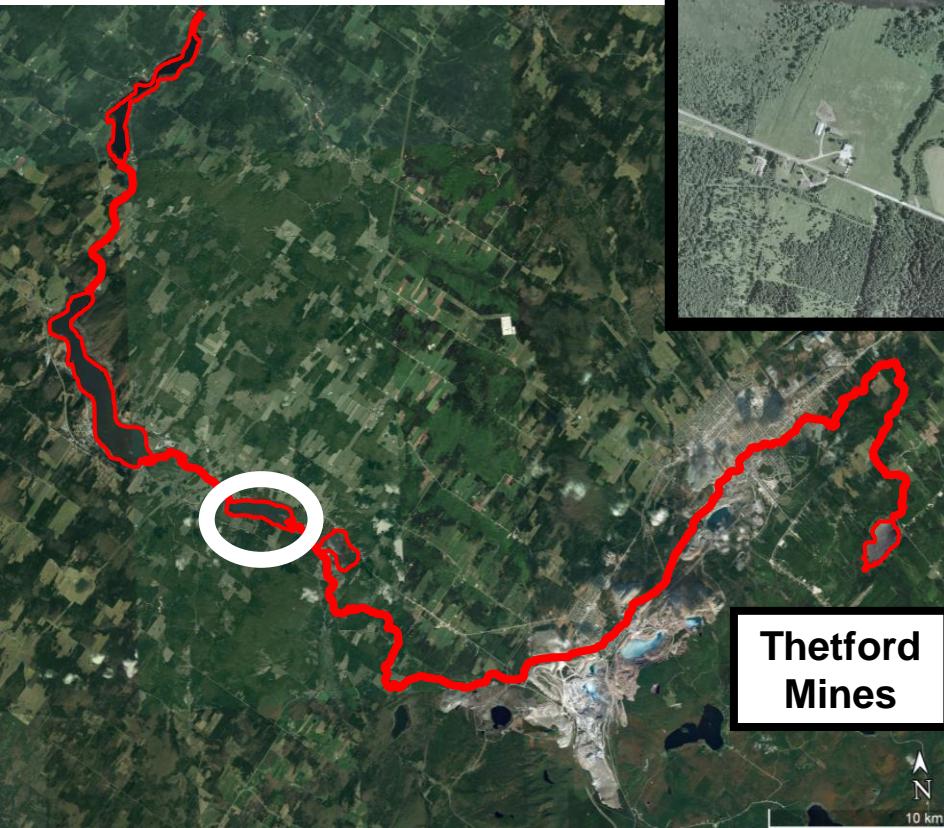
# **Summary : Massive mine tailing erosion has strong impacts on the Bécancour River**



Photo credit: Chum 2015

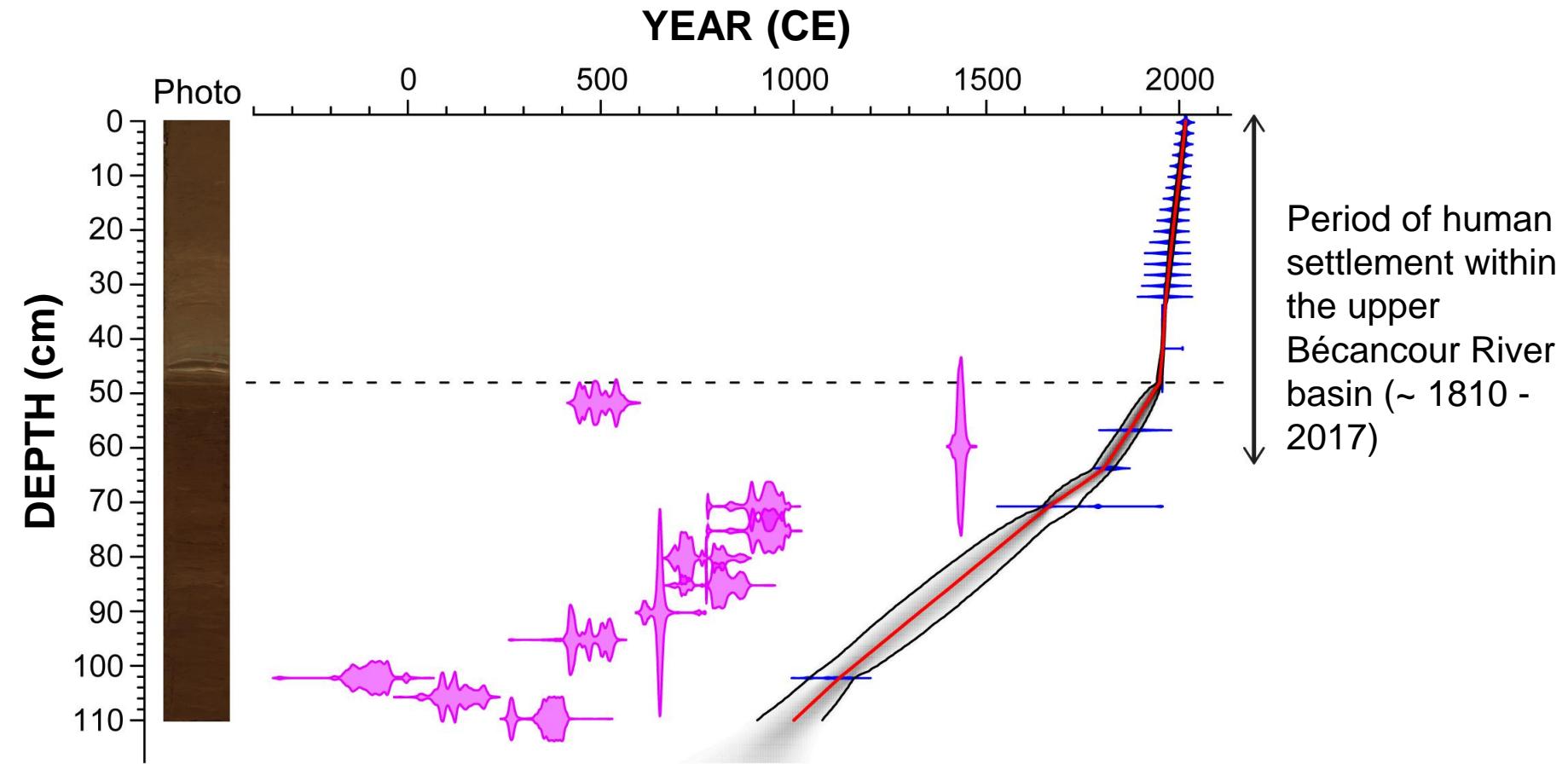
Photo credit: APLTI

# Lac à la Truite

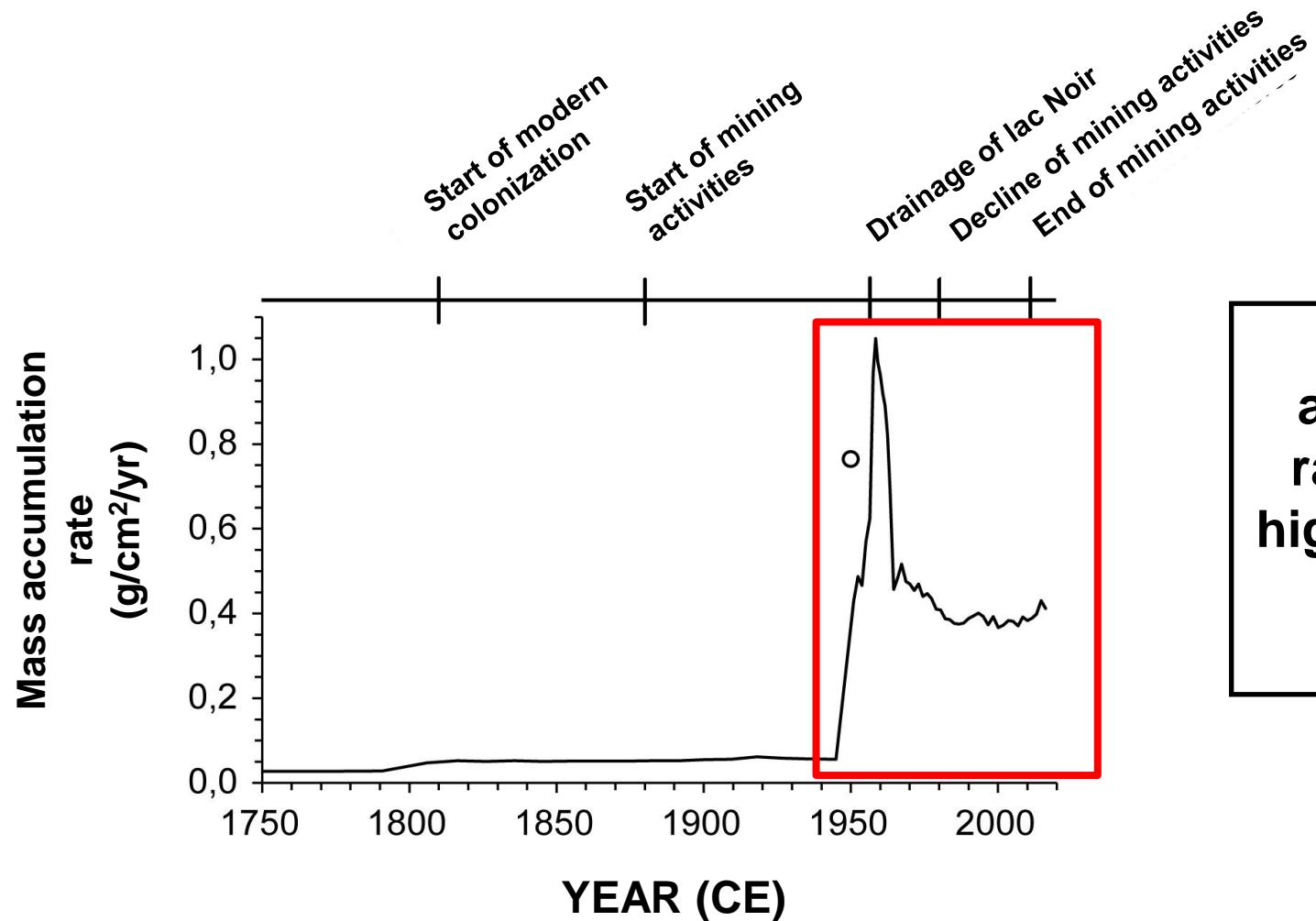


**2nd water body  
located downstream  
from the mines**

# Lac à la Truite – Chronology



# Lac à la Truite – sediment accumulation rates



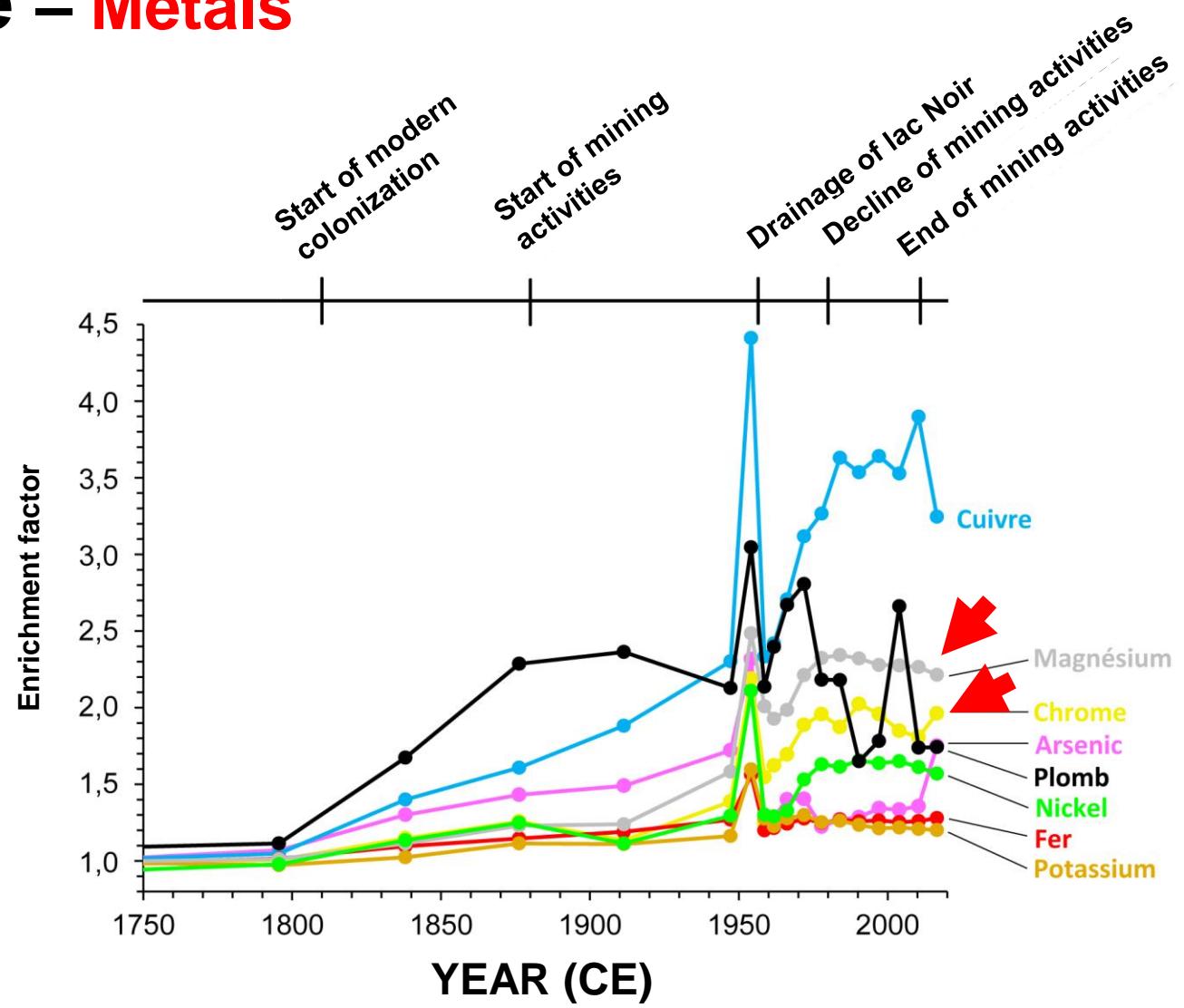
**Sediment accumulation rates still very high since 1954 :**

**$\sim 0,7 \text{ cm/yr}$**

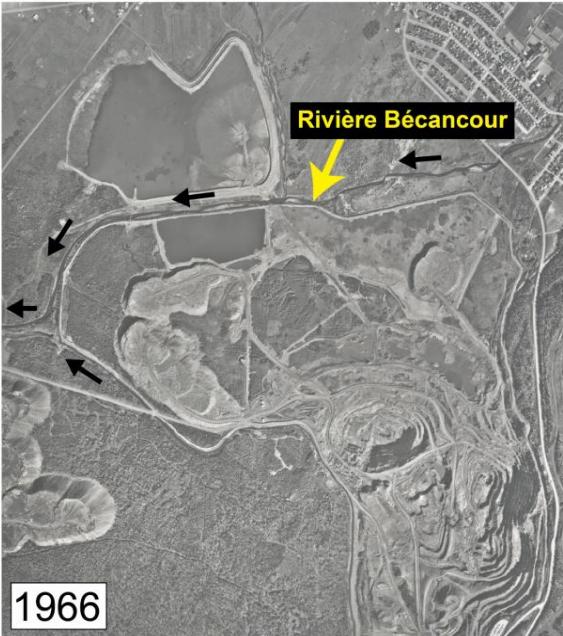
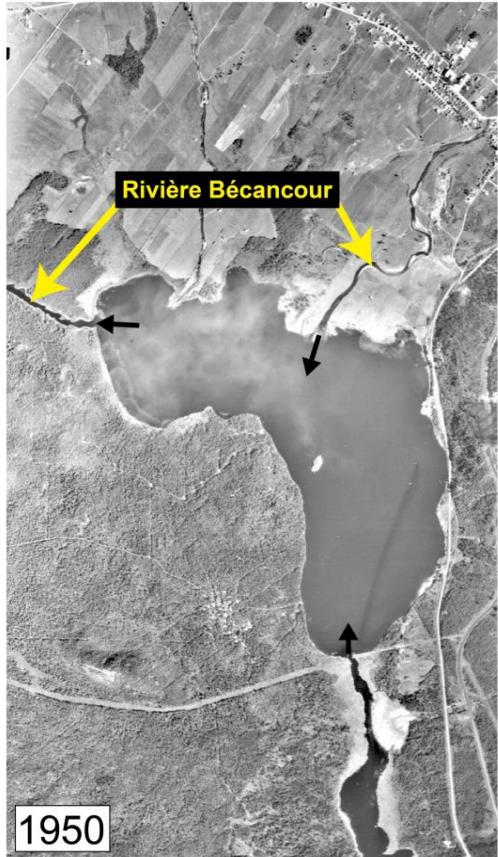
# Lac à la Truite – Metals



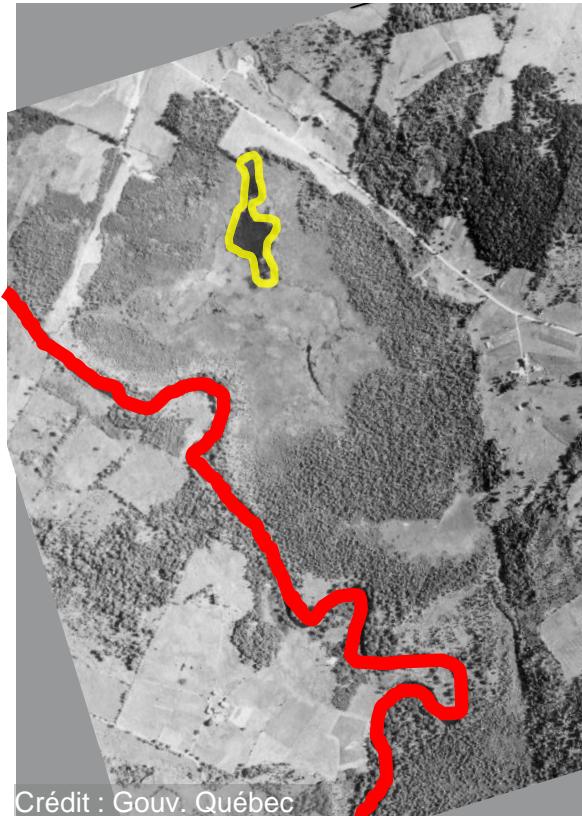
Important inputs  
of mining  
residues



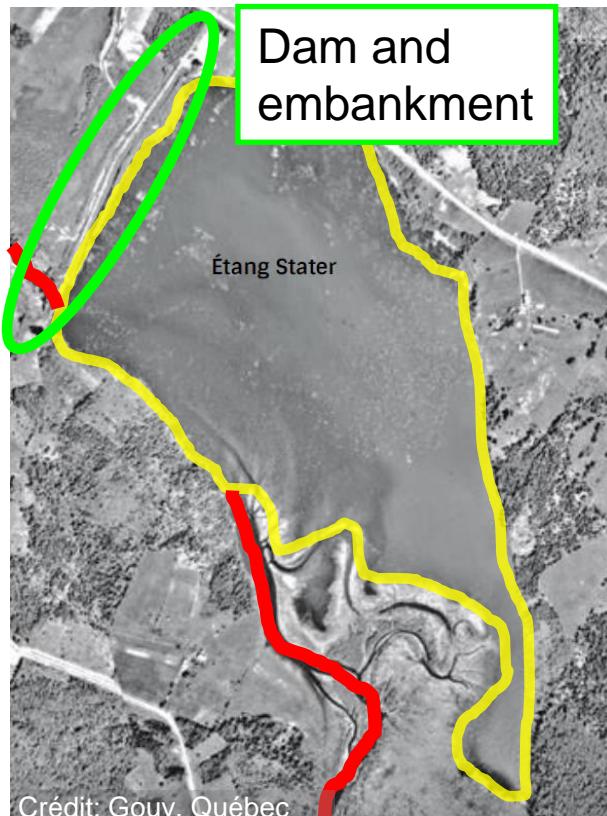
# Major impact event: Drainage of lac Noir (1955-1959)



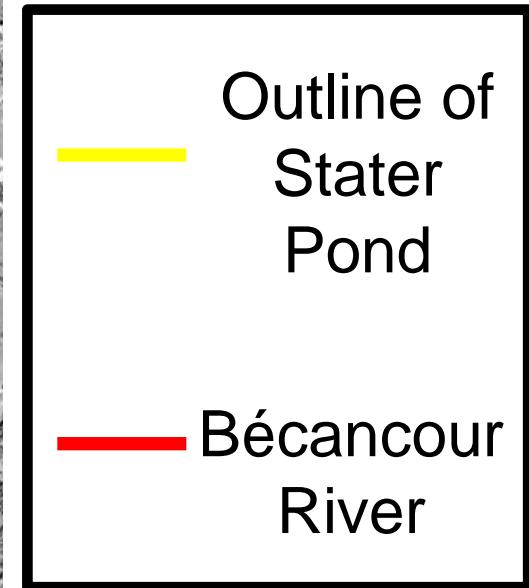
# Conclusion: Stater Pond was not sufficient as a sediment retention basin



Before 1954

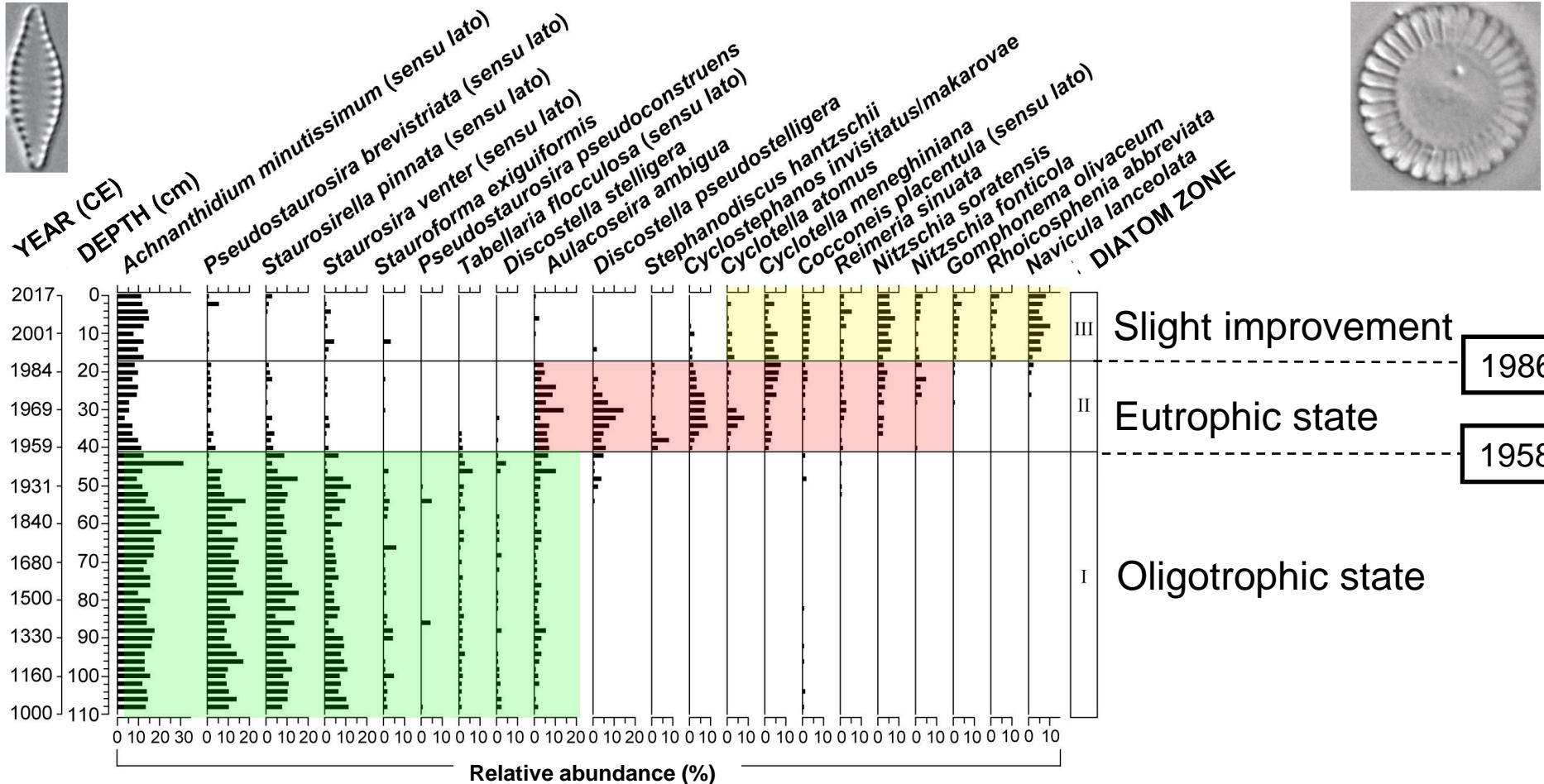


After 1959



# Lac à la Truite –

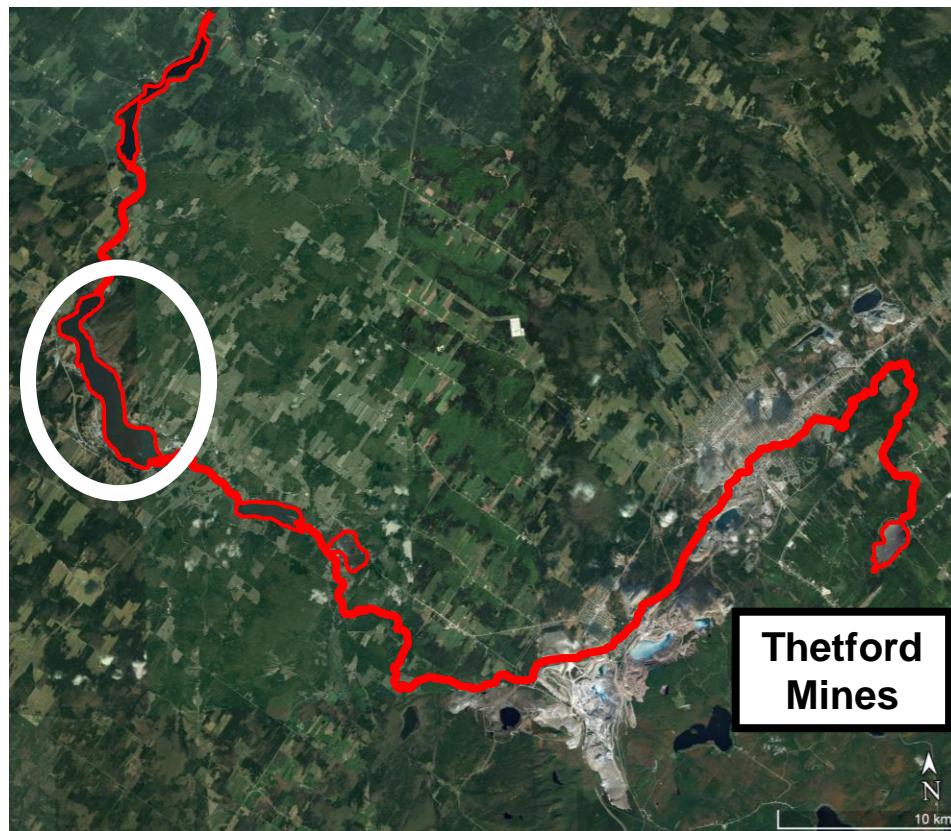
## Fossil algae (diatoms) and trophic state



# Water treatment station of the Upper Bécancour River (since 1986)

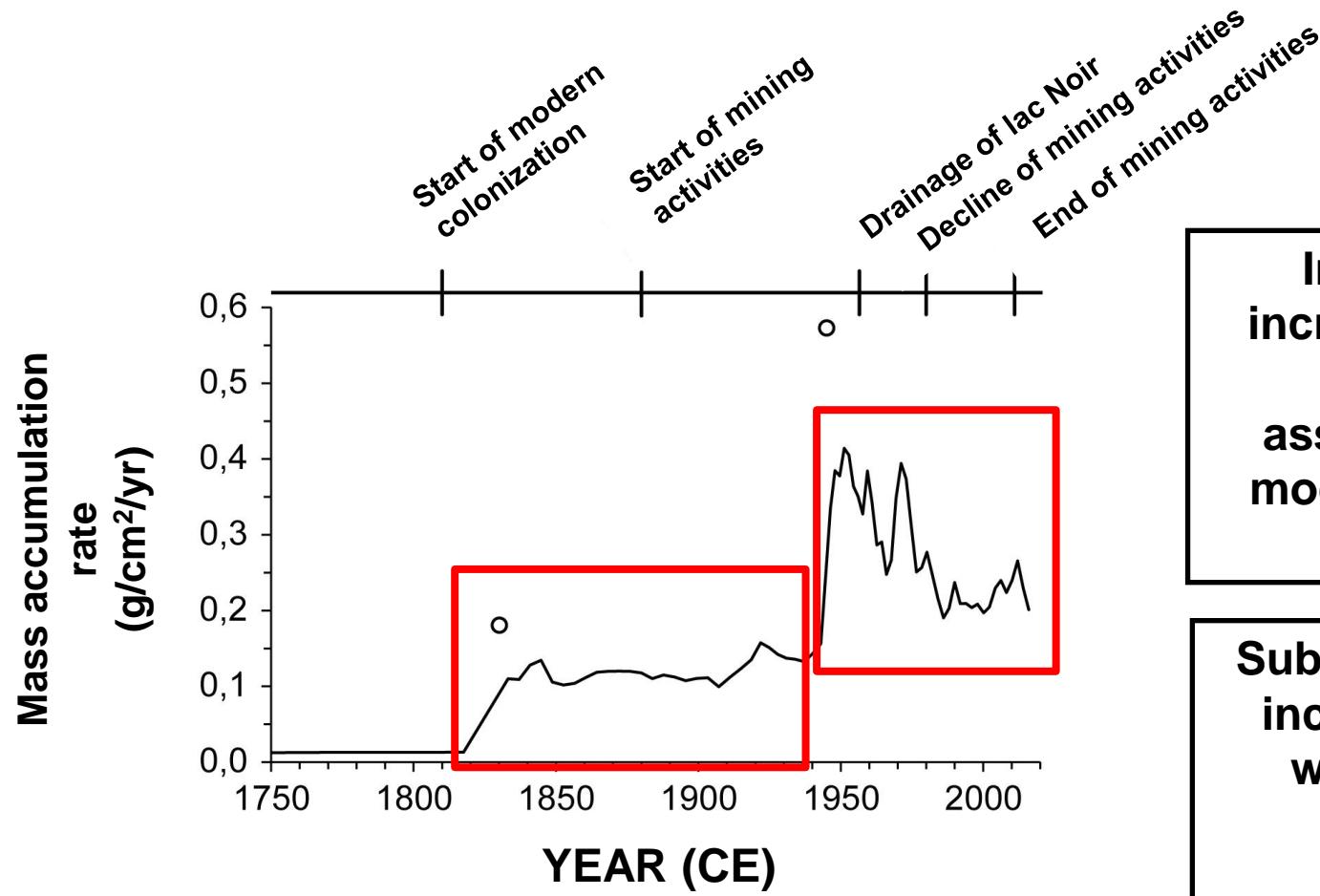


# Lac William



**3rd water body  
located  
downstream from  
the mines**

# Lac William – sediment accumulation rates



**Important initial increase in sediment accumulation associated with the modern colonization (0,3 cm/an)**

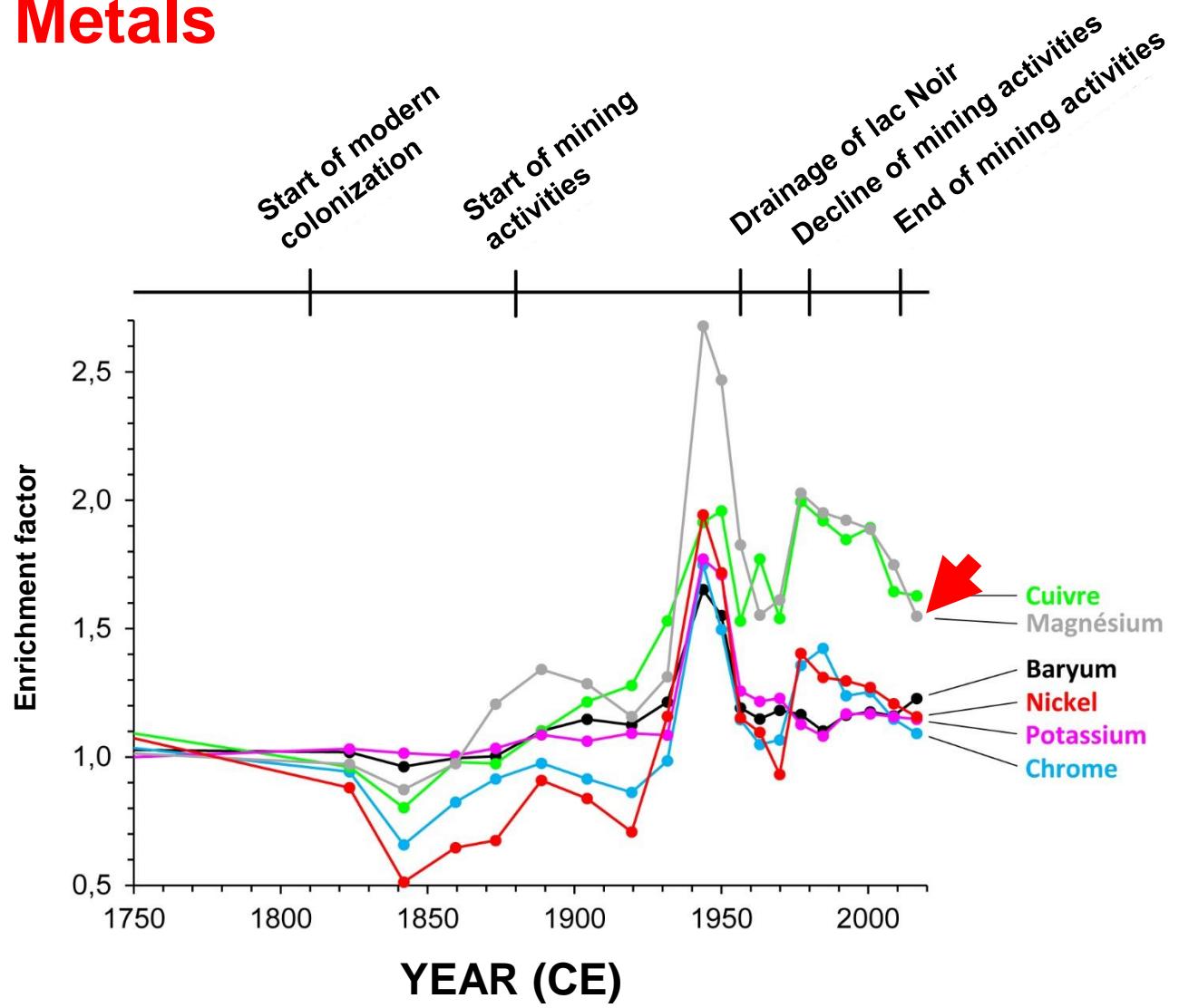
**Subsequent important increase associated with the drainage of lac Noir**

**Since 1954 : ~ 0,5 cm/an**

# Lac William – Metals

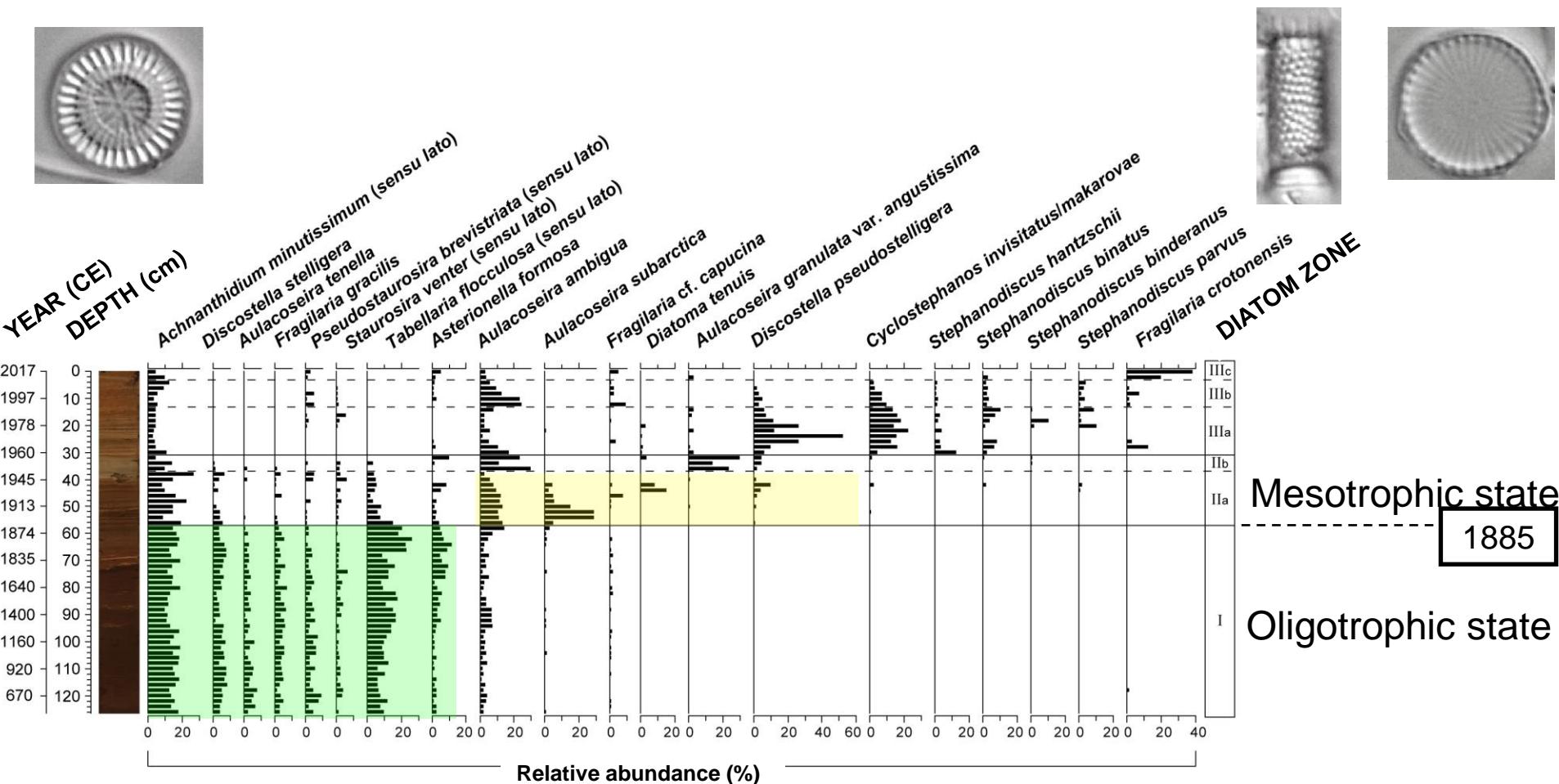


Important inputs  
of mining  
residues



# Lac William –

## Fossil algae and trophic state (diatoms)

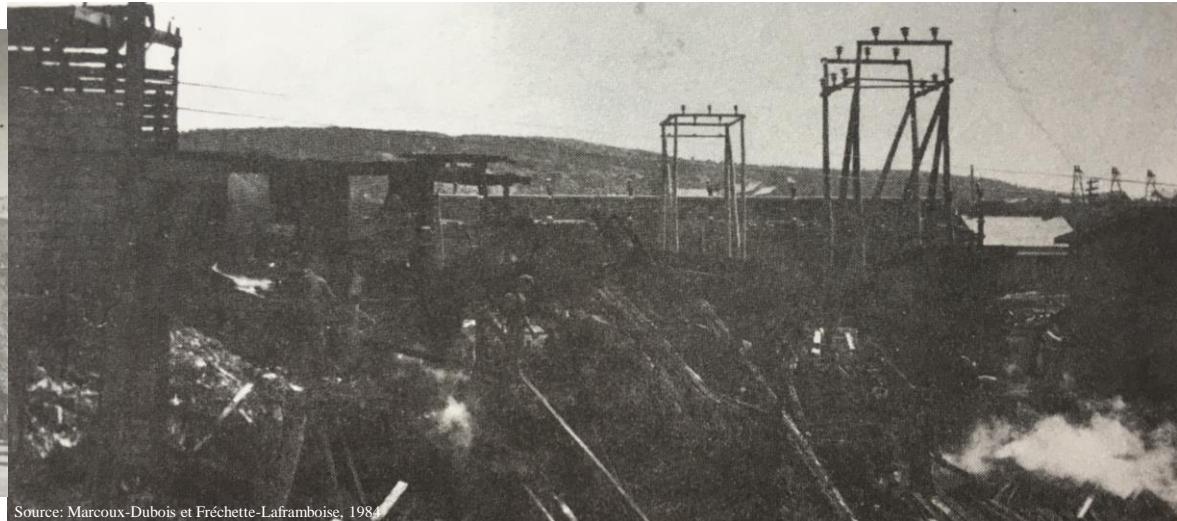


# Important changes/events in the watershed of Lac William:

- ❖ **Opening of Saint-Julien hospital in 1872** (Marcoux-Dubois et Fréchette-Laframboise, 1984);
- ❖ **Timber trade and log drive on Lac William since 1885** (Marcoux-Dubois et Fréchette-Laframboise, 1984);
- ❖ **Construction of the first sewer system around 1900 ?**

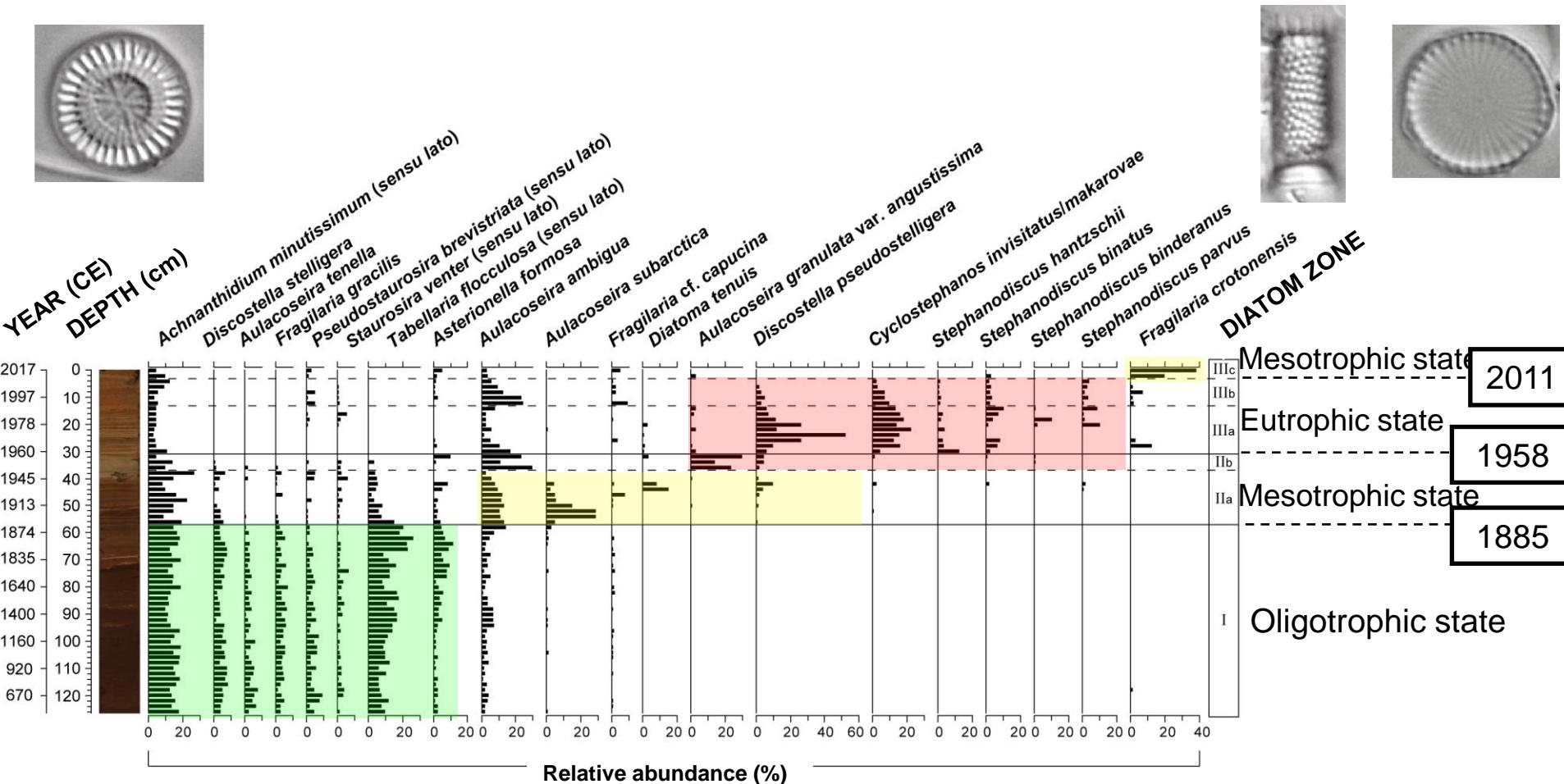


Source: Marcoux-Dubois et Fréchette-Laframboise, 1984



Source: Marcoux-Dubois et Fréchette-Laframboise, 1984

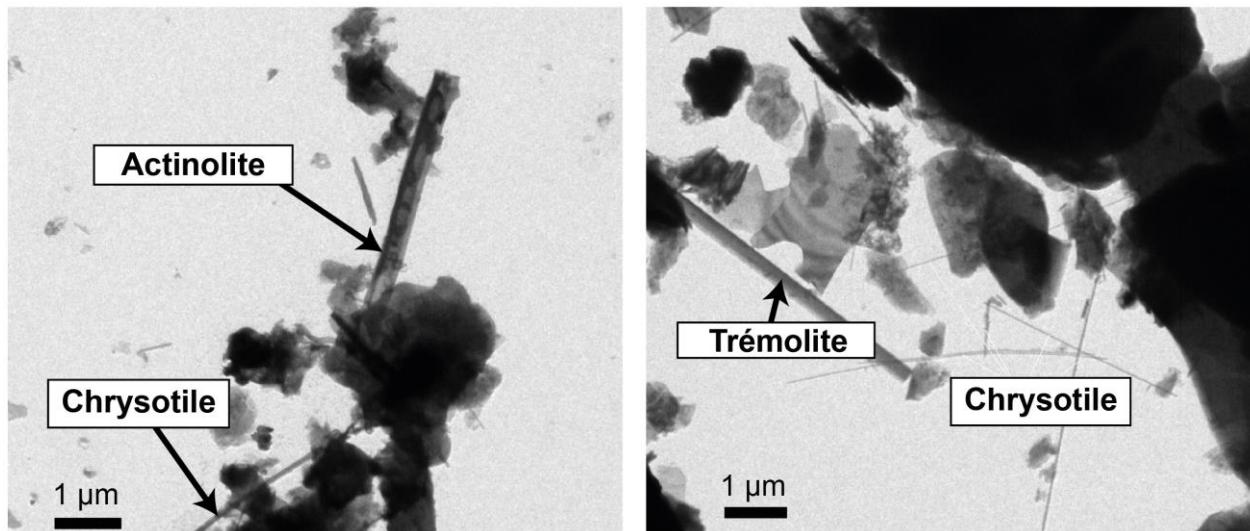
# Lac William – Fossil algae (diatoms)



# Asbestos in the sediments

	Lac Bécancour	Étang Stater	Lac à la Truite	Lac William	Lac Joseph
Natural watershed sediments (%)	0,0–1,5	0,0	1,1–3,5	0,0–0,3	0,0 à < 0,1 %
Lake surface sediments (%)	4,3	3,1	1,7	4,0	2,0
Maximum (%)	4,4	5,2	6,9	4,0	2,0

- ❖ Mostly chrysotile fibers
- ❖ Up to 2,1 % actinolite and 0,3 % trémolite (amphibole asbestos)
- ❖ Fiber length mostly under 5 µm



# Major research conclusions

- ❖ Lakes of the Bécancour River displayed good/healthy ecological conditions until the event of modern colonization;
- ❖ The sudden drainage of lac Noir (1955–1959) had a catastrophic impact on all lakes located downstream from Thetford Mines;
- ❖ Massive erosion of asbestos mining residues occurred towards the Bécancour River;
- ❖ Stater Pond and lakes à la Truite and William have very high sediment accumulation rates resulting in rapid sediment infilling;
- ❖ Thetford Mines wastewater greatly affects downstream lakes;
- ❖ Sediments of the Bécancour River chain of lakes display high asbestos fiber concentrations.



# Main research recommendations

- ❖ Curb the transport of sediments from asbestos-containing mine tailings to the Bécancour River;
- ❖ Reduce pollution associated with Thetford Mines' municipal wastewater;
- ❖ Develop an efficient nutrient and sediment retention basin along the Bécancour River;
- ❖ Increase riparian buffer zones along lakes and rivers;
- ❖ Assess asbestos fiber content in water and ambient air along the Bécancour River.

Plan de contrôle des sédiments amiantés du secteur minier de la Haute-Bécancour (Thetford Mines) 2022-2027



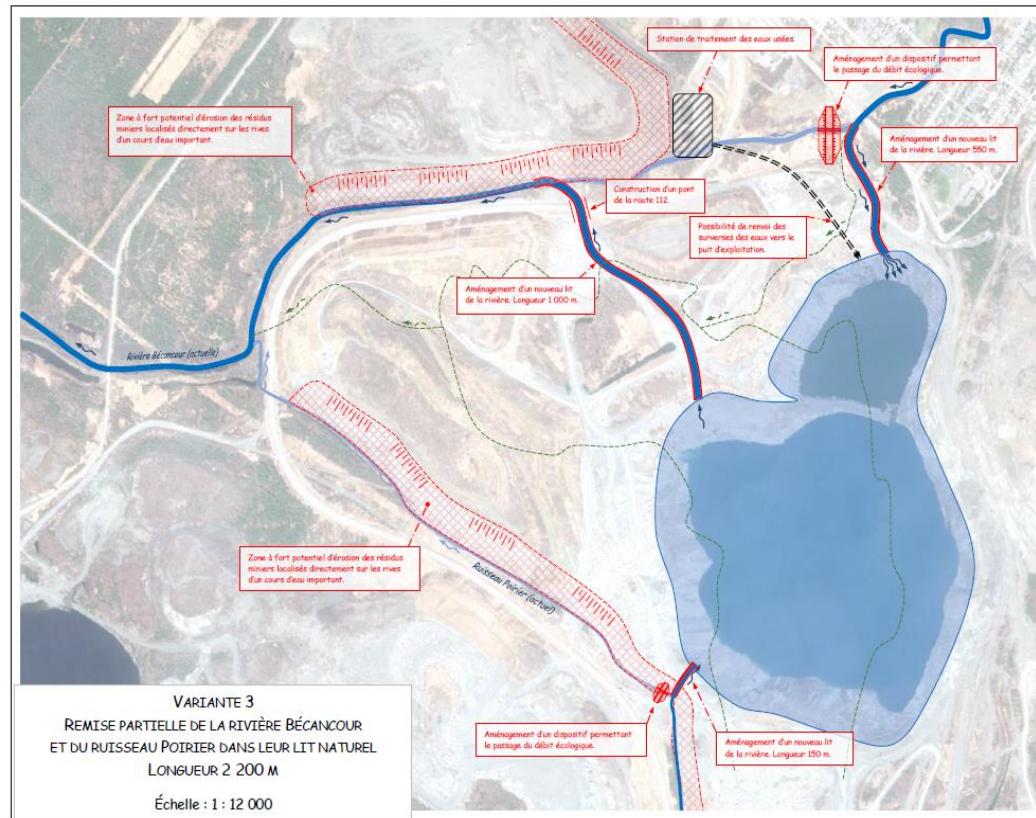
Réalisé par



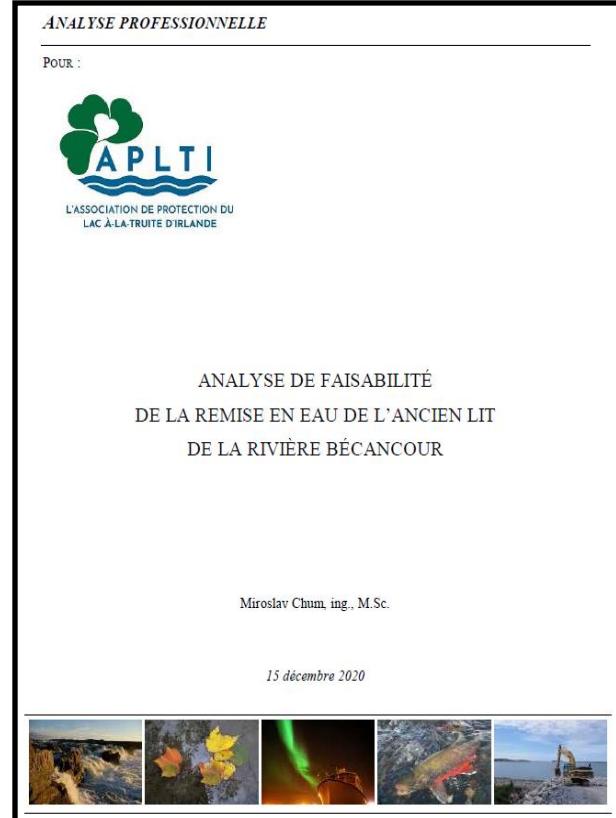
Janvier 2022

# Revitalization of the old river bed (oxbows)

## Revitalization/reconnection of lac Noir, Upper Bécancour River



<b>APLTI</b> L'ASSOCIATION DE PROTECTION DU LAC À-LA-TRuite D'IRLANDE	<b>ANALYSE PROFESSIONNELLE</b>
Projet	Analyse de faisabilité de la remise en eau de l'ancien lit de la rivière Bécancour
No du projet	2020-09-02
Référence du client	
Plans d'eau	Rivière Bécancour
Plan	Variante 3 Remise partielle de la rivière Bécancour dans son lit naturel
Localisation	N 46° 02' 25" W 71° 22' 07"
Échelle	1: 12 000
Projeté par	Miroslav Chum, ing., M.Sc. Miroslav Chum, Inc. 835, rue Kelly Les Meuniers (Québec) G6R 1B2 Tél.: (418) 554-8300 ou (418) 320-2186 Courriel : miroslav@miroslav.ca
Dessiné par	Miroslav Chum
Sceau	 Miroslav Chum 2 décembre 2020
Unités	Système métrique SI Distances en mm Élévations en m
Format d'origine	11 x 17" 2 790 x 4 320 mm
Date	2 décembre 2020
Plan 6	



# A spark of hope !

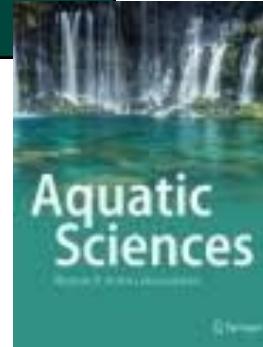
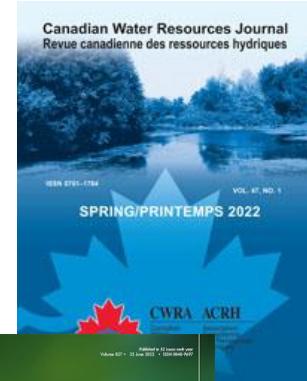


Vézina retention basin near former Normandie (Vimy Ridge) asbestos mine

# Thank you for your attention !

## Relevant published papers:

- ❖ Jacques, O. & R. Pienitz. 2022. **Impacts des activités minières d'amiante sur l'évolution du lac à la Truite d'Irlande, région de Thetford Mines (Québec, Canada) / Impacts of asbestos mining activities on the evolution of Lac à la Truite d'Irlande, Thetford Mines region (Quebec, Canada).** Canadian Water Resources Journal / Revue canadienne des ressources hydriques 47(1): 40–60. doi : 10.1080/07011784.2021.2004930.
- ❖ Jacques, O. & R. Pienitz. 2022. **Asbestos mining waste impacts on the sedimentological evolution of the Bécancour River chain of lakes (southern Quebec, Canada).** Science of the Total Environment 807: 151079. doi : 10.1016/j.scitotenv.2021.151079.
- ❖ Jacques, O. & R. Pienitz. 2022. **Assessment of asbestos fiber contamination in lake sediment cores of the Thetford Mines region, southern Quebec (Canada).** Environmental Advances 8: 100232. doi : 10.1016/j.envadv.2022.100232.
- ❖ Jacques, O. & R. Pienitz. 2023. **Limnological history of three lakes from the former asbestos mining region of Thetford Mines (southern Québec, Canada).** Aquatic Sciences (submitted 12 March 2023).



# Freshwater Management

Global Versus Local Perspectives



Springer

## 2-3. Generic Approaches Towards Water Quality Monitoring Based on Paleolimnology

Reinhard Pienitz and Warwick F. Vincent

*Centre d'études nordiques, Université Laval, Québec G1K 7P4, Canada*

### Abstract

Long term environmental records for lake and river ecosystems provide a valuable generic tool for water quality management. These data sets can play a pivotal role in determining natural baseline conditions, detecting early evidence of change, identifying the causal mechanisms of water quality deterioration, and in gauging the success of remediation measures. At most sites, however, such data are sparse or completely lacking. New advances in paleolimnology, that is the study of past environments based on the analysis of sediments, offer considerable potential for reconstructing these historical records. This paleolimnological approach is illustrated by way of water quality research on three ecosystems in Québec, Canada. Lake St-Augustin is a small lake characterized by episodes of bottom-water anoxia and summer blooms of cyanobacteria that result in its municipal closure to swimming and other lake activities for several weeks each summer. A paleolimnological analysis based on fossil diatoms showed that there have been four phases of nutrient enrichment over the last 240 years coinciding with initial colonisation and land development (1760-1900), farm development (1900-1950), increased fertiliser use and intensification of agriculture (1950-1980), and major road and residential expansion (1980-present). The paleolimnological application of diatom-based transfer functions for total phosphorus analysis of Lake St-Charles, the principal drinking water supply for Québec City,