Ecohydrological dynamics of a degrading subarctic peatland: Implications for arsenic mobility

J. M. Galloway, M. Gałka, G. T. Swindles, M. Amesbury, S. A. Wolfe, P. D. Morse, R. T. Patterson, H. Falck, L. Kung

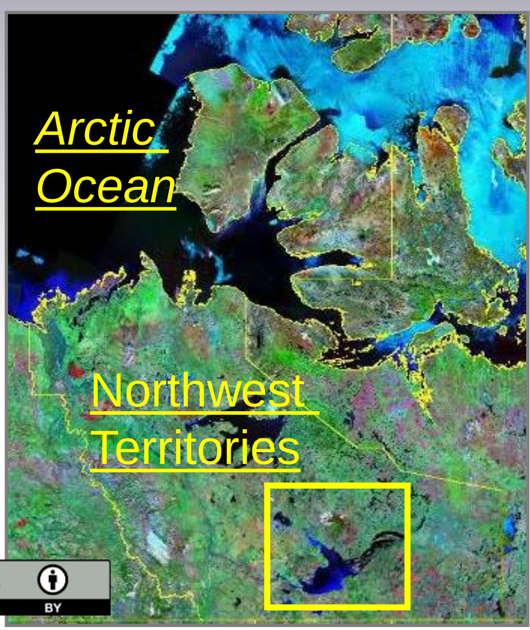
Two subarctic peatlands are investigated to reconstruct past hydrology, ecology, and chemistry

We use the occurrence of *Sphagnum riparium,* testate amoebae, and changes in pollen and charcoal between ca. 3300 and 2500 BP to interpret wet and minerogenic conditions associated with permafrost degradation

Chemical profiles in the peatlands show differences in the concentration of arsenic and other elements of potential concern over time

Permafrost peatlands are repositories of elements that will be released to the environment with permafrost thaw

History of mining



Gold mining left a legacy of As, Hg, and Pb contamination in sensitive subarctic environments of the Northwest Territories, Canada

What will be the fate of these elements with 21st. c. climate change?

Peatlands

- Permafrost peatlands are repositories of soil organic carbon preserved under cold conditions that supress anaerobic decomposition. The implications for carbon budgets are of global importance through biosphere-climate feedbacks that have the potential to accelerate or dampen climate change

- The long-term fate of permafrost peatlands is not known – increase in productivity and C sequestration or release of CO_2 and CH_4 and elements of potential concern through permafrost degradataion (collapse, deepening active layer)

- Canada has some of the most dynamic landscapes in the World

- It is difficult to reconstruct permafrost dynamics due to the complex feedbacks between climate, overland hydrology, vegetation, and thermal response

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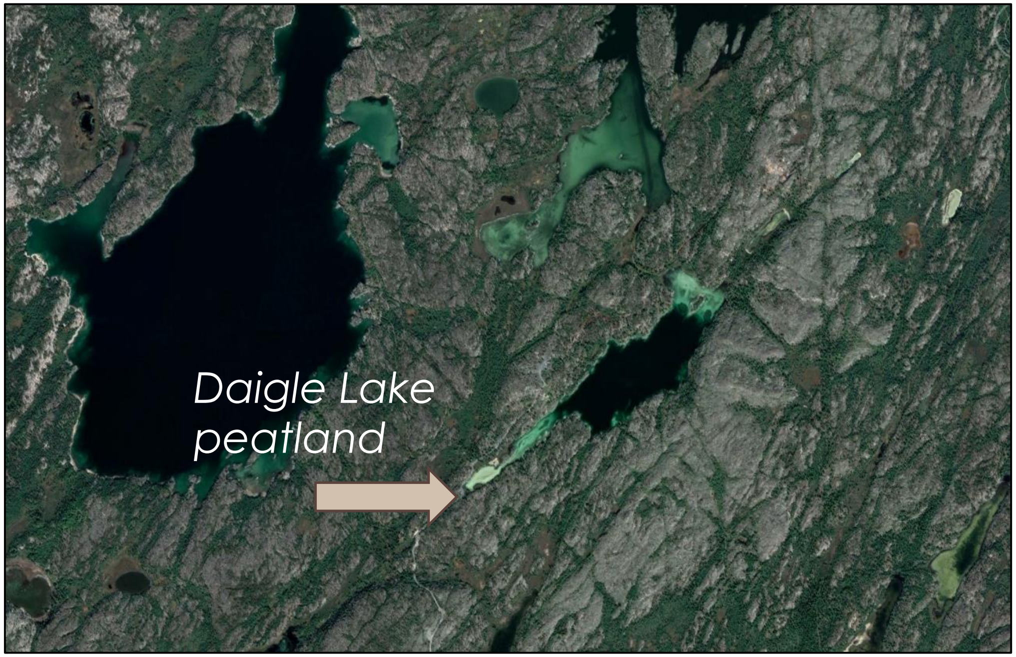
A tale of two peatlands



85-cm monolith and 3.0 m long core

Daigle Lake peatland overlies Au-hosting shear zone

The peatland became established ca. 8500 cal yr BP

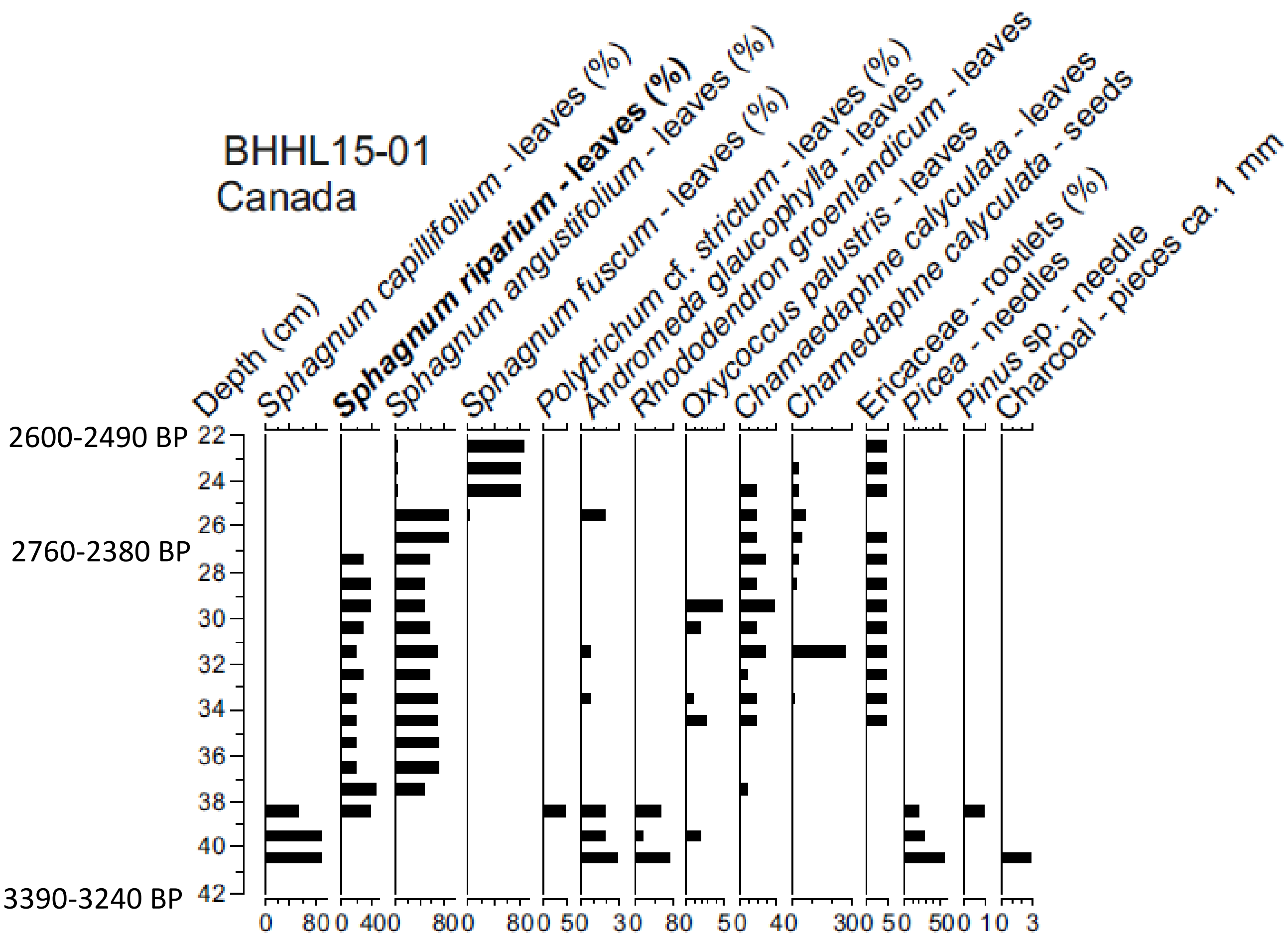
65-cm monolith and 1.4 m long core

Handle Lake peatland overlies granitoid bedrock

The peatland became established ca. 7000 cal yr BP

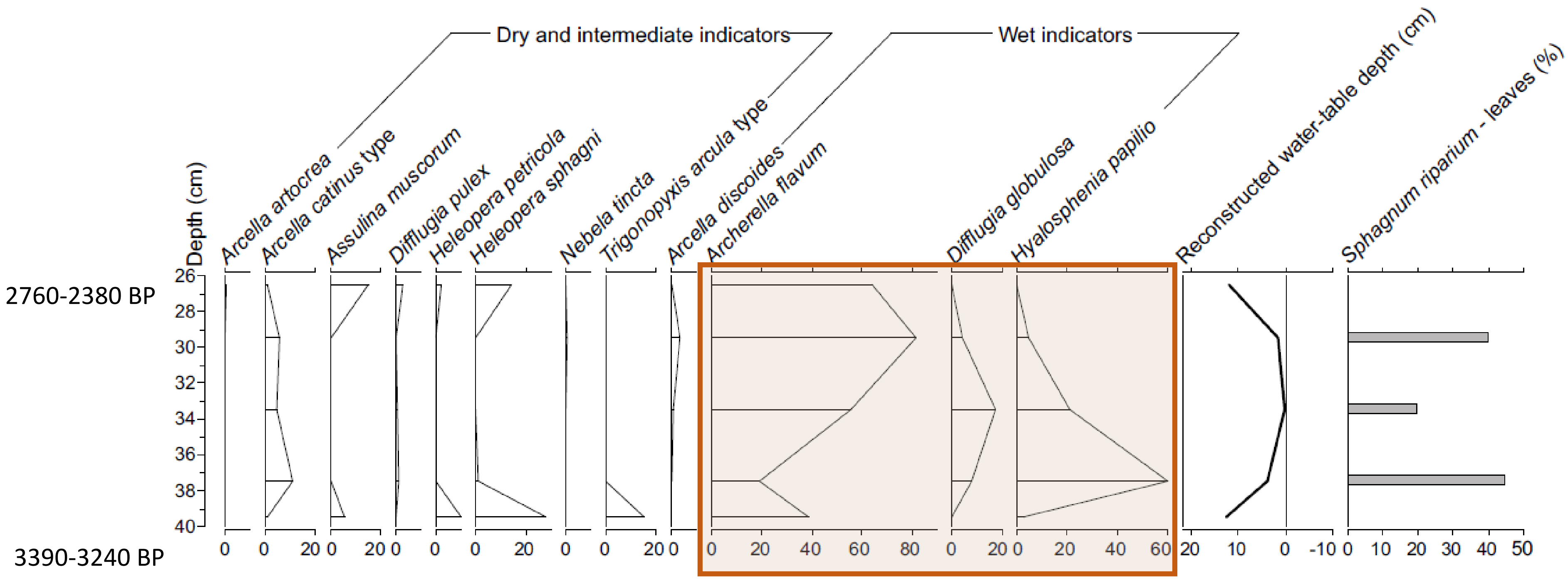
Plant macrofossils of Handle Lake peatland

Sphagnum riparium occurs in a 11-cm thick layer together with *S. angustifolium* between ca. 3300 and 2500 BP. Subsequent decline due to autogenic trophic shift and succession towards more acidophilic conditions favourable to species such as *S. fuscum*



Gałka et al. 2018. Rev. Pal. Pal. 254, 1-7

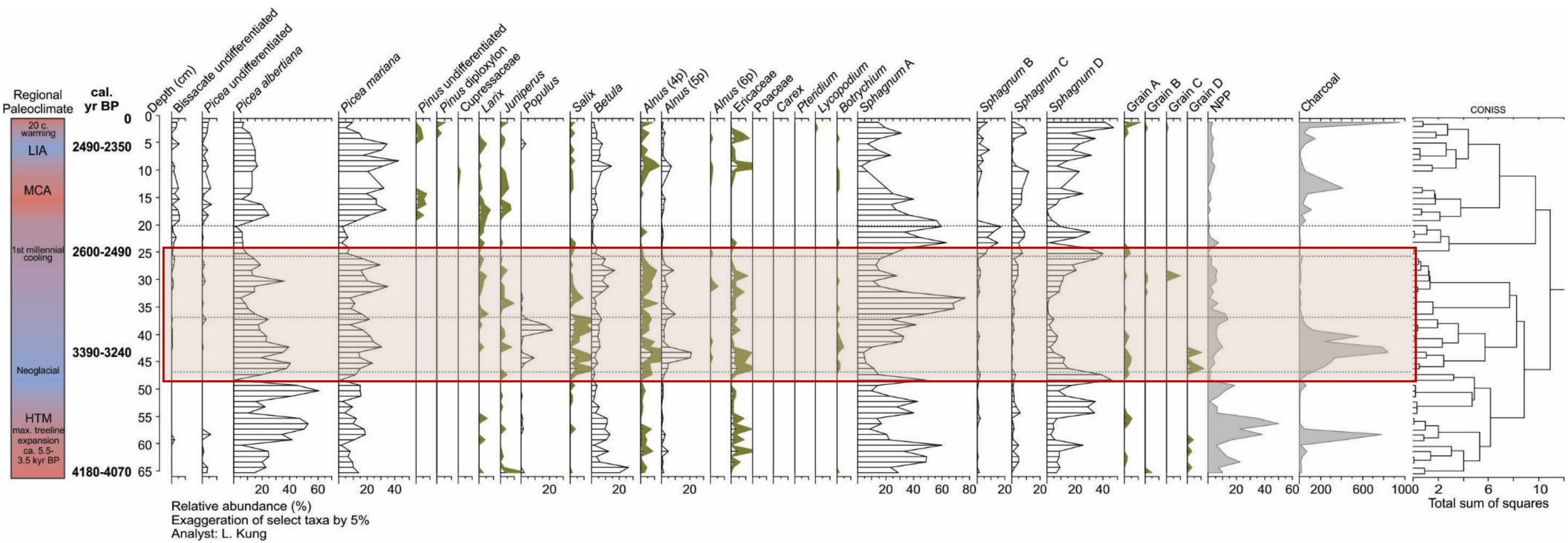
Water table depth of Handle Lake peatland



The *S. riparium* sub-fossils are present with the hydrophilous testate amoebae species *Archerella flavum, Hyalosphenia papilio*, and *Difflugia globulosa*. These taxa indicate a water table depth 0-4 cm below the Handle Lake peat surface

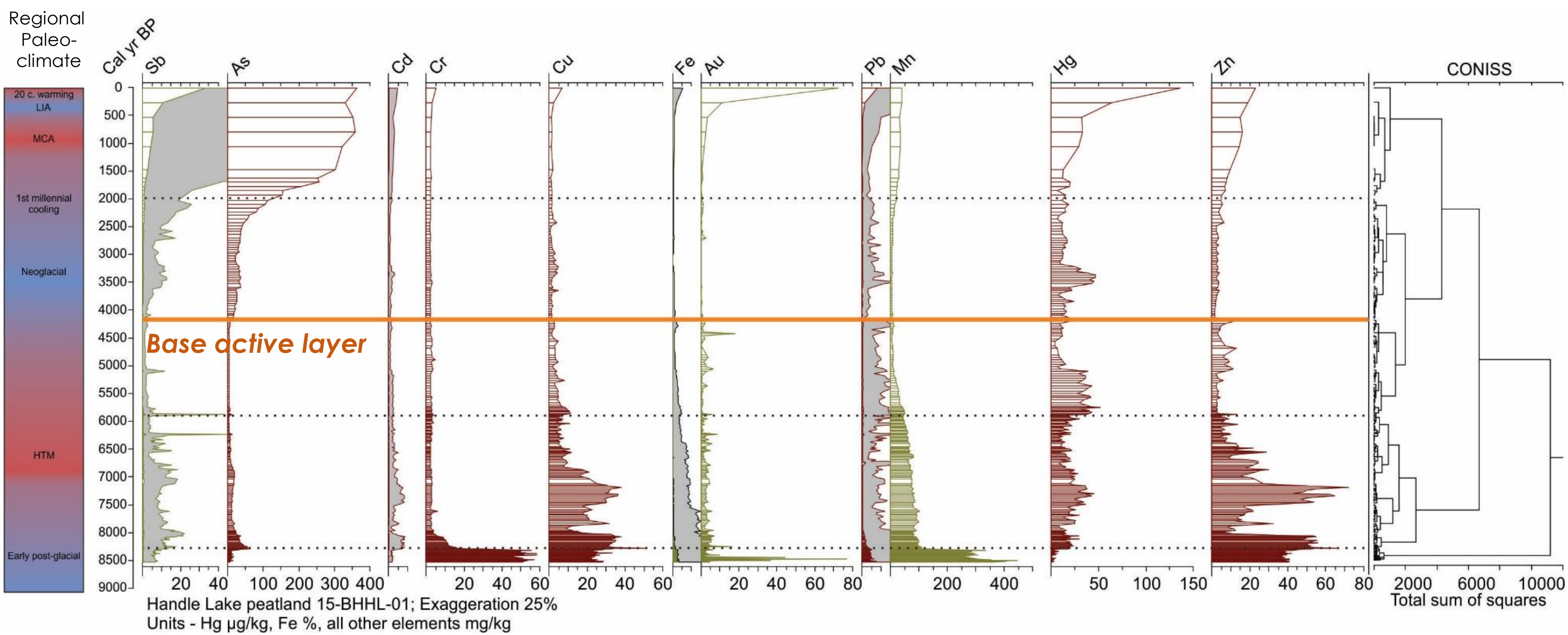
Palynology of Handle Lake peatland

Sphagnum spores and *Alnus* pollen increase between 43 cm (3390-3240 BP) and 25 cm (2760-2380 BP), following a peak in microscopic charcoal (45-35 cm). Interpreted as a response to permafrost degradation associated with an increase regional fire



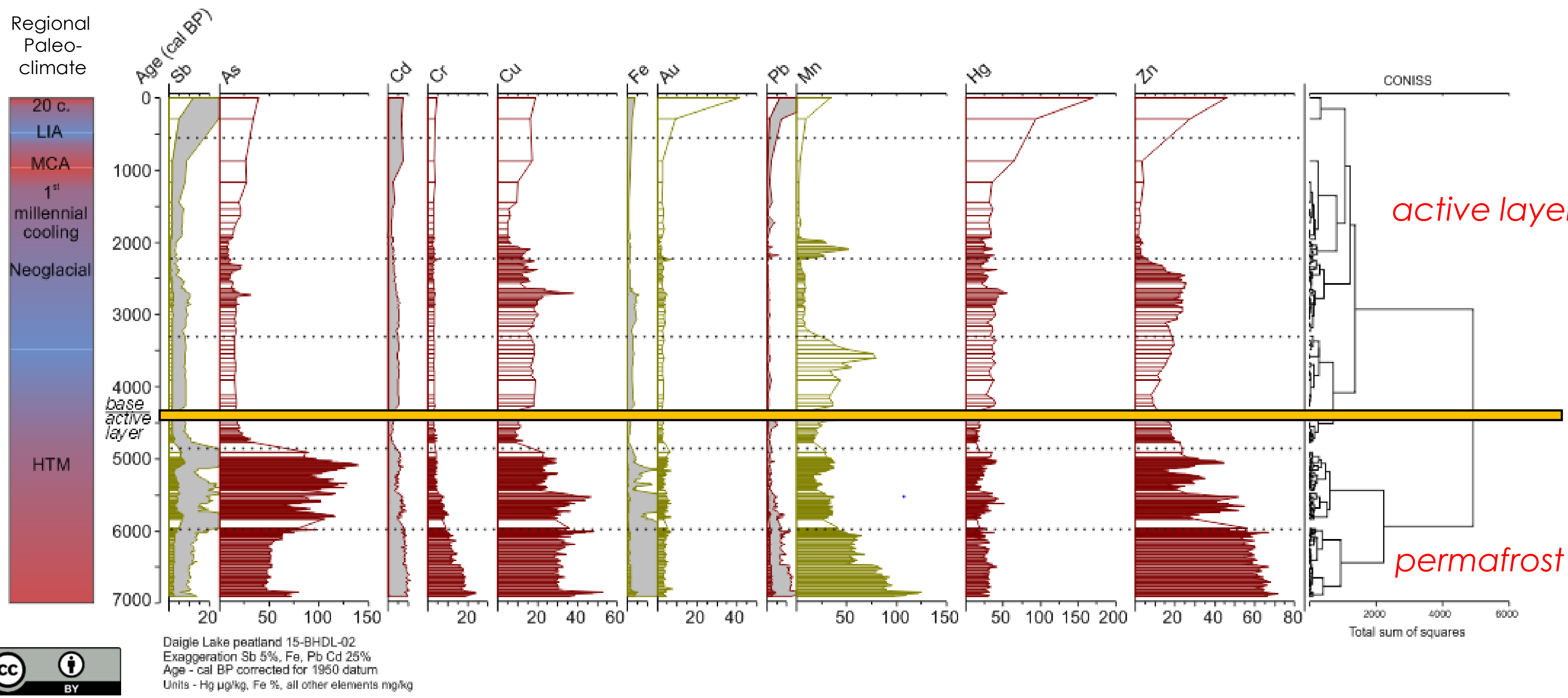
Geochemistry of Handle Lake peatland

Background As ~50 ppm (vs. Canadian interim sediment quality guideline of 5.9 ppm) or less until ca. 2000 BP. Increasing As starting about 2000 years BP, along with Sb, Hg, and Zn could be the result of increased chemical and physical weathering. The uppermost sample, with high Au concentration as well as Sb and Hg, reflects recent contamination by mineral processing at the now closed Giant Mine.



Geochemistry of Daigle Lake peatland

The chemical profile at Daigle Lake is different. Background [As] peaks to ~150 ppm during the Holocene Thermal Maximum, but became stable near 25 ppm for last 4000 years. Much of the As is stored in permafrost in this peatland. Fire can thicken active layer by ~0.5 m in boreal peatlands. The Daigle Lake permafrost peatland is thus a repository of As, Cu, and Zn that could be instantaneously released to the environment following a fire. Increases in the concentration of Sb, Au, Hg, and Zn at the top of the core are associated with mineral processing at the now closed Giant Mine.



Summary

1. Permafrost is expected to degrade substantially due to 21st c. climate change. This will result in a reduction from 67% at present to 2% by 2100, although latent heat effects are poorly understood

2. Background arsenic concentration in the two subarctic peatlands studied range from ~25 to150 ppm; peatlands are repositories of elements of potential concern and need to be considered when estimating geochemical changes expected with climate variability and land-use change

3. *Sphagnum riparium* is an indicator of wet and minerotrophic conditions in paleoecological records. This species is a key pioneer species in disturbed peatlands and is used herein as a proxy for permafrost degradation in cold regions peatlands

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Your comments are welcomed

Jennifer Galloway
Geological Survey of Canada
Natural Resources Canada
3303-33rd St. NW Calgary, AB, T2L 2A7
Jennifer.Galloway@canada.ca

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