Photoelectron Emission Microscopy Studies of Carbon Overturn in Lake Sediments from the Alaskan Coastal Plain

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Introduction

• Why study carbon cycling in the arctic tundra?

• What are some strategies for quantifying carbon turnover rates?

• Current progress

• Conclusions
The Big Picture

- Cellulose and lignin compose cell walls in vascular plants
- Carbon turnover gradually converts original cell wall material into humified products and CO$_2$
- Quantifying lignin in peat may allow estimates of carbon accumulation rates during the life span of thaw lakes
Lignin Precursors

(E)-Coniferyl alcohol

(E)-p-Coumaryl alcohol

(E)-Sinapyl alcohol
The Arctic Tundra: Thermal Karst Lakes

• Arctic tundra plays a crucial role in carbon sequestration

• The formation of thermal karst lakes serves as a climatic record
  – Patterned ground develops from annual freeze-thaw cycles
  – Water accumulating in depressions acts as a thermal sink thinning the underlying permafrost
  – Peat accumulates in shallow thaw lakes sequestering carbon until erosion drains the lake
Thermal Karst Lakes

Arctic Ocean

Point Barrow, Alaska

Photo: W. Eisner, Univ. Cincinnati
Introduction Cont’d

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- **What are some strategies for quantifying carbon turnover rates?**
- Current progress
- Conclusions
Chemical X-ray Techniques

• Sample Preparation
  - embedding
  - plating
Polybed-812 & Spurr's Resin
1:1 mixture; 8 μm thickness

50 μm
Chemical X-ray Techniques
Cont’d

• Sample Preparation
  - embedding
  - plating

• Photoelectron Emission Microscopy
  - spatial data
Resin

Peat

PEEM Image carbon K-edge

10 μm
Chemical X-ray Techniques

Cont’d

• Sample Preparation
  - embedding
  - plating
• Photoelectron Emission Microscopy (PEEM)
  - spatial data
• **X-ray Absorption Near Edge Spectroscopy (XANES)**
Carbon K-edge Spectrum
Oxygen K-edge Spectrum
Nitrogen K-edge Spectrum

![Nitrogen K-edge Spectrum Graph](image)
Introduction Cont’d

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Outlook

• Developed a normalization procedure to provide better quality data (quantitative x-ray data requires improved methods for reliable measurement)

• Combine data with Nuclear Magnetic Resonance (NMR) spectra

• Discriminating original cell wall materials from humified products appears feasible
• Why study carbon cycling in the arctic tundra?
• **What are some strategies for quantifying carbon turnover rates?**
• Current progress
• **Conclusions**
Future Directions

• Establish a link between chemical analysis and microbiology via lipid/enzyme analysis

• Eventually combine data with pollen analysis (climate -> carbon storage -> responsible microbial populations)
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Carbon K-edge

Intensity

Energy, eV

Aspen Lignin
Cellulose
Carbon K-edge

Alaskan Peat

Energy

Intensity
Oxygen K-edge

![Graph showing Oxygen K-edge spectra for Aspen lignin, IHSS 1R101F, and Cellulose.]

- Aspen lignin
- IHSS 1R101F
- Cellulose

Energy, eV

Intensity

525 530 535 540 545 550
Nitrogen K-edge

![Graph showing nitrogen K-edge spectra for 2S102F, Aspen Lignin, and Glycine.](image)