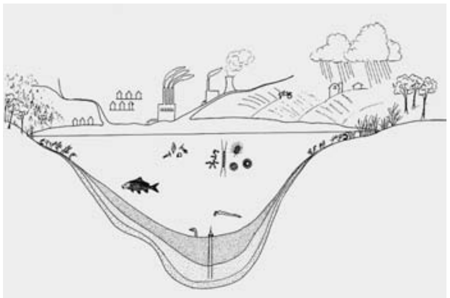
St. Croix Watershed Research Station

Paleolimnology – recreating the history of a lake



Background: Every Minnesota lake accumulates sediment. Since the glaciers left over 11,000 years ago most lakes have accumulated between 10 and 80 ft of sediment in their deep basins. Sediments preserve a record of physical, chemical, and biological clues of how, when, and why a lake and its watershed have changed.

Sediment coring

A piston corer

- ✓ Scientists (called paleolimnologists) work from an anchored boat or from the surface of the ice and use specialized equipment designed for recovering sediment cores. For example, a piston corer uses a clear tube that is lowered to the lake bottom using 10 ft-long alloy rods that thread together. The tube is fitted with a piston that is held in place with a cable; as the tube is pushed into the mud, the piston helps "pull" the sediment into the tube.

Sediment core analyses – we test and measure physical, chemical, and biological clues that are preserved in the sediment

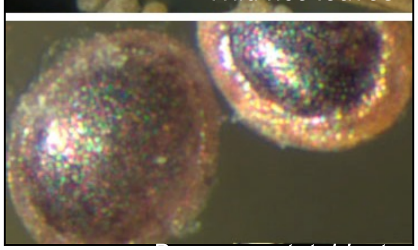
- ✓ ***Radioisotopes*** – To establish a date-depth relationship for a core, we use natural (Lead-210) or man-made (Cesium-137; from atomic bombs) radioisotopes. This tells us the approximate year that a layer of sediment was deposited.

Ostracod shells

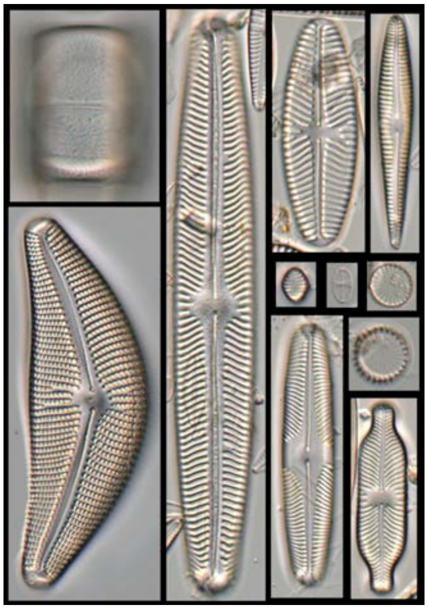
- ✓ ***Sediment type*** – We do a test called "Loss-on-ignition" to figure out what makes up the sediment:
  Inorganics – a measure of the mineral matter in the core. Inorganics may increase with erosion, land clearance, or rising water levels
  Carbonates – carbonates accumulate due to input of hard groundwater and as a result of plant and algae photosynthesis
  Organics – a measure of biological material in a core from the breakdown of plant, algae, and animal remains

Wild rice leaves

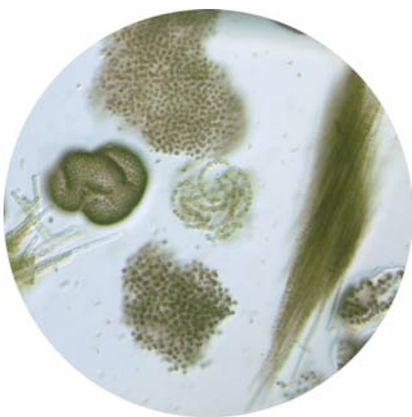
- ✓ ***Biogeochemistry*** – We analyze natural and man-made chemicals in cores:
  Phosphorus – a measure of all types of phosphorus in a core, generally increased phosphorus inputs to a lake causes plant/algae growth to increase
  Biogenic silica – a measure of the amount of diatom algae growth; diatom accumulation normally increases with increased nutrients



- ✓ ***Fossils*** – Most organisms in a lake leave some sort of "fossil" remains:
  Macrofossils (plant, algae, animal) – many organisms leave identifiable remains in sediments that we count to determine their abundance and when they appear or disappear. Plants fossils can be charcoal (forest fires) or aquatic plant leaves (wild rice) and seeds. Algae can be free-floating species (*Pediastrum*) or attached (*Chara*). Animal remains can be zooplankton (e.g., *Bosmina*), insects (e.g., chironomids), or even fish.



Fossil sediment diatoms



Algae leave clues in the mud

✓ ***Fossils, cont.***

Diatoms – Diatoms are a group of microscopic algae common in all types of lakes. They are special because they have a cell wall that is beautifully ornamented and made of biologically produced GLASS! That means when they die, they become microscopic glass fossils in the sediment – there are billions of them in a teaspoon of mud. Different diatoms species live in different types of lakes and in different habitats within lakes. We've studied diatoms throughout Minnesota lakes and each diatom species has specific types of habitats and water quality that it prefers.

We have used our knowledge of Minnesota diatoms to develop models that allow us to look predict what historical water quality and ecolgy was in a lake. By counting the diatoms in each layer of a core and looking at how the diatom community changes over time, we can show how and when the ecology of a lake has changed, how specific water quality parameters like total phosphorus and pH have changed, and identify reference or background conditions (what you might want your lake to look like!).

Fossil Algal Pigments – The amount and types of algae in a lake are one of the most important indicators of lake and water quality; no one wants to swim in or see nasty algae in their lakes. But every lake has algae in it. Just like the grass on land, algae form the base of the food web in lakes and rivers, taking energy from the sun, and converting it to food through photosynthesis, that then moves up the food web. There are many different types of algae in lakes—green algae, cyanobacteria or blue-green algae, diatoms, dinoflagellates—and each type has specific pigments. The pigments are used for photosynthesis and give each group of algae their specific color. When the algae die or sink to the bottom of the lake, their pigments remain as part of the sediments. We extract them and can estimate how much algae were in the lake, what types were present, and importantly when and why the algae changed.

Paleolimnology is an important tool in Minnesota...

- ✓ *Management goals* – Because we did not monitor lakes before the 1970s, paleolimnology is the only tool we have to understand what a lake used to be like. For example, to set management goals for the St. Croix River, a large paleolimnology study on Lake St. Croix showed that the lake had changed dramatically after WWII. Diatoms were used to estimate what levels of phosphorus were present in the 1940s, and those phosphorus levels were set as goals by MN and WI for nutrient reduction in the river.
- ✓ *Nutrient standards* – The state of MN used paleolimnological studies of over 70 lakes across Minnesota to develop the nutrient standards for phosphorus that are in place to protect our lakes. The lake standards differ among the state's ecoregions and between shallow and deep lakes in most of the ecoregions. Lakes that exceed these levels of nutrients are labelled impaired and have plans developed for fixing them.
- ✓ *Prioritizing management* – For areas with many impaired lakes or lakes that are on the threshold of impairment, paleolimnology is used to identify how much lakes have changed, when and why they changed, which lakes are most likely to respond to management, and whether some lakes may not be capable of meeting MN lake standards. This information is critical for most effectively using lake management $$$.

Funding Partners
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