El'gygytgyn Drilling Project

More than Mud

A Student Investigation of the

Lake El'Gygytgyn Sediment Core

These instructions are to be used in conjunction with

The Lake El'gygytgyn sediment core poster.

Lake El'Gygytgyn Sediment Core 5011 MIS 11

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Overview

The sediment in Lake El'gygytgyn, (pronounced EL-gee-GIT-gin) located in NE Siberia, holds one of the longest records of climate change anywhere in the continental Arctic. How can sediment (clay and mud) tell us about past climate? Proxy data! By studying the microfossils of diatoms and pollen in the sediment, we can re-construct the lake environment from millions years ago.

Objectives

In 1777 James Hutton, the father of Geology, wrote that …to understand the future we must understand the past. Students (and adults) frequently find it difficult to understand how scientists can reconstruct past climate records without direct measurement of weather conditions. By completing this lesson, students should have a basic understanding of several types of proxy data and how scientists are using proxies to understand our changing climate.

Background

Over its long history, the Earth has experienced many variations in climate. While the instrumental record for measuring weather and climate goes back slightly more than one hundred years, scientists from many different disciplines have discovered evidence of the changing climate preserved in numerous different biological and geological records. Some notable records include dendrochronology (tree rings), ice cores, and lake and ocean sediments. Of these, lake and ocean sediments preserve the longest records of climate history. Consequently sediment samples from lakes all over the world have been used to re-construct a history of past climate change.

While many lakes exist in Canada, Alaska, Asia and Europe, almost all of these Arctic lakes (and their sediments) were disturbed by glaciers during the last ice age. Because of this, scientists have had little data to use when attempting to reconstruct past climates in the Arctic regions.

Lake El'gygytgyn (Lake E) is located in the Chukotka province of the Russian Federation. This 18km (12 mile) meteor impact crater is located 100km north of the Arctic Circle. Due to its unique location in central Beringia, Lake E was never glaciated during the ice ages. In fact, the sediment in Lake E holds a continuous record of the changing climate that goes back 3.58 million years to the point of the asteroid impact that formed the lake.

In the winter of 2009, as part of the International Polar Year, an international scientific drilling expedition collected over 300 meters of sediment cores and over 200 meters of impact fractured rock core samples from the lake. The impact rocks have been studied by planetary scientists and the sediments have been extensively studied because they hold the longest, uninterrupted record of climate change of any location in the continental Arctic.

Once the sediment cores were extracted from the Arctic lake, they were packed and shipped to Germany for splitting, initial measurements, and sub-sampling. One half of the split core was sub-sampled and the other half has been preserved at an archive for study at a later date. From

Germany the sediment sub-samples were sent to laboratories around the world for more in depth analysis.

Since the expedition, a team of scientists from around the globe has studied the sediment samples. Their goal is to try and reconstruct the climate history of this region of the Arctic. Two areas of study have been diatoms and pollen. Different species and the relative abundance of these biological sediments give clues to the climate and environmental conditions of the lake.

The basic scientific concepts are quite simple. Although the NE region of Siberia (Part of Beringia or the western side of the land bridge to N. America) was never covered by large continental glaciers, during the last several ice ages, it is known that the lake was frozen throughout these ice ages. During these cold periods, there was considerably less biological activity in and around the lake. Scientists have correlated times of low bio-productivity with the ice ages. The science team has also been able to track changes in the plant communities around the lake by studying the pollen grains, diatom productivity, and other organic matter in the sediment that accumulated during the interglacial times.

The core sample used in this lesson spans one of the dramatic "interglacial" periods. This sample extends from the composite depth 17.4 meters below Lake Floor (MBLF) to 19.6 MBLF which corresponds to 378,000—430,000 years ago. This is the time period is frequently identified as Marine Isotope Stage 11 (MIS 11).

How to Use the Lesson

The following are suggested activities with the Lake El'gygytgyn Sediment Core printed poster. (Suggested 1 poster per 8 students.)

Note: Poster file is designed to be printed 8' long. (It may be tile printed on six sheets of 11"X17"paper.) This will be a "life size" core sample. If printed at this scale, the diatom images are scaled so that 1mm = 1µm.

Visual Inspection (All students)

When scientists first study a core, a visual inspection is made. Color of the sediment is documented with using the Munsell color system. Sediment texture or grain size is also analyzed. While textural analysis is not possible from an image, students should make some basic visual observations. If possible have students document Munsell color, otherwise make general observations about the core. The core may be divided into sections and each student group may describe 0.5 or 1 meter of the core. For the rest of the activity some students will be Diatomists (Scientists who study diatoms) and others Palynologists (Scientists who study pollen).

Diatomists:

Examine the microscopic images on the poster or in supplementary materials to reconstruct the environmental conditions of the past by comparing each sample. Group 1 (2 students) - Count the number of diatoms on each image then graph results. Group 2 - Measure the diameter of the 2 largest diatoms on each image, calculate averages, and then graph results. Both groups: Compare results and construct hypothesis to explain observed changes.

Palynologists:

Examine the data tables on the poster or in the supplementary materials to reconstruct the environmental conditions of the past by comparing each sample.

Note: Due to inconsistencies in sample size and extraction procedure, relative abundance of pollen type is studied rather than simple numeric counts. For pollen analysis of these samples, compare the type of pollen to the total pollen count.

Group 3 and 4 – Calculate the total number of pollen grains in each sample. Group 3 - Calculate and graph the relative percentages of tree/shrub pollen, herb pollen and spores. (Using MS Excel, a 100% stacked area graph works well for representing the changing percentages) Group 4 - Calculate and individually graph the percentage change of Pine, Alder and Grass pollen. Both groups: Compare results and construct hypothesis to explain observed changes.

More in depth analysis may be conducted with full data set files.

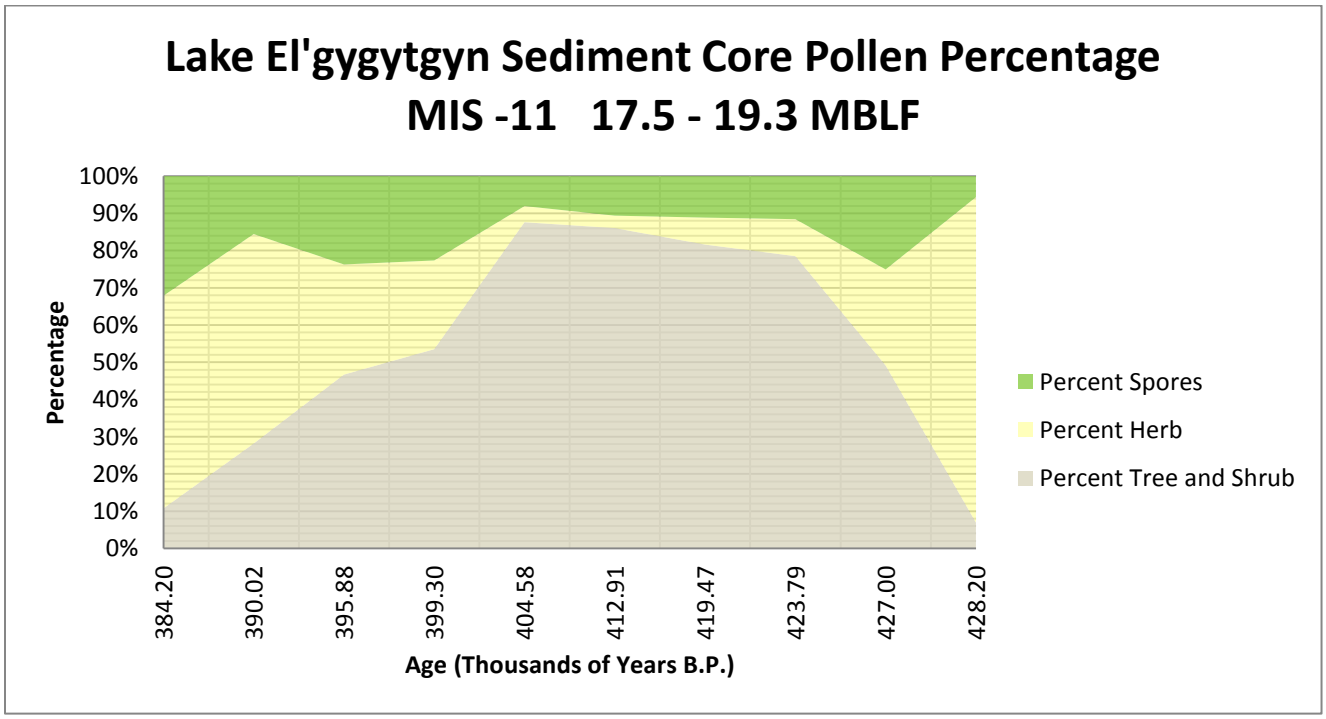
Diatomists and Palynologists should then discuss results with each other.

Conclusion and Key for Teachers – (Spoiler Alert)

Pollen Data

Currently, the environment around Lake E is dominated by herb and grass tundra with only a few low shrubs. The closest trees are nearly 150 km from the lake while the closest true forest is 300 km to the south. When pollen percentages are calculated and graphed an obvious change in the flora is evident for this time period. During MIS 11 the area around Lake E was dominated by forest. With forest, the percentage of grass and herb pollen drops significantly.

(Example A stacked area graph constructed in MS Excel with calculated percentages of general pollen types)

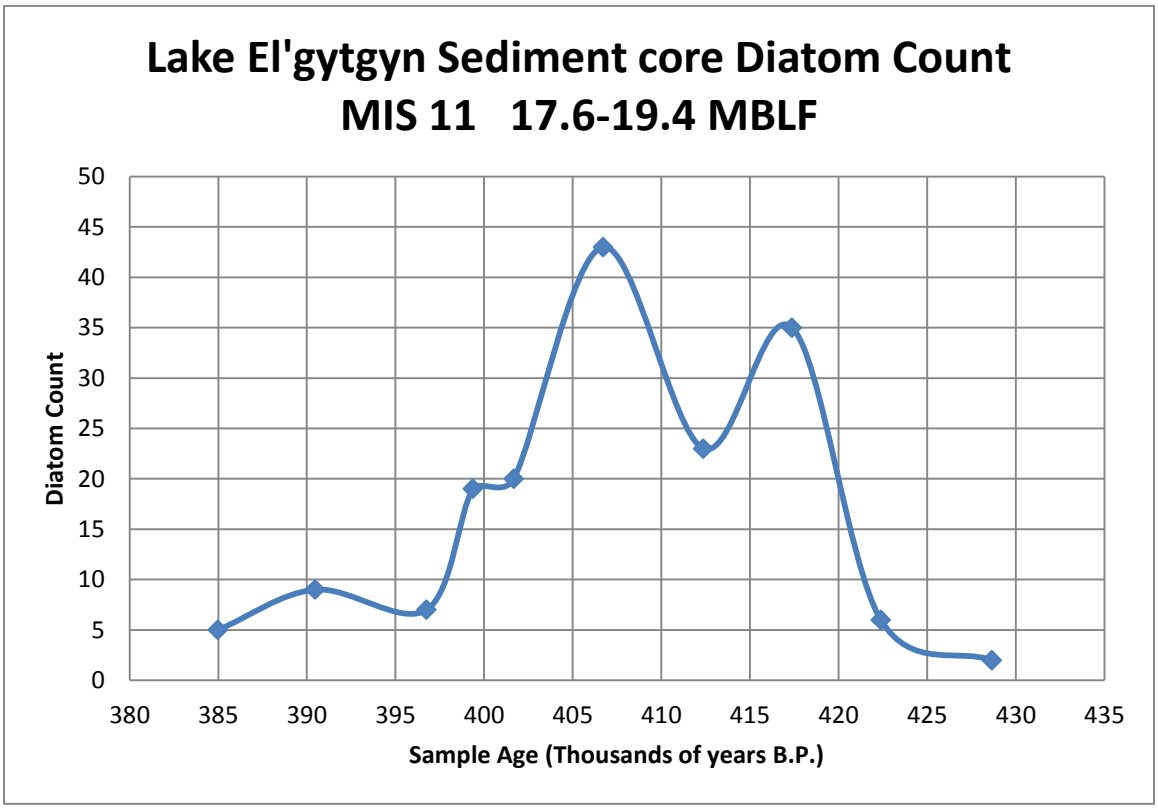


Diatom Data

A quick glance at images on the accompanying poster shows an increase in both number and size of diatoms in the central region of this core sample. This can easily be graphed to show the increase and decrease of the bio-productivity of the lake.

Example diatom count graph - Average numeric count of diatoms per image on poster.

(Fragments counted if larger than 50% of diatom present)



Summary

Climate reconstructions indicate that for these changes to occur the mean temperature of the warmest summer months could be as much as 8°C or 15°F warmer than present conditions.

As the science community understands more about the climate of the past, humans will have a better understanding of the trends and changes currently observed around the world.

Extension

If your school is near a body of water (or even with a small pond/aquatic habitat), have students go out and collect sediment samples and look for environmental indicators in your home community. The following two videos provide instructions for using a simple sediment coring device and analyzing sediment cores in the classroom.

https://www.youtube.com/watch?v=vYPSqHWntew&list=UUJ1-dZ8HrnDTwRGAGFaX0_w

https://www.youtube.com/watch?v=xZRmdr6-9tw&list=UUJ1-dZ8HrnDTwRGAGFaX0_w

Published Scientific Papers

Vegetation responses to interglacial warming in the Arctic: examples from Lake El'gygytgyn Far East Russian Arctic. A.V. Lozhkin and P.M. Anderson, Clim. Past, 9, 1211-1219, 2013

http://www.clim-past.net/9/1211/2013/cp-9-1211-2013.pdf

Dynamic diatom response to changing climate 0-1.2 Ma at Lake El'gygytgyn Far East Russian Arctic. J.A. Snyder, M.V. Cherepanova, and A Bryan, Clim. Past, 9, 1309-1319, 2013

http://www.clim-past.net/9/1309/2013/cp-9-1309-2013.pdf

Other Resources

For a full account of the expedition, read the expedition journal at:

http://polartrec.com/geologic-climate-research-in-siberia

Videos from the expedition:

https://www.youtube.com/watch?v=Ou1yDtSwNGM&list=PLA32489E0A3B3358A

Polar Archive – Program about the expedition produced by DFG Science TV

http://dfg-science-tv.de/en/projects/polar-archive

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