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SIDEBAR | Millennial-Scale Arctic Climate Change of the Last 3.6 Million Years: Scientific Drilling at Lake El'gygytgyn, Northeast Russia

By Julie Brigham-Grette, Martin Melles, Pavel Minyuk, and Christian Koeberl

Successful deep drilling at Lake El'gygytgyn (67°30'N, 172°05'E), in the center of western Beringia, recovered 315 m of sediment, representing the longest time-continuous sediment record of past climate change in the terrestrial Arctic. The core was taken using the DOSECC GLAD800 (Global Lake Drilling 800 m) hydraulic/rotary system engineered for extreme weather, using over-thickened lake ice as a drilling platform. El'gygytgyn is a Yup'ik name that has been variously translated as "the white lake" or "the lake that never thaws." Today, the lake maintains an ice cover nine to 10 months per year.

Cyclic changes in the shape and orientation of Earth's orbit around the Sun influence climate. Before about 900,000 years

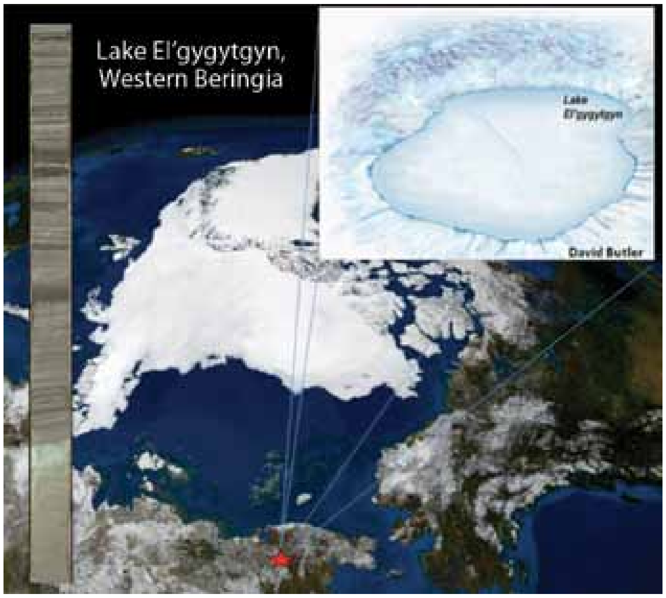

Figure 1. Lake El'gygytgyn (red star) is located 100 km north of the Arctic Circle in the middle of Chukotka, northeast Russia. The lake is 12 km in diameter and 175 m deep, situated inside an 18 km diameter meteorite crater (inset). The Arctic map shows the minimum summer sea ice extent of 2007 (from NOAA). The sediments taken from the lake, like those shown in the column on the left, contain evidence of Arctic change over the past 3.6 million years that can be compared to evidence from the Arctic Basin and marginal seas.

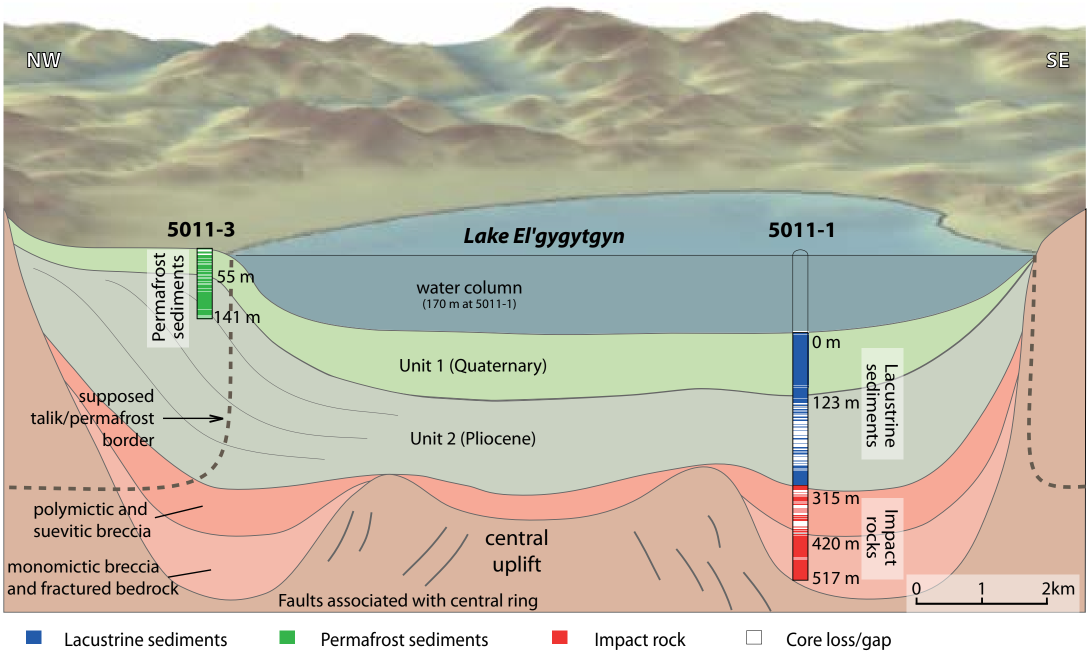

Figure 2. Schematic cross section of the geology of Lake El'gygytgyn, an ancient lake formed by a meteorite impact. A continuous climate record was recovered from a drill core at site 5011-1 in lacustrine sediments to 315 m depth (blue colors). Meteorite impact rocks (including polymictic and suevitic breccia and fractured bedrock) were also drilled below (red colors) to a depth of 517 m. Core 5011-3 was drilled on land next to the lake to a depth of 141 m for studies of sedimentology and permafrost. Permafrost (or frozen ground) extends hundreds of meters outside of the talik (thawed zone) beneath the lake.

ago, climate pulsed between cold glacial and warm interglacial periods every 41,000 years (a result of changes in Earth's wobble, or tilt); after that time, climate changes were driven by longer, 100,000-year cycles (a result of variations in the roundness, or eccentricity, of Earth's orbit). Because Lake El'gygytgyn was formed 3.6 million years ago by a meteorite impact event, sediments, fossils, and organic matter, including fossil pollen, deposited in this unique lake captured terrestrial change in this high-latitude region over the duration of the "41,000-year world" and the late Cenozoic "100,000-year world." Analyses of these lake cores are being used to understand the history and pace of Arctic change and will be integrated into a network of sites collected by the geological community from the Arctic Ocean to Antarctica (especially ANDRILL, the Antarctic Drilling Program).

Lake El'gygytgyn has been accumulating sediments since the warmest part of the middle Pliocene (3–5 million years ago) when large parts of the Arctic borderlands were forested and the Greenland Ice Sheet may not yet have formed (this point is still being debated). Paleomagnetic reversal stratigraphy forms the basis of our geochronology. The Pliocene portion of the lake record (from 3.6–2.6 million years ago) extends from 123–315 m depth below the lake floor, and has accumulated sediment at nearly five times the rate of the Quaternary (2.6 million years ago to present), presumably due to enhanced hydrologic systematics (i.e., warmer and wetter climate). Fossil pollen studies of the Pliocene portion of the core show that the landscape around the lake was largely dominated by trees, with compositional changes over time between high-latitude boreal and deciduous forests of pine (Pinus), larch (Larix), spruce (*Picea*), fir (*Abies*), alder (*Alnus*), and hemlock (*Tsuga*), although there were brief intervals of dominant tundra, like today. The Quaternary section is roughly 123 m long. It includes a complete record of glacial/interglacial change, including warm intervals correlative with well-known marine isotopic stages 5e, 9, 11, and 31, which each differ in character, presumably due to orbital forcing and feedbacks. Because many of these warm episodes at Lake El'gygytgyn surpass the warmth of the last interglacial (~ 125,000 years ago) when the Greenland Ice Sheet is thought to have been smaller than today, these new data will contribute to modeling efforts that test the vulnerability of Arctic sea ice and the Greenland Ice Sheet to global warming.

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