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Lake El’gygytgyn’s emerging IPY record of Pliocene to recent Arctic change

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Lacustrine sediments representing the last 3 glacial cycles from NE Russia chronicle the magnitude and dynamics of millennial-scale change across the western Arctic. Logistics are now underway in a multi-national effort to collect the complete paleoclimate archive from this region back to 3.6 Myr ago.

Imagine looking at a circum-Arctic map of northern hemisphere glacial ice extent and being given the opportunity to select an ideal setting where one might record an undisturbed time-continuous terrestrial record of Arctic climate change. Unprecedented, Lake El’gygytgyn (pronounced e’gegitgin), is such a place, formed by astrophysical chance 3.6 Myr ago, when a meteorite struck Earth 100 km north of the Arctic Circle in Chukotka on the drainage divide between the Arctic Ocean and the Bering Sea (Layer, 2000) (Fig. 1).

When the meteorite hit, the middle Pliocene Arctic was exceedingly different from today, with mean annual temperatures estimated at 12°C warmer and global averages 3-4°C warmer than today (Dowett, 2007; Saltzman et al., 2008). At that time, most of the Arctic borderlands were heavily forested, the Arctic Ocean lacked permanent sea ice, and the Greenland Ice Sheet did not exist, at least in its present form (Brigham-Grette and Carter,

Figure 2 exemplifies the correlation of cores along the Mendeleev and Alpha Ridges, based on normal remanent magnetization (NRM) records, along with distribution of detrital carbonates (indicated by Ca concentrations), and radiocarbon and amino-acid racemization (AAR) dates. Being overall much lower than on the Alaskan margin, sedimentation rates in the central Arctic appear to change dramatically, from nearly a hiatus in some areas during the height of glacial intervals to several cm/kyr during deglaciations and interglacial intervals. In addition to HOTRAX materials, the GPC special issue presents related data from the Siberian seas and modeling results of the MIS6 glaciation—potentially the biggest ice sheet in the history of the Eurasian Arctic.

Note

Data from this research is being archived at the Joint Office for Science Support at the University of Colorado. Metadata on the HOTRAX collection are posted on the NGDC MGG website (www.ngdc.noaa.gov/mgg/curator/curator.html).

References


Polyak, L., et al., in review: Late Quaternary stratigraphy and sedimentation patterns in the western Arctic Ocean, Global and Planetary Change.

For full references please consult: www.pages-igbp.org/products/newsletters/ref2009_1.html
Deep Drilling Initiation

After several years of preparation, pre-site survey work and arduous logistical planning, Lake El'gygytgyn is now the focus of a challenging interdisciplinary multinational drilling campaign that is part of the International Continental Drilling Program (ICDP). With drilling initiated in November 2008, the goal is to collect the longest time-continuous record of climate change in the terrestrial Arctic, and to compare this record with those from lower latitude marine and terrestrial sites to better understand hemispheric and global climate change. Coring objectives include replicate overlapping lake sediment cores of 330 m and 420 m length at 2 sites (D1 and D2 in Fig. 1; four cores total) near the deepest part of the lake. Coring shall be continued 300 m (D1) and 100 m (D2) into the underlying impact breccia and brecciated bedrock, in order to investigate the impact process and the response of the volcanic bedrock to the impact event. One additional land-based core (site D3, lake shore) to ~200 m in lake sediments now overlain by frozen alluvial sediments will allow better understanding of sediment supply to the lake and spatial depositional heterogeneity since the time of impact. This latter drill site at the west edge of the lake outside the talik (unfrozen ground in an area of permafrost) will also be used for permafrost studies and be permanently instrumented for future ground temperature monitoring, as part of the Global Terrestrial Network for Permafrost (www.gtnp.org/).

Drilling of the primary D1 and D2 sites will take place from February to the middle of May 2009, using the lake ice as a drilling platform. The project is using a new GLAD-800 drilling system modified for extreme weather conditions by Drilling, Observation and Sampling of the Earth's Continental Crust Inc. (DOSECC). Moreover, the science and logistics involves close cooperation with the Russian Academy of Sciences (Far East Geological Institute, Vladivostok; and Northeast Interdisciplinary Scientific Research Institute, Magadan) and Roshydromet’s Arctic and Antarctic Research Institute, St. Petersburg.

In summer 2009, the cores will be flown by chartered cargo plane to St. Petersburg. Later they will be trucked to the University of Cologne, Germany, where sub-sampling by the international team and their students will start in September. The archive core halves will be shipped to the University of Minnesota LacCore Facility, USA for post-moratorium studies.

Pilot Cores and Initial Results

The impetus for deep drilling at Lake El'gygytgyn is largely based on field and laboratory studies carried out over the past decade. Seismic work in the lake and morphostratigraphic work in the catchment and surrounding region confirmed that the lake record was undisturbed, without evidence of glaciation or desiccation (Niessen et al., 2007; Glushkova and Smirnov, 2007). A 12.9-m-long sediment core retrieved from the deepest part of the lake in 1998 revealed a basal age of ~250 kyr and demonstrated, using a variety of proxies, the sensitivity of this lacustrine environment to record high-resolution climate change across NE Asia at millennial timescales (Brigham-Grette et al., 2007; Melles et al., 2007; Nowaczyk et al., 2007; Forman et al., 2007; plus 7 other papers in same issue; Fig. 2). A 16.7-m-long sediment core taken nearby in 2003 dated to nearly 300 kyr and confirmed the reproducibility of the record (Juschus et al., 2007). This research also showed that nearly every proxy can be systemically linked to changes in the duration of seasonal lake ice cover, regional temperature, and changes in hydrologic input driven largely by high latitude precessional cycles and feedbacks.

Potential Implications

Our ability to inform policy makers about global/regional climate and related environmental change and its uncertainties depends on our capacity to understand the role of the Arctic region in modulating past periods of change under different climate forcing conditions. Of prime interest to the scientific community is determining why and how the Arctic climate system evolved from a warm forested ecosystem into a cold permafrost ecosystem between 2-3 Myr ago. A continuous depositional
record in this unique lake will provide a means of capturing the mechanisms and dynamics of glacial/interglacial and millennial-scale change from this region over the duration of the “41 kyr world” and late Cenozoic “100 kyr world”. This record will then be compared with other long records from around the world but especially the low-latitude ocean records, to evaluate polar amplification, model systemic teleconnections and leads/lags relative to insolation forcing. This record will also provide insight into whether rapid change events identified during the last glacial cycle are typical of earlier glacial periods. We hope to provide the science community with an understanding of the poorly documented regional sensitivity of the NE Asian Arctic to millennial-scale abrupt change (Heinrich and D/O scale) and interglacial warmth detected at global vs. regional scales, within the timeframe of the EPICA ice cores, long Asian loess and lake records, and comparable marine records. Climate modeling is also an important aspect of the program in allowing these relationships to be evaluated systematically.

Note
All data produced by the project will be stored with NOAA/NGDC (www.ncdc.noaa.gov/paleo/paleo.html) and PANGAEA/WDC-MARE (www.pangaea.de/).

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For full references please consult: www.pages-igbp.org/products/newsletters/ref2009_1.html

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