

## Lake El'gygytgyn Scientific Drilling, NE Russia, unlocks secrets of Arctic Climate Change and Meteorite Impact Processes

Over the past 6 months, an international team of scientists from the USA, Germany, Russia, and Austria have staged scientific drilling operations in remote NE Russia to recover hundreds of meters of lake sediment and impact breccia that will provide new insights into the climate evolution of the Arctic and the formation of the crater. The completion of the project in early May 2009 marks the end of years of challenging logistical planning and the development of international partnerships to share in the scientific goals of the project. Lake El'gygytgyn, located 100 km (62 miles) north of the Arctic Circle (67°30' N, 172°05' E), was created 3.6 Million years ago (Ma) by a meteorite impact.

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 and 3 million years ago. The continuous depositional record collected in this unique lake will provide a means of capturing the mechanisms and dynamics of glacial/interglacial and millennial-scale change from this high latitude region over the duration of the "41 kyr world" and late Cenozoic "100 kyr world". The results of analyses from these cores will be used to understand the history of Arctic change and become integrated into a network of sites collected by the geological community from the Arctic Ocean (ACEX) to Antarctica (especially ANDRILL).

The deep drilling collected cores representing the longest time-continuous sediment record of past climate change in the terrestrial Arctic. The research team will compare this record with oceanic and land based records from the lower latitudes to better understand hemispheric global climate change and polar amplification. Below the sediments, cores into bedrock at the site will offer geologists a rare opportunity to study impact melt rocks and target rocks from one of the best preserved large impact craters on Earth. It is the only terrestrial impact known to have formed in siliceous volcanics and will give geologists a chance to study shocked metamorphism in volcanic lithologies. During the impact event, a 1-km-diameter (0.62 miles) asteroid hit the Earth's surface, and within just a few minutes formed an 18-km-diameter (11 mile) crater with a central uplift, whereby a mountain of about 1.5 km height (0.93 mile) and several km diameter was uplifted by 1-2 km (.62-1.2 miles) within less than a minute. The energy released during this impact was orders of magnitude larger than the combined nuclear arsenal of the whole world, and the drill core studies will help constrain the environmental effects of this event.

Drilling in the center of Chukotka was a massive logistical undertaking with international funding. The drilling rig and supplies were shipped from the site of construction in Salt Lake City, USA to Pevek, Russia, by way of Vladivostok and the Bering Strait. In Pevek it was loaded onto trucks driven with bulldozer assistance more than 350 km (217 miles) over winter roads to its operative location in one of the most remote areas of the world. Heavy drilling operations took place on 2.3 meters (7.5ft) of lake ice monitored by ice engineers.

The length and geologic significance of the climate record successfully collected by the project is absolutely unprecedented in the entire Arctic region, and more than 30 times longer than records from the Greenland Ice Sheet. The project completed three holes from the center of the lake (Site D1):

*Hole 1 A, to a depth of 146.58 m (480.8 ft) with 92% recovery*

*Hole 1 B, to a depth of 111.92 m (367.1 ft) with 98% recovery*

*Hole 1 C, to a depth of 517.3 m (1696.7 ft) with 63% recovery.*

From the three sites drilled the team recovered a total of 355 m (1165 ft) of sediment with replicate cores to roughly 2.0 Ma with outstanding recovery. In addition they collected sediment cores to the time of impact at 3.6 Ma at 315 m depth below lake floor (1033.5 ft), albeit with lower recovery due to surprising sequences of coarse sand and gravel interbedded with lacustrine mud. These coarser units provide new revelations to the science team and suggest unexpected glacial sources for these materials. Equally exciting is that the team recovered roughly 40 meters (131 ft) of the earliest history of the lake in the warm middle Pliocene with nearly 100% recovery. This interval is especially fascinating as a possible analog for future climate due to CO<sub>2</sub> forcing. Beneath the lake sediments, the team successfully recovered 157 m (516.2 ft) of various impact breccias and suevites (breccia with melted rock) over a depth interval of 207 m (680 ft). Over all at D1, the team cored 684.84 m (2246.3 ft) and recovered 512.11 m of core (1680 ft), for an overall recovery of 75%.

Initial results from the drilling are still limited for a reason. The sediment cores could not be opened in the field because of the remoteness of the drilling site and rough transportation overland transportation issues in central Chukotka. Moreover, the science team was not allowed by Russian Customs to import a small routine radiation source that would have allowed scientists to measure a number of physical properties on the full cores. Yet they could measure whole core magnetic susceptibility (a function of magnetite content) and a range of other properties using down hole logging instruments. Warm and cold cycles, similar to those seen in pilot cores extending to 300,000 yrs ago (16 meters sediment depth), can be seen in the new cores extending to more than 100 m but any estimates on the age and meaning of the cycles is premature. The record does suggest that the cores will produce new and exciting information on the style and onset of Northern Hemisphere glacial cycles for the first time seen with such clarity in an arctic terrestrial setting.

The project also recovered 141 m (462 ft) of core (site D3) in November representing alluvial fan and lake deposits in permafrost at the west edge of the lake outside the talik (unfrozen ground in an area of permafrost). After drilling, the borehole was permanently instrumented for future ground temperature monitoring as part of the Global Terrestrial Network for Permafrost ([www.gtnp.org/index\\_e.html](http://www.gtnp.org/index_e.html)).

Drilling to a depth of 517 m blf (meters below lake floor) (1696 ft), the project set a new depth record using the DOSECC GLAD-800 drilling system, surpassing the previous record of 470 m blf (1542 ft) set in Lake Bosumtwi, Ghana in 2004.

The scientific understanding of high latitude climate systems and how they react to changes in the global climate system is of great importance to climate research. The Arctic climate system is vulnerable to anthropogenic forcing and by studying the system and its changes throughout geologic history scientists gain critical knowledge for making predictions on the affects of future impacts. Understanding the modes of variability in arctic climate on millennial time scales, along with the spatial-temporal patterns and consequences of past warming scenarios will provide key insights into the future of arctic climate. Of key interest to the project is the phasing and Arctic expression of Milankovitch driven orbital cycles on glacial/interglacial cycles starting before the onset of Northern Hemisphere glaciation (2.6 Ma) through the Holocene (the last 10,000 yrs).

The geological project was developed and organized by principle investigators from the four collaborating countries -- Julie Brigham-Grette (US chief, UMass Amherst), Martin Melles (German chief, Univ of Cologne), Pavel Minyuk (Russian chief, NEISRI Magadan) and Christian Koeberl (Austrian chief, Univ Vienna). The Lake El'gygytyn Drilling Project is an international effort funded by the International Continental Drilling Program (ICDP), the US National Science Foundation Earth Sciences Division and Office of Polar Programs (NSF/EAR/OPP), the German Federal Ministry for Education and Research (BMBF), Alfred Wegener Institute (AWI), GeoForschungsZentrum-Potsdam (GFZ), the Russian Academy of Sciences Far East Branch (RAS/FEB), Russian Foundation for Basic Research (RFBR), and the Austrian Ministry for Science and Research. The leading Russian institutions include the Northeastern Interdisciplinary Scientific Research Institute (NEISRI), the Far East Geological Institute (FEGI), and Roshydromet's Arctic and Antarctic Research Institute (AARI). The deep drilling system for Arctic operations was developed by DOSECC Inc, and LacCore-University of Minnesota handled core curation.

In early June, the cores will be flown by chartered cargo plane to St. Petersburg. Later they will be trucked to the University of Cologne, Germany, for sub-sampling starting in October by the international team and their students; the archive core halves will be shipped to the University of Minnesota LacCore Facility in the US for post-moratorium studies. The impact breccia cores will be sampled at a separate event at the ICDP headquarters in Potsdam, Germany.

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Web Links:

- ICDP Main website -- <http://www.elgygytgyn.icdp-online.de/> ; click on “*news*”, then “*Daily news*” for blogs and pictures. Click on “*public data*” for weekly news updates for download in English, German and Russia.
- US Science Team -- [http://www.geo.umass.edu/lake\\_e/index.html](http://www.geo.umass.edu/lake_e/index.html)
- German Science Team -- <http://www.elgygytgyn.uni-koeln.de>
- Educational Outreach -- <http://www.polartrec.com/geologic-climate-research-in-siberia>. Follow 8<sup>th</sup> grade earth science teacher Tim Martin, on his “Polar Trec” with support from the US National Science Foundation.
- Boston Globe graphic [http://www.boston.com/interactive/graphics/20090316\\_siberia](http://www.boston.com/interactive/graphics/20090316_siberia)
- NASA Image -- <http://earthobservatory.nasa.gov/IOTD/view.php?id=36151>