Complex Drilling Logistics for Lake El'gygytgyn, NE Russia

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Introduction

Lake El'gygytgyn was formed by astrophysical chance when a meteorite struck the Earth 100 km north of the Arctic Circle in Chukotka 3.6 Myrs ago (Layer, 2000) on the drainage divide between the Arctic Ocean and the Bering Sea. The crater measures ~18 km in diameter and lies nearly in the center of what was to become Beringia, the largest contiguous landscape in the Arctic to have escaped continental scale glaciation. Within the crater rim today, Lake El'gygytgyn is 12 km in diameter and 170 m deep, enclosing 350–400 m of sediment deposited since the time of impact (Gebhardt et al., 2006). This setting makes the lake ideal for paleoclimate and impact research.

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 multi-national drilling campaign as part of the International Continental Scientific Drilling Program (ICDP). With drilling initiated in late fall 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 two sites (D1 and D2, Fig. 1) near the deepest part of the lake. Coring will 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, Fig. 1) measures ~200 m in lake sediments now overlain by frozen alluvial sediments on the lakeshore; D3 will allow a better understanding of sediment supply to the lake and spatial depositional heterogeneity since the time of impact. 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 uses a new Global Lake Drilling 800m (GLAD800) system modified for extreme weather conditions by Drilling, Observation and Sampling of the Earths Continental Crust (DOSECC). Moreover, the science and logistics involves close cooperation with the Russian Academy of Sciences (Far East Geological Institute-Vladivostok; and Northeastern Interdisciplinary Scientific Research Institute-Magadan) and Roshydromet's Arctic and Antarctic Research Institute (AARI), St. Petersburg.

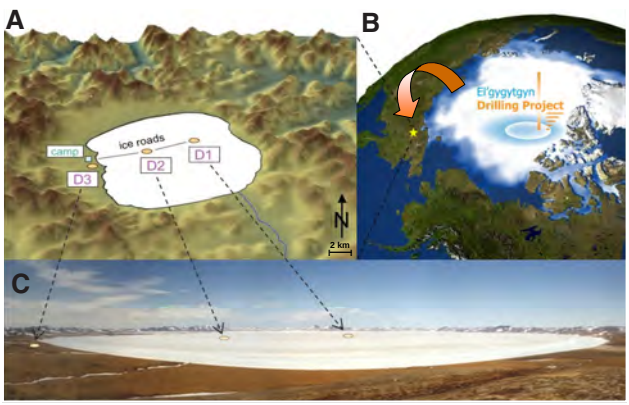

Figure 1. [A] Digital elevation model, [B] drill site locations, projected onto a panoramic view of Lake El'gygytgyn in May facing north, [C] location of Lake El'gygytgyn at 67.5°N and 172°E, ~100 km north of the Arctic Circle in Chukotka, northeastern Russia (base map courtesy of Arctic Climate Impact Assessment).

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 is undisturbed, without evidence of glaciation or desiccation (Niessen et al., 2007; Glushkova and Smirnov, 2007). Short sediment cores demonstrated the sensitivity of this lacustrine environment to record high-resolution climatic change across NE Asia at millennial timescales (Brigham-Grette et al., 2007; Melles et al., 2007; Nowaczyk et al., 2007; Fig. 2). Documenting the dynamics and controls on the lake's seasonal ice cover (Nolan and Brigham-Grette, 2007) has been key to understanding lake circulation and has been critical to developing safety plans for ice thickening and engineering prior to drilling from the lake's frozen surface.

Logistical Challenges

Lake El'gygytgyn is located 255 km inland from the village of Pevek on the coast of the East Siberian Sea. Because there are no roads to the lake, maritime shipments with the drilling system, fuel, mud, drill pipe, etc. need to be delivered in the open water season by barge through the Bering Strait

Figure 2. The new "Russian"GLAD assembled and modified by DOSECC in Salt Lake City in consultation with Alex Pyne (Antarctica Research Center, New Zeland).

by way of Vladivostok. Traversing the DOSECC drill rig and all supplies, pipe, and equipment from Pevek to Lake El'gygytgyn requires a 360-km overland bulldozer-supported trek after the rivers and tundra are well frozen and can sustain heavy loads. Most of the field party will reach the lake by helicopter out of Pevek.

Winter Drilling

Drilling in the extreme cold, darkness, and isolation of the Arctic required that the drilling system be completely enclosed and outfitted with a reliable heating system and adequate power and backup systems. Moreover, the drill system was designed to rest on a steel sledge for relocation and for cold air to circulate underneath the rig (to prevent melting). Crew changes and the transportation of cores from the rig on the lake ice to the science camp on the shore will be done in an enclosed personnel carrier. The drill sites on the lake ice are being carefully engineered for load requirements of 1.5 m of ice achieved by clearing snow and flooding the ice over an area of about 100 m in diameter. These drill pads and the road back to camp will be monitored continuously for cracks and wear. The sediment cores will be processed for whole-core physical properties and will be stored at the lake in a temperature-controlled container until they are flown to Pevek and staged for airfreight to St. Petersburg and later trucked to the University of Cologne for core opening and study by the international team. The archive halves of the core will go to LacCore, University of Minnesota.

Acknowledgements

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Related Web Links

DOSECC: http://www.dosecc.org/html/glad800.html
El'gygytgyn Drilling Project: http://elgygytgyn.icdp-online.org

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Fig. 1: [A] photo by Conrad Kopsch, AWI; [B] photo by Volker Wennrich, University of Cologne; [C] base map courtesy of Arctic Climate Impact Assessment
Fig. 2: photo by David Zur, DOSECC