Ice-free Arctic may be in our future, says research

May 9 2013

Co-authors Julie Brigham-Grette and Pavel Minyuk celebrate when drilling reached the bottom of lake sediments at a depth of 318 m below the lake bottom. At that point, drilling began reaching into the 3.6-million-year-old impact rock. Credit: Tim Martin

Analyses of the longest continental sediment core ever collected in the Arctic, recently completed by an international team led by Julie Brigham-

Grette of the University of Massachusetts Amherst, provide "absolutely new knowledge" of Arctic climate from 2.2 to 3.6 million years ago.

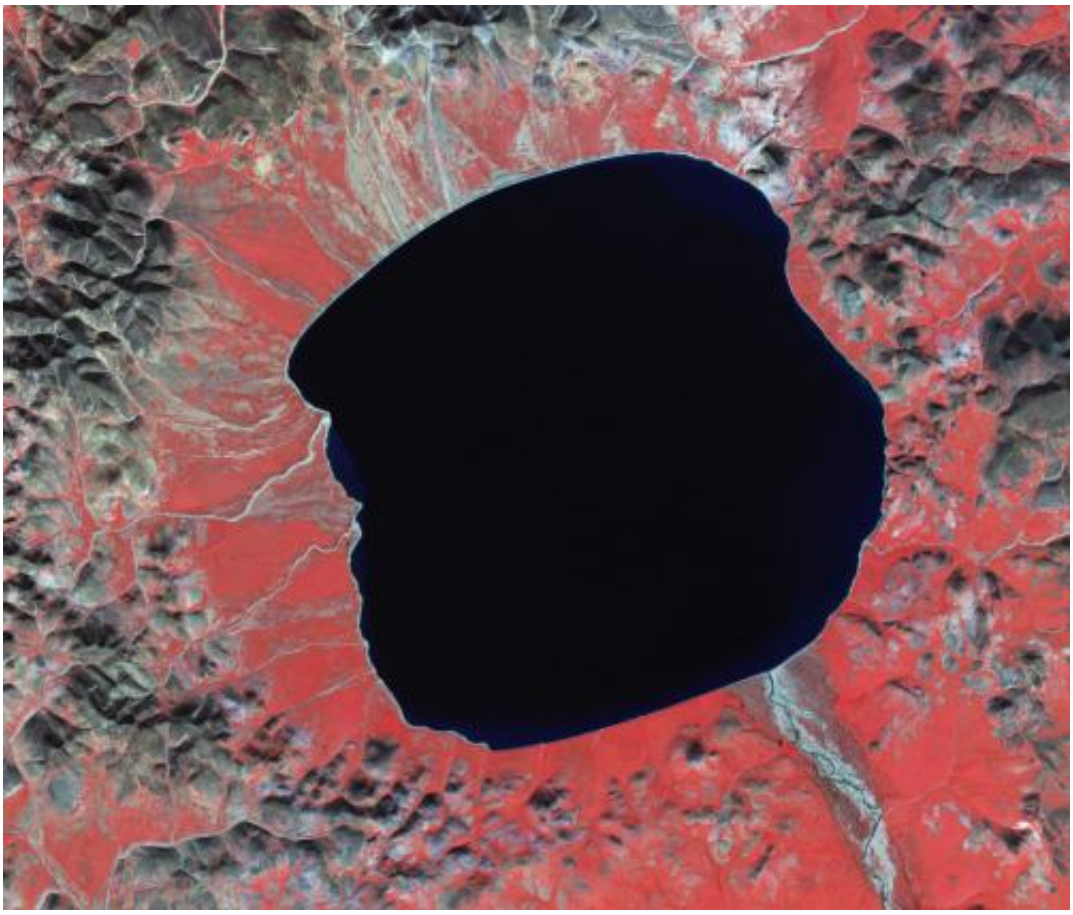
"While existing geologic records from the Arctic contain important hints about this time period, what we are presenting is the most continuous archive of information about past climate change from the entire Arctic borderlands. As if reading a detective novel, we can go back in time and reconstruct how the Arctic evolved with only a few pages missing here and there," says Brigham-Grette.

Results of analyses that provide "an exceptional window into environmental dynamics" never before possible were published this week in *Science* and have "major implications for understanding how the Arctic transitioned from a forested landscape without ice sheets to the ice- and snow-covered land we know today," she adds.

Their data come from analyzing sediment cores collected in the winter of 2009 from ice-covered Lake El'gygytgyn, the oldest deep lake in the northeast Russian Arctic, located 100 km north of the Arctic Circle. "Lake E" was formed 3.6 million years ago when a meteorite, perhaps a kilometer in diameter, hit the Earth and blasted out an 11-mile (18 km) wide crater. It has been collecting sediment layers ever since. Luckily for geoscientists, it lies in one of the few Arctic areas not eroded by continental ice sheets during ice ages, so a thick, continuous sediment record was left remarkably undisturbed. Cores from Lake E reach back in geologic time nearly 25 times farther than Greenland ice cores that span only the past 140,000 years.

"One of our major findings is that the Arctic was very warm in the middle Pliocene and Early Pleistocene [~ 3.6 to 2.2 million years ago] when others have suggested atmospheric CO2 was not much higher than levels we see today. This could tell us where we are going in the near future. In other words, the Earth system response to small changes in

carbon dioxide is bigger than suggested by earlier climate models," the authors state.



False-color image of Lake El'gygytgyn. This image was taken by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite on August 18, 2008. Red indicates vegetation, gray-brown indicates bare land and deep blue indicates water. Credit: NASA's Earth Observatory

Important to the story are the fossil pollen found in the core, including Douglas fir and hemlock. These allow the reconstruction of vegetation around the lake in the past, which in turn paints a picture of past

temperatures and precipitation.

Another significant finding is documentation of sustained warmth in the Middle Pliocene, with summer temperatures of about 59 to 61 degrees F [15 to 16 degrees C], about 14.4 degrees F [8 degrees C] warmer than today, and regional precipitation three times higher. "We show that this exceptional warmth well north of the Arctic Circle occurred throughout both warm and cold orbital cycles and coincides with a long interval of 1.2 million years when other researchers have shown the West Antarctic Ice Sheet did not exist," Brigham-Grette notes. Hence both poles share some common history, but the pace of change differed.

Her co-authors, Martin Melles of the University of Cologne and Pavel Minyuk of Russia's Northeast Interdisciplinary Scientific Research Institute, Magadan, led research teams on the project. Robert DeConto, also at UMass Amherst, led climate modeling efforts. These data were compared with ecosystem reconstructions performed by collaborators at universities of Berlin and Cologne.

The Lake E cores provide a terrestrial perspective on the stepped pacing of several portions of the climate system through the transition from a warm, forested Arctic to the first occurrence of land ice, Brigham-Grette says, and the eventual onset of major glacial/interglacial cycles. "It is very impressive that summer temperatures during warm intervals even as late as 2.2 million years ago were always warmer than in our pre-Industrial reconstructions."

Minyuk notes that they also observed a major drop in Arctic precipitation at around the same time large Northern Hemispheric ice sheets first expanded and ocean conditions changed in the North Pacific. This has major implications for understanding both what drove the onset of the ice ages

The Lake El'gygytgyn drilling rig is shown at night. Credit: The Lake El'gygytgyn Drilling Project

The sediment core also reveals that even during the first major "cold snap" to show up in the record 3.3 Million years ago, temperatures in the western Arctic were similar to recent averages of the past 12,000 years. "Most importantly, conditions were not 'glacial,' raising new questions as to the timing of the first appearance of ice sheets in the Northern Hemisphere," the authors add.

This week's paper is the second article published in *Science* by these authors using data from the Lake E project. Their first, in July 2012, covered the period from the present to 2.8 million years ago, while the current work addresses the record from 2.2 to 3.6 million years ago. Melles says, "This latest paper completes our goal of providing an overview of new knowledge of the evolution of Arctic change across the

western borderlands back to 3.6 million years and places this record into a global context with comparisons to records in the Pacific, the Atlantic and Antarctica."

The new Lake E paleoclimate reconstructions and climate modeling are consistent with estimates made by other research groups that support the idea that Earth's climate sensitivity to CO2 may well be higher than suggested by the 2007 report of the Intergovernmental Panel on Climate Change.

More information: Pliocene Warmth, Polar Amplification, and Stepped Pleistocene Cooling Recorded in NE Arctic Russia," by J. Brigham-Grette et al. *Science*, 2013.

www.icdp-online.org/front_content.php?idcat=512
www.geo.umass.edu/lake_e/
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Provided by University of Massachusetts Amherst