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Director, Keck Geology Consortium
Pomona College

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Union College

Carol Morgan
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Diane Kadyk
Symposium Proceedings Layout & Design
Department of Earth & Environment
Franklin & Marshall College

Keck Geology Consortium
Geology Department, Pomona College
185 E. 6th St., Claremont, CA 91711
(909) 607-0651, keckgeology@pomona.edu, keckgeology.org

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Short Contributions—Hövsgöl Rift, Mongolia

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Project Faculty: KARL W. WEGMANN: North Carolina State University, TSALMAN AMGAA: Mongolian University of Science and Technology, KURT L. FRANKEL: Georgia Institute of Technology, ANDREW P. deWET: Franklin & Marshall College, AMGALAN BAYASAGALN: Mongolian University of Science and Technology

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Research Advisor: Dr. Andy deWet

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GABRIELLE VANCE, Whitman College
ESUGEI GANBOLD, Mongolia University of Science and Technology
Research Advisors: Bob Carson and Nick Bader
INTRODUCTION

The Lake Hövsgöl region receives most of its annual precipitation during the mild summer months of July and August, while winter is harsh and typically very cold and dry. Climatic data sets from 3 meteorological monitoring stations (MMS) near Lake Hövsgöl reveal a 1°C increase in mean annual temperature over the past 20 years. The findings of Batima et al. (2005), with similar data, agree that the mean air temperature has increased by 1.66°C for the last 70 years, with distinct warming from the beginning of the 1970s increasing toward the end of the 1980s and 1990s. This indicates that both the summers and winters of Lake Hövsgöl are warming. Do the nomadic and semi-nomadic herders of Lake Hövsgöl (or for that matter all Mongolians) have reason to be concerned about a 1°C increase in temperature over the past 20 years? What is the impact of this temperature change on the Mongolian ecosystem? Changes in weather patterns may disrupt the growth of grasses which are key to the survival of foraging livestock upon which the majority of the Mongolian populous depends. Nearly 50 percent of Mongolia’s population is reliant on animal husbandry with an additional 35% of the population dependent upon agricultural gross production, which accounts for 30% of Mongolia’s export. Climatic changes may adversely impact pasture availability, threatening forage yield, endangering livestock productivity, and ultimately adversely impacting the food production capacity of local and national food producers.

The goal of this project is to characterize the variability of precipitation and temperature change through the construction of native tree ring chronologies and ring-width indices spanning several hundred years for the northern Lake Hövsgöl region and perform stable isotopic analysis of extracted alpha-cellulose in an effort to validate the instrumented climatic observations over longer time periods. Analysis of the ratios of stable isotopes (O, H) in cellulose can be used as “paleothermometers” to help reconstruct a climatologic record (Wilson and Grinsted, 1977). For this project, analysis was performed on a single wood component, cellulose, in order to minimize the variability of the ratio of wood constituents like lignin-to-cellulose as noted in (Wilson and Grinsted, 1977).

Figure 1. Study areas and meteorological monitoring stations (MMS) near Lake Hövsgöl
METHODS AND MATERIALS

This study was conducted in two phases, tree ring analysis to construct chronologies and ring-width indices and the stable-isotope analysis of the core samples.

Tree Ring Analysis

During the months of July and August 2010, a total of thirty-one tree cores were taken from twenty-nine L. Siberica using a 5 mm increment borer at breast height. The tree cores were taken parallel to the slope contour thereby avoiding reaction wood. Two cores were taken from selected trees in order to obtain a full diameter core section. The cores were stored in plastic straws to avoid damage in transit and storage prior to preparation.

Cores were prepared using Speer’s methodology. The cores were removed from the straws and placed in wooden sample holders; some samples showed evidence of mold. The cores were glued into the concave slot of the sample holders using wood glue and allowed to dry for at least 24 hours. The protruding upper half of the core was then removed down to the level of the sample holder by both belt and hand sanding with progressively finer grit sandpaper until a smooth surface was obtained. The orientation (bark-ring) of the sample was denoted on the sample holder for reference.

The prepared samples were then visually analyzed under a binocular microscope at 30x magnification and the width of individual rings measured and recorded with a Velamax Rapid Advance Unislide linear encoder that interfaces between the microscope and a PC using the ring counting procedure outlined by Speer. This process starts by assigning the year of the core acquisition to the bark end of the sample and then counts rings backwards in time to the sample pith. Total ring widths (including early and late wood) were measured to within 0.01 mm using the MeasureJ2X software package interfaced to the Velamax encoder. The ring width was exported from MeasureJ2X into a text file per core sample. The text files were manually edited to correct data format problems. These files were then imported into the

STUDY SITES

The Hövsgöl basin lies at the southern limit of the continuous Siberian boreal (taiga) forest. At the latitude of northern Lake Hövsgöl, forest stands are naturally composed almost entirely of Siberian larch (Larix siberica). The tree core samples for this study were gathered from several sites that lie along the northern shores of Lake Hövsgöl in the Horoo Gol valley (51.570° N; 100.462° E). Siberian larch chosen for this study are growing on south facing slopes, widely separated from other trees in the stand, and have large diameters (> 2 m) and heights (>18 m). Southern slopes were chosen because they are moisture-limited, making the stable-isotope analysis more feasible. Additionally, the selected trees were screened to avoid those with signs of burn scars, insect infestation or outward signs of heart-rot (to which L. Siberica is prone) and those with obvious anthropogenic influence. The slope aspect of the selected trees ranged from 0 to 31° (mean = 8°) and are covered with thin mantles and solifluction debris composed of granitic and balsatic rocks. The position of the tree line and the diversity and distribution of species in northern Mongolia are climatically controlled by humidity (total effective moisture) and temperature gradients (Jacoby et al., 2003).

| Tree | Longitude | Latitude | Elevation | Circumference | Age | Species | Slope
|------|-----------|----------|-----------|---------------|-----|---------|-------|
| 101  | 51.570° N| 100.462° E | 1762 | 23.3 | 28 | None | L. Siberica | 24
| 102  | 51.570° N| 100.462° E | 1807 | 23.3 | 28 | None | L. Siberica | 24
| 103  | 51.570° N| 100.462° E | 1727 | 2.7 | 23 | None | L. Siberica | 24
| 104  | 51.570° N| 100.462° E | 1699 | 2.3 | 25 | None | L. Siberica | 24
| 105  | 51.570° N| 100.462° E | 1938 | 1.4 | 28 | None | L. Siberica | 18
| 106  | 51.570° N| 100.462° E | 2001 | 1.8 | 28 | None | L. Siberica | 18
| 107  | 51.570° N| 100.462° E | 1999 | 2.5 | 21 | None | L. Siberica | 22
| 108  | 51.570° N| 100.462° E | 1997 | 2.1 | 21 | None | L. Siberica | 22
| 109  | 51.570° N| 100.462° E | 1982 | 1.9 | 20 | None | L. Siberica | 21
| 110  | 51.570° N| 100.462° E | 1842 | 1.9 | 15 | None | L. Siberica | 20
| 111  | 51.570° N| 100.462° E | 1822 | 1.5 | 18 | None | L. Siberica | 20
| 112  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 113  | 51.570° N| 100.462° E | 1818 | 1.3 | 20 | None | L. Siberica | 20
| 114  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 115  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 116  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 117  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 118  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 119  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 120  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 121  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 122  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 123  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 124  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 125  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 126  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 127  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 128  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 129  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20
| 130  | 51.570° N| 100.462° E | 1816 | 1.3 | 20 | None | L. Siberica | 20

Table 1. Trees cored by location, elevation, circumference, slope, aspect, species, height and age.
TSAPWin software package (Rinntech GmbH, 2011) for cross-dating of time series. This step is critical to eliminate false rings, allow for insertion of missing rings and determine correlation between sites.

**Stable Isotope Analysis of Alpha Cellulose**

Because of reaction tissues and growth disturbances, most of the trees sampled were not dateable by dendrochronology. These tissues and disturbances disrupt the expected environmental signal of wide and narrow rings that enable cross-dating. Of the dated trees, three trees were selected for the hydrogen and oxygen isotopic analysis, however due to time limitations, only one tree was used. Selection criteria was based on three criteria used by (Loader et al., 2007): wood quality based on the absence of reaction tissue or rot, chronology (no partial/false rings) and age (to avoid potential isotopic ‘juvenile’ effects, samples chosen were greater than 150 years old). Alpha-cellulose was extracted and purified from the wood samples using a slightly modified Brendel method (; Fig. 3; Brendel et al., 2000) and placed in a desiccator filled with anhydrous silica gel prior to isotopic analysis. Oxygen and Hydrogen isotopes from the extracted alpha-cellulose were measured on an isotope ratio mass spectrometry (IRMS) in the North Carolina State University Stable Isotope Laboratory. At the time of writing, these analyses were ongoing.

**RESULTS AND DISCUSSION**

Although the results of the isotope analysis are not yet complete, the project intends to perform correlation analysis between dendroclimatic and stable isotope $\delta^{18}O$ data with the data sets obtained from

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**Table 1**

<table>
<thead>
<tr>
<th>Step 1</th>
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<tbody>
<tr>
<td>• Take 10-100 mg milled sample</td>
</tr>
<tr>
<td>• Add 2 mL 80% v/v acetic acid</td>
</tr>
<tr>
<td>• Add 2 mL 69% v/v nitric acid</td>
</tr>
<tr>
<td>• Seal and vortex</td>
</tr>
<tr>
<td>• Boil gently at 120°C for 20 minutes</td>
</tr>
</tbody>
</table>

**Step 2**

- Allow to cool
- Add 2.5 mL of 99% v/v ethanol

**Step 3**

- Seal and vortex
- Centrifuge for 5 minutes at 2000 rpm
- Decant supernatant

**Step 4**

- Add 2 x 2.5 mL of 99% v/v ethanol
- Repeat Step 3

**Step 5**

- Add 2 x 2.5 mL deionized water
- Repeat Step 3

**Step 6**

- Add 2 x 2.5 mL of 99% v/v ethanol
- Repeat Step 3

**Step 7**

- Add 2 x 2.5 mL acetone
- Repeat Step 3

**Step 8**

- Add .4 mL acetone
- Add 6 mL acetone
- Transfer sample to 1.5 mL microfuge tube
- Vacuum dry

---

3 meteorological monitoring stations (MMS) around Lake Hövsgöl. Climatic data sets were obtained from Hotgol at the south end of lake, Hanh at the northern end of lake, and Renchinkhumb to the west in the Darhad depression. The mean annual, summer and winter temperature was plotted. A 0.05°C per year increase in temperature for the 3 stations equaling a 1°C increase in the past 20 years is observed as shown in Figure 5. Batima et al. (2005), using shorter temperature records from these three stations came to
similar findings that the mean annual air temperature has increased by 1.66 °C for the last 70 years, with distinct warming from the beginning of the 1970s increasing toward the end of the 1980s and 1990s. The warming has been most pronounced and evident by a mean winter (October – March) temperature increase of 3.6 °C. Annual precipitation has increased by 1 to 3.5 mm/yr as recorded by the three meteorological stations, as might be expected for a warming atmosphere.

CONCLUSION
Further discussion of the results and the conclusions based upon them are pending completion of the ongoing stable isotope analysis of the extracted alpha-cellulose. However, from the available recorded climatic data observations, it is evident that the mean annual temperature and the annual precipitation are both increasing. Because of the agrarian-basis of much of the Mongolian economy, changes to the climate, which potentially affect the growth of both fodder and forage are likely to have a bigger impact than they would on a more industrial-based economy. It might seem counter-intuitive that an increase in precipitation and temperature would have a negative impact on the continental climate of Mongolia, but historic flooding in 2009 which devastated even populated areas like Ulaanbaatar illustrates that such changes often result in negative outcomes.

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REFERENCES


