KECK GEOLOGY CONSORTIUM

PROCEEDINGS OF THE TWENTY-SECOND ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

April 2009
Franklin & Marshall College, Lancaster PA.

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2008-2009 PROJECTS

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Faculty: *WILLIAM H. PECK*, *BRUCE W. SELLECK* and *MARTIN S. WONG*: Colgate University
Students*: JOE CATALANO*: Union College; *ISIS FUKAI*: Oberlin College*; STEVEN HOCHMAN*: Pomona College; *JOSHUA T. MAURER*: Mt Union College*; ROBERT NOWAK*: The College of Wooster*; SEAN REGAN*: St. Lawrence University*; ASHLEY RUSSELL*: University of North Dakota; *ANDREW G. STOCKER*: Claremont McKenna College; *CELINA N. WILL*: Mount Holyoke College

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Students: *GARRISON LOOPE*: Oberlin College; *DOUGLAS MERKERT*: Union College; *JOHN LINDEN NEFF*: Amherst College; *NANCY PARKER*: Lafayette College; *KYLE TROSTLE*: Franklin & Marshall College; *BEVERLY WALKER*: Colgate University

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Students: *AVERY R. COTA*: Minnesota State University Moorhead; *JANE DIDALEUSKY*: Smith College; *ROWAN HILL*: Colorado College; *ANNA PENDLEY*: Washington and Lee University; *MAIJA SIPOLA*: Carleton College; *STACEY SOSENKO*: Franklin and Marshall College

GEOLOGY OF THE HÖH SERH RANGE, MONGOLIAN ALTAI
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Students: *ALANA BARTOLAI*: Macalester College; *EMMA KRAVET and CONOR VEENEMAN*: Wesleyan University; *RACHEL NEURATH*: Smith College; *JESSICA SCHEICK*: Bryn Mawr College; *DAVID JAKIM*: SUNY.

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Keck Geology Consortium: Projects 2008-2009
Short Contributions – MONGOLIA

GEOLOGY OF THE HÖH SERH RANGE, MONGOLIAN ALTAI

NICHOLAS E. BADER and ROBERT J. CARSON: Whitman College
A. BAYASGALAN: Mongolian University of Science and Technology
KURT L. FRANKEL: Georgia Institute of Technology
KARL W. WEGMANN: North Carolina State University

APATITE FISSION TRACK THERMOCHRONOLOGY OF THE HÖH SERH RANGE, MONGOLIAN ALTAI

ELIZABETH BROWN: Occidental College
Research Advisor: Professor Ann Blythe
GANBAYAR RAGCHAASUREN: Mongolia University of Science and Technology

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***KRISTIN E. SWEENEY*:** Carleton College
Research Advisor: Sarah Titus
TSOLMON ADIYA: Mongolia University of Science and Technology

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***JODI SPRAJCAR*:** The College of Wooster,
Research Advisor: Shelley Judge
ERDENEBAT BOLOR : Mongolia University of Science and Technology

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ICE LAKE VALLEY GLACIATION, HÖH SERH RANGE, MONGOLIAN ALTAI

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RECONSTRUCTING LATE HOLOCENE CLIMATE THROUGH TREE-RING ANALYSIS OF SIBERIAN LARCH: ALTAI MOUNTAINS, WESTERN MONGOLIA

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INTRODUCTION

The Höh Serh Range of the Mongolian Altai preserves a glacial record since the late Pleistocene. Small glaciers still exist in the tectonically active range, however Ice Lake Valley at the center of the Höh Serh Range is not currently glaciated. The Höh Serh Fault is located at the mouth of the west-draining Ice Lake Valley where it joins the much larger south-draining Delüün Valley. The upper part of Ice Lake Valley is underlain by granite, and the lower part of the valley by phyllite. Ice Lake Valley is named for a large lake, approximately 1000 m by 150 m, that drains a tributary stream to the Buyant Gol in Delüün Valley.

GEOMORPHOLOGY

Ice Lake occupies a former glacial trough. Large granite boulders cover the phyllite bedrock of the lower valley sides and floor (Fig. 1). The cirque headwall is polished, indicating that the glacier was warm-based at one time. Cryoplanation terraces above the granitic erratics indicate a periglacial environment adjacent to the former glacier.

Figure 1: Large erratic granite boulder on the north side of Ice Lake Valley.

Five distinct moraines represent periods of climate stability. Valley Moraine, a terminal moraine (Fig. 2), is located in the Delüün Valley west of the Höh Serh Fault (Fig. 3). Ger Moraine, located approximately 1.75 km upvalley from Valley Moraine (Fig. 3), contains a distinct outer edge, suggesting readvance of the Ice Lake glacier. Ground moraine exists between Ger Moraine and Lake Moraine. Lake Moraine dams Ice Lake on the west side. Two other moraines, Young and High Moraine, are located upvalley of Ice Lake close to the cirque headwall. Upvalley of Ger Moraine many cirques and cirque complexes sit high on both valley sides.

Figure 2: Valley Moraine, a terminal moraine where the Höh Serh Fault crosses the mouth of Ice Lake Valley.

ELA

Using a topographic map and a GPS receiver, ice limits for the Last Glacial Maximum (LGM) and

Moraine	AAR (67%) ELA (m)	TSAM (50%) ELA (m)	Mean ELA (m)	ELA Elev. Difference (m)	Change in temperature[1] (°C)	Area (km^2)	Volume (km^3)
Valley	3,050	3,080	3,065			11.7	1.4
				135	<0.4		
Ger	3,160	3,240	3,200			6.0	0.7
				42	<0.2		
Lake	3,200	3,285	3,242			3.7	0.6
				758±	2.5		
PM Glacier[2]			4,000±				

[1] Based on an assumed lapse rate of 300m/1°C assuming no change in precipitation
[2] Existing glacier on Praying Mountain, 8 km south of Ice Lake Valley

Table 1: ELAs, ice areas and volumes, and calculated temperature changes for Ice Lake Valley.

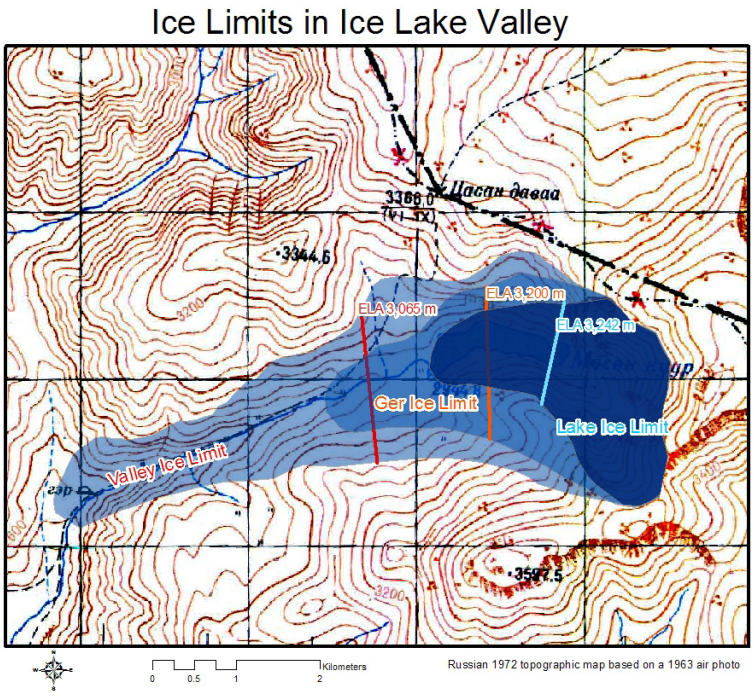

Figure 3: Ice limits and ELAs for the three major moraines in Ice Lake Valley.

later times of ice stability were determined by plotting moraines and erratic boulders (Fig. 3). GIS was used to create a map of the ice limits, areas, and volumes when each moraine was deposited. From these ice limits calculations were made to determine the Equilibrium Line Altitude (ELA) for each period using both the Accumulation Area Ratio (AAR) Method and the Toe-to-Summit Altitude Method (TSAM) (Table 1).

Based on field measurements a glacier with an area of 11.7 km^2 and a volume of 1.4 km^3 once existed in Ice Lake Valley (Fig. 4). The ELA of the Valley Terminal Moraine glacier was 3,065 m, presumably during the LGM. The glacier on Praying Mountain, 8 km south of Ice Lake Valley, currently has an ELA of at least about 4,000 m. This demonstrates a 760 m increase in the ELA since the Valley Moraine was deposited at about 35 Ka. Assuming a normal lapse rate of !°C/300m and constant precipitation, this

Moraine	Crest Height	Relative Boulder Frequency	Relative Boulder Height	Relative Soil and Vegetation
Valley	~50 m	low	low	grass with well developed soil
Ger	≤10 m	high	medium	grass with well developed and some hommocky ground
Lake	≤15 m	medium	medium high	grass with well developed and hommocky ground

Table 2: Field data collected from the three largest moraines in Ice Lake Valley.

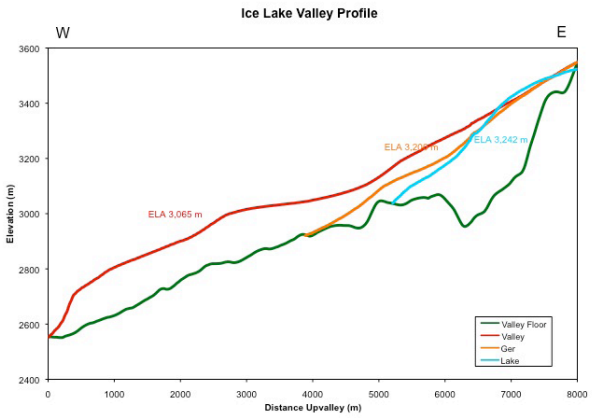

Figure 4: Ice Lake Valley longitudinal profile.

constitutes about a 3˚ C mean annual temperature increase since the LGM.

DATING

The moraines within Ice Lake Valley can be relatively dated using boulder frequencies, boulder heights, soil development, and location in the valley (Table 2). Valley Moraine was deposited first, likely during the LGM. The other four moraines were deposited more recently than Valley Moraine. Boulder height supports Ger Moraine being older than Lake Moraine (Table 2). Allowing for elevation differences, all five moraines have about the same degree of soil development, so it appears that no neoglacial moraines are present in Ice Lake Valley.

Samples of granite erratic boulders on three moraines, Valley, Lake and Ger (Fig. 3), were collected for ^{10}Be cosmogenic dating. Four surface exposure dates yield ages of 40, 35, 60, and 70 Ka (mean and standard deviation = 51 +/- 17 Ka).

DISCUSSION

We calculated a 3˚ C mean annual temperature increase since the LGM based on ELAs. This change in temperature is less than expected. This may relate to local climate. Potential inaccuracies in the amount of mean annual temperature change might result if the seasonality or total amount of local precipitation changed between the LGM and today. Mongolia during the LGM was dry and cold, compared to the more humid time during the interglaciation as evident by high lake levels (Grunert et al., 2000). Before 10 Ka the Mongolian Altai was similar to the modern steppe and arid-desert with dry and cool conditions. Between 10 and 5 Ka the extent of boreal forests increased southward with more precipitation. After 5 Ka, steppe vegetation dominates the paleo pollen spectrum, indicating a return to cool and dry conditions (Rudaya et al., 2009). Precipitation increased during the Holocene because the Pacific Ocean became a moisture source for the Altai Mountains, whereas the Atlantic Ocean was a moisture source during the LGM (Rudaya et al., 2009). Due to the gentle gradient of the valley, a drastic loss in ice volume occurred after the LGM (Fig. 4).

In addition, ^{10}Be surface exposure ages from the Valley Moraine, along with those from other terminal moraines on the eastern flank of the Höh Serh Range, suggest ice reached its maximum extent at ~35 Ka.

REFERENCES

Grunert, Jörg, Frank Lehmkuhl, and Michael Walther, 2000, Paleoclimatic evolution of the Uvs Nuur basin and adjacent areas: Quaternary International, v. 65/66, p. 171-192.

Rudaya, Natalia, Pavel Tarasov, Nadezhda Dorofeyuk, Nadia Solovieva, Ivan Kalugin, Andrei Andreev, Andrei Daryin, Bernhard Diekmann, Frank Riedel, Narantsetseg Tserendash, and Mayke Wagner, 2009, Holocene environments and climate in the Mongolian Altai reconstructed from the Hoton-Nur pollen and diatom records: A step toward better understanding climate dynamics in Central Asia: Quaternary Science Reviews, v. 28, p. 540-554.