KECK GEOLOGY CONSORTIUM

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

April 2011
Union College, Schenectady, NY

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Students: *ERIN CAMP*, Amherst College, *EVAN N. DETHIER*, Williams College, *HAYLEY CORSON-RIKERT*, Wesleyan University, *KEITH M. KANTACK*, Williams College, *ELLEN M. MALEY*, Smith College, *JAMES A. MCCARTHY*, Williams College, *COREY SHIRCLIFF*, Beloit College, *KATHLEEN WARRELL*, Georgia Tech University, *CIANNA E. WYSHNYSZKY*, Amherst College.

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Faculty: *KELLY MACGREGOR*, Macalester College, *CATHERINE RIIHIMAKI*, Drew University, *AMY MYRBO*, LacCore Lab, University of Minnesota, *KRISTINA BRADY*, LacCore Lab, University of Minnesota

Students: *HANNAH BOURNE*, Wesleyan University, *JONATHAN GRIFFITH*, Union College, *JACQUELINE KUTVIRT*, Macalester College, *EMMA LOCATELLI*, Macalester College, *SARAH MATTESON*, Bryn Mawr College, *PERRY ODDO*, Franklin and Marshall College, *CLARK BRUNSON SIMCOE*, Washington and Lee University.

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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.
Students: *BRIANA BERKOWITZ*, Beloit College, *DAENA CHARLES*, Union College, *MELLISSA CROSS*, Colgate University, *JOHN MICHAELS*, North Carolina State University, *ERDENEBAYAR TSAGAANNARAN*, Mongolian University of Science and Technology, *BATTOGTOH DAMDINSUREN*, Mongolian University of Science and Technology, *DANIEL ROTHBERG*, Colorado College, *ESUGEI GANBOLD, ARANZAL ERDENE*, Mongolian University of Science and Technology, *AFSHAN SHAIKH*, Georgia Institute of Technology, *KRISTIN TADDEI*, Franklin and Marshall College, *GABRIELLE VANCE*, Whitman College, *ANDREW ZUZA*, Cornell University.

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Students: *JESSE GEARY*, Macalester College, *KATHERINE KRAVITZ*, Smith College, *RAY MCGAUGHEY*, Carleton College.

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Keck Geology Consortium: Projects 2010-2011
Short Contributions— Hövsgöl Rift, Mongolia

GEOLOGIC, GEOMORPHIC, AND ENVIRONMENTAL CHANGE AT THE NORTHERN TERMINATION OF THE LAKE HÖVSGÖL RIFT, MONGOLIA
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: Karl Wegmann

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Research Advisor: Eric Leonard

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ESUGEI GANBOLD, Mongolia University of Science and Technology
Research Advisors: Bob Carson and Nick Bader

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ANDREW ZUZA, Cornell University
ARANZAL BAT-ERDENE, Mongolian University of Science and Technology
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TIMING AND EXTENT OF LATE QUATERNARY GLACIATIONS NEAR LAKE HÖVSGÖL, MONGOLIA: IMPLICATIONS FOR CLIMATE CHANGE IN CENTRAL ASIA

AFSHAN SHAIKH, Georgia Institute of Technology
Research Advisor: Kurt L. Frankel

INTRODUCTION

The tectonic activity of the Indo-Asia collision can be studied by looking at its resulting deformation. One region that is affected by this tectonic activity experiences deformation >2500 km to the north. Mongolia is in a peculiar place in Asia at the transition between contracting deformation to the south and extensional deformation to the north (Figure 1). The northern Lake Hövsgöl rift, near the Russian-Mongolian border is located at the southern portion of the extending region. Late Pleistocene valley glaciers at the northwestern end of Lake Hövsgöl deposited distinct moraines that appear to be diachronous between valleys. We hypothesized that the apparent variability in the timing of terminal position for glaciers in adjacent valleys at the northern end of the Hövsgöl rift may reflect gradients in surface uplift driven by active faulting along the western rift-bounding fault. Determining the timing of glacial advances in this region therefore, provides constraints for regional climate correlations and the impact that rising mountain ranges might have on the preservation of glacial sequences.

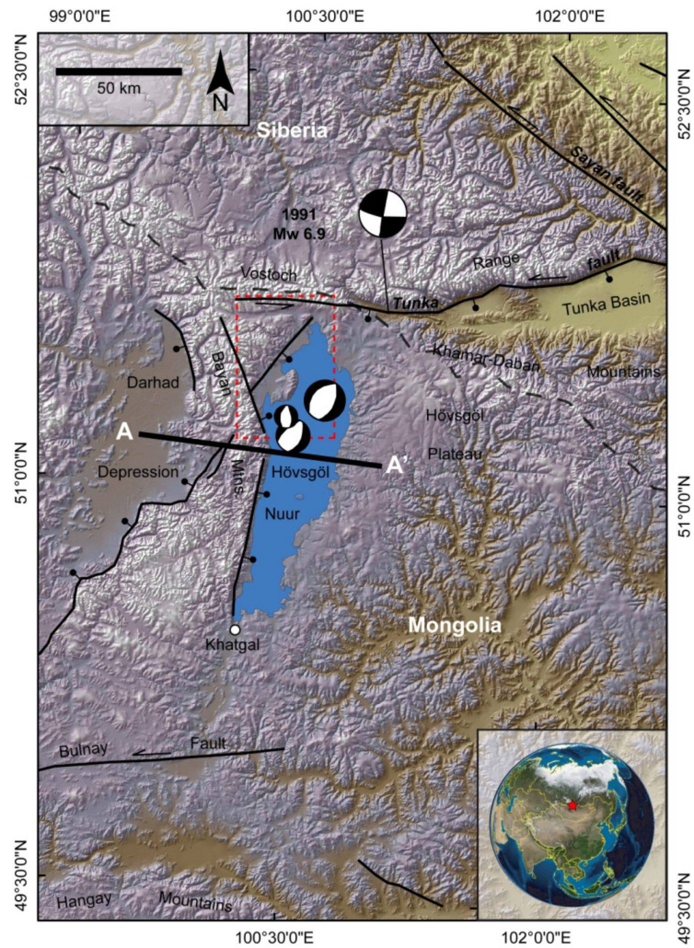

Figure 1Digital Elevation Model of the Hövsgöl rift and Tunka basin with active faults. Post-1950 > 4.0 mag. focal mechanism (Delouis et al., 2002) for the northern Hövsgöl rift.Project area delineated with dashed red box.

GEOMORPHOLOGY

The Horoo Gol valley shows clear evidence of past glaciations by the morphology of the landscape. Running through the center of the valley is glacial melt water from the Northern Sayan Mountains. Moraines and terraces are the most characteristic features of the area. Moraine morphology varies from steep and hummocky near the mouth of Horoo Gol and tends to flatten out and decrease in surface boulder frequency toward the outermost (southwest) terminal moraine, which is preserved near the modern day lake shore. There are also fluvial fill terraces that are located along Horoo Gol and a set of terraces located closer to Lake Hövsgöl. The terraces closer to lake Hövsgöl are also surrounded by a hummocky topography.

RESULTS

Surface exposure ages from the two moraines reveal two distinct age populations (Figure 2). The outermost moraine exhibits six ages ranging from ~9 ka to ~32 ka (Figure 2). Two of these ages are ~9 ka and ~12 ka, which we suggest is the result of boulder exhumation subsequent to deposition. Therefore, we

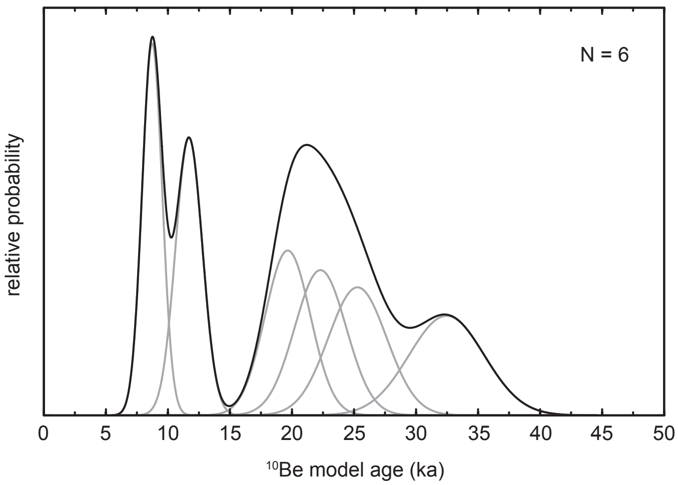

Figure 2

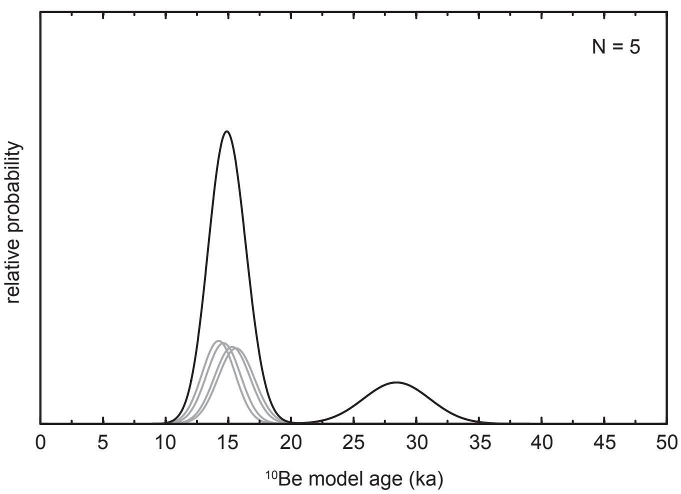

Figure 3

use the average and standard deviation of the remaining four ages as the age of the outermost piedmont moraine. This yields an age of 25 ± 6 ka.

Five of the six samples collected from the prominent moraine near the mouth of Horoo Gol yielded information suitable for surface exposure age calculations. These samples range in age from ~14 ka to ~28 ka, with four of the five samples clustering tightly (Figure 3). The ~28 ka age is likely representative of inheritance (exposure prior to deposition); the four remaining samples yield an age of 15 ± 1 ka (Figure 3).

METHODS

Glacial deposits were mapped in the field on 1:50,000 scale topographic maps. Individual units were broken out on the basis of relative ages based on moraine morphology and position within the valley. Once moraines were identified and mapped, boulder density counts and rock mass strength test were conducted on the deposits. On the moraine crest, we measured all the boulders within a 5 m radius circle. Each boulder inside the circle was measured, however only boulder's that were larger than 2.5cm on their longest axis were measured. These measurements were taken to help determine relative amounts of weathering on each moraine. Differential GPS was also used to produce detailed topographic profiles of each identified moraine.

Cosmogenic samples were also collected from the moraine crest to obtain numerical ages. We collected a total of 12 samples from quartz-rich granitic boulders; six were collected from a prominent moraine near the mouth of the Horoo Gol valley and six samples were collected from the terminal moraine complex on the northern Lake Hövsgol piedmont (Table 1). Samples were collected from the tops of granitic boulders standing high above the moraine crests. When choosing which boulders to use, we made sure to select only ones that were exposed at the surface. We took care to not collect samples from boulders that had obviously been exhumed following deposition or which showed signs of significant weathering or spallation. In addition, we focused our efforts on boulders with relatively flat tops to minimize the need for geometric corrections for self-shielding. For each sample collected, a rock hammer and chisel were used

Sample name	Latitude (DD)	Longitude (DD)	Elevation (m)	Elv/pressure flag	Thickness (cm)	Density (g cm^{-2})	Shielding correction	Erosion rate (cm yr^{-1})	[Be-10] (atoms g^{-1})	+/- (atoms g^{-1})	Be Standard	[Al-26] (atoms g^{-1})	+/- (atoms g^{-1})	Al Standard	Be age (yrs)	+/- (yrs)		
HG-0710-1	51.54531	100.4435	1661	std	5	2.7	1	0	590994	18705	07KNSTD	0	0	KNSTD	32467	3026	20022	8771
HG-0710-2	51.54517	100.44353	1665	std	5	2.7	1	0	408160	12927	07KNSTD	0	0	KNSTD	22296	2073		
HG-0710-3	51.54982	100.44181	1675	std	5	2.7	1	0	161597	5162	07KNSTD	0	0	KNSTD	8729	810		
HG-0710-4	51.55138	100.43839	1680	std	5	2.7	1	0	467898	14815	07KNSTD	0	0	KNSTD	25281	2352		
HG-0710-5	51.55001	100.4407	1680	std	5	2.7	1	0	217216	6899	07KNSTD	0	0	KNSTD	11697	1085		
HG-0710-6	51.55	100.44081	1680	std	5	2.7	1	0	364382	11544	07KNSTD	0	0	KNSTD	19661	1827		
HG-0710-8	51.59438	100.43893	1767	std	5	2.7	1	0	290227	9203	07KNSTD	0	0	KNSTD	14618	1357		
HG-0710-9	51.59555	100.47244	1731	std	5	2.7	1	0	295611	9489	07KNSTD	0	0	KNSTD	15307	1423		
HG-0710-10	51.59552	100.47255	1732	std	5	2.7	1	0	547669	17341	07KNSTD	0	0	KNSTD	28431	2647		
HG-0710-11	51.59696	100.47472	1740	std	5	2.7	1	0	276744	8826	07KNSTD	0	0	KNSTD	14227	1321		
HG-0710-12	51.58976	100.46648	1696	std	5	2.7	1	0	293625	9309	07KNSTD	0	0	KNSTD	15625	1450		

*HG-0710-7 died in the accelerator - current too low

Table 1

to obtain ~600 g of material from the top 3 cm of the boulder.

The samples were then crushed sieved to obtain 300 g of 250 µm to 500 µm size grains. Each sample was subjected to a series of HCl and HF acid leaches in order to separate and purify quartz grains. Once the pure quartz was obtained from the sample, the sample was dissolved, beryllium was extracted from the samples by ion exchange chromatography, precipitated as Be(OH)2, and oxidized to BeO (e.g., Bierman et al., 2002). After ignition of the BeO, the samples were then mixed with niobium and packed in stainless-steel cathodes. The 10Be/9Be ratios were measured at the Lawrence Livermore National Laboratory Center for Accelerator Mass Spectrometry. The 10Be/9Be ratios were converted into 10Be concentrations and surface exposure ages were calculated following the methods outlined in Balco et al. (2008).

DISCUSSION

Previous work on glacial chronologies in Mongolia, suggest similarly timed glacial advances as those in the Hövsgöl region. According to Gillespie et al. (2008) the Darhad Basin immediately to the west of the Hövsgöl rift, preserves evidence for at least two glacial advances in the late Pleistocene, once during marine isotope stage MIS 2 and the other in MIS 3, with a likely older glacial advance during MIS 6. According to Coggan and Burenjargal (2007), there were four areas that were glaciated during the Pleistocene, the Khentey, Hangay, Darhad and the Altai. Available geochronology on the ages of these glacial advances suggests that they are all broadly synchronous.

Our results suggest that there was a major glacial advance in the northern Hövsgol rift during MIS 2, with ice reaching its furthest downvalley extent at ~25 ka. This is broadly consistent with results from the adjacent Darhad Basin (e.g., Gillespie et al., 2008). However, our results also suggest that following the maximum ice extent off the southern flanks of the Sayan Range, the ice either stagnated or readvanced at ~15 ka, resulting in formation of the prominent moraine near the mouth of Horro Gol. Our data do not allow us to discriminate between these two possibilities. However, it is clear from our data that by ~15 ka climate must have begun warming as the northern hemisphere emerged from the LGM, pushing equilibrium line altitudes higher in elevation and causing ice to retreat further up valley.

The ages presented here, while providing some insight into the timing of ice advance and retreat during the LGM cannot alone allow us to determine whether late Pleistocene surface uplift lowers ELAs as has been suggested for the western flank of the Hövsgol Rift. Continued work on dating moraines in the Lake Hövsgol basin will lead to improved insight into the role surface uplift may play in controlling ELAs and ultimately, ice extent.

CONCLUSION

Herein we use cosmogenic 10Be surface exposure geochronology to determine the age of late Pleistocene moraines on the north end of Lake Hövsgol. Six samples from the terminal moraine yield an age of 25 ± 6 ka, while five samples from a prominent recessional moraine near the mouth of Horoo Gol valley yield and age of 15 ± 1 ka. These ages are consistent with the timing of maximum ice extent during the Last Glacial Maximum both in the nearby Darhad Basin as well as other parts of central Asia. Our results, thus, suggest that the timing of glaciations during the LGM across central Asia are broadly synchronous. However, future work dating moraines from active fault bounded ranges both in the Hövsgol rift and throughout Mongolia will help reveal to what degree surface uplift controls equilibrium line altitude and down valley ice extent during the late Pleistocene.

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