KECK GEOLOGY CONSORTIUM

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

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

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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
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PLEISTOCENE GLACIATION OF THE EASTERN SAYAN RANGE, NORTHERN MONGOLIA

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

INTRODUCTION

The Vostoch Range has small extant glaciers and evidence of extensive past ones. The Horoo Gol Valley (51.570° N, 100.462° E) is an east-draining glacial trough running along the base of the Vostoch Range at the north end of Lake Hövsgöl. Valley elevations range from 1645 m at the shore of the lake to 2540 m in the cirques of the Vostoch Range. The moraine complex between the head of the Horoo Gol Valley delta plain and the shore of Lake Hövsgöl likely marks the greatest extent of glaciation during the Last Glacial Maximum (LGM). This study sought to map and date the moraines of the Horoo Gol Valley in hopes of determining timing, extent, and number of Pleistocene glaciations.

METHODS

Ice limits were designated using field observations, topographic maps, GPS, and satellite imagery. Ten moraines were identified and labeled Qma (outermost) through Qmj (innermost) (see Berkowitz, this volume). Boulder frequency, mass strength, height, and size (long and short axes) were measured in the interest of relative dating (Table 1). Five sampling areas, each 10 m in diameter, were randomly chosen along each moraine crest. Areas of obvious human intervention, e.g., cairn construction, were avoided. Boulders exposed on a young, low fluvial terrace near base camp were used as a control for boulder strength.

The moraine complexes at the end of Horoo Gol Valley were surveyed by differential GPS using handheld roving GPS units and a base station. GIS was used to extrapolate field mapping and observations into a model of the Horoo Gol Valley glacial system during the Pleistocene. GIS was used to delineate ice limits and estimate ice dimensions, as well as to calculate Equilibrium Line Altitude (ELA) values.

Moraine	Crest Height (m)	Slope (%)	Boulder Frequency (per m^2)	Boulder Height	Rock Mass Strength (R)
Qma	30	32	0.216	7	39
Qmb	7	6	0.14	7	37
Qmc	15	14	0.102	7	35
Qmd	6	10	0.102	6	30
Qme	20	7			
Qmf	12	5			
Qmg	18	9			
Qmh	7	5			
Qmi	16	5	0.204	8	47
Qmj	60	24	0.293	9	47

Table 1. Average moraine properties. The three highest values in each category are highlighted in yellow, and suggest that the outermost (Qma) and innermost (Qmj) moraines have similar ages.

Figure 1. View west up the U-shaped glacial trough of the Horoo Gol Valley. The nearby trees are Siberian larch. Author's photo.

GEOMORPHOLOGY

Horoo Gol Valley is a U-shaped glacial trough with steep walls and a broad floor (Fig. 1). Meanders in the upper valley suggest the presence of a former moraine-dammed lake. Lateral moraines are visible part of the way up the valley sides. Granitic erratics abound, with the highest observed at 1950 m on the east side of the valley on the flanks of a large hill (Fig. 2).

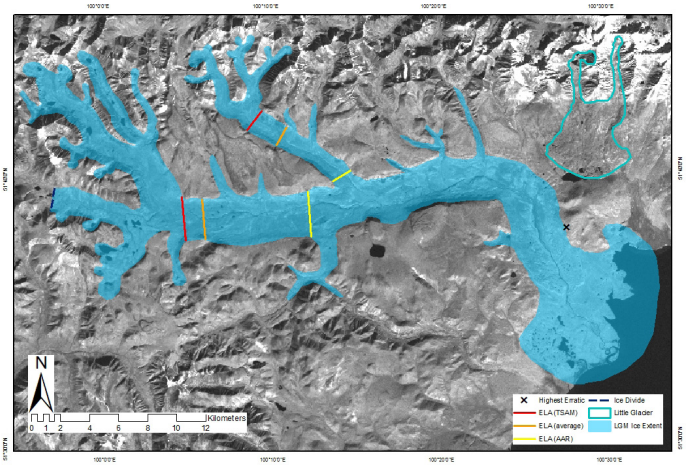

Figure 2. Pleistocene ice extent model for the Horoo Gol Valley, with ELAs of 2325 m (TSAM), 2100 m (AAR), and 2213 m (average) shown.
Aerial photo courtesy of Andy de Wet.

Between the valley mouth and the shore of Lake Hövsgol lies a nested moraine sequence which appears to have end moraines of different ages (Krivonogov et al., 2003). The innermost moraine of the complex is well-defined and about 60 m high, while the downvalley moraines have more subdued topographic profiles (Fig. 3). Other geomorphic features of note include hummocky topography, kettle ponds, and small moraine-dammed lakes both on and south of moraine Qmj. Also of interest are periglacial features like aufeis and pals northeast of Lake Hövsgöl.

DISCUSSION

ELAs were calculated with GIS using both the Toe-Summit Altitude (TSAM) and Accumulation Area Ratio (AAR) methods. AAR assumes that the accumulation area of the glacier accounts for 67% of its total area, while TSAM places the ELA halfway between the toe elevation and that of the highest peak in the catchment area. The calculated LGM ELA values for the Horoo Gol Valley glacier are 2325 m (TSAM) and 2100 m (AAR), for an average value of 2213 m (Fig. 2). The modern ELA for this region is likely near or above the tops of the peaks, as no modern glaciers of significant extent are present.

In Lake Hövsgöl's neighboring Darhad basin, Gillespie et al. (2008) found an LGM ELA of ~ 2225 m.

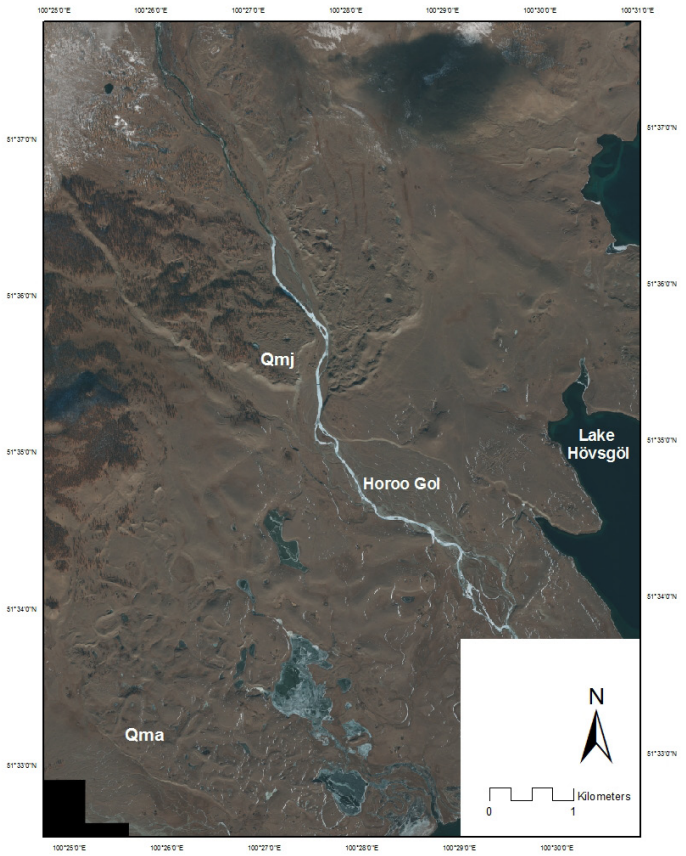

Figure 3. GeoEye image of the moraine complex between the mouth of the Horoo Gol Valley (Qmj) and the shore of the lake (Qma). Image courtesy of Karl Wegmann, modified by author.

Mongolia's other major mountain ranges, the Hangay and Altai, both exhibit evidence of LGM and penultimate glaciations (Lehmkuhl and Lang, 2001). In the Altai, Lehmkuhl et al. (2004) found an LGM ELA of 2800-3000m, versus an LGM ELA of 2700-2900 m in the Hangay (Lehmkuhl, 1998). The LGM ELA determined for the Vostoch Range is significantly lower than those of the Altai and Hangay, while it is similar to that of the Darhad depression. Both the Darhad and the Vostoch Range are more northerly than the other ranges and receive more precipitation.

All average moraine properties, indicators of relative age, have maxima at outermost moraine Qma and innermost moraine Qmj, suggesting that they have similar ages (Table 1). Cross-cutting relationships also suggest that Qmj could have been deposited by a re-advance of the glacier that deposited the outer terminal and recessional moraines (See Berkowitz, this

volume). Relative and cosmogenic dates confirm that Qma and Qmj are the same age (LGM), rather than from two different glaciations as hypothesized.

DATING

Pieces of granitic boulders were gathered for cosmogenic 10Be dating. Whenever possible, prominent, uncracked, flat-topped boulders were chosen on or close to moraine crests. Surface exposure ages of 18 +/- 6 ka for the valley moraine Qmj and 20 +/- 9 ka for the piedmont moraine Qma correspond to the LGM Sartan Glaciation, 15 to 32 +/- 6 ka, Marine Isotope Stage 2 (MIS 2) (Lehmkuhl, 1998).

CONCLUSIONS

The modeled late Pleistocene Horoo Gol Valley glacier was 50 km long, 2 km wide, and 300 m thick, with an approximate area of 260 km2 and a volume of 80 km3. The dashed area shown on the glacier model (Fig. 2) shows the ice divide between glaciers flowing into the Horoo Gol Valley and those flowing into the Darhad Basin to the west. The complexity of the topography of the lakeshore moraine complex suggests episodes of stagnation, the presence of a piedmont lobe, and/or possible surging. Though the moraines of the Horoo Gol Valley were hypothesized to be two different ages, cosmogenic dating established that the outermost and innermost moraines are the same age (LGM), a conclusion supported by the relative dating data. The more subdued morphology of the outer moraines could be due to erosion by post-LGM lake level increases. The calculated LGM ELA of 2213 m is lower than those of other Mongolian mountain ranges. This could be due to a flawed glacial model or to the Vostoch Range's proximity to Lake Hövsgöl and resultant increased precipitation.

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