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

THE BLACK LAKE SHEAR ZONE: A POSSIBLE TERRANE BOUNDARY IN THE ADIRONDACK LOWLANDS (GRENVILLE PROVINCE, NEW YORK)
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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Faculty: *DAVID SUNDERLIN*: Lafayette College, *CHRISTOPHER J. WILLIAMS*: Franklin & Marshall College
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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GEOLOGY OF THE HÖH SERH RANGE, MONGOLIAN ALTAI
Faculty: *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
Students: *ELIZABETH BROWN*: Occidental College; *GIA MATZINGER, ANDREA SEYMOUR, RYAN J. LEARY*, *KELLY DUNDON* and *CHELSEA C. DURFEY*: Whitman College; *BRITTANY GAUDETTE*: Mount Holyoke College; *KATHRYN LADIG*: Gustavus Adolphus College; *GREG MORTKA*: Lehigh U.; *JODI SPRAJCAR*: The College of Wooster; *KRISTIN E. SWEENEY*: Carleton College.

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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
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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

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

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Research Advisor: Sarah Titus
TSOLMON ADIYA: Mongolia University of Science and Technology

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ERDENEBAT BOLOR : Mongolia University of Science and Technology

MOVEMENT AND TECTONIC GEOMORPHOLOGY ALONG THE HÖH SERH FAULT, MONGOLIAN ALTAI

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***JARGAL OTGONKHUU*: ** Mongolian University of Science and Technology

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GLACIATION OF YAMAAT VALLEY, HÖH SERH RANGE, MONGOLIAN ALTAI
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BATTOGTOKH DAVAASAMBUU: Mongolia University of Science and Technology

GLACIATION OF DEBRIS FLOW AND LAKE VALLEYS, HÖH SERH RANGE, MONGOLIAN ALTAI
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Research Advisor: Robert J. Carson
TAMIR BATTOGTOKH: Mongolia University of Science and Technology

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GREG MORTKA: Lehigh University
Research Advisor: David J. Anastasio
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RECONSTRUCTING LATE HOLOCENE CLIMATE THROUGH TREE-RING ANALYSIS OF SIBERIAN LARCH: ALTAI MOUNTAINS, WESTERN MONGOLIA
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GLACIATION OF YAMAAT VALLEY, HÖH SERH RANGE, MONGOLIAN ALTAI

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INTRODUCTION

Yamaat Valley is a Y-shaped, west-draining glacial trough (between 200 and 500 m deep) (Fig. 1). The north fork (8 km long) maintains a modern glacier at the summit of Praying Mountain, and the south fork (5.7 km long) has a moraine-bound lake at its drainage divide with the adjacent valley to the south (Debris Flow Valley). Elevations of the valley range from 4,019 m to 2,340 m a.s.l. The bedrock is Paleozoic metasedimentary rocks and granitics. The large terminal moraine at the mouth of the valley marks the maximum extent of Pleistocene glaciation, which was probably deposited during the Last Glacial Maximum (LGM). A probable recessional moraine is positioned 1 km upvalley of the mouth. No other moraines are exposed, possibly because of extensive and abundant mass-wasted material. The goal of this project was to map glacial features in Yamaat Valley in order to reconstruct its Pleistocene glacial history.

METHODS

Ice limits were determined by locating moraines and granitic erratics with topographic maps and a GPS. Glacial erratics were collected for cosmogenic 10Be surface exposure dating. Collected field data included GPS locations, measurements, and photographs of landforms, sediments, and boulders for dating.

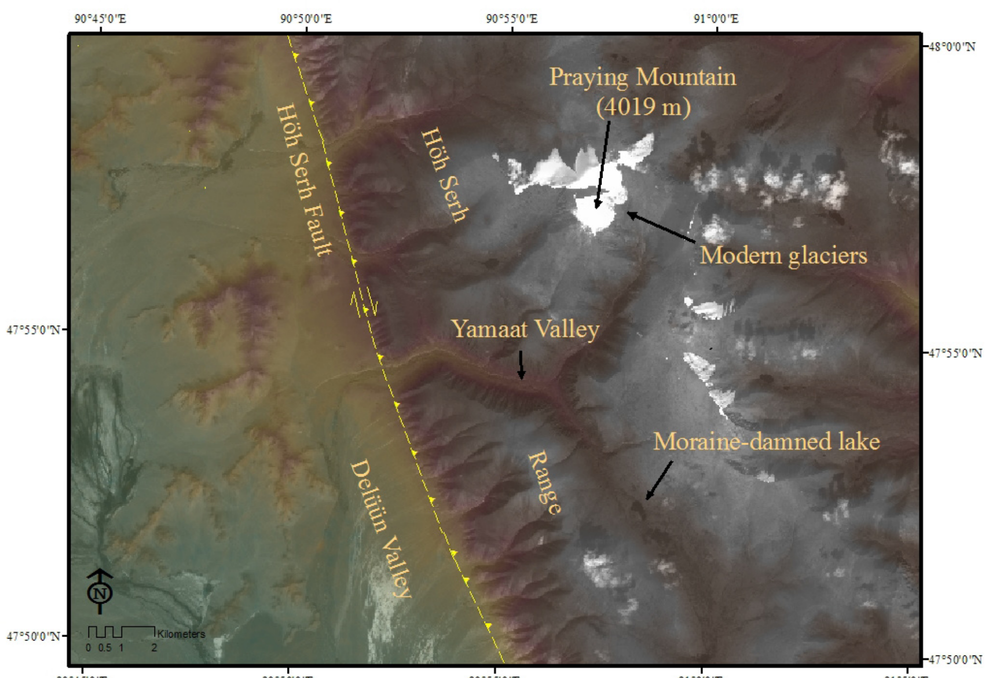

Figure 1. SPOT image of Yamaat Valley. Elevation is indicated by color ramp.

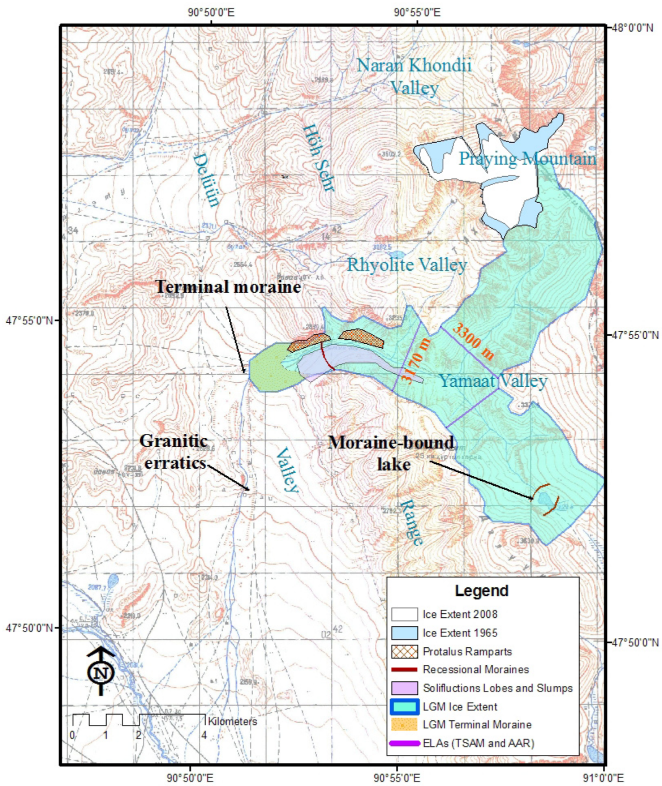

Figure 2. Geomorphic map of Yamaat Valley including maximum ice extents and ELAs for both TSAM (3170 m) and AAR (3300 m) methods.

GIS was utilized to compile field data to estimate LGM ice area, volume and Equilibrium Line Altitude (ELA).

Paleodischarge of a possible jöhkulhlaup was estimated using topographic maps and the Manning equation:

$$Q = AR^{2/3} S^{1/2} n^{-1}$$

where A is the channel cross-sectional area, R is the hydraulic radius, S is the slope and n is the Manning resistance factor. For this analysis we estimated n = 0.035-0.100 resistance.

GEOMORPHOLOGY

A modern glacier (ELA > 4000 m) caps Praying Mountain, and several cirques rim the north fork of Yamaat Valley. From Praying Mountain, Pleistocene ice flowed southwest into the main valley (Fig. 2). Presence of a moraine-dammed lake at the south fork drainage divide (elevation 3129 m) indicates that ice covered this area. Ice flowed both northwest into the main valley and south along the Höh Serh Range ridge crest in the vicinity of the moraine-dammed lake (Fig. 2). Granitic bedrock along the ridge crest is the source of glacial erratics found downvalley. Ice from both forks merged (at an elevation of 2640 m) and flowed west to Delüün Valley. Ice volume within the valley at this time was approximately 10 km^3 and covered an area of approximately 40 km^2. Striated boulders preserved in drift deposits suggest that the glacier was at least partially warm-based.

The LGM glacier was up to 500 m thick in places. The thickest sections occurred where ice from the two forks merged 8 to 10 km downvalley of Praying Mountain summit.

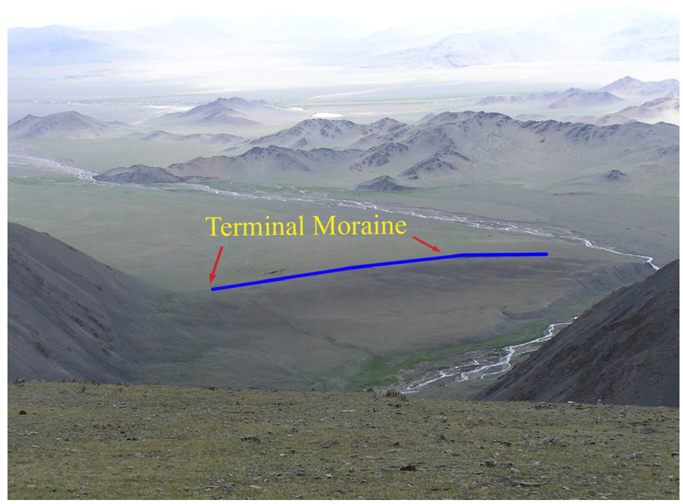

Figure 3. View of the terminal moraine looking southwest into Delüün Valley.

A prominent terminal moraine (57 m high) lies at the mouth of Yamaat Valley, recognized by hummocky topography, kettles, and high concentrations of granite boulders (1-3 m in diameter) (Fig. 3). The south side moraine till is thicker, suggesting that more of the ice exiting the valley mouth probably flowed to the southwest, perhaps because the elevation of the bajada was lower here.

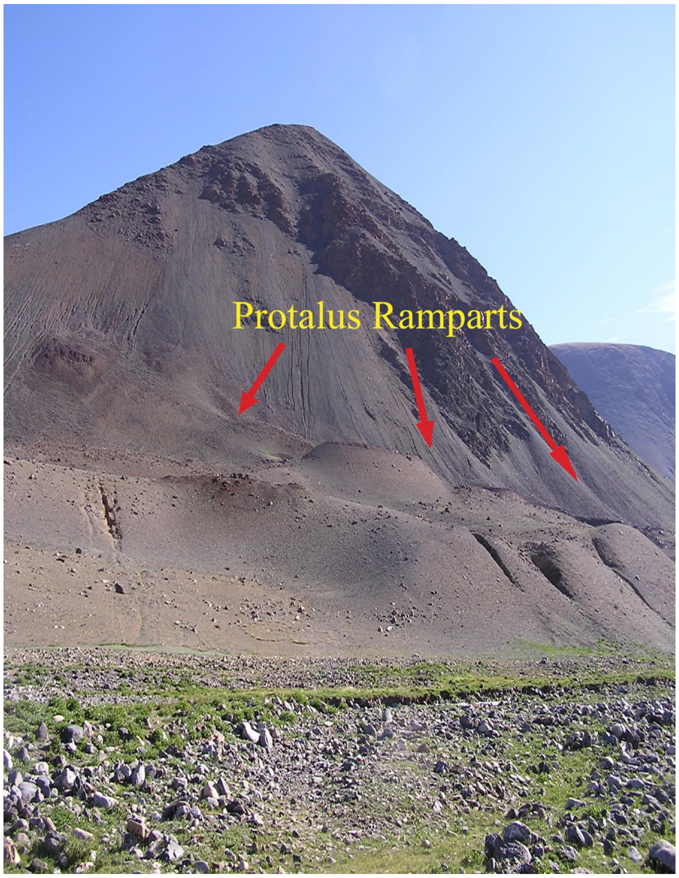

Figure 4. Probable Protalus ramparts at mouth of Yamaat Valley.

A recessional moraine 1 km upvalley from the terminal moraine is distinguished by hummocky topography, a rise in local elevation, kettles and an increased concentration of granitic boulders (Fig. 2). No other recessional moraines are exposed; either (1) no other moraines were deposited, or (2) moraines were later covered by colluvium.

Ice deepened and steepened the preexisting valley, carving a trough up to 0.5 km deep and 2 km wide. Glacier retreat greatly reduced lateral support of the steep valley sides, causing extensive mass-wasting of weak metasedimentary rocks. Colluvium from slumps and rockfalls cover both sides of the valley. Solifluction lobes line part of the south side of Yamaat Valley (Fig. 2). Abundant rockfall also explains the existence of several large probable protalus ramparts. Individual ramparts vary significantly in age based on differences in vegetation and lichen cover (Fig. 4).

Valleys In Study Area	ELA (m)	
	AAR (67%)	TSAM (50%)
Ice Valley	3050 m	3080 m
Naran Khondii	3320 m	3340 m
Rhyolite Valley	3050 m	3330 m
Yamaat Valley	3300 m	3170 m
Debris Flow Valley	3270 m	2880 m
Mean	3200 m	3180 m

Table 1. ELAs of Yamaat Valley and nearby glaciated valleys.)

Granite cobbles were found 3.5 km southwest of the terminal moraine, partly up a ridge in Delüün Valley (anomalous granitic erratics in Fig. 2). Because the entire ridge is made of metasedimentary rocks, a jökulhlaup or moraine burst may have deposited these granitic cobbles. We calculated that such a flood would require a paleodischarge of roughly 1 - 3×10^3 m^3/s, depending upon the range of probable Manning's resistance factors utilized (from 0.035 to 0.1).

DISCUSSION

ELAs were determined using GIS analysis and the Accumulation Area Ratio Method (assuming accumulation was 67%) and the Toe-To-Summit Method (assuming 50% distance from the summit of Praying Mountain to the terminal moraine). Calculated LGM ELAs for Yamaat Valley are 3300 m (AAR Method) and 3170 m (TSAM Method). Table 1 summarizes ELAs found for Yamaat Valley and nearby glaciated valleys within the Höh Serh Range. Lehmkuhl et al. (2004) calculated LGM ELAs of 2800 to 3000 m in the northern Mongolian Altai and 3000 to 3600 m present ELAs in the Chinese and Mongolian Altai; he estimated an ELA depression of 500 m within the latter region during the Late Pleistocene (Lehmkuhl et al., 2004). The 2008 Keck group calculated an average ELA of 3160 m for five LGM glaciers in the Höh Serh (Table 1).

While no single factor determines the ELA of a glacier, winter precipitation and summer temperatures account for 90% of ELA variance in the Colorado

Rockies (Leonard, 1989). Mongolia has low mean annual precipitation (200 mm/yr at 2000 m). Mean annual temperatures can drop to around -20°C to -30°C in the winter while summer temperatures can exceed 20°C (Lehmkuhl, 1998). Paleoclimate research suggests that LGM climate was associated with a dry and cold period in western Mongolia, resulting in low-reaching glaciers and low lake levels (Grunert et al., 2000). Based on past and present ELAs, approximate rise in mean annual temperature since the LGM can be estimated at 2.5ºC using a temperature lapse rate of 1ºC/300 m and assuming constant precipitation.

DATING

Cosmogenic ^{10}Be nuclide samples taken from the crest of the terminal moraine yeild exposure ages of 31 +/- 3 ka, 33 +/- 3 ka, and 44+/- 4ka (mean 36 +/- 7 ka). This is consistent with the 32 +/- 6 ka estimate of the age of the last (Sartan) glaciation in central Mongolia (Lehmkuhl, 1998). Also, the measured boulder density of 0.12 boulders per m^2 is comparable to the boulder density of 0.18 boulders per m^2 from a probable LGM moraine in the Hangay Range 700 km east of the Altai (Coggan, 2007).

WATER RESOURCES

Present glacial retreat in this part of the Mongolian Altai is an order of magnitude greater than the long-term average retreat from 1963 to LGM. In Central Asia, increasing temperatures are speeding the rate of glacial retreat despite increasing precipitation. In China and the Tibetan Plateau, meltwater-supplied lake levels are increasing while those predominantly supplied by precipitation are dropping (Yao et al., 2007). The majority of precipitation falls in the summer months, which will reduce winter glacier accumulation and reduce stored water. Mongolia's nomadic people have historically relied on glacial meltwater for subsistence in areas of sparse vegetation. Temporary benefits from increased discharge of meltwater-charged rivers will be offset by the negative effects of precipitation variability, seasonal shifts in water supply, and flood risks (Batima et al., 2005).

CONCLUSIONS

The maximum extent of glacial ice in Yamaat Valley occurred during the LGM. This late Pleistocene, partially warm-based glacier deposited a large terminal moraine at the valley mouth and a recessional moraine partially concealed by abundant mass-wasted material further upvalley. GIS analysis of reconstructed glacial topography indicates that about 10 km^3 of ice covered and area of approximately 40 km^2 during the LGM. A longitudinal profile indicates that ice thickness reached 500 m in places. The LGM ELA was at about 3200 m, somewhat higher than ELAs reported in Lehmkhul et al. (2004), either due to poorly constrained ice limits or to anomalous temperatures and/or precipitation during the LGM. The loss of ice mass from glacial retreat has social repercussions: nomadic groups will have limited access to consistent and reliable water sources as global temperatures rise and more precipitation falls as rain instead of snow.

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