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

PALEOECOLOGY & PALEOENVIRONMENT OF EARLY TERTIARY ALASKAN FORESTS, MATANUSKA VALLEY, AL.
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

SEAFLOOR VOLCANIC AND HYDROTHERMAL PROCESSES PRESERVED IN THE ABITIBI GREENSTONE BELT OF ONTARIO AND QUEBEC, CANADA
Faculty: LISA A. GILBERT, Williams College and Williams-Mystic and NEIL R. BANERJEE, U. of Western Ontario
Students: LAUREN D. ANDERSON: Lehigh University; STEFANIE GUGOLZ: Beloit College; HENRY E. KERNAN: Williams College; ADRIENNE LOVE: Trinity University; KAREN TEKVERK: Haverford College

INTERDISCIPLINARY STUDIES IN THE CRITICAL ZONE, BOULDER CREEK CATCHMENT, FRONT RANGE, CO
Faculty: DAVID D. DETHIER: Williams College and MATTHIAS LEOPOLD: Technical University of Munich
Students: EYVE GANNWAY: The U. of the South; KENNETH NELSON: Macalester College; MIGUEL RODRIGUEZ: Colgate University

GEOARCHAEOLOGY OF THE PODERE FUNGHI, MUGELLO VALLEY ARCHAEOLOGICAL PROJECT, ITALY
Faculty: ROB STERNBERG: Franklin & Marshall College and SARA BON-HARPER: Monticello Department of Archaeology
Students: AVERY R. COTA: Minnesota State University Moorhead; JANE DIDALEUSKY: Smith College; ROWAN HILL: Colorado College; ANNA PENDLEY: Washington and Lee University; MALIA SIPOLA: Carleton College; STACEY SOSENKO: Franklin and Marshall College

GEOLOGY OF THE HÔH SERH RANGE, MONGOLIAN ALTAI
Faculty: NICHOLAS E. BADER and ROBERT J. CARSON: Whitman College; A. BAYASAGALAN: 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. DURFEE: Whitman College; BRITTANY GAUDETTE: Mount Holyoke College; KATHRYN LADIG: Gustavus Adolphus College; GREG MORTKA: Lehigh U.; JODI SPRAJCAR: The College of Wooster; KRISTIN E. SWEENY: Carleton College.

BLOCK ISLAND, RI: A MICROOSM FOR THE STUDY OF ANTHROPOGENIC & NATURAL ENVIRONMENTAL CHANGE
Faculty: JOHAN C. VAREKAMP: Wesleyan University and ELLEN THOMAS: Yale University & Wesleyan University
Students: ALANA BARTOLAI: Macalester College; EMMA KRAVET and CONOR VEENMAN: Wesleyan University; RACHEL NEURATH: Smith College; JESSICA SCHEICK: Bryn Mawr College; DAVID JAKIM: SUNY.

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Short Contributions – MONGOLIA

GEOLOGY OF THE HÔH 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 THERMOCRONOLOGY OF THE HÔH SERH RANGE, MONGOLIAN ALTAI
ELIZABETH BROWN: Occidental College
Research Advisor: Professor Ann Blythe
GANBAYAR RAGCHAASUREN: Mongolia University of Science and Technology

CHARACTERIZATION OF THE HÔH SERH AND TSAGAAN SALAA FAULTS, HÔH SERH RANGE, MONGOLIAN ALTAI
KRISTIN E. SWEENEY: Carleton College
Research Advisor: Sarah Titus
TSOLMON ADIYA: Mongolia University of Science and Technology

CALCULATING THE RATE OF DEXTRAL STRIKE-SLIP MOTION ALONG THE HÔH SERH FAULT, MONGOLIAN ALTAI
JODI SPRAJCAR: The College of Wooster,
Research Advisor: Shelley Judge
ERDENERBAT BOLOR: Mongolia University of Science and Technology

MOVEMENT AND TECTONIC GEOMORPHOLOGY ALONG THE HÔH SERH FAULT, MONGOLIAN ALTAI
CHELSEA C. DURFEY: Whitman College
Research Advisors: Nick Bader and Bob Carson
JARGAL OTGONKHUU: Mongolian University of Science and Technology
ICE LAKE VALLEY GLACIATION, HÖH SERH RANGE, MONGOLIAN ALTAI

**Andrea Seymour**: Whitman College
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GEOMORPHOLOGY OF NARAN KHONDII, HÖH SERH RANGE, MONGOLIAN ALTAI

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GLACIATION OF RHYOLITE VALLEY, HÖH SERH RANGE, MONGOLIAN ALTAI

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GLACIATION OF YAMAAT VALLEY, HÖH SERH RANGE, MONGOLIAN ALTAI

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GLACIATION OF DEBRIS FLOW AND LAKE VALLEYS, HÖH SERH RANGE, MONGOLIAN ALTAI

**Ryan J. Leary**: Whitman College
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A LARGE GLACIAL-OUTBURST DEBRIS FLOW DEPOSIT, HÖH SERH RANGE, MONGOLIAN ALTAI

**Greg Mortka**: Lehigh University
Research Advisor: David J. Anastasio

**Naranchimeg Mergen**: Mongolia University of Science and Technology

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

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INTRODUCTION

The Altai is the only currently glaciated range in Mongolia. Klinge (2001), in Lehmkuhl (2004), estimates that the modern area of these glaciers is at least 850 km$^2$. The only modern glaciers near Debris Flow Valley are in Naran Khondii, about 20 km to the north. These small glaciers are found on the north and east sides of Praying Mountain (~4000m). During the Pleistocene, glaciation was far more extensive, and numerous glacial deposits remain including those in Debris Flow and Lake Valleys (47°48'N, 90°59'E) (Fig 1).

The purpose of this study was to reconstruct the glacial history of the southern Höh Serh Range, determine Pleistocene Equilibrium Line Altitude (ELA), and examine the origin of the Delüün Debris Flow.

METHODS

Debris Flow Valley was mapped using handheld GPS receivers. Maximum ice extent was estimated using the location of granitic erratics. Because granite crops out only in the northernmost part of the study area, erratics are easily indentified on the metasedimentary rocks of the lower valley. Samples of granitic erratics from a recessional moraine were collected for cosmogenic $^{10}$Be surface exposure dating.

ELA was calculated using an Accumulation Area Ratio (AAR) of 67% and Toe-to-Summit Average Elevation (TSAM) of 50%. TSAM was calculated separately for Debris Flow and Lake Valleys because minimum ice elevation in these valleys differed by 436 m.

GEOMORPHOLOGY

The geomorphology of this area is unusual in that a broad, shallow trough runs south, parallel to the range crest, from a low saddle before splitting and turning southeast and west (Fig. 1). This north-south valley, named Lake Valley, is separated from west-sloping Debris Flow Valley by a drainage divide. The bedrock in upper Lake Valley is granite. There are no apparent glacial landforms in this section, the walls are gently sloped, and the valley is as wide as 5 km in some places. To the south, Lake Valley becomes narrower, and there is a moraine-dammed lake just east of the divide separating Lake

Figure 1. Map of study area showing maximum ice extent, ELAs, geomorphology, and orientation of photographs. DFTM – Debris Flow Terminal Moraine, DTM – Divide Terminal Moraine, LVTM – Lake Valley Terminal Moraine, CMC – Cairn Moraine Complex. Background is modified SPOT image (SICORP).
Valley from Debris Flow Valley (Fig 2). As Lake Valley turns southeast, it becomes steep, V-shaped, and narrow.

In upper Debris Flow Valley, several rock steps as tall as 15 m show prominent glacial striations. Below these steps, there are as many as 30 recessional moraines. A debris flow deposit roughly 3 km² in area extends 1.5 km onto the floor of the Delüün Valley.

Lake Valley Terminal Moraine marks the farthest ice advance down Lake Valley to the southeast. The moraine is a subdued, arcuate mound less than 5 m high and lies along the north side of Lake Valley. It has been deeply eroded and is largely buried by colluvium. The elevation of this moraine is 2836 m, 436 m higher than the terminal moraine in Debris Flow Valley. Aspect, slope, and valley morphology may be primarily responsible for this difference in elevation.

Divide Terminal Moraine, at 3110 m a.s.l., is south of the divide separating Lake and Debris Flow Valleys. Its position is atypical in that it was deposited not at the lowest elevation of ice extent as are most alpine terminal moraines, but as ice flowing south in Lake Valley ran against a mountainside and split into two lobes which flowed down opposite sides of the divide. As a result, this moraine is morphologically similar to a lateral moraine; the crest is linear with a relatively flat top that merges into the hillside. On its eastern side, the moraine plunges gradually downhill into lower Lake Valley where it is a classic right lateral moraine. Along the western side, it plunges abruptly and terminates at steep cliffs in Debris Flow Valley.

Pond Moraine (Fig. 3) is in Debris Flow Valley, roughly 1.5 km upvalley of the terminal moraine. Its crest, 360 m long, runs parallel to the valley trough. It stands roughly 30 m high and has very steep sides (~ 35°). Pond Moraine has been completely removed from the southern half of the valley, and is eroded along the northern wall. Along both sides of the crest are large, ripple-like landforms 1-3 m high (Fig. 3 & 4). From the ground, they appear to be nested recessional moraines, but they more closely resemble giant ripples when viewed from above.

The Cairn Moraine Complex, a system of recessional moraines deposited above Pond Moraine, consists of as many as 19 small and chaotically organized

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**MORAINE COMPLEXES**

Moraines in Debris Flow and Lake Valleys can be grouped into five major complexes: Debris Flow Terminal Moraine, Lake Valley Terminal Moraine, Divide Terminal Moraine, Pond Moraine, and the Cairn Moraine Complex. The terminal moraines are deposited at 2400 m, 2836 m, and 3110 m, respectively.

Debris Flow Terminal Moraine represents the maximum ice advance down Debris Flow Valley. The center of the moraine has been removed by erosion, but associated right and left lateral moraines are preserved. Minimum elevation of these moraines is 2400 m, and ice would have extended to at least this elevation. The crest of the moraine stands roughly 30 m high and is relatively sharp with little soil development. Large clasts in the till are primarily metasediments, but granite is also present. The Delüün Debris Flow deposit is immediately below the breach in this moraine.

Figure 2. View southeast down Lake Valley from north of the drainage divide. The divide is visible to the right of the lake, and Divide Terminal Moraine is against the far hill.
crests. Most are between 1 and 2 m high, with a few as tall as 10 m. This complex can be subdivided into groups separated by marshy areas. Either till was not deposited in these areas, or it has since been eroded. Several large solifluction lobes are active between moraines, and four alluvial fans extend off the south valley wall. All moraines in this complex have been removed along the north side of the valley where a small, intermittent stream is located. A large protalus rampart sits directly against the valley wall north of this stream; it extends from Pond Moraine to the base of the first rock step. Based on lack of soil and lichen development on colluvium, this rampart is younger than the moraine complexes.

**GEOLOGIC PROCESSES**

During the Last Glacial Maximum (LGM), ice traveling south in Lake Valley split, one lobe flowing southeast, the other lobe crossing the divide and flowing west down Debris Flow Valley (Fig. 1). Where Debris Flow Valley emerges from the range front, there is a large debris flow deposit (the Delüün Debris Flow) roughly 3 km² in area. This may have been deposited when a lake impounded behind a recessional moraine burst its dam and rushed westward, forming giant ripples and removing parts of Pond Moraine and Debris Flow Terminal Moraine (Fig. 3 & 4).

**AGE OF GLACIATION**

Lehmkuhl (2004) divides late Pleistocene glaciations in western Mongolia into two stages based on Russian stratigraphy: the Sartan Glaciation (Marine Isotope Stage 2) and the Early Zyrianka Glaciation (Marine Isotope Stage 4). Based on Optically Stimulated Luminescence (OSL) dates, the Stage 2 deposits are at least 21 Ka, correlative with the LGM (Lehmkuhl and Lang, 2001).

Based on poor soil development on till, it is believed that terminal moraines preserved in Debris Flow and Lake Valleys represent ice advance during the LGM. Cosmogenic ¹⁰Be surface exposure samples from Pond Moraine yielded dates of 12.5 +/- 1.1, 62.7 +/- 5.7, and 116.8 +/- 10.6 Ka. It is assumed that 12.5 +/- 1.1 Ka is the correct age, while older dates are due to inheritance. Unlike deposits in the Hangay Mountains of central Mongolia and in the Altai Mountains along the Chinese-Mongolian border east of the Delüün Valley, there is no evidence of older (e.g. Zyrianka; MIS 4) glaciation in either Debris Flow or Lake Valleys.

**PALEOCLIMATE AND REGIONAL CONTEXT**

Based on TSAM, Lehmkuhl (1998) calculates a
modern ELA of 3521 m. for the northern Altai; however, based on the active glaciers roughly 20 km north of Debris Flow Valley, we estimate the modern ELA to be at least 4000 m, in the Höh Serh Range, above the highest peaks in the region. Lehmkuhl does not use the AAR method because of poor topographic maps and lack of data on the behavior of Asian cold-based glaciers. However, topographic maps of the Höh Serh Range are relatively accurate, and prominent striations on bedrock in Debris Flow Valley indicate that the ice was at least partly warm-based. Because ice flowed south in Lake Valley and then split, terminating at elevations ~430 m apart, TSAM calculations yield two different values. Given these factors, ELA calculated using AAR is preferred. We used an AAR of 67%, based on successful results with this ratio in similar alpine regions (Gross et al., 1978 in Lehmkuhl, 1998).

<table>
<thead>
<tr>
<th>Method of Calculation</th>
<th>ELA (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR 67%</td>
<td>3270</td>
</tr>
<tr>
<td>TSAM 50% (Southeast Lake Valley)</td>
<td>3373</td>
</tr>
<tr>
<td>TSAM 50% (Debris Flow Valley)</td>
<td>3140</td>
</tr>
</tbody>
</table>

*Table 1. Calculated ELAs for Debris Flow Valley.*

Lehmkuhl (2004) calculates an LGM ELA between 2900 and 3000 m a.s.l. for the northern Altai and between 2700 and 2900 m. in the Hangay Mountains, 700 km to the east. Reconstructed LGM ELA values for Debris Flow Valley were 3270 m (based on AAR 67%) and 3140 m. (based on TSAM). Based on calculations in this and nearby valleys (Table 1), the mean LGM ELA for the Höh Serh Range was 3170 m (AAR 67%) and 3210 m (TSAM). Given a standard environmental lapse rate of 6.5°C/km, LGM temperatures were ~5.3°C cooler than today, assuming no change in precipitation. This represents a significantly smaller change in temperature than has been found in the Hangay Mountains of Central Mongolia where LGM average temperatures were estimated to be 7.8 – 9.75°C colder than today (Coggan, 2007). This suggests that reduced precipitation may have elevated LGM ELAs in the Höh Serh Range.

**CONCLUSION**

Debris Flow Valley contains numerous terminal and recessional moraines. The maximum ice extent was probably during the LGM, based on morphology of moraines and poor soil development on till. During this period, ice flowed south, parallel to the range crest, and then split, flowing down opposite sides of the drainage divide. Based on field surveys, the LGM ice area in Debris Flow and Lake Valleys was ~24 km². Pond Moraine may have dammed a glacial lake which overtopped the moraine and rushed westward, removing much of Pond Moraine and Debris Flow Terminal Moraine and forming a large debris flow deposit beyond the valley mouth. The LGM ELA is calculated at 3270 m and 3140 m using AAR 67% and TSAM 50%, respectively. This suggests that LGM temperatures were ~5.3°C cooler than at present.

**REFERENCES**


