KECK GEOLOGY CONSORTIUM

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

April 2009
Franklin & Marshall College, Lancaster PA.

Dr. Andrew P. de Wet, Editor
Keck Geology Consortium Director
Franklin & Marshall College

Dr. Stan Mertzman
Symposium Convenor
Franklin & Marshall College

Kelly Erb
Keck Consortium Administrative Assistant

Diane Kadyk
Academic Department Coordinator
Department of Earth & Environment
Franklin & Marshall College

Keck Geology Consortium
Franklin & Marshall College
PO Box 3003, Lancaster PA 17604-3003
717 291-4132 keckgeology.org

ISSN # 1528-7491

The Consortium Colleges National Science Foundation

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

ISSN# 1528-7491

April 2009

Andrew P. de Wet
Editor & Keck Director
Franklin & Marshall College

Keck Geology Consortium
Franklin & Marshall College
PO Box 3003, Lanc. Pa, 17604

Stan Mertzman
Symposium Convenor
Franklin & Marshall C.

Keck Geology Consortium Member Institutions:
Amherst College, Beloit College, Carleton College, Colgate University, The College of Wooster, The Colorado College Franklin & Marshall College, Macalester College, Mt Holyoke College, Oberlin College, Pomona College, Smith College, Trinity University Union College, Washington & Lee University, Wesleyan University, Whitman College, Williams College

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 P. DETHIER*: Williams College and *MATTHIAS LEOPOLD*: Technical University of Munich
Students: *EVEY GANNAWAY*: 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; *MAIJA SIPOLA*: Carleton College; *STACEY SOSENKO*: Franklin and Marshall College

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.

BLOCK ISLAND, RI: A MICROCOSM 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 VEENEMAN*: Wesleyan University; *RACHEL NEURATH*: Smith College; *JESSICA SCHEICK*: Bryn Mawr College; *DAVID JAKIM*: SUNY.

Funding Provided by: Keck Geology Consortium Member Institutions and NSF (NSF-REU: 0648782)

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

CHARACTERIZATION OF THE HÖH SERH AND TSAGAAN SALAA FAULTS, HÖH 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 HÖH SERH FAULT, MONGOLIAN ALTAI

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

MOVEMENT AND TECTONIC GEOMORPHOLOGY ALONG THE HÖH 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
Research Advisors: Bob Carson and Nick Bader
GALBADRAKH SUKHBAATAR: Mongolia University of Science and Technology

GEOMORPHOLOGY OF NARAN KHONDII, HÖH SERH RANGE, MONGOLIAN ALTAI

KATHRYN LADIG: Gustavus Adolphus College
Research Advisor: Laura Triplett
ENKHBAYAR MUNK-ERDENE**:** Mongolia University of Science and Technology

GLACIATION OF RHYOLITE VALLEY, HÖH SERH RANGE, MONGOLIAN ALTAI

KELLY DUNDON**:** Whitman College
Research Advisors: Bob Carson and Nick Bader
ESUKHEI GANBOLD**:** Mongolian University of Science and Technology

GLACIATION OF YAMAAT VALLEY, HÖH SERH RANGE, MONGOLIAN ALTAI

GIA MATZINGER**:** Whitman College
Research Advisors: Bob Carson and Nick Bader
BATTOGTOKH DAVAASAMBUU: Mongolia University of Science and Technology

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

RYAN J. LEARY : Whitman College
Research Advisor: Robert J. Carson
TAMIR BATTOGTOKH**:** Mongolia University of Science and Technology

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

BRITTANY GAUDETTE**:** Mount Holyoke College
Research Advisors: Al Werner
DELGERTSEGTSEG BURENDELGER: Mongolia Univ. of Science and Technology

Visitors:

Tsolman Amgaa	Mongolia University of Science and Technology
Steven Boettcher	University of Bayreuth
Laura Gregory	Oxford University
Richard Walker	Oxford University

Funding provided by: Keck Geology Consortium Member Institutions and NSF (NSF-REU: 0648782)

Keck Geology Consortium
Franklin & Marshall College
PO Box 3003, Lancaster Pa, 17603
Keckgeology.org

A LARGE GLACIAL-OUTBURST DEBRIS FLOW DEPOSIT, HÖH SERH RANGE, MONGOLIAN ALTAI.

GREG MORTKA: Lehigh University
NAVANCHIMEG MERGEN: Mongolian University of Science and Technology
Research Advisor: David J. Anastasio

INTRODUCTION

The Delüün Debris Flow Valley (DDFV) drains the southern Höh Serh range into the Delüün Valley to the west (Fig. 1). The valley is oriented ENE-WSW, perpendicular to the trace of the transpressional Höh Serh fault (HSF), which runs along the base of the Höh Serh range. The bedrock of the DDFV is mostly phyllite grading to schist, with some basaltic dikes and quartz veins in small sections of the valley. Extending westward from the mouth of the DDFV is a large lobate hummocky deposit about 2 km long (Fig. 2).

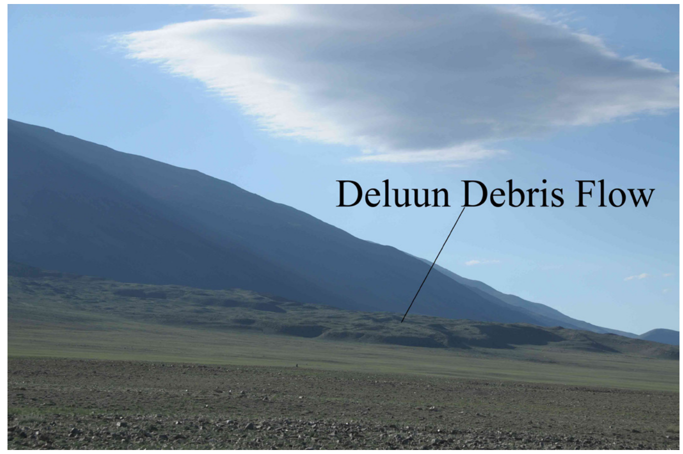

Figure 2. The Delüün Debris Flow viewed from the north.

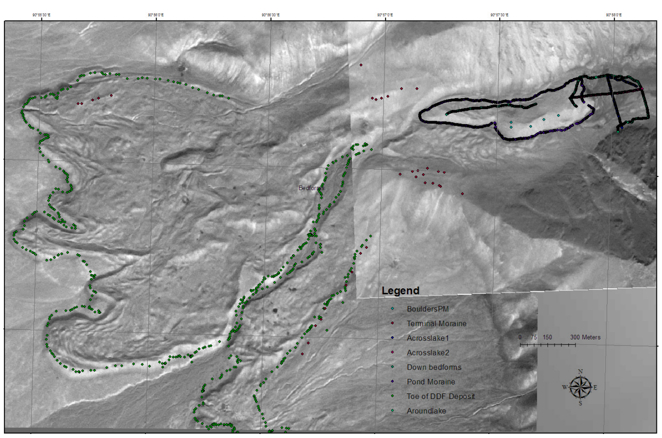

Figure 1. The Delüün Debris Flow Valley in the southern part of the Höh Serh Range.

Preliminary reconnaissance suggested that the deposit was produced by a large debris flow, and we will hereafter refer to it as a debris flow deposit. The goal of this study was to characterize the debris flow deposit and gather evidence for its origin. To this end, we mapped the deposit and the glacial features in the DDFV, and simulated comparable slope-failure events using a flume model. To investigate the possible role of a moraine-burst flood in producing the debris flow deposit, we mapped glacial features in the DDFV above the deposit.

METHODS

Field measurements on the debris flow deposit and in the DDFV were collected using a differential GPS (DGPS). We quantified the distribution of boulders and grain sizes at the surface of the debris flow deposit, and repeated these measurements in fluvial drainages to quantify differences at depth in the deposit. Boulder measurements were taken on the A, B, and C axes where possible. A Ro-tap machine was used to measure the distribution of grain sizes in by mass in the matrix, and we used KaleidaGraph software to find the mean grain size of the matrix.

DGPS measurements of the valley were compiled in ArcGIS (ESRI) in order to measure the length and slope of the valley, the size of the moraines, the size and depth of the lake, the slope of the valley walls and the cirque wall, the width of the flow, and the distance from the end of the moraine to the flow

(Fig. 2). These measurements were scaled to construct a 1:2600-scale flume model of the DDFV (Fig. 3). A 240 cm-long plywood board was used for the base of the valley. A mixture of 15% kaolinite clay, 45% 4 φ sand, 40% 0.25 - 0.75 φ sand, and a small amount of 2 mm sand was used to approximate the sediment distribution of Pond Moraine, the moraine that we believe dammed the paleo-glacial lake (see Discussion).

Figure 3. Flume model used to simulate debris flow event. A: the model before dam rupture; B: ruptured dam representing Pond Moraine.

Several possible causes of the outburst of the moraine-damned lake were tested on the flume model, based on the most typical failure mechanisms causing debris flows. Ice avalanching is a common trigger for moraine dam failures because many glaciers have retreated up to steep rock slopes since they abandoned their moraines. Toes of glaciers clinging to steep slopes are heavily crevassed and wet, and are thus prone to failure (Clague et al., 2000). Incorporating ice into the model lake simulated ice avalanching. We simulated piping of water through the moraine and resultant undercutting on the downflow side by allowing water to sit overnight in our model lake. We simulated earthquakes, which are likely due to tectonic activity by mechanically shaking the model.

The volume of the glacial lake was calculated in ArcGIS using field measurements of the probable lake extents, assuming the lake was at least as high as the lowest section of the Pond Moraine. We collected GPS waypoints along two transects through the paleo-lake to estimate the approximate profile of the lake bottom. In addition three cosmogenic nuclide (TCN) samples were taken on Pond Moraine as well as a radiocarbon sample from the toe of the DDFV.

RESULTS

The debris flow deposit extends 2.3 ± 0.5 km from the drainage divide of the DDFV and is 2.2 ± 0.5 km from the northern tip to the southern tip. The perimeter of the toe is 11.3 ± 0.5 km. The flow is hummocky; hummocks are about 10 m long and 3 m in amplitude. The deposit contains closed depression and swales that are finer-grained than the ridges. Lithologically, the debris flow deposit is matrix-supported deposit composed primarily of phyllite. Granite, gneiss, vein quartz, quartzite, basalt, schist, quartz pebble conglomerate, and epidote all exist in smaller quantities. Clasts at the surface of the debris flow deposit are larger than clasts deeper in the deposit. Clasts at the surface measured 91 ± 5 cm along the principal axis (± 1 SD); clasts exposed in drainages measured 33 ± 5 cm. There are more granite boulders at the surface of the deposit than at depth. The clasts range from pebble to boulder size with the largest measuring 60 x 33 x 12 cm (A, B, and C axis, respectively). The matrix is predominantly fine sand with an average size of 3.35 mm.

The DDFV shows extensive evidence of glaciation. A retreating mountain glacier still exists upvalley to the north. At the top of the DDFV is an extant glacial lake. Downvalley of the lake, glacial striations are visible in the valley bedrock. Just above the debris flow deposit is a boggy depression containing patterned ground such as hummocks, solifluction lobes, and "mud cracks" due to permafrost. Just downvalley between the depression and the debris-flow deposit is a large moraine (Pond Moraine), which is missing from the southern side of the DDFV. Below Pond Moraine is a terminal moraine complex marking the furthest extent of glacial ice.

The Pond Moraine returned TCN ages of 120 +/- 10 ka, 63 +/- 5 ka, and 13 +/- ka. The two older ages are interpreted as an inheritance signature and therefore as older than the deposition of the moraine. The radiocarbon age of 370 +/- 15 y is a limiting minimum age from ponded sediments deposited on top of the DDF deposit. This brackets the age of the flow between 355 y and 14 ka.

DISCUSSION

Based on geomorphology, the deposit at the mouth of the DDFV was probably produced by a massive debris flow. The boulders on the top of the flow were generally larger than those contained within the flow; this is consistent with debris flow deposits elsewhere (Yong et al., 2005). Furthermore, the deposit is matrix-supported unlike primary glacial deposits.

The debris flow deposit was probably formed by the catastrophic release of glacial meltwater dammed behind the Pond Moraine Complex. The DDFV is a very steep-walled valley; most moraine-dammed lakes occur in cirques or the upper reaches of steep-walled valleys behind end moraines (Clague et al., 2000). Pond Moraine has steep slopes of between 31 and 40 degrees, consistent with those found in other valleys that have produced debris flows (Costa and Schuster, 1988). Closed depressions on the debris flow deposit may have been produced by pieces of glacial formerly occupied the depression above Pond Moraine contained a minimum of 3.9 km^3 ± .05 km^3 of water.

The results of the flume experiment support the interpretation that an ice avalanche caused the damn to be overtopped and eventually eroded on the southern side (Fig. 3). Other scenarios such as piping, saturation, and simulated earthquake did not result in dam failure. Enough water was contained in the lake behind Pond Moraine to remove the entire south side of the flow.

The DDF Terminal Moraine Complex is the oldest complex that is a large moraine that extends as low as 2400 m elevation. This complex is cut by a large channel and is possibly a principal source of DDF material. By comparison with other valleys in our study area, the glaciation that produced the DDF Terminal moraine complex was probably Last Glacial Maximum (LGM) as there is no evidence of ice advance farther downvalley. During its retreat, the glacier deposited several recessional moraine complexes including the Pond Moraine complex.
The debris flow deposit is sufficiently old that soil processes are evident at its surface: there is stage two pedogenic carbonate growth on the bottom of the rocks located in the upper 20 cm of the flow, and there is a small amount of organic matter accumulation in the incipient A-horizon. The southern side the flow is being covered by recent alluvial fans eroding from the Höh Serh range.

CONCLUSION

The deposit below Debris Flow Valley was formed in a large debris flow event, based on its morphology and the features of the valley above. This debris flow event was probably produced by a moraine burst that allowed a glacial lake containing about 3.9 km^3 ± .05 km^3 of water to catastrophically empty from the valley.

AKNOWLEDGEMENTS

I would like to thank all of the professors that helped in the process of analyzing and reviewing my field observations and data. I would specifically like to thank Mathew Bennet for his help in the computation of specific field data. None of this would have been possible without the help and support of my colleagues as well as my department and those individuals in it that go out of their way to help.

REFERENCES

Capart, H., D.L. Young, and Y. Zech. Comparison of idealised experiments, numerical solutions, and field features for dam-break waves over granular beds. Tech.

Clague, J. J., and S. G. Evans, 2000, A review of catastrophic drainage of moraine-dammed lakes in British Columbia: Quaternary Science Reviews, v. 19, p. 1763-783.

Costa, J. E., and R. L. Schuster, 1988, The formation and failure of natural dams: Geological Society of America Bulletin, v. 100, p. 1054-068.

Iverson, R. M., 1997, The physics of debris flows: Reviews of Geophysics, v. 35, p. 245-96.

Richardson, S. D., and J. M. Reynolds, 2000, An overview of glacial hazards in the Himalayas: Quaternary International, p. 31-47.

Yong, Li, Chen Xiaoqing, H. U. Kaiheng, and H.E. Shufen, 2005, Fractality of grain composition of debris flows: Journal of Geographical Sciences, v. 15, p. 353-59.

Strasser, M., C. Schindler, and F.S. Anselmetti, 2008, Late Pleistocene earthquake-triggered moraine dam failure and outburst of Lake Zurich, Switzerland: Journal of Geophysical Research, v. 113, p. 1-16.