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

April 2014
Mt. Holyoke College, South Hadley, MA

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KECK GEOLOGY CONSORTIUM
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2013-2014 PROJECTS

MAGNETIC AND GEOCHEMICAL CHARACTERIZATION OF IN SITU OBSIDIAN, NEW MEXICO*:*
Faculty: *ROB STERNBERG*, Franklin & Marshall College, *JOSHUA FEINBERG*, Univ. Minnesota, *STEVEN SHACKLEY,* Univ. California, Berkeley, *ANASTASIA STEFFEN*, Valles Caldera Trust, and Dept. of Anthropology, University of New Mexico
Students: *ALEXANDRA FREEMAN*, Colorado College, *ANDREW GREGOVICH*, Colorado College, *CAROLINE HACKETT*, Smith College, *MICHAEL HARRISON,* California State Univ.-Chico, *MICHAELA KIM*, Mt. Holyoke College, *ZACHARY OSBORNE*, St. Norbert College, *AUDRUANNA POLLEN*, Occidental College, *MARGO REGIER*, Beloit College, *KAREN ROTH*, Washington & Lee University

TECTONIC EVOLUTION OF THE FLYSCH OF THE CHUGACH TERRANE ON BARANOF ISLAND, ALASKA*:*
Faculty: *JOHN GARVER*, Union College, *CAMERON DAVIDSON*, Carleton College
Students: *BRIAN FRETT*, Carleton College, *KATE KAMINSKI*, Union College, *BRIANNA RICK*, Carleton College, *MEGHAN RIEHL*, Union College, *CLAUDIA ROIG*, Univ. of Puerto Rico, Mayagüez Campus, *ADRIAN WACKETT*, Trinity University,

EVALUATING EXTREME WEATHER RESPONSE IN CONNECTICUT RIVER FLOODPLAIN ENVIRONMENT*:*
Faculty: *ROBERT NEWTON*, Smith College, *ANNA MARTINI*, Amherst College, *JON WOODRUFF*, Univ. Massachusetts, Amherst, BRIAN YELLEN, University of Massachusetts
Students: *LUCY ANDREWS*, Macalester College, *AMY DELBECQ*, Beloit College, *SAMANTHA DOW*, Univ. Connecticut, *CATHERINE DUNN*, Oberlin College, *WESLEY JOHNSON*, Univ. Massachusetts, *RACHEL JOHNSON,* Carleton College, *SCOTT KUGEL*, The College of Wooster, *AIDA OROZCO*, Amherst College, *JULIA SEIDENSTEIN,* Lafayette College

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Students: *KYRA BRISSON*, Hampshire College, *KYLE METCALFE*, Pomona College, *MICHELLE PARDIS*, Williams College, *CECILIA PESSOA*, Amherst College, *HANNAH PLON*, Wesleyan Univ., *KERRY STREIFF*, Whitman College

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Students: *RYAN EDGLEY*, California State Polytecnical University-Pomona, *EMILIE SINKLER*, Wesleyan University

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Students: *SUSAN KONKOL*, Univ. Nevada-Reno, *JESSICA MCHALE*, Mt. Holyoke College, *RYAN SAMUELS,* Franklin & Marshall College, *MEGAN SWITZER*, Colgate University, *HESTER VON MEERSCHEIDT*, Boise State University, *CHARLES WISE*, Vassar College

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Faculty*:* *JEFF MARSHALL*, Cal Poly Pomona, *TOM GARDNER*, Trinity University, *MARINO PROTTI, OVSICORI-UNA, SHAWN MORRISH*, Cal Poly Pomona
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HOLOCENE AND MODERN CLIMATE CHANGE IN THE HIGH ARCTIC, SVALBARD NORWAY
Faculty: *AL WERNER*, Mt. Holyoke College, *STEVE ROOF,* Hampshire College, *MIKE RETELLE*, Bates College
Students: *JOHANNA EIDMANN*, Williams College, *DANA REUTER*, Mt. Holyoke College, *NATASHA SIMPSON*, Pomona (Pitzer) College, *JOSHUA SOLOMON*, Colgate University

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Keck Geology Consortium: Projects 2013-2014
Short Contributions— Climate Change, Svalbard, Norway Project

HOLOCENE AND MODERN CLIMATE CHANGE IN THE HIGH ARCTIC, SVALBARD, NORWAY
Faculty: AL WERNER, Mount Holyoke College
MIKE RETELLE, Bates College
STEVE ROOF, Hampshire College

A PALEOCLIMATE RECONSTRUCTION OF LAKE LINNÉ, SVALBARD, NORWAY
JOHANNA EIDMANN,Williams College
Research Advisor: Mea Cook

INTERPRETATION OF SEDIMENTATION EVENTS DURING THE 2012/13 SEASON IN A PROGLACIAL LAKE, LAKE LINNÉ, SVALBARD
DANA REUTER, Mount Holyoke College
Research Advisor: Alan Werner

INVESTIGATIONS INTO ABRUPT AND LARGE SCALE LAKE LEVEL FLUCTUATIONS IN AN ARCTIC KARST LAKE, KONGRESSVATNET, KAPP LINNÉ, SVALBARD
NATASHA D. SIMPSON, Pitzer College
Research Advisor: Robert Gaines

ANALYSIS OF 2012-2013 SEDIMENT TRAPS IN LINNÉDALEN, SPITSBERGEN: IMPLICATIONS FOR VARVE FORMATION AND PALEOCLIMATE INTERPRETATION
JOSH SOLOMON, Colgate University
Research Advisor: Bruce Selleck

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HOLOCENE AND MODERN CLIMATE CHANGE IN THE HIGH ARCTIC, SVALBARD, NORWAY

AL WERNER, Mount Holyoke College
MIKE RETELLE, Bates College
STEVE ROOF, Hampshire College

INTRODUCTION

The Arctic is an area of active research because it is highly sensitive to climate change and because climatically induced environmental changes in this region can catalyze further changes of global consequence (Overpeck et al., 2006; IPCC, 2013). Recently published data indicate that the Arctic is warming far faster than lower latitudes and even greater rates of change and ecosystem disruption are predicted with the continuing decay of the Arctic Ocean pack ice (Serreze et al., 2000). The Svalbard archipelago (figure 1) is strongly influenced by the northern end of the warm Gulf Stream current, and therefore its climate is sensitive to changes in global scale oceanic circulation. Svalbard has warmed considerably during the last 90 years (Humlum, 2002) and climate proxies indicate even greater Holocene climate variability (D'Andrea et al., 2012). Despite this, little is known of sub-century climate change and virtually nothing is known of decadal scale variability in this Arctic region.

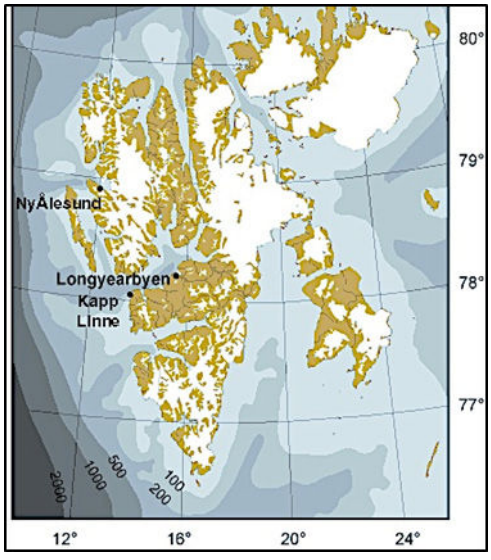

Figure 1: Svalbard and Field site (Linnédalen).

Annualy laminated sediment, or varve records from glacier-fed lakes are used routinely to reconstruct late Holocene climate change in a variety of Arctic locations (Kaufman, 2012). Previous work has related varve thickness or texture to changing glacier mass balance and summer air temperatures. Although many of the interpretations appear robust (high correlation coefficients), few studies have carried out process studies to validate their interpretations. Earlier work in the Linné Valley has used the sediment record to determine the onset of Neoglaciation (Mangerud and Svendsen, 1990; Werner, 1989) and the timing and relative magnitude of the Little Ice Age (Snyder et al., 2000). The research at the Lake Linné field site attempts to understand how environmental conditions influence sedimentation in the Lake Linné basin. To this end, we monitor glacier mass balance, the rate of snow melt, the inflow temperature, weather conditions in the valley and conditions in the lake including temperature profiles, water turbidity, sediment deposition and lake level. We also have four automated cameras that document conditions in the valley twice a day.

PROJECT GOALS

This research focuses on a glaciolacustrine system in order to establish linkages between climate, glacier mass balance, sediment transport, and sedimentation in a proglacial lake (Figure 2). Our

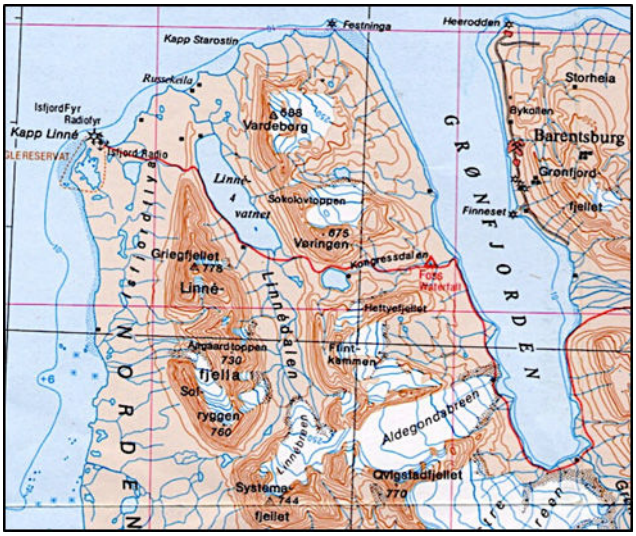

Figure 2: Kapp Linné and Linnévatnet. Isfjord Radio at Kapp Linné served as our base of operations.

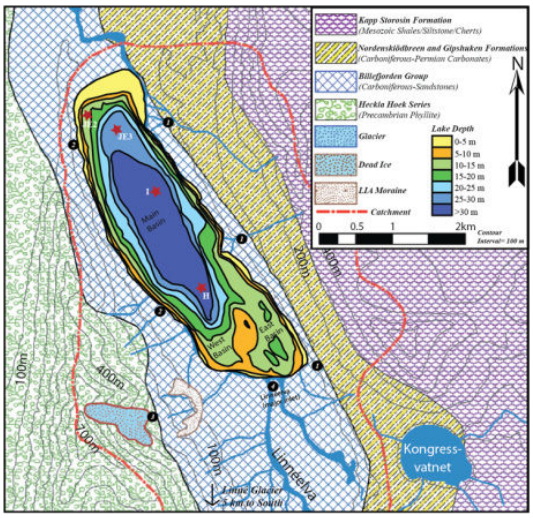

Figure 3: Bathymetry map of Linnévatnet and the surrounding geology.

network of monitoring instruments deployed at the field site combined with our summer fieldwork provide a valuable and growing database critical to understanding the inherent variability of these natural systems. Specifically, we are attempting to: 1) quantify the response of the glacial, fluvial, lacustrine, and fjord systems to measured weather fluctuations; and 2) using these relationships to calibrate and interpret sediment records from lakes in order to more reliably reconstruct late Holocene climatic changes.

STUDENT PROJECTS

ANALYSIS OF 2012-2013 SEDIMENT TRAPS IN LINNE'DALEN, SVALBARD, NORWAY: IMPLICATIONS FOR VARVE FORMATION AND PALEOCLIMATE INTERPRETION

JOSH SOLOMON, Colgate University

Josh's project was to correlate and interpret the sediment trap record in order to determine what events caused sedimentation in the lake. Josh performed particle size analysis on sediment trap samples to document the micro-stratigraphy of the traps and then compared the results with an automated sediment trap to determine the timing and rate of sedimentation. Sedimentation events were then compared to lake water turbidity, lake and inflow stream temperatures, the timing and rate of snow melt and the presents of lake ice. Josh's work demonstrates that annual sedimentation is varved and that nearly all of the silt is deposited during the spring melt – prior to glacier ablation. It appears that the rate of melting of the valley snowpack determines the thickness and texture of the associated sediment.

A PALEOCLIMATE RECONSTRUCTION OF LAKE LINNÉ, SVALBARD, NORWAY

JOHANNA EIDMANN, Williams College

Johanna, was determined to recover the longest core with the oldest mud of the summer. She set her sights on the most distal (to the inflow stream) part of the lake, near the north shore (figure 3). Previous work has shown that proximal cores are often too noisy recording individual sedimentation events as well as overall yearly sedimentation. Distal cores not only are associated with slower sedimentation (and thereby a longer stratigraphic record) but have the potential to provide less complicated varve records. Johanna recovered sediment cores from the north end of the deep main basin and from the shallow shelf at the north end of the lake – a location in the lake not yet studied. She described the physical stratigraphy of the cores and using ITRAX data correlated her core stratigraphies with the more proximal cores. Johanna sampled her cores for plutonium analysis and measured downcore varve thickness.

INVESTIGATIONS INTO ABRUPT AND LARGE SCALE LAKE LEVEL FLUCTUATIONS IN AN ARCTIC KARST LAKE, SVALBARD, NORWAY

NATASHA D. SIMPSON, Pitzer College

Active karst systems are rare in the Arctic due to widespread permafrost, poorly developed soils and the lack of ground water flow. Natasha's project focused on the bizarre lake level changes of a karst lake adjacent to the Linné Valley. Lake Kongress is interpreted as a deep karst lake and shoreline observations and recently collected lake level data indicate 3m+ changes in lake level. Level logger data collected since 2007 documents that large lake level fluctuations (both rises and falls) occur over a matter of hours to days and often is coincident with water level rises in Lake Linné. These events often occur when air temperatures are below freezing and prior to rainfall and snowmelt.

INTERPRETATION OF SEDIMENTATION EVENTS DURING THE 2012/13 SEASON IN A PROGLACIAL LAKE, LAKE LINNE, SVALBARD, NORWAY

DANA REUTER, Mount Holyoke College

How is sediment distributed in a proglacial lake? Dana's project used water temperature data to identify and map the fate of plumes of sediment delivered by the inflow stream. Inflow stream and lake water density is determined by temperature and suspended sediment load resulting in a complicated density interplay that influences how sediment disperses and is deposited in the lake basin. Dana documented seasonal changes in the occurrence and importance of underflow, interflow and overflow sedimentation. These variations can cause differences in lamination stratigraphy through-out the basin and therefore differences in sediment core records within the basin. One implication of Dana's work is that sediment dispersal in the lake during past climate change events (e.g. the Little Ice Age) may have been profoundly different if lake ice conditions, air temperature, inflow water turbidity, etc.,were different, and therefore varve thickness changes, often interpreted as a proxy of average summer temperatures may be subject to reinterpretation

SCIENTIFIC ACCOMPLISHMENTS

Recent research has determined that the sediment deposited in glacial lake Linné is indeed varved and that the "summer silt" is actually deposited during the spring melt season, prior to glacier melting. Sedimentation events are related to high discharge events of the inflow stream related to rapid snow melt, heavy rain or both. Sedimentation rates and sediment texture decrease into the summer melt season. Studies of in-lake sediment distribution processes have been found to be transient and variable during the melt season. As a result the lamination stratigraphy is not easily compared throughout the lake basin. Underflows can transport coarse material great distances and tend to follow the bathymetric low areas. Overflows, on the other hand, are subject to wind shear and can carry plumes of fine grained sediment down the lake, however the Coriolis effect often pins the plume against the eastern shore, thereby by-passing the more proximal basins. Long story short, sedimentation in a proglacial lake is more complicated than is often thought and care must be taken when selecting core sites and interpreting varve stratigraphies.

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REFERENCES

D'Andrea, W. J., Vaillencourt, D. A., Balascio, N. L., Werner, A., Roof, S. R., Retelle, M., & Bradley, R. S. (2012). Mild Little Ice Age and unprecedented recent warmth in an 1800 year lake sediment record from Svalbard. *Geology*, *40*(11), 1007–1010. doi:10.1130/G33365.1

IPCC 2013 Report: Physical Science Basis. https://www.ipcc.ch/report/ar5/wg1/

Kaufman, D.S., 2012, Introduction to the JoPL Special Issue, “Holocene paleoenvironmental records from Arctic lake sediment”. Journal of Paleolimnology 41, 1-8.

Mangerud, J. and Svendsen, J.I., 1990. Deglaciation chronology inferred from marine sediments in a proglacial lake basin, western Spitsbergen, Svalbard, Boreas, 19, p. 249-272.

Overpeck J.T., Otto-Bliesner B.L., Miller G.H., Muhs D.R., Alley R.B., and Kiehl, J.T., 2006. Paleoclimatic Evidence for Future Ice-sheet Instability and Rapid Sea-level Rise. Science 331, p. 1747-1750.

Serreze, M. C., Walsh J. E., Chapin III F. S., Osterkamp T., Dyurgerov, M., Romanovsky, V Oechel., W. C., Morison J., Zhang T., and Barry R. G., 2000. Observational Evidence of Recent Change in the Northern High-Latitude Environment, Climate Change, 46, p. 159-207.

Snyder, J.A., Werner, A., and Miller, G.H., 2000, Holocene cirque glacier activity in western Spitsbergen, Svalbard: Sediment records from proglacial Linnévatnet: Holocene, v. 10, p. 555-563.