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

April 2014
Mt. Holyoke College, South Hadley, MA

Dr. Robert J. Varga, Editor
Director, Keck Geology Consortium
Pomona College

Dr. Michelle Markley
Symposium Convener
Mt. Holyoke College

Carol Morgan
Keck Geology Consortium Administrative Assistant

Christina Kelly
Symposium Proceedings Layout & Design
Office of Communication & Marketing
Scripps College

Keck Geology Consortium
Geology Department, Pomona College
185 E. 6th St., Claremont, CA 91711
(909) 607-0651, keckgeology@pomona.edu, keckgeology.org

ISSN# 1528-7491

The Consortium Colleges   The National Science Foundation   ExxonMobil Corporation

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

ISSN# 1528-7491

April 2014

Robert J. Varga
Editor and Keck Director
Pomona College

Keck Geology Consortium
Pomona College
185 E 6th St., Claremont, CA 91711

Christina Kelly
Proceedings Layout & Design
Scripps College

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

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

Funding Provided by:
Keck Geology Consortium Member Institutions
The National Science Foundation Grant NSF-REU 1062720
ExxonMobil Corporation

A GEOBIOLOGICAL APPROACH TO UNDERSTANDING DOLOMITE FORMATION AT DEEP SPRINGS LAKE, CA
Faculty: *DAVID JONES*, Amherst College, *JASON TOR*, Hampshire College,
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

POTENTIAL EFFECTS OF WATER-LEVEL CHANGES ON ON ISLAND ECOSYSTEMS: A GIS SPATIOTEMPORAL ANALYSIS OF SHORELINE CONFIGURATION
Faculty**:** *KIM DIVER*, Wesleyan Univ.
Students: *RYAN EDGLEY*, California State Polytecnical University-Pomona, *EMILIE SINKLER*, Wesleyan University

PĀHOEHOE LAVA ON MARS AND THE EARTH: A COMPARATIVE STUDY OF INFLATED AND DISRUPTED FLOWS
Faculty: *ANDREW DE WET*, Franklin & Marshall College, *CHRIS HAMILTON*. Univ. Maryland, *JACOB BLEACHER*, NASA, GSFC, *BRENT GARRY*, NASA-GSFC
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

THE GEOMORPHIC FOOTPRINT OF MEGATHRUST EARTHQUAKES: A FIELD INVESTIGATION OF CONVERGENT MARGIN MORPHOTECTONICS, NICOYA PENINSULA, COSTA RICA
Faculty*:* *JEFF MARSHALL*, Cal Poly Pomona, *TOM GARDNER*, Trinity University, *MARINO PROTTI, OVSICORI-UNA, SHAWN MORRISH*, Cal Poly Pomona
Students: *RICHARD ALFARO-DIAZ*, Univ. of Texas-El Paso, *GREGORY BRENN*, Union College, *PAULA BURGI*, Smith College, *CLAYTON FREIMUTH*, Trinity University, *SHANNON FASOLA*, St. Norbert College, *CLAIRE MARTINI*, Whitman College, *ELIZABETH OLSON*, Washington & Lee University, *CAROLYN PRESCOTT*, Macalester College, *DUSTIN STEWART*, California State Polytechnic University-Pomona, *ANTHONY MURILLO GUTIÉRREZ*, Universidad Nacional de Costa Rica (UNA)

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

Funding Provided by:
Keck Geology Consortium Member Institutions
The National Science Foundation Grant NSF-REU 1062720
ExxonMobil Corporation

Keck Geology Consortium: Projects 2013-2014
Short Contributions— Fluvial Response to Extreme Weather Project

EVALUATING EXTREME WEATHER RESPONSE IN THE CONNECTICUT RIVER FLOODPLAIN ENVIRONMENT
Faculty: ROBERT NEWTON, Smith College
JON WOODRUFF, University of Massachusetts
ANNA MARTINI, Amherst College
BRIAN YELLEN, University of Massachusetts

EXTREME PRECIPITATION AND EROSION IN UPLAND WATERSHEDS: A CASE STUDY FROM SHERMAN RESERVOIR, MA
LUCY ANDREWS, Macalester College
Research Advisors: Kelly MacGregor and Brian Yellen

IDENTIFYING STORM DEPOSITS IN A DRY FLOOD CONTROL RESERVOIR IN WESTERN MASSACHUSETTS, USA
AMY DELBECQ, Beloit College
Research Advisor: Susan Swanson

SEDIMENTATION BEHIND CONWAY ELECTRIC DAM, SOUTH RIVER, WESTERN MASSACHUSETTS
SAMANTHA DOW, University of Connecticut
Research Advisor: William Ouimet

A CASE STUDY OF STORM DEPOSITION IN LITTLEVILLE LAKE, HUNTINGTON, MA
CATHERINE DUNN, Oberlin College
Research Advisor: Amanda Schmidt

DELTA PROGRADATION IN A FLOOD CONTROL RESERVOIR: A CASE STUDY FROM LITTLEVILLE LAKE, HUNTINGTON, MA
RACHEL JOHNSON, Carleton College
Research Advisor: Mary Savina

IMPACTS OF EXTREME PRECIPITATION ON SEDIMENT YIELDS FOR POST GLACIAL UPLANDS OF THE NORTHEAST
WESLEY JOHNSON, University of Massachusetts Amherst
Research Advisor: Jon Woodruff

DISCERNING EXTREME WEATHER EVENTS IN THE CONNECTICUT RIVER SYSTEM THROUGH THE STUDY OF SEDIMENTS IN UPLAND DAMS AND FLOOD CONTROL RESERVOIRS OF WESTERN MASSACHUSETTS AND SOUTHWESTERN VERMONT
SCOTT KUGEL, The College Of Wooster
Research Advisors: Dr. Mark Wilson and Dr. Meagen Pollock

GEOCHEMICAL AND MICROFOSSIL RECORD OF MASS HEMLOCK DECLINES IN THE SEDIMENT OF BARTON'S COVE, WESTERN MASSACHUSSETS: IMPLICATIONS OF HEMLOCK DIEOFF TODAY
AIDA OROZCO, Amherst College
Research Advisor: Anna M. Martini

Funding Provided by:
Keck Geology Consortium Member Institutions
The National Science Foundation Grant NSF-REU 1062720
ExxonMobil Corporation

CLAY MINERALOGY FINGERPRINTING OF SEDIMENTS DEPOSITED FROM TROPICAL STORM IRENE IN THE CONNECTICUT RIVER WATERSHED

JULIA SEIDENSTEIN, Lafayette College
Research Advisor: Dru Germanoski

Funding Provided by:
Keck Geology Consortium Member Institutions
The National Science Foundation Grant NSF-REU 1062720
ExxonMobil Corporation

Learning Science Through Research
Published by Keck Geology Consortium

Short Contributions
27th Annual Keck Symposium Volume
26 April, 2014
ISBN: 1528-7491

CLAY MINERALOGY FINGERPRINTING OF SEDIMENTS DEPOSITED FROM TROPICAL STORM IRENE IN THE CONNECTICUT RIVER WATERSHED

JULIA SEIDENSTEIN, Lafayette College
Research Advisor: Dru Germanoski

INTRODUCTION

Tropical Storm Irene had a major effect on New England when it made landfall in late August of 2011. The Connecticut River Watershed was especially affected. The storm caused major flooding and massive sediment transport through the Connecticut River watershed and unprecedented high sediment load through the Connecticut River. Flooding was especially severe in the Deerfield River and associated tributaries where landslides and scour mobilized large volumes of glacial sediment and as much as 40% of this sediment came from the Deerfield River Watershed. (Yellen et al, 2014) Precipitation preceding Irene was abnormally high at around 180mm and then Irene produced an additional 180 and 250mm of rain to fall in less than 12 hours leading to a record peak flow in the Deerfield of 3100m3 /sec. (Yellen et al, 2014)

This study is based on previous work by Yellen et al (2014) which began to look at Irene sediment deposited in the Connecticut River Watershed. The abnormal characteristics of the storm resulted in a distinct record of the storm-deposited sediment. Deposits from this storm have been found to be finer grained, enriched in potassium and depleted in zirconium as well as lower in organics relative to underlying sediment. This indicates that the process of sedimentation was different during Irene or there was a different source for the sediment. The lower organic content and enrichment of potassium indicated a greater amount of clay minerals in the Irene-deposited sediment. This study investigates the connection between landslides in till from the upland tributaries of the Connecticut River watershed and sediment deposited during Irene by examining the clay mineralogy and in an attempt to fingerprint mineralogic characteristics of the Irene-deposited sediment.

Figure 1. All of the sample sites are shown relative to the Deerfield and Westfield Watersheds. The Deerfield Watershed had the most rainfall during Tropical Storm Irene.

In the Connecticut River Watershed area of Massachusetts, there are two till units locally referred to as the Lower Till and Upper Till. The upland landslides occurred in the Lower Till which was likely deposited during the early Wisconsin. Although no surficial geology maps are available in the area of the landslides, the characteristics of the deposits make it possible to correlate with other known exposures. There have been some previous clay mineral studies of the lower till but none in this area and none of these studies have looked at how the mineralogy of the till relates to the mineralogy of the alluvium sediments.

METHODS

Sample Collection

The sediment collected in this study is from locations throughout the Connecticut River Watershed. See Figure 1 for a map showing the locations of each sampling site. The upland sediment is from Tuttle Brook which is a tributary of the Middle Branch of the Westfield River which feeds into the Littleville Reservoir in Western Massachusetts. This is part of the Westfield Tributary of the Connecticut River.

Figure 2. This picture shows the bottom portion of the biggest slide at the Tuttle Brook till exposure site. The slide extended about 20m up from Tuttle Brook. This is sample site #4.

The sediment was taken at mass-wasting sites that could have occurred during Irene. (See Figure 2 for a photo of a Tuttle Brook mass-wasting event sampling site.) These exposures reveal the full range of till characteristics found in this landscape. Samples were taken both on the surface of the active slide and were taken both on the surface of the active slide and from stratigraphic sections exposed along the banks of the stream. Alluvial sediment samples from the possible Irene layer—as well as bellow and above it—were collected using gravity coring and vibracoring at Littleville Reservoir. Samples from a known Irene sediment layer were also collected from the Ball Mountain Reservoir located on the West River, a tributary of the Connecticut, in southeastern Vermont. Connecticut River floodplain samples containing Irene, pre-Irene and post-Irene sediments were collected at Rainbow Beach, near Northampton, Massachusetts and Keeney Cove located near Glastonbury, Connecticut. Keeney Cove has a clear Irene sediment layer that has been studied previous so this Irene layer was the most characterized of all the Irene deposited sediment.

Sample Preparation

The methods utilized in this study are based on the methods compiled in the book *X-Ray Diffraction and the Identification and Analysis of Clay Minerals (2nd ed)* by Moore and Reynolds, 1997.

To study the clay mineralogy of the samples, oriented slides of <1µm material were prepared for analysis by X-Ray Diffractometer (XRD). Less than 1µm material was separated by first sonicating a suspension of sample and deionized water with a Fischer Scientific 550 Sonic Dismembrator for 1min15sec. The suspension was then decanted into a 250 mL centrifuge bottle and centrifuged at 1500rpm for 5min24sec. After centrifuging, the remaining material in suspension (<1 µm) is decanted into a second bottle. A small split is then filtered through a 0.45 µm cellulose nitrate filter. The material on the slide is then transferred to a glass microscope slide by pressing the sediment side of the filter onto the glass slide and allowing to dry in a 50°C oven for 1-2 minutes. After removing from the oven the filter is immediately peeled off the slide leaving behind a thin layer of oriented clay minerals. The slide is then left to complete drying in the air.

X-ray diffraction analyses were done on air dried samples and on samples that had undergone 3 other treatments. After XRD analysis of the air dried sample it was then placed in a dessicator containing ethylene glycol vapor for a period of at least 24 hours in order to fully expand low charge minerals. The glycolated slides must analyzed by XRD immediately after being taken out of the dessicator because after about an hour, the expandable clays begin to collapse. After glycolation slides go through two heat treatments. A 300°C heating for at least one hour followed by XRD analysis after the slide has cooled to room temperature and then repeat of this test after heating at 550°C.

XRD Methods

The slides were analyzed on a PANalytical Empyrean X-Ray Diffractometer equipped with a PIXel 3D Detector A Ni Filter was used to provide copper Kα radiation. The divergent slit was set to ¼° and the antiscatter slit was set to ½°. Samples were scanned from 2° to 32° 2Θ at a scan speed of 0.016726°/s.

Analysis of Results

The XRD patterns were plotted using the software Kaleidagraph. Plots were made for each sample by stacking the air-dried, glycolated and heated to 300°C and 550°C patterns. Ratios of certain peaks were done by measuring the height of peaks above background. The clay minerals were identified by determining the d-spacing of each peak and matching that with the known d-spacing pattern for certain clay minerals. Some peaks, such as the 7Å may be associated with more than one clay mineral, (kaolinite (001) verses chlorite (002)). In this case, the (002) of kaolinite at 3.57Å was used to differentiate it from the (004) of chlorite 3.53Å.

RESULTS

X-Ray Diffraction patterns were determined for air-dried, glycolated, and heated samples of the tills at Tuttle Brook and Black brook and the alluvial sediments of Littleville Reservoir, Ball Mountain Reservoir, Keeney Cove and Rainbow Beach. Figure 4 shows a typical pattern for the Tuttle Brook till. Figure 5 shows patterns for the pre-Irene, Irene, and post-Irene deposited sediment.

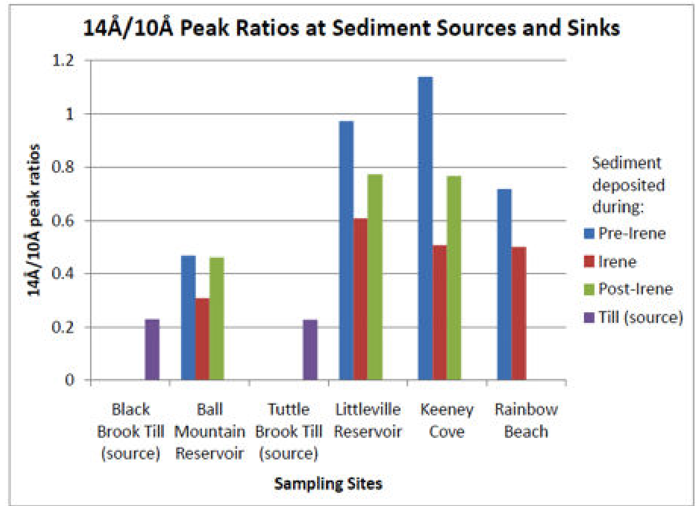

Figure 3. The Irene-deposited sediment is different from the pre-Irene and post-Irene deposited sediment. The Irene sediment is similar to the till. The post-Irene sediment is different from the pre-Irene, showing that Connecticut watershed is still responding to effect of Irene.

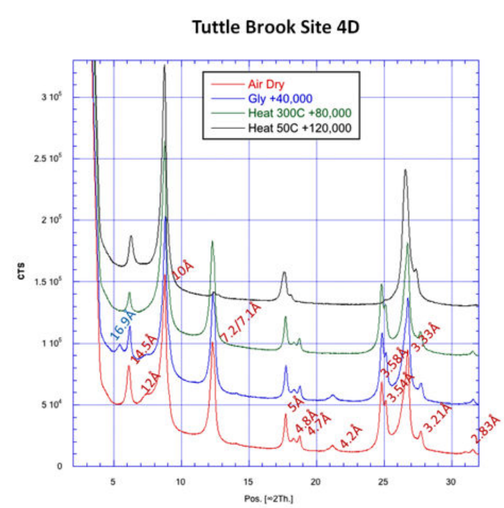

Figure 4. Tuttle Brook 4D is a representative sample from the group of samples taken at the Tuttle Brook till outcroppings. This sample comes from site #4, which is pictured in figure 2. This sample was taken 18m up the slide from the Tuttle Brook water level. The peaks are labeled in red for the air-dry sediment. Stacked above the air-dry is the glycolated (with one peak labeled in blue), and heated to 300°C and 500°C. Not shown on this graph are two peaks near 3° at 28.3Å and 23.3Å.

DISCUSSION

The mineralogy of the till at Tuttle Brook contains a variety of clays. (Figure 4) Chlorite is seen at the 14.5Å, 7.1Å, 4.7Å and 3.54Å peaks. Kaolinite is seen at the 7.2Å and 3.57Å peaks. Illite is shown at the 10Å, 5Å and 3.38Å peaks. Upon expansion by glycolation, a 16.9Å peak is formed, which represents smectite. After being heated to 300°C, this peak collapses. Chlorite and kaolinite peaks overlap at 7Å, but the ratios of the two peak heights are shown by the 3.58Å peak of kaolinite and the 3.54Å peak of Chlorite. At Tuttle Brook, the 3.58Å peak of kaolinite is higher than chlorite meaning that the 7 Å peak contains slightly more kaolinite than chlorite.

The Tuttle Brook till was derived from the erosion by glaciers of metamorphic rocks in Western Massachusetts. Tuttle Brook flows through the Hoosac Formation which is a quartz-albite-biotite-muscovite schist and gneiss containing minor garnet, chlorite and albite megacrysts (Hatch, 1969). The kaolinite in the till likely came from the feldspar in the metamorphic rocks. The smectite possibly weathered from the chlorite. The illite is fine grained muscovite and biotite. The vermiculite is a weathering product from the breakdown of biotite.

The samples taken from sediment deposited at Keeney Cove, Littleville Reservoir, Ball Mountain and Rainbow beach contain sediment deposited under normal conditions and under Irene conditions. The same clay minerals are present in all of this sediment, but there are differences in the intensity of peaks representing different amounts of the clay minerals present between the samples.

The 14Å/10Å ratio indicates the amount of weathering of the clay sediment. The less weathered sediment, like the Tuttle Brook till has a low 14Å/10Å ratio. (See figure 4 for the Tuttle Brook XRD pattern.) The higher the 14Å/10Å ratio the more weathered the sediment because biotite is weathering to vermiculite. This can be seen in the pre-Irene samples. The Irene sediment has a higher 14Å/10Å ratio than the till but lower 14Å/10Å ratio than the pre-Irene. This change of ratios from pre-Irene to Irene to post-Irene shows up in the XRD patterns at Keeney Cove shown on Figure 5. These differences are seen at all other sediment deposition areas which are shown on Figure 3. This suggests that the Irene sediment has a lower 14Å/10Å ratio than sediment deposited under normal conditions.

There is evidence to show that the conditions during Irene changed the type of sediment moving through the system after the storm as well as during the storm. Ratio differences show that post-Irene sediment is less mature than Irene-deposited sediment and more mature than pre-Irene-deposited sediment. This suggests that the watershed is still responding to Irene.

CONCLUSION

The XRD patterns for the sediment deposited at Littleville Reservoir, Rainbow Beach, Keeney Cove and Ball Mountain Reservoir show enough similarities show enough similarities with the Tuttle Brook and

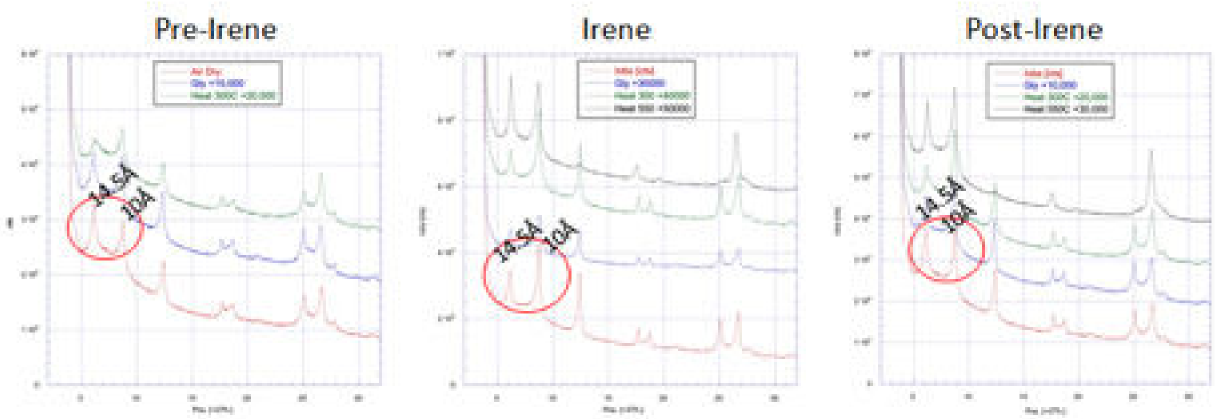

Figure 5. XRD patterns show a different 14Å/10Å ratio in the pre-Irene, Irene and Post-Irene deposited sediment. These samples were taken from a core at Keeney Cove that contains a known Irene sediment layer.

Black Brook till to confirm that the till is the source for sediment in this area of the Connecticut River Watershed. However, there are differences which show up as differences in peak intensities. These differences are vital fingerprinting for identifying the Irene deposits.

Differences in XRD patterns of the till and sites of sediment deposition show that the sediment deposited during Irene has a distinct fingerprint that stands out from the sediment deposited under normal conditions. This is portrayed as a 14Å/10Å ratio that is lower in the Irene sediment than the non-Irene sediment. This allows Irene sediment to be fingerprinted in Bald Mountain, an upland reservoir, Keeney Cove, near the main channel of the Connecticut and Rainbow Beach, a floodplain of the Connecticut. The Irene-deposited sediment is more clay rich and the clay-sized fraction has a less mature composition of clays. During a normal rainfall event, flooding traps upland sediment on the floodplain within flood formed bars preventing much of it from moving great distances downstream. Downstream sediment comes mainly from more weathered remobilized sediment and thus accounts for the clay mineral differences between the Irene and pre- and post-Irene.

This research has led to more questions and possibilities for further research. What is known about the Irene sediment could be used to look deeper into the sediment record for signs of earlier Irene-like storms in New England. An Irene-like storm would be another storm that had very high and localized rainfall in the uplands causing landslides and flooding there. This would be vital in understanding whether Irene was a normal occurrence, a freak storm or a possible indicator of a changing climate.

ACKNOWLEDGMENTS

Thanks to the Keck Consortium. A big thank you to my advisors, Dru Germanoski at Lafayette College and Robert Newton at Smith College. Thank you to Brian Yellen, PhD candidate at UMass, for project guidance and John Wilson of Lafayette College for lab support and GIS help. Thank you to my peers at the Keck Irene project for sample collection help. Thank you to the rest of my Lafayette College professors for additional support: Kira Lawrence, Larry Malinconico, Guy Hovis and Dave Sunderlin.

REFERENCES

Hatch, N.L Jr., 1969, Geologic Map of the Worthington Quadrangle, Hampshire and Berkshire Counties, Massachusetts, Map GQ 857, USGS.

Moore, D.M., and Reynolds, R.C. Jr.,1997, X-Ray Diffraction and the Identification and Analysis of Clay Minerals. 2nd ed. Oxford University Press

Yellen, B., Woodruff, J.D., Kratz, L.N., Mabee, S.B., Morrison, J., and Martini, A.B., 2014, Geomorphic Impacts of Extreme Precipitation on Post-Glacial Rivers: Insights from Hurricane Irene. (Unpublished).