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

April 2014
Mt. Holyoke College, South Hadley, MA

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ISSN# 1528-7491

The Consortium Colleges The National Science Foundation ExxonMobil Corporation

KECK GEOLOGY CONSORTIUM
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ISSN# 1528-7491

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A GEOBIOLOGICAL APPROACH TO UNDERSTANDING DOLOMITE FORMATION AT DEEP SPRINGS LAKE, CA
Faculty: *DAVID JONES*, Amherst College, *JASON TOR*, Hampshire College,
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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
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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
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HOLOCENE AND MODERN CLIMATE CHANGE IN THE HIGH ARCTIC, SVALBARD NORWAY
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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

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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

KECK Geology Consortium
Learning Science Through Research
Published by Keck Geology Consortium
Short Contributions
27th Annual Keck Symposium Volume
26 April, 2014
ISBN: 1528-7491

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AIDA OROZCO, Amherst College
Research Advisor: Anna M. Martini

INTRODUCTION

In recent years, the Hemlock Woolly Adelgid (HWA) has aggressively infested a large portion of the American hemlock (*Tsuga canadiensis*) population spanning from Maine to Georgia. This infestation has led to a massive decline and the transformation of forest ecosystems in the region (Hessl and Pederson, 2012). One consequence is that local watersheds are being loaded with extra dissolved organic matter and nutrients, promoting the eutrophication of lakes and ponds. The pollen record in lake sediments in the northeastern region of North America indicates a series of declines in the hemlock populations at around 6000 – 4800 years before present comparable to the decline we see today (Hessl and Pederson, 2012). Tree-ring analysis suggests that these declines were the result of a series of droughts in the mid-Holocene (Foster et al., 2006; Shuman et al., 2004; Hessl and Pederson, 2012). Droughts lower the water table and potentially increase eutrophication rates. The effects of the current hemlock decline are being accentuated by the rebound of earthworm populations in the region, after their decimation during the Last Glacial Maximum. These worms are cycling dissolved nutrients out of the soil organic matter faster than the biota can re-adsorb them (Hale, 2006). This culminates in large amounts of nutrients being flushed into nearby bodies of water, leading to further eutrophication (Templer, 2001; Templer, 2004; Hale, 2006). The process is also likely magnified by global warming as reaction rates (often stemming from microbial processes) increase with soil temperature. In this study, we will examine a deep, Hemlock surrounded plunge pool in Barton's Cove, MA, to look for signals of past Hemlock declines using geochemical analysis and the microfossil record. We will also examine experimental data on hemlock and deciduous forest soils to quantify the additional nutrient release to be expected by worm colonization of these forests.

Environmental scientists have, for more than half a century, understood the role of phosphorus (P) in deposited sediments as a major indicator of ageing and/or eutrophication of natural bodies (Aspila et al., 1976). While nitrogen (N) is commonly regarded as the primary limiting nutrient in the productivity of temperate forest, its relative abundance is increasing via atmospheric deposition, which potentially increases the importance of P as a limiting nutrient

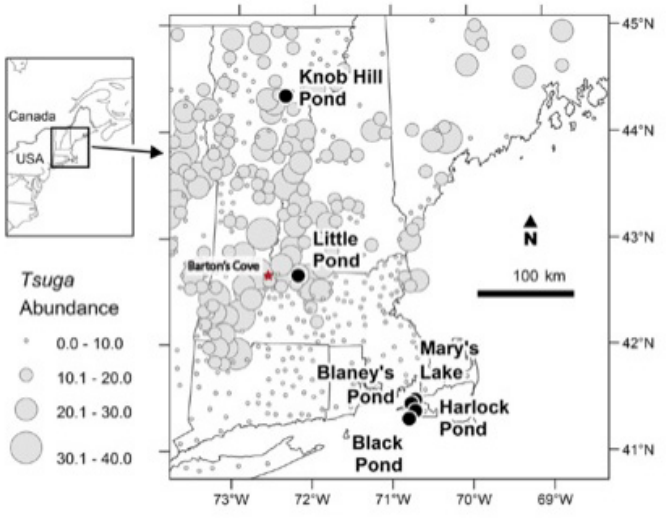

Figure 1. Pre-European settlement Hemlock population in New England. Barton's cove indicated by a star

Figure 2. Barton's Cove in Gill, MA. Arrow pointing at coring site

(Finzi, 2009). Intake and output of N and P are very species dependent (Lovett et al., 2004).

Barton's Cove is a former plunge pool that lies 117 kilometers north of the mouth of the Connecticut River. The low-energy environment of the pool makes it an ideal sink for fine-grained sediments and the organic material that runs off from the surrounding forest. The excess of N and P can be dangerous for these lake-like environments. Organic rich sediments can become layered and continuously anoxic, which could lead to the enhanced solubility of phosphates, which in turn enhances the eutrophication process (Hutchinson 1973). Different stages of eutrophication can be monitored by examining the nutrient sensitive macro- and microorganisms in the water. In this study we will explore whether the diatoms communities of Barton's cove reflect the expected changes in water chemistry during a massive die-off of acidic trees.

METHODS

Barton's Cove Core

To examine the history of nutrient runoff, an 8-meter core (Core BC 16) was recovered from Barton's Cove using a piston-style coring device. The exact place of extraction is illustrated in figure 2. Carbon 14 dates were acquired for deeper sections of the core. Sedimentation rates for the top meter of the core was determined via Cesium-137 using a gamma counter.

Worm Experiment

This experiment was set up with the intent to quantify the impact of worms in hemlock rich soil vs. deciduous rich soil on the availability of nutrients in the soil, especially P. This experiment was performed at Smith College under the supervision of Professor Robert Newton. Eight microcosms each of soils from hemlock and deciduous dominated areas were created and *Eisenia fetida* were introduced into half of each group of microcosms. Soil samples were collected from the surface, middle, and lower sections of all microcosms 4 weeks after the worms were introduced (Fig 3).

Phosphorus Digestion

The sediment and soil acquired from Barton's cove and the worm experiment respectively were dried at 80°C, powdered and an aliquot used to measure total organic content through loss on ignition (550°C for 1 hour). Approximately 0.1g of the ashed sample was boiled in 25mL of hydrochloric acid for 30 minutes using heat lamp and condensation tubes. The resultant solution was filtered (0.45 µ) and analyzed on an ICP-OES instrument for P and trace metals.

Diatoms

Wet sediment was subsampled from 10 different locations at 10 cm intervals along the core in the

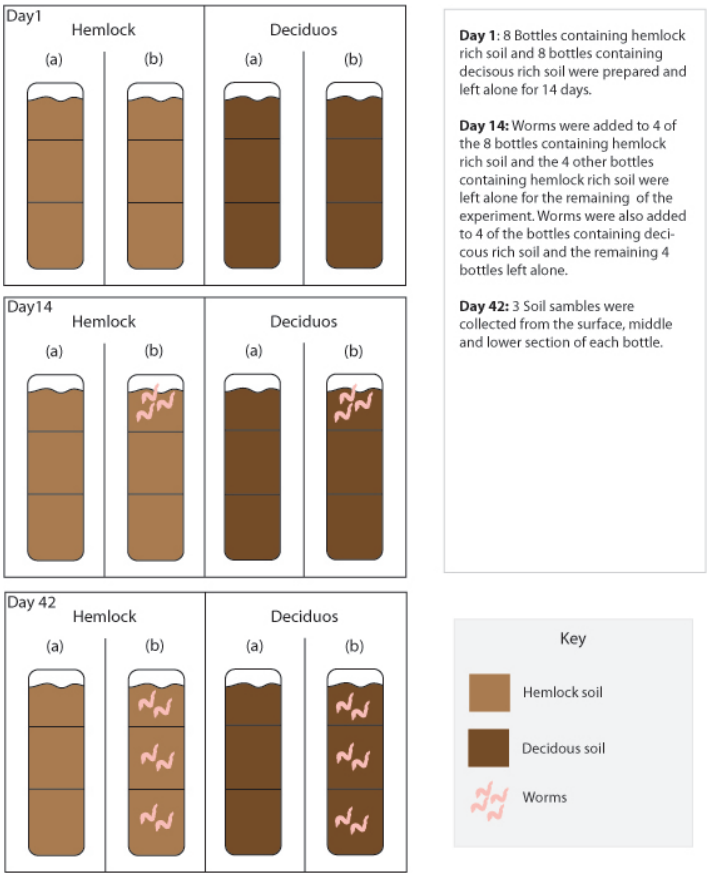

Figure 3. Eisenia fetida microcosms

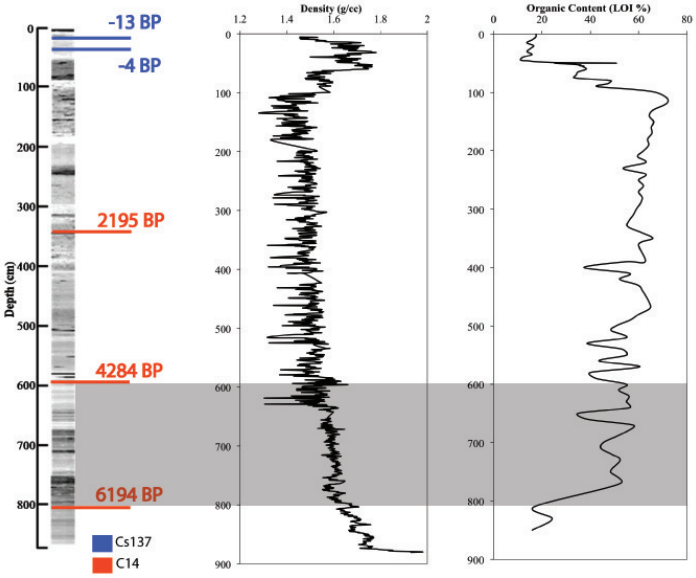

Figure 4. X-ray of Barton's Cove sediment core. Density and organic content analysis. The grey area indicates the period of the mid-Holocene hemlock die-off

area bounded by the appropriate dates, between approximately 4300 years BP and 5300 years BP. The samples were dissolved in a few drops of water and 5ml of 30% hydrogen peroxide was slowly added. The solution was heated to ~40°C on a hot plate for ~6 hours. 25 ml of water was added, the solid contents allowed to settle and the excess water removed with a disposable pipet. This process was repeated several times in order to rinse off the hydrogen peroxide. After several rinses, two drops of the remaining 5ml of solution were placed in a cover slip, allowed to dry and mounted on a glass slide for classification and quantification.

RESULTS & DISCUSSION

Dates

A study of hemlock pollen size in lake sediments from New England, indicate that the area surrounding Barton's Cove had a significant Hemlock abundance pre European settlement (Day et al., 2013). The carbon dates acquired from BC 16 indicate that sediment at ~594 cm dates to 4284 years before present and sediment at 805 cm dates to 6194 BP. The series of die-offs has been dated to ~6000 - ~4800 BP. The hemlock die-off, if recorded in the Barton's cove sedimentary record, should be found somewhere between 600 cm and 800 cm of depth. Figure 4 displays the dates acquired through Carbon and Cesium dating methods.

TOC

From 600 cm to 800 cm depths within the core, there are a series of TOC spikes (Figure 4). Overall, organic matter content ranges from 40% to ~75% TOC, and the carbon isotopic values of the organic matter indicate a mainly terrestrial origin (-33.5‰ to -28‰). These spikes might be linked to the increased runoff of nutrients into the cove during the hemlock die-off of the mid-Holocene.

Worms

As the worm experiments demonstrate, hemlock rich O-horizons contain a larger amount of phosphorus and mercury than the deciduous soil (Figure 5). For both the control and worm microcosms, the hemlock

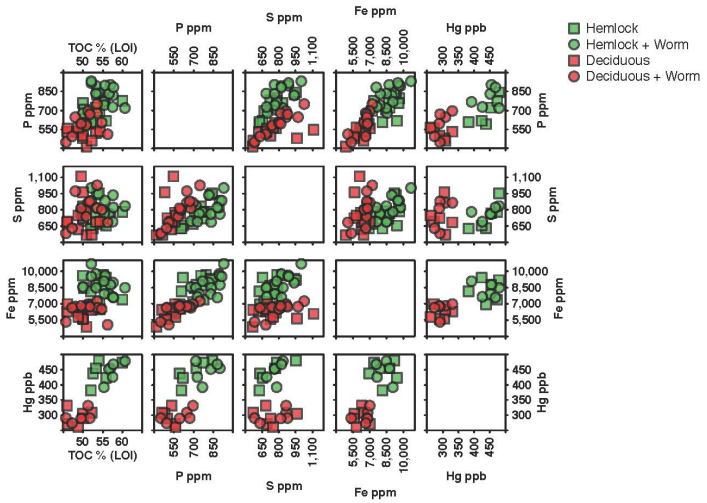

Figure 5. Elemental analysis of hemlock vs. deciduous O horizon after worm experiment via digestion in HCl and ICP-OES analysis.

soil proved to be more acidic and readily able to fix atmospheric mercury. The findings of this project may contribute to predicting ongoing changes due to hemlock declines and rapid soil organic mobilization by the Woolly Adelgid and earthworms, respectively. While the Woolly Adelgid might transiently increase the acidity of the forest soil and water, as the forest tree populations transition to a deciduous species dominated one, their litter could allow for less acidic soils and potentially restore the balance of the aquatic communities.

As we move forward in this project, elemental analysis of the core will indicate if there are spikes in the phosphorus and mercury that correspond to the spikes in TOC. TOC and P spikes alone could be misleading, since unknown factors might have been causing very organic rich runoff into the lake.

Diatoms

Classification and quantification of diatoms is still in progress.

AKNOWLEDGEMENTS

Thank you to the Consortium for supporting this project. Special thanks to the project advisor Anna Martini at Amherst College. Thanks to Bob Newton at Smith College for leading the worm experiments. Mark Hellmer at Amherst College, Jon Woodruff and Brian Yellen at UMass Amherst for acquiring and caring for the core. Thank you to my fellow Keck project members for their support.

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