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KENAI - THE GEOMORPHOLOGY AND DATING OF HOLOCENE HIGH-WATER LEVELS ON THE KENAI PENINSULA, ALASKA
Faculty: Greg Wiles (The College of Wooster), Tom Lowell, (U. Cincinnati), Ed Berg (Kenai National Wildlife Refuge, Soldotna AK)
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Faculty: Kirsten Nicolaysen (Whitman College) and Rick Hazlett (Pomona College)
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Keck Geology Consortium: Projects 2009-2010
Short Contributions – ALASKA-KENAI

THE GEOMORPHOLOGY AND DATING OF HOLOCENE WATER LEVELS AT JIGSAW LAKE, KENAI PENINSULA, ALASKA

***GREG WILES*:** The College of Wooster;
***THOMAS V. LOWELL*:** University of Cincinnati;
***ED BERG*:** US Fish & Wildlife Service, Kenai National Wildlife Refuge, Soldotna, AK.

USING PEAT HUMIFICATION FOR HIGH RESOLUTION LAKE LEVEL RECONSTRUCTION: JIGSAW LAKE, KENAI LOWLANDS, ALASKA.

ALENA GIESCHE
Middlebury College
Research Advisors: Jeffrey Munroe and Pete Ryan

BASIN SUBSIDENCE INFERRED USING GEOPHYSICAL DATA, JIGSAW LAKE, KENAI PENINSULA, ALASKA

JESSA V. MOSER
University of Cincinnati
Research Advisor: Thomas V. Lowell

RECONSTRUCTING THE PALEO-ENVIRONMENT: EARLY HOLOCENE MOISTURE VARIABILITY OF THE KENAI LOWLANDS, ALASKA

TERRY RACE WORKMAN
The College of Wooster
Research Advisor: Gregory Wiles

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

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THE GEOMORPHOLOGY AND DATING OF HOLOCENE WATER LEVELS AT JIGSAW LAKE, KENAI PENINSULA, ALASKA

GREG WILES: Geology, The College of Wooster;
THOMAS V. LOWELL: Department of Geology, University of Cincinnati;
ED BERG: US Fish & Wildlife Service, Kenai National Wildlife Refuge, Soldotna, Alaska.

PROJECT DESCRIPTION

Understanding the impact of climate on the hydrologic cycle is a key concern of research in western North America. Despite a suite of recent research efforts, outstanding questions remain regarding the causes and mechanisms of North Pacific climate variability. One key uncertainty concerns the nature of decadal fluctuations of the North Pacific climate system. Another, perhaps larger uncertainty, concerns the relative role of external and internally-forced factors in causing variability over longer (100-1000 yr) time scales.

The Keck project in the summer of 2009 on the Kenai Peninsula sought to reconstruct lake levels by geophysical surveying and recovery of 23 sediment cores from Jigsaw Lake in the Kenai Lowlands. The data generated in this work from three student projects builds on previous lake studies and geomorphologic studies from surrounding lakes and bogs. This new work together with previous studies suggests a rising water level during early to mid-Holocene time (between ~9-8 cal ka). However, interpretation of this relative lake level rise is confounded by the possibility that the land dropped because of ongoing kettle formation well into the Holocene. This added complexity was only recognized due to the intensive core sampling guided by and linked to the extensive suite of geophysical imaging and bathymetry. Results of student projects presented in the following three contributions either support or refute some aspects of the ongoing discussion that kettle formation into the Holocene was active and needs to be considered when interpreting the paleoenvironmental record of Jigsaw Lake.

CLIMATIC AND GEOLOGIC SETTING OF THE KENAI LOWLANDS

Several factors modulate the climate around the North Pacific rim on short time scales (Latif and Barnett 1994, Minobe and Mantua 1999, Seager et al. 2001, Schneider and Cornuelle 2005). The modern climatology of the region on timescales of years to decades is reasonably well studied, however, the behavior and interactions of these phenomena and perhaps others on century and longer time scales, remain poorly understood. Large-scale changes in moisture variability recorded in the changing lake levels is an untapped proxy resource that is just now emerging as a source of Northeast Pacific coastal climate records.

The western Kenai Lowland lies in a strong rain shadow from the Kenai Mountains to the east, with annual precipitation of 40-50 cm, in contrast to precipitation of 170-300 cm on the eastern (Prince William Sound) side of the mountains. The relatively arid climate of the western Kenai is sensitive to weather patterns of the North Pacific, and correlates strongly with indices such as those of the Pacific Decadal Oscillation, El Niño – La Niña, and Aleutian Low. The existence of higher than present lake levels on the Kenai lowland comes from previous studies of ice push ridges and wave cut scarps. Collectively these suggest major departures in the Holocene North Pacific climate, which have not been documented, to the best of our knowledge.

Previous Paleoclimatic Studies from the Kenai Lowlands - Reger et al (2007) summarize much of the recent paleoclimate work done for the area (Figure 1). The Jigsaw Lake basin study site originated as an ice-filled kettle about 13-15,000 years ago with the melting of Wisconsin-age glaciers that covered most of the Kenai Peninsula (Reger et al., 2007). Kaufmann (unpublished data) recovered a sediment core from the Northeast basin at Jigsaw Lake that contained a thin terrestrial peat 12 m below the present lake level suggesting a lower water stand at 9.5 ka and presumably drier conditions during this time of the Holocene thermal Maximum (Kaufmann et al., 2004). Based on macrofossil work at nearby Portage and Arrow Lakes within the lowland complex, studies by Anderson et al, (2006) inferred rising lake levels after 8.0 to 8.1 ka. An additional core from Jigsaw Lake (Mitchell and Kishaba, unpublished data) had a basal age of 9.6 ka supporting the 9.5 ka age obtained by Kaufmann. Testate amoebae work from the same core indicates a general rise in water levels since 9.5 ka with yet-undated, brief intervals of lowstands.

Many lakes, including Jigsaw Lake on the western Kenai Lowland show evidence of periods of water levels as much as 7.5 m above present lake levels. At Jigsaw a 2.4 m high, undated wave-cut bench is recognized. The oldest and highest lake levels from surrounding basins are evidenced by wave-cut scarps that ring many of the central Kenai Lowland lakes. The size and steepness of these scarps suggests a long period of wave erosion and are often a gently sloping wave-washed terraces that extend from the base of the scarp to the lake shore.

In some cases a younger period of high water, which are indicated by ice-shoved ramparts lie on the wave-washed terraces (Berg and Reger, unpublished data). These ramparts are presumably formed during spring break-up by large pans of ice driven onshore bulldozing up lake sediments. At least eight lakes exhibit these features typically on the southwest or west shores, where ice pans would be driven by strong northeast winds typical for this area. Preliminary radiocarbon dating of organic material under these ramparts indicates that they are at least 4500 years old. Determining the age of the wave-cut scarps is challenging, because they are erosional. These previous lake coring and shoreline studies suggest that the Kenai Lowland lakes have experienced a large range of Holocene lake levels that appear to have occurred rapidly.

GOALS AND RESEARCH QUESTIONS

A primary goal at the outset of the project was to reconstruct past lake levels using sediment core analyses coupled with geophysics. For our study, 23 sediment cores in five kettle sub-basins of Jigsaw Lake (Fig. 2) were located based upon detailed geophysical and bathymetric maps. This work

Figure 1. The Kenai Peninsula of southcentral Alaska. The numbered sites are those that are relevant to the present study at Jigsaw Lake (28) amd discussed in the text and subsequent contributions (Reger et al., 2007): (1-3) Headquarters Lk, (4) Brown's Lk, (5) Swan Lake Rd, (6) Diamond Cr, (7) Coal Cr, (8) Funny River Rd, (9) Wynn Nature Center, (10) Que'ana Bar, (11) Ski Hill Rd, (12) Big John's, (13) Anchor Pt Tr, (14) Anchor Pt, (15) Watson Lake, (16) Woodcutting Rd, (17) Moose River Rd, (18) Nikiski South, (19) Nikiski North, (20) Engineer Lk, (21) Oilwell Rd, (22) Tall Tree Rd, (23) Point Lk, (24) Fox Lk 1, (25) Fox Lk 2, (26) Coho Lp, (27) Bottenintnin Lk, (28) Jigsaw Lk, (29) Headquarters Lk, (30) No Name Cr, (31) Marathon Rd, (32) Merganser Cr, (33) K-Beach Gasfield, (34) K-Beach bluff, (35) Kasilof River, (36) Coho Lp bluff, (37) Coal Cr South, (38) Warren Ames Bridge, (39) Kenai River terrace, (40) Sterling Moosehorn moraine, (41) Chickaloon bluff, (42) Anchor Pt North Fork Rd, (43) Homer Beach Munson Pt, (44) Funny River Horse Trail, (45) Swanson River Fen, (46) Discovery Pond, (47) Stones Steps bluff (from Reger et al., 2007).

allowed for piston coring and the examination of stratigraphic and structural architecture of the sediment in the basins. The dating of the relative lake level history was the overall goal of this work. A key change in lake level is recognized as a transition from peat to gyttja in most cores and the timing and character of this change and other transitions will allow us to address a series of hypotheses relevant to the Holocene climate change.

Jigsaw Lake, Alaska, 2009

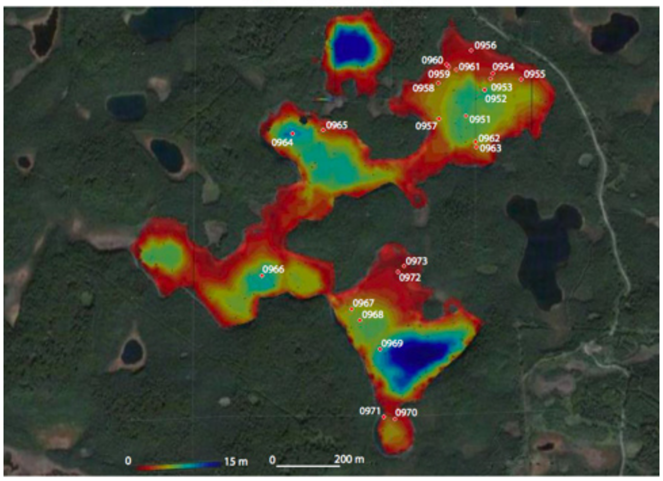

Figure 2. Location map of the 23 overlapping sediment cores taken from Jigsaw Lake. The base map is the bathymetric map generated by J. Moser. See Figure 1 for location in Alaska.

Research Questions:

A series of research questions was generated by the analyses of the stratigraphy, radiocarbon dating of transitions and further individual student follow up measurements of lake cores coupled with processing of the geophysical data. These key questions provide the framework for the following three student contributions.

1 - How is the transition from the early Holocene Thermal Maximum manifested in the water budget for the region?

2 – How do the lake level fluctuations reconstructed from sediment cores compare with the morphological evidence of high stands such as wave cut benches and ice push ridges?

3 – How does the landscape evolution of the lake basins in terms of kettle formation affect the lake sediment record and paleoclimate interpretation?

4- How do lake level histories compare with intervals of known Abrupt Climate Changes such as the Younger Dryas and 8.2 ka events?

5–Are past sustained intervals of high precipitation (high lake levels) linked to tropical and/or exratropical forcing from the Pacific that channels storm tracks north into coastal Alaska at the expense of lower latitudes in the America Southwest.

STUDENT PROJECTS

While in the field on the Kenai Peninsula participants performed preliminary analyses on the sediment cores, including, core description, magnetic susceptibility, and photography (Figure 3). Partial processing of the bathymetric and geophysical data was also done while on site in Alaska. Details of the methods used in the three student projects are provided in the individual contributions that follow. Jessa Moser focused on geophysics of the lake basin, Alena Giesche on the paleoecology of the peats and Terry Workman on the dating and stratigraphic analyses of select sediment cores and comparison with regional paleoclimate datasets.

Moser's creative and innovative work examined the utility of using a variety of geophysical imaging equipment in these small lake basins. The data were used to provide a seismic stratigraphic framework, side-scan imaging and bathymetry to then core at various locations within the Jigsaw basin complex. These same data were then interpreted to point out different "views" of the underwater features that yielded the recognition of significant slumping, faulting and post-depositional deformation as well as inundated shoreline features.

Giesche's work focused on using peat humification analysis to identify some of the variable moisture conditions that the widespread peat layer experienced between 9.4 and 7.9 ka. She chose one core for her in-depth work and together with radiocarbon and loss on ignition (LOI) analyses provided some of the details that indicated changing water levels in the 80 cm interval of Spagnum Fuscum. In addition to exploring the botanical and preservation aspects of the sediment cores, Alena provided the team with regional fence diagrams that tie together the stratigraphy of multiple cores from each of the sub basins.

Workman chose to work with multiple cores to better understand the timing and conditions of the transition between a peat to gyttja transition indicating increased moisture in the basin between 8.6 and 7.9 ka. His additional analyses included LOI and a suite of radiocarbon analyses that better bracket the timing of increasing water levels. He also compared these data with regional proxy records that indicate wetting and drying at other sites across North America to suggest changes in large-scale circulation patterns.

Each of these projects contributes to a more complete understanding of the complexity and evolution of the Jigsaw lake basin and its potential for extracting climate information and a reliable chronology. The 23 cores and a complete geophysical data set for the basin offered a unique opportunity to ask questions regarding the evolution of the basin. One new wrinkle was the hypothesis that the region continued to experience ice-melt out and kettle formation through at least the first few millennia of the Holocene. If so, this could explain some of the relative lake level changes. This possibility, not uniformly agreed on by the Keck Kenai participants, potentially adds some complexity to interpretations, but furthers our understanding of the landscape evolution and paleoenvironmental history of the region.

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