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2009-2010 PROJECTS

SE ALASKA - EXHUMATION OF THE COAST MOUNTAINS BATHOLITH DURING THE GREENHOUSE TO ICEHOUSE TRANSITION IN SOUTHEAST ALASKA: A MULTIDISCIPLINARY STUDY OF THE PALEOGENE KOOTZNAHOO FM.
Faculty: Cameron Davidson (Carleton College), Karl Wirth (Macalester College), Tim White (Penn State University)
Students: Lenny Ancuta, Jordan Epstein, Nathan Evenson, Samantha Falcon, Alexander Gonzalez, Tiffany Henderson, Conor McNally, Julia Nave, Maria Princen

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Faculty: David Dethier (Williams) *Students: Elizabeth Dengler, Evan Riddle, James Trotta*

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Keck Geology Consortium: Projects 2009-2010
Short Contributions – SE ALASKA

EXHUMATION OF THE COAST MOUNTAINS BATHOLITH DURING THE GREENHOUSE TO ICEHOUSE TRANSITION IN SOUTHEAST ALASKA: A MULTIDISCIPLINARY STUDY OF THE PALEOGENE KOOTZNAHOO FORMATION

CAMERON DAVIDSON, Carleton College
KARL R. WIRTH, Macalester College
TIM WHITE, Pennsylvania State University

FISSION TRACK AGES OF DETRITAL ZIRCON FROM THE PALEOGENE KOOTZNAHOO FORMATION, SE ALASKA

LEONARD ANCUTA: Union College
Research Advisor: John Garver

PALEOMAGNETISM AND GEOCHEMISTRY OF TERTIARY INTRUSIONS AND FLOWS ASSOCIATED WITH THE KOOTZNAHOO FORMATION NEAR KAKE, SOUTHEAST ALASKA, AND IMPLICATIONS FOR THE WRANGELLIA COMPOSITE TERRANE

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SAMANTHA FALCON: West Virginia University
Research Advisor: Dr. Helen Lang

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TIFFANY HENDERSON: Trinity University
Research Advisor: Kathleen Surpless

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CONOR P. MCNALLY: The Pennsylvania State University
Research Advisor: Tim White

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JULIA NAVE: The Colorado College
Research Advisor: Henry Fricke

PALEOMAGNETIC STUDY OF THE PALEOGENE KOOTZNAHOO FORMATION, SOUTHEAST ALASKA

MARIA PRINCEN: Macalester College
Research Advisor: Karl Wirth

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CAMERON DAVIDSON, CARLETON COLLEGE
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INTRODUCTION

The Paleogene is perhaps one of the more enigmatic times in Earth history marked by relatively rapid carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotope excursions in deep sea sediments (Zachos et al., 2001), extensive volcanism (Courtillot & Renne, 2003), elevated levels of extraterrestrial material (e.g. ^{3}He; Farley, 1998) and rapid uplift and exhumation of the Coast Mountains batholith in North America (Gehrels et al., 2009). How these various events are recorded in the rock record and their impact on global climate has received a considerable amount of interest in recent years (e.g. Zachos et al., 2008). In Southeast Alaska, the Kootznahoo Formation was deposited in a marginal marine fluvial to paludal environment throughout most of the Paleogene (Lathram et al., 1965; Muffler, 1967; Dickinson et al., 1990) and during the exhumation of the Coast Mountains batholith (Karl et al., 1999; Gehrels et al., 2009). The Kootznahoo Formation is primarily composed of conglomerate, sandstone, and shale. Locally, coal seams up to one meter thick are present, shale horizons contain deciduous leaf impressions, and carbonized wood fragments and tree stumps are preserved (Lathram et al., 1965; Dickenson and Vuletich, 1990). These observations support the growing body of evidence that Earth was considerably warmer near the poles during the Paleocene and Eocene. In addition, conglomerate and sandstone from the Kootznahoo Formation contain abundant lithic fragments, feldspar, zircon, and other heavy minerals suggesting that the source region for much of the detritus is from the adjacent igneous and metamorphic rocks of the Coast Mountains batholith complex.

In this study we use 1) U-Pb and fission track dating of detrital zircon, 2) paleomagnetism and magnetostratigraphy, 3) stable isotope geochemistry ($\delta^{13}C$ & $\delta^{18}O$), and 4) palynology to unravel the depositional history of the Kootznahoo Formation in Southeast Alaska with a specific focus on the exhumation history of the Coast Mountains batholith (CMB), and how high latitudes (~57°N) recorded overall global cooling from the Paleocene-Eocene thermal maximum (PETM) through the Eocene-Oligocene transition to the present icehouse state.

GEOLOGIC SETTING

The western margin of North America is composed of a collage of lithotectonic terranes accreted to the margin during a ~180 Ma history of subduction and associated arc volcanism as North America moved west during the break up of Laurasia (e.g. Coney et al., 1980; Monger et al., 1982; Gehrels et al., 2009). In southeast Alaska, the Wrangellia composite terrane (WCT) (Ridgway et al., 2002) was accreted to North America starting in mid-Cretaceous time with high-grade metamorphism, pluton emplacement, and shortening of the Gravina basin in the Late Cretaceous from ~100 Ma to ~78 Ma (Fig. 1; Himmelberg and Brew, 2005; Gehrels et al., 2009). Accretion of the WCT was followed by extension, high grade metamorphism, pluton emplacement, and rapid exhumation of the axial portion of the CMB, east of the Coast Shear Zone, from ~55 Ma to ~48 Ma (Klepies et al., 1998; Andronicos et al. 2003; Rusmore et al., 2005). The Kootznahoo Formation, a Paleogene marginal marine to non-marine silici-

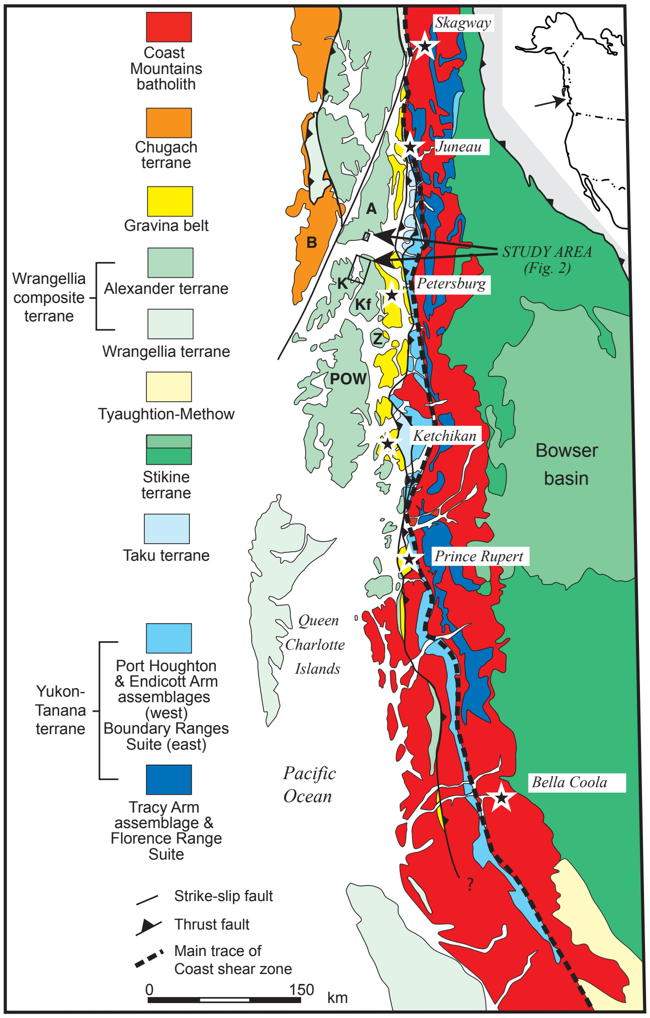

Figure 1. Tectonic map of Southeast Alaska and British Columbia (modified from Gehrels et al., 2009). Various islands referred to in text are labeled: A=Admiralty, B=Baranof, K=Kuiu, Kf=Kupreanof, POW=Prince of Wales, Z=Zarembo. Study area shown in Figure 2 is outlined.

clastic unit, was deposited unconformably on the Wrangellia composite terrane, and crops out discontinuously for over 100 kilometers from Angoon in the north to Zarembo Island in the south (Fig. 1). Outboard of the WCT, the Chugach-Prince William (CPW) terrane formed as an accretionary complex along the North American margin, perhaps as much as 1100 km south of its present location, during the Late Cretaceous to Early Tertiary (Plafker et al., 1994; Cowen, 2003). The CPW terrane northwest of the study area on Baranof Island, experienced metamorphism, pluton emplacement, and cooling at ~46-35 Ma, may have been 800 km south of its present position at 50 Ma, and was subsequently transported north by dextral motion on the Queen Charlotte-Fairweather fault and Chatham Strait-Denali fault system (Fig. 1; Cowen, 2003).

STUDENT PROJECTS AND RESULTS

We had nine students and three faculty who worked out of three research vessels (skiffs) from our home base in Kake, Alaska in June, 2009. Karl Wirth (Macalester College) was captain of the RV Detrital Zircon that included students Lenny Ancuta (Union College), Nate Evenson (Carleton College), and Tiffany Henderson (Trinity University). Tim White (Penn State University) was captain of RV Stratigraphy with students Samantha Falcon (West Virginia University), Conor McNally (Penn State University), and Julia Nave (Colorado College), and Cam Davidson was captain of RV Paleomagnetism with students Jordan Epstein (Carleton College), Alex Gonzalez (Amherst College), and Maria Princen (Macalester College). Sample locations and simplified stratigraphic columns from the study area are in Figures 2 and 3, respectively.

Lenny Ancuta (Union College) uses fission track dating of detrital zircon to help constrain the depositional age of the Kootznahoo Formation to be between ~ 57 Ma and ~32 Ma. He also shows that the crosscutting basaltic dikes were intruded at ~23 Ma, confirming a previously published U-Pb date by Haeussler et al. (1992). Finally, Lenny uses his results to show that the primary source of the siliciclastic sediments deposited in the Kootzahoo basin comes from the adjacent Coast Mountains batholith, but suggests that higher in the stratigraphic section there may be a signal from the Chugach-Prince William terrane.

Nate Evenson (Carleton College) and Tiffany Henderson (Trinity University) use U-Pb dating of detrital zircon and sedimentary petrography to help constrain the provenance and depositional age of the Kootznahoo Formation. Tiffany focused her efforts on the lowest part of the section and Nate took the upper (Figs. 2 & 3). Together, they show that most samples plot within the fields of basement uplifts or dissected arcs on a QFL diagram; one

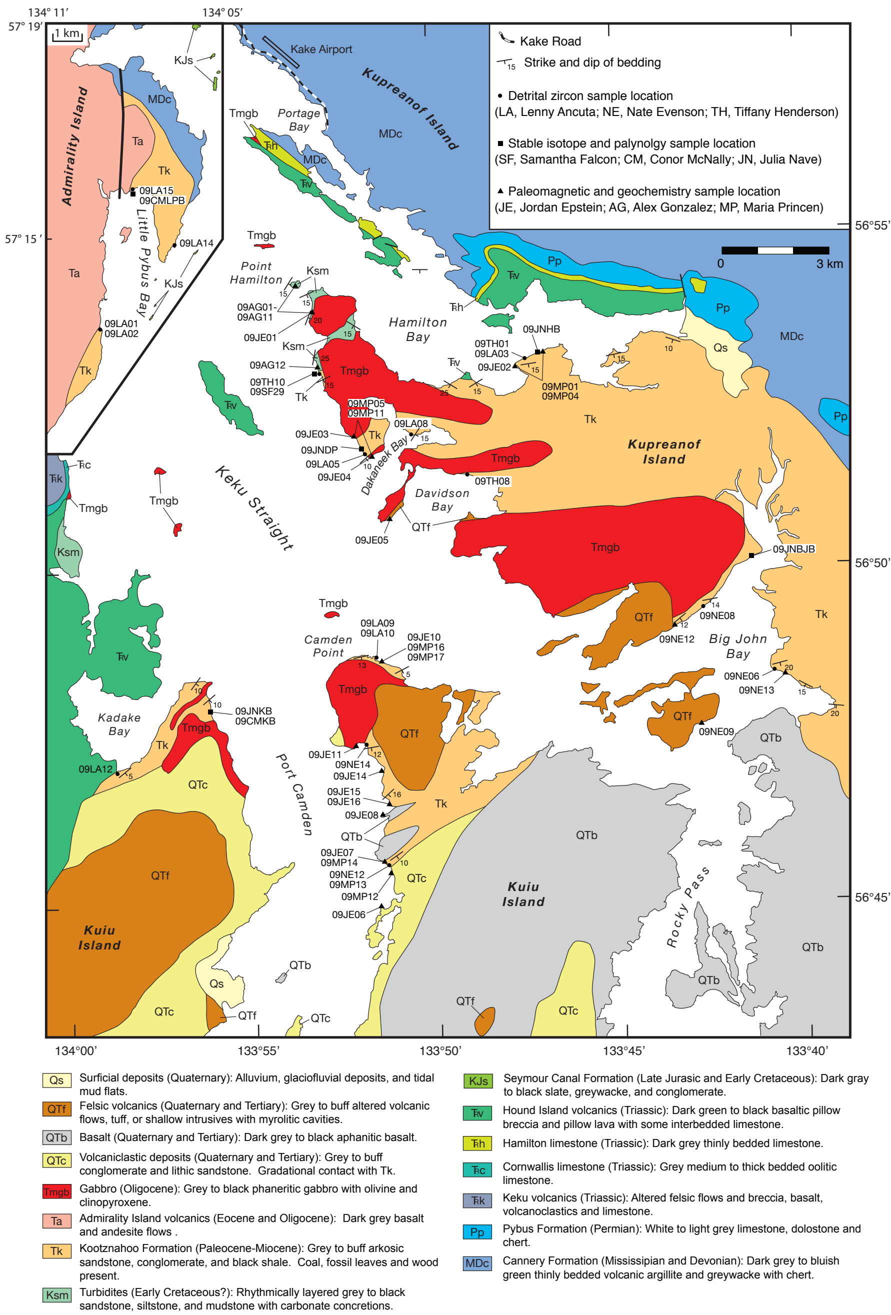

Figure 2. Geologic map and sample locations from the Keku Strait area and Little Pybus Bay (inset), Southeast Alaska. Modified from Lathram et al. (1965), Muffler (1967), and Brew et al. (1984). Location of map area shown in Figure 1.

sample near the top of the section plots in the undissected arc field. They also obtained 1169(!) detrital zircon U-Pb dates from 12 samples that collectively yield a broad peak on a relative probability diagram at 190-160 Ma, and well-defined peaks at 93-85 Ma, 65-50 Ma, and 30-24 Ma. They demonstrate that the initial input of zircon into the Kootznahoo basin is from the erosion of the adjacent western portion of the Coast Mountain batholith complex, followed by a pulse of zircon from the initial un-roofing of the axial portion of the CMB, east of the Coast Shear zone (Fig. 1).

Samantha Falcon (West Virginia University) helped measure detailed (cm-scale) sections in the Kootznahoo Formation at select areas in the study area. She ended up focusing her efforts on recovering fossil pollen and spores from silty mudstones in the lower part of the section near Point Hamilton (Fig. 2). After much effort, Sam was able to extract some poorly preserved pollen and spores. Therefore, she restricted her analyses to describing the various morphologies present in her samples, but could not obtain any meaningful age control.

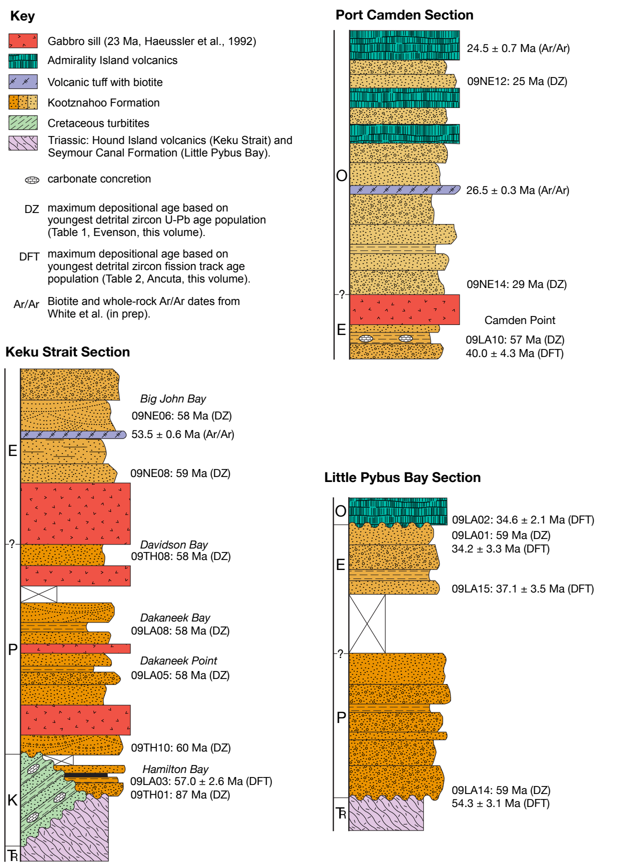

Figure 3. Simplified stratigraphic columns of Keku Strait, Port Camden, and Little Pybus Bay sections. Modified from White et al. (in prep). Approximate sample locations are shown.

Conor McNally (Penn State University) targets two paleosols within the Kootznahoo Formation identified by White et al. (in prep) and collected high-resolution (cm-scale) samples for carbon isotope stratigraphy (Fig. 2). Conor finds that both paleosols display carbon isotope excursions with similar patterns of a pronounced $\delta^{13}C$ depletion followed by a less pronounced positive excursion. He suggests that these excursions are consistent with other terrestrial paleosol excursions found in North America and formed during the Paleocene-Eocene Thermal Maximum at 55.9 Ma. This suggests that the two locations correlate linking the Little Pybus Bay section north of Fredrick Sound with the Kadake Bay section about 50 km to the south.

Julia Nave (Colorado College) uses carbon and oxygen isotope values of carbonate cements in the Kootzahoo Formation to help constrain the environmental and paleoclimatic conditions of carbonate formation. She also uses clumped isotope thermometry to estimate the temperature of carbonate formation and shows that most, if not all the carbonate cement in the Kootzahoo Formation formed during burial or from the circulation of hydrothermal fluids associated with 23 Ma gabbros found throughout the section. Using a fluid mixing model, Julia shows that most of her data can be explained by the mixing of seawater and meteoric water and that the $\delta^{18}O$ values from the lowest, Paleocene part of the Kootznahoo Formaton are representative of a local hydrological cycle, and that isotope values from the rest of the formation are consistent with a more global Eocene hydrological cycle.

Jordan Epstein (Carleton College) focused his efforts on a detailed paleomagnetic and geochemistry study of the 23 Ma gabbros, basaltic dikes, and lava flows found throughout the Kootznahoo Formation. Based on major and trace element geochemistry, Jordan shows that there are two distinct suites of basaltic rocks, one with ocean floor signatures and the other plotting in the within-plate or calc-alkaline field. The paleomagnetic study yielded reliable poles for most sites with all but one site showing normal polarity. With a tilt correction based on the local dip of the Kootnahoo Formation, Jordon shows that the poles preserved on Kupreanof Island match the North American pole for 20 Ma. However, the poles preserved in the Port Camden section on Kuiu Island have declinations that differ by 45° from the North American pole suggesting that this area experienced a 45° counter clockwise rotation since the early Miocene.

Alex Gonzalez (Amherst College) uses paleomagnetism to try and retrieve a magnetic stratigraphy and average paleomagnetic pole from a 170 m thick section of Early Cretaceous turbidites that lie below the unconformity with the overlying Kootznahoo Formation (Fig. 2). All samples have normal polarity with a NNW trending and steeply inclined magnetization that closely matches the North American pole at ~20 Ma. He suggests that this represents a secondary magnetization caused by thermal overprinting and growth of ferromagnetic minerals during intrusion of the 23 Ma gabbros in the area. In addition to the paleomagnetic work, Alex collected and identified a suite of terrestrial plant leaf fossils from the uppermost part of the previously mapped Cretaceous section that lies immediately below the Tertiary unconformity. These fossils are most likely Late Cretaceous in age and suggests that there is an unconformity present somewhere in the mapped Cretaceous section between Point Hamilton and the Tertiary unconformity with the overlying Kootznahoo Formation.

Maria Princen (Macalester College) took on the challenge of using paleomagnetism to obtain a magnetic stratigraphy of a ~600 m section of the Kootznahoo Formation in the Keku Strait area. Her work focused on sampling concretions and well-cemented sandstones from the otherwise poorly lithified Kootznahoo Formation. All her samples proved to have extremely weak natural remnant magnetism and she valiantly attempted to tease usable paleomagnetic poles from her noisy data using AF and thermal demagnetization procedures. The results yield poles with steep inclinations and mostly northerly declinations, but with significant scatter within and between sampling sites. It was not possible to recover magnetic polarity information from the cores due to the complex remnant magnetism and the relatively low stratigraphic resolution of the samples.

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