

**KECK GEOLOGY CONSORTIUM
PROCEEDINGS OF THE TWENTY-THIRD
ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY
ISSN# 1528-7491**

April 2010

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Franklin & Marshall College

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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.

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Students: Adam Curry, Allison Goldberg, Lauren Idleman, Allan Lerner, Max Siegrist, Clare Tochilin

**Funding Provided by: Keck Geology Consortium Member Institutions and NSF (NSF-REU: 0648782)
and ExxonMobil**

**Keck Geology Consortium: Projects 2009-2010
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**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

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LEONARD ANCUTA: Union College

Research Advisor: John Garver

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SAMANTHA FALCON: West Virginia University

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ALEXANDER BRIAN GONZALEZ: Amherst College
Research Advisor: Peter Crowley

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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

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

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PALEOMAGNETISM OF EARLY CRETACEOUS TURBIDITES NEAR POINT HAMILTON, KUPREANOF ISLAND, ALASKA

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Research Advisor: Cameron Davidson

INTRODUCTION

Southeast Alaska has a complex tectonic history during which the western margin of North America was built outward (Coney, et al., 1980; Beck, et al. 1973; Cowan, et al., 1997; McClelland, et al. 1992). Terrane accretion may have occurred much to the south of the present-day latitude of Alaska with northward translation during the Late Cretaceous period (e.g. Cowan et al., 1997). Deciphering this tectonic history is complicated by the relative lack of unaltered Cretaceous aged rocks in SE Alaska. This paleomagnetic study attempts to fill that void by examining the paleomagnetism recorded in a 170 m section of Early Cretaceous sedimentary rocks from Point Hamilton, Kupreanof Island, Alaska.

GEOLOGIC SETTING

The Early Cretaceous strata are exposed in nearly continuous northeast dipping section of beach exposures near Point Hamilton on Kupreanof Island (Fig. 1; Fig.2, Davidson et al., this volume). Cretaceous strata near Point Hamilton are dominated by an unnamed unit of marine turbidites composed of interbedded fine-grained sandstone, mudstone, calcareous concretions, and carbon-rich shale. Muffler (1967) assigned an Early Cretaceous age to these rocks based on two poorly preserved marine *Buchia* sp. fossils in the region (near 09-ABG-04, Fig. 1). In general, the section fines upwards becoming dominated by fissile shale and calcareous concretions at the top. The lower 170 m of the section examined in this study forms a nearly continuous exposure along the shoreline. There is discontinuous outcrop for another two kilometers south along the western shore of Point Hamilton. At the top of the section (09-ABG-12, Fig. 2) just below an angular unconformity with the overlying Kootznahoo Formation



FIGURE 1 Sample locations for 12 sample sites in the Early Cretaceous turbidites (09-ABG-1 to 09-ABG-11) and overlying Late Cretaceous terrestrial shale (09-ABG-12).

(Fig.1, Davidson et al., this volume) the rocks are composed of interbedded fissile carbon-rich shale and calcareous sandstone that appear similar to the uppermost strata of the lower 170 m marine unit exposed at Point Hamilton. However, these strata locally contain abundant Late Cretaceous angiosperm fossils (Fig. 2, identified by Leo Hickey, pers. comm., 2010). These fossils suggest the presence of a previously unrecognized disconformity within this section between Early Cretaceous marine strata and Late Cretaceous terrestrial strata. A thick 23 Ma (Haeussler and Coe, 1992) gabbroic sill intruded

into these rocks above the section studied here (Fig.2, Davidson et al., this volume).

METHODS

STRATIGRAPHY AND SAMPLING OF HAMILTON POINT

Twelve sites on Kuperanof Island were drilled and sampled for paleomagnetism (Fig. 1), eleven of which are from the Early Cretaceous marine part of the section and one from the younger terrestrial rocks (Fig. 1). The sites are spaced approximately 15 to 20 m apart. At each site between 2 and 7 cores (~8 cm long) cores were collected. An attempt was made to sample different lithologies: turbidite sandstone, turbidite mudstone, fissile carboniferous shale, and calcareous concretions. Prior to the cores extraction, core orientation was measured while still attached to the bedrock. At each site detailed structural, and sedimentological measurements were described and photographed. Cores from each sample were cut into at least 2 (~2.5 cm) specimens. Since the angiosperm plant fossils (Fig. 2) were found on the last day of fieldwork, further research could not be done on identifying the location of the unconformity.

ALTERNATING FIELD DEMAGNETIZATION

Paleomagnetic directions and magnetic intensities were recovered from between 2 and 7 samples from each site using the SQUID cryogenic magnetometer at the paleomagnetism lab at The University of Massachusetts at Amherst. Initially, the orientation and intensity of the natural remnant magnetization (NRM) was recovered from each specimen and determined to be above the signal to noise ratio (10^{-8}). Each specimen was then progressively demagnetized using alternating-field demagnetization techniques. The cores were subjected to increasing AF intensities from 2.5 to 80 mT depending on the existing intensity. After each step, a cryogenic magnetometer was used to measure the core's magnetic intensity and orientation until all magnetization was removed.



FIGURE 2 Leaf fossils from site 09-ABG-12 10 suggest a previously unrecognized paraconformity in the section. (A) *Equisetum* sp. (Carboniferous to Recent), (B) *Platanus* sp. (Late Albian to Recent), (C) *Parataxodium* sp. (Campanian to Maestrichtian)

THERMAL DEMAGNETIZATION

Thermal demagnetization was used to remove low coercivity secondary magnetizations at the paleomagnetism lab at Yale University. After measuring the orientation and intensity of the NRM, each specimen was progressively heated to temperature increments ranging from 100 to 520 °C cooled to approximately 30 °C using nitrogen and oxygen to regulate the cooling process to ensure the steady acquisition of a thermoremanent magnetization. After each step, the cores were placed in an automated sample-changing cryogenic magnetometer used to measure the core's magnetic intensity and orientation until all magnetization was removed.

SEM/EDS

Two samples, one from the Early Cretaceous marine unit and the other from the overlying Late Cretaceous terrestrial unit, were chosen because of their contrasting demagnetization behavior. They were examined under an SEM primarily to observe the morphology of Fe-bearing minerals and identify a primary magnetic carrier. Backscattered electron (BSE) images were examined to find small BSE bright (high mean atomic weight) grains. Mineralogy was determined from both qualitative and quantitative analysis of EDS spectra of the BSE bright grains.

RESULTS

ALTERNATING FIELD DEMAGNETIZATION

NRM measurements and selective removal of low coercivity magnetizations by AF revealed complex multi-component magnetizations. J/J_0 graphs show complex and variable multi-component magnetizations with ~50% of the magnetization removed by AF fields of <20 mT. In general, more than 95% of the magnetization was removed by an AF field of 60-80 mT, although several specimens were not completely demagnetized in the final AF step due to their magnetic components having coercivities greater than 99 mT.

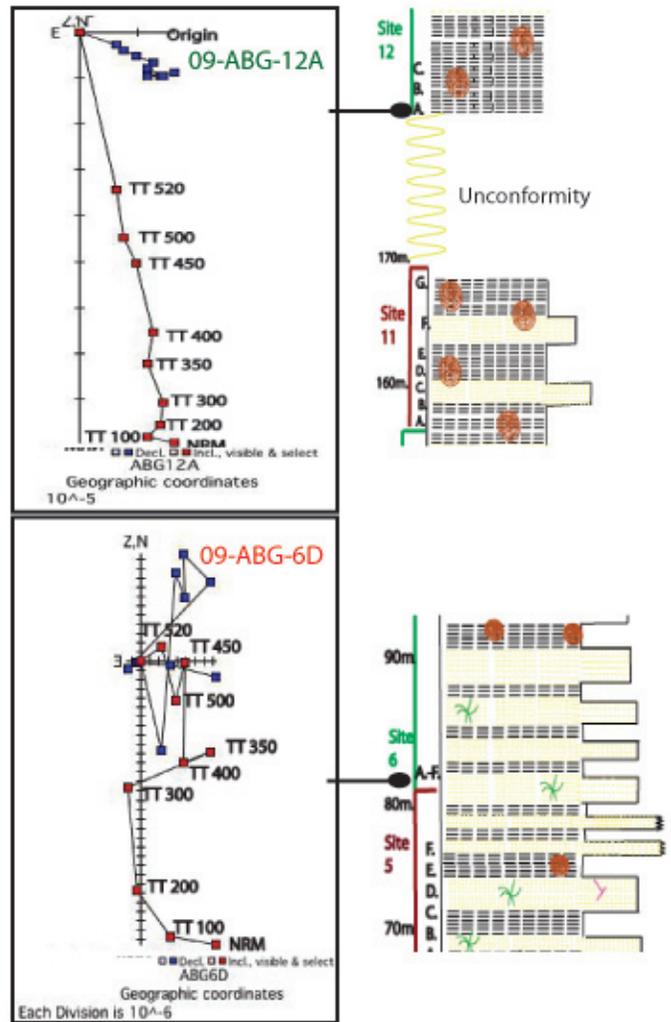


FIGURE 3 Zijderveld plots from thermal demagnetization indicate that stable high Curie temperature magnetizations were recovered for some, but not all, samples. Sample 09-ABG-12A displays a stable magnetization with normal polarity, steep inclination, and northwesterly declination. Sample 09-ABG-6D shows a complex multi-component magnetization from which a stable paleomagnetic direction was not recovered.

Zijderveld projections indicate that stable high coercivity magnetizations were recovered from some but not all specimens (Fig. 3, 09-ABG-12A). Those specimens with stable magnetizations all have normal polarity, steep inclinations and slightly northwesterly declinations in tilt-corrected coordinates. Many specimens that do not preserve a high coercivity stable magnetization appear to have a lower coercivity magnetic component that has a similar orientation. It forms a strong cluster of points on an equal area stereographic plot of magnetic orientation for all AF steps (NRM through complete

demagnetization). Almost all of these AF demagnetization steps recovered a normal polarity remnant magnetization.

THERMAL DEMAGNETIZATION

Thermal demagnetization steps up from 100 to 520 °C removed a significant amount (<90%) of the each specimen's magnetic intensity. As with the AF demagnetization, thermal demagnetization appears to have recovered complex and variable multi-component magnetizations. Zijderveld plots from thermal demagnetization recover stable high Curie temperature magnetizations from some but not all samples (Fig. 3). Those samples that preserve stable directions by AF procedures tend to be the same ones that preserve stable magnetizations by thermal procedures. Those specimens with stable magnetizations all have normal polarity, steep inclinations and slightly northwesterly declinations similar to those recovered by AF demagnetization. Many specimens that do not preserve a high stable magnetization seem to have a lower Curie temperature magnetic component that has this orientation. Unlike the AF demagnetization steps, the highest Curie temperature steps record magnetic components that have both normal and reversed polarity.

SEM/EDS

The most common Fe-rich mineral is pyrite. Pyrite occurs as very fine (<10 µm) grains and as larger (up to mm sized) framboidal grains. Several fine grained Ti minerals were found including rutile and titanite that were generally very fine grained. The most significant observation was that even under the highest magnification no Fe-oxides or Fe-Ti oxides were identified. This indicates either no Fe-oxides are present or that any Fe-oxides must be finer grained than ~5µm and possibly even finer than 2 µm.

PLANT FOSSILS

The plant fossils (Figure 2) found in a single exposure of fissile carbon-rich shale and brown sandstone near sample location 09-ABG-12 (Fig.

1) were examined to determine relative ages and morphologies. Six distinct plant morphotypes were recognized in the slabs collected from this exposure. These morphotypes have been tentatively identified (L. Hickey, pers. comm., 2010) as the following taxa.

Form	Range of Age
Equisetum sp.	Carboniferous to Recent
Elatides sp.	Jurassic to Paleocene
Parataxodium sp.	Campanian to Maestrichtian
"Grewi" alaskana or Nordenskiöldia sp.	Cenomanian or Campanian to Eocene
Platanus sp.	Late Albian to Recent
aff. Platanus newburyana	Cenomanian to later in the Late Cretaceous
aff. Platanus crassum	Cenomanian

Due to the moderate preservation quality of the fossils it was only possible to identify the genus level of the fossils (L. Hickey, pers. comm., 2010). The diversity of angiosperm fossils and the presence of Equisetum (Fig 2) indicates a terrestrial depositional environment for these strata. Furthermore, the abundance of angiosperm forms argues against an Early Cretaceous age, suggesting a Late Cretaceous or younger age. The presence of Parataxodium (Fig. 2) would require these strata to be Late Cretaceous in age.

CONCLUSIONS

MAGNETIC COMPONENTS

The Cretaceous rocks studied here lost almost all of their magnetization at temperatures less than 520 °C and AF fields of less than 80 mT, suggesting that the primary magnetic carrier is a Fe-Ti oxide such as titanomagnetite. Neither magnetite nor titanomagnetite was found with the SEM, suggesting that these minerals are very fine grained (<5µm) and therefore either single domain or pseudo single domain. However, pyrite, including pyrite with framboidal morphology typical of diagenetic pyrite, is a common matrix mineral in these rocks indicating that the magnetization recorded in oxide minerals is a secondary magnetization that was frozen into the Cretaceous strata after deposition and lithification.

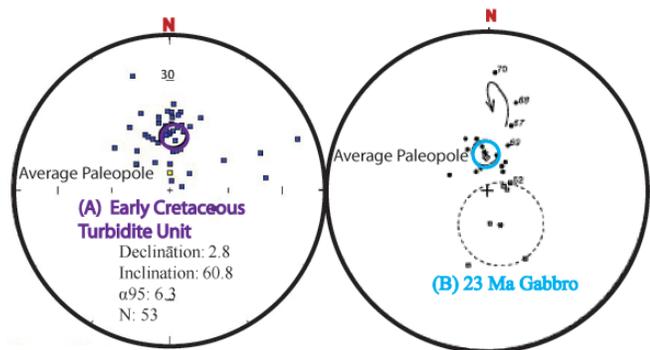


FIGURE 4 (A) Stereographic projection of best-fit paleomagnetic directions in a stratigraphic (tilt-corrected) coordinate system for all samples from AF demagnetization measured. The mean paleomagnetic direction for Cretaceous rocks is nearly identical to that of (B) a 23 Ma gabbro (Haeussler, et al 1992), suggesting that the magnetization was acquired at that time.

THERMAL OVERPRINTING

Samples from all sites record a moderate to high coercivity normal polarity, with a NNW trending steeply inclined magnetization. In a non-tilt corrected coordinate system this magnetization is very similar to the present day magnetic field (Fig. 4). It is also very similar the magnetization of a 23 Ma gabbro (Fig. 4; Haeussler and Coe, 1992) that intruded stratigraphically above these rocks. The magnetizations found by Haeussler and Coe (1992) have both normal and reversed polarities suggesting that they recovered primary magnetization. Although the Cretaceous rocks could be recording a modern magnetization, the high coercivity of the remnant magnetization argues against that. I suggest that magnetization was acquired when pyrite was converted to a Fe-Ti oxide during heating from the gabbro.

Cretaceous magnetizations may still be preserved in the highest temperature thermal and a highest field AF demagnetization step from several samples but are not well resolved to recover a Cretaceous direction. The abundance of diagenetic pyrite in these samples make it unlikely Cretaceous magnetizations will be found in other nearby sections.

PARACONFORMITY

Fossils found near sample location 09-ABG-12 (Fig. 1) point to a previously unrecognized paraconformity that exists between the Early Cretaceous unit and Late Cretaceous to Tertiary unit. The paleoecology of the paleofossils indicates that the overlying unit is non-marine based on the presence of *Equisetum* which are typically found in silty to sandy stream levees (Fig. 2). The appearance of the paraconformity suggests that the transition from a marine basin to a terrestrial setting may have occurred sooner than previously believed due to its location in the stratigraphy.

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