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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: Lenny Ancuta, Jordan Epstein, Nathan Evenson, Samantha Falcon, Alexander Gonzalez, Tiffany Henderson, Conor McNally, Julia Nave, Maria Princen

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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

JORDAN EPSTEIN: Carleton College
Research Advisor: Cameron Davidson

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SAMANTHA FALCON: West Virginia University
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TIFFANY HENDERSON: Trinity University
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CHEMOSTRATIGRAPHIC ($\delta^{13}C$) ANALYSIS OF A PROMINENT PALEOSOL WITHIN THE PALEOGENE KOOTZNAHOO FORMATION, ADMIRALTY AND KUIU ISLANDS, ALASKA

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

USING STABLE AND CLUMPED ISOTOPE GEOCHEMISTRY TO RECONSTRUCT PALEOCLIMATE AND PALEOHYDROLOGY IN THE KOOTZNAHOO FORMATION, SE ALASKA

JULIA NAVE: The Colorado College
Research Advisor: Henry Fricke

PALEOMAGNETIC STUDY OF THE PALEOGENE KOOTZNAHOO FORMATION, SOUTHEAST ALASKA

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INTRODUCTION

Shallower than expected paleomagnetic directions from the Coast Mountains batholith complex have been interpreted to indicate large-scale northward transport of the Wrangellia composite terrane (WCT) of about 4000 km from its present-day location (Beck, 1976, 1981; Irving et al. 1985, 1996); this interpretation is coined the Baja BC hypothesis (Irving et al., 1985, Cowan et al., 1996). However, Butler et al. (1989, 2006) note that the Baja BC hypothesis challenges a wealth of geological evidence, and instead suggest that these shallow inclinations are better explained by a combination of <1000 km of coastwise displacement and local deformation (tilting).

In the Keku Strait area of Alaska, the Paleogene Kootznahoo Formation sits unconformably on the WCT and is intruded by ~23 Ma basaltic dikes and sills (Fig. 2, Davidson et al., this volume; Haeussler et al., 1992). In this contribution, I present whole-rock geochemistry and paleomagnetic data to distinguish between these igneous rocks and to help constrain post-Paleogene deformation experienced in the area.

MAJOR AND TRACE ELEMENT GEOCHEMISTRY

Representative samples were collected from sixteen sites associated with the Kootznahoo Formation: six mafic sills (Point Hamilton, Big John Bay, Point Camden, Port Camden), six mafic dikes (Point Hamilton, Hamilton Bay, Point Camden, Port Camden, Admiralty Island), two mafic flows (Port Camden), and two felsic flows or intrusions (Davidson Point, Horseshoe Island) (Fig. 2, Davidson et al., this volume). Two samples yielded high LOI values (~14 wt%) and unrealistically low SiO_2 (<40 wt%) and were removed from consideration. On a total alkali vs. silica (TAS) diagram (Fig. 1A), eleven samples plot in the basalt and basanite fields, and three are rhyolites. Major and trace geochemistry show that the Point Hamilton gabbro is depleted relative to all other sites (Fig. 1B), and has geochemical signature consistent with ocean floor basalts, while all other samples are suggestive of within-plate or calc-alkaline basalts (Fig. 1C). This suggests at least two distinct magma types with different sources or crystal/melt processes.

PALEOMAGNETIC METHODS AND RESULTS

Seventy-one paleomagnetic samples were collected from 12 sites of basaltic dikes, sills, and volcanic flows exposed on shorelines of islands west of Kake in southeast Alaska (Fig. 2, Davidson et al., this volume). A portable coring device was used to collect six or more oriented samples from each site. At the Institute of Rock Magnetism at the University of Minnesota, a ten-step alternating field demagnetization was performed on each sample. All measurements were made using a 2G three axis cryogenic magnetometer in a shielded room. For 8 sites (49 cores), characteristic remnant magnetism (ChRM) was easily isolated, and little evidence of thermal or chemical overprinting was present.

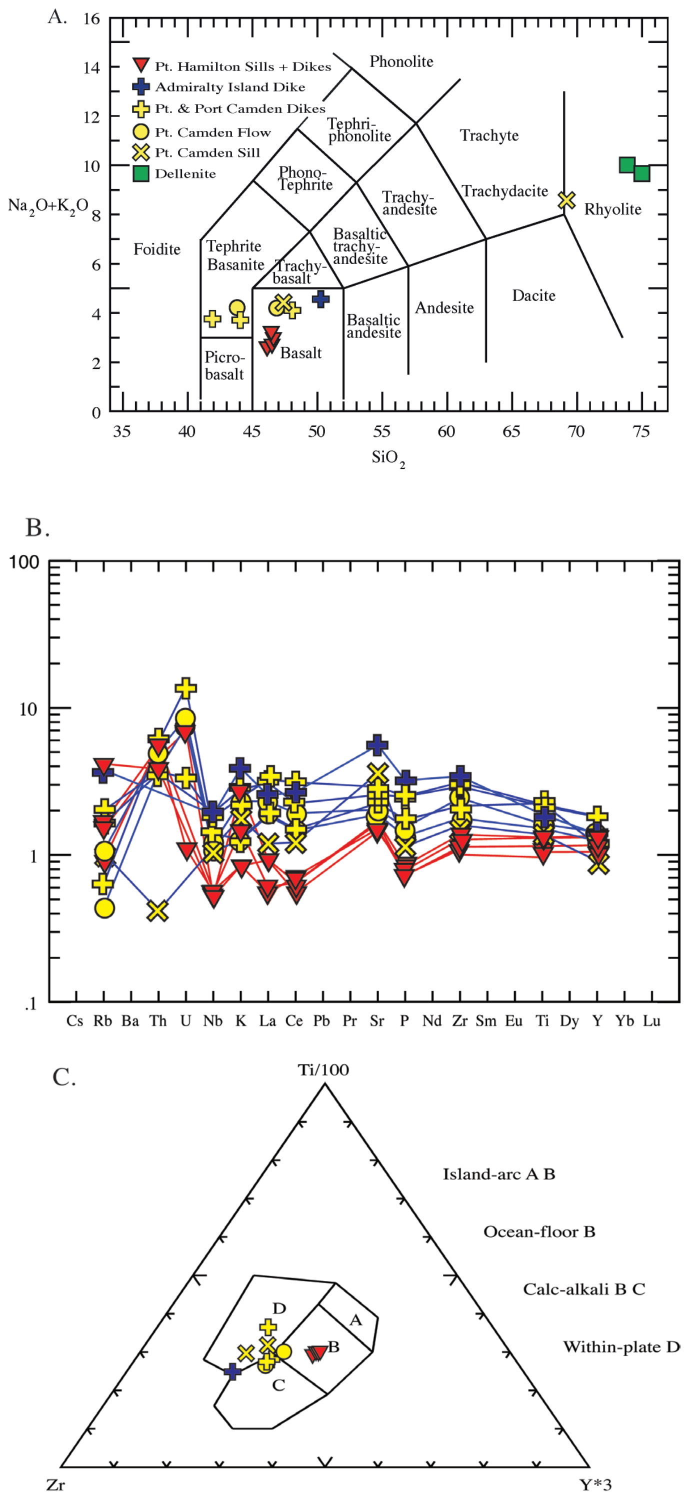

Figure 1: A. Total alkali versus silica diagram, after Lebas et al. (1986). The Point Hamilton sills and dikes have significantly lower total alkali content than all other samples. There is a silica gap from 48 to 70 wt. percent, excluding the Admiralty Island dike. B. EMORB-normalized spider diagram of Sun and Mc-Donough (1989). The Point Hamilton sills and dikes (in red) are noticeably depleted in immobile elements relative to all other sites (in yellow, blue), suggesting distinct evolution histories. C. Tectonic discrimination plot for basalts with 12-20 wt. percent CaO + MgO, after Pearce and Cann (1973). The Point Hamilton sills and dikes plot exclusively in the ocean-floor basalt, while all other samples plot as within-plate or calc-alkaline basalts.

Paleomagnetic data from the Keku Strait area are organized by locality and presented in Table 1. Magnetic directions are compared to the 20 Ma reference pole of Hagstrum et al. (1987) at 87.4° N, 129.7° E, A95 = 3.0°, with expected direction of I = 73.5° ± 1.5°, D = 359.6° ± 5.9° (Fig. 2). Using the Oligocene reference pole at 84.0° N, 168.0°, A95 = 4.0° (Diehl, 1988), the expected Oligocene direction differs by only I = +1.5° and D = +7°, so the choice of reference pole has largely negligible effect for paleomagnetic comparison. Magnetic directions for individual sites are compared to expected values, and values for inclination flattening (F ± ΔF) and rotation of declination (R ± ΔR) are calculated using the methods of Beck (1980) and Demarest (1983). Site 09JE15 is the only site to record a magnetization direction within error of the expected direction; all other sites record shallower than expected inclinations, and declinations west of the expected north. Structural corrections are performed on all sites by rotating to horizontal based on the local strike and dip of the Kootznahoo Formation. All structurally corrected dikes and sills on Kupreanof Island fall close to within error of the expected paleomagnetic direction (Fig. 2D). For the Port Camden flows sampled at sites 09JE06, 09JE07, and 09JE08, the average in-situ declination is 46° west of the Oligocene reference pole, and the inclination is 11° too shallow (Fig. 2E). Averaging the poles for these three sites to reduce the error due to secular variation is justified because there are tens of meters of volcaniclastic sedimentary rocks between each flow, and site 09JE08 is reversed, suggesting >10^5 years separates the sites. Correcting the flows based on the bedding of the local Kootznahoo Formation eliminates the inclination discordance, but still leaves a 45° counterclockwise declination gap unresolved (Fig. 2F).

DISCUSSION

Paleomagnetic results from this study suggest that the ~23 Ma basaltic sills and dikes that crosscut the

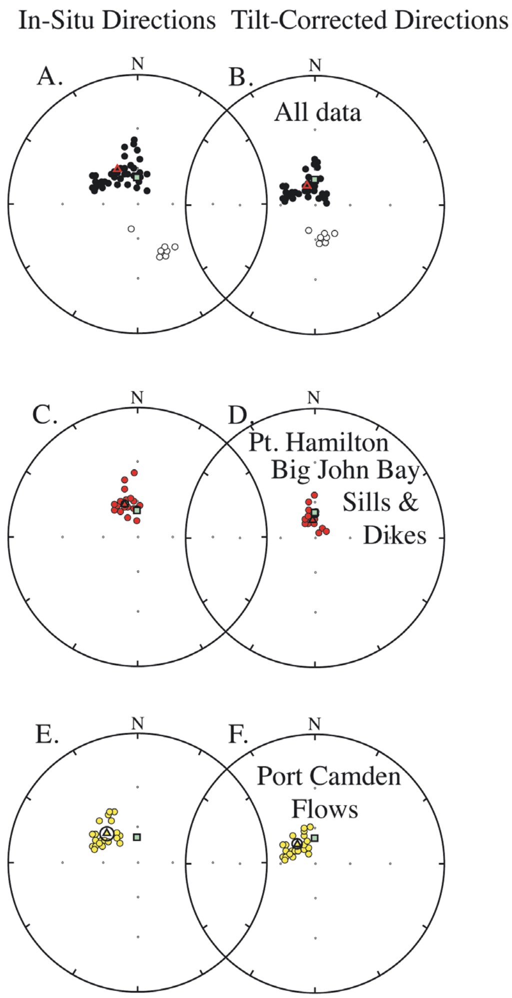

Figure 2: A. In-situ directions for all cores. Black circles are normal and white are reversed polarities. The red triangle is the calculated mean pole. The green square is the expected direction as compared to a Miocene pole. Comparison with the expected direction shows directions are 28.3° ± 7.8° counterclockwise and 7.0° ± 2.9° more shallow than expected. B. Tilt-corrected directions for all data. Comparison with the expected direction shows declinations are 20.6° ± 9.7°counterclockwise and inclination within error of expected. C. In-situ directions for cores. Red circles are individual cores, red triangle is the mean, black circle is the α95 confidence interval. The green square is the expected direction as compared to a Miocene pole. Comparison with the expected direction shows mean is 20.6° ± 8.9° counterclockwise and 5.9° ± 3.2° more shallow than expected. D. Tilt-corrected directions. Comparison with the expected direction shows directions are within error of expected. E. In-situ directions for cores converted to lower hemisphere. Yellow circles are individual cores, yellow triangle is the mean, black circle is the α95 confidence interval. The green square is the expected direction as compared to a Miocene pole. Comparison with the expected direction shows mean is 46.3° ± 8.3° counterclockwise and 10.8° ± 3.5° more shallow than expected. F. Tilt-corrected directions. Comparison with the expected direction shows declinations are still 44.7° ± 11.5°counterclockwise and inclination within error of expected.

Kootznahoo Formation were emplaced prior to tilting, and that the Port Camden area may have experienced up to 44.7 ± 11.5° of counterclockwise vertical-axis rotation since the end of the Oligocene (Fig. 2F). These data appear to be at odds with previously published paleomagnetic data from Haeussler et al. (1992), who found insignificant evidence of Tertiary tilting or counterclockwise rotation anywhere in the Keku Strait area. However, close inspection of their data reveals systematic differences in paleomagnetic directions based on locality, and it appears only fortuitous that the disparate directions averaged to yield no directional discordance. Parsing their data by location, both studies are consistent with local tilting and heterogeneous counterclockwise vertical-axis rotation.

CONCLUSIONS

The recent tectonic history of the Keku Strait area is decidedly complex with the deposition of the Kootnazahoo Formation and intrusion of two geochemically distinct basaltic magmas and lava flows being followed by crustal tilting and vertical-axis rotations. Paleomagntic data from this study and Hauessler et al. (1992) provide evidence of Neogene regional tilting of 10-15° and counter clockwise vertical-axis rotation up to 45°. Such deformation should be considered when determining paleomagnetic directions for older rocks in the region, which have been used to constrain the location of the Wrangellia composite terrane in relation to the Baja BC hypothesis.

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Table 1: Paleomagnetic data from Keku Strait and Port Camden, Southeast Alaska. Abbreviations as follows: M — inferred magnetization group, with: (red) Point Hamilton gabbro group, (orange) Point Camden gabbro, (yellow) Port Camden flows, and (green) recent dike; N — indicates the number of cores used out of the total collected; P — polarity, whether normal (n), reversed (r) or no good (ng); R — the vector length of the mean direction; α95 — indicates the 95% confidence interval; k — the Fisher precision parameter; I — Inclination; D — Declination; R — Rotation (positive for clockwise) as compared to the expected declination based on the 20 Ma North American pole of Hagstrum et al.(1987); F — Flattening, after Beck et al. (1981) and Demarest (1983); Bedding S & D— best estimate for strike and dip of the Kootznahoo Formation near site.

Epstein (2009) data.

Site In-Situ Directions

M	Site	Latitude(°)	Longitude(°)	N	P	r	α95	*k*	I	D	R	ΔR	F	ΔF	Bedding S	Bedding D
●	09JDE3+4	56.86	133.87	9/10	n	8.9	5.3	86	70.5	335.8	-23.8	13.6	3.1	4.5	47	10
●	09JDE06	56.75	133.87	7/7	n	7	2.2	646	62.7	298.3	-61.3	6.1	10.8	2.3	49	10
●	09JDE07	56.76	133.87	6/6	n	6	5.8	111	68.5	312	-47.6	13.7	5.0	4.9	49	10
●	09JDE08	56.77	133.87	6/6	r	6	3.6	290	-55.4	148	-31.6	6.9	18.1	3.2	49	15
	09JDE10	56.80	133.86	0/6	ng											
●	09JDE11	56.79	133.88	5/6	n	5	7.7	81	59.0	2.5	2.9	12.9	14.5	6.3	80	12
●	09JDE12	56.82	133.74	6/6	n	6	3.8	254	69.1	324.3	-35.3	9.9	4.4	3.4	75	15
●	09JDE13	56.80	133.68	6/6	n	5.9	8.4	54	61.4	352.5	-7.1	14.9	12.1	6.9	47	12
	09JDE14	56.78	133.86	0/6	ng											
●	09JDE15	56.78	133.87	4/6	n/r	4	6.3	160	76	7.9	8.3	22.1	-2.5	5.3	49	16
	09JDE16	56.78	133.87	0/6	ng											

Site Tilt-Corrected Directions

M	Site	Latitude(°)	Longitude(°)	N	P	r	α95	*k*	I	D	R	ΔR	F	ΔF	Bedding S	Bedding D
●	09JDE3+4	56.86	133.87	9/10	n	8.9	4.5	119	78.6	356.5	-3.1	19.1	-5.0	3.9	47	10
●	09JDE06	56.75	133.87	7/7	n	7	2.2	669	72.3	291.7	-67.9	7.4	1.2	2.3	49	10
●	09JDE07	56.76	133.87	6/6	n	6	5.8	112	78.4	313.1	-46.5	24.6	-4.9	4.9	49	10
●	09JDE08	56.77	133.87	6/6	r	6	3.4	327	-69.2	159.2	-20.4	9.0	4.3	3.1	49	15
●	09JDE11	56.79	133.88	5/6	n	5	7.7	81	70.5	9.6	9.7	19.4	3.0	6.3	80	12
●	09JDE12	56.82	133.74	6/6	n	6	3.8	258	80.3	339.1	-20.5	19.2	-6.8	3.4	75	15
●	09JDE13	56.80	133.68	6/6	n	5.9	8.4	54	76.1	0.1	0.5	30.2	-2.6	6.9	47	12

Group In-Situ Directions

M	Group	N	P	r	α95	*k*	I	D	R	ΔR	F	ΔF	Bedding
●	All Data	49/71	n/r	48.9	3.1	*43.95*	66.5	331.3	-28.3	7.8	7.0	2.9	Variable
●	Port Camden Flows	19/19	n/r	18.8	3.9	*75*	62.7	313.3	-46.3	8.3	10.8	3.5	
●	Point Hamilton and Big John Bay	21/22	n	20.7	3.6	*79*	67.6	339.0	-20.6	8.9	5.9	3.2	

Group Tilt-Corrected Directions

M	Group	N	P	r	α95	*k*	I	D	R	ΔR	F	ΔF	Bedding
●	All Data	49/71	n/r	48.9	2.4	*75*	76.9	339.0	-20.6	9.7	-3.4	2.4	Variable
●	Port Camden Flow	19/19	n/r	18.8	3.6	*90*	74.3	314.9	-44.7	11.5	-0.8	3.2	
●	Point Hamilton and Big John Bay	21/22	n	20.7	2.9	*118*	78.5	353.6	-6.0	12.8	-5.0	2.8	

Tilt-Corrected Point Camden sill Compared to Late Cretaceous Pole (Mcelhinney, 1979)

M	Site	Latitude(°)	Longitude(°)	N	P	r	α95	*k*	I	D	R	ΔR	F	ΔF	Bedding S	Bedding D
●	09JDE11	56.79	133.88	5/6	n	5	7.7	81	70.5	9.6	-24.6	19.8	4.3	6.4	80	12

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