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

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Dr. Robert J. Varga, Editor
Director, Keck Geology Consortium
Pomona College

Dr. Tekla Harms
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Amherst College

Carol Morgan
Keck Geology Consortium Administrative Assistant

Diane Kadyk
Symposium Proceedings Layout & Design
Department of Earth & Environment
Franklin & Marshall College

Keck Geology Consortium
Geology Department, Pomona College
185 E. 6th St., Claremont, CA 91711
(909) 607-0651, keckgeology@pomona.edu, keckgeology.org

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Editor and Keck Director
Pomona College

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2011-2012 PROJECTS

TECTONIC EVOLUTION OF THE CHUGACH-PRINCE WILLIAM TERRANE, SOUTH-CENTRAL ALASKA
Faculty: *JOHN GARVER*, Union College, *Cameron Davidson*, Carleton College
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ORIGINS OF SINUOUS AND BRAIDED CHANNELS ON ASCRAEUS MONS, MARS
Faculty: *ANDREW DE WET*, Franklin & Marshall College, *JAKE BLEACHER*, NASA-GSFC, *BRENT GARRY*, Smithsonian
Students: *JULIA SIGNORELLA*, Franklin & Marshall College, *ANDREW COLLINS*, The College of Wooster, *ZACHARY SCHIERL*, Whitman College.

TROPICAL HOLOCENE CLIMATIC INSIGHTS FROM RECORDS OF VARIABILITY IN ANDEAN PALEOGLACIERS
Faculty: *DONALD RODBELL*, Union College, *NATHAN STANSELL*, Byrd Polar Research Center
Students: *CHRISTOPHER SEDLAK*, Ohio State University, *SASHA ROTHENBERG*, Union College, *EMMA CORONADO*, St. Lawrence University, *JESSICA TREANTON*, Colorado College.

EOCENE TECTONIC EVOLUTION OF THE TETON-ABSAROKA RANGES, WYOMING
Faculty: *JOHN CRADDOCK*. Macalester College, *DAVE MALONE*. Illinois State University
Students: *ANDREW KELLY*, Amherst College, *KATHRYN SCHROEDER*, Illinois State University, *MAREN MATHISEN*, Augustana College, *ALISON MACNAMEE*, Colgate University, *STUART KENDERES*, Western Kentucky University, *BEN KRASUSHAAR*

INTERDISCIPLINARY STUDIES IN THE CRITICAL ZONE, BOULDER CREEK CATCHMENT, FRONT RANGE, COLORADO
Faculty: *DAVID DETHIER*, Williams College
Students: JAMES WINKLER, University of Connecticut, SARAH *BEGANSKAS*, Amherst College, *ALEXANDRA HORNE*, Mt. Holyoke College

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THE HRAFNFJORDUR CENTRAL VOLCANO, NORTHWESTERN ICELAND
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SEDIMENT DYNAMICS OF THE LOWER CONNECTICUT RIVER
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Students: *MICHAEL CUTTLER*, Boston College, *ELIZABETH GEORGE*, Washington & Lee University, *JONATHON SCHNEYER*, University of Massachusetts-Amherst, *TIRZAH ABBOTT*, Beloit College, *DANIELLE MARTIN*, Wesleyan University, *HANNAH BLATCHFORD*, Beloit College.

ANATOMY OF A MID-CRUSTAL SUTURE: PETROLOGY OF THE CENTRAL METASEDIMENTARY BELT BOUNDARY THRUST ZONE, GRENVILLE PROVINCE, ONTARIO
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Keck Geology Consortium: Projects 2011-2012
Short Contributions— Teton-Absaroka Ranges, Wyoming Project

Keck Geology Consortium
Pomona College
185 E. 6th St., Claremont, CA 91711
Keckgeology.org

A MINERALOGICAL TEXTURAL AND CHEMICAL CHARACTERIZATION OF A HYPOTHESIZED KIMBERLITE AT WHITE MOUNTAIN, SUNLIGHT BASIN, WYOMING

STUART KENDERES, Western Kentucky University
Research Advisors: John Craddock, David Malone, and Andrew Wulff

ABSTRACT

This research involves the characterization and identification of an enigmatic vertical outcropping of brecciated rock located on White Mountain, Sunlight Basin, Wyoming, which was originally interpreted as a kimberlite. Samples were collected for geochemical and textural comparison, and cut into thin sections for analysis using polarized light microscopy. Remaining sample material was powdered for X-ray fluorescence geochemical analysis, and for heavy mineral splits for U-Pb dates of primary zircons. Collected samples contain clasts of different rock types, including peridotite, marble, and porphyritic andesite, ranging in shape from sub-angular to angular, and exhibiting a mortar texture around the predominantly peridotite grains. U-Pb zircon dates indicate an age of 48.9 mya. Ranges in bulk compositions include: 42-57% SiO_2; 11-19% Al_2O_3; 5-11% Fe_2O_3; 6-25% CaO; 4-14% MgO; and up to 1641 ppm Sr. Preliminary analysis of data suggests that the rocks comprise a metabreccia associated with the Heart Mountain detachment system.

INTRODUCTION

The Heart Mountain detachment (HMD) is renowned for being one of the largest known subaerial landslides in the world. With an areal extent more than 30 miles wide and 60 miles long (Pierce 1957) it is no surprise that it has captured the attention of geologists for over a century. Several hypotheses regarding the emplacement of the HMD have been presented including: the rapid tectonic denudation model (Pierce 1957); the slow moving continuous allochthon model (Hague 1990); volcanic collapse (Malone 1995); and the rapid continuous allochthon (Beutner 2010). Rapid emplacement is currently favored based on tightly constrained radiometric dates indicating emplacement between 49.7-49.5 mya, and emplacement rates exceeding 126 m/s (Craddock et al. 2009). White Mountain is a block of metamorphosed Madison (Mississippian) and Bighorn (Ordovician) carbonate emplaced during the HMD. The mountain is located in Sunlight Basin, Wyoming, and possesses a number of rock units identified as injected detachment breccias deemed carbonate ultracataclasite (CUC) (Craddock et al. 2009). These CUC bodies seemed to be all similar in chemical composition except for one, which exhibited an Orangeite heavy mineral assemblage, including olivine, spinel, and garnets. This paper more closely examines this hypothesized kimberlite in order to further the understanding of the HMD.

METHODS

Samples were collected during the 2011 summer field season and prepped for analysis at Macalester College in St. Paul, Minnesota. Five samples of the formerly identified kimberlite body were collected along the length of the unit on the western-most ridge of White Mountain (Fig. 1). Additional samples were collected from isolated igneous bodies on White Mountain, and one sample was collected from a ridge of a surrounding valley, that could correlate to the originally identified kimberlite material.

The samples from White Mountain were first cut into 22 thin section billets. Then remaining sample material was powdered using a Tungsten Carbide shatterbox, which was thoroughly cleaned after each sample in order to reduce the possibility of contamination during major and trace geochemical analysis. Powders were then sent to University of Wisconsin at Eau Claire for complete major and trace elemental analysis. Thin sections were analyzed using polarized light microscopy (PLM) at Western Kentucky University. The remainder of one sample (#11-K-5),

Figure 1. Enigmatic vertical unit located on White Mountain, Sunlight Basin, Wyoming. Photograph facing north with the area of study highlighted.

X-Ray Fluorescence Major and Trace Elemental Analysis

Sample	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Total
11-K-1	57.41	0.82	13.89	5.97	0.10	4.42	7.20	0.93	8.64	0.62	100.00
11-K-2	43.05	0.51	10.74	4.91	0.00	14.21	25.56	0.10	0.72	0.20	100.00
11-K-3	48.28	1.66	15.71	10.93	0.10	5.72	9.37	1.66	5.10	1.46	100.00
11-K-4	52.89	0.93	19.73	7.44	0.10	4.44	6.40	3.51	3.82	0.72	100.00
11-K-5	48.78	0.85	14.21	6.47	0.10	6.15	18.45	1.91	2.23	0.85	100.00
Margarita Gulch	55.26	0.74	16.37	6.91	0.10	4.78	8.18	3.08	4.14	0.43	100.00
10-WY-CUCab "K"	43.30	0.74	14.45	6.10	0.09	9.83	23.04	1.32	0.46	0.66	100.00
10-WY-CUCh "K"	45.71	0.84	14.21	8.28	0.11	7.42	18.55	1.96	2.09	0.83	100.00
CUC-1	49.58	0.84	14.98	6.12	0.10	5.80	16.98	2.32	2.53	0.74	100.00
CUC-5	14.52	0.14	1.78	1.10	0.00	21.23	60.68	0.14	0.27	0.14	100.00
CUCS-Silvergate	47.38	0.13	4.13	1.38	0.20	1.88	43.75	0.13	0.88	0.13	100.00
CUC-8	22.87	0.13	4.65	1.68	0.00	17.57	52.71	0.13	0.13	0.13	100.00
11-PA-1	55.72	0.84	17.84	7.03	0.10	4.20	3.78	2.94	7.03	0.52	100.00
Main Andesite	56.05	0.94	17.43	7.83	0.10	4.38	6.26	3.97	2.61	0.42	100.00
SW Mountain Gully	53.12	0.74	16.61	7.20	0.10	5.82	9.63	3.07	3.28	0.42	100.00
WMD-1	63.64	0.52	17.24	5.33	0.10	2.93	4.08	3.03	2.93	0.21	100.00
WMD-2	54.95	0.84	15.79	8.21	0.10	8.42	5.79	2.95	2.63	0.32	100.00

Sample	Nb	Zr	Sr	Zn	Ni	Cr	V	Ce	Ba	La	Y	Rb	Th	Pb	Sc	Co	Nd	Hf
11-K-1	6.0	210.0	1220.0	54.0	40.0	67.0	112.0	84.0	1874.0	47.0	8.0	104.0	4.0	16.0	11.0	24.0	31.0	3.0
11-K-2	6.0	95.0	150.0	35.0	33.0	52.0	68.0	45.0	602.0	19.0	21.0	20.0	4.0	7.0	19.0	15.0	22.0	2.0
11-K-3	14.0	187.0	1178.0	73.0	39.0	88.0	219.0	167.0	1652.0	91.0	16.0	82.0	3.0	16.0	15.0	33.0	62.0	2.0
11-K-4	14.0	258.0	1641.0	64.0	58.0	127.0	114.0	96.0	1452.0	50.0	9.0	102.0	8.0	18.0	8.0	28.0	31.0	3.0
11-K-5	12.0	267.0	1313.0	61.0	40.0	62.0	112.0	97.0	1009.0	52.0	21.0	46.0	8.0	18.0	17.0	22.0	38.0	4.0
Margarita Gulch	8.0	197.0	1099.0	68.0	24.0	34.0	123.0	85.0	1510.0	46.0	11.0	92.0	7.0	17.0	13.0	22.0	30.0	3.0
10-WY-CUCab "K"	Na	Na	Na	25.0	38.0	103.4	112.3	86.0	1191.5	Na	Na	Na	Na	Na	11.0	18.0	Na	Na
10-WY-CUCh "K"	Na	Na	Na	47.0	86.0	215.4	131.3	104.0	1315.8	Na	Na	Na	Na	Na	7.0	32.0	Na	Na
CUC-1	13	298	1147	62	38	47	108	100	939	53	23	54	9	27	15	19	35	6
CUC-5	1	23	137	14	3	0	10	0	43	0	7	8	2	6	22	3	9	0
CUCS-Silvergate	2	43	222	15	15	10	21	20	143	0	10	13	1	8	19	4	11	0
CUC-8	1	37	210	21	8	0	25	21	54	4	9	5	1	7	21	3	11	0
11-PA-1	11	220	1038	45	21	26	122	99	1537	57	8	133	8	19	10	23	32	4
Main Andesite	7	197	929	68	50	65	175	86	1274	46	15	51	5	10	15	30	40	3
SW Mountain Gully	8	204	1154	64	25	38	131	83	1566	51	15	64	6	15	14	23	33	3
WMD-1	6	187	775	76	15	93	90	65	1641	37	19	51	5	17	10	20	26	4
WMD-2	4	148	809	69	80	204	175	44	1113	26	16	37	2	11	21	37	23	2

Table 1. X-Ray Fluorescence major and trace elemental analysis for samples collected during the 2011 and 2010 field seasons. Samples in red were collected from the hypothesized "kimberlite." Samples in blue are samples collected from carbonate ultracataclasite. Samples in green were collected from igneous bodies around White Mountain. Samples 10-WY-CUCab "K" and 10-WY-CUCh "K" were collected during the 2010 field season. Major weight percentages are normalized to 100%. Trace elements measured in ppm.

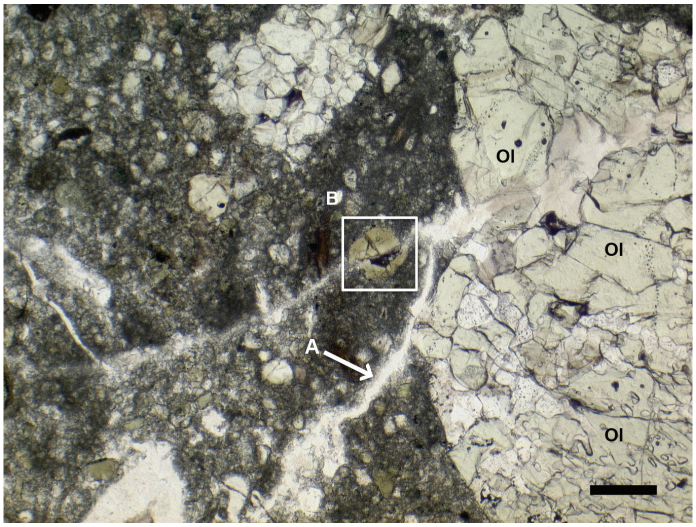

Figure 2. Photomicrograph taken from sample 11-K-5 in plane polarized light. Secondary aragonite fills fractures as veins (A). Peridotite (Ol) clast exhibits mortar texture (B). Scale is equal to 200 µm.

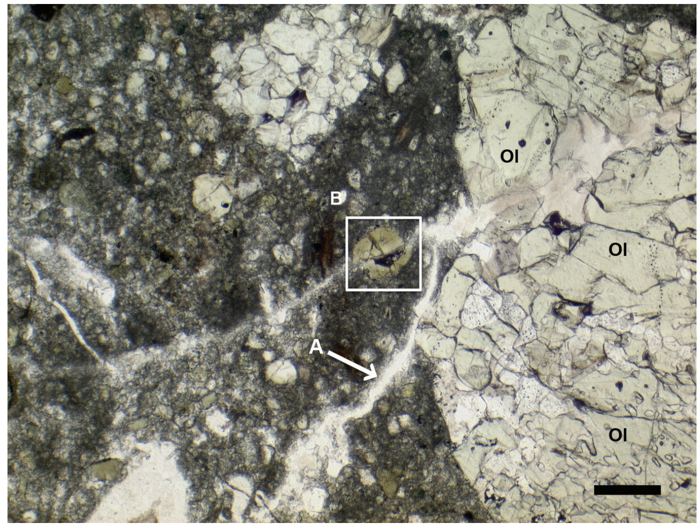

Figure 3. Transmitted light scan of thin section 19 sample 11-K-5. Foliated texture visible around an andesitic clast (A).

taken from the unit on White Mountain, was crushed and separated into zircon mineral splits for analysis of U-Pb dates at the Laserchron Lab at the University of Arizona.

RESULTS

Whole rock geochemical analysis show up to 42-57% SiO_2, 11-19% Al_2O_3, 5-11% Fe_2O_3, 6-25% CaO, 4-14% MgO, up to 1641 ppm Sr. Complete results are shown in Table 1.

Analysis using PLM show kimberlitic samples contain lithic clasts within a plagioclase rich matrix. Three dominant rock types present as clasts include peridotite, marble, and porphyritic andesite. A mortar texture is also present around clasts, particularly the peridotite (Fig. 2). A distinct foliation is noticeable around some clasts in thin section (Fig. 3). A number of clasts contained generally euhedral apatite crystals, of unknown origin at this point. Minerals present include olivine, clinopyroxene, plagioclase feldspar, biotite, hornblende, garnet, spinel, zircon, and apatite. Radiometric dates (U/Pb) from zircons from sample 11-K-5 and igneous samples show an age of 48.9 mya (+/- 1.2 mya). This age is consistent with accepted ages for the HMD.

DISCUSSION

Geochemical results are inconsistent with kimberlite whole rock geochemistry results (from published comparison data available from GEOROC). There is a wide range in concentrations for Ca, Mg, Si, and Fe. Concentrations for calcium and magnesium are high for carbonate rocks of the CUC samples. Several of the "kimberlitic" whole-rock analyses have high concentrations of Ca and Mg, suggesting contamination from spatially related carbonate units in the field. Samples collected this year appear to have a similar chemical makeup to those analyzed last year. Issues related to interpretation of the whole-rock XRF analyses include that the samples powdered for analysis included a variety of lithic types, either as xenoliths, inclusions, or clasts. These clasts were generally angular and noted in the field to range in size from cm to meters (Fig. 4).

The presence of the variety of rock clasts in the samples deems XRF analysis inconclusive. Consideration of both thin sections and field observations point to the strong heterogeneity of the samples (Fig 4). A variety of rock types were identified in a mostly plagioclase feldspar matrix including peridotite, porphyritic andesite, and marble. Clasts were generally angular suggesting close proximity to their source. Clasts also exhibited grain size diminutia exemplified by a

Figure 4. Photograph of unit of study in the field. Clasts of peridotite in plagioclase rich matrix are visible ranging in size from centimeters to nearly a meter in length.

mortar texture (Fig. 2), which suggests a structurally related origin. Foliation occurred around some clasts (Fig. 3) as well, indicating potential metamorphism of these rocks. Aragonite veins (Fig. 1-A) are present in both thin section and hand sample indicating a primary fracturing of the unit followed by secondary precipitation of carbonate.

Radiometric ages of zircons taken from sample 11-K-5 are consistent with ages of the HMD. The presence of zircons exhibiting ages concordant with the timing of the detachment may indicate a greater influence of igneous activity in the detachment event.

CONCLUSIONS

While this metabreccia exhibits characteristics similar to those of a type 2 kimberlite, textural and field observations suggest otherwise. Further research on this unit would include geochemical analysis of the matrix of the unit located on White Mountain. A closer examination of the clasts contained within the unit as well as a more robust number of rock types present could help further the understanding of the role this unit plays in the larger picture.

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