TECTORIC EVOLUTION OF THE CHUGACH-PRINCE WILLIAM TERRANE, SOUTH-CENTRAL ALASKA
Faculty: JOHN GARVER, Union College, Cameron Davidson, Carleton College
Students: EMILY JOHNSON, Whitman College, BENJAMIN CARLSON, Union College, LUCY MINER, Macalester College, STEVEN ESPINOSA, University of Texas-El Paso, HANNAH HILBERT-WOLF, Carleton College, SARAH OLIVAS, University of Texas-El Paso.

ORIGINS OF SINUOUS AND BRAIDED CHANNELS ON ASCRAEUS MONS, MARS
Faculty: ANDREW DE WET, Franklin & Marshall College, JAKE BLEACHER, NASA-GSFC, BRENT GARRY, Smithsonian

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 CRADDICK, 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 KRASUSAAR

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
DEPH-RELATED PATTERNS OF BIOEROSION: ST. JOHN, U.S. VIRGIN ISLANDS
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THE HRAFNJØRDUR CENTRAL VOLCANO, NORTHWESTERN ICELAND
Faculty: BRENNAN JORDAN, University of South Dakota, MEAGEN POLLOCK, The College of Wooster
Students: KATHRYN KUMAMOTO, Williams College, EMILY CARBONE, Smith College, ERICA WINELAND-THOMSON, Colorado College, THAD STODDARD, University of South Dakota, NINA WHITNEY, Carleton College, KATHARINE, SCHLEICH, The College of Wooster.

SEDIMENT DYNAMICS OF THE LOWER CONNECTICUT RIVER
Faculty: SUZANNE O’CONNELL and PETER PATTON, Wesleyan University
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
Faculty: WILLIAM PECK, Colgate University, STEVE DUNN, Mount Holyoke College, MICHELLE MARKLEY, Mount Holyoke College
Students: KENJO AGUSTSSON, California Polytechnic State University, BO MONTANYE, Colgate University, NAOMI BARSHI, Smith College, CALLIE SENDEK, Pomona College, CALVIN MAKO, University of Maine, Orono, ABIGAIL MONREAL, University of Texas-El Paso, EDWARD MARSHALL, Earlham College, NEVA FOWLER-GERACE, Oberlin College, JACQUELYNE NESBIT, Princeton University.

Funding Provided by:
Keck Geology Consortium Member Institutions
The National Science Foundation Grant NSF-REU 1005122
ExxonMobil Corporation
Keck Geology Consortium: Projects 2011-2012
Short Contributions—Teton-Absaroka Ranges, Wyoming Project

EOCENE TECTONIC EVOLUTION OF THE TETON-ABSAROKA RANGES, WYOMING
Project Faculty: JOHN P. CRADDOCK, Macalester College & DAVE MALONE, Illinois State University

DETRITAL ZIRCON PROVENANCE STUDY OF YELLOW SANDSTONES FROM THE WILLWOOD FORMATION IN THE BIGHORN BASIN, WYOMING, USA
ANDREW L. KELLY, Amherst College
Research Advisors: Tekla A. Harms & Peter D. Crowley

A MINERALOGICAL TEXTURAL AND CHEMICAL CHARACTERIZATION OF A HYPOTHESIZED KIMBERLITE AT WHITE MOUNTAIN, SUNLIGHT BASIN, WYOMING
STUART KENDERES, Western Kentucky University
Research Advisor: Andrew Wulff

THE DYNAMICS AND EMPLACEMENT OF THE HEART MOUNTAIN DETACHMENT: ANISOTROPY OF MAGNETIC SUCEPIBILITY AND DETRITAL ZIRCON ANALYSIS OF VERTICAL INJECTITES AT WHITE MOUNTAIN AND SILVERGATE, WYOMING
BENJAMIN KRAUSHAAR, Fort Lewis College
Research Advisor: John P. Craddock

STRUCTURAL EVOLUTION OF THE EOCENE SOUTH FORK DETACHMENT, PARK COUNTY, WYOMING
ALISON MACNAMEE, Colgate University
Research Advisor: Martin Wong

CALCITE TWINNING STRAIN ANALYSIS OF THE ALLOCHTHONOUS JURASSIC SUNDANCE, SOUTH FORK DETACHMENT, NORTHWEST WYOMING
MAREN MATHISON, Augustana College
Research Advisor: Jeffrey Strasser & Michael Wolf

PROVENANCE ANALYSIS OF THE WAPITI FORMATION (EOCENE) SANDSTONE IN THE ABSAROKA BASIN, WY USING DETRITAL ZIRCON GEOCHRONOLOGY
KAT HRYN SCHROEDER, Illinois State University
Research Advisor: David H. Malone

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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% SiO₂; 11-19% Al₂O₃; 5-11% Fe₂O₃; 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.
**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

<table>
<thead>
<tr>
<th>Sample</th>
<th>SiO₂</th>
<th>TiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>MnO</th>
<th>MgO</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>P₂O₅</th>
<th>Total</th>
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<td>11-K-1</td>
<td>57.41</td>
<td>0.82</td>
<td>13.89</td>
<td>5.97</td>
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<td>0.93</td>
<td>8.64</td>
<td>0.62</td>
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<td>4.24</td>
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<td>10.10</td>
<td>0.80</td>
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<td>3.51</td>
<td>3.82</td>
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<tr>
<td>11-K-4</td>
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<td>4.81</td>
<td>9.14</td>
<td>1.91</td>
<td>2.54</td>
<td>0.63</td>
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<td>59.26</td>
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<td>16.87</td>
<td>6.51</td>
<td>0.10</td>
<td>4.78</td>
<td>8.18</td>
<td>3.68</td>
<td>4.14</td>
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</tr>
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<td>10-WY-CUCab &quot;K&quot;</td>
<td>43.30</td>
<td>0.74</td>
<td>14.48</td>
<td>6.10</td>
<td>0.09</td>
<td>5.80</td>
<td>19.58</td>
<td>2.32</td>
<td>2.53</td>
<td>0.76</td>
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<tr>
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<td>14.58</td>
<td>6.29</td>
<td>0.10</td>
<td>5.43</td>
<td>18.71</td>
<td>2.56</td>
<td>2.60</td>
<td>0.79</td>
<td>100.00</td>
</tr>
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<td>CUC-1</td>
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<td>0.59</td>
<td>14.17</td>
<td>5.90</td>
<td>0.00</td>
<td>4.62</td>
<td>9.20</td>
<td>3.51</td>
<td>3.82</td>
<td>0.72</td>
<td>100.00</td>
</tr>
<tr>
<td>CUC-5</td>
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<td>0.77</td>
<td>16.87</td>
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<td>0.10</td>
<td>4.78</td>
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</tbody>
</table>

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-CUCCh “K” were collected during the 2010 field season. Major weight percentages are normalized to 100%. Trace elements measured in ppm.
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% SiO₂, 11-19% Al₂O₃, 5-11% Fe₂O₃, 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
mortal 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 metabrecia 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.

ACKNOWLEDGMENTS

Funding for this project was provided by the Keck Geology Consortium, National Science Foundation, and USGS EdMap Program. I would like to thank my project advisors Drs. John Craddock and David Malone for their direction and support, my research advisor Dr. Andrew Wulff for teaching me about not only geology but life, and six colleagues in the field Andrew Kelly, Ben Kraushaar, Ali MacNamee, Maren Mathisen, Kat Schroeder, and Jamie Bardwell.

REFERENCES


