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Robert J. Varga
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Keck Geology Consortium
Pomona College
185 E 6th St., Claremont, CA
91711

Diane Kadyk
Proceedings Layout & Design
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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

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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

Keck Geology Consortium
Pomona College
185 E. 6th St., Claremont, CA 91711
Keckgeology.org
Eocene Tectonic Evolution of the Teton-Absaroka Ranges, Wyoming

John P. Craddock, Macalester College
David Malone, Illinois State University

Project Summary

Our initial goal was to continue the previous years’ effort on the South Fork detachment, our investigation of fault gouge injectites at White Mountain in the Heart Mountain detachment (Craddock et al., 2009), and study the footwall folds (Archean thrust over Paleozoic sediments) in the Teton Range. Sadly, deep snowpack made the folding projects inaccessible but we did return to the Hominy Peak section to collect additional samples of the Eocene Pinyon Conglomerate.

In the end, we remapped a large portion of the South Fork detachment area SW of Cody, WY, enough so we could make a structural and palinspastic effort to unravel the Eocene deformation (Mathisen, MacNamee). We also crawled all over the Sunlight basin area near White Mountain and better understand the fault gouge injectite dynamics (Kraushaar; see Craddock et al., 2012) and discovered an ultramafic intrusion that is likely the cause of the Heart Mountain detachment (Kenderes). We also expanded our sample coverage of Paleocene-Eocene clastic sediments in the Bighorn basin, analyzing the heavy mineral and detrital zircon provenance of the Lower Stratified, Ft. Union and Willwood Fms. (Schroeder, Kelly). FIGURE 1 (caption on Figure).

Logistically, we spent 3+ weeks in the field, starting

Geochronology = gray star; Box = 2010 sample; Circle = 2011 sample; Colored rim = Quarzite clast; unfilled rim = matrix or sandstone; Pale green = Flathead; dark blue = Cloverly; pale blue = Pinyon, Yellow = Harebelle; Purple = Fort Union; Red = Willwood; Maroon = Crandall; Gray = Eocene Volcanic; Black = CUC.
and ending at Macalester College. We also spent a week at Macalester preparing thin section tabs and separating zircons and other heavy minerals from a host of clastic sediments and igneous rocks. We were in Tucson, AZ January 22-28, 2012 using the LA-ICPMS in George Gehrels lab U-Pb dating zircons (~120 continuous hours).

**White Mountain detachment “injectites” (Ben Kraushaar, Stuart Kenderes)**

Faults of all types have a linear relationship between fault offset and the thickness of generated fault gouge (Scholz, 1989). Faults that generate a frictional melt force that melt into the adjacent country rock a distance equal to the fault zone melt thickness. The discovery of 150 m high carbonate breccia “injectites” at White Mountain is anomalous to all reported fault fluid breccia (pseudotachylite) relationships. Heart Mountain detachment upper plate blocks moved ten’s of kilometers and the resultant fault gouge is grossly under-represented. On the other hand, the fault gouge, while not a carbonate melt, behaved as a fluid and would be expected to have been injected 3 meters. The injectites are only found in the hanging wall, and up to 150 meters in height. Ben and Stuart mapped and sampled the injectite relations at White Mountain, and documented their common origin chemically (XRF) and petrographically (microscope, SEM-WDS) and their injection mechanics by using AMS as a proxy for magmatic flow. Stuart studied all the igneous dikes at White Mountain, including what ended up being a carbonate-rich breccia with an ultramafic affinity. This volcanic breccia was dated (U-Pb, zircon) at 48.8 Ma, the age of similar zircons found in the fault breccia, which precisely dates the Heart Mountain detachment event.

**South Fork Detachment (Mathisen, MacNamee)**

The South Fork detachment (SFD) is exposed over ~400 km² in a valley eroded through all the Sunlight (Absaroka) volcanics that has a relief of 6000 feet (Clarey, 1990). The SFD rocks include allochthonous sediments of Jurassic-Cretaceous age that are in fault contact with the underlying Eocene Willwood Fm. The youngest detrital zircons in the offset Willwood Fm. are 49 Ma, and the entire structure is overlain by the Deer Creek member of the Wapiti Fm. (48 Ma) thereby limiting the SFD formation to a narrow time window. The kinematics of this fault contact change along strike. The hanging wall sediments are folded (SW-NE trends, shallow plunges), and in places, are overturned nappes. Maren and Alison helped remap parts of the SFD, and collected oriented samples of the Jurassic Sundance Fm. (biosparite limestone). Upper plate Sundance samples (n= 23) record a layer-parallel shortening strain, in many orientations, and footwall samples (n=8) record a predominantly bedding-normal shortening strain. Alison used the LPS twinning strain fabric and the details of SFD internal deformation to constrain the structural evolution of the SFD by creating NE-NW palinspastic restorations. As the SFD motion was pre-HMD, was this rootless allochthon a contemporaneous landslide block, or is it part of the older Sevier-Laramide tectonism??

It is important to note that the funding for this project available from Keck was enhanced by a USGS ED-MAP grant to Malone to construct a detailed geologic map of the Belknap Creek Quadrangle.

**Bighorn and Absaroka Basin Provenance (Schroeder, Kelly)**

Over the last two years, we have conducted an extensive detrital zircon provenance analysis of rocks that span the transition between Sevier-Laramide tectonism and Absaroka volcanism. Overall, more than 5000 zircon were analyzed (~3300 in 2012). This work was subsidized by more than $12,000 ISU monies (indirect costs recovery on other Malone grants) Rocks analyzed in 2012 include the Cambrian Flathead (4 samples), Cretaceous Cloverly (5 samples), Pinyon-Hominy-Fort Union (5 samples), Eocene Crandall Conglomerate-Wapiti Formation (6 samples), Willwood Formation (15 samples; both Bighorn and Absaroka Basins), and various Eocene ash beds and intrusive rocks (8 samples). The principal goal of this project is to establish the Eocene paleogeography of northwest WY at time of Heart Mountain and South Fork faulting.

The DZ pattern for the lower Willwood Formation is complex, with frequency peaks of ca. ~160 Ma, 380 Ma, 1050 Ma, 1450 Ma, 1650 Ma, and 2750 Ma. The
upper Willwood Formation is dominated by 2500-3250 Ma zircons, and other frequency peaks occur at ca. 70 Ma and 1825 Ma. The complex DZ pattern of the lower Willwood indicates a provenance of recycled Paleozoic and Mesozoic sandstone units shed as the adjacent Laramide uplifts were being unroofed. The DZ pattern of the upper Willwood indicates that the basement rocks of adjacent Laramide uplifts were largely exposed. In addition, the Absaroka Basin was open to the west, as some sediment was derived from the distal Mesozoic orogen. The Wapiti Formation sandstones were sampled from a 300 m section of epiclastic volcanic rocks in the upper South Fork Shoshone river valley. Overall, the DZ pattern for these rocks is similar to the upper Willwood, with peaks at ca. 50 Ma, 1650-1850 Ma and 2500-2800 Ma. The proportion of Eocene (syn-volcanic) zircon ranges from 12% in the basal sandstone to 61% in the upper sandstone. The provenance of the Wapiti formation was initially dominated by recycled and primary sands derived from Laramide uplifts to one dominated by primary volcaniclastic materials.

REFERENCES


