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

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Pomona College, Claremont, CA

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

Dr. Jade Star Lackey
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Pomona College

Carol Morgan
Keck Geology Consortium Administrative Assistant

Christina Kelly
Symposium Proceedings Layout & Design
Office of Communication & Marketing
Scripps 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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Robert J. Varga
Editor and Keck Director
Pomona College

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

Christina Kelly
Proceedings Layout & Design
Scripps College

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THE VOLCANIC SEDIMENTS OF LOOKINGGLASS CREEK
MICHELE EVERTZ, Whitman College
Research Advisor: Nick Bader.

Keck Geology Consortium
Pomona College
185 E. 6th St., Claremont, CA 91711
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THE VOLCANIC SEDIMENTS OF LOOKING GLASS CREEK

MICHELE EVERTZ, Whitman College
Research Advisor: Nick Bader

INTRODUCTION

The CRBG consists primarily of stacks of cooled basaltic lava flows. Between some of these basalt flows are distinct, pale-colored interbeds of volcaniclastic sediment representing poorly-understood episodes of silicic volcanism. These sediments can help us understand the eruptive style and regional extent of these silicic eruptions, and also provide snapshots of the paleoenvironment and paleoclimate of the region. We studied a sedimentary interbed at Lookingglass Creek, about 26 miles north of Elgin, Oregon. The unit lies between two CRBG basalt flows; the basal unit is the Frenchman Springs member of the Wanapum Basalt and the upper unit is the Umatilla Member of the Saddle Mountain Basalt (Ferns et al, 2010).

Previous studies conducted on the sedimentary units between CRBG flows have been mainly based in Washington. The most extensively studied is the Ellensburg Formation, located in South-central Washington, which lies above the Saddle Mountain Member of the CRBG (Bingham and Grolier, 1966). The Ellensburg Formation is described as a unit of both sedimentary and pyroclastic deposits and has been dated by fossils to be late Miocene to early Pliocene (Bingham and Grolier, 1966). The Lookingglass Creek locality lies between the Frenchman Springs Member and The Umatilla Member, dated respectively at 15.3 Ma and 13.5 Ma (Ferns et al, 2010). Three potential origins of the Lookingglass Creek unit have been identified; 1) the Powder River Volcanic Field 2) the Dooley Mountain rhyolite eruptive center, and 3) the Tower Mountain Caldera (Ferns et al, 2010); all of which may be related to the movement of the Yellowstone hot spot (Perkins and Nash, 2012).

In this study we analyzed the stratigraphy, fossils, and chemistry of the Lookingglass Creek interbed to determine the environment and potential origins of the sediments and correlate the section to other defined units. The regional correlation of these units could explain the origin and nature of silicic volcanism within the CRBG. We collected samples for thin sections and pXRF analysis, and made detailed description and grain size analysis for all units. Using these modes of analysis the resulting regional correlation will help us to better understand the origin and nature of silicic volcanism within the CRBG.

METHODS

Field

The Lookingglass Creek outcrop is located along Palmer Junction Road, about 26 miles north of Elgin, Oregon, UTM zone 11N, WGS84, 432374 E, 5065298 N (Fig. 2, Bader and Nicolaysen, this volume). This section was measured and described between July 20th and July 26th, 2012. Measurements were made using a standard measuring tape and Brunton compass. Multiple exposures of the section were described and measured to compile a composite lithologic stratigraphic column. Samples were collected from all units to use for grain size analysis, thin sections for compositional analysis, and fossil identification.

Palmer Junction road grades down to Lookingglass Creek. The outcrop is exposed along this road with limited access to different units at multiple locations.

Four major locations were used for measurement and description to build a composite stratigraphic column. The units at these locations were correlated to each other via the presence of a marker bed. This bed is the airfall ash unit of the Lookingglass Creek sediments discussed later in the paper.

Lab

Portable x-ray fluorescence analysis was used to compile chemical composition data for the three units of volcanic origins. The samples were prepared using mortar and pestle and ground into a fine powder. The powder was packed into standard pXRF sample cups with one face covered in only saran wrap. These cups were loaded into the pXRF test stand with the pXRF attached. The readings were calibrated using a set of three USGS standards: BHVO-2, AGV-2, and BCR-2. These standards were run through the pXRF prior to the unknown samples, then the unknowns, and then the standards were run again to ensure that there was no drift within the readings during the analysis process.

RESULTS

Stratigraphy

The Lookingglass Creek unit has not been previously described in the formal literature, so much of the work that went into this project was detailed description and classification of the constituent units. The total thickness of the described section is about 20 meters, with CRBG flows at the top and bottom of the section. The basal layer is the Frenchman Springs member of the Wanapum basalt dated at approximately 15.5 Ma (Barry et al, 2010) and the top is overlain by the Umatilla member of the Saddle Mountain basalt with an age of about 13.5 Ma (Ferns et al, 2010). This brackets the age of the Lookingglass Creek interbed to between 15 and 13 million years ago, spanning up to 2 million years in time.

The two basal members of the Lookingglass Creek unit are secondary volcaniclastic clays and sands that have been reworked by fluvial processes. The uppermost units are tuff and ash deposits probably of primary volcaniclastic origin (Fig. 1). The third unit is a volcaniclastic, lithic-bearing, vitric-bearing

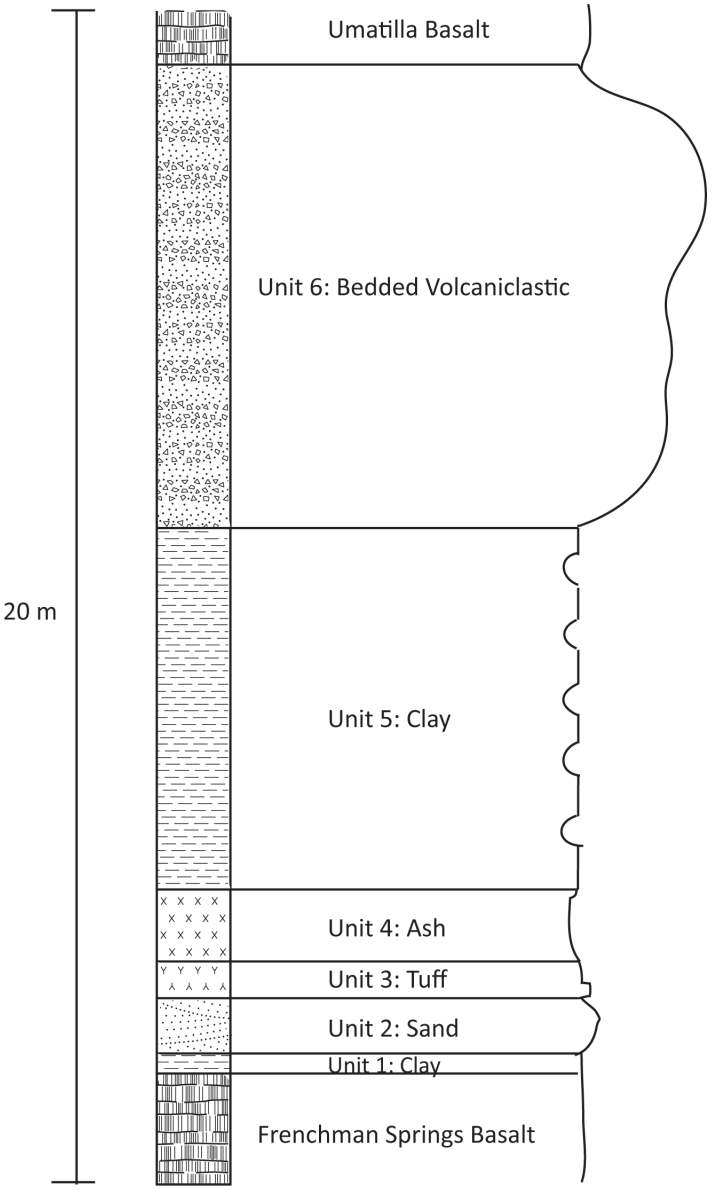

Figure 1. Composite stratigraphic column of the Lookingglass Creek Formation.

tuff that is overlain by about a meter of airfall ash that is a cool grey color with a massive, homogenous composition. Above that lies another clay unit in which lots of fossil leaf and woody debris imprints were extracted, with a thick volcaniclastic unit above it. The thick volcaniclastic unit is very rich in pumice with alternating beds of fine and coarse pumice clasts.

Fossils

Fossils were excavated from the Unit 5 clay member of the Lookingglass Creek unit. This unit has a platy appearance alternating between beds of two lithologies, some beds are ashy and unconsolidated and the

others are clay rich and indurated. In the layers of consolidated clay and silt sediments, fossils of leaves and woody debris are present. Leaf fossils in particular are abundant and were collected for identification and analysis; however, whole leaves were hard to find making identification more difficult.

Tentative identifications have been made using the Miocene fossil flora from Clarkia, Idaho (Rember, 2013), placing these leaf fossils within the birch family, Betulaceae.

Chemistry

Chemical analyses were performed on the three volcaniclastic members of the Lookingglass Creek unit. One sample from the Unit 3 tuff, one sample from the Unit 4 ash, and two samples from the Unit 6 pyroclastic deposit were analyzed (Fig. 1). The data from these four samples was compared with data from research conducted by Perkins and Nash (2012) that analyzed the chemical compositions of silicic volcanic deposits throughout the northwestern US. Two subsets of their data were created, one based on age (Fig. 3) and one based on regional proximity (Fig. 4) to the Lookingglass Creek locality. Figure 3 depicts that the closest correlation of the Lookingglass Creek unit is with the Mascall Ash. In Figure 4, the ash and surge deposit of the Lookingglass Creek unit correlates most strongly with the Mascall Ash and an ash found at a location in Richland, OR.

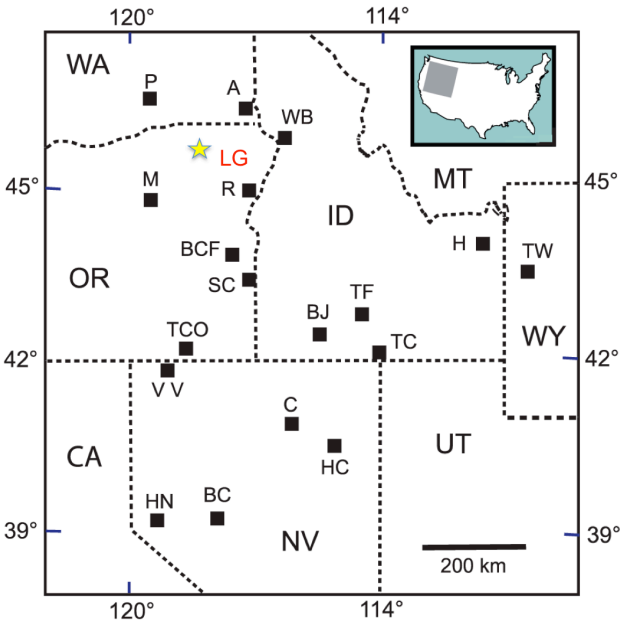

Figure 2. Map of sampling locations for chemical analysis (figure from Perkins and Nash, 2012). The labeled black squares are locations where chemical analyses were performed. The yellow star represents the site of the Lookingglass Creek unit.

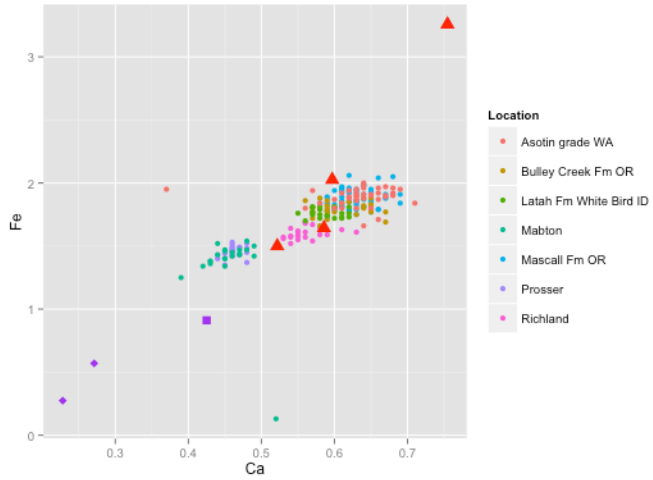

Figure 3. Age subset representing the weight % Ca and weight % Fe of samples taken from Perkins and Nash (2012) and the volcaniclastic units of the Lookingglass Creek Formation (red triangles). The Purple diamonds represent samples taken by Ferns et al. (2010) and the purple square is from the Cricket Flat basal volcaniclastic unit (see e.g. Lopez-Maldonado, this volume)

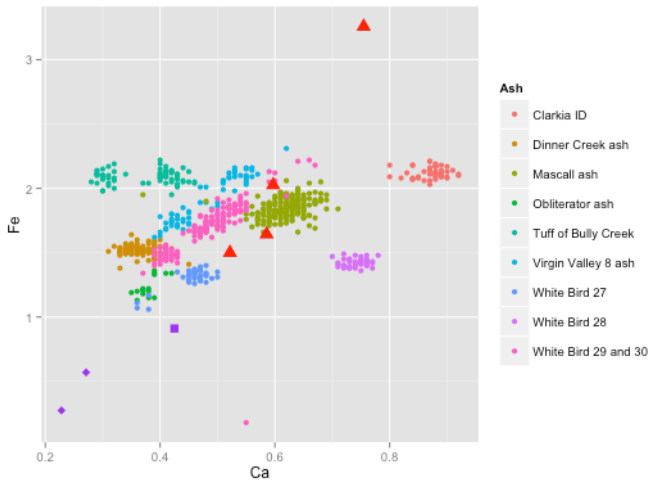

Figure 4. Location subset representing the weight & Ca and weight % Fe if samples taken from Perkins and Nash (2012) and the volcaniclastic units of the Lookingglass Creek Formation (red triangles). The Purple diamonds represent samples taken by Ferns et al. (2010) and the purple square is from the Cricket Flat basal volcaniclastic unit (see e.g. Lopez-Maldonado, this volume)

DISCUSSION

The sediments at Lookingglass Creek record the depositional history of the area. Following the eruption of the Frenchman Springs basalt, the site was dominated by fluvial deposition of reworked volcaniclastic sediments. Direct effects of volcanism began to affect this area, first with a pyroclastic event that appears to be short-lived based on the relative thickness of the tuffaceous bed, and followed by a layer of grey ash that blanketed the tuff. Deposition of the thick clay, fossiliferous bed provides evidence for the presence of hardwood trees as well as slow settling conditions for this sediment. This habitat was likely destroyed by the deposition of volcaniclastic sediment by pyroclastic surge events. Finally, the Umatilla basalts were erupted, covering the sediments.

The leaf fossils suggest that during the deposition of Unit 5, the area was intermittently covered in a hardwood forest. Trees in the birch family, Betulaceae, have the ability to thrive in a wide variety of habitats, including dry volcanic ash (Benson, 2004). Birch fossils growing in the middle of the section indicate repeated periods of stability during deposition of the section, to allow time for establishment of a hardwood forest.

The Powder River Volcanic Field is the closest source to the Lookingglass Creek locality of alkaline and calc-alkaline volcanism, rather than the tholeiitic basalts that dominate the CRBG. Beginning as early as 14 Ma, the PRVF units were erupted around the Grand Ronde Valley (Bailey, 1990). The eruptions occurred from multiple vents scattered throughout this region and the lavas produced basalts, andesites, dacites, and basanites, all in relatively low-volume eruptions (Ferns et al, 2010). Although geographically close to Lookingglass Creek and more silicic in composition than the CRBG, the eruptions of the PRVF are much smaller in volume than the sediments of the Lookingglass Creek unit.

Ferns et al. (2010) identifies the Tower Mountain Caldera and the Dooley Mountain rhyolite eruptive center as the closest eruptive centers to the Miocene ashes and outcrops of silicic volcanism within the Grand Ronde region, including the units found at Lookingglass Creek. The deposits associated with the Dooley Mountain eruptive center have been dated between 14.8 to 14.7 Ma (Ferns et al, 2010), within the range of the Lookingglass Creek unit, but the Ca-Fe composition of Dooley Mountain deposits (see Dinner Creek ash on Fig. 3) make this source an unlikely correlation. The Tower Mountain Caldera is a large-scale rhyolite caldera, but has been dated at 29.8 to 28.1 Ma, much older than the Lookingglass Creek unit (Mclaughry, 2009).

The closest correlations based on weight percent calcium and iron can be made between sections of the Lookingglass Creek unit and the Mascall Ash and an outcrop of Hazen Ash found at Richland, OR (2012). The Mascall Ash is a regionally extensive ash that is dated at about 15.7 million years old (Perkins and Nash, 2012). The type locality of the Mascall Formation is in central Oregon near in association with the John Day Basin (Bestland et al, 2008). The Mascall formation has been extensively studied due to the large amount of fossils that have been found within it (Bestland et al, 2008). The Lookingglass Creek locality lies within this region, making it a feasible correlation in terms of location. However, the age of the Mascall Ash is probably slightly older than the range that is possible for the Lookingglass Creek unit (Bestland et al, 2008). The exception to this is a sample location at Asotin grade, WA, where the Mascall Ash has been dated at 14.5 Ma (Perkins and Nash, 2012). This age falls into the possible age range of the Lookingglass Creek unit and is also the closest Mascall Ash sample location site to the Lookingglass Creek locality.

The main locality of the Hazen Ash is in eastern Nevada; however, a unit bearing an identical chemical composition has been found and sampled in Richland, OR, due south of the Lookingglass Creek locality (Perkins and Nash, 2012). This outcrop is dated at about 9.8 Ma (Perkins and Nash, 2012), which is far younger than the potential age of the Lookingglass Creek unit. The physical description of the outcrop as described by Perkins and Nash is identical to the physical description of the Unit 4 airfall ash found at Lookingglass Creek, as a massive, grey ash, a little over a meter thick. Although the weight percent composition of calcium and iron, the location, and the physical description of the outcrop in Richland, OR all

align with the Lookingglass Creek unit, the difference in age makes this correlation unfeasible.

CONCLUSIONS

The sediments of Lookingglass Creek record a period of secondary fluvial deposition of volcaniclastic material, followed by primary deposits of airfall ash and pyroclastic surge deposits. The primary volcaniclastic deposits were interrupted by periods of stability during which birch forests became established. The chemical analyses correlate the weight percent Ca and Fe with other known deposits, yielding a feasible match with the volcanic sediments of the Mascall Ash.

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