**Astromaterials Research and Training Opportunity (ASTRO) Student Report**

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# Textural and Mineralogical Changes of Tuff Ring Deposits, Central Oregon, USA, through Hydrothermal Processes and Implications for Martian Geologic History

We are examining the hydrothermal alteration of basaltic tuff deposits of Fort Rock Volcanic Field in Central Oregon, USA and using this location as a potential Martian analogue. The deposits were produced by hydrovolcanic eruptions though an ancient lake basin making them distinct in that they were produced in the presence of water. Characterizing the formation of hydrothermal alteration minerals such as smectite clays, and zeolites, as well as palagonitic products that form under aqueous conditions may help in understanding the alteration of Martian protoliths and the conditions that once existed in Gale Crater. By studying the deposits of tuff rings, a greater understanding of basaltic protolith material and secondary alteration as indicators of past climate can be gained, as well as how composition of the basaltic protolith, fluid circulation and primary textures determine alteration assemblages.

## Field Work

In June 2012 I participated in 10 days of field work. I travelled to Fort Rock Oregon, USA, where I camped in the desert and traversed the dried up Fort Rock lake basin searching for hydrovolcanic deposits and collecting field data. Volcanic features including spatter cones, scoria cones, massive basaltic lava flows, flow banded rhyolite and lava tubes were all explored. The Fort Rock basin contains over 40 hydrovolcanoes in the form of tuff rings and tuff cones, which were our main interest for sample collection. The main tasks involved navigation using GPS and topographic maps, searching for representative samples exhibiting a range of textures and degrees of alteration of juvenile basaltic material for each hydrovolcano visited, and examining and describing them as thoroughly as possible. GPS coordinates and locations on topographic maps for each sample were recorded. Over 50 samples weighing over 70 kg were collected and more than 10 volcanoes of phreatomagmatic origin were explored. One highlight of the trip was being filmed by the Discovery Channel for the Daily Planet special (Mars Landing 2012: The New Search for Life), which aired on international television on August 6, 2012. *Figure 1* below depicts me doing field work in the Oregonian desert.

**Figure 1:** *Left* - Resting on the talus slope of the Black Hills tuff rings with volcanoes visible in the distance. *Center* - Hammering a lava flow on the flank of a tuff ring. *Right* - Recording detailed notes describing a collected sample.

**Lab Work**

Once tuff samples were collected from the field, thin sections needed to be produced. I had a chance to partake in the entire process of developing thin sections of desired samples for analysis, which gave me experience using rock cutters, impregnating samples with resin, and grinding and polishing them down to 30 µm thicknesses. I then spent time characterizing the samples petrographically by examining and describing them using a petrographic microscope. I also travelled to the University of Western Ontario on two separate occasions where I had a chance to use a Micro X-Ray Diffraction Instrument. This analysis allowed for the determination of the sample mineralogy, specifically those that were too fine grained to identify under the microscope. *Figure 2* shows a diffraction output indicating the presence of calcite infilling a pore in an altered tuff sample, which was an unexpected discovery. One day also involved additional filming of some of this lab work for the Discovery Channel special in which I made my international television debut. Other laboratory work included sample preparation for geochemical analyses for both Alpha Particle X-Ray Spectrometry, which is Canadian contribution to instruments on board the Mars Science laboratory Rover Curiosity, as well as preparing samples for X-Ray fluorescence. This required using a jaw crusher and a shatter box to make rock chips and powder. *Figure 3* below depicts some of the lab work I did over the summer. The data collected during my ASTRO research period in the summer is being used in my current undergraduate thesis this year and will eventually also be incorporated as part of my future Master's Thesis.

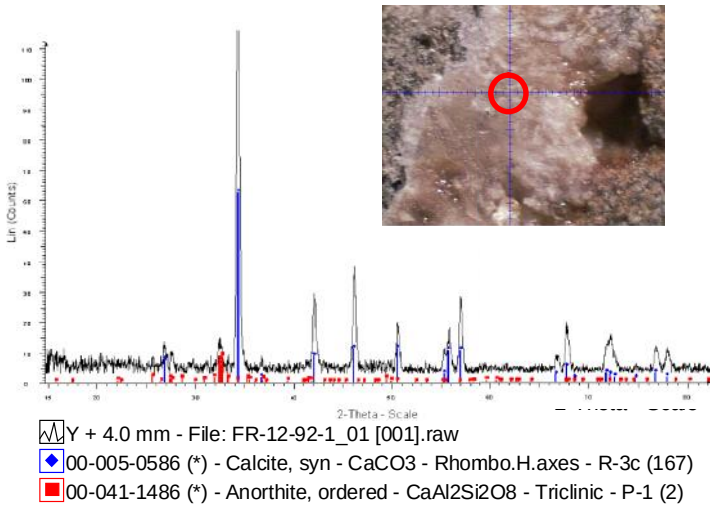


**Figure 2**: µXRD data of a volcanic tuff obtained using a Bruker D8 Discover diffractometer. Inset: micrograph of spot analyzed showing 100 µm diameter spot analyzed in red.

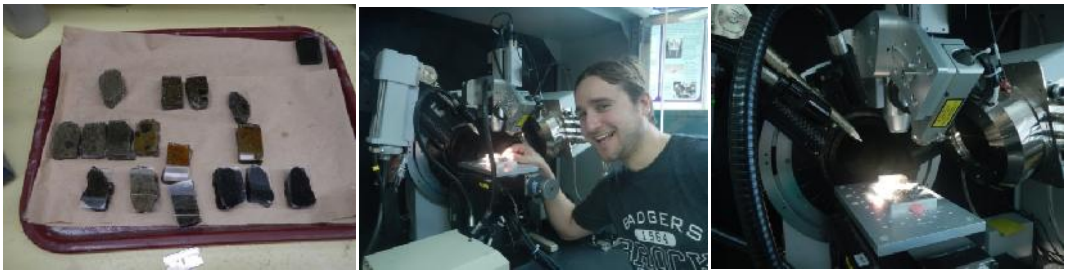

**Figure 3:** *Left* - Rock slabs cut from samples collected in Oregon being adhered to glass with epoxy resin in the petrographic thin sectioning lab at Brock University. *Center* - Placing tuff sample slabs into the Micro X-Ray Diffraction Instrument at the University of Western Ontario. *Right* - Bruker D8 Discover Diffractometer with General Area Detector Diffraction System at the University of Western Ontario.