Crummy Outcrops Have Stories Too:

The Geology in the Southeast Corner of the Cascade-Siskiyou National Monument, Oregon and California

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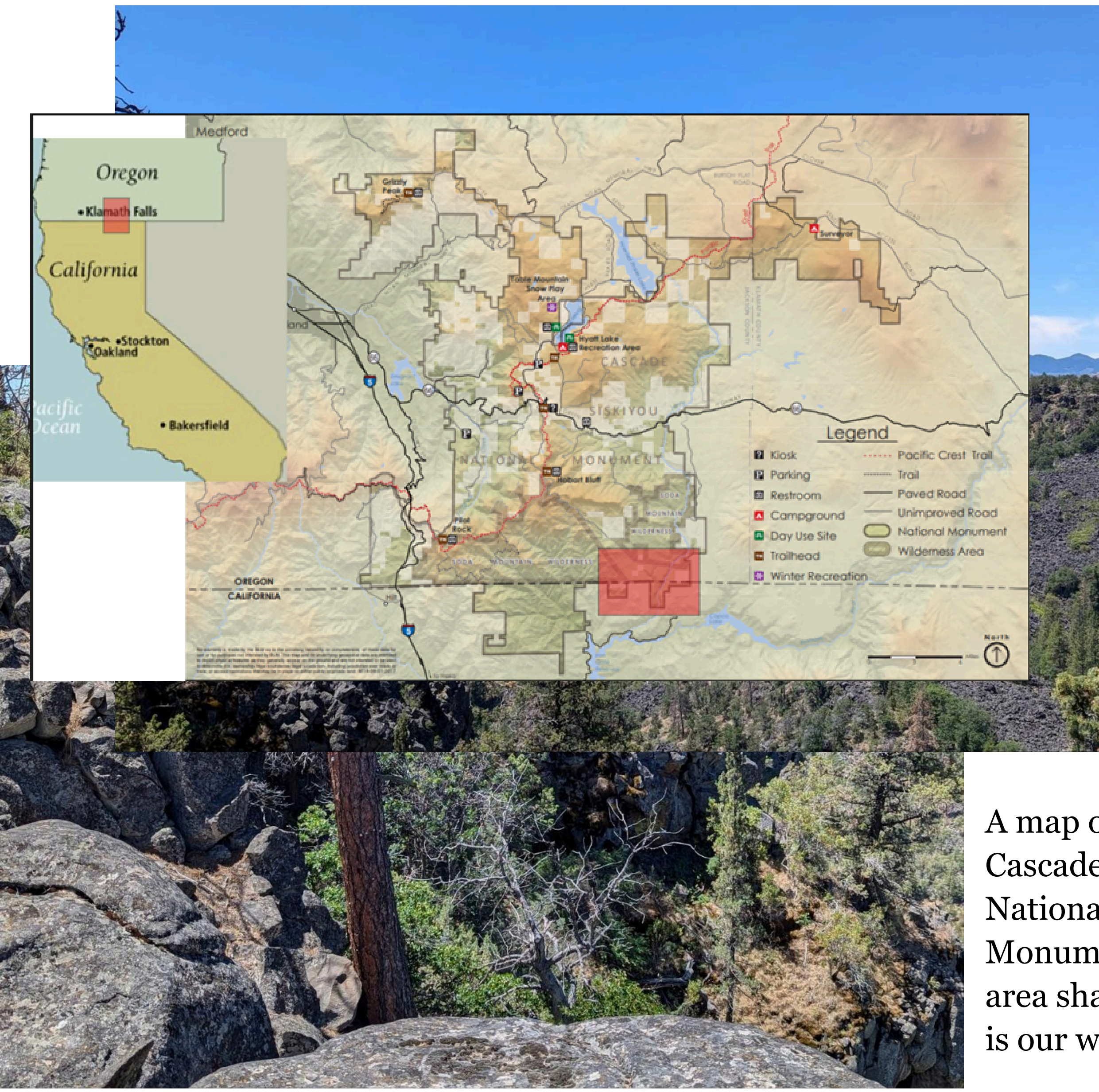


Figure 1

A map of the Cascade-Siskiyou National Monument. The area shaded in red is our worksite.

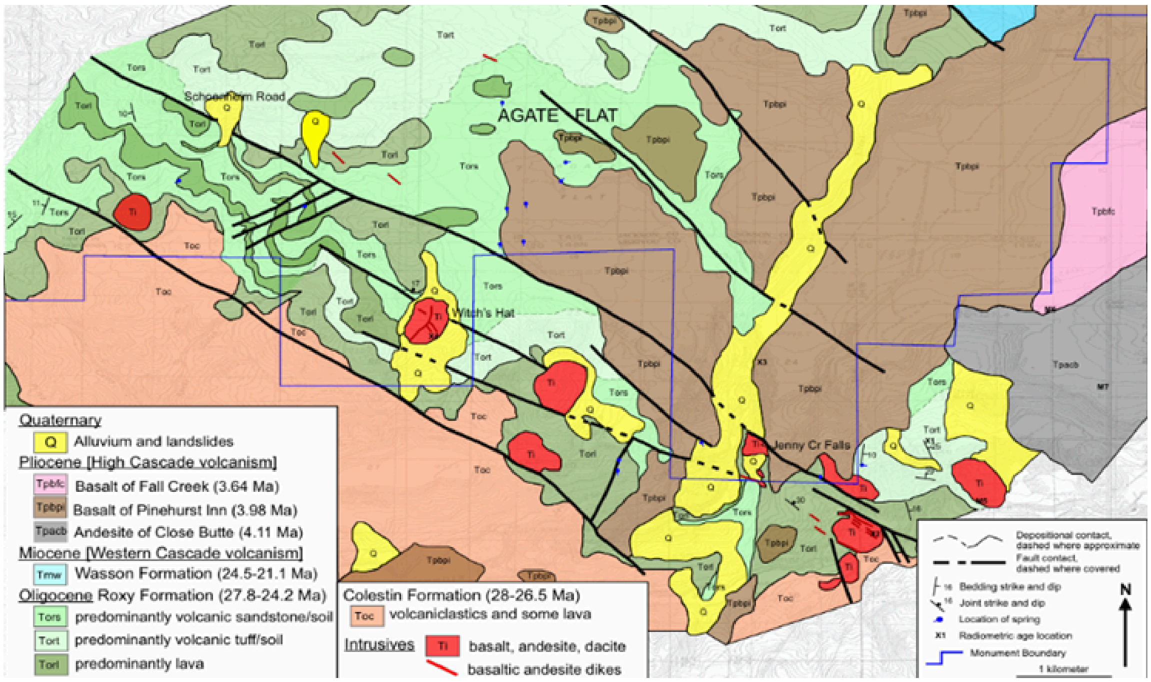


Figure 2

The final geologic map that was made during the summer of 2024. The circles show our main areas of interest.

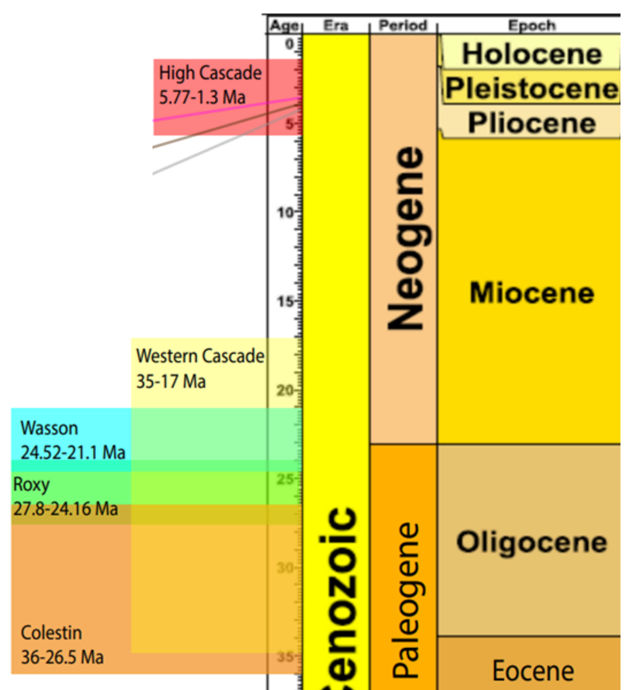
Introduction

In the early summer of 2024, Jad D'Allura of Southern Oregon University and I (Erin Medler of University of Oregon) explored the southeastern corner of the Cascade-Siskiyou National Monument, located in southern Oregon and Northern California (Fig 1). Our goal was to look at the rocks and soil and attempt to travel back in time (so to speak) to discover what forces caused the creation of the current landscape. We focused heavily on the Western Cascade (**WC**) and High Cascade (**HC**) volcanic series. The Western Cascade Formations are 35 million years old

(**Mya**). There are three units within the Western Cascades; Colestin (36 Ma), Roxy (27.8 Mya), and Wasson (24.5 Mya) made up of a combination of basaltic lavas, debris flows, tuff (a rock made of volcanic ash), and volcanic sandstone (sedimentary rocks made up of broken and fragmented volcanic rock of varying shapes and sizes that have been transported and cemented together). There is some overlap between these units, meaning there were numerous eruptions happening at the same time. The High Cascades are much younger, only 5.7 Mya. One of our goals was to accurately find the age of the units within the High Cascades, the Basalt of Fall Creek (**Tpbfc**), the Basalt of Pinehurst Inn (**Tpbpi**), and the Andesite of Close Butte. Our other goals were to create a geologic map of the area (fig. 2) completing a full geologic map of the Cascade-Siskiyou monument. Friends of the Cascade-Siskiyou National Monument and the Bureau of Land Management (**BLM**) provided funding for this project.

Figure 3a

According to previous work done in the area, (Hammond, 1983 and Bestland, 1987), the formations in the region are Colestin (36-26.5 Ma), Roxy (27.8-24.16 Mya), Wasson (24.52-21.1 Mya), Western Cascade (35-17 Mya),



and High Cascade (5.77-1.3 Mya). There is an overlap in dates for the older formations (Colestin, Roxy, Wasson and WC).

Background

Before we could go into the field we wanted to get a bird's eye view, so D'Allura borrowed Medford BLM's aerial images, as well as some LiDAR bare earth photos that were taken in the 80's. LiDAR are images taken by pulses of lasers emitted from an airplane that can accurately measure the topography below. Based on previous research done by D'Allura, we already knew there was a zone of weakness to the southeast of our worksite (D'Allura 2017). The Earth's crust had been shifting, causing it to fracture and shift, causing something called faults, where rocks that had been created in a straight-line shift against each other, forming faults. This means there has been long term movement in this part of the Earth's crust. This zone of weakness makes it much easier for magma underneath the crust to come to the surface, leading to the lava littered landscape we see today. We saw the continuation of this in visible faults in the LiDAR photos (these faults can be seen as the black lines in figure 2). We also looked at thin sections (rock samples cut thin enough so that light from a microscope can be seen through them) from certain lava flows in the WC. Analyzing these thin sections allowed us to see in detail the minerals that make up the rock, and it can tell us more about how the rock cooled. For example, we could tell that there were two stages of cooling in the WC rocks because the larger Olivine crystals (a common volcanic mineral) had time to grow, compared to the smaller plagioclase minerals (another common volcanic mineral) that make up the background that cooled much quicker.

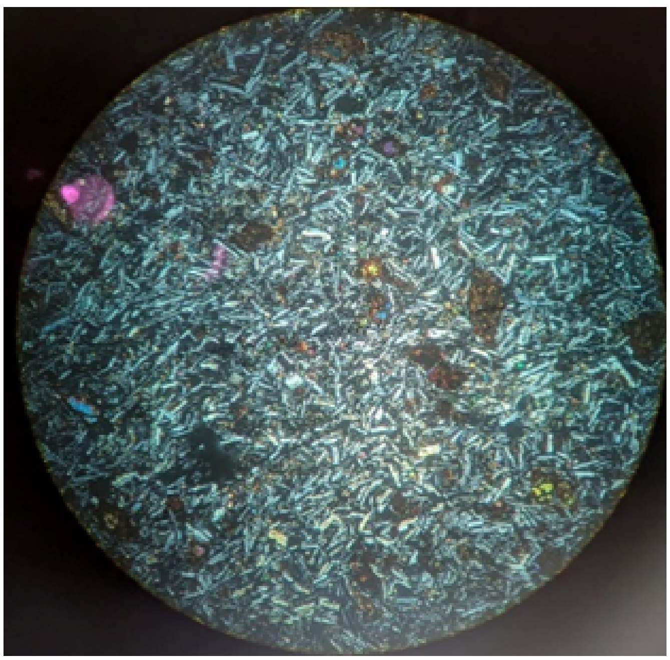
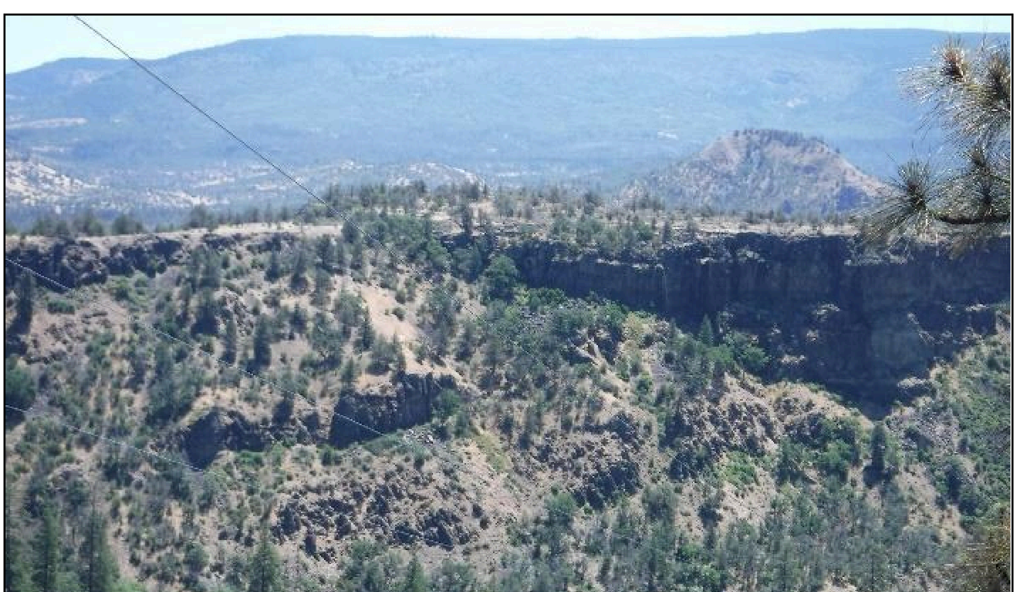


Figure 4

A picture of a thin section under the microscope. The olivine is brown and blotchy, meaning they had time to grow, while the thin plagioclase is black, white, and smaller.

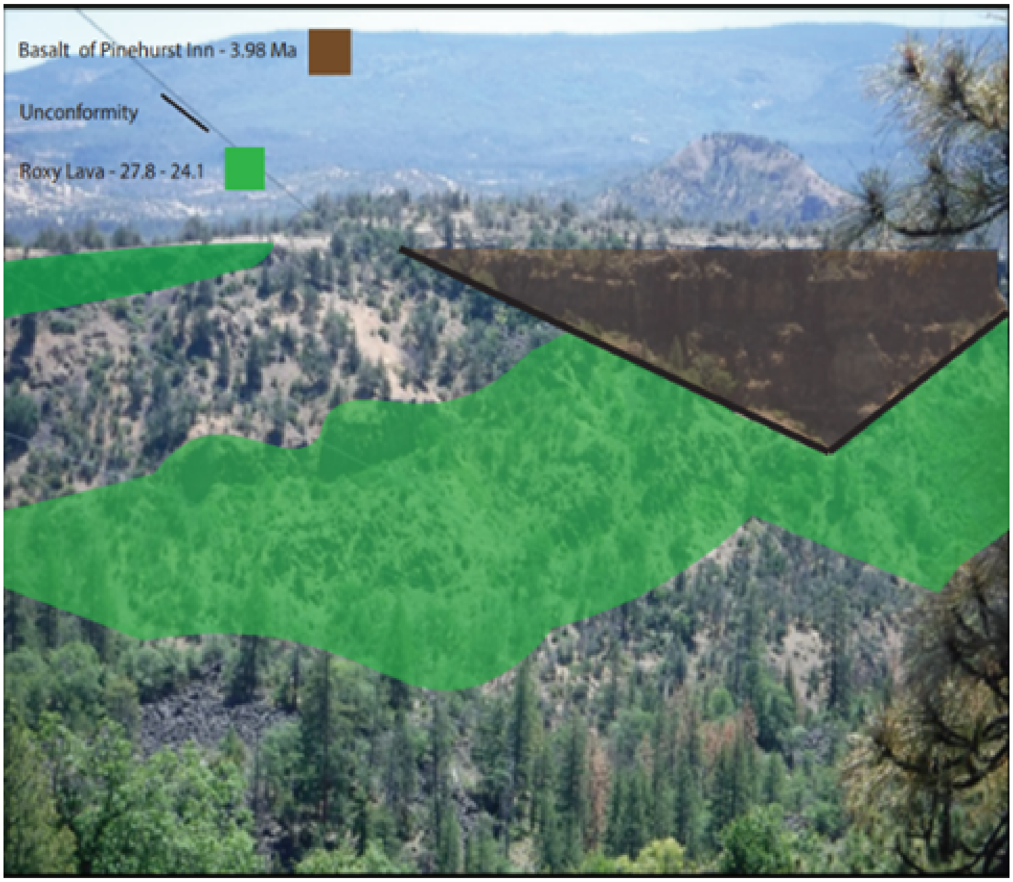
Techniques

Once in the field, we were either scrambling over heavily fractured rubble or walking over hills of wild grass (that got into every crevice a boot could have). We quickly noticed that the outcrops were very susceptible to weathering, meaning they were not always visible. While this was frustrating at times, the amount a rock weathers can tell us a lot about its creation and chemical makeup. To identify and map outcrops and contacts effectively, we utilized the variation in color and texture of the soil. Volcanic sandstone weathers to a sticky reddish-brown soil, and tuffs weather to a light gray soil. We also saw shrink-swell clays (clays that are sticky when wet and shrink, forming large cracks when dry) as thin, horizontal layers to the west that become dominant in the Agate Flat area. Colestin and lower Roxy exposures, the two older WC units, contain a greater abundance of volcaniclastic rocks. Volcanic sandstones are extremely rare, so seeing them means that most of these rock units were deposited quickly, covered, and were not exposed to weathering or moisture. There were much more tuffs in the Colestin formation as well as thinner, widely spaced, and more easily eroded lava flows which lead to gentler topography and grassy slopes. The Roxy formation units contain greater abundances of numerous thick flows.



Figures 5 a, 5b

5a. A view across Jenny Creek Canyon from one of our lunch spots. Canyon that shows an unconformity, a spot where a large chunk of geological history is missing, where the surface either didn't form rocks or they were eroded away



5b. A view across Jenny Creek, more clearly showing the unconformity between the underlying Roxy lava in green and the overlying Basalt of Pinehurst Inn in brown.

Findings In the Field

In the field, we saw large faults trending to the northwest that dip to the northeast. These related intrusions revealed the previously mentioned long-lasting zone of weakness. There were also smaller faults and fractures, likely caused by the stress of the overall movement of the area.

There were two sections of high interest, Jenny Creek Falls and Agate Flats. Jenny Creek Falls was formed by a series of parallel, steep, nested

WC dikes (a nested dike is an intrusion within another intrusion. These intrusions are known as dikes) with the same northwest trend as other dikes. Jenny Creek Falls is made up of tilted, platy WC lavas, river gravel, and pillow breccia (angular fragments of pillow basalt cemented together. Pillow basalt is basalt that erupted underwater). When the basalt of Pinehurst Inn (**Tpbpi**) flowed through the ancient creek, it pooled behind the obstruction of WC intrusions. When the hot lava hit the water of Jenny Creek, it quenched and created a yellow, porous glass. On top of that was more pooled lava, which cooled into the columnar basalt subsequently cutting its way through portions of the Tpbpi as we see it today (Fig. 6).

Figure 6

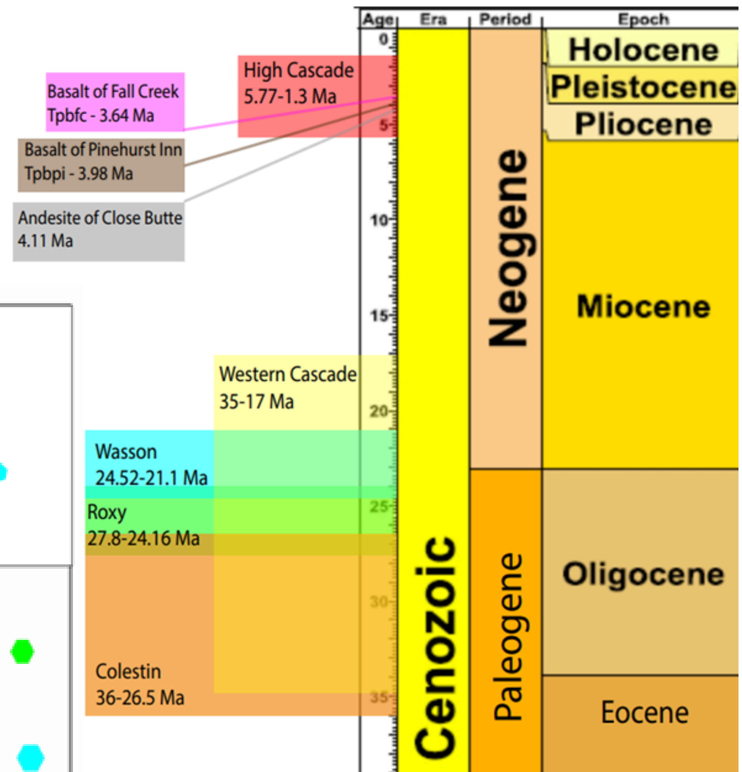
A close-up of Jenny Creek Canyon, showing basalt on top of the quenched, yellow glass. The lava then pooled and cooled into the columnar basalt on top.

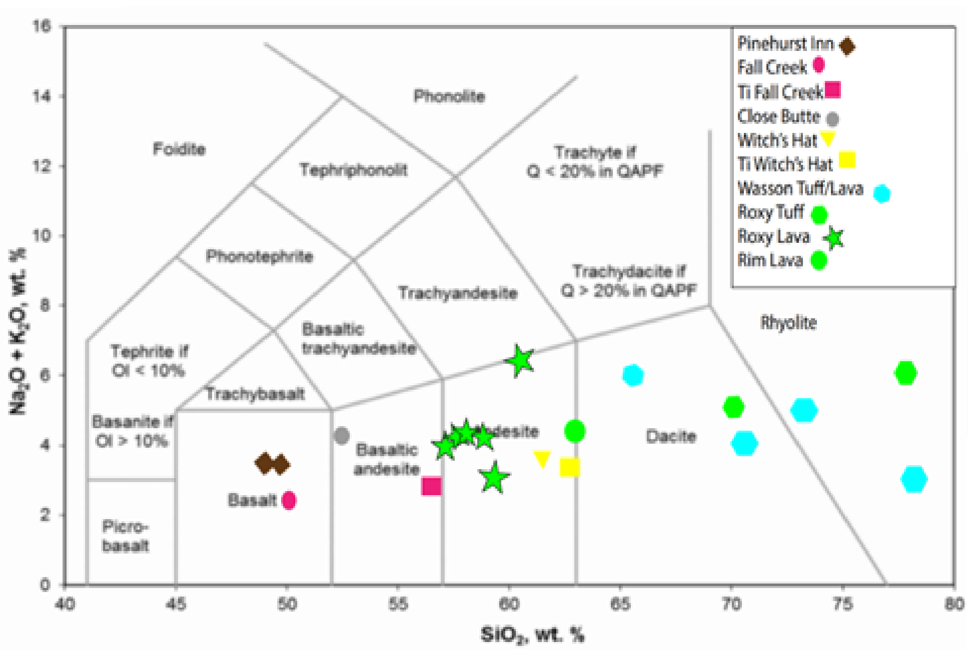
The Tpbpi eventually overflowed from Jenny Creek, over exposed volcanic rocks into the valley now known as Agate Flat. Agate Flat is composed of volcaniclastic rocks and numerous lava flows, with a wide range of sizes and chemical compositions as well as a plethora of agates. When silica has space (often air pockets) and groundwater to concentrate in, the wet quartz squeezes into the air pockets and solidifies, forming agates. Agates are rarely found in HC lava, as the silica content is relatively low (silica being the primary ingredient of agates), but they are sparsely seen in WC lava flows. The lower WC units have a much higher silica content and mixed with the air bubbles and moisture from Tpbpi, allows for the creation of agates. As lava flows creep into Agate Flat, they become thinner and separate. These easily weathered rocks explain the wide, flat terrain of Agate Flats. The northern part of Agate Flat contains small outcrops of light gray tuff. In the south the soil is slightly darker (light brown) in color, possibly reflecting underlying sandy volcaniclastic rocks. The contact between the Colestin Formation and the overlying Roxy Formation appears to overlap in the Agate Flat region.

Along the way we found many springs and bogs. The springs we found occur either along notable fractures and faults or at contacts of dissimilar rock types where the downhill rock unit is less permeable (doesn't let as much water or material through) than the rock unit above it. HC lavas trap winter snow and spring water, forming seasonal bogs (they disappear from mid to late spring). The trapping of bog water is due to the grouping of clays weathered from the lava in areas between steeper parts of lava flows and the relatively low percolation rate (this means the water takes a long time to move through the soil and reach the water table) of those flows. Due to deep burial, WC rocks have become altered because of exposure to groundwater over time. These rocks are very porous or are full of small holes and interconnected structures that are often only a few centimeters large. You can think of them as sponges that hold onto whatever water they can. These alterations lower the permeability of all WC rocks.

Findings In the Lab

Once we had our samples from the field, we prepared them for radiometric $^{40}Ar/^{39}Ar$ dating in the Oregon State University Geochronology lab. This process involves looking at the number of radioactive isotopes in a sample, which have a known rate of decay, meaning we can calculate how long a sample has been decaying. We started the process by crushing the rocks with a heavy mortar and pestle into a fine dust, then placed the samples in a furnace to convert the dust into glass beads. After removing the glass beads from the furnace, we repeated the process of smashing and melting a second time to create homogenous samples. These glass beads were then sent to Oregon State University to be radiometric dated. We also got to see the silicic makeup of our samples, as shown in figure 7. The oldest samples from the Roxy formation (27.8 – 24.16 Mya) have a higher silica content, meaning they are made up of rocks known as andesite, dacite and rhyolite. The younger samples from Pinehurst inn (3.98 Mya) Close Butte (4.22 Mya) have less silica, which means they are basaltic. The HC samples have much lower silica content compared to the WC samples, which means that the WC eruptions were much more explosive than the HCs.





Figures 7, 3b

An Alkali-Silica diagram. Shows makeup of 6 samples, Tpbpi, Tpbfc, Close Butte, Witch's Hat, Wasson and Roxy. There is a trend that shows a lowering in silica content as the younger the samples get, meaning that the younger eruptions are less and less explosive, and more effusive, or runnier. Attached is figure 3, now completed with HC unit ages.

A Jargon Heavy Conclusion

With a successfully updated map, we now have a deeper understanding of the Agate Flat-Jenny Creek area, and the surrounding volcanic activity that created the area we can see today. The WC volcanic series consists of basaltic lavas, volcaniclastic sandstone, debris flows, and tuff. Being slightly tilted to the northeast, these rocks are unconformably overlain by the HC lava of Pinehurst Inn (Tpbpi) in the HC volcanic series. The upper sections of the Tpbpi lava are mostly vesicular, meaning the outcrops are blocky and rubbly with columnar and platy joints forming cliffs and sediment heavy aprons deposited over WC rocks. Steeply inclined northwest-trending faults affect both WC and HC. Intrusions ranging from basalt, andesite, and dacite (low to high silica content) formed along a zone paralleling the fault pattern. These intrusions range in age from 36 to 1.3 Mya, revealing a long-lived zone of weakness.

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