Exploring Correlations Between Tumalo Volcanic Center deposits with Quartz and Plagioclase Cathodoluminescence Zoning Patterns

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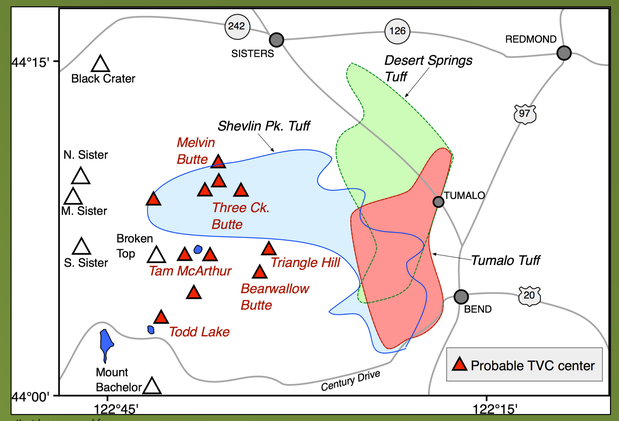
Introduction and Setting

The goal of this research project is to compare the TVC units according to their proposed correlations using CL imaging in order to determine if there is shared history recorded in the quartz and plagioclase feldspar growth zoning.

The ~700 km^2 Tumalo Volcanic Center (TVC) is in Central Oregon between the city of Bend and the Three Sisters volcanoes. It consists of mid to late Pleistocene intermediate-to-silicic lava and explosive deposits.
The TVC has produced three large pyroclastic deposits (Hildreth, 2007):
(1) Desert Spring Tuff (~650 ka), dacitic, welded, pink and tan tuff
(2) Tumalo Tuff/Bend Pumice (~300-440 ka), rhyolitic pyroclastic flow airfall deposits
(3) Shevlin Park Tuff (≤260 ka), a mixed andesitic tuff.
The source vent locations and magmatic origins of these events are not well constrained. However, petrologic and fieldwork have suggested that Desert Spring Tuff was sourced from Bearwallow Butte, Tumalo Tuff/Bend Pumice from Three Creek Butte/Melvin Butte, and Shevlin Park Tuff from Triangle Hill (Taylor, 1990; Hildreth, 2007).

Cathodoluminescence (CL) is created by the interaction between an electron beam and a solid (Götze, 2012). CL images show the growth textures of crystals. Zoning occurs due to an inconsistent environment in which a crystal grows (Barbee, 2020).



Kent (pers. comm.) for map

Methods

- Examined thin sections from each of the three large pyroclastic deposits, as well as, from the minor tephra units to identify quartz and feldspar crystals.
- Used the JEOL JSM-IT500HR scanning electron microscope (SEM) and Deben Centaurus cathodoluminescence (CL) detector at Denison, to image the thin sections
- The images collected were analyzed for similarities using Photopea and ImageJ software.
- Used an accelerating voltage of 15.0 kV, a working distance of ~17-18 mm, and a probe current of 50.0 nA

Acknowledgements

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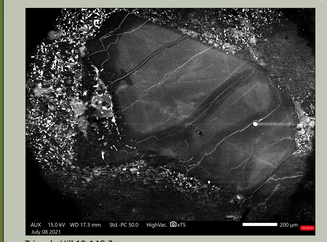
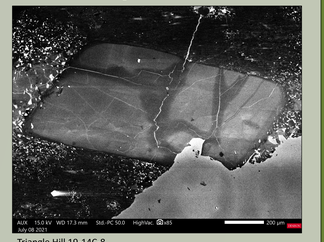
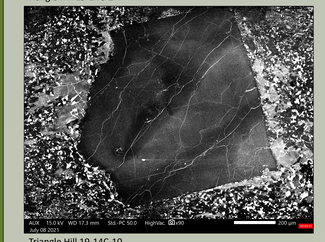
CL Zoning Groups

Group 1: White fractures bordered with dark areas

These crystals have white fracturing with darker shadowing around them.


Triangle Hill 19-14C-2

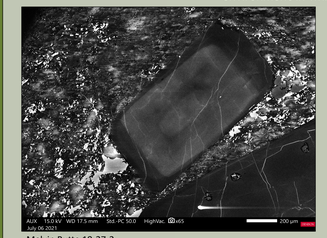

Triangle Hill 19-14C-8

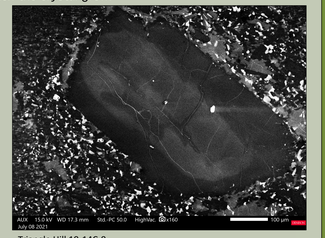

Triangle Hill 19-14C-10

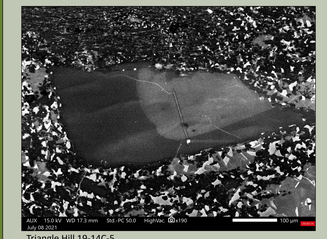

Triangle Hill 19-14A-9

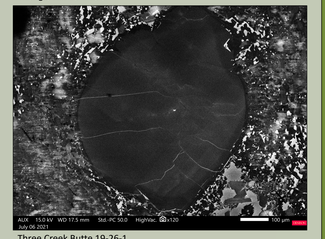
Group 2: Dark rims with lighter cores

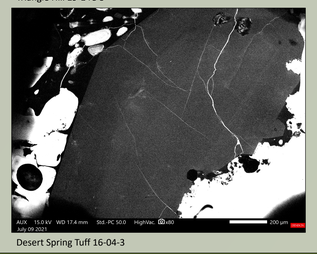
The crystals present a clear distinction between their cores and rims, indicating a change in environment in which the crystal grew.

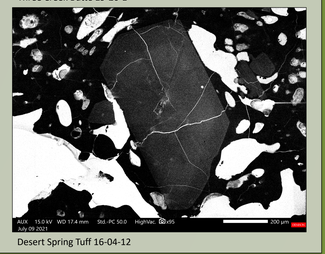

Melvin Butte 19-27-2


Triangle Hill 19-14C-9


Triangle Hill 19-14C-5

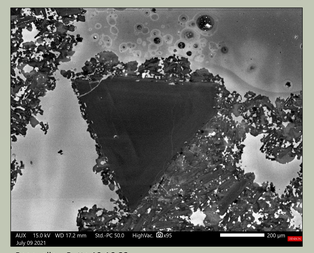

Three Creek Butte 19-26-1

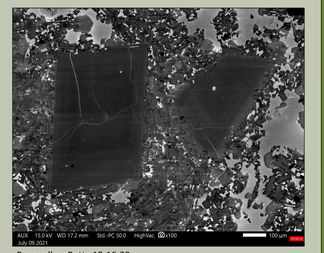

Desert Spring Tuff 16-04-3


Desert Spring Tuff 16-04-12

Group 3: Distinct zoning throughout the crystal

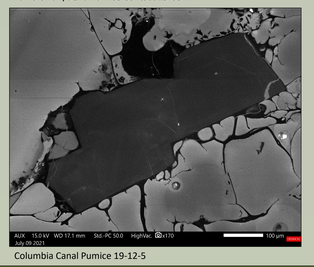
Crystals exhibiting distinct zoning show that the crystals have undergone temperature, pressure, and compositional changes during their growth.


Bearwallow Butte 19-16-23


Bearwallow Butte 19-16-20


Tumalo Tuff/Bend Pumice Contact 19-08-4

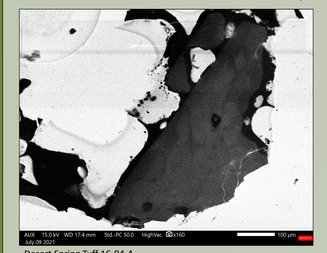

Tumalo Tuff/Bend Pumice Contact 19-08-7

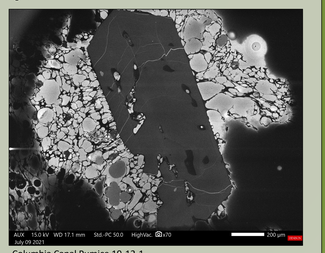

Columbia Canal Pumice 19-12-5

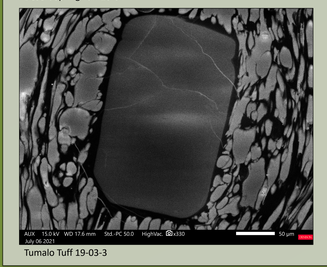

Shevlin Park Tuff 16-08-1

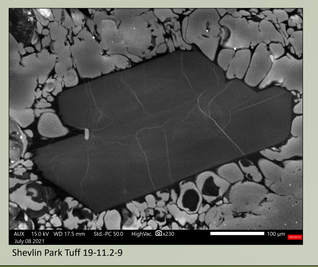
Group 4: No zoning

These crystal lack CL zoning and can look flat with no texture. However, there are some crystals which have CL textures present but are not zoned potentially alluding to some alterations occurring but after the crystal's growth.


Desert Spring Tuff 16-04-4


Columbia Canal Pumice 19-12-1


Tumalo Tuff 19-03-3


Shevlin Park Tuff 19-11.2-9

Observations of Potential Correlations

Desert Spring Tuff → Bearwallow Butte
- More complex zoning present in Bearwallow Butte crystals compared to Desert Spring Tuff crystals which have lighter cores and darker rims.

Tumalo Tuff, Bend Pumice, & Tumalo Tuff/Bend Pumice Contact → Three Creek Butte & Melvin Butte
- Tumalo Tuff and Bend Pumice crystals are similar in that they lack distinctive zoning, but Tumalo Tuff/Bend Pumice contact has unique zoning present.
- Crystals from Three Creek Butte and Melvin Butte tend to have dark rims and lighter cores

Shevlin Park Tuff & Columbia Canal Pumice → Triangle Hill
- Shevlin Park Tuff and Columbia Canal Pumice have subtle zoning towards the rims of the crystals.
- Triangle Hill crystals have a variety of CL textures including zoning.

Discussion

Bearwallow Butte and Desert Spring Tuff are lack shared zoning and characteristics. However, within each crystal set, there is distinct zoning, which suggests correlation. While the zoning in both Bearwallow Butte and Desert Spring Tuff crystals show that the crystals have gone through a complex history, it is hard to tell if they share the *same* complex history.
Correlation: Inconclusive

Crystals from the Tumalo Tuff/Bend Pumice contact area are distinct from the crystals from Bend Pumice and Tumalo Tuff individually, hinting at unique history for these crystals. However, given that the crystals from Bend Pumice, Tumalo Tuff, the Bend Pumice/Tumalo Tuff contact area, Three Creek Butte and Melvin Butte do not share many characteristics, it is hard to definitively say whether they correlate. Three Creek Butte and Melvin Butte have similarities of CL texture and zoning. **Correlations: Buttes and TT/BP: Inconclusive. Melvin and Three Creek Buttes: Likely correlated.**

It is ambiguous whether Shevlin Park Tuff, Columbia Canal Pumice and Triangle Hill correlate. Triangle Hill exhibits 3 populations of textures, one of which is shared with the Shevlin Park Tuff. The variety in the Triangle Hill crystals could be related to different events which correlate to Shevlin Park Tuff and Columbia Canal Pumice. **Correlation: Inconclusive but suggestive.**

In the future, I plan to create elemental maps on the SEM of the samples in order to determine whether there is specific compositional variation in zoning within the crystals. Completing elemental mapping will help us clarify the correlations between the pyroclastic deposits and their potential origins.

References

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Götze, J. (2012) Application of Cathodoluminescence Microscopy and Spectroscopy in Geosciences. Microscopy and Microanalysis, 18, 1270-1284.
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