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Analysis of Concentric Growth Rings in Hydrothermal Epidote

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Putting a Ring on Geological Research:
What mineral growth can tell us about underground systems

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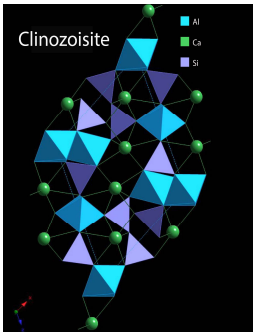
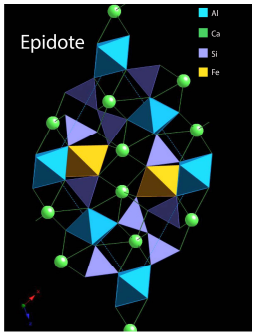
Introduction

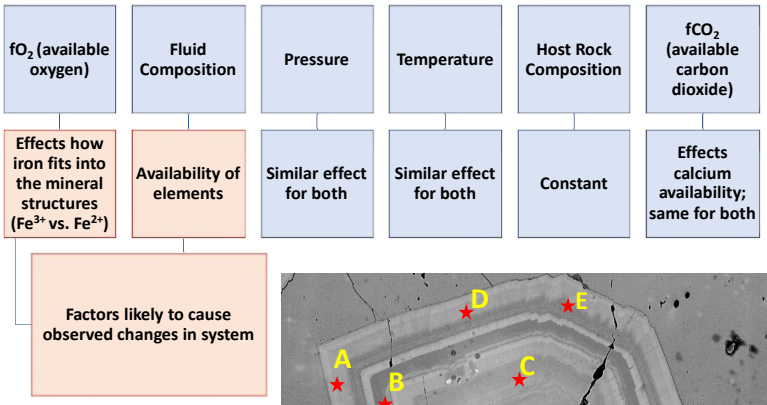
This project is giving a new meaning to "put a ring on it" with examining strange chemical growth rings in minerals. The minerals were collected from rock cores on Akutan Island, Alaska. This island is home to a volcano which has led to a hydrothermal (heated ground water) system underground.





The difference between epidote (Ep) and clinozoisite (Czo) is in the atomic structures.

What is causing the different compositions in each chemical zone?



Methodology: analyzing microscope slides of rocks

- Images and chemistry using WWU's scanning electron microscope (SEM)
- Chemical maps of sample 2-49-319-2 were made on WWU's SEM (Figure 5)
- Cathodoluminescence (CL) analysis at WWU (combines optical and SEM techniques; Figure 6)
- Laser ablation analyses of sample 2-49-319-2 was conducted on WWU's LA-ICP-MS (Figure 4)
- Electron Probe microanalysis (EPMA) at U. of Washington (Figures 1, 2, and 4A)

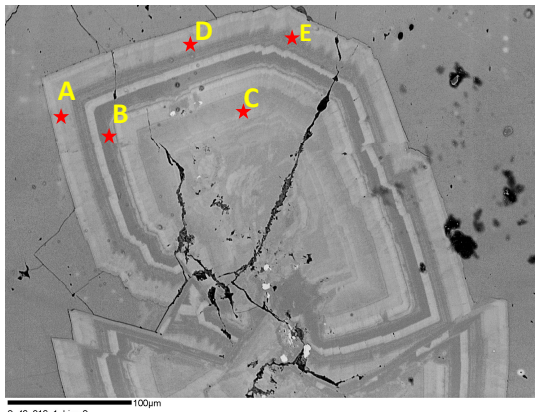
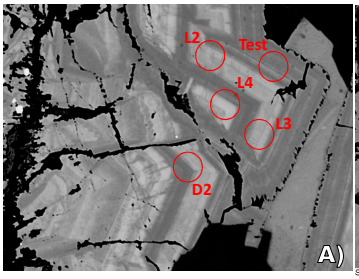
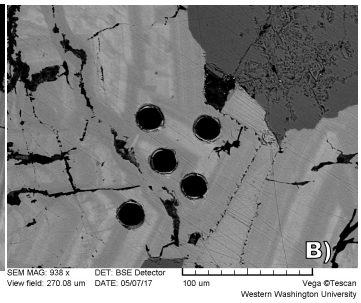


Figure 1: Large crystal of Czo showing growth patterns, taken at UW. Stars represent analysis locations. The dark bands represent iron-low bands and the light bands are iron-high bands.





Laser Hole	% Dark Band	% Light Band
Test	95	5
L2	20	80
L3	15	85
L4	25	75
D2	50	50

Figure 3: Table shows percentages of band color from photo A.

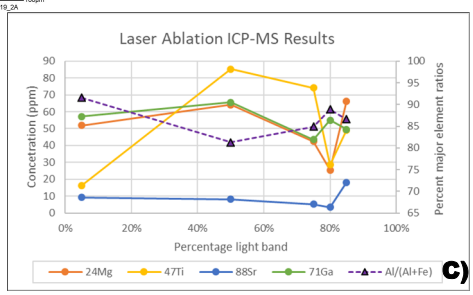


Figure Group 4: A) Images of Czo crystal before laser ablation (spot locations identified) and B) after, showing ablation pits. Note that the laser footprint is wider than each band, so each analysis has some amount of light and dark material present. C) Concentration of selected elements related to the amount of light or dark band ablated in each analysis.

Sample Letter on 2-49-319-1	Color of Band	Wt % Al_2O_3	Wt % FeO
A	Light	17.21	8.47
B	Dark	22.62	0.24
C	Dark	24.54	0.18
D	Light	18.88	6.75
E	Dark	24.5	0.88

Figure 2: Shows chemical relationship between iron and aluminum oxides in the light and dark bands of crystal 2-49-319-1. Zones analyzed can be seen in Figure 1.

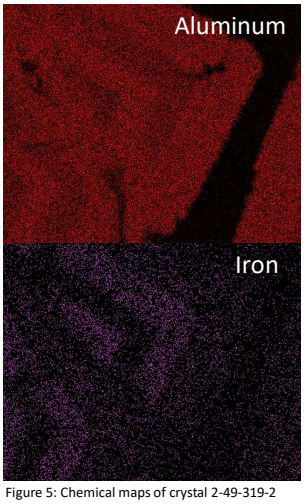


Figure 5: Chemical maps of crystal 2-49-319-2 showing concentrations of iron and aluminum.

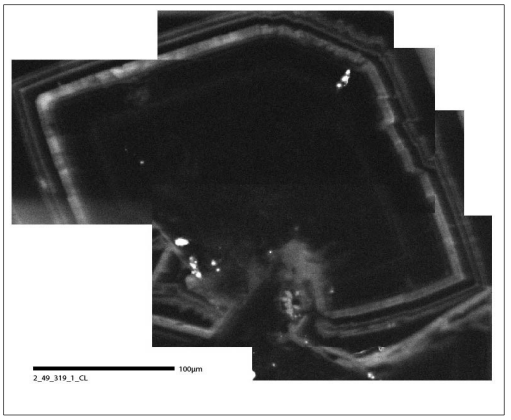


Figure 6: Same crystal as above but as shown in CL taken at WWU. Iron quenches the light, the iron rich bands are dark, and the iron poor bands are white.

Results

- Zoning patterns were found in each type of analysis
  - Zoning occurs when there is a change in chemical composition throughout a crystal
- Found many zoned crystals but used crystals with the widest, most distinct bands for microprobe, laser analysis
- Data from UW revealed the light bands have a higher Fe content than the dark bands (Figure 1) and in chemical maps (Figure 5)
- Trace elements vary substantially between different bands

Discussion

- Since the zones do not grade into each other, a rapid change in the system is causing the distinct boundaries between zones
- There is a trade off between Al and Fe in the bands. (Figures 2, 4c, 5). This supports changes in available free oxygen (oxygen fugacity)
- Trace elements change a lot between bands. This supports changes in fluid chemistry
- Conclusion: Bands are likely result of both changes in available oxygen and fluid composition

Outstanding Questions

- **Concluding question**: What causes the fluid to change?
  - Boiling? Changing fluid flow direction? Variable contributions of different fluids?

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