

The Palisade Rhyolite

Presented by Hannah Reed

NDSU Petrology GEOL 422

April 28, 2022

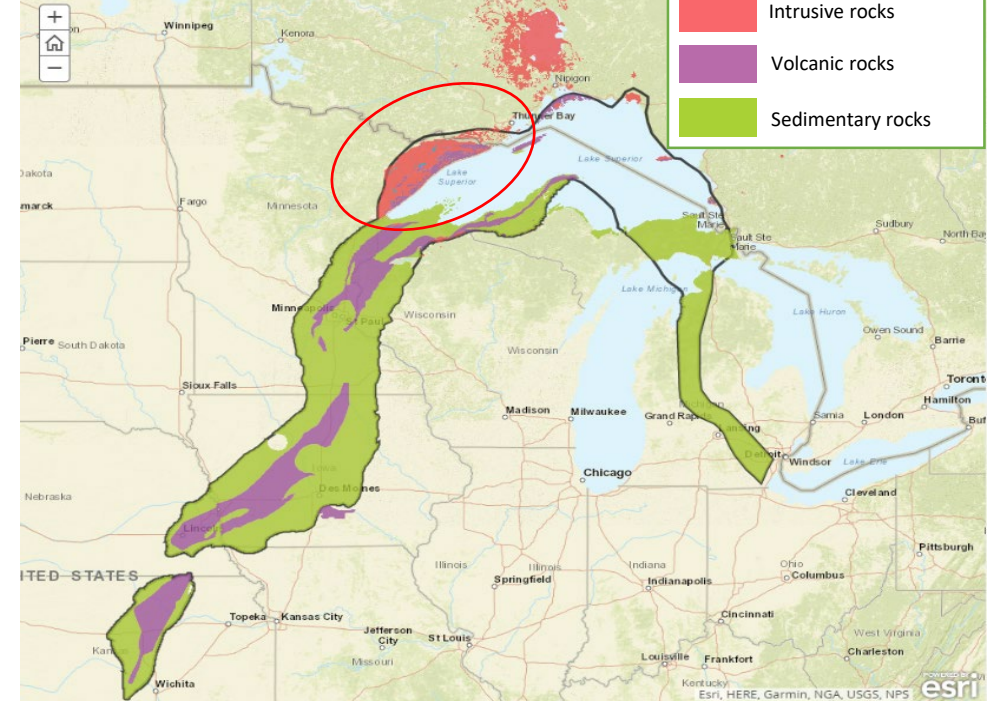


Overview

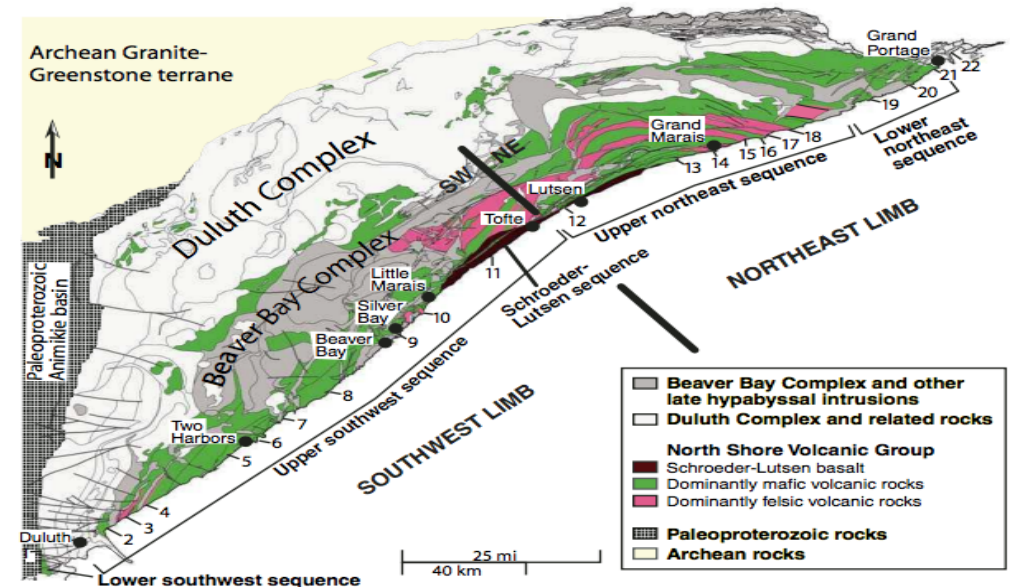
- Background
- Location
- The Palisade Rhyolite
- XRD
- SEM
 - Comparisons to data in literature
- Define rheognimbrite
- Felsic lavas in a mafic setting

Background

- Midcontinent rift (1.1 Ga)
- North Shore Volcanic group
 - plateau lava sequence, 7-9 km thick (Green et al. 2011)
 - exposed at the southwestern sequence along the north shore of Lake Superior
 - includes an unusually large proportion (10-25%) of felsic flows (Green and Fitz 1993)



Mid continental rift, USGS



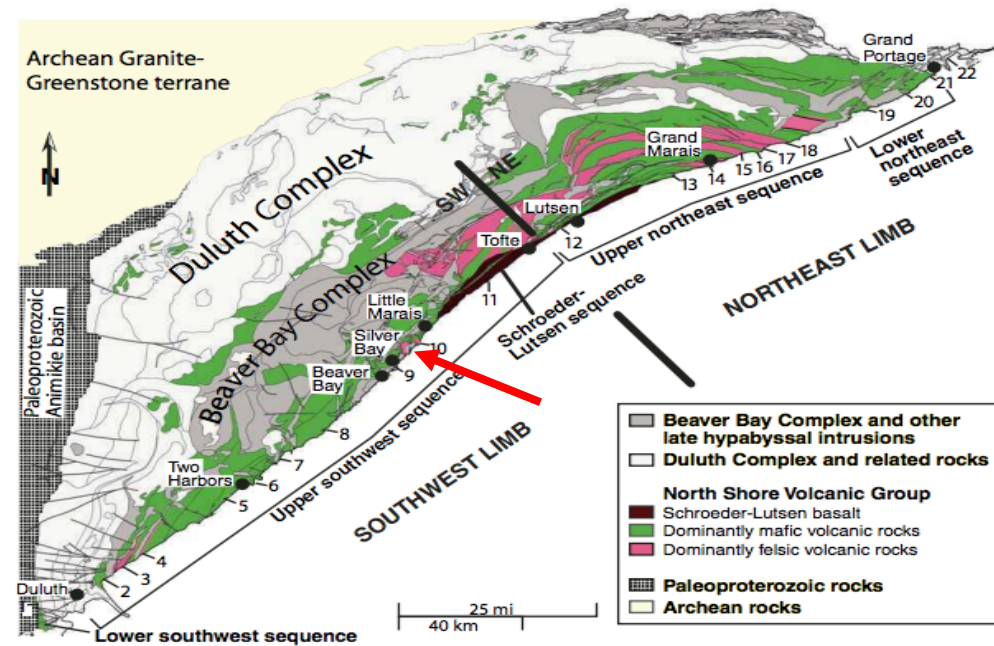
Green et al. (2011)

Location

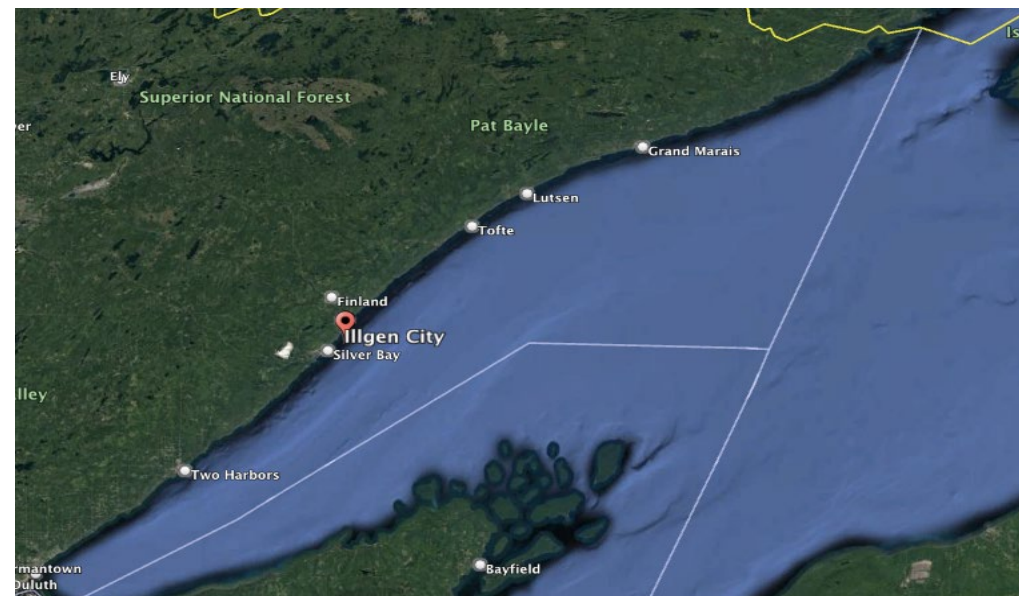
- Located in the upper southwest limb of the North Shore Volcanic Group near Illgen City



Near intersection of MN-61 and State Highway 1 (Google Earth)



Green et al. (2011)



Google Earth

The Palisade Rhyolite

- Porphyritic, pink to reddish-purple fine-grained matrix with angular phenocrysts and lighter colored flow banding
- Consists of about 5-10% phenocrysts of alkali feldspar, cubic quartz, oxidized iron silicates, sanidine, zircon, and magnetite (Green and Fitz, 1993)



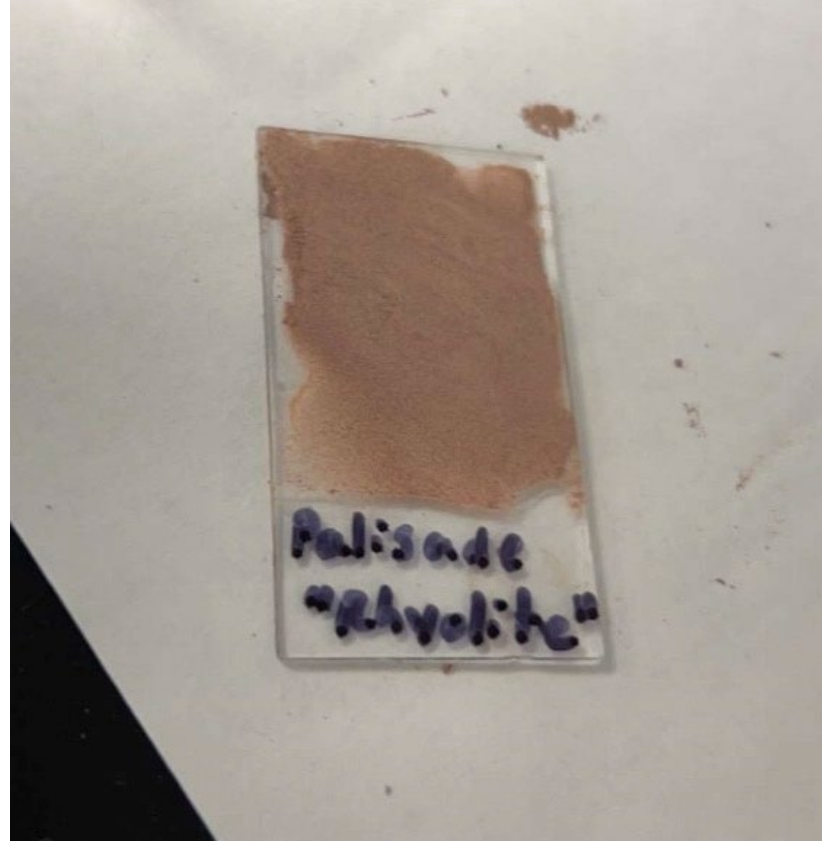


Illustration by Rick Kollath



Research Interests

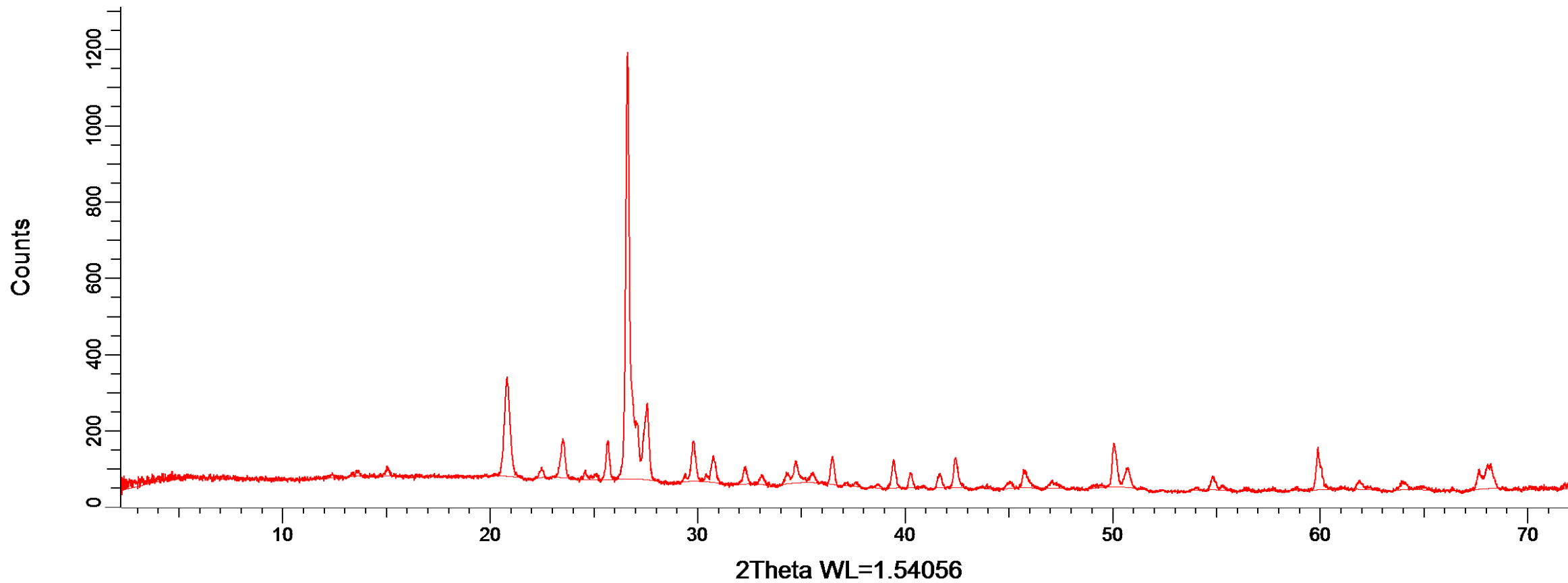
- Are the phenocrysts tridymite or quartz pseudomorphs?
- How does my sample composition compare to compositions in literature?
- Rhyolite or rhyodacite?
- How does such a high percentage of felsic rocks exist in a predominantly mafic setting?



X-Ray diffraction

- XRD irradiates a material with incident X-rays and then measures the intensities and scattering angles of the X-rays that leave the material (JoVE Science Education Database, 2022)
- Used XRD to uncover the mineralogy of the palisade rhyolite

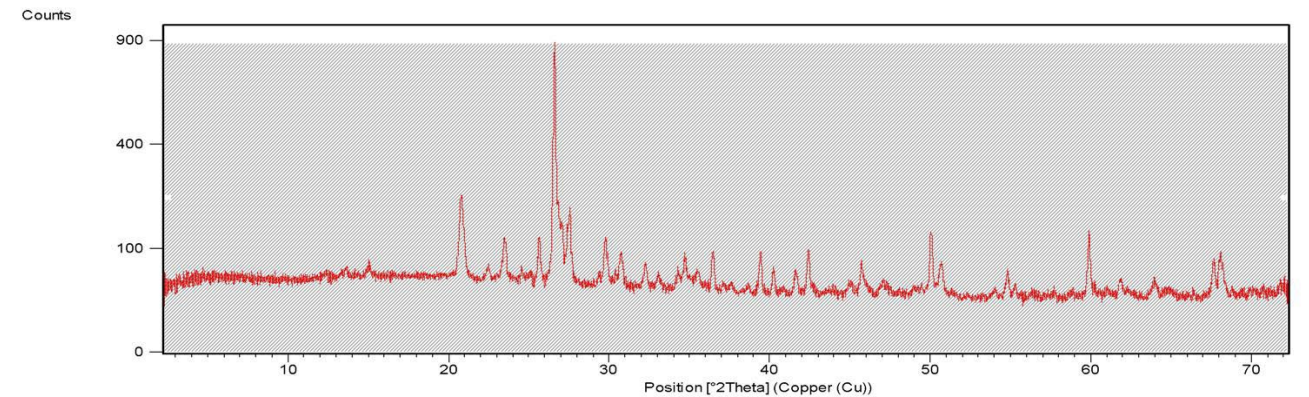
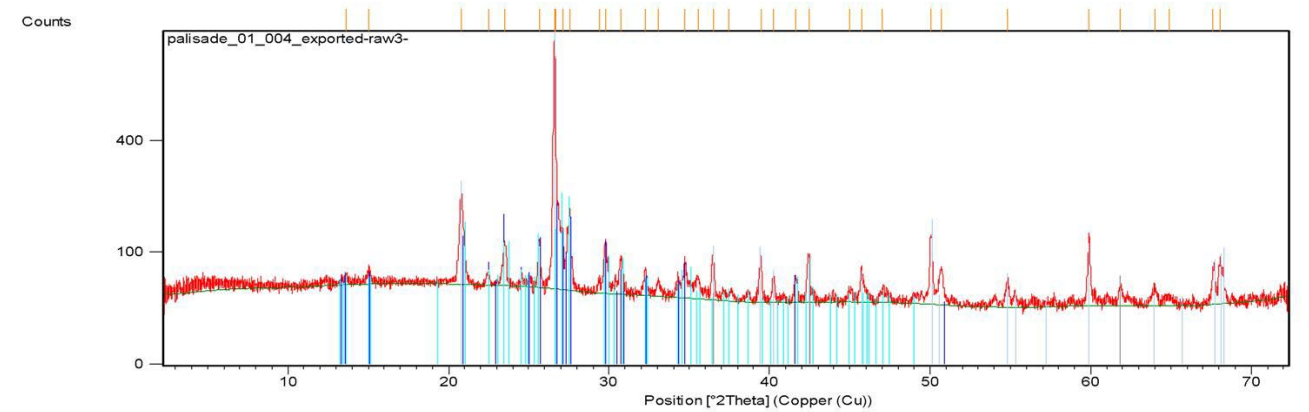
XRD Data



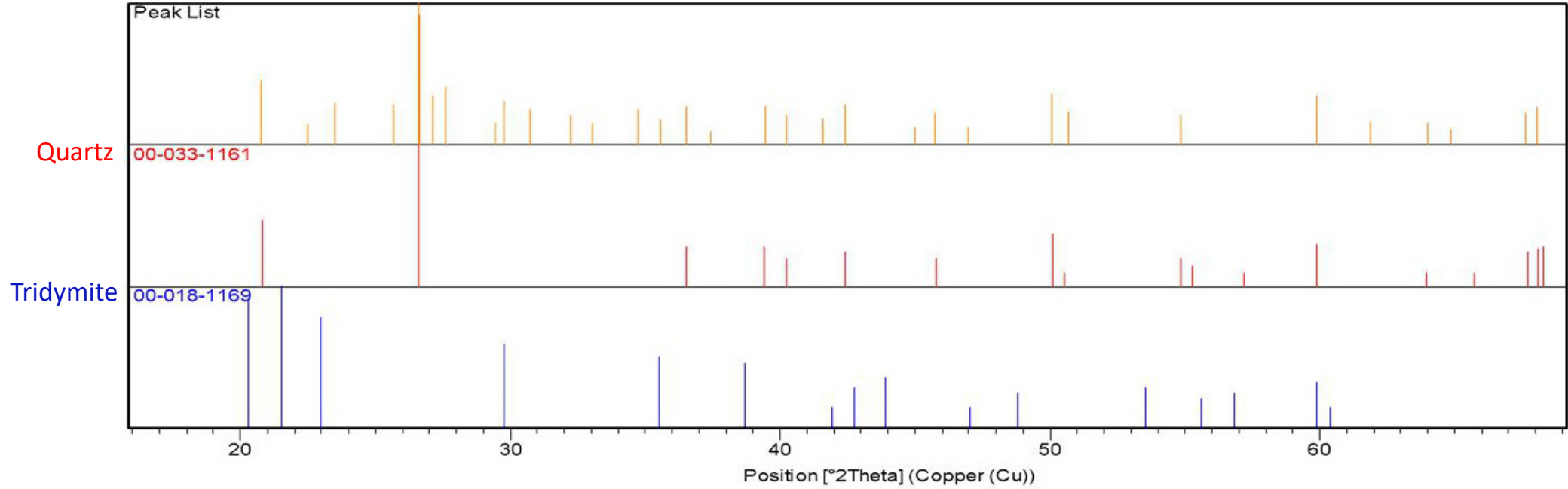
XRD Data (cont.)

- Low quartz
- Microcline
- Sanidine
- Periclase

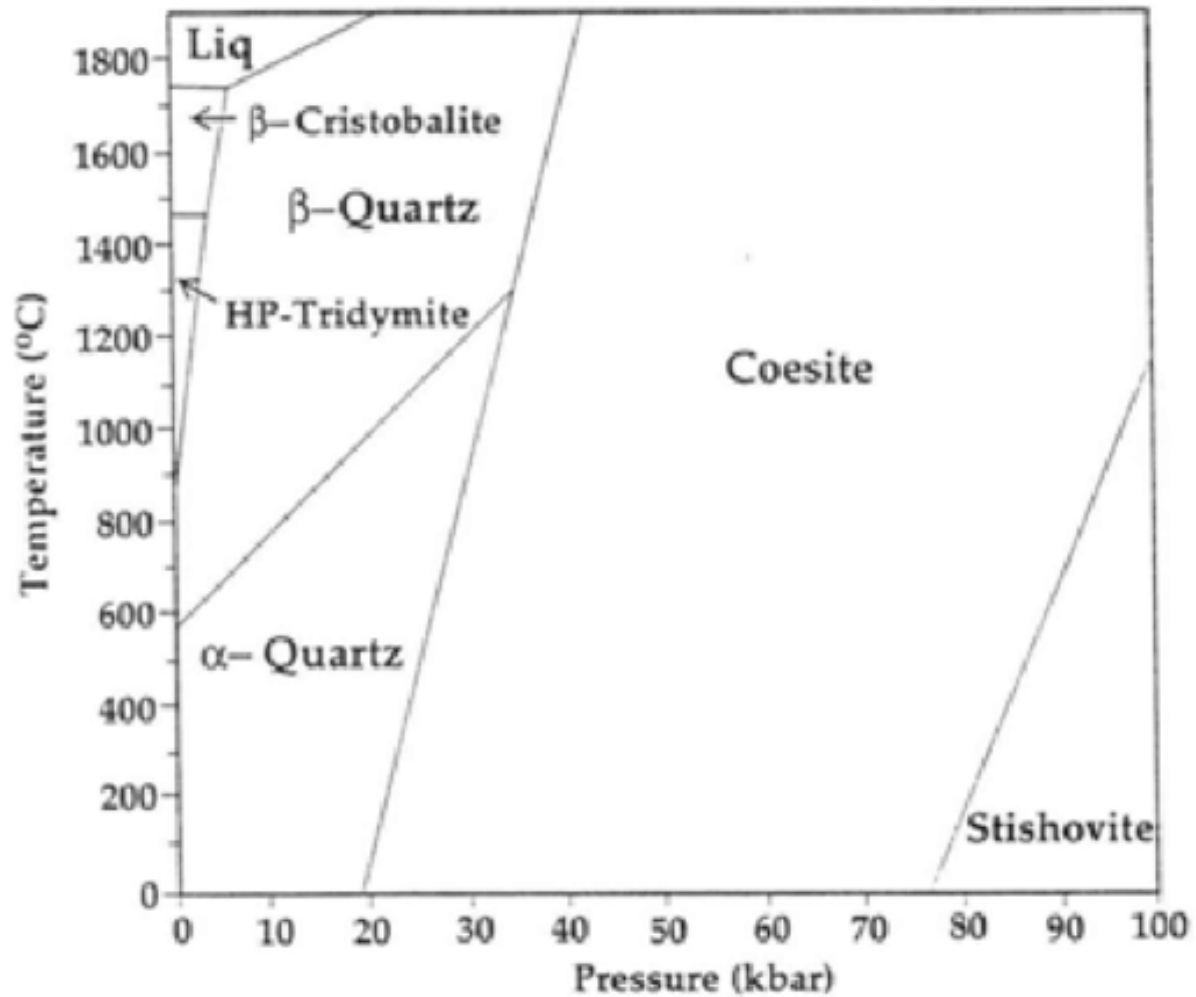
Date: 4/27/2022 Time: 6:36:10 PM File: palisade_01_004_exported-raw3- User: geosci

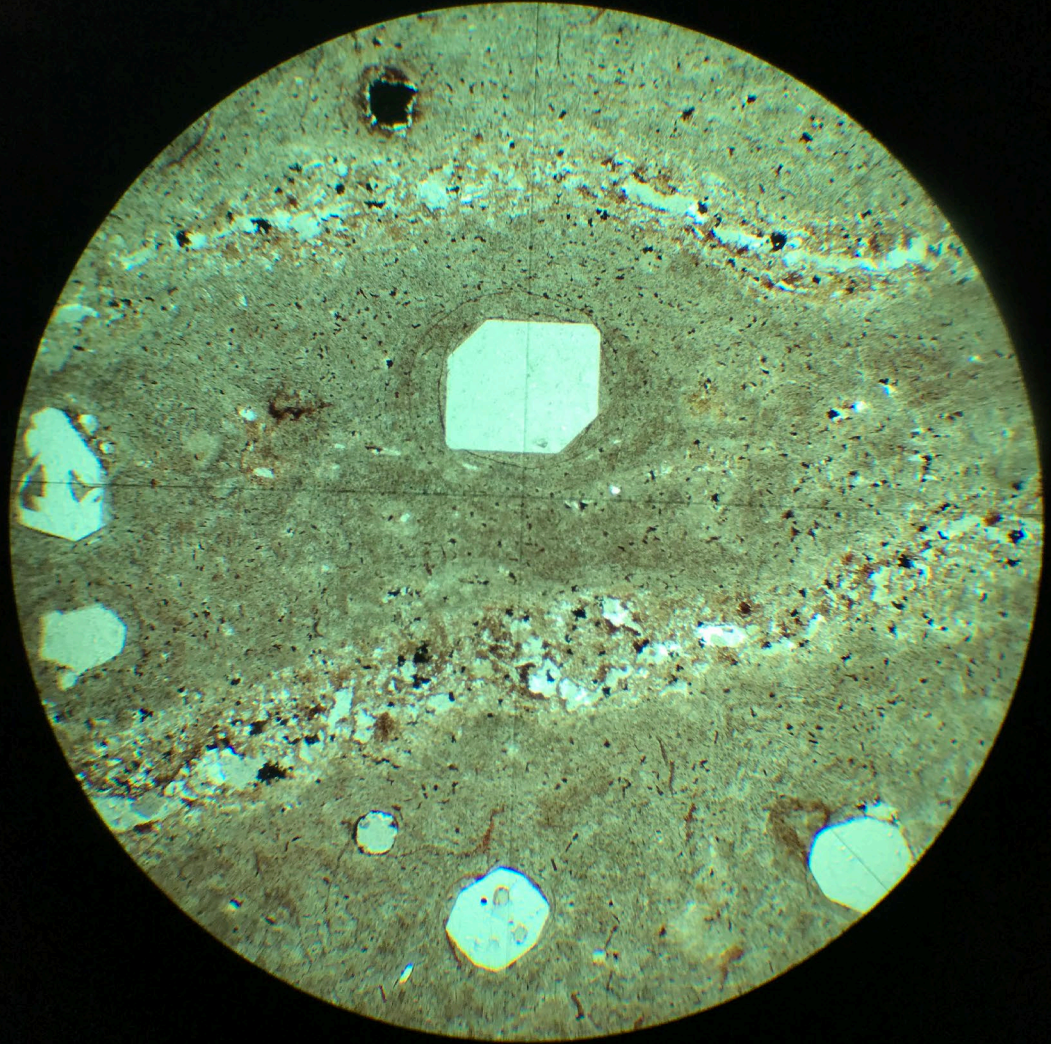


XRD Data (cont.)



Silica phase diagram

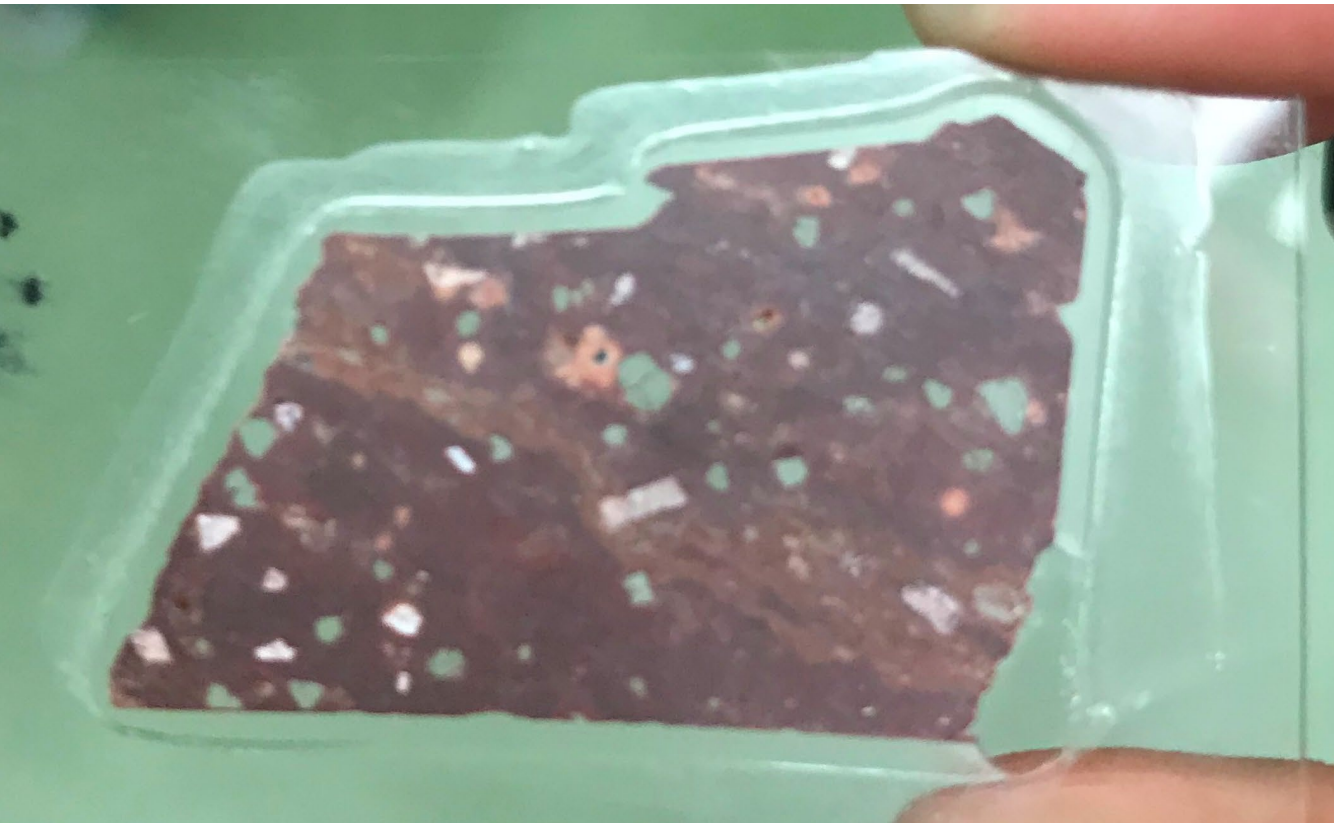




FOV: 4 mm

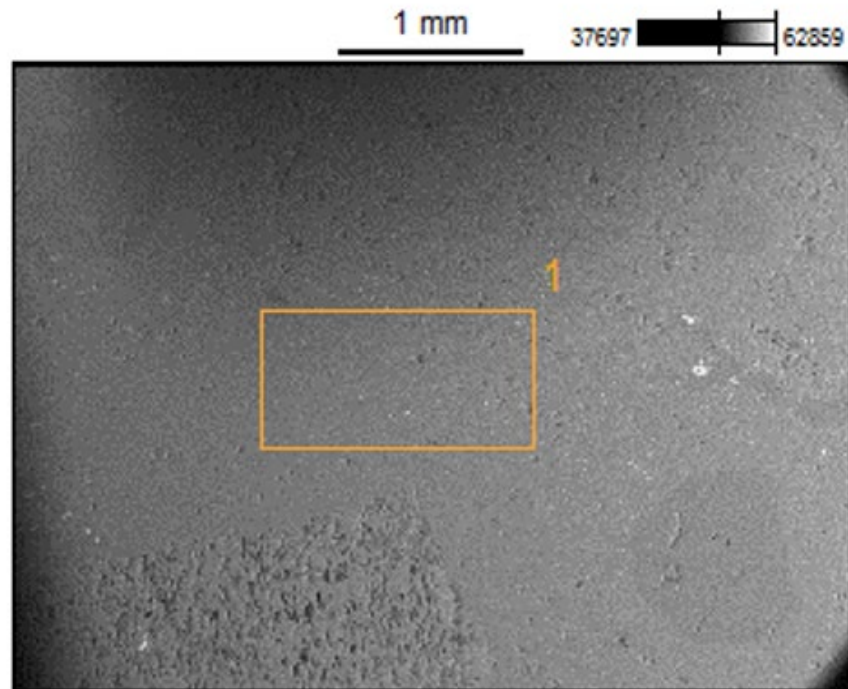
Scanning electron microscope

- A scanning electron microscope (SEM) is a type of microscope which uses a focused beam of electrons to scan a surface of a sample to create a high-resolution image. SEM produces images that can show information on a material's surface composition and topography. ((JoVE Science Education Database, 2022)
- Used SEM to gather data on whole rock compound composition
- Compare results to those of Green & Fitz (1993) and Grout, Sharp, & Schwartz (1959)

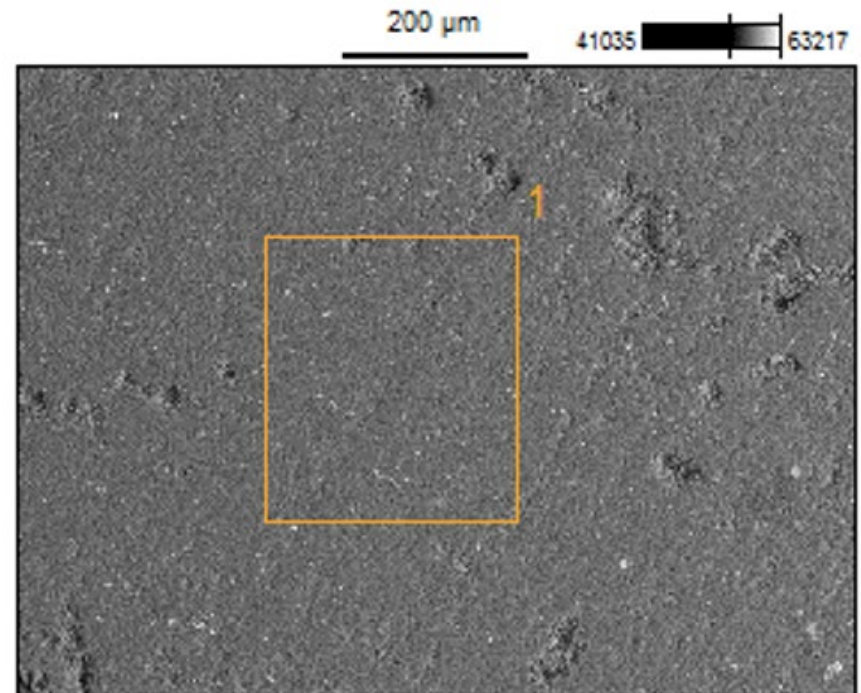


Scan locations

220600 PAL-RHY(3)



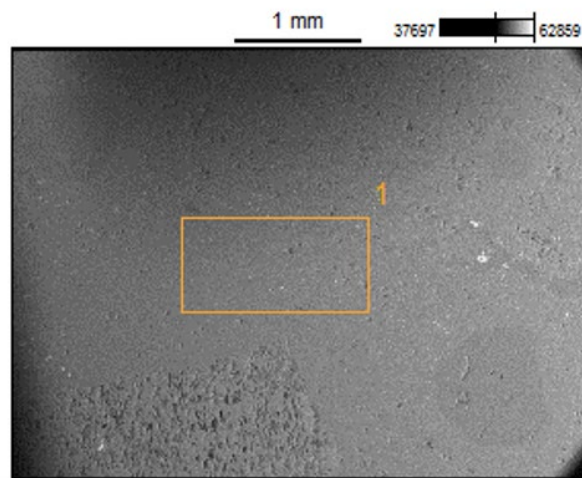
220600 PAL-RHY(5)



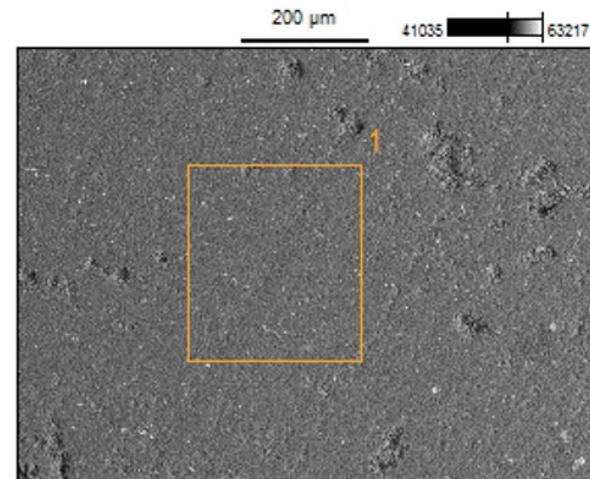
Data

Compound %	PAL-RHY(3)	PAL-RHY(5)	Average
Na ₂ O	0.57	0.43	0.5
Al ₂ O ₃	9.68	8.91	9.30
SiO ₂	80.88	81.82	81.35
K ₂ O	7.2	6.76	6.98
FeO	1.67	2.08	1.88

220600 PAL-RHY(3)



220600 PAL-RHY(5)

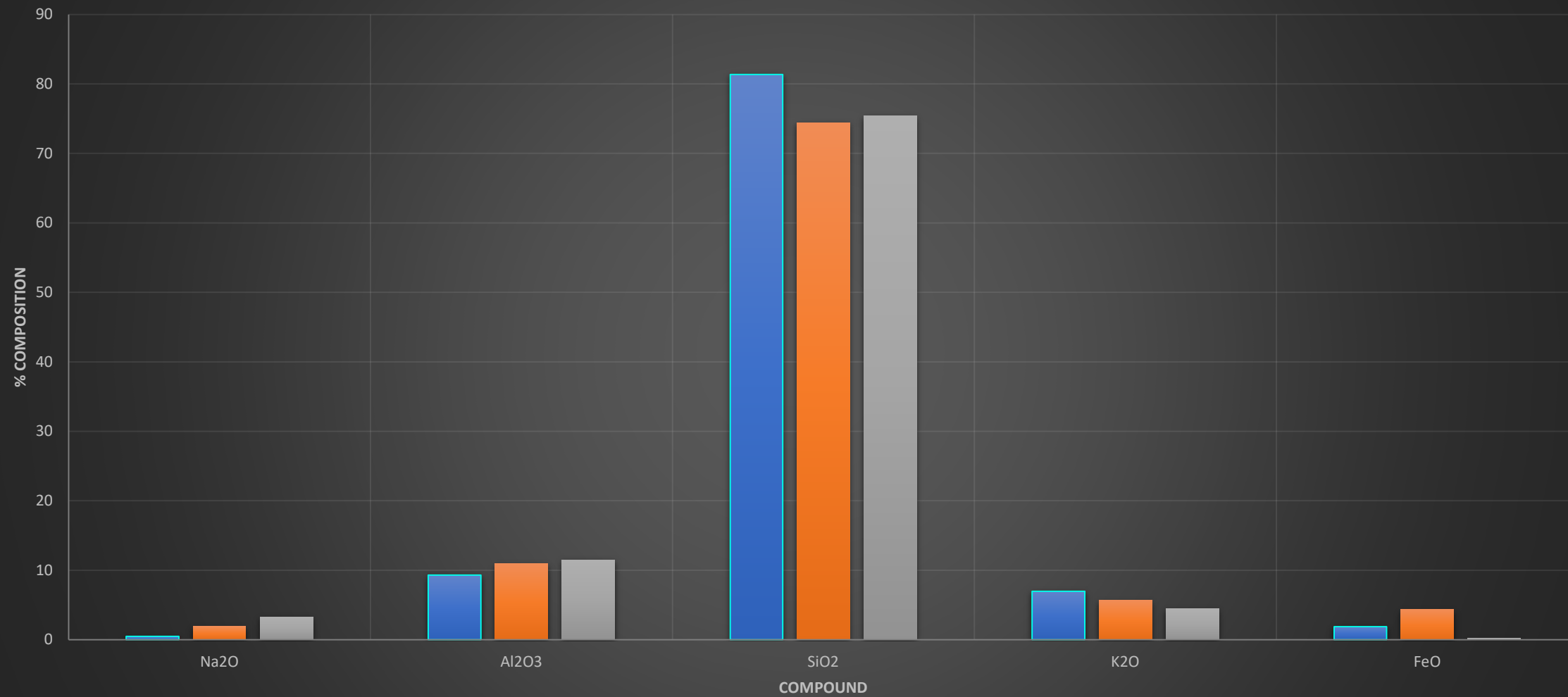


Relating data to literature



Compound %	My Data	Green & Fitz (1993)	Grout, Sharp, & Schwartz (1959)
Na ₂ O	0.5	1.93	3.33
Al ₂ O ₃	9.3	10.95	11.53
SiO ₂	81.35	74.41	75.4
K ₂ O	6.98	5.64	4.44
FeO	1.88	4.38	0.22

Palisade Rhyolite % Composition of Compounds

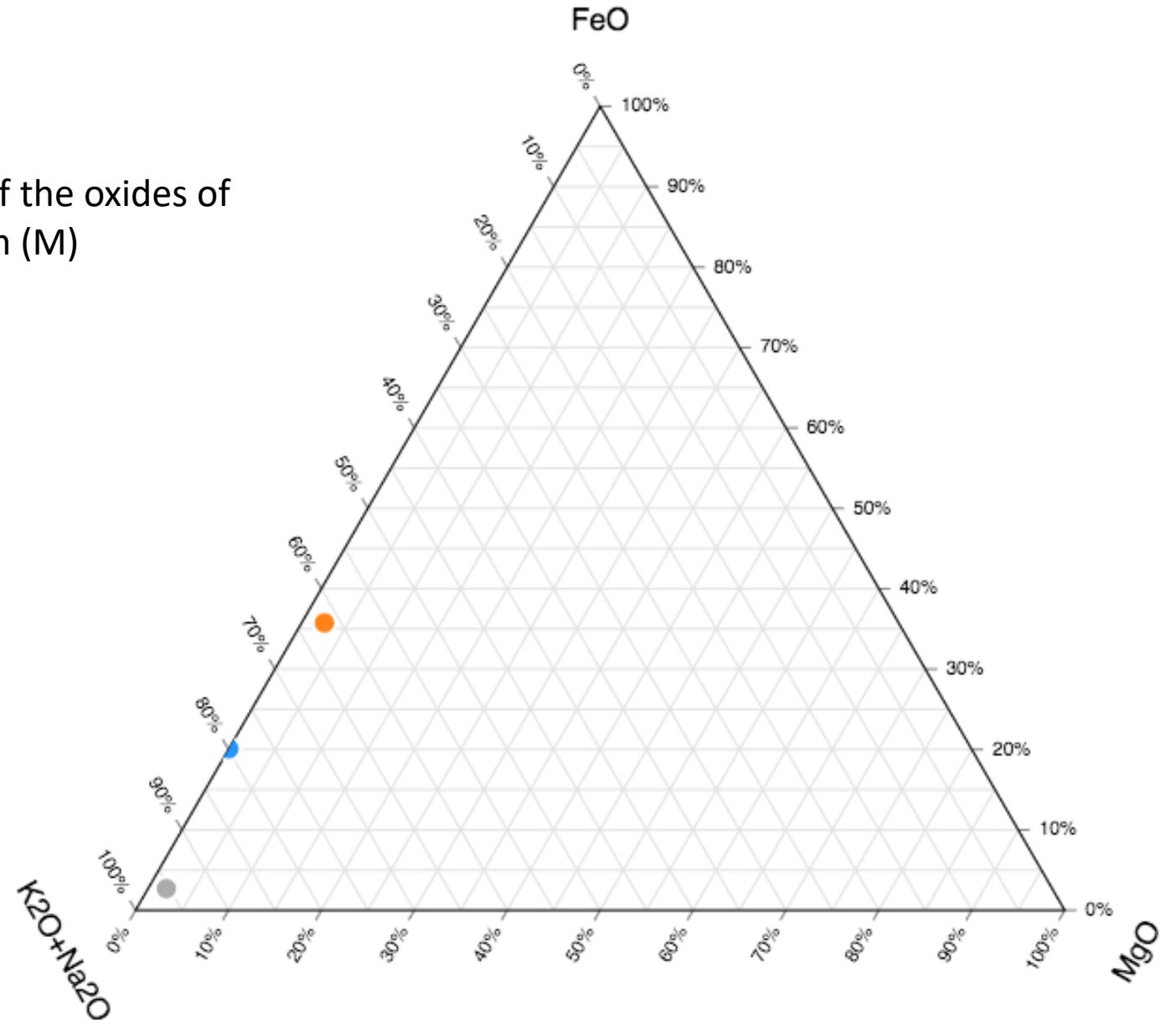


■ My Data ■ Green & Fitz (1993) ■ Grout, Sharp, & Schwartz (1959)

AFM diagram

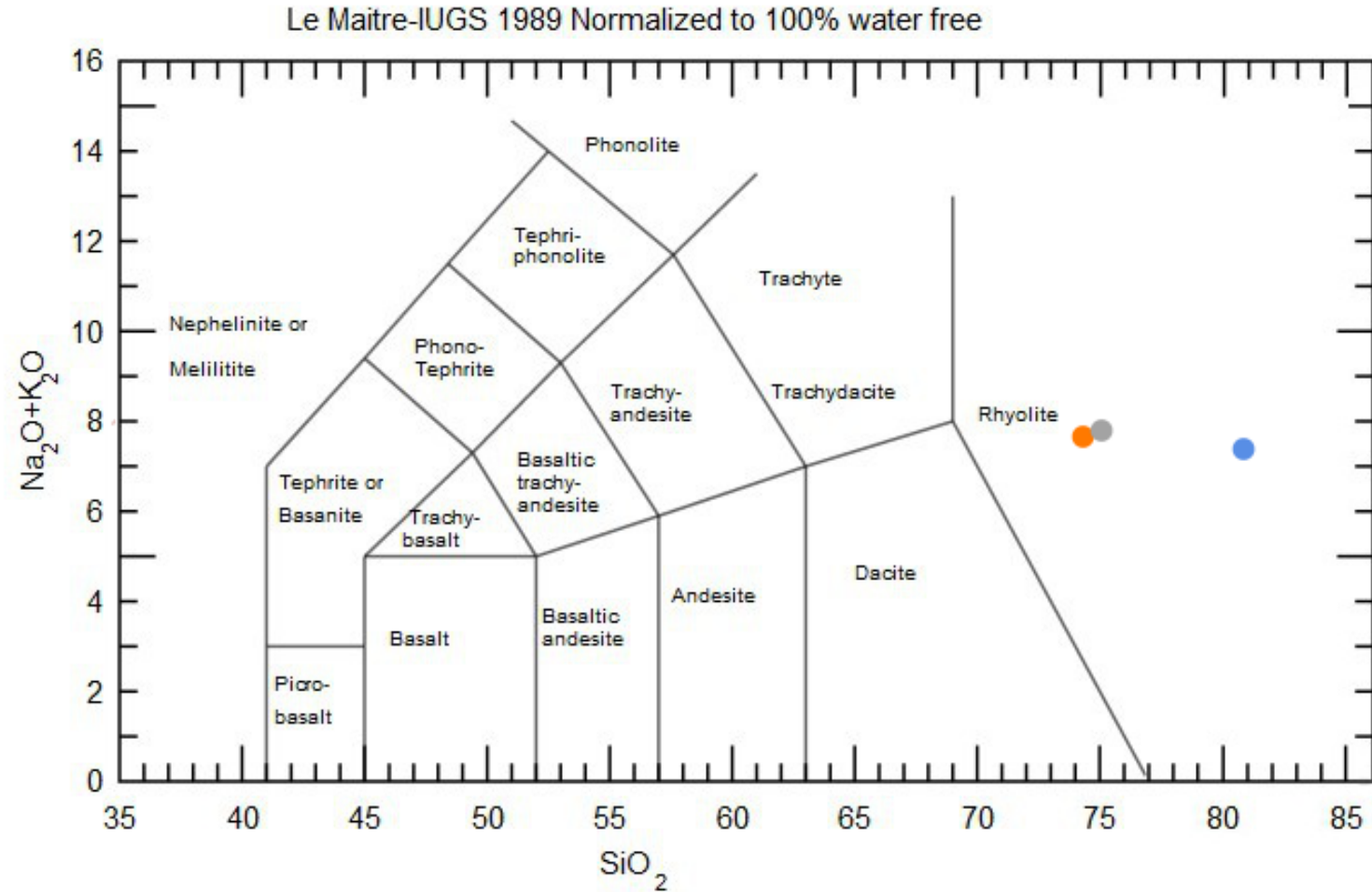
Displays the relative proportions of the oxides of alkalis (A), iron (F), and magnesium (M)

- My data
- Green & Fitz (1993)
- Grout, Sharp, & Schwartz (1959)



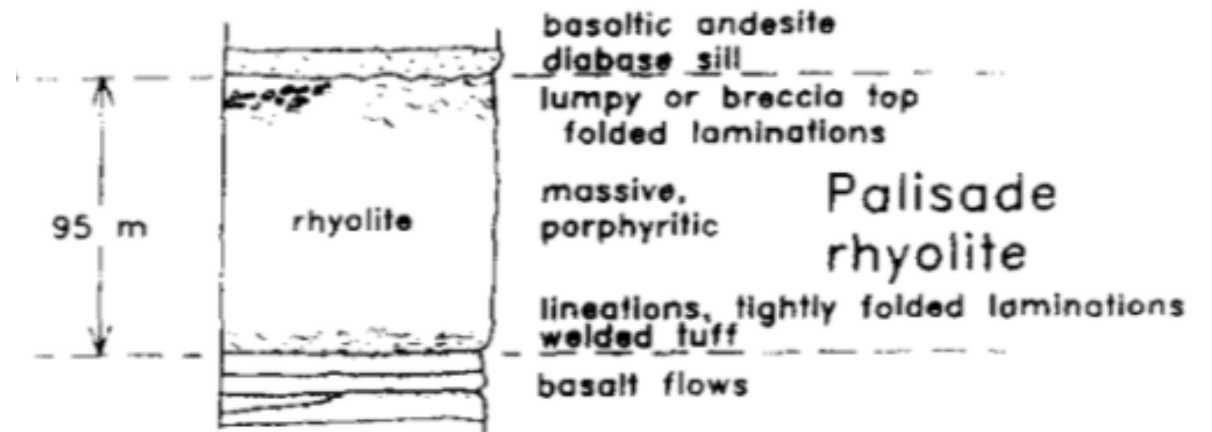
TAS diagram

- My data
- Green & Fitz (1993)
- Grout, Sharp, & Schwartz (1959)



Rheoignimbrite

- Defined as a welded volcanic ash or tuff that has been remobilized due to flow. (Miller et al., 1999)
- Lowest region of palisade rhyolite is a welded tuff, made evident by the very closely packed “devitrified glass shards and collapsed pumice fragments which are wrapped around quartz and sanidine phenocrysts” (Green et al., 2011)
- Has an origin of a rheoignimbrite that existed at a very high temperature at about 900-1100 degrees Celsius. (Green and Fitz, 1993)



Stratigraphic section of the Palisade rhyolite. (Green and Fitz, 1993)

How does such a high percentage of felsic rocks exist in a predominantly mafic setting?

- Vervoort et al. 2007
 - Correlated granophyre ages to those of rhyolite ages in the NSVG using neodymium isotopic signatures
 - Early-stage midcontinent rift magmatism occurred 1109-1106 Ma and is “characterized by mafic mantle-derived magmas with minor amounts of silicic magmas.” (Vervoort et al. 2007)
 - Main magmatism stage resumes at around 1100 Ma, “with voluminous basaltic volcanism and mafic intrusions. The silicic magmas produced during this stage are more abundant and distinctly more crustal in character than during the early magmatic stage magmas. We suggest that these silicic magmas have been derived from partial melts of more evolved crustal sources, perhaps at higher levels in the crust.” (Vervoort et al, 2007)

Conclusions

- Palisade rhyolite contains cubic quartz pseudomorphs that were initially tridymite, which transformed due to a decrease in temperature.
- My sample contains a higher silica concentration than Green and Fitz and Grout with lower concentrations of alkalis.
- The composition is rhyolitic but the magmatic processes by which it formed as well as its characteristics classifies the palisade rhyolite as a rhyolite with a rhyolitic composition.
- Felsic lavas may have been derived from the partial melting of crustal sources during the later stage magmatism of the midcontinent rift.

References cited

Green, J.C., & Fitz, T.J. (1993). Extensive felsic lavas and rheognimbrites in the Keweenawan Midcontinent Rift plateau volcanics, Minnesota: petrographic and field recognition. *Journal of Volcanology and Geothermal Research*, 54, 177-196.

Grout, Frank F.; Sharp, Robert P.; Schwartz, George M.. (1959). Bulletin No. 39. The Geology of Cook County Minnesota. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, <https://hdl.handle.net/11299/57040>.

John C. Green, Terrence J. Boerboom, Susanne Th. Schmidt, Thomas J. Fitz, 2011. "The North Shore Volcanic Group: Mesoproterozoic plateau volcanic rocks of the Midcontinent Rift System in northeastern Minnesota", *Archean to Anthropocene: Field Guides to the Geology of the Mid-Continent of North America*, James D. Miller, George J. Hudak, Chad Wittkop, Patrick I. McLaughlin

Miller, J.D., Jr., Tipping, B., and Green, J., 1999, Geology and geohydrology of the North Shore and Gunflint Trail: St. Paul, MN, AIPF-MGWA-AWG Fall Field Trip Guidebook. Minnesota Geological Survey.

Vervoort, J. D., Wirth, K., Kennedy, B., Sandland, T., & Harpp, K. S. (2007). The magmatic evolution of the Midcontinent rift: New geochronologic and geochemical evidence from felsic magmatism. *Precambrian Research*, 157(1–4), 235–268. <https://doi.org/10.1016/j.precamres.2007.02.019>

JoVE Science Education Database. *Materials Engineering*. X-ray Diffraction. JoVE, Cambridge, MA, (2022).

Aasly, Kurt & Malvik, Terje & Myrhaug, E.. (2007). Advanced methods to characterize thermal properties of quartz. INFACON. 11.