Crystal Size Distribution Analysis of the Half Dome Pluton in Yosemite National Park

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Introduction

The Half Dome pluton in Yosemite National Park exhibits equigranular and porphyritic domains separated by a mostly gradational contact between the two. The textures between the two cannot be explained by neither their geochemistry nor their modal mineralogy. I propose to perform a crystal size distribution analysis on both textural domains to gain insight into the cause of the textural differences. Crystal size distribution (CSD) analysis is a valuable tool to aid in linking the crystal textures to the crystallization kinetics and the nucleation of the crystals. Using CSD analyses, it is possible to determine the physical and chemical changes and processes igneous rocks undergo during their formation.

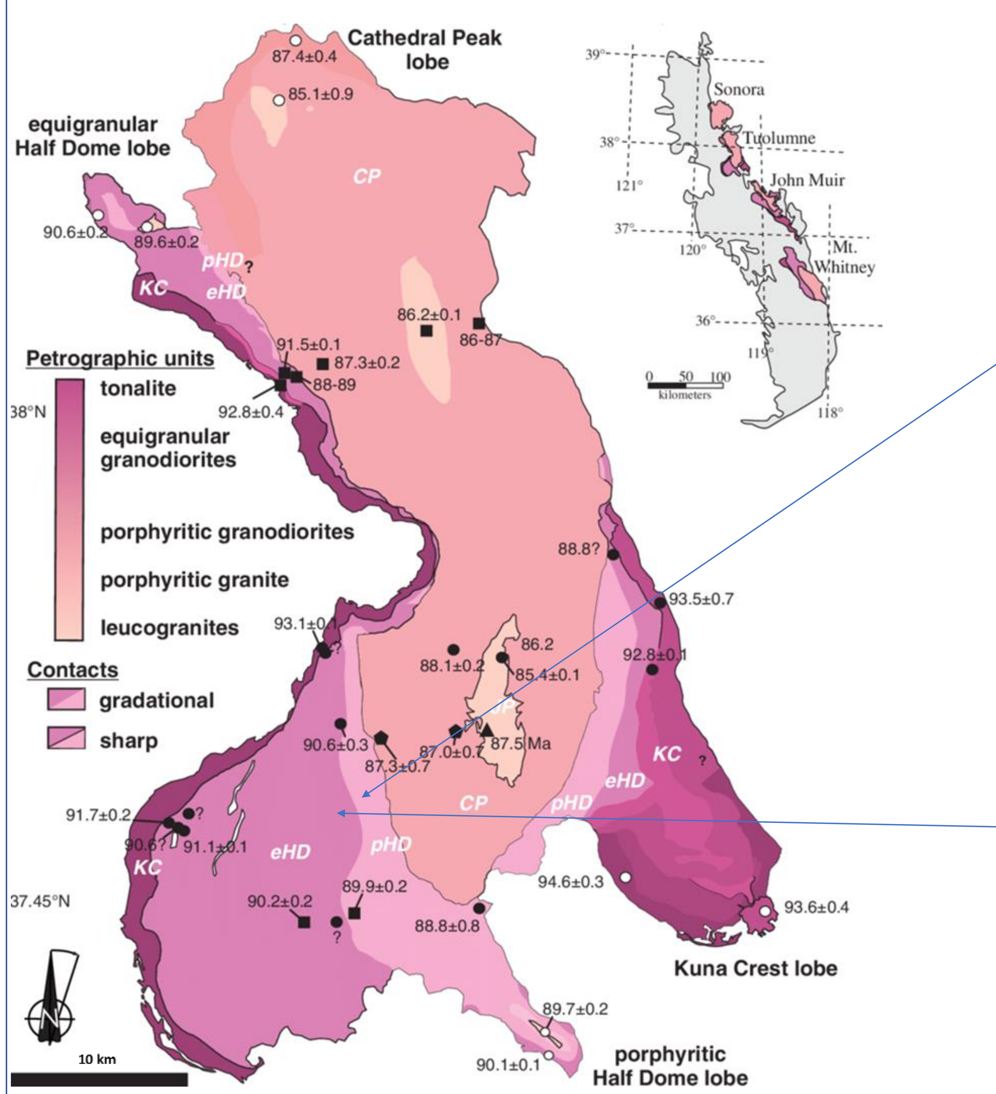


Figure 1 : Geologic map of the Tuolumne Intrusive Suite (modified from Huber et al., 1989) with detailed lobe mapping (from Memeti et al., 2010). The numbers on the map are U-Pb zircon radiometric ages (in millions of years).

Porphyritic (top) and equigranular (bottom) Half Dome samples.

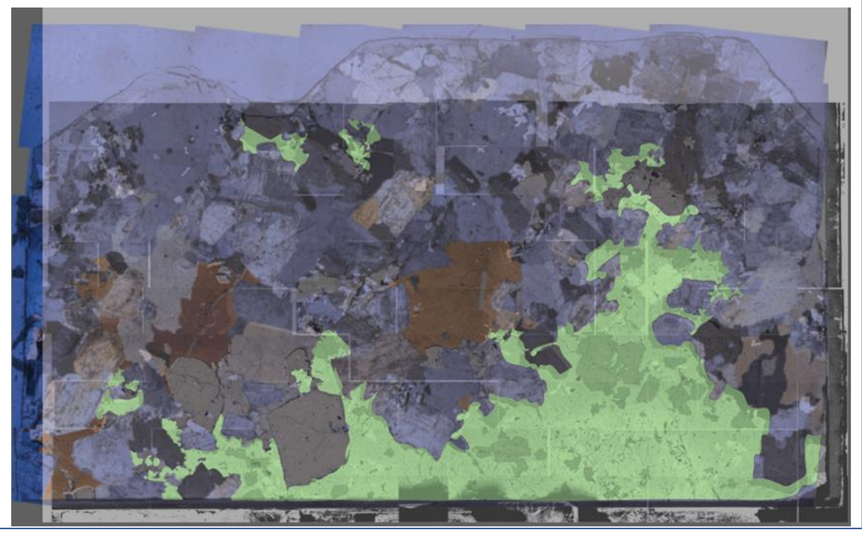
Hypothesis

The CSD plots of the equigranular and porphyritic Half Dome will be different, with the porphyritic Half Dome showing a change in slope consistent with the accumulation direction due to the presence of phenocrysts when compared to the equigranular Half Dome.

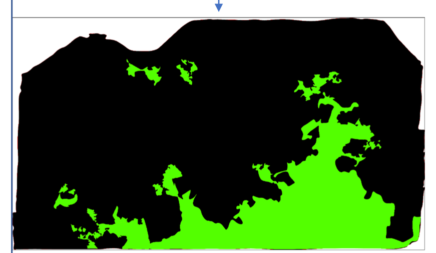
Methods and Results

Thin sections of both the equigranular and porphyritic domains will be photographed in cross polarized light and used in conjunction with backscatter electron images to distinguish between the minerals present. The images will be mosaiced together in Adobe Illustrator where all the alkali feldspar crystals will be highlighted. Images of the alkali feldspar will be transferred to Fiji, an image analysis program, to calculate the total area of each of the alkali feldspar grain, the number of grains and their percent of the total area of the thin section. The area data will then be uploaded into the program CSDCorrections (Higgins, 1999) that converts the 2-dimensional areas into 3 dimensional volumes. CSDCorrections takes the measurements of the long and short axes of the intersected cut through a plugin in Fiji called CSD output and compares them to an ellipsoid or parallelepiped. The program then calculates a best fit for the 2-dimensional ratio with known crystal shapes after which crystal size distribution plots will be created for analysis.

Figure 2: Superimposed photomicrograph and backscatter electron image. Alkali feldspar is highlighted in green. Field of view is 47 mm wide.



Upload image* → Convert image to 8-bit → Set measurement scale → Highlight all the grains needed for analysis → Analyze the grains to get the number of grains, area of each of the grains and total area of alkali feldspar



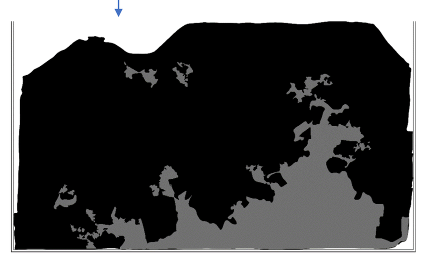


Figure 3: Flowchart detailing the process involved in Fiji, the image must first be converted to 8-bit, the measurement scale must be accurate, the threshold must be changed to highlight the portion needed for analysis then the analysis can be run.

Figure 4: A schematic of a CSD plot showing the relationship between the grain size and nucleation. Interpretation of crystal size distribution graphs is based off location of the y intercept and the shape of the slope.

G=growth rate, t= growth time, n= population density.

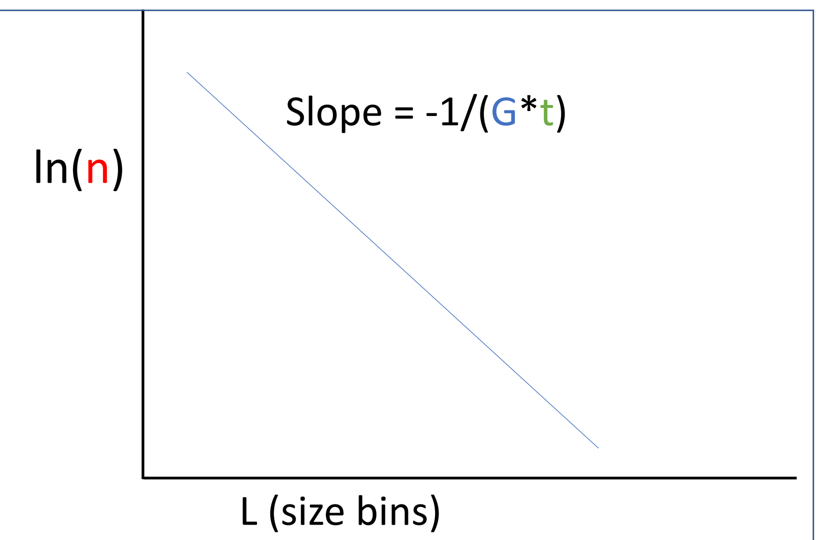


Figure 5: Diagram from Higgins (1999) shows different ways to interpret changes in crystal size distribution patterns based on slope and intercept changes. Movement of the y-intercept and kinking or curvature of the slope are formed by different physical and/or chemical processes that form textures.

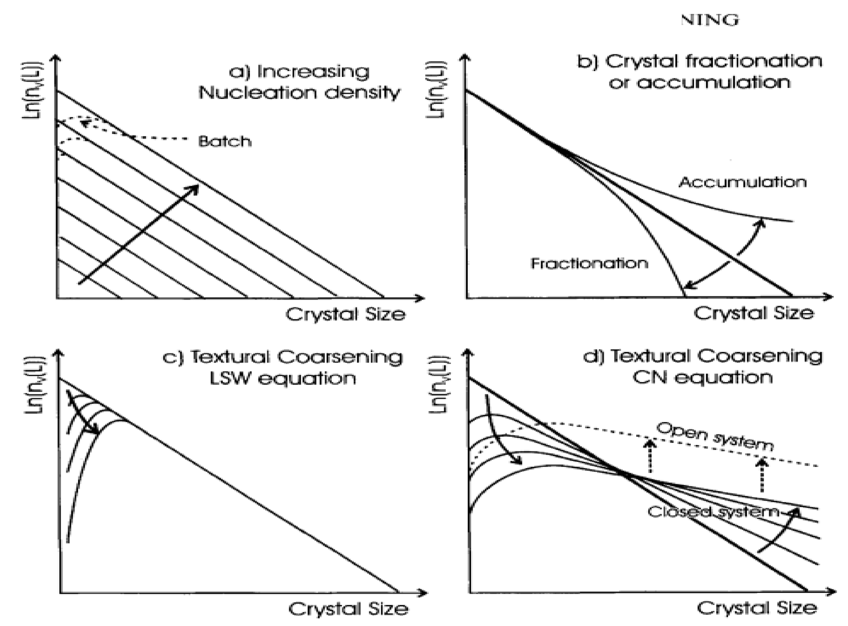
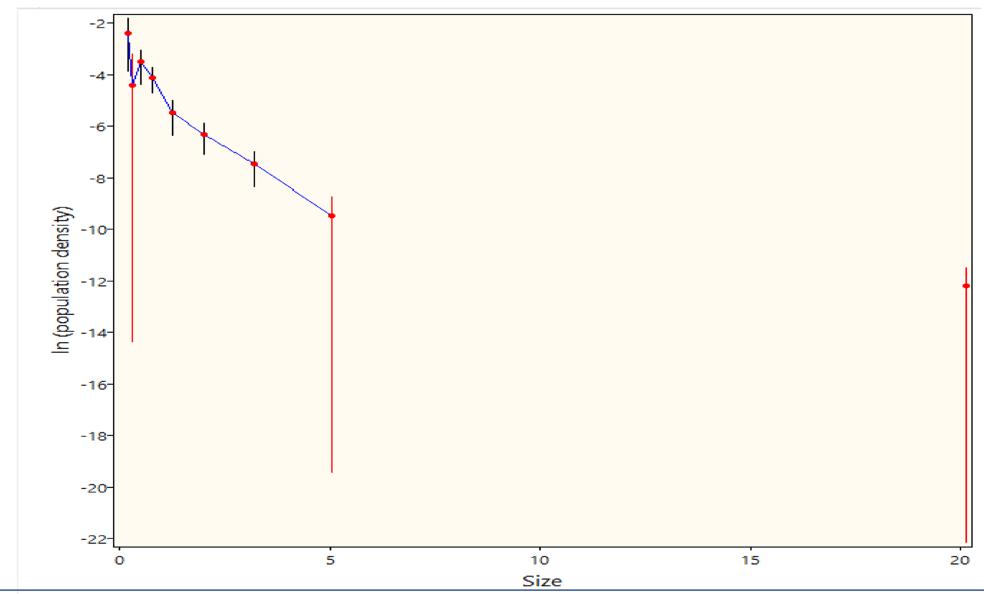


Figure 6 : Preliminary crystal size distribution plot of the porphyritic thin section. Y axis is the natural log of the population density while the x axis are the size bins. The slope is concave up, consistent with crystal coarsening and/or accumulation.



Conclusions

- The porphyritic domain is most likely not just a natural continuation of the equigranular domain.
- The porphyritic domain shows kinking in the slope, indicating that some process occurred that caused either crystal accumulation and/or textural coarsening.

Next semester, phenocrysts from rock slabs and possibly more thin sections of the porphyritic domain will be analyzed to create a more definitive plot that will help determine the cause of the kinking.

Work next semester on thin sections from the equigranular domain will allow for a basis of comparison.

References

Higgins, M.D. (1999) Origin of megacrysts in granitoids by textural coarsening: a crystal size distribution (CSD) study of microcline in the Cathedral Peak Granodiorite, Sierra Nevada, California. Geologic Society, London, Special Publications 168, 207-219.

Memeti, V, et al (2010) Magmatic lobes as "snapshots" of magma chamber growth and evolution in large, composite batholiths: An example from the Tuolumne intrusion, Sierra Nevada, California. GSA Bulletin 122, 1912-1931.

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