Major, Trace and Rare Earth Elements in Minerals in a Dike in the Tuolumne Batholith

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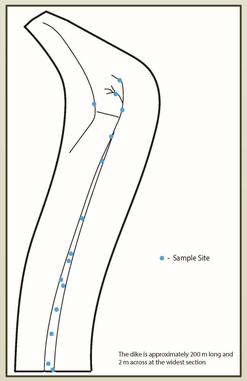
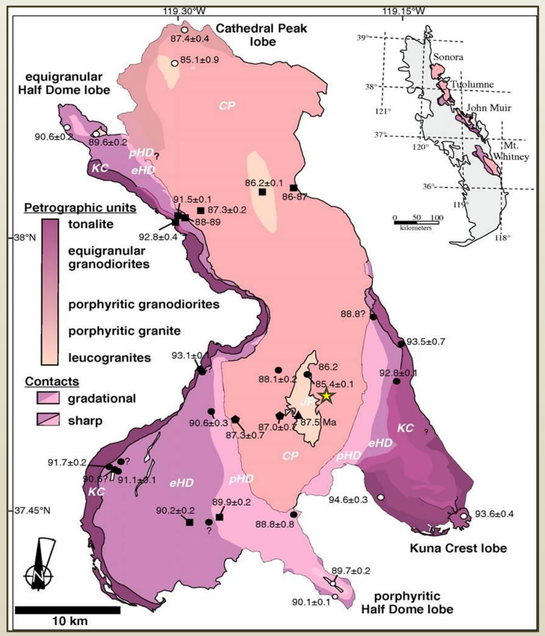
Abstract

The focus of this study is a dike that crops out on Lembert Dome, part of the Tuolumne Batholith. The batholith displays concentric compositional and textural zoning, with has been interpreted to be the result of fractionation by some researchers (Bateman and Chappell, 1979). The dike varies in width along its ~200 m length. The wide end of the dike, interpreted to be proximal to the source, has a mineralogy nearly identical to the host Cathedral Peak granodiorite. At the more distal end of the dike, the mineralogy and texture change, and there includes the presence of tourmaline and garnet. I expect to see higher concentrations of trace and rare earth elements in minerals in the distal end. I also expect to see mineral zoning and fractionation across the width and along the length of the dike. EPMA and LA-ICP-MS will be used to characterize the chemical composition of the minerals in various locations on the dike and to measure the concentrations of rare earth and trace elements in the constituent minerals. By measuring the variation in chemical composition and identifying zoning in the constituent minerals of the dike, I will be able to interpret the role fractionation may have in its formation.

Right: Map of the Tuolumne Batholith (modified from Paterson et al., 2011). Lithologies, textures, ages (U-Pb zircon) and the nature of contacts have been noted. A star denotes the location of Lembert Dome.

Below: Schematic of dike with locations of samples



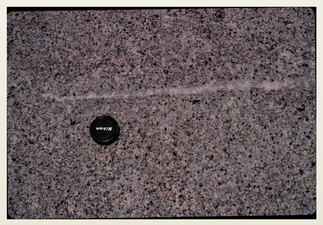


Hypothesis

The concentrations of rare earth and trace elements in the constituent minerals will be highest in the interior and distal regions of the dike, and also higher than the Cathedral Peak country rock.

Background

The dike crops out on Lembert Dome, in the Tuolumne Batholith, part of the larger Sierra Nevada Batholith. The batholith as a whole formed over about 10 Myr, between 95 Ma to 85 Ma, from U-Pb zircon dating methods (Coleman et al., 2004) and the rocks that comprise the dome formed approximately 88.1 ± 0.2 million years ago. The batholith has a "peanut" shape, about 10 km across and 60 km long. The rock type ranges from granodiorites to granites, and the textures range from equigranular to porphyritic grading from the outermost portions of the batholith to the center (Paterson et al., 2011).

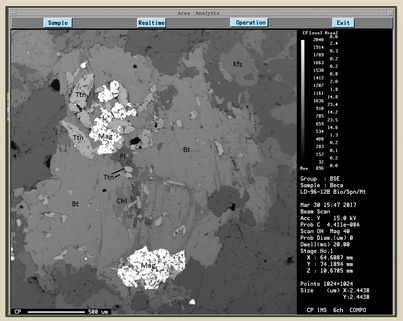


Above: One of the terminal ends of the dike, credit: Dr. Phil Piccoli

Left: Lembert Dome from Tioga Road https://upload.wikimedia.org/wikipedia/commons/6/68/Yosemite-tuolumne_meadows-lembert_dome_1.jpeg

Methods

- Optical microscopy on 20 thin sections from different locations on the dike
- EPMA: EDS of 4 mineral grains, WDS of 104 sites from three epoxy mounts and four thin sections
- LA-ICP-MS: concentrations of 35 rare earth and trace element isotopes for seven minerals

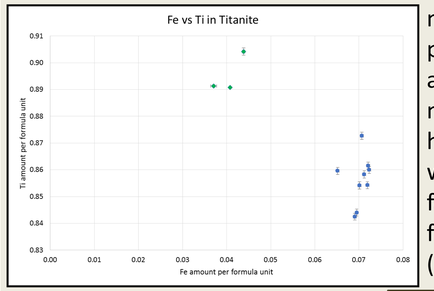


Above: Scan of thin section LD-96-12B

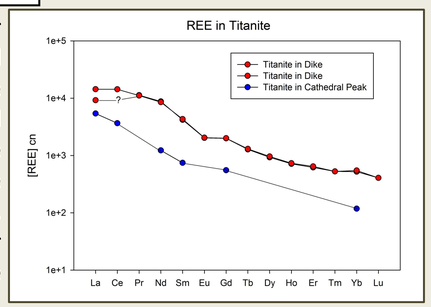
Right: Back scatter electron image of the boxed area of LD-96-12B

Results

The thin sections display a variation in textures, but similar overall mineralogy. From EPMA, I saw some variation in the chemical formulas of the primary minerals of the rock. That minerals from different locations on the dike were compared to quantify the difference in chemical compositions based on where it is, and therefore when it crystallized, potentially indicating fractionation. I analyzed zoning in individual grains of garnet, titanite, biotite, tourmaline, plagioclase feldspar, and alkali feldspar. I also found grains of what is thorite ($ThSiO_4$), which may indicate a large concentration of thorium in my sample. The blue points are from the narrow end of the dike, the green points are from the wide end of an adjacent dike. The grains from the narrow, younger end of the dike have higher concentrations of iron, which deviates from the ideal formula, indicating fractionation, from coupled REE/Fe substitution. (Piccoli et al., 2000).



Data from LA-ICP-MS shows higher concentrations of rare earth and trace elements in titanite in the dike compared to the Cathedral Peak country rock. The "?" in the titanite from the dike had a value that was too high to be measured, which still indicates a higher concentration of Ce in the titanite in the dike than the country rock.



Future Work

- Analyze samples from more locations in the dike and country rock with EPMA and LA-ICP-MS
- Compare findings across the width and length of dike to each other and to previously measured samples from the surrounding country rock

References:

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▪ Piccoli, P., Candela, P., and Rivers, M., 2000, Interpreting magmatic processes from accessory phases: titanite—a small-scale recorder of large-scale processes: Special Paper 350: The Fourth Hutton Symposium on the Origin of Granites and Related Rocks, p. 257–267.