

# Petrogenesis of the Andesitic Eldorado Dike Swarm: Last Surge of Magmatism at the Searchlight Pluton, Nevada?

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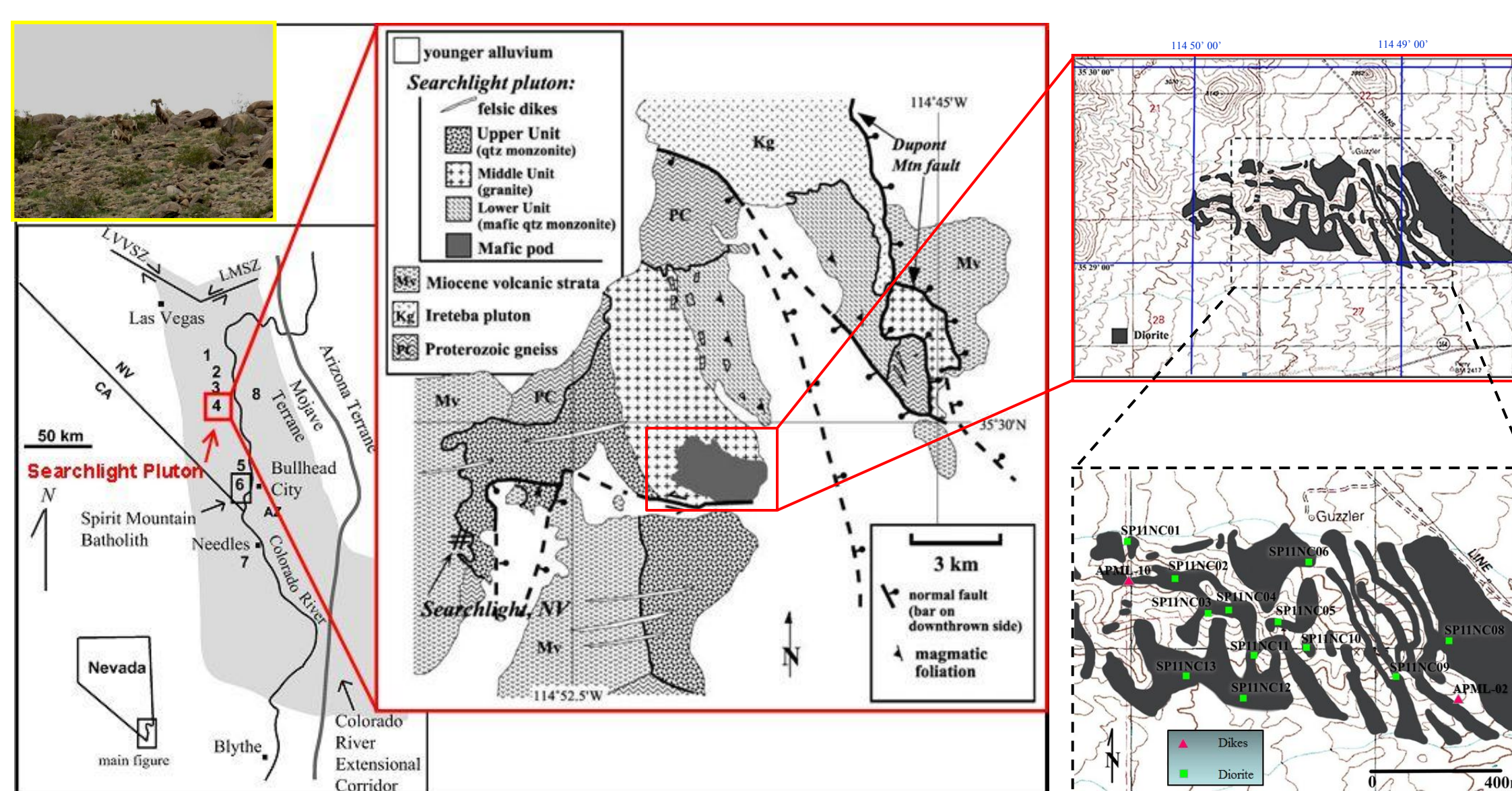
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## Abstract

Several plutons located within the Colorado River extensional corridor (CREC), a 50-100 km wide extensional belt that includes parts of Nevada, Arizona, and California, are tilted steeply to the west, which has revealed most of the entire thickness of these plutons. Plutonism in the region was restricted to a geologically brief interval around 16 Ma, and the last surge of magmatism may be related to the emplacement of the extensive ~15.5 Ma Eldorado dike swarm that cuts several plutons in the CREC and is interpreted to postdate these intrusions by as little as 0.2 Myr. Fe-Ti geothermometer/barometer phase relations indicate a low-temperature/high oxygen-fugacity equilibration of binary oxides found in Eldorado dikes samples from the mafic pod at the Searchlight Pluton. The magnetite and ilmenite phases from sample APML-02 plot at high-oxygen fugacity ( $\Delta \log fO_2 \sim 4$ ), and at a low temperature of ~400-450 °C, indicative of extremely slow cooling, perhaps due to the higher temperature, recent nature of the plutonism. This trend indicates a sub-solidus, late-stage exsolution of ilmenite in the binary oxides. Calc-alkaline crystallization trends and Eldorado dike mineral assemblages suggest a highly-differentiated calc-alkaline petrogenesis for the andesitic Eldorado dikes. Hornblende mineral chemistry of synplutonic diorite samples from the mafic pod at Searchlight Pluton and from andesitic dike samples that cut the mafic pod indicate distinct compositional differences and reveal evidence for fractional crystallization and evolution of the magma source for this region. The diorite hornblendes are enriched in the mobile element K relative to the dike hornblendes, while the dike samples have a higher Mg#, pointing to a less evolved magma source for the andesitic Eldorado dikes. These relationships suggest that the Eldorado dike swarm represents a final late-stage surge of magmatism at Searchlight Pluton, NV.

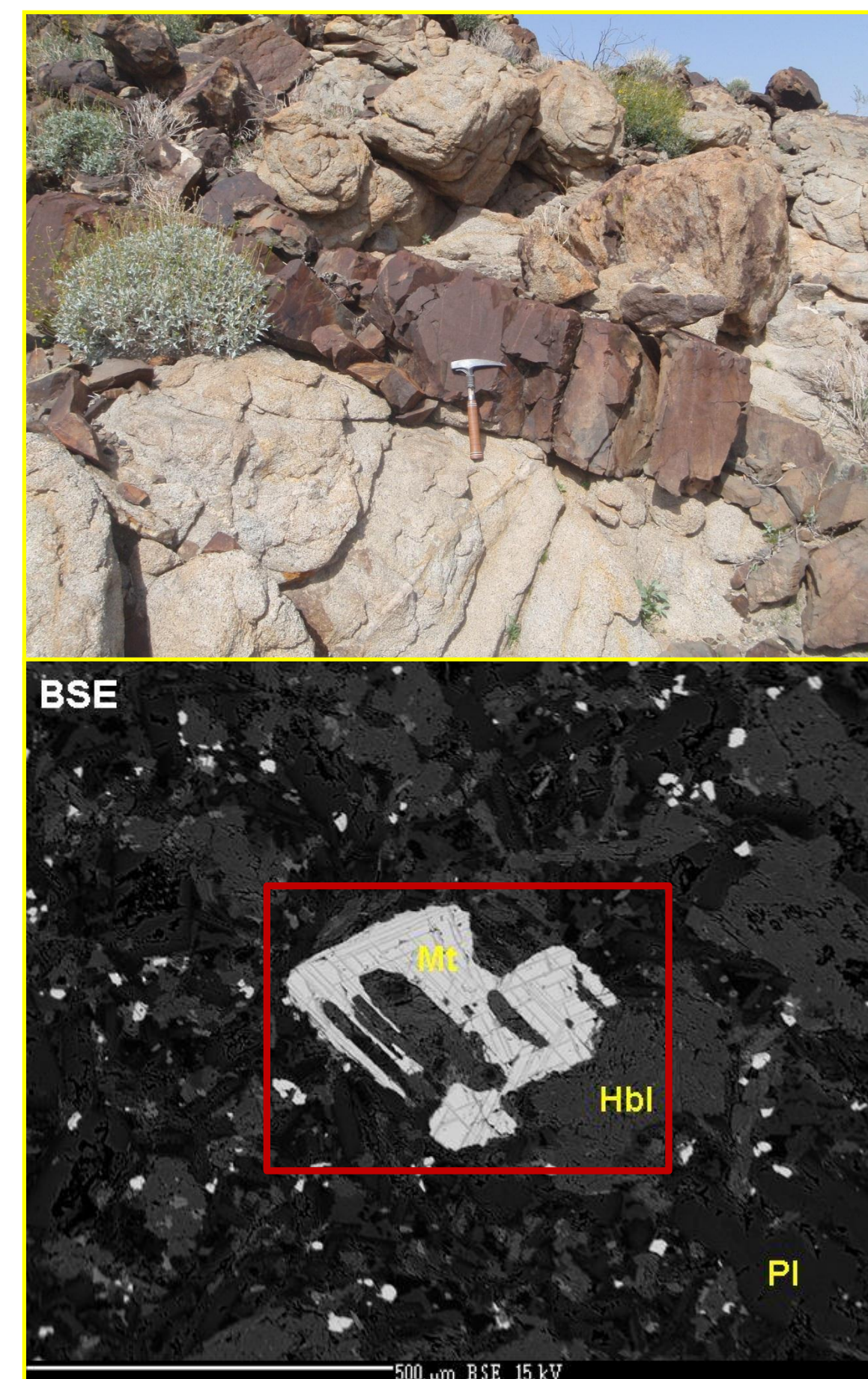
## Introduction/Geologic Setting

- ❖ Several plutons within the CREC are tilted steeply to the west (e.g., Mt. Perkins, Searchlight, and Spirit Mountain plutons).
- ❖ Searchlight Pluton is an extraordinary, ~13 km thick, roof-to-floor cross-section of a stratified magma chamber (Bachl et al, 2001).
- ❖ A large kilometer-scale mafic pod is exposed within the middle granitic unit of the Searchlight Pluton.
- ❖ The mafic pod is intruded by 0.5-10 m thick dikes that cut dioritic rocks common in the mafic pod. Eldorado dikes strike ~330° and dip ~30° NE and extend northward for ~20 km where they cut the western portion of the Aztec Wash pluton (Steinwinder et al., 2004; Falkner et al., 1995).



Geologic map of the Searchlight Pluton shows the adjacent Ireteba pluton and surrounding volcanic strata (modified from Walker et al., 2007; Miller and Miller, 2002). Field geologic mapping of diorite (upper) and sample locations (lower).

## Petrologic Description



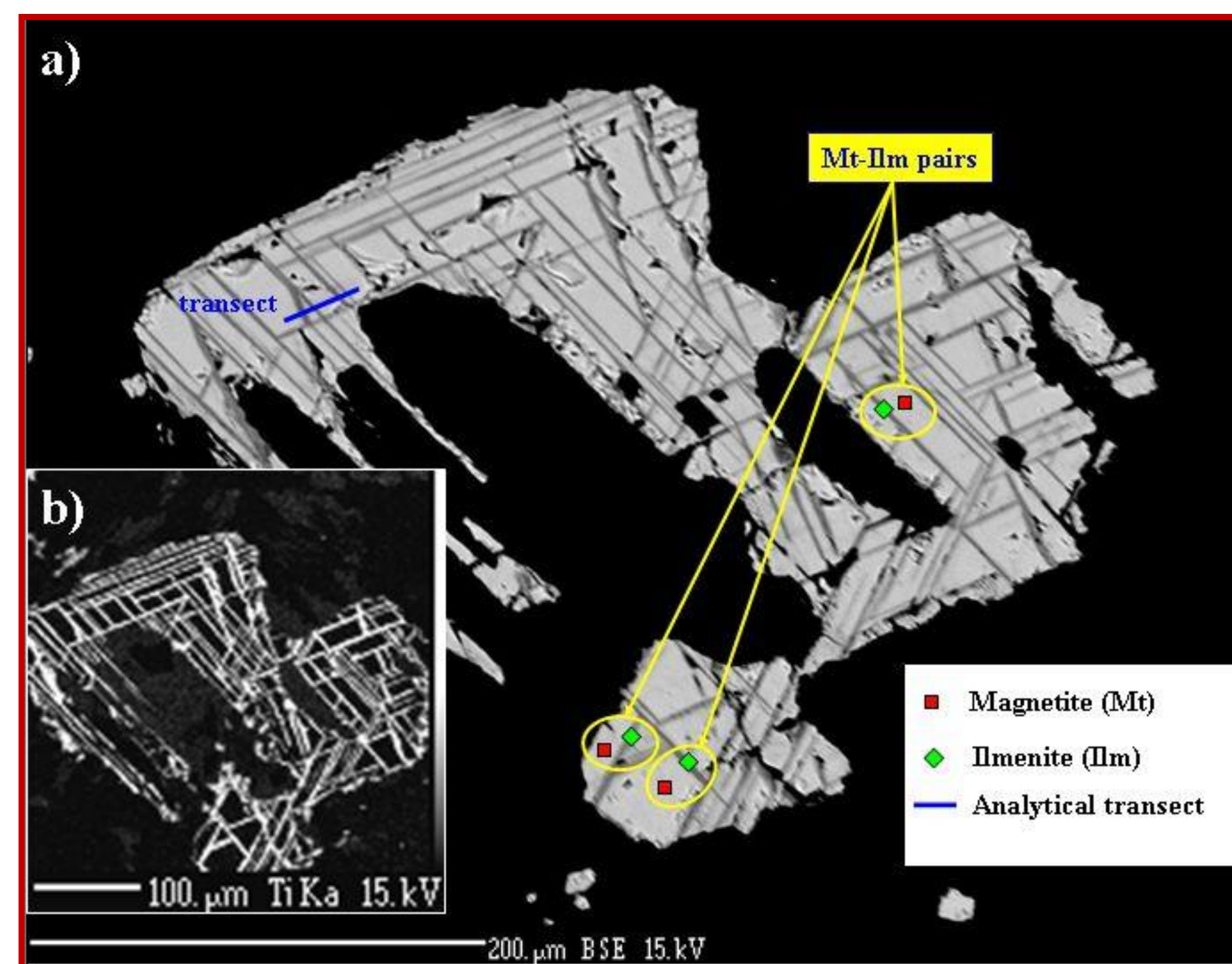
- Suite of 15 dike samples and 12 diorite samples collected from the mafic pod

Eldorado dike sample groundmass is fine-grained (<50 µm) and consists mainly of plagioclase and minor quartz. Phenocrysts are 0.5 - 1 mm subhedral to euhedral plagioclase and hornblende phenocrysts. The largest plagioclase phenocrysts display sericite alteration, and several of the larger phenocrysts show evidence of compositional zoning. *Pyroxene is absent.*

### Modal mineralogy dike sample (APML-02):

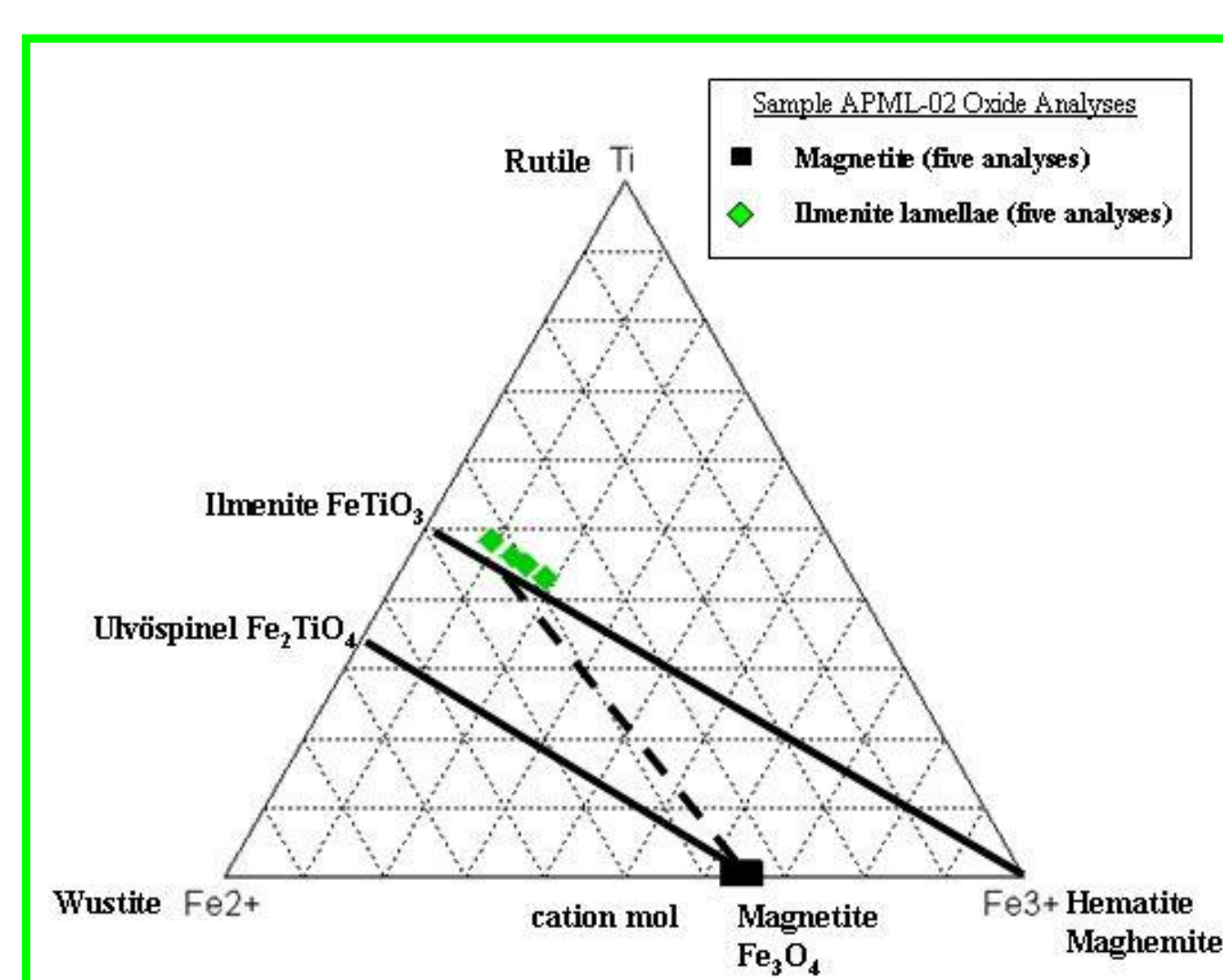
- plagioclase (An<sub>27</sub>) - 60 %
- magnetite - 10 %
- hornblende - 10 %
- chlorite - 10 %
- orthoclase (Or<sub>94</sub>) - 5 %
- quartz - 5 %
- sphene - <1 %

## Fe-Ti Geothermometer/Oxygen Barometer



(a) BSE image of a binary oxide grain displaying ilmenite trellis lamellae from sample APML-02, also showing locations of EPMA analyses (b) Ti Kα X-ray map of the same oxide grain.

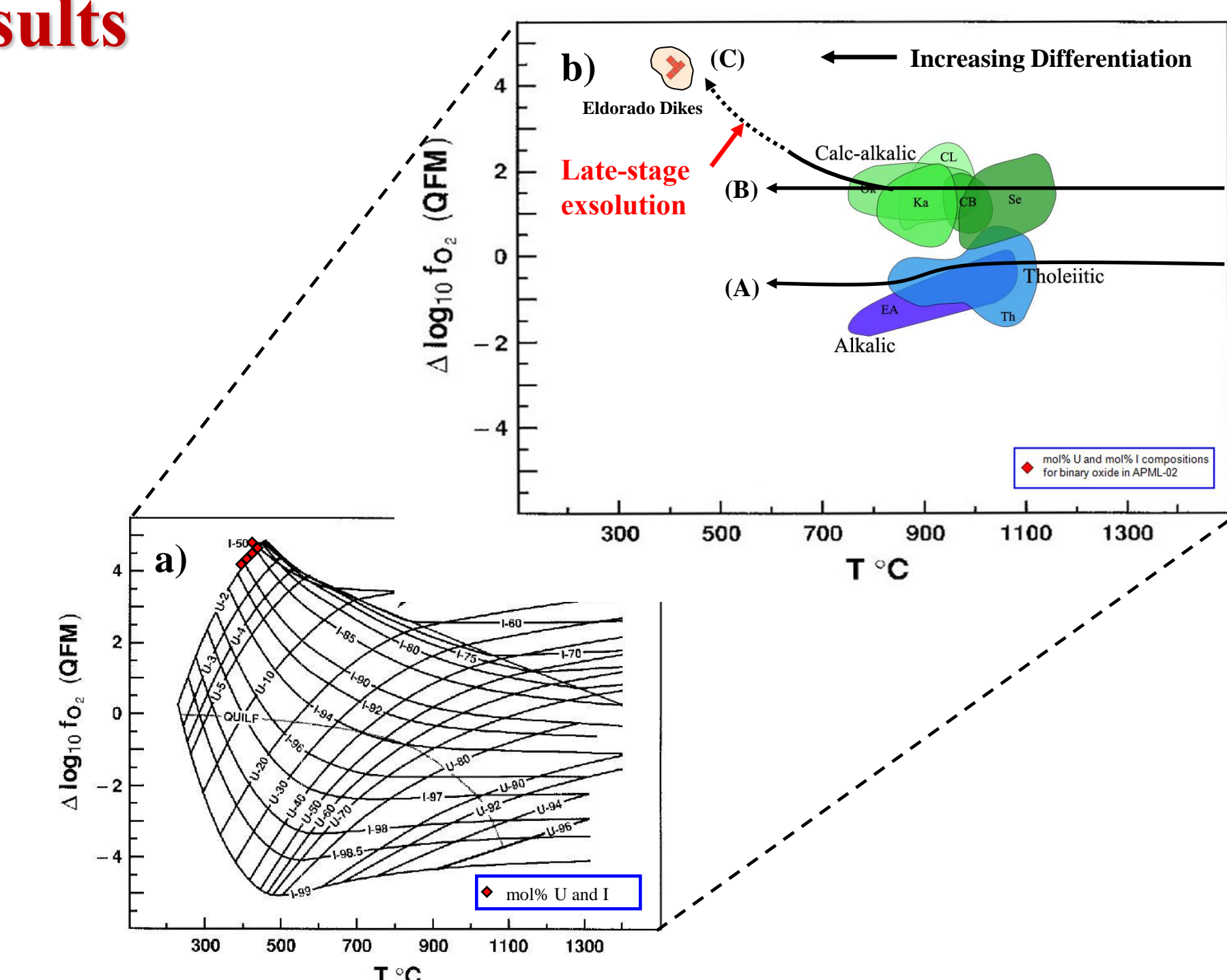
- ❖ Fe-Ti Geothermometer/Oxygen Barometer analysis performed using the formulation of Ghiorso and Sack (1991).



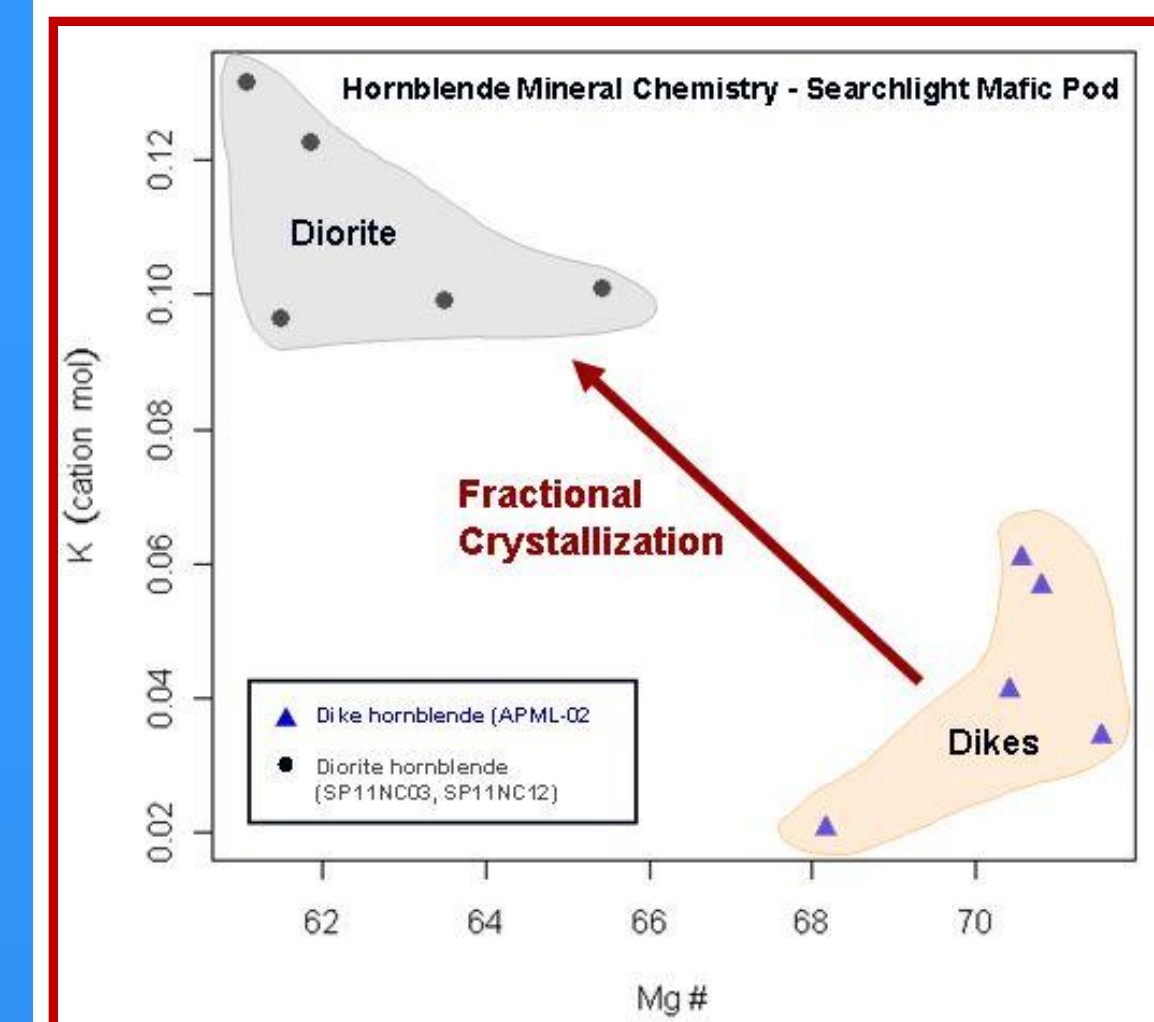
### Co-existing Oxide Phases:

- ❖ FeO-TiO<sub>2</sub>-Fe<sub>2</sub>O<sub>3</sub> system displaying the Hm-Ilm and Mt-Usp solid solution tie-lines.
- ❖ Compositions of five ilmenite and five magnetite analytical pairs from the binary oxide grain in Figure (a) above.

## Results



(a) Fe-Ti geothermometer (Ghiorso and Sack, 1991) illustrating the  $\Delta \log fO_2$ -temperature relationship for five pairs of Mt and Ilm analyses from binary oxide sample APML-02. (b) crystallization trends for suites of tholeiitic (lt. blue), alkalic (blue), and calc-alkaline (green) magmas (fields adapted from Frost and Lindsley, 1992); differentiation paths for the (A) tholeiitic suites, (B) calc-alkaline suite, and (C) calc-alkaline suite that contains hornblende or biotite without orthopyroxene (paths adapted from Frost and Lindsley, 1991).



### Hornblende Mineral Chemistry:

- ❖ Diorite hornblendes enriched in K relative to Eldorado dikes
- ❖ Eldorado dikes have higher Mg#
- ❖ Evidence for fractional crystallization
- ❖ Less-evolved parental melts for the Eldorado dikes

## Summary

- Fe-Ti phase relations → low-temp./high oxygen-fugacity re-equilibration of binary oxides
- Crystallization trends and dike mineral assemblage → highly-differentiated calc-alkaline petrogenesis
- Hornblende mineral chemistry → fractional crystallization and evolution of magma
- CREC extension increased → transition from plutonism (~16 Ma) to diking (~15.5 Ma) → tapping deeper levels of the magma system

## Future Work

- ❖ Compare petrology and whole-rock geochemistry of syn-plutonic dioritic rocks from the mafic pod at Searchlight Pluton with the Eldorado dikes using the suite of samples collected in March, 2011.
- ❖ Comprehensive study to examine the petrology and geochemistry of Eldorado dikes that cut other plutons in the CREC (e.g. Ireteba, Aztec Wash).

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