Comparison of Parental Basaltic Liquids at the Apollo 12 Site

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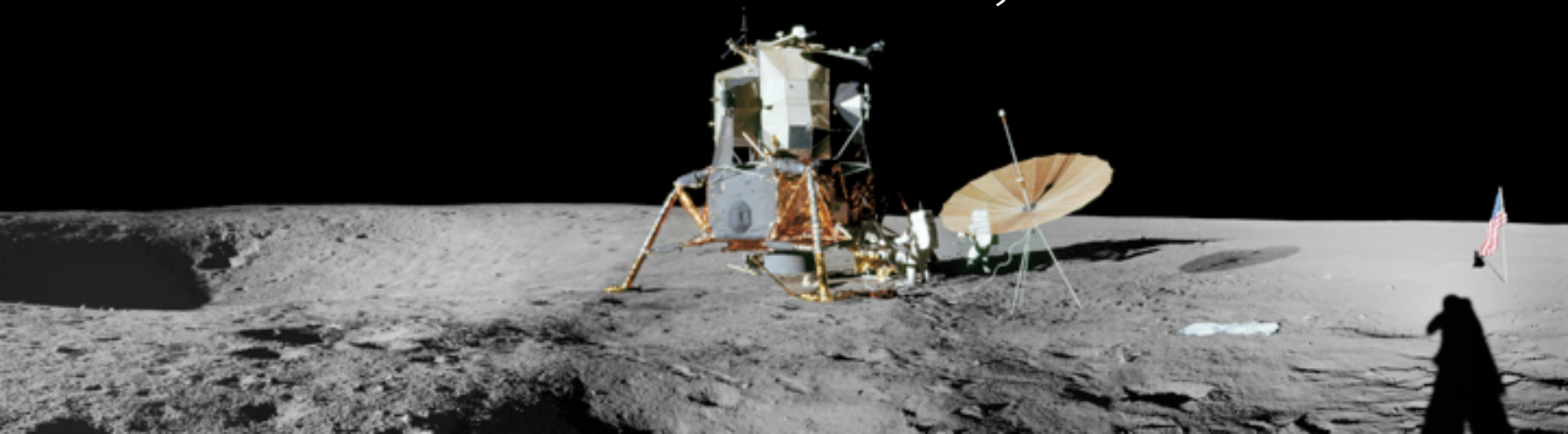


Purpose of Study

- Mare basalts can be used as probes into the Lunar interior
- Can gain insight into the composition of the interior
- Understand post-magma generation processes (assimilation, fractional crystallization)

Purpose of Study

- Efficiency of Lunar Magma Ocean crystallization (overturn, fractional crystallization)
- Lunar Magma Ocean crystallization processes may apply to many planetary bodies

Background

- Previous studies have determined that Apollo 12 basalts must have had multiple source regions (e.g. Dungan and Brown, 1977; Neal et al., 1994; Nyquist et al., 1979).
- Apollo 12 basalt sources isolated early in lunar history (Nyquist et al., 1979).
- The ultimate aim of this study is to determine the trace element.
- characteristics of these reservoirs and any post magma generation processes - start by defining parental melts.

Apollo 12 Basalt Types

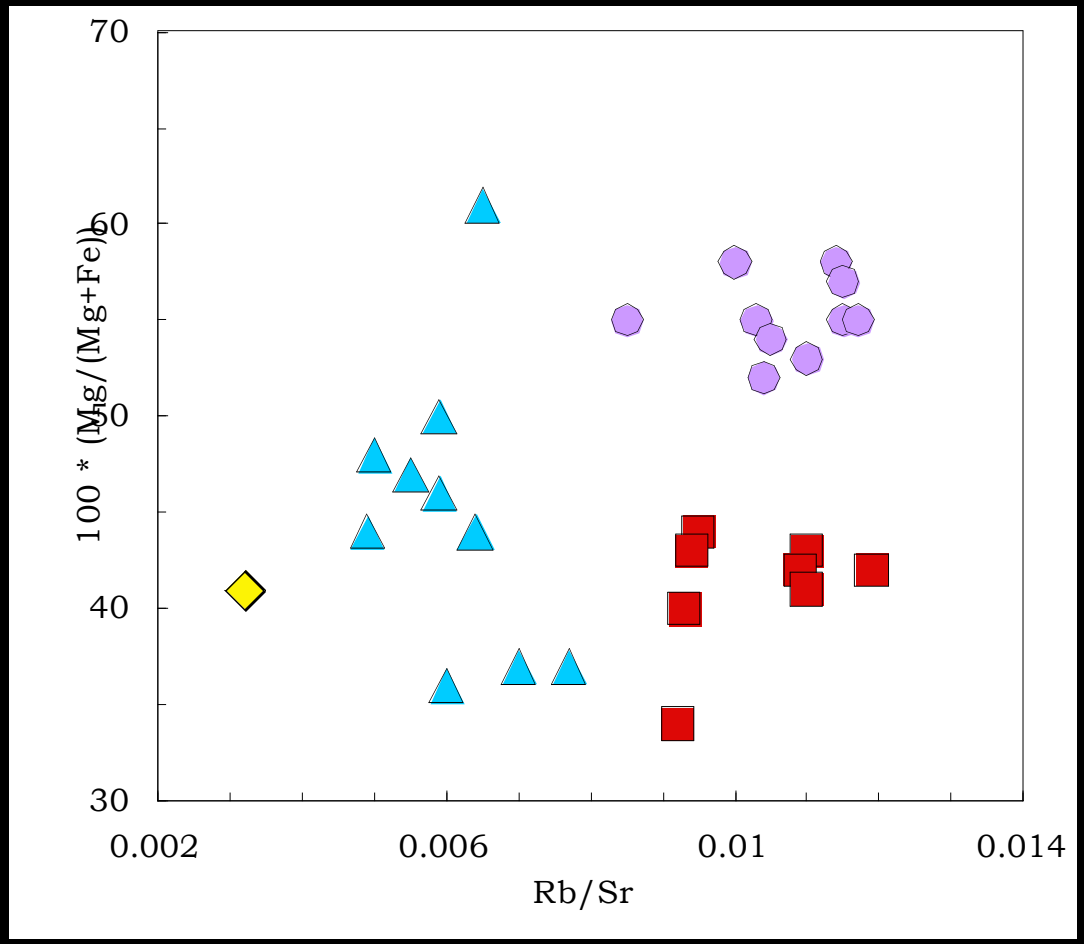
- Based on whole rock geochemistry basalts fall into 4 groups:

ilmenite

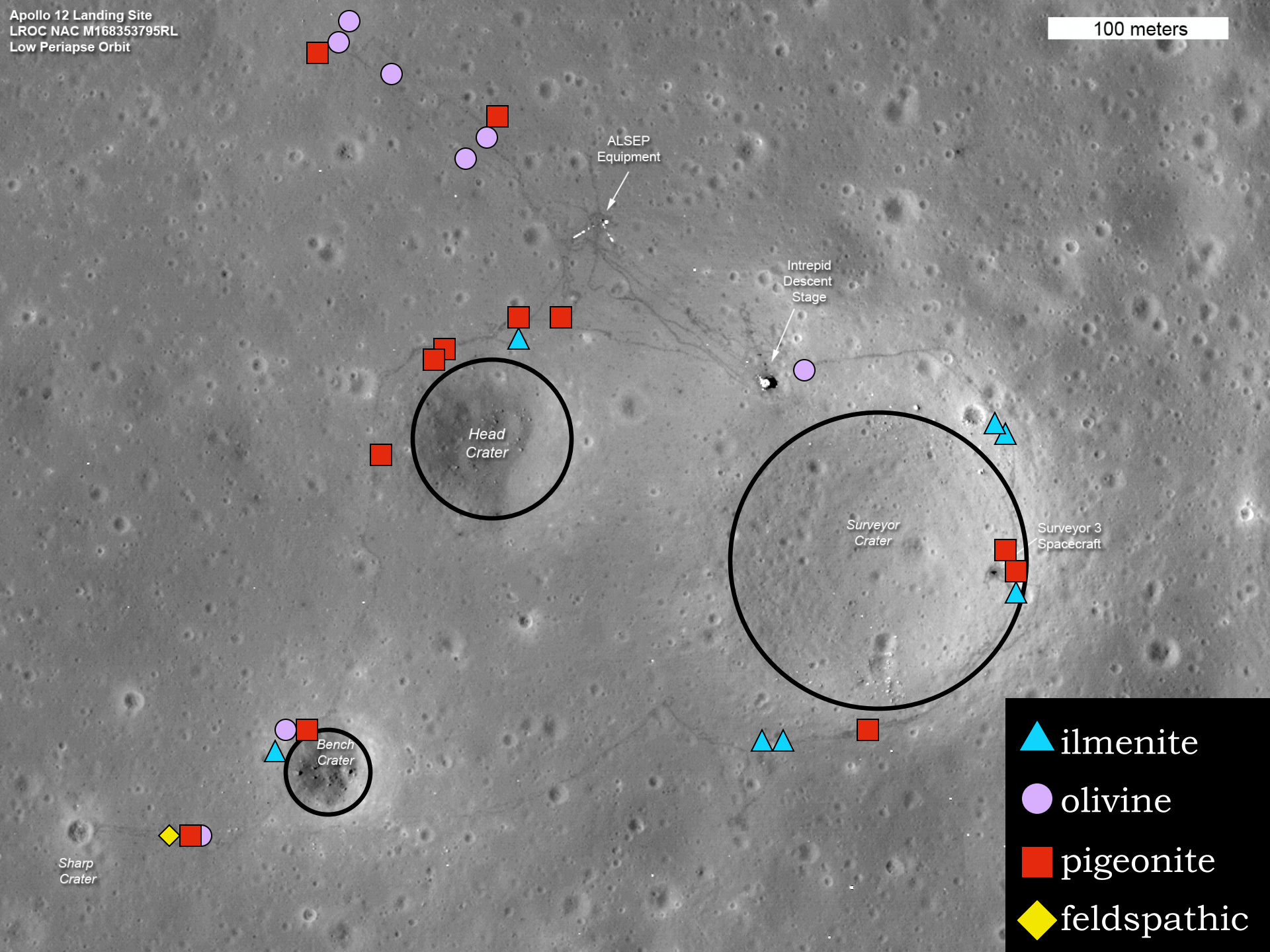
olivine

pigeonite

feldspathic



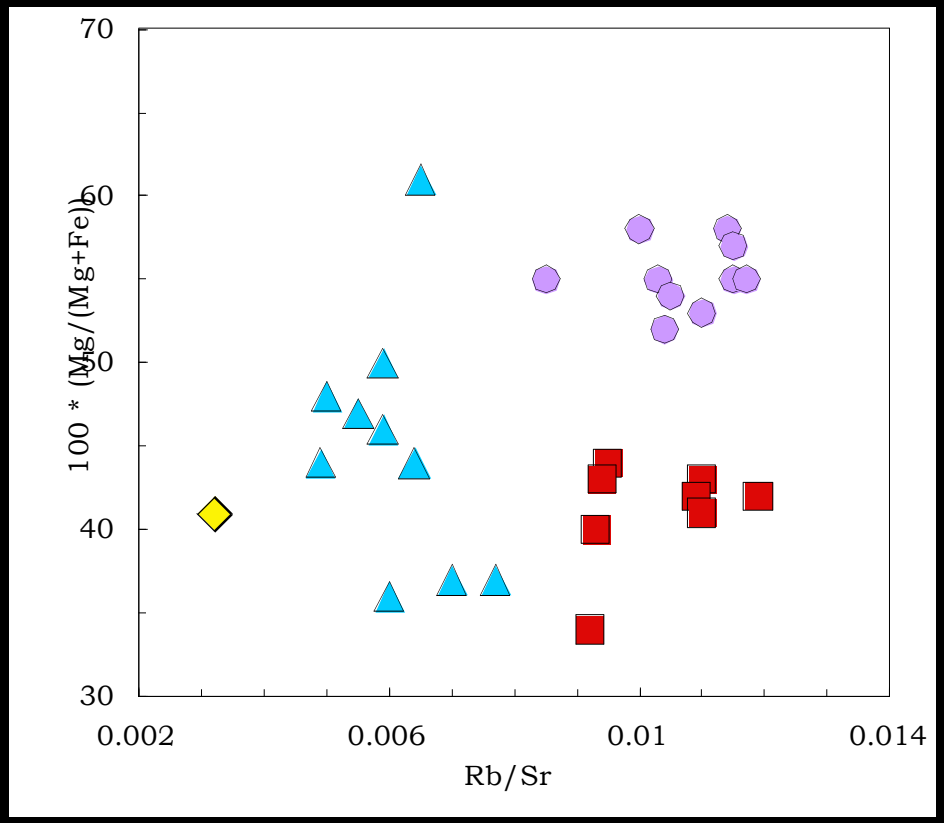
Adapted from Neal et al., 1994


Apollo 12 Landing Site
LROC NAC M168353795RL
Low Periapse Orbit
100 meters
ALSEP Equipment
Intrepid Descent Stage
Head Crater
Surveyor Crater
Surveyor 3 Spacecraft
Bench Crater
Sharp Crater
ilmenite
olivine
pigeonite
feldspathic

Apollo 12 Basalt Types

- Our study utilizes pyroxene phenocrysts, from three of these suites (Olivine Basalts = future work):

ilmenite
olivine
pigeonite
feldspathic



Adapted from Neal et al., 1994

Papike et al., 1979

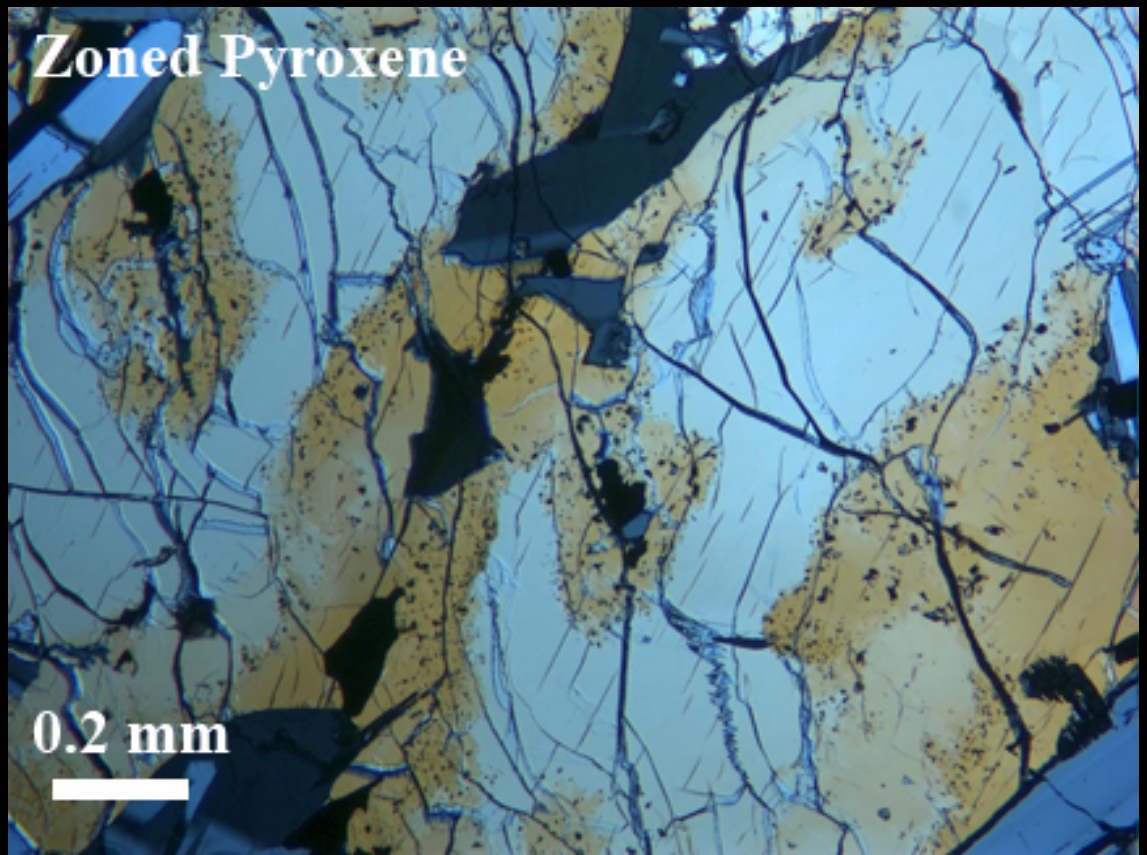
A12 Ilmenite Basalts

- Pyroxene comes on the liquidus early (Papike et al., 1976);
- Stays on the liquidus for much of the crystallization:

olivine + spinel → pigeonite → augite + plagioclase + ilmenite + spinel

On the importance of pyroxene

- It can therefore act as a recording device for most of crystallization;
- Zones within pyroxene provide snapshots of magma at different times.



Methods

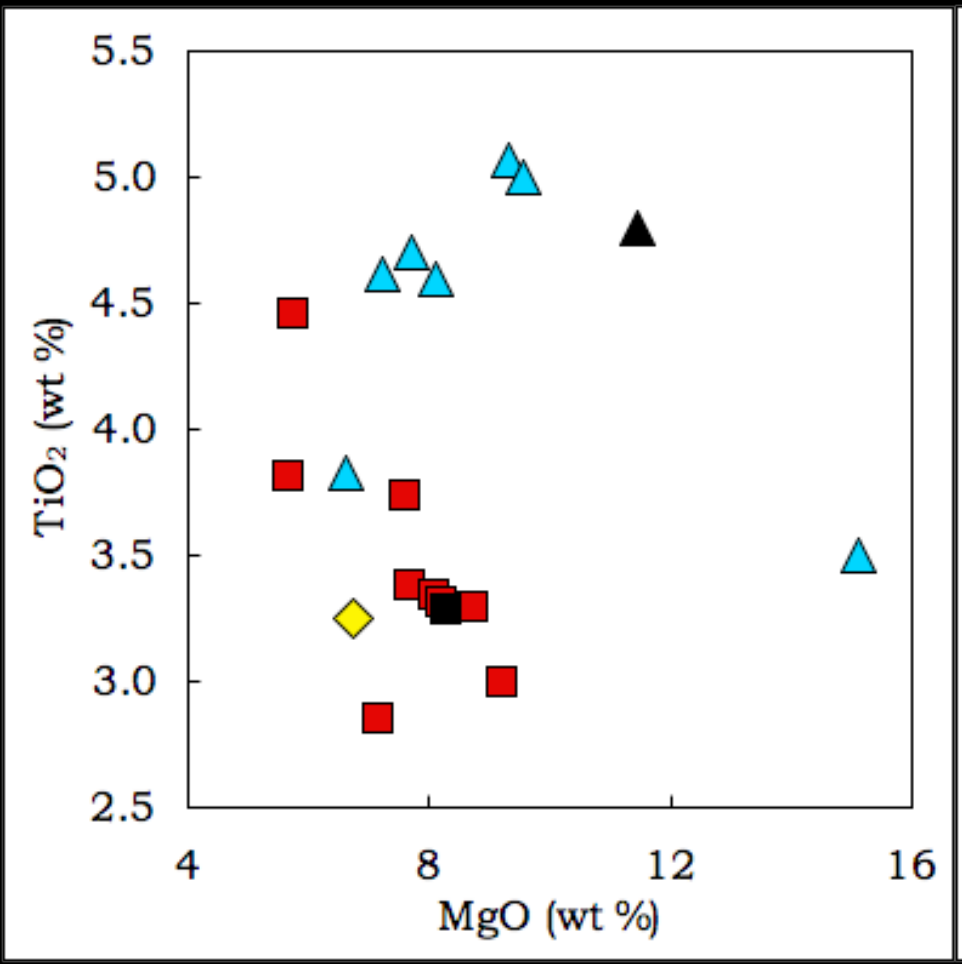
- Major elemental abundances combined with backscatter images to find primitive pyroxene *(via electron microprobe)*
- We determine trace element concentrations of large primitive pyroxene crystals *(via laser ablation ICPMS)*
- Using published partition coefficients we calculate equilibrium liquids of the basalts

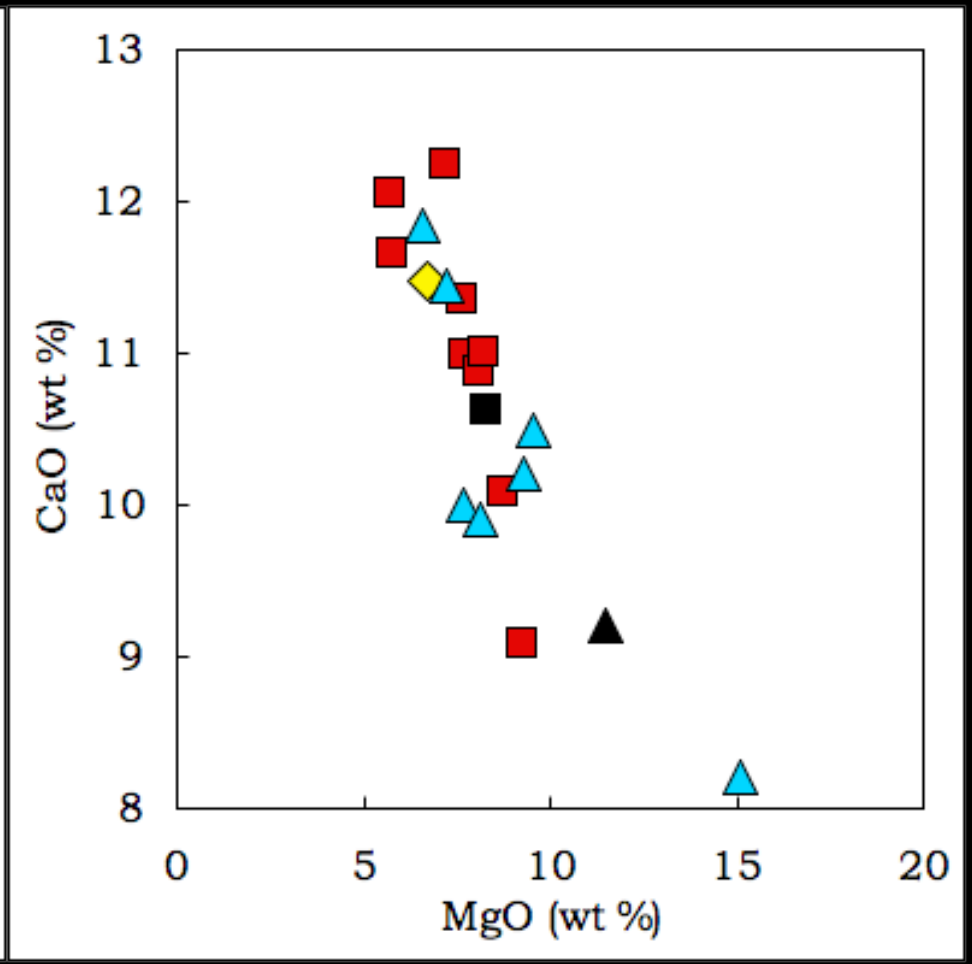
Previously Calculated Apollo 12 Parents

- Neal et al., 1994a,b; used whole rock data from vitrophyric samples to calculate parent for each suite
- Pigeonite Suite- vitrophyre 12011
- Ilmenite Suite- average of vitrophyric/ quenched samples 12008, 12022, 12045
- Feldspathic Suite- not calculated because it is comprised of only one sample

ilmenite suite
pigeonite suite
feldspathic suite
ilmenite parent
pigeonite parent

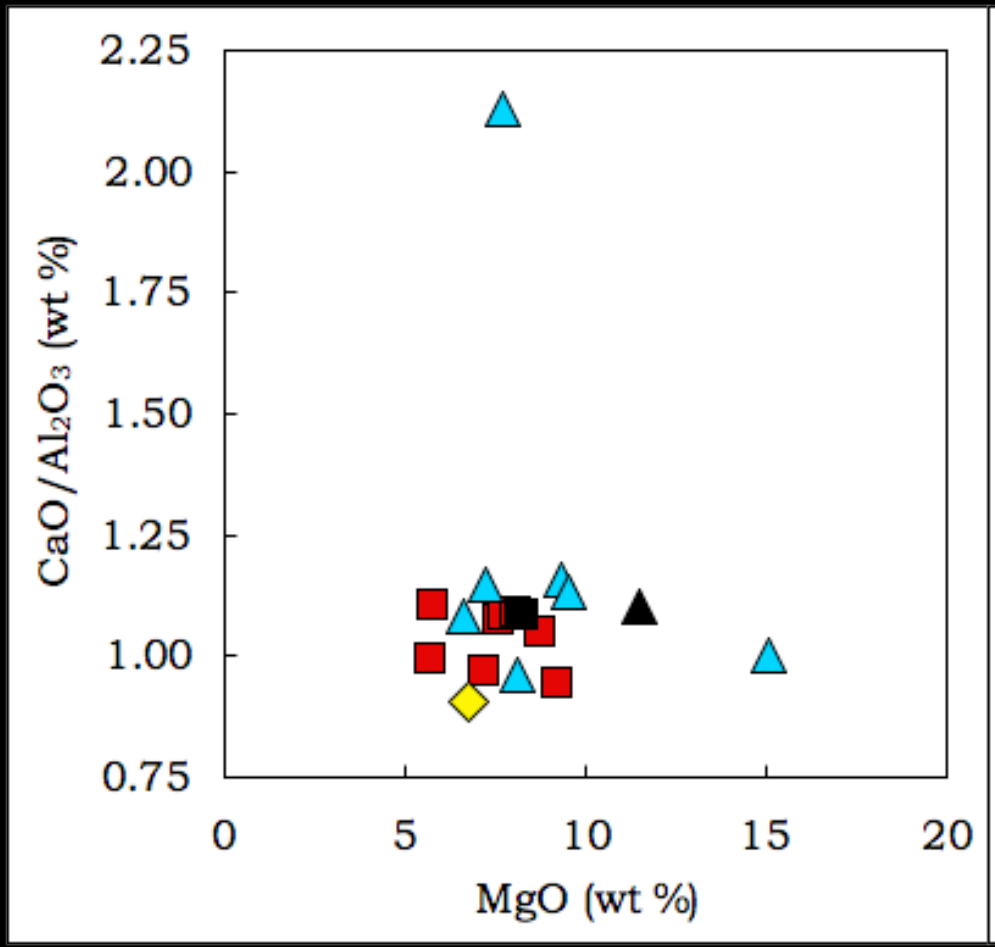
Whole Rock Major Element Trends

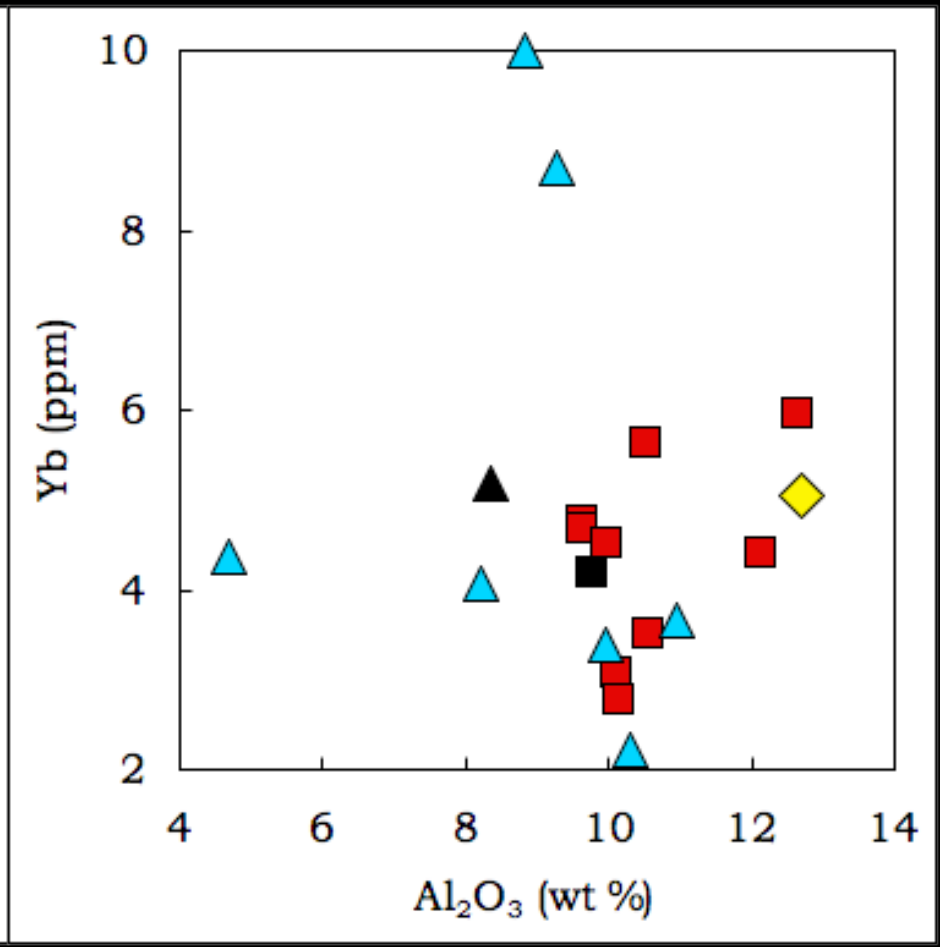




ilmenite suite
pigeonite suite
feldspathic suite
ilmenite parent
pigeonite parent

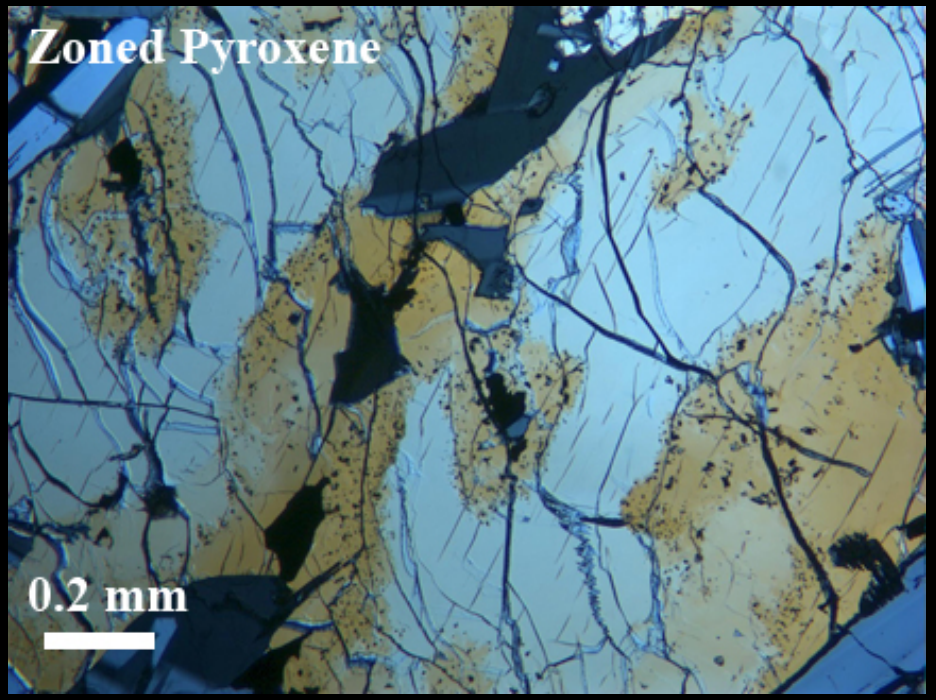
Whole Rock Major Element Trends



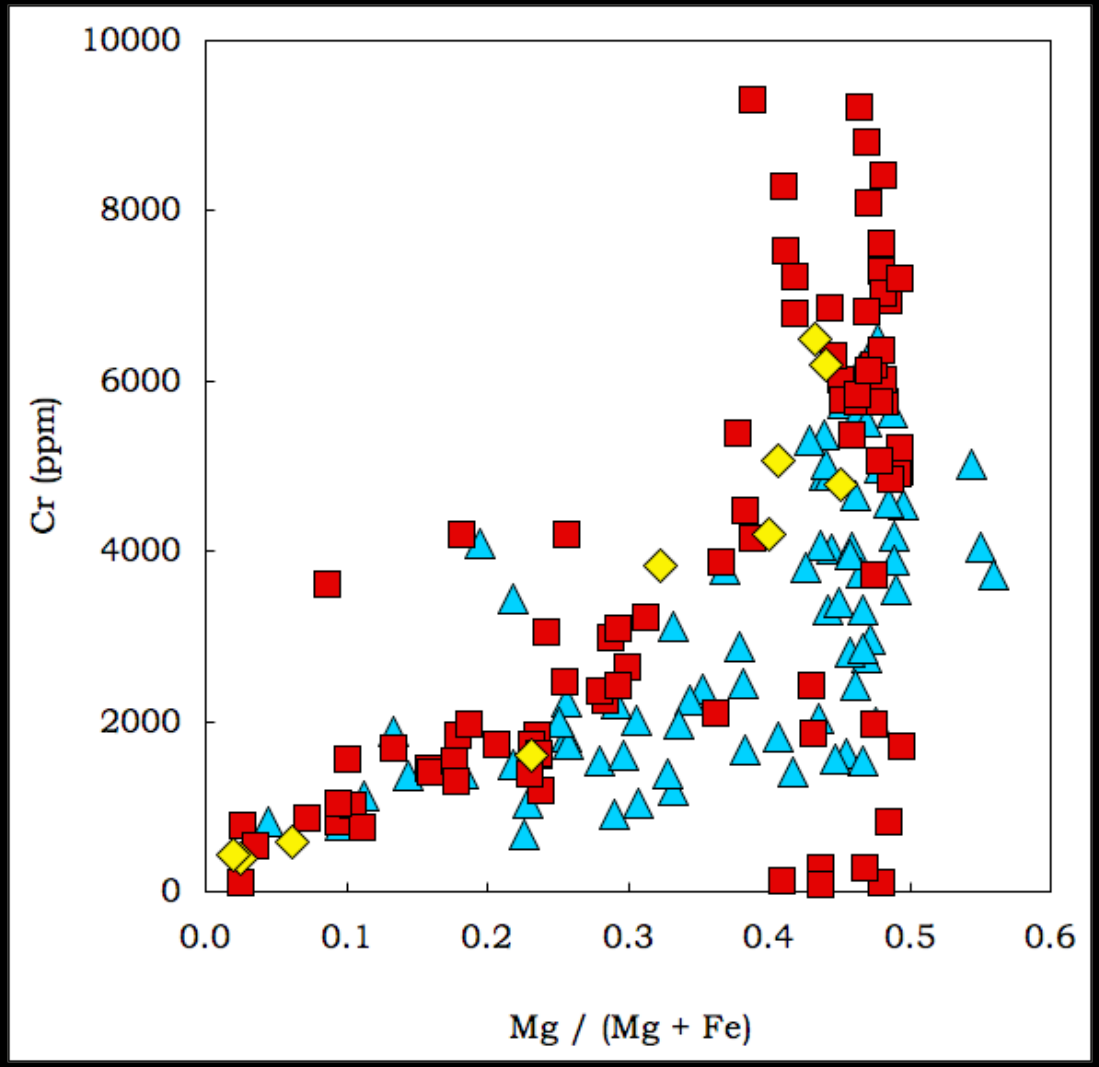


Whole Rock Data

- Whole rock compositions represent an average of the processes that affected a magma during formation/crystallization;
- Crystal stratigraphy (CS) is revealing more primitive compositions than whole rock;
- CS can track magma evolution

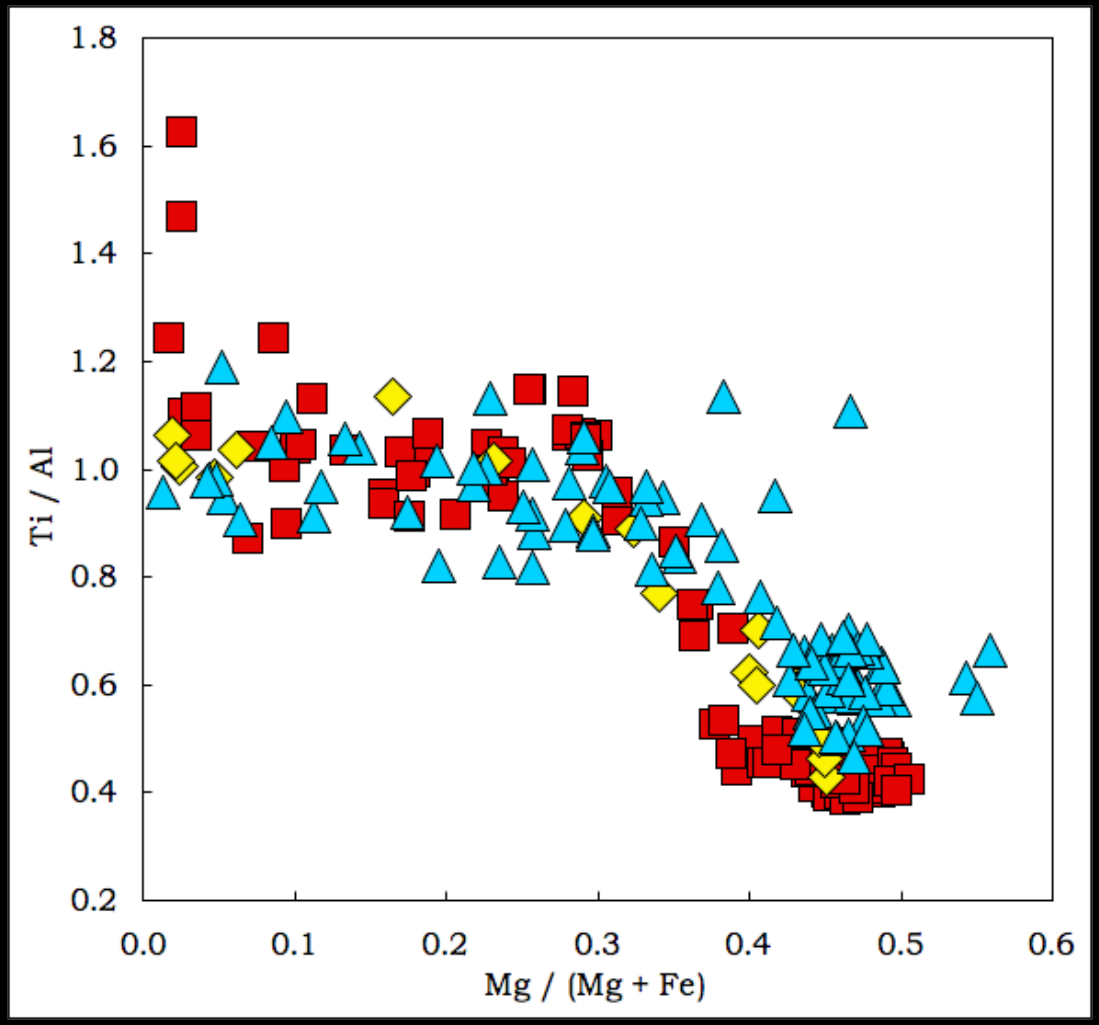


Identifying Primitive Pyroxene



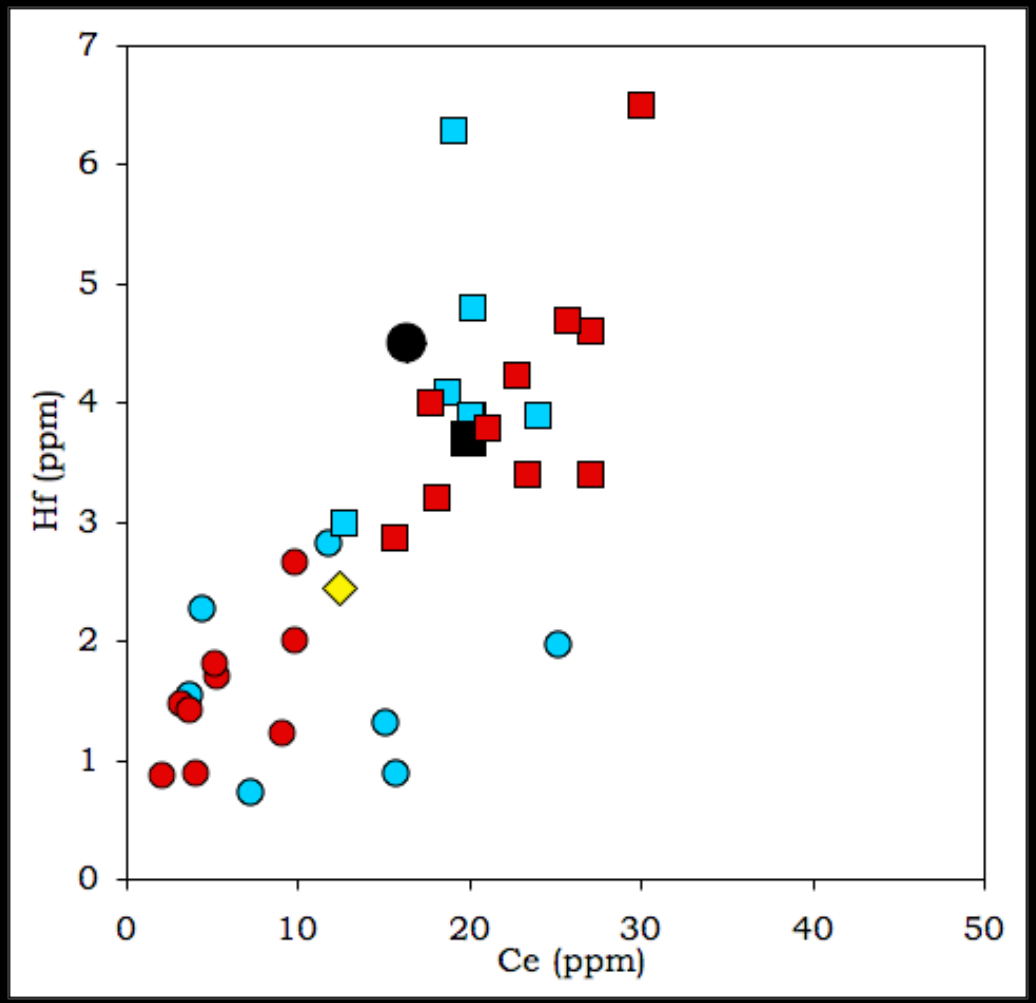
ilmenite suite
pigeonite suite
feldspathic suite

Identifying Primitive Pyroxene



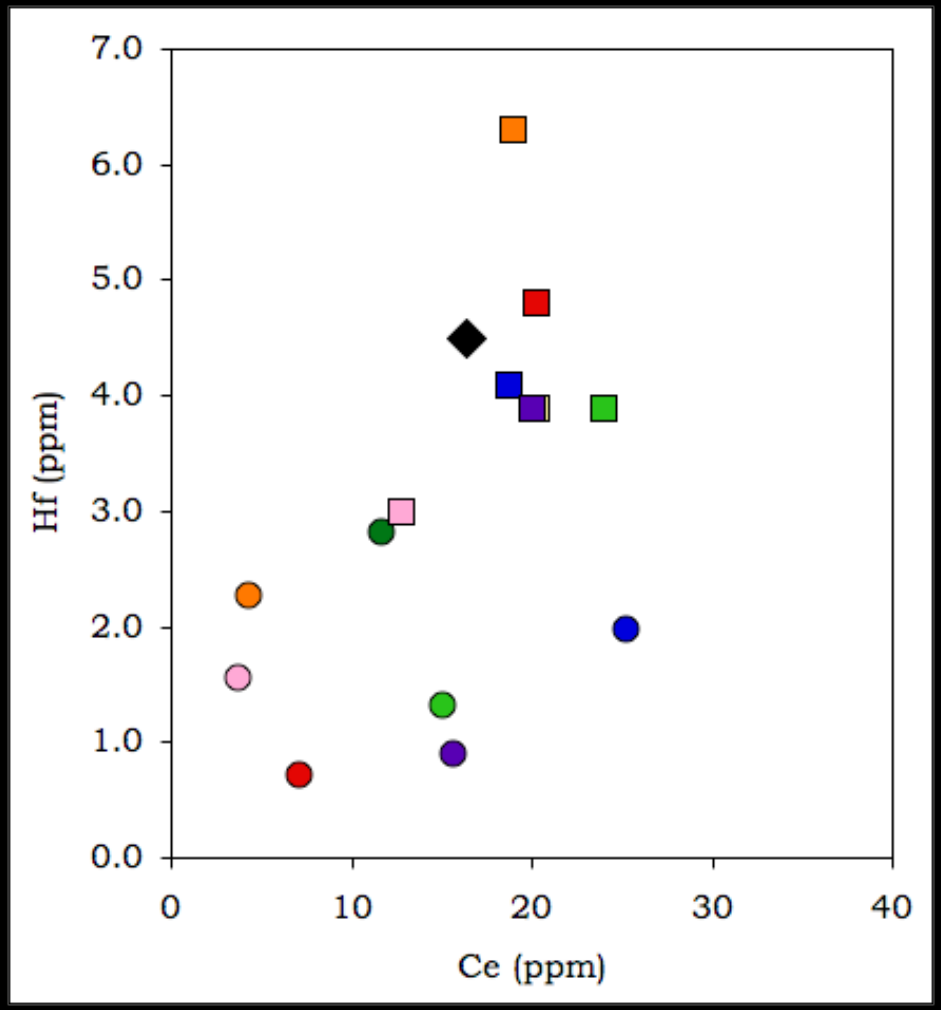
ilmenite suite
pigeonite suite
feldspathic suite

Calculated Equilibrium Liquids



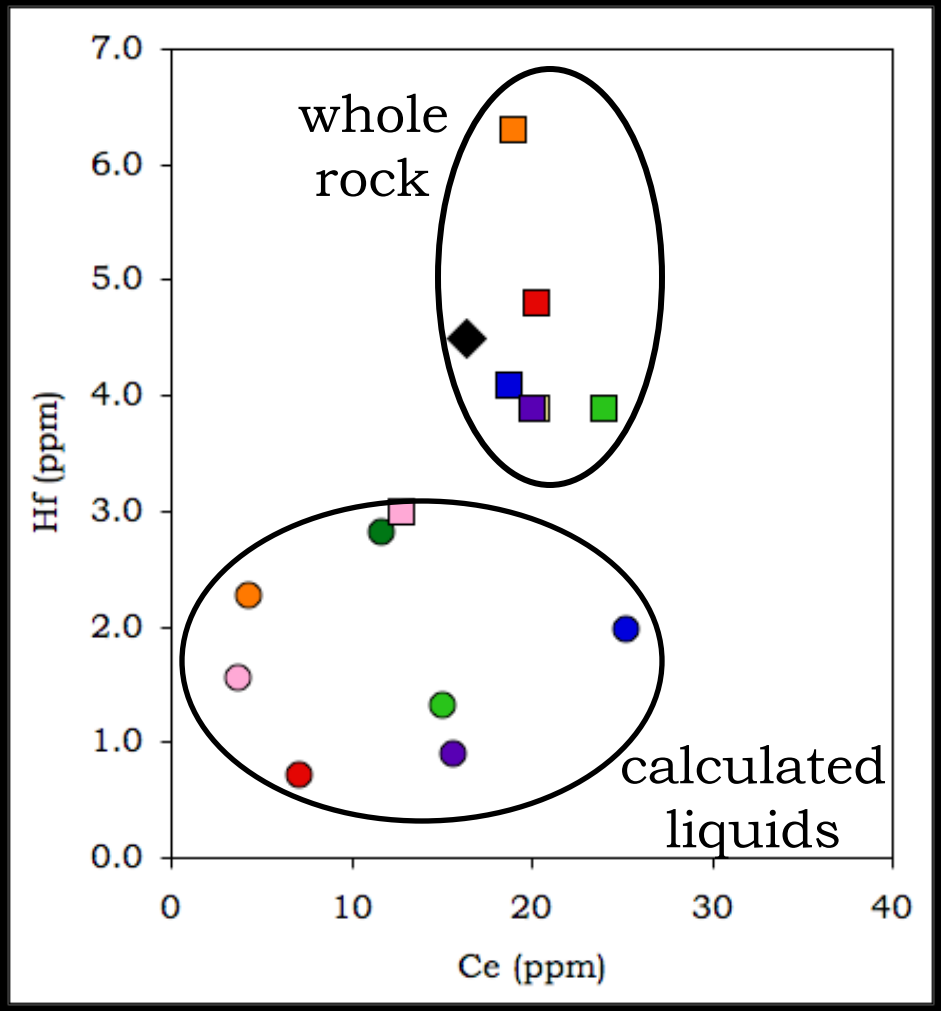
ilmenite suite- calculated
ilmenite suite-whole rock
pigeonite suite-calculated
pigeonite suite-whole rock
feldspathic suite-calculated
ilmenite suite parent
pigeonite suite parent

Ilmenite Suite Equilibrium Liquids



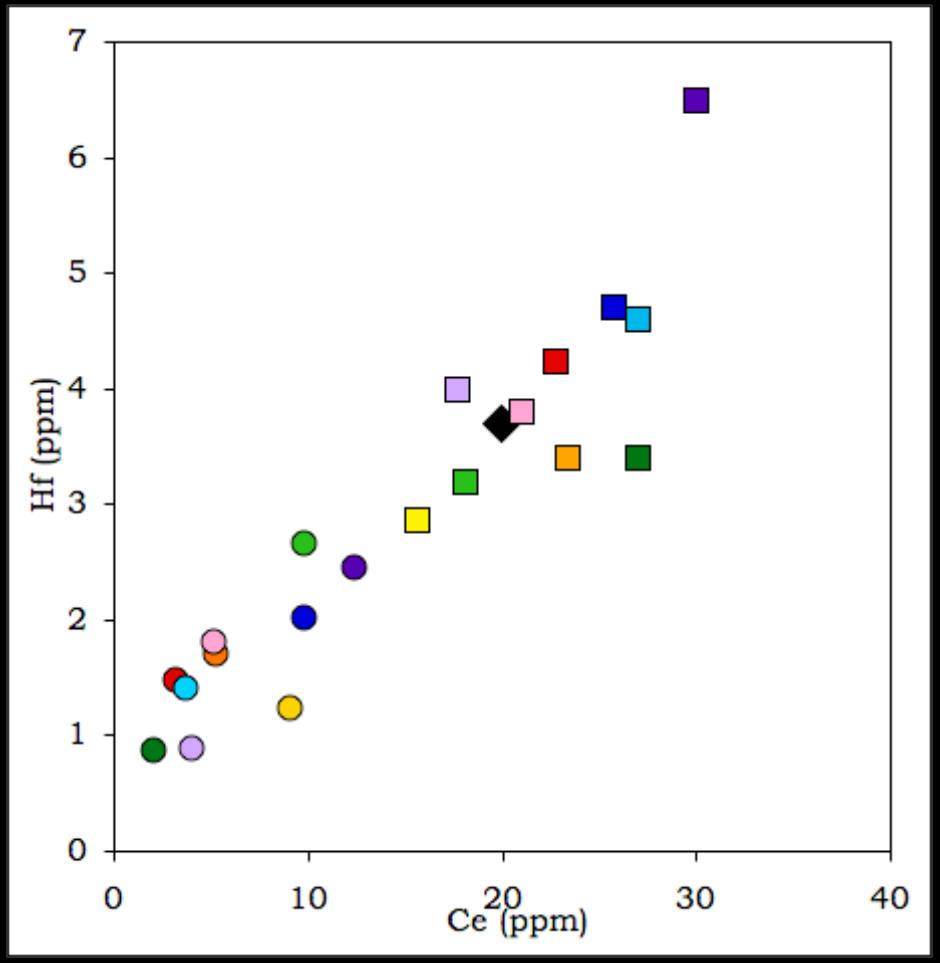
12016
12062
12051
12063
12054
12064
12056

Ilmenite Suite Equilibrium Liquids



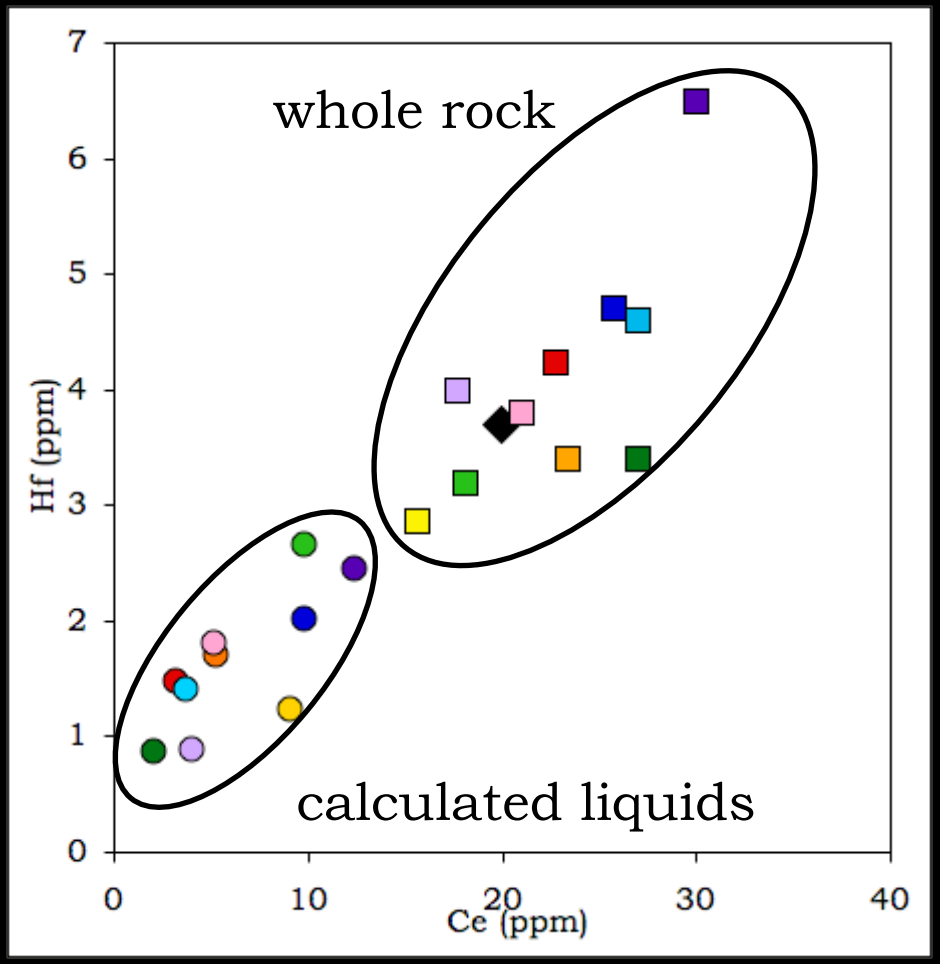
12016
12062
12051
12063
12054
12064
12056

Pigeonite Suite Equilibrium Liquids



12007	12039
12017	12043
12019	12052
12021	12053
12031	12038

Pigeonite Suite Equilibrium Liquids



12007	12039
12017	12043
12019	12052
12021	12053
12031	12038

Summary & Conclusions

- Crystal stratigraphy is revealing more primitive parental compositions than whole rock data;
- Characterization of parents to limited samples is possible with this method, such as the single Feldspathic suite basalt, 12038;
- The next step is to use these calculated parental liquids to calculate source compositions.

Acknowledgements

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- Thanks to Paul Carpenter and Antonio Simonetti for their guidance in the EMP and ICPMS labs.