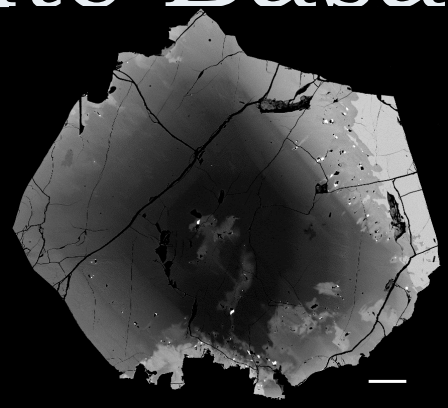
Crystal Stratigraphy

of the

Apollo 12 Pigeonite Basalt Suite



Katie M. O'Sullivan

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Apollo 12 samples

breccia

First appearance of KREEP!

basalt

<u>4 types</u>:

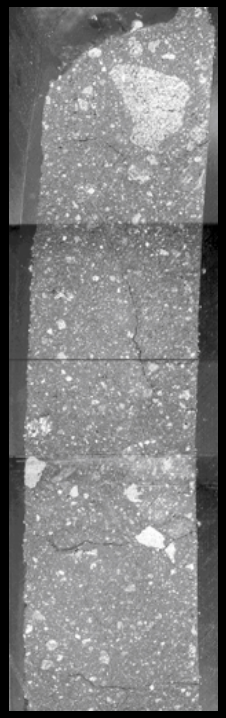
olivine

pigeonite

ilmenite

feldspathic

core



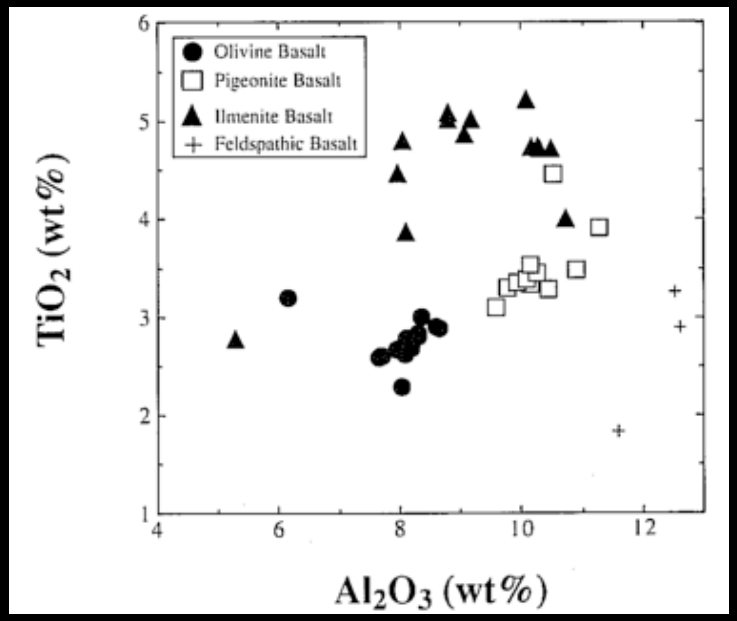
4 cm

soil

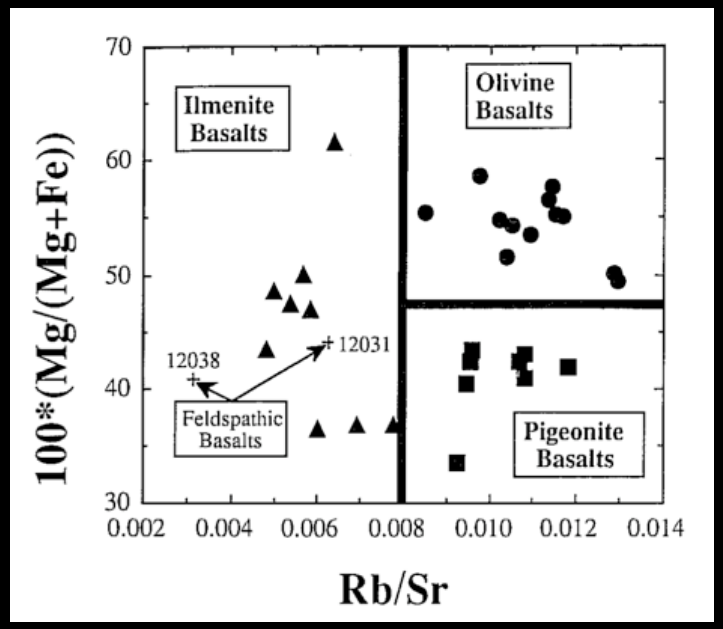
+

rock fragments

Apollo 12 basalts



<u>4 types</u>:
olivine
pigeonite
ilmenite
feldspathic



Or more simply:

- olivines have slightly higher olivine
- ilmenites have slightly higher ilmenite

etc…

Neal et al., *Meteoritics*,1994a

Previous Research-Pigeonites

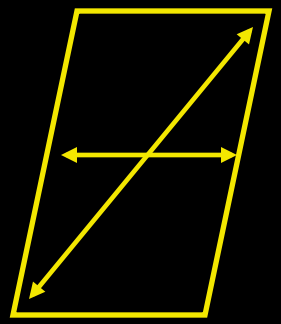
- James & Wright, *GSA bulletin*, 1972
  - olivine & pigeonite basalts are co-magmatic
- Neal et al., *Meteoritics*, 1994a,b
  - no, they come from distinct sources
  - pigeonite group assimilated a crustal component

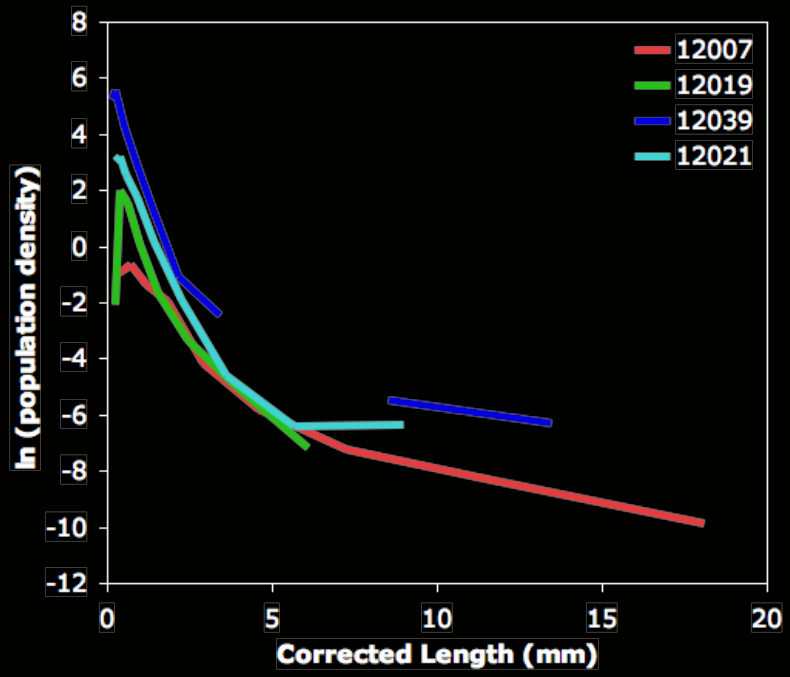
Approach

- Crystal Size Distributions
  - identify multiple crystal populations (if any)
- Electron Microprobe
  - major elements
- LA-ICP-MS
  - minor & trace elements
  - use microprobe Ca concentrations as internal standard
- Crystallization Modeling
  - Equilibrium
  - Fractional
  - In Situ

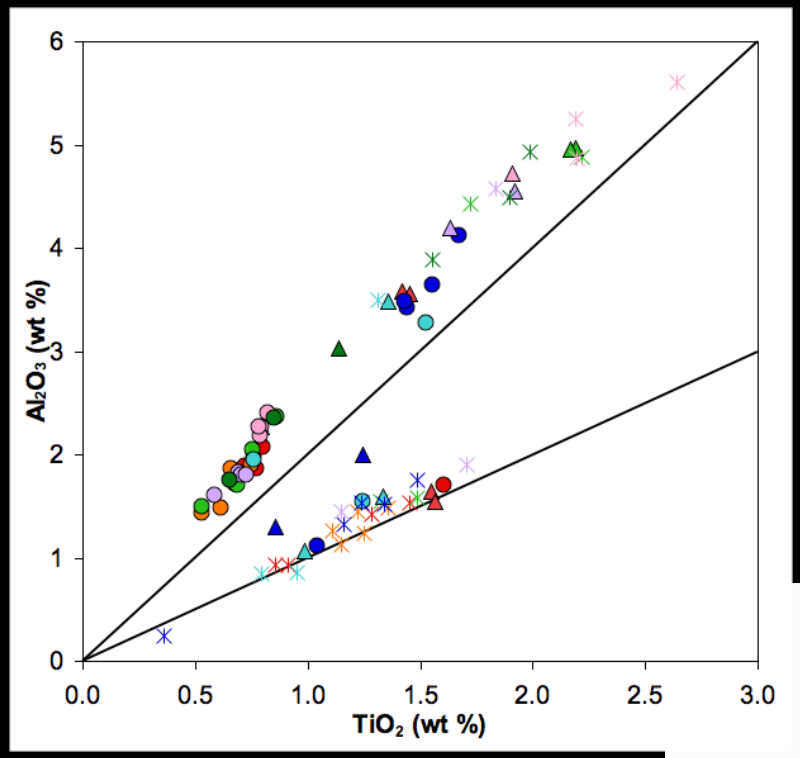
Distribution of Crystal Sizes

- Trace crystals in thin section
- Traces analyzed with:
  - ImageTool
    - area & short and long axes
  - CSDslice
    - 2D -> 3D
    - most probable crystal habit
  - CSDcorrections
    - sorts crystals
    - plot as length vs. population density



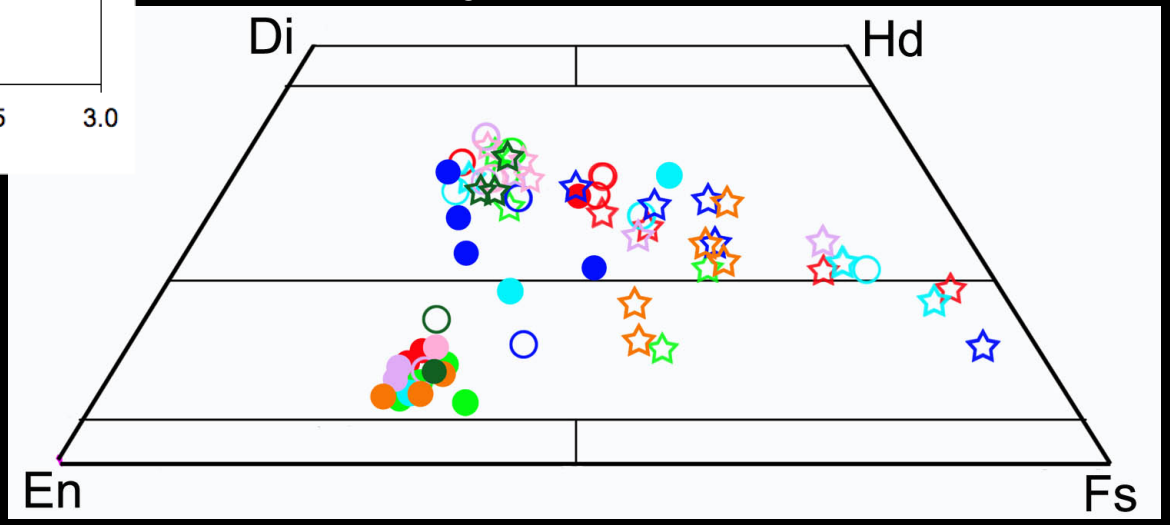


Pyroxene Major Elements

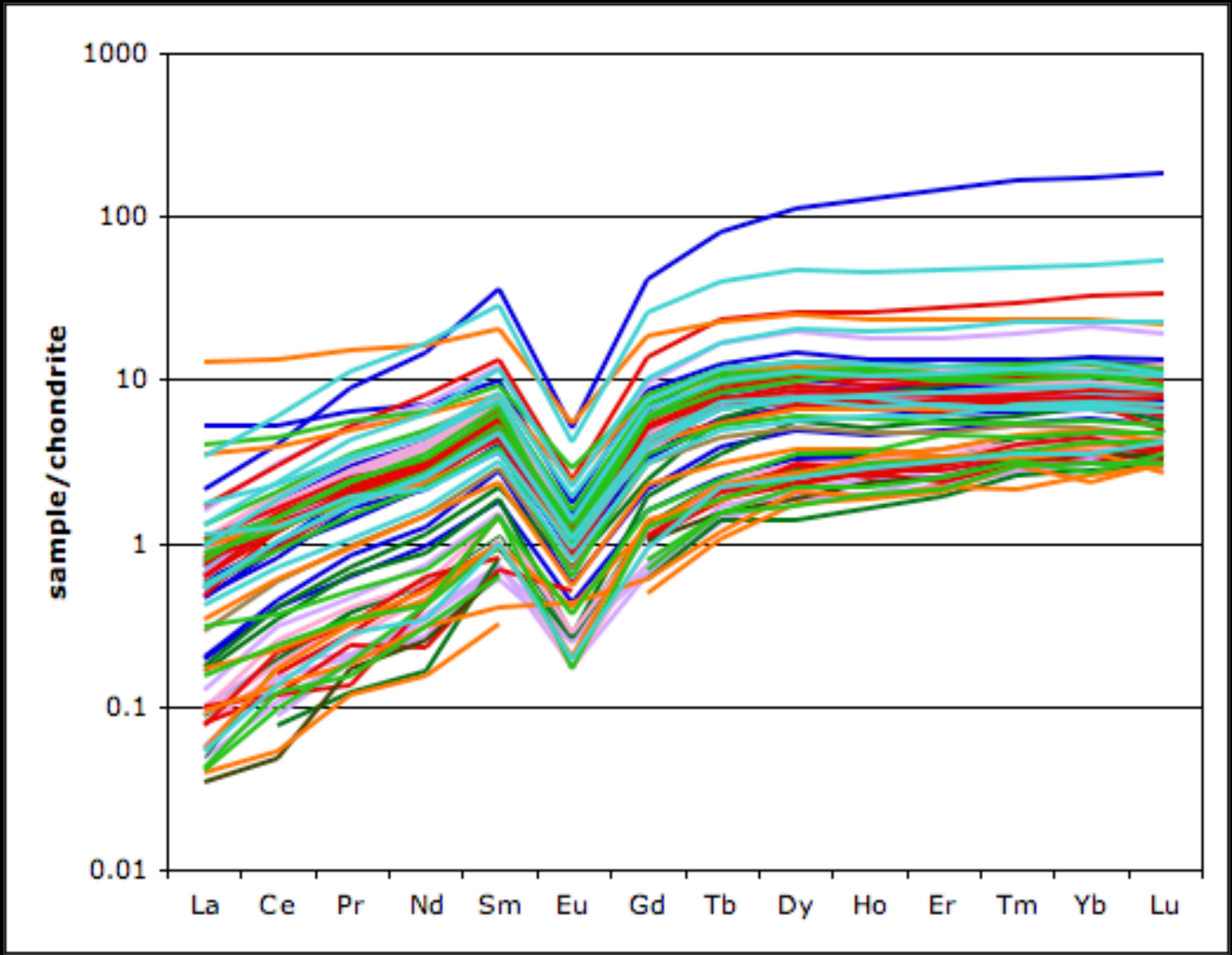


12007 12039
12017 12043
12019 12052
12021 12053

● core
▲ middle
★ rim

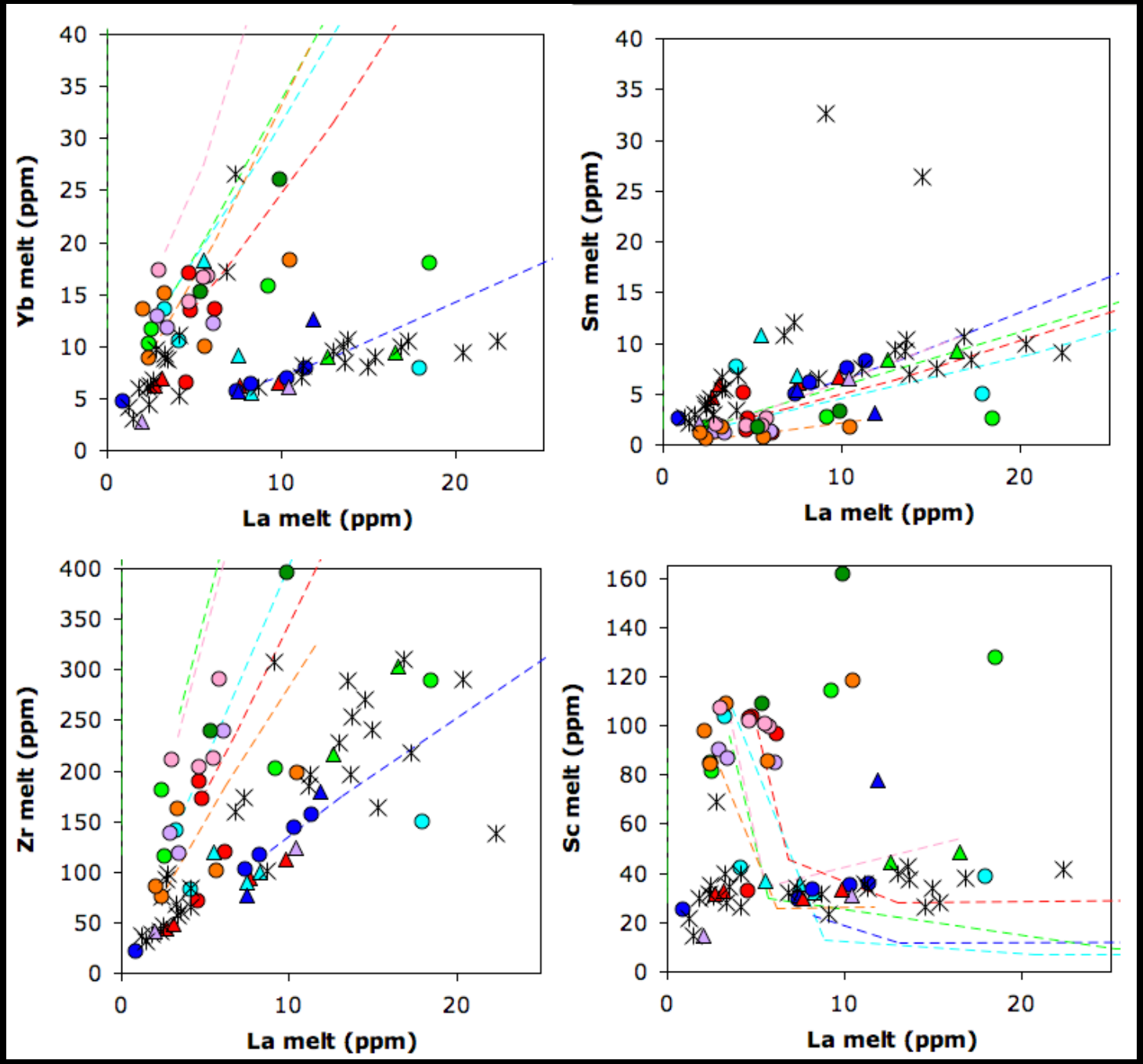


Pyroxene Rare Earth Elements



Modeling

- Pyroxene
  - crystallizes over a long time
- Core compositions
  - calculate parental liquids
- Choose partition coefficient values wisely!
- Vary the bulk distribution coefficient as melt evolves
- Model rims:
  - Fractional
  - Equilibrium
  - In situ crystallization



..... model
● core
▲ middle
★ rim

12007
12017
12019
12021
12039
12043
12052
12053

Conclusions

- Crystal stratigraphy allows for detailed examination of samples
- In situ and equilibrium crystallization don't work!
- The petrogenesis of some samples can be explained with fractional crystallization
- Some cannot!
  - microcosms of melt
  - zircon or apatite as late stage phases
    - would account for Sm
  - partitioning values not ideal
    - no Fe-rich pyroxenes in literature

Future Work

- Include apatite and/or zircon in model
- Find better Kd values
  - *after 200 papers the search continues…*
- Assimilation modeling
- More pyroxene data
  - 12021, 12052, 12053 only have data for a couple of pyroxene crystals

Acknowledgements

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Questions!