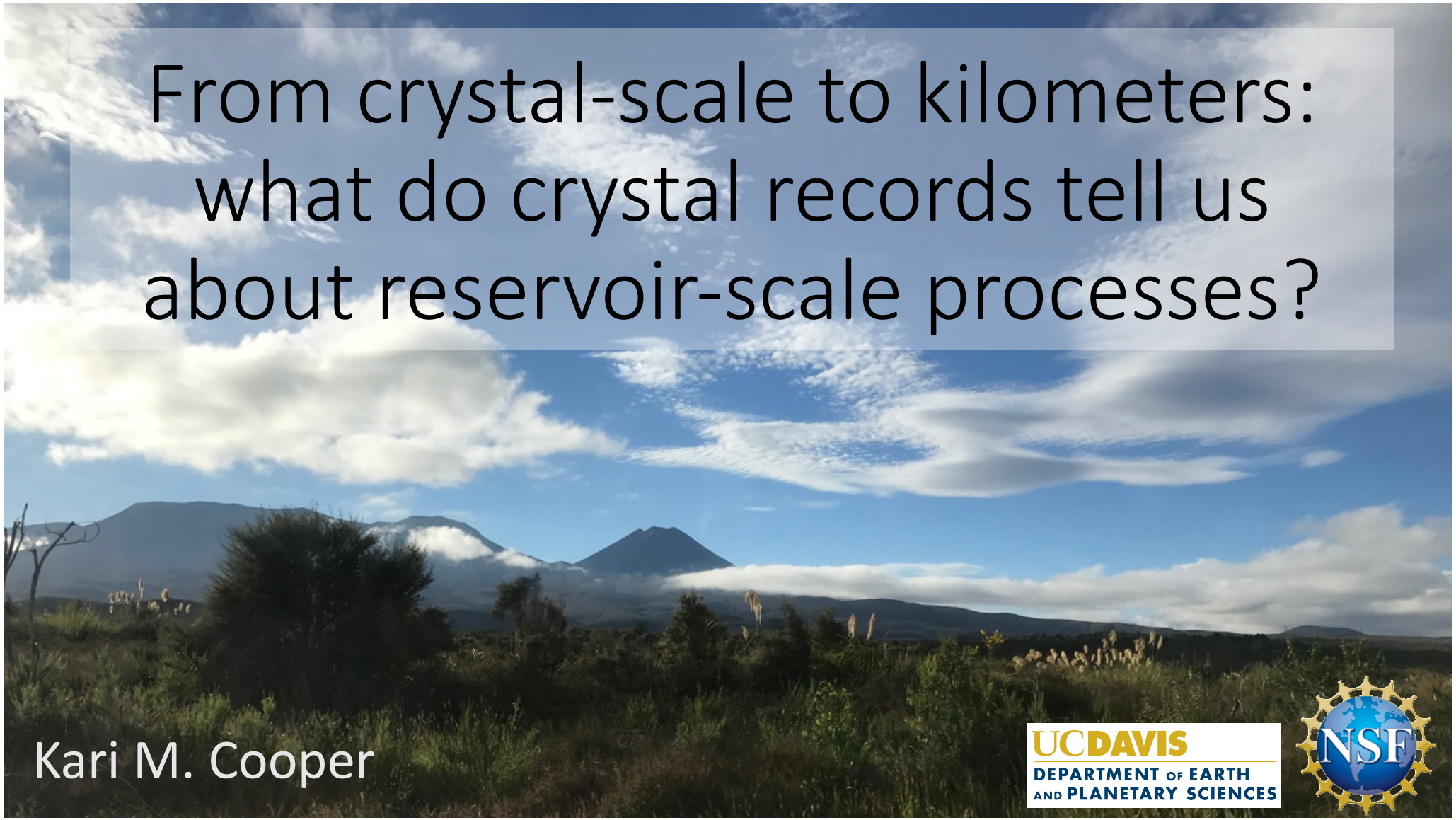
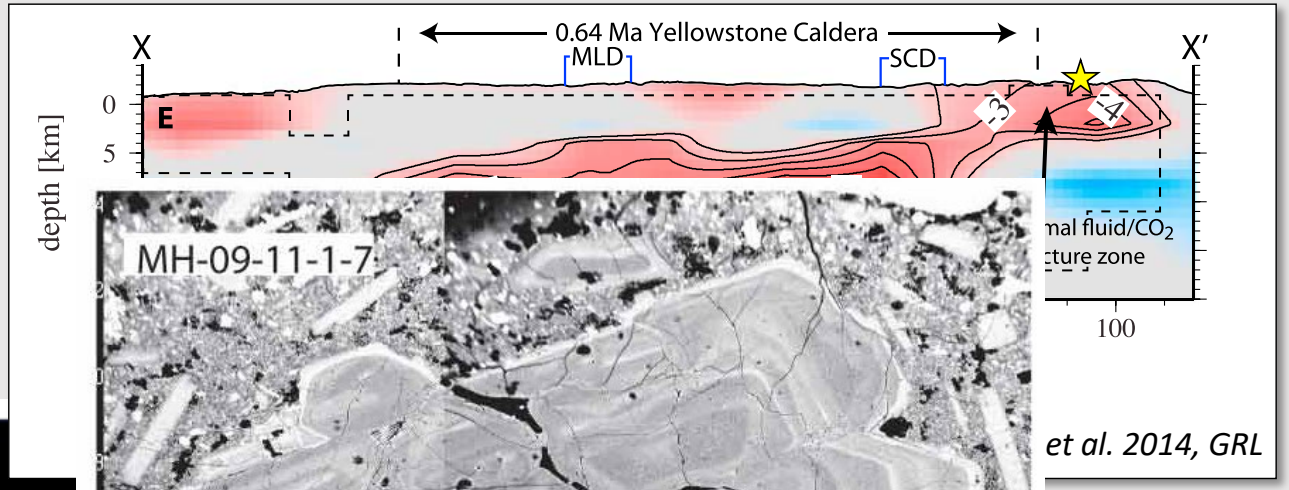
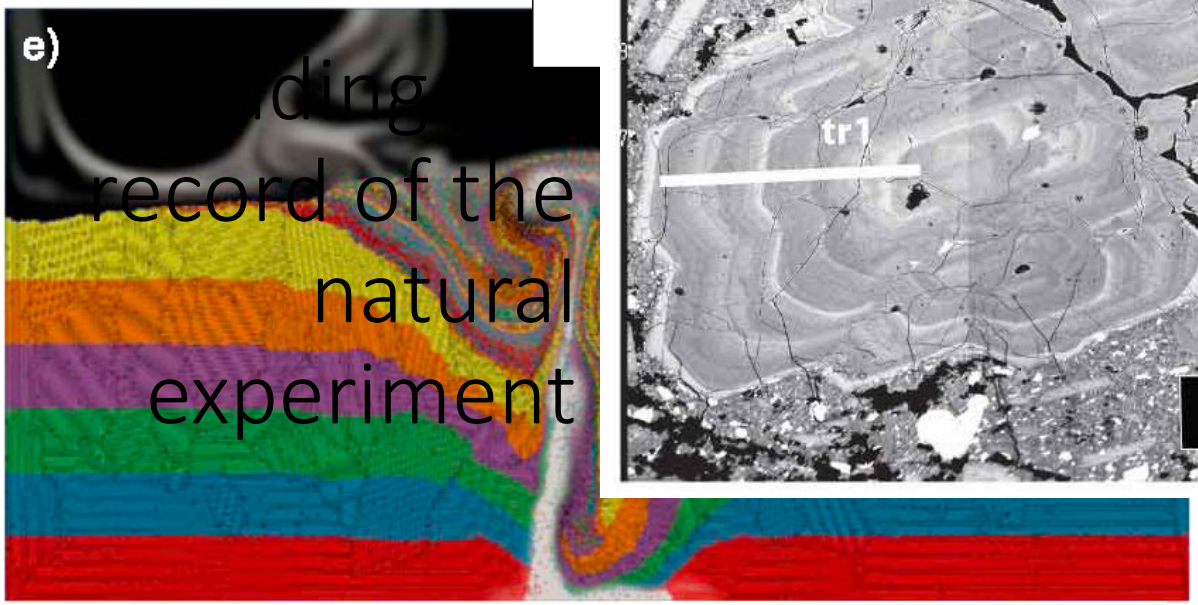
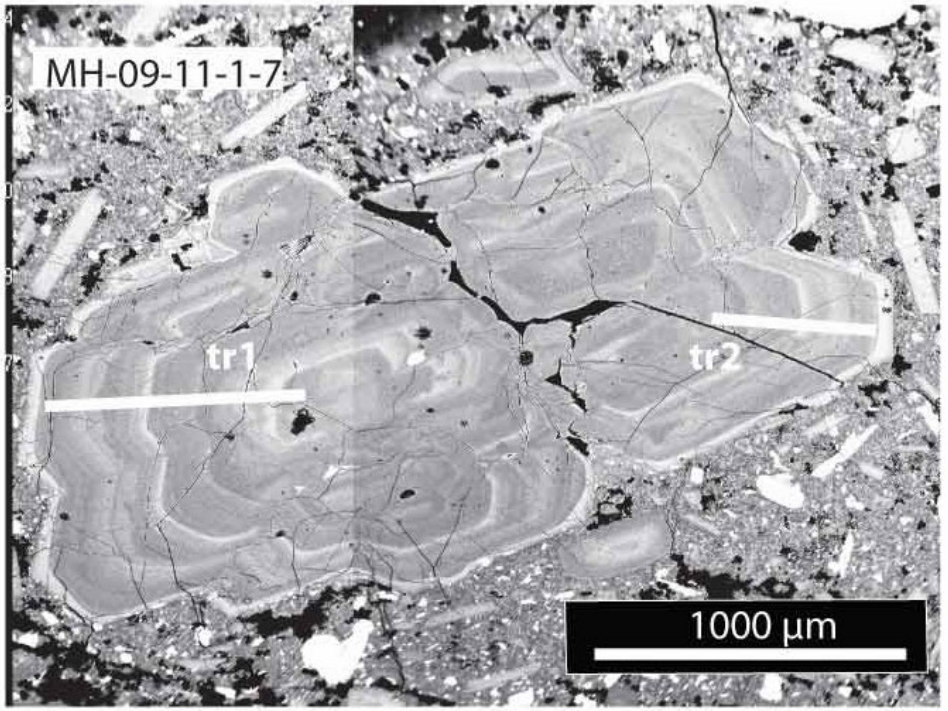

From crystal-scale to kilometers: what do crystal records tell us about reservoir-scale processes?
Kari M. Cooper
UCDAVIS
DEPARTMENT OF EARTH AND PLANETARY SCIENCES
NSF

Why study crystals?



et al. 2014, GRL

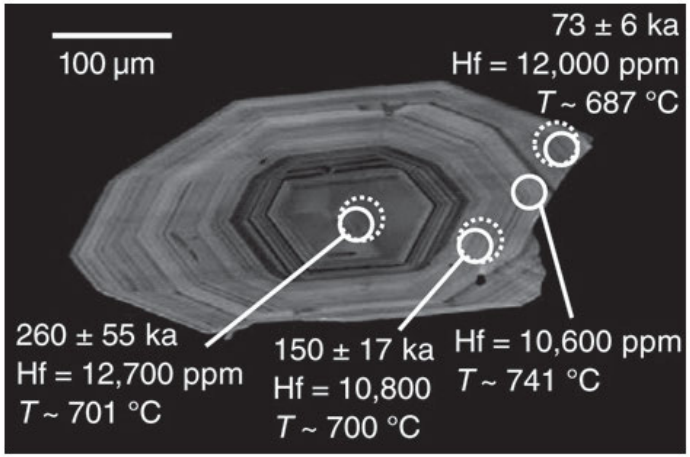


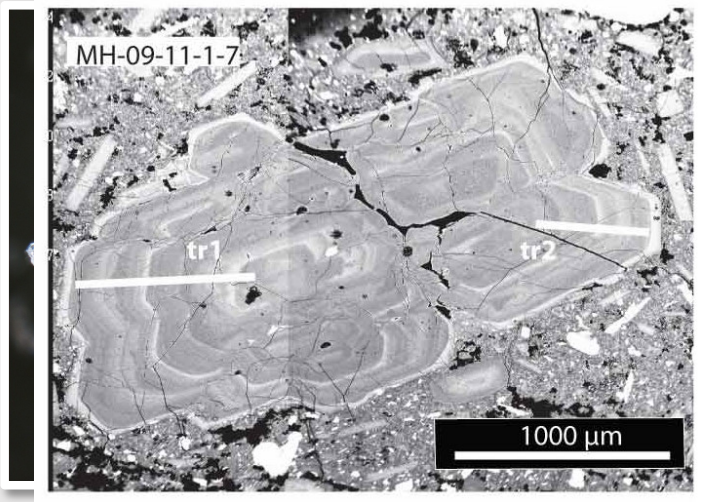


Bergantz et al. 2017 JGR

What do crystals record?

- Absolute ages of crystallization
- Compositional variations within crystals

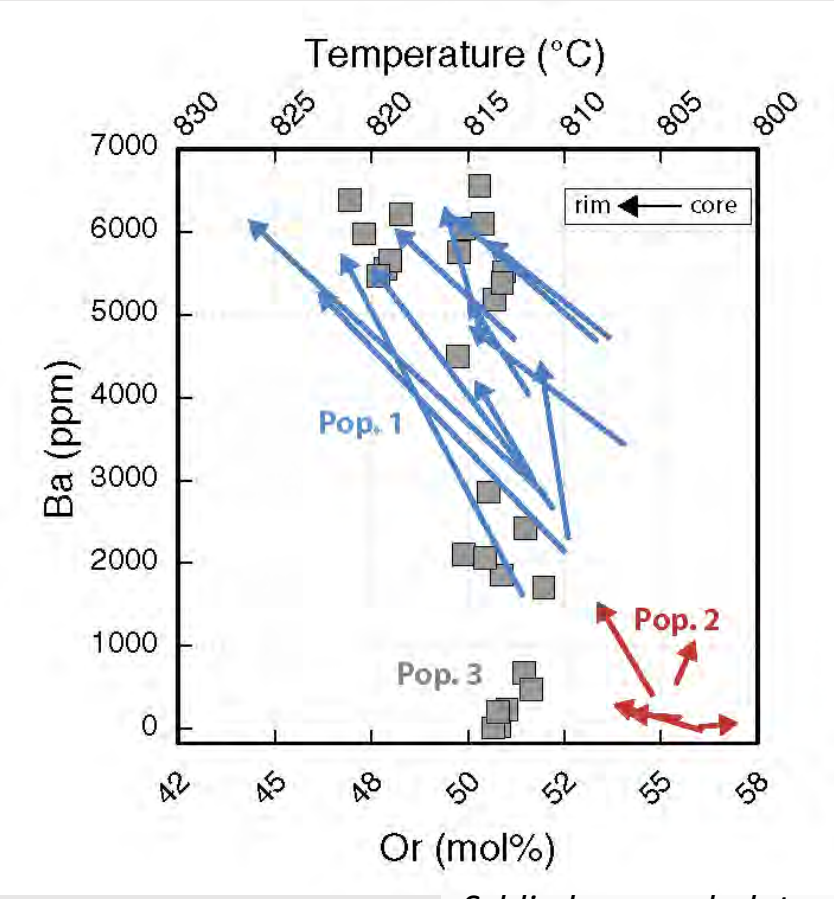




Claiborne et al. 2014, Geology

What do crystals record?

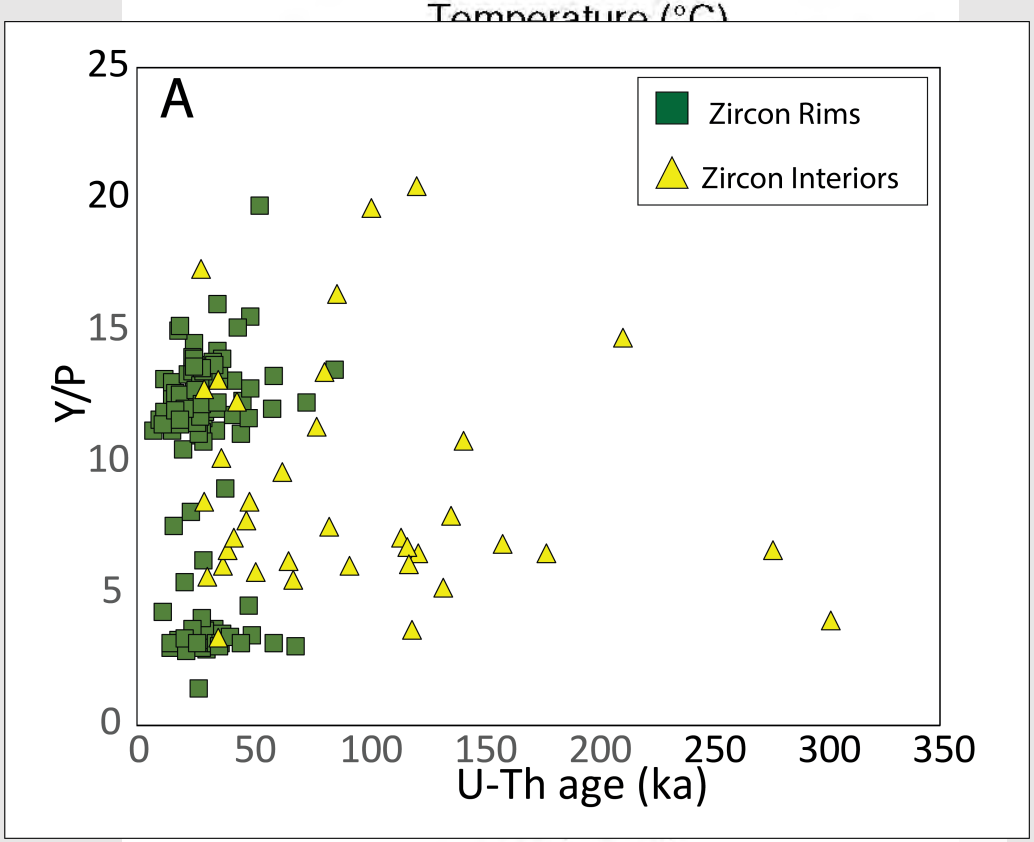
- Absolute ages of crystallization
- Compositional variations within crystals
- Thermometry, barometry, hygrometry



Schlieder, unpub data

What do crystals record?

- Absolute ages of crystallization
- Compositional variations within crystals
- Thermometry, barometry, hygrometry

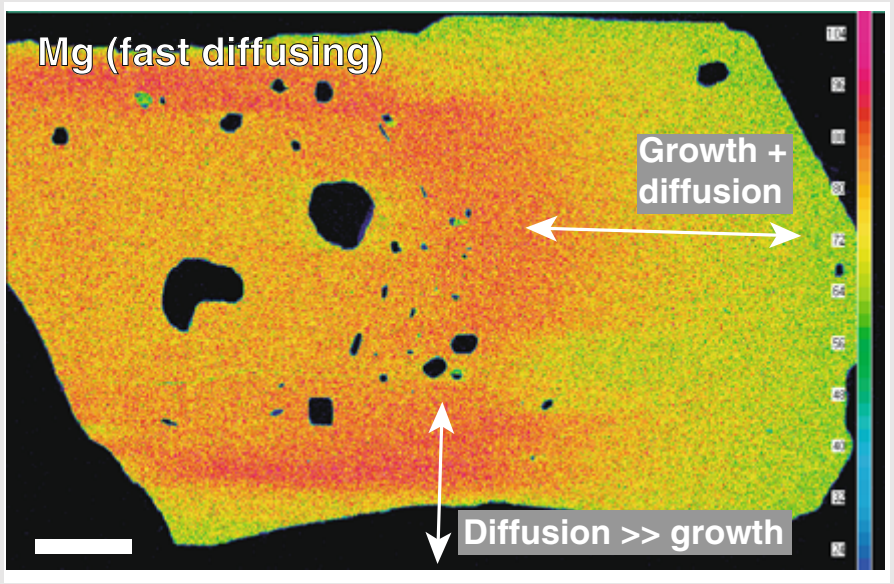


Schlieder, unpub data

Shamloo & Till 2019, CMP

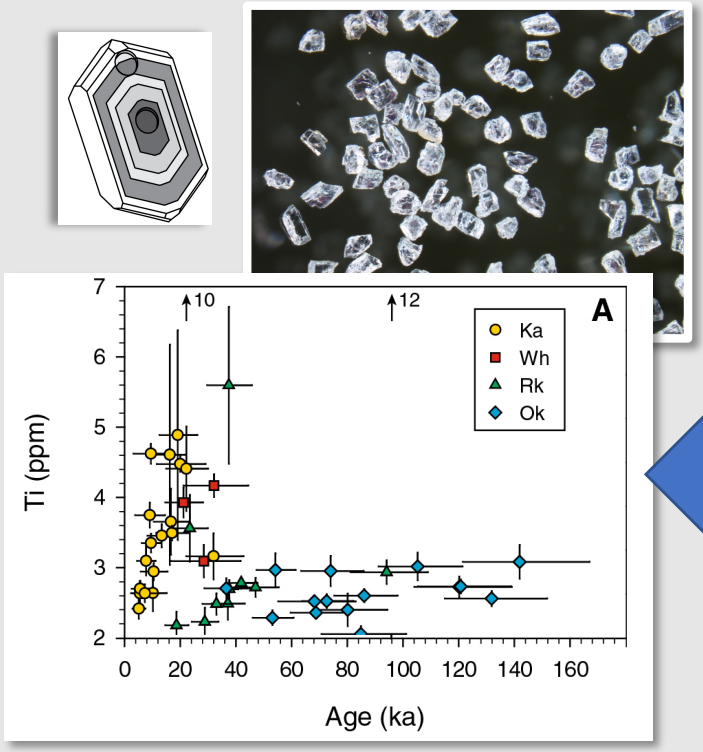
What do crystals record?

- Absolute ages of crystallization
- Compositional variations within crystals
- Thermometry, barometry, hygrometry
- Time since formation of zoning (at a known temperature)
- Etc…

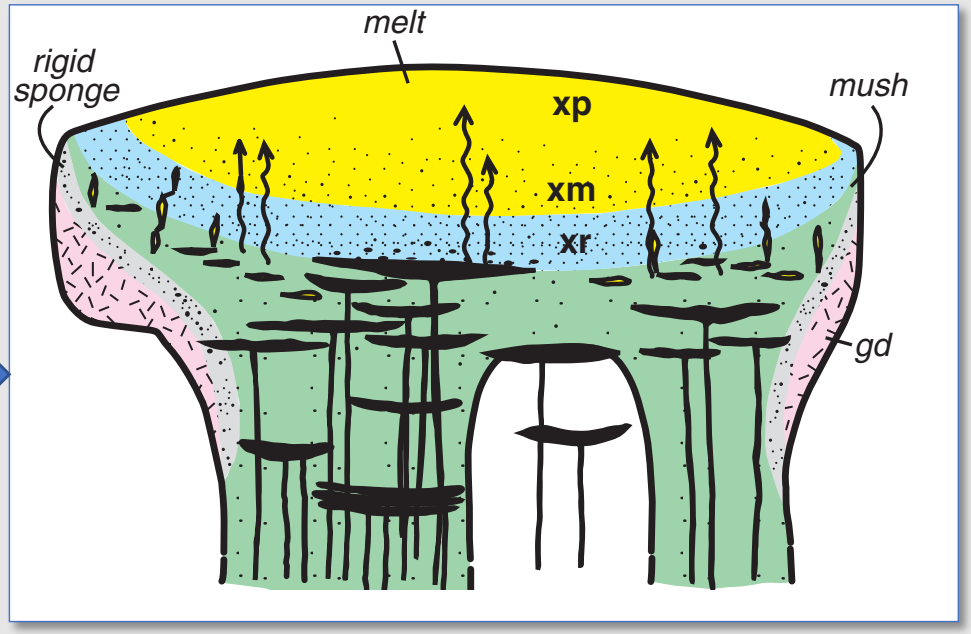


Allan et al. 2013, CMP

How do these data help understand magmatic processes?

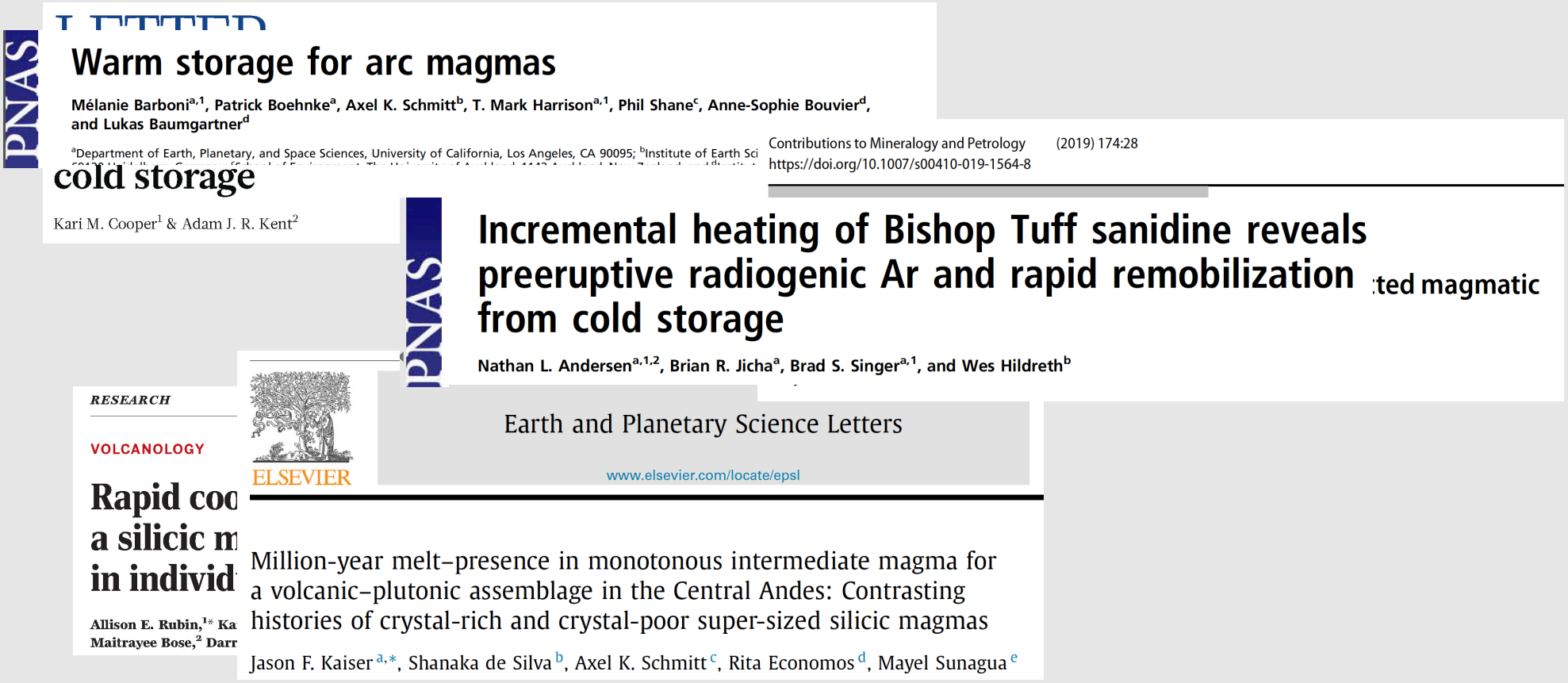


Storm et al. 2014



Hildreth and Wilson, 2007, J. Pet.

The spurious controversy over “warm storage” vs. “cold storage”



PNAS

Warm storage for arc magmas

Mélanie Barboni[a,1], Patrick Boehnke[a], Axel K. Schmitt[b], T. Mark Harrison[a,1], Phil Shane[c], Anne-Sophie Bouvier[d], and Lukas Baumgartner[d]

[a]Department of Earth, Planetary, and Space Sciences, University of California, Los Angeles, CA 90095; [b]Institute of Earth Sci

cold storage

Kari M. Cooper[1] & Adam J. R. Kent[2]

Contributions to Mineralogy and Petrology (2019) 174:28
https://doi.org/10.1007/s00410-019-1564-8

PNAS

Incremental heating of Bishop Tuff sanidine reveals preeruptive radiogenic Ar and rapid remobilization from cold storage

Nathan L. Andersen[a,1,2], Brian R. Jicha[a], Brad S. Singer[a,1], and Wes Hildreth[b]

ted magmatic

RESEARCH

VOLCANOLOGY

Rapid coo
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Allison E. Rubin,[1]* Ka
Maitrayee Bose,[2] Darr

ELSEVIER

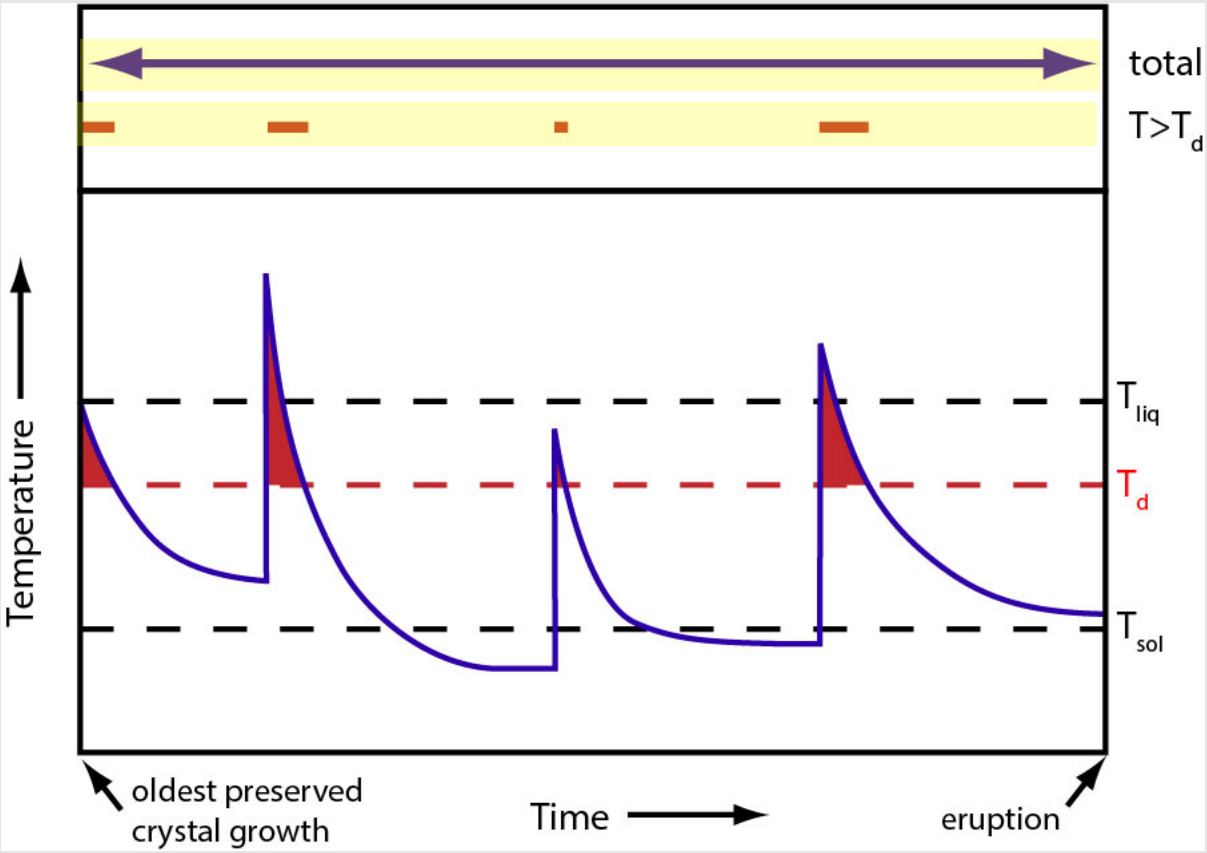
Earth and Planetary Science Letters

www.elsevier.com/locate/epsl

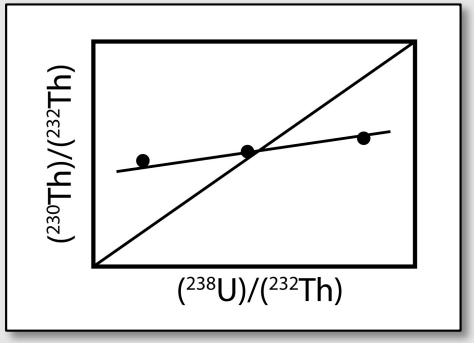
Million-year melt–presence in monotonous intermediate magma for a volcanic–plutonic assemblage in the Central Andes: Contrasting histories of crystal-rich and crystal-poor super-sized silicic magmas

Jason F. Kaiser [a,*], Shanaka de Silva [b], Axel K. Schmitt [c], Rita Economos [d], Mayel Sunagua [e]

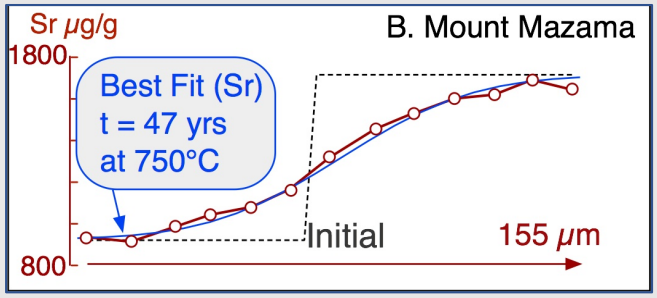
Thermal histories of crystals



Modified from Cooper and Kent, 2014, Nature

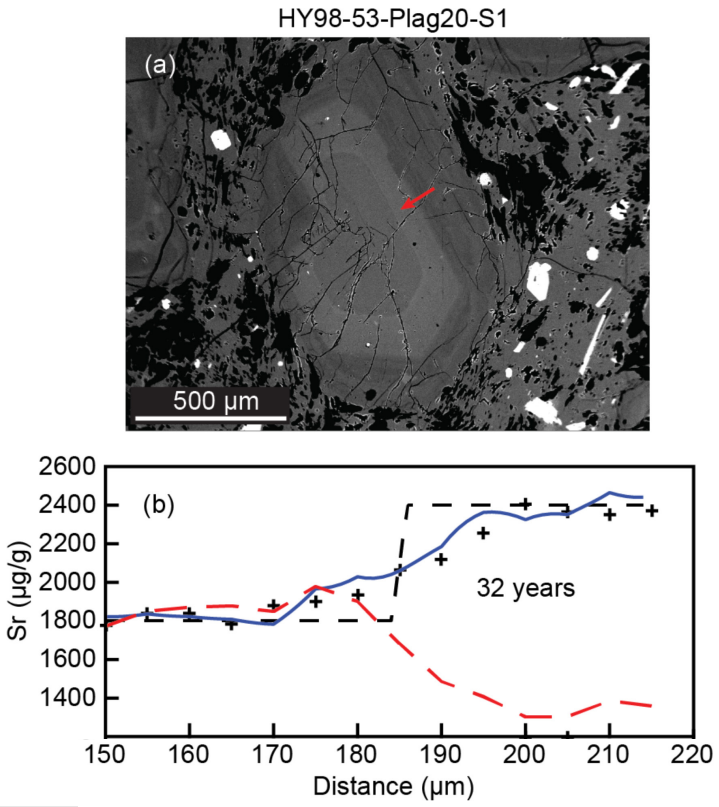


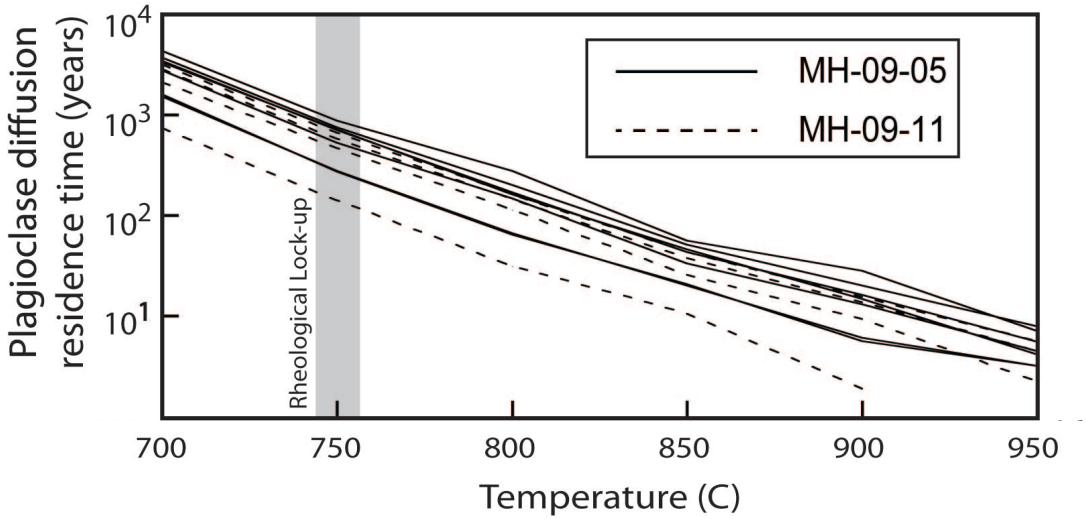
1. Total crystal lifetime



2. Time at temperature T_d

Mount Hood



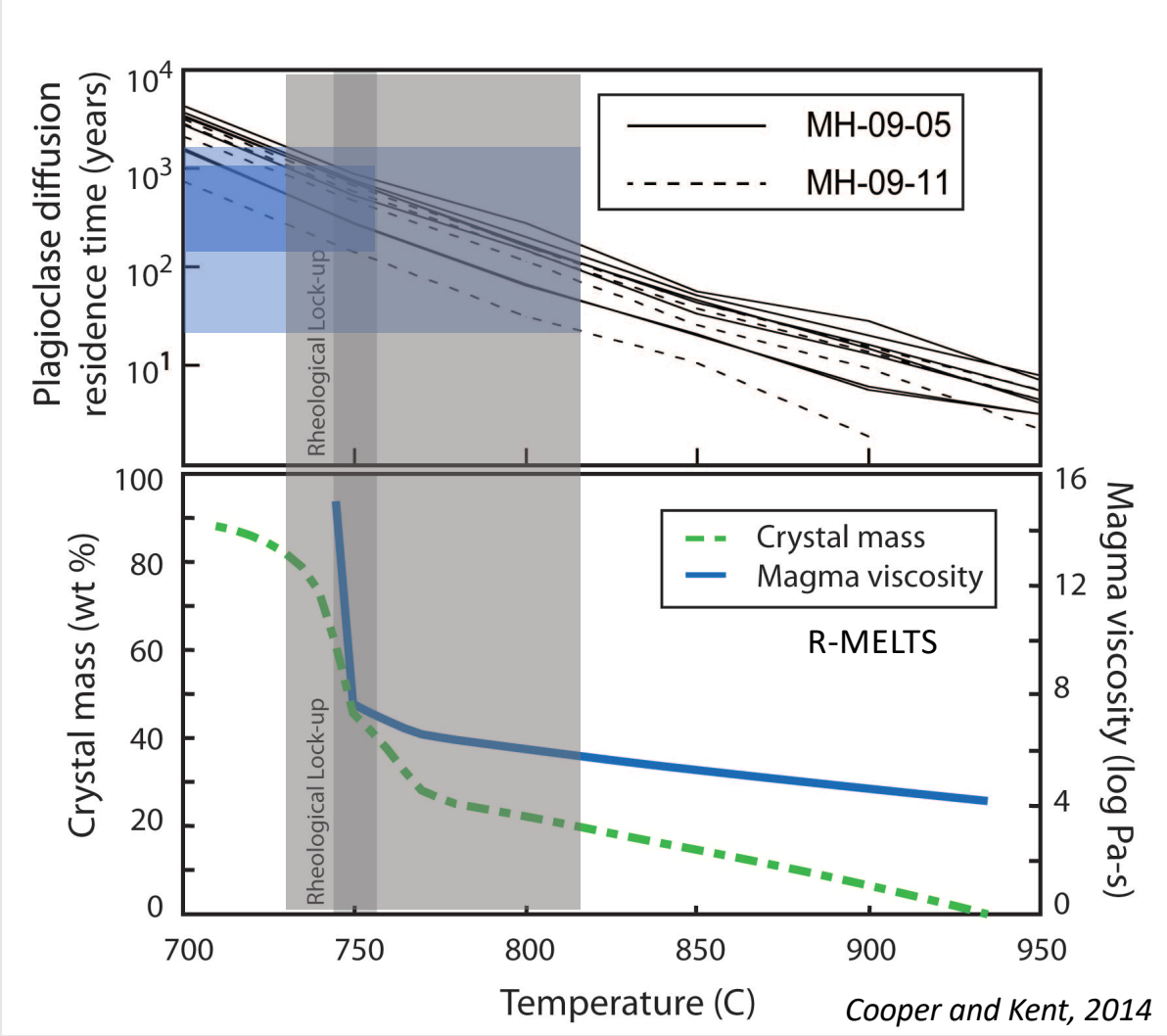


Cooper and Kent, 2014

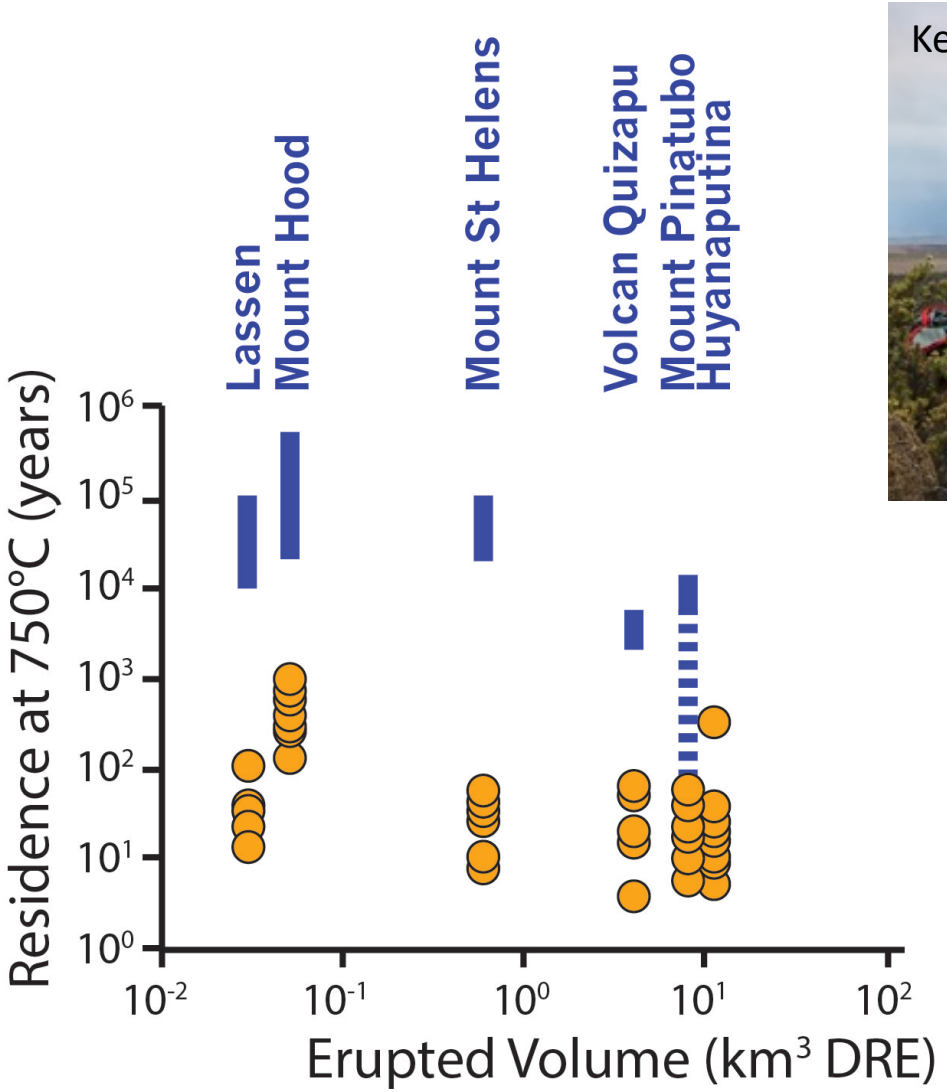
Mount Hood

1. Diffusion durations at 750°C are 144-1100 y
2. *Minimum* age of old plagioclase is 21 ky

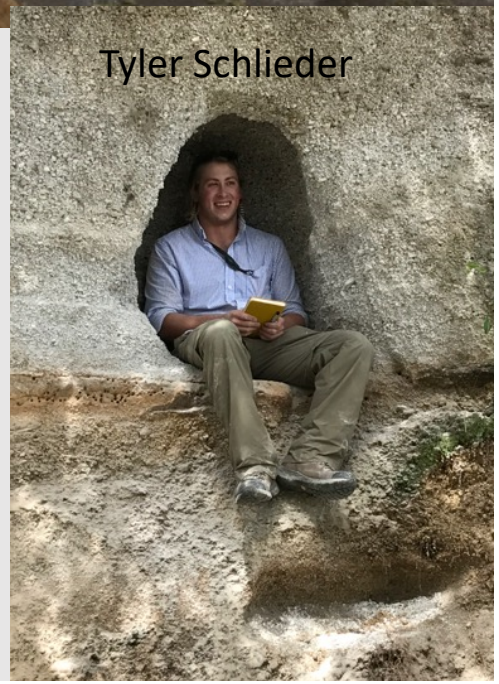
➢less than ~10% of crystal lifetime was spent above 750°C

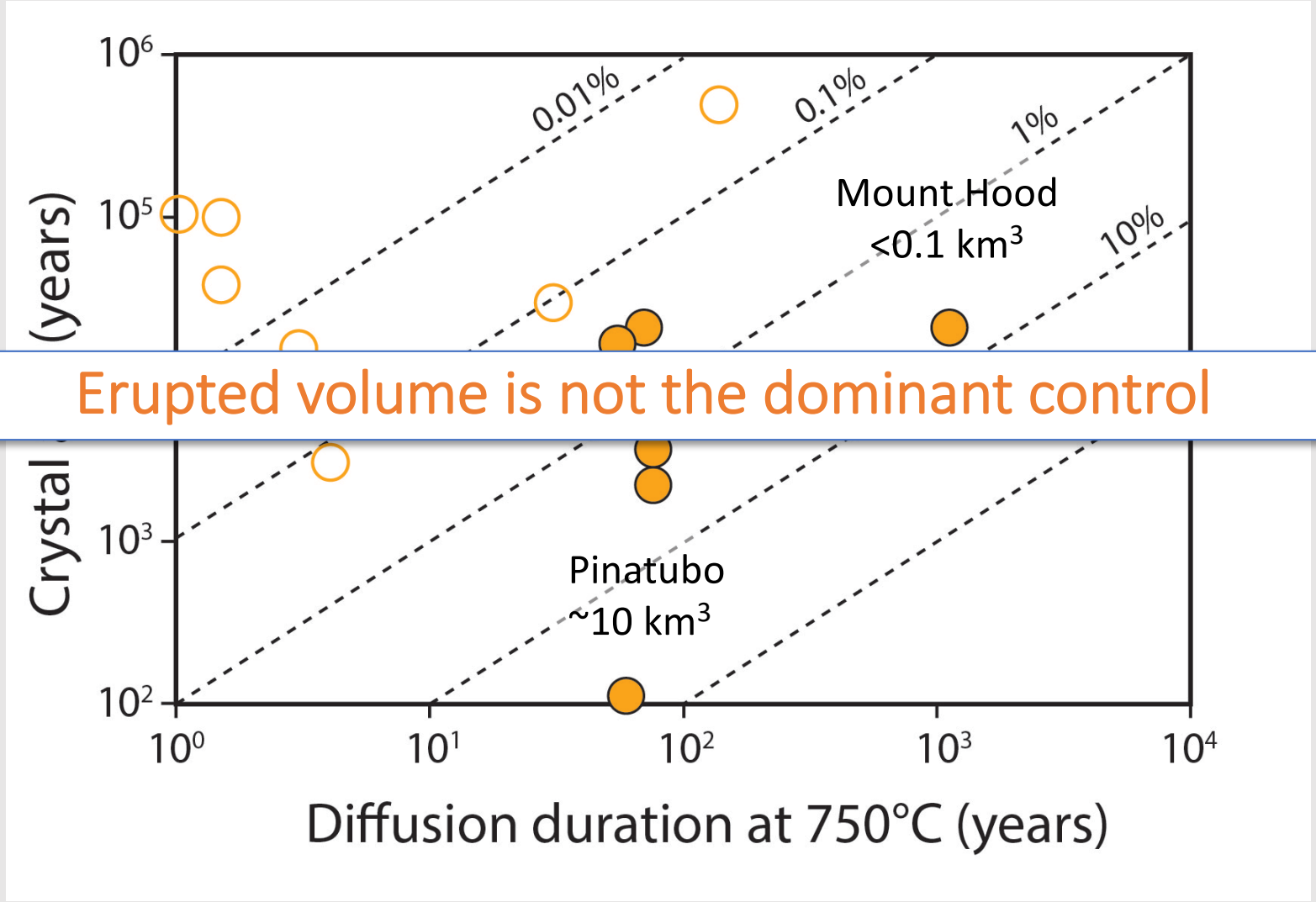


What controls thermal history?

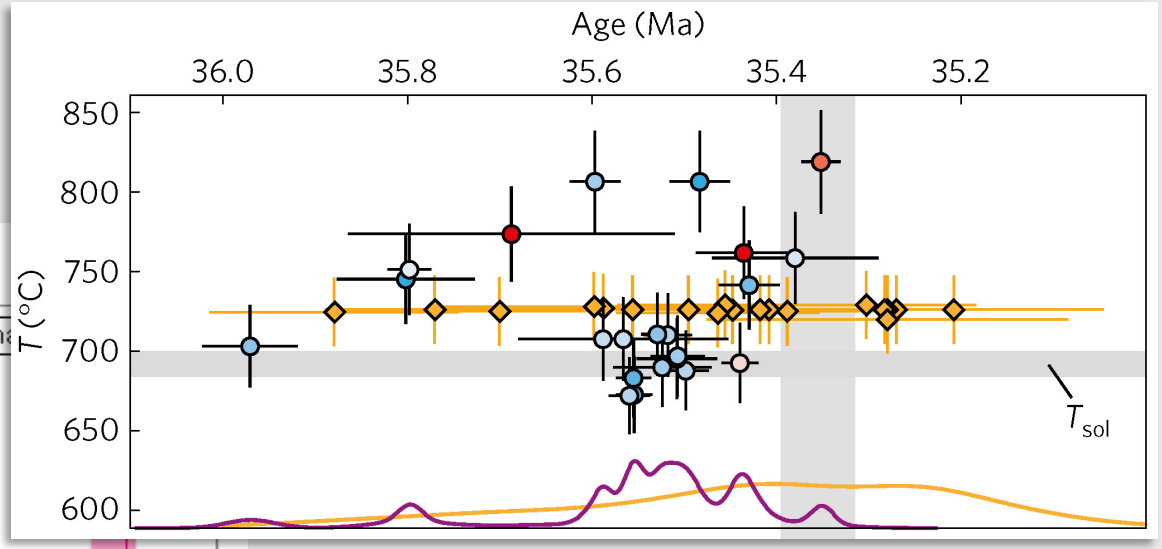

Lassen
Mount Hood
Mount St Helens
Volcan Quizapu
Mount Pinatubo
Huyanaputina
Residence at 750°C (years)
10^6
10^5
10^4
10^3
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
10^1
10^2
Erupted Volume (km^3 DRE)


Kevin Schrecengost

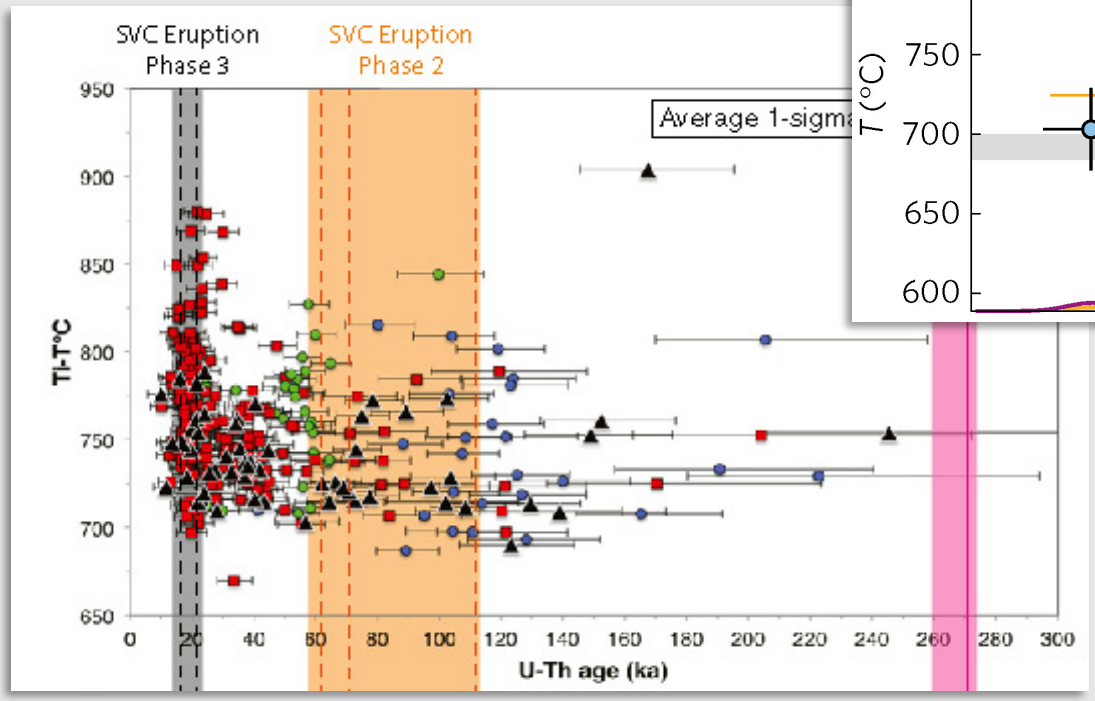

Tyler Schlieder


Erupted volume is not the dominant control
0.01%
0.1%
1%
10%
Mount Hood
<0.1 km3
Pinatubo
~10 km3
Crystal (years)
Diffusion duration at 750°C (years)
10^6
10^5
10^3
10^2
10^0
10^1
10^2
10^3
10^4

Thermal history of the reservoir *from* crystals

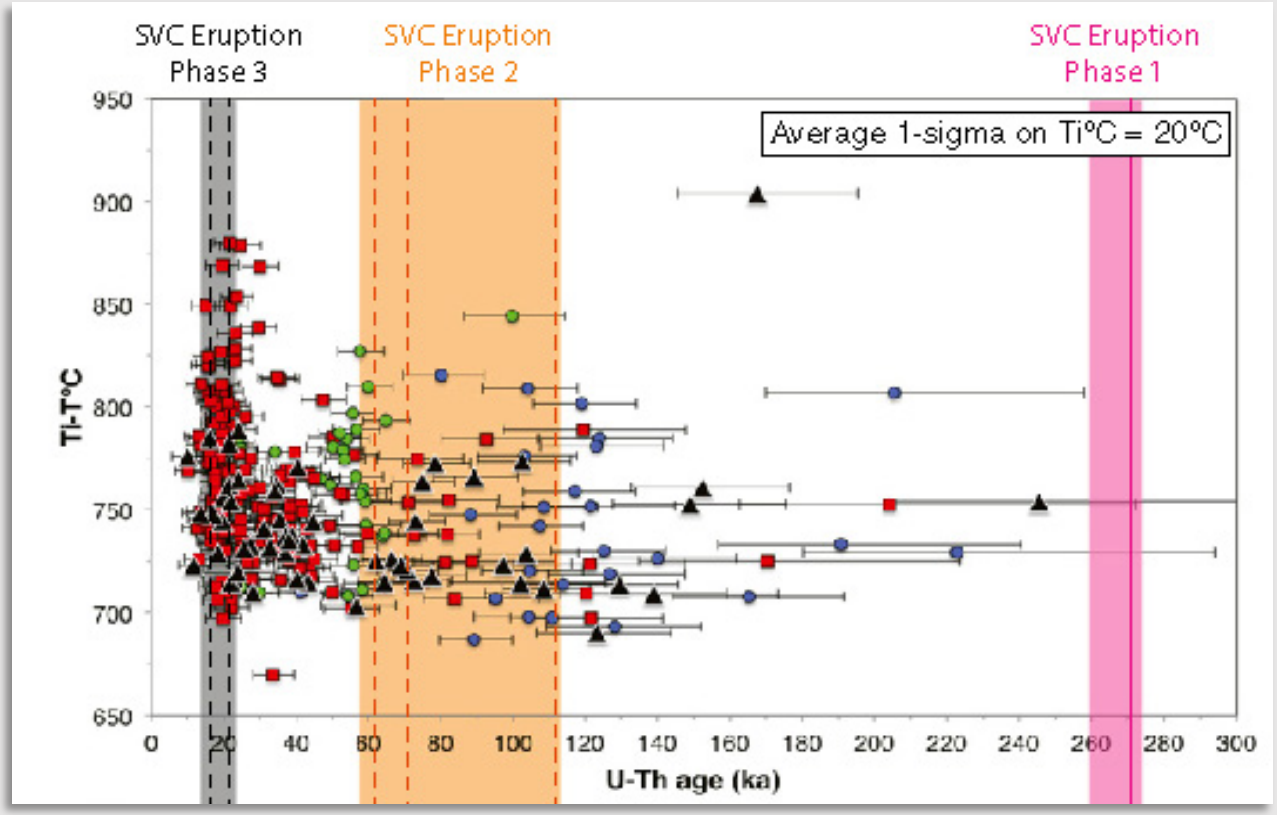


Szymanowski et al. 2017, Nature Geo.



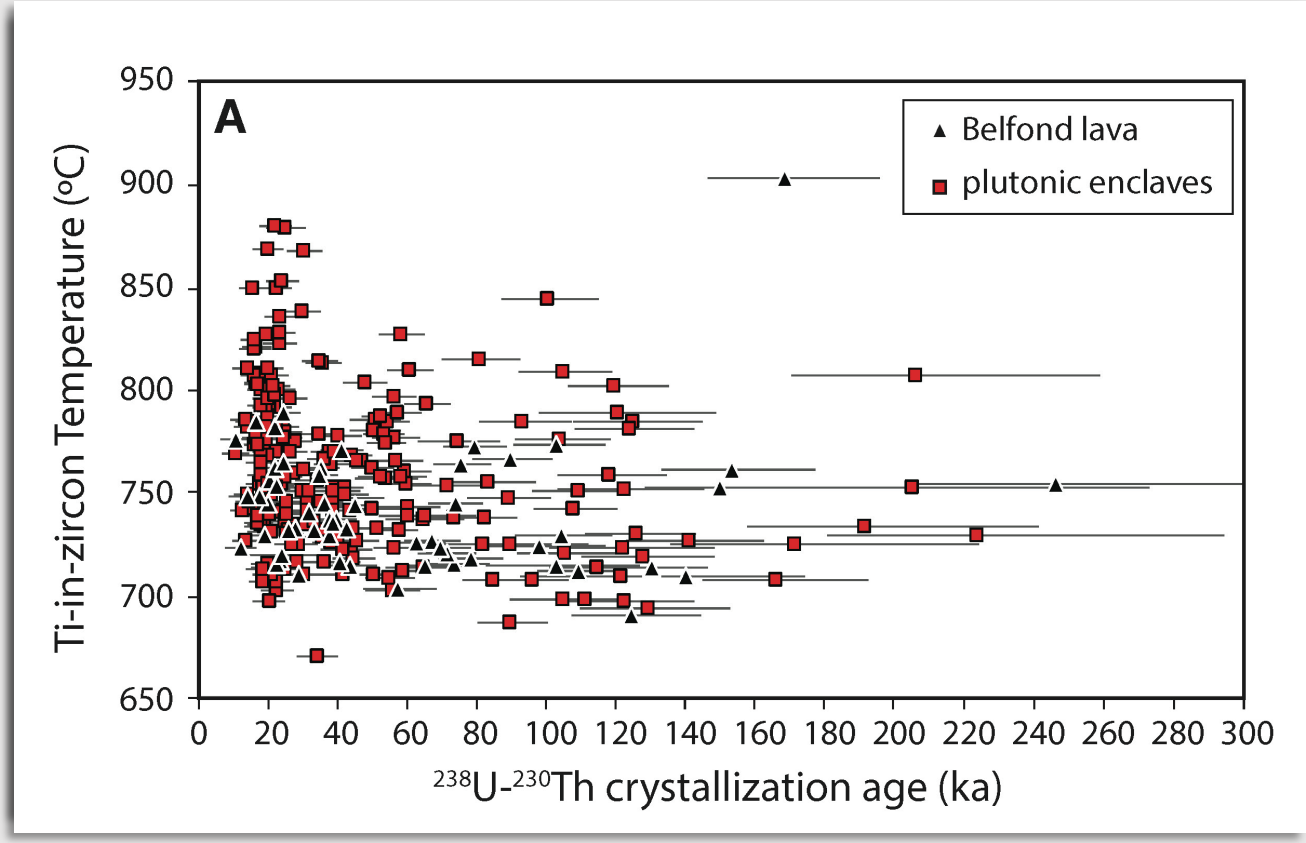
Barboni et al. 2016, PNAS

Thermal histories *from* crystals



"…we show that arc magmas may generally be stored warm (are able to erupt for >100 ka)."
-Barboni et al. 2016, PNAS

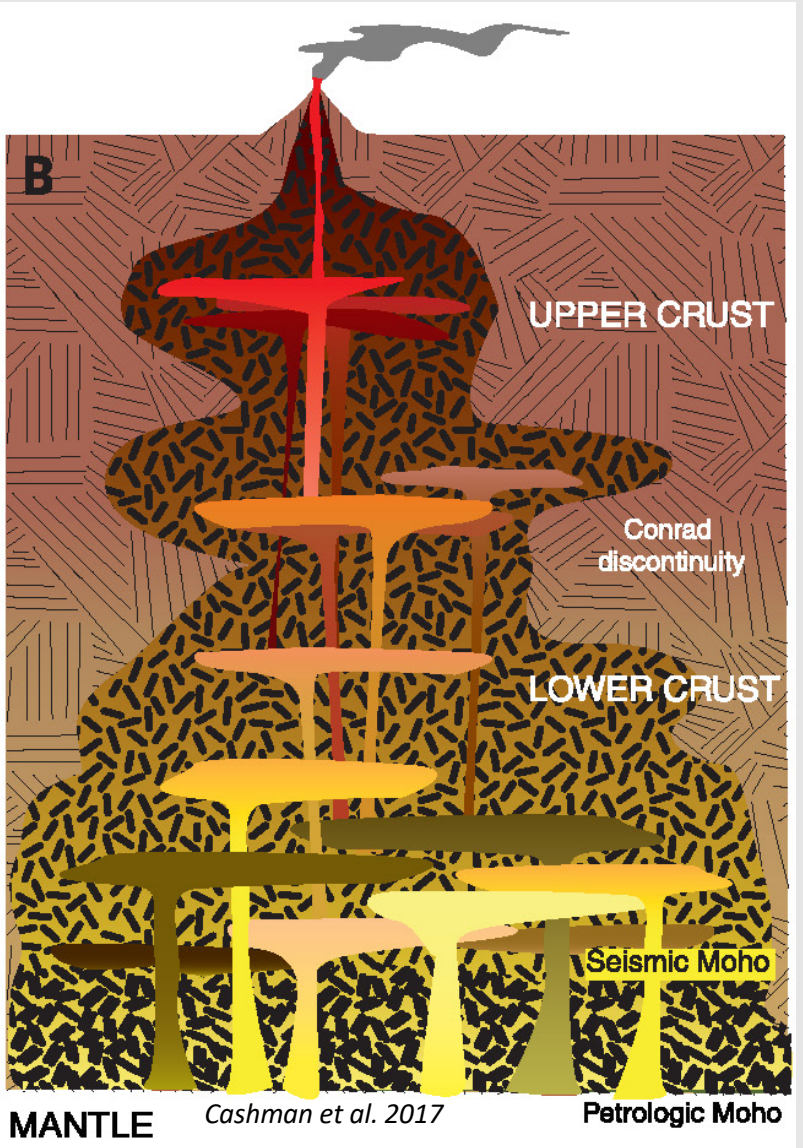
Thermal histories *from* crystals



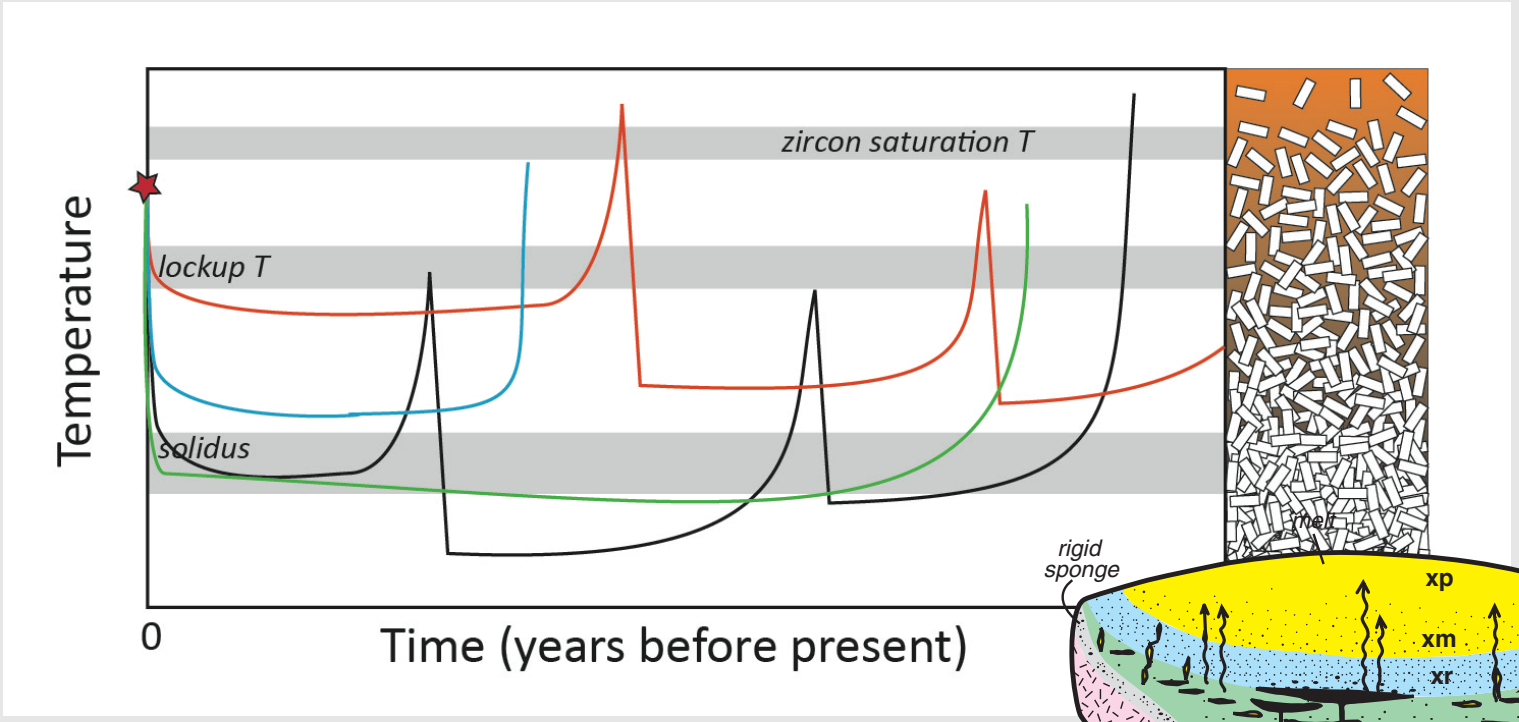
"…we show that arc magmas may generally be stored warm (are able to erupt for >100 ka)."
-Barboni et al. 2016, PNAS

Active part of reservoir is long-lived and compositionally diverse

Crystals (in dacitic-rhyolitic systems) are derived mostly from colder regions



Cashman et al. 2017



Where, when, and for how long are crystals and/or magmas stored warm?

Hildreth and Wilson, 2007, J. Pet.

Implications