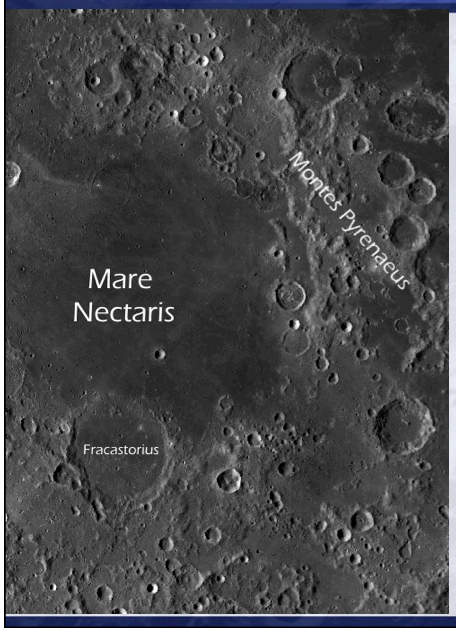

What do impact-melt rocks from the the Nectaris basin look like, and where can we find them?

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1

Nectaris as a time-stratigraphic marker

- Wilhelms recognized Nectaris as a stratigraphic horizon based on overlapping ejecta
- Revised by Fassett et al. based on higher-resolution LRO imagery
- Nevertheless, Nectaris is part of a group of “middle-aged” basins that define (or refute) the Lunar Cataclysm and a solar-system-wide late heavy bombardment

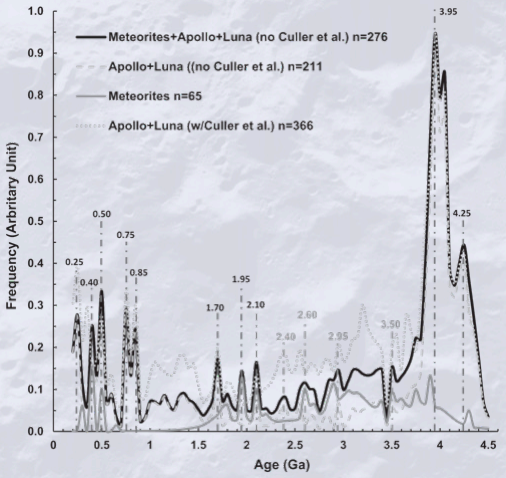
Eon	Stage (Era)	when began My ago	duration My	Notes
Hadean	Early Imbrian	3,900	100	Formation of Archean crust
	Nectarian	3,950	50	Late Heavy Bombardment
	"Ryderian"	4500	550	differentiation of core, mantle and "protocrust"
	Cryptic	4560	~60	Accretion of Earth from solar disk; Theia Event; formation of Moon

Jesus and Einstein on the Expansion of the Universe, www.theologyonline.com

2

Nectaris as a pin in the absolute age curve

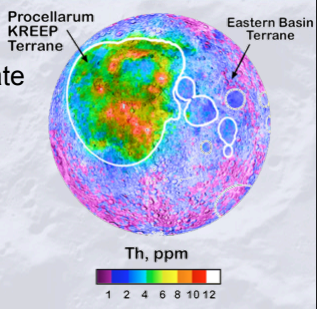
- Impact-melt samples from Apollo 16, particularly those collected at Stations 11 and 13, have been used to date the Nectaris Basin
- Best ages for Nectaris range from 3.85 Ga - 4.2 Ga (Schaeffer et al. 1976, Schaeffer et al. 1985, Reimold et al. 1985)
- We know that KREEP-rich fragments from several sites cluster around 3.85 Ga. Finding more evidence for Ar ages around 4.2 Ga (Fernandes et al. 2013, Cassata et al. 2015)
- Is Nectaris 4.2 Ga? Or is that Serenitatis? Or something else entirely?

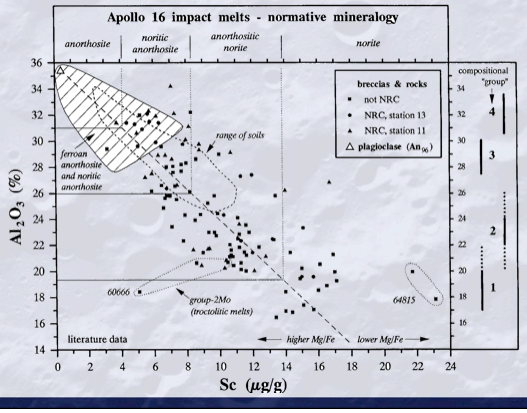


3

Identifying Nectaris melt - composition

- No KREEP halo around Nectaris
- Impact depth (45 km) may be enough to incorporate a noritic lower crustal component
- ….along with a significant anorthositic component from the upper crust



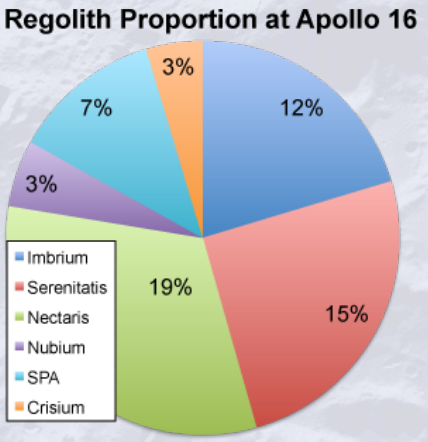


- Group 4 impact-melt rocks may be a candidate, being some of the older samples (Stöffler et al. 1985)

4

Identifying Nectaris melt - location

- Ejecta from North Ray crater (Apollo 16 Stations 11 and 13) excavated material of the Descartes Formation
- Descartes Formation was emplaced or reworked by either Nectaris or Imbrium ejecta – origin is controversial (James 1981; Stöffler et al. 2006, Norman et al. 2010).
- Norman et al. 2010 argued that none of the dated fragments from Decartes are Nectaris melt. But! Modeling (Petro and Pieters 2000, etc.) shows it to be one of the larger contributors to the Apollo 16 site. So where is it?



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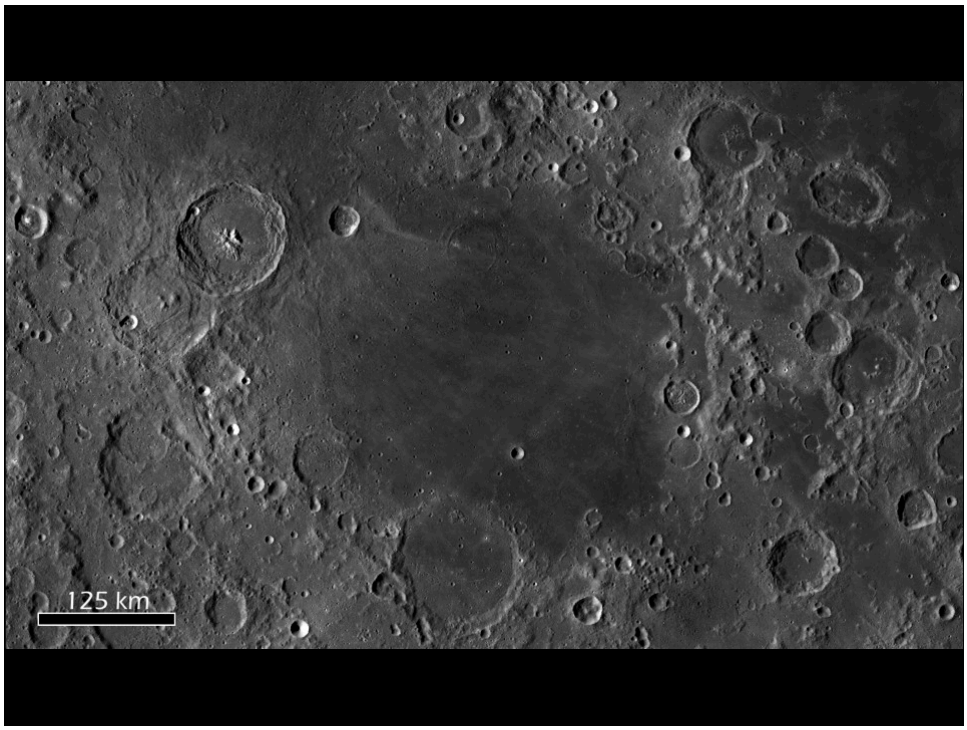
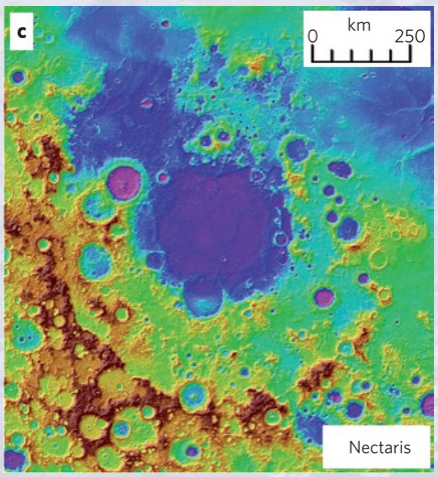
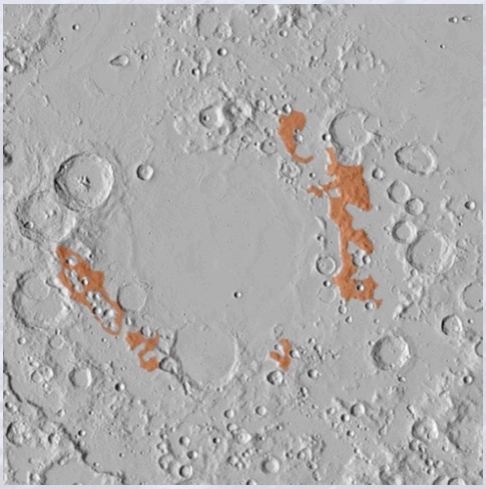


Mapped impact-melt deposits

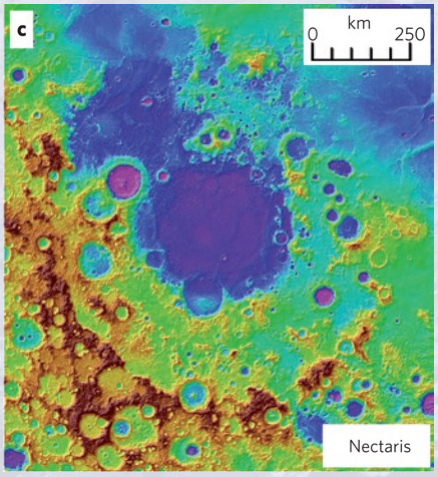


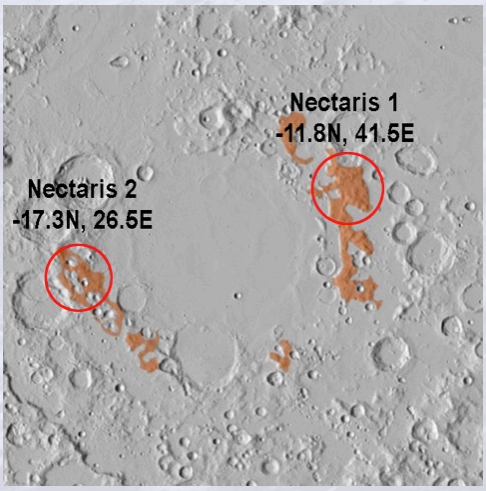


- Small plains near inner basin ring massifs and intermassif “draped” deposits mapped as Nectaris basin impact melt sheet remnants (Spudis and Smith 2013)

7

Mapped impact-melt deposits





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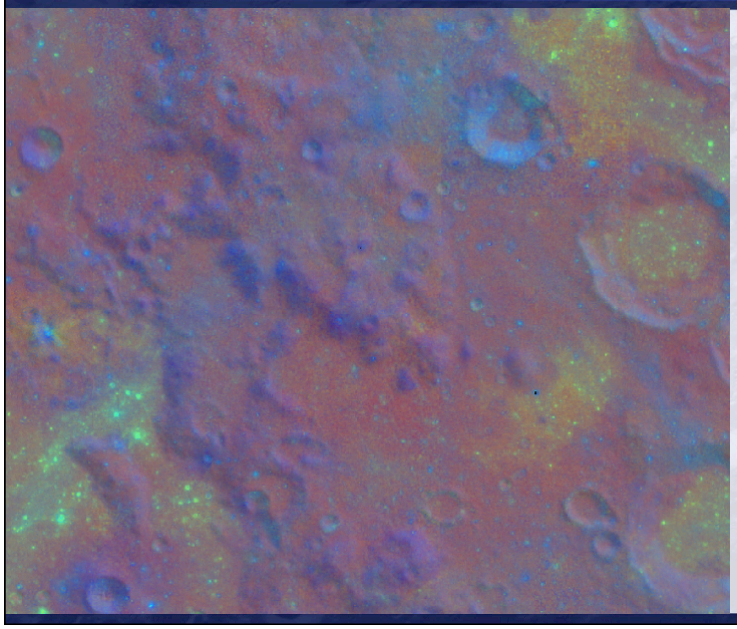
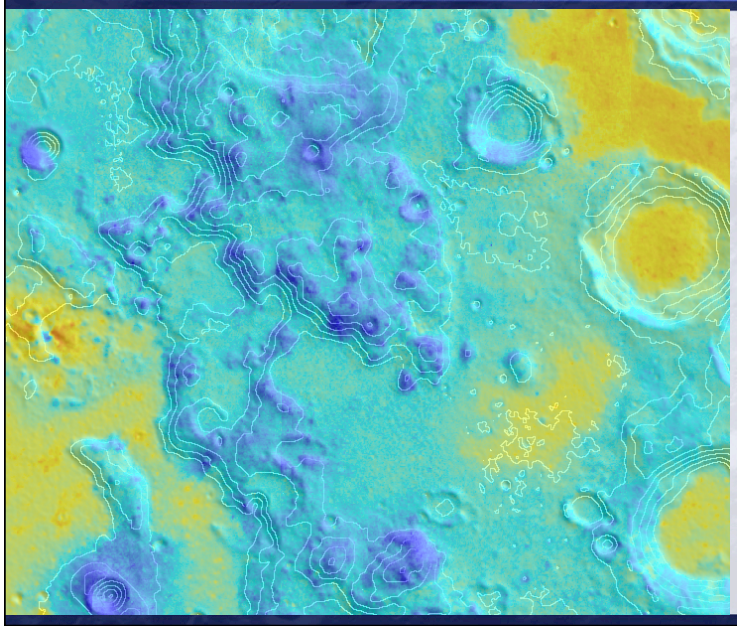
Nectaris1



Clementine UVVIS ratio over WAC/ LOLA topography

9

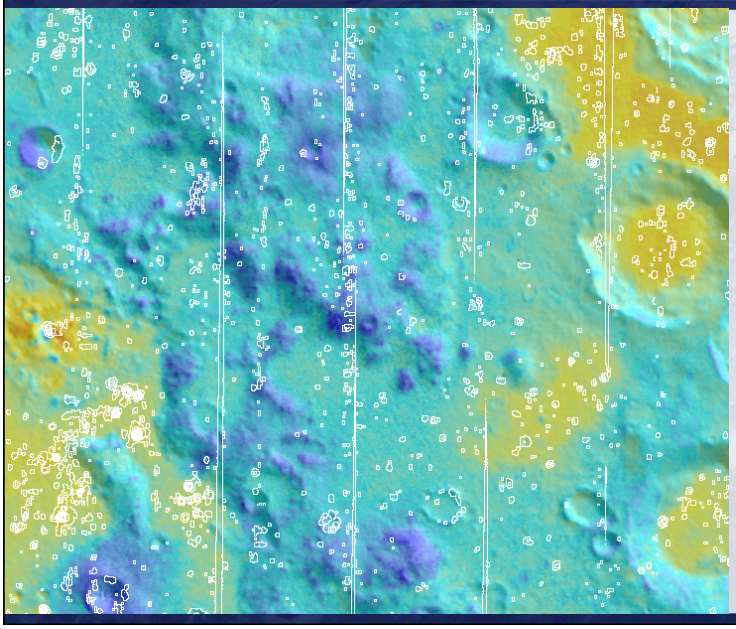
Nectaris1



Clementine FeO map with LROC WAC contours

10

Nectaris1



Clementine FeO map over WAC/ LOLA topography with Diviner rock abundance

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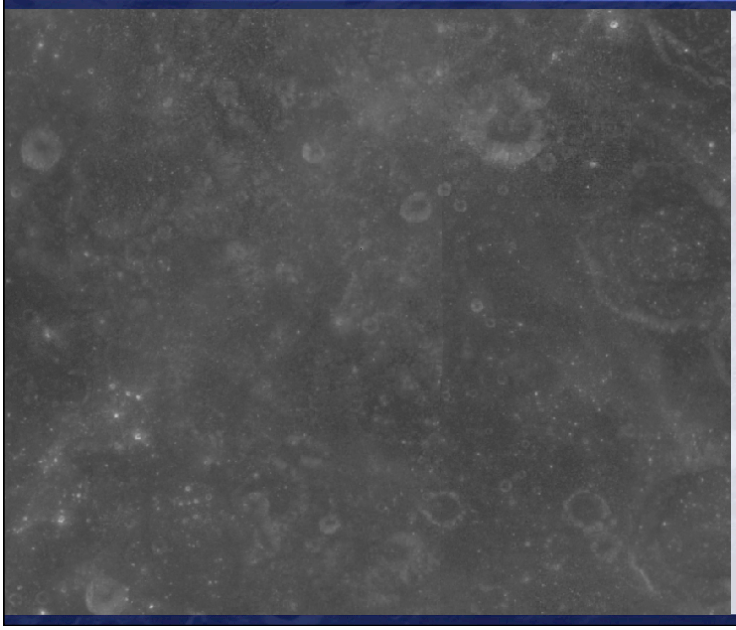
Nectaris1



Clementine maturity map

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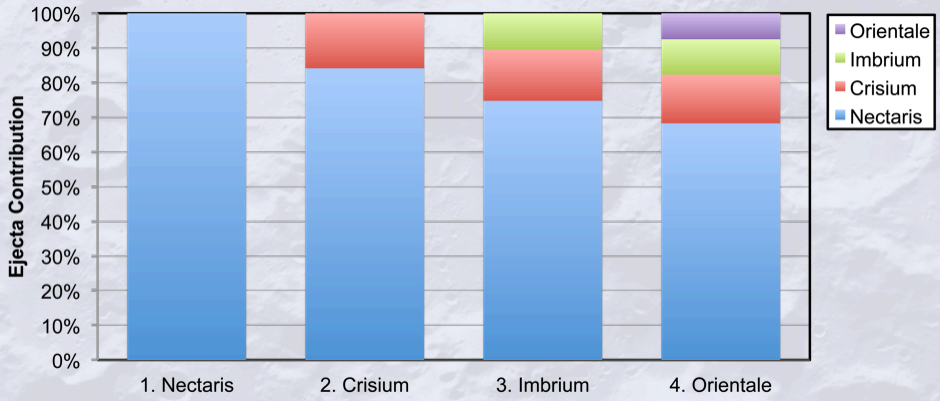
Ejecta mixing model for Nectaris1



- New modeling of basin ejecta based on Petro and Pieters (2010) using updates stratigraphy from Fasset et al. (2012) and other improvements

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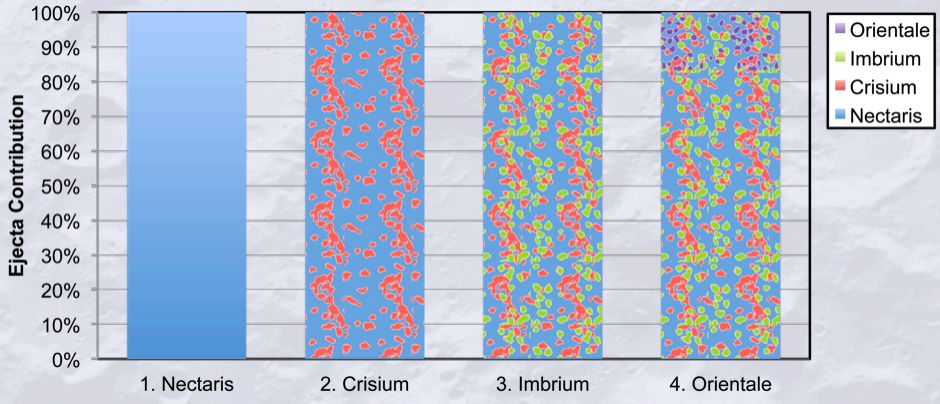
Ejecta mixing model for Nectaris1



1. Nectaris	2. Crisium	3. Imbrium	4. Orientale
N: 100%	N: 84% C: 16%	N: 72% C: 14% I: 10%	N: 63% C: 13% I: 9% O: 7%

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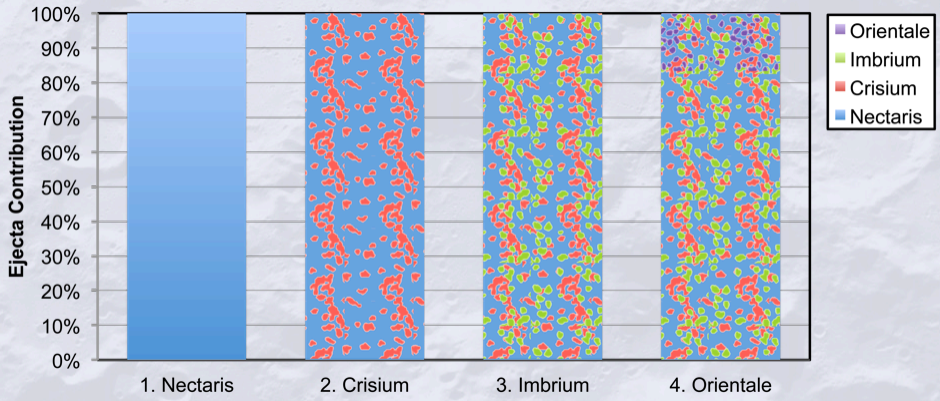
Ejecta mixing model for Nectaris1



Even less simple:

- How much from each basin was melted or sufficiently shocked to have a reset isotopic age?
- How much from each basin is remobilzed material from previous ejecta deposits?
- What was the historical distribution of KREEP as basin formation proceeded?

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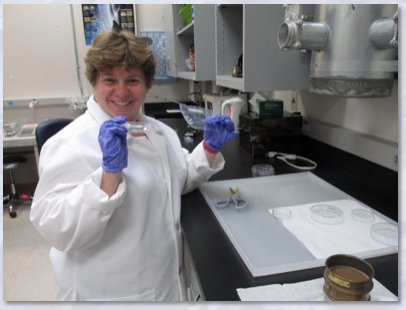
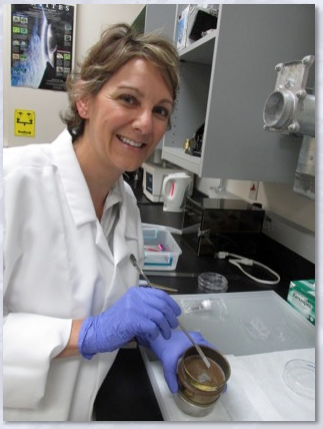
Future work: Searching for Nectaris melt

- Revisit the Apollo 16 Group 4 **aluminous impact-melt** rocks. Techniques and precision have improved to help understand the formation ages of "clast-laden" samples.





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Future work: Searching for Nectaris melt

- Revisit the Apollo 16 Group 4 aluminous impact-melt rocks. Techniques and precision have improved to help understand the formation ages of “clast-laden” samples.
- Using the **proportion of components** predicted at the Nectaris melt remnant sites, the **compositions** of at least some of them (Imbrium melt, Crisium melt, Orientale impact melt, anorthositic lunar crust), and the constraints from **orbital composition and mineralogy**, create mixing models to define the parameter space of plausible compositions for Nectaris impact melt.

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- Using this composition, **search in existing collections** for new pieces to investigate in the laboratory, or…..

18

Future work: Searching for Nectaris melt

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- Using this composition, search in existing collections for new pieces to investigate in the laboratory, or…..
- **Go straight to the source!** In situ dating (K-Ar, Rb-Sr) techniques have significantly matured in the last several years in multiple laboratories. Whether impact-melt fragments are 3.9 or 4.2 Ga can be determined by direct analysis.

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