Introduction to the Geochemistry Session

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There was a time – not so long ago – when we knew that the Moon had bright areas with lots of holes and dark areas with fewer holes.

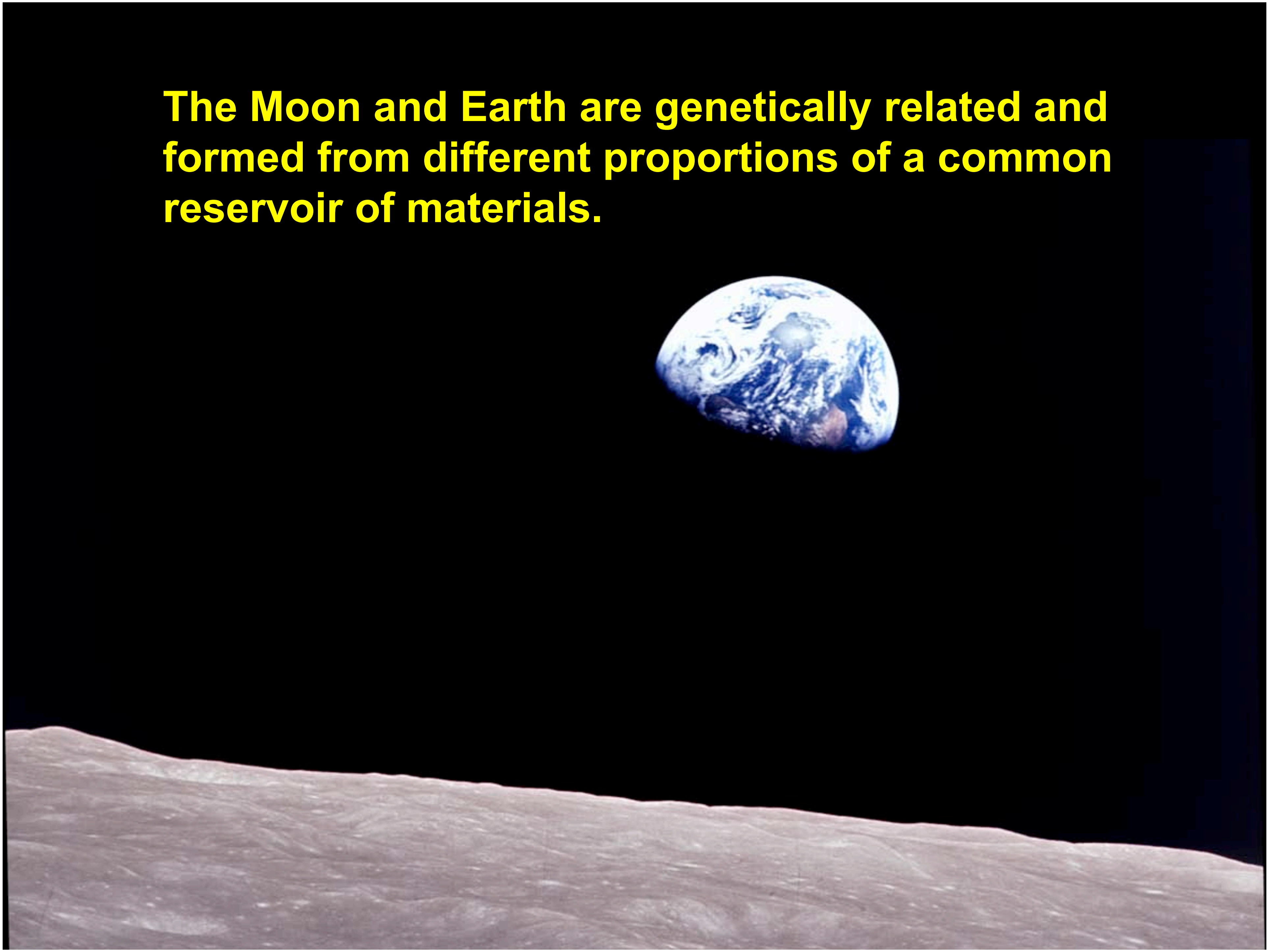
Everything else was speculation.

We went to the Moon in 1969 with very little idea of what we would find.

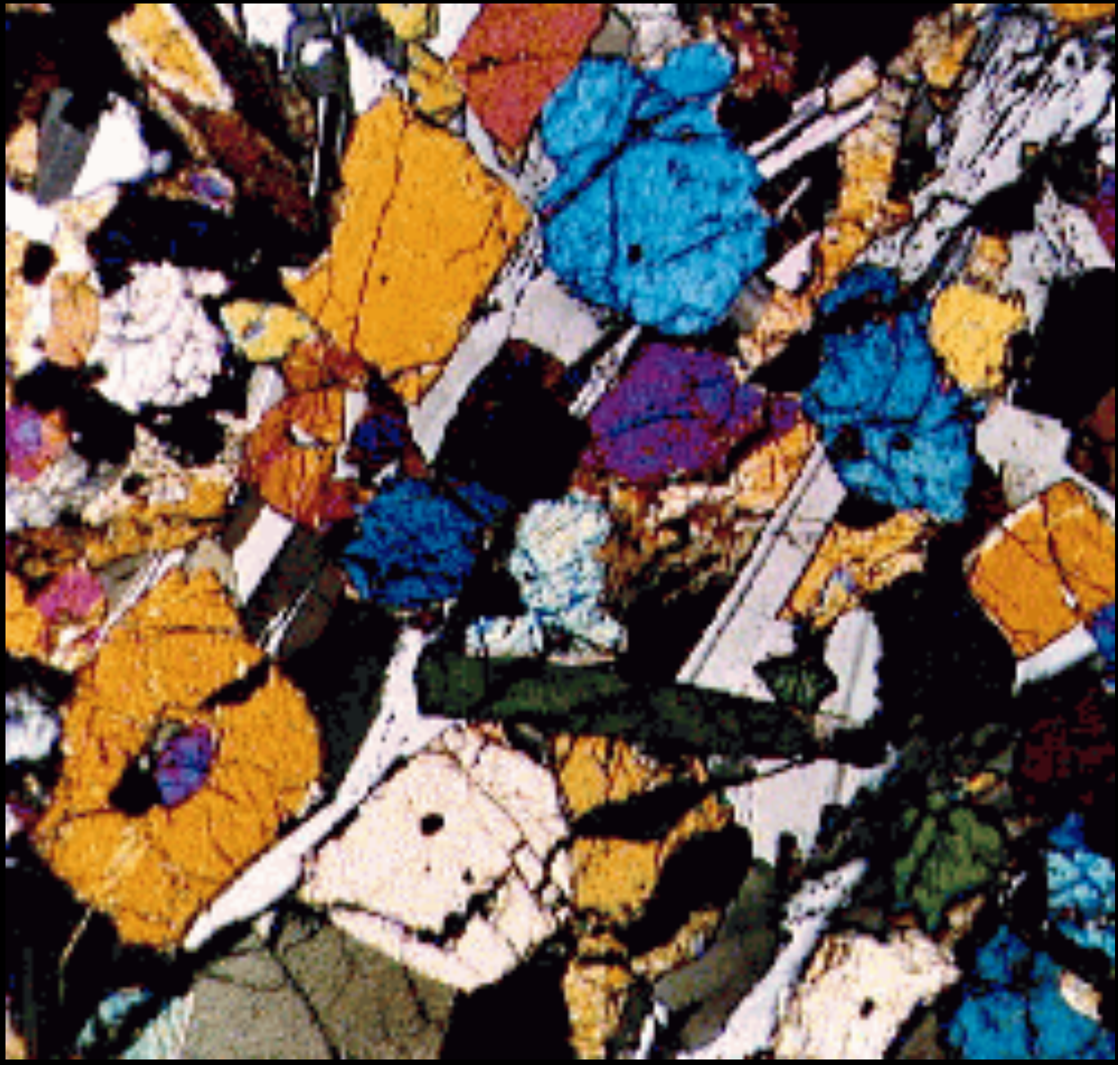
Much of what we have since learned, especially concerning lunar “geo”chemistry, has come from studying the rocks and soil.

So what have we learned ?

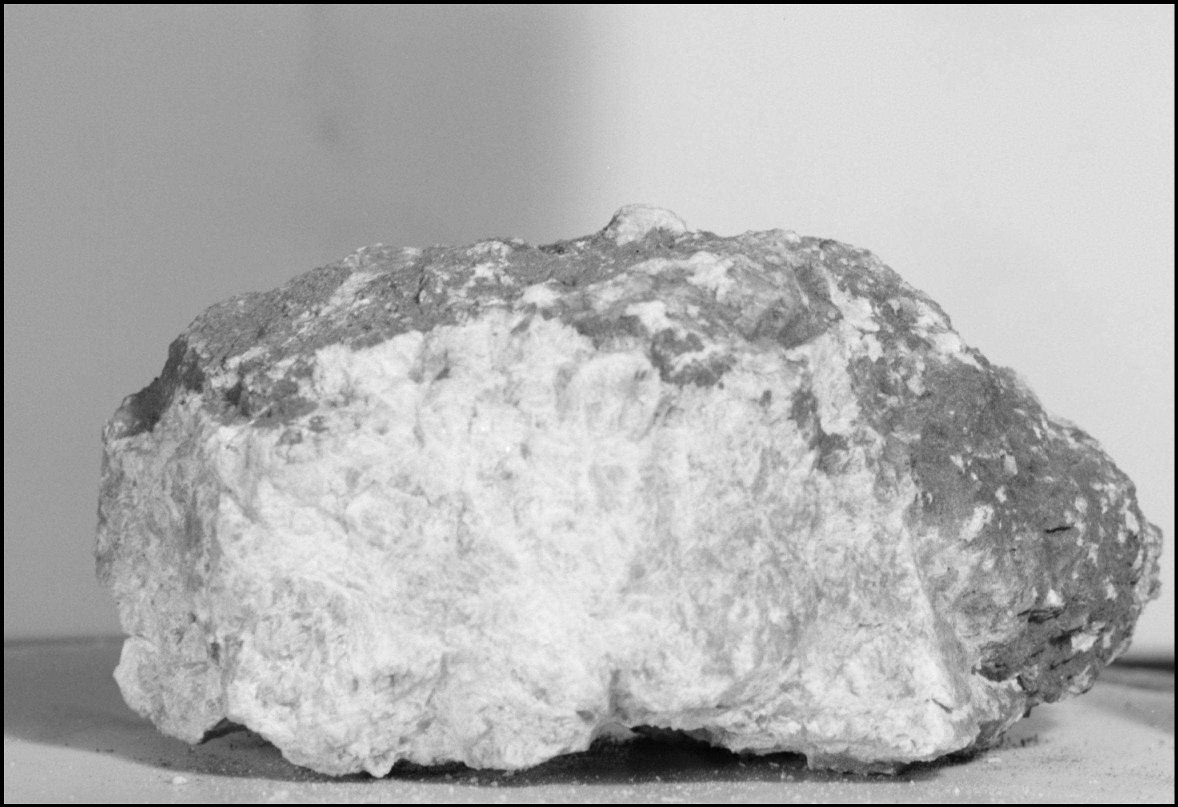
The Moon is not a primordial object; it is an evolved terrestrial planet.


The Moon and Earth are genetically related and formed from different proportions of a common reservoir of materials.

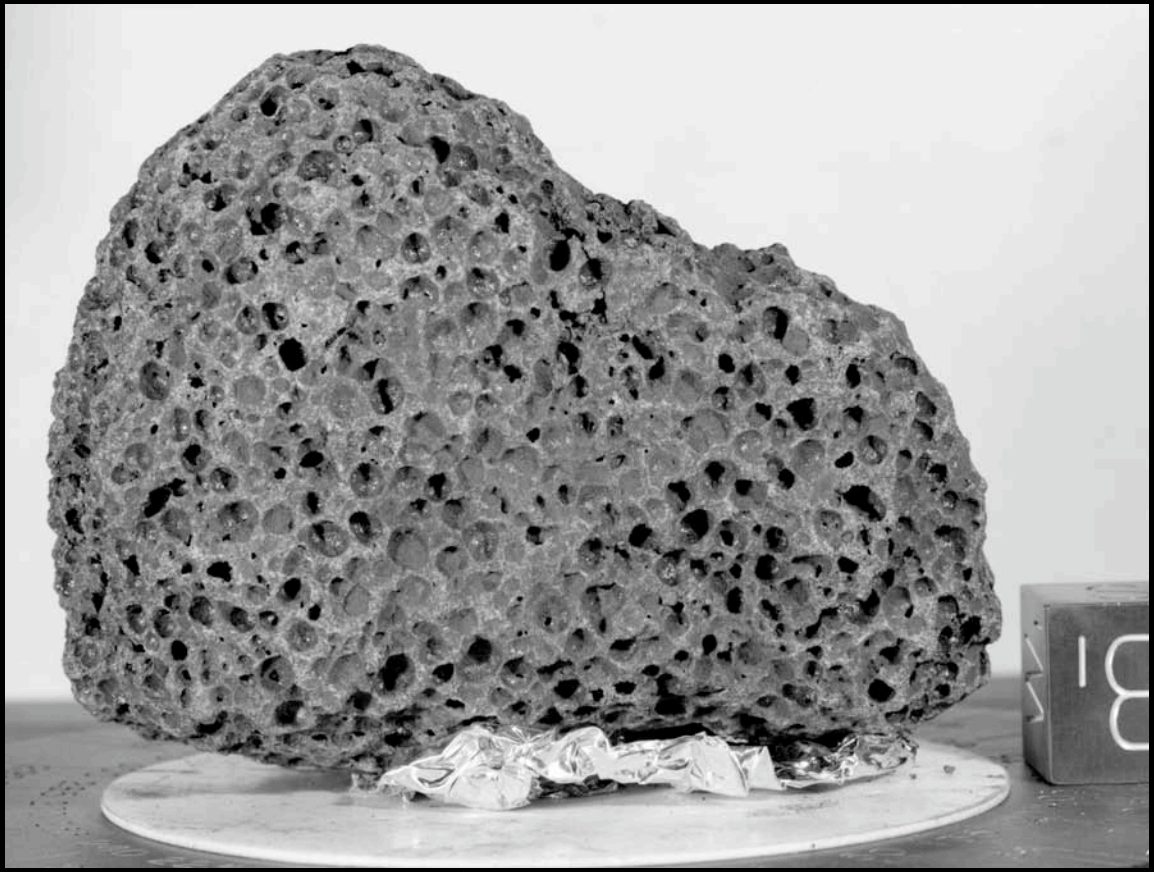
All Moon rocks originated through high-temperature processes with little or no involvement with water.



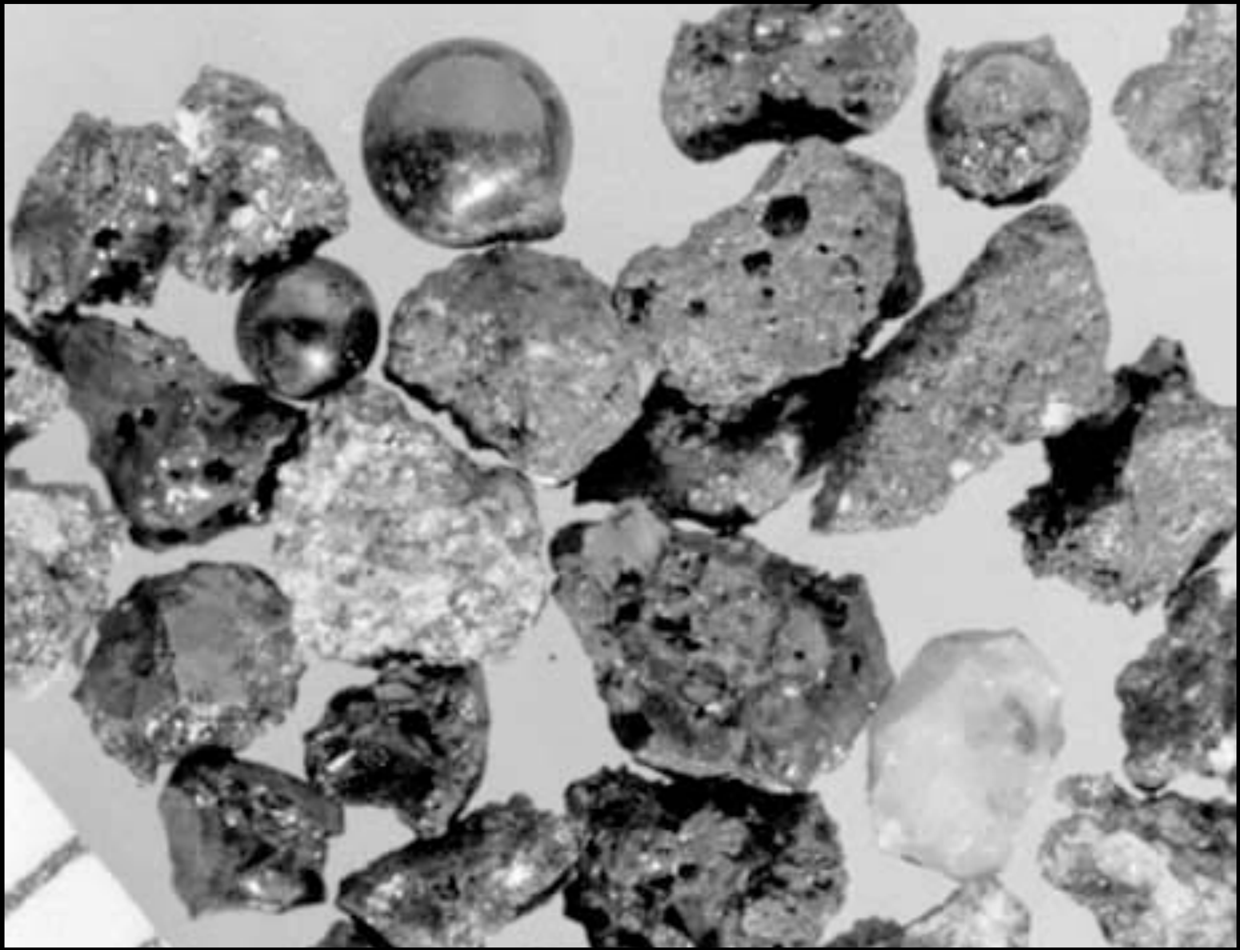
Early in its history, the Moon was melted to great depths to form a "magma ocean." The lunar highlands contain the remnants of early, low-density rocks that floated to the surface of the magma ocean.



The lunar magma ocean was followed by a series of huge asteroid impacts that created basins that were later filled by lava flows.



The surface of the Moon is covered by a layer of rock fragments and dust, called regolith, that was produced by innumerable meteorite impacts through geologic time.



Our picture of the Moon is evolving with a huge volume (100's of TB) of new remote sensing data . . .

- **LRO – Diviner and LEND**
- **Chandrayaan – C1XS and M^3**
- **Selene – NIR spectrometer**
- **Lunar Prospector – γ ray and neutron spectrometers**
- **Clementine – UV-VIS spectrometer**

The Geochemistry Session will feature:

Comparison of remote sensing data with lunar sample “ground truth”

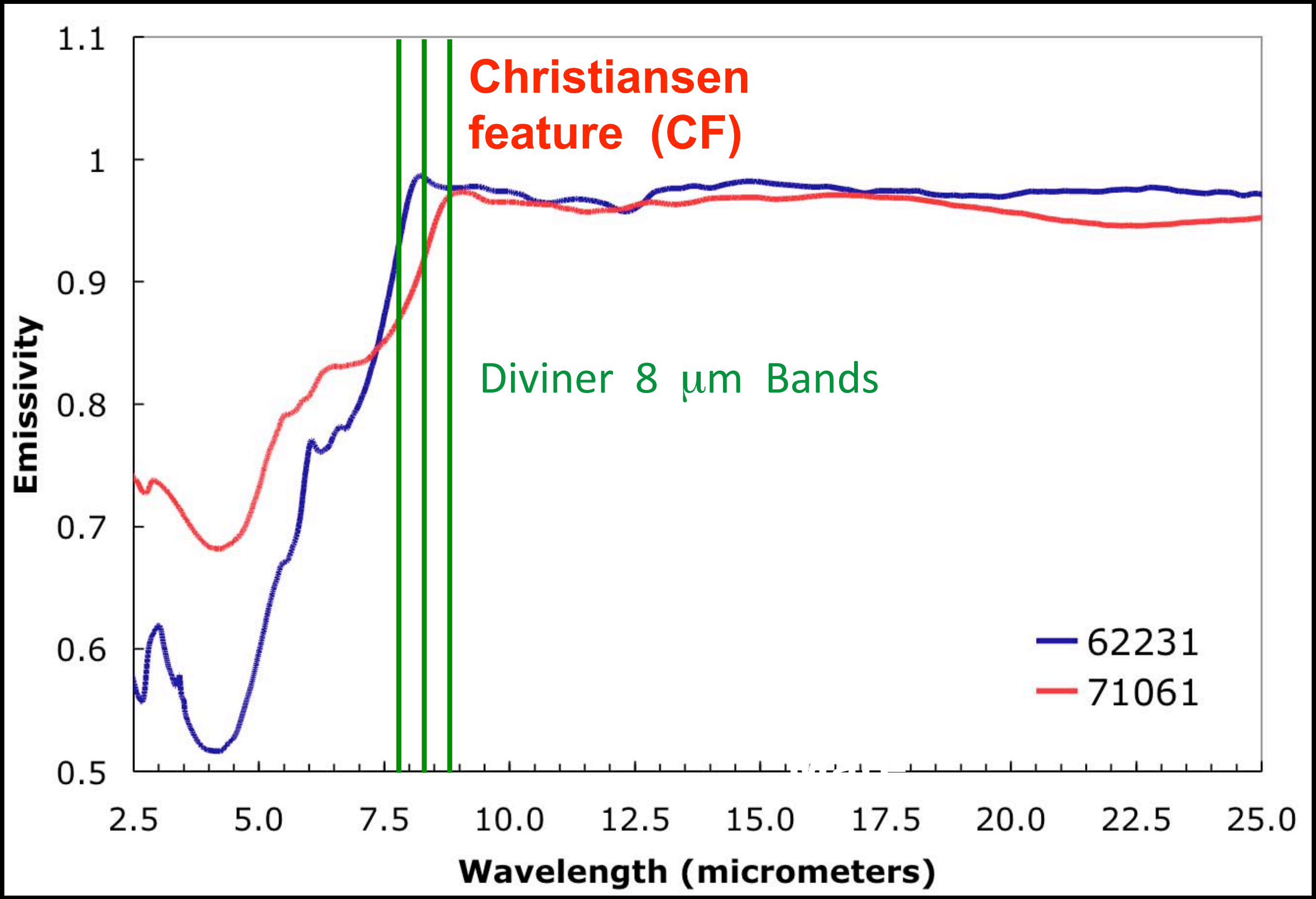
Mapping of geochemically defined units from orbit – olivine, plagioclase, rock forming elements, hydrogen

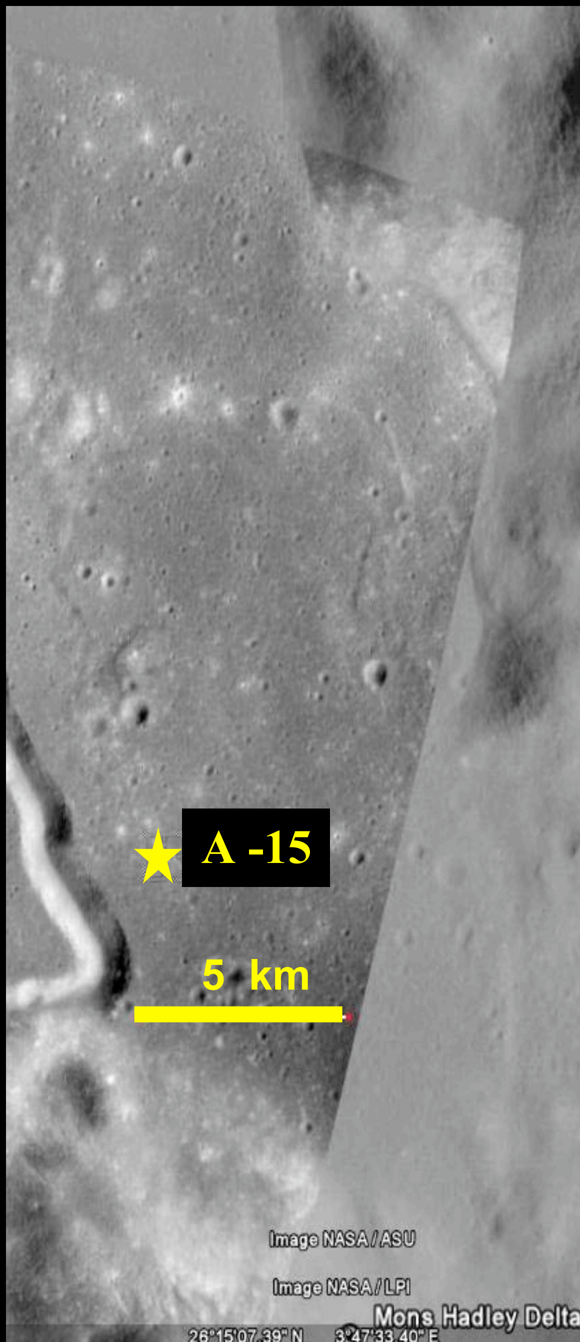
Inter-comparison among data sets

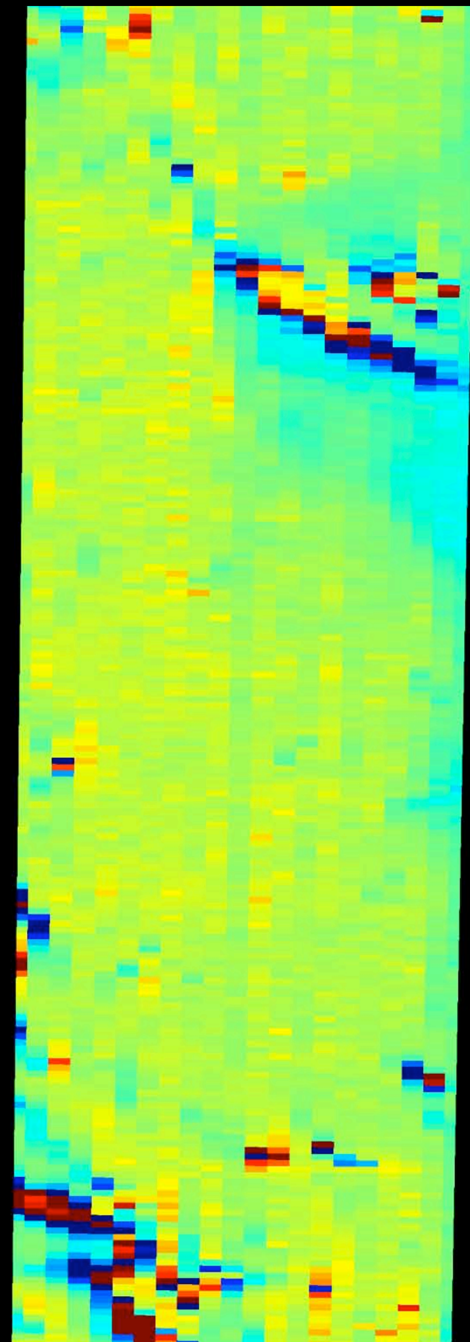
Secondary effects on remote sensing data – topography, cratering, maturity, seismic shaking

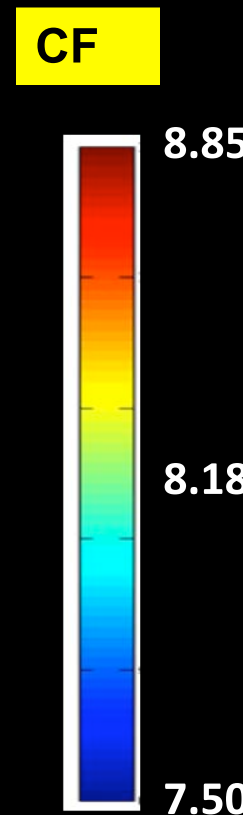
LRO DIVINER SOIL COMPOSITION MEASUREMENTS – LUNAR SAMPLE "GROUND TRUTH"

Carl Allen



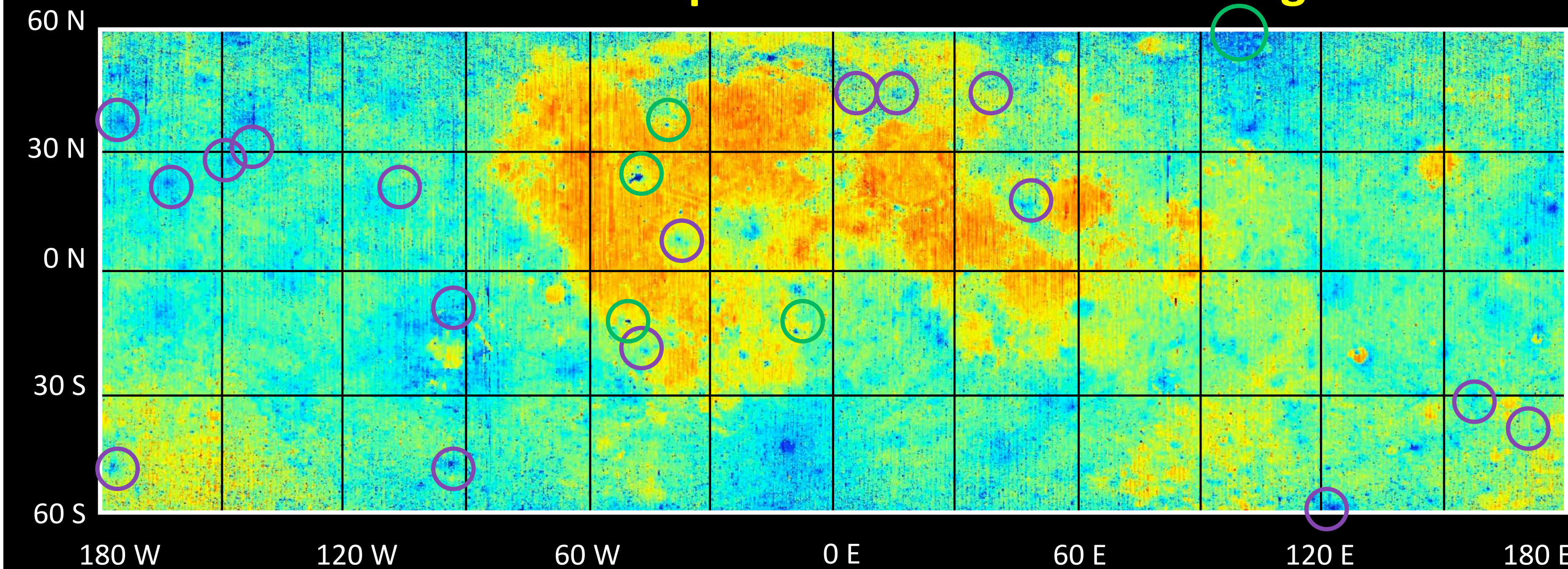


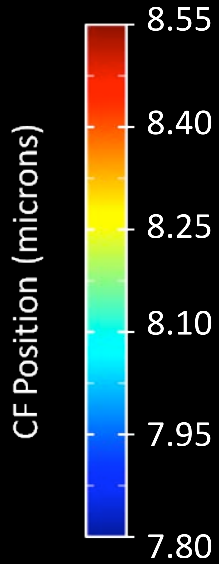




CF varies with topography, mineralogy. and maturity

Diviner Global Composition   Ben Greenhagen

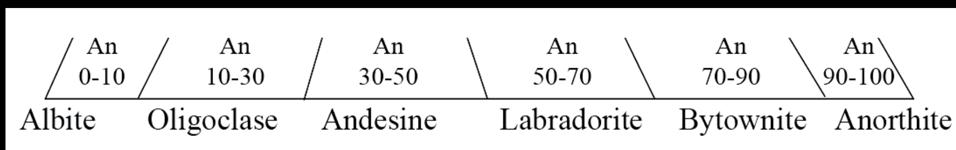


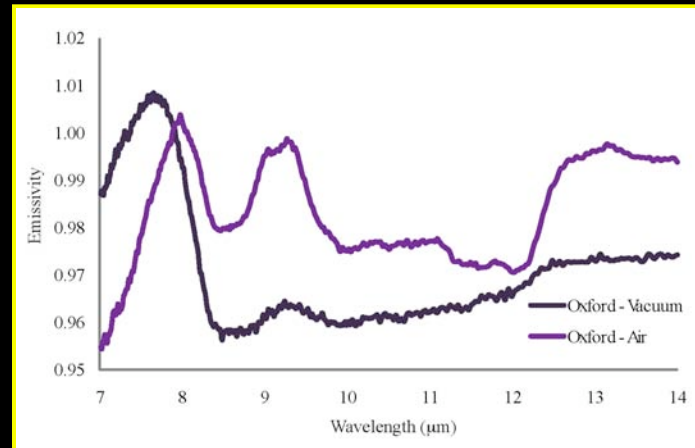


- Some areas with thorium anomalies display high silica content
  - Aristarchus Crater, Gruithuisen Domes, Hansteen Alpha, Lassell, and Compton-Belkovich thorium anomaly
- There are plagioclase-rich areas that are not pure anorthite
  - Including 15 of 69 Ohtake et al. 2009 plagioclase-rich sites
- No multi-kilometer exposures of extremely olivine-rich and feldspar-poor soils

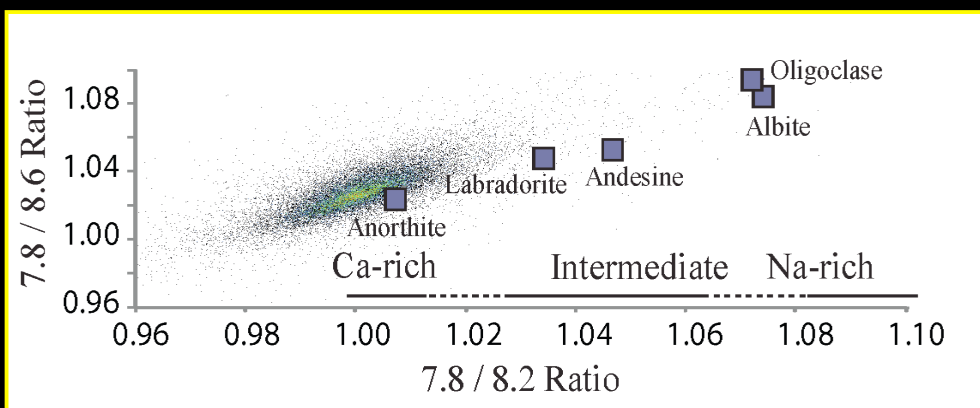
Diviner Plagioclase Studies   Michael Wyatt

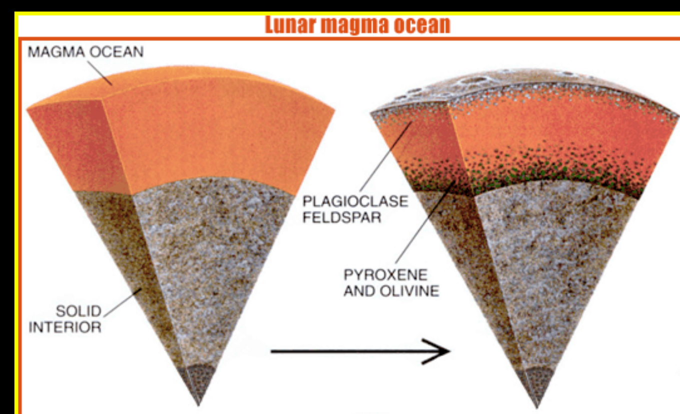
- New laboratory TIR emission spectra of the plagioclase solid solution series measured under lunar-like conditions.





- Constrained compositions of plagioclase-rich regions (An #) on the Moon with implications for the lunar magma ocean.

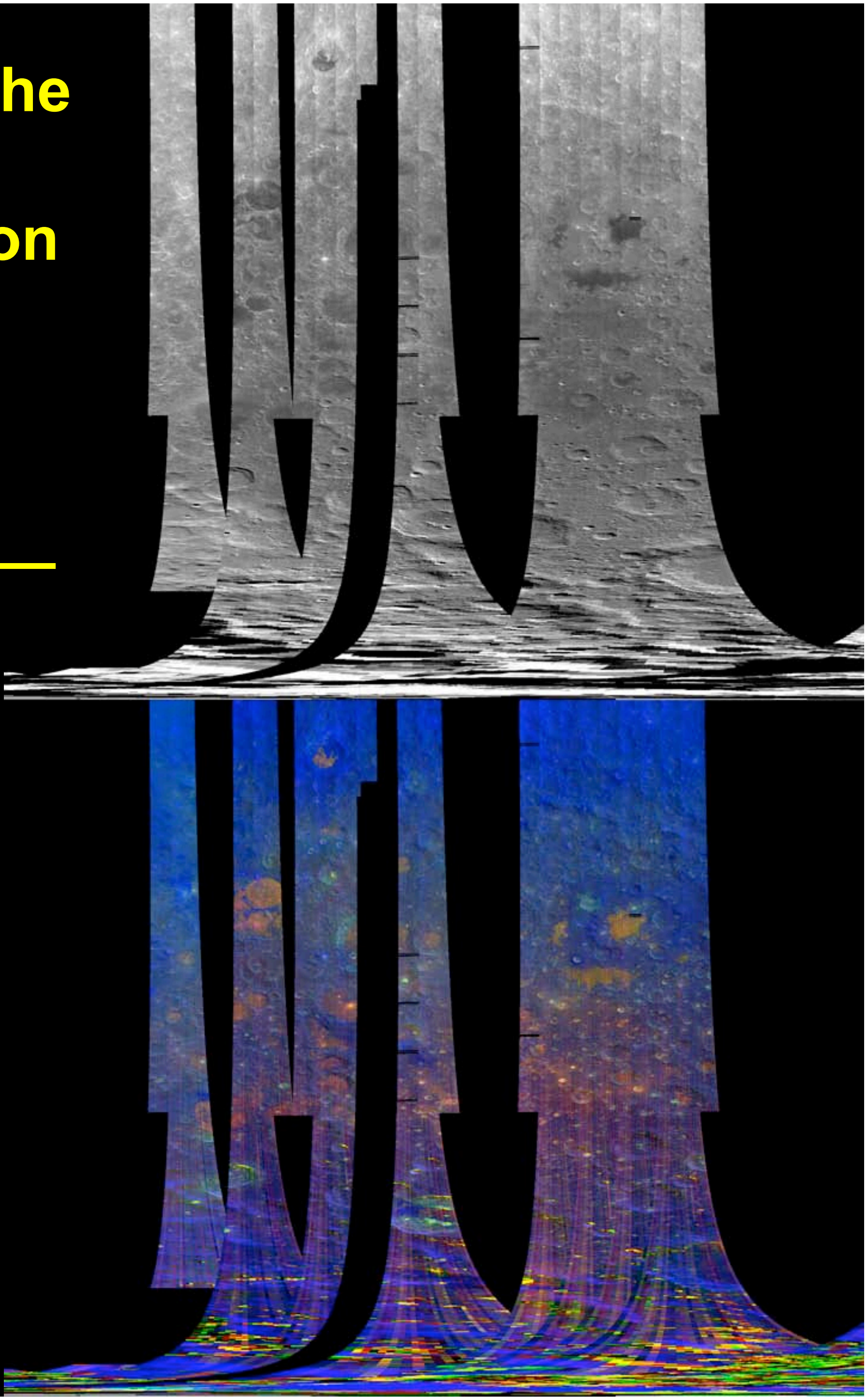




Compositional Diversity in the South Pole-Aitken Basin (SPA) as Viewed by the Moon Mineralogy Mapper (M3)

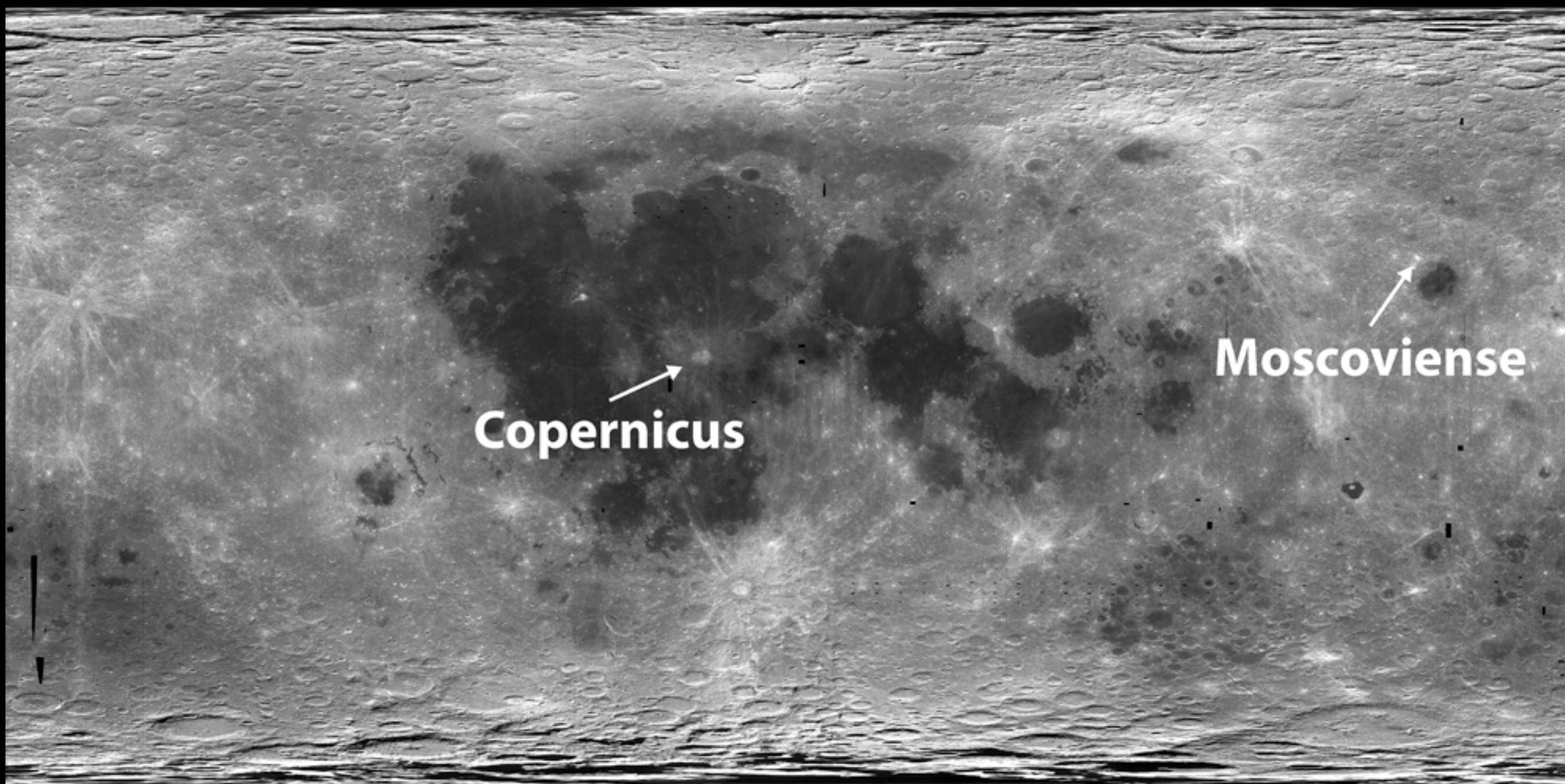
Noah Petro

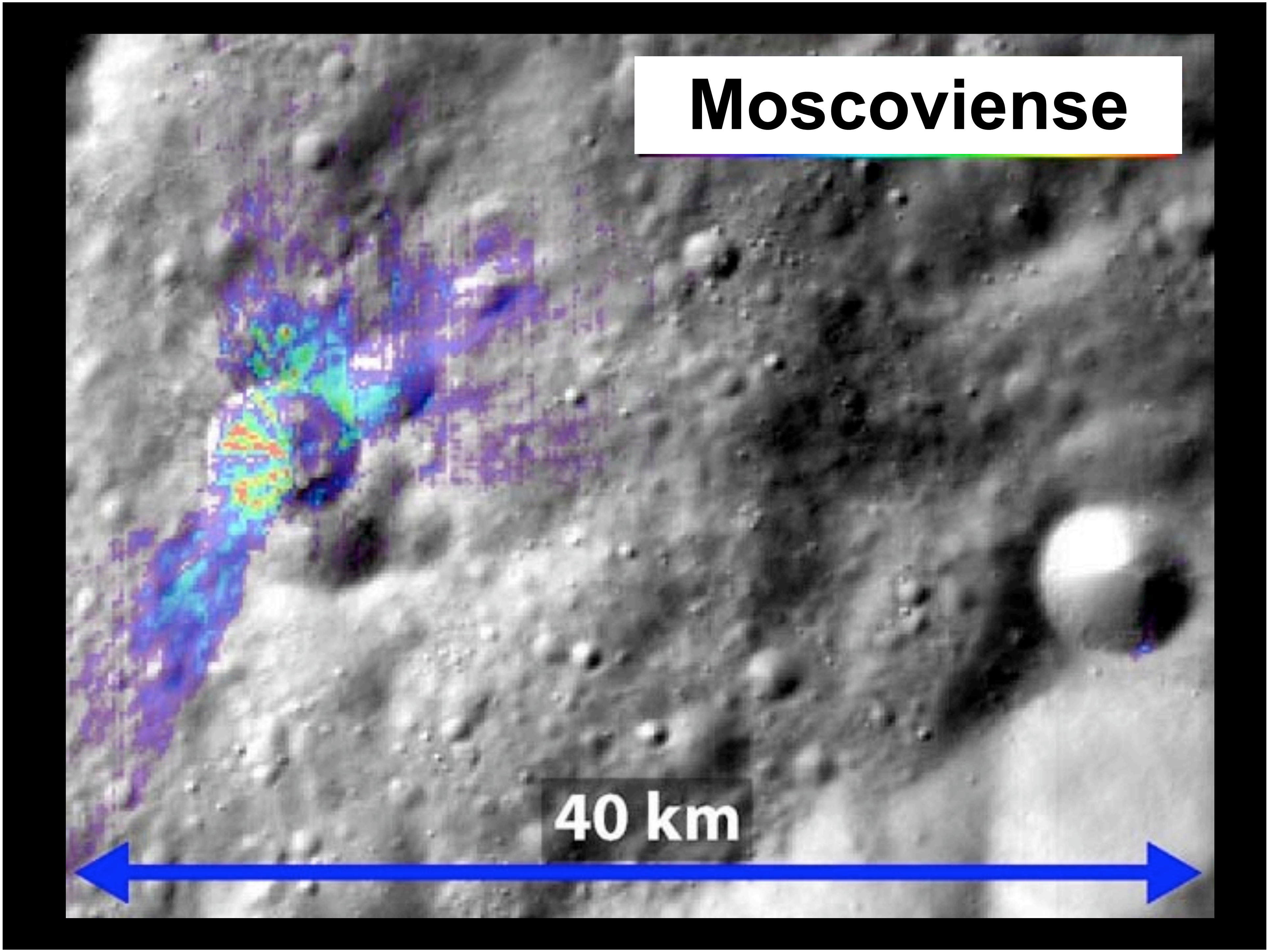
- **Moon Mineralogy Mapper spectral data reveal a range of compositions across SPA**
  - **Pervasive noritic interior and in central peaks**
  - **Small gabbroic region in center**
  - **Low iron regions**



Remote Compositional Analysis of Lunar Olivine with Moon Mineralogy Mapper (M3) Vis/NIR Reflectance Spectra

Peter Isaacson




Moscoviense
40 km

Western Oceanus Procellarum as seen by C1XS on Chandrayaan-1

Weider, Kellett, Swinyard, Crawford, Joy & the C1XS team

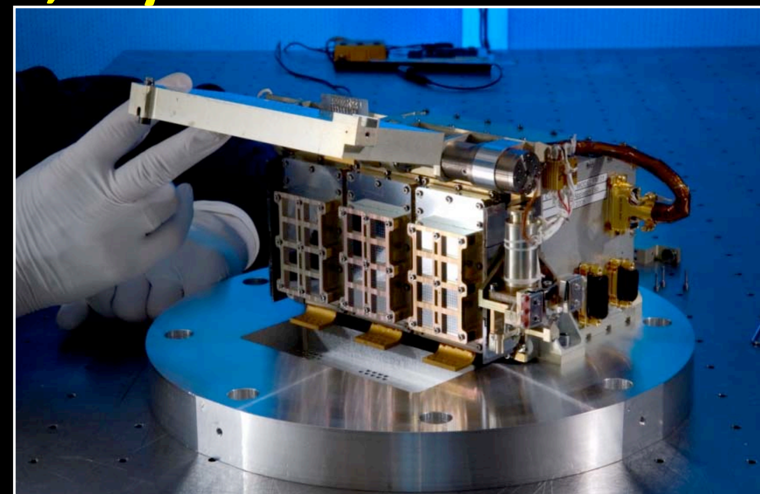
• Chandrayaan-1 X-ray Spectrometer (C1XS) – ESA instrument on Chandrayaan-1, built at the Rutherford Appleton Laboratory, UK.

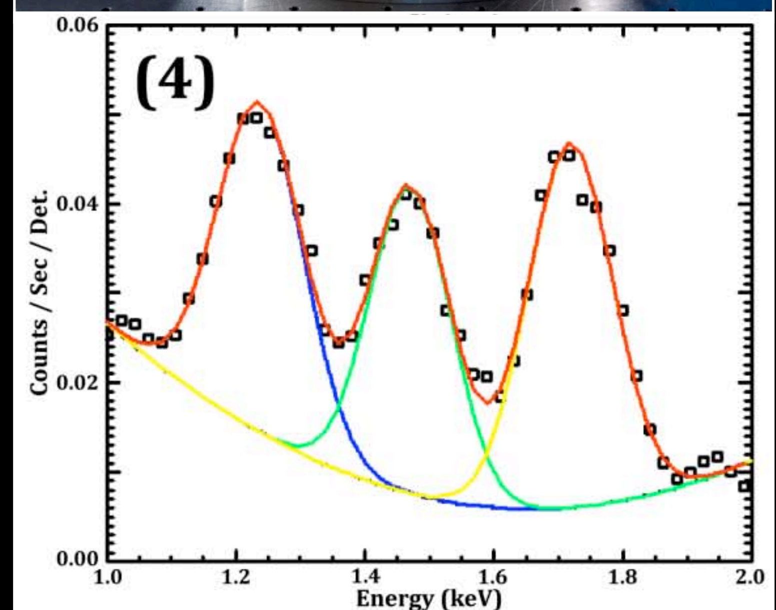
• Designed to measure abundance of major rock forming elements (e.g. Mg, Al, Si, Ca, Ti & Fe) in lunar regolith, using process of X-ray fluorescence (XRF).

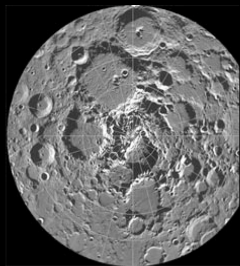
• Easily able to resolve three low-energy characteristic lines for Mg, Al & Si.

• Data presented comes from a solar flare interval, with a footprint in western Oceanus Procellarum.

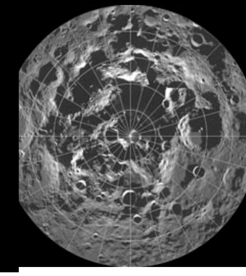
• Mg/Si & Al/Si abundance ratio values from forward modelling algorithm are presented and compared with existing datasets.







Lunar Compositional Information Provided by Orbital Neutron Data from the Lunar Reconnaissance Orbiter (LRO)

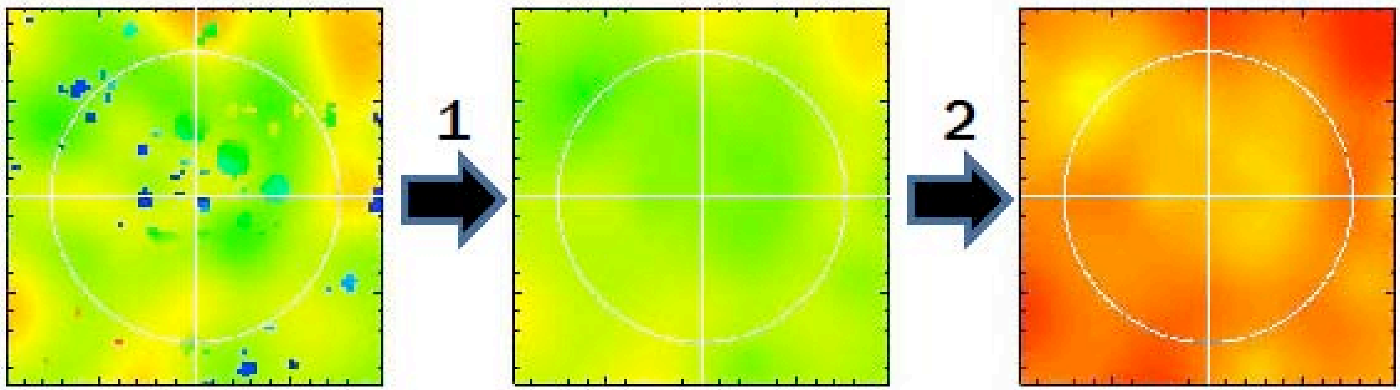


David Lawrence

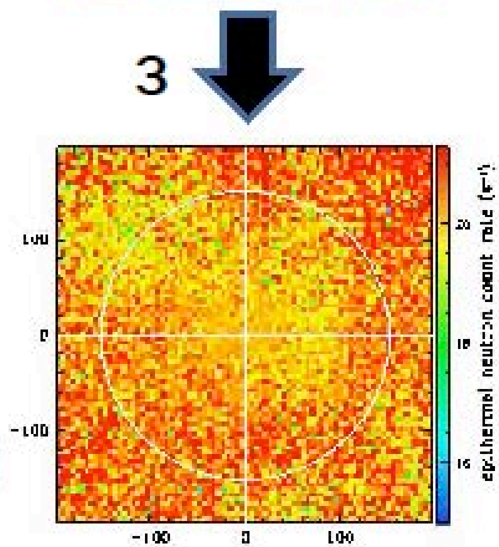
- The APL LSI node has a task to study surface -based hydrogen measurements using neutrons
  - Medium energy (or epithermal neutrons) strongly sensitive to planetary hydrogen abundances.
  - LSI study includes use of uncollimated/collimated neutron sensors.
- The LRO Lunar Exploration Neutron Detector (LEND) is an orbital, collimated neutron detector.
  - LEND data available through the Planetary Data System (PDS).
  - Use PDS data from 9/15/2009 to 3/15/2010.
- ***Goal of study:*** Use LEND data to provide a benchmark understanding for uncollimated/collimated neutron sensors

A Study of Orbital Neutron Data from the Lunar Prospector and Lunar Reconnaissance Orbiter Missions

Vincent Eke



Lunar Prospector SP

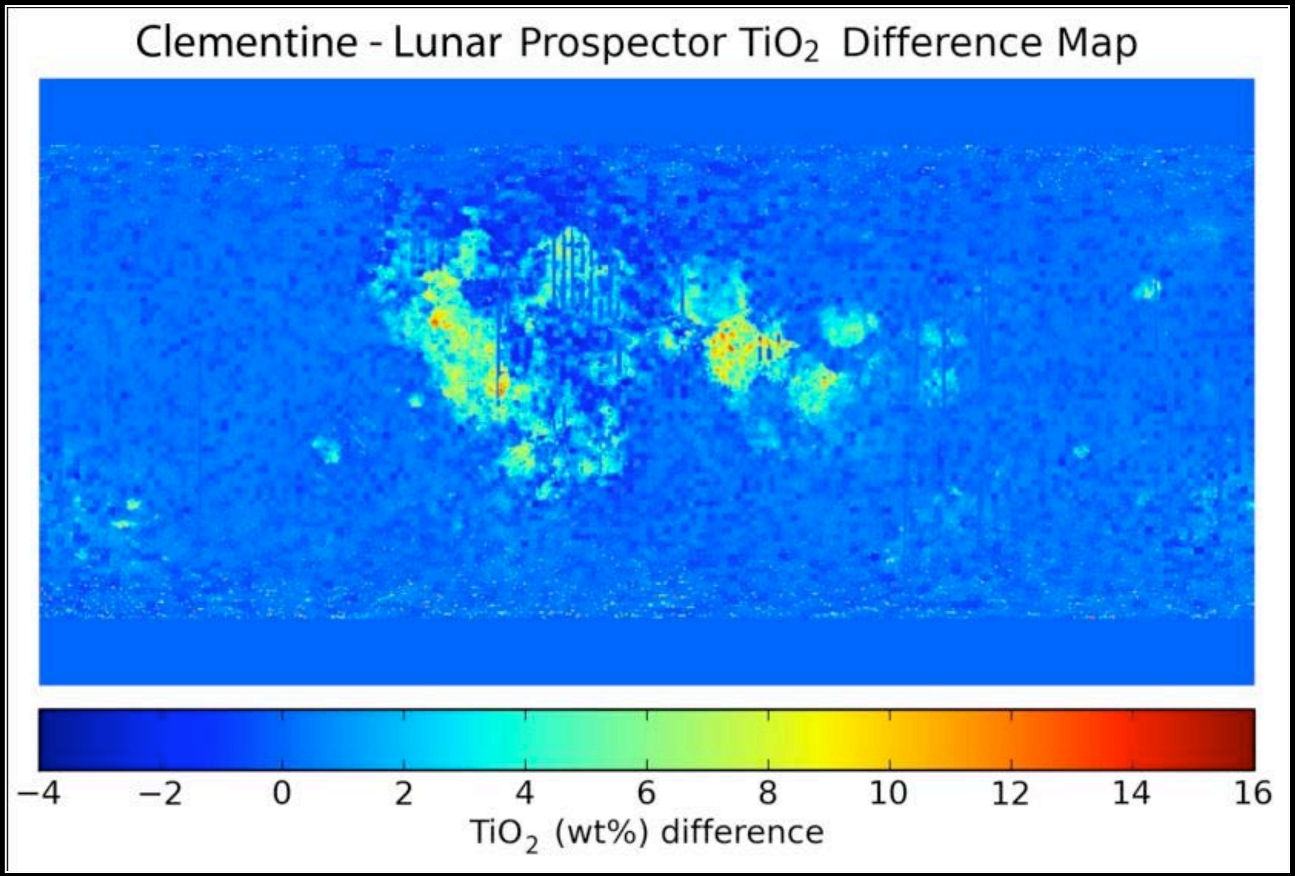


1. Instrumental blurring
2. Addition of background
3. Noisy realisation

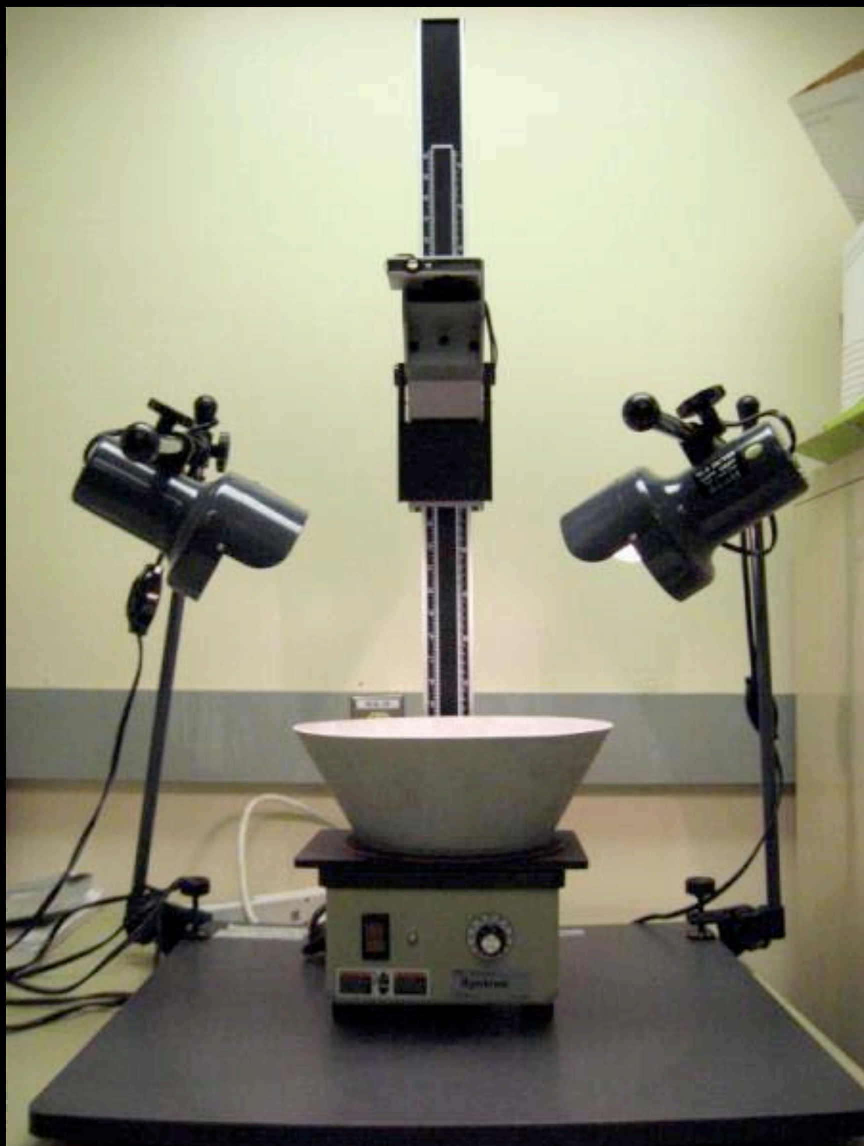
Observed data

Seismic shaking effects on grain size and density sorting with implications for constraining lunar regolith bulk composition

Lillian Ostrach



Do vertical vibrations promote mechanical sorting of a sample “regolith”?



Ilmenite
ρ=4.70-4.78 g/cc*

Basalt
ρ=2.40-3.10 g/cc

Glass beads, ρ=2.46-2.49 g/cc

There was a time – not so long ago – when we knew that the Moon had bright areas with lots of holes and dark areas with fewer holes.

We're learning an awful lot more !

This is good.