

# **X-Ray Diffraction in the Field and Lab on the Moon**

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# X-Ray Diffraction in the Field and Lab on the Moon

- Need for laboratory instruments on the Moon
- The CheMin/Terra instrument
- Lunar sample analysis
- Examples of science targets
- Conclusions
- Important implications

# Motivation for Lab Instruments on the Moon: LEAG Goals

- Objective 1A-8: Development and implementation of sample return technologies and protocols
  - Investigation-3: Understand what analyses (field and laboratory) need to be done on the Moon to aid field studies and optimize the value of samples returned to Earth.

Implication: To optimize lunar surface activities, facilities must be designed with space and power for laboratory instruments.

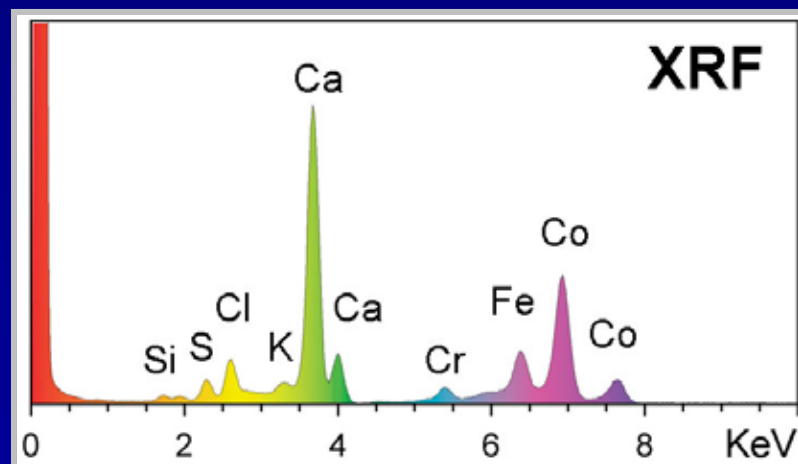
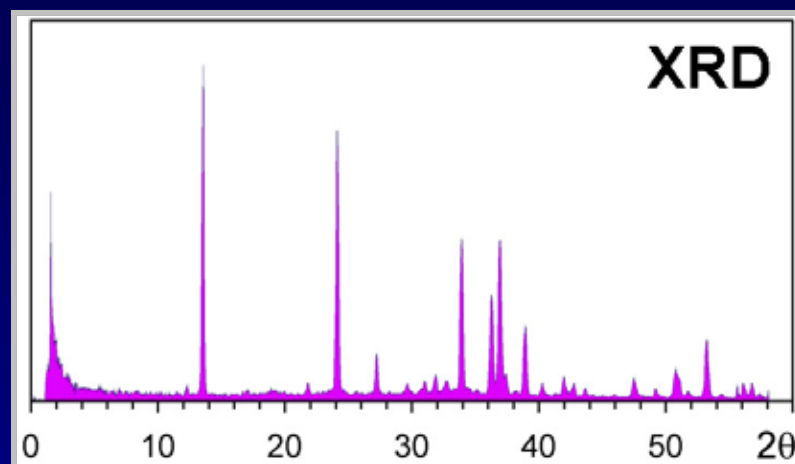
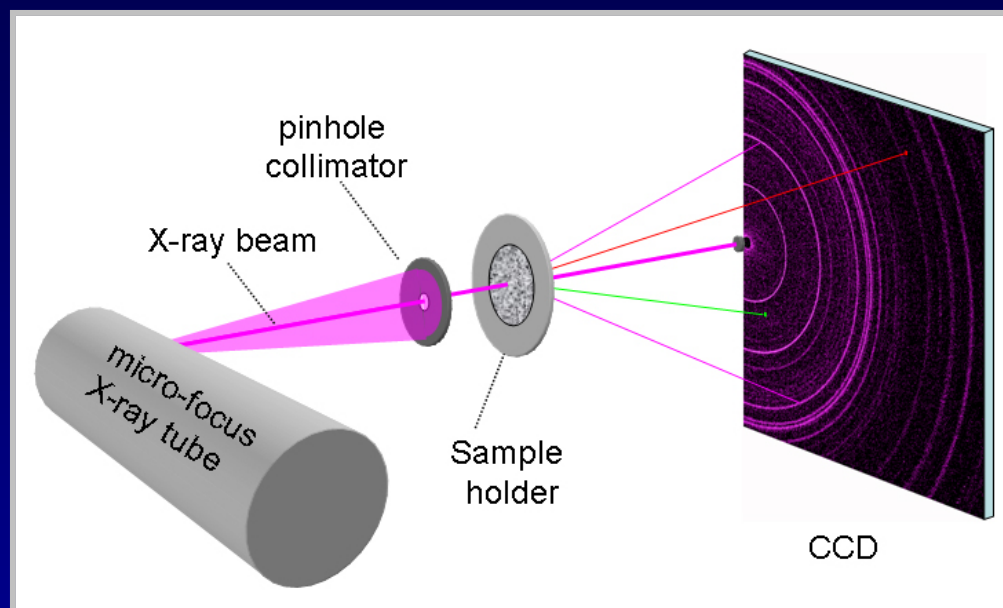
## Inverse Motivation

- From a review of an XRD instrument for use on the Moon (submitted to LASER program):

“Developing instruments for a lunar habitat should be deferred until decisions on habitat architecture are made.”

**This is short sighted and backwards reasoning.**

# The CheMin Instrument Concept



Sold commercially by inXitu, Inc.  
as *Terra*.

# CheMin on Mars Science Laboratory



# Terra Tested in Field



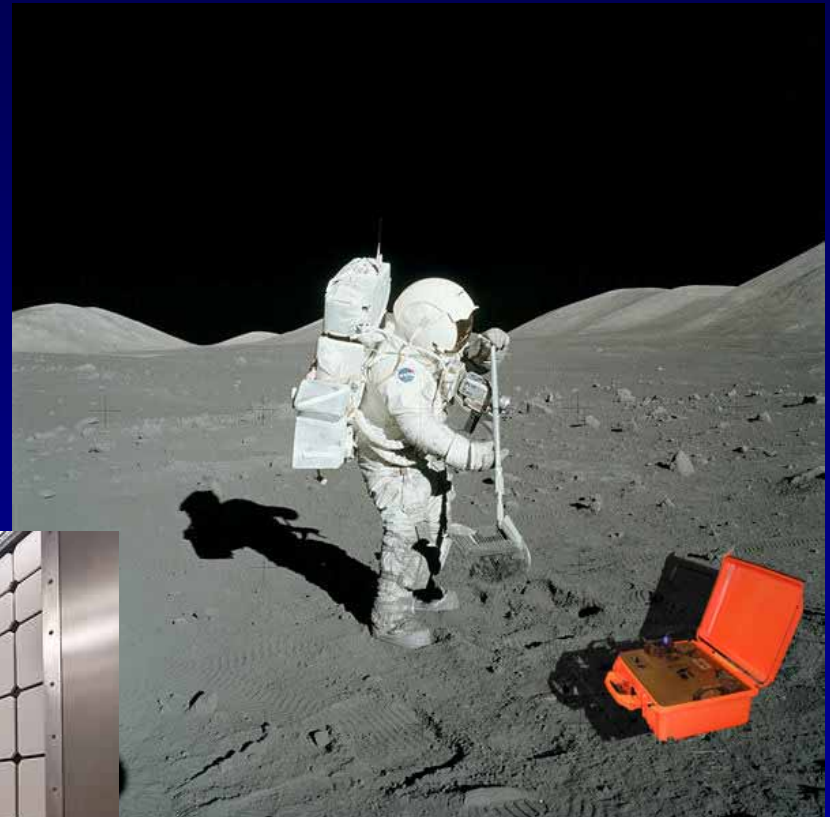
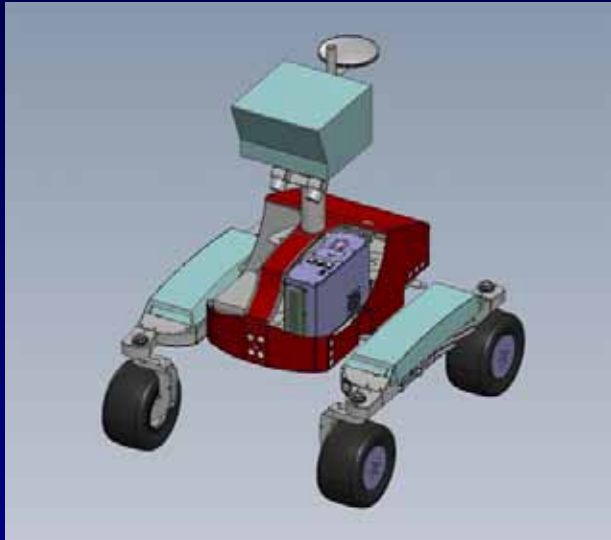
Doug Ming with Terra in the dry valleys of Antarctica, January, 2008



Terra in Svalbard, Norway (80° N), AMASE Expedition, Aug. 2007



# Use on the Moon



XRD on the Moon

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# Terra Tested with Lunar Samples

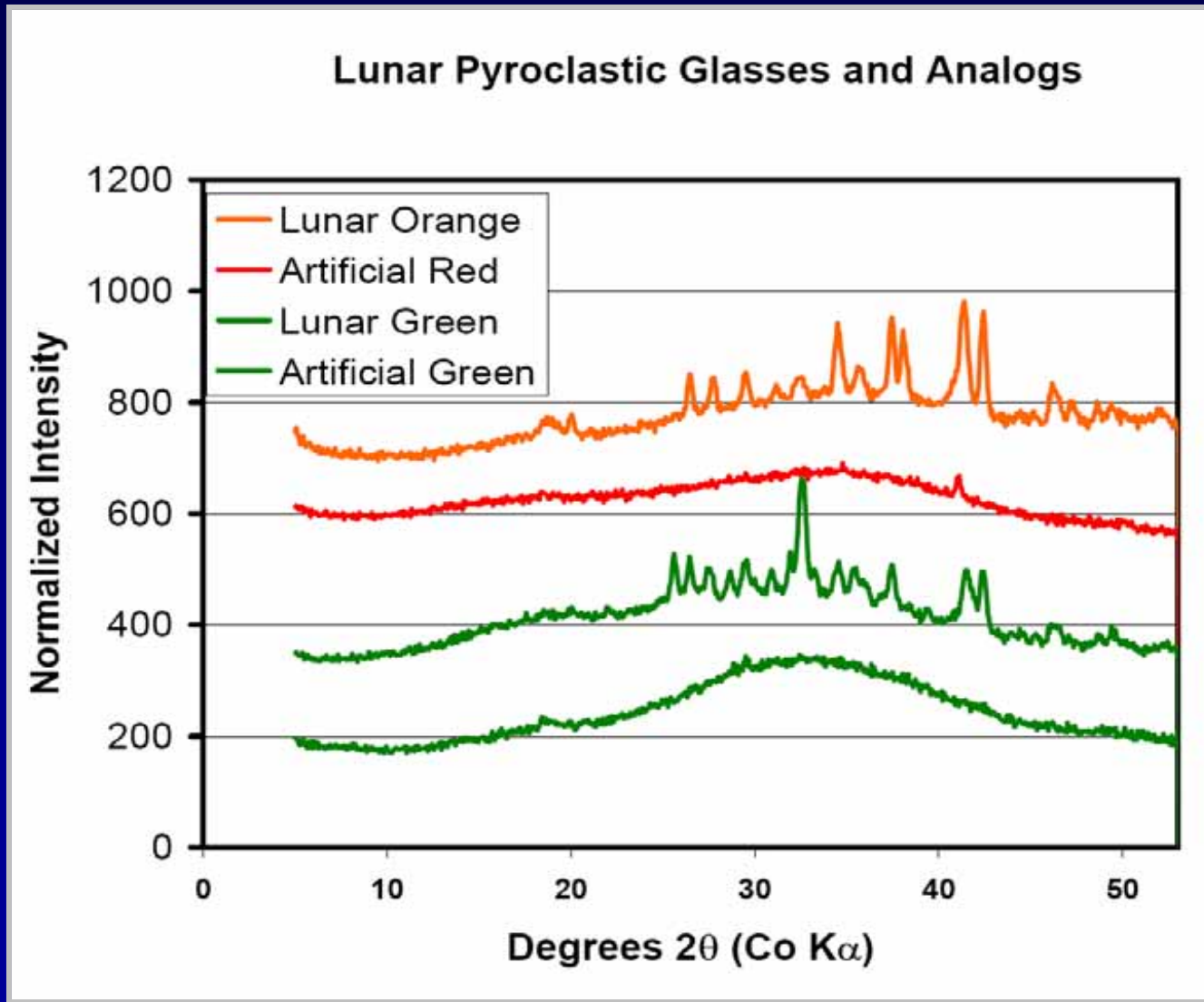


XRD on the Moon

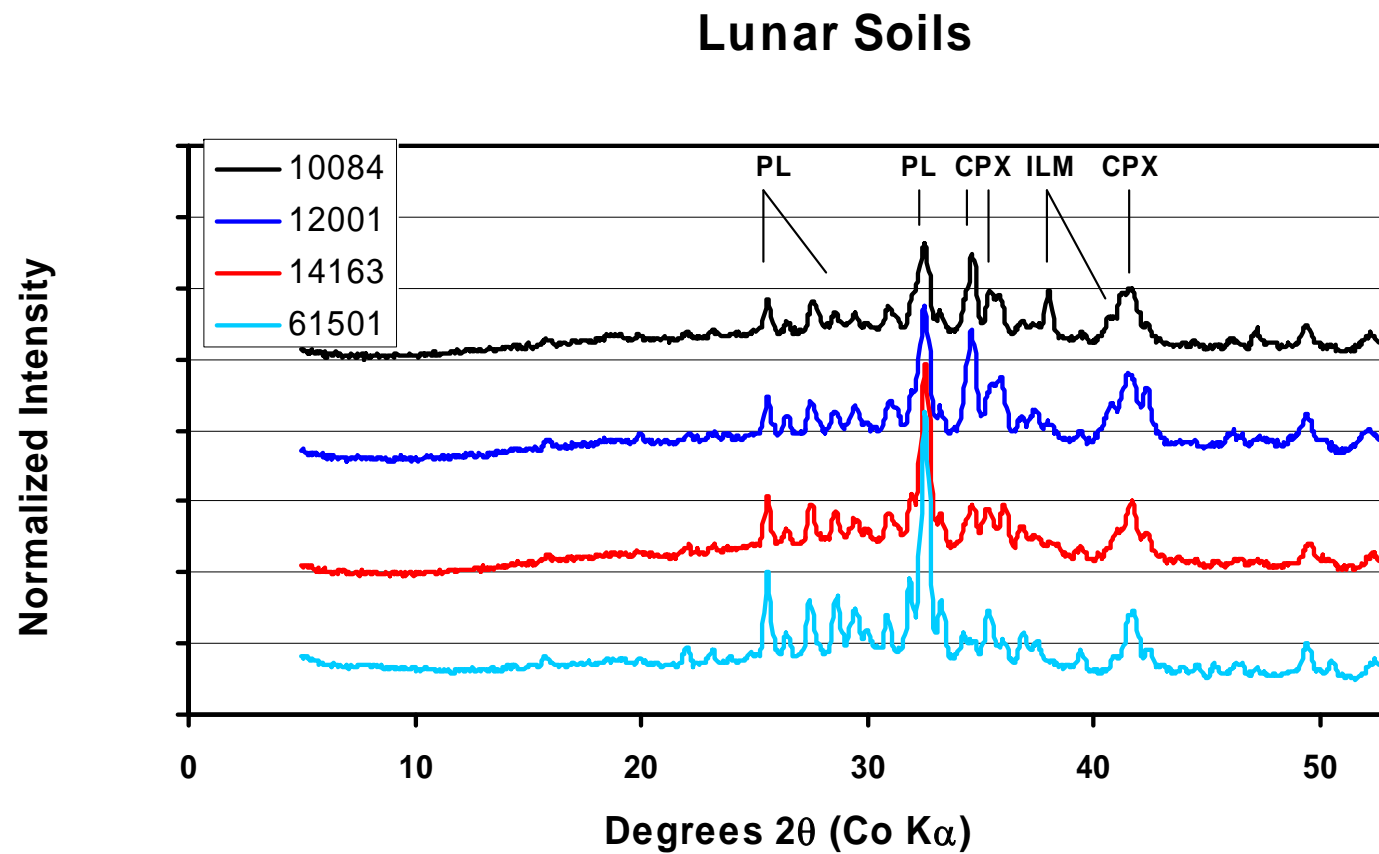
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# Terra Tested with Lunar Samples

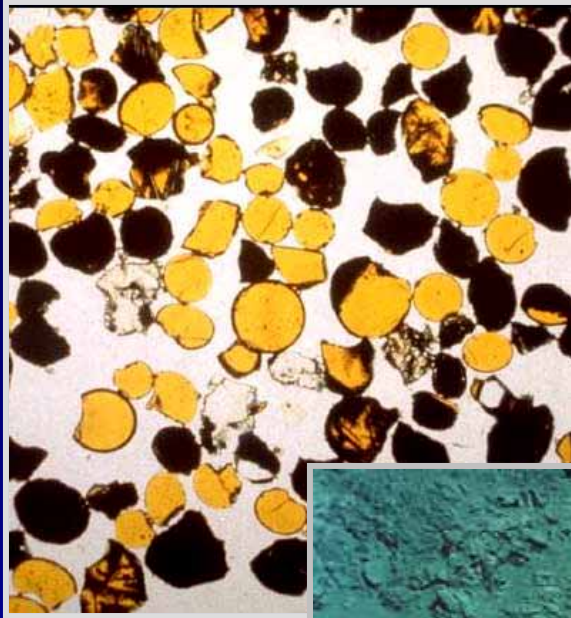


# Lunar Soils





# Examples of Science Targets

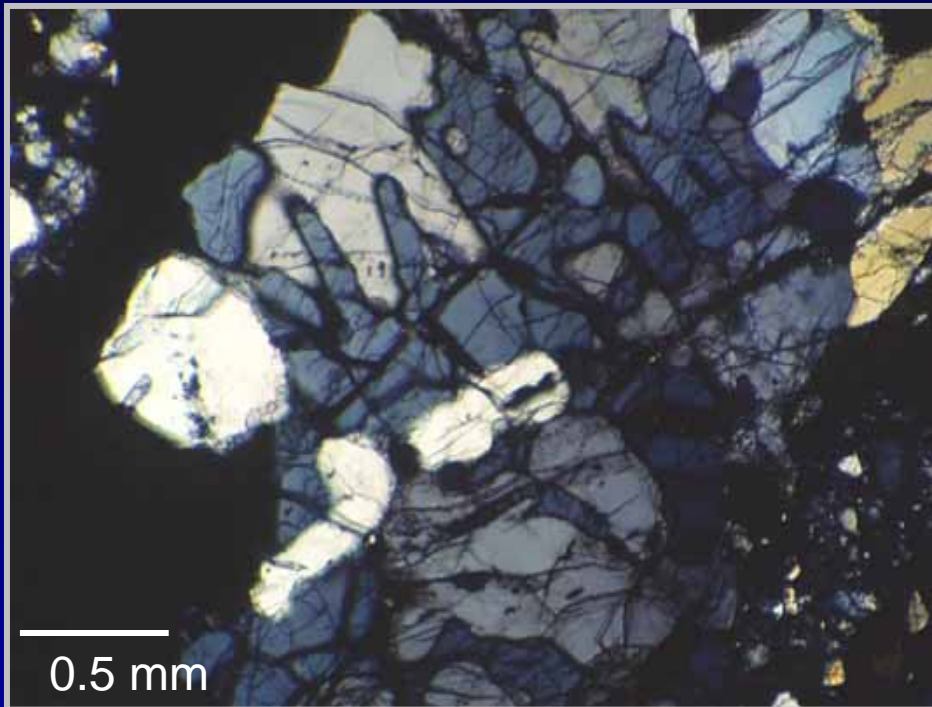


- Pyroclastic deposits
  - Glass/crystal ratio
  - Minerals present
  - Chemical composition





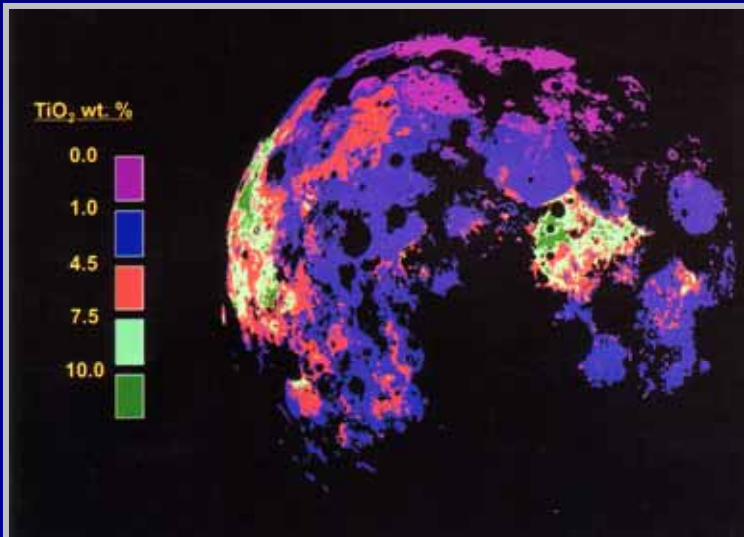
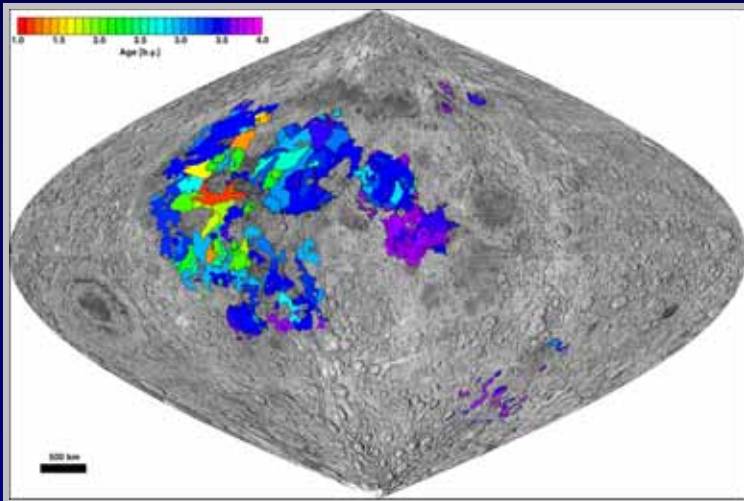
# Examples of Science Targets



- Evolved magmas
  - Abundance of rare lunar minerals:
    - Alkali feldspar
    - Quartz
    - Phosphates
    - Zircon
  - Distinctive chemical compositions
  - Potential resources



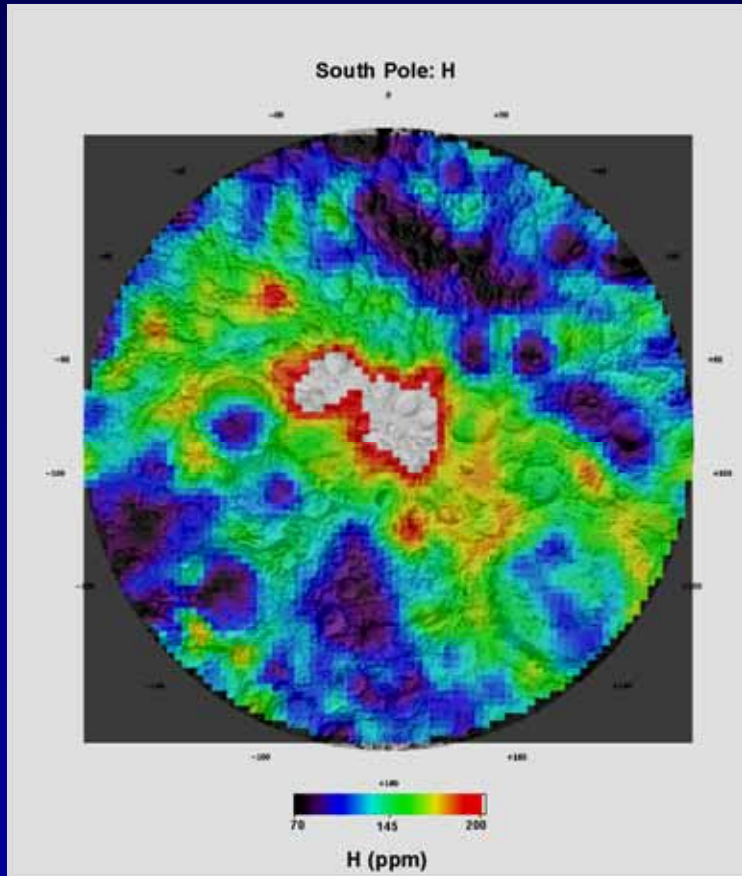
# Examples of Science Targets



- Mare basalts
  - Detailed mapping of compositional units
  - Stratigraphy
  - Mineral changes:
    - Olivine abundance
    - Ilmenite abundance
    - Feldspar abundance

From:  
Hiesenger et al. (2003), top  
Giguere et al. (2003), bottom

# Examples of Science Targets



- Polar deposits
  - Search for unusual products:
    - Clathrates
    - Water ice
    - Hydrous minerals
  - Understanding lateral and vertical variations in them

# Conclusions

- Terra would be valuable in lunar geologic exploration
- Can be used:
  - On a robotic rover
  - On a robotic rover accompanying humans
  - In a laboratory at a lunar base
- Qualitative analysis can be done in 5 min
- Does not require significant astronaut time in the lab or field

# Important General Implications for Optimizing Lunar Science Activities

Surface facilities must be designed with space and power for laboratory instruments.

We need to determine what instruments are most needed and most cost-effective.

# Optimizing Future Lunar Activities in General

We must decide what astronauts will do on the Moon and design facilities to allow them to do those things.

We must not design facilities first, and then expect astronauts to accomplish significant lunar science and exploration goals.