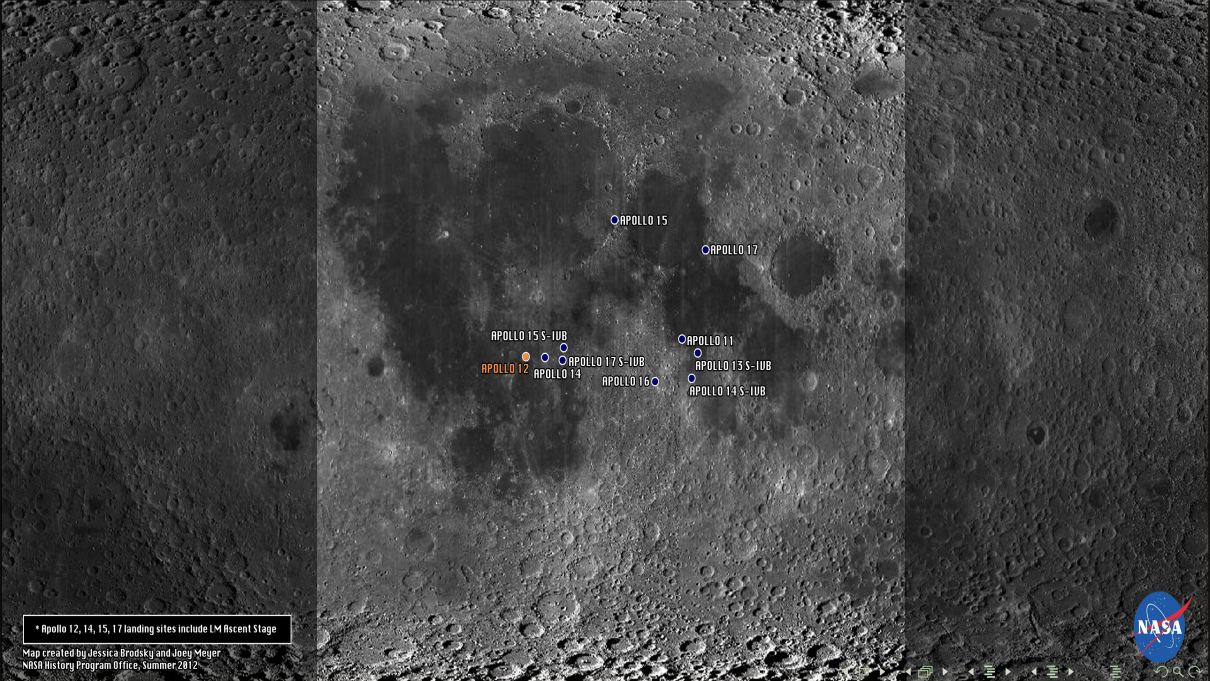
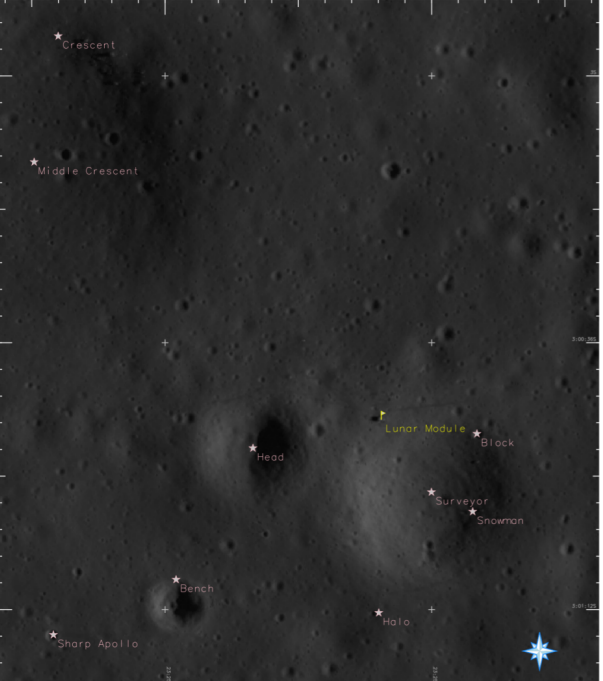
Assessment of spectral properties of Apollo 12 landing site

Yann Chemin, Ian Crawford, Peter Grindrod, Louise Alexander

Birkbeck
UNIVERSITY OF LONDON

1. Preamble
   - Location/timelines
   - Objectives
   - Cross-section
2. Chandrayaan-1 M^3
   - Craters location map
   - Craters hyperspectral signal
3. Methods and results
   - FeO Mapping
   - Zhang et al. corrected
   - Object-based classification
   - Relative Age Mapping
   - Manual seek and compare
   - Manual seek: 12063,79NT
4. Conclusions

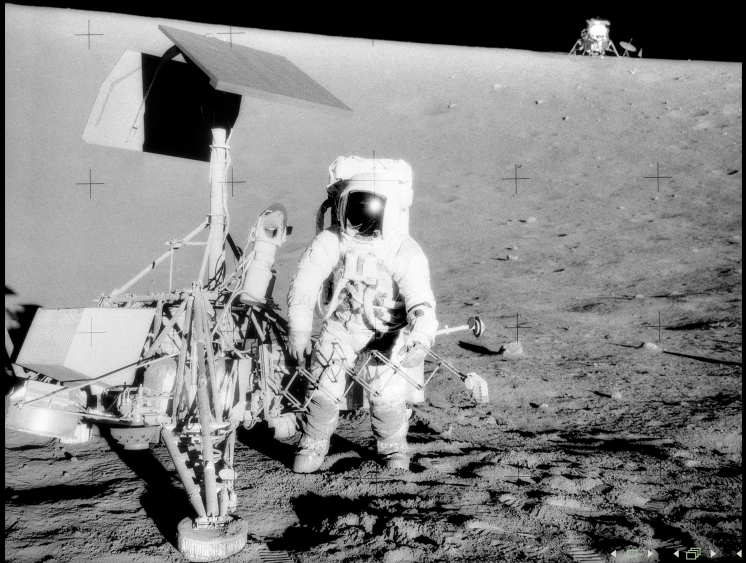

APOLLO 15
APOLLO 17
APOLLO 15 S-IVB
APOLLO 12
APOLLO 14
APOLLO 17 S-IVB
APOLLO 16
APOLLO 11
APOLLO 13 S-IVB
APOLLO 14 S-IVB
* Apollo 12, 14, 15, 17 landing sites include LM Ascent Stage
Map created by Jessica Brodsky and Joey Meyer
NASA History Program Office, Summer 2012



Location/timelines

- 3.2S 336.62E
- Surveyor: 19 April 1967
- Apollo 12: 19 November 1969
- Chan-1: 2 October, 2008
- Chan-1: 312 days
- (LROC NAC image here)

Fortezzo and Hare (2013) classify Apollo 12 landing site in an Erastothenian system with an age ranging from 1.1 to 3.2 Ga.



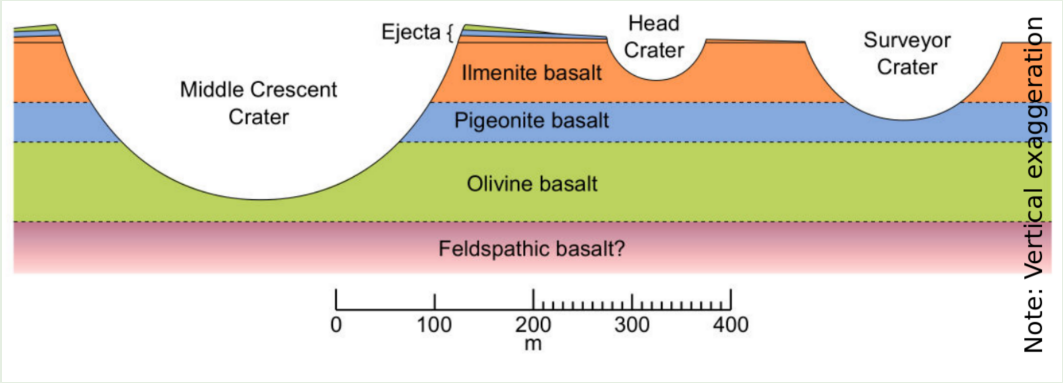
Objectives

- Initially designed to complement Alexander [2015]*
- Different scale and point of view from remote sensing
- Keeping the scale at the landing site level
- Using the Moon Multispectral Mapper (M^3) @150m/pixel

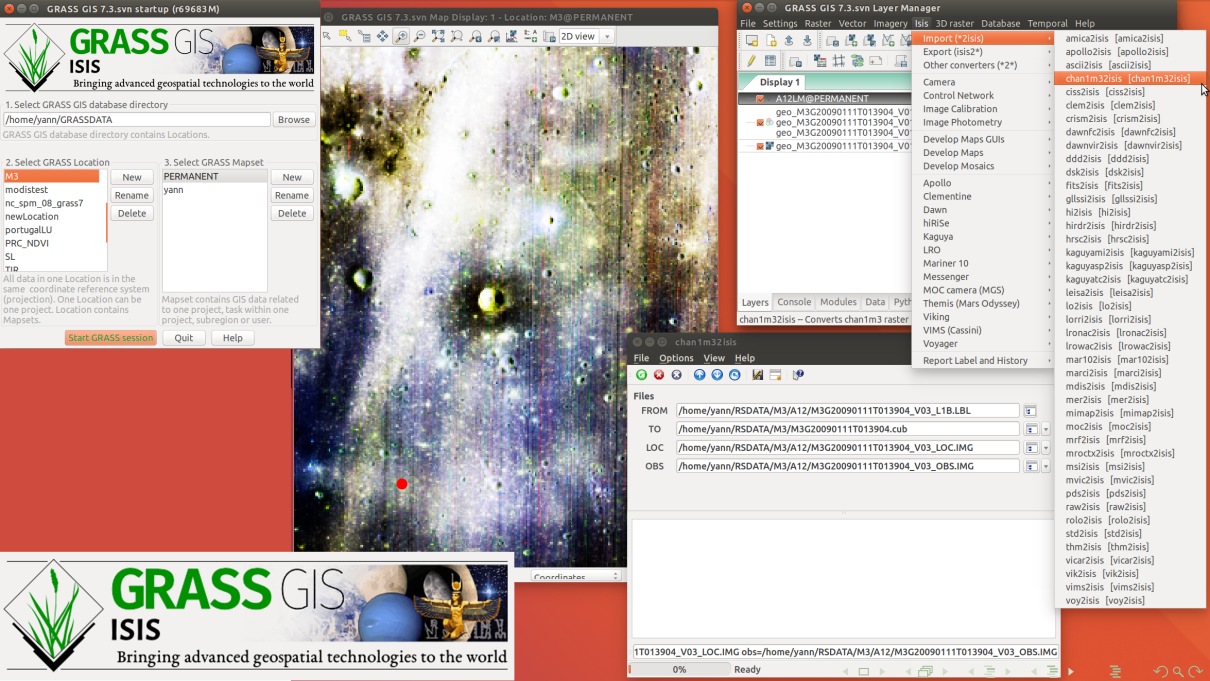
- Hyperspectral signatures from lunar samples
- Hyperspectral response curves from M^3
- Can we say something from those about the A12 landing site?

[*]Alexander, L. *A geochemical and mineralogical study of lunar basaltic fines collected at the Apollo 12 landing site*. PhD thesis, University of London, London, U.K., 2015.

Cross-section



Apollo 12 Landing site mineralogical cross-section [Snape et al., 2013]


GRASS GIS 7.3.svn startup (r69683M)
GRASS GIS
ISIS
Bringing advanced geospatial technologies to the world
1. Select GRASS GIS database directory
/home/yann/GRASSDATA
Browse
GRASS GIS database directory contains Locations.
2. Select GRASS Location
3. Select GRASS Mapset
M3
modistest
nc_spm_08_grass7
newLocation
portugalLU
PRC_NDVI
SL
TIR
New
Rename
Delete
PERMANENT
yann
All data in one Location is in the same coordinate reference system (projection). One Location can be one project. Location contains Mapsets.
Mapset contains GIS data related to one project, task within one project, subregion or user.
Start GRASS session
Quit
Help
GRASS GIS 7.3.svn Map Display: 1 - Location: M3@PERMANENT
2D view
Coordinates
GRASS GIS 7.3.svn Layer Manager
File Settings Raster Vector Imagery Isis 3D raster Database Temporal Help
Import (*2isis)
Export (isis2*)
Other converters (*2*)
Camera
Control Network
Image Calibration
Image Photometry
Develop Maps GUIs
Develop Maps
Develop Mosaics
Apollo
Clementine
Dawn
hiRISe
Kaguya
LRO
Mariner 10
Messenger
MOC camera (MGS)
Themis (Mars Odyssey)
Viking
VIMS (Cassini)
Voyager
Report Label and History
amica2isis [amica2isis]
apollo2isis [apollo2isis]
ascii2isis [ascii2isis]
chan1m32isis [chan1m32isis]
ciss2isis [ciss2isis]
clem2isis [clem2isis]
crism2isis [crism2isis]
dawnfc2isis [dawnfc2isis]
dawnvir2isis [dawnvir2isis]
ddd2isis [ddd2isis]
dsk2isis [dsk2isis]
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lo2isis [lo2isis]
lorri2isis [lorri2isis]
lronac2isis [lronac2isis]
lrowac2isis [lrowac2isis]
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mdis2isis [mdis2isis]
mer2isis [mer2isis]
mimap2isis [mimap2isis]
moc2isis [moc2isis]
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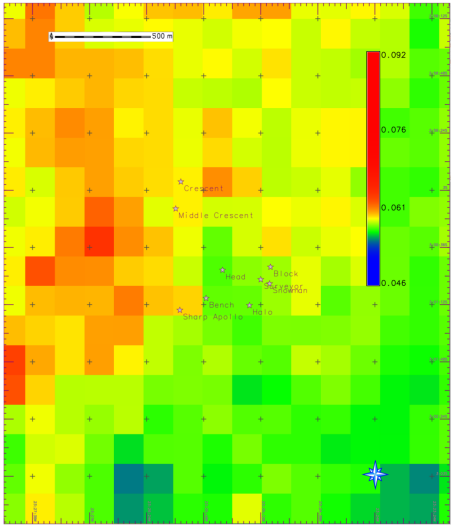
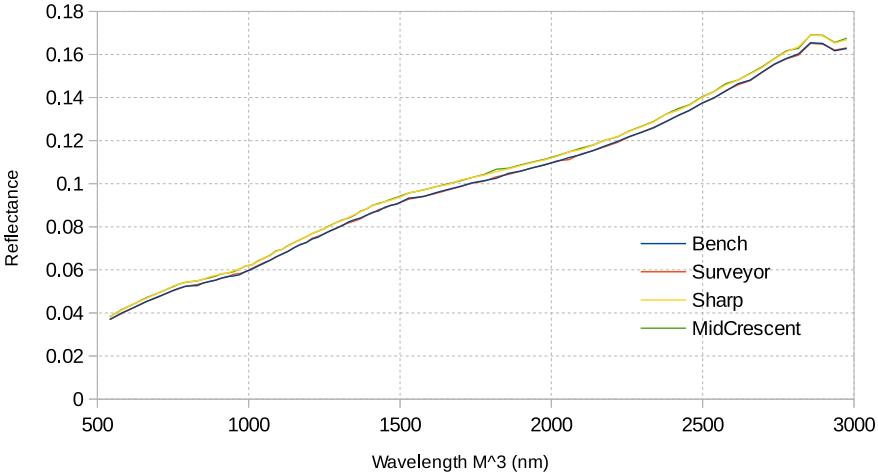
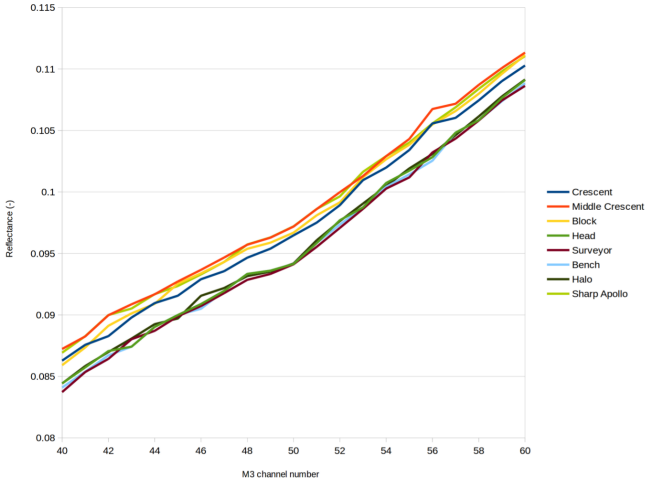
msi2isis [msi2isis]
mvic2isis [mvic2isis]
pds2isis [pds2isis]
raw2isis [raw2isis]
rolo2isis [rolo2isis]
std2isis [std2isis]
thm2isis [thm2isis]
vicar2isis [vicar2isis]
vik2isis [vik2isis]
vims2isis [vims2isis]
voy2isis [voy2isis]
Display 1
A12LM@PERMANENT
geo_M3G20090111T013904_V0
geo_M3G20090111T013904_V0
geo_M3G20090111T013904_V0
geo_M3G20090111T013904_V0
Layers
Console
Modules
Data
chan1m32isis -- Converts chan1m3 raster
chan1m32isis
File Options View Help
Files
FROM /home/yann/RSDATA/M3/A12/M3G20090111T013904_V03_L1B.LBL
TO /home/yann/RSDATA/M3/M3G20090111T013904.cub
LOC /home/yann/RSDATA/M3/A12/M3G20090111T013904_V03_LOC.IMG
OBS /home/yann/RSDATA/M3/A12/M3G20090111T013904_V03_OBS.IMG
1T013904_V03_LOC.IMG obs=/home/yann/RSDATA/M3/A12/M3G20090111T013904_V03_OBS.IMG
0%
Ready
GRASS GIS
ISIS
Bringing advanced geospatial technologies to the world



Crater location map (M^3 band 19, reflectance @ 950nm)



A12 Craters hyperspectral signal



A12 Craters hyperspectral signal Zoom

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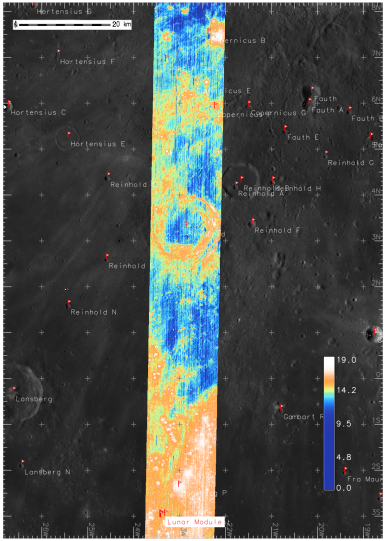
FeO equation

- Derived from Clementine work and type of equation
- Performs well regionally
- Zhang and Bowles [2013]*
- Made a GRASS GIS v7 Add-on: i.feotio2
- FeO and TiO_2 equations for Clementine and Chan1-M^3

$$\theta_{Fe}[wt\%] = -arctan\left[\frac{\frac{R_{950}}{R_{750}} - 1.26}{R_{750} - 0.01}\right] \quad (1)$$

[*]Zhang, W. Bowles, N.E. *Mapping lunar TiO_2 and FeO with Chandrayaan-1 M^3 data*. In Lunar and Planetary Institute Science Conference Abstracts, volume 44, page 1212, 2013.

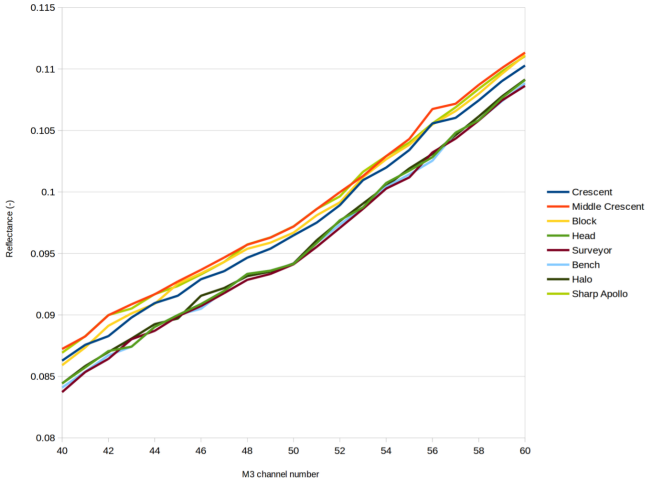


Zhang et al [2013] FeO[wt%]

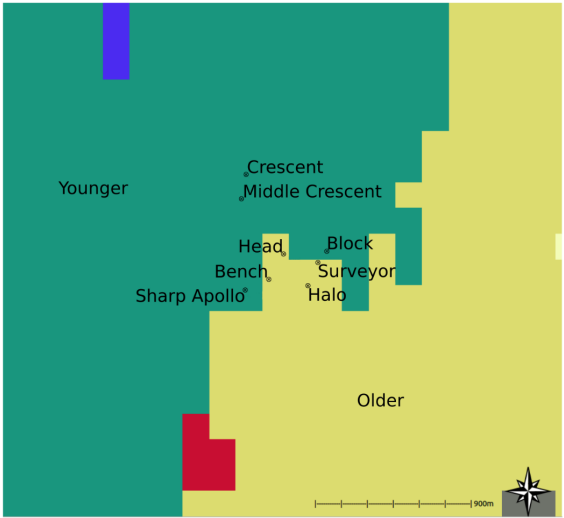
Object-based classification

- Classification based on both spectral and region growth statistics
- Removed M^3 band 1 & 2 as empty
- Configured to simplify large regions instead of small units
- Trying to exploit the reflectance gap in craters signal
- Momsen and Metz [2012]*
- GRASS GIS: i.segment

[*]Momsen, E., Metz, M. *Object-oriented classification in GRASS GIS*, GSoC, 2012.



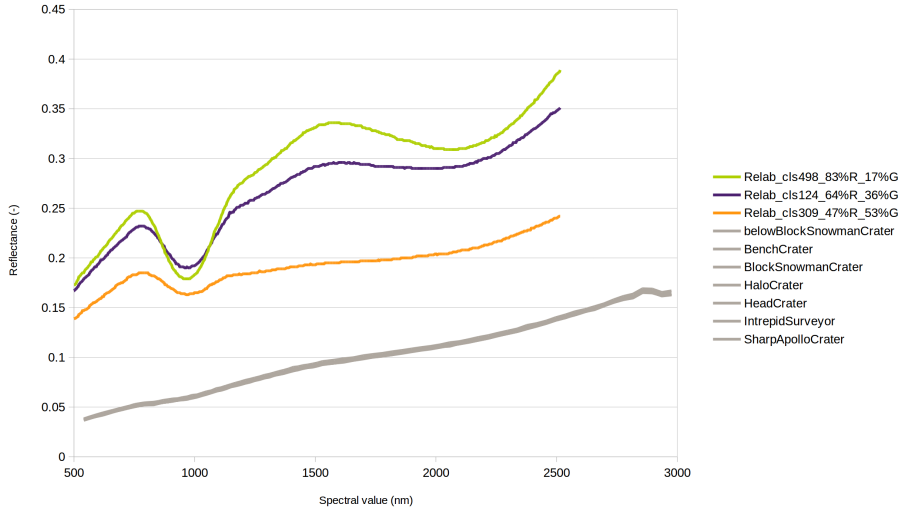
A12 Craters hyperspectral signal gap



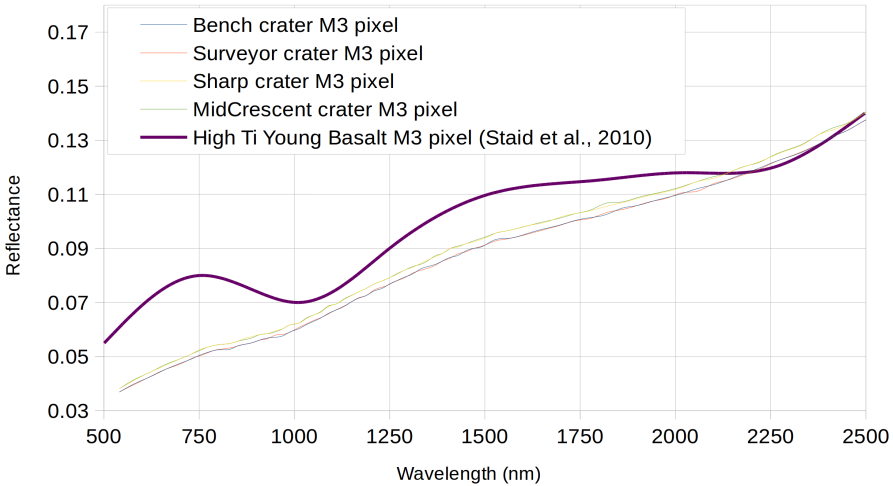
Object-based classification

Manual seek and compare

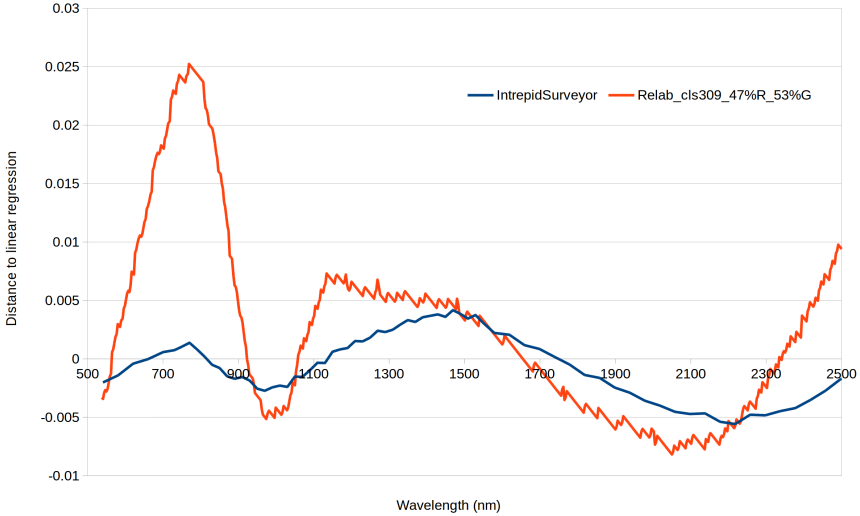
- Compare each Relab signal from Apollo 12 to M^3
- Removed M^3 band 1 & 2 as empty
- Closest found are half glass half rock (12063,79NT)
- M^3 signal too linear



Manual seek: 12063,79NT (Relab cls309)

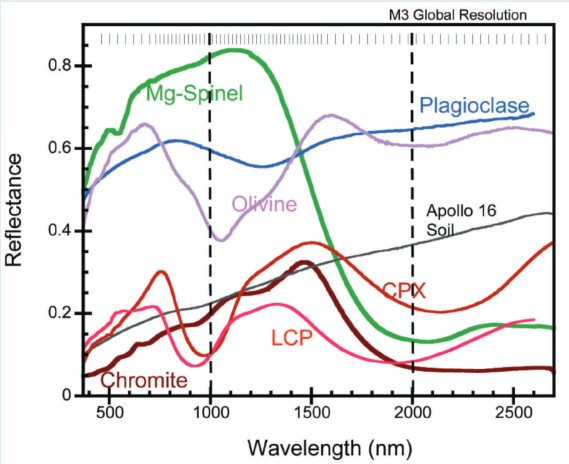


Manual seek: 12063,79NT compare Staid et al. [2011] Mare Basalt



Manual seek: 12063,79NT compare Relab cls309 (detrended)

Finding: CPX



Graph from Pieters et al. [2014]

Finding: CPX

- **Pre-copernican**
  Augite/pigeonite leaning towards Hedenbergite ($CaFeSi_2O_6$)
- **Copernican**
  Augite/pigeonite leaning towards Endiopside/Diopside ($CaMgSi_2O_6$)
- Layer within 5000m in Copernicus crater (Pieters et al., 1985)*
- Aging going out of the ray, increase FeO[wt%]

[*]Pieters, C.M., Adams, J.B., Mouginis-Mark, P.J., Zisk, S.H., Smith, M.O., Head, J.W., McCord, T.B. *The nature of crater rays: The copernicus example*. Journal of Geophysical Research: Solid Earth, 90(B14):12393–12413, 1985.

This study

- Found some Copernican and pre-Copernican CPX
- with FeO differences

Future

- 2018: Imaging IR Spectrometer on Chandrayaan-2 (600-2500nm)
- Will enhance this work, and add mineralogical identification power
- I would like to be involved, to continue bridging Lunar samples to RS data


Lunar Module
Block
Head
Surveyor
Snowman
Thank You
Bench
Halo
Sharp Apollo