

# Mojave Volatiles Prospector – Water in the Mojave Desert as an Analog to the Lunar Poles

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Apollo 17 EVA 2 Station 3

Mojave Desert



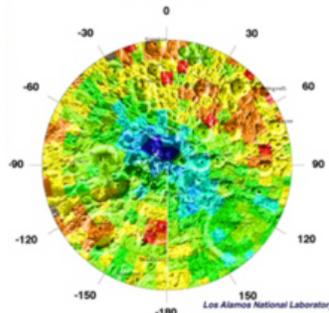
# Looking for Lunar Water



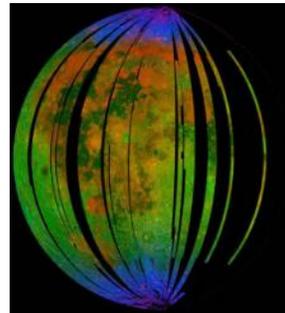
**Apollo Samples**



**Lunar Prospector  
LRO**



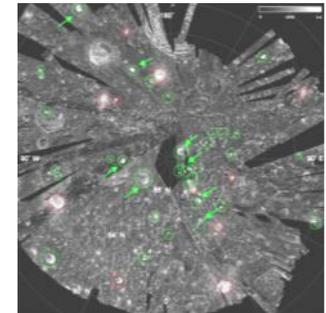
**Moon  
Mineralogical  
Mapper (M<sup>3</sup>)**



**LCROSS**

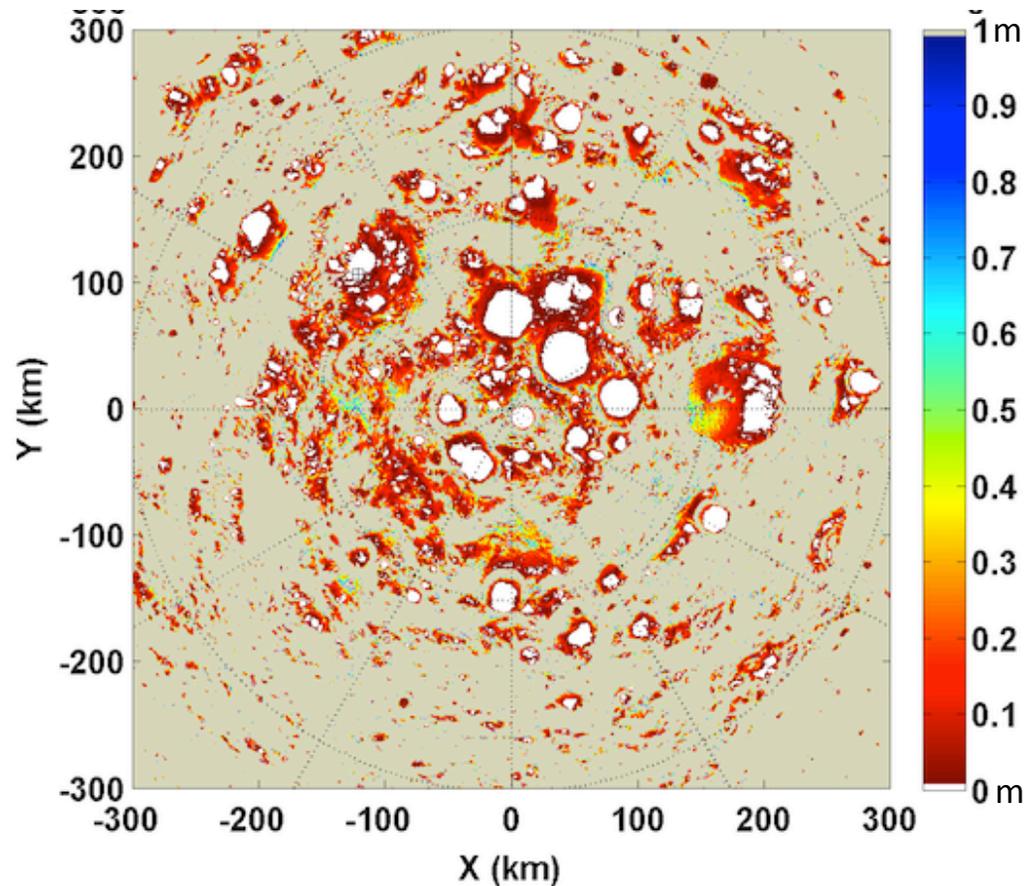


**Clementine  
Chandrayaan  
Mini SAR/RF**



	<b>Solar Wind</b>	<b>Core Derived Water</b>	<b>Water/Hydroxyl</b>	<b>Polar Volatiles</b>	<b>Polar Ice</b>
Concentration	Hydrogen (50 to 150 ppm) Carbon (100 to 150 ppm)  Helium (3 to 50 ppm)	0.1 to 0.3 wt % water in Apatite  0 to 50 ppm water in volcanic glass	0.1 to 1% water	3 to 10% Water equivalent Solar wind & cometary Volatiles (CO, H <sub>2</sub> , NH <sub>3</sub> , organics)	Ice layers
Location	Regolith everywhere	Regolith; Apatite	Upper latitudes	Poles; Permanent shadowed craters and possibly temporary lit locations	Poles; Permanent shadowed craters
Depth	Top several meters; Gardened	Top 10's of meters	Top mm's of regolith	Below 10 to 20 cm of desiccated layer	Top 2 meters

# Lunar Polar Volatiles



- Ice Deposits have been detected throughout the Lunar Poles
- Ice concentrates in the near surface around permanently shadowed craters.
- Detailed surface mapping required for human use.

South Pole depth to Ice from Diviner (1km/pixel  
Paige et al., Science 2010)

# Resource Prospector- Expedition 1 (RP)

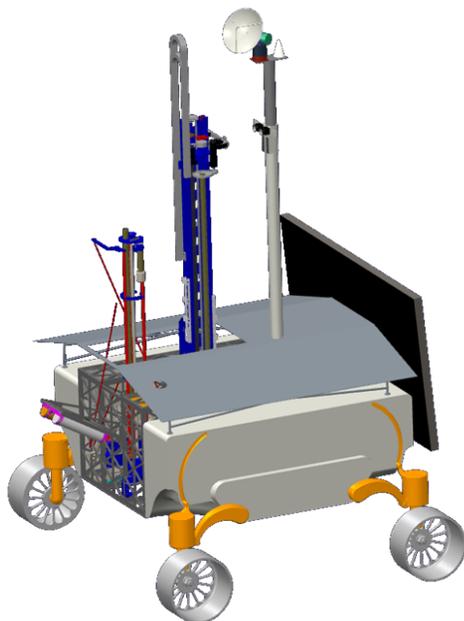


## RPM Mission Options – Notional Traverse

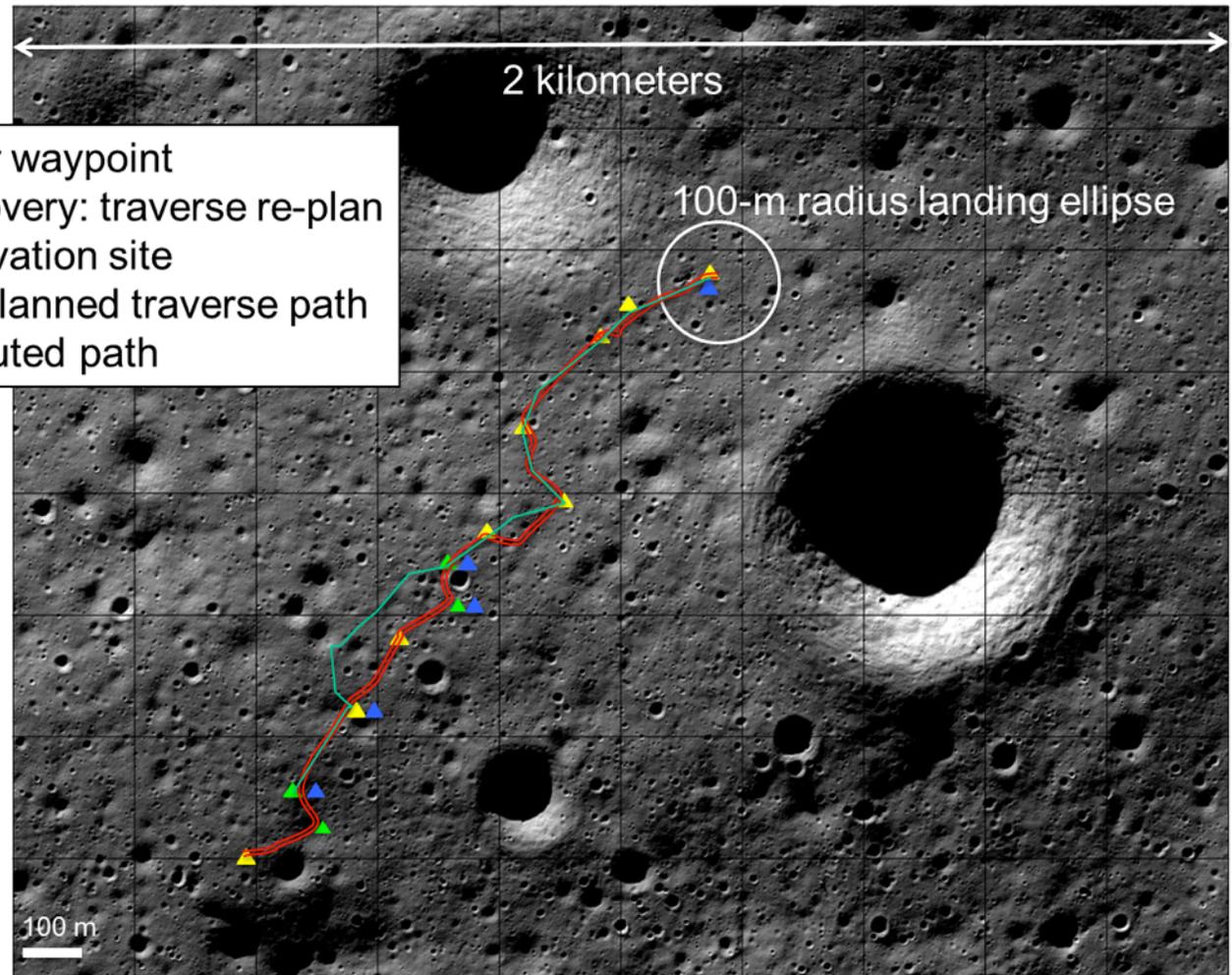
RP Rover Key

Instruments:

- Drill
- VNIR Spectrometer
- Neutron Spectrometer



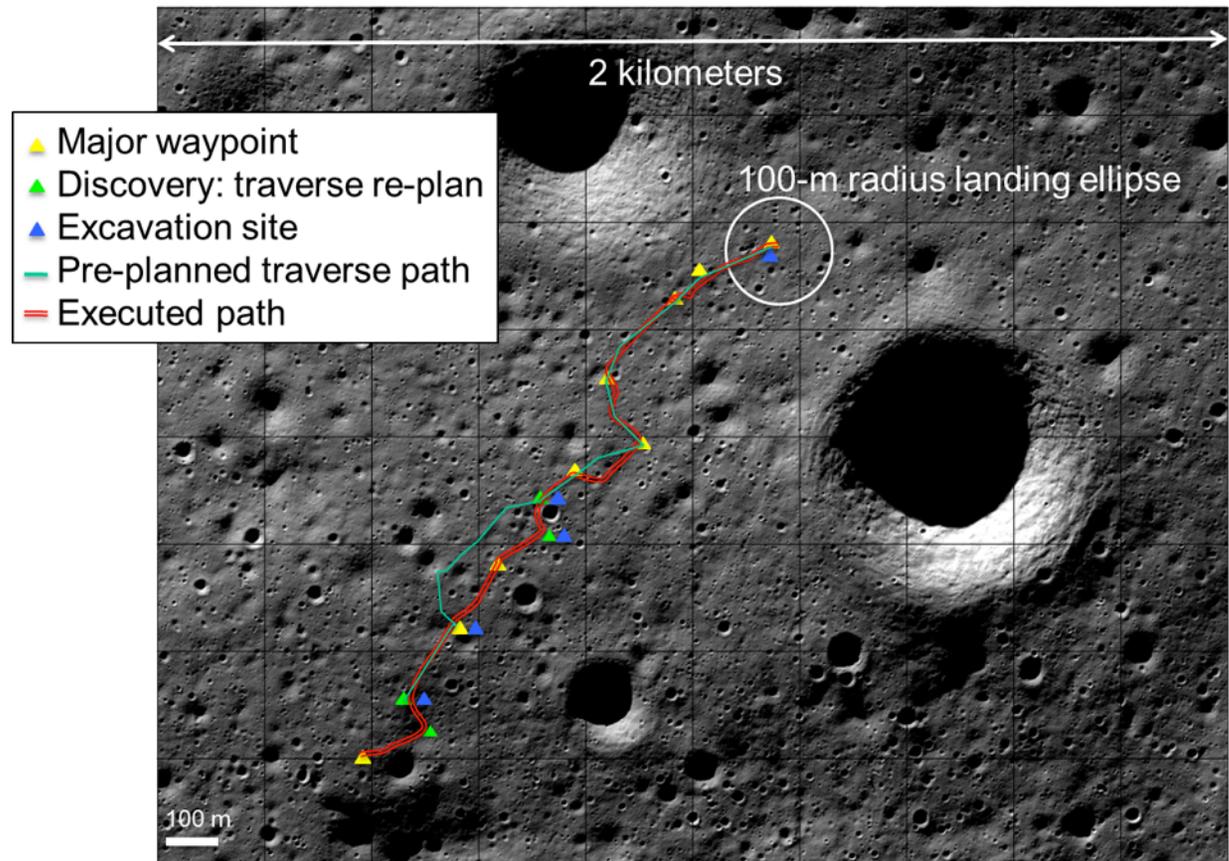
- ▲ Major waypoint
- ▲ Discovery: traverse re-plan
- ▲ Excavation site
- Pre-planned traverse path
- Executed path



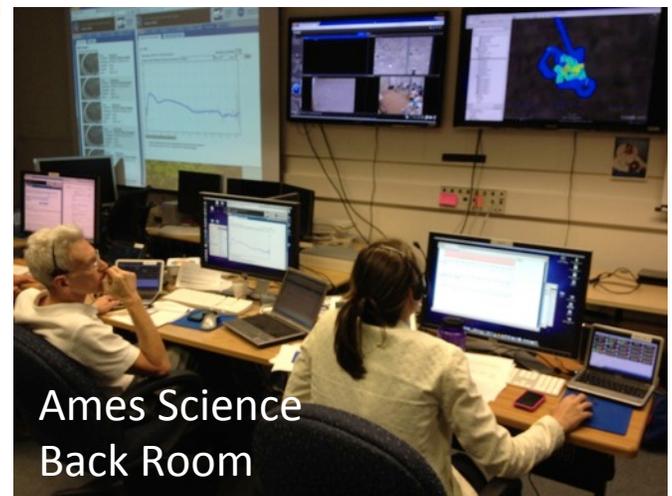
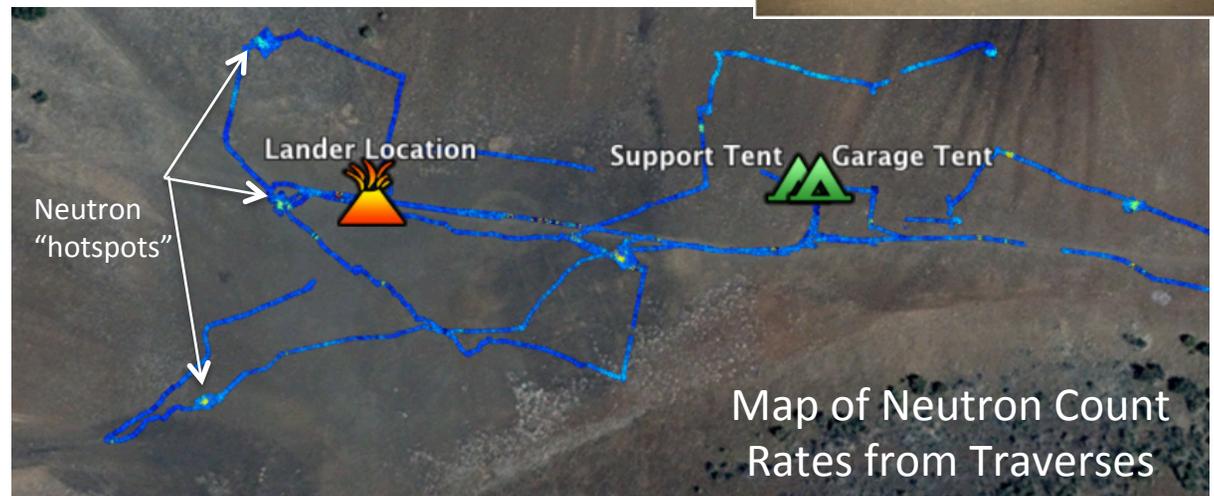
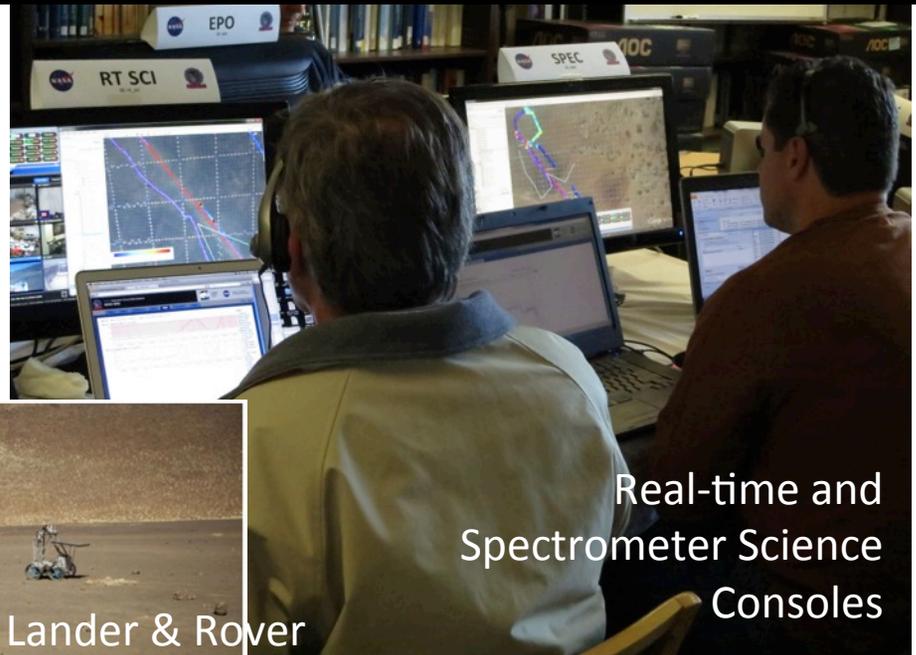
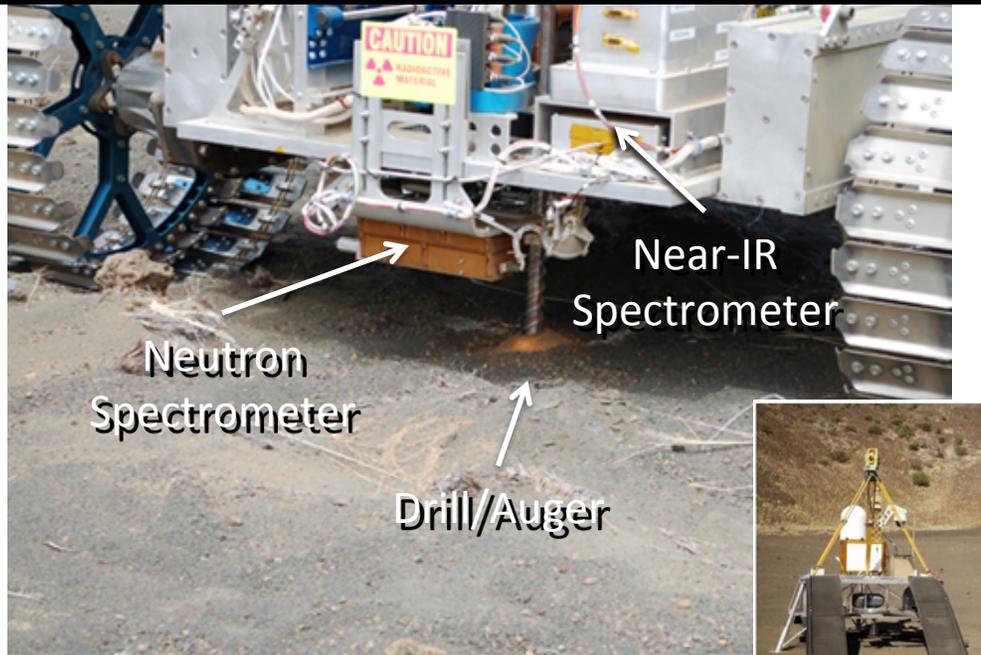
# What do we need to know?



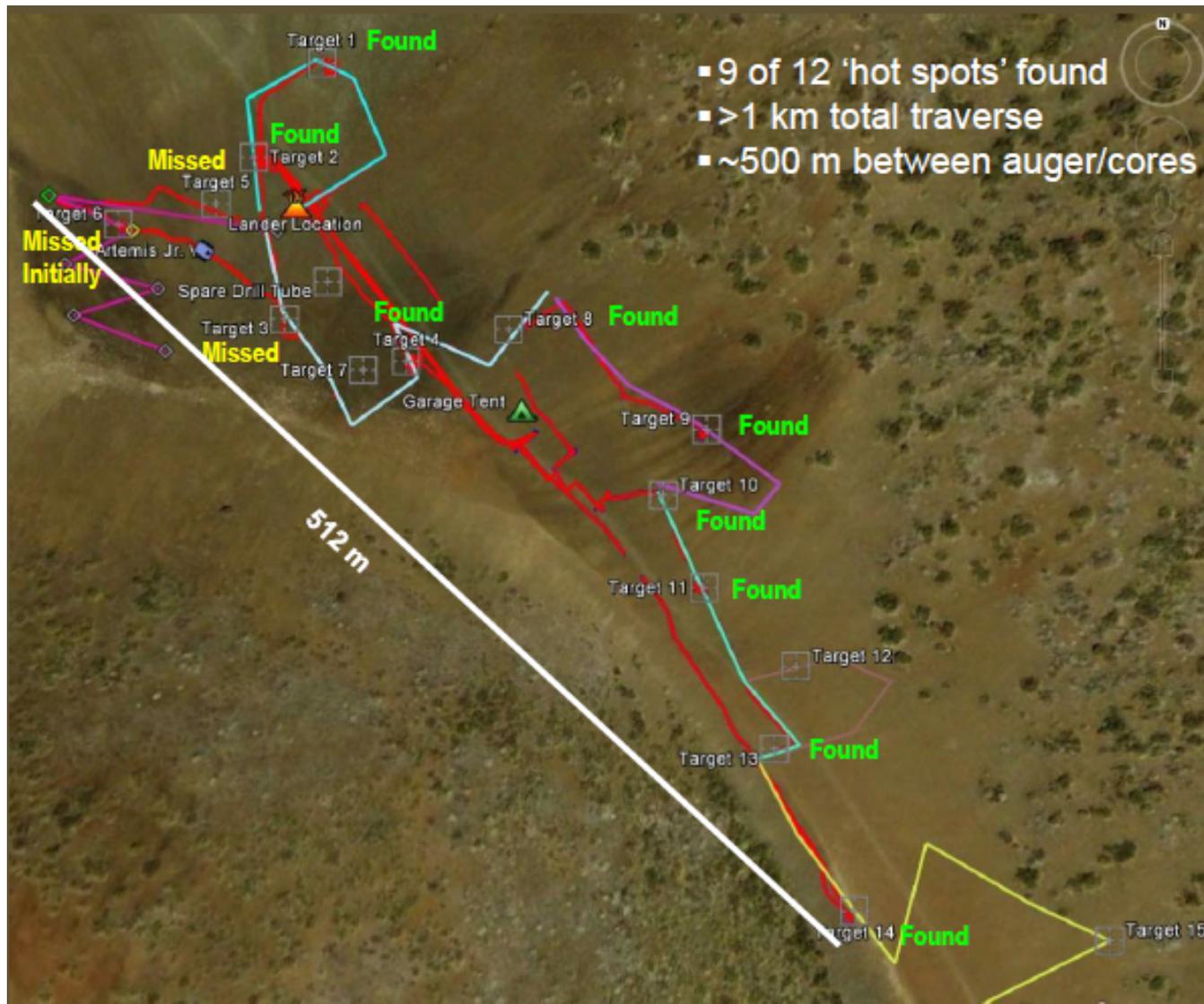
- How do you map a hydration distribution with a single traverse?
- How do you combine neutron and spectral data to detect hydration?
- How do you maximize roving?



# July 2012 Field Campaign (Hawaii)



# July 2012 Field Campaign (Hawaii)



# July 2012 Field Campaign (Hawaii)



10.10.150.90/xgds\_isru/xgds\_plot/plots/ trickle bandwidth example

Asteroids TWC 94035 Weather ... Most Visited 2009 AGU Fall M... Latest Headlines NASA WebDir DC PLRP 2009 Personal OSEWG Bookmarks

Disable Cookies CSS Forms Images Information Miscellaneous Outline Resize Tools View Source Options



xGDS Exploration Ground Data Systems  
NASA ISRU



Intelligent  
Robotics  
Group



National Aeronautics  
and Space Administration

Home

Maps

Console Log

Plans

Plots

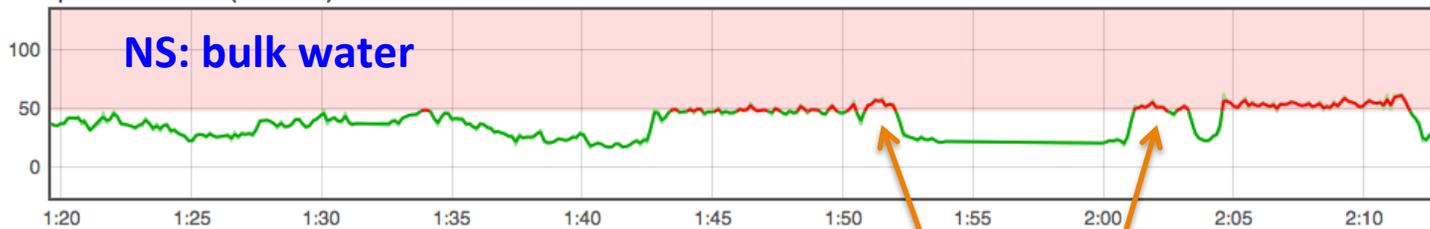
Instruments

Images

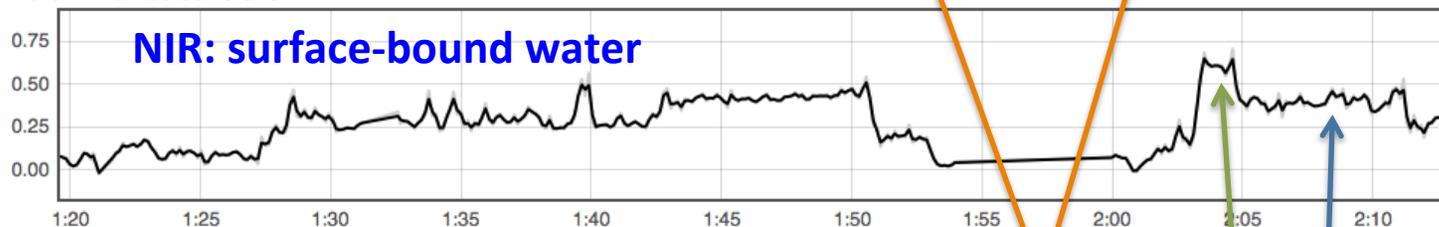
Matthew [Logout](#)

Live Tue, 17 Jul 2012 01:19:36 ... Tue, 17 Jul 2012 02:13:07 UTC

Neutron Spectrometer Sn (counts/s) 02:13:04 20.750



NIR Water 1 01:50:33 0.543



### Plots

- Neutron Spectrometer Sn/Cd Ratio
- Neutron Spectrometer Sn (counts/s)
- Neutron Spectrometer Cd (counts/s)
- Drill Thrust (N)
- Drillhead Position (cm)
- NIR Water 1
- NIR Water 2
- NIR Bound OH
- NIR Grass
- Latitude
- Longitude

Bulk water only

Surface-bound water only

Surface-bound and bulk water

# Mojave Field Campaign (Oct. 2014)



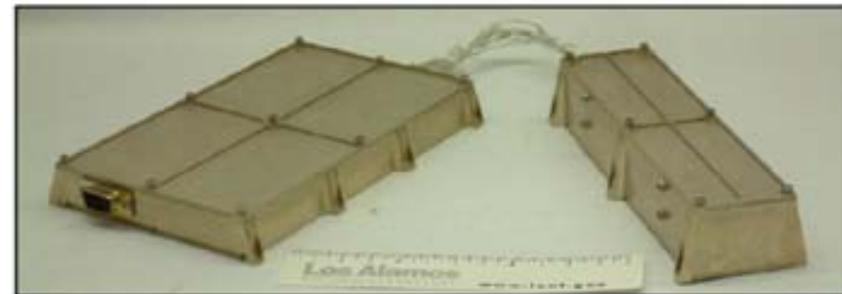
## Project overview & goals

- **Goal 1:** Mature the NIRVSS and Hydra prospecting operations concept through integration and robotic field testing in native soils in a lunar analog setting.



Near Infrared Spectrometer

NIRVSS (SW:1600-2400nm,  
LW:2300-3400nm)



Neutron Spectrometer



# Mojave Field Campaign (Oct. 2014)



## Project overview & goals

- **Goal 1:** Mature the NIRVSS and Hydra prospecting operations concept through integration and robotic field testing in native soils in a lunar analog setting.
- **Goal 2:** Improve and mature xGDS real-time science tools through analog science operations in a natural setting where the abundance and distribution of water is not known a priori.
- **Goal 3:** Conduct a scientific investigation of water content in the Mojave Desert by mapping native water distribution and variability in abundances similar to lunar polar volatiles as a realistic analog to robotic mapping at the lunar poles.

# Mojave Field Campaign (Oct. 2014)



- Science Goal: Understand H<sub>2</sub>O emplacement, retention, and distribution in Mojave Desert.

# Mojave Field Campaign (Oct. 2014)



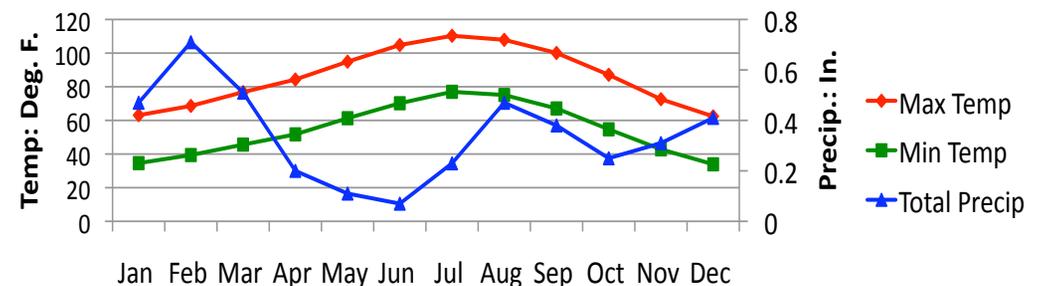
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## Mojave Desert

- Field site = Alluvial Fan
- Elevation ~ 450 m
- Climate = arid (12-25 cm mean annual precipitation) & hot (16-18C mean annual temperature)
- Located 14 km SW of Baker, CA and 180 km NE of Los Angeles, CA.



Mojave Test Site Temperature and Rainfall by Month



# Mojave Field Campaign (Oct. 2014)



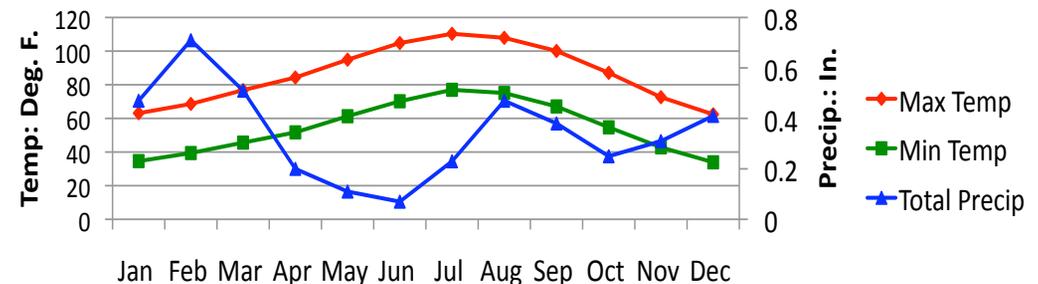
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## Lunar analog

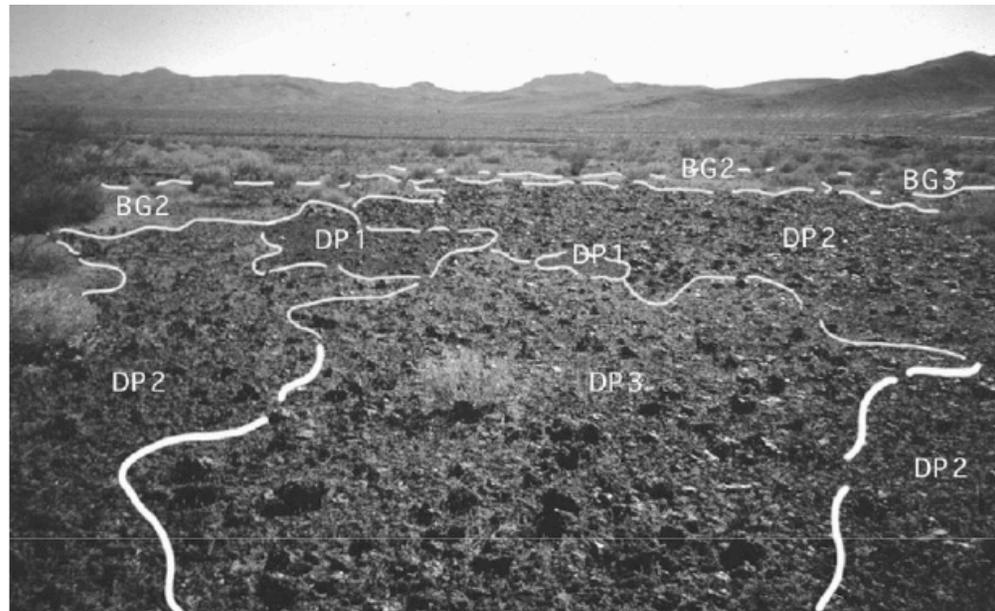
**Both Moon & Mojave = low, naturally occurring water abundance in an arid environment.**

### Water abundances:

LCROSS (Moon): ~5-6 wt %

Sahara Desert (Earth): 2-3 wt %

Mojave Desert (Earth): 2-6 wt %

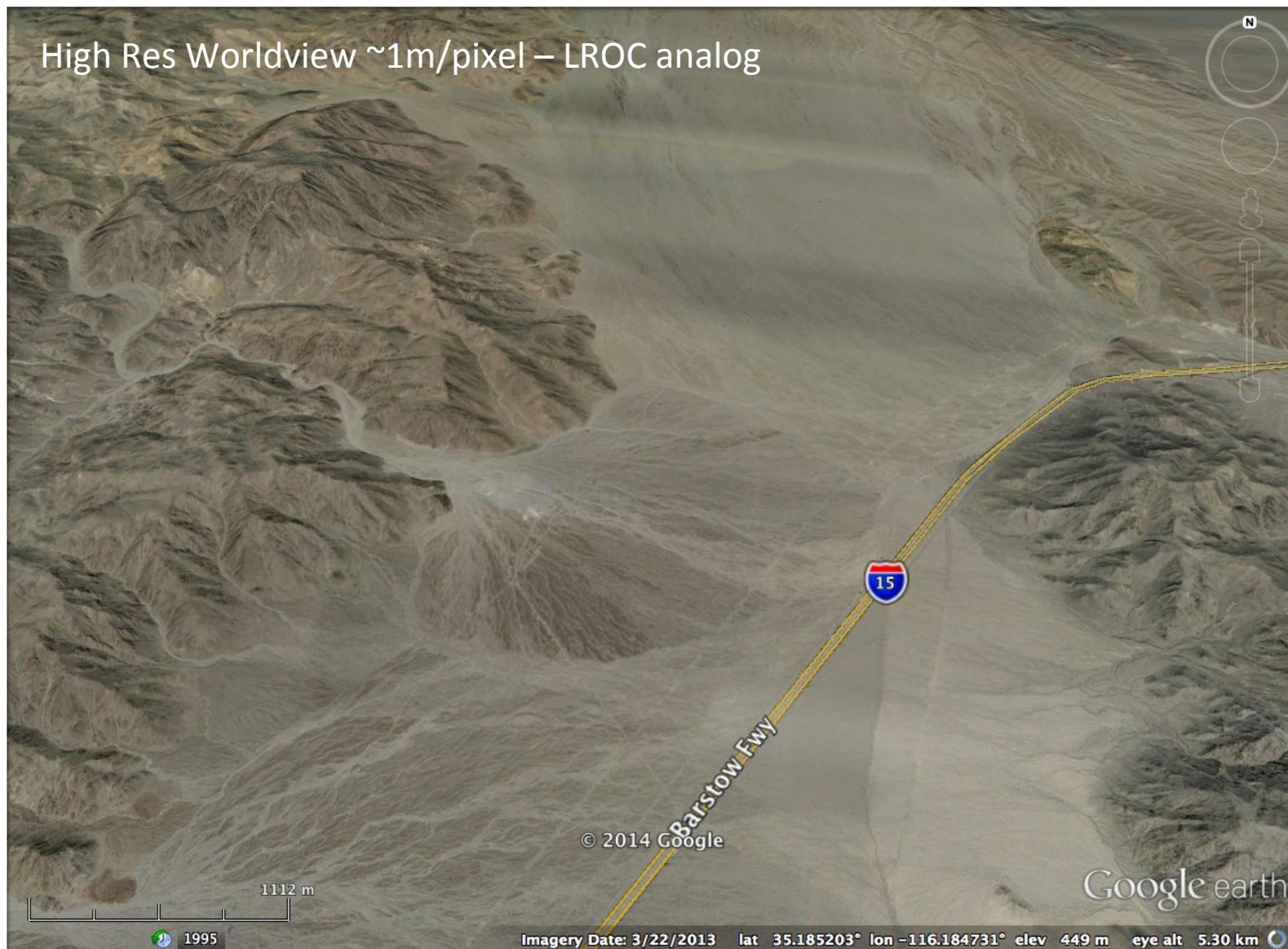


*Mapping of soil clast cover in Mojave National Preserve. The close proximity of various surface types in this region helps ensure we will traverse multiple types of ground cover during the field test. From Wood et al. 2002.*

# Mojave Field Site



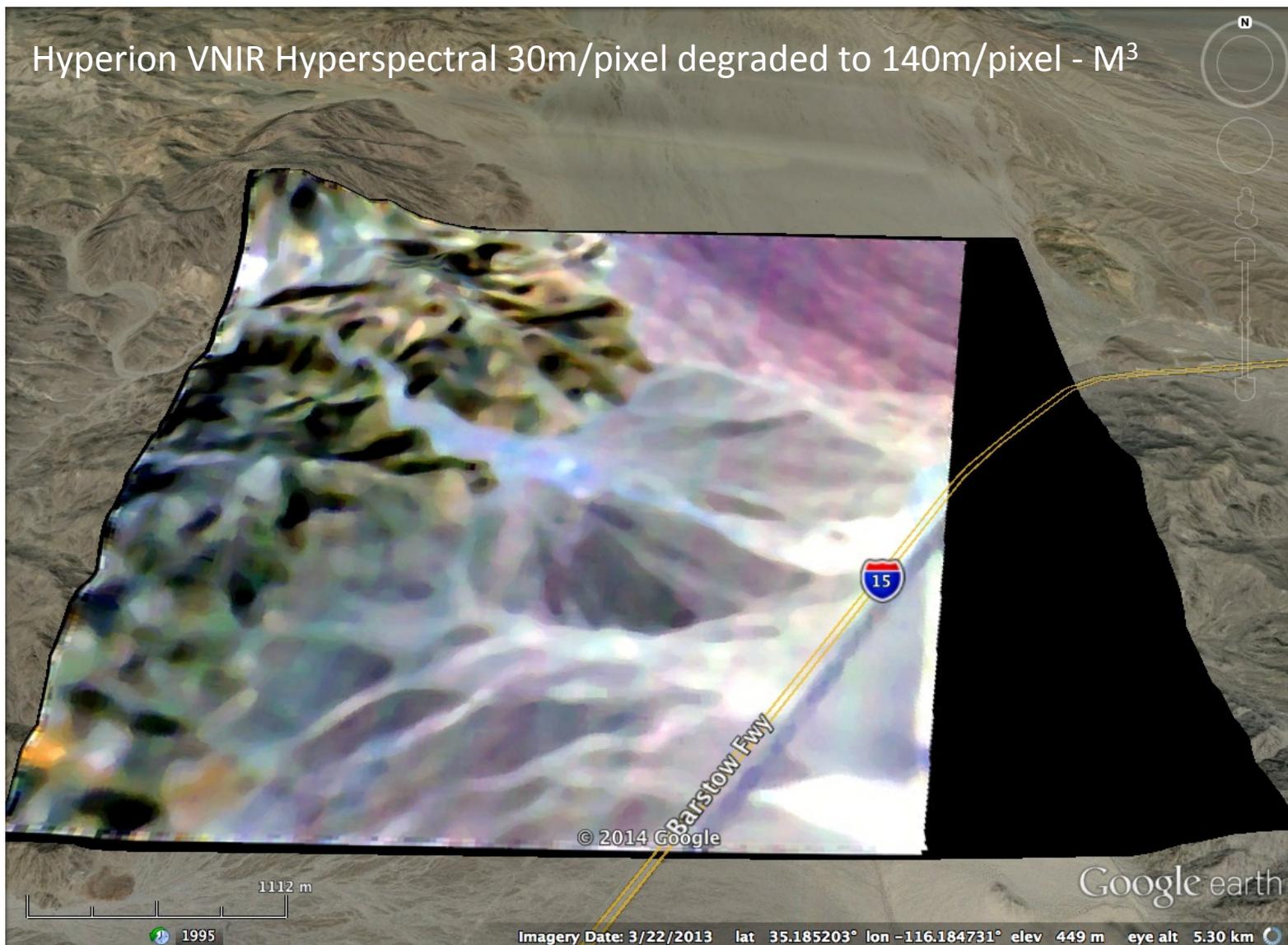
High Res Worldview ~1m/pixel – LROC analog



# Mojave Field Site



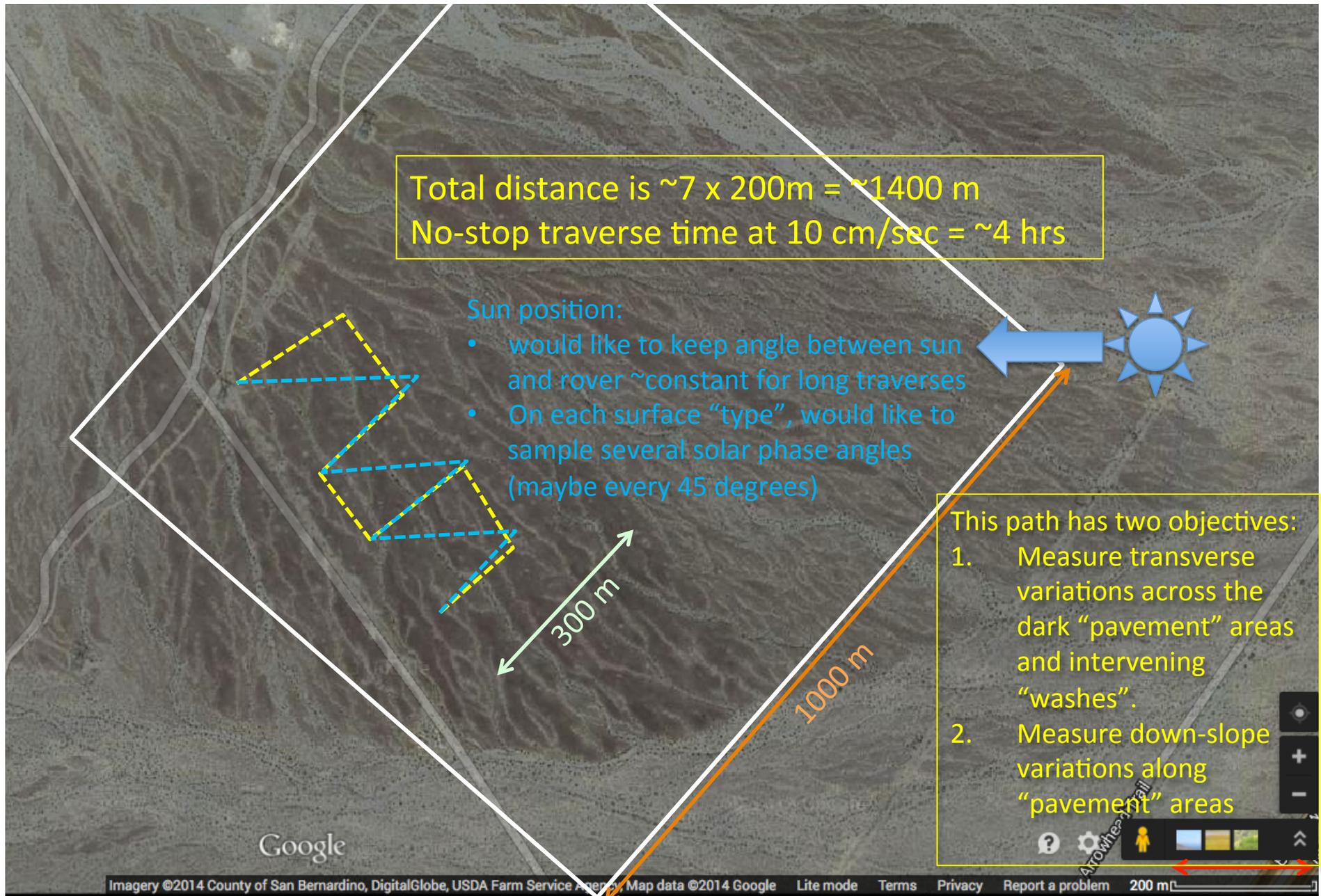
Hyperion VNIR Hyperspectral 30m/pixel degraded to 140m/pixel - M<sup>3</sup>



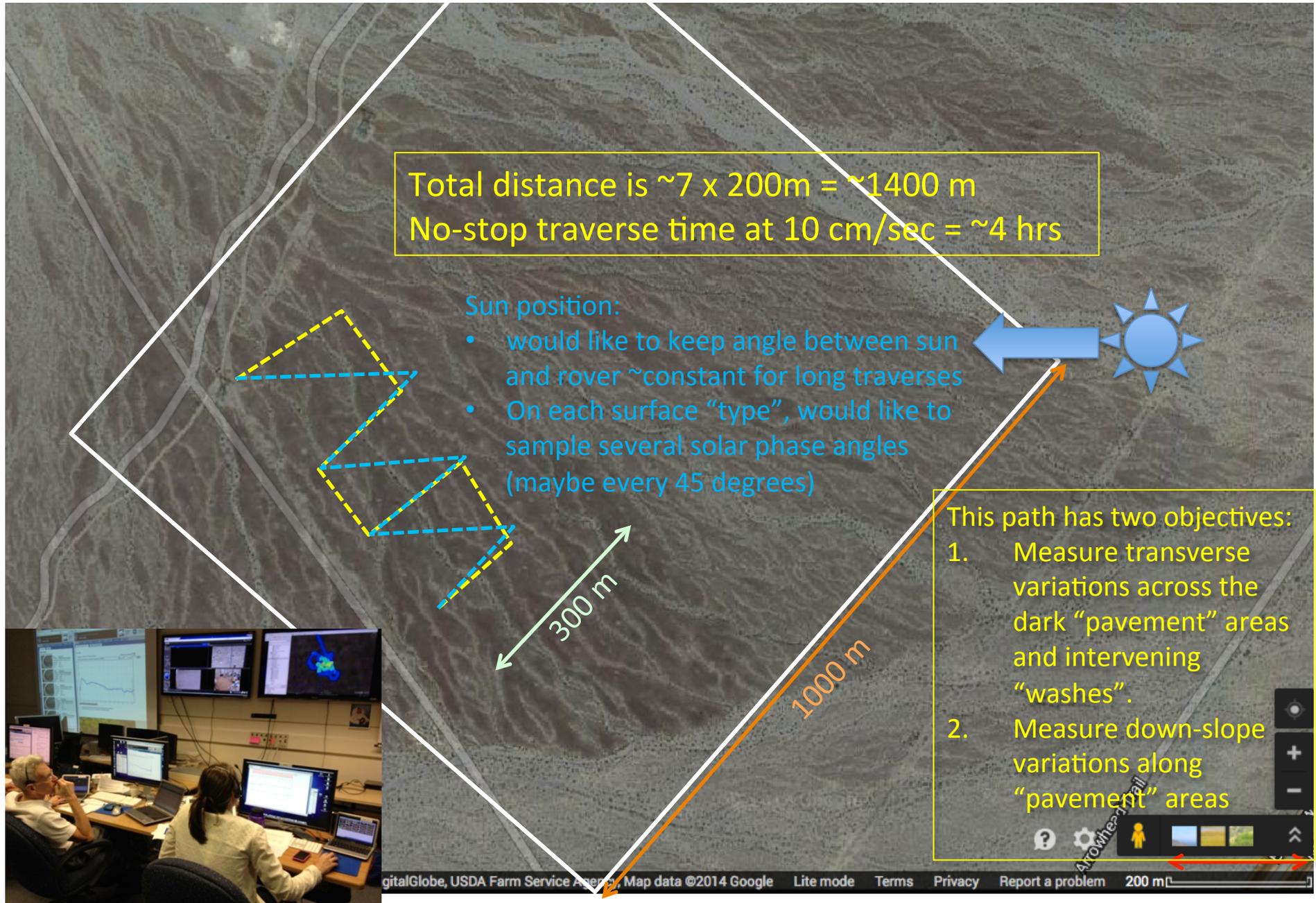
# Mojave Field Site



# Notional Day 1 Traverse for MVP Planning Purposes



# Notional Day 1 Traverse for MVP Planning Purposes



# Questions



Apollo 17 EVA 2 Station 3



Mojave Desert