Hot Science Cool Talks

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Astronauts, Robots, and Rocks: Preparing for Geological Planetary Exploration

Dr. Mark Helper

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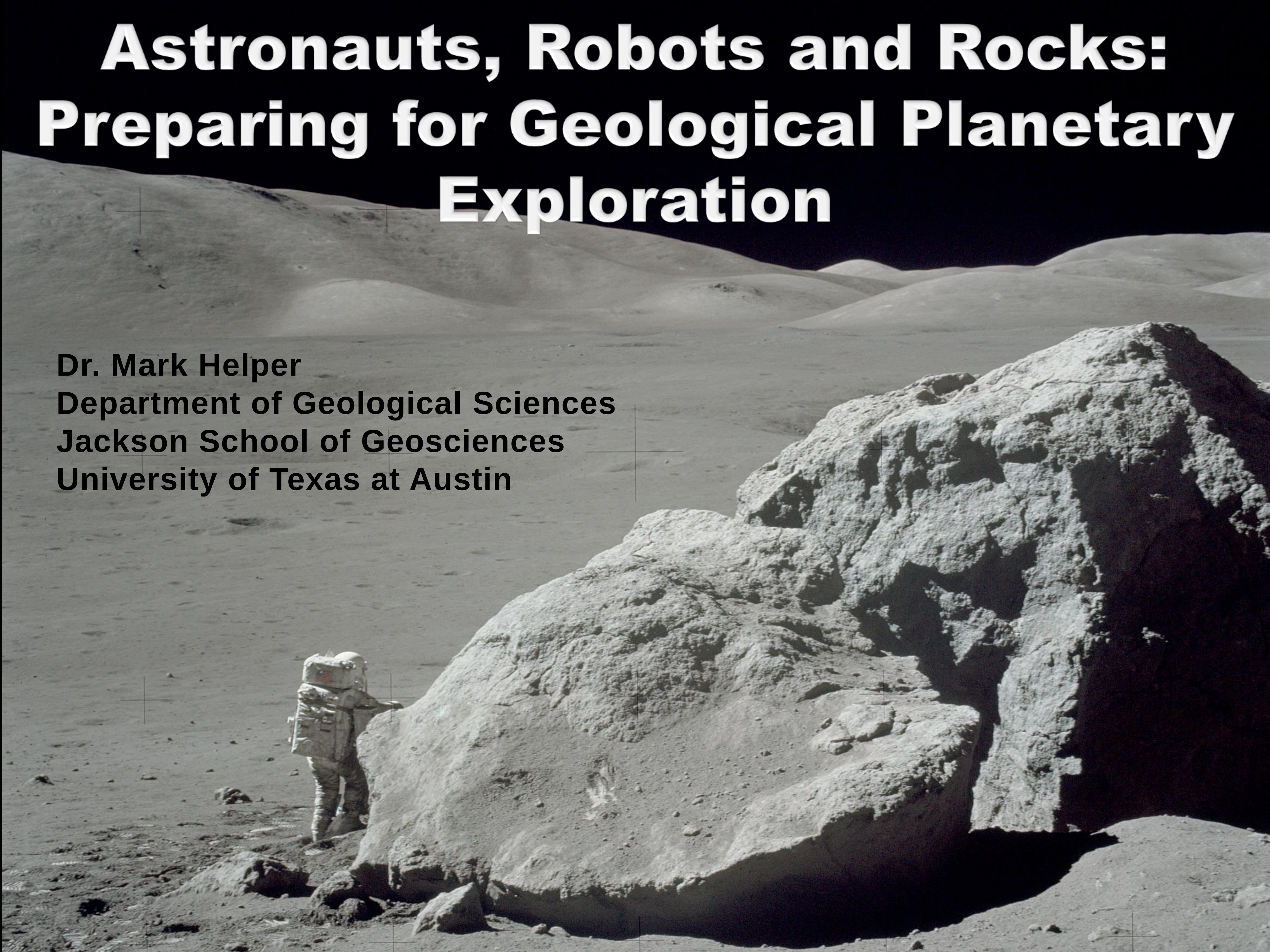
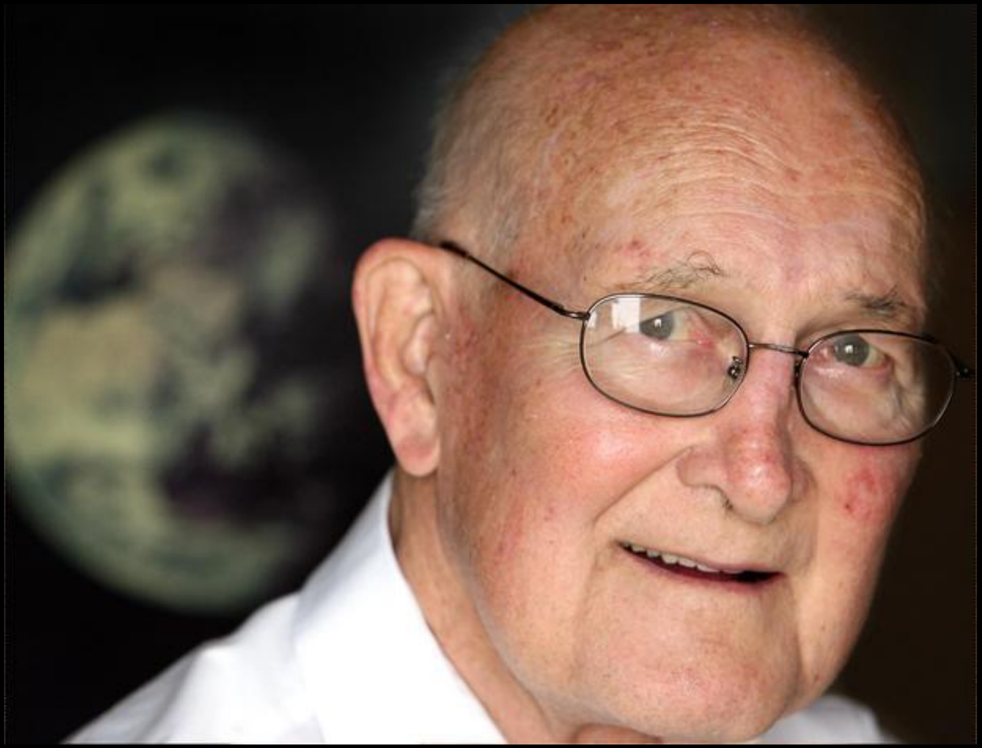


Dr. William R. Muehlberger



1923 - 2011

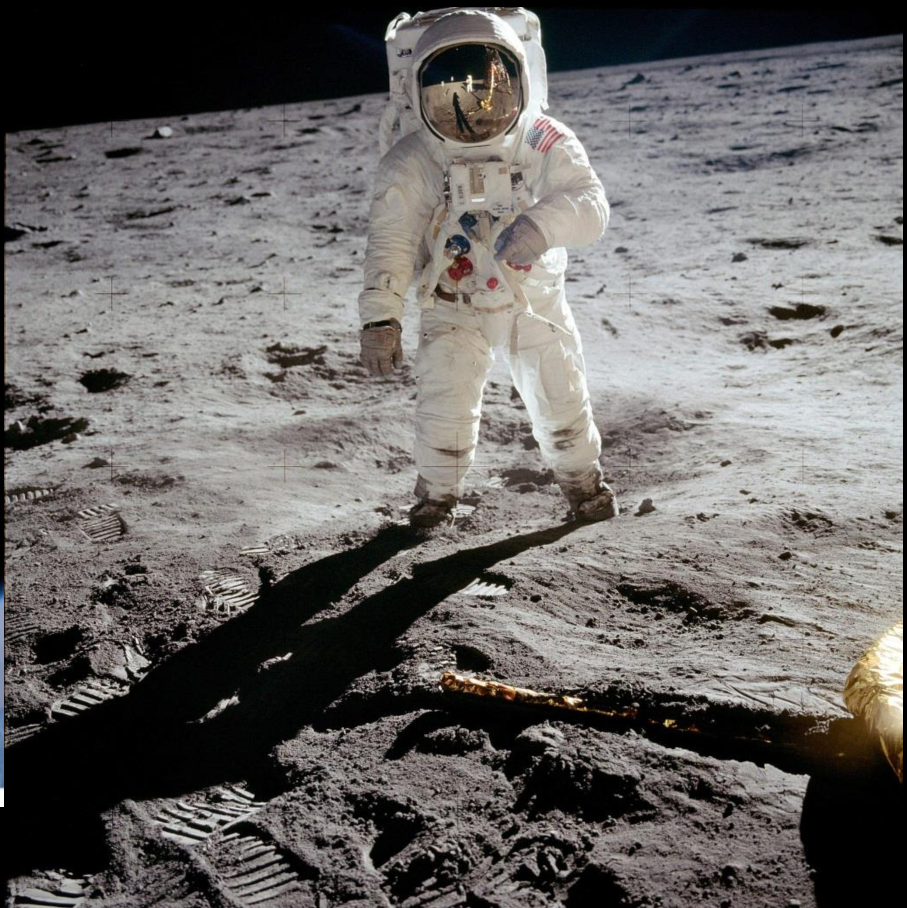
Human Space Flight: What Are The Goals?

"*Fifty years after the creation of NASA, our goal is no longer just a destination to reach. Our goal is the capacity for people to work and learn and operate and live safely beyond the Earth for extended periods of time, ultimately in ways that are more sustainable and even indefinite*."

- President Barack Obama, April 15, 2010

Why Human Space Exploration?

It is part of what makes us a great nation



Why Human Space Exploration?

There are discoveries that await us:

- Can humans survive elsewhere?
- How did the planets form and evolve?
- Is there (or was there) life elsewhere?

Don’t we already know how to do this?

Apollo Moon Landings: 1969-1972

**6 moon landings,
12 astronauts
walk on the Moon**

Space Shuttle Era: 1981-2011

135 missions to low earth orbit

Goal: simple, safe and cheap space flights

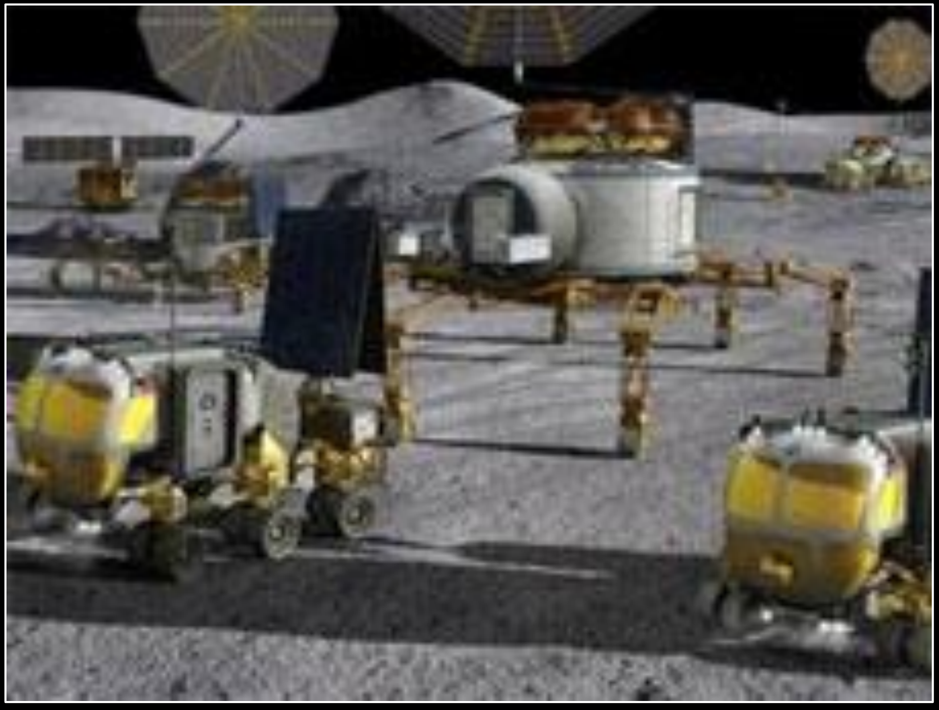
- Platform for science and observing earth
- Satellite emplacement and repair (HST)
- Ferrying large objects to space – build ISS

International Space Station: 2000-present

~400 km orbit
Continuous occupation for 11 years
~300 visitors for up to 196 days

Our experience gained is substantial but…

- ~40 years since humans have ventured beyond low earth orbit
- New technologies and strategies for *extended missions* in deep space are untested

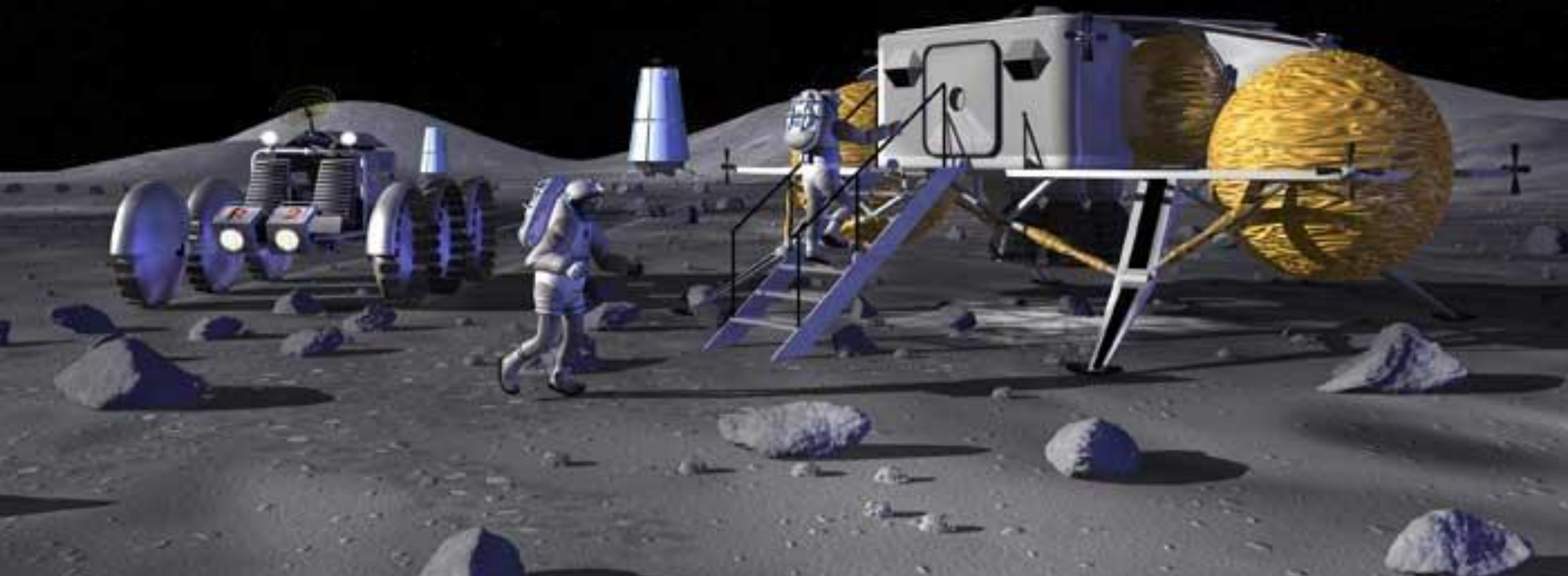


How will we do it ?

2004: A Vision for Space Exploration:

"Goals of human spaceflight should be worthy of the cost, risk and difficulty"

- Use Moon as a laboratory and stepping stone to:
  - Learn to live and work for extended periods off-earth
  - Develop and test techniques to "live off the land"
  - Test new surface science exploration tools



2010 Revisions

- Larger role for private enterprise
- Greater emphasis on international collaboration
- Near-Earth asteroid instead of the Moon

Apollo: A “Playbook” for Human Exploration?

- ~8 years of precursor data gathering and flight testing
- Longest stay 3 days; ~9 days per mission
- Moon walkers: 11 pilots, 1 geologist
- Last 3 missions devoted to geoscience
- ~380 kg (840 lbs.) of rocks returned
- Amazing successes, very few failures

Can't anybody take photos and pick up rocks?

Yes but…

- What kind of rocks should you collect?
- What are the most important observations needed to document a geologic history?

Answer:

Ask a Field Geologist

An expert at interpreting landscapes and rocks to deduce geologic processes and histories

Apollo Astronaut Geology Training

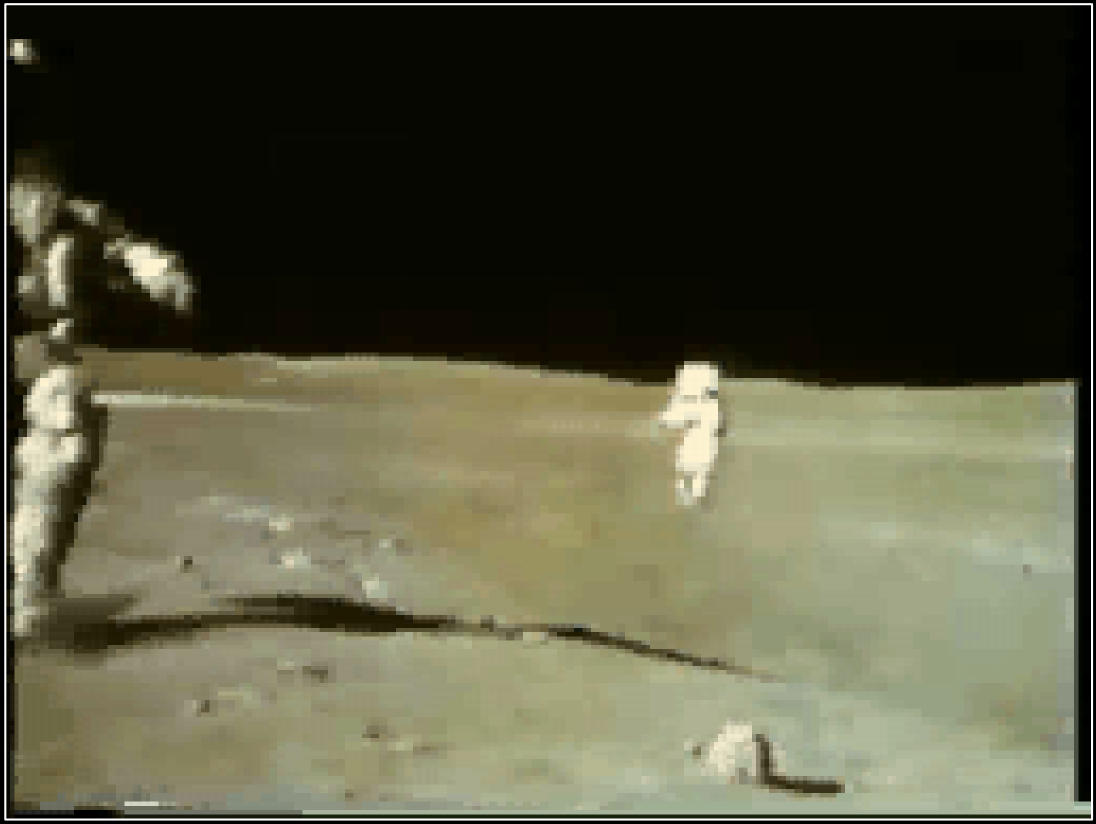
- General Geology
- Field Trips and Field Geology Exercises

- Practice with Tools and Equipment

Apollo: 800-900 days of classroom and field training

How was it done?

Apollo 16: Collecting “Big Muley”

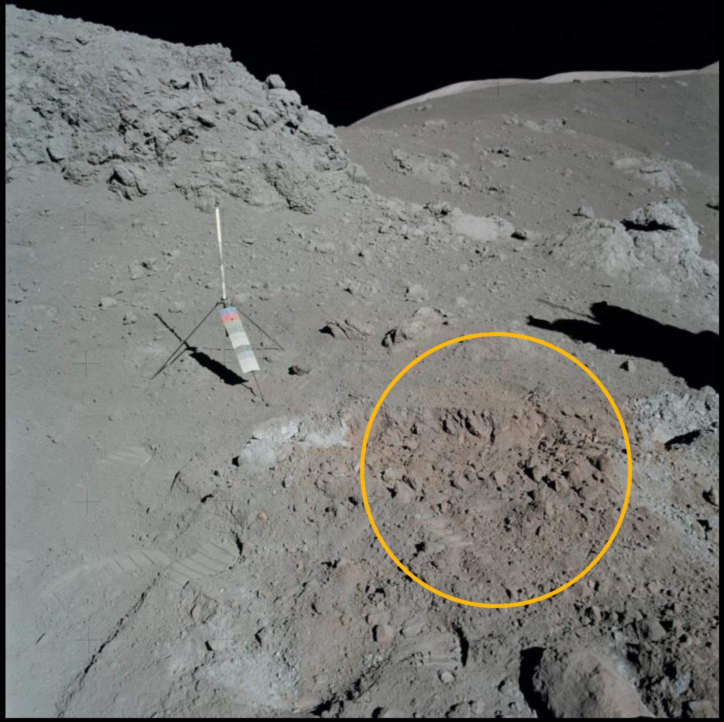


- 3.97 billion years old
- Impact melt rock (igneous rock melted by meteorite impact)
- Largest moon rock collected, ~12 kg (~26 lb)

How was it done?

Apollo 17: Discovery of Orange Soil

Harrison Schmitt collecting sample

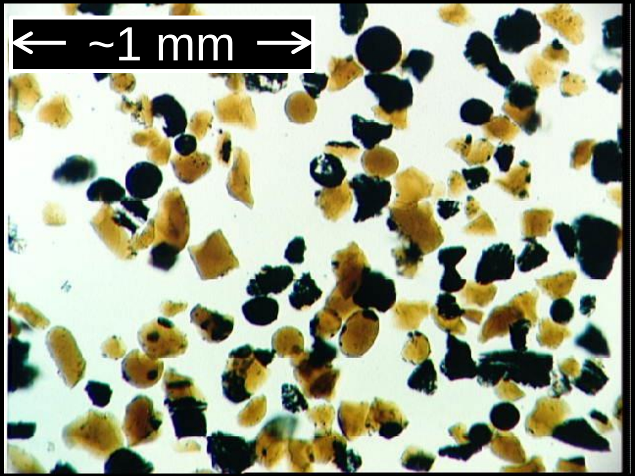


Site of “orange soil” discovery

How was it done?

Apollo 17: Discovery of Orange Soil

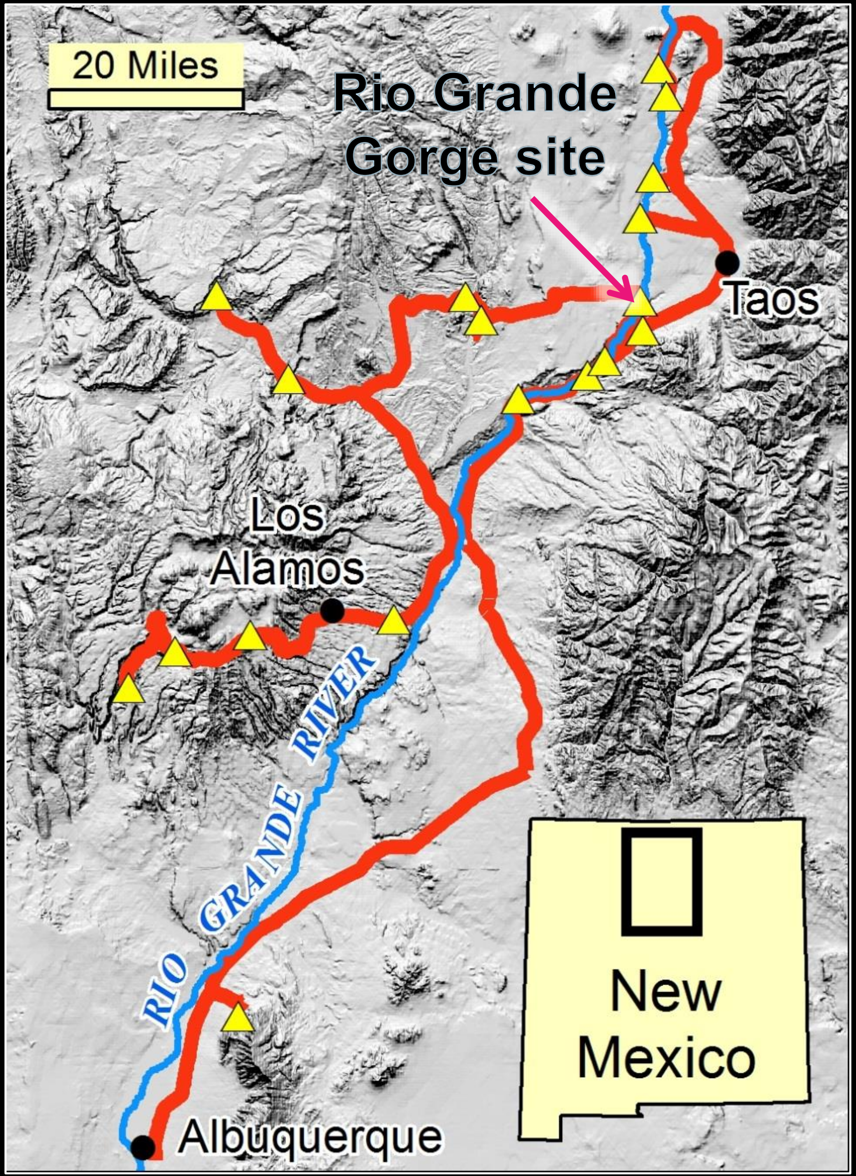
Fire fountain, Hawaii



Orange soil sample, magnified

- Droplets of glassy lava
- ~3.6 billion years old
- Evidence for fire fountain eruption

2010 Astronaut Training Sites, NM & AZ



Geology Training Today

- Classroom Training
- Field Training & Mentoring

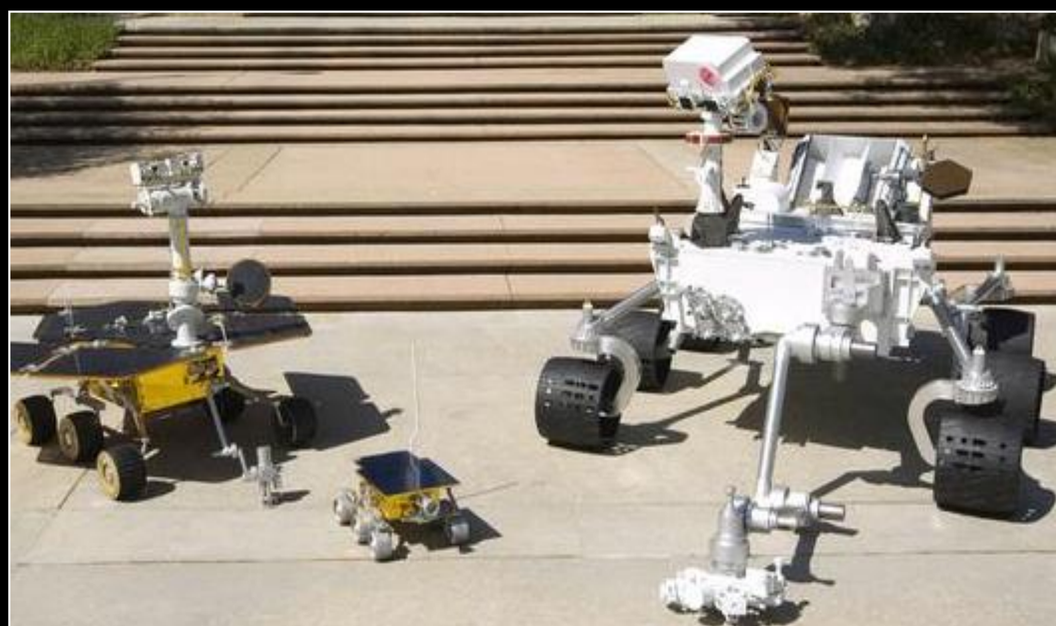
2009 Astronaut Candidate Class
Group 1

Testing Concepts, Tools and Equipment

Desert Research and Technology Studies
northern Arizona

Astronaut Kjell Lindgren

What else has changed since Apollo?



How will robots be used?

- Reconnaissance prior to human landings
- Side-by-side human assistants
- Autonomous investigators e.g. Mars rovers
- Follow-up to human exploration
- Utility functions - maintenance, construction, etc.

Robotic Follow-up Research Project

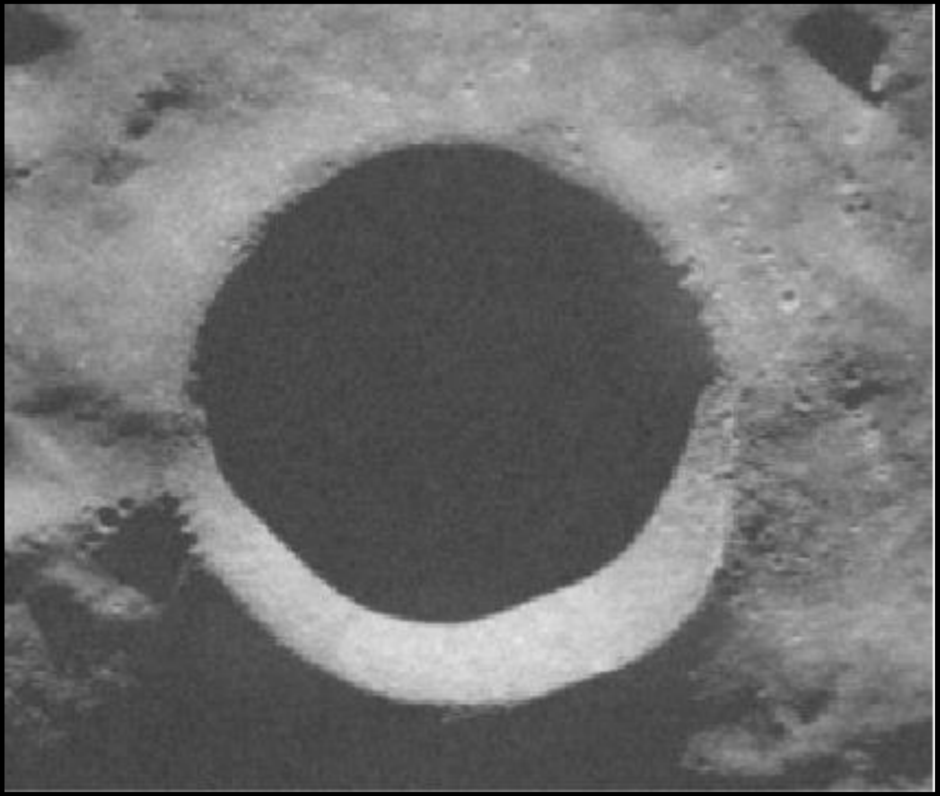
- To study how an astronaut geologist might do a field geology study with robotic follow-up in mind
- To discover how best to pair human and robotic geologic investigations

Use a setting that is analogous (in as many ways as possible) to that on Moon or Mars

Haughton Crater As A Lunar Analog

Moon
Shackleton Crater,
19 km diameter

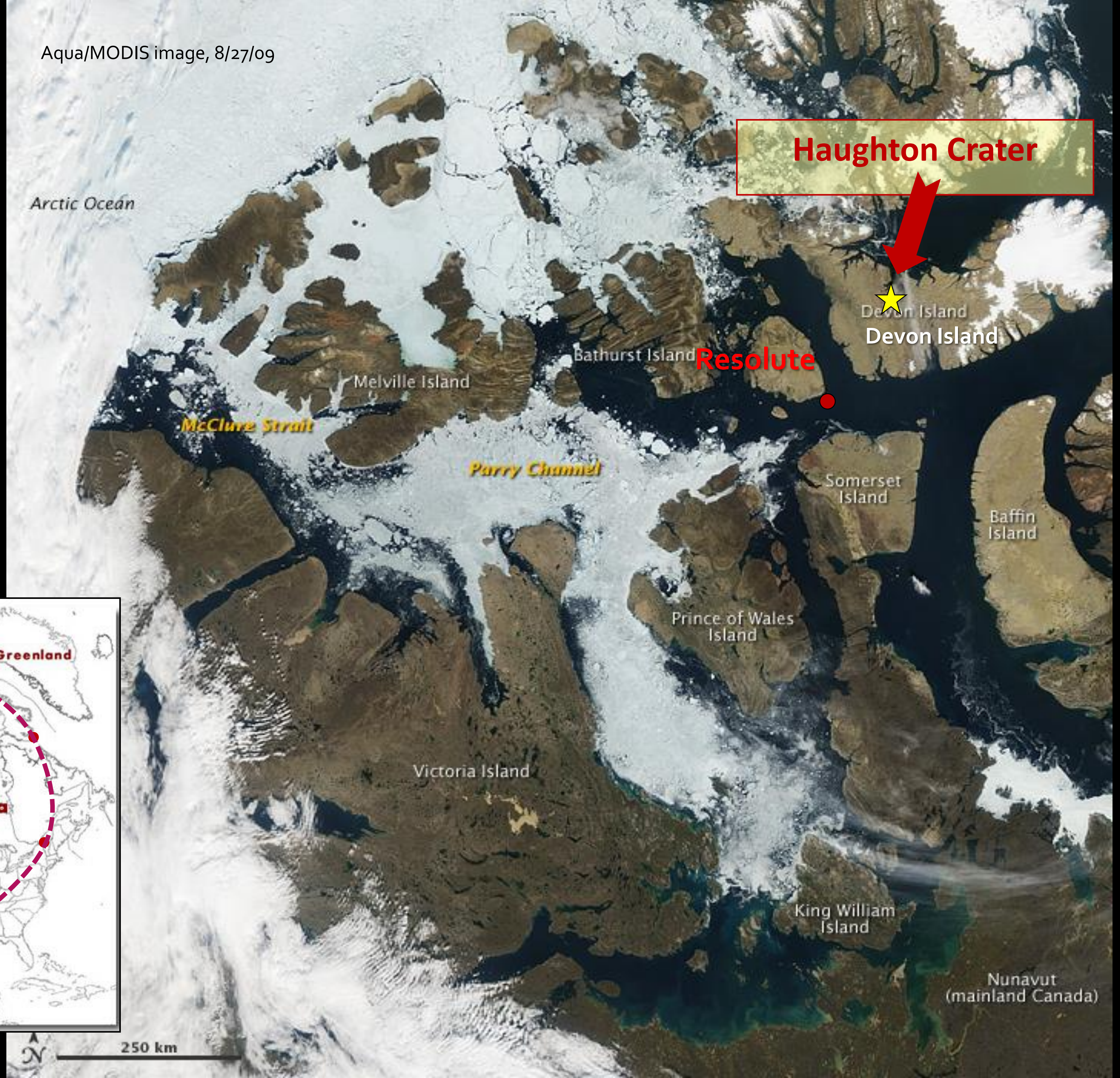
Earth
Haughton Crater, 20 km diameter.
(Devon Island, Canada)



- Potential lunar outpost site

Best preserved crater of this size on Earth
Rocky, polar desert with H_2O ground ice

Haughton Impact Crater Location



Haughton Crater, Devon Island

Crater Interior – Impact Melt & Breccia

Base Camp

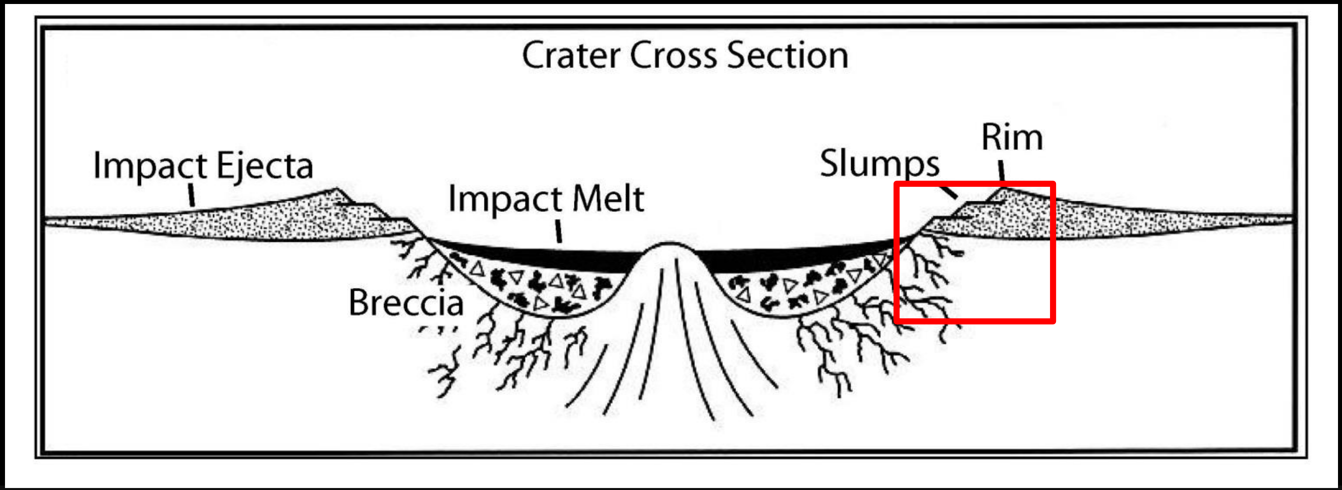
Ground Rules for Experiment

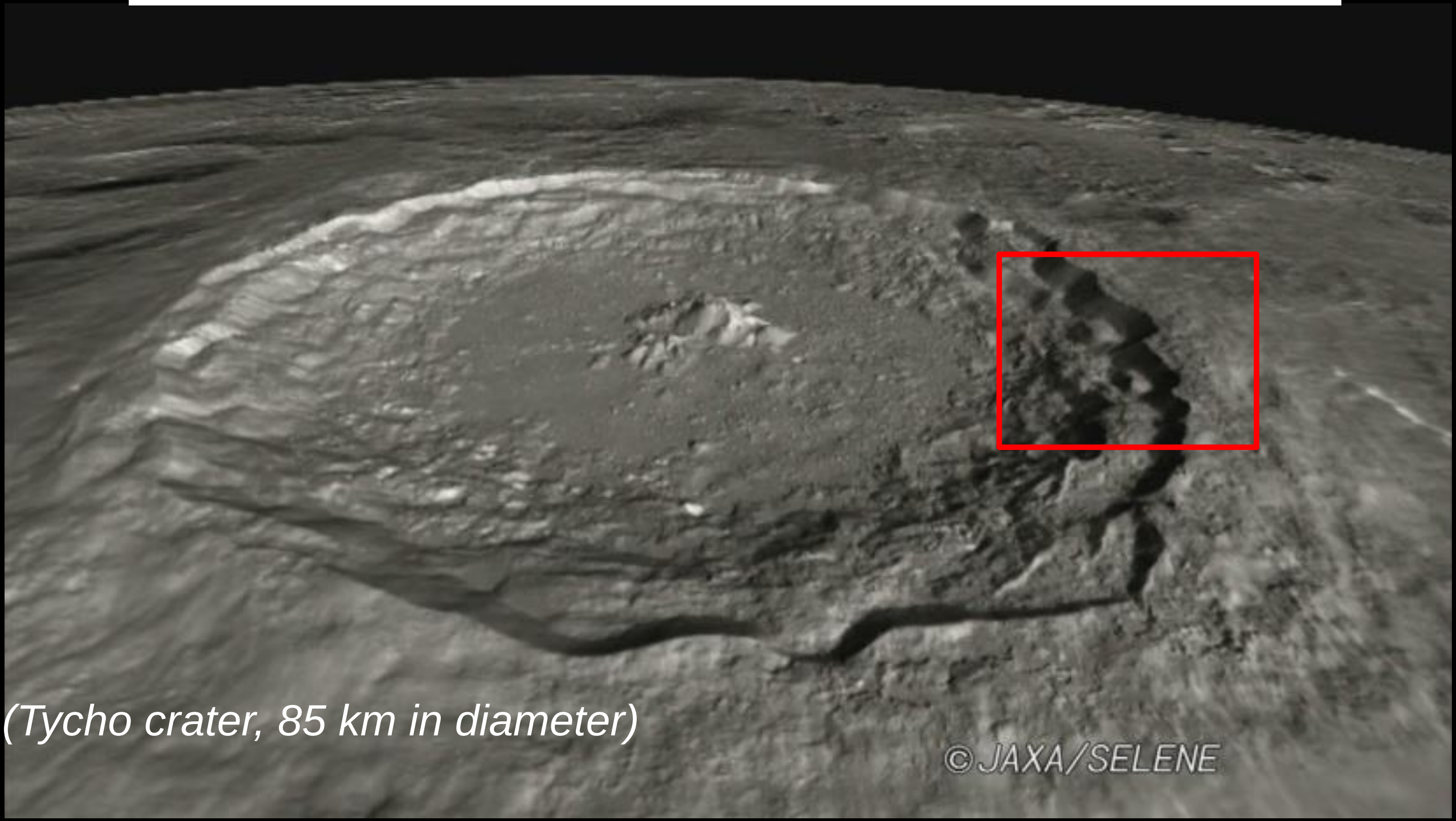
- No prior knowledge except that obtained from remote sensing
- Travel by rover or walk in simulated space suit
- Traverse restrictions on time, distance, speed; emulate a real lunar traverse

Analog Traverse Equipment & Rules

HumVee with
Suit Port

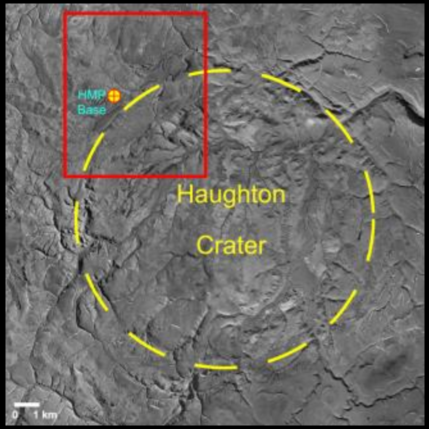
NASA Space Exploration
Vehicle

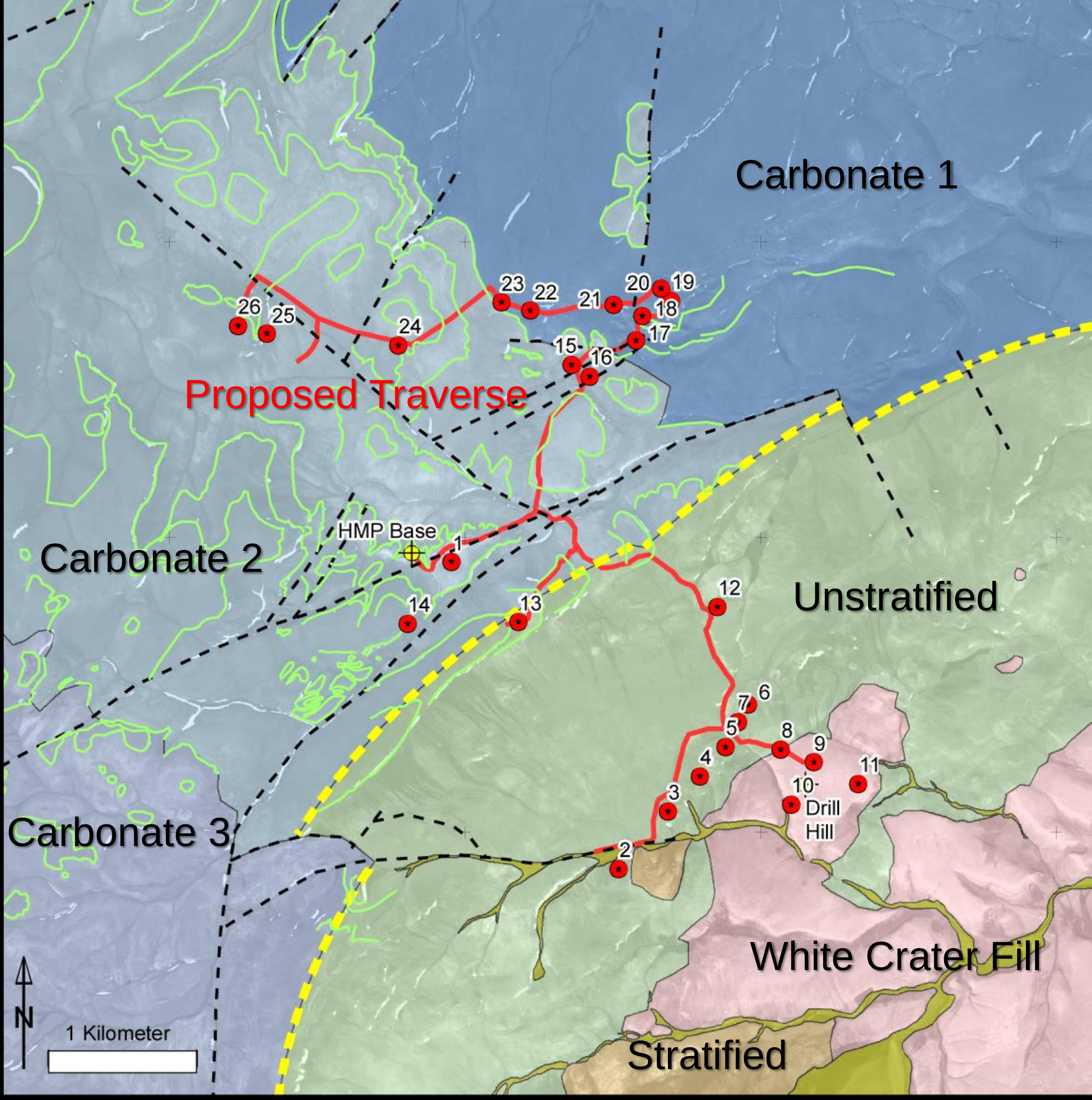




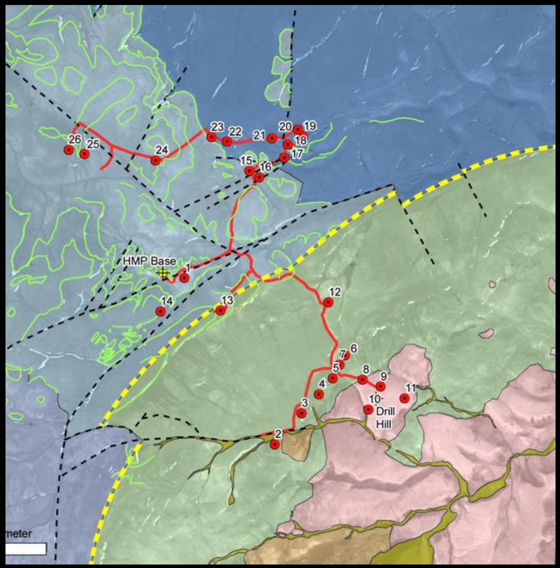
(Tycho crater, 85 km in diameter)

Geologic Map from Remote Sensing with Traverse Route/Stations





Geological Objectives

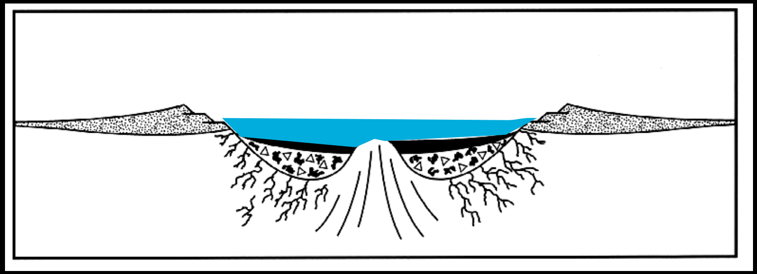


- Geologic Mapping
  - Discover and document geologic history, cratering or otherwise

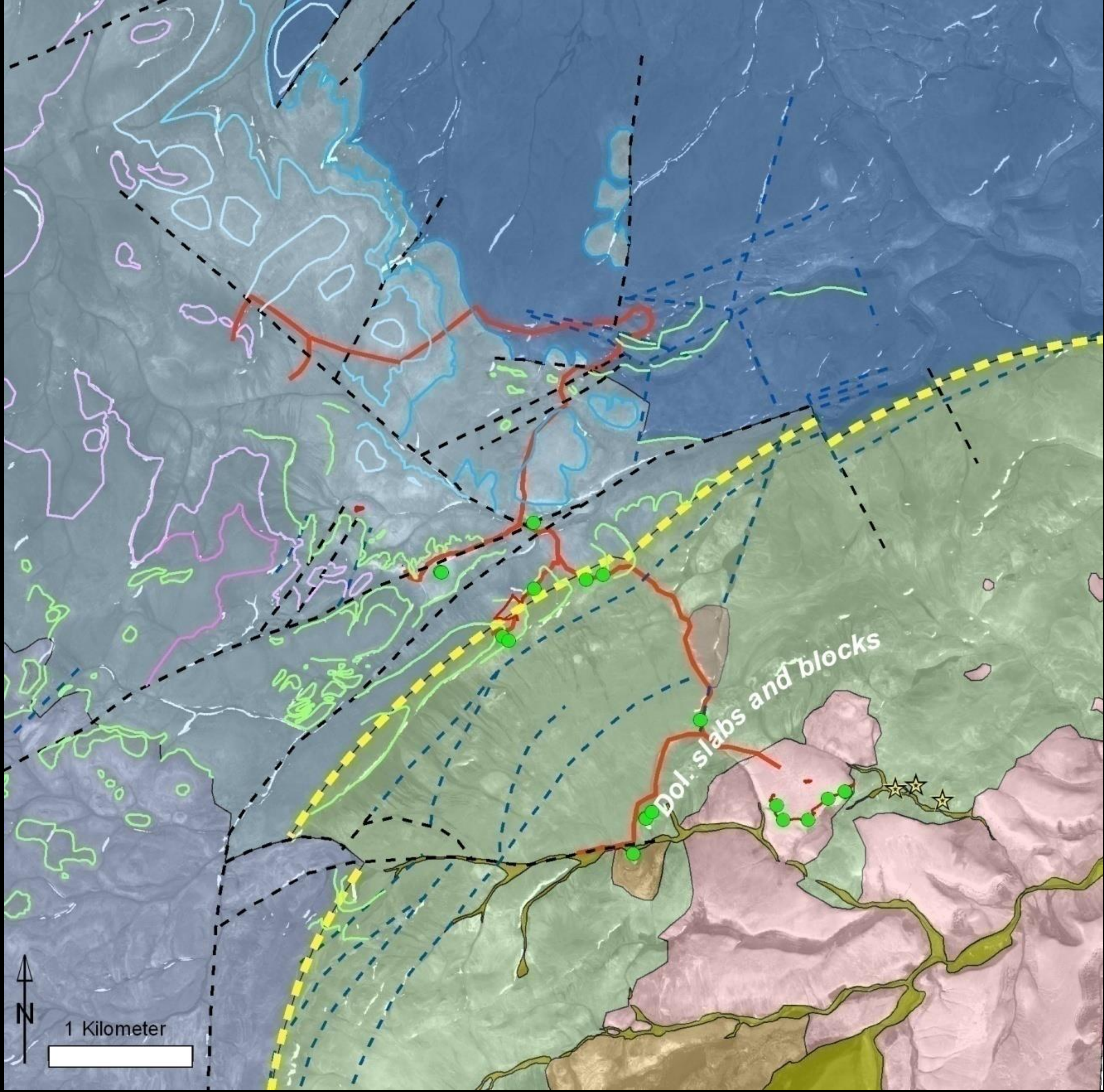
- Sampling
  - Sample all major units, with focus on impact rocks

Traverses and EVAs

Photo Pans and Samples



Revised Geologic Map

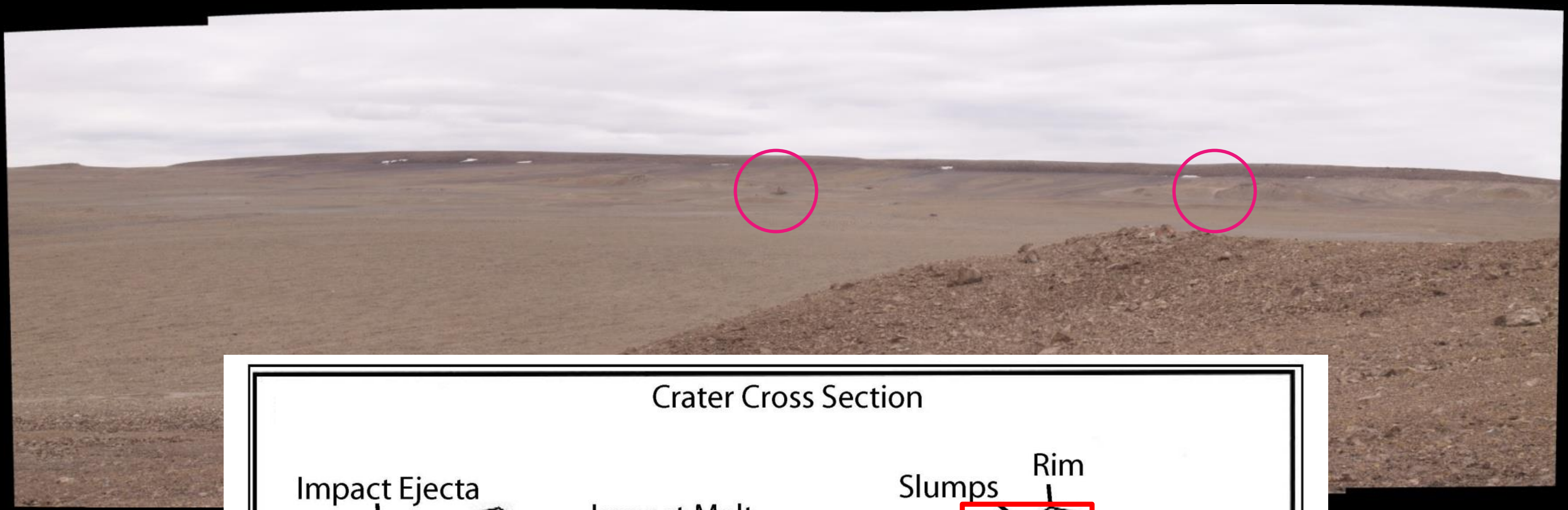


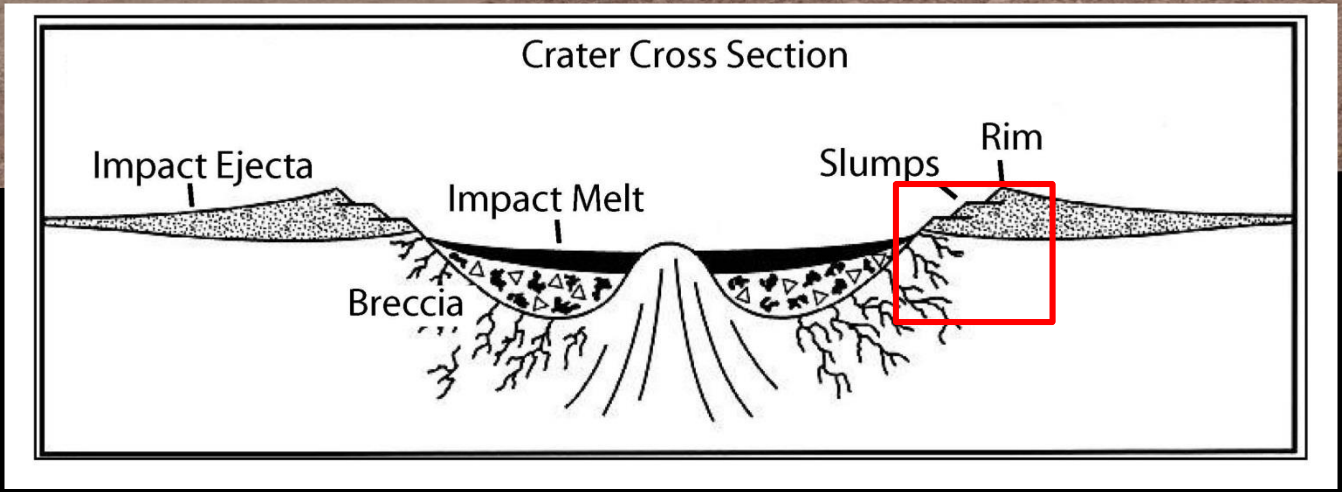
A Lot Was Left for Robotic Follow-up

Courtesy T. Fong, IRG, NASA ARC

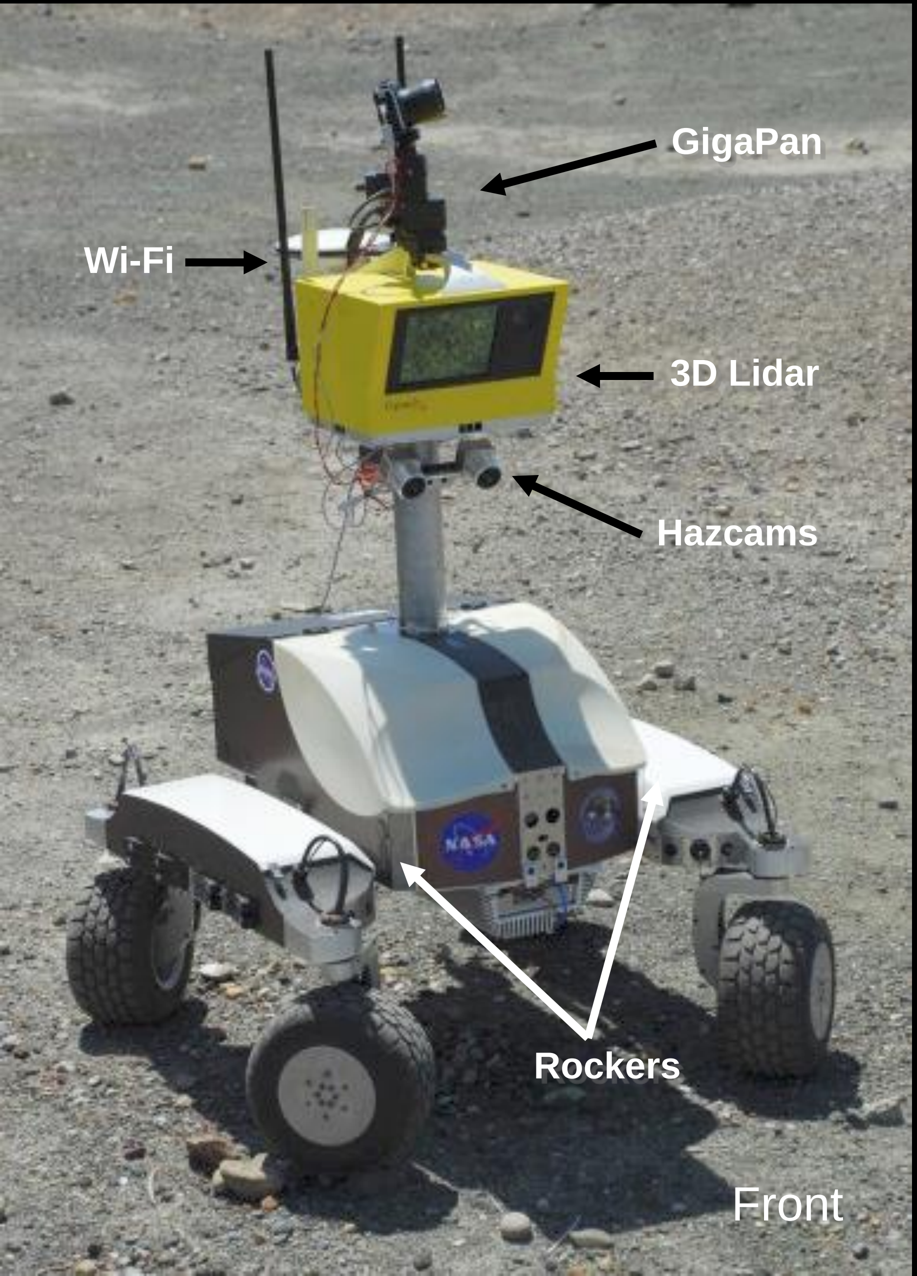
Crater Rim – what are large blocks?

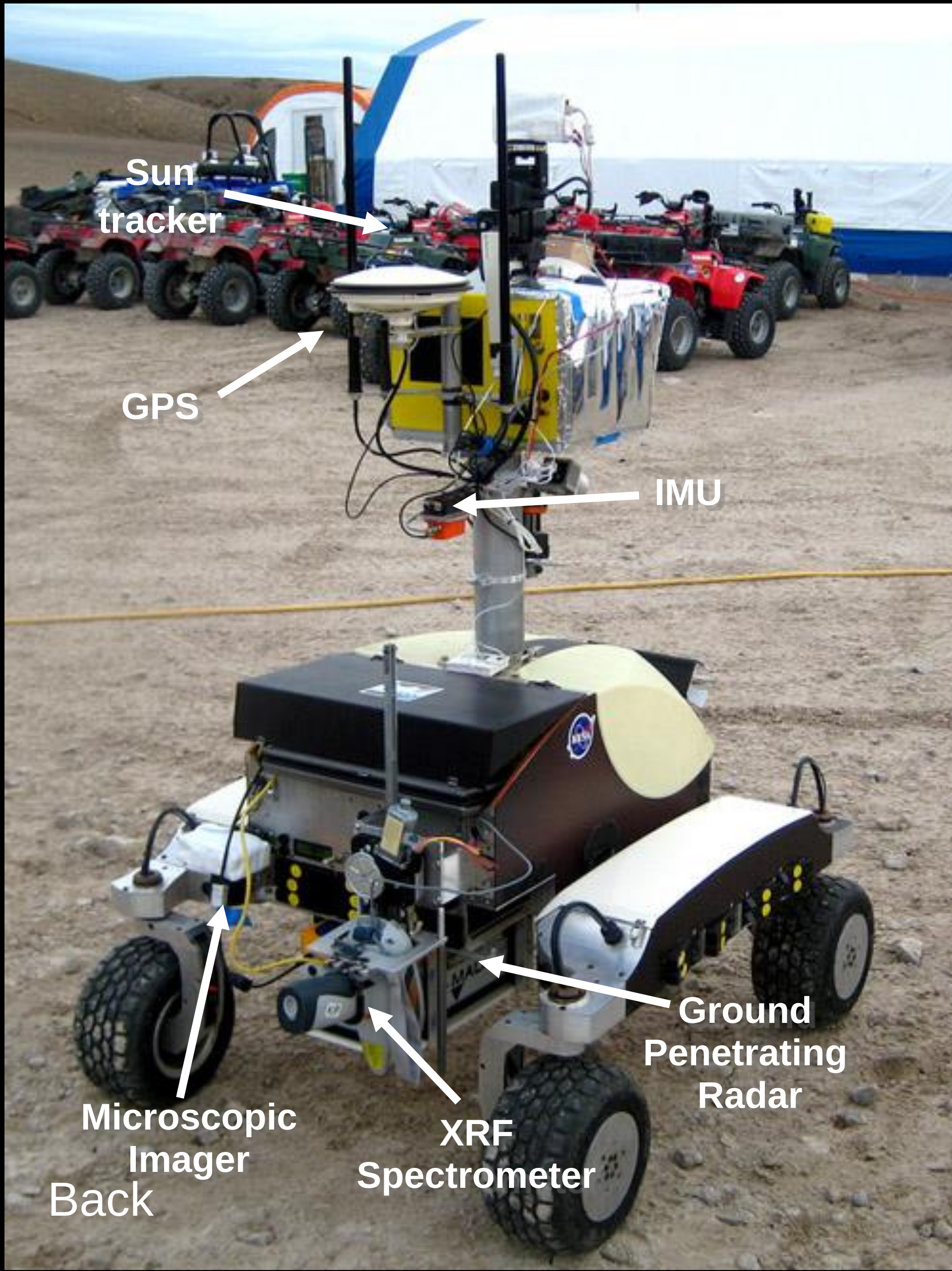
- W and SW crater wall – ejecta blocks? vs. down-faulted section? vs. megabreccia? vs. younger glacial deposits





K10 Robot

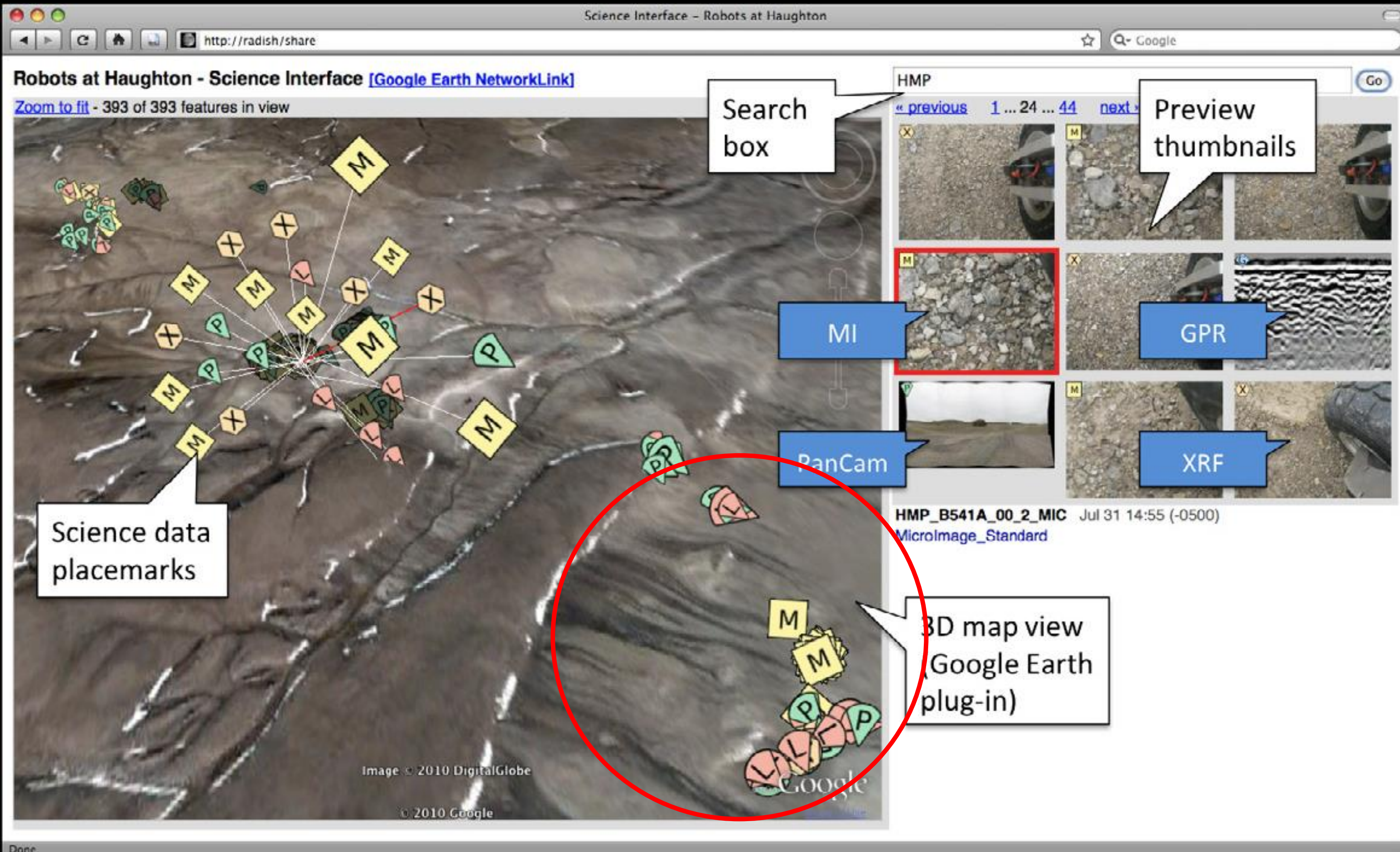

GigaPan
Wi-Fi
3D Lidar
Hazcams
Rockers
Front


Sun tracker
GPS
IMU
Ground Penetrating Radar
Microscopic Imager
XRF Spectrometer
Back

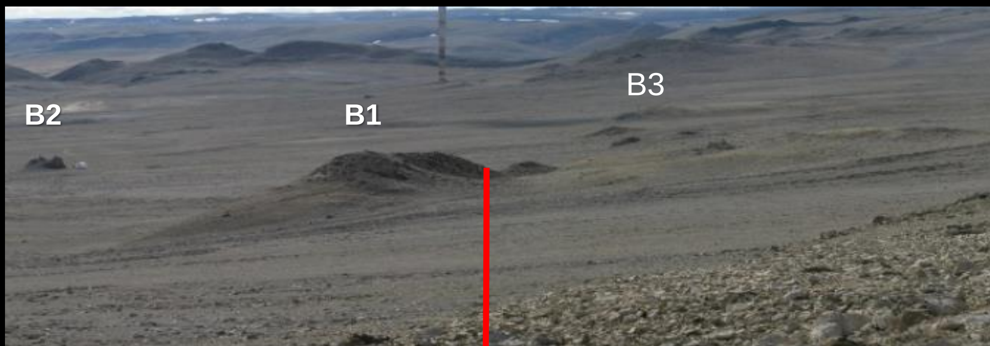
The “Science Backroom”:

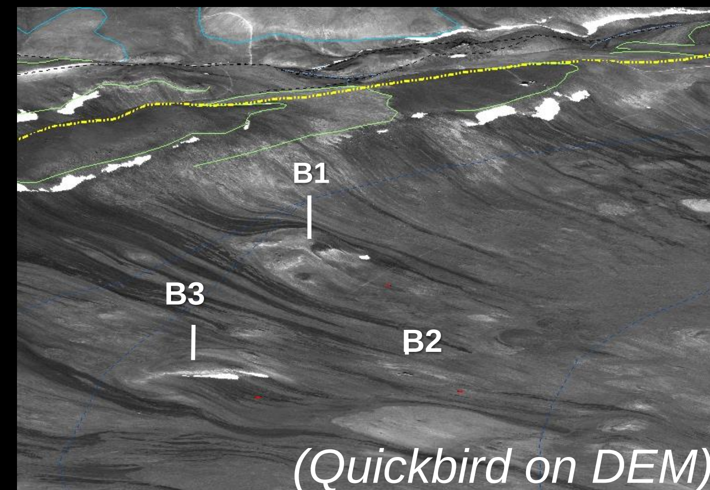
Analyzing Rover Results

Accessing Robotic Data - Web Browser



Robotic GigaPan, Crater Wall (Site B1)



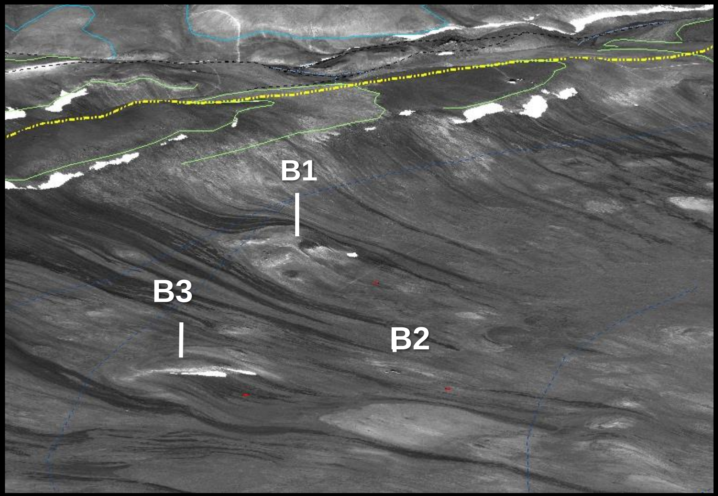


(Quickbird on DEM)


(Tycho crater, 85 km in diameter)

Down-faulted section from crater rim !

Results, Crater Wall (Site B2)



Ejecta blocks !

Conclusions

- Human exploration coupled with robotic data collection maximizes scientific return.

- The training of astronauts in field geology is as important today as it was 40 years ago.

- Geologic explorations provide an important foundation for understanding the history of our solar system.

Dr. Mark Helper

Dr. Mark Helper is a Distinguished Senior Lecturer in the Department of Geological Sciences at the University of Texas Jackson School of Geosciences. He teaches undergraduate courses in introductory and advanced Field Geology, GIS and GPS Applications in the Earth Sciences, and Gems and Gem Minerals, and lectures and leads fieldtrips for other undergraduate and graduate classes. His current research explores geochemical and Isotopic similarities of Proterozoic and Archean crust in East Antarctica and the southwestern U.S. As co-chair of FEAT (Field Exploration and Analysis Team), Dr. Helper is also involved in the geological field training of astronauts and allied activities, in preparation for NASA's return to