

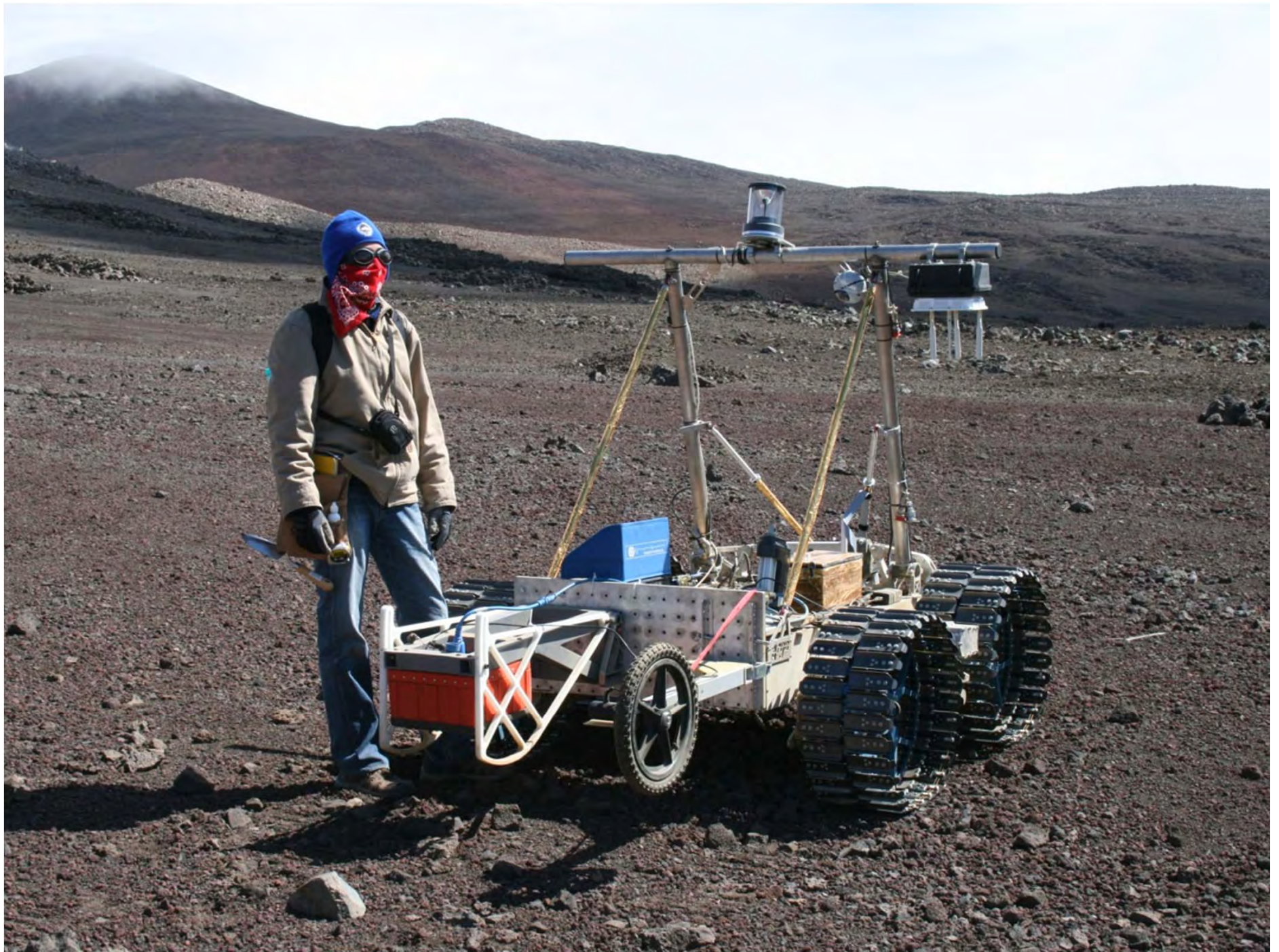
Analog Field Testing Opportunities in Hawai`i

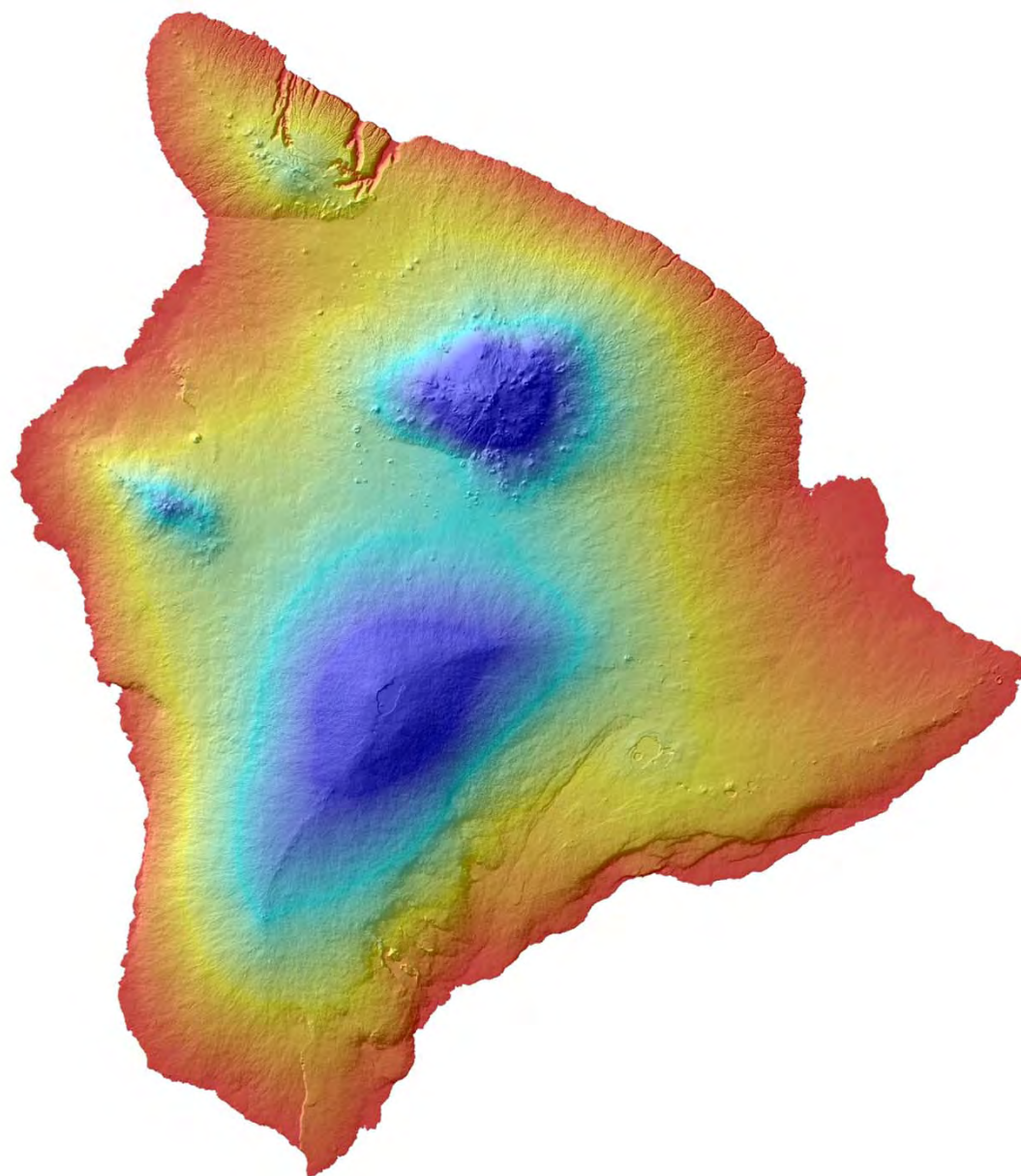
(2012 Summer test review & future prospects)

John Hamilton

Test Logistics & EPO Manager

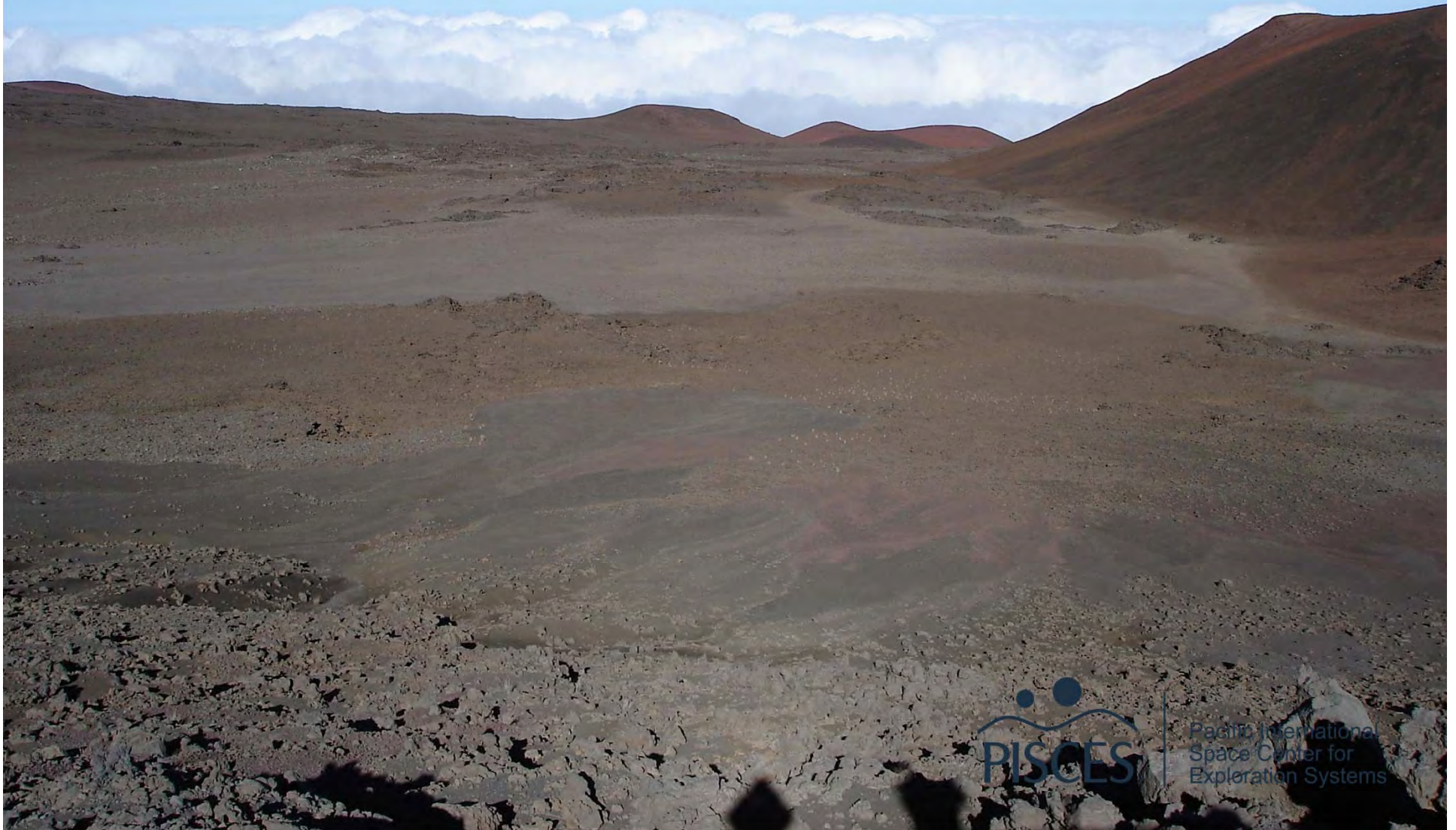




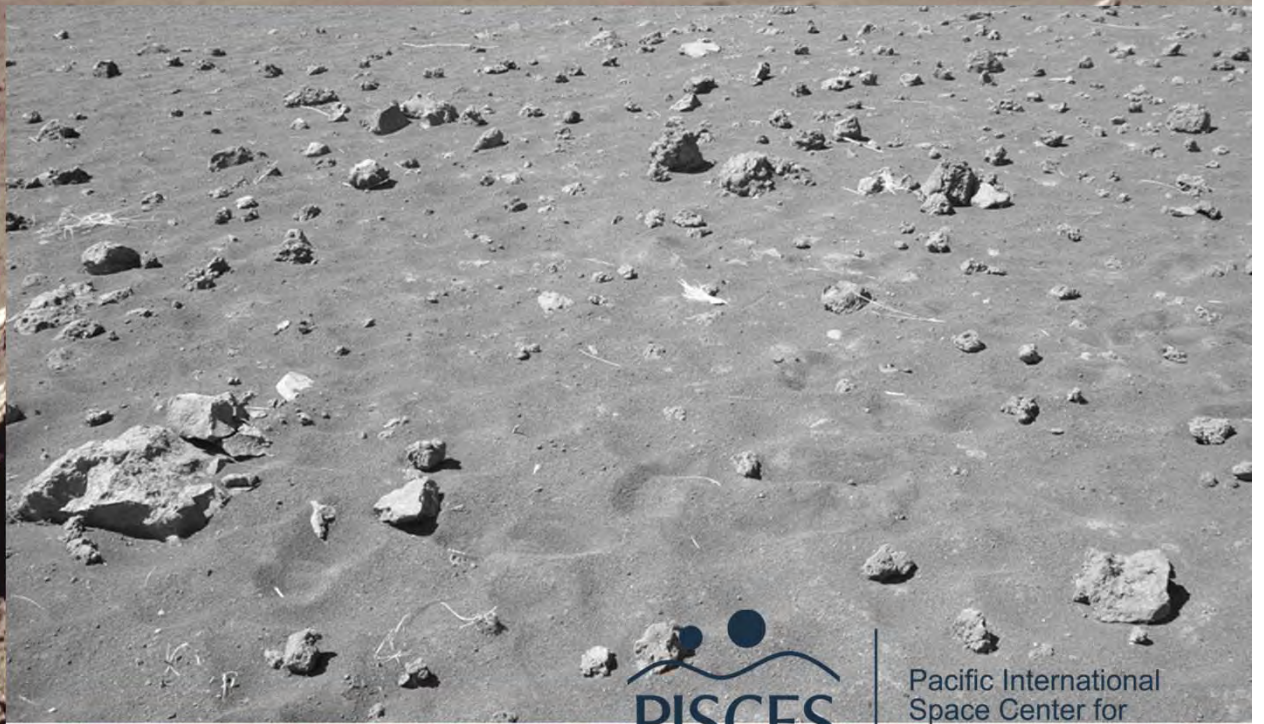




Hawai`i Island is a terrestrial analog to mars



...and the moon



Pacific International
Space Center for
Exploration Systems

PISCES Historical Timeline

- **P**acific **I**nternational **S**pace **C**enter for **E**xploration **S**ystems
 - PISCES created by Hawaii Legislature 2007
 - Established at UH-Hilo 2007-2012
 - 2008 First International Analog Field Test
 - 2010 Second International Analog Field Test
 - 2012 Third International Analog Field Test
 - 2012 Legislatively reorganized & funded as State Agency attached to Dept. of Business & Economic Development – Office of Aerospace Development

Nov 2008

First International Analog Field Test

National Aeronautics and Space
Administration
(NASA)



Canadian Space Agency
Agence Spatiale Canadienne
(ASC-CSA)



German Aerospace Center
*Deutsches Zentrum für Luft- und
Raumfahrt*
(DLR)





2010 Second International Analog Field Test Jan-Feb



National Aeronautics and
Space Administration
(NASA)



Canadian Space Agency
Agence Spatiale Canadienne
(ASC-CSA)

3rd International Hawai'i Analogue Field Test

July 2012, Hawai'i Island

Complete Simulation of RESOLVE Lunar Polar Mission
MMAMA Activities



Apollo Valley

Site 2

Site 1

Communication
to Allow Remote
Operation

Pu'u haiwahini



Observatory
Infrastructure & Housing
for Test Support



19°46'33.16" N 155°26'59.41" W elev 10874 ft

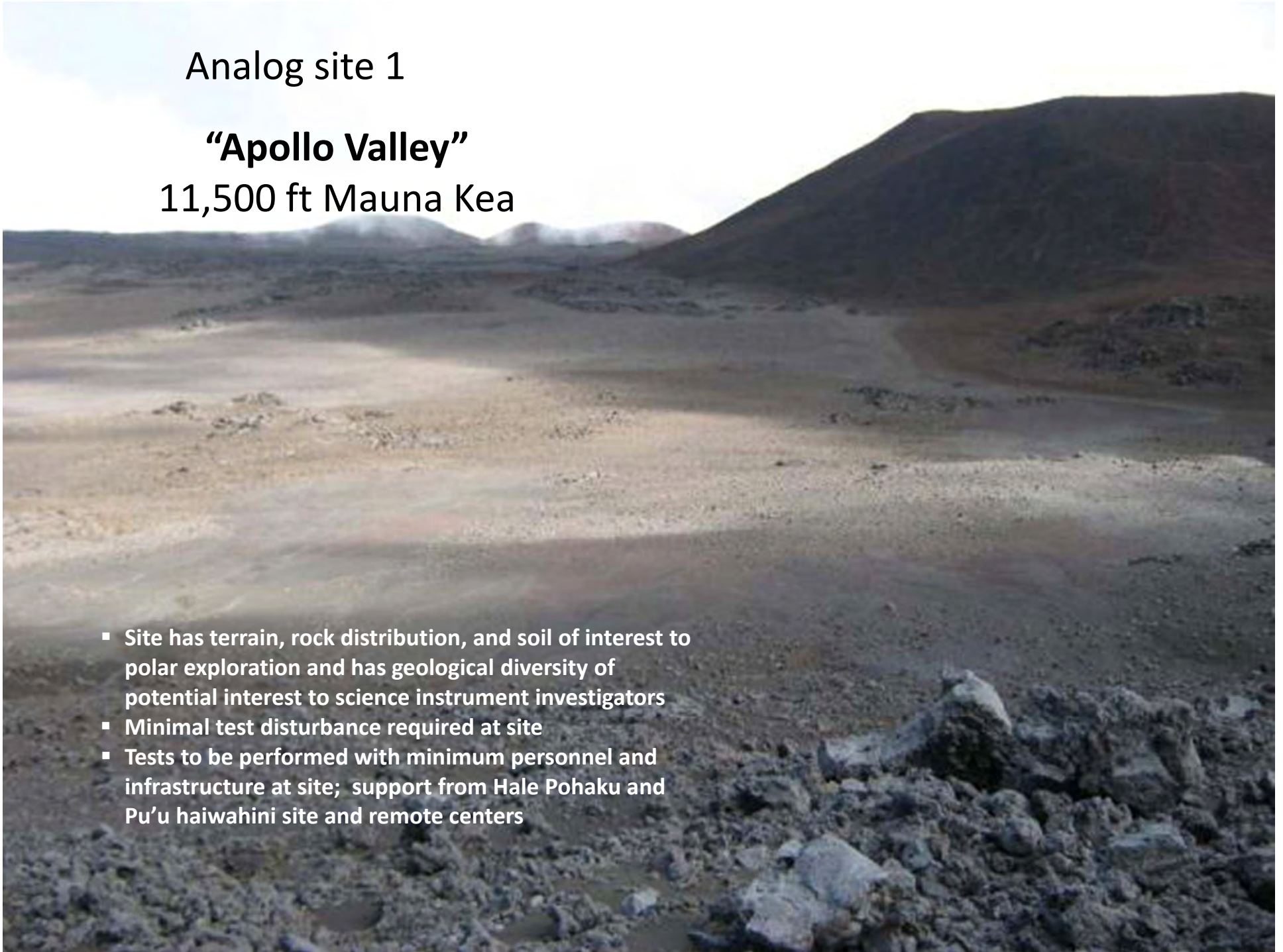
©2010 Google

Eye alt 28

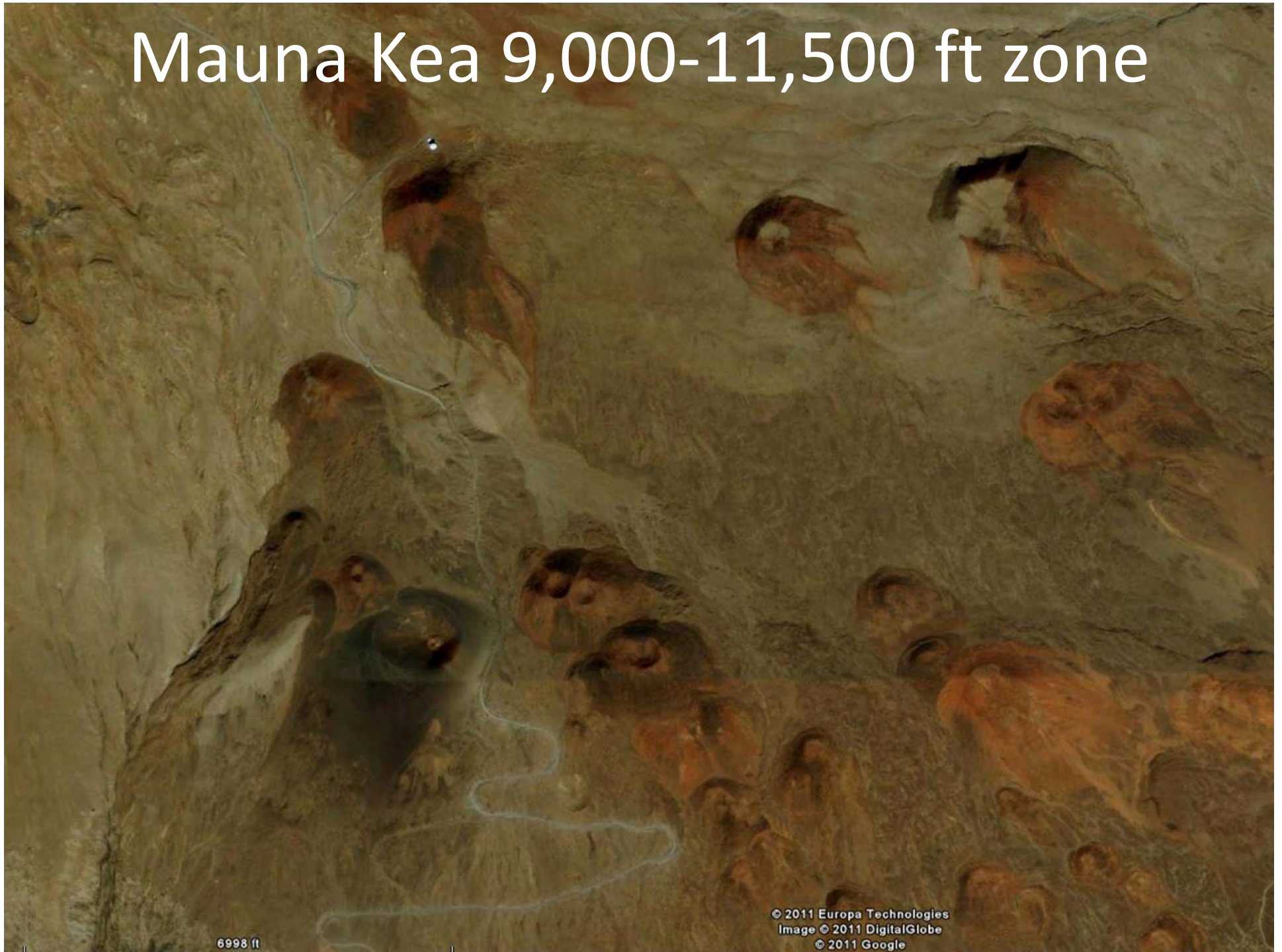
Analog site 1

“Apollo Valley”
11,500 ft Mauna Kea

- Site has terrain, rock distribution, and soil of interest to polar exploration and has geological diversity of potential interest to science instrument investigators
- Minimal test disturbance required at site
- Tests to be performed with minimum personnel and infrastructure at site; support from Hale Pohaku and Pu'u haiwahini site and remote centers

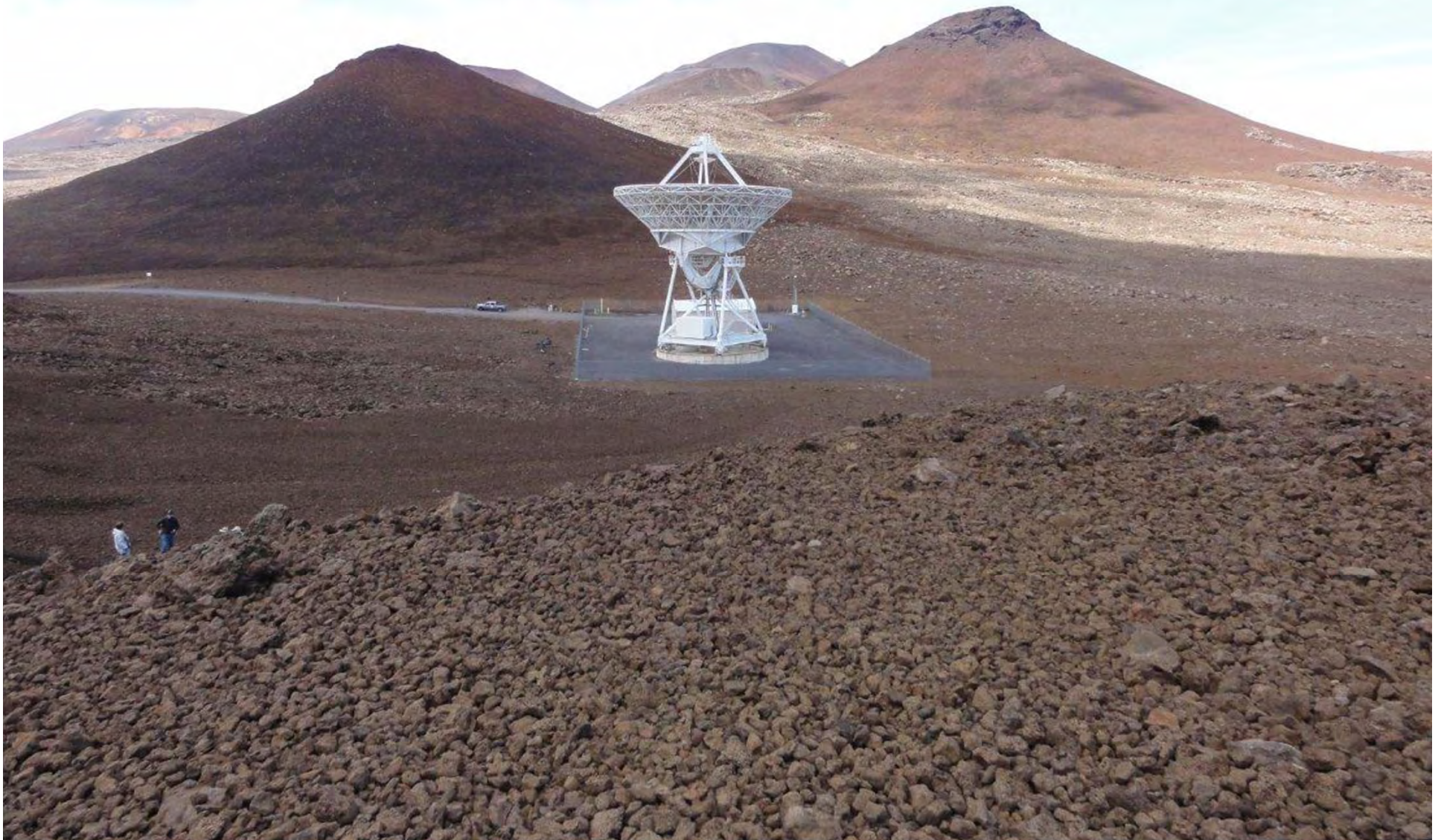


Mauna Kea 9,000-11,500 ft zone



VLBA Antenna

(North View)



Apollo Valley

Possible
Rover
Path

Rover

Rove start point

100 m

Image © 2011 DigitalGlobe

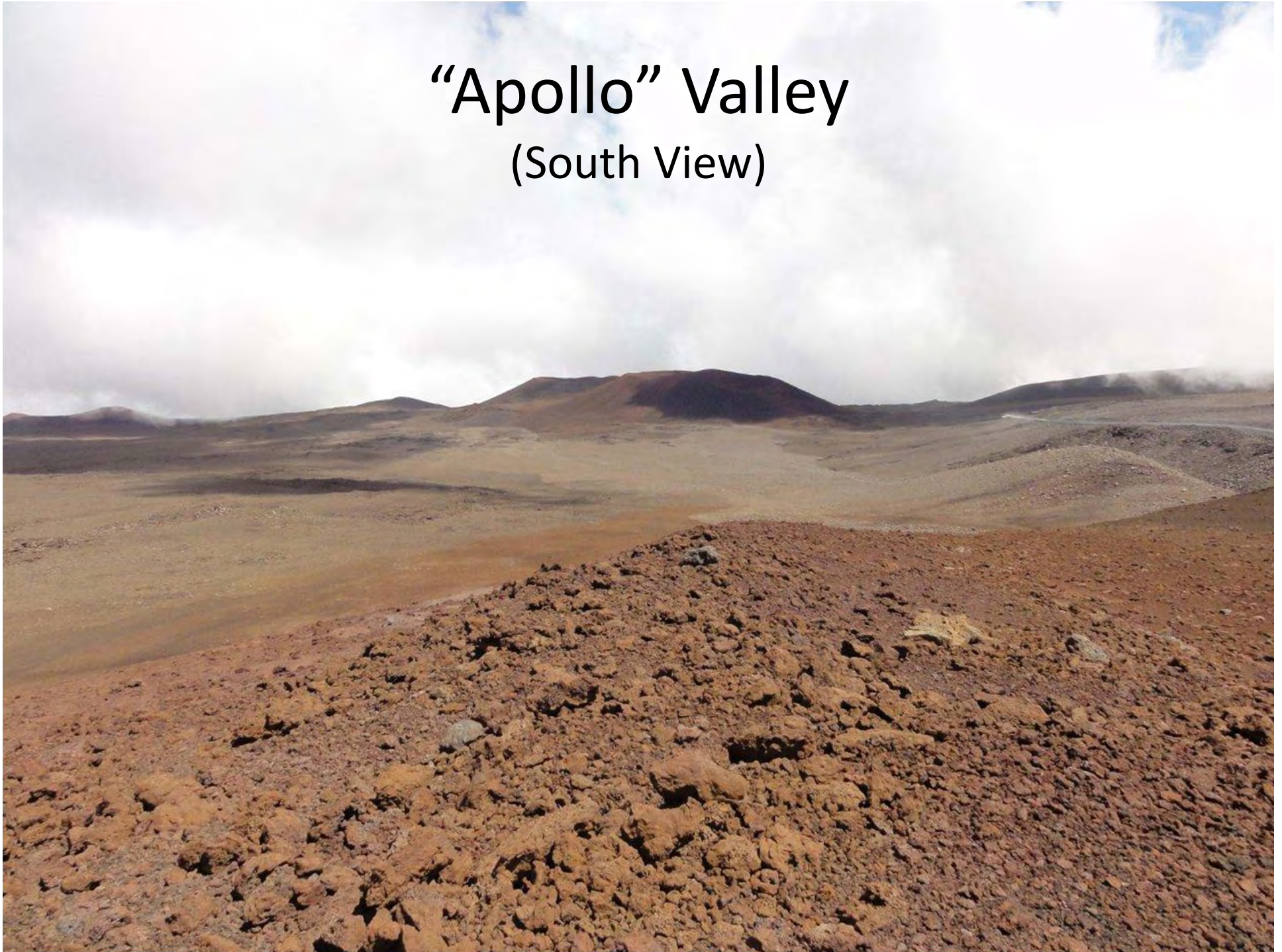
©2010 Google

19°47'07.47" N 155°27'11.40" W elev 11431 ft

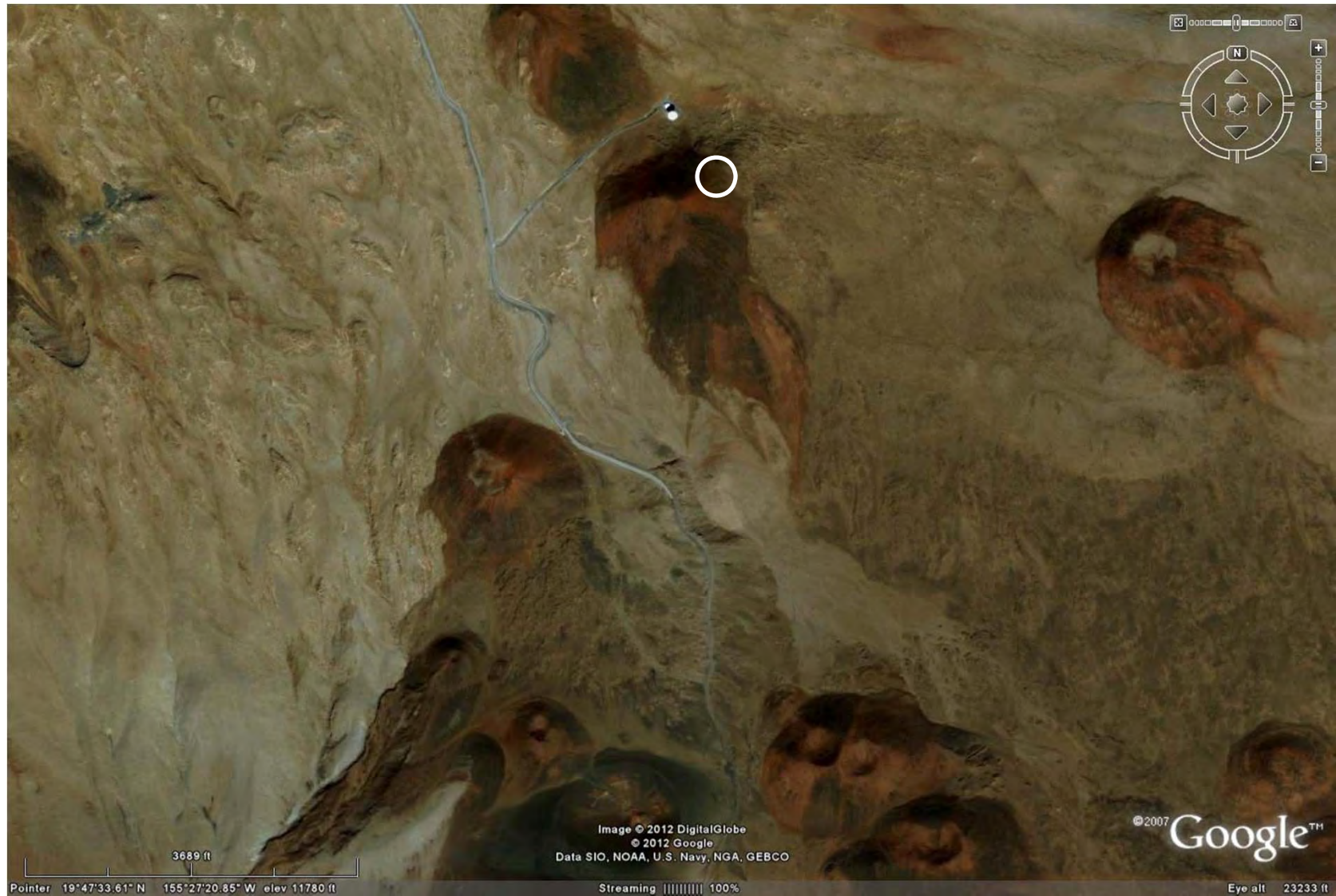
Eye alt 12638 ft

“Apollo” Valley

(South View)

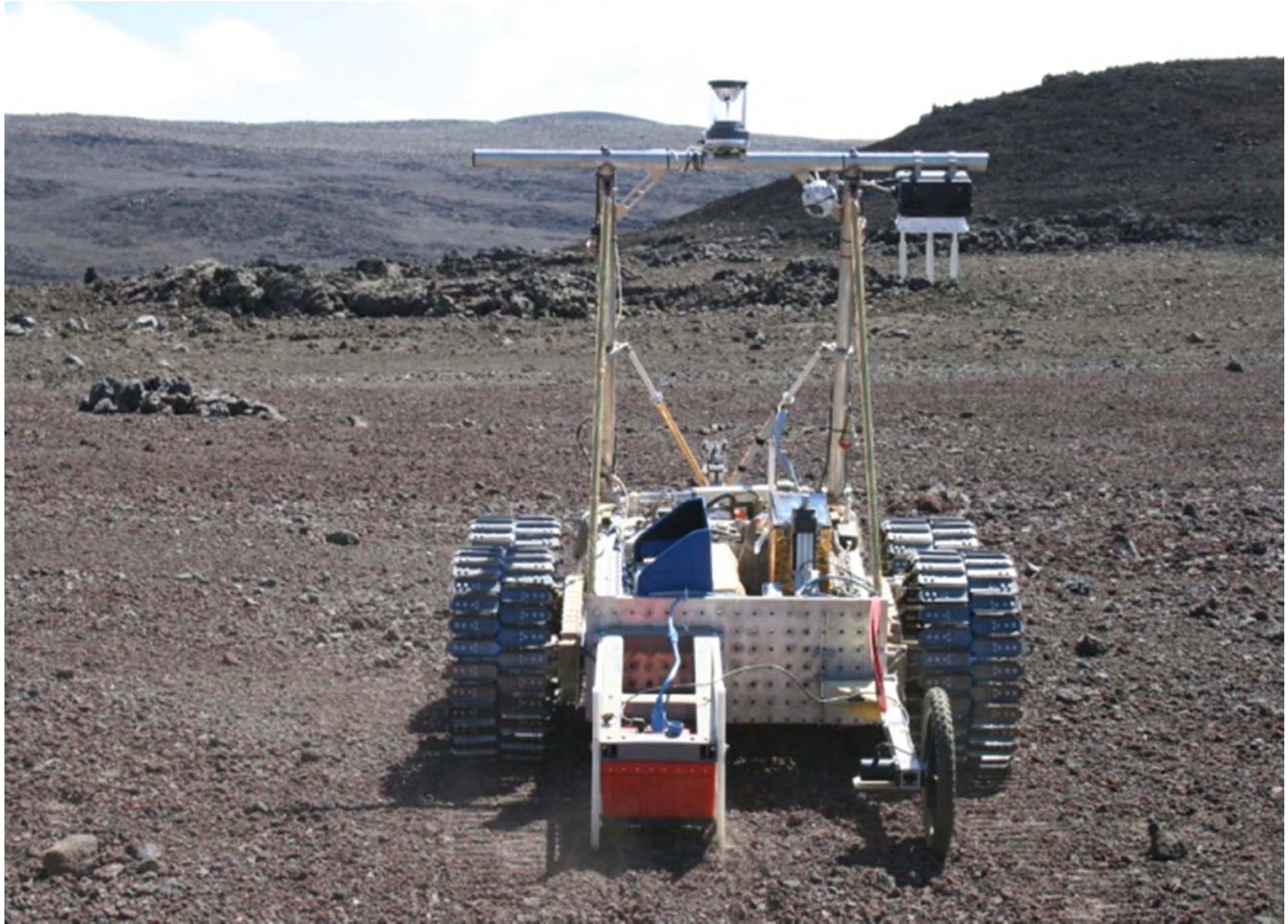


WiFi Antenna Location





WiFi Antenna



Apollo Valley VIDEO



Mission Control at Hale Pohaku

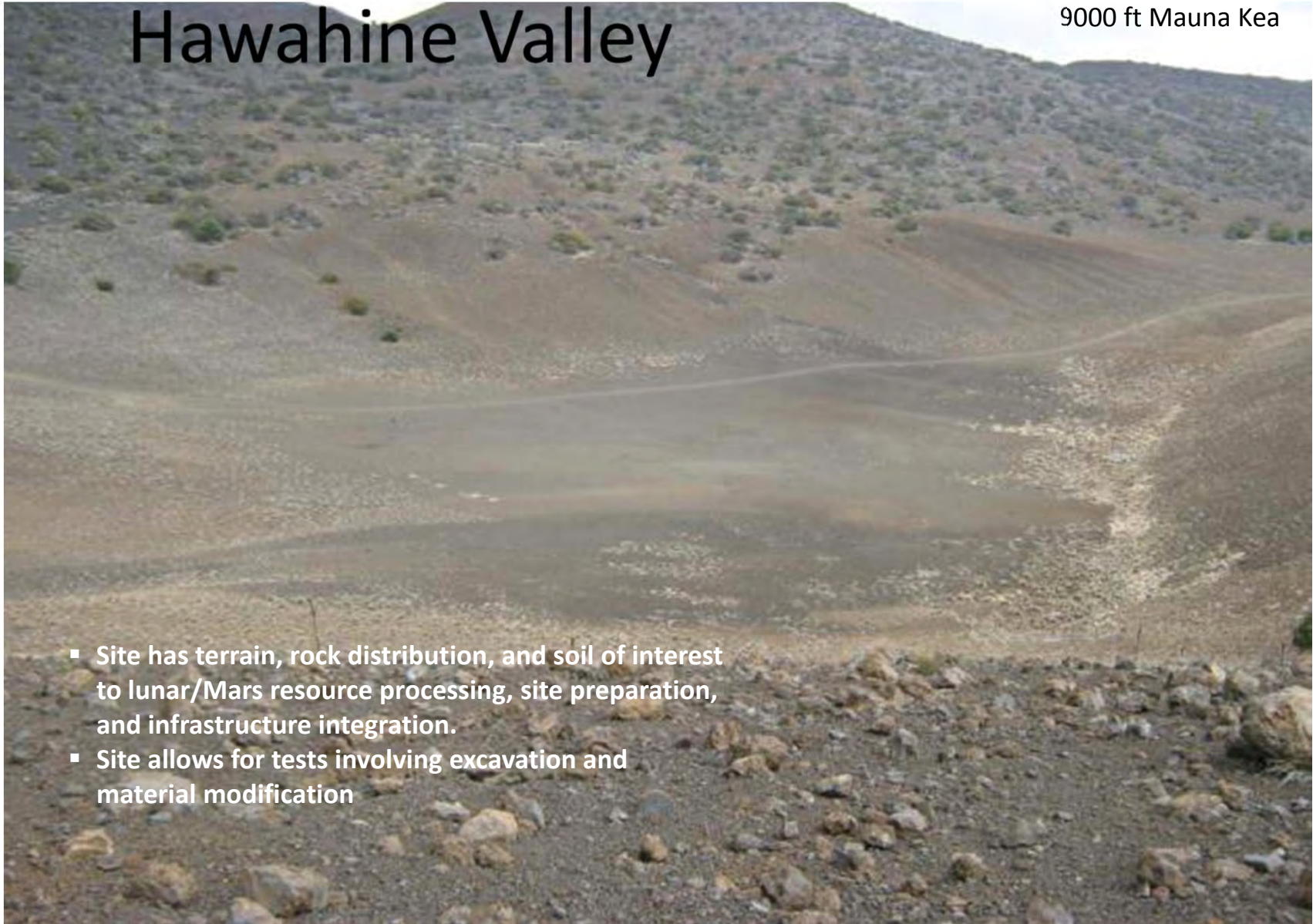


2012 Analog Site 2

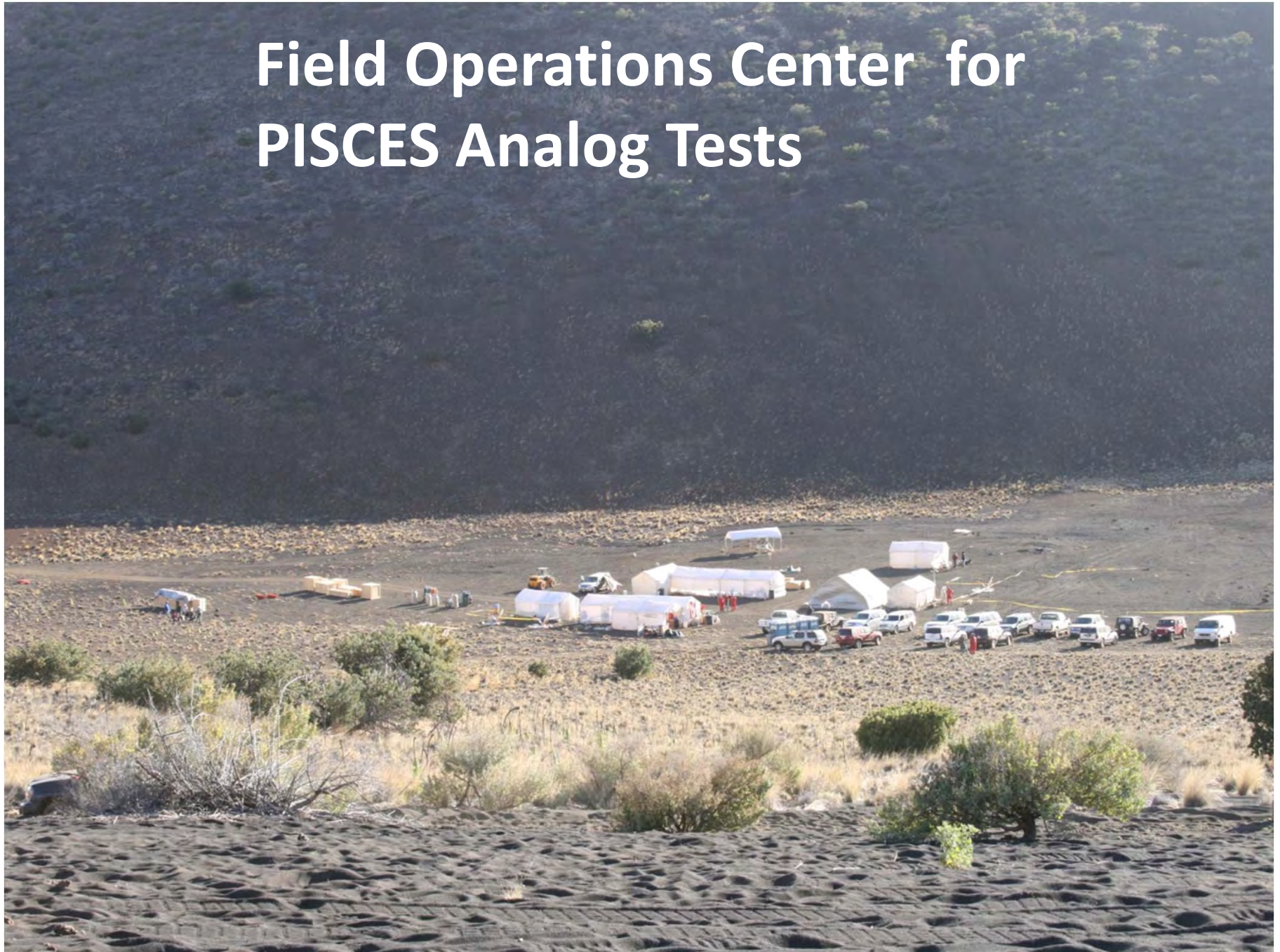
Hawahine Valley

Pu'u haiwahini
9000 ft Mauna Kea

- Site has terrain, rock distribution, and soil of interest to lunar/Mars resource processing, site preparation, and infrastructure integration.
- Site allows for tests involving excavation and material modification



Field Operations Center for PISCES Analog Tests





**Prospecting -
2008**

CMU SCARAB, NorCAT Drill,
NepTec Tridar, Michelin TWEEELS

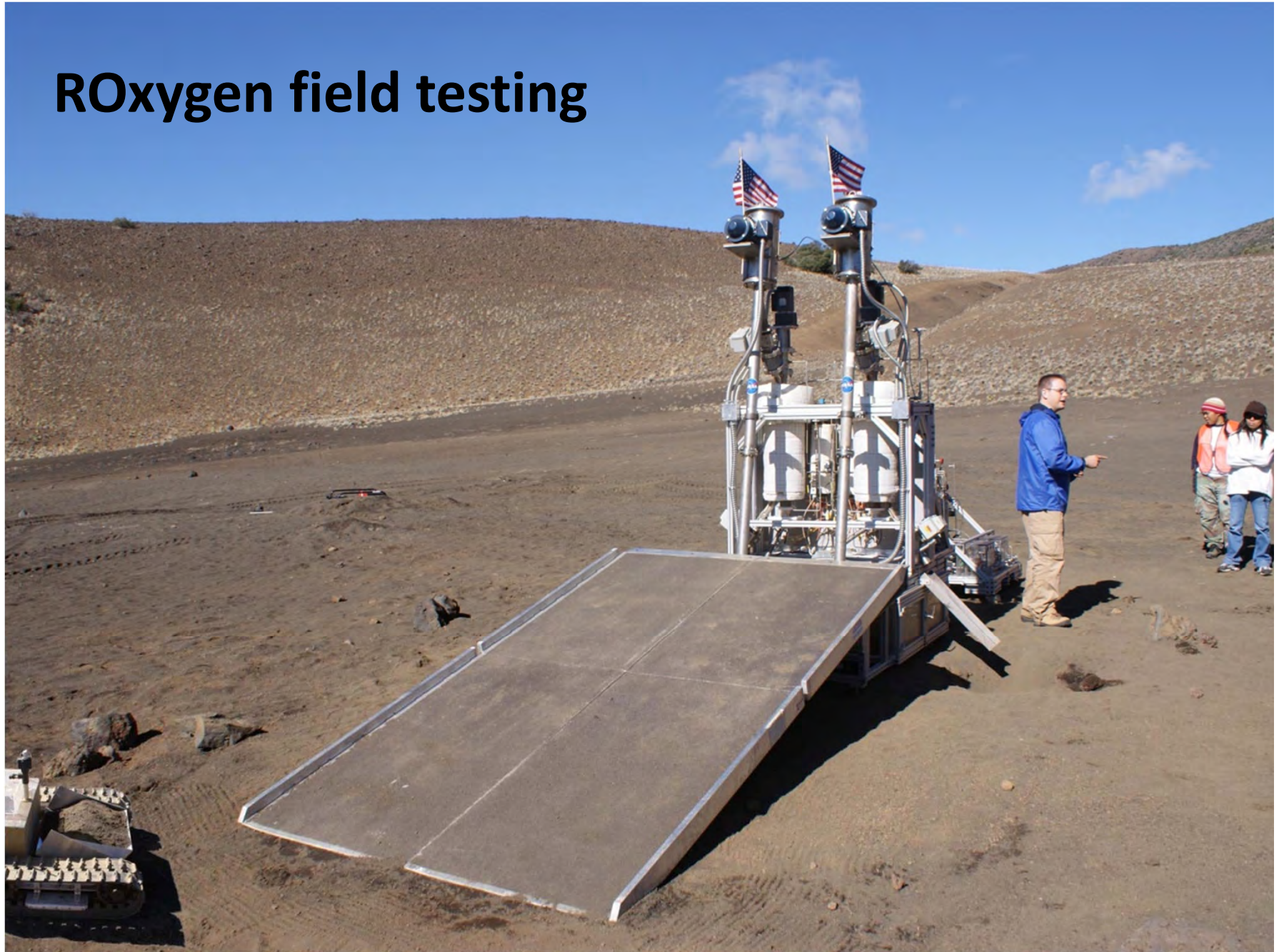
Lockheed Martin PILOT at Haiwahine Valley 2008



Reprocessed Regolith –
Note color change

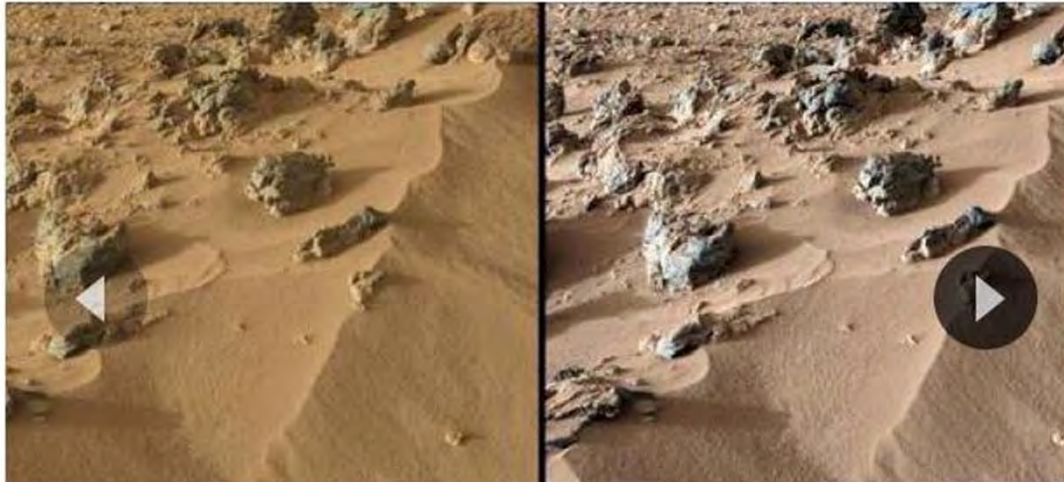


ROxygen field testing

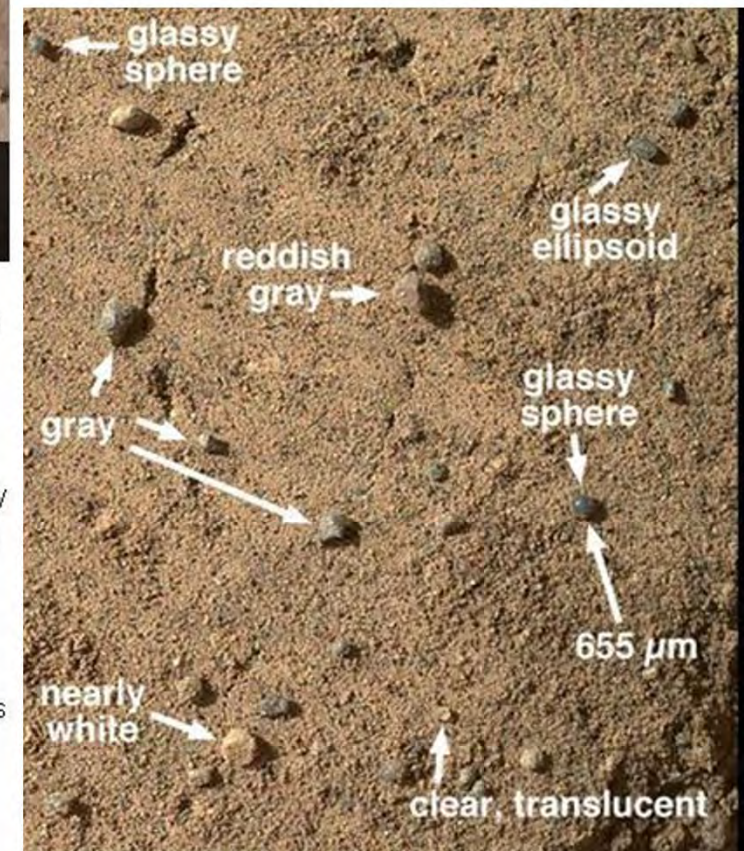


Mars dirt similar to Hawaiian volcanic soil

By Mike Wall / Published October 31, 2012 / Space.com



This pair of images from NASA's Curiosity rover shows part of a wind-blown deposit dubbed "Rocknest." At left is an unmodified shot, showing how the scene appears on Mars; the image at right has been white-balanced to show how it would look und (NASA/JPL-CALTECH/MSSS)



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Share 4

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• NASA's Huge Mars Rover

The first-ever in-depth analysis of Martian dirt reveals a mineralogical makeup similar to that of Hawaiian volcanic soils, researchers announced Tuesday.

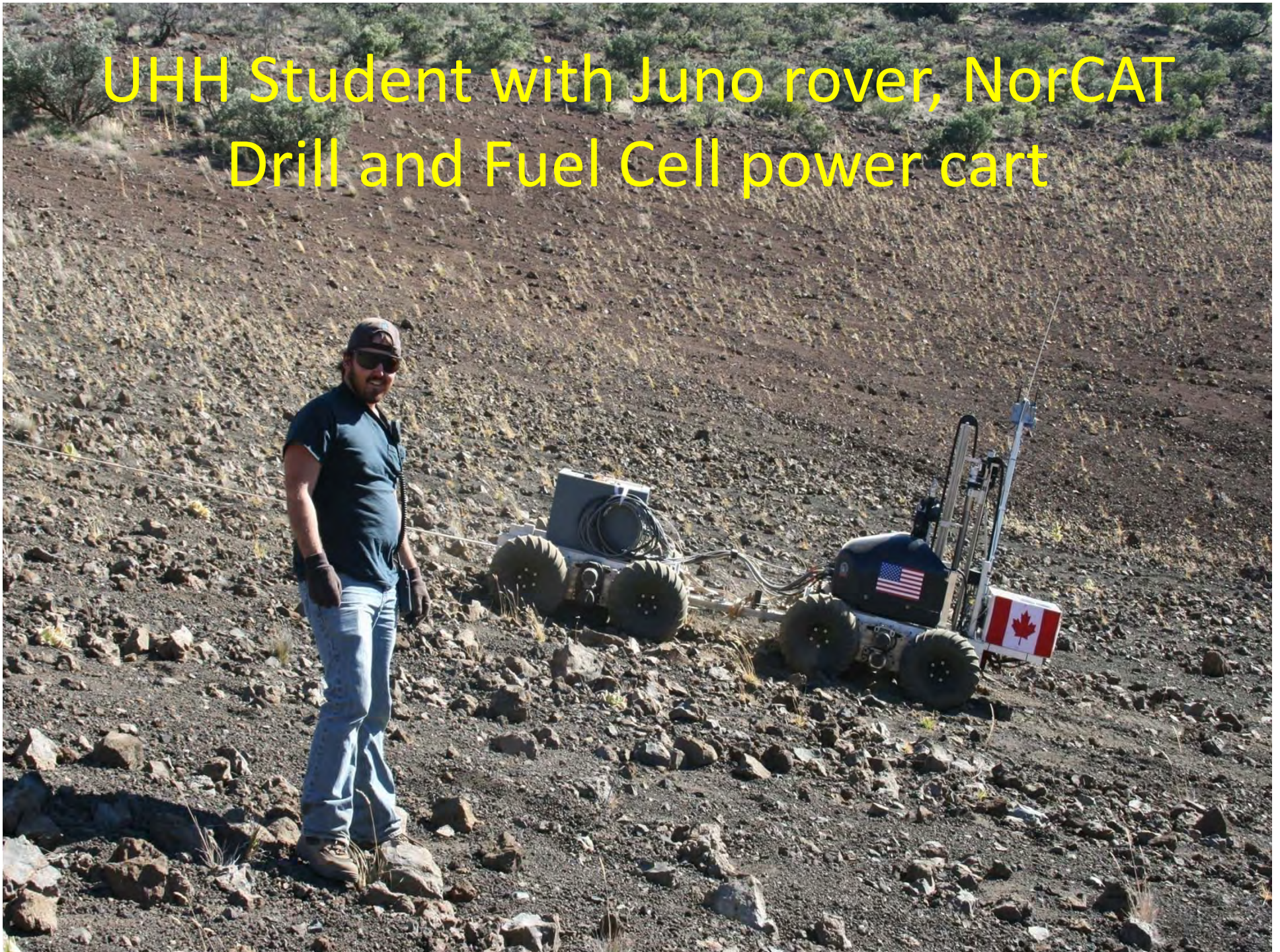
The results come from NASA's [Mars rover Curiosity](#), which recently studied a scoop of Red Planet dirt with its Chemistry and Mineralogy instrument, or CheMin, for the first time.

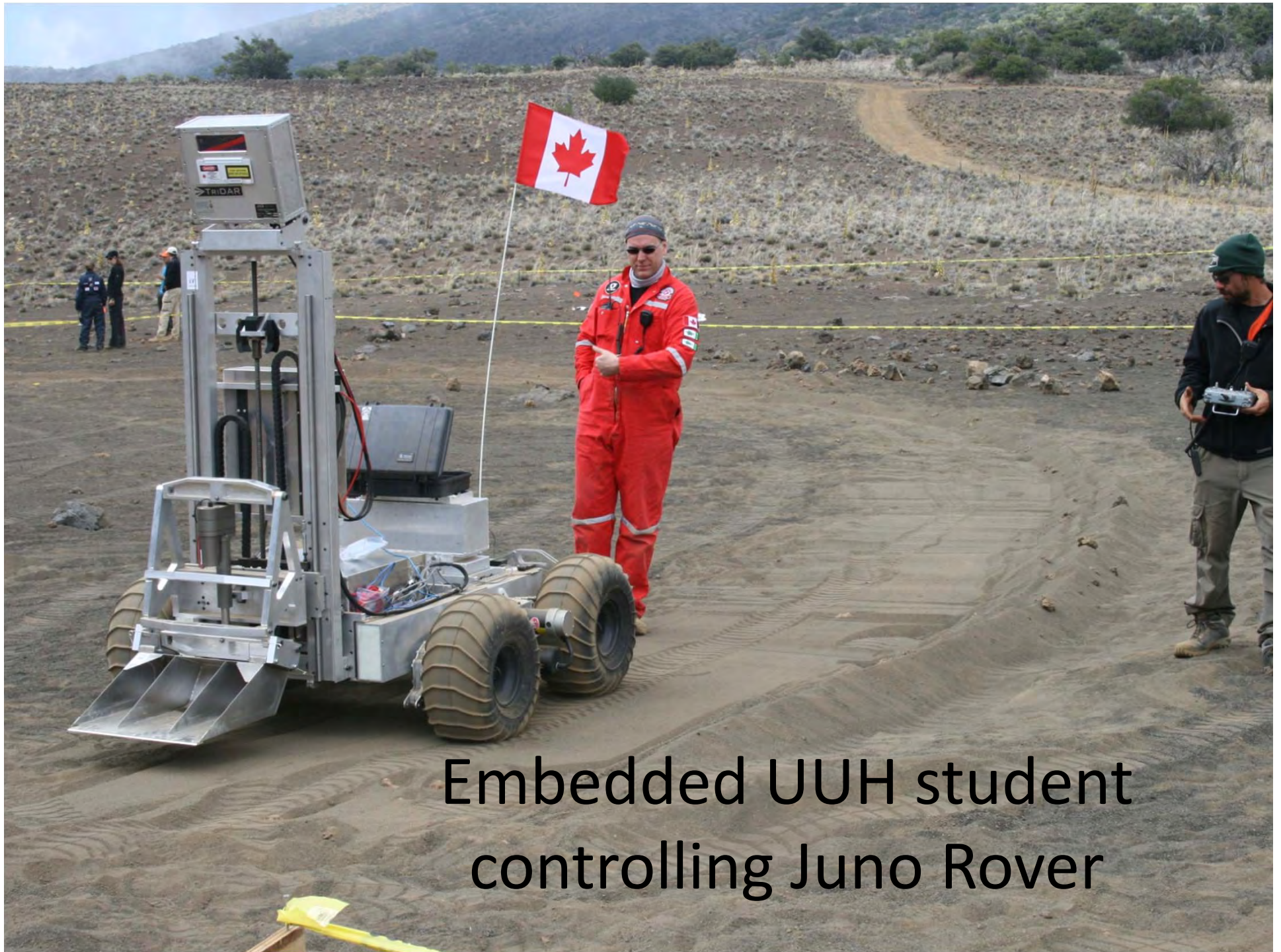
"This Martian soil that we've analyzed on [Mars](#) just this past week appears mineralogically similar to some weathered basaltic materials that we see on Earth," David Bish, a CheMin co-investigator with Indiana University, told reporters. He cited as an example the "weathered soils on the flanks of Mauna Kea in Hawaii."





UHH Student with Juno rover, NorCAT Drill and Fuel Cell power cart





Embedded UUH student
controlling Juno Rover



Juno prototype in 2010





Dust to Thrust!

**Firing of rocket engine with fuel derived
from in-situ tephra – 2010**

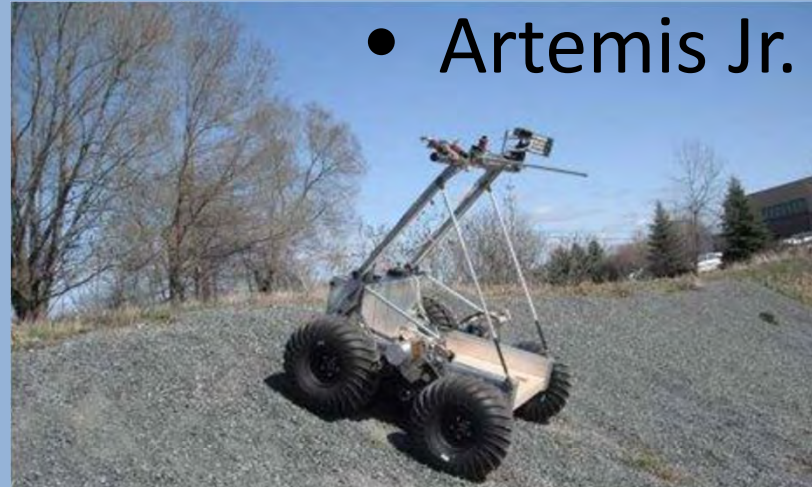
ISRU Fuel Production Verification

Developmental testing in Canada

- Juno



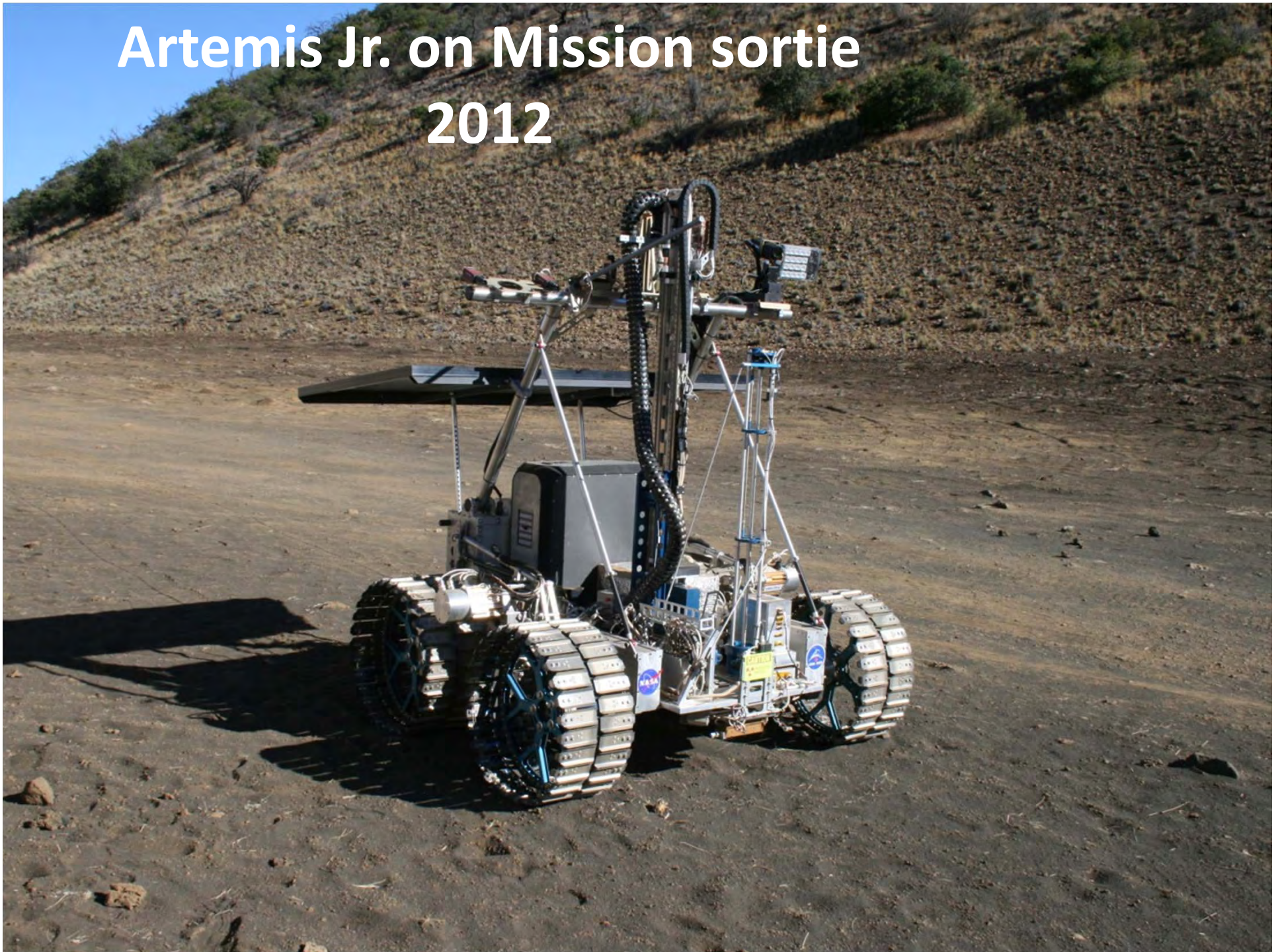
- Artemis Jr.



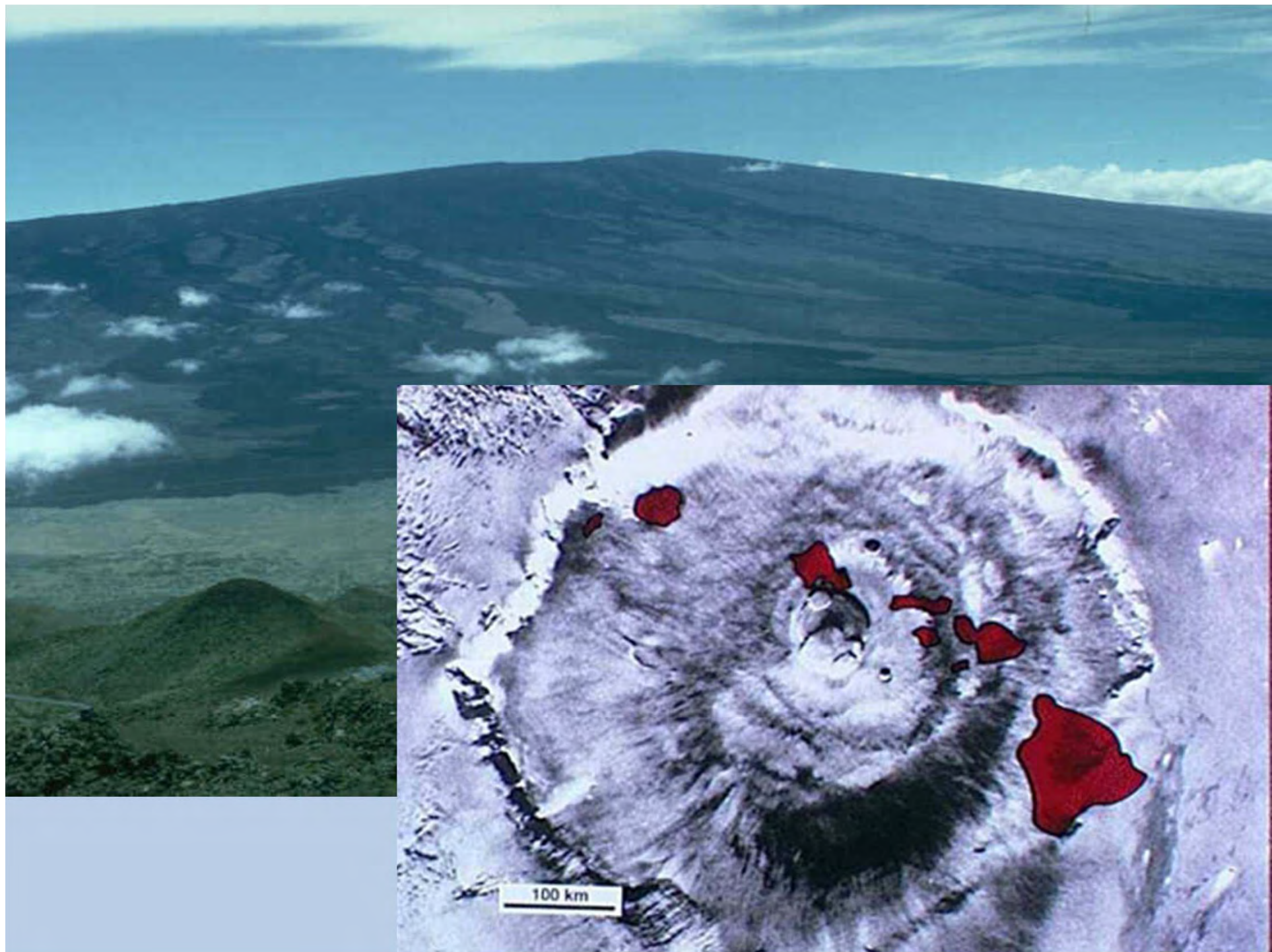
Non-pneumatic “Moon” wheels” for both Juno II and Artemis Jr. rovers



Artemis Jr. on Mission sortie 2012



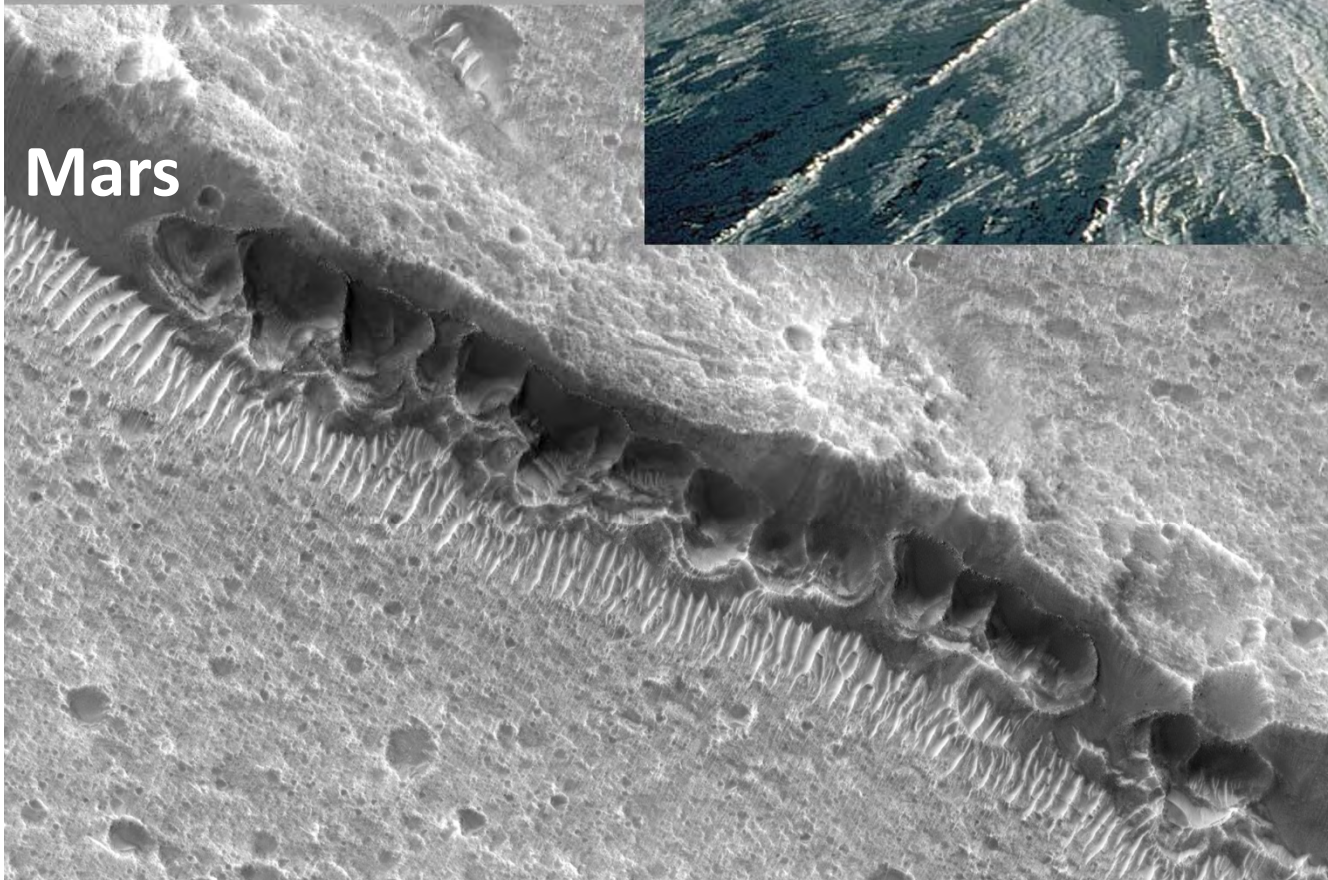
RESOLVE VIDEO



Hawai'i



Mars





Moon

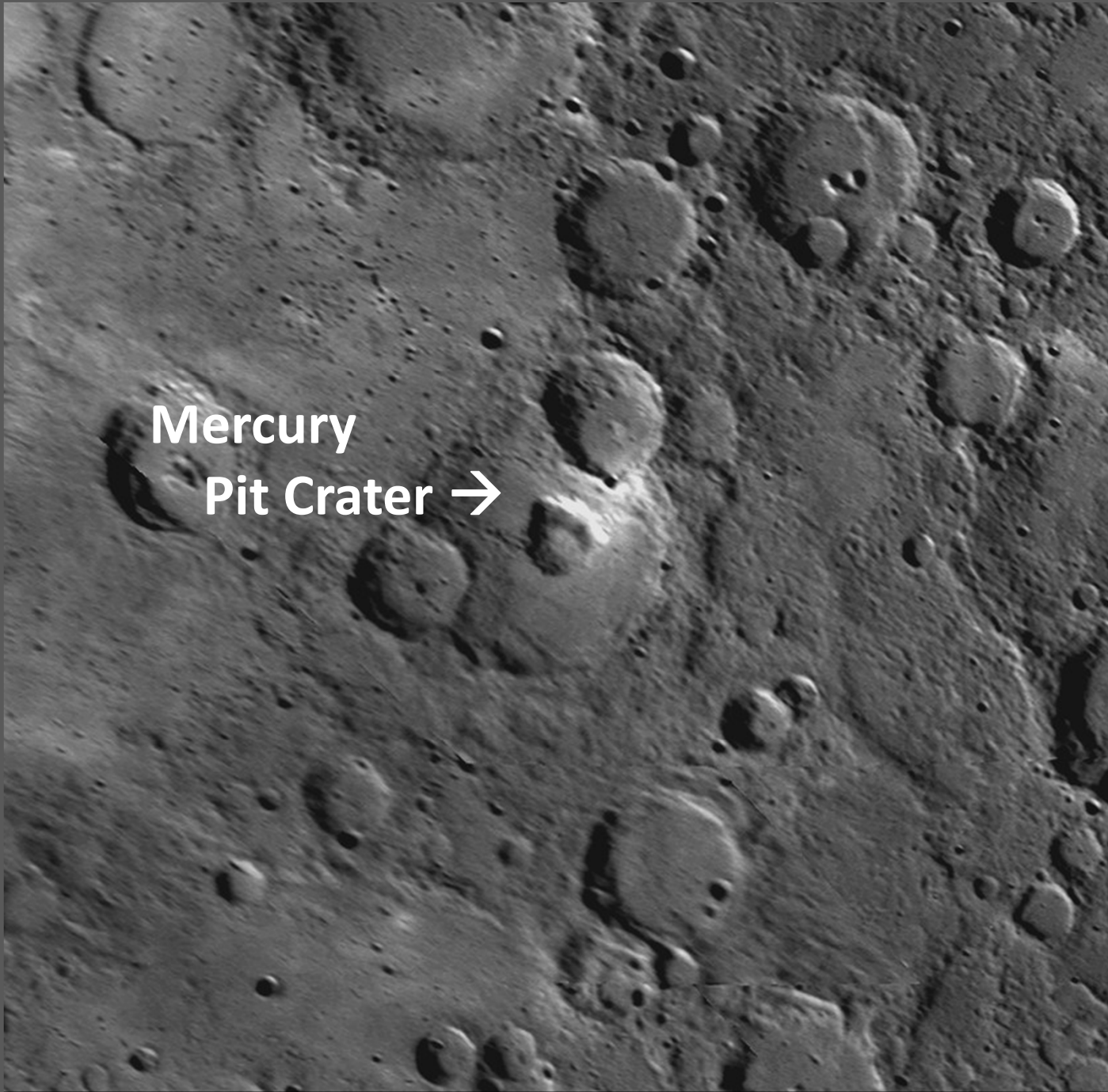


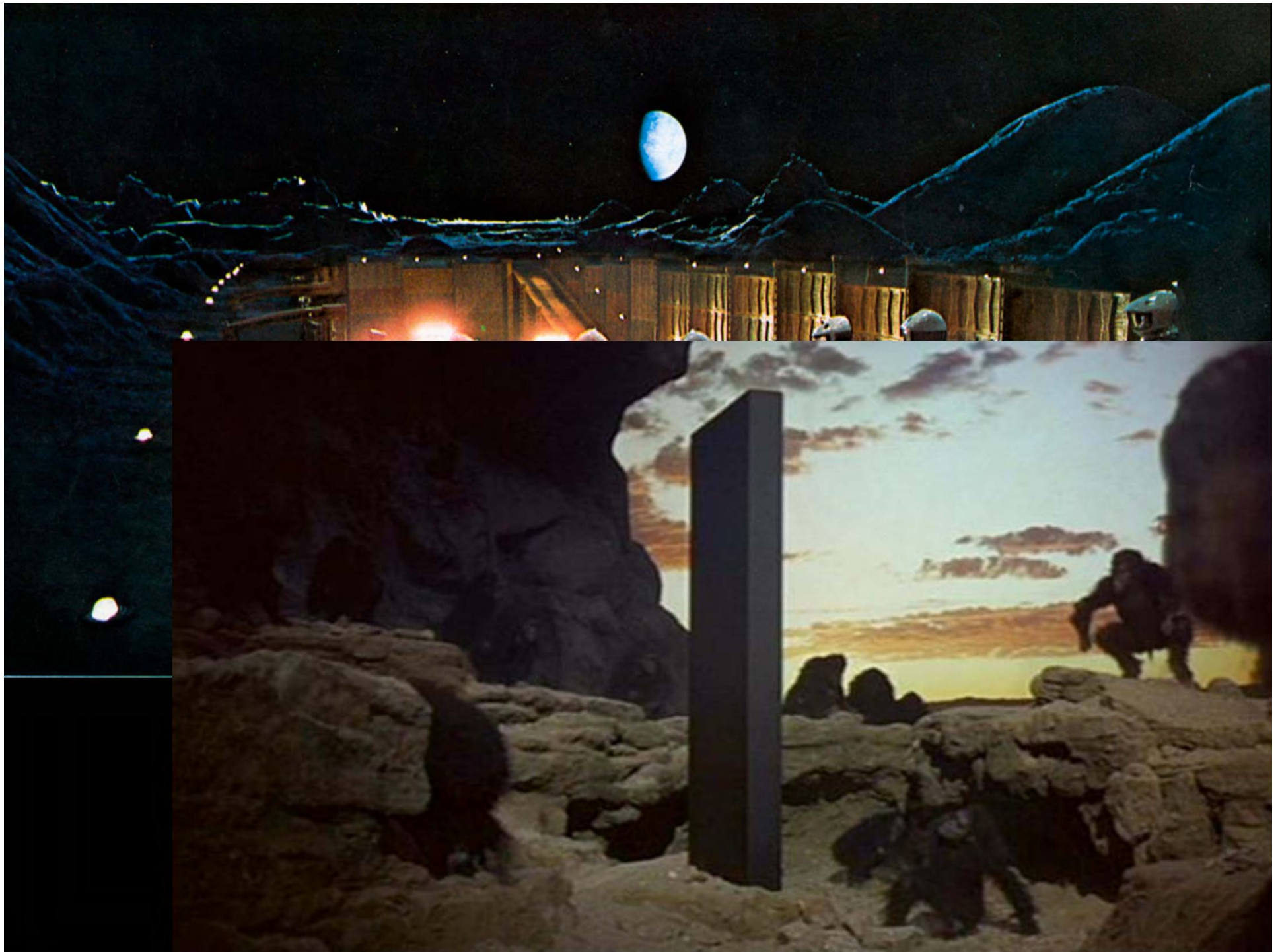
Hawai`i



Mars

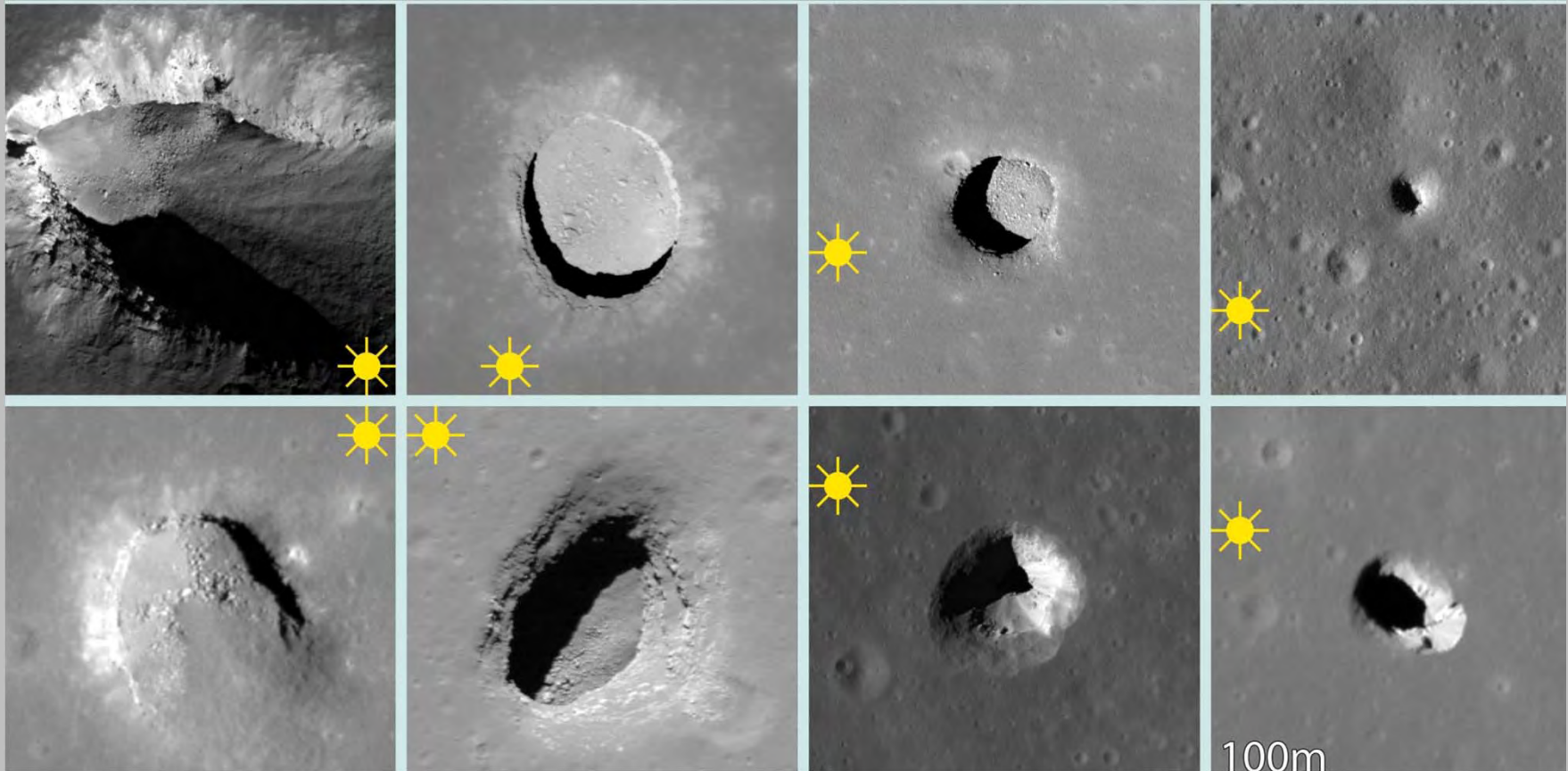
Mercury
Pit Crater →



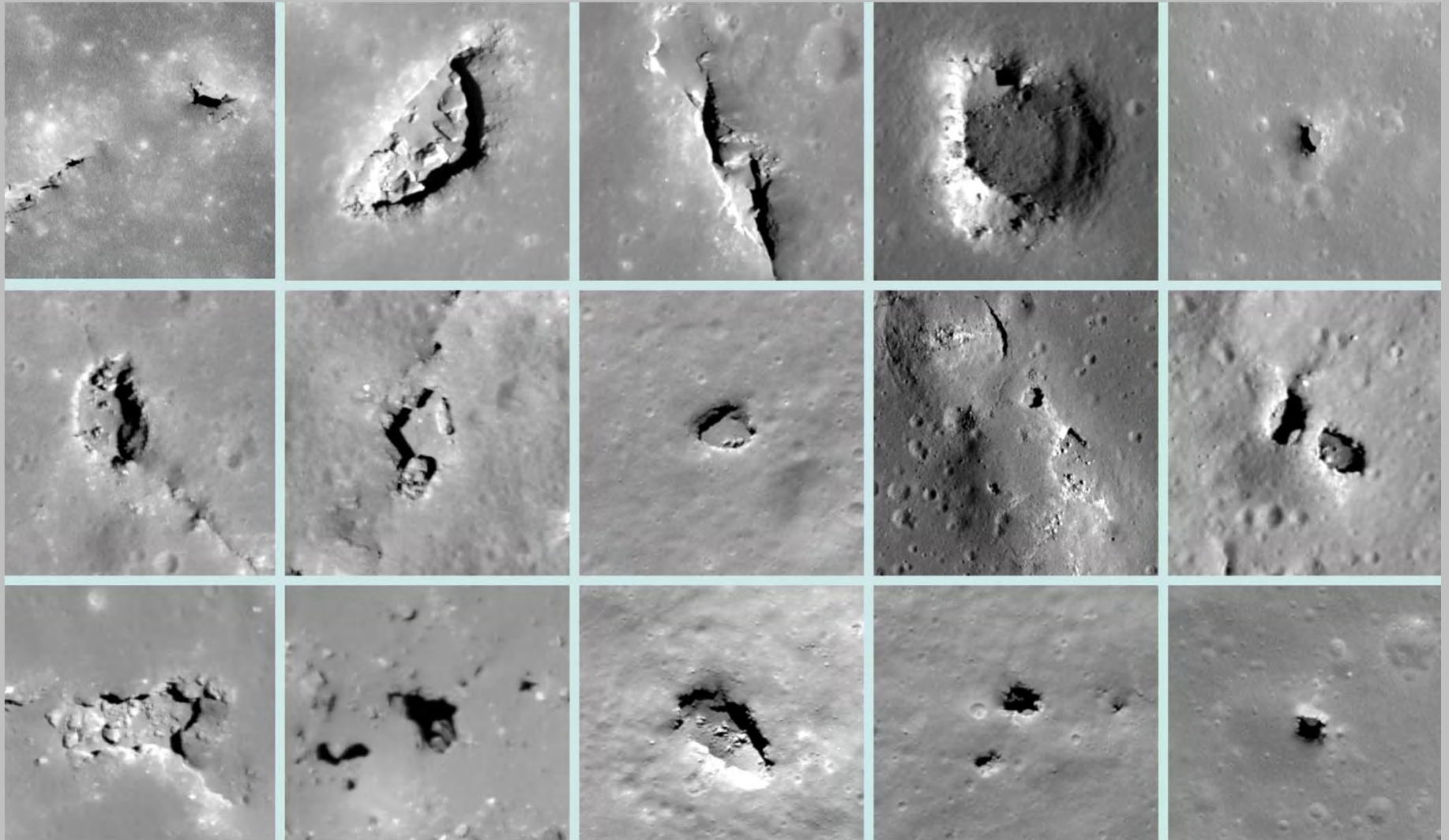


LRO Lunar Surface Openings

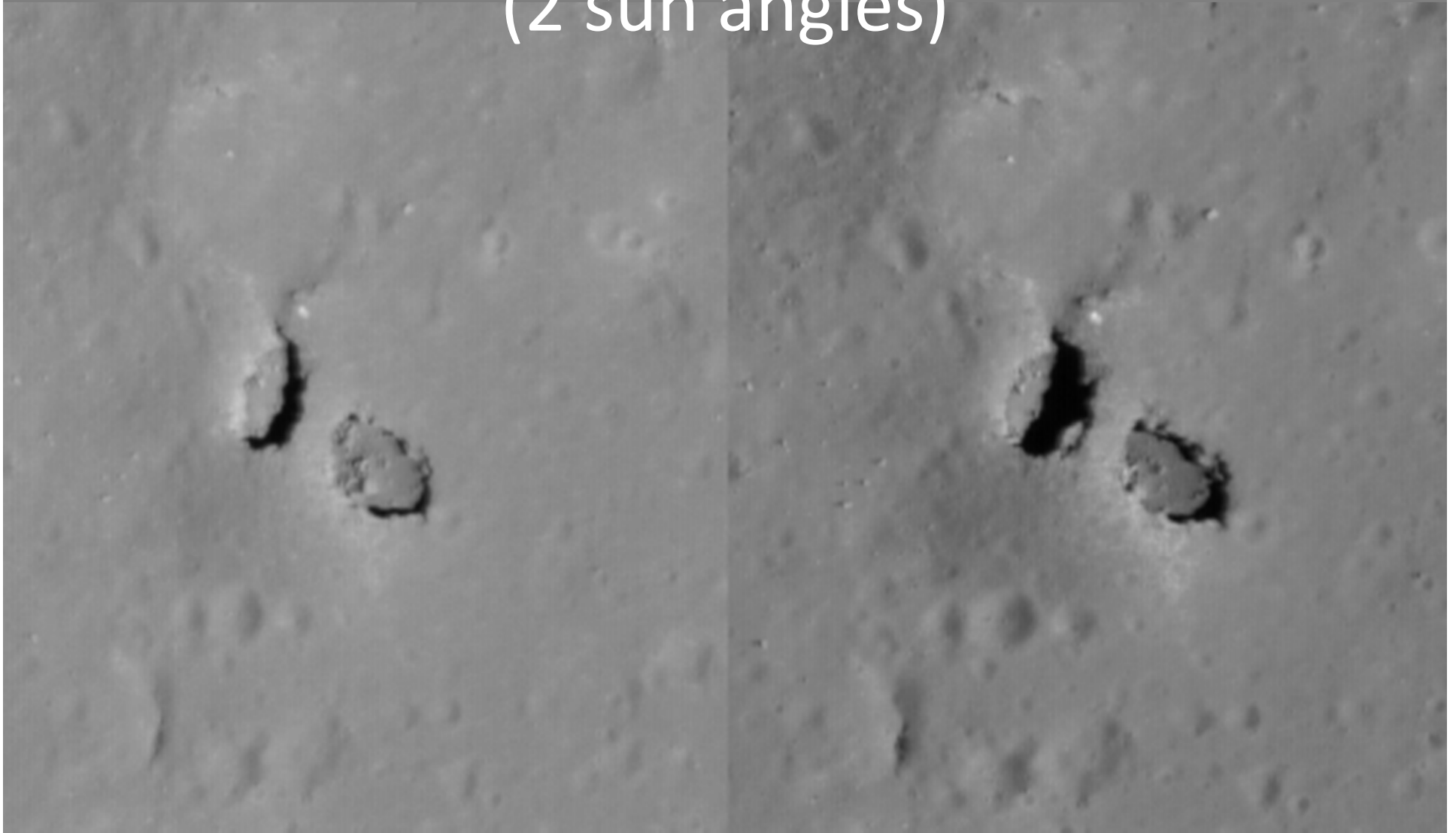
Pit craters, lava tube skylights or collapse voids?



More varied morphology



Bridged opening (2 sun angles)



Tethered Entry Method

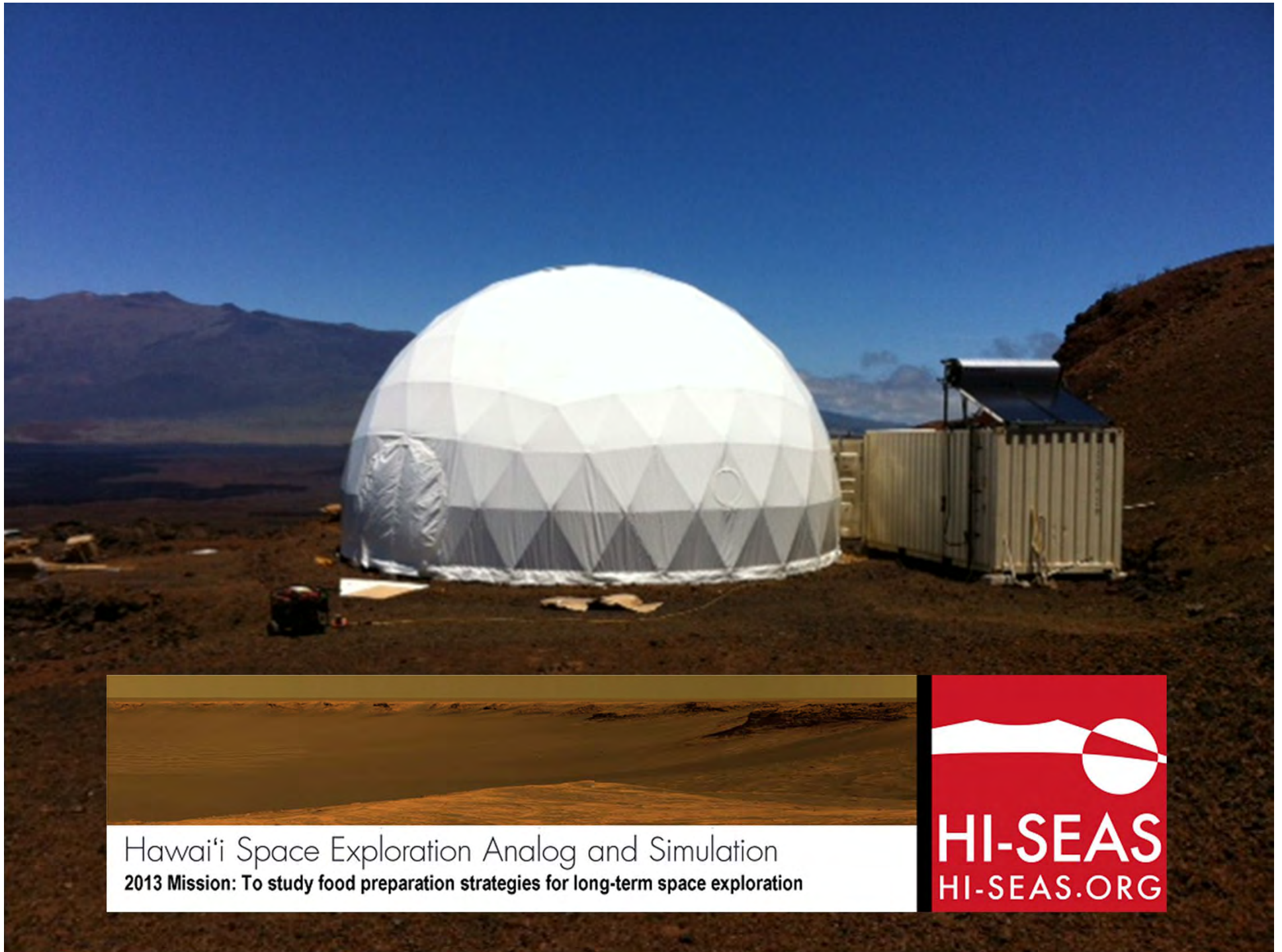












Hawai'i Space Exploration Analog and Simulation
2013 Mission: To study food preparation strategies for long-term space exploration



Hawai`i: The *Premier Analog Testing Destination* in the World

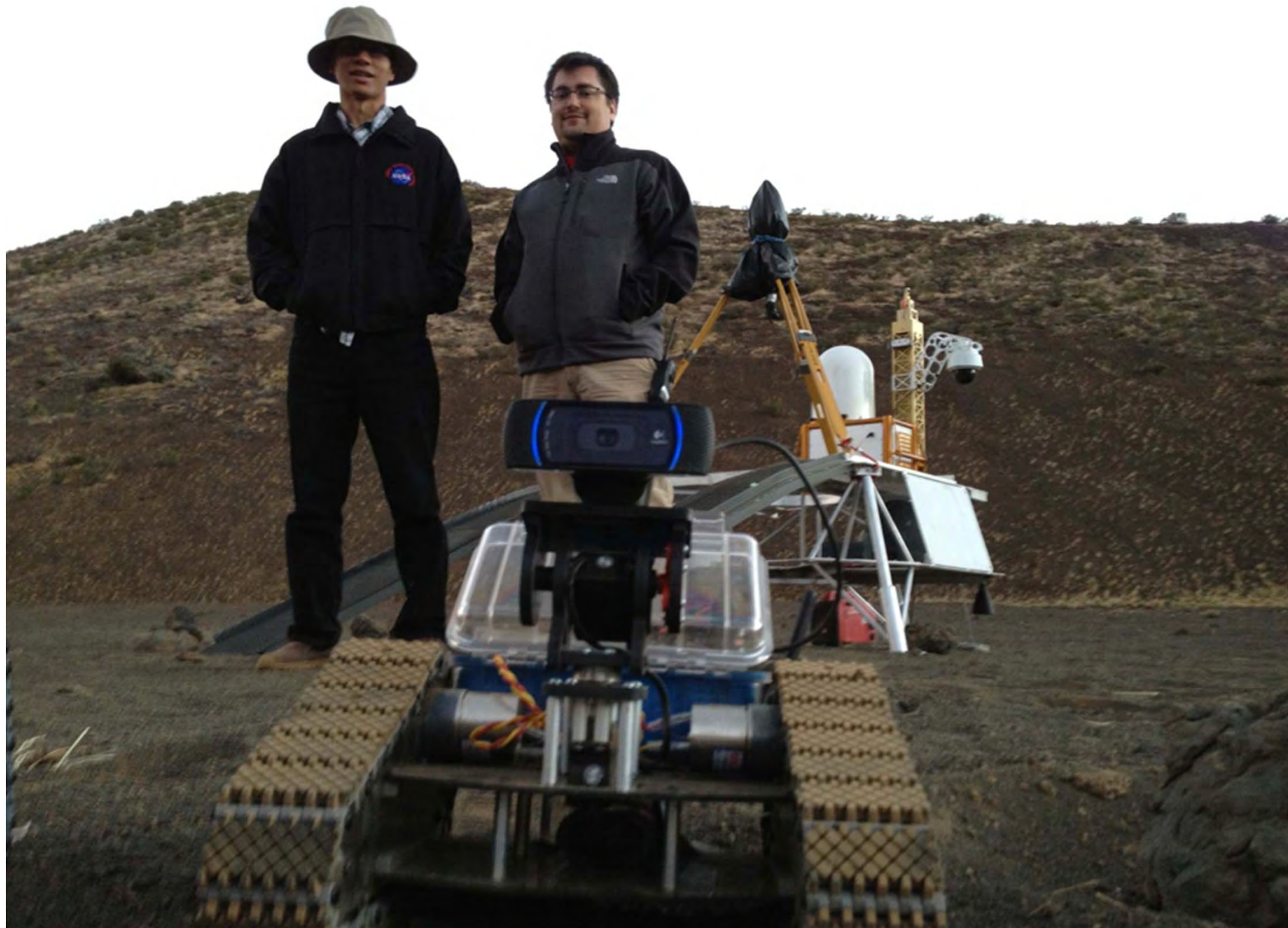
Assets

- History of Success
 - Apollo Astronaut Training
 - PISCES
- Proven Hi-Fidelity Analog Sites
 - Geology
 - Geochemistry
 - Terrain morphology
- Ranges for extended roving
- A variety of analogs co-located
- Variety of altitude regimes
- Location - mid Pacific
- Location – central to most space faring nations
- Location – Year round testing climate
- Stable economic & political climate
- Diverse multicultural society
- 2 Intl Airports
- 2 Deep water Harbors
- USN Pete Conrad tracking station

PISCES supporting infrastructure

Asset Buildout

- Base support facilities
- Mobile field support facilities
- Communications
 - World-wide control
 - NASA C & C standards
 - Delay tolerant coms



NASA Ames Exploration Uplink Mini - Rover

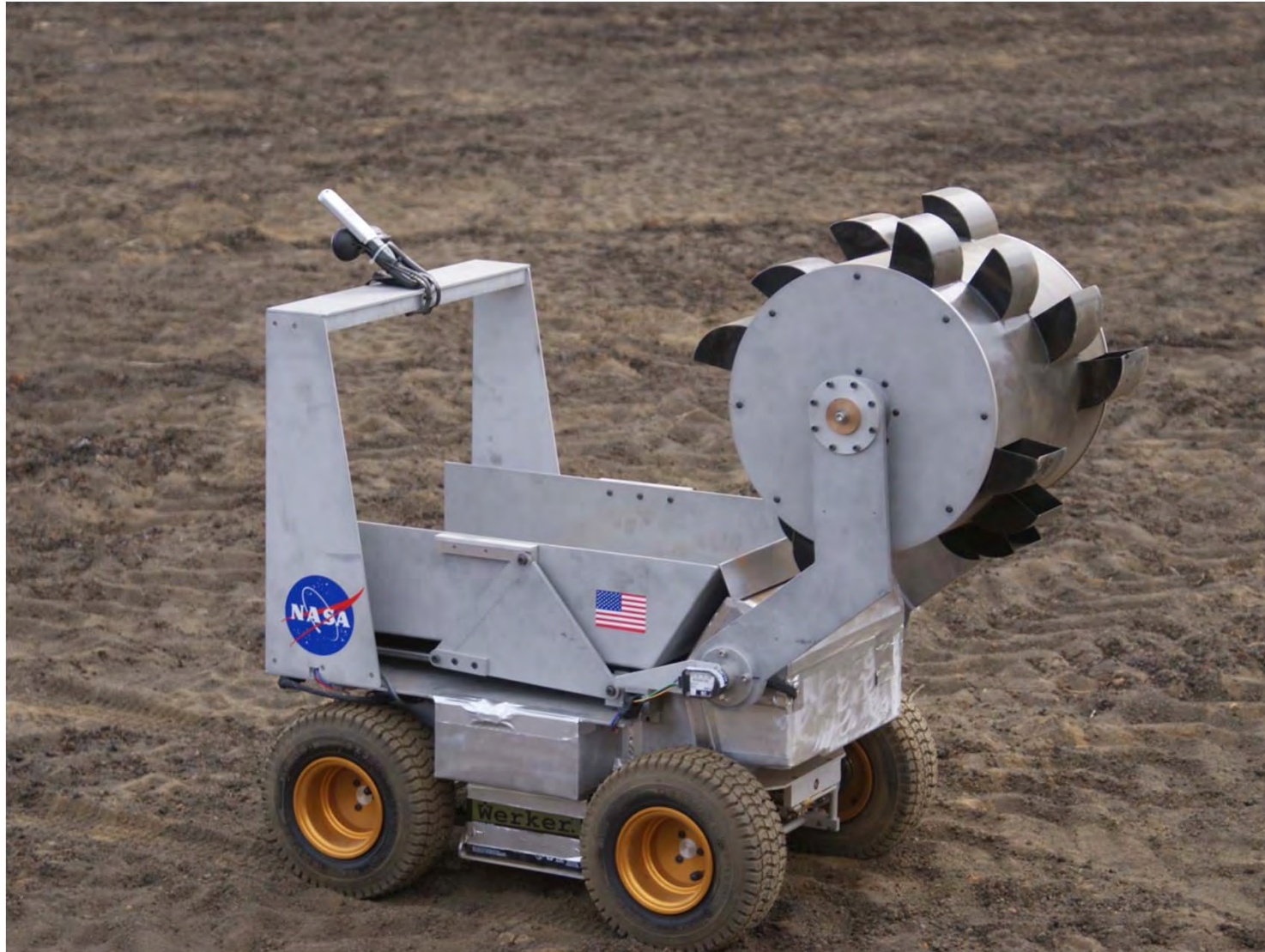
Global Control - HTTP protocol

- Chile
- Canada
- South Africa
- Hawai`i Island
- Honolulu
 - Live stream to APEC Display
 - Schools
- Live and remote control with situational awareness
- Control Delays
- Classroom and Field use

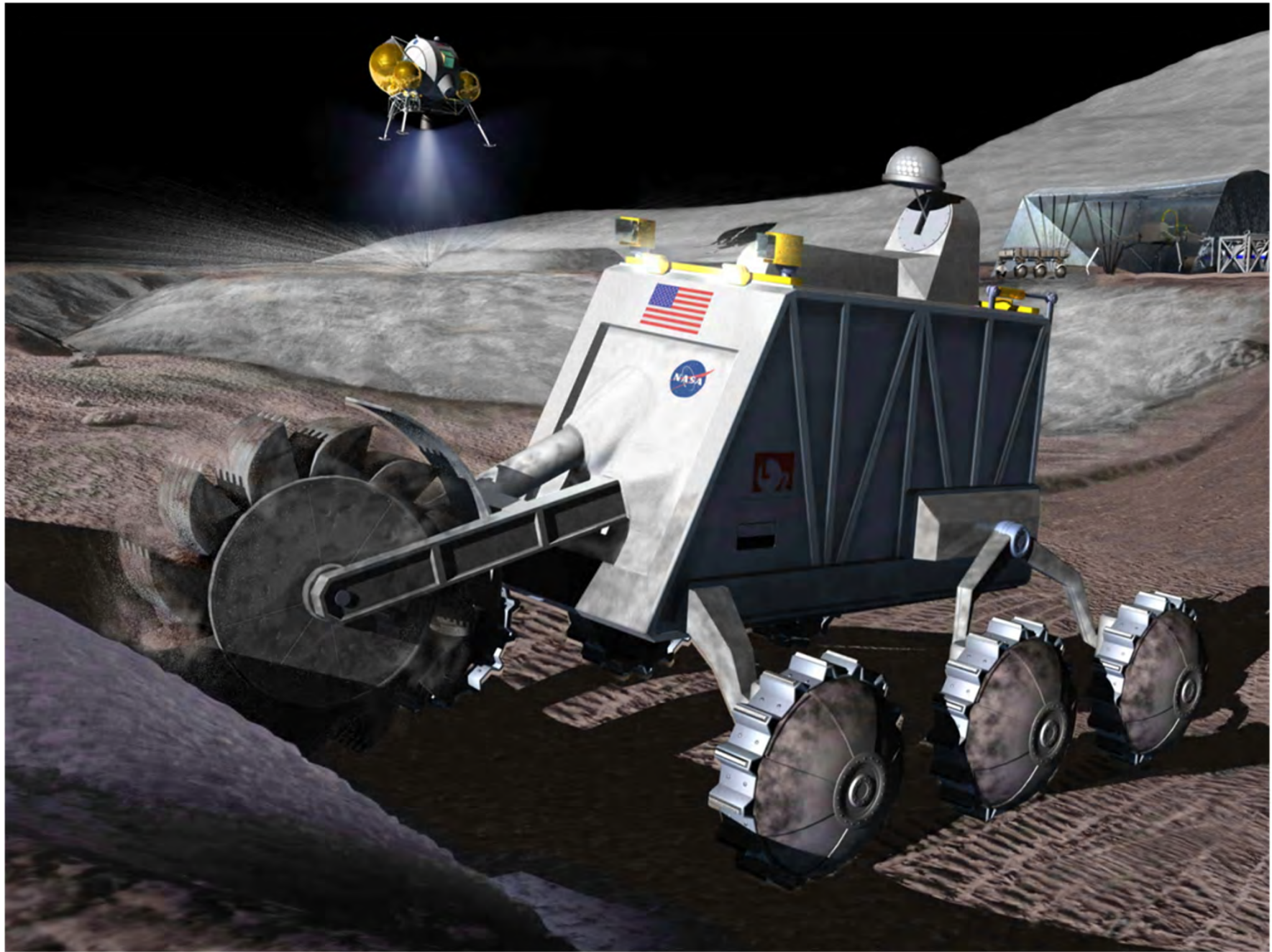


Public Outreach = Community Support





**Lockheed Martin Bucketwheel Excavator
2008 test – Hawai`i**





**2012 Lunabotics Champs Univ. of Alabama
@ PISCES Conference November 2012**







Pat Rawlings

Mahalo

