GEOPHYSICAL EXAMINATION OF VOLCANIC FEATURES & PROCESSES

WITH IMPLICATIONS TO LUNAR SCIENCE OPERATIONS

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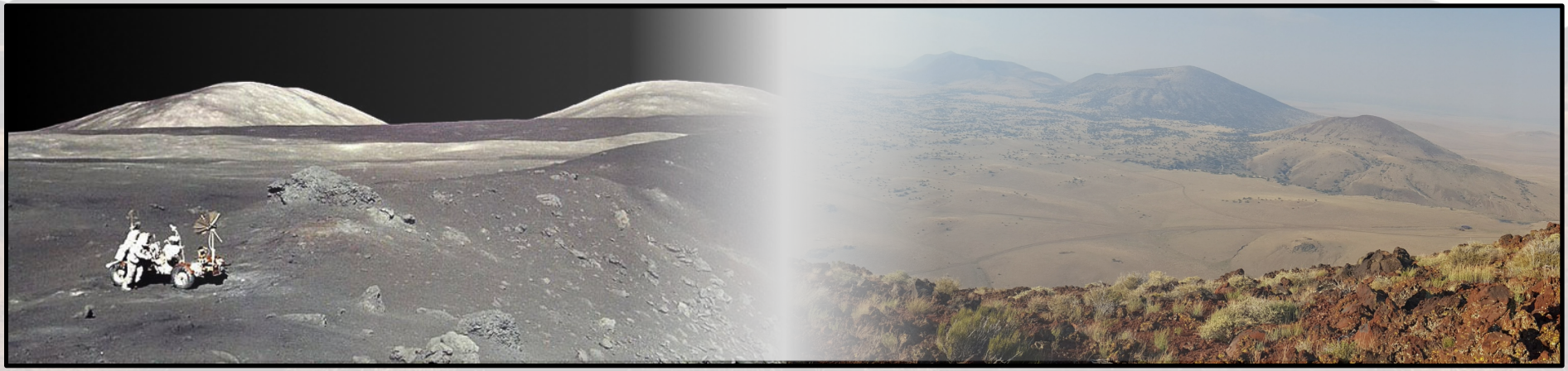
PLANETARY ANALOGS

- To date, the only experience humans have of performing geologic & geophysical fieldwork on another planetary body comes from the Apollo lunar missions
- On Earth, planetary analogs provide representative environments of locations on other planetary bodies



View of Jack Schmitt at Shorty Crater during Apollo 17.

(image credit NASA)

View from top of the SP Crater cinder cone, overlooking the cinder cone field to the south.

- Uses for terrestrial based analog locations:

Scientific Investigations

Operational Scenarios

Engineering Tests

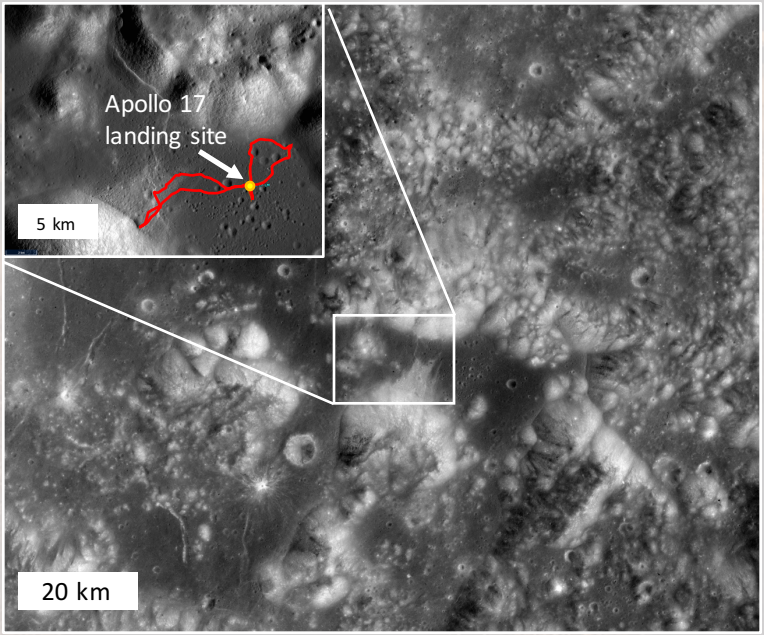
MOTIVATION OF STUDY:
1) LUNAR VOLCANIC FIELD PROCESSES

Marius Hills region

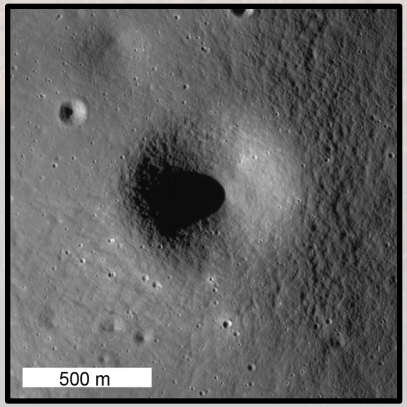
- *lower frames:* possible cinder cone vents from within region

Taurus-Littrow region

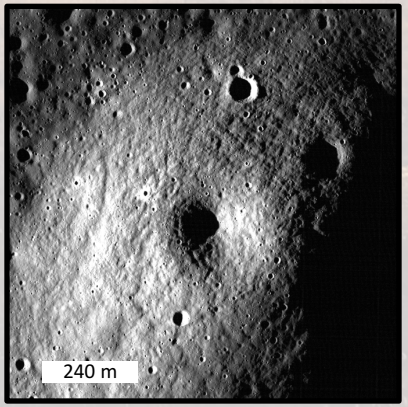
- *inset:* Apollo 17 mission area showing traverse paths



(Images credit NASA/GSFC/LROC)



(25 Jul 2012, Images credit NASA/GSFC/ASU/LROC NAC M181173832LR)



(27 Apr 2011, Image credit NASA/GSFC/ASU/LROC NAC M148618400R)

MOTIVATION OF STUDY:
2) ANALOG HUMAN LUNAR FIELD OPERATIONS

- NASA Desert Research and Technology Studies (RATS)
- Engineering based studies on operability of performing geologic field activities
- 2010: realistic human piloted rover traverse in the San Francisco Volcanic Field (SFVF) with prototype habitable rovers, habitats, & communication

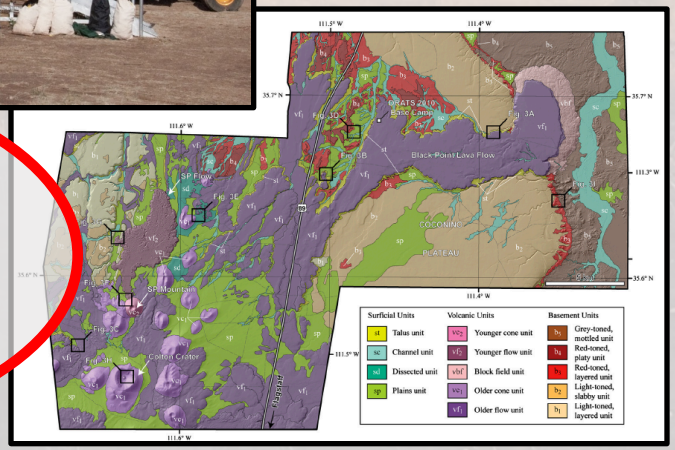
(Image credit NASA/JSC)

(Image credit NASA/JSC)

(Image credit NASA/JSC)

(Image credit NASA/JSC)

Geophysical tools and exploration were <u>not included</u>



(Image credit USGS)

PROJECT OBJECTIVES

- ***Geophysical science objectives:***
  1. Characterize terrestrial volcanic features with respect to subsurface structures for extrapolation to planetary locations.

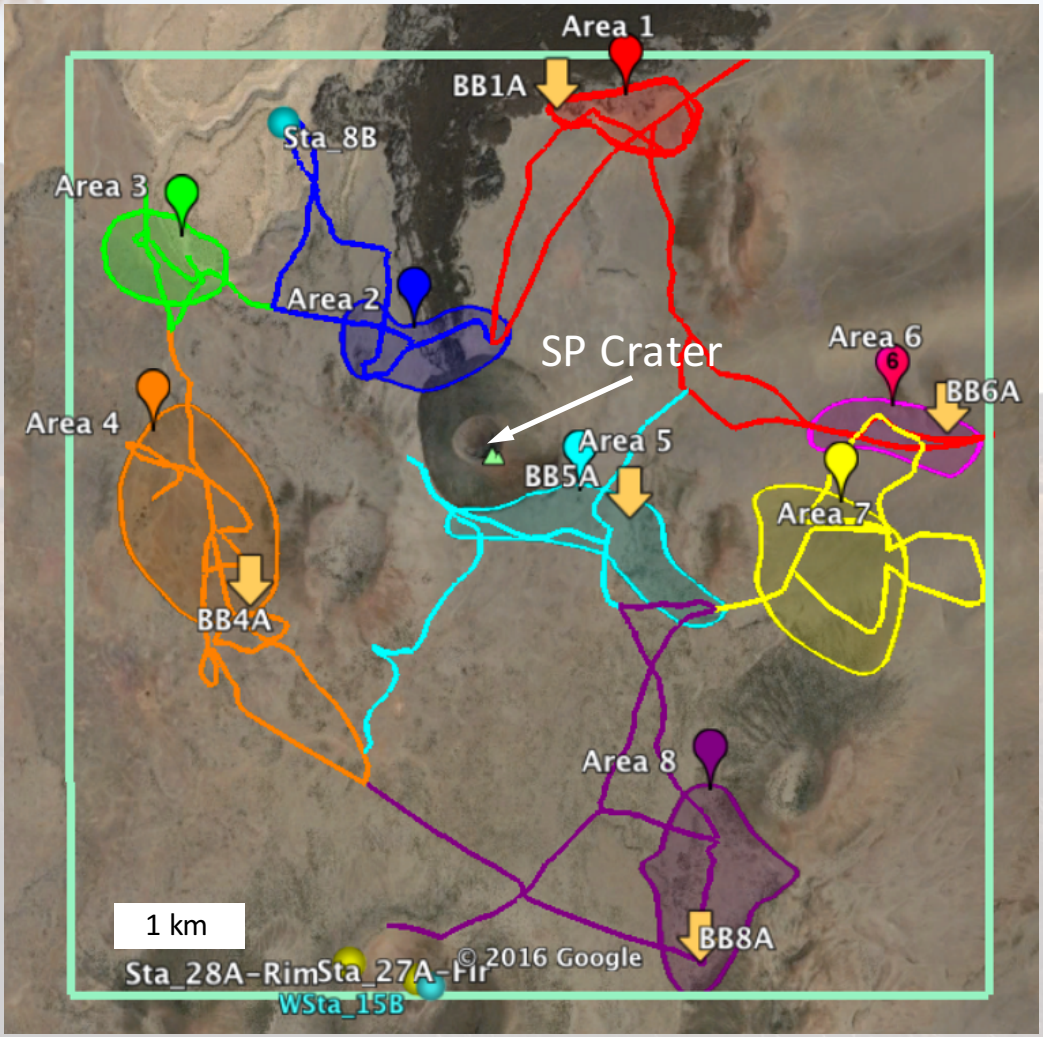
- ***Planetary exploration operations objectives:***
  1. Develop operational techniques for geophysical science operations (human & robotic) on planetary surfaces.

PROJECT OVERVIEW

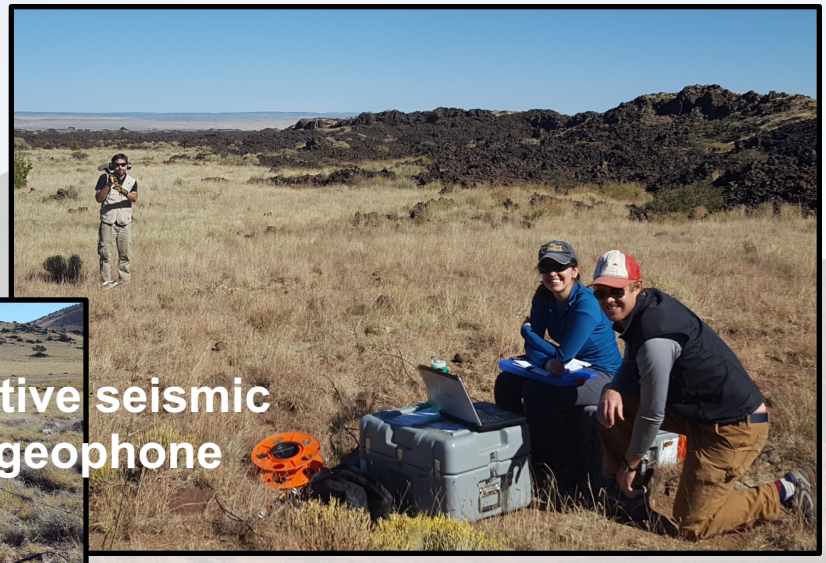
- Consists of multi-year field campaign
  - *Year 1*: Acquire and analyze a geophysical data set from sites restricted to locations from the NASA Desert RATS simulated lunar mission
  - *Year 2*: Select a specific geologic problem, and acquire a data set using standard terrestrial techniques
    - Accessible locations not restricted to Year 1 locations
  - *Year 3*: Conduct 'optimized' traverse-based geophysical exploration of the study area based on comparative analysis of Year 1 and Year 2
    - Desert RATS traverse modified to include geophysical operations

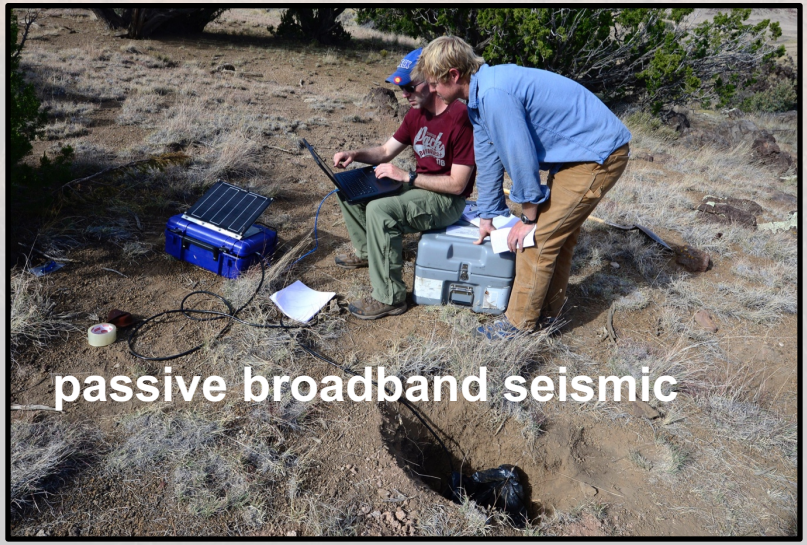
STUDY REGION

- San Francisco Volcanic Field
- 7 km x 7 km region, analogues to Marius Hills & Taurus-Littrow lunar region
- Roughly centered on SP Crater (cinder cone with 250 m of relief)
- Contains cinder cone volcanoes & lava flows
- Includes significant portion of Desert RATS rover traverses
- Eight areas encompass science stations used for simulated crew extravehicular activities



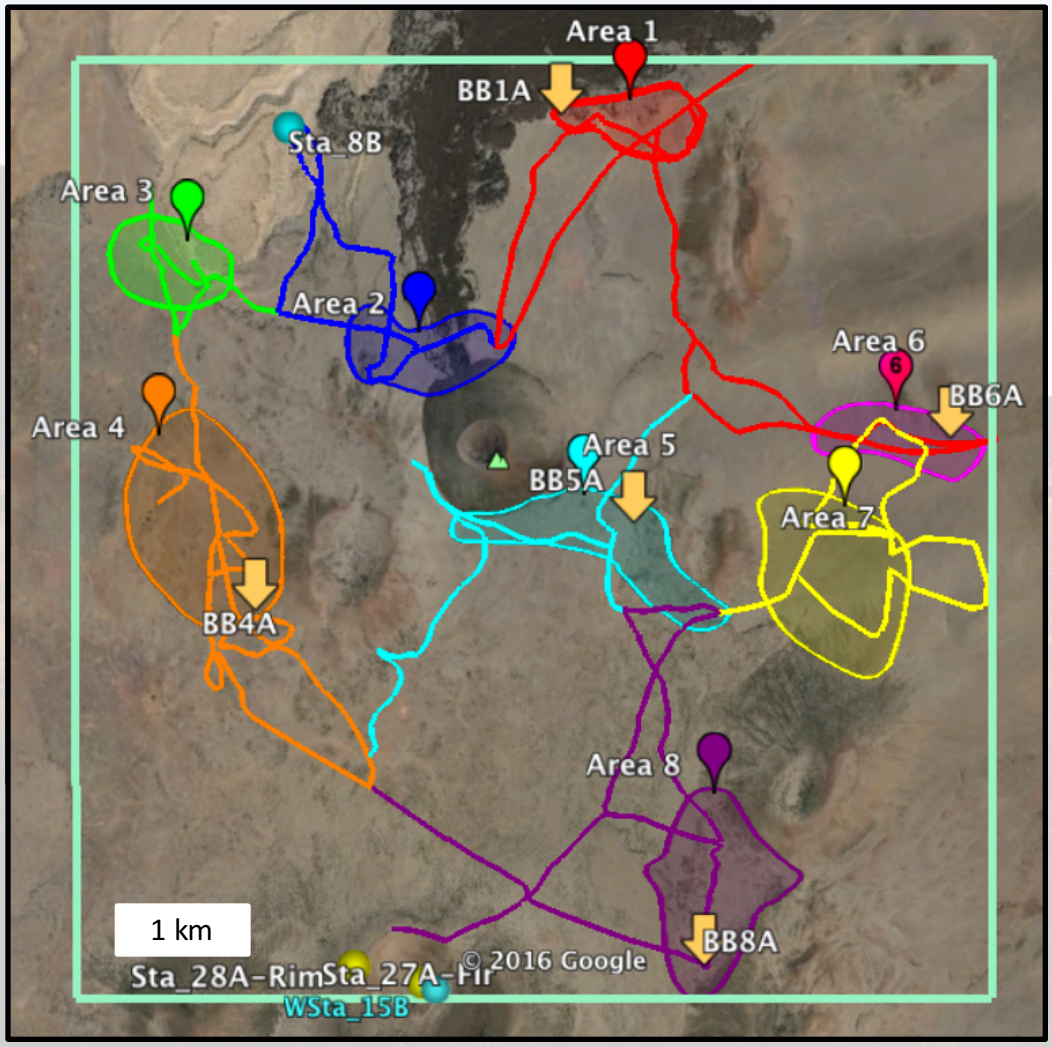
STUDY APPROACH:
TOOLS OF THE TRADE



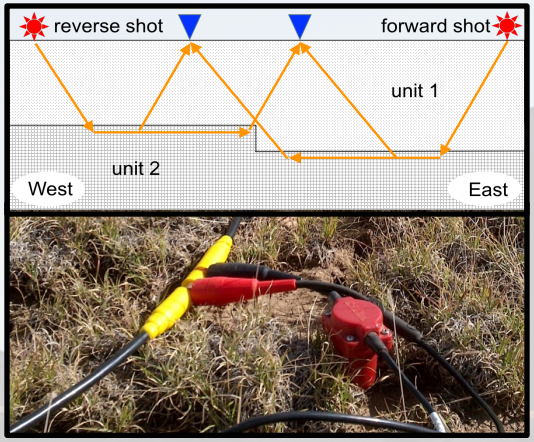


YEAR 1:
TRAVERSE BASED MISSION PLANNING RULES

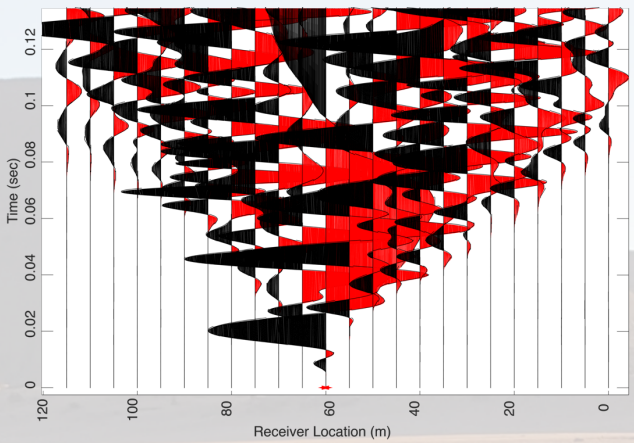
1. Assume geophysical objectives were secondary in relation to Desert RATS geologic traverse planning
   A. Discern & connect multiple overlapping lava flows
2. Seismic locations (active & passive):
   A. Within100 m of Desert RATS traverse science stations
   B. Planned locations based on Desert RATS precursor data (primarily USGS geologic map of SFVF, SP Crater region)
3. Magnetometry and GPR surveys were performed along the route of the Desert RATS rover traverse paths
   - Assumed were mounted on the rovers, but did not dictate route



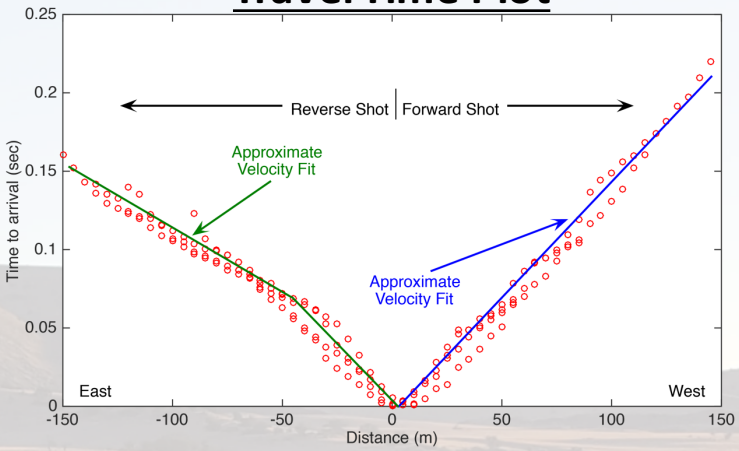
YEAR 1 ANALYSIS:
ACTIVE SEISMIC ANALYSIS, AREA 3



Seismic Wave Propagation

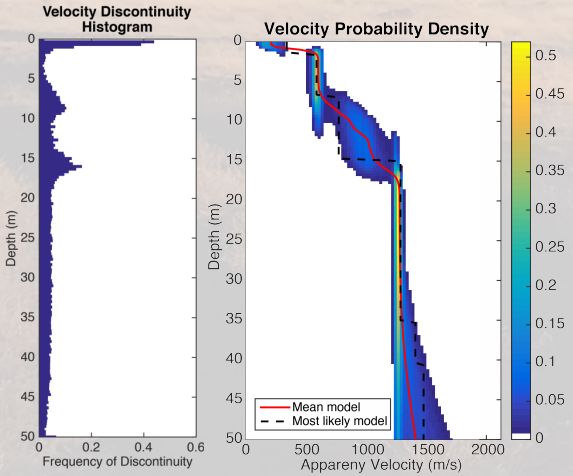


Travel Time Plot

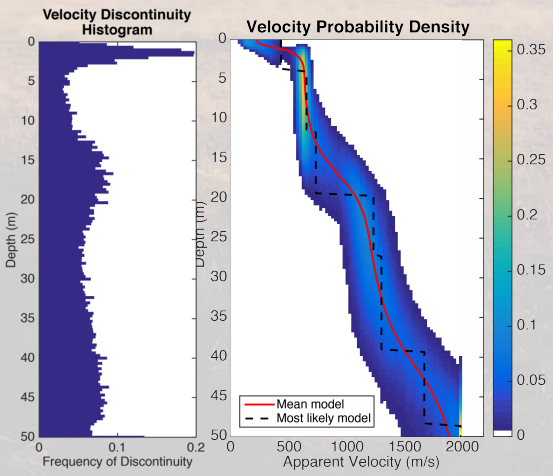


REVERSE SHOT

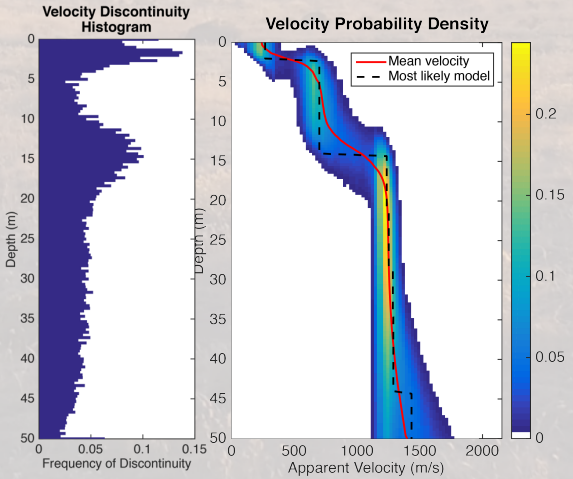
Western Profile



Central Profile

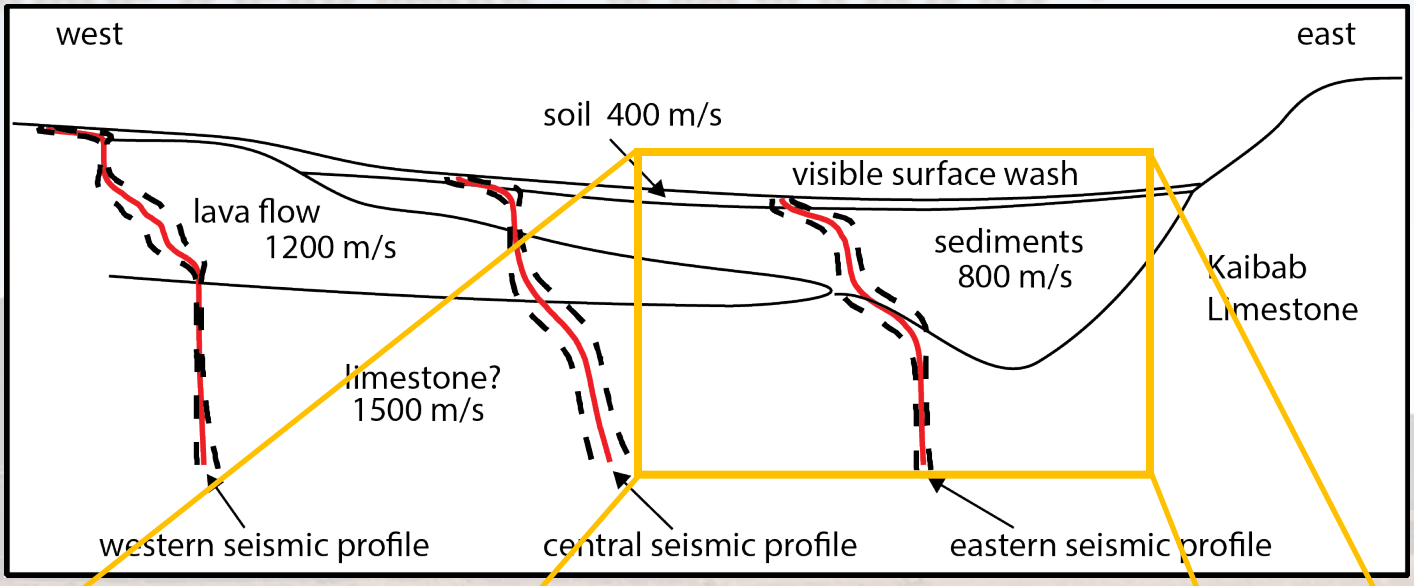


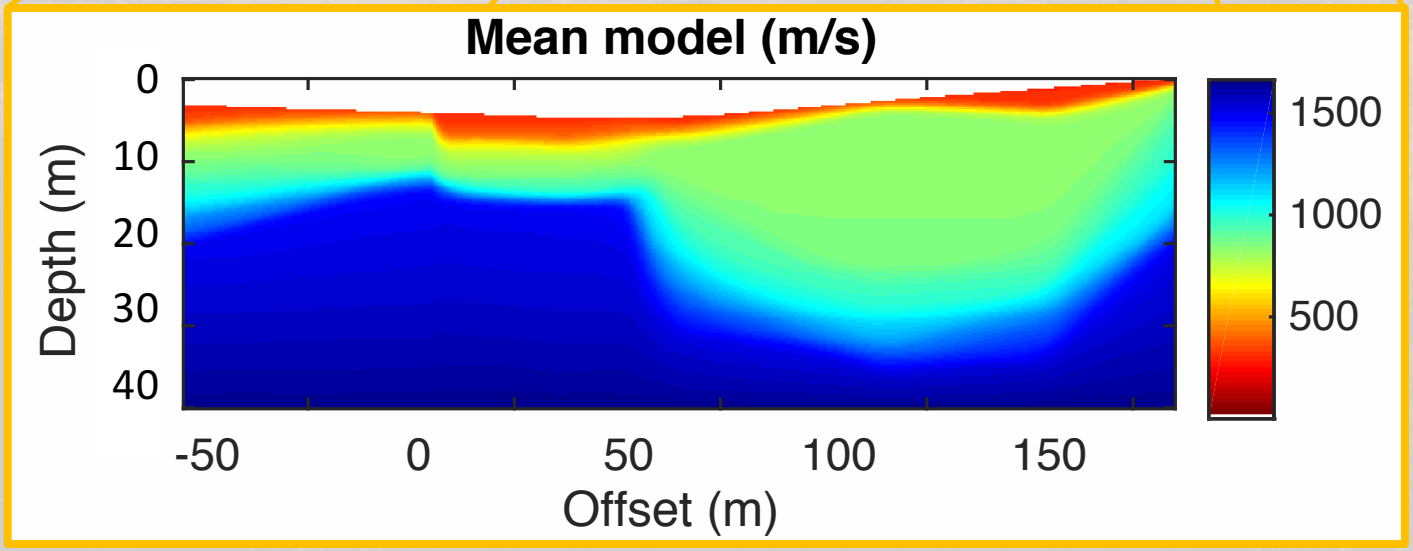
Eastern Profile



- For each set: Left plot = Likelihood of seismic discontinuity at a given depth
  Right plot = Resulting apparent subsurface seismic velocity profiles

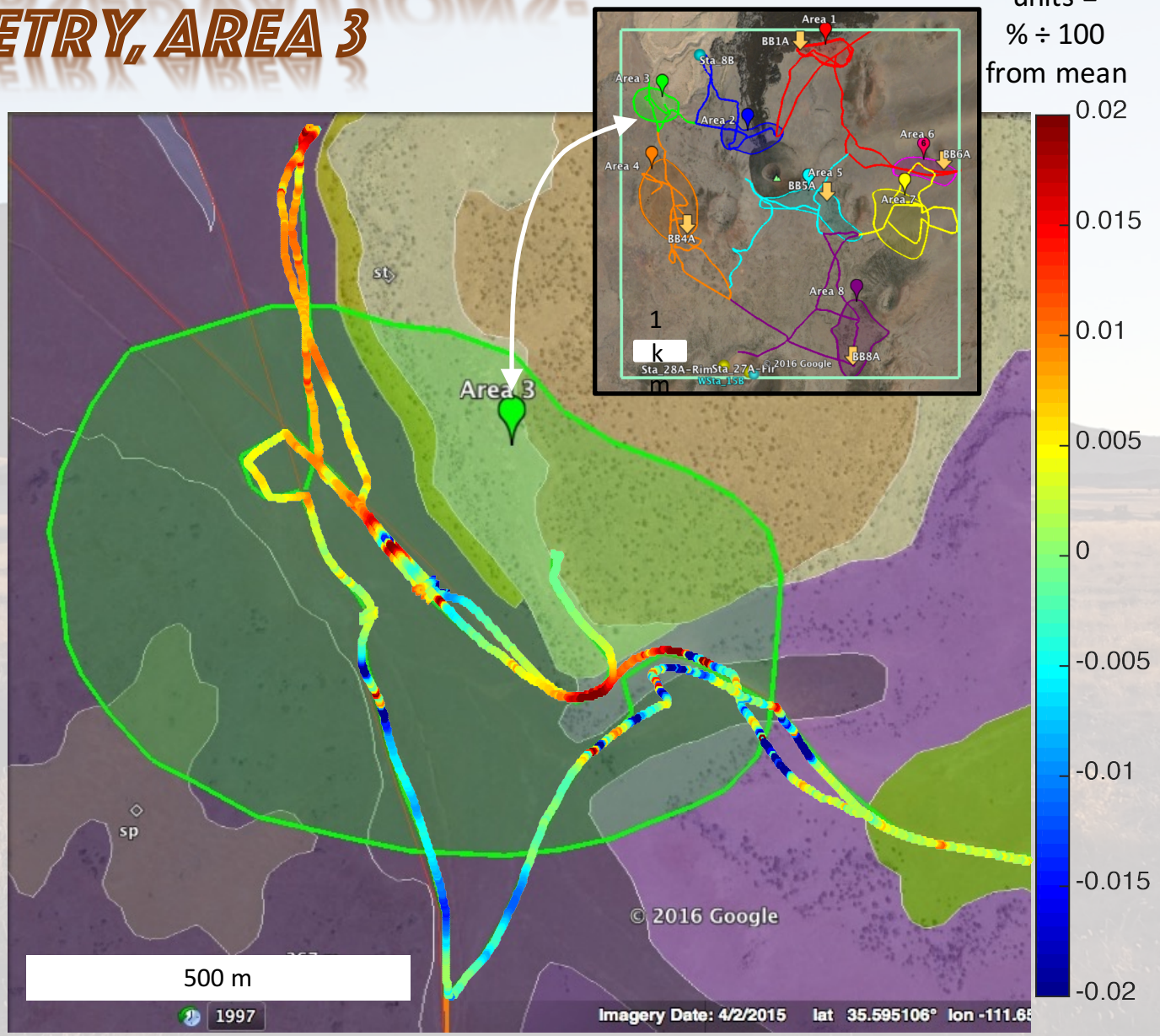
ACTIVE SEISMIC ANALYSIS (CONTINUED)





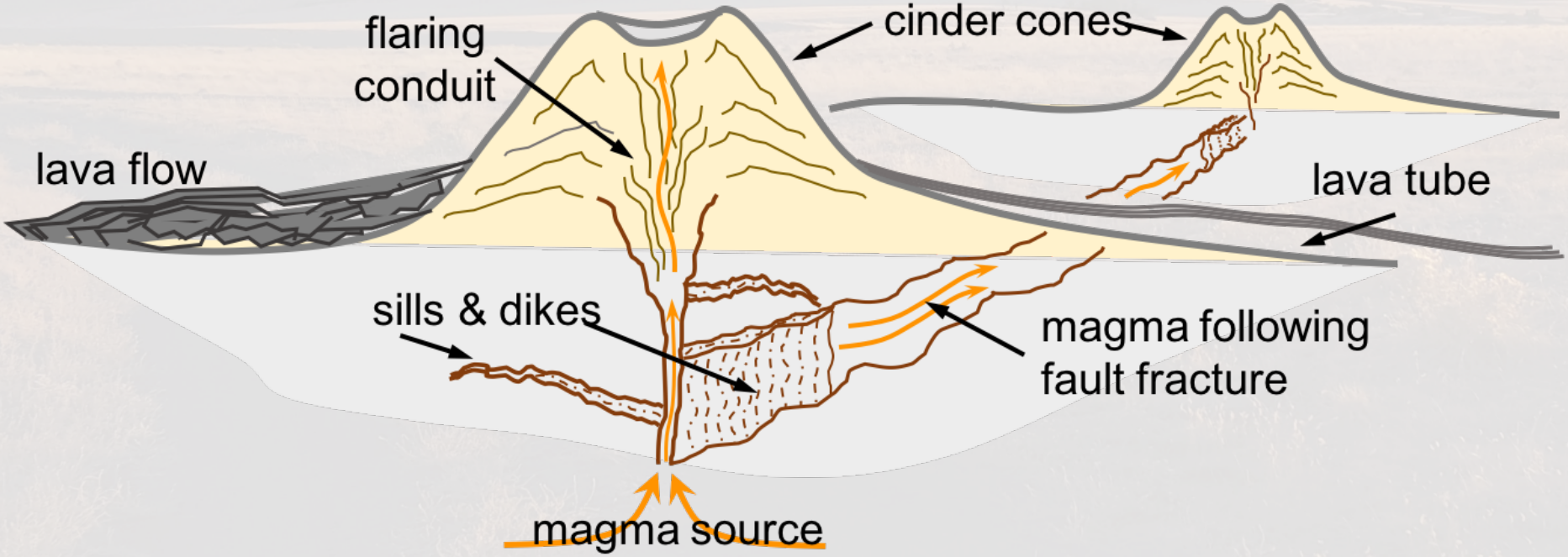
YEAR 1 OBSERVATIONS:
MAGNETOMETRY, AREA 3

- Magnetic variations normalized about the mean
  (% max ÷ 100 – mean)
- Note possible trend along geologic units

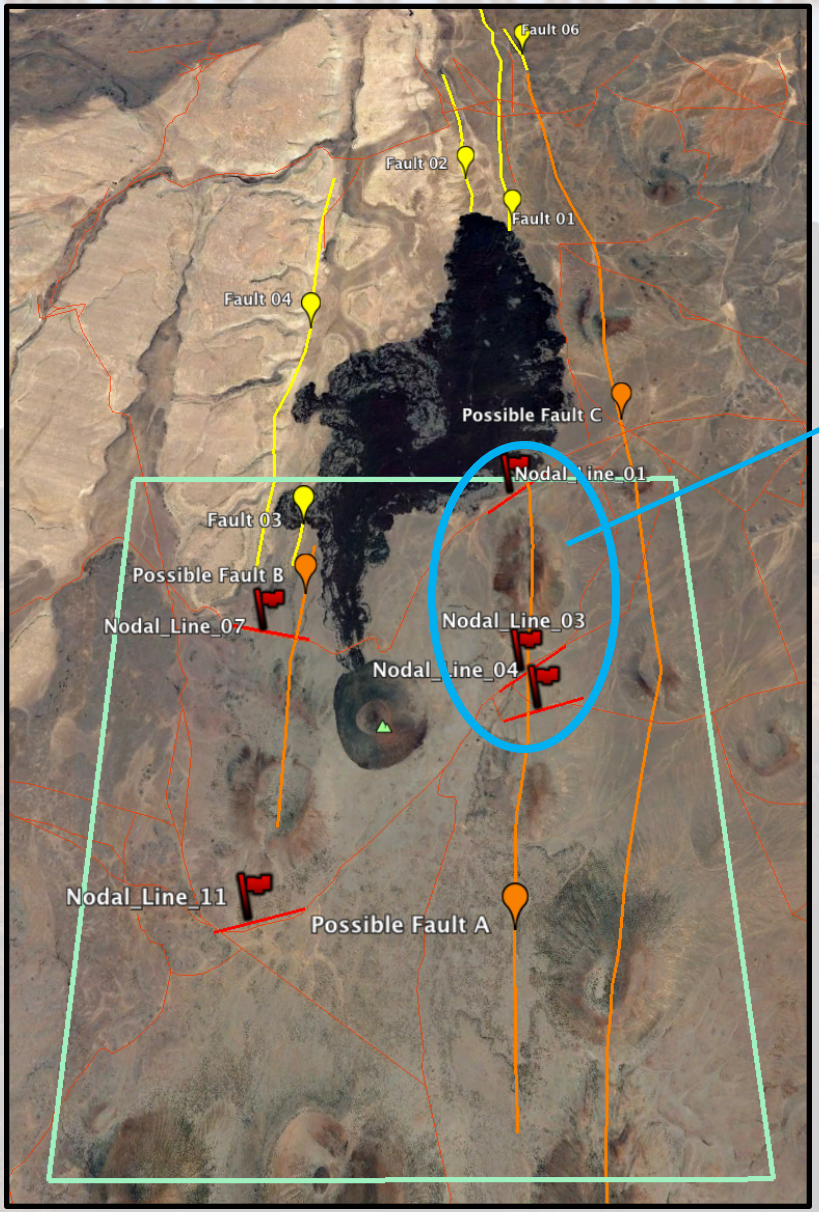


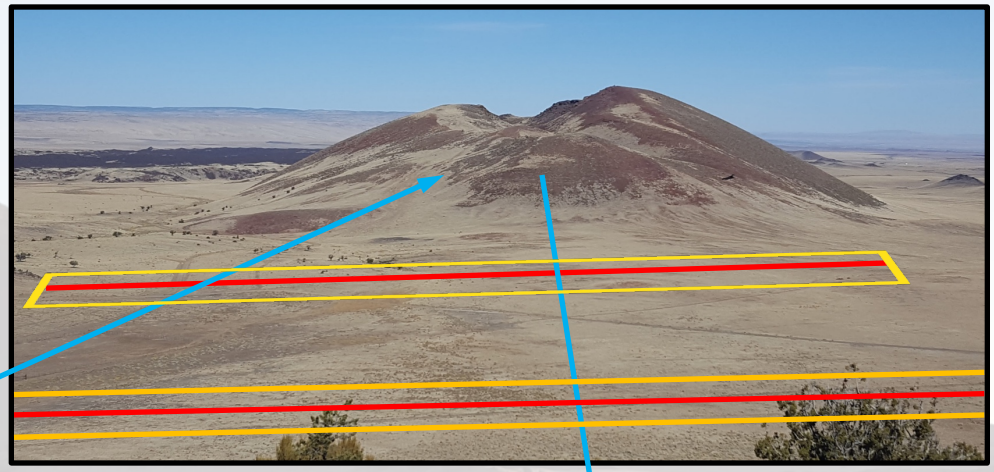
YEAR 2:
MAGMA FOLLOWING FAULTS?

1. Operationally: No restrictions on location(s) for data acquisition
2. Geophysically: Selection of specific problem(s) to address
   A. Location of local fault(s) facilitating magma propagation between vents
   B. Locate near-surface dikes/sills between volcanic vents and determine any correlation to local fault system



MAGMA FOLLOWING FAULTS? (CONTINUED)





CURRENT OBSERVATIONS

Geologic:

- Year 1: Active seismic geophones:
  - Can resolve layers to ~40 m depth, including soil, sediment, lava, & limestone, providing 'snapshot' of specific science station locations
- Year 1: Magnetic traverse:
  - Data appears to show some possible trends to Desert RATS precursor USGS geologic map
- Year 2: Active seismic nodal lines:
  - Using seismic refraction analysis can resolve to depth of several hundreds of meters
  - Using seismic reflection analysis can resolve to > 1000 meters

Planetary Traverse Operations:

1. Insertion of non-specifically targeted geophysical measurements into geologic plan results in an incomplete area picture
   A. Provides only localized non-connected location specific details
   B. Resulting 'rough sketch' provides incomplete evaluation of area for selecting sites for follow-on studies
2. Coordination is required between geophysical measurements and geologic hypotheses.
   A. Results in proper geophysical instrument strategy
   B. Provides for connection between interpretation of subsurface structure and visible surface features

Summary: This study researches geophysical characterization of near-surface terrestrial volcanic features as analogs to planetary locations within the context of planetary science operations.

https://www.facebook.com/UMD.PlanetaryAnalogs/

QUESTIONS?

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