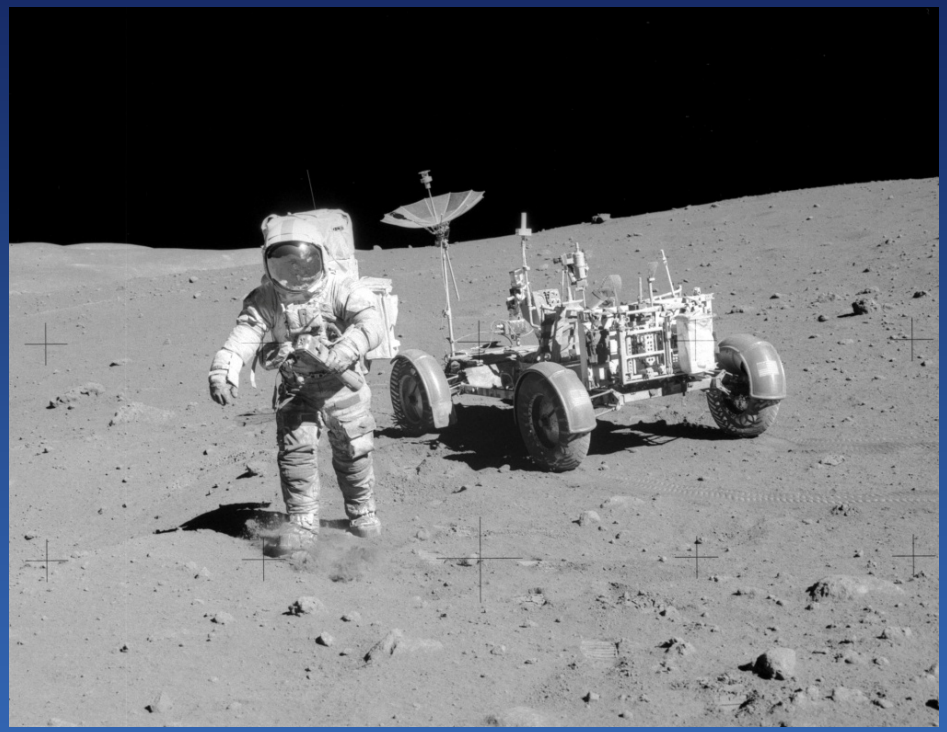
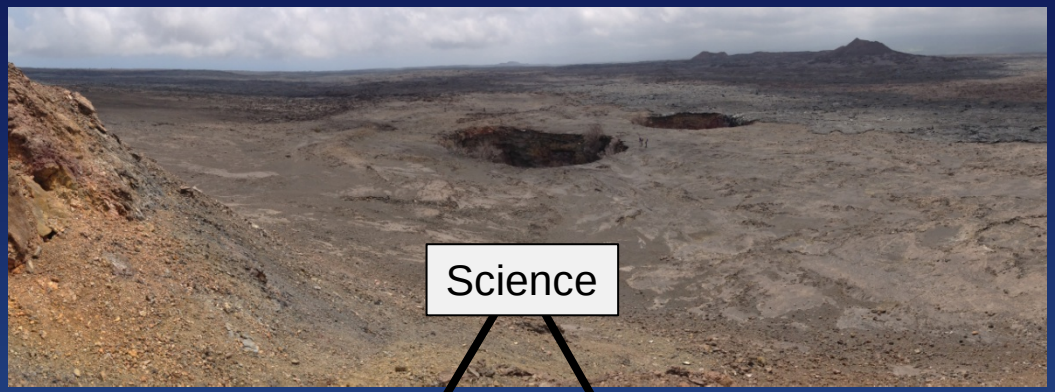
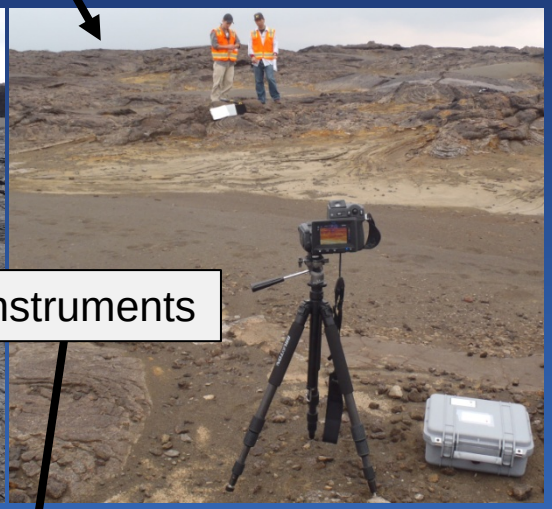
The effect of portable science instruments on EVAs as used by astronauts during geologic exploration of the solar system

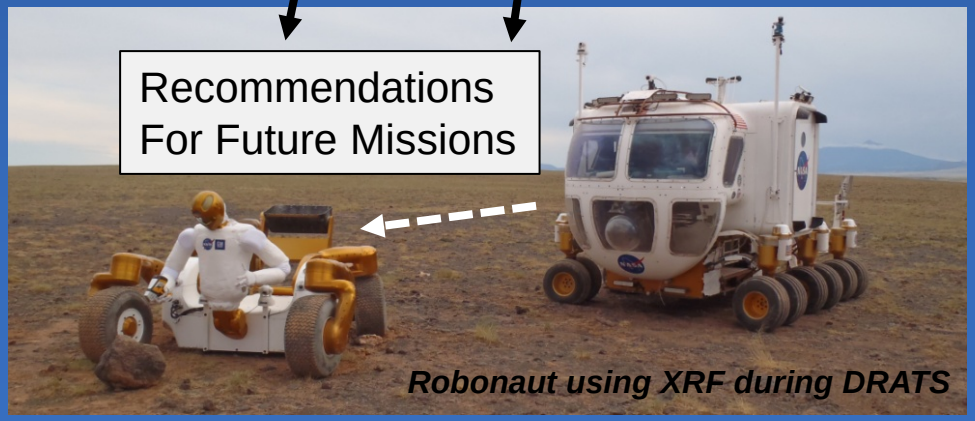


Jacob Bleacher, Deanne Rogers, Kelsey Young, Brent Garry, Amy McAdam, Tim Glotch and the RIS^{4}E field team

RIS^{4}E FIELD METHODS





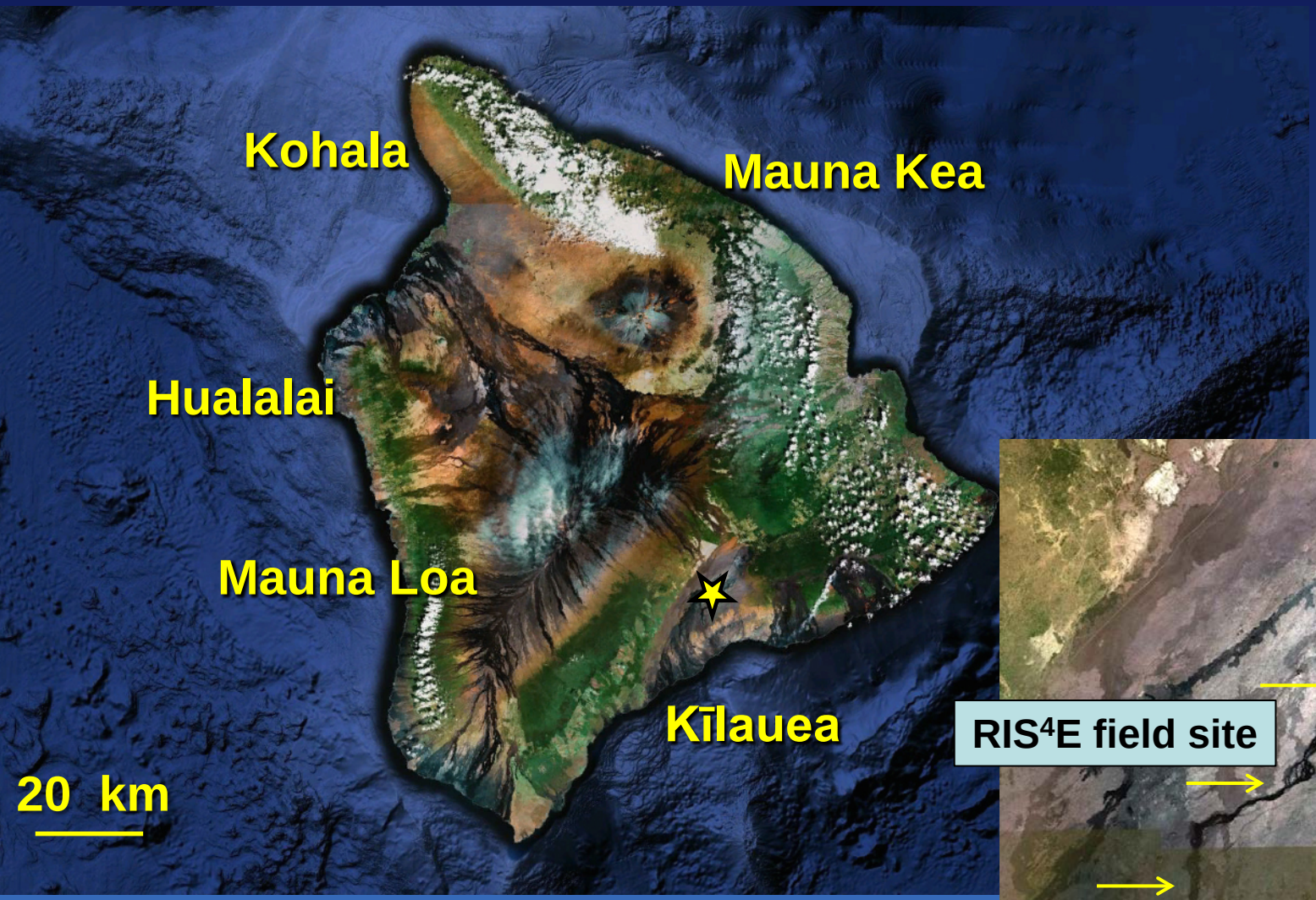


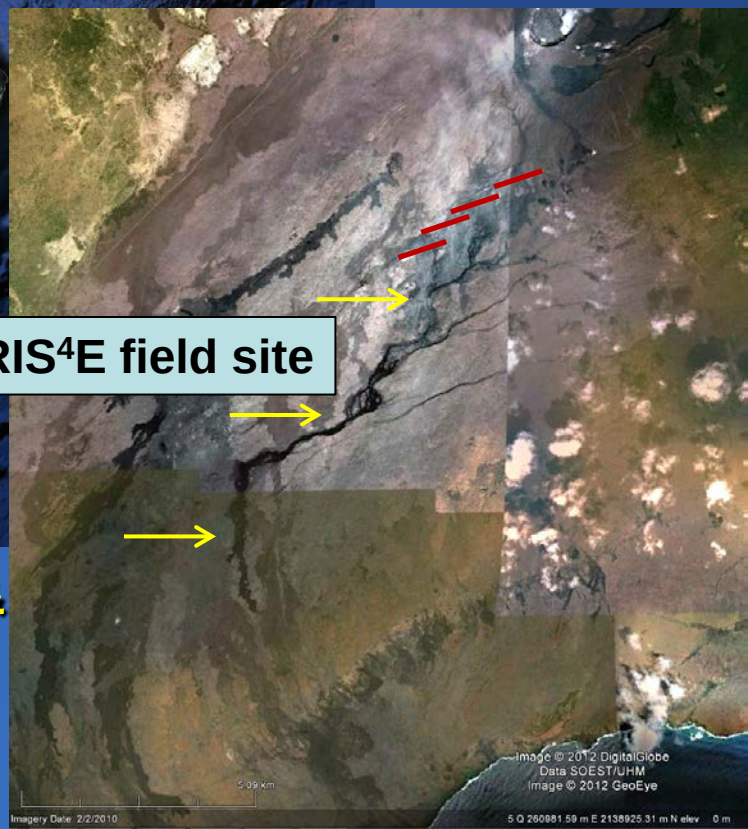
Robonaut using XRF during DRATS

- **New science**
  - **Pit and cave formation (geophysics, morphometry)**
  - *** Geochemistry, mineralogy and alteration processes**
- **Evaluate role of handheld/portable instruments for *in situ* measurements**
- **Recommendations for instrument operations and technology development**

**** Focus of 2015 Field Campaign***

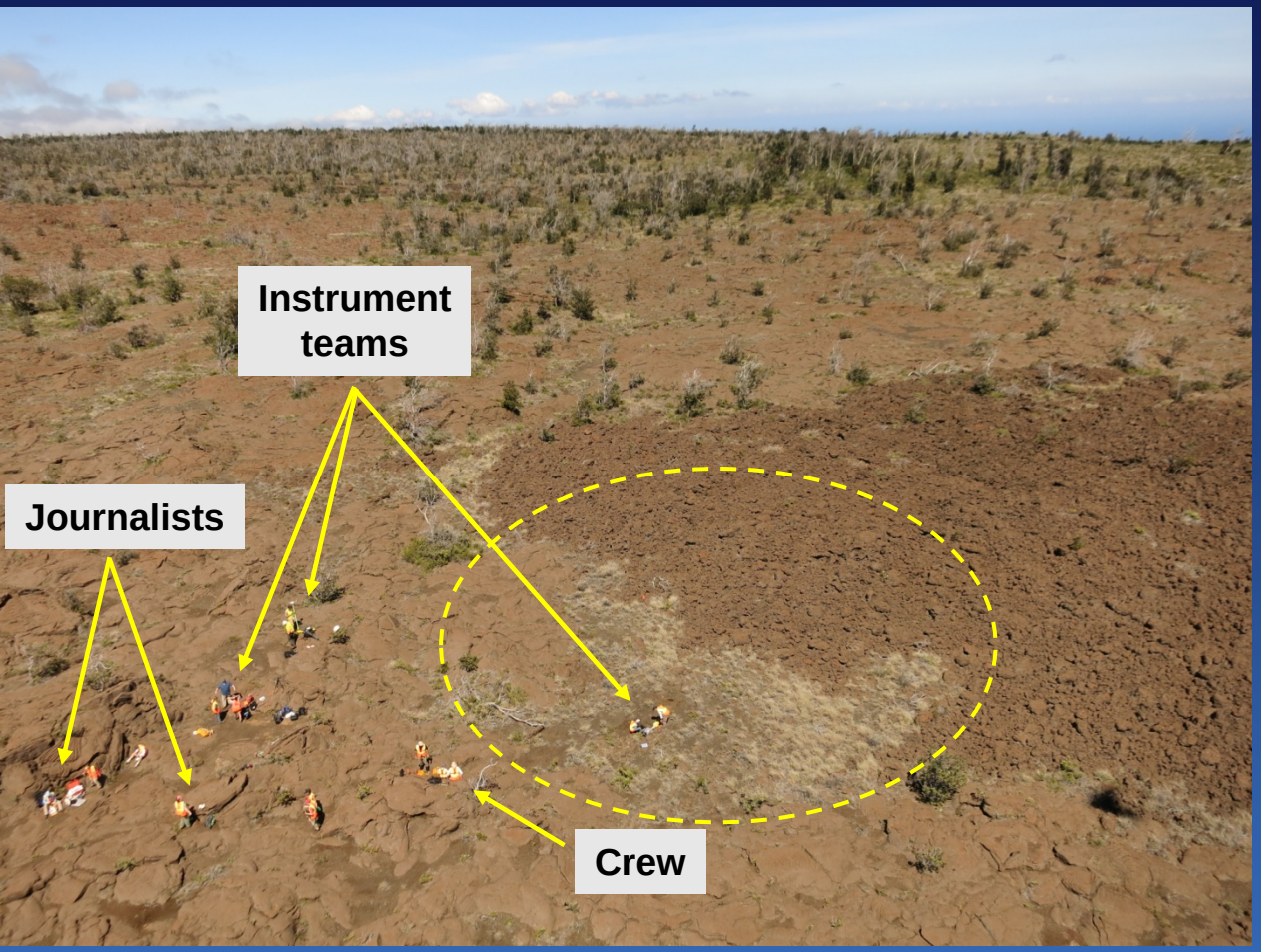
RIS^{4}E FIELD SITE: Kīlauea December 1974 Flow





RIS^{4}E field team building on 6 years of PGG & MMAMA-funded research to study physical volcanology & characterize chemistry & mineralogy of lava and alteration products

2015 FIELD OPERATIONS



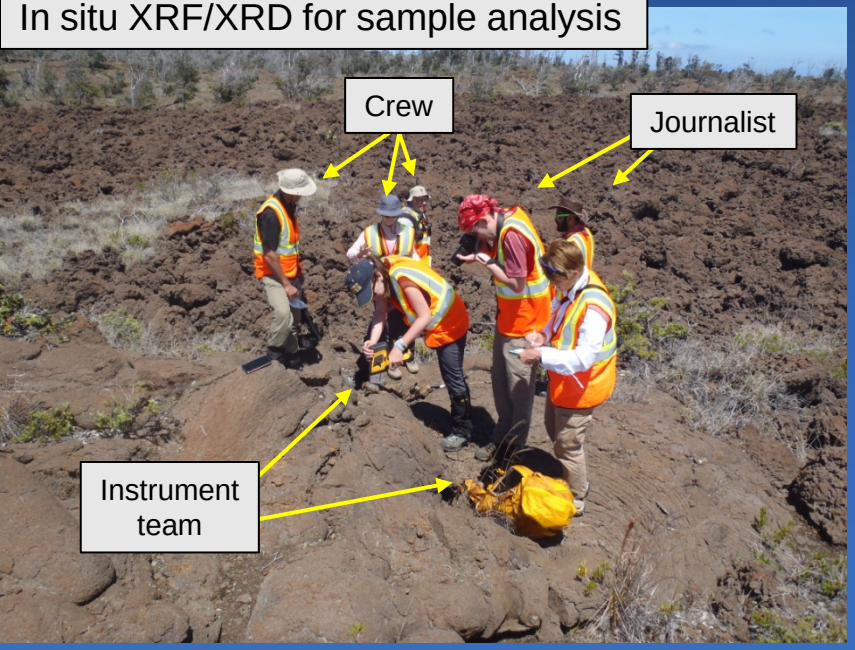
- Crew of 3 explored geologically relevant sites
- Objective: develop basic operations timeline including currently existing portable, in situ instruments
- Objective: compare results of in situ data with laboratory data
- Objective: characterize chemistry/mineralogy
- Instrument teams supported crew decisions for measurements
- Journalism students participated in all field operations

2015 FIELD OPERATIONS

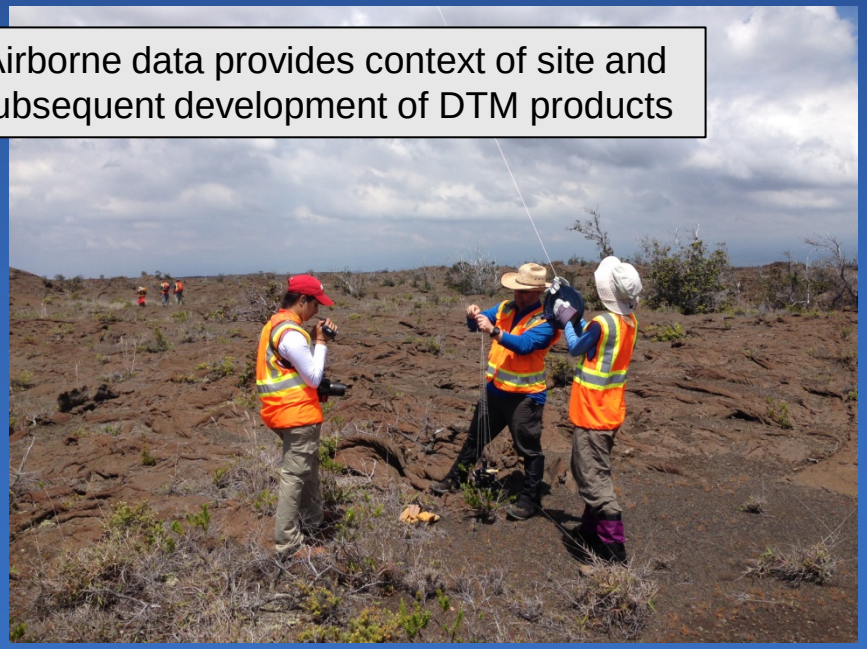
TIR & LiDAR for broad FOV

- Portable measurements fall into
  - Broad FOV (site survey)
  - Sample specific (in situ)
  - Overhead (recon)
- All data types ultimately integrated for subsequent study of site
- All can provide real time to near-real time data for decision making
- Instruments are current "off-the-shelf" with some modifications

In situ XRF/XRD for sample analysis



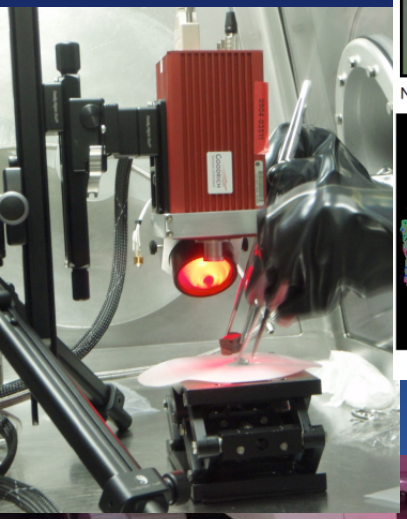
Airborne data provides context of site and subsequent development of DTM products



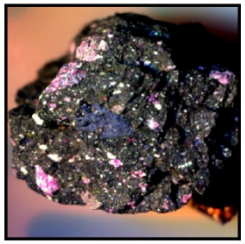
2015 FIELD OPERATIONS

- Operational assumptions derived from Desert RATS
- Crew arrive at site of scientific interest
- Crew initiate observations from rover mounted instruments and survey site
- Upon completion of site survey crew egress for EVA

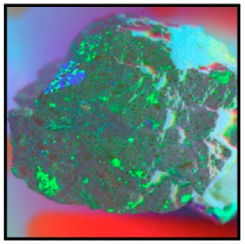
DRATS INSTRUMENTS



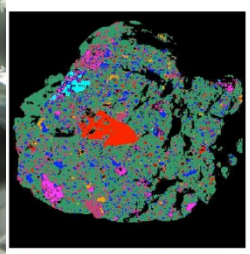
Natural-color (463, 522, 641 nm)



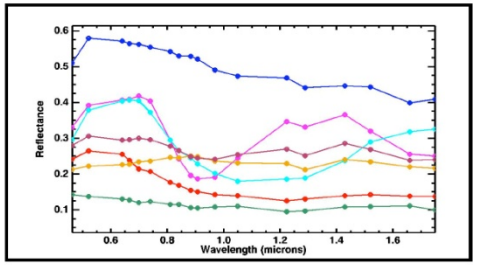
False-color (522, 908,1430 nm)

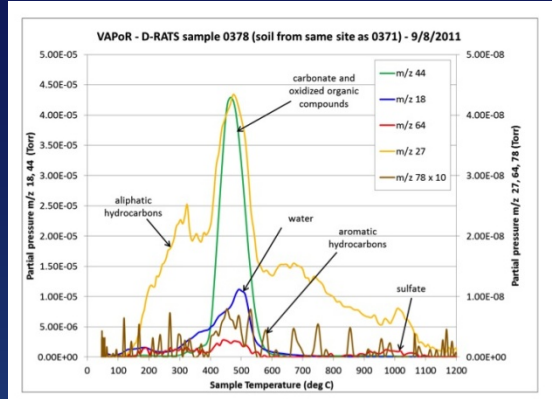


Ratio (1660/1050,1290/908,970/1290)

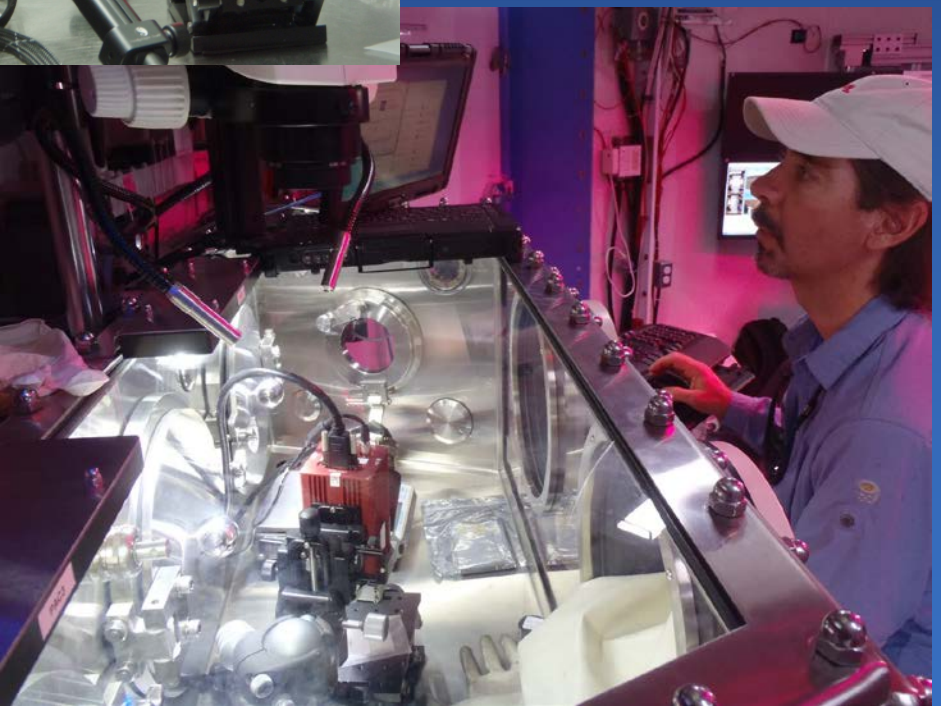


Spectral end-member map

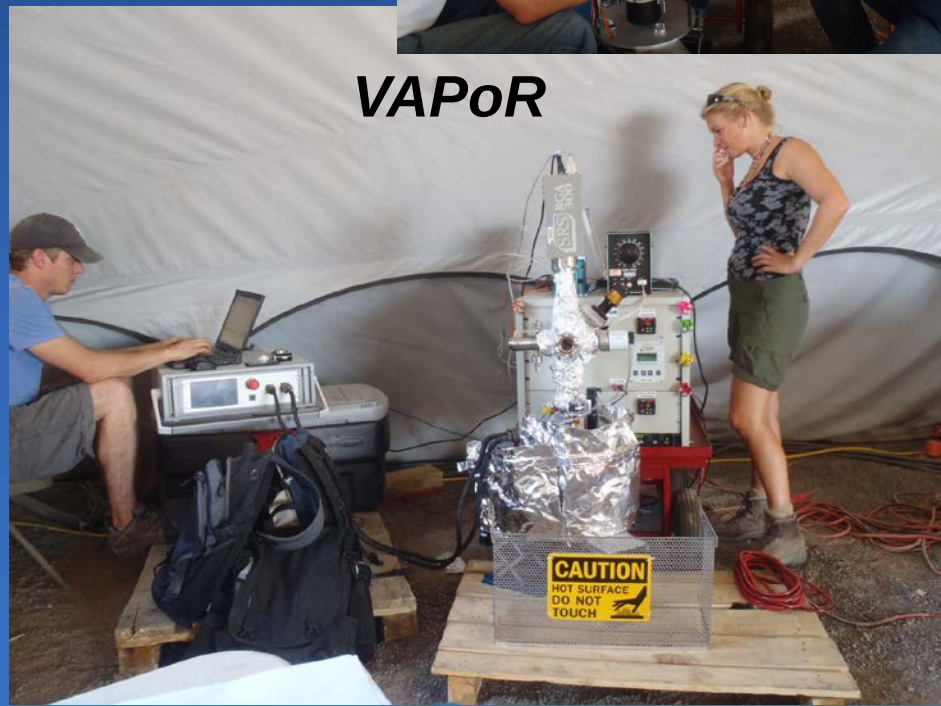




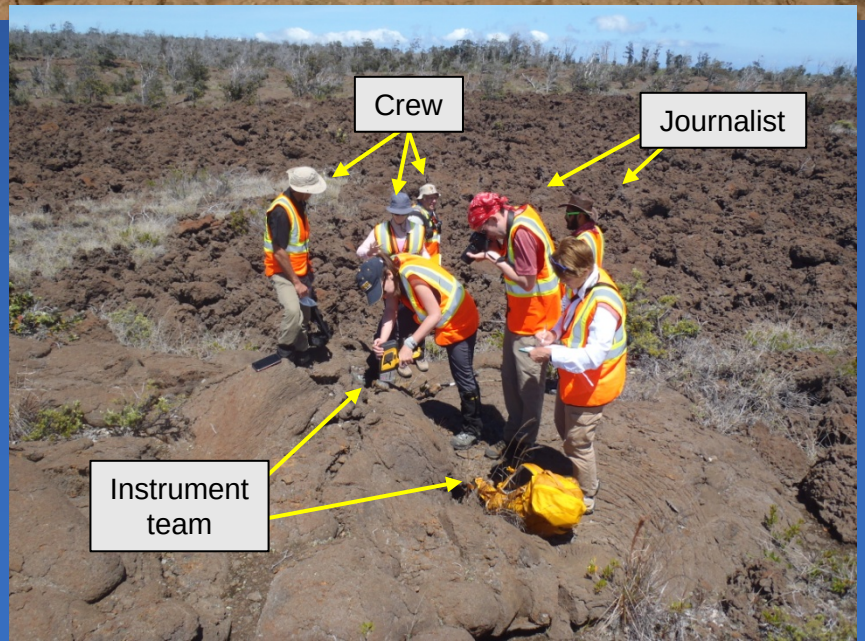
MMI



VAPoR



2015 FIELD OPERATIONS

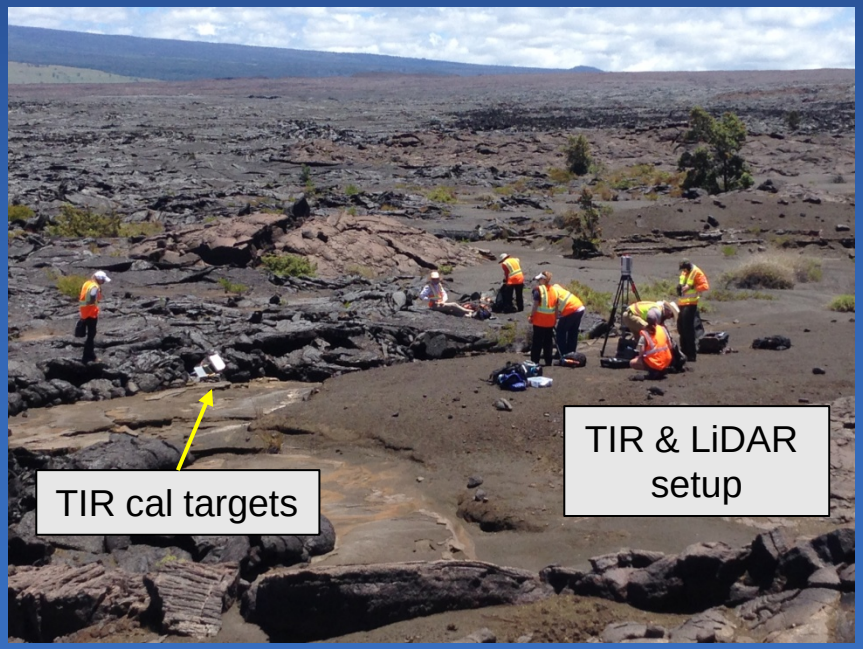


- Operational assumptions derived from Desert RATS
- Crew arrive at site of scientific interest
- Crew initiate observations from rover mounted instruments and survey site
- Upon completion of site survey crew egress for EVA
- Crew determined positions for sample specific instrument measurements
- Timelines recorded for all steps
- Timelines are entirely focused on science tasks
  - Timeline data does not include vehicle or EVA prep
  - Final results require integration with DRATS

SITE SURVEY

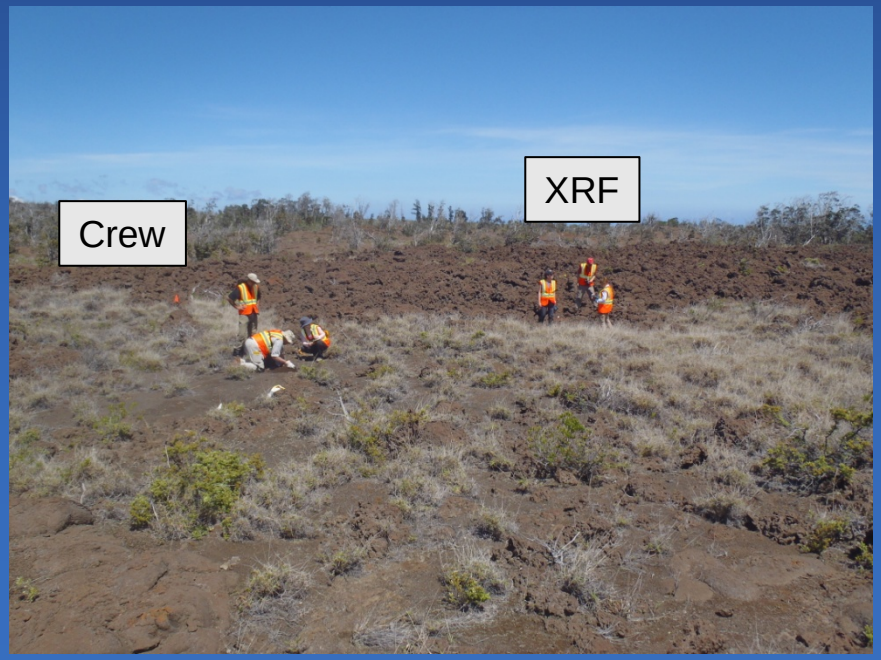
TIR & LiDAR for broad FOV

- Site survey times averaged 23 minutes
- Both TIR and LiDAR would be mast mounted on rover and times could be reduced
  - LiDAR times include set up of tripod
  - TIR times largely controlled by heat up of calibration targets



TOTAL EVA TIME

- Total crew EVA time averaged 65 minutes
- Individual XRF measurements take 2 minute to acquire
- Crew plus XRF time averaged 79 minutes
- Crew identified locations for XRF measurements and then collected samples for XRD
- XRD active at least 30 minutes

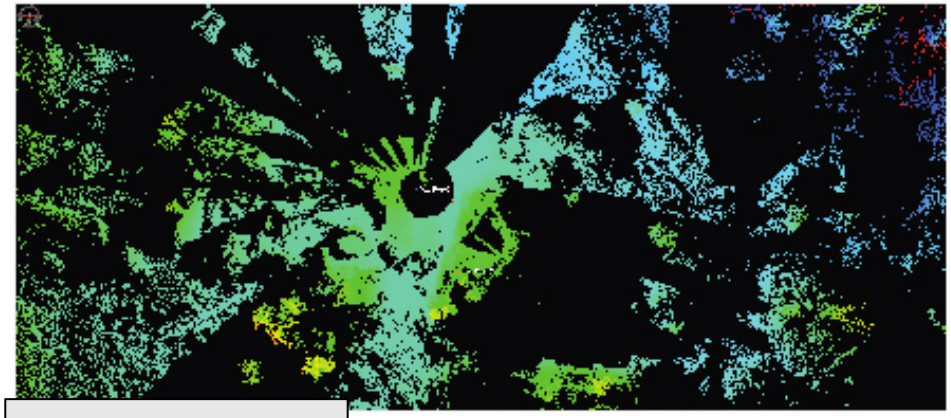


AIRBORNE OBSERVATIONS

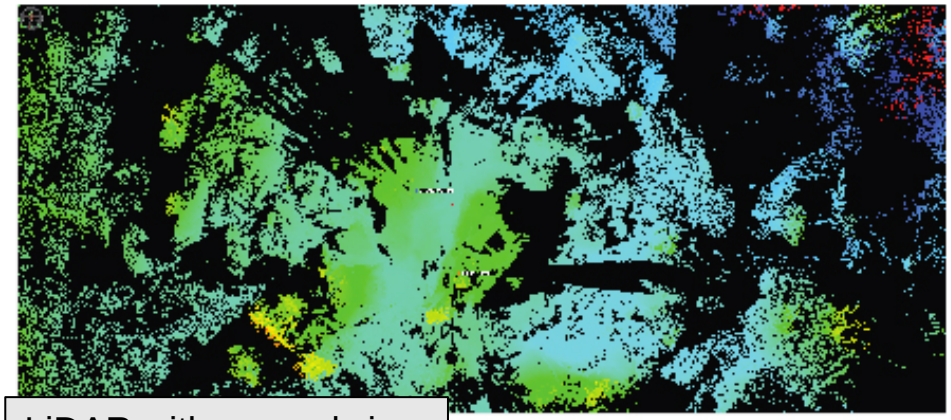
- Kites provide airborne view of site
- Produce high resolution context image mosaics
- Also produce high resolution DTMs of field site

AIRBORNE OBSERVATIONS

RESULTS LiDAR

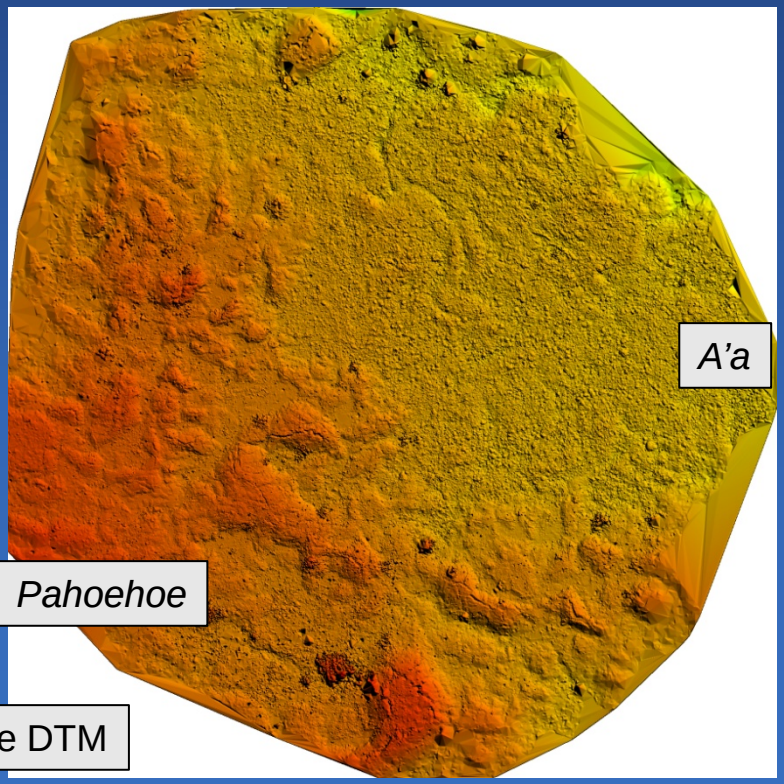


LiDAR single view



LiDAR with second view

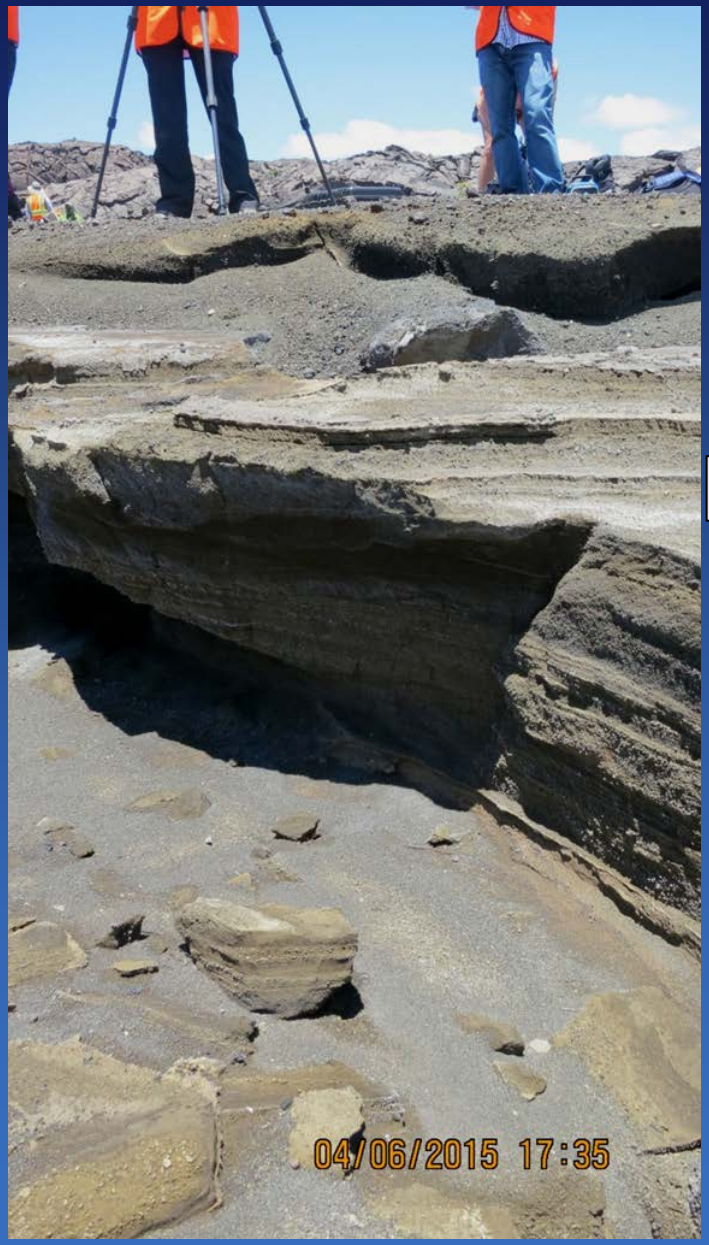
- Single scan produces up to 80% of scene in shadow
- 1 additional scan from different location reduces shadows to ~60% of scene
- Coupling LiDAR with airborne DTM data provides excellent 3D coverage



Kite DTM

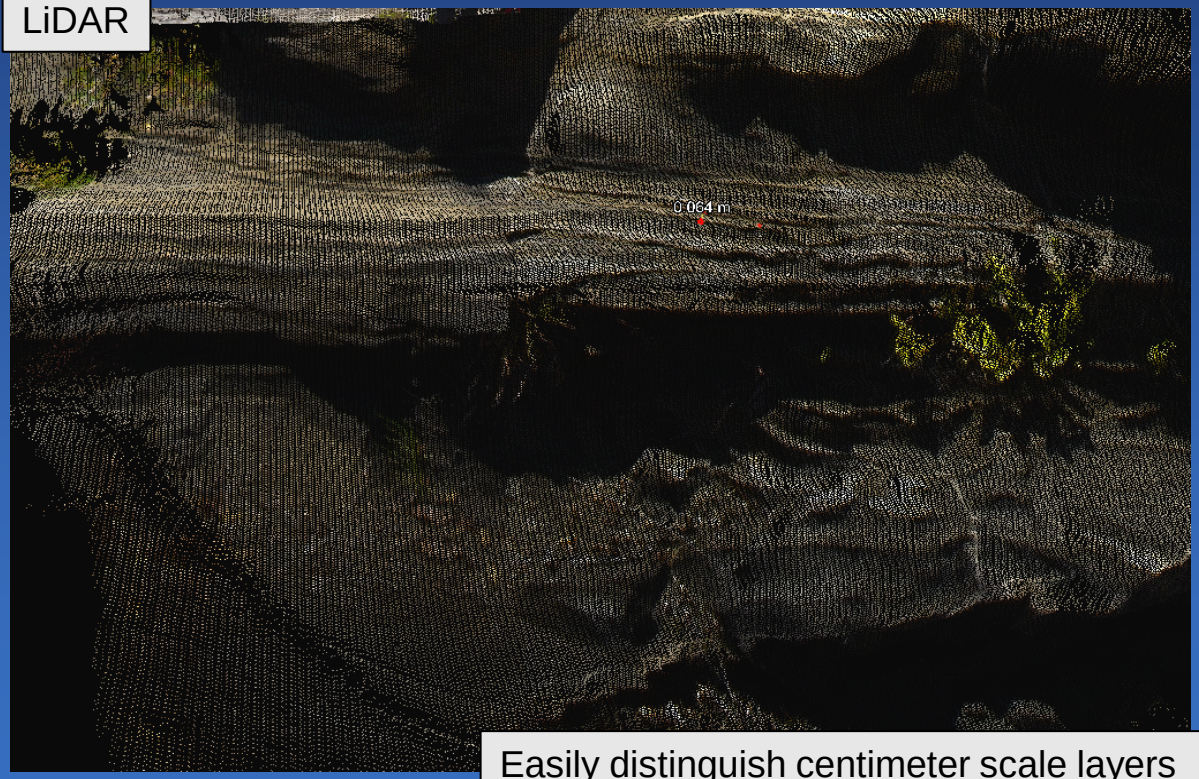
- Multiple scans from different positions is highly desirable
- Site survey instruments mounted on rover/robotic assistant?

RESULTS LiDAR



- LiDAR can capture quantitative textural data of vertical faces at millimeter scale
- Ideal for shadowed faces of outcrop
- Coupling LiDAR with airborne DTM data provides excellent 3D coverage of scene

LiDAR

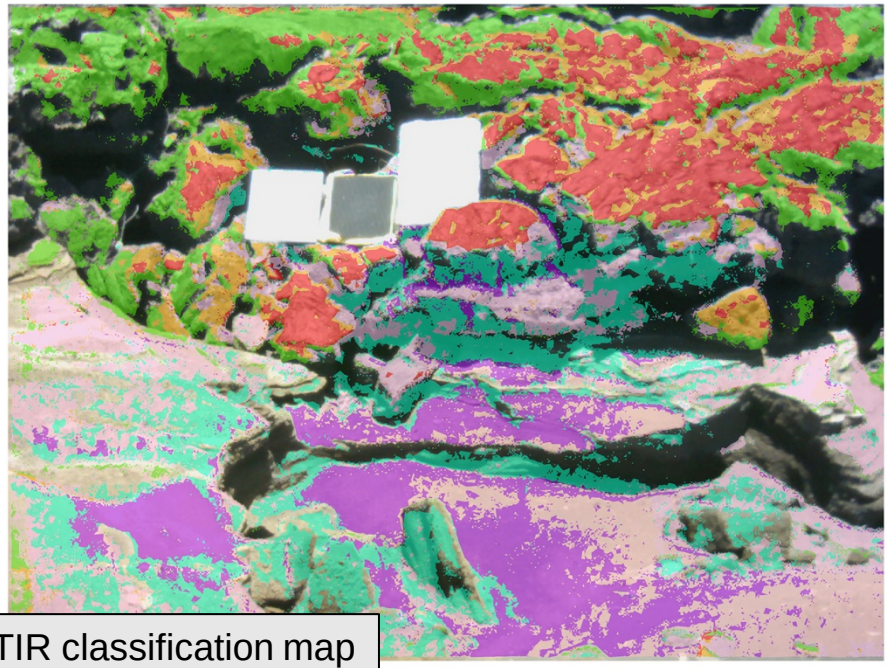


Easily distinguish centimeter scale layers

RESULTS TIR

- Broad field of view TIR provides ability for identification of unique surfaces
- Can identify variability
- Data can be used qualitatively in real time to influence sample decisions and other instrument measurements

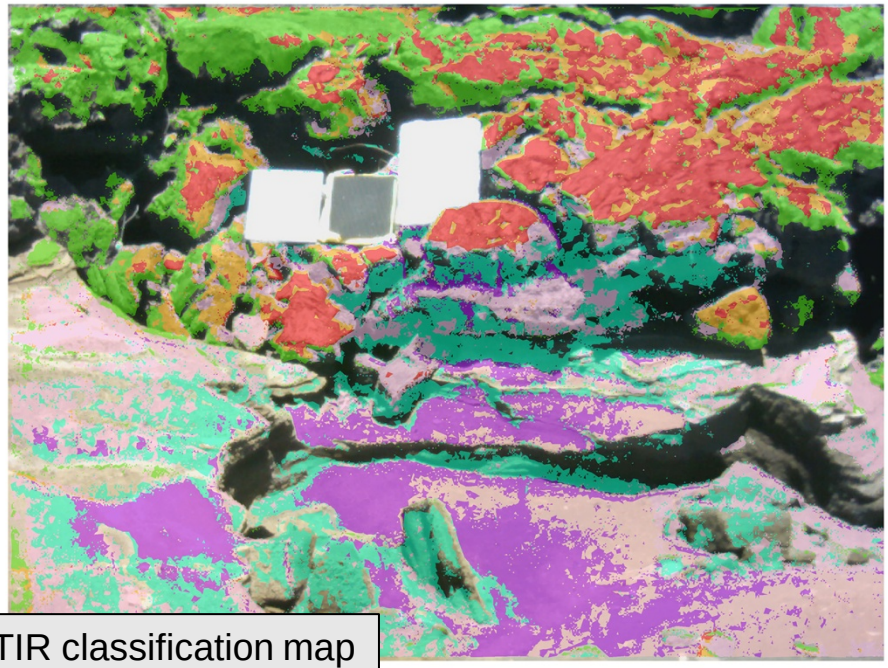
VIS



TIR classification map

RESULTS XRF

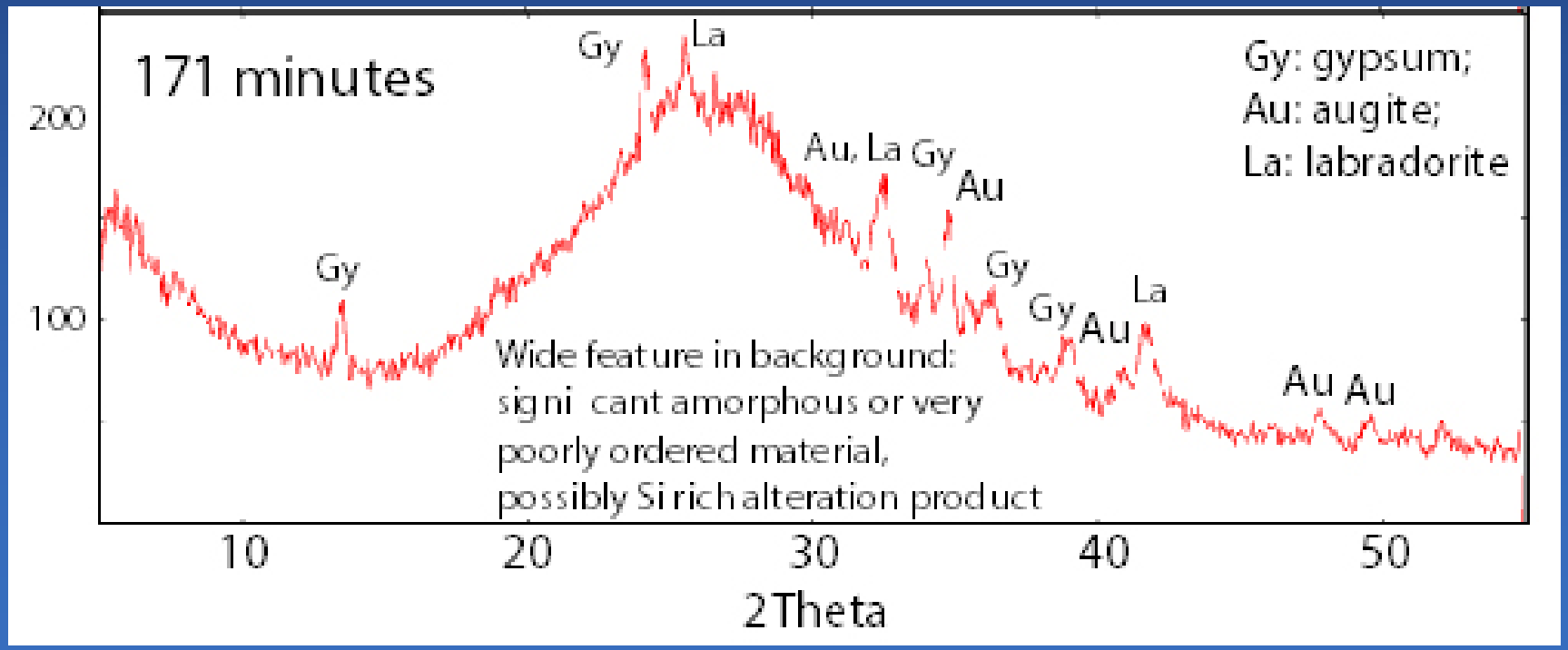
- Contact instruments enable high spatial resolution, in situ mapping of geochemical variability
  - Rock chemistry
  - Alteration products & coatings
- Contact measurements also provide ground truth from which broad FOV spectral data interpretation is enhanced
- Real time sample selection information



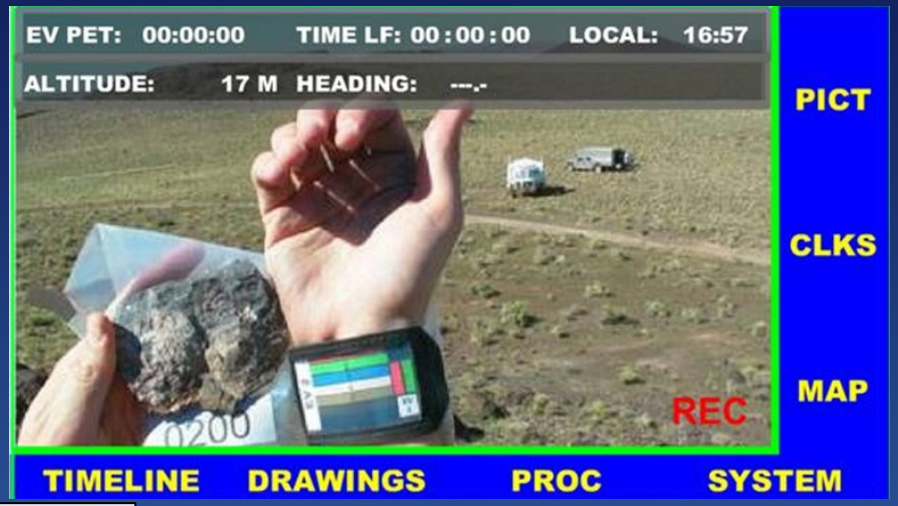
TIR classification map

RESULTS XRD

- XRD mineralogy is desirable
- Measurements of complex multiphase rocks can take up to 3 hours (sample prep)
- Traditional XRD approach likely requires modification
- New contact XRD capabilities might provide rapid data return



DATA ACCESS & IVA



EVAIS

- Site survey data should be available to crew during EVA
- Qualitative evaluation of data enhances sample selection
- Also directs site decisions for in situ measurements of geochemical variability

Use of wearable computers

DATA ACCESS & IVA

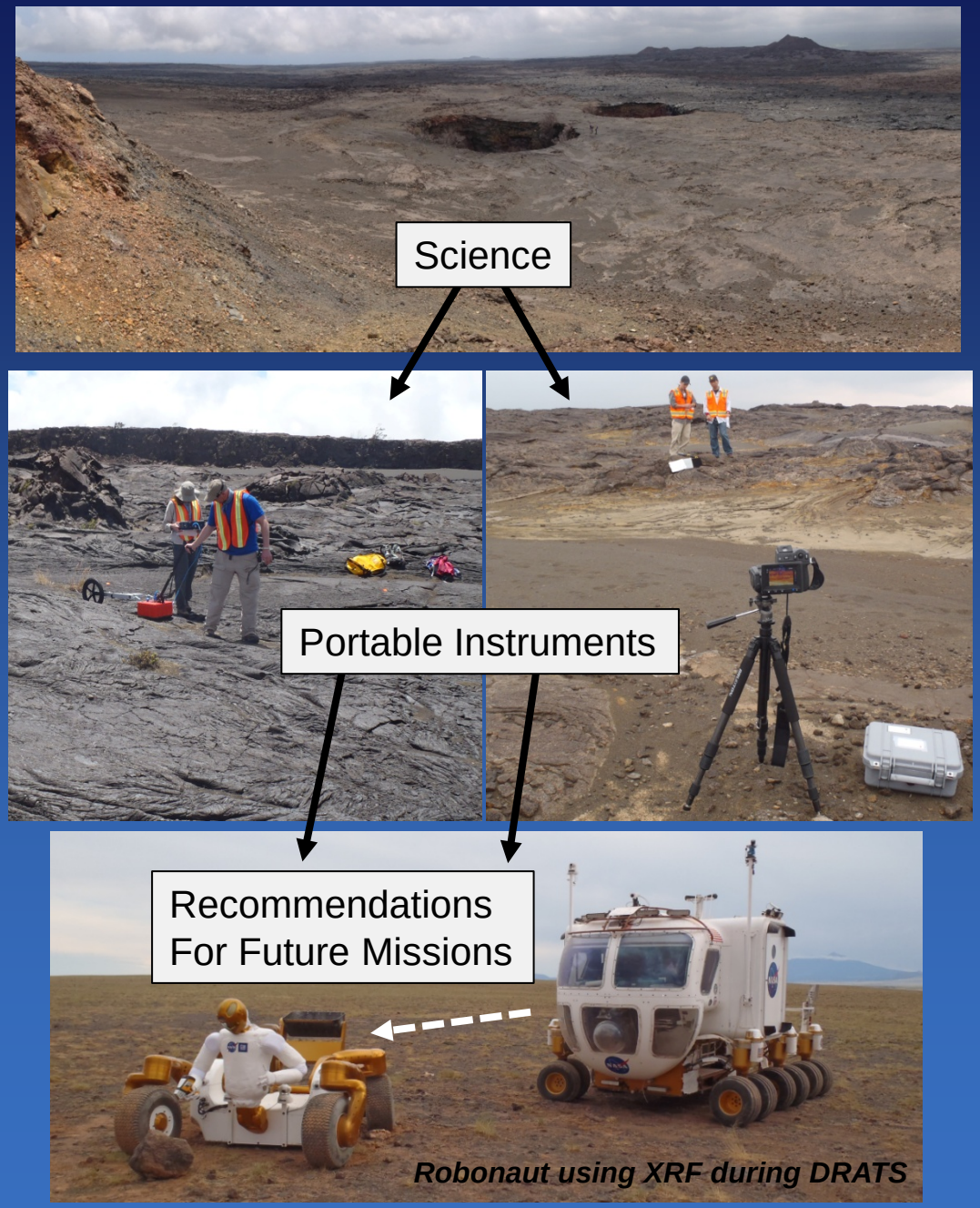
- Communication delays make use of Intra-Vehicular Activity (IVA) critical
- IV crew can evaluate data from site survey and in situ instruments
- Requires real-time data sharing between wearable computers and local (IV) crewmembers who are supporting EVA

IV in MMSEV

Multiple EVA crew

IV in DSH

CONCLUSIONS



- Real time, qualitative use of portable and in situ instrument data can be implemented in a beneficial way into EVA activities for science
- Real time data enables
  - High spatial resolution mapping
  - Sample high grading
  - Calibration points and geologic context for broad FOV data
- Instrument timelines developed here can be integrated with DRATS traverse timelines to assess impact on scientific exploration