Squeezing More Science Out of Our Orbiters: Using the Mars 2020 Rover and Returned Samples to Ground Truth Spectral Datasets

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Take-Home Message

“The Mars 2020 rover provides us with a unique opportunity to validate past, current, and future remote sensing datasets through contemporaneous and synergistic surface characterization, well-planned spectral observations, and the selection of appropriate samples for caching and eventual return to Earth.”
Outline

• Why make ground truthing a priority?
• Ground truthing success stories
• How to ground truth with the Mars 2020 rover
• Potential ground truthing targets
  — Columbia Hills
  — Jezero crater
  — NE Syrtis and Midway
Ground Truthing as a Priority

Arvidson et al. (2006)

Lapotre et al. (2017)

Edwards et al. (2018)

Ruff et al. (2006)
Ground Truthing as a Priority

- **Goal of remote spectroscopy**: Derive surface properties
  - Composition, thermophysical properties, etc.
- **Many unknowns exist**, including:
  - (Ever changing) atmospheric contributions
  - Bidirectional reflectance distribution
  - Surface (and subsurface) properties, including packing, grain size distribution, etc.
- **Assumptions must be made to address these unknowns**

Success Stories

- Lunar samples have long been used to validate remote sensing datasets
  - Gamma ray spectroscopy (right)
  - Reflectance spectra (e.g., Pieters et al., 2009)
  - Emission data (below)

- Have provided insight into the source of many major spectral features
  - E.g., space weathering (Pieters et al., 2000; Noble et al., 2001)
Success Stories

• Ground truthing of orbital datasets in the McMurdo Dry Valleys (MDV) of Antarctica
  – Pre-field determination of ground truthing locations
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  - Documentation and laboratory investigations
  - Association with other analyses and identification of key relationships
Success Stories

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  - Pre-field determination of ground truthing locations
  - Documentation and laboratory investigations
  - Association with other analyses and identification of key relationships
  - Translate back to remote sensing data for broader application to non-validated locations

Modified from Salvatore et al. (2014)
Success Stories

Snippets from Salvatore (2015)
Ground Truthing with Mars 2020

Mars 2020 Rover

- RIMFAX Electronics
- SHERLOC Electronics
- SuperCam Calibration Target
- Mastcam-Z Calibration Target
- RIMFAX Antenna
- SuperCam Body Unit
- MOXIE
- MEDA Thermal Infrared Sensors
- 3 x MEDA Air Temperature Sensors
- MEDA Electronics & Pressure Sensor
- MEDA Radiation & Dust Sensor
- SuperCam Mast Unit
- 2 x Mastcam-Z Camera
- 2 x MEDA Wind Sensors
- SHERLOC Sensor
- SHERLOC Calibration Target
- SHERLOC Sensor
- 2 x MEDA Air Temperature Sensors
- PIXL Sensor
- PIXL Calibration Target
- PIXL Electronics
- Mastcam-Z Digital Electronics Assembly

NASA
Ground Truthing with Mars 2020

Wellington et al. (2017)
Ground Truthing with Mars 2020

Credit: NASA/JPL-Caltech
Ground Truthing with Mars 2020

Credit: NASA/JPL-Caltech

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Ground Truthing with Mars 2020

(a) Image of the Mars surface with a robotic arm. 
(b) Image showing the 31 sample cache with sealing and sample tubes. 
(c) Graph showing the emissivity as a function of wavenumber (cm⁻¹) with peaks at certain wavenumbers.
Ground Truthing with Mars 2020

(a) Image of Mars surface with robotic arm.

(b) Image of 31 Sample Cache components:
- Seal
- Sample Tube
- Core Sample

(c) Graph showing emissivity vs. wavenumber (cm⁻¹) for:
- 58% Basalt
- 31% Olivine
- 11% Carbonate
- Bulk Returned Sample
- Modeled Result from Mineral Endmembers

Credit: NASA/JPL-Caltech
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Ground Truthing with Mars 2020
Ground Truthing with Mars 2020

[Image of a scene from Mars, labeled Credit: NASA/JPL-Caltech]

[Image of a sample cache and related hardware, labeled Credit: NASA/JPL-Caltech Modified from Original Form]

[Graph showing emissivity vs. wavenumber (cm⁻¹), labeled Quantitative Carbonate Parameter, THEMIS Spectrum, Modeled Result from Mineral Endmembers, 58% Basalt, 31% Olivine, 11% Carbonate, Bulk Returned Sample]
Ground Truthing with Mars 2020

Credit: NASA/JPL-Caltech

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What Makes a Good Ground Truthing Candidate?

- Unique spectral/morphological signatures
  - Indicative of formation and/or modification processes
- Spatially extensive
  - Can be identified and characterized from orbit
- Geologically relevant
  - Informative and applicable to broader geologic questions

*Sounds like our current strategy for sampling and surface analyses!*
Ground Truthing @ Columbia Hills

• Spatially extensive geologic units:
  – Basaltic plains, surface dust, Comanche/Algonquin unit (Ruff et al., 2014)?

• Basaltic plains:
  – “Typical” Hesperian-aged volcanics
  – Datable surface – correlation to weathering (e.g., Mazatzal?)

• Surface dust:
  – Globally pervasive and physically/compositionally homogeneous
  – Valuable for spectral mixing models, understanding the effects of thin layers, human exploration implications, etc.

• Comanche/Algonquin unit:
  – Volcaniclastic unit, ~40 wt% olivine, ~25 wt% carbonate
  – Relationship to carbonate-bearing units in NE Syrtis region?
Ground Truthing @ Jezero Crater

• Spatially extensive geologic units:
  – Volcanically resurfaced floor, carbonate-bearing floor material, fan deposits

• Volcanically resurfaced floor:
  – “Typical” Hesperian-aged volcanics?
  – Relationship to underlying olv/carb-bearing unit?

• Carbonate-bearing floor material:
  – Relationship to regional carbonate unit,
    Comanche/Algonquin unit in Gusev crater, etc.?

• Fan deposits:
  – Aggregate of units present within the Jezero watershed
  – Smectite signatures and relationship to mode of formation
    (authigenic or detrital?)

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Ground Truthing @ NE Syrtis & Midway

• Spatially extensive geologic units:
  – Smectite-bearing basement, olivine-carbonate units, megabreccia blocks

• Smectite-bearing basement:
  – Correlate spectral and compositional diversity
  – Inform complex spectral unmixing models and compositional estimates

• Olivine-carbonate unit:
  – Relationship to Comanche/Algonquin unit in Gusev crater and other regionally extensive olv-carb-bearing units?

• Megabreccia blocks:
  – Ancient remnants of ancient Noachian crustal materials?
  – Diverse suite of samples could serve to validate remote sensing efforts of the ancient Noachian crust
Summary & Take-Home Message

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