Instrument Case History: Calibration, Characterization, & Cataloguing
or
A recipe for a healthy instrument

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Calibration, Characterization, & Cataloguing

- What is the process?
- Why calibrate with geologic samples?
- Examples of past and current calibrations with geologic samples
- Lessons Learned
- How can we make the process better?

Example of Process

(stolen from Mike Hecht during a recent MECA Calibration Review)

	Verification	Validation	Calibration	Characterization	Cataloguing
Description (What?)	Confirm L4 requirements are met	Confirm L3 requirements are met	Get information needed to process data	Learn capabilities & vulnerabilities	Collect response library
Responsibility (Who?)	Project team	Project Team	Science defines, Project tests	Science Team	Science Team
Primary Platform (Where?)	Engineering Qualification Model (EQM)	EQM	Flight Model (FM)	Testbed EQM	Testbed EQM
Delivery (When?)	Spacecraft Integration	Spacecraft Integration	Spacecraft Integration	Start of mission	End of mission
Purpose (Why?)	Make sure widget works	Make sure widget does the right thing	Make sure we can *use* the widget data	Make sure we can *understand* the widget data, seize opportunities, and avoid failures	Make sure we can *interpret* the widget data

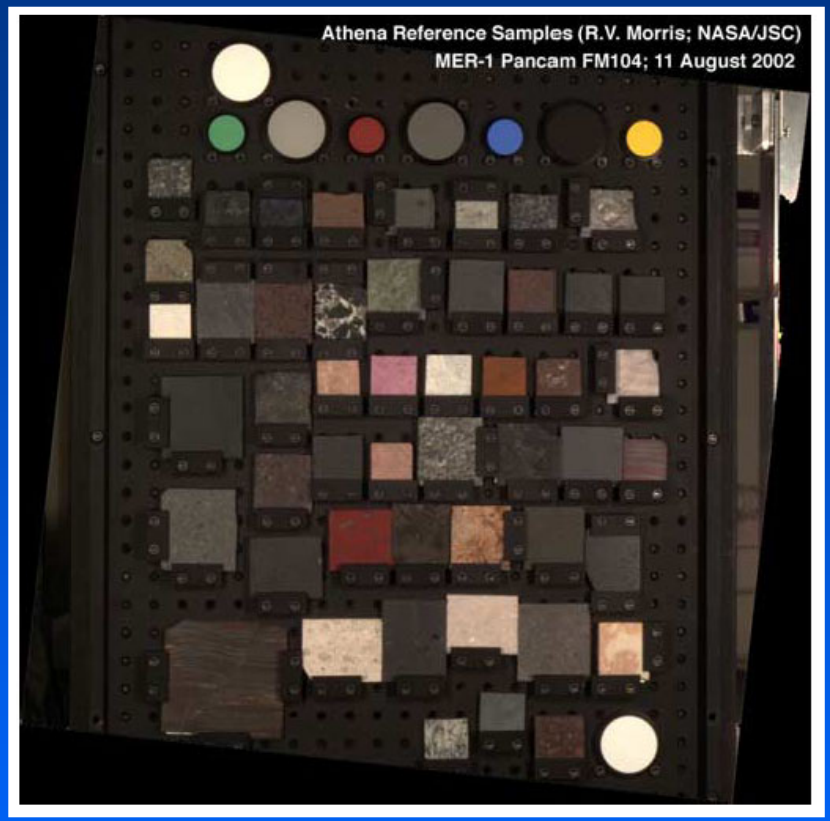
Why Measure Geologic Samples with FM and/or EM Science Instruments?

- To validate for mission teams and the general scientific community the primary instrument calibrations and performance.
  - Validation for general scientific community communicated via pre-mission peer-reviewed scientific publications.
- To provide a backup to and a refinement for primary instrument calibrations, i.e., validation of instrument calibration (e.g., for cameras NIST-traceable color and grey-scale standards are also imaged as targets).
- To provide a set of flight-instrument data on geologic samples for use in ORTs.

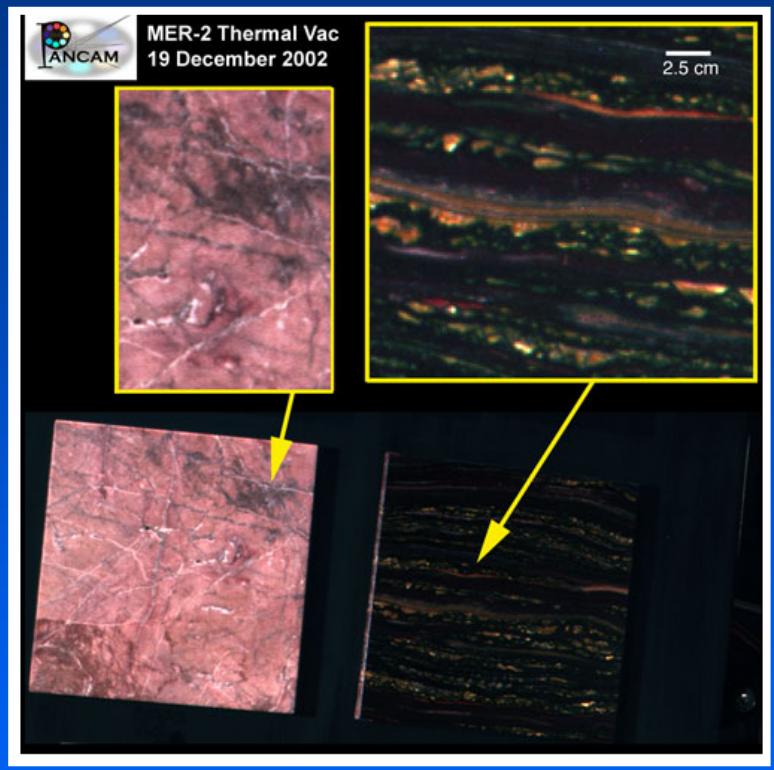
Why Measure Geologic Samples with FM and/or EM Science Instruments?

- Provide an element of cross-calibration among mission science instruments (e.g., For MER, to document the relative sensitivity of Pancam, MB, and mini-TES to olivine in olivine-bearing samples).
- To aid in characterization of measurement errors and identification anomalies in data returned from Mars.
- Measurement of geologic samples has been done for flight-model and/or engineering model instruments for:
  - MPL TEGA
  - MER Pancam, MI, mini-TES, MB, and APXS
  - CONTOUR CRISP and CFI
  - MESSENGER
  - MRO CRISM and MARCI
  - Mars Express OMEGA
  - Phoenix (RAC-FM to date)

Examples from MER FM Pancam (from Bell et al., *JGR*, 2003)



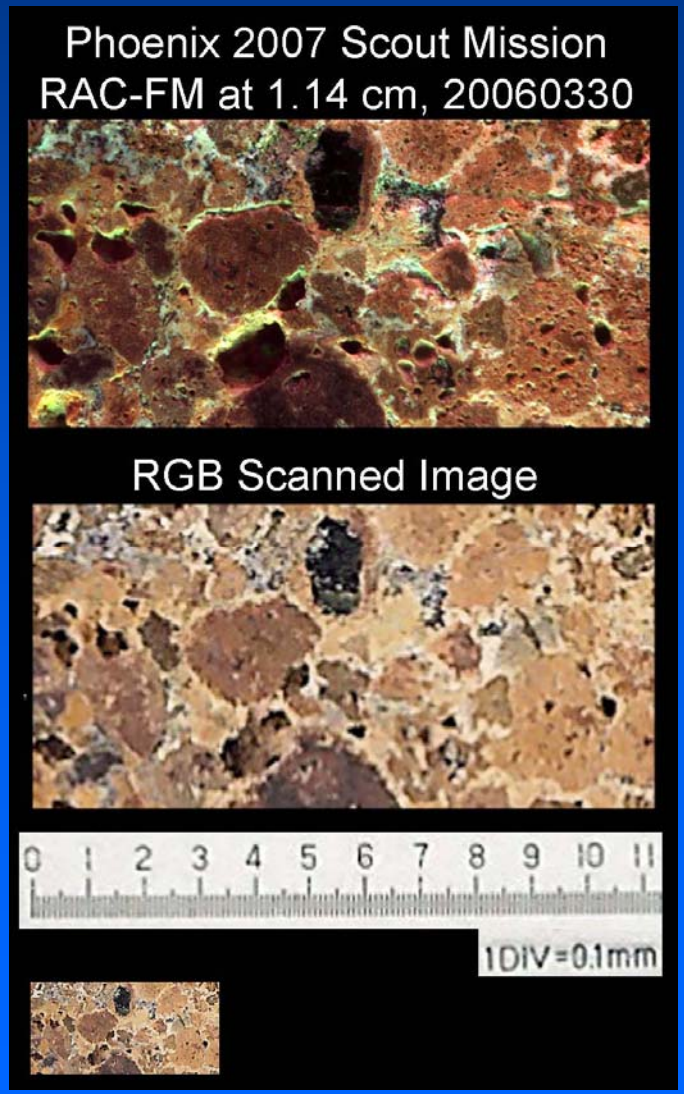
Pancam color composite image of rock target imaged during standalone camera thermal vacuum testing at -55 ºC [1024 x 1024 image from MER-1 left Pancam bands L4 (602 nm), L5 (535 nm), and L6 (483 nm)]



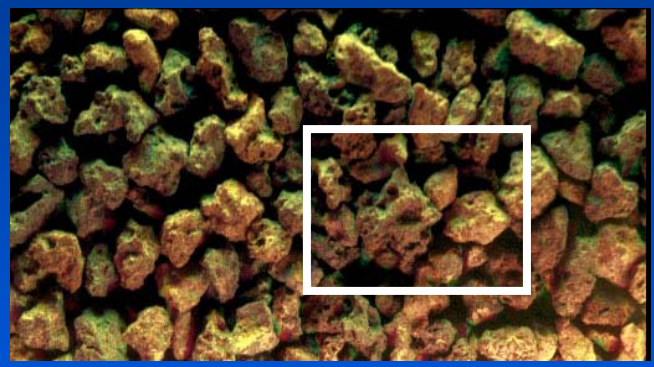
Pancam color composite image of rock target imaged during rover system thermal vacuum testing a -30ºC [1024 x 1024 image from MER-2 left Pancam bands L4 (602 nm), L5 (535 nm), and L6 (483 nm)]

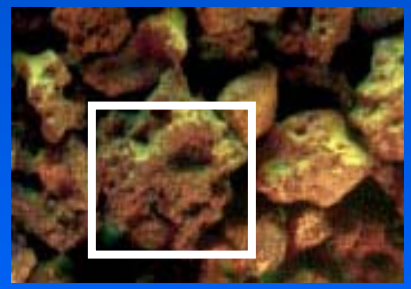
Examples from Phoenix RAC-FM

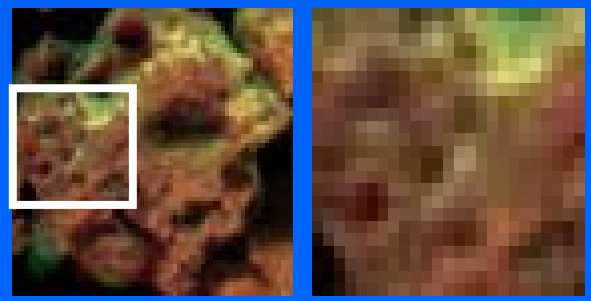
(Preliminary images not fully calibrated; room temperature)



500-1000 µm size fraction of volcanic Tephra at 1.14 cm, March 30, 2006

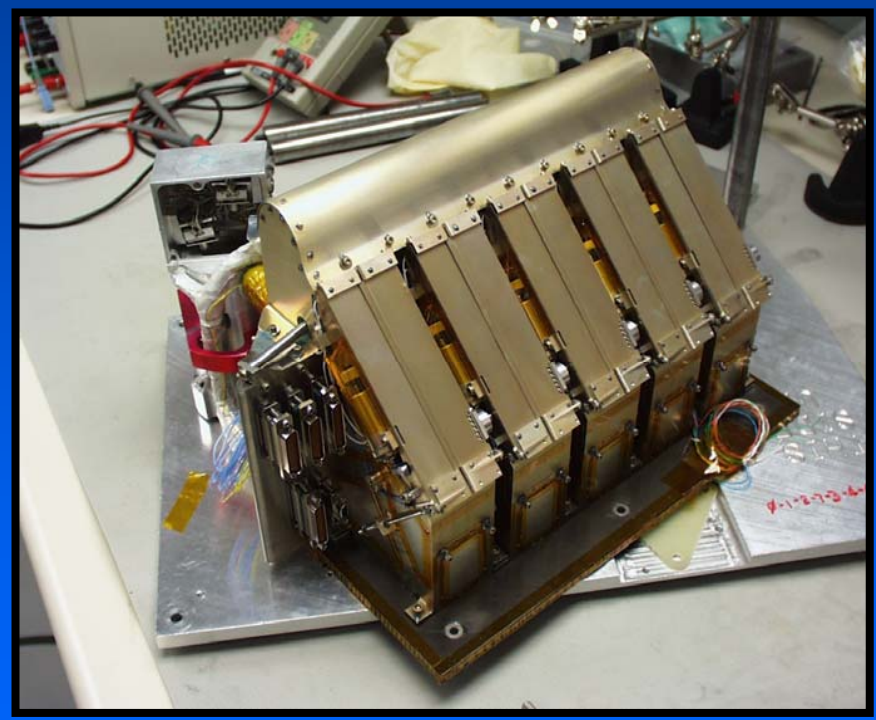






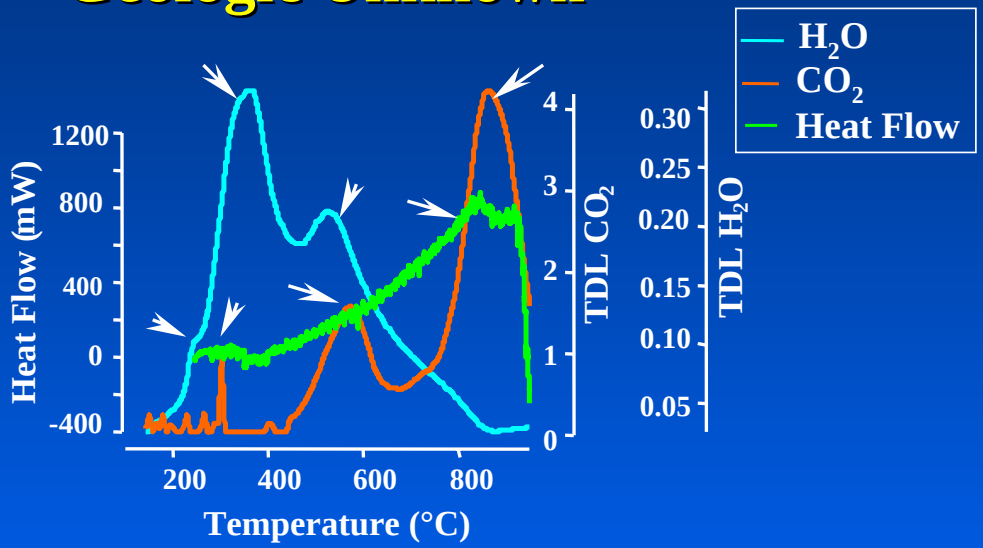
MPL Thermal Evolved Gas Analyzer (TEGA) Geologic Unknown Test

- Geologic unknown sample supplied by Dick Morris
- TEGA team examined DSC and EGA data from geologic unknown sample run on TEGA-EQM during MORT
- Unknown interpreted using DSC/EGA catalogue of geologic samples (obtained on laboratory testbed)



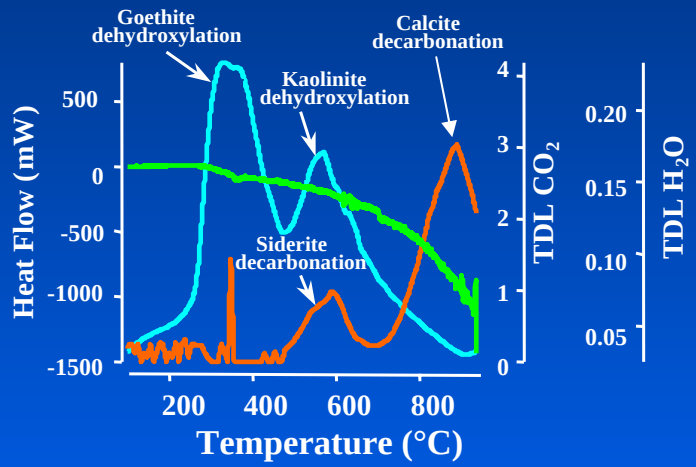
MPL TEGA Geologic Unknown Test

Geologic Unknown*



mineral	wt. %
siderite	12.1
calcite	44.1
**1:1 phyllosilicate	12.5
goethite	29.1
quartz	2.3

"Best Guess" Sample



mineral	wt. %
siderite	8
calcite	38
kaolinite	6
goethite	28
tephra	20

*British Chemical Standard (BCS302), Lincolnshire iron ore.

**Note: 1:1 phyllosilicate not identified by BCS

Recommendations and Lessons Learned

- Develop Calibration, Characterization, and Cataloguing (CC&C) Plan early in the process (before PDR)
  - Formal peer review of the “Plan”
- Get the Science Team involved in the development of the “Plan” and during CC&C activities
- Use well-characterized geologic samples during calibration and characterization activities
- Have an internal calibration sample/target when applicable (e.g., CCT for MB on MER, Cal Target for Pancam, organic blank, etc.)

How do we improve the process?

- I don’t know – that is the purpose of this exercise
- Possibilities?
  - Have a repository of well-characterized geologic samples for C&C (something like what Dick Morris does for instrument teams)
  - Have a mechanism to get calibration data into the hands of the science community (PDS, peer reviewed publications, internal documents?)
  - Place Cataloguing data on the PDS (CRISM model)