The Mars Microbeam Raman Spectrometer (MMRS):

From Concept to Category-1 Proposal

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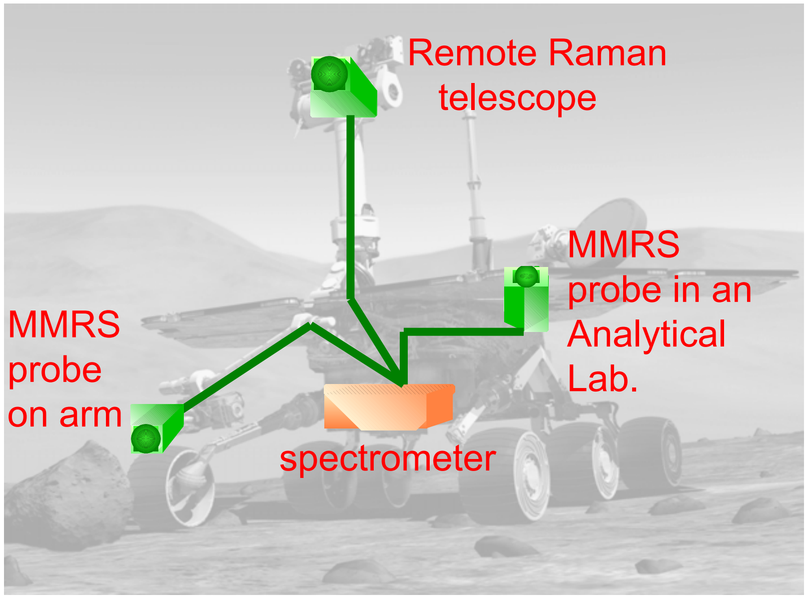
Outline

- Formulating the Concept
- Science Rationale and Applications
- Development History
  - First Opportunity & Teaming with JPL
  - Further Development – Athena ’03
  - Continued Development – MSL
- High Hurdles and Lessons Learned

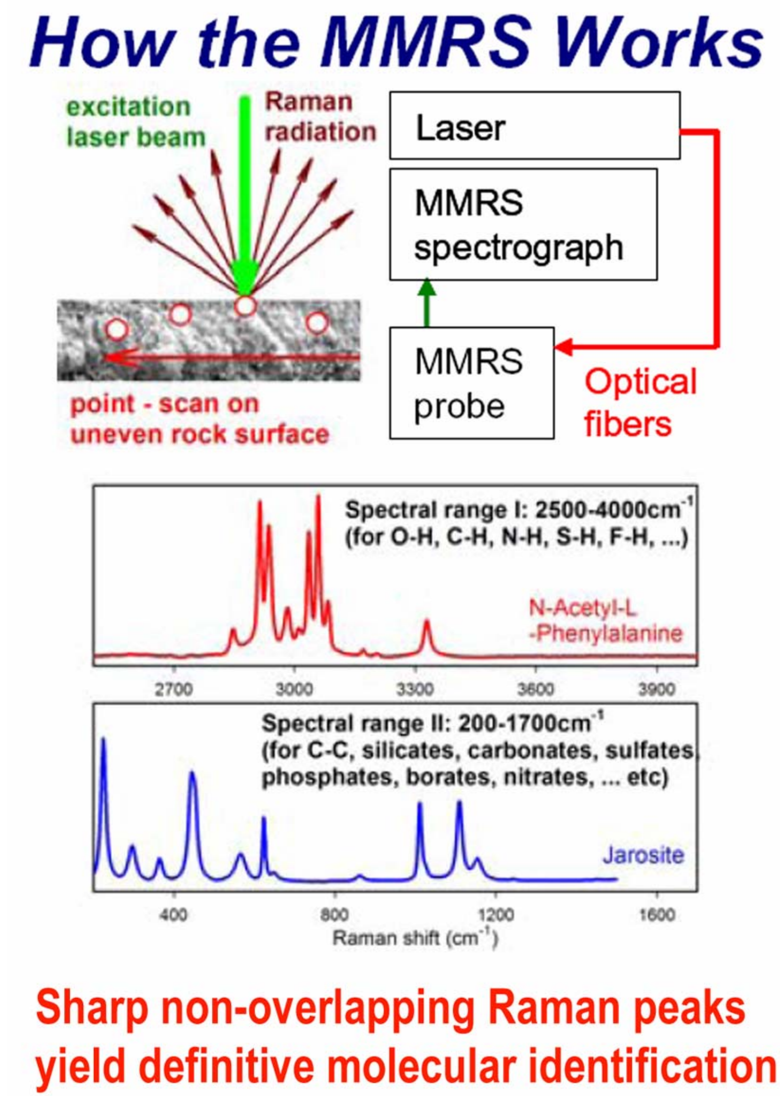
What is the MMRS?

Mars Microbeam Raman Spectrometer



- **Laser Raman Spectroscopy is flexible – can be deployed in many ways.**

- **MMRS tailored for rover-based mobility platform and for Mars fundamental science objectives.**



Formulating the Concept

- **Hallway chats, Lunar Discovery concepts (early '90s), and a clever Raman Spectroscopist…**
- **Tests using laboratory instruments on lunar samples**
  - **The would-be PI had to be convinced…**
  - **Results presented at LPSC & other conferences**
- **JPL Raman Spectroscopy Workshop, 1997**

❖ **The MMRS was initiated by science requirements – to determine mineralogy, mineral chemistry, & molecular phase identification, including organics.**

Science Rationale & Applications

- **Rock-forming mineral identification**
- **Identify minerals in mixtures**
- **Mineral Chemistry**
- **Mineral Modes (proportions)**
  - Including minor/trace phases
- **Alteration**
  - Olivine alteration
  - Phyllosilicate clay alteration
  - hydration
- **Bio-Signatures**

Rock origins, Environments, Role of water, Carbon

Science is the driving force for development.

Rock-forming Minerals; Mixtures

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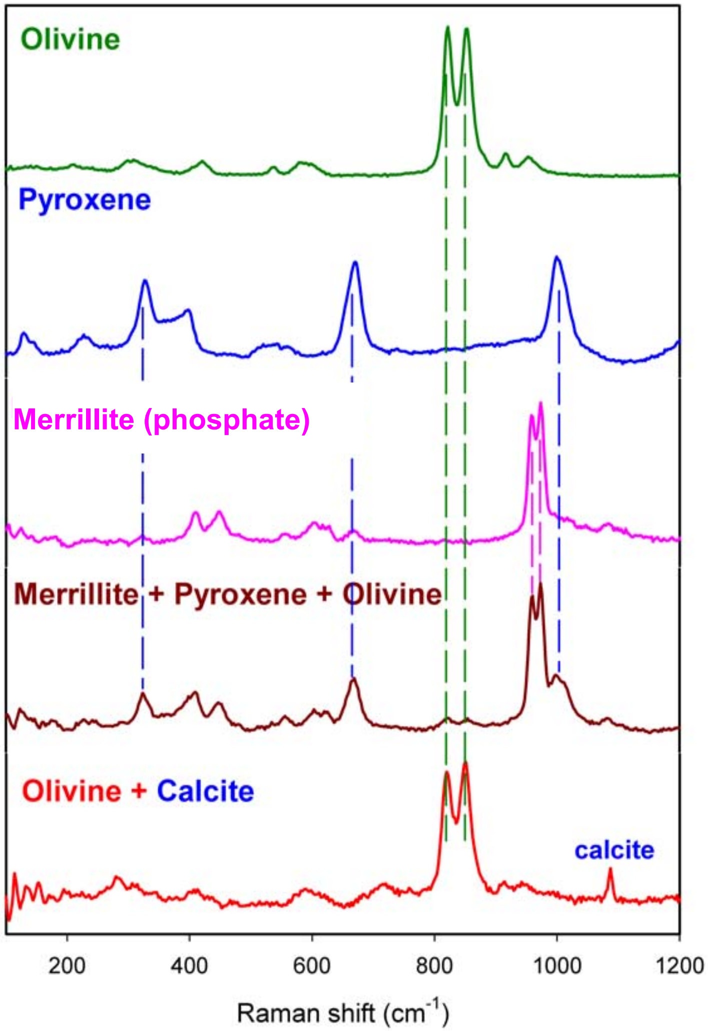
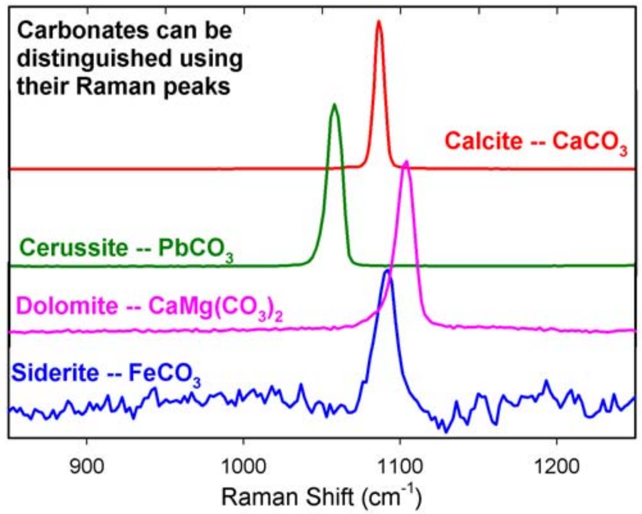
Igneous



Sedimentary



Mineral mixtures are readily determined because peaks are sharp and non-overlapping.

Mineral Compositions → Petrogenesis

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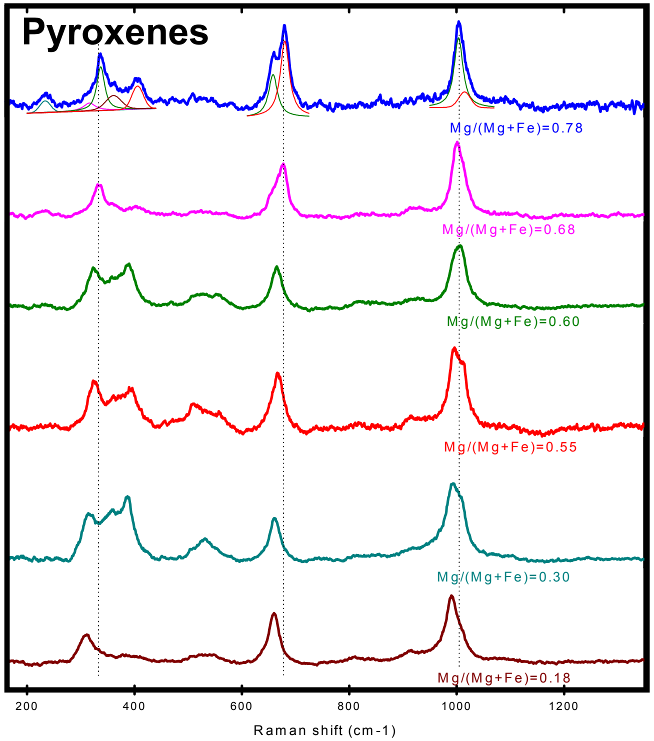


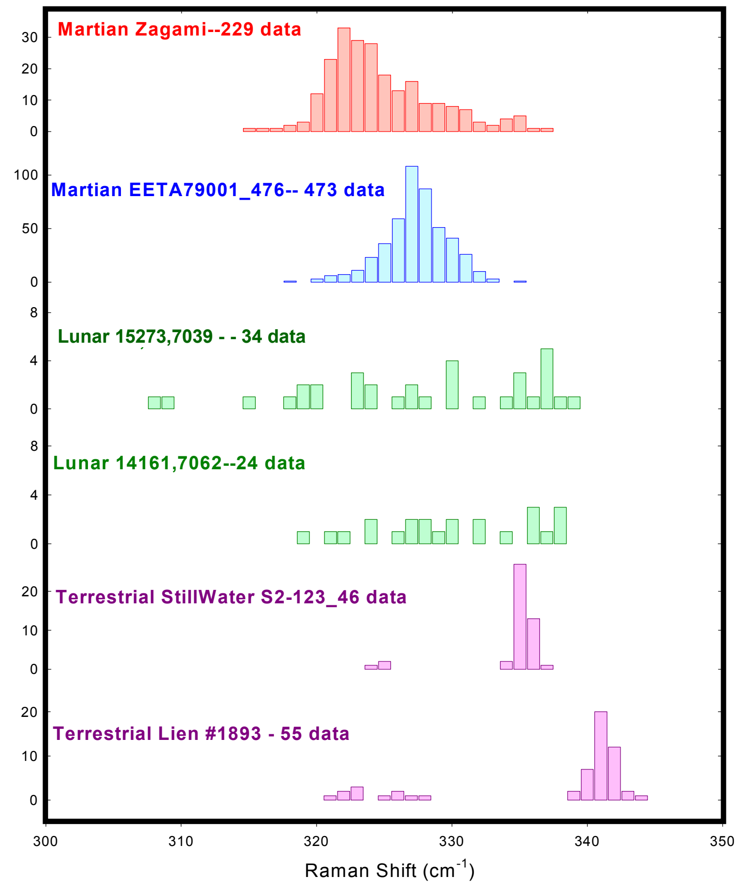
Structure

orthorhombic

monoclinic

triclinic (pyroxenoid)

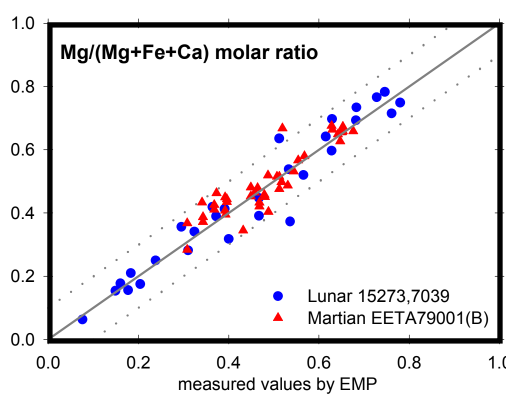
Crystallization History



Distribution reflects cooling history

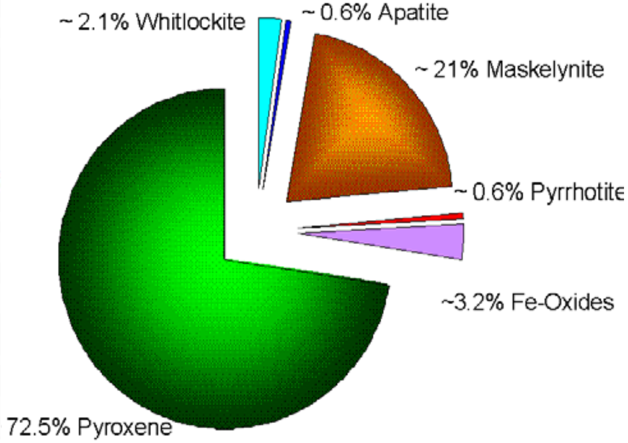
Composition

Mg/(Mg+Fe+Ca)



Mineral Mode & Trace Phases

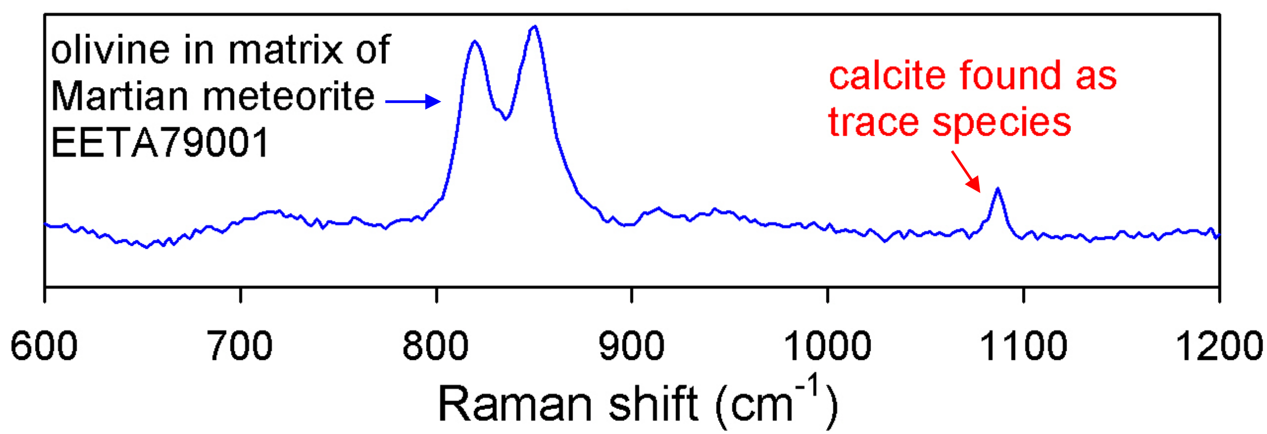
Zagami



What is the mineral assemblage?

What does it tell us about the rock's origin?

Secondary phases indicate alteration process.



JPL

Alteration: Olivine

Washington University in St. Louis

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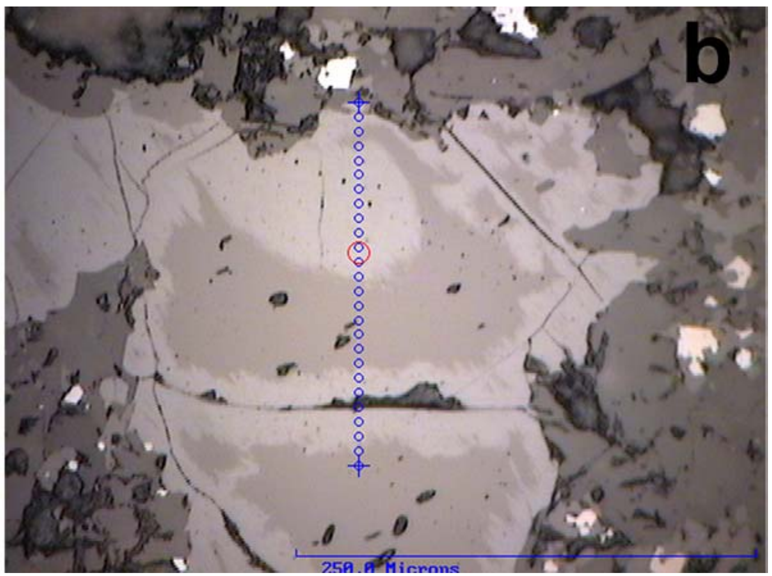
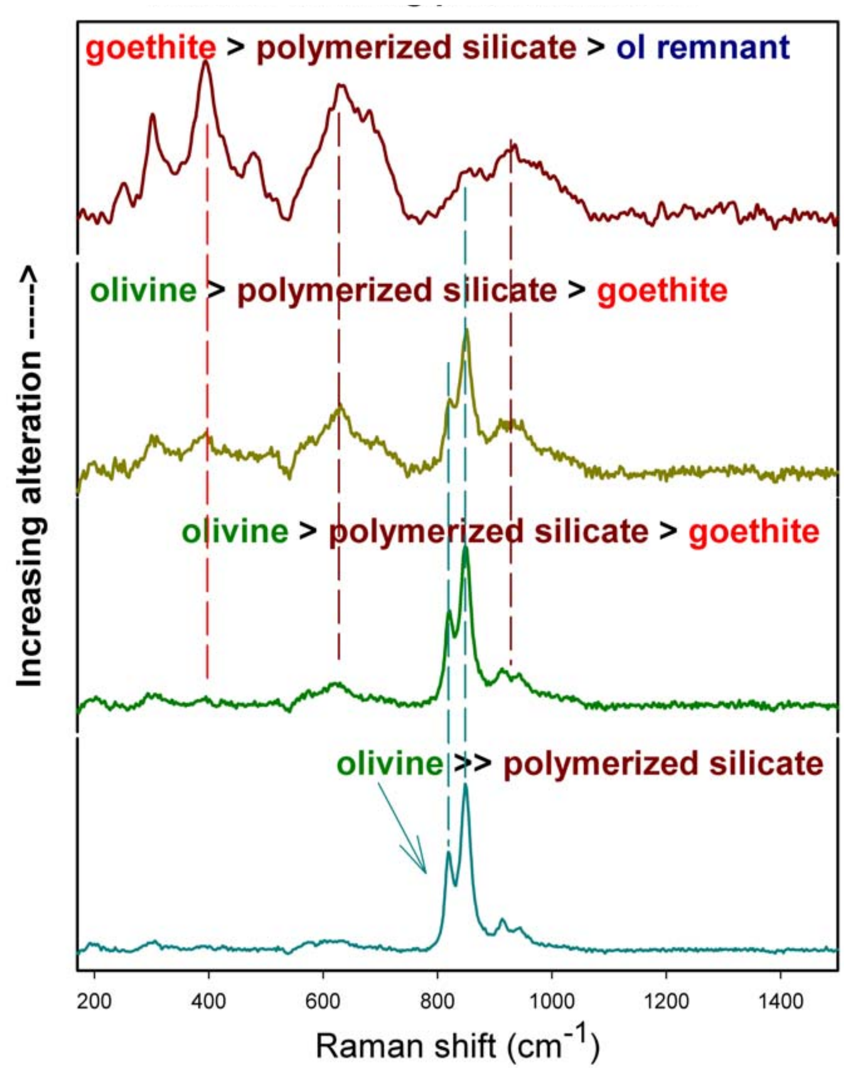
What is the degree of alteration and what was the environment in which it occurred?



Reflected-light microscopic image of olivine partially altered to iddingsite.



Secondary Mineralization

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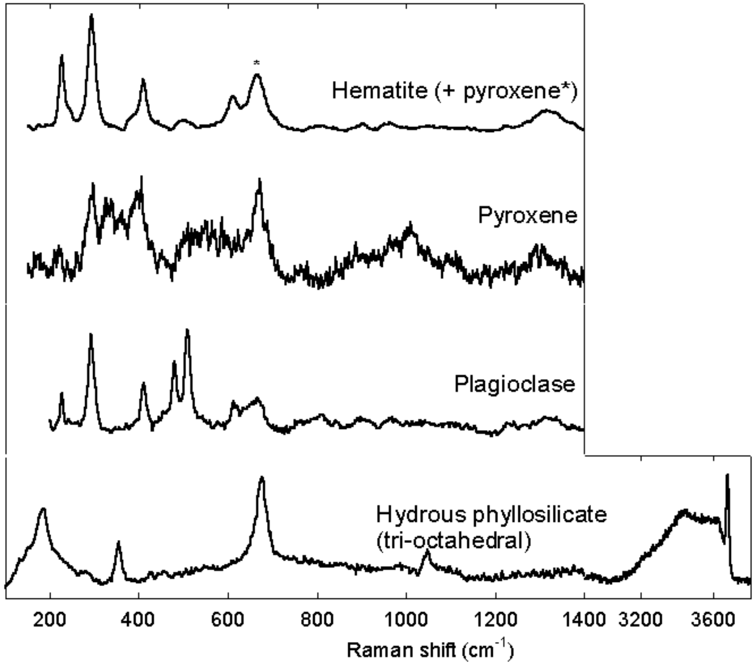

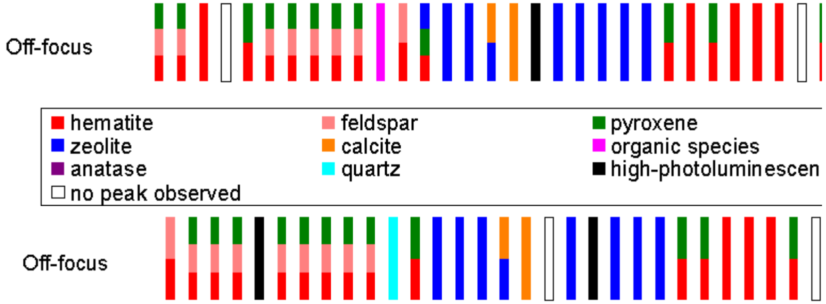

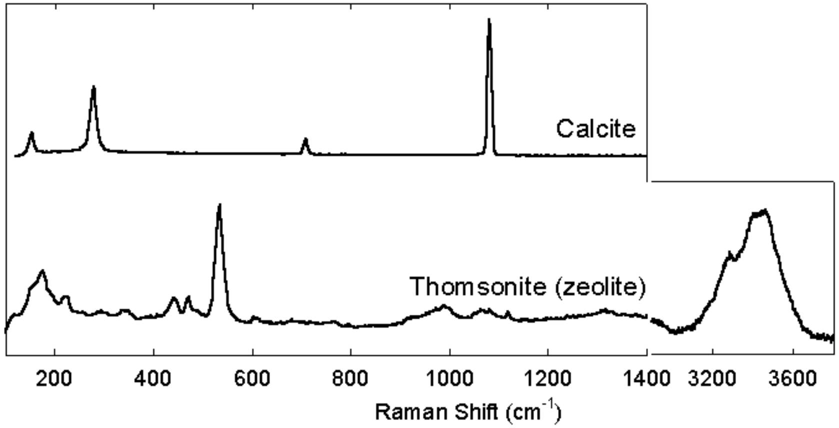

JPL

Alteration – phyllosilicate clays

Washington University in St.Louis

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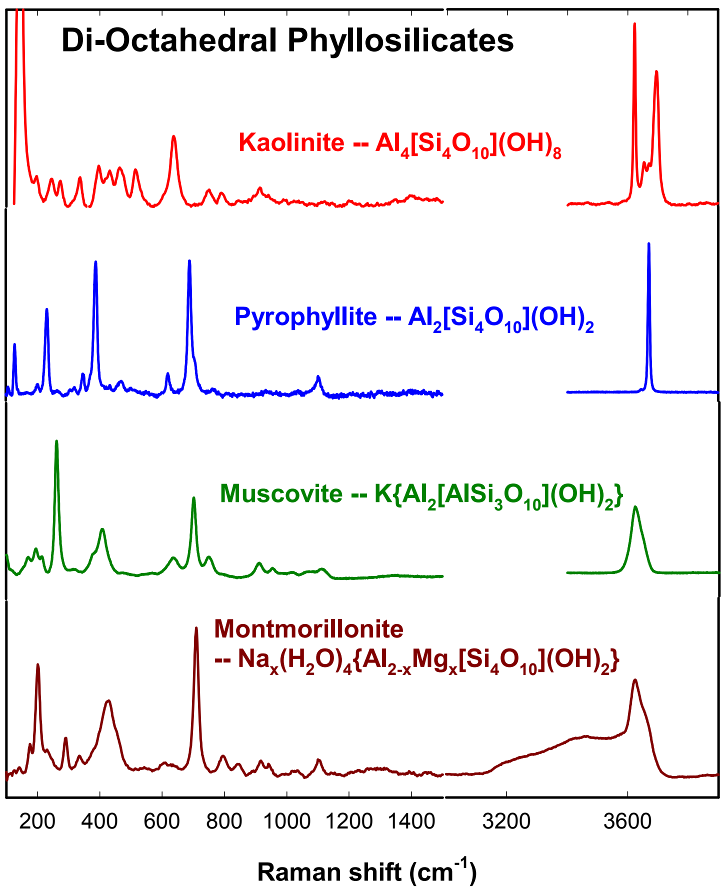
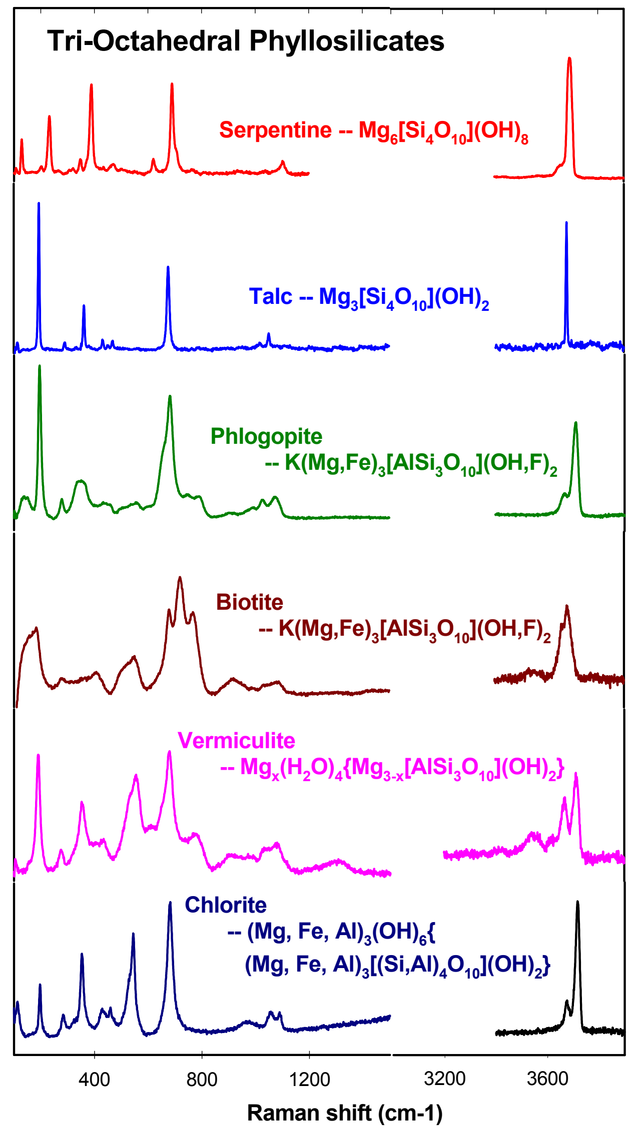


How & where is water sited and what were the conditions of formation?



Alteration: Hydration States

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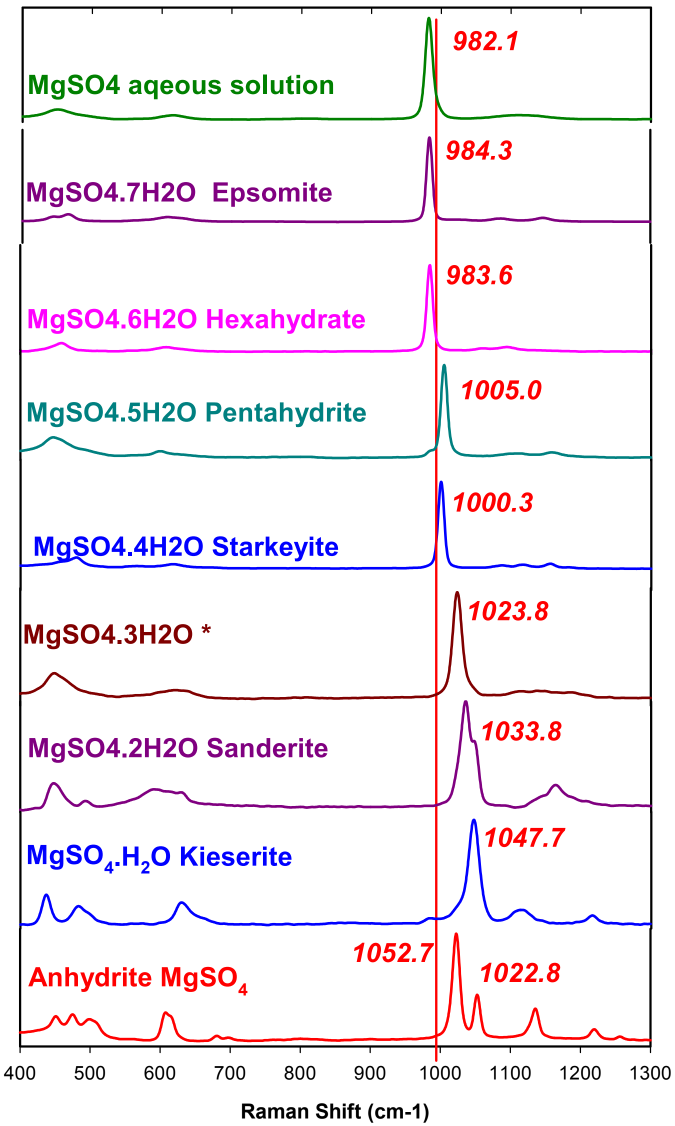
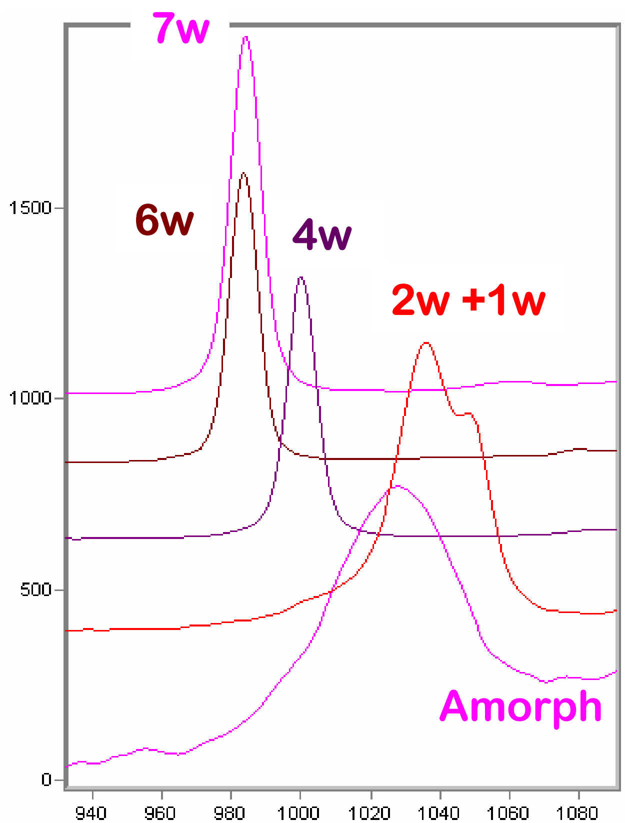


How much water is held in martian sulfates?



Mg-sulfate phase changes

Bio-signatures: – water, ice, carbon

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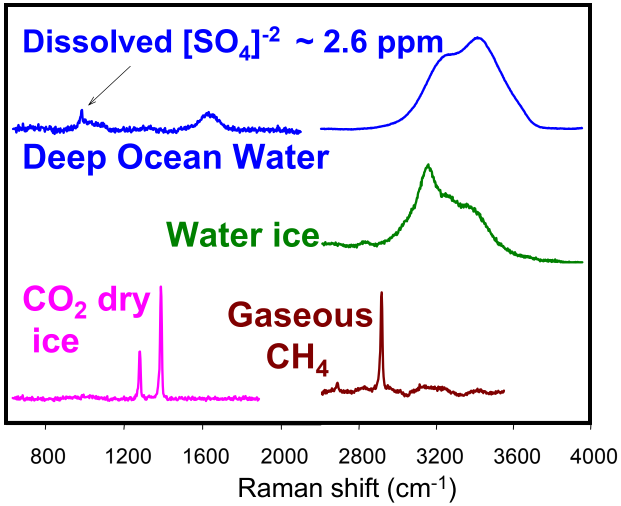
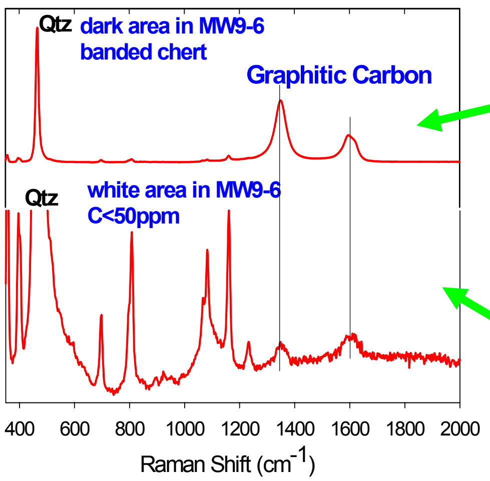
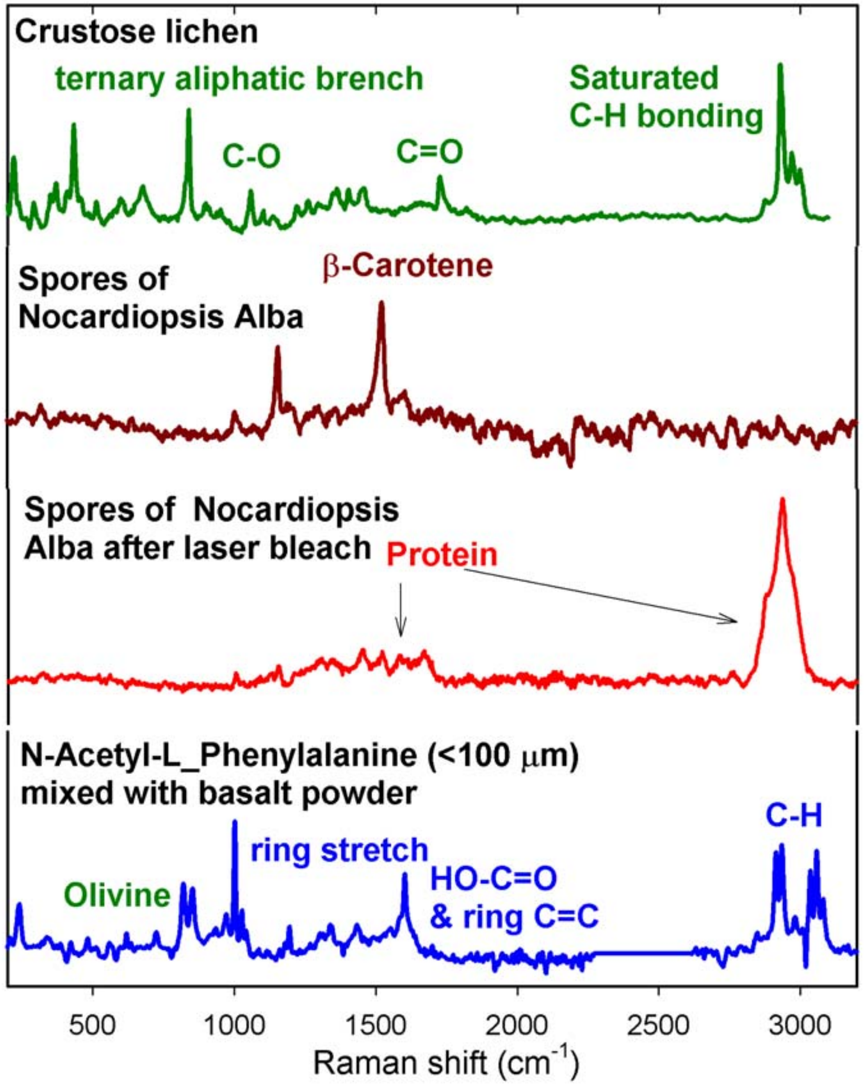


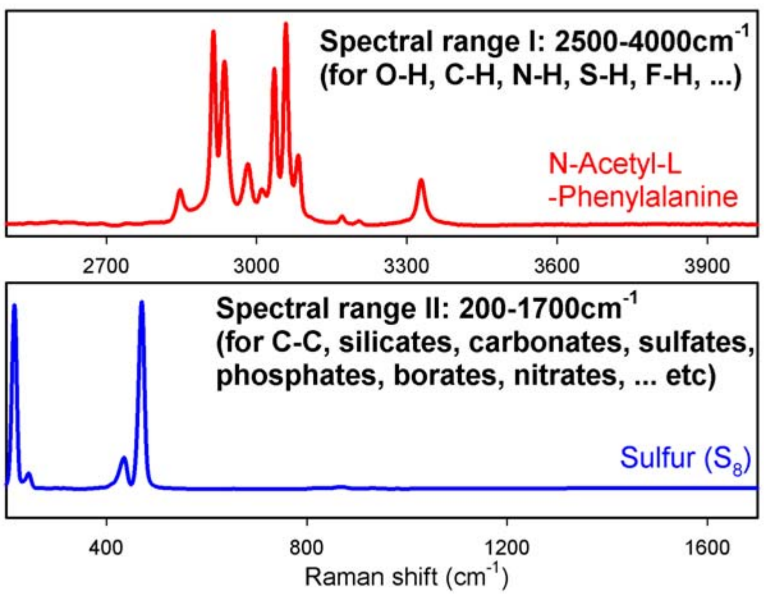




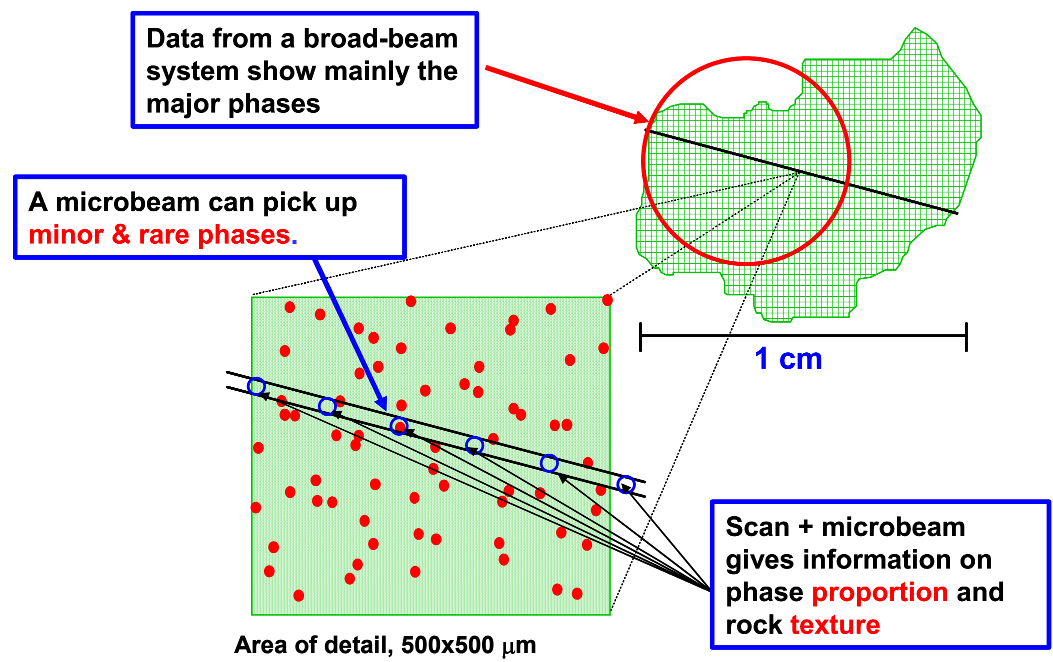
Key Design Elements

Mars Microbeam Raman Spectrometer

High resolution & wide range



Microbeam & line scan



Development & Funding

- **PIDDP: 1996-1997 (Washington Univ.)**
- **MSR Athena '01/'03 payload: 1997-2001**
- **Additional PIDDP (WU)**
- **MIDP (JPL)**
- **Institutional funds**
  - **JPL internal funds**
  - **Washington University (L. Haskin)**
- **[Science Programs (e.g., MFRP)]**

Dedication of PI and team members has been based on <u>recognition</u> of the <u>scientific importance</u> of this technology, not $$.

MMRS Cold Test (-24°C)

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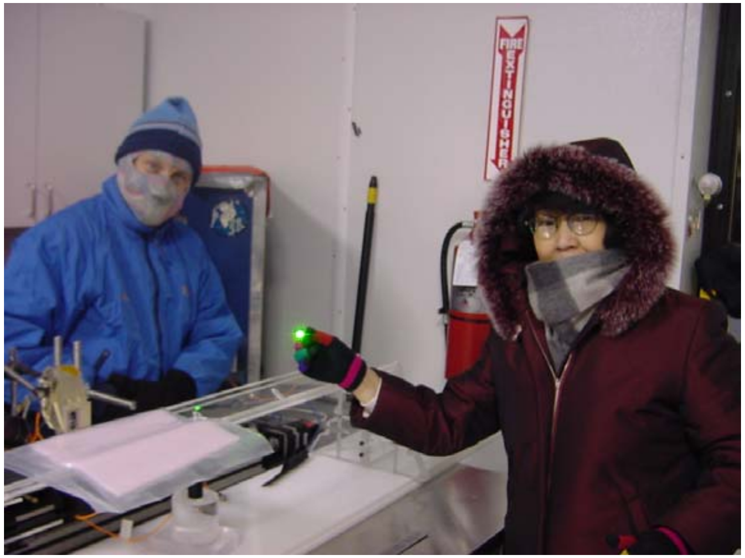
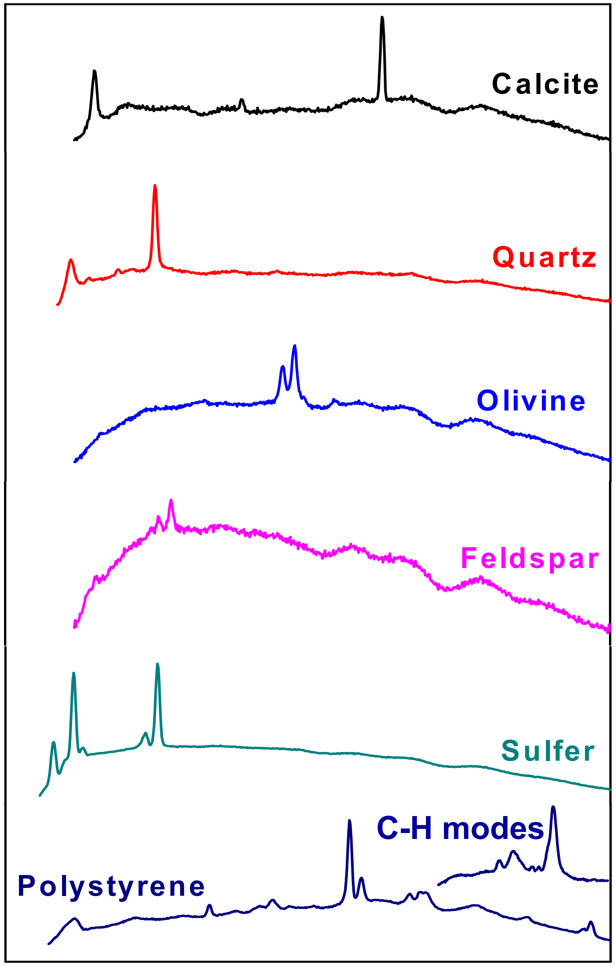
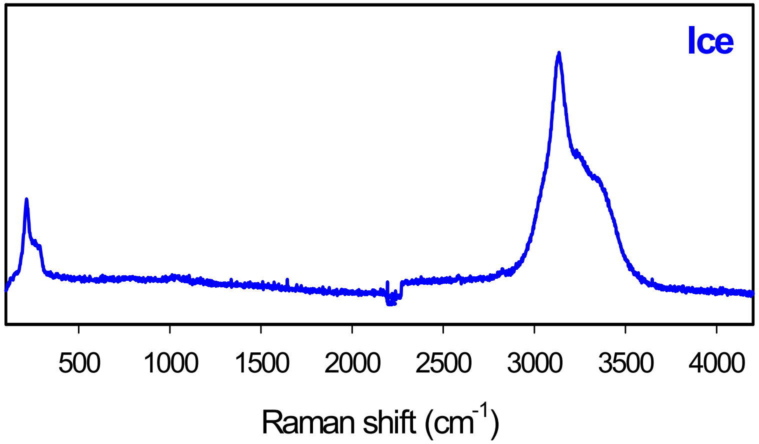


Raw Raman spectra of standard minerals at –24°C



Raw Raman spectrum of ice core at –24°C



MMRS Field Test (CA)

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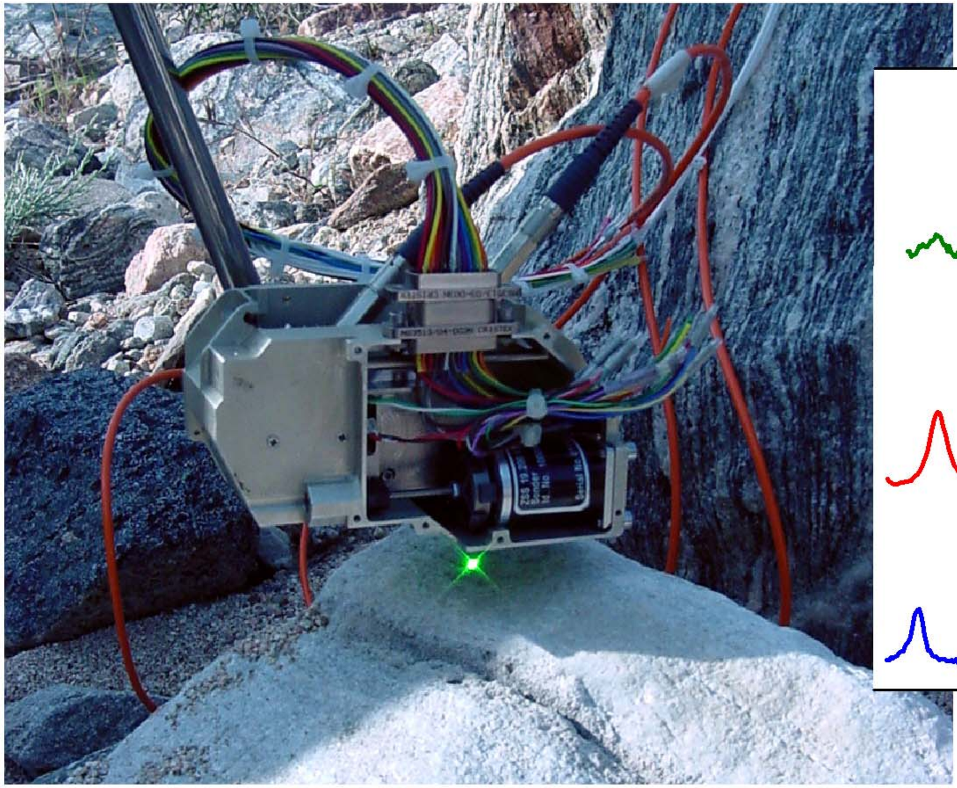
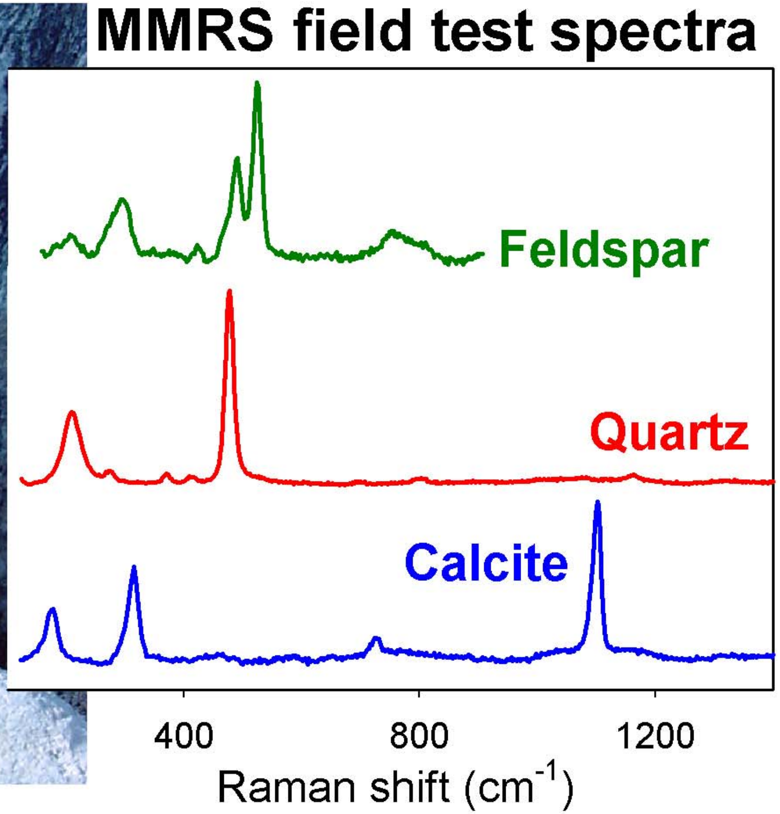
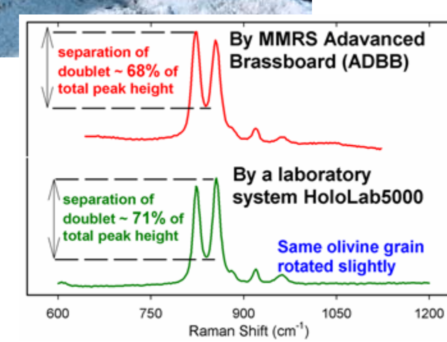




High Hurdles

- **Keeping the Instrument Team together**
- **Sustained Funding**
  - **Including science**
  - **To bridge gaps & retire risk**
- **Realistic field tests and demonstrations**
  - **Realistic environments**
  - **Cost of maintaining BB instrument**
- **Finding and Responding to Flight Opportunities**
  - **Realism in cost estimates (with experience from Athena)**



MMRS – MSL Evaluation

During MSL Evaluation & Selection:

1. MMRS achieved the highest category ranking: "1"
2. Summary scores of "High"
   a. Science merit – *accepted by Sci. community*
   b. Science Implementation
   c. TMC – *Technical maturity accepted by mission engineer and managers*
3. Overall risk rating of "low".

Non-selection for MSL payload - mainly related to budget limitations and payload configuration issues.

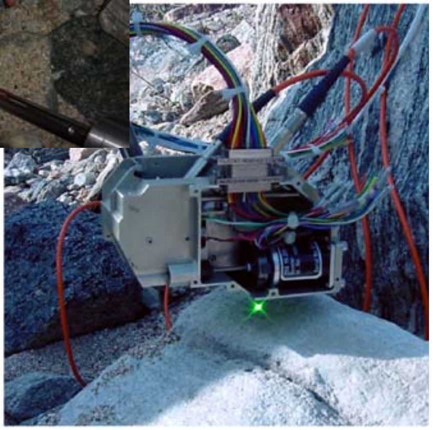
MMRS is ready for any near term mission to Mars & Moon.

MMRS Strengths

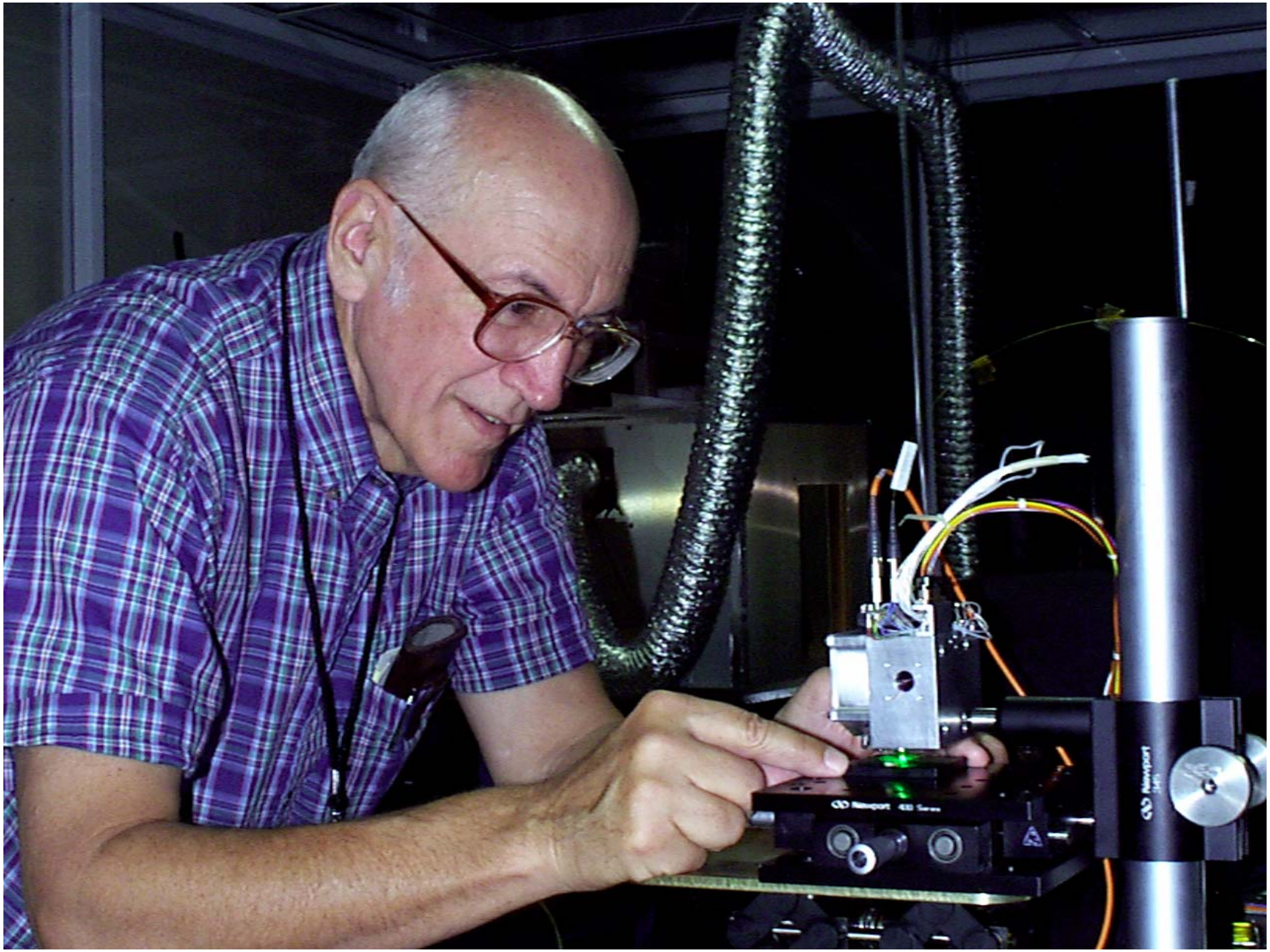
- A strong instrument team
  - PI, Co-I's at Wash U.
  - Engineering Team led by JPL
  - Strong extended Science Team
  - Perseverance and belief in the product
- A successful design
  - Design to science-based requirements
    - Top priority = highest possible signal strength
    - High spectral resolution & wide spectral range
    - Microbeam and linear scanning
    - Deployment strategies (arm-based, in-situ, Haskin point-count traverse method)
    - Flexibility: multiple probes w/ a single spectrometer

Lessons Learned

- Importance of a coherent development team!
- Integration & accom-modation heritage - - experience gained in prep for Athena ’01/’03.
- Think outside box to maintain funding…
- Importance of field and environmental testing and demonstration.
- Need to recognize that instruments must keep up with technology. What we put on the shelf after MIDP might be obsolete by the next opportunity.



Dedication: Larry A. Haskin, PI – MMRS



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