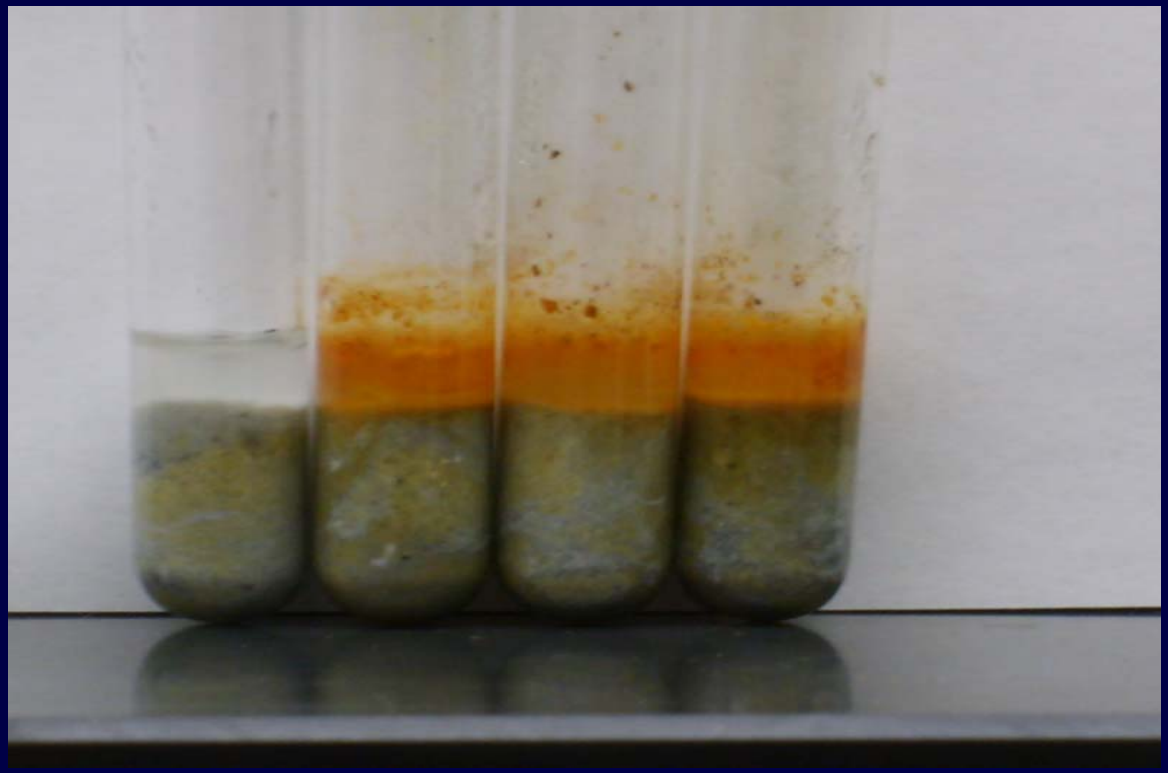
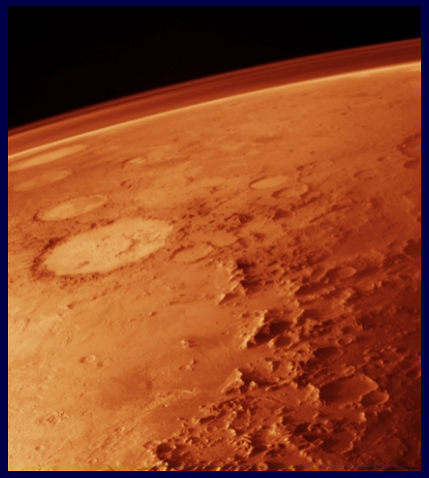
I only gave half the story

- *Methanogenium frigidum* was incubated at 6º C.



Growth and Biomediated Mineral Alterations by Methanogens Under Geochemical Conditions Similar to the Martian Subsurface



Courtesy: NASA

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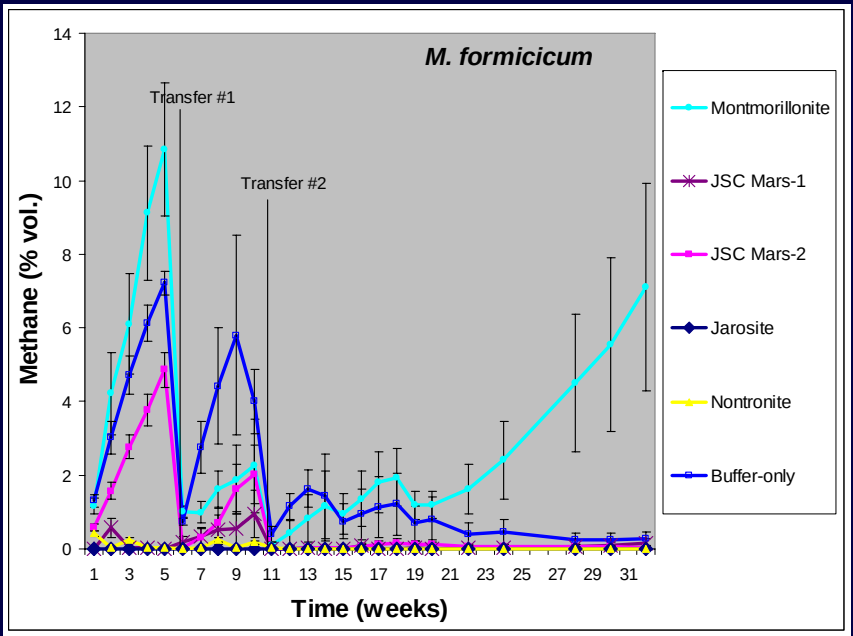
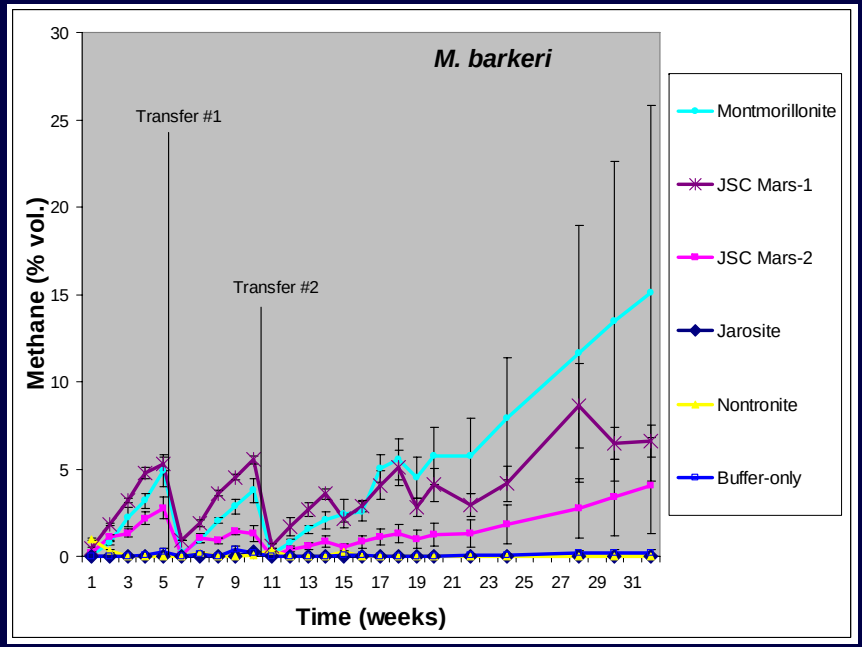
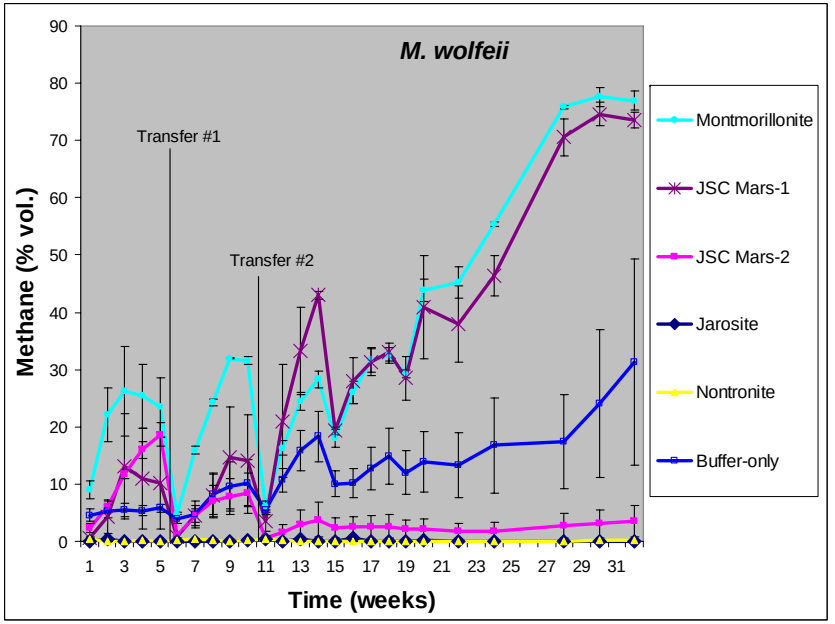
This Study:

- H_2 (energy)
- Bicarbonate buffer/CO_2 (carbon/water)
- Regolith analogs (micronutrients)
  - Jarosite
  - Nontronite
  - Montmorillonite
  - JSC Mars-1
  - JSC Mars-2 (45% montmorillonite/45% basalt/10% hematite)
- Do any of the analog materials support methanogenic metabolism?







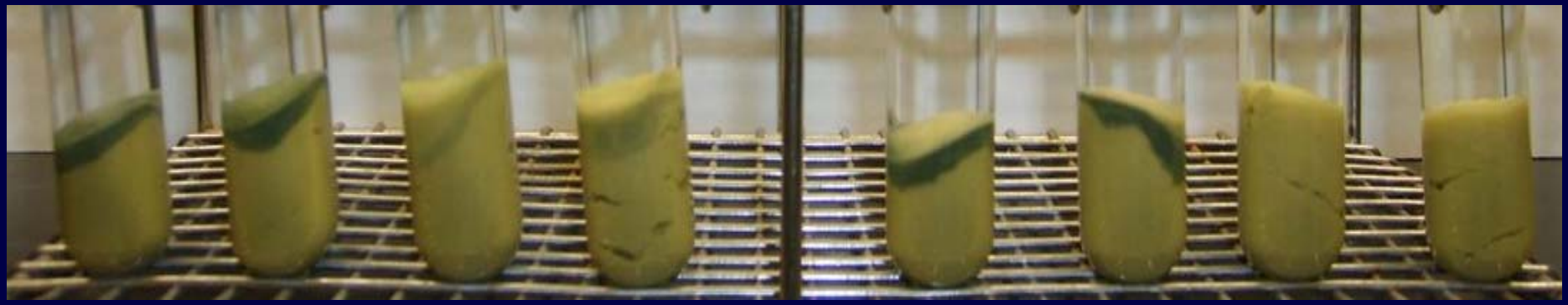
Why would montmorillonite results be so dramatically different from those of nontronite or JSC Mars-2?

Steps to address the Fe^{3+} anomaly

- Geochemical studies showed that neither the analogs nor ferric nitrate solutions effectively oxidized methane.

- A follow-up biological study investigated possible Fe^{3+} reduction by the methanogens.
  - No transfer of cultures

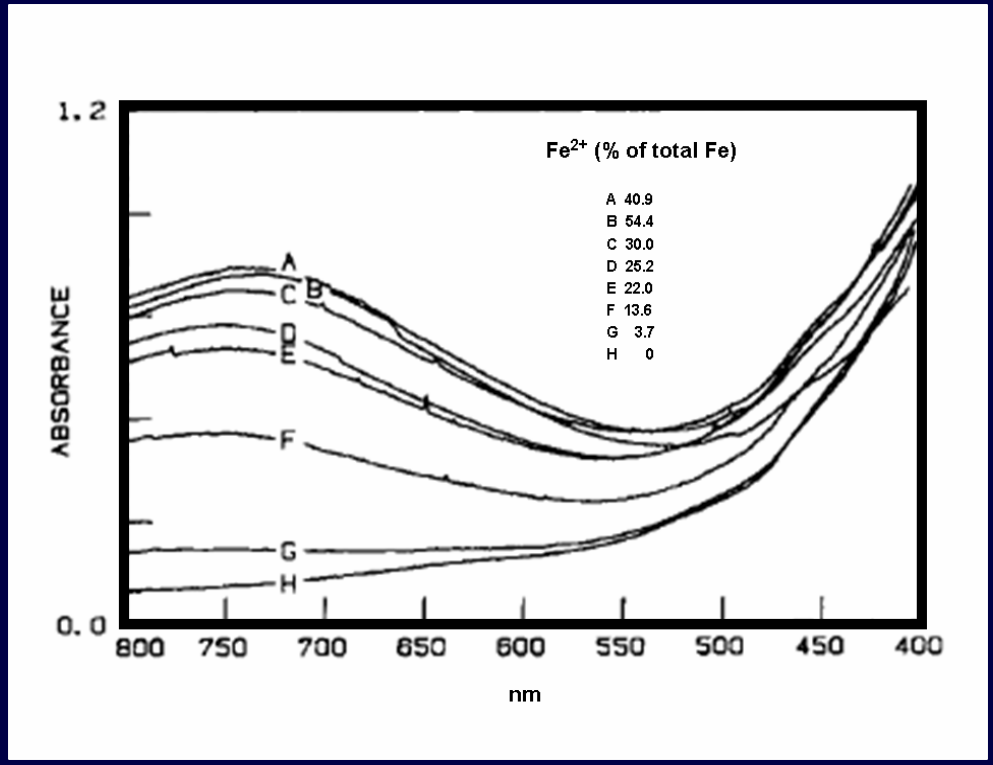
Reduction and Visual Alteration

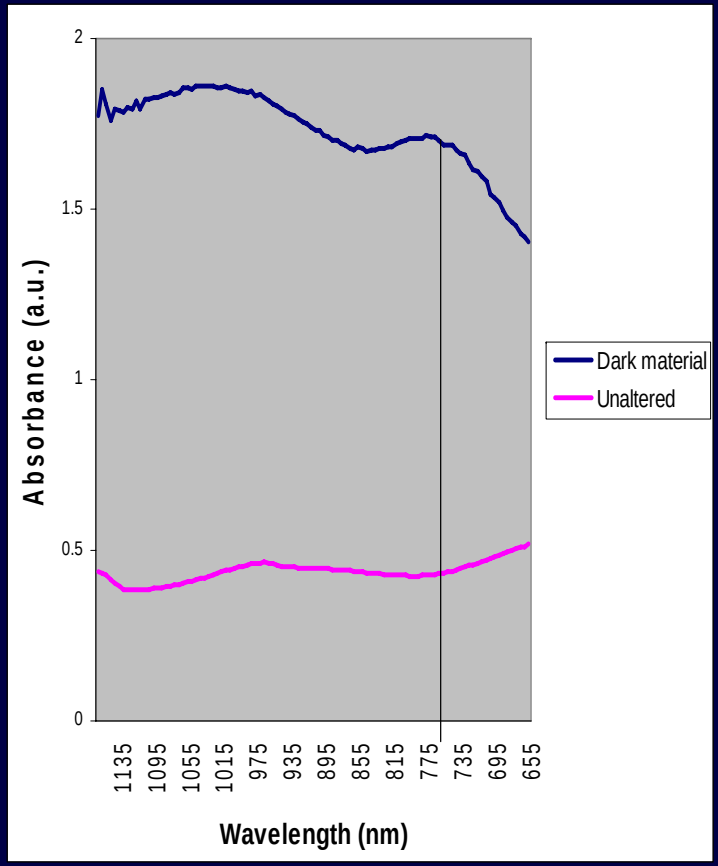


	Absorbance (510 nm)	g/L Fe^{2+}
M. formicicum	0.013	2.46E-04
M. barkeri	0.012	2.29E-04
M. wolfeii	0.003	7.28E-05
Control	0.003	7.28E-05

Colorimetric assay for ferrous iron in solution

Reduced Nontronite





750 nm IT band of nontronite in various reduced states. The peak flattens in samples that are either fully oxidized or fully reduced. (Lear and Stucki, 1987)

Important Follow-up Results

- *M. formicicum* produced no methane for more than two months, even though Fe^{3+} was being reduced.
  - Methane production increased rapidly thereafter and ended study at ~60%
- *M. barkeri* simultaneously reduced Fe^{3+} and CO_2 (methanogenesis), though methanogenesis greatly decreased.
- Until 3 days before embarking for Italy, *M. wolfeii* was assumed “dead” and unable to effectively reduce Fe^{3+}……

April 10, 2009 July 22, 2009 Sept. 24, 2009

M. formicicum

M. wolfeii

Control

In the last 2-3 weeks

First 7+ months of study

Just a few days ago

Implications for Mars

- Mars possesses the basic, obtainable natural resources necessary for methanogenic metabolism.
- Methanogens can "subsist" and even alter their environment until improved conditions are available.
- Bishop *et al*. (2008) identify an unknown Fe^{2+}-bearing smectite layer overlying a "nontronite-like" Fe^{3+}-bearing smectite.
- Biomass could be enormous without necessitating large amounts of methane.