

Beyond the Hematite: More Reasons To Visit Meridiani



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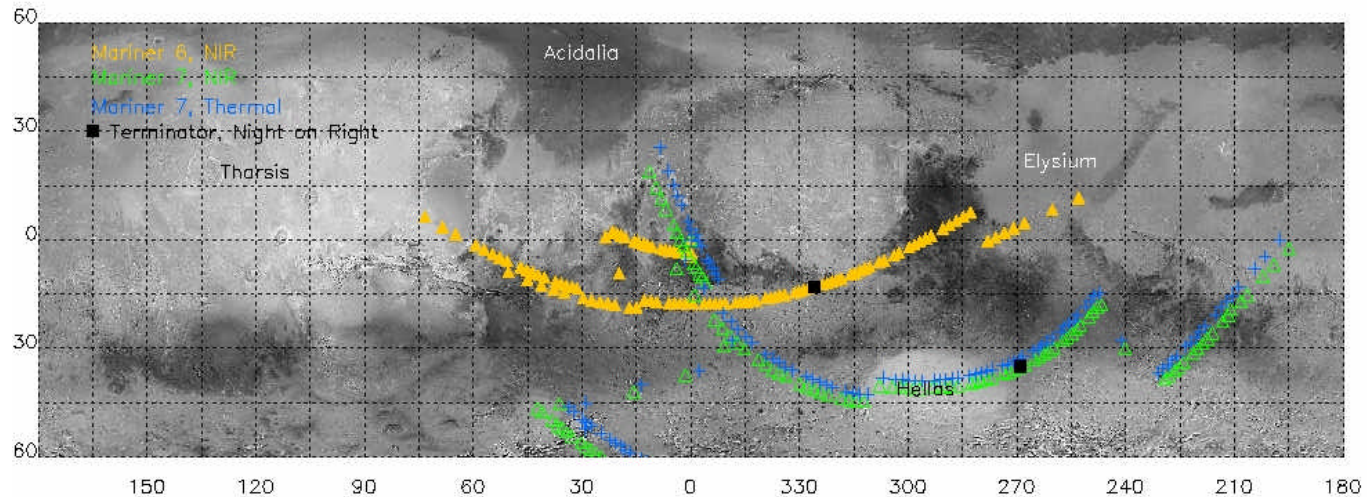
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Overview

- Mariner 6/7 IRS, Locations, footprint
- Hydration of hematite sites (Meridiani and Aram!)
- Methods
- Amount of Water
- Synthesis 0.4 to 50 μm
- Alteration Analogs
- Astrobiology Potential
- Hypothesis Testing

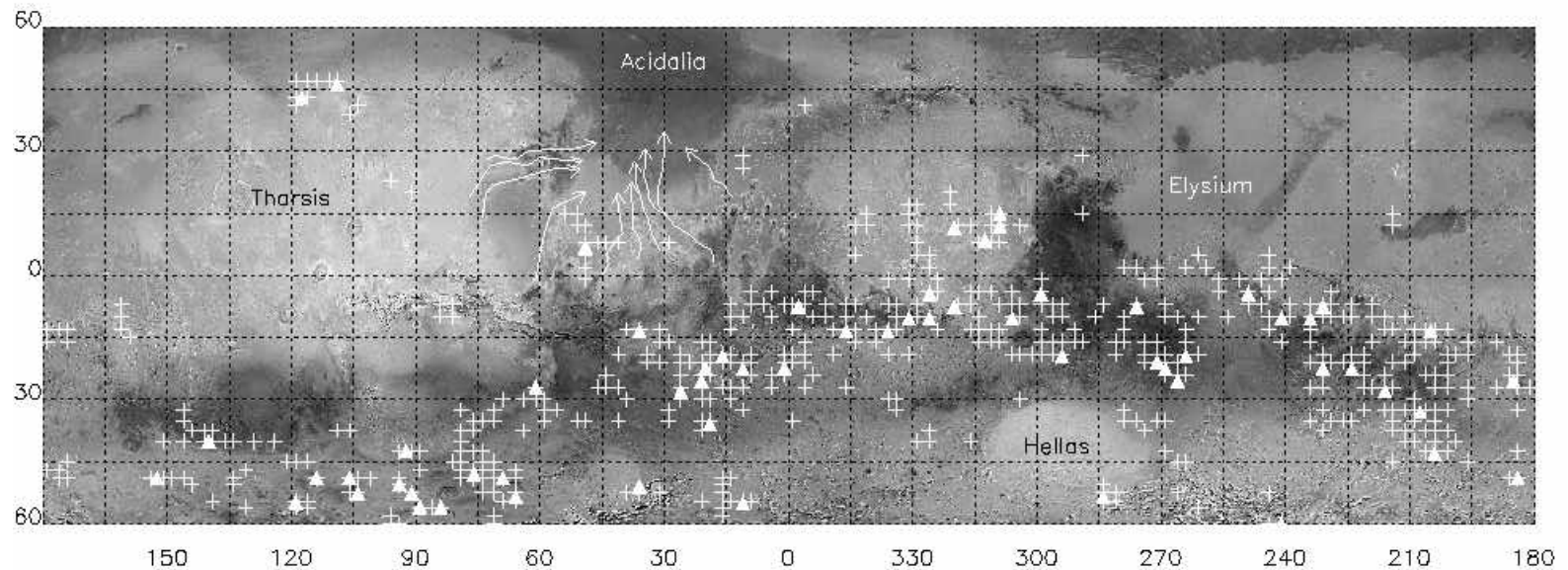
Mariner 6/7 IRS: 1969 Flybys



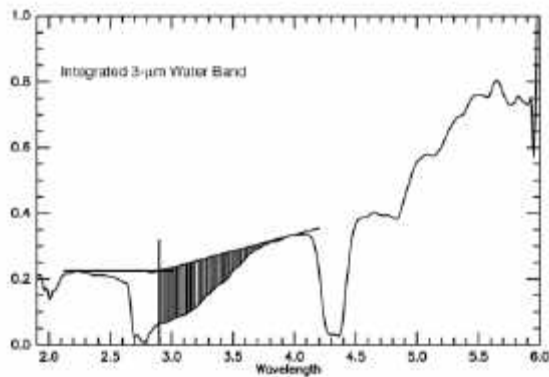
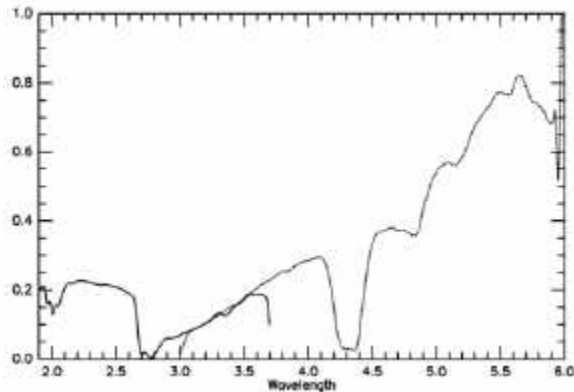
- Mariner 6: 2-6 μ m, 2 segments
- Mariner 7: 2-6 μ m; 5-15 μ m, 4 segments
- Footprint 100km x 200km
- Both crossed the Meridiani Site. M6 crossed the Aram site. Neither covered W Candor site.

Where was/is the water?

- Early M6 analysis shows some low albedo regions more hydrated.
- Noted correlation with classic low albedo regions and drainage density
- Proposed a model of dark alteration consistent with ISM/IRS spectra.

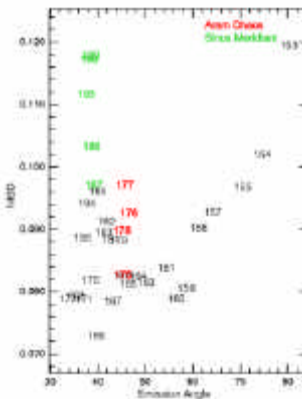
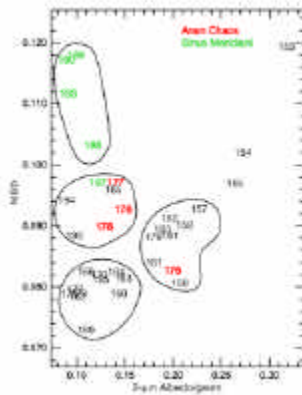


Determining Hydration State



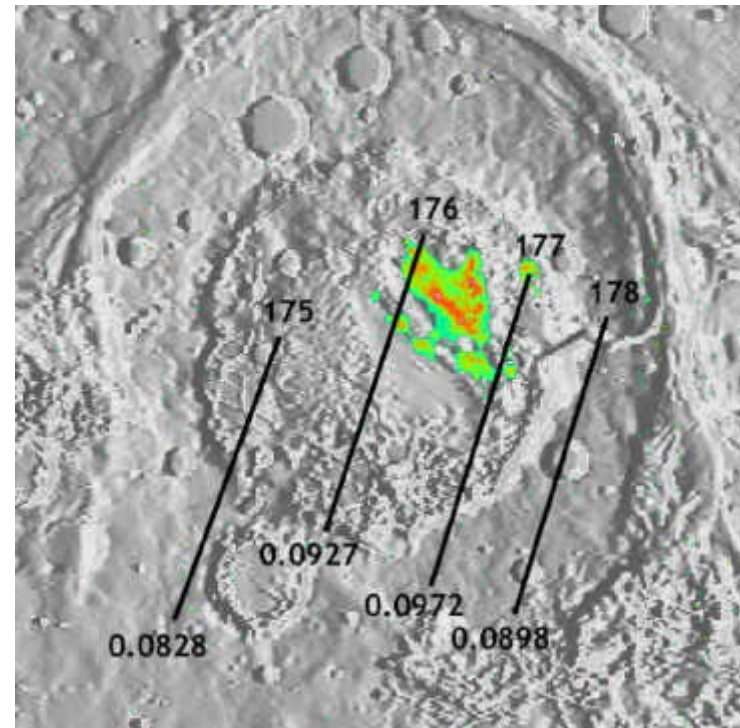
- Normalized, Integrated Band Depth
- Convert data to radiance
- Calculated I/F where $F = \text{solar} + \text{planck fit}$, divided by $\cos(i) \cos(e)$
- Merge wavelength segments
- Integrate 3 μm band depth and divide out albedo at both 2.2 μm and 4 μm .

Hydration Clusters



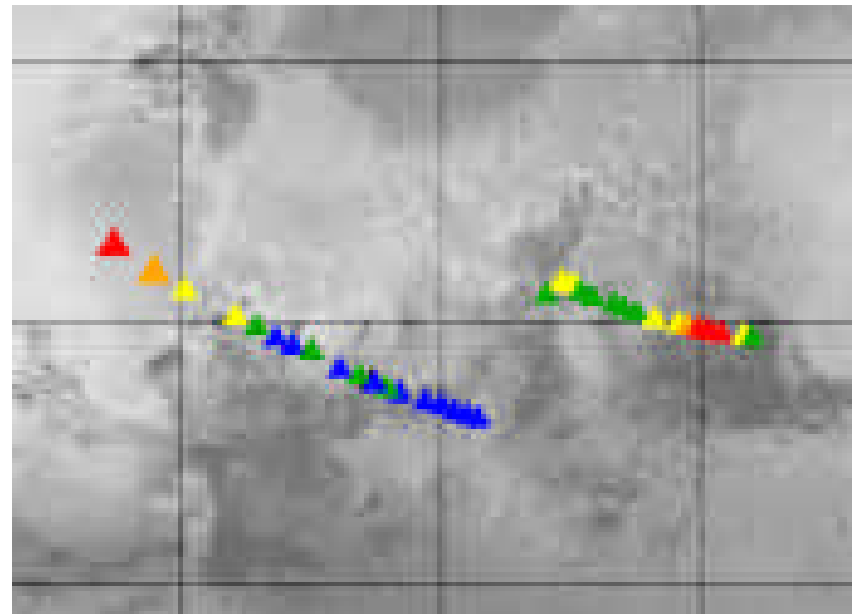
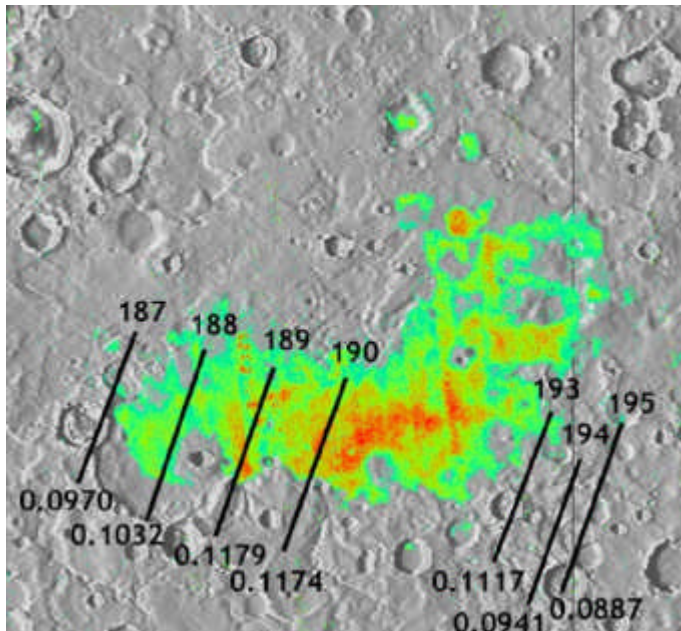
- Compare NIBD with albedo, incidence, emission angles
- High hydration, low albedo
- Mid hydration, moderate albedo
- Low hydration, low albedo
- Remnant high incidence, emission angle effects

Hydration of Aram Chaos



- Strong correlation of hydration and hematite.

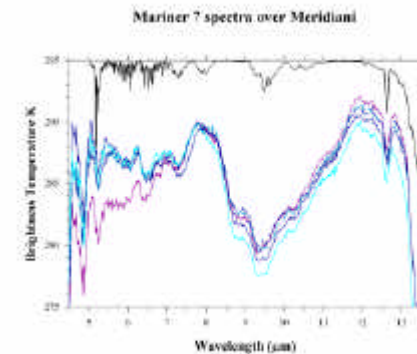
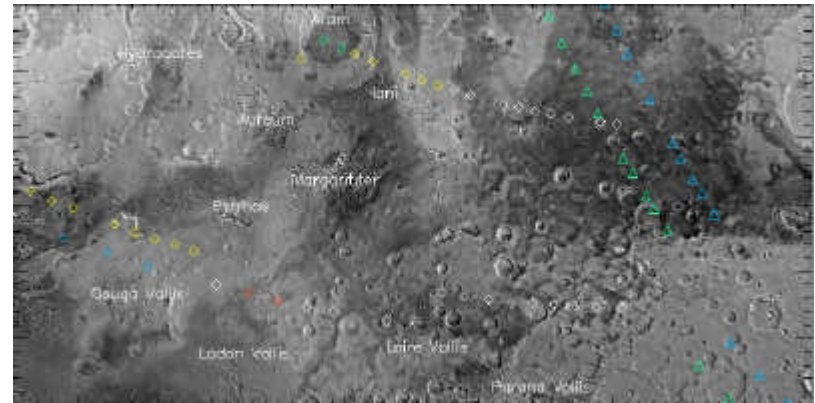
Hydration of Meridiani



- Precise correlation between increased hydration and mapped hematite boundaries.

Mariner 7 over Meridiani

- $3\mu\text{m}$ also show increased band depth.
- Thermal wavelengths consistent with more water in surface minerals.
- Need to look at TES at the short wavelengths.
- Better data with mini-TES





How much water is there?

- Little systematic work on 3- μ m band strength and amount of water.
- Grain size and albedo can be important.
- Miyamoto and Zolensky (1994) showed linear correlation between integrated band depth and bulk H in C-chondrites.
- Yen et al. (1998) showed apparent absorbance method works well for constant albedo, grain size.
- **Based on apparent absorbance Mariner data suggest 2% additional water by weight at hematite sites.**
- **As the average is inferred to be only 1-2% this is a significant local increase in water bound in minerals.**
- GRS also supports broad regional hydration at Meridiani. The hematite sites may be small surface expression of a more extensive global layer at depth.



Spectral Properties 0.4 to 50 μ m

- TES shows bulk hematite, but no strong variation in Si signature from 8-12 μ m.
- Mariner shows increased hydration at 3- μ m and from 5 to 7 μ m.
- Subtle variation in 1- μ m “pyroxene” band.
- Hematite is not hydrated
- So what is?
- Oxy-hydroxides, Sulfates, Carbonates, Ferrous Silicates.

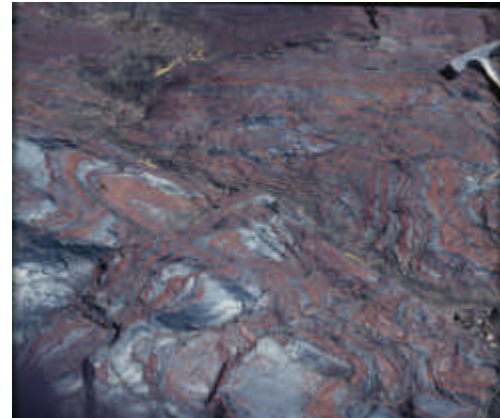
Where's the Water?

Dark Alteration Analogs

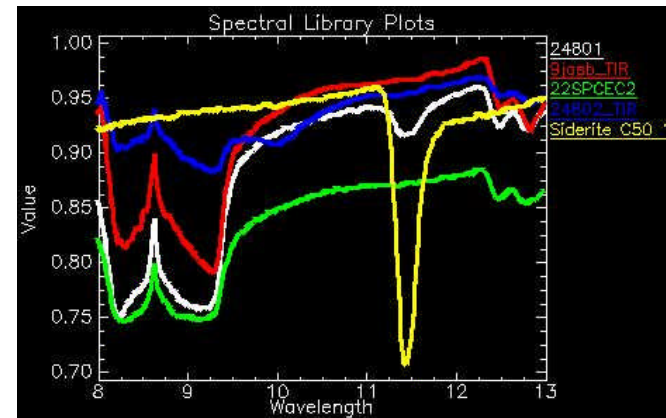
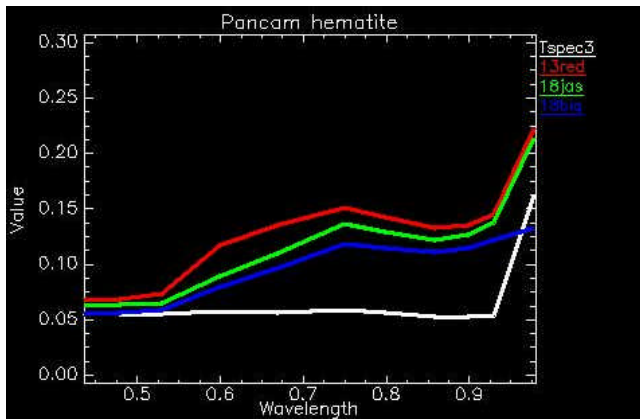
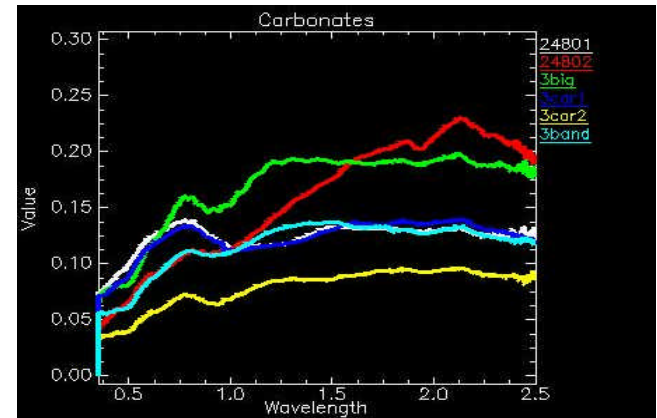
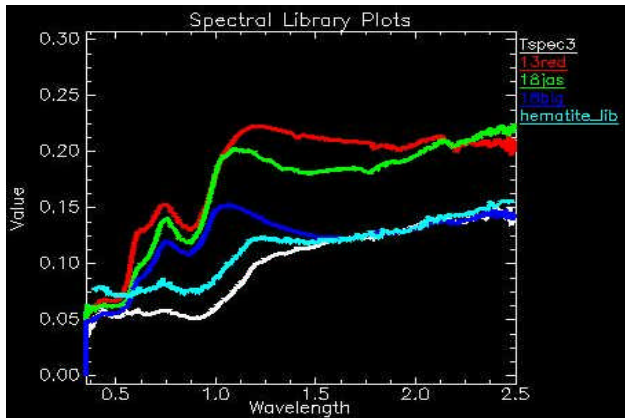
| Facies | Archean Iron Formation | Carbonaceous Chondrites |
|-----------|--|---|
| Oxide | Magnetite/Hematite | Magnetite, Fe-oxy-hydroxides |
| Sulfide | Pyrite | Fe,Ni Sulfides, Tochilonite |
| Silicate | Greenalite, Stilpnomelane | Cronstedtite, Greenalite |
| | Chamosite, Minnasotaite | Antigorite, Chrysotile |
| Carbonate | Siderite | (none/minor) |
| | carbonaceous cherts are also found in Archean deposits | carbon forms a detrital carbonaceous matrix |

Banded Iron Formation

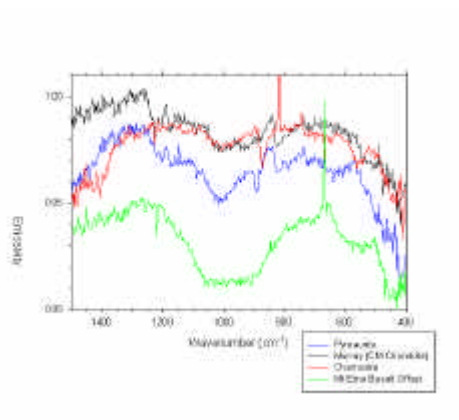
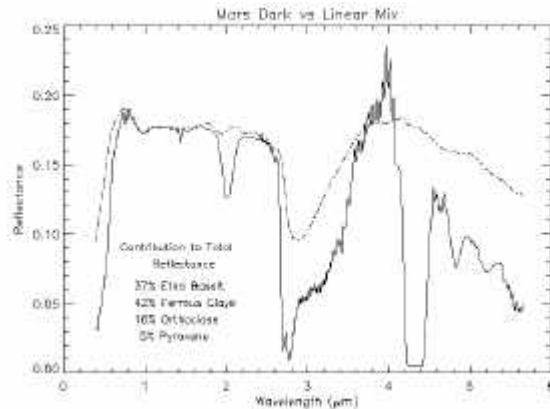
- Shallow marine vs Deep Sea
- Dominant in rock record before ramp up in atmospheric O_2
- Gradations among facies endmembers



BIF- Oxide & Carbonate



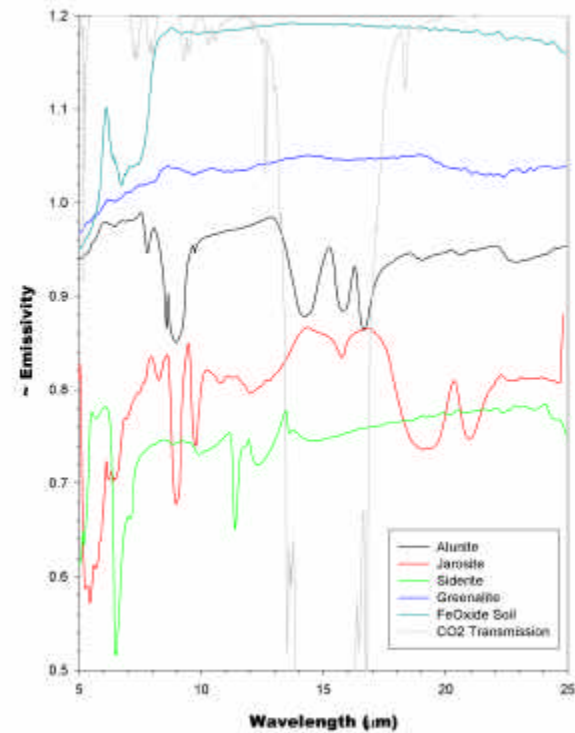
Ferrous Silicates



- Common in C-chondrite matrix
- BIF silicate facies
- Model shows nice fit to ISM/IRS data, especially 1- μm band.
- No strong features 8-12 μm
- Need measurements at long wavelengths.

Other options

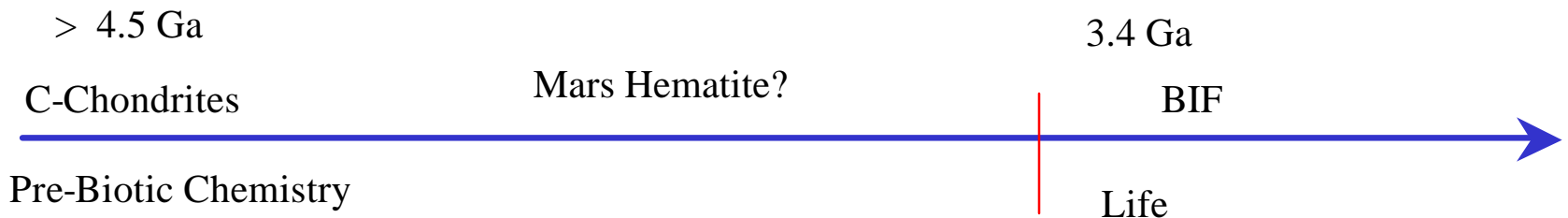
- Sulfates
- Acid Gels
- Carbonates
- Ferrous Silicate





Astrobiology Implications

- Role of biological precipitation in BIF
- Presence of organic signatures in C-chondrites (amino acids)
- If hematite locations reflect this kind of alteration scenario, potential for associated organics could be high.





Hypothesis Testing

- Water WAS involved in the formation of the hematite regions.
- In all cases: What carries the water?

Dark Alteration Model

- Sub-aqueous origin (BIF analog). Look for: Layers, other facies, C in carbonate or carbonaceous cherts, sedimentary structures
- Ground water interaction (C-chondrite analog). Look for: minerals intermixed on very small scale, C in carbonaceous detritus
- Look for sulfides (though not source of hydration)



Hypothesis Testing - 2

- If H₂O is in other oxy-hydroxides says something about history and duration of alteration event.
- Mossbauer, mini-TES and PanCam all needed to unambiguously resolve auxiliary minerals.



From Here to There

Work in the Interim to assist with MER

- Characterize ferrous clays to 50 μm , also w/ Mössbauer, $\text{Fe}^{3+}/\text{Fe}^{2+}$
- More naturally occurring hematites
- BIF Carbonate composition
- TES < 8 μm