# Water on Mars:

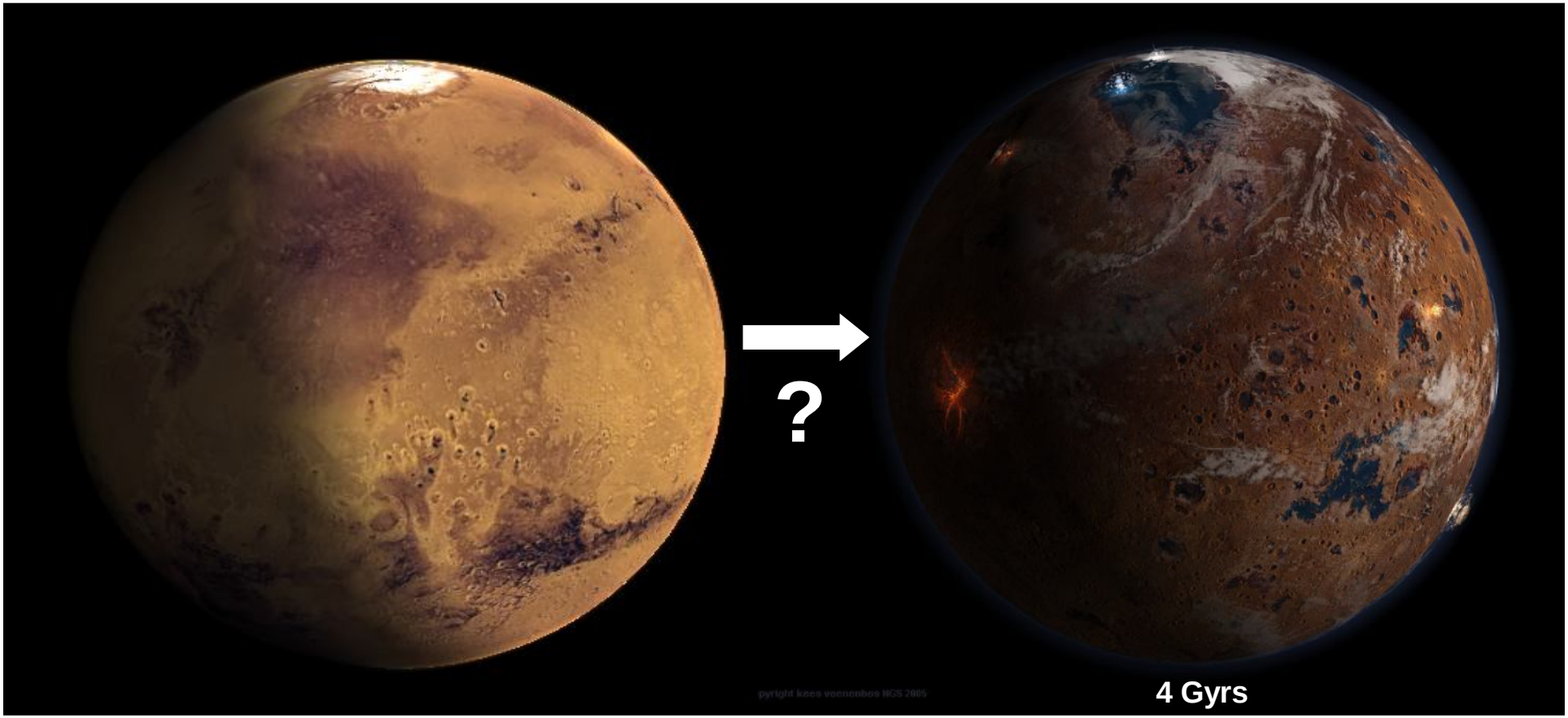
# Assessing the habitability of the early Martian environments

*ESO Chile*

*IAS, Université Paris-Sud*

**John Carter, F. Poulet, N. Mangold, S. Murchie, J.-P. Bibring**

# Constraining the early Martian environments



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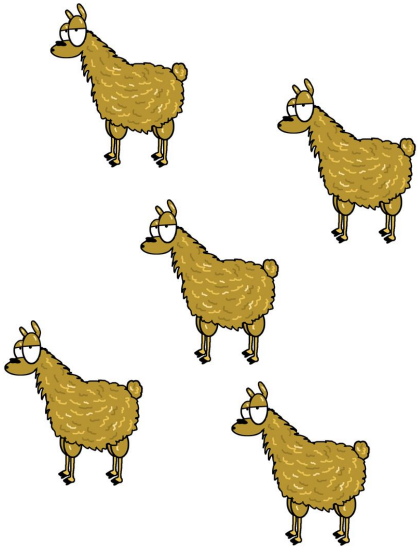

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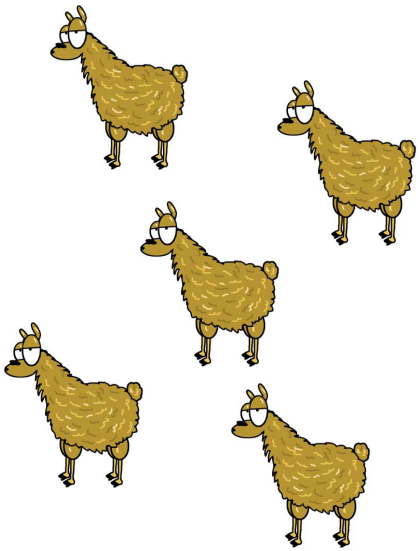
**10% abiotic (endogenic)**



**Serpentinization** of the oceanic crust and upper mantle (>50-200ºC)

$$(Fe,Mg)_2SiO_4 + nH_2O + CO_2 \rightarrow (Fe,Mg)_3Si_2O_5(OH)_4 + Fe_3O_4 + CH_4$$

**Olivine** (> 50% mantle)

**Serpentines**

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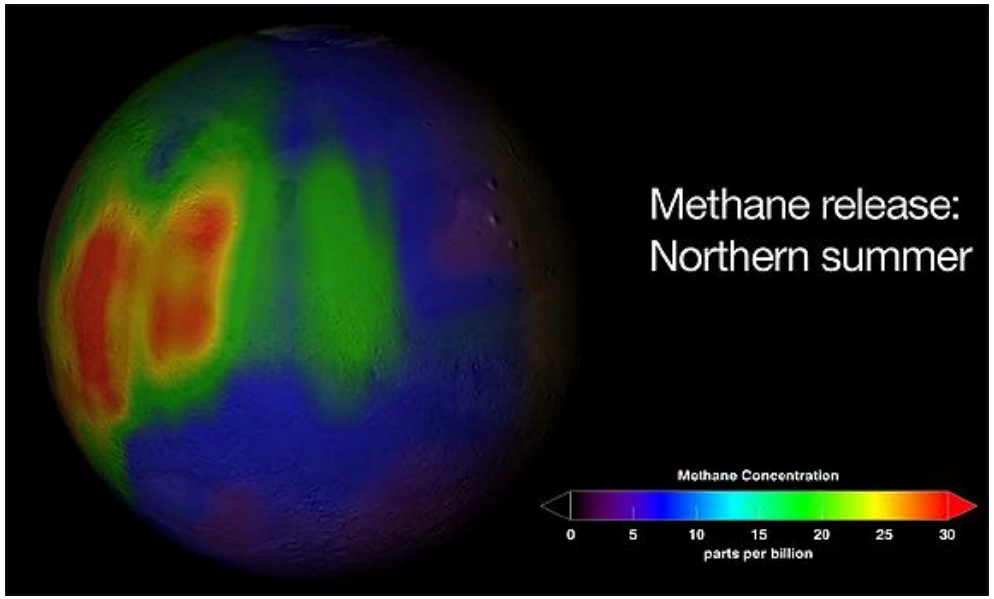


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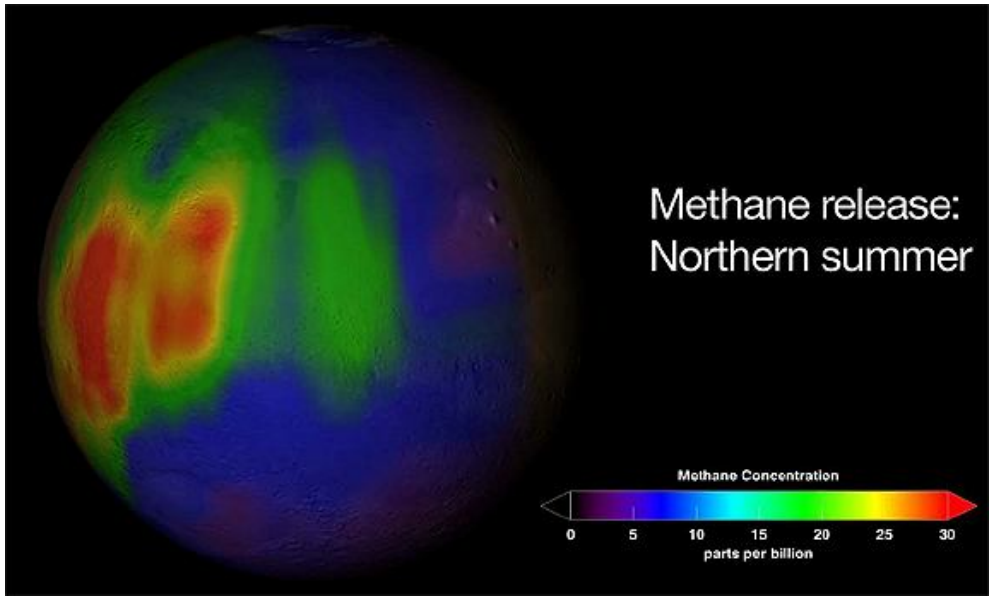


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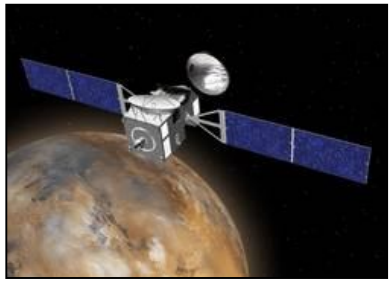
**Methane-centric missions**

- MAVEN (2013)

- TGO (2016)



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Abiotic origin requires large amounts of buried serpentine (Chassefiere et al., 2011)

➔ **Serpentine very rare phase on Mars** (< 250 sq meters) (Ehlmann et al., 2010, Carter et al., 2012)

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**Massive release of $CH_4$ in Martian atmosphere is problematic**

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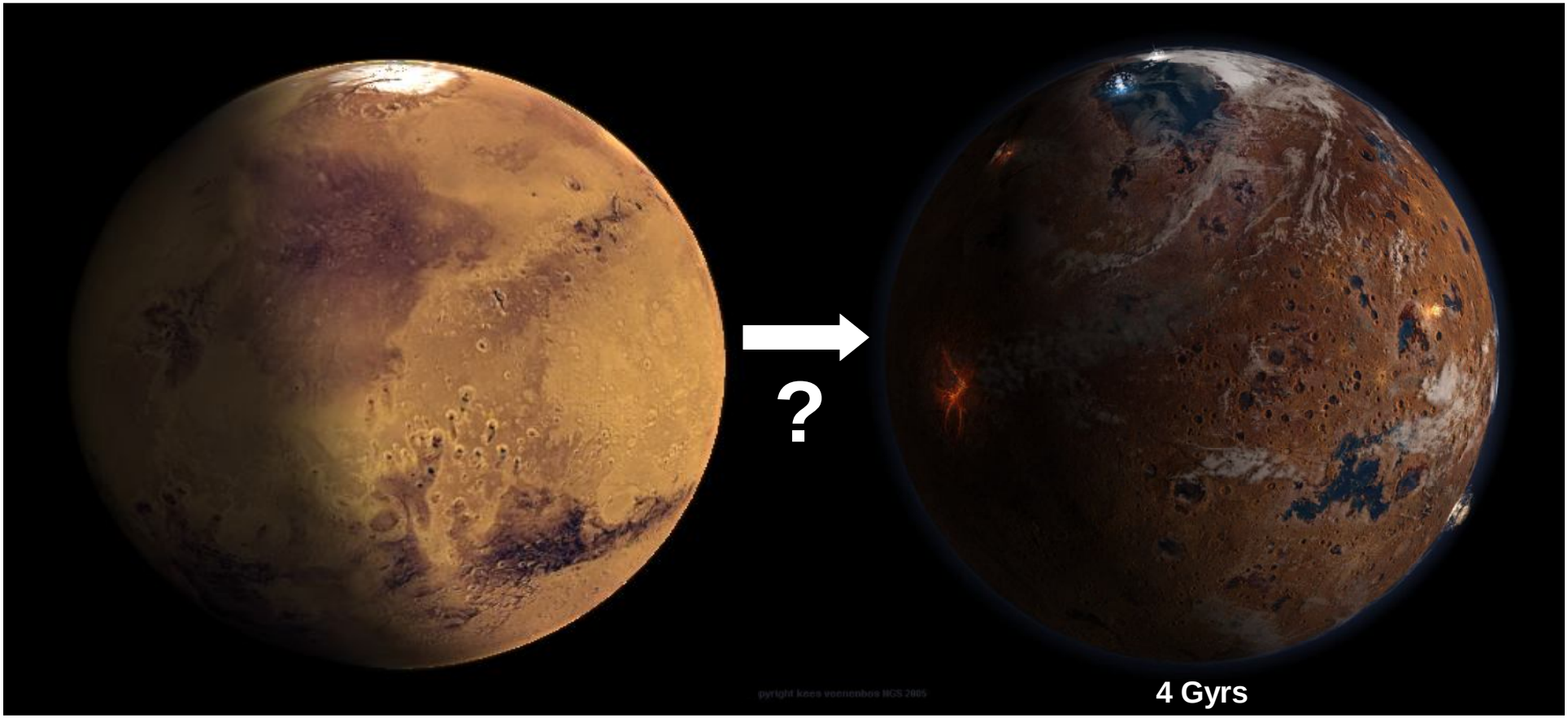
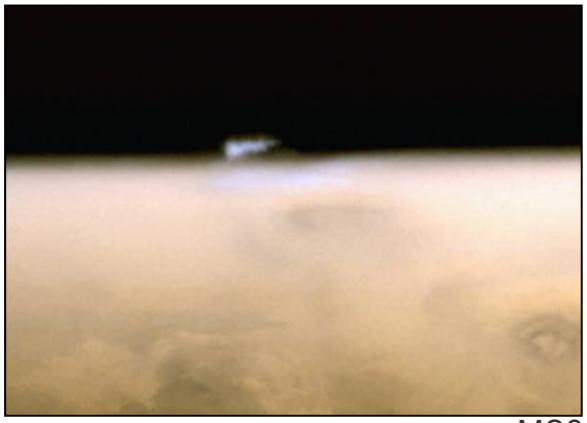


# Water on Mars today



MOC

Phoenix

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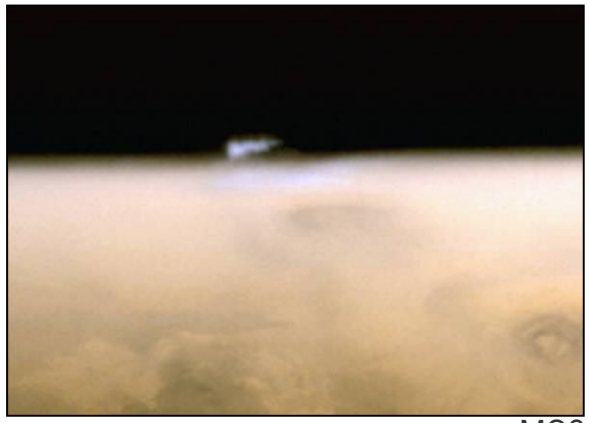

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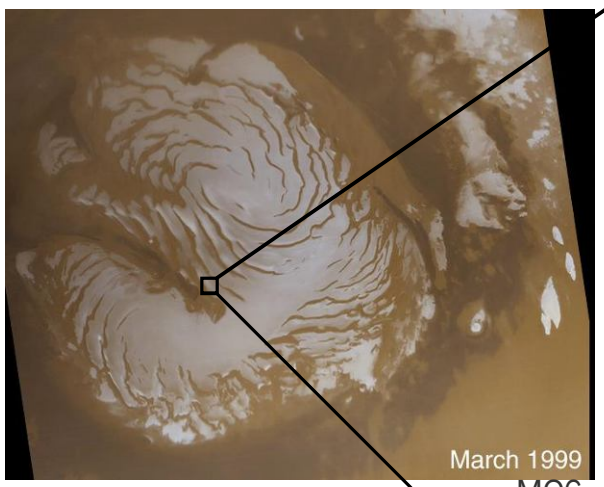


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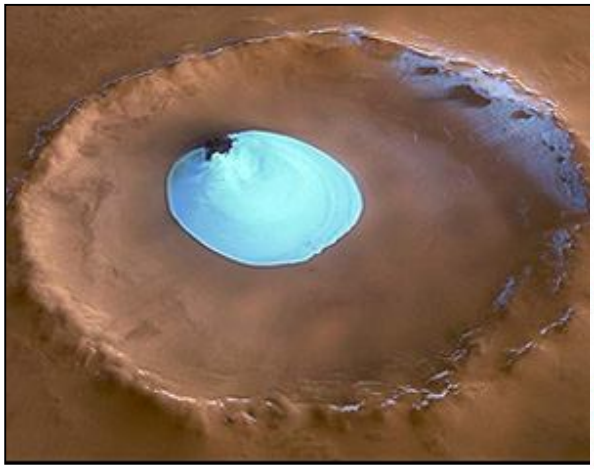
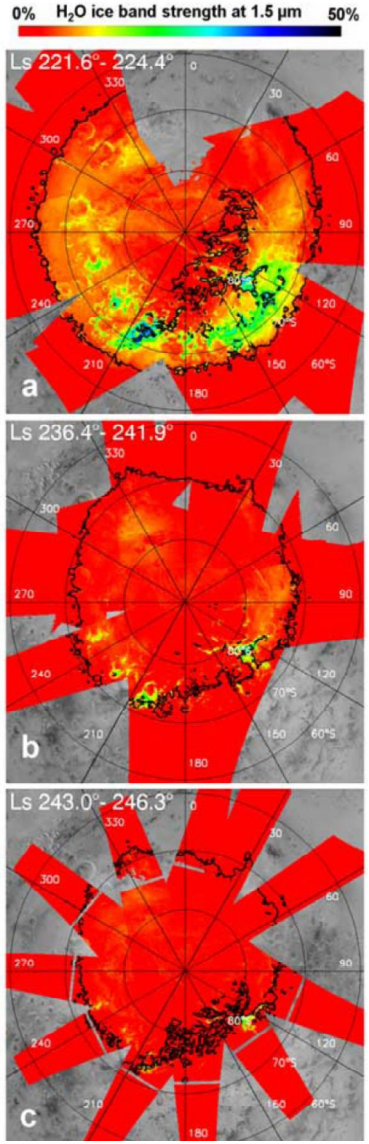
HiRISE



HRSC




OMEGA

Radar sounding & GRS → **no aquifers on Mars**, but shallow (10s meters) sub-surface ice

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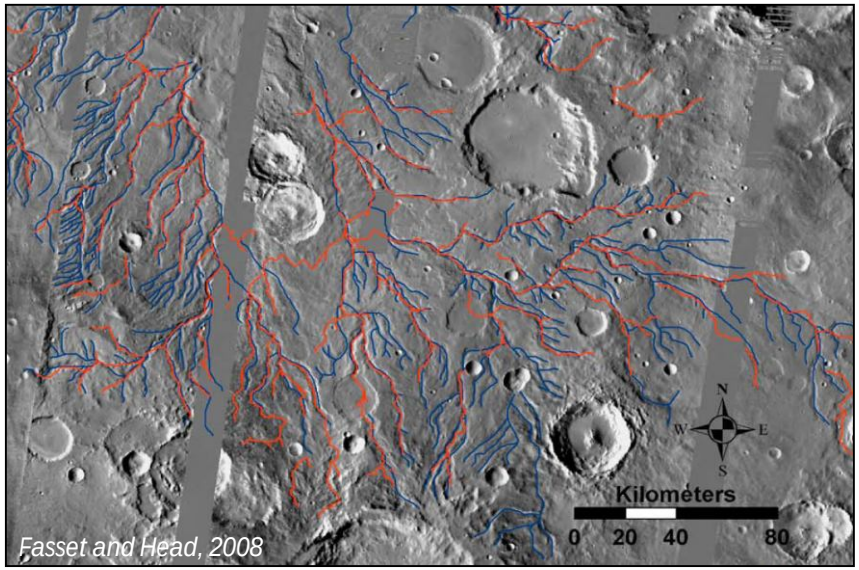
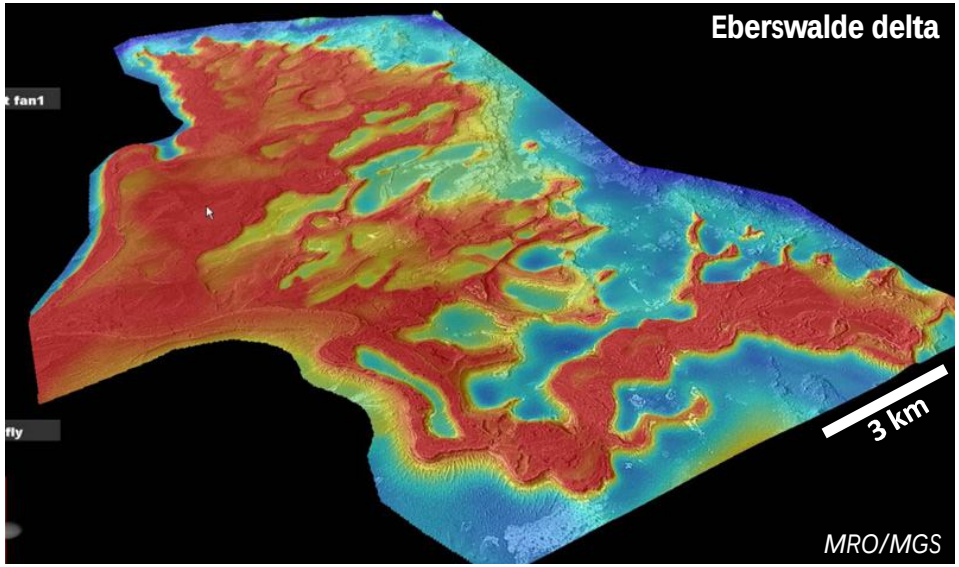
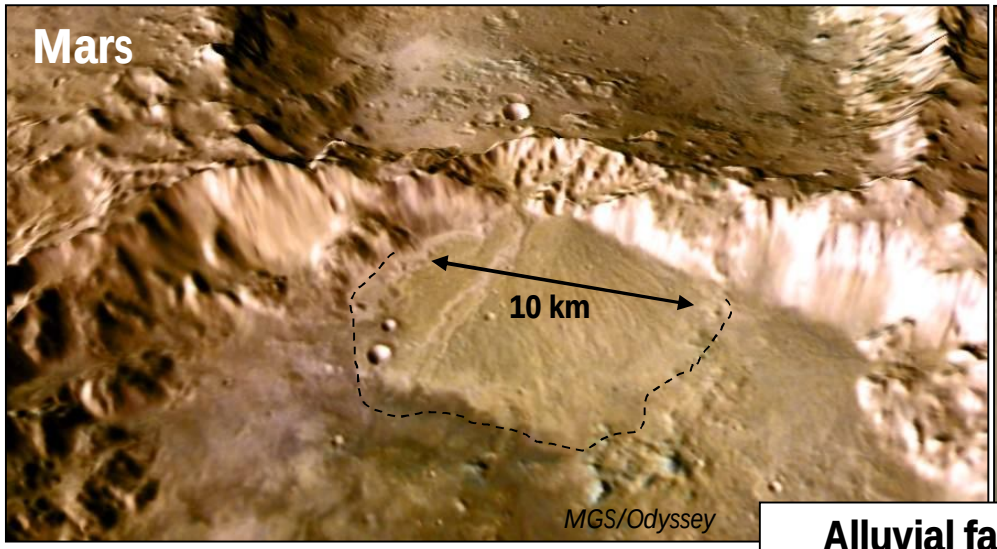
# Remnants of surface flow features on early Mars

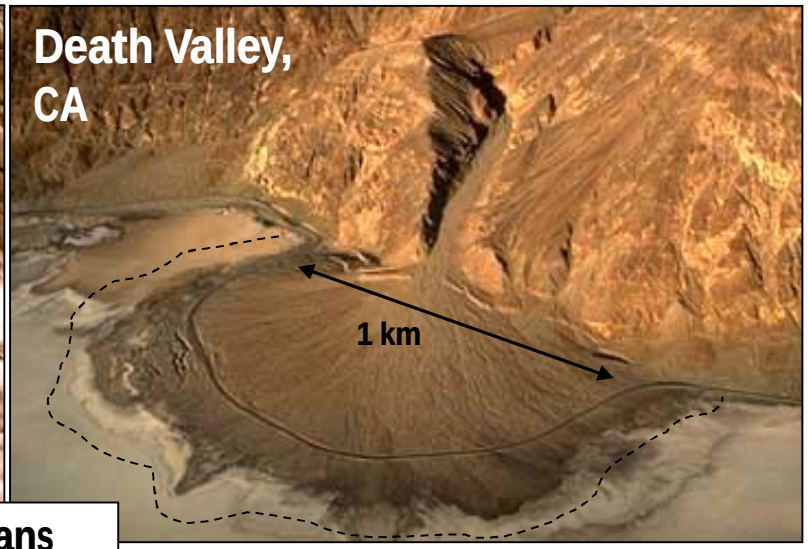



Dendritic valleys




Deltas




Alluvial fans

**Weak (arid) hydrological system ~ 4 Gyrs**

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# Remnants of chemical interaction of water with the crust

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**Hydrated minerals – Clays, salts**

- Smectites
- Kaolins
- Chlorites
- Micas
- Zeolites
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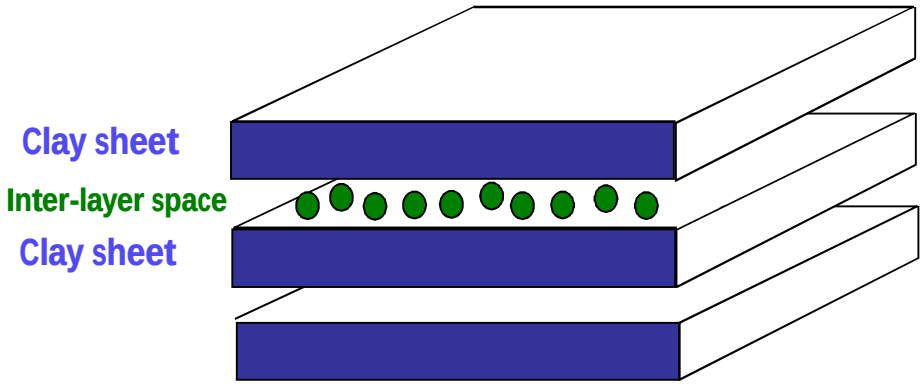

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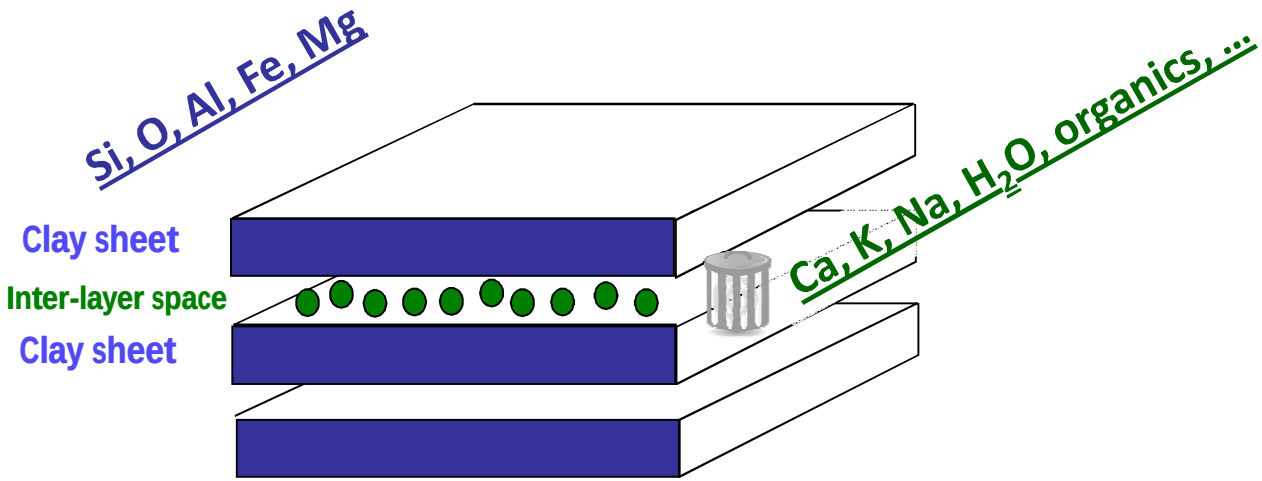

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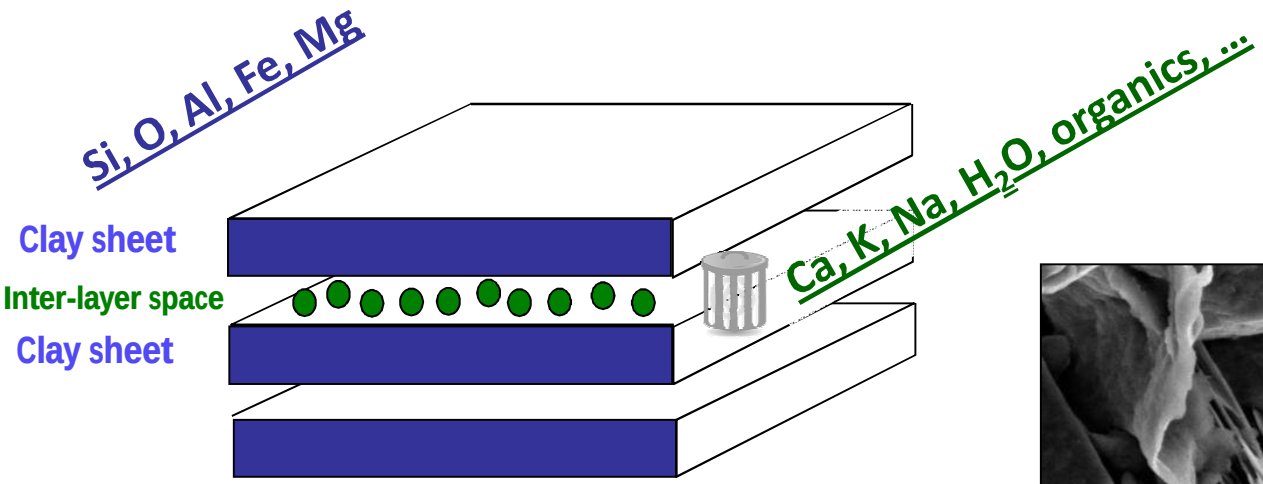


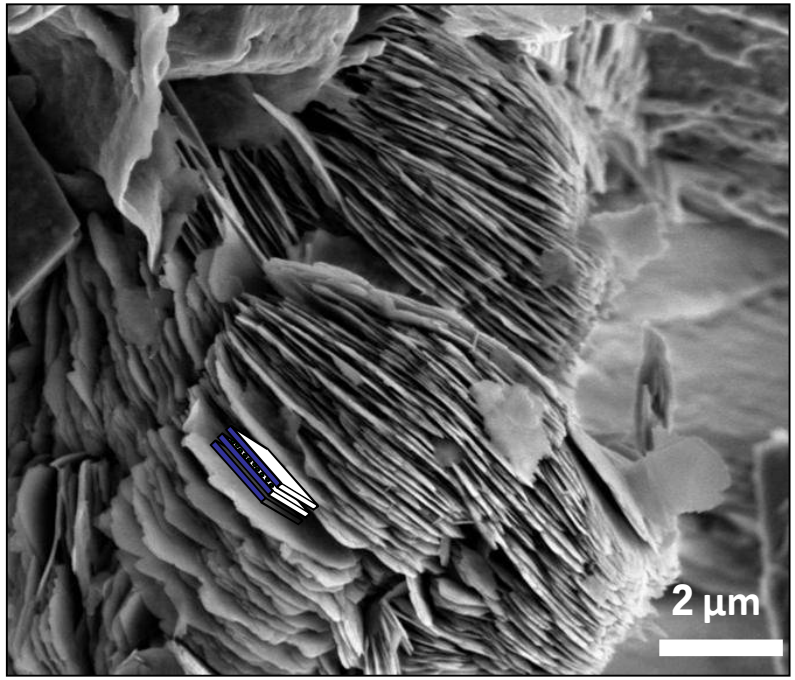


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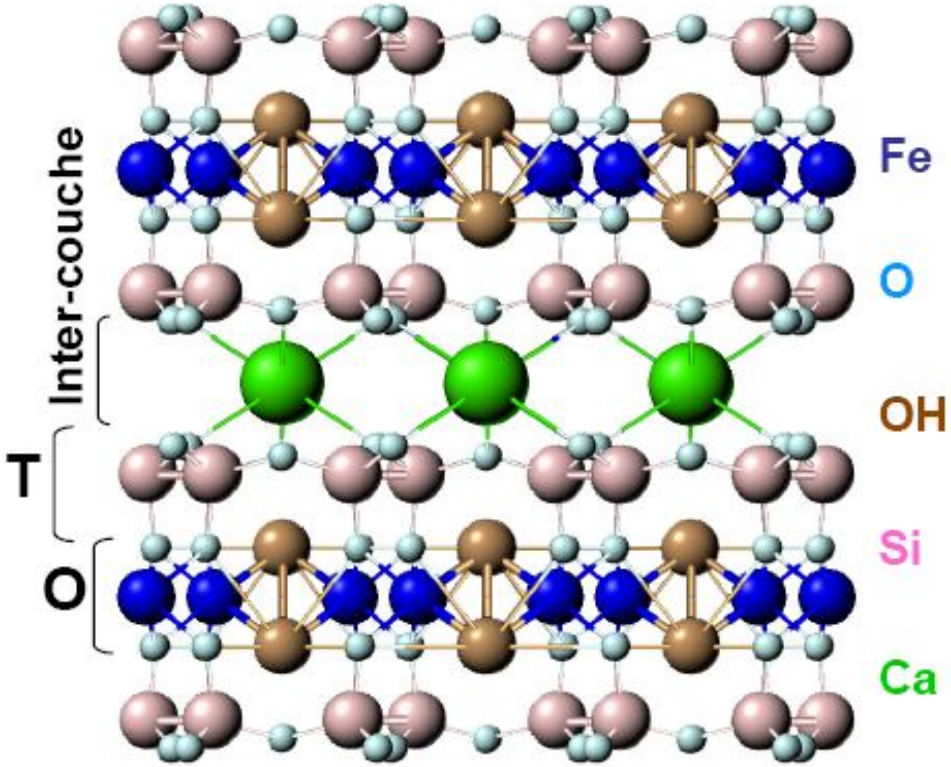
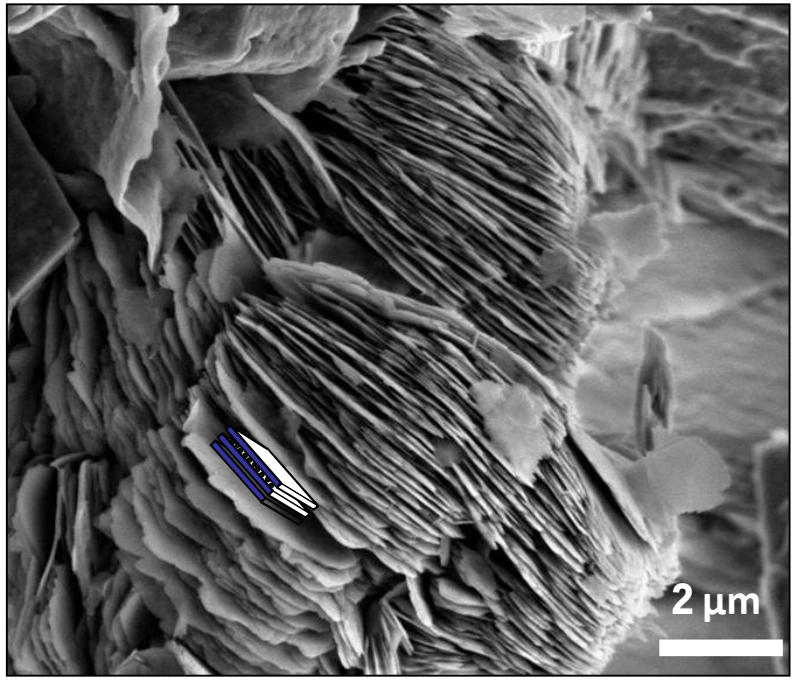



Nontronite 2:1 tri-octaédrale $(Fe)_3$

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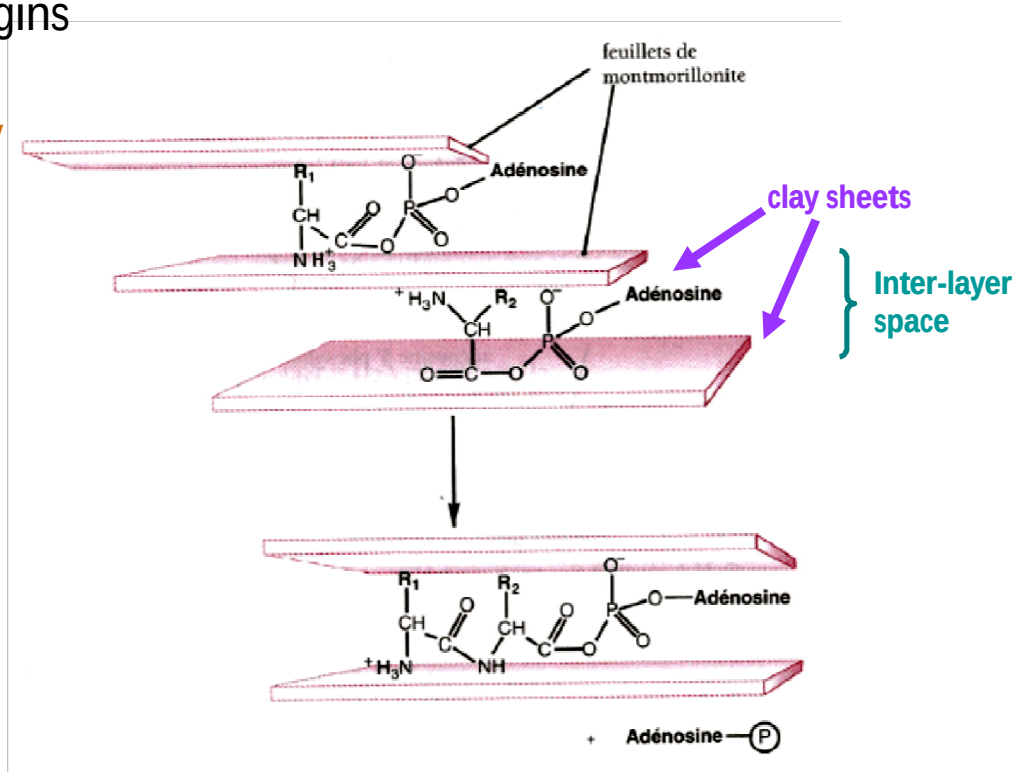


M.C. Maurel, ed. Dunod

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neutral pH (>3-4)

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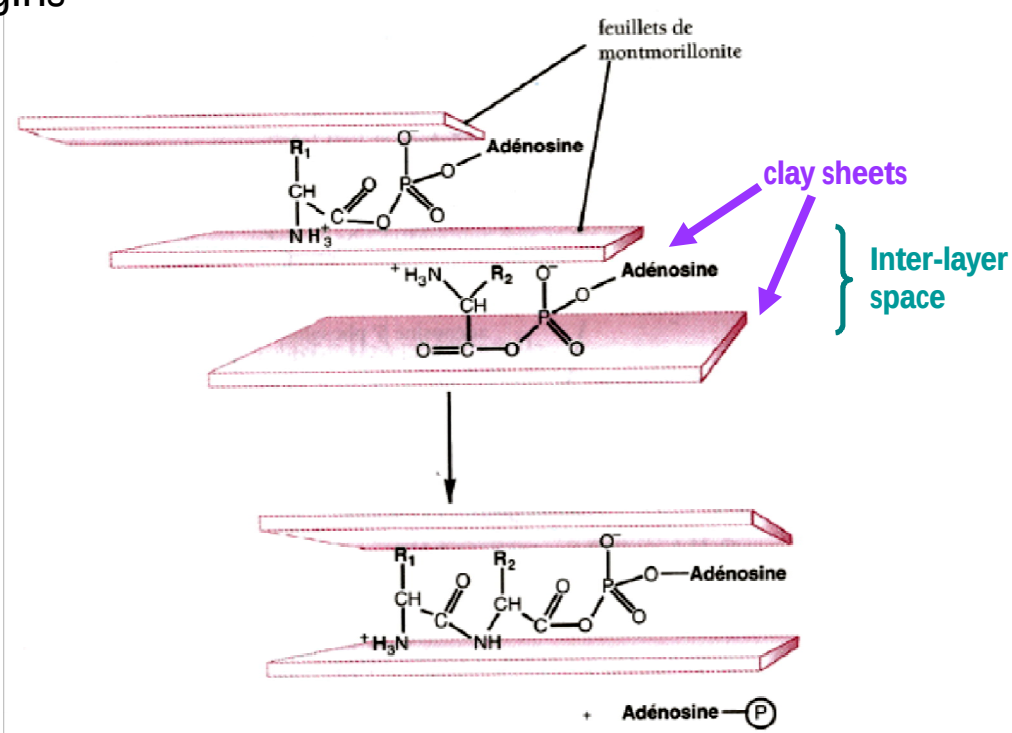


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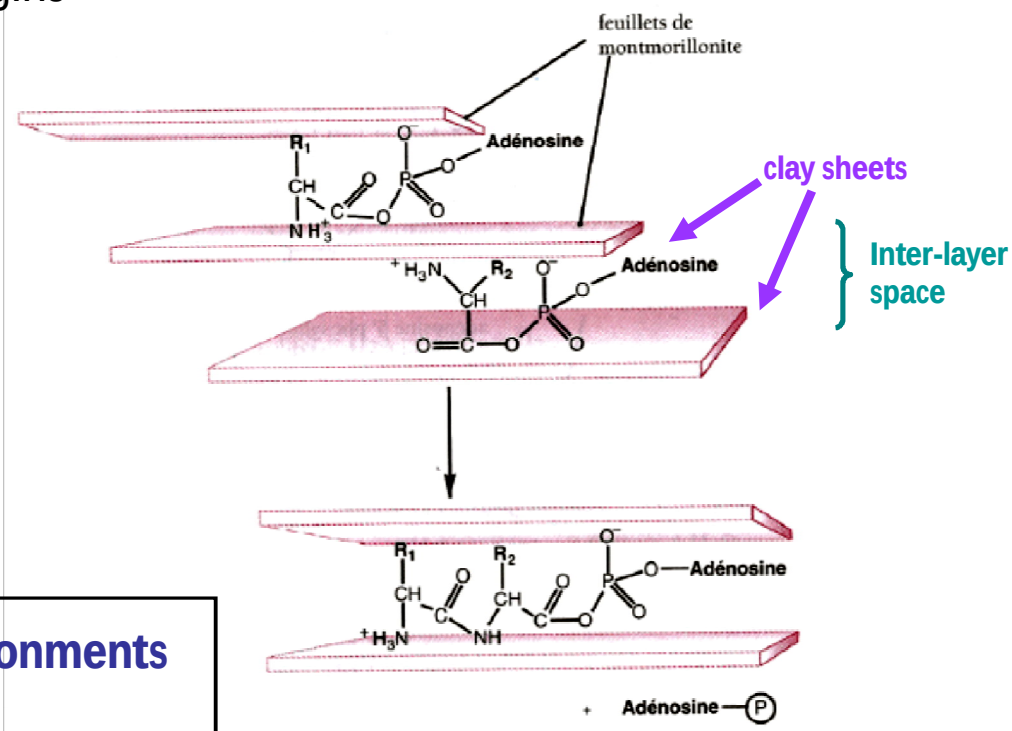
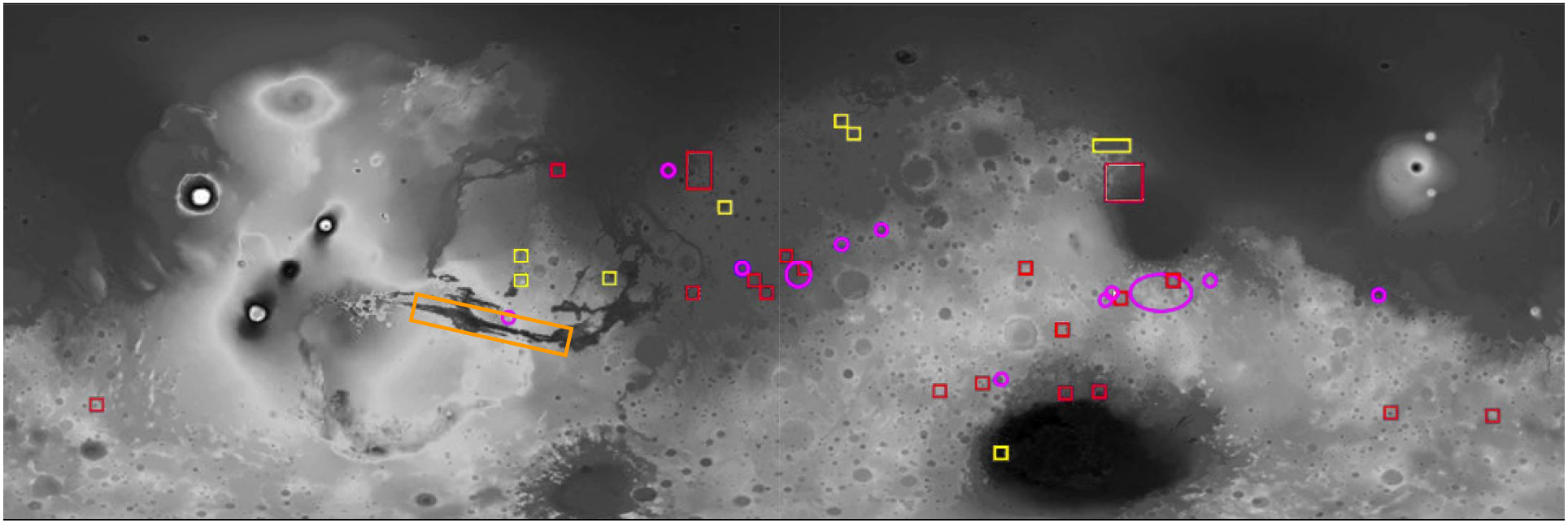



M.C. Maurel, ed. Dunod

- **Clays indicate existence of favorable environments**
- **Clays can enhance pre-biotic chemistry**
- **Clays can preserve bio-relics**

# Clays on Mars

- OMEGA (ESA) and CRISM (NASA) IFS: 18 m/pixel 0.3-5 µm $R_{2\mu m}$~ 140-300
- High-resolution topography, inertia and imagery data: 20 cm/pixel



Poulet et al. 2007

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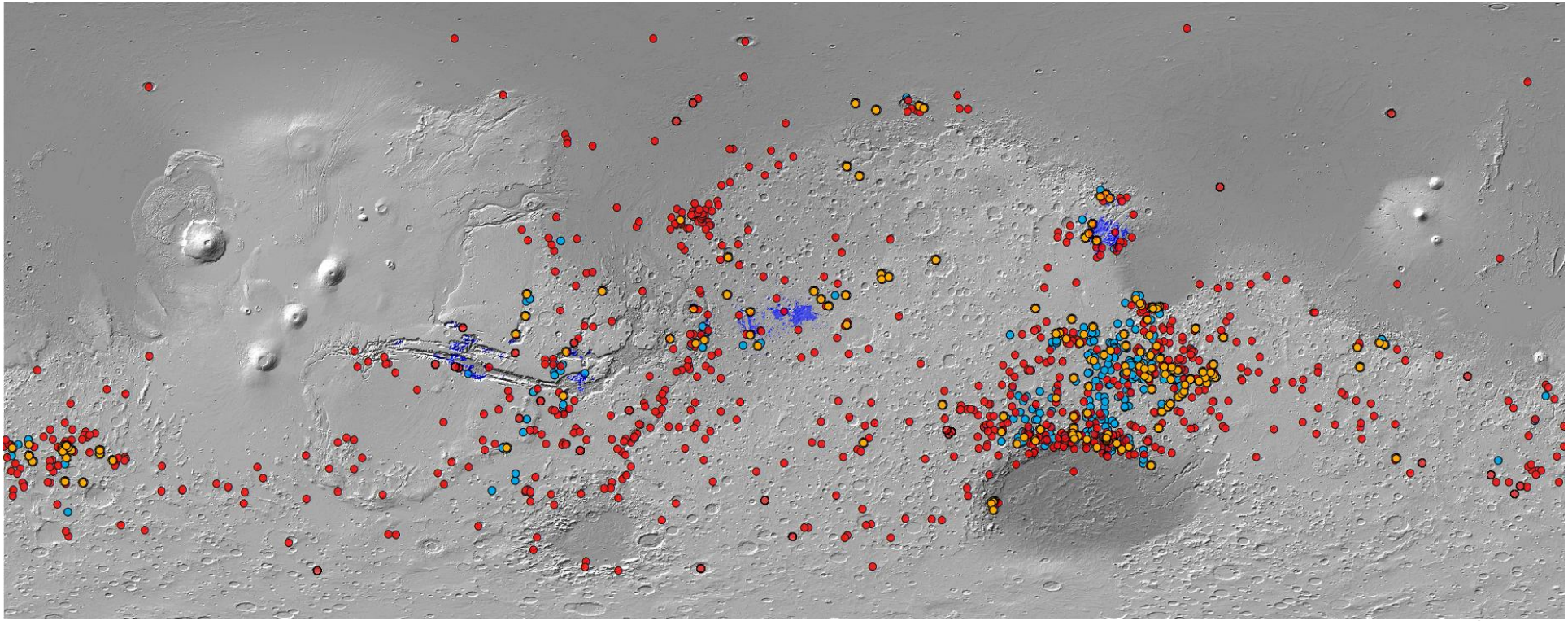

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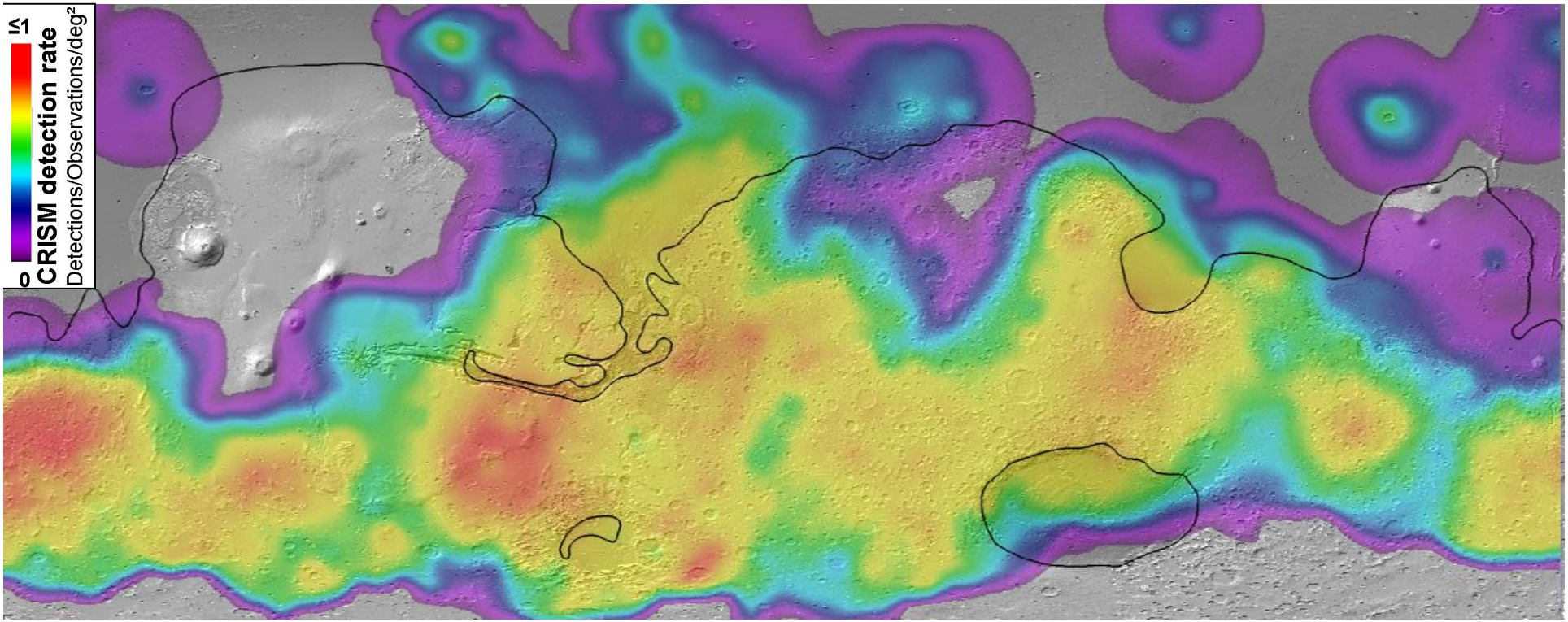


Carter et al., 2012

**The entire ancient surface of Mars was altered into clays**

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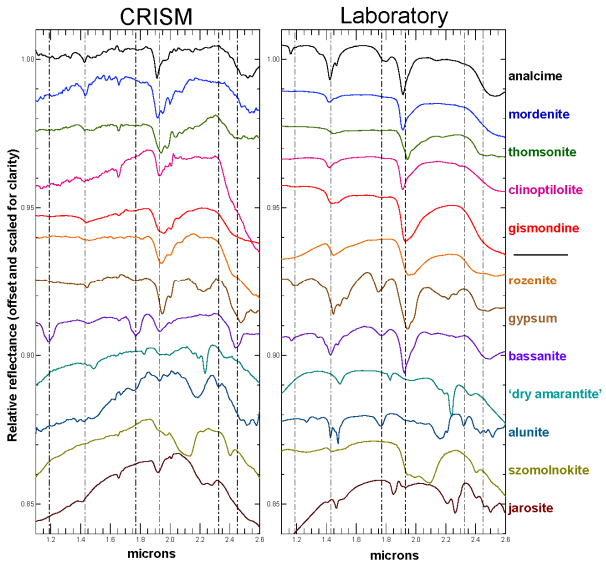


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Poulet et al., 2005; Milliken et al., 2008; Ehlmann et al., 2009; Carter et al., 2012

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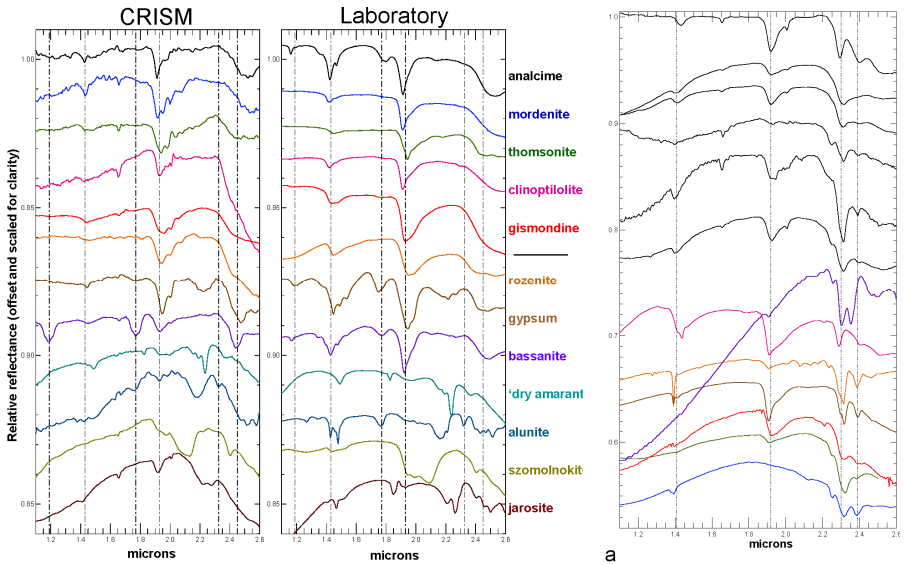


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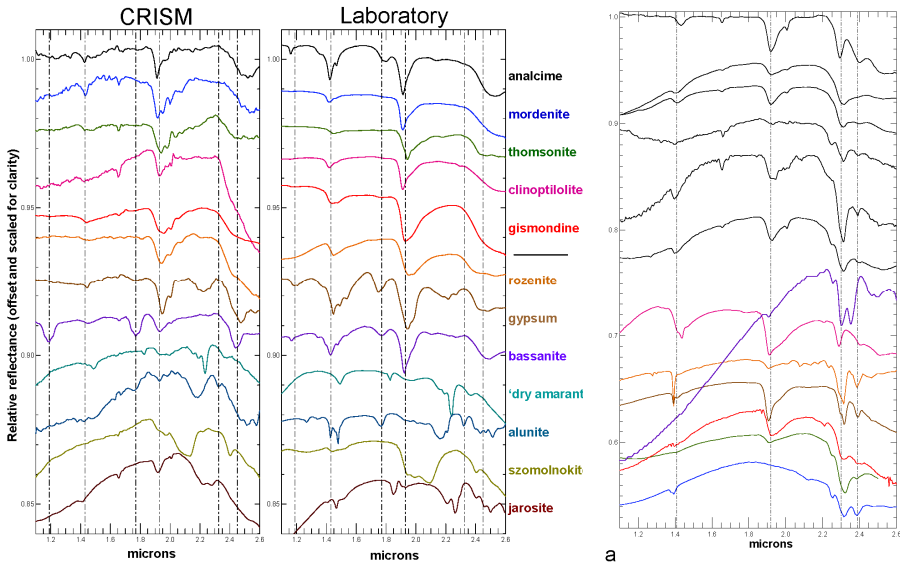


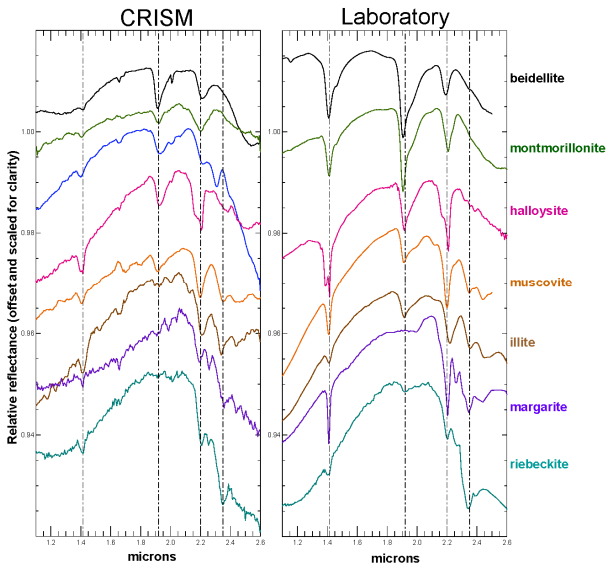


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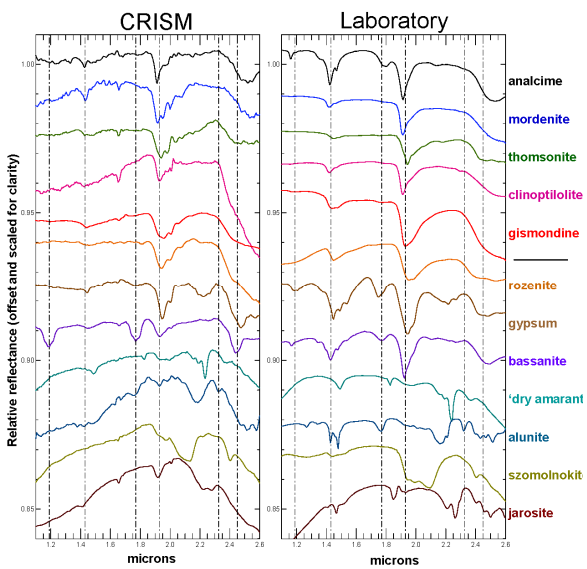


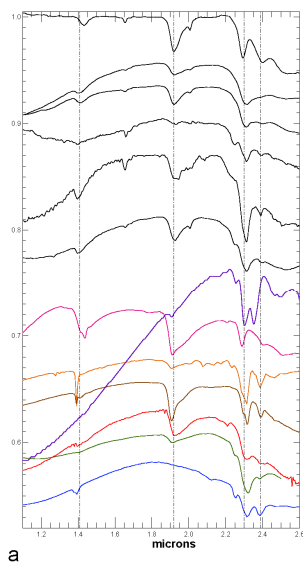


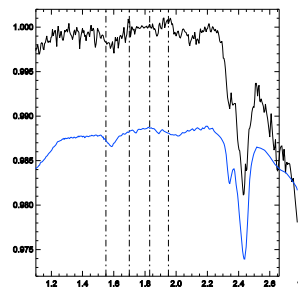

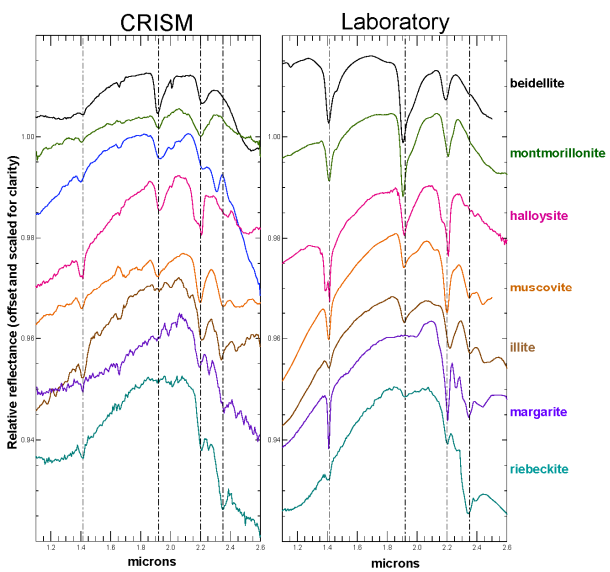


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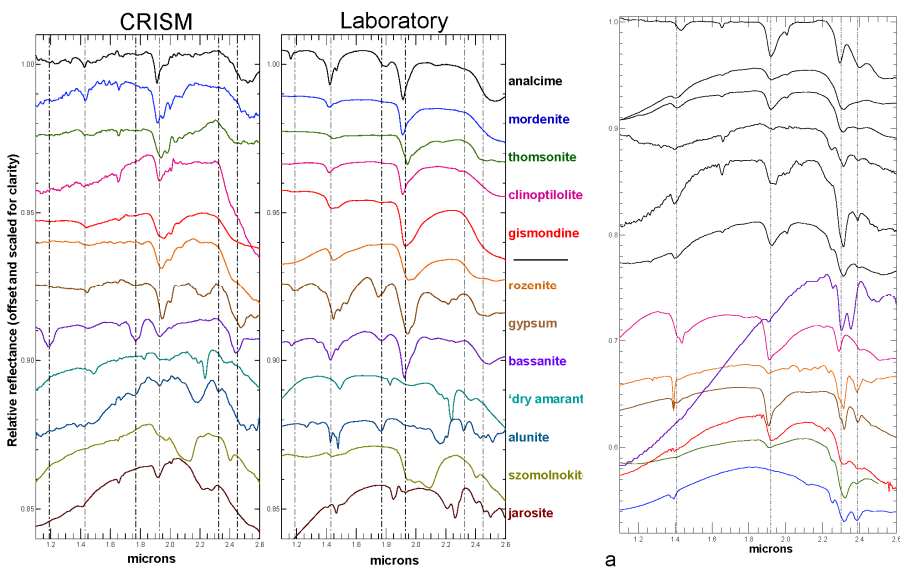


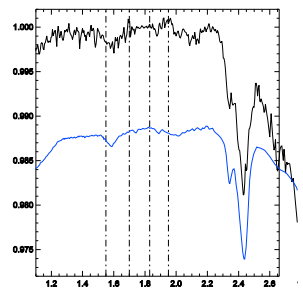

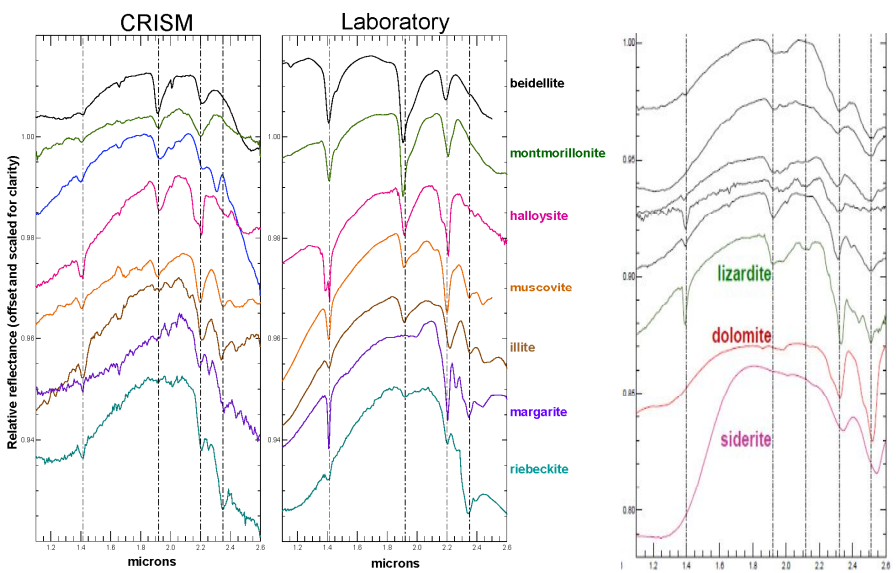


- Zeolites
- Sulfates
- Smectites
- Chlorites
- Kaolins
- Micas
- Amphibole
- Epidote
- Carbonates
- Serpentines

Poulet et al., 2005; Milliken et al., 2008; Ehlmann et al., 2009; Carter et al., 2012

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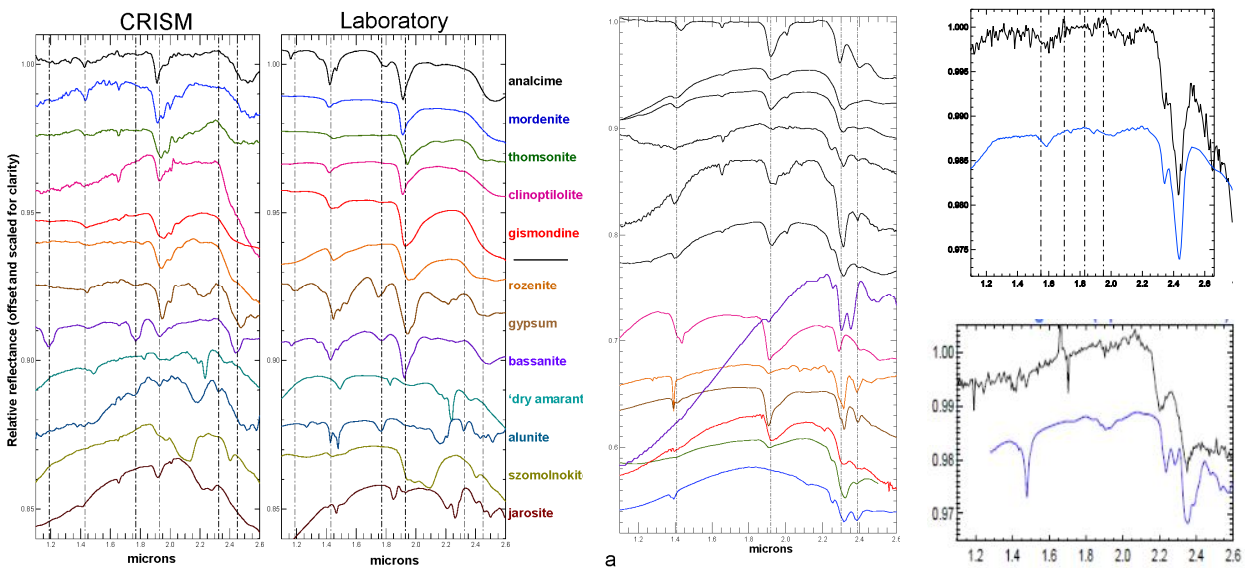


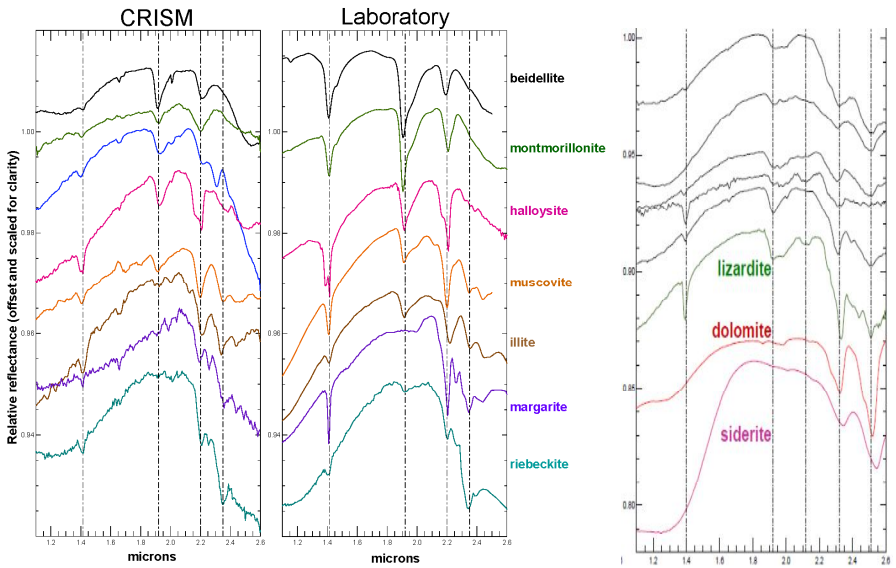


- Zeolites
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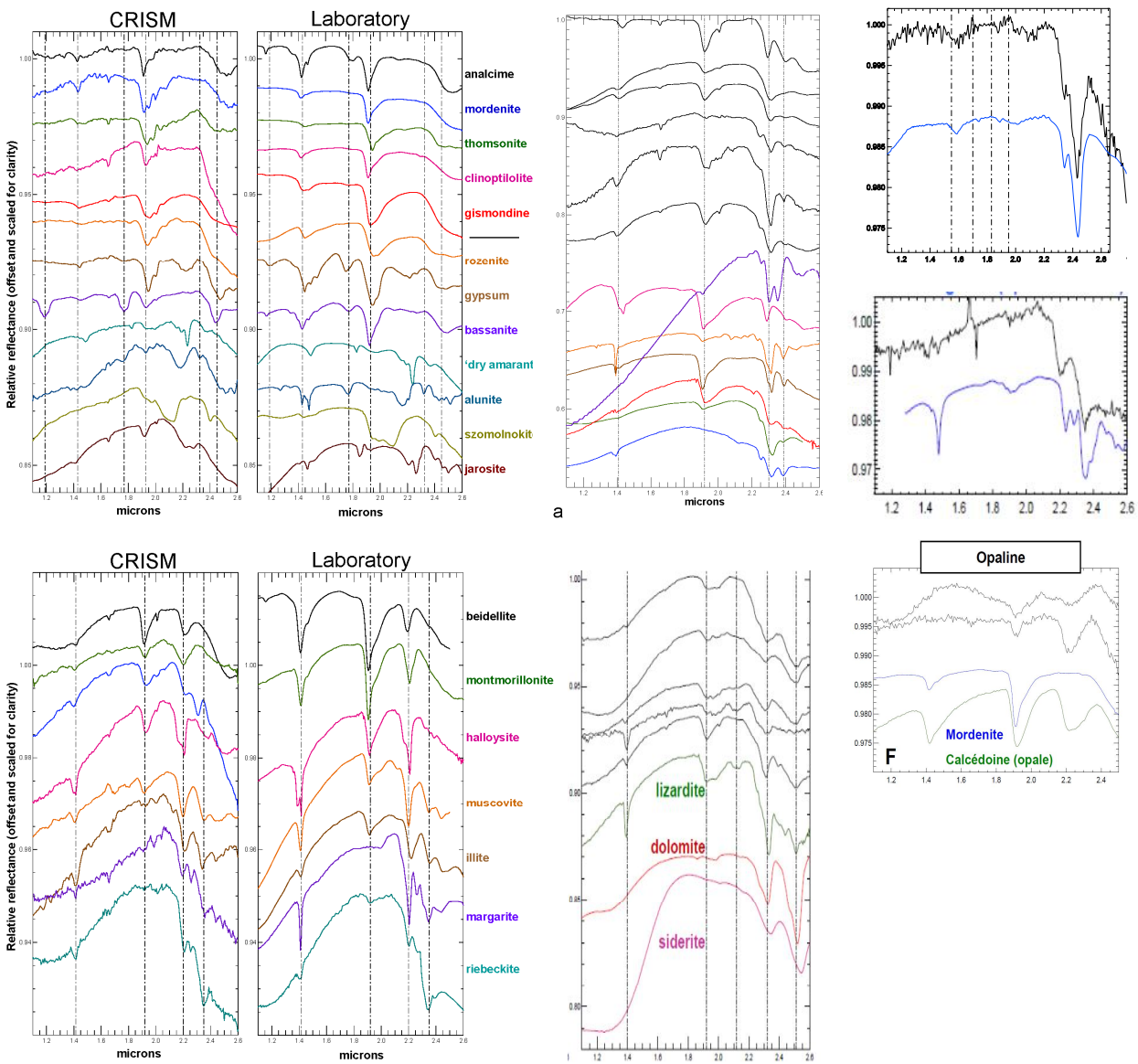


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- Prehnite
- Opaline silica

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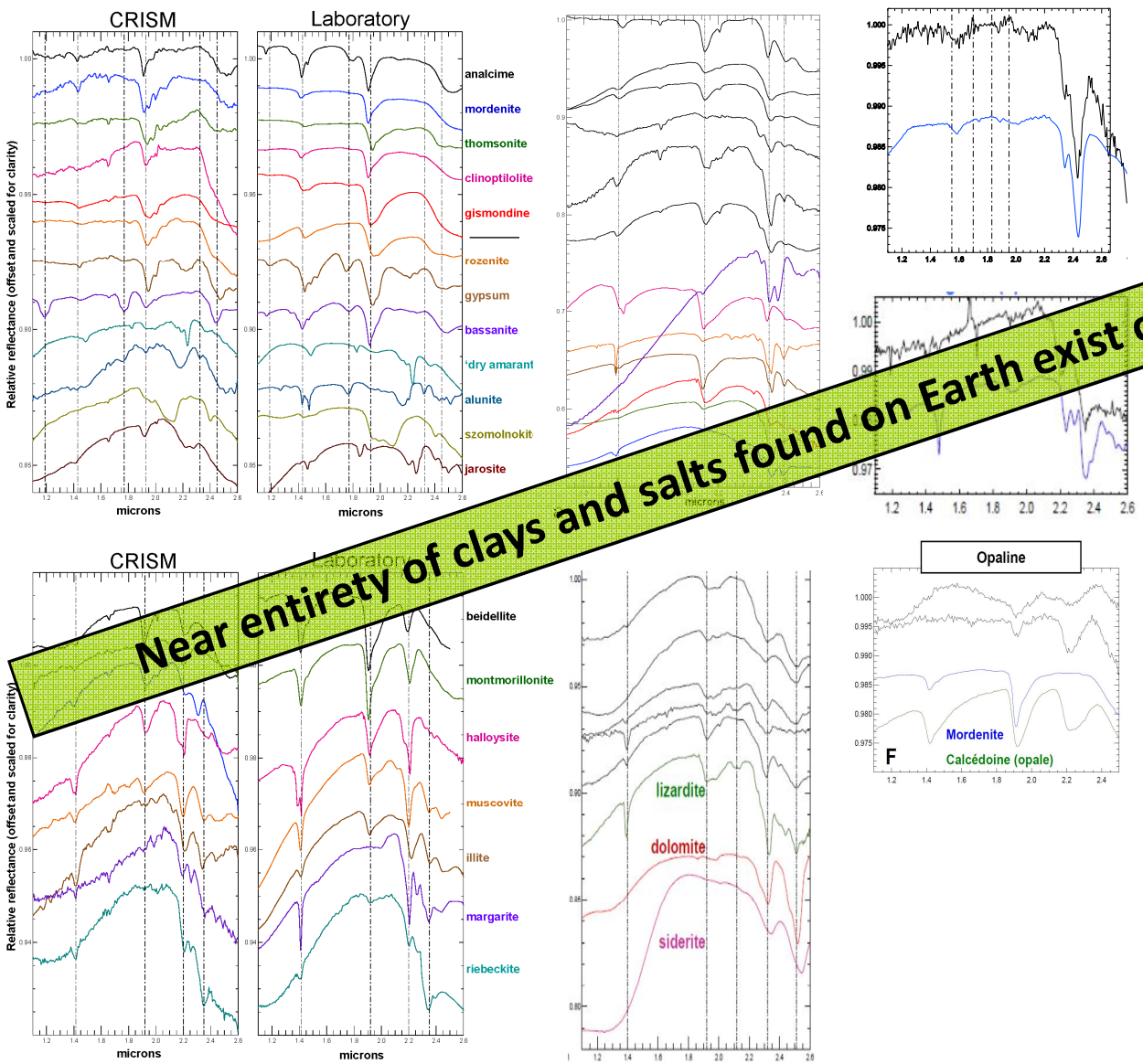
# Clays on Mars




**Near entirety of clays and salts found on Earth exist on Mars**

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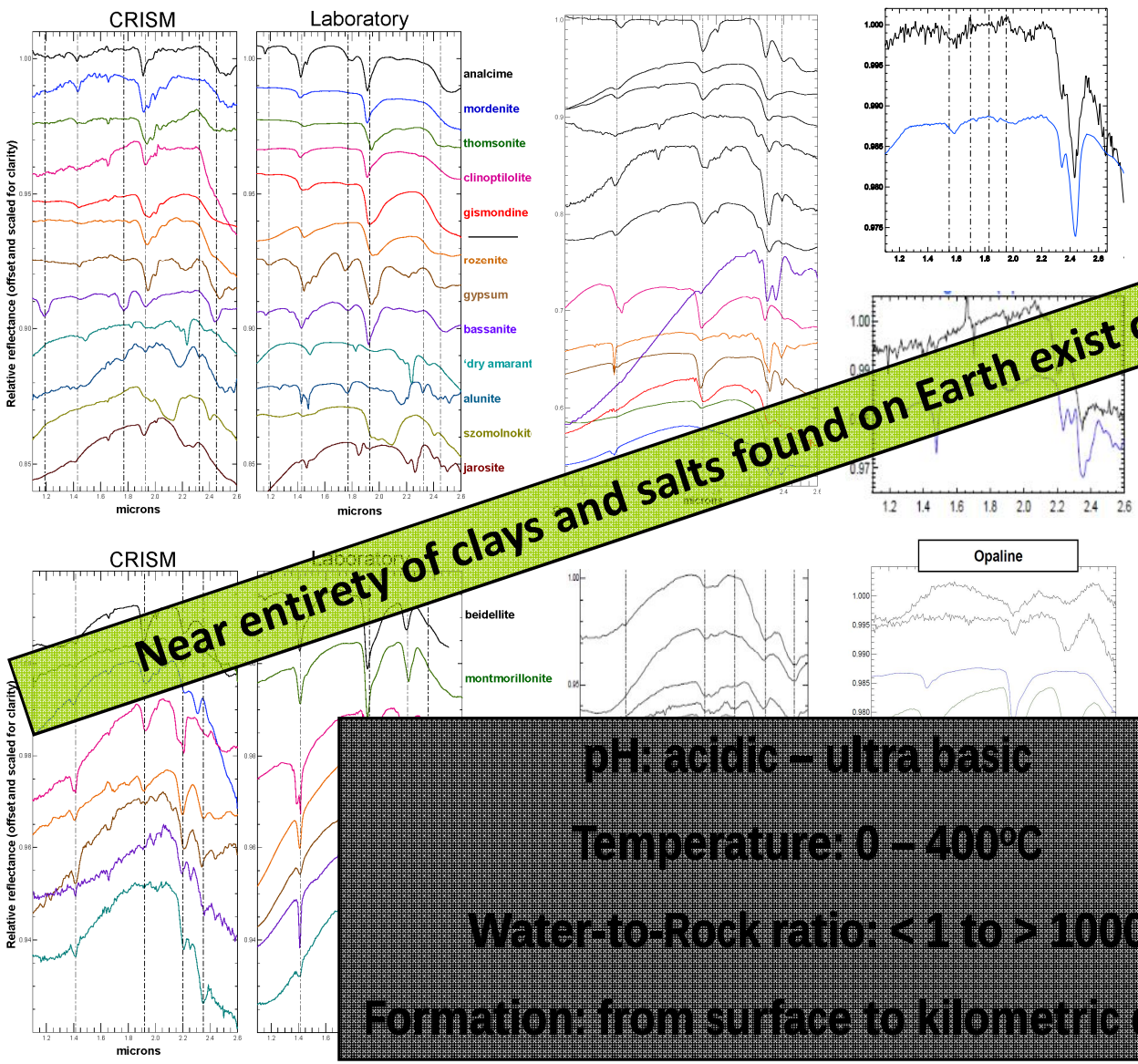


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**pH: acidic – ultra basic**

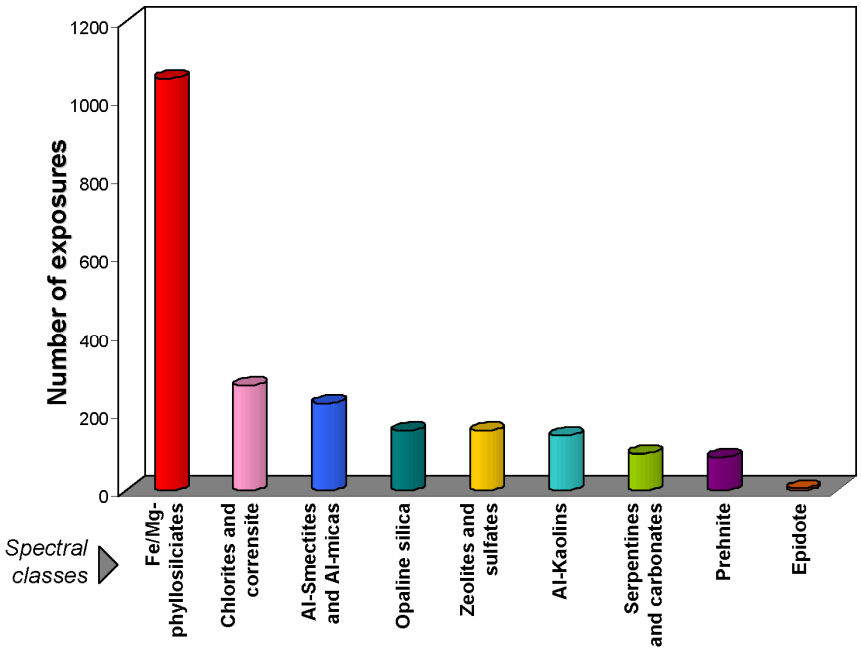
**Temperature: 0 – 400°C**

**Water-to-Rock ratio: < 1 to > 1000**

**Formation: from surface to kilometric depth**

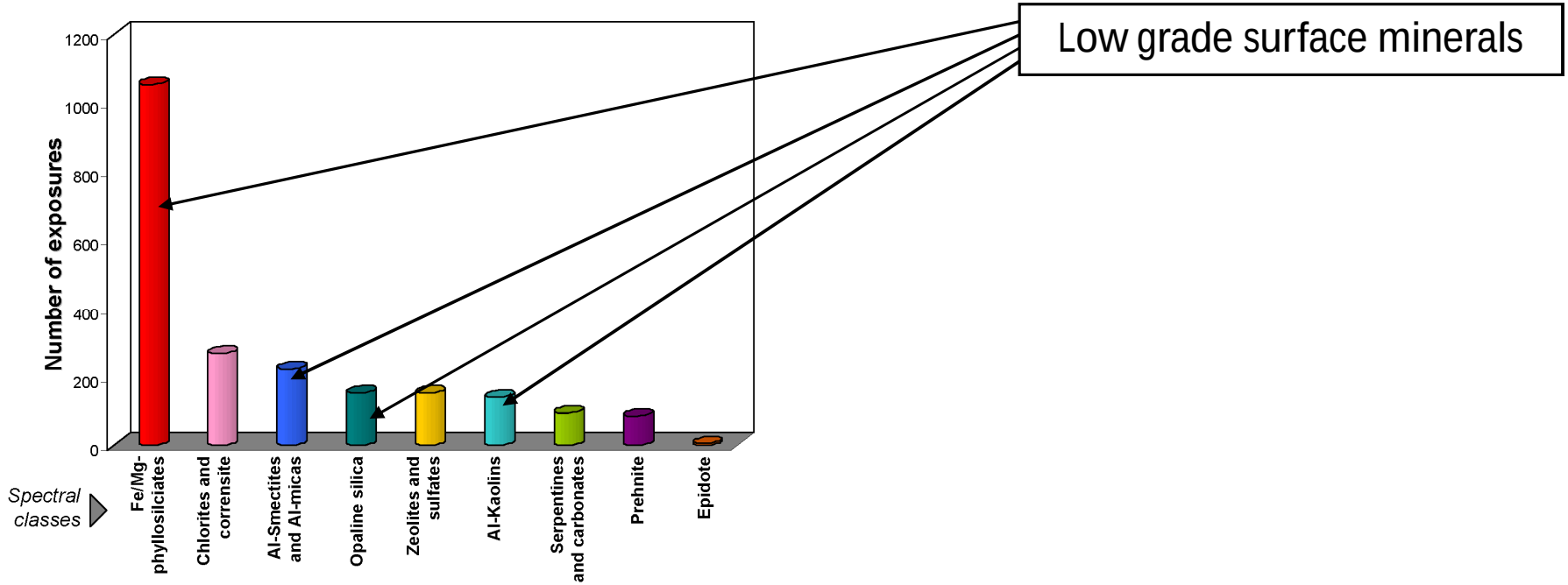
Poulet et al., 2005; Milliken et al., 2008; Ehlmann et al., 2009; Carter et al., 2012

# Clays on Mars



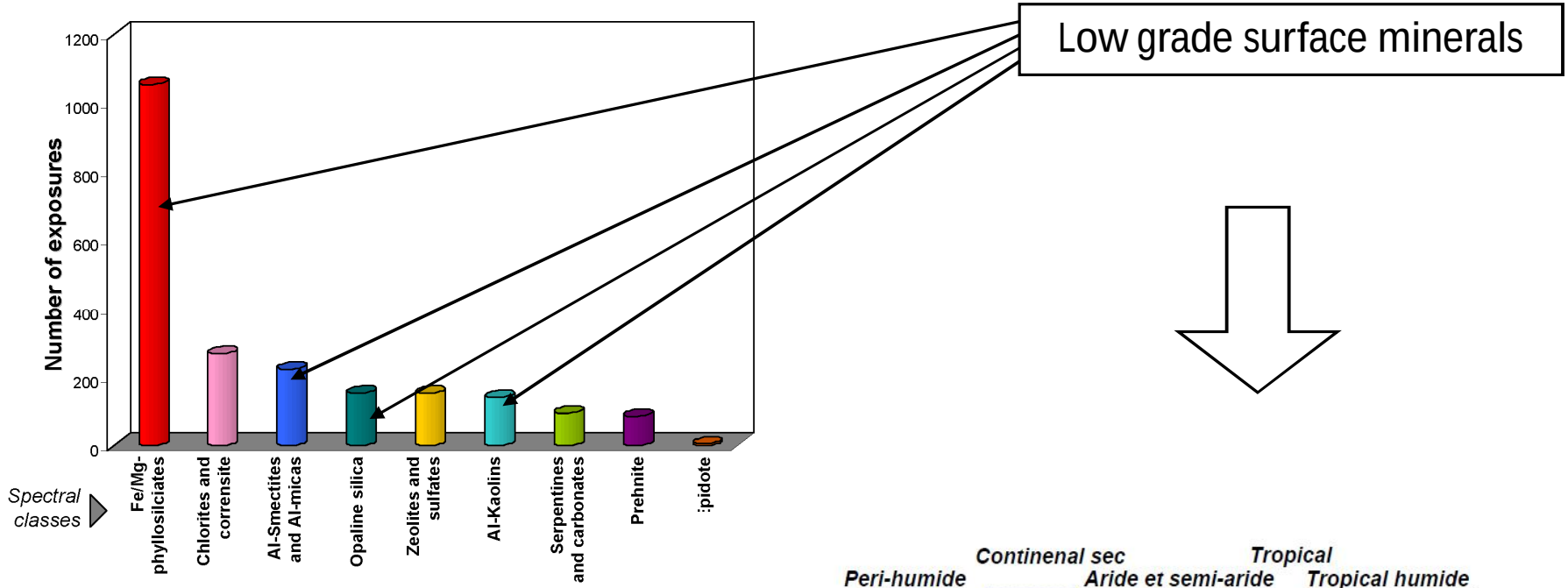

*John Carter – OPS II – March 2012*

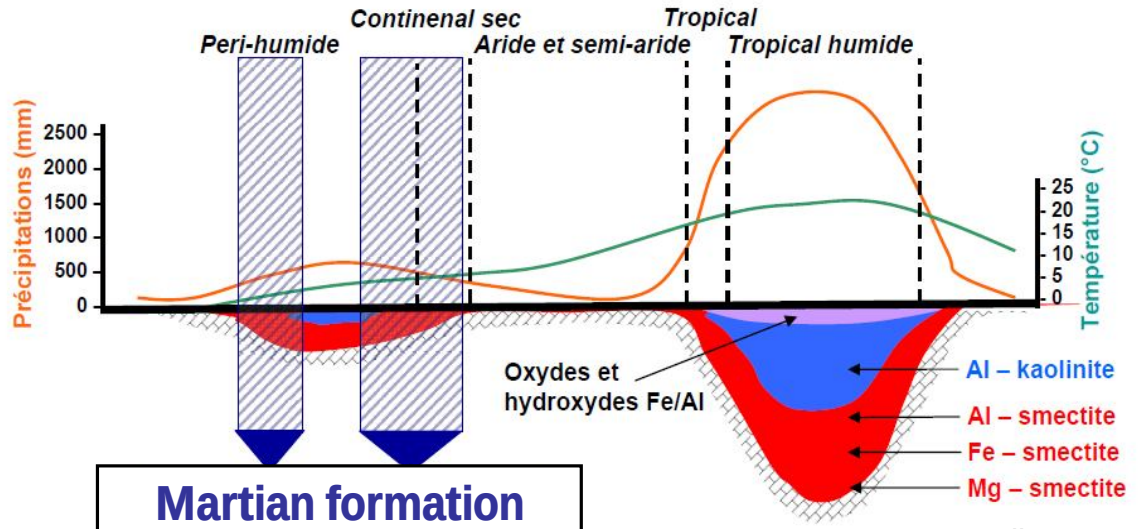
# Clays on Mars




*John Carter – OPS II – March 2012*

# Clays on Mars



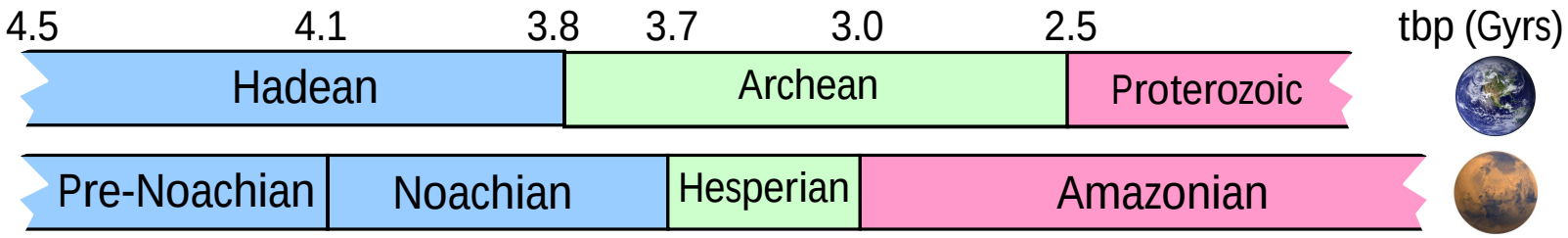

Allen, 1997

**Martian formation environments**

*John Carter – OPS II – March 2012*

# Clays on Mars

Hadean Earth : surface composed primarily of basalts ( = Mars), widely altered into clays (Meunier et al., 2010)



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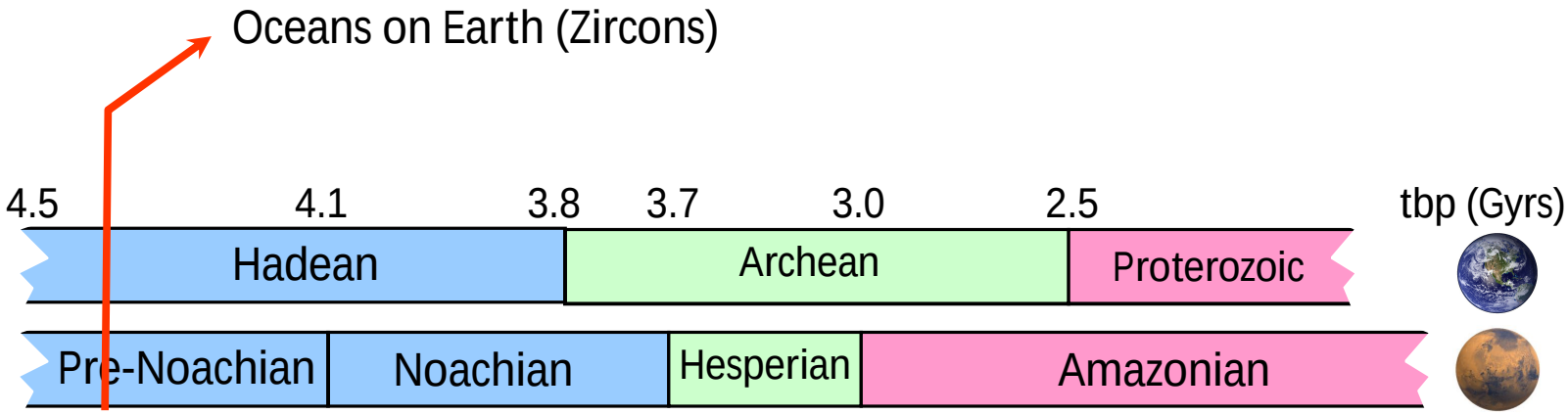

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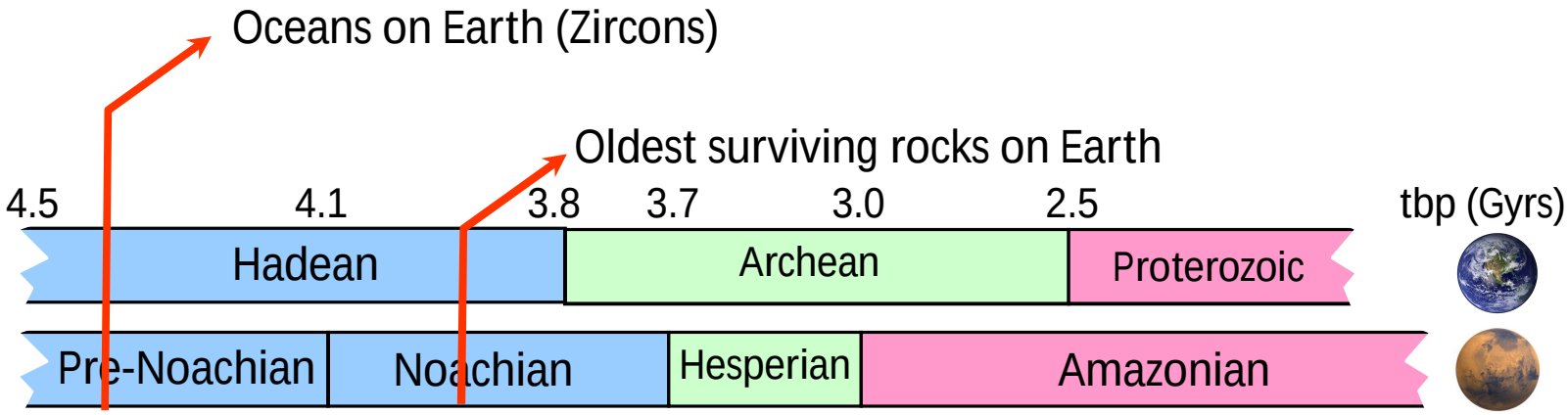

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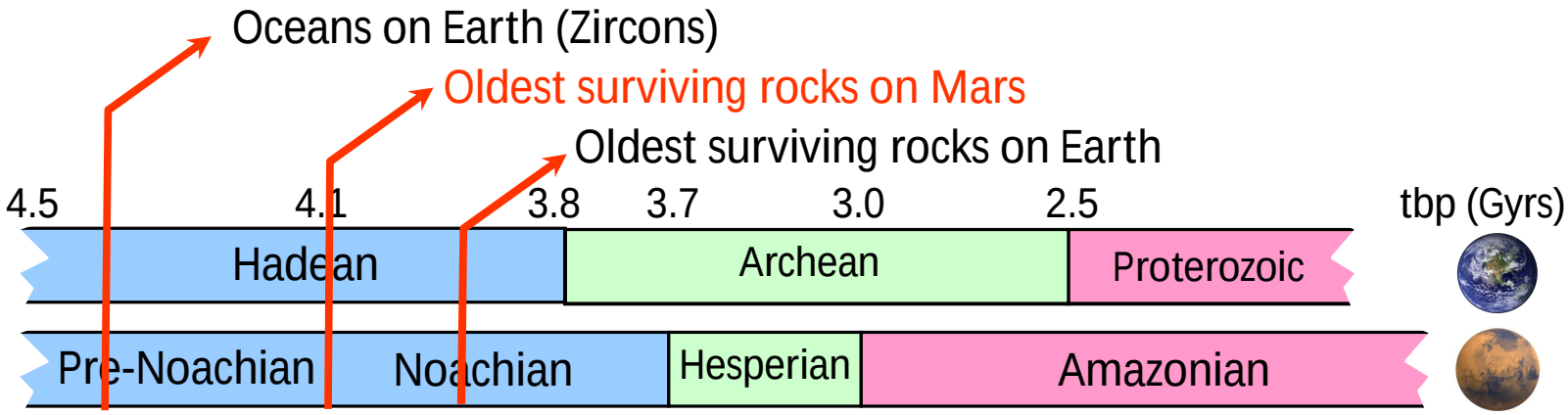

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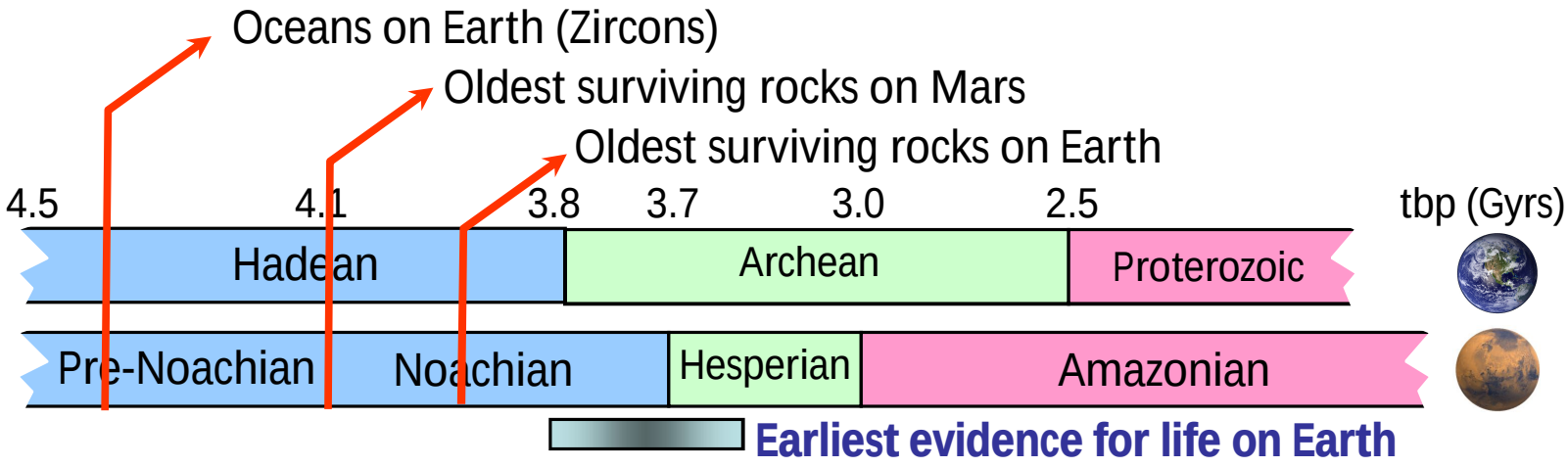

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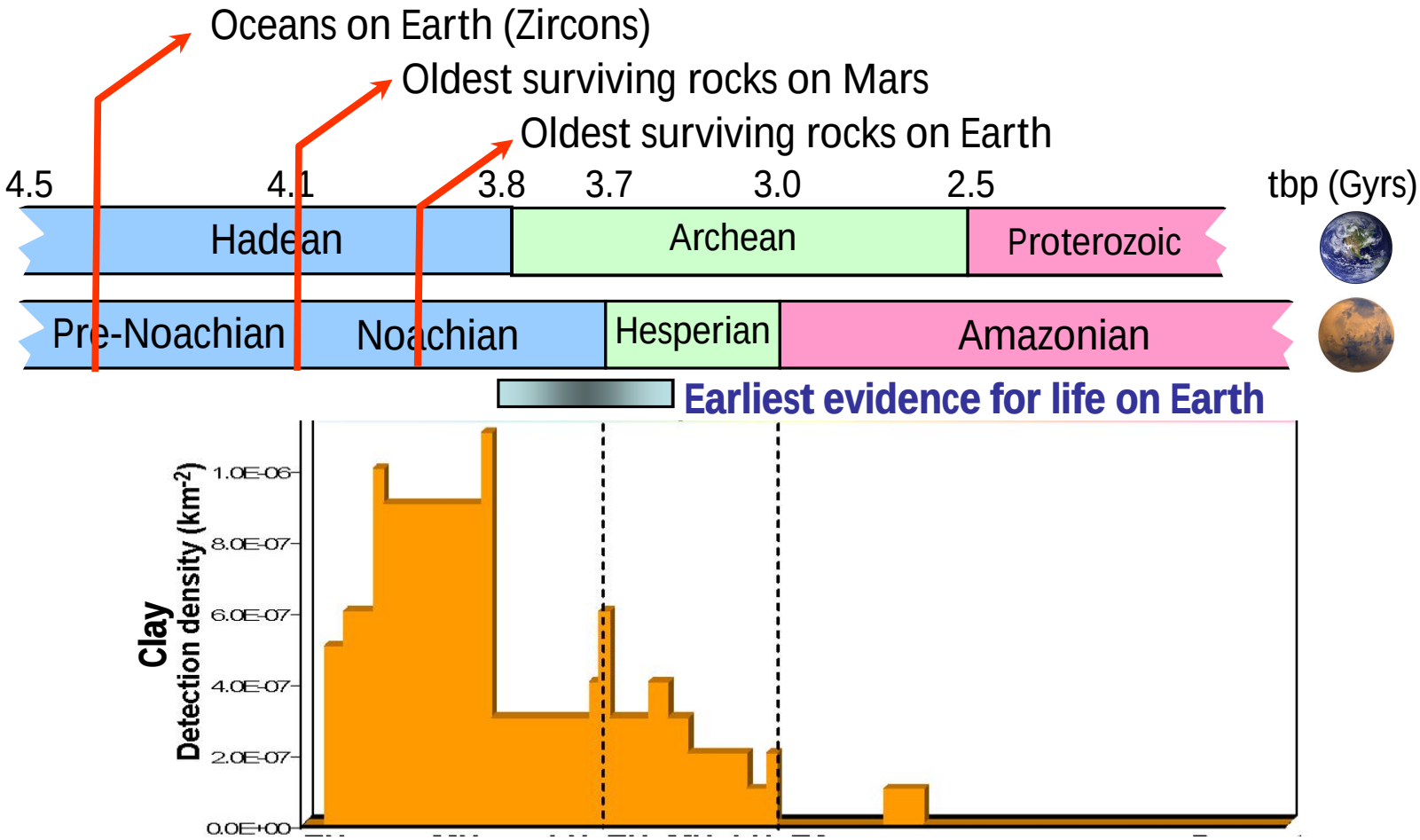


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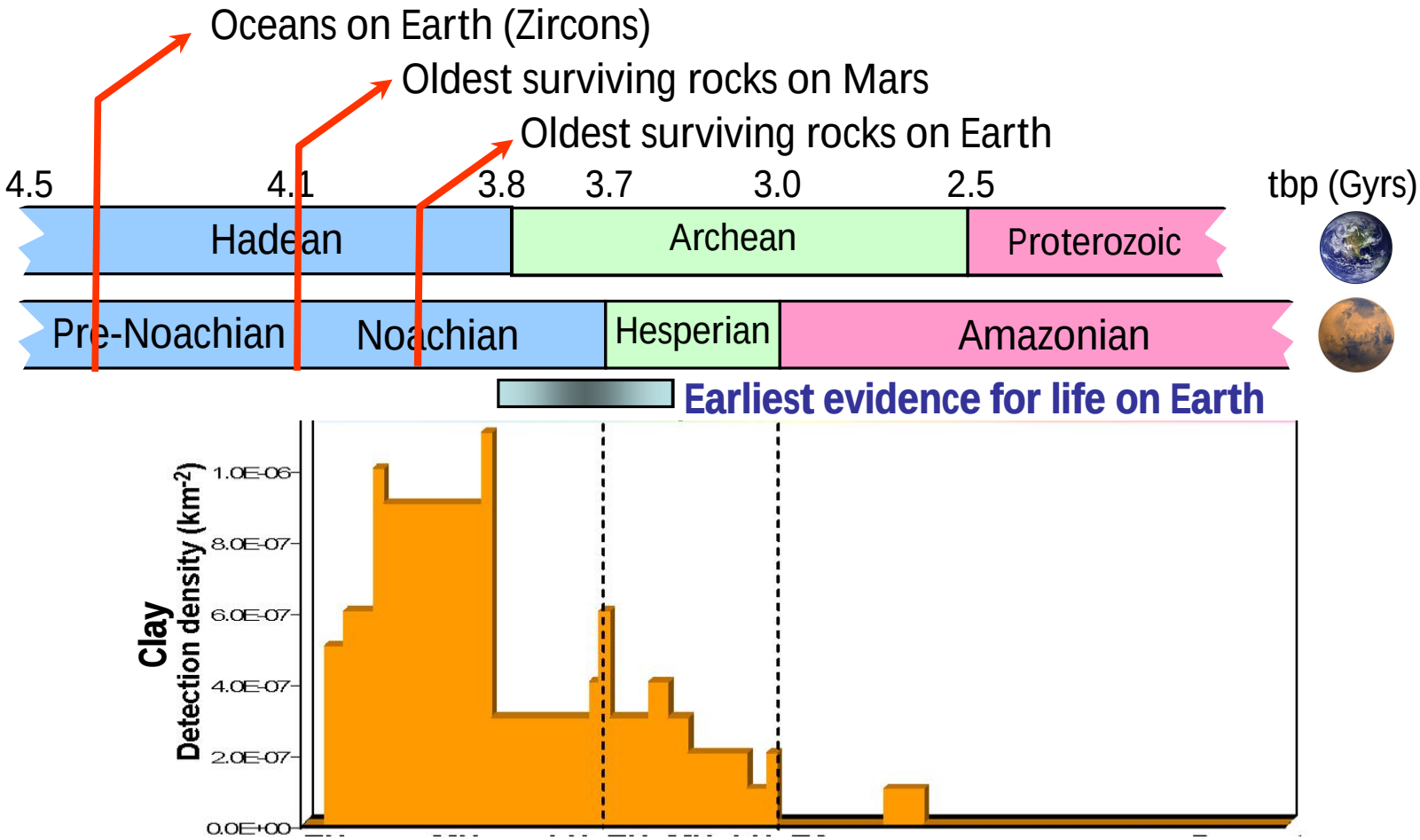



**Contrarily to Earth, Mars has widely preserved Hadean-aged environments**

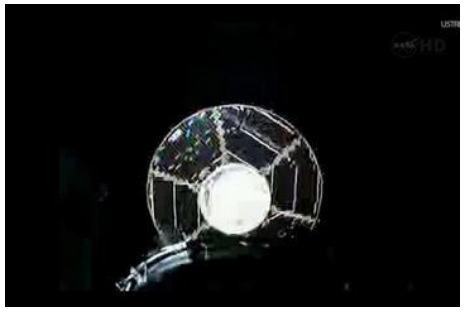
**These were altered by liquid water into clays like on Earth but material is preserved**

**If life is a generic process, we should find remnants of pre-biotic and possibly biotic activity**

*John Carter – OPS II – March 2012*

# Looking for bio-markers in-situ with NASA's Mars Science Laboratory

Launched Nov 2011



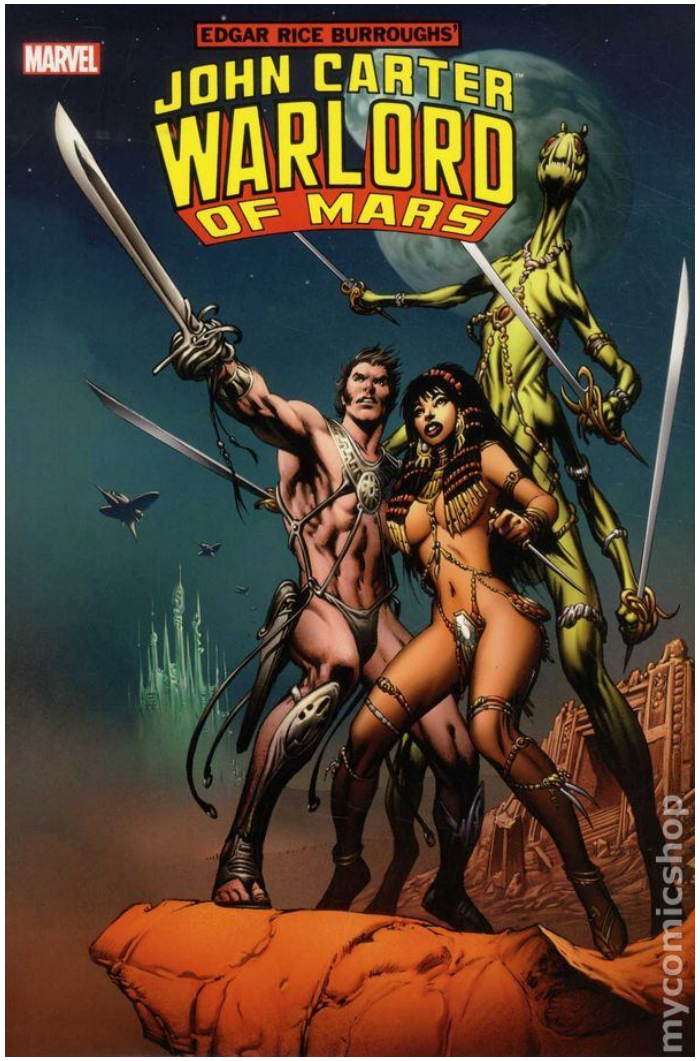
1/3 thru cruise

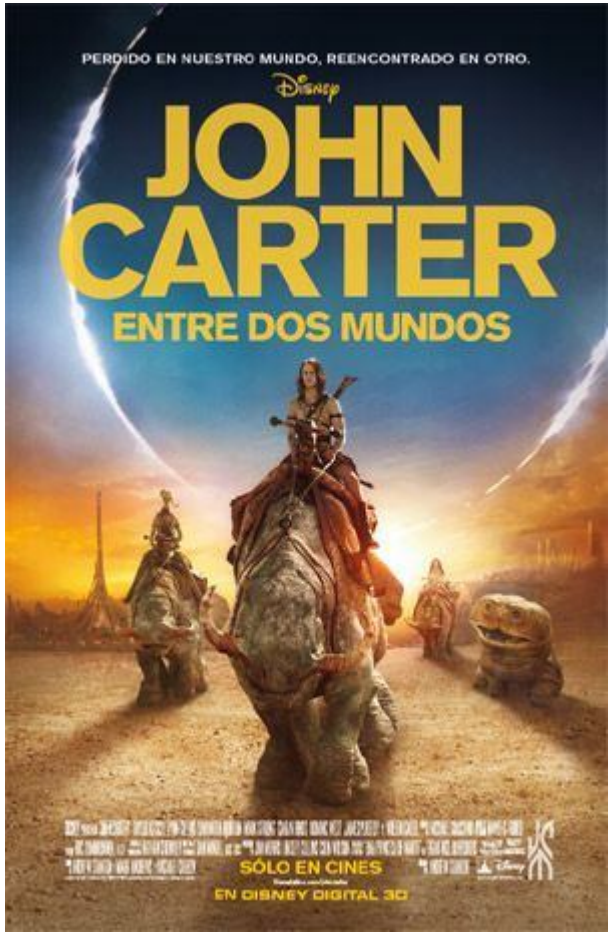
Landing on Aug. 6, 2012

Clay-bearing lake (?) deposits in Gale crater

# Looking for bio-markers on Mars ?

# Look no more…




Disney et al.