Since the times MSL goals were established, the MERs and Mars Express have operated. Out of the impressive data acquired, an in-depth revisiting of Mars History is being built. Does it modify the prime MSL goal (search for past habitability)?

No.

On the contrary, a new perspective is offered for Mars to have harbored habitable conditions. The role water may have played is by far better understood. This fundamentally opens an exciting perspective, while at the same time it indicates that most previous drivers to search for favorable sites were partly biased. The new view modifies the way to achieve the goal, and in particular the site to explore.

The process of rebuilding the Mars History is far for being consolidated. This on going activity must be actively pursued in close cooperation. However, key directions can already be drawn, that can readily feed the landing site selection process.

Mineralogical MSL landing site selection: the OMEGA/MEx potential contribution

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Orsay

on behalf of the entire OMEGA team

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Pasadena, June 1, 2006

Mineralogical MSL landing site selection: the OMEGA/MEx potential contribution

1. Spirit: we (OMEGA/MEx), rather than providing an OMEGA list of sites, offer to contribute to this selection process, both through data already acquired, and data still to be acquired, in conjunction with CRISM.

2. With respect to the prime MSL goal ("habitability"), OMEGA potential is to couple

   - imaging (geomorphology)

     to

   - composition (mineralogy) at a regional/local (sub km) scale .

   One key finding of OMEGA is the presence of hydrated minerals in a variety of localized sites; some (most!) would not have been identified by optical images as having been processed by persistent liquid water.

Pasadena, June 1, 2006

Mineralogical MSL landing site selection: the OMEGA/MEx potential contribution

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2. With respect to the prime MSL goal ("habitability"), OMEGA potential is to couple

   - imaging (geomorphology)

     to

   - composition (mineralogy) at a regional/local (sub km) scale .

   Site should contain minerals with clear O-H signatures.

   Within these minerals, some might be more favorable (habitat-wise).

Pasadena, June 1, 2006

Mineralogical MSL landing site selection: the OMEGA/MEx potential contribution

In global terms, OMEGA has identified three families of minerals derived by alteration of the pristine mafics:

- anhydrous ferric oxides,
- hydrated sulfates,
- hydrated phyllosilicates.

They were formed

- in distinct periods
- through distinct processes
- requiring distinct environments

$\Rightarrow$ they trace distinct eras, with distinct importance wrt prime MSL goal

Pasadena, June 1, 2006

Mineralogical MSL landing site selection: the OMEGA/MEx potential contribution

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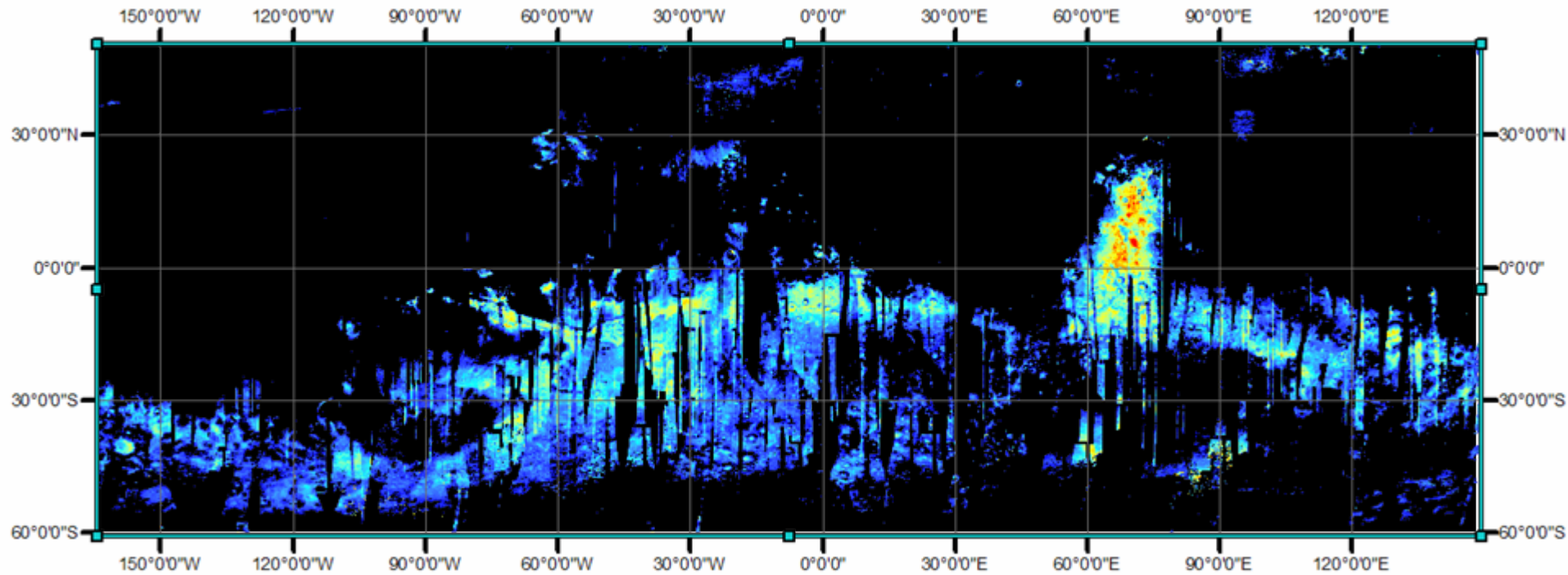
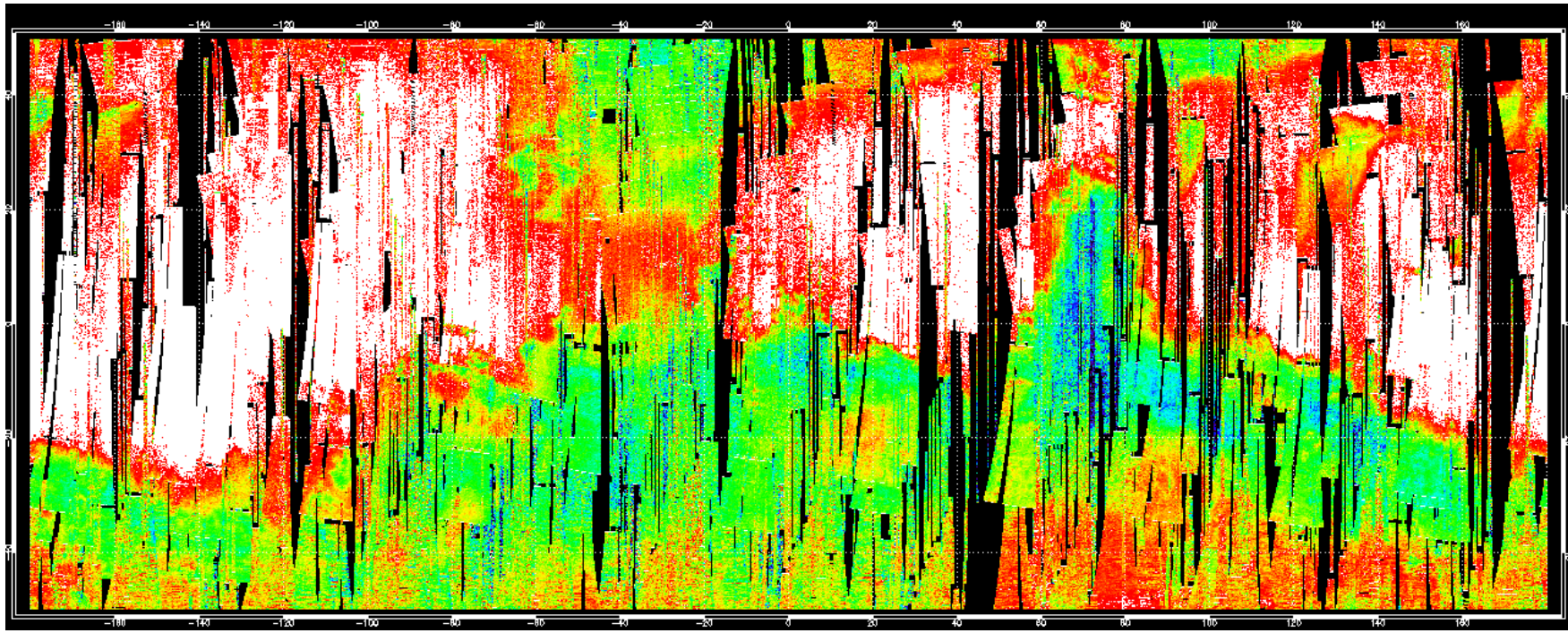
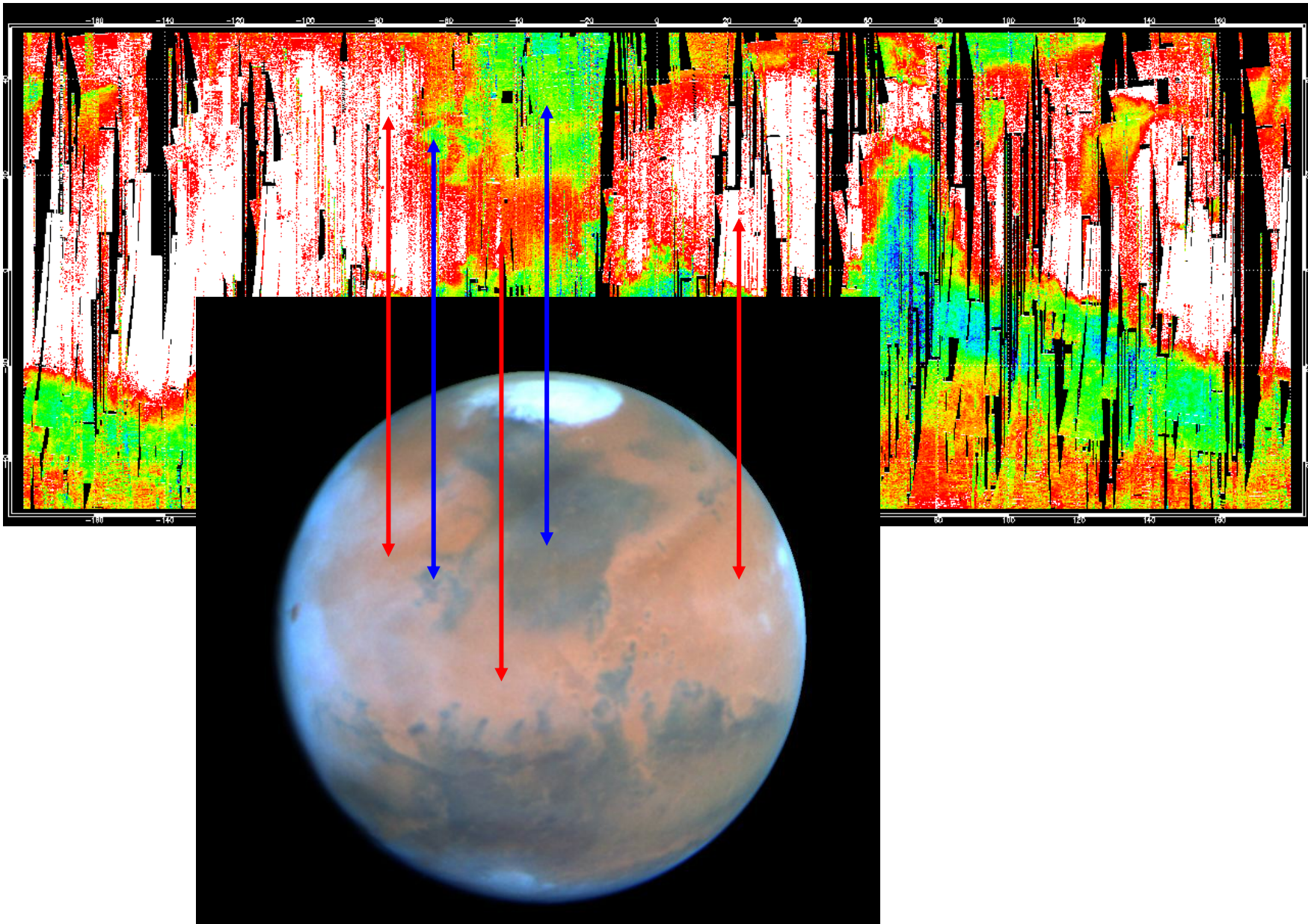
Pyroxenes

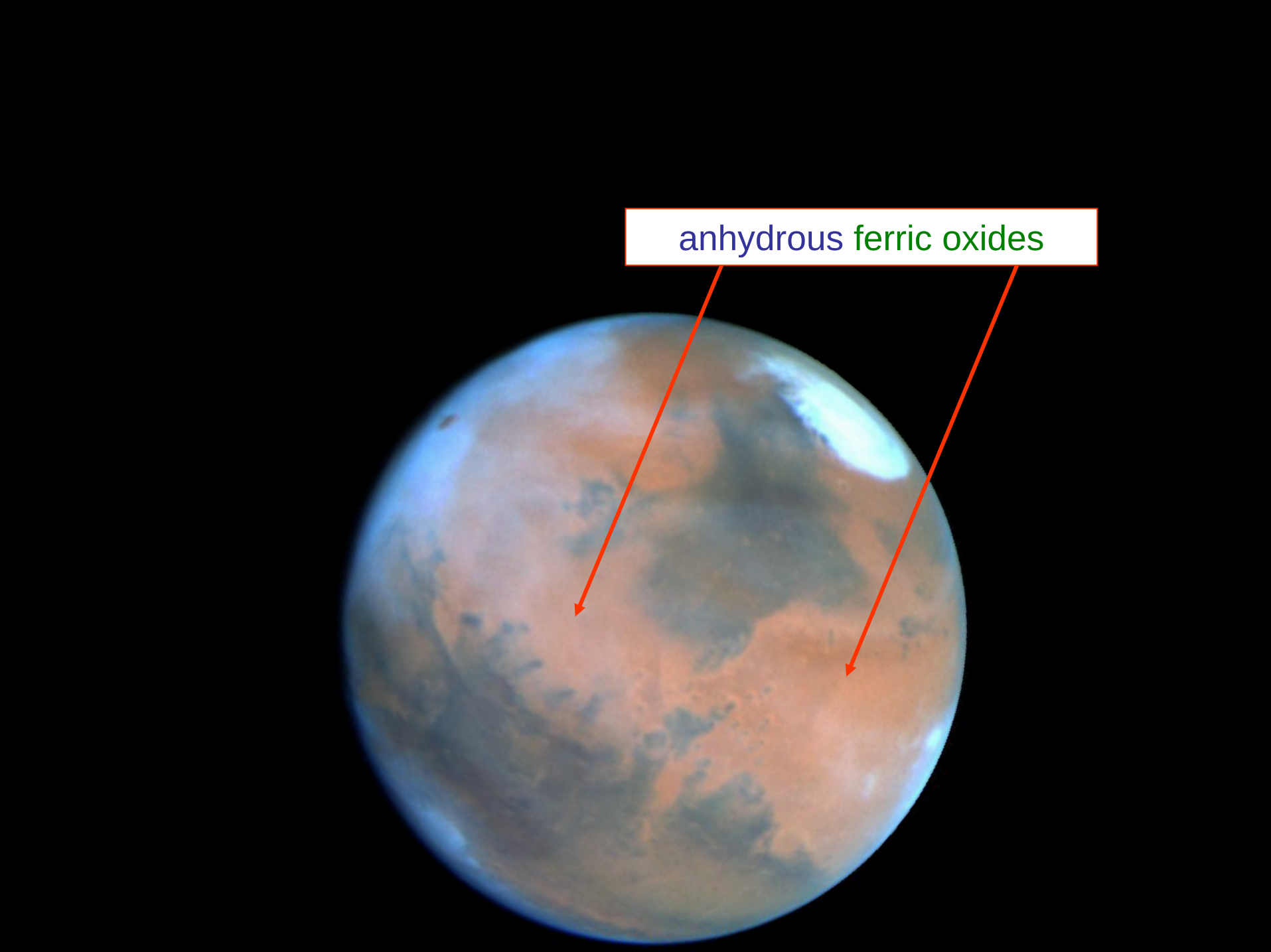

150°0'0"W
120°0'0"W
90°0'0"W
60°0'0"W
30°0'0"W
0°0'0"
30°0'0"E
60°0'0"E
90°0'0"E
120°0'0"E
30°0'0"N
0°0'0"
30°0'0"S
60°0'0"S

Fe^{3+} (ferric oxides)

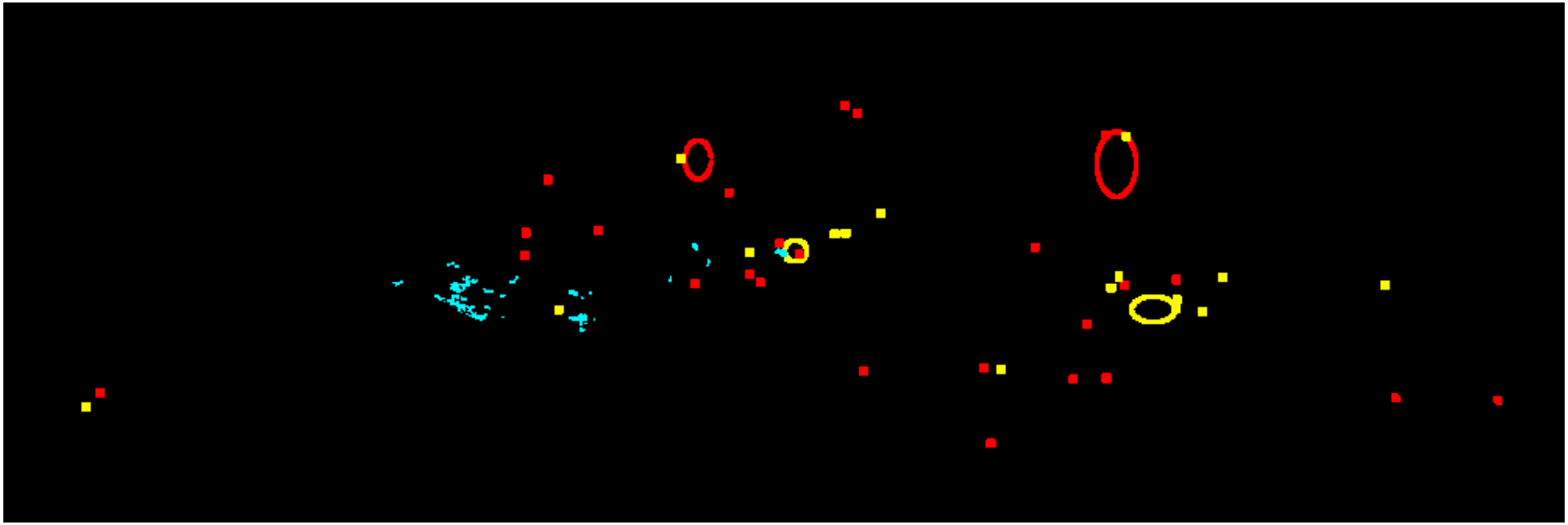


Fe^{3+} (ferric oxides)



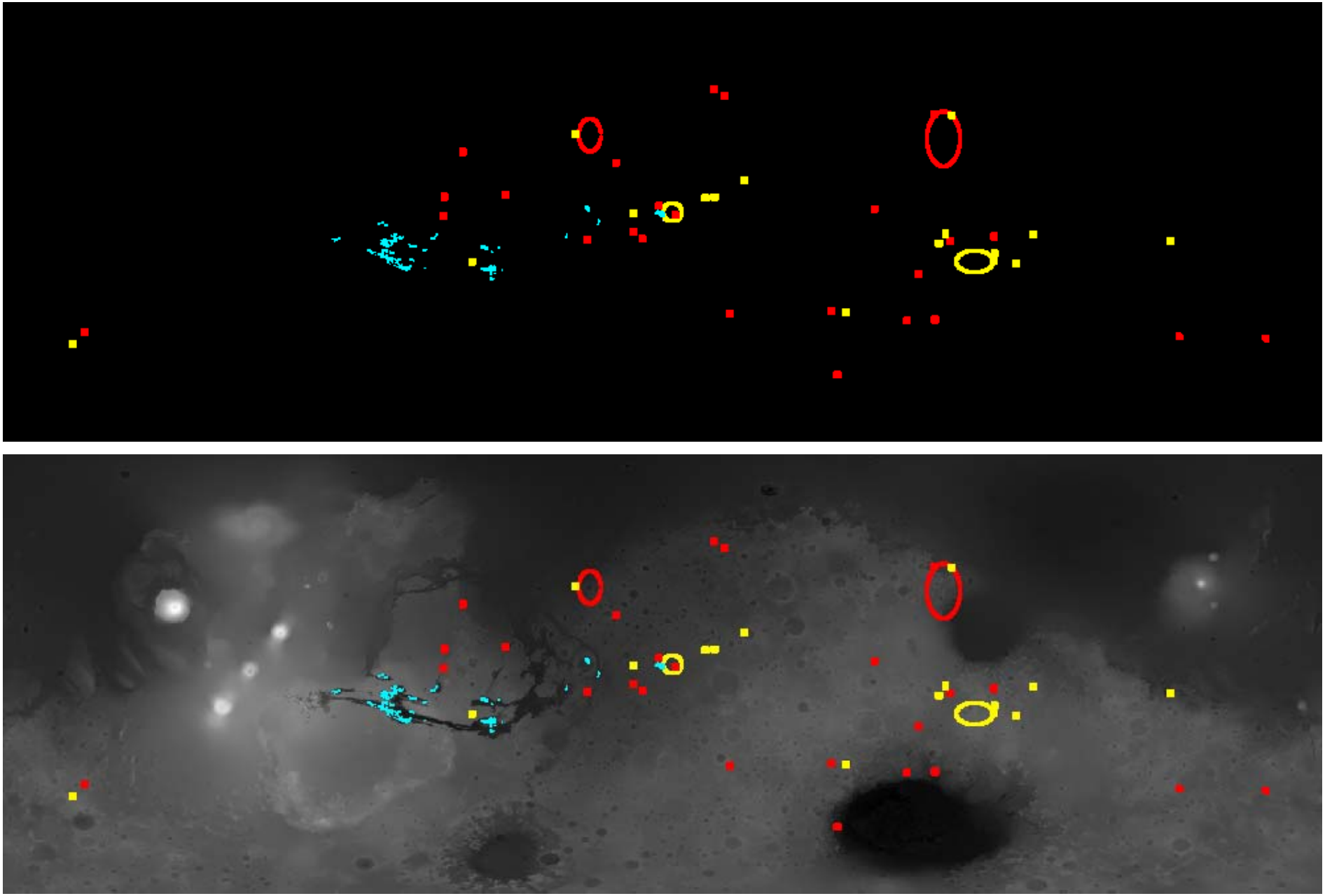

anhydrous ferric oxides

Global map of the hydration band @ 1.9 µm



blue:	sulfates
red:	phyllosilicates
yellow:	other hydrated minerals

Global map of the hydration band @ 1.9 µm



Mineralogical MSL landing site selection: the OMEGA/MEx potential contribution

In global terms, OMEGA has identified three families of minerals derived by alteration of the pristine mafics:

- anhydrous ferric oxides: “dust”,
- hydrated sulfates

have been detected in a variety of localized areas, within Terra Meridiani and the ILDs of Valles Marineris:

Mangold et al. paper this morning

Pasadena, June 1, 2006

Mineralogical MSL landing site selection: the OMEGA/MEx potential contribution

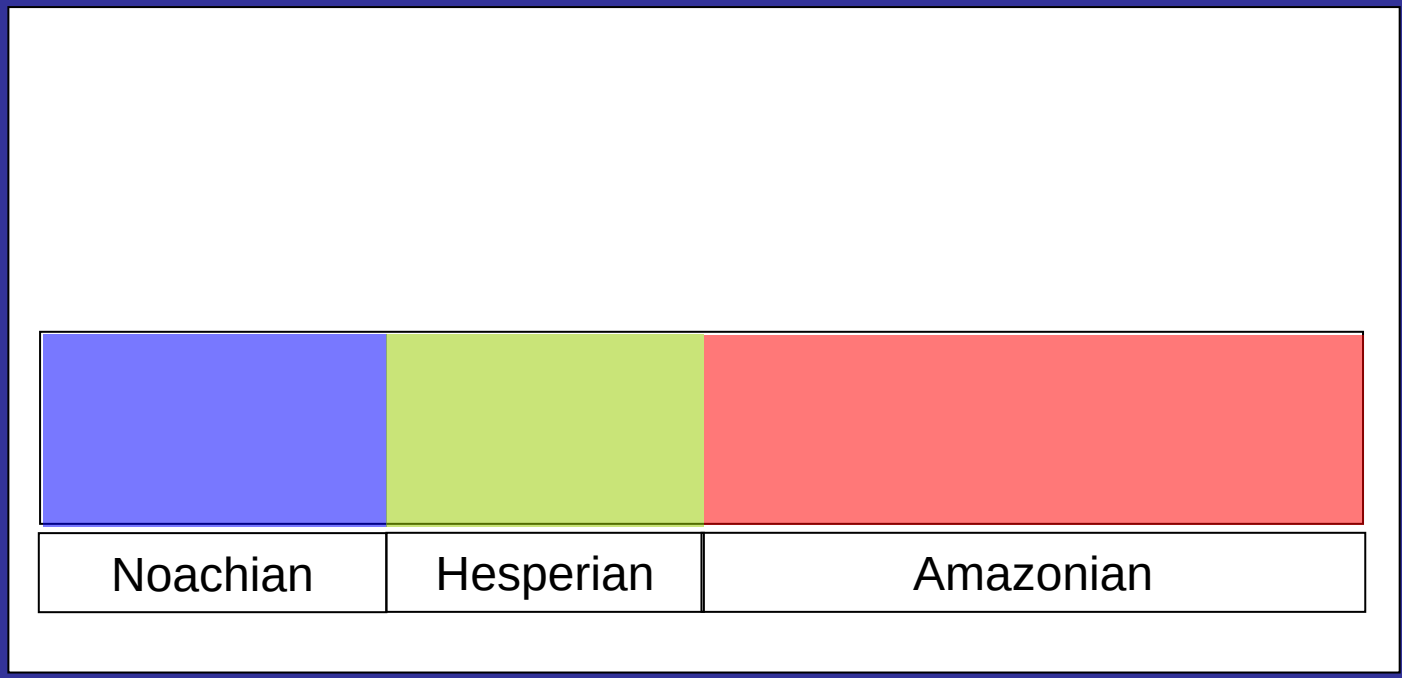
In global terms, OMEGA has identified three families of minerals derived by alteration of the pristine mafics:

- anhydrous ferric oxides: “dust”,
- hydrated sulfates,
- hydrated phyllosilicates

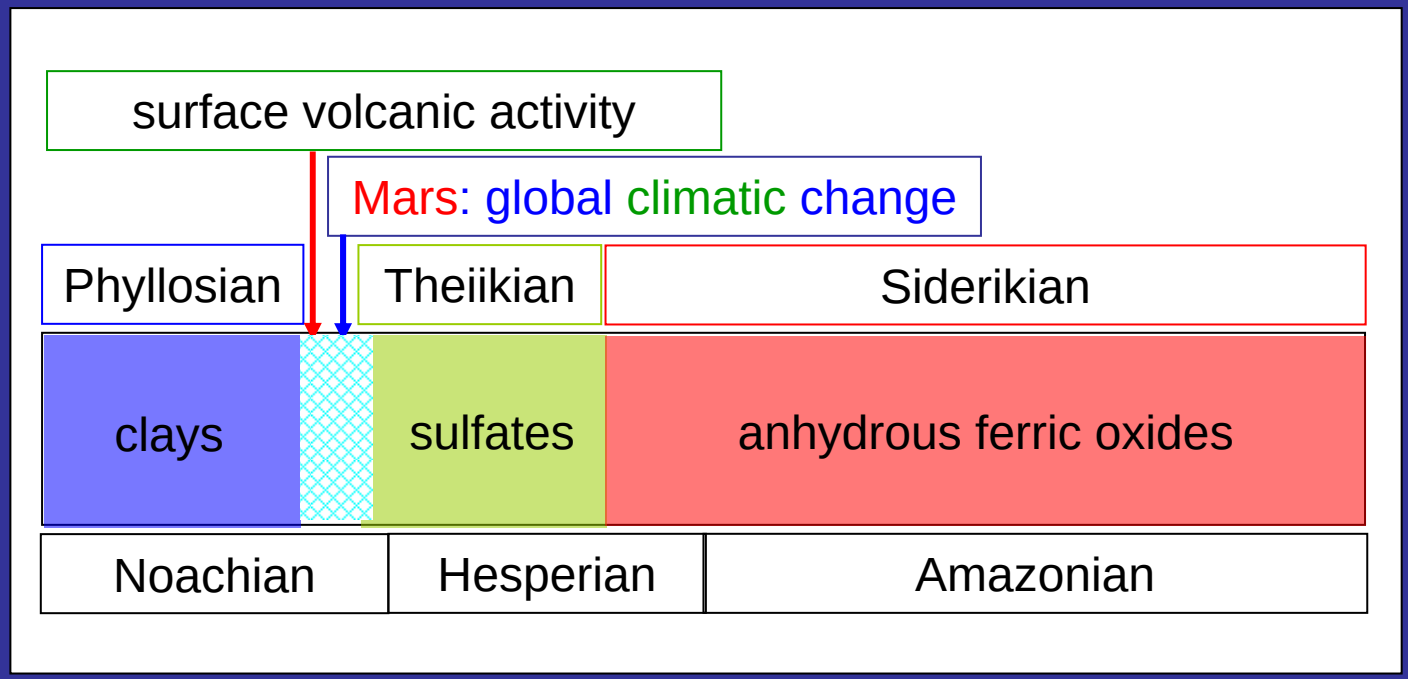
have been detected in a variety of localized spots.

They likely trace back the earlier Mars era, during which liquid water was stable over extended periods.

Pasadena, June 1, 2006



Mars History derived from surface **structures**



Mars History derived from surface **mineralogy**

Phyllosilicates formed first, within perennial liquid water

Sulfates formed later, following a Mars global climatic change

- The climatic global change (towards acidic) is directly derived from the surface onset of volcanic activity.

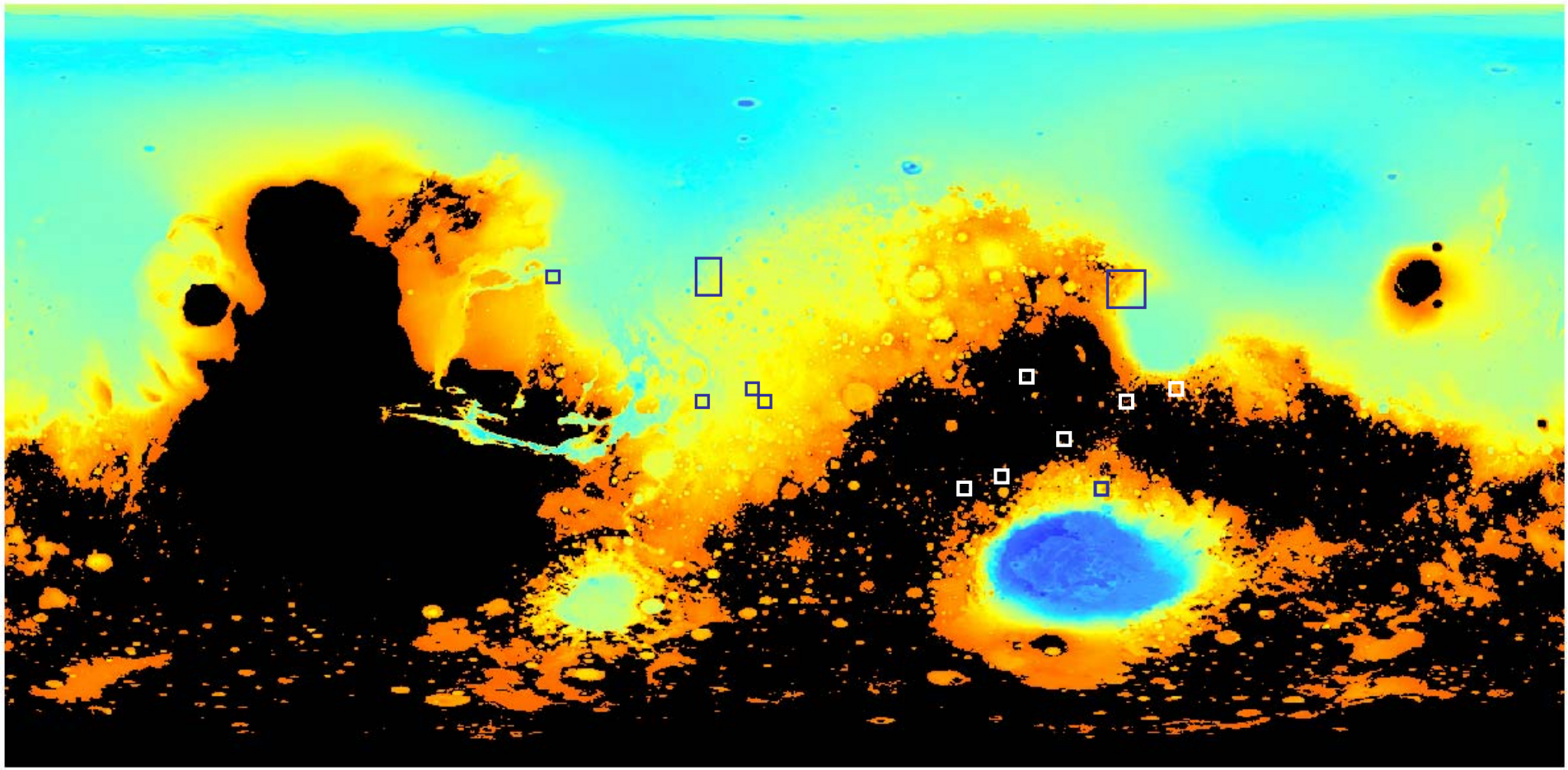
- Volcanic activity (Tharsis building) started some 10's millions years after the global dynamo had ceased: with no shield, most atmosphere had escaped (no more green house effect).

- In the earlier times, while the dynamo was efficient, surface (and/or sub-surface) water was stable, recorded by phyllosilicates.

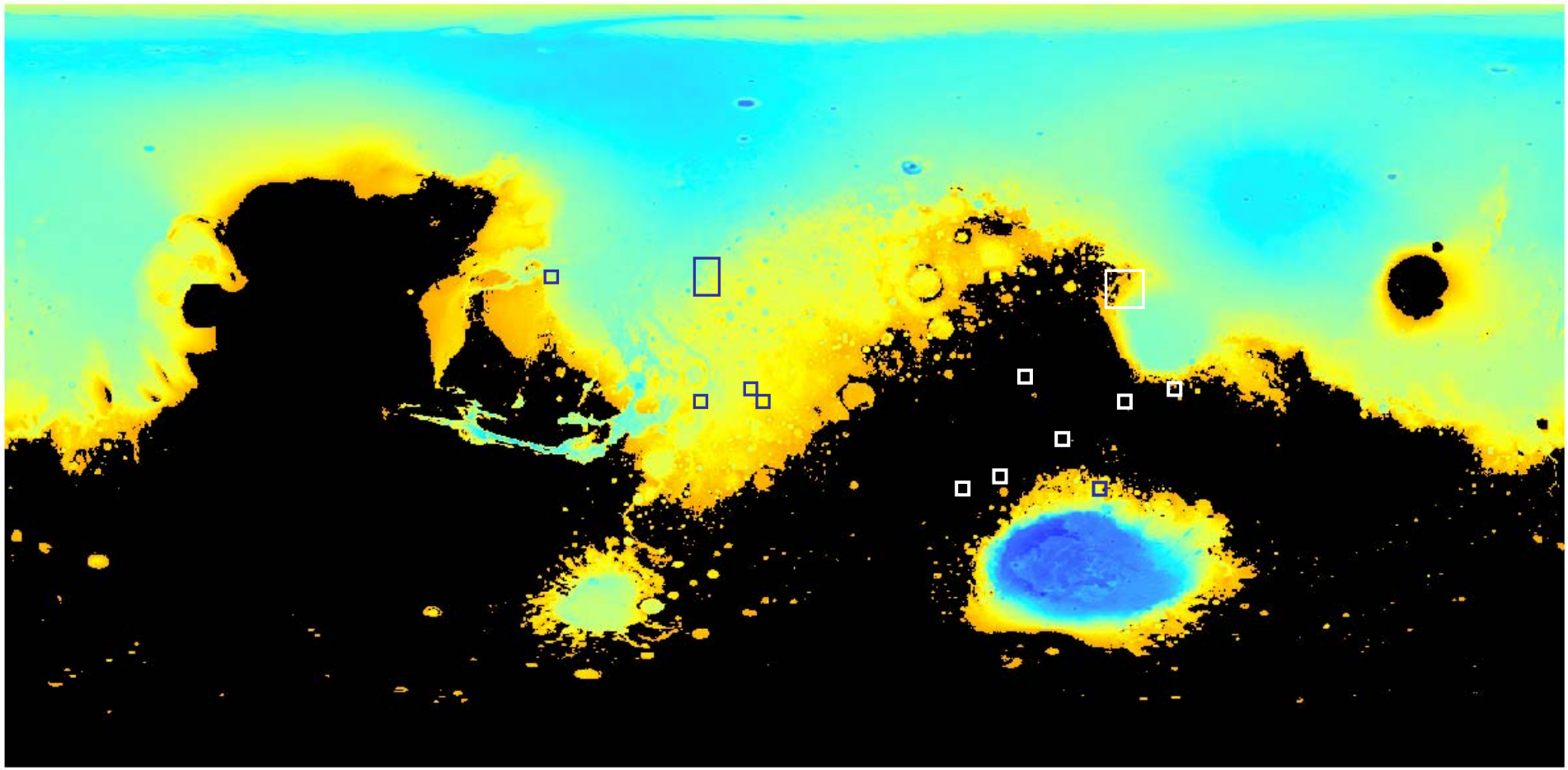
Global map of the hydration band @ 1.9 µm

Accessibility offering margins

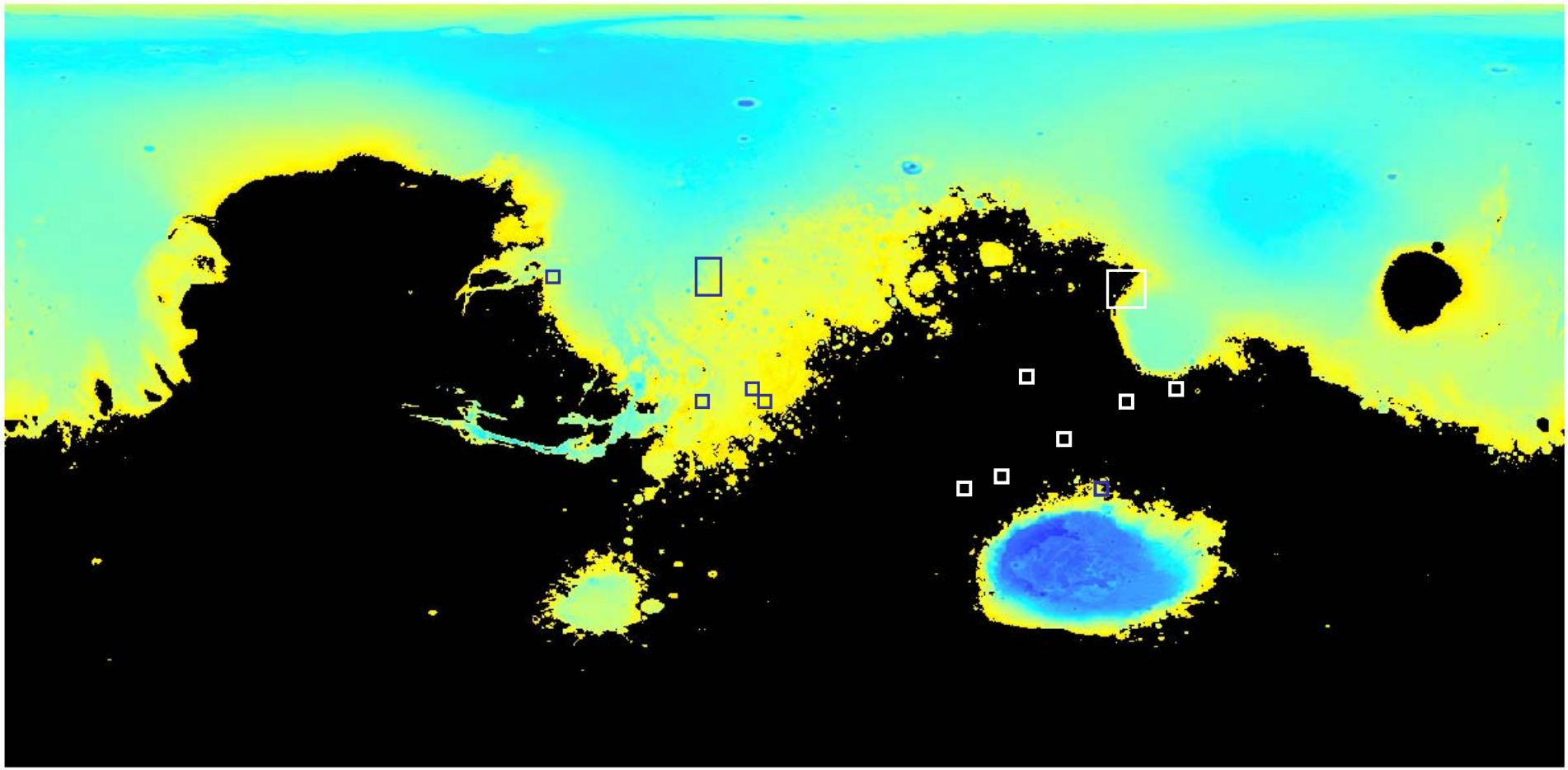
black areas: above 1.0 km



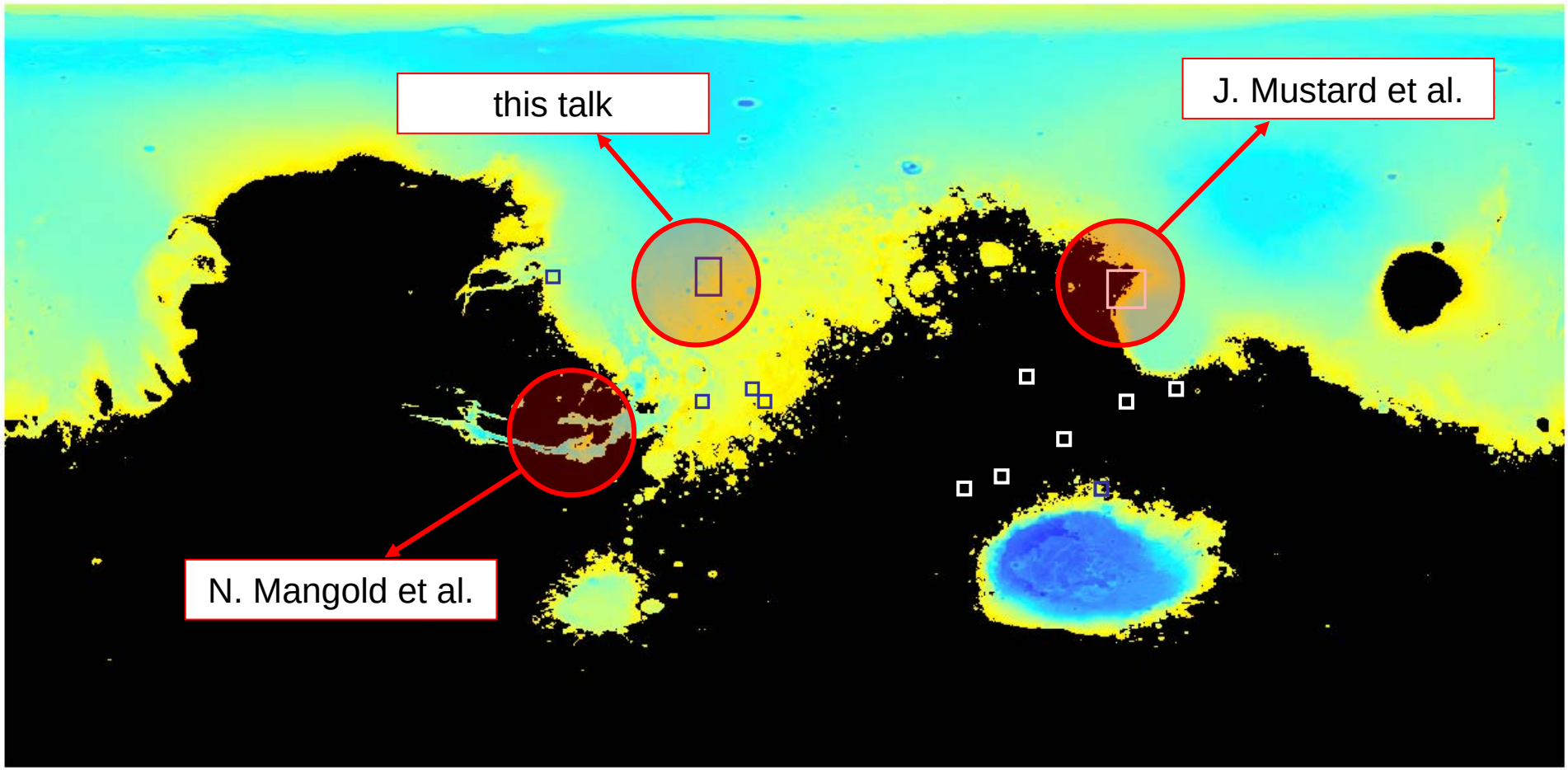
black areas: above 0.0 km



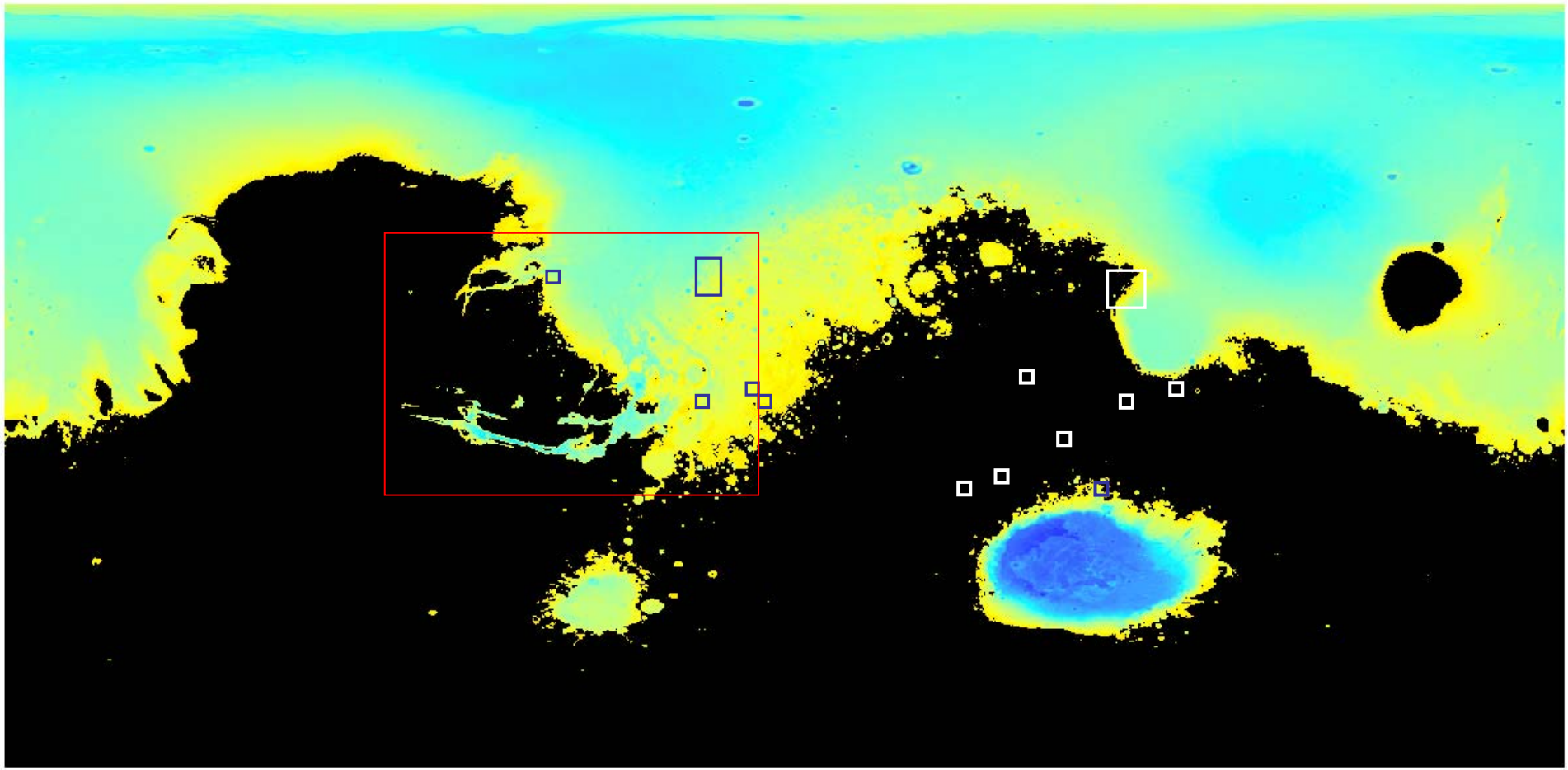
black areas: above -1. km



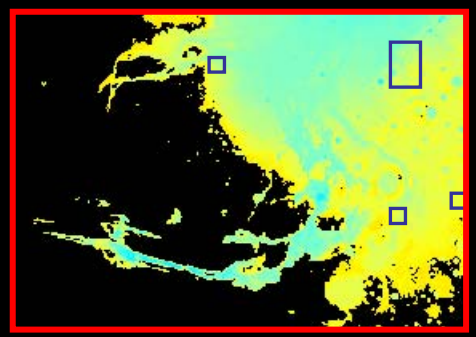
black areas: above -1. km



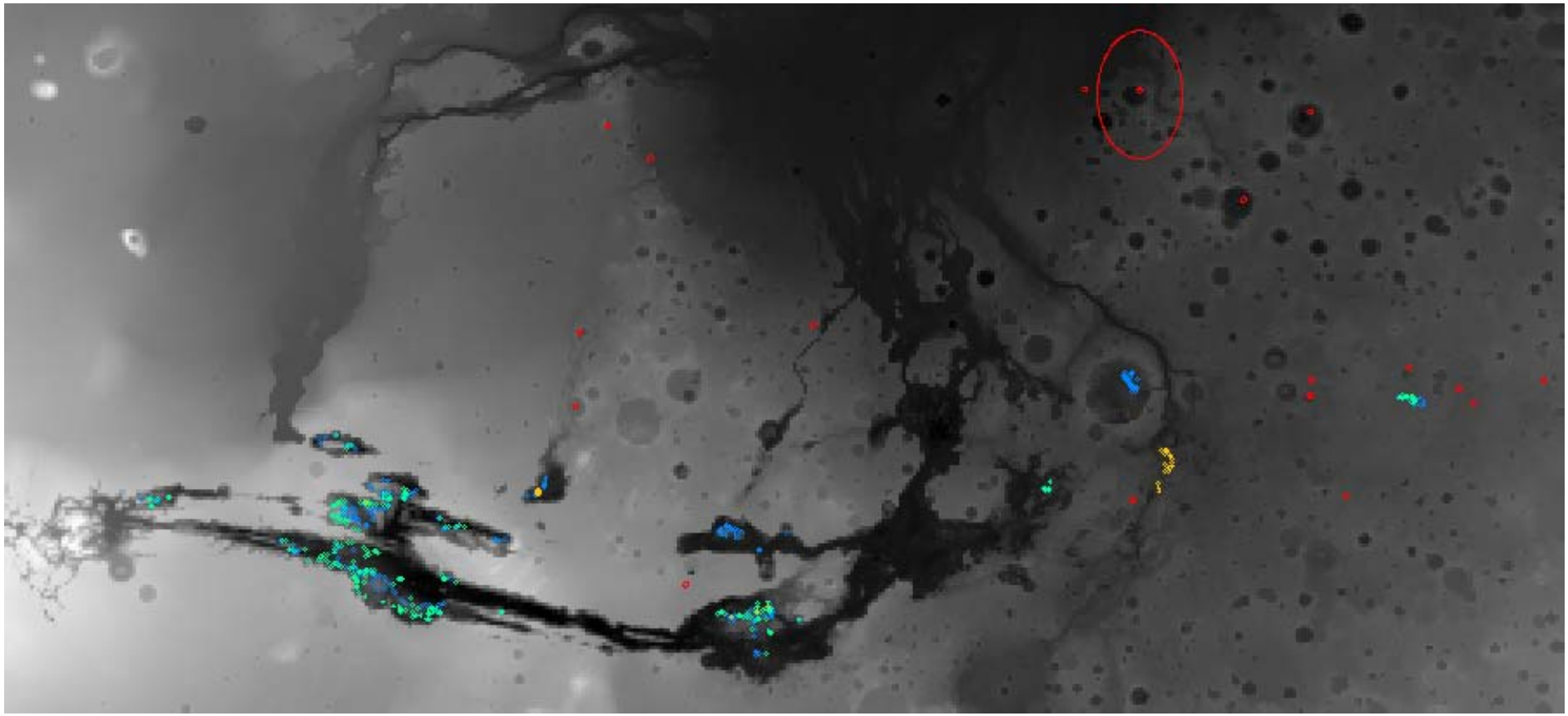
black areas: above -1. km



black areas: above -1. km

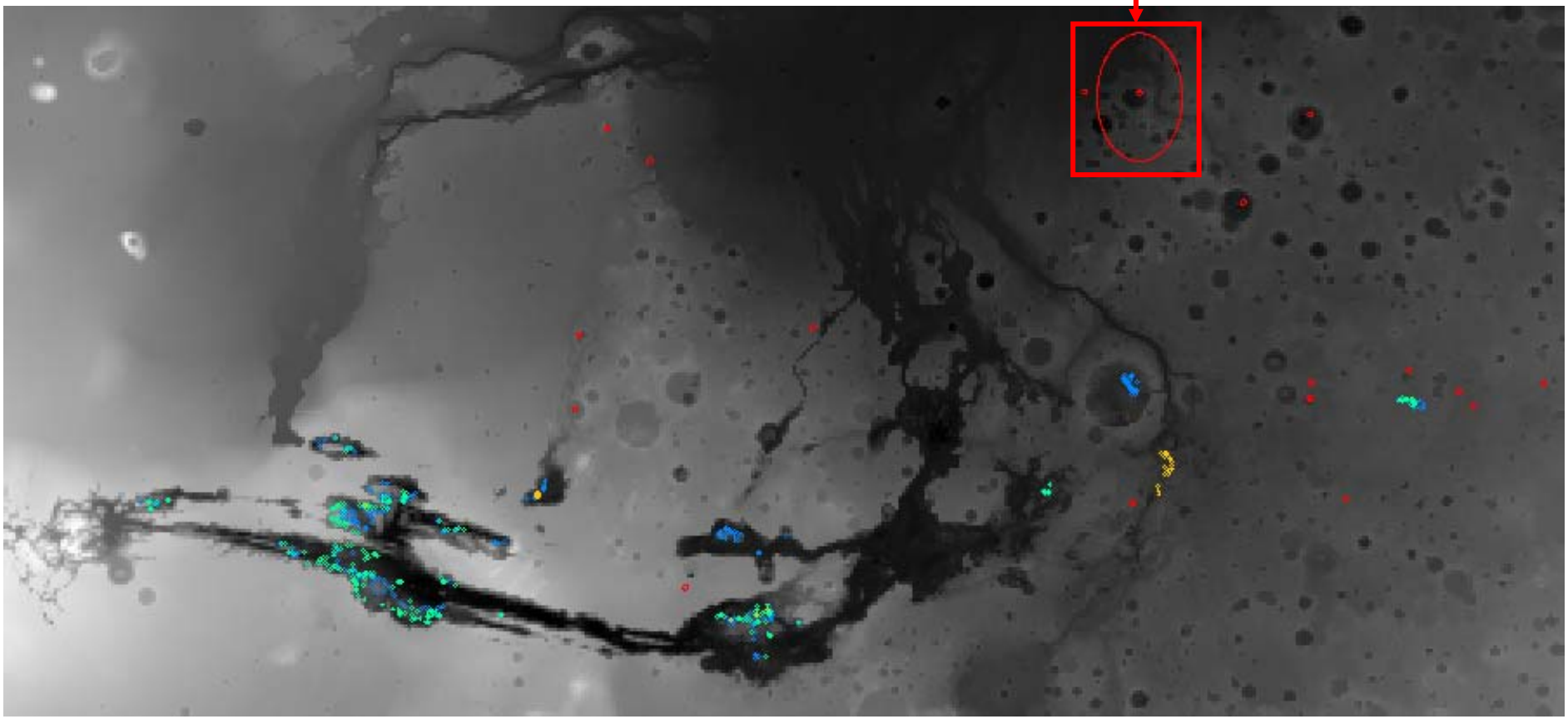


regional map of hydrated minerals

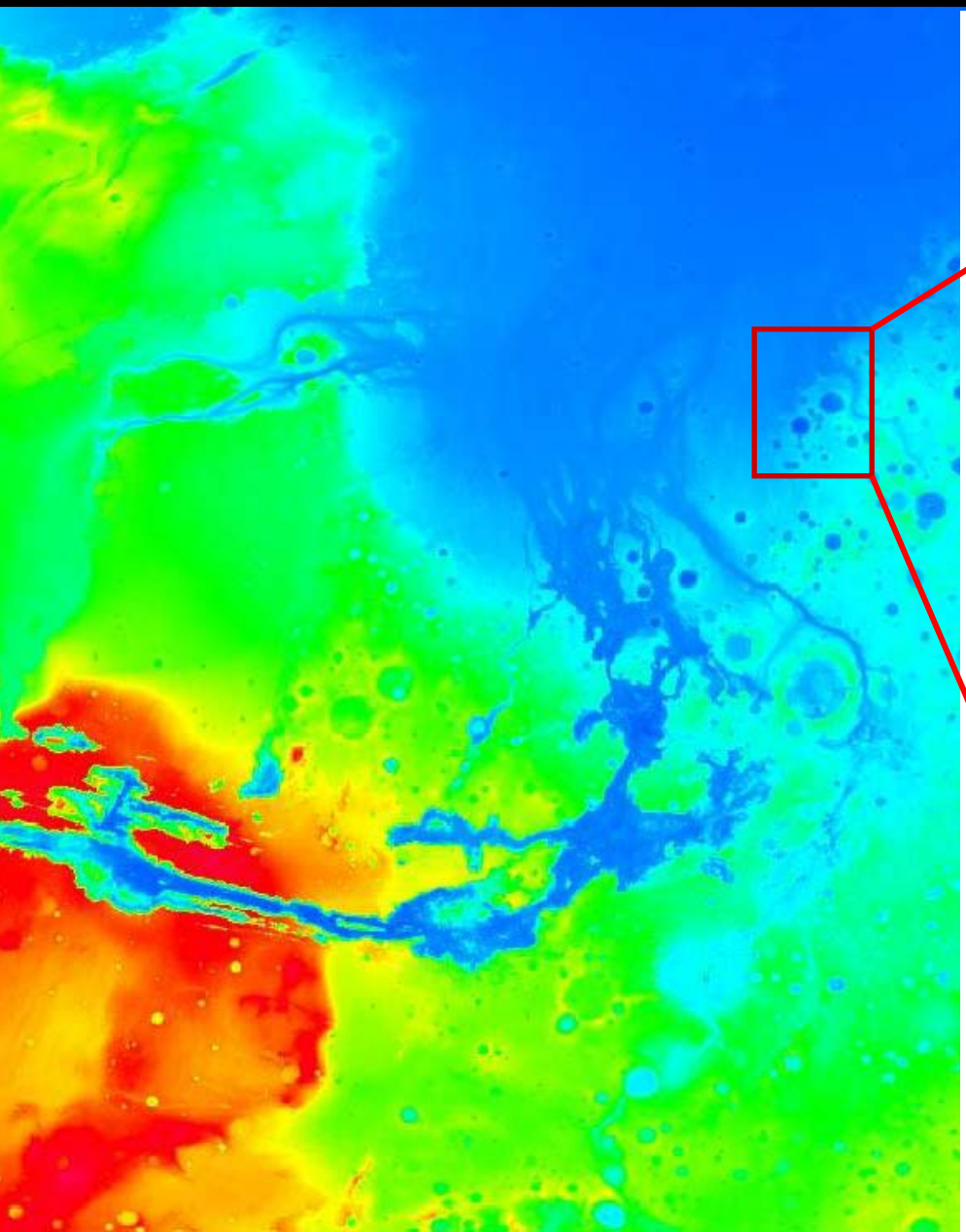


blue:	kieserite ($MgSO_4$, H_2O)
green:	polyhydrated sulfates
yellow:	gypsum ($CaSO_4$, 2 H_20)
red:	phyllosilicates

example: Marwth Vallis



example: Marwth Vallis

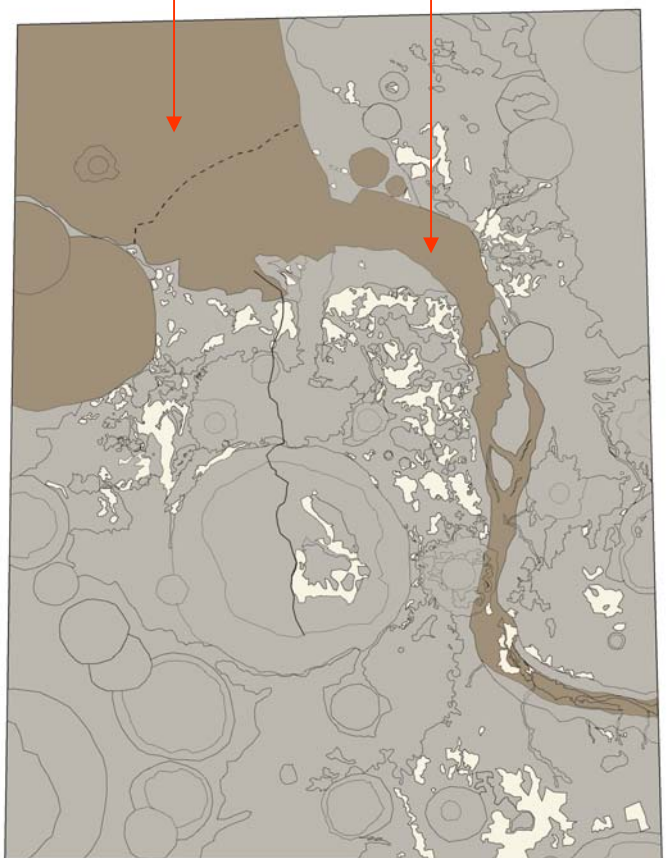


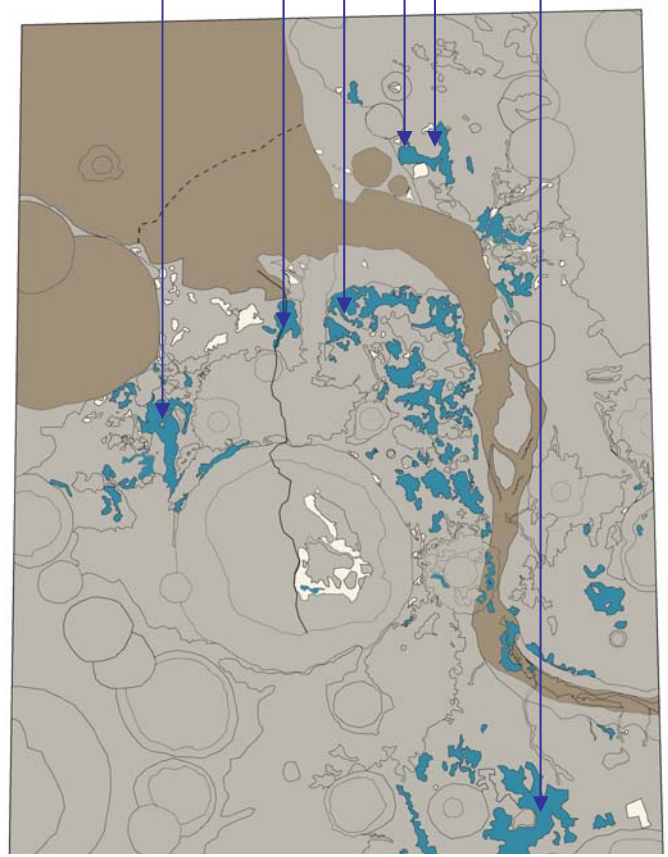
Optical map (HRSC), with colors suggesting persistent flooding

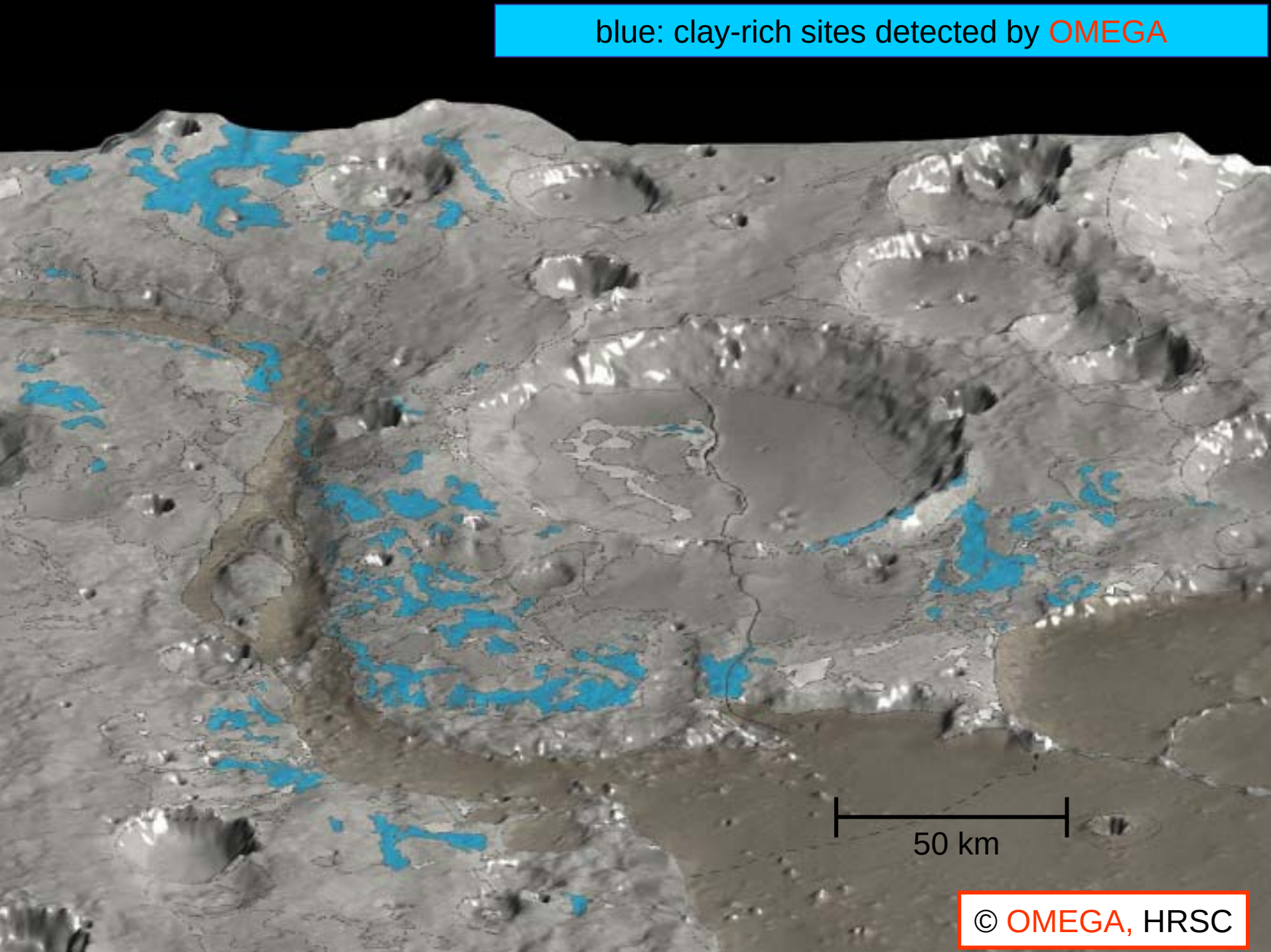
OMEGA shows: no hydration

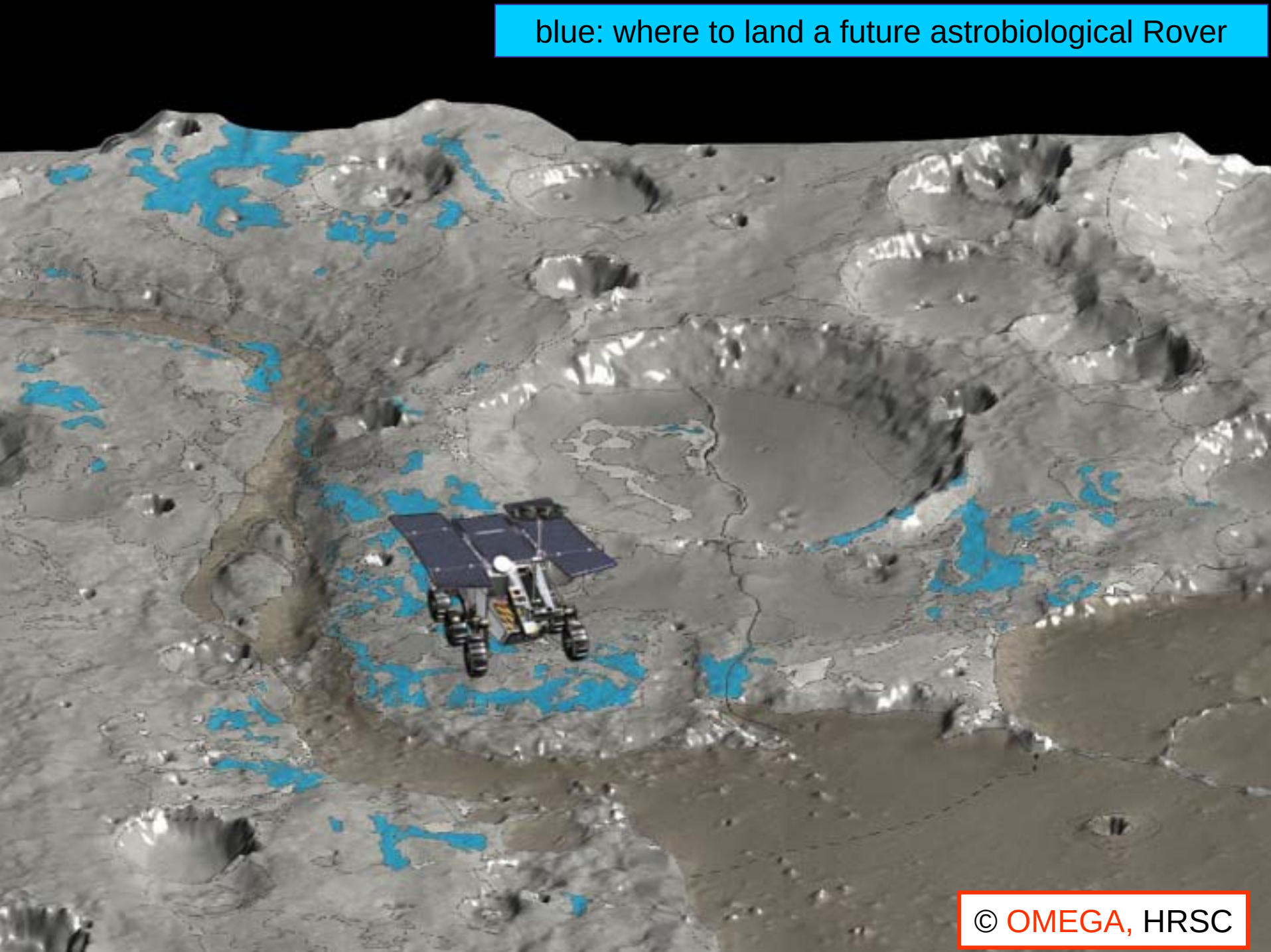
but

OMEGA detected hydrated clays

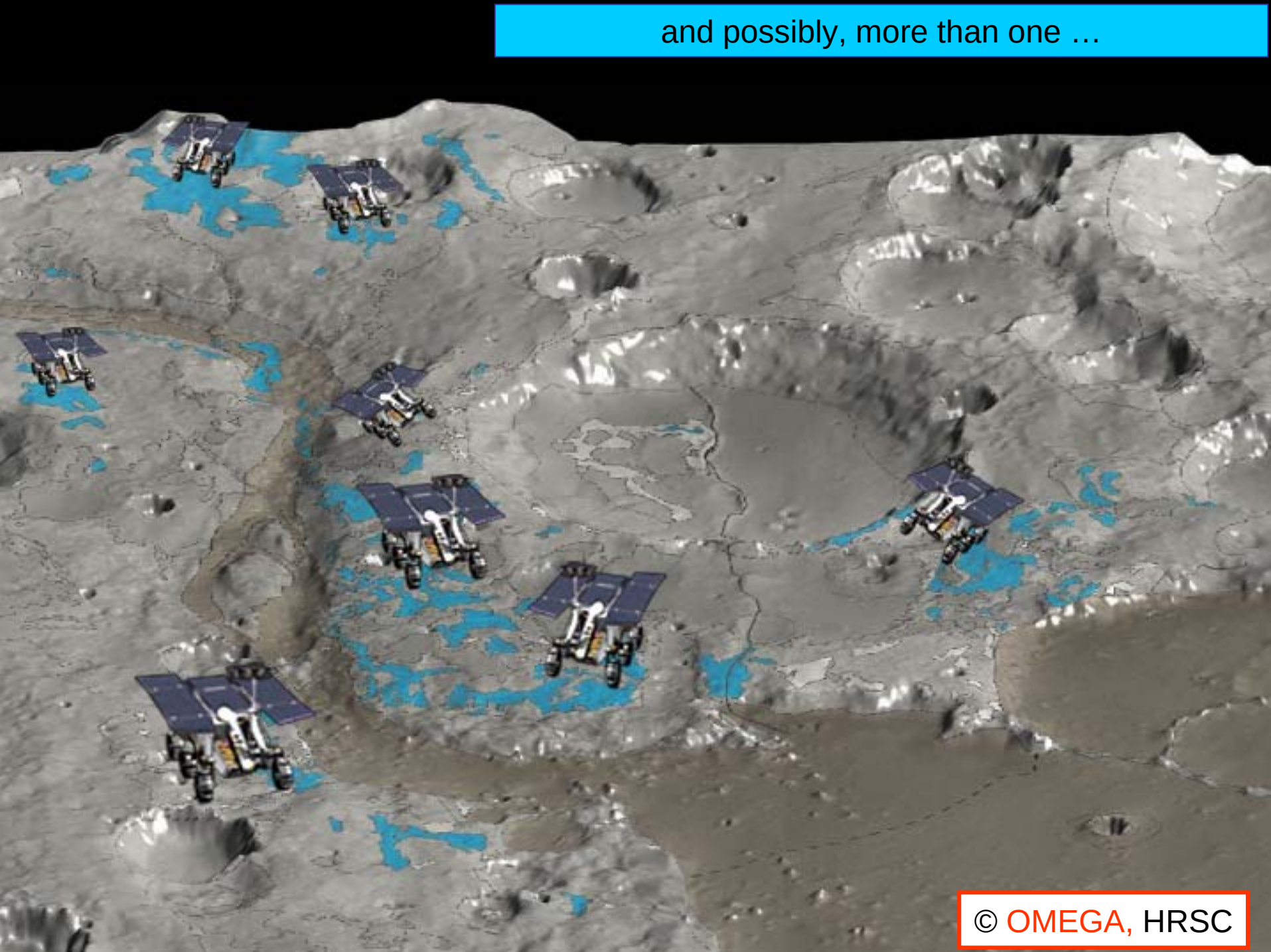




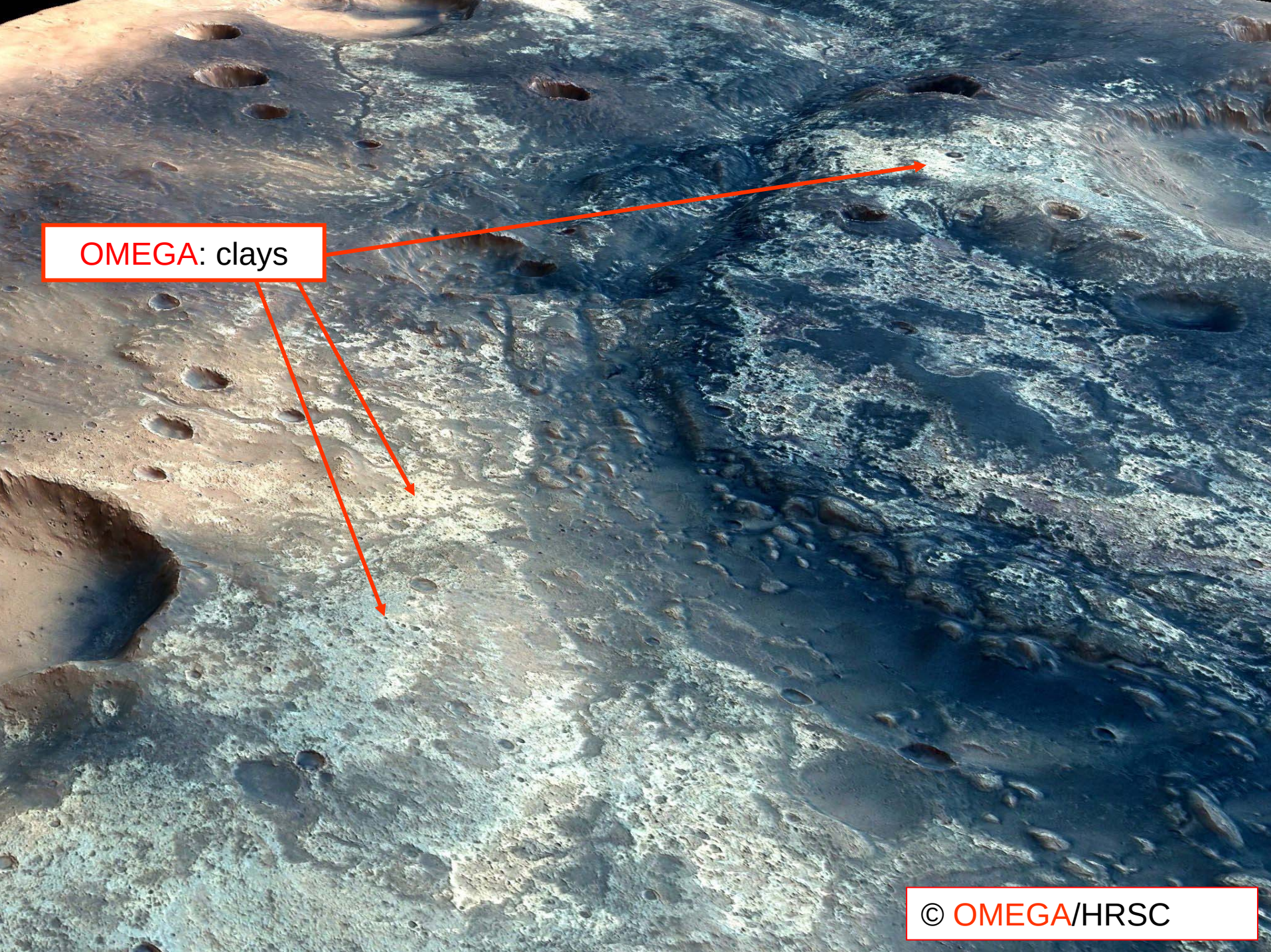

blue: clay-rich sites detected by OMEGA
50 km
© OMEGA, HRSC

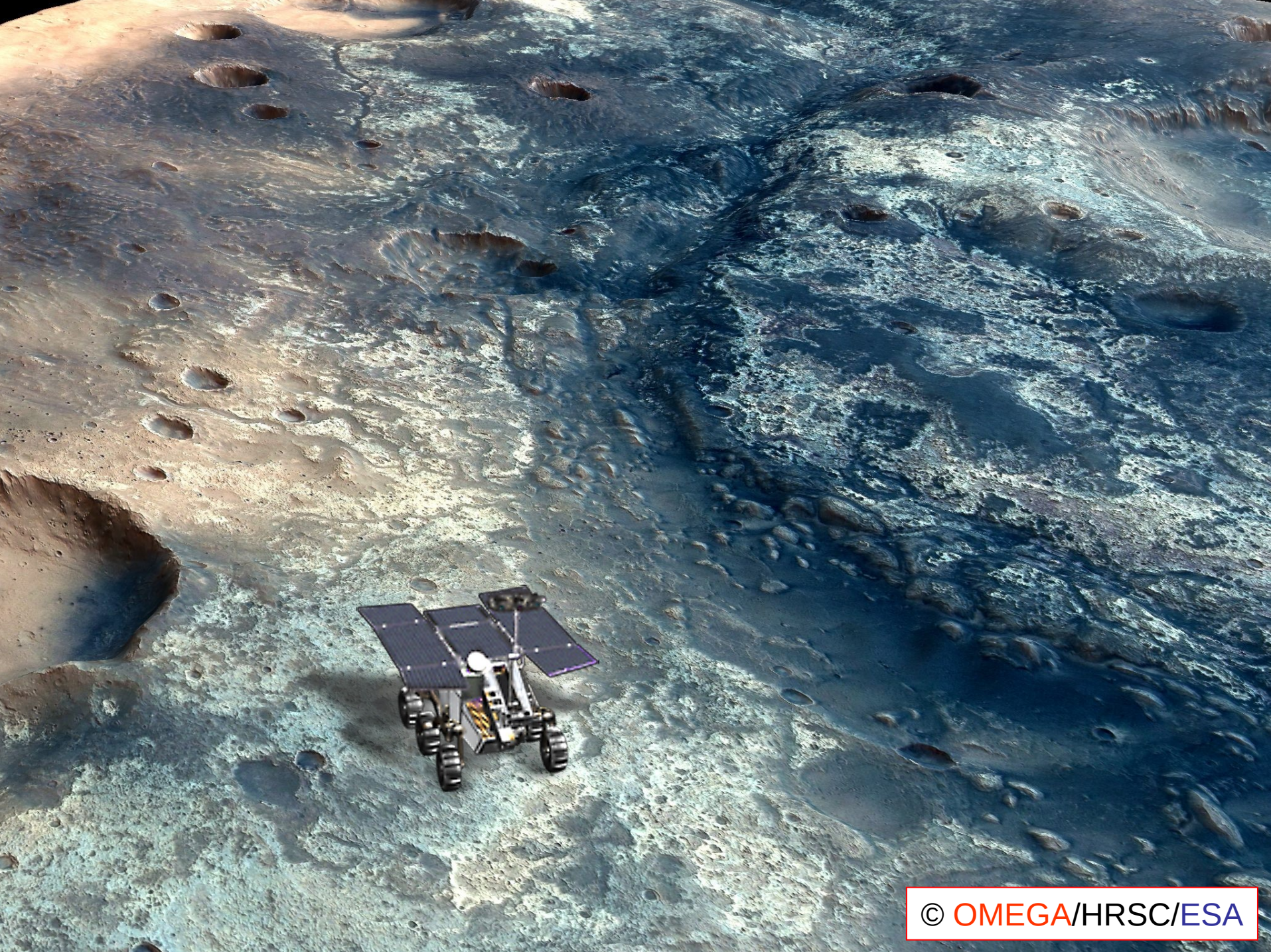

blue: where to land a future astrobiological Rover
© OMEGA, HRSC

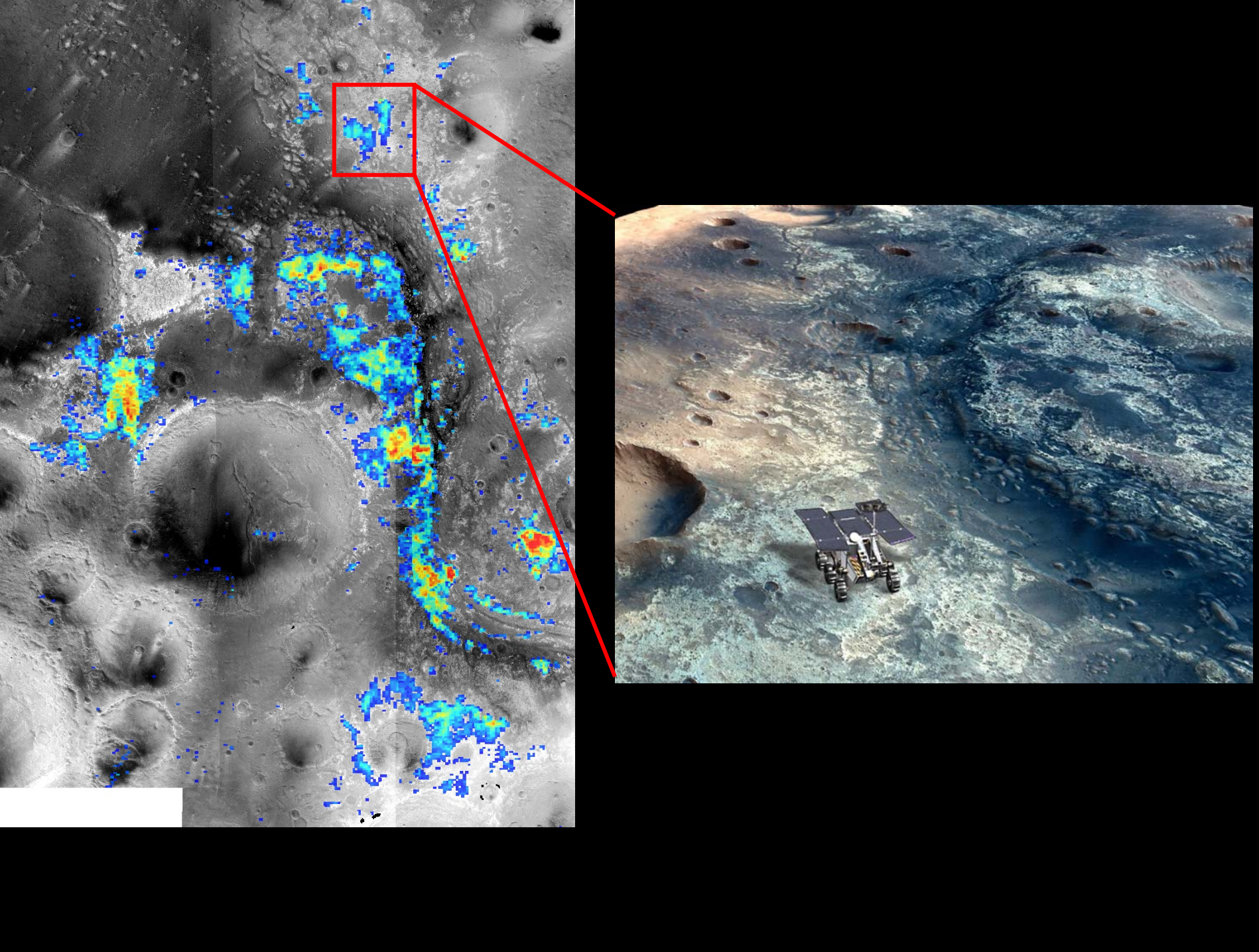
and possibly, more than one …



© OMEGA, HRSC


OMEGA: clays
© OMEGA/HRSC


© OMEGA/HRSC/ESA



Phyllosilicates formed first, within perennial liquid water

Sulfates formed later, following a Mars global climatic change

Phyllosilicate-rich sites look more favorable to have harbored habitable conditions

It is suggested to target such phyllosilicates -rich sites for future astrobiological *in situ* Mars missions

At a microscopic scale, samples containing phyllosilicates could still host Mars bio-relics or bio-signatures, and carbonate grains ($\Rightarrow CO_2$ history)

An optimized target,
based on its being exhumed phyllosilicate-rich, could enable sampling:

- the early igneous crust (LCP-rich)
- its water-altered phase, possibly preserving bio-relics
- the later flooded lava (HCP-rich)

It was not obvious, a while ago, that we would be in a position to much better delineate the (short) Mars era that might have harbored habitable conditions.
Up to Opportunity, no hydrated minerals had been unambiguously identified. We now know that actually hydrated sulfates (rather than carbonates), and (more importantly) hydrated phyllosilicates were formed, and are still preserved.
It is trivial to state that we do not know yet if life ever emerged at Mars.
We know though where (and how) to better address this key question.
We should not miss the opportunity.

Up to now, all *in situ* probes landed in either

Siderikian sites
(Viking, PathFinder, Spirit)

or

Theiikian sites
(Opportunity).

for MSL: go Phyllosian !

Pasadena, June 1, 2006

Upcoming related activities:

- MERs/OMEGA workshop 12-14/06/2006 to address early Mars climate (change)

- JGR-Planet OMEGA special issue, with (among others) dedicated papers on:
  - Nili Fossae extensive study
  - VM ILDs summary
  - Marwth Vallis extensive study

for MSL: go Phyllosian !

Pasadena, June 1, 2006