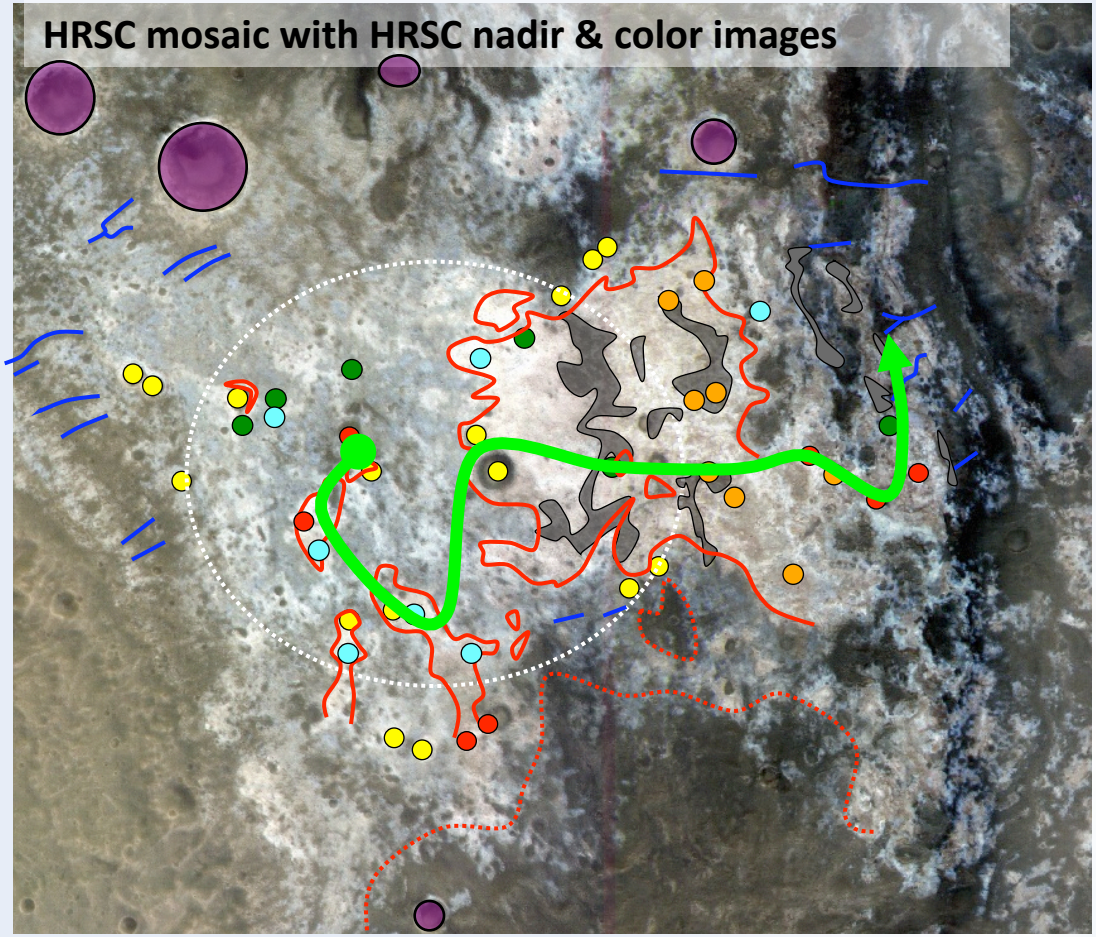
Targets to address MSL goals and major Martian science objectives at Mawrth Vallis

N. Mangold, LPG Nantes
D. Loizeau, J.-P. Bibring, J. Carter, F. Poulet,
R. Arvidson, J. Bishop, B. Ehlmann, J. Michalski, J. Mustard,
N. Mc Keown, E. Noe Debra, M. Parente, L. Saper, J. Wray

Main goals that can be achieved by various targets at Mawrth



Example of traverse in green

All targets

- boundary Al-Fe
- craters with layered walls
- circular layered structures
- remnant layered buttes
- zone of large fractures
- unique targets

- fluvial landforms
- larger, deeper craters

- specific layers
- putative limits of eroded lobate ejecta

Main goals that can be achieved by various targets at Mawrth

1. Sampling a ~4 by old alteration sequence

The Al-kaolinite / Fe-smectites sequence suggests various alteration stages

2. Sampling evidence for fluid circulation

Large fractures, veins, suggest hydrothermal/fluid controlled minerals

3. Sampling a huge diversity of mineralogy and associated aqueous environments

Detection of various clays, sulfate/zeolite in distinct layers

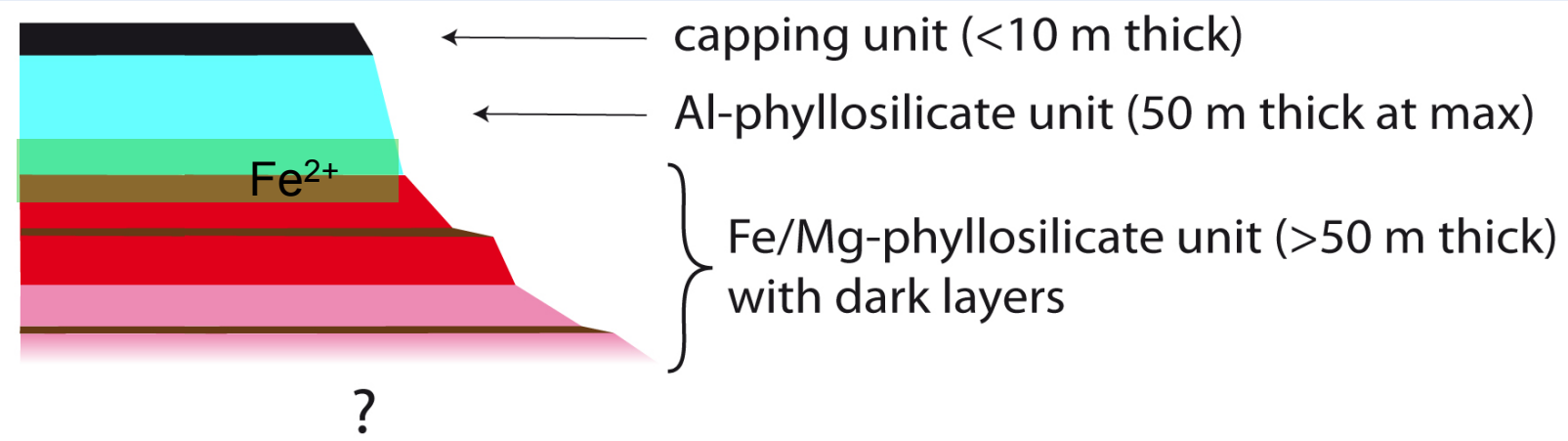
4. Sampling a prolonged record of sedimentary deposition

Going downward in the > 200 m thick section enables to sample older deposits, going to earliest times

5. Analyzing late aqueous episodes

Inverted channels enables study late aqueous episodes and transition to drier environments

1. Sampling a ~4 b.y. old alteration sequence



Observation:

Al-bearing clay unit overlies Fe/Mg-smectite material

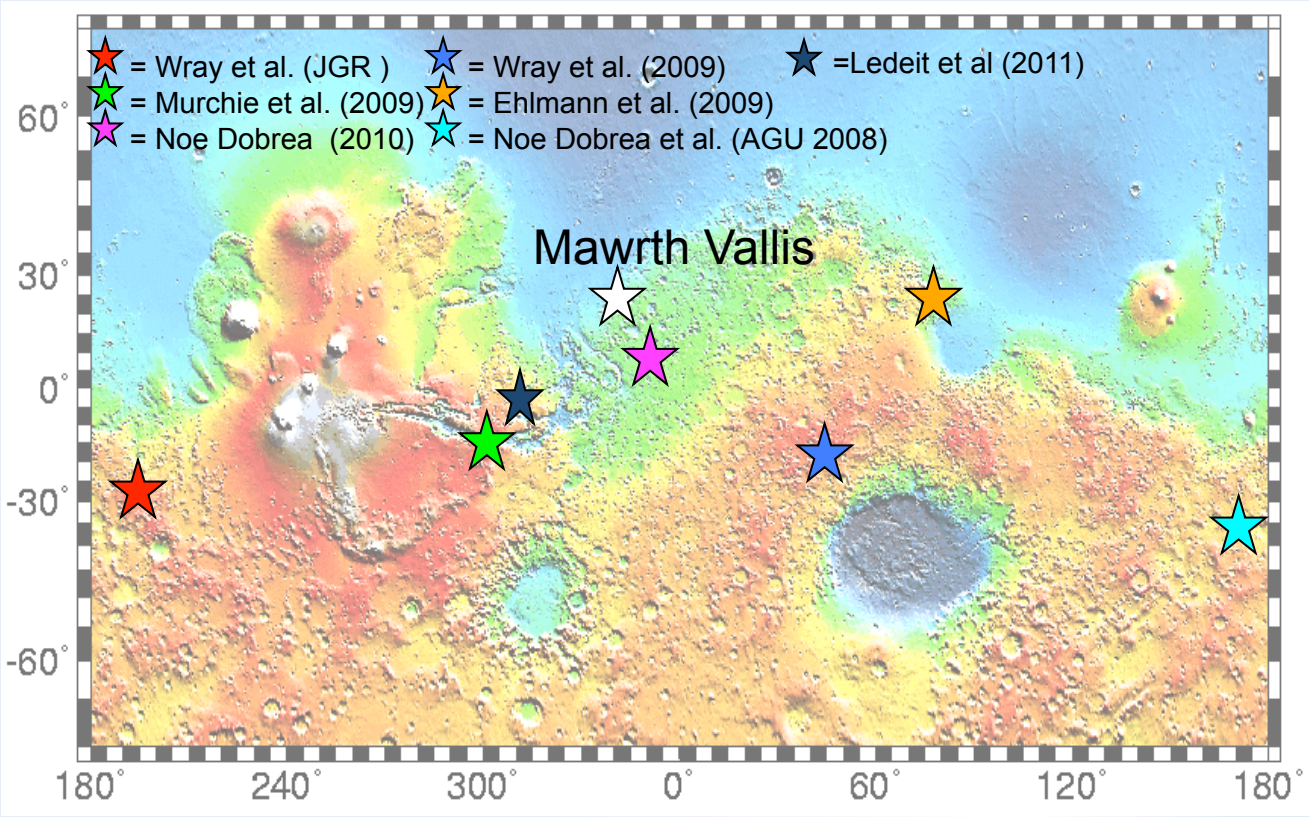
Working Hypothesis:

Pedogenetic/Diagenetic alteration during a wet period during the Noachian

=> Paleosoils with clays may incorporate reduced carbon compounds and other biomarkers as do paleosoils on Earth.

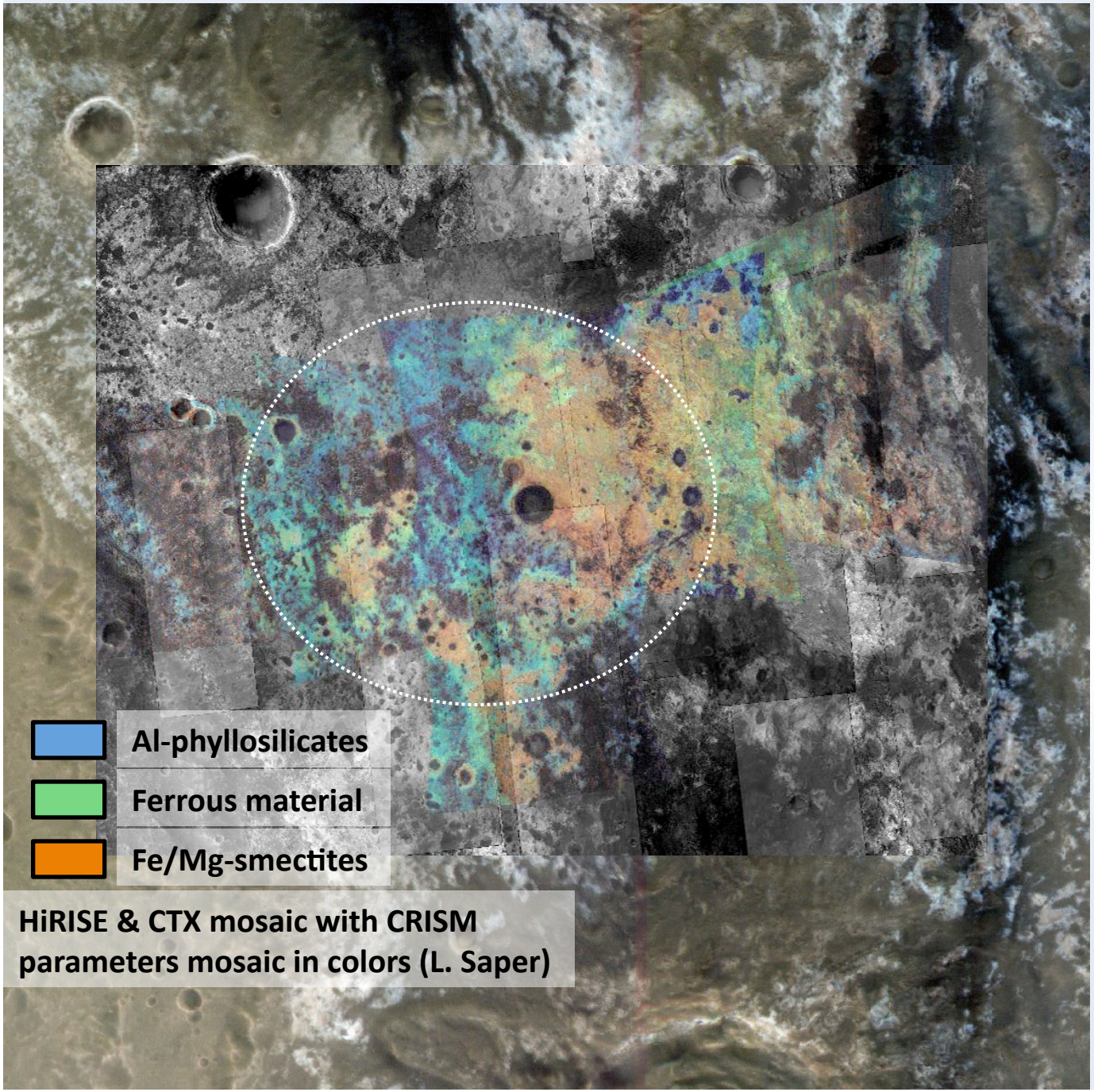
Al- over Fe-clays has been found in many regions on Mars

Regions of Mars with Al-clays found to date:

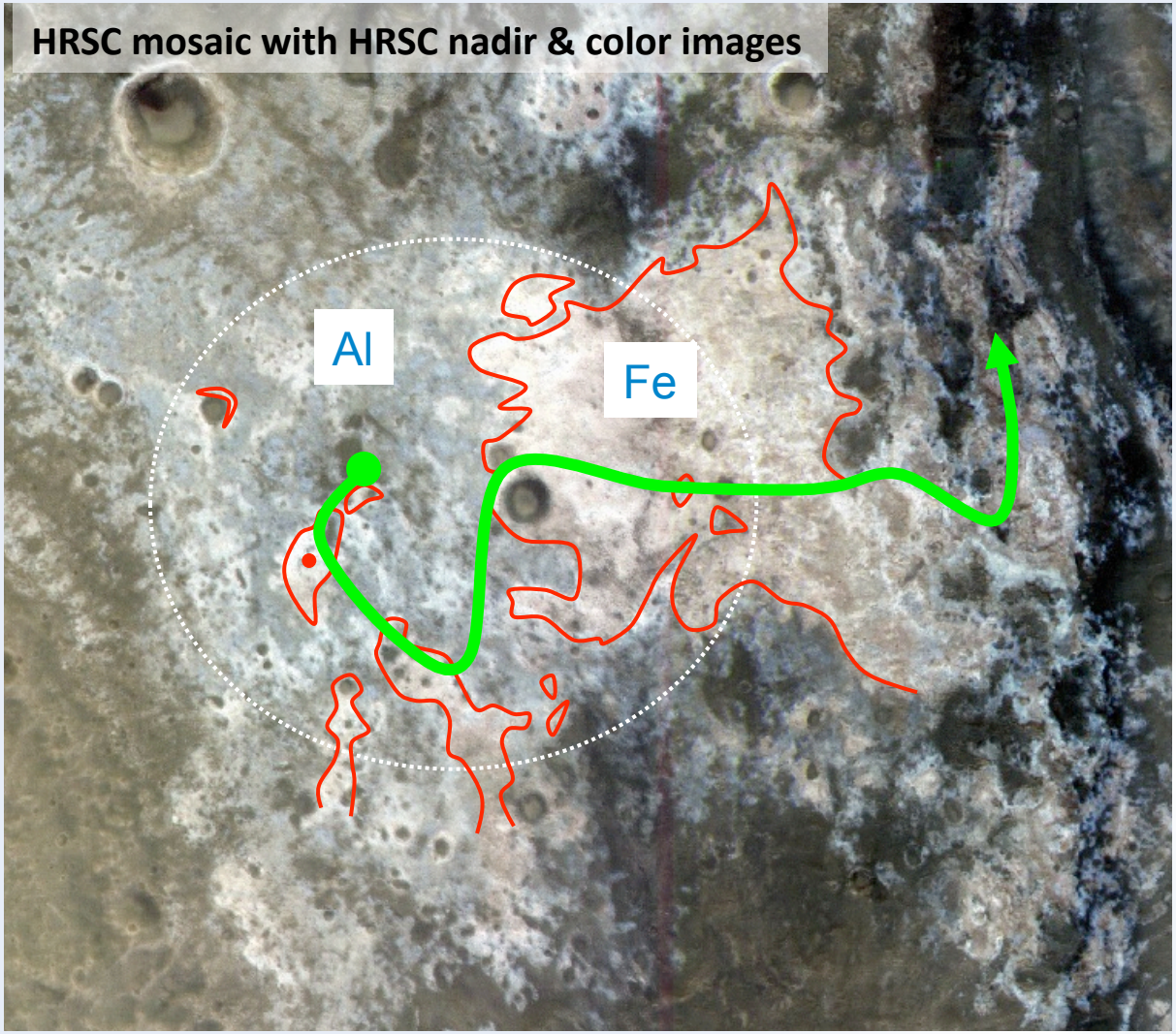


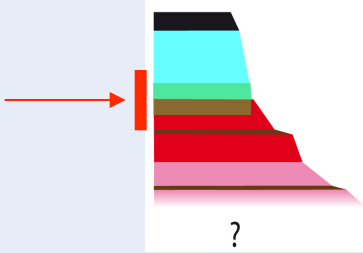
In **every** known case, Late Noachian Al-clays overlie Fe/Mg-clays

Mawrth Vallis is the best preserved and most widespread location of a general process that could have preserved early climate conditions and organics



HiRISE & CTX mosaic with CRISM parameters mosaic in colors (L. Saper)

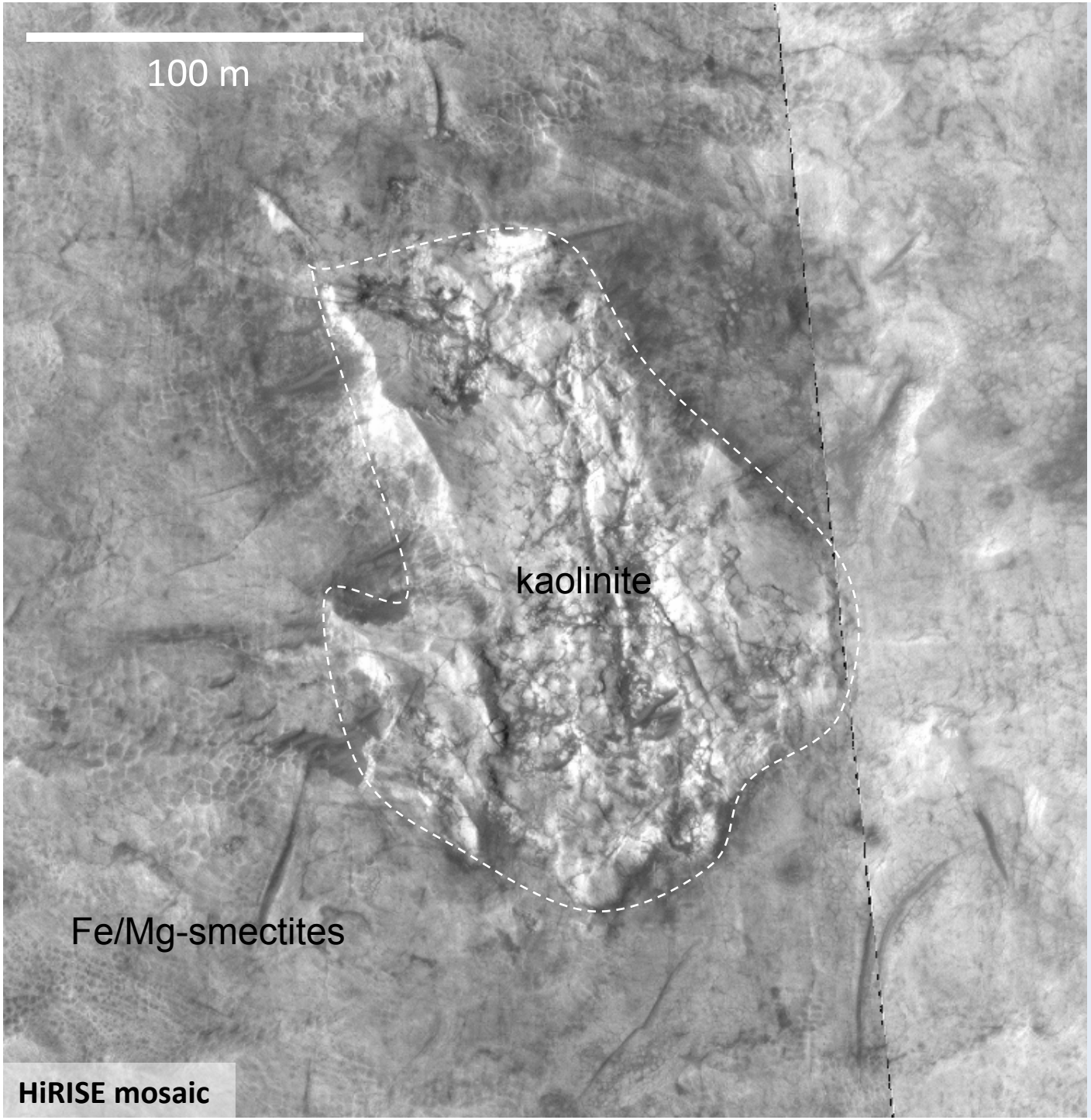




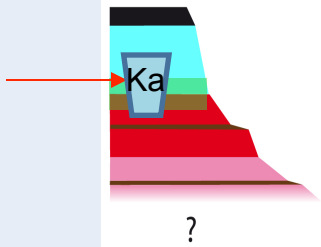
Boundary between Al-phyllosilicate and Fe/Mg-smectites

Morphology & mineralogy: An upper bluish Al-clay unit (montmorillonite, kaolinite, hydrated silica) (<50m thick) A lower reddish Fe/Mg-smectite rich unit (> 150 m thick).

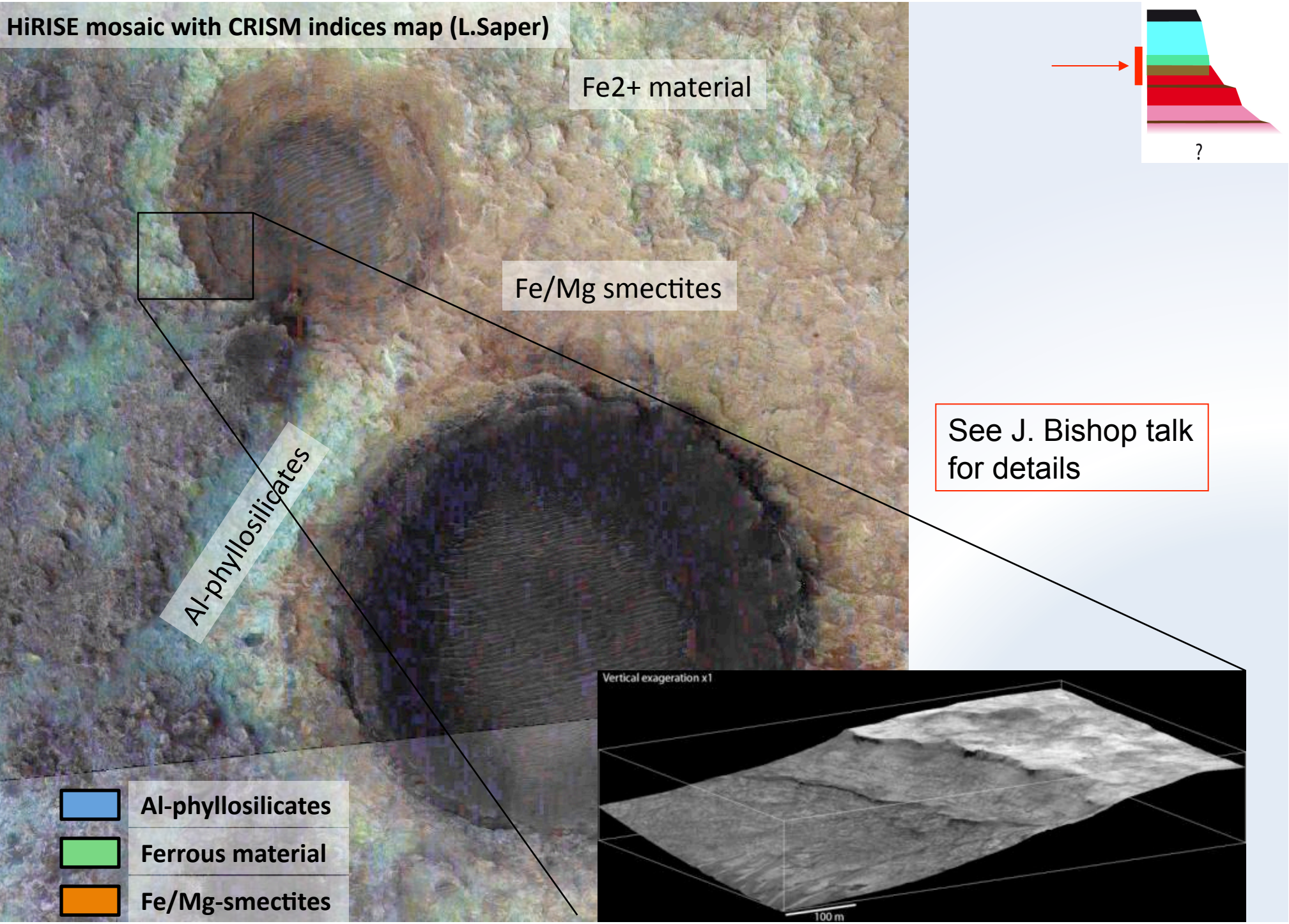
MSL tasks: Study the transition and variations from one to the other unit in chemistry, mineralogy and facies.



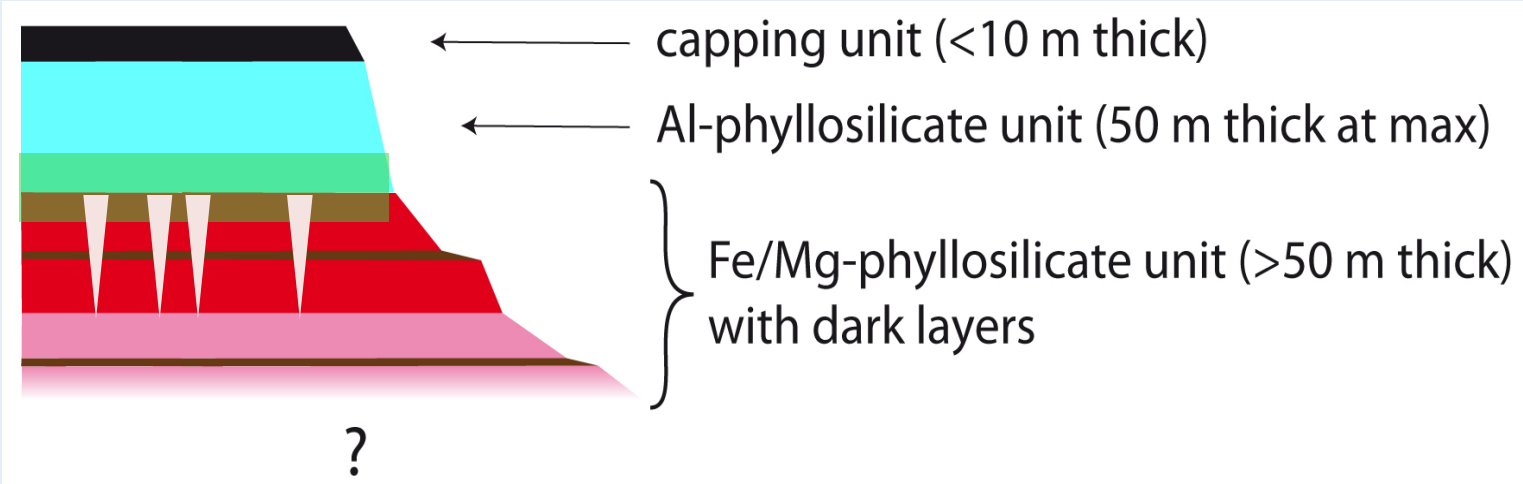
HiRISE mosaic



Example of kaolinite-bearing outcrop with strong absorption band in CRISM data


HiRISE mosaic with CRISM indices map (L.Saper)
Fe2+ material
Fe/Mg smectites
Al-phyllosilicates
Al-phyllosilicates
Ferrous material
Fe/Mg-smectites
Vertical exageration x1
100 m
?
See J. Bishop talk for details

2. Sampling evidence for fluid circulation

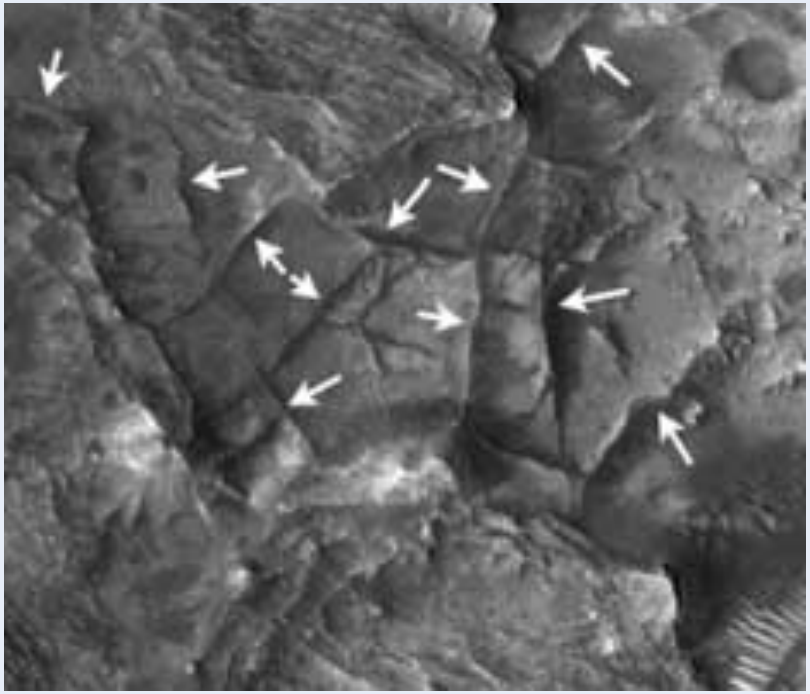


Observation: Mawrth Vallis records some evidences of veins and filled fractures

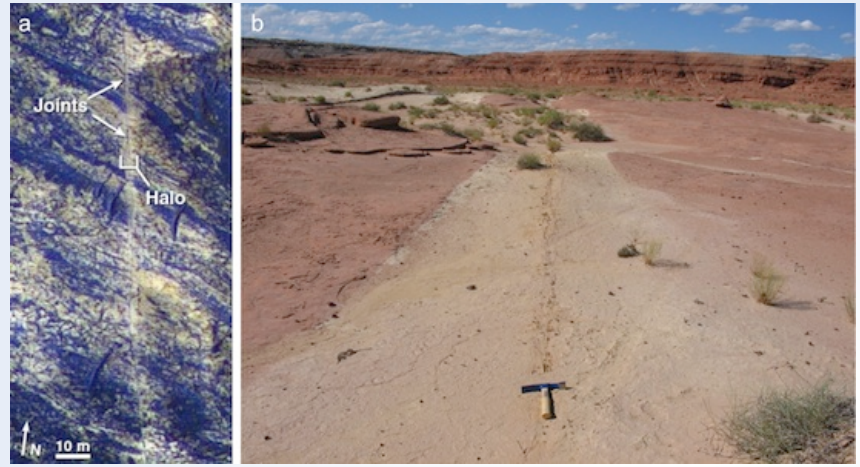
Working hypothesis: Fluid circulation formed these veins in specific micro-environments.

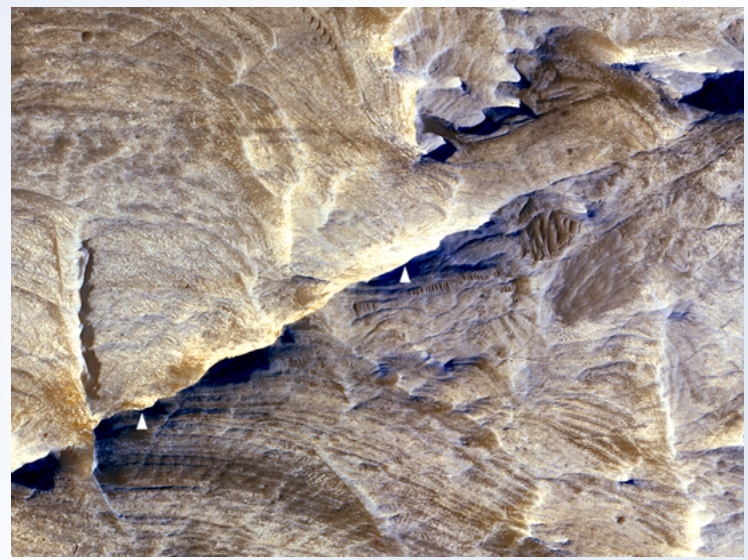
=> Such aqueous environments may be the location of specific biologic development promoted by heat sources at depth.

Fluid circulation and hydrothermal activity has been considered as a main process for Mars alteration (both from orbital and in situ data).



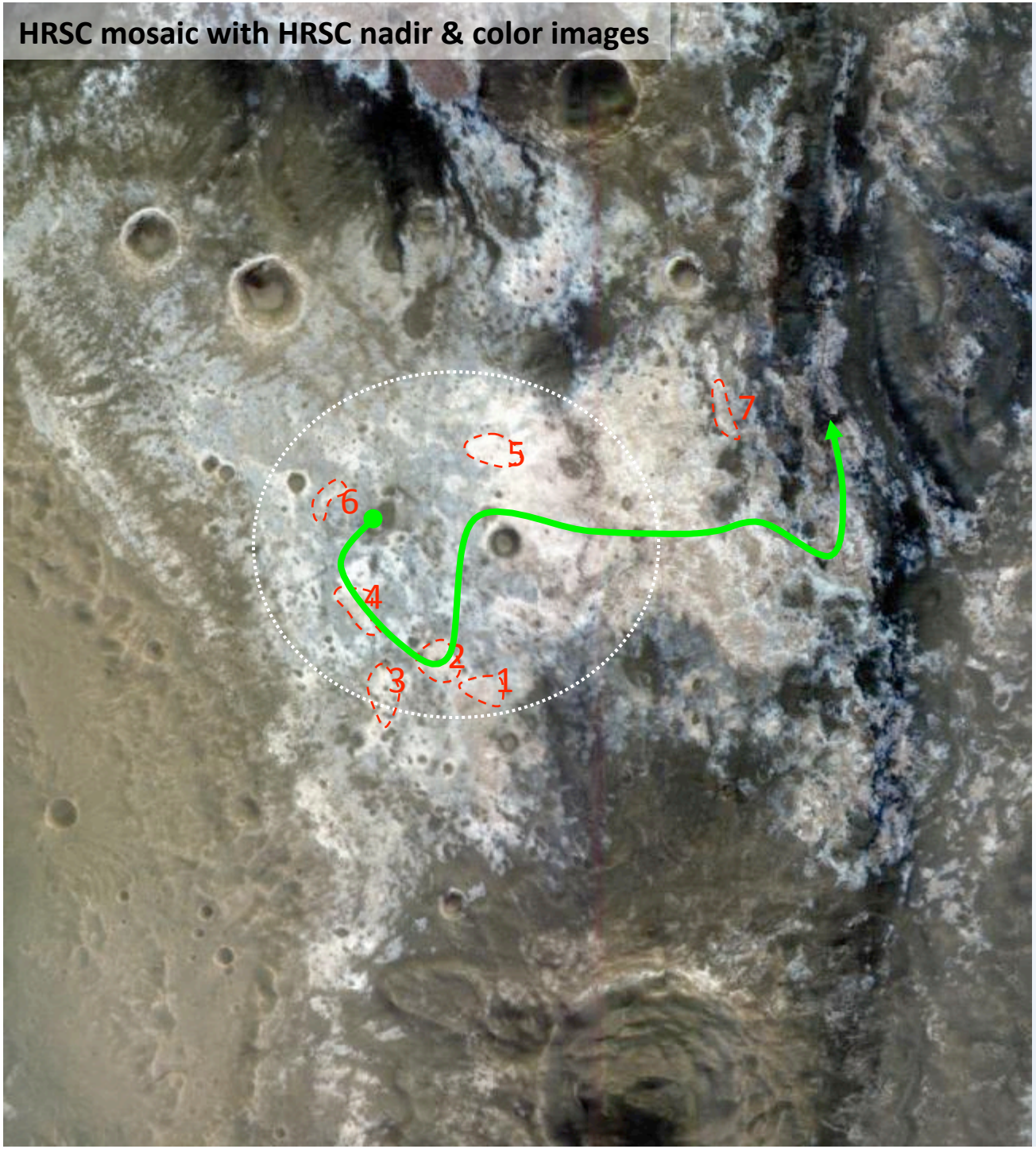
Mustard et al (JGR, 2007) in Nili Fossae

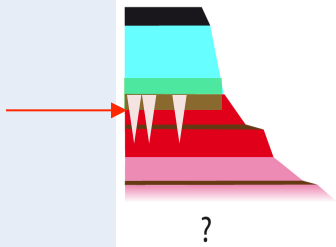




Okubo et al (Science, 2007) in Candor Chasma

Veins indicate fluid circulation from warm aqueous fluids (whatever heat source is impact or geothermal fluids)

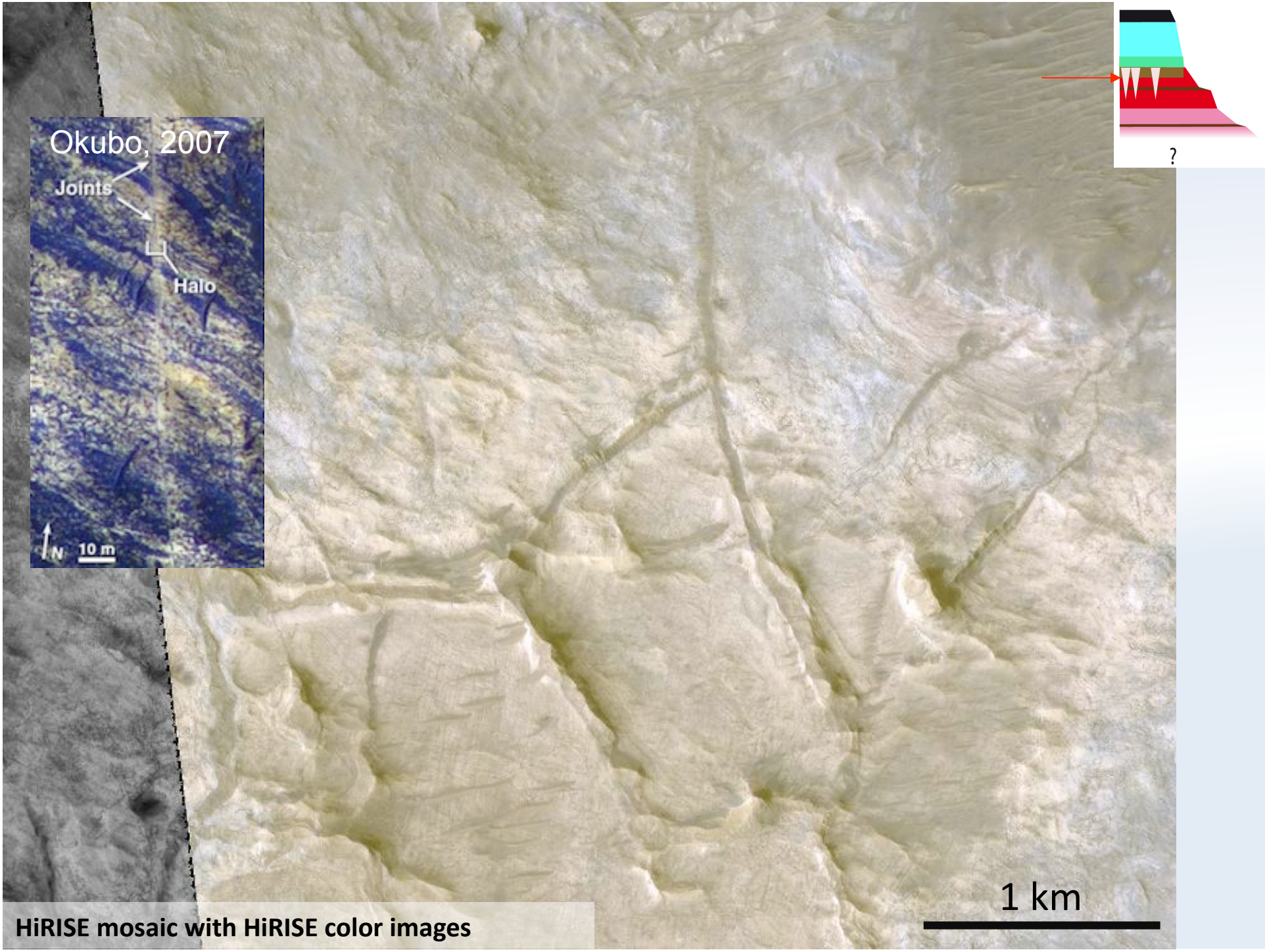




Large fractures with potential fluid-controlled minerals

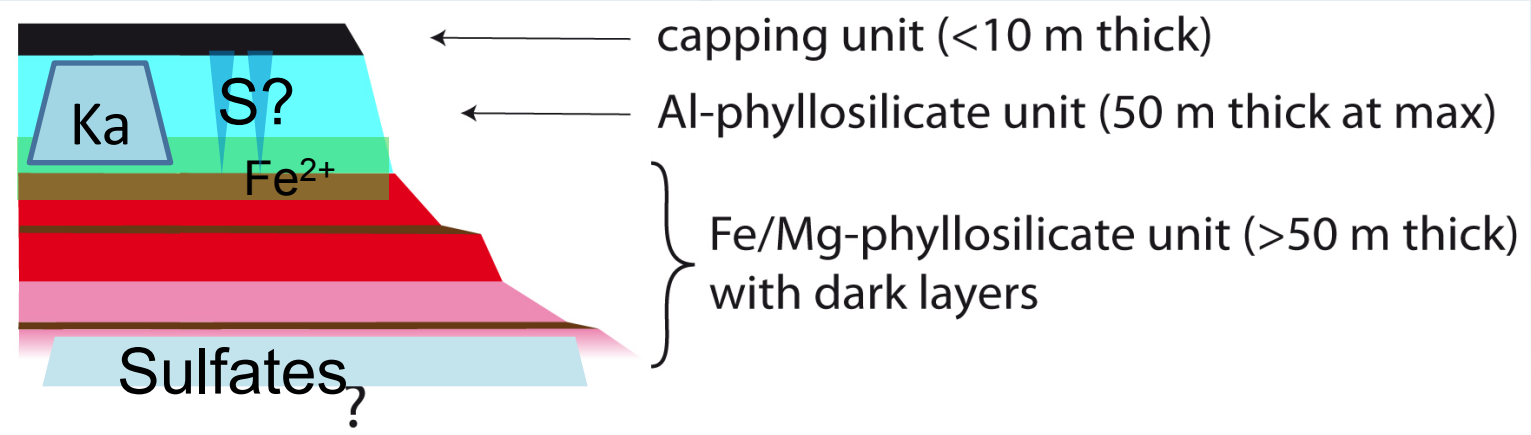
Morphology & mineralogy:
Large fractures are present on outcrop of the Fe/Mg-clays.

MSL tasks:
Study the mineralogy and chemistry of vein materials



HiRISE mosaic with HiRISE color images

3. Sampling a huge diversity of mineralogy and associated aqueous environments



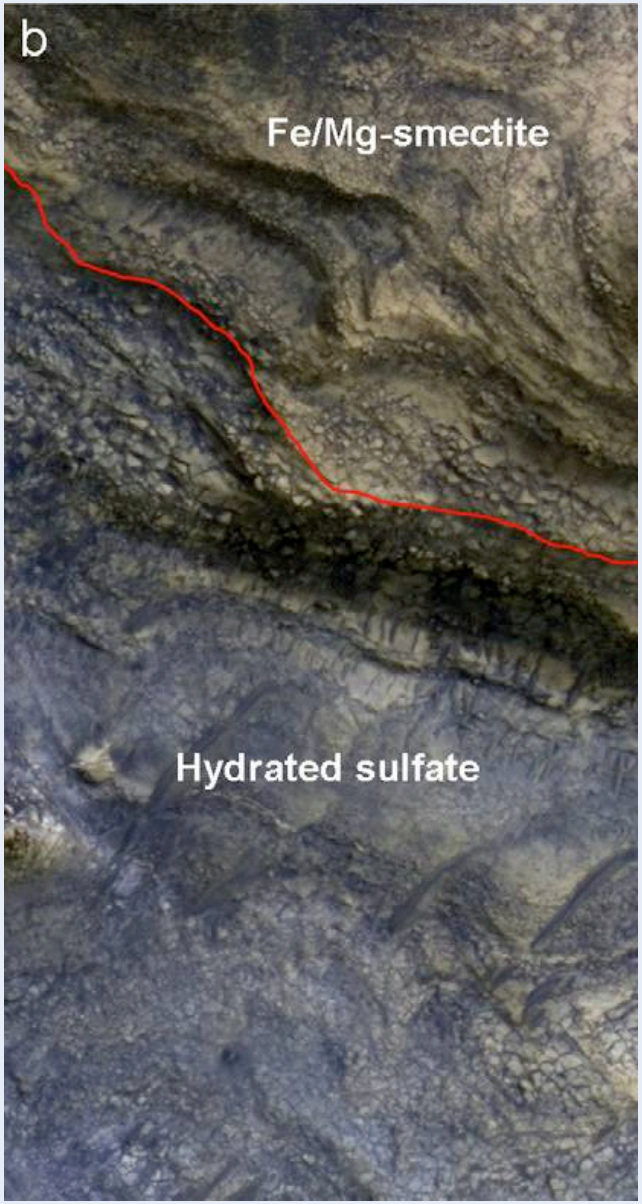
Observation: Many minerals (Al/Fe smectites, kaolinite, hydrated sulfates, mafics, etc.) were found in morphologically distinct layers or as admixing.

Working hypothesis: A diverse mineralogy indicates distinct aqueous environments.

=> A variety of conditions increases the probability of finding organics.

⇒ Maximizes the probability that Curiosity will detect a variety of phases

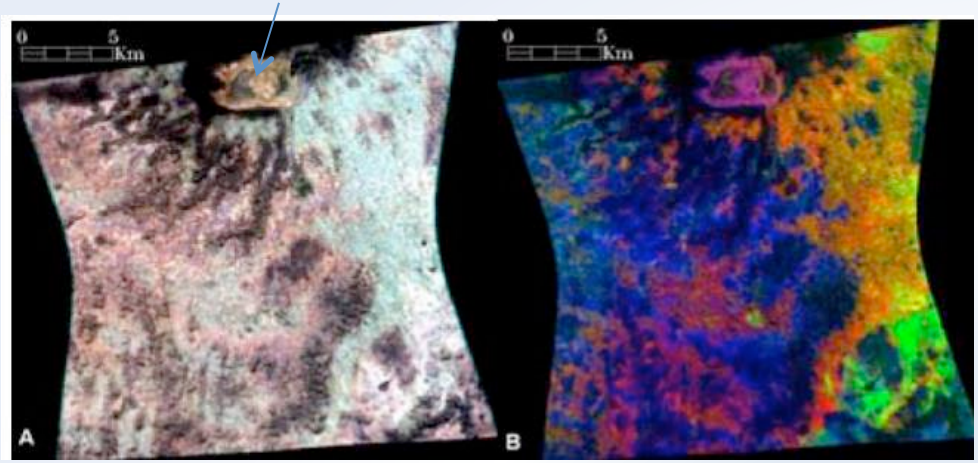
Hydrated sulfates such as bassanite was found in specific layers



Wray et al 2010

Presence of more acidic phases (sulfates, especially jarosite) in various locations of Mawrth Vallis plateau

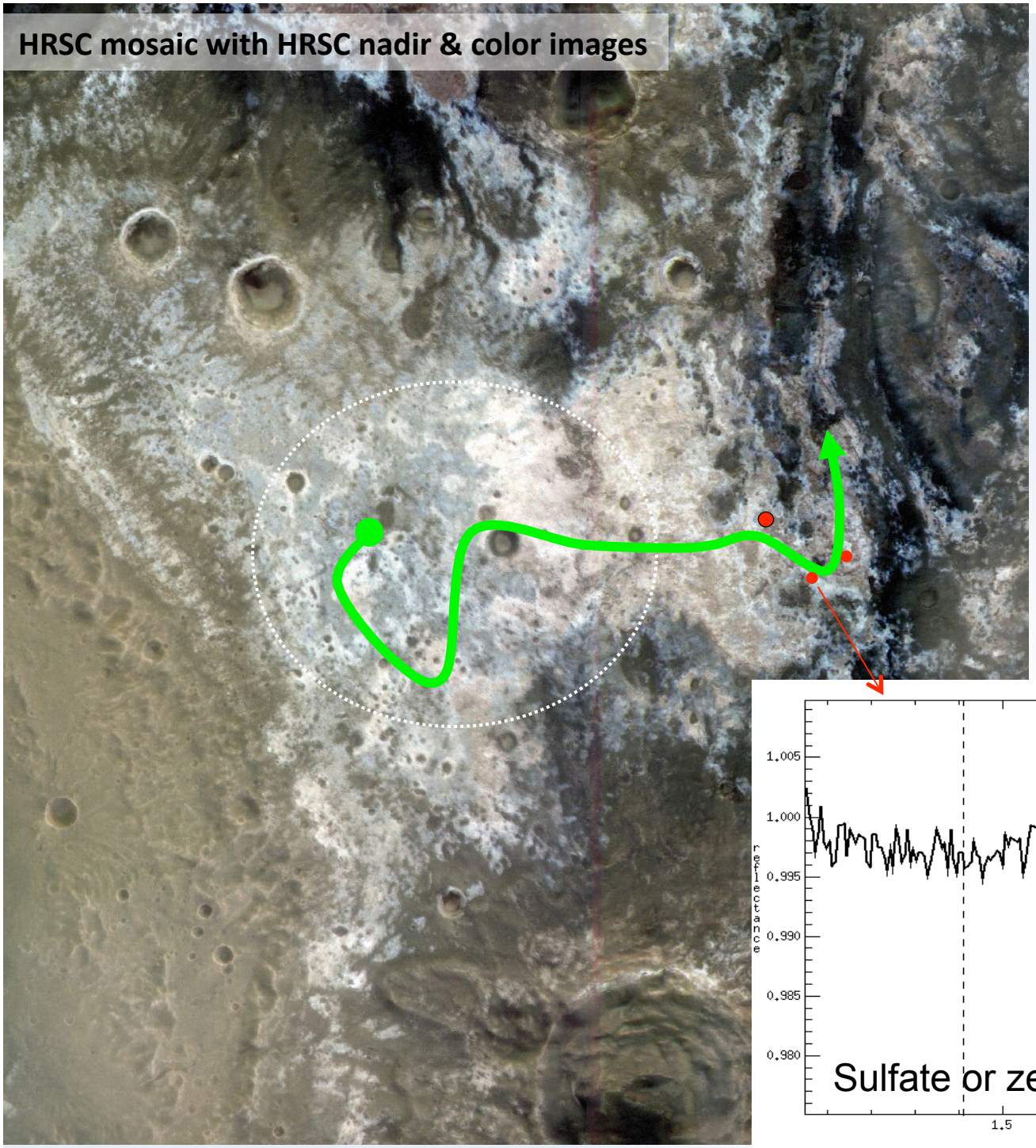
Jarosite

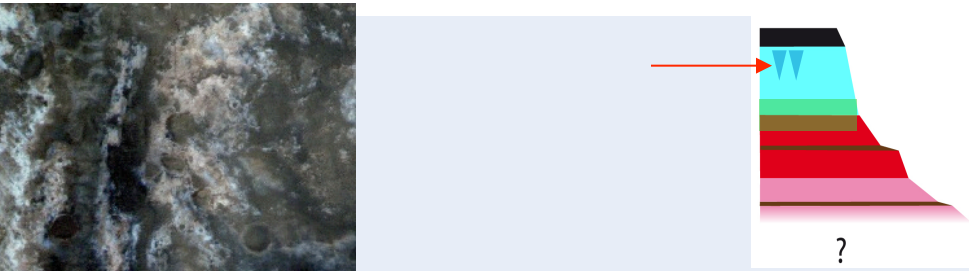


Farrand et al., 2009

The chosen site contains a mineralogical diversity that includes most species found on Mars

S?

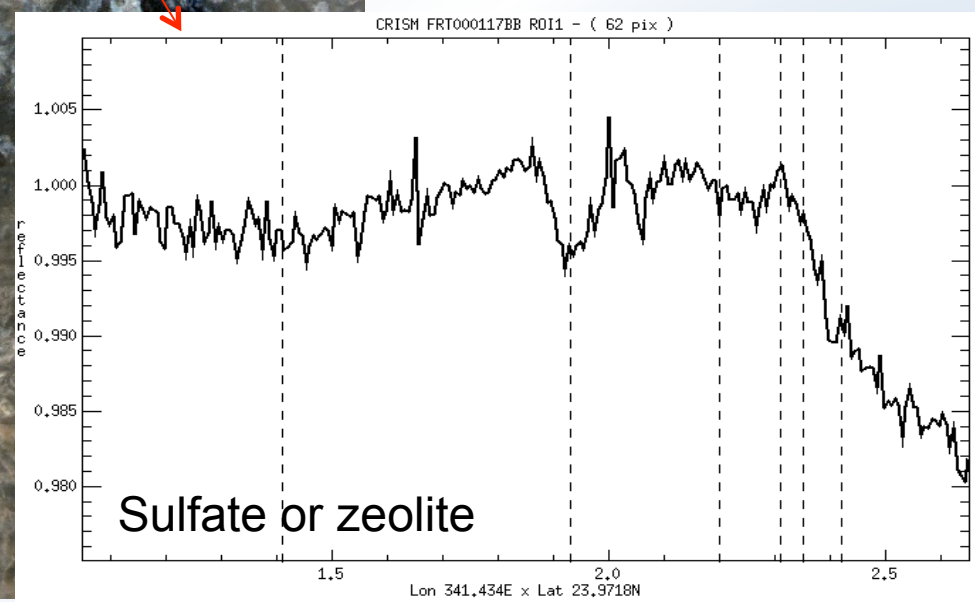


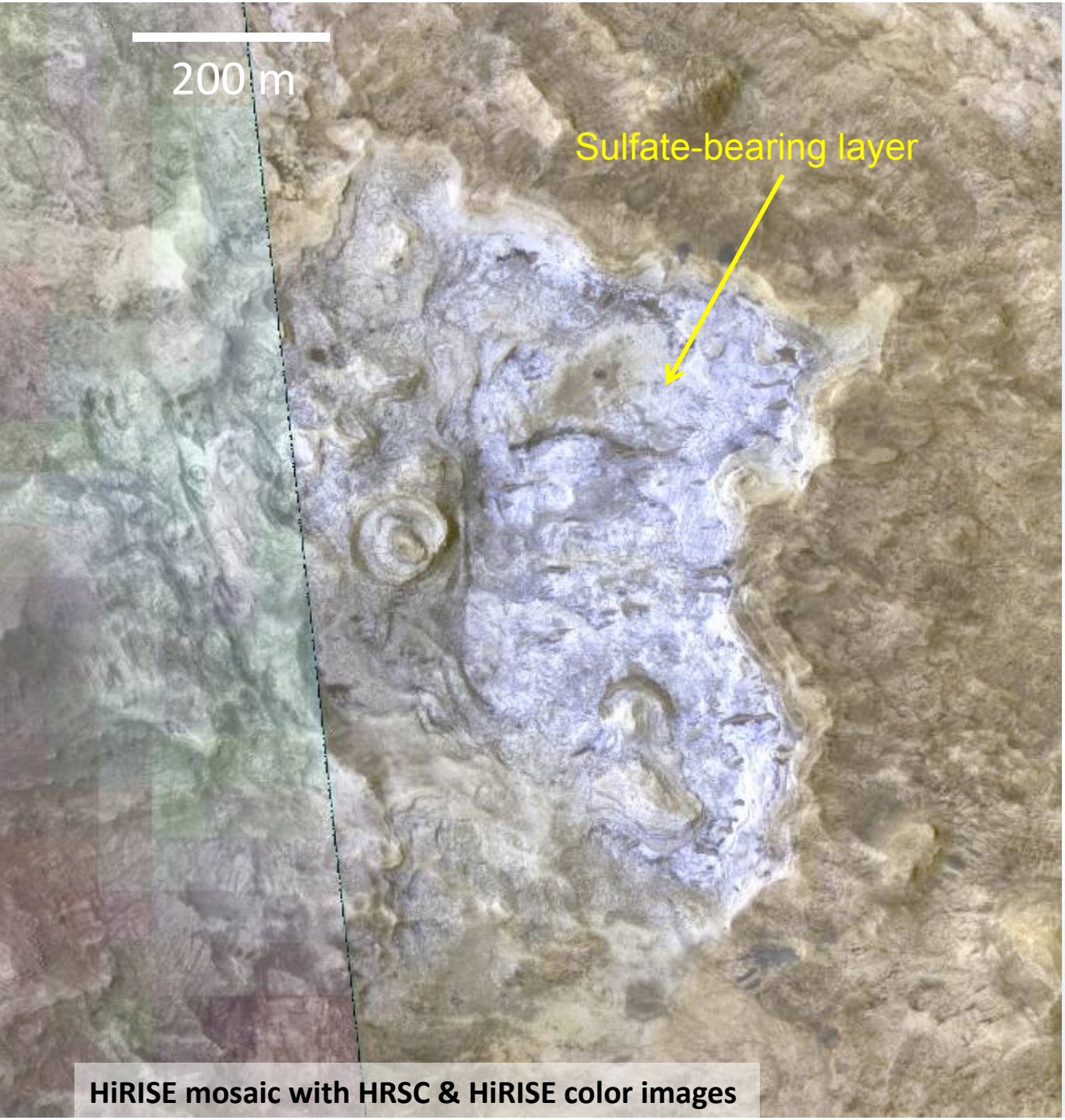


Possible sulfate-rich units

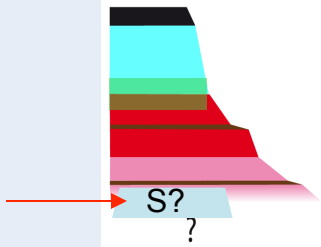
Morphology & mineralogy: Three levees show spectra similar to zeolite or sulfate.

MSL tasks: Mineralogy and relation with lower and upper layers.





HiRISE mosaic with HRSC & HiRISE color images

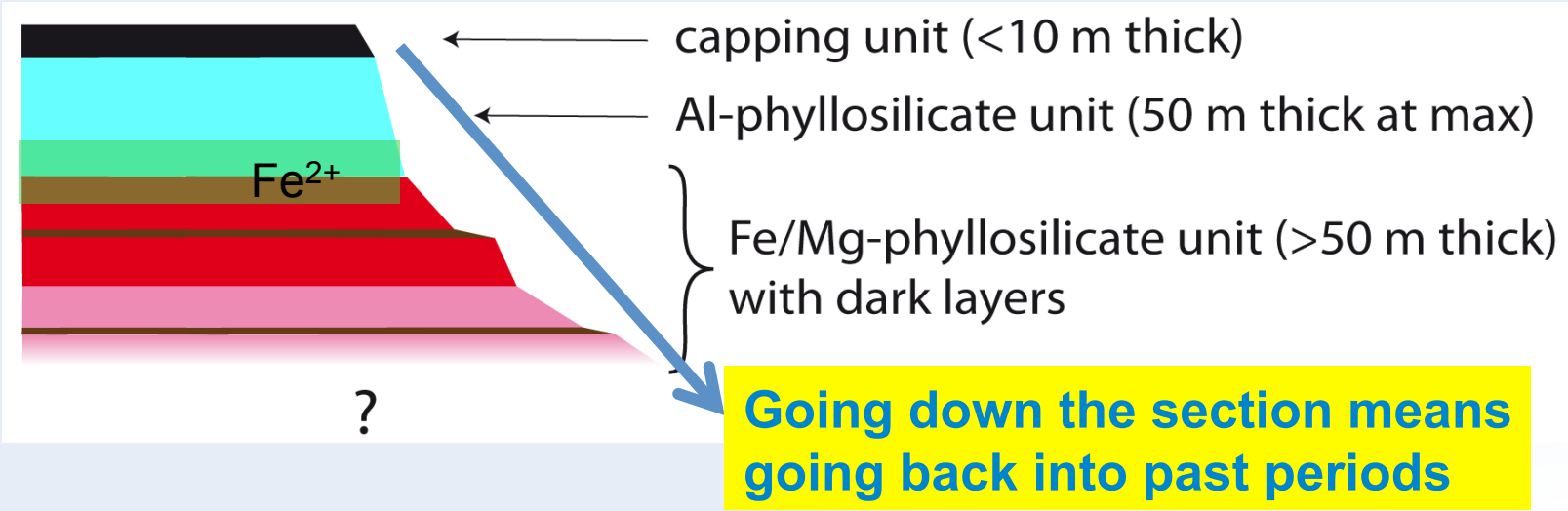


Lower blue unit

Morphology & mineralogy: A layer east of the ellipse shows light blue layers beneath the light-red layers of Fe/Mg-smectites.

MSL tasks: Mineralogy and chemistry and facies of these specific layers.

4. Sampling a prolonged record of sedimentary deposition

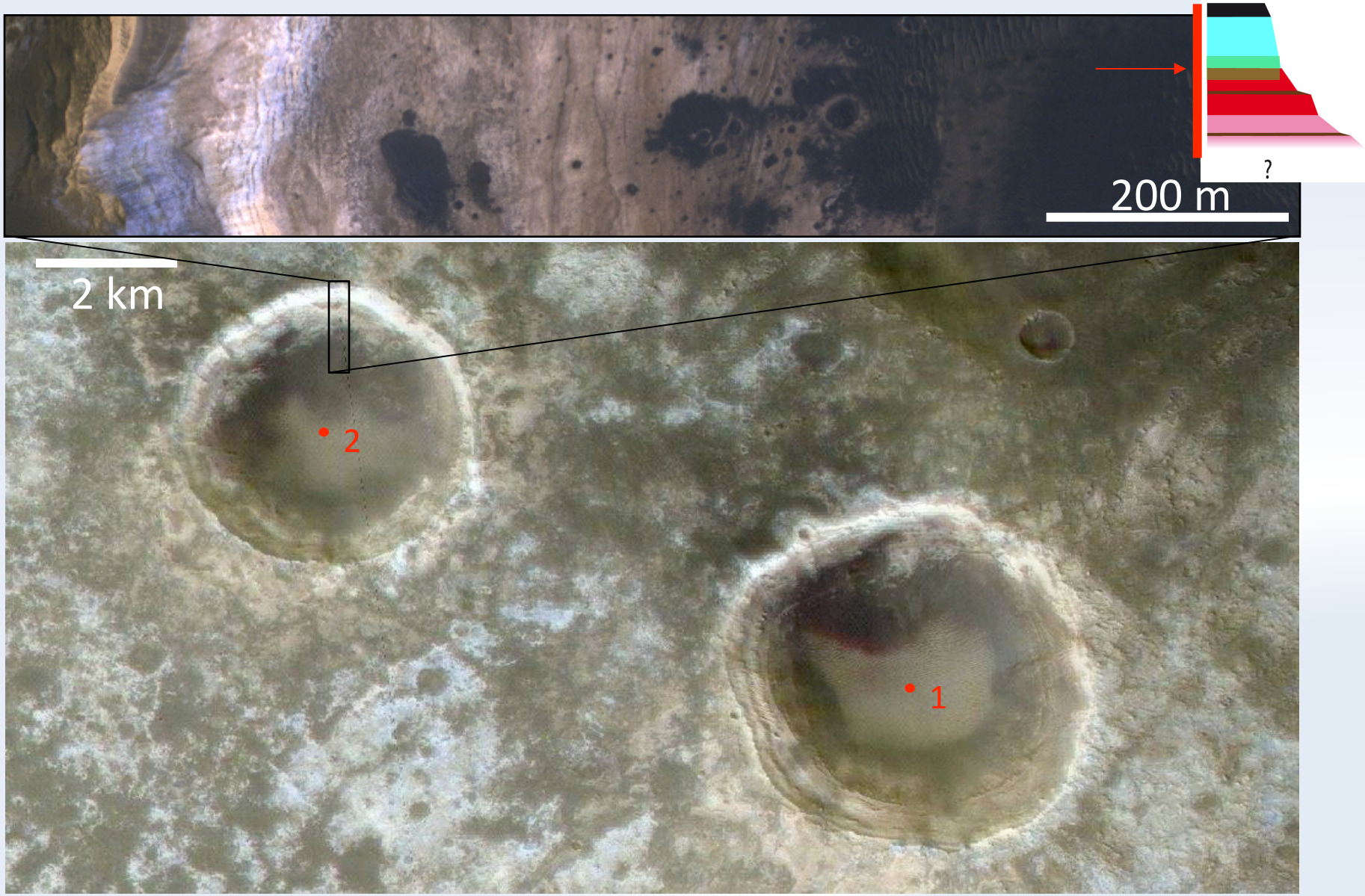


<u>Observation:</u> Many layers can be sampled by going down the section

<u>Working hypothesis:</u> Sediments record a long period of deposition in a wet environment as indicated by widespread Fe/Mg smectites.

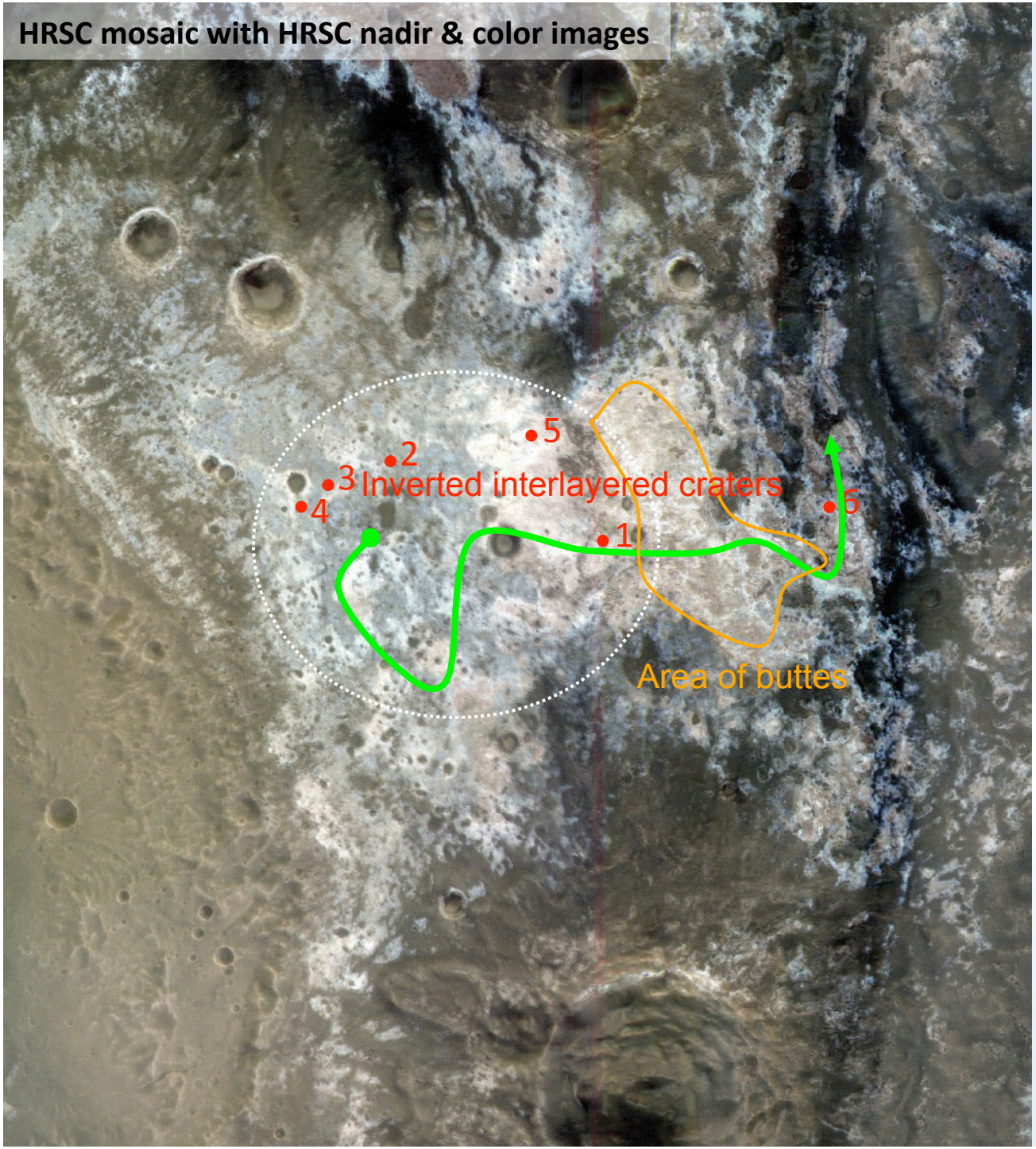
⇒ Prolonged aqueous activity increases probability to have life development

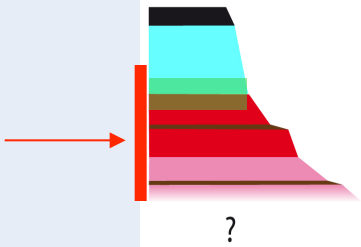
⇒ Earlier periods may be even more favorable to life



Large craters indicate >200 m thick layered deposits

How to access layers without having the largest craters in the ellipse:
Small buttes and Mawrth vallis flanks



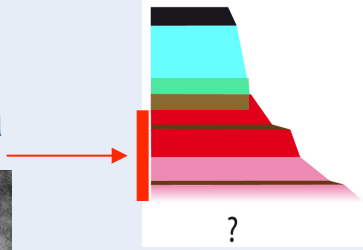


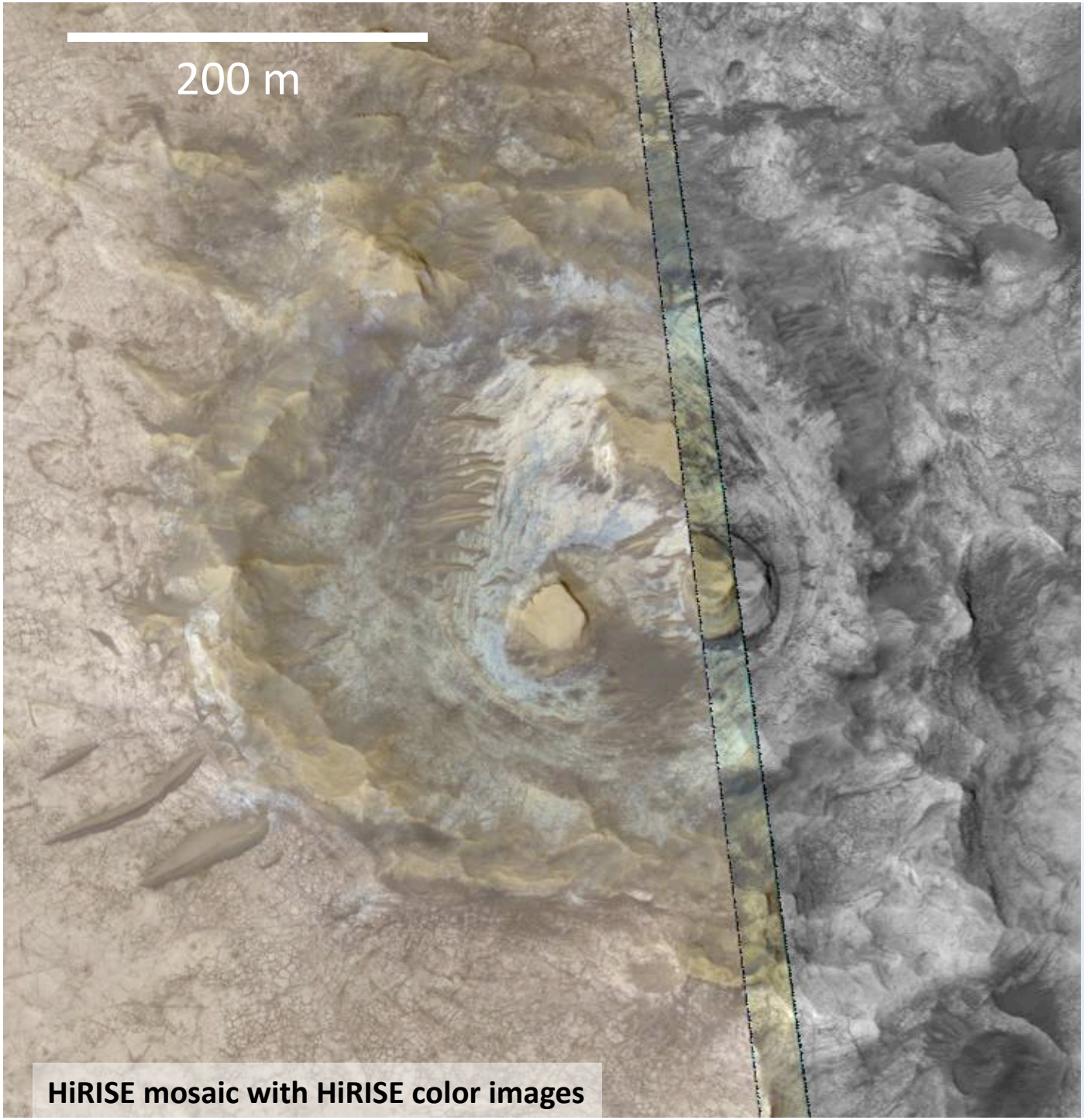
Circular layered structures (inverted craters and buttes)

Morphology & mineralogy: Some circular, layered structures are present inside the clay-layered unit.

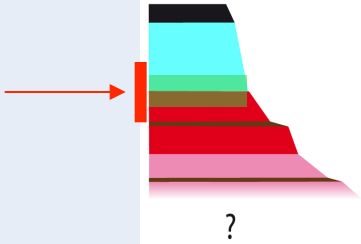
MSL tasks: Specific location to study facies, mineralogy and chemistry in distinct layers, and determine their alteration as well as depositional history.

<1 Meter thick layers on a 50 m high scarp
=> Fine layering, no breccia, distinct from lava flows and ejecta breccia

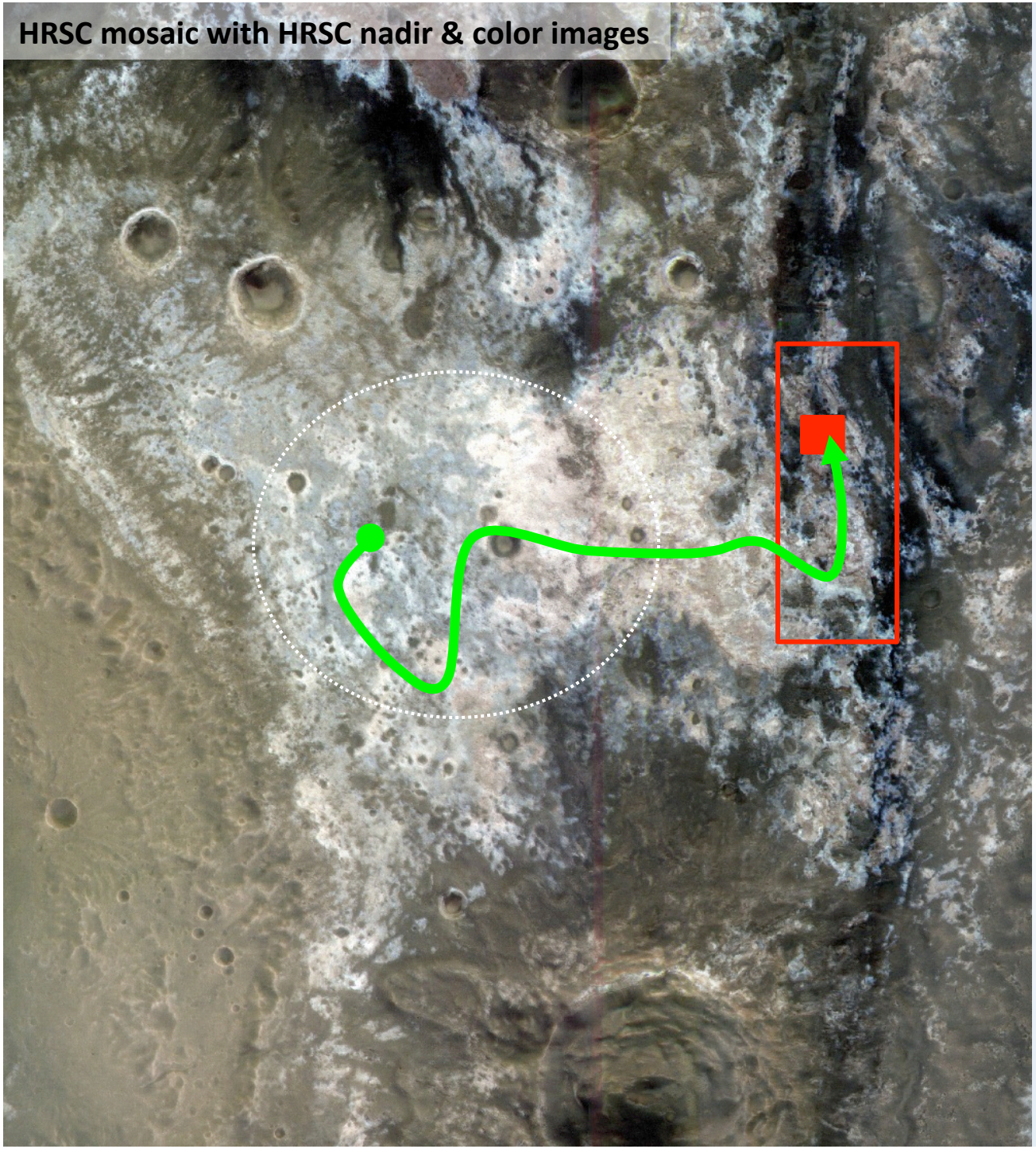


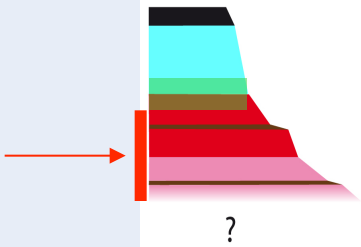


HiRISE mosaic with HiRISE color images



Circular layered butte



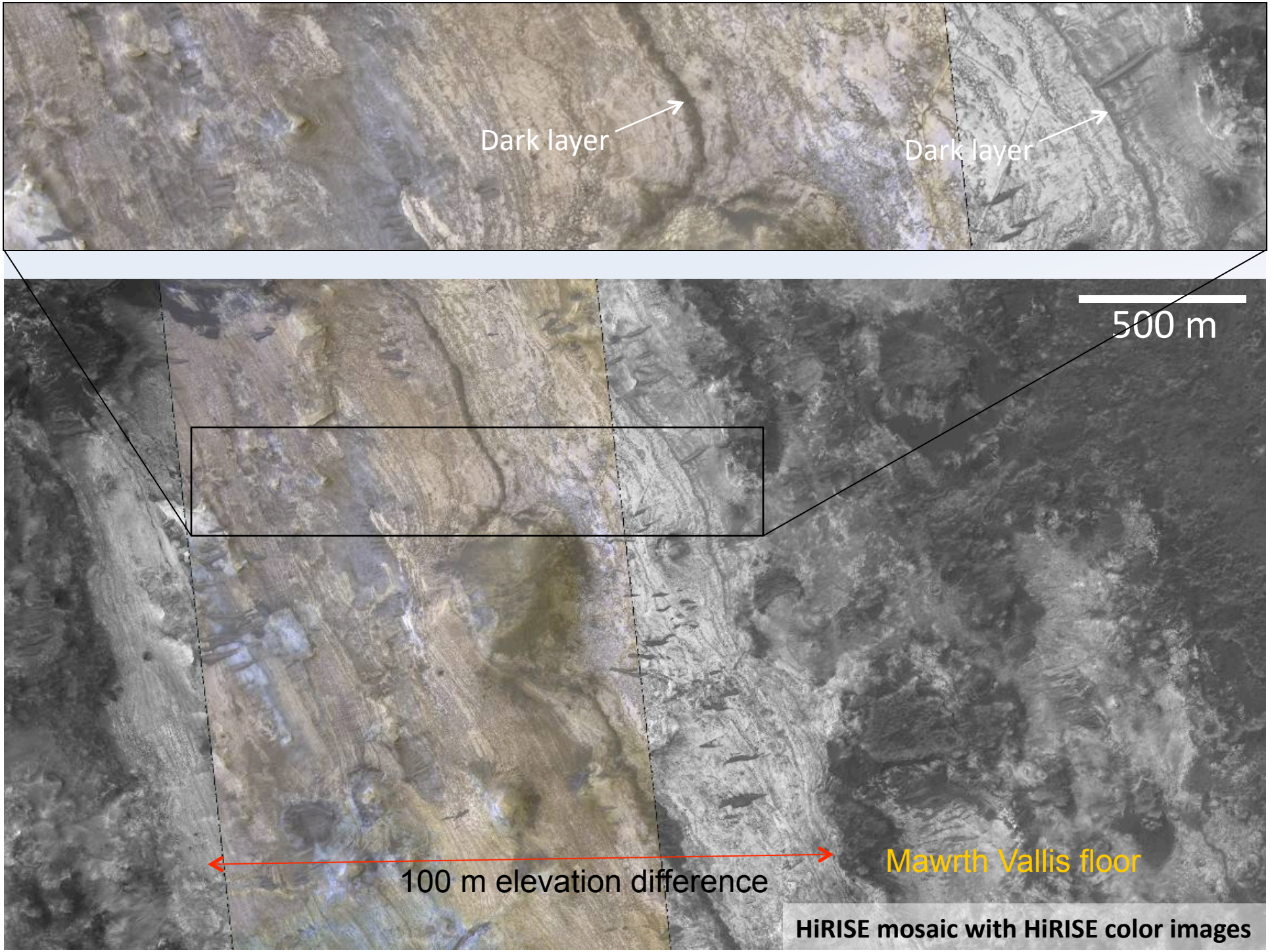


Layers on flanks and floor of Mawrth Vallis

Morphology and mineralogy: Extent layers of light-toned rocks, with some dark interlayered beds. Fe/Mg-smectites are predominant. Al-phyllosilicates exist locally as an alteration level unconformably to layers dip.

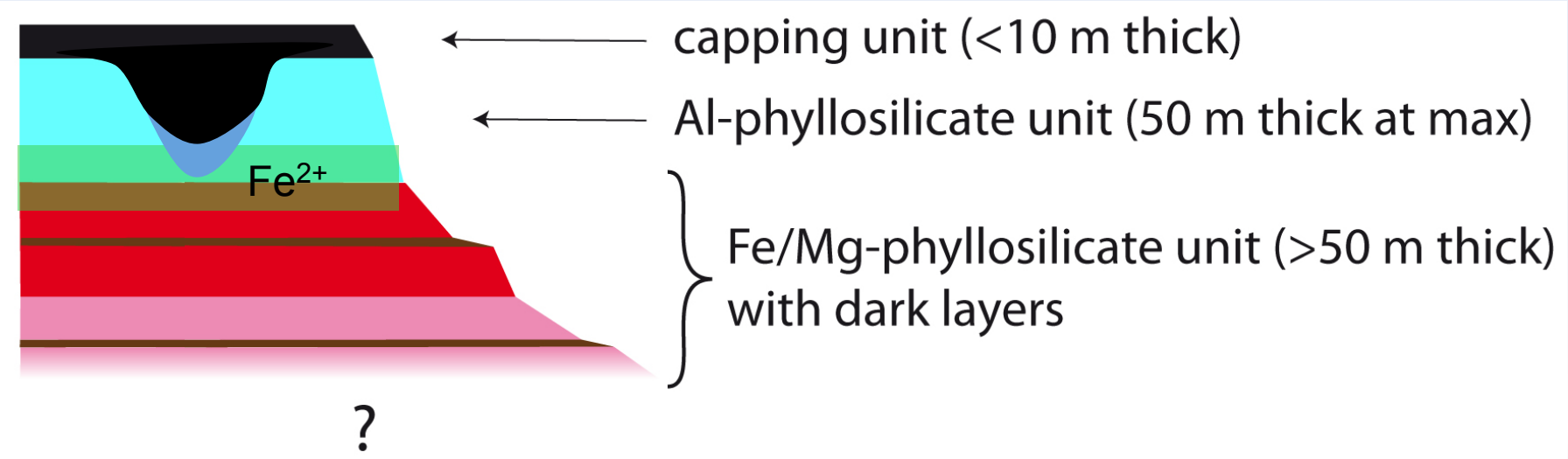
.

MSL tasks: Study the facies, the mineralogy and chemistry of the rocks and the variations between layers going down.



HiRISE mosaic with HiRISE color images

5. Analyzing late aqueous episodes



Observation: Fluvial valleys erode clay-bearing layers and are often inverted forming inverted channel deposits.

Working hypothesis: Sediments in inverted channels preserved signatures from the deposition environment that post-dates most alteration phases.

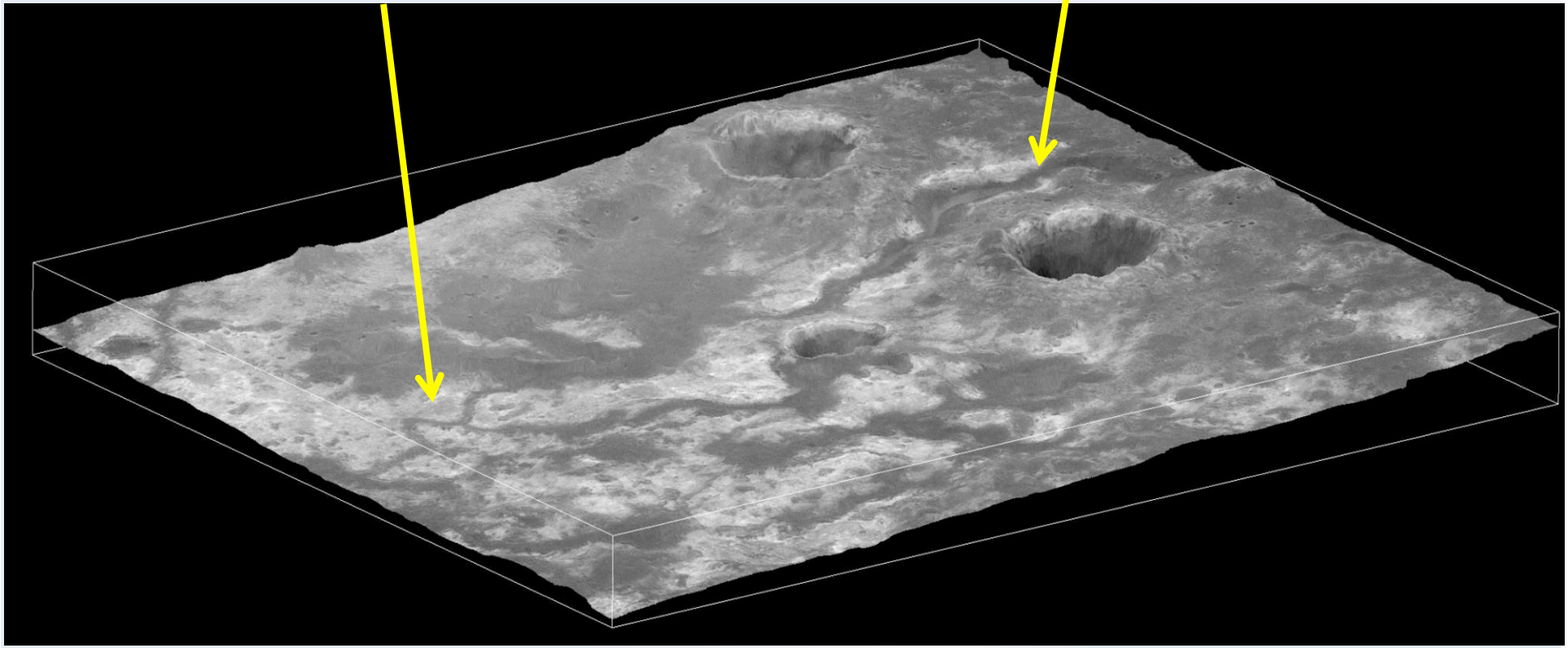
Sediments can help us to understand the transition to drier environments.

Fluvial valleys eroded the clay-bearing unit deposits subsequently to their formation

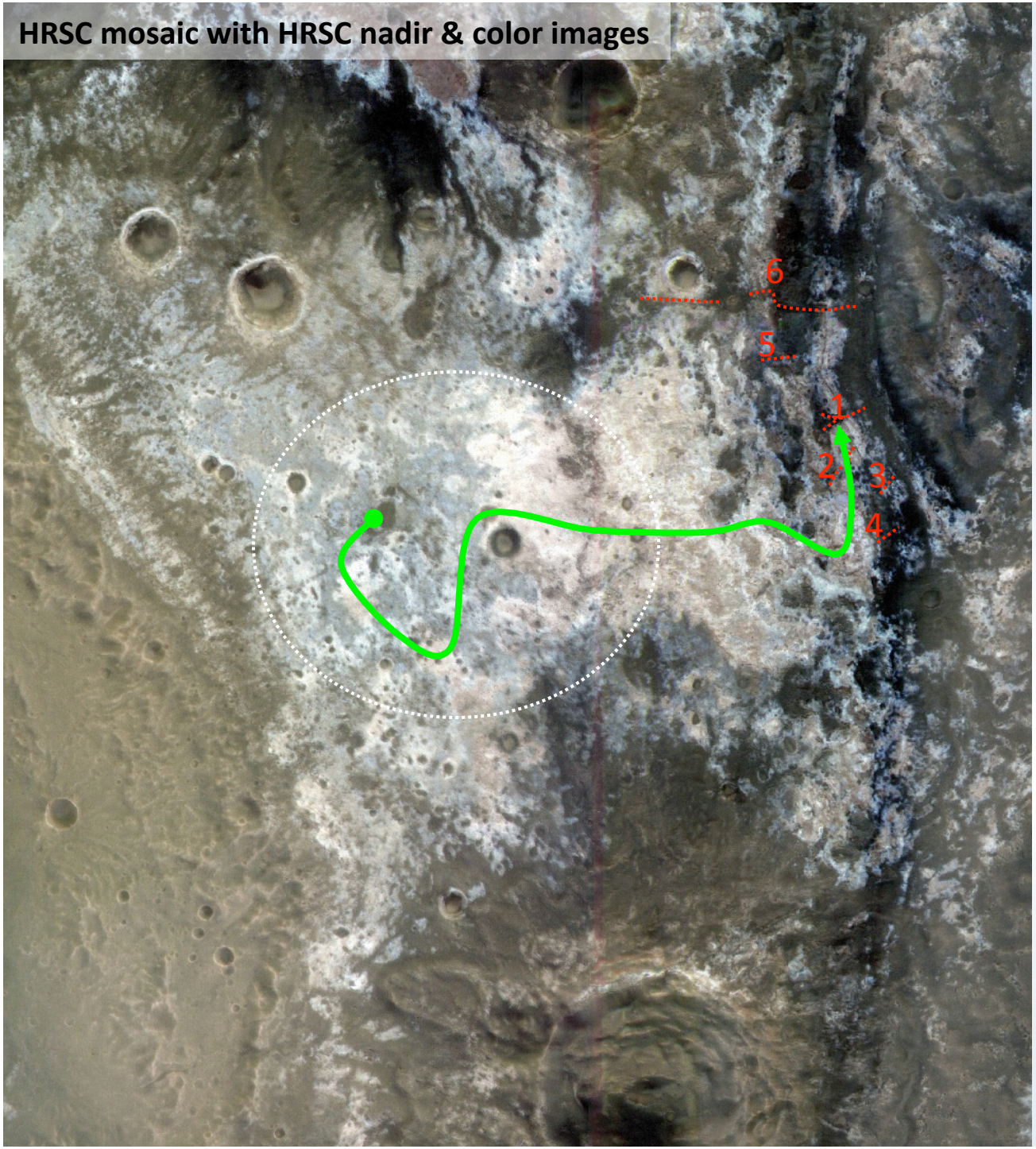
100-200 m thick eolian erosion removed fluvial valleys subsequently

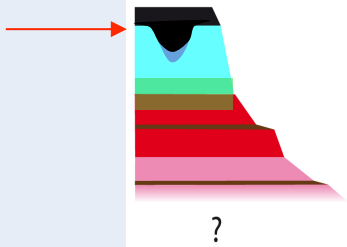
Inverted channel
No more topographic valley

~150 m deep valley



Inverted channels preserve sediments from the latest aqueous episodes

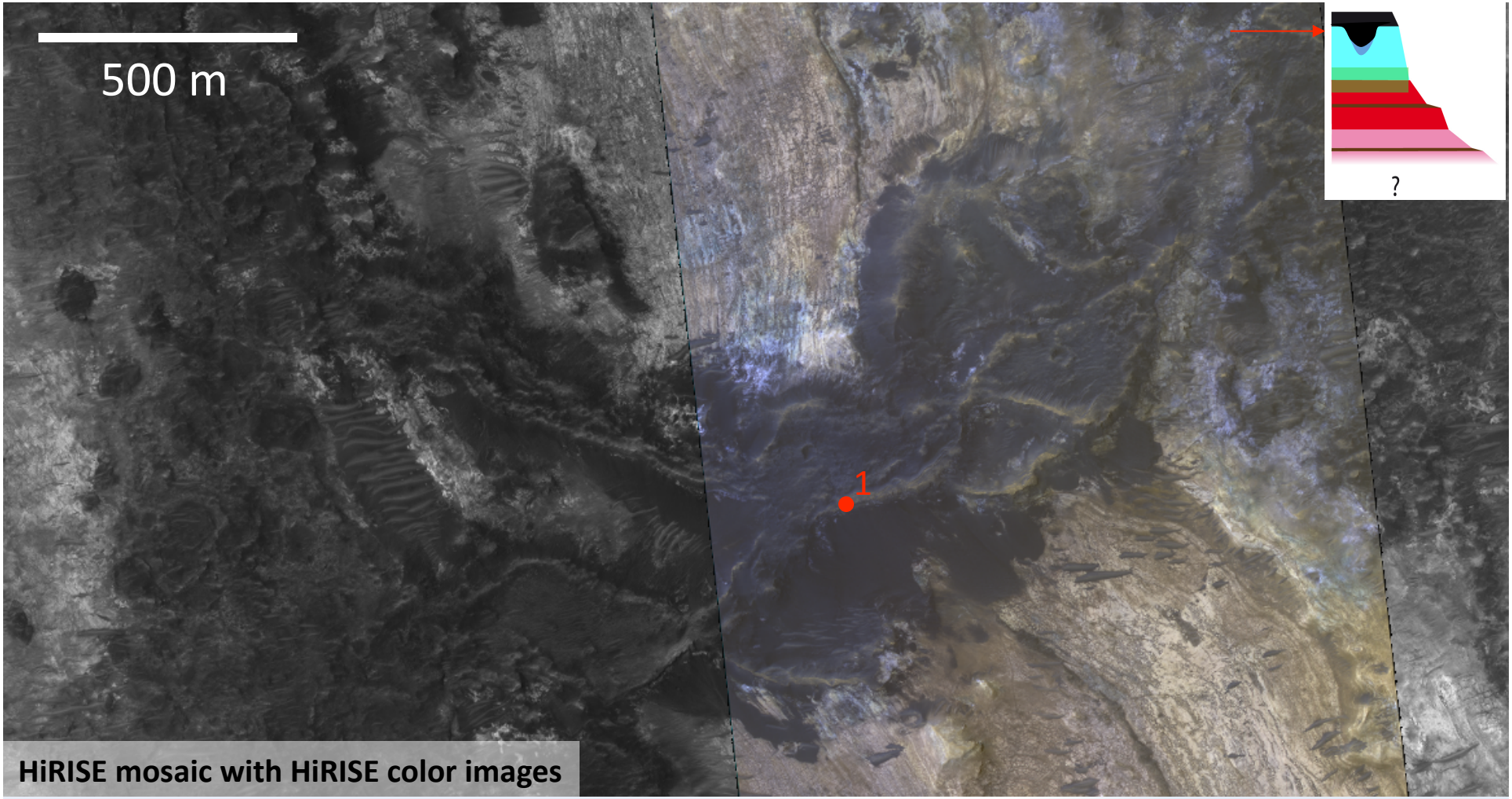




Valleys & inverted valleys in Mawrth Vallis flank

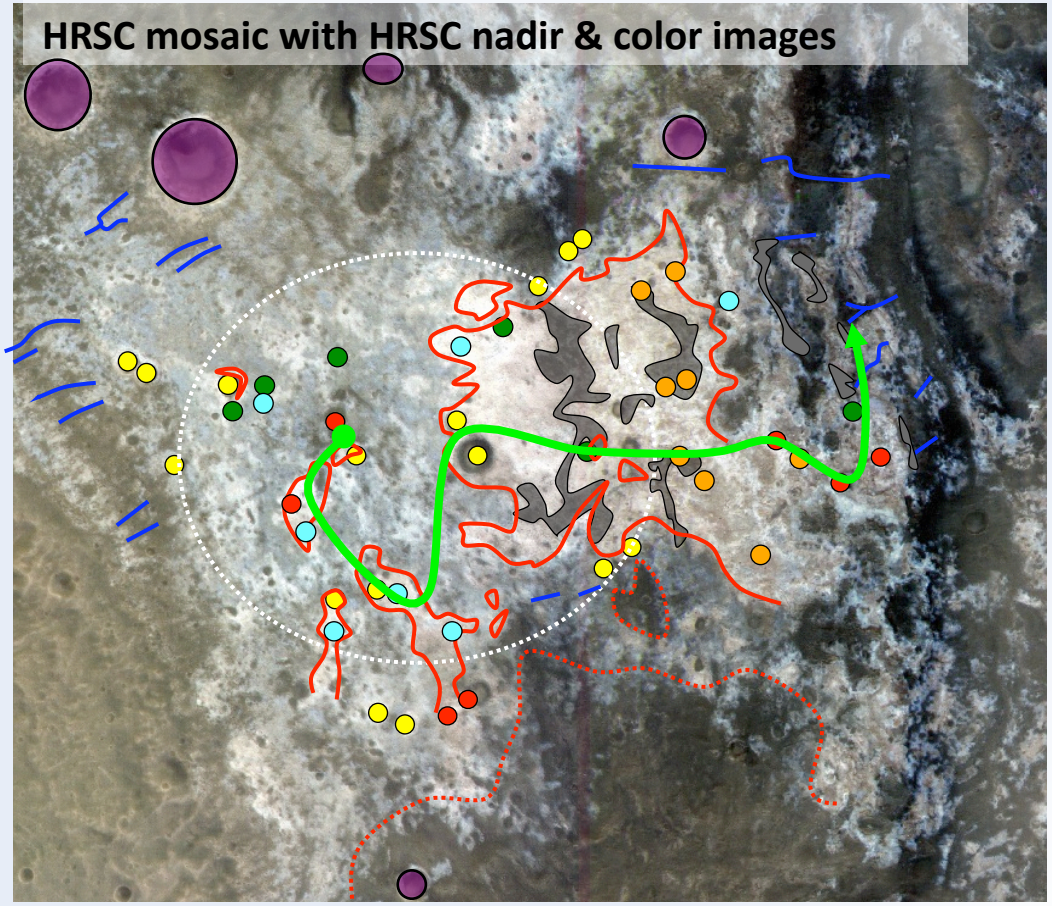
Morphology & mineralogy: Valleys and inverted valleys filled by dark material are on the slope of the flank of Mawrth Vallis. They are only few kilometers long and some postdate Mawrth Vallis.

MSL tasks: Determine if alteration is related to fluvial activity.



HiRISE mosaic with HiRISE color images

Main goals that can be achieved by various targets at Mawrth



All targets

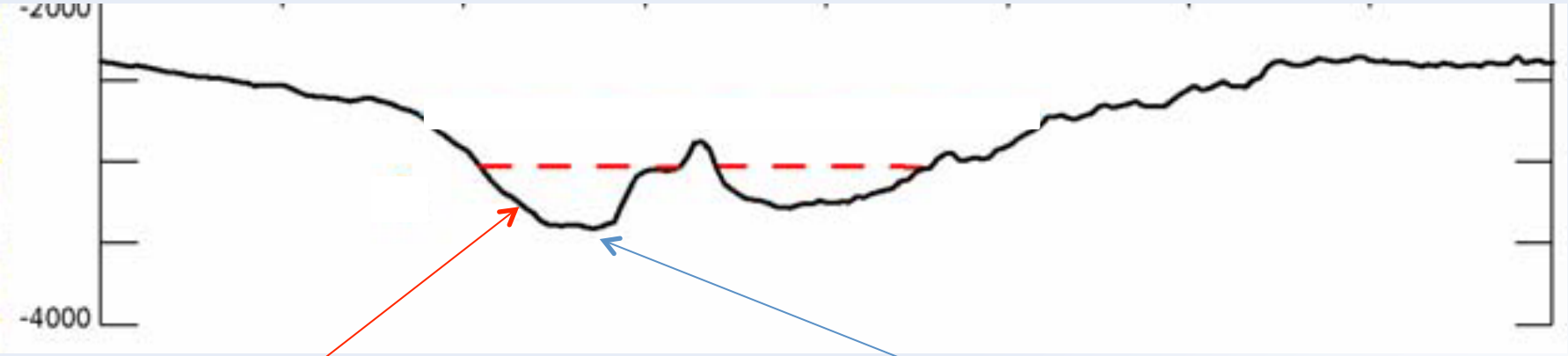
- boundary Al-Fe
- craters with layered walls
- circular layered structures
- remnant layered buttes
- zone of large fractures
- unique targets

- fluvial landforms
- larger, deeper craters

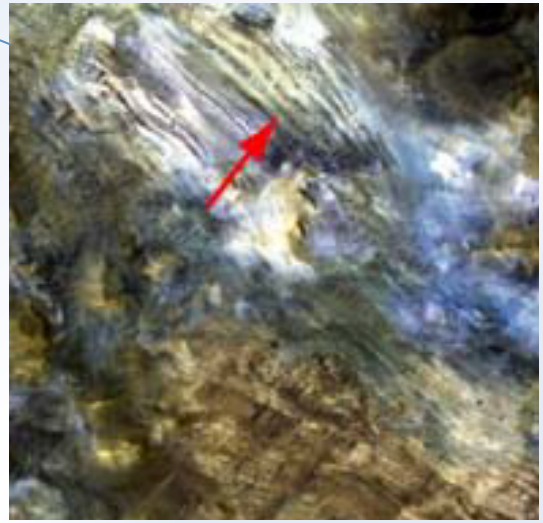
- specific layers
- putative limits of eroded lobate ejecta

Conclusions:

Key science can be achieved right after landing wherever MSL lands
Major goals can be achieved while traversing the entire ellipse
and even more outside the ellipse in a prolonged mission



Mawrth Vallis entrenched Fe-clays bearing sediments deposited on a pre-Mawrth Vallis valley



On the floor of Mawrth Vallis

[59] 5. The different hypotheses of formation of this phyllosilicate-rich unit include (1) sediments deposited by water in an aqueous environment (i.e., deposition of transported phyllosilicates) and (2) alteration by liquid water of volcanic ash deposits, or other wind deposited unit, to produce in situ phyllosilicates. A contribution of phyllosilicate-rich wind-blown material is possible but this process might better explain more recent redeposition such as in crater A. A contribution of craters ejecta during the heavy bombardment is an alternative process, but seems less likely based on the phyllosilicate-rich unit extent and characteristics.

Loizeau et al., 2007

Ash deposits and local ponding deposits
with fossil-bearing paleosoils

Brittle cracks in
organic bearing shales