Fluvial Landforms and Hydrated Minerals due to Impact Craters Hydrothermalism on Mars

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CRISM data processing by John Carter

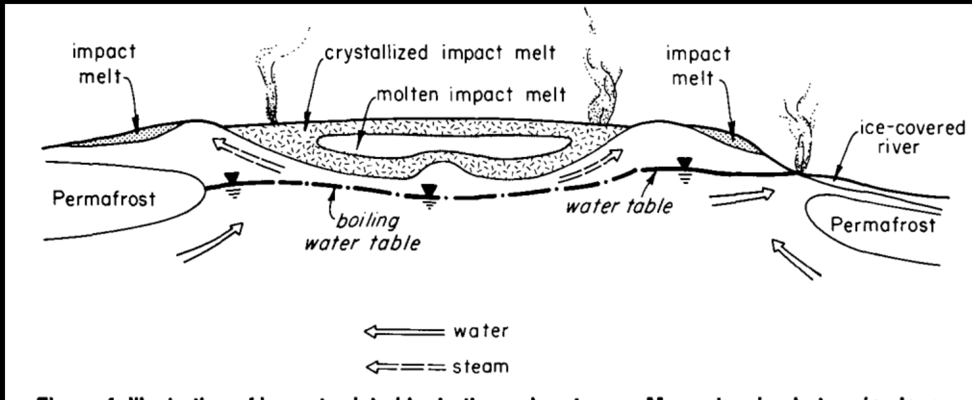
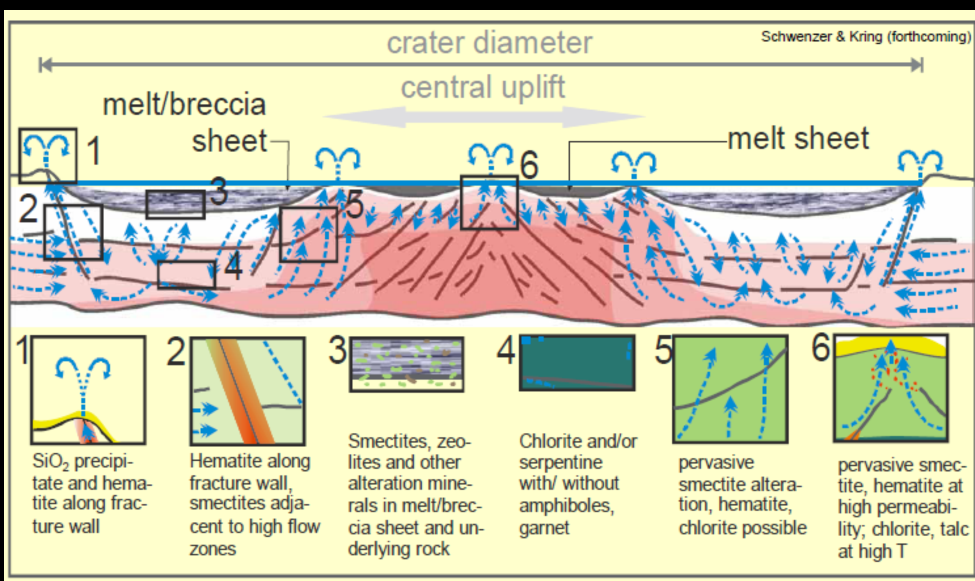


Figure 4. Illustration of impact-related hydrothermal system on Mars, showing hot-spring locations around melt-sheet fringes. Modified from Newsom (1980).

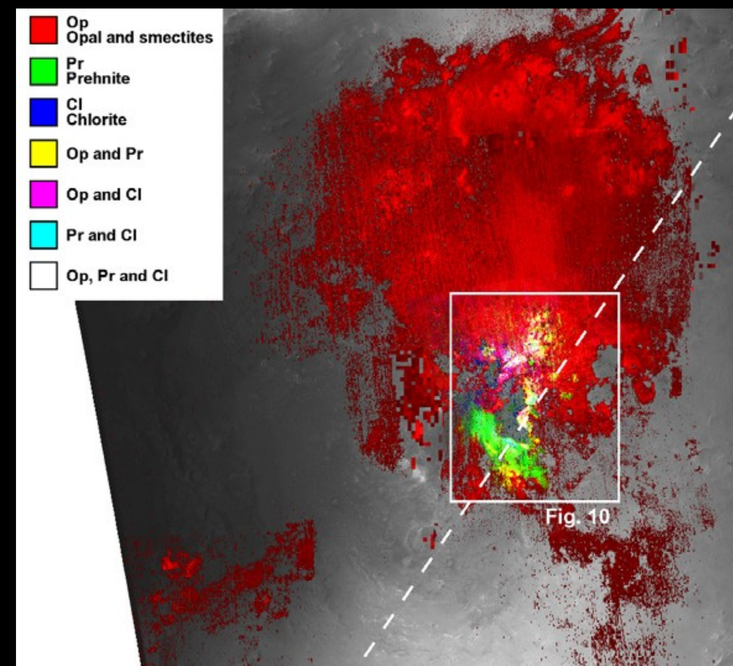
Impact crater - water ice interactions predicted (Newsom, 1980)



A variety of hydrothermal minerals predicted for large impact craters (Schwenzer and Kring, 2009)

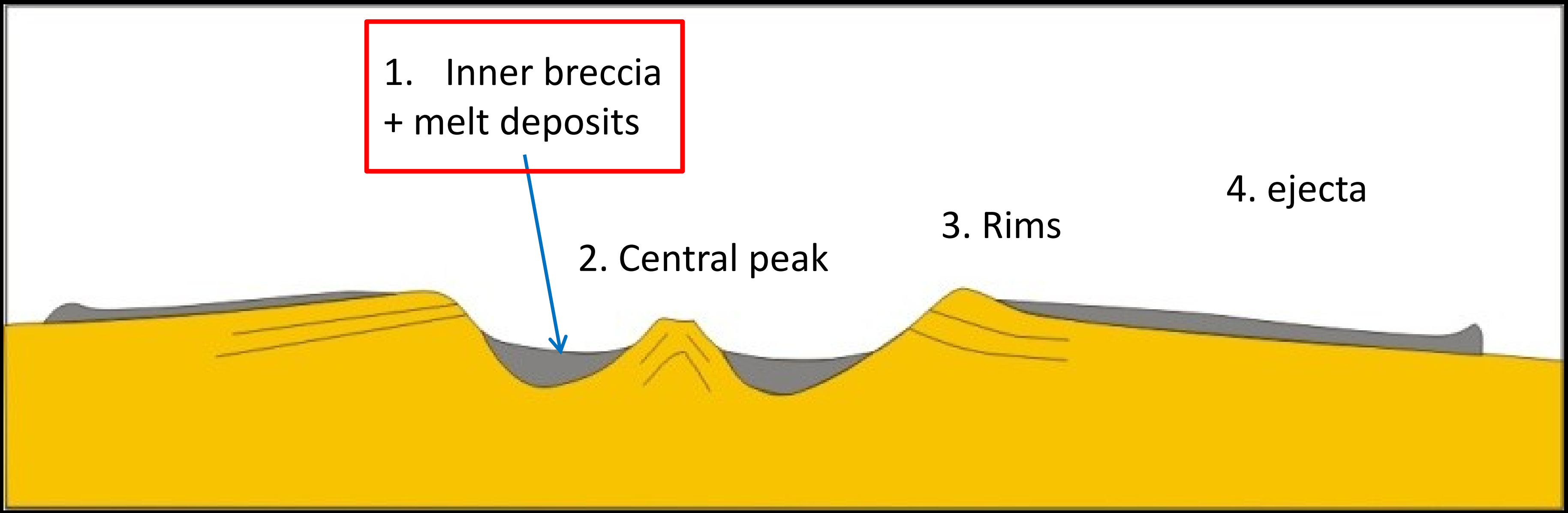
Hydrothermal alteration has been proposed for at least one crater, Toro crater (North Syrtis Major)

Marzo et al., 2010



Still in debate because excavation can also explain some observations, especially on central peak

Presentation includes two examples of alteration on crater floors

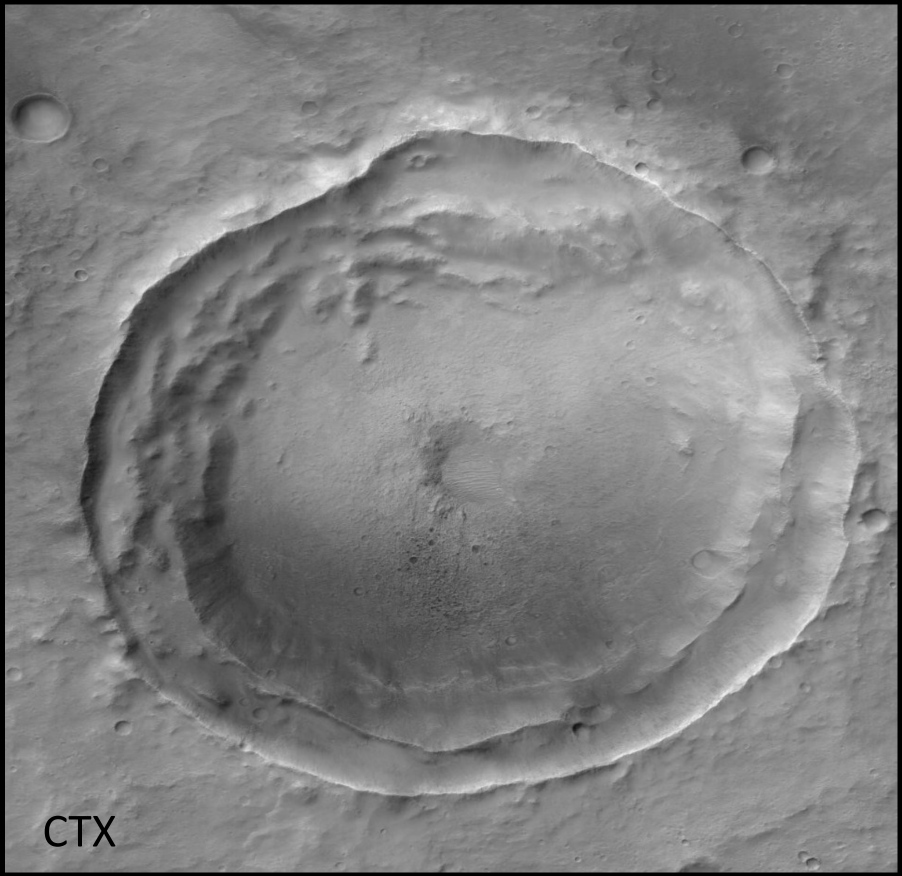


⇒ Impact melt is common for craters > 10 km diameter

⇒ On Earth, the 23 km diameter Ries impact contains inner breccia over >200 meters where temperatures locally exceeded 800 C

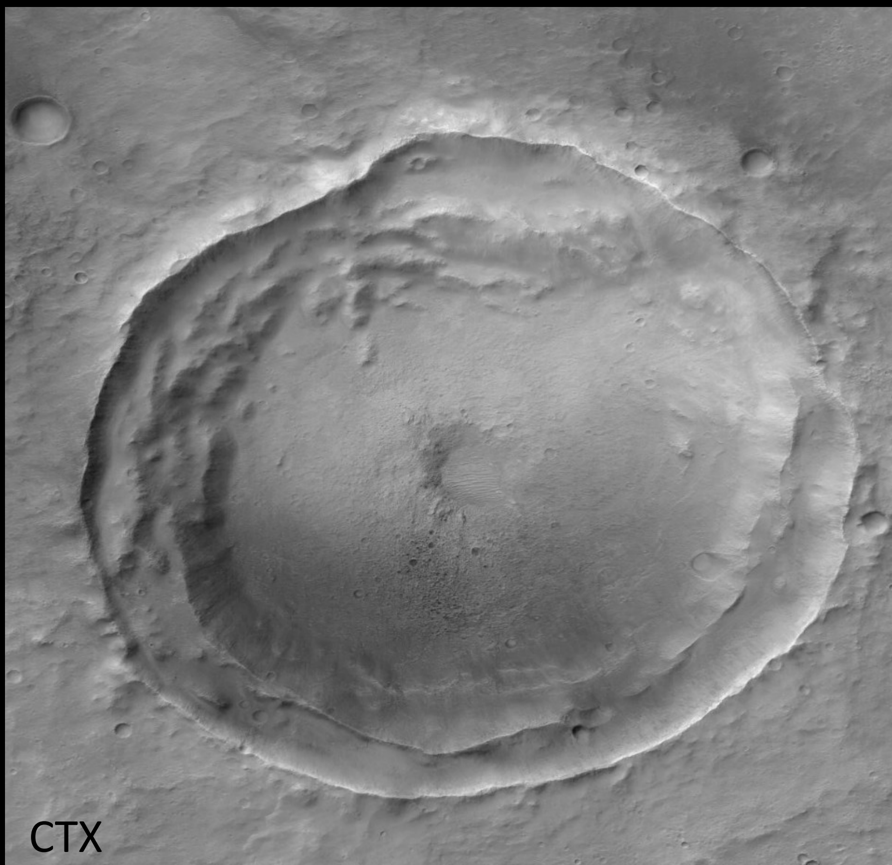
Post-Noachian crater inside lava plains
Lava plain not altered

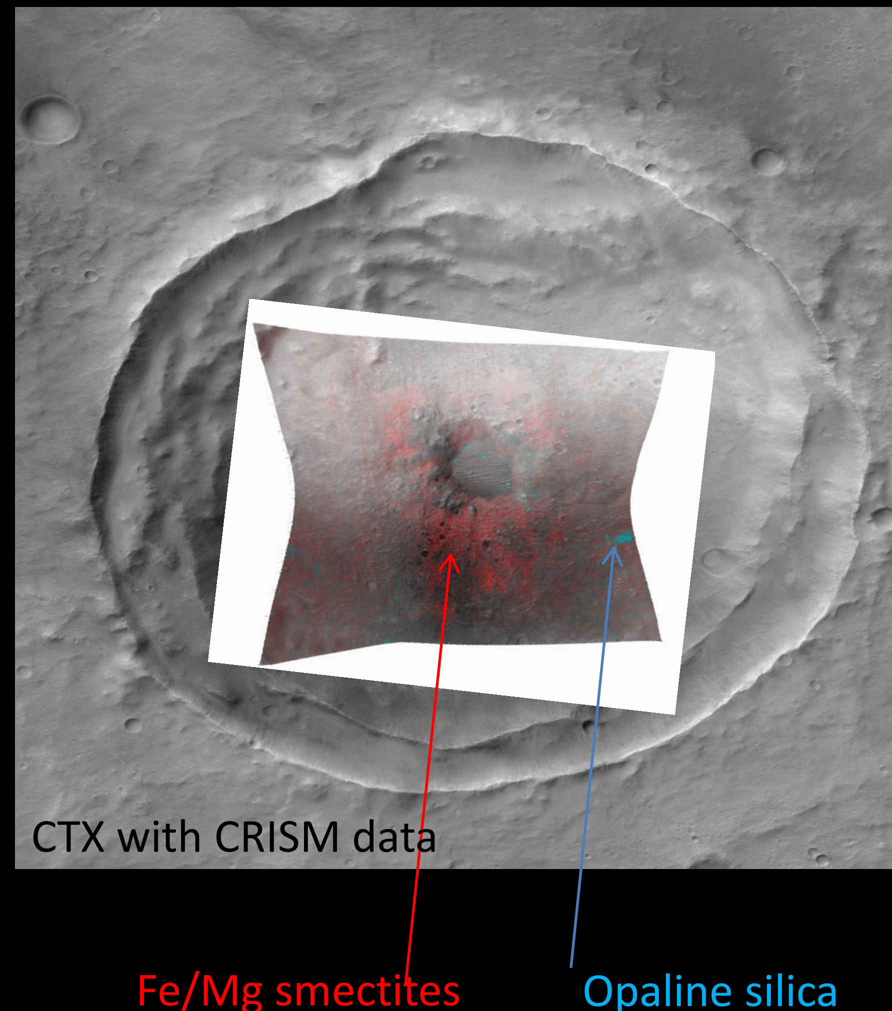
20 km diameter fresh crater
1-2 km of lava flows at this location



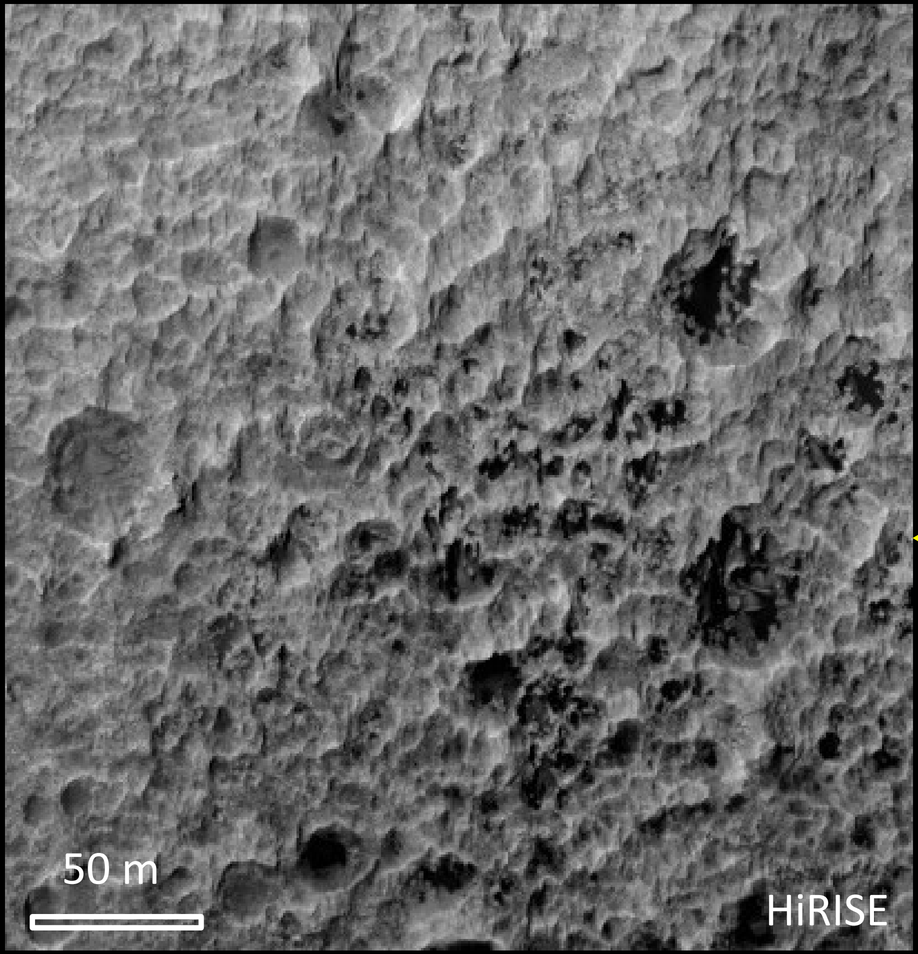
Crater is located at 20°S, usually considered as ice free region

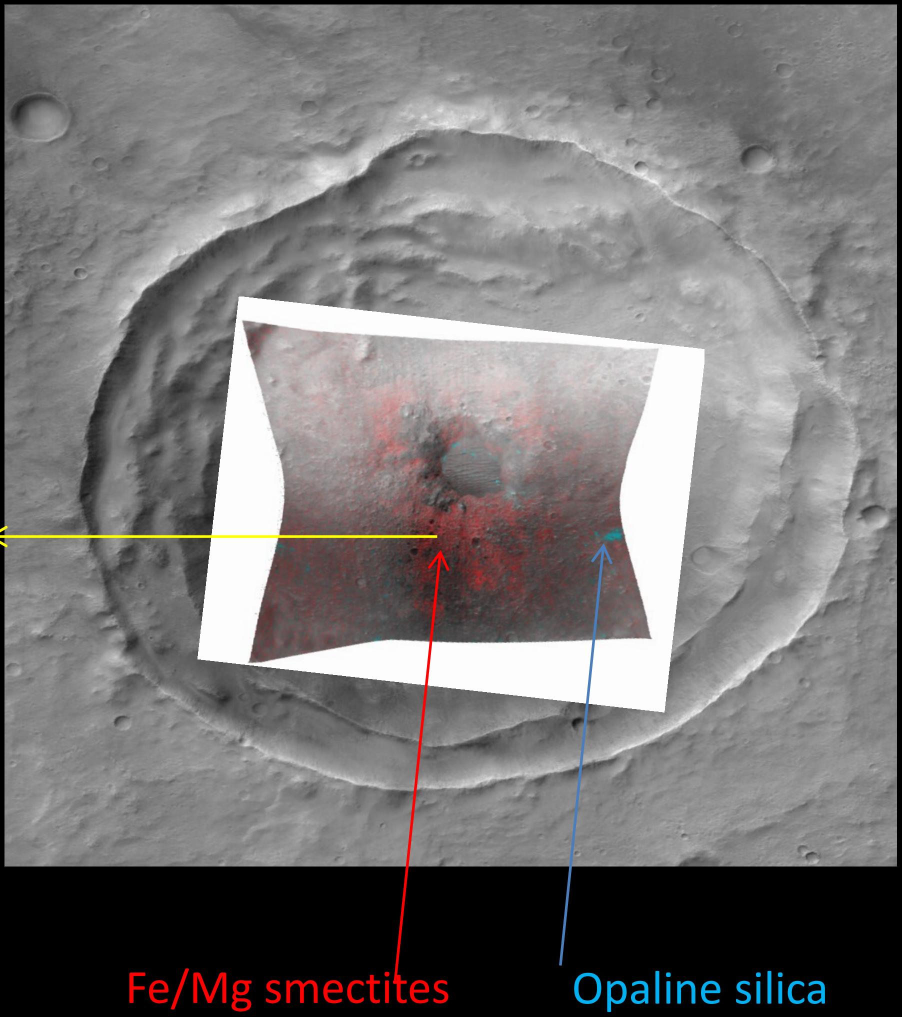
Hydrated minerals detected on the crater floor, such as smectites and opaline silica





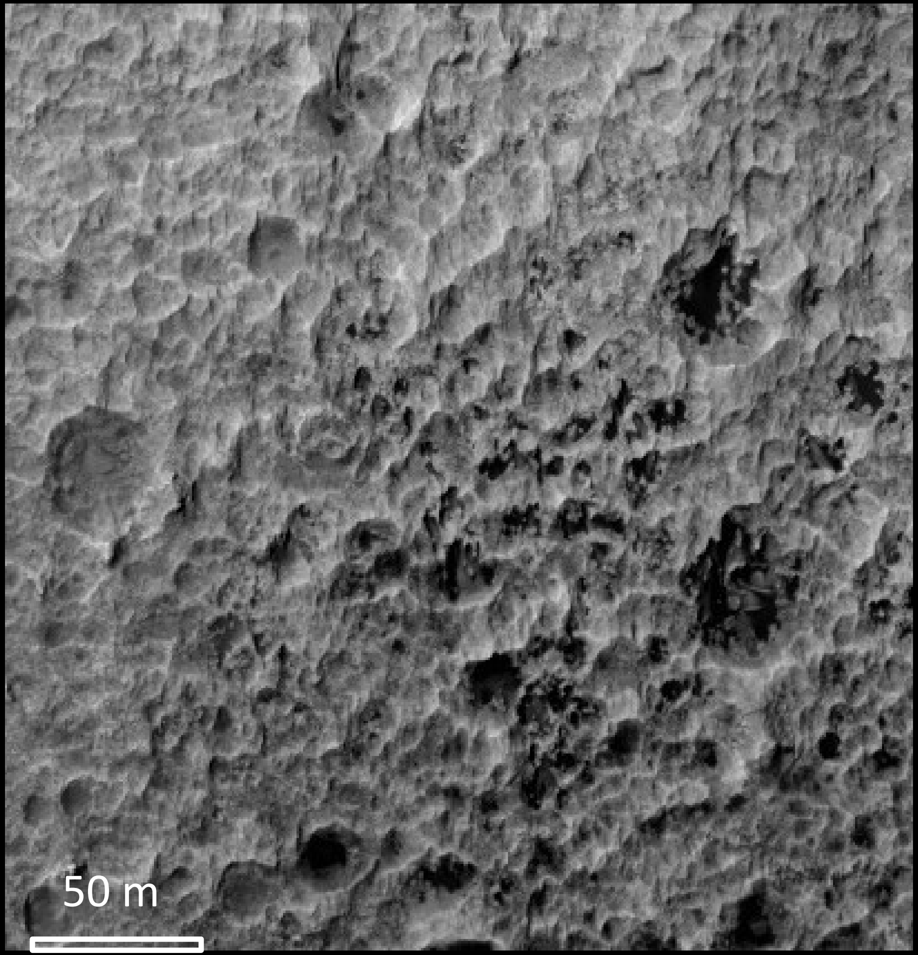
The altered material is a pitted texture, not only small impact craters



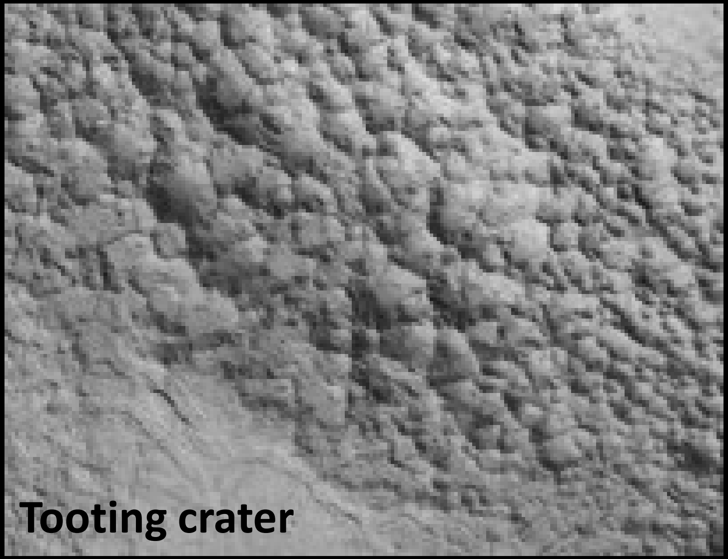


The pitted texture ressembles the texture of suevite-like material as interpreted in recent craters on HiRISE images

Difference is higher scouring/erosion and older age



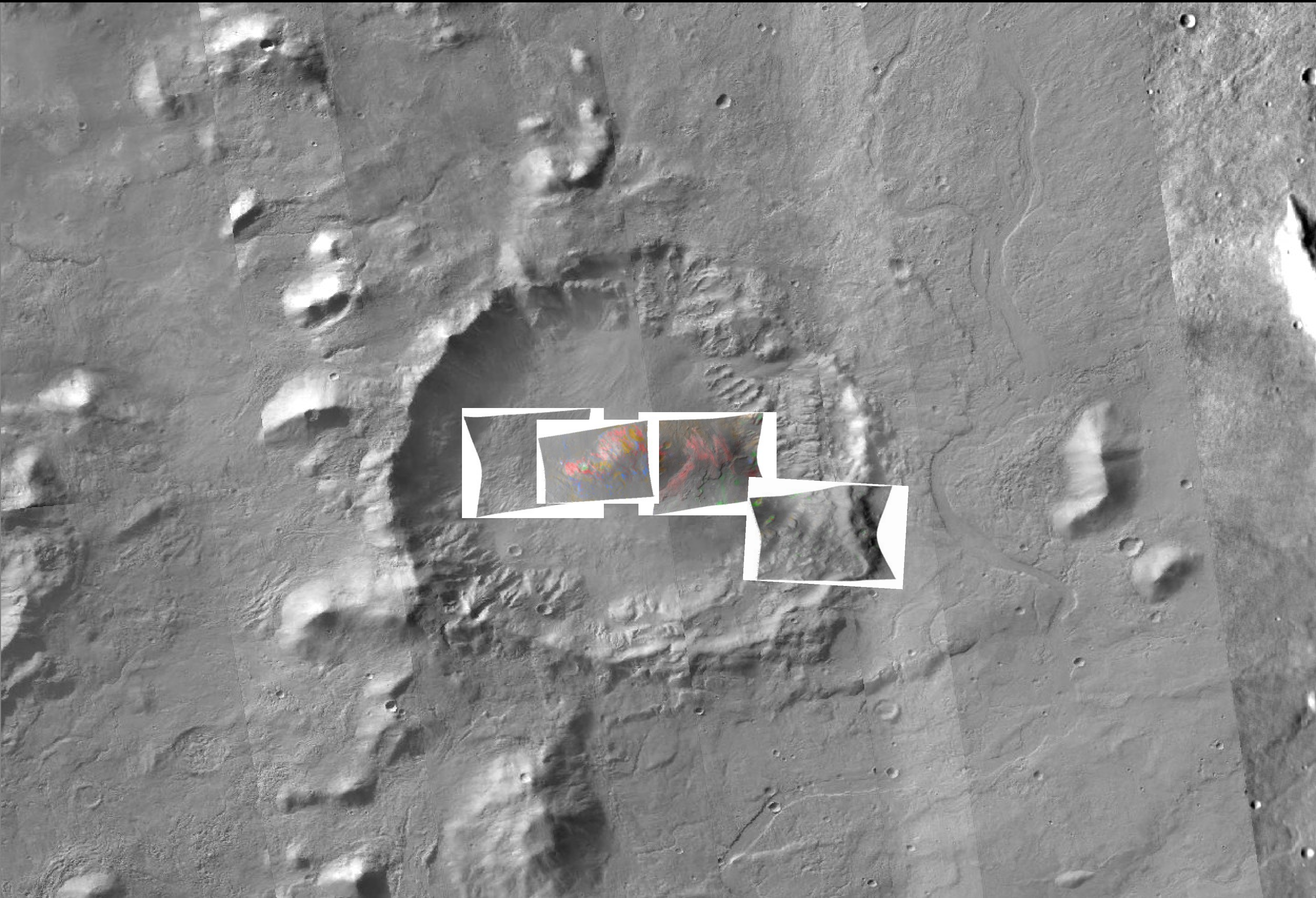
Alteration related to warm impact melt with ambient water (snow, ground ice?)

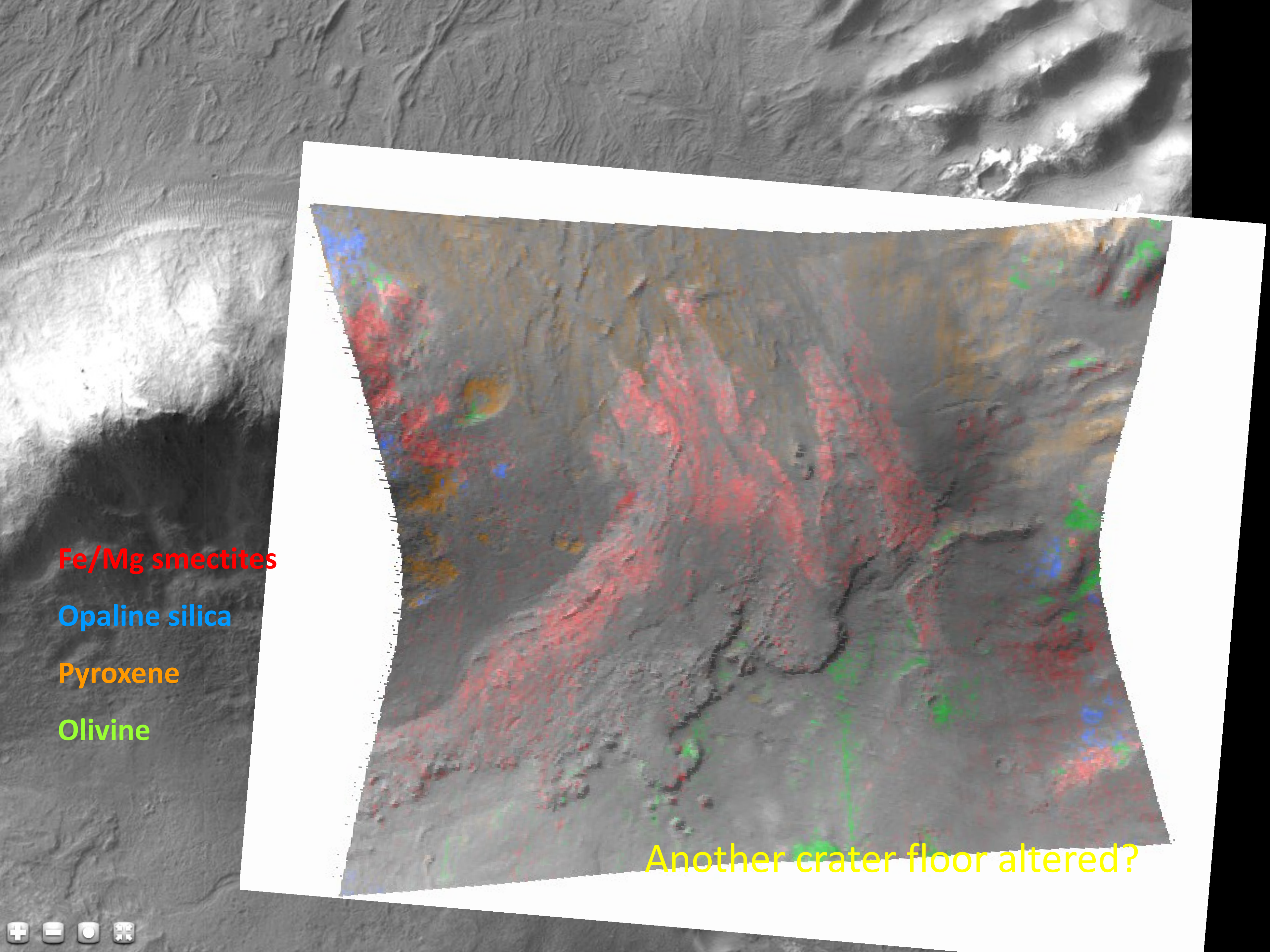


Pitted texture explained as devolatilization of impact melt (Boyce et al., 2011)

45 km diameter crater formed inside the Late Hesperian lava plains
Crater is Late Hesperian or younger

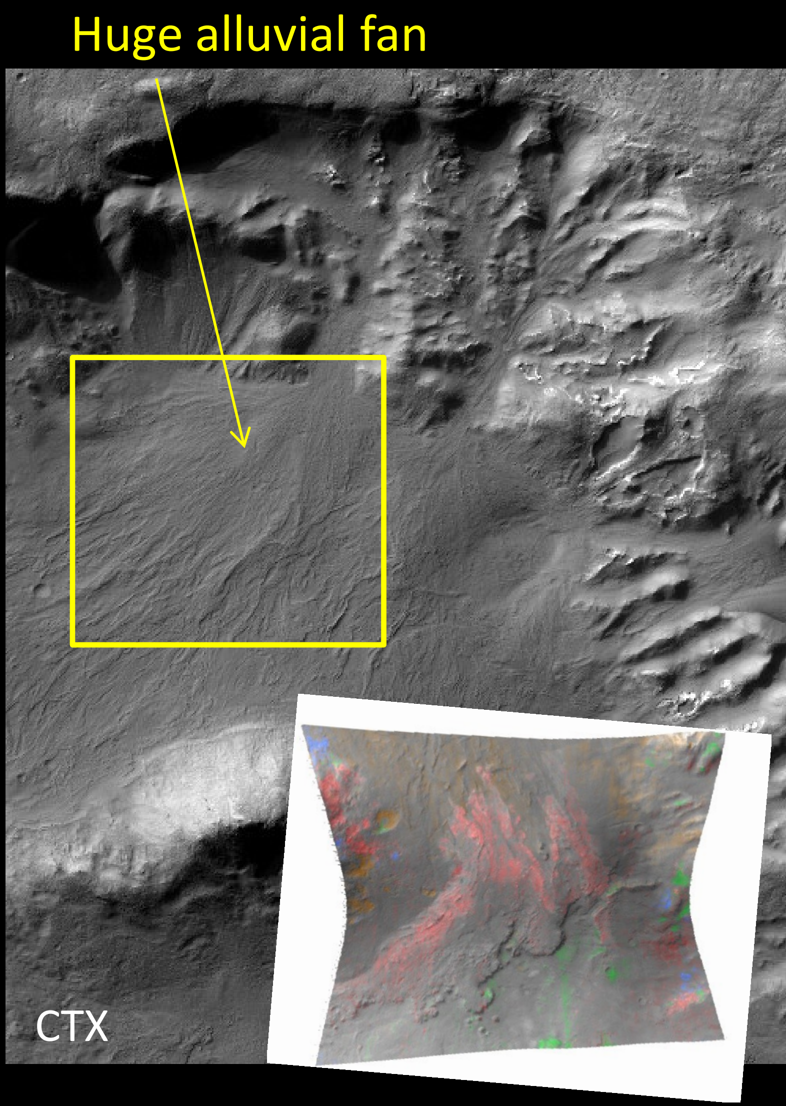
CTX mosaic with 4 CRISM cubes/Data processing by J. Carter

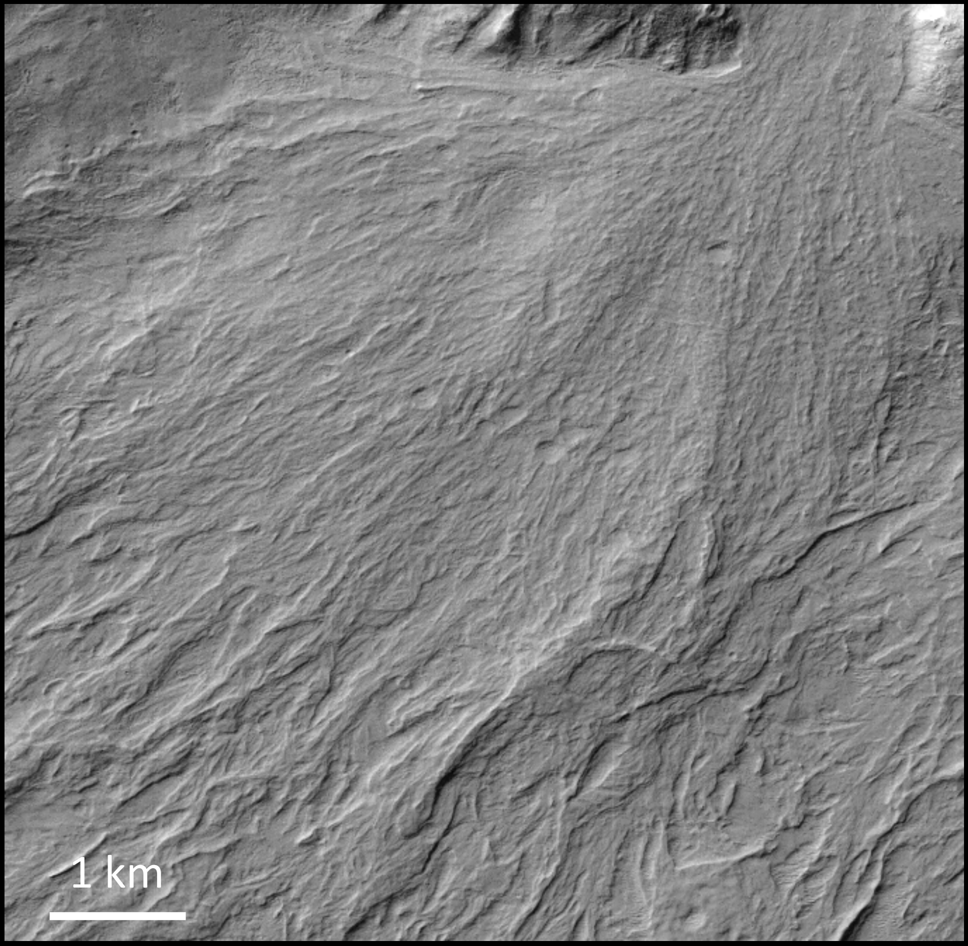




Fe/Mg smectites
Opaline silica
Pyroxene
Olivine
Another crater floor altered?

The altered material corresponds to the terminal part of a widespread alluvial fan

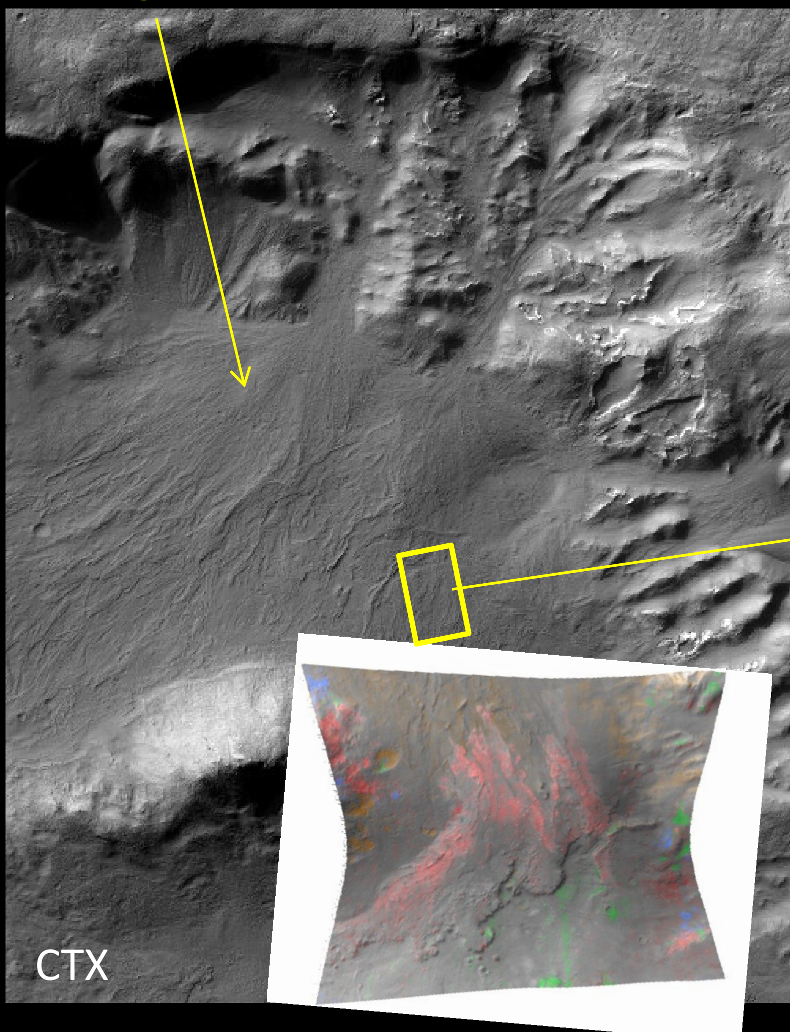


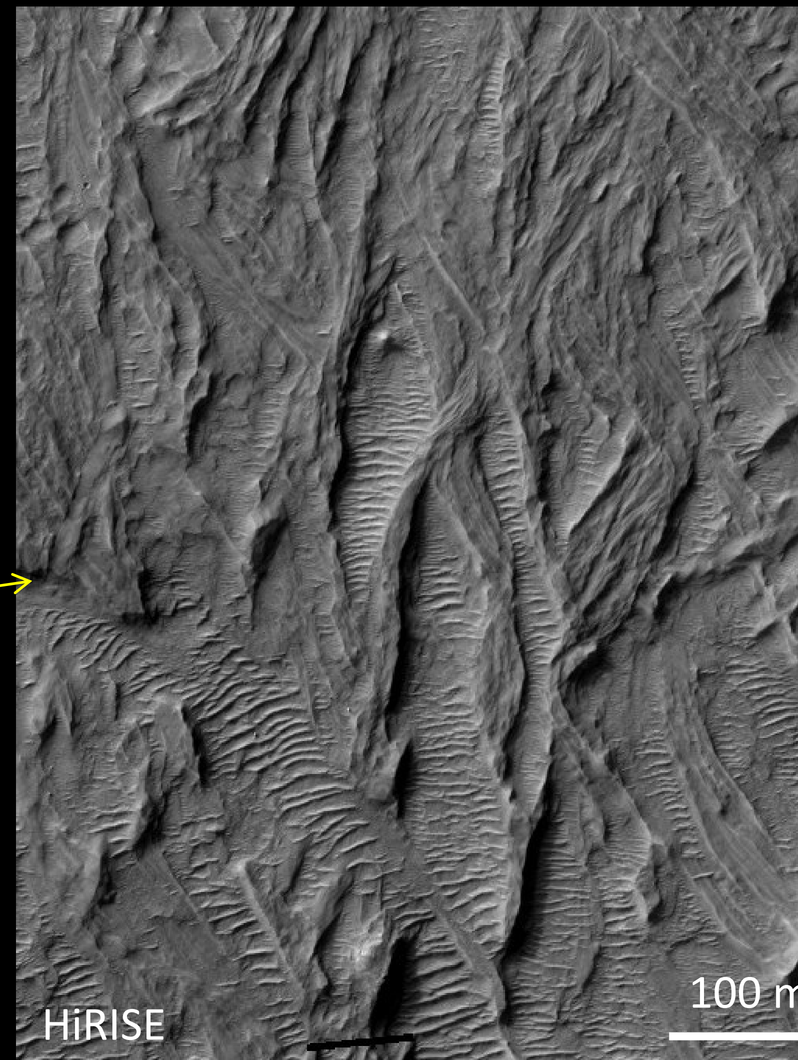


CTX close-up on alluvial fan

The altered material corresponds to the terminal part of a widespread alluvial fan

Huge alluvial fan

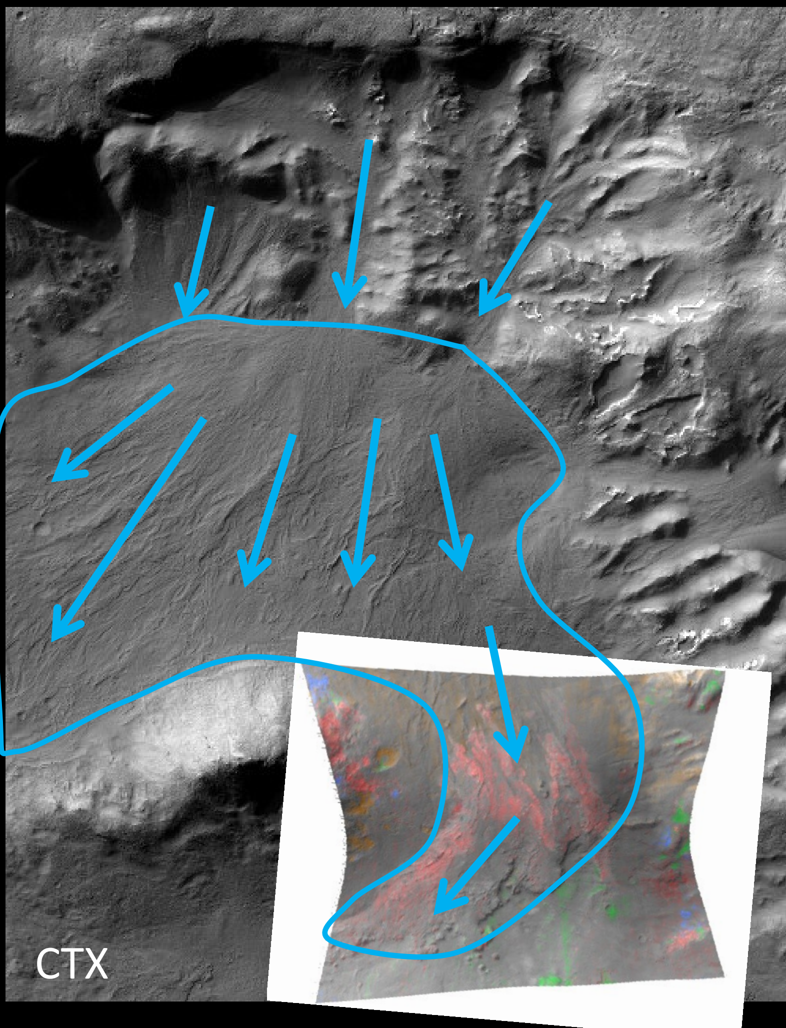


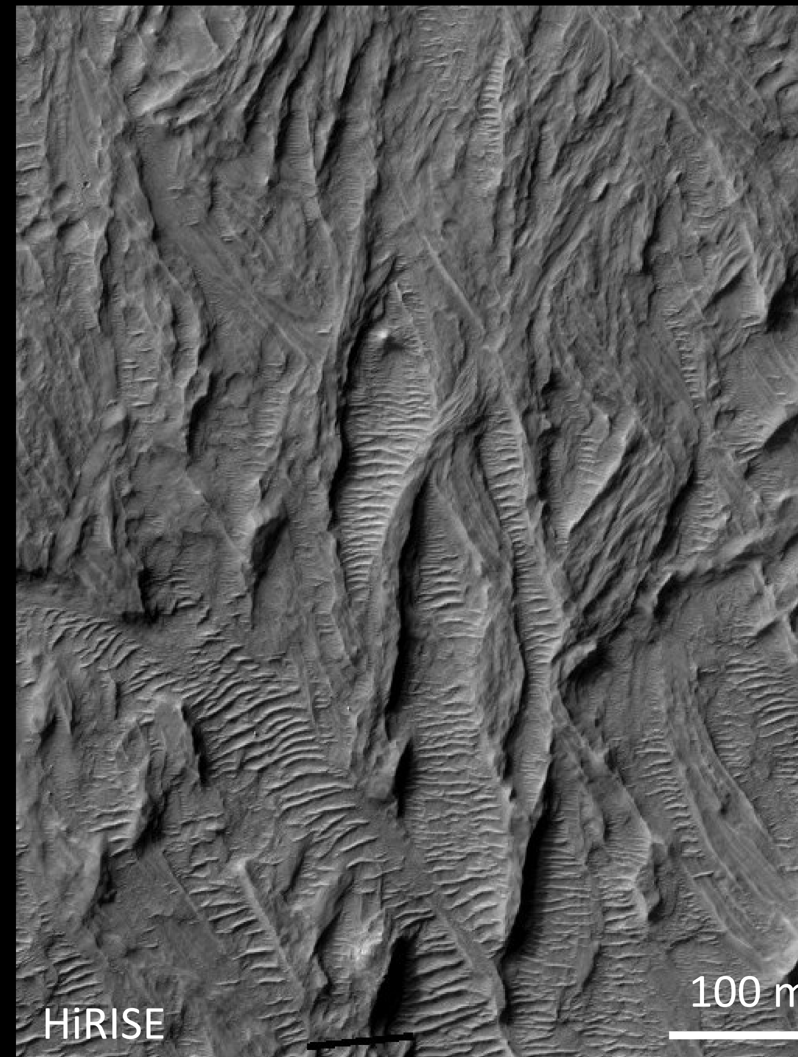


Inverted fluvial channels

The altered material corresponds to the terminal part of a widespread alluvial fan

Huge alluvial fan

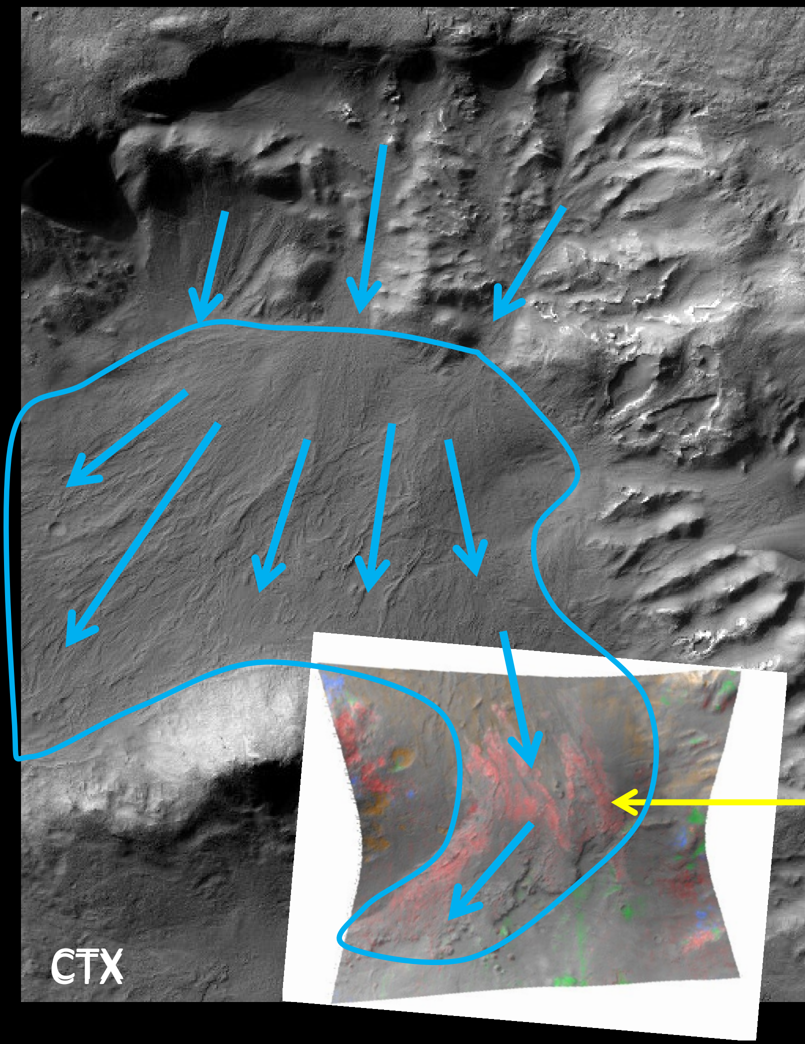




Inverted fluvial channels

The altered surface corresponds to a cemented section of the alluvial fan

Huge alluvial fan



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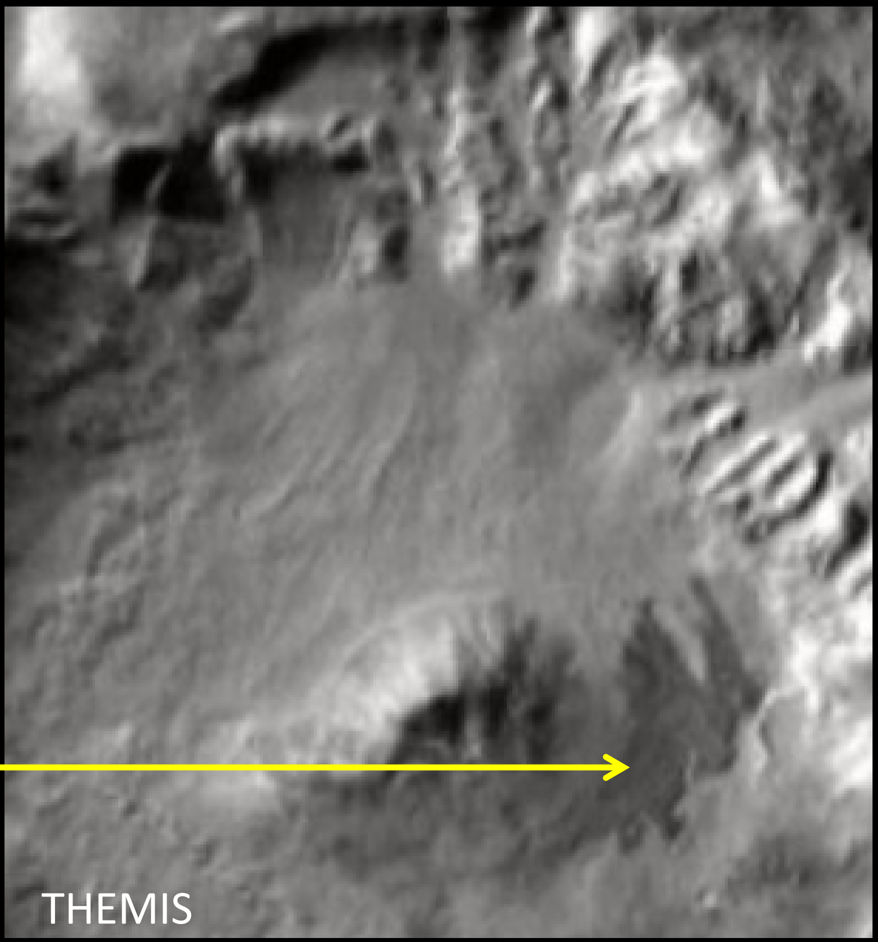
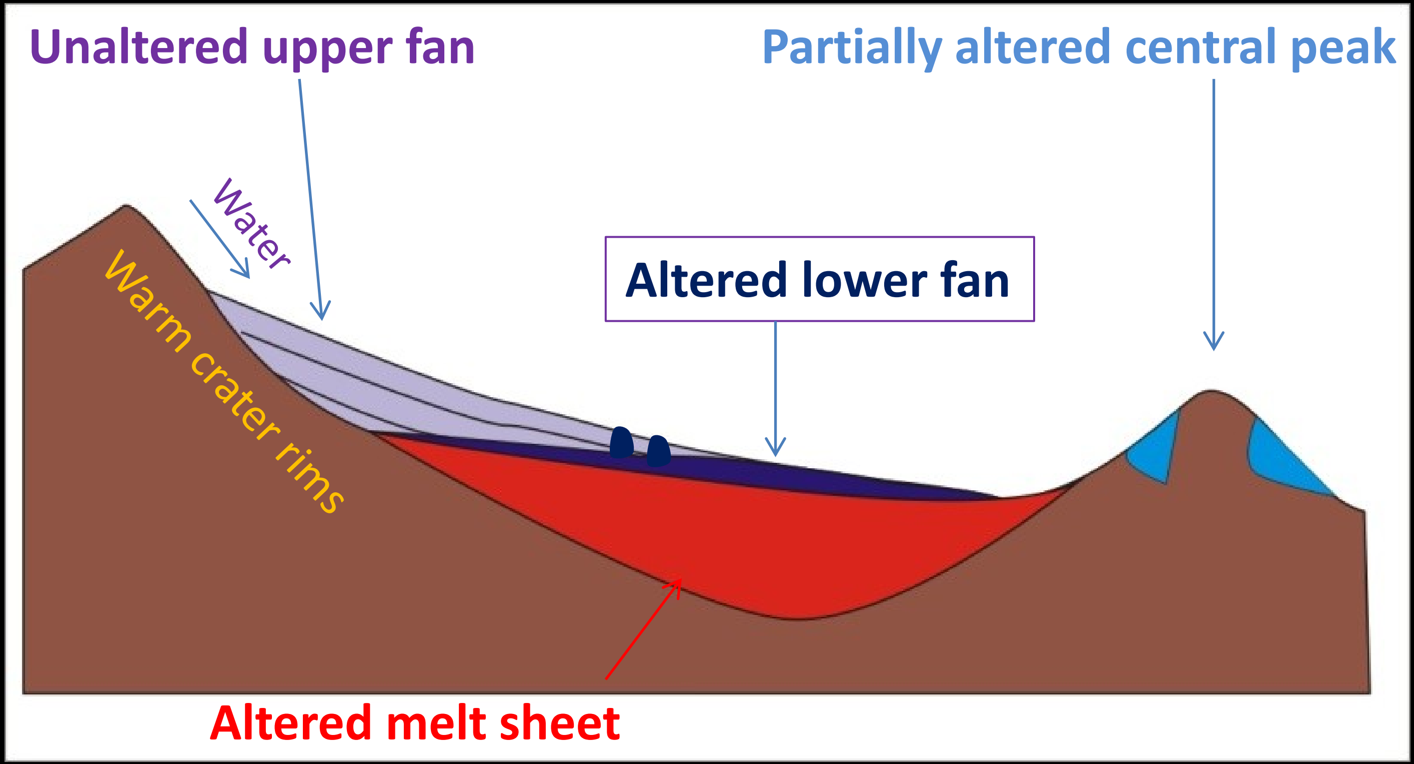


The base of the fan is cemented by bottom-up hydrothermal alteration
Alteration may be due to interaction of water with warm crater floor



Other explanations?
By weathering alteration would be top down, and not limited to a given level
By transport of clays from crater rims, hydrated minerals would have been mixed everywhere inside the fan

Conclusions:

Alteration as Fe/Mg smectites is observed on the floor of large craters >20 km (4 other examples identified)

Interaction between water, especially from snowmelt, and warm impact melts is able to explain this alteration

(Part of) alluvial fans formed in Late Hesperian/Early Amazonian craters may be related to snow melted by warm craters

Habitability:

Local oases for life may have existed in large craters well after early Mars classic period (Noachian)