Geologic Map of the Source Region of Shalbatana Vallis, Mars

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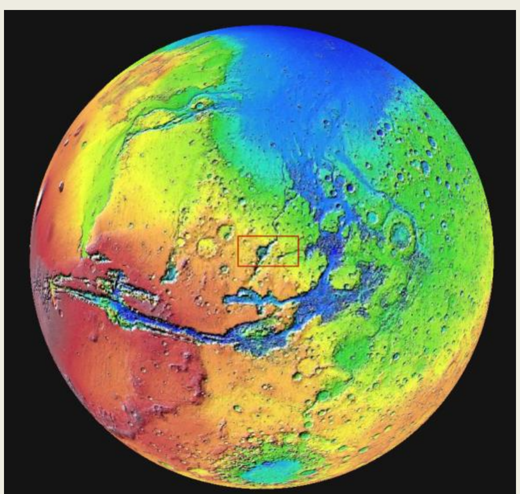
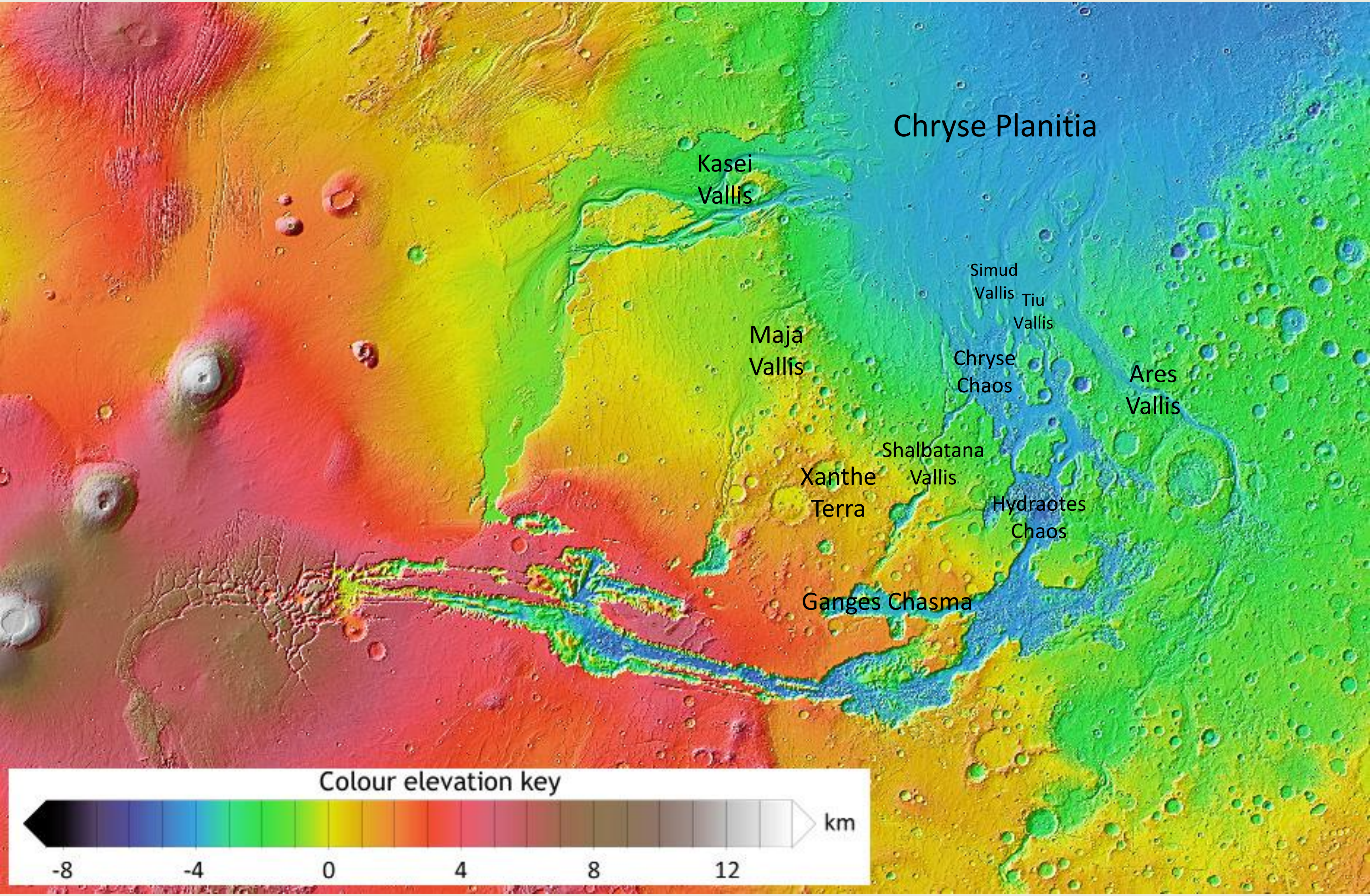


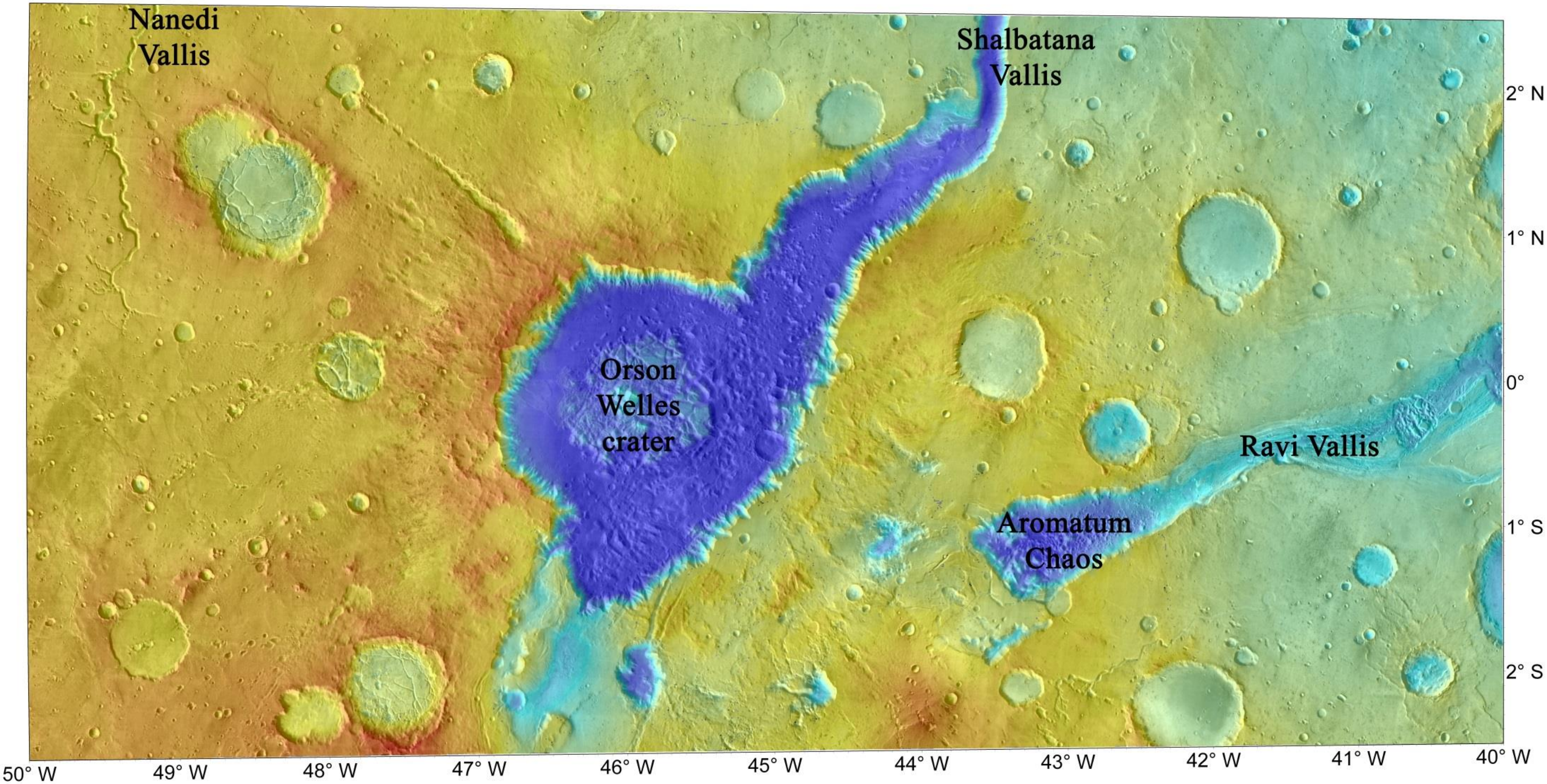
Introduction

- We are currently producing a 1:500,000-scale USGS geologic map of MTM quadrangles 00042 and 00047 in the Xanthe Terra region of Mars (2.5°S - 2.5°N, 310° - 320°E). The map region has been extensively modified by outflow channels and chaotic terrains and contains cratered plains deformed by subsidence. Mapping is being conducted on a THEMIS IR daytime base mosaic, with CTX and HiRISE images as supplements where available.

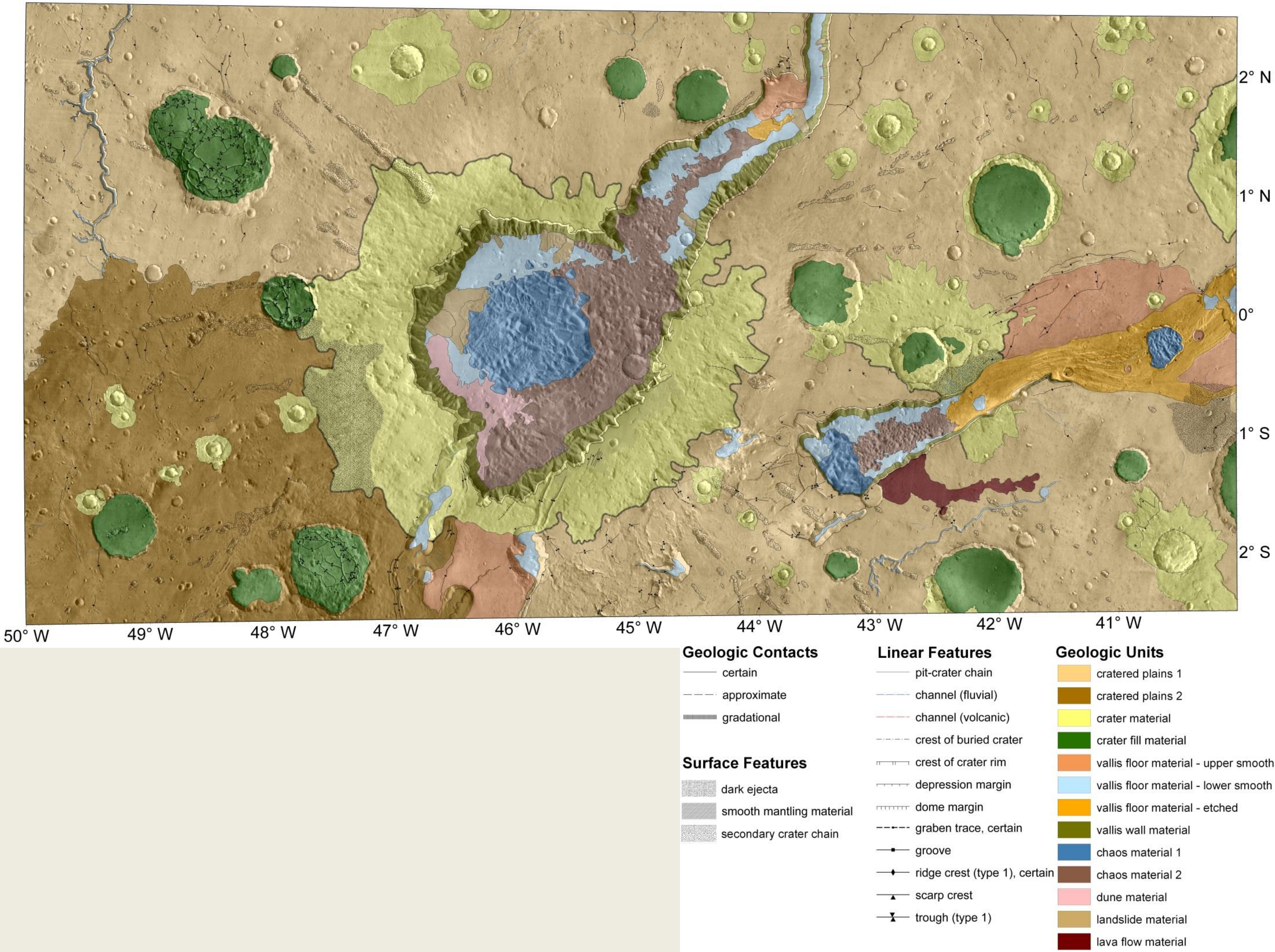
- The overarching goal of this project is to develop an understanding of how regionally integrated hydrologic systems have been affected by (1) impact crater formation, (2) melting of subsurface ice leading to the generation of subsurface cavity space and then subsidence, and (3) erosional and depositional flooding events of various types and ages.



Chryse Planitia
Kasei Vallis
Simud Vallis
Tiu Vallis
Maja Vallis
Chryse Chaos
Ares Vallis
Shalbatana Vallis
Xanthe Terra
Hydraotes Chaos
Ganges Chasma
Colour elevation key
km
-8
-4
0
4
8
12



Nanedi
Vallis
Shalbatana
Vallis
Orson
Welles
crater
Ravi Vallis
Aromatum
Chaos
2° N
1° N
0°
1° S
2° S
50° W
49° W
48° W
47° W
46° W
45° W
44° W
43° W
42° W
41° W
40° W



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1° N
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1° S
2° S
50° W
49° W
48° W
47° W
46° W
45° W
44° W
43° W
42° W
41° W
Geologic Contacts
certain
approximate
gradational
Surface Features
dark ejecta
smooth mantling material
secondary crater chain
Linear Features
pit-crater chain
channel (fluvial)
channel (volcanic)
crest of buried crater
crest of crater rim
depression margin
dome margin
graben trace, certain
groove
ridge crest (type 1), certain
scarp crest
trough (type 1)
Geologic Units
cratered plains 1
cratered plains 2
crater material
crater fill material
vallis floor material - upper smooth
vallis floor material - lower smooth
vallis floor material - etched
vallis wall material
chaos material 1
chaos material 2
dune material
landslide material
lava flow material

Description of Map Units

Plains Units

- cratered plains 1 – smooth to mottled, heavily cratered plains marked by secondary chains, wrinkle ridges, and zones of incipient collapse. Ejecta of many large craters entirely or partly eroded
- cratered plains 2 – similar to cratered plains 1, with dark signature in THEMIS day IR (bright in night IR) and some knobs

Crater Units

- crater material – crater ejecta, rim, and floor materials
- crater fill material – smooth or fractured fill materials, may be same material as chaos

Chaos units

- chaos material 1 – higher elevation, larger, often flat-topped blocks
- chaos material 2 – knobby blocks

Vallis Units

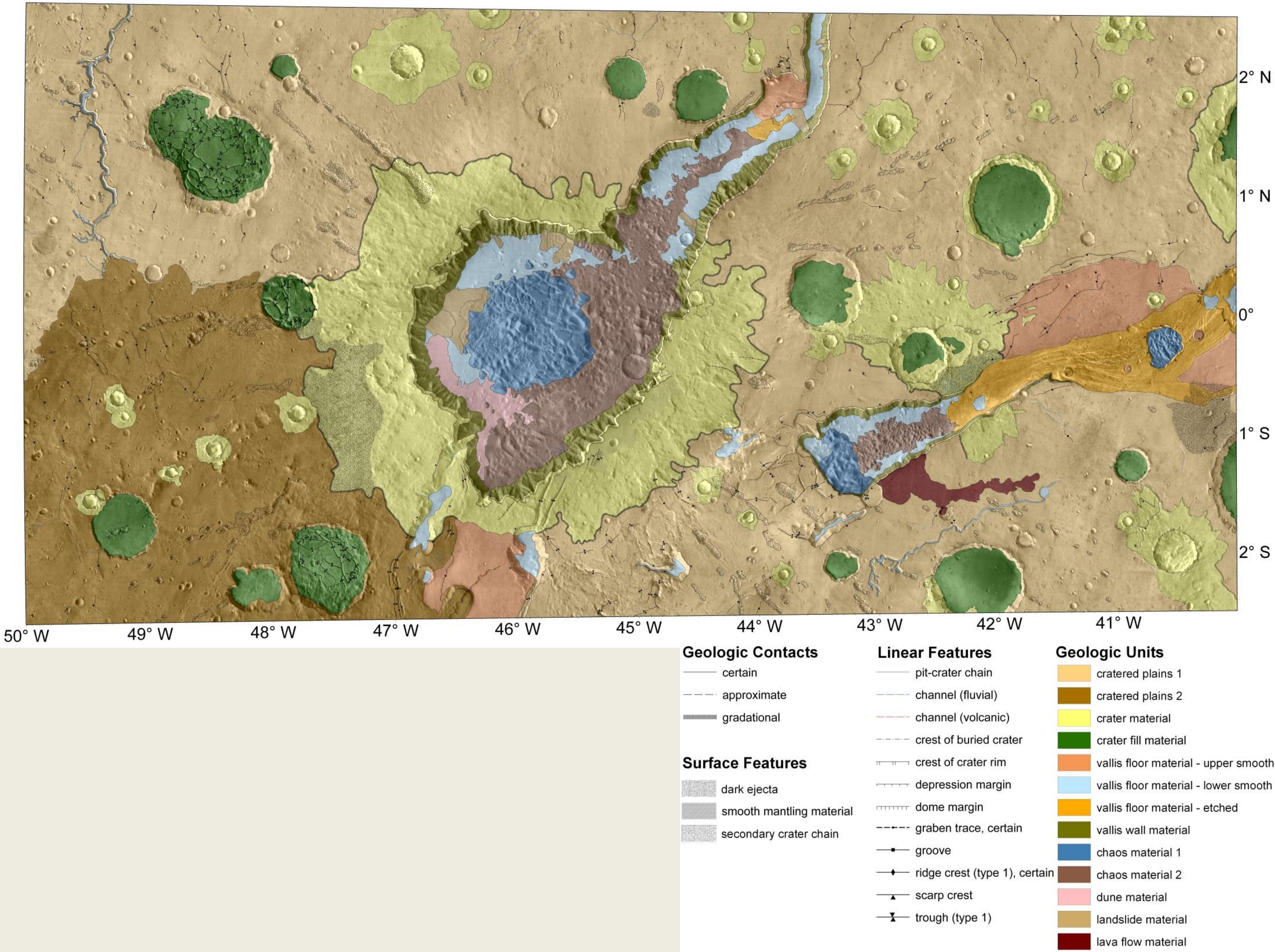
- vallis floor material - upper smooth
- vallis floor material - lower smooth
- vallis floor material - etched – Ravi Vallis lower floor
- vallis wall material – bedrock exposures, talus

Other

- dune material – on floor of Orson Welles crater
- landslide material – along vallis walls, fluidized lobes
- lava flow material – extending from Aromatum Chaos

Geologic History - Orson Welles crater and Shalbatana Vallis

- The impact that formed Orson Welles crater may have penetrated an aquifer or subsurface ice lens leading to initial outflow and incision of Shalbatana Vallis.
- Following impact, the plains unit was resurfaced with weakly consolidated (potentially ice-rich) materials; Orson Welles and other large craters in the map region were infilled and their ejecta and rims partially to completely removed.
- Melting of subsurface ice (perhaps by magmatic intrusion) led to the collapse of the infill material, resulting in chaos material 1.
- The remaining infill material was swept away during resulting catastrophic flooding and outflow, incising Shalbatana Vallis, and leaving behind chaos material 2 and smooth floor material.
- Subsequent collapse and retreat of the crater walls led to talus deposits on the walls and landslides. Some of the blocks on the floor of chaos material 2 may also be from wall collapse and retreat.



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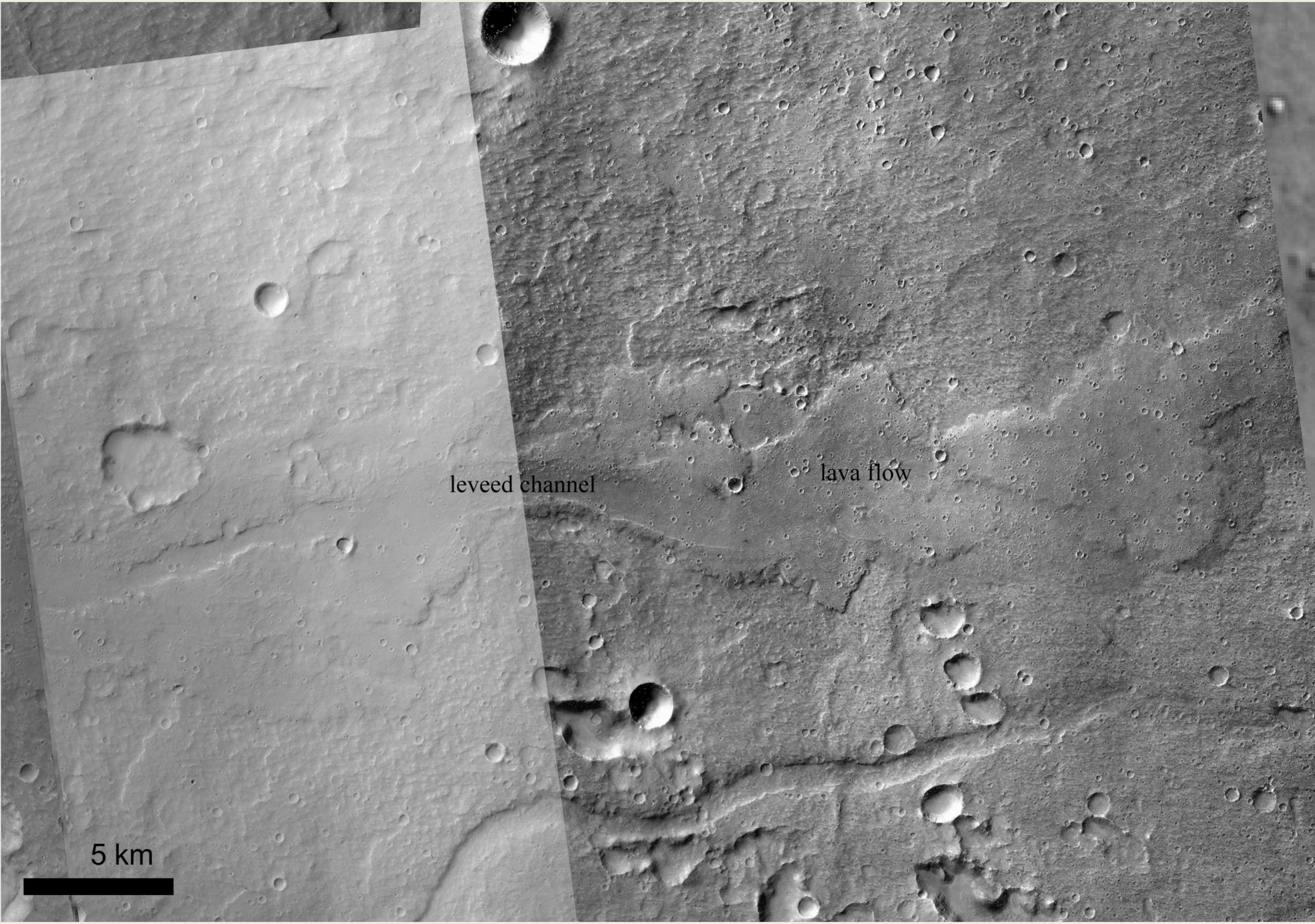
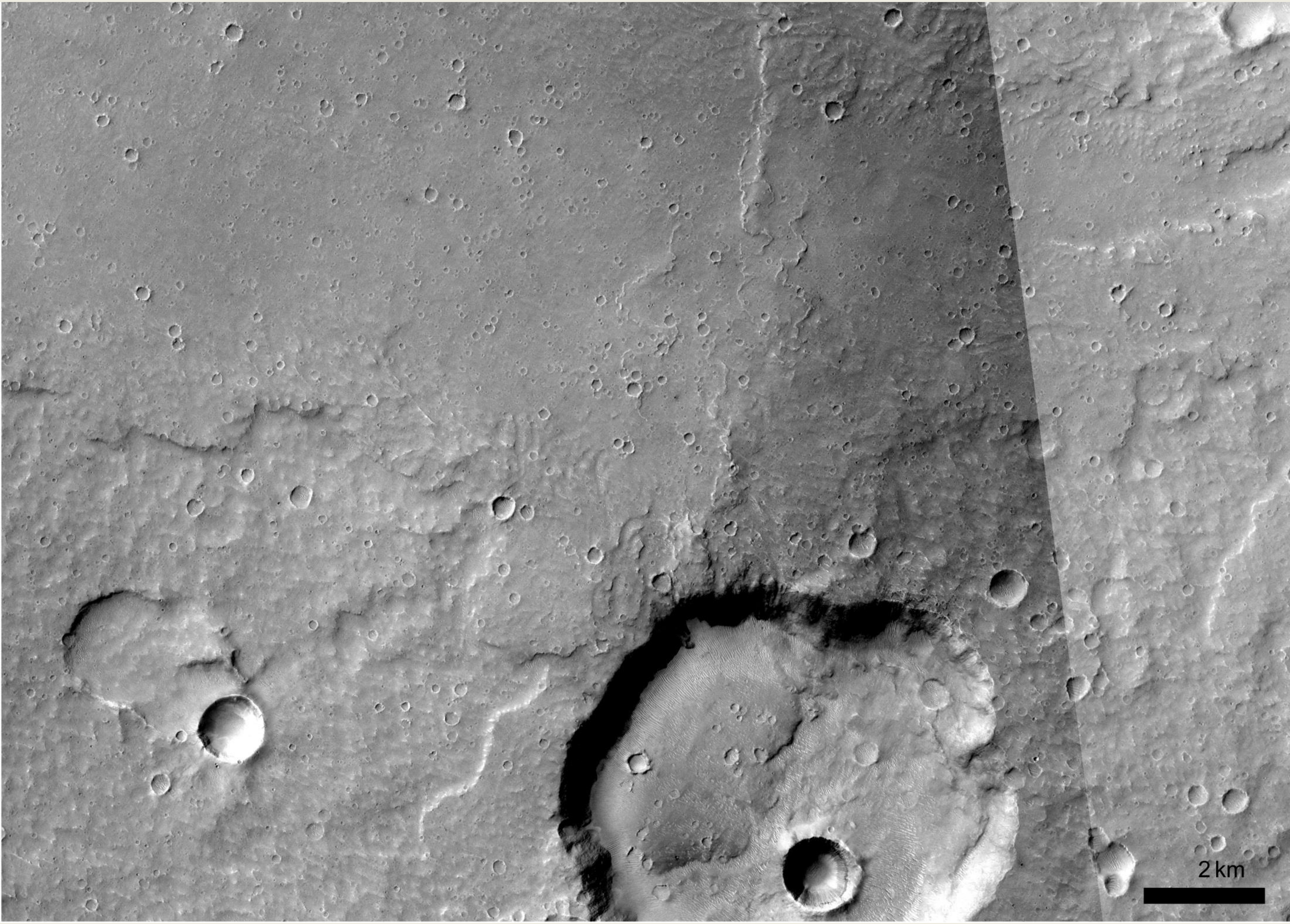
Geologic History - Aromatum Chaos

- Our mapping shows that Aromatum Chaos is unique in that it forms the source area of both a lava flow and an outflow channel (Ravi Vallis). The lava flow likely erupted from a fissure parallel to the southern margin of the chaotic terrain that was subsequently destroyed during ongoing collapse and retreat of the canyon wall.


leveed channel
lava flow
5 km


2 km

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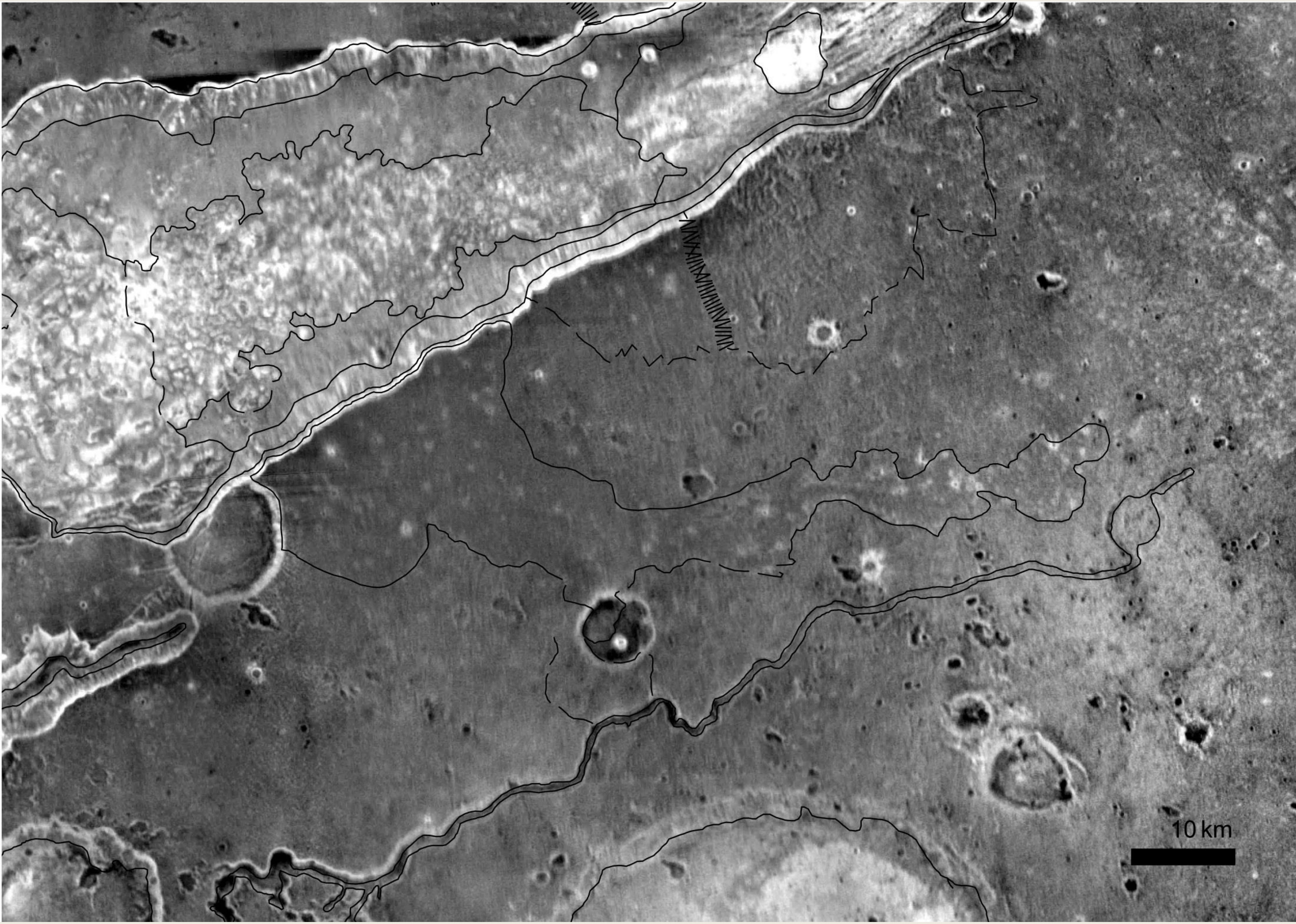
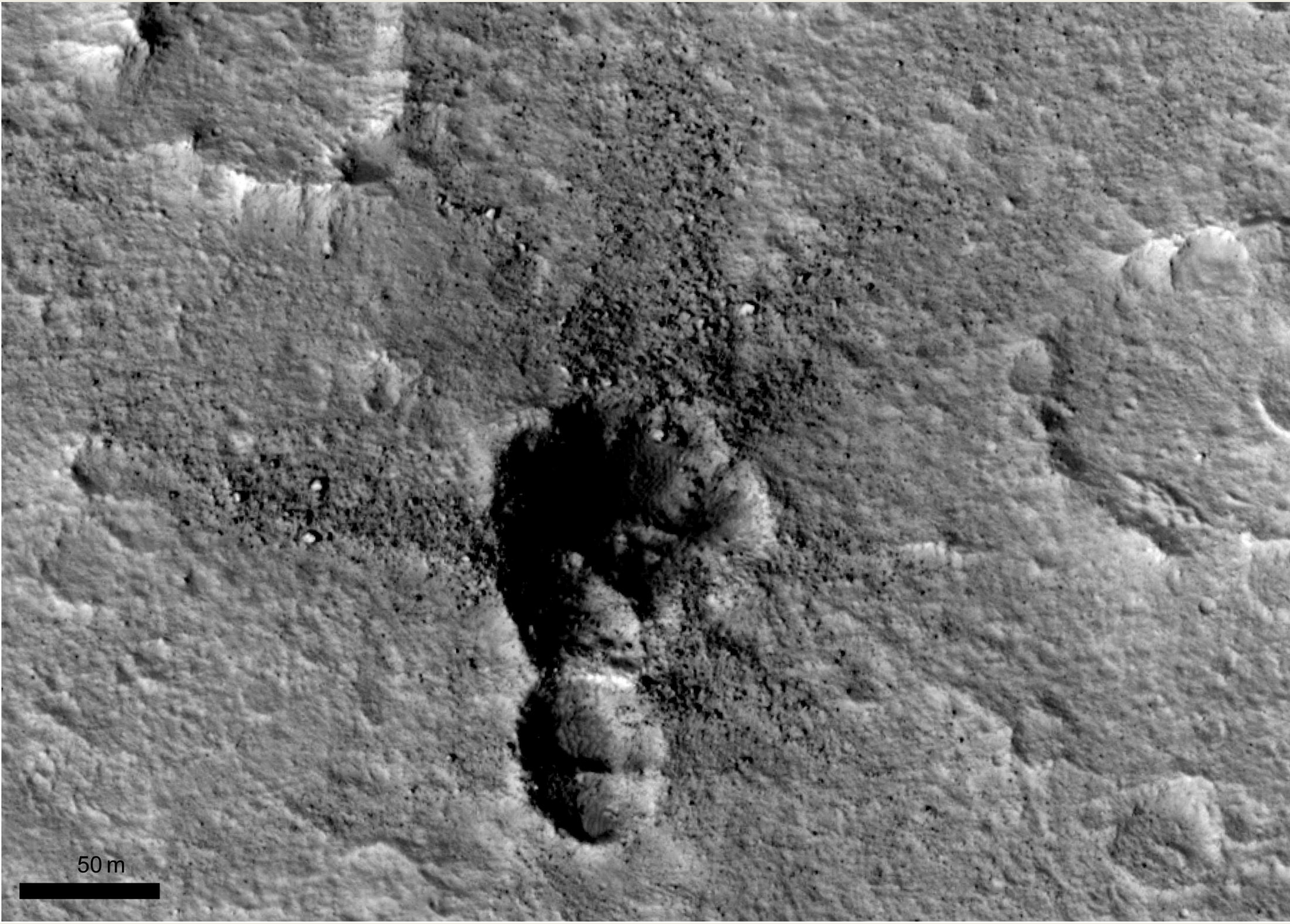
- Craters impacted into the lava flow exhibit high thermal inertia ejecta blankets with large boulder deposits.


10 km


50 m

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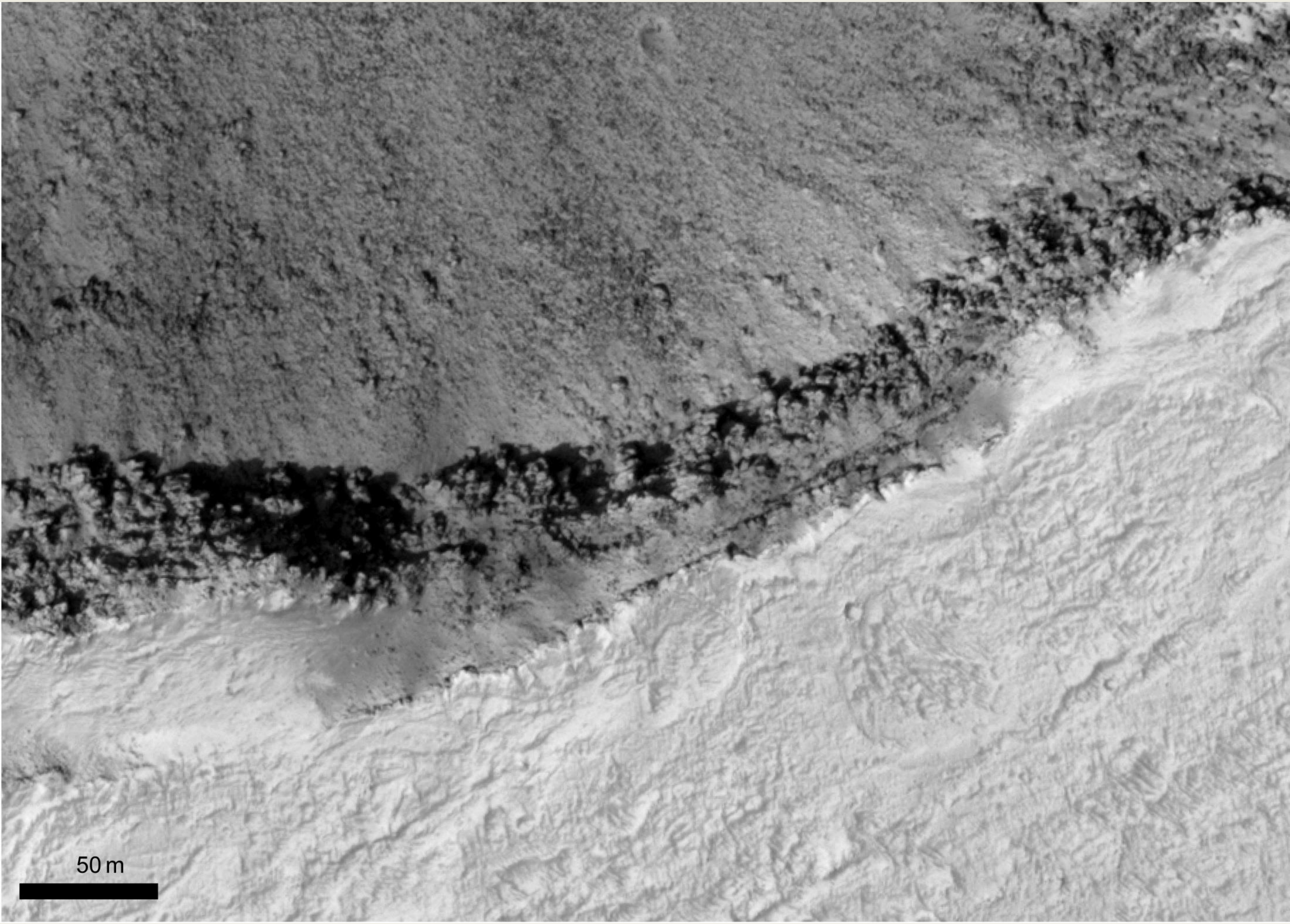
- Craters impacted into the lava flow exhibit high thermal inertia ejecta blankets with large boulder deposits.
- Close examination of the southern wall of Aromatum Chaos in HiRISE images reveals evidence for a sequence of possible buried lava flows that form low-albedo bouldery outcrops.


50 m

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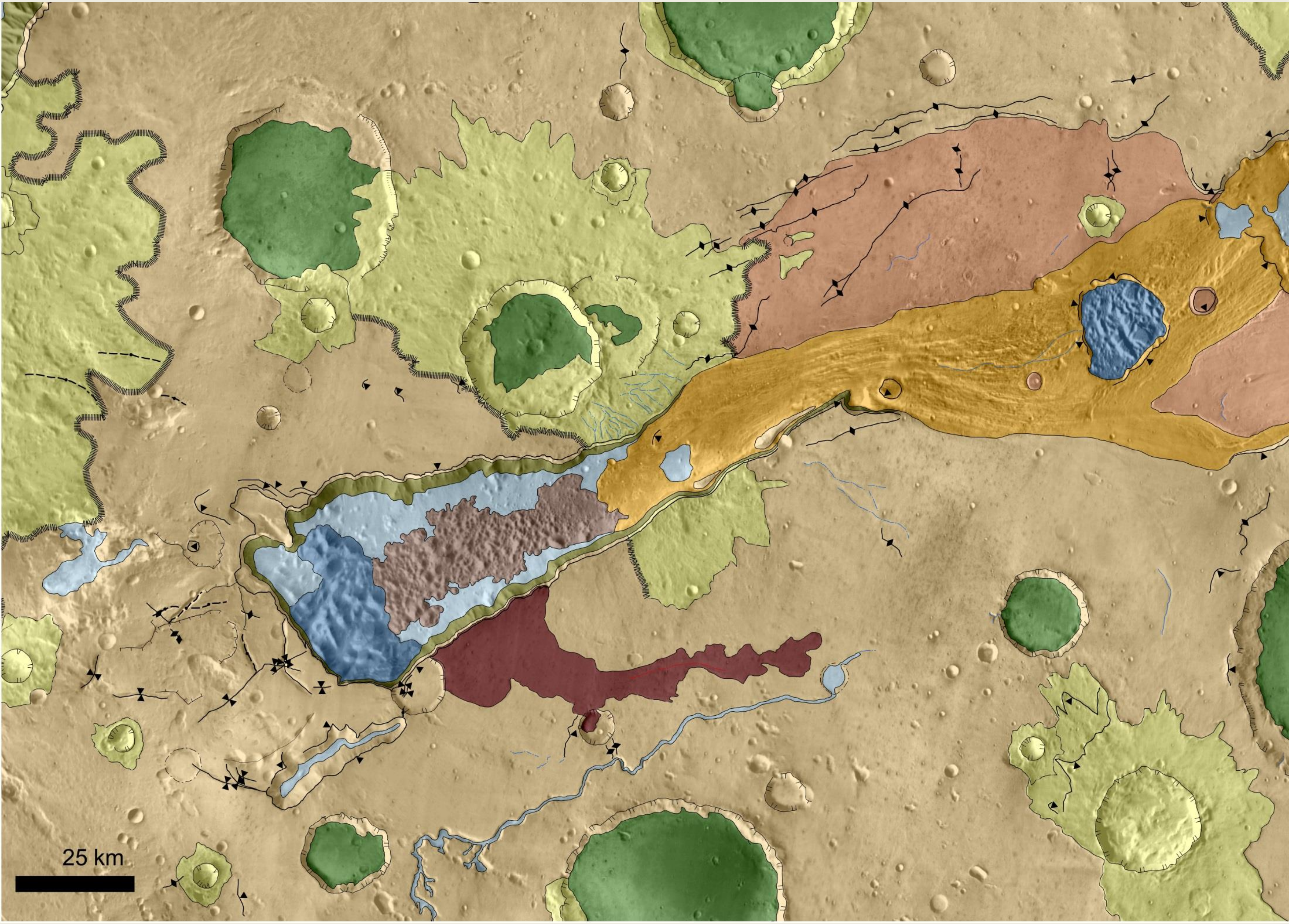
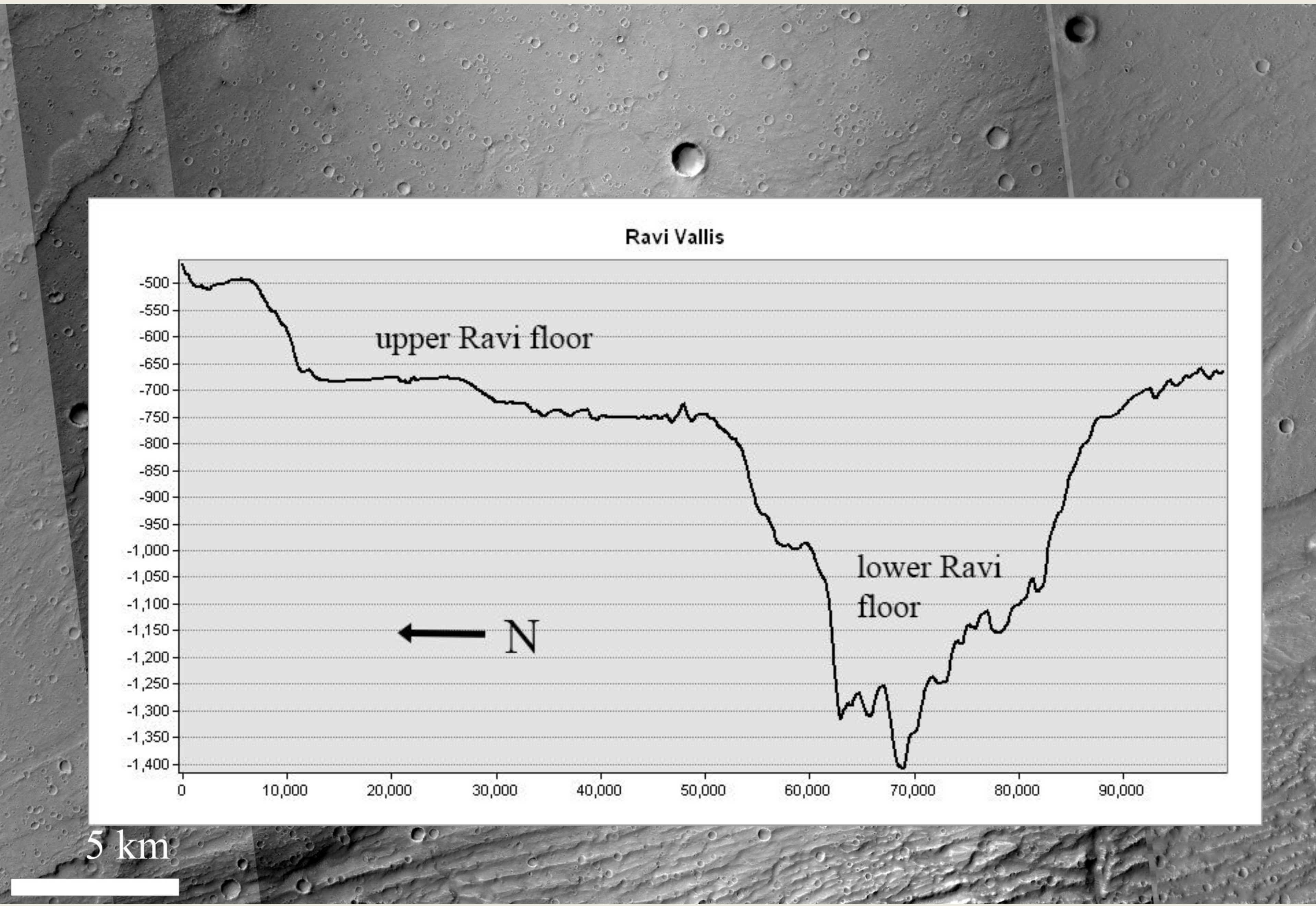
- Close examination of the southern wall of Aromatum Chaos in HiRISE images reveals evidence for a sequence of possible buried lava flows that form low-albedo bouldery outcrops.
- Episodic volcanic activity in the region could have provided high geothermal conditions conducive to groundwater outburst leading to catastrophic flooding.

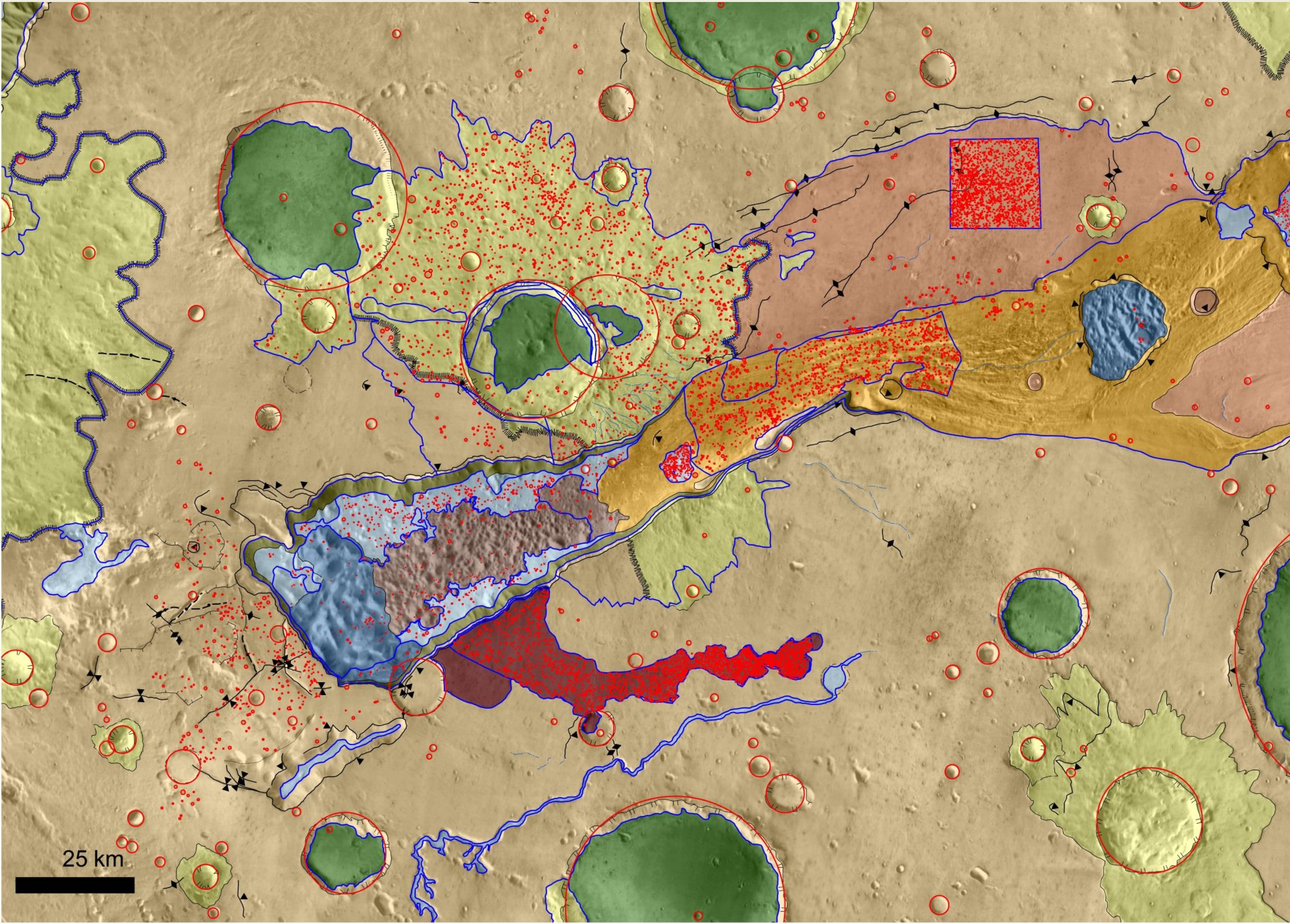
Geologic History - Ravi Vallis

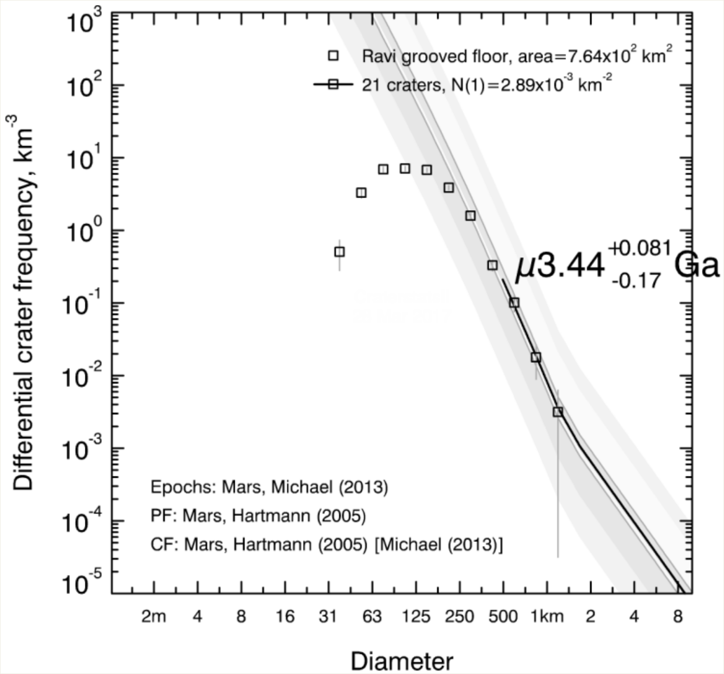
- Flooding in Ravi Vallis inundated plains surfaces above the margins of its grooved floor, where the floods deposited widespread smooth deposits, locally marked by small-scale streamlined landforms.
- These smooth floors flank the lower scoured sections and their origin might be related to earlier floods that were not topographically constrained within a channel and thus spread (and thinned out) over the intercrater plains, thereby rapidly losing velocity.
- This scenario indicates a possible transition from non-catastrophic floods (depositional) to catastrophic (erosional) floods.


25 km

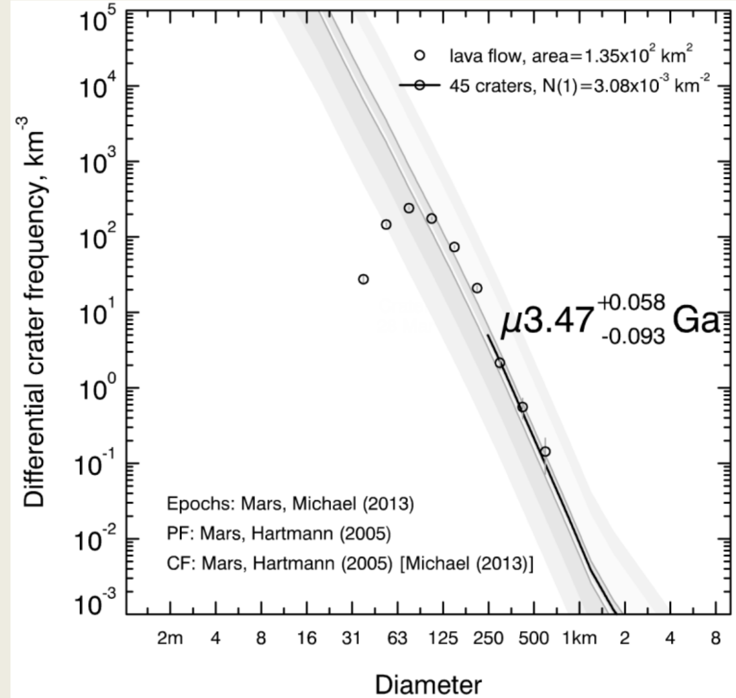

Ravi Vallis
-500
-550
-600
-650
-700
-750
-800
-850
-900
-950
-1,000
-1,050
-1,100
-1,150
-1,200
-1,250
-1,300
-1,350
-1,400
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
upper Ravi floor
lower Ravi floor
N
5 km

Crater Counts

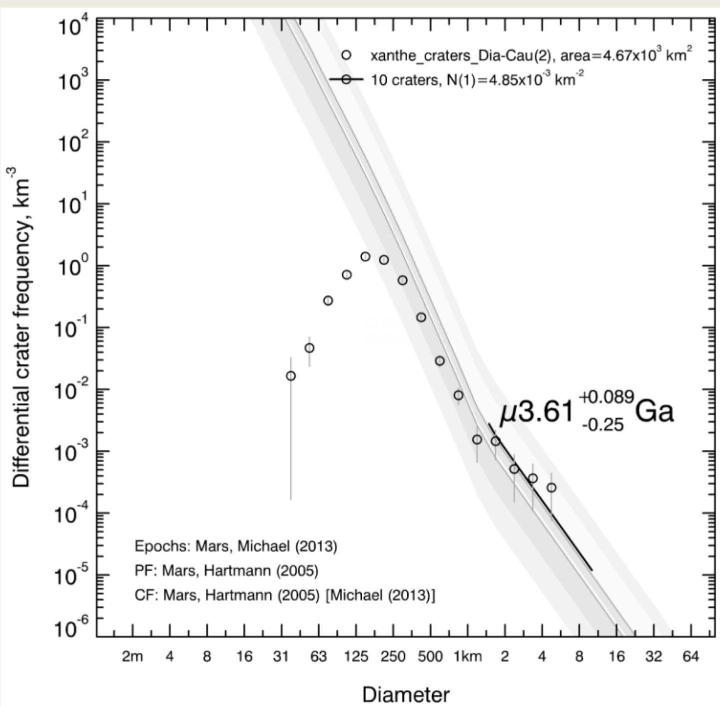




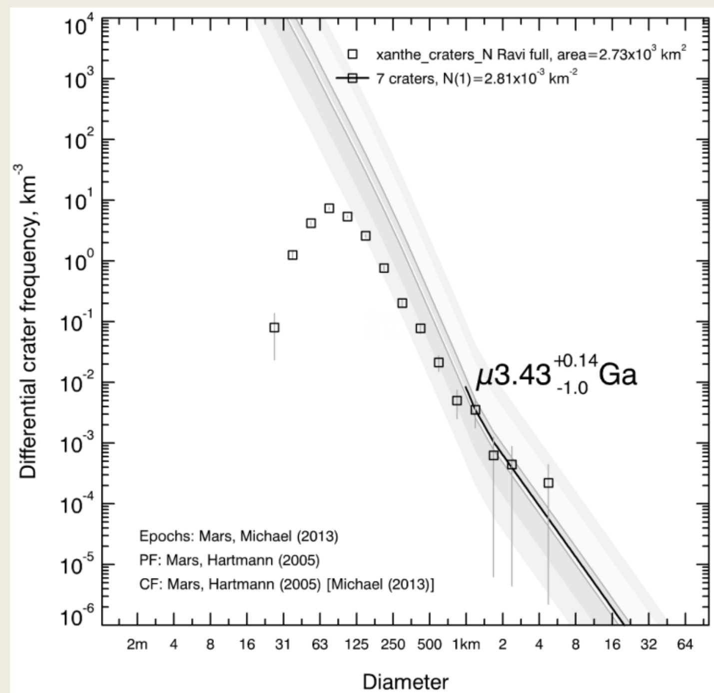
Lower Ravi floor– Early Hesperian



Lava flow– Early Hesperian



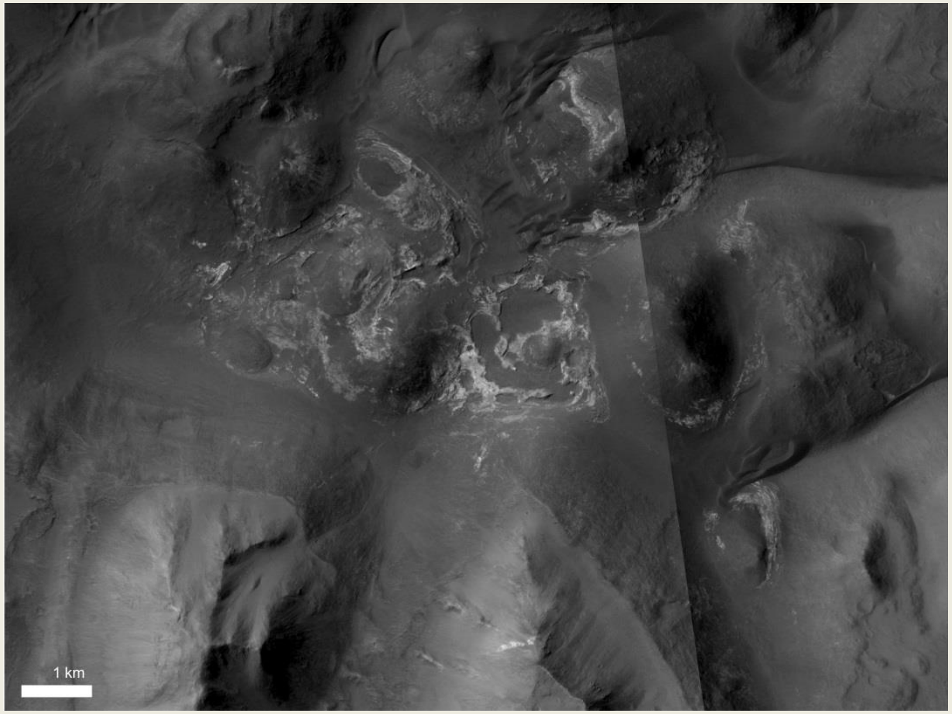
Dia Cau crater– Late Noachian

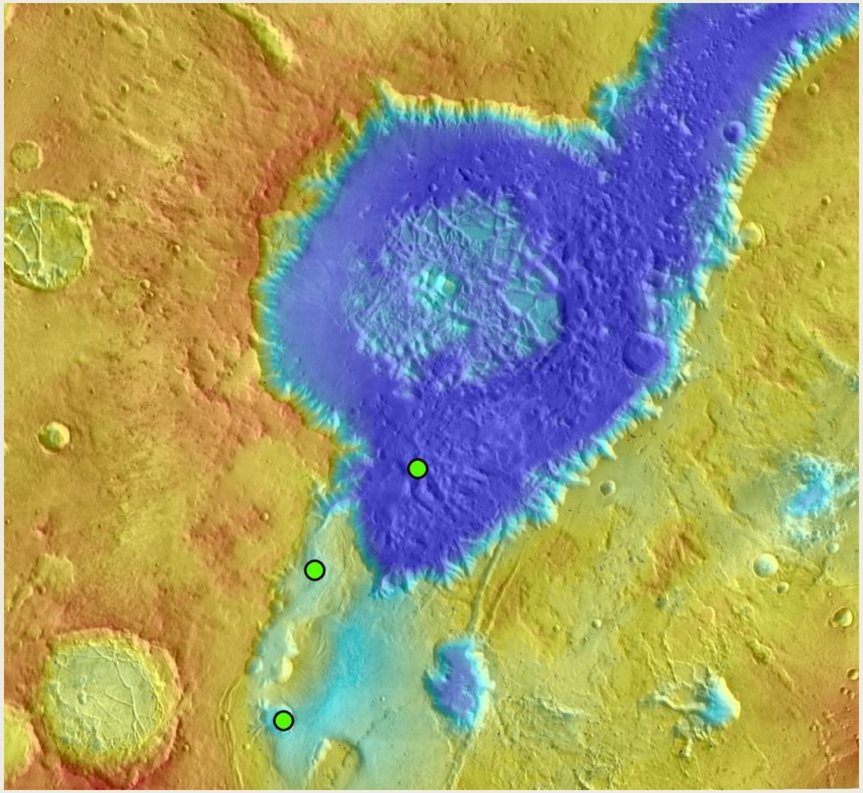


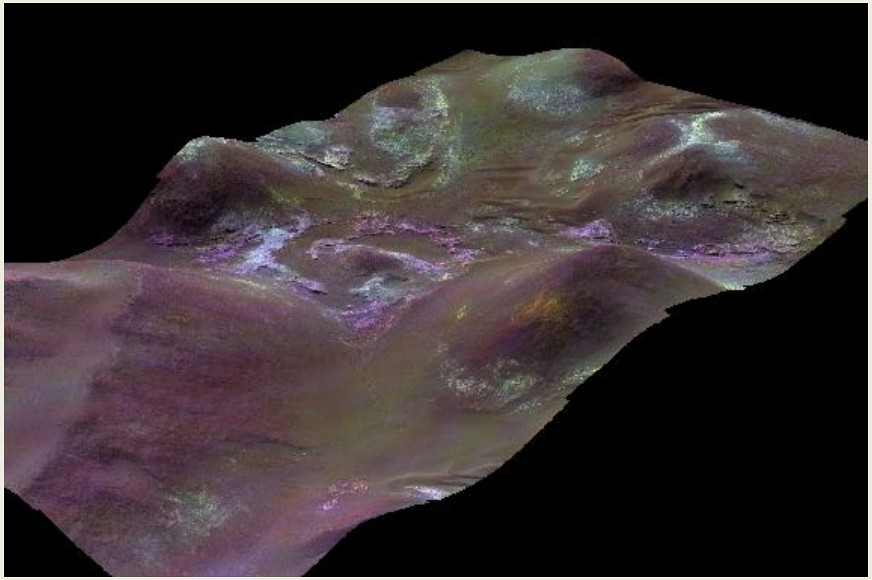
Ravi upper floor – Early Hesperian

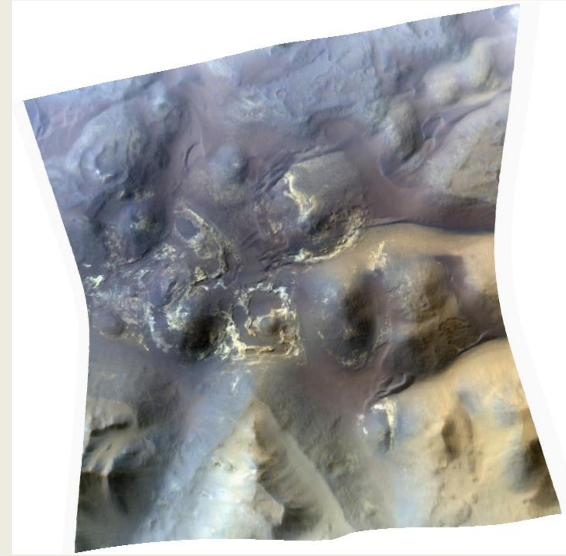
Light-toned deposits

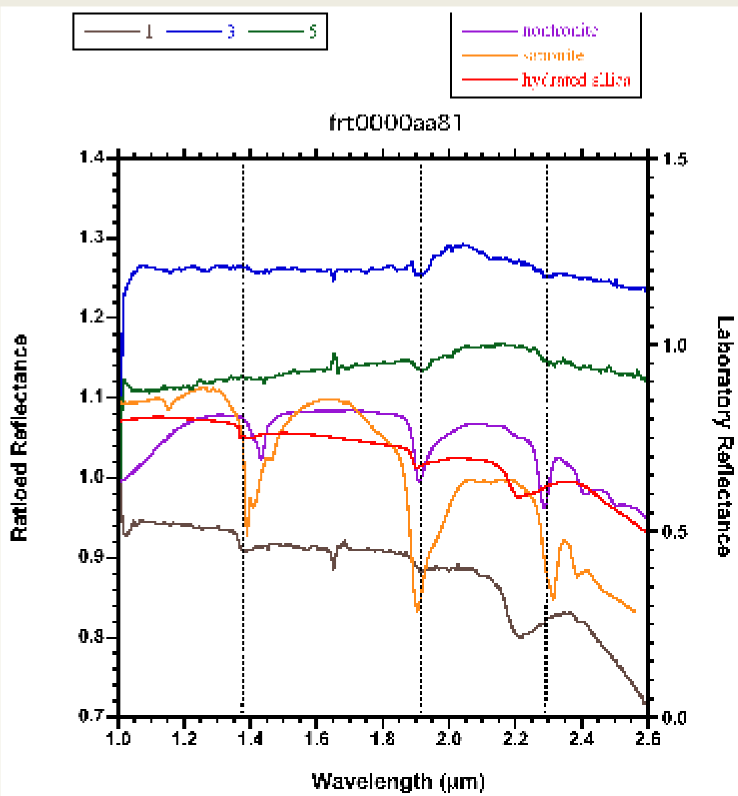
Light-toned deposits are observed in several locations on the floors of subsided terrain (smooth floor material and chaos material 2) and craters. CRISM analyses of these deposits show evidence for Fe/Mg-smectites. In addition, light-toned Fe/Mg-smectite deposits are observed along the upper wall of one of the craters, indicating the deposits predate the impact. These results are consistent with the melting of subsurface ice lenses, with water interacting with and altering subsurface layers to form smectites, which are later exposed due to either impact crater formation or subsidence and collapse.



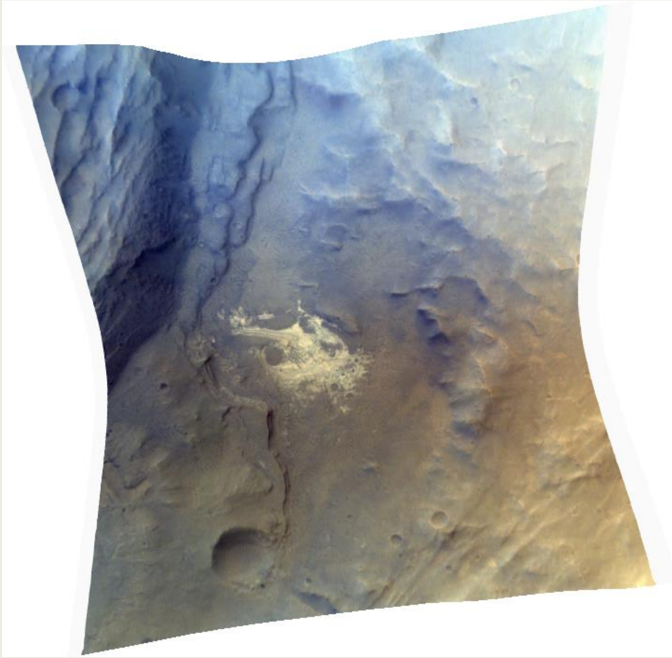


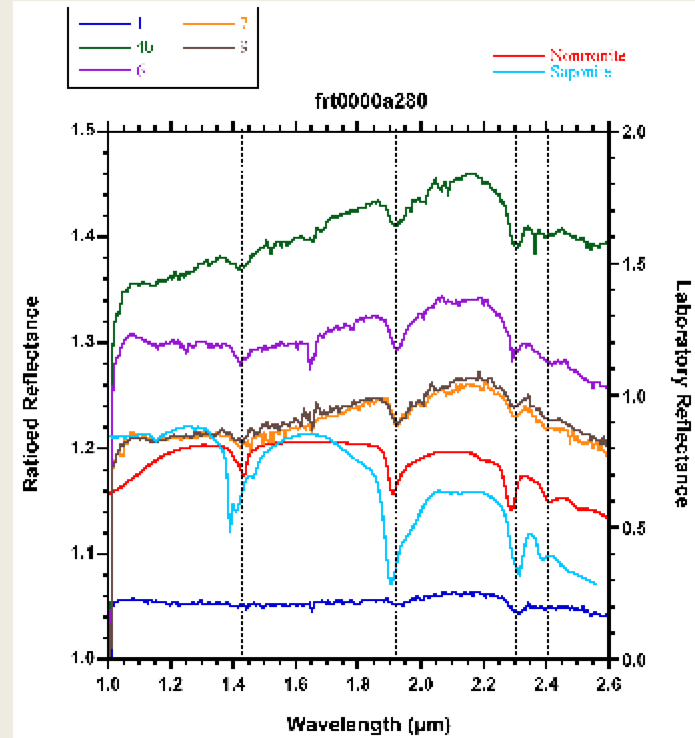




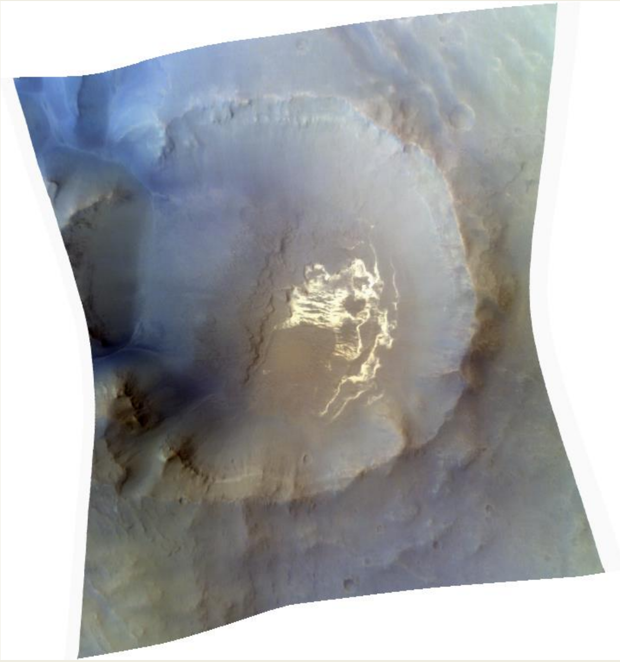


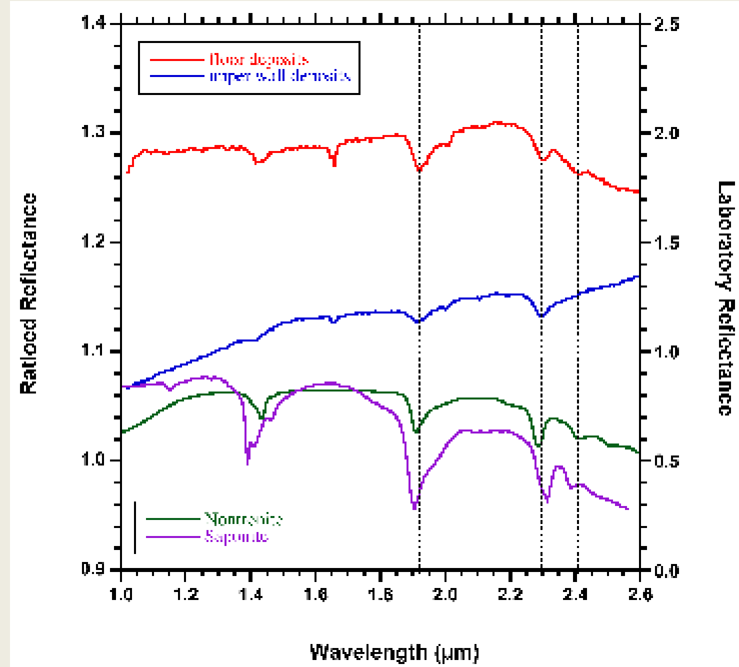
(Top Left) Perspective view showing a merge of CRISM color from image FRT0000aa81 to a Digital Terrain Model of HiRISE images PSP_008391_1790 and ESP_028566_1790 showing the chaos material 2 within Orson Welles crater. The color represents CRISM spectral parameters that have been merged to the DTM. (Bottom Left) CRISM spectra extracted from the light-toned layered deposits. **The deposits contain Fe/Mg-smectites (blue and green spectra). In contrast, light-toned material within the chaos hills have spectra indicating the presence of hydrated silica (brown spectrum).**

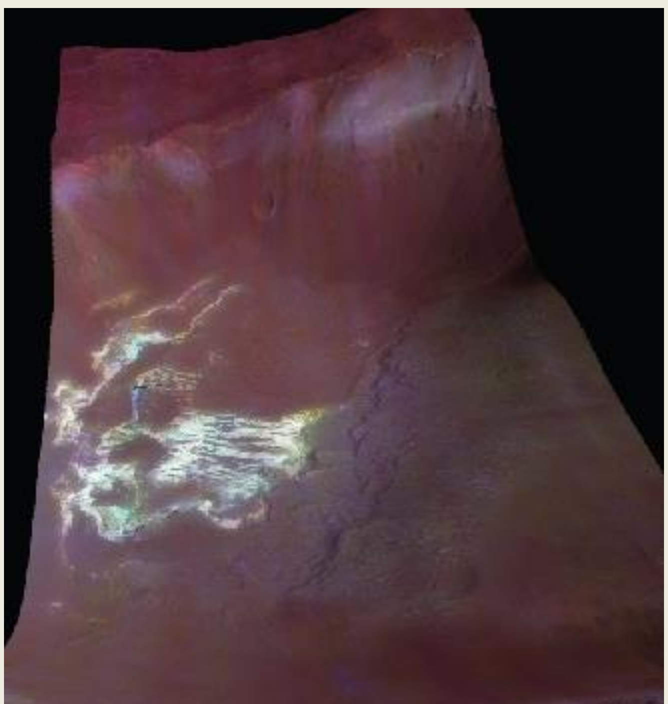




(Left) Perspective view showing a merge of CRISM color from image FRT0000a280 to a DTM of HiRISE images PSP_007455_1785 and ESP_033458_1785 showing smooth floor material, including an exposure of light-toned layered deposits. The color represents CRISM spectral parameters that have been merged to the DTM. (Above) CRISM spectra extracted from the light-toned layered deposits are shown at right. **The deposits contain Fe/Mg-smectites.**







(Left) Perspective view showing a merge of CRISM color from image FRT00008ebf (red is olivine index, green is 1.9 μm band depth, and blue is 2.3 μm drop off) to a DTM of HiRISE images PSP_006598_1780 and ESP_033326_1780. There are light-toned deposits both along the crater rim and on the floor. (Above) Spectra for CRISM image FRT00008ebf, **consistent with Fe/Mg-smectites, with a more Fe-rich smectite likely.**

Conclusions

Geologic mapping, combined with geomorphic and spectral analyses, show that subsurface ice in this region melted (via a combination if impact-related heating and intrusive magmatism), leading to a complex history of potentially multiple episodes of evacuation, collapse, and flooding, leaving behind cavities that have led to continuing deformation and collapse of surface units.

Future Work

- Finalize units and symbols
- DOMU
- COMU
- Complete crater counts
- Submit map!