A more vast and accessible Martian sedimentary rock record

Ken Edgett – February 2017

Sol 1385 mcam06798

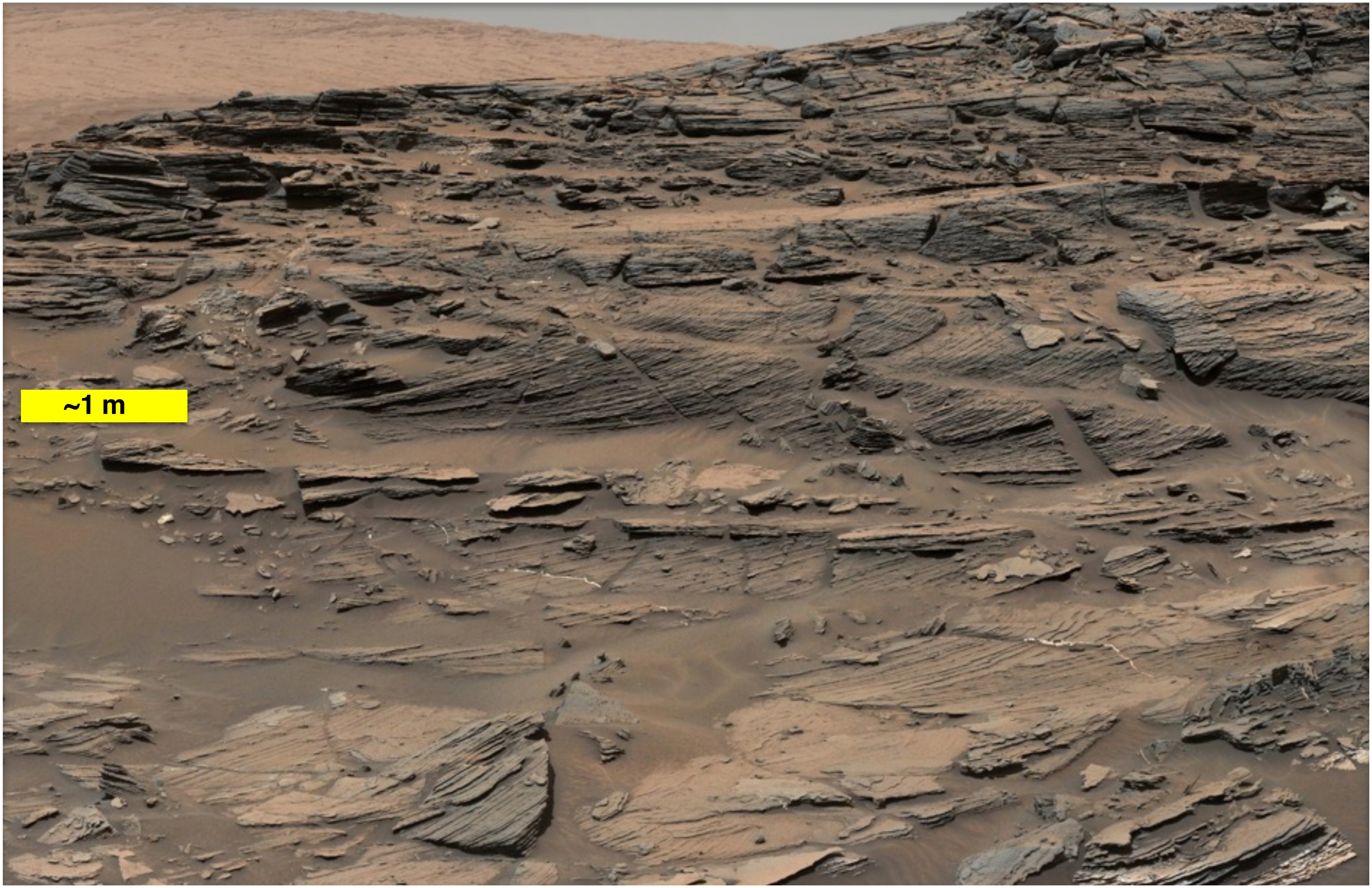

Malin
Space
Science
Systems
www.msss.com
We Build & Operate Space Cameras in San Diego
Mars Orbiter Camera
Mars Observer & Mars Global Surveyor
Mast Camera, Mars Hand Lens Imager,
Mars Descent Imager
Lunar Reconnaissance
Orbiter Cameras
ASU
JunoCam
OSIRIS-REx TAGCAMS
ASU
THEMIS VIS
Mars Odyssey
Engineering
Cameras
Mars Context Imager
Mars Reconnaissance Orbiter
Mars Color Imager
Mars Climate Orbiter &
Mars Reconnaissance Orbiter
Psyche cameras
ASU
ASU
Mars 2020 rover
- Mastcam-Z
- SHERLOC/WATSON
- descent cameras
Edgett – Mars Sedimentary Rock – February 2017
2

sediment – example – windblown sand

MSL MAHLI focus merge product 1604MH0004580000602124R00

sedimentary rock – example – sandstone

sedimentary rock – records of past environment



Stimson formation – Sol 1087 – 27 August 2015

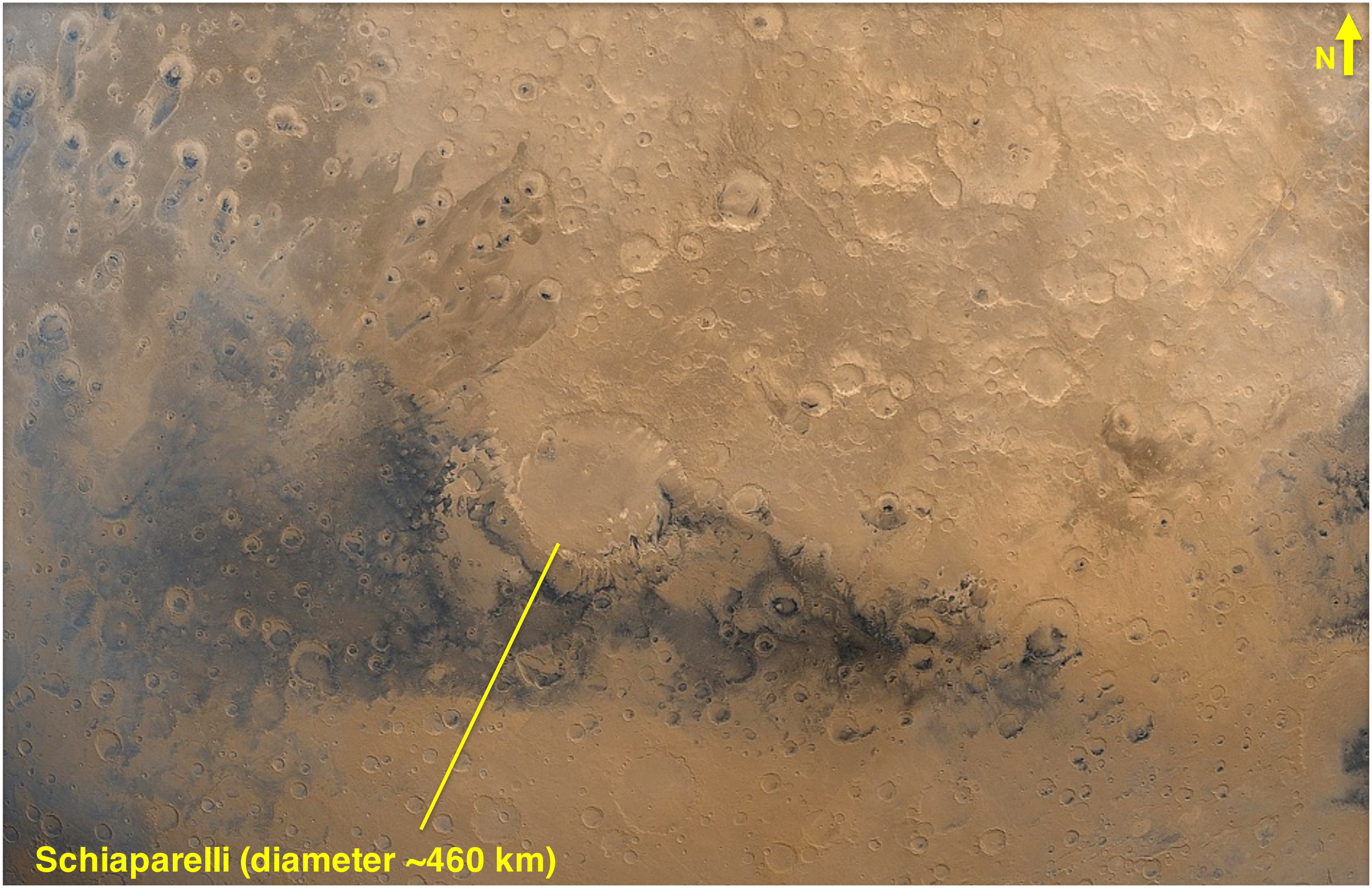
Mars sedimentary rock record importance

Mars – sedimentary rock record (environment record) older than the oldest preserved on Earth (or Venus).

Physics the same but the "experiment" ran differently.

- **no plate tectonics, more mafic, different fluids, less(?) organics.**

Mars heavily cratered terrain – very ancient



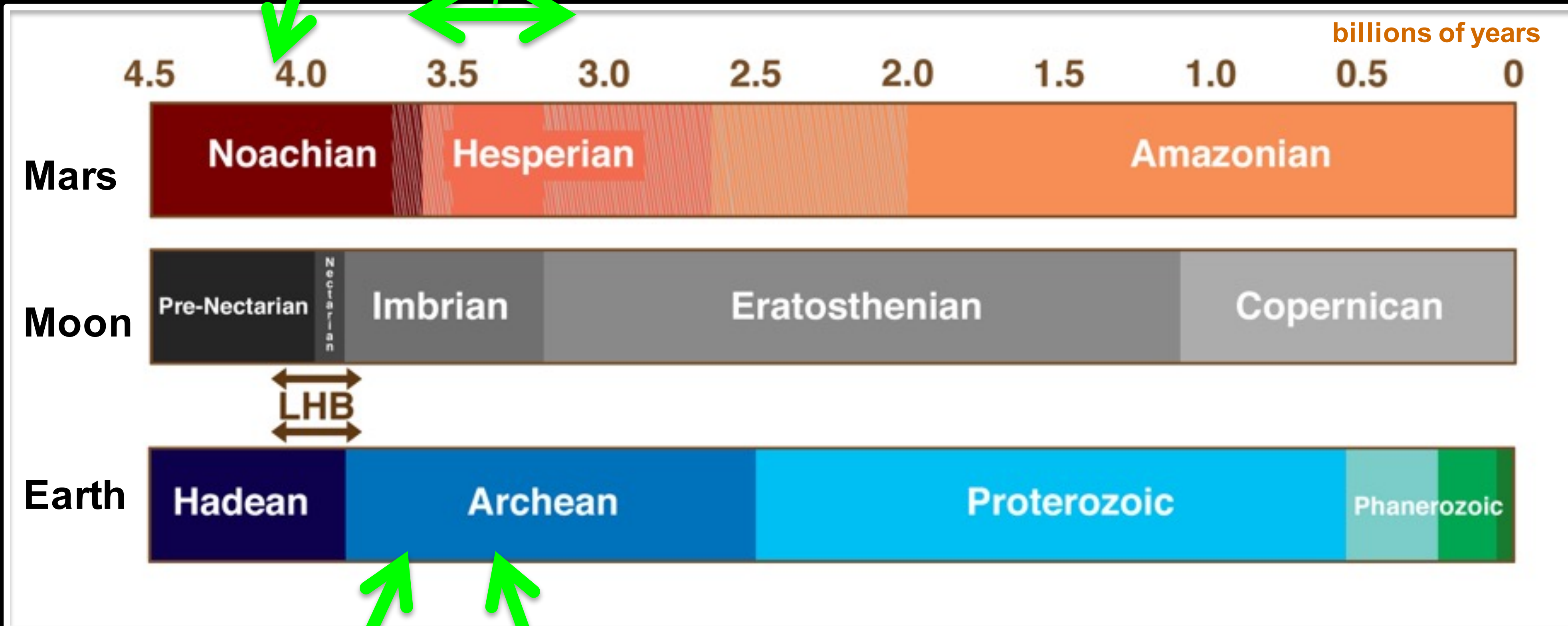
Viking 1 Orbiter – 1980

Mars sedimentary rock record importance

MARS

Sedimentary rocks older than Earth's oldest

Sedimentary rocks in Gale (Curiosity)



EARTH

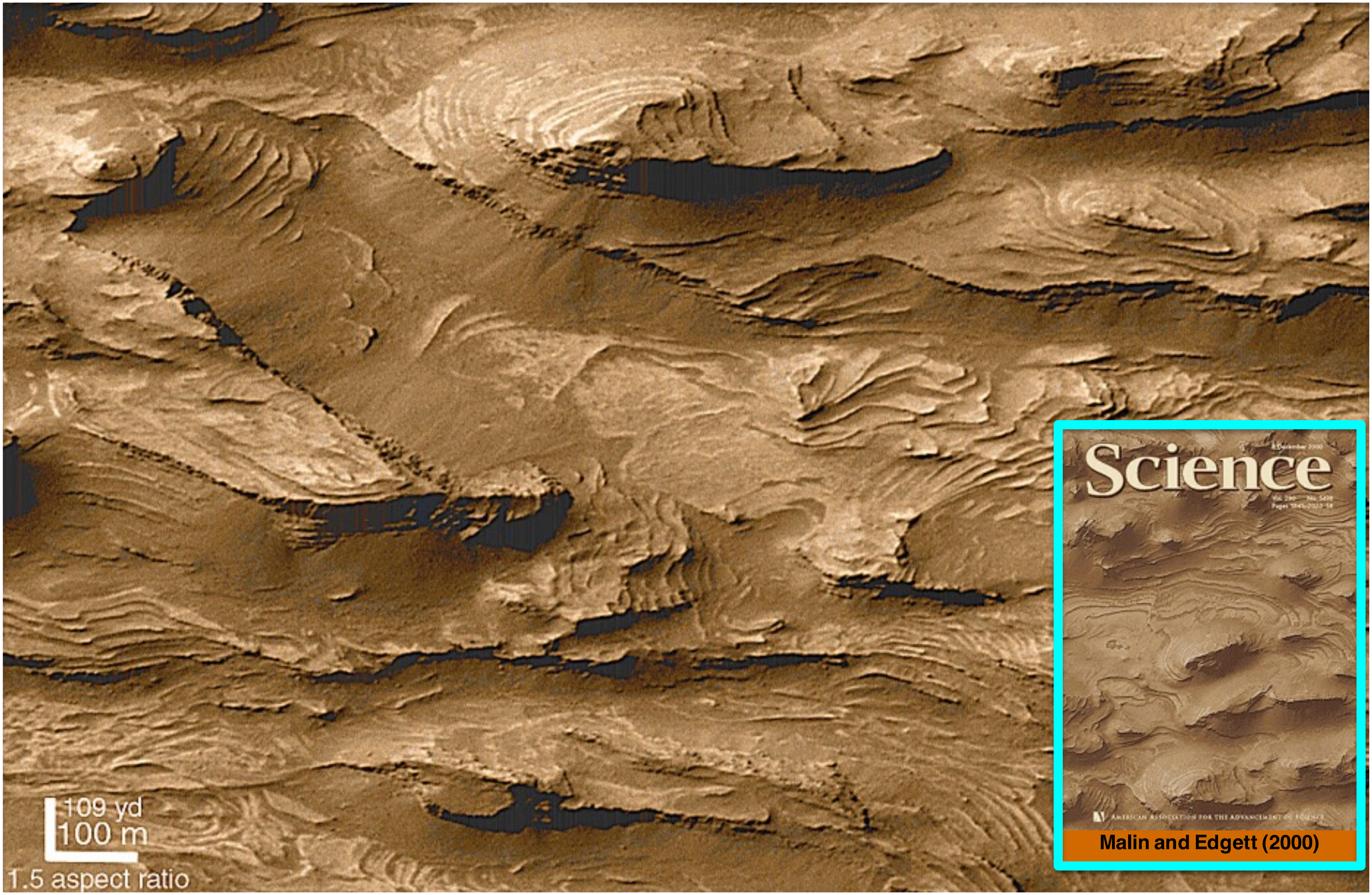
~3.8 Ga

Isua Greenstone Belt, Greenland

~3.4 Ga

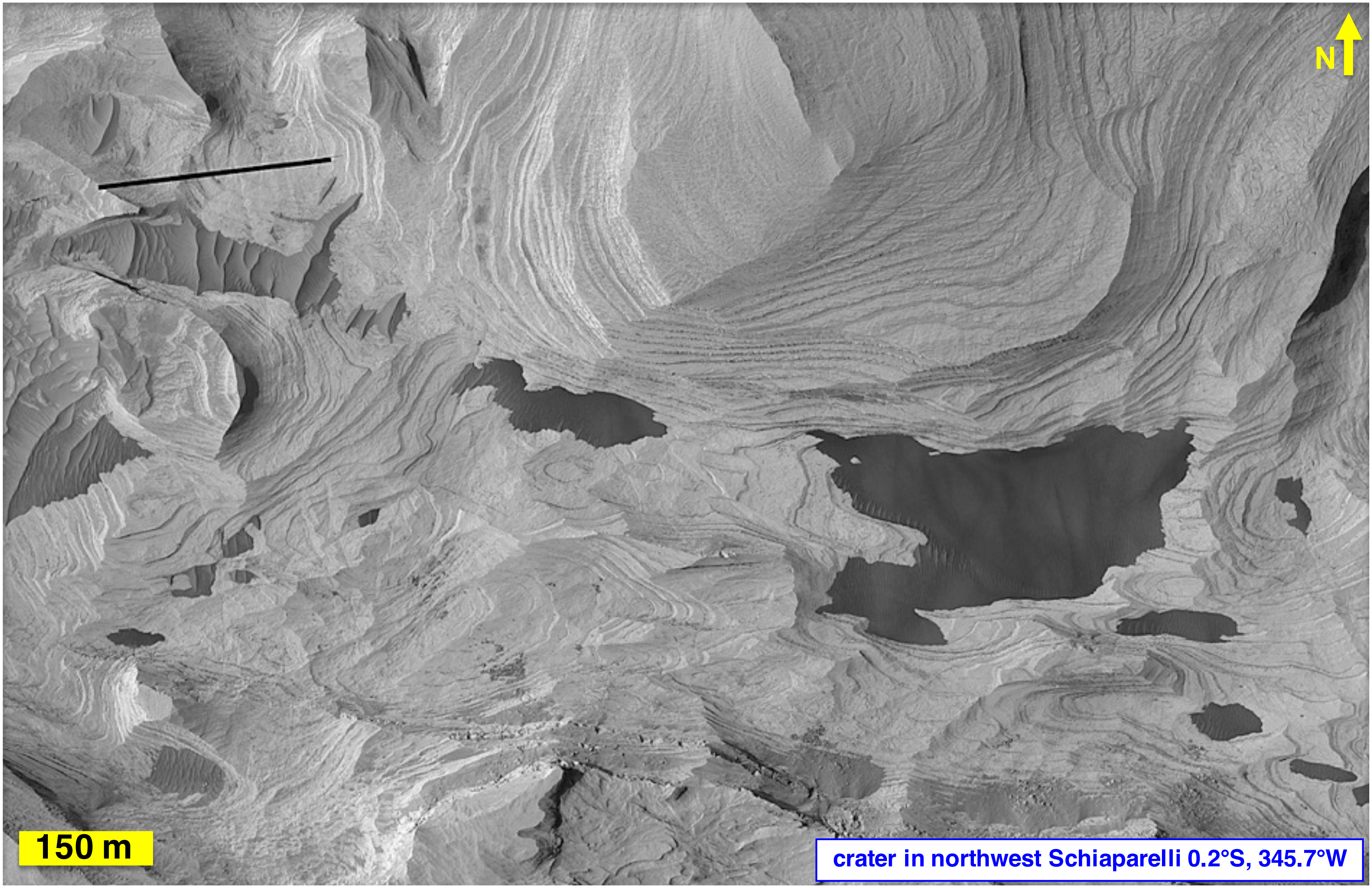
Warawoona Group, Western Australia
Barberton Greenstone Belt, South Africa

sedimentary rock – published December 2000



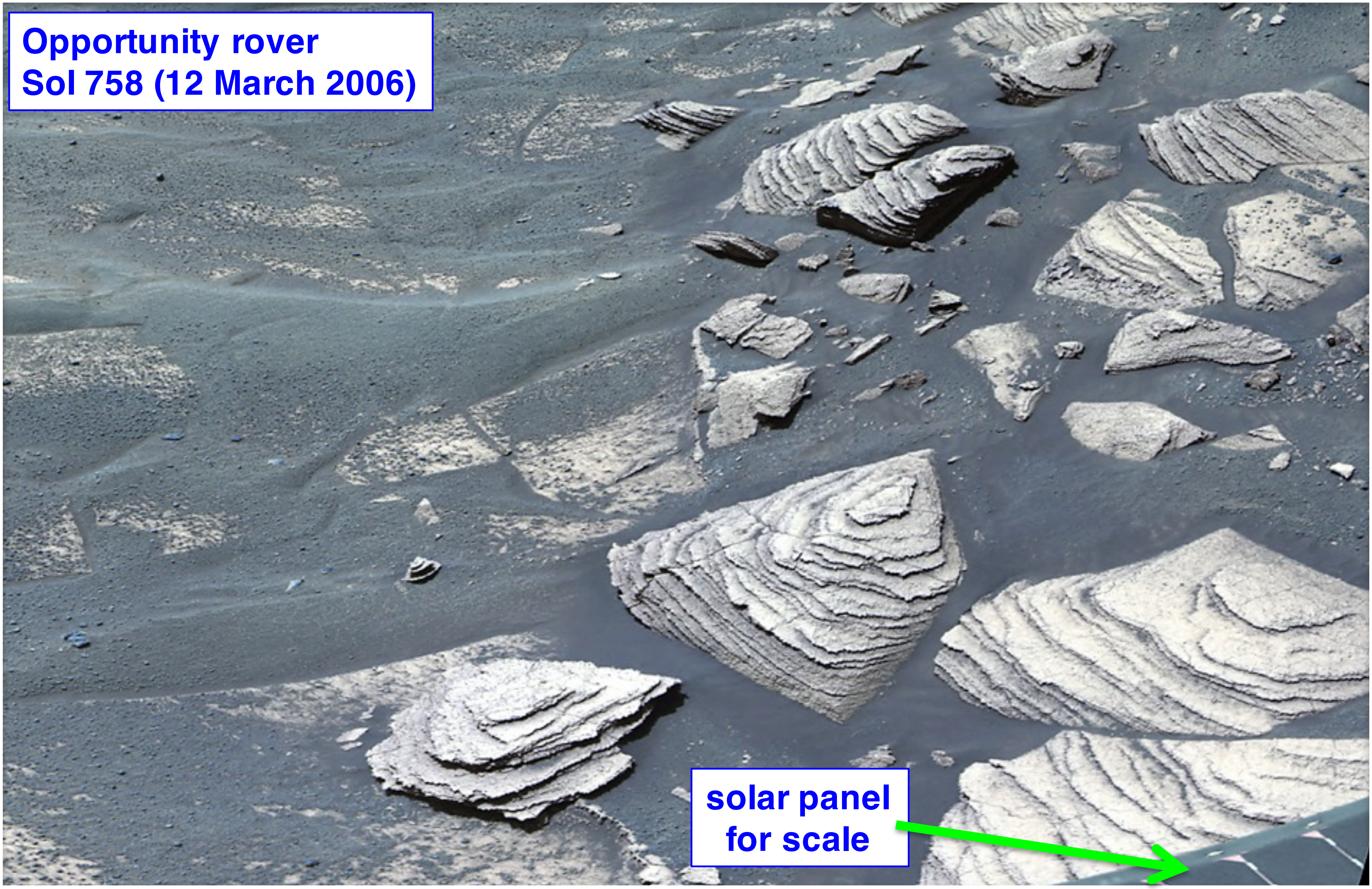
MOC image FHA-01278

typical – light-tone, layered, few impact craters



HiRISE PSP_002218_1800

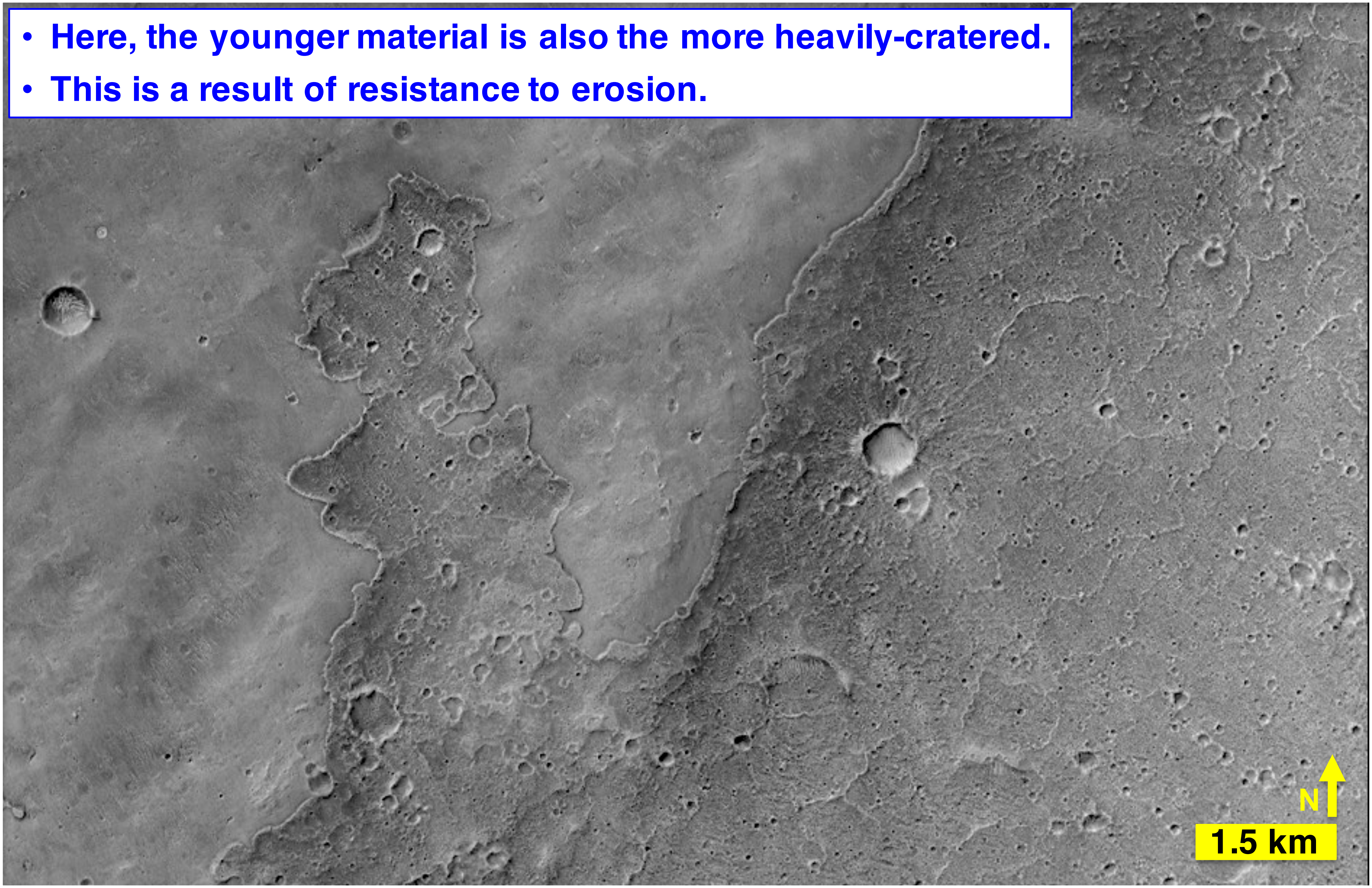
typical – light-tone, layered, few impact craters



color adjusted; Pancam mosaic – target named Hokan

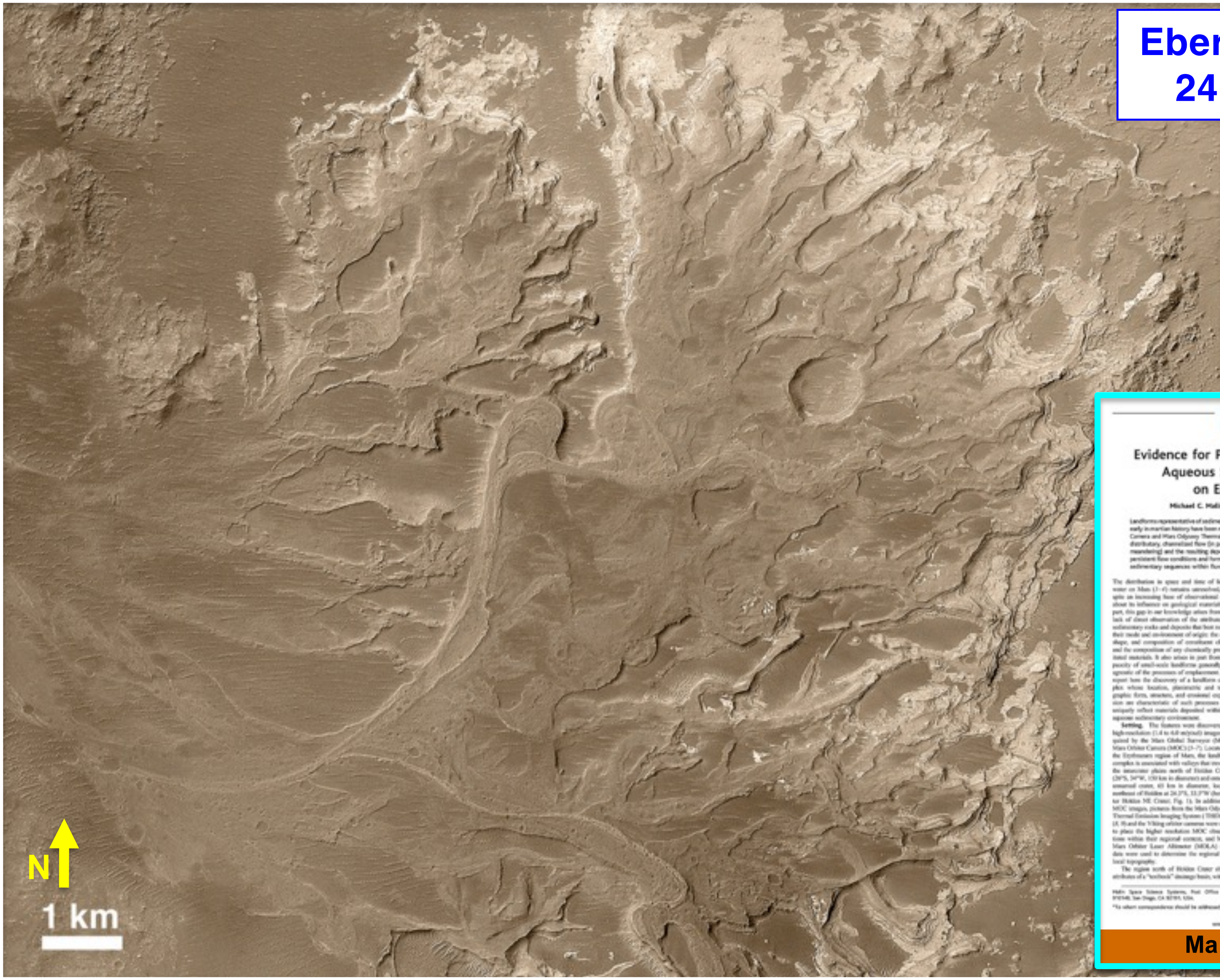
typical – lavas are more resistant to erosion

- Here, the younger material is also the more heavily-cratered.
- This is a result of resistance to erosion.



west of Sinus Meridiani – 1.4°N, 10.5°W – CTX P15_006834_1793_XN_00S010W

fluvial transport and deposition of sediment



Eberswalde Crater
24.1°S, 33.7°W

RESEARCH ARTICLES

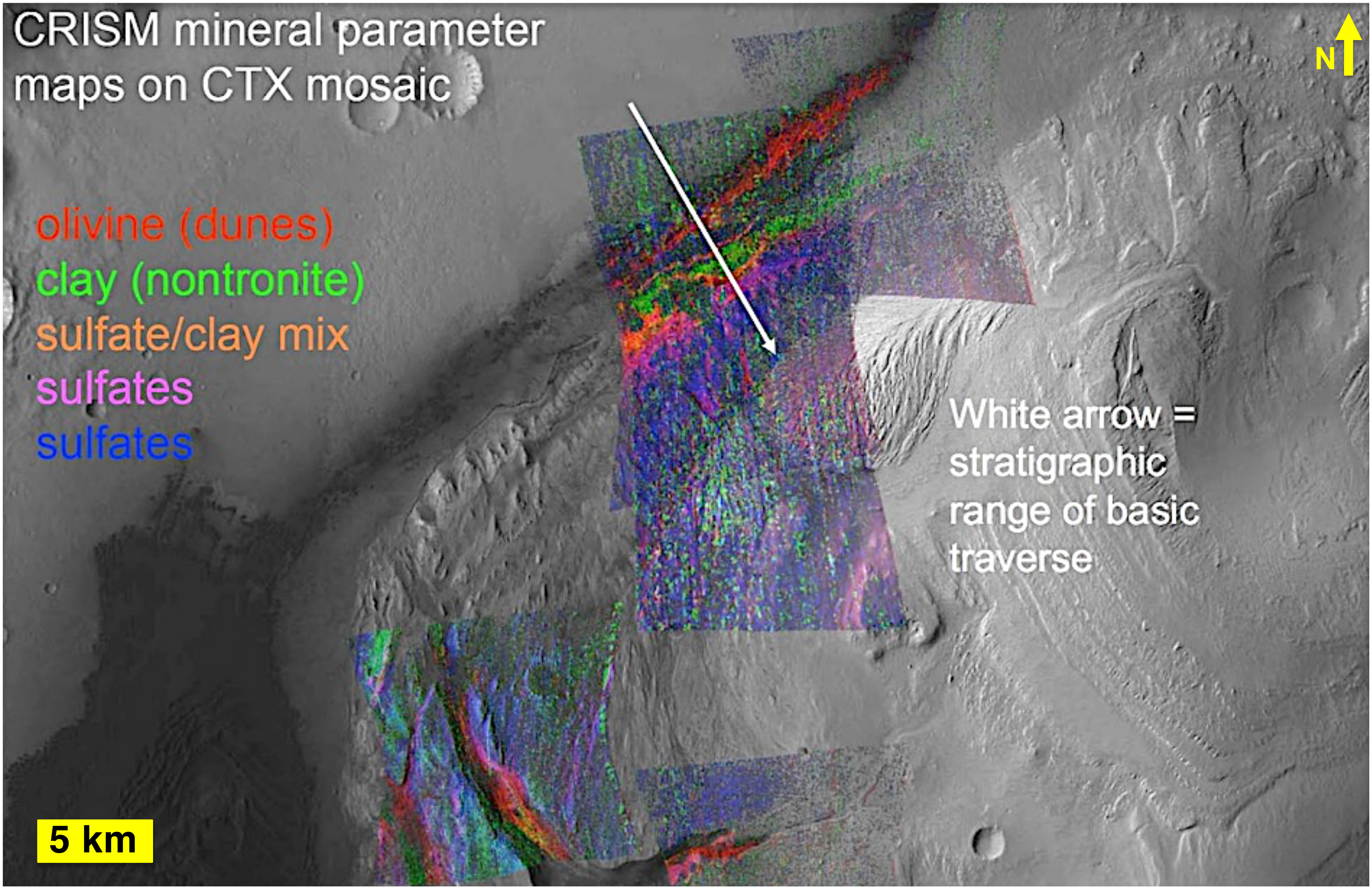
Evidence for Persistent Flow and Aqueous Sedimentation on Early Mars

Michael C. Malin* and Kenneth S. Edgett

Malin and Edgett (2003)

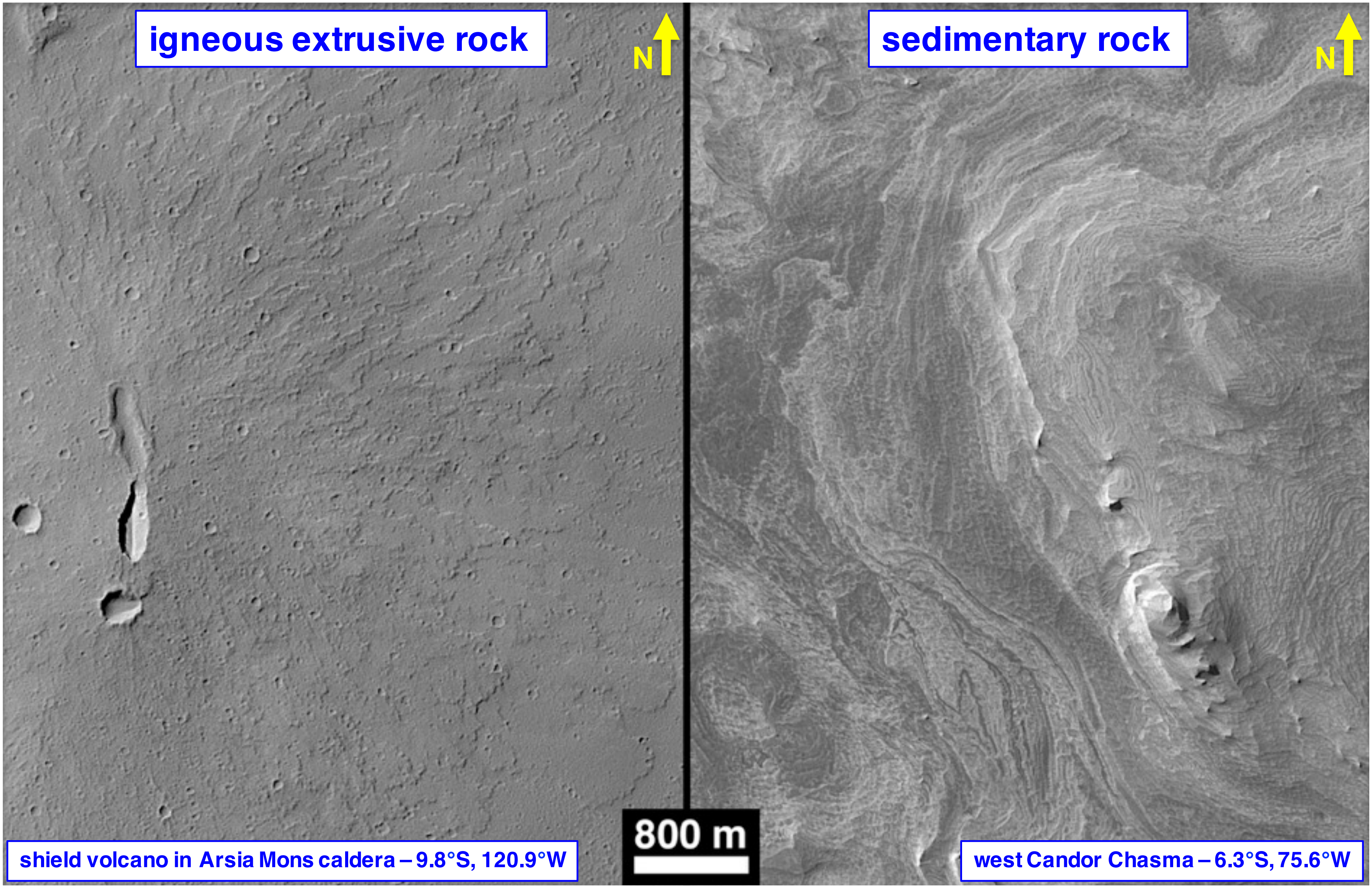
Mosaic of MOC images

where not obscured by dust – some mineral info

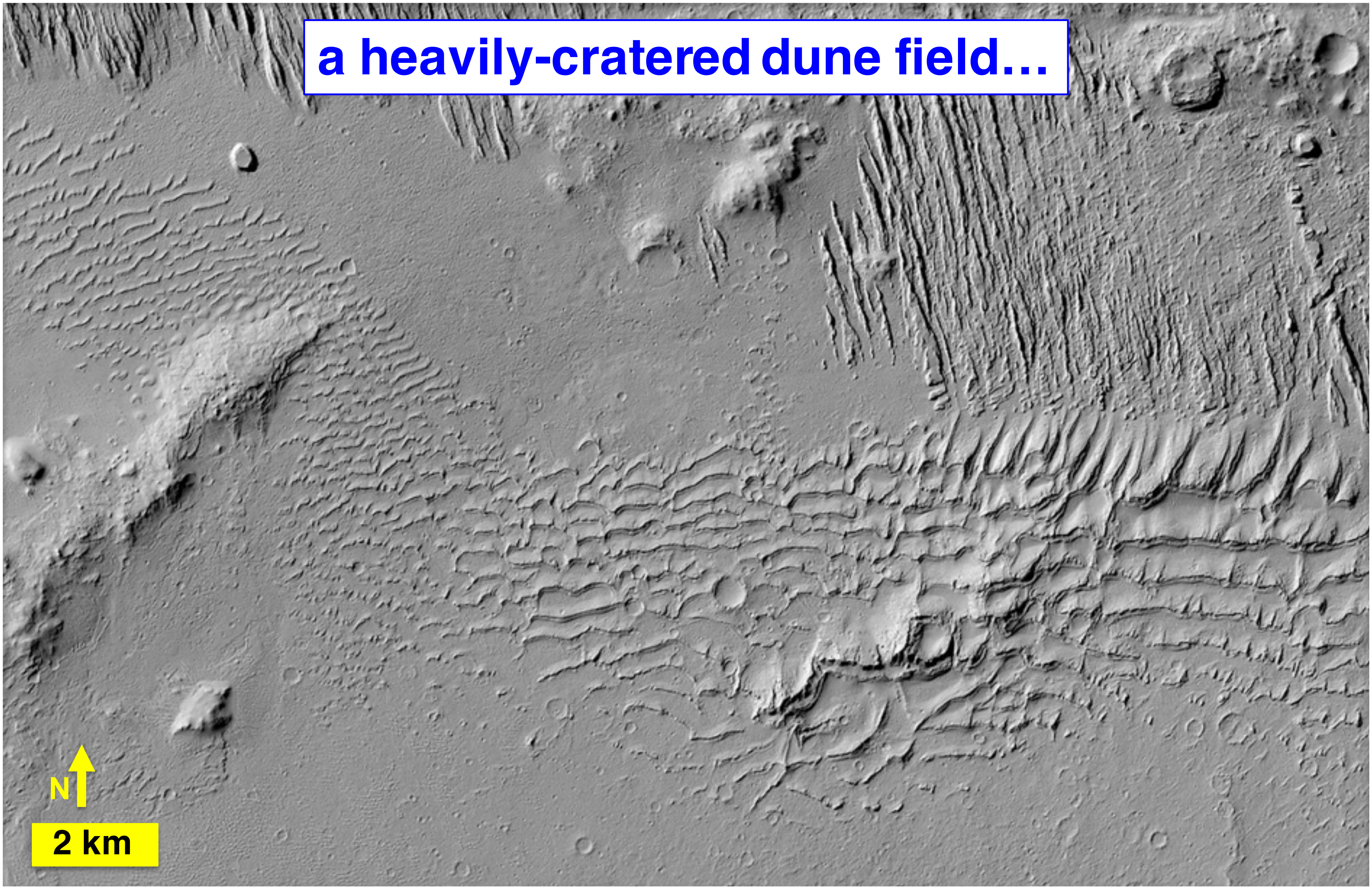


Gale crater figure from Ralph Milliken

but… there was this weird problem…

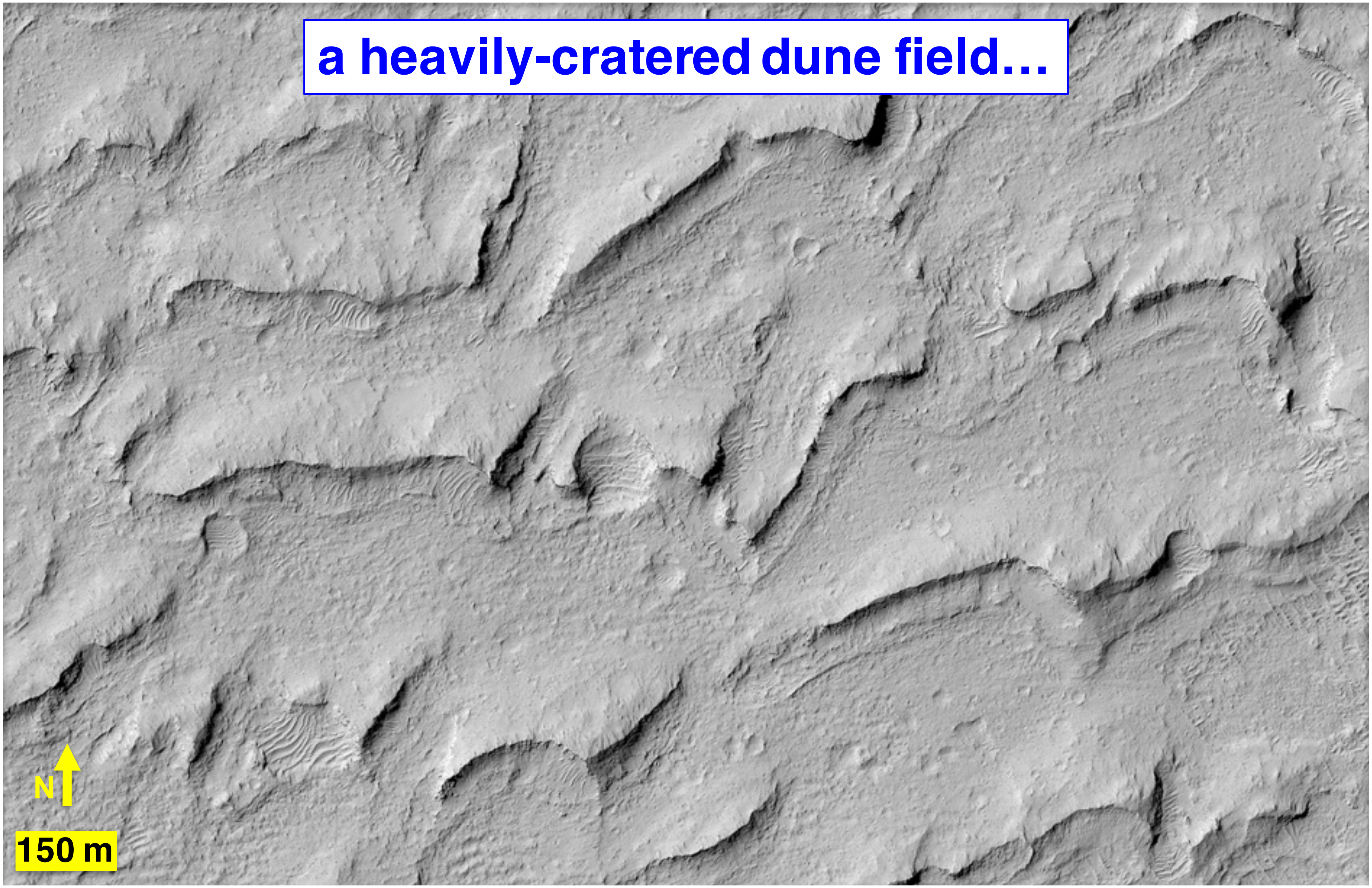


but… there was this weird problem…

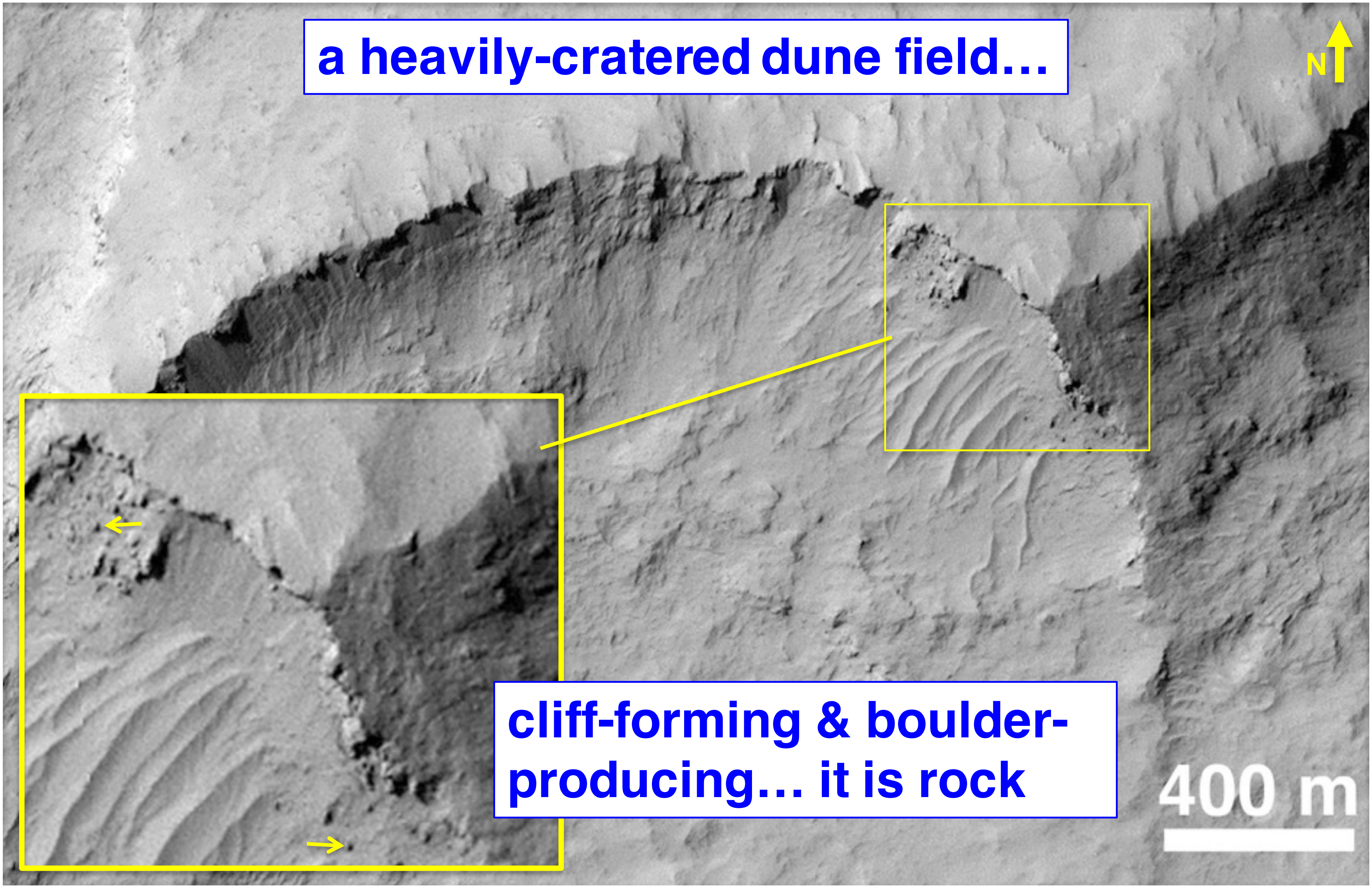


Apollinaris Sulci – CTX image P22_009609_1674_XN_12S182W

but… there was this weird problem…

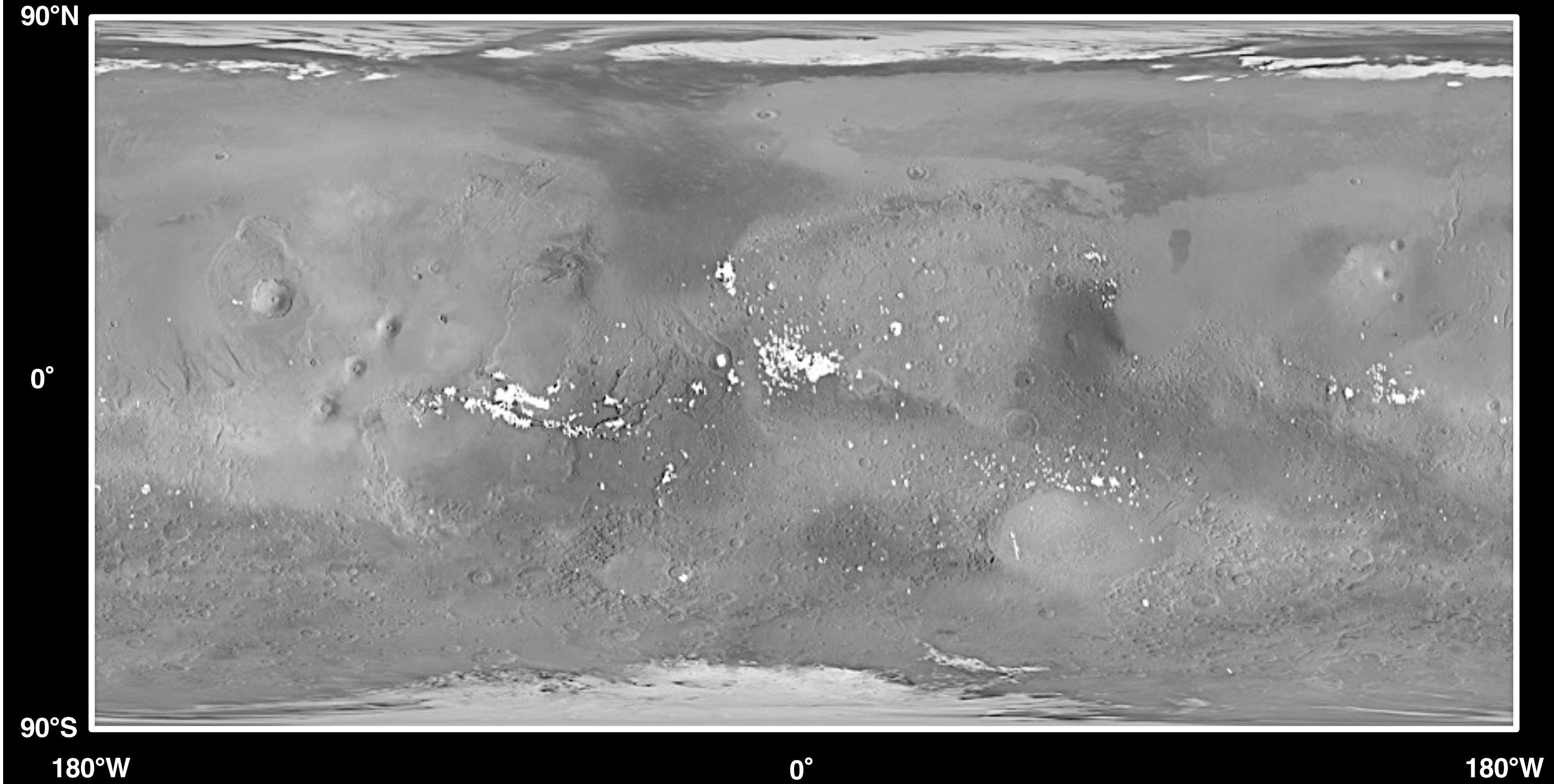


sedimentary rock that resists erosion like lava?



HiRISE image PSP_007460_1675

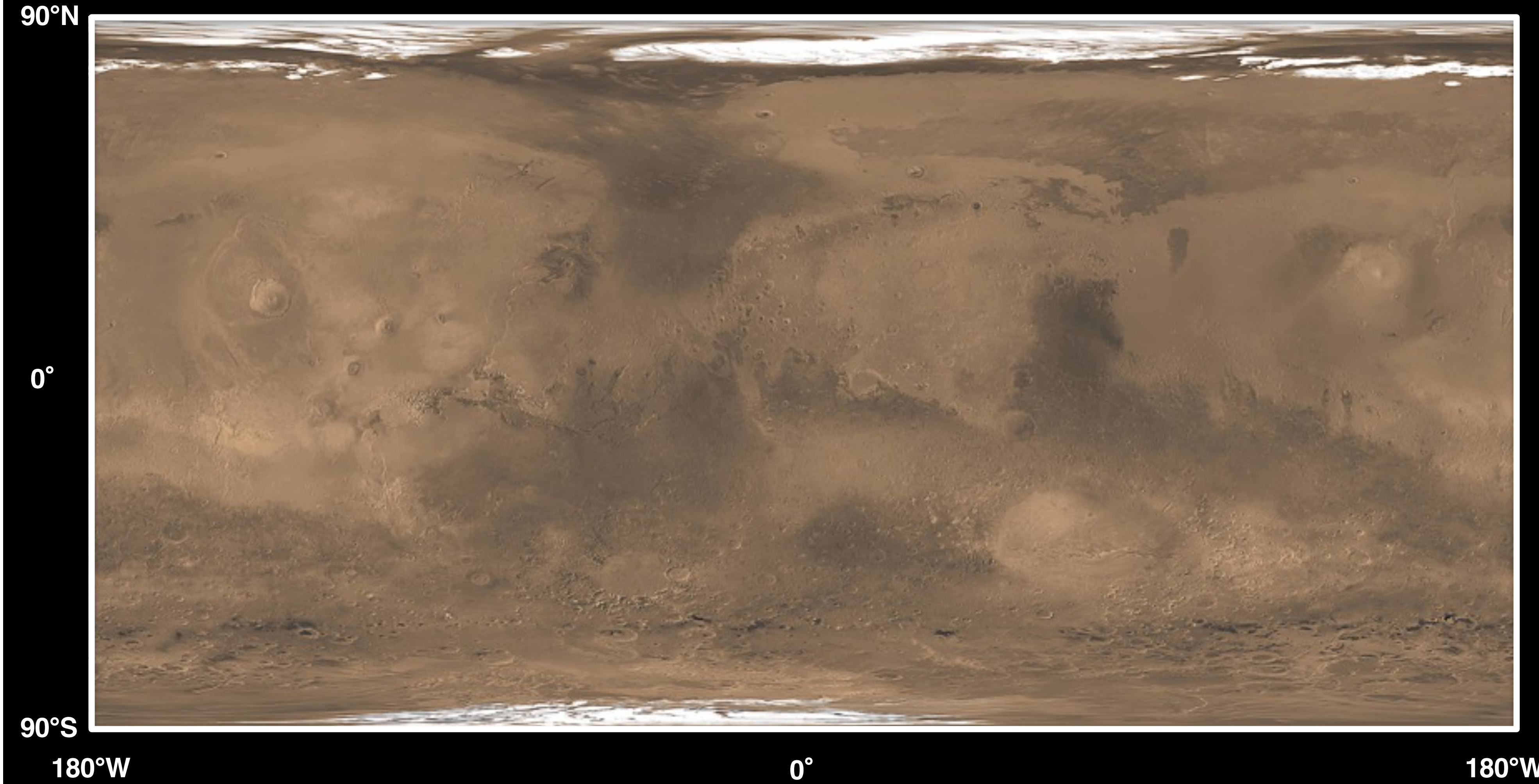
sed. rock occurrences – what we used to think



Identified from MGS MOC Images

Malin, Edgett, *et al.* (2010) doi:10.1555/mars.2010.0001

sedimentary rock occurrences – NOW

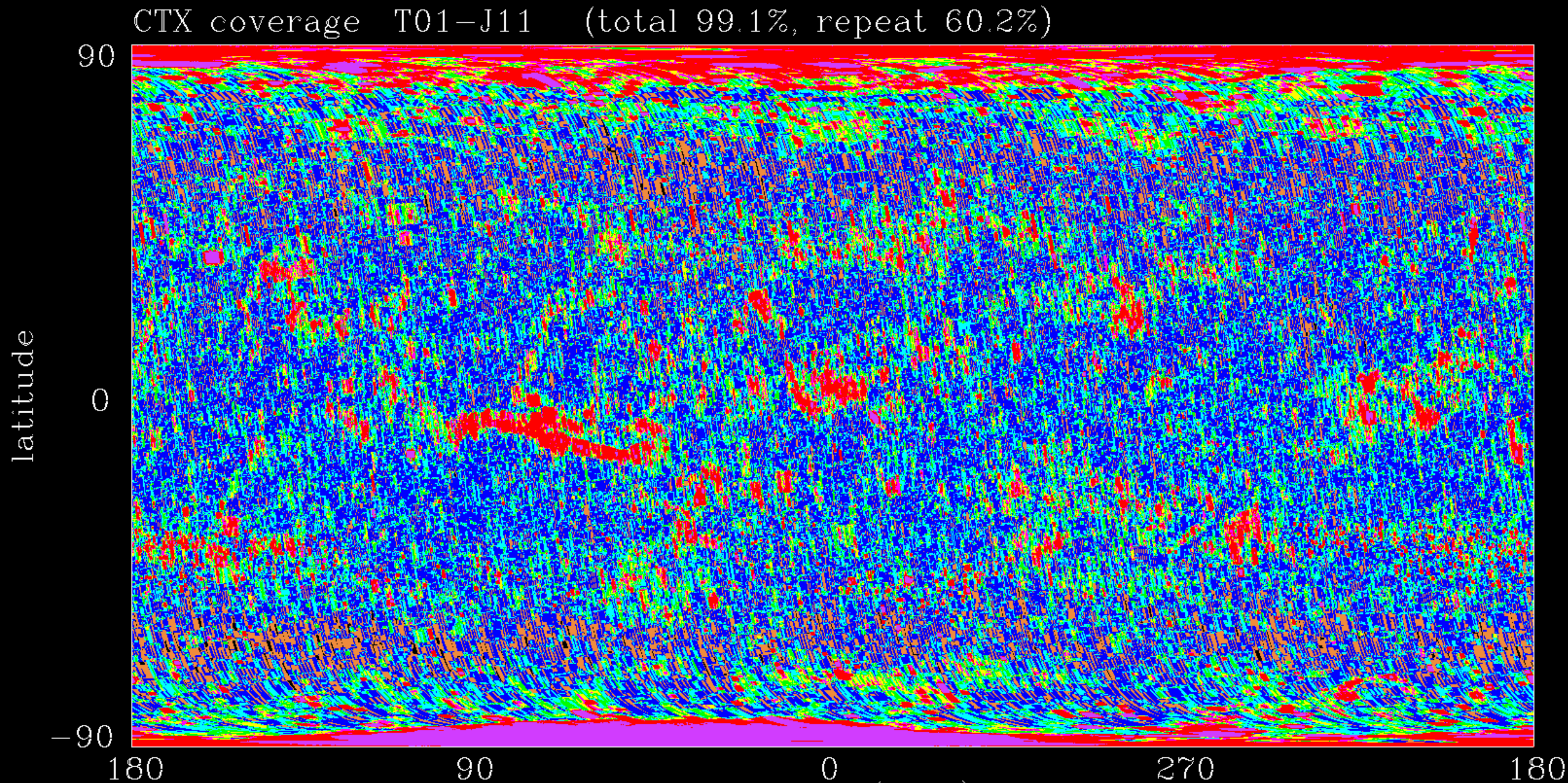


Can't…. Map….

One could spend the rest of one's career putting dots on the map!

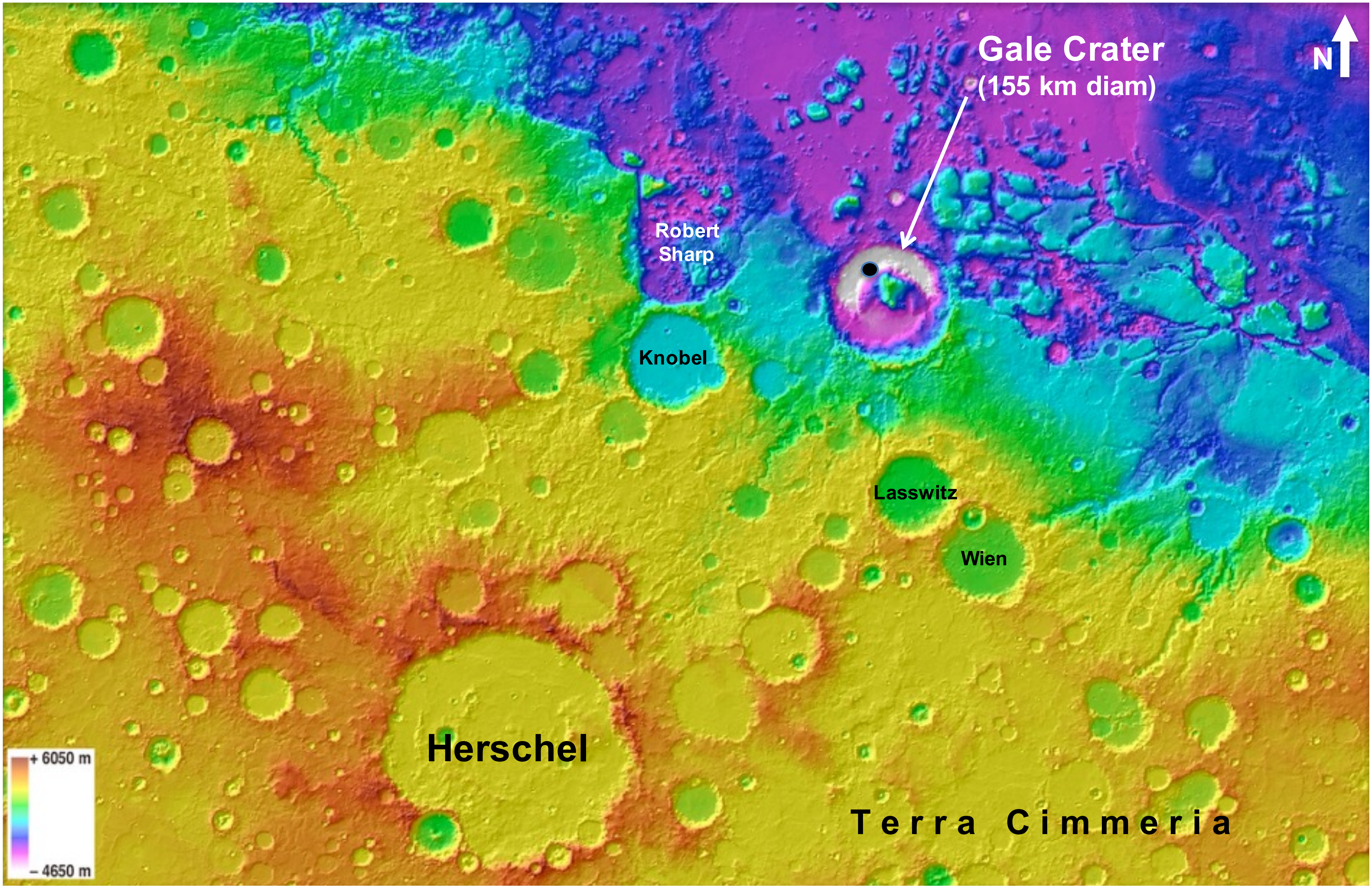
Mars >99% mapped, 6 m per pixel and higher

MRO CTX Coverage through January 2017



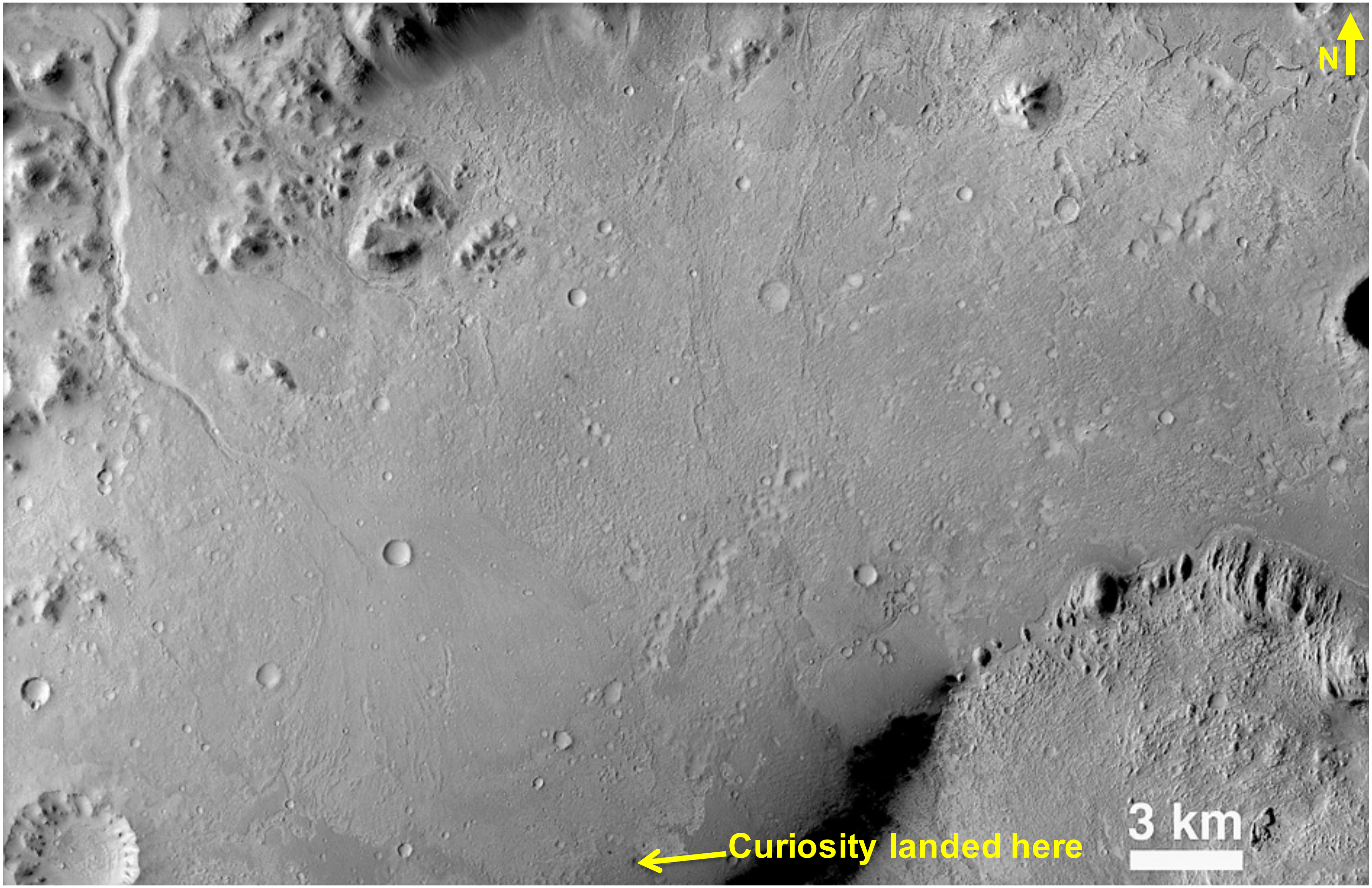
MGS MOC + MRO HiRISE + MRO CTX

+ Curiosity rover in Gale crater



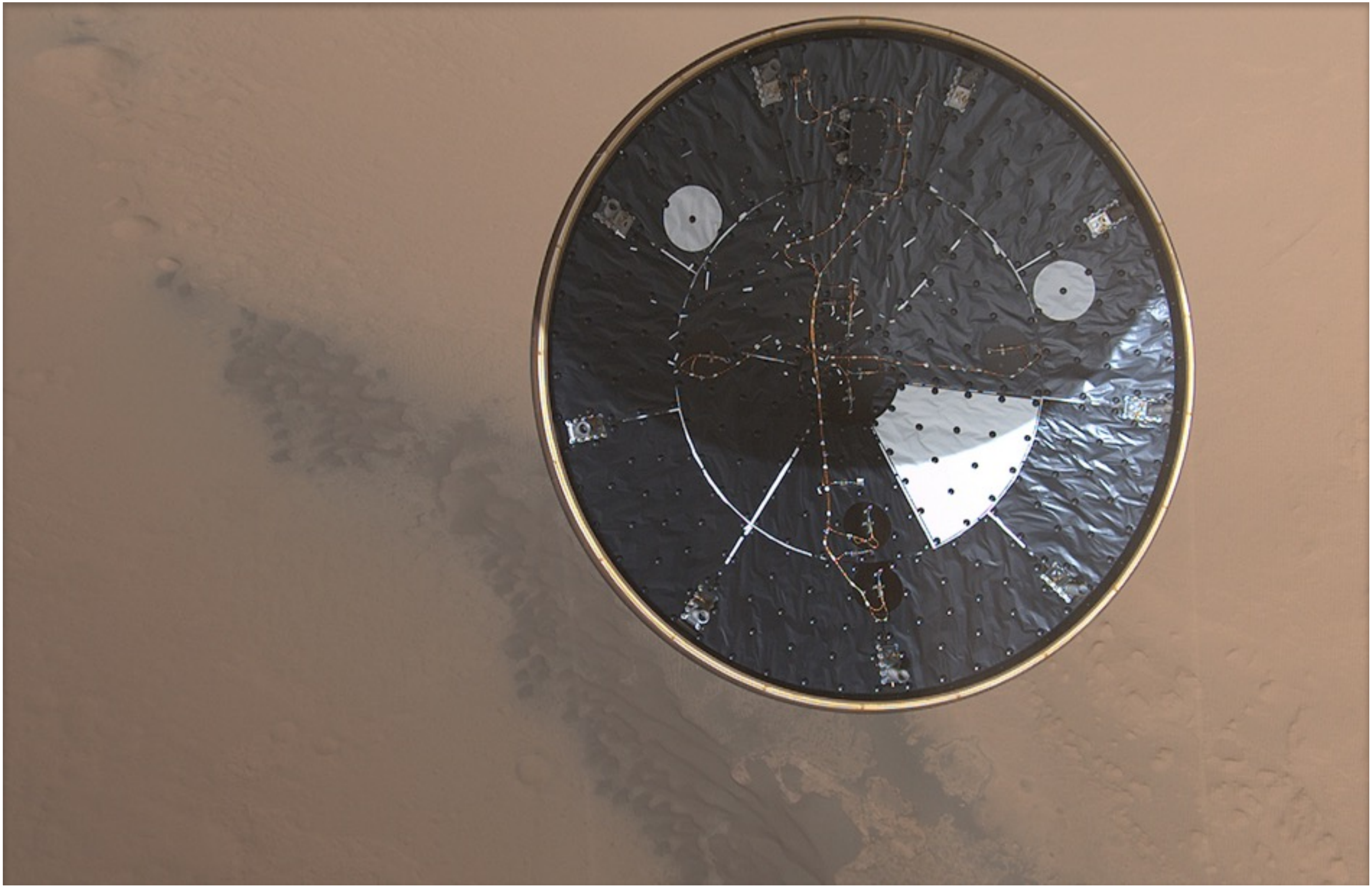
MGS MOLA topography

+ Curiosity rover in Gale crater



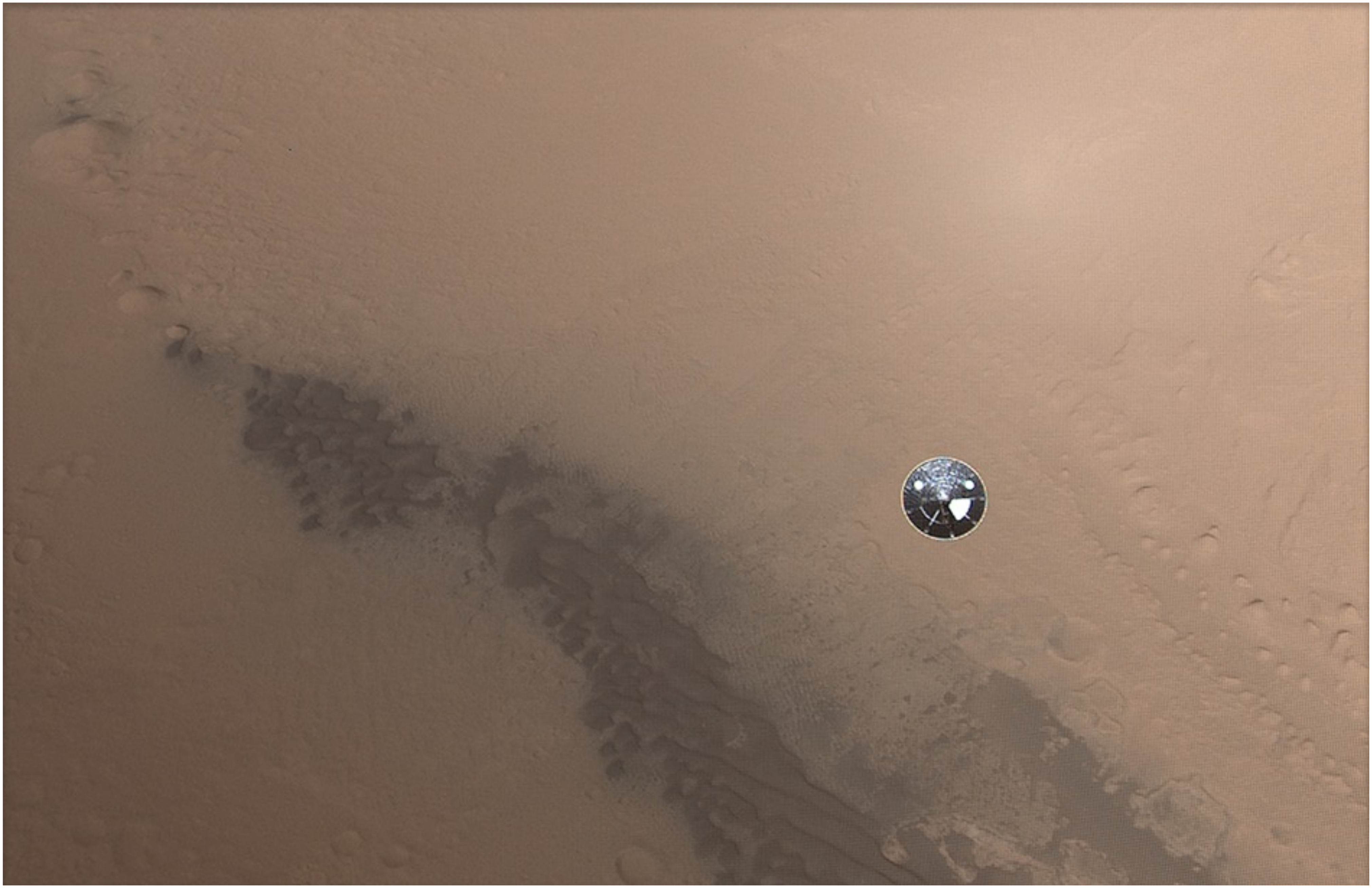
CTX D03_028269_1752_XI_04S222W

+ Curiosity rover in Gale crater



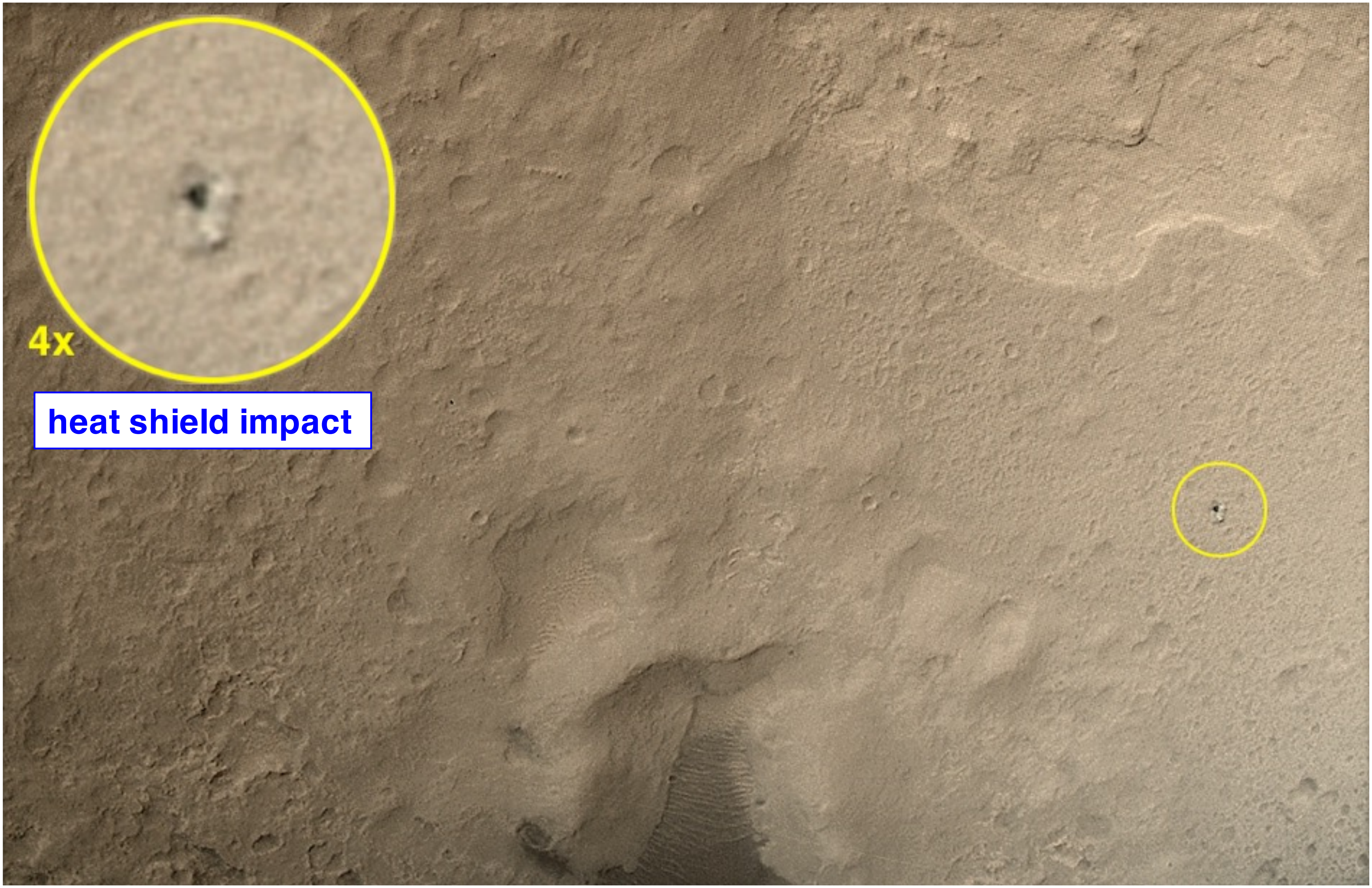
Curiosity descent – 6 August 2012

+ Curiosity rover in Gale crater

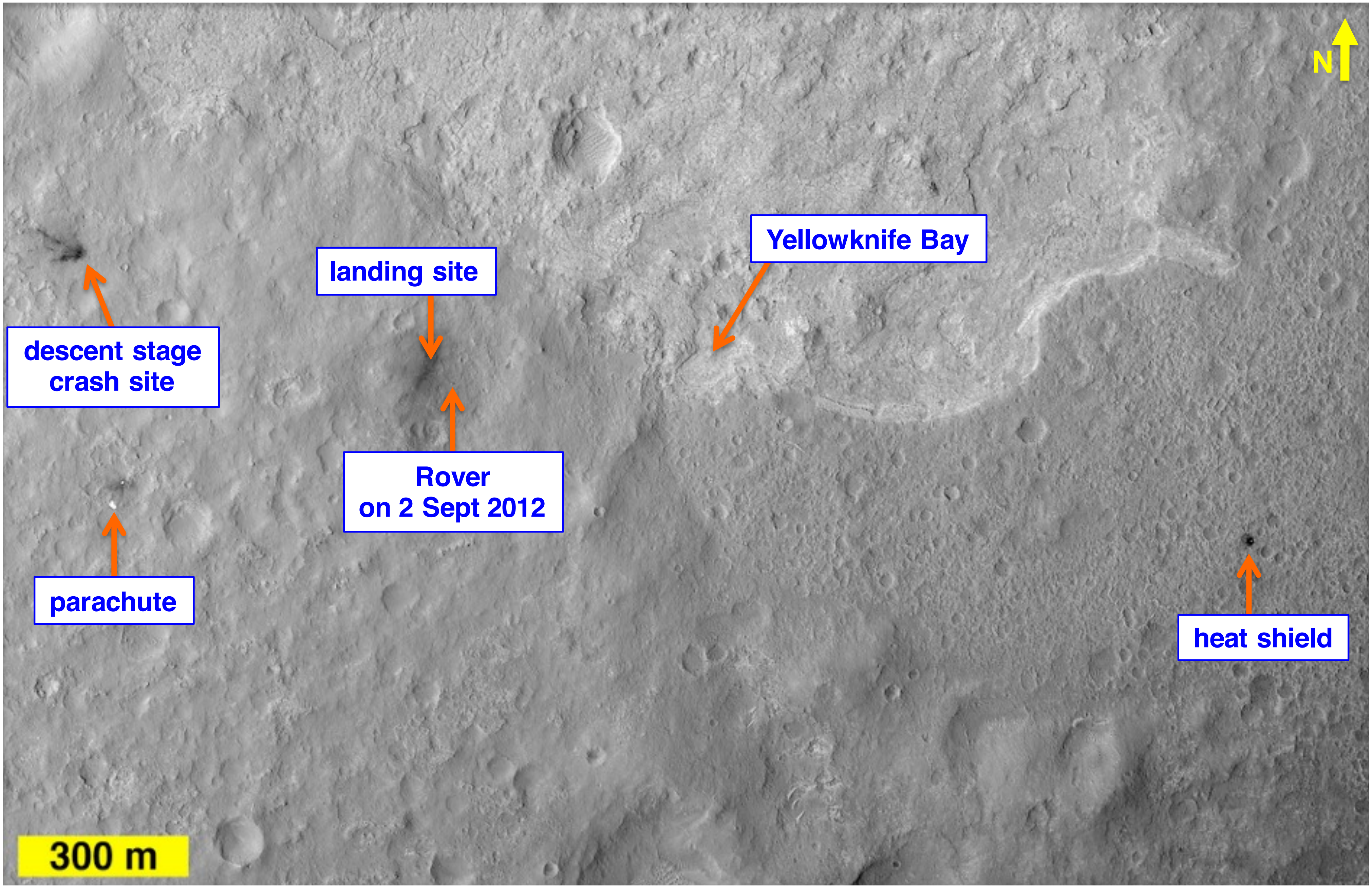


Curiosity descent – 6 August 2012

heat shield impact site on cratered surface



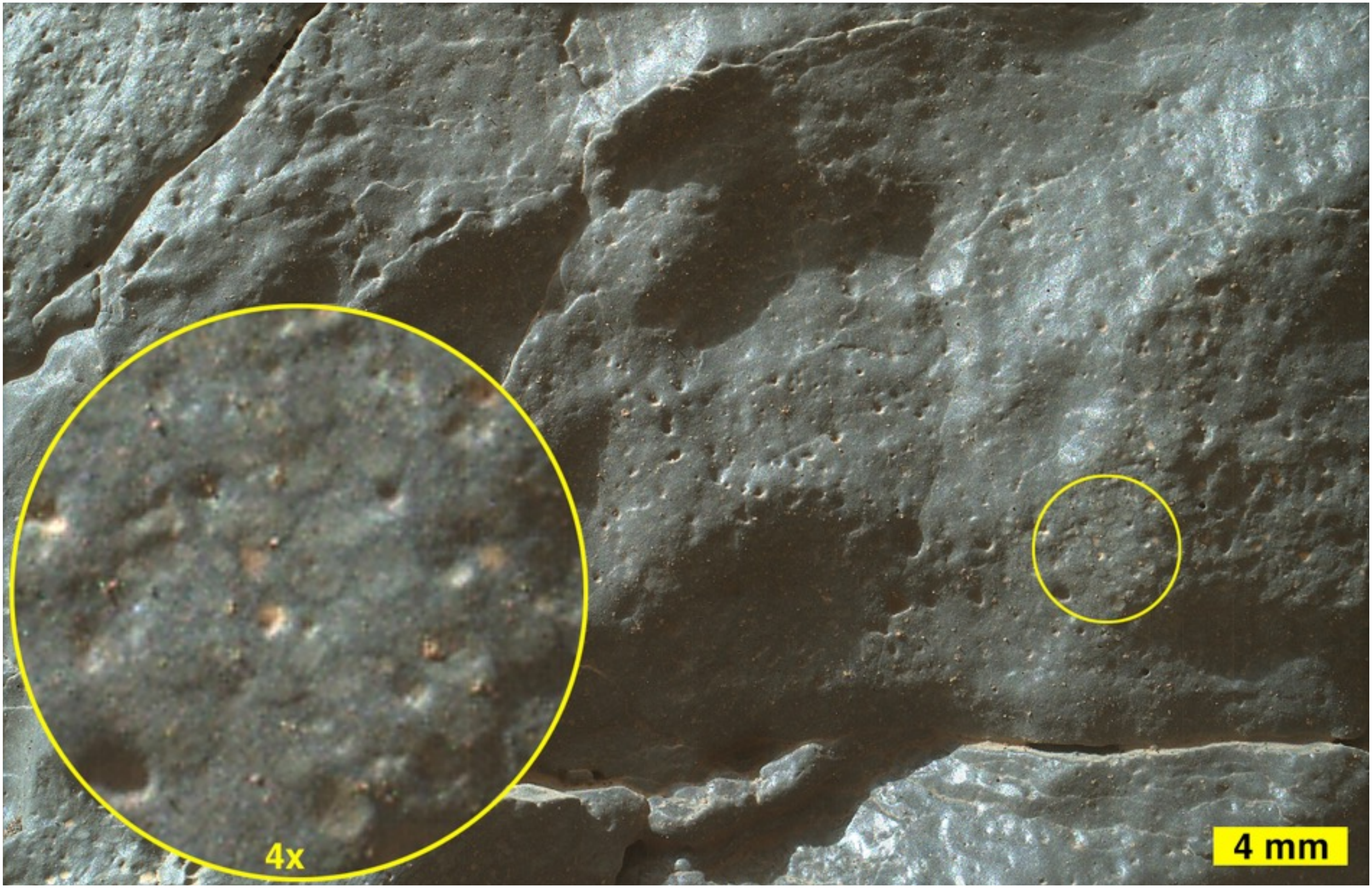
heat shield impact site on cratered surface



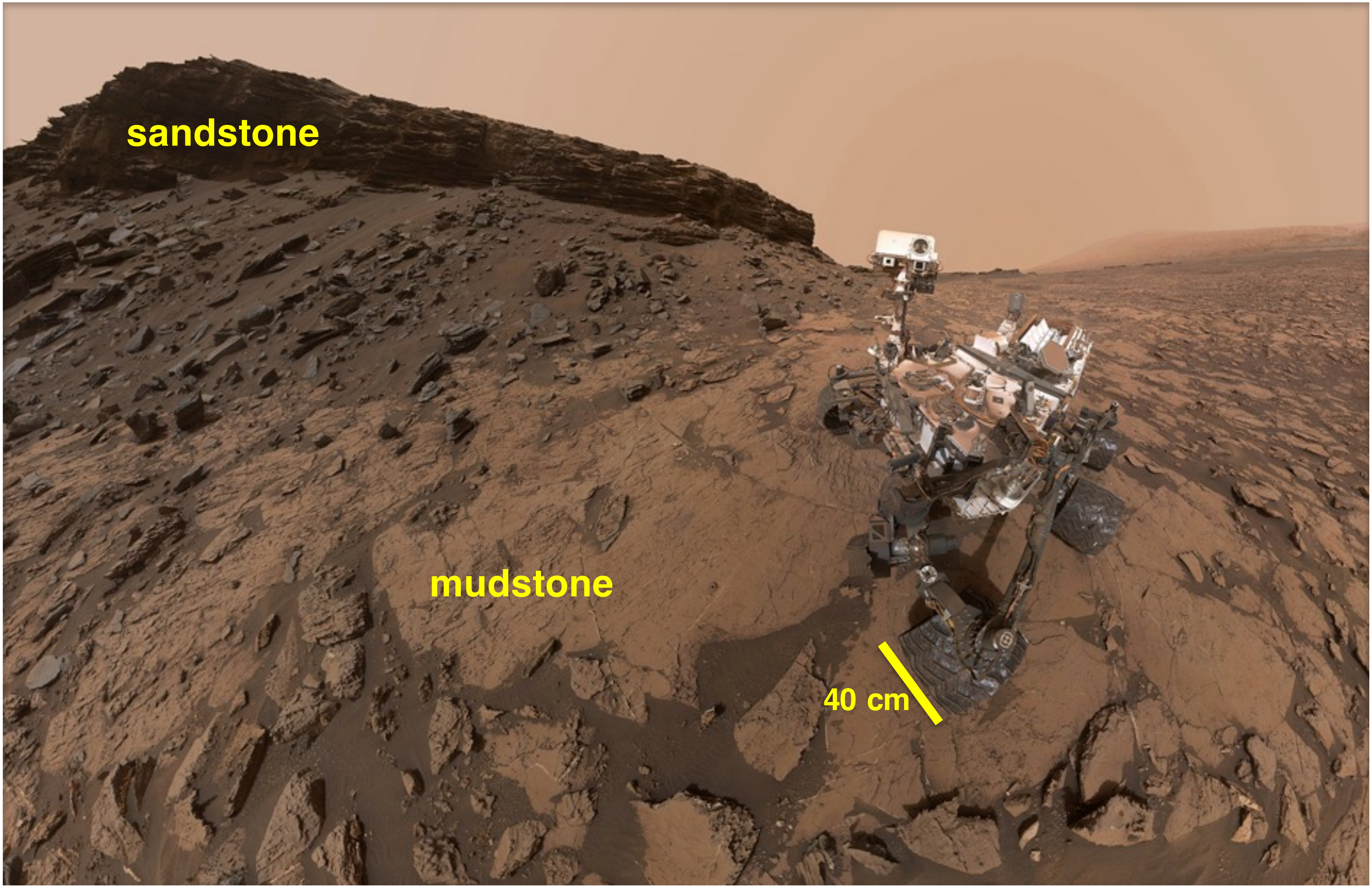
HiRISE ESP_028612_1755

that cratered surface – the rock is sandstone!

dark gray well-cemented sandstones common

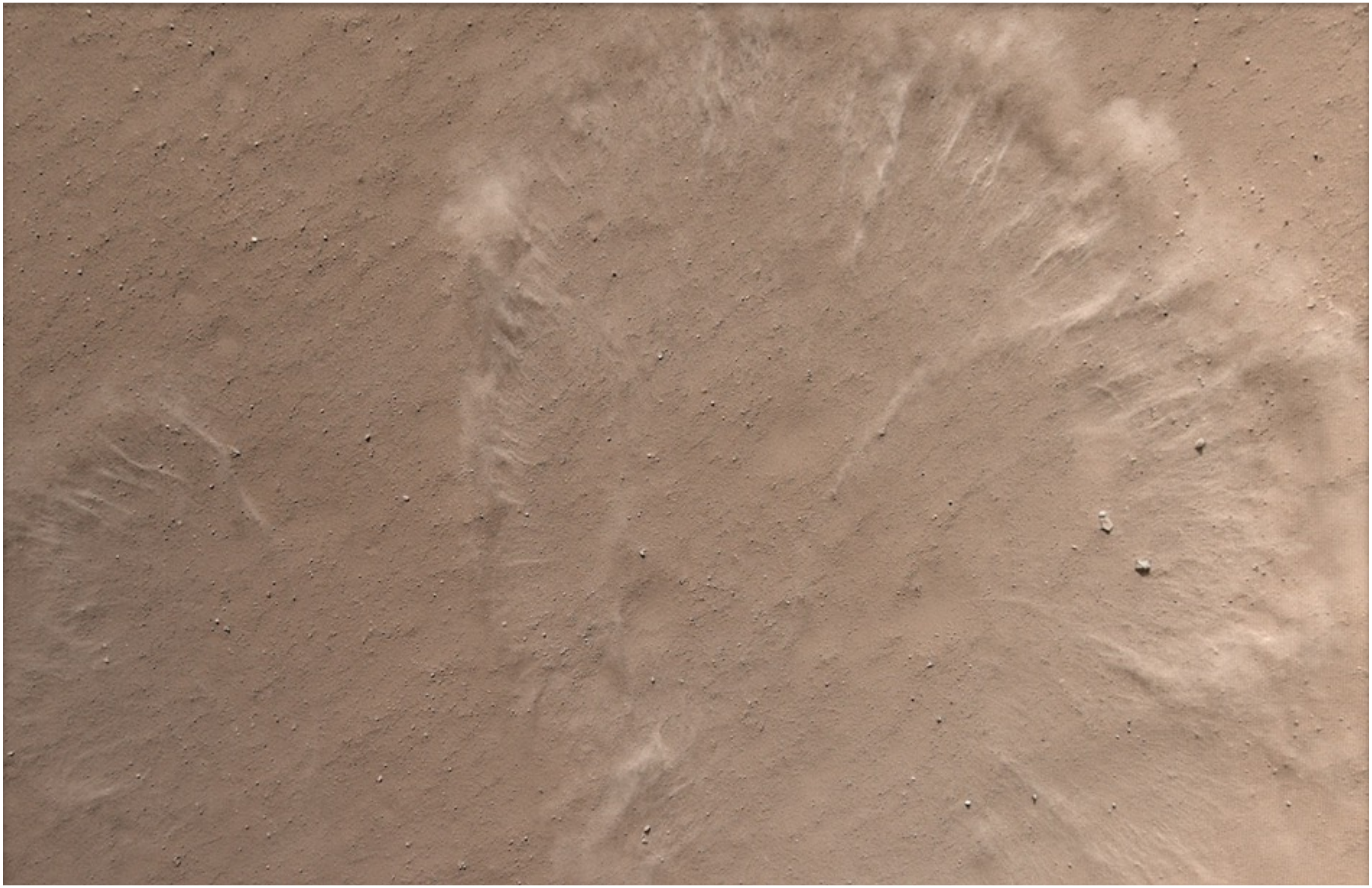


… and erosion-resistant

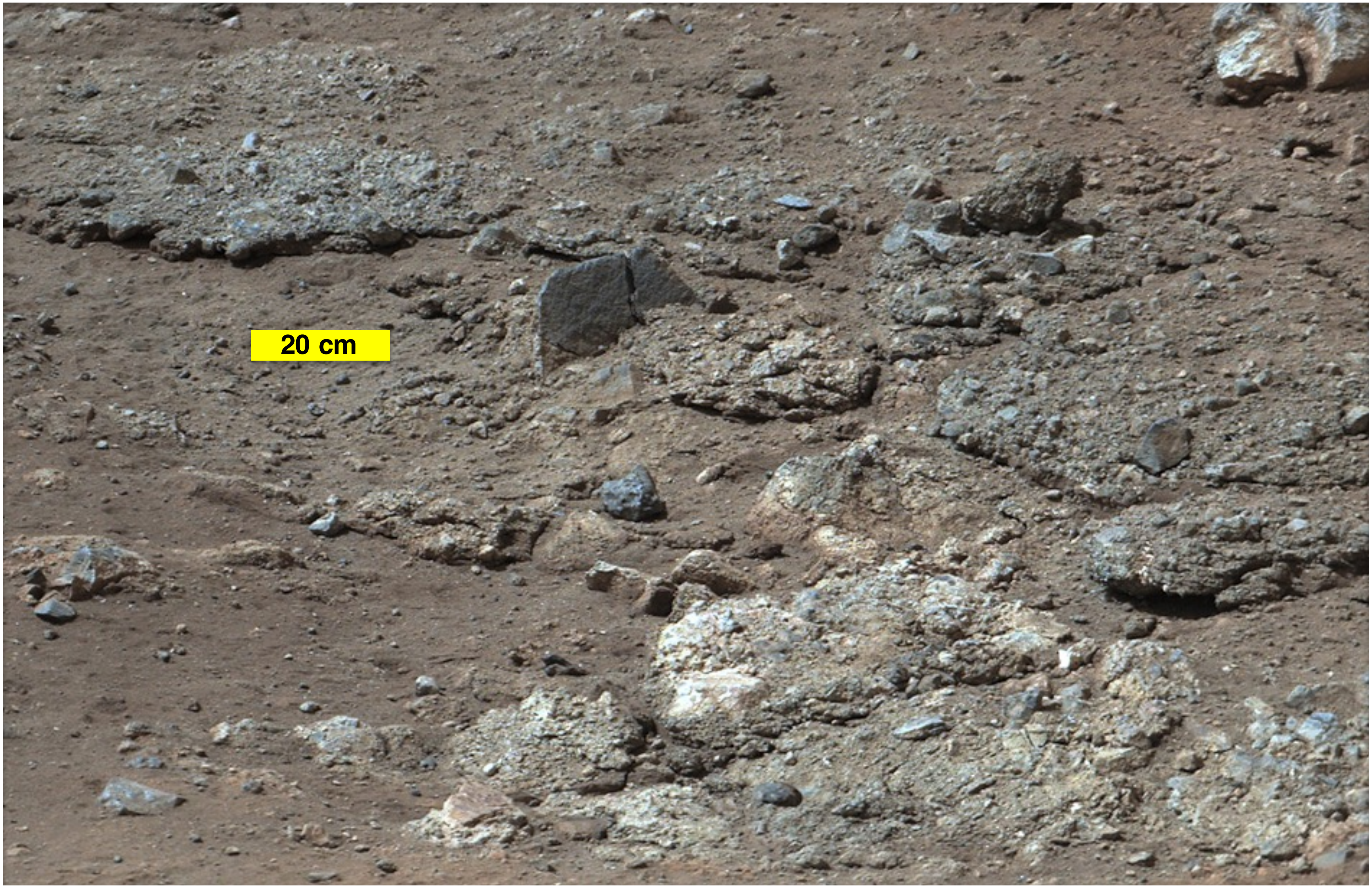


Curiosity rover – September 2016

back to… Curiosity's terminal descent…



descent engines exposed conglomerates



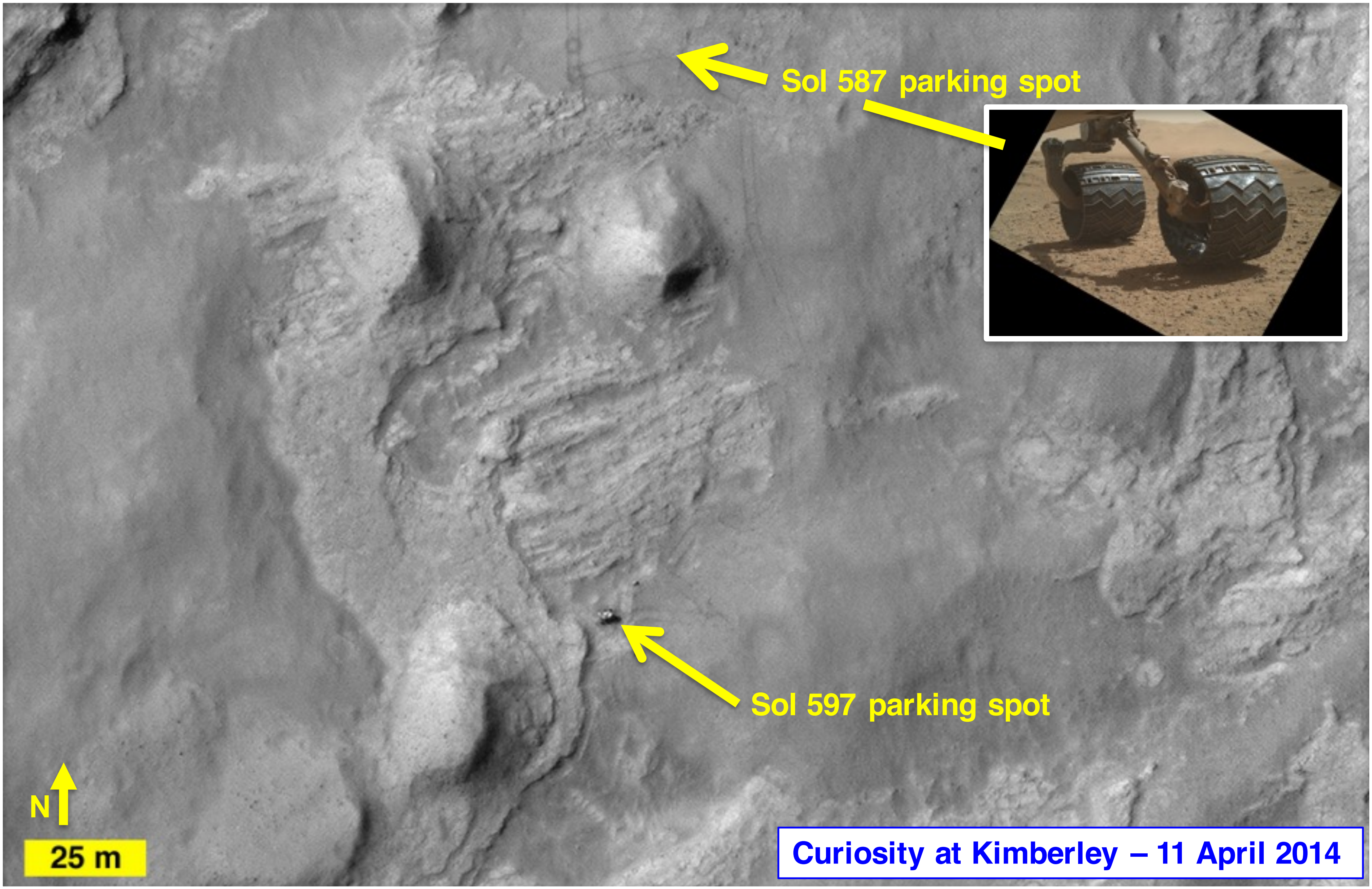
Mastcam view – Sol 13 – 19 August 2012

conglomerate – erosional expression

Imaged at Sol 587 parking spot

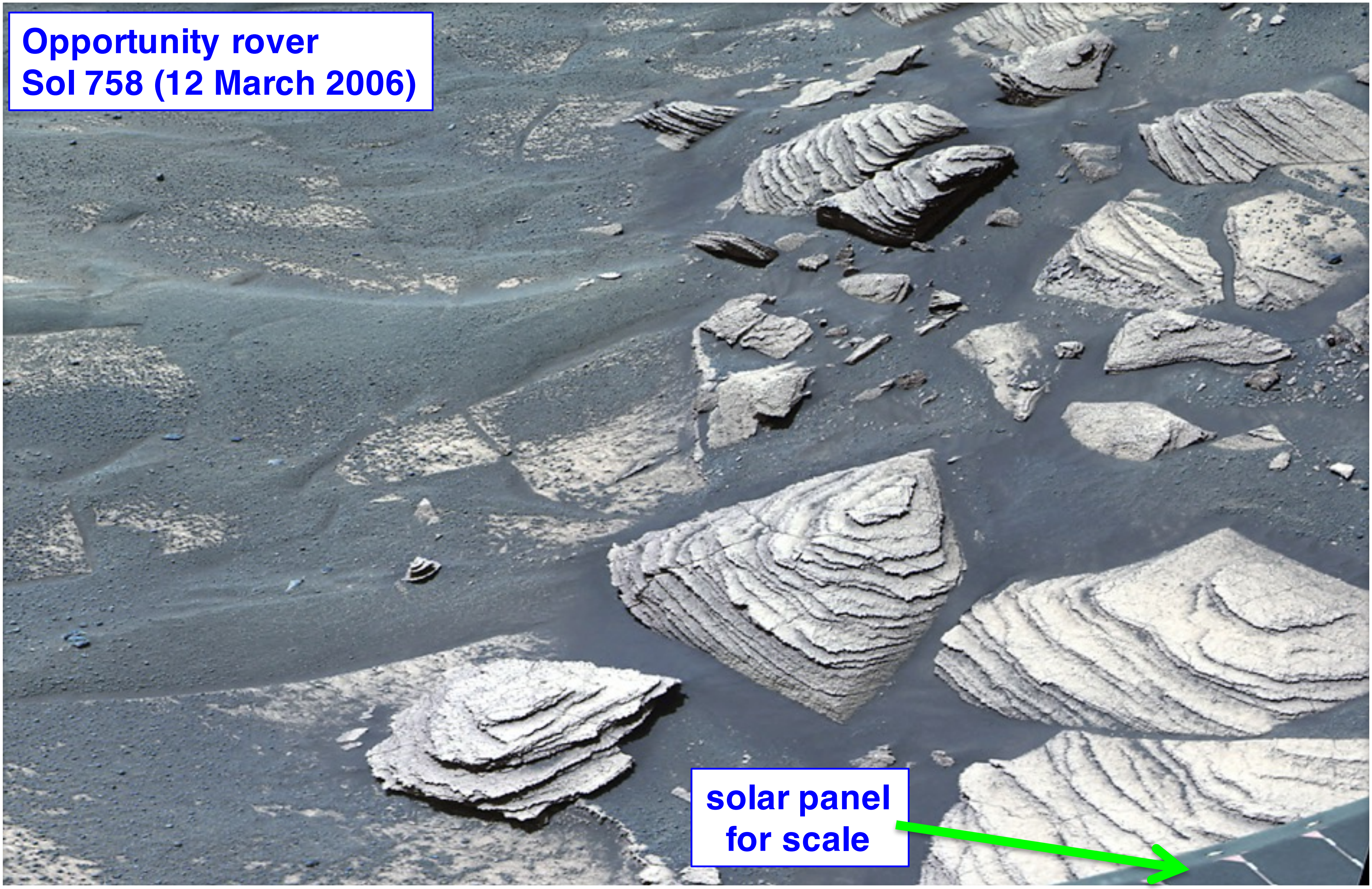
MAHLI image 0588MH0002640000203027E01

conglomerate erosional expression from above



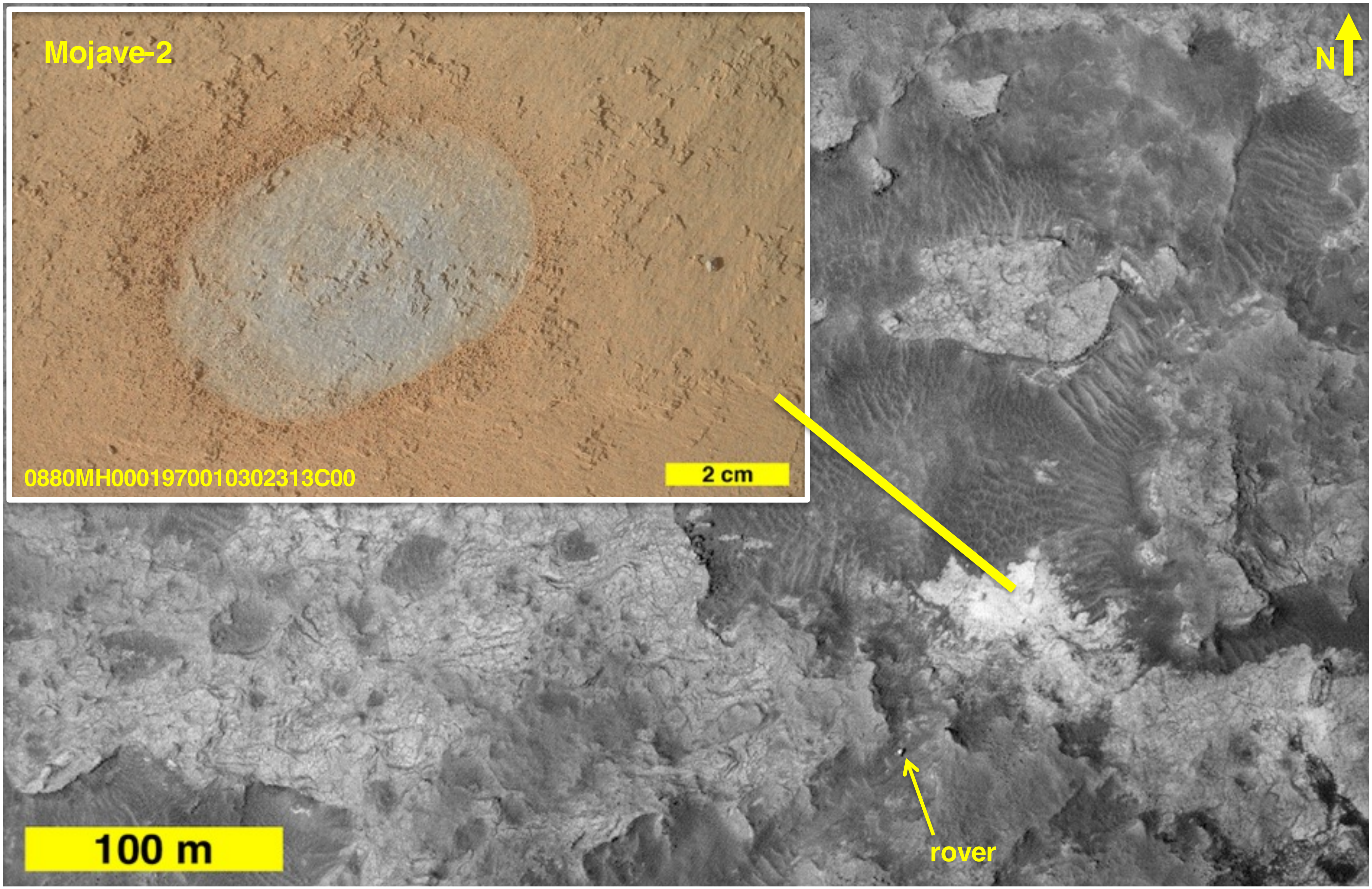
HiRISE ESP_036128_1755

the meaning of light tone



color adjusted; Pancam mosaic – target named Hokan

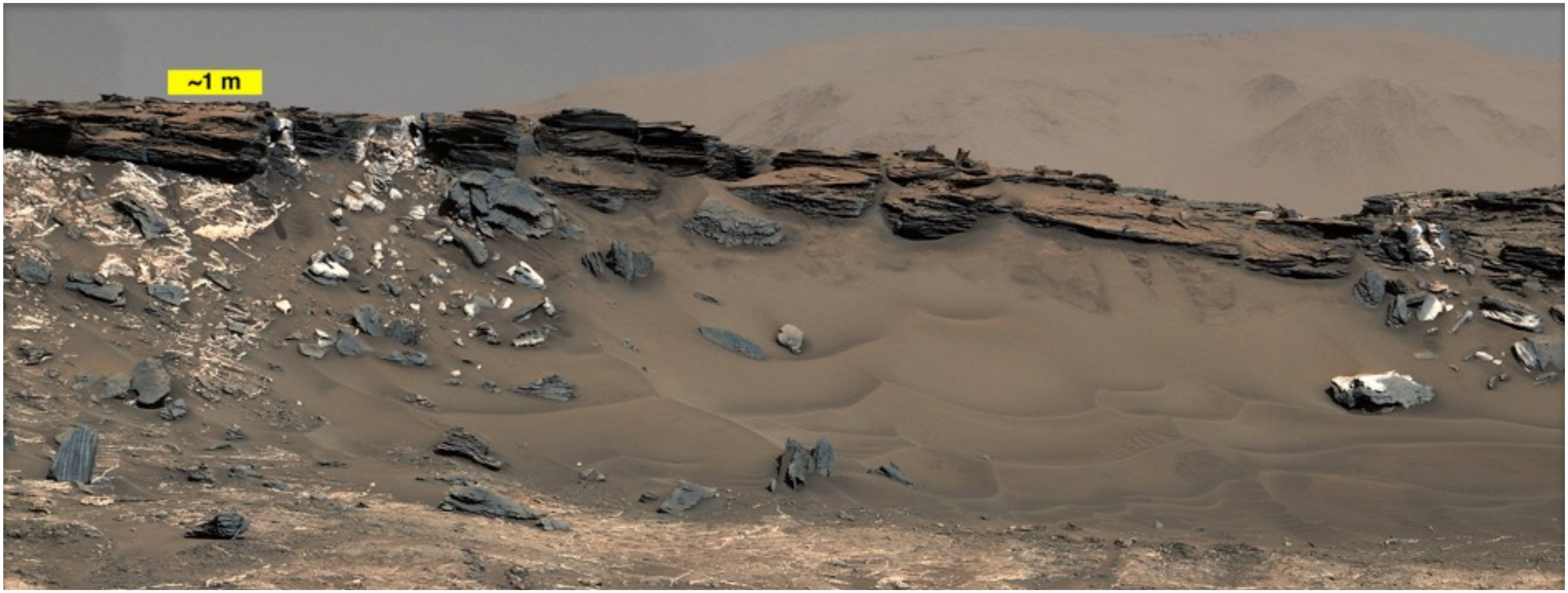
the meaning of light tone



Pahrump Hills Site – HiRISE ESP_040770_1755 8 April 2015

even more stuff learned from Curiosity…

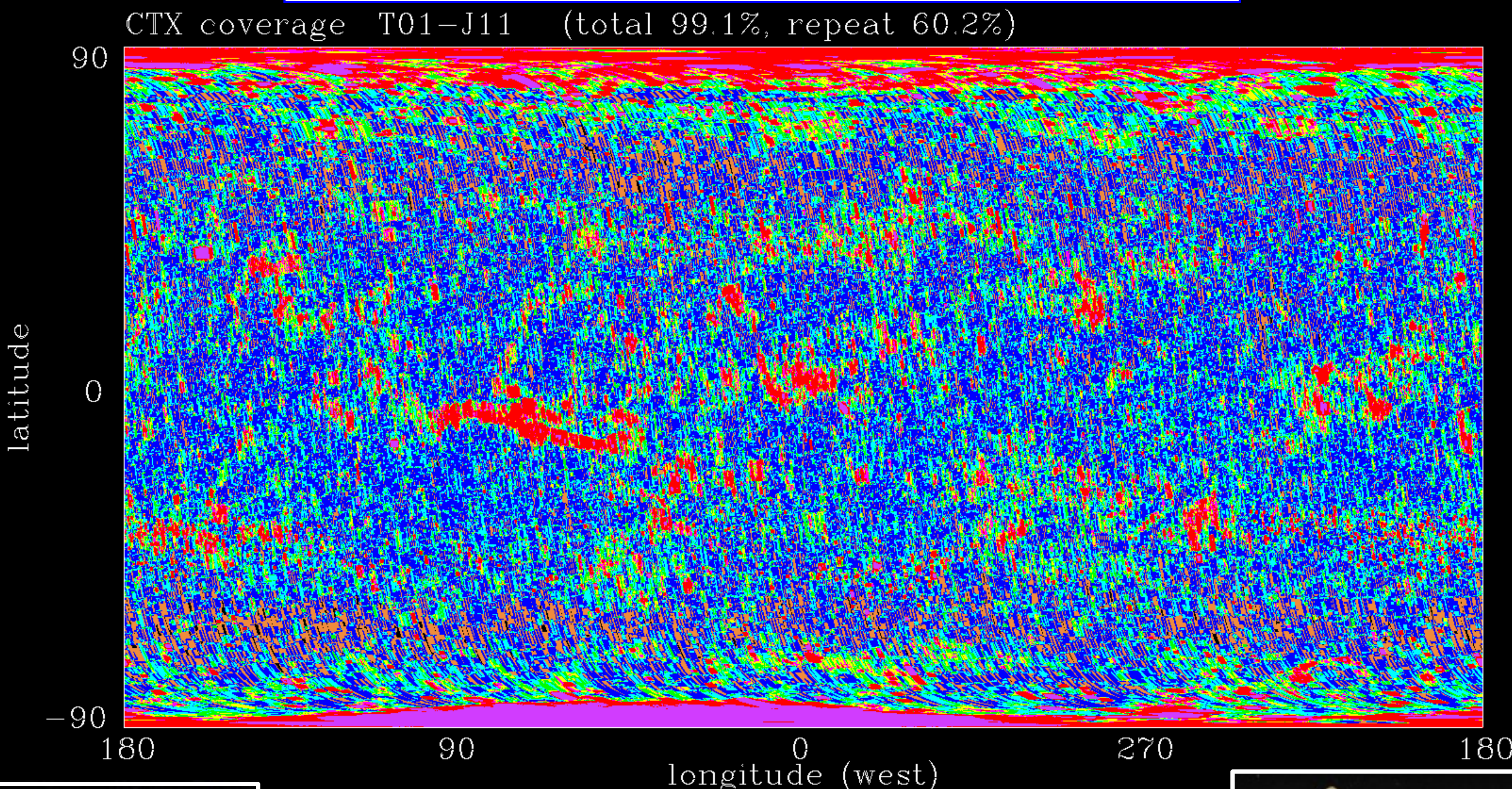
- Bedrock always at or near the surface.
- Importance of wind erosion.
- Rock type and erosion resistance influence on landscape geomorphology.
- Fracture patterns, veins, halos in sedimentary rock.



West Naukluft Plateau – Sol 1267 – Mastcam-100 mcam05931

the rest of Mars…

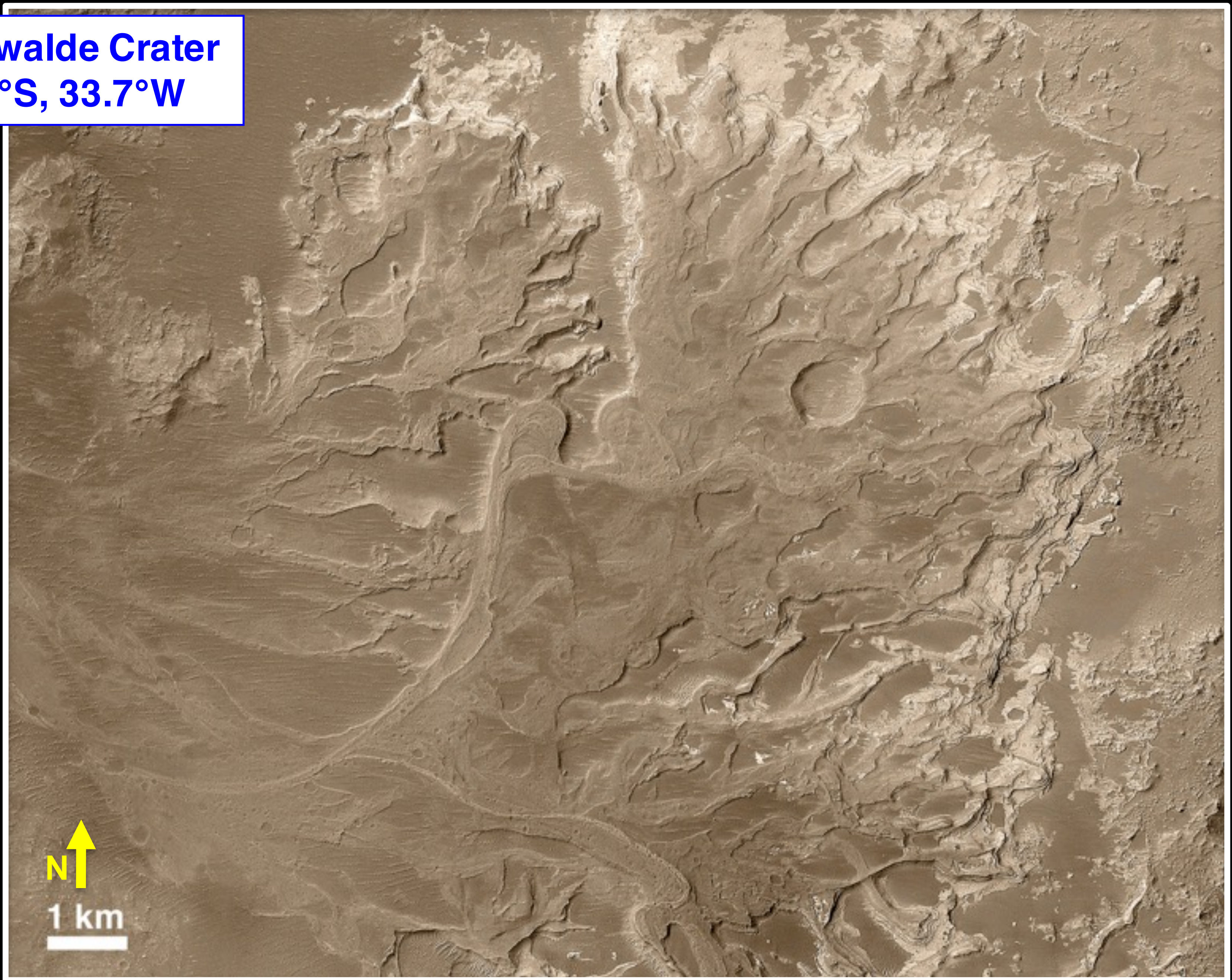
MRO CTX Coverage through January 2017



1 | 2 | 3 | 4 | 5 | 6 | >6

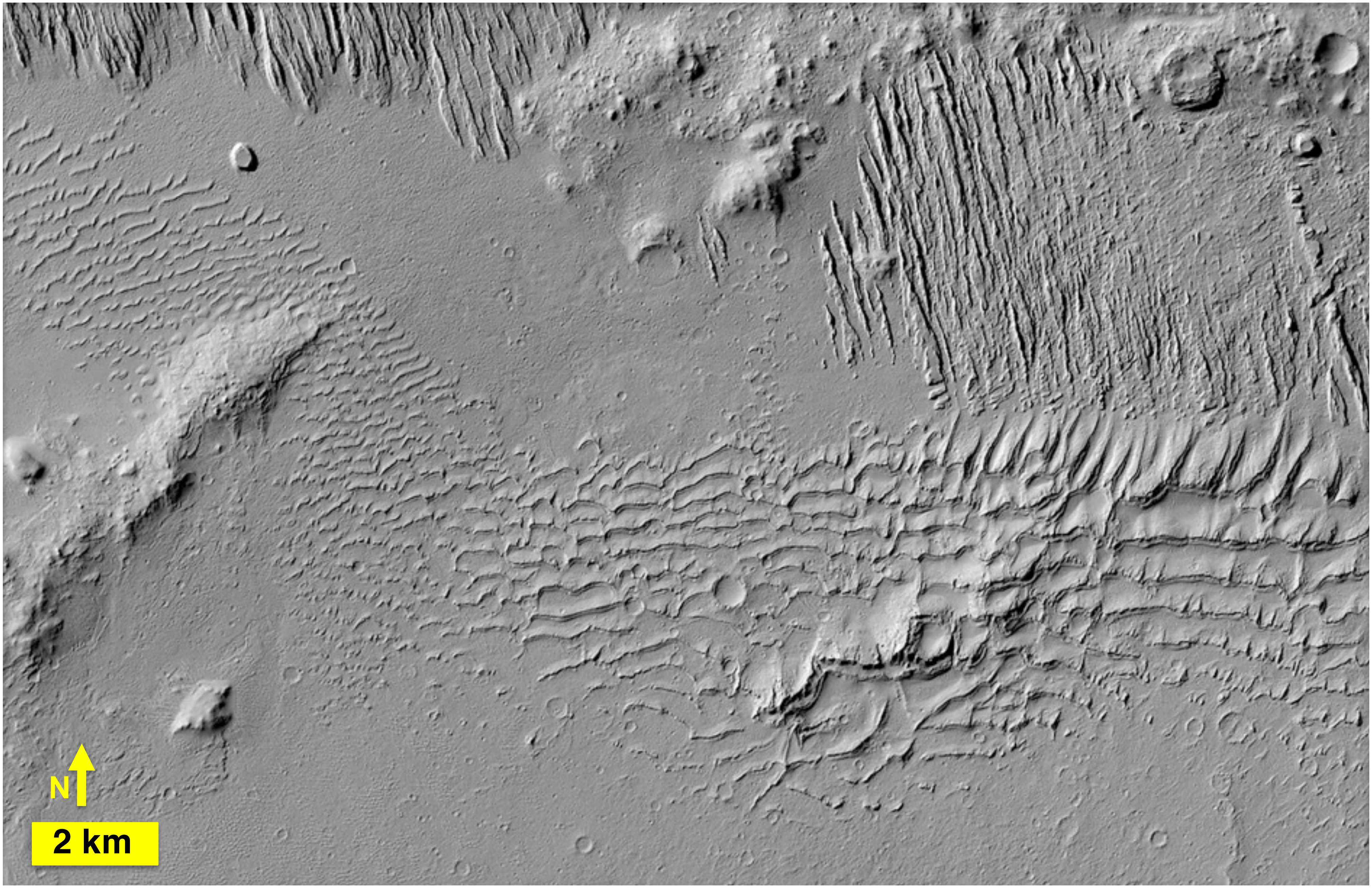
MGS MOC + MRO HiRISE + MRO CTX

depositional setting mimicry – fluvial delta



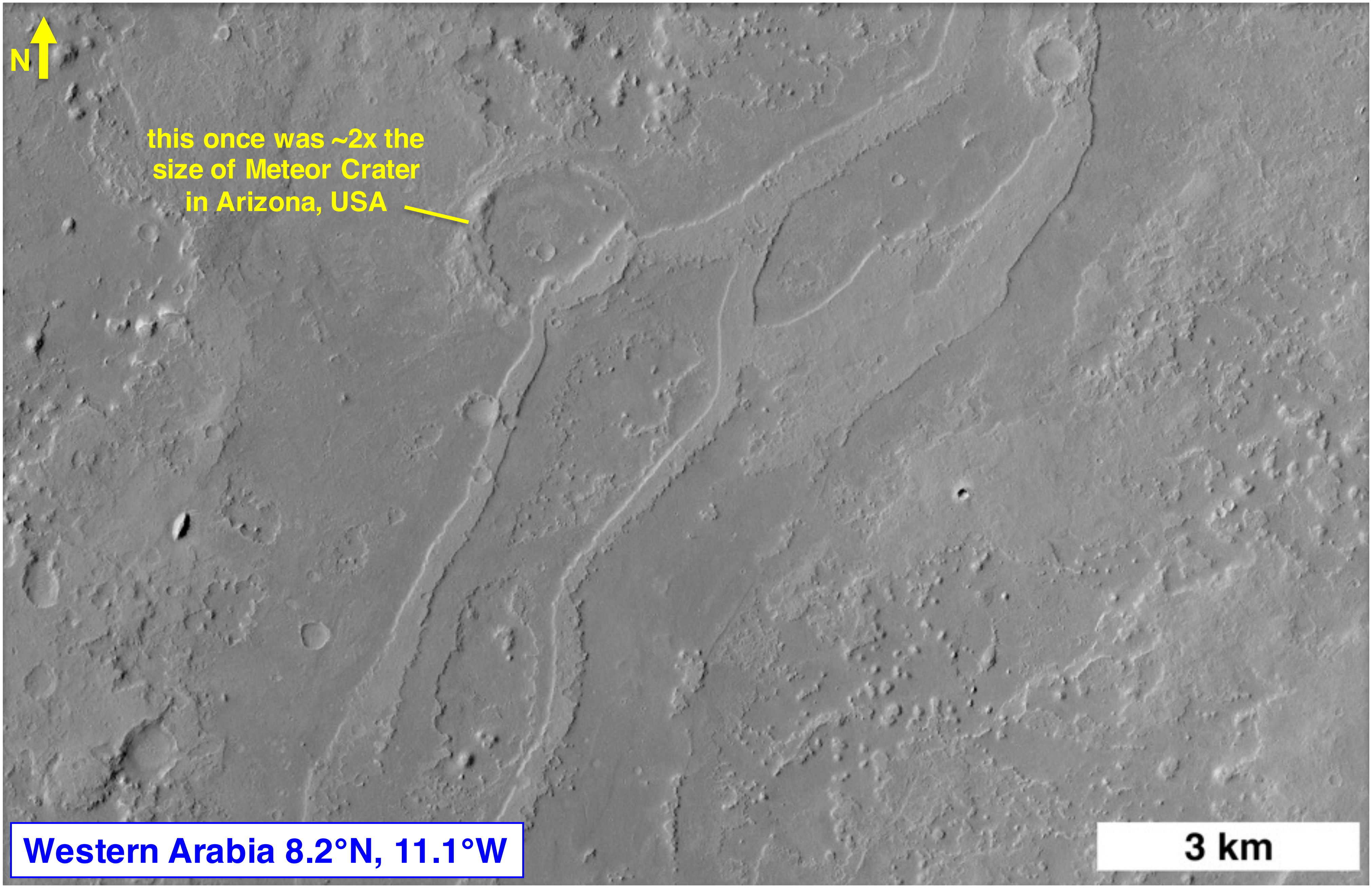
Mosaic of MOC images

depositional setting mimicry – eolian dune field

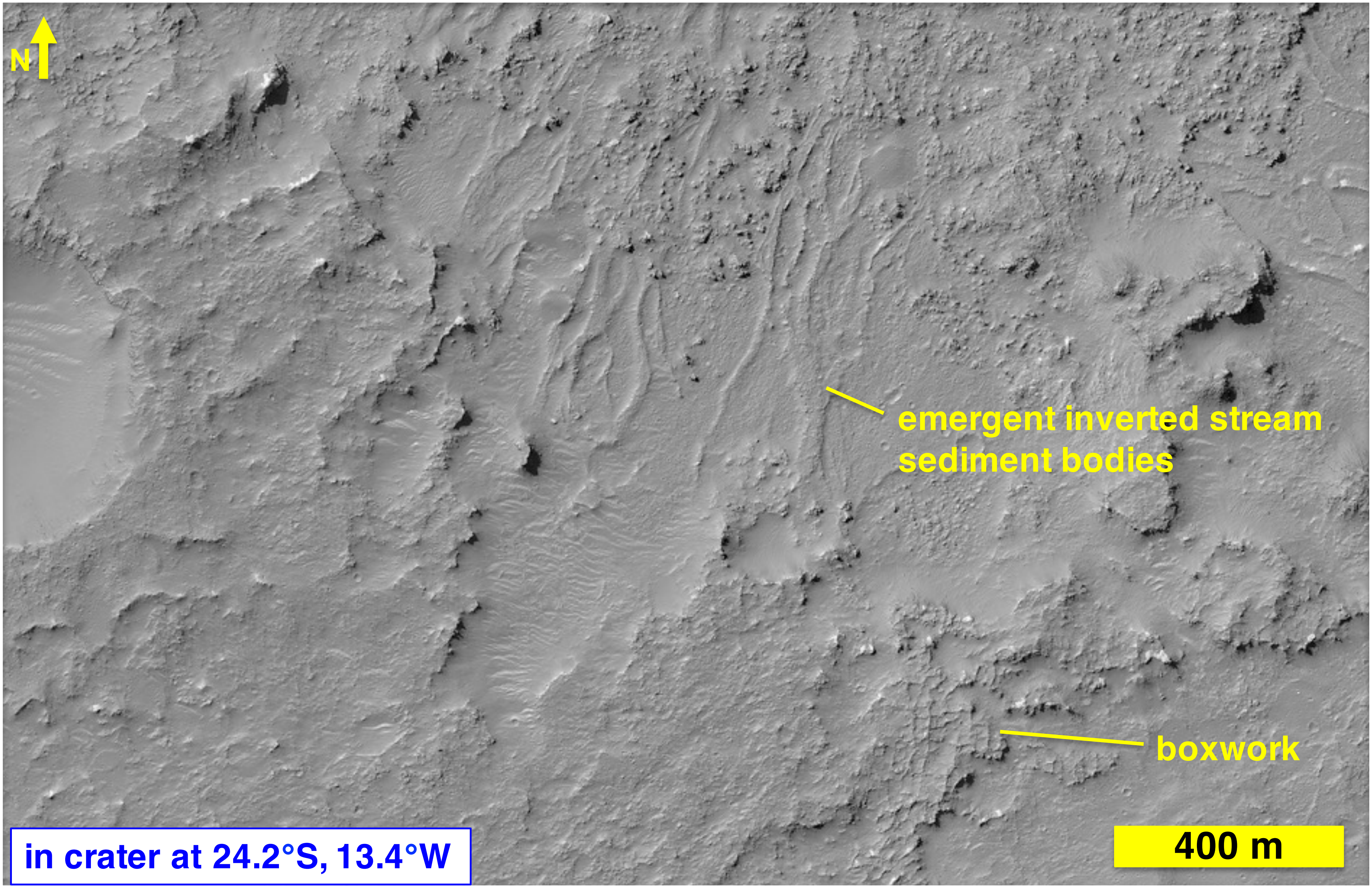


Apollinaris Sulci – CTX image P22_009609_1674_XN_12S182W

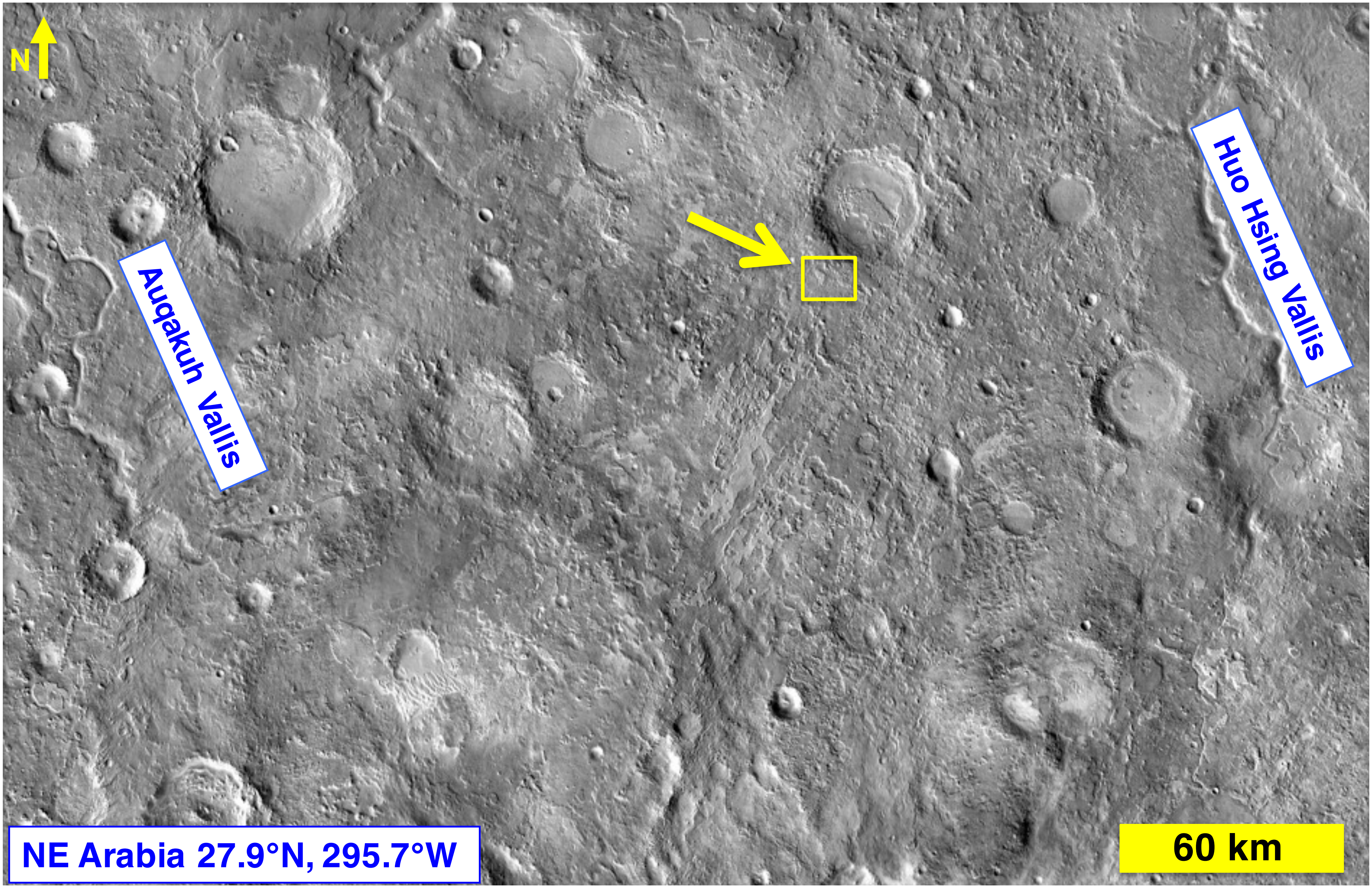
depositional setting mimicry – stream channel



depositional setting mimicry – stream channel

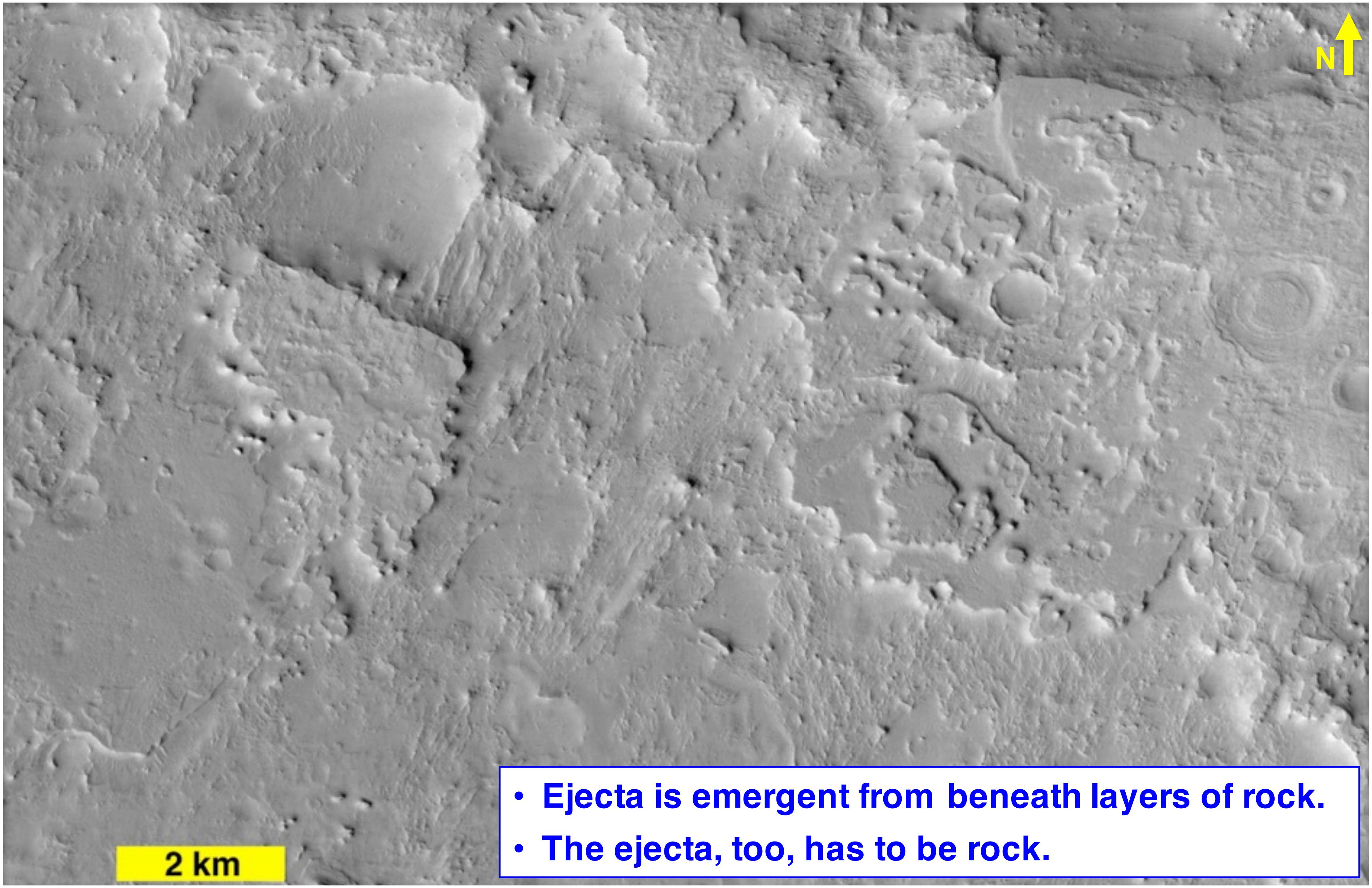


depositional setting mimicry – impact ejecta



from THEMIS IR day mosaic, Christensen, ASU

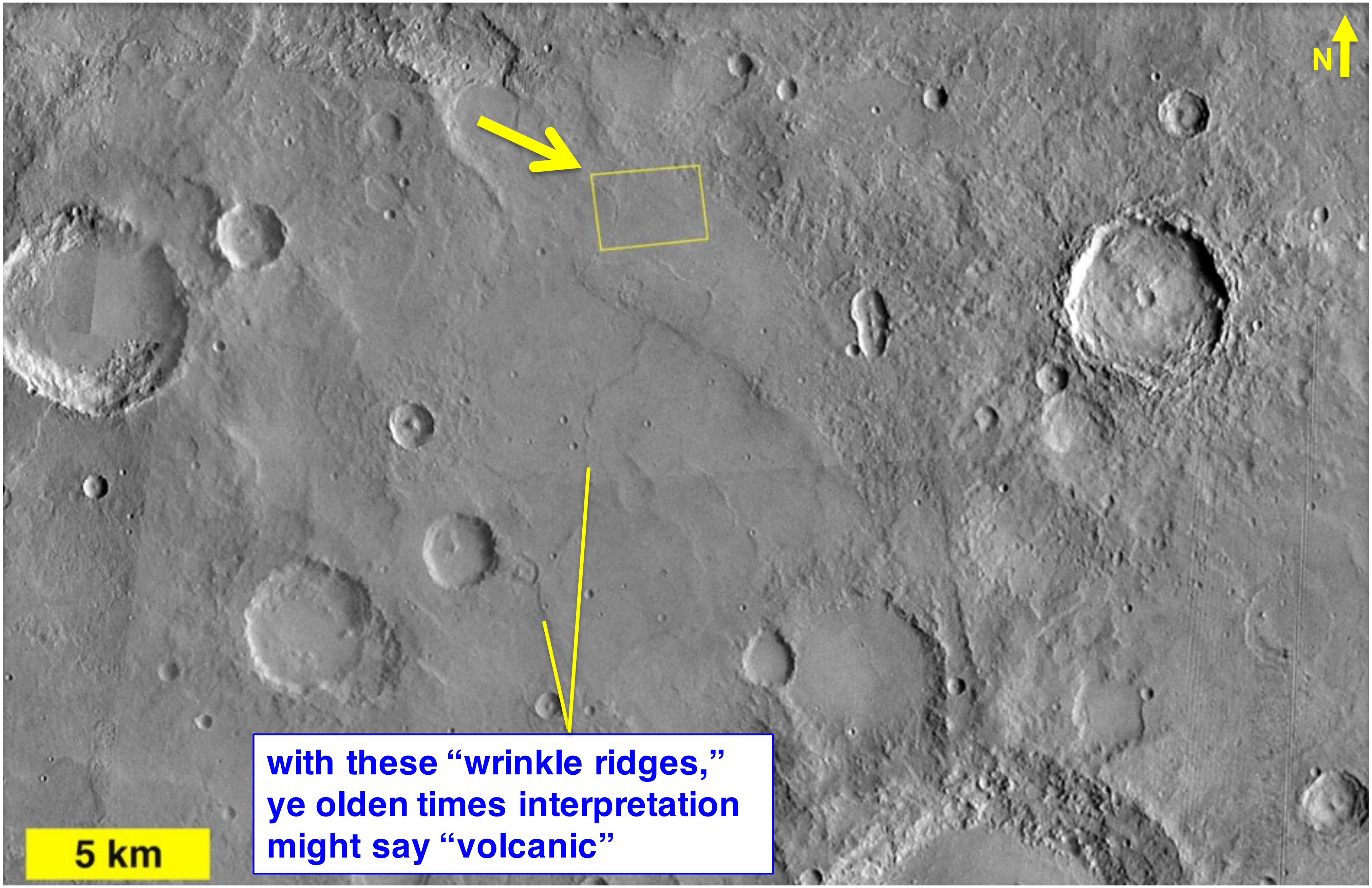
depositional setting mimicry – impact ejecta



- Ejecta is emergent from beneath layers of rock.
- The ejecta, too, has to be rock.

CTX P06_003271_2081_XI_28N295W

intercrater plains in heavily cratered terrain…

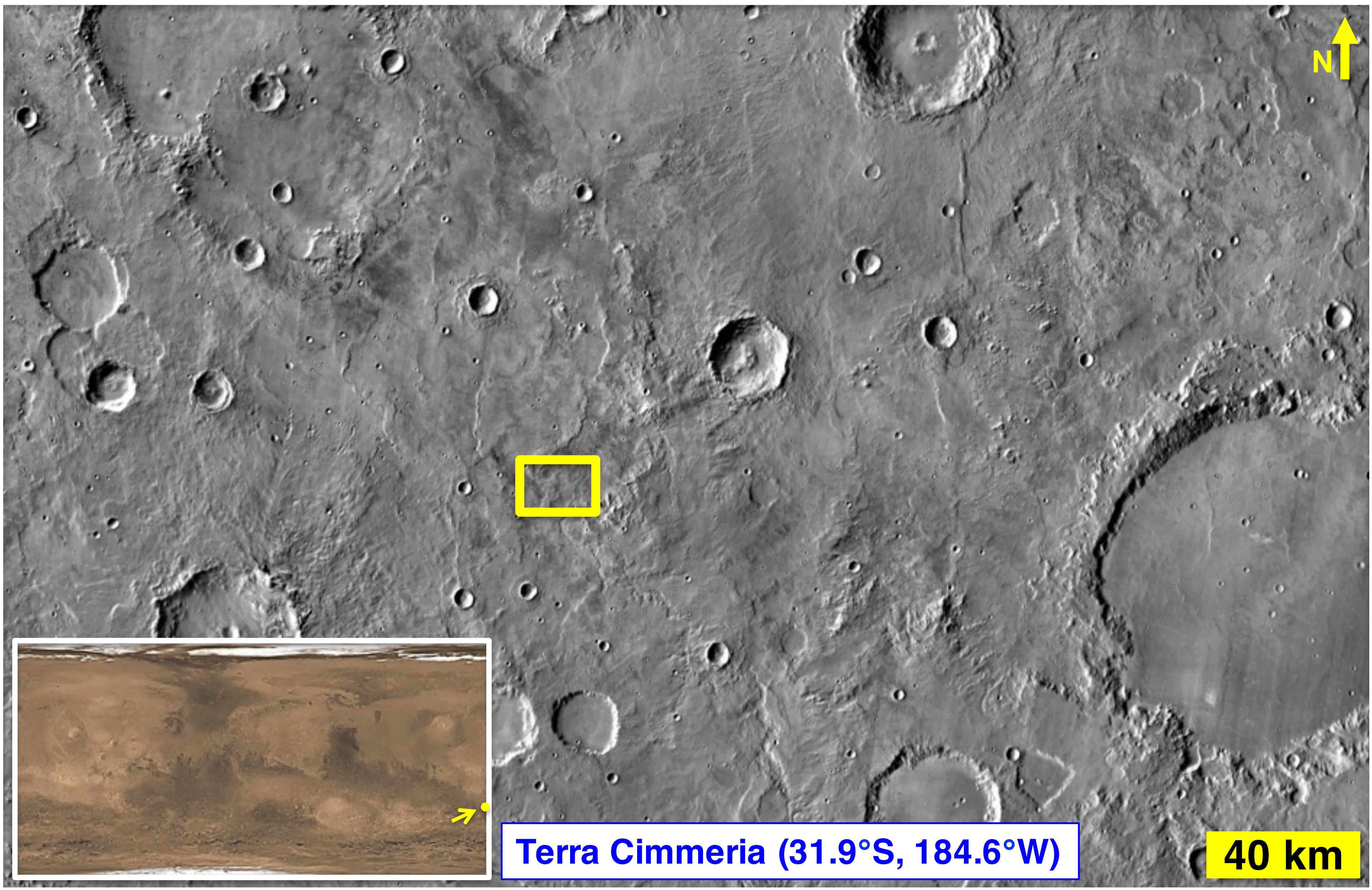


Arabia Terra – 23.1°N, 337.0°W – Viking orbiter mosaic

intercrater plains in heavily cratered terrain…

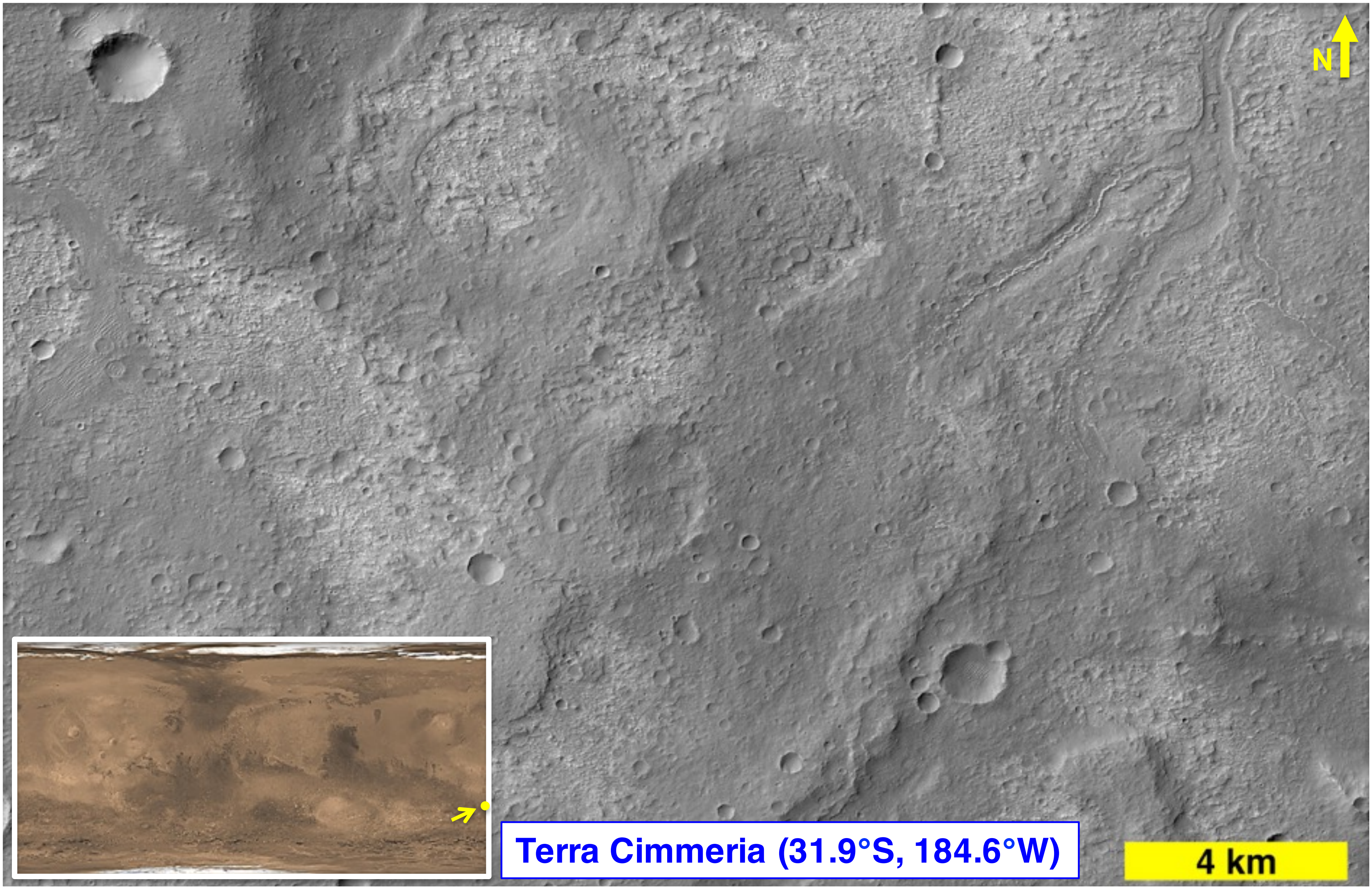
Arabia Terra – 23.1°N, 337.0°W – F23_044730_2028_XI_22N336W

examples abound in heavily-cratered terrain…



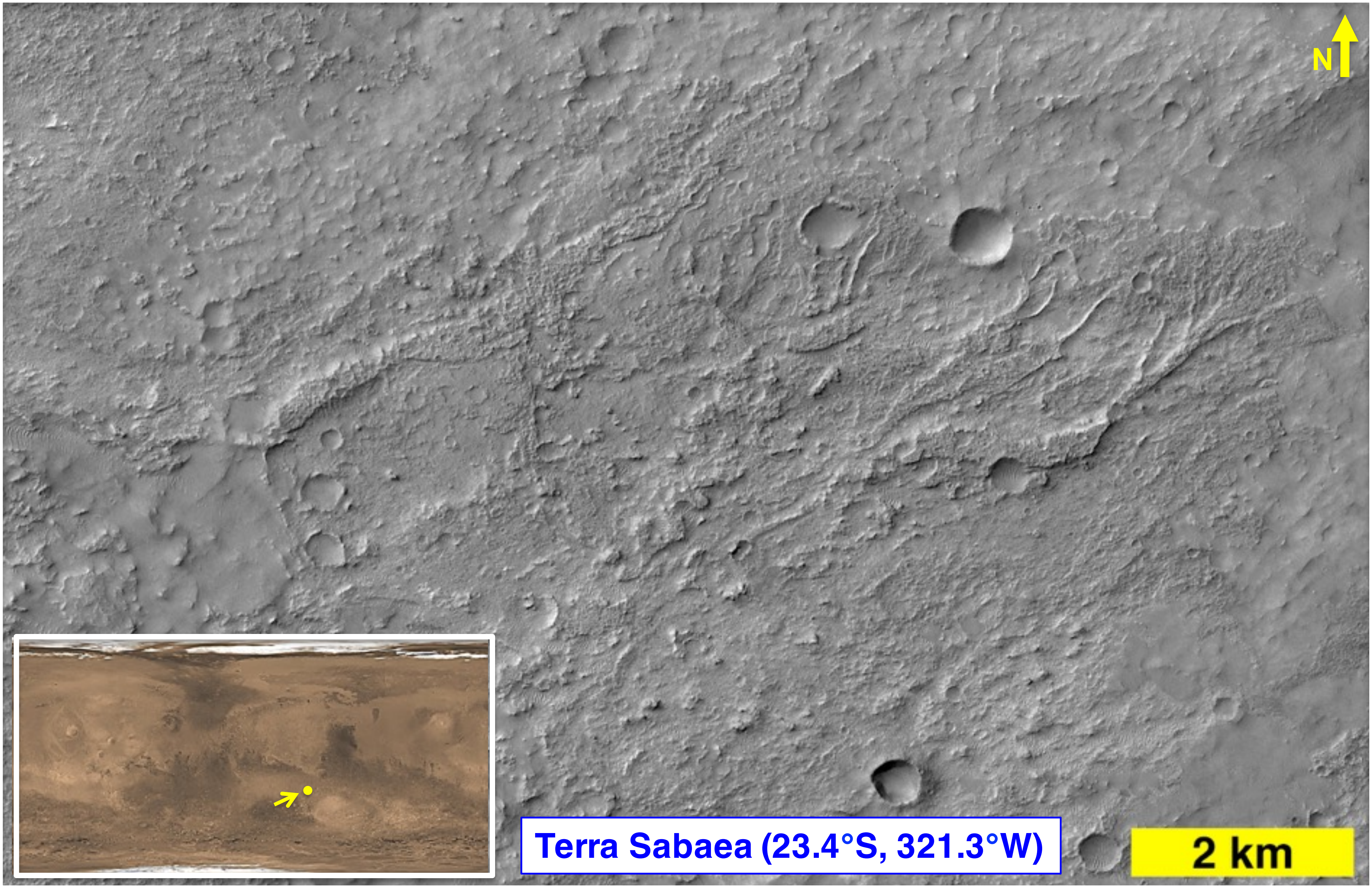
from THEMIS IR day mosaic, Christensen, ASU

examples abound in heavily-cratered terrain…



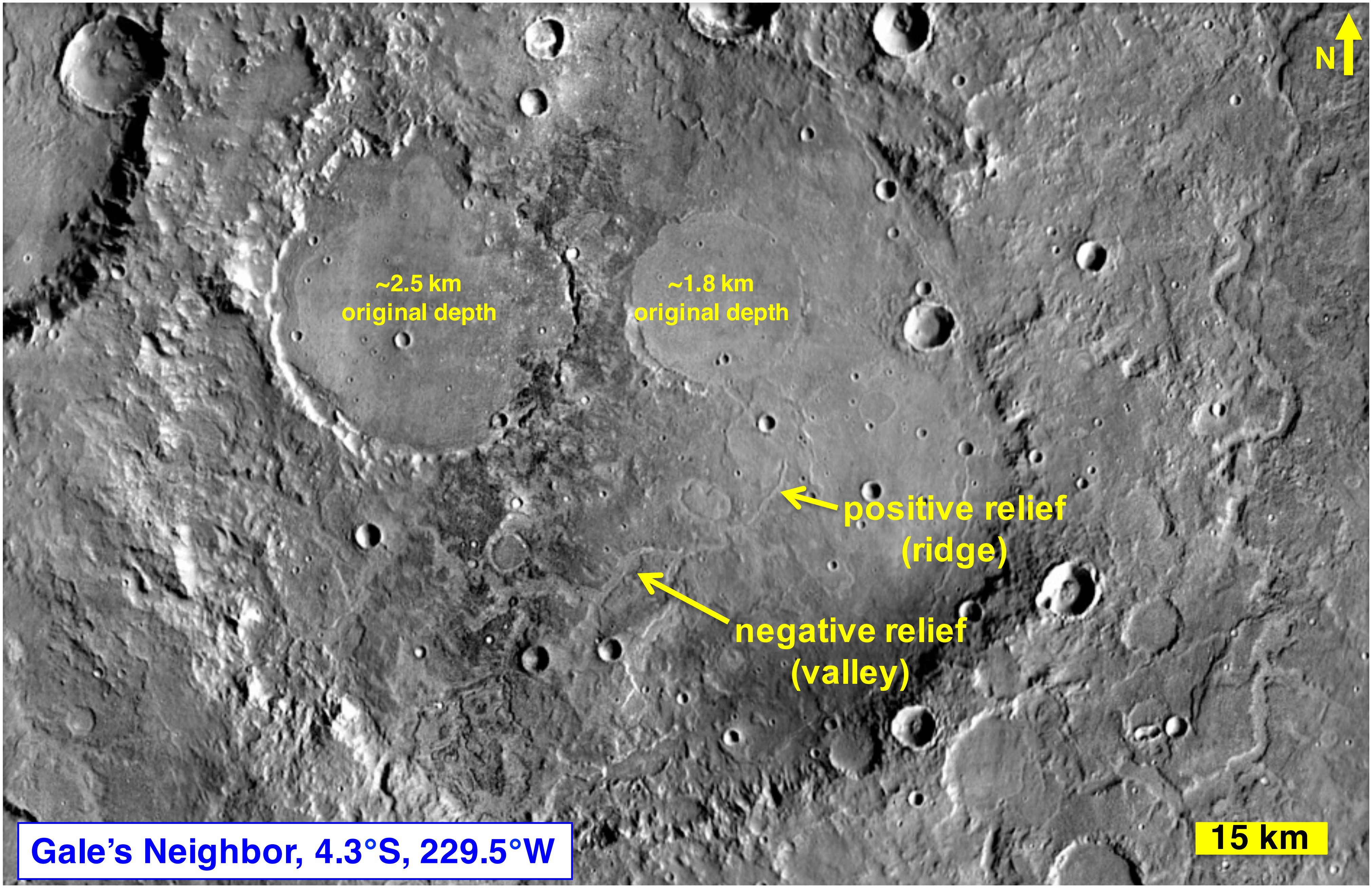
CTX P14_006590_1474_XN_32S184W & P16_007447_1470_XI_33S184W

examples abound in heavily-cratered terrain…



CTX F17_042422_1564_XI_23S321W

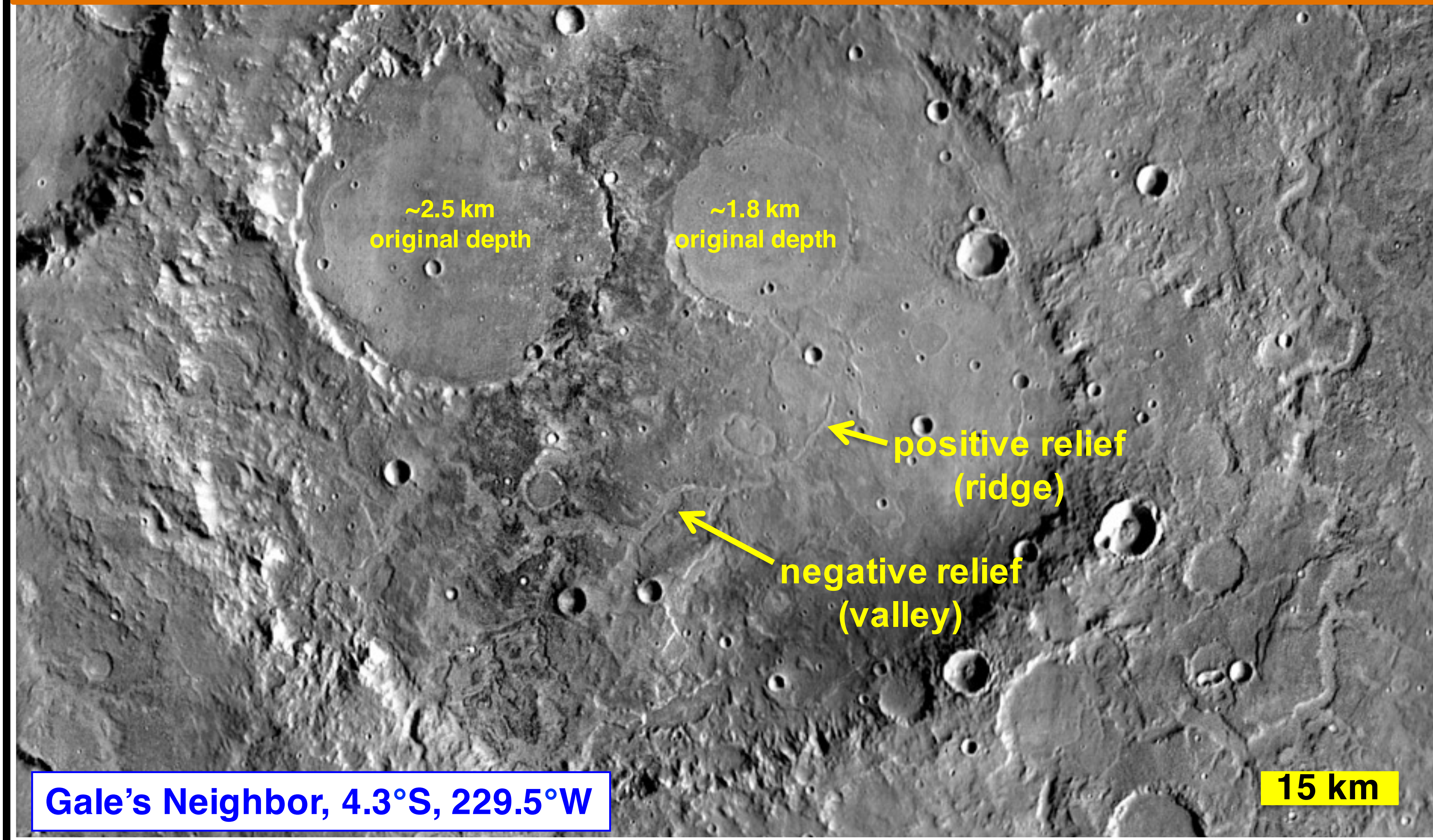
finally… always have to ask "what is missing?"



From THEMIS day IR map; ASU – DNs inverted

"what is missing?"

and "how did it go missing?"



From THEMIS day IR map; ASU – DNs inverted

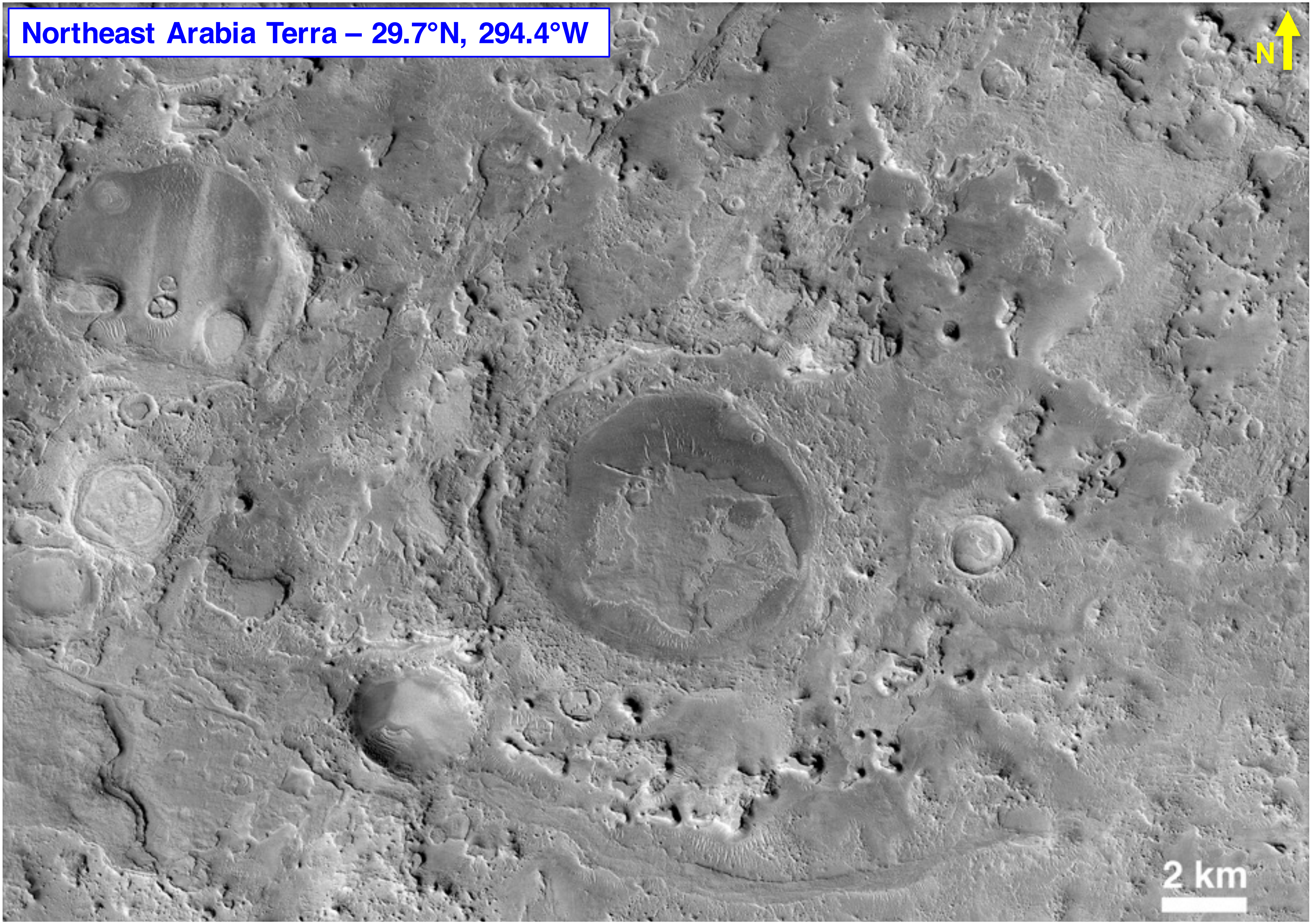
take-home messages

Mars sedimentary rock record –

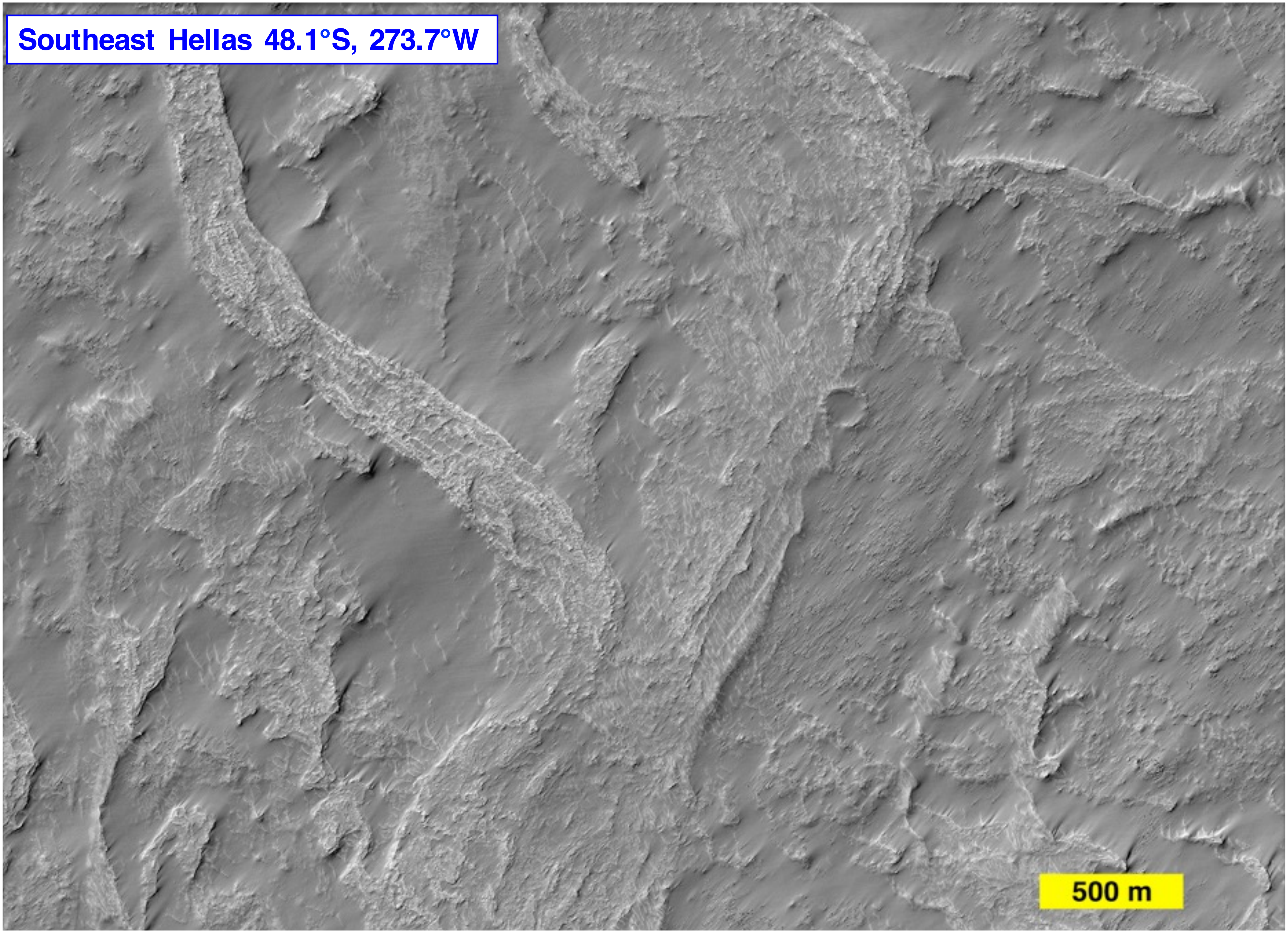
- the last 16 years focused on most obvious sub-set
- new observations → new interpretation capabilities
- still <u>building</u> <u>the</u> <u>foundation</u>
  - how to recognize examples missed for 16+ years
  - role in landscape evolution
  - always ask, "what is missing?" – and how did stuff go missing?
  - Curiosity & Opportunity landscape observations suggest rocks are at and near the surface
- burden of proof may have shifted – what you see might be sedimentary until demonstrated otherwise

Sol 549 – 21 February 2014

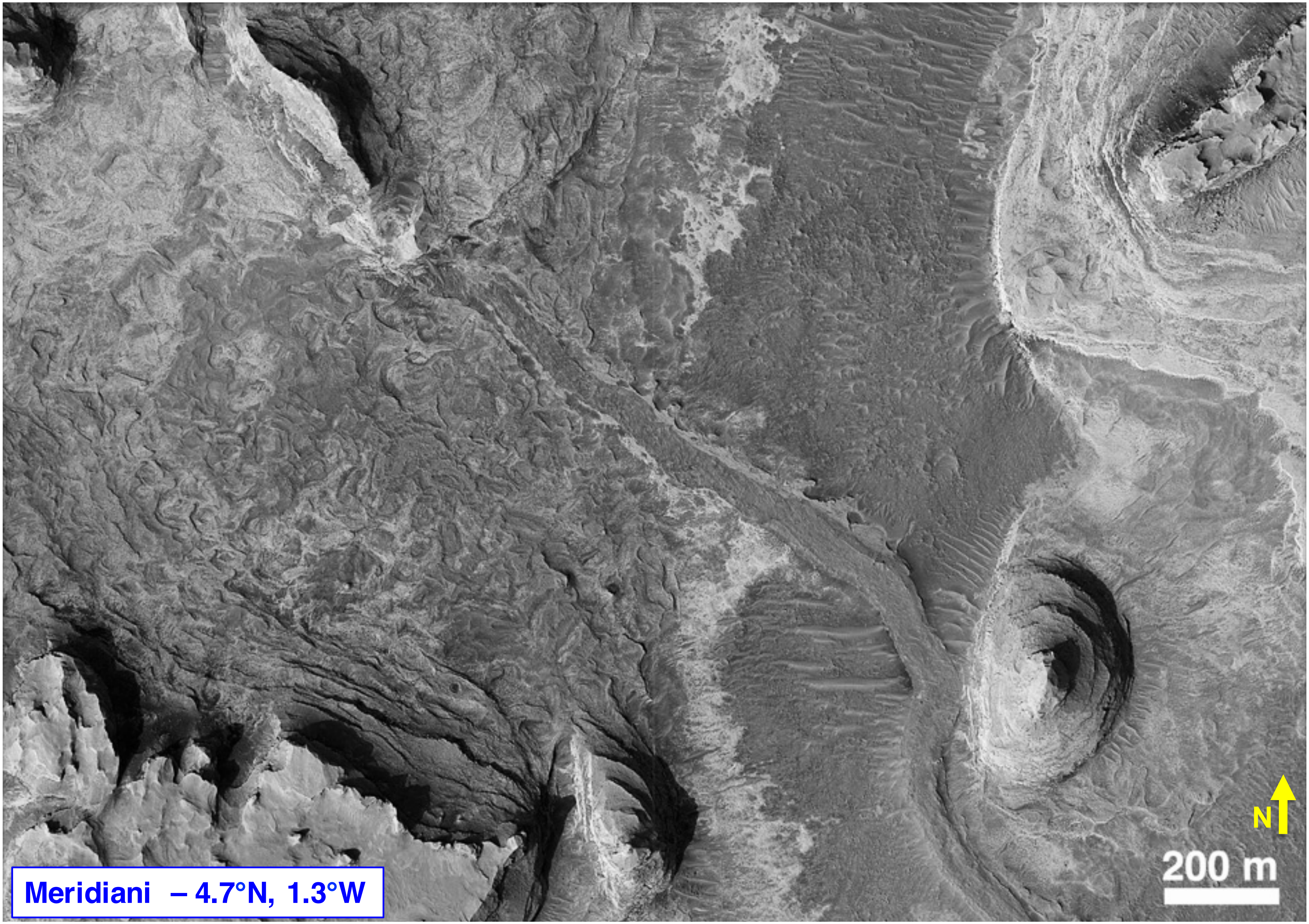
→ ADDITIONAL FIGURES / BACKUP



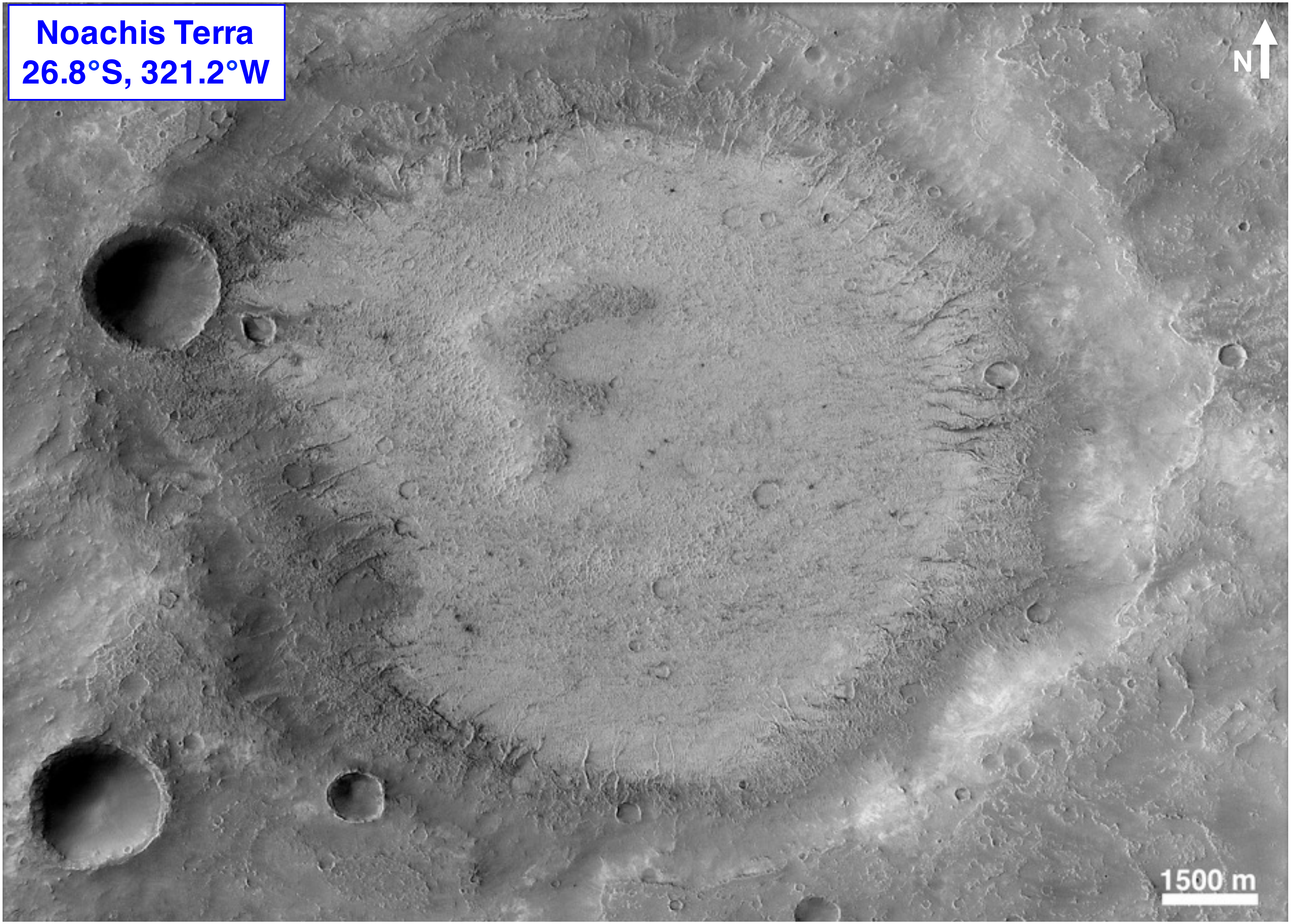
CTX P13_006185_2116_XN_31N294W & P07_003917_2072_XN_27N294W

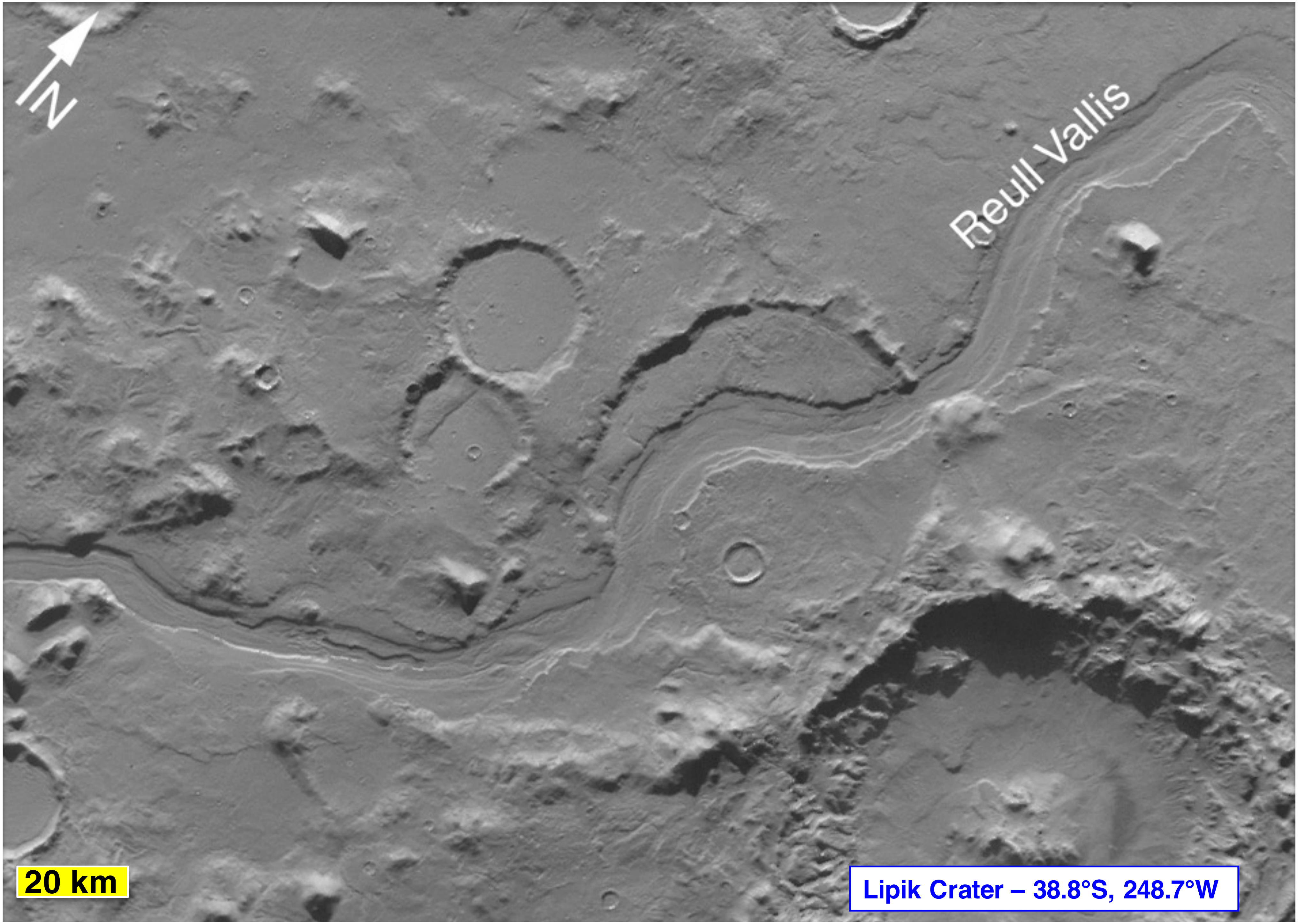


From HiRISE ESP_032293_1320



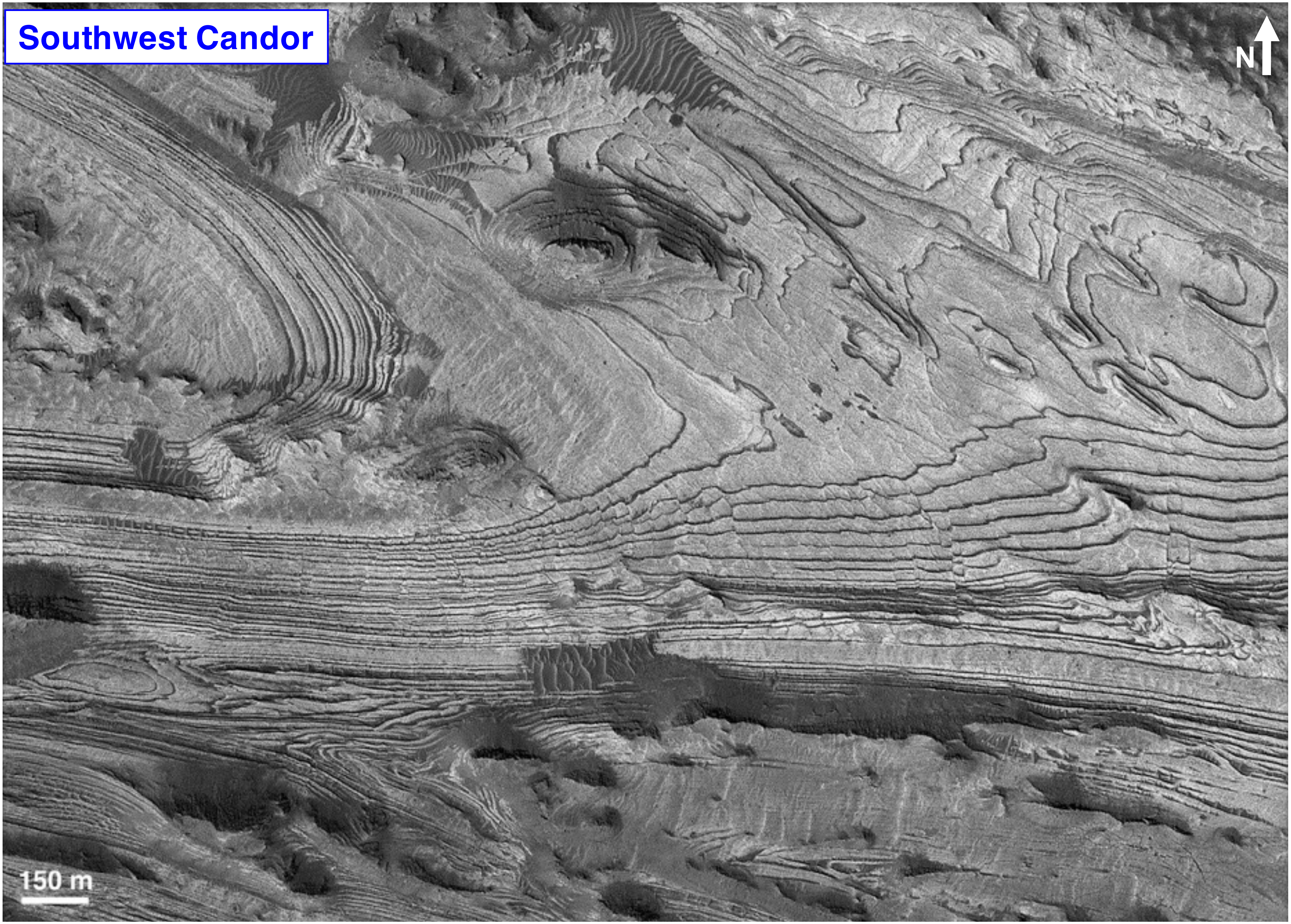
HiRISE image PSP_004091_1845


Noachis Terra
26.8°S, 321.2°W
N
1500 m



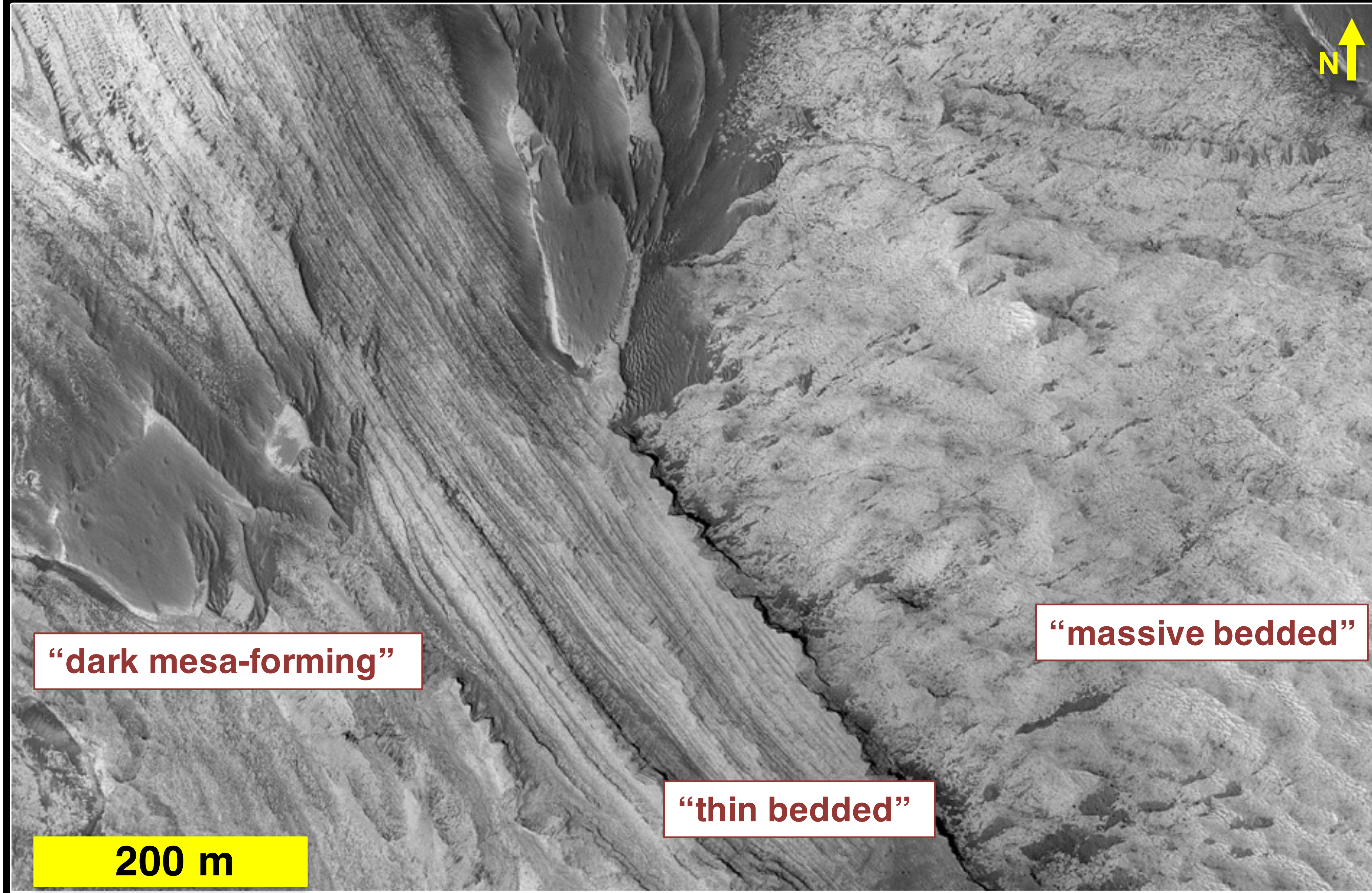
Viking 1 orbiter image 413S27

Southwest Candor



From MOC S10-00653

typical – light-tone, layered, few impact craters

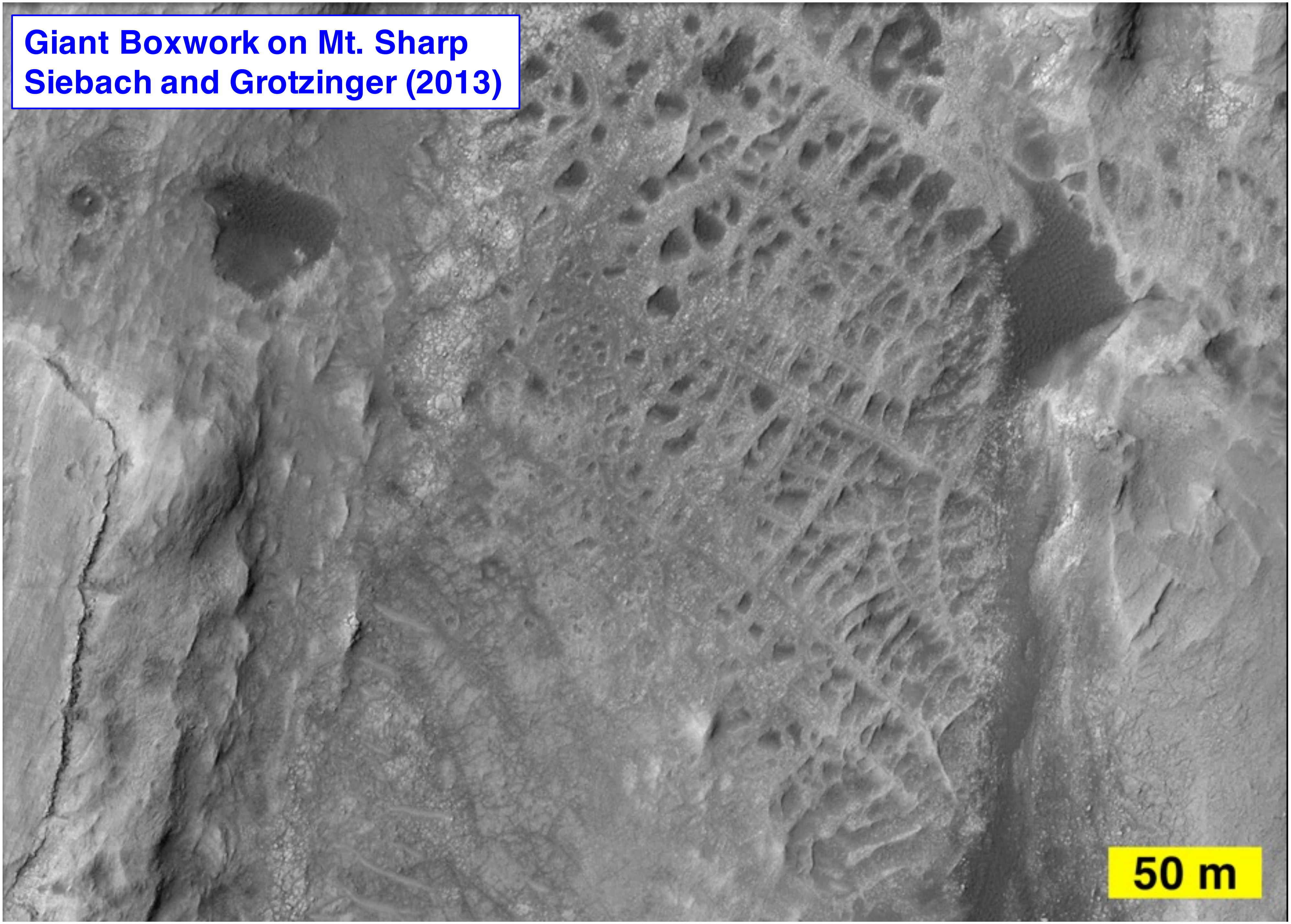


Tithonium Chasma – 4.9°S, 89.8°W – HiRISE PSP_005281_1750

sedimentary rock – example – pebbly sandstone

Sol 400 – 21 September 2013

Giant Boxwork on Mt. Sharp
Siebach and Grotzinger (2013)



from HiRISE PSP_001752_1750

Garden City – Sol 926 – 15 March 2015 – Mastcam-34