

Mars: Past, Present, and Future

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NASA Solar System Ambassador



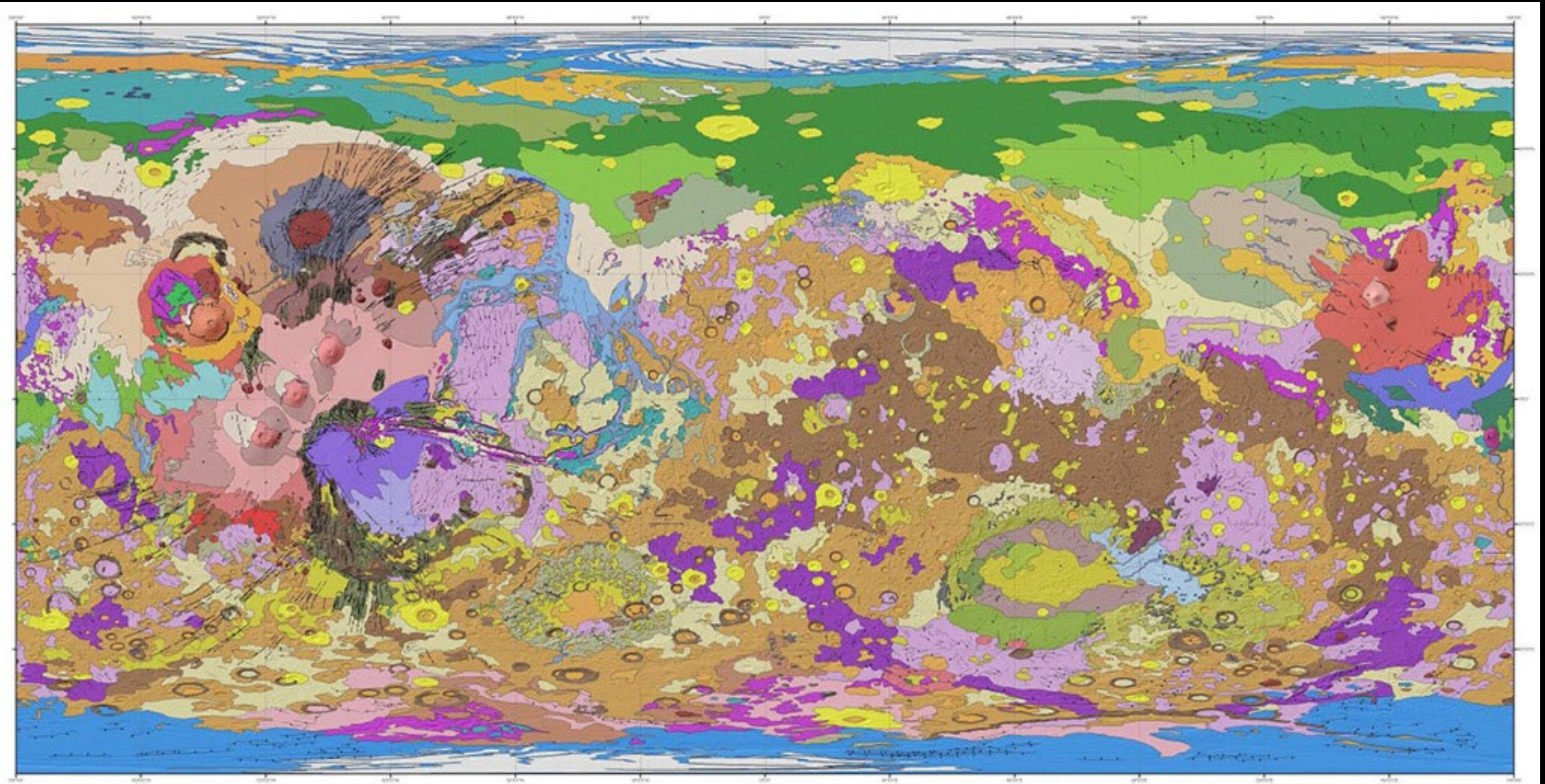
A little about Mars...



A little about Mars...

- Terrestrial (rocky) planet
- About half the size of Earth
- -230° to 70° Fahrenheit
- Lots of geology!
- No magnetic field
- Thin atmosphere
- 1 sol = 24 hours, 37 minutes
- 1 year = 687 days





Tanaka, 2011

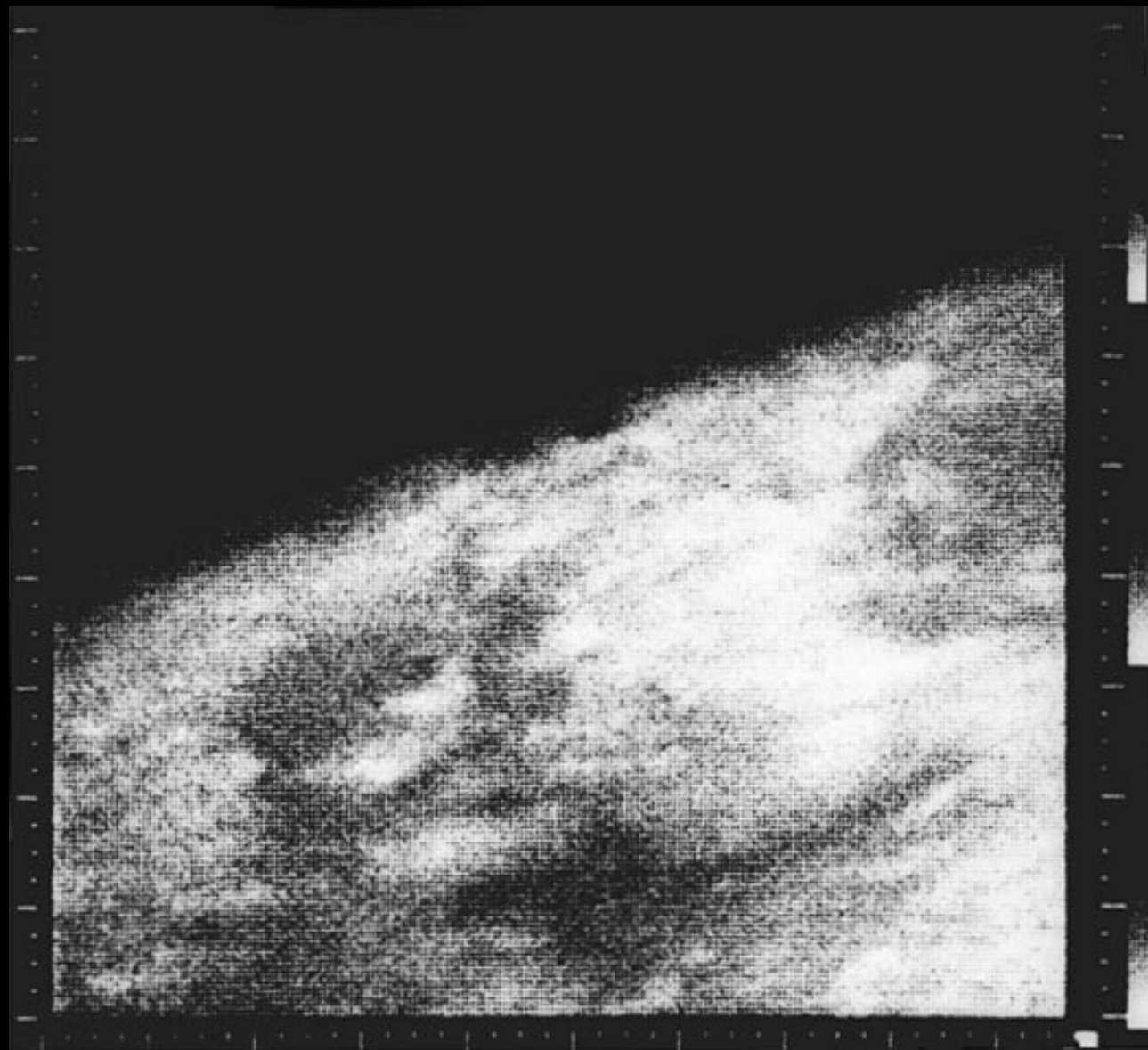
How many missions?

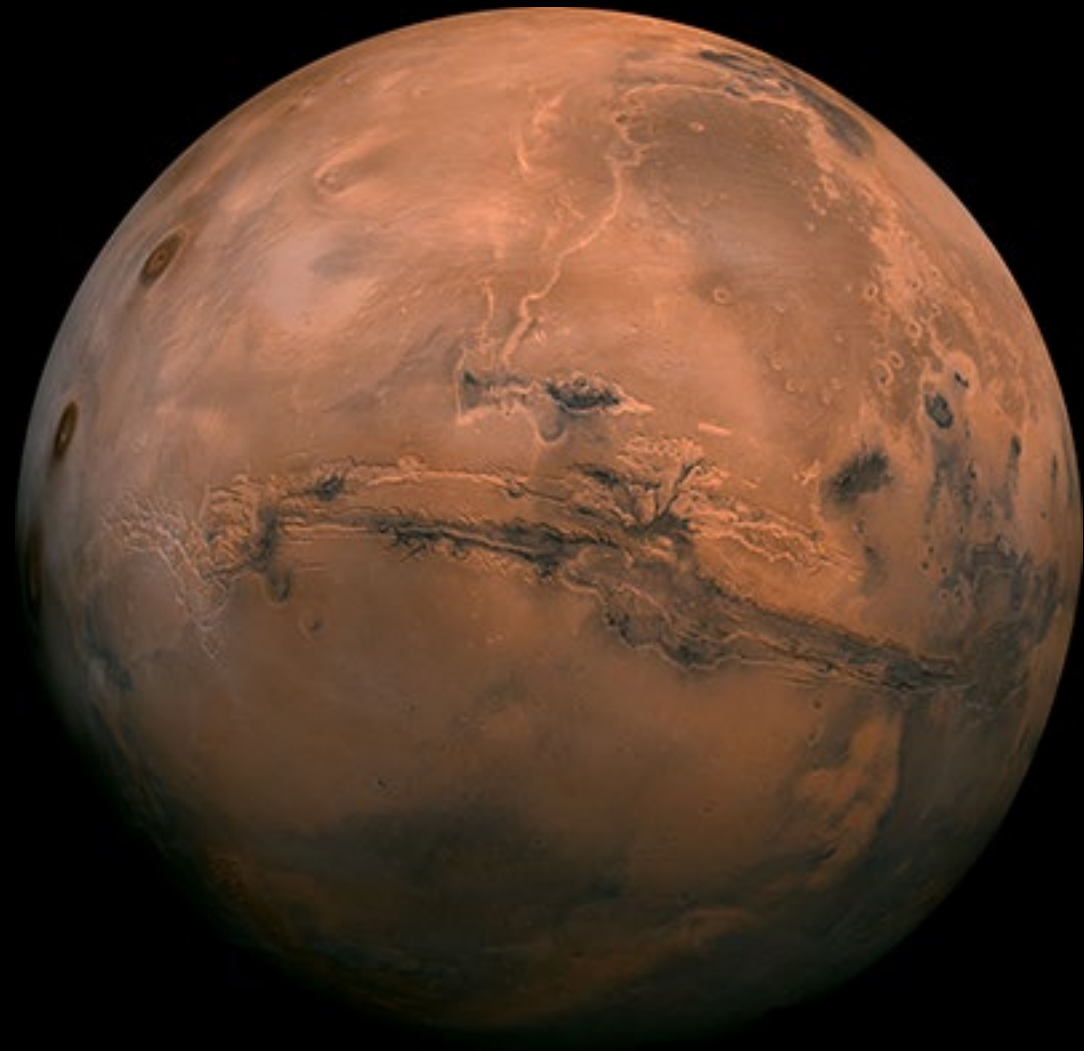
Missions

- Flybys:
 - Mariner 4
 - Mariner 6, 7
- Orbiters:
 - Mariner 8, 9
 - Viking 1,2
 - Mars Observer
 - Mars Global Surveyor
 - Mars Climate Orbiter
 - 2001 Odyssey
 - Mars Express (ESA)
 - Mars Reconnaissance Orbiter
 - Mars Atmosphere and Volatile Evolution (MAVEN)
 - Hope (UAE)
 - Tianwen-1 (CNSA)
- Landers & Rovers
 - Viking 1, 2
 - Pathfinder & Sojourner
 - Polar Lander
 - Mars Exploration Rovers (Spirit, Opportunity)
 - Phoenix
 - Mars Science Laboratory (Curiosity)
 - Perseverance

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How do we know what
kinds of minerals and
rocks?

Mineralogy & Petrology

- Fundamentally an igneous planet
- Minerals crystallize from magma

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- Mineral data from rovers and orbiters
 - THEMIS, TES, Mini-TES, CRISM, APXS, OMEGA

Mineralogy & Petrology

- Fundamentally an igneous planet
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- Mineral data from rovers and orbiters
 - THEMIS, TES, Mini-TES, CRISM, APXS, OMEGA
- Similar mineralogy to Hawaiian and Icelandic volcanoes
- Some mineral mysteries from meteorites

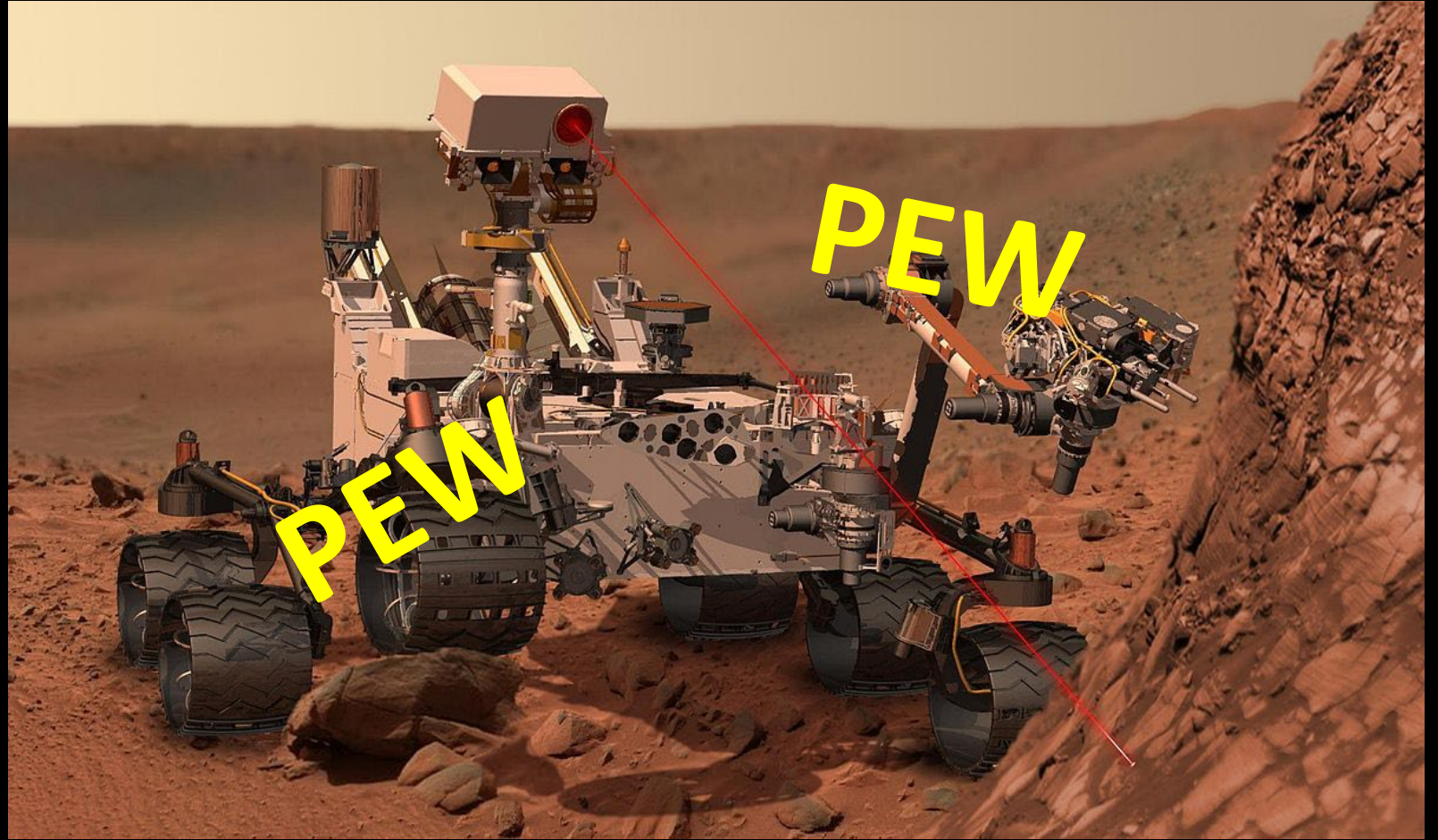
Mars Reconnaissance Orbiter

- 2005-present
- History of water and small-scale features
- HiRISE camera
 - Best high-resolution camera to date
 - 19.7 inch aperture
 - 15-30 cm per pixel

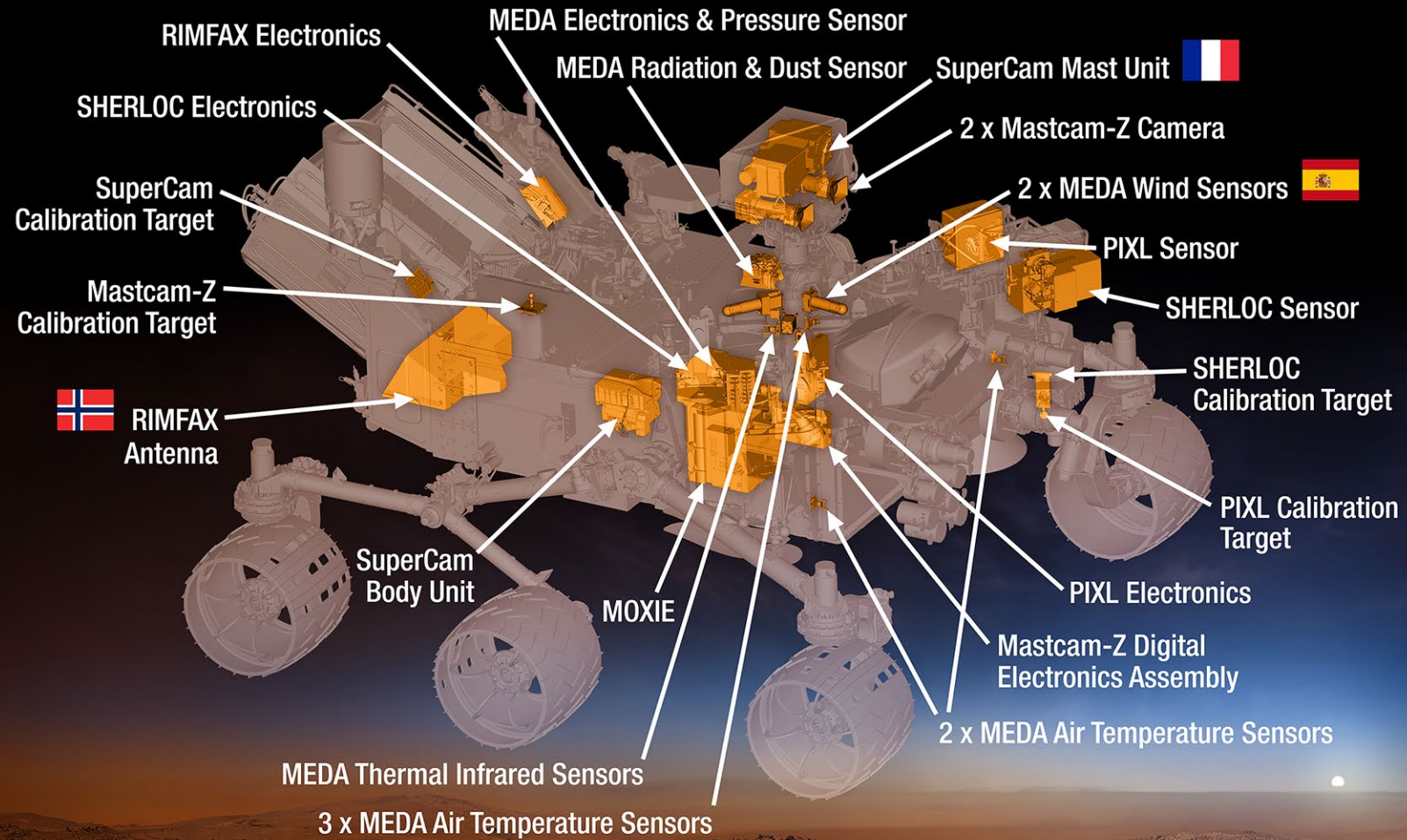


MSL-Curiosity

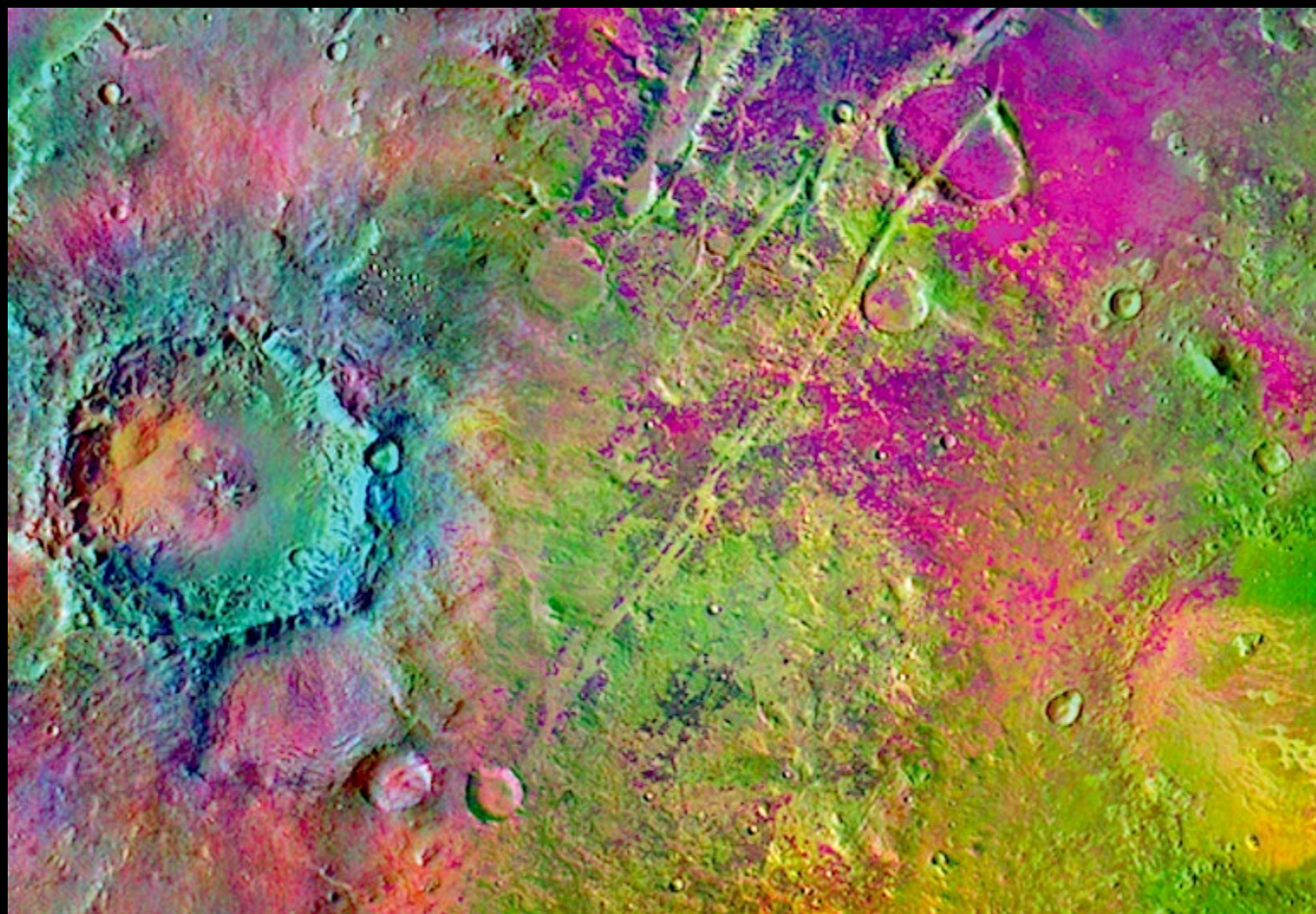
- 2012-present
- 13 instruments
- Landed in Gale Crater

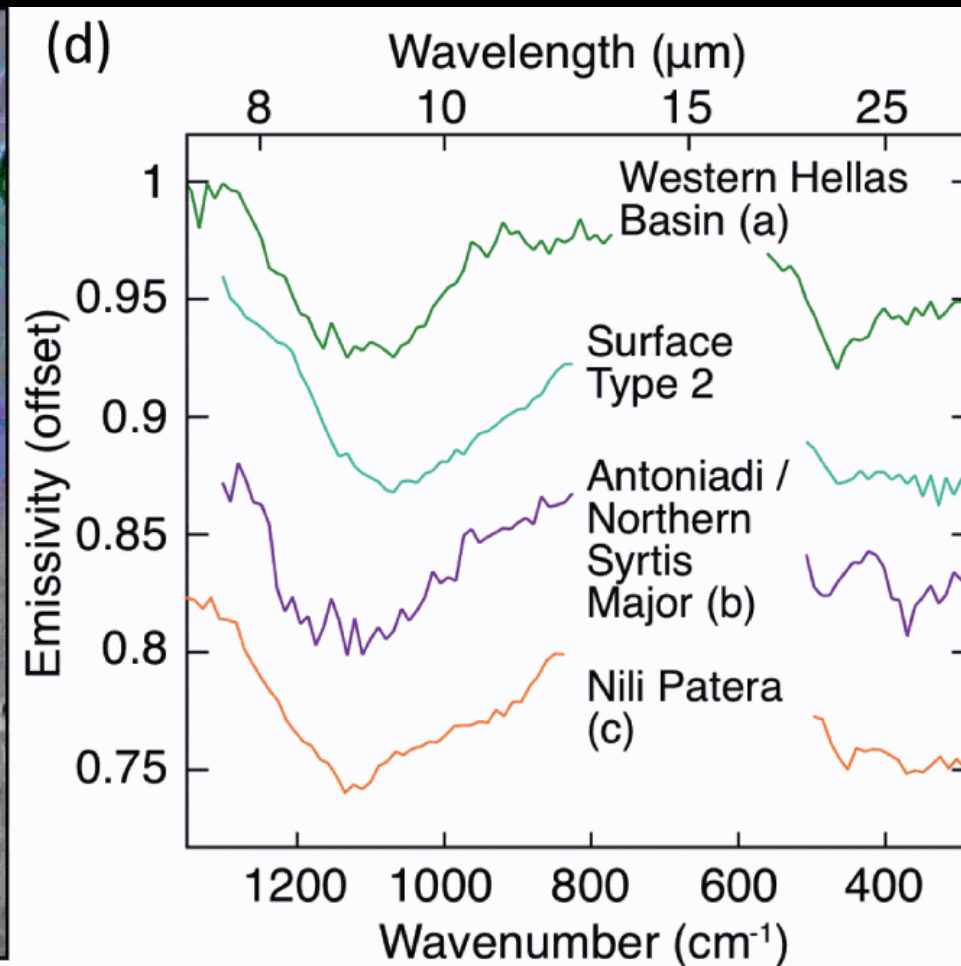
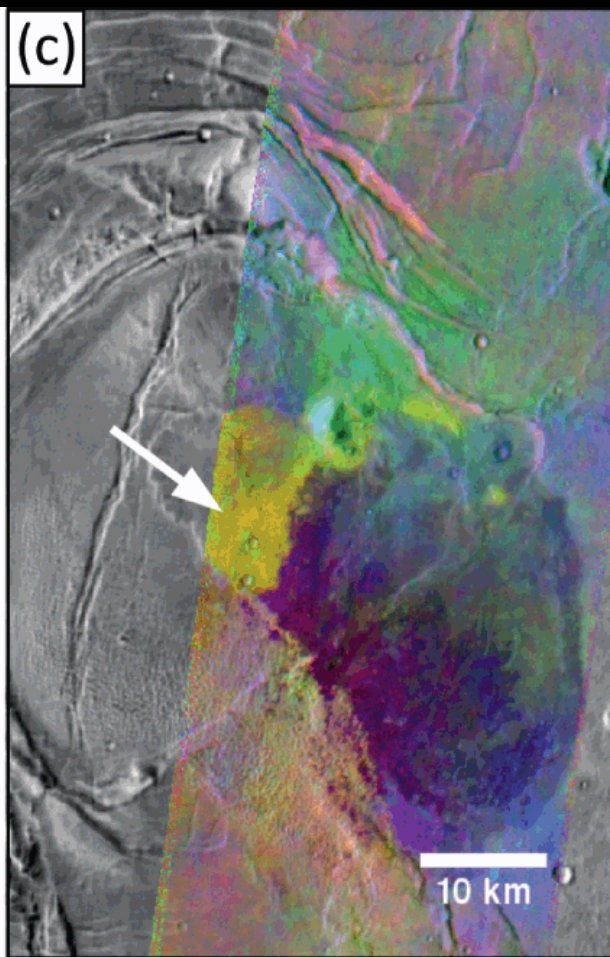
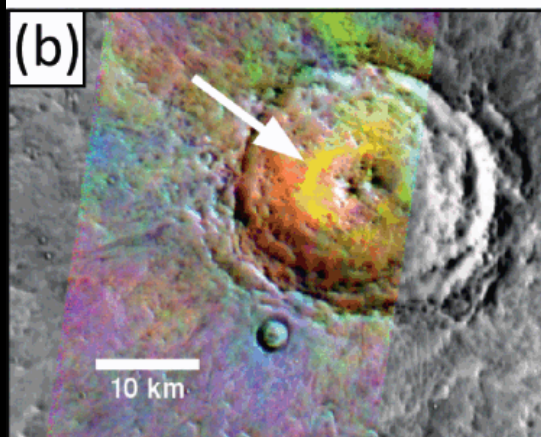
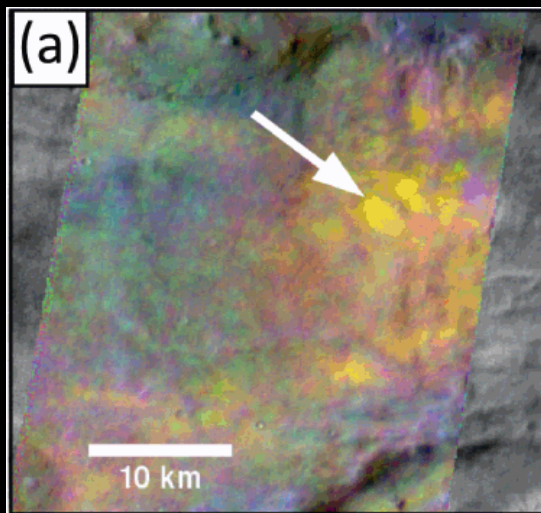


Mars 2020 Rover









Stilbite



Bytownite



Andesine



Anorthite



Microcline



Quartz



Jarosite



Dolomite



Olivine



Enstatite



Labradorite



Augite



Talc



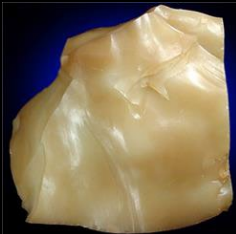
Oligoclase



Gypsum



Opal



Chlorite



Muscovite



Calcite



Montmorillonite



Hematite



Bronzite



Illite



Meteorites

Martian Meteorites: SNCs

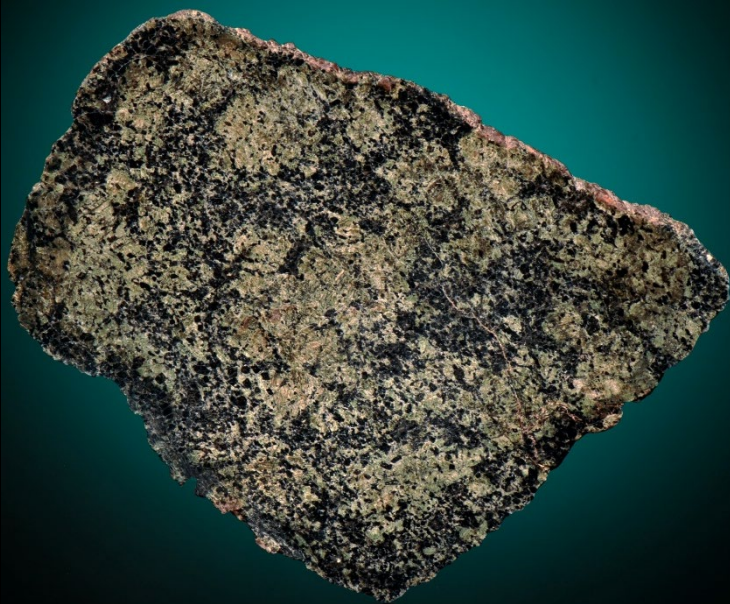
Martian Meteorites: SNCs

Shergottites
(basalt)



Martian Meteorites: SNCs

Shergottites
(basalt)



Nakhlites
(augite, olivine)



Martian Meteorites: SNCs

Shergottites
(basalt)



Chassignites
(mostly olivine - dunite)



Nakhlites
(augite, olivine)



Black Beauty

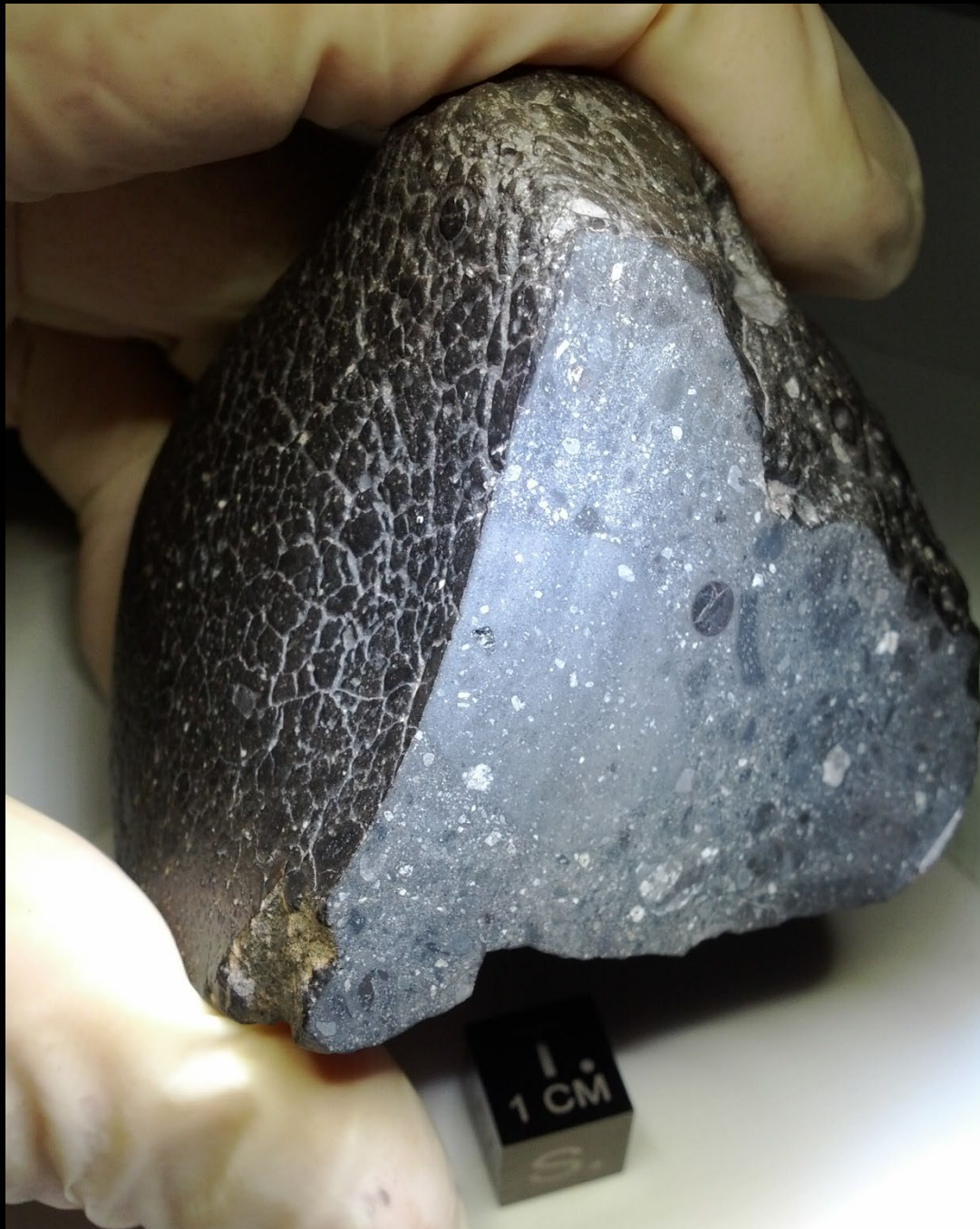
NWA 7034

Morocco

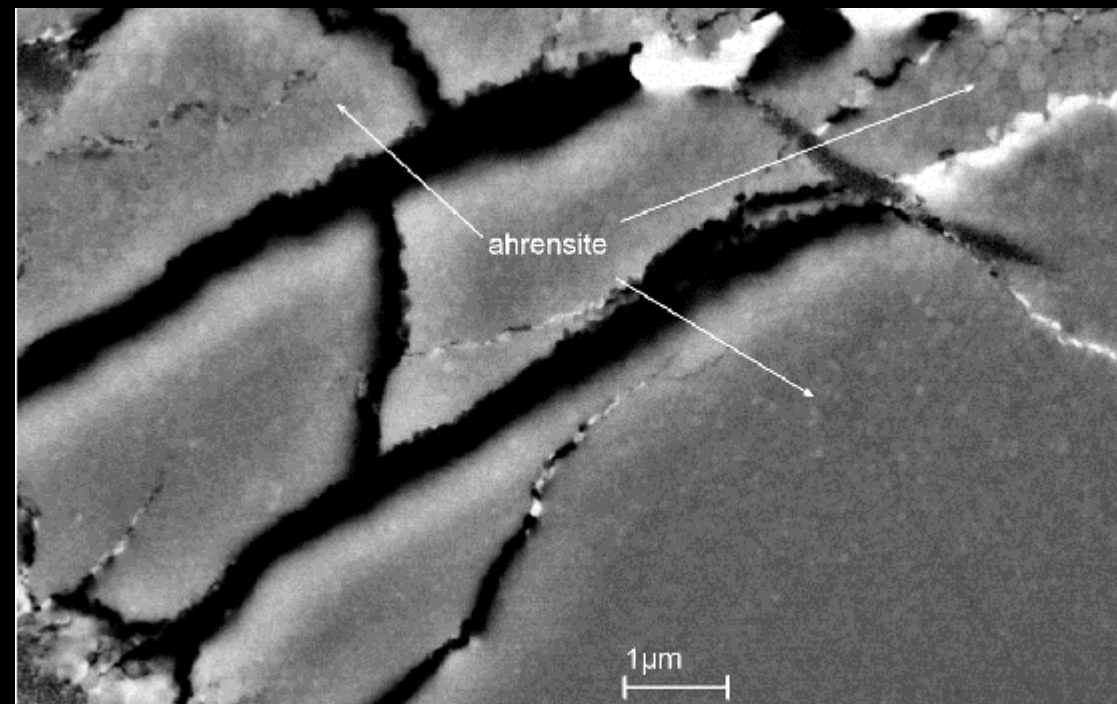
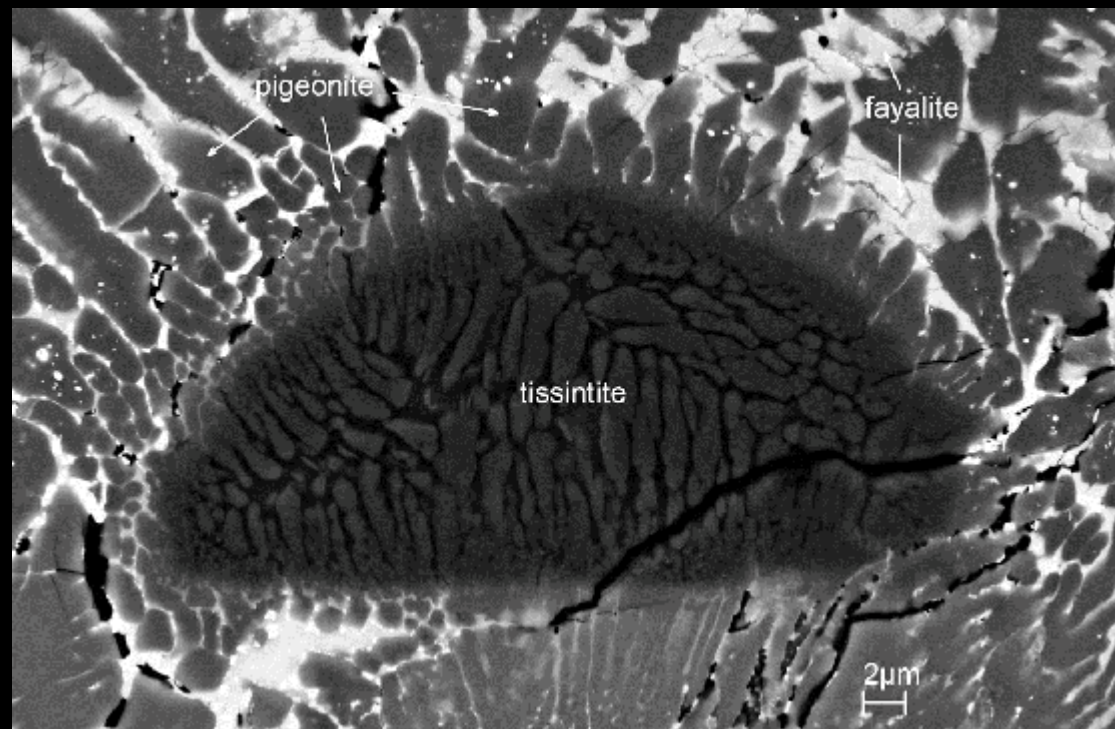
2011

Achondrite

Plagioclase, pyroxene

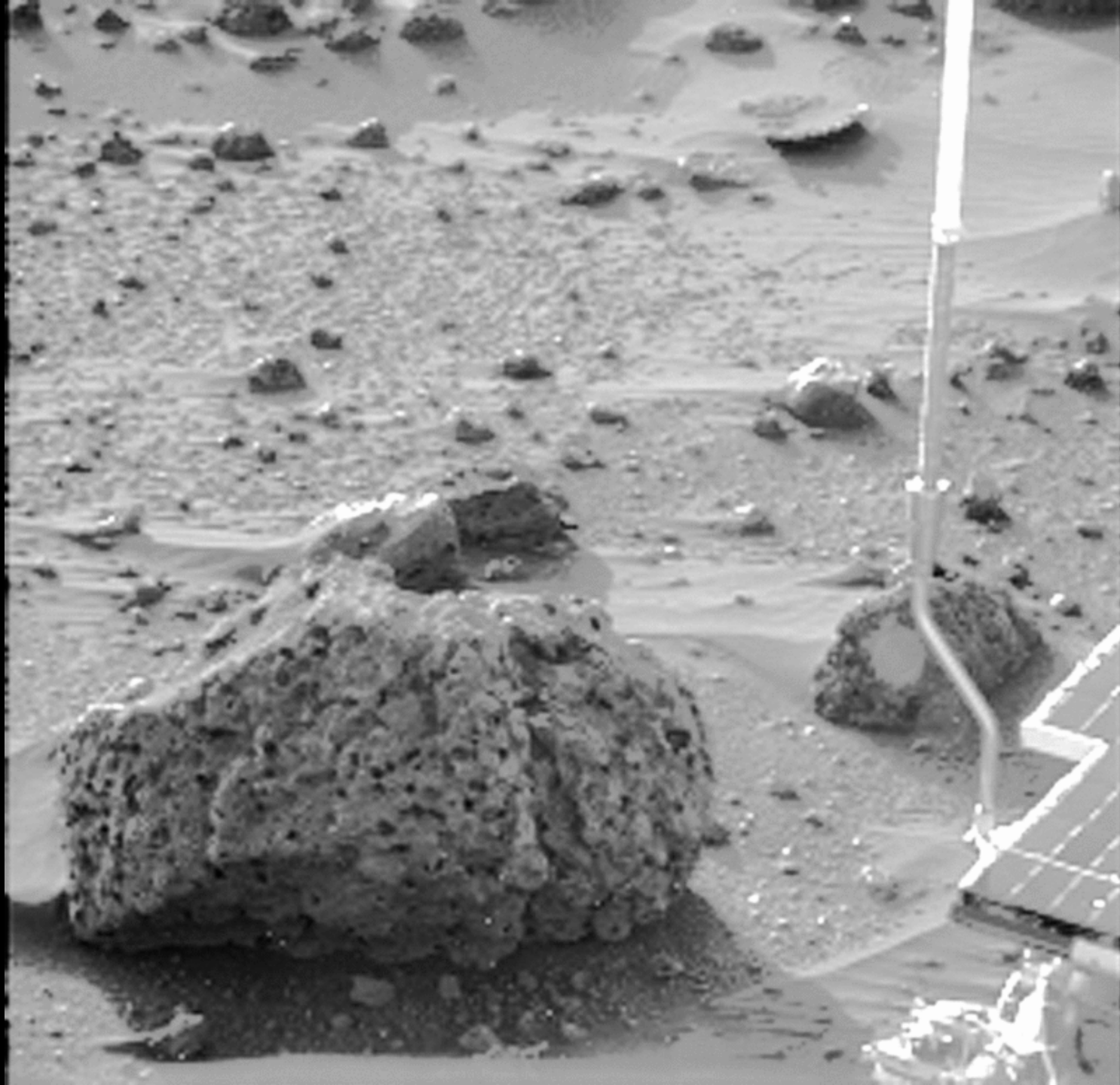


New minerals! (As of 2014)



Rocks from Rovers

Barnacle Bill
Mars Pathfinder
Andesite rock



El Capitan

Opportunity rover
Layered rock outcrop



Heat Shield Rock
Opportunity rover
Iron IAB type – iron/nickel



Hottah rock outcrop
Curiosity Rover
Possible ancient streambed?

10 cm



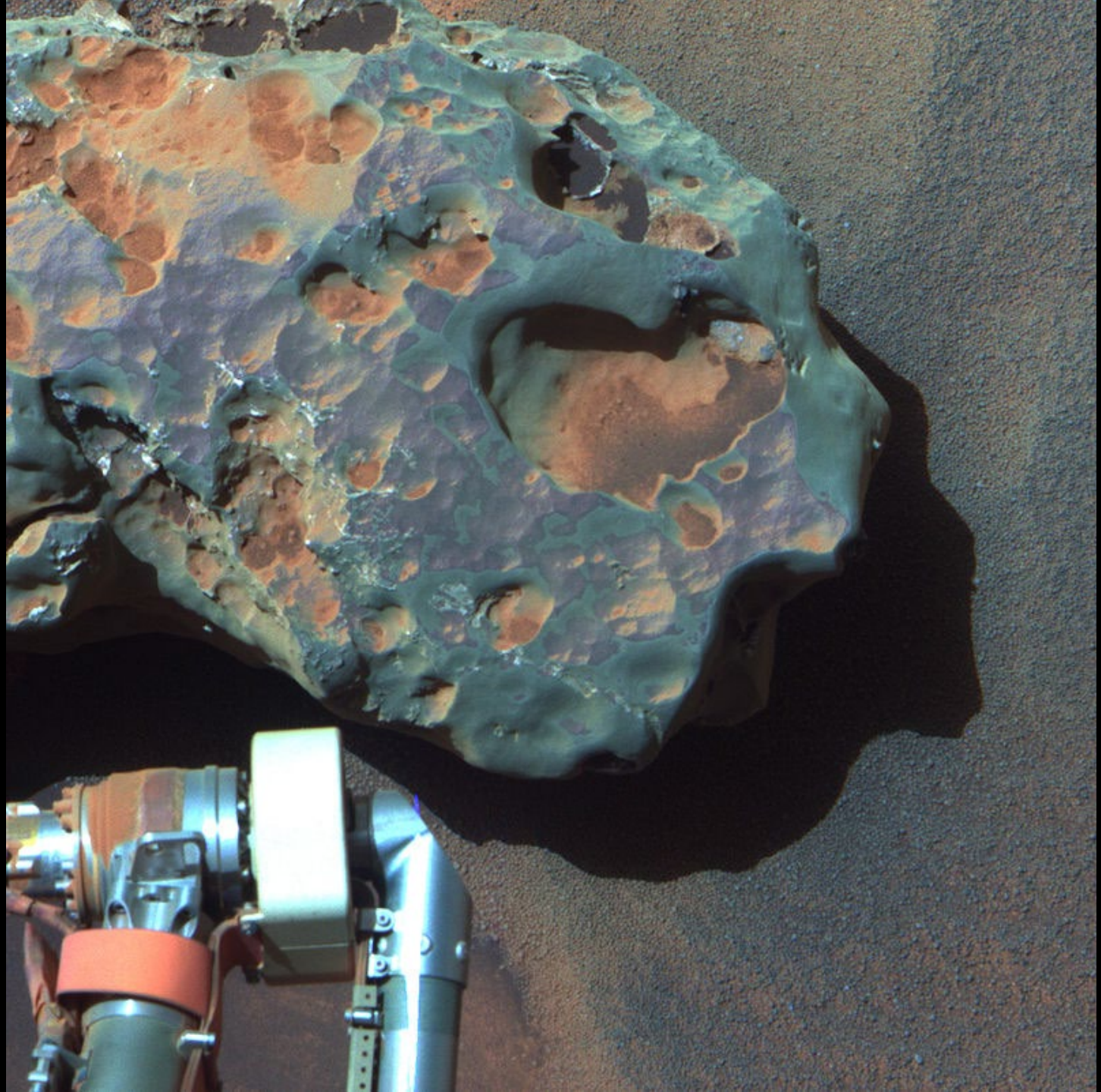
[Link outcrop](#)
Curiosity rover
Sedimentary
Conglomerates
similar to terrestrial
fluvial streams



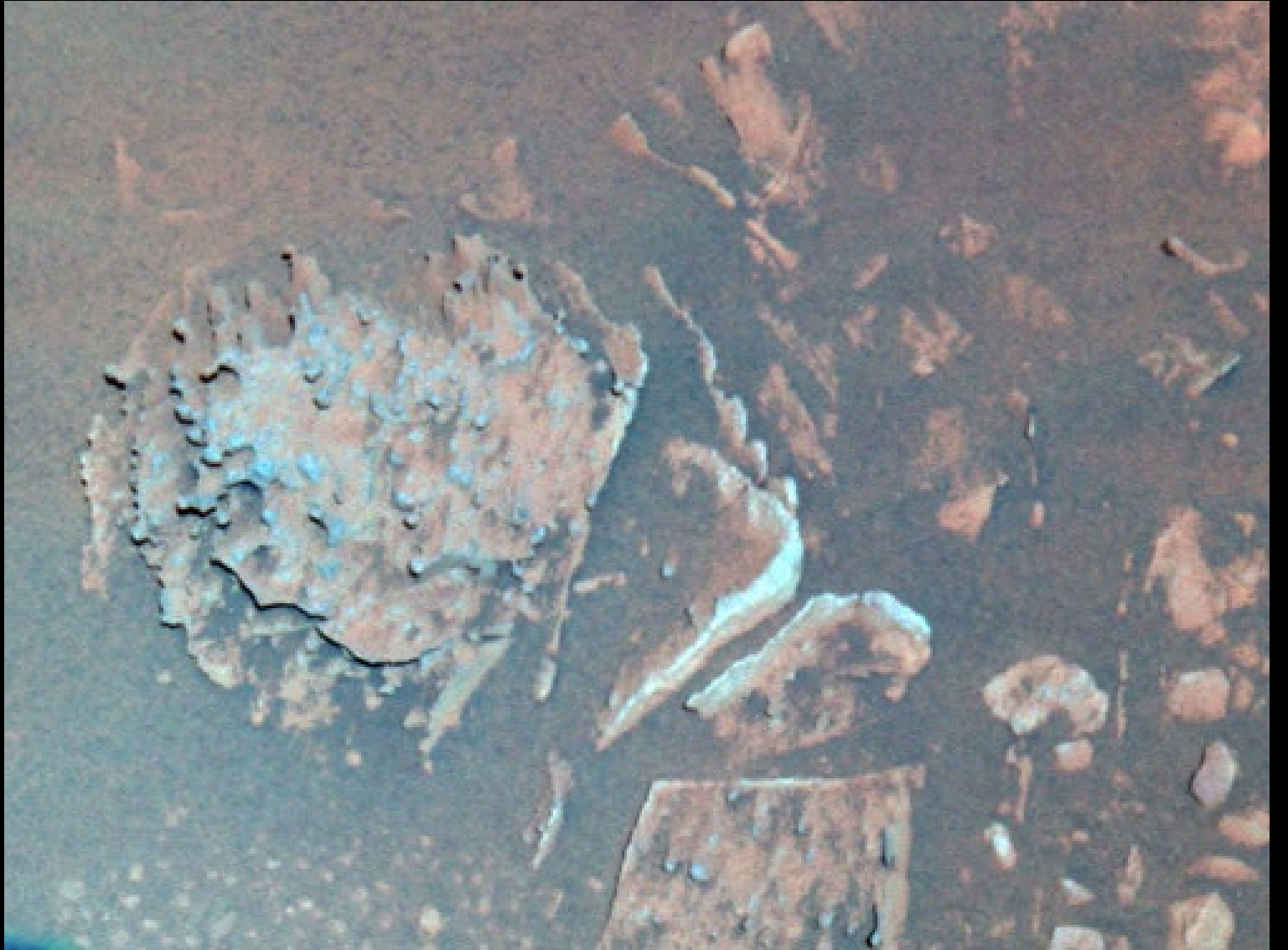
A black and white photograph of a rocky beach. The foreground shows gentle waves washing onto the shore, creating white foam. In the middle ground, a dark, irregularly shaped rock is visible on the beach. The background features a dark, silty beach that extends to a low, dark ridge or dune under a dark sky. The text "Hey Look! A Rock!" is overlaid in the center of the image in a bright orange, sans-serif font.

Hey Look! A Rock!

Oilean Ruaidh
Opportunity rover
(False color image)
Nickel-iron
meteorite



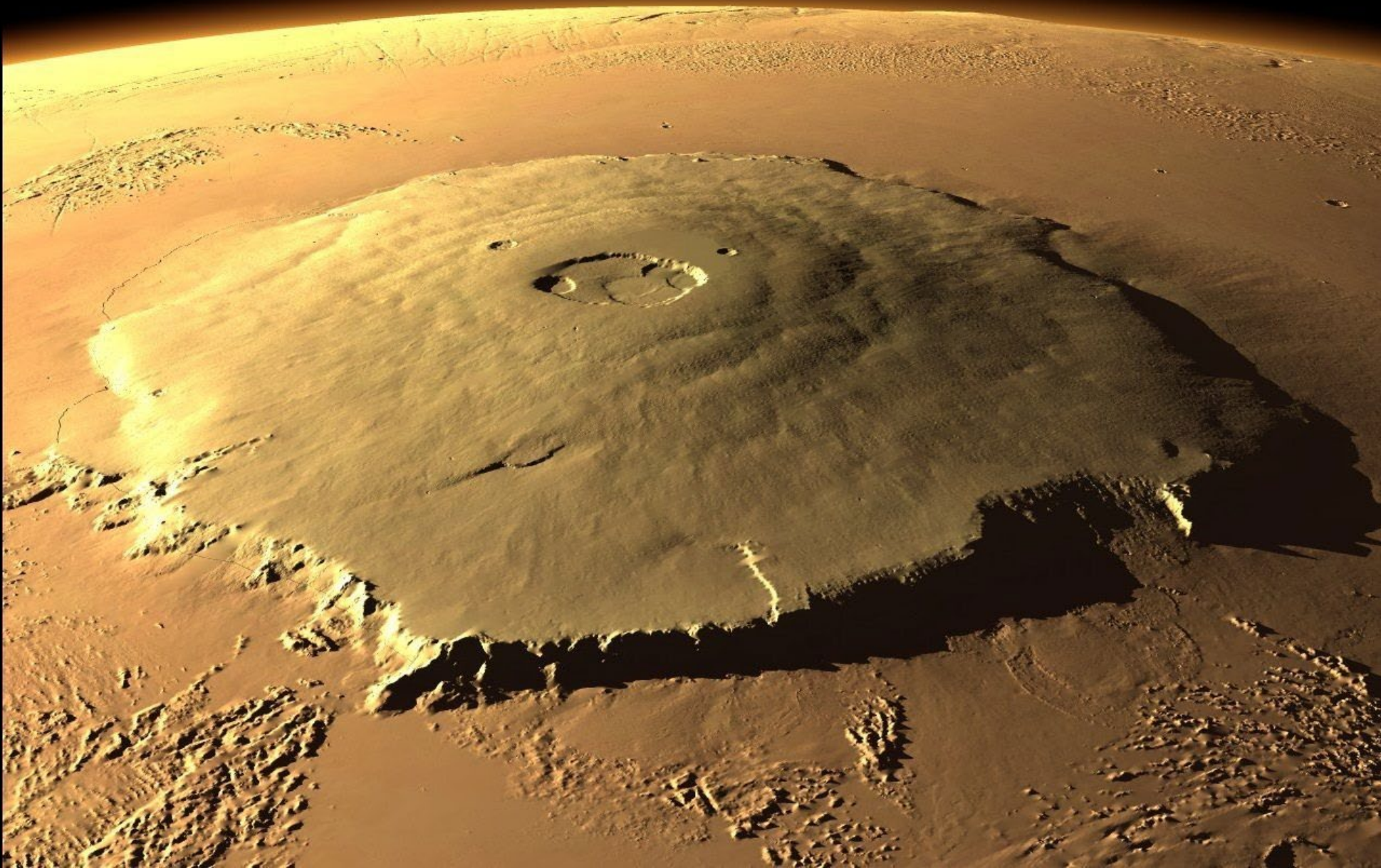
Pot of Gold outcrop
Softball-sized knobs
Spirit Rover
Hematite

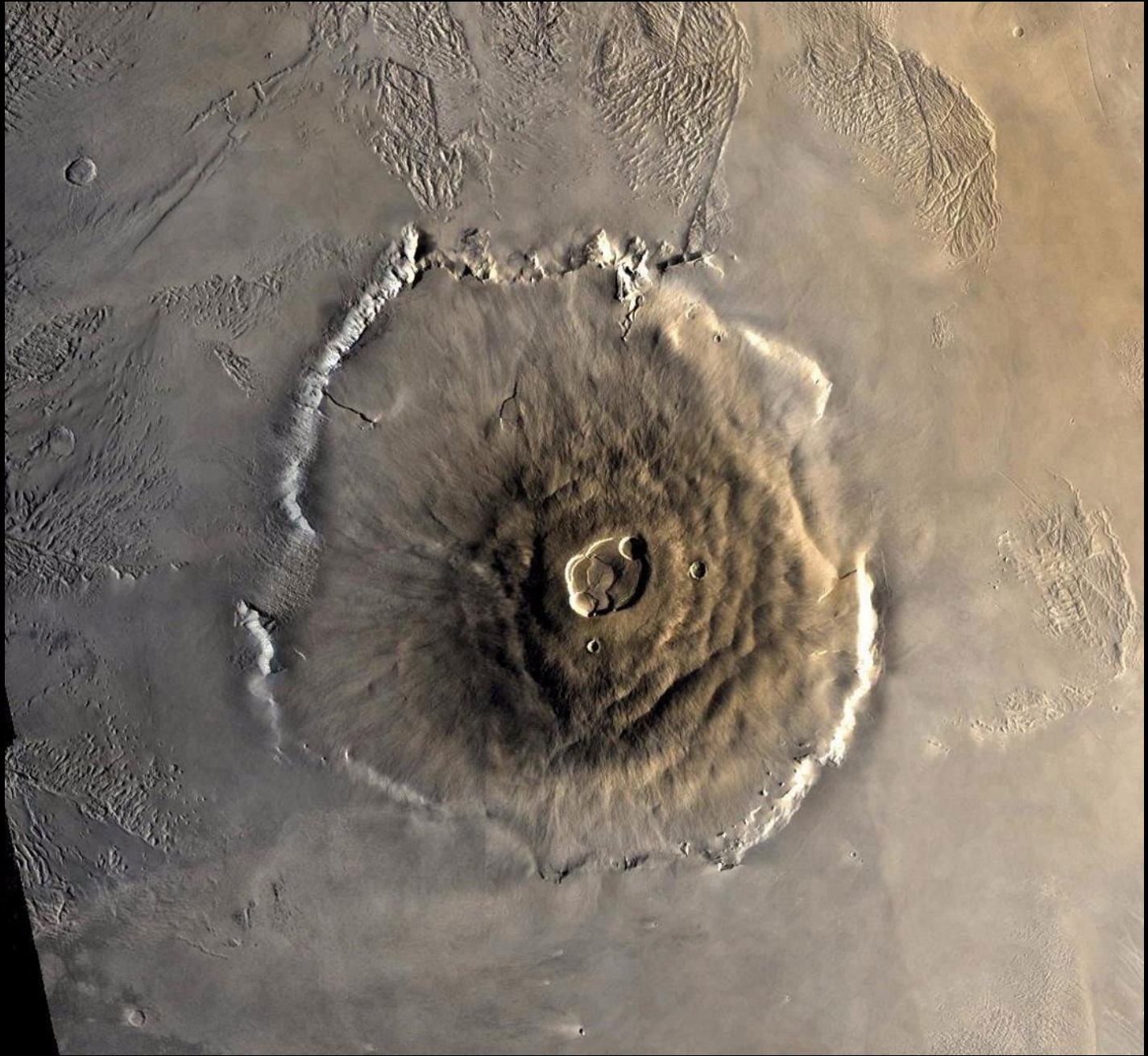


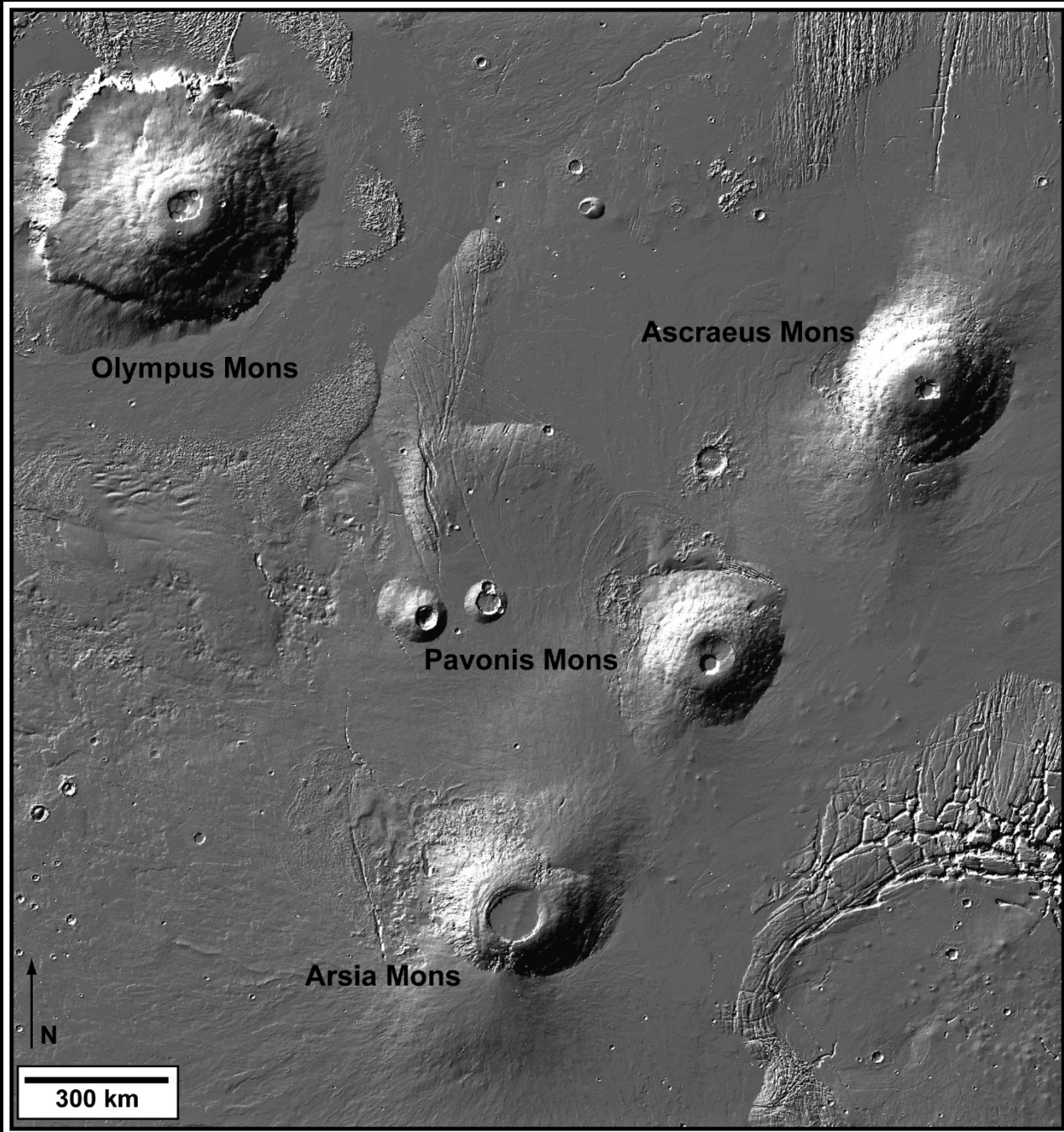
Blueberries!



GEOLOGY!





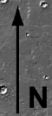


Olympus Mons

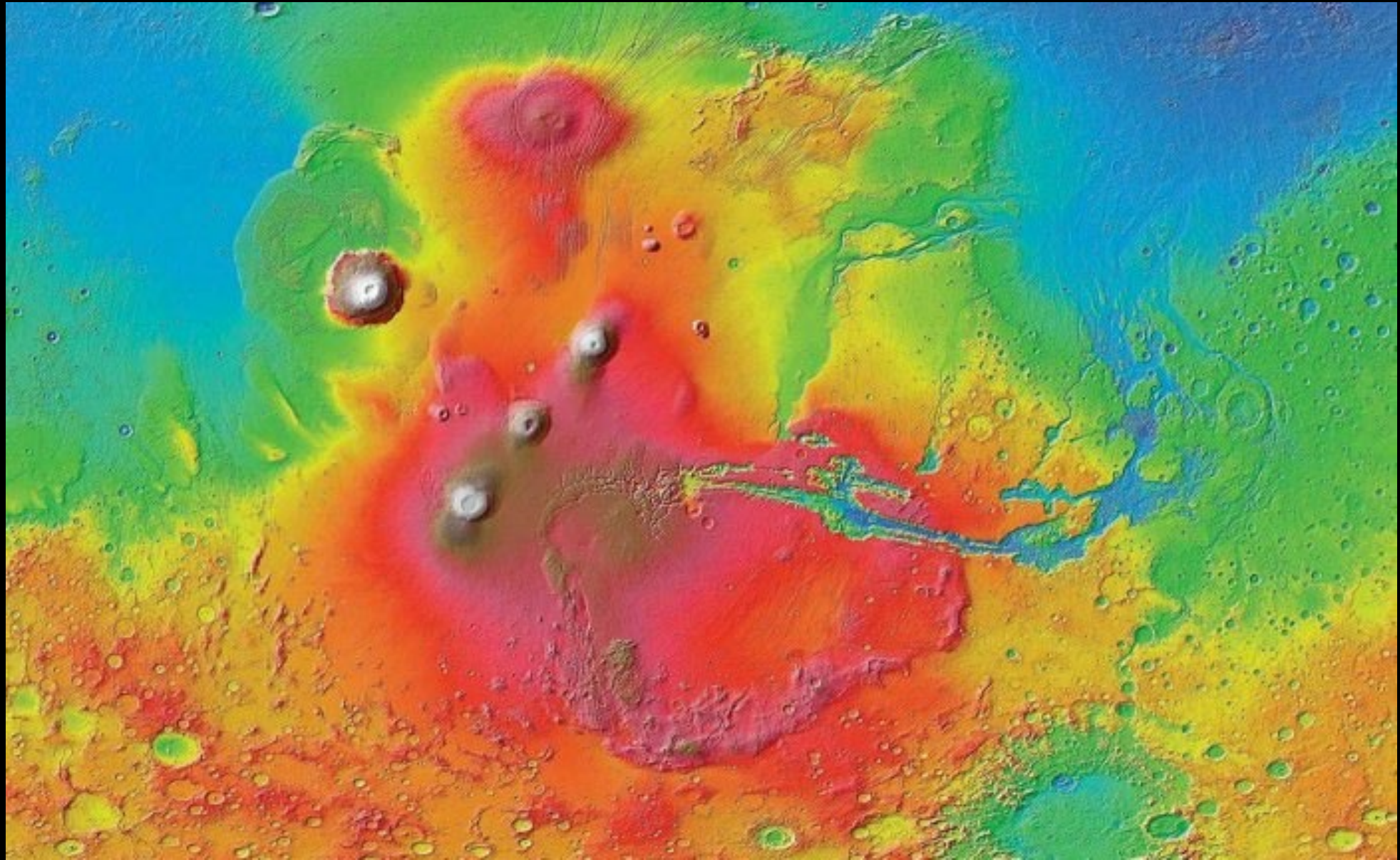
Asraeus Mons

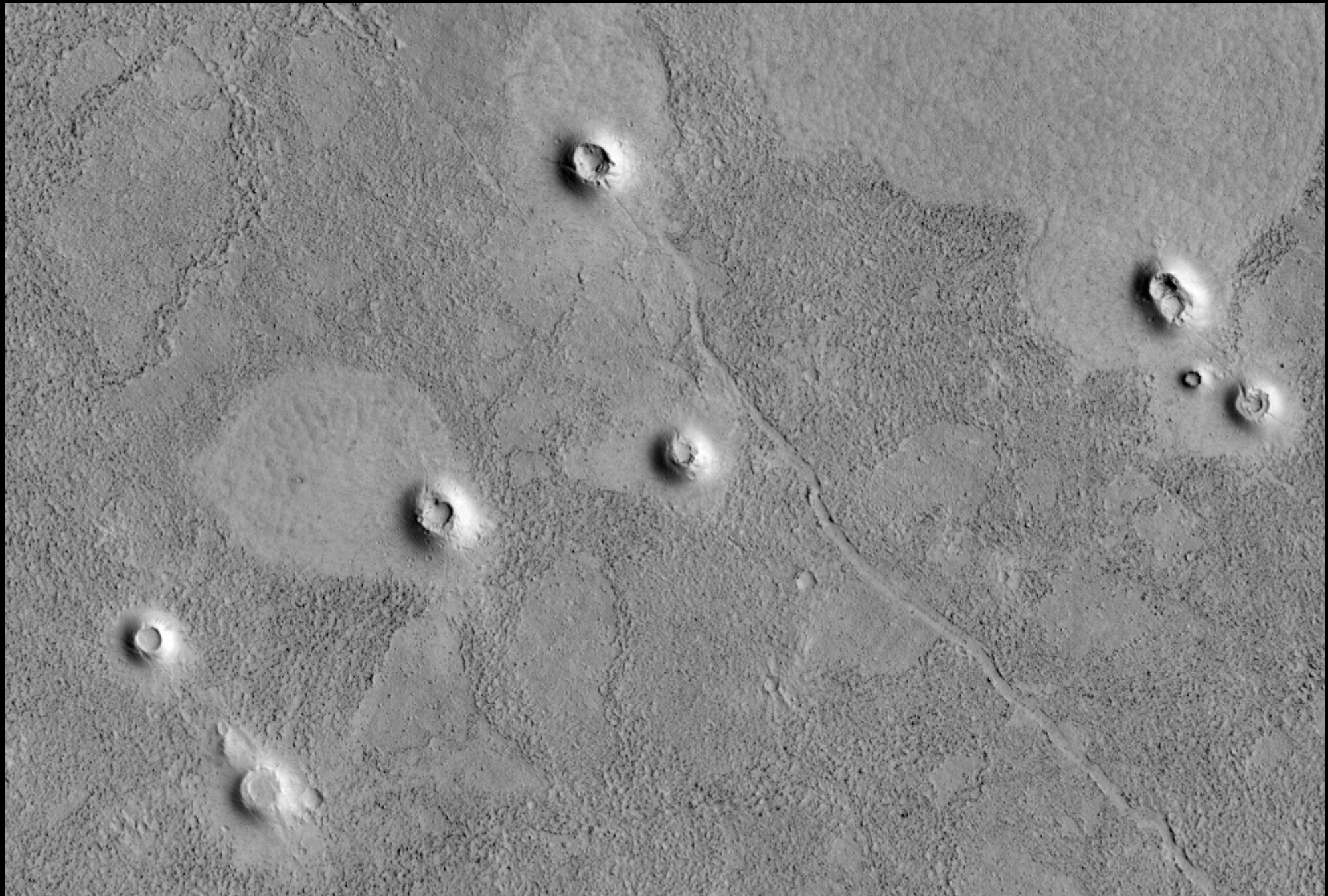
Pavonis Mons

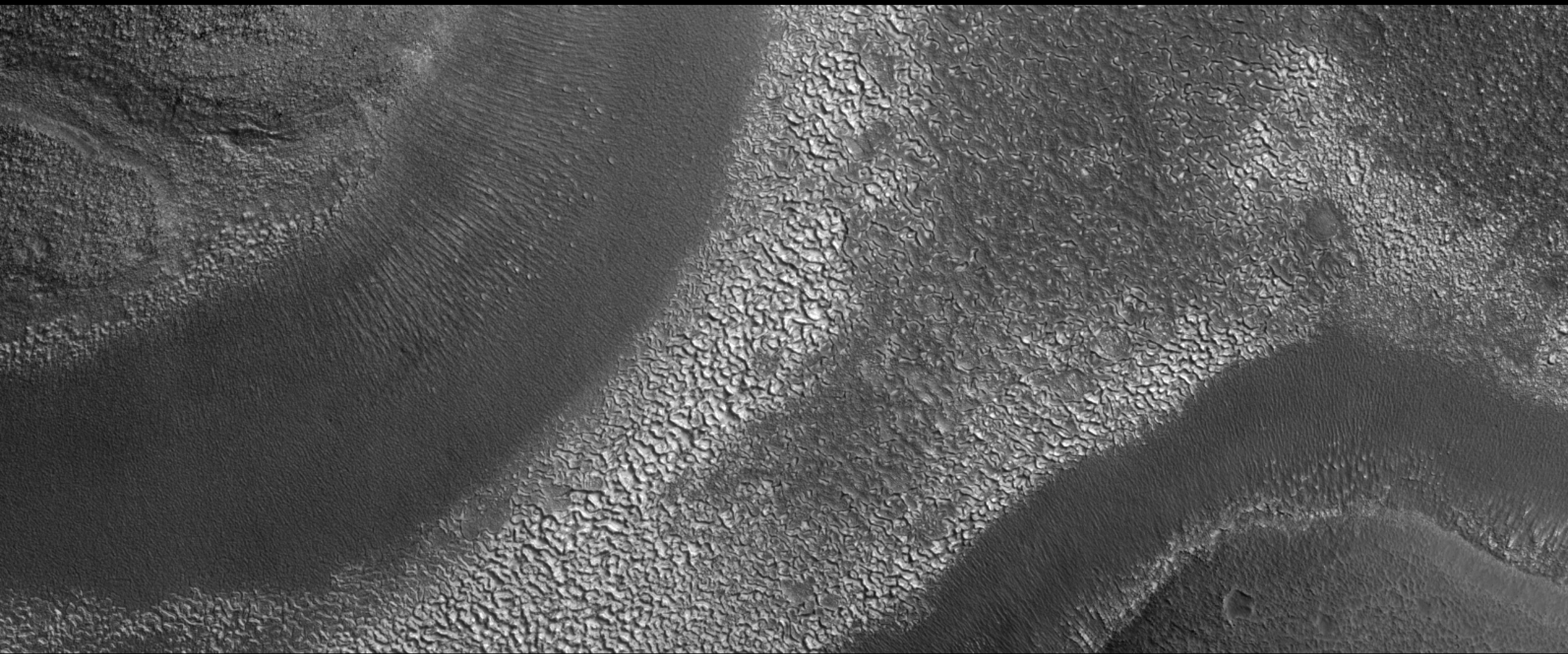
Arsia Mons

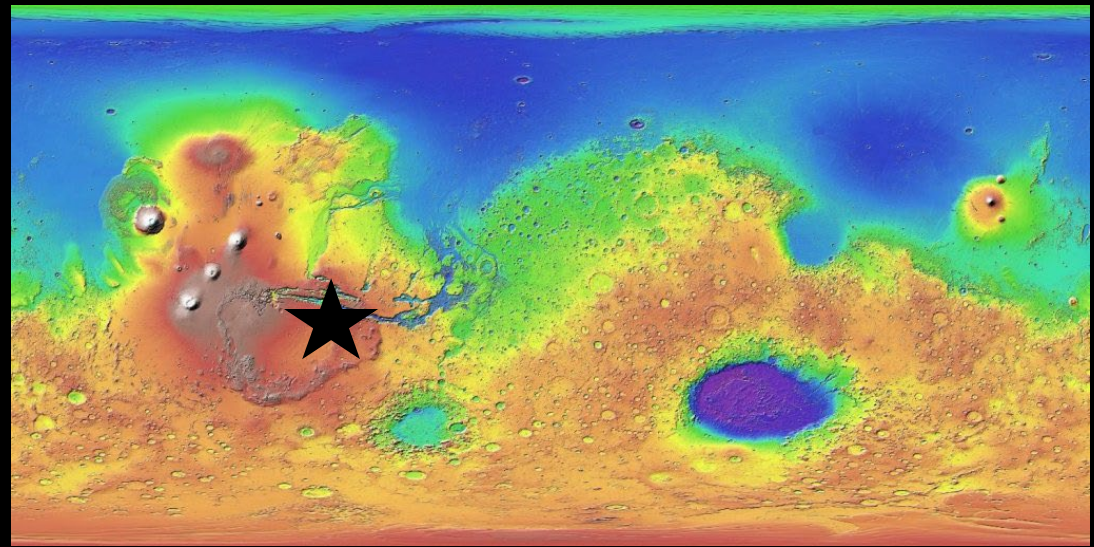


300 km



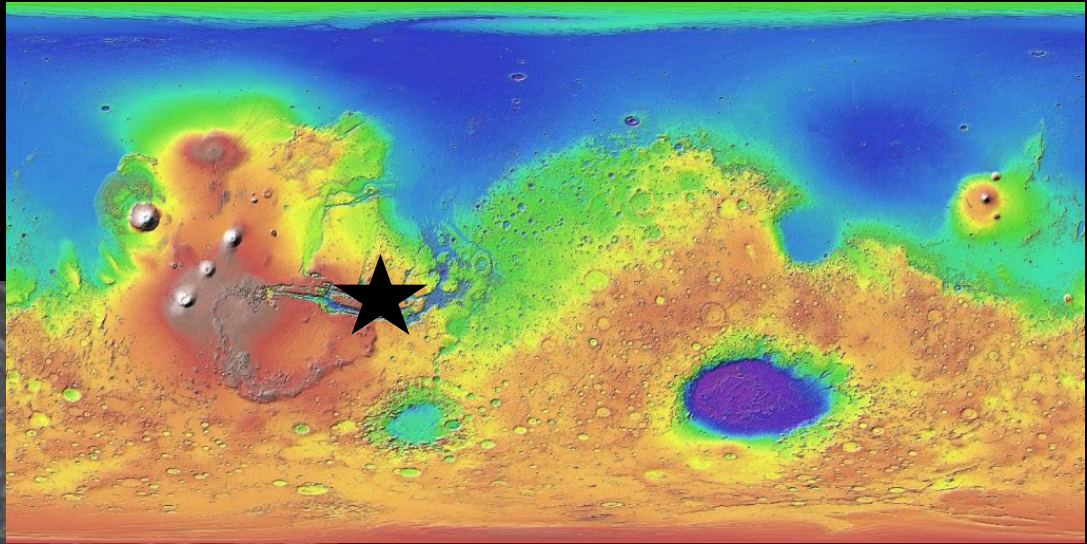




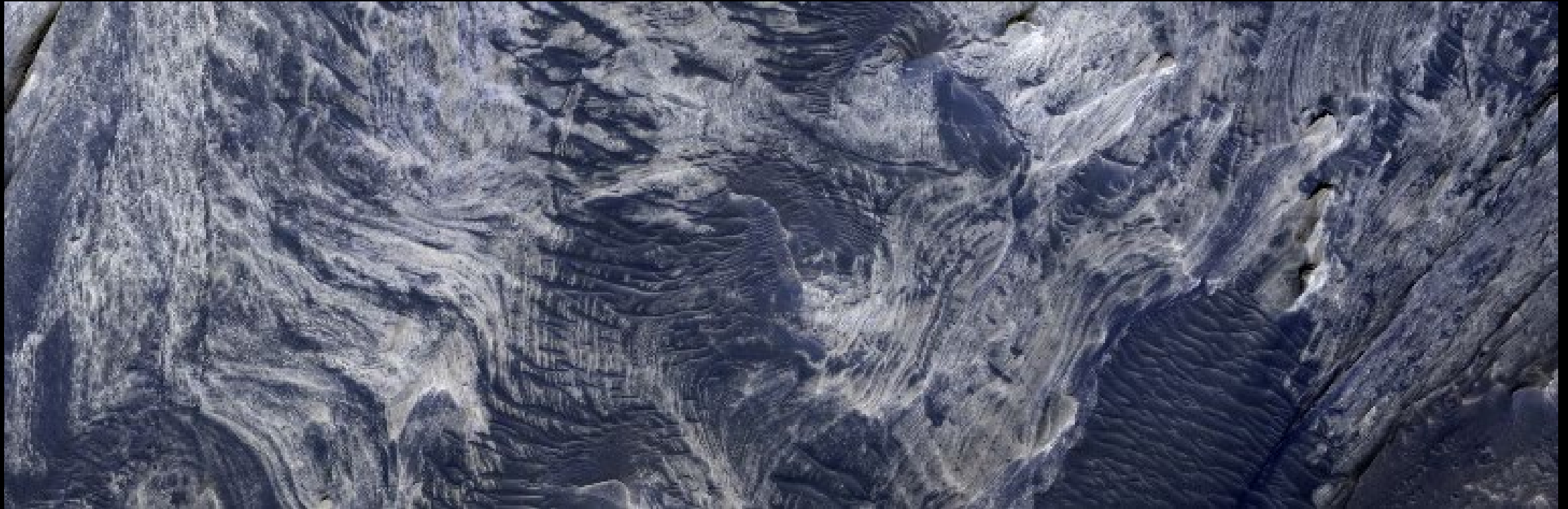
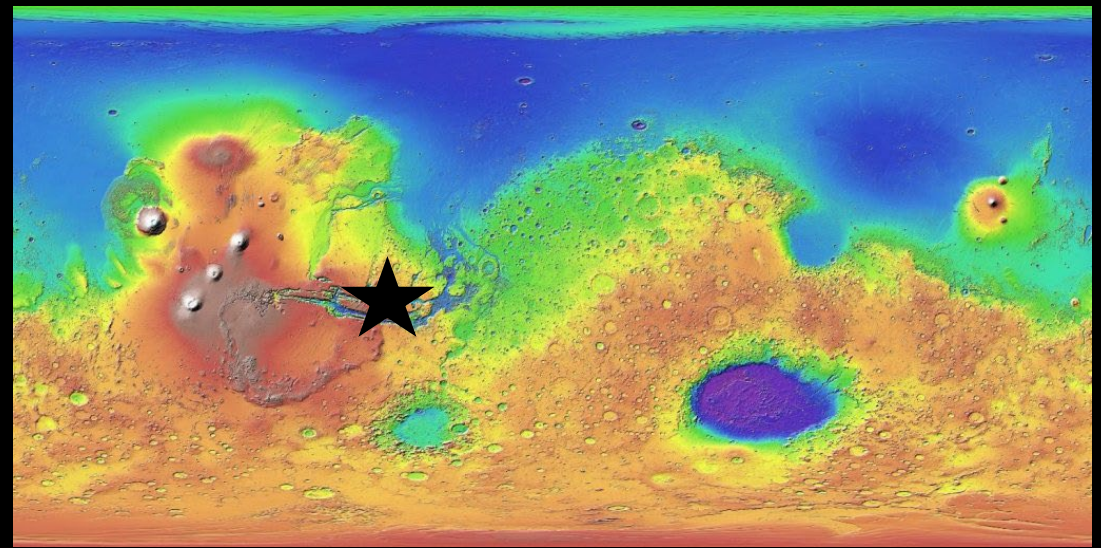


Opal deposits
Valles Marineris

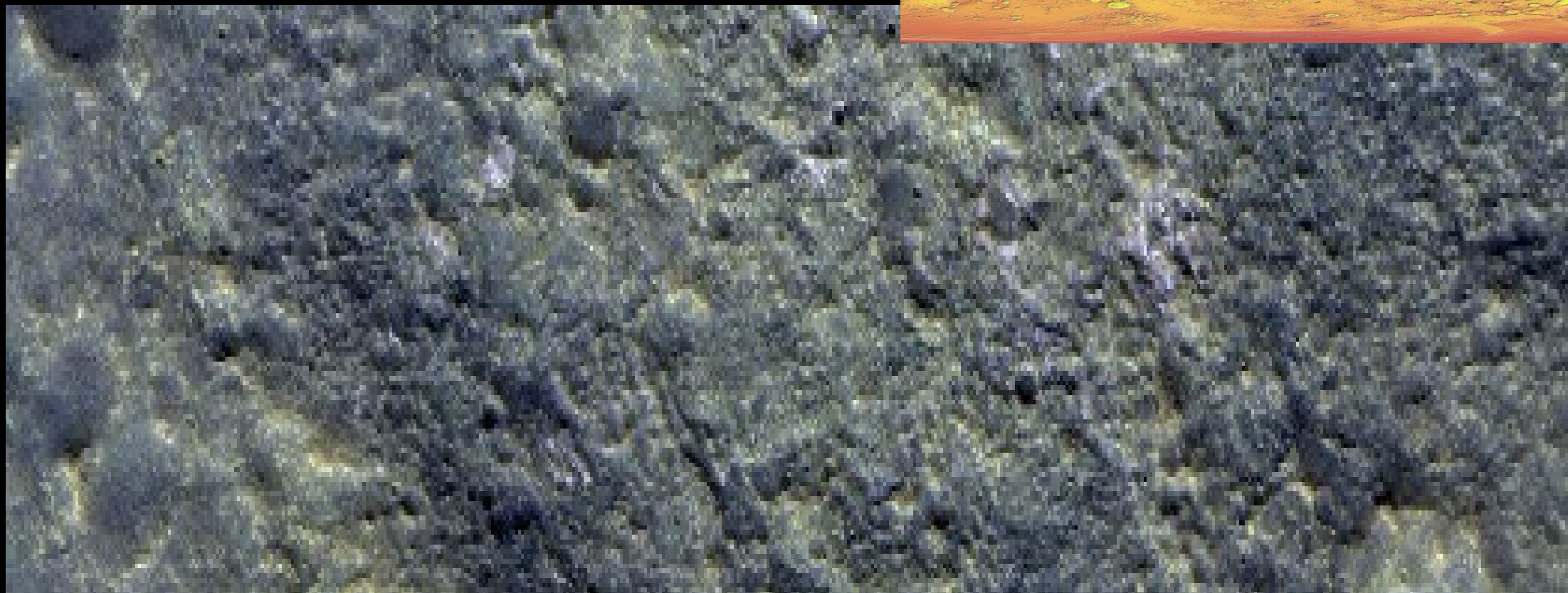
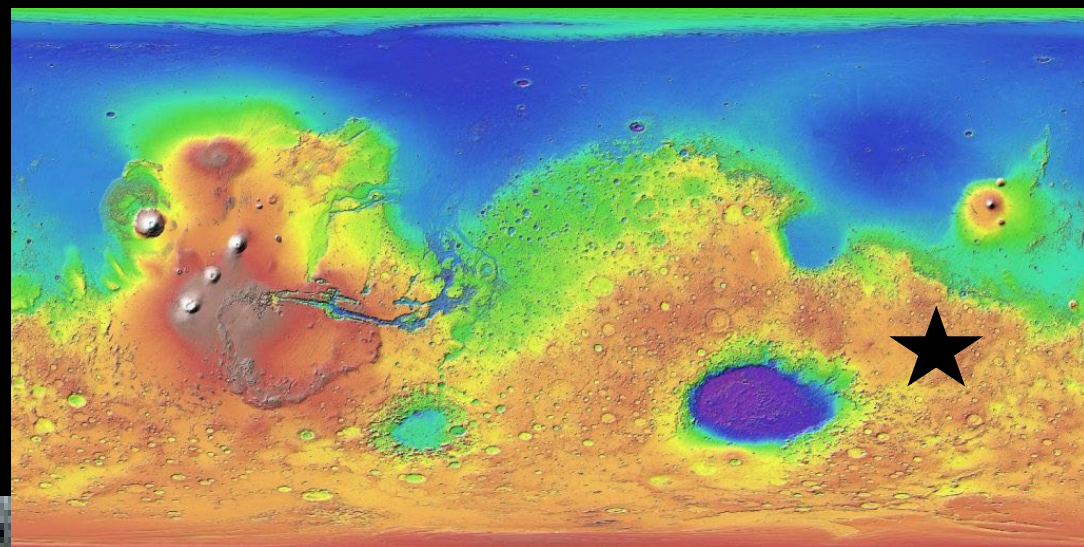
Salt fields, sulfur-minerals (gypsum)
Candor Chasma

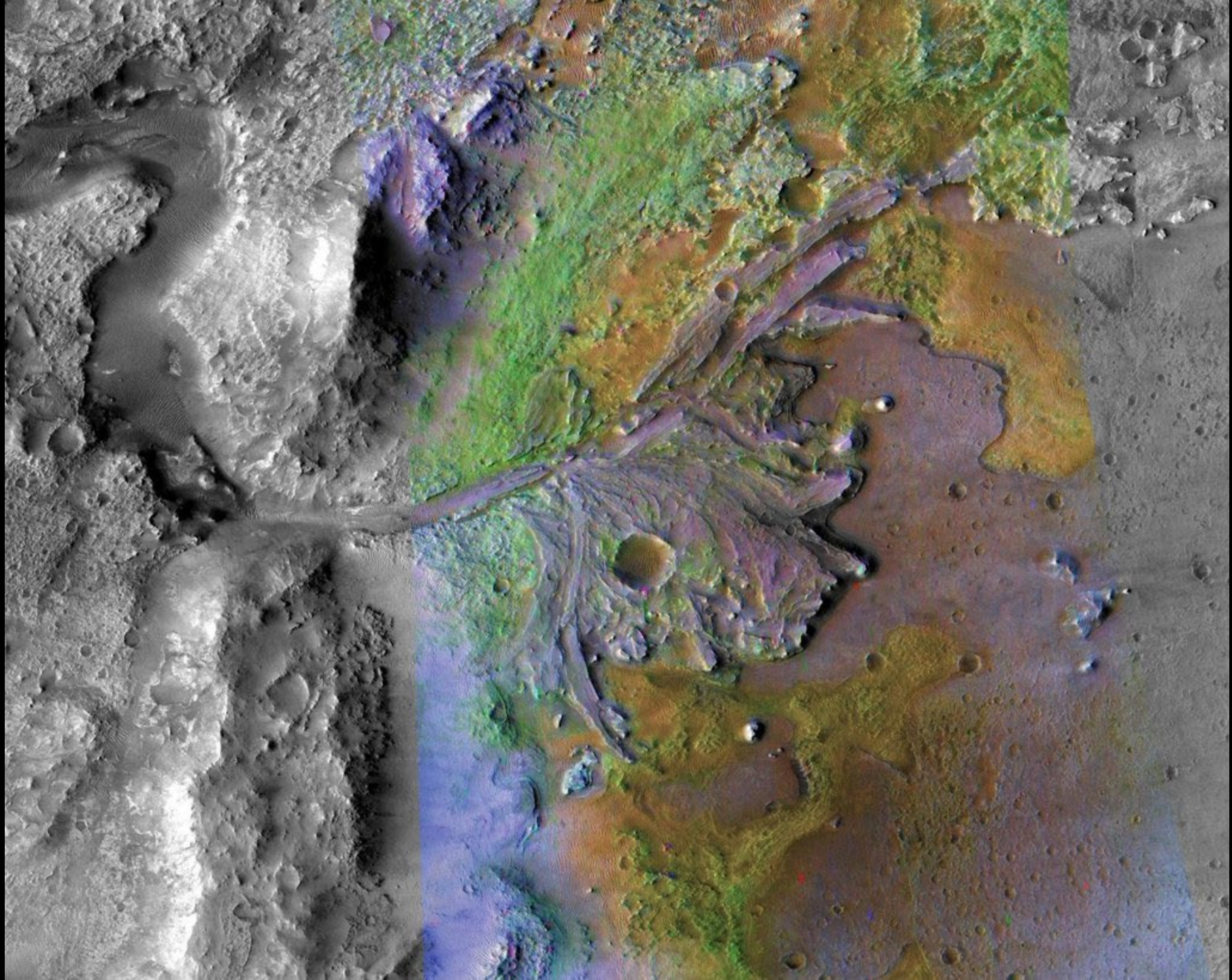


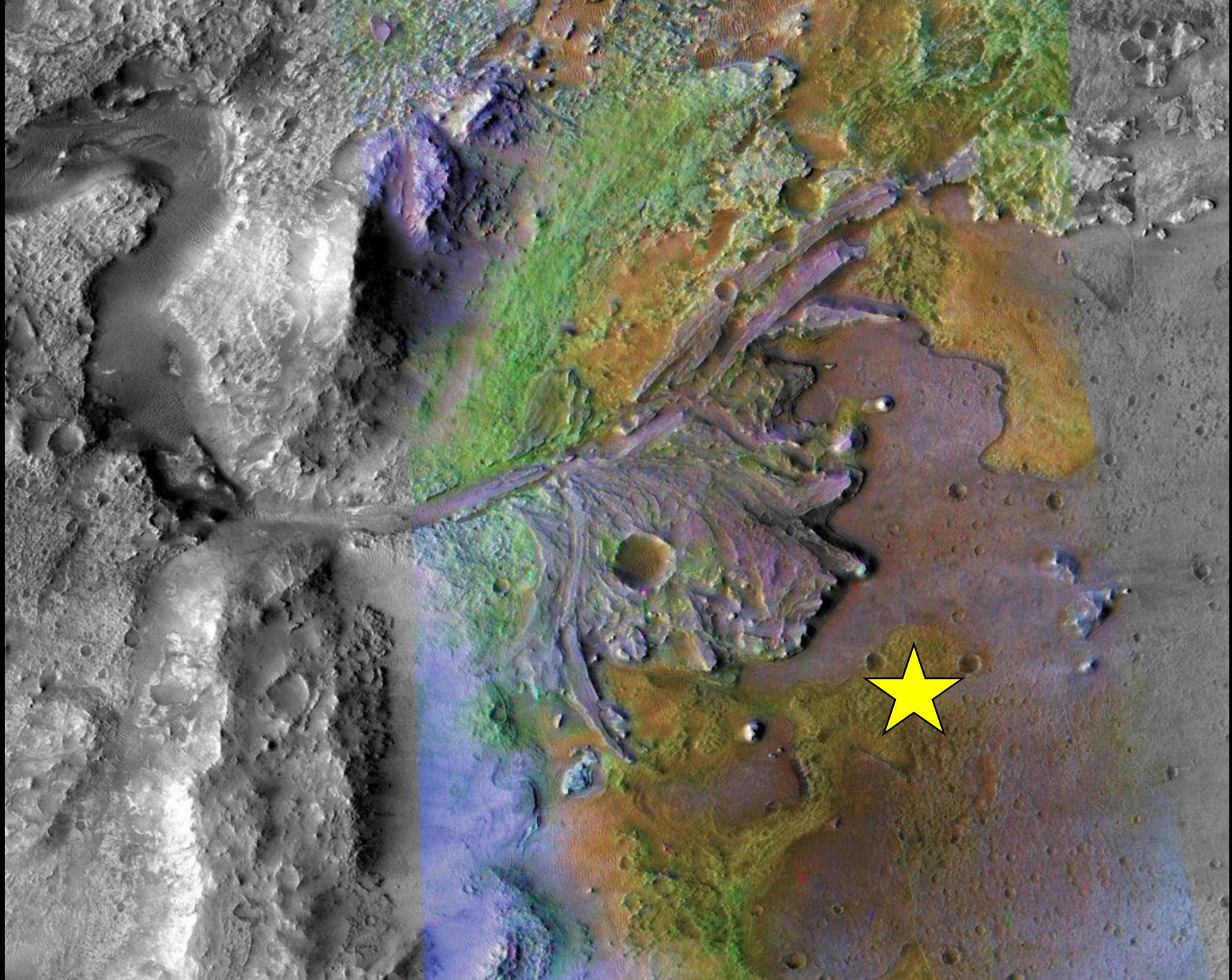
Salt fields, sulfur-minerals (gypsum, anhydrite)
Candor Chasma

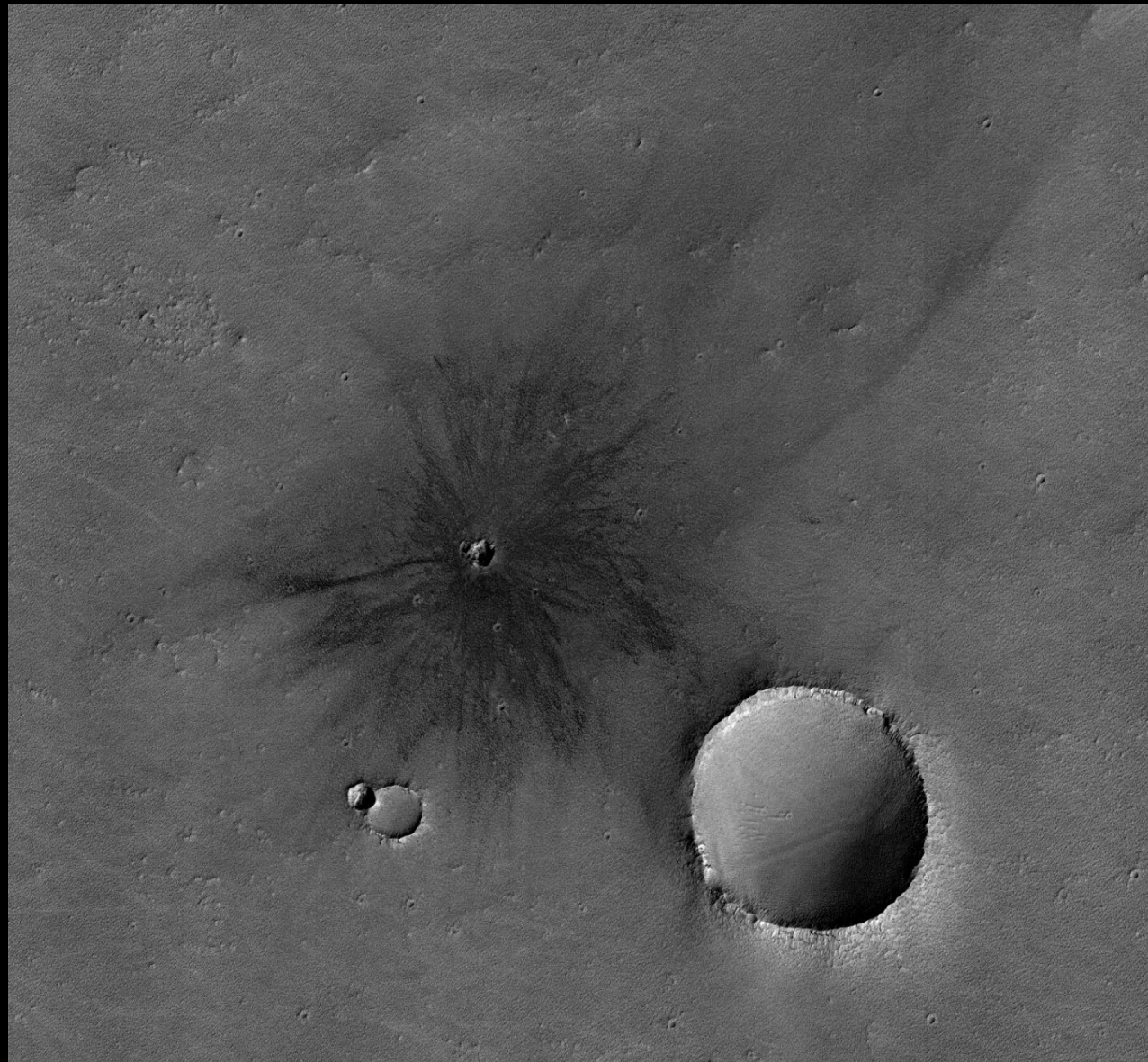


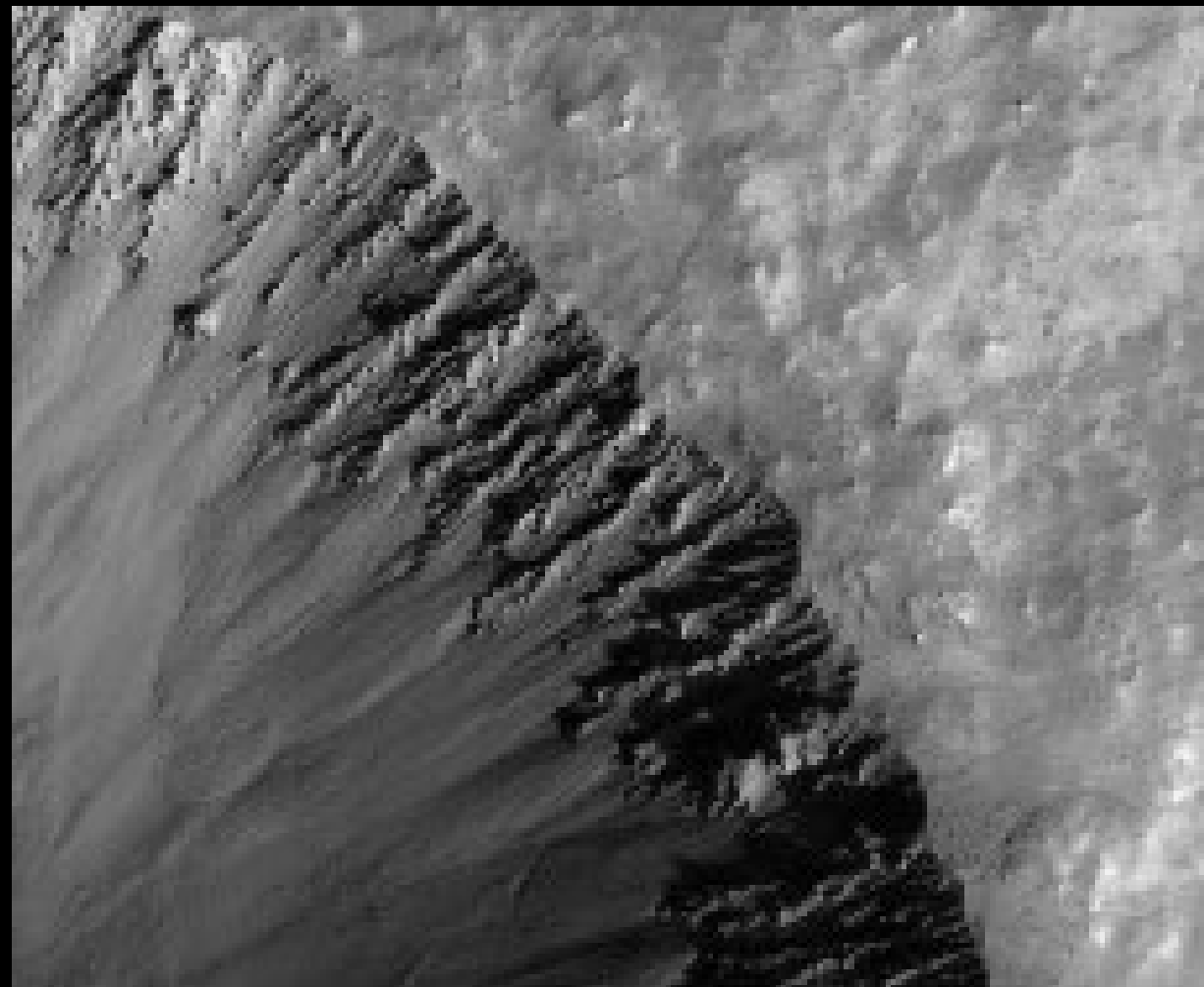
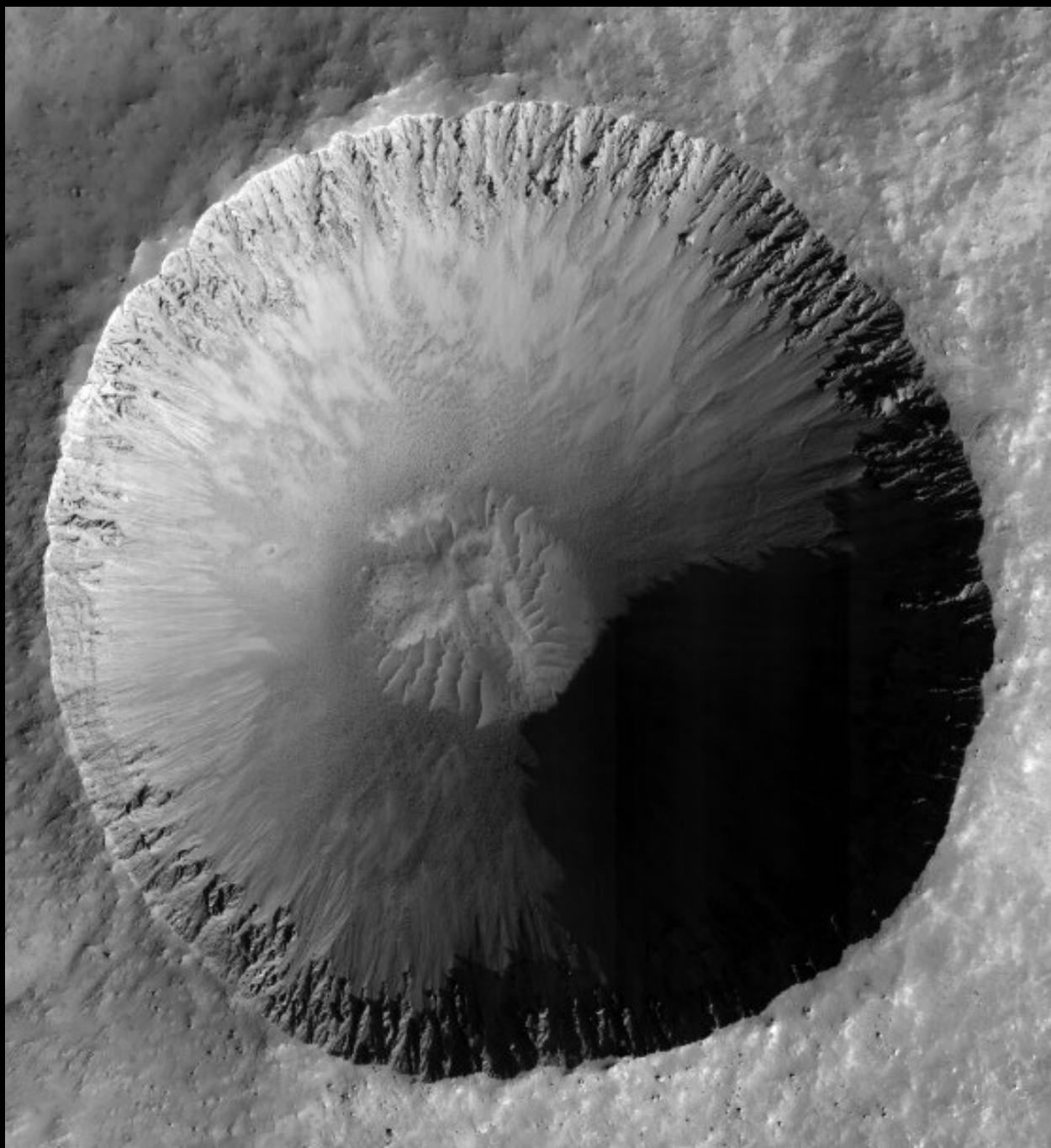
Chloride salt fields
Terra Cimmeria

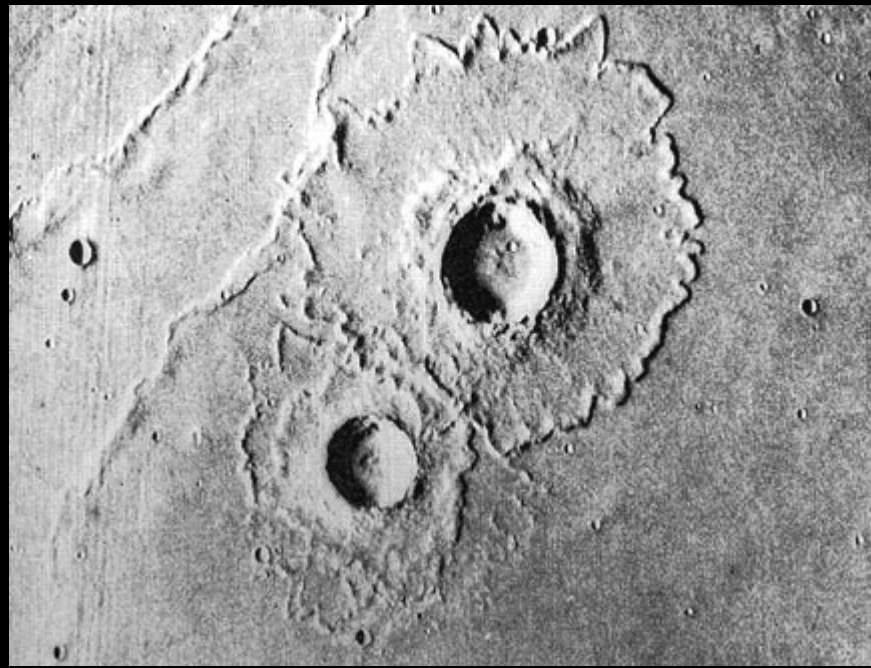
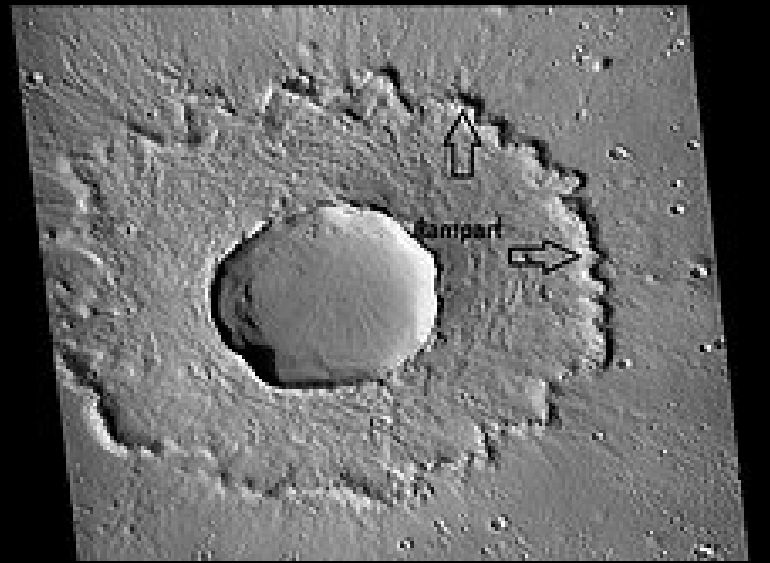
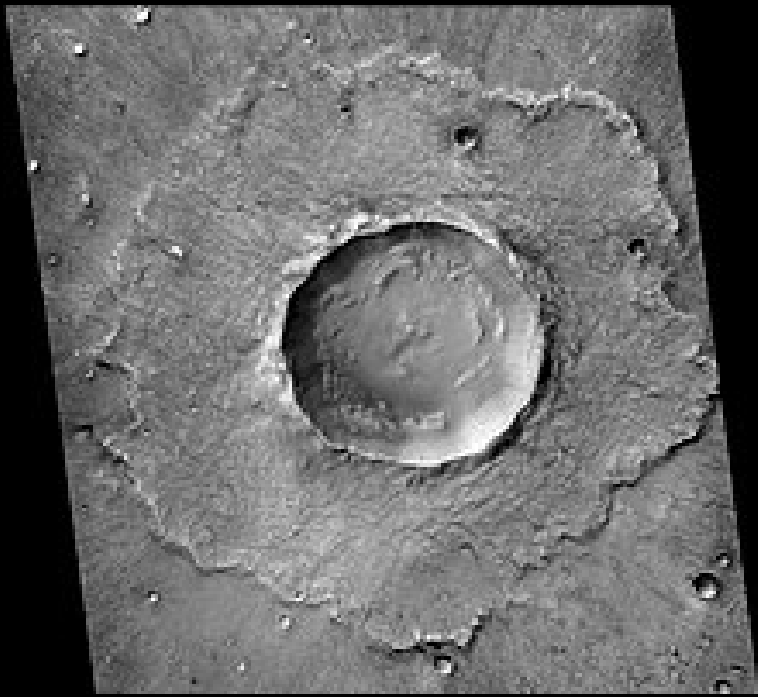












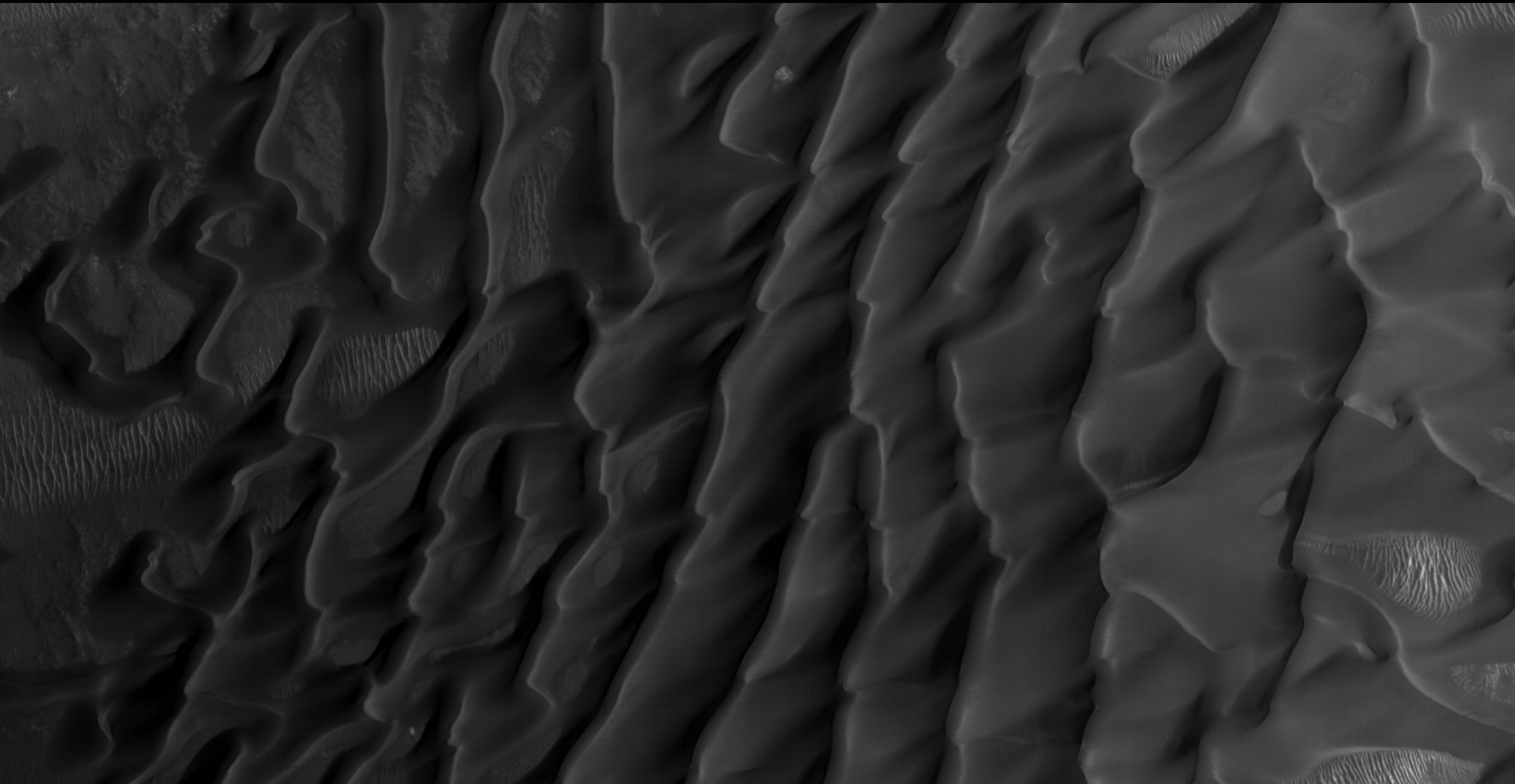


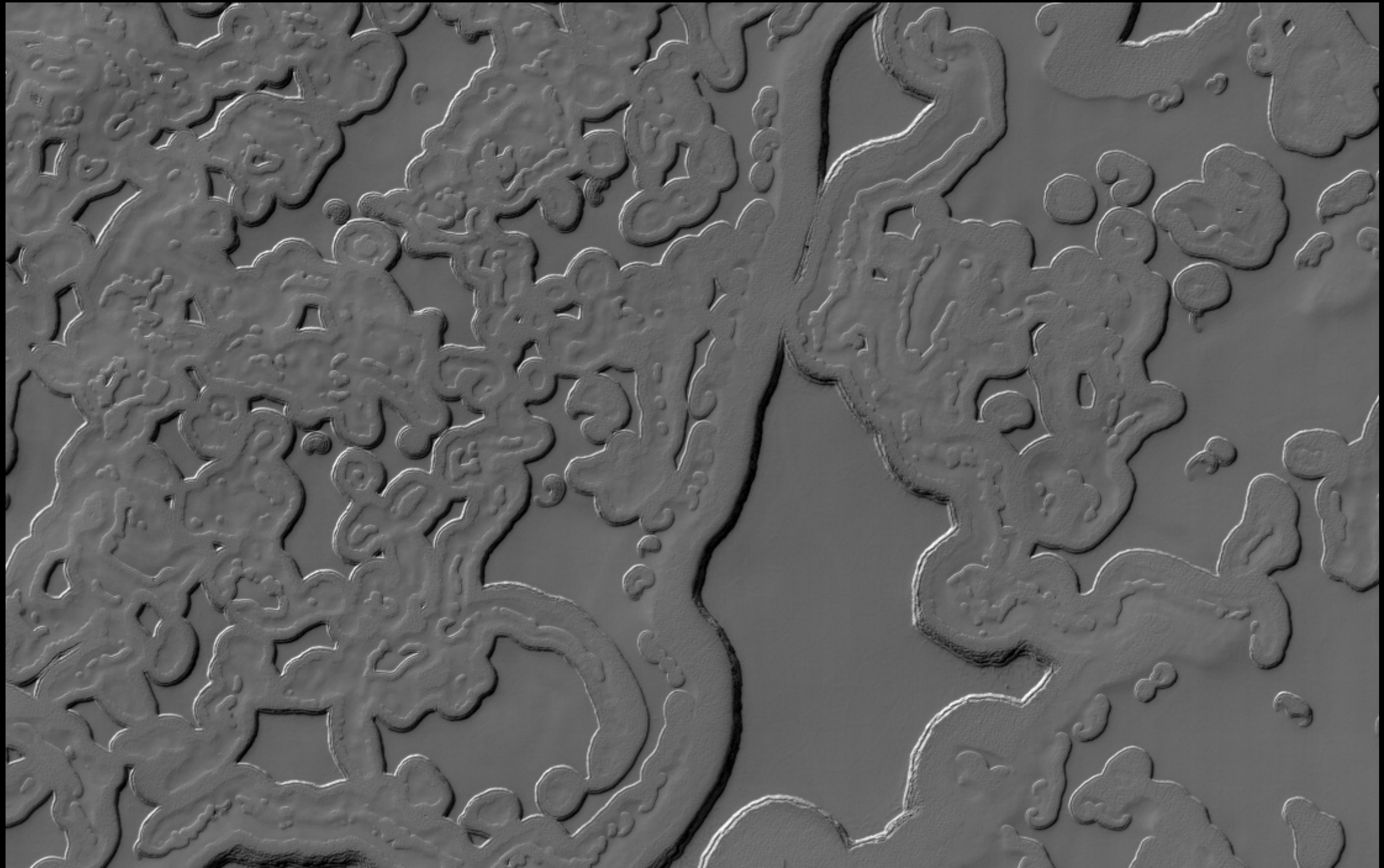




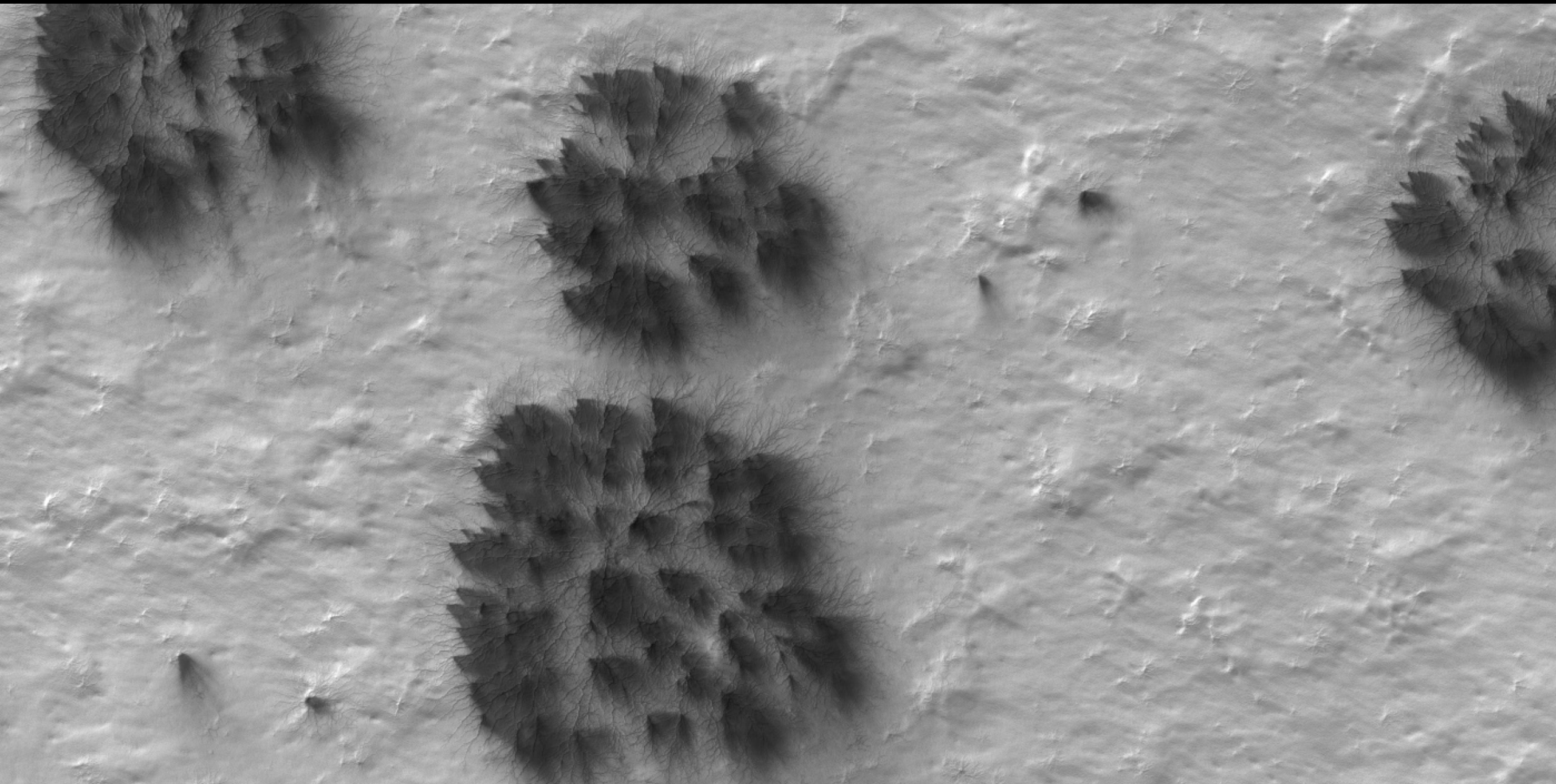
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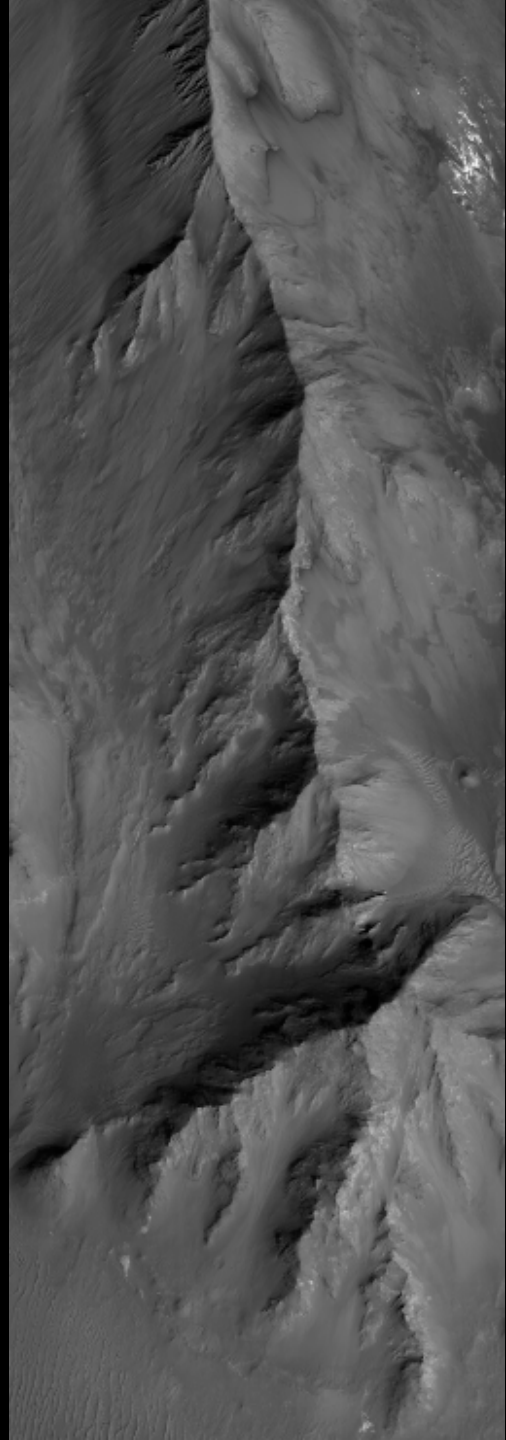


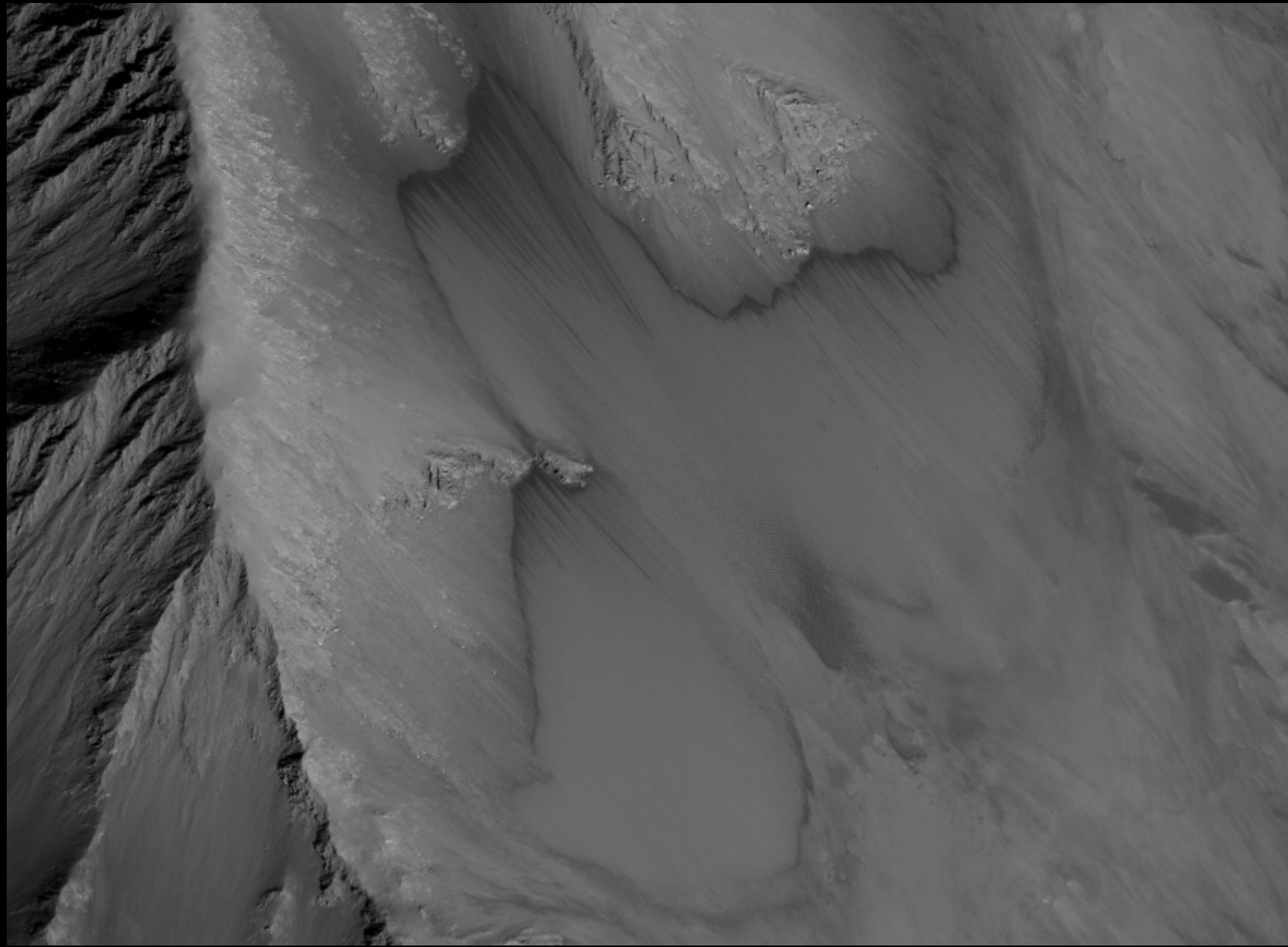












Giovanni Leone *Editor*

Mars: A Volcanic World



 Springer

Thank you!



MAHLI image mosaic from April 27, 2014 (Sol 613)
Credit: NASA/JPL-Caltech/MSSS
Edited by Jason Major