Gale Crater layered mound: A closed hydrologic system

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Outline

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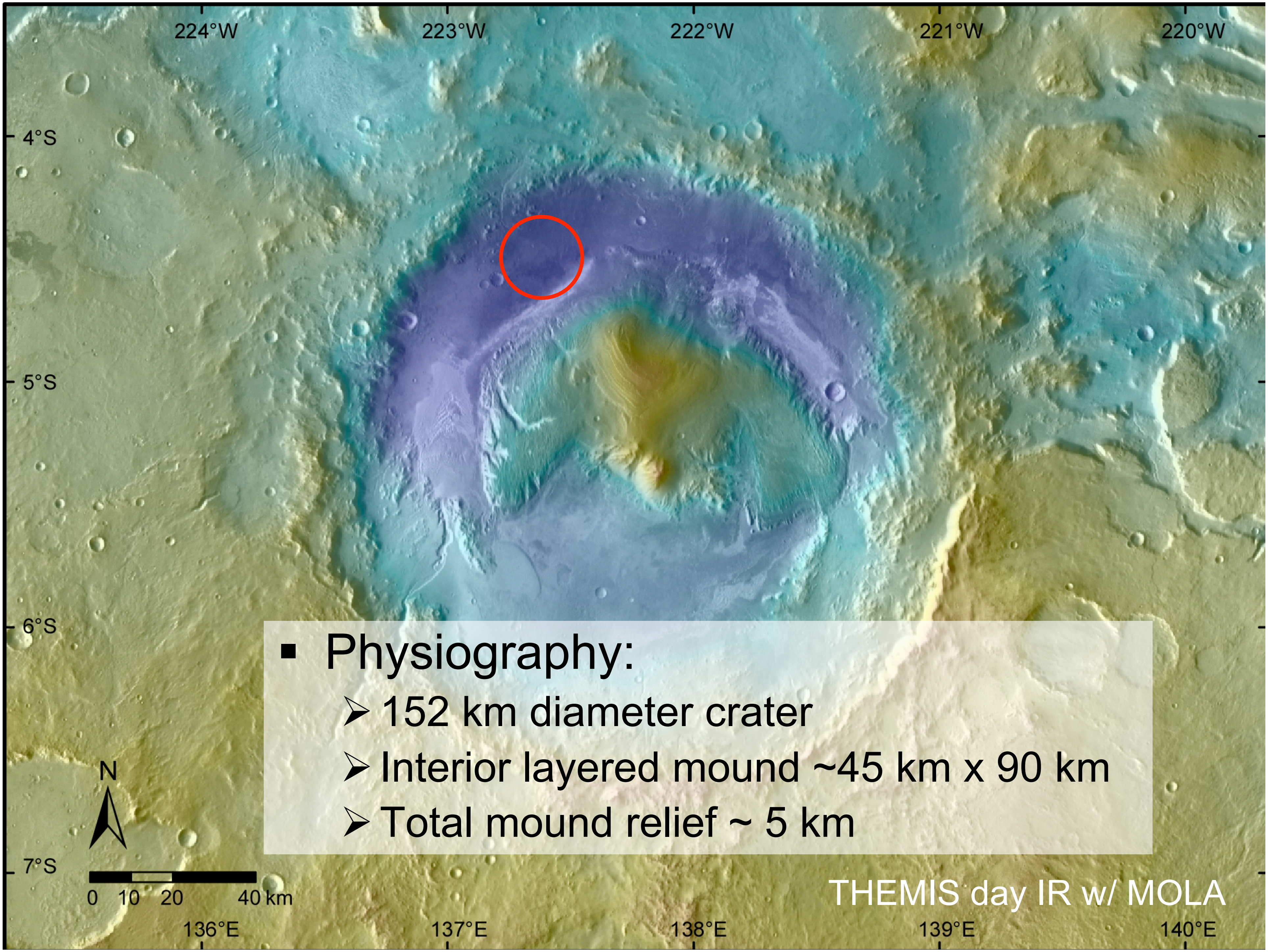
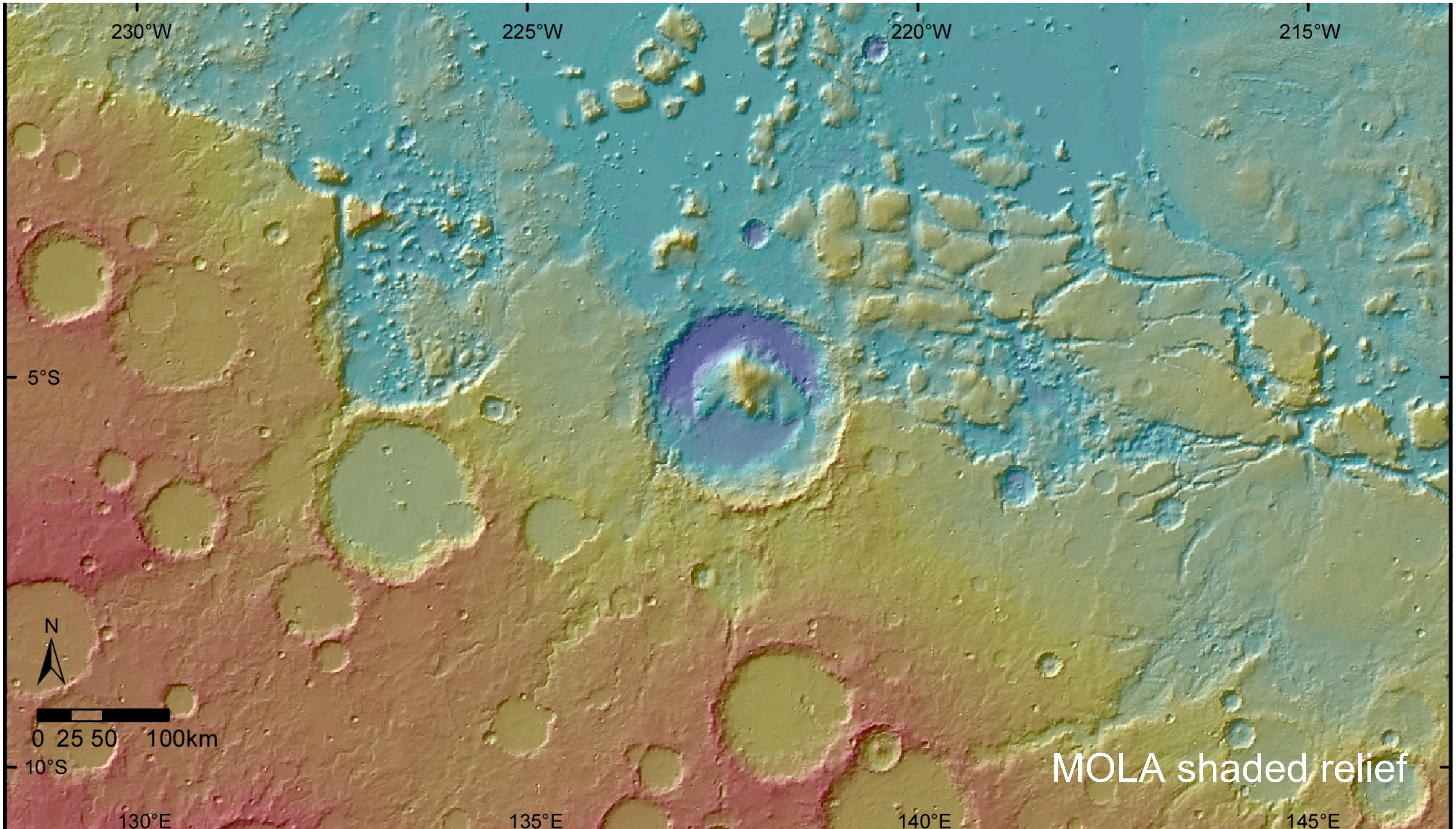
2. Fluvial geomorphology
3. Nature of layered material
4. Layer compositional signatures
5. Inferred geologic history
6. Engineering constraints
7. Science objectives for MSL

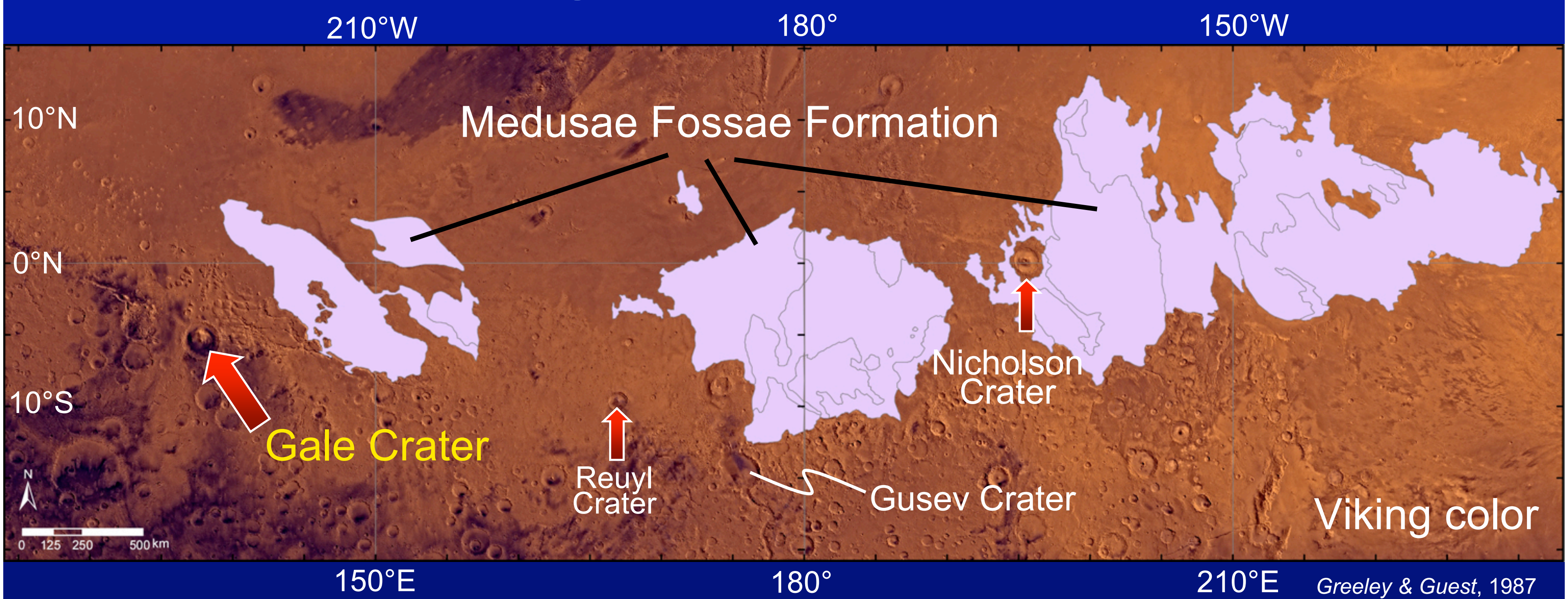


- Physiography:
  - 152 km diameter crater
  - Interior layered mound ~45 km x 90 km
  - Total mound relief ~ 5 km



- Regional context
  - Straddles hemispheric dichotomy boundary
  - Noachian plateau sequence
    (1:15M scale geo units Npld, Npl2)

Regional context

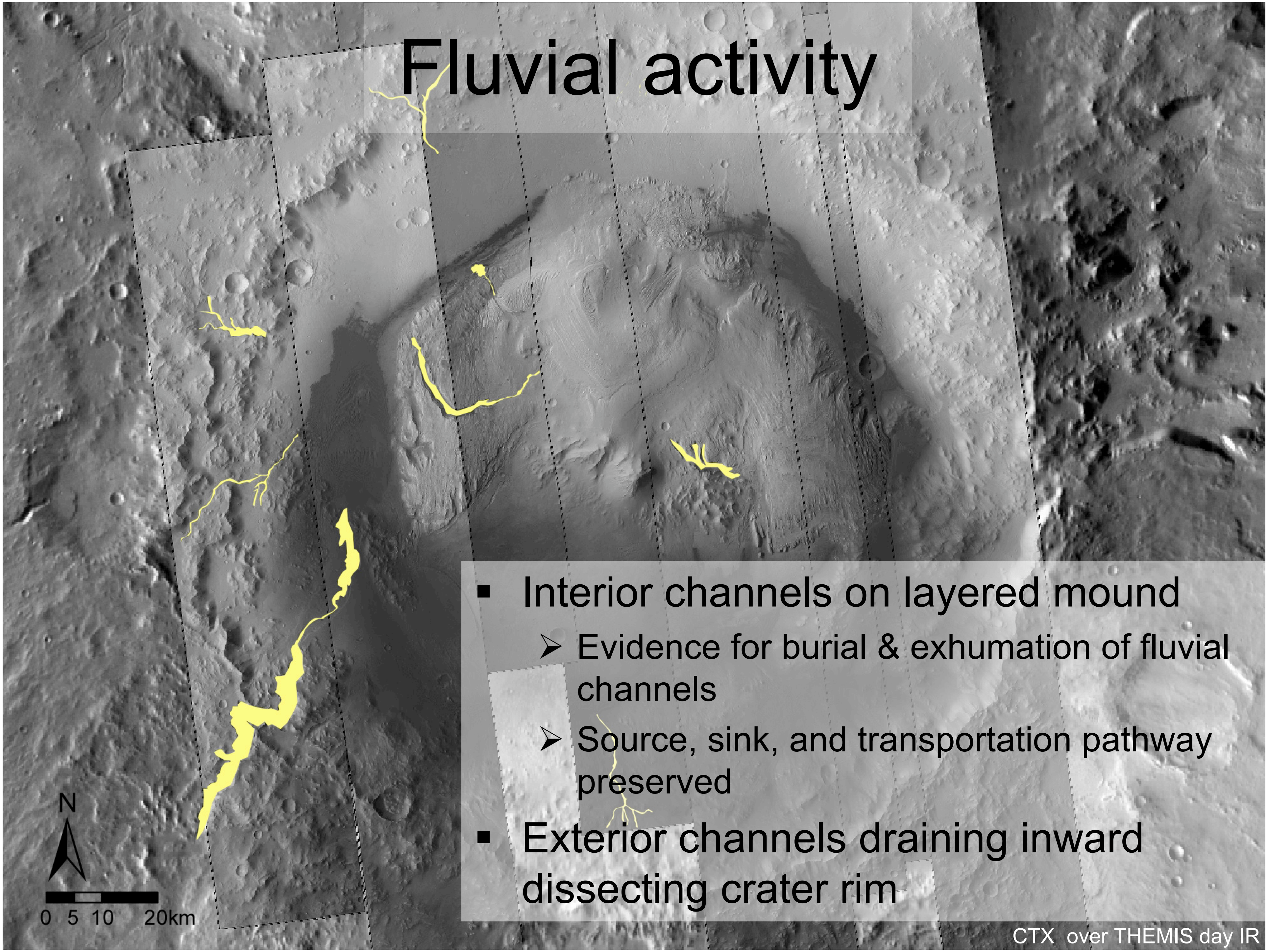


Greeley & Guest, 1987
Scott & Tanaka, 1987

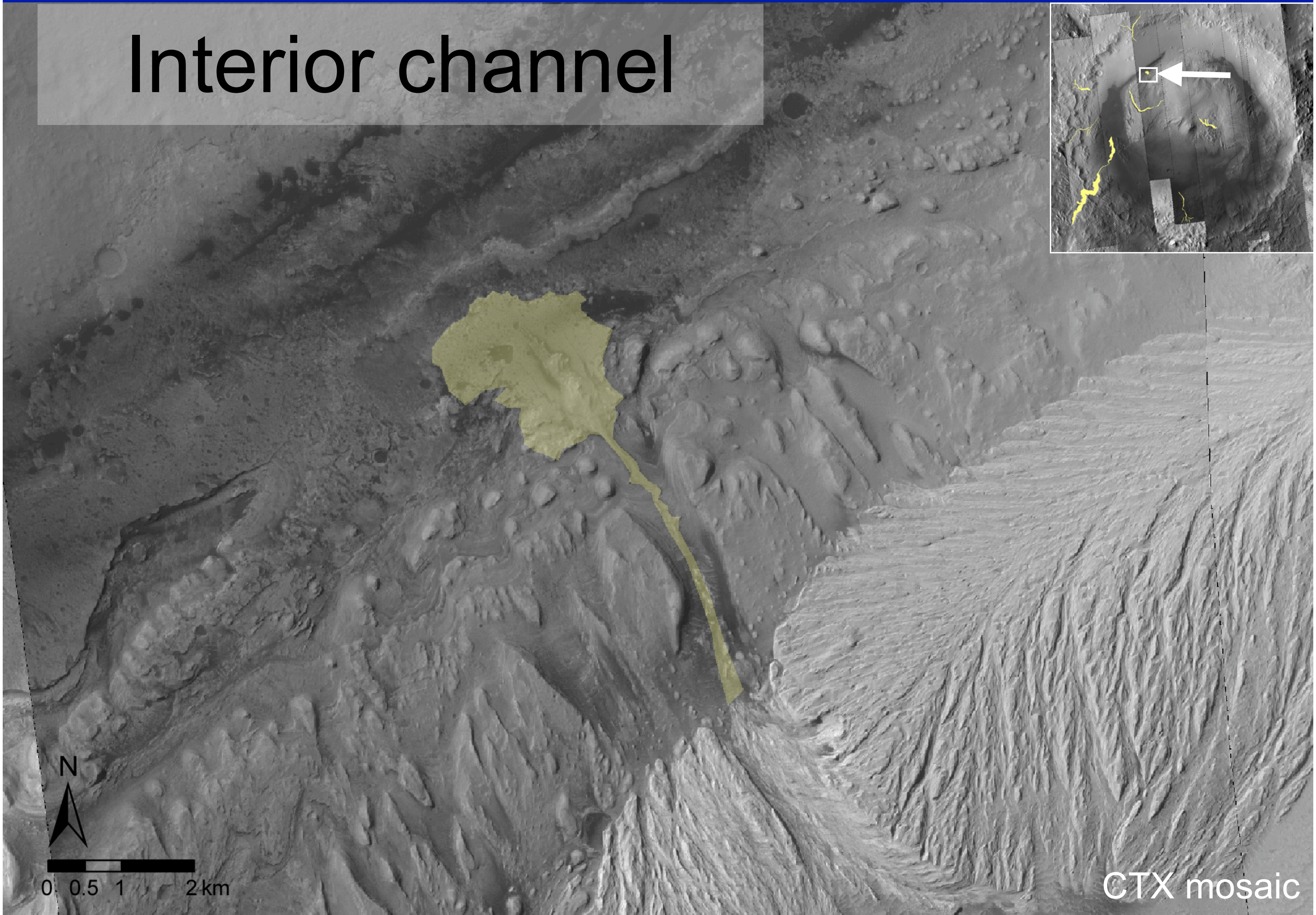
- Massive/layered sedimentary sequences not limited to Gale
- Medusae Fossae Formation (MFF) nearby
  - Numerous additional outliers
- Also Gusev Crater, Apollinaris Patera in vicinity

Fluvial activity

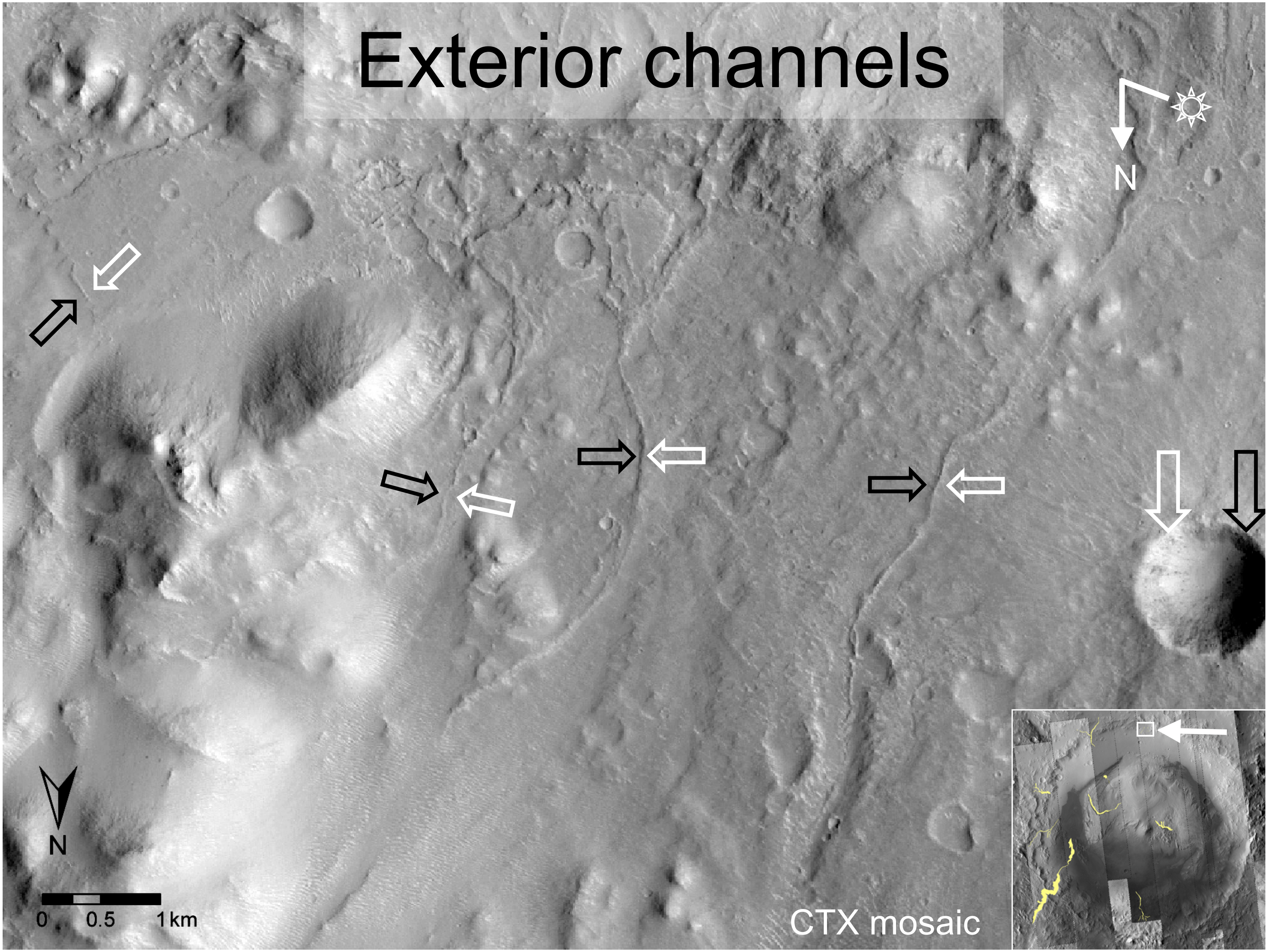
- Interior channels on layered mound
  - Evidence for burial & exhumation of fluvial channels
  - Source, sink, and transportation pathway preserved
- Exterior channels draining inward dissecting crater rim



Interior channel

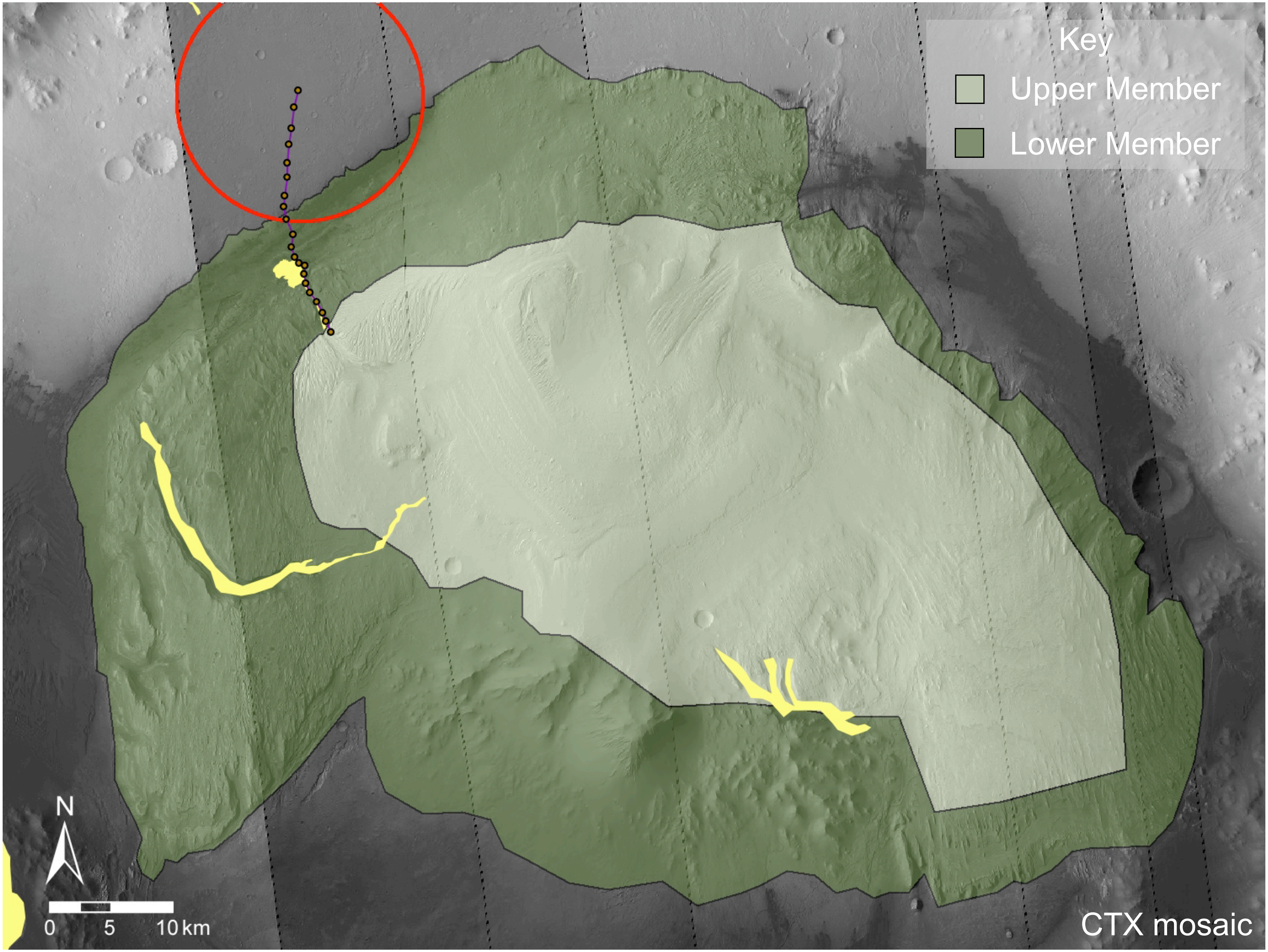


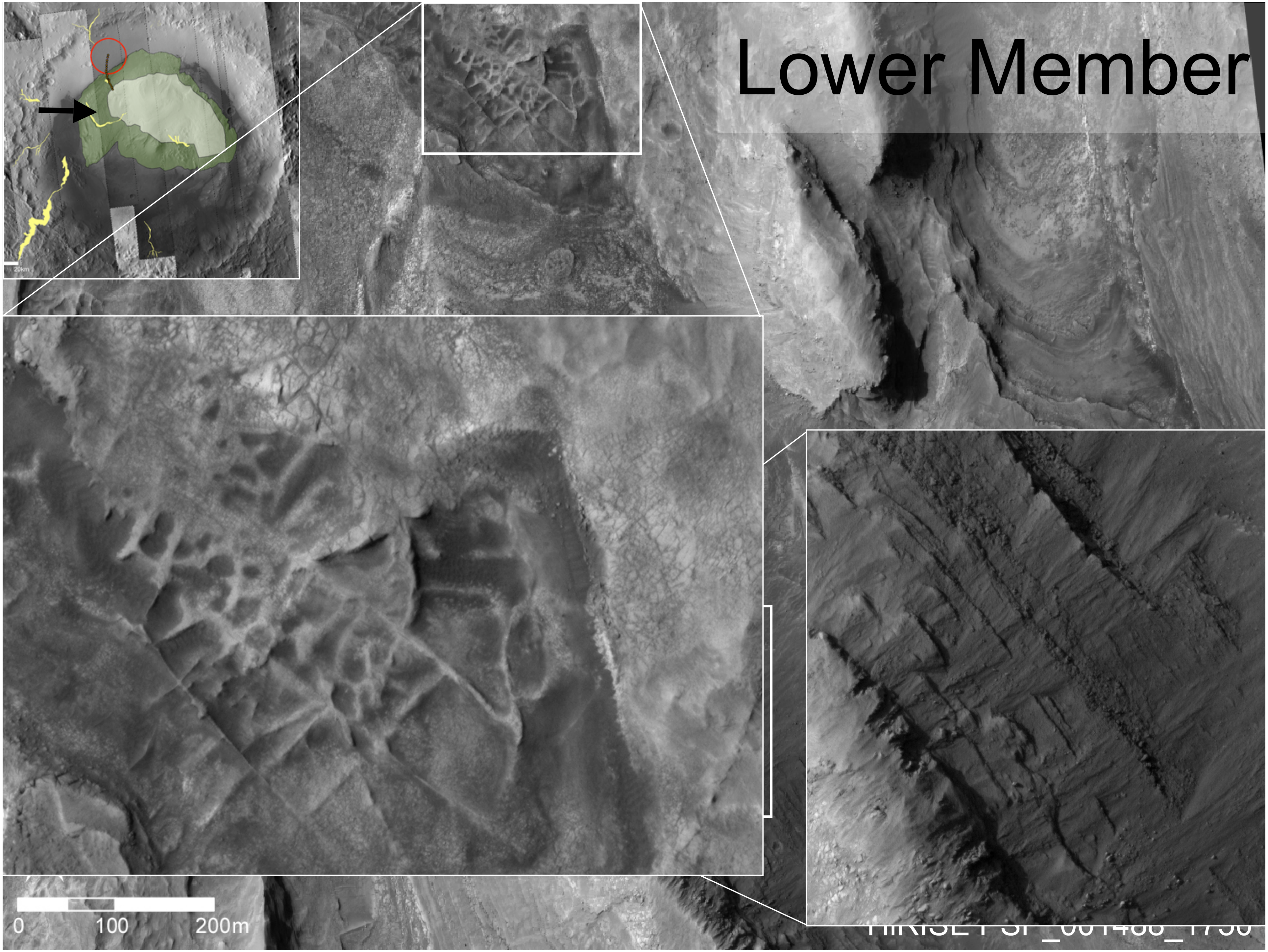
Exterior channels



Nature of layered material

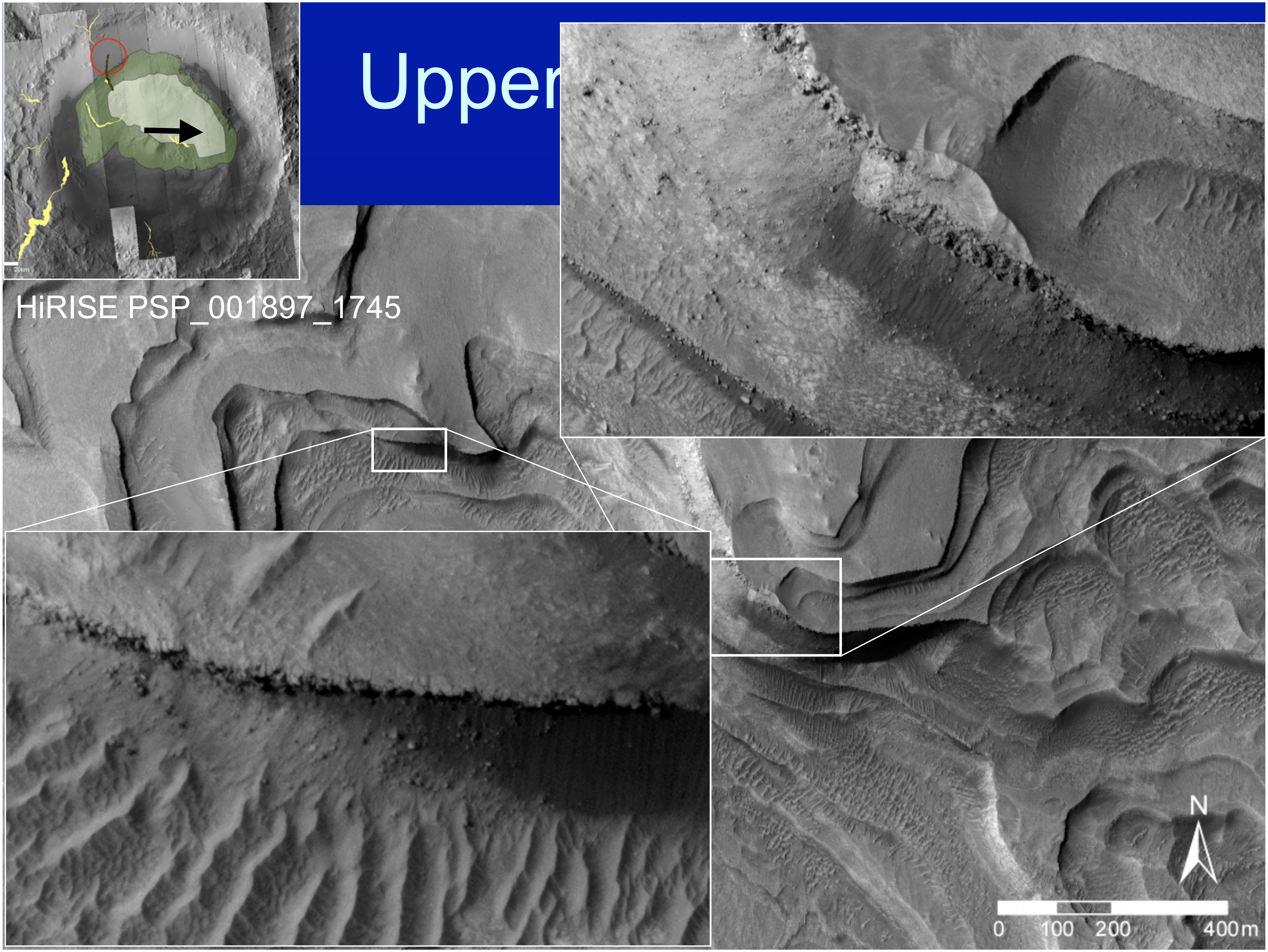
- Mound consists of two distinct members
- Lower member:
  - Finely layered
  - Conformal contact relationships
  - Total thickness ~1.5 km
- Upper member:
  - Erosional contact with lower member [*Edgett & Malin*, 2000]
  - Both massive and layered units
  - Max thickness ~3.5 km (mean 2.5 km)
- Stratigraphy records significant changes in depositional and erosional regimes


Key
Upper Member
Lower Member
N
0
5
10 km
CTX mosaic



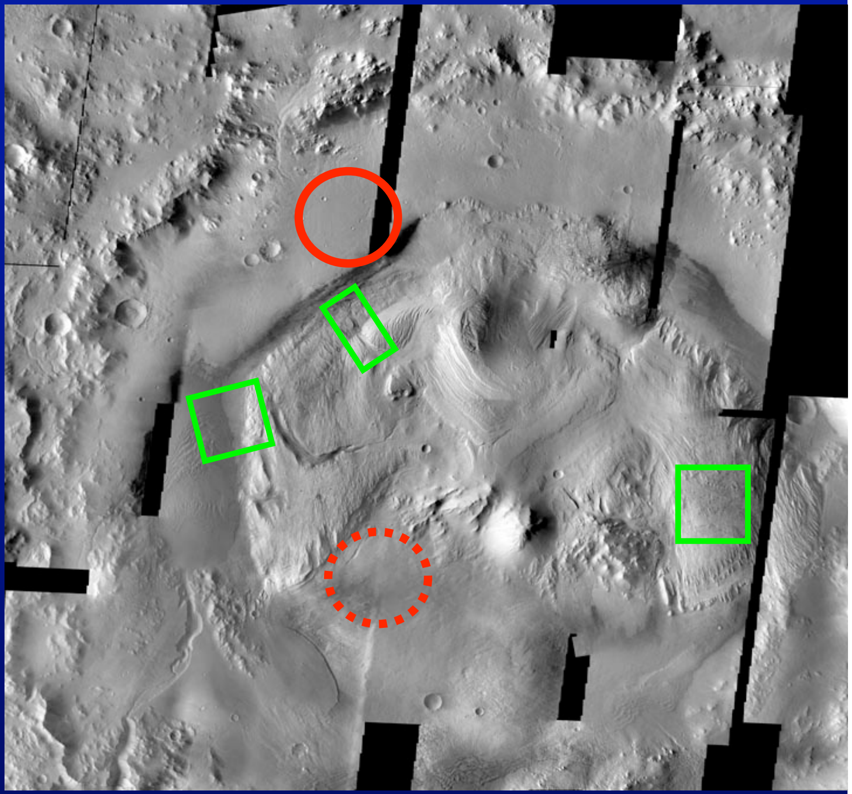
Lower Member
0
100
200m

Upper



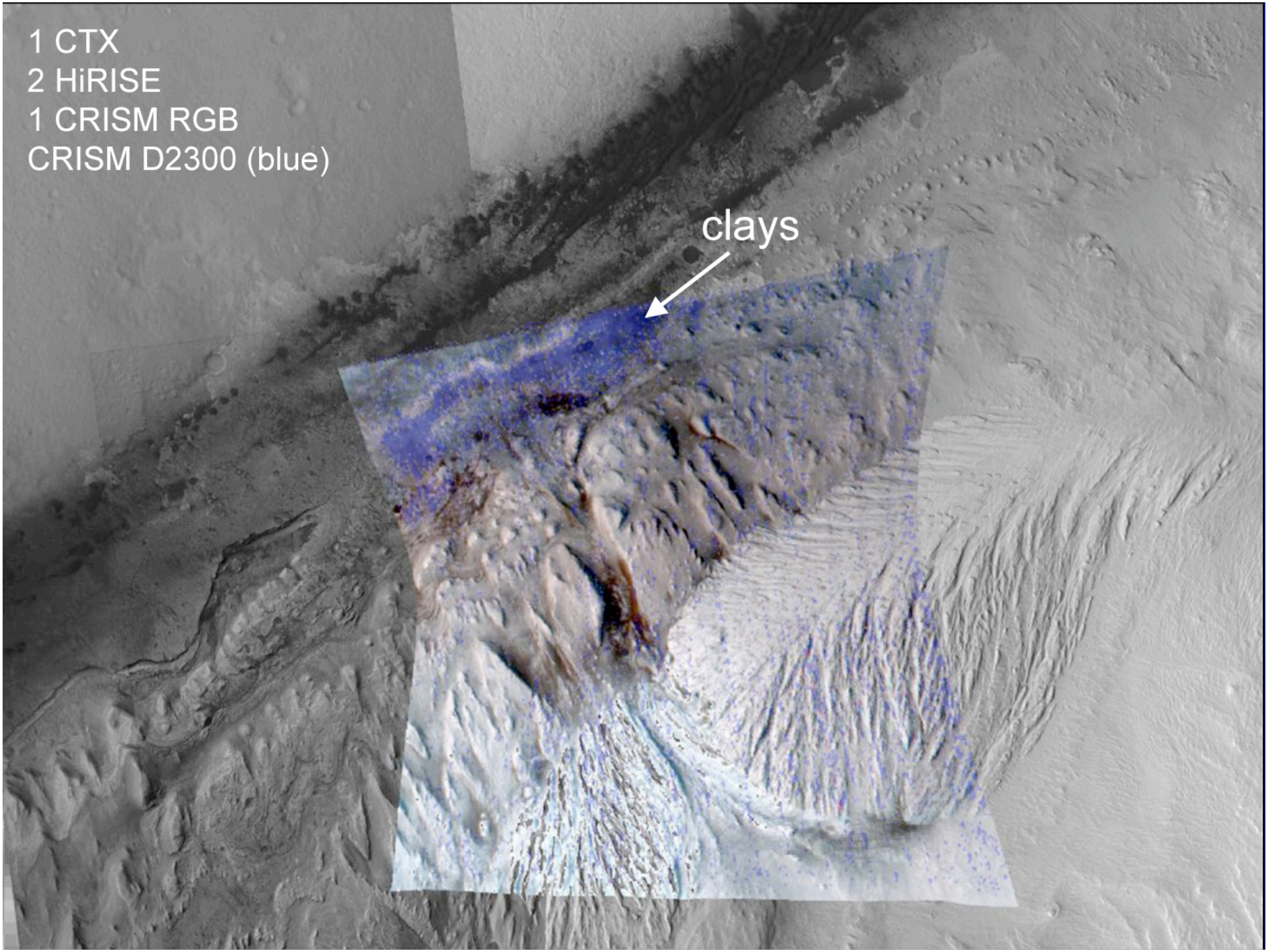
Layer compositional signatures

- Evidence for phyllosilicates
- Alteration mineralogy
- Implies large water/rock ratios, moderate to high degrees of alteration

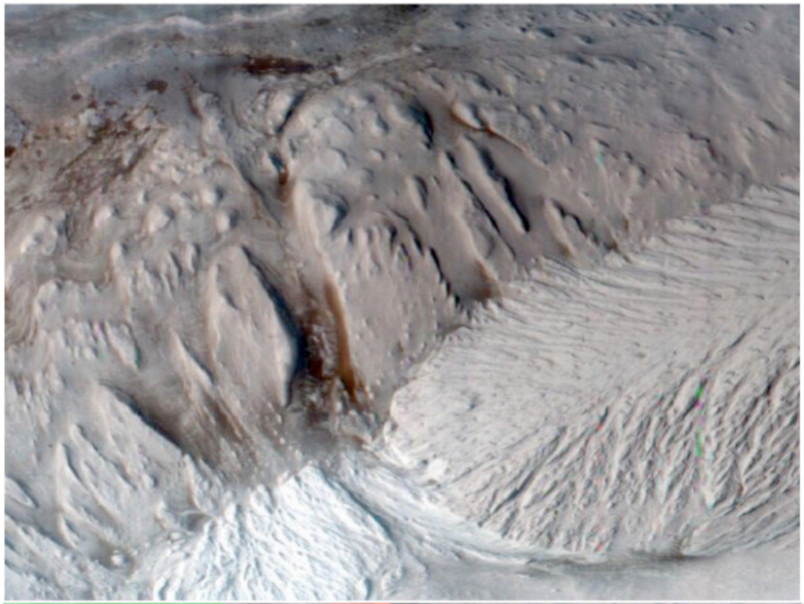


Red circle: potential landing ellipse, dashed = backup

Green boxes: CRISM FRT locations (approx)

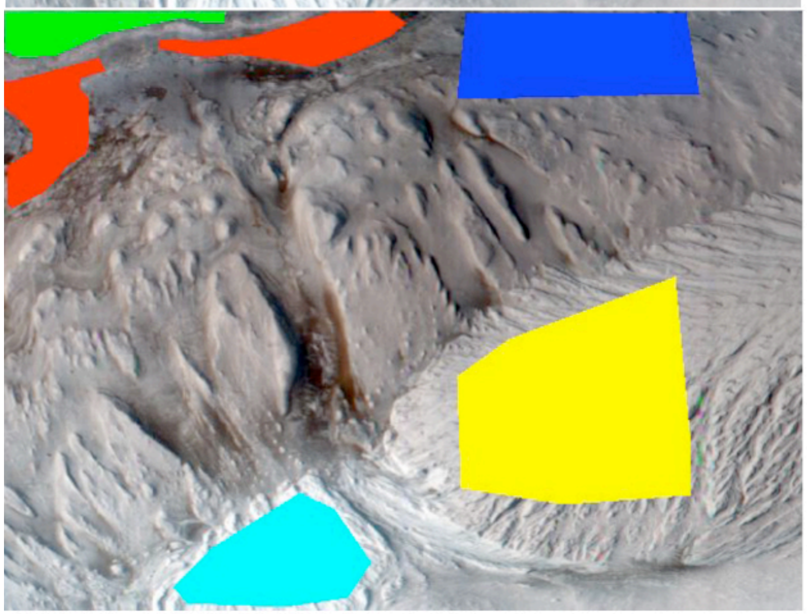


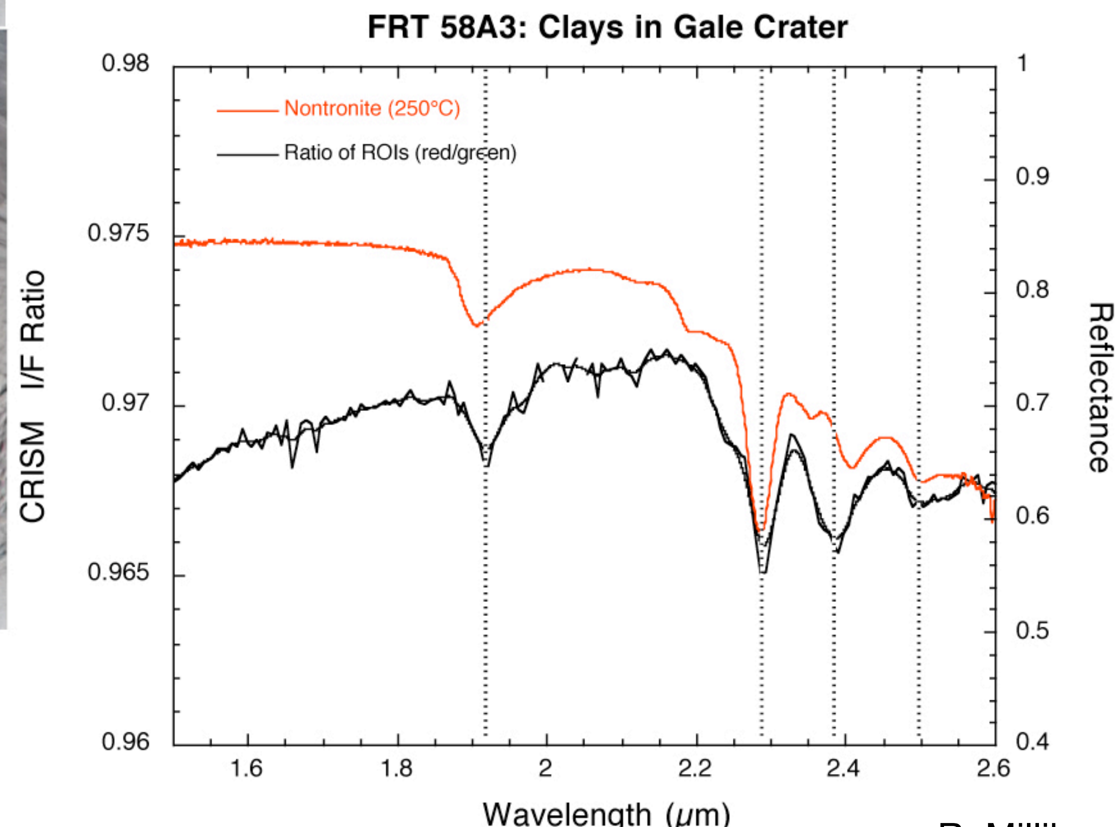
1 CTX
2 HiRISE
1 CRISM RGB
CRISM D2300 (blue)
clays



Absorptions are most consistent with an Fe/Mg-bearing smectite. There are clear spectral features at 1.91, 2.28, 2.39, and 2.5 µm.

Similar to partially dehydrated nontronite, although the 1.9 and 2.4 µm bands are shifted slightly.





Used Region of Interests (ROIs) to get higher S/N and improved spectral ratios; best results are achieved when using ROI's at similar elevations.

R. Milliken

Inferred geologic history

- Superposition indicates Gale Crater predates fretted terrain formation (dichotomy boundary)
- Lower Member of layered mound formation
  - Possible lacustrine or distal fluvio-deltaic contributions
  - Mineralogic evidence for aqueous alteration
  - Mass wasting contribution from degraded northern rim
- Upper Member of layered mound formation
  - Erosional contact with Lower Member indicates depositional hiatus
  - Massive to finely layered units, low thermal inertia $\Rightarrow$ suggests airfall deposit possibly linked to Medusae Fossae Formation
  - Intermittent fluvial activity - possible volatile component mixed with dust/ash component
- Continued eolian erosion, some potential late-stage fluvial activity

Engineering constraints

Engineering Parameter	Requirement	Gale site value
Latitude	45°N to 45°S	4.5°S
Elevation	≤ +1 km	-4.4 ± 0.1 km
Slopes (2-10 km length scale)	≤ 20º	2.78 km baseline: 6.7° max
Terrain Relief (1-2 km length scale)	≤ 43 m relief at 1 km; ≤ 720 m at 2 km	1.39 km: 95 m relief 2.78 km: 328 m relief
Terrain Relief (0.2-1 km length scale)	≤ 43 m relief	T.B.D.
Slopes (2-5 m length scale)	≤ 15º	T.B.D. by photoclinometry

Engineering constraints

Engineering Parameter	Requirement	Gale site value
Rock height	≤ 0.55 m (< 0.50% chance of 0.55 m rock in 4 m^2). Suggests low to moderate rock abundance.	IRTM rock abundance: 10%
Radar reflectivity	Ka band radar backscatter cross-section (> -20 dB and < 15 dB)	T.B.D.
Load bearing surface	Thermal inertia >100 $J/m^2s^{0.5}K$ albedo <0.25 radar reflectivity >0.01	TES TI: 483 TES albedo: 0.238 TES DCI: 0.96

Science objectives

- Confirm nature of alteration assemblage
  - ➢ What minerals are present?
    - – What are grain sizes, shapes, textures, relation to other constituents?
  - ➢ Assess degree of alteration, biologic habitability potential
- Determine origin of lower and upper sedimentary member formation:
  - ➢ Subaerial (airfall, impact, mass wasting) and/or subaqueous (lacustrine, fluvial)?
- Explore closed hydrologic system
  - ➢ Sources, sinks, and transportation pathways all accessible in single locality

MSL instrument suite

Acronym	Full Name	Description
MastCam	Mast Camera	Mast-mounted stereo camera
MAHLI	Mars Hand Lens Imager	Arm-mounted surface imager
APXS	Alpha Particle X-Ray Spectrometer	Arm-mounted chemistry probe
ChemCam	Chemistry & Camera	Laser induced breakdown spectroscopy with remote micro-imager
CheMin	Chemistry & Mineralogy	XRD / XRF delivered sample analysis
SAM	Sample Analysis at Mars	GCMS & Tunable Laser Spectrometer for delivered sample analysis

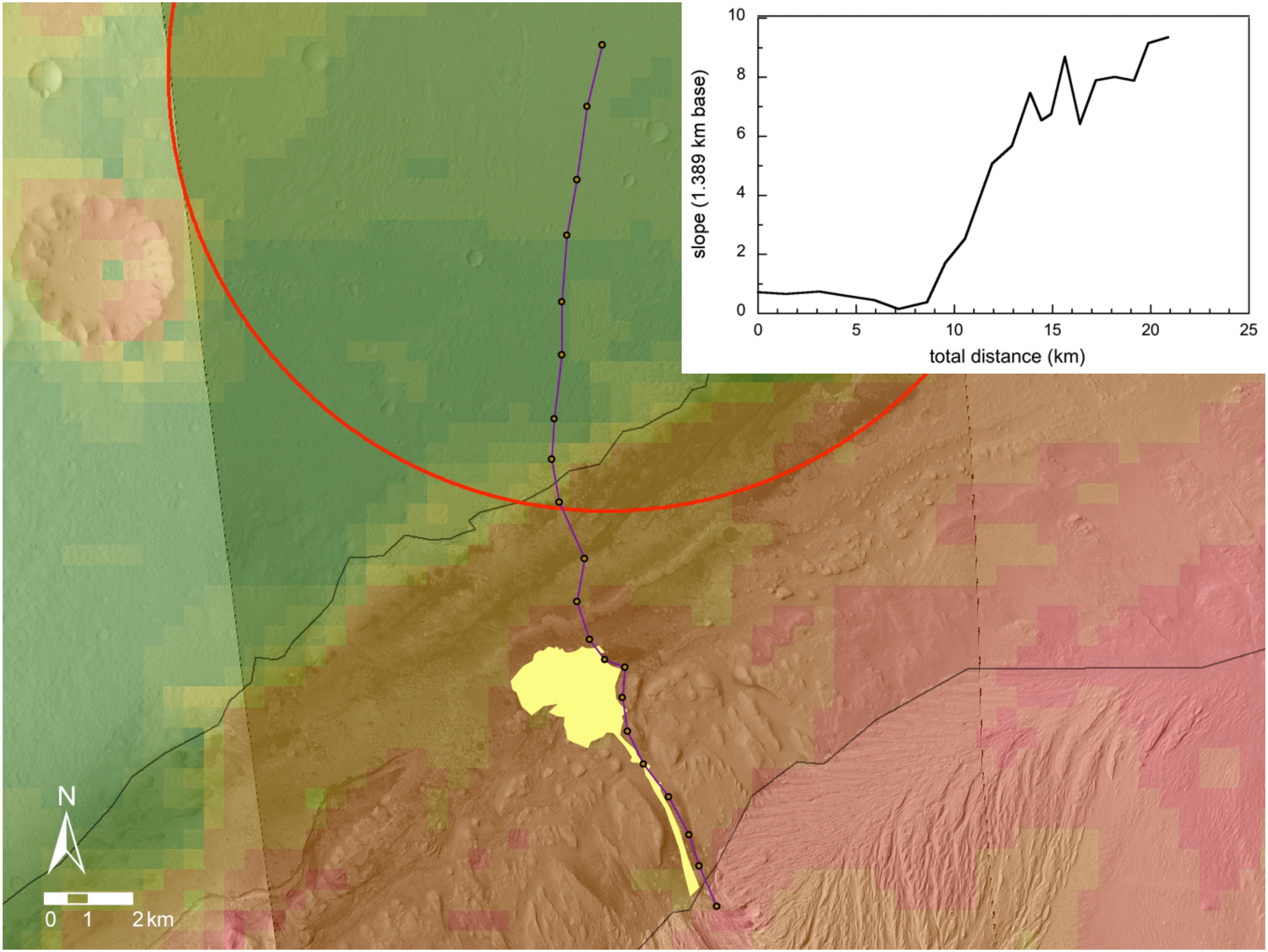
Science Traceability Matrix

Goal	Objective	Instruments
Confirm nature of alteration assemblage	Identify alteration minerals	APXS, CheMin, SAM, ChemCam
	Characterize grain sizes, shapes, textures, relation to other constituents	MAHLI, ChemCam
	Assess degree of alteration, biologic habitability potential	APXS, CheMin, SAM, ChemCam
Determine layer origin(s)	Examine constituent particles: grain size, sorting, shapes, textures	MastCam, MAHLI, ChemCam
	Look for bedding relationships, sedimentary structures	MastCam, ChemCam
	Identify primary and secondary mineralogy	APXS, CheMin, SAM, ChemCam
Explore closed hydrologic system	Determine cementation agent, evidence of alteration	all

Extra

Additional considerations

- Unlike Meridiani, here the entire stratigraphic column is exposed
- Any rover traverse path will start with the oldest units
  - Lower strata appear to be clay-bearing
  - Can drive up section to access younger strata
- Key alteration mineralogy can be accessed very early in mission
- Low energy depositional environment has high biomarker preservation potential


10
8
6
4
2
0
slope (1.389 km base)
0
5
10
15
20
25
total distance (km)
N
0
1
2 km