Polyphase Amazonian floods in the Olympica – Jovis Fossae channel system

EPSC abstract

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Introduction

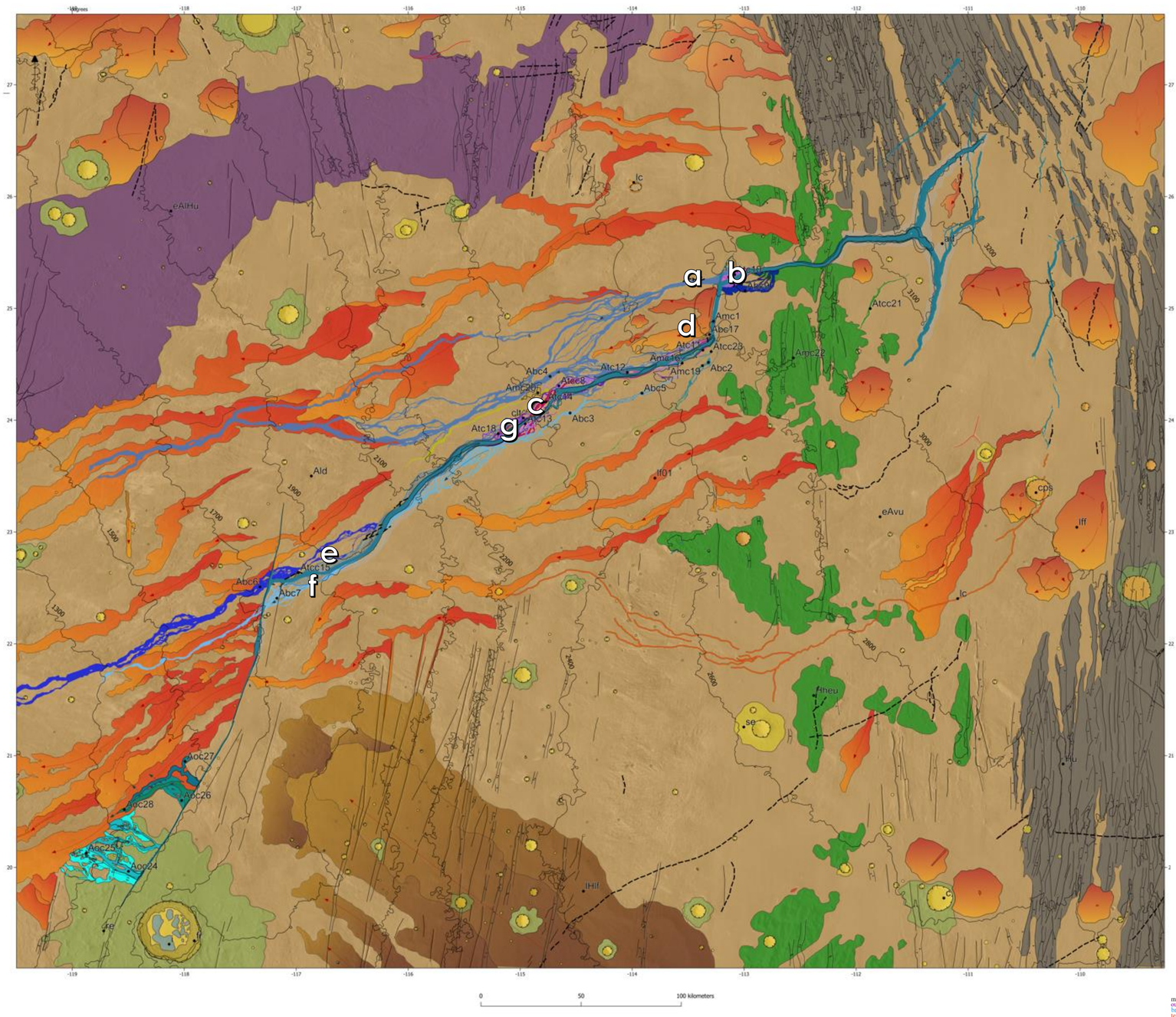
Outflow channels of the Tharsis on Mars testify to the drainage of groundwater reservoirs through magmatic and tectonic processes. We present **a new geologic map of Olympica-Jovis Fossae** where we mapped landforms and geological units, dated them relatively, and identified the chronological succession of outflow events and deposition of lava flows, airfall, and sedimentary units.

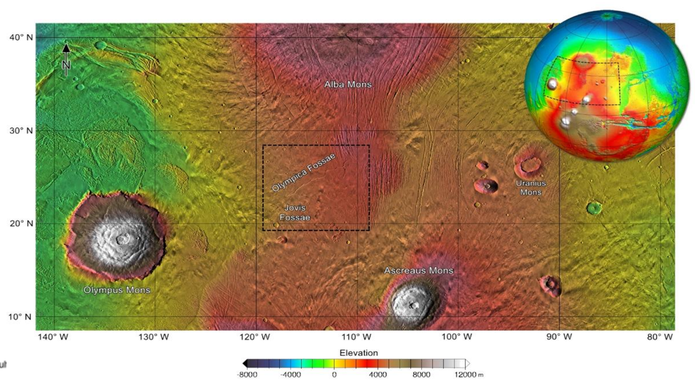
Cross-cutting relationships indicate a complex succession of **28 channel incisions** in the volcanic stratigraphy. The six identified morphological channel types indicate different flow dynamics at different times and places. The map highlights the role of intensive volcanic activity in releasing water from overpressurized aquifers and possible subglacial flows, and will assist in a better understanding of the general conditions for **catastrophic groundwater flooding** in a volcanic context.

Methodology

- **To map morphological and geological features** we used visible imagery from the MRO CTX with a resolution of 6 meters per pixel and MRO HiRISE camera with a resolution of 25 cm per pixel.
- **To constrain the intersecting relationships between channels** we used the newest DEM topography data (2021 – 2023) from the Mars Express HRSC with a resolution of ~20-40 meters per pixel, and from the ExoMars Trace Gas Orbiter, Colour and Stereo Surface Imaging System with a resolution of 4.8 meters per pixel.
- **To identify and map the outlines of lava flows** we used the daytime infrared global mosaic from the Mars Odyssey THEMIS with a resolution of ~100 meters per pixel, in combination with the CTX images.

Results





Legend:

Contact Types
certain
approximate

Geological Structures
normal fault
second generation of normal faul
third generation of normal fault
graben
linear cracks

Glacial Lineations
Agl - Amazonian glacial lineation

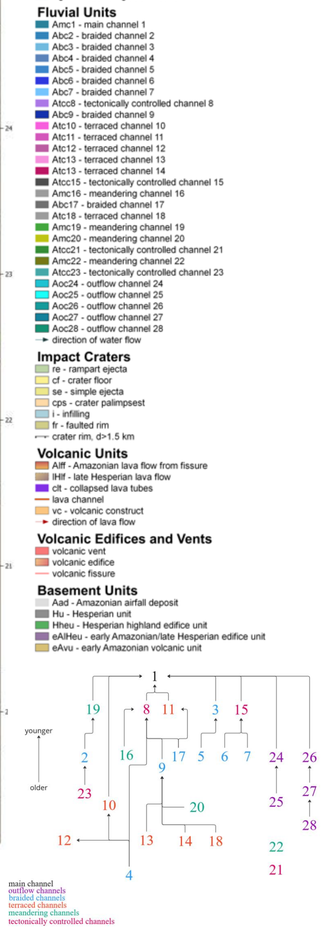
Fluvial Units
Amc1 - main channel 1
Abc2 - braided channel 2
Abc3 - braided channel 3
Abc4 - braided channel 4
Abc5 - braided channel 5
Abc6 - braided channel 6
Abc7 - braided channel 7
Atcc8 - tectonically controlled channel 8
Abc9 - braided channel 9
Atc10 - terraced channel 10
Atc11 - terraced channel 11
Atc12 - terraced channel 12
Atc13 - terraced channel 13
Atc13 - terraced channel 14
Atcc15 - tectonically controlled channel 15
Amc16 - meandering channel 16
Abc17 - braided channel 17
Atc18 - terraced channel 18
Amc19 - meandering channel 19
Amc20 - meandering channel 20
Atcc21 - tectonically controlled channel 21
Amc22 - meandering channel 22
Atcc23 - tectonically controlled channel 23
Aoc24 - outflow channel 24
Aoc25 - outflow channel 25
Aoc26 - outflow channel 26
Aoc27 - outflow channel 27
Aoc28 - outflow channel 28
direction of water flow

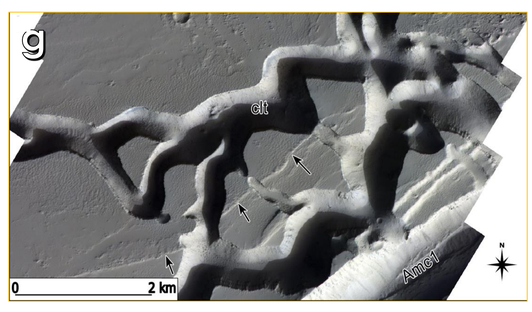
Impact Craters
re - rampart ejecta
cf - crater floor
se - simple ejecta
cps - crater palimpsest
i - infilling
fr - faulted rim
crater rim, d>1.5 km

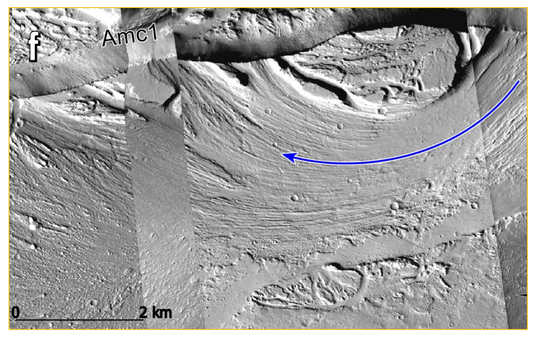
Volcanic Units
Alff - Amazonian lava flow from fissure
lHlf - late Hesperian lava flow
clt - collapsed lava tubes
lava channel
vc - volcanic construct
direction of lava flow

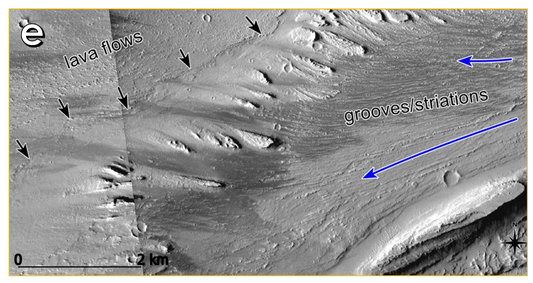
Volcanic Edifices and Vents
volcanic vent
volcanic edifice
volcanic fissure

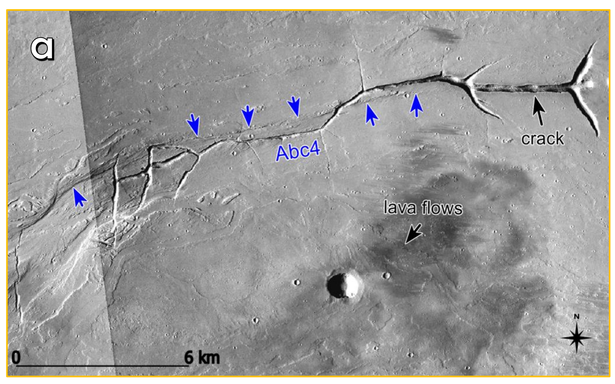
Basement Units
Aad - Amazonian airfall deposit
Hu - Hesperian unit
Hheu - Hesperian highland edifice unit
eAlHeu - early Amazonian/late Hesperian edifice unit
eAvu - early Amazonian volcanic unit

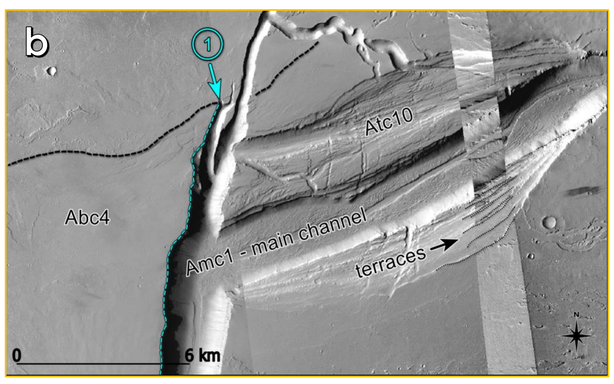


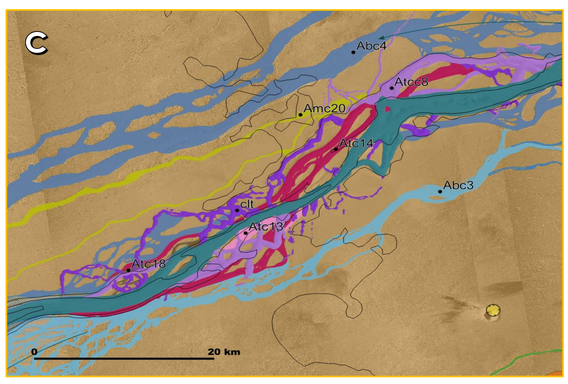


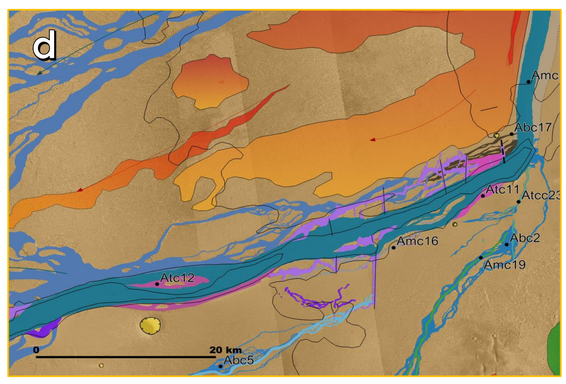












Discussion

The map presents major groups of geological and morphological units: geological structures defined as linear cracks, grabens, and three generations of faults; volcanic features which include volcanic vents, lava flows, lava channels, and the direction of lava flows; basement units, from oldest to youngest: Noachian/Hesperian highland edifice unit, Hesperian unit, Hesperian/Early Amazonian unit, the most extensive Early Amazonian volcanic unit; **twenty-eight fluvial units** grouped into six morphological types of channels: braided systems, tectonically controlled channels, terraced channels, meandering channels, outflow channels, and the main channel; **glacial lineations**; **impact craters**; and **airfall deposit unit**.

A general investigation of the mapped units reveals the correlation between volcanic activity on Tharsis and Amazonian flooding events. The geological map displays many lava flows and volcanic edifices, partially covering the Tharsis volcanic plains, that formed after the Amazonian flooding events.

Conclusions

- The Olympica – Jovis Fossae system extends over 500 km, but the significance of its deep and narrow channels for the Tharsis dome is poorly understood.
- The observed morphological features, such as **channels with terraces and teardrop-shaped islands**, suggest that water flowed in the Olympica and Jovis Fossae channels. The existing literaturę on the morphology of channels and valleys on Mars indicates **long-lasting fluvial activity**. It is the most likely dominant mechanism for eroding channels and leaving terrain with typical fluvial marks.
- As the documented channels are incised in, but also partially covered by lava flow sequences, water must have flown after the emplacement of a large-scale Tharsis lava field, and before renewed lava flow emplacement.
- Our map documents not one flooding event by water, but **a prolonged history of repeated outflow** from various fissures, possibly related to an intensive period of distributed volcanism.

Acknowledgement & References

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