

An aerial photograph of a Martian landscape. In the background, a large, reddish-brown volcano with a prominent rim is visible. The foreground and middle ground show a vast, flat, sandy plain with some subtle ridges and depressions. The overall color palette is a range of reds, oranges, and browns.

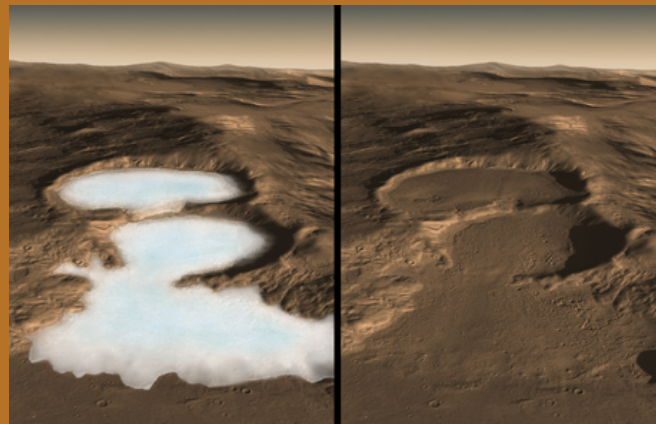
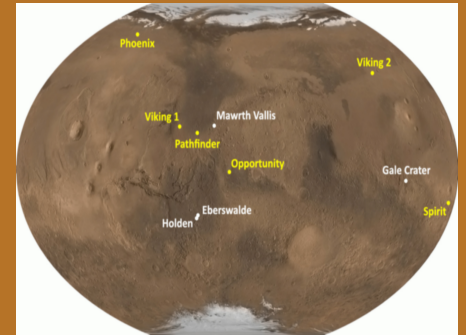
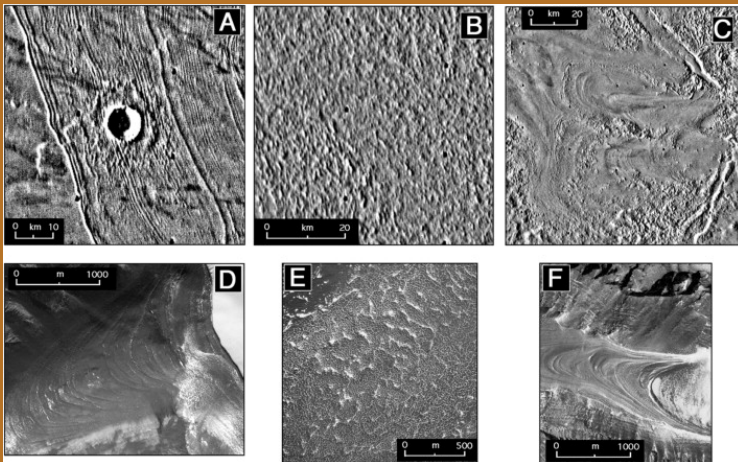
Mapping Evidence of Glaciation Around Olympus Mons, Mars

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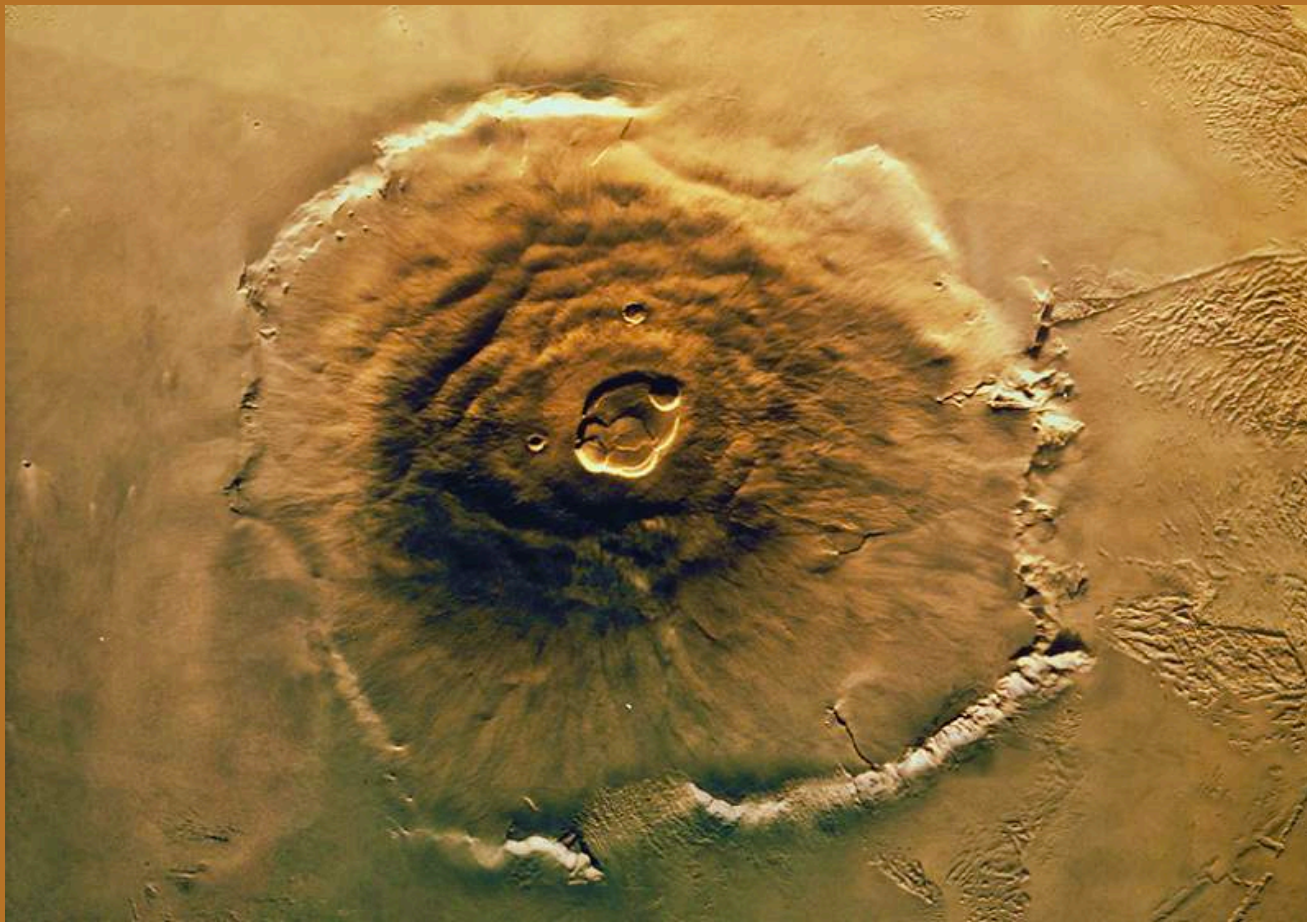
Background

- Rock facies indicate glacial formations on Mars
- Some speculate the obligatory patterns of the orbit
- Uneven orbit causes the glaciers to advance and recede



Hypothesis

How is the evidence of glaciers distributed around Olympus Mons?



(Edu-net, 2012)

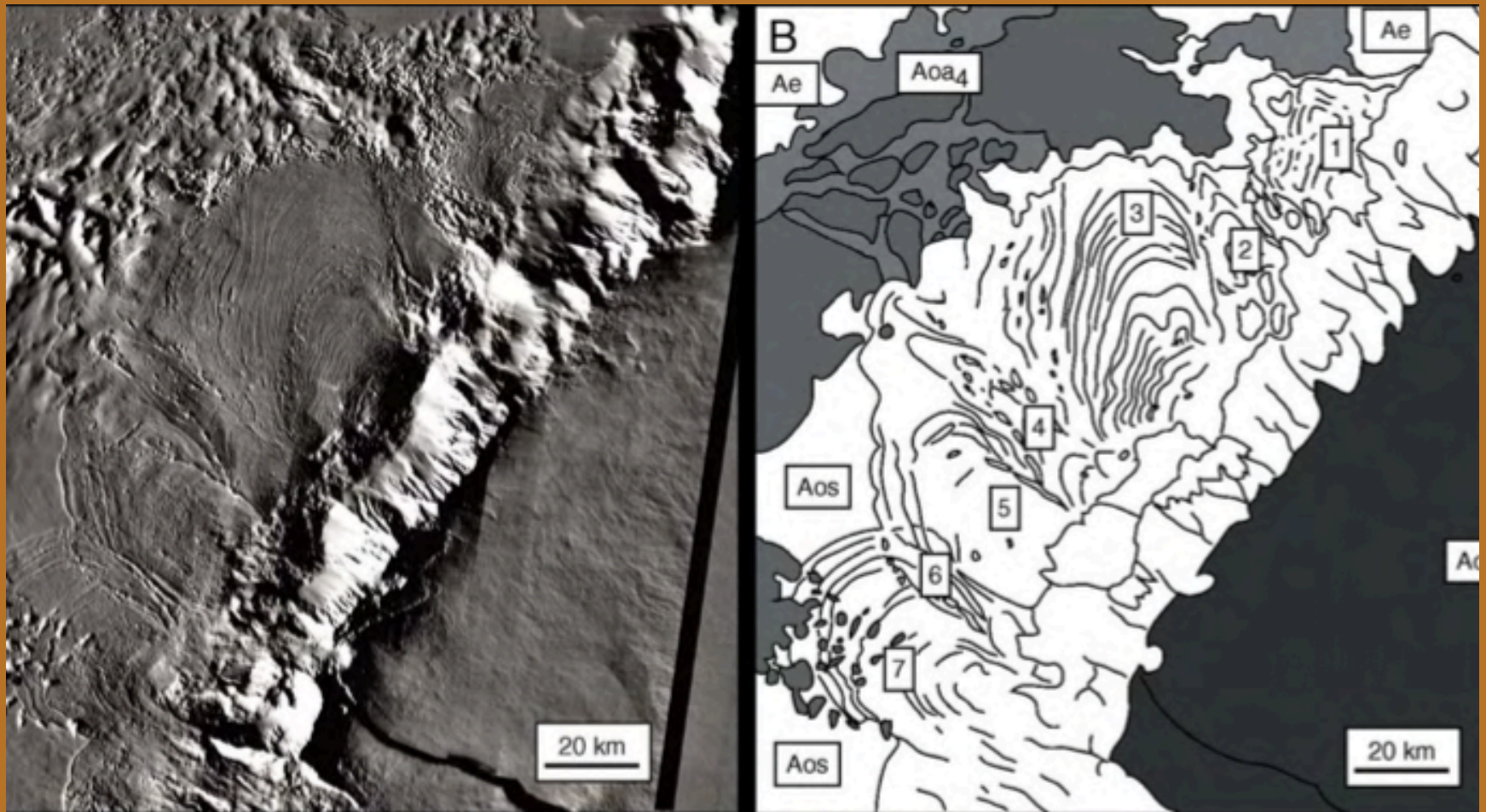
Lobes

- Ice and debris features
- Distinctive ‘tongue’ shape
- Distinguishable from lava flows, etc. by shape, features, dimensions.



Aerial photo of Canadian protalus lobes from a rock glacier.

Lobes, contd.



Map of Martian lobate deposits, likely the remnants of a Piedmont glacier.

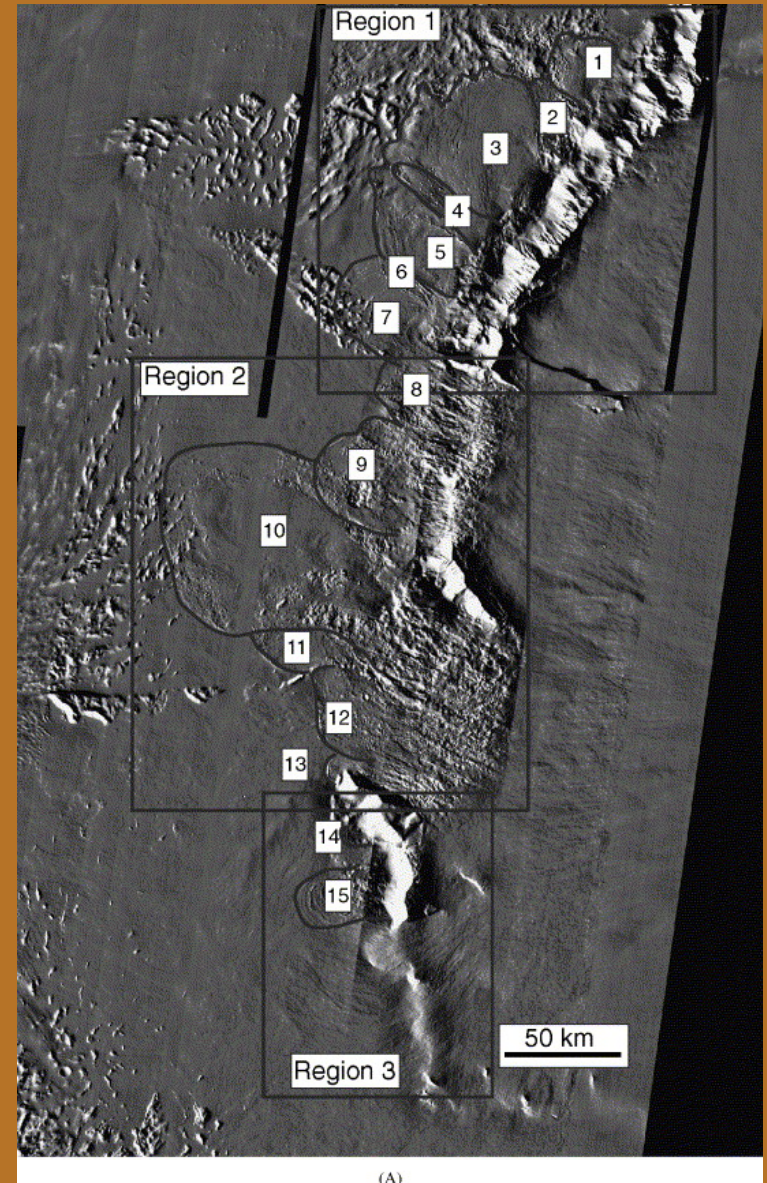
Glacial Ridges on Mars



- Large deposits of sediment and glacial till, scraped up by forceful movement of glaciers
- Similar to Terrestrial moraines

Alcoves

- Theater shaped
- Found on basal escarpment
- Lobes found below formation
- Large moraines and scarps

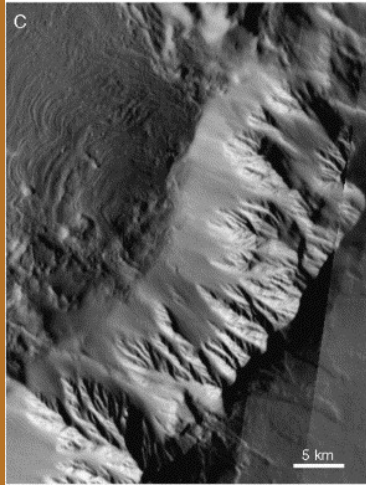
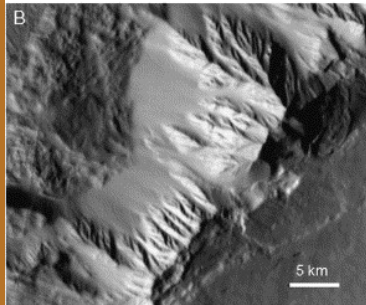
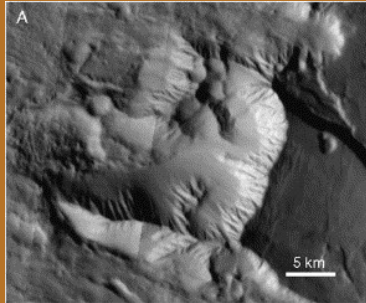


(A)

Cones

- Talus Cone – a sloping apron of rocks along the base of a cliff

1.



2.

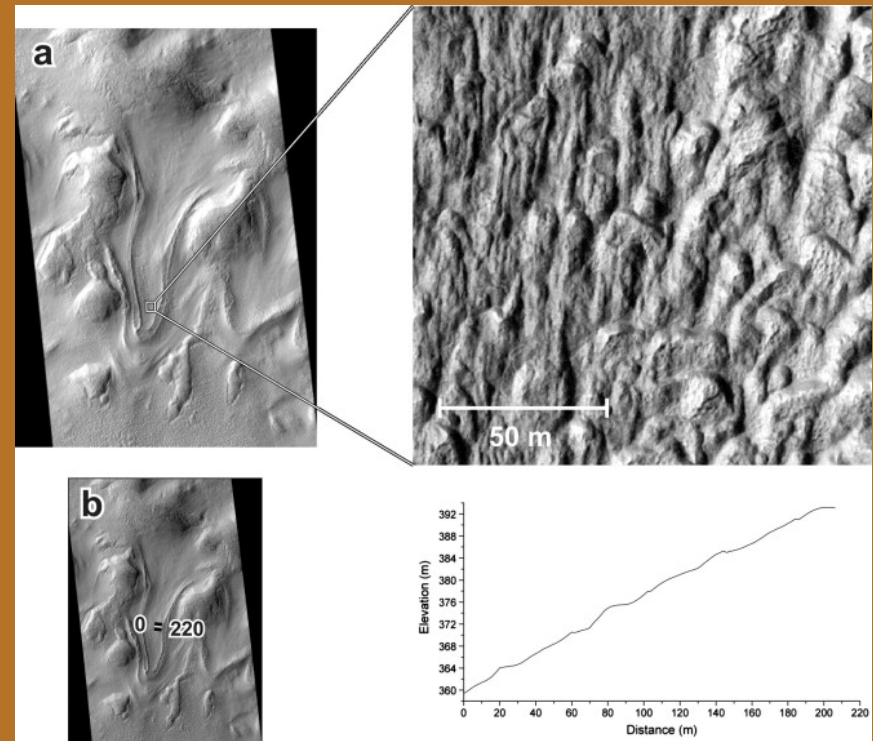


Glacier National Park in Canada

Olympus Mons, Mars

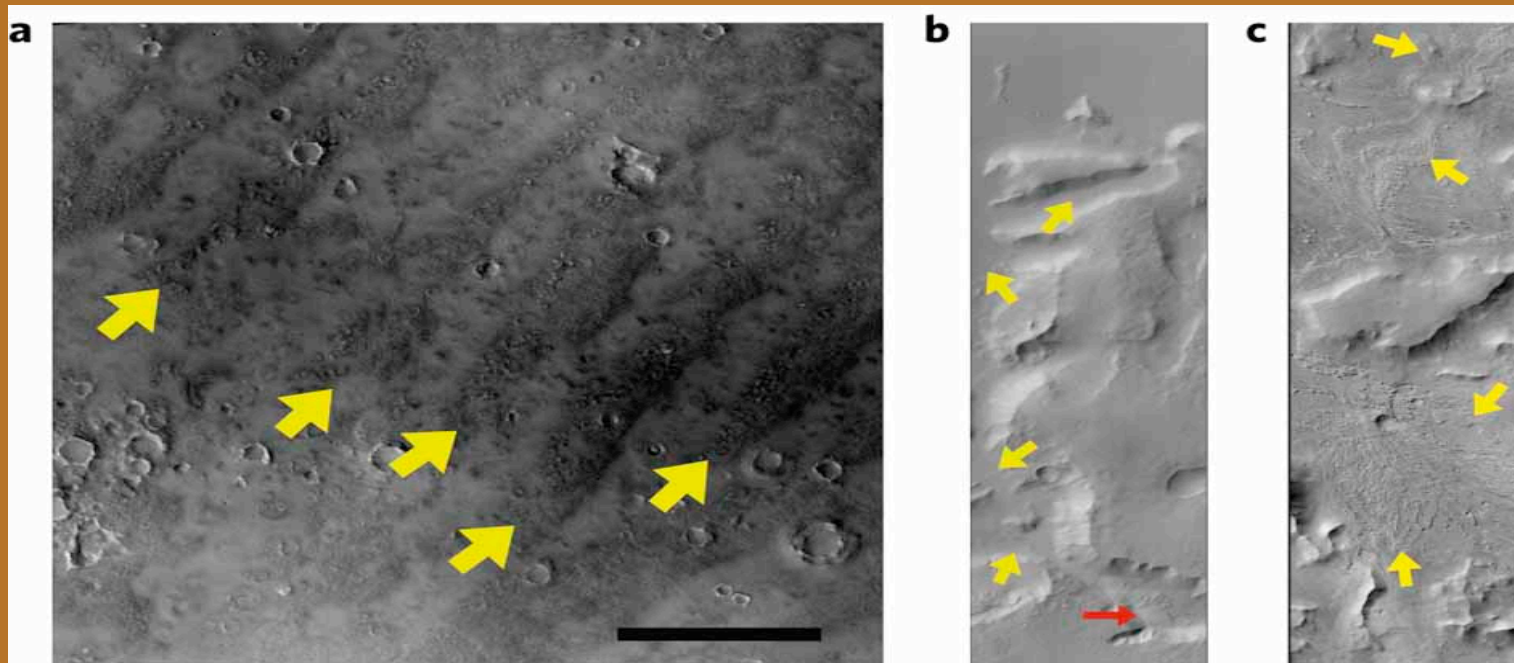
Mound-and-Tail Terrain:

- Break-up of terrain into closely-spaced and elongated mounds.
- Typically 30-50m long.
- Steep up-glacier facing core and a shallow elongated tail.
- Hellas Planitia Mounds.
- Found in the glacier-like-form basin.
- Similar in look to Drumlins on Earth.



Lineated Valley Fills

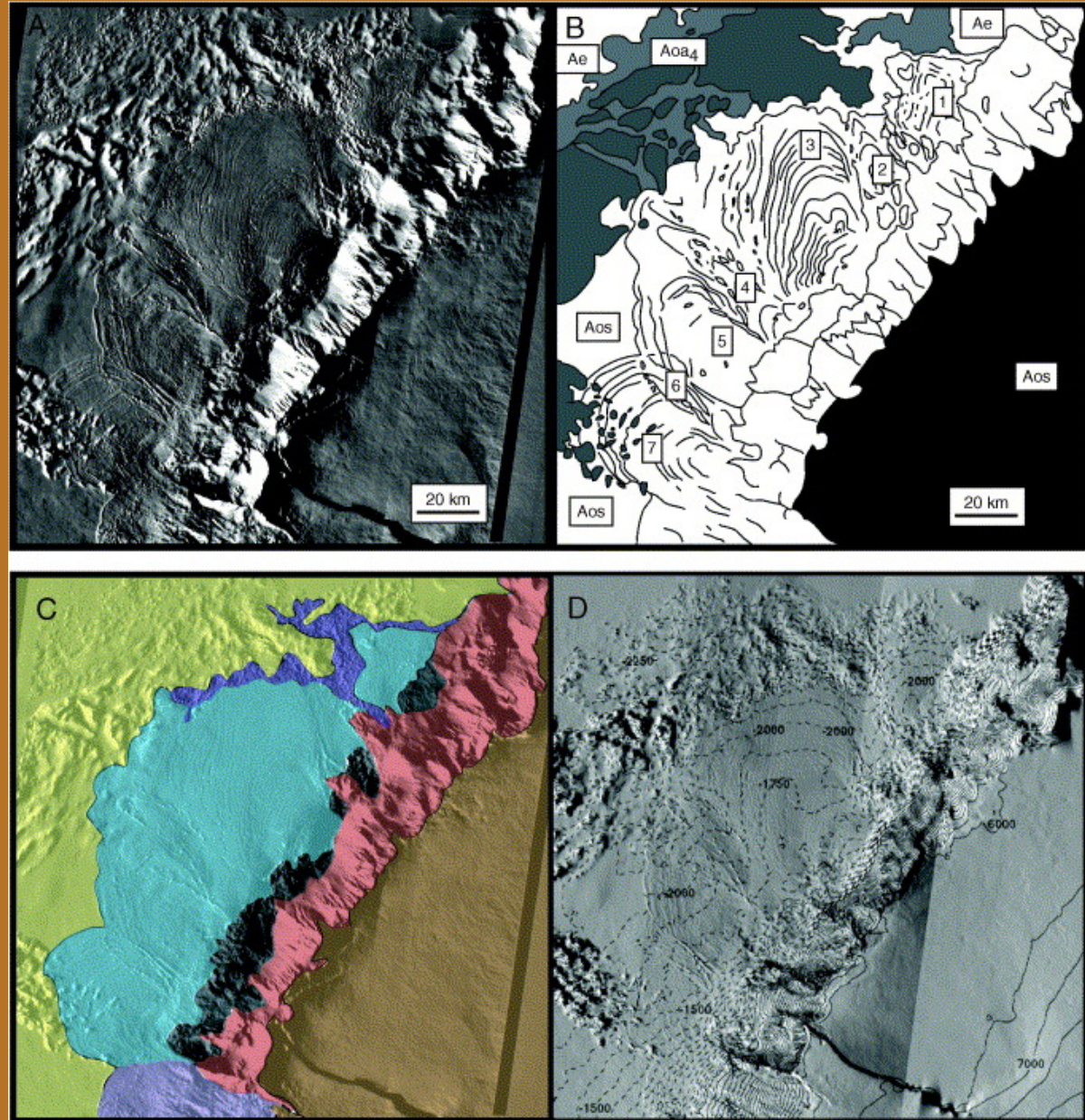
- Distinguished by a continuation of ridges in the topography that have a single direction of flow
- “Found in Constrained Valleys” (Dickson, Head, and Fasset, 2012)



(Farien et al,
2012)

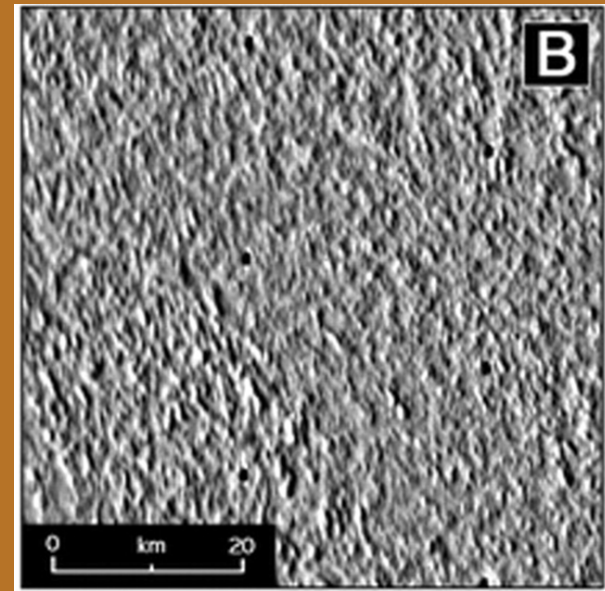
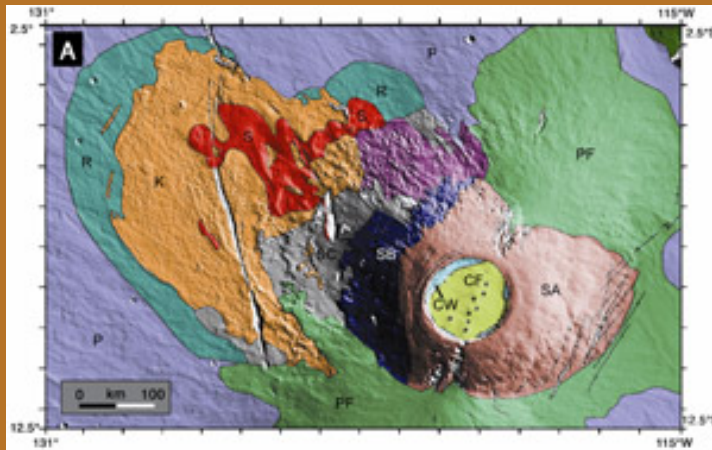
Troughs (U-Shaped Valleys)

- Identifying features of glaciation appear to be located within troughs
- Troughs are located down from cirques
- Troughs can only be created by glaciers



Knobby Facies

- Caused by Sublimation tills
- Located before ridged facies
- Are a sign of cold based glaciers
- Similar to the Antarctic cold based glaciers



A) Geologic sketch of Arisa Mons. Knobby facies indicated by letter K and ridged facies by letter R. B) Ridged facies seen on Mars. Photos from Cold-based mountain glaciers on Mars: Western Arisa Mons by James Head & David Marchant

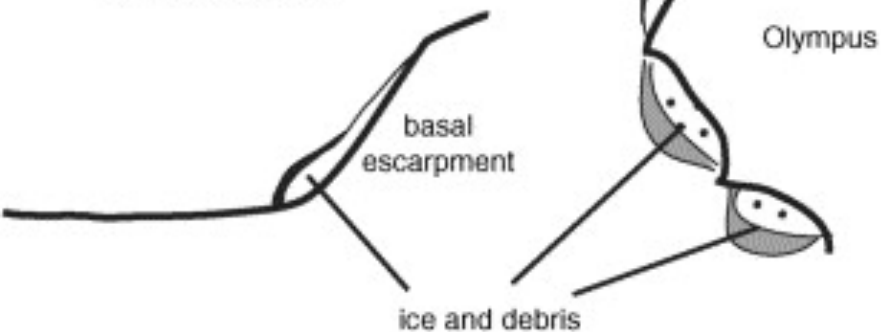
Cross Section

Map View

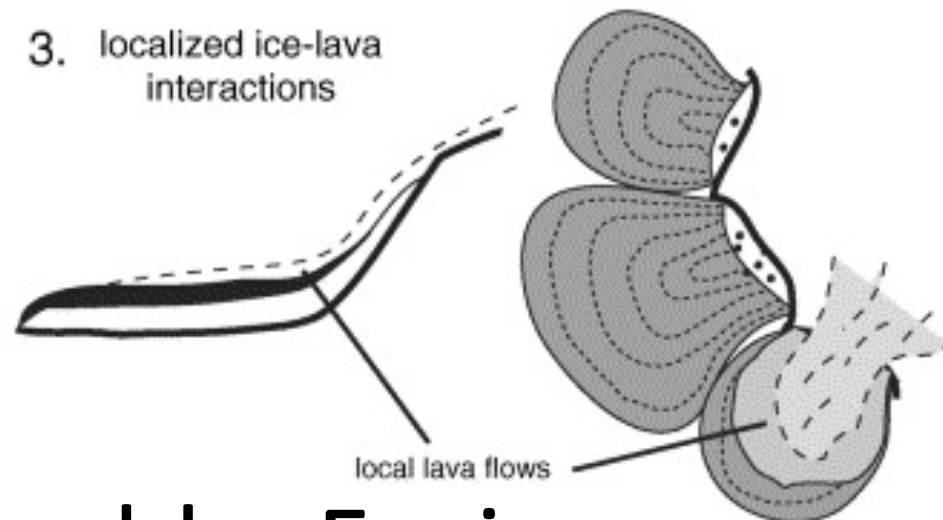
Cross Section

Map View

1. accumulation of ice and debris

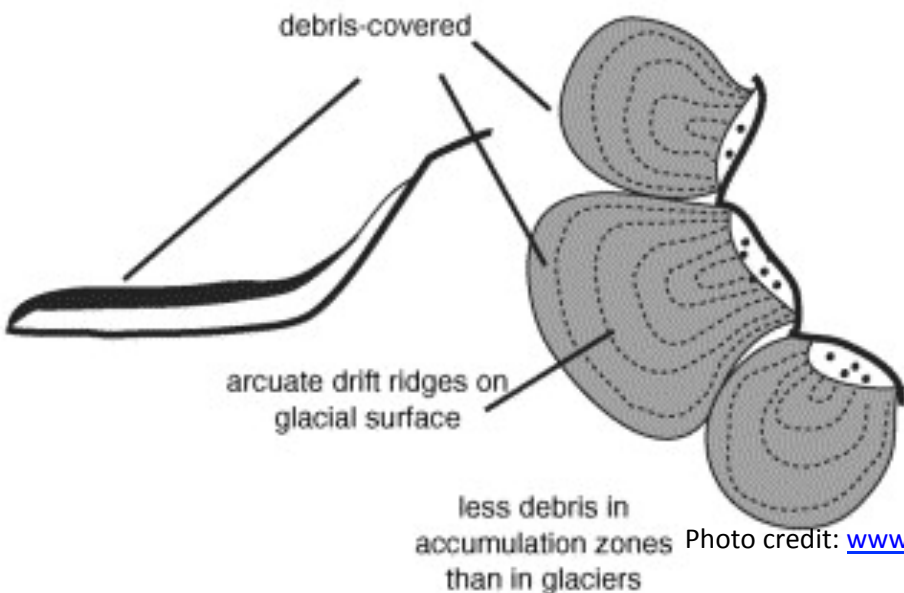


3. localized ice-lava interactions



Formation of Knobby Facies

2. formation of glaciers



4. sublimation of unprotected ice

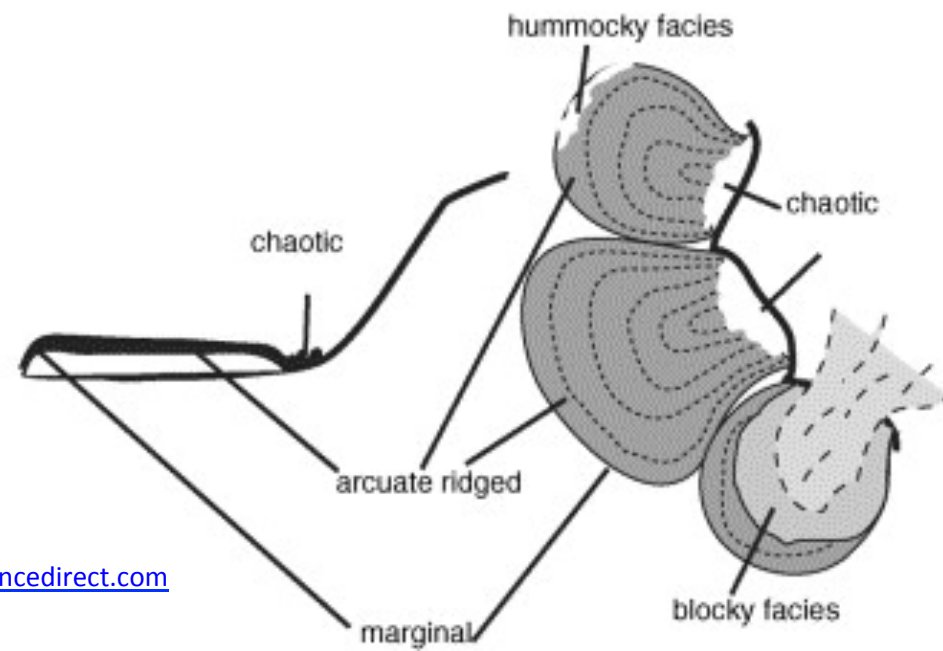
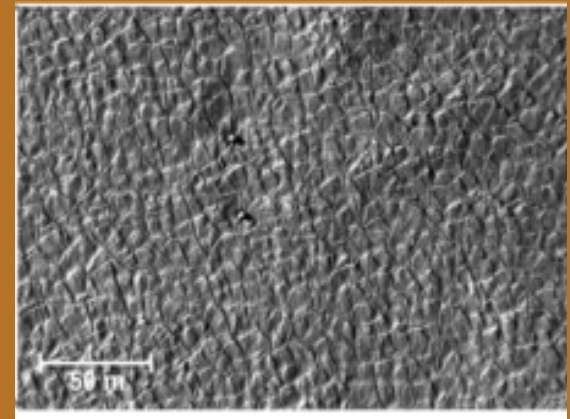


Photo credit: www.sciencedirect.com

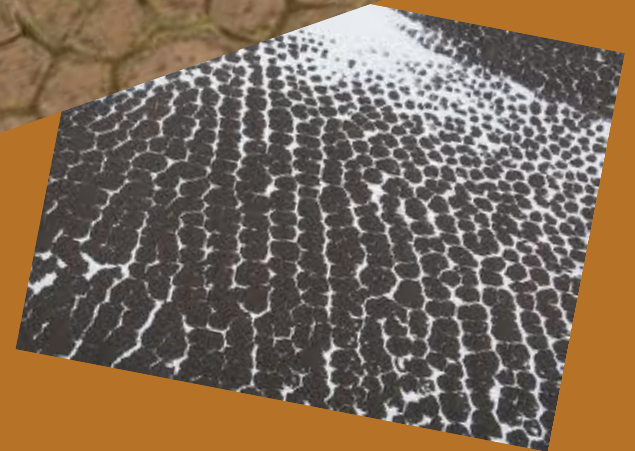
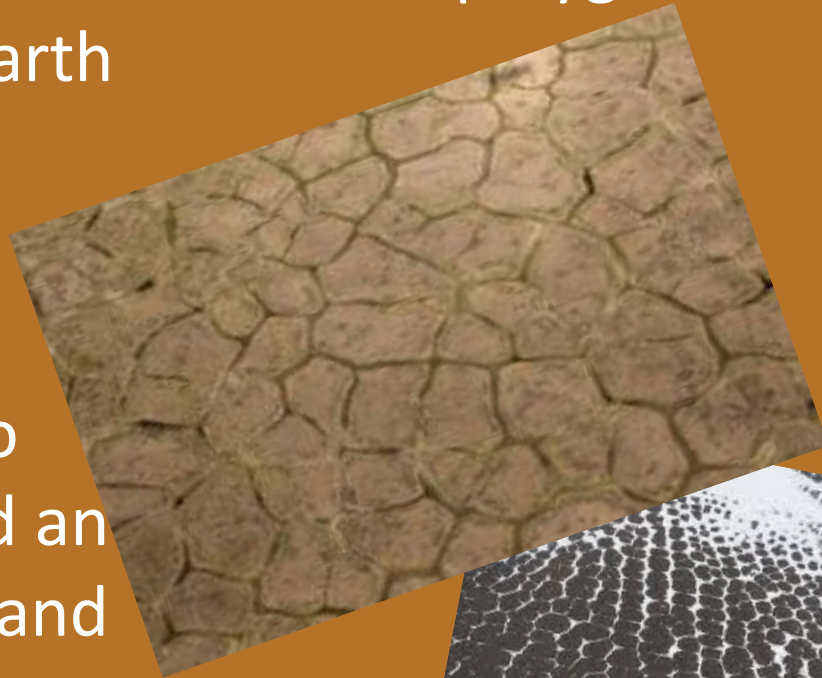
Scaly Terrain

- Land has a “scale” like pattern. The scales are 5-6 sided and are 10-20 meters across.
- The scales have 1-3 upslope facing edges that are raised and a body that dips down slope. This creates cracks between the adjacent scales.



Scaly Terrain Continued:

- Similar to thermally cracked periglacial surfaces found on Earth and other areas on Mars.
- Permafrost is known to make polygons.



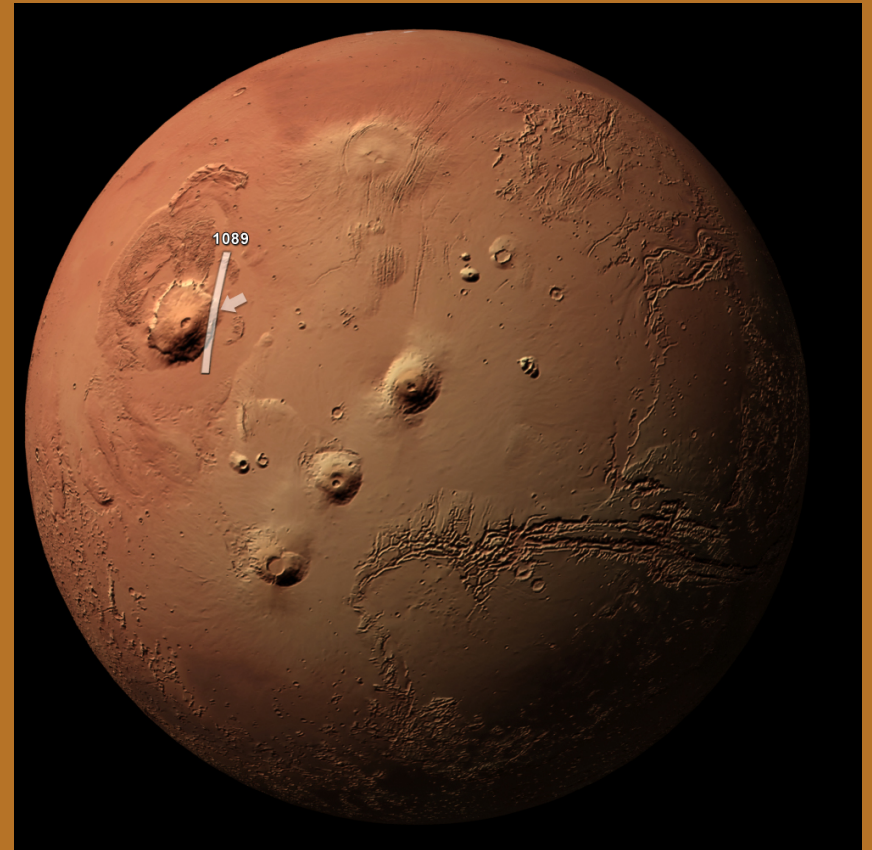
Impact Craters (IC' s)



- Examined in order to gain a concept of time scale by observing the total quantity of IC' s present in a defined area in comparison to another
- Process called “Crater Counting”

Methods:

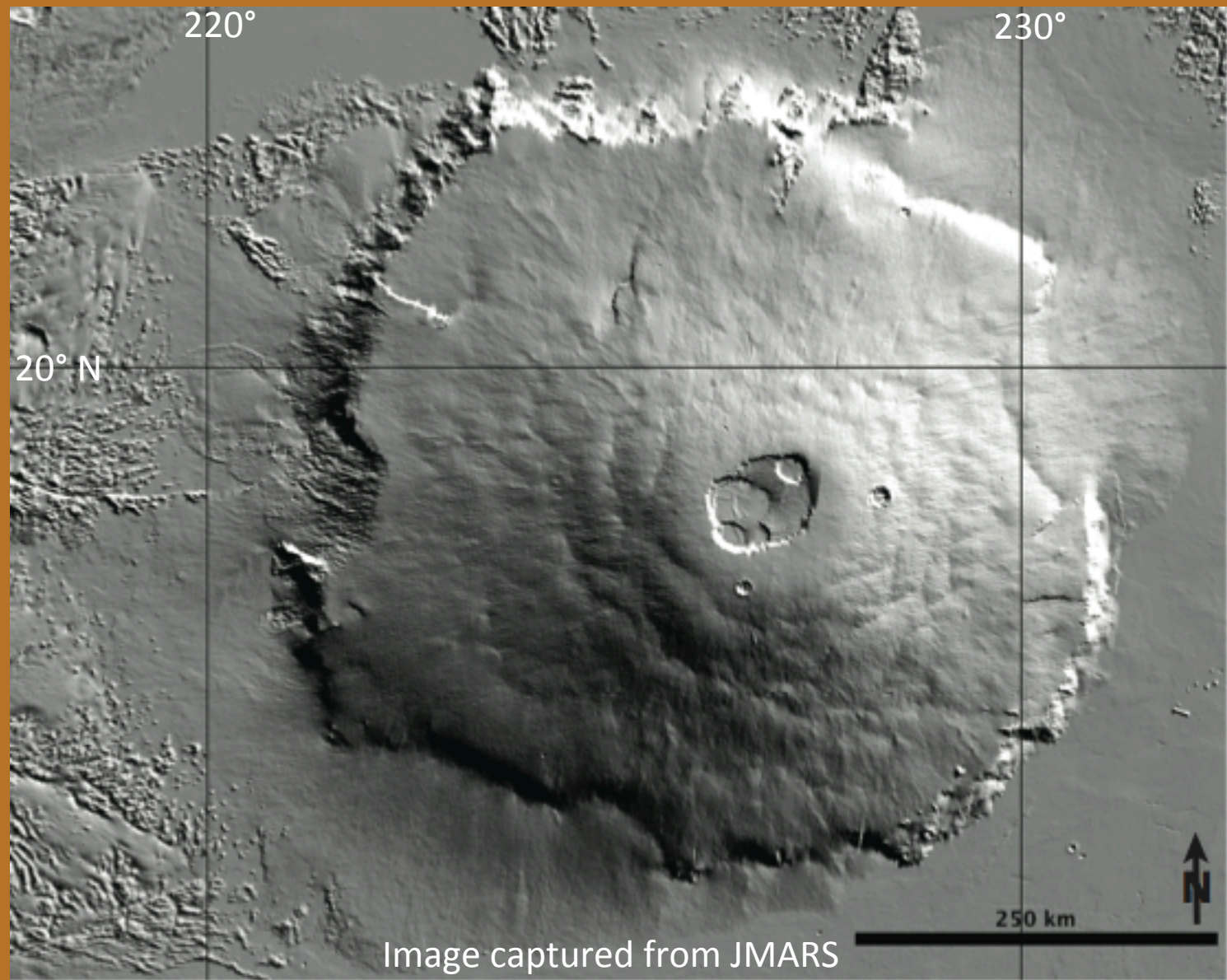
- Base map from JMARS.
- Our class is focusing on the area beyond the escarpment of Olympus Mons.
- Each student becomes a specialist on a specific glacial feature.



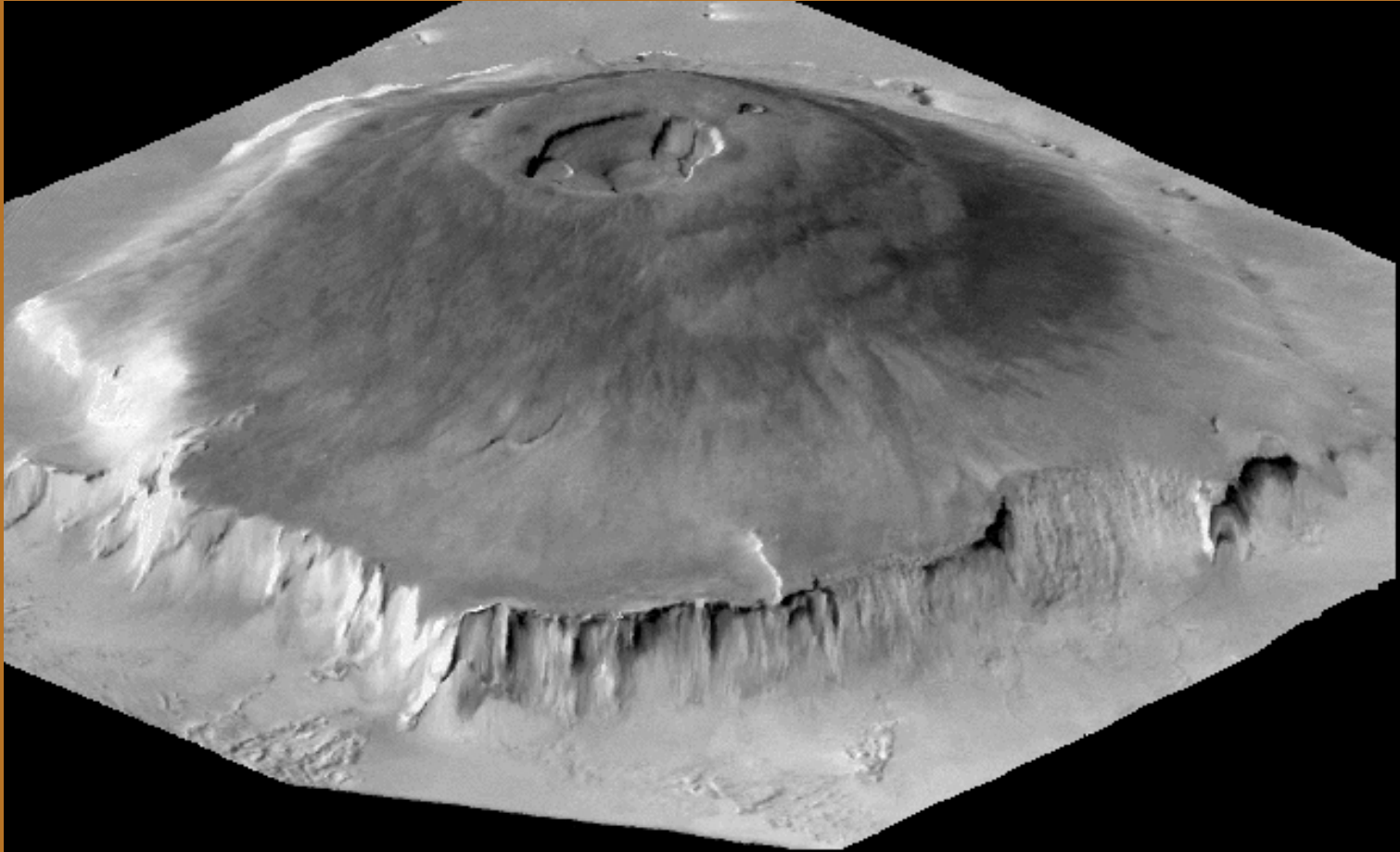
Methods, contd.

- Each student will add manually marks to the base map as features of interest are found in THEMIS images
- Finally, findings will be transcribed on a new map created in Adobe Illustrator

Base Map



Base Map



Disseminating our Research:

- Accessible through our school website for other students.
- Presentation at CNY Earth Science Student Symposium-April 12, 2013.
- Large presentation of research displayed in the Hobart and William Smith Geoscience Department.

References

Dickson, J & Head, J, 2012, 'The formation and evolution of youthful gullies on Mars: Gullies as the late-stage phase of Mars' most recent ice age.' *Icarus*. Vol. 204. *ScienceDirect*. Web. <<http://www.sciencedirect.com/science/article/pii/S0019103509002668>>.

Dickson, J, Head, J & Fassett, C. I. 2012, *Patterns of accumulation and flow of ice in the mid-latitudes of Mars during the Amazonian*. *Icarus*.

Edu-net. 2012. *Mars Volcano Olympus Mons*. Retrieved from http://edu-net.nl/_scripts/displayinframe.asp?dir=%5CRuimtevaart/Planeten%20en%20manen&item_name=Mars%20Volcano%20Olympus%20Mons.jpg&source=edu-net.nl

Hubbard, B., Milliken, R. E., Kargel, J. S., Limaye, A. & Souness, C. 2011, *Geomorphological characterisation and interpretation of a mid-latitude glacier-like form: Hellas Planitia, Mars*. *Icarus*, 211, 330-346.

<http://capone.mtsu.edu/cdharris/GEOL100/erosion/talus-creep.htm>

http://disc.sci.gsfc.nasa.gov/geomorphology/GEO_9/GEO_PLATE_G-13.shtml

References

Marshak, S, 2012, *Earth: portrait of a planet*. W. W. Norton & Co., New York.

Milkovich, S, Head, J & Marchant, D, 2006, *Debris-covered piedmont glaciers along the northwest flank of the Olympus Mons scarp: Evidence for low-latitude ice accumulation during the Late Amazonian of Mars*. *Icarus*, 181, 388-407.

Nature Geoscience. *Figure 2: Glaciers on Early Mars*. Retrieved from [http: www.nature.com/ngeo/journal/v4/n10/fig_tab/ngeo1243_F2.html](http://www.nature.com/ngeo/journal/v4/n10/fig_tab/ngeo1243_F2.html)

Olympus Mons. *Encyclopedia Britannica Online Academic Edition*. N.p., n.d. Web. 12 Feb. 2013. <<http://www.britannica.com/EBchecked/topic/428149/Olympus-Mons>>.

Olympus Mons. NASA. Web. 12 Feb. 2013. <<http://marsprogram.jpl.nasa.gov/gallery/atlas/olympus-mons.html>>.

Whalley, W & Azizi, F, 2003, 'Rock glaciers and protalus landforms: Analogous forms and ice sources on Earth and Mars.' *Journal of Geophysical Research*, 108, 8032, doi: 10.1029/2002JE001864.