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Is Erosion by Lava Important on Mars?

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Outline

- Is erosion by lava even possible?
- If so, are the primary physics of aqueous and lava floods different?
- If not, how are we going to tell their channels apart?
  - Consilience: geologic context, transition zones, etc.

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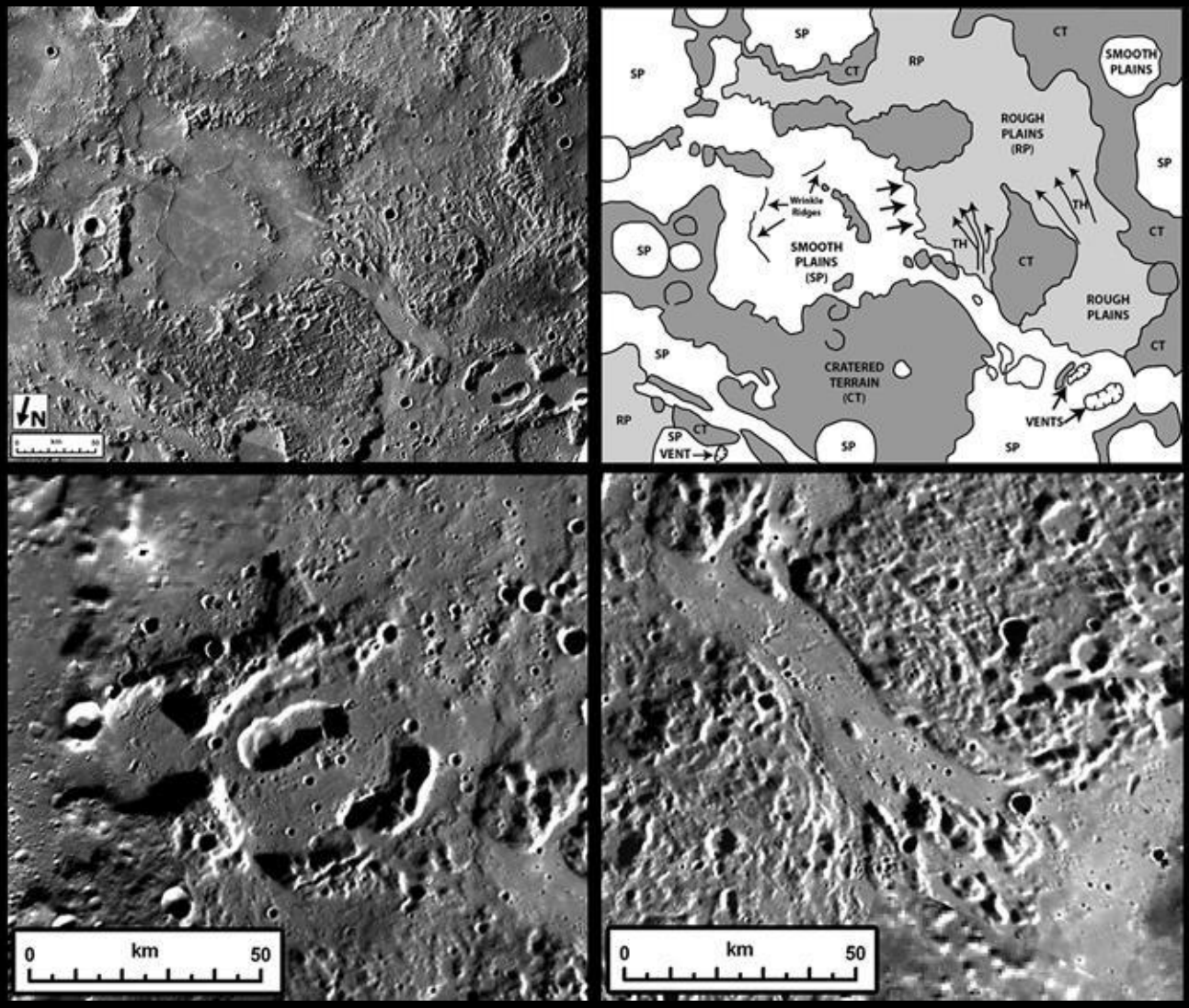
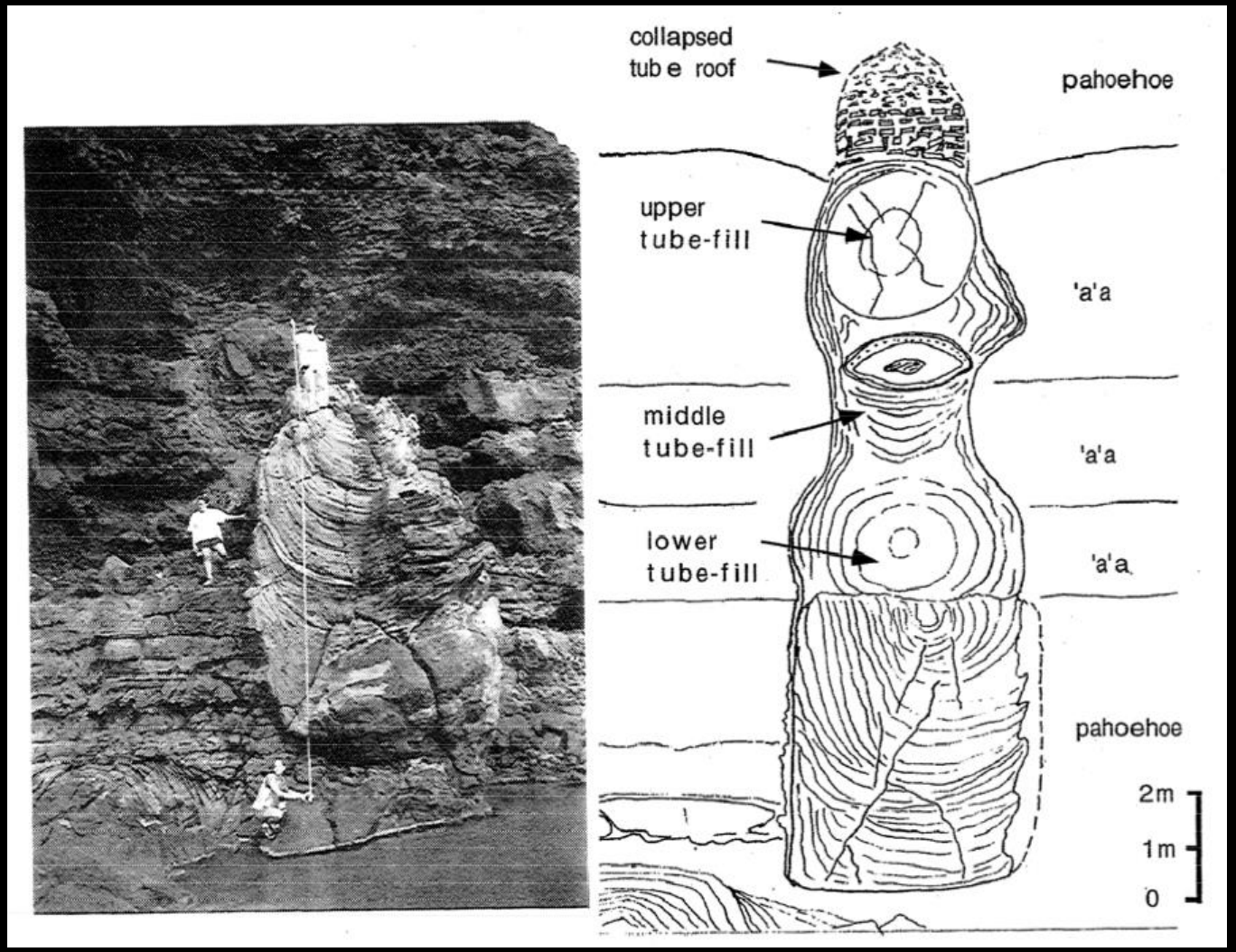
Erosion by lava happens on Mercury



Erosion by lava happens on Venus

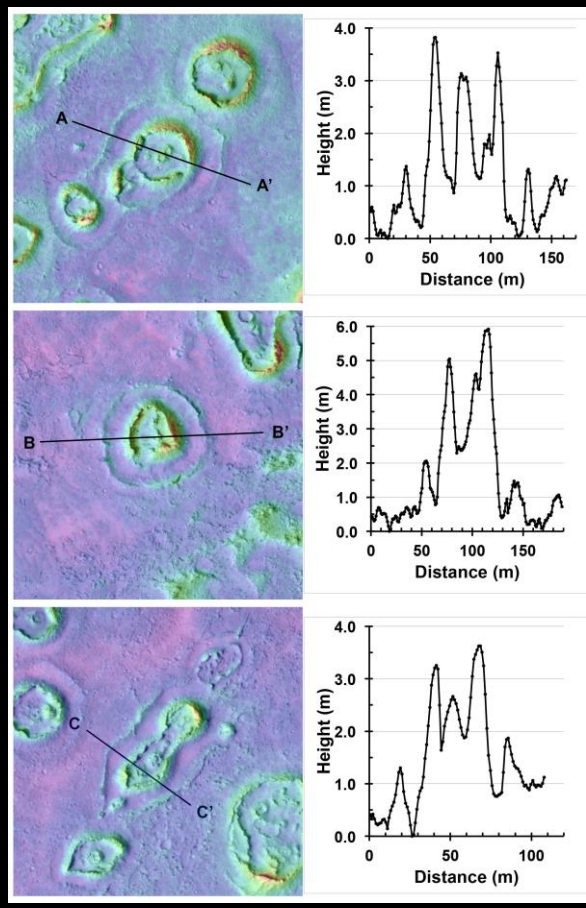
Erosion by lava on the Moon

Erosion by lava on the Earth



But on Mars it is controversial

There is a real bias to call upon water…



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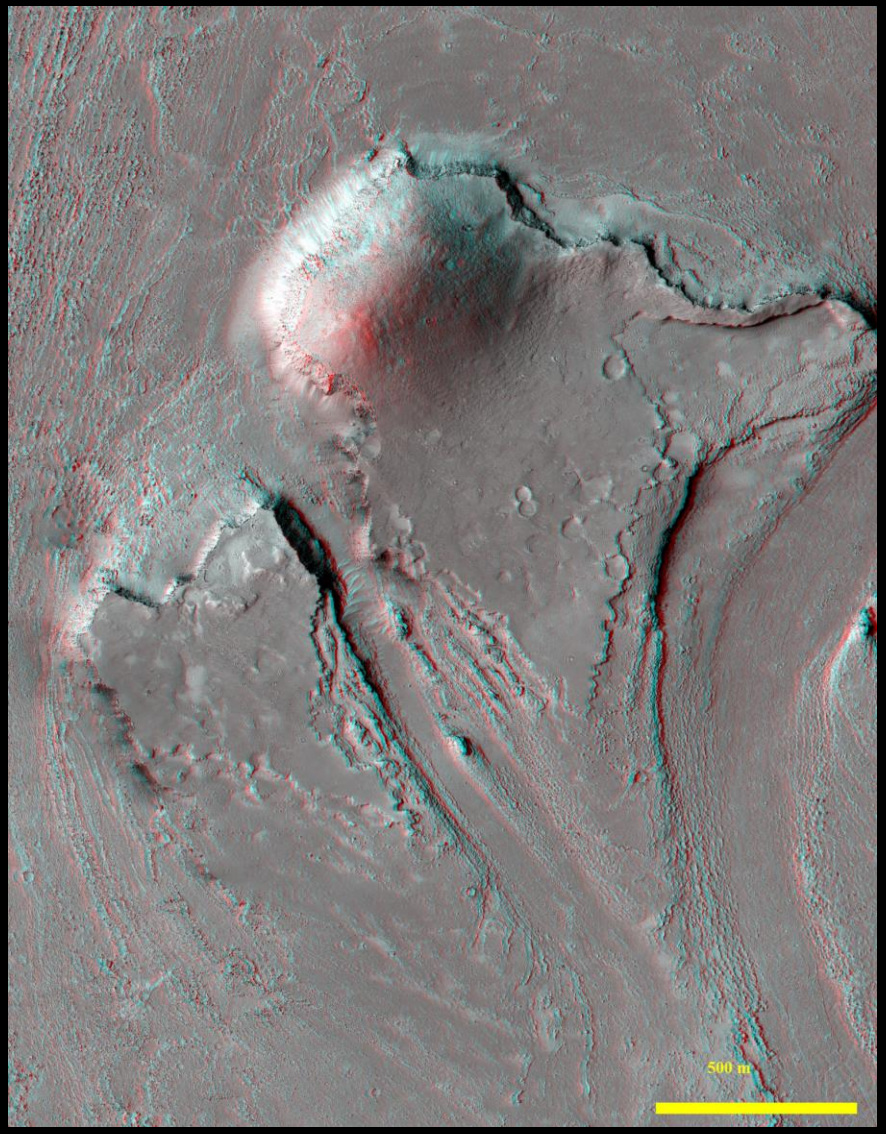
Aqueous or Volcanic?



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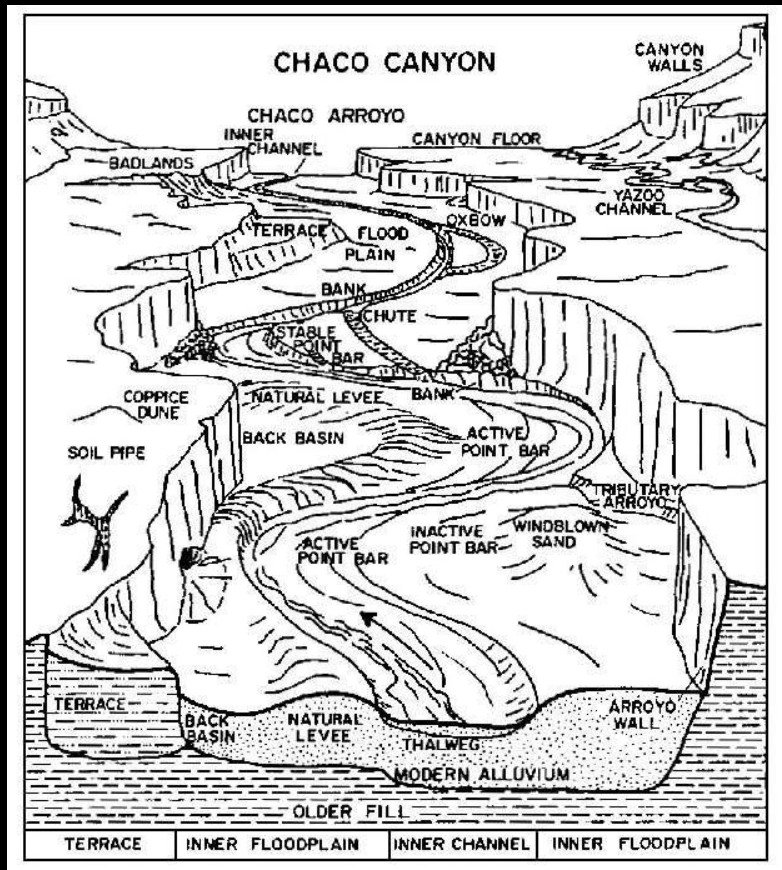
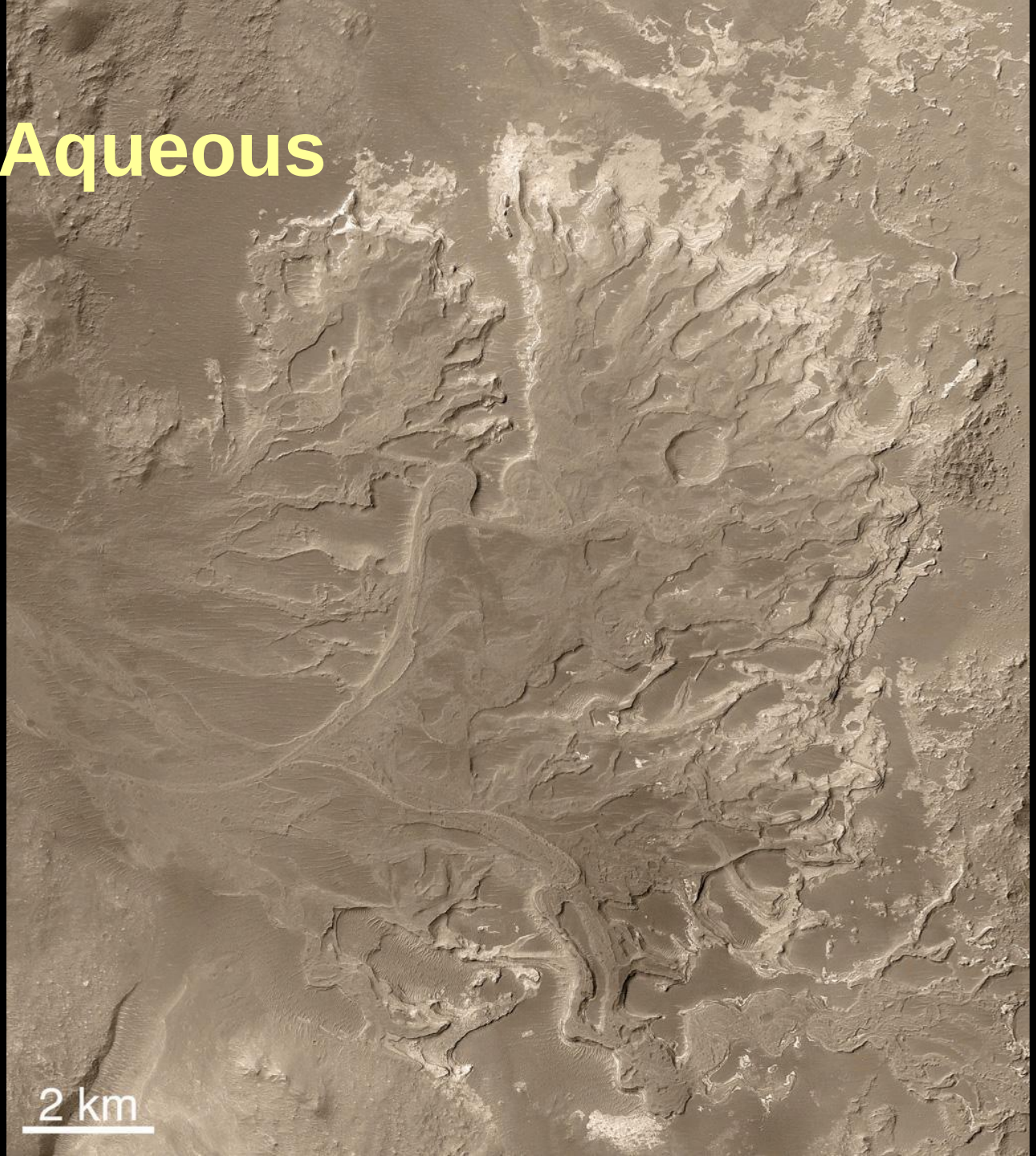
How to we distinguish fluvial and volcanic channels?

- We (sort of) know how to distinguish erosional fluvial channels from constructional volcanic channels…



Clearly Aqueous



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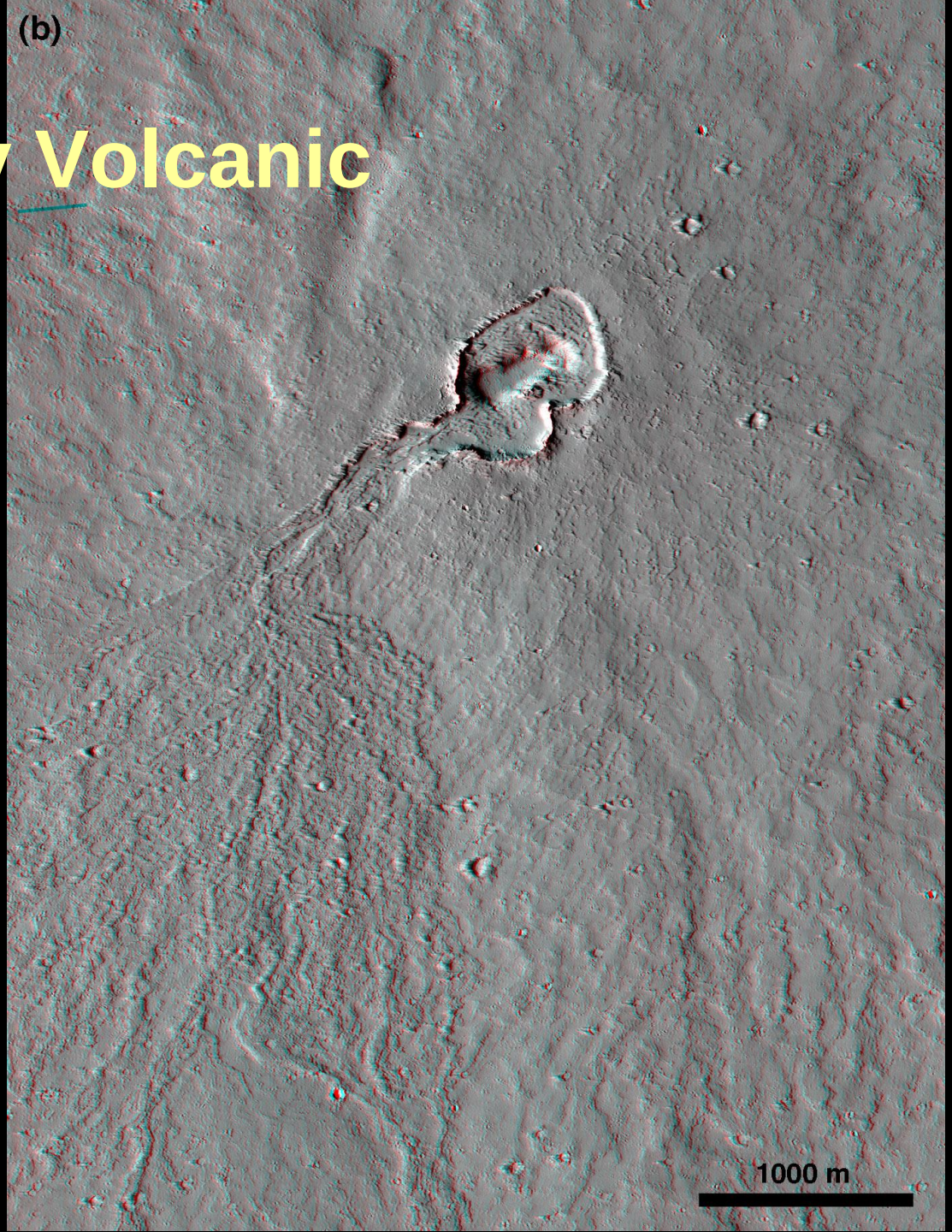
Clearly Volcanic



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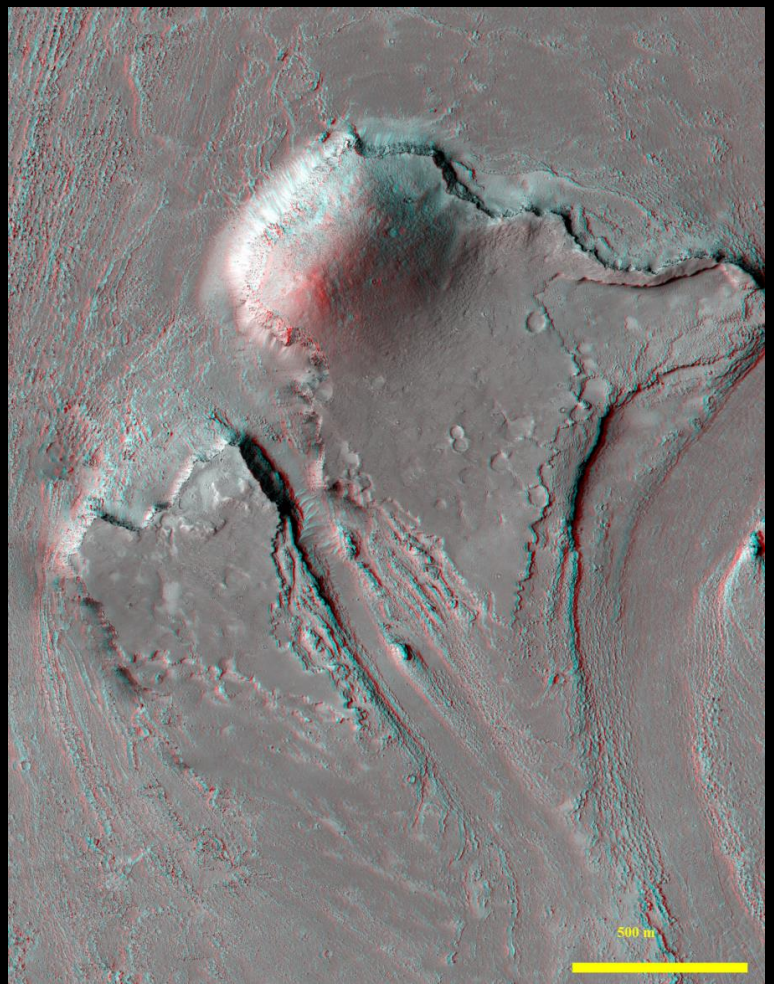
How to we distinguish fluvial and volcanic channels on Mars?

- Much harder to differentiate channels formed by turbulent floods



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Physics of turbulent lava flows

- Much harder to differentiate channels formed by turbulent floods
  - In turbulence, Re ($\rho vL/\eta$) is what matters
  - It does take a greater L for lava to go turbulent
  - For a given L, lava will have a lower Re
- Recent studies suggest erosivity controlled by Shields Number

$$\tau^* = \tau/(\Delta\rho\, g\, D)$$

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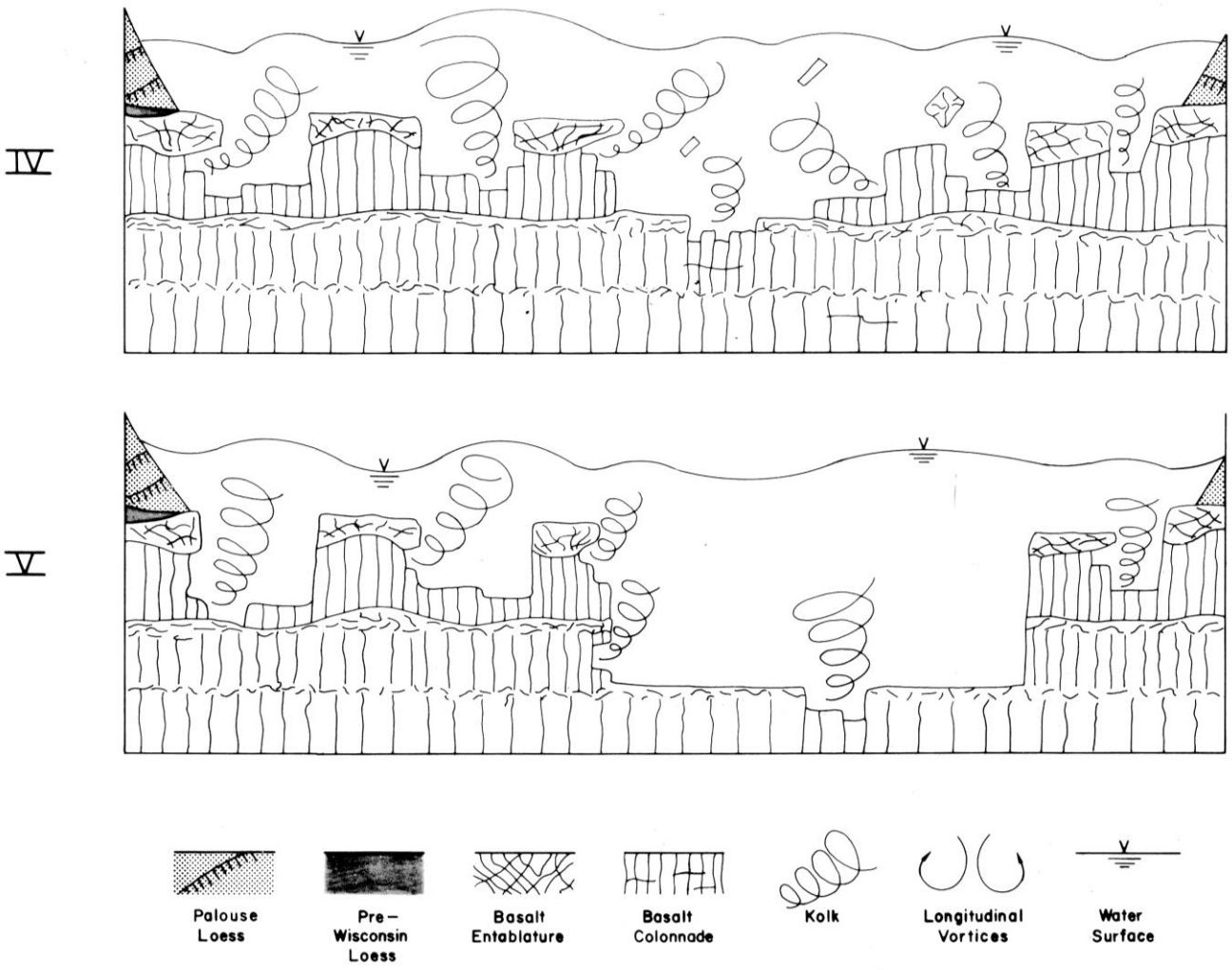
Physics of turbulent lava flows



What about thermal erosion?

- **Melting the substrate takes time – rate limited by conducting heat into cold ground**

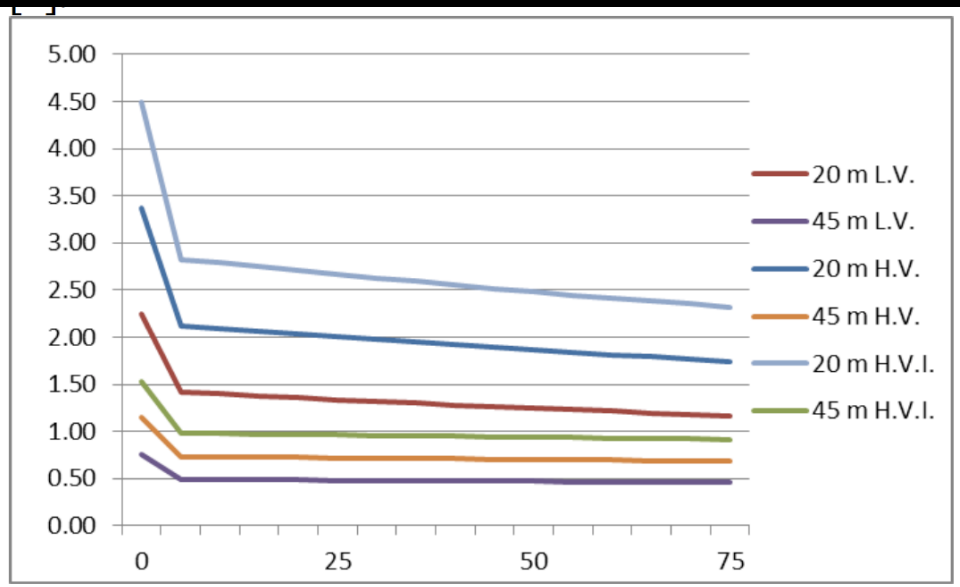


Figure 1: Erosion depth in meters (y-axis) plotted against distance from lava source in kilometers. 20 m and 45 m are flow thicknesses; L.V. = lower volumes = 5000 km^3; H.V. = higher volumes = 7500 km^3. H.V.I. = higher volume + 25% substrate H_2O.

Cataldo et al. 2014

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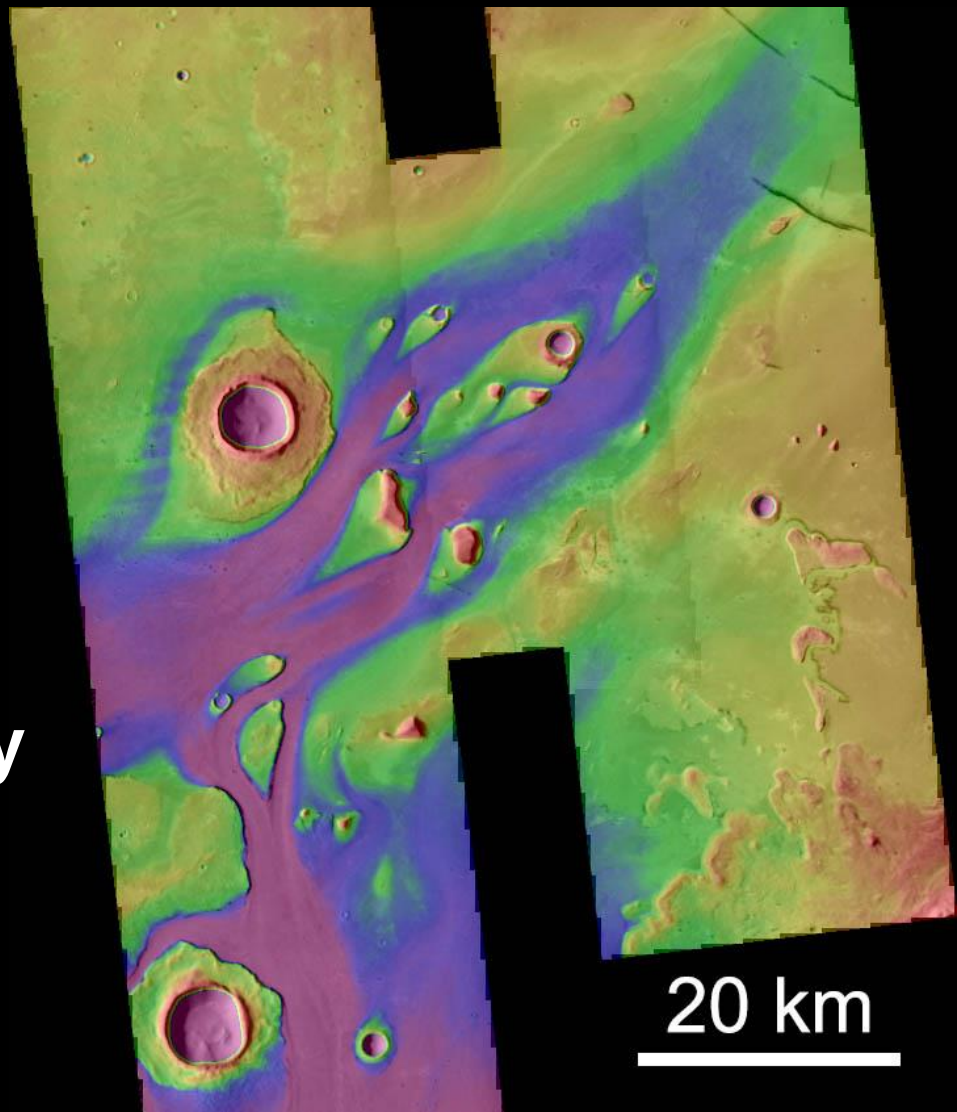
How to we distinguish fluvial and volcanic channels on Mars?

- Scale and style of major erosion should be identical
- Can’t be eroded by lava if there is no lava – but there can be draping lava
- Key may be secondary features…



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How to we distinguish fluvial and volcanic channels on Mars?

- Lava should not create m-scale erosion channels
- Lava should not create bedload features (dunes, bars, deltas) because rocks stay in suspension

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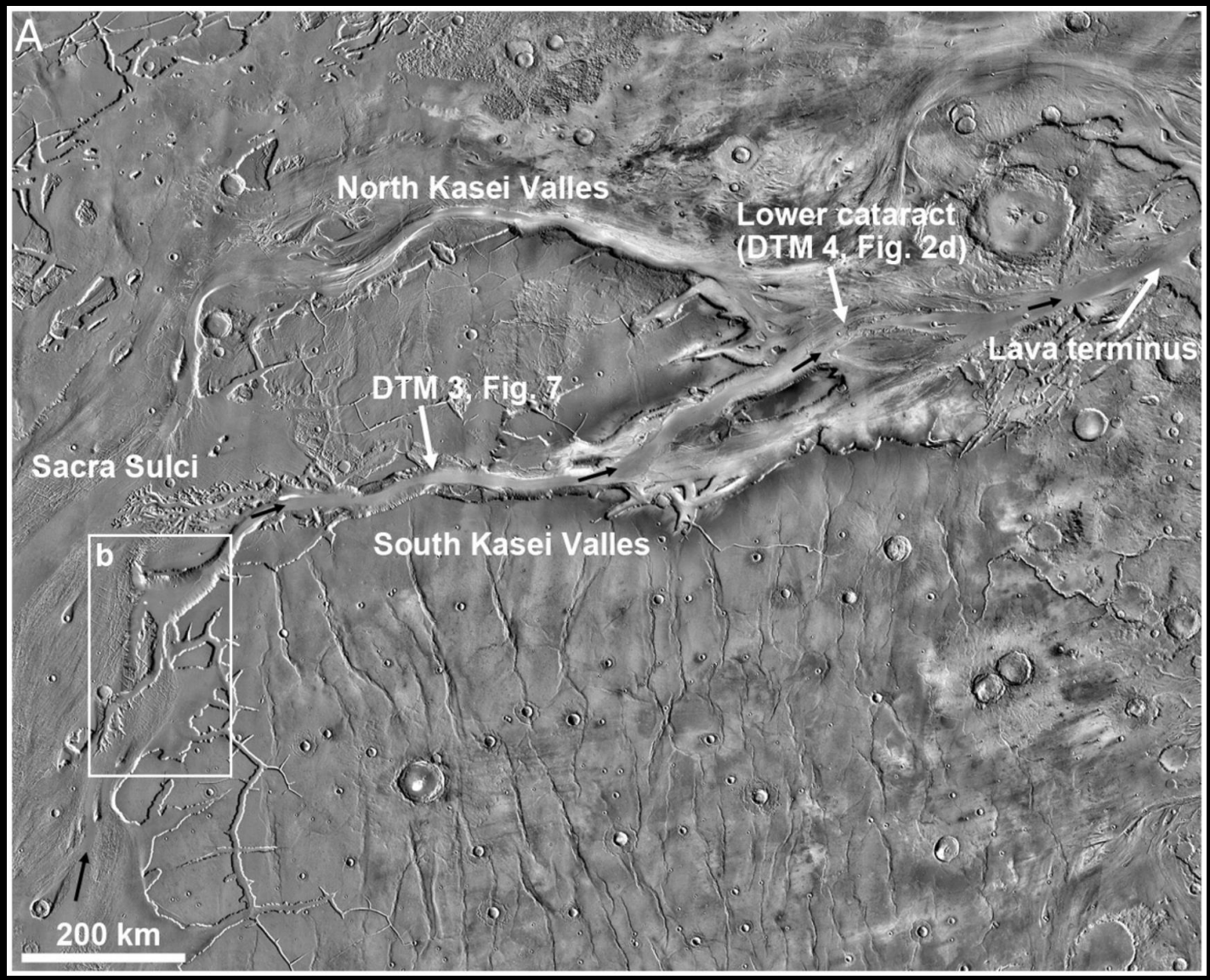
Examples: Kasei Valles



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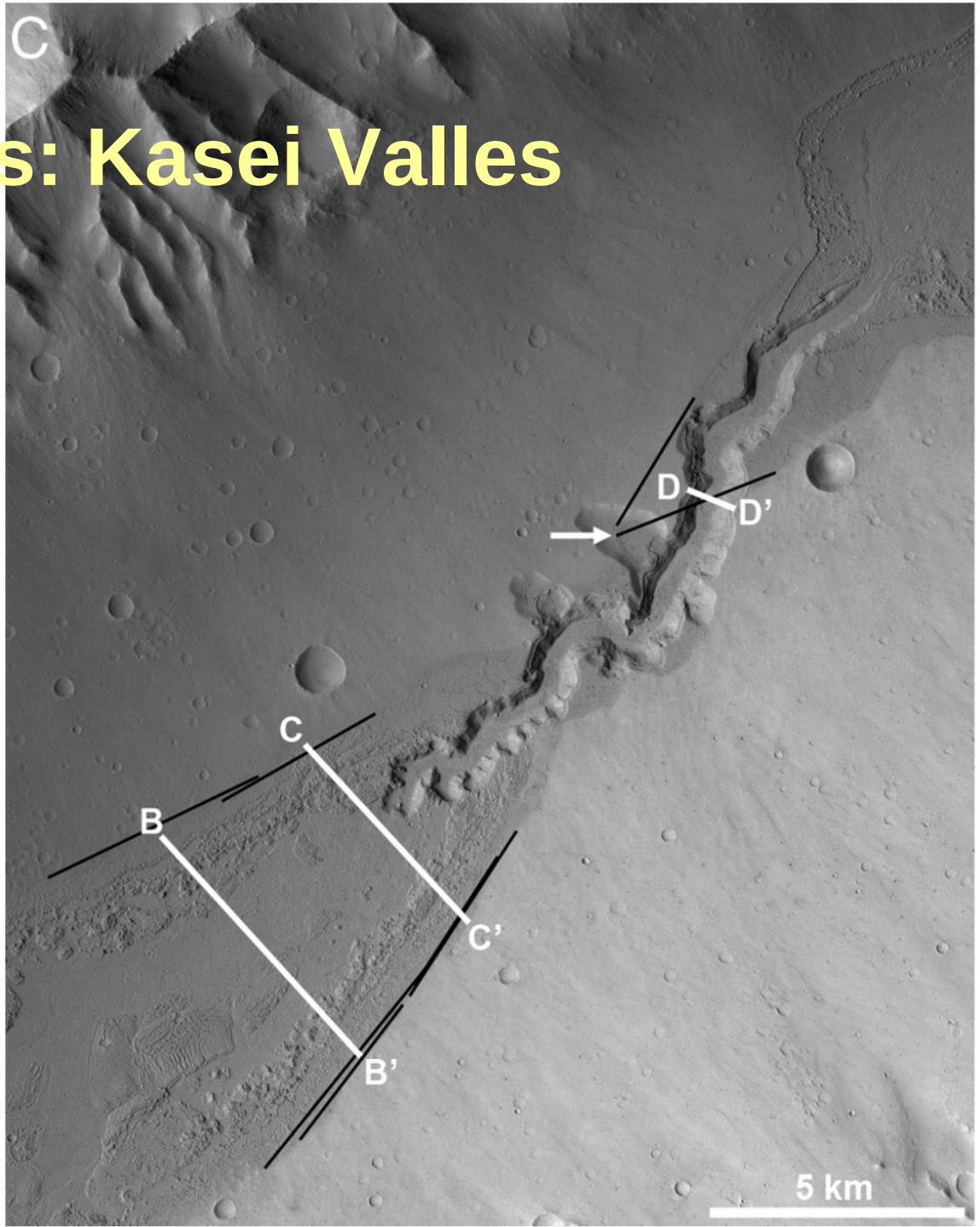
Examples: Kasei Valles



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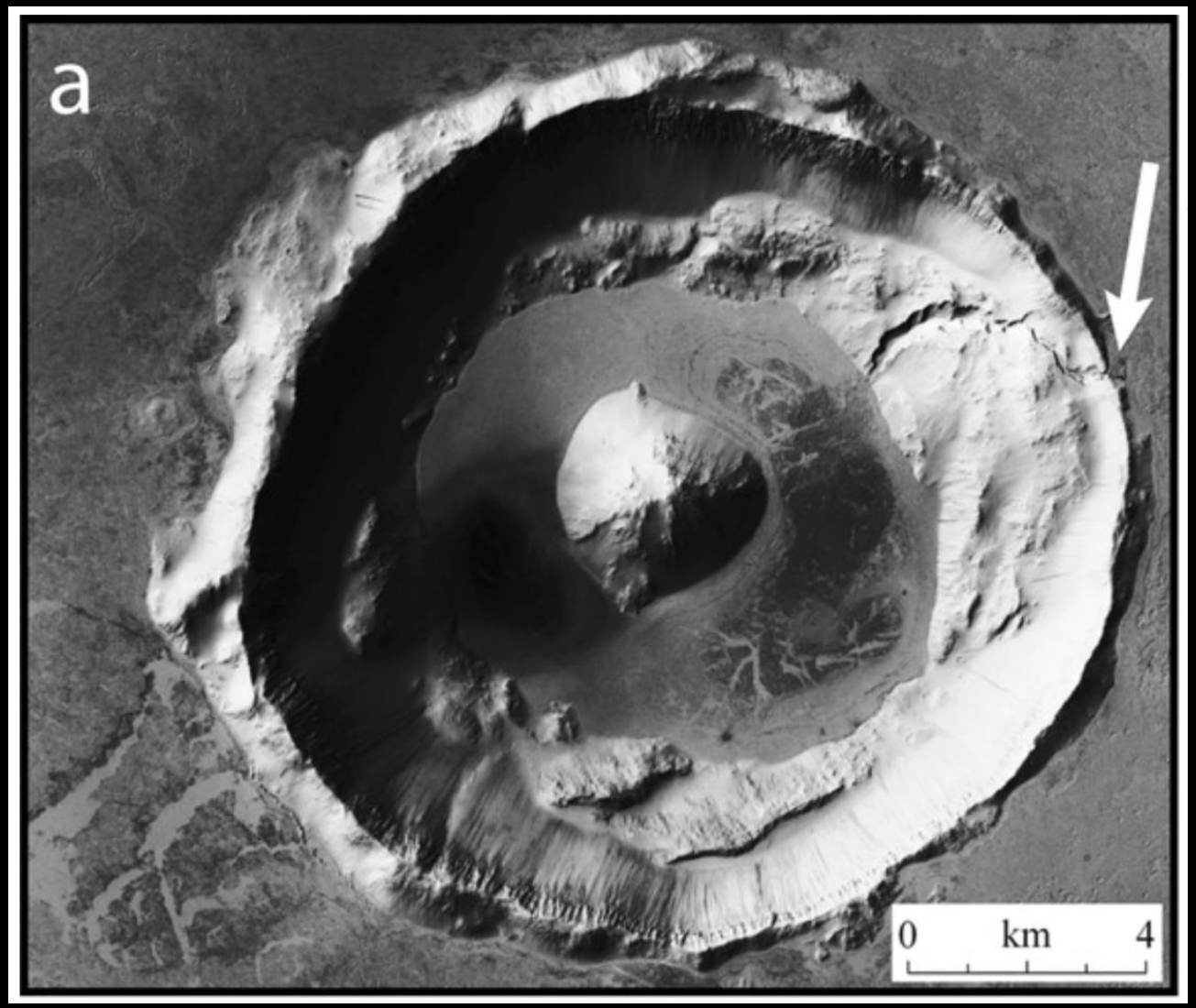
Examples: Hurwitz et al 2010



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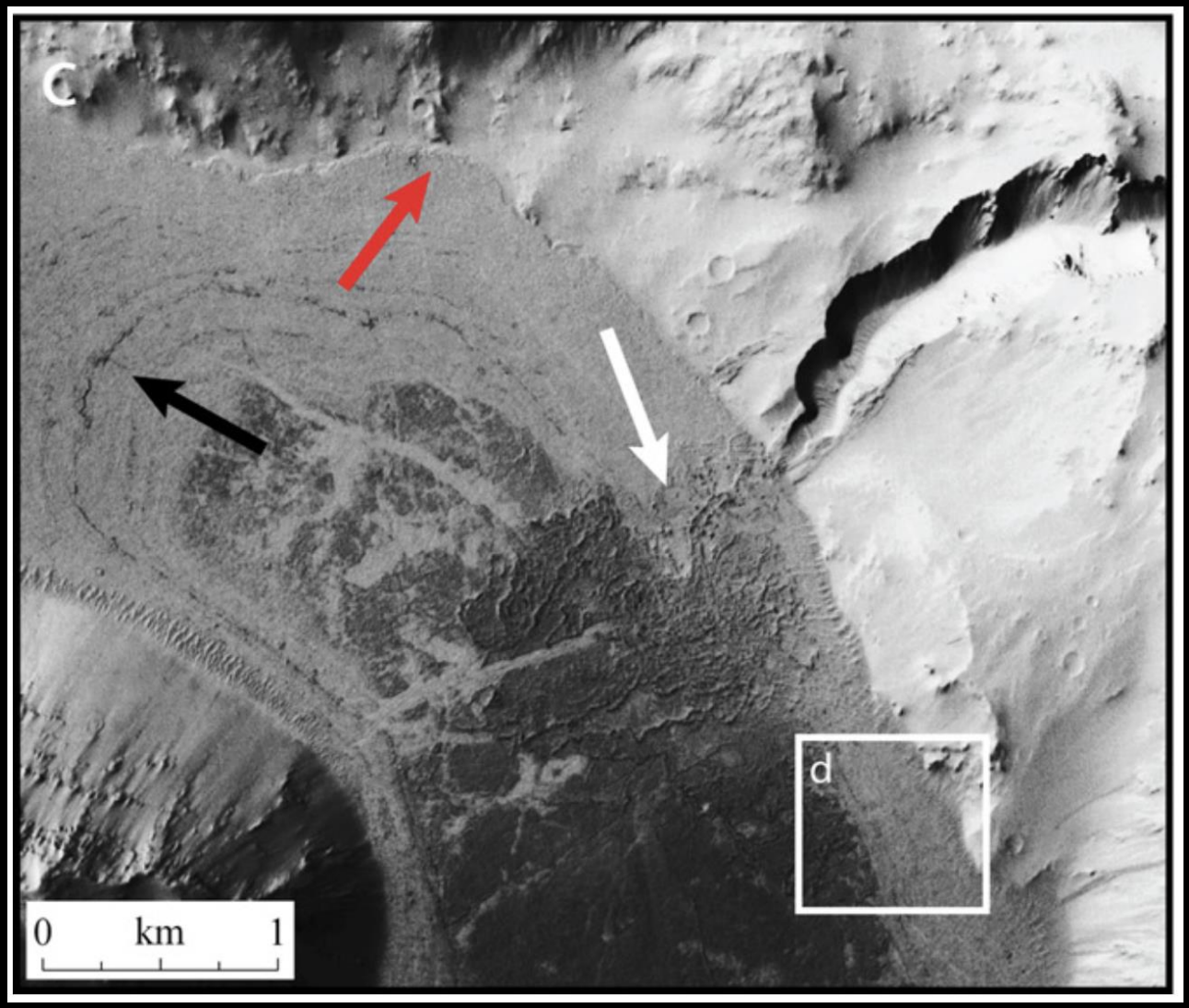

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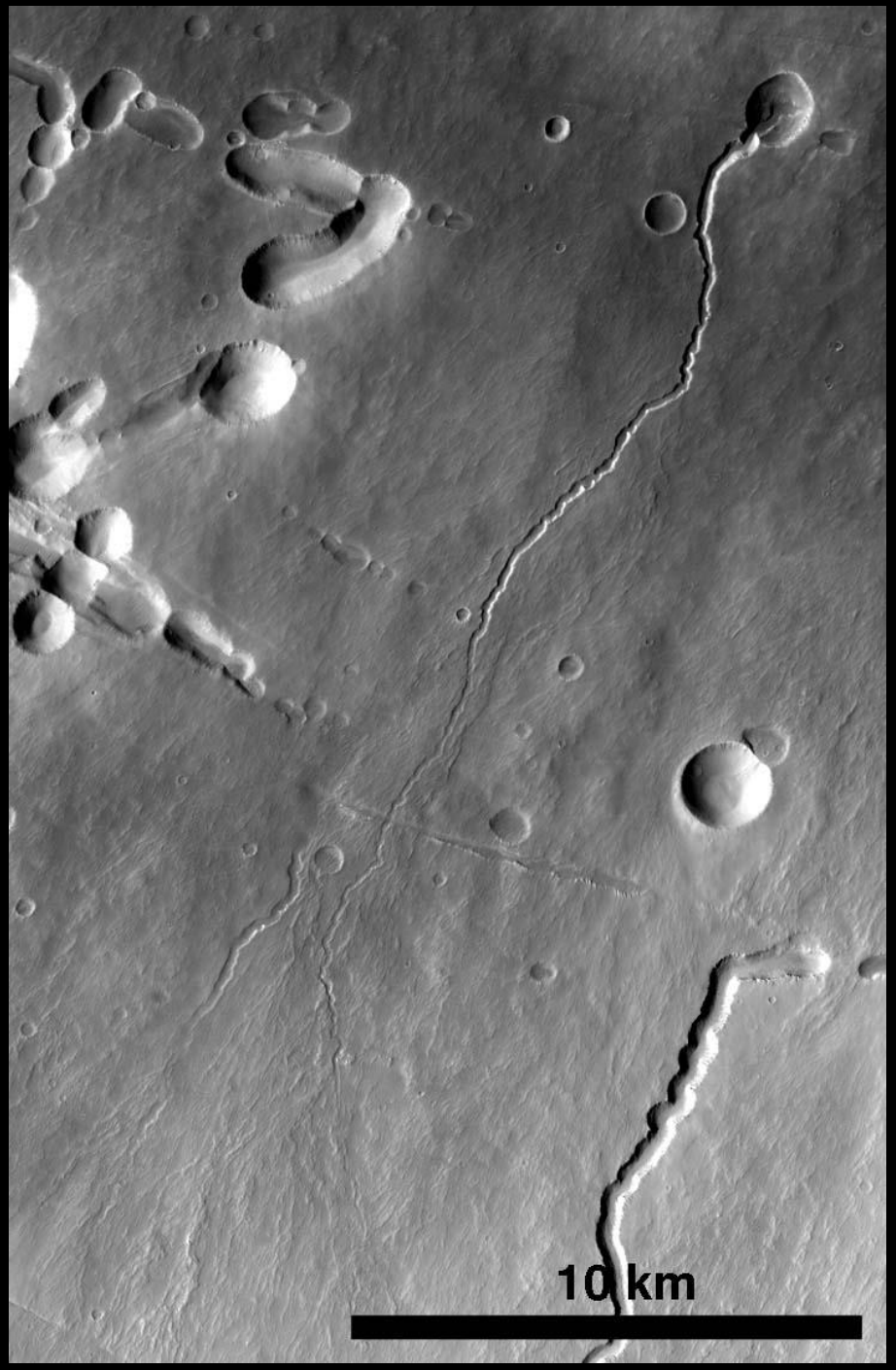
Examples: Rilles



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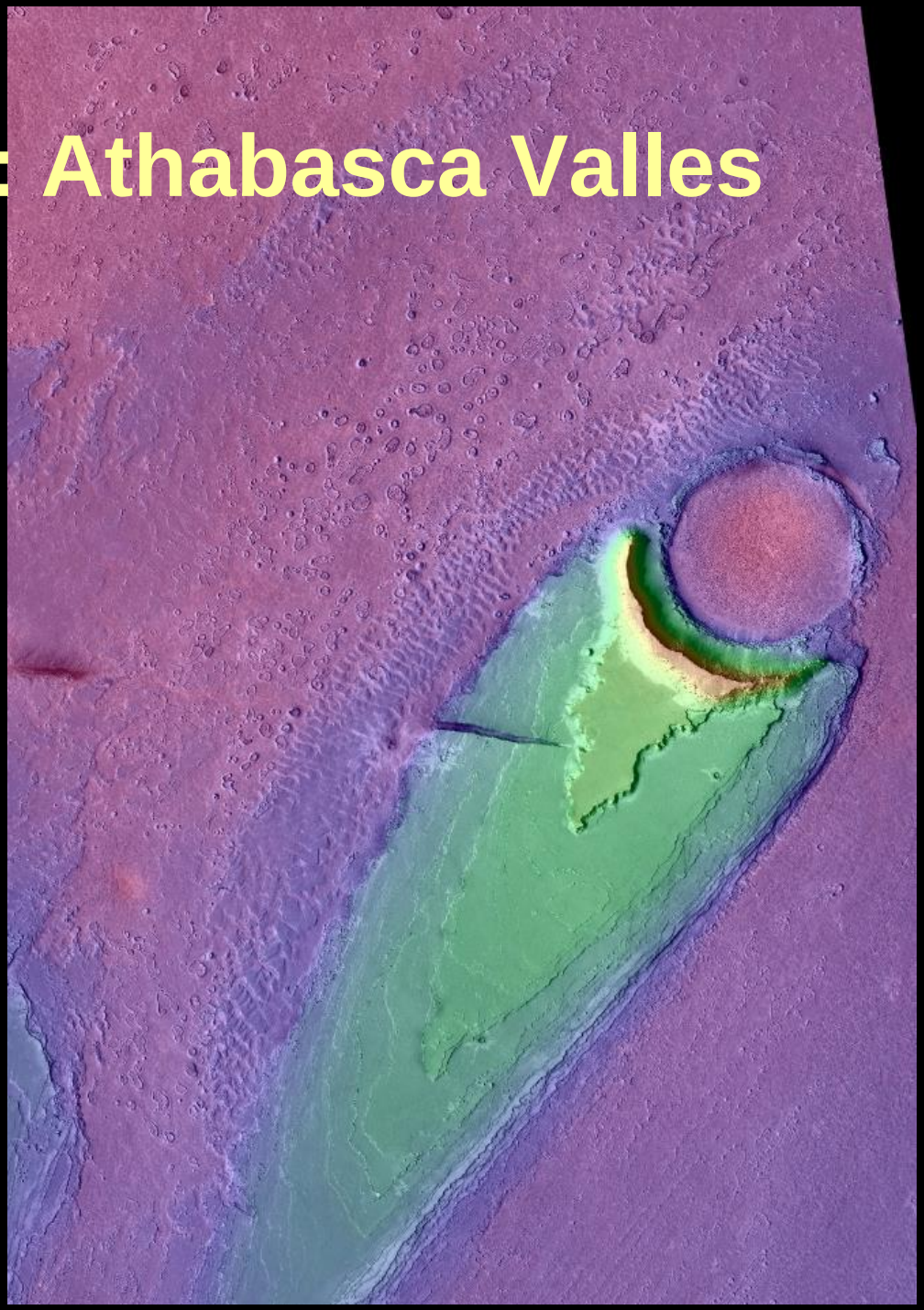
Examples: Athabasca Valles



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Conclusions

- Erosion by lava is possible.
- The primary erosion by aqueous and lava floods should be very similar.
- We can identify the erosive fluid when we can observe secondary features.
- There are many good examples of erosion by lava on Mars.
- There are many places that require further study.

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