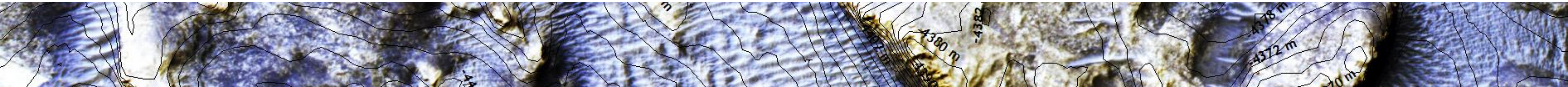
Deep dyke exposures in northern Valles Marineris highlight the significance of erosion in chasma genesis

Daniel MÈGE
Joanna GURGUREWICZ
Space Research Centre, Polish Academy of Sciences, Warsaw

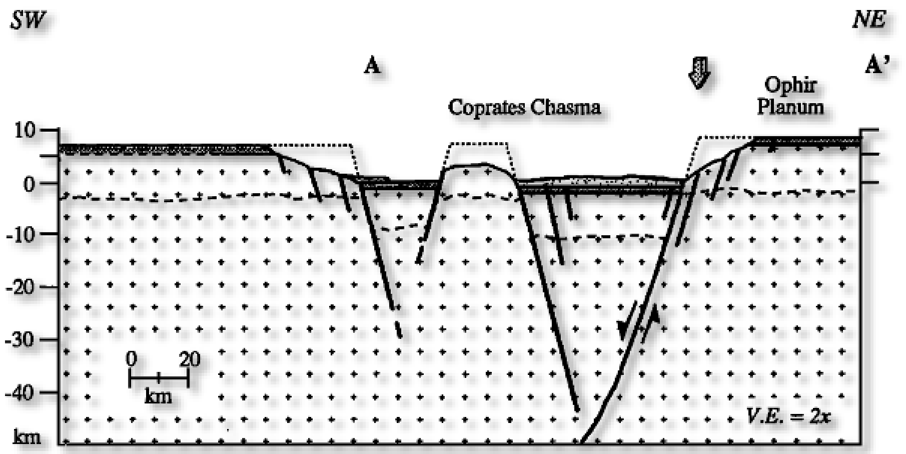
Olivier BOURGEOIS
Planetology and Geodynamics Laboratory, CNRS UMR 6112, University of Nantes



How were the large Valles Marineris chasmata formed?

HORST AND GRABEN

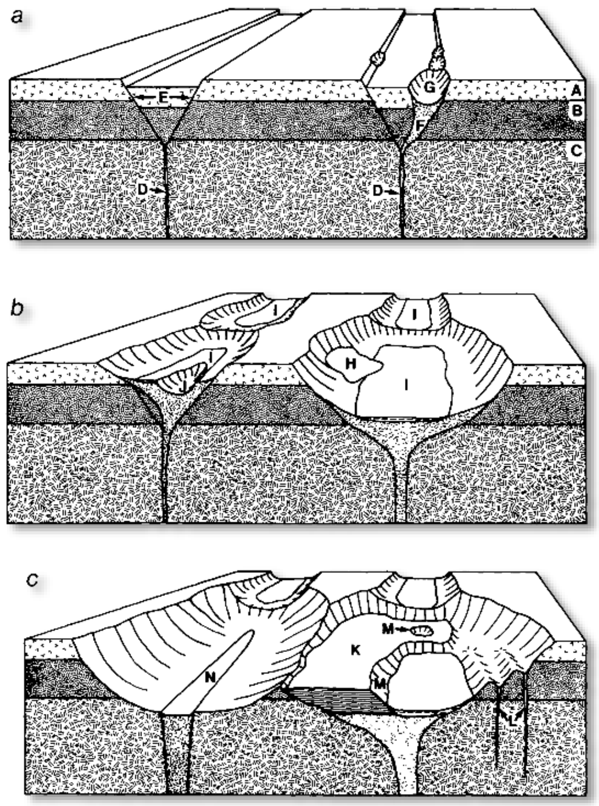
Frey 1977, Masson 1977



Schultz 1991

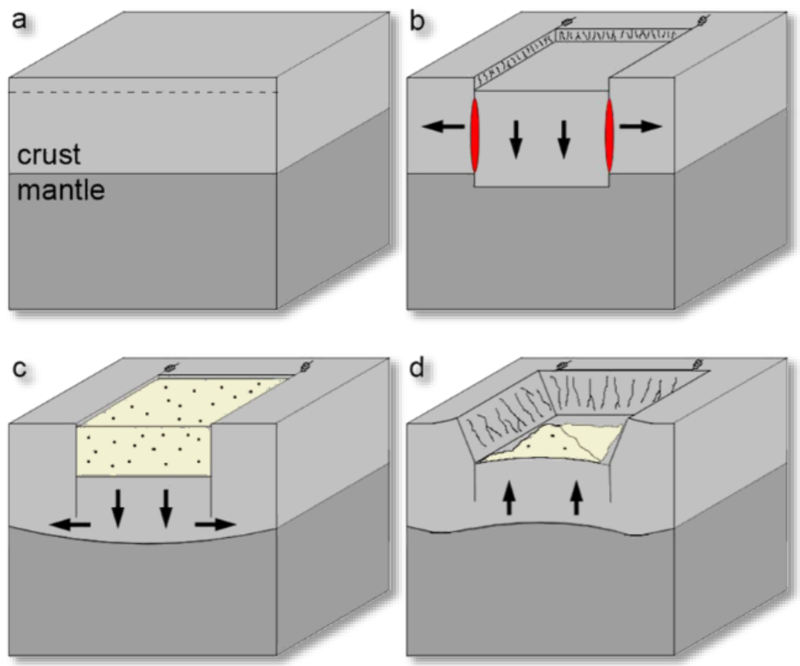
COLLAPSE INTO SUBSURFACE VOIDS

Tanaka and Golombek 1989

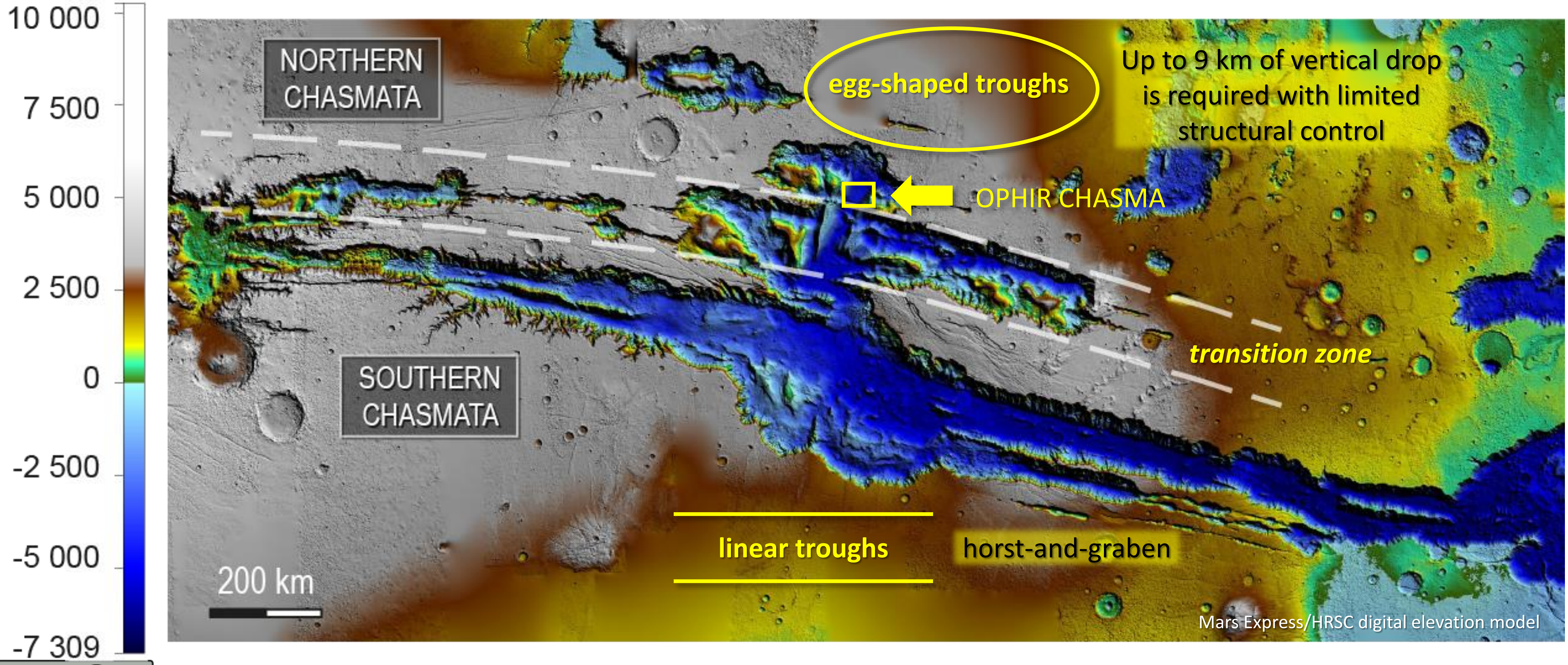


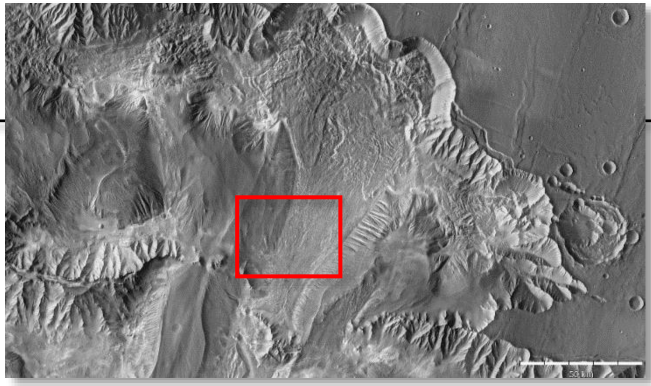
VERTICAL SUBSIDENCE

Andrews-Hanna 2012

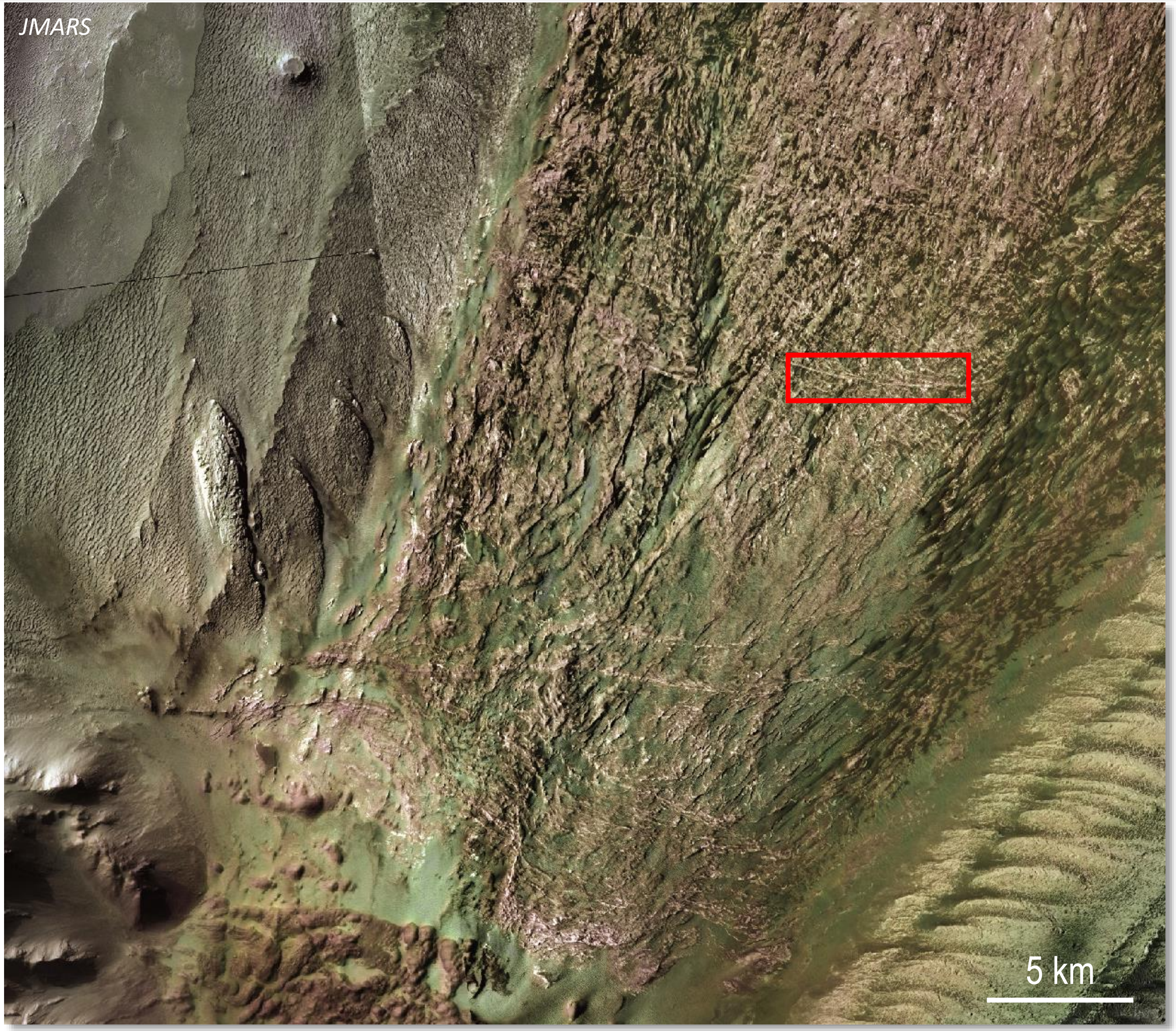


A composite model is necessary





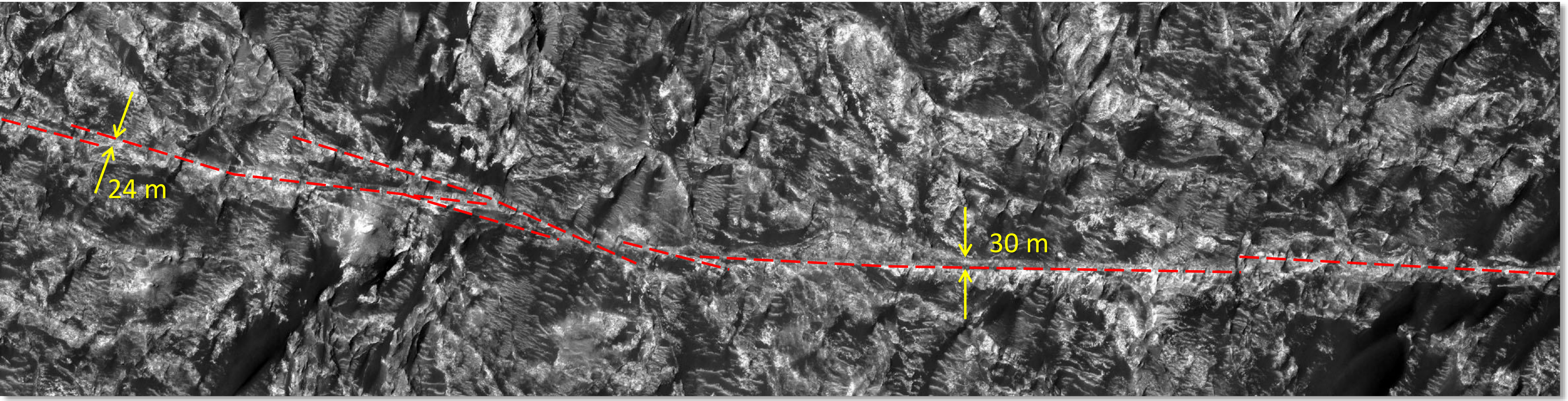
The Ophir Chasma dyke swarm



CTX image mosaic + Themis Day/Night IR

The Ophir Chasma dyke swarm

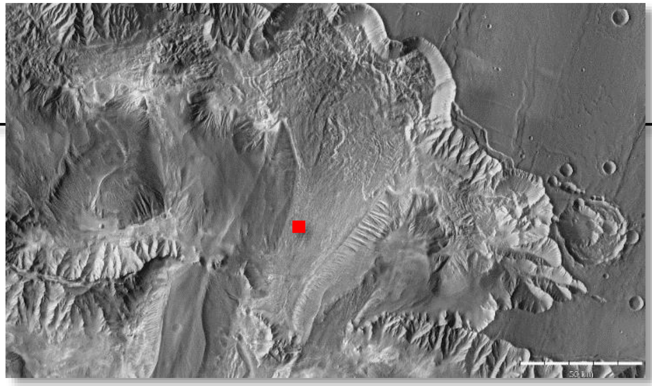
- Vertical rock sheet of constant thickness
- Branching segments, bridges

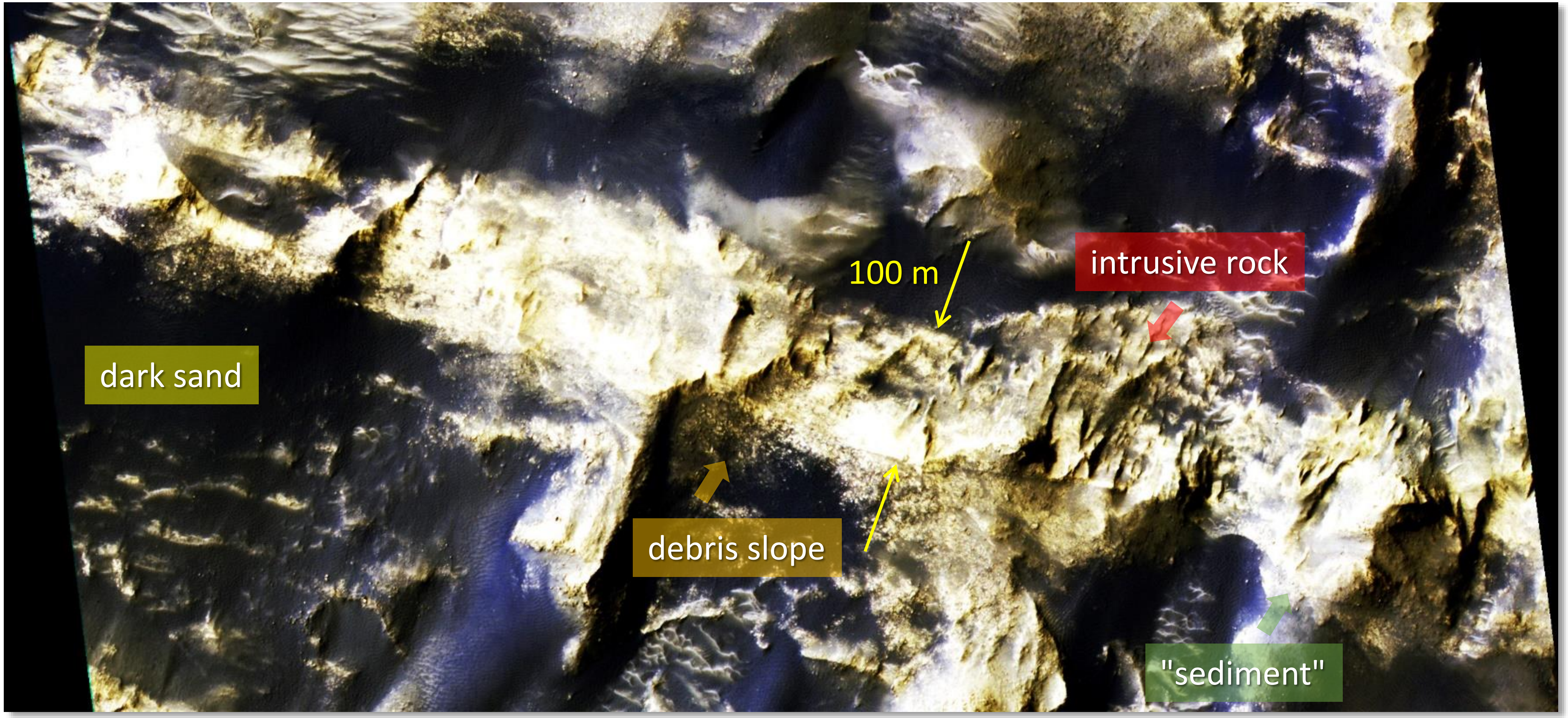


ESP_024479_1755

500 m

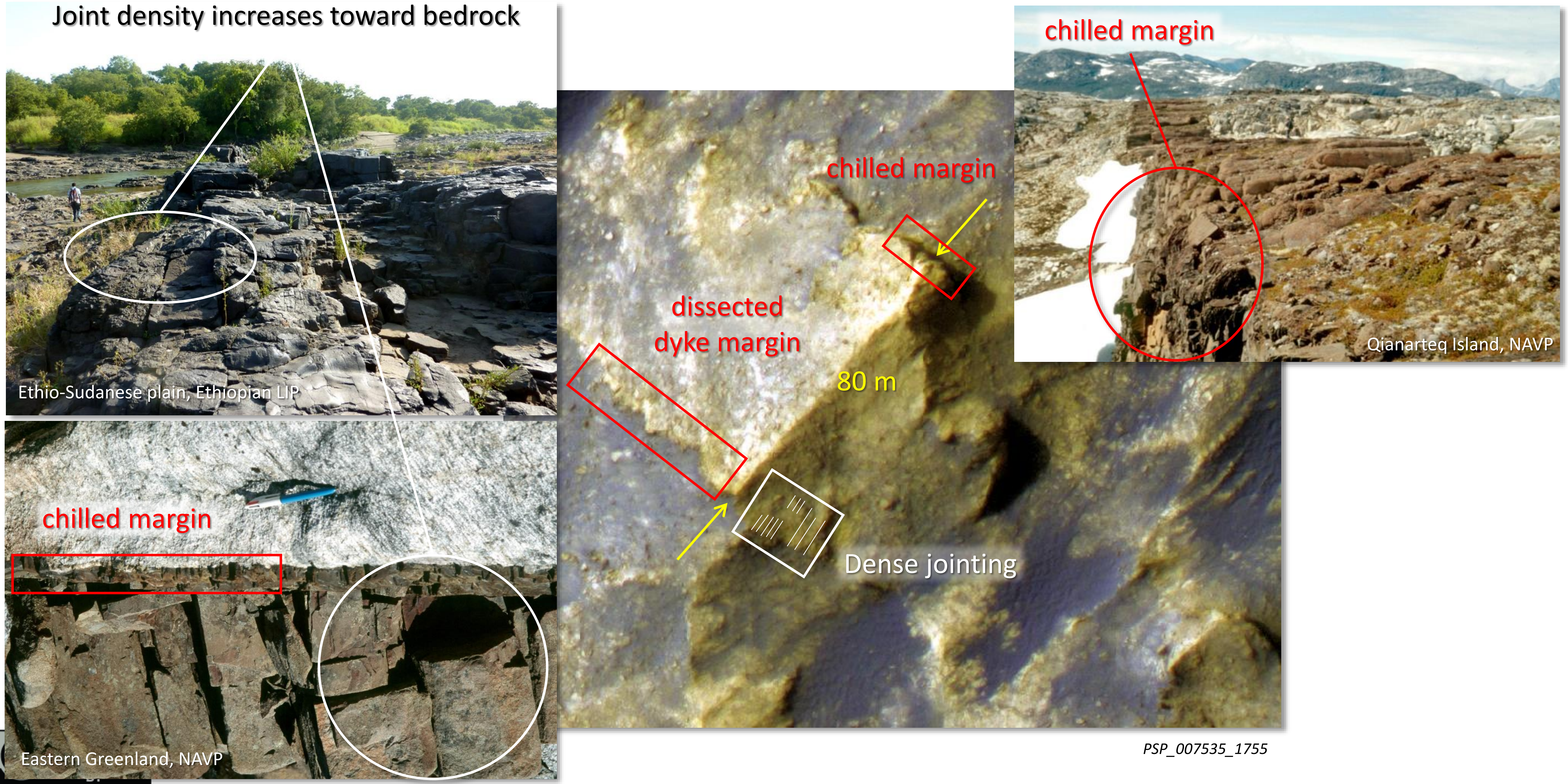
The Ophir Chasma dyke swarm



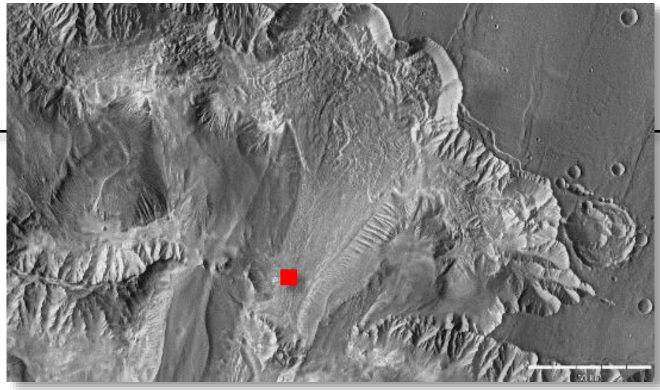


ESP_045459_1755

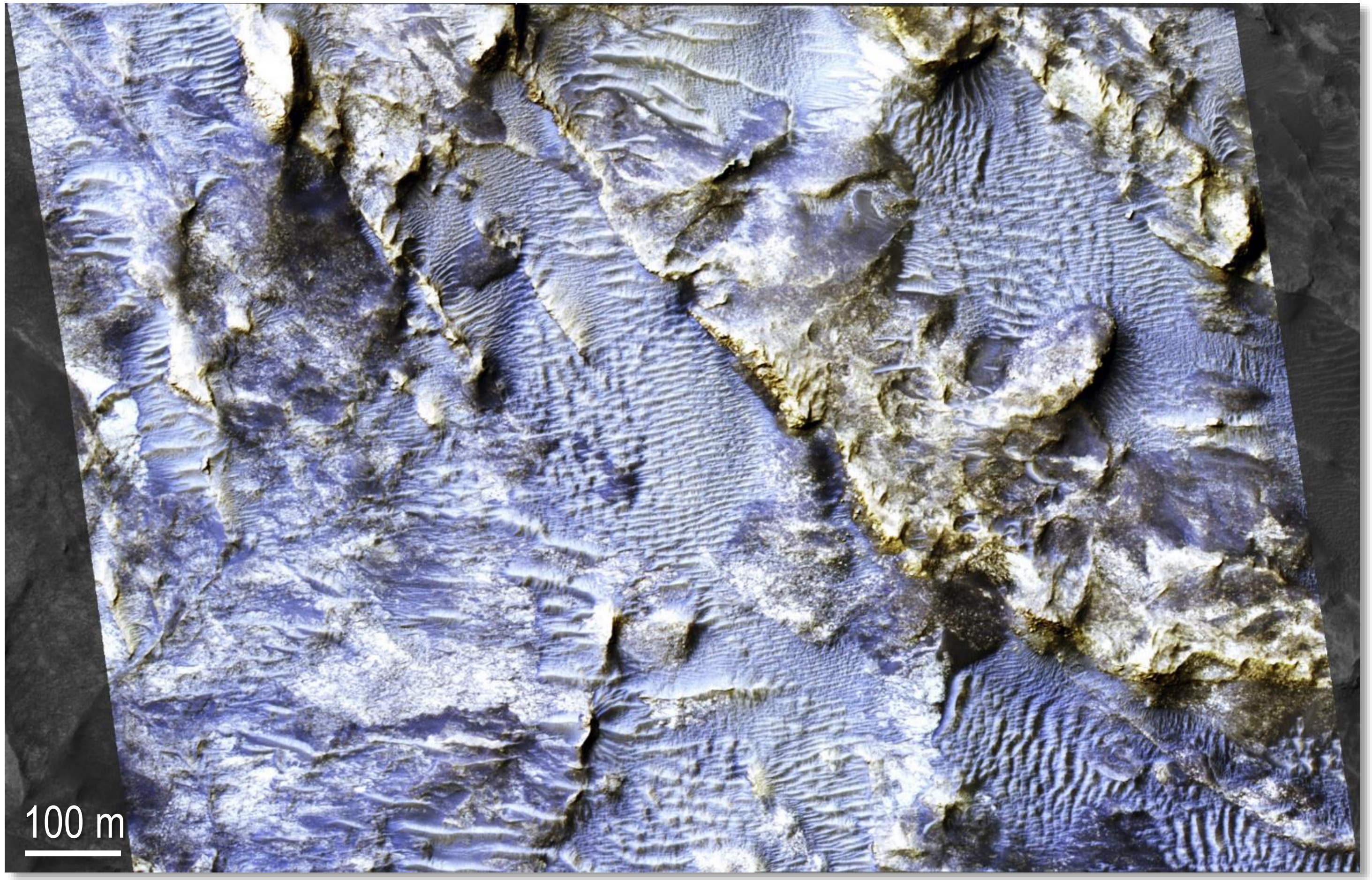
The Ophir Chasma dyke swarm



PSP_007535_1755

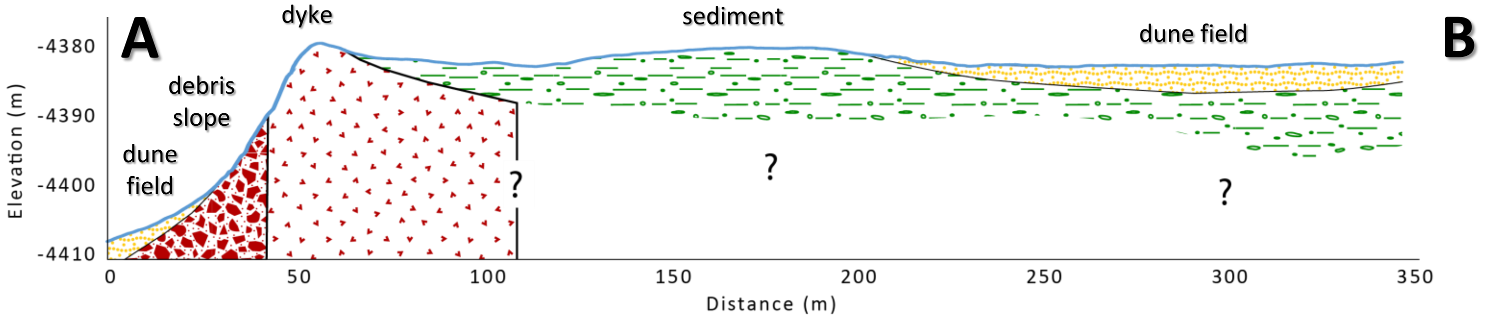


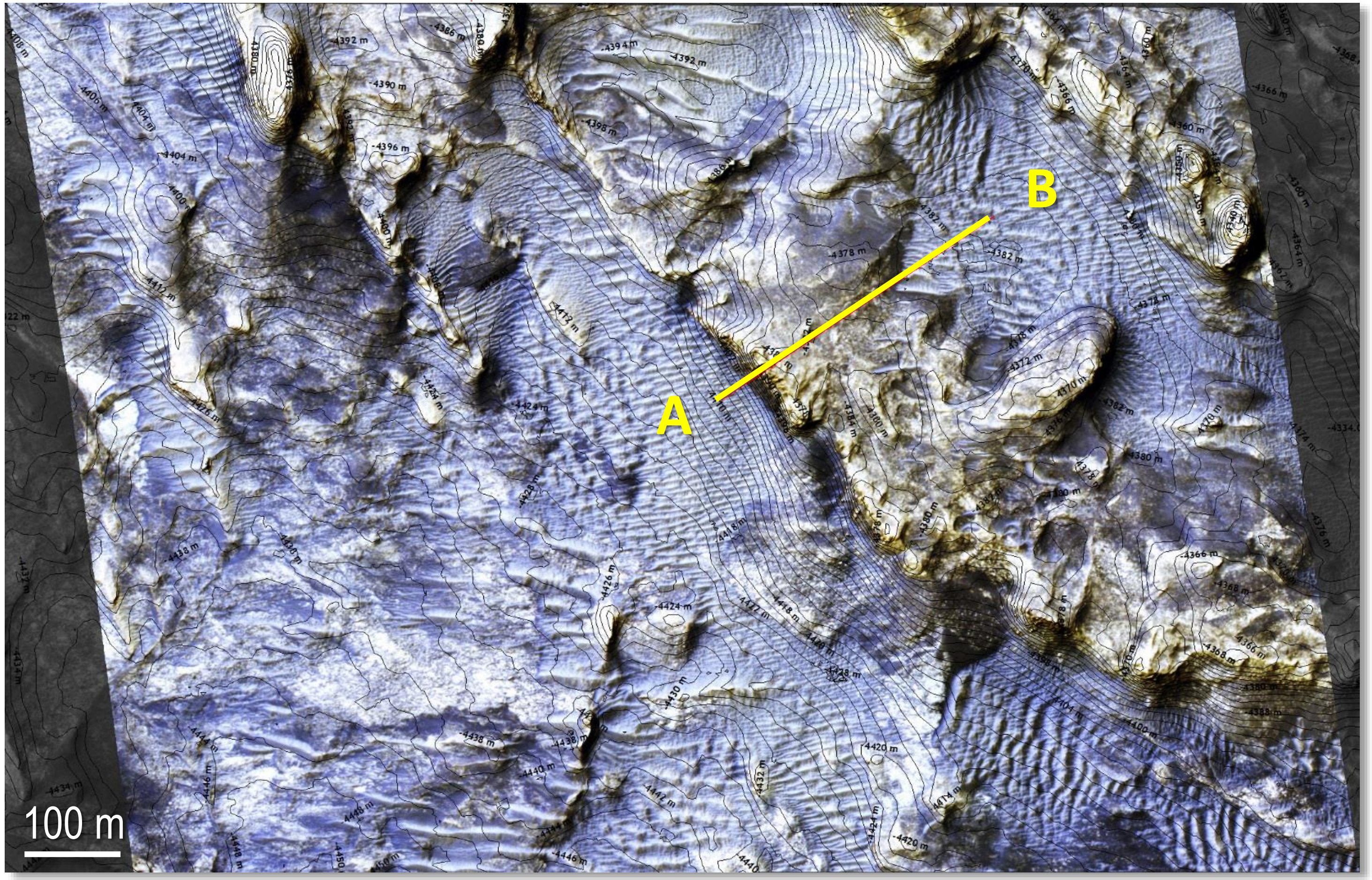
The Ophir Chasma dyke swarm



ESP_042993_1750

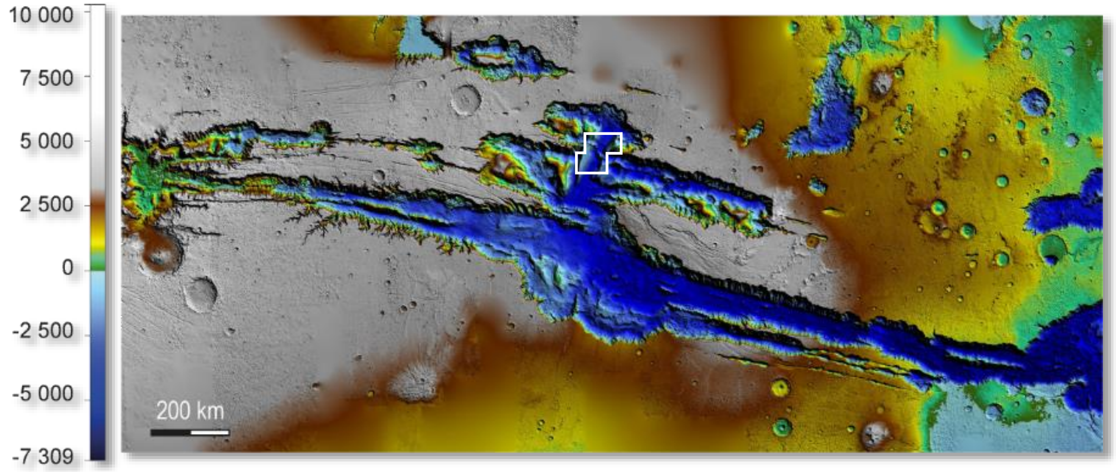
The Ophir Chasma dyke swarm

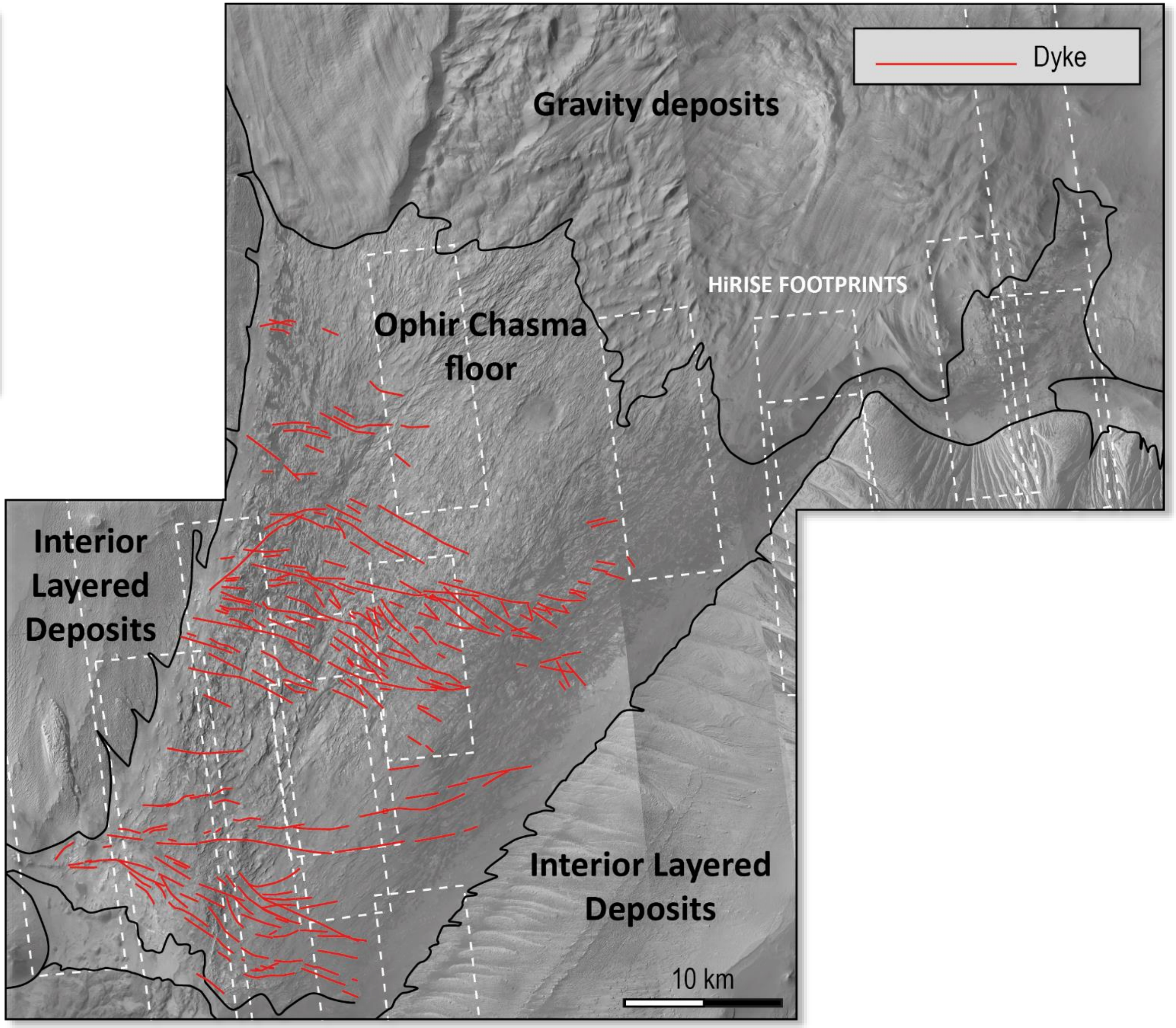




DEM ESP_042993_1750 + ESP_043138_1750
generated using MarsSI

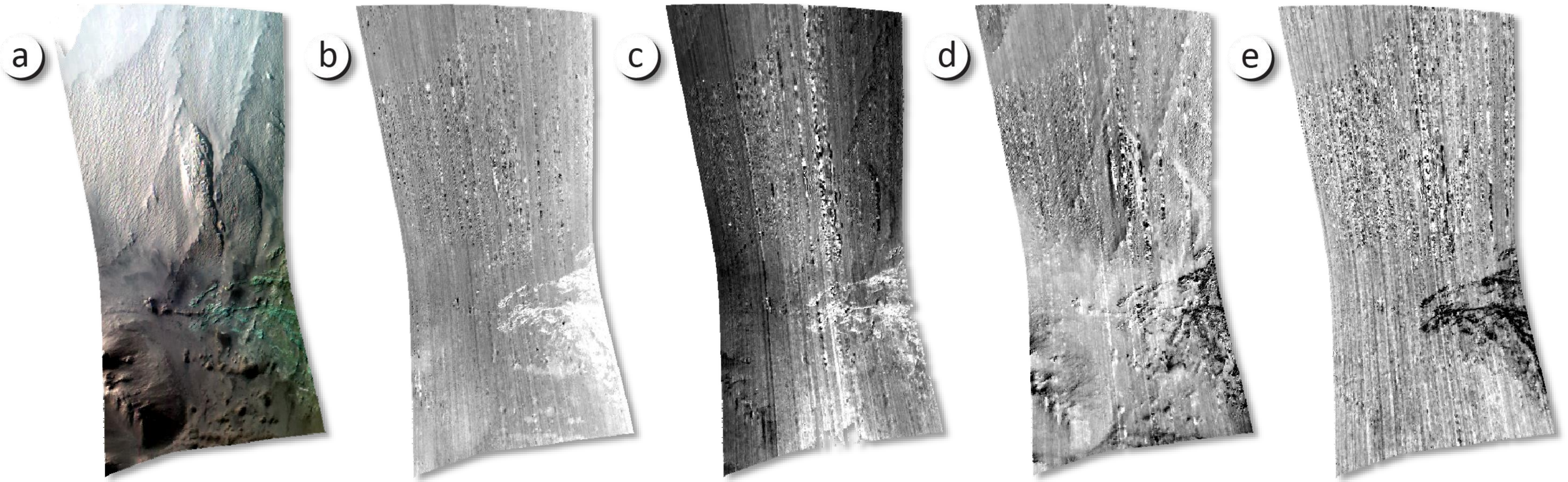
dyke swarm mapping





Dykes are commonly tens of meters thick.

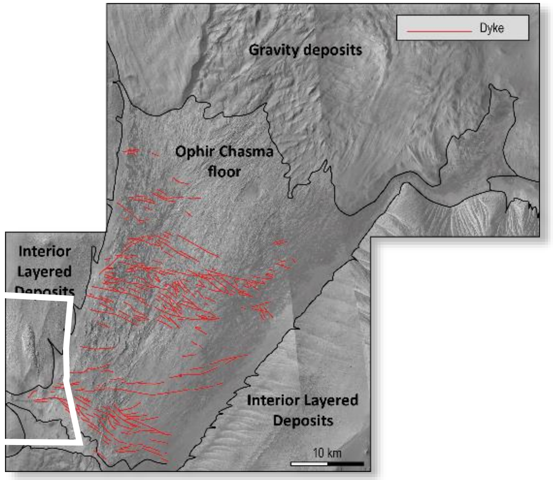
Dyke composition (provisional)



Lithologic contrasts (RGB 233 78 13) | Olivine (OLINDEX2) | high-Ca pyroxene (HCPINDEX) | low-Ca pyroxene (LCPINDEX) | Hydrated minerals/phyllosilicates (D2300)

CRISM cube hrl0000b7d4_07_if182l_trr3

Indexes after Pelkey et al. 2007; Salvatore et al. 2010

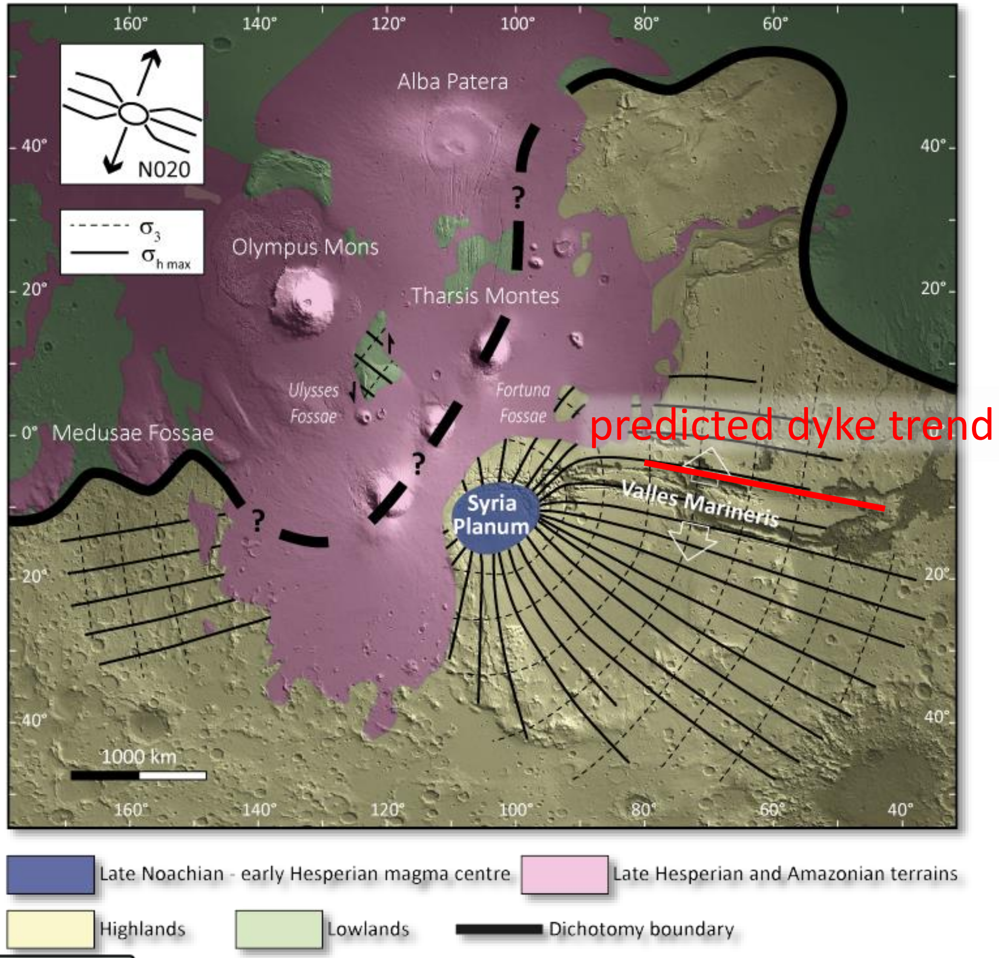


The dykes are mafic, have Ca-rich pyroxenes,
and show no evidence of phyllosilicate alteration.

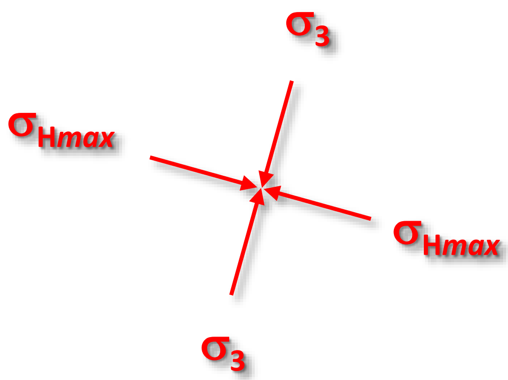
Dyke swarm origin

Lower Hesperian Syria Planum Large Igneous Province

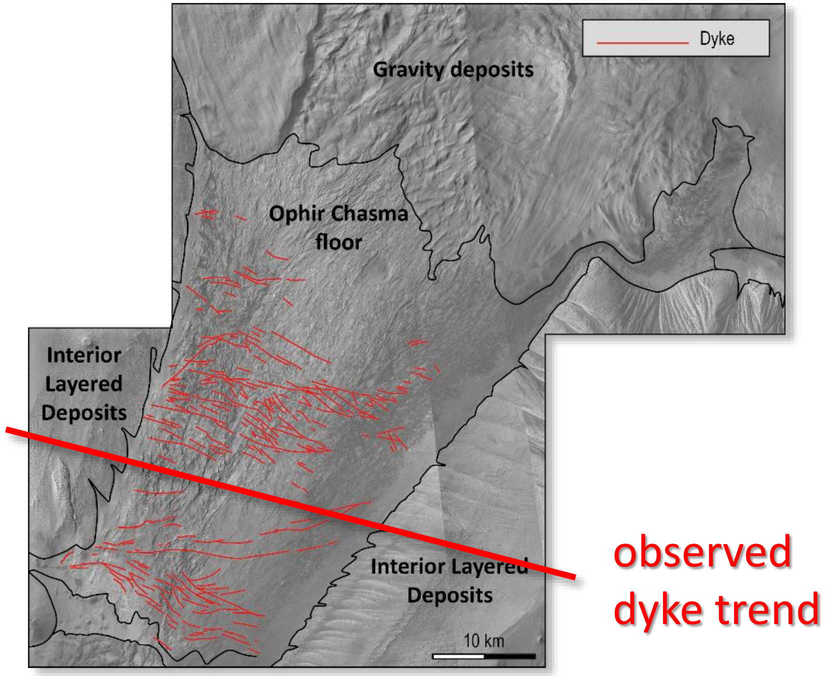
Horizontal principal stress trajectories inferred from dyke-related morphologies identified on Viking data



- The orientation of the Ophir Chasma dyke swarm is predicted by Syria Planum-centered plume activity during the Lower Hesperian.

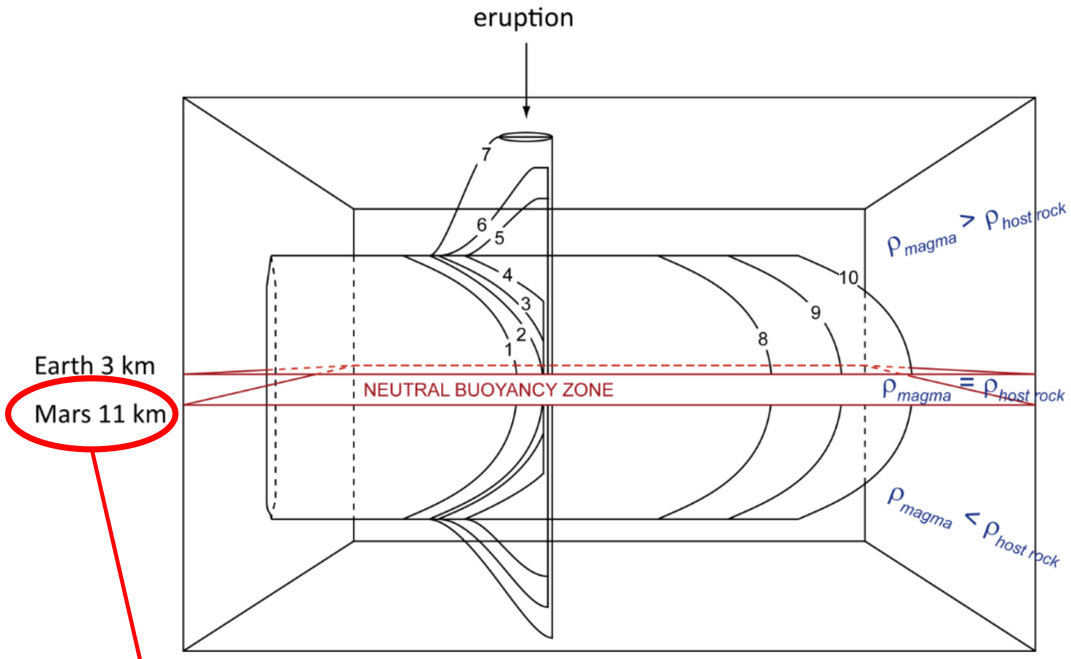


Mège and Masson 1996



Implications for Ophir Chasma genesis

Optimal propagation depth for basaltic dykes



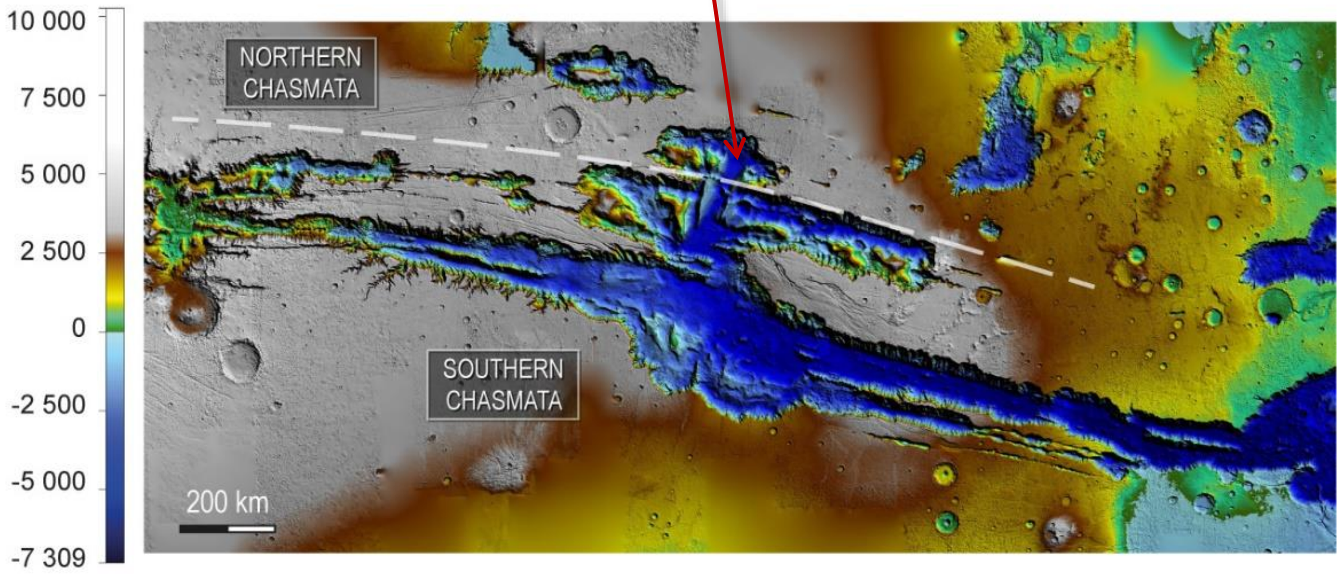
Ryan 1994

thickest dykes

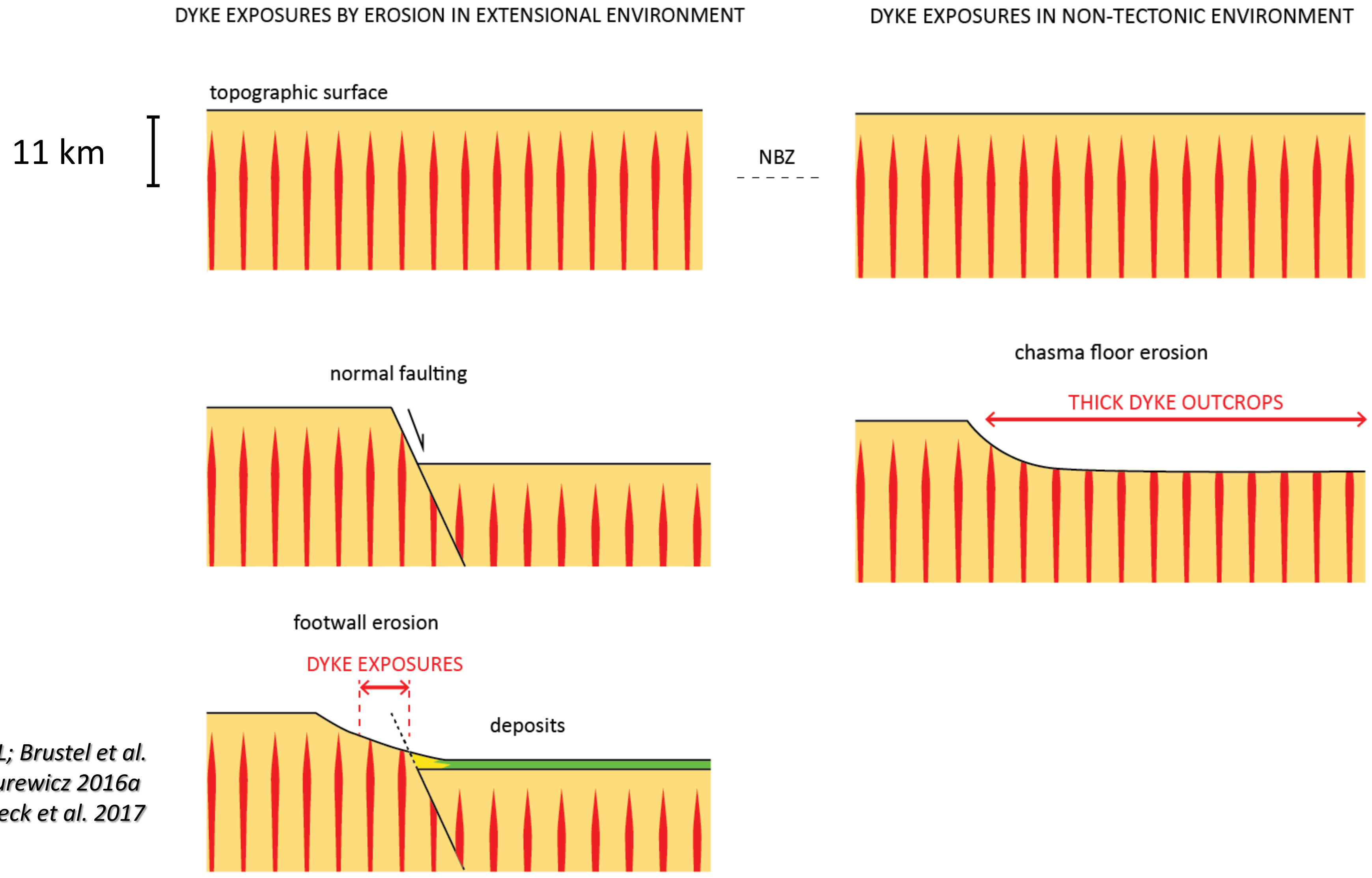
Wilson and Head 1994

- <u>Erosion must have been intense.</u> Such swarms of thick mafic dykes are observed on Earth on deeply eroded continental crust only.

Ophir Chasma depth is 9 km



Formation of the northern and southern chasmata



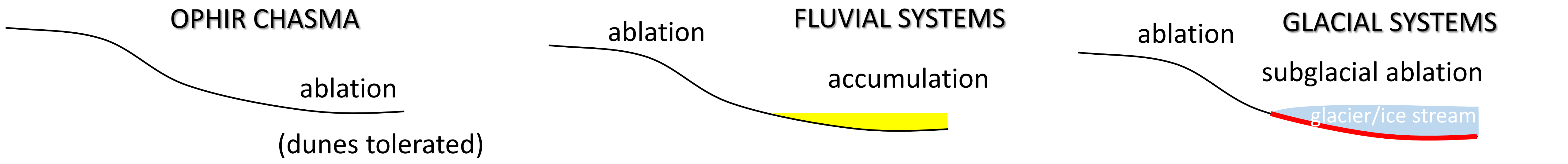
Flahaut et al. 2011 GRL; Brustel et al. 2017; Mège and Gurgurewicz 2016a Geol. Sinica; Viviano-Beck et al. 2017 Icarus

Mège and Gurgurewicz 2016b Geol. Sinica

Coprates Chasma - Ius Chasma - Candor Chasma

Ophir Chasma

Which erosional factors in Ophir Chasma?



- No fluvial drainage system observed
- Glacial landsystem identified in VM

Mège and Bourgeois 2011; Gourronc et al. 2014

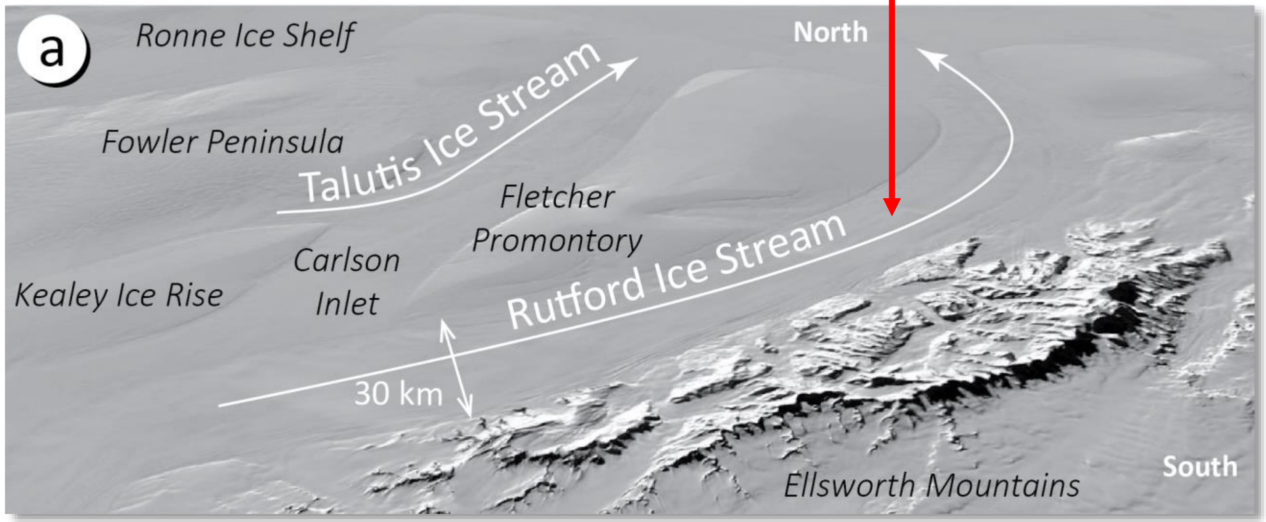
Up to 1 m/year

Smith et al. 2007

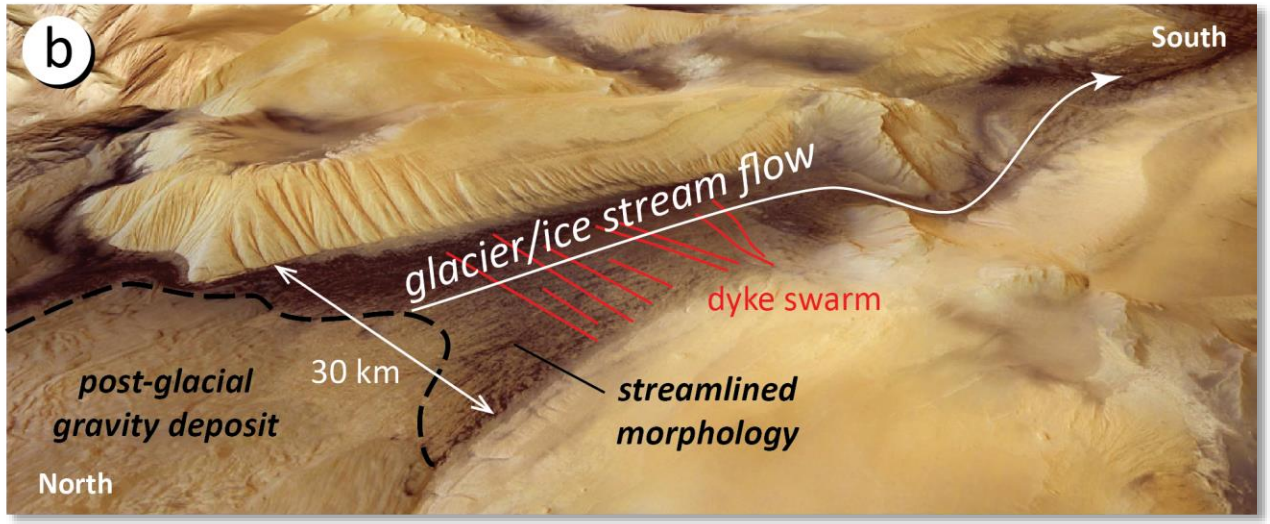
Already 2.4 km removed

King 2009

Antarctica



Ophir Chasma



CONCLUSION

- The **Ophir Chasma dyke swarm** was identified on the chasma floor. It is composed of Lower Hesperian dykes up to tens of meters thick, having a high-Ca content.
- The thickness of the dykes indicates that we are observing **deep crust exposures**, implying that **erosion of kilometers of crust** after dyke emplacement was a major factor in Ophir Chasma genesis.
- **Subglacial erosion** is an efficient way to erode the chasma floor of Ophir Chasma that agrees with observations.
- Dykes are also dilational patterns that indicate that **tectonic extension** must also have contributed to chasma formation.
- The reported observations indicate that the **role of erosion in the genesis** of some of the largest chasmata **needs to be strongly reevaluated** and it should be taken into account in any realistic models of Valles Marineris formation, Tharsis evolution, and palaeoclimate models.