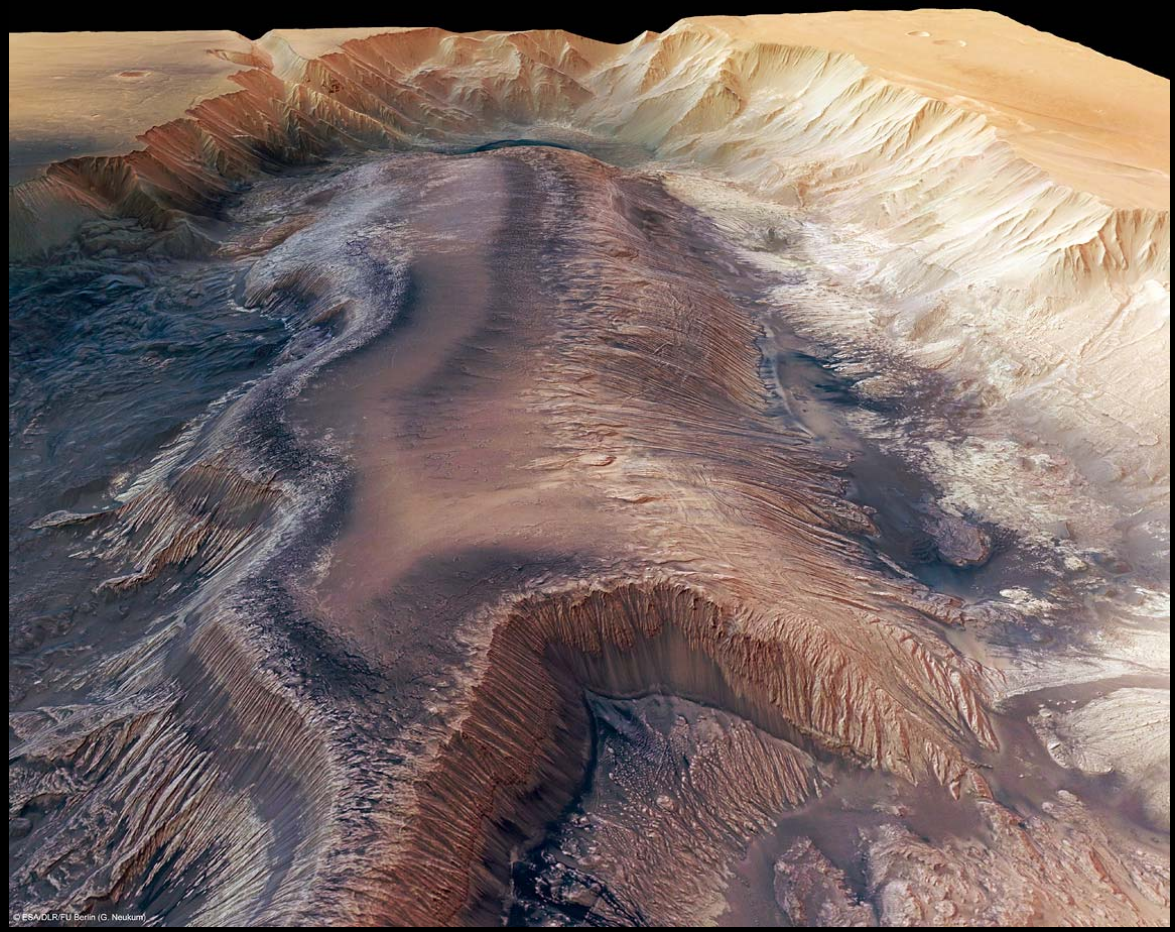
Martian Salt Tectonics?



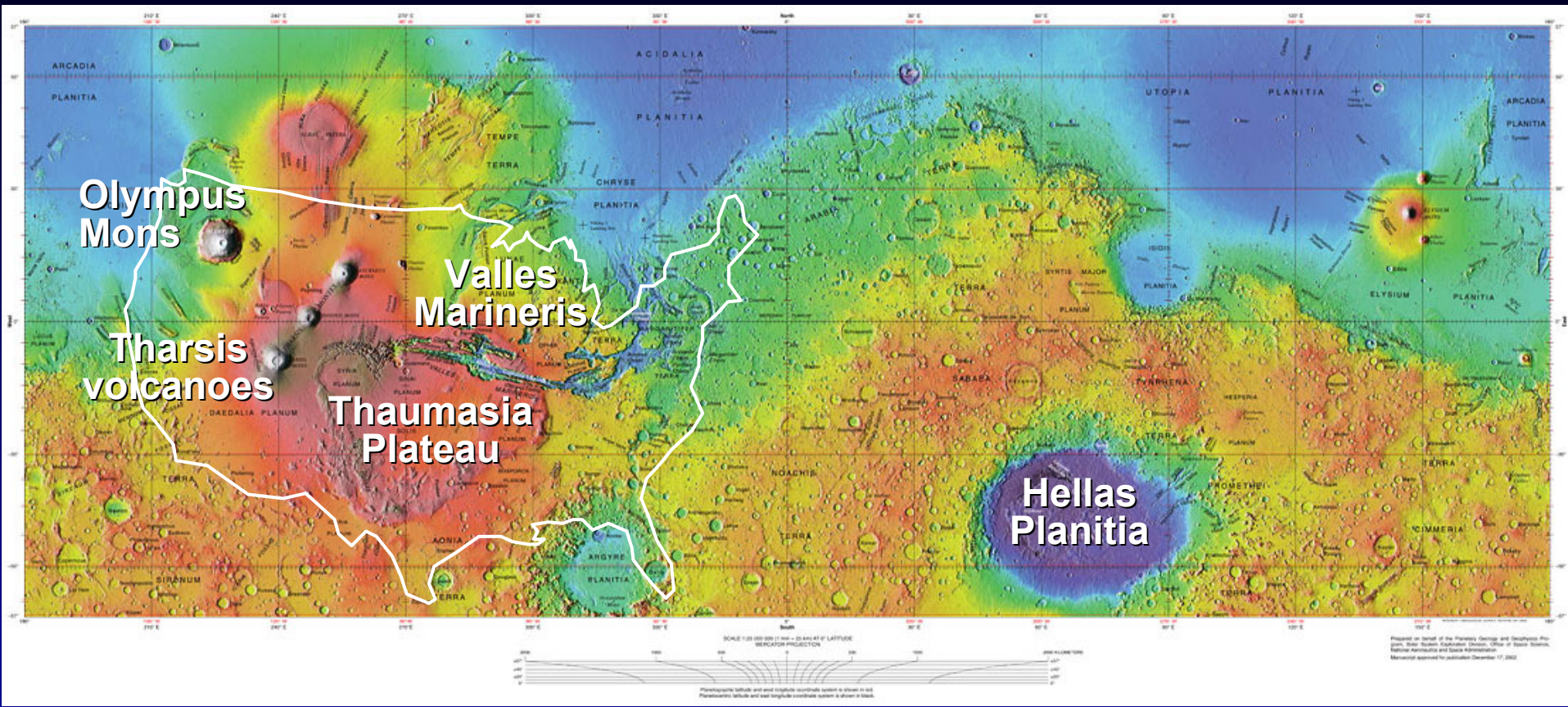
Martin Jackson

AGL
APPLIED
GEODYNAMICS
LABORATORY

Martin Jackson

- Structural geologist, Bureau of Economic Geology, Jackson School of Geosciences.
- Research focused on salt tectonics, using physical and numerical modeling, seismic data, field mapping, and remote sensing.
- Main research: terrestrial, funded by oil industry.
- Sideline research: tectonics of Mars and Neptune's moon, Triton.
- Collaborating on Mars with Dept. Earth and Space Sciences, University of Washington.

What's Where?



- Valles Marineris chasmata (canyons) expose deepest crust on Mars.
- Thaumasia Plateau is highest plateau in Mars (~3000 km wide).

Structural Map of Thaumasia Major

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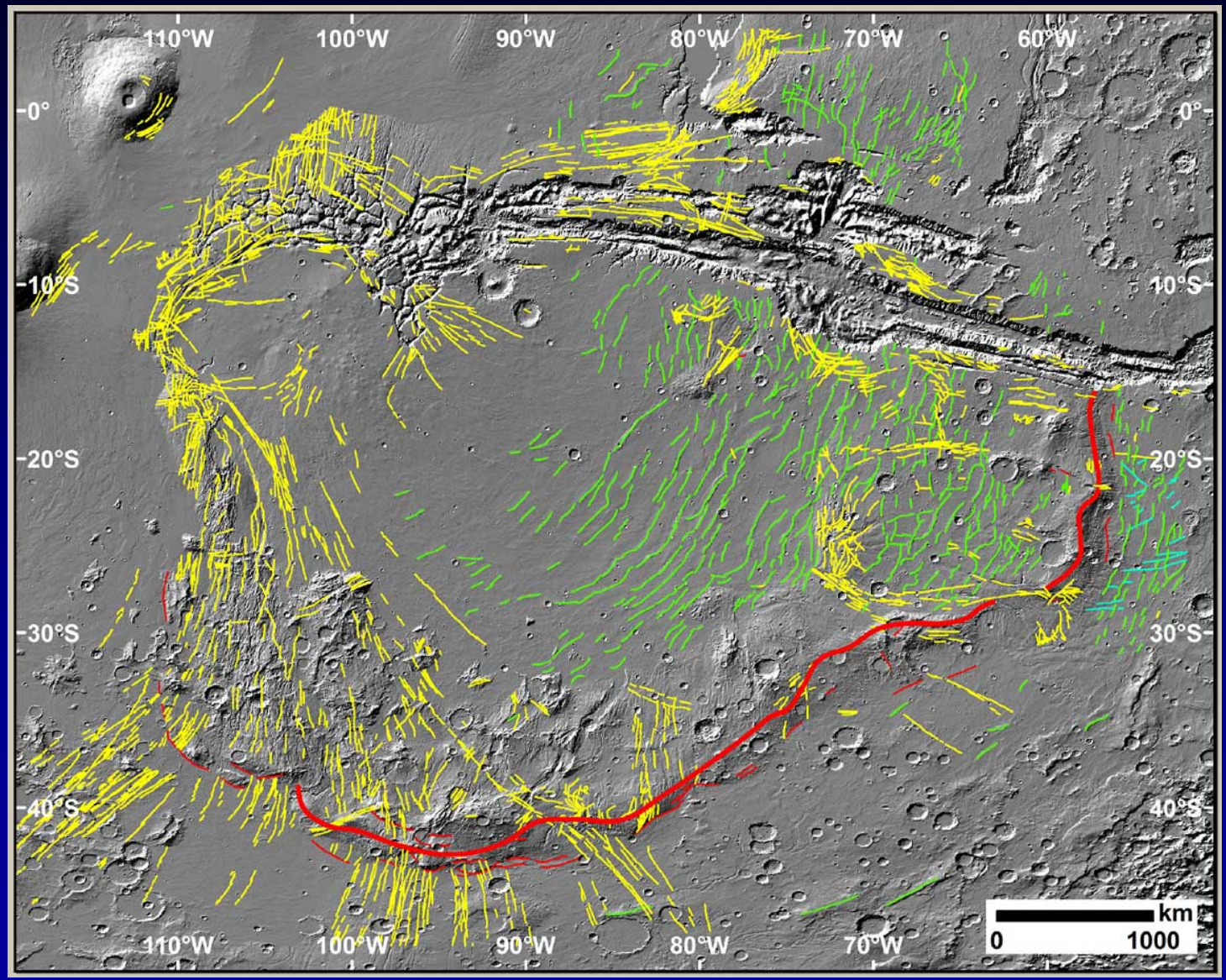
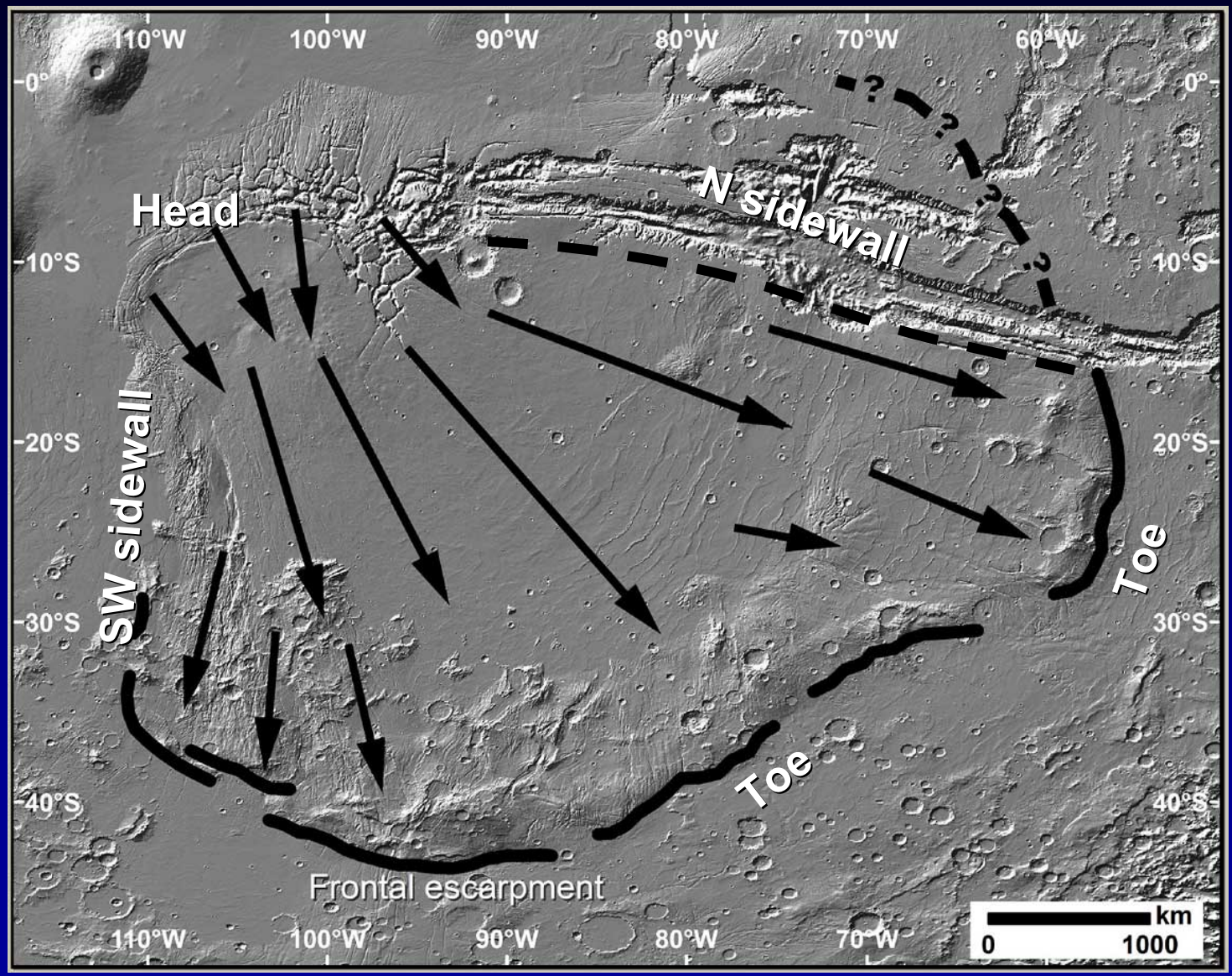
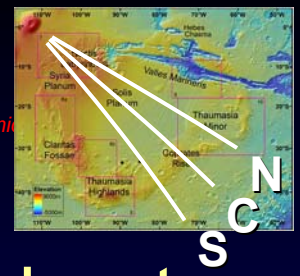


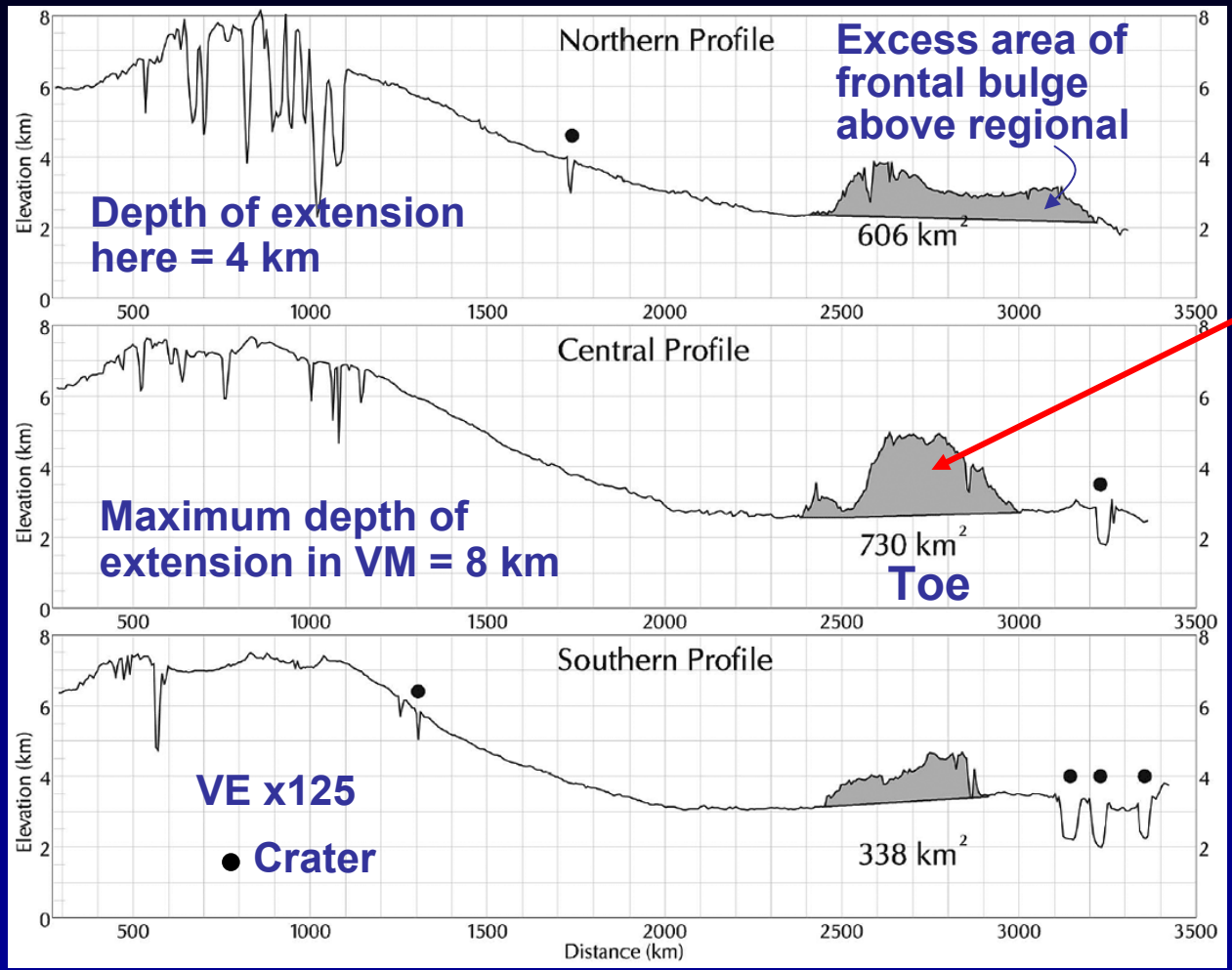
- Yellow = grabens
- Green = wrinkle ridges
- Blue = dikes
- Thin red = thrusts
- Thick red = frontal anticline
- Thaumsia Minor

Gravity Spreading System



Shortening and Depth to Detachment



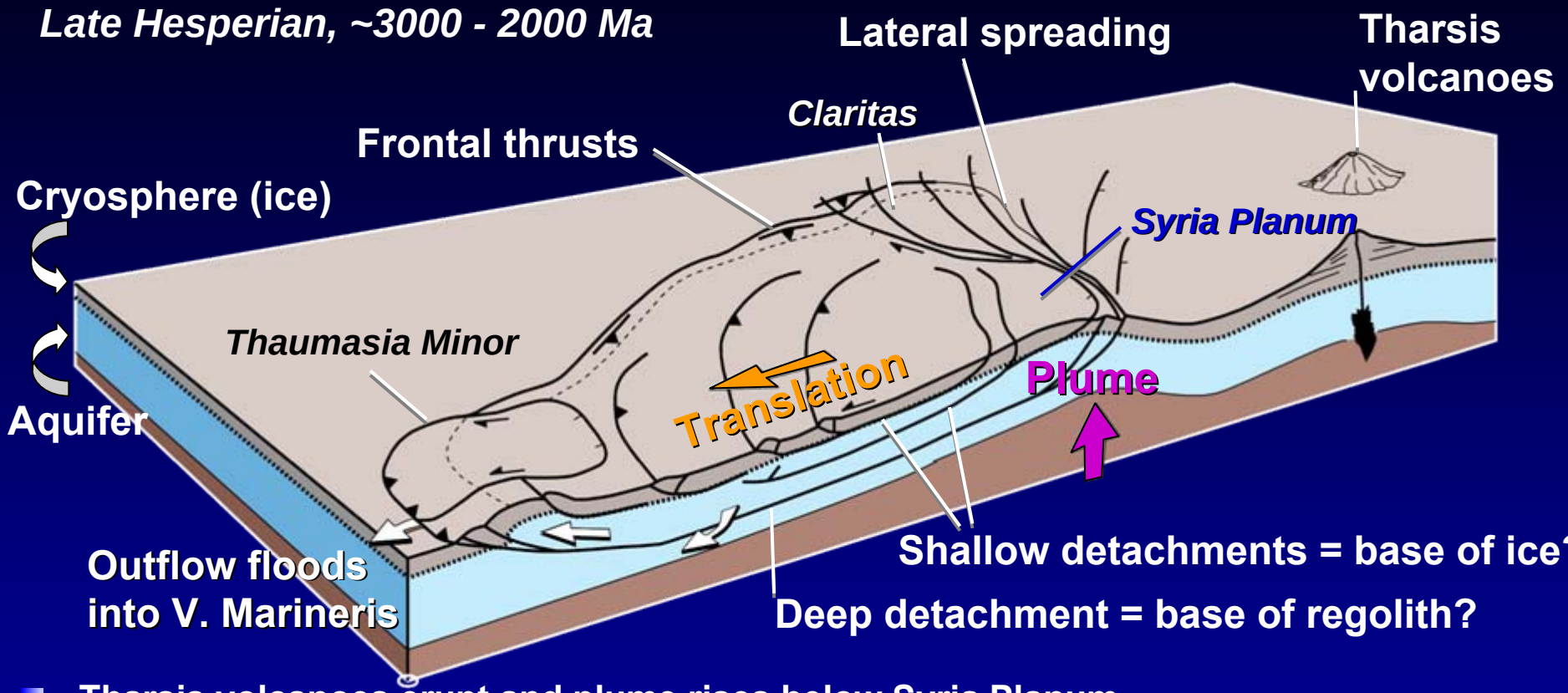


- **Deep detachment** 8-10 km deep.
- Excess area (730 km²) indicates plateau shortened by 35-75 km (2%).
- **Shallow detachments** 1-4 km deep.
- Wrinkle ridges have excess area of 6-9 km².
- Wrinkle shortened by 2-9 km.

- **Stability analysis** for observed 1° slope → 22 km of artesian head needed for slip on overpressured, fractured basalt. Unlikely.
- Detachments must be on weak rocks, like salt or ice.

Stage 3 – Gravity Spreading

Late Hesperian, ~3000 - 2000 Ma



- Tharsis volcanoes erupt and plume rises below Syria Planum
- Increased heat flux and regional slope
- Heat melts ground ice and dewaters hydrous salts → overpressured fluids
- Layers of salts, ice, and tephra in regolith provide multiple detachments
- Fractures cut cryosphere to connect aquifer with the surface → rapidly drains aquifer
- Outbursts carved channels along Tharsis radial extensional faults → VM canyons

Hebes Chasma

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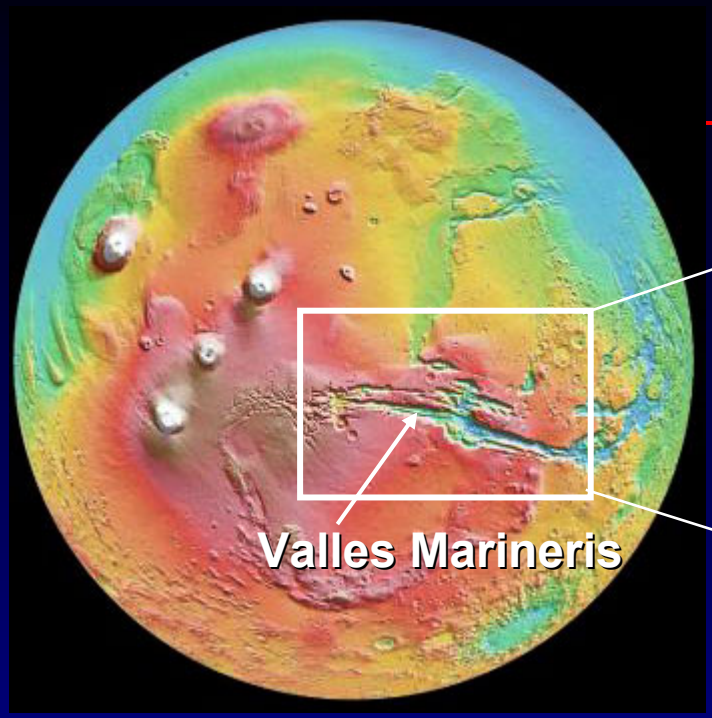

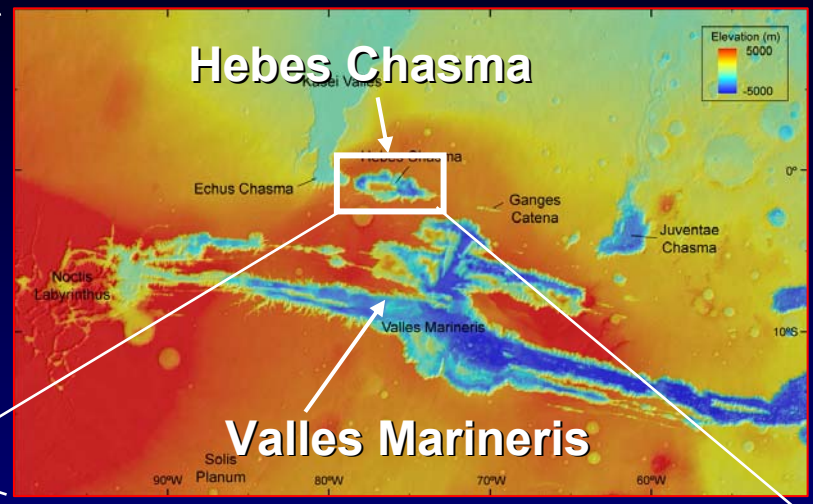

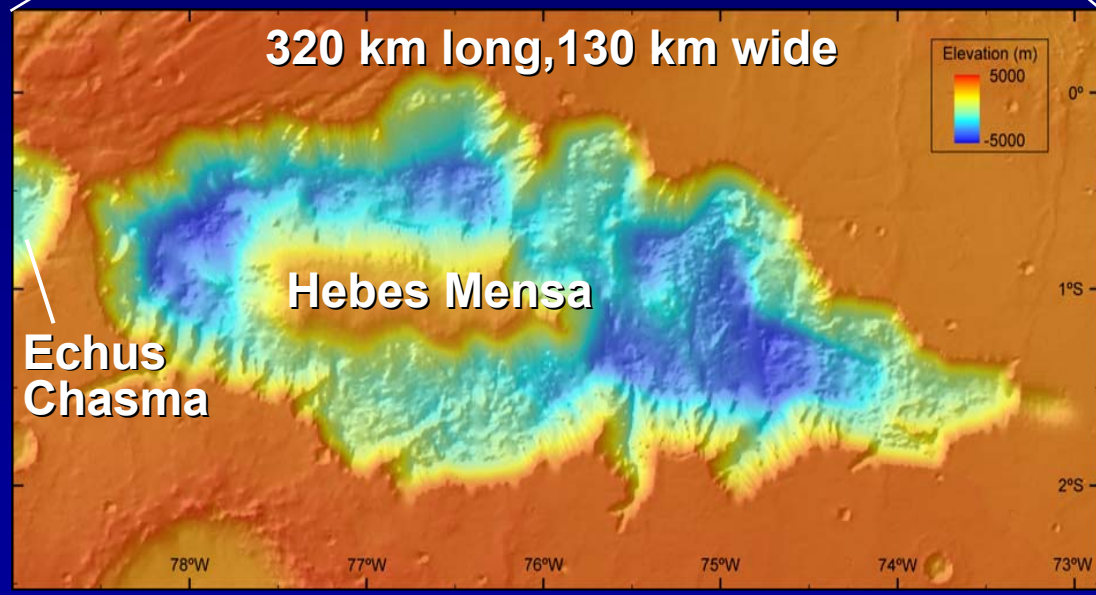

- Hebes Chasma is part of Valles Marineris canyons.
- Hebes Chasma is stubby but 8 km deep.
- Closed depression.
- How did canyon form? Where did missing 104,500 km^3 mass go?

Candor Chasma

Layered Deposits

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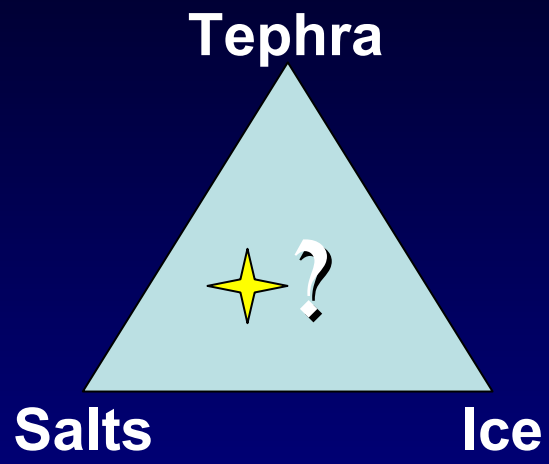
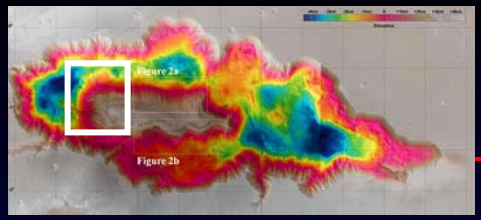
Pale layered deposits have resistant, cemented fractures



- Regolith ~8-km-thick.
- Layered deposits in canyon walls and on plains.
- 3 possible ingredients in varying proportion.
- **Salts** could flow any time; may dissociate to yield water on heating.
- **Ice** could flow any time until it sublimates on exposure to atmosphere; melts to yield water.
- **Tephra** could flow soon after deposition while hot from eruption, but later stiffens.



Flow off Hebes Mensa

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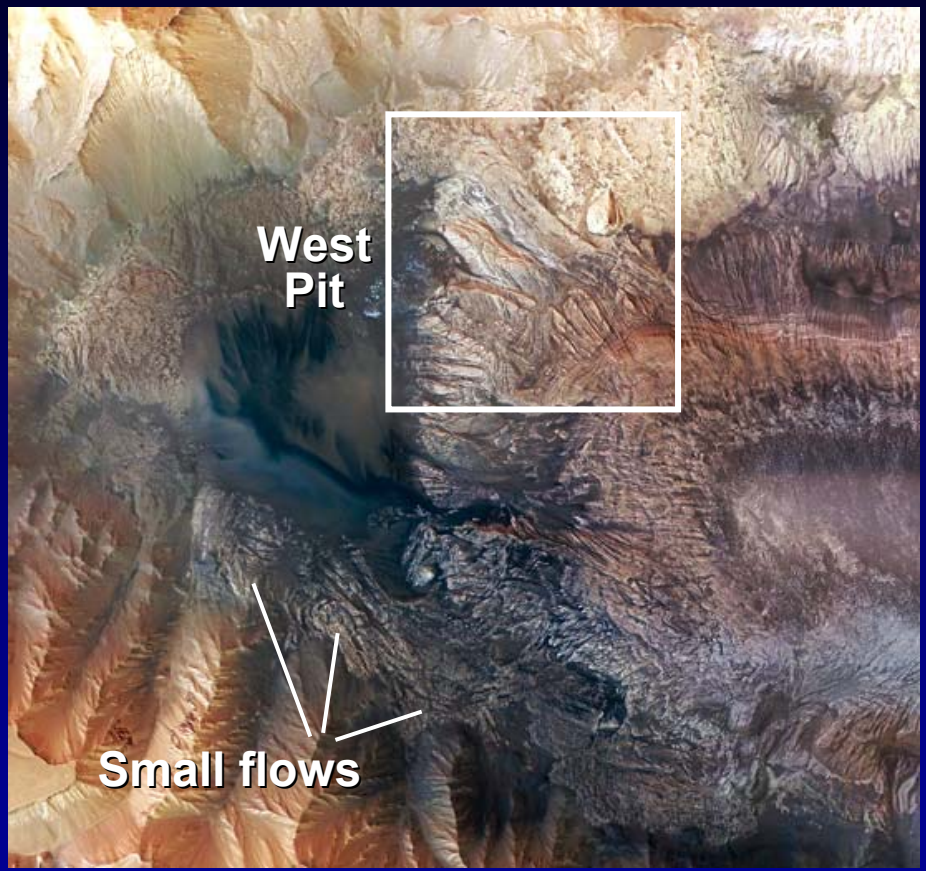
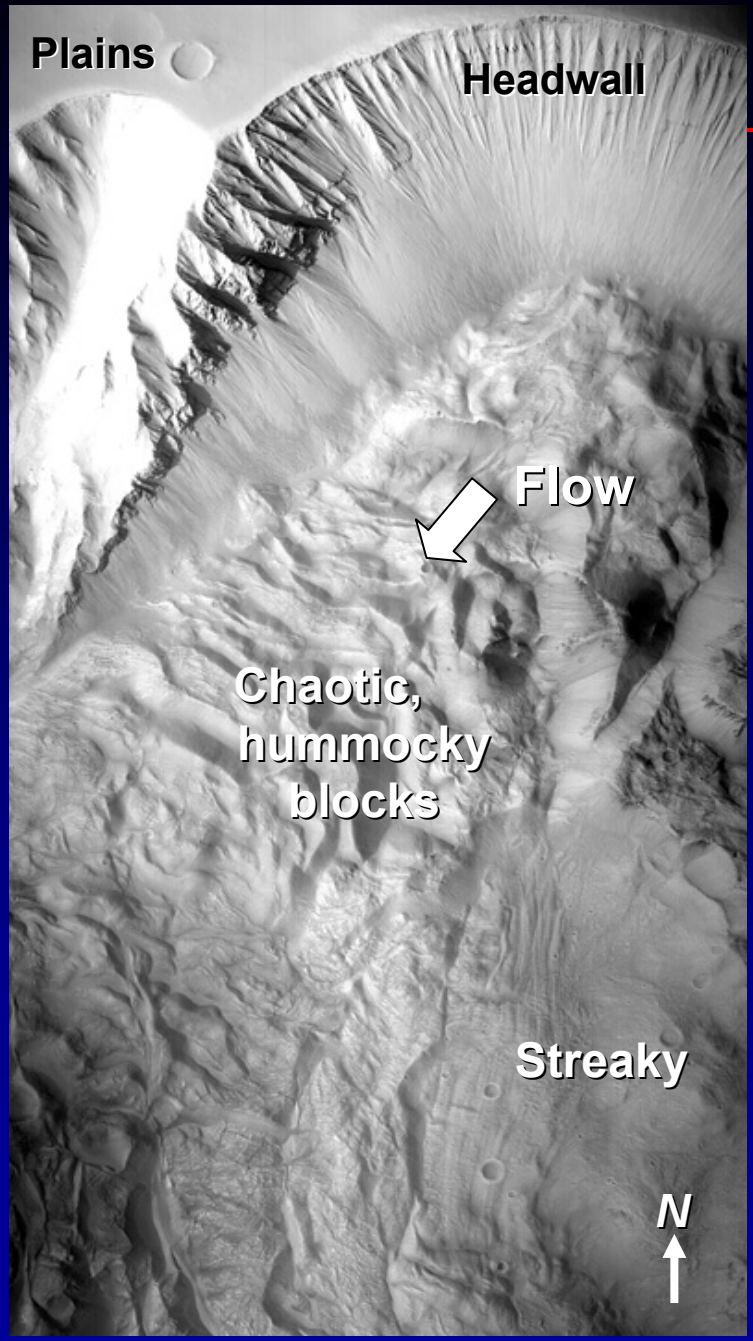
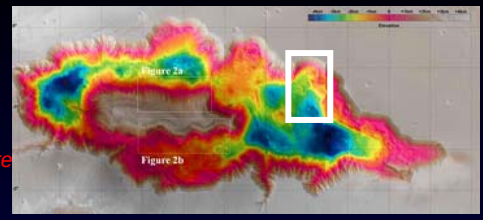


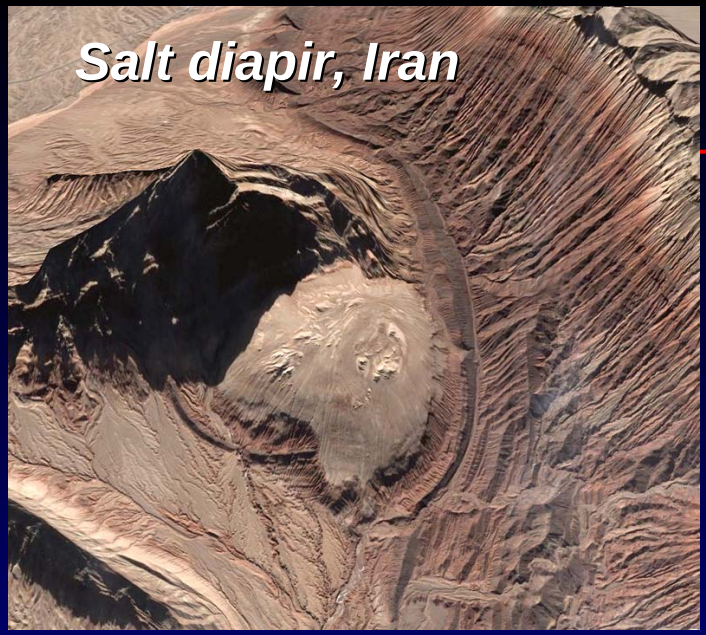
- 17-km-long flows from stratified, stratabound layer, high in Hebes Mensa.
- Source layer contains bulbous structures in km-scale cells.
- Must have flowed after Mensa was eroded.



Great NE Flow



- Flow is >44 km long.
- Emerges from base of headwall.
- Flow on slopes <5° indicates low viscosity like salts or ice.
- Flow ends in pit in chasma floor without accumulating.
- Closed basins and pits (blue-green).
- Missing mass (100,000 km^3).
- Outburst floods a few km away in Echus Chasma.



Diapir in Tithonium Chasma

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- Tithonium Chasma is ~1000 km south of Hebes.
- Diapir is 30 km long and 3.5 km high.
- Diapir contains kieserite (hydrous magnesium sulfate).

Subsidence Hypothesis Tested by Physical Model

Animation

- Deep magmatism supplied heat.
- (1) Permafrost ice melted, (2) hydrous salts dewatered.
- Water drained down fractures in solution or slurry, then escaped to surface at outburst sites.
- 3 layers in model:
- Upper is blue, brittle strong (dry sand)
- Middle is white, brittle, weak (glass microspheres)
- Bottom is gray, viscous, weak, buoyant (silicone)
- Two competing processes in model:
  - Subsidence due to drainage
  - Diapirism due to density inversion.