Martian Salt Tectonics?

Martin Jackson
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.
Valles Marineris chasmata (canyons) expose deepest crust on Mars.

Thaumasia Plateau is highest plateau in Mars (~3000 km wide).
Structural Map of Thaumasia Major

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

Bureau of Economic Geology
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 dewatered 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 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?
Layered Deposits

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.

Candor Chasma

Pale layered deposits have resistant, cemented fractures

Tephra

Salts

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