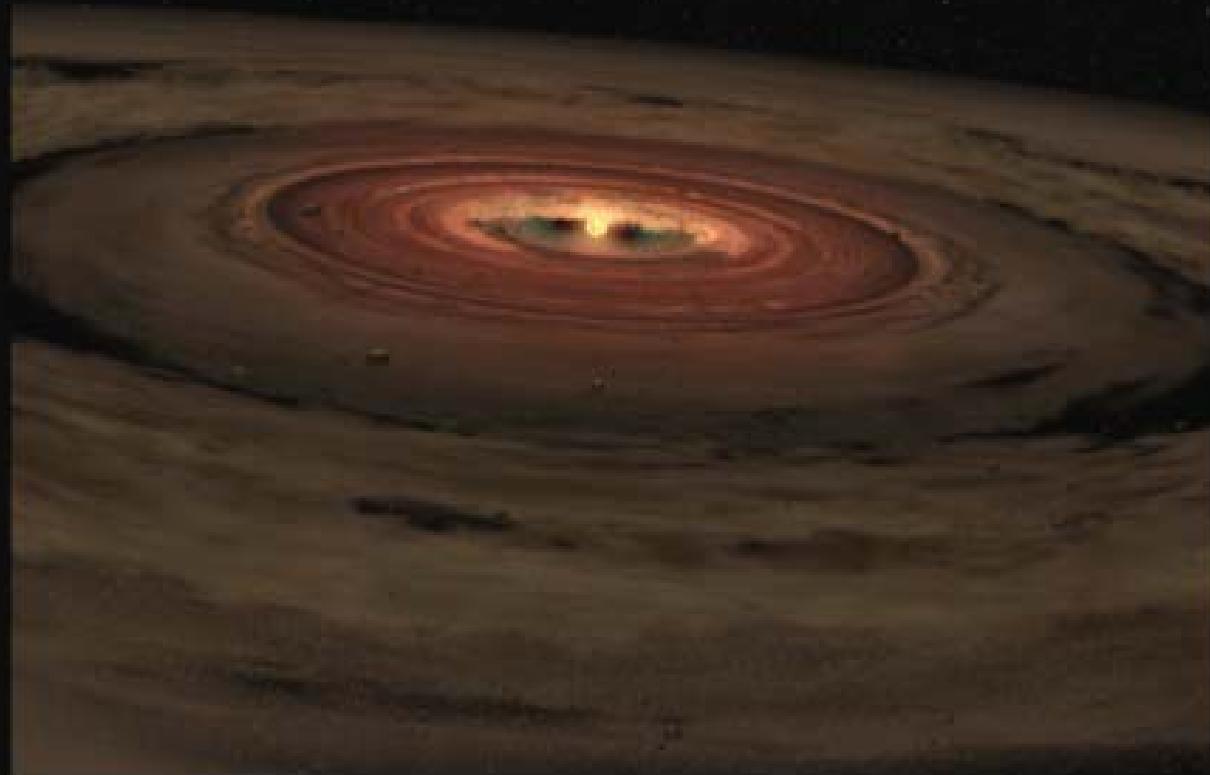


In the beginning ...



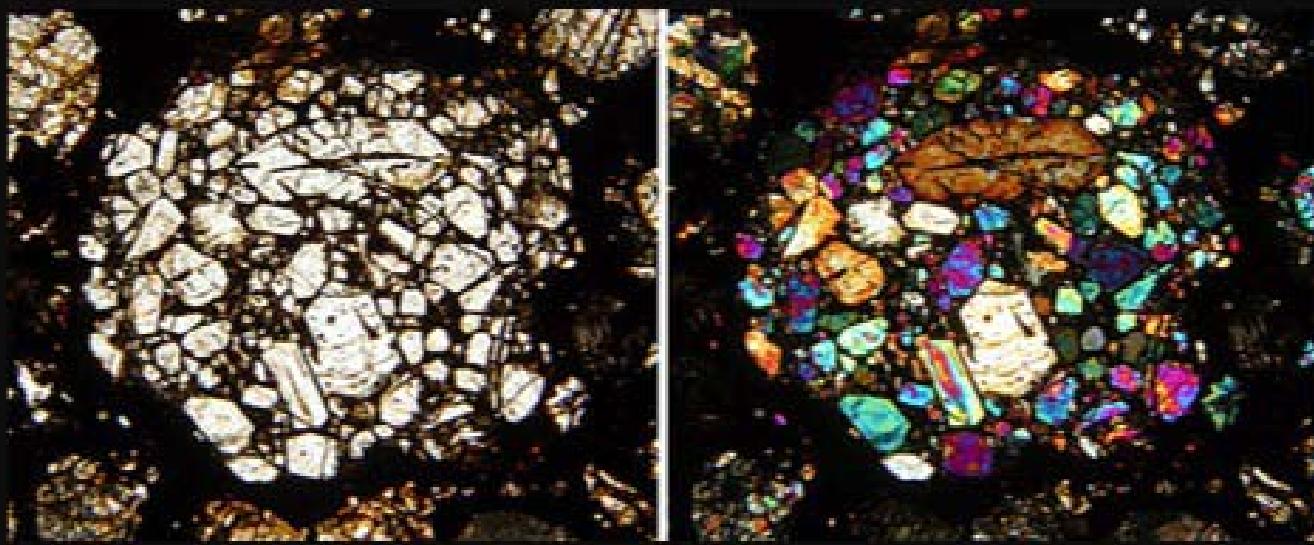
Artist's impression of the early Solar Nebula

NASA

Chondrules ... sliced and rough surface



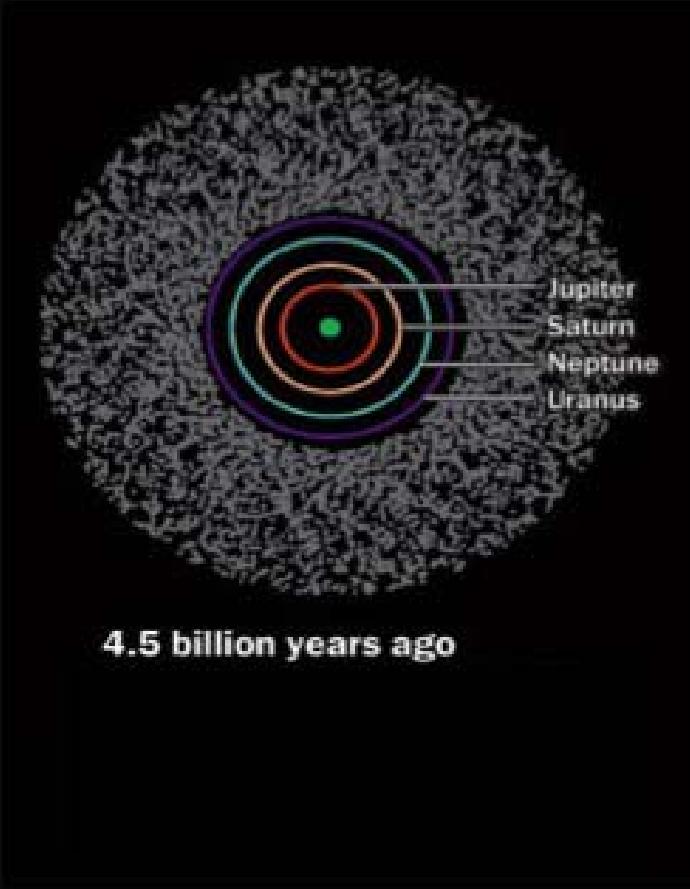
Chondrules ... polycrystalline plus glass



Northern Arizona Meteorite Laboratory

Slide04

In the beginning ... the "Grand Tack" and "Nice" models



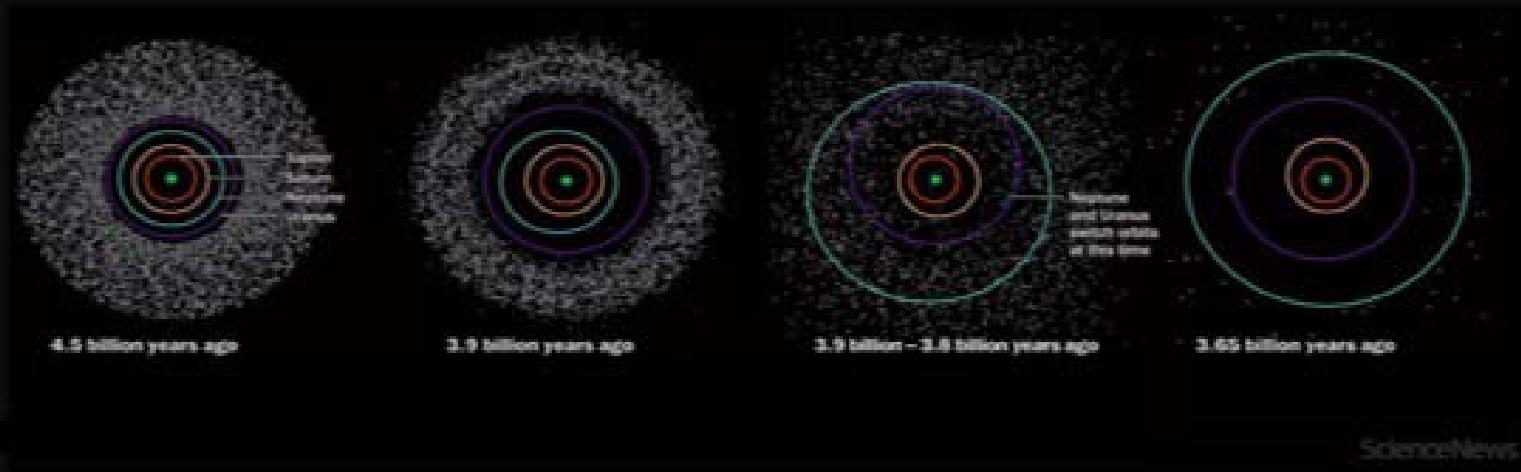
During initial planet formation,
surrounded by the Kuiper Belt – Jupiter
migrated toward the interior of the
Solar System ...

... then it migrated back out again

Grand Tack model

https://en.wikipedia.org/wiki/Nice_model

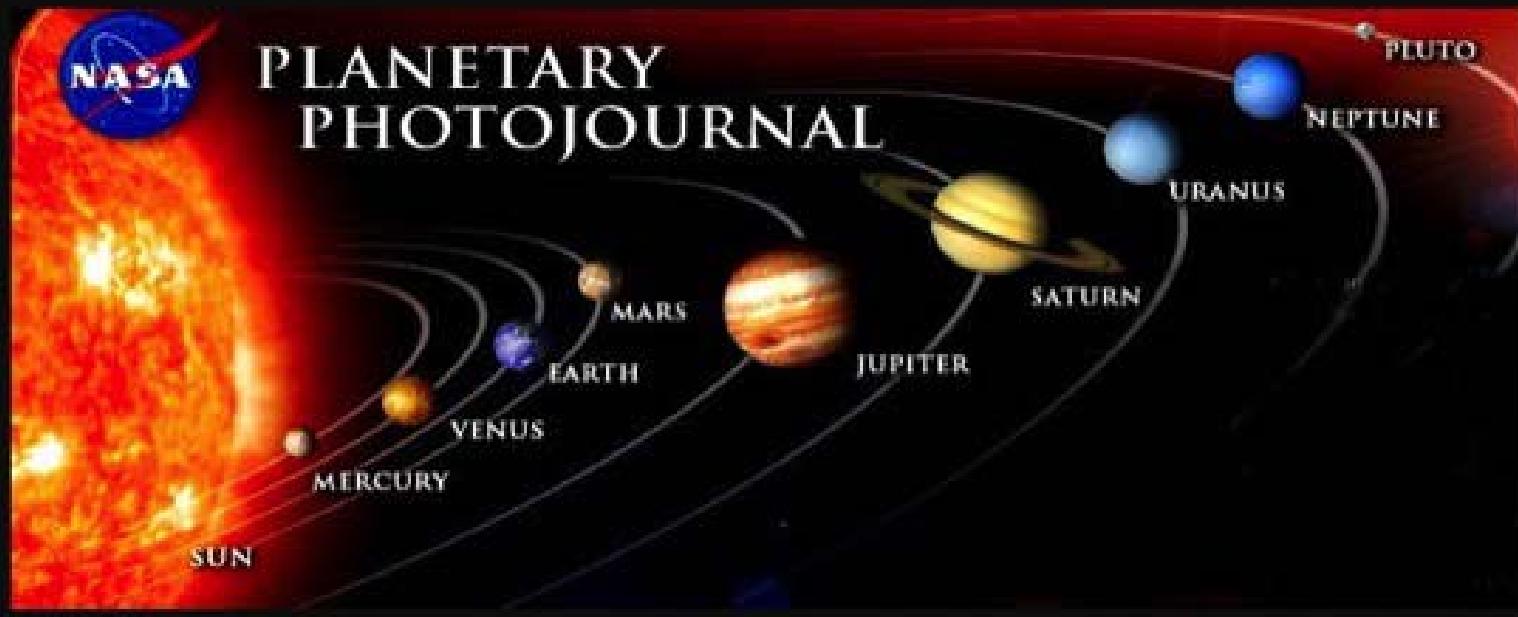
~600 Ma later ... all hell broke loose



... and the *Late Heavy Bombardment* got underway
... for a while
... then suddenly tapered off

- Potentially explained by the *Nice model*

https://en.wikipedia.org/wiki/Nice_model



NASA

Slide07

Mercury ...

MESSENGER =

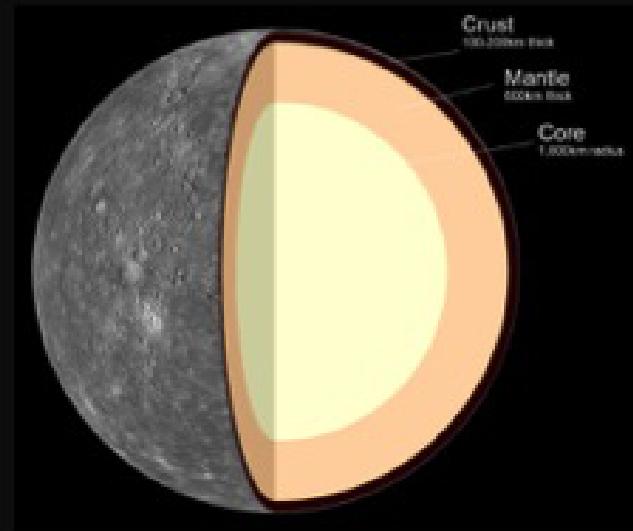
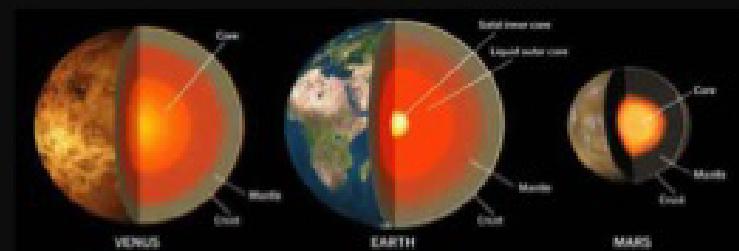
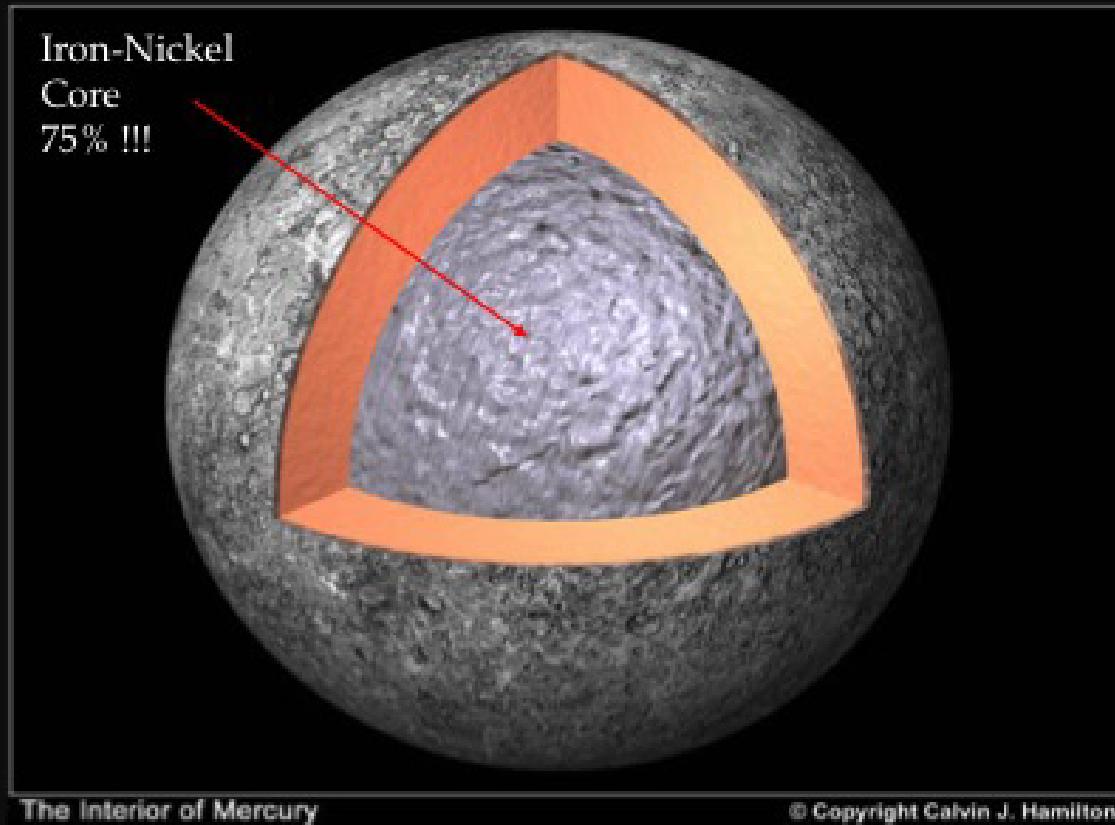
**MErcury Surface Space
ENvironment G_eochemistry
Ranging**



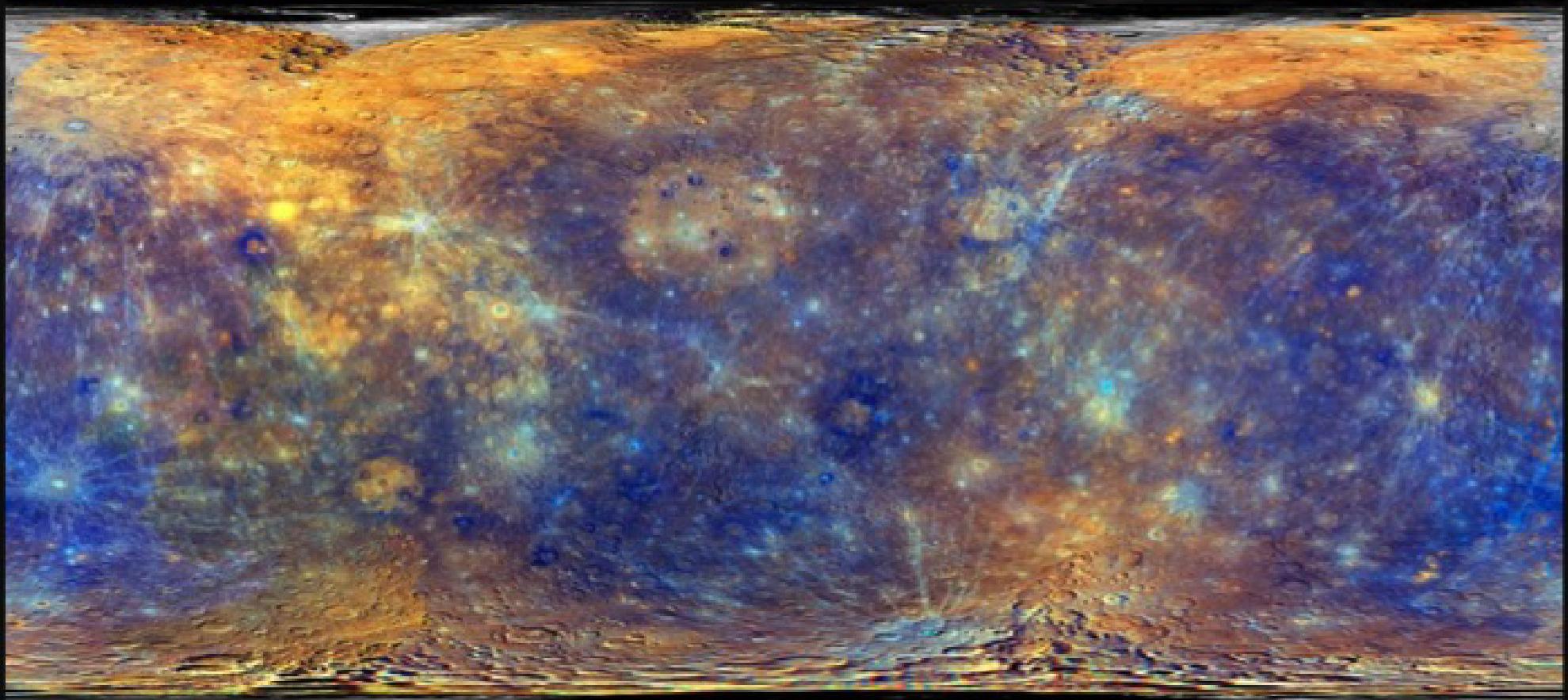
Messenger / NASA

Slide08

Mercury ... anomalously large core – or anomalously small mantle



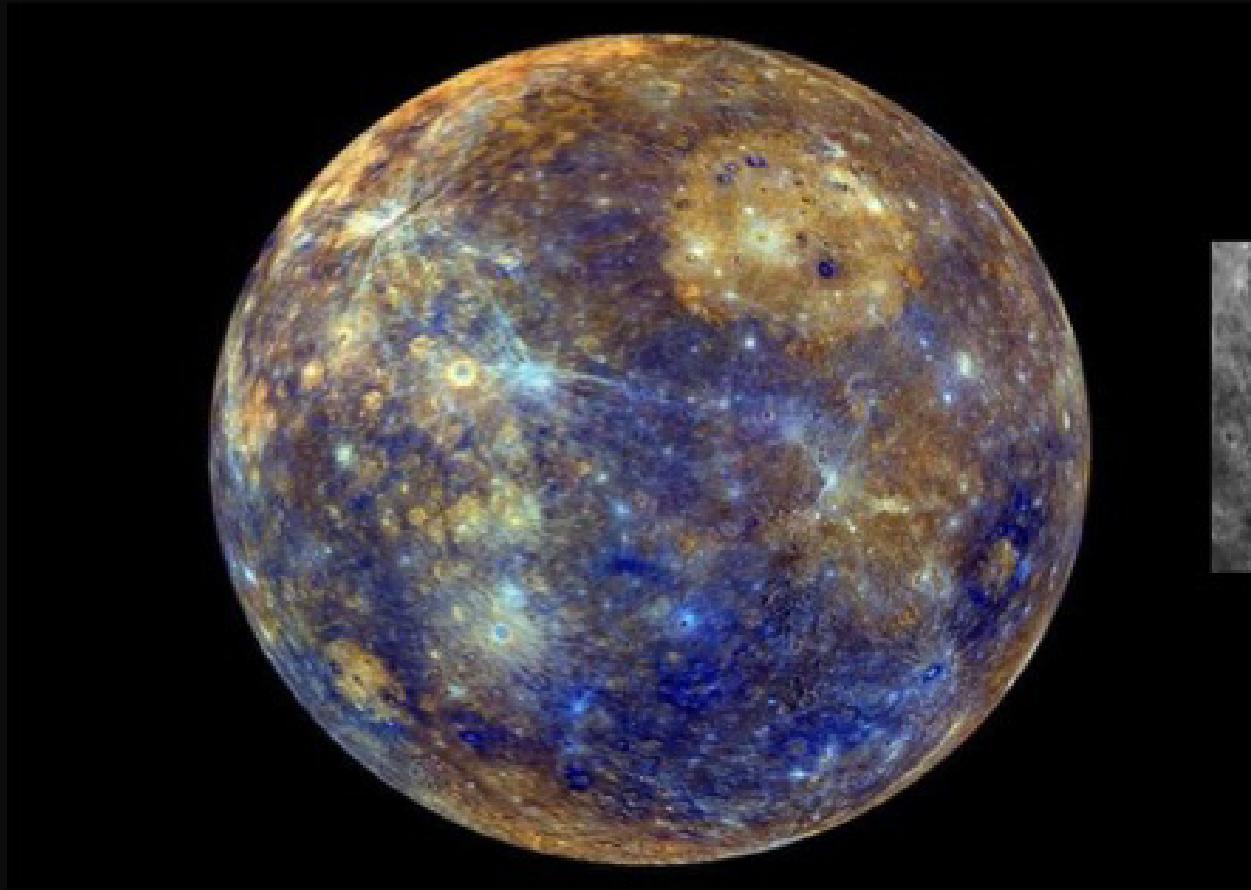
Mercury ... basaltic, not anorthositic crust – so what did this mean ?



NASA

Slide10

Mercury ... abundant carbon = component of recycled primeval crust !



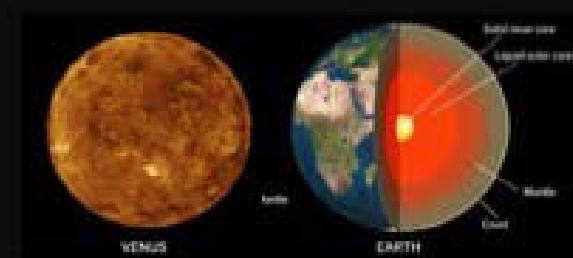
Basho crater

NASA

Earth What's going on deep inside ?



wiseGEEK



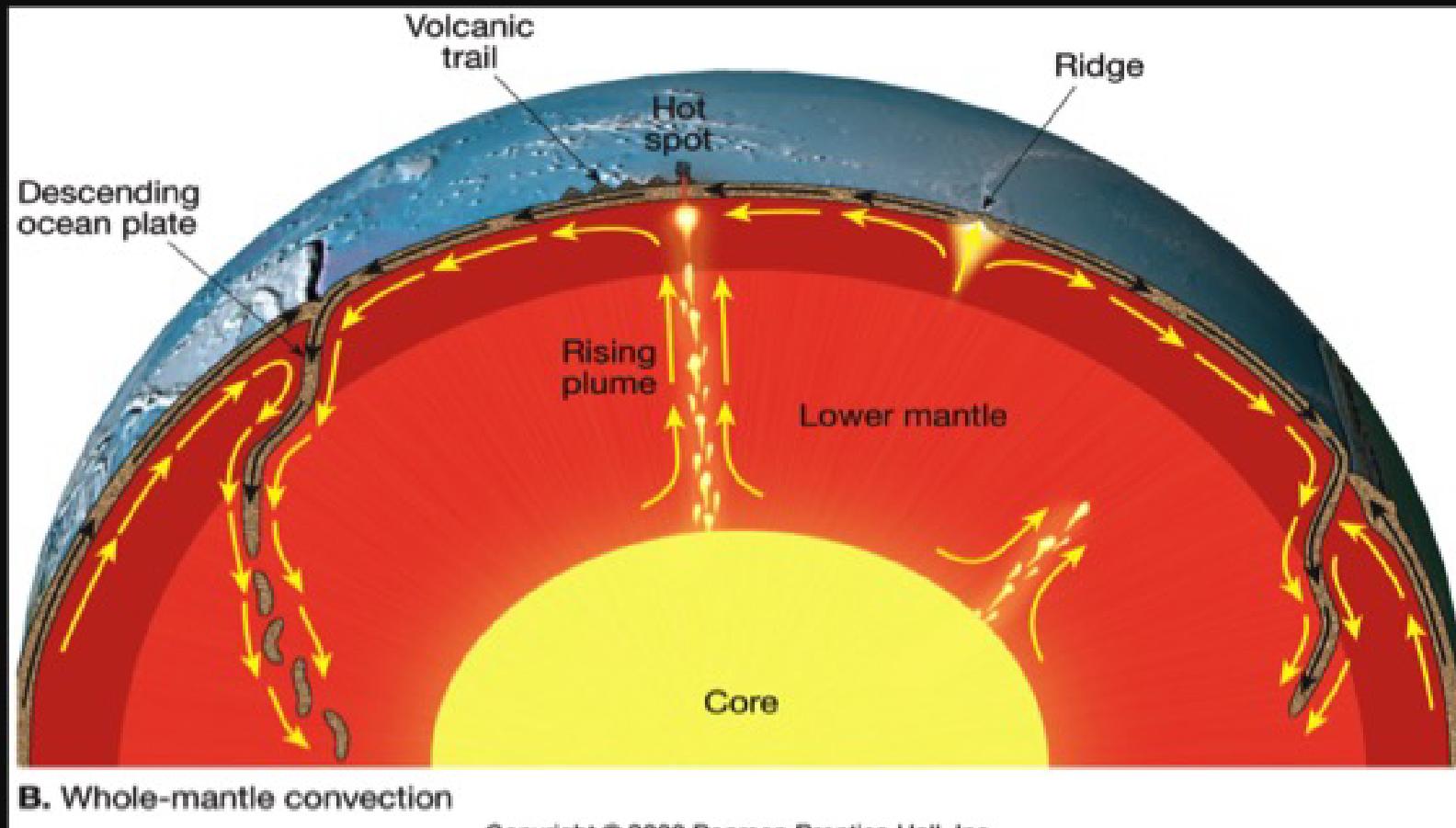
Earth :

- the only planet we can “see” inside
- The template for interpreting other planets

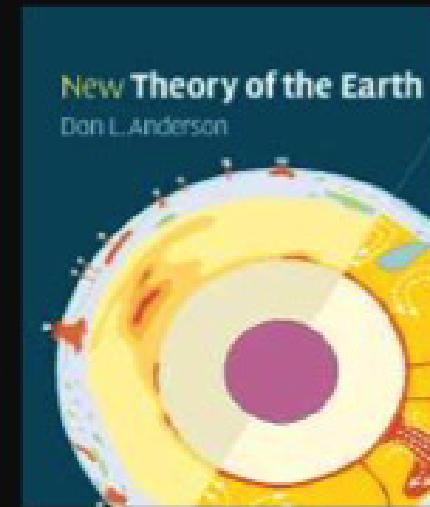
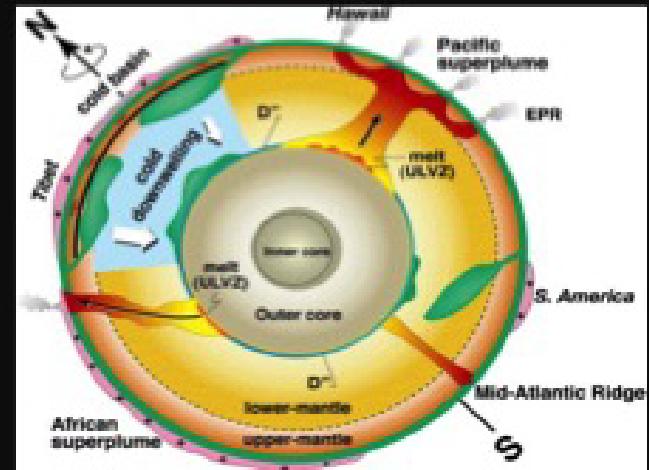
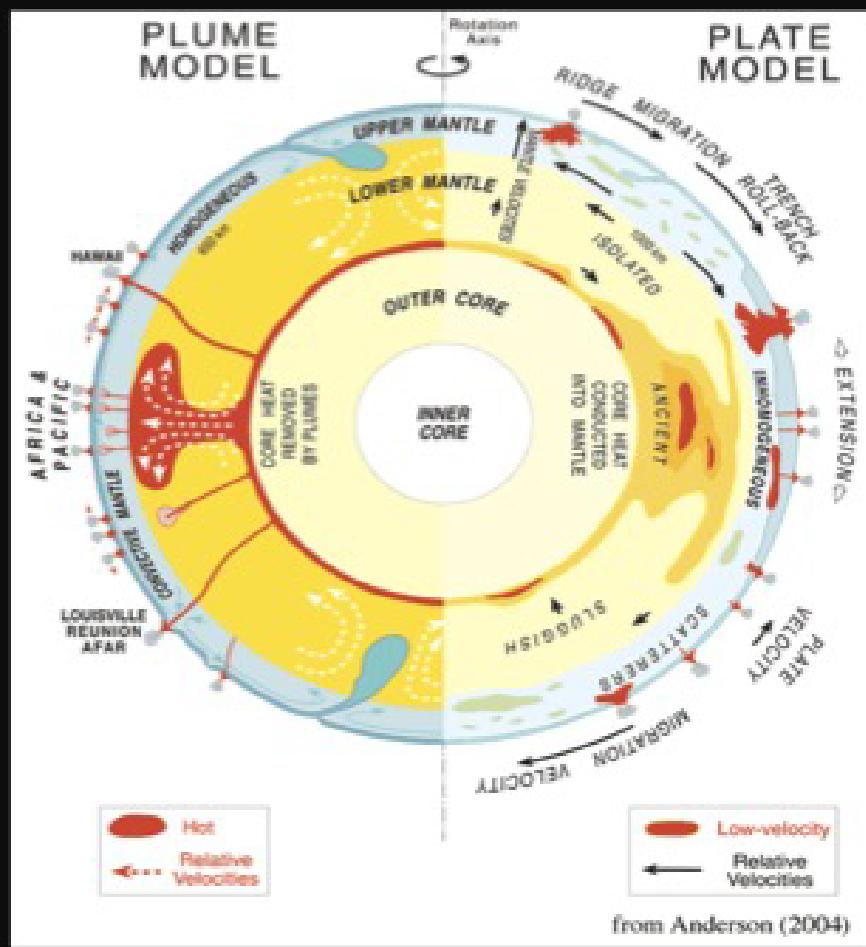
Slide12

NASA

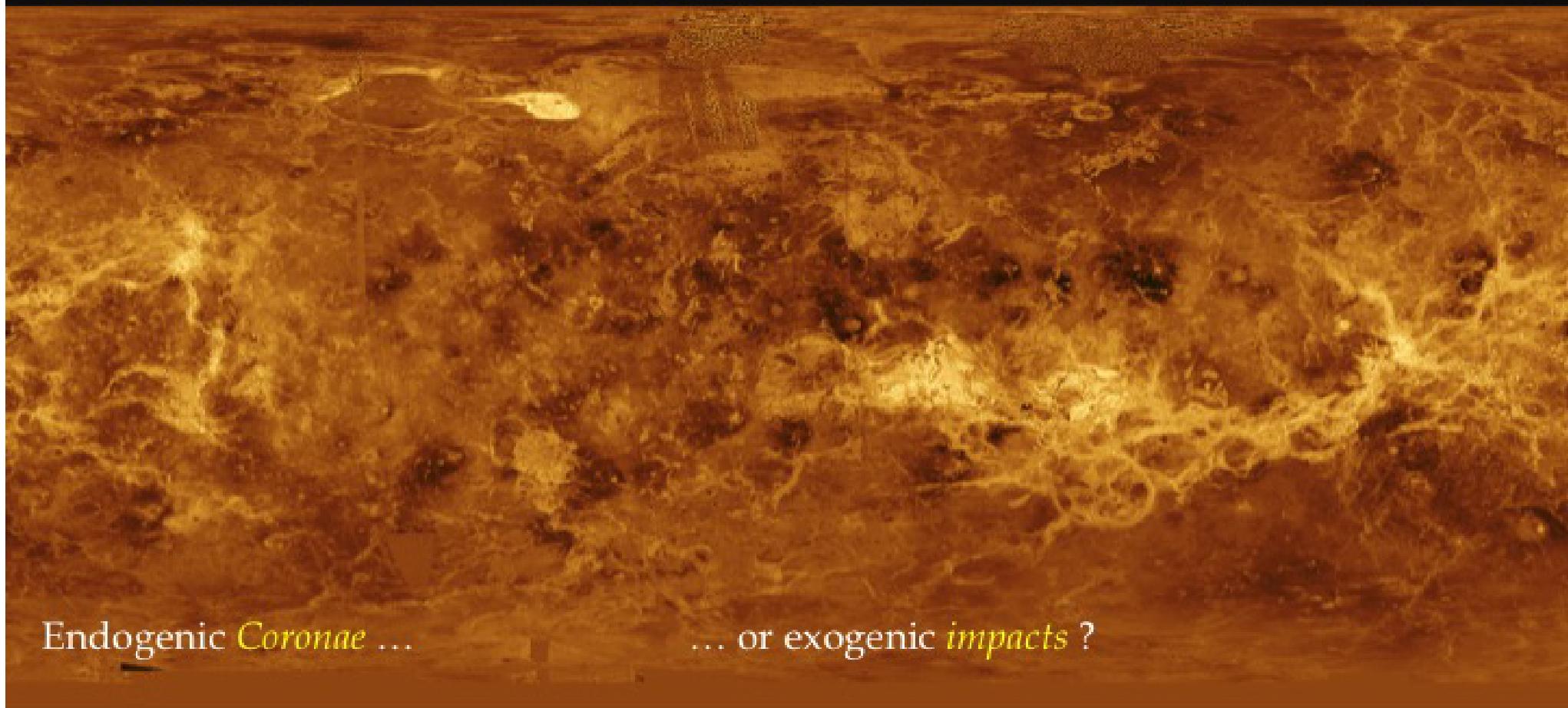
Earth What's going on deep inside ?



Earth ... What's going on deep inside ?



Venus ... How did its surface features form ?

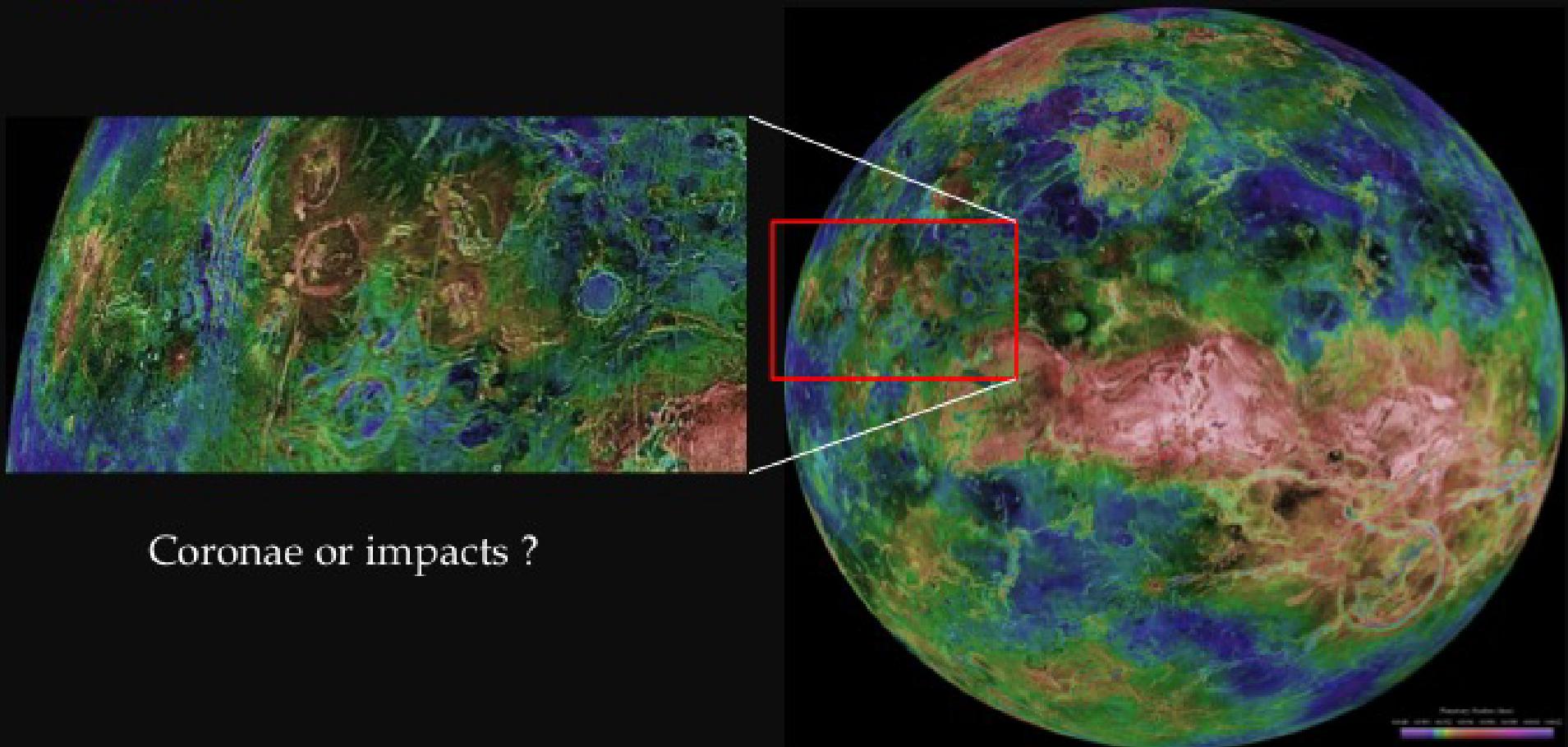


Endogenic Coronae ...

... or exogenic *impacts* ?

NASA

Venus ... How did its surface features form ?

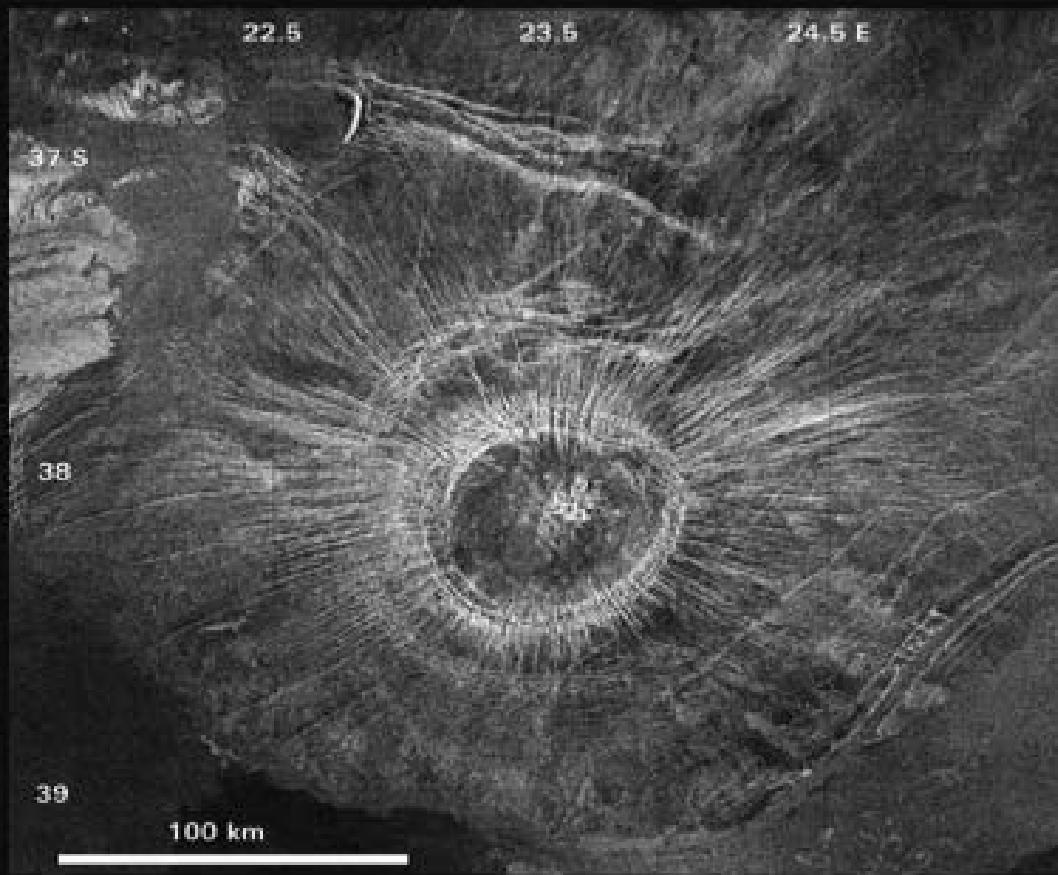


Coronae or impacts ?

Slide16

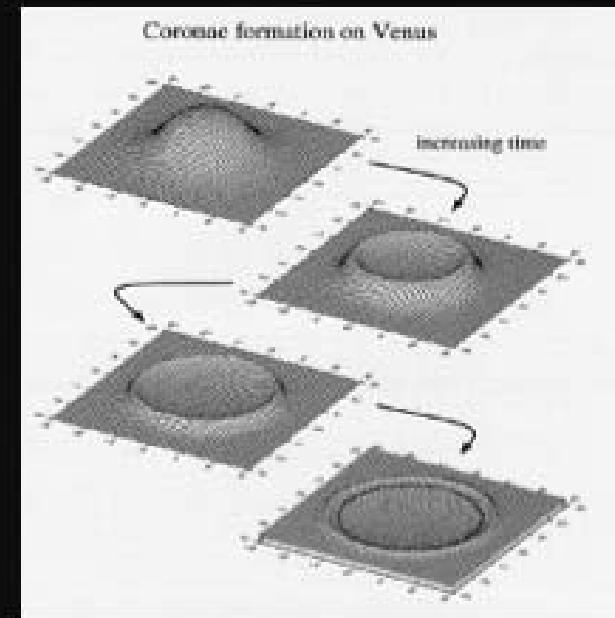
NASA

Venus ... How did its surface features form ?



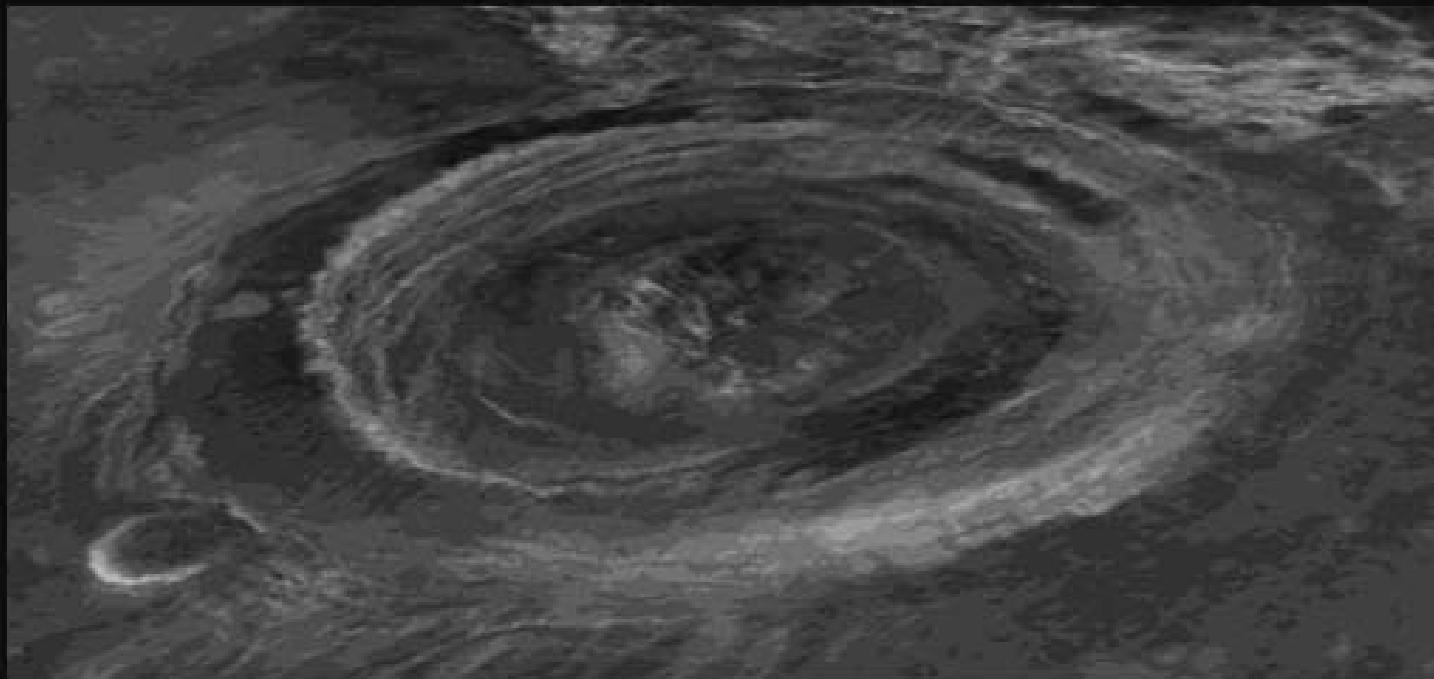
Ninhursag Corona

Corona or impact ?



NASA

Venus ... How did its surface features form ?

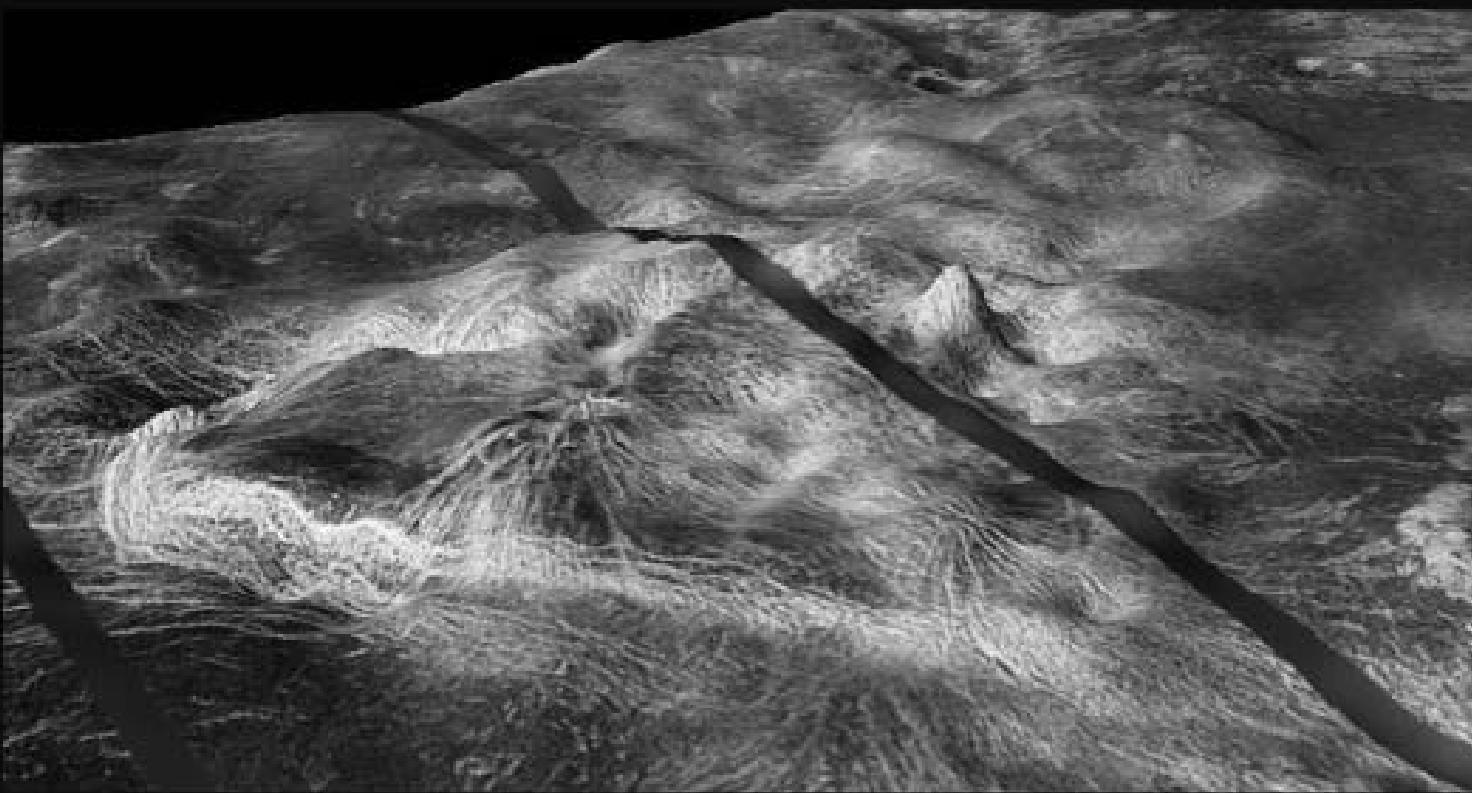


Aramaiti Corona

Corona or impact ?

NASA

Venus ... How did its surface features form ?

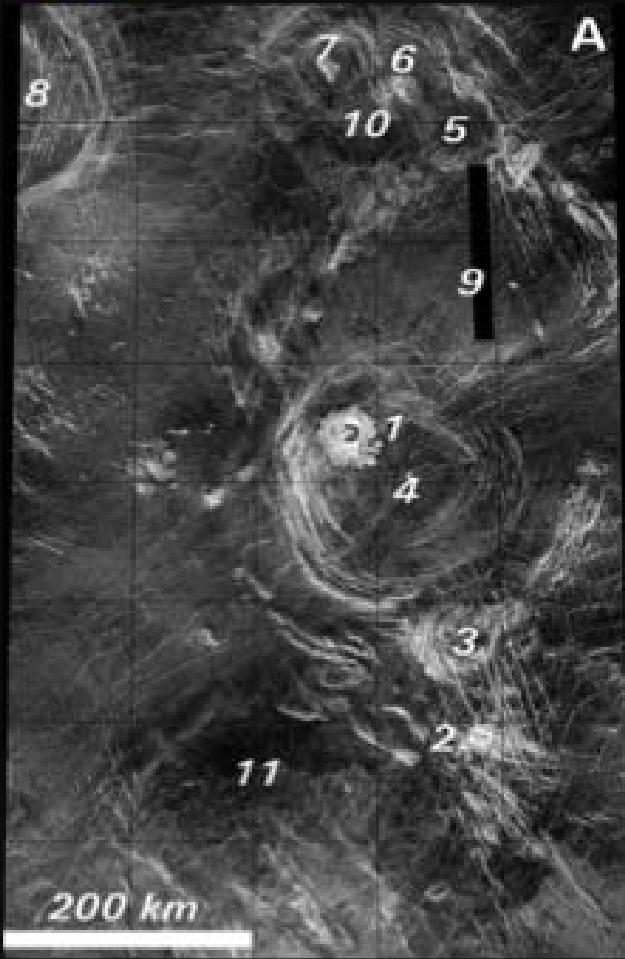


Yavine Corona

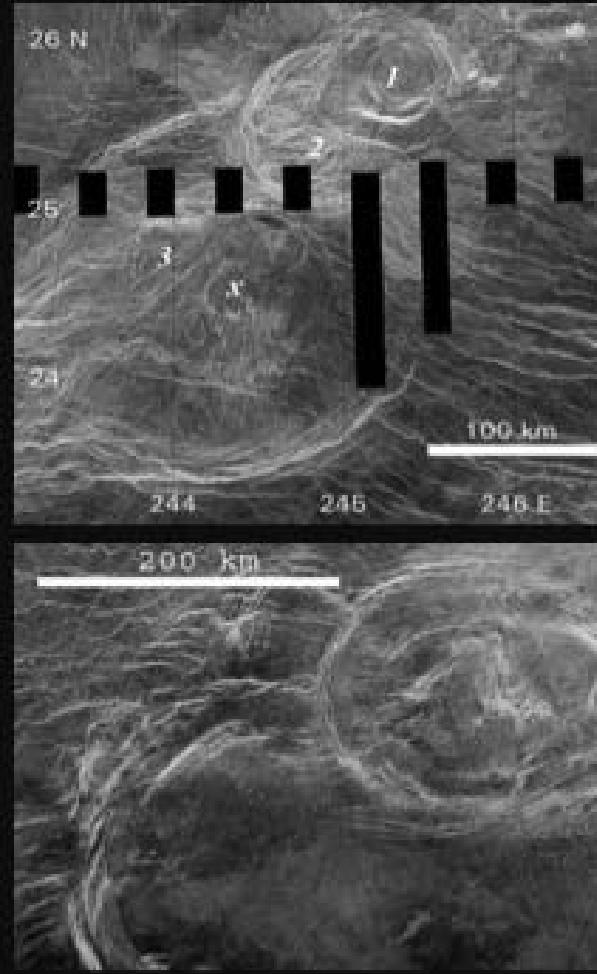
NASA

Venus ... How did its surface features form ?

Coronae on Niobe Planitia



Slide20



Ved-Aua Corona

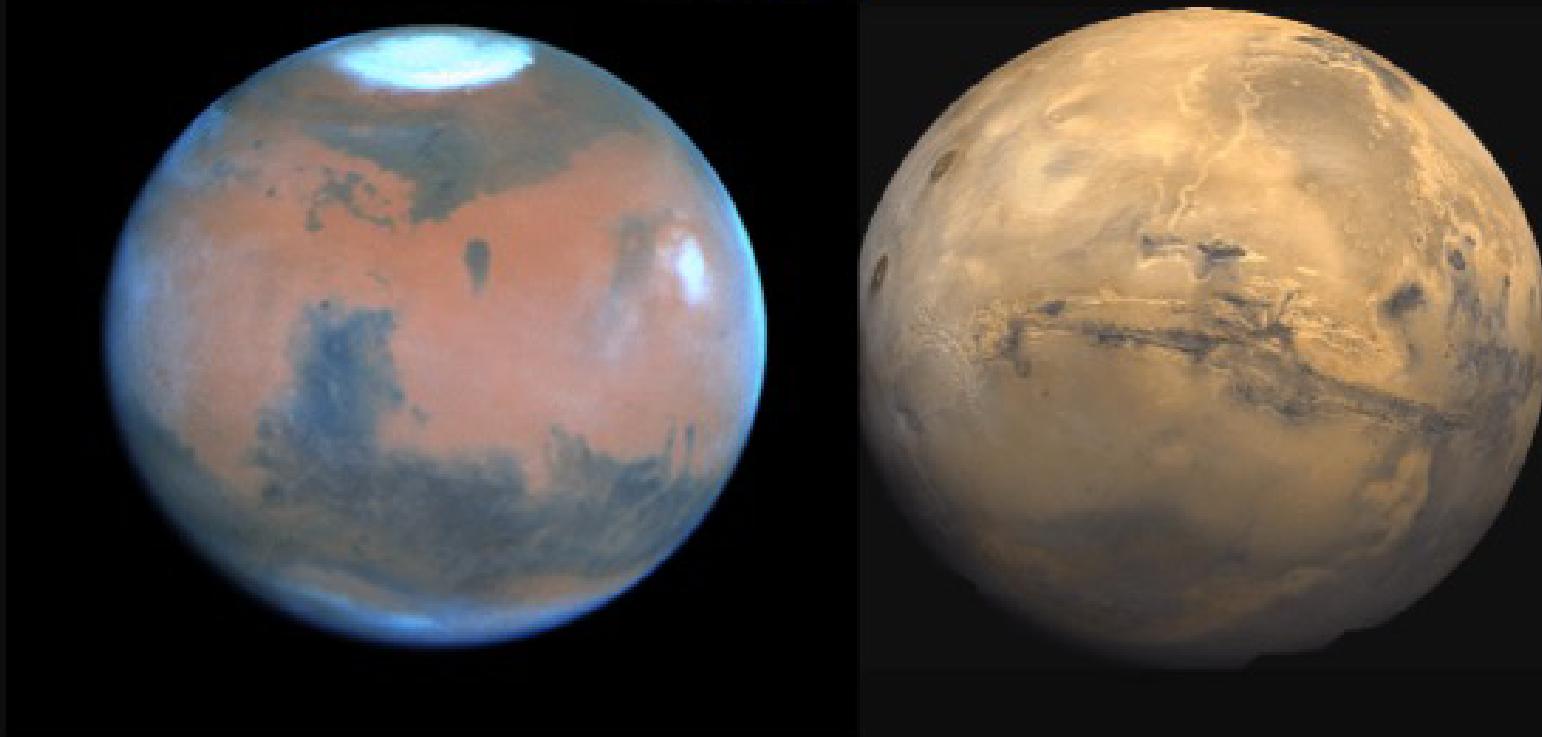
Acrea Corona



NASA

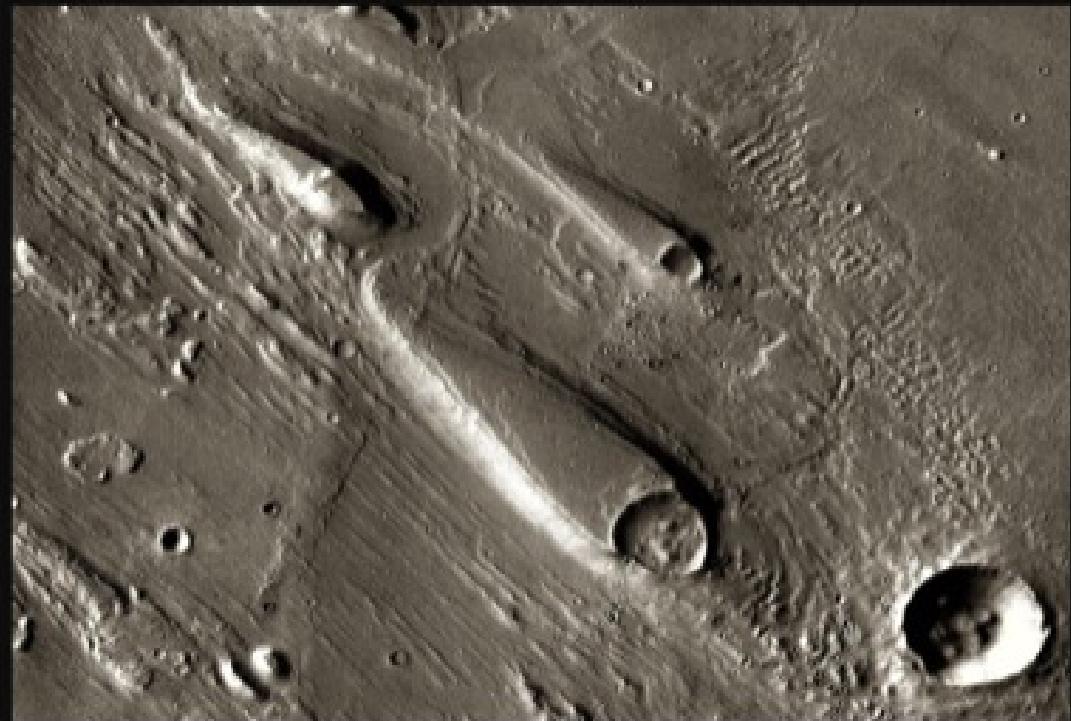
Mars ... the existence of water on the red planet is *not* a controversy !

... topography is !



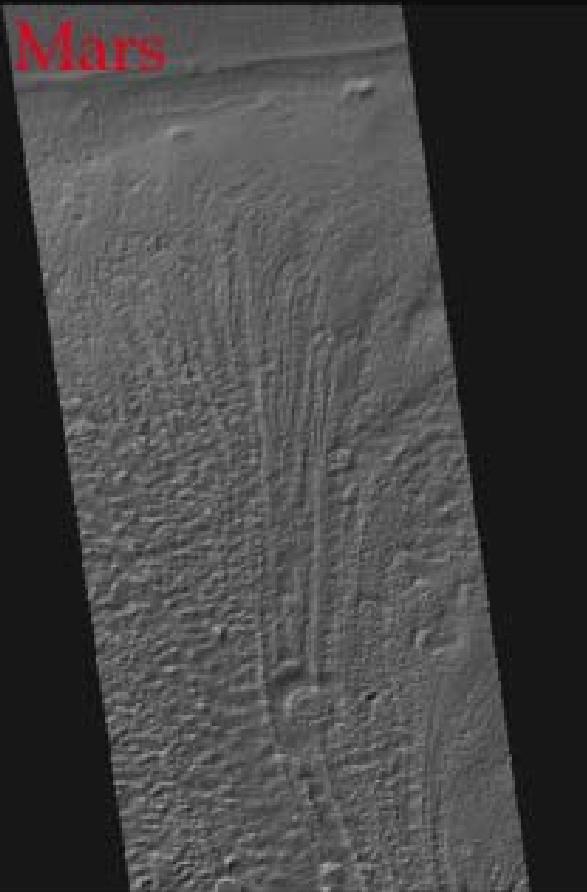
NASA

Mars ... hydrodynamic islands sculpted by flowing surface water



NASA

Mars ... water locked up in ice - as *recent* glaciers or as permafrost



Glaciers ...

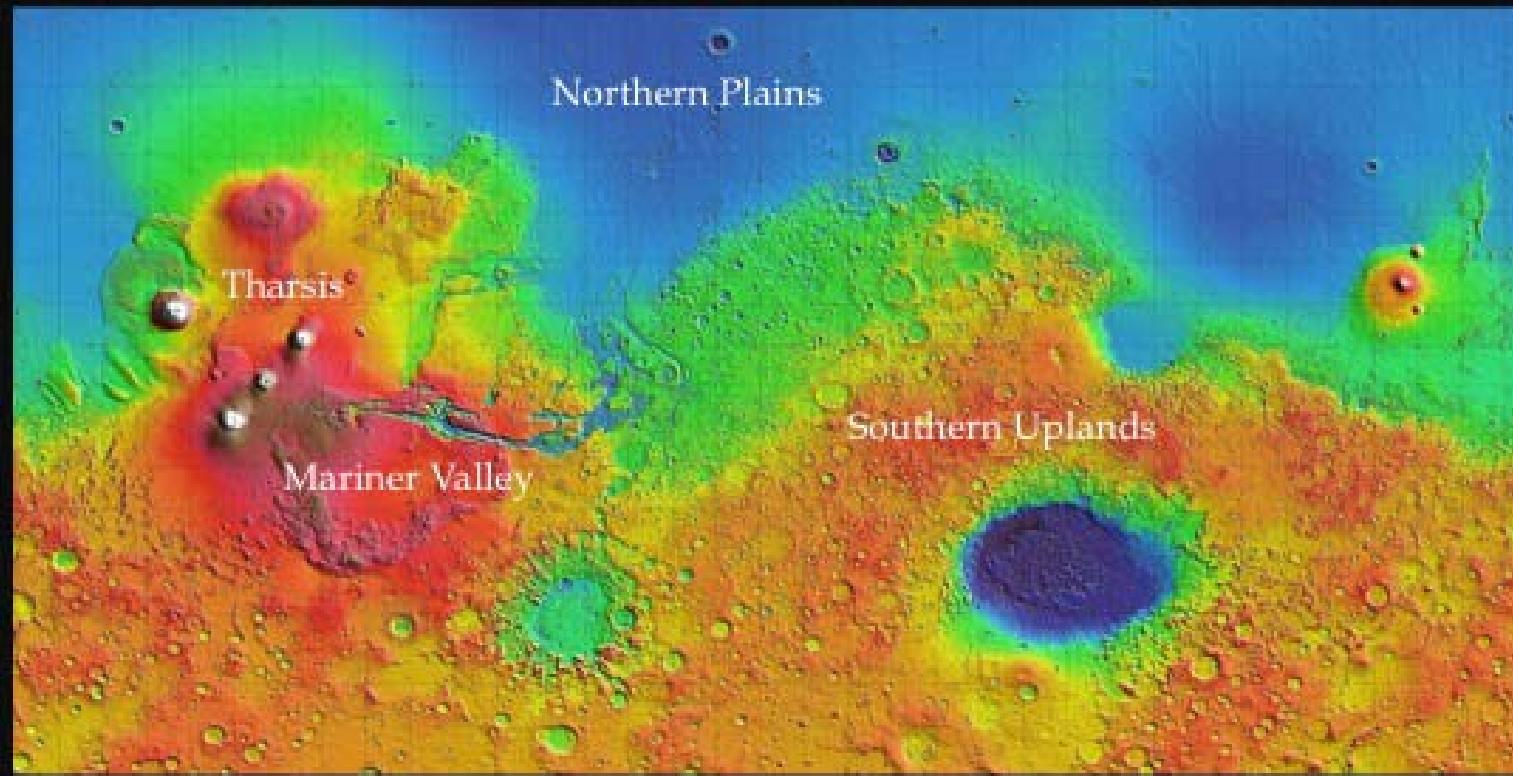
NASA / JPL / University of Arizona 2003

Mars ... water locked up in ice - as *very recent* glaciers



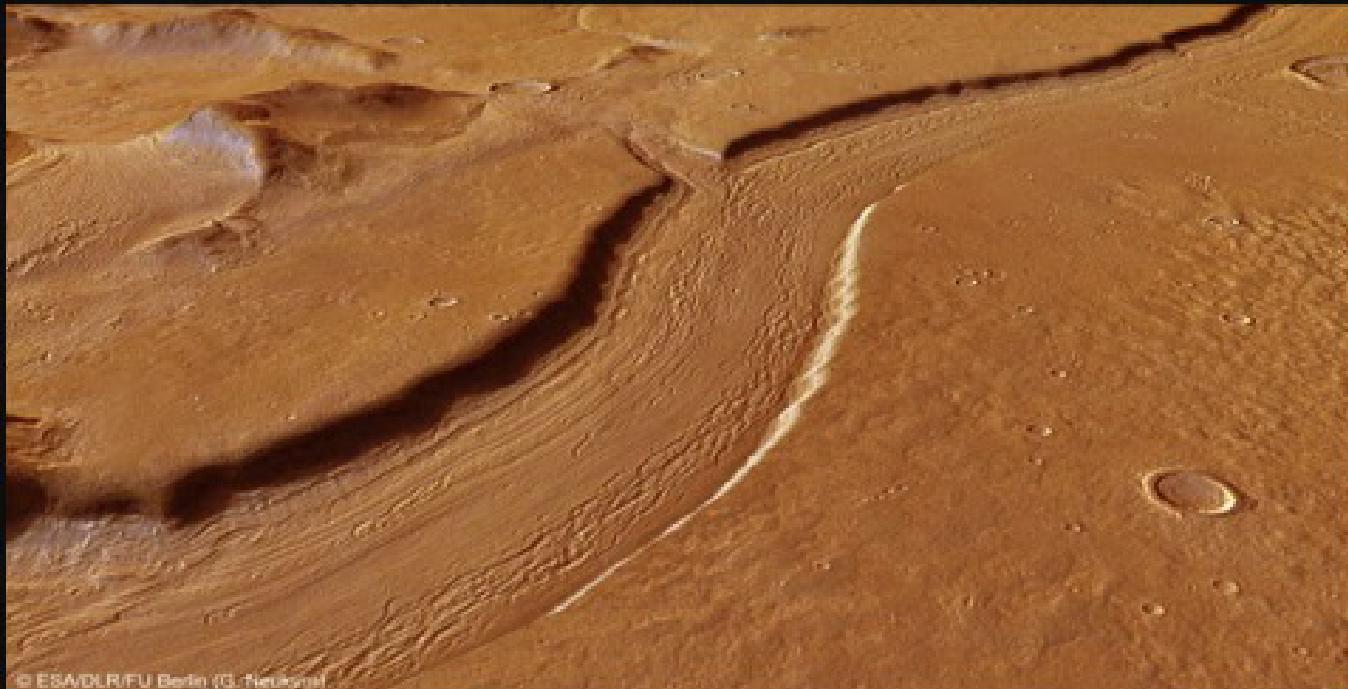
NASA / HiRISE 2003

Mars ... outflow channels



NASA

Mars ... outflow channels : Reull Valles as an example



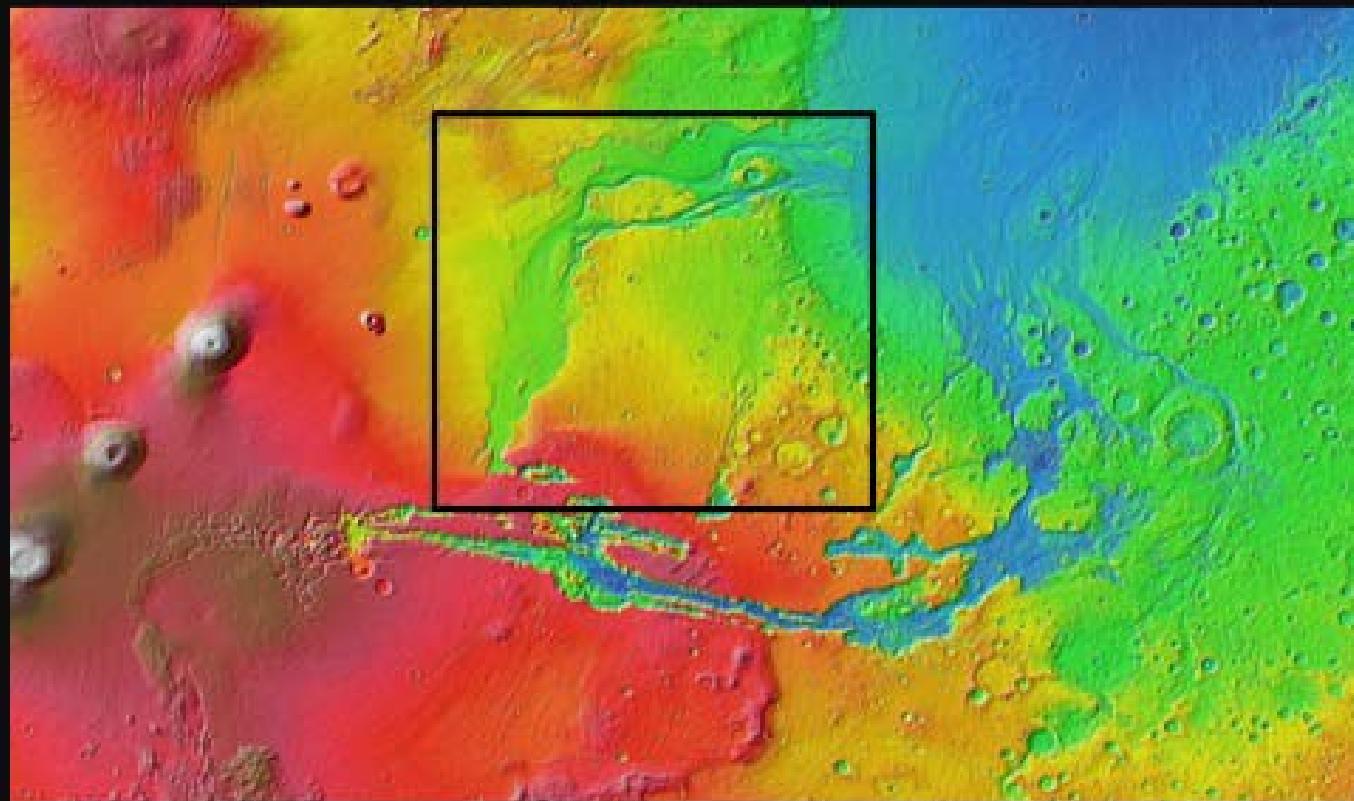
Curvilinear, flat bottomed channel

Steep sides ...

Very few tributaries ... not a "classical" river valley

ESA

Mars ... Kasei Valles : the type martian outflow channel



NASA

Channelled Scablands ... Glacial Lake Missoula



Once upon a time ~15000 years ago ...

Ice Age Floods Institute

Grand Coulee ... looking upstream



- Curvilinear, flat bottomed channel
- Steep sides ...
- Very few tributaries ... not a "classical" river valley

Simon Hammer, 2014

Grand Coulee ... looking down stream



- Curvilinear, flat bottomed channel
- Steep sides ...
- Very few tributaries ... not a "classical" river valley

Simon Hammer, 2014

Grand Coulee ... Castle Cataracts - looking upstream



- *Paired* dry cataracts
- Remnant rocky “blade”

Simon Hammer, 2014

Grand Coulee ... Dry Falls - western cataract headwall



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Simon Hammer, 2014

Slide32

Grand Coulee ... Dry Falls



- *Paired* dry cataracts
- Remnant rocky “blade”

Simon Hammer, 2014

Grand Coulee ... Dry Falls



- Remnant rocky
"blade"

Simon Hammer, 2014

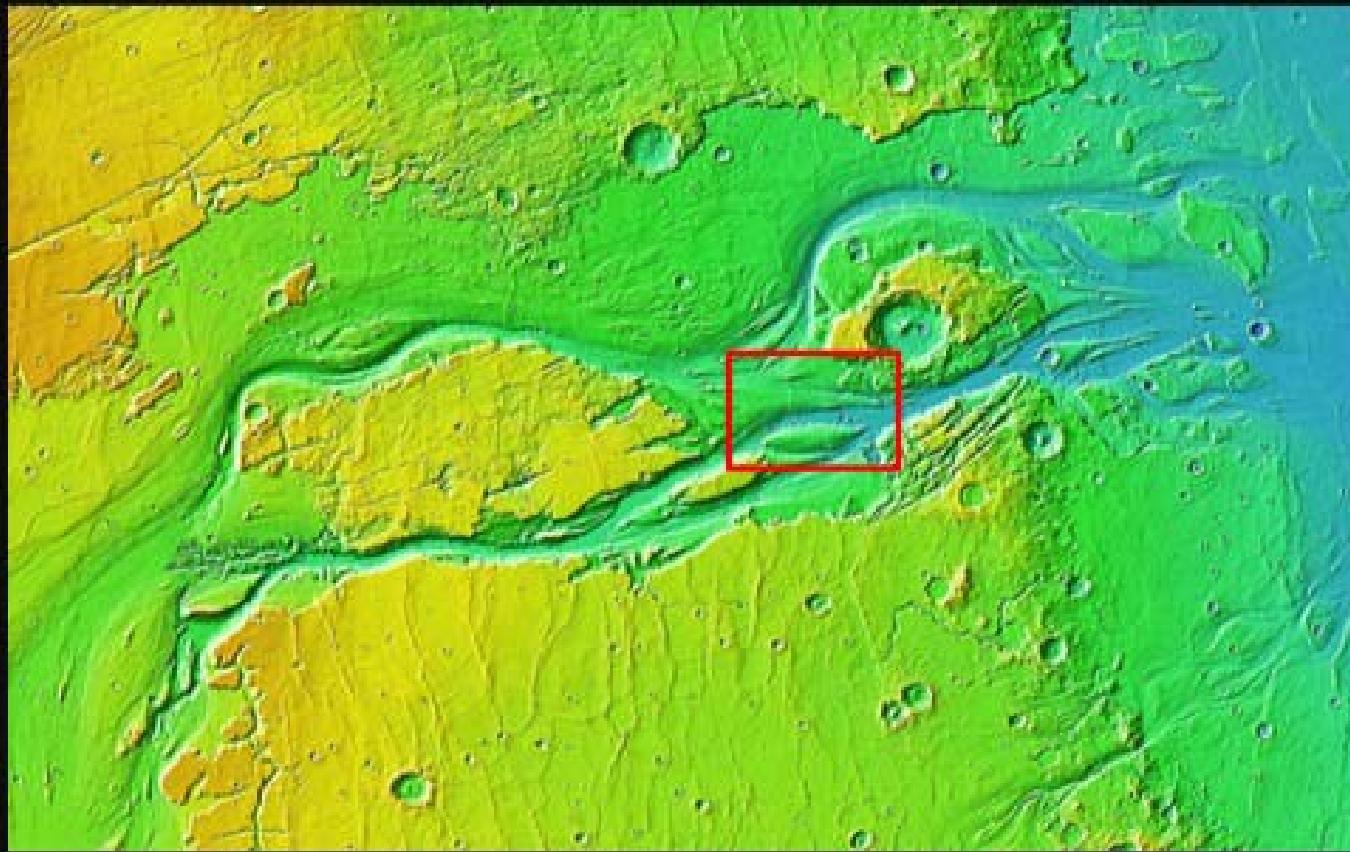
Grand Coulee ... Steamboat Rock



Isolated
rocky
"blade"

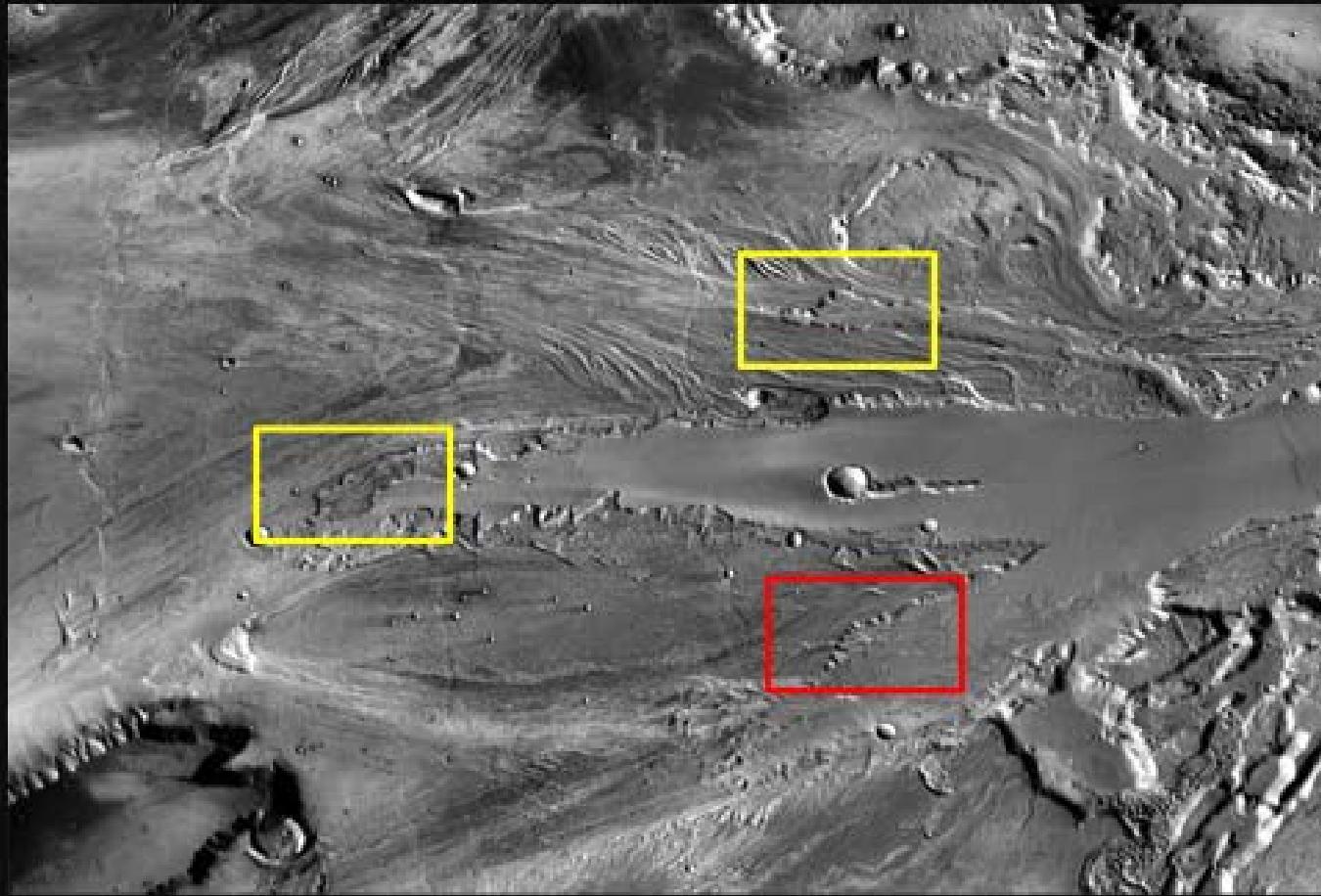
Simon Hammer, 2014

Mars ... Kasei Valles : the type martian outflow channel



NASA

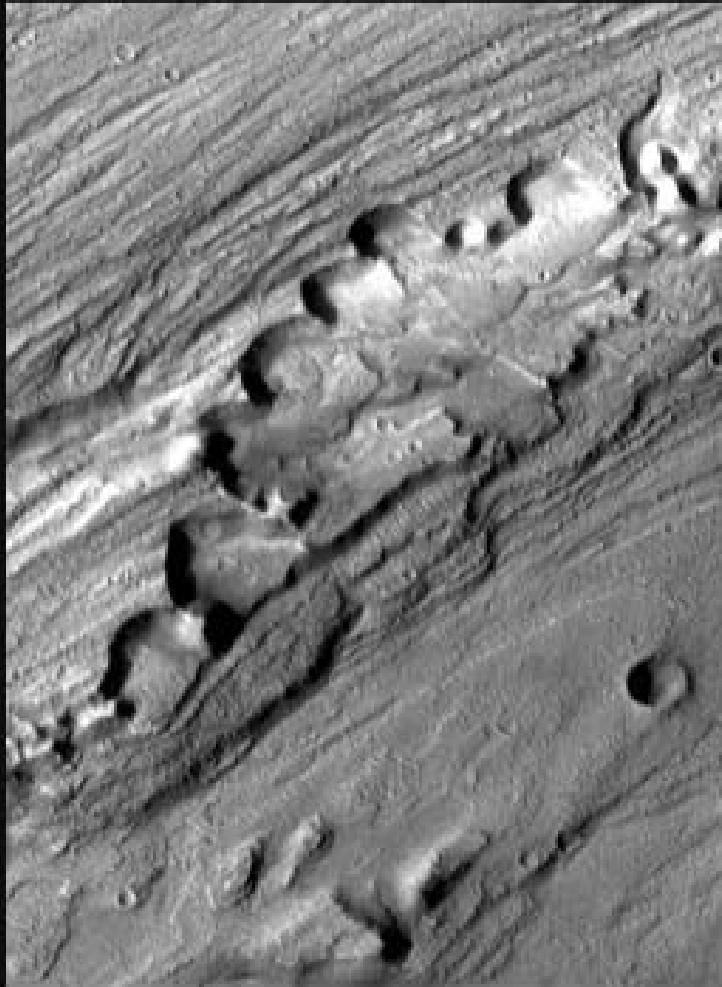
Kasei Valles ...



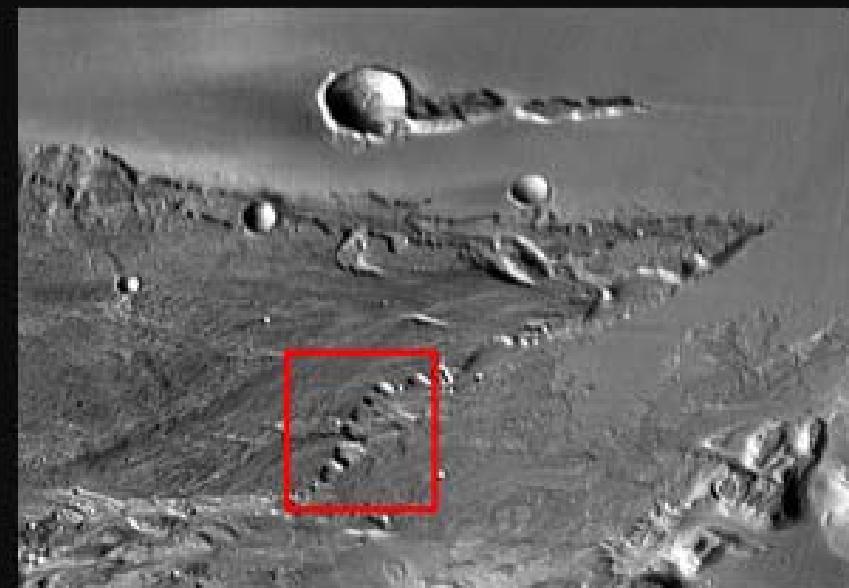
Slide37

NASA

Kasei Valles ...

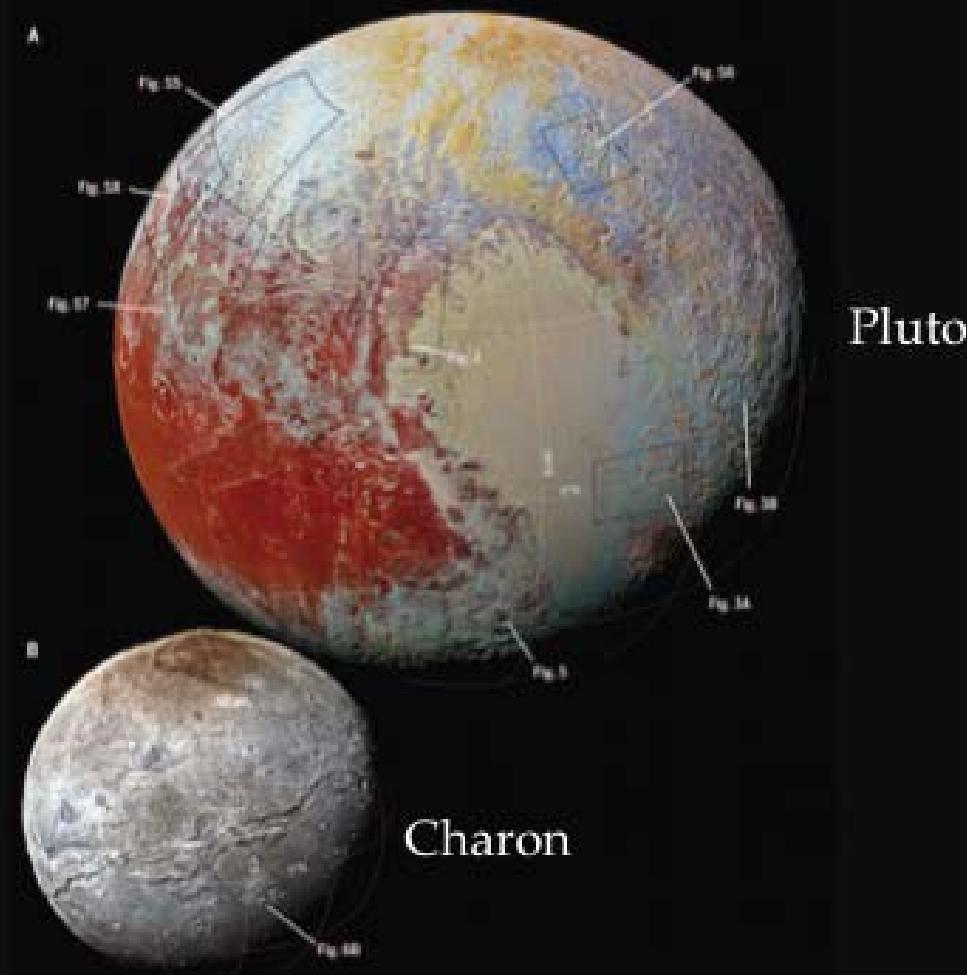


Dry cataracts ...
Rocky "blades" ?



NASA

Pluto ...

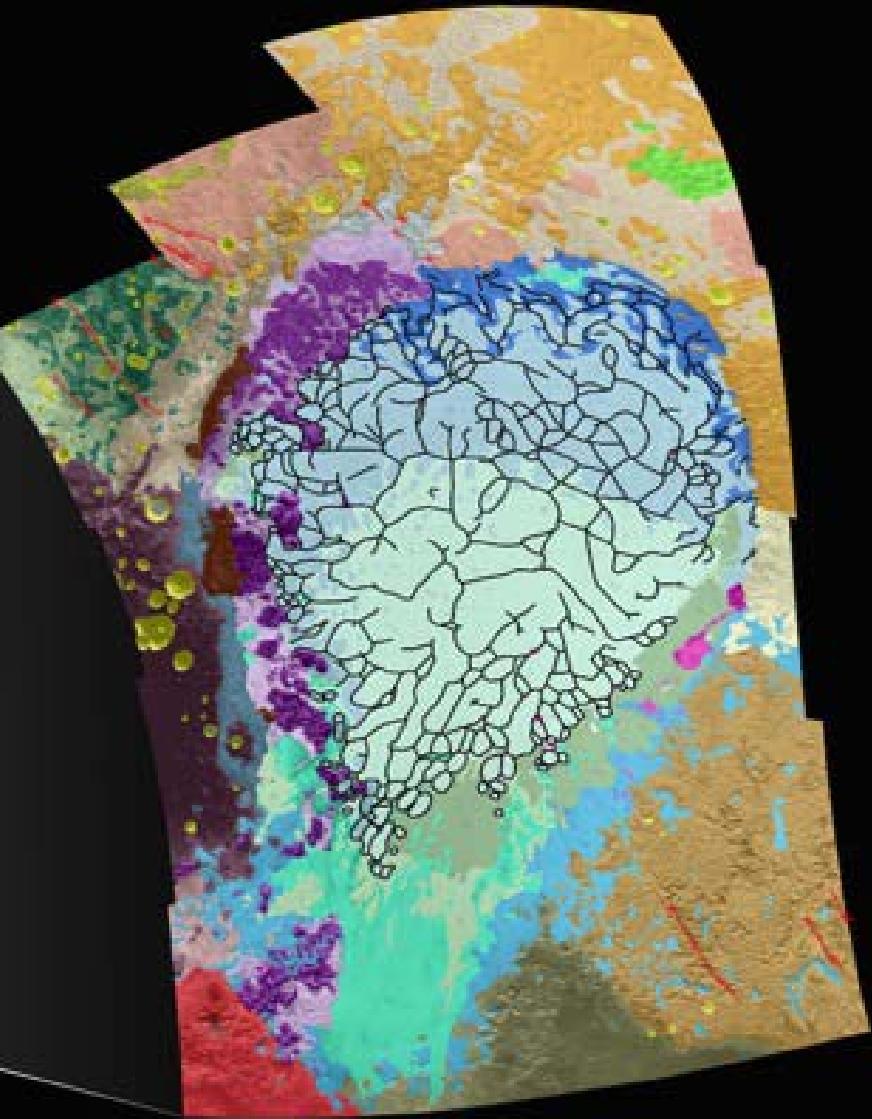


Jeffrey M. Moore et al. Science 2016;351:1284-1293

Science

AAAS

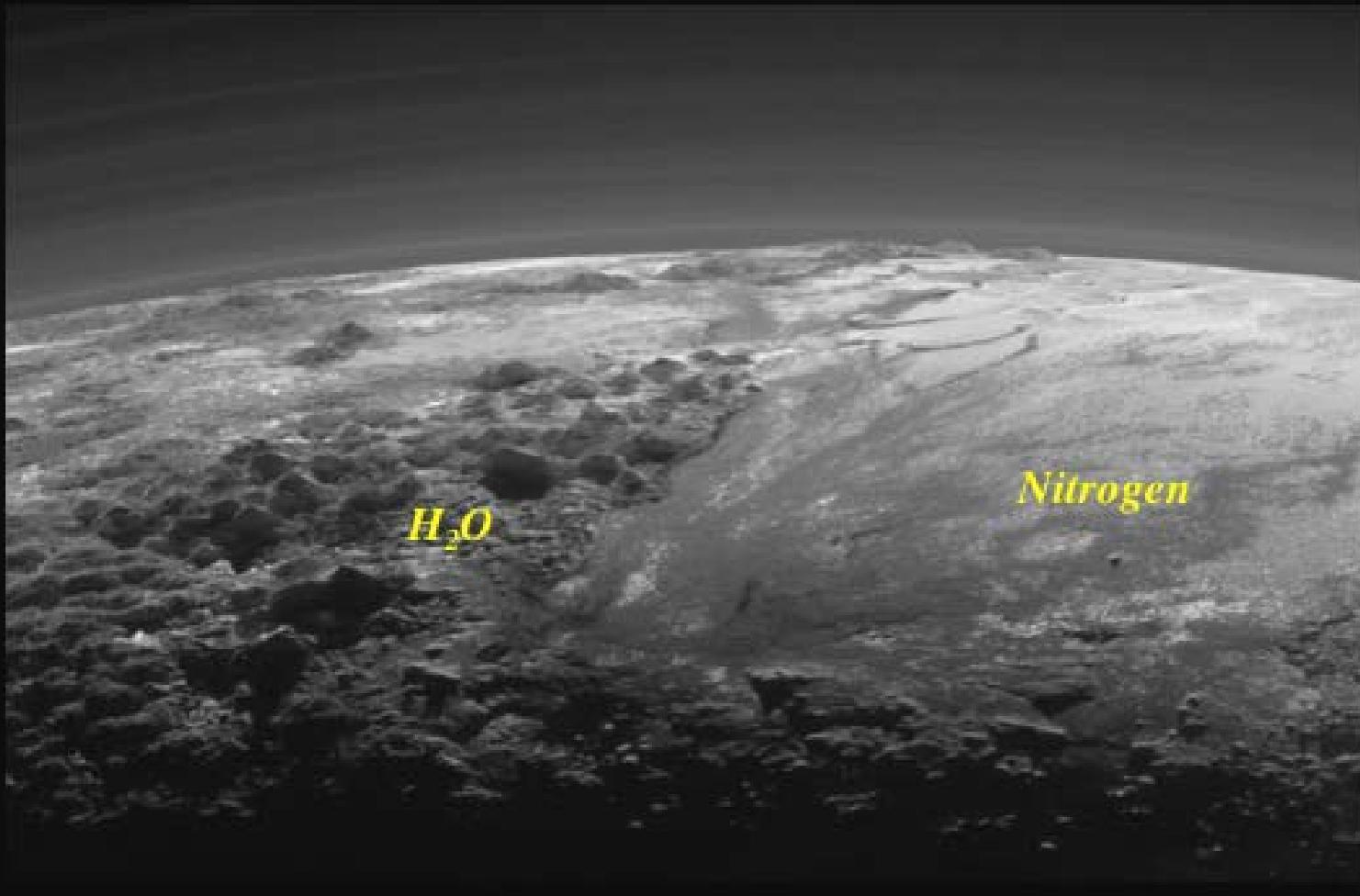
Pluto ... Sputnik Planitia (Nitrogen ice)



NASA

Slide40

Pluto ... Nitrogen and Water (H_2O) ices



Sputnik
Planitia

NASA

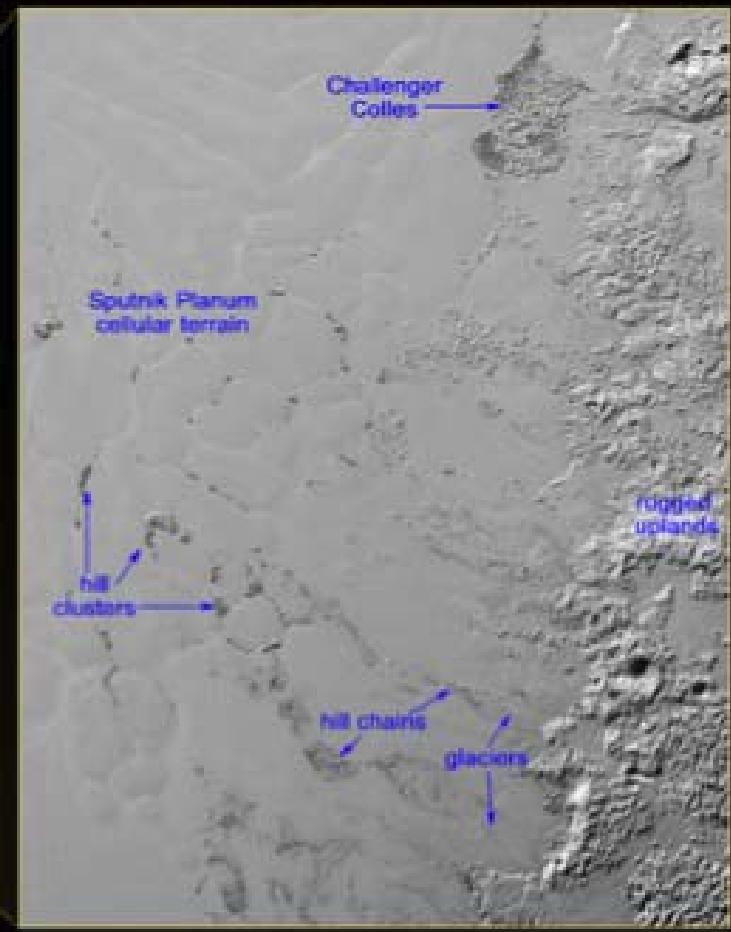
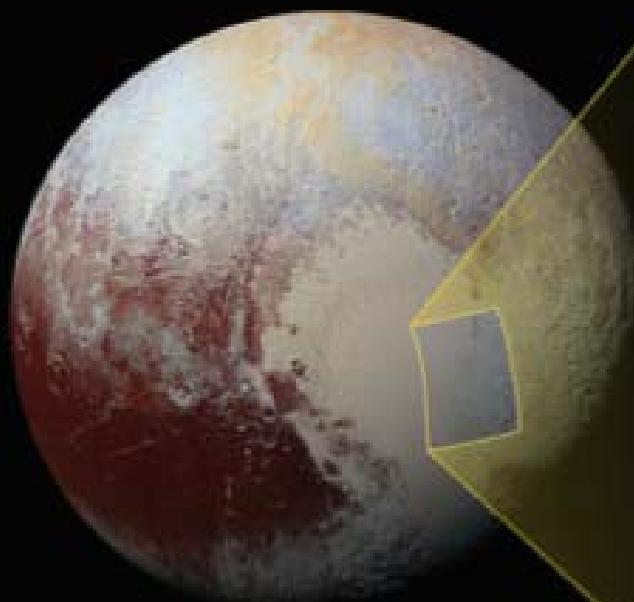


Pluto ... Nitrogen polygon formation

Convection

or

Cryovolcanism*

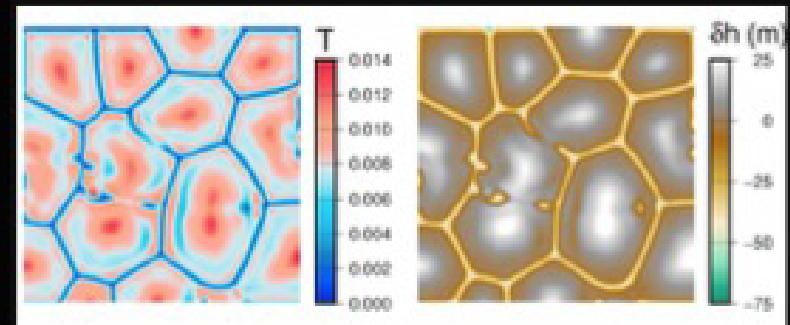
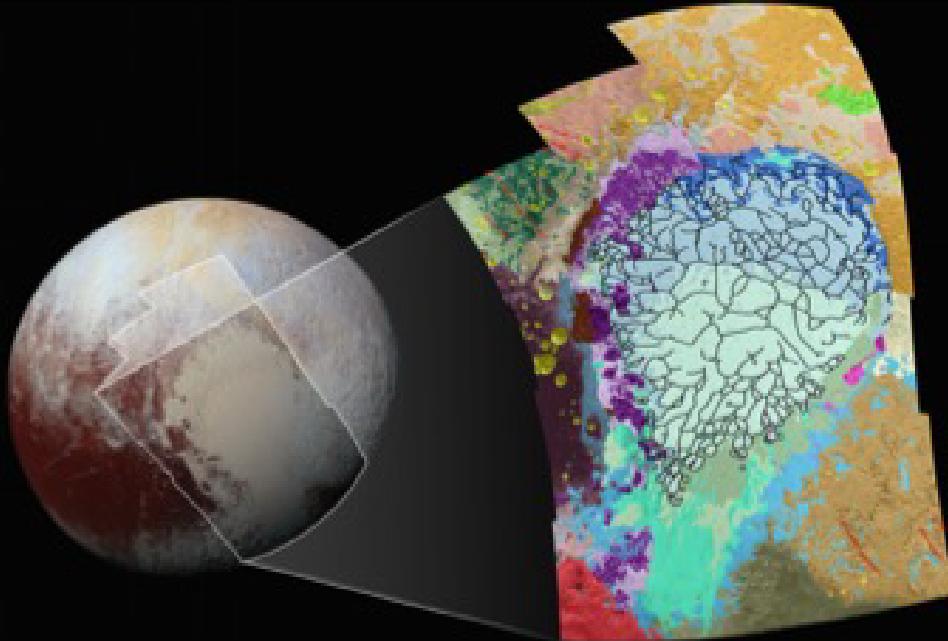


* Cryo = ice in Greek

NASA

Pluto ... Sputnik Planitia (Nitrogen ice)

Larger polygons are **elongate / irregular** ... experimental polygons are **symmetrical / uniform**



Experimental convection

Vidella & Deschamps, JGR-Planets, 2017

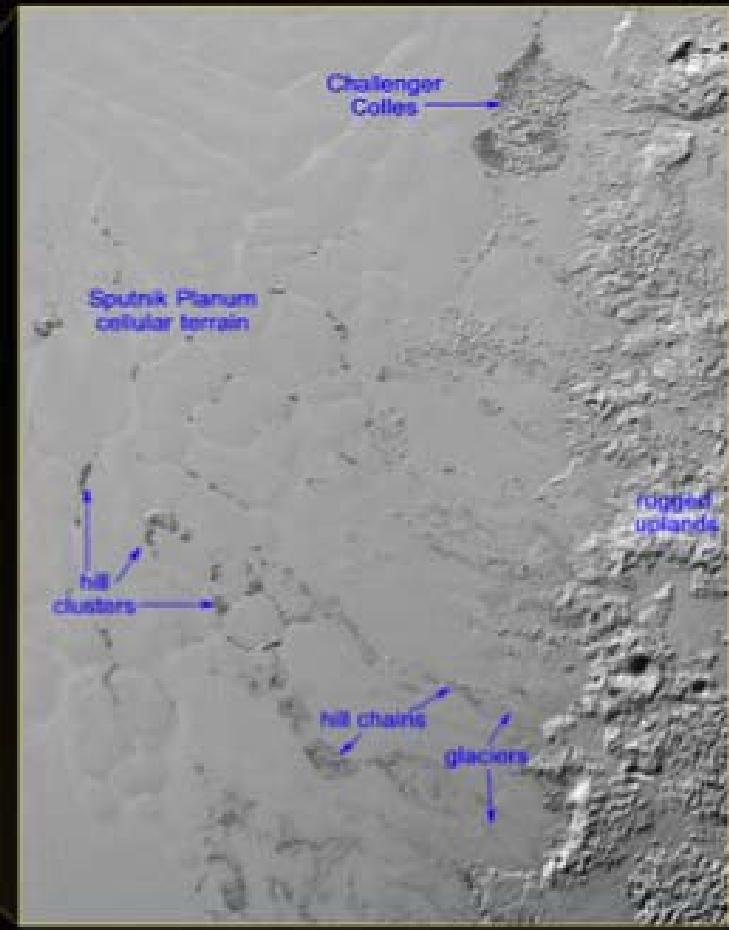
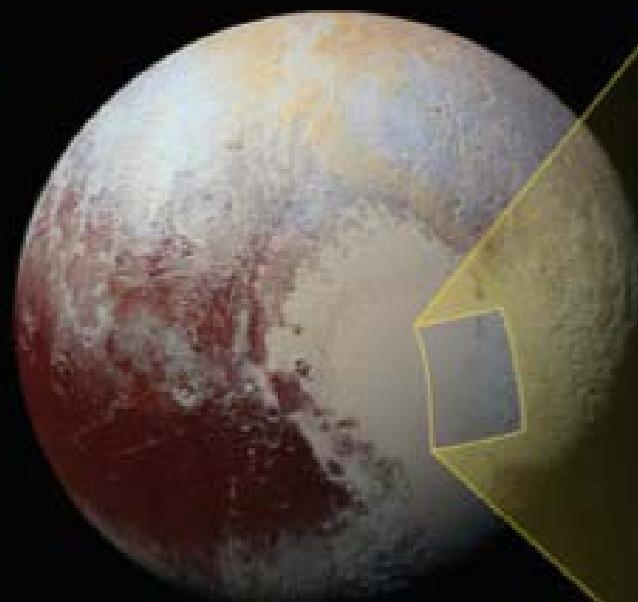
NASA

Pluto ... Nitrogen polygon formation

Convection

or

Cryovolcanism*



* Cryo = ice in Greek

NASA

So many controversies, so little time !



Slide45