Interactions between regional transcurrent shearing, rifting, & mantle flow on Venus - radar & gravity interpretations & Earth analogues

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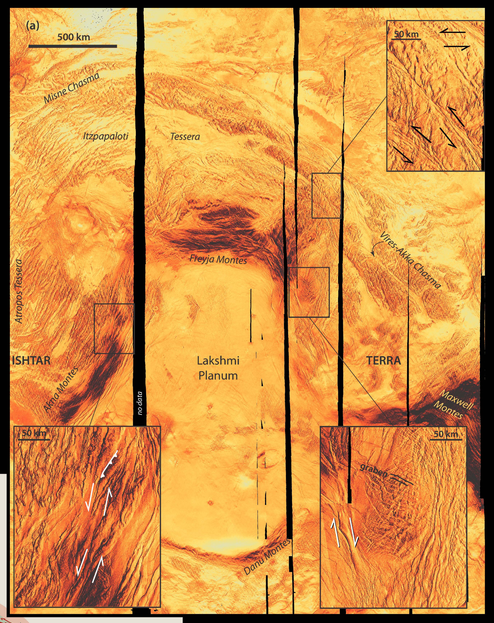
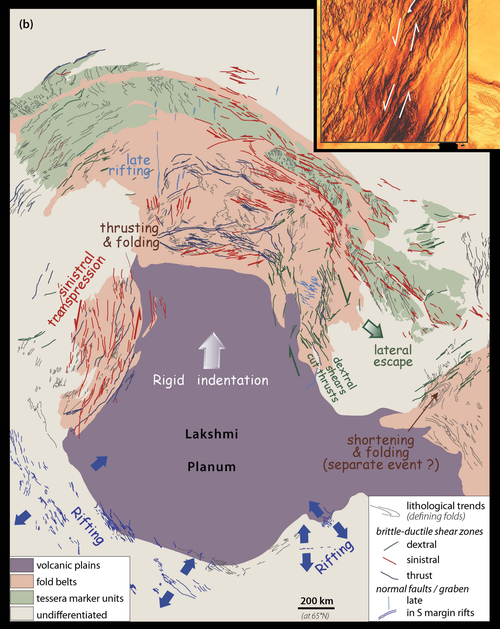
Indentation & lateral escape tectonics in Ishtar Terra, Venus

Venus shows no evidence for plate tectonics.

- No evidence for 'modern', single-sided subduction.
- No arcuate volcanic chains.
- Venus is dominated by mantle plumes formed within a stagnant lid convection regime.

Plana (such as Lakshmi Planum in Ishtar Terra) are elevated areas resembling continents on Earth.





Magellan radar images over Lakshmi Planum in western Ishtar Terra (a) portray structures (b) similar to the Himalayan-Indochina collision & lateral escape system on Earth, BUT which were formed without plate tectonics.

- The tectonics of Venus must be re-evaluated based on these new results implying a large lateral translation of Lakshmi Planum.

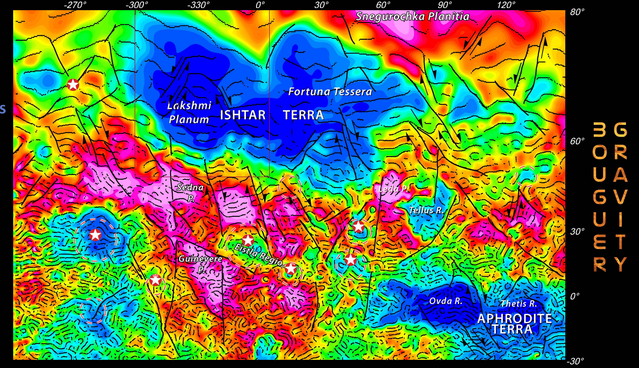
- This interpretation has significant implications for Archaean terrains on Earth: modern plate tectonics is not required for their deformation.

Bouguer gravity & crustal thickness

Bouguer lows = craton-like blocks with deep keels

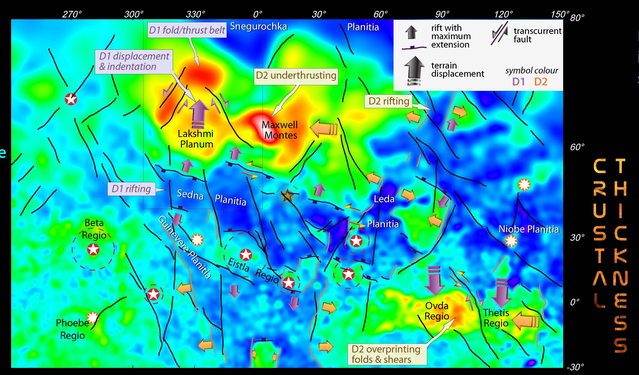
Bouguer highs = rifts

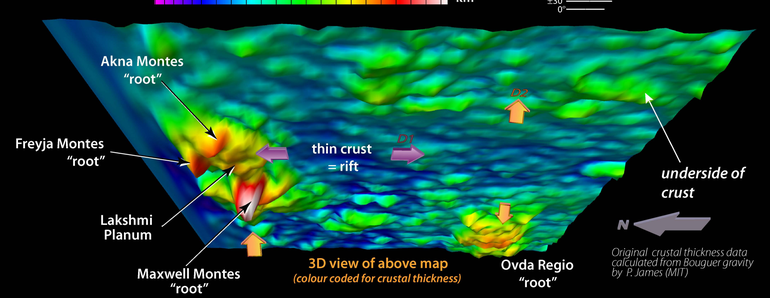
Offset &/or deflection of 'worms' & anomalies = regional transcurrent shear zones



Fold & thrust / transpressional belts = areas of thick crust

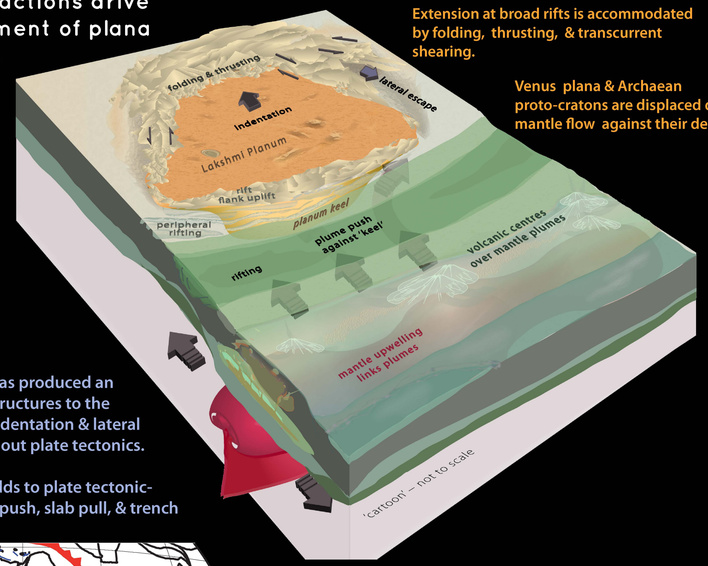
Mantle plumes form an elongate wall of slightly thicker crust flanked by thin crust = rifts





Original crustal thickness data calculated from Bouguer gravity by P. James (MIT)

Mantle tractions drive displacement of plana on Venus



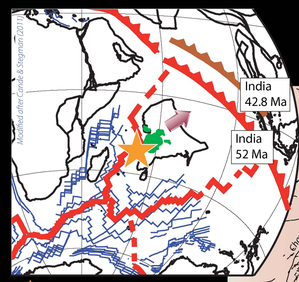
Extension at broad rifts is accommodated by folding, thrusting, & transcurrent shearing.

Venus plana & Archaean proto-cratons are displaced due to mantle flow against their deep keels.

Plume push on Venus has produced an identical geometry of structures to the Himalayan-Indochina indentation & lateral escape system BUT without plate tectonics.

Plume push on Earth adds to plate tectonic-induced forces of ridge-push, slab pull, & trench suction.

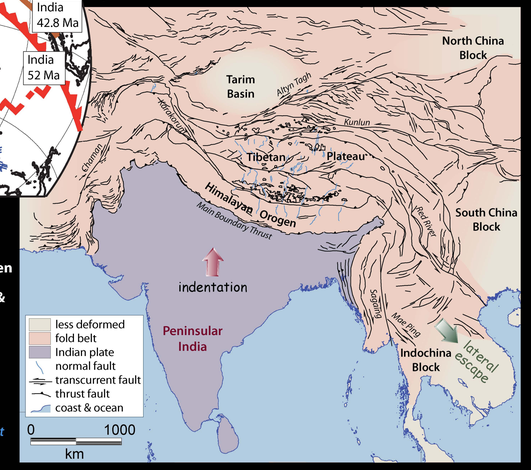
Mantle tractions drive rapid early & ongoing, post-collisional displacement of India



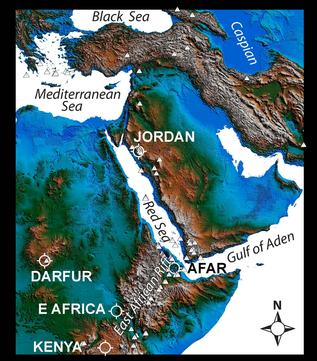
Indian plate motions are driven by the push force of the Réunion mantle plume head & mantle flow in addition to plate boundary forces.

The Réunion plume head is a major driving force for tectonic events between ca. 70 & 45 My ago.
Cande & Stegman (2011), Nature 475

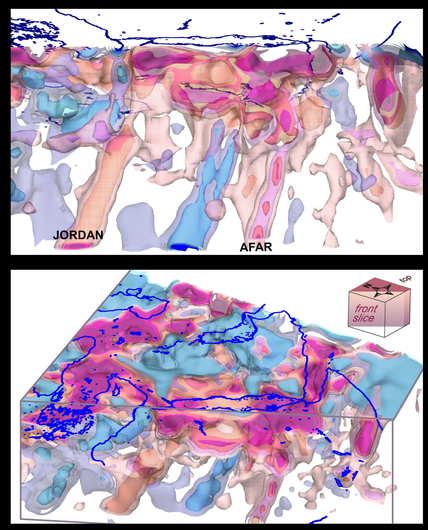
Continued northward displacement of India after collision is due to basal tractions of mantle flow against its thick cratonic roots.
Alvarez (2010) EPSL 296



EARTH



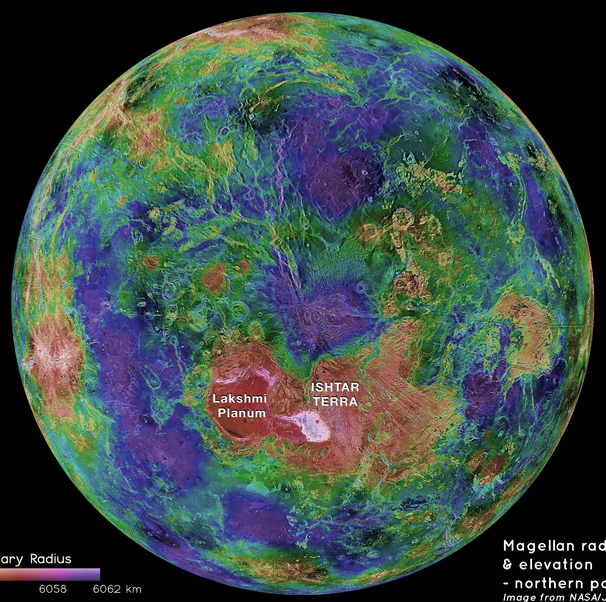
3D seismic tomographic isosurfaces portray merging of upwelling plumes (warm colours) accompanying the Red Sea & Gulf of Aden rifts, & downwelling plumes (cold colours). A similar relationship is proposed for Venus.



MANTLE PLUMES

3D isosurfaces calculated from velocity data provided by S.-J. Chang

VENUS



Magellan radar & elevation - northern polar view
Image from NASA/JPL

Venus - an analogue for an Archaean Earth without plate tectonics

► Gravity & radar images show that transcurrent shear zones on Venus (a planet without plate tectonics) are of far greater extent than previously mapped.

► 'Plate-like' horizontal displacements of several hundred kilometres on Venus occurred without the stresses created by 'ridge push', 'slab pull', & 'trench suction' associated with plate tectonics on Earth.

► Lateral displacement of 'craton-like' plana on Venus result from mantle tractions at their base ± plume push within a stagnant lid to transitional convection regime.

► Broad fold & thrust belts & regional transcurrent shear zones on Venus illustrate that 'modern' plate tectonics is not required to form similar structures in Archaean terrains, previously attributed to subduction-related collision & arc accretion.

► Studies of Venus support a cratonic mobilism model for the Archaean Earth where cratons are displaced due to mantle flow acting upon their deep lithospheric keels.