Ongoing structural mapping reveals an amazingly rich tectonic history, in which dyke swarms reveal multidirectional and polyphase extension (Cipriate, Ophir, Condor chasmas), a strike-slip relay zone (Hydra Cavaus) echoes brittle-plastic shear zones (Ophir and Hebes chasmas), chasma floor erosion reveals complex pre-volcanic basement fracturing and pre-elastostatic, crustal folds may turn to volcanic complexes (Ophir Planum), and wrinkle ridges may form by inversion tectonics (Jovianite Dorsa).

**Brittle-plastic shear zones**

Brittle-plastic deformation occurs dominantly in Ophir and Hebes Chasmas, showing chasmas and similarly places, as well as C. Chasma in Ophiuchus Chasma. The orientation and kinematics of the shear planes are consistent with extension parallel to the main chasmas. The observed shear geometry implies tectonic deformation, and contraction of the host rock will help dissipate the extension and thus cause the production of brittle-plastic shear zones. The former deformation devoid of plastic deformation in the surrounding plateaus areas indicates stress transfer in the evolution of Valles Marineris.

**Inversion tectonics**

Wrinkle ridges are parallel to grabens cut by linear troughs mapped to have formed dominantly non-crenulated. Because dyke propagation could be only coincidentally guided by wrinkle ridge thrust faults, wrinkle ridges north of Valles Marineris are probably inversion structures.

**Multidirectional polyphase tectonic stretching**

Rift valleys cut in Coprates and Ophir chasmas indicate fracture orientation unrelated to concordant opening of Valles Marineris perpendicular to the main chasma trend. However, all the trending dikes in Coprates, Coprates chasma, and Hydra Cavaus are radial or extensional orientation. In addition, Veritas Fossae fan is separated with a similar fracture pattern perpendicular to the main chasma.

**Volcanic ridge belt**

These high topography crescent-shaped features interpreted as marginal and rift systems, however, tensional isobaric evidence of collisional structures. Indeed, the ridge on the margin are aligned along a 4-deg trend running north and east of Valles Marineris. Geomorphology and tectonic implications suggest that they could be either anastomized and magnetic choromagnetism.

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**Deep dyke swarms**

Ophir Chasma

- Dyke Swarms

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**Retraction tectonics in Hydra Cavaus**

In Hydra Cavaus, is rotated block in a ring zone between two strike-slip and extensional deformation. The crustal blocks are currently reinterpreting the tectonic regime from dominantly extensional to rotational. This suggests the reorientation of the fractures into a rotated zone (Smithsonian Project).

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**Qanah Chasma**

- Dyke Swarms

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**Conclusion**

The tectonic record of Valles Marineris is poorly revealed within the chasma due to intense chasma erosion. However, the region still bears a complex diversity of tectonic deformation, both in the chasma and on the surrounding plateaus, pointing toward a much more complex tectonic evolution than simple crustal stretching of the southern chasma perpendicular to the chasma trend, as commonly thought.
OPHIR CHASMA

ETHIOPIAN TRAPS
Ongoing structural mapping reveals an amazingly rich tectonic history, in which dyke swarms reveal multidirectional and polyphase extension (Conopites, Ophe, Conor, Chajnantor), a strike-slip relay zone (Hydra Cavius) encounters brittle-plastic shear zones (Ophe and Hebes chasma), chasma floor erosion reveals complex pre-volcanic basement fracturing and protovolcanic activity, crustal folds may turn to volcanic complexes (Ophe Planum), and wrinkle ridges may form by inversion tectonics (Juventae Dorsa).

Inversion tectonics

Wrinkle ridges are parallel to grabens and to linear troughs perpendicular to former fracture planes, forming a dominantly non-cylindrical system of highly asymmetric wrinkle ridges. Dyke propagation can be seen to be guided by wrinkle ridge fractures, wrinkle ridges north of Hydra Cavius are probably inversion structures.

Deep dyke swarms

The dyke swarms are found in the chasma floor, indicating that tectonics were active during the formation of the northern, Older dyke swarms, not only the southern, younger-stage chasmas. However, the tectonic activity is thought to be confined to a smaller area of the chasma floor, suggesting that the dyke swarms were formed during a period of intense tectonic activity.

The tectonic record of Valles Marineris is poorly revealed within the chasma due to intense chasma erosion. However, the region still bears a highly diverse tectonic history, with both the chasma and the surrounding plateau, pointing toward a much more complex tectonic evolution than simple crustal stretching of the southern chasma peripheral to the chasma trend, as commonly thought.

Multidirectional polyphase tectonic stretching

The stretching of Chasma at the ends of the chasma is characterized by extensive contraction, with no opening of Valles Marineris perpendicular to the main chasma trend. However, the stretching of Chasma at the ends of the chasma is characterized by extensive contraction, with no opening of Valles Marineris perpendicular to the main chasma trend.