Layered deposits with volcanic intrusions in Gangis Chasma, Mars.


Layered terrains on the floor of Valles Marineris were first recognized in the Mariner 9 Images. They are about 100-200km long, 50km wide and 1-5km high, and characterized by well-developed, near-horizontal layers. Proposed origins are summarized by the following hypotheses:

1. Erosional remnants of the surrounding plains. This hypothesis is probably incorrect because the erosional style is very different than that of the canyon walls ([1],[2]).
2. Eolian deposits. Peterson [1] suggested that cross bedding in the Candor and Ophir layered terrains could be explained by global dust storm deposition, but Nedell, et al. [2] argued against this idea because of the lack of similar deposits on the surrounding plains and walls.
3. Pyroclastic deposits. A pyroclastic origin by ash fall or flow is based on the similarity between the erosional pattern of terrestrial ash flow and welded tuff and that of the resistant layer in the Hebes layered terrain [1]. However, because there are no similar deposits on the surrounding plains and no evidence for an associated caldera, Nedell, et al. [2] rejected this hypothesis.
4. Lacustrine deposits. This hypothesis is favored because it can explain the location, near horizontality, lateral continuity, great thickness and stratigraphic relationship ([2],[3],[4]). Moreover, a substantial subsurface aquifer system may have supplied water to fill or partially fill the canyons at or near the time of outflow channel and canyon formation [2].

Geologic setting of Gangis layered terrain. The area surrounding the Gangis layered terrain show a variety of geologic features relevant to its origin (Fig. 1). The canyon walls are about 2km high and show gully and spur topography and landslides. Fewer craters on the canyon floor than on the surrounding plains suggests that the floor is younger, possibly as a result of fluvial or eolian processes. A large crater on the southern upper plain shows evidence of ponding and outburst of water to the east forming an outflow channel. On the western part of the canyon floor are blocky mesa a few to 20km across and about 1km high. Their morphology is similar to the mesas of chaotic terrains thought to be the source of outflow channels.

Gangis layered terrain. The approximate size of Gangis layered terrain is 100km, 40-50km wide, and 1.5-2.0km high. To the west, the terrain seems to have been more eroded than to the east. The relatively gentle south-facing side has a slope of a few degrees, and is conspicuously fluted. This fluting could be due either to wind scouring or to the seep of ground water. On the eastern part of the southern upper plain are two blocky slabs, each about 10km wide. Their blocky nature and fold-like texture in them suggest they may be large landslide masses that have been subsequently shaped by erosion. Extending in a north-south direction from the summit of the layered terrain to near its base are several lines of darker domes and ridges. In some cases, areas of dark material surround the domes. These structures may be volcanic domes and dikes intruded into the layered deposits and subsequently exposed by the erosion which shaped the present-day layered terrain. The associated dark deposits could be erosional products from the structures or pyroclastic material. Part of slope has texture smoother than the fluted area. This region could be covered by the pyroclastic material suggesting volcanism could have been active until recently. The layered terrain itself can be divided into three main stratigraphic units (A,B,C in Fig.1) based on the erosional morphology. Each main unit consists of other less well-defined units not shown in Fig.1. The upper two layers are relatively thin and have steeper slopes than the lower unit. Strata within the middle unit (B) appear to thin and pinch out against the upper unit (C) suggesting an angular unconformity (arrow 1). Similarly, a dark layer within the lower unit (A) appears truncated by the middle unit indicating another angular unconformity (arrow 2).

To the west, these three main units disconformably overlie a heavily eroded base rock that might be ancient cratered terrain. The angular conformation between the main stratigraphic units suggest that there were at least two intervals of erosion between the deposition of these three units. Domes, ridges and dark materials suggest that volcanism has modified the Gangis layered terrain. Whether Gangis layered terrain was laid down in a lake is still controversial, but assuming it originated as sedimentary deposits in the lake and the angular unconformities are real, then the following sequence of events appears to apply.

1. Formation of early closed Gangis Chasma and filling with water from subsurface. Hills and mesas may be remnants of chaotic terrain associated with this event. 2. Layer A deposited. 3. Draining or evaporation of lake and erosion of layer A during minor tectonic tilting. 4. Refilling of canyon with water from subsurface and deposition of layer B unconformably on layer A. 5. Draining or evaporation of lake and erosion of layer B during minor tectonic tilting. 6. Refilling of canyon with water from subsurface and deposition of layer C unconformably on layer B. 7. Intrusion of volcanics into layered deposits. 8. Catastrophic draining of lake to the east and erosion of layered deposits to expose volcanic intrusions.

Layered terrains may provide important clues for understanding the history of canyon formation and the Martian hydrologic cycle. Our current interpretation suggests multiple cycles of canyon filling and draining. This may be consistent with the proposed cycles of ancient oceans in the northern plains [5].

REFERENCES
Figure 1. Geologic map of western Canyon Chasma.

Layered Deposits in Canyon Chasma, CKD Mosaic and R.G. Strom