NEAR-SURFACE STRATIGRAPHY BENEATH XANTHE TERRA.

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Four lithologic units are exposed in the uppermost half-kilometer of Vallis and Chasma walls on Xanthe Terra. Where the walls transect impact craters, these units pass uninterrupted beneath crater rims and floors. This relationship seems unlikely if the units are lava flows or sediments .

Introduction: An unexpected result from Mars Orbiter Camera (MOC) high-resolution images is the near-ubiquity of horizontal layering exposed on Martian chasm and valley walls [1]. These kilometer-deep horizontal layers do not fit the conventional view of Martian highlands crust as mega-regolith, and suggest that a "new paradigm" is needed in Martian geology [2]. Horizontal layers are also visible at the <u>tops</u> of chasm and valley walls, in the uppermost portion of the Martian crust [3,4], and are of interest for understanding surface and near-surface geology [5-7]. Here, I describe lithologic layers exposed in the uppermost kilometer of the Martian crust in Xanthe Terra, an area of Noachian cratered terrain that is cut by portions of the Valles Marineris system and by several outflow channels including Nanedi Vallis.

Near-Surface Stratigraphy: High-resolution MOC and Viking Orbiter (VO) images of Valles and Chasma in Xanthe Terra commonly show a consistent sequence of lithologic units at the tops of their walls. The units are best exposed (so far) in MOC image 08003 (Figure 1), on the southern edge of the mesa in Coprates Chasma. From the top of that mesa downward, four distinct units can be seen.

1. At the wall top is a ~15-20 m thick layer of high albedo. It appears relatively resistant to erosion, as it supports a moderately sharp lip at the Chasma top.
2. Next down is a complex unit, ~400 m thick, which commonly appears only as a moderate-albedo slope. This interval may be complex in detail. In some exposures, it contains a dark layer immediately below unit 1. In other locations (Fig. 1) this interval may contain a thin high-albedo layer
3. Next is a ~15-20 m thick layer of very low albedo, which commonly appears to support cliffs.
4. Beneath these three units is an undivided sequence of dark and bland layers, each 20-100 m thick, continuing to kilometers depth. This unit is visible on nearly MOC images of walls in the Valles Marineris and has been identified as a sequence of flood lavas, presumably of basalt [1,8-10].

These units are exposed on Chasm and Vallis walls in Xanthe Terra and adjoining regions, including on MOC images 06305, 07906, 08505, 08606(?), 08704 (Fig. 2), 08705, 08706, 08805, 25004, 23107(?), and 25204. The sequence is visible, without detail, on many VO images (e.g., 083A34 [5,6]).

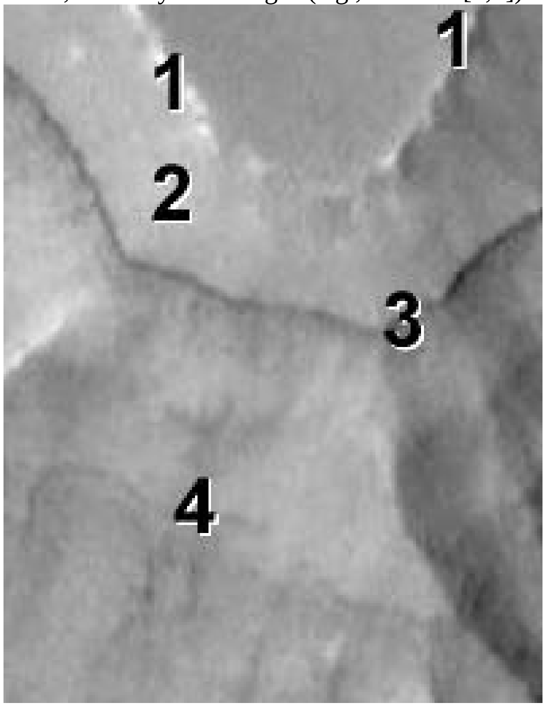

Figure 1. From MOC 08003, ~1.1 km across, showing the top of the mesa in Coprates Chasma (top center) and a portion of its south wall. Numbers on units referred in text.

Origin of Layers: Here, I consider only the uppermost units 1-3. These units were identified earlier as diagenetic horizons [5,6], and similar units west of Xanthe were identified as lava flows [3,4].

A telling feature of the layers is that they continue uninterrupted beneath Noachian-age impact craters (Figs. 2, 3, 4). This relationship is seen best in MOC image 08704 of Nanedi Vallis (Fig. 2). There, the Vallis transects a degraded impact crater, 3 km diam., on the Terra surface. This crater is similar in degradation state to other nearby craters on Xanthe (e.g., MOC 08703, 08705). On the Vallis wall, layers 1-3 can be followed continuously from outside the crater, beneath its rim, and beneath its flat floor. Similarly, near-surface layers can be followed across and beneath impact craters along the south wall of Gangis Chasma (Fig. 3) and the southeast wall of Eos Chasma (Fig. 4).

How is it possible for these layers to continue uninterrupted beneath impact craters? Layers 1-3 could not be older than the impact craters – their rocks would have been disrupted, melted, and/or ejected by the impact. The layers could not be sediments or lava flows that were younger than the craters – subaerial or subaqueous sediments and flows could not be emplaced under a crater. The layers could not be igneous intrusions younger than the craters – the topmost layer is not an intrusion (it's at the Terra surface); a sequence of thin sills would not be expected at the same depth and thickness under all of Xanthe.

So, layers 1-3 could not be sedimentary or igneous (intrusive or extrusive) rocks that are older or younger than the craters. Having thus excluded all "normal" geological origins for layers 1-3, I and co-workers have been forced to an unusual explanation. A possible, self-consistent, origin for layers 1-3 is that they formed in place by alteration, i.e. diagenesis, of pre-existing materials [5,6]. Possible diagenetic processes (which cannot be distinguished here) include cementation, weathering, low-temperature alteration, and pedogenesis (= soil formation). Diagenesis is also consistent with the broad lateral extent of layers 1-3 – provided the pre-existing materials and diagenetic agents were grossly similar across the whole region.

Implications: If these layers are diagenetic, a solvent would be required to permit chemical transport. The most likely solvent is liquid water, which would not be required in abundance. Intergranular films and adsorbed layers of water can enable rapid chemical transport [11], even when temperatures remain below 0°C [12,13]. If water were available from subjacent aquifer or ground ice [12], formation of thin films of saline water would only require T > ~250K (-23°C) and water vapor pressures above ~75Pa (~0.75mbar) [12]. These conditions could probably have been realized in Mars' past.

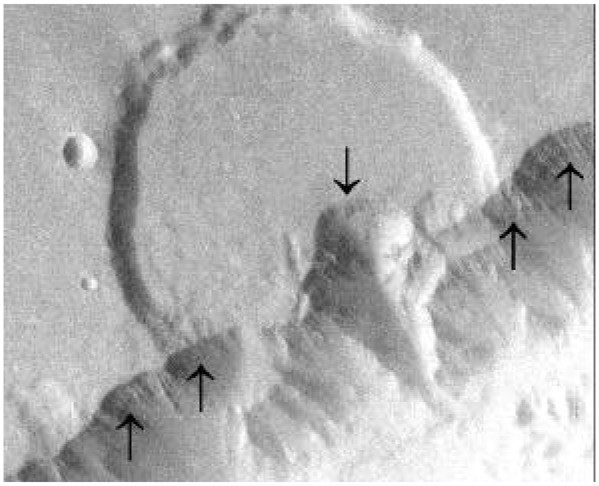

Figure 3. From VO 429A16, Eos Chasma, SE wall. Arrows point to layers on wall that pass uninterrupted from outside to beneath the 20 km crater.

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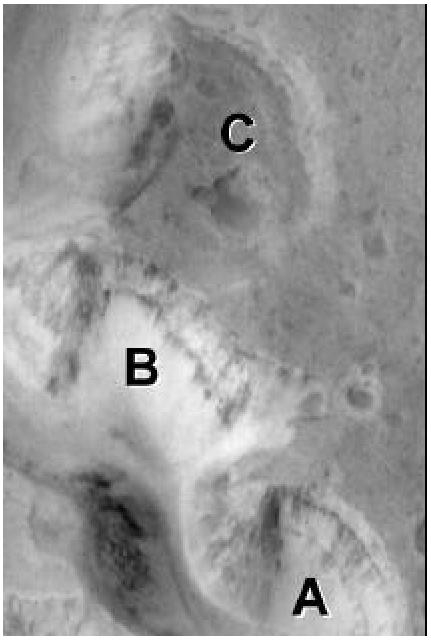

Figure 2. From MOC 08704, Nanedi Vallis, 3.5 km across. Layers 1-3 best exposed at A. At B, they pass beneath the rim of an impact crater C (3 km diam.).

Figure 4. From VO 014A30, Gangis Chasma, S wall. Arrows point to layers on wall that pass beneath the rim of the impact crater (30 km diam.).