DELTA-LIKE DEPOSITS IN XANTHE TERRA, MARS, AS SEEN WITH THE HIGH RESOLUTION STEREO CAMERA (HRSC).

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Summary: HRSC images [1] reveal the existence of several fan- or delta-like deposits in the Xanthe Terra region of Mars. We report on our investigation of two possible lacustrine deltas at the mouths of Nanedi and Sabrina Valles, respectively (Fig. 1). Their morphologic characteristics suggest a formation as Gilbert deltas by clastic sedimentation of fluvially transported material in crater lakes.

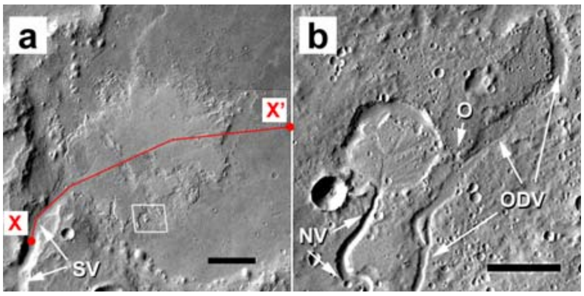

Figure 1: (a) "Large" delta at the mouth of Sabrina Vallis (SV). Box shows location of Fig. 2, red line X-X' shows location of profile in Fig. 3a (orbit 894); (b) "Small" delta at the end of Nanedi Valles (NV). A small outlet (O) breaches the eastern crater wall and continues as an inner channel for a short distance within an old, degraded valley (ODV) which connects to Hypanis Vallis to the north (orbit 905). In both images, scale bars are 5 km and north is up.

Background: Possible alluvial fans and deltas on Mars have been observed in Viking Orbiter [e.g., 2-4] and, more recently, in Mars Orbiter Camera (MOC) [5,6] and Thermal Emission Imaging System (Themis) [e.g., 7] imagery. Such deposits contain a record of past hydrological conditions and, therefore, are important for environmental and climatic studies. A point of debate has always been whether sedimentary bodies like the one reported by [5] have been deposited under subaqueous (=true deltas) [6] or subaerial (=alluvial fans) [8] conditions.

Geological Context: The part of Xanthe Terra that is of interest to this study is a near-equatorial region of old terrain between Maja Vallis to the west and Shalbatana Vallis to the east. The delta-like deposits are located in strongly degraded impact craters, which are part of the Noachian-aged *subdued cratered unit* (Npl_2) [9]. It is characterized by a high density of craters with >10 km diameter and resurfacing in the late Noachian. Today, the surface of unit Npl_2 is probably composed of fissure-fed lavas, eolian and perhaps some fluvial deposits [9]. It is cut by several valley systems, the characteristics of which (amphitheater-shaped heads, few tributaries, almost constant widths) suggest an origin by groundwater sapping rather than by precipitation and run-off. Their formation might have begun in the Noachian and continued into the Early Hesperian [9,10].

Morphology and Morphometry: Both delta-like deposits are situated where fluvial channels debouch into impact craters. Due to their differences in morphology and dimension, we describe them independently, based on HRSC (resolution 20 m/pixel) and MOC (~3 m/pixel) images, and HRSC and Mars Orbiter Laser Altimeter (MOLA) elevation data.

The "large" delta. The larger of the two deposits (near 11.9°N, 313.2°E; Fig. 1) has a lobate shape and a generally flat and featureless (at the scale of HRSC and MOC images) surface. Several depressions on this surface (impact craters and pits with irregular outlines) are partly filled with eolian dunes or ripples. Tab. 1 shows our measurements of area and volume in comparison to the recently detected deposit near Holden crater [5,6].

Table 1: Area and volume of the "large" delta.

	"large" delta		Holden NE fan or delta	
	HRSC	MOLA	from [5]	from [6]
area	210 km^2	225 km^2	115 km^2	88 km^2
volume	5 km^3	5 km^3	<6 km^3	13.2 km^3

The proximal portion of the deposit (~40% of the total area) has a slightly higher elevation and a darker albedo than the rest. Here, near the apex of the delta, a weakly expressed radial pattern of possible distributary channels can be distinguished. The distal portions of the deposit are bordered by a relatively steep, layered front ("L" in Fig. 2). Hence, the materials must be consolidated to some degree to form steep slopes. The pattern of layer outcrops around an isolated erosional remnant hill of the deposit ("H" in Fig. 2) suggests near-horizontal layering. The crater floor near the steep front displays a polygonally fractured appearance ("P" in Fig. 2). This might be the surface expression of dessication cracks, which could have been developed in wet material after the lake had dried up. Themis-IR nighttime images show that the deposit is darker than its surroundings and has a relatively low thermal inertia. This and the lack of boulders or coarse talus at the base of the steep front would be in agreement with clastic sediments. A longitudinal topographic profile (X-X' in Fig. 1) across the deposit shows a remarkable similarity to cross-sections of Gilbert-type fan deltas (Fig. 3). A topographic scarp marks the distal edge of the darker part of the deposit and might indicate a former higher water level.

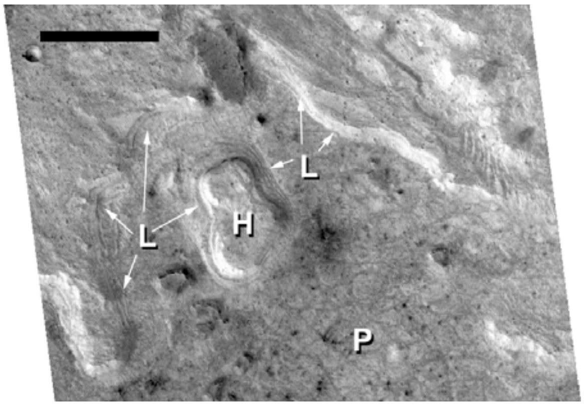

Figure 2: Distal part of "large" delta (see Fig. 1 for location and text for details). Scale bar is 500 m, north is up (MOC R13-02726).

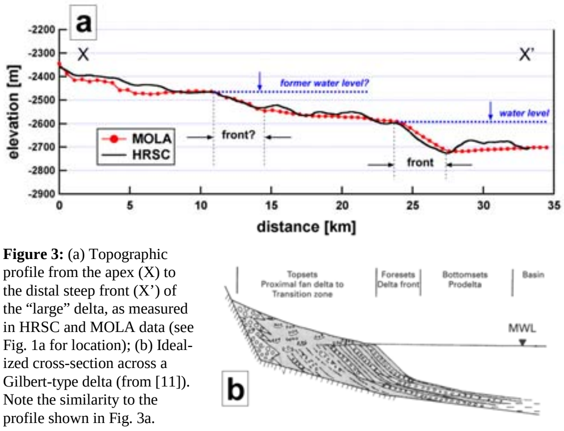

Figure 3: (a) Topographic profile from the apex (X) to the distal steep front (X') of the "large" delta, as measured in HRSC and MOLA data (see Fig. 1a for location); (b) Idealized cross-section across a Gilbert-type delta (from [11]). Note the similarity to the profile shown in Fig. 3a.

The "small" delta. The smaller of the two deposits (near 8.5°N, 312°E) has also a lobate shape (Fig. 1). The entire surface (area: ~22 km^2) is dissected by a anabranching pattern of radially distribu-ting conduits. Where they do not onlap the inner crater wall, the distal parts are marked by a steep front, along which layers are exposed. The delta-like body almost completely fills a small, ~5 km-diameter impact crater. The crater has a small outlet channel at its eastern part. Delta formation would have occurred in an open system and, therefore, been dominated by clastic sedimentation. It is interesting to note that the small crater and the delta are situated at a place where ejecta from a large impact crater to the west have interrupted the original path of the Nanedi Valles. The valley narrows and ends in the small crater (with the exception of the small outlet). The outlet joins an abandoned branch of the original valley to the east of the crater, which connects to Hypanis Vallis to the north.

No terraces. No terraces are observed at the inner walls of the craters. Although terraces are common landforms in terrestrial lacustrine settings, their absence at former Martian lakes may well be explained: The small crater areas (~1.250 km^2 and ~34 km^2, respectively) limit the fetch necessary for significant wave-cutting action (as argued by [12] *against* wave-cut terraces in some Martian craters). The low atmospheric pressure also makes wave generation inefficient, further restricting the formation of shorelines [13]. Finally, the formation of terraces depends on the nature of the material that is shaped by wave action. All this is in agreement with the lobate plan form of the deltas, which is typical for river-dominated deltas (in contrast to wave- or tide-dominated deltas): Gilbert type deltas are carrying large amount of bed-load that dwarf any other secondary process.

Conclusion: HRSC data show delta-like deposits at the terminations of Nanedi and Sabrina Valles. Their flat surfaces and the steep fronts are consistent with a formation as Gilbert-type deltas in a standing body of water, i.e., in a Martian lake. The volumes of the deposits are small relative to the eroded volume of Nanedi and Sabrina Valles (area: >3.200 km^2, depth: 200-500 m). Our results are in agreement with other HRSC-related studies reporting evidence for deposition in lacustrine environments on Mars [14,15].

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