

A STEEP FAN AT COPRATES CATENA, VALLES MARINERIS, MARS, AS SEEN BY HIGH RESOLUTION STEREO CAMERA (HRSC). G. Di Achille¹, G.G. Ori¹, D. Reiss², E. Hauber², K. Gwinner², G. Michael², G. Neukum³ and HRSC Co-Investigator Team. ¹International Research School of Planetary Sciences, Pescara, Italy (gadiachi@irsps.unich.it), ²Institute of Planetary Research, DLR, Berlin, Germany, ³Remote Sensing of the Earth and Planets, Freie Universität, Berlin, Germany

Introduction: Sedimentary fan-shaped features on Mars occur in a variety of settings and display interaction with past standing bodies of water [1, 2, 3]. As a result, they show a large variety of facies and morphologies spanning the entire spectrum of sedimentary environments from alluvial fans to fan-deltas (the latter including Gilbert-type deltas). This variety of sedimentary bodies and environments is probably also reflected in a variety of interacting depositional processes which makes their investigation difficult. However, the high-resolution images and stereo data obtained by the HRSC camera [4] enable the detailed three-dimensional analysis of these fan-shaped deposits and can help in interpreting the depositional complexes [5, 6, 7]. The stereo-derived DTMs provide a spatial resolution of up to 50 m with a mean 3D point error of few tens of meters. Thorough morphometric and sedimentological analysis should determine whether a standing water body was present during their formation, allowing to discriminate between an alluvial or deltaic origin for the fan-shaped features. In this study, we present an unusually steep and high deposit at the entrance of a channel into one of the secondary troughs associated to Coprates Catena (here-after referred to as the Coprates fan, Fig. 1-2).

Regional Settings: The study area encompasses Late Noachian and Hesperian plateaus bounding the northwest-southeast oriented Valles Marineris and a series of parallel troughs and pit chains, belonging to Coprates Catena (Fig. 1). Two large troughs, likely formed by coalescing pits, show evidence of sedimentary deposition (A and B in Fig. 1). The steep-walled trough A is 48 km long and 16-km-wide with a maximum depth of 3.3 km (Fig. 2a). Trough B shows almost identical dimensions but with a rather smooth floor. A valley system extends almost perpendicular to

the regional tectonic trend and comprises four northeastward trending valleys differently eroded and filled (Fig. 1). The nearly 44-km-long feeder channel of the Coprates fan preserves the freshest morphology with respect to the others. Its width and depth increase downstream up to 4.5 km and 1.3 km, respectively, with a mean slope of 1.7°. The valley can be divided into two main sections. The first starts from no obvious source and extends for 30 km along a low-sinuosity course characterized by an almost flat floor and well-defined lateral walls. The second part is 15-km-long and consists of a younger inner sapping valley starting from an amphitheater-like valley head which re-incises and deepens the floor of the first portion (Fig. 2a-b).

Fan morphology: The Coprates fan radius ranges from 4900 m in the westernmost part up to 8500 m in front of the valley mouth (Fig. 3a). The fan apex lies approximately 1100 m above the trough floor and the mean slope of the deposit is about 7.4°. These remarkable gradient and height highlight the anomalous character of the studied deposit. On Earth, exceptionally high slope values (up to 3.4°) have been found on small (4 km in length) alluvial fans [8]. The surface of the fan appears rather eroded, pitted by several craters, and incised by eolian scours. It shows clear concentric and layered steps whose height seems to progressively decrease toward the distal part (Fig.

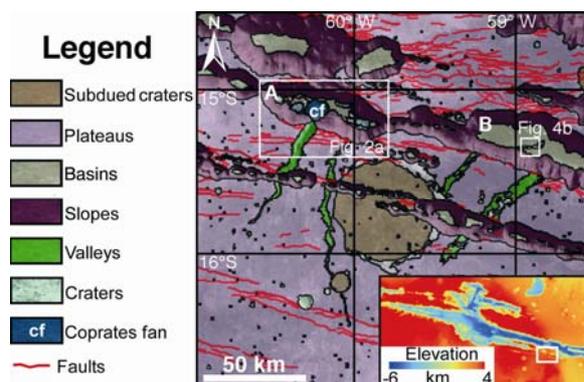


Fig. 1-Geomorphological map of the study area.

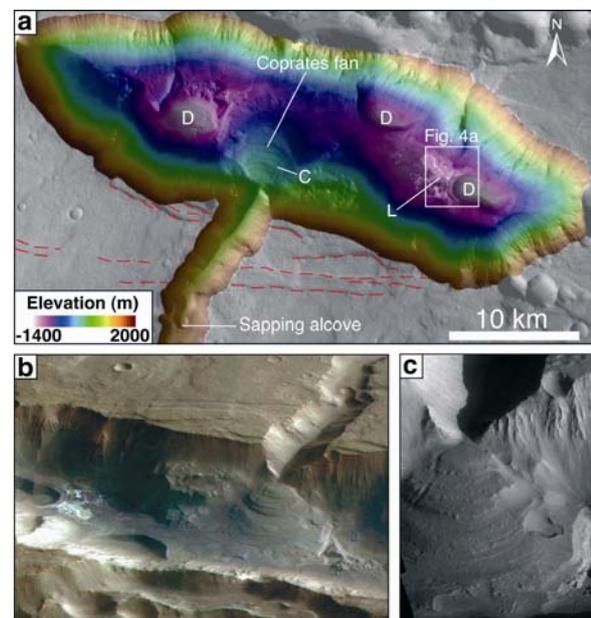


Fig. 2- (a) The Coprates Catena trough from HRSC orbit 1929: nadir image and stereo-derived topography; (b) HRSC 3D color view; (c) THEMIS VIS draped on HRSC DTM.

3a-b). The fan is characterized in the proximal part by a channel that sharply terminates at a radial distance of 3500 m (Fig. 3b). At its terminus, about 600 m below the fan apex, there is no evidence of lobe deposits nor drainage continuation. However, the channel termination coincides with a prominent step (~100-m-high) seen as a cusp along the HRSC radial topographic profile XY (z in Fig. 3a-b). This point also separates the fan into two parts characterized by different slopes: the proximal channelled part with an average value of 9.7° and the distal part with an average value of about 5.7° .

Discussion and Inferences: In term of processes sedimentary fan deposits can be mainly deposited by stream flows, sheet flows, and debris flows. The well-defined shape and the overall morphology of the Coprates fan feeder channel suggest excavation by turbulent water which would be incompatible with the laminar conditions of a debris-flow. Concentric steps on fan deposits were also cited as evidence of mass-wasting movements by Malin and Edgett [9]: they interpreted these features either as a result of successive surges of the material or as the expression of compressive stress inside the deposit. However, such a stress field seems incompatible with the undisturbed layering shown by the Coprates fan, moreover debris-flow deposits are usually massive, chaotic and do not show significant internal bedding. Additionally, successive surges of debris-flow do not expand laterally to form homogenous fan-shaped distributary deposits, but produce elongate lobes with sharp, nose-like, downstream termini, resulting in a multilobate deposit characterized by a stacked mounded pattern and a rugged topography. The internal bedding of the Coprates fan, its homogenous lateral extension and the lack of a channel system on its surface suggest that it was mainly deposited by successive and decreasing sheet flows. We interpret the concentric steps as the relic of an aggradational stacking pattern of the depositional sequences, exposed after the removal of their fine and loose components. Whether the Coprates fan was deposited as a fan-delta or as an alluvial fan is uncertain. However, we favor an alluvial, sheet flow dominated deposition for the distributary feature, though there is weak evidence for a possible stationary water level (~500 m depth) and a fan-delta origin. The fan evolution has been likely affected by a change in the size of the transported riverbed materials in the feeder channel which is reflected in the two different depositional slopes between the proximal and distal parts of the fan [10]. In fact, this grain size transition is typical along rivers affected by a change in gradient [8]. The younger inner sapping part of the feeder channel likely provided such a gradient change during the latest depositional activity. This was likely characterized by the headward

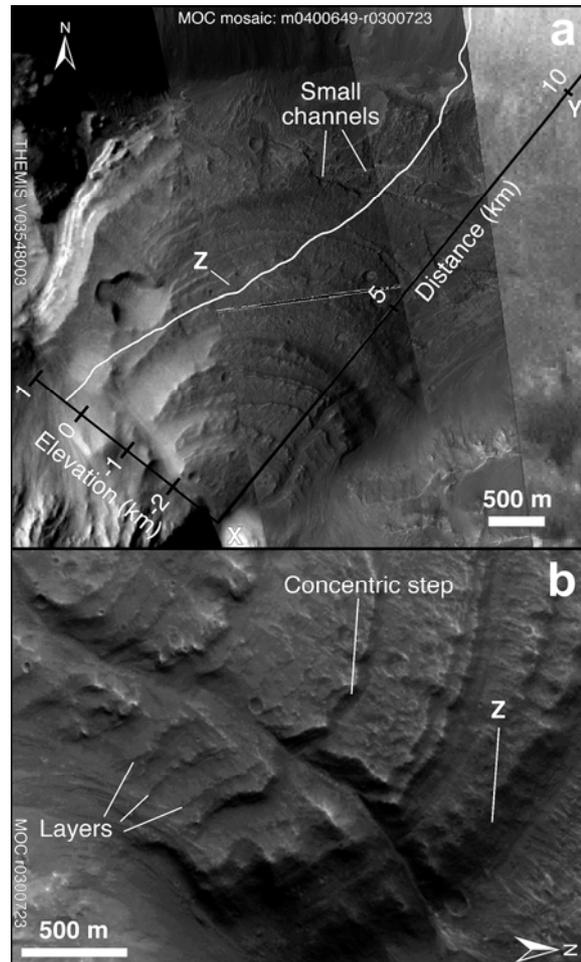


Fig. 3- (a) MOC and THEMIS view of the Coprates fan with superimposed topographic profile from HRSC; (b) the proximal, layered and stepped part of the fan.

retreat of the sapping with an associate retrograde movement of the fan intersection point, resulting in an upstream migration of the flows' expansion. Then, the coarser and gradually waning discharges from the rejuvenated stretch formed the steeper proximal part of the fan above the less-inclined distal portion deposited within the previous physiographic settings of the channel. Finally, regional morphotectonics and previous geological mapping suggest that groundwater-related aqueous sedimentation was active until the end of the Hesperian implying favorable climatic conditions for the flow and possible ponding of water during that period.

References: [1] Ori et al. (2000) *JGR*, 105; [2] Pondrelli et al. (2005), *JGR*, 110; [3] Irwin et al. (2005), *JGR*, 110; [4] Neukum et al. (2004), *ESA Spec. Pub.*, 1240; [5] Di Achille et al., *JGR* (in press); [6] Hauber et al. (2005), *LPSC*, 1661; [7] Di Achille et al., (submitted); [8] Saito and Oguchi (2005), *Geomorphology*, 70; [9] Malin and Edgett (2003), *Science*, 302; [10] Calvache et al. (1997), *Geomorphology*, 21.