STRATIGRAPHIC ARCHITECTURES IN SOUTHERN MELAS BASIN, VALLES MARINERIS, MARS.

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Introduction: Several topographic depressions within Valles Marineris (VM) are closed systems which may have acted as sediment traps for fluid moving during a young, i.e., Hesperian, period of active hydrological cycling ([1], [2]). Thereby, a sedimentary basin within VM is a feasible concept.

We describe in Melas Chasma a complex system of sedimentary layers called strata which are cut and exposed down the landscape. It looks like "cross bedding" because of geometry, but actually it occurs at a scale of hundreds of meters. Analogous patterns have been studied on Earth through seismic reflection data and outcrop exposures. This particular set of strata is arranged in depositional sequences bounded by stratigraphic unconformities. Insights into these three-dimensional deposit geometries are used to tentatively isolate specific depositional processes and point to ancient subaqueous settings.

Setting: We discovered [3] the stratigraphic complex in high-resolution images obtained by Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC). Thermal Emission Imaging System (THEMIS) was used to place the MOC views in their regional context. MGS Mars Orbiter Laser Altimeter data (MOLA) were processed to obtain regional and local topography. The study area referred to as "Southern Melas Basin" (SMB) is an enclosed depression ~30 km across and 60 km long, located 10°S/76.5°W. SMB corresponds to a marginal trough of Melas Chasma perched at ~1 km above the central canyon floor.

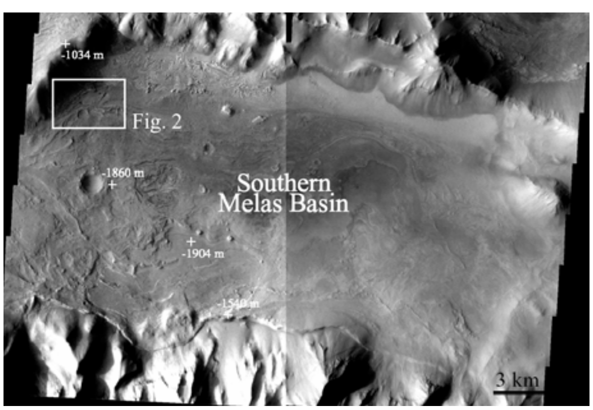

Fig.1: General view (THEMIS image) of Southern Melas Basin.

Stratal Pattern: At least three depositional sequences are exposed in northwestern SMB. Depositional sequences have been defined as conformable successions of genetically-related strata (i.e., discrete bundles of geometrically similar strata), bounded at the top and base by unconformities (geometric discontinuities ; surfaces of erosion) or their correlative conformities (surfaces lacking erosion) [4].

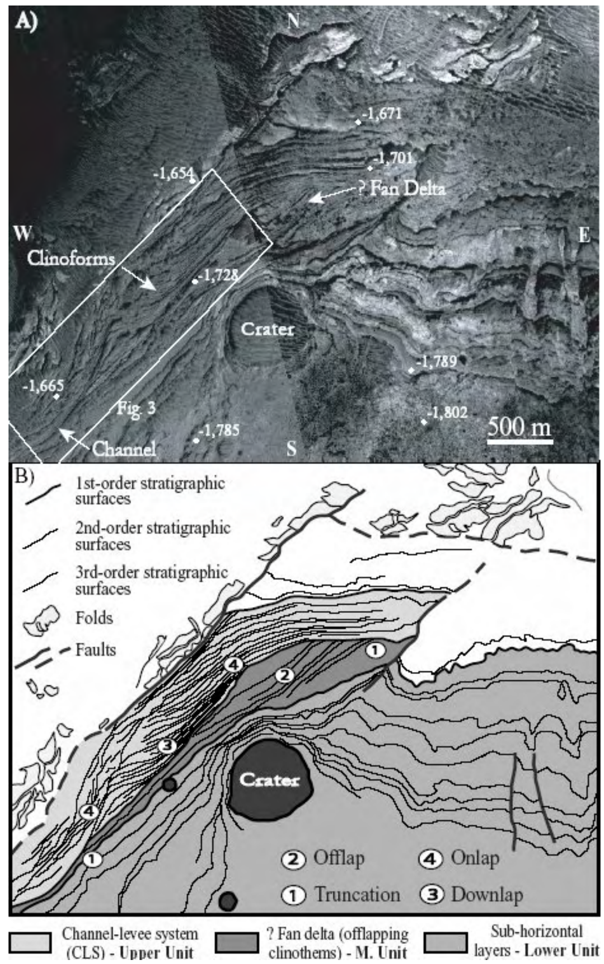

Fig.2: Uninterpreted (A) and interpreted (line drawing, B) mosaic of portions of MOC images R 1200541 and R 2001281 (3.27 and 2.9 m/pixel) showing three depositional sequences and their first-order architetectural elements (flat-lying layers, steeply inclined foresets, channel-levee system). Elevations are in meters.

The lower sequence is made up of sub-horizontal, conformably-stacked layers. The overlying middle sequence is composed of a series of high-relief (~30 m), planar, steeply-inclined, conformable foresets (offlapping strata). The updip terminations of the dipping strata are sharp, yielding a typical angular unconformity (erosional truncation). The upper stratigraphic complex shows a bowl-shape, channel-like surface downcutting into horizontal layers and flanked by a wedge-shaped depositional ridge. Large-scale cross-beds and contorted layers (? slumped beds) fill the channel-axis. The tabular layers within the channel terminate against the inclined inner bounding surface of the channel, producing an "onlap" termination pattern. The lateral ridge is composed of a 80 m-thick stack of large-scale, climbing and migrating sedimentary waves (Fig. 2, 3). The wave migration tends to be orthogonal to the channel-axis. The waves are asymmetric showing a short inner and a long outer slope, respectively. Outer faces of waves display a general sigmoidal shape characterized by a round-edged exponential profile in the upper slope passing down to a concave-up part in the middle and lower slope. Distal parts of the basal layers show base-discordant relations in which the layers terminate downdip against an initially horizontal surface, defining a typical "downlap" feature. The dipping layers of the outer slope can thus be referred to as "clinoforms". The lengths of these sigmoidal clinoforms, covering the distance from crest to toe of slope, are ~1500 m. The crests have a relative elevation of several tens of meters. The ridge shows a decrease in thickness of over 50% from near the ridge crest to the lower flanks of the ridge. The convergence and coalescence of clinoforms in the down dip direction provide direct evidence for distal section condensation (Fig. 3), with a possible decrease in grain size.

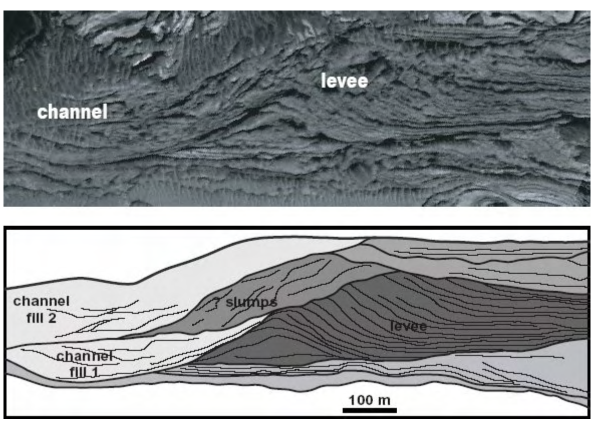

Fig. 3: Uninterpreted (A) and interpreted (line drawing, B) close up, showing architectural elements of the channel-levee sytem (erosional surface, outer levees). The clinoforms have been rotated to a position more consistent with their original geometry.

Depositional processes and environments: We interpret the steeply-inclined strata of the middle sequence to be the foresets of a steep-face subaqueous fan. On Earth, there are two basic varieties of steep-face fans to mind that are conical underwater deltas lacking subaerial distributary plain, and "Gilbert"-type deltas with a tripartite depositional geometry consisting of topset, foreset and bottomset segments. Terrestrial steep-face deltas which exhibit maximum slopes of 35° develop where an alluvial bedload river arrives into an excessively deep coastal water (e. g., into a fjord). Fan delta may also form in association with eskers and other sediment-laden englacial or periglacial meltwater streams. Whatever the setting, the steep slopes of such deltas on Earth are subaquaeous. The removal of the upper slope of foresets might be related to fluvial erosion or scraping by an ice sheet.

The general stratal stacking pattern of the upper sequence fairly well compares to that of a terrestrial channel-levee system (abbreviated to CLS) that is a single channel-belt bordered by levees. On Earth, channels flanked by giant levees have been recognized as important components of deep-water depositional fans in past and modern, marine and lake environments. The levees of the terrestrial CLS form from the overbanking of fine-grained sediments because of spillover as flows move down the channel thalweg. A noticeable difference lies in the fact that the outer levee flank in SMB dips at angles (Fig. 3) apparently much larger than typical levees in deep-water fans on Earth (i.e., 25–30° against a maximum of 9° in the Geneva Lake [5]).

The topography of the Southern Melas Basin (Fig. 1) would permit enclosure by a thick ice sheet. This might have allowed water flows to enter a subglacial lake body and produced fan systems [6]. In this way, water may be more common than under restrictions of atmospheric pressure on Mars.

Conclusion: The particular set of strata exposed in SMB reveals that there are complex stratal patterns on Mars similar to those in terrestrial deposits and we can start applying sequence stratigraphy on another planet than Earth. Current interpretations for these depositional complexes are tentative only, even if a subaqueous fan at least, and a channel-levee system maybe, have manifested some characteristics of deep-water, possibly sub-glacial, lacustrine activity.

Importantly, these depositional complexes afford potential sorting mechanisms for the different grain-sizes and mineralogical components of the clastic sediments at the surface of Mars.

References: [1] Mangold N. et al. (1997) *Science, 305,* 78-80. [2] Quantin C. et al. (2005) *JGR, 110*. [3] Dromart G. et al. (2007) *Geology*, in press. [4] Mitchum R. M. et al. (1977) *AAPG Mem. 26,* 205-212. [5] Zing O. et al. (2003) *Eclog. Geol. Helv., 96*, 21-30. [6] Domack E. et al., (2006) *Geomorphology*, *75*, 125-142.