FLUVIAL STRATIGRAPHY AT AEOLIS DORSA, MARS, RECORDS BASE LEVEL CHANGES AND BACKWATER SEDIMENTATION CONTROLLED BY A FLUCTUATING DOWNSTREAM BODY OF STANDING WATER.

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Introduction: Aeolis Dorsa, a large sedimentary basin on Mars, contains an array of fluvially dominated sedimentary deposits [1-4]. These deposits preserve a record of fluvial erosion and deposition during early martian history. The exhumation and topographic inversion of the deposits [1-2] has created the opportunity to observe this portion of the martian rock record in three dimensions and across significant distances. We present evidence that a subset of these fluvial deposits, which we refer to as "channelized corridors", represent incised valleys carved and filled during falls and rises in base level, which were likely controlled by changes in water surface elevation of a large lake or sea. The channelized corridors are 3 connected, low-albedo features branching towards the southeast, composed of densely packed fluvial deposits (Fig. 1).

Incised Valleys: Incised valleys are defined as topographic lows produced by riverine erosion [5-6]. Fluvial erosion producing incised valleys may be the result of (a) increasing the water-to-sediment discharge which lowers the bottom slope of a river, or (b) by dropping the water-surface elevation of a terminal body of water that lowers the base level for the river system. (a) is associated with erosion in upstream segments of the river, while (b) is associated with erosion located across a broader coastal zone [7-8].

Valley development via river incision following a base level drop has been studied using numerous methods [9-12]. Lateral migration of the incising river over time widens valleys, produces scalloped wall geometries (Fig. 2), while laying down laterally-amalgamted point bars at the base of the valley. Basal deposits are later buried beneath riverine and possibly estuarine or lacustrine strata during a rise in base level [5].

In cases where valley cutting and filling is controlled by elevation fluctuations in a terminal body of water, these fluctions are also expected to influence the character of associated fluvial stratigraphy. In the backwater zone of a river, where the mean elevation of the river bed dips beneath the elevation of the surface of the standing body of water near the coastline, the wetted perimeter of the channel increases downstream at bankful and lesser flows. This results in a reduction of flow velocity and the ability of the flow to transport sands, reducing the sand available for deposition on the lateral accretion surface of point bars and, as a result, reducing river migration rates [14]. When this process is integrated over time, a reach of time-integrated channel belt constructed within the backwater zone will be narrower relative to a reach of the same river constructed upstream of the backwater zone [15].

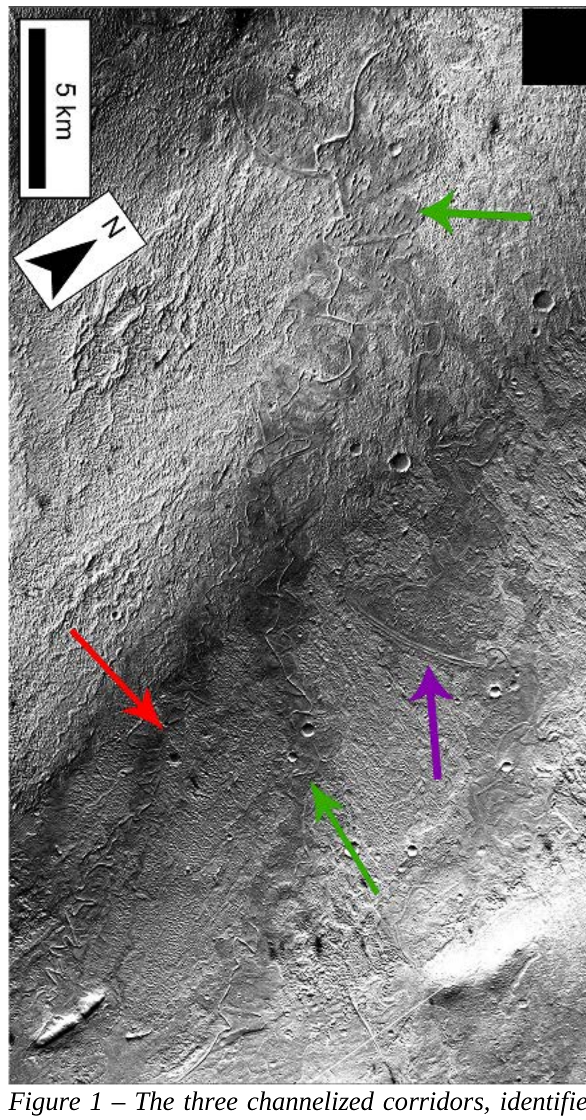

Figure 1 – The three channelized corridors, identified with green, purple, and red arrows, branch towards the southeast and are identifiable by their low albedo. The continuous green corridor cross-cuts the red corridor.

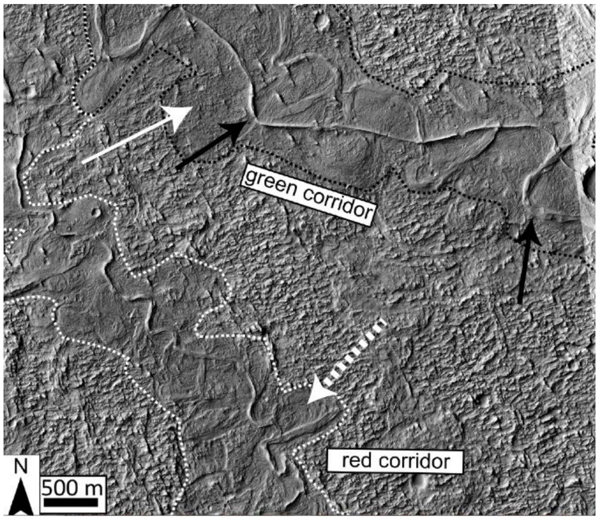

Figure 2 – Corridors are outlined and labeled. Note the low albedo and relative smoothness of strata within corridors. Scalloped boundary shapes are frequently observed. Black arrow points to stratigraphically high sinuous ridge. Dashed white arrow points to basal curved strata, and near sinuous ridges following corridor boundary. Solid white arrow points to smooth, structureless deposits within corridor with a lower albedo than terrain beyond the corridors..

Results: Deposits contained within the channelized corridors fit one of three facies: sinuous ridges, which are elongate topographic highs interpreted as topographically-inverted channel-filling deposits [1], curved strata, interpreted as the eroded, planar exposures of point bar lateral accretion surfaces [16], and structureless deposits differentiable from terrain beyond the corridors due to their low albedo, relative smoothness, and high thermal inertia (Fig. 2). Switching of sinuous ridge directions at different stratigraphic levels are characteristic of channel-reoccupation and stacking (Fig. 2), common occurrences in a net-depositional environment [17] such as a filling valley. The curved strata are consistently located beneath the sinuous ridges within the corridors.

Sinuous ridges stay completely within, and sometimes are positioned against, the corridor boundaries, indicating the boundaries were once associated with walls that confined flow and sedimentation to the area within the corridors (Fig. 2). Additionally, the corridor boundaries feature the scooped shape associated with lateral channel migration (Fig. 2), indicating these walls were shaped by the same processes as incised valley walls on Earth.

The stratigraphic sequence of facies is consistent with valley filling stratigraphy on Earth. At Aeolis Dorsa, the basal point bars (Fig. 2) represent a time of relatively high migration rates in a river reach we interpret as being upstream of the backwater zone. The sinuous ridges stacked above the point bars are consistently narrower than the laterally amalgamated point bars, representing a time of lower migration rates in a river reach we interpret as being located within the backwater zone. The fluctuation of the backwater zone over time is attributed to a fluctuating coastline position, consistent with a rising and falling coastline position inferred from episodes of incision and fill.

Rarely does valley incision depth equal the drop in water surface elevation in the terminal basin. This is due to lengthening of the fluvial system into the basin during the fall that decreases the amount of incision required for the river bed to reach quasi-equilibrium with a lower coastline elevation [e.g., 18]. Therefore, the thickness of a valley fill is only ever a minimum estimate of the total change in water surface elevation. At Aeolis Dorsa, the significantly eroded and potentially incompletely exhumed surface adds to this being a minimum estimate. Across-corridor relief varies from less than 10 to nearly 50 meters. Therefore, we place a minimum on total elevation change of the downstream water body at 50 meters. Cross-cutting corridors indicate at least two episodes of water level fall and rise of this magnitude. Interpreted deltaic deposits to the southeast [19] and the asymmetry of sinuous ridge bends [20] indicate that both paleoflow direction and the downstream body of water were located to the southeast.

Conclusions: The fluctuations of the standing body of water described here were slow enough to allow fluvial sedimentation styles to adjust, suggesting hydrologic activity inconsistent with brief catastrophic episodes.

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