SEDIMENTOLOGY OF AN ANCIENT OCEAN MARGIN AT AEOLIS DORSA, MARS. B. T. Cardenas[1] and M. P. Lamb[2], [1]Department of Geosciences, Penn State, University Park, PA, USA btcardenas@psu.edu, [2]Division of Geological and Planetary Sciences, Caltech, Pasadena, CA, USA

Introduction: The presence of an ancient ocean in the northern hemisphere of Mars is debated. Geomorphic features interpreted as ancient shorelines are unlikely to survive various erosional processes that have been active on Mars for the last several billion years[1-3]. Here, we provide new evidence for a northern ocean based on sedimentologic and stratigraphic analysis of sedimentary basin fill at Aeolis Dorsa, a region of Mars with the most dense collection of fluvial ridges[4], some of which have been interpreted as deltaic[5,6]. Aeolis Dorsa is a modern-day trough bound east and west by 2 km high plana and south by the hemispheric dichotomy boundary, along some hypothesized shorelines (Fig. 1).

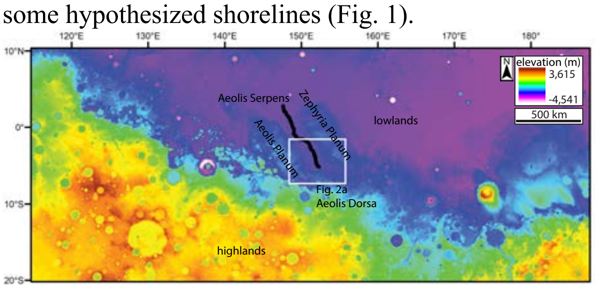

Fig. 1 – Aeolis Dorsa location map. White box shows location of Fig. 2. Black line shows Aeolis Serpens.

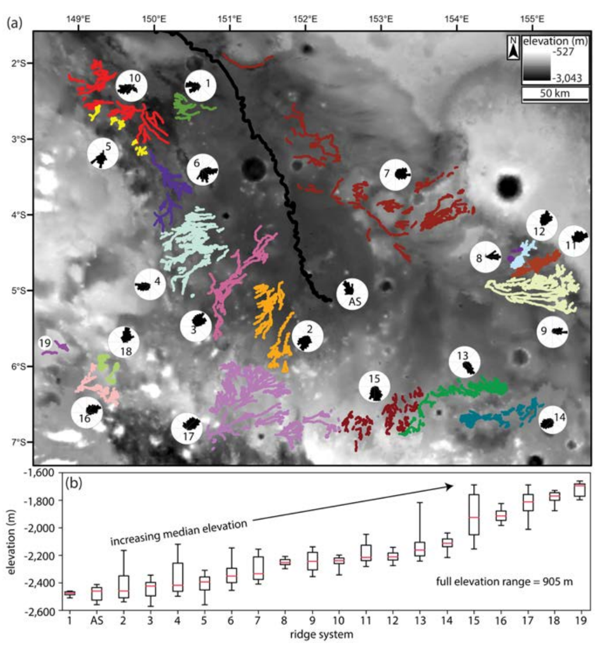

Fig. 2 – A: Numbered ridge systems and paleoflow directions at Aeolis Dorsa. B: Boxplots showing extracted ridge-system elevations, organized by median elevation used to define stratigraphic position.

Methods: We mapped ridges at Aeolis Dorsa using the new CTX global mosaic[7], and grouped them into 20 systems based on stacking, intersections, and proximity, including the singular 900 km ridge Aeolis Serpens[8] as its own system. Using CTX stereo-pair DEMs, we extracted ridge-top elevations for each system, using median elevation as an approximation for stratigraphic position. We measured paleoflow directions along each ridge top, assuming flow to have generally been towards the direction of branching. This assumption is supported by the results.

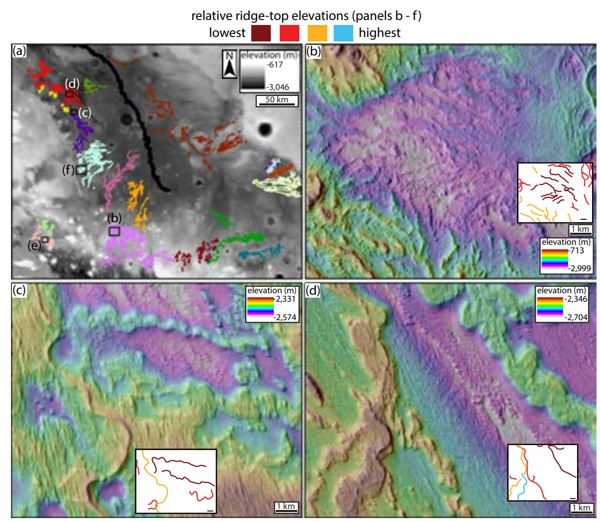

Fig. 3 – Belt stacking. A: Locations of panels. B-D: stacking examples. Insets show relative stratigraphic positions of different channel belts.

Results: We identified 20 ridge systems (Fig. 2). Ridge systems occupy over 900 m of vertical elevation (Fig. 2). Paleoflow directions represent the entire compass, with no consistent relationship to the modern topography (Fig. 2). Most systems contain stacked channel belts (Fig. 3), laterally shingled lobes, and trunk channel belts (Fig. 4). This is consistent with depositional systems[9,10] and distributary branching[11]. The primary exception is Aeolis Serpens, which has larger bends, a longer distance, and shows no evidence for branching (Fig. 1, 2).

Discussion: The stacking, shingling, and trunk channel belts present in most ridge systems are consistent with deltas filling in a large sedimentary basin. Stacking and shingling suggest the strata accumulated over time in an ancient landscape had relatively low relief set by laterally decreasing sedimentation rates away from channels. This is in stark contrast to the modern relief, which we interpret as erosional and not representative of any paleolandscape. Further, if Aeolis Dorsa is not a paleolow, the surrounding plana are not paleohighs. Trunk channels suggest the ridge systems were not alluvial fans, which originate at sudden changes in channel confinement and slope, rather than at an avulsion node along a primary channel. Megafans, large fluvial systems which may have trunk channels but not a downstream water body, would require a time-varying source of steep topography within the basin as a source, which we see no other evidence for.

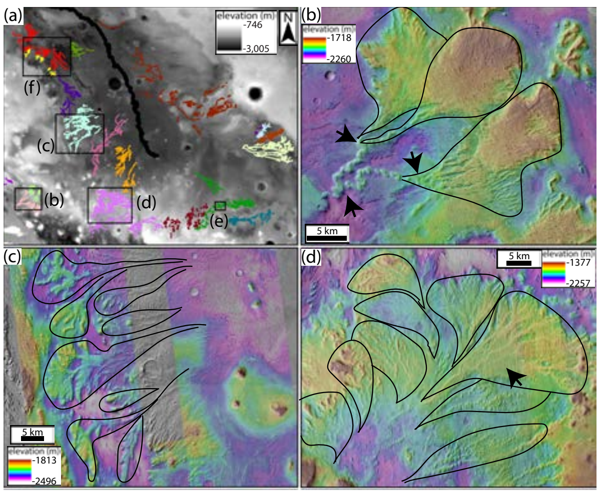

Fig. 4 – Ridge-system lobes. A: Locations of panels. B-F: Lobe outlines, based on geometry of branching deposits and locations of trunk channels.

The relatively high thickness of Aeolis Serpens, suggested by its unique 900 km continuity in spite of variable erosion, its larger bends, and lack of branching are consistent with a submarine channel belt[12]. Ridge system 1, the only stratigraphically lower system, is oriented as a splay of the main channel belt would be (Fig. 2). The length of Aeolis Serpens sets the minimum length of the basin, which is consistent with a northern ocean (Fig. 1).

We grouped ridge systems by location, stratigraphic position, and paleoflow direction, and reconstructed paleoshorelines at 5 timesteps (Fig. 5). Together, the sequence describes a three-dimensional shoreline that prograded northward, then retrograded to the south, with changes in primary sediment sources (east and west highlands) and the overall shape of the coastal plain. This shoreline evolution occurred during at least 900 m of net ocean-level rise, capturing the filling of the basin with water and sediment.

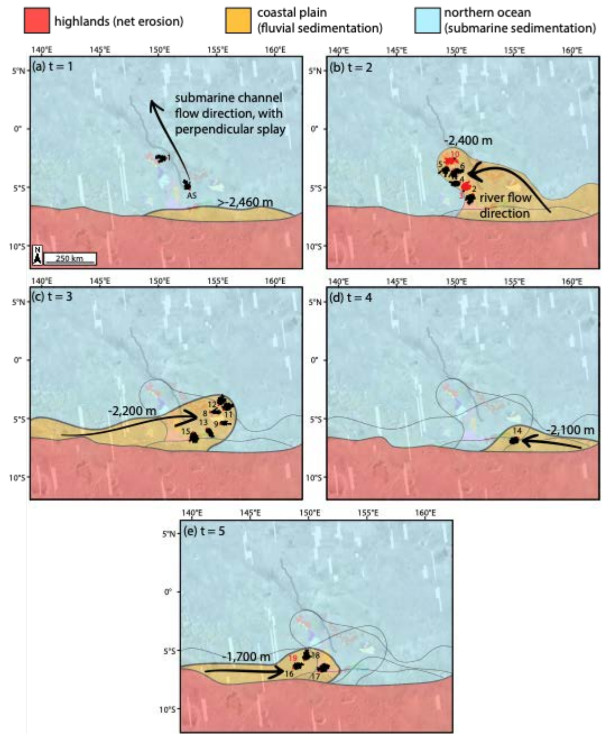

Fig. 5 – Paleogeography of ocean shoreline over 5 timesteps. Each panel shows general flow direction with the arrow, shoreline location and elevation. Rose diagrams match Fig. 2.

The 900 m of fluvial ridges is a minimum constraint on basin-fill thickness and sea-level rise. Uneroded plana bounding Aeolis Dorsa (Fig. 1) may contain similar, unexhumed deposits. Ridge system 14 (Fig. 2) is variably eroded from west to east, to the point of becoming indistinguishable from the bounding plana landscapes. This, coupled with the low-gradient paleotopography, suggest the only difference between the Aeolis Dorsa trough and the surrounding plana (Fig. 1,2) is the degree of erosion. If correct, basin-fill thickness and captured sea-level rise could exceed 2 km. Even these highest estimates are within bounds of ancient martian water volumes [13].

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