HYPANIS VALLES DELTA: THE LAST HIGH-STAND OF A SEA ON EARLY MARS. P. Fawdon[1], S. Gupta[2], J. Davis[3]. N, Warner[4], E. Sefton-Nash[5], J. Adler[6], J. Bell[6], M. Balme[1], P. Grindrod[3], [1]Dept. of Physical Scienc-es, Open University, Milton Keynes, UK, (Peter.fawdon@open.ac.uk), [2]Dept. of Earth Science and Engineering, Imperial College, London, UK, [3]Dept. of Earth Sciences, Natural History Museum, London, UK, [4]Department of Geological Sciences, SUNY Geneseo, Geneseo, NY, [5]ESTEC, European Space Agency, The Netherlands, [6]Arizona State University School of Earth and Space Exploration, Tempe, AZ

Introduction: The sediment fan complex at the termination of Hypanis Valles is the largest proposed delta system on Mars (Fig. 1), and is likely late-Noachian/early-Hesperian in age [1, 2]. The location of such a large delta here, at the dichotomy boundary between the northern lowlands and southern highlands, suggests the past presence of a large water-body in the northern plains. However, the concept of a stable standing body of water filling the northern lowlands is contentious: while many Noachian-aged surfaces display evidence for ancient water flow such as the valley networks [3], palaeolake basins [4] and sedimentary fan deposits [e.g., 5, 6], consistent geomorphic evidence for a shoreline around Mars' northern lowlands [e.g., 7] is more tenuous. Perhaps the best evidence comes from the identification of sedimentary fans around the martian dichotomy boundary along an equipotential surface (-2,540 m; [3]). Here we describe the palaeogeomorphology of the Hypanis fan and consider the evidence for its origin.

Observations: The Hypanis sediment fan is located in a tectonically stable region at the boundary between the Noachian-aged Xanthe Terra region and the Amazonian-aged surface of Chryse Planitia [1]. The fan complex comprises a series of distinct semi-circular to lobe-shaped sediment bodies, connected by multiple bifurcating flat-topped ridges. Elements of the fan system appear to extend at least 140 km NE of the Hypanis Valles outlet, and descend 500 m in elevation. Key observations are summarized here:

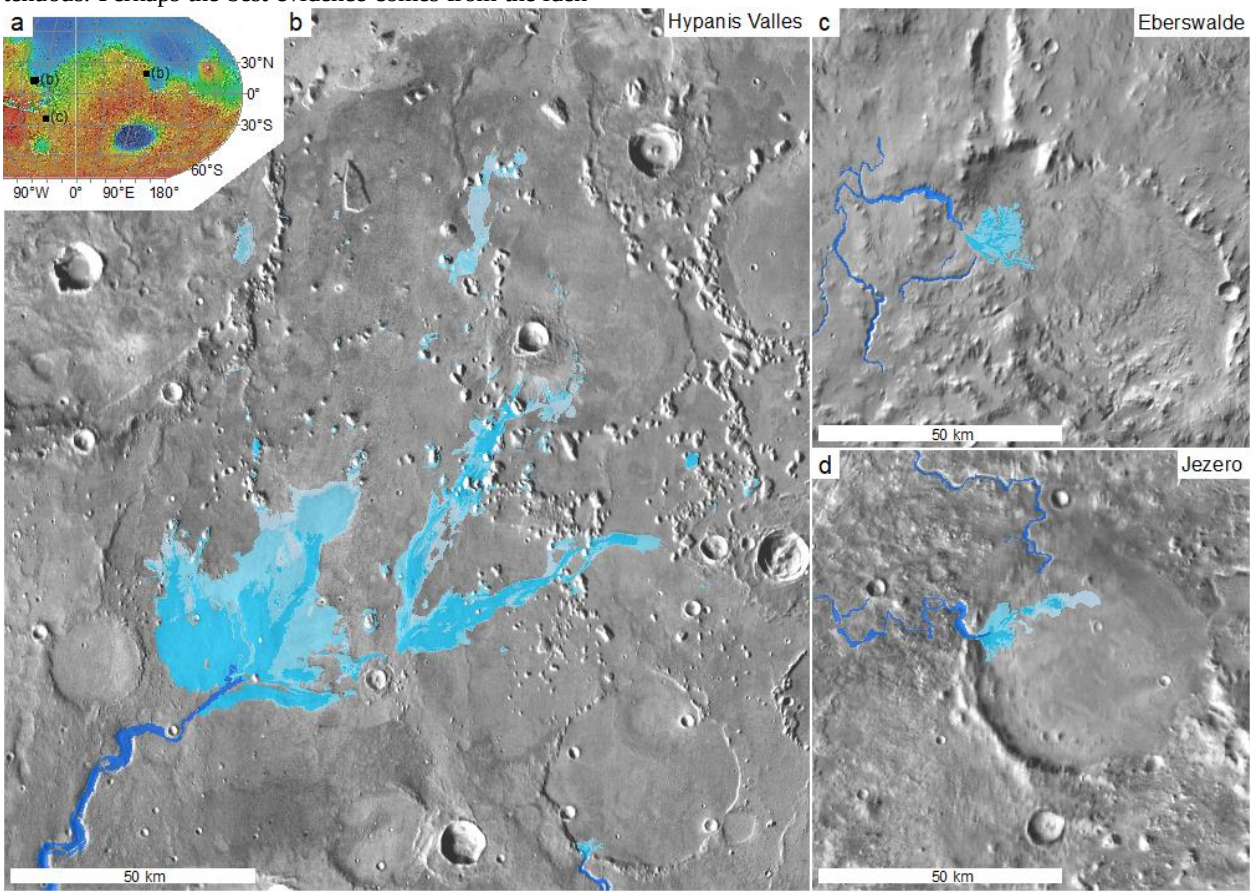

Fig 1: The Hypanis delta is multi-lobed sediment fan system located at the margin of Chryse Plantia (a,b)). With an area of ~970 km^2 Hypanis is >7 times larger than comparable sediment fans elsewhere on Mars such as (b) Eberswalde at ~125 km^2 and (c) Jezero crater at ~65 km^2. (Fan upper surfaces; mid blue, eroded surfaces; light blue, and associated channels; dark blue).

Primary fan sediment bodies. The largest sediment fan body forms an semi-circular arc with irregular outer edges that is composed of several arcuate and finger like-projections (fig 2a) which extend ~25 km from the outlet of Hypanis Valles (located at an elevation of ~ -2500 m). The main fan body upper surface contains a latticework of subparallel, curvilinear, flat-topped ridges with length scale of tens of meters. The fan edge is a scarp in which meter-scale, sub-horizontal layering is exposed, contiguous for tens of kilometers (fig 2b).

Superposed on the primary fan body, we observe a 13 km long 2 km wide flat-topped ridge, initiating at the Hypanis outlet and extending NNE across underlying fan deposits, before stepping out onto plains materials. It then forms a 13 km by 10 m lobe-shaped deposit overlying dark-toned plains materials (fig 2c).

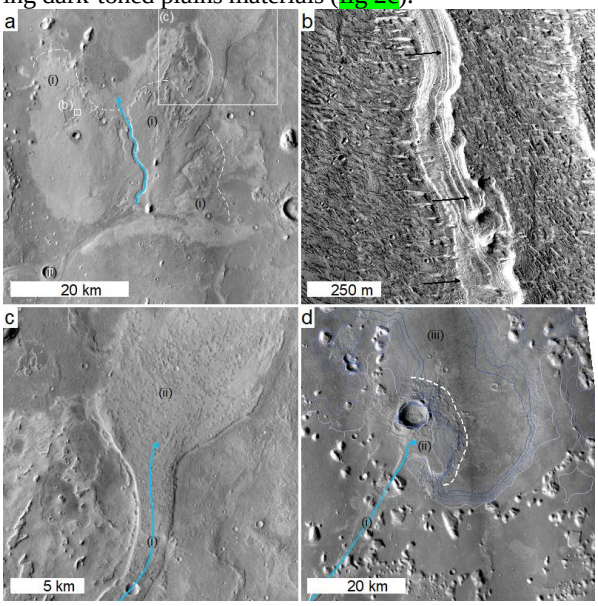

Fig 2: Elements of Hypanis Valle sediment fan systems including (a) surface of the main fan (b) layering the erosional scarp (c) first prograded fan and (d) downslope fan.

Ribbon-like palaeochannels and distal fan lobes. In addition to the primary fan deposit, a series of ribbon-like ridges (~1 km wide) extend up to ~170 km from the Hypanis outlet. Their upper surfaces contain curvilinear lineations that we interpret as the margins of former channel deposits that have become laterally stacked. HiRISE images indicate that the ridge cross-sections are comprised of meter-scale layering, continuous on a 10 km-scale. 120 km northeast of the Hypanis outlet, the ribbon-like ridge opens out into a lobe-like plateau (fig 2d). This lobe, > 10 km wide and identified by exposures of light-toned layered material is at ~ -2900 m elevation. The furthest outcrops of distal channel arms and remnant fans occur ~145 km northeast from the main entry point at ~ -3025m elevation. All these fans are topographically unconfined northwards, so open into Chryse Planitia.

Erosion and incision. The Hypanis Valles sediment fan complex and ridges extending from the Hypanis outlet are preserved in inverted relief. The main sediment fan body is incised by a ~1 km wide channel. This either records fluvial incision during base-level fall or a late-stage incisional episode related to increased fluvial discharge.

Interpretation: The size, morphology, and sedimentary architecture of the Hypanis sediment fan complex appear to be inconsistent with deposition as an alluvial fan. The Hypanis fan shows multiple channel-lobe transitions which do not occur only at the bedrock-pinned outlet of Hypanis Vallis, but instead are located basinwards of this point. Moreover these are not transitions from an incised channel to a depositional lobe, but instead occur basinwards of a ridge interpreted as an inverted depositional channel. An explanation for the channel-lobe transition is that it records deposition at the margin of a standing body of water. The channel-lobe transitions show progressive basinward 'step-out' as the stratigraphy youngs but drop in elevation.

We propose that this basinward-step in the apex of the channel-lobe transition reflects basinward progradation of fan bodies through time but also basinward-shoreline migration through time. Our observations are inconsistent with the Hypanis fan being a simple alluvial fan, in which the fan body is formed by channels avulsing around the fixed node at the Hypanis outlet. Instead we interpret the Hypanis fan complex to be a deltaic deposit composed of multiple channels and lobes [8, 9], which formed at the margin of a large, standing body of water. The deltaic deposits have since been exhumed and are now preserved in inverted relief.

Conclusion: Crucial to that history is the possibility of an ocean early in martian history. The sedimentary architecture and palaeo-geomorphology of the Hypanis Valles sediment fan and its catchment is compelling evidence for an ancient delta that prograded into a standing body of water. Because Hypanis Valles is open to Chryse Planitia, the system potentially records the last high-stand of a sea or ocean during the late-Noachian or early-Hesperian.

References: [1] Tanaka et al., 2014 USGS map 3292, [2] Warner et al., LPSC XLVIII #1089 [3] Hynek and Di Achille (2010) Nature geosci 3, 7; [4] Fassett and Head (2008), 198,1,37-56; [5] Moore et al., (2003) J. Geophy. Res., 112, p.E05S03, [6] Rice et al., (2013) Mars; v. 8, p. 15-57, [7] Clifford and Parker, (2001) Icarus, v. 154, p. 40–79, [8] Van Dijk et al., (2009) Sedimentology, v. 56, p. 1569–1589 [9] Van Dijk et al., (2012) Sedimentology, v. 59, p. 2125–2145