HYDROLOGICAL HISTORY OF A COMPLEX LAKE AND VALLEY SYSTEM IN WESTERN ARABIA TERRA, MARS. Z. I. Dickeson[1,2], P. M. Grindrod[1], I. Crawford[2], M. R. Balme[3], S. Gupta[4], J. L. Davis[1], [1]Dept. of Earth Sciences, Natural History Museum, London, UK (z.dickeson@nhm.ac.uk), [2]Dept. of Earth and Planetary Sciences, Birbeck College, University of London, London, UK, [3]Dept. of Physical Sciences, Open University, Milton Keynes, UK, [4]Dept. of Earth Science and Engineering, Imperial College, London, UK.

Introduction: Arabia Terra hosts diverse landforms indicative of hydrological processes including: fluvial valleys [1], deltas [2], palaeolakes [3], possible ocean shorelines [4], and groundwater upwelling [5]. However, there is little consensus on the timing, duration or interaction of hydrological processes, and detailed study is often limited by the resolution of topographic data. This study focuses on a small area in western Arabia Terra of middle Noachian age [6] situated near the crustal dichotomy, and utilizes high resolution digital terrain models (DTMs) to reconstruct the past hydrological system. The goal of this work is to reveal the interplay and relative timing of hydrological process in the broader region which includes the ExoMars 2020 rover landing site.

Observations: Geomorphological features were mapped using CTX, HiRISE and THEMIS images in ArcMap. Topographic data derived from ISIS and SOCET SET were used to obtain a DTM mosaic at 2 m/pixel and 20 m/pixel from HiRISE and CTX stereo imagery respectively, and supplemented with 150 m/pixel HRSC DEMs.

Fluvial valleys were observed across the study area as apparently unconnected segments with a maximum width and depth of ~1 km and ~250 m. The valley heads are characterized as being shallowly incised and beginning within basins, with the few tributary branches beginning in box canyons. A combined ~166 km of valleys were mapped in the study area with the longest section being ~43 km long (Fig.1).

Seven distinct basins were identified and possible palaeolake extents in each were inferred from three different outlet channel elevations (Fig.2). The effect of younger topographic features such as impact craters and collapse pits on calculated palaeolake extents was not significant, and the total maximum surface area of all inferred palaeolakes is 2187 km^2, with the largest individual body being 1045 km^2.

Five sedimentary fans were identified by morphology, topography and fine sedimentary structures. Two of the fans empty into closed basins at elevations similar to outlet channels in the same basins, and three other fans occur at locations and elevations open to the northern lowlands, at –3430 m, –3560 m and –3860 m. The largest fan opens into the northern lowlands and has an area of ~61 km^2.

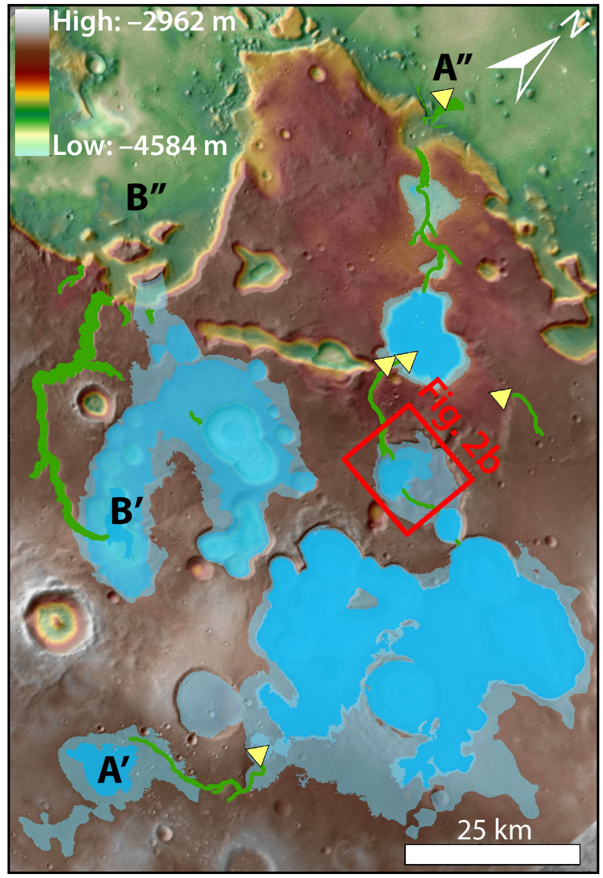

Figure 1 – Topographic map of study area, with valleys (green lines), sedimentary fans (yellow triangles), and palaeolakes inferred from outlet valley start (dark blue), valley floor spillover (blue), and bank spillover (pale blue). The beginnings and ends of two valley systems are marked as A'/B' to A''/B'' respectively. (CTX, HiRISE and HRSC DEM over THEMIS IR Day mosaic, top left corner of map at 16°W 31°N)

Interpretation: A lack of meandering channels and branching tributaries along with the presence of abandoned channels may indicate high discharge rates and periodic activity. Bank spillover elevations are interpreted as representing earlier maximum palaeolake extents, while valley base and outlet start elevations represent progressively later post-incision extents with smaller and lower surfaces. Changes in palaeolake level and extent over time are supported by the occurrence of a topographically higher sedimentary fan incised by a valley to form a new lower fan within

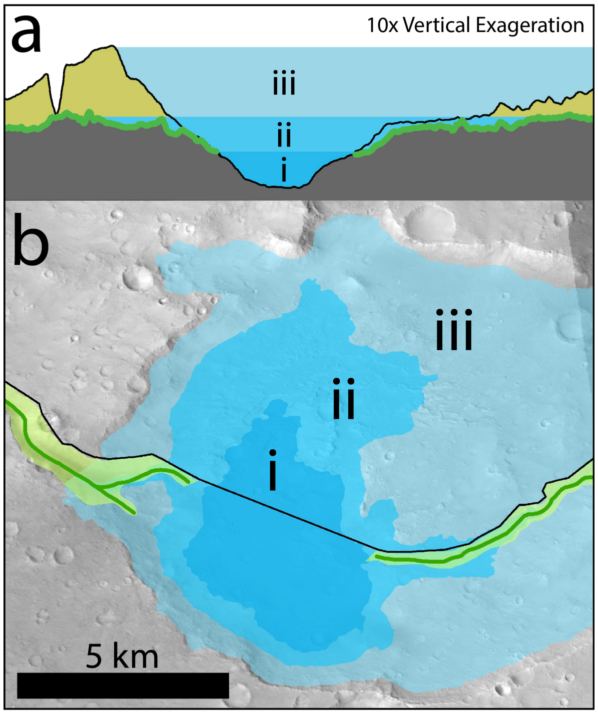

Figure 2 – Detail of inferred palaeolake (a) levels and (b) extents derived from outlet valley elevations at (i) start of outlet valley –3600 m (dark blue), (ii) spillover along valley base –3530 (blue), and (iii) spillover at valley bank –3390 m (pale blue) with topography (black line), valley base (green line), and incised valley (light green area). Inferred direction of flow is right to left. (CTX image D16_033549_2114_XI_31N014W)

the same basin. In basins where inlet and outlet valleys were not connected, the elevations at the start of the outlet and the end of the inlet were a good match (Fig.2,i), supporting the existence of a standing water body. Palaeolake extents inferred from outlet valley elevations link the majority of discontinuous channel segments into connected valley and palaeolake chains (Fig.1). Two separate lake chain systems are identified that are not connected at surface level, and which drain into the northern lowlands through different valleys. The surfaces of the largest palaeolakes in both systems share an elevation (–3390 m), and based on current topography are only separated laterally by ~1.5 km. These correlations along with the observation that the smaller system has a limited catchment area may suggest groundwater connectivity between the bodies. Even the larger system 'A' has a small catchment area, and it may be that both systems are the result of groundwater filling.

One palaeolake (valley system 'B' in Fig. 1) inferred by bank spillover did not describe a closed basin on current topography, and its extent was artificially truncated to be isolated from the northern lowlands. This inconsistent extent may have resulted from the removal of a bounding basin edge, of which only a few high mesas remain. The narrow areas in which the basin opens to the lowlands are steep-sided asymmetrical depressions resembling chaos terrains, and may be the result of collapse at a time after the palaeolake existed. Another apparent inconsistency is that all outflow valleys beginning in palaeolake basins are lower (up to 270 m) than the valley base spillover elevation (Fig.2,i&ii). These segments of apparent upslope valleys in the downstream direction are more shallowly incised than the majority of the valley and may indicate a later period of erosion into a reduced palaeolake, the hydraulic pressure of overlying ice, or subsidence of the lake area.

Conclusions: Sedimentary fan deposits and palaeolake extents inferred from outlet channel elevations serve to reconstruct the hydrological setting of the area, and reveal two valley and lake systems with no surface connection. The close proximity of the two systems, their shared surface elevation, and the limited potential catchment area suggests groundwater connectivity and filling. Palaeolake extents inconsistent with basin topography may be the result of subsidence and collapse linked to groundwater drawdown or base level change, and valley slopes inconsistent with inferred flow directions may indicate processes related to subsidence or extensive ice cover.

The Oxia Planum landing site of the ExoMars 2020 rover is situated on the crustal dichotomy ~900km to the SSW and at a similar elevation (–3000 m to –3400 m) to the study area. Therefore the hydrological processes active within the study area – particularly groundwater upwelling and open sedimentary fans – are of relevance to the landing site.

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