INVERTED CHANNELS IN ARABIA TERRA, MARS: REMNANTS OF AN ANCIENT DRAINAGE NETWORK. J. M. Davis[1, 2], M. Balme[3], P. M. Grindrod[2, 4], R. M. E. Williams[5], and S. Gupta[6]. [1]Dept. of Earth Sciences, University College London, London, UK, [2]Centre for Planetary Sciences at UCL-Birkbeck, University College London, London, UK; joel.davis.09@ucl.ac.uk, [3]Dept. of Physical Sciences, The Open University, Milton Keynes, UK, [4]Dept. of Earth and Planetary Sciences, Birkbeck, University of London, London, UK, [5]Planetary Science Institute, Tucson, AZ, USA, [6]Dept. of Earth Science and Engineering, Imperial College London, London, UK.

Introduction: Valley networks are some of the strongest lines of evidence for sustained fluvial erosion by running water on Mars [1]. Unlike most Noachian terrains, valley networks are sparse throughout much of Arabia Terra, an ancient terrain that borders the highland-lowland dichotomy. This is unusual, not least because some climate models for early Mars predict high rates of precipitation in Arabia Terra [2].

Here, we present the results of a survey, which shows that Arabia Terra contains a quasi-continuous system of channels and valleys of hitherto unrecognized extent. These features are visible as inverted channels, positive relief landforms left after extensive differential erosion of water-lain sediments.

Our results suggest that the inverted channels in Arabia Terra are contiguous with the highland valley networks further south and that they may have formed an important fluvial link between the equator and the northern plains.

Geology of Arabia Terra: Arabia Terra comprises the most northerly portion of Mars' southern highlands and is generally considered to be one of the oldest terrains on the planet (mid- to late-Noachian; [3]).

Remnants of thick, layered sedimentary units that mantle topography (sometimes referred to as "etched terrain"; [4]) suggest that Arabia Terra was once subject to widespread resurfacing and denudation, indicating that any valley networks may have been buried and/or removed by erosion [5]. Valley networks that flow north from the equator are truncated beneath these units.

Survey Results: Several previous studies have reported on the presence of inverted channels in Arabia Terra [e.g. 6]. We performed a CTX-scale (~ 6 m/pixel) survey to map all sinuous and/or branching features likely to be inverted channels (Fig. 1, 2). Nearly 14,000 km of inverted channels were identified across the study area in various states of preservation as part of a quasi-continuous network between the equator and the northern lowlands (Fig. 3). The majority of these have not previously been reported.

Inverted Channel Morphology: Like the Noachian valley networks, many of the better preserved inverted channels are dendritic, sinuous, have low junction angles, and similarly high stream orders (Fig. 1, 2). Some inverted channels show HiRISE-scale layering (where coverage is available), suggesting they may have aggraded as part of a depositional channel complex.

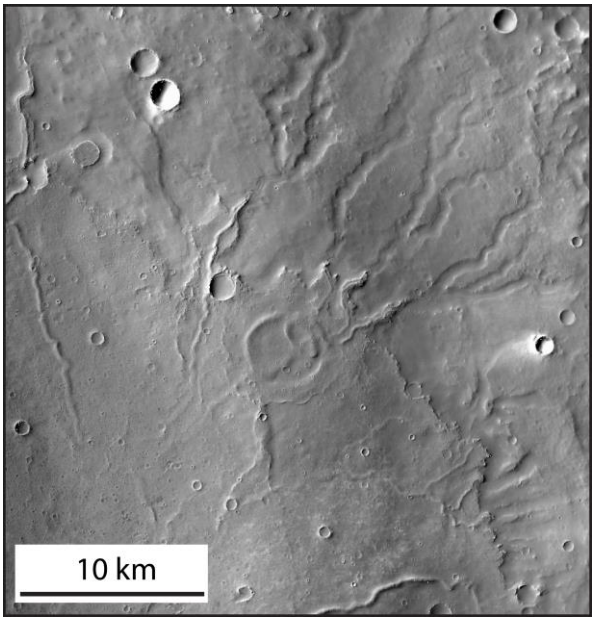

Figure 1: CTX mosaic of valley networks (north-east) which transition into inverted channels (south-west) in Arabia Terra. Strahler stream orders of up to 4 are seen.

Distribution and Stratigraphy: Unlike the better preserved valley networks further south, the inverted channels often occur in isolated and disjointed segments. The longest individual segment was ~200 km, though spatial relations suggest that some segments were once contiguous as part of a wider system (Fig. 3).

Some areas show high concentrations of inverted channels, most notably the south-west Arabia Terra region, just north of Meridiani Planum, where the drainage densities can be as high as 0.2 km^{-1} for individual networks. This is similar to the maximum observed drainage density value recorded for individual valley networks elsewhere (0.14 km^{-1}; [1]). However, many other regions within the study area are largely free of inverted channels. As these areas tend to be topographically low, it is possible all traces of the inverted channels have been removed by erosion.

The inverted channels almost exclusively occur on flat-lying Noachian terrains, near the bottom of the stratigraphy. They are usually found beneath or near the base of the etched terrain (e.g. Fig 2b). Additionally, some inverted valleys appear to radiate away from local highs (e.g. craters), suggesting they had a local source, and others interconnect with the Noachian valley networks further south (Fig. 1, 3). The similarities between the inverted channels and the Noachian valley networks suggest that the two may have had a similar origin.

Implications for Fluvial History: The inverted channels indicate that during the Noachian there were probably extensive valley networks throughout Arabia Terra that formed as a result of precipitation driven surface-runoff. Differential erosion between the channel sediment and surrounding material then led to the formation of inverted channel systems. These were then buried by the etched terrain, which formed at the late Noachian/early Hesperian boundary, protecting the inverted channels from erosion, before it was more recently eroded back, exposing the channels.

The inverted channels may have originally formed the middle part of a global south to north fluvial transport system between the equator and the northern lowlands. Our results show that there is no need to search for an explanation for "missing" valley networks in Arabia Terra: dissection was more globally extensive than previously thought.

References: [1] Hynek et al (2010) *J. Geophys. Res., 115*. E09008; [2] Wordsworth et al (2015) *J. Geophys. Res. Planets, 120*, 1201-1219; [3] Tanaka et al (2014) *USGS Sci. Invest. Ser. Map* 3292; [4] Hynek and Di Achille (2016, in press) *USGS Sci. Invest. Ser. Map*; [5] Hynek and Phillips (2001) *Geology, 29*, 407-410; [6] Willams and Chuang (2012) *LPSC XLIII*, Abstract #2156.

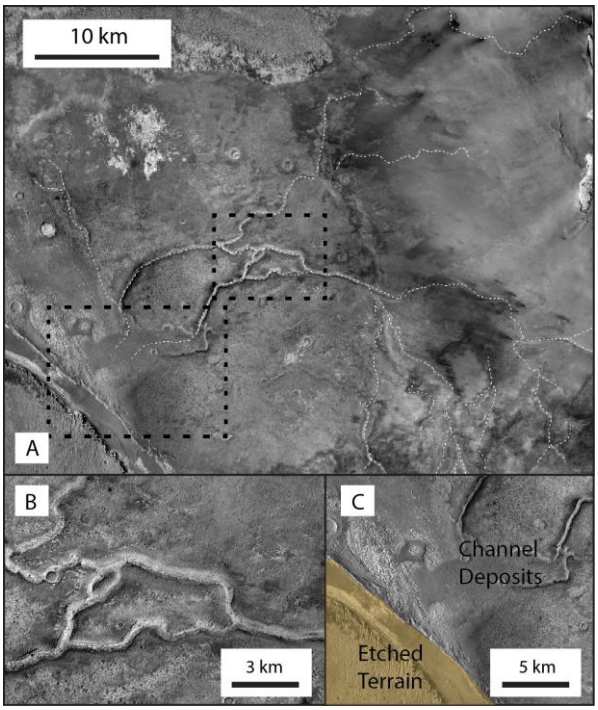

Figure 2 (above): (a) CTX mosaic of inverted channel network. Drainge is thought to be from east to west; (b & c) enlargments of (a); (b) anastomosing inverted channel approximately 50 m in height above surrounding plains; (c) inverted channel deposits which terminate under younger, early Hesperian "etched terrain".

Figure 3 (below): Map of inverted channel deposits (black) throughout Arabia Terra. Valley networks mapped by [1] are shown in white. The inverted channels fill much of the gap between the valley networks and the northern lowlands. Concentrations of inverted channels are highest in SW Arabia Terra.