FLUVIAL MAPPING AND STRATIGRAPHY OF THE SOUTH-WESTERN MELAS BASIN AND PLATEAU, VALLES MARINERIS, MARS: EPISODIC FLUVIAL PHASES AND IMPLICATIONS FOR CLIMATE. J.M. Davis[1,2], P.M. Grindrod[2,3], R.M.E. Williams[4], P. Fawdon[2,3], S. Gupta[5], and M.R. Balme[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 Earth and Planetary Sciences, Birkbeck, University of London, London, UK, [4]Planetary Science Institute, Tucson, AZ, USA, [5]Dept. of Earth Science and Engineering, Imperial College London, London, UK, [6]Dept. of Physical Sciences, The Open University, Milton Keynes, UK.

Introduction: The south-western Melas Chasma basin (SMB) is an enclosed depression in Melas Chasma, Valles Marineris. The basin is widely recognised as having hosted a variety of longed-lived surficial and near-surficial aqueous processes [e.g., 1-3]. Central to this interpretation are branching valley networks and a valley-fed palaeolake in the eastern half of the basin. Crater counting has constrained this aqueous activity to the early Hesperian [2], later than the global valley-forming phase at the end of the Noachian [e.g., 4]. However, recent work suggests there were at least two lake highstands in the SMB [3]. Building on this understanding, we present high-resolution maps documenting the aqueous features present and the stratigraphic evolution of the SMB.

Motivations and Methods: Fluvial features in the SMB have previously been mapped using THEMIS-IR (100 m/pix)data, as well as some spatially-limited THEMIS-VIS (18 m/pix) and MOC (1.5-12.5 m/pix) data [1, 2]. The stratigraphy of the palaeolake has also been well documented at high-resolution [3], in part due to the site's candidacy for landed missions such the NASA 2020 rover mission [5, 6].

Here, we utilize recent, near-continuous, high-resolution HiRISE (0.25 m/pix) and CTX (6 m/pix) images and DEMs to map fluvial features previously below the available image resolution to understand the broader stratigraphic architecture and evolution of the SMB, initially summarized in [7].

Results: We have observed identified a much larger number and density of valley and channel networks in the SMB, particularly at the distal ends of the basin. We define six drainage networks within the SMB and an additional network outside it (Fig. 1). Two of these drain into the paleolake; the other five drain directly into Melas and Ius Chasma. Valleys and channels are generally denser and have higher stream orders than previously identified: all are at least fourth order systems; drainage densities range between 0.11-1.97 km^{-1}.

We also identify a series of branching and sinuous ridges across the SMB, which we have interpreted as inverted fluvial channels. These inverted channels have a complex stratigraphy and have been subsequently incised by later channels (Fig. 2). We also find topographic and stratigraphic evidence for earlier paleolakes existing within the SMB, distinct from the main paleolake that has been previously identified [2, 3].

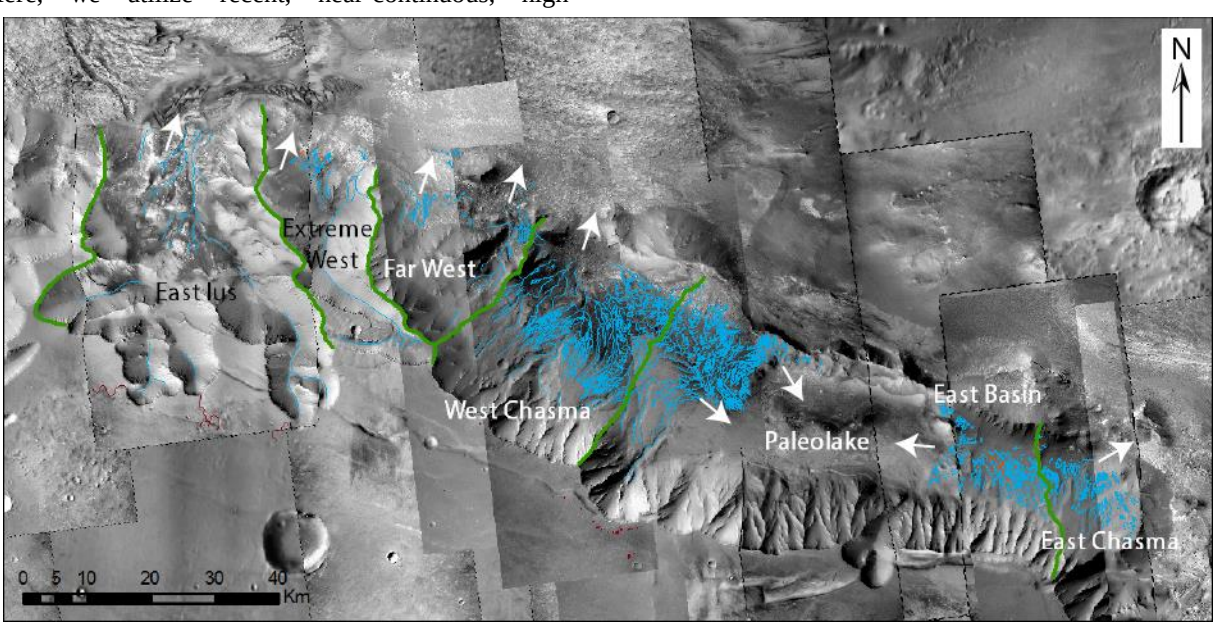

Fig. 1: Updated drainage maps of the SMB and plateau region on CTX and THEMIS basemap. Valleys and channels = blue lines; inverted channels = orange lines; plateau valleys = red lines; watersheds = green lines.

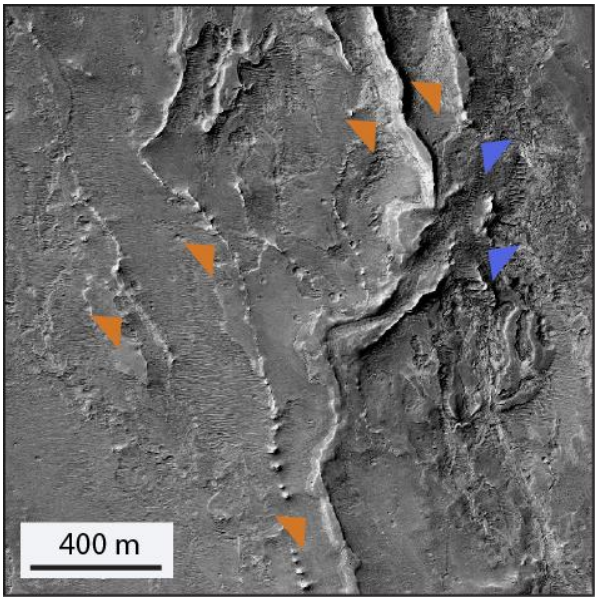

Fig. 2: Inverted channels (orange arrowheads) in the SMB. They have been incised by later channels (blue arrowheads), indiciating a break in fluvial activity.

Fluvial systems incise into, and are preserved on a medium-toned, layered draping material throughout the SMB (defined as ML, "medium-layered" [8]). Erosional outliers indicate that several hundred meters of vertical thickness of ML has been removed from the SMB. These outliers are bounded at their bases and top surfaces by regular and inverted channels. Many of the valley and channels have been infilled by light-toned material (defined as LD, "light-draping" [8]), which appears to have been re-worked from high up on the wall slopes of the basin [8]. LD has also been subsequently incised by later stage channels, although these are narrower in width than fluvial systems elsewhere, and more geographically restricted throughout the basin. Both ML and LD are thought to originally have formed as airfall units [8].

In addition, we also observe fluvial systems on the plateaus of Melas and Ius Chasma. These systems are dendritic and originate at multiple elevations, and converge on the heads of amphithreate-headed tributary canyons, which themselves drain into Melas and Ius Chasma. We have not fully mapped the extent of these fluvial systems, although they extend for at least ~150 km west along Ius Chasma. Within some of these tributary canyons, there are fluvial valleys that do not originate from the plateau and instead drain from the canyon wall slopes; in other places, the contents of the canyons are buried by talus materials.

Discussion: Our new fluvial maps indicate that fluvial acitivity appears widespread across the entire SMB region and into Ius Chasma, and possibly on the Melas and Ius plateaus. The drainage density values here are among the highest reported for martian valley channels; even the lowest density is well above the mean for Noachian highland valley networks (0.0115 km^{-1}; [9]) and they are indicative of long-lived sediment routing systems that were frequently recharged.

The vertical thickness of ML removed suggests that ML is at least several hundred meters thick. The stratigraphy of this unit is consistent with multiple fluvial phases occurring during the history of the SMB. ML likely formed as a result of a fluctuating balance between airfall deposition and erosion throughout a series of repeated "wet-dry" phases.

ML initially accumulated as an airfall deposit. During the "wet" phases, the SMB fluvial systems were active, leading to the erosion and possible mineralogical alteration of ML. During the "dry" phases, ML continued to accumulate and fluvial channel sediment was exhumed and inverted. Repeated "wet-dry" phases must have occurred as (1) inverted channels occur at multiple stratigraphic levels and (2) they are cross-cut by later channels. The dissection of LD valley-infill by young fluvial channels indicates there was a later, weaker fluvial phase after ML had ceased to form.

Outside of the SMB, the existence of dendritic valleys at the heads of the tributary canyons leading into Melas and Ius Chasma appears inconsistent with the point origin of a groundwater outlet, and more consistent with precipitation driven runoff. The presence of additional valleys and channels within these tributary canyons also supports this formation mechanism.

Conclusions and Implications for Climate: The fluvial maps and morphometrics are consistent with widespread precipitation across a 120 km section of Melas Chasma [10]. The stratigraphy suggests there were repeated "wet-dry" phases throughout the history of the SMB. Indeed, fluvial activity may have been more regional, with runoff-fed systems draining from Melas and Ius plateau into Valles Marineris. Regionally extensive conditions may have been favourable for liquid water for sustained periods of geologic time in the early Hesperian.

References: [1] Mangold et al., 2004, *Science* 305 78-81; [2] Quantin et al., 2005, *JGR* 110 E12S19; [3] Williams and Weitz, 2014, *Icarus* 242 19-37; [4] Irwin et al., 2005b, *JGR* 110 E12S15; [5] Williams et al., 2015, Mars 2020 Landing Site Workshop, Arcadia, CA; [6] Davis et al., 2017, *LPSC XLVIII* abstract #1873; [7] Davis et al., 2015, *LPSC XLVI* abstract #1932; [8] Weitz et al., 2015, *Icarus* 251 291-314; [9] Hynek et al., 2010, *JGR* 115 1-14; [10] Craddock and Howard, 2002, *JGR* 107(E11).