THE EVOLUTION OF ANCIENT FLUVIAL SYSTEMS IN MEMNONIA SUCLI, MARS: IMPACT CRATER DAMMING, AGGRADATION, AND A DRYING INNER SEA ON THE DICHOTOMY? J. M. Davis[1], L. Aranos[2] and P. Fawdon[3] [1]Dept. of Earth Sciences, Natural History Museum, London, UK (joel.davis@nhm.ac.uk), [2]Dept. of Earth Science and Engineering, Imperial College London, London, UK, [3]School. of Physical Sciences, Open University, Milton Keynes, UK.

Introduction: Fluvial systems near the topographic dichotomy of Mars show conflicting evidence [1,2] for an ancient northern ocean, which has major implications for the early climate. In this study, we investigate a series of dichotomy fluvial systems (valley networks, paleolakes, sediment fans) in Memnonia Sucli, on the margin of the Medusae Fossae Formation (MFF; [3]). We consider the evolution of both the upslope catchment and the downslope basin. Our study site is situated in the western Memnonia Sulci region (-11.3°N, 174°E). Here, the dichotomy is bordered by heavily cratered Noachian highlands to the south and the MFF to the north [4]. The region between the dichotomy and the MFF forms a topographically enclosed basin, which runs 500 km SW-NE along its longest axis.

Observations: *Catchment of the fluvial systems.* Erosional valley networks in this region drained north towards the dichotomy. One of the longest of these systems was fed by a 64,000 km^2 watershed, which intersects an open basin paleolake containing terrace structures [5]. Our study focuses on the 190 km northern section of this valley network (V1N; Fig. 1), which runs from the terraced paleolake to the dichotomy. The walls of the valley network here are highly degraded and valley itself has been significantly infilled. Along distinct two sections, the valley infill is incised, one section beginning at the paleolake outlet (I1) and the other at a knickpoint approximately 70 km south of the valley mouth (I2; Fig. 1).

The ejecta blankets of two impact craters (crater A: D=20 km; crater B: D=12 km) overlie parts of V1N. As I1 approaches crater A, it becomes infilled by ejecta until it is no longer recognizable. Similarly, I2 has also been infilled by ejecta from crater B at its northern end, but the ejecta has subsequently been incised. A 5 km long ridge, interpreted as fluvial channel deposits now preserved as an inverted channel system, is situated within I2, which also overlies the ejecta from crater B (Fig. 2A). South of crater B is another valley network (V1W), approximately 80 km in length, which runs sub-parallel to V1N. Like V1N, V1W is highly degraded and has been significantly infilled. At it approaches crater B, V1W abruptly changes direction to the SW, where it debouches into a 13 km closed basin (sub-basin 1), likely a highly degraded impact crater. Branching and re-joining ridges, also interpreted as inverted channels are found in this region (Fig. 2B).

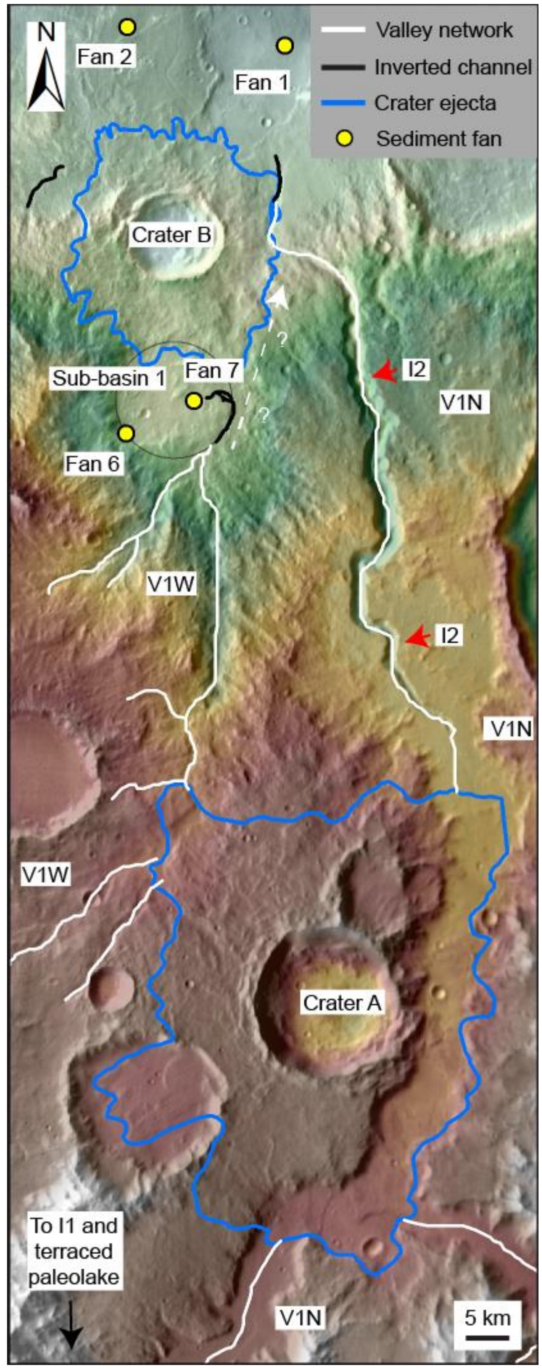

Figure 1: HRSC-MOLA topographic map of V1N and V1W, valley networks which have undergone incision, impact damming, re-routing and aggradation.

Sediment fan deposits. We have identified five sediment fans (Fans 1-5) within the basin bound by the dichotomy and the MFF (Fig. 3). With one exception, the fans all form into topographically closed regions of this basin (i.e., not open to the lowlands). These fans comprise exhumed, bifurcating ridges and lobate deposits. Fans 1-4 occur very near the MFF and we believe that they may be interstratified, however this is far from clear. Four of these fans have catchments originating in the highlands (V1N and nearby systems). Fan 1 is found at the end of a ~20 km near continuous inverted channel system, which appears to originate from (although is not confined by) V1N. Successive ridges within Fans 1 & 2 are stacked, and many more channel systems appear buried/partially exhumed within the adjacent terrain. We also identified two additional degraded fans (Fans 6-7) within sub-basin 1.

Chronology of the fluvial systems. V1N and its tributaries are incised into mid-Noachian terrain; the basin north of the dichotomy is early Hesperian [4]. As crater A overlies V1N and it not incised, its formation put a lower age bracket on fluvial processes. Counting all craters which overlie crater A's ejecta (where D>70 m) revealed that crater A has a maximum age of ~ 3.5 Ga. Thus, fluvial processes may have occurred between the mid-Noachian and early Hesperian.

Discussion: *Damming, filling, and incision of the catchment.* The evolution of the catchment fluvial systems is complex, with multiple stages. The walls of V1N have been heavily degraded by impact cratering. The fill within V1N may be associated with these impacts, the fluvial systems themselves, or both. The two incised regions of V1N, I1 and I2, cut into the valley fill. I1 begins at the terraced paleolake outlet, so the incision may have been caused by a lake breach [6]. I2 begins at a knickpoint north of crater A, although it is unclear if the two are related. Although crater B has dammed I2, its ejecta has subsequently been incised and is overlain by an inverted channel system.

V1W may have originally been a tributary for V1N, until crater B formed, diverting it SW into sub-basin 1 (Fig. 1). The depositional channels and sediment fans at the east margin of sub-basin 1 may have developed due to aggradation caused by the impact damming from crater B. The ejecta from crater B may also have supplied ample sediment to these systems, which may also explain the other inverted channel systems associated with crater B. Overall, impact cratering appears to have had a significant role in the evolution of these valley networks: filling, damming, and diverting them, as well as likely causing the aggradation of sediment.

Evolution of the downslope basin. The morphology of the fans is consistent with forming into water bodies, rather than sub-aerially. As most fans occur in topographically closed regions of the downslope basin, they likely formed into localized paleolake basins, rather than a regional water body. However, at least two fans show evidence for downslope migration over time, suggesting the water level of these basins was receding. Its possible that these basins once joined up to form a larger regional basin, although this water body would still not be open to the lowlands. The MFF may have formed the northern boundary to this ancient inner sea when the fluvial systems were active, although further investigation is needed to support this.

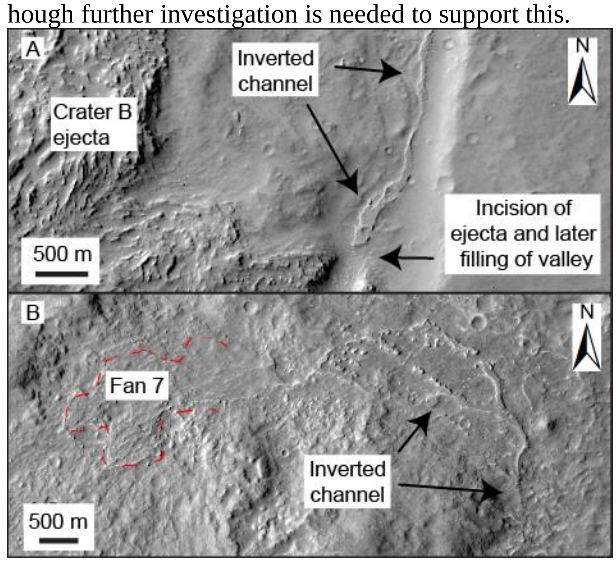

Figure 2: (A) CTX image of crater B ejecta, which has filled V1N, but subsequently been incised. V1N has also been filled by an inverted channel system. (B) Inverted channel and fan system in sub-basin 1.

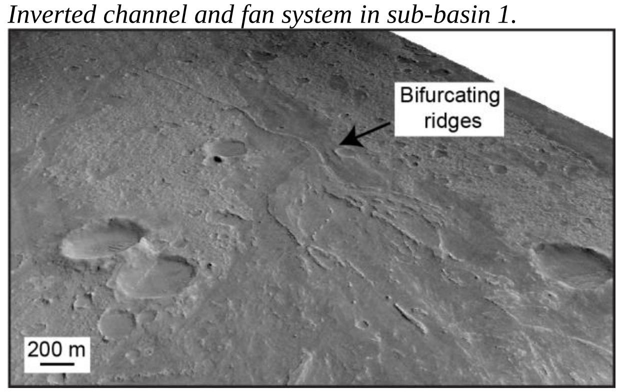

Figure 3: Oblique view of HiRISE DEM showing Fan 1.

References: [1] Fawdon et al. (2018) EPSL 500, 225-241. [2] Rivera-Hernández and Palucis (2019) GRL 46, 8689 – 8699. [3] Kerber et al. (2011) Icarus 216, 212-220. [4] Tanaka et al. (2014) USGS Sci. Invest. Ser. Map 3292. [5] Ori et al. (2000) JGR 105, 17,629-17,641. [6] Goudge and Fassett (2018) JGR 123, 405-420.