INVERTED PALAEOLAKES IN ARABIA TERRA, MARS: EVIDENCE FOR FLUCTUATING EROSION AND DEPOSTION IN THE NOACHIAN. J.M. Davis[1], M. Balme[2], P.M. Grindrod[1], P. Fawdon[2], S. Gupta[3], [1]Dept. of Earth Sciences, Natural History Museum, London, UK, joel.davis@nhm.ac.uk, [2]Dept. of Physical Sciences, Open University, Milton Keynes, UK, [3]Dept. of Earth Science and Engineering, Imperial College, London, UK.

Introduction: Arabia Terra is the most northern part of Mars' Noachian (> 3.7 Ga) southern highlands. Here, ancient e river valley networks from other highland regions further south, transition into depositional channel systems and are now often preserved in inverted relief [1]. These inverted channels are strong evidence for channel belt and flood plain deposits across Arabia Terra which developed during the Noachian. These were part of a wider, regional fluvial system which transported water and sediment northwards towards the dichotomy and the northern lowlands. Regionally extensive sedimentary material, informally known as the "etched units" [2,3], appears to have contributed to the preservation of the inverted fluvial systems [1].

Given the gently sloping topography of Arabia Terra, water and sediment are also likely to have ponded in local depressions and basins across the region to form palaeolakes, as well as in the flood plains adjacent to the inverted channels. Although several large putative palaeolakes have been identified in the eastern part of Arabia Terra, few have been identified in the wider region [4,5]. The existence and prevalence of palaeolakes in Arabia Terra is important for understanding the fluvial history of the region, and for wider water and sediment transport across Noachian Mars.

Here, we have identified, mapped, and catalogued palaeolake systems in Arabia Terra. Palaeolakes were identified and systematically mapped using Context Camera (CTX; 6 m/pixel; [6]) data and were identified on the basis of where basins, depressions, and sedimentary deposits intersect our database of inverted fluvial channels and valleys [1]. We have characterized the palaeolakes according to previous classifications as either open or closed-basin systems [4,5], and evaluated them to assess their deposition context. Finally, we discuss the implications of the palaeolakes for the regional fluvial processes.

Observations: 48 putative palaeolakes were identified across the Arabia Terra using our database of inverted channel systems. At least 17 of the palaeolakes have clear evidence for an outlet channel or valley, and were therefore classified as open-basin systems. The remaining 31 either had inlet channels and valleys only, or it was unclear whether outlets existed. Two of the palaeolakes have terraces around their rims. The palaeolakes typically range in size from tens of meters to tens of kilometers across.

Many of the palaeolakes occur in basins or depressions (usually impact craters). However, multiple other palaeolakes are not found in negative relief, but instead are laterally contiguous with the inverted channels and are preserved in positive relief (Fig. 1). The majority of these "inverted palaeolakes" appear to be former impact craters that have been infilled with layered, sedimentary material, and had their rims and impact ejecta removed. Several of these inverted palaeolakes were previously identified in a more localized study of fluvial processes in the Meridiani area [7].

Numerous other inverted palaeolakes exist outside the defined study area, however these were not systematically mapped. In addition, inverted impact craters also exist which are not contiguous with inverted channels, making their origin unclear. However, it is not unreasonable to assume that inlet and outlet inverted channels could have been removed by later erosion, as sedimentary terrains in generally have been extensively eroded across much of Arabia Terra [1].

Palaeolake Formation and Preservation: The existence of numerous palaeolake deposits is strong evidence that water and sediment ponded across Arabia Terra. Water appears to have been stored locally in closed-basin lakes at a range of scales, as well as in chain lake systems as part of the regional fluvial system, which transported water from south-to-north towards the northern lowlands.

The origin of the inverted palaeolakes, however, poses many questions. The indurated sediment comprising the inverted palaeolakes could be (1) primary detrital or evaporitic deposits formed in a lacustrine environment that was later cemented [e.g., 8]; (2) secondary material which infilled the palaeolake, such as cemented aeolian deposits or volcanic ash, possibly associated with the emplacement of the etched units [e.g., 2,3]; or (3) a combination of the above (i.e., lacustrine material overlain by non-lacustrine material).

A non-lacustrine origin for the palaeolakes is hard to reconcile with the textural similarity between the inverted palaeolakes and the inverted channels, as the latter show strong evidence for comprising indurated fluvial sediment [1]. Even if the material comprising the sediment in the inverted craters is not lacustrine, these locations are still palaeolakes as they are ingressed and egressed by fluvial channels. Given the spatial extent over which inverted palaeolakes are found, however, regional variations in their composition or preservation mechanisms are certainly possible.

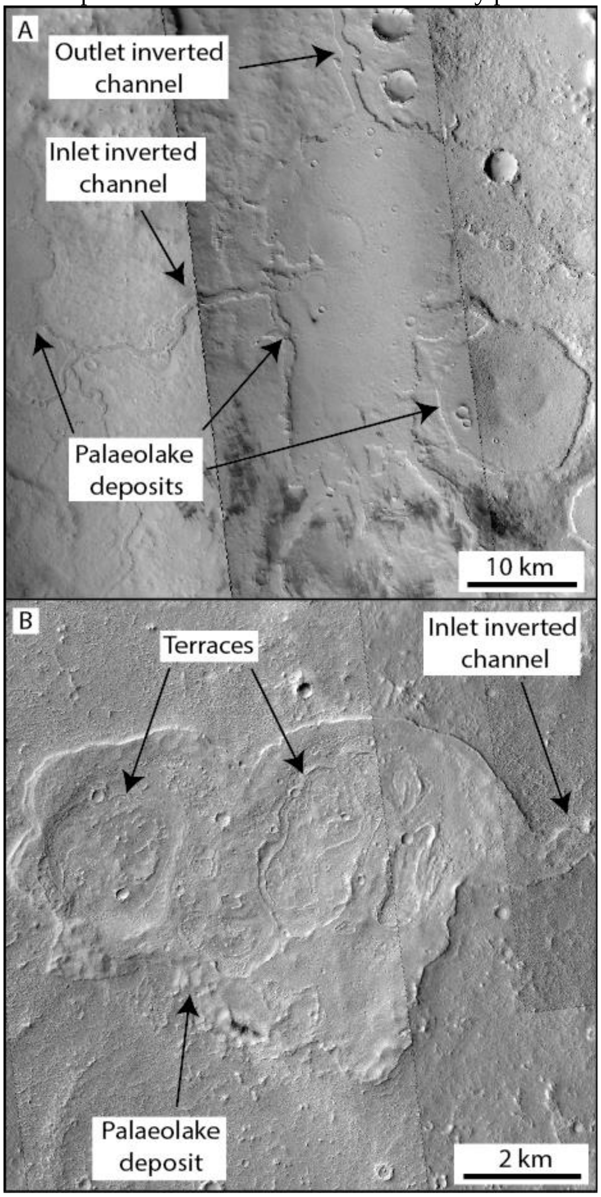

Figure 1: CTX mosaics of inverted palaeolakes in Arabia Terra with (A) inlet and outlet channels and; (B) inlet channels only. The circularity of some of the deposits suggests they are modified impact craters.

The inversion of the palaeolakes was probably coeval with the inversion of the depositional channels, after aqueous processes ceased at the end of the late Noachian [e.g., 9]. As with the inverted channels, the emplacement of the etched units likely contributed to the selective preservation of the inverted palaeolakes after their exhumation and inversion. It is likely that many more have been eroded away where the palaeolakes were not protected by the etched units.

Implications for Regional Aqueous Processes: Assuming that the inverted palaeolakes were once impact craters, their rims and ejecta at some point must have been removed by erosion to form simple, bowl-shaped depressions. This probably occurred prior to sediment deposition in the palaeolake; it seems unlikely that either cemented lacustrine, aeolian, or volcanic ash deposits would be preserved, while impact crater rims and ejecta were entirely removed. Many other impact craters elsewhere on Mars have had their rims and ejecta blankets similarly removed, consistent with an intense period of erosion during the mid-Noachian [10,11]. Given the context of the fluvial systems throughout Arabia Terra, intense fluvial erosion could be responsible for this modification of impact craters.

However, widespread depositional channels, flood plains, and palaeolakes throughout Arabia Terra record a period of net sediment deposition [1], indicating a transition from net fluvial erosion. Water and sediment were deposited in the now modified impact craters, forming palaeolakes (assuming here that the sediment in the palaeolakes is lacustrine). Other, late Noachian impact craters, which have well-preserved rims and ejecta blankets, overlie the fluvial and lacustrine deposits, suggesting that this transition occurred during the mid to late Noachian. The existence of many wide "filled valleys" – fluvial valleys that contain inverted channels and probable flood plain deposits in Arabia Terra [1] is further evidence for fluctuating periods of erosion and deposition in the Noachian. These valleys formed via fluvial erosion and were later infilled by sediment as the valleys flooded when erosion transitioned to deposition.

As the inverted palaeolakes and filled valleys occur widely across Arabia Terra, this transition from erosion to deposition may have been induced by regional processes, such as fluctuations in base level. The regional base level may have been initially low (net erosion), later rising in the late Noachian (net deposition). Records of these changes be more strongly recorded in the sedimentary landscape of Arabia Terra than other highland regions, given its gently sloping gradient and relatively low-lying topography, and hence the geology here has the potential to inform about the wider mid- to late Noachian environment and climate.

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