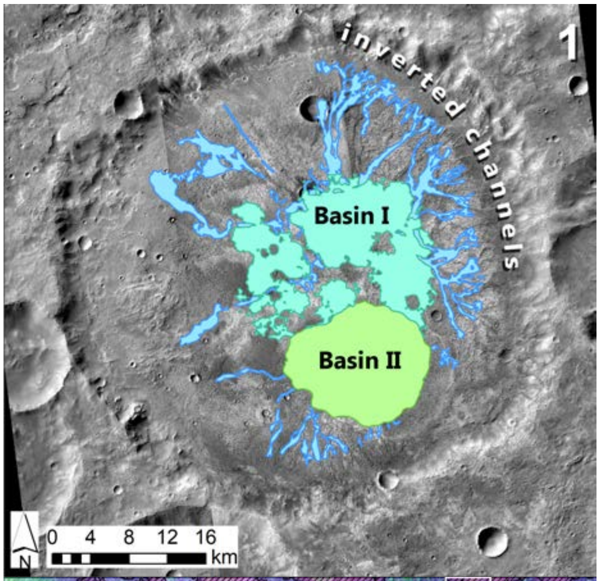
NEW VOLUME ESTIMATES AND TIMING OF PROGLACIAL LAKE FORMATION IN A NOACHIAN CLOSED-SOURCE DRAINAGE BASIN CRATER ON MARS.

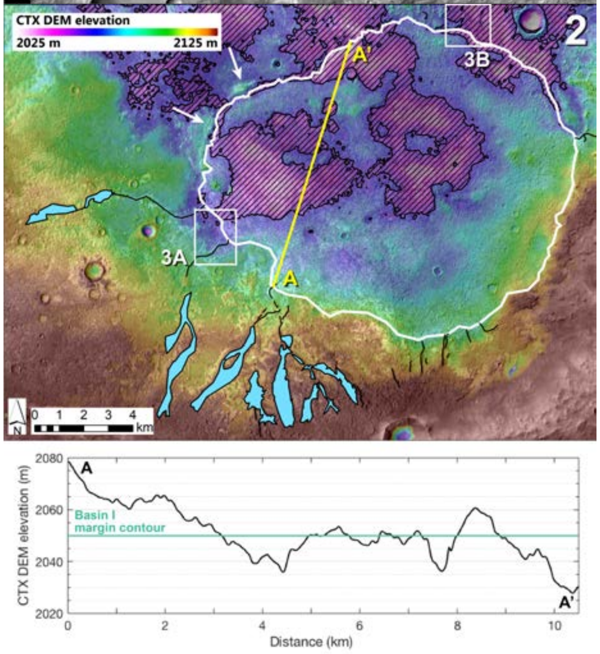
B. D. Boatwright and J. W. Head, Dept. of Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI 02912 USA (benjamin_boatwright@brown.edu).

Introduction: Closed-source drainage basins (CSDBs) are a distinct type of crater basin lake on Mars that is fed entirely by intracrater fluvial drainage with no hydrologic connectivity to its surroundings. We previously hypothesized that CSDBs were the sites of one or more ephemeral lakes fed by localized supraglacial melting and proglacial fluvial channel formation in the Noachian [1-2]. These features provided supporting evidence of a "cold and icy" early Mars climate scenario dominated by an adiabatic cooling effect (ACE) leading to widespread glaciation of the southern highlands [3-5]. We also estimated paleodischarges for a selection of inverted fluvial channel segments that fed the paleolake basins within the CSDB crater "B" (20.3˚S 42.6˚E, *D* = 54 km), finding a range of possible values ~2–7,000 m^3/s [6]. The spread in these values is due to both the variation in inverted channel height as well as the inherent uncertainty in measuring the thickness of the caprock and thus channel depth [6].

Here, we attempt to constrain further the water volumes and timing of lake formation and sediment deposition within crater B. We first estimate the amount of water that may have filled the crater during the period of proglacial fluvial activity and the timescales required to fill the crater to its interpreted peak level. We then assess the stratigraphic and topographic relationships between two distinct basins within the crater (herein referred to as Basins I and II; Fig. 1), which we use to infer a more detailed history of fluvial activity and sediment deposition in the crater.

Basin volumes and filling timescales: Basin I (~184 km^2) is defined as the area enclosed by the +2050 m contour that does not overlap with Basin II (this differs slightly from our definition in [1], which instead used geologic units corresponding to the lowest/most heavily eroded areas of the crater floor). Our current definition of Basin I corresponds with the termination points of the inverted channel networks throughout the northern half of the crater floor, suggesting control by an equipotential surface (i.e. a lake); "chicken wire" terrain on the basin floor may represent subaqueous depositional landforms [1]. Basin II (~141 km^2; Fig. 2) is located to the south of Basin I and is defined by an area of morphologically distinct terrain containing closely spaced transverse aeolian ridges (TARs) enclosed by a boundary trough [1].





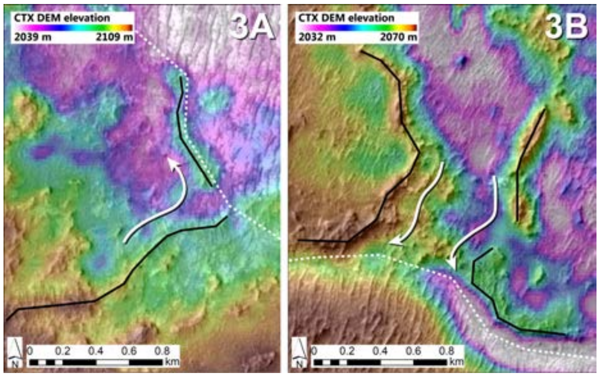


Fig. 1. Context map of crater B showing locations of Basins I and II with inverted channels. **Fig. 2.** Topographic map and profile of Basin II (white outline) with surrounding inverted channels (light blue). Blocks of elevated material (arrows) may be erosional remnants of a Basin II shoreline. Hatched areas fall below the Basin I contour of +2050 m. **Fig. 3.** Examples of "knees" (arrows) within flow features (black lines) surrounding Basin II margin (white dotted lines).

We take the volume enclosed by the Basin I contour on the present day crater floor to represent a minimum volume that could have been filled by water flowing through the channels in crater B. We find this volume to be ~2.58 km^3. Our paleohydrology calculations [6] can be combined with this volume estimate to provide an approximate idea of the timescales required to fill Basin I to the +2050 m contour. Since we do not have paleodischarge estimates for the entire inverted channel network due to limitations in high-resolution stereo topography coverage, a conservative filling timescale can be calculated by considering the range of discharges from individual trunk streams. The other inverted channels in the crater have similar geometries and are not likely to have varied substantially in terms of their peak discharge. Among those we measured, the discharge range for inverted channel trunk streams draining into Basin I is ~20–3,900 m^3/s [6], resulting in diurnal to seasonal filling timescales of ~8 days to ~4 Earth years of continuous flow. This estimate is consistent with the value we initially derived of ~1 Earth year of continuous flow [1]. As we explain below, any volume estimates of Basin II are highly uncertain due to subsequent erosion and modification, and we do not attempt to provide an exact value here.

Basin stratigraphy and topography: Basin I is defined topographically, while Basin II is defined morphologically. The modern topography of Basin II does not form a closed contour. The S–SE part of the basin interior is elevated by ~30 m relative to the Basin I contour in correspondence with inverted channels originating at the base of the southern crater wall, suggesting enhanced fluvial erosion in this part of the crater. The N–NW area of the basin interior has an elevation equal to or even lower than the Basin I contour (+2050 m).

If Basin II originally formed a closed contour, then any confining topography on the northern side of the basin must since have been removed. Two discontinuous areas of elevated terrain (Fig. 2, arrows) bound the basin to the northwest with concentrically oriented lineations that slope inward toward the basin interior, somewhat suggestive of strandlines. These blocks could be the erosional remnants of an originally enclosed Basin II margin that was "perched" some 30 m above the surrounding crater floor in Basin I. Remnant crater floor snow and ice deposits could likewise have influenced the orientation of the two basins by forming ephemeral topographic barriers. We noted multiple locations surrounding Basin II where fluvial features extend toward the basin and make a sharp bend, or "knee," that then follows the basin margin (Fig. 3). This suggests that flows were diverted around the margin of Basin II, perhaps also due to the presence of confining topography.

The timing of basin formation in crater B is therefore complex. Due to a lack of inverted channel stacking and migration, we initially interpreted the fluvial features in crater B as evidence of a single terminal event that preserved the waning stages of glacial melting and removal in the crater [1]. These flows could have been reactivated multiple times within the same channels, with different areas of the crater floor (i.e. basins) being favored at different times due to variations in glacial melting rates or ice availability. Even with potential episodicity taken into account, however, our filling estimates for Basin I still suggest that fluvial and lacustrine activity in crater B occurred over very short geologic timescales.

Conclusions: The CSDB crater B serves as a type location of hydrologically isolated fluvial and lacustrine activity that was potentially linked to localized glacial melting on early Mars [3-5]. The crater contains two distinct basins (I and II). We found that the volume of the larger Basin I is ~2.58 km^3 and could have been filled with water on the order of days to years, consistent with our previous estimates [1]. The more southerly Basin II is morphologically distinct from its surroundings and does not form a closed contour, but elevated areas surrounding the basin suggest that it may have originally been enclosed. Snow and ice in the crater floor could also have formed ephemeral barriers. Sharp bends, or "knees," within fluvial features surrounding Basin II suggest that these flows were diverted around an elevated boundary.

Deciphering the history of fluvial and lacustrine deposition in crater B is important for understanding the broader evolution of early Mars climate. Our assessment of repeated but generally short-lived activity in the two basins supports previously presented evidence of glacial retreat and removal in the circum-Hellas highlands in the Late Noachian–Early Hesperian [7-10].

References: [1] Boatwright B.D., Head J.W. (2021) PSJ 2; [2] Boatwright B.D., Head J.W. (2022) PSJ 3; [3] Wordsworth R. et al. (2013) Icarus 222; [4] Wordsworth R. et al. (2015) JGR 120; [5] Fastook J.L., Head J.W. (2015) PSS 106; [6] Boatwright B.D., Head J.W. (2022) GRL 49; [7] Bouquety A. et al. (2019) Geomorph. 334; [8] Bouquety A. et al. (2020) Geomorph. 350; [9] Fastook J.L., Head J.W. (2022) LPSC 53; [10] Head J.W. et al. (2022) LPSC 53.