THE GEDIZ VALLIS INVERTED CHANNEL: EVIDENCE FOR LATE-STAGE FLOW IN GALE CRATER, MARS? J. Davis[1], W. Dietrich[2], S. Gupta[3], A. Bryk[2], S. Banham[3], S. Wilson[4], M. Hughes[5], L. Thompson[6], A. Roberts[3], C. Fedo[7], O. Gasnault[8], H. E. Newsom[9], G. Caravaca[8], G. Paar[10], E. Kite[11] [1]Birkbeck, U. London, joel.davis@bbk.ac.uk, [2]U.C. Berkeley, [3]Imperial College London, [4]National Air and Space Museum, [5]Wash. U. St. Louis, [6]U. New Brunswick, [7]U.T. Knoxville, USA, [8]IRAP CNRS, [9]UNM, [10]Joanneum Research, [11]U. Chicago.

Introduction: The Mars Science Laboratory (MSL) Curiosity rover continues to ascend the foothills of Aeolis Mons (Mt. Sharp), Gale crater, Mars, with the goal of characterizing former habitable environments [1]. Previously, Curiosity encountered evidence for fluvial and lacustrine environments [2], which existed prior to the formation and exhumation of Aeolis Mons. An ongoing goal for the mission is to assess whether and how water and habitability persisted after the formation of Aeolis Mons. As of Sol 3702, Curiosity is approaching the mouth of Gediz Vallis, a ~9-km long, ~500-800 m wide, ~100-250 m deep canyon incising into Aeolis Mons, possibly formed by wind and water-driven erosion [3, 4]. On the Gediz Vallis floor are a series of landforms: a channel, an inverted channel-like ridge, and Gediz Vallis ridge (GVR) [3]. The Gediz Vallis inverted channel (GVIC) is the first such landform to be encountered on the ground on Mars; elsewhere on Mars, inverted channels from orbit have been interpreted as filled fluvial valleys, ephemeral and perennial channels, and channel-belts [5]. Key questions for the GVIC include: Were the rocks which make up the GVIC deposited by flowing water, such as by a debris flow or streamflow? Did deposition occur across the wider GV floor, or was it restricted to the GVIC area? Does the GVIC comprise rocks deposited by one or multiple flow events? Here, we present both contextual orbital observations of the GVIC and long-distance observations as seen by Curiosity, and make initial interpretations of the depositional environment.

Context Observations from Orbit: In HiRISE images [6], the GVIC forms a quasi-sinuous, ~1.5 km long, ~80-100 m wide, ~5-30 m high, ridge (Fig. 1). To the south, the GVIC is confined by a channel incising into likely Mt. Sharp group bedrock and layered sections and both dark and light-toned debris are visible in the GVIC [6]. To the north, the channel margin is no longer exposed. Near the mouth of Gediz Vallis, the GVIC transitions into the broader GVR, previously interpreted as a degraded alluvial fan [3] or delta [7]. Similar debris filled canyon floors are present elsewhere on Aeolis Mons (e.g., Sakarya Vallis [5]).

Long Distance Rover Imaging: Curiosity has had three significant opportunities to image the GVIC eastern slopes: from Sols 3570-3596, 3651-3658, and 3667-3687, with a closest approach of ~300 m. Multiple Navcam [8] and Mastcam [9] mosaics were acquired, providing well-resolved coverage along a ~600 m axial section of the northern GVIC, in addition to several ChemCam LD-RMI mosaics [10, 11].

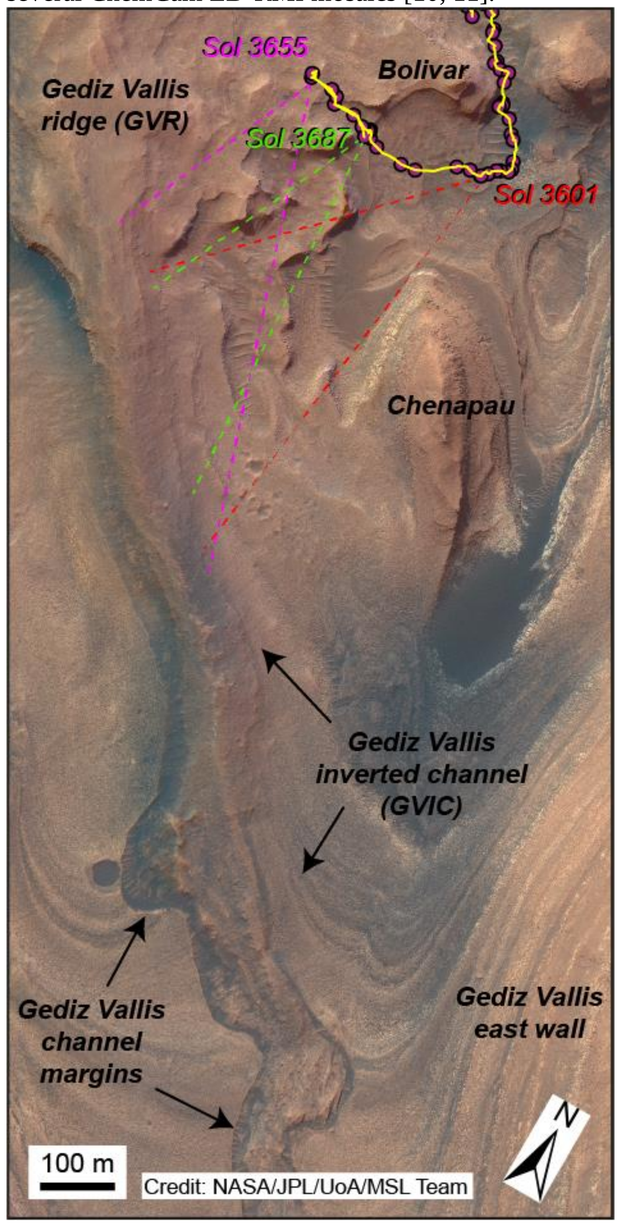

Fig. 1: HiRISE mosaic showing Gediz Vallis inverted channel along with Curiosity traverse. Dashed lines show approximate viewsheds where significant Mastcam and LD-RMI coverage was acquired.

Observations from Mastcam and LD-RMI mosaics: Sections of clearly exposed, in-situ bedrock are rare on the GVIC eastern slopes (Fig. 2). Instead, most of the GVIC is formed of loosely consolidated, very poorly sorted sedimentary rocks. Within this deposit, at least two distinct block types are observed. Most common are decimeter to meter-scale, dark-toned, resistant, angular blocks (largest: ~7 m), which are present throughout the ridge. Dark blocks are both on the GVIC surfaces and entrainment within finer scale, matrix material (Fig. 2). The dark block themselves are lithified, frequently containing well-exposed, planar and inclined stratified sections. The stratification orientation in these dark-toned blocks varies from block to block, indicating the blocks are transported and likely not an erosional lag of in-situ bedrock.

Apparently lighter-toned, decimeter to meter-scale, relatively recessive blocks are also observed in the GVIC (Fig. 2). These blocks are rarer and generally more rounded than the dark blocks with stratification sometimes exposed. Near the GVIC crest, some crudely planar strata are present (~0.1 m thick), which show semi-continuous exposure for at least 20 m laterally and may represent in-situ bedrock (Fig. 2). Other examples of localized stratified sections are present lower down in the ridge, however, it is not clear whether these are in-situ bedrock. From current views, no obvious networks of fractures of veins appear visible within the GVIC. A shallow scarp forms near the base of the GVIC, which may be the basal contact with the underlying Mt. Sharp group bedrock, although the presence of loose scree and blocks obscures the exact position of the contact. While some dark blocks overlie the Mt. Sharp group bedrock near the GVIC (< 50 m), likely having rolled down the ridge, none have yet been observed elsewhere on the GV canyon floor.

Initial Environmental Interpretation: The position of the GVIC filling a channel within GV indicates that its deposition postdates canyon formation. The diversity and characteristics of the different blocks within the GVIC suggest they are clasts derived from different catchment regions, such as the GV canyon walls or floor, or higher up Aeolis Mons. Therefore, at least boulder (>0.25 m) size clasts may have been transported; highly energetic flows would be needed to do this. The large clast sizes and extremely poor sorting within the GVIC deposits, as well as its topographic setting, are consistent with being deposited by debris flows, sediment gravity flows in which clasts are supported by a cohesive muddy matrix. Debris flows have a high sediment to water ratio and can transport a wide range of clast sizes, as well as erode the underlying bedrock. The confinement of the GVIC to a channel argues against a completely unconfined flow, such as a drier landslide, forming the deposit, at least in this downslope region. These would be consistent with an alluvial fan interpretation of the downslope GVR [3]. The presence of crudely planar stratified horizons near the top of the GVIC may represent a transition to alternative modes of deposition (e.g., streamflow or sheetfloods), suggesting the ridge may represent multiple depositional events. Following its initial deposition, the dark and indurated blocks may have armored the GVIC against subsequent erosion.

Outlook: Curiosity's planned traverse should take it much closer to the GVIC [10], enabling the environmental interpretation to be further developed. A mud-rich matrix would support the debris flow interpretation and the transported clasts may provide access to lithologies from higher up Aeolis Mons.

References: [1] Grotzinger et al. (2012), *Space Sci. Revs.* 170, 5-56. [2] Grotzinger et al. (2015), *Science*, 350, 6257, aac7575–aac7575. [3] Bryk et al. (2019), *LPSC*, The Woodlands, TX, 2132. [4] Hughes et al. (2022) *J. Geophys. Res. Plan*. 127, e2021JE006848. [5] Zaki et al. (2021), *Earth Sci. Revs*., 216, 103561. [6] McEwen et al. (2007), *J. Geophys. Res. Plan*. 112, E05S02 [7] Palucis et al. (2016) *J. Geophys. Res. Plan*. 121, 472–496 [8] Maki et al. (2012) *Space Sci. Revs.* 170, 1–4, 77–93 [9] Bell et al. (2017) *Earth Space Sci.* 4, 7, 396–452 [10] Le Mouélic et al. (2015) *Icarus*, 249, 93–107. [11] Gasnault et al. (2017), *LPSC*, The Woodlands, TX, 2995. Wilson et al. (2023), *LPSC*, The Woodlands, TX, this conference.

Fig. 2: LD-RMI mosaics of the GVIC, acquired from ~300-400 m away. Dashed yellow line indicates possible in-situ bedrock.