CONSTRAINING THE PALEOENVIRONMENT OF THE DARWIN OUTCROP IN GALE CRATER FROM FACIES AND STRATIGRAPHIC MAPPING. M. Tebolt[1], T. A. Goudge[1], K. M. Stack[2], C. M. Fedo[3], S. Gwizd[3], F. Rivera-Hernández[4], Department of Geological Sciences, Jackson School of Geosciences, University of Texas at Austin (mtebolt@utexas.edu), [2]Jet Propulsion Laboratory, California Institute of Technology, [3]Dept. of Earth & Planetary Sciences, UT Knoxville, Knoxville, TN, [4]Georgia Tech, School of Earth & Atmospheric Sciences, Atlanta, GA.

Background: The Bradbury Rise traverse includes data collected from sols 0-750 of the Mars Science Laboratory (MSL) *Curiosity* mission. The region has been generally interpreted as a prograding braided river delta [1,2]. Although the outcrops of Bradbury Rise were analyzed and interpreted when data were first collected [1,2,3], many specific sites have yet to be evaluated in detail. This work aims to study the sedimentology and stratigraphy of one area along the Bradbury Rise traverse, the Darwin outcrop, in order to interpret the paleoenvironment, as successfully done at previous sites, like Shaler [3] along the traverse. This study integrates images from multiple MSL cameras to examine the rocks from outcrop to individual grain scale and create a detailed facies map and stratigraphic reconstruction. The rocks in this location can provide additional constraints on the nature, duration, and intermittency of a braided river-delta system with relevancy the habitability of this section of the Gale stratigraphy.

Description of the Darwin Outcrop: *Curiosity* data was collected from the Darwin outcrop during sols 392-401. Previous studies have identified conglomerate, sandstone, and dark float rocks within the area, interpreting the region as sedimentary deposits in and around a ~200 m diameter crater [4] (Fig. 1). Past work has hypothesized that the outcrop is either exposures of sedimentary rock that filled the crater after it impacted a primary substrate, or that all the visible outcrop is an originally horizontal deposit that was then modified by an impact cratering event [4]. Additionally, linear structures identified in the Darwin outcrop have been interpreted as sand-filled fractures, veins, or possibly deformation bands [5,6]. These hypotheses can be tested with a detailed investigation of the area, as done here.

Methods: Images from the Navigation Camera (Navcam), the Mast Camera (Mastcam), and the Mars Hand Lens Imager (MAHLI) were downloaded from the MSL Analyst's Notebook on the PDS. Mastcam images were viewed using ENVI and examined for any sedimentary outcrop. Observations made of each image include grain size, bedding type, and any other obvious sedimentary structures. The spatial extent of the images was contextualized using Navcam mosaics. Sols 392-395 have been analyzed to date, which includes over 200 individual Mastcam image frames. We have also characterized distinct sedimentary facies within the outcrop using observations of the grain size and bedding.

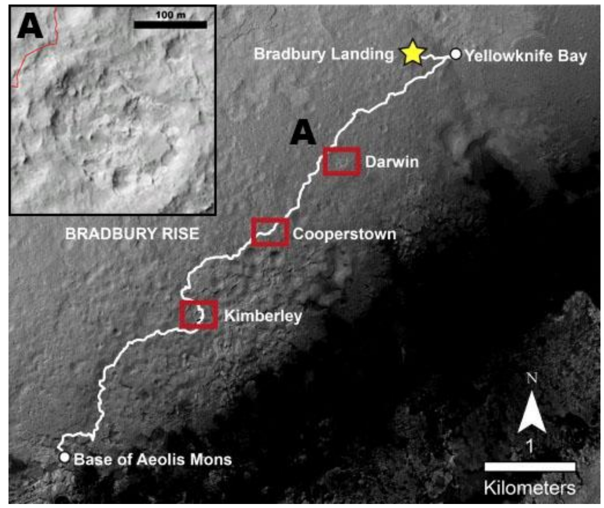

Fig. 1. Overview of the MSL traverse of the Bradbury Rise showing the location of the Darwin outcrop (A). Inset shows potential filled impact structure. Figure adapted from Stack et al., 2016 [4].

Preliminary Results: A facies map has been created for sols 392-395 using Mastcam images in context with Navcam images (Fig. 2). Three facies have been identified and characterized. From stratigraphically lowest to highest they are: conglomerate (Fig 2A), gravelly sandstone (Fig 2B), and dark float (Fig 2C). At the base of the outcrop, the conglomerate facies consists of predominantly gravel and cobble sized clasts, with little to no matrix visible between clasts. At the landscape-scale, this facies can be identified by a distinct “crumbly” weathering texture, with clasts protruding and/or shedding from the surface. The boundary between the conglomerate facies and the overlying gravelly sandstone facies is gradational, with some areas appearing to alternate between the two facies (Fig 2D). The gravelly sandstone facies has significantly fewer visible clasts than the conglomerate facies, but still contains some gravel sized clasts that can appear to be shedding from the outcrop. The dark float facies lies directly above the gravelly sandstone and consists of cobble and boulder sized float rocks with varying degrees of roundness. Individual float rocks consist of fine-grained sediment. The float is a darker color and smoother texture than the previous two facies.

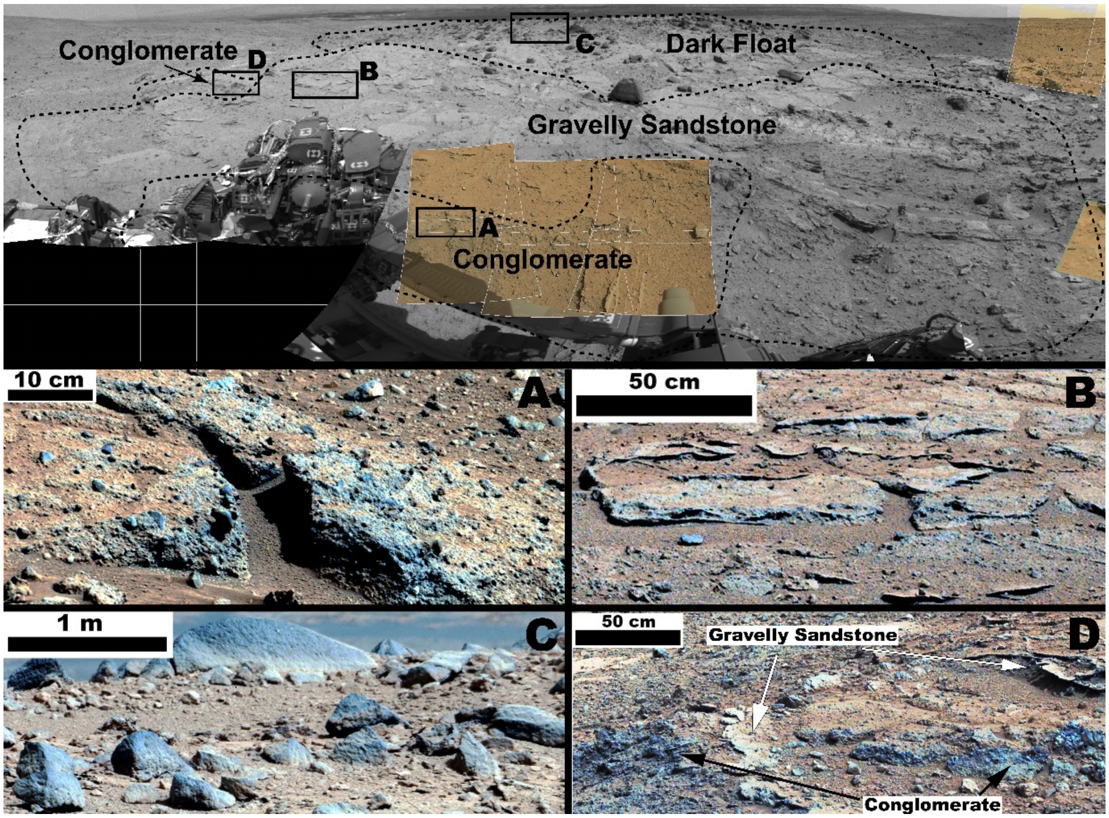

Fig. 2. Overview of the Darwin outcrop with preliminary facies map boundaries shown in dashed lines. Background is Navcam image 0397XEDR016CYL_S_0148. Insets show examples of the main facies: A) Conglomerate (Mastcam image 0395mr0016260310302206e01), B) Gravelly sandstone (Mastcam image 0395ml0016260140200632e01), C) Dark float (Mastcam image 0395mr0016260080302183e01), D) Alternating conglomerate and gravelly sandstone (Mastcam image 0395ml0016260180200636e01).

Discussion & Future Work: Initial observations of the Darwin outcrop suggest that the rocks in the gravelly sandstone facies appear to have horizontal-to-wavy surfaces embedded within layers (Fig 2B). These could be diagenetic features, or possibly primary sedimentary structures (e.g., bedform cross-strata) that would aid with paleoenvironmnetal reconstruction. Additionally the nature of the contact between the dark float facies and the gravelly sandstone facies suggests that the dark float facies is a laterally extensive caprock.

Next steps involve completing the analysis of all Mastcam images from sols 392-401 and further developing the facies map of the outcrop. The units will then be examined at a smaller scale using MAHLI images to perform a clast survey, of particular relevance to the conglomerate facies (Fig 3). This data will be used to consider the possible modes of sediment transport and deposition of the grains based on, for example, measurements of roundness and grain size [7]. As a final step to get a complete picture of the paleoenvironment, a 3D facies map will be created of the region. This will then be used to make quantitative measurements of sedimentary structures, to constrain possible flow directions and depths.

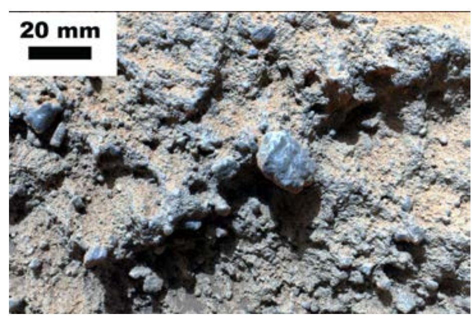

Fig. 3. Individual clasts within the conglomerate facies from MAHLI image 0394mh0001900010104439c00.

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References: [1] Grotzinger, J. P., et al. (2014) *Science*, vol. 343, no. 6169, [2] Grotzinger, J. P., et al. (2015) *Science*, vol. 350, no. 6257. [3] Edgar, Lauren A., et al. (2017) *Sedimentology*, vol. 65, no. 1, pp. 96–122. [4] Stack, K. M., et al. (2016) *Icarus*, vol. 280, pp. 3–21. [5] Vasavada, A. R., et al. (2014) *Journal of Geophysical Research: Planets*, vol. 119, no. 6, pp. 1134–61. [6] Caine, J. S., et al. (2015) 46th Lunar and Planetary Science Conference, no. 2919. [7] Szabó, T. et al. (2015) *Nature Communications*, vol. 6, no. 1, p. 8366.