BEDDING ORIENTATION ALONG THE OPPORTUNITY ROVER TRAVERSE. E. C. House-Hay[1] and K. W. Lewis[2], [1]Johns Hopkins University, Dept. of Earth and Planetary Sciences, Baltimore, MD (ehouseh1@jhu.edu).

Introduction: The Opportunity Rover, part of the Mars Exploration Rover Mission, has been exploring Mars' Meridiani Planum since January of 2004 and has enabled significant discoveries involving sedimentary deposition and aeolian processes on Mars [1]. The first rock formation that Opportunity investigated at Meridiani is the Burns Formation, which extends to an estimated 600m beneath Meridiani and covers the terrain from the Opportunity landing site at Eagle Crater to the beginning of Endeavour Crater [2,8]. The Burns formation is estimated to be as old ~3.7 Ga [5]. The formation consists of several characterized facies that tell a story of aeolian deposition, diagenesis, and ancient dune fields [2]. It is best exposed within ancient craters along Opportunity's traverse, such as Eagle, Endurance, Victoria, and Erebus craters [3]. The Burns Formation has various sandstone facies that make up distinct stratigraphic units. These indicate an environment resembling aeolian depositional systems on Earth. There is evidence of cross-bedded, planar to low-angle cross-bedded, and wavy sandstones, all comprised of siliclastic-rich evaporitic sediments [2].

Opportunity performed extensive imaging along its traverse (Fig. 1) using its panoramic (Pancam) and navigation (Navcam) cameras, revealing a wide array of surface features. Of interest to this study were images taken of outcrops of sedimentary rock in the Burns Formation, particularly those outside of the well-studied large impact craters visited by the rover. The goal of this analysis was to use stereo imaging of stratification in these low-relief outcrops and to determine any large scale bedding patterns throughout the traverse of the rover.

Previous Work: Measurement of bedding orientation in cross-bedded sedimentary rocks can be used to infer paleoflow conditions at the time of deposition. Much of the previous work to find the bedding orientations within the Burns Formation has been conducted on outcrops exposed in the walls of large impact craters. These measurements have contributed to the overall geologic interpretation at locations like Victoria Crater and Erebus Crater [3,6,7]. The results of these studies have led to detailed stratigraphic characterization of these well-exposed sections but have not covered less prominent outcrops outside of the craters.

Methods: We used stereo images and derived terrain meshes from both Pancam and Navcam spanning from sol 1 to sol 2681 (where the Shoemaker Formation begins) [4]. Images were selected on the basis of their

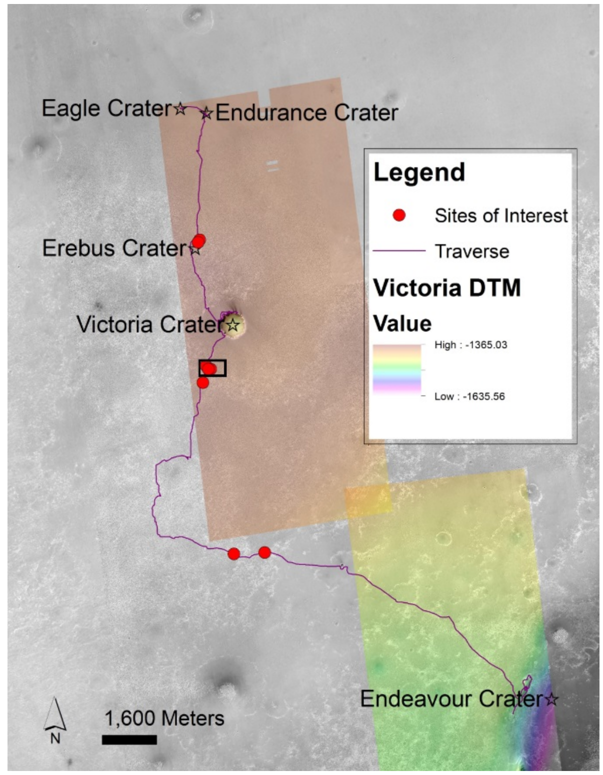

Figure 1 | Opportunity's traverse across Meridiani Planum. In red are sites of interest where outcrops are well-exposed and yield information on bedding orientation. The black box contains the site example shown in Figure 2, to the south of Victoria crater. Base map and DTMs from HiRISE data.

contents (i.e. whether they had observable layering) and then sorted by rover position. Figure 1 indicates the location of sites with adequate imaging of well-expressed bedding at close range, outside of the major, impact crater-hosted outcrops. Images were then read into and processed with MATLAB. Processing involved selecting layers and extracting topographic profiles, which were then fit to a planar surface using linear regression. The resulting dip measurements, along with orthorectified images, were imported into ArcMap, from which we could map larger stratigraphic trends along the traverse.

Results: We successfully recovered bedding information from several new low-relief outcrops exposed along the traverse, bridging the gaps between the major sections studied in detail by Opportunity. Many of these outcrops show consistent orientations over 10-100 meter scales. One example of a consistent outcrop-scale region is show in Figure 2. Results from one rover position are shown Figure 2a. This site is compared to a more distant outcrop in Figure 2b. These outcrops have generally consistent westward dips and are located about 160m apart. Figure 2c shows exposed outcrop within one Navcam image analyzed at this site from Sol 1709 prior to orthorectification. More data is needed to confirm kilometer scale consistency of the exposed erosional surface of the Burns Formation across Opportunity's traverse.

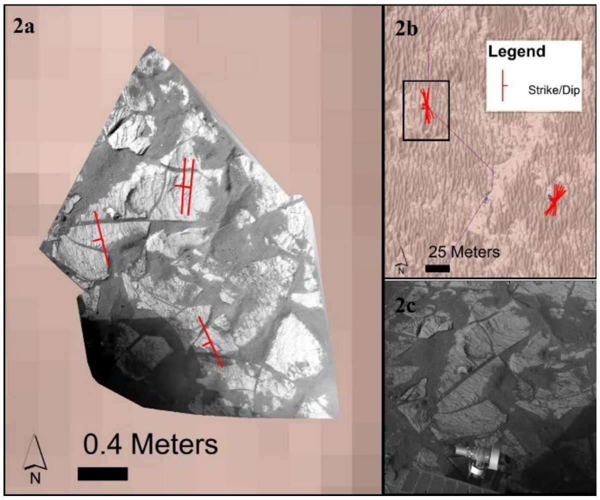

Figure 2 | Strike and dip measurements extracted at one selected site on Sol 1709. Figure 2a shows orthorectified Navcam image data with locations of well-constrained dip measurements, consistently to the west. The location of the black box in Figure 2b is shown in Figure 1. Figure 2c shows an example image of the outcrop shown in 2a prior to orthorectification.

Discussion: These results indicate that on at least a tens of meters scale, the erosional surface of the Burns Formation is largely intact and not entirely brecciated. Consistency across more distant outcrops, including those exposed in craters, could allow for broader study of the stratigraphic architecture of the Burns Formation, potentially linking the detailed observations at previously-studied outcrops. This could yield important results on the depositional history and lateral variability of the formation throughout the rover traverse in Meridiani.

Future Study: Future study aims to identify additional outcrops that could yield more data on the bedding geometry of the Burns Formation at the modern erosional surface. This would, in turn, further constrain the degree of brecciation and the degree of consistency in bedding styles within the Burns Formation.

A study into the correlation between elevation and dip is also a target for future study. Using the dip azimuths collected along the traverse, elevation can be determined and then compared against the change in dips from various regions. Information from previous studies could be incorporated to evaluate potential stratigraphic correlations between distant outcrops within the Burns Formation.

References: [1] Squyres, S. W. et al (2004) *Science* 307, 1698-1703. [2] Grotzinger, J. P. et al (2005) *Earth and Planetary Science Letters* 240, 11-72. [3] Edgar, L. A. et al (2012) *SEPM Special Publication* 102, 195-209. [4] Squyres S. W. et al (2012) *Science* 336, 570-576. [5] Nahm A. L. et al (2007) *Geophysical Research Letters* 34, L20203. [6] Hayes A. G. et al (2011) *Journal of Geophysical Research* 116, E00F21. [7] Metz J. M. et al (2009) *Journal of Sedimentary Research* 79, 247-264. [8] Hynek B. M. et al (2002) *Journal of Geophysical Research* 107, 5088.