SURFACE AND ORBITAL MONITORING OF THE "GREELEY DUNE FIELD" IN ENDEAVOUR CRATER, MERIDIANI PLANUM, MARS. M. Chojnacki[1], J.R. Johnson[2], J.E. Moersch[1], and J.F. Bell III[3], [1]Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN (chojan1@utk.edu), [2]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, [3]School of Earth and Space Exploration, Arizona State University, Tempe, AZ.

Introduction and Context: Reports from orbital observation have clearly documented evidence for contemporary Martian ripple and dune mobility events [1–3]. These events demonstrate that the threshold wind speed for entrainment was exceeded under current conditions in these locations. However, the timing (what season) and duration of sand movement are poorly constrained due to the infrequent temporal coverage of orbital observations.

Meridiani Planum exhibits ample evidence in orbital images and ground-based observations by the Mars Exploration Rover (MER) Opportunity for aeolian activity, with dunes, ripples, and dark streaks [4–5]. The 2011 arrival of Opportunity at the western rim of Endeavour crater (Cape York) provided an excellent chance to look for activity over a multi-season time span in the same low albedo dunefield (Fig. 1) where orbital observations documented changes over the past decade [2]. Here we report the first results from a dedicated Pancam campaign to monitor these dunes and to document any aeolian surface changes more frequently than is possible with orbital observations alone.

Endeavour crater has two populations of duneforms. The eastern bedforms consists of poorly developed transverse and dome dunes, which were the focus of earlier studies due to the large degree of apparent activity (*e.g.,* deflation and/or translation of eight small dome dunes) observed in MGS-MRO images [2]. These dunes are >11 km downrange from Opportunity at Cape York and are partially obscured by the interior crater's hummocky surface. The western dune field (Fig. 2) consists of 26 barchans and one large barchanoid compound dune (Figs. 1 & 3). The ~20 resolvable duneforms, informally named the "Greeley Dune Field" after late planetary scientist Ronald Greeley, are 6–8 km downrange from Cape York and are the subject of this abstract.

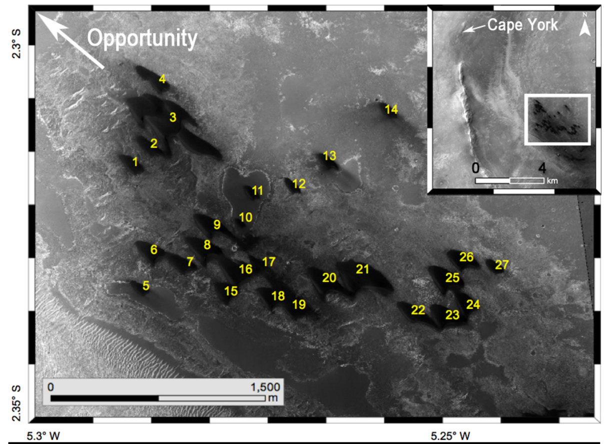

Fig. 2. HiRISE image PSP_005779_1775 of Endeavour crater's western dune field. Inset shows a CTX mosaic with the dune field's location relative to Cape York.

Methods: For our investigation of dune variability, we used orbital images from the MRO Context Camera (CTX) [6] and the High Resolution Imaging Science Experiment (HiRISE) [7]. Surface observations used Pancam [8] images of the crater interior and western dune field. As part of the Opportunity winter campaign, ten dune field images (as of April 2012) were acquired every ~20 sols (L_s=3°–89°), usually as late afternoon observations, using various filter combinations to look for evidence of surface changes. These included two "super resolution" sequences [9] that slightly improve Pancam's native resolution (0.28 mrad/pixel).

Results and Interpretations: *Dune Morphology*.

Individual dune morphology and projected heights are resolvable in Pancam images using various filter combinations and super resolution (Figs. 1 & 4). Opportunity's viewing azimuth was/is oriented roughly parallel to the dunes' paleo-transport direction (*i.e.*, paleo-downind), as inferred from evidence listed below. Thus, the crestlines of these dunes as projected

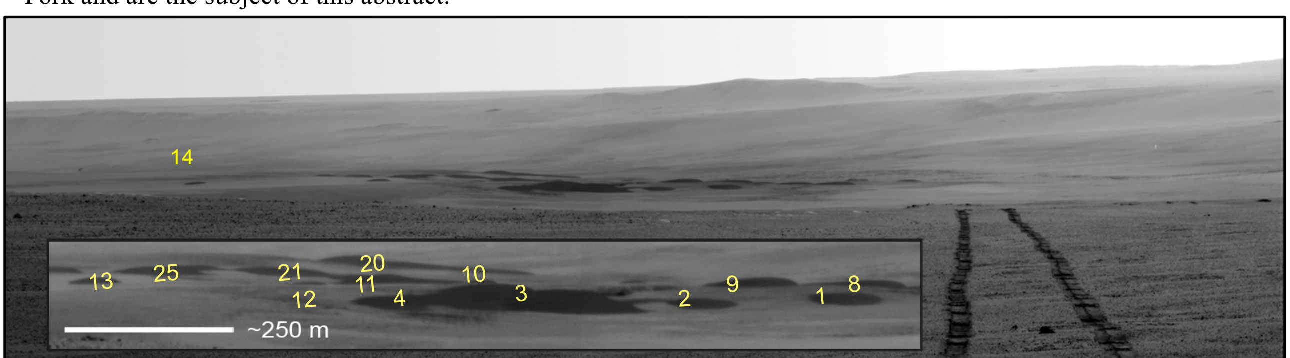

Fig 1. Southeastward Pancam "super resolution" view of the Endeavour crater interior and the "Greeley Dune Field". Acquired on Sol 2759 (sequences P2568 and P2569) from Cape York. The largest visible barchanoid dune is shown centered in the inset. Numeric labels identify the same dunes that are seen from orbit in Fig 2.

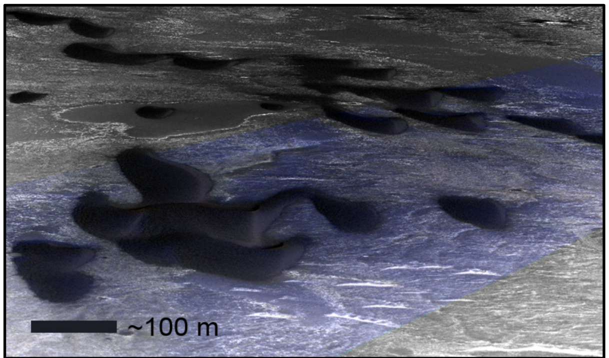

Fig. 3. A color HiRISE (PSP_005779_1775) southeastward prospective view (at a similar azimuth as Pancam images) using an HRSC DTM [10] of the closest dunes (dunes 1–4) to Opportunity.

in Opportunity's images are good approximations for their transverse (to the wind) profiles. Qualitatively, the crestlines appear symmetric about their centers and Gaussian in their slopes. Similarly, HiRISE nadir-viewing images show these dunes to have relatively symmetric planform shapes and a lack of horn extensions (Figs. 1 & 3). Together these properties may be resulting from dune equilibrium (*i.e.,* coupling between wind flow, shear stress, and morphology) within a unidirectional wind regime [11–12].

Wind Regimes and Evidence for Activity. As was observed in previous studies [2,3,13], slip face orientations and the timing/orientation of local dark/light streaks suggest a southern autumn northwesterly wind regime, consistent with mesoscale wind modeling. Partial support for this wind regime came from paired-HiRISE observations (2007–2008) where notable dark streaks emanating SSE from one isolated barchan (Fig. 2, dune #14) at this time of season (see [2, Fig. 4]). By the time of Opportunity's arrival at Cape York, at the onset of southern winter, this dune's SSE-oriented dark streak was still resolvable (Fig. 4a). This dark streak appears to have faded in several later observations. Analysis of abundant CTX images can also resolve changes in dune dark streaks and would predict a ~180° shift in the streak-orientation with a southeasterly (southern winter-spring) wind regime [2,3,13]. With the arrival of southern spring, continued Pancam monitoring of the dark streak may be able to detect and monitor this shift.

Although there has been no unambiguous evidence for dune translation/deflation from Pancam some additional hints at aeolian activity were found between Pancam super resolution sub-frames (not shown, Sol 2759 sequence P2569) with evidence for a dust-lifting event just south of the dune fields. From wind tunnel experiments, local gusts capable of entraining dust were should also have been sufficient to initiate sand saltation [14]. Likewise, dust-cleaning events around the same time at Cape York resulted in notable increases in solar array power.

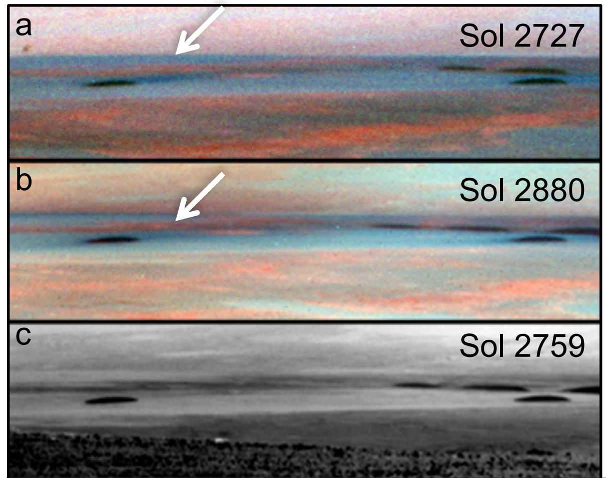

Fig 4. (a-b) Southeastward Pancam false-color views of the "Greeley Dune Field" using filters at 753, 535, and 432 nm. Sol 2727 (L_s=6°) and sol 2880 (L_s=77°) were both acquired in the late afternoon (13:45-14:45 LST) and under similar lighting conditions. (c) Similar view using super resolution (Fig. 1) for comparison. Dune #14 (left) is ~55 m wide. Note that images were taken from different locations ~500 m apart along Cape York, resulting in some viewing parallax.

Discussion and Future Observations: Once available solar power increases enough from its winter low, Opportunity may depart to Cape Tribulation and new science targets. A southward traverse would shorten the distance to the dunes and increase Pancam's sensitivity to small dune changes. The western dunes, although on average volumetrically larger than the eastern dunes, do possess some smaller barchans of a similar scale (~50 m wide) as those known to deflate completely elsewhere in the crater (see [2, Fig. 2]). Likewise those earlier orbital studies deduced migrations rates of ~7 m per Martian year averaged over the 2.3 year temporal baseline available for two small eastern dunes [2]. This rate would imply ~1.5 m of translation over the ~90-sol baseline of Opportunity's observations if the dunes move a uniform rate. This small amount of translation, projected into the Pancam image plane, would be below the threshold for detectability for changes in the images. Further Pancam observations will be needed to attempt to determine whether dune movement is gradual or (perhaps more likely) episodic, and what the actual rate of movement is during periods of activity.

References: [1] Silvestro et al. (2010) GRL, 37, 2010GL044743. [2] Chojnacki et al. (2011) JGR, 116, 2010JE003675. [3] Bridges et al. (2012) Geology, 40, 31-34. [4] Geissler et al. (2008) JGR, 113, 2008JE003102. [5] Johnson et al. (2011) EPSC-DPS, 6, 1205. [6] Malin et al. (2007) JGR, 112, E05S04. [7] McEwen et al. (2007) JGR, 112, E05S02. [8] Bell et al. (2003) JGR, 108, 2003JE002070. [9] Bell et al. (2006) JGR, 111, 2005JE002444. [10] Neukum, et al. (2004) ESA SP - 1240, 17–35. [11] Hesp and Hastings (1998) Geomorph., 22, 193–204. [12] Bourke (2010) Geomorp., 205, icarus.2009.08.023. [13] Sullivan et al. (2005) Nature, 436, nature03641. [14] Greeley et al. (1980) GRL, 7, 121–124.