SHIFTING SANDS ON MARS: 3 CASE STUDIES. P. E. Geissler[1], N. W. Stantzos[1,2], N. T. Bridges[3], and the HiRISE Science Team, [1]U. S. Geological Survey, Flagstaff, AZ 86001 (pgeissler@usgs.gov); [2]Northern Arizona University, Flagstaff, AZ 86011 (nws6@nau.edu); [3]Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723 (nathan.bridges@jhuapl.edu).

Introduction: Martian sand dunes were long thought to be immobile, because of a dearth of evidence for bedform movement in early, low resolution images. The implications were that the dunes were fossil relics of an earlier climatic epoch or were frozen in place by interbedded ices. The HiRISE camera on Mars Reconnaissance Orbiter has been carrying out an orchestrated campaign to re-image sand dunes and other eolian features under similar lighting conditions at intervals of Martian years. Initial results of this survey show sand movement in many places on Mars, particularly in the north polar erg [1]. Here we focus on three tropical sites with verifiable surface changes caused by windblown sand. These sites are all intracrater dune deposits in the Arabia Terra/Meridiani Planum region but they are separated by up to 2000 km and lie in distinctly different terrain with different sand sources.

Pasteur crater: Pasteur crater is located at 24.7° E, 19.4° N, in a generally dust-covered region of eastern Arabia with relatively high albedo and low thermal inertia. The intracrater dune deposits consist of small, isolated, dark barchans clustered in the southwest quarter of crater. The sparse dunes are found sheltered in the lee of topographic obstacles and in depressions such as small craters. The dune orientations indicate that they formed from northeasterly winds. The dark dunes overlie bright soils made up of dust and transverse aeolian ridges (TARs). Changes in the dunes were observed over 1 Martian year between Dec 11 2006 and Nov 2 2008. Figure 1 shows that these changes cannot be ascribed to deposition or removal of a dust coating, but rather require local sand motion in a southwesterly direction.

The Pasteur crater dunes are interesting because they appear to arise from a local source within Pasteur crater itself. The small crater Euphrates, upwind of the dunes at 24.8° E, 19.8° N, appears to have excavated layered sediments and collected a pool of dark sand at its base (Figure 2). The dark bands within the layered deposit may be eroding to generate the sands in Euphrates and elsewhere within Pasteur.

Becquerel crater: Becquerel crater is located at 352.2° E, 22.1° N in a region of western Arabia Terra with intermediate albedo and thermal inertia.

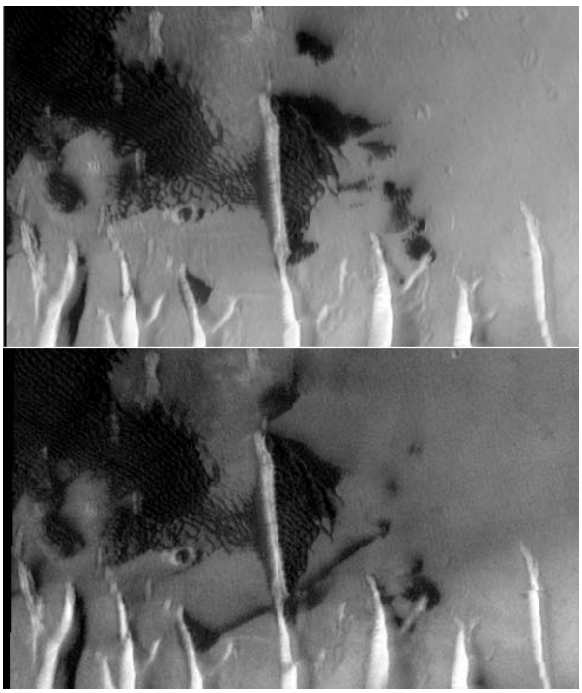

Figure 1: Pasteur (top) PSP_001756_1995, 2006-Dec-11 (bottom) PSP_010643_1995, 2008-Nov-02

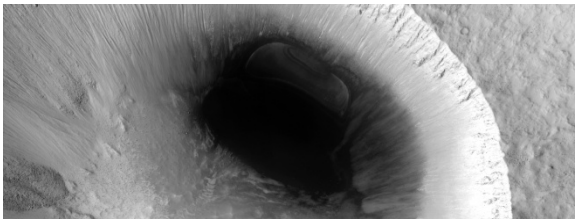

Figure 2: Euphrates crater, PSP_007004_2000

Becquerel is particularly interesting because a deposit of bright layered sedimentary rock is found near the southern rim of crater. Southerly trending wind streaks cross the surface of the layered deposit, which is sculpted into knobs and yardangs [2]. Dark dunes are clustered along the northern edge of the layered deposit, presumably providing the source of the dark streaks. The orientation of the barchans indicates that they were formed by northerly winds. No local sources of sand have been identified in Becquerel crater. The dark sands to the north (upwind) of the layered deposit appear to have blown in from outside of Becquerel crater. Changes in the distribution of the sand with respect to the layered deposits were

observed over 2 Martian years between Nov 24 2006 and Sep 5 2010. The most obvious changes occurred along the margins of the dunes and in the pattern of ripples atop the dunes (Figure 3).

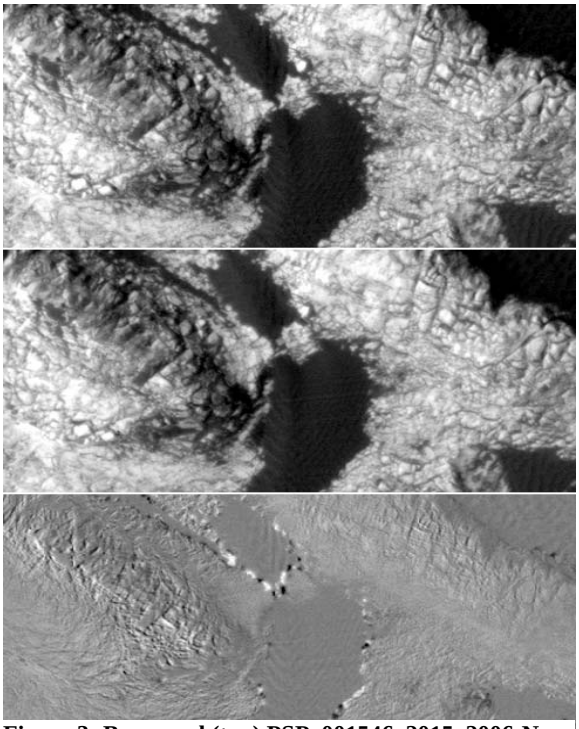

Figure 3: Becquerel (top) PSP_001546_2015, 2006-Nov-24. (middle) ESP_019268_2015, 2010-Sep-05. (bottom) difference.

These observations suggest that the sands in Becquerel are currently mobile and actively contribute to the sandblasting that has evidently eroded the layered deposit. Already acquired stereo images will allow construction of a DTM to orthorectify the images and (with another stereo pair) quantify sand fluxes at this site.

Meridiani: The third site is another intra-crater dune deposit in an un-named crater located at 4.7° E, 3.1° N on edge of low albedo, high thermal inertia terrain in Meridiani planum. The dunes are situated in the southwest quarter of the crater on bright bedrock which is complexly fractured and convoluted. The orientation of the coalescing barchans suggests that they were shaped by north to northeasterly winds. The dunes are graded by size with the largest upwind. No local sand sources could be identified within the crater. Changes were observed over 1 Martian year between Jan 25 2008 and Jan 29 2010. Many conspicuous changes took place at the edges of dunes and in the pattern of ripples on the surface of the sand dunes (an example is shown in Figure 4).

Discussion: These results are consistent with the surface observations of the MER rover Opportunity,

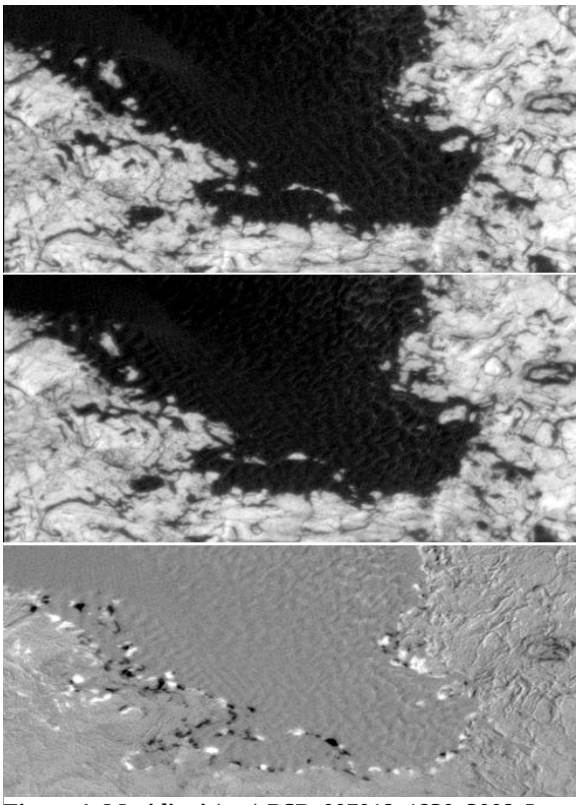

Figure 4: Meridiani (top) PSP_007018_1830, 2008-Jan-25. (middle) ESP_016459_1830, 2010-Jan-29. (bottom) difference.

which documented sand movement at Meridiani Planum in MI and Pancam images [3-5]. The detection of sand movement by HiRISE in this region provides some confidence that the orbital observations can be used to discern the mobility of sands elsewhere on Mars. Although we are still in the early stages of this survey, the detection of sand movement both in the tropics of Mars and in the north polar erg suggests that Martian dunes are presently active, at least on their surfaces. Several other sites show more modest changes than those shown above, such as streaks and avalanches along the steep downwind slip faces of the dunes. Conversely, there are many locations where no changes are detected, in spite of favorable imaging conditions. All three of the sites described above were targets chosen for the easy visibility of the dark dunes contrasting with the background of bright bedrock or soil. This suggests that sand movement may be common elsewhere on Mars but more difficult to detect.

References: [1] Bridges, N. T. *et al*. (2011) this meeting. [2] Rossi, A. P. *et al*. (2009) *LPSC 40:1588* [3]. Herkenhoff, K. E. *et al*. (2006) *LPSC 37:1816* [4]. Geissler, P. E. *et al*. (2008) *JGR 113,* doi :10.1029/2008JE003102. [5] Geissler, P. E. *et al*. (2010) *JGR 115,* doi : 10.1029/2010JE003674.