HIRISE OBSERVATIONS OF MARTIAN ALBEDO BOUNDARIES. P. E. Geissler[1] , L. Tornabene[2], C. Verba[3], N. Bridges[4] and the HiRISE Team [1]U.S. Geological Survey, Flagstaff AZ 86001 USA (pgeissler@usgs.gov), [2]University of Arizona, Tucson AZ USA, [3]Northern Arizona University, Flagstaff AZ USA, [4]JPL, Pasadena CA USA

Introduction: Albedo boundaries divide bright and dark terrain at the front of the battle between wind and dust on Mars. Mars undergoes profound albedo changes on annual and decadal time scales, that have visibly affected as much as a third of the surface during the interval between the earliest spacecraft observations and the present [1]. These brightness changes affect the absorption of solar energy by the surface and impact the global climate and circulation of winds on Mars [2]. The surface changes are due to deposition and erosion of dust by the winds, but the detailed mechanisms of dust transportation are still largely unknown. Many areas of Mars change appearance repeatedly, as layers of dust are deposited by global dust storms and are subsequently eroded by a combination of steady seasonal winds, continual scouring by dust-devils, and episodic strong winds generated during dust storms.

HiRISE has targeted several diverse albedo boundaries for two reasons. First, we wish to understand the mechanisms of surface change and how they vary with location and season. Second, the images will provide documentation that will enable future studies to monitor the rates of change at the highest resolution. The morphologies of the various boundaries observed range from knife-edged straight streaks to delicate sketches made by dancing dust-devils. Here we focus attention of two prominent albedo boundaries in Utopia Planitia that show close similarities in morphology but drastic differences in their behavior over time.

Previous Observations: Figure 1 shows how the albedo patterns in western Utopia Planitia have changed over the twenty Earth years between Viking and Mars Global Surveyor [1]. The dark terrain at the north of the picture is known as Nilosyrtis in the west and Utopia in the east. The isolated dark patch to the southeast is called Alcyonius. The dark terrain enlarged by more than a million square kilometers over the interval between the Viking observations (1976-1980) and the MOC images from MGS (1999-2001). The albedo of the affected area dropped by up to 50%. Images from Mariner 9 show that surface changes in this region began as early as 1972.

The albedo boundaries in this region are strikingly sharp and irregular in comparison to the sweeping, diffuse transitions left by windstreaks elsewhere on Mars. High resolution MOC images revealed that the dark terrain is dominated by the tracks of dust-devils, particularly in the higher latitudes from 45 to 65 degrees north [1]. Monitoring by MGS has shown [3] that the northern albedo boundary (between the northern dark regions of Nilosyrtis and Utopia and the bright plains to the south) has continued to shifted southwards over the 4 Martian years between 1999 and 2005. The rate of gradual southwards movement is consistent with the total change seen from Viking to the arrival of MGS, suggesting that the albedo changes shown in Figure 1 may have been produced by a similar gradual process. In contrast, the albedo boundary dividing the bright plains from the southern dark terrain in Alcyonius has been stationary over the past few Martian years. Why the Alcyonius albedo boundary remains fixed in location while nearby Nilosyrtis advances is a mystery.

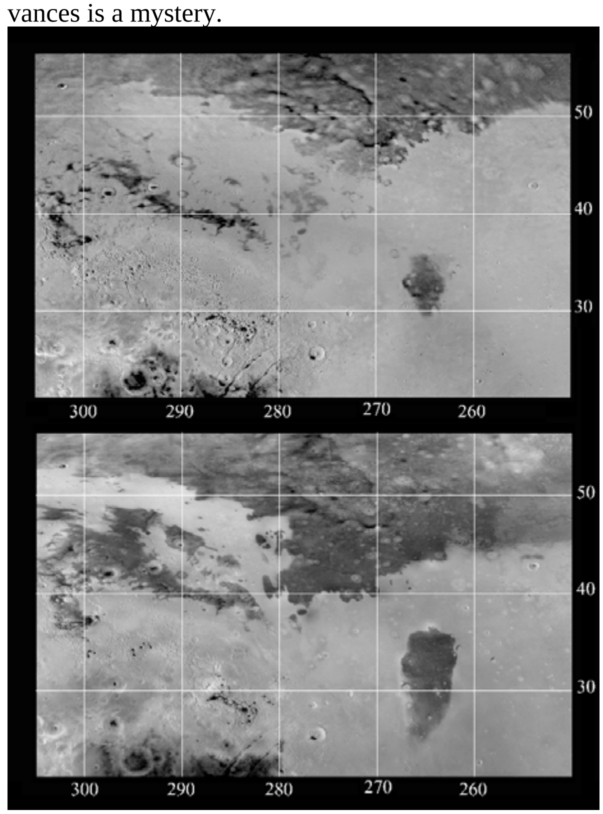

Figure 1: Surface Changes in Utopia Planitia

HiRISE Observations: Survey images transecting albedo boundaries in Utopia Planitia were acquired while the MRO spacecraft was nadir pointed. Because of the uncertainty in the location of the moving target, a 32 km long traverse of the Nilosyrtis albedo boundary (image PSP_006250_2200) was acquired by subsampling the image margins and retaining full resolution only along the image center. This image shows curvilinear tracks at the albedo boundary that are characteristic of dust devils (Figure 2). A close-up (Figure 3) shows that the dark floored fractures in the landscape are filled with dark sediment, probably basaltic sand. The solitary bright ripples are among the last holdouts in a landscape largely stripped of dust.

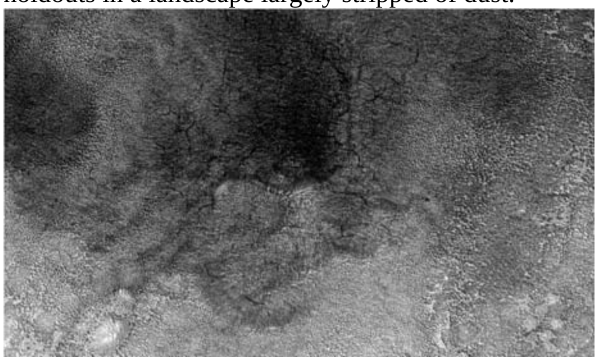

Figure 2: Nilosyrtis albedo boundary.

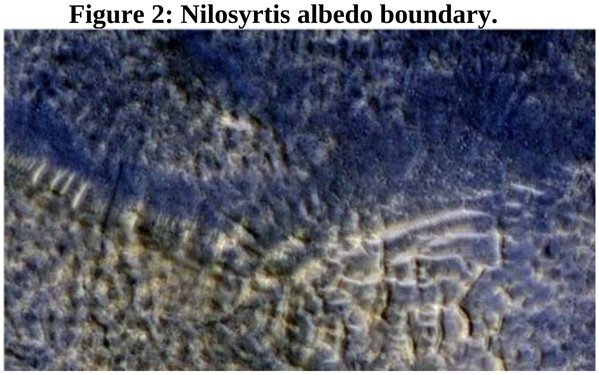

Figure 3: Nilosyrtis close-up of sand and ripples.

Alcyonius' northern boundary was targeted in a shorter full resolution image, PSP_006474_2165. The albedo boundary here is also populated by dust-devil tracks, unlike Alcyonius' southern boundary which is dominated by wind streaks. Interestingly, a comparison of cutouts (Figure 4) shows no notable difference in morphology between the bright and dark terrain north and south of the sharp boundary, except that the bright dust in the dark area is reduced to patches.

Discussion: The albedo boundaries in western Utopia Planitia are apparently sustained by dust-devils. Dust-devils are expected to form along albedo boundaries, as cooler air over bright regions replaces warmer air rising over dark areas [4]. Global circulation models [5] predict that the region experiences only light winds year round, particularly during local summer when dust-devils are expected to be most common. These models suggest that Nilosyrtis' advancing albedo boundary is not driven by northerly winds.

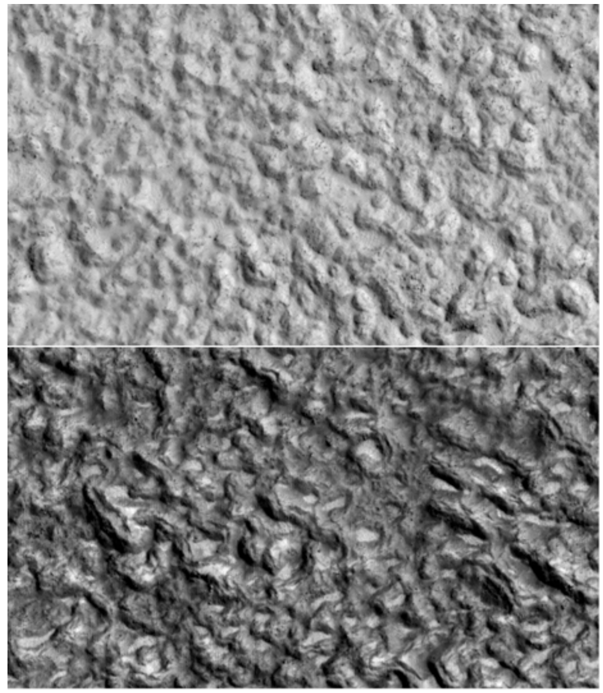

Figure 4: Alcyonius bright and dark terrain.

The HiRISE images argue against the possibility that Alcyonius' stationary albedo boundary is grounded by the intrinsic properties of the surface, such as rock abundance or sand supply. The bright terrain north of the albedo boundary appears similar in all respects to that south of the boundary, except that it is mantled in dust.

Why then is the Nilosyrtis albedo boundary advancing while Alcyonius is not? We suspect that the global temperature gradient drives the advance of Nilosyrtis. Dust-devils preferentially form along the southern boundary of the dark band, where the surface is warmest. As new dark area is exposed, it grows warmer than the previously cleaned surface because it is closer to the equator. The opposite situation exists along the albedo boundary of Alcyonius, where new dark area exposed by dust-devils is farther from the equator and hence cooler than the previously scoured surface. Here, the battle between wind and dust may have reached a temporary impasse.

References: [1] Geissler, P.E., JGR, 110, E02001, doi:10.1029/2004JE002345, 2005. [2] Fenton, L. et al., Nature, 446, doi:10.1038/nature05718, 2007. [3] Geissler, P.E., and M. Enga, LPSC 38, p.2190, 2007. [4] Renno, N. et al., JGR, 105, doi:10.1029/1999JE001037, 2000. [5] Haberle, R. et al., JGR, 102, doi:10.1029/97JE00383, 1997.