VARIATIONS IN SURFACE TEXTURE OF THE NORTH POLAR RESIDUAL CAP OF MARS.

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Introduction: The northern polar residual cap (NPRC) of Mars is a water ice deposit with a rough surface made up of pits, knobs, and linear depressions on scales of tens of meters [1]. This roughness manifests as a series of bright and dark patches in visible images; these bright and dark patches have a characteristic wavelength and orientation (Fig 1). Spectral data indicate that the surface of the NPRC is composed of large-grained (and therefore old) water ice. Due to the presence of this old ice, it is thought that the NPRC is in a current state of net loss of material [2].

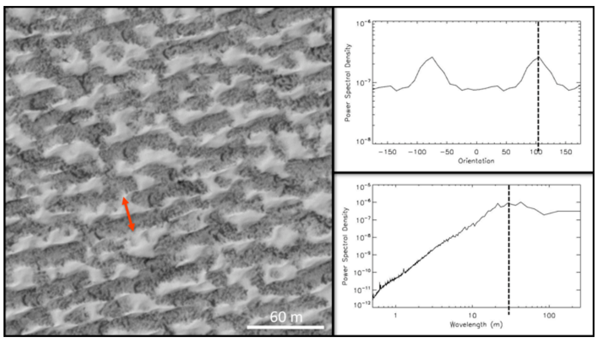

Figure 1: North Polar Residual Cap material. Left: subframe of HiRISE image ESP_018598_2745. Red arrow indicates the orientation and wavelength results of FFT analysis. Upper right: result of orientation analysis; dotted line indicates dominant orientation. Lower right: result of wavelength analysis; dotted line indicates dominant wavelength.

The NPRC provides a link between the current martian climate and the historical climate recorded within the layers of the underlying north polar layered deposits. By characterizing and mapping the variations in surface texture of the NPRC, we seek to understand what factors (distance from the pole, wind direction and strength, etc) are currently at work in resurfacing the deposit, and may have been at work in shaping the layers below.

Methods: Maps of NPRC texture wavelength and orientation are being produced from images taken by the High Resolution Imaging Science Experiment (HiRISE) onboard Mars Reconnaissance Orbiter (MRO). 41 HiRISE images have been analyzed thus far; these images cover an Ls range of 65˚ to 161˚.

The quasi-regular spacing of the depressions and knobs that make up the NPRC surface texture lends itself to quantitiative, automated analysis via two-dimensional Fourier analysis. This technique reconstructs an image using many sinusoidal functions of varying wavelengths and power; the functions that have wavelengths and orientations matching patterns within the image will have more power.

2D FFT analysis is performed upon two 256 meter x 256 meter regions (corresponding to 512 x 512 pixels in 0.5 cm/pxl images, or 1024 x 1024 pixels in 0.25 cm/pxl images) within each image analyzed. The dominant wavelength of the resulting peak power spectrum corresponds to the average size of a pit-knob pair in the image, and so is a proxy for the scale of the surface roughness. The orientation of the surface roughness (i.e., the trend of a chain of pits and mounds) is measured from a narrow range of wavelengths encompassing the dominant wavelength. An example can be seen in Fig. 1. Results for both locations examined within an image are consistent ~70% of the time.

Orientation Results: Images located near troughs tend to have surface textures that trend in the same direction as the troughs. However, images located in the polar flats (i.e., Gemini Lingula and the polar dome) do not have any general trend (Fig 2).

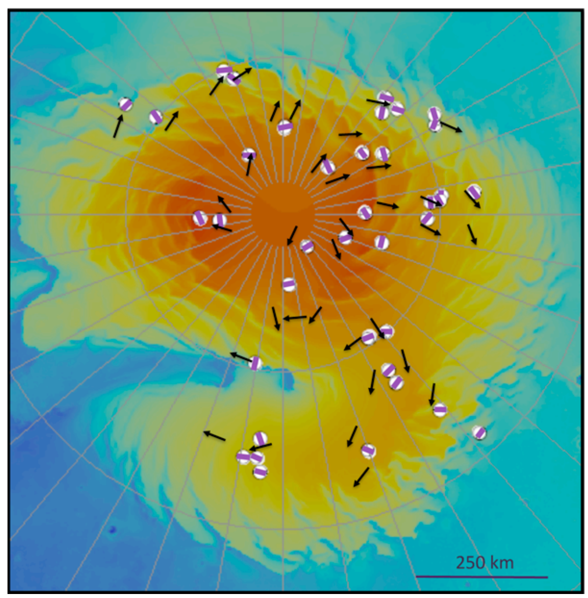

Figure 2: Orientation analysis results (purple lines in white circles) compared to wind directions inferred from frost streaks in Viking images by [3] (black arrows).

Howard [3] examined the orientations of frost streaks in Viking imagery to infer the direction of the wind around the polar deposits. When we compare these results to our orientation results, we see that near the troughs, the wind tends to run perpendicular to the surface texture orientation (Fig 2). Thus, wind direction may have an influence on texture orientation. However, there is no general relationship between surface texture orientation and wind direction away from the troughs, so wind direction cannot be the only factor determining texture orientation.

Wavelength Results: No trends were observed when comparing wavelength results to solar azimuth or incidence angle. However, wavelength did show dependencies on elevation and Ls.

Seasonal dependence. Three locations were observed at several seasons. For each image pair, the earlier image contained surface texture with a larger wavelength than the later image (Fig 3). Therefore, we speculate that in northern spring and early summer, perennial CO_2 frost may be covering portions of the surface and lengthening the wavelength of the surface texture. Examining all images taken after Ls=120˚ (which should be frost-free) shows that a majority of mid-to-late summer images have wavelengths < 21 m. It should be noted that many images taken before Ls 120˚ also have wavelengths < 21 m; longer wavelengths however are rarely observed after Ls 120˚.

Visual investigations of a single location in the NPRC over multiple years and Ls do show an increase in brightness in early spring which may be due to the presence of frost, followed by a decrease in albedo that may be due to annealing of ice [4]. This is consistent with our observations.

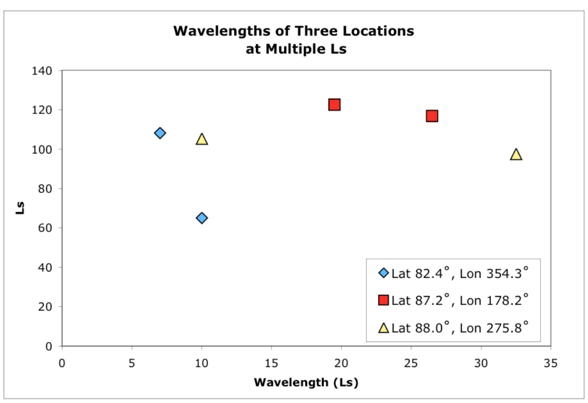

Figure 3. Ls versus wavelength for three locations observed at multiple Ls. Later Ls corresponds to shorter wavelengths.

Elevation dependence. If we focus on the smaller wavelengths (< 25 m), we see that wavelength roughly tends to increase with increasing elevation. This means that the depressions within the surface texture tend to be larger and spaced further apart the higher they are (Fig 4). Due to the shape of the polar dome, higher elevation is correlated with higher latitude; thus ablational processes may have a role in controlling the size and spacing of the NPRC surface texture.

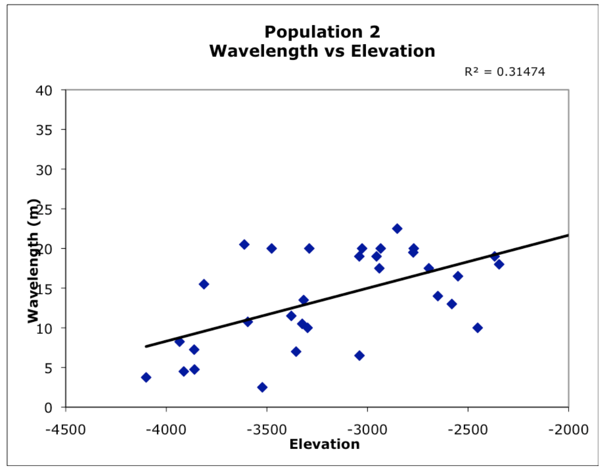

Figure 4. Wavelength versus elevation for images with wavelengths less than 25 meters.

Future Work: No one factor is able to fully explain the orientation and wavelength features observed in the NPRC. It is probable that many processes are at work shaping the surface texture, and thus their effects are tangled together. Surface frost, elevation or latitude, and wind direction appear to have significant effects.

This preliminary examination of the dataset suggest several promising avenues for further exploration and will determine where additional images will be analyzed. These include closer comparison of texture orientation with proximity to troughs and examining more locations at multiple seasons.

References: [1] P. C. Thomas et al, Nature 404, 161-164, 2000. [2] Y. Langevin et al, Science 307, 5715, 1581-1584, 2005. [3] A. Howard, Icarus 144, 267-288, 2000. [4] K. Herkenhoff et al, AGU Fall meeting, abstract P35F-02, 2010.

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