Tracking Gully Activity Within the North Polar Erg, Mars. S. Diniega[1], C.J. Hansen[2], [1]Jet Propulsion Laboratory, California Institute of Technology (4800 Oak Grove, Pasadena, CA 91109; serina.diniega@jpl.nasa.gov), [2]Planetary Science Institute.

Introduction

Analyses of high-resolution observations have shown that the dunes within the Martian North Polar Erg (AKA Olympia Undae) are currently very active on seasonal and yearly timescales. Over 40% of the dunes sampled within the North Polar Erg show dune brinks that seem to erode each year with small alcoves [1] (Figure 1). Sometimes these avalanche features also contain a large, but thin, depositional fan (Figure 1) that may reflect a mechanism for dune advancement [1]. Additionally, many of these degraded brinks are then "restored" to a crisp and continuous edge. When considering these dunes in aggregate, it has been proposed that present-day conditions result in a net equilibrium between erosion and restoration processes [1], although interannual variation has been observed [2]. However, it has not yet been determined exactly which processes are reshaping these dunes, or at what rates this activity occurs.

This project seeks to conclusively distinguish between a general aeolian versus a seasonal frost process origin of the gullies observed to form annually on these dunes. An initial study found that these features formed during the spring season and proposed that sublimation activity could destabilize the dune slopes and overlying seasonal CO_2 frost [1]. A subsequent study showed that many of the "new" alcoves seen in the spring were present and visible beneath the frost [3]. Thus, they proposed that alcove formation may occur before CO_2 accumulation and is due to aeolian processes in the mid- to late-summer. A third study reinforced the evidence for seasonal frost-driven processes, but acknowledged difficulties with detecting a gully (and thus identifying when it first appears) due to effects of frost and lighting changes [2].

These three studies [1-3], along with studies of dune gullies formed in the southern hemisphere [e.g., 4-6], have shown that a clear identification of when the gully first appeared is a key factor when considering activity under current environmental conditions. This project aims to definitively determine the timing and nature of gully formation within the North Polar Erg by carefully examining seven sites, dispersed around the pole, over four Mars years. We also aim to investigate any subset(s) of gullies that appears distinct in morphology aspects or other gully characteristics, and to connect those variations to environmental conditions or process specific to a locale or season. This will greatly aid geomorphological interpretation of HiRISE images of the North Polar Erg.

This presentation

Preliminary results, examining gully formation within at least one location, will be presented. Observed trends and patterns will be discussed, especially with regards to location of the gullies on gully slopes, slope orientation, and gully size and shape (average and variation). Methodology will be also discussed, along with issues encountered. In particular, this study is complicated by the fact that during winter – when gullies are perhaps forming on these dunes – is when images are not taken within the polar region as it is too dark (Figure 2). Comments will be welcome.

Significance for dune studies

In addition to identifying the gully formation mechanism, this project also aims to measure the rate of gully formation and dune restoration. Doing so will allow estimation of the volume of sediment transport occurring through each activity. Estimates of sediment flux are valuable constraints for most studies of present-day Martian surface modification as aeolian processes play a large role in both material redistribution and erosion. Finally, consideration and measurement of the effects of both seasonal and aeolian processes on the north polar dunes will form a much more complete picture of present-day conditions and activity within this extensive region that plays an important role in the global climate. Our results will help promote a better local, regional, and global understanding of seasonal and aeolian processes active on Mars.

References: [1] Hansen et al., 2011, Seasonal erosion and restoration of Mars' northern polar dunes, *Science* **331**, 575-578. [2] Hansen et al., 2015, Agents of change on Mars' northern dunes: CO2 ice and wind, *Icarus*, in-press. [3] Horgan and Bell, 2012, Seasonally active slipface avalanches in the north polar sand sea of Mars: Evidence for a wind-related origin, *Geophys. Res. Lett.* **39**, L09201. [4] Diniega et al., 2010, Seasonality of present-day Martian dune-gully activity, *Geology* **38**, 1047–1050. [5] Dundas et al., 2012, Seasonal activity and morphological changes in Martian gullies, *Icarus* **220**, 124-143. [6] Treiman, 2008, Wind and the origin of Martian gullies: A local and regional test in Cimmeria, *Workshop on Martian Gullies: Theories and Tests*, Ab. 8020.

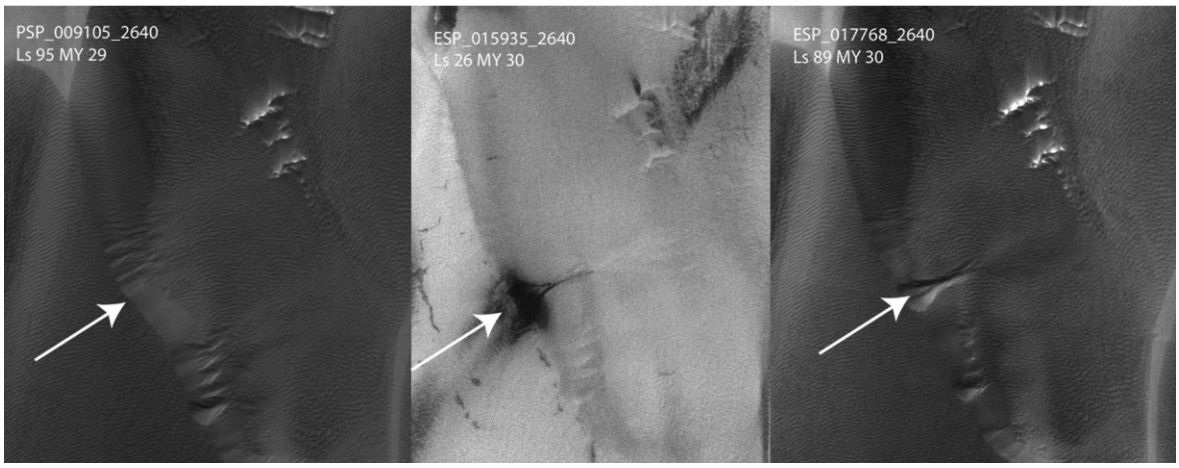

Figure 1. Alcove formation on a dune slope (at 84°N, 233°E) within the North Polar Erg. The white arrows point to a location on the brink of this dune that had no alcove in MY29 and experienced sublimation activity (middle), which resulted in the new alcove and fan (with total length of 120 m) in MY30. The layer of new material forming the apron is very thin and does not obscure pre-existing ripples. Restoration of the dune slope (or degradation of the gully) then also occurs, with alcoves being filled in on either side of the highlighted feature and new ripples forming across all surfaces. Image taken from [1].

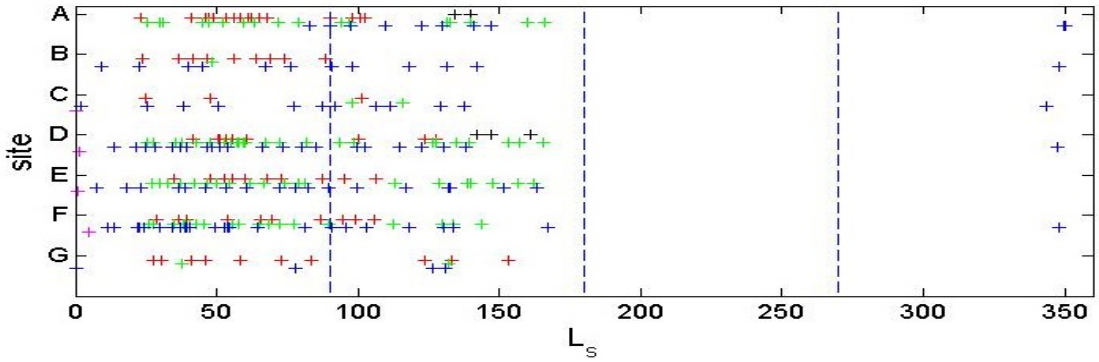

Figure 2. Plot of all publically-available images (as of Summer 2014) taken over seven sites dispersed around the pole (spanning latitudes 76-85°N and longitudes 0-334°E; locations will be shown in presentation). L_s is solar longitude – in the northern hemisphere, spring = L_s 0-90, summer = L_s 90-180, autumn = L_s 180-270, and winter = L_s 270-360. Black markers = MY28, red = MY29, green = MY30, blue = MY31, and magenta = MY32. The only non-spring or summer images were taken at the end of MY31 (A-D, F) and a few sites (C-F) have MY32 images available. [1] tracked changes within Sites A/F over MY 29-30. [2] tracked changes in Site A over MY29-30.