SLOPE-STREAK FORMATION AND DUST DEPOSITION RATES ON MARS. Norbert Schorghofer, Oded Aharonson, Mimi Gerstell, *Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena CA 91125, USA (norbert@gps.caltech.edu, oa@caltech.edu, mfg@gps.caltech.edu).*

Introduction

Slope-streaks are a class of features forming on the surface of present-day Mars. They were first discovered in high-resolution Viking Orbiter images (1; 2), but only Mars Orbiter Camera (MOC) images (3) revealed that they are currently active. Sullivan et al. (4) developed a kinematic model for dry dust avalanches that is consistent with observed characteristics of slope streaks. Schorghofer et al. (5) correlated streak regions with surface properties including low thermal inertia, topographic roughness, and peak temperature, and suggested that a phase transition of trace amounts of water may play a role in triggering such avalanches. Ferris et al. (6) suggested that more voluminous aqueous processes are involved in streak formation.

In this study we choose to avoid questions of slope-streak triggering and formation mechanisms, but assume that the observed albedo contrast is due to an event that removes a (usually brighter) dusty material, exposing a (usually darker) subsurface (4; 5). The varying states of fading seen in streaks are assumed to result from the subsequent redeposition of dust over time.

Figure 1 shows the occurrence of new streaks at a site that has been imaged three times, illustrating the ongoing streak formation process.

Image Survey

The survey of MOC narrow angle images was conducted as follows. First, a sample of 12,999 images at all latitudes was surveyed. Having found that streaks occur only at low latitudes, the remainder of the survey focused on the latitude range between 30°S and 60°N. In total, 29,326 images were examined, with ∼1,300 exhibiting features that were unambiguously identified as slope streaks. For each image containing slope streaks a set of parameters were compiled, including estimates of the numbers of dark and bright streaks in the image with associated uncertainties, azimuthal directions of dark and bright streaks, and the width of the widest streak in the image.

At least 50,000 dark slope streaks and 900 bright slope streaks have been imaged so far. The estimated density of streaks in the low-latitude low-thermal inertia regions is ∼0.03 km^{-2}. In this area, one in five MOC narrow-angle images shows slope streaks, so streaks are “typical” for the dust-covered low-latitude regions. The low-thermal inertia regions cover roughly 23×10^6 km^2, containing a crudly estimated ∼700,000 streaks.

The ∼1,300 streak images were automatically searched for overlap pairs using the image corner coordinates. This procedure identified 162 overlapping image pairs, containing ∼2,300 streaks and ∼120 new streaks. The time difference between image pairs ranges from 7 days (E0501337/E0502070) to 2.2 Mars years (AB103104/E1103665). The status of the image survey is summarized in Table 1, which also illustrates the rapid increase in available overlap images.

mission phases	AB-M23	AB-E12
surveyed MOC N/A images	∼23,000	∼30,000
slope streak images	∼800	∼1,300
overlap pairs	38	162
pairs with new streaks	7	48

Table 1: Current status of our MOC slope streak survey, compared to the status of one year earlier. Overlap images provide rapidly growing amount of information about current occurrences.

Formation Rates

Overlap images allow an accurate determination of the rate of streak formation. A formation rate q can be defined as the number of new streaks per year relative to the number of streaks in the overlap area. The probability of a streak forming over a small time interval dt is therefore $qndt$, where n is the number of streaks in the overlap region. If the formation rate is low, the probability of a sequence of events, over a time interval Δt, is

$$p(\Delta t, n, \Delta n; q) \quad = \quad \frac{1}{\Delta n!} e^{-qn\Delta t} (qn\Delta t)^{\Delta n}. \qquad (1)$$

The probability of all observations is

$$\mathcal{P}(q) = \prod_i p(\Delta t_i, n_i, \Delta n_i; q),$$

where the index i denotes the i-th image pair. The most likely q maximizes $\mathcal{P}(q)$, that is, $d\mathcal{P}(q)/dq = 0$. This can be solved to yield the rate q that best explains the observations:

$$q = \frac{\sum_i \Delta n_i}{\sum_i n_i \Delta t_i}. \qquad (2)$$

The sum is over image pairs. This formula yields an average formation rate of 7±1% new streaks per existing streak per martian year. However, there are statistically significant regional variations of this rate (Figure 2).

Such a high temporal rate, together with a high spatial density implies a high absolute frequency. The estimated global formation rate is 7%×700,000≈50,000 new streaks per Mars year. If the events occur uniformly in time this amounts to ∼70 per day. In this sense, slope streaks are the most dynamic geologic feature observed on the surface Mars.

Fading Rates

The inverse of the formation rate is 1/0.07∼14 Martian years or ∼26 years, so that the observed slope streaks are expected to be young features. If the slope streak population is in steady state, the formation rate must balance the fading rate.

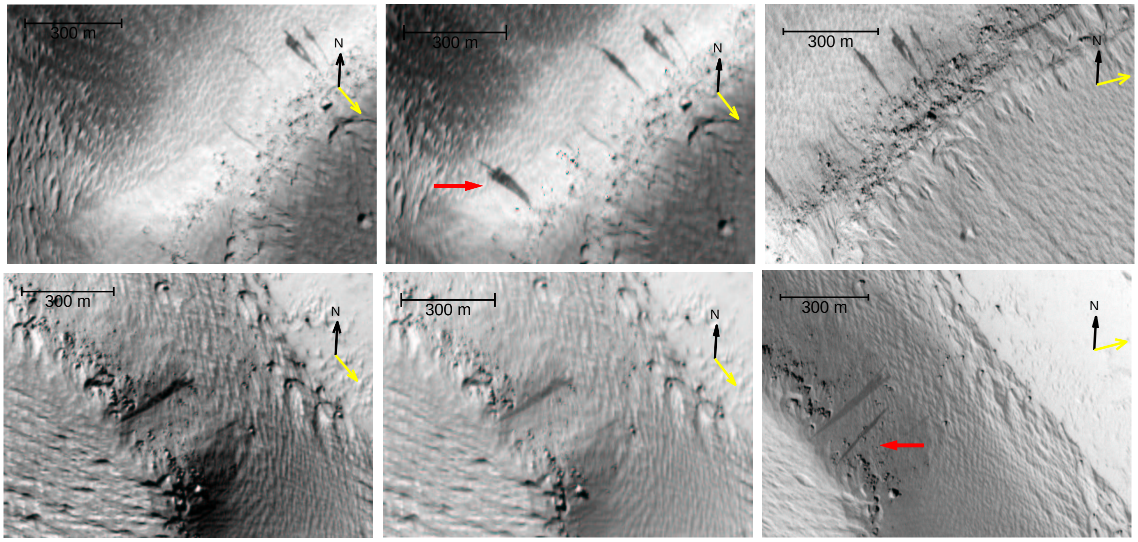

Figure 1: A triplet of overlap images taken on (from left to right) 1999-03-18, 2001-01-06, and 2002-01-03. The two rows correspond to subframes within the same image less than 4 km apart. New streaks (red arrows) occur twice at this site southwest of Daedalia Planum. The azimuths of solar illumination (yellow arrows) and north direction (black arrows) are indicated.

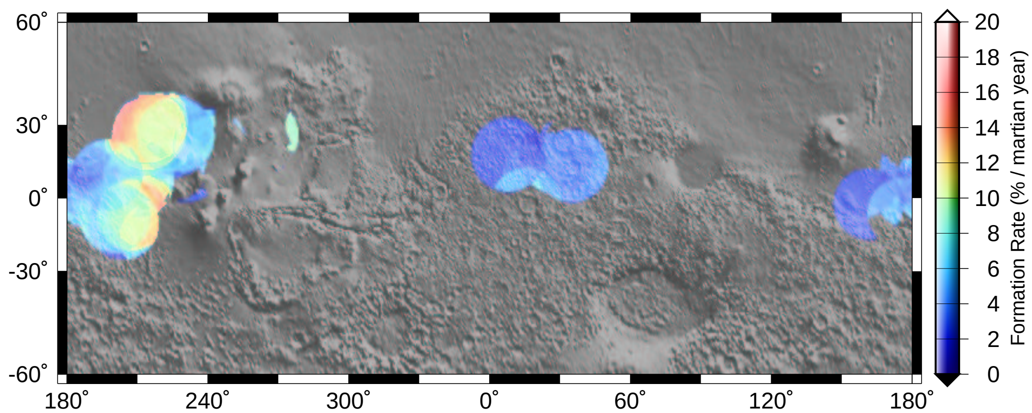

Figure 2: Regional variations of the slope streak formation rate. Rates are only plotted where the statistical error of the local rate is less than ±3%/martian year.

Terrestrial experiments (7) suggest that a 10 g/m^2 layer of 1-5μm sized dust particles cause significant albedo variations. A fading time of 26 years thus corresponds to a deposition rate of ∼0.4 g/m^2/yr. In contrast, Pollack et al. (8) estimated global dust sedimentation rates of 20 g/m^2/yr, with a large fraction taking place at the North Pole in association with CO_2 condensation. Another constraint was derived from dust accumulation upon the solar panels at the Mars Pathfinder landing site, estimated to be 0.28 %/day (9), that is, ∼10 g/m^2/yr. However this rate was seen to decrease later in the mission.

Streaks seen in Viking images and still observed in MOC images (4) exhibit little change in albedo. These imply locally (even) smaller net deposition rates. A systematic analysis of Viking-MOC overlap images is currently ongoing.

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