EPSC Abstracts
Vol. 12, EPSC2018-455-1, 2018
European Planetary Science Congress 2018

Short-Term Equatorial Albedo Changes on Mars: Deliquescence or Dust?

Alfred McEwen (1), Nicolas Thomas (2), Antoine Pommerol (2), Cecilia Leung (1), Sarah Sutton (1), Jason Perry (1), Stephen Scheidt (1), Matthew Chojnacki (1).
(1) LPL, University of Arizona, USA, (2) Physikalisches Inst., University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland.

Abstract

Puzzling short-term albedo changes have been seen on colluvial fans associated with Recurring Slope Lineae (RSL), especially within Valles Marineris, often associated with episodes of high dust opacity [1, 2]. Two leading hypotheses are (1) deliquescence associated with the lower daytime temperatures under dusty air, and (2) removal and redeposition of thin layers of surface dust. If (1) is correct, we should see dark areas in morning imaging by TGO/CaSSIS that disappear in the afternoon when observed by MRO's HiRISE and CTX. If (2) is correct, colour variations consistent with dust removal and deposition should be observed.

1. Introduction

CaSSIS (Colour and Stereo Surface Imaging System) on the ExoMars Trace Gas Orbiter (TGO) began systematic observing of Mars in May of 2018 [3,4], and provides the unique ability to observe equatorial Mars at all local times of day within each season. However, to distinguish seasonal albedo changes from shorter-term changes, we also need to rely on the High Resolution Imaging Science Experiment (HiRISE) [5] and the Context Imager (CTX) [6] on Mars Reconnaissance Orbiter (MRO), which observe the dayside at mid-afternoon local times.

2. Puzzling RSL

RSL are transient low-albedo features that initiate at bedrock outcrops and extend down steep slopes [1]. Individual slopes may have hundreds of lineae, with widths up to 5 m and lengths up to 1.5 km, so the largest lineae will be detectable by CaSSIS at ~4.5 m/pixel. RSL are active during the warmest seasons and are associated with the transient presence of hydrated salts [7], which suggests some role for salty water. But if the RSL were caused by fluid flow, they should not be precisely confined to angle-of-repose or steeper slopes (>28 deg.) [8], so these seem to be dry granular flows whose activity is somehow associated with small amounts of water.

One key unknown about RSL is the time of day when they are most active; MRO can only observe in the middle afternoon, the driest time of day. The 74° inclined orbit of TGO rotates through ~24 hours local time 1-2 times per Mars season, affording unique opportunities to image Mars in the morning when deliquescent liquids are most stable on the surface [9]. If the RSL or their fans are transiently dark due to deliquescence, then this process probably isn't restricted to steep slopes, rather it triggers granular flows (RSL) only on steep slopes. A goal of CaSSIS is to detect anomalous and transient dark patches in the morning. Although CaSSIS can re-image these locations in the mid-afternoon several Earth months before or after the morning images, seasonal changes complicate identification of diurnal changes. Fortunately, MRO can often image these sites within a couple of weeks of the morning image.

3. Puzzling Albedo Changes

One mystery is the transient relative darkening of large (>100 m) fans upon which RSL terminate, such as in Valles Marineris [1,2]. Although the monitoring is far from uniform in space and time, there seems to be an association with periods of dusty air in Valles Marineris. Regional dust storms (area > 1.6×10^6 km^2, and persisting for ⩾ 3 sols) occur 18 to 50 times per Mars year, with the more opaque dust storms occurring between L_s = 134°-49° [10]. About half of these regional storms follow the Acidalia storm track from north to south and tend to spread into eastern and central Valles Marineris. Some of the widespread RSL fans and nearby dune fields become relatively darker (compared to surroundings) during or shortly after these dusty periods, returning to their previous appearance within weeks when the air is back to normal. How can we explain this observation? We explore two hypotheses:

(1) Daytime surface temperatures are lower and nighttime temperatures are higher, each by ~10°C, when the air is very dusty [11]. Given the anticorrelation between temperature and relative humidity, this means that conditions needed for deliquescence may exist for extended periods of the day when the air is dusty, and the conditions needed for efflorescence should be reduced mid-day [9]. However, we are ignorant about actual relative humidity levels at these times and places except via modeling, and about local salt compositions and concentrations.

(2) Increased winds associated with the Acidalia storms could lead to increased saltation of sand, which kicks up and removes dust from sandy surfaces. This includes active sand ripples frequently observed on RSL fans [2]. As the winds die down, the dust is redeposited, increasing the albedo most markedly over the darkest surfaces. This seems like a straightforward explanation, but in detail some fans and dunes darken while others do not, and in some cases the darkening appears to be due to a greater density of RSL.

4. Joint CaSSIS-HiRISE Planning and Data Analysis

TGO plans observations at least 8 weeks prior to execution, and controls the orbit to match the plan. In contrast, MRO lets the orbits drift to minimize fuel use, but has a later planning cycle. This works well for joint observations, because the CaSSIS imaging plans will be known well in advance, so HiRISE and CTX can target the same locations within ~2 weeks, given MRO's ability to point up to 30 degrees off-nadir.

These morning-afternoon image pairs will not be easy to compare because the lighting angles will be completely different over sloping terrain. Digital terrain models (from CaSSIS, CTX or HiRISE) will be used to model and remove topographic shading from the images. The detection of morning dark patches and their patterns in space and time will test the deliquescence hypothesis for the origin of water affecting RSL. If there is sufficient deliquescence on the surface to detect darkening, that should be happening over many places, not just over steep slopes. Analysis of surface colour variations is complicated by dusty air which makes dark dust-free surfaces resemble dusty surfaces [12].

5. Summary and Conclusions

We are entering both the peak season for regional dust storms and the highest data rate period this summer (on Earth), so there should be many useful MRO-TGO image comparisons to present and discuss at the conference.

References

[1] McEwen, A. S., et al.: Recurring slope lineae in equatorial regions of Mars, Nat. Geosci., 7(1), 53–58, doi:10.1038/ngeo2014, 2013.

[2] Chojnacki M. et al.: Geologic context of recurring slope lineae in Melas and Coprates Chasmata, Mars. J. Geophys. Res. Planets 121, 1204-1231, doi: 10.1002/ 2015JE004991, 2016.

[3] Thomas, N. et al.: The Colour and Stereo Surface Imaging System (CaSSIS) for the ExoMars Trace Gas Orbiter. Space Sci. Rev., 212, 1897, 2017.

[4] Thomas, N. et al.: CaSSIS – First images from science orbit, this conference, 2018.

[5] McEwen, A.S., et al.: Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE). J. Geophys. Res. 112, E05S02, 2007.

[6] Malin, M.C., et al.: Context camera investigation on board the Mars Reconnaissance Orbiter. J. Geophys. Res. 112 (E5). doi:10.1029/2006JE002808, 2007.

[7] Ojha, L., et al.: Spectral evidence for hydrated salts in recurring slope lineae on Mars, Nature Geoscience 8, 829-832, doi:10.1038/NGEO2546, 2015.

[8] Dundas, C. M., et al.: Granular flows at recurring slope lineae on Mars indicate a limited role for liquid water , Nature Geoscience, doi: 10.1038/s41561-017-0012-5, 2017.

[9] Gough, R. V., V. F. Chevrier, and M. A. Tolbert: Formation of aqueous solutions on Mars via deliquescence of chloride-perchlorate binary mixtures, Earth Planet. Sci. Lett. 393, 73–82, doi:10.1016/j.epsl.2014.02.002, 2014.

[10] Cantor, B.A., Malin, M.C., Edgett, K.E.: Martian Dust Storms—Observations by MGS-MOC and MRO-MARCI. Eighth International Conference on Mars, LPI Contribution No. 1791, p.1316, 2014.

[11] Ryan, J.A., Henry, R.M.: Mars atmospheric phenomena during major dust storms, as measured at surface. J. Geophys. Res. 84, 2821-2829, 1979.

[12] Fernando, J. et al.: Mars Atmospheric Dust Contamination of Surface Albedo and Color Measurements. 48th Lunar and Planetary Science Conference, LPI Contribution No. 1964, id.1635, 2017.