EPSC Abstracts
Vol. 11, EPSC2017-260, 2017
European Planetary Science Congress 2017

Formation of recurring slope lineae on Mars by rarefied gas-triggered granular flows

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Abstract

Recurring Slope Linae or RSL are seasonal dark features appearing when the soil reaches its maximum temperature. They appear on various slopes at the equator of Mars, in orientation depending on the season. Today, liquid water related processes have been promoted, such as deliquescence of salts. Nevertheless external atmospheric source of water is inconsistent with the observations. Internal source is also very unlikely. We take into consideration here the force occurring when the sun illuminates granular soil in rarefied gas conditions to produce a Knudsen pump. This process significantly lowers the angle of repose of sandy material. Hence, relatively low slope could start to flow. RSL seems to originate from rough terrains and boulders. We propose that the local shadows due to boulders over the soil, is the triggering phenomena. In this case, the Knudsen pump is magnified and could lead to flow. This new exotic dry process involving neither water nor CO2 and is consistent with the seasonal and facet's orientation appearance of RSL.

1. Introduction

The temperature and solar irradiation dependence has been recognized very early, and has been mainly interpreted as an effect of humidity [1, 2]. Indeed, RSL activity occurs in the closest point to liquid water in the phase diagram, at present time on Mars [3]. Various sources of liquid water have been discussed: subsurface aquifers, melting of subsurface ice, deliquescence of salt recharged by atmospheric water [4].

Nevertheless, the location of RSL is near the equator where atmospheric water vapor is at the lowest [5]. Also, the surface condensation of atmospheric water ice rarely occurs and subsurface ice is not stable. The source of water seems still a mystery because an internal source, such as a subsurface aquifer, has also been excluded near the crater rim [3]. In addition, the actual amount of atmospheric water required to re-charge the RSL's source each year seems not sufficient. The precise thermal calculations using THEMIS measurement instrument show no evidence of liquid water [6] and there is no direct evidence of liquid water from CRISM, but only indirect detection [4].

We propose here a re-interpretation of the RSL features and a new process to explain the RSL activity without involving any volatiles. This process aims to reconcile all available data. We put forward that the photophoretic effect, triggered by the sun radiation, modifies seasonally the angle of repose of the granular material. Since the slopes of granular material are stable near 30°, even a minor change in the angle of repose due to the air flux in the porous space of the soil could significantly change the stability.

2. Method

Knowing the direct solar flux, the one scattered by the atmosphere, and the thermal infrared flux from the Mars Climate Database [7], we estimate the incoming energy fluxes on various facet. By using these values as boundary conditions on a precise thermal surface balance model [8,9], we aim at estimating the Knudsen pump effects on one particular RSL site: Garni crater. Each facet is computed for a slope of 30° and different orientation, throughout all the seasons.

3. Results

Figure 1 shows the angle of repose of a granular material, modified by the natural pump. Without this pumping effect, the angle of repose remains constant though time with a values ~30°. With regular pumping effect, there is only very few changes in the angle of repose.

Figure 2 shows the same for an enhanced pump due to the shadowing of a boulder. Here we show that the switch off of direct solar irradiation considerably lowers the angle of repose, but also varies along the solar cycle. Figure 2 also superposes the activity observed in Garni carter [3]. Flows activity occurs always in period of low repose angle. The proposed mechanism has a good agreement between activity and low period of angle of repose.

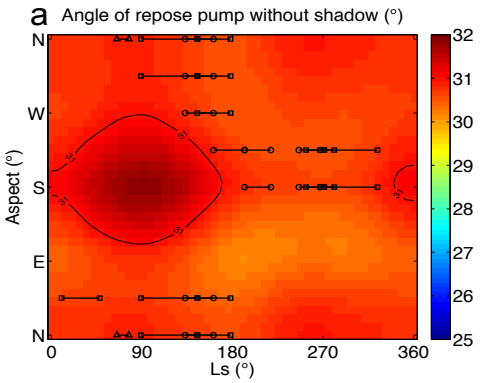

Figure 1: Angle of repose, modified by the Knudsen pump effect, as a function of slope aspect and season for the regular pump. Black lines represents the RSL activity observed at Garni crater. Each activity is encompassed by two images: before and after.

4. Conclusion

We propose an original mechanism for RSL as a result of a dry natural pump within the granular soil [10]. This mechanism is exotic and can't occur on Earth due to high-pressure level. On Mars, our model suggests that the Knudsen pump is efficient enough to trigger a flow in accordance with observed seasonality of RSL. Since the equator of Mars is most probably volatiles depleted, this mechanism should be considered as good candidate to explain RSL features. In this case, liquid water may not be present on Mars at present time.

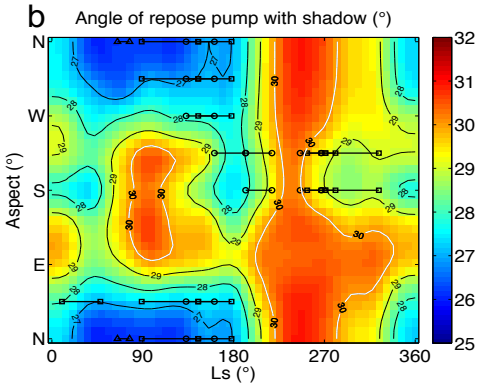

Figure 2: Idem figure 1, expect for the enhanced pump.

References

[1] McEwen, A. S., et al. (2011), Science, 333, 740-743 [2] McEwen, A. S., et al. (2014), Nature Geoscience, 7, 53-58 [3] Chojnacki, M., et al. (2016), Journal of Geophysical Research: Planets, 121, 1204-1231 [4] Ojha, L., et al. (2015), Nature Geoscience, 8, 829-832 [5] Smith, M. D. (2002), JGR, 107, 5115- [6] Edwards, C. S. & Piqueux, S. (2016), GRL, 43, 8912-8919 [7] Lewis, S. R., et al. (1999), JGR, 104, 24177-24194 [8] Kocifaj, M., et al. (2010), Monthly Notices of the Royal Astronomical Society [9] Kocifaj, M., et al. (2011), Icarus, 211, 832-838 [10] Schmidt., F. et al. (2017), Nature Geoscience, 10, 270-273