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Recurring Slope Lineae: Evidence for Present-Day Flowing Water on Mars?

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Abstract

Recurring slope lineae (RSL) are relatively low-albedo features that extend down steep slopes from bedrock outcrops (Fig. 1). Hundreds may form in rare locations, often associated with small channels [1]. In the southern mid-latitudes, RSL appear and grow incrementally during the late southern spring through summer. They favor equator-facing slopes--times and places with peak surface temperatures from ~250 to 300 K. RSL are recurring: they form and grow in the warm season, then fade and usually completely disappear in cold seasons. During the next warm season, similar but new features form and grow. If RSL are due to flowing water as we suspect, then they mark key locations for future exploration.

1. Introduction

Pure water is highly unstable on the surface of Mars and will rapidly evaporate (often boiling) and/or freeze. However, salts can dramatically lower the freezing point and evaporation rates, making salty water much more stable [2]. The discoveries of perchlorate [3] and other hygroscopic salts make liquid water in the current climate much more likely. In fact, some salts must form small quantities of water at certain geographic locations and times of day [4]. Although RSL are not necessarily driven by deliquescence, they suggest that at certain times and places there may be enough water to flow down steep slopes.

As potential sites of present-day water on Mars, RSL and deliquescent salts raise the exciting potential for near-surface extant life [5]. However, they also raise issues of planetary protection that complicate in-situ exploration and especially sample return [6].

2. Recent Observations

The primary data set for studying these meter-scale features is imagery from the High Resolution Imaging Science Experiment (HiRISE) on NASA's Mars Reconnaissance Orbiter (MRO). As of early 2012, 15 RSL sites had been confirmed between 52-32°S latitudes [7]. Confirmation requires that we observe many new lineae forming at a site in more than one Mars year, distinguishing RSL from episodic dry mass wasting triggered by eolian or seismic activity. The warm-location activity distinguishes RSL from dark flows of dust and sand (sometimes carving detectable gullies) that occur while CO_2 is on the ground [8, 9]. We have recently confirmed three more sites, two in the southern mid-latitudes and the first equatorial site--in a crater on the floor of Coprates Chasma (14.1° S, 296.9° E). The latter site suggests that there may be more special regions near Mars' equator; monitoring of other candidate equatorial RSL sites is ongoing.

Frequent monitoring during the most recent southern summer (in 2011) revealed many details, best seen in animations available at http://hirise.lpl.arizona.edu/sim/science-2011-aug-4.php. Individual flows fade at different rates. Some may become inactive and fade while others are growing, even in the summer. At a given site, the abundance, lengths and exact sites of RSL may vary significantly from year to year.

RSL have very specific seasonal behaviour and exhibit slow, incremental growth, strongly suggesting the action of a volatile. Near-surface brines might explain RSL activity. Temperatures are far too warm for CO_2. The source of water must be either the atmosphere or the subsurface, but is not currently understood.

MRO's Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) has so far not observed water bands in RSL. This can be explained by the combination of resolution (CRISM pixels are an order of magnitude larger than most lineae) and weakening of absorption bands at 1.5 and 2 μm as wet soil dries out [10]. Drying is expected in the mid-afternoon when MRO observes Mars [4]. The strongest absorptions near 3 μm are the focus of ongoing work.

3. Future Observations

HiRISE continues to search for RSL activity in equatorial and northern mid-latitude sites during the northern summer, and image the southern hemisphere locations to monitor fading and check for evidence of frost. Substantial amounts of CO_2 frost are highly unlikely on these slopes, which generally face north, east or west and receive ample solar heating throughout the year. CRISM has acquired a number of Along-Track Oversampled (ATO) observations of RSL sites, and analysis of these data is ongoing. The ATO mode provides somewhat higher resolution and signal-to-noise ratio than standard full-resolution targets. As southern summer returns in early 2013 we will resume intensive monitoring of known active sites, including some of those intensively monitored in 2011 to characterize interannual variations.

Future orbital or landed investigations are needed to acquire compositional and other data addressing the role of water. A landed investigation is currently difficult to plan because (1) we haven't found a landing site near active RSL that meets current safety requirements, and (2) a greater understanding is needed to select the most scientifically compelling site. Future orbital measurement requirements [11] and a mission concept [12] have been described for a workshop on future Mars exploration.

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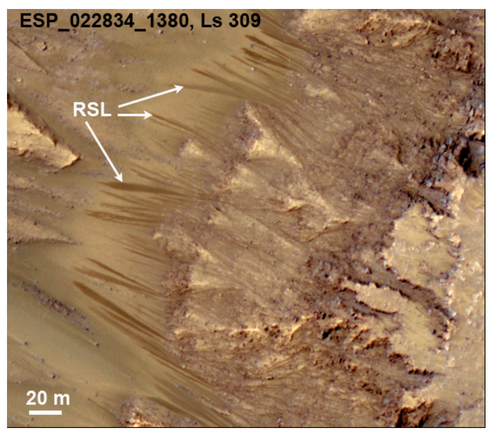

Figure 1: Example of well-developed RSL in Palikir crater inside Newton crater. Slope is downhill to the northwest (north is up).