**GEOLOGIC CONTEXT OF RECURRING SLOPE LINEAE IN COPRATES CHASMA.**
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**Introduction and Motivation:** Recurring Slope Lineae (RSL) are narrow, dark-toned streaks that occur on steep, low-albedo slopes and incrementally grow, fade, and reappear yearly. They were initially detected in the mid-latitude southern highlands [1,2]. Their seasonal behavior and preference for warm equator-facing slopes suggests the involvement of a volatile, possibly briny water, an attractive explanation for this phenomenon [3,4]. More recently, abundant RSL have been detected in equatorial sites, particularly within Valles Marineris (VM), which provide new clues to their origin [3] - yet the source of the putative water remains elusive.

Here, we describe numerous RSL detected among diverse geologic settings within the deep canyons of Coprates Chasma (**Fig. 1**) that provide new constraints on these unique phenomena. In this abstract we will focus on several questions: What types of geologic environments do Coprates RSL form in? What is the elevation range over which RSL occur? Do RSL form in places where the topography precludes sufficient groundwater flow reaching the surface without special mechanisms?

**Data Sets and Methods:** To assess RSL activity, we used repeat visible-wavelength images from HiRISE [5]. In addition, we constructed several Digital Terrain Models (DTMs) from HiRISE stereo pairs for topographic analysis of well-monitored RSL sites. The resulting DTMs were co-registered with MOLA data points and have elevation postings every 1 m with sub-meter vertical precision [6]. Overlapping orthorectified images were used to characterize the temporal behavior of RSL.

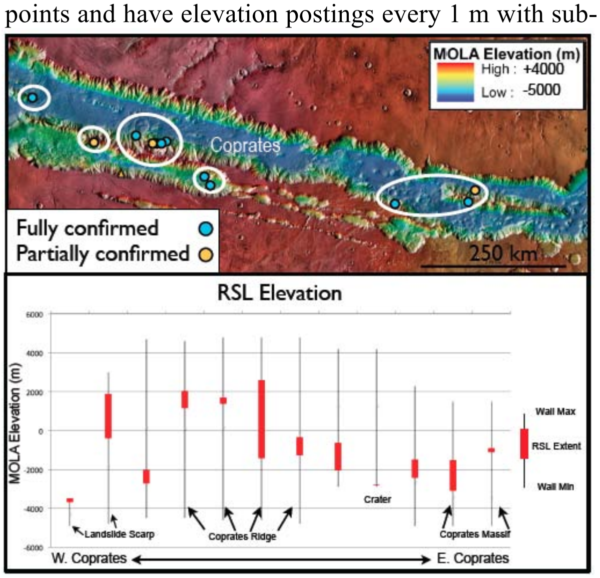


**Fig. 1.** (top) THEMIS daytime infrared mosaic of Coprates Chasma RSL sites colorized with MOLA topography. (bottom) RSL elevation distribution (red boxes) compared with local topographic extent (gray bars). Note, sites are evenly spaced with respect to longitude.

**Results-Overview:** Twelve RSL sites have been identified within Coprates Chasma (**Fig. 1**): eight fully confirmed sites with recurrence (flows and fading) in multiple Mars years, and four partially confirmed sites where slope lineae (SL) slowly grow but do not fade. Many other sites are identified in lower-resolution images, but require repeat HiRISE targeting for confirmation. Coprates RSL sites (from source to toe) occur across the East-West oriented chasm and over 5–45% of the local range in elevation (**Fig. 1**) (from -3.7 km to +2.6 km elevation). Coprates RSL are active over a greater range of elevation than other reported confirmed non-VM sites that occur from -1.5 km to +2 km elevation [2]. One especially active wall location (**Fig.1**; informally named Coprates Ridge) consists of five known sites spread over ~30 km and >4 km in elevation.

**Associated Landforms:** These sites occur with a variety of geologic contexts and landforms. Similar to initial detections of RSL [1], a few sites occur in small craters, located here on the canyon floors [3]. VM crater-related RSL form similar flows on steep and smooth crater walls, as has been observed with mid-latitude sites [1,2], but are active throughout the year favoring the currently illuminated slope [3]. Two sites are located along slopes on or below landslide scarps of bedrock, generally toward the higher portions of the slides. Landslide-related RSL are often found within small gullies (which they appear to have helped carve) forming long (~1 km), narrow flows that are few in number. Most sites have adjacent duneforms that also show seasonal SL that appear to fit the criteria for RSL

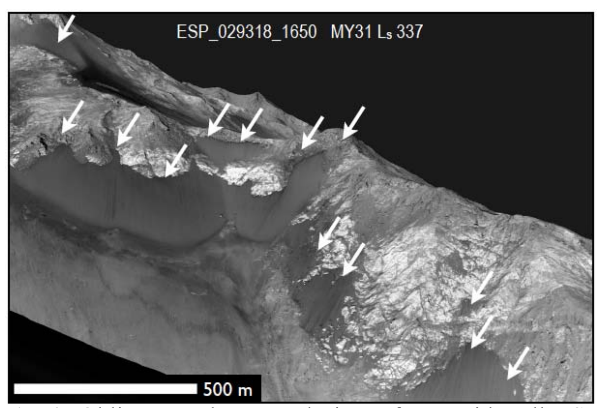


**Fig. 2.** Oblique northeastward view of one mid-wall RSL site in eastern Coprates (using HiRISE-derived topography). RSL source areas are indicated by white arrows. See http://www.uahirise.org/sim/ for an animated movie.

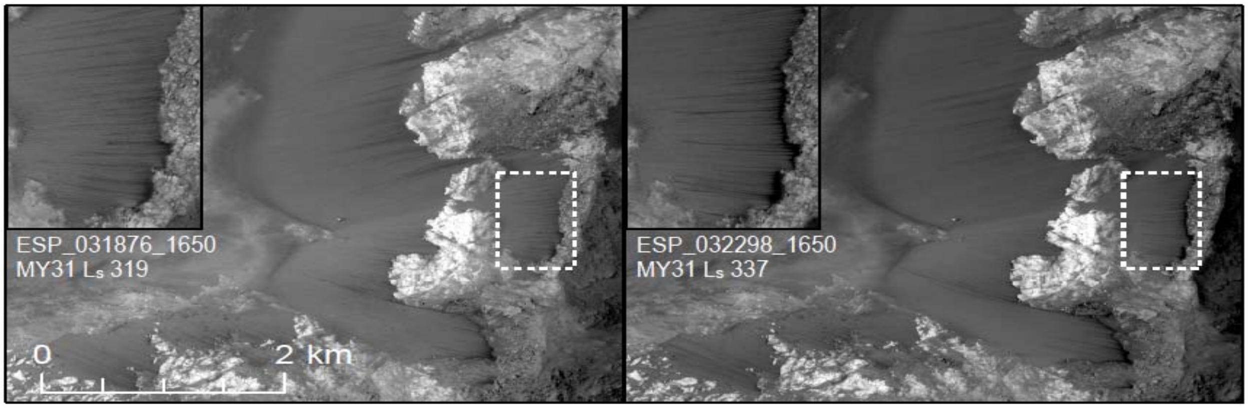


**Fig. 3.** HiRISE images showing where RSL activity on southwest-facing slopes following the southern summer solstice. See Fig. 2 for an oblique view. Downhill is to the left and insets have an ~650 m FOV.

[3], but may form by a different process than other RSL. The majority of Coprates sites are associated with spur-and-gully wall morphologies, either along low-albedo, mid-wall spurs (**Fig. 2-4**) or on the steep slopes at the base of walls. This class is the focus of the remainder of the abstract, but results are broadly applicable to other VM RSL sites.

**Spur-and-Gully RSL Sites:** This class is typically located on north or south sides of the E-W-oriented wall remnants or structural horsts that make up Coprates Chasma. RSL activity on south-facing slopes generally occurs during the southern summer, $L_s$ 270-360° (**Fig. 3**), then shifts to north-facing slopes during the southern winter, favoring locations of maximum solar insolation. This shift may occur at the same site on either side of local topography (**Fig. 4**). Many sites have RSL concentrated near ridge crests which are local topographic highs. For example, the apparent source outcrops for RSL in **figures 2-4** is within 20-100 meters elevation of the adjacent ridge summits.

RSL and their associated depositional fans have characteristic properties in HiRISE IRB color products and CRISM spectral data that appear to vary with RSL activity [3,7]. In a few cases, Coprates wall-related RSL flow over distinct light-toned lineae that are similar in morphology to typical dark-toned RSL (**Fig. 4**). These light features have not been detected to grow, fade, or darken with time. Their yellow-green hue in HiRISE Infrared-Red-Blue/green (IRB) color products is consistent with the presence of ferric minerals and possible surface alteration [7]. Light-toned SL may be old RSL tracks that have faded and represent previous seasons of activity.

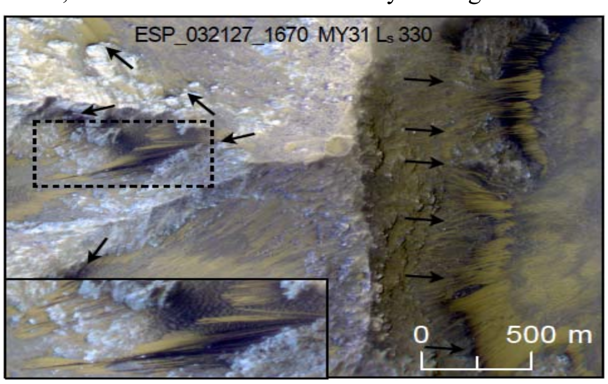


**Fig. 4.** Enhanced (IRB) color image of a central Coprates wall spur and summit showing light- and dark-toned SL. Inset has a ~750 m FOV.

**Discussion and Summary:** Coprates Chasma RSL are detected within diverse and widespread geologic environments. This region holds some of the most densely populated RSL sites detected yet. Craters, landslides, dunes, and canyon walls all host Coprates RSL, although it is unclear if they all form from similar mechanisms. The broad-scale spatial and vertical distribution of sites suggests a widespread mechanism is recharging the RSL. Certain characteristic light-toned bedrock layers appear to source RSL over broad regions (**Fig. 3**). These layers are densely fractured, and may dictate fluid migration as many crater-related RSL sites are correlated with faulting [9]. Elevations here span a greater range than elsewhere on Mars, suggesting that conditions and/or surface properties (e.g., albedo) are more conducive to RSL formation. Topographic analyses of HiRISE DTMs show many sites have RSL originating from very local topographic highs within 100 meters of ridge crestlines. This geometry makes deep ancient brines or sub-surface ice reservoirs (which do not get recharged) an unlikely source for RSL fluids because of the limited overlying volume. Similarly, a regional groundwater source is problematic due to the topographic isolation of source bedrock and the limited hydraulic head it provides. Atmospheric deliquescence might explain such localized flows – however, CRISM peak column abundances of water vapor are quite low and seasonally offset over these locations [3]. Continued monitoring and analysis will test these hypotheses.

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**References:** [1] McEwen A. S. et al. (2011) *Science, 333*, 740–743. [2] Ojha L. et al. (2014) *Icarus, in press*. [3] McEwen A. et al. (2013) *Nature Geoscience, 7*, 53–58. [4] Grimm, R. E. (2014) *Icarus, in press*. [5] McEwen et al. (2007) *JGR, 112*, E05S02. [6] Kirk R. L. et al. (2008) *JGR, 113,* E00A24. [7] Ojha L. et al. (2013) *GRL, 40*, 5621–5626. [8] Watkins J. (2014) *this conference*.