

Recurring Slope Lineae (RSL): Flow of Briny Water on Present-Day Mars? A. S. McEwen (LPL), S. Byrne (LPL), C. Dundas (USGS), L. Ojha (Georgia Tech.), S. Murchie (APL), N. Thomas (U. Bern), J. Wray (Georgia Tech.)

One key to present-day habitability is the presence of liquid H₂O. Pure water must be extremely rare and short-lived on the surface of Mars today, where it will rapidly evaporate (even boiling) and/or freeze. The possibility of present-day habitability near the surface has been enhanced by the discovery of recurring slope lineae (RSL), which could be evidence for the seasonal flow of salty water on warm slopes (McEwen et al., 2011, *Science* 333). RSL are narrow (0.5-5 m), relatively dark markings on steep (25°-40°) slopes that appear and incrementally grow during warm seasons and fade when inactive. They extend downslope from bedrock outcrops, often associated with small gullies, and many individual flows form in some locations. The initially confirmed RSL appear and lengthen in the late southern spring/summer from 52°S to 32°S latitudes favoring equator-facing slopes--times and places with peak surface temperatures from ~250-300 K. We consider RSL "confirmed" if we observe either simultaneous incremental growth of multiple (>10) flows at a location, or formation of >10 new features in multiple Mars years (recurrence). The current tally of confirmed RSL sites in the southern mid-latitudes is 18 (Ojha et al., in preparation). Liquid brines wetting the surface might explain this activity, but the exact mechanism and source of water are not understood. Concentrated brines are far more likely than pure water, because of their lowered freezing temperatures and evaporation rates, and because the Martian surface is salty.

Recent observations by the High Resolution Imaging Science Experiment (HiRISE) on MRO confirm active RSL inside Valles Marineris (latitude 6-15°S). This equatorial activity places new constraints on the origin of RSL, and has implications for future exploration. A number of candidate equatorial RSL sites have been monitored, but all of the equatorial sites with convincing evidence of activity (10 confirmed sites) are inside the canyons of Valles Marineris (VM). The confirmed RSL extend from west-central VM to the eastern canyons, and are especially concentrated in Coprates Chasma. They have not been seen in far western VM where the slopes are dust-covered and at higher altitudes (>2 km above the baseline established by MOLA).

RSL in VM are quite similar to those in the southern middle latitudes, but there are much longer steep slopes in VM, with longer RSL--up to a few hundred meters. These larger features help reveal the morphologic associations and provide larger targets for CRISM. RSL in VM are commonly associated with gullies, and are a close fit in size to these small gullies, suggesting that RSL activity may erode the channels. The larger gullies observed to be active today are in times and places where seasonal CO₂ frost is present on the ground, which must promote the activity (Dundas et al., 2012, *Icarus* 220). However, insignificant CO₂ frost is deposited in VM or on the generally equator-facing slopes where RSL are seen in the middle latitudes, so a different gully formation mechanism is needed if they are currently active.

RSL probably interact with 3 basic types of surfaces:

1. Bedrock, where the RSL may temporarily darken the surface or where the darkening may be difficult to see under some lighting conditions (perhaps hiding in cracks and shadows).
2. Slopes with fine-grained soils that are slowly permeable, where RSL flow may gradually erode small gullies.
3. Slopes covered by permeable materials such as

windblown sand, where water might infiltrate and wick to the surface in discontinuous lines.

If RSL are due to briny water, what is the composition of the salts? Chevrier et al. (2012, *GRL* 39) favored CaCl₂ because the eutectic temperature is about right if RSL originate from melting shallow (10-20 cm deep) frozen brines. CaCl₂ is expected to be abundant in the shallow subsurface of Mars (Burt and Knauth, 2003, *JGR* 108) and is consistent with the possible chloride deposits (Osterloo et al., 2010, *JGR* 115). Anhydrous chlorides lack distinctive absorption bands in either the near-IR or thermal-IR spectral regions. A mixture of salts is likely. CRISM data and HiRISE color suggest a concentration of Fe⁺³ on the fans where RSL terminate (Ojha et al., *this workshop*).

The origin of RSL is an open question. The seasonality and temperature dependence suggest a key role for a volatile, for which briny water is in the right temperature range. This includes the hypothesis that volatiles somehow trigger dry flows. Flow of actual water or wet debris is an attractive model for RSL as it can explain the seasonal darkening and fading. McEwen et al. (2011) favored some other darkening mechanism, such as roughness changes, based on the lack of water absorption bands seen in CRISM data. Stable eutectic brines should not be expected at the surface near the 3 PM observing time of MRO (Gough et al., 2011, *EPSL* 312). However, laboratory measurements of brine-wetted Mars analogue soil shows that darkening persists when there is only a few percent water present (Masse et al., 2012, *LPSC*).

Shallow ice has been detected in the north middle latitudes and is expected to occur also in the southern hemisphere. Such ice could provide a water source for the RSL by seasonal melting of frozen brines that are a remnant from a past climate (Chevrier et al., 2012). The warm slopes should rapidly dry out, so a recharge mechanism may be needed. The presence of shallow frozen brines from a former climate may be more difficult to explain in equatorial VM, so the deeper and older brines envisioned by Burt and Knauth is a possibility.

An alternate origin for the water is deliquescence from the atmosphere, as documented for water tracks in Antarctica (Levy, 2012, *Icarus* 219). This mechanism seems highly unlikely on Mars based on peak column abundances of water vapor of 10-20 precipitable microns over these locations. Nevertheless, the relative humidity near the surface controls the stability of water at the surface, so RSL visibility may vary with seasonal variation in atmospheric water vapor. RSL appear to have been more abundant in Mars Year 28 after the 2007 dust storms.

Implications for Future Exploration of Mars:

COSPAR has defined "Special Regions" on Mars as any region experiencing temperatures >248 K for a few hours/yr and with a water activity >0.5, the limits for reproduction of terrestrial organisms (Kminek et al., 2010, *ASR* 46). Hence, special regions need added planetary protection during future surface exploration or sample return. Based on the best available information up to 2010, they concluded that there are probably no special regions in the equatorial latitudes of Mars. The discovery of RSL in Valles Marineris suggests that it is time to reconsider this question.

