EXPERIMENTAL SIMULATIONS OF RECURRING SLOPE LINEAE. E.A. Eddings[1,2], M.E. Sylvest[2], J.C. Dixon[2,3], and V.F. Chevrier[2], [1]Department of Physics, Astronomy, and Geophysics, Connecticut College, New London, CT 06320 [eeddings@conncoll.edu], [2]Arkansas Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, AR 72701, [3]Department of Geosciences, University of Arkansas, Fayetteville, AR 72701.

Introduction: Recurring Slope Lineae (RSL) are dark streaks that have been observed on Mars. They appear on mostly equator facing, southern hemisphere slopes. RSL appear seasonally, growing longer and darker in warm summer months and fading in the colder winter months. [1]. A possible mechanism of formation for these streaks involves the presence of liquid water. Given that the temperature of the regions in which RSL are mostly present can reach up to 250-300K during these warm southern months, it is possible that the formation of the RSL can be linked to the formation of liquid brines [1]. Liquid brines have a lower melting point than pure water, and have become the common source for potential liquids on Mars. The first experimental simulations of RSL were designed using wet streaks in Antarctica as an analog to RSL. In Antarctica, thawing permafrost causes the formation of wet streaks, and so a similar mechanism was used to simulate the formation of similar features in the lab [2].

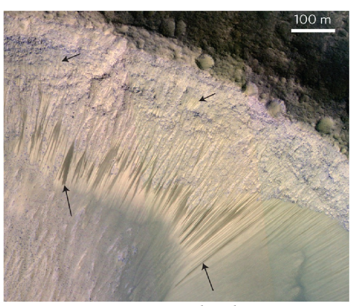

Image 1: RSL on a rocky slope on Mars [3]

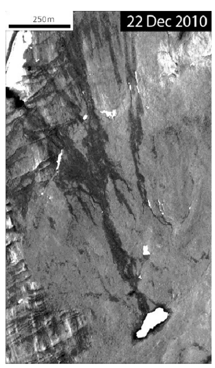

Image 2: Antarctic wet streaks [2]

Methods: Initial experiments were conducted using a plexiglas, open top box. This box was about 12" long, 4" wide, and had sloped sides from about 6" at one end to about 1" at the bottom. All experiments used playground sand and pure liquid water. Preparing a permafrost layer was done by mixing dry sand with enough water to saturate the sand without having any excess water; this mixture was spread evenly on the bottom of the box at a depth of about 1 inch. In the first set of experiments, the plexiglas box was placed in a domestic freezer until the bottom layer was completely frozen. A dry layer of sand was then spread across the top of the permafrost with a varying topography for each experiment and the box was left out at ambient temperature surrounded by styrofoam for insulation. The box was placed on the same slope for all experiments, of approximately 12°. During the thawing of the permafrost, observations were made of the surface of the sand to note any features that appeared as a result of the melting permafrost. In experiments in which features similar to those of wet streaks or RSL formed, the box was replaced in the freezer and removed to rethaw in order to observe the effects of a freeze/thaw cycle on the formation of the features that appeared.

In the second set of experiments, a cold room and heat lamp were used to simulate the freeze/thaw cycles. Freezing was done in a room at -20°C followed by thawing in a room at 4°C, sped up with a 150W heat lamp. Experiments used a slightly wider copper metal box. In addition to observing the features formed by various topographic distribution of the top layer of dry sand, experiments were done to observe the effects that placing large boulders in the sand would have on the melting of the permafrost. Various objects were placed in the box to simulate the effect of boulders on the melting of permafrost. These objects included small metal nuts, approximately 1/2" to 1" for preliminary experiments, which were followed by experiments using a 2" steel sphere. Objects representing boulders were placed so that they rested partially in the permafrost layer near the top of the slope before freezing. For the boulder experiments, after freezing the permafrost and boulder combination, a dry layer was added to the surface in the -20°C cold room and allowed to cool to the same temperature as the permafrost before removing for thawing in order to observe the effects that the different materials with various heat transfer properties had on the melting of the permafrost when the entire box was thawed.

Results and Discussion: Four different topographies were tested during the first set. A uniform, flat layer of overburden about 1/2" thick showed signs on the surface of melting uniformly, with no indication of line formations. Sloping the dry sand parallel with the slope of the box yielded similar results, with the surface darkening due to melting uniformly across the width of the box beginning at the bottom where the overburden was most thin and moving up the slope over time.

The first indication of the formation of a linear feature occurred when the overburden was sloped perpendicular to the slope of the box; the side of the box in which the dry sand was thinner darkened as a result of the melting of the permafrost while the deeper overburden areas did not, as shown in image 3. The most distinct linear feature was observed when the overburden was spread with a channel through the center of the box, shown in image 4.

Image 3: Thinner overburden on right side darker than thick overburden on left

Image 4: Central valley shows dark line of wet sand

This last result was refrozen and rethawed. During the rethaw, more uniform darkening and wetting of the surface was observed than in the first thaw. It should also be noted that all of the experiments conducted in the plexiglas box had a minor limitation set by the height of the sides of the box itself; near the bottom of the slope, the outer edge of the box is lowest and therefore the overburden layer here was always thinnest. Darkening and wetting of the surface here was attributed to this limitation, but further demonstrates the correlation between thickness of overburden and amount of time for the surface to darken from the meltwater.

The dark line observed in the channel of the overburden showed that as the permafrost melted, the liquid water was drawn up through the sand and was able to reach the surface sooner where the distance between permafrost and overburden was the shortest. Upon rethawing, however, the water was higher in the sand throughout the box and was therefore able to reach the surface uniformly, rather than only in the channel. A larger difference in distance between the permafrost and surface of overburden or a shorter thaw period in which less of the permafrost actually melts to liquid might keep the surface darkening to only within the linear channel.

The experiments which included the placement of boulders have only yielded preliminary results. The sand immediately surrounding both the largest of the metal nuts and the 2" steel sphere has shown signs of melting slightly earlier than in the other areas of the box. It has not yet been confirmed, though, that these observations were a direct result of the properties of the materials. It is possible that it may also be due to small yet still significant differences in the depth of such a thin dry layer spread on top of the permafrost.

Conclusions and Future Work: Overall, both sets of experiments showed that in order to simulate the formation of a feature similar to an RSL, there must be some heterogeneity introduced to the set up of the experiment. The first set of experiments concluded that observations of wet streaks on the surface are possible if there is a linear channel formed in the sand. If RSL are, in fact, a result of darkening of the surface from liquid water appearing in warmer months, there would have to be a sufficient line along the slope in which the distance between frozen water and the surface of sand is small enough for the amount of water that melts to be drawn up to the surface.

Topography experiments will focus on a wider variation of overburden as well as simulations using Mars regolith simulants and liquid brines.. A larger flume is currently in construction for these future experiments. A variety of different boulder materials will also be used, and measurements of temperature in various parts of the box will be taken. These measurements will provide more conclusive evidence for the role of heat transfer properties of these materials in the melting of the permafrost. Boulders will also be combined with the varying topography to determine if the placement of boulders in different areas can effect the formation of the wet streak features. This combination may also yield results which are representative of the lengthening characteristic of RSL, which has not yet been achieved in previous experiments..

References and Acknowledgements: [1] McEwen, A. et al. (2011) *Science, 333,* 740-743 [2] Levy, J. (2012) *Icarus, 219,* 1-4 [3] McEwen, A. et al. (2014) *Nature Geoscience, 7,* 53-58

This research was funded by NSF grant number 1157002. Thank you to Dr. Kennefick for organization of the REU program and to Dr. Owens-Hanning for allowing use of her cold room for experiments.