RESULTS FROM LONG DISTANCE REMOTE MICRO IMAGER MONITORING OF LINEAE-FORMING SLOPES ON AEOLIS MONS, MARS.

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Introduction: Slope streaks and lineae were first observed on Mars by the Viking orbiters [1, 2], and many subsequent studies have made use of higher-resolution images from more recent missions to interpret streaks and lineae in detail. The numerous types of slope features include bright and dark streaks, bright gully deposits, linear gullies on dunes, and recurrent slope lineae (RSL) [e.g. 3,4,5,6]. These features are of interest because they represent modern, active geological processes, and because they have been interpreted as exhibiting properties indicative of liquid water.

Small (10s of meters) dark lineae have been observed on the slopes of Aeolis Mons in Gale crater by HiRISE [7]. We report here on the results of a two-Earth-year campaign to use ChemCam's high resolution Remote Micro Imager (RMI) to monitor locations where lineae were observed from orbit. Partial results were previously reported in [8].

Methods: We used the locations identified in HiRISE by [7], in combination with a digital elevation model of the Curiosity landing site and traverse area, to determine the locations along the traverse from which each location would be visible to ChemCam. Many of the locations were not visible at all, and others were only briefly visible due to their location on the flanks of valleys that were only briefly aligned with Curiosity's line of sight. In some cases, although the lineae of interest were not visible, or were only briefly visible, we continued to monitor the neighboring slopes to watch for the formation of new lineae. In addition, we monitored two prominent slopes (dubbed "A" and "B") where no lineae were observed by HiRISE, to watch for any changes.

Long distance observations are not the primary purpose of the RMI, and there are challenges associated with using the instrument in this way. Due to a variety of factors it can be difficult to accurately point the observations such that the distant location of interest is captured, and if pointing is good, focus sometimes is not, especially in scenes that span significant changes in distance. Mispointed and poor focus observations are not included in Table 1.

Two periods of time are under-represented in our observations: 1. between April and November of 2017, Curiosity was approaching Vera Rubin Ridge, and the ridge blocked the view of Aeolis Mons, 2. Between February and November of 2018, a planet-encircling dust event limited visibility, making long distance observations impossible or low-quality.

We compared the observations with HiRISE images, and in the case of repeated RMI coverage, with each other, to identify any new lineae or fading of existing lineae.

Location	Sequence	Sol	Earth Date	Ls
34	ccam08232	1232	23-Jan-16	99
13*	ccam07239	1239	30-Jan-16	102
50	ccam01256	1256	17-Feb-16	110
46*	ccam02283	1283	15-Mar-16	123
33	ccam02286	1286	18-Mar-16	124
44	ccam05313	1313	15-Apr-16	137
B	ccam04332	1332	5-May-16	147
44	ccam06355	1355	28-May-16	159
A	ccam03360	1360	3-Jun-16	163
B	ccam04414	1414	29-Jul-16	194
13*	ccam05518	1520	14-Nov-16	261
44	ccam03521	1521	15-Nov-16	262
B	ccam02625	1625	2-Mar-17	326
46*	ccam04627	1627	4-Mar-17	327
44[1]	ccam03632	1632	9-Mar-17	330
A	ccam02661	1661	8-Apr-17	346
Aeolis Mons not visible				
34* & 46*	ccam04877	1878	16-Nov-17	88
13*	ccam02886	1888	27-Nov-17	93
B	ccam03947	1948	28-Jan-18	121
A[1]	ccam04959	1959	8-Feb-18	126
A	ccam01961	1961	1-Feb-18	127
Dust Storm				
46*	ccam05240	2242	26-Nov-18	295
34*	ccam03260	2260	14-Dec-18	306

*Outcrop near HiRISE location

Results: We have observed eight locations on Aeolis Mons over the last 2 Earth years (Table 1). We did not observe any new lineae in any of the locations. In one instance, illustrated in Figure 1, we observed a linea at location 44 fade over a period of ~200 sols. In observations of the same locations before and after the 2018 dust storm, we do not see any evidence of new lineae or other albedo changes.

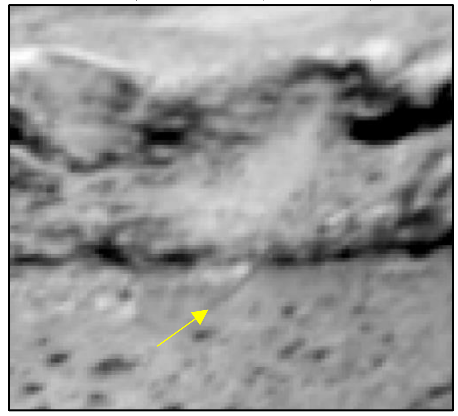
Discussion: The lack of evidence for new slope lineae over observations spanning more than one Mars year suggests that there is not a strong tendency for these features to recur annually at Gale crater. The observed fading of one feature at location 44 is likely due to gradual accumulation of atmospheric dust on the surface. One might expect the period after a major dust storm to exhibit more activity, as freshly deposited dust is disturbed by small rockfalls or other mass wasting. The lack of new features to date suggests that either the areas observed since the dust storm have not had any rockfalls or other triggering events, or the wind conditions in this area prevent dust accumulation.

In most cases the areas with repeated observations are not the precise areas where lineae were originally observed, so the lack of new lineae observed may simply reflect the highly localized nature of the linea formation and/or our observations.

Curiosity did observe an intermediate-scale dark streak on sol 1959 on an outcrop considerably closer to the rover than the monitoring locations. Mastcam observations of sandy slopes with rocky overhangs throughout the mission have also exhibited recent dark grain flows [9].

We hypothesize that all of these lineae, from the cm scale in Mastcam, to the meter- or tens-of-meter-scale observed in RMI are the result of the same process: dry grain flows on nearly angle of repose slopes [e.g. 10, 11]. We see no evidence to suggest that the lineae observed at Gale crater are related to flowing water. The exact origin of the triggering of the flow is still to be determined.

References: [1] Ferguson, H.M., Lucchitta, B.K., 1984. NASA Washington Rept. of Planetary Geol. Programs. pp. 188–190., [2] Morris, E.C., 1982. JGR Solid Earth 87, 1164–1178. [3] Sullivan, R. et al. 2001. JGR Planets 106, 23607–23633. [4] Malin, M.C. et al., 2006. Science 314, 1573–1577. [5] Diniega, S., et al., 2013. Icarus 225, 526–537. [6] McEwen, A.S., et al. 2014. Nature Geoscience 7, 53–58. [7] Dundas, C.M., McEwen, A.S., 2015. Icarus 254, 213–218. [8] Anderson, R.B., et al., 2017. 48th LPSC, 2312. [9] Dickson, J.L., Head, J.W., Kulowski, M., 2016. 47th LPSC, 1726. [10] Schmidt, F. et al., 2017. Nat. Geo. 10, 270–273. [11] Dundas, C.M. et al., 2017. 10, 903-907.



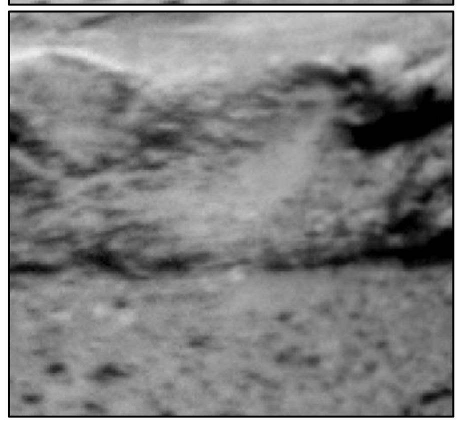
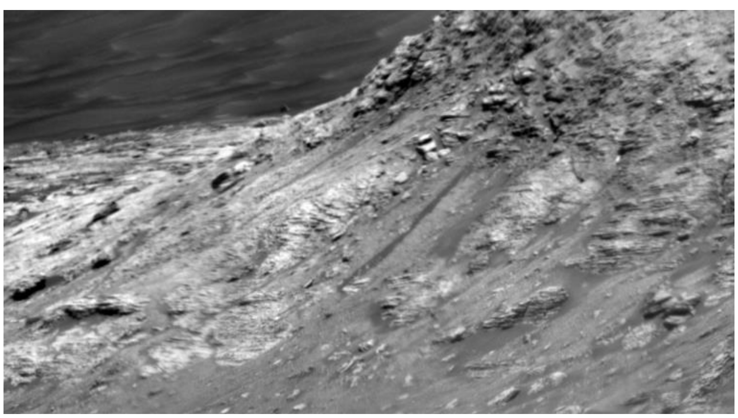


Figure #: (Top) Detail of an RMI image of location 44 on Sol 1313, showing a small linea (arrow). (Bottom) Detail of the same area on Sol 1521. The faint linea is no longer visible.



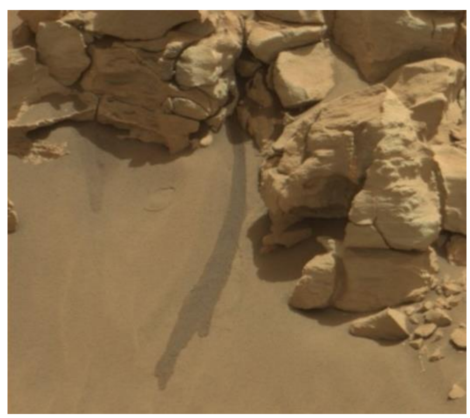


Figure #: (a) ChemCam RMI image of target Stromness on sol 1959, showing an intermediate-scale (several meters) dark lineation on an outcrop several hundred meters from the rover. (b) Mastcam image from sol 712 (mcam03030) showing one example of the small scale (few to 10s of cm) dark streaks that have been observed throughout the traverse on steep sandy slopes.