# ATTEMPT OF SERENDIPITOUS SCIENCE DURING THE MOJAVE VOLATILE PROSPECTOR FIELD EXPEDITION.

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**Introduction:** On 23 October a partial solar eclipse occurred across parts of the southwest United States between approximately 21:09 and 23:40 (UT), with maximum obscuration, 36%, occurring at 22:29 (UT). During 21-26 October 2014 the Mojave Volatile Prospector (MVP) field expedition deployed and operated the NASA Ames Krex2 rover in the Mojave desert west of Baker, California (Fig. 1, bottom). The MVP field expedition primary goal was to characterize the surface and sub-surface soil moisture properties within desert alluvial fans, and as a secondary goal to provide mission operations simulations of the Resource Prospector (RP) mission to a Lunar pole. The partial solar eclipse provided an opportunity during MVP operations to address serendipitous science.

Science instruments on Krex2 included a neutron spectrometer, a near-infrared spectrometer with associated imaging camera, and an independent camera coupled with software to characterize the surface textures of the areas encountered. All of these devices are focused upon the surface and as a result are downward looking. In addition to these science instruments, two hazard cameras are mounted on Krex2.

The chief device used to monitor the partial solar eclipse was the engineering development unit of the Near-Infrared Volatile Spectrometer System (NIRVSS) near-infrared spectrometer. This device uses two separate fiber optic fed Hadamard transform spectrometers. The short-wave and long-wave spectrometers measure the 1600-2400 and 2300-3400 nm wavelength regions with resolutions of 10 and 13 nm, respectively. Data are obtained approximately every 8 seconds. The NIRVSS stares in the opposite direction as the front Krex2.

**Field Observations:** The primary objective of MVP on 23 October was to characterize a specific alluvial fan, and to confirm repeatability of spectral observations. A back-and-forth raster scan was designed and implemented along an approximately east-west direction from the proximal to distal portion of the fan (R1, Fig. 1, top). At the end of this initial scan a reverse scan, from the distal to proximal portion of the fan was performed, but with a distal offset (R2, Fig. 1, top). Initial eclipse observations oriented the rover facing away from the sun to allow NIRVSS to more directly view the reflected sunlilght. Unfortunately, positioning the rover carefully was quickly deemed too time consuming to achieve the primary science objective. To place the texture definitions into context, the team focusing on the camera for texture definition requested observations where Krex2 rotated 360° obtaining a image every 60°. In lieu of dedicated eclipse observations, NIRVSS operated continuously during these spins.

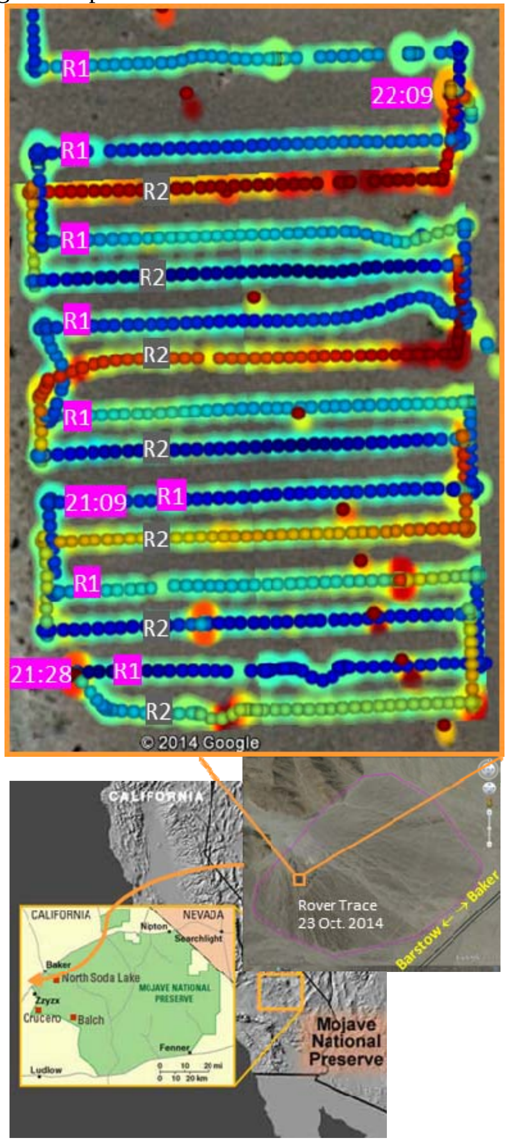

**Figure 1.** MVP field expedition located in the Mojave (bottom, overview maps from National Park Service) and the rover tracks during the eclipse observations on 23 October 2014 (top). R1 is the proximal to distal raster pattern and R2 is the opposite raster pattern. Times germane to the eclipse are highlighted.

These dynamic observations are obtained as the position of the rover, surface, sun, and any clouds change during the traverses. Disentangling the influence of each is challenging. Fortunately NIRVSS data was obtained at similar times on other days (Fig. 2, top) and permit comparison to the eclipse observations.

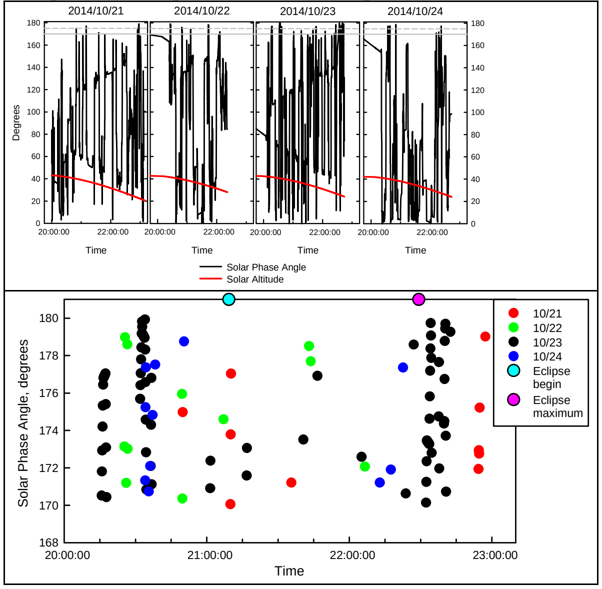

**Figure 2.** Solar phase angle and altitude are shown for each day of MVP operations (top). Gray lines indicate phase angles of 170° (solid) and 175° (dashed). Data for each day with a phase angle >170° (bottom). Beginning, and maximum of the eclipse are indicated along the top axis.

**Analyses:** We initially restrict the analyses to observations at >170° solar phase angle (Fig. 2, bottom). As a proxy for brightness we use the short-wavelength radiance. This value is defined as the mean radiance value measured by the short-wavelength spectrometer and are shown as the open circles in Fig. 3. As the solar altitude decreases (Fig. 2, red lines), potentially more sunlight comes under Krex2. We applied a correction for incidence angle and scaled the data to the initial measurement in each day; $r_c = r_{in} / [\cos(i) / \cos(in)]$, where $r_c$ and $r_{in}$ are the calculated and initial measured radiance, $i$ (90°-solar altitude) is incidence angle for a given observation, an $in$ is the incidence angle for the initial measurement. The results are shown as the lines in Fig. 3. With the exception of the 10/22 points, the trends seen in the data points are generally described by this correction. However, scatter remains for the observations and we speculate this may be due to surface reflectance differences, atmospheric influence on the mean radiance calculation, and/or variable clouds. Images from the NIRVSS camera (Fig. 4) exhibit significant shadowing and surface granular differences that can contribute to the scatter in the observed radiances.

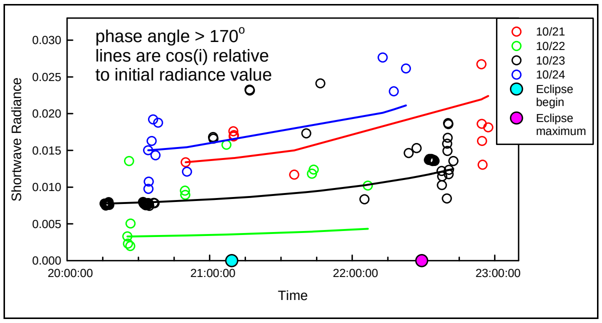

**Figure 3.** Predicted radiance variation due to changes in solar incident angle (lines) compared to observations (open circles). Beginning and maximum of the timing of the eclipse are indicated along the abscissa.

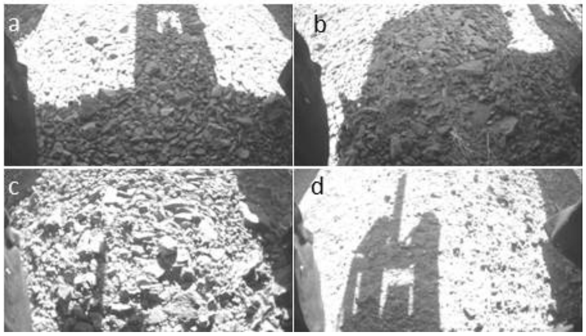

**Figure 4.** NIRVS camera images from 23 October 2014. a) 20:15, before the eclipse, b) 21:15, after the beginning of the eclipse c) 22:32, near maximum obscuration, and d) 22:42 after maximum obscuration.

**Discussion:** During these serendipitous observations there is a slight decrease in the mean short-wavelength radiance associated with the maximum of the partial solar eclipse. However, it is not currently possible to conclude that this is due solely to the eclipse event, especially since the radiance increases noticeably immediately after the maximum obscuration. If atmospheric influences are the cause of the increase in radiance, then this will not be an issue on the lunar surface. However, the influence of surface reflectance and textural differences remain to be fully characterized.

In an ideal situation to acquire the serendipitous science associated with the partial solar eclipse, Krex2 would have remained in the same location and only rotated to track the changing solar azimuth angle. However, during a lunar mission such a dramatic departure from the primary science goals may not be scientifically acceptable.