First Look at the March 14, 2025 Lunar Eclipse at Thermal Infrared Wavelengths

by Darryl Wilson

The most recent lunar eclipse offered this author an opportunity to collect thermal imagery of the of the moon during rapid cooling of the lunar surface that only happens when the earth blocks the sun in a timeframe of only a few hours. A thermal imager (TE-EV1, i3System.com) with superior ergonomics, better software, and superior electronic capabilities helped make these observations a success.

Weather conditions at the beginning of the penumbral phase were ideal but steadily deteriorated over the next couple of hours. By the beginning of the umbral phase a thick layer of ground fog reduced visibility and contrast and a thin scattered cloud layer forced intermittent pauses in image collection. Nevertheless, many excellent images were recorded due to the improved ease-of-use of the thermal imaging equipment.

This short paper contains no quantitative analysis of the data that was gathered. At the time of the publication deadline, only a fraction of the images have been processed and there has not yet been time to match many interesting thermal features to their visible light counterparts. This work will be the subject of a future paper. Time series analysis of radiative cooling effects will be possible for some features and areas on the lunar surface and these analyses will also be presented. For now, a peek at the imaging results is presented.

Figure 1 is a visible light image of the full disk taken 13 minutes before the start of the eclipse. It is useful as a reference image for comparison of thermal features to visible light features. Although this can be done with reference to existing moon maps, it is advantageous to have a comparison image with the moon at the same libration.

Figure 1
Visible Light Lunar Image
13 minutes before entering penumbra
20250314-0343UT
3" Refractor
Celestron Skyris 274M

Figure 2 is also a visible light image of the moon. It was taken 34 minutes after the umbral shadow contacted the limb. According to The March 2025 issue of Sky and Telescope, the umbral shadow had crossed Copernicus 9 minutes earlier and Tycho 18 minutes earlier. This image was taken only 3 minutes before the beginning of the thermal image mosaic presented below.

Figure 2
Visible Light Lunar Image
Midway into umbral phase
20250314-0543UT
3" Refractor
Celestron Skyris 274M

Figure 3 is an image of the umbral shadow crossing the disk 17 minutes later. This image was taken just 1 minute after the last of the thermal mosaic images was collected. Figures 2 and 3 bracket the timeframe of the thermal images.

Figure 3
Visible Light Lunar Image
Well into umbral phase
20250314-0600UT
3" Refractor
Celestron Skyris 274M

Figure 4 is a mosaic of 4 thermal images taken from 546 UT to 559 UT. Each mosaiced image was actually a coregistered stack of about 60 to 90 individual raw images. Note that the lunar limb is visible against the background sky, even in areas within the umbral shadow. An unexpected characteristic of the image is that there is no easily discernable transition between the umbral shadow and the area in penumbra. Significant radiative cooling on the lunar surface happens on a timescale longer than an hour or two. Of course, we know from thermal imagery of the waning phases that the terminator is approximately in the same location on visible and thermal images. This means that somewhere between 2 hours and 24 hours the surface cools from daytime temperatures to temps so low that an earthbound sensor can no longer detect a signal. This is consistent with results that were published by the LRO science team several years ago.

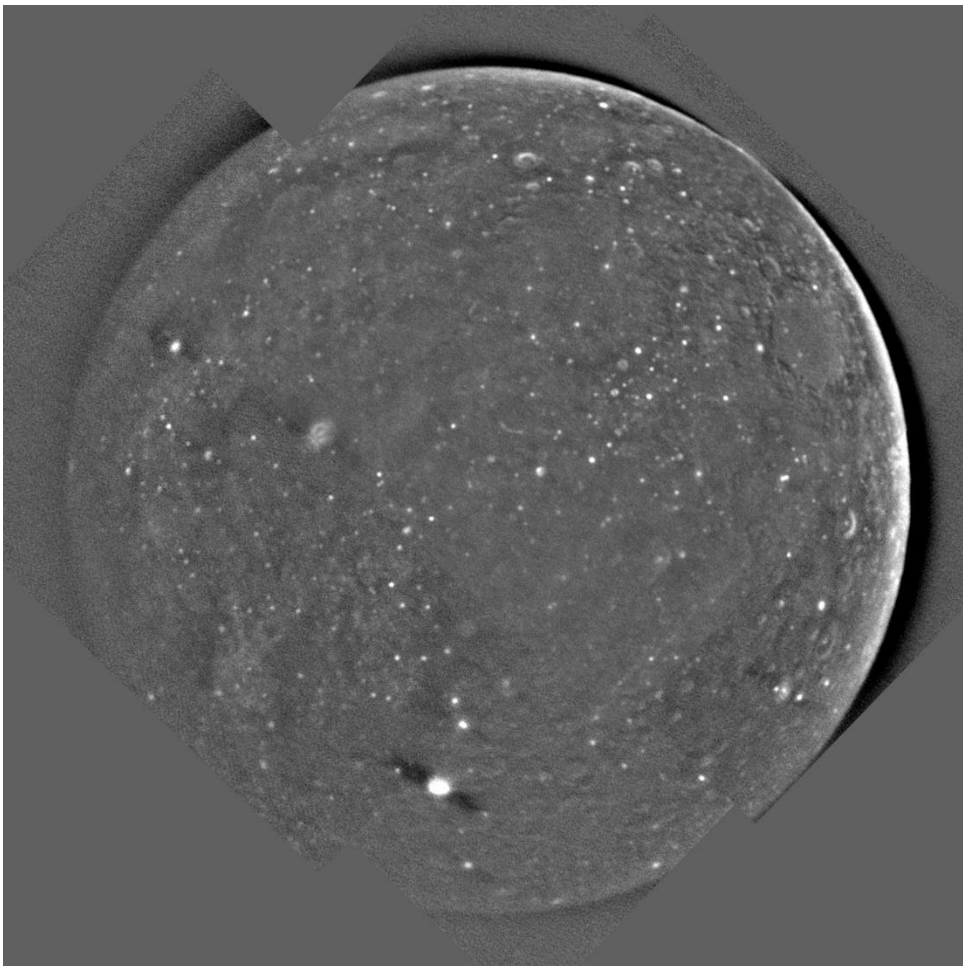

Figure 4
Thermal Infrared Lunar Image
Mosaic of images from 546UT to 559UT
20250314-0346UT-359UT
Celestron 12" Newtonian
i3System TE-EV1 Thermal Imager

A first impression is that it looks like a dark gray ball with many bright spots arranged in complicated patterns on the surface. The bright spots are known as hot spots because in thermal images brighter means warmer. Several of the more prominent hot spots are easily identifiable. The most noticeable is Tycho, near the bottom of the disk. The crater rim and the central peak are both well resolved. Copernicus can also be found easily. It has a swirl pattern, more complicated than Tycho. Aristarchus, Langrenus, and a few others are also fairly easy to find. After those, many other hot spots do not seem to correspond to any well-known lunar features. Clearly, something is different about these lunar features, but visible light images provide conflicting and confusing hints as to the cause of their brightness. We'll discuss the reasons in a future article, but if you read "Basic Interpretation and Analysis of Lunar Thermal Images" [JALPO Vol. 63, No. 2, Spring 2021] you may already know.

In summary, this author collected an information-rich data set that will support several future articles based on thermal observables recorded during this eclipse. One topic will be the TE-EV1 itself. A close examination of the thermal mosaic shows seamless merging of the individual images - evidence of the electronic and radiometric quality of the TE-EV1. A future article will describe how to use this imager to collect images of the lunar surface.

References:

"Sky and Telescope", March 2025, p. 48.

"The Lunar Observer", March 2025, p. 7