**OBSERVATION OF FROST AT THE EQUATOR OF MARS BY THE OPPORTUNITY ROVER.** Geoffrey A. Landis[1] and the MER Athena Science Team, [1]NASA John Glenn Research Center, 21000 Brookpark Road, mailstop 302-1, Cleveland OH 44135; geoffrey.a.landis@nasa.gov.

**Introduction:** During the winter of the first year of the MER rovers on the surface of Mars, we searched for early morning frost at both the MER landing sites.

*Prior Frost Observations.* The Viking 2 lander (VL-2), at the Utopia Planitia site at latitude 47.7 degrees N, observed a thin white coating of frost on the ground during late winter and spring in the northern hemisphere [1]. This observation was repeated over successive years. The frost seen was a very thin layer [2], and visible primarily on the ground, not on rocks [3]. Since the frost persisted into the afternoon, at temperatures above the sublimation point of carbon dioxide, the frost is observed to be water ice.

*MER Observation Background:* Since the MER rovers are solar powered, during winter science operations were severely power constrained and limited to a few hours near solar noon. Although the VL-2 saw frost persisting through mid-day, no signs frost was seen in the MER images during the winter in these routine operations. Since both MER rovers were considerably closer to the equator than the Viking lander (MER A at 14.57° S latitude, B at 1.95° S), this was not unexpected. However, southern-hemisphere winter temperatures are lower than northern hemisphere winter, with night temperatures at the MER-A site reaching 185K, and hence it is still reasonable to expect that frost might form at the MER sites, but sublime away before mid-day. MER-B (Opportunity) is nearly at the equator, but since the southern winter occurs at aphelion, temperatures also are at a seasonal low. Hence, a sunrise measurement for frost might be fruitful.

**Observation:** Because of the power resources required to wake the rovers and heat the cameras, it was only possible to make the observation once on each rover. We determined that the most likely time for frost observation would be late winter, when maximum amount of water vapor from the sublimating northern cap would be in the atmosphere [4], but while temperatures would still be at near-aphelion lows.

*Observation Plan.* The plan was to wake the rover for an image just after sunrise. Since the frost was expected to sublimate away as the sun hits it, the pointing was chosen to look toward the shadow of the rover. We intended to look for frost primarily on soil, which has low thermal inertia and hence cools rapidly at night, allowing the longest time at low temperatures for the frost to accumulate. The aim point also included the Pancam calibration target, and a portion of the solar array at the back of the rover.

Because of the low power available on the rover, and the significant power resources required to wake the rovers before the solar arrays have significant sun exposure, every expedient was taken to minimize the power requried for the observation. At the morning temperatures observed, all use of motors required heating. To eliminate motor use, the cameras were prepointed at the target, and were not stowed before the rover was put to sleep, and the image was taken without using the scan motors. To avoid filter wheel motion, the Pancam filters were preselected for the left and right camera to be a red-blue pair (R1L2), which were set before the sleep. The red/blue filter combination is an effective tool for discriminating dust (which is dark in the blue) from frost (which is bright in the blue). The camera electronics required approximately 21 minutes of heating to be brought to the temperature needed for operation. Camera details are given in [5].

**Results:** The observation was done on MER-B on sol 257B, and on MER-A about 23 sols later, sol 304A. No frost was seen at MER A site at Gusev Crater. On MER-B, images were taken at 6:15 True Local Solar Time (TLST), about 10 minutes after sunrise. These were compared to a pair of images taken well after sunrise, about 9:21 TLST. Figure 1 shows the images from the left camera, taken in the red filter L2, centered at a wavelength of 753nm, and Figure 2 shows the right camera view, taken in the blue filter R1 centered at 436 nm. (Because of the stereo separation, the two views are from slightly different vantage points).

No frost is visible in the background soil. (while bright patches are seen in the soil, the bright areas are brightest in the red filter and dark in the blue, indicative of dust, and there is no differnece between the brightness in the sunrise image and the 9:21 image.) The rover deck and calibration target, on the other hand, shows significant evidence of frost. This should not have been unexpected, since the rover deck and calibration target have high thermal emissivity thus cool well by radiation to the sky. The frost is visible in the difference between the two images, and most significantly in the blue images. The solar arrays have an apparent light color, which appears to be a very light frost coating, although the difference between the diffuse illumination of the 6:15 image and the direct sunlight of the 9:21 image makes this identification difficult. Frost is clearly visible on the calibration target and post. This is visible clearly in figure 3, which shows a close-up of the regions of interest.

**Summary:** Frost was observed to be form on the MER-B rover in late winter, at 1.95°S latitude.

**References:** [1] Jones, K. L., *et al.* (1979) *Science 204*, 799-806. [2] Clark, R. N. (1980) *LPS XI*, 160-161. [3] Viking image; NASA Image ID number: 22E169. [4] Jakowski, B.M. and Haberle, R.M. (1992) *Mars*, Chap. 28, U. Arizona Press, 969-1016. [5] Bell, J.F., *et al.* (2003) *JGR 108*, 10.1029 2003JE002070.

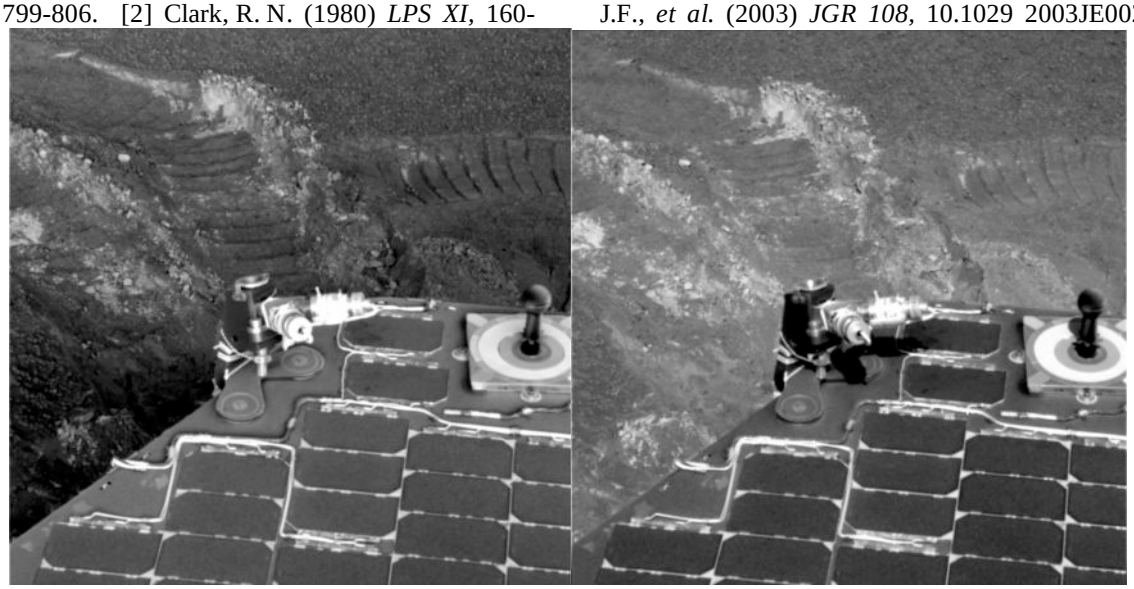

Figure 1: MER-B sol 257 pancam image, filter L2 (red). Left: image at 6:15 TLST; right, same view at 9:21 TLST.

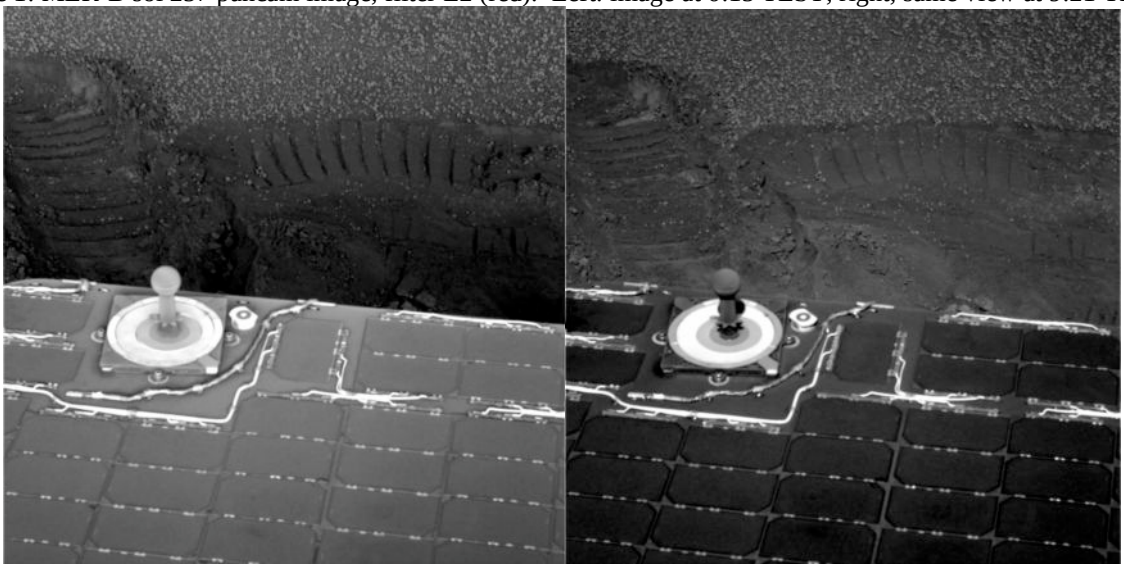

Figure 2: MER-B sol 257 pancam image, filter R1 (blue). Left: image taken at 6:15 TLST; right, same view at 9:21.

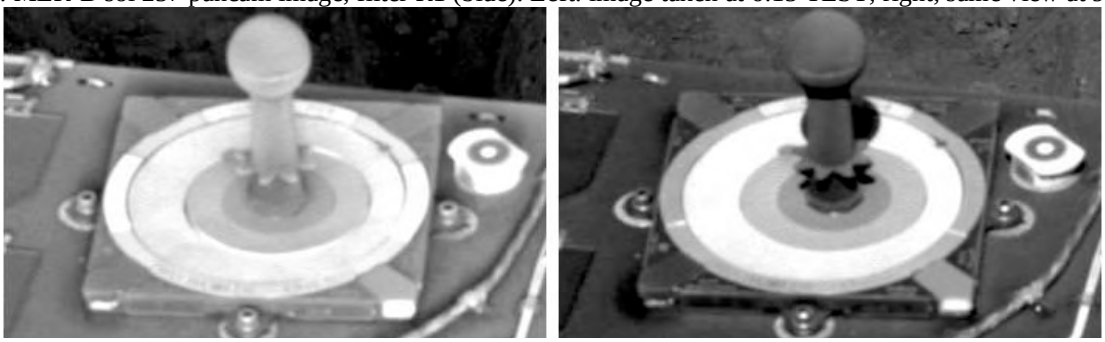

Figure 3: Detail of the calibration target, filter R1 (437 nm). Left, 6:15 TLST; right, 9:22, with frost burned away.