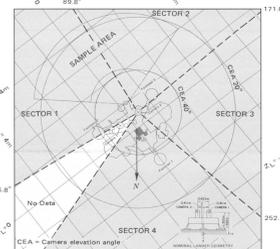


CAMERA CONTROL AZIMUTH

DESCRIPTION OF SCENE

The Viking Lander 1 pictures show a surface strewn with rocks in the centimeter to meter-size range; several areas interpreted as bedrock are also present (line 310, sample 2570). Much of the foreground between the large blocks is blanketed by very fine grained (approximately 100 μ m) material that has been sculptured by martian winds into "tail" behind rocks (line 850, sample 2770). Light and dark drifts of this material can be seen among the blocks just below the near horizon at left center in the mosaic (line 190, sample 2080); these deposits are about 15 m from the lander. Larger drifts cover the surface at the far left. The drifts probably are remnants of a thick blanket of very fine grained material that once covered the area and was subsequently eroded by wind. Large blocks on the near horizon in the upper left of the mosaic (line 70, sample 2350) are about 80 m from the lander; the largest block is about 3 m across. The blocks rest on the rim (R-1) of an old degraded crater (C). The far horizon at the center of the mosaic (line 130, sample 4100) is probably a ridge beyond the 3 km nominal horizon. Other distant ridges that project above the horizon are identified by number on the Viking Orbiter picture at the lower left was caused by exhaust from the rocket engines during landing. Small rock fragments blown out by the exhaust made little pits and tracks in the fine-grained material as they rolled along the surface (line 850, sample 3970).



THE VIKING MISSION

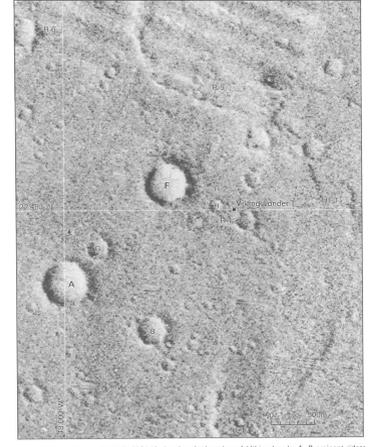
Two Viking spacecraft, each consisting of an orbiter and lander, were launched from Kennedy Space Center on August 30 and September 9, 1975. The Viking 1 spacecraft arrived at Mars on June 19, 1976, and was placed in a highly elliptic orbit around the planet at a pericenter altitude of nearly 1500 km. The orbiter cameras were used in conjunction with other instrumental methods to find a suitable landing site for the lander. After about 30 days in orbit, the lander was separated from the orbiter and on July 20, 1976, Viking Lander 1 touched down on the surface of Mars at lat 22.48° N and long 47.36° W. (Murray and Jones, 1980) on the west edge of a large basin called Chryse Planitia. It landed in a stable position at a 3° tilt downward in the direction 284.9° clockwise from north.

The side of the lander on which the two cameras are mounted faces southwest. When the cameras are pointed in the direction normal to the front of the lander, the viewing direction is 141.0° clockwise from north along the horizon. The first picture from the surface of Mars, of an area near the lander's footpad (3), was taken immediately after landing by camera 2. During the ensuing 43 days, the camera responded to all commands and successfully stored on tape all data. On September 2, the activities of Lander 1 were reduced to accommodate the planned receipt of data from Viking Lander 2.

On September 3, 1976, Viking Lander 2 successfully landed on Utopia Planitia of Mars (47.966° N, 225.736° W), more than 6500 km northwest of Lander 1 (Majumdar and others, 1977; Davies and others, 1978). Lander 2 faces approximately north and tilt 4.2° downward in the direction of 277.4° clockwise from north. The viewing direction of its camera when pointed in a direction normal to the front of the lander is 292.0° clockwise from north along the horizon. The camera on Viking Lander 2 operated successfully for 61 days until the primary mission of both landers was completed on November 15, 1976, at solar conjunction.

During the primary mission, 454 pictures of the martian surface were processed from Viking Lander 1 data and 582 pictures from Viking Lander 2 data. The extraordinary mission of Viking began December 15, after solar conjunction, and ended in June 1978. During this period, an additional 1636 pictures were obtained from Lander 1 data and 1311 pictures from Lander 2 data. A detailed description of the multiple camera Viking primary mission and the results of eight scientific experiments aboard the landers were given in the report in the Journal of Geophysical Research (v. 82, no. 28, Sept. 30, 1977; HIR, References).

*Distances are anaglyphic (two de Vaucouleurs and others, 1973).



Viking Orbiter pictures 452810, 452811 showing the location of Viking Lander 1. Prominent ridges on the horizon in the lander pictures are designated by numbers; craters are designated by letters.

VIKING LANDER MOSAICS

The Viking Lander camera acquired many high-resolution pictures of the Chryse Planitia and Utopia Planitia landing sites. Each picture is the product of computer processing on Earth of digital-image data transmitted from Mars as a result of "camera events" carried out by one of the lander camera systems. Further computer processing of data from a selected number of these events yielded a total of 10 mosaics. Two pairs of mosaics from Lander 1 data (one mosaic from each camera) consisted of one pair made from data taken in the morning (0700-0800 hours) and one pair made with data acquired in the afternoon (1400-1510 hours). Similarly, these pairs of mosaics for the Lander 2 site consisted of one pair between 0700 and 0800 hours, one pair at noon, and one pair between 1700 and 1800 hours.

Procedures used for processing the Viking Lander camera data were described by Levinthal and others (1977). The individual camera events used in each mosaic are identified in the outline of the accompanying camera view. Detailed descriptions and reproductions of these camera events were given by Tucker (1978). Copies of the Viking Lander pictures can be obtained from the National Space Science Data Center, Goddard Space Flight Center, Greenbelt, MD, 20771. The Lander camera system (Hick and others, 1975a) has selectable focus settings for a depth of field from 1.2 m to infinity in the high-resolution (0.04" instantaneous field of view) mode. The survey (low-resolution) mode had an instantaneous field of view of 0.12; this mode was used in the mosaics only where no high-resolution data were required.

Each complete mosaic extends 24.25° in azimuth, from approximately 5° above the horizon to 60° below. A complete mosaic incorporates approximately 15 million picture elements (pixels). In order to manage the processing of such large data bases, each mosaic was compiled from four individual azimuthal sectors.

Most of the data used in the mosaics were selected from the primary mission. In some cases, extended mission data were included where primary mission coverage was absent or where the surface was obscured by the sampler arm. Further selection was made on the basis of optimum focus.

The image data were photometrically corrected (Hick and others, 1975b; Patterson and others, 1977; Wolfe and others, 1977) for differences caused by variations in exposure and for solar lighting differences caused by minor time-of-day variations in the pictures of the set. The geometry was then transferred to a local Mars horizon and corrected for perspective, camera errors (Patterson and others, 1977; Wolfe, 1979). The corrected pictures composing a sector were then combined by the computer into a single image, and an optimum contrast correction was applied.

The mosaics are composites of the best pixels of all the Lander pictures used for each sector. In the computer mosaicking process, the image data derived from the camera events for each sector were assigned priorities on the basis of quality or detail. These data were examined by the computer in sequence according to the priorities, and the best pixels of each data set were used for the mosaic.

The computer formatting of the Viking Lander mosaics was done at the Image Processing Laboratories of the Jet Propulsion Laboratory of the California Institute of Technology, Pasadena, Calif., under the general supervision of Elliott C. Levinthal of the Department of Genetics, Stanford University, who represented the Viking Lander Imaging Team. A detailed description of the multiple camera Viking primary mission and the results of eight scientific experiments aboard the landers were given in the report in the Journal of Geophysical Research (v. 82, no. 28, Sept. 30, 1977; HIR, References).

GEOMETRY OF THE MOSAICS

The camera on the Viking Lander acquires data by sampling in equal increments of elevation and azimuth angle. In the accompanying mosaic, 2.9 mm subtends a 1° horizontal or vertical angle, regardless of the plane of measurement within the panorama. If the martian surface were flat, one pixel (0.04") on the surface would be 1 mm wide at 40° camera elevation and 2 m wide at the horizon 3 km away. Characteristically for this type of imaging system, most straight lines in the scene appear curved in the reconstruction. This representation of the picture data differs from that of a conventional camera having "point perspective" picture geometry, in which rays are projected from object space, through the perspective point in the camera lens, to an image plane in the camera.

The geometry of the Lander pictures is complicated by additional factors. Because both landers are tilted with respect to the horizon, the uncorrected pictures the horizon represents a sine curve. Computer rectification of the pictures results in a straight horizon along which vertical angles can be measured with respect to the local gravity vector, and horizontal angles can be measured from martian north. These angles are not related in any simple way to the azimuth and elevation angles given in "camera coordinates" for the unrectified pictures.

There are other geometric distortions due to the camera: optic path distortion that affects a light ray after it passes the camera window; and camera-system distortions, or "hold-down" errors, that are caused by the way the camera are mounted on the lander. The geometric transformations used in creating the mosaics took into account the optic path distortion but not the "hold-down" errors. However, along the horizon, the error in azimuth angle is equal to the rotational "hold-down" error for each camera to an accuracy of less than 1 pixel. The scale "azimuth angles from Mars north" has been adjusted to take into account this correction.

The residual azimuth angle errors are less than 1 pixel along the horizon and become larger with steeper elevation angles and larger lander tilt. For the worst case, Lander 2 camera 1, this error is a maximum of 3.7 x 1 pixel at 40° elevation. The somewhat sinusoidal elevation-dependent residual elevation error is a maximum of 3 x 1 pixel for Lander 2, camera 1, and approximately 1 pixel for the other cameras.

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**VIKING LANDER 1 PHOTOMOSAIC
EVENING SCENE - CAMERA 2**