





COMPLETE MOSAIC, EVENING SCENE, CAMERA 1

(Corrected for tilt)

SECTOR 3 SECTOR 1 N SECTOR 2 SECTOR 2 SECTOR 3 SECTOR 3

VERTICAL VIEW SHOWING VIKING LANDER 1 ORIENTATION

Grid is in spacecraft coordinates

several meters in size. Bedrock is exposed in some places through the thin covering of fragmental material (line 300, sample 3200). The blocky ridge forming the horizon southeast of the Lander (line 90, sample 2800) is the rim of 150 meter diameter crater C. The large blocks (line 70, sample 2600) resting on the crest of the rim are about 3 m across and about 80 m from the lander. A shallow depression forms the surface immediately in front of the lander. The surface rises gradually towards the south, until the rim of the depression forms the near horizon about 130 m from the lander. Two large blocks (line 120, sample 3590) each about 3 m across, lie on the rim. In the far distance, a broad flat ridge (line 120, sample 3400) is just barely visible above the near horizon. The near end of the ridge (R-4) is about 2 km from the lander. The object at right center of the scene (line 700, sample 3700) is the surface sampler instrument The true form of the instrument is not apparent because the image is a mosaic of three pictures taken when the instrument was in different positions so that it would block a minimum of the surface. The box-like structure at the lower left (line 1300, sample 2900) is the housing in which the meteorology instruments were stowed during launch and transit to Mars.

DESCRIPTION OF SCENE

of the lander shows a rock-strewn landscape with

several small drifts of very fine grained material

scattered among the rocks (line 230, sample

2850). The rocks range from a centimeter to

Viking Lander I faces southeast. This view south

THE VIKING MISSION Two Viking spacecraft, each consisting of an orbiter and lander, were launched from Kennedy Space Center on August 20 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 periapsis 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 22.483° N.* and long 47.968° W. (Morris 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 southeast. When the cameras are pointed in a direction normal to the front of the lander, the viewing direction is 141.6° 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 cameras responded to all commands and successfully carried out their assigned mission. 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 northeast of Lander 1 (Mayo and others, 1977; Davies and others, 1978). Lander 2 faces approximately north and tilts 8.2° downward in the direction of 277.4° clockwise from north. The viewing direction of its cameras when pointed in a direction normal to the front of the lander is 29.0° clockwise from north along the horizon. The cameras on Viking Lander 2 operated successfully for 61 days until the primary mission of both landers was completed on November 15, 1976, at solar 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 extended 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 comprehensive description of the Viking primary mission and the results of eight scientific experiments on board the landers were published in the Journal of Geophysical Research (v. 82, no. 28, Sept. 30, 1977; see References).

*Latitudes are areographic (see de Vaucouleurs and

others, 1973).

struction of the Viking Lander mosaics and an acknowledgment of the many people who assisted in the project were given by Levinthal (1980).

GEOMETRY OF THE MOSAICS

The cameras on the Viking Lander acquire data by sampling in equal increments of elevation and azimuth angle. In the accompanying mosaic, 8 mm subtends a 1° horizontal or vertical angle, regardless of the place of measurement within the panorama. If the martian surface were flat, one pixel (0.04° on the surface would be 1 mm wide at -60° 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 con-

VIKING LANDER MOSAICS

The Viking Lander cameras 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 sel-

ected 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 midafternoon (1400-1530 hours). Similarly,

three pairs of mosaics for the Lander 2 site consisted of one

pair between 0700 and 0800 hours, one pair at noon, and

Procedures used for processing the Viking Lander camera

data were described by Levinthal and others, (1977). The in-

dividual camera events used in each mosaic are identified in

the outline of the accompanying camera view. Detailed des-

criptions 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,

The Lander camera system (Huck 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 has an in-

stantaneous field of view of 0.12°; this mode was used in the

Each complete mosaic extends 342.5° in azimuth from

approximately 5° above the horizon to 60° below. A com-

plete 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 indivi-

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 image data were photometrically corrected (Huck and

the surface was obscured by the sampler arm. Further selec-

others, 1975b; Patterson and others, 1977; Wolfe and others,

for solar-lighting differences caused by minor time-of-day

variations in the pictures of the set. The geometry was then

transformed to a local Mars horizon and corrected for geo-

metric camera errors (Patterson and others, 1977; Wolfe,

1979). The corrected pixels composing a sector were then

combined by the computer into a single image, and an

The mosaics are composites of the best pixels of all the

Lander pictures used for each sector. In the computer mo-

saicking 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 com-

puter in sequence according to the priorities, and the best

The computer formatting of the Viking Lander mosaics was

done at the Image Processing Laboratories of the Jet Propul-

sion Laboratory of the California Institute of Technology,

Pasadena, Calif., under the general supervision of Elliott C.

Levinthal of the Department of Genetics, Stanford Univer-

sity, who represented the Viking Lander Imaging Team. A

detailed description of the multiple steps involved in the con-

1977) for differences caused by variations in exposure and

tion was made on the basis of optimum focus.

optimum contrast correction was applied.

pixels of each data set were used for the mosaic.

mosaics only where no high-resolution data were acquired.

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one pair between 1700 and 1800 hours.

dual azimuthal sectors.

ventional 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, on the uncorrected pictures the horizon resembles 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 windows; and camera-system distortions, or "bolt-down" errors, that are caused by the way the cameras are mounted on the lander. The geometric transformation used in creating the mosaics took into account the optic path distortion but not the "bolt-down" errors. However, along the horizon, the error in azimuth angle is equal to the rotational "bolt-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 correc-The residual azimuth angle errors are less than 1 pixel along the horizon and become larger with steeper elevation angles and large lander tilts. For the worst case, Lander 2, camera 1, this error is a maximum of 5.7 ± 1 pixels at -60° elevation. The somewhat sinusoidal azimuth-dependent residual elevation error is a maximum of 3 ± 1 pixels for Lander 2, camera 1, and approximately 1 pixel for the other cameras.

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