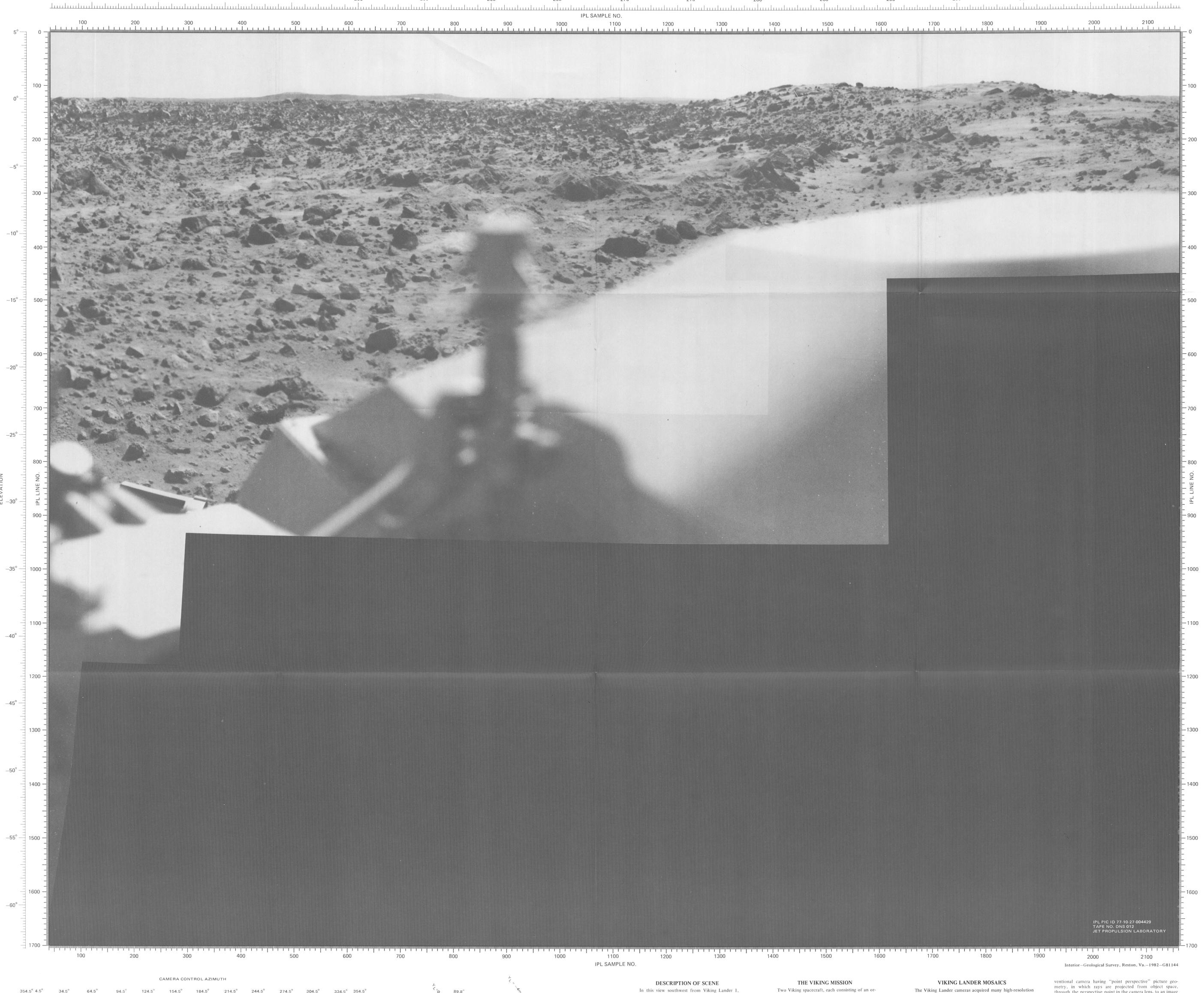
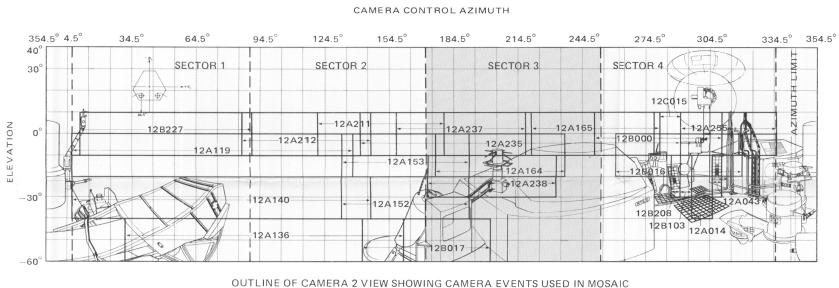
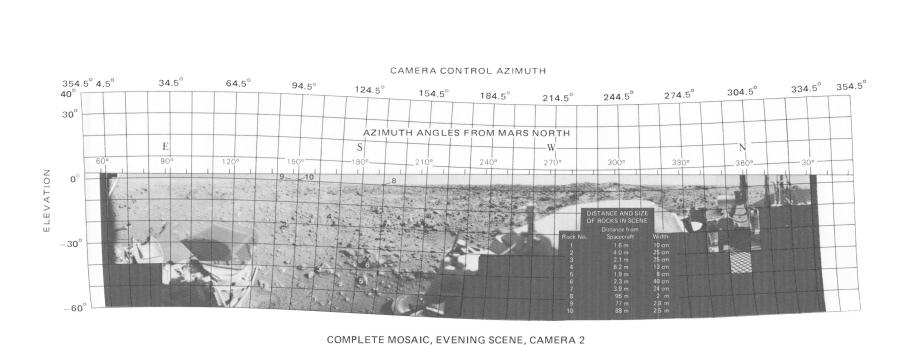
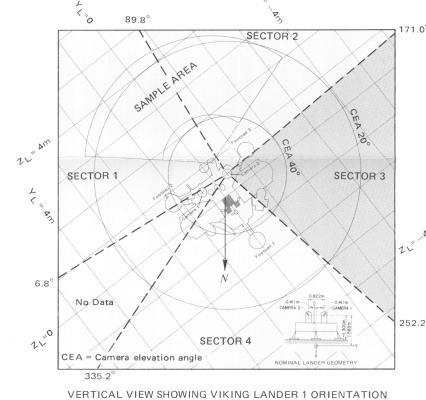
AZIMUTH ANGLES FROM MARS NORTH







(Corrected for tilt)



Grid is in spacecraft coordinates

In this view southwest from Viking Lander 1, the raised rim of a 410-m diameter crater projects above the horizon (line 100, sample 650) and subtends an angle of about 12.5°. The crater is 1.85 km from the lander. The rim of another crater (150 m in diameter) forms the near horizon west of the lander (right side of image). Much of the near surface is occulted by the spacecraft because the view iis over the top of the lander. Parts of the lander that form the bottom edge of the panorama are: the cover of one of the Radioisotope Thermoelectric Generators (RTG's) that power the lander (line 400, sample 1750), the S-band low-gain antenna (line 400, sample 900), and upper parts of leg 3 (line 850, sample 100). Immediately above leg 3, (line 250, sample 870), partly in view, and lying on the surface is the hollow metal canister that covered the surface sampler instrument until after the landing on Mars. It was ejected from the sampler arm upon command from Earth, impacted the surface, bounced and came to rest about a meter west of footpad 3.

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).

biter and lander, were launched from Kennedy

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

Space Center on August 20 and September 9,

transformed to a local Mars horizon and corrected for geometric 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 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 Propul-*Latitudes are areographic (see de Vaucouleurs and sion Laboratory of the California Institute of Technology, others, 1973). 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 steps involved in the con-

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-

struction of the Viking Lander mosaics and an acknowledg-

ment of the many people who assisted in the project were

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 vielded 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

one pair between 1700 and 1800 hours.

dual azimuthal sectors.

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 surface was obscured by the sampler arm. Further selec-

The image data were photometrically corrected (Huck 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

tion was made on the basis of optimum focus.

mosaics only where no high-resolution data were acquired.

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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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