Reports

The First Viking Mission to Mars

The Viking 1 lander has landed on Mars in the Chryse Planitia basin at approximately 22.5°N, 48.0°W and has begun to transmit data back to Earth.

Two unmanned 3500-kg Viking spacecraft were launched from the Kennedy Space Center on 20 August and 9 September 1975, by Titan-Centaur launch vehicles. Each spacecraft consists of an orbiter-lander combination. During the Earth-to-Mars cruise the spacecraft were relatively inactive, with some of the scientific instruments being exercised only for check-out and calibration. Viking 1 went into orbit about Mars on 19 June and Viking 2 will follow it on 7 August.

Viking 1 was placed into a Mars-synchronous orbit (period 24.6 hours) with its periapsis near the preselected landing site of 19.5°N, 34.0°W. Pictures of this region taken by the orbiter cameras indicated it to have features that may represent hazards, and nearly 4 weeks were spent in searching for a nearby landing site which appeared safe on the basis of the evidence of orbiter photography and Earth-based radar data.

On the 30th orbital revolution, the lander separated from the orbiter in response to a command from Earth, and 3 hours 22 minutes later it touched down on the surface at 11:53 G.M.T. on 20 July. Measurements were made of the properties of the interplanetary plasma, the ionosphere, and the atmosphere. Immediately after landing two pictures of its surroundings were taken by one of the lander cameras, and these were received on Earth and displayed within 1 hour.

At landing the local Mars time was about 4 p.m., the season was seven Mars days past the summer solstice in the northern hemisphere, the Earth-Mars distance was 341.5 million km or 19.0 light-minutes, and the orbital relation of the two planets was 128 days before solar conjunction.

The orbiter is currently in a synchronous orbit with a period of 24.61 hours, inclined 37.74° to the equator; the distance from the planet center is about 4900 km at periapsis and 36,000 km at apoapsis. On each orbit, it passes over the lander about 3 minutes before periapsis at an altitude of approximately 1500 km, at which time it receives a radio transmission of data from the lander for up to 40 minutes. This information is stored and transmitted to Earth shortly thereafter. A two-way direct radio link between the lander and Earth is established daily for about 1 hour, during which the program of stored commands in the lander's computer controller is updated and additional data are transmitted. The transmission of data collected by the scientific instruments on the orbiter is nearly continuous.

Orbiter and lander have begun to carry out their planned scientific investigations, which will continue for at least 40 days before the commencement of a similar mission by Viking 2. Preliminary results of the investigations are presented in the reports that follow (Table 1).

The Viking spacecraft. The Viking spacecraft (Fig. 1) consists of the orbiter, the lander capsule, and the lander support structure that is jettisoned by the orbiter after the landing. The orbiter is similar in construction and operation to the series of Mariner planetary spacecraft, particularly Mariner 9, which is in Mars orbit; but it is considerably larger and has expanded capabilities for the storage and execution of commands and for the storage and transmission of data. Like its Mariner ancestors, it is three-axis stabilized, solar-powered, and carries two antennas (high-gain parabolic and low-gain omnidirectional) for two-way communication with the NASA (National Aeronautics and Space Administration) Deep Space Network stations. To accommodate its passenger, the lander, it has a relay antenna for receiving the data transmissions from the Mars surface and facilities for supplying power and command information to the encapsulated lander and for accepting information from it so that the lander subsystems can be thoroughly checked out before separation. Some characteristics of the spacecraft are summarized in Table 2.

The Viking lander. The Viking lander is a three-legged 450-kg aluminum hexagonal structure. Within the body are the computer, power, data, thermal control, and science instrument systems. Mounted on top are the cameras, seismometer, antennas, and radioisotope thermoelectric generators to supply power. When attached to the orbiter, the lander is within a double capsule. It is nested in an aeroshell used during the descent. The other half of the capsule connects to a base-cover and parachute system. The second and outer capsule consists of a bioshield and base and cap. All systems in the lander were sterilized at 111°C for 40 hours just prior to launch. The bioshield cap was deployed after launch. The bioshield base was retained on the orbiter until after landing. The aeroshell was released in the Mars atmosphere as was the parachute and the base cover.

Viking 1 mission chronology. The spacecraft was launched from the Kennedy Space Center in Florida on 20 August 1975 into an orbit that would bring it

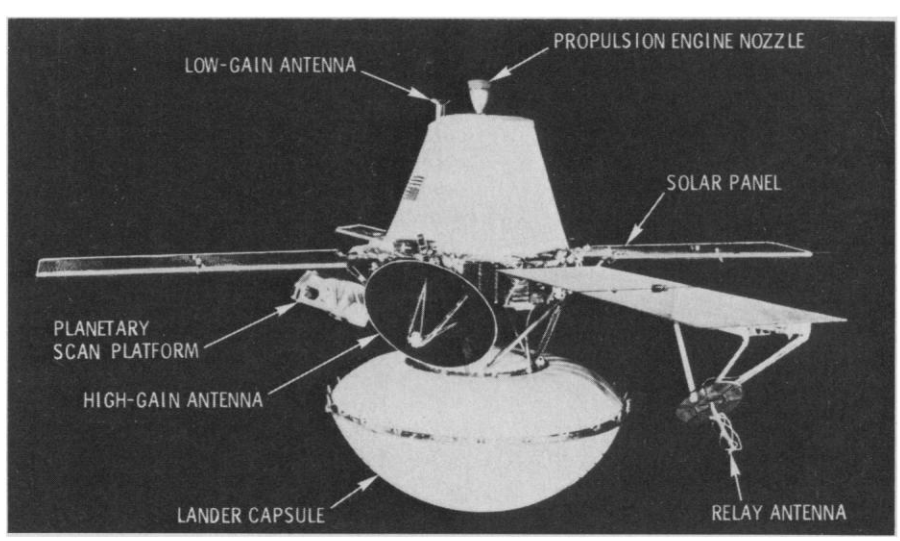

Fig. 1. The Viking spacecraft (the flag is upright in the launch configuration).

close to Mars in June 1976 but not so close as to entail a significant risk of impacting and contaminating the planet. On day 7 after launch (L + 7) an orbit correction maneuver was executed, which was so precise that the spacecraft could have gone into Mars orbit with only the single propulsive maneuver at the planet without any earlier adjustments to the orbit.

A preliminary check-out of the subsystems in the encapsulated lander was made soon after launch, and during the next few months several tests were run on the gas chromatograph–mass spectrometer (GCMS) and on the temperature sensors of the meteorology experiment. Certain engineering subsystems on the lander, including the gyroscopes and the tape recorder, were checked out periodically. The computers were programmed and batteries were conditioned by telemetered command, but the scientific instruments of the lander were otherwise dormant until the next to last day of the 304-day interplanetary cruise.

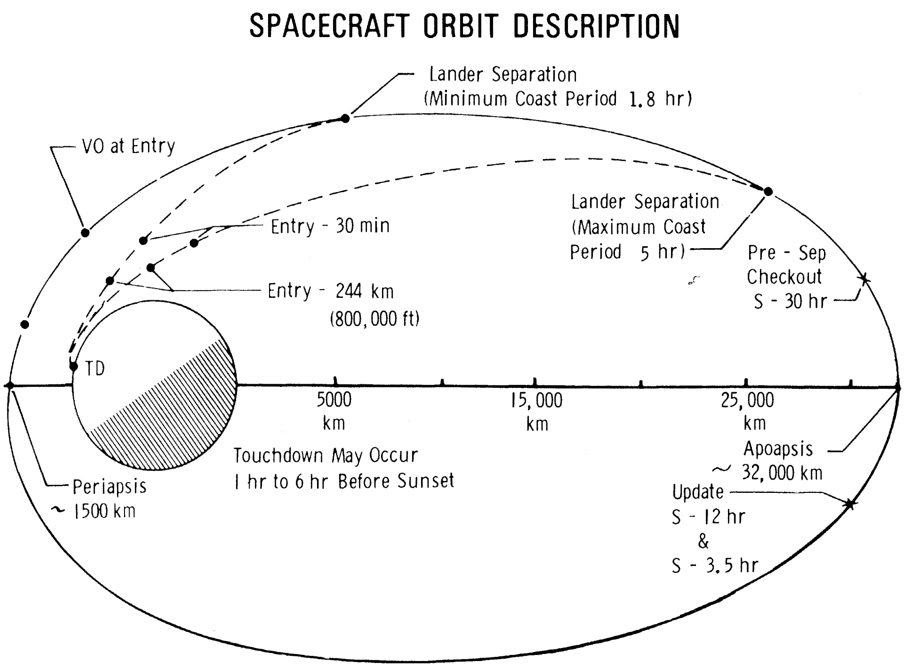

Fig. 2. Viking orbit and descent trajectory.

Table 1. The Viking science projects.

Investigations	Instruments
Orbiter	
Imaging (VIS)	Two vidicon cameras
Water vapor mapping (MAWD)	Infrared spectrometer
Thermal mapping (IRTM)	Infrared radiometers
Entry	
Interplanetary plasma and ionospheric properties	Retarding potential analyzer
Atmospheric composition	
Atmospheric structure	Mass spectrometer
	Pressure, temperature, and density sensors
Lander	
Imaging	Two facsimile cameras
Biology	Three analyses for metabolism, growth, or photosyntheses
Molecular analysis	Gas chromatograph–mass spectrometer (GCMS)
	X-ray fluorescence spectrometer
Inorganic analysis	Pressure, temperature, wind velocity
Meteorology	Three-axis seismometer
Seismology	Magnet on sampler observed by cameras
Magnetic properties	Various engineering sensors
Physical properties	
Radio	
Orbiter/lander location atmospheric and planetary data, interplanetary medium	Orbiter or lander radio and radar systems

On day L + 61 a picture of Earth was taken with one orbiter camera, for purposes of calibration. Over the next 8 months several large sets of pictures of star fields were taken to provide geometric and photometric calibrations of the cameras and to determine accurately the pointing of the scan platform on which the orbiter science instruments are mounted.

Fifty-seven days before Mars orbit insertion (MOI − 57) preparations for orbital operations began with the first of several lander battery conditioning sequences involving discharge and recharge of the batteries, with power supplied by the orbiter. Subsequently both orbiter cameras recorded pictures of the planet Jupiter to provide photometric calibration, and the other orbiter science instruments were also calibrated.

Between days MOI − 33 and MOI − 6, three optical navigation sequences were performed in which one orbiter camera took pictures of Mars and the other took pictures of the star field close to Mars. These pictures were analyzed to determine the position of the Viking-Mars line, and this technique of optical navigation considerably increased the precision of our knowledge of the spacecraft position which had previously been obtained from radio tracking data.

During the last 3 days before MOI a final set of optical navigation pictures was obtained, this time showing the satellite Deimos against the star background. Pictures of the whole lighted disk of Mars were also taken at 2-hour intervals down to MOI − 20 hours, some being taken in two or three colors.

It had been planned to have a single final orbit correction maneuver on day MOI − 10, but when the propulsion system was made ready for that event, a small leak was detected in a pressure regulator. To prevent excessive pressure buildup from that leak, three maneuvers were made. Each reduced the spacecraft velocity slightly so that the arrival at Mars was 6.2 hours later than planned. This delay was compensated by inserting the spacecraft into an orbit with a period of 42.6 hours so that it reached its first periapsis at precisely the time that had been planned for the second periapsis. A maneuver at that time settled the spacecraft into the desired 24.61-hour orbit, and thereafter the mission proceeded on the preplanned schedule until the rejection of the original landing site.

The Mars orbit insertion maneuver began on 19 June at 10:38 G.M.T., and the propulsion engine burned for 38 minutes, reducing the spacecraft velocity by 1.1 km/sec.

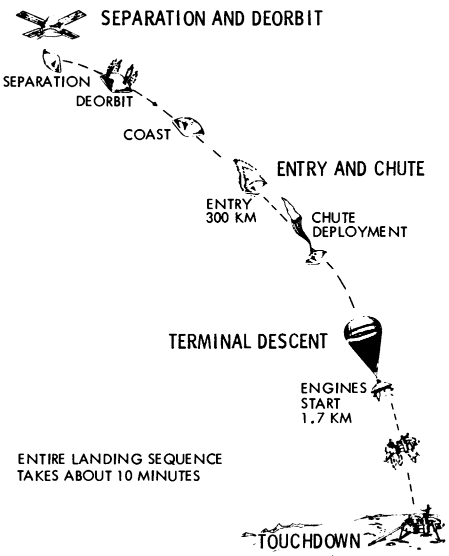

Fig. 3. The lander descent sequence.

With the spacecraft safely in orbit, the site certification phase of the mission began (*1*). An extensive program of observations by the orbiter cameras and the other orbiter science instruments was planned, leading, as we hoped, to the choice of a specific landing target in the preselected area and a 4 July landing.

The site certification observations began on rev 3 (this was actually the second revolution after orbit insertion because of the double length of the first revolution, but the original numbering was retained to prevent confusion) with a set of widely dispersed pictures surrounding the preselected site at 19.5°N, 34.0°W. Swaths of contiguous pictures to cover in stereo the dispersion ellipse around the nominal landing site were laid down on revs 4 and 6. These pictures show unexpected detail and clearly indicated the presence of fluvial features and some mottled terrain, which looked too hazardous to attempt a landing. (The resolution of the orbiter cameras is about two orders of magnitude from seeing the rock hazards that could be fatal to the lander.) Consequently the picture sequences for revs 8 and 10 were retargeted to the northwest of the original site in the direction of the Chryse Planitia basin. These pictures did not look reassuring; therefore after a few days for replanning and redesigning the command sequences (during which observations of possible mission 2 landing areas were made), an orbit trim was made on rev 19 to lengthen the orbital period slightly so that the subperiapsis point on the surface moved westward by about 2° of longitude per day. Pictures were taken on revs 20 and 22 of areas westward of the rev 10 coverage. Study of these pictures together with the results of radar data in the area from Arecibo observations in early July resulted in selecting an acceptable landing site at 22.4°N, 47.5°W. Landing was planned for rev 30 on 20 July.

The checking out of the lander began 30 hours before separation from the orbiter. The separation command was sent from Earth and received within 28 minutes of actual separation. The descent capsule with the Viking lander was separated at a preprogrammed time for the completely automated 3-hour descent to the Mars surface (Fig. 2). The round-trip light time (38 minutes) precluded any real-time control from Earth.

After separation, the lander aligned itself for the deorbit maneuver with the use of small attitude control jets (Fig. 3). At this time it was traveling at 4.6 km/sec. After deorbit and a 3-hour coast period, the braking was performed by three systems: an ablative aeroshell, a supersonic parachute, and terminal descent rocket engines.

The lander entered the Mars atmosphere with its attitude still controlled by the jets. Instead of a ballistic entry, the angle of attack was set to obtain a small amount of lift, which contributed to the deceleration needed for the soft landing. The first lander investigations to measure the ions, electron, and neutral species of the Mars upper atmosphere were performed during this phase (*2*). During entry, the ablation of the aeroshell heat shield protected the capsule from atmospheric heating.

Sequential operation of the systems was accomplished by the use of the landing radar system, operating with the onboard computers, gyros, and accelerometers, to determine the direction and distance to the surface. Peak deceleration occurred at 25 km above the surface.

Table 2. Viking spacecraft characteristics.

Weights (kilograms)	
Spacecraft at launch	
Total spacecraft	3530
Orbiter	2330
Orbiter propellants	1430
Lander capsule and adapter	1200
Orbiter without propellants	900
Lander capsule at separation	1185
Lander on Mars	605
Dimensions (meters)	
Spacecraft overall length	5.08
Solar panel tip-to-tip wingspread	9.88
Lander capsule diameter	3.66
Lander capsule thickness	2.03
Lander overall height (to top of high-gain antenna)	3.1
Lander camera height	1.3
Lander body ground clearance (minimum)	0.22
Diameter of circle through center of landing legs	2.79
Soil sample collector extension	2.9
Electrical power (watts)	
Orbiter solar panel output	800
Lander radioisotope thermal generator output	70

At an altitude of 6 km (descending at 250 m/sec) the parachute was deployed by a mortar, and 7 seconds later the aeroshell was jettisoned. Eight seconds later the lander's legs were extended. The aeroshell was carried away from the landing site by aerodynamic lift. The parachute operated for 45 seconds until the lander was 1.5 km above the surface (descending at 60 m/sec). The terminal descent engine fired for 40 seconds to reduce the final velocity to 2 m/sec, and touchdown on the Mars surface was successful.

During the final descent (30 m) the lander was in a vertical flight path at a

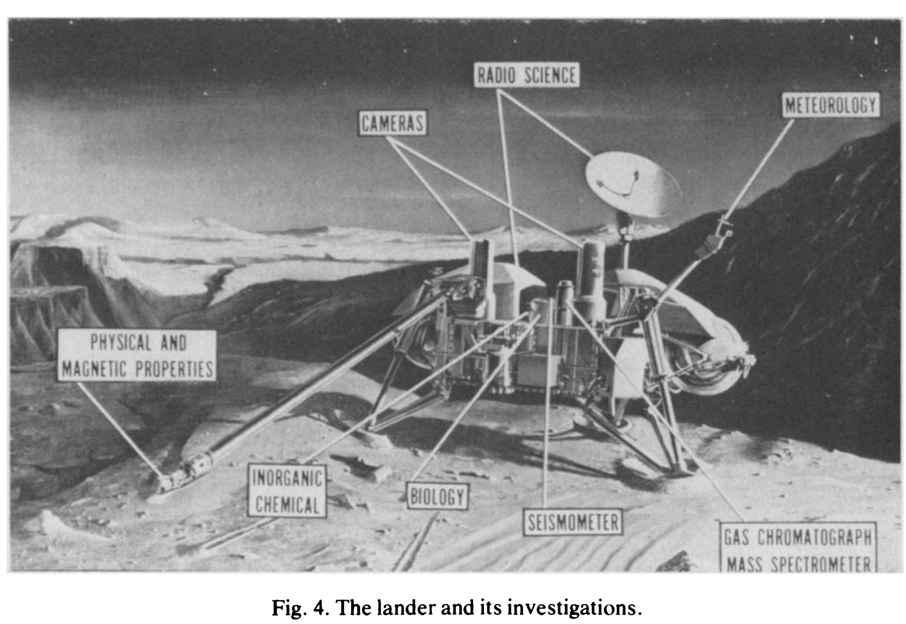

Fig. 4. The lander and its investigations.

constant velocity. A switch on the lander footpad automatically shut off the descent engine when the first leg touched the surface. Honeycomb aluminum shock absorbers in the legs helped to cushion the impact.

The computers and the landing radar systems were critical to all events, including deployment of the parachute and ignition of the descent engines. Every system worked flawlessly. The Viking 1 lander was landed in a flat valley within 3° of vertical, the cameras facing to the southeast. Figure 4 is an illustration of the lander on an imaginary Mars surface.

After 25 seconds one camera was initiated and began to take a high-resolution picture of one of the lander's footpads. The slow scanning camera performed in this mode for 4 minutes and the first picture from Mars was obtained (*3*). During this time the lander activated itself. A high-gain antenna was erected and pointed for the direct communication to Earth. The meteorology boom with its sensors was deployed (*3, 4*). The second picture of the 300° panoramic scene was taken in the next 7 minutes. (At the time the President of the United States telephoned his congratulations to the Viking team scientists.) On the day after landing the first color picture of the surface was taken.

The two means of returning data to Earth from the lander are (i) by a relay link up to the orbiter and back, and (ii) by the direct link to Earth. The relay link will carry about ten times the data of the direct link. The capacity of the relay link is 10 to 20 million bits per day, of the direct link, of the order of 1 million per day.

Planned mission timeline. The basic plan of the lander mission is to continue to take different pictures of the terrain throughout the mission. Within the first week, GCMS was used to perform several atmospheric analyses (*5*). During the second week the samples will be ob-

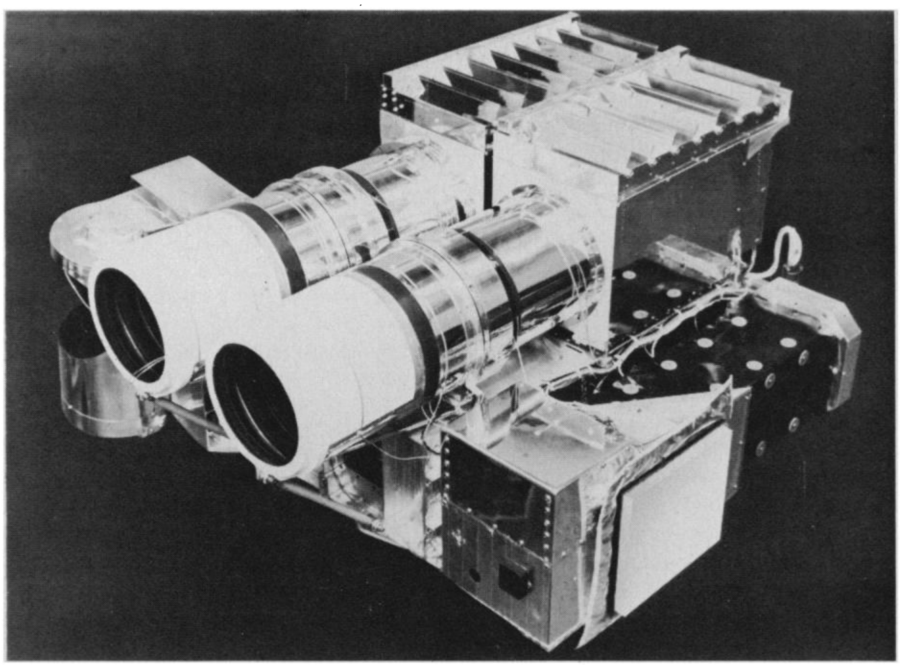

Fig. 5. The planetary scan platform. The MAWD is on the right and the IRTM on the left, with the two VIS cameras between. In flight it is covered by a thermal control blanket.

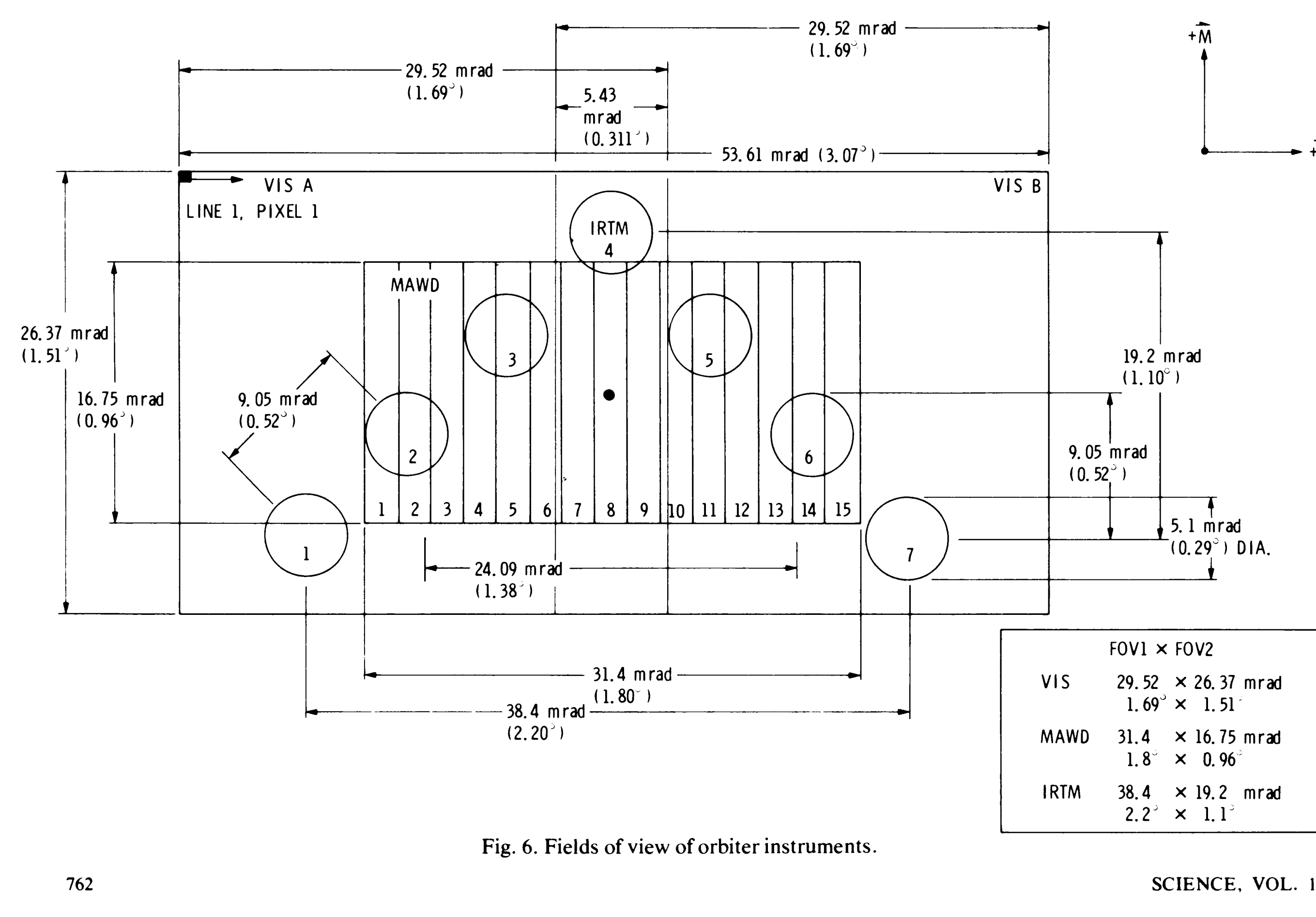

Fig. 6. Fields of view of orbiter instruments.

tained from the surface for analysis by the biology, molecular analysis, and inorganic chemical investigations. Meteorological and seismic data are gathered every day. The mission plan provides the flexibility to respond to the data that are returned. The plan is to continue to gather and analyze surface and atmospheric samples until the Viking 2 is landed, now scheduled to occur on 4 September. The two spacecraft have identical payloads but will land at different sites.

During the first few weeks after landing, the orbiter will remain in the synchronous orbit with periapsis near the lander, and the orbiter observations will be constrained to the areas that are accessible from this orbit. The visual imaging subsystem will be searching for evidences of changing weather near the lander and will be covering with contiguous mapping frames an ever enlarging region near the lander and to the southwest along the orbital ground track. Specific targets that are of interest geologically or because of frequent cloudiness will be photographed. Some areas will be photographed in color or stereoscopically.

The infrared thermal mapper (IRTM) and the Mars atmospheric water detector (MAWD) will make daily observations of both extended and restricted regions (including, for IRTM, those in the dark) to search for changes in water vapor, temperature, and albedo.

At the end of the first primary mission, and when the second orbiter becomes available to handle the data relay from lander 1, and, if needed, it is planned to have the first orbiter "walk around the planet" in a slightly nonsynchronous orbit. This will make other regions of the surface accessible, substantially increasing the capability to observe diurnal variations.

The timeline for the second mission, with MOI on 7 August and landing currently scheduled for 4 September, will be generally similar, and the activity of both orbiter 1 and lander 1 will be greatly restricted during the second mission. Both missions will terminate when the radio communication links become degraded because of the proximity of the sun about 2 weeks before superior solar conjunction on 25 November. In mid-December it is planned to reactivate all four spacecraft to commence an extended mission which is planned to extend for a full martian year, until July 1978.

The orbiter science instruments. Since Viking was to be predominantly a lander mission, a very small complement of scientific instrumentation was included on the orbiters. The instruments were chosen primarily for their potentialities for contributing to the choice and certification of landing sites and for supplementing and complementing the observations made by the landers. Each has the capability also to make observations pertinent to solving some of the major scientific problems about the planet Mars.

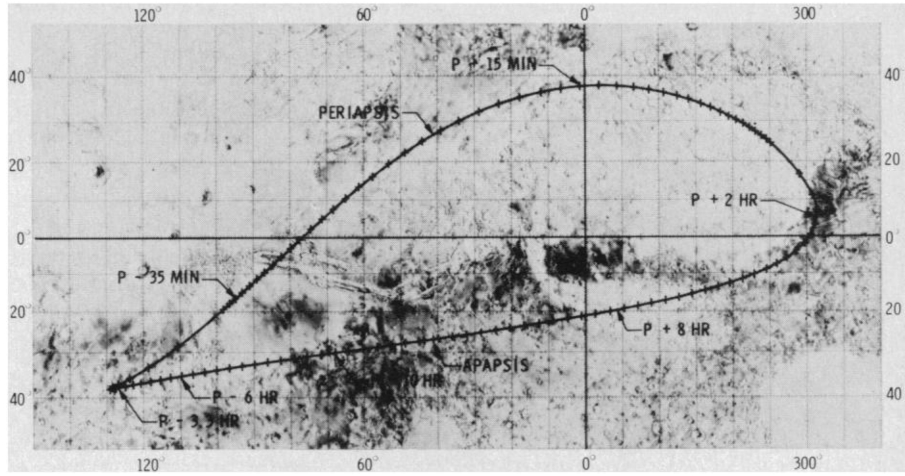

Fig. 7. Trace of suborbiter point on planet surface during one orbit. Points marked are discussed in the text.

The visual imaging subsystem (VIS), comprising two slow-scan vidicon cameras, each with a telescope of 475-mm focal length and a six-position color filter wheel, has been used to provide very precise navigation information by photographing Mars or Deimos against the star background. Its pictures from orbit enabled us to reject several prospective landing sites and finally to settle on the one where the landing was successfully made. They have also revealed many new features of the martian landscape such as had not been seen clearly in the Mariner 9 pictures (*6*). The VIS will continue to make frequent observations of the site to monitor its weather and look for changes in the surface. It will also map a large area in the vicinity of the lander at higher resolution than was previously obtained and will observe in detail the various geologically interesting features—such as volcanoes, canyons, faults, and "river" channels—that are accessible.

The MAWD is a grating spectrometer operating in the 1.4-μm region of the infrared (*7*). In its principal operating mode it measures, every 280 msec, the intensity of reflected sunlight in five narrow spectral bands, from which the quantity of water vapor along the line of sight can be inferred. Thus, it can measure the abundance of atmospheric water vapor with a spatial resolution considerably surpassing that of any earlier measurements. Its observational program is designed to measure the variations in water vapor abundance diurnally, seasonally, and spatially so as to understand the details of water transport on the planet. Its contributions to the certification of the mission 1 landing site were minimal because safety of the landing was the overriding consideration, but it is expected that the water measurements will be an important input into the landing decision for the second craft.

The IRTM has four small telescopes, each focusing incident light on an array of seven small thermopile detectors to measure the thermal emission of the martian surface and atmosphere and the total reflected sunlight (*8*). Various filters divide the 28 detectors among six wavelength bands. Making a full set of measurements every 1.12 seconds, and utilizing the motion of the spacecraft or the scan platform to move the line of sight over the surface, the IRTM can map the variations of radiation intensity at each wavelength. By measuring the diurnal variation of radiation at a given location, the thermal inertia of the surface can be computed, and inferences can be drawn regarding the mean grain size of the surface. These data were helpful in understanding the landing site. The IRTM maps may also indicate variations in mineral content of the surface. A major scientific objective of the investigation is the study of the polar region.

The details of the observations by these three instruments are discussed in the reports that follow.

A fourth orbiter science experiment is provided by the radio subsystems, including the X-band and S-band on the orbiter. Doppler and ranging measurements on the two-way radio link between the spacecraft and the Deep Space Network tracking station determine the spacecraft velocity and range with great accuracy. These data can be analyzed to yield a variety of information about the gravitational field, the atmosphere, and the ephemeris of the planet, as has been done on all planetary missions since Mariner 4. The first result of this investigation has been to determine the location of the lander on the surface (9).

The lander science instruments. The retarding potential analyzer and the mass spectrometer were attached to the aeroshell (1). The other lander science instruments are mounted in or on the lander body. Meteorological sensors are mounted on an extendable boom to avoid interference with the lander body. A three-axis seismometer is mounted on the lander surface. A retractable sampler boom, protected and cleaned of organics, is used to pick up samples from the Mars surface. This boom with its scoop can be extended to 3 m and swing through 110° of azimuth. The two slow-scan facsimile cameras can take pictures in black and white or color, stereoscopically, and have channels sensitive to the infrared. Each of the surface analytical experiments has a separate hopper into which the samples are introduced. Biology and molecular analysis hoppers were capped to prevent contamination, and were opened after landing by firing pyrotechnic devices. Inside the lander are batteries, a tape recorder for recording data, a power condition system, a system for processing the data, the computer, and the telecommunications electronics. The terminal descent rockets have been designed to avoid displacement or heating of the surface in the last few meters. Hydrazine is the sole propellant: its products are H_2 and N_2, and small amounts of NH_3 and H_2O. A special design of the rocket engines enable touchdown with no more than 1°C increase of local temperature and no more than 1 mm of surface stripping beneath the engine. The engines were

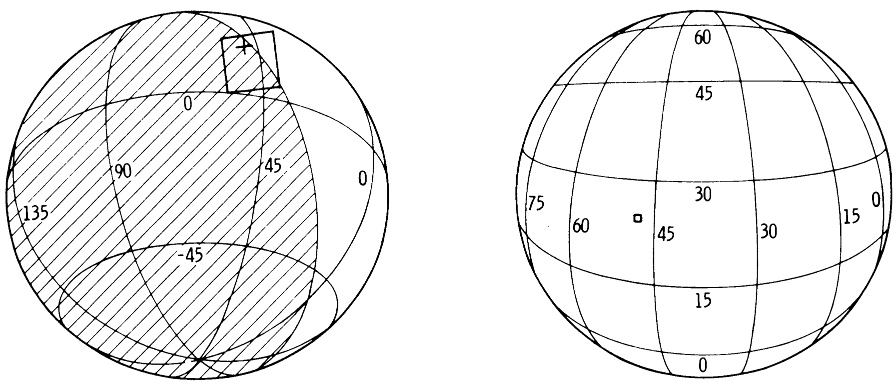

Fig. 8. Perspective plots of Mars as viewed by the orbiter: (left) at lander sunrise, 10 hours before orbiter periapsis (the cross marks the landing site), and (right) at periapsis.

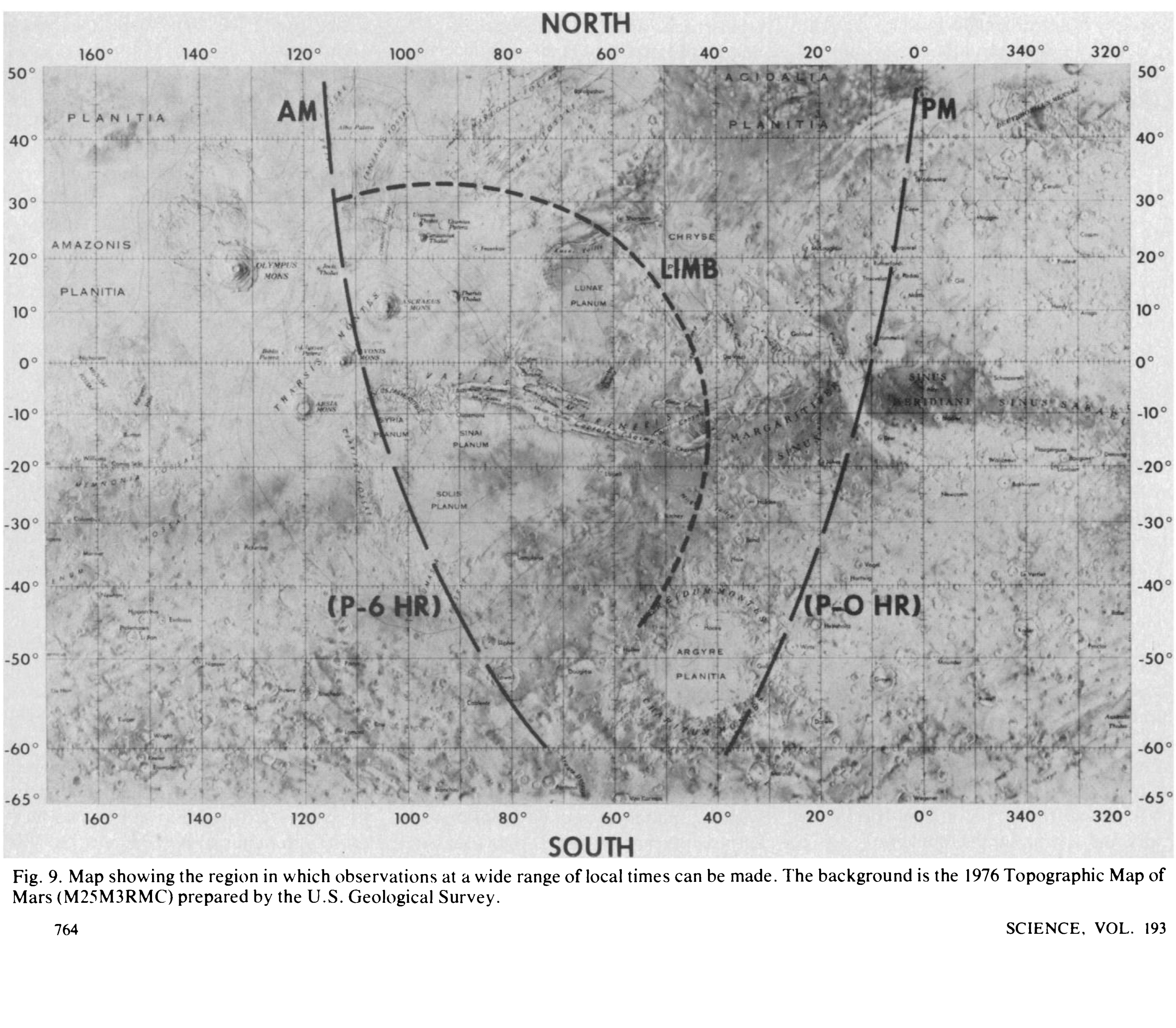

Fig. 9. Map showing the region in which observations at a wide range of local times can be made. The background is the 1976 Topographic Map of Mars (M25M3RMC) prepared by the U.S. Geological Survey.

throttled during descent before touchdown.

Other experiments associated with the lander are the magnetic and physical properties experiments. Small magnets are mounted strategically and will be photographed. Engineering aspects of the lander will be used by the physical properties team (*1*).

The planetary scan platform and instrument fields of view. The Viking orbiter is a three-axis stabilized spacecraft; its orientation is normally maintained fixed by special optical sensors that provide the signals for locking onto the sun and the star Canopus. When it is required for changing the orbit or for observing a particular spot, some other orientation can be chosen and maintained gyroscopically. All three orbiter science instruments are mounted on the planetary scan platform (see Fig. 5) which can move with two degrees of freedom—azimuthally in "clock angle" about the orbiter's axis of symmetry (normally the spacecraft-sun line) and in "cone angle" which is measured from the symmetry axis. The platform can be moved in steps of one-fourth of a degree, and its control system can be programmed to move it as desired about either or both rotation axes at rates of one or four steps per second. These motions, combined with the orbital motion of the spacecraft, provide a reasonable flexibility in covering the planet surface.

The fields of view of the three instruments overlap so that simultaneous observations are obtained whenever the VIS is operating. The pattern of observation in the absence of spacecraft or platform motion is as shown in Fig. 6. The optic axes of the two cameras diverge by 1.38°, and since the cameras are shuttered alternately, there is normally a considerable overlap between successive pictures. The seven circles represent the "chevron" pattern of each of the four sets of IRTM sensors. For pure cone-angle motion, these give seven parallel equally spaced tracks of observation; for other motions, the width of coverage is smaller and the overlap greater. The 15 small rectangles represent the individual fields of view (IFOV) of the MAWD which result from the rotational stepping motion of a small mirror inside the instrument aperture. For pure cone-angle motion the resulting surface coverage is 1.8° wide and everywhere dense; less optimum coverage is obtained for other directions of motion.

Surface coverage and observation conditions. The Mars synchronous orbit passing over the lander imposes viewing constraints on the orbiter instruments and restricts the scientific measurements that can be made, since the viewing conditions are essentially identical day after day. The effect on the IRTM and MAWD investigations is particularly severe, as it is the diurnal variations of temperature and water vapor that are of primary interest, and it is essential to observe the same area at as many different times of the day as possible. For this reason, it is planned on both Viking missions that the orbiter will be released from its lander for a few days. The orbital period will be changed by 2 or 3 hours so that the periapsis point will move around the planet. Synchronism will then be reestablished.

Since all observations up to now have been made from near-synchronous orbit, it will suffice for an understanding of the observational conditions to describe the orbit on rev 30, the landing orbit. The subspacecraft track during this orbit is shown in Fig. 7. The crosses are spaced 2 minutes apart on the northern portion and 20 minutes on the southern. Passing over the landing site and through the periapsis point, the track moves approximately toward the northeast. The sun elevation at lander overfly is 31°, the local time corresponding to just after 4 p.m. During this passage, the landing site is in view for only about 50 minutes. The track crosses the terminator into the dark 15 minutes after periapsis, and the lighted planet is a rather thin crescent between about 1 and 8 hours after periapsis, the minimum being 2.3 hours. Between 2 and 3.5 hours before periapsis, the spacecraft is almost stationary over the vicinity of 37.5°S, 128°W, and the track crosses the terminator into the light at 3.3 hours before periapsis, when the orbiter is at an altitude of about 18,000 km.

Consider now the observability of the landing site, starting with the spacecraft at the extreme right of the track in Fig. 7, at 5°N, 297°W, 2 hours after periapsis. As the orbiter moves south, gains altitude, and slows down and the planet rotates beneath it, about 8 hours after periapsis the site appears over the dark northwest limb, becoming "visible" to the IRTM, and it remains in view near the northern limb for more than 10 hours as the orbiter goes through apoapsis far to the south. Ten hours before periapsis the site crosses the terminator into the light (sunrise), and 4 hours later it disappears over the northeast limb. On the low-altitude pass over the site, it reappears over the northeast limb 35 minutes before periapsis and disappears over the southeast limb 15 minutes after periapsis, and soon thereafter the sun sets on the site out of view of the orbiter.

This orbit chronology is summarized by the numbers on the ground track in Fig. 7. The landing site is visible to the VIS and the MAWD for only 50 minutes at low altitude at a local time around 4 p.m. and at high altitude for only 4 hours after sunrise when the site is so near the limb that good observations are difficult. Figure 8 illustrates the views of the planet from the orbiter at lander sunrise and at periapsis, the rectangle in each picture being the coverage of one VIS picture.

The geometrical considerations above explain why many of the infrared observations in the synchronous orbit are made on areas away from the landing site. A particularly favorable area is near the equator between 60°W and 100°W. Figure 9 shows the situation 6 hours before periapsis; the sunlit and visible portion of the planet lies between the morning terminator (marked *AM*) and the arc delineating the limb. Portions of this area remain visible from this time until periapsis, permitting observations from sunrise until late afternoon. For the IRTM the important predawn observations are also available in this general region. The evening terminator (*PM*) is in the position shown at the time of periapsis passage.

At the time of this writing the Viking lander 1 has collected a surface sample for the biology instrument and the inorganic chemical instrument (*11*). Analysis has begun. The seismometer instrument is still caged. The Viking 2 orbiter is approaching Mars and has made its final approach maneuver.

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12. The Viking mission is a part of NASA's Office of Space Science Planetary Exploration Program and is managed by the Langley Research Center. The orbiter was built by the Jet Propulsion Laboratory and its subcontractors; the lander by Martin Marietta Corporation and its subcontractors. The launch vehicle was provided by Lewis Research Center. The mission's operations are conducted by a 750-man Viking flight team, managed by the Langley Research Center. The flight team is a totally integrated organization, staffed by personnel from NASA, JPL, Martin Marietta, their subcontractors, and all of the Viking scientists. The effort is the result of thousands of dedicated men and women who provided the ingenuity, the loyalty, the perseverance, and the faith in our future to make the Viking mission possible. A special note of thanks goes to the student interns for their technical assistance. The interns were supported by grants from the Alfred P. Sloan Foundation and NASA. Finally, it should be recognized that the project was organized and led by James S. Martin, A. T. Young, B. T. Lee, P. Lyman, and J. Goodlett.

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Preliminary Results from the Viking Orbiter Imaging Experiment

Abstract. *During its first 30 orbits around Mars, the Viking orbiter took approximately 1000 photographic frames of the surface of Mars with resolutions that ranged from 100 meters to a little more than 1 kilometer. Most were of potential landing sites in Chryse Planitia and Cydonia and near Capri Chasma. Contiguous high-resolution coverage in these areas has led to an increased understanding of surface processes, particularly cratering, fluvial, and mass-wasting phenomena. Most of the surfaces examined appear relatively old, channel features abound, and a variety of features suggestive of permafrost have been identified. The ejecta patterns around large craters imply that fluid flow of ejecta occurred after ballistic deposition. Variable features in the photographed area appear to have changed little since observed 5 years ago from Mariner 9. A variety of atmospheric phenomena were observed, including diffuse morning hazes, both stationary and moving discrete white clouds, and wave clouds covering extensive areas.*

This report is a preliminary assessment of pictures acquired from the Viking 1 orbiter during its first 30 orbits (designated as revs). During this period, attention was focused on the selection of landing sites. However, the pictures acquired have broad scientific interest, both for geology and for studies of the martian atmosphere.

The Viking visual imaging system (VIS) (*1*) consists of two high-resolution, slow-scan television framing cameras. Conceptually similar to the Mariner camera systems used in previous Mars, Mercury, and Venus missions, the VIS incorporates improvements designed to increase both spatial resolution and coverage. Each camera employs a 475-mm diffraction limited telescope and a 37-mm-diameter vidicon, the central region of which is scanned with a raster format of 1056 lines by 1182 samples and produces a 1.54° by 1.69° field of view. The optical axes of the cameras are offset by 1.38°. Cameras are shuttered alternately, resulting in contiguous swaths of images 80 km wide, with resolution better than 100 m near periapsis. Six color filters are available to restrict the image spectral bandpass to limited portions of the cameras' near-visual response characteristics.

The orbiter imaging experiment started acquiring calibration data 50 days before Mars orbit insertion (MOI); acquisition of scientific Mars data did not, however, begin until 120 hours before MOI when red and violet picture pairs were acquired every 4 hours. Beginning at MOI − 56 hours, three-color pictures were taken every 2 hours through MOI − 25 hours. A series of pictures taken with the red, the minus blue, and the violet filters completed the approach imaging. These early frames allayed any fears that the planet's atmosphere would interfere with photographing the surface. In several regions, particularly Hellas, Argyre, and Memnonia, they also revealed local brightenings interpreted as surface frost or ice clouds low in the atmosphere. One surprise was the visibility of the surface in the regions of the south pole, where a hood of clouds had been anticipated. After MOI, the orbiter cameras were devoted to finding suitable sites for the Viking landers.

Prior to insertion, detailed plans had been formulated to evaluate potential hazards at the landing site (A1) at 19°N, 34°W (Fig. 1), near the mouth of the large Chryse channels at the southern edge of the Chryse basin. The plan involved a calibration sequence on rev 1, extended coverage of the A1 site area on rev 3, and stereo coverage of the specific landing area on revs 4, 6, and 8. Because of a delayed arrival at the planet, the rev 1 observations were not made; the first high-resolution frames were acquired on rev 3. These revealed surprising detail in the A1 area (discussed below), sufficient to cause apprehension about its suitability as a landing site. Consequently, it was decided to look elsewhere for a safer site. The region to the northwest of the original site appeared most likely to yield a smooth area because it is farther from the mouths of the large channels, close to the deepest part of the Chryse basin, and might therefore be a site of fluvial deposition. This area (A1NW) did appear smooth in the pictures. Radar data (*2*) acquired later, however, indicated adverse conditions and resulted in searches on revs 20 and 22 for additional sites to the west, where a suitable site was eventually found. During this period two sites for the second lander were also examined (Fig. 1). These are the B site at 10°W, 44°N (revs 9 and 26) and the C site at 44°W, 6°S (revs 12 and 14). While the low-altitude coverage was being acquired, high-altitude observations continued to monitor atmospheric activity.

The Chryse Planitia region. Regional and local geological analyses (*3*) on the basis of pre-Viking data show that the area consists of relatively smooth plains of Chryse Planitia near the terminus of three large channel systems (Ares Vallis, Tiu Vallis, and Simud Vallis) that originate in chaotic terrain of Margaritifer Sinus and drain northward into the Chryse basin (Fig. 1). These channels and their associated distributary networks are considered to be primarily fluvial in origin and to have been modified by aeolian processes; however, the degree of modification by wind has not been established.

The predominant feature in the A1 area is lightly cratered plains typified by ridges similar to those on the lunar maria, and which increase in frequency and prominence to the northwest. By analogy to lunar geology, presence of the ridges suggests that the plains are lava flows with low viscosity in the melting range and are probably of basaltic composition. The second most extensive unit in the area forms plateaus which stand topographically above the plains. These are probably remnants of a surface that is older than the lava plains. Almost everywhere in this region streamlined plateau forms indicate sculpturing by fluid flow. In the transition zone between the Chryse basin and the cratered uplands, individual impact craters formed effective barriers to flow; downstream