FIRST HIGH RESOLUTION PHOTOS OF CHRYSE

Presented in this issue of the status bulletin are a group of the first high resolution pictures of Mars taken by Viking 1 near the end of its first and second mission passes, P3 and P4. The use of "P" and a number is the designation for the periapsis (low point) on the orbit and its sequence. P0 was the point at which the first revolution following MO1 began. P2 was the point at which the trim maneuver was performed to place the spacecraft on its mission orbit, and P3 — at the other end of the revolution starting with P2 — was the point near which the first pictures were taken.

These frames were acquired as part of the Viking 1 landing site certification work now well underway for site A1 in the Chryse region (19.5°N, 34°W). The spacecraft is near periapsis (lowest orbital altitude) as the landing site is photographed, and these pictures are therefore representative of the best resolution now possible.

Resolution is exceptional, but it should be remembered that the very smallest craters visible are about the size of a large football stadium. The spacecraft and ground equipment imagery systems are working better than expected at this point, with the probability that quality will improve with experience and operational refinements. The features being resolved are thought to be significantly smaller than those resolved by Mariner 9. This is the result of an improved camera system, considerable refinement of the ground equipment, and a clearer atmosphere on Mars which does not appear to hold a great deal of dust in suspension as it did in 1971.

Some rather dramatic surprises were discovered in pictures taken on the very first pass — and, in fact, in the very first picture reconstructed at JPL. Because the total area under study is still very incomplete in terms of photo coverage, no attempt will be made at this time to provide in-depth interpretation commentary. Site certification will continue to require an expansion of both the photo coverage and associated interpretive information, and these three aspects will be correlated in detail in an upcoming issue of the bulletin.

The crater Yuty was one of the more dramatic features seen by Viking 1 during its first photo reconnaissance of the A1 landing site area in the region known as Chryse. Yuty is 11 miles across and the ejecta flows produced by the impact of the meteorite are layers of broken rock and other debris. The leading edge forms a ridge as on the flows of great avalanches on Earth. Wind erosion has worn the area down, and water erosion may have been responsible for some of the features. Viking 1 was at a range of 1196 miles when this picture was taken.
Channel features that strongly suggest the flow of water or fluid on the surface of Mars are strongly in evidence in nearly all of the pictures of the channels. Flow lines are seen in many places on the floor of the channels, water lines can be seen on the "islands," and partially missing craters and knobby protuberances suggest the involvement of a strong surface erosion process such as what might be produced by the flow of water.

The two frames below overlap one another. What clearly looks like an island in a dry river channel, complete with water lines, is seen in the lower center part of the combined picture pair. The frame at the right was the first picture to be reconstructed and viewed at JPL, and its appearance on monitor consoles brought excited cheers from Flight Team engineers and scientists. The unusual features along the edge of the channel, and seen later in other pictures, were a surprise and will be shown again in another picture. Though transmitted first, the frame at the right was the 33rd of 58 pictures taken during a seven-minute period on the spacecraft’s first pass over the A1 area.
This is a partial mosaic of the A1 landing site, representing overlapping swaths running northeasterly across the area. Many of the features pictured elsewhere in this bulletin edition can be seen in relationship to surrounding terrain.
Eastern Chryse reveals still more of the braided channeling and flow-eroded features that strongly suggest the presence and movement of a substantial volume of water at some time in Mars' past. In this mosaic of five frames, the frame at the lower right reveals a distinct shoreline along the edge of the main channel.
This frame looks down on the exact center of the A1 landing site. The photo covers an area of 775 square miles, and was taken from a range of 965 miles. While the excellent resolution of the pictures provided substantial new information about the landing site area that gives the site certification process additional concern, a substantial portion of the area is still relatively smooth and is being evaluated for landing safety. There are several possible targets in the landing area defined for Viking 1 on the basis of Mariner 9 photos taken in 1971, and these are now being studied intensely to determine which will be safest for the planned July 4th landing.

The floor of the channels in the Chryse region revealed irregular depressions like these – similar to the ones seen along the edge of the channel in the frames on the opposite page. They are lower than the surrounding terrain, and their relatively sharp edges suggest that the material was somehow etched – either by wind or water – from the crust of the channel. While cratering is infrequent in the channels, relative to older cratered terrain, the fact that many are seen suggests that any water flow on the surface of Mars must have occurred in the very distant past. Some of the craters are secondary craters created by ejecta from primary craters some distance away. A few are suspected of being volcanic in origin. Also note the light colored line running northeast from the lower left corner. These are not understood, but are not uncommon and may be associated with faults.
The question concerned with what might have caused the river-like channel features in Chryse seems all but fully answered by the pictures taken during Viking 1's first two high-resolution passes over the region. The features look more and more fluvial in structure as their pictorial form takes shape on the tables of the Orbiter imaging team at JPL and the U.S. Geological Survey team at Flagstaff, Arizona.

The current flow appears to have been northerly and quite strong — strong enough to erode grooves and layers from the large island-like and crater features resisting in its path. Along the edge of the main channels, smaller eddy channels can also be seen — again suggesting a strong fluvial current. This picture contains six frames acquired during the P4 reconnaissance of the A1 landing site area.
NEW LANDING SITE ANNOUNCED,
TENTATIVE LANDING PLAN OUTLINED

Dr. James C. Fletcher, Administrator, National Aeronautics and Space Administration, joined Viking Project Manager James S. Martin in announcing the start of preparations to maneuver the Viking 1 spacecraft over the newly proposed A1-NW landing site. The announcement was made at a noon press conference Thursday, July 1, after a long night of photo evaluation and interpretation of pictures of Viking's "Northwest Territory."

Dr. Fletcher expressed optimism for the probability of landing at the A1-NW site July 17 on the basis of data thusfar available. James Martin also expressed satisfaction with the encouraging information being gathered in reference to the site, but added that "we still have several gates to get through before the landing can occur."

He expressed appreciation for a suggestion by Dr. Robert Hargraves of Princeton, Team Leader for the Lander Magnetic Properties Investigation, which triggered interest in the Chryse basin near which A1-NW lies. Dr. Hargraves was the first to suggest, at seeing the worrisome etched features in the dry river channels, that it might be wise to look for the depositional (settling) area for the sediments washing downstream from the scablands. "Dr. Hargraves kicked off the process that got us where we are today," the Project Manager said.

Dr. Hal Masursky, United States Geological Survey, leader of the site certification effort, said that the vote by the group — which includes an extensive representation from all parts of the Flight Team — was unanimously in favor of the A1-NW decision. He explained that crater densities in the area were significantly lower, and that the rough fluvial features so predominant in the original site near the mouth of the channels had essentially disappeared — to be replaced by smoother plains and aeolian features in the basin.

Dr. Masursky explained that an exhaustive effort had been made by the Orbiter Imaging Team, with help from other teams and an enthusiastic group of college interns, to count and evaluate craters, interpret features, and extrapolate geological processes and their Viking implications.

The decision to begin preparations to move the Viking Spacecraft to a new sync orbit for the A1-NW site is only the first step in a ladder of option-decisions. It rules out a July 9 landing in the original A1 area and sets into motion a landing timeline for A1-NW, but a number of critical option gates must be crossed before A1, A2 or any other proposed site is fully ruled out in favor of A1-NW and the July 17th landing date. The timeline for the July 17th landing, if it progresses on schedule, is presented here.

Timeline of Events for Landing at A1-NW

July 1 & 3 Comparative evaluation of C1 (Capri) Viking 2 site.
July 2-5 Radar coverage of A1-NW by Arecibo station in Puerto Rico.
July 5 Engine burn to provide orbit phasing maneuver.
July 8 Mars Orbit Trim (MOT) to sync with A1-NW (50 meters per second).
July 9 & 11 Photo coverage of A1-NW site.
July 13 Final landing coordinates.
July 14-15 A1-NW weather observations.
July 15 Lander checkout.
July 16 Separation — midnight PDT.
July 17 Landing — 3:00 AM PDT.
As this mosaic shows, Viking's "Northwest Territory" offers visual encouragement for a safe landing in comparison to the eroded and etched fluvial region near the mouth of the channels that empty into the Chryse basin. The islands and scablands are gone, knob features are fewer and more subdued, the crater population is lower, and there is evidence of an aeolian (wind) process in the region. Many of the craters look younger and fresher in A1-NW when compared to those in the original A1 site. The Chryse basin is two to three kilometers below Mars' mean elevation, and therefore has a higher atmospheric pressure — perhaps seven to eight millibars (enough to allow water to liquify, if frozen on or under the surface, when it is warm enough). Viking scientists have speculated about the possibility of permafrost vaporization in association with meteoric impacts and the unusual ejecta blankets around such craters. The concept suggests that water vapor would serve to make the atmosphere briefly denser during the outflow of the impact shockwave carrying the ejecta debris. This might produce a pressure flow that behaves like a liquid with the debris, creating the flow-like lobes on the ejecta blankets. Though the landing coordinates are not firm, they are generally centered at 23°N 43°W approximately 300 kilometers (185 miles) northwest from the original area. Each frame covers an area of about 31 by 37 miles.
"We're finally in orbit, and I must admit I'm relieved," were the words James S. Martin, NASA's Viking Project Manager, used Saturday afternoon at JPL to announce that Viking 1 had indeed been successfully placed in orbit around Mars. His announcement — perhaps reflecting a little of the pressure of nearly two weeks of tense pre-MOI activity, which included a spacecraft problem that necessitated a change in the approach and orbit insertion plan — was made only moments after the Orbiter's engine-shutdown was confirmed at 4:16 PM PDT.

The sequence of events needed to prepare the spacecraft for the orbit insertion, and the long engine burn itself, appear to have been successful in virtually flawless style — all of which is reflected in the accuracy of the orbit achieved. The Mars orbit insertion maneuver for Viking 1 required the longest engine burn yet in deep space far from Earth — 38 minutes consuming 2330 pounds of propellant. In comparison, Mariner 9 required an engine burn of 15 minutes when placed in Mars orbit in 1971.

On the MOI...

James S. Martin, Viking Project Manager:
"It took an awful lot of people around the world to make this happen."

Tom Young, Viking Mission Director:
"All systems appear to be performing nominally."

Dr. P. T. Lyman, Director, Spacecraft Performance and Flight Path Analysis:
"...computers and DSN worked like clockwork."

W. J. O'Neil, Head, Flight Path Analysis Group:
"...can only be described as excellent."

EDITOR: Each team playing a part in the conduct of the Viking mission is dedicated to the ultimate quality possible in their area of responsibility. The product of each team's work is the first concern and point of reference for the manager or director charged with contributing that technology to the unified objective of a successful mission. It is therefore not surprising that they should take great pride in their organizations and people when the proof of performance can be illustrated so dramatically in the harmony of success.
The spacecraft was slowed somewhat by the two approach midcourse maneuvers last week as its trajectory was corrected. Velocity was increasing gradually until the spacecraft began to enter the rapidly strengthening influence of Mars' gravitational attraction. Viking 1's speed then began to increase rapidly. With only an hour to go before engine ignition, the spacecraft's velocity was up to nearly 8000 mph relative to Mars—and, just prior to ignition, had reached almost 9000 mph.

The expected high velocity and acceleration at this point figured most prominently in the reason for the long engine burn, for without strong deceleration the speed of the spacecraft would have carried it past the planet on a fly-by trajectory. Viking 1 had to be slowed down to a velocity that would allow the influence of Mars' gravity to override the spacecraft's approach speed and capture it in orbit. This had to be accomplished in a manner that would allow the spacecraft to achieve an orbit selected and designed to the dimensions needed to accomplish the mission.

It is for the latter reason that the precise time and energy of the insertion burn are so important, and it is a factor that adds considerable complexity to the relatively simple problem of slowing the spacecraft enough to acquire "any" orbit available through chance. The Viking 1 orbit insertion burn was designed to slow the spacecraft by 2500 mph. The first 36 minutes of the engine burn were needed to get the spacecraft into orbit, and the last 2 minutes to "fine tune" the orbit to mission specifications.

Orbit Insertion — Dawn to Dusk

Throughout the morning of the 19th, all activity was focused on the orbit insertion maneuver—no science was to be performed. Early in the morning, gyros took over the task of spacecraft pointing so it could be maneuvered independent of celestial references. Beginning early in the afternoon, a roll-yaw-roll sequence of positioning maneuvers was performed to get the spacecraft precisely pointed for the orbit insertion engine burn. The Orbiter's high-gain antenna was also repositioned so that a communication link with the spacecraft would be assured during the burn. These maneuvers produce a short, expected blackout period when the communication link is lost—3:06 to 3:31 PM PDT* for Viking 1—during the latter moments of their performance prior to engine ignition. However, the events ticked off as certainly as the seconds on the mission clock, and the stage was set for Viking 1's orbit insertion.

Ignition was right on time at 3:38 PM PDT*. The huge 210-foot antenna at Goldstone gathered in the faint signals, amplified them, and sent them into the Viking Control Center at JPL to be monitored and evaluated. Within moments of ignition, the first excited words of confirmation came over the Flight Team's voice nets—"...right on the predict!" There were no dissenters, each echoed the one before.

Confirmation of engine shutdown came at 4:16 PM PDT*, and it was quickly noted that the burn had ended 10 seconds earlier than predicted. The spacecraft computer had detected that engine thrust was 7-tenths of a pound greater than its design thrust of 300 pounds, and the 10-second-early shutdown was a sensitive compensation for that variance. The spacecraft was then "unwound" through a reversal of the pre-MOI roll-yaw-roll maneuvers, the high-gain antenna was again repositioned, and Viking MOI was essentially concluded at 5:23 PM PDT*.

These roll-yaw-roll maneuvers positioned the spacecraft for the orbit insertion burn Saturday, and then repositioned it for mission performance after the burn was completed. These kinds of maneuvers are performed with the Orbiter's attitude-control-system gas jets which get their propulsive energy from pressurized nitrogen stored in bottles that are not part of the main propulsion system. The small gas jets are located at the ends of the solar panels.
The incredible navigation accuracy was the result of intense work performed by the Flight Path Analysis Group headed by its "Chief Navigator," Bill O'Neil, of JPL. Their product, with that of the Orbiter Performance Analysis Group headed by Ron Ploszai, combined with the quality of the spacecraft's performance to produce an orbit of remarkable accuracy.

**The Importance of Accuracy**

The accuracy of the insertion orbit is very important to the planning and accuracy of the mission orbit to which the spacecraft is trimmed after only one full revolution. The nominal insertion orbit would have been 1500 kilometers at its periapsis (low point) and 50 600 kilometers at its apoapsis (high point). The revolution period for the spacecraft on this orbit was designed to be 42.6 hours.

After close analysis of spacecraft data following orbit insertion, in conjunction with the pin-point accuracy of the Deep Space Network (DSN), it was determined that Viking 1's orbit period was only 12 minutes short, at 42.4 hours, as compared to a possible allowed variance of 2 hours on a plan of 99% accuracy. The periapsis, which was initially predicted would be 1511 kilometers, is only 3 kilometers higher at 1514 kilometers. In orbit, the spacecraft's velocity varies like that of a rollercoaster – from approximately 9000 mph at periapsis to about 800 mph at apoapsis. The trim burn was performed at periapsis in order to reduce the spacecraft's velocity and thereby the orbital period.

**Trim to Mission Orbit**

The trim maneuver was successfully performed at 10:44 AM PDT* Monday morning, June 21. It required an 80-meter-per-second

Orbit geometry for the insertion and mission orbits is illustrated here. Viking 1 completed only one revolution on the insertion orbit before the trim maneuver placed it on the mission orbit. The tick marks indicate spacecraft flight hours with periapsis as the zero point. Additional information at selected points along the insertion orbit indicate where the spacecraft was that day relative to Earth Pacific Daylight Time. A complete revolution of Mars on the mission orbit takes 24.6 hours, the length of a Martian day. The orbit is synchronized with the landing site in that the spacecraft will pass over the site once a day near periapsis, allowing maximum resolution orbital photography of that region for site certification and surface-data (after landing) correlation.

*The times indicated for mission events have been translated to Earth-received times – real-time for the events is 18 minutes earlier at Mars, requiring that amount of time for transmission to Earth at the speed of light.*
burn lasting 132 seconds, and consumed a third of the remaining 425 pounds of propellant. During the maneuver, the apoapsis was lowered from its insertion orbit altitude of 50 300 kilometers (31 255 miles) to the mission altitude of 32 800 kilometers (20 381 miles), with the periapsis remaining unchanged at 1514 kilometers (941 miles). Once the trim was completed, Viking 1 was in a 24.6-hour orbit that will pass the spacecraft over the Viking 1 prime landing site in Chryse. The landing site will then be in view on each subsequent revolution near its lowest altitude. The first landing site certification pictures will be taken Tuesday for transmission back to Earth late Tuesday afternoon. The mission orbit is still being evaluated for accuracy, but indications are that it is well within the nominal design.

With the completion of orbit insertion and trim, the baton has been passed. The Orbiter has performed the critical part of its transportation task with remarkable perfection, and it is the Lander’s turn. We are now only 13 days away from our first landing on Mars.