FINAL SCRIPT

(32 minute version

MARS IN 3-D

IMAGES FROM THE VIKING MISSION

produced by

ELLIOTT C. LEVINTHAL

directed by

KENNETH L. JONES

beg	orb	test laser	1	2 →

Edit Synch (Bead Synch) = 00

End 835' 30 FR

Skip 15

Running Time: 32 minutes

First Fixed: January 13, 1979

First Shown: January 15, 1979 (Polarization Version)
2nd International Colloquium on Mars
California Institute of Technology
Pasadena, California

August 31, 1979 (Anaglyph Version)
Exploratium
San Francisco, California

Test chart 41' 06 FR
7' 08 FR

1646
282
1357 FR

To end of Sunset after cuts! 21' 13'' 763' 35 FR

22' 56'' to end of rolling titles
826' 04 FR

The movie opens with the following narration on the sound track:

"All of you should have received stereo glasses. Place them carefully over any glasses you normally wear. Start at the top of the test chart and slowly read down as far as you can."

At the start of the last sentence the following appears on the screen in stereo as a descending staircase projecting from the screen.

To gain a preception of depth in
the stereo movie you are about
to see, you need the stereo
glasses. They can be worn over
the glasses you normally wear.
Sit back and relax your eyes.
If you are fusing the two images
into a single image, this text
should look like a staircase
with steps descending towards you.

OPENING TITLES

1.NASA logo (white on red background)

2.Dr. Leighton, Hale Observatories, earth-based photo of Mars appears as background photo, then title, MARS IN 3-D, appears in stereo in front of the screen, and finally subtitle, IMAGES FROM THE VIKING MISSION, apears in stereo, between the main title and the screen.

3.Crescent photo, taken on Viking Orbiter approach, appears as background, then "produced by Elliott C.Levinthal Stanford University" appears in three lines, in stereo,in two planes in front of the screen, with Elliott C. Levinthal farthest from the screen.

4.Canyon photo of Mars, taken from orbit, appears as background, then" directed by Kenneth L. Jones Planetary Research, Inc." appears in three lines, in stereo, in two planes in front of the screen, with Kenneth L. Jones farthest from the screen.

remove 25'31f of movie from beginning

PART 1 - SCENES FROM VIKING ORBIT

LIVE NARRATION: (The narration starts with the narrator on screen and a shot of Mars from orbit in background.)

MARS IN 3-D, explores the three-dimensional character of the surface of Mars as revealed by the Viking cameras. Since there is nothing exciting or flattering about pictures of your narrator in stereo, the narration scenes are presented monoscopically.

The first stereo scenes were taken by the Viking orbiter cameras. The initial orbiter task was to select a safe site for the lander spacecraft, avoiding the difficulties presented by the Mars terrain. After the landing, the orbiter served as an invaluable relay station, passing each day over the lander horizon. Following the orbiter pass, signals, stored on its tape recorder, were sent to earth, to be received by one of three 64 meter antennas spaced around the world so that one of them always has Mars in view.

As the orbiter traveled in an elliptical path around Mars, ranging from several hundred to many thousand kilometers above its surface, numerous stereo image pairs were acquired; the spacecraft traveling hundreds of kilometers between each image of the pair. This large separation exaggerated the three dimensional appearance of surface relief. Features appear higher or deeper relative to their horizontal size than they actually are. This effect is dramatically illustrated in these first stereo scenes of taken at the Chryse basin.

VIKING ORBITER SCENES remove 25' 31f from music at this pt.

Orbiter scene 1 (271518) (numbers refer to IPL pic I.D.'s)

The ten kilometer diameter crater appears much deeper than it actually is. Subtle details of the surface are also emphasized. Note the edges of the teardrop shaped plateau. Features such as this were apparently formed a long while ago, when a catastrophic flood of water rushed over the surface. The crater protected the plateau from erosion, as material in the surrounding region was removed and carried downstream.

In order to understand the possible ancient sources of this water, stereoscopic images were acquired of fluvial channels leading into Chryse basin.

Orbiter scene 2 (183452)

Separate channels, clearly seen in three dimensions as winding depressions, cut through the older, more crated terrain located to the west of Chryse Planitia. The stereo images make it possible to calculate the gradients of these channels, and the volumes of water required to create these features. The rough appearance of this surface led to the rejection of the preplanned landing site. A two week search began and a safer region was located several hundred kilometers to the northwest.

Orbiter scene 3 (174754)

We come next to an area north of the large volcano, Olympus Mons. Because the two images were acquired at different times of the day, the shadow positions make it difficult for the stereo viewer. As we move north the shadow problems become less pronounced. Extensive faulting caused numerous offsets in the surface topography. Large blocks are either lifted or dropped relative to the surface. The smooth portions are more recent volcanic flow, filling the low areas of the scene after the faulting had occurred.

Orbiter scene 4 (195914)

Three-dimensional imaging of the surface allows detailed mapping of faults and structures such as these. Mapping the various faults and determining the time order in which they occurred, makes it possible to unravel a considerable amount of the volcanic and structural history of the region.

The most dramatic three-dimensional orbiter scenes are the massive canyons extending 4000 kilometers in the equatorial region of the planet.

Orbiter scene 5 (165352)

As we move across the floor of the Candor Chasma, we suddenly come upon the edge of the canyon and spectacular relief. Stereoscopic data is essential for the interpretation of the strange light and dark regions on floor of the canyon.

Orbiter scene 6 (124250)

Near Ius Chasma, we look down into a branch of the main canyon. This side canyon is as large as the Grand Canyon on earth. The canyon walls reach 4-6 kilometers above the floor. Widening seems to occur by sapping. Material falls from the walls to the bottom of the canyon and is carried away, on Earth, usually by a river; on Mars, the process of removal is unknown.

PART 2 - SCENES OF VIKING TEST LANDER AT JPL Begin music as before

LIVE NARRATION: (The narrator appears with a photo of the Test Lander spacecraft in the background).

These next scenes are of the Viking Lander, taken at the Jet Propulsion Laboratory in Pasadena, California. Here a fullscale test spacecraft with an operating soil sampler and two operating camera systems, was installed. Commands to be carried out on Mars could be duplicated to aid the planning activities of scientists here on earth. In the background, is an artist's concept of Mars painted prior to landing.

The lander spans almost three meters and reaches two meters from the footpads to the top of the large antenna. The bottom clears the surface by just 23 cms. In front we see one of three terminal descent engines, ignited when the spacecraft is traveling about 225 km per hour. They slow the lander to 9 km per hour by the time it touches the surface.

VIKING TEST LANDER SCENES

Scene 1 - front view of Lander

The final shock is absorbed by the compressible honeycomb aluminum in the three landing legs. The two cylindrical turrets, I pointed out earlier, house identical cameras. Separated by .8 meters, they view the Martian scene from a vantage point 1.3 meters above the surface. Protruding on the right is the metereology boom. Every day the measurements of this Martian weather station are transmitted to earth for study. Between the two cameras we now see the surface sampler arm , with its ten foot retractable boom in its initial stow position in the gold shoe-box size cannister.

On either side of the top of the lander are the covers that surround the radioactive isotope thermo-electric generators. These use plutonium 238 to provide energy for the lander.

Scene 2 - sideview arm and metereology boom

The boom is constructed of two stainless steel pieces of foil welded together along the edges. When the boom is extended, the steel layers form a double curved rigid tube, much in the same manner as an every day measuring tape.

Scene 3 - arm goes straight out - view of two cameras and magnets

The circles below the collector head are magnets mounted on the back-hoe to study the magnetic properties of the soil. With the aid of a computer based ranging system, the images acquired by the two camera "eyes" on Mars were used to create a model of the Martian terrain in front of the test lander you are seeing here at JPL. This model was used to generate arm commands that placed the arm in precisely the right position to acquire samples, dig trenches and roll rocks.

Move your head slowly from side to side and you will observe an interesting effect.

Scene 4 - arm lowers to surface, digs, withdraws, and lifts

The arm extends the commanded length and then lowers itself to the surface. Using information from computer-generated vertical profiles of the surface, arm commands instruct the collector to push forward, to dig, and acquire a sample. The head at the end of the boom can lift 5 pounds. [The cover in the test lander doesn't quite close and a great deal of the sample is lost.

Cut 390' 39 FR to 461' 00

Scene 5 and 6 - side view extended arm, mirror, sample delivery

We see the mirror on the side of the arm. This allows the cameras to look underneath the spacecraft. The arm retracts, and then rotates to deliver handful size samples to the three inlets on top of the spacecraft.

One leads to the chromatograph which separates different organic molecules into groups which are then drawn into a mass spectrometer. The output electrical signals produced are recorded and sent to earth to complete the organic chemical analysis of the Martian soil.

Another inlet system distributes its soil sample to three biology experiments that search for signs of living micro-organisms. A labelled release experiment looks for signs of metabolism, the pyrolytic release looks for organisms that function by a process that assimilates carbon from the carbon dioxide rich Martian atmosphere. Photosynthesis would be an example. The gas exchange experiment detects organisms by measuring changes in gases in a closed environment.] 77' 13F

We see the sample delivered to the third inlet on the right, where it enters the x-ray fluorescence experiment. Different atomic spectra are emitted for each chemical element in the sample. Here again the electrical signals are transmitted to earth for analysis.

cut 480' 26 to 497'-39 ? cut if possible in sound track

Scene 7 - Charts - microdot - mirror

[Also on top of the lander are three test charts. Two can be viewed by each camera from a distance of about 1 meter. The grey and colored patches and tribars aid in calibrating the camera. The grid allows us to study movement of dust. Next to the central test chart is a microdot emblem that contains the signatures of ten thousand people who contributed to the success of the mission. Above this emblem is a magnifying mirror that aids in viewing the magnetic particles on the back-hoe.] 15' 18F

Scene 8 - two cameras - flag, bicentennial emblem, stowed cameras

Inside the camera protective housing a mirror gathers light from each point of the scene on Mars and directs it to an array of twelve photosensor microdiodes. Some of the diodes gather light from a .12 degree aperture, which may have red, green, blue, or infrared filters.

Scene 9 - two cameras

Others have a .04 degree aperture and take high resolution black and white images at different focal distances from the spacecraft. An electrical signal proportional to the incident light is sampled and transmitted to earth as a binary string of six zeros or ones. These instruct the ground reconstruction equipment which of the sixty-four levels from black to white is to be assigned to that one element of the image. We look through the double protective window to the nodding scan mirror. Each time it nods downward it gathers light from a vertical line of the scene on Mars and creates five hundred and twelve picture elements or pixels to be sent to earth.

Scene 10 - close-up mirror

The mirror having nodded up and down is ready for the next vertical scan line. The camera rotates and steps clockwise in azimuth, separating each scan line by .12 or .04 degrees, depending on the diode being used.

remove 92' 3 f from music

PART III - VIKING LANDER SCENES

LIVE NARRATION (narrator appears with slide of first scene from front of Viking Lander 1 in background)

By command from earth we determine the central angle of the nodding mirror and the start and stop values of the azimuth stepping. In this way over a period of time we accumulated pictures ranging over 342.5 degrees in azimuth and from 40 degrees above the horizon to sixty degrees below. Joining individual camera events, occurring on different days throughout the mission, using both cameras on each spacecraft, computer-generated mosaics were made which are the basis of the stereo movies of the lander scenes. Each 342.5 degree panorama incorporates approximately fifteen million picture elements or pixels.

Because of the large, .8 meter, separation between the two cameras the images have an emphasized stereoscopic effect. The scene appears to be miniaturized and there is a large change in parallax in going from the horizon to the near field. The movie has been made to make it easiest to achieve stereo fusion at the horizon. Once you get accustomed to the image, you can move slowly down and retain the stereo effect.

We begin our three dimensional tour of the surface at Chryse Planitia, the Viking 1 Lander site, 22 degrees north, 48 degrees west, where twenty-five seconds after touchdown, in the afternoon, at 16:13 after local Mars midnight on July 20th 1976, camera two on lander one was unstowed and took the first pictures of the surface of Mars.

VIKING LANDER 1 SCENES

(Dissolve to lander 1 scene 1, initial hold.)

Concentrate first on the horizon. The prominent rock on the ridge is an ideal starting point. Relax your eyes until you begin to see the stereoscopic effect. After achieving fusion, slowly move your eyes along the horizon. Now shift your attention gradually to the foreground.

As you do this you should be seeing a series of ridges and rocks. Many people have difficulty fusing the bottom half of the image. Don't feel left out if you can't see the nearest rocks. Enjoy the more distant vistas along the horizon as we take you on a three dimensional journey over the surface of Mars.

(Begin 42 sec. zoom at word "Mars") level sound at "Chryse"

The present surface of Chryse Planitia was formed long ago when volcanic flows and lavas buried an even older surface. However, as we move over these volcanic plains, we see little that suggests lava flow. Instead, the most abundant features we see are loose rocks lying about on the surface, fractured and dislodged from the underlying bedrock by some process of erosion.

At both lander sites, we now believe that asteroid impacts are the major process creating loose rocks. These impacts form craters, fracture the bedrock, and eject loose blocks at high velocities in all directions. Photographs from the orbiters show that there are numerous small impact craters surrounding the lander 1 site.

(Scene 1, hold 12-15 sec, begin pan left - 90 secs.)

The loose rock here may have come from an impact crater just over the horizon in front of you. If we could rise up and peer over this ridge, we would find ourselves staring into the interior of a shallow impact crater. (NOTE: key narration to light drift in front of ridge) Nestled in a small depression, you can see what appears to be a smooth bright feature. This is a small isolated deposit of dust material which has been transported and deposited by the Martian winds. We shall see other more extensive areas of drift material behind the lander.

(key narration to the bedrock outcrop). One of several outcrops of ancient volcanic flows is visible in the mid-field. Horizontal layers are clearly seen. [A curious black linear structure extends from the lower right to the upper left. This structure is possibly a fault or a fracture, and can be seen in both the bedrock and the adjacent landscape.] 678' 32 - 705 35 27' 3F

(Hold 1 sec. Dissolve to scene 2, hold for length of following paragraph.) (too abrupt)

About 10 meters from the lander, at the left of the scene, may be seen several accumulations of drift material. Exposed ridges are visible on the surface of the drifts. These are believed to be deposition layers within the drift material. As the wind erodes the drift at an angle to the deposition layers, the edges are exposed. This is the best example, at the lander site, that shows that the drifts are being eroded rather than being slowly transported across the surface as a unit in the manner of moving sand dunes.

(start pan right) dissolve after pan stops

The nearest rocks visible in the foreground are only four meters away. The highest point on the distant ridge is 5 meters above the lander. A sequence of smaller ridges at intermediate distances can be seen between the foreground and the horizon. [In order to appreciate the usefulness of three dimensional information in understanding the scene, try closing one eye for just a moment.

cut 736 21 to 761 27 Dissolve

You are looking to the southeast of lander one, directly to the front. The images comprising the mosaic were acquired around seven in the morning, local lander time. The sun is twenty degrees above the horizon to the upper left of the scene.

(End pan right, hold for length of following paragraph.)

In addition to the bright drift area shown earlier, two additional isolated drifts can be seen on the right side of this scene.

(Dissolve to scene 3, hold.)] 25' 18F

In the preliminary imaging sequences made prior to touchdown, relatively little time was allotted to the areas behind the landers, since most of the surface is obscured by parts of the spacecraft. However, as we see in this scene, some very spectacular three dimensional images were acquired of features behind the lander. A sequence of ridges can be seen extending to increasing distances. The far ridge is over 100 meters distant, the nearer ridge is only twenty meters away.

(Begin scene 3 zoom - 21 secs.) cut 782' 21 - 794 36

[Many people have difficulty achieving a stereo effect because of the discontinuity in parallax between the nearer and farther ridge. The effect is called jump-fusion, because the eyes must jump between the front and distant ridges. Fusion may be difficult or impossible to achieve for both ridges simultaneously.] 12' 25 F

(Scene 3, hold 2 secs. Begin pan left - 110 secs- pan down-13 secs.)

As we look due West, we see an additional ridge spaced between the previous two ridges. The near ridges are partially blanketed by dust which has been swept over the surface from right to left by the prevailing winds in this region. The prominent block on the hill is 1 meter across.

cut 810' 31

[cut The distance which the cameras can see is determined by the height of the cameras above the ground, the height of objects in the distance, and how the spacecraft is situated, on a hill or a depression. The cameras are 1.3 meters above the surface. If the lander were sitting on a perfect Mars-sized sphere, the horizon would be about three kilometers away and objects there about two meters in size would be one picture element. However, the lander is apparently on top of a slight rise, thus significantly increasing the distance we can see.

(Key to pan). The most distant features seen by lander 1 cameras are these light hills, about 8 kilometers away, barely visible beyond the near ridge. The distance to these hills is known because they can be seen in both orbiter and lander images.

Also visible in both lander and orbiter images is the ridge now entering the field of view. This has been identified as the right rim of an impact crater 500 meters across and just over 2 kilometers away.

(End pan down, hold 10 secs. Cut to scene 4, hold 8 secs. Pan - 80 secs.)

Additional hills are visible to the Northwest. As before, there is a nearby ridge which may create some problems in obtaining stereo fusion. (Start pan). On this ridge, there are numerous larger rocks interspersed with an extensive blanket of drift material. These rocks are believed to have originated from still another impact crater.

The drifts you are now seeing are the edge of a field which extends more than one third of the way around the lander.

bad double image

910' 31

Perhaps the distinction we previously made between sand dunes and dust drifts needs further clarifcation. The word "dust" implies a smaller grain size than "sand". The word "drift" implies that the material is being eroded and sculpted by the wind, rather than being continually moved across the surface.

(End pan, hold 5 sec. Dissolve to scene 5. Hold 2 secs. Pan left - 50 secs.)

In sharp contrast to these drift accumulations, the area south of the lander is almost devoid of dust. Based on the eroded appearance of the drifts in the rest of the scene, it is believed that similar drift material may have blanketed much more of the scene than it does now.

However, whether the rocks and surface seen here were buried is presently unknown. All that we see today is a variety of exposures of barren bedrock and loose block.

(Hold at end of pan for phrase below.)

Part of our understanding of the lander 1 site comes from the ability to compare it to another region, visible to lander 2 about 10,000 kilometers away on the other side of the planet, 48 degrees north and 226 degree west. (fade out and in to scene 6 during this passage)

VIKING LANDER 2 SCENES

(Scene 6, hold 2 secs. Pan right 95 secs.)

At first glance, the surface here at Utopia Planitia, where lander 2 touched down on September 3, 1976, appears to be remarkably similar to the surface of Chryse Planitia. The predominant objects are loose rocks. Just as the at the Viking 1 site, most of these rocks were originally broken from the bedrock by the impacts of asteroids on the Mars surface. The loose rocks around lander 2 were probably derived from the large impact crater Mie, 100 kilometers in diameter, located 160 kilometers to the northeast.

Far to the east is a series of hills. Their sizes and distances are unknown. Unlike the lander 1 site, there are no clearly indentifiable horizon features which can be correlated with orbiter images. Consequently, we have not yet been able to uniquely position the lander relative to the surface features visible in the orbiter images.

One of the characteristics of the Mars environment is the yearly occurrence of planetwide dust storms. These storms are viewable from earth, and have often been seen to enshroud the entire planet. Such wide-spread storms would seem to suggest that a considerable amount of dust is involved, and that erosion rates on the surface might be quite high.

However, despite the occurrence of two such global dust storms during the Viking mission, the landers have only seen a general darkening of the scene. Distant features seen here, as well as at the lander 1 site, remained visible during the height of the storms, suggesting that amounts of dust present during the dust storms may be far less than previously was suspected.

(End pan, cut to scene 7, hold and pan right 40 secs.)

44' 27F — good from here

Around most of the lander ~~2 scene, the horizon is closer than the distant hills now in view.~~ Nearby rises in the surface topography block our views of distant vistas. As we look at these jumbled piles of rocks, and remember that the lander clears the surface by only 23 cms, it seems fortuitous that the lander was able to touchdown without damage. In fact the lander 2 footpad is partially supported by a large rock.

During the winter season at the lander 2 site, the surface became covered with a thin layer of water-ice. This water-ice was transported northward from the equator to the Utopia region, remaining for over one-hundred Mars days. The thickness of the ice ranged from several to tens of microns, insignificant on Earth but not on Mars. The close-up observation of water-ice provided us with clues to the possible history of Mars soil material.

(During above paragraph there is a short hold at end of scene 7 pan-dissolve to 8. Brief holds at beginning of scene 8 and during scene 8)

One of the most puzzling features seen in the lander 2 images is a network of shallow troughs. The most prominent is visible in the foreground of this scene. When these depressions are mapped, they are shown to form a crude geometrical pattern. Although the troughs are evidently not cut by running water, alternative explanations remain indeterminate. One possible mechanism is that they result from buried ground ice. The troughs resemble features commonly seen in the polar regions of earth, called patterned ground. These depressions on earth result from the complex distortions of the surface due to the freezing and thawing of subsurface ice. (Start zoom). Note the variety of rocks. Each type implying a different origin and erosional history.

(fade out after end of zoom and fade in to sunset photo on righthand image and black on left side. Sunset photo becomes background for first closing credit.)

You should now remove the stereo glasses. Please put them in any protector you may have reveived and return them to the box at the exit. You will enjoy the monoscopic scenes that appear with the closing credits, following this scene of sunset on Mars as seen by one of the cameras on Lander 1.

1/3/90 — New Music End: 240 feet

CLOSING CREDITS.

1.

written by
ELLIOTT C. LEVINTHAL
KENNNETH L. JONES

(background camera event 12A240)

2.

produced by
ELLIOTT C. LEVINTHAL

(background camera event 11B097)

3.

directed by
KENNETH L. JONES

(background camera event 11A251)

4.

film advisor and editor
URI GEVA

(background camera event 11A097)

5.

Original Computer Music
MICHAEL McNABB
WILLIAM G. SCHOTTSTAEDT
Center for Research
in Music and Acoustics
Department of Music, Stanford University
Professor JOHN M. CHOWNING, Director

(background camera event 11A017)

6.

narration by
ELLIOTT C. LEVINTHAL

(background camera event 12A006)

7.

Sound Mixing W.A.PALMER FILMS,INC.

Sound URI GEVA
MICHAEL SILVERS

Assistant Camera SUE MILLER

(background camera event 22A207)

8.

Viking Orbiter Stereo
Photography Images Provided by
Viking Orbiter Imaging Team

Stereo Animation
RICHARD FINN
MARCY PAGE

California State University
at San Francisco

(background jpl photo p-17442)

9.

Viking Science Test Lander Photography

3- Dimension Cinematogrpahy Consultant	Director of Photograhy
PAUL VLAHOS	CHUCK COMISKY

(background jpl photo p-18108)

10.

Viking Lander Stereo
photography images provided by
Viking Lander Imaging Team

Stereo Animation
W.A.Palmer Fiilms,Inc.

(background camera event 11A078)

11.

Technical Advisors

Science Test Lander Operator
PHILLIP M. COULSON

Stereo Consultants
SIDNEY LIEBES, Jr.
STEPHEN D. WALL

Titling
CATHERINE PICKERING

(background camera event 21B059)

12. (The following is a rolling title with a hold in the middle.)

The producer wishes to acknowledge the assistance of the Communication Department, Stanford University, Professor Henry S. Breitrose, chairman, and two laboratories of the Jet Propulsion Laboratory, California Institute of Technology: the Image Processing Laboratory, William B. Green, manager, and the Photolaboratroy, John C. Hewitt, manager.

The earth-based color photograph of Mars was provided, courtesy of Dr. R.B. Leighton and the Hale Observatories and copyrighted by California Institute of Technology.

This film was produced for the National Aeronautics and Space Administration under Langley Research Center contract NAS1-9682 with Stanford University, and

have never
used original
as