NASA CONTRACTOR REPORT

NASA CR-2194

NASA CR-2194

# SEDIMENTARY FEATURES ON THE SURFACE OF MARS AS SEEN FROM MARINER 6 AND 7 PHOTOGRAPHS

*by Ronald L. Parsley*

*Prepared by*
TULANE UNIVERSITY
New Orleans, La. 70118
*for*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • MARCH 1973

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| NASA CR-2194 | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| SEDIMENTARY FEATURES ON THE SURFACE OF MARS AS SEEN FROM MARINER 6 AND 7 PHOTOGRAPHS | March 1973 |
| | 6. Performing Organization Code |
| 7. Author(s) | 8. Performing Organization Report No. |
| Ronald L. Parsley | |
| 9. Performing Organization Name and Address | 10. Work Unit No. |
| Department of Geology<br>Tulane University<br>New Orleans, LA 70118 | 11. Contract or Grant No.<br>NGR 19-002-032 |
| 12. Sponsoring Agency Name and Address | 13. Type of Report and Period Covered<br>Contractor Report |
| National Aeronautics and Space Administration<br>Washington, D. C. 20546 | 14. Sponsoring Agency Code |

15. Supplementary Notes

16. Abstract

Martian sedimentation is primarily aeolian with the principal source areas being the cratered highlands. Lighter albedo in areas of sedimentation may be due to minerals of smaller grain size and/or lighter specific gravity. Martian erosion-sedimentation seems to be active as evidenced by removal and/or burial of ejecta mounds and ray ejecta patterns around fresh bowl-shaped craters. It is suggested that at least some chaotic terrain may be formed by aeolian removal of material in areas of closely spaced faulting. Transitional areas between uplands and basins are sometimes "muted" by down slope winds.

| 17. Key Words (Suggested by Author(s)) | 18. Distribution Statement |
|---|---|
| Mars<br>Mariner 6 and 7 photos<br>Aeolian sedimentation<br>Cratered terrain<br>Chaotic terrain | UNCLASSIFIED-UNLIMITED |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price* |
|---|---|---|---|
| UNCLASSIFIED | UNCLASSIFIED | 24 | $3.00 |

*For sale by the National Technical Information Service, Springfield, Virginia 22151

# SEDIMENTARY FEATURES ON THE SURFACE OF MARS AS SEEN FROM MARINER 6 AND 7 PHOTOGRAPHS

by

Ronald L. Parsley

The primary scope of this report is to comment on martian surface features which are sedimentary in origin or are related to the probable sedimentary regime. Other geomorphic features and processes such as the origin of craters have been discussed by others and do not fall into the scope of this report. Nevertheless a number of features related to craters are germane to our discussion of sedimentary features and will be discussed below.

With the scale derived from the near encounter, B-Camera pictures from Mariner 6 and 7, it is evident that our knowledge of major geomorphic features and the forces acting upon them is still rudimentary. From what we do see on the martian surface, it appears that it is neither closely similar to the lunar surface nor to that of the earth, although some interesting close analogues exist in the latter case (Lowman, 1971).

This work was undertaken following certain assumptions: 1) Water plays or has played little or no role in the transportation of sediments. 2) Sufficient winds are generated in the martian atmosphere (Sagan et al., 1971) to transport fine sedimentary material. 3) Most transportation of material on the martian surface has been by aeolian processes.

The general terminology for terrains on Mars described by Leighton et al. (1969) is used herein; however, in some frames intermediate conditions can be recognized.

## MARTIAN AEOLIAN SEDIMENTS—GENERAL STATEMENT

On Mars, as on the earth, the greatest accumulation of sediments is in topographically depressed areas, e.g., in rills (which frequently appear to be

grabens), in "local" protected areas as on the bottoms of craters, or in large basins such as Hellas. Directly related to this is the fact that much of the topographically higher areas (usually cratered terrains) appear to be relatively clean without thick sedimentary coverings. This is demonstrated in the sequence of frames 6N9 to 6N25, which shows an area between the martian equator and 20° south latitude and contains much cratered terrain. In this sequence the walls of extensively eroded craters are sharply defined, and features such as rim faults and slumps are still clearly visible. This strongly argues for an active transporting agent, viz. martian winds, which are removing mechanically weathered sedimentary material (probably in the form of dust-sized particles) off the highlands into basins or into protected areas (floors of craters, rills, valley-like depressions, etc.). These upland cratered areas must therefore be the principal source areas since it is illogical to assume that sedimentary basins and grabens self-generate their contained sediments.

Albedo differences on some parts of Mars have been observed to change. Some short period albedo changes may be due to dust storms; however, it is probable that most albedo changes are due to other surface conditions. Most of these light-dark areas, especially the latter, are somewhat independent of topography and altitude. It is possible that the breakdown of rocks on the martian surface results from the disarticulation and mechanical reduction of mafic and leucocratic minerals to dust-sized particles. (The mechanism of weathering is enigmatic. The role played by hydration, particle bombardment, and mechanical-thermal disarticulation of grains is still in the conjectural stage.) The surface material may be very fine grained to begin with (especially if the martian surface went through a heating and rapid cooling phase), and disarticulated grains could be immediately transportable. Martian winds may segregate the finer portions of this weathered material and in some areas leave aeolian lag deposits of mafic materials which generally have higher specific gravities. In these areas it is likely that mafic materials are also being actively transported, but the net transport

favors the lighter minerals. Boundaries of the lag deposits may change with the winds, either by advancing or retreating fronts of heavier minerals or by settling of lighter grains in lag deposit areas at the cessation of an aeolian storm. Surface winds probably can effect such albedo changes without the presence of long-standing clouds or other phenomena observable on the Mariner 6 and 7 frames. Conditions that affect the movement of mafic minerals in the thin martian atmosphere may be akin to low-level movement of material, as seen in the African ergs.

The relatively gentle slopes on Mars would explain some of the independence of terrain relationships so far as dark areas on the highlands are concerned. Cutts et al. (1971) have pointed out, however, that topography does in some instances affect albedo differences; their suggestion that it is affected by aeolian transportation is in total agreement with this study. In craters, basins, and rills, fine grained, high albedo sediments would probably mask the darker coarser sediments.

Woronow and King (1972) point out that one cratered area with low albedo is more cratered than adjacent high albedo areas. They argue that this low albedo area may be younger. It is also possible that part of the albedo difference may be due to darker material remaining in a more cratered area due to reduced fetch of martian winds. This upland area in and around Meridiani Sinus is probably a source area for fine grained material blowing out of it.

This explanation for the changes in albedo between light and dark areas relies on only two assumptions: 1) that the surface of Mars is being degraded (which is observable), and 2) martian winds blow with steady velocities over sufficient distances to segregate the light and heavy fractions of weathered rocks (segregation being due to mineralic and/or size differences alone). In the latter case, this is somewhat verifiable by the filling of rills, craters, and basins by the higher albedo, finer grained fraction. If the total fraction of the weathered surface were evenly transported, it seems likely that basin and other fillings should have approximately the same albedo as in many of the upland areas. The fact that this is not so argues for differentiation or an unexplained type of segregation of rock types on the martian surface.

This is not in total agreement with the findings of Pollack and Sagan (1969), who argue for a monomineralic surface (goethite) with albedo differences being a function of grain size only. Particles in high albedo areas have an "average particle radius of 25$\mu$," while the mean particles in low albedo areas range from 100$\mu$ to 200$\mu$. Their findings, if true, would indicate size segregation, probably by aeolian action as suggested by Woronow and King (1972), and indicate that if these low albedo areas are not younger, they are certainly at least active source areas.

## CRATERED TERRAINS

A great deal has been written about cratered terrains, especially in respect to their origin and sequence of events in which the two included types of craters were formed. The first and oldest type are large and flat-floored; many of these are highly eroded. These craters probably were produced by impacts in the planet's primordial surface. Numerous smaller, rounded bowl-shaped craters are younger than the previous type as indicated by their presence on the rims and crater bottoms of the flat-bottomed type. In a number of cases, the second type of crater is seen modifying older round-bottomed craters. There does not seem to be any modifying of bowl-shaped craters by larger flat-bottomed ones; thus the sequence of events is assured.

The length of time taken for the flat-bottomed craters to be produced is not known; however, when we look at their state of degradation, considerable variation is observed. While most of these craters show erosion, some seem to show much more. This would seem to argue for 1) a considerable period of time in their formation, 2) variable composition of the crust (hence variable resistance to weathering), 3) local variations in structural fabric which would facilitate weathering, e.g., small criss-cross networks of faults, 4) the possibility of persistent local weather conditions which would increase the rate of weathering, and 5) other forces and/or combinations of the above. It is interesting to note that there is no evidence in Mariner 6 and 7 photographs of flat-bottomed craters developed in sediments.

Perhaps this argues for a shorter period in the formation of these craters. At least some bowl-shaped craters can be shown to have impacted in sediments and argue for a longer and perhaps continuous (albeit on some sort of decreasing scale) post flat-bottomed crater history. This will be discussed below.

Flat-floored craters seem to have the following observable history (excluding those which have an apparent volcanic stage by flooding of the bottoms by flows): 1) formation by infall of flux on the planet's surface, and 2) modification of the craters (some of which are essentially coeval with formation) by rim faults, slumping infalls of other material, large-scale faulting (producing faceted craters which reflect a large-scale fabric on the planet's surface), and infilling by aeolian sediments. Infilling of sediments in some cases can produce "bajadas" (as seen in the crater in the southwest corner of frame 6N17). The sources of these sediments must be twofold, from the eroding rims and from sources away from the rims. When the rims are high and fresh, they form a natural wind barrier. Then, as erosion of the rims increases, the winds deposit a higher percentage of non-rim originated material. As the crater rims erode, they form progressively less of a barrier until they reach a point where winds can blow sediment into and out of them. In situations where the rims are reduced to little more than an arcuate series of monadnocks, transport out of the crater may match and probably exceed transport into the crater, i.e., by removal of accumulated unconsolidated sediments.

In frame 6N22 (fig. 9), the large, greatly eroded crater warrants our attention. Broad shallow canyons are visible inside the crater. Small impact craters in this crater are either developed in intercanyon areas (in sedimentary rocks?) or on the crater floor where active erosion or sedimentation is taking place. In some situations "lumpy" fall-back can be observed on the bottoms of craters, exhumed from the primary state (see lower center of frame 6N16, fig. 5). Further study of intensity of winds, grain size, etc.—probably after a manned expedition—will be able to quantify this observation. Most flat-bottomed craters with raised

rims are assumed to have an infilling of sediment to explain their smooth nature except in some cases where lava flows have, along with sediments, helped form flat floors.

In comparison, bowl-shaped craters generally show either the typical impact crater morphology of smooth, concave rounded bottoms or have a central peak similar to numerous lunar impact craters. In the former case the bottoms are usually smooth with fall-back debris (and small central peaks) being covered by fine grained sediments, e.g., frame 7N6 (fig. 10). In the martian highlands few, if any, of the smaller bowl-shaped craters are eroded to the point where their rims are denuded or the fall-back ejecta has been exposed (assuming that the ejecta is coarse enough to be detected on the photos).

Martian craters, even seemingly very fresh craters, do not manifest the ray ejecta patterns that are so common on the moon. Fresh bowl-shaped craters, however, sometimes do have hummocky ejecta patterns. Similar patterns are seen in some explosion craters and impact craters such as the Barringer Crater in Arizona. Hummocky ejecta is clearly visible in frame 6N20 (fig. 8). It is likely that such features are not uncommon on Mars but are now erased by aeolian processes. The hummocky ejecta in frame 6N20 is associated with fresh, sharp craters with little visible erosion. Eroded craters such as in frame 7N6 (fig. 10) show very low and denuded ejecta mounds. This perhaps bespeaks not of variation in surface composition, flux velocity, etc., but of efficiency of surface aeolian processes. Even if welded by heat upon impact, ejecta, being highly fractured, would be considerably less resistant to erosion than crustal rock. Hummocky ejecta may have been a more common phenomenon than is observed on the martian surface but is ephemeral relative to the length of time to erode the crater rim.

## CHAOTIC AND ASSOCIATED TERRAIN

Chaotic terrain and features such as long sinuous rills are developed in the Aurorae Sinus region. This area seems to be topographically depressed (Collins,

1971) below the general level of the upland cratered terrain. As various authors have pointed out, chaotic terrain does not seem to have analogues (at least easily identifiable ones) on the earth or moon. In the often cited photo 6N14 (fig. 4), the prominent depression bears at least superficial resemblance to "badlands" topography in arid regions of earth. Perhaps what we are seeing here is "rejuvenescence," caused not by uplift, but by removal of material by aeolian action along jumbled parallel fault zones. Parallel faults enhanced by downdrop (grabens), slump, and probably aeolian removal (downslope winds) of material are clearly visible.

Badlands topography on earth typically develops in fine-grained, poorly consolidated horizontal sediments. Much of the Aurorae Sinus area could be a sedimentary basin and the broad "gulleys" as in frame 6N14 (fig. 4), or long sinuous rills or grabens as in frames 6N5 (fig. 1) and 6N7 (fig. 2), may be developed in sediments. Because these features are also closely fault-controlled, the depressed Aurorae Sinus area may be caused by deflation of a less resistant crustal material made susceptible by closely spaced faulting. Whatever the subsurface material is, this area is susceptible to weathering and transport as evidenced by the sharply reduced number of craters adjacent to chaotic and "rill terrains."

The parallel rill patterns on frame 6N7 (fig. 2) show that they are fault-controlled and that there is headward erosion or valley widening along parallel fault swarms or along graben walls. In both frames 6N5 (fig. 1) and 6N7 (fig. 2), one of the long rill valleys seen on each is sinuously offset. The direction of the offset seems to parallel some of the planetary grid system faults (Binder and McCarthy, Jr., 1972). The broader eroded portions of the rills are considerably higher in albedo and probably contain trapped sediments.

## CRATERED-TO-FEATURELESS TERRAIN TRANSITIONAL AREA

Photos 7N25 (fig. 11), 7N26 (fig. 12), and 7N27 (fig. 13) are some of the most important of the Mariner 6 and 7 series. These photographs record the

transition from the cratered highlands into the nearly featureless sedimentary basin of Hellas. This transitional area is characterized by Basin and Range type faulting (Lowman, 1971), trending in a north-south to slightly northwest direction. Most of the ridges dip toward the basin or are manifested as stair-stepped normal faults. Frequently the fault scarps are truncated or modified by craters, which generally postdate them. It is evident, however, that post-cratering activity has occurred along some of the faults as evidenced by faceting of some crater walls. Close inspection shows that a number of these fault blocks are strongly "muted" by sedimentation, e.g., frame 7N26 (fig. 12); in some instances where the tops of the ridges are occupied by craters, these also are muted. The clean crisp appearance of the adjacent cratered highlands clearly indicates that in the transition area the ridges and craters (all muted) are major sediment traps.

In frame 7N27 (fig. 13), at least five craters adjacent to the basin of Hellas have breached rims on the adbasin side. To some degree this effect may be localized muting of features by down-slope winds (Sagan, 1970), but some of this is probably due to marginal normal faulting and part of the Basin and Range faulting regime adjacent to Hellas. (In the situation seen along the eastern margin of frame 6N8 (fig. 3) between an upland and basin area, the faulting is not in upthrown blocks or stair-stepped; rather it appears to be vertical tensional release swarms of parallel fractures which are modified by slump and aeolian action to produce chaotic terrain.)

## FEATURELESS TERRAIN

Upon close inspection it is evident that featureless terrain is anything but featureless. Craters, albeit highly muted ones, are visible in the western part of Hellas (frame 7N27, fig. 13). To the east (frame 7N29, fig. 14) the data are rather poor because of "noisy" photos, but some circular features, assumed to be craters, are visible.

Hellas is assumed, due to its lower and smoother topographic relationship to the cratered highlands (as evidenced by radar profiles, etc.), to be a large

sedimentary basin. The lack of larger muted craters suggests that the sediments must be at least several kilometers deep, i.e., deep enough to bury craters that formed on the bottom of the basin during the early history of the planet. It is possible that in the center of the basin more than 10 km of sediments are present.

Some poorly defined circular patterns in the Hellas basin suggest impact into soft unconsolidated sediment. Subsequent aeolian action reduces such craters and their ejecta to near the general level of the basin. The fact that such features can be seen indicates that flux into the surface has continued over a long period of time. As pointed out by Sharp et al. (1971), the circular basin of Hellas is very old and probably has been collecting sediments over much of the planet's history. The smooth surface is also indicative of variable winds; at least in the available photos, dune features do not seem to be present in Hellas.

ACKNOWLEDGMENTS

This study was supported by NASA Grant No. NGR 19-002-032. Steven Dwornik, John Allingham and Elliot Morris of NASA have lent valuable assistance.

Miss Amanda Hunt, Tulane University, printed the photographs from NASA negatives and reviewed the manuscript.

## REFERENCES


Binder, A. B.; and McCarthy, A. B., Jr.: Mars: The Lineament Systems. Science, vol. 176, no. 4032, 1972, pp. 279-281.

Collins, S. A.: The Mariner 6 and 7 Pictures of Mars. NASA SP-263, 1971, pp. 1-159.

Cutts, J. A., et al.: The Surface of Mars, 3: Light and Dark Markings. J. Geophys. Res., vol. 76, no. 2, 1971, pp. 343-356.

Leighton, R. B., et al.: Mariner 6 and 7 Television Pictures: Preliminary Analysis. Science, vol. 166, 1969, pp. 49-67.

Lowman, P.D., Jr.: Terrestrial and Lunar Analogues of Martian Topography. X-644-71-360, Goddard Space Flight Center, 1971, pp. 1-45, figs. 1-30.

Murray, B.C.: The Surface of Mars, 1. Cratered Terrains. J. Geophys. Res., vol. 76, no. 2, 1971, pp. 313-330.

Pollack, J.D.; and Sagan, C.: An Analysis of Martian Photometry and Polarimetry. Space Sci. Rev., vol. 9, 1969, pp. 243-299.

Sagan, C., et al.: Observational Consequences of Martian Wind Regimes. Cornell Univ. Center for Radiophysics and Space Research CRSR-440, 1971, pp. 1-48, figs. 1-14.

Sharp, R. P.: The Surface of Mars, 2: Uncratered Terrains. J. Geophys. Res., vol. 76, no. 2, 1971, pp. 331-342.

Woronow, A.; and King, E.A.: Size Frequency Distribution of Martian Craters and Relative Age of Light and Dark Terrains. Science, vol. 175, 1972, pp. 755-757.

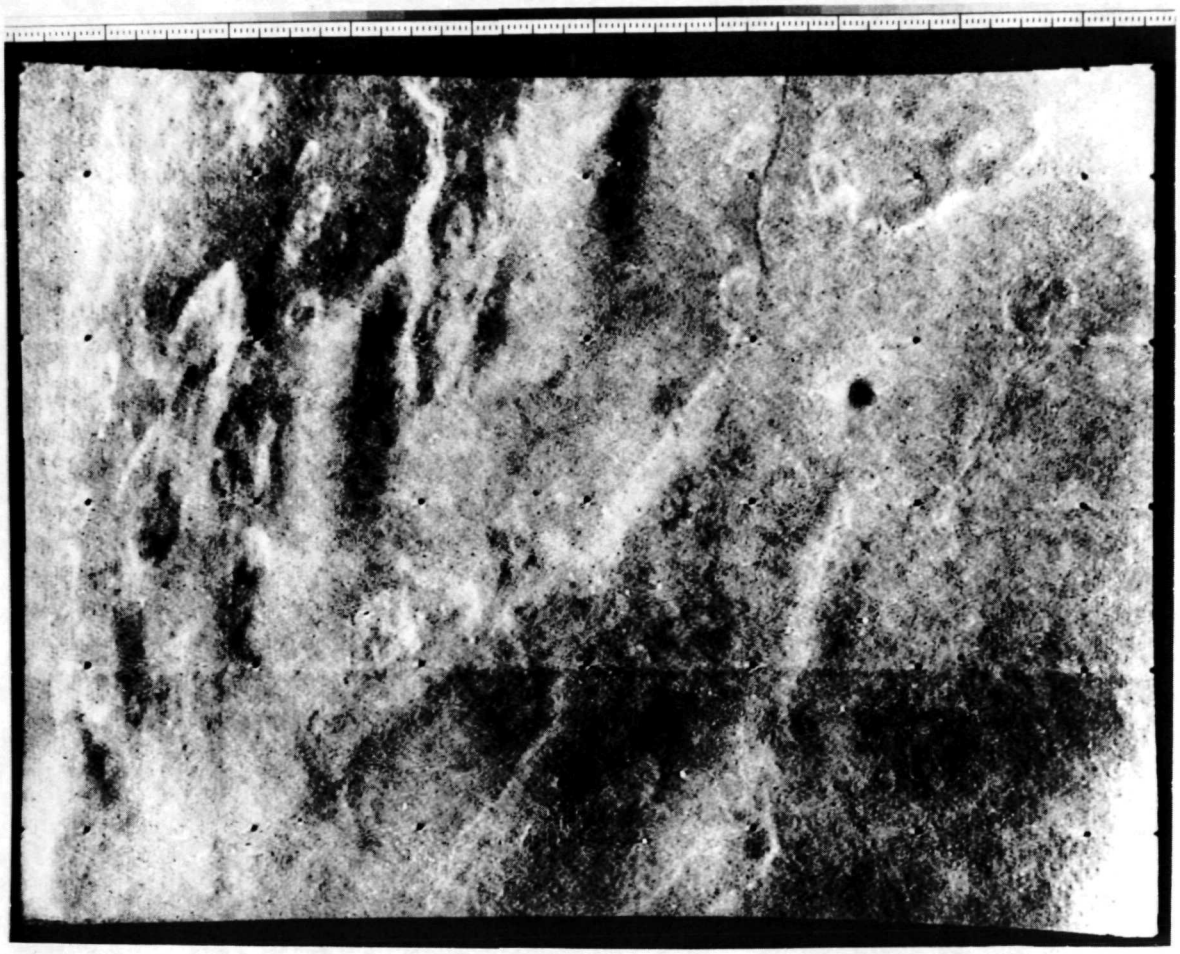

Figure 1.—Mariner Frame 6N5, A Camera, approximate area 2277 X 1125 km. The northeast trending high albedo bands appear to be sediment-filled grabens. The graben on the eastern side of the photo is sigmoidal and is probably due to down-drop along two intersecting fault systems.

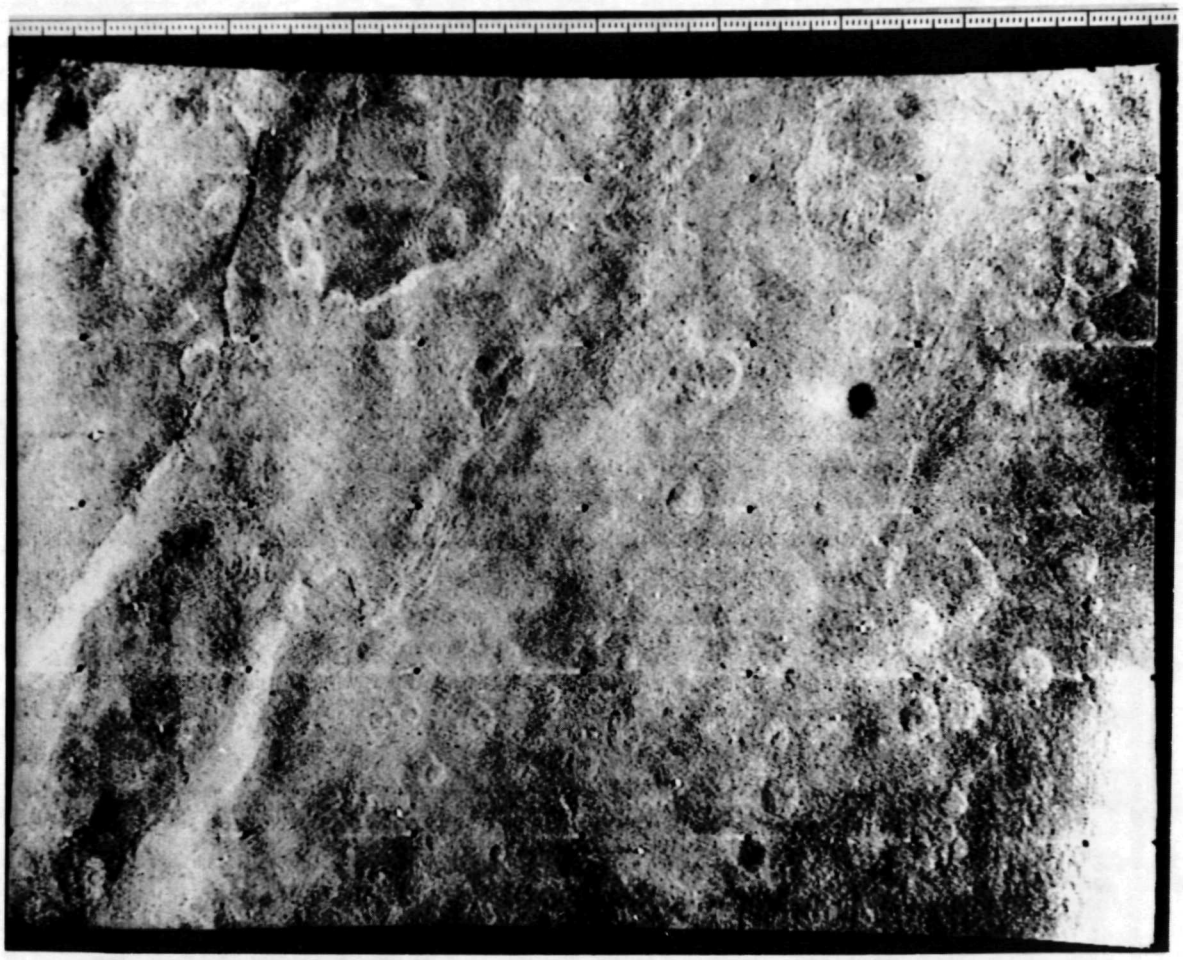

Figure 2.—Mariner Frame 6N7, A Camera, approximate area 141 X 993 km. In the western half of the frame, two grabens (rills) are well developed and contain in their broader portions high albedo sediments. The western rill appears to widen, but actually maintains essentially the same width throughout its length. The southern part appears wider, probably due to sediments stacking up against the topographically higher darker area. The eastern graben system is more or less parallel to the western but is developed in its northern part (above the sigmoidal offset of the system) more as a set of fault ridges. The offset is probably due to intersection of two fault systems. The southern part of the system is broad and appears to have high albedo sediments covering the eastern slopes of the depression.

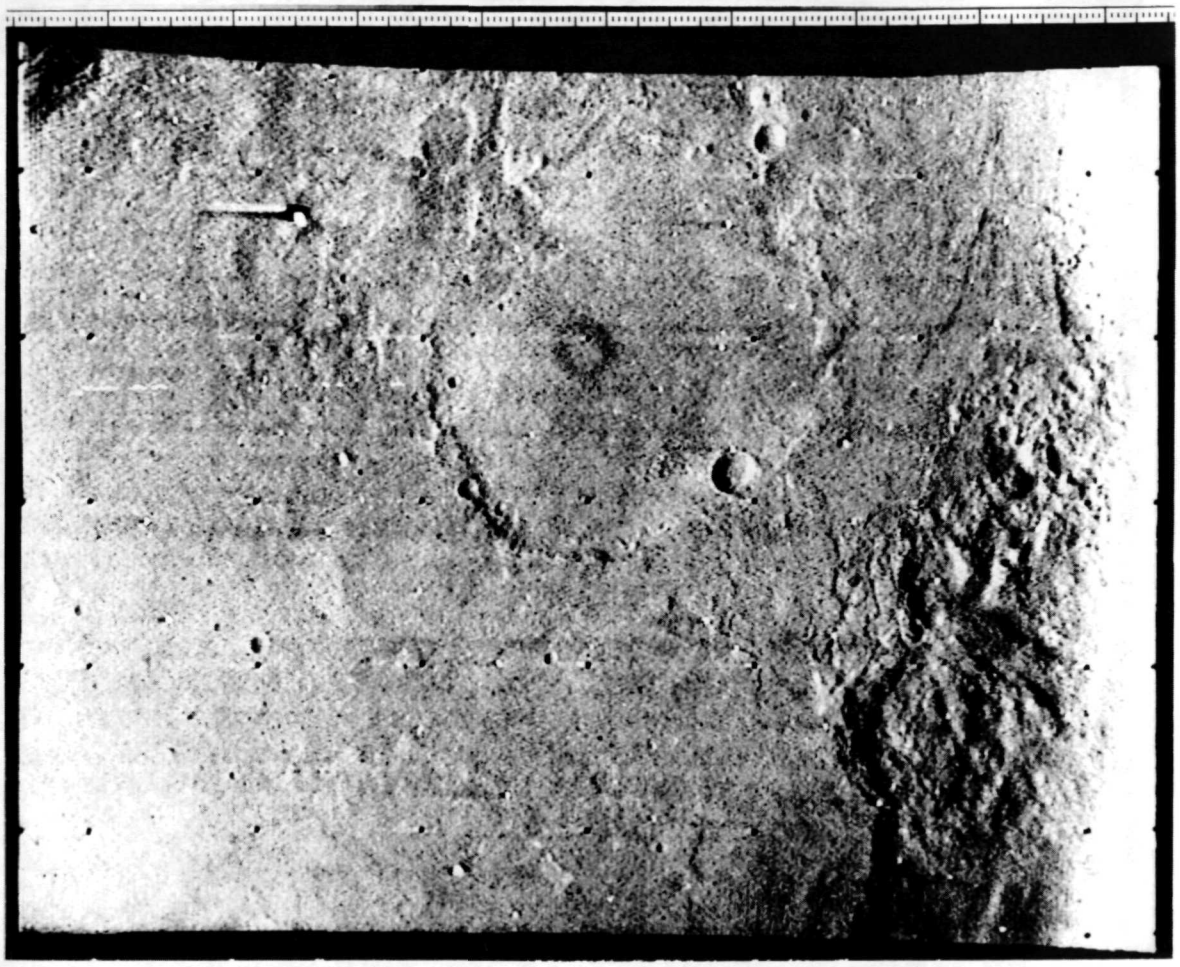

Figure 3.—Mariner Frame 6N8, B Camera, approximate area 126 X 97 km. Note the chaotic terrain caused by slumping and probable aeolian action along a parallel fault system.

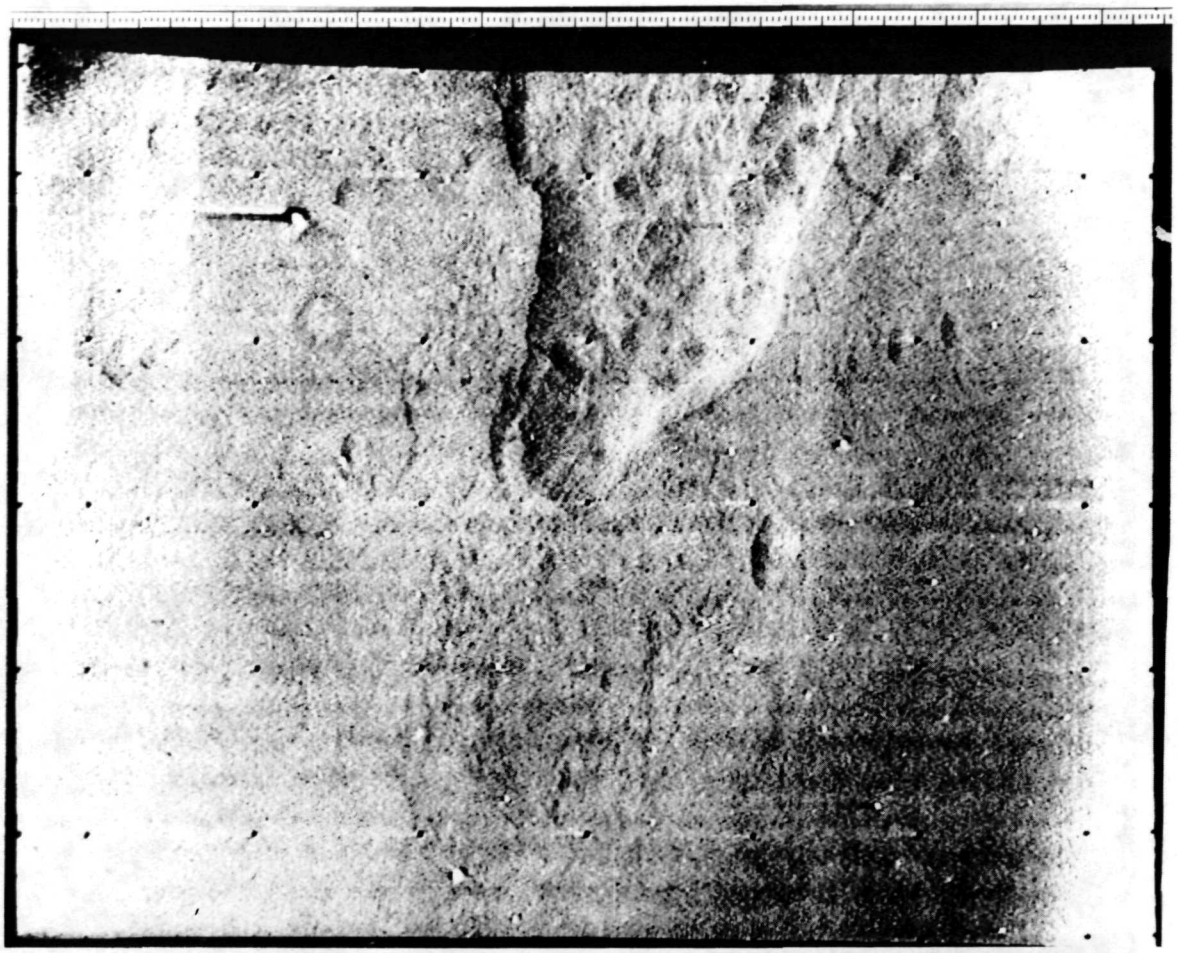

Figure 4.—Mariner Frame 6N14, B Camera, approximate area 237 X 99 km. The broad depression in this frame is believed to be primarily fault-controlled. Note what appears to be a fault swarm extending away from the head wall of the depression. Grabens parallel to this feature on this frame and on frame 6N15 lend support to the theory that this is a highly faulted area. The depression itself is probably due to removal of fractured and weakened material by winds. Headward growth and widening is facilitated by slumping. If this hypothesis is true, then chaotic terrain, as seen on the bottom of the depression, may generally prove to be wind-sculptured, faulted terrain.

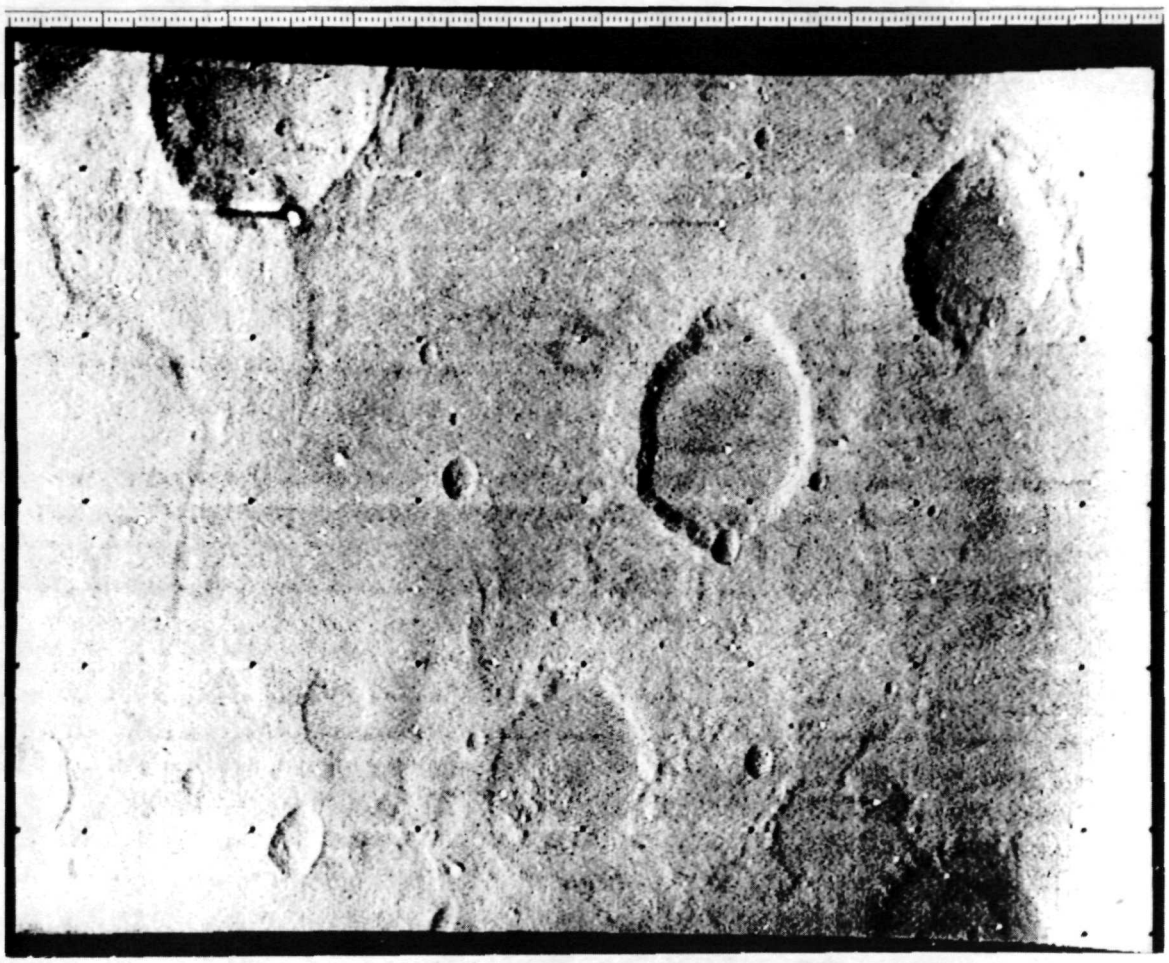

Figure 5.—Mariner Frame 6N16, B Camera, approximate area 134 X 83 km. Note the eroded crater with sufficient crater-fill sediment removed to reveal what appears to be impact fall-back. The sinuous rill on the western edge of the frame is probably a graben that is partly filled with sediment. The straight sides of the faceted crater near the center of the frame are essentially parallel to the trend of the rill, suggesting that the shapes of craters can be controlled by the regional structural fabric.

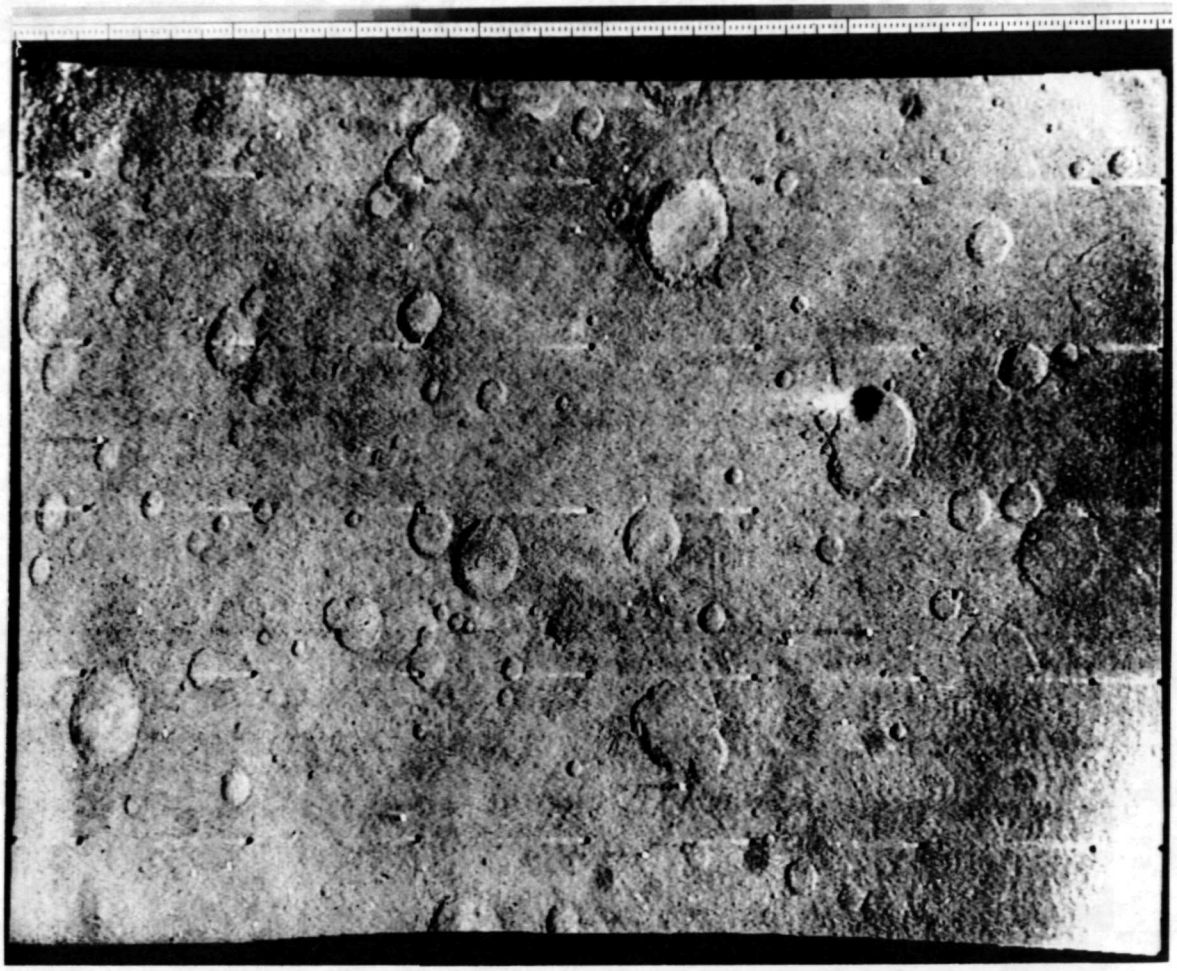

Figure 6.—Mariner Frame 6N17, A Camera, approximate area 1240 X 760 km. Cratered area with numerous flat-bottomed craters in various states of erosion. The large crater in the southwest corner of the frame, despite the high sun angle, appears to be well filled with sediment. Adjacent craters are also filled with higher albedo sediments, as are most flat-bottomed crater floors. Craters with more eroded rims seem to have thicker sediment fillings as evidenced by smoother floors and "bajadas" adjacent to the rims.

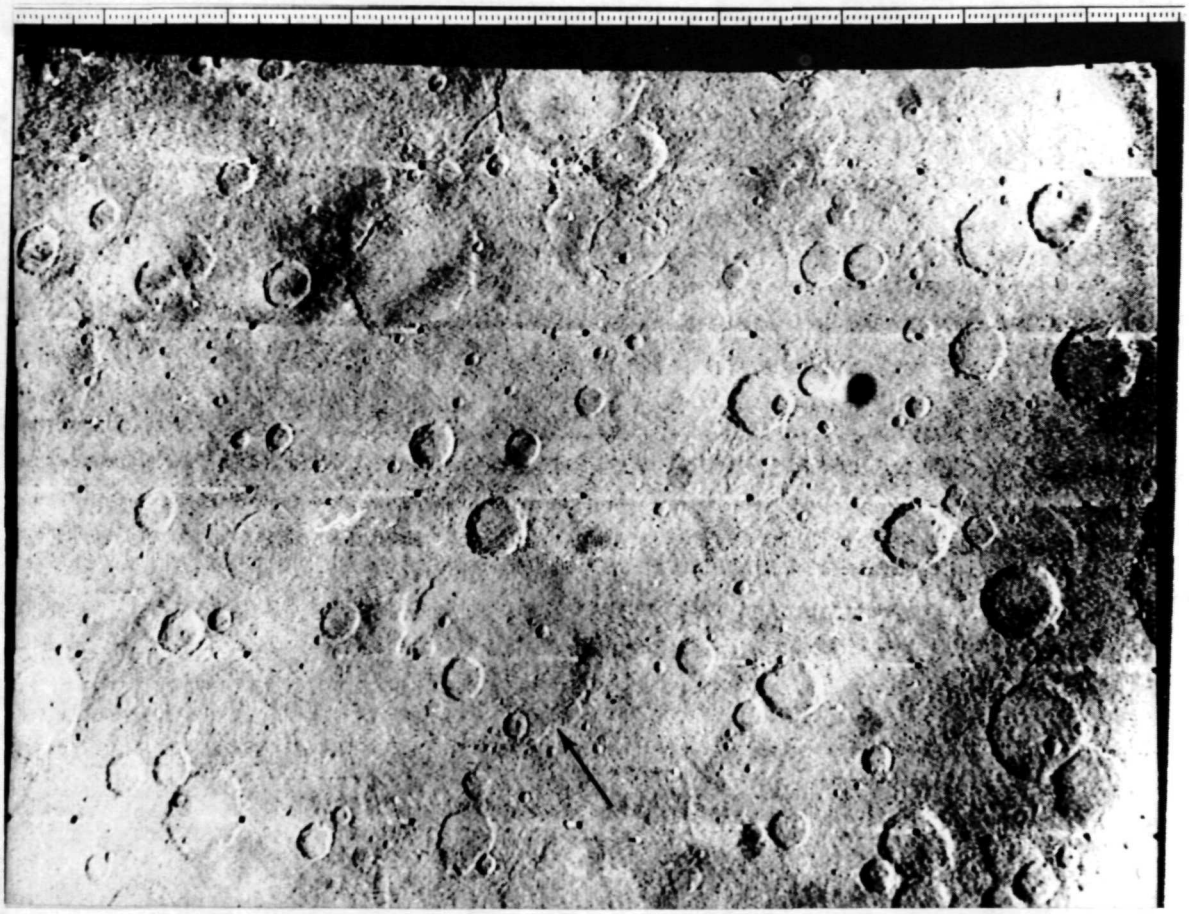

Figure 7.—Mariner Frame 6N19, A Camera, approximate area 1000 X 722 km. Arrow points to an outstanding example of a highly eroded crater. Note the fresh bowl-shaped craters, some with central peaks in them, and a smaller flat-bottomed crater within the greatly eroded rim. The sediment cover within the rim is probably thinner than in nearby craters where the craters serve as traps. There is probably considerable transport out of the eroded crater.

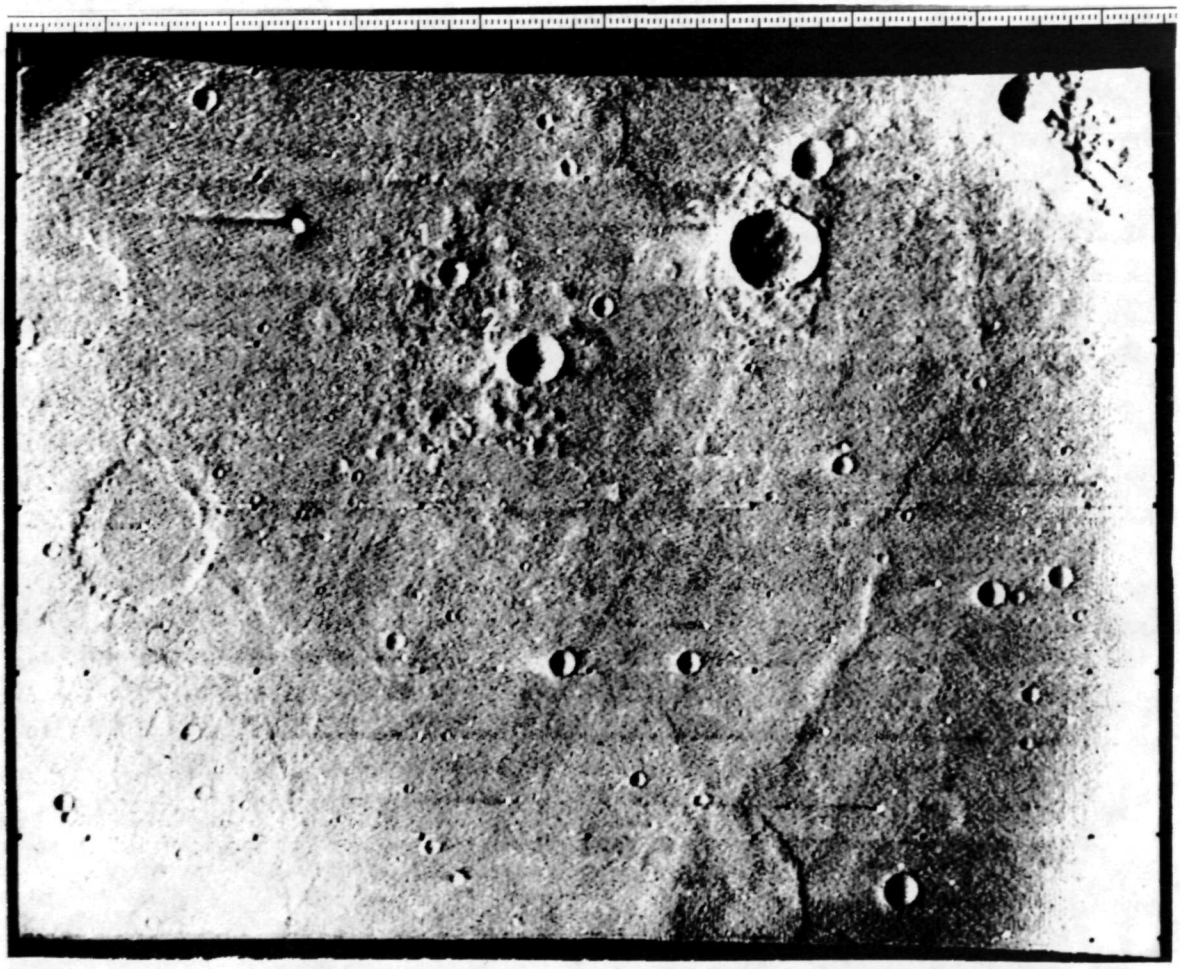

Figure 8.—Mariner Frame 6N20, B Camera, approximate area 89 X 73 km. At least three of the large fresh craters (nos. 1-3) show hummocky ejecta. Ejecta probably is ephemeral on Mars due to its erosion by winds. On the western edge of the photo is a double flat-bottomed crater; possibly the central portion is a rebound feature as seen on terrestrial cryptovolcanic or astrobleme structures.

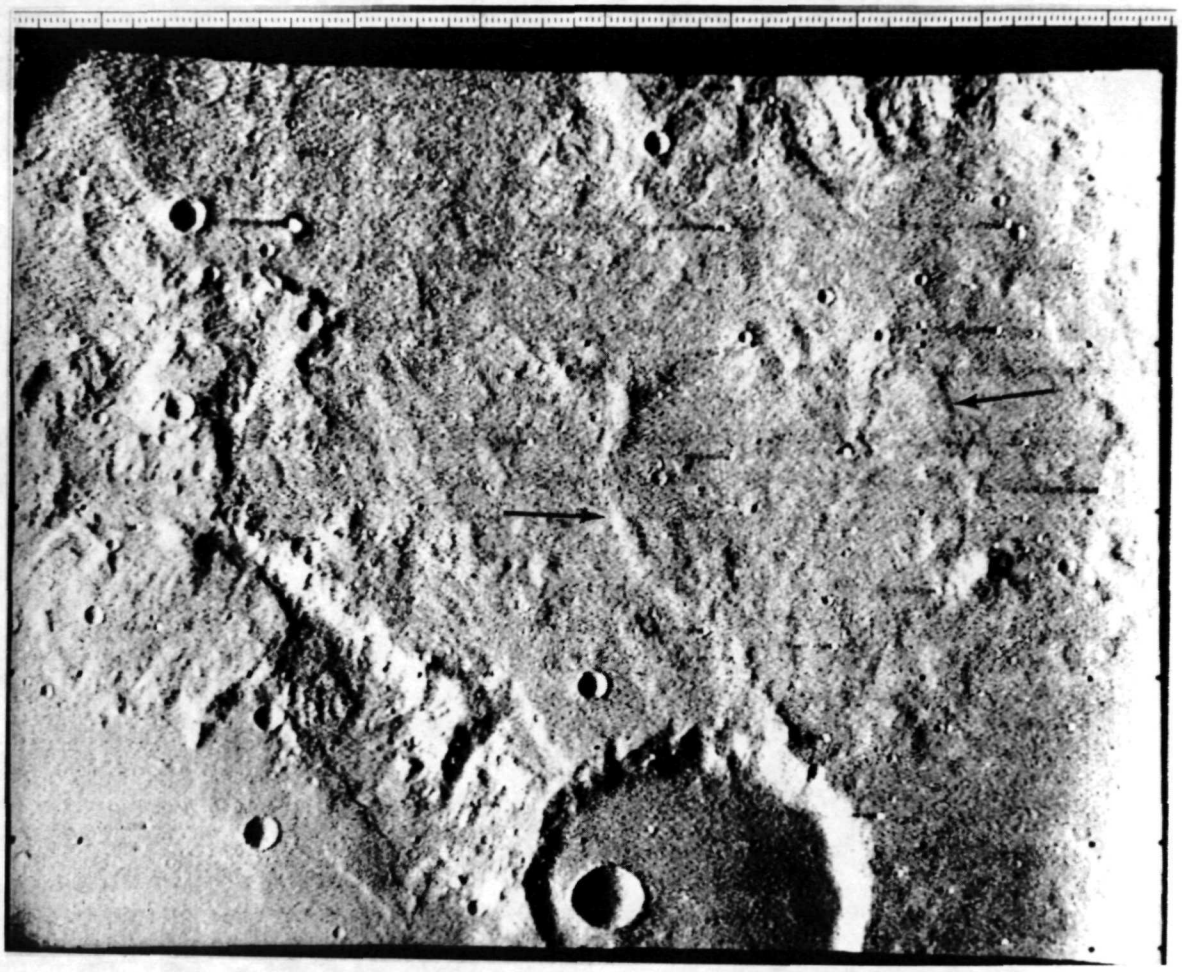

Figure 9.—Mariner Frame 6N22, B Camera, approximate area 84 X 73 km. In the greatly eroded and filled crater (arrow), there appears to be erosion taking place manifested by shallow rounded depressions. There is also a virtual lack of small craters in these areas suggesting active erosion. Small craters are present in what appear to be divides and higher non-dissected areas. Inside the crater there also seems to be a low crater density, perhaps indicating high erosive and/or sedimentary activity.

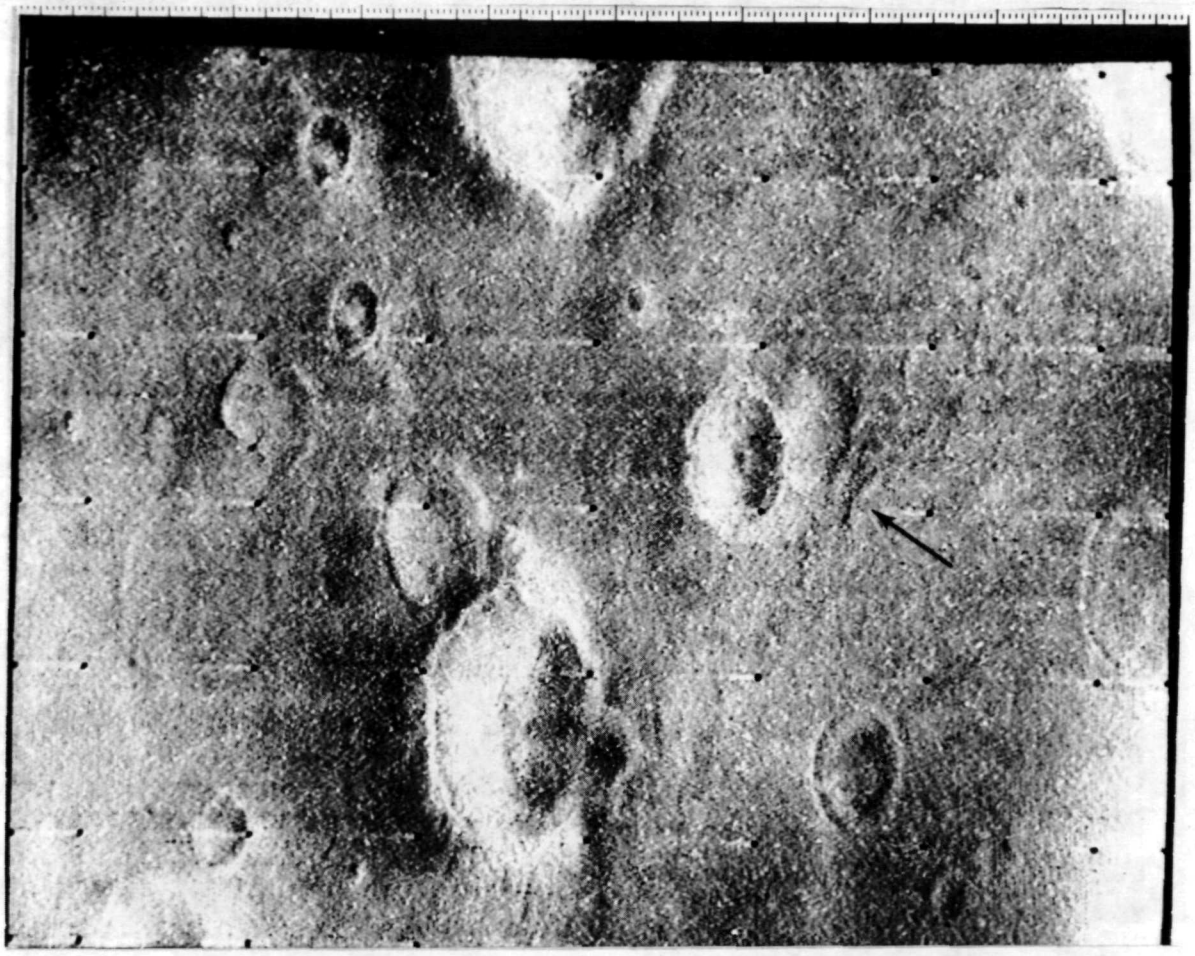

Figure 10.—Mariner Frame 7N6, B Camera, approximate area 268 X 152 km. With one exception the central peaks and fall-back debris are masked by higher albedo sediments in these moderately fresh craters. Note that what appear to be rim faults or slumps are sharply defined. Some ejecta mounds are present but appear to be greatly eroded (arrow).

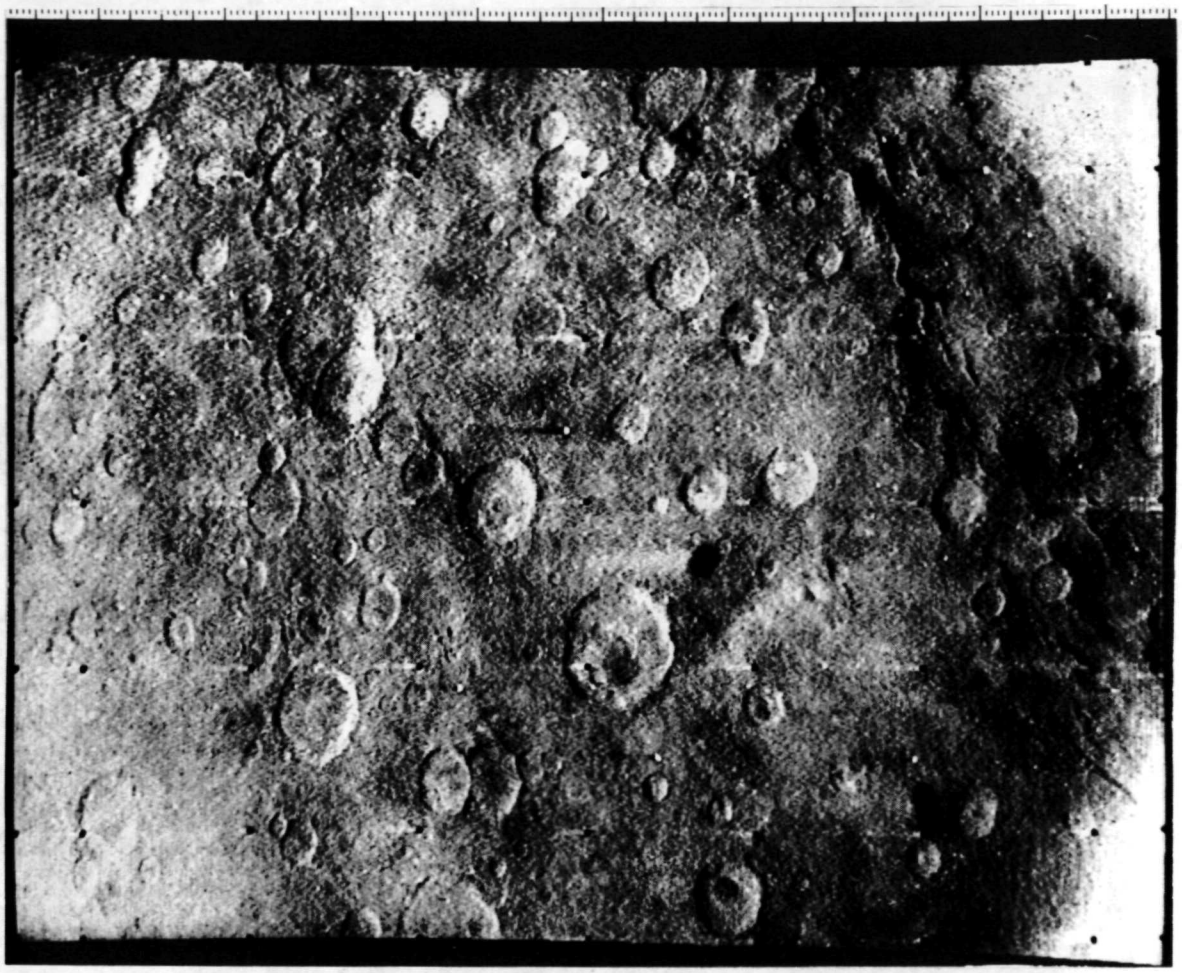

Figure 11.—Mariner Frame 7N25, A Camera, approximate area 1128 X 723 km. Martian cratered highlands which border the large basin of Hellas. Basin and range type block faults are prevalent in the transition area between the basin and the uplands.

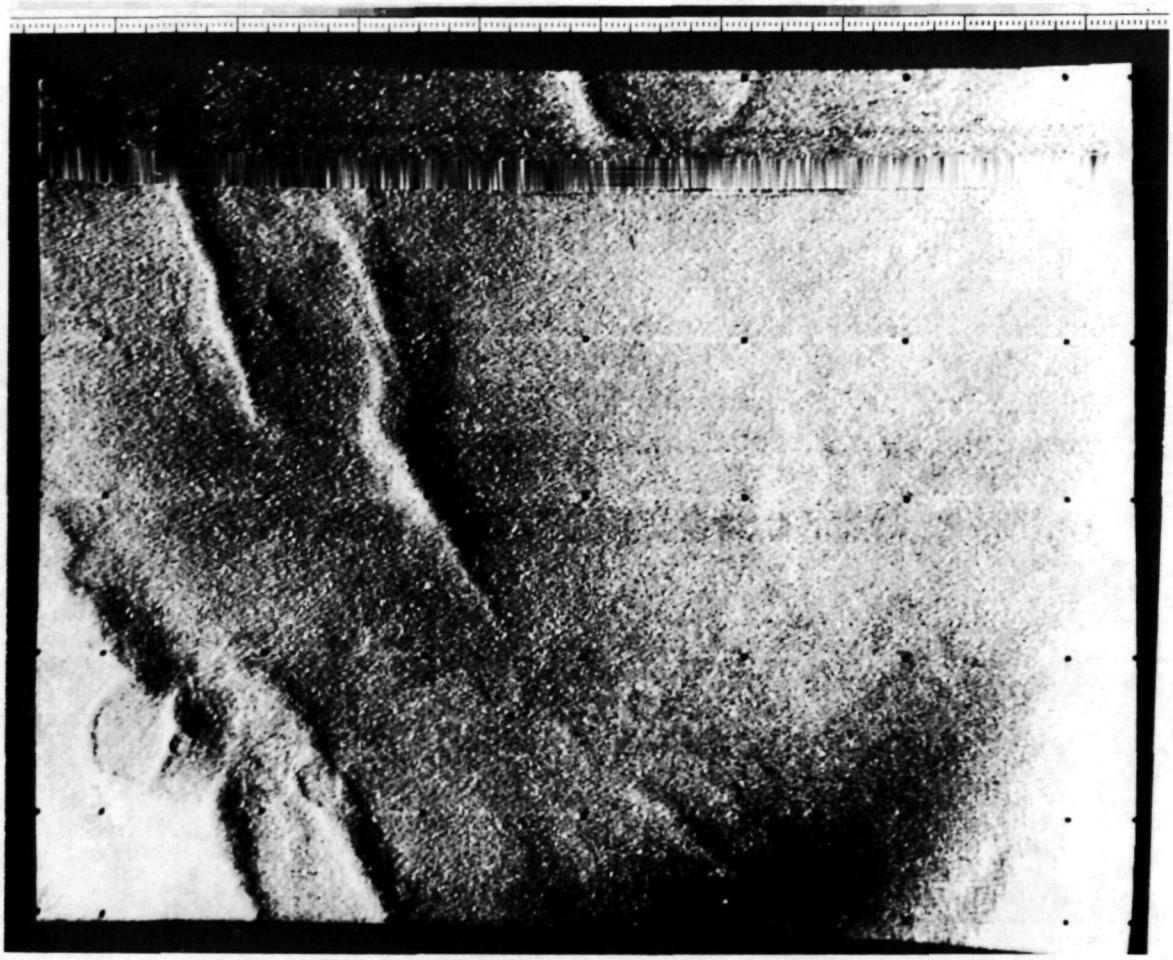

Figure 12.—Mariner Frame 7N26, B Camera, approximate area 101 X 77 km. This is part of the transitional area between the highlands and the basin of Hellas. (See 7N25 and 7N27.) The craters and fault ridges (cuestas), as well as the nearly featureless valleys, are "muted" by a heavy sedimentary cover. The uplifted crater in the western corner of the frame gives ample evidence of post-crater faulting.

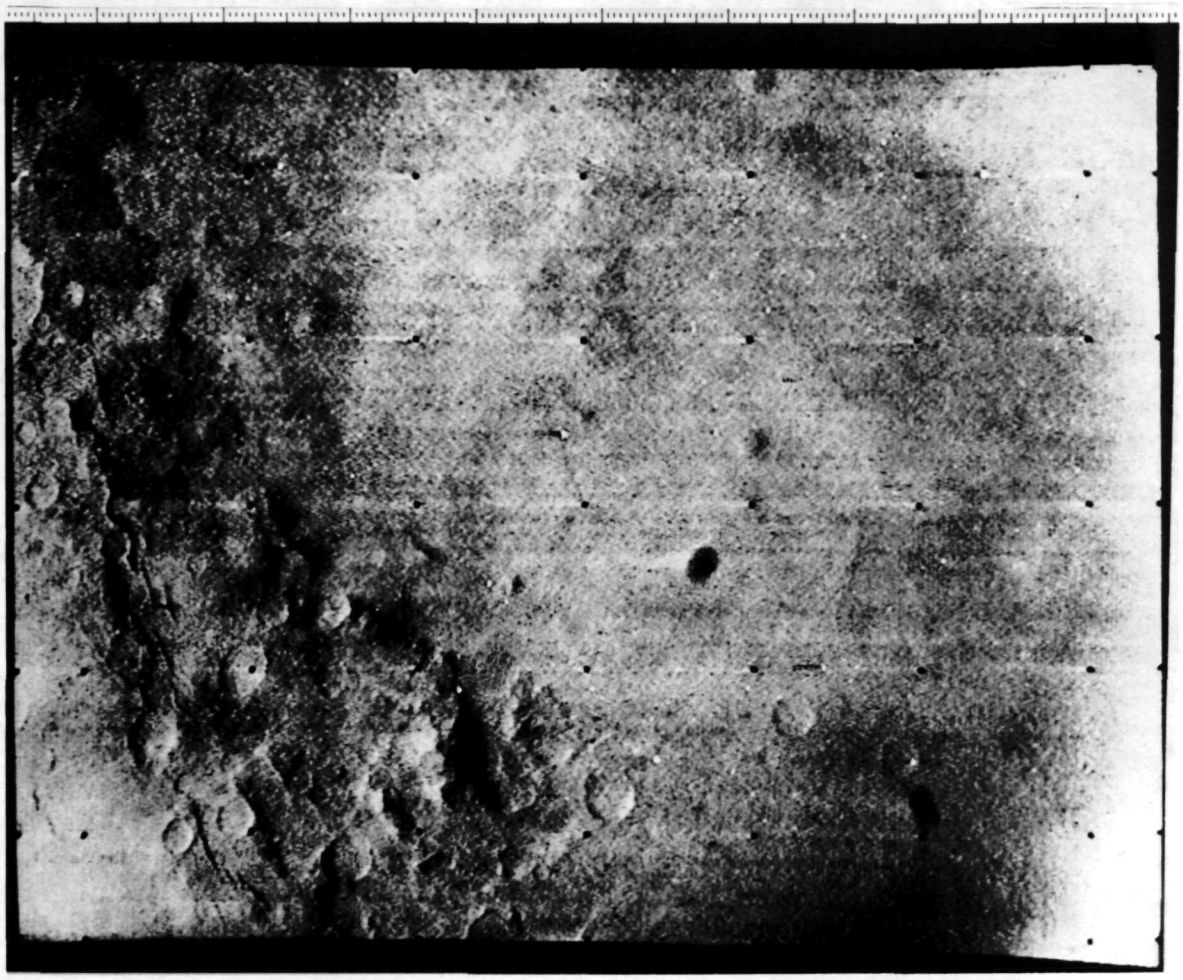

Figure 13.—Mariner Frame 7N27, A Camera, approximate area 998 X 723 km. The transitional area between Hellas and the uplands is well exposed. While the craters generally postdate the faulting, subsequent movement has increased fault relief. This is evidenced by faulting of some crater walls.

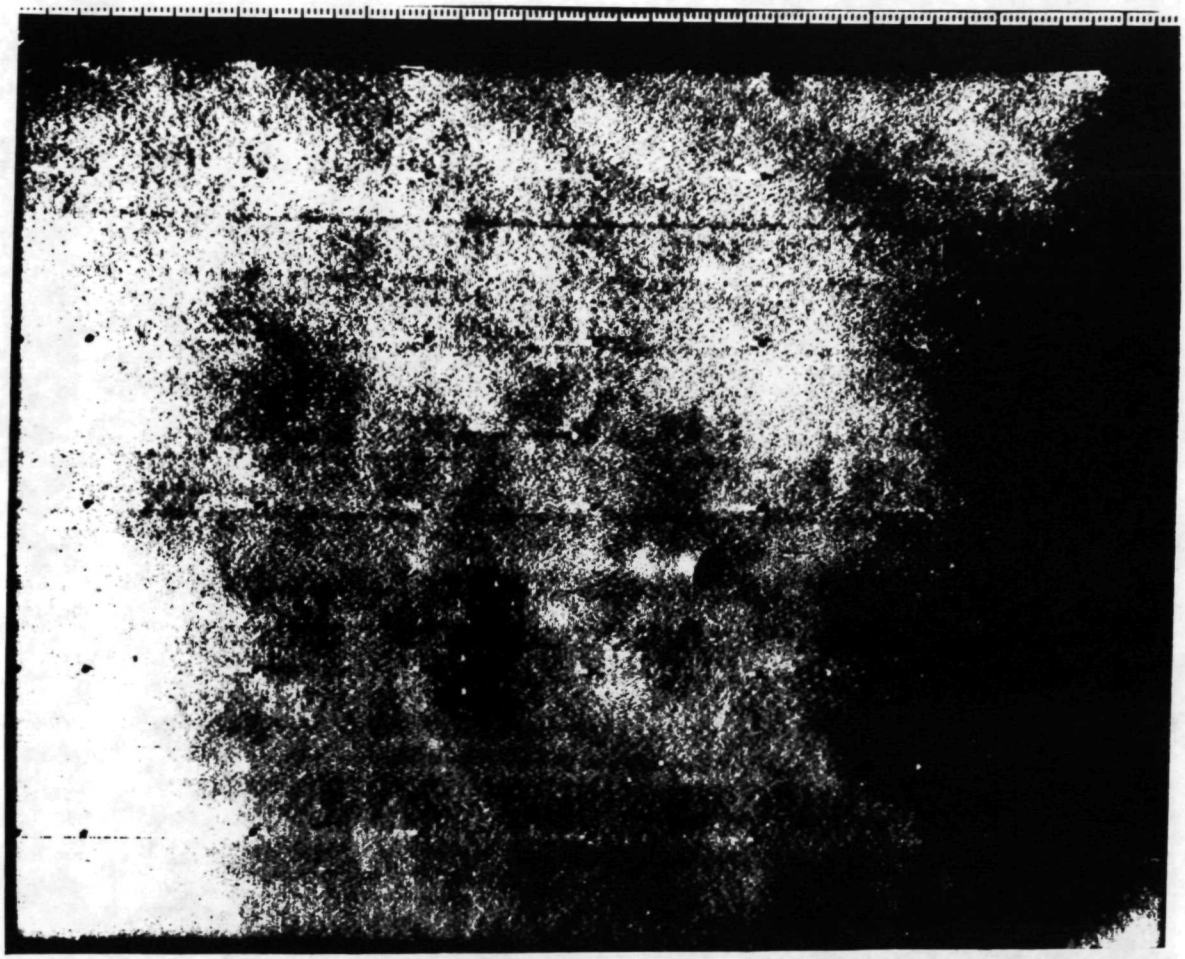

Figure 14.—Mariner Frame 7N29, A Camera, approximate area 937 X 780 km. The frame of the floor of Hellas is nearly featureless, probably due to drifting sediments. Close examination reveals several small "muted" craters, suggesting that impact features are ephemeral in this basin.



NASA-Langley, 1973 —— 30 CR-2194

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

SPECIAL FOURTH-CLASS RATE
BOOK

POSTAGE AND FEES PAID
NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION
451

U.S.MAIL

POSTMASTER: If Undeliverable (Section 158 Postal Manual) Do Not Return

*"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."*

—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

# NASA SCIENTIFIC AND TECHNICAL PUBLICATIONS

TECHNICAL REPORTS: Scientific and technical information considered important, complete, and a lasting contribution to existing knowledge.

TECHNICAL NOTES: Information less broad in scope but nevertheless of importance as a contribution to existing knowledge.

TECHNICAL MEMORANDUMS: Information receiving limited distribution because of preliminary data, security classification, or other reasons. Also includes conference proceedings with either limited or unlimited distribution.

CONTRACTOR REPORTS: Scientific and technical information generated under a NASA contract or grant and considered an important contribution to existing knowledge.

TECHNICAL TRANSLATIONS: Information published in a foreign language considered to merit NASA distribution in English.

SPECIAL PUBLICATIONS: Information derived from or of value to NASA activities. Publications include final reports of major projects, monographs, data compilations, handbooks, sourcebooks, and special bibliographies.

TECHNOLOGY UTILIZATION PUBLICATIONS: Information on technology used by NASA that may be of particular interest in commercial and other non-aerospace applications. Publications include Tech Briefs, Technology Utilization Reports and Technology Surveys.

***Details on the availability of these publications may be obtained from:***

**SCIENTIFIC AND TECHNICAL INFORMATION OFFICE**

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**Washington, D.C. 20546**