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The Mosaics of Mars

As Seen by the Viking Lander Cameras

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Preface

This publication describes the mosaics and derivative products produced from many individual high resolution images acquired by the Viking Lander Camera Systems. Ten mosaics were produced; a morning and afternoon mosaic for both cameras at the Lander I Chryse Planitia site, and a morning, noon, and afternoon camera pair at Utopia Planitia, the Lander II site.

The derived products include special geometric projections of the mosaic data sets, polar stereographic ("donut"), stereoscopic, and orthographic. Additionally, the mosaics were used to produce contour maps and vertical profiles of the topography. These map products were then overlaid on the mosaics from which they were derived. Sets of stereo pairs were extracted and enlarged from stereoscopic projections of the mosaics. A movie, "Mars in 3-D", was made from some of these same stereoscopic projections.

For all of these products, the method by which they were created is described. In addition, information is given concerning the final forms of the various products that are available and how they may be procured. It is believed that these mosaic products will serve much of the need for Viking Lander imaging data.

The products described in this publication are in a special products category of the Team Data Record (TDR) of the Lander Imaging Team. A few additional products, also in this category, but not derived from the mosaics, are described in an appendix.

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All figures have been placed in the back of this publication with a sufficient margin along the binding so that some can be conveniently cut out and removed to allow them to be used for stereo viewing. Alternatively, separate glossy prints can be ordered from the NSSDC. An NSSDC order form is included with the publication.

I. INTRODUCTION

Two Viking spacecraft, each consisting of an orbiter and lander, were launched from the Kennedy Space Center on August 20 and September 9, 1975. The Viking 1 spacecraft arrived at Mars on June 19, 1976, and was placed in a highly elliptical orbit around the planet with a periapsis altitude of nearly 1500 km. The orbiter cameras were used in conjunction with other methods to find a suitable landing site for the lander. After about 30 days in orbit, the lander was separated from the orbiter and on July 20, 1976, Viking Lander 1 touched down on the surface of Mars at lat 22.483° N.* and long 47.968° W. (Morris and Jones, 1980) on the west edge of a large basin called Chryse Planitia. It landed in a stable position with a 3° tilt downward in the direction 284.94° clockwise from north. The side of the lander on which the two cameras are mounted faces southeast. When the cameras are pointed in a direction normal to the front of the lander, the viewing direction is 141.63 +/-.79° clockwise from north along the horizon. The first picture from the surface of Mars was taken immediately after landing by camera 2, of the area in the vicinity of the lander's footpad 3. During the ensuing 43 days, the cameras responded to all commands and successfully carried out their assigned mission. On September 2, the activities of Lander 1 were reduced to accommodate the planned receipt of data from Viking Lander 2.

On September 3, 1976, Viking Lander 2 successfully landed on the Utopia Planitia of Mars (47.966° N., 225.736° W.), more than 6500 km northeast of Lander 1 (Mayo et al, 1977). Lander 2 faces approximately north and tilts 8.2° downward in the direction of 277.44° clockwise from north. The viewing direction of its cameras when pointed in a direction normal to the front of the lander is 29.08+/-.79° clockwise from north along the horizon. The cameras on Viking Lander 2 operated successfully for 61 days until the primary mission of both landers was completed on November 15, 1976, at solar conjunction.

During the primary mission, 454 pictures of the Martian surface were processed from Viking Lander 1 data and 582 pictures from Viking Lander 2 data. The extended mission of Viking began December 15, after solar conjunction, and ended in June 1978. During this period, an additional 1636 pictures were obtained from Lander 1 data and 1311 pictures from Lander 2 data. A description of the Viking primary mission and the results of eight scientific experiments on board the landers were published in the Journal of Geophysical Research, 1978, v. 82, no. 28; some papers are listed in Section V, References.

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* Latitudes are areographic. See de Vaucouleurs et al (1973). The lander locations are those given by Davies et al (1978). For a discussion of the lander orientation see section II.A.

II. THE MOSAICS

A. General Discussion

During the Viking Mission, the Lander Camera System acquired many high-resolution images of the scenes at Chryse Planitia and Utopia Planitia landing sites. Using individual camera events, which occurred on many days throughout the mission, computer mosaics have been created for both sites as viewed by each of the two cameras on the spacecraft.

For Lander 1, two sets of mosaics have been produced; one pair for camera 1 and 2 images acquired early in the morning (7:00-8:00), and one pair for images acquired in the mid-afternoon (14:00-15:30). For Lander 2, three sets of mosaics were compiled: in the morning (7:00-8:00), around noon, and in the early evening (17:00-18:00). Thus a total of ten mosaics have been generated. The general procedures for processing the Viking Lander Camera data are described by Levinthal et al (1977). The purpose of this description of the mosaicking process is to provide, to the users of the mosaics, sufficient understanding of the processing so that they will be able to correctly interpret the scenes.

The individual camera events that were incorporated into each mosaic are identified in the tables in section II.C.. The detailed description of each such event, including a reproduction of its image, are given by Tucker (1978) in the Picture Catalog Data Record (EDR). (This publication covers Camera Events 12A001 through 12B198 for VL-1, and 22A001 through 21C070 for VL-2.)

The Lander Camera system (Huck et al, 1975) incorporates twelve command selectable photo-sensors in each camera [see p. 5-8, Tucker (1978), for a brief description]. Four diodes (BB1, BB2, BB3, BB4), with an instantaneous field of view of 0.04^{o} are at different distances from the lens, allowing optimization of focus selection (1.9, 2.7, 4.5 and 13.3 m respectively). This results in an overall depth of field from 1.2 m to infinity. Almost all the events used for mosaicking were acquired by those diodes. One diode (survey) with a 0.12^{o} aperture was used for black-and-white panoramas. In a few cases data from this diode was used where no high resolution data was acquired. Otherwise all the mosaic image data was acquired using the 0.04^{o} aperture diode.

Each complete mosaicked scene extends 342.5^{o} in azimuth, and from approximately 5^{o} above the horizon to 60^{o} below. A complete mosaic incorporates approximately 15 million picture elements (pixels). In order to manage the processing of such large data bases, each mosaic was compiled from four individual azimuthal sectors. (These are referred to as quadrants in some of the photoproducts.)

The mosaic negatives have been made on an Optronics Photowriter (Model P-1500) in two forms. In one case, using a 25 micron spot size, the complete four sectors of a single mosaic are contained on a single 8 X 10 inch negative. In the second case, three products are made using a 50 micron spot size. They cover sectors 1 and 2, 2 and 3, and 3 and 4 respectively on each of three 8 X 10 inch negatives. The azimuthal coverage for each sector is as follows:

Sector	CACCS* Azimuth limits	LACCS** Start Azimuth (Camera 1)	LACCS** Start Azimuth (Camera 2)
1	0° -90°	279.5°	95.5°
2	84° -174°	3.5°	179.5°
3	168° -258°	87.5°	263.5°
4	252° -342°	171.5°	347.5°

*CACCS - Camera aligned camera coordinate system

**LACCS - Lander aligned camera coordinate system

Figure 1 [from Tucker (1978)] describes the coordinate systems and the lander orientations. The orientations shown in this figure are those based on calculations made by the Lander Performance Analysis Group (LPAG). These are derived from pre-launch calibration of the Inertial Reference Unit. These values were used in the preparation of the mosaics and all the ranging activities. Later calculations, based on analysis of entry data by LPAG were published in a report (Final Report: "Entry Data Analysis for Viking Landers 1 and 2", Martin Marietta Corp., Denver, Colo., NASA TN-377-0218, Nov. 1976). Subsequently errors in those calculations were discovered. The values given for the Lander orientations in Section I, Introduction, and in the text associated with the lithographic mosaic products, are from a private communication, May 15, 1980, from K.W. Villyard, Martin Marietta Aerospace, Cape Canaveral, Florida, who was the author of the relevant section of the above referenced report. These values differ slightly from those shown in Figure 1.

Because the spacecraft are both tilted with respect to the horizon, there is no simple correspondence between the azimuth angles for individual camera events, as shown in the EDR, and the azimuth angles provided on the border of the complete mosaics. The azimuth angles shown on the top border of the mosaic products are measured approximately from north (see Section II.B.3. for details).

B. Methodology

1. General Mosaicking Technique

The creation of the Viking Lander high resolution mosaics can be separated into the steps of selection, preparation, mosaicking, and photometric correction. The selection process focuses on the Primary Mission Viking Lander EDR camera events. In some cases, Extended Mission camera events are included where primary mission coverage is absent or inadequate. This was often the result of obscurations caused by sampler arm activities. From images resulting from these camera events, sets of images from early morning, afternoon, and, in addition for Viking Lander 2, noon time frames are selected. A further selection criterion is that the range to the nominal surface plane at each elevation should be matched (as best as possible) with the diode which focuses closest to that range. (For example, the diode designated BB4 has its focus at 13.3 m and a depth of field permitting imaging at infinity. Thus an elevation command of zero degrees in the mosaic should be filled in with an image taken using the BB4 diode.)

After a set of images for each camera and a time of day is selected, the preparation step is begun. Each image is radiometrically corrected (Huck et al, 1975; Patterson et al,1977; Wolfe et al, 1977) and differences caused by variations in gain and off-set settings are removed from each image in the set. In addition, a solar lighting correction (based on a model of a Lambertian surface; sine of incidence angle) is performed to remove minor time of day variations in the various images of the set. Next a geometric transformation (Patterson et al, 1977; Wolfe, 1980) is performed on each image. This transformation is the combination of a camera geometry correction and a de-tilting of the image into a local Mars zenith system. (Both landers are tilted relative to a flat landing plane. Figure 1 describes the orientation of both Landers.) The transformed images are now aligned so that the horizon of the nominal surface plane will project into the image as a horizontal straight line.

In the mosaicking step, all images comprising a sector are combined into a single image. This process sometimes is preceded by an ad hoc contrast correction of some images (all of them being from the extended mission) for which the previously applied photometric correction alone was inadequate. The mosaicking process proceeds as follows. First, each image is assigned a priority. Then, for each picture element (pixel) the pixel DN value of the highest priority image is examined. If it is non-zero, then that value becomes the DN value of the pixel in the resultant image. Otherwise, the search continues through all pixels in the exact same position in order of decreasing priority until a non-zero DN value is found or until the picture list is exhausted (in which case the resultant DN value for that pixel becomes zero).

After the mosaics have been generated, a general cleanup is performed. Processing artifacts (at image boundaries) and narrow gores (1-5 pixels wide) are removed from the mosaics by a process of averaging. Pixels bounding the artifact on a particular line are identified. The DN values of artifact pixels are replaced by the weighted average of the DN values of the two boundary pixels. The weight is the ratio of distance of the artifact pixel from a boundary pixel to the distance between boundary pixels. (This procedure is often referred to as linear interpolation.) Also, the surface sampler arm and housing are removed from the mosaics when they can be replaced by unobscured portions of low resolution images. This procedure is performed by setting a polygonal area of the mosaic to zero DN value. The corresponding low resolution image is geometrically transformed to a high resolution format (and is detilted as well) and the high resolution mosaic and low resolution image are then mosaicked together with the low resolution image given lower priority.

2. Photometric Corrections

Following the above general procedures the solar lighting variations are removed from the scene. These variations are the result of the large changes in phase angle between the sun and camera over the azimuth range. The objective is to obtain an image for which ground material of similar albedo (i.e., reflectivity) and surface normal presents the same DN value regardless of its position in the scene. The solar lighting function is assumed to be a multiplicative function of detilted camera azimuth only. Although not a "true" photometric correction, this approximation is found to perform the desired correction within adequate ranges. An empirical approach to the determination of the function is taken. Test patches on the surface, which are flat and without large rocks or noticeable surface texture, are chosen in the four sectors of the mosaic at intervals of approximately every twenty degrees of azimuth. The average DN value of each test patch is determined. For test patch i, let the average DN value be DN_i. Then each sample at the (detilted) azimuth of test patch i is multiplied by $128/DN_i$ to give the corrected DN value. The correction for pixels at azimuth value intermediate between test patch azimuths is calculated by linear interpolation (or extrapolation), using the nearest test patch correction values. After the four sectors have been corrected for solar lighting effects, they are mosaicked together in a manner analogous to that described above.

3. Geometric Corrections

The geometric transformation is carried out as part of the preparation step on each individual image. The camera geometric distortions may be separated into two types - optic path distortions and camera system distortions. The optic path distortions are those which affect a light ray after it passes the camera window, such as PSA rotation, PSA off-axis effect (coning distortion) etc. Camera system distortions (i.e., rotation and offset) relate to the way in which the cameras are mounted on the Lander. The geometric transformation that is performed in generating the mosaics includes a correction for the optic path distortions, and for the distortions due to the tilt of the lander spacecraft. It does not, however, correct for the distortions of the camera system related to its method of mounting, sometimes referred to as bolt-down errors. As a result, the mosaics retain a small error in azimuth and elevation values, relative to the values which appear in the fiducial annotations on the images. Along the horizon, the error in azimuth angle is equal to the bolt-down error for each camera to an accuracy small compared to a pixel. This has been taken into account in the lithographic products (Section II.D.2.) by an appropriate translation of the fiducial markings that read "Azimuth Angles from Mars North". The residual errors are given in Table 1. However these fiducial markings were not adjusted for bolt-down error in the mosaic photoproducts (Section II.D.1.). For these products, a correction for the bolt-down error plus the residual error must be made. Unfortunately, for the Lander 1 versions of these same products, an additional error of scale was made. This requires that a further correction of 3.91° must be made to get the correct reading of azimuth angle from Mars north.

The residual error in azimuth angle changes with elevation angle and becomes more noticeably azimuth dependent for small elevation angles, a larger lander tilt and a large bolt-down error. For example, for Lander 2 camera 1, with a tilt of 8.2° and a bolt-down error of -.92° the residual error at an elevation angle of -60° and an azimuth angle of 90° is +.23 equal to 5.75 pixels. This is the largest residual error of this type in the mosaics.

Neglecting the bolt-down error is equivalent to having the cameras at a slight tilt with respect to the horizon. This gives a somewhat sinusoidal azimuth dependent residual elevation error throughout the mosaics. Table 1 gives those errors. They are a maximum of 1 pixel for Lander 1 camera 1 and 3 pixels for Lander 2 camera 1 and less than one pixel for the other two cameras.

The above calculations and Table 1 only take into account the errors in bolt-down due to rotation and not those due to cant or offset. These latter errors contribute a further error of about 1 pixel for each of the four cameras.

TABLE 1

RESIDUAL ERRORS IN AZIMUTH AND ELEVATION ANGLES
(Errors in Degrees)

AZIMUTH ANGLE FROM MARS NORTH	LANDER 1 Tilt = 3° @ 285.18										LANDER 2 Tilt = 8.2° @ 277.7									
	Camera 1 (Bolt-down error=-.85)					Camera 2 (Bolt-down error=-.17)					Camera 1 (Bolt-down error=-.92)					Camera 2 (Bolt-down error=-.22				
	Residual Azimuth Error for Elevation Angle =				Elev. Error	Residual Azimuth Error for Elevation Angle =				Elev Error	Residual Azimuth Error for Elevation Angle =				Elev Error	Residual Azimuth Error for Elevation Angle =				Elev. Error
	-60	-40	-20	0		-60	-40	-20	0		-60	-40	-20	0		-60	-40	-20	0	
0	-.02	-.01	-.00	.00	-.04	-.00	-.00	-.00	.00	-.01	-.02	-.01	.00	.01	-.13	-.01	-.00	.00	.00	.03
30	.02	.01	.01	.00	-.04	.00	.00	.00	.00	-.01	.09	.05	.03	.01	-.12	.02	.01	.01	.00	-.03
60	.05	.03	.01	.00	-.03	.01	.01	.00	.00	-.01	.19	.10	.05	.01	-.08	.05	.02	.01	.00	-.02
90	.08	.04	.02	.00	-.01	.02	.01	.00	.00	.00	.23	.12	.06	.01	-.02	.06	.03	.01	.00	.00
120	.08	.04	.02	.00	.01	.02	.01	.00	.00	.00	.22	.11	.05	.01	.05	.05	.03	.01	.00	.01
150	.06	.03	.01	.00	.03	.01	.01	.00	.00	.01	.15	.08	.04	.01	.10	.04	.02	.01	.00	.02
180	.02	.01	.01	.00	.04	.00	.00	.00	.00	.01	.04	.02	.02	.01	.13	.01	.01	.00	.00	.03
210	-.02	-.01	.00	.00	-.04	-.00	-.00	-.00	-.00	-.01	-.07	-.03	-.01	.01	.12	-.02	-.01	-.00	.00	.03
240	-.05	-.02	-.01	.00	.03	-.01	-.01	-.00	.00	.01	-.17	-.08	-.03	.01	.08	-.04	-.02	-.01	.00	.02
270	-.07	-.03	-.01	.00	-.01	-.01	-.01	-.00	.00	.00	-.22	-.10	-.04	.01	.02	-.05	-.02	-.01	.00	.00
300	-.07	-.03	-.01	.00	-.01	-.01	-.01	-.00	.00	-.00	-.20	-.09	-.04	.01	-.05	-.05	-.02	-.01	.00	-.01
330	-.05	-.03	-.01	.00	.03	-.01	-.01	-.00	.00	-.01	-.13	-.06	-.02	.01	-.10	-.03	-.01	-.00	.00	-.02

The correct values are arrived at by adding these calculations of residual error to the indicated values of Azimuth Angle From Mars North and Elevation Angle taking into account the sign of the error. Thus a plus (+) indicates a clockwise correction to the azimuth angles. The photoproducts require both the correction for boltdown and the indicated residual error. For the Lander 1 photoproducts an additional correction of -3.91° must also be made.

C. List of Camera Events Used in Mosaics

The following lists identify the camera events used to create each sector of each mosaic in the order of decreasing priority.

L1.C1.AM

1	2	3	4
11A154	11A154	11A156	11A156
11B051	11A129	11A129	11A157
11A111	11A097	11B022	11A158
11A025	11A078	11A097	11B064
		11A022	11A023
		11A079	11B129
		11A078	11B052
		11A048	11A022
		11B226	11B053
			11B226
			11B093
			11B225
			11B219
			11B224
			11A097
			11C039
			11B225

L1.C2.AM

1	2	3	4
12A112	12A116	12A125	12B063
12B054	12A112	12A155	12A125
12A010	12A107	12A116	12A110
12B128	12A010	12A107	12A068
12A059	12A108	12B056	
12A124	12A003		
12A003	12B056		
12B060	12B055		
12A116	12B207		
12C042	12A103		
12C043	12A124		
12C044			
12B203			

L1.Cl.PM

1	2	3	4
11A174	11A143	11A132	11B036
11A173	11A251	11A133	11B037
11B073	11A250	11A137	11A017
11B229	11A174	11B059	11A114
	11A144	11B050	11A141

11B050	11A051	11A030
11B098	11A114	11A127
	11B037	11B059
	11A127	11A132
	11A143	11A051
	11A144	11A137
	11A251	11B067
	11B220	11A132
	11B223	11B120
		11B165
		11C033

L1.C2.PM

1	2	3	4
12A119*	12A238	12A165	12A255
12A140	12A211	12A164	12B016
12A119*	12A212	12A153	12B000
12A136	12A153	12A238	12A235
12A212	12A119	12B000	12A165
12B227	12A152	12A211	12B208
12A119*	12A140	12A152	12B103
12A002	12A136	12B017	12A014
	12B017	12A235	12A043
	12A235	12A237	12C015

* Camera Event 12A119 was used in various forms with and without the sampler arm (by removing the arm and setting DN values to zero). This was done to get the best coverage of the scene in combination with other camera events used. The highest priority use was with the whole event without the sampler arm. The next priority use was the left-hand part of the event. The third priority use was the whole event, including the sampler arm. Similar techniques were used in other sectors.

L2.C1.AM

1	2	3	4
21B010	21A164	21A221	21B009
21B008	21B010	21B034	21B001
21A204	21B054	21B021	21B039
21C098	21B040	21A225	21C036
	21A076	21A222	21A174
	21A077	21B033	21B040
		21B022	21B094
			21B015
			21B093
			21C069
			21A079
			21A050
			21A077

L2.C2.AM

1	2	3	4
22A205	22A176	22A206	22A027
22B000	22A095	22A088	22A207
22A236	22A205	22A223	22A223
22B002	22A206	22A220	22A105
22B199	22A178	22B231	
22A178	22B061	22A106	
22B061	22A220		
22B025	22A236		
22A097	22B000		
22A002	22B231		

L2.C1.Noon

1	2	3	4
21A237	21A237	22A221	21A226
21A238	21A225	21B034	21A222
21A125	21B034	21B021	21B022
21A040	21A221	21A225	21A225
	21B021	21A222	21B035
	21C204	21B033	21B033
		21B022	21B021
		21C152	21C153
			21C208

L2.C2.Noon

1	2	3	4
22B004	22A252	22B003	22B003
22B013	22B013	22A253	22B056
22B046	22B057	22A252	22A124
22B045	22B058	22B012	22B020
22B058	22B012		22A002
22B120	22A251		
22C202	22B046		
22C138	22A002		
22C160			
22C162			
22A002			

L2.C1.PM

1	2	3	4
21B213	21A139	21A147	21A168
21A127	21A142	21A149	21A161
21A134	21A150	21A075	21A151
21A139	21A147	21A069	21A075
21A023	21A128	21B057	21A111
	21B059	21A044	21A149
		21A128	21B214
		21A052	21A032

		21A110	21A044
		21A031	21A216
		21A132	21B060

L2.C2.PM

1	2	3	4
22A118	22A148	22A140	22A140
22A255	22A143	22A141	22A135
22A143	22A011	22A104	22A133
22A011	22A163	22A148	22B211
22A046	22A005	22A119	
22A121	22A103	22B090	
22B091	22A119		
22A005	22B215		
22B212	22B091		
22B014	22C178		
22B215			
22A002			

D. The Final Mosaic Products

1. Photoproducts

The mosaic negatives have the following general form. At the top and bottom of the image is a 16 step gray scale. Beneath the gray scale at the top of the image are two sets of rulings. The upper one is labeled 'az' and specifies the local Mars azimuth of the scene clockwise from north(see Section II.B.3. for a discussion of the errors). Beneath this scale is a scale labeled IPL sample no. An identical scale is beneath the image. This refers to the sample number in the digital image data set. The IPL sample no. increases from left to right. To the left of the image are two sets of scales. The leftmost of these is labeled 'EL' and specifies the elevation of the detilted image. To the right of this scale is a scale labeled IPL line no. An identical scale appears to the right of the image. This refers to lines of data or data records in the data set. The IPL line no. increases in the downward direction. The pixel in the upper left corner has the IPL coordinate (1,1).

Beneath the image, two sets of annotation appear. The smaller annotation refers to a specific image in the collection which was used to generate the mosaic. This annotation is of no interest to the general user. The larger annotation is a block of the form:

HIGH RESOLUTION MOSAIC
IPL PIC ID 77/10/21/012442
L1.C2.AM.Q1+Q2+Q3+Q4

The term "HIGH RESOLUTION MOSAIC" describes the type of product. The Image Processing Laboratory Picture Identifier (IPL PIC ID) is expressed as the date of creation on the computer (YY/MM/DD/HHMMSS). The last line identifies the individual product in a more descriptive terminology--in this case Lander 1 (L1), Camera 2 (C2), morning (AM), and four sectors are contained on the photoproduct (Q1+Q2+Q3+Q4). (Note: In the case of these photoproducts the word quadrant is used instead of sector.) The IPL PIC ID is a designator used to uniquely identify a photoproduct generated in IPL. All inquiries concerning a print should include the IPL PIC ID designator. Figure 2 illustrates this product.

Two sector mosaics consist of the three combinations Q1+Q2, Q2+Q3, and Q3+Q4. The various combinations of landers (2), cameras (2), times of day (2 for VL-1, 3 for VL-2), and sectors result in a total of 40 individual photoproducts. The IPL PIC ID's for the available products are summarized in Table 2. Figures 3 and 4 are illustrations of the two sector mosaics.

TABLE 2

HIGH RESOLUTION MOSAICS

IPL PIC IDs

	Q1+Q2	Q2+Q3	Q3+Q4	Q1+Q2+Q3+Q4
L1C1 AM	77/10/20/194103	77/10/20/200106	77/10/20/201659	77/10/24/210928
L1C2 AM	77/10/11/195106	77/10/11/200426	77/10/11/201443	77/10/21/012442
L1C1 PM	77/12/03/001934	77/12/03/003600	77/12/03/005146	77/12/05/231630
L1C2 PM	77/10/27/002228	77/10/27/003331	77/10/27/004429	77/10/26/230247
L2C1 AM	77/10/25/200033	77/10/20/003550	77/10/20/004849	77/10/22/041946
L2C2 AM	77/10/08/071542	77/10/08/072731	77/10/08/074330	77/10/21/194644
L2C1 N	77/10/13/203604	78/01/14/162816	77/10/13/205527	77/10/21/003131
L2C2 N	77/10/11/203346	77/10/11/204252	77/10/11/205239	78/01/23/203555
L2C1 PM	77/10/10/210627	77/10/10/211805	77/10/10/213201	77/10/22/022809
L2C2 PM	77/10/12/214621	77/10/12/220159	77/10/12/221152	77/10/22/055641

2. Lithographic Products

The United States Geological Survey (USGS) is producing a set of fifty lithographic sheets approximately 30 x 40 inch each derived from first generation negatives. For each of the mosaics there will be a set of five sheets consisting of four single sheets for each sector and a fifth sheet with the complete mosaic with an image 8 inches high and 38 inches long. The one-sector sheets, each with an image 24 inches high by 30 inches wide, assembled together would thus make a mosaic two feet high by ten feet wide. A standard procedure for making the lithographs is used with a screen of 130 lines/inch.

Each single sector lithographic product has two sets of fiducial scales bordering the image. One gives the azimuth angle from Mars north and the elevation angle relative to the nominal horizon (see Section II.B.3. for a discussion of the errors). The second set gives the IPL line and sample number. This refers to the picture element or pixel in the digital data set used to generate the negative from which the particular sheet was produced. This allows reference to the image line record on the appropriate 800 bpi tape described in the following section.

In addition to text describing some general aspects of the Viking mission, the methodology of producing the mosaics, and providing a geological description of some of the important features of the scene, each sheet contains three small images. One gives a schematic overhead view of the spacecraft showing its orientation and that of the sectors with respect to Mars north. This image is overlain with camera elevation angles and a grid in spacecraft coordinates. The second image is a skyline drawing giving the geometry of a complete view of the scene and spacecraft as viewed by the appropriate camera. The coordinates of the superimposed grid are camera control azimuth and elevation. On the skyline drawing are also the "footprints" of the individual camera events used to construct the mosaic. This permits referencing the EDR and TDR (see section IV.A.) photoproducts covering any part of the mosaic scene. To assist this cross-referencing a third image is provided. This is a reduced image of the complete four-sector mosaic. On this image is the camera control azimuth and elevation grid distorted by the same computer program that removed the horizon tilt in producing the rectified mosaics. A second set of horizontal fiducial markings giving azimuth angles from Mars north permits referencing back to the large image of the mosaic sector. This reduced image gives the width and distance from the spacecraft of some rocks labelled in the scene.

The sector 1 sheet covers line 170 to 2290 from the sector 1 and 2 800 bpi digital tape, the sector two sheet lines 2200 to 4320 from this same tape. The sector 3 sheet and sector 4 sheet cover lines 40 to 2160 and 2070 to 4190 respectively from the sector 3 and 4 800 bpi tape. There are approximately 90 lines of overlap of the scene between adjacent sector images.

The fifth sheet for each mosaic has two 8 inch high by 38 inch images of the complete mosaicked scene. One is bordered by IPL line and sample numbers that reference the four-sector 1600 bpi digital tape for that mosaic. The second serves the same purpose as the reduced image in the single sector sheets, giving the relationship between rectified camera control coordinates and azimtuh angles from Mars north. It also identifies the distance and size of rocks in the scene. Besides the text, overhead view, and skyline drawing described above, these sheets have two other images of interest. One is a 7 inch diameter image of a polar stereographic projection of the mosaic. This is the "donut" projection described in section III. A. below. A second is an image acquired by the Viking Orbiter cameras showing the location of the Viking Lander.

3. Magnetic Tapes

The mosaic data sets are stored in digital form on a series of magnetic tapes. The tapes are recorded on 9 track tape drives. Each image is stored as a separate file. Every file begins with a variable number of label records followed by the actual image. Each label record is 360 bytes in length, and is comprised of 5 logical labels of 72 bytes each. The last byte (byte 72) of each logical label consists of an EBCDIC character, either 'C' or 'L'. A 'C' indicates that another logical label follows, while an 'L' indicates that this is the last logical label. If the last label record contains fewer than 360 bytes, it is padded on the right. The label records contain EBCDIC information which is formatted and displayed at the bottom of a masked print of the image. The first logical label of the first label record contains information relating to the size of the image. Bytes 33-36 contain a four character right adjusted EBCDIC format integer which specifies the number of lines in the image. Bytes 37-40 similarily contains a number which specifies the number of picture elements per image line. A more detailed explanation of the label format is given by Tucker (1978).

The image is stored following the label records. Each image line is stored as one record. The data is available either recorded at 800 BPI or 1600 BPI. The 800 BPI tapes each contain one two-sector mosaic (either sectors Q1 and Q2, Q2 and Q3, or Q3 and Q4) with record lengths equal to 4350 bytes and 1852 records (not including the label records). The 1600 BPI tapes each contain a complete mosaic of four sectors (Q1 + Q2 + Q3 + Q4) with record lengths equal to 8650 bytes and 1852 records for the imagery data. Table 3, which follows is a list of available tapes. This list also includes the 20 tapes containing the Standard VLStereo data sets described in Section III.B. below.

TABLE 3

TAPE LIST

MOSAICS

Tape Number	Contents	Density (BPI)
DNS 001	L1.C1.AM.Q1 + Q2	800
DNS 002	L1.C1.AM.Q2 + Q3	800
DNS 003	L1.C1.AM.Q3 + Q4	800
DNS 004	L1.C2.AM.Q1 + Q2	800
DNS 005	L1.C2.AM.Q2 + Q3	800
DNS 006	L1.C2.AM.Q3 + Q4	800
DNS 007	L1.C1.PM.Q1 + Q2	800
DNS 008	L1.C1.PM.Q2 + Q3	800
DNS 009	L1.C1.PM.Q3 + Q4	800
DNS 010	L1.C2.PM.Q1 + Q2	800
DNS 011	L1.C2.PM.Q2 + Q3	800
DNS 012	L1.C2.PM.Q3 + Q4	800
FNS 001	L2.C1.AM.Q1 + Q2	800
FNS 002	L2.C1.AM.Q2 + Q3	800
FNS 003	L2.C1.AM.Q3 + Q4	800
FNS 004	L2.C2.AM.Q1 + Q2	800
FNS 005	L2.C2.AM.Q2 + Q3	800
FNS 006	L2.C2.AM.Q3 + Q4	800
FNS 007	L2.C1.NOON.Q1 + Q2	800
FNS 008	L2.C1.NOON.Q2 + Q3	800
FNS 009	L2.C1.NOON.Q3 + Q4	800
FNS 010	L2.C2.NOON.Q1 + Q2	800
FNS 011	L2.C2.NOON.Q2 + Q3	800
FNS 012	L2.C2.NOON.Q3 + Q4	800
FNS 013	L2.C1.PM.Q1 + Q2	800
FNS 014	L2.C1.PM.Q2 + Q3	800
FNS 015	L2.C1.PM.Q3 + Q4	800
FNS 016	L2.C2.PM.Q1 + Q2	800
FNS 017	L2.C2.PM.Q2 + Q3	800
FNS 018	L2.C2.PM.Q3 + Q4	800
DNS 013	L1.C1.AM.Q1 + Q2 + Q3 + Q4	1600
DNS 014	L1.C2.AM.Q1 + Q2 + Q3 + Q4	1600
DNS 015	L1.C1.PM.Q1 + Q2 + Q3 + Q4	1600
DNS 016	L1.C2.PM.Q1 + Q2 + Q3 + Q4	1600
FNS 019	L2.C1.AM.Q1 + Q2 + Q3 + Q4	1600
FNS 020	L2.C2.AM.Q1 + Q2 + Q3 + Q4	1600
FNS 021	L2.C1.NOON.Q1 + Q2 + Q3 + Q4	1600
FNS 022	L2.C2.NOON.Q1 + Q2 + Q3 + Q4	1600
FNS 023	L2.C1.PM.Q1 + Q2 + Q3 + Q4	1600
FNS 024	L2.C2.PM.Q1 + Q2 + Q3 + Q4	1600

STANDARD VLSTEREO

DNM 001	L1.C1.AM. FRONT	1600
DNM 002	L1.C2.AM. FRONT	1600
DNM 003	L1.C1.AM. BACK	1600
DNM 004	L1.C2.AM. BACK	1600
DNM 005	L1.C1.PM. FRONT	1600
DNM 006	L1.C2.PM. FRONT	1600
DNM 007	L1.C1.PM. BACK	1600
DNM 008	L1.C2.PM. BACK	1600
FNM 001	L2.C1.AM. BACK	1600
FNM 002	L2.C1.AM. FRONT	1600
FNM 003	L2.C2.AM. FRONT	1600
FNM 004	L2.C2.AM. BACK	1600
FNM 005	L2.C1.NOON. BACK	1600
FNM 006	L2.C1.NOON. FRONT	1600
FNM 007	L2.C2.NOON. FRONT	1600
FNM 008	L2.C2.NOON. BACK	1600
FNM 009	L2.C1.PM. BACK	1600
FNM 010	L2.C1.PM. FRONT	1600
FNM 011	L2.C2.PM. FRONT	1600
FNM 012	L2.C2.PM. BACK	1600

The first 0 (zero) in the number following either DNS, FNS,DNM or FNM is replaced by a number 0 to 9, indicating the copy number. D indicates that the contents refer to Lander 1 and F to Lander 2. N means that the data source from which the image is derived is the EDR (Engineering Data Record).

III. Derived Products

A. "Donut" Projections

The term "donut" was an informal name that seemed such an appropriate descriptor that the term remained. Actually, the transformation is a polar stereographic projection centered around a vertical line from the camera to the surface as referenced through the approximate nodal point of the camera. The horizon becomes the 90° circle in the stereographic projection. The result is that the horizon seems to wrap around in a circle. The final product is quite useful for determining relative and actual compass directions between objects. North is at the top in all products. Since the cameras can only image down to -60° a hole remains in the center that cannot be filled, thus the term "donut".

A polar-type projection was chosen so that compass angles would be preserved. A stereographic projection was chosen since it restores the proper vertical-to-horizontal aspect ration of all objects in the field of view. Camera azimuth remains unchanged except for an orientation relative to north. Camera elevation is transformed into radius. However, the scale at each radius in the projection is different. If the latter were to be preserved, the images must be mapped using a gnomonic projection, producing an aerial view of the lander site (see description of orthographic projections, Section III. D.).

The input dataset for each "donut" was the four-sector high-resolution mosaic. In order to accomplish the transformation in a finite amount of computer time, the mosaic dataset was subsampled by a factor of three, both in the horizontal and vertical directions.

Each photoproduct is labelled at the bottom with an annotation block of the format:

HIGH RESOLUTION DONUT PROJECTION
IPL PIC ID 78/01/03/185404
L1. C1. AM

The term "HIGH RESOLUTION DONUT PROJECTION" identifies the product type. The Image Processing Laboratory Picture Identifier (IPL PIC ID) is expressed as the date of creation on the computer (YY/MM/DD/HHMMSS). The last line describes the high-resolution mosaic dataset from which the donut was made: Lander 1 (L1), camera 1 (C1), morning (AM). Figure 5 illustrates this product.

The IPL PIC ID's for these products are summarized in Table 4.

TABLE 4

"DONUT" PROJECTIONS

IPL PIC IDs

SPACECRAFT	TIME OF DAY	CAMERA 1	CAMERA 2
VL-1	A.M.	78/01/03/185404	78/01/03/185533
VL-1	P.M.	78/01/27/105201	78/01/27/105536
VL-2	A.M.	78/01/14/031941	78/01/14/040855
VL-2	Noon	78/01/16/204108	78/01/14/054523
VL-2	P.M.	78/01/09/205946	78/01/13/220654

B. Stereoscopic Projections

1. General Discussion

The three dimensionality or relief of a scene is conveyed to a viewer because each eye sees the same object from a different perspective. The two different retinal images are conveyed to the brain where they are "fused" to synthesize a three-dimensional or stereo image. The equivalent effect can be achieved by presenting the viewer with a pair of photographs of the same scene taken from different positions. Such a pair would be known as a "stereo pair". Stereo is a standard tool used by geologists to qualitatively and quantitatively investigate surfaces of interest, capturing the information by photography.

The two cameras on each of the Viking spacecraft are separated by 0.813 meters. Such a large separation allows more accurate determinations of range and position of points on the surface than a smaller camera separation would allow. A more familiar example would be a rangefinder as employed by military observers.

There are many ways of viewing stereo pairs. For image pairs where the width of each image is about 65 mm, namely the interocular separation, there are many inexpensive stereo viewing arrangements. The old fashion hand-held stereopticon and its modern counterparts serve this purpose. There are also many inexpensive pocket stereoscopes. In addition there is the method of free-fusion which requires no special viewing equipment. For free-fusion the images are held at normal reading distance, wearing reading glasses if ordinarily required. The images are aligned horizontally so that common points in both images are aligned parallel to a line joining the viewer's eyes. The idea is then to allow vision convergence to relax so that double images are seen. This occurs when the left eye is directed and focused on the left member of the pair and the right eye on the right member. When the images pairs are small enough, the stereo image pair can be put directly in front of the viewer's eyes so they are directed as if they were looking at a distant horizon. When the images are larger and the common points of interest in the pair are further apart then the interocular separation, the viewer's eyes must go "wall-eyed". This is not impossible but it is difficult for the untrained viewer. Some prefer to reverse the images so that the left image is on the right-hand side and the right image on the left-hand side. In this case they are viewed "cross-eyed". Figures 13 and 14 provide two image pairs which can be used for free-fusion.

There are many standard stereoscopes designed to permit the viewing of the larger images. Many arrangements of prisms and mirrors will permit one eye to only see one image of the pair while the other eye sees only the other. Two stereoscopes used by the imaging team members are the Kail Model K-10 Precision Mirror Stereoscope and the ODSSIII (Old Delft) Scanning Stereoscope.

Unfortunately, the wide baseline or separation of the Viking cameras has the disadvantage of producing pairs of images that are impossible to "fuse" visually. The major constraints on achieving stereo fusion are:

a) The images must be related in their content.

b) Each corresponding point in the left and right images must be horizontally positioned.

c) The scale at corresponding points in the image pairs must be the same.

The first constraint merely means that it is not possible to fuse images of completely different subjects. The second means that the images cannot be tilted or misaligned. The third means that one image cannot be larger or smaller than the other. (Actually, experiments have shown that there is a certain degree of tolerance in each of these constraints that can be allowed without destroying one's ability to achieve fusion.)

Unfortunately, the high-resolution mosaics violate all three of the above criteria. Parts of the spacecraft block the scene from one camera and not from the other. The cameras are far enough apart so that objects off to one side of the spacecraft as seen by one camera are vertically misaligned with respect to the same objects as seen by the other camera. Additionally, objects to the side of the spacecraft appear either larger or smaller than as viewed by the other camera. Although it is not possible to fill in the areas which the cameras can't image, it is possible to generate a computer program that can "rubber-stretch" the images so that the last two criteria are achieved. This rubber-stretch algorithm assumes a flat nominal surface at the landing site and does **not** use true point-by-point topographic information. (Although it is theoretically possible to produce such a refined product, the expense in time and dollars was not practical.) However, the rubber-stretch approach is qualitatively informative, and the procedure accomplishes its primary purpose - allowing stereoscopic fusion of the lander images.

A computer program, called VLSTEREO was developed to supply the necessary tiepoint information to the rubber-stretch program. In doing so, it was quickly found that, by a judicious choice of parameters, an entire family of transformations were possible, each of which not only allowed stereoscopic fusion but also emphasized certain topographic characteristics of the scene. The major two transformations that appeared most useful were "changing" the apparent intercamera separation and "lifting" the camera higher above the surface. In both cases, the visual results are quite startling.

Before describing the actual operation of VLSTEREO, it is desirable to try the following exercise with the imaging pairs. The descriptions of the parameters in VLSTEREO will then make more sense.

1) Stereoscopically view a pair of high-resolution mosaics. L1.C1.AM.Q3+Q4 (left - IPL PIC ID 77/10/20/201659) (Figure 3) and L1.C2.AM.Q1+Q2 (right - IPL PIC ID 77/10/11/195106) (Figure 4) is a good example. While stereo fusion is easy at the horizon and straight down the center of the image, the lower left and lower right corners are quite difficult without repositioning the prints.

2) Stereoscopically view a pair of "STANDARD VLSTEREO" images. The same scene as above may be found as IPL PIC ID 78/10/19/171012 (left) (Figure 6) and 78/10/19/175118 (right) (Figure 7). The scene is now viewable stereoscopically over the entire common field of view. A comparison to the high-resolution mosaics above shows how the scene has been distorted. However, there is still a considerable amount of "depth" between foreground and background in these images so that many people still have problems achieving stereo fusion.

3) Substitute one of the "SPECIAL VLSTEREO" images with the apparent camera separation (CAMSEP) = 0 , IPL PIC ID 78/10/10/185301 (Figure 8), for the left image (171012) only. This, combined with the right side image above, has the effect of reducing the intercamera baseline by 50% (see discussion of CAMSEP Parameters in following section). The result should seem much easier to fuse than in the previous example.

4) Now substitute IPL PIC ID 78/09/08/113258 (Figure 9) also with CAMSEP = 0 for the right image (175118) of the above pair; this new pair reduces the apparent intercamera baseline to zero. In the foreground, subtle topographic information is emphasized. In the background, the result is rather confusing since one is viewing the surface at an oblique angle.

5) To understand the way the transformation works, put two right eye images under a stereoscope at once - specifically 78/09/08/113258 and 78/10/19/175118. What one should see is a slanting surface corresponding to the nominal plane which is being distorted by the transformation within VLSTEREO. The rocks themselves appear to be a flat image tilted at an angle. The effect of changing the intercamera baseline is to subtract this "biasing" of the scene, leaving only the variations from this slanted plane and not the plane itself.

6) In reality, the apparent baseline of the lander's cameras changes as a function of the pointing direction. The apparent baseline is zero only along a line running through the nodal points of the two cameras. The apparent baseline is a maximum (0.813 meters) only along a line bisecting the two

cameras and running along the surface directly in front or behind the spacecraft. For this reason, an additional transformation (NODEL) was created to preserve the apparent separation as a function of viewing azimuth. These "SPECIAL VLSTEREO" products are labelled "UNCORRECTED FOR CHANGING APPARENT CAMERA SEPARATION WITH AZIMUTH". IPL PIC ID 79/02/07/000423 (left) and 78/08/12/114001 (right) shows a pair of such products (Figures 10 and 11 respectively).

7) As before, the pairing of two camera 1 images illustrates the effect of the transformation being employed. If the right image above (114001) is replaced by 78/10/10/185301, the deeply bowed surface is clearly seen. This illustrates the effect of the changing baseline as seen on the nominal plane. This also illustrates an additional problem--what should be done at the horizon since the geometry degenerates at that position. What was decided was to "hinge" the horizon, essentially continuing the scene from below the horizon without distorting it horizontally. While this hinge effect is clearly seen in this example, it is difficult to detect in true left/right pairs. It is an artificial constraint and should thus be kept in mind when viewing objects above the horizon level surface.

8) The final type of product was found by accident. In an additional attempt to alter the apparent amount of stereo in the scene, and thus make the images easier to view, it was thought that "lifting" the spacecraft off the surface might work (HEIGHT and ALPHA parameters). The side effects of this transformation were unanticipated, but the resulting product is the most successful in emphasizing the topographic nature of the Martian terrain. IPL PIC ID 78/08/27/010209 (left) and 78/08/06/222439 (right) are the most spectacular examples (Figures 12 and 13 respectively). These "SPECIAL STEREO" products are labelled "APPARENT CAMERA HEIGHT 4.024 SLANT 60.0."

2. Operation of VLSTEREO

Basically, the program VLSTEREO references each point in an image to a set of lines extending radially away from a point on the nominal surface positioned halfway between the two cameras. This reference line is taken to be that radial line which is perpendicular to the line bisecting the two cameras--that is, straight away from the lander between the two cameras. As seen in an image from either camera, such a line drawn on the surface would appear to be curved, bending either to the left or right in the near field depending on whether it is the right or left camera, repectively. (Note: when looking in front of the lander, Camera 1 is left and Camera 2 is right; behind the lander, Camera 2 is left and Camera 1 is right.) VLSTEREO relates all other lines radiating from the point between the cameras to this reference line. In doing so, the problems of nonvertical disparity and non-uniform scale are removed.

In all products labelled "STANDARD VLSTEREO," all radial lines described above are forced to be "parallel" to the reference line, and the intercamera baseline of 0.813 meters is preserved across the scene. The other transformations illustrated above are accomplished by changing the shape of the reference line. There were four variables that were used to generate the stereoscopic databases. Other options were written into the program, but were not used.

The parameter CAMSEP allows one to change the apparent intercamera separation. The normal was CAMSEP = 1.0 (corresponding to 0.813 meter.) In the case where CAMSEP = 0.0, the reference line no longer curves, but instead becomes a straight vertical line when viewed in the images. All other radial lines extending from the point on the surface halfway between the two cameras would appear as vertical straight lines. The parameter NODEL allows the intercamera separation to vary from its maximum of CAMSEP = 1.0 straight out from the lander to CAMSEP = 0.0 at either side of the lander following a simple cosine function. The two parameters HEIGHT and ALPHA are used to reposition the lander at any point in space above or behind the normal position. The defaults are HEIGHT = 1.0 (corresponding to 1.3 meters above a nominal landing surface) and ALPHA = 45.0^{o} (which has no effect if HEIGHT = 1.0). Increasing the HEIGHT parameter raises the lander by the appropriate factor. ALPHA of 90^{o} would mean straight up; ALPHA of any other angle means a lower angle backwards from the original position. These parameters were required for even the STANDARD VLSTEREO products above, necessitated by the original tilt of the spacecraft and subsequent difference between the height of the two cameras above the surface. Even a small tilt of 3^{o} for VL-1 and 8^{o} for VL-2, after the detilting process in preparing the high-resolution mosaic datasets, caused a disparity in objects between left and right images. The HEIGHT parameter used to compensate for this vertical offset between the cameras is as follows:

VL-1, camera 1 (HEIGHT = 1.008), camera 2 (HEIGHT = 1.024);
VL-2, camera 1 (HEIGHT = 1.057), camera 2 (HEIGHT = 0.971).

3. The VL Stereo Products

a. Standard VLSTEREO

The high-resolution mosaic datasets have been processed through VLSTEREO in the "optimum" mode to produce twenty separate photoproducts (10 pairs). Individual pairs exist for all of the times of day included in the mosaics.

A photoproduct pair is labelled with large-type descriptors with the following formats:

STANDARD VLSTEREO
L1.C1.AM.Q3+Q4 (FRONT - LEFT EYE)
IPL PIC ID 78/10/19/171012

STANDARD VLSTEREO
L1.C2.AM.QI+Q2 (FRONT - RIGHT EYE)
IPL PIC ID 78/10/19/175118

The term "STANDARD VLSTEREO" describes the type of photoproduct. "L1.C1.AM.Q3+Q4" refers to the high-resolution mosaic from which this image was created. "FRONT" (or "BACK") refers to the front or back of the lander. "LEFT EYE" (or "RIGHT EYE") tells which eye should view the image. The Image Processing Laboratory picture identifier (IPL PIC ID) is expressed as the date of creation on the computer (YY/MM/DD/HHMMSS). See Figures 6 and 7.

In the example above, the image pair is identified by matching up the lander (L1), time of day (AM), front or back of the lander (FRONT). The left and right eye information is redundant and is supplied only for convenience. Other pairs are similarly identified.

A complete summary of the IPL PIC ID's for these stereoscopic products is provided in Table 5. The STANDARD VLSTEREO data sets are also stored in digital form on a series of magnetic tapes. These tape numbers are included in Table 3.

b. Special VLSTEREO

The high-resolution mosaics have been processed through VLSTEREO in various modes that emphasize or enhance certain topographic characteristics of the scene. Twenty (20) separate photoproducts (10 pairs) have been produced in this way.

Each photoproduct is labelled with a large-type descriptor in the format:

SPECIAL VLSTEREO
L1.C1.AM.Q3+Q4 (FRONT - LEFT EYE)
IPL PIC ID 78/08/12/114001
UNCORRECTED FOR CHANGING APPARENT CAMERA SEPARATION WITH AZIMUTH

The term "SPECIAL VLSTEREO" identifies the type of product. The term "L1.C1.AM.Q3+Q4" refers to the high-resolution mosaic from which the image was created. "FRONT" (or "BACK") refers to the front of the lander (or back of the lander). "LEFT EYE" (or "RIGHT EYE") tells which eye should view the image. The Image Processing Laboratory picture identifier (IPL PIC ID) is expressed as the date of creation on the computer (YY/MM/DD/HHMMSS).

There are three special transformations used in preparing these photoproducts. These are distinguished by the last phase in the descriptor. In the above example, the NODEL parameter has been used and this product is sometimes referred to by this name. The other two alternative descriptors are "APPARENT CAMERA SEPARATION = 0.0" and "APPARENT CAMERA HEIGHT 4.024, SLANT 60.0." These are illustrated in Figures 8-13.

A complete summary of the IPL PIC ID's for these photoproducts is given in Table 5.

TABLE 5

STANDARD AND SPECIAL VLSTEREO PRODUCTS

IPL PIC IDs

VL-1

STANDARD VLSTEREO

	LEFT	RIGHT
FRONT AM	78/10/19/171012 (A)	78/10/19/175118 (B)
BACK AM	78/10/19/175121 (C)	78/10/19/173518 (D)
FRONT PM	78/09/02/100058	78/09/09/095212
BACK PM	78/09/03/051633	78/09/06/081441

SPECIAL VLSTEREO

	LEFT	RIGHT
NODEL: FRONT AM	79/02/07/000423 (A)	78/08/12/114001 (B)
BACK AM	78/08/12/084735 (C)	78/08/02/005437 (D)
CAMSEP = 0: FRONT AM	78/10/10/185301 (A)	78/09/08/113258 (B)
HEIGHT = 4: FRONT AM	78/08/27/010209	78/08/06/222439
BACK AM	78/08/27/005139	79/02/01/151349

VL-2

STANDARD VLSTEREO

	LEFT	RIGHT
FRONT AM	78/09/08/092354 (E)	78/09/08/095331 (F)
BACK AM	78/08/29/170746 (G)	78/09/08/091712 (H)
FRONT NOON	78/10/31/183212 (I)	78/10/21/012248 (J)
BACK NOON	78/10/31/183328	78/10/12/165801
FRONT PM	78/10/21/014626	78/10/21/001159
BACK PM	78/12/05/162330	78/10/12/171808

SPECIAL VLSTEREO

	LEFT	RIGHT
NODEL: FRONT AM	78/10/10/184155 (E)	78/08/12/092416 (F)
BACK AM	78/08/01/211315 (G)	78/08/02/190605 (H)
CAMSEP = 0: FRONT NOON	78/09/03/045817 (I)	78/11/28/221305 (J)
HEIGHT = 4: FRONT AM	78/10/12/170244	78/08/26/093213
BACK AM	78/07/21/003550	78/08/15/210125

NOTE: ALL IMAGES MARKED BY THE SAME LETTERS MAY BE SUBSTITUTED FOR EACH OTHER FOR DIFFERENT STEREO EFFECTS.

C. Stereo Pairs

1. Stereo Windows From the Mosaics

An additional set of images was reproduced on the GRE (Ground Reconstruction Equipment) from digital datasets used to produce the Standard and Special VLSTEREO pairs described above. In all cases, either a 512 x 512 or a 256 x 256 square pixel area (called "windows") were extracted and reproduced on the GRE film recorder.

The GRE was built specially for the Viking Lander Imaging Equipment by the ITEK Corporation. It generates 5 x 12 inch negatives. Prints from these negatives are distributed as 5 inch rolls separated into individual rolls identified by a TDR (Team Data Record) roll number. Each 5 x 12 inch negative contains two photoproducts. They are arranged so that stereo pairs can be viewed by placing two negatives adjacent to each other. This also makes it convenient when the rolls of contact prints are cut into 5 x 12 inch pieces each with two images.

Thus two such photoproducts with SEQ-001 comprise two stereoscopic pairs. The top images from each is a pair; the bottom images from each is a pair. "STEREO-L" or "STEREO-R" identifies left or right. "L1.C1.AM" identifies the high-resolution mosaic from which the windows were extracted.

The pairs of photoproducts are identified along the top by an annotation label of the form:

STEREO-L SEQ-001 L1.C1.AM
STEREO-R SEQ-001 L1.C2.AM

The Special Products TDR catalogue (see Section IV.A.) gives information about the center of each image and its size. Since these "windows" were extracted from both standard and special stereo datasets, this distinction is also identified. Figures 14 and 15 illustrate the stereo pair products.

Table 6 summarizes these photoproducts.

TABLE 6

STEREOSCOPIC WINDOWS FROM THE MOSAICS

GRE PHOTOPRODUCTS

VL-1

SOURCE OF IMAGES		SEQUENCE RANGE (for Stereo-L Stereo-R pairs)	TDR ROLL #
FRONT	AM	SEQ-001 to SEQ-016	40
BACK	AM	SEQ-017 to SEQ-027	40
FRONT	PM	SEQ-058 to SEQ-063	48
BACK	PM	SEQ-064 to SEQ-074	48
HEIGHT=4, FRONT	AM	SEQ-075 to SEQ-078	51
BACK	AM	SEQ-079 to SEQ-084	51
CAMSEP=0, FRONT (note- can be used with VL-1, AM above to make CAMSEP=0.5)	AM	SEQ-085 to SEQ-099 and SEQ-154	51

VL-2

SOURCE OF IMAGES		SEQUENCE RANGE	TDR ROLL #
FRONT	AM	SEQ-035 to SEQ-041	48
BACK	AM	SEQ-049 to SEQ-051	48
FRONT	NOON	SEQ-028 to SEQ-034	48
BACK	NOON	SEQ-052 to SEQ-054	48
FRONT	PM	SEQ-042 to SEQ 048	48
BACK	PM	SEQ-055 to SEQ-057	48
HEIGHT=4, FRONT	AM	SEQ-155 to SEQ-160	51
BACK	AM	SEQ-161 to SEQ-165	51

2. Other Special Stereo Pairs

Numerous imaging pairs were acquired throughout the mission (notably of surface sampler arm related activities) that were not included as part of the high-resolution mosaic datasets. These individual pairs also require processing through the program VLSTEREO in order to be fusible. A total of 53 additional pairs of images were generated from these images.

The photoproducts were created on the GRE, and are identified along the top by labels of the format:

STEREO-L SEQ-100 11A055
STEREO-R SEQ-100 12A056

STEREO-L and STEREO-R together, both with SEQ-100, comprise a stereo pair. The terms "STEREO-L" or "STEREO-R" identify the left or right hand image. The sequence number "SEQ-100" identifies the stereo pair. "11A055" and "12A056" identify the camera events from which the image pair was produced.

Each negative has two images, vertically arranged from each other. The top of each pair has been processed with an apparent camera separation of 1.0. The bottom has been processed with a separation of 0.0. By using the top (or bottom) of a STEREO-L image with the bottom (or top) image of a STEREO-R image, the result is a pair with an apparent separation of 0.5.

These special stereo pairs are contained on TDR # 50 (SEQ-100 to 153).

D. Orthographic Projections

Thirteen (13) 8 x 10 inch Optronic products were created from the high-resolution mosaics that display the area near each lander as viewed from above. As for the stereoscopic images described in Section III. B., this transformation is a rubber-stretch algorithm that does not use the point-by-point information necessary to produce a true overhead representation.

Although these products are termed orthographic projections (analogous to overhead views as produced from orbiter images), the actual transformation treats camera azimuth and elevation as a polar gnomonic projection centered at a point directly below each camera.

The IPL PIC ID photoproducts created using this projection are summarized in Table 7. Figure 16 is an illustration of one of the orthographic projections.

TABLE 7

ORTHOGRAPHIC PROJECTIONS

VL-1

Camera 1, AM

PIC ID	AZIMUTH RANGE (in degrees)	ELEVATION RANGE (in degrees)
79/12/30/003608	60 to 160	-25 to -60
79/12/29/235241	150 to 215	-25 to -60
79/12/30/032214	25 to 105	-15 to -30
79/12/30/040900	95 to 175	-15 to -30

Camera 2, AM

PIC ID	AZIMUTH RANGE (in degrees)	ELEVATION RANGE (in degrees)
79/12/30/034701	130 to 195	15 to 30
79/12/30/041538	185 to 250	15 to 30
79/12/30/012037	120 to 220	25 to 60

Camera 2, PM

PIC ID	AZIMUTH RANGE (in degrees)	ELEVATION RANGE (in degrees)
80/03/14/061206	105 to 165	40 to 60

VL-2

Camera 1, Noon

PIC ID	AZIMUTH RANGE (in degrees)	ELEVATION RANGE (in degrees)
79/12/30/024400	55 to 315	25 to 60
79/12/30/043602	260 to 340	15 to 30
79/12/30/044245	330 to 50	15 to 30

Camera 2, Noon

PIC ID	AZIMUTH RANGE (in degrees)	ELEVATION RANGE (in degrees)
79/12/30/020334	10 to 110	25 to 60
79/12/30/050107	25 to 105	15 to 30

E. Map Products*

During the intensive data acquisition period of the Viking mission, virtually all of the available panorama was imaged in high resolution at multiple times of day by both cameras of both landers. Thereby, virtually all of the scene that was visible in common to both cameras on each lander was imaged stereoscopically. During and immediately following this period, an interactive computerized video stereophotogrammetry system (Liebes and Schwartz, 1977) installed at the Jet Propulsion Lab (JPL), was employed to generate topographic map information from the imaging data recorded by the lander cameras. The system consisted of a Stereo Station developed at

Stanford University, a computer, and a substantial computer program, RANGER, developed at JPL. The stereo station supported a pair of video monitors arranged so that they could be viewed stereoscopically by a photogrammetrist. Computer resident digital stereo imaging data could be called forth for display upon the video monitors.

The computer could be commanded to project upon the monitors an artificial three-space mark, consisting of a pair of appropriately coupled video dot overlay cursors. The photogrammetrist, viewing the displayed images stereoscopically, could employ a track ball to move the three-space video mark over the perceived relief. A most common operating mode involved commanding the computer to constrain the three-space mark to a selected member of a set of horizontal or vertical surfaces, for the purpose of enabling the generation of contours or vertical profiles. The task of the photogrammetrist then became the traditional one of moving the mark along his perception of the intersection of the mathematical surface of constraint with the Martian relief. In this manner, contours or profiles of any desired kind could be generated. The fundamental system product was a computer readable, and plottable, range data set (RDS).

Two general classes of topographic analysis were performed: one a study of feature specific detail, and the other a survey of the entire stereoscopically mappable surroundings of the two landers. The latter led to the preparation of publishable map material for the following:

1. Systematic contour map data (intersections with Mars of planes oriented perpendicular to the local Martian zenith), extending from the immediate foreground to the remote limits of ranging capability, in excess of 100 m range, for the front and back of both landers.

2. Systematic vertical profiles (intersections with Mars of planes radiating out from the lander and containing the local Mars zenith), at 5^{o} azimuth intervals, from the immediate foreground to the remote limits of ranging capability, for the front and back of both landers. The origin of these planes is the same as the origin of the Lander Aligned Coordinate System (LACS, see Liebes, et al [1977]).

The systematic map data, derived as it is from two cameras located approximately 0.8 m apart and 1.3 m above the nominal Martian surface, is of a quite unorthodox character. The ranging accuracy is approximately quadratically dependent upon range, with absolute single point ranging accuracy varying from +/- 1 cm near the lander to +/- 20 m at 100 m range. Relative accuracy of the data is judged to be approximately ten times better than these figures. The contour interval spacing varies from a few centimeters in the foreground to a meter at 100 or more meters range.

Bearing in mind that the ranging accuracy of the map data is highly range dependent, the policy adopted in producing the contour maps was to ensure that somewhere in the collection of delivered map materials there will be found, for any location, a sheet that is of such scale that a reader can visually examine the data to the limit of meaningful resolution for that location. This policy led to the production of contour maps at eleven different scales: 1:1, 1:2, 1:5, 1:10, 1:20, 1:50, 1:100, 1:200, 1:500, 1:1000, and 1:2000. The map grids are all standardized to a 50 cm square frame, thus, e.g. the single sheet at 1:2000 records map data out to 500 m in all directions from the centrally located lander. Multiple sheets are required at the smaller scales. There are 65 sheets for each lander.

All of the maps are formatted and produced by computer. The output device is a Varian Statos 4222 electrostatic printer/plotter, with 4224 styli spaced at 0.005 inch intervals over the 21.12 inch writing width.

The coordinate system is the Local Gravity-Normal (LGN) system, defined as follows: The LGN system is orthogonal and right-handed. The origin coincides with that of the Lander Aligned Coordinate System (LACS). the Z-axis points toward the zenith. The Y-axis points in the direction of the projection of the LACS-z-axis normal to the horizontal plane through the origin.

All sheets are configured about an identical 50 cm X 50 cm grid. The number of sheets at any given scale is variable, and governed by the dictates of the above stated policy. For any given scale the sheet complement is a set or subset of a contiguous, non-overlapping array. Figure 17 illustrates one of these products for VL-2 at a scale of 1:20. Since it has been reduced 2.5:1, all the detail is not legible.

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* This section is abstracted from presentations made at the Planetary Geology Principal Investigators' meetings of June, 1979 and January, 1980 by Sidney Liebes Jr. and Elliott C. Levinthal.

F. Contour and Vertical Profile Overlays

Thirty-two (32) 8 X 10 inch Optronics photoproducts display the systematic graphic representations of point-by-point 3-dimensional topographic information described in the previous section.

Both profile and contour datasets have been overlain on the high-resolution mosaic datasets (16 products). Contours have been superimposed on both STANDARD VLSTEREO mosaics (4 pairs) and SPECIAL VLSTEREO mosaics (4 pairs).

Each of these photoproducts is identified with a large-type descriptor in the format:

RANGE DATASET (CONTOURS) OVERLAIN
ON HIGH-RESOLUTION MOSAICS
IPL PIC ID 79/07/15/100746
L1.C1.AM.Q3+Q4

The term "RANGE DATASET OVERLAIN ON HIGH-RESOLUTION MOSAICS" identifies the type of product. Profile datasets are identified by the substitution of the word (PROFILES). The term "L1.C1.AM.Q3+Q4" refers to the high-resolution mosaic from which the product was made. The Image Processing Laboratory picture identifier (IPL PIC ID) is expressed as the date of creation on the computer (YY/MM/DD/HHMMSS). Figure 18 illustrates the profiles overlain on the mosaic of the scene at the back of Lander 2.

The stereoscopic products are identified by labels of the format:

RANGE DATASET (CONTOURS) OVERLAIN
ON STANDARD VLSTEREO MOSAIC
IPL PIC ID 79/09/04/071241
L1.C1.AM.Q3+Q4 (FRONT - LEFT EYE)

The term "RANGE DATASET (CONTOURS) OVERLAIN ON STANDARD VLSTEREO MOSAIC" identifies the type of product. The exaggerated stereoscopic pairs are identified with the term "RANGE DATASET (CONTOURS) OVERLAIN ON EXAGGERATED VLSTEREO MOSAIC". The other label information is as above, except for the additional term "FRONT - LEFT EYE" identical to the descriptions for the VLSTEREO products described in a previous section. Figures 19 and 20 are the contours overlain on the Standard VLSTEREO mosaic of the scene in front of VL-2 and form a pair that can be viewed stereoscopically.

A complete list of the IPL PIC ID's for all Range Dataset Overlay products may be found in Table 8.

TABLE 8

RANGE DATASET (RDS) OVERLAYS

IPL PIC IDs

HIGH RESOLUTION MOSAICS

VL-1

		Cam 1	Cam 2
Contours - Front	AM	79/07/15/100746	79/03/22/035818
Profiles - Front	AM	79/07/15/102049	79/06/06/021223
Contours - Back	AM	79/03/20/034017	79/07/15/112532
Profiles - Back	AM	79/03/20/044430	79/07/15/113640

VL-2

Contours - Front		AM	79/10/11/055137	79/03/15/022628
Profiles - Front		AM	79/10/11/060732	79/03/15/032905
Contours - Back		AM	79/04/04/030319	79/10/08/233417
Profiles - Back		AM	79/04/04/041347	79/10/08/234537

Standard VLSTEREO (Contours only)

			Cam 1	Cam 2
VL-1	Front	AM	79/09/04/071241	80/06/10/221347
VL-1	Back	AM	79/10/25/020224	79/09/04/070518
VL-2	Front	AM	79/09/03/064209	79/09/05/052010
VL-2	Back	AM	79/10/08/220956	79/08/11/035149

Enhanced VLSTEREO (Contours only)

			Cam 1	Cam 2
VL-1	Front	AM	79/06/16/011832	79/08/26/061348
VL-1	Back	AM	79/04/29/200756	79/05/05/103617
VL-2	Front	AM	79/06/08/014304	79/08/12/072833
VL-2	Back	AM	79/10/08/230320	79/05/05/092111

G. Movie, " Mars in 3-D "

1. Technical Description

The movie combines techniques of computer image processing, animation, and stereo movie technology. It includes some stereo scenes acquired by the Viking Orbiter cameras, shots taken at the Jet Propulsion Laboratory showing the operation of the Viking Lander Spacecraft, and the surface of Mars as viewed in three dimensions, at both lander sites, by the Viking Lander Camera System.

As described in Section III.B.1, a stereo pair of photographs can be used to present surface topography to the viewer. However, even with highly developed stereoscopes, it is difficult to convey a surface in its complete panoramic setting with a series of static images. A movie provides an answer to this problem. Converting the digital data received on earth from the flying-spot scanning cameras on Mars to a movie required a series of steps which are described below.

The essential first step was the creation of mosaics of scenes to be included in the movie. The procedure for doing this is described in section II. B. of this publication.

There remained another large computer processing task specifically directed toward stereo viewing. The two cameras on each spacecraft are separated by .8 meters (our eyes are separated by only 65 mm) causing objects in the near field to be at significantly different viewing angles and distances from each camera. This causes vertical displacements which are very difficult for the stereo viewer, and changes in scale for parts of the scene common to both left and right camera mosaics. These were removed by the next step in the process which was to carry out the transformation discussed in section III.B.1. It still is difficult for the stereo viewer to accomodate the large change in disparity from the horizon to the near field that remains due to the .8 meter camera separation.

The mosaics, transformed into a new stereo data set, were then outputted to an Optronics Photowriter which made a single 8 x 10 negative with a 50 micron spot size for the forward and backward facing scenes for each of the four cameras. These are available as separate photproducts and are described more fully in section III.B.1. Enlarged prints of these negatives were then used to lay out the scenario of the movie. An animation stand, used to the limit of its mechanical accuracy then carried out the specified "moves", pans, and zooms for the left and right hand original film material.

The orbiter scenes in the movie were also generated using animation techniques. The stereo pairs, provided by Karl R. Blasius of the Orbiter Imaging Team, required no special computer processing because of the simpler camera geometry involved. However because of the large effective stereo baseline, or separation of the orbiter spacecraft in acquiring the image pairs, there is a great deal of exaggeration of the vertical relief.

The live shots of the spacecraft were taken at the Jet Propulsion Laboratory by Paul Vlahos using a two-camera system with adjustable separation and convergence angle designed by Vlahos-Gottschalk for comfortable stereo viewing.

The musical accompaniment to "Mars in 3-D" was produced by William Schottstaedt and Michael McNabb at the Center for Computer Research in Music and Acoustics, Stanford University. The sound was generated with the Systems Concepts Digital Synthesizer controlled by a DEC PDP-10 general-purpose computer.

The choral-like sections were realized by first analyzing the spectral content of a soprano's voice using Fourier analysis programs, and then reconstructing it with the digital synthesizer. Subtle and precisely controlled shifts of timbre, special tuning systems, and changes in intonation and choral density are then possible, along with control over the apparent spatial position of each note.

The orchestral sections were produced using frequency modulation synthesis, wherein a complex harmonic spectrum results from the modulation of one or more frequencies by on or more other frequencies. By using two carriers with slightly mistuned modulators, the sound of an entire section of an orchestra can be produced by one computer "instrument". The pitched noise that appears prominently at the end is created by modulating the modulators themselves with a random number generator.

2. Available Forms of the Movie

The movie is available in two forms and two lengths. Each form uses a different method of achieving stereo separation for the audience. The polarized version uses left and right reels on two interlocked 16 mm projectors, each with oppositely polarized filters. The audience is provided with appropriately polarized glasses that allow each eye to see only the correct image. The screen must have a metalized surface that does not depolarize the images. In this form the movie can be viewed in true color and is, in fact, in color in some of the scenes. The two independent optical sound tracks allow the music to be presented, as created in stereo. The running time for the polarization version is 32 minutes. Since special equipment and an experienced projectionist are required to exhibit this version of the film, showings are expensive and have to be individually arranged. The second method uses anaglyph techniques for stereo separation. The lefteye and righteye films are printed through filters onto a single reel to give superimposed red and green images. In this case the audience is given glasses with red and green filters which again allow each eye to see only the correct image. The image is in black and white for the scenes which were black and white in the original material and "false" color in the remaining scenes. It can be shown using a single standard 16 mm projector with optical sound and a standard screen. Since there is only one sound track the music is not in stereo. Because the glasses significantly attenuate the light, it is necessary to produce a very bright image for comfortable viewing. This can be accomplished best by using a projector with a high intensity lamp and using a "high gain" screen such as aluminum (Ektalite), lenticular, or beaded. With such screens the light intensity decreases as the viewer moves off the axis of the projection beam. In all cases attention should be paid to providing seating only in a good viewing area. Kodak Publication No. S-18, Reflection Characteristics of Front-Projection Screen Materials gives detailed information. In showing a stereo movie it is particularly important that the audience not sit too close to the screen. Stereo is achieved because of the difference in parallax between the left and right eye views of the scene. This disparity results in a separation of the two images projected on the screen. In the case of the scenes of the surface of Mars this has been made equal to zero at the horizon but is much greater than the viewer would normally experience in the near field because the cameras are separated by .8 meters rather than the 65 mm normal interocular separation. The angular separation increases as one approaches the screen, requiring the viewers to go "wall-eyed" if they are too close. It is recommended that the audience sit at least twice the image width from the screen and the image width be no more than half of what ordinarily might be used in the auditorium in which the movie is being shown.

An anaglyph movie relies on exposing the magenta layer of three layered color film with the image for one eye and the cyan layer with the other image. Because the dyes are not perfect there are low level double images which only become apparent when there are, for example, very dark objects against a light background and, as in the near field, the separation is large compared to the size of the objects. To eliminate these problems and to make the movie more enjoyable for the viewer the anaglyph version has been edited to a 23 minute length. This edited version still contains all the important elements of the original movie and is the version recommended for most uses. For special purposes, a 32 minute anaglyph version and a video cassette of the 23 minute anaglyph version can be made available.

IV. PROCUREMENT OF PRODUCTS

A. Photoproducts

The photographic products, except for the movie, are available from the National Space Science Data Center (NSSDC), Code 601.4, Goddard Space Flight Center, Greenbelt, Maryland 20771. An order form is included in the back of this publication.

The complete photographic record of the Viking Mission, for the Lander Camera System is called the Experimenter Data Record (EDR). Tucker (1978) is a picture catalog of that record for the Primary Mission which covers the period touchdown until the transmission from both spacecraft was temporarily halted on November 7, 1976. Additional such catalogues are being published for the remainder of the mission. Tucker (1978), NASA reference publication 1007, is available from NSSDC on black and white microfiche. The NSSDC Data ID Number is 75-075C-06C-06E for Lander I and 75-083C-06E for Lander II. A limited number of the printed catalogues are also available from NSSDC. This catalogue should be used to order any individual EDR images. The individual images are available as 5 x5 inch frames or on 5 inch rolls. They have been contrast-enhanced to maximize the use of the gray scale of the photographic products. However, no digital filtering, or geometric or photometric corrections have been applied.

Those images of most general scientific interest have been assembled into what is called the Team Data Record (TDR). These were produced with the highest quality that could be achieved on the GRE described in section III.C. Essentially all the images which comprise the mosaic data sets are included in the TDR. Various versions of these images have been produced resulting from different computer enhancements. The TDR catalogue that describes the parameters of each image is available on microfiche. The NSSDC Data ID numbers are 75-075C-06K and 75-083C-06K for Landers I and II respectively. These catalogues should be used to order individual images which are supplied on 5 x 12 inch black and white film. These catalogues include the special products, listing data concerning all the Stereo Pair, 1 mil 3x, and Diffpix products and should be used for ordering these products.

Table 9 gives the NSSDC Data ID numbers for all the mosaic and derived products discussed in this publication. That number and the IPL PIC ID numbers given in the individual sections will permit 8 x 10 inch black and white negatives, contact prints and enlargements to be ordered from NSSDC.

TABLE 9

NSSDC DATA ID NUMBERS

NSSDC ID	NAME
	Lander 1
75-075C-06H	High-Resolution Mosaics Photographs
75-075C-06W	High-Resolution Mosaics Lithographs
75-075C-06I	Donut Projection
75-075C-06R	Standard VL Stereo
75-075C-06R	Special VL Stereo
75-075C-06R	Stereo Pairs
75-075C-06S	Orthographic Projection
75-075C-06T	Map Products - Contours
75-075C-06T	Map Products - Vertical Profiles
75-075C-06T	Contour Overlays
75-075C-06T	Vertical Profile Overlays
75-075C-06U	1 MIL, 3X
75-075C-06V	Diffpix
	Lander 2
75-083C-06H	High-Resolution Mosaics Photographs
75-083C-06W	High-resolution Mosaics Lithographs
75-083C-06I	Donut Projection
75-083C-06R	Standard VL Stereo
75-083C-06R	Special VL Stereo
75-083C-06R	Stereo Pairs
75-083C-06S	Orthographic Projection
75-083C-06T	Map Products - Contours
75-083C-06T	Map Products - Vertical Profiles
75-083C-06T	Contour Overlays
75-083C-06T	Vertical Profile Overlays
75-083C-06U	1 MIL, 3X
75-083C-06V	Diffpix
75-083C-10A	Backhoe Magnets

B. Magnetic Tapes

The EDR is available on 9-channel industry compatible digital magnetic tapes from NSSDC. The tape numbers and label record information is contained in Tucker (1978). Copies of the tapes can be procured from NSSDC.

The mosaic data sets are stored in digital form on a series of magnetic tapes described in section II.D.3. No formal procedure exists for generating additional copies. Inquiry about the digital data for both the mosaics and the derived products can be made to Ms. Kathy Lee, Regional Planetary Image Facility, Jet Propulsion Laboratory (JPL), 4800 Oak Grove Drive, Pasadena, California 91103 (213-354-3354).

The following table is a list of the digital products that have been delivered to various members of the Lander Camera Team and the addresses of the recipients.

TABLE 10

RECIPIENTS OF DIGITAL PRODUCTS

	MOSAICS (1)	CONTOUR VERTICAL OVERLAYS IN MOSAICS (2)	VLSTEREO STANDARD (3)	RANGE DATA SETS (4)	VLSTEREO OVERLAYS (5)	ALL OTHER PRODUCTS (6)
ARVIDSON	X	X	X	X		
HUCK	X	X	X			
JONES	X	X	X	X		
LEE	X	X	X			
LEVINTHAL	X	X	X	X	X	
MORRIS	X	X	X			
MUTCH	X	X	X	X		
POLLACK	X	X	X			
SAGAN	X	X	X			
IPL @ JPL	X	X	X	X	X	X

(1) 30 nine track/800 BPI for 2-sector portions of mosaics
10 nine track/1600 BPI for 4-sector complete mosaics
(2) 8 nine track/800 BPI tapes
(3) 20 nine track/1600 BPI tapes
(4) 9 nine track/800 BPI tapes for contour and vertical profile range data sets
18 nine track/800 BPI for arm-specific and miscellaneous range data sets
(5) 8 nine track/800 BPI contours only

LIST OF ADDRESSES OF RECIPIENTS OF DIGITAL PRODUCTS

Raymond E. Arvidson
McDonnell Center for the Space Sciences
Department of Earth and Planetary Science
Washington University, Box 1169
St. Louis, Missouri 63130
314-889-5679

Friedrich Huck
Mail Stop 473
Langley Research Center
Hampton, Virginia 23665
804-827-3761

Elliott C. Levinthal
Department of Genetics
Stanford University
Stanford, California 94305
415-497-5813

Elliot C. Morris
U.S. Geological Survey
601 East Cedar Avenue
Flagstaff, Arizona 86001
602-779-3311, ext. 1426

Image Processing Laboratory
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103

Kenneth L. Jones
Mail Stop 264-317
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
213-354-5942

Kathy Lee
Regional Planetary Image Facility
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
213-354-3343

Thomas Mutch
Department of Geological Science
Brown University
Providence, Rhode Island 02912
401-863-3339

James A. Pollack
Ames Research Center
Moffett Field, California 94035

Carl Sagan
Director, Laboratory for
Planetary Studies
Center for Radiophysics and
Space Research
Cornell University
Ithaca, New York 14850
607-256-4971

C. Lithographic Products

The lithographic products described in section II.D.2 can be procured either through the NSSDC or the United States Geological Services (USGS). See Table 9 for NSSDC ID numbers. They can also be procured from the USGS over the counter and by mail from the following two main distribution centers.

Branch of Distribution
U.S. Geological Survey
1200 South Eads Street
Arlington, Virginia 22202

Branch of Distribution
U.S. Geological Survey
Federal Center
Denver, Colorado 80225

They are ordered as "Atlas of Mars, Viking Lander Mosaic Series, Miscellaneous Investigators Map". The USGS identification number for the first set to be issued, VL-1, Morning Scene - Camera 2, is I-1243. The ID numbers for the remaining 9 sets have not as yet been issued. Further information about these can also be obtained from any of the Public Inquiries Offices of the USGS listed in Table 11 below.

TABLE 11

USGS PUBLIC INQUIRIES OFFICES

ALASKA

108 Skyline Building
508 Second Avenue
Anchorage, Alaska 99501

TEXAS

1C45 Federal Building
1100 Commerce Street
Dallas, Texas 75202

CALIFORNIA

7638 Federal Building
300 North Los Angeles Street
Los Angeles, California 90012

504 Custom House
555 Battery Street
San Francisco, California 94111

COLORADO

1012 Federal Building
1961 Stout Street
Denver, Colorado 80202

DISTRICT OF COLUMBIA

10288 General Services Building
19th and F Streets NW.
Washington, D.C. 20244

UTAH

8102 Federal Building
125 South State Street
Salt Lake City, Utah 84138

VIRGINIA

302 National Center
Reston, Virginia 22092

WASHINGTON

678 U.S. Court House
West 920 Riverside Avenue
Spokane, Washington 99201

D. Map Products

These products can be procured through the NSSDC. See Table 9 for NSSDC ID numbers.

E. Movie - "Mars in 3-D"

Copies of the 23 minute anaglyph 16 mm film version are available for both rental and purchase for non-profit use. Contact Code LFD-13, NASA Headquarters, Washington, D.C. 20546, telephone 202-755-3500. Further information on the availability of the movie in its various forms can be obtained by writing or telephoning Ms. Elsa Henderson, Room S047, Genetics Department, Stanford University Medical Center, Stanford, California 94305, (telephone: 415-497-5565 or 497-5141). The viewing glasses are provided with the rental film. They can be purchased from Deep-Vision 3-D Box 38386, Hollywood, Calif. 90038 (tel. 213-465-5819) for $75 for a box of 500. They are made using Roscogel filters no. 222, fire red, for the right eye and no. 258, light green-blue, for the left eye, available from Rosco, 36 Bush Avenue, Port Chester, N.Y. 10573 (tel. 914-937-1300).

F. Regional Planetary Image Facilities (RPIF)

Regional Planetary Image Facilities have been established by the Planetary Geology Program, NASA, at the institutions listed below. Each of the regional facilities is jointly sponsored by the institution and NASA. The RPIFs are primary reference libraries of space photography and provide access to the photographic and engineering data acquired by this country's space project for use by NASA's principal investigators, faculty, students and the general public. They are not facilities for reproduction of photographs for non-government funded investigators and the general public. The regional facilities will however provide valuable assistance in ordering data from NSSDC.

TABLE 12

REGIONAL PLANETARY IMAGE FACILITIES

SPACECRAFT IMAGERY CENTER
Lunar and Planetary Laboratory
University of Arizona
Tucson, AZ 85721
Facility Director:
Mr. Robert G. Strom
Librarian:
Gail S. Georgenson
(602/626-4861)

PLANETARY IMAGE FACILITY
Lunar and Planetary Institute
Houston TX 77058
Facility Director:
Dr. Peter H. Schultz
Librarian:
Ron Weber
(713/486-2172)

PLANETARY DATA FACILITY
Astrogeology Branch
U.S. Geological Survey
Flagstaff AZ 86001
Facility Director:
Dr. Elliot Morris
Librarian:
Jody Swann
(602/779-3311)
(FTS: 261-1505)

BROWN REGIONAL PLANETARY DATA CENTER
Brown University
Providence RI 02912
Facility Director:
Dr. James Head, III
Librarian:
John Crowley
(401/863-3243)

SPACECRAFT IMAGING CENTER
Cornell University
Ithaca NY 14853
Facility Director:
Dr. Joseph Ververka
Librarian
Margaret Dermott
(607/256-3833)

PLANETARY IMAGE FACILITY
McDonnell Center for Space Sciences
Washington University
St. Louis MO 63130
Facility Director:
Dr. Raymond E. Arvidson
Librarian:
Betty Weiss
(314/889-5679)

PLANETARY IMAGE FACILITY
Jet Propulsion Laboratory
California Institute of Technology
Pasadena CA 91103
Facility Director:
    Dr. R. Stephen Saunders
Librarian:
    Kathy Lee
    (213/354-3343)
    (FTS: 792-3343)

V. REFERENCES

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Huck, F. O.; McCall, H. F.; Patterson, W. R.; and Taylor, G. R,: The Viking Mars Lander Camera. Space Sci. Instrum., vol. 1, no. 2., pp. 189-241, May 1975.

Huck, Friedrich O.; Burcher, Ernest E.; Taylor, Edward J.; and Wall, Stephen D.: Radiometric Performance of the Viking Mars Lander Cameras. NASA TM X-72692, 1975.

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Liebes, Sidney, Jr.; and Schwartz, Arnold A.: Viking 1975 Mars Lander Interactive Computerized Video Spectrophotogrammetry. J. Geophys. Res., vol. 82, no. 28, pp. 4421-4429, Sept. 30,1977.

Mayo, A.P.; Blackshear, W.T.; Tolson, R.H.; Michael, W.H., Jr.; Kelly, G.M.; Brenkle, J.P.; and Komarek, T.A.: Lander locations, Mars physical ephemeris, and solar system parameters: determination from Viking Lander tracking data. Journal of Geophysical Research, vol. 82, no. 28, pp. 1297-1304, Sept. 30,1977.

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Morris, E.C. and Jones, K.L.; Revised Location of Viking 1 Lander on the Surface of Mars. Science (in press).

Patterson, William R., III; Huck, F. O.; Wall, S. D.; and Wolf, M. R.: Calibration and Performance of the Viking Lander Cameras. J. Geophys. Res., vol. 82, no. 28, pp. 4391-4400, Sept. 30, 1977.

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Wolf, Michael R.: Viking Lander Camera Geometric Calibration Report. Volume 1. Publ. No. 79-54, Jet Propul. Lab., California Inst. Technol., , 1980.

VI. ACKNOWLEDGEMENTS

It is not possible to acknowledge all the individual contributions to the creation of the Viking Lander Camera Mosaics. The project was under the general supervision of Elliott Levinthal, Genetics Department Stanford University, representing the Lander Imaging Team. The process started with the generation of the appropriate camera commands for the necessary high-resolution images. During most of the nominal mission this was the responsibility of Alan Binder, Institut fur Geophysic, University of Kiel. It then came under the direction of C.E. Carlston, Martin Marietta Company.

The techniques for successful data recovery and bit error removal from the from the imagery acquired from individual camera events were developed by Kenneth L. Jones, Brown University. From data, incorporating these corrections, the database for the Mosaics, the Experimental Data Record (EDR), was generated under the guidance of Robert Tucker.

The computer-formatting of the Mosaics, using the methodology outlined in this description was carried out in the Image Processing Laboratories (IPL) of the Jet Propulsion Laboratory. IPL was then under the management responsibility of William Green. The mosaicking task at IPL was initiated in August of 1976 under J.W.Berry. The initial mosaics were then generated by Steven Albers. The initial work on the final mosaics was carried out by Joel A. Mosher. There can be no doubt, however, that the major credit for the perseverance, diligence, and attention to detail necessary to complete the task of computer generation of these Mosaics belongs to Susan LaVoie, who worked under the supervision of Arnold A. Schwartz. The final Mosaic photoproducts were delivered in April, 1978.

The production of the Mosaic lithographics sheets in their final form is being carried out by the U.S. Geological Survey, Flagstaff, Arizona, under the general supervision of Elliot C. Morris.

The special transformations, "Donut", VLStereo, orthographic, which formed the basis of the derived products were due to the efforts of Dr. Kenneth L. Jones. Dr. Sidney Liebes Jr., Stanford University, was responsible for the map products. The contours and vertical profiles used in the overlay products involved the joint efforts of Dr. Liebes and Arnold A. Schwartz, of JPL's IPL, in designing RANGER and in carrying out the ranging activities using the Stereo Station designed by Dr. Liebes.

Dr. Levinthal was the producer and Dr. Jones the director of the movie, "Mars in 3-D".

Special note should be made of the fact that for the period since April 1978, Dr. Jones and Sue LaVoie took complete responsibility for the IPL and JPL efforts in generating these products.

APPENDIX I

USE OF THE MOSAICS FOR PHOTOGRAMMETRY

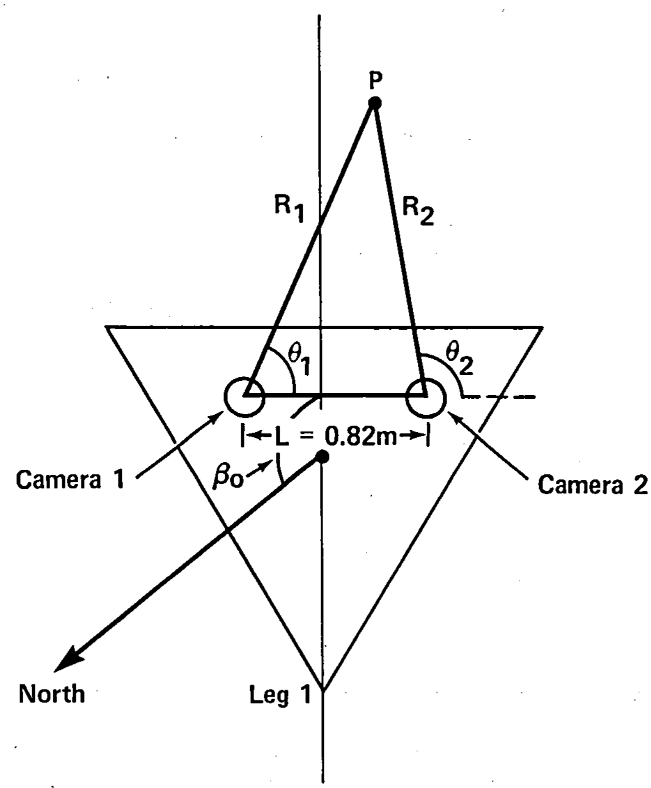
A. Approximate method of ranging using mosaic photoproducts and lithographs

This method, suggested by S. Liebes, Jr., does not take into account the change in the inter-camera distance L due to the tilt of the spacecraft. It is accurate to about 1%.

1. Specify the Azimuth angle from north for the common point to be ranged found in the camera 1 and camera 2 mosaics. Call these angles Az_{1N} and Az_{2N}. These angles should be corrected, for points below the horizon, as shown in Table 1.

2. $Az_{1N} = \beta_0 + 90^\circ - \theta_1$

   $Az_{2N} = \beta_0 + 90^\circ - \theta_2$



β_0 = Azimuth of Z direction in LACS
= 141.627° for Lander 1
= 29.077° for Lander 2

For Lithographic products where bolt-down corrections have been made to the scale Azimuth Angle from North.

$$R_1 = L \frac{\sin(180 - \theta_2)}{\sin(\theta_2 - \theta_1)} = L \frac{\sin(Az_{2N} - \beta_o + 90^o)}{\sin(Az_{1N} - Az_{2N})}$$

$$R_1 = L \frac{\sin(\beta_o + 90^o - Az_{1N})}{\sin(Az_{1N} - Az_{2N})}$$

3. For photoproducts, corrections are required for bolt-down errors and for Lander 1, an additional 3.91^o ccw correction.

For Lander 1

$$R_1 = L \frac{\sin(Az_{2N} - 3.91 + Btn_2 - \beta_o + 90^o)}{\sin(Az_{1N} - Az_{2N} + Btn_1 - Btn_2)}$$

$$R_1 = .82 \frac{\sin(Az_{2N} - 55.71)}{\sin(Az_{1N} - Az_{2N} - .68)} \text{ meters and}$$

$$R_2 = .82 \frac{\sin(\beta_o + 90^o + 3.91 - Btn_1 - Az_{1N})}{\sin(Az_{1N} - Az_{2N} + Btn_1 - Btn_2)}$$

$$R_2 = .82 \frac{\sin(236.39 - Az_{1N})}{\sin(Az_{1N} - Az_{2N} - .68)}$$

where $Btn_{1 \text{ or } 2}$ refers to the bolt-down errors for cameras 1 and 2

and for Lander 2 we have

$$R_1 = .82 \frac{\sin(Az_{2N} + 60.70)}{\sin(Az_{1N} - Az_{2N} - .70)} \text{ meters and}$$

$$R_2 = .82 \frac{\sin(120.00 - Az_{1N})}{\sin(Az_{1N} - Az_{2N} - .70)} \text{ meters}$$

B. Method used by RANGER to give pointing direction in LACS

This section of the appendix details the method used by RANGER to convert pixel position in a Viking Lander mosaic image to a pointing direction given in the Lander aligned coordinate system (LACS). The detilted mosaic images have been transformed to a system whose axis is aligned with the local Mars gravity normal. This method takes into account all the errors identified in Section II.B.3 except those due to the difference between pre- and post-entry LPAG calculations. These differences could result in small changes in the rotation matrix T.

1. Given a detilted Viking Lander mosaic image, first identify a pointing direction by specifying the IPL line and sample positions. Let L = line and S = sample.

2. Calculate the azimuth (a) and the elevation (e) from

$$a = a_o + 0.04^*(S-1)$$

$$e = e_o - 0.04^*(L-1)$$

where a_o is a function of which mosaic product is used.

0.0 for 2-sector mosaic, Q1 + Q2, sector 1 and 2 lithographs and 4-sector products covering Q1+Q2+Q3+Q4

84.0 for 2-sector mosaic, Q2 + Q3
168.0 for 2-sector mosaic, Q3 + Q4 and sector 3 and 4 lithographs

e_o is 5.0

(The azimuth values relate to the fact that each quadrant is 2250 IPL samples long, and there is an overlap of 151 samples between sectors.)

3. It is useful at this point to consider the form of the mosaics as used by the program RANGER. For a ranging session, a camera 1 and camera 2 image pair was extracted from the detilted mosaics. The extracted segment was about two sectors long (4350 samples) but did not start on a sector boundary. The start azimuths for the ranging mosaics is:

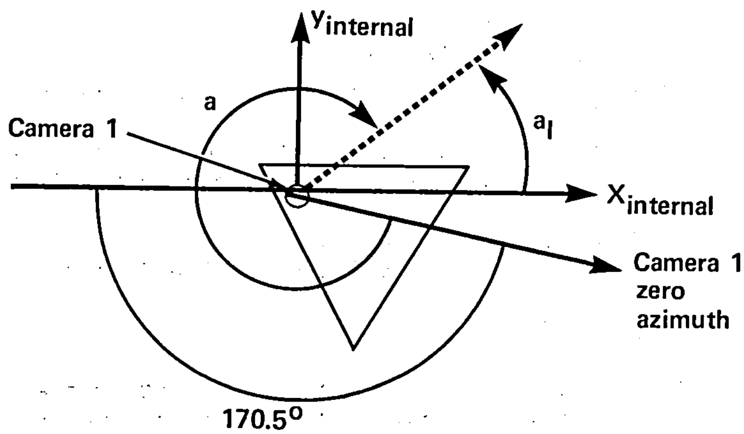
170.0 for camera 1 front
0.0 for camera 2 front
360.0 for camera 1 rear
174.0 for camera 2 rear

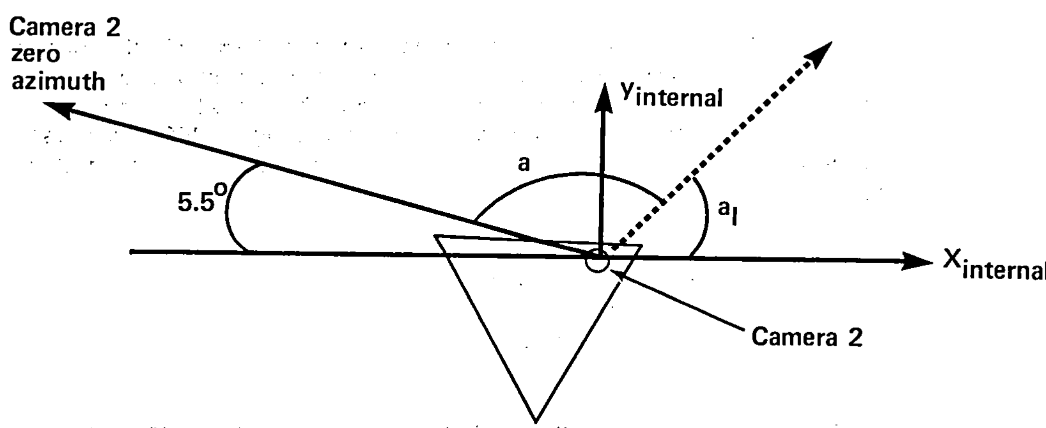
4. After calculating the azimuth and elevation as described in item 2 above, calculate the RANGER azimuth

$$a_I = 180 - (a - 170.5) \text{ for camera 1}$$

$$a_I = 180 - (a + 5.5) \text{ for camera 2}$$

* This section of the appendix is derived from a memo written by Arnold A. Schwartz, JPL.

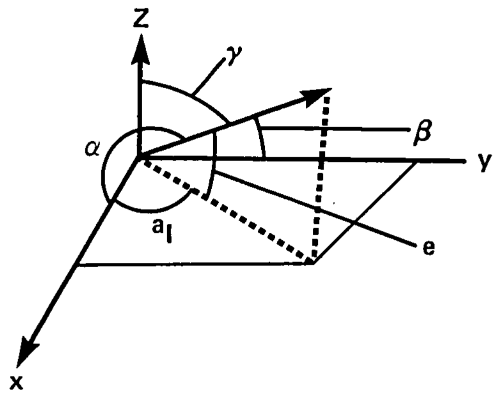




The RANGER internal azimuth is measured counterclockwise from the $x_{internal}$ axis, which is parallel to the negative y LACS axis.

5. Generate the direction cosines of the viewing direction.

$$\vec{v} = \begin{pmatrix} \cos\alpha \\ \cos\beta \\ \cos\gamma \end{pmatrix} = \begin{pmatrix} \cos a_l \cos e \\ \sin a_l \cos e \\ \sin e \end{pmatrix}$$



6. Transform to LACS coordinates:

$$S = (T) \quad (V) = \begin{pmatrix} S_1 \\ S_2 \\ S_3 \end{pmatrix}$$

where T is a 3 by 3 rotation matrix which is a function of camera and lander. The matrix values are defined below. The elements of the S vector are the direction cosines of the viewing direction given in LACS coordinates.

$$L1\ C1,\ T = \begin{pmatrix} -0.0309362 & +0.0406977 & -0.9986925 \\ -0.9994010 & +0.0142363 & +0.0315383 \\ +0.0155012 & +0.9990699 & +0.0402329 \end{pmatrix}$$

$$L1\ C2,\ T = \begin{pmatrix} -0.0316184 & +0.0423075 & -0.9986042 \\ -0.9994932 & +0.0022760 & +0.0317429 \\ +0.0036158 & +0.9991019 & +0.0422141 \end{pmatrix}$$

$$L2\ C2,\ T = \begin{pmatrix} +0.1329880 & +0.0517036 & -0.9897681 \\ -0.9910388 & +0.0195218 & -0.1321389 \\ +0.0124900 & +0.9984715 & +0.0538364 \end{pmatrix}$$

$$L2\ C2,\ T = \begin{pmatrix} +0.1322667 & +0.0518658 & -0.9898563 \\ -0.9912130 & +0.0082630 & -0.1320151 \\ +0.0013321 & +0.9986196 & +0.0525030 \end{pmatrix}$$

7. Finally one must take into account the locations of cameras in the LACS coordinate system as given below.

LANDER 1 (LACS coordinates)

	CAM 1	CAM 2
X	-1.58348	-1.58307
Y	+0.41249	-0.4062
Z	+00.46911	+0.47101

LANDER 2 (LACS coordinates)

	CAM 1	CAM 2
X	-1.58269	-1.58353
Y	+0.40811	-0.40906
Z	+0.46899	+0.46847

APPENDIX II

OTHER TEAM DATA RECORD SPECIAL PRODUCTS

The following is a description of other special TDR photoproducts which are not derived from the mosaic data sets. A complete listing of each of these products is given in the Special Products TDR catalogue which may be ordered from NSSDC.

A. 1-Mil, 3X

An 8-mil scanning spot size is normally used on the GRE for both black-and-white and color TDR photoproducts. The only exceptions are the products labelled (1-mil, 3X) which are produced on the GRE with a 1-mil spot size. These are individual lander images. Since the image would be rather small (one-eighth the size of the regular TDRs), the images are computer-expanded 3 times in both horizontal and vertical dimensions prior to GRE playback. Additionally, a "smoothing" algorithm is employed to avoid a blocky appearance. It was found that these 1-mil products, when enlarged to a greater size, appear far more like conventional photographs than do the 8-mil products. This is mainly because a 1-mil spot approximates the resolution limit of the original negative film. An additional advantage of these photoproducts is that they can contain a much larger contiguous image than is possible using an 8-mil spot size. Enlargements from these negatives were used extensively in the NASA Special Publication SP-425, "The Martian Landscape". (This publication, Library of Congress Catalog # 78-6060041, is available from the Government Printing Office, Superintendent of Documents, Washington, D.C. 20402.)

Each photoproduct is labelled vertically along the left edge with an annotation label of the form :

1-MIL,3X   12A001   VER-C   SEG-1/1

The term "1-MIL,3X" designates the type of product. "12A001" designates the camera event; "VER-C" designates that a version C (convolution filtered) input image was used, and "SEG-1/1" designates that only one segment exists for this image. A more extensive explanation of the various versions (A,B,C,D) may be found in a descriptive catalog for the Primary Mission Team Data Record.

These products are contained in TDR rolls as follows:

TDR # 43 VL-2
TDR # 44 VL-1
TDR # 51 VL-1, VL-2
TDR # 54 VL-1, VL-2

B. DIFFPIC

The term "DIFFPIC" refers to a program at the Image Processing Laboratory which performs a picture differencing operation on two input images. The two images are vertically and horizontally positioned relative to each other, the numberical difference taken on a pixel-by-pixel level, the result biased to the mid-range of the gray scale, and the result contrast stretched over the brightness range. Any value that varies from mid-range gray appears either brighter or darker than in the original image. The major purpose of picture differencing is to search for changes at the two lander sites.

Each photoproduct is labelled along the left edge with an annotation label of the form:

DIFFPIC SEQ-024 SEG-1/1
11F193BB3 MINUS 11C033BB33

The term "DIFFPIC" describes the type of product. "11F193" and 11C033" are the two images being compared. The sequence numbers run from "Seq-1" through "Seq-102" for the DIFFPIC photoproducts. "SEG-1/1" designates that only one segment exists for this image.

Histogram information is provided at the right side of the last segment of each image. There are four histograms, corresponding to the two input images, the difference between the two images, and the contrast stretched difference between the images. INPUT1 is the lower numbered frame count (in the above example C033) and INPUT2 is the higher numbered frame count (F193). All DIFFPIC products in the TDR have been differenced so that the time sense has been preserved -- that is, if the result is brighter than mid-range gray, the scene has become brighter over time.

These products are contained in TDR rolls as follows:

TDR # 46	VL-1
TDR # 49	VL-2

C. Special

These special photoproducts, depicting images important to the magnetic properties experiment, were included in the TDR. One product (Special 003) was included in TDR Roll # 40, and two products (Special 001,2) on TDR Roll # 49. These depict the backhoe magnets on the surface sampler arm on Viking Lander 2.

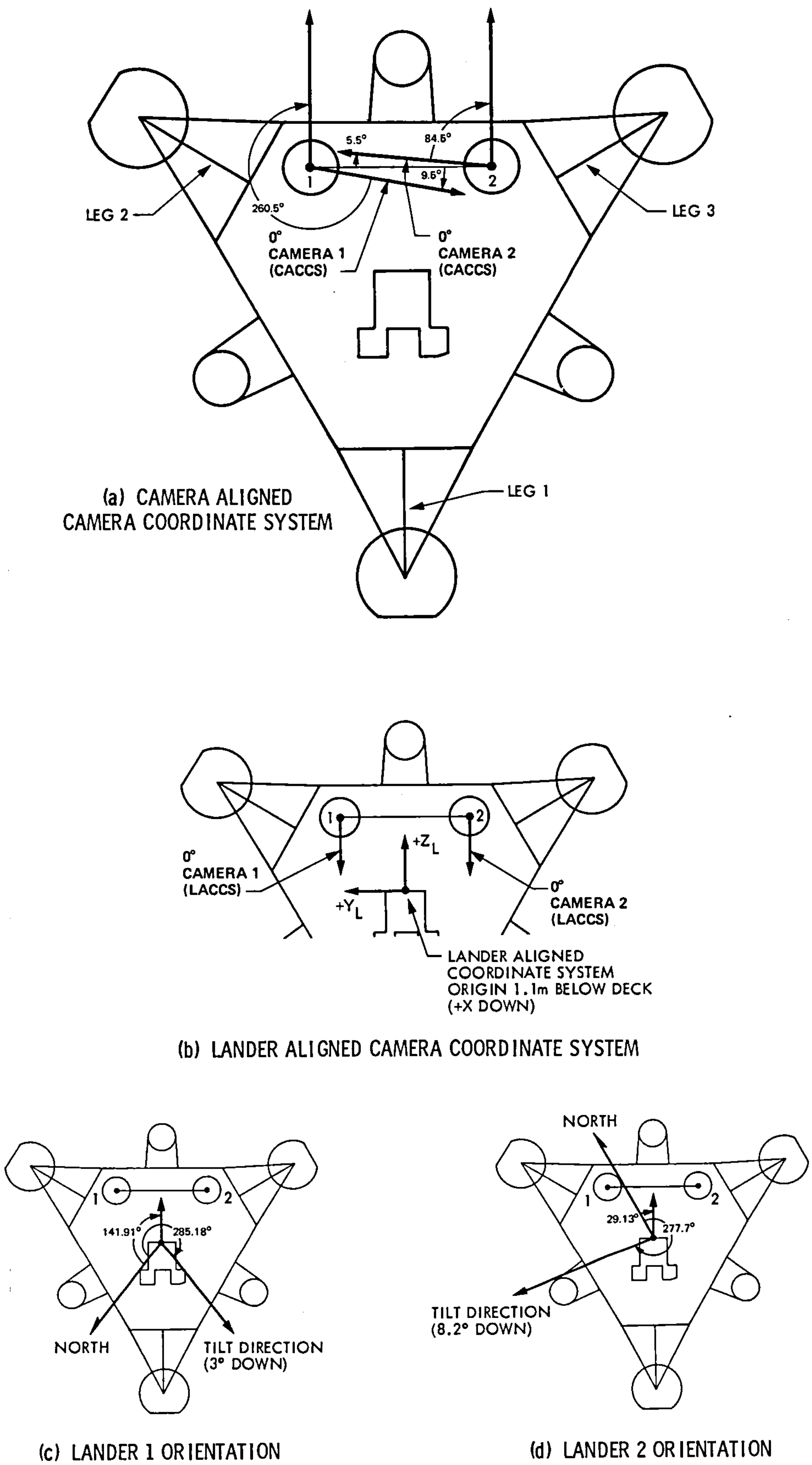


Figure 1. Camera Coordinate Systems and Orientation of Landers.

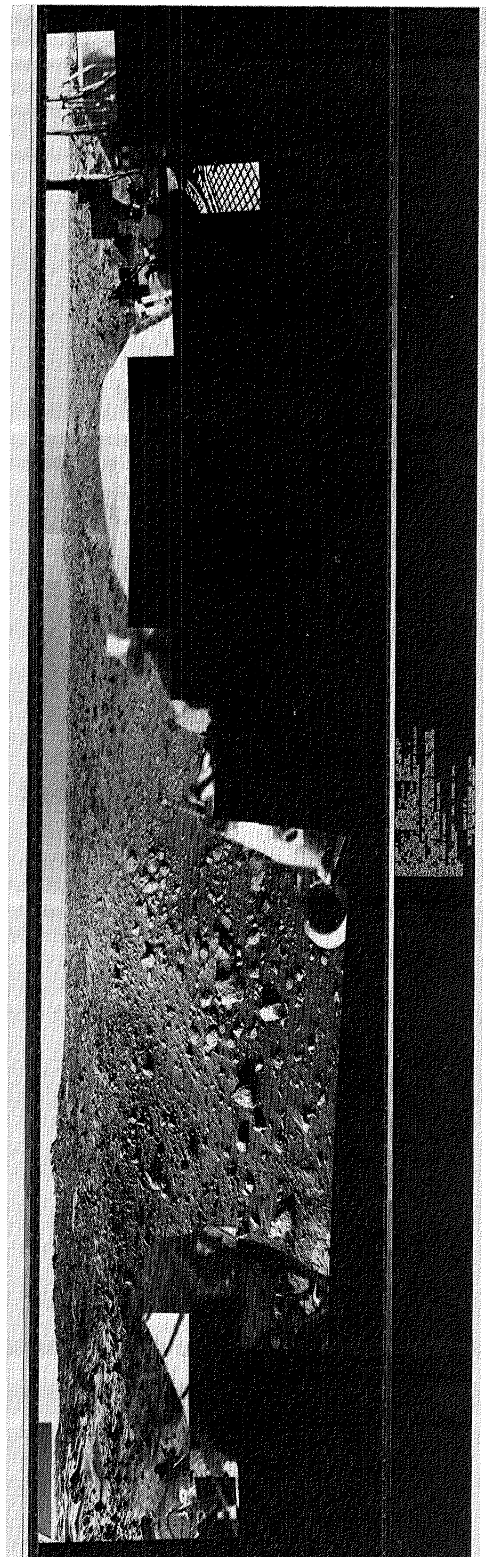


Figure 2. 4-Sector Mosaic, L1.C2.AM, IPL PIC ID 77/10/21/012442.

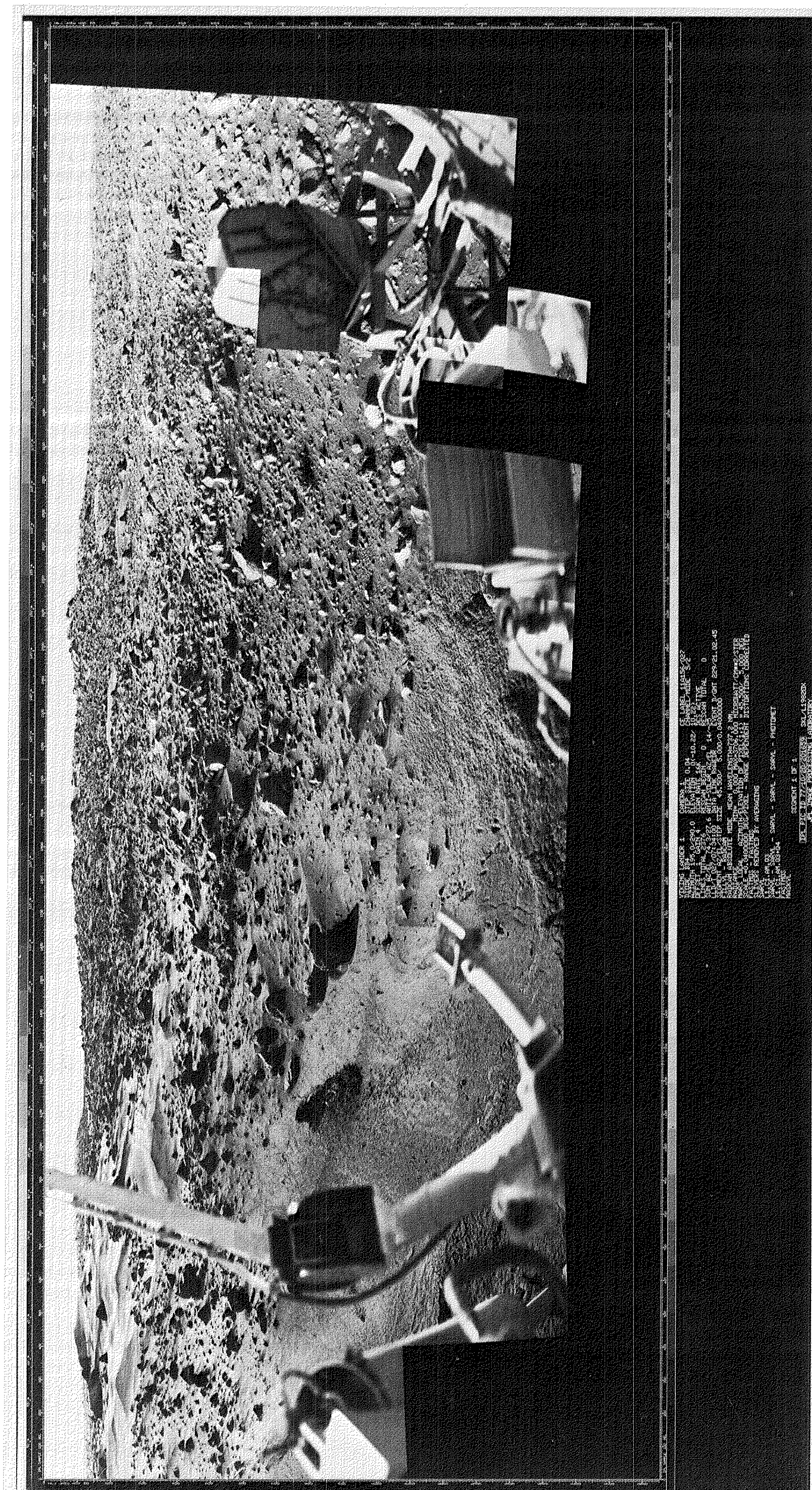


Figure 3. 2-Sector Mosaic, L1.C1.AM, Q3+Q4, IPL PIC ID 77/10/20/201659.

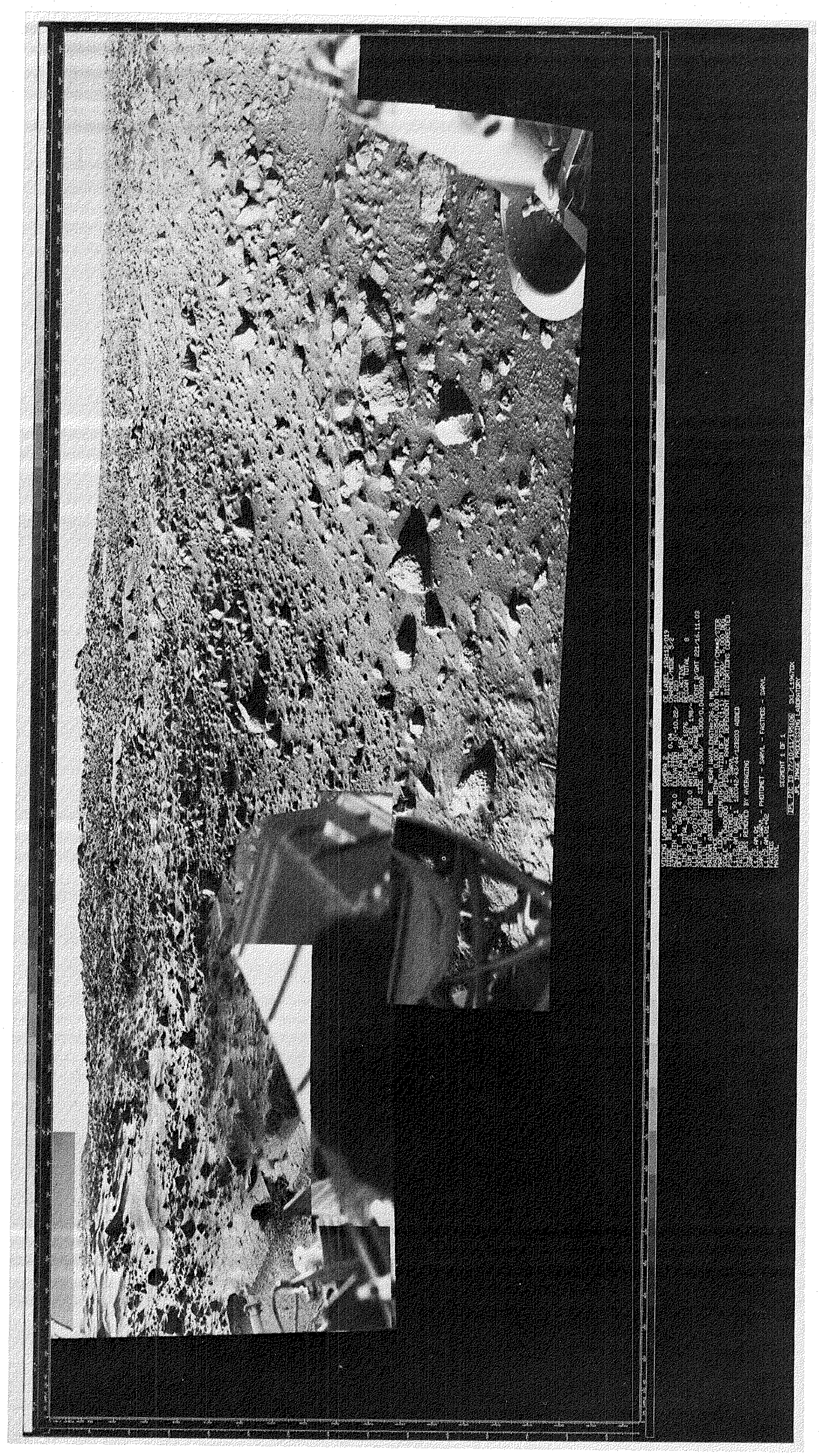


Figure 4. 2-Sector Mosaic, L1.C2.AM, Q1+Q2, IPL PIC ID 77/10/11/195106.

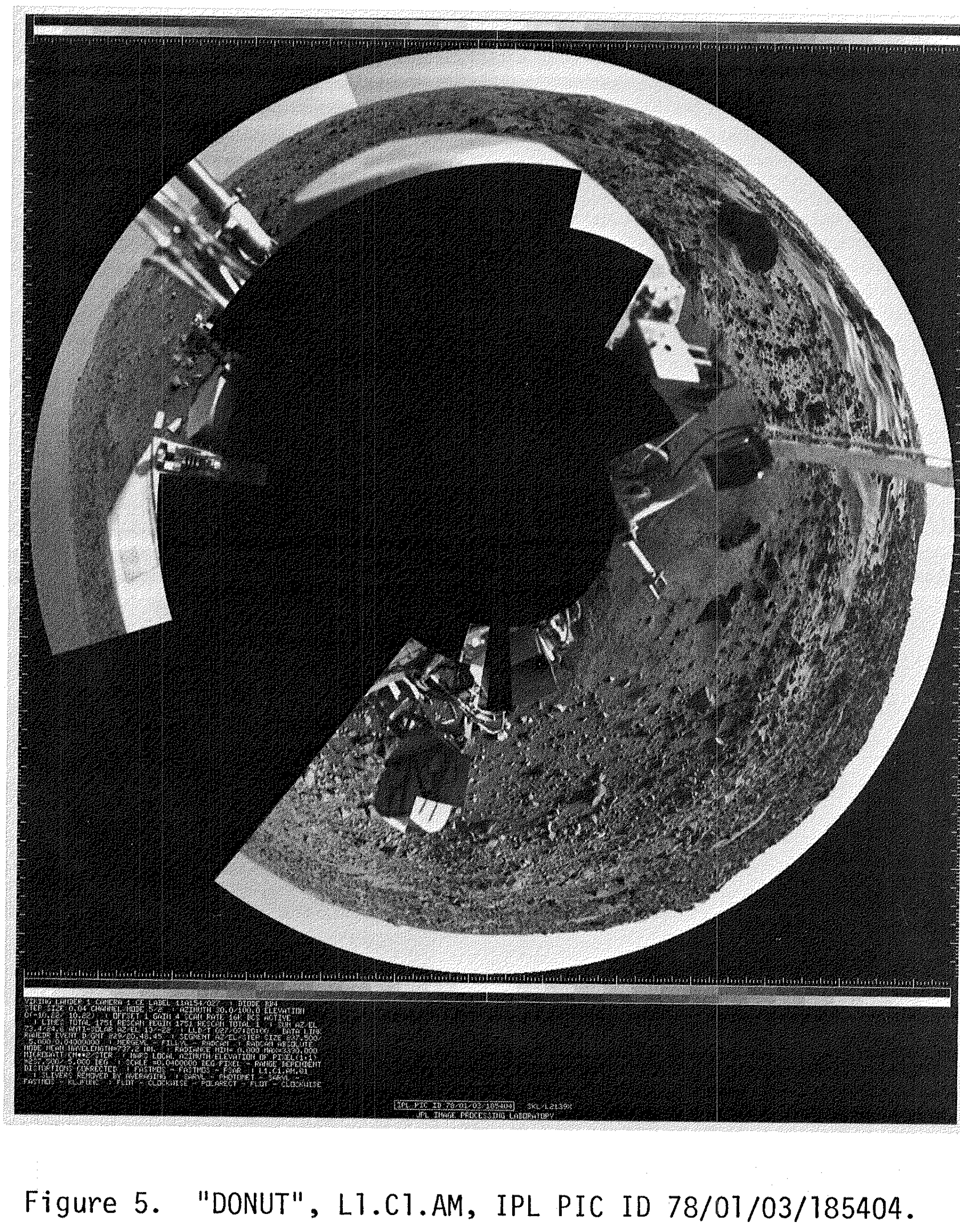


Figure 5. "DONUT", L1.C1.AM, IPL PIC ID 78/01/03/185404.

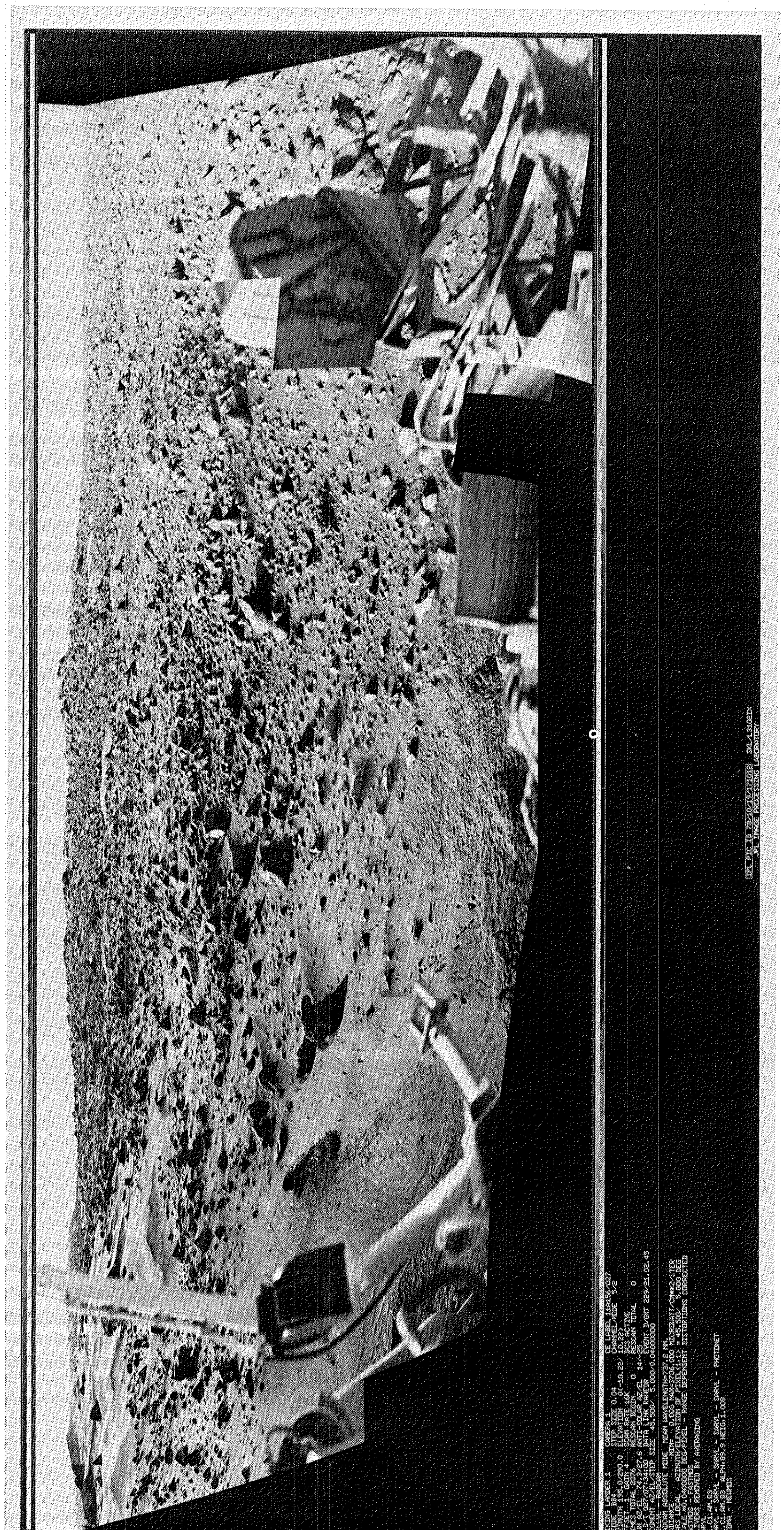


Figure 6. VL Stereo, L1.C1.AM, Q3+Q4, IPL PIC ID 78/10/19/171012 (Front - Left Eye).

Figure 7. VL Stereo, L1.C2.AM, Q1+Q2, IPL PIC ID 78/10/19/175118
(Front - Right Eye).

Figure 8. Special VL Stereo L1.C1.AM, Q3+Q4 IPL PIC ID 78/10/10/185301
(Front - Left Eye - CAMSEP = 0).

Figure 9. Special VL Stereo L1.C1.AM, Q1+Q2 IPL PIC ID 78/09/08/113258
(Front - Right Eye - CAMSEP = 0).

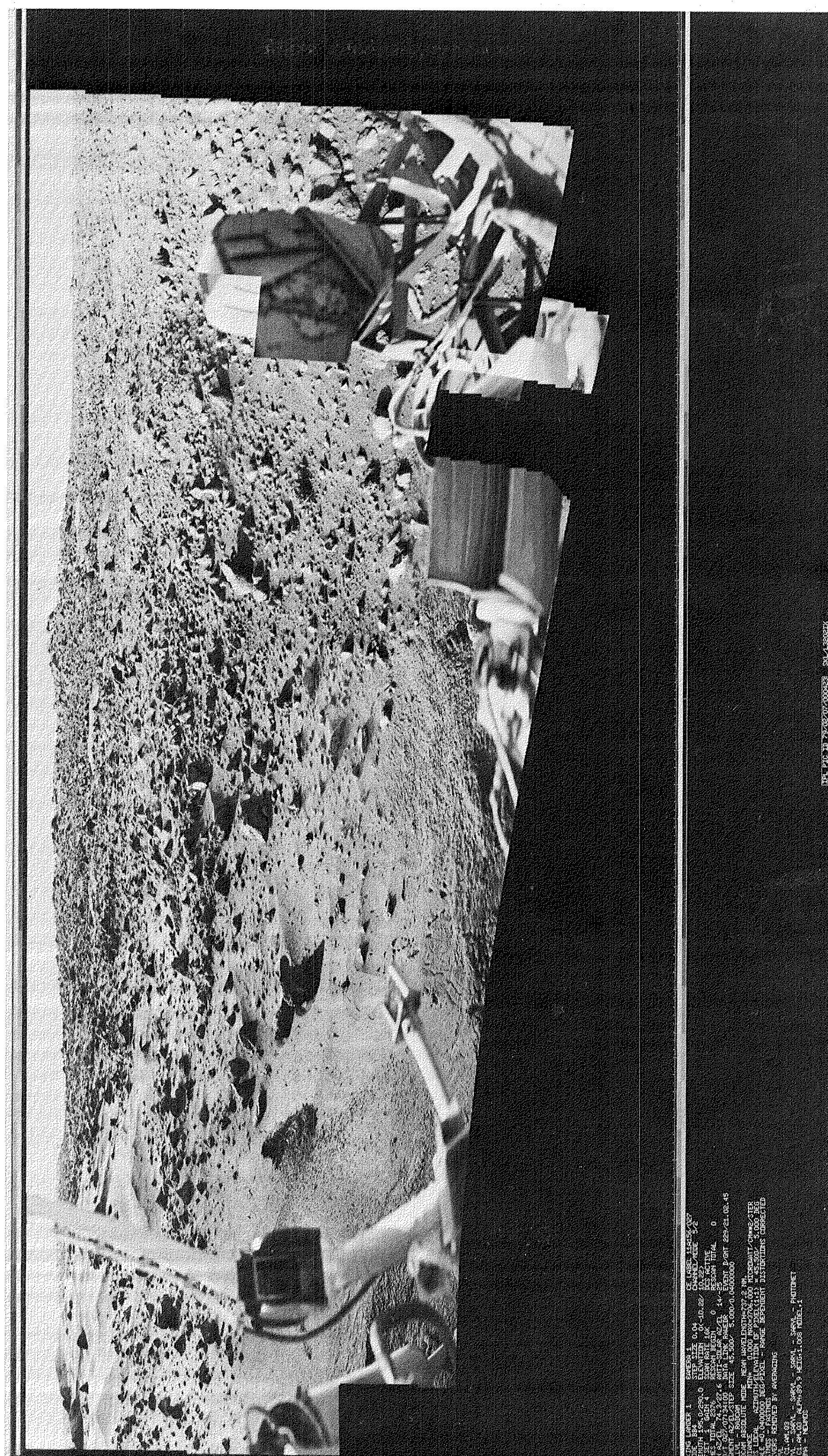


Figure 10. Special VL Stereo, L1.C1.AM, Q3+Q4 IPL PIC ID 79/02/07/000423 (Front - Left Eye - Nodel) Uncorrected for Changing Apparent Camera Separation With Azimuth.

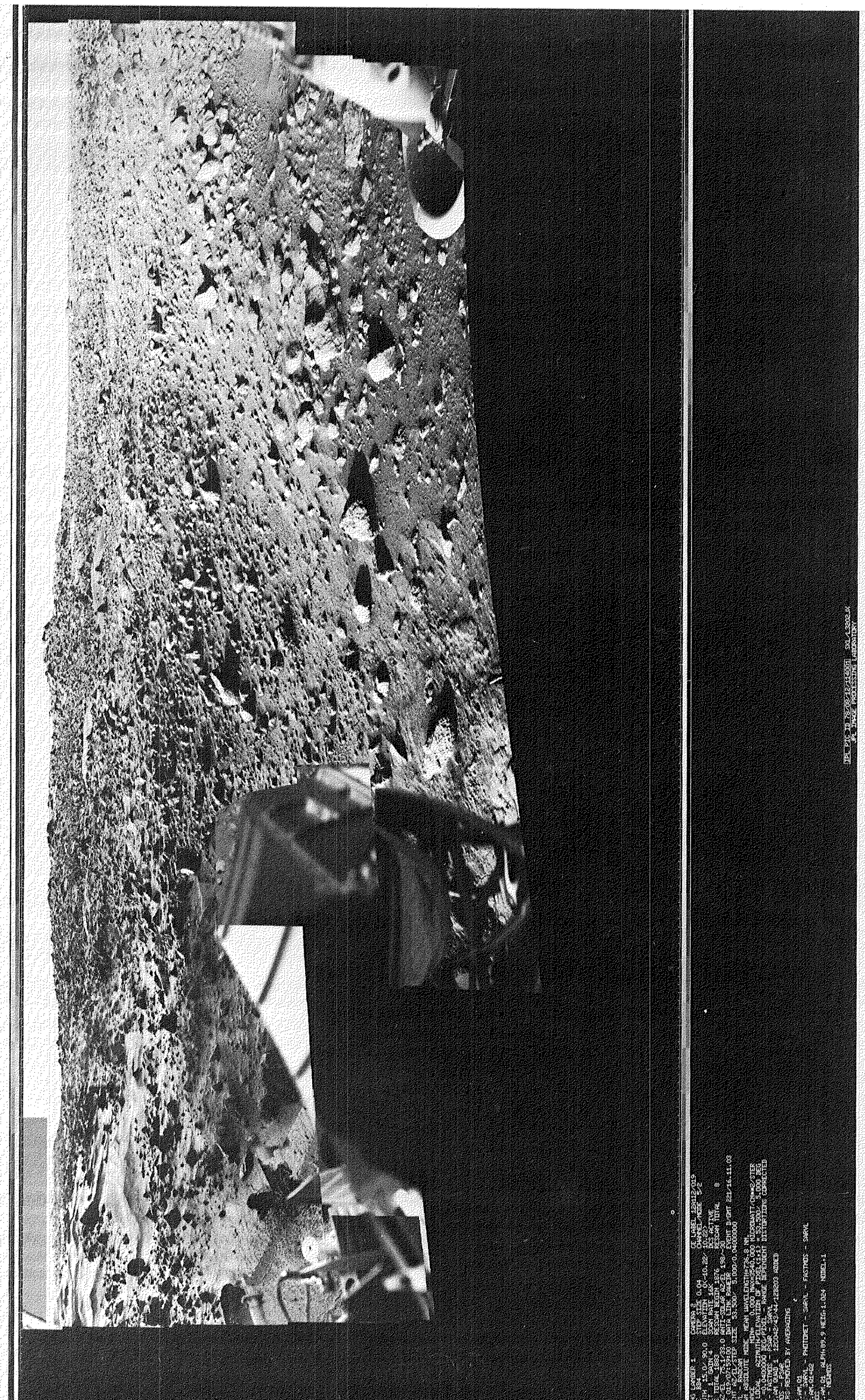


Figure 11. Special VL Stereo, L1.C1.AM, Q1+Q2 IPL PIC ID 78/08/12/114001 (Front - Right Eye - Nodel) Uncorrected for Changing Apparent Camera Separation With Azimuth.

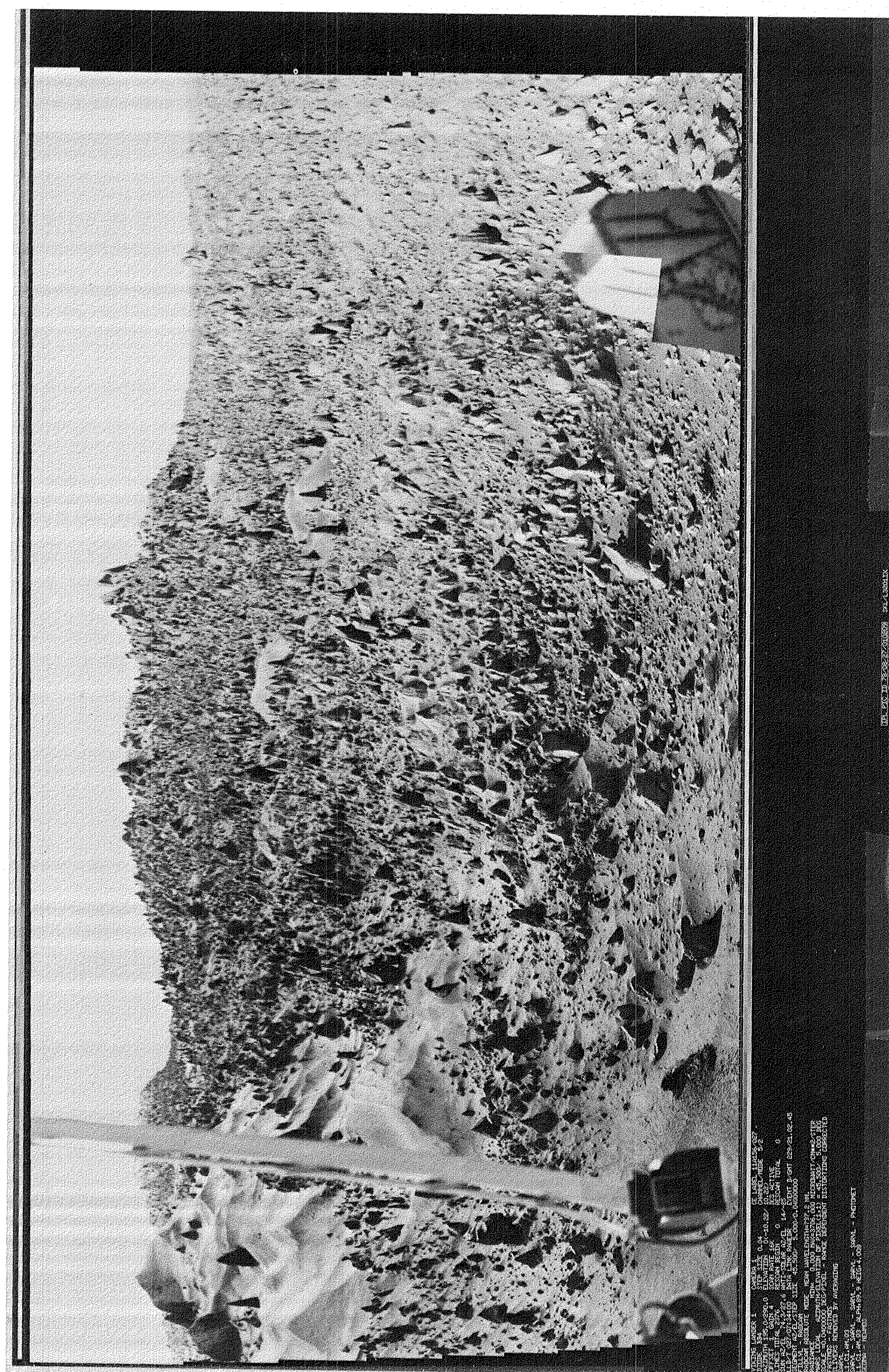


Figure 12. Special VL Stereo, L1.C1.AM, Q3+Q4 IPL PIC ID 78/08/27/010209 (Front - Left Eye - Height=4) Apparent Camera Height 4.008, Slant 60.0.

Figure 13. Special VL Stereo, L1.C1.AM, Q1+Q2 IPL PIC ID 78/08/06/222439
(Front - Right Eye - Height=4) Apparent Camera Height 4.024, Slant 60.0.

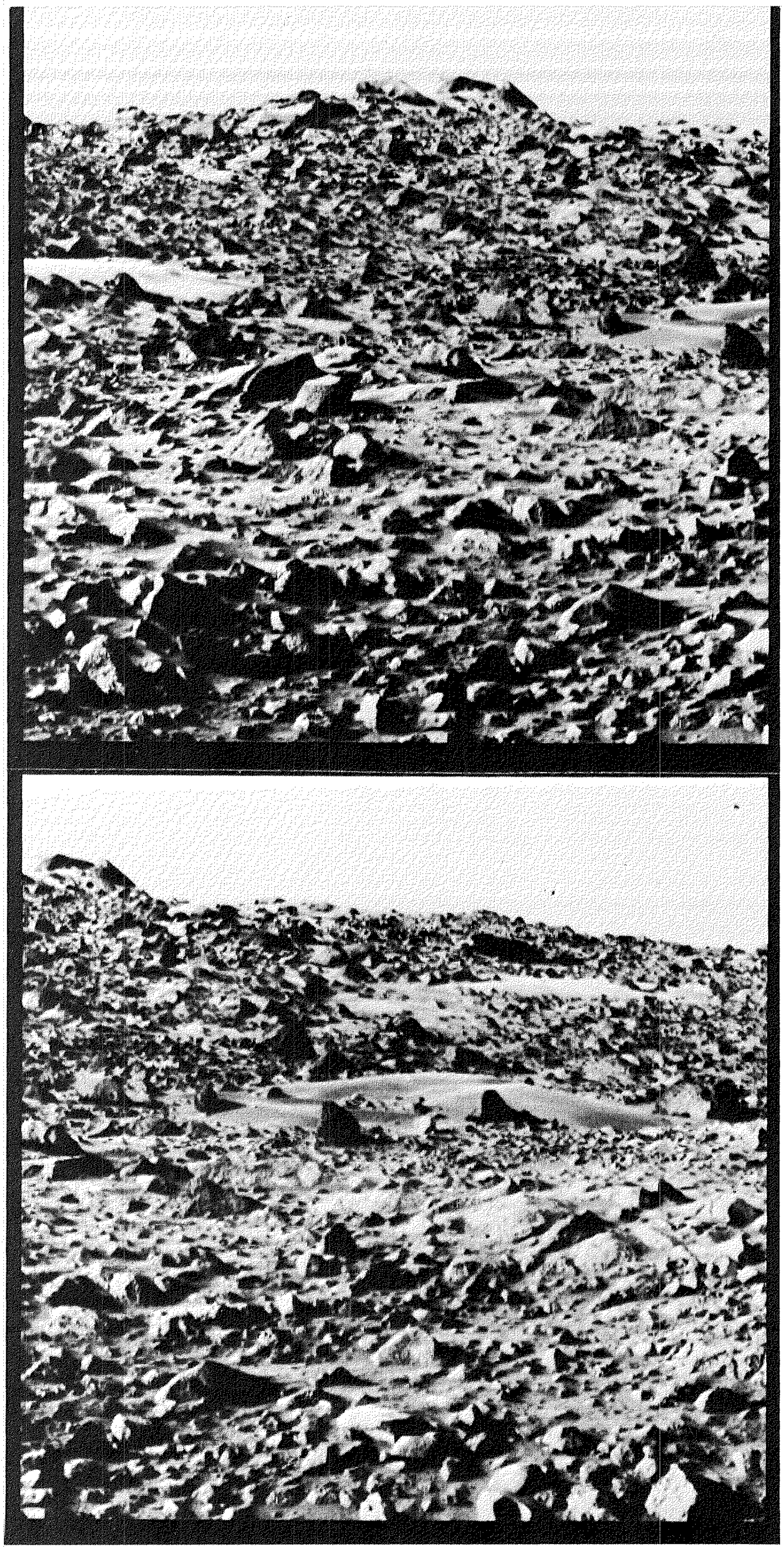


Figure 14. Stereo Pair L1.C1.AM, Stereo-L IPL PIC ID 78/06/10/093912 (SEQ - 004).

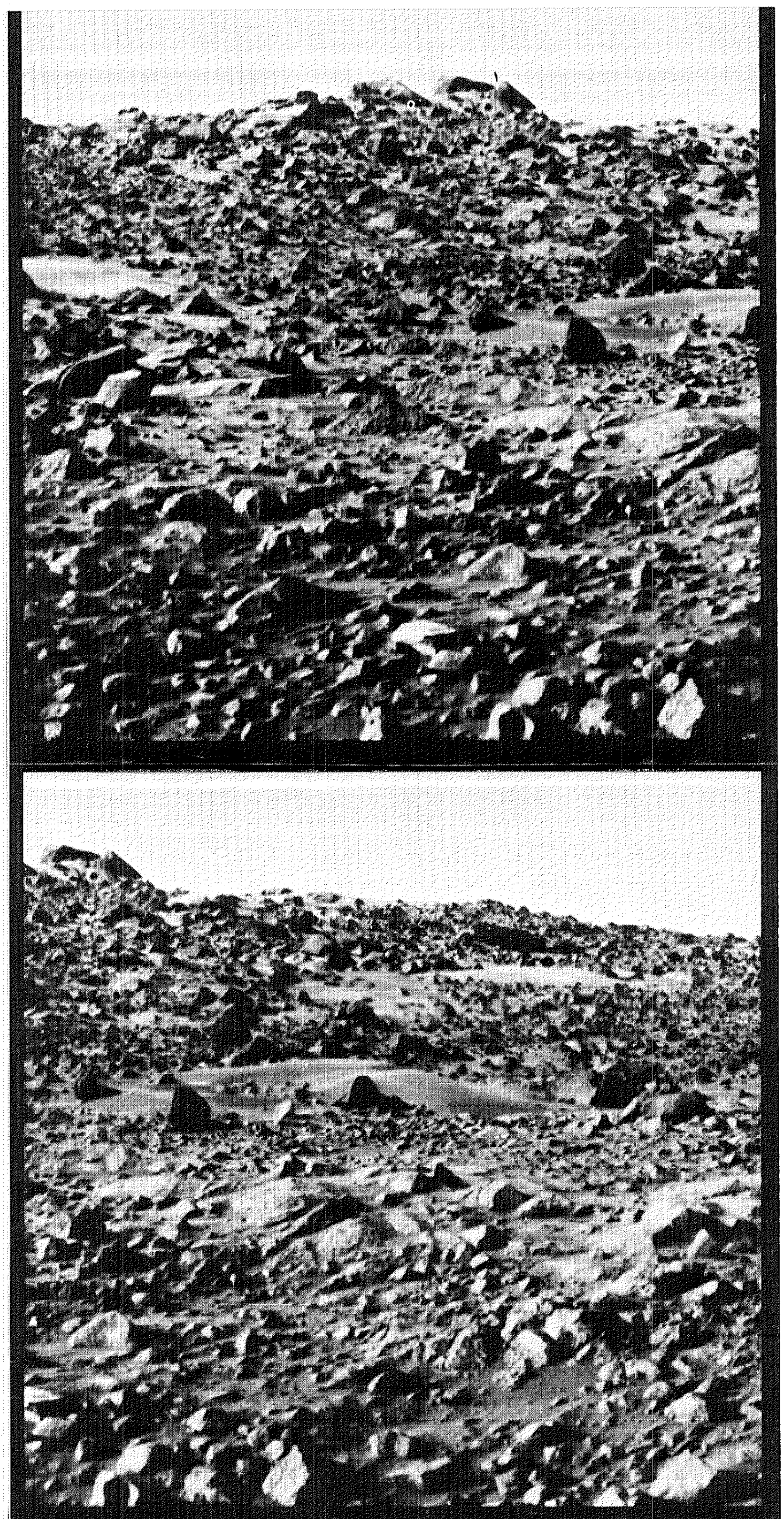


Figure 15. Stereo Pair L1.C2.AM, Stereo-R IPL PIC ID 78/06/04/143553 (SEQ - 004).

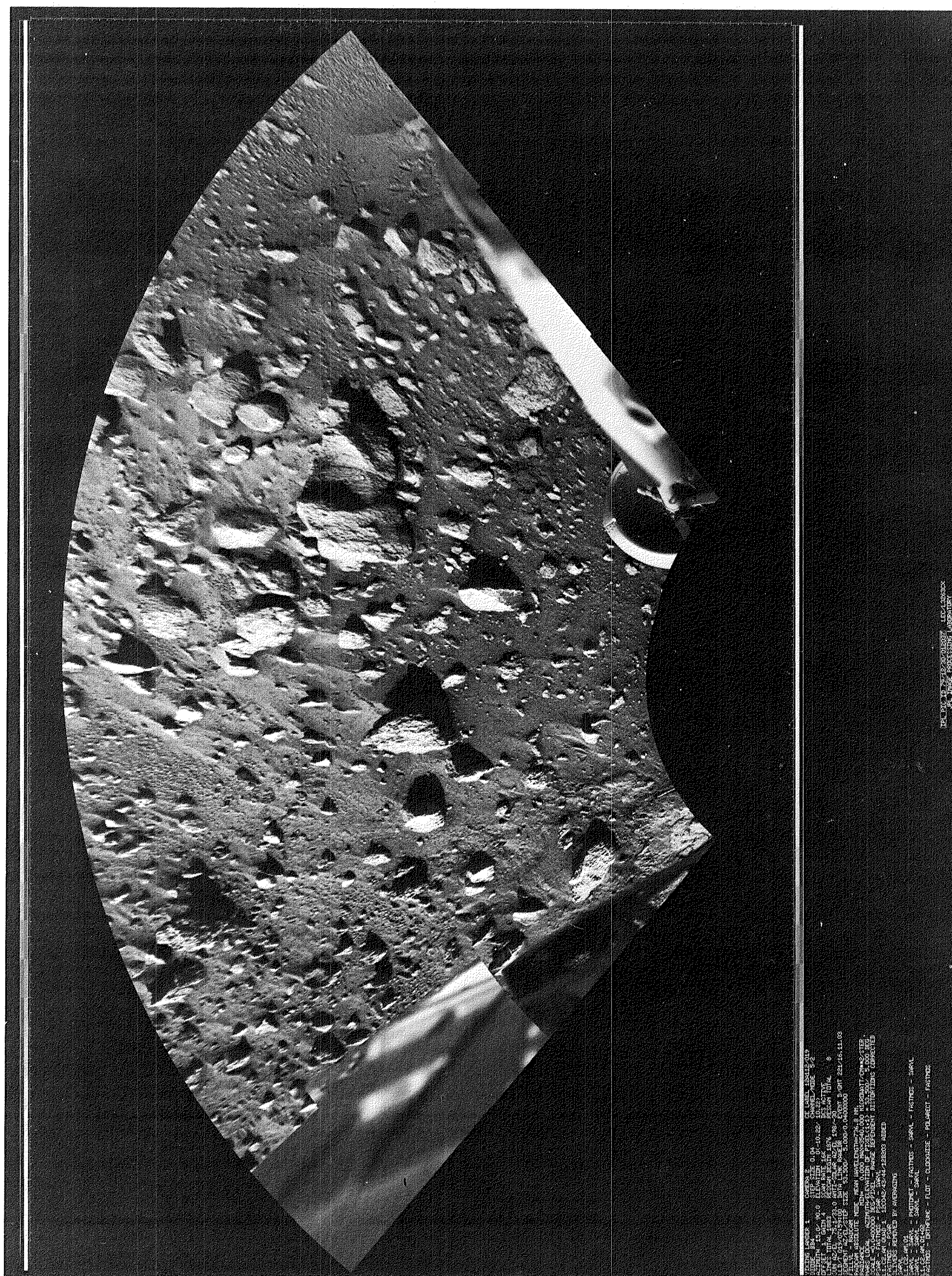


Figure 16. Orthographic L1.C2.AM, IPL PIC ID 79/12/30/012037 (Azimuth Range 120-220^{o}, Elevation Range 25-60^{o}.

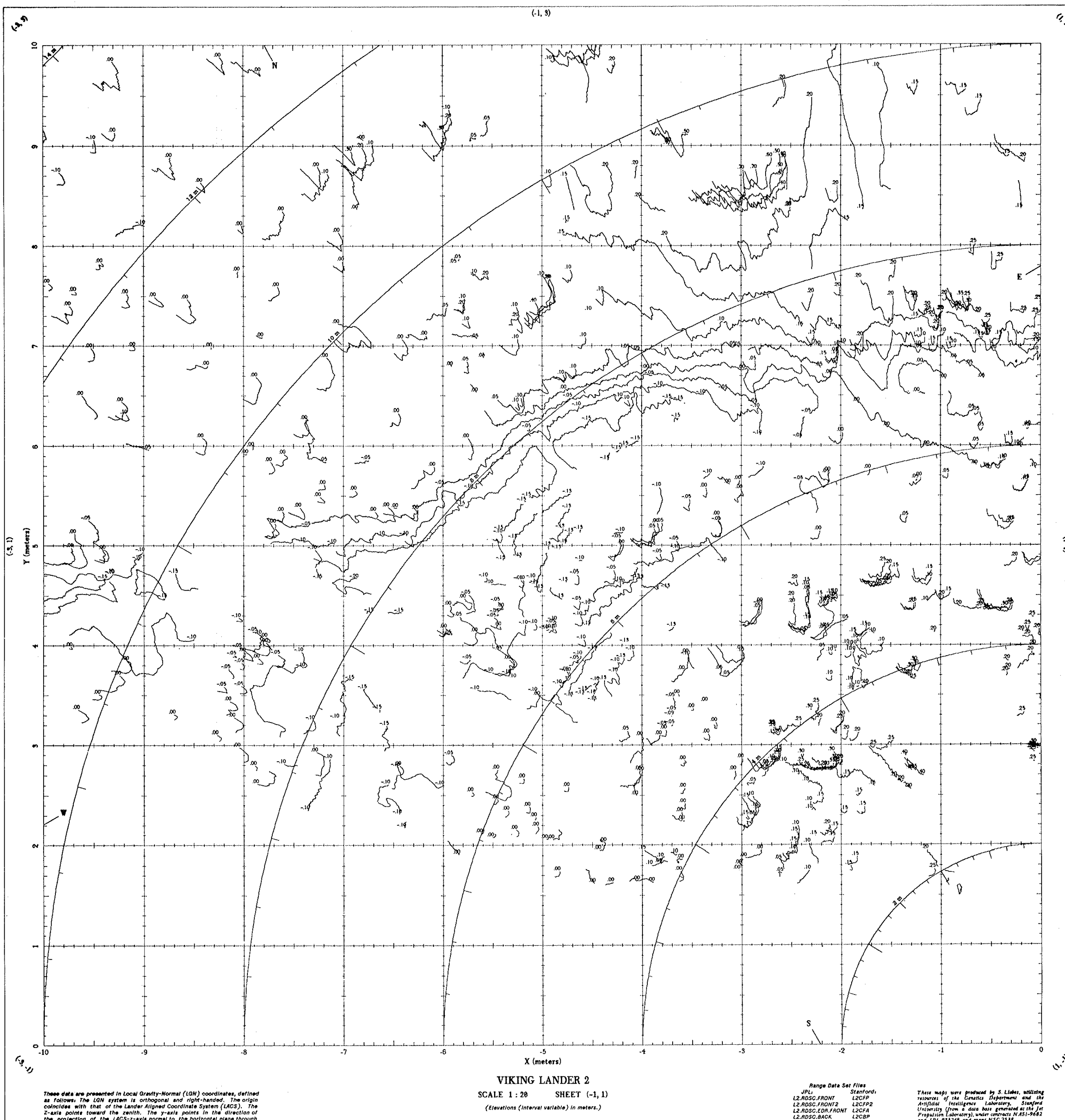


Figure 17. Map Product, VL-2 Scale 1:20 (Reduced 2.5:1).

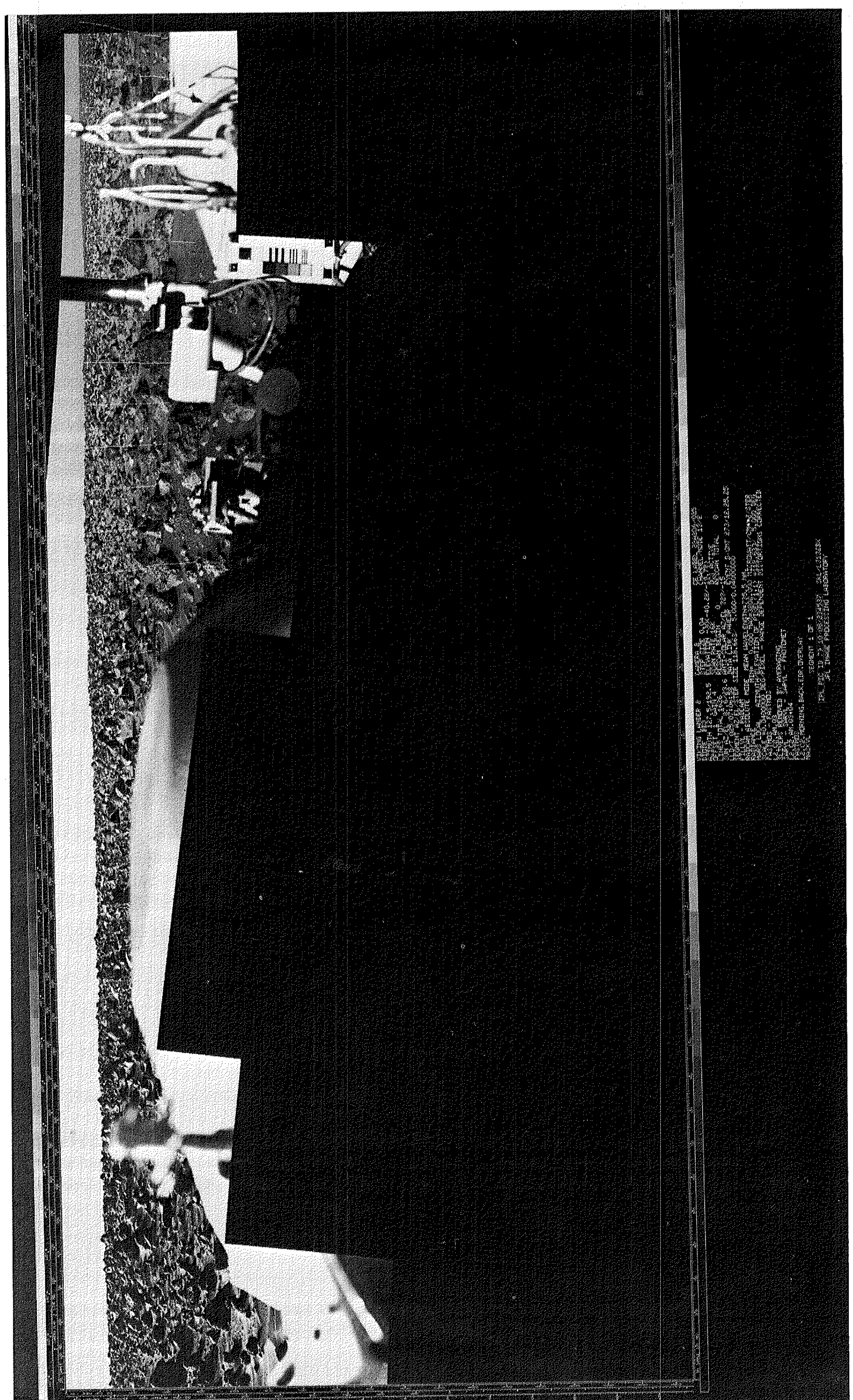


Figure 18. Range Data Sets (Profiles) Overlain on High Resolution Mosaics L2.C2.AM - Back. IPL PIC ID 79/10/08/234537.

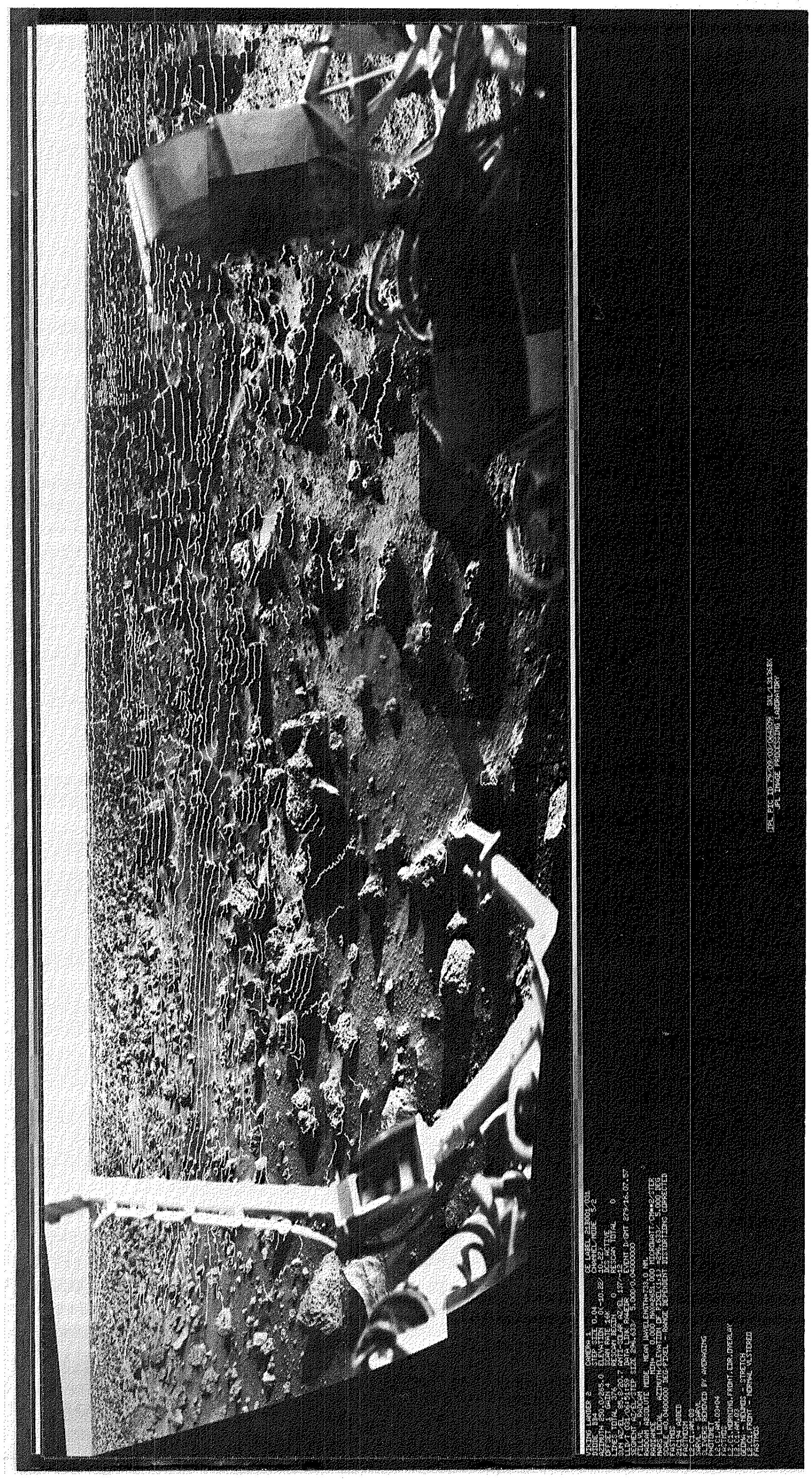


Figure 19. Range Data Sets (Contours) Overlain on Standard VL Stereo L2.C1.AM - Front. IPL PIC ID 79/09/03/064209.

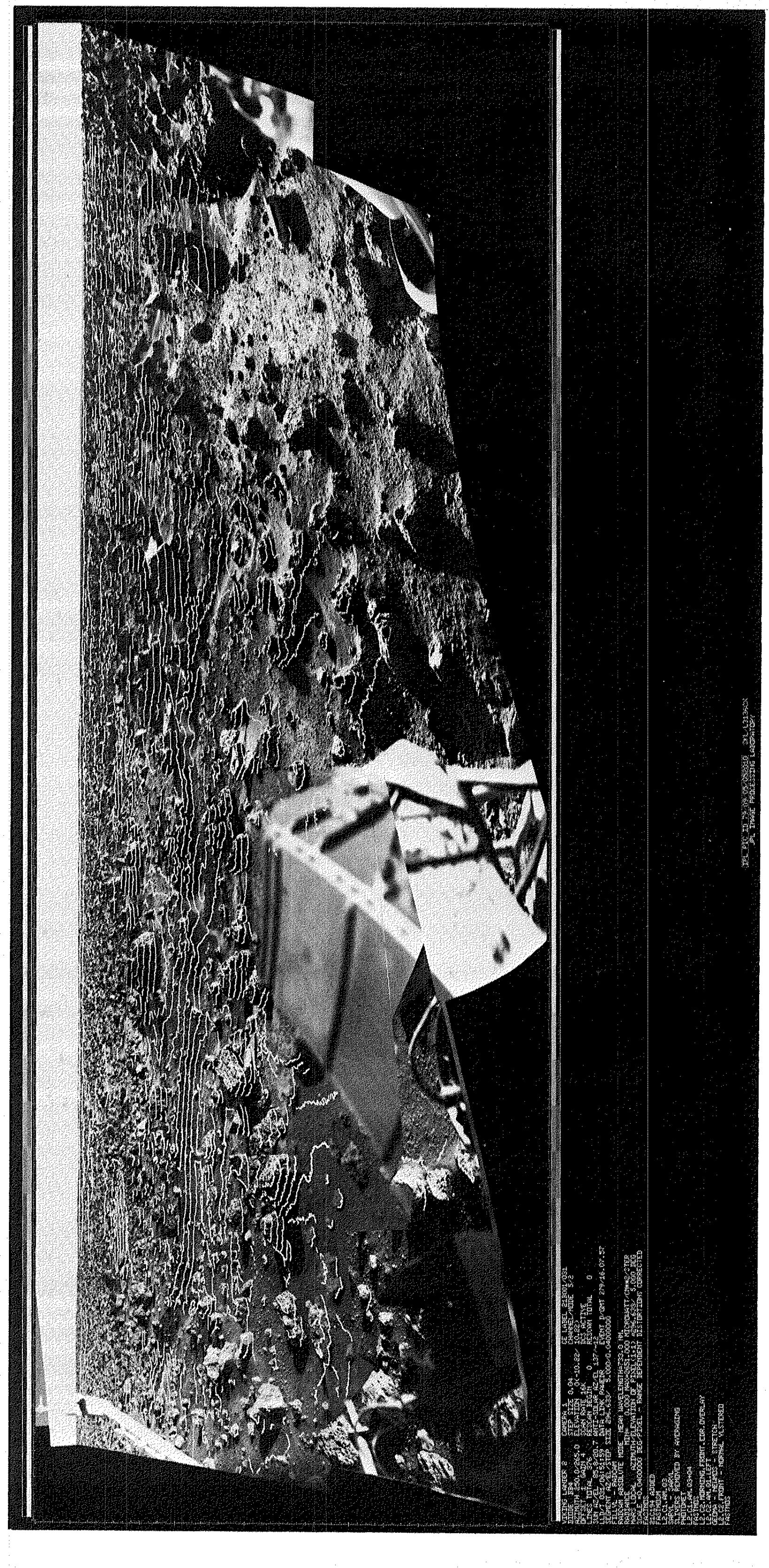


Figure 20. Range Data Sets (Contours) Overlain on Standard VL Stereo L2.C2.AM - Front. IPL PIC ID 79/09/05/052010.

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15. Supplementary Notes

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16. Abstract

This publication describes the mosaics and derivative products produced from many individual high resolution images acquired by the Viking Lander Camera Systems. Ten mosaics were produced; a morning and afternoon mosaic for both cameras at the Lander I Chryse Planitia site, and a morning, noon, and afternoon camera pair at Utopia Planitia, the Lander II site.

The derived products include special geometric projections of the mosaic data sets, polar stereographic ("donut"), stereoscopic, and orthographic. Additionally, the mosaics were used to produce contour maps and vertical profiles of the topography. These map products were then overlaid on the mosaics from which they were derived. Sets of stereo pairs were extracted and enlarged from stereoscopic projections of the mosaics. A movie, "Mars In 3-D", was made from some of these same stereoscopic projections.

For all of these products, the method by which they were created is described. In addition, information is given concerning the final forms of the various products that are available and how they may be procured. It is believed that these mosaic products will serve much of the need for Viking Lander imaging data.

The products described in this publication are in a special products category of the Team Data Record (TDR) of the Lander Imaging Team. A few additional products, also in this category, but not derived from the mosaics, are described in an appendix.

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