No. 13 EVALUATION OF THE RUSSIAN PHOTOGRAPHS OF THE MOON'S FAR SIDE

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1. Introduction

THE published photographs of the moon's far side (1960*a*) are copied, retouched and combined in order to present the maximum amount of information in as few photographs as possible. As a check on the image quality in the 60 degree sector common to both Lunik III and earth-based photographs, a special projection apparatus is used to produce a view of this sector as seen from the vehicle at the time of photography.

In view of the many misidentifications and misinterpretations present in the Moscow map (1960*a*), and to a lesser extent in the Leningrad map (1960*b*), a schematic chart is given which points out the main features of the photographs.

In October 1959, the Soviet spacecraft Lunik III was successfully orbited around the moon's far side, and photographs taken on 35 mm film through cameras equipped with lenses of approximately 8 and 20 inches focal length were televised back to ground stations after the craft had returned to the earth's vicinity. Hastily assembled and retouched prints were released to the press at the end of that month, but these were not of the best quality, so that doubts as to their authenticity were expressed at that time. It was not until the close of 1960 that the fully processed and reduced data were published by the U.S.S.R. Academy of Sciences; translations into English of this work are now available (1961*a*, 1961*b*).

The book briefly describes the method of securing the original photographic negatives, the technique used to convert them into radio signals, the reception and recording of the signals, and the reconstruction of the photographic images from the taped records. Dealt with in somewhat greater detail are methods used to enhance small local differences in contrast, and procedures for producing a map from the photographs and for obtaining selenographic coordinates of various features. The remainder of the book contains reproductions, at various degrees of contrast, of selected original negatives; an extensive table of identified features, with longitudes, latitudes and descriptions; and finally, a map based on a study of the photographs.

An independent reduction of the photographs was made at Leningrad (1960*b*), with the production of a schematic chart and an accompanying table of identifications.

2. Configuration of Sun, Moon, and Lunik III

At the time of photography, the selenocentric coordinates of Lunik III were approximately 117 deg. west longitude (astronomical direction) and 17 deg. north latitude. The sun's coordinates being about 120 deg. west longitude and 0 deg. latitude at this time, it will be appreciated that the moon presented an almost full aspect to the cameras, the maximum defect of illumination (approx. 16 deg.) being situated slightly east of the north pole. These circumstances are illustrated in plan in Fig. 1, in which T_1WT_2 represents the sunlit hemisphere, T_1T_2 the terminator, and T_1ET_2 the night hemisphere (stippled). E and W are the moon's east and west limbs (astronomical directions as seen in the sky), situated at longitudes 270 deg. and 90 deg. respectively. The dashed line L_3CL_4 represents

the limit of visibility of the lunar surface, due to librations, as seen from earth. The dashed line L_1L_2 represents the limb as viewed from Lunik III. The sector T_2CL_4 is common to both earth-based and Lunik III photographs, while the sector L_3CL_1 has never been seen at all. The distance between Lunik III and the moon at this time was roughly 40,000 miles, or one sixth the earth's mean distance from the moon. Thus, the moon subtended an angle of about 3 deg. to the cameras, giving image diameters on the film of 0.4 and 1.0 inches.

3. *Brief Review of the Published Material*

The reproductions of the televised photographs in the Moscow atlas appear to be of good quality, a heliogravure type of process having been used since the images produced by the television apparatus already have a dot structure. The photographs are presented in a totally un-retouched form, electronic interference and patches due to under-development being clearly visible in all cases.

The map and table of identifications suffer from the considerable disadvantage that, notwithstanding the fact that the moon presented an almost full aspect to the cameras at the time of photography, the tendency throughout is to describe the markings in terms of topographical features. For example, the bright area named the Soviet Range and described as a range of mountains "because of its reflectivity" is actually an extensive nimbus surrounding two distinct ray centers, together with some of the rays. There is no foundation whatever for the assumption that mountain ranges located in the moon's continental regions would appear bright at the full phase; indeed, for the earthward hemisphere, the only large mountain ranges are located at the boundaries of the largest walled plains, and these are invisible at full.

The value of this map and table is also reduced by the inclusion of too much doubtful detail; the vaguest patches present in the photographs tend to be represented by circular outlines, with the resulting inevitable description as "crater."

The use of topographic maps only (those of Neison, 1876, and Wilkins, 1955) to identify features in the 60 degree sector common to both Lunik III and earth-based views has likewise resulted in several misidentifications, firstly, because both these maps are unreliable in their content and positioning of lunar features near the limb, and secondly because they give no indication of the position of light and dark areas. Thus, feature 762, identified as Marinus and described as a grey formation on a light background, is actually the prominent crater-sea Marinus D. The crater Marinus itself is quite invisible under high illumination. Similarly, feature 733 is actually the dark patch Struve, but as it is flat and has no mountain boundary, identification could not be made from the maps.

The Leningrad schematic chart is superior to the Moscow map in that a good attempt has been made to reproduce both the shapes and brightnesses of the areas of different reflectivity. However, some interesting detail, mainly towards more westerly (astronomical direction) longitudes, has been either omitted or over-generalized. The accompanying table of identifications is also considerably more reliable than the Moscow version; a few minor errors were noted in the identifications of features in the common 60 degree sector, but the interpretations of features in the averted hemisphere are quite realistic, being in terms of bright rays, nimbi, dark patches, etc.

4. *Retouching and Combination of the Photographs*

In order to combine the maximum amount of information presented in the 30 atlas plates into as few photographs as possible, and also to suppress the distracting influence of the electronic interference, etc., the following procedures were adopted:

Firstly, the two photographs obtained with the 8-inch focus lens (*Atlas* plates 1 and 2), which included almost the entire lunar disk, were photographed and enlarged somewhat to a uniform scale. Next, the electronic interference, i.e. readily recognizable black and white spots crossing the images in straight lines, was reduced considerably by retouching, and the sky background rendered completely black. Spurious markings were detected by making an inter-comparison of the photographs, and were also reduced by retouching. The two prints were next placed in contact, face up, and carefully adjusted until the upper image was lying exactly in register over the lower; a single negative was then made of the two prints by giving half the exposure to each print. This negative was then used to make the print illustrated in Plate 13.1.

In the case of the photographs obtained with the 20-inch focus lens, a somewhat different procedure was adopted. Plates 3, 6, 7, 23, 27 and 28 of the Moscow atlas were photographed; positives on film were prepared at the original scale for all but plate 23, which was given slightly greater enlargement in order to maintain a uniform scale for all the

copies. Plate 13.2 is an un-retouched copy of *Atlas* plate 3, in which the darker areas appear black, but the lighter areas are shown with fair contrast. It should be pointed out here that the half-tone reproductions which are included in this report do not adequately duplicate the originals from which they were prepared; in particular, the contrast at the two ends of the tone range has been reduced to some degree.

For the copy of plate 3 used in subsequent operations, an extra stage was introduced in which contact copies were prepared using a fluoro-dodge contact printer; this decreased the contrast between the larger over- and under-exposed regions without reduction in contrast of the smaller details. The six positives were carefully retouched to reduce electronic interference, underdeveloped patches, etc., as before.

Subsequent operations were directed towards the following two objectives: firstly, to prepare an optimum reproduction of original Lunik frame 26; and secondly, to prepare a composite print from original frames 26, 28, and 32 for comparison with earth-based photographs.

The first objective was realized by combining the positive of plate 3 with a very weak positive of plate 7 (plate numbers refer to reproductions in 1960*a*); this procedure restored detail to the burned-out highlights of plate 3, and the result is illustrated in Plate 13.3. The second objective was realized by combining this print with the copy of plate 6, in order to restore a little detail near the edges of the frame and to increase contrast between the maria and the surrounding regions. Finally, portions of copies of plates 23, 27, and 28 were added to complete the montage. The final print is reproduced in Plate 13.4.

5. *Preparation of Re-centered Photograph*

In order to simplify both the evaluation of the quality of the Lunik photographs and the identification of features in the common 60 deg. sector, the print illustrated in Plate 13.5 was prepared, using the special projection apparatus at this laboratory (see *Communication* No. 6). Two positive transparencies of the moon were chosen, displaying maximum favorable librations for the NW and SW limbs (astronomical directions). These were projected in turn onto the matt white hemisphere of the apparatus, and the images photographed from a direction judged to be similar to that occupied by Lunik III at the time of photography. Space limitations in the projection room prevented attainment of the requisite scale distance, with the result that all features are displaced small distances radially from the disk center. Prints were then made from the two negatives, and a montage prepared with the joint along a line from about Neper to Petavius.

6. *Preparation of Schematic Chart*

The chart illustrated in Plate 13.6 was prepared in order to combine the main features visible in the Lunik photographs into a single representation, and particularly to emphasize certain features which show up imperfectly or not at all in the half-tones accompanying this report. The chart was prepared by tracing partly from the plates of the Moscow atlas, and partly from the prints used to make Plates 13.1, 13.3, and 13.4. Many of the smaller light and dark spots have been omitted, since their inclusion would cause congestion, and they are well shown in Plate 13.3 anyway.

The maria and other dark areas, including shadows and the unilluminated segment, are represented by stippling. Bright rays, bright areas and nimbi are indicated by dashed lines and radial dashes, respectively; bright craters are also outlined by a dashed line. Explanations of the numbered features are given in Table I.

7. *Interpretation of the Photographs and Identification of Features*

Since the photographs are essentially full moon views, interpretation of the features must be made in terms of areas of different reflectivity; thus, one should look for maria, irregular dark patches, crater-seas (such as Plato, Crüger, etc.), ray centers, ray systems, nimbi, small bright craters, and so on. The re-centered photograph (Plate 13.5) illustrates this point well, the chief features being the objects just referred to; the great majority of topographic features, such as craters, ring plains, etc., are totally invisible. The only location in which the surface topography can be readily seen is in a narrow segment close to the terminator, where crater walls and similar features are rendered visible by the shadows that they cast.

The schematic chart (Plate 13.6) was compiled with these criteria in mind, so that some confidence may be placed in the interpretations.

Comparing Plates 13.1 and 13.5, it will be seen that the resolution is such that the outlines of the larger maria are reproduced with some fidelity, but

smaller features such as Mare Undarum (No. 31 in the chart) appear only as dark areas with indefinite outlines. It should be pointed out here that some of the features mentioned may not be visible in the half-tone reproductions for reasons already stated.

A comparison between Plates 13.4 and 13.5 reveals both a better rendering of tones and considerably increased resolution; shapes of light and dark patches are reproduced very well, and objects about 10 miles across can be readily detected when the contrast between them and their surroundings is sufficient.

In Table 1, 60 of the more important or interesting features given in the chart are briefly described.

8. Conclusion

A comparison of Plate 13.3 with an earth-based full moon photograph shows at once that the portion of the moon's far side revealed by the Lunik III photographs is mainly "continental" in character, duplicating almost exactly the same type of region situated on the earthward hemisphere (e.g., the sector from Mare Australe to Sinus Medii to the south pole). However, the most unexpected and significant feature of this part of the moon is the total absence of large maria; Mare Muscoviense is considerably smaller than Mare Humorum, while the region of Mare Ingenii appears to be of a semi-mare nature similar to the area enclosed by the craters Endymion, Mercurius, Franklin, and Hercules, and therefore cannot be classed as a true mare. This dearth of maria leads one to suspect a definite connection between the distribution of the maria and the distribution of mass in the moon. The center of area of the known maria can be roughly estimated to be in the vicinity of the crater Eratosthenes; even if the as yet unseen 60 degree sector contains several large maria, this center would not be displaced further east than Kepler. Since the axis of distribution of mass passes through the moon's center of gravity and the point of intersection of the equator and prime meridian (i.e. the mean center of face), the chances against this proximity being accidental are 16 to 1 for the Eratosthenes center, and 5 to 1 for the Kepler center.

If we now assume that there is a connection between the distribution of the maria and the distribution of mass, one is now faced with the following problem: were the maria produced as a result of the synchronization of the moon's periods of rotation and revolution, perhaps by some tidal effects, or did the presence of some or all of the maria cause the synchronization?

TABLE I

Features shown on Plate 13.6

1. Two large, contiguous walled plains, rendered visible by the shadows cast by the walls.
2. A prominent ring plain, filled with shadow except possibly for a central peak; situated close to the north pole.
3. A large, anonymous walled plain, visible in the re-centered photograph (Plate 13.5). It contains Franz's measured point Meton E, apparently a peak (1913).
4. Petermann.
5. Cusanus. There are numerous shadows of crater walls visible in the region between here and No. 1.
6. Strabo E.
7. Strabo and Thales.
8. Endymion.
9. The dark portion of the floor of Mare Humboldtianum. The shape is seen to be quite similar in Plates 13.4 and 13.5, but it must be noted that the mountain boundary of this mare does not coincide with the limits of the dark area.
10. A very bright area, crossed by several narrow, bright rays.
11. A grey area of distinctive shape, outlined and crossed by the rays just noted.
12. Struve, a dark patch without walls.
13. Franklin, shadow-filled.
14. Franz's "Mare trans Hahn" (1913), a small, dark patch situated between two bright rays.
15. Giordano Bruno, the center of a ray system rivaling that of Tycho. Some of the rays extend well on to the earthward hemisphere, and may be seen in the re-centered photograph.
16. Maxwell, an irregular patch of dark material.
17. Lomonosov, a circular patch of dark material.
18. Edison, an irregular patch of dark material.
19. Joliot-Curie, a dark marking with a distinctive shape. This is the Mare Novum of Franz and the I.A.U. (1935); a photograph taken at the Pic-du-Midi Observatory on December 21, 1961 shows that the dark markings are situated on the level floor of a magnificent walled plain some 90 miles in diameter, with a grand central cluster of peaks.
20. A very dark, horseshoe-shaped marking situated on the floor of the prominent ring plain Plutarch A.
21. Mare Anguis and the bright crater Eimmart.
22. Mare Crisium.
23. Firmicus and an adjacent dark patch.
24. Dark patch on the floor of Condorcet.
25. Dark areas of distinctive shape; Franz's Mare Marginis a, b, c, d, and e.
26. Mare Marginis.
27. A circular dark patch surrounded by an eccentric bright area. Actually a large, dark-floored ring plain, Franz's Mare Marginis k.
28. Popov, a vague bright nimbus.
29. Hertz, a distinct bright nimbus.
30. Neper, a large walled plain with irregular dark floor, bright walls, and a bright central peak.
31. Mare Undarum, a series of "flooded" valleys and craters.

32. Mare Spumans.
33. Mare Fecunditatis.
34. Langrenus, with bright walls and central peak.
35. Petavius B and its small ray system.
36. Mare Smythii. Bright craters and other markings on the surface are well shown.
37. A bright area, with several small, well-resolved bright spots nearby (Plate 13.3). The smallest of these are slightly less than 10 miles across, and probably represent individual bright craters.
38. Lobachevsky, a distinct dark patch.
39. Pasteur, an irregular bright area.
40. Sklodowska-Curie, a distinct, very bright patch; possibly two bright craters with surrounding nimbus.
41. Humboldt. The dark streaks on the floor, the bright walls, and the bright central peaks and crater are well seen in Plate 13.3.
42. The bright ray systems centered on Stevinus A and Furnerius A.
43. Mare Australe, a large region of dark-floored ring plains and irregular dark patches.
    a) Franz's Abel, the dark floor of a large ring plain. The hook-shaped dark formation to the NW is Franz's measured point No. 1111.
    b) Marinus D, a distinct circular ring plain with a dark floor.
    c) Oken, similar to the above but somewhat larger.
    d) Marinus K, which is Franz's Kelvin and Wilkins' Ibañez; a distinct, deep ring plain with bright walls.
    e) Brisbane G (Wilkins' Pratdesaba), a large, dark-floored formation with low walls.
    f) A circular formation with very distinct, bright walls and a dark floor.
44. Very bright areas, presumably nimbi.
45. Tsiolkovsky, a very prominent and unique formation. It has broad, bright walls, a very dark floor, and a very bright central peak or crater connected to the north wall by a bright isthmus.
46. Possibly a small ray system, lying next to a distinctive linear dark marking. The region between these features and the south limb is very bright, suggesting the existence of a ray center near the south pole. This supposition is confirmed by the fact that earth-based full moon photographs exhibit several bright rays in the south polar region which appear to radiate from a center just beyond the pole, and thus on the averted hemisphere.
47. Jules Verne, a distinct dark circular patch situated very near the antipodes of the center of Mare Imbrium.
48. A small bright area bounded on the south by a distinct dark patch. A light area stretches from here to No. 46, possibly rays.
49. Mare Ingenii, an extensive region of irregular dark patches and grey areas.
50. A bright area with a distinctive shape.
51, 52, 58. The so-called Soviet Range, an area of bright rays and extensive nimbi.
51. A very bright area surrounded by a large nimbus; it is the center of a major ray system, as shown in Plate 13.6.
52. A similar very bright area surrounded by an even more extensive nimbus. Rays emanating from this center may be traced for considerable distances, mainly towards more northerly latitudes.
53. Mendeleev, a distinct dark patch.
54. A prominent and extensive bright ray.
55. Mare Muscoviense, a true lunar mare. It is rather smaller than Mare Humorum, and is approximately circular in outline. The existence of Astronauts' Bay, supposedly situated on the SE (astronomical direction) shore is not confirmed. Two bright rays may cross the Mare as shown.
56. The location of Tsu Chung-Chi, a vague area that is slightly brighter than the surroundings.
57. Kurchatov, a distinct bright area, possibly a ray center.
58. Rays from both Giordano Bruno and ray center No. 52 overlap in this general area.
59. An indistinct bright area, possibly a ray center.
60. Dark patches near the limb and terminator. Several grey areas are situated near the limb between this location and Mare Ingenii.

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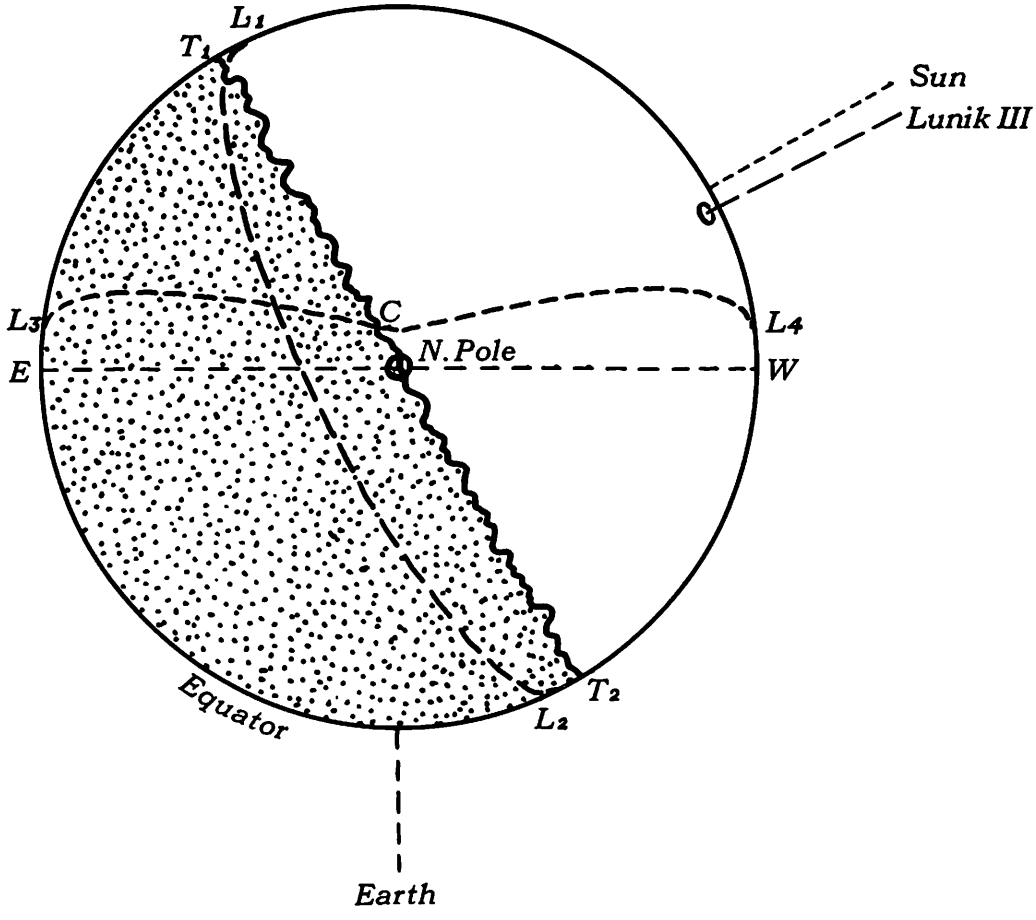

Figure 1. Plan view of moon at time of photography.

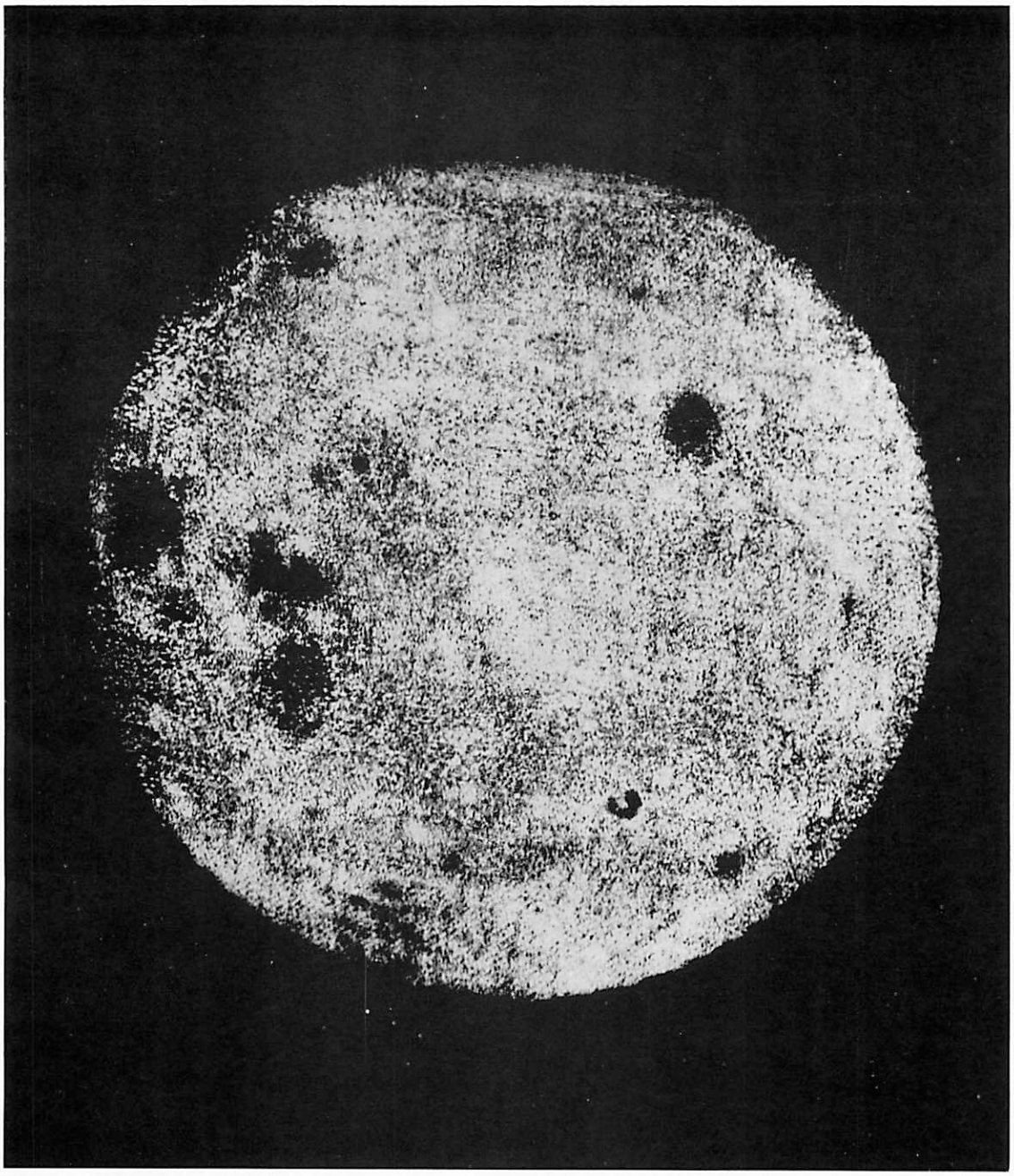

Plate 13.1. Combined print of the two small-scale photographs.

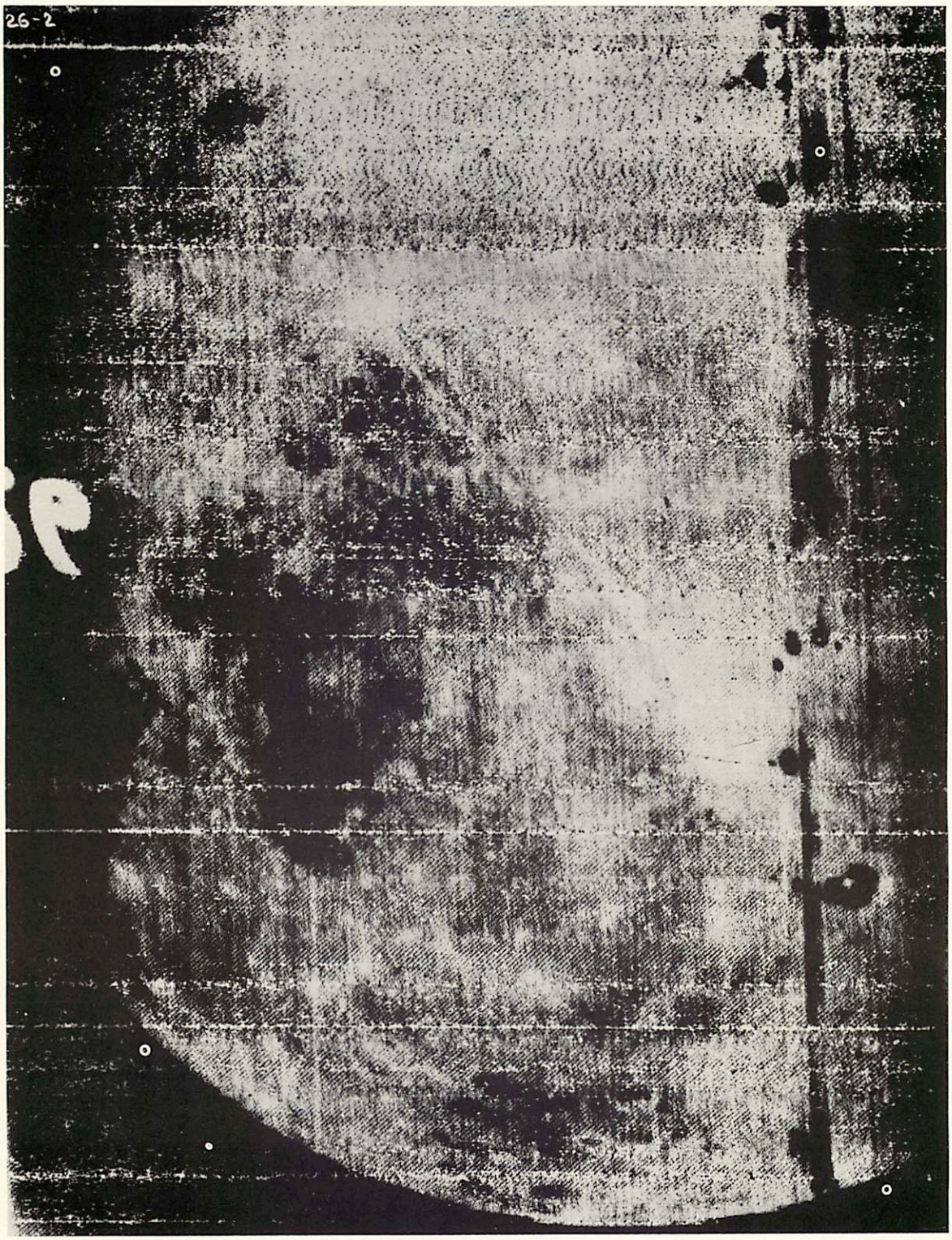

Plate 13.2. Unretouched copy of atlas plate 3.

Plate 13.3. Improved rendering of original frame 26.

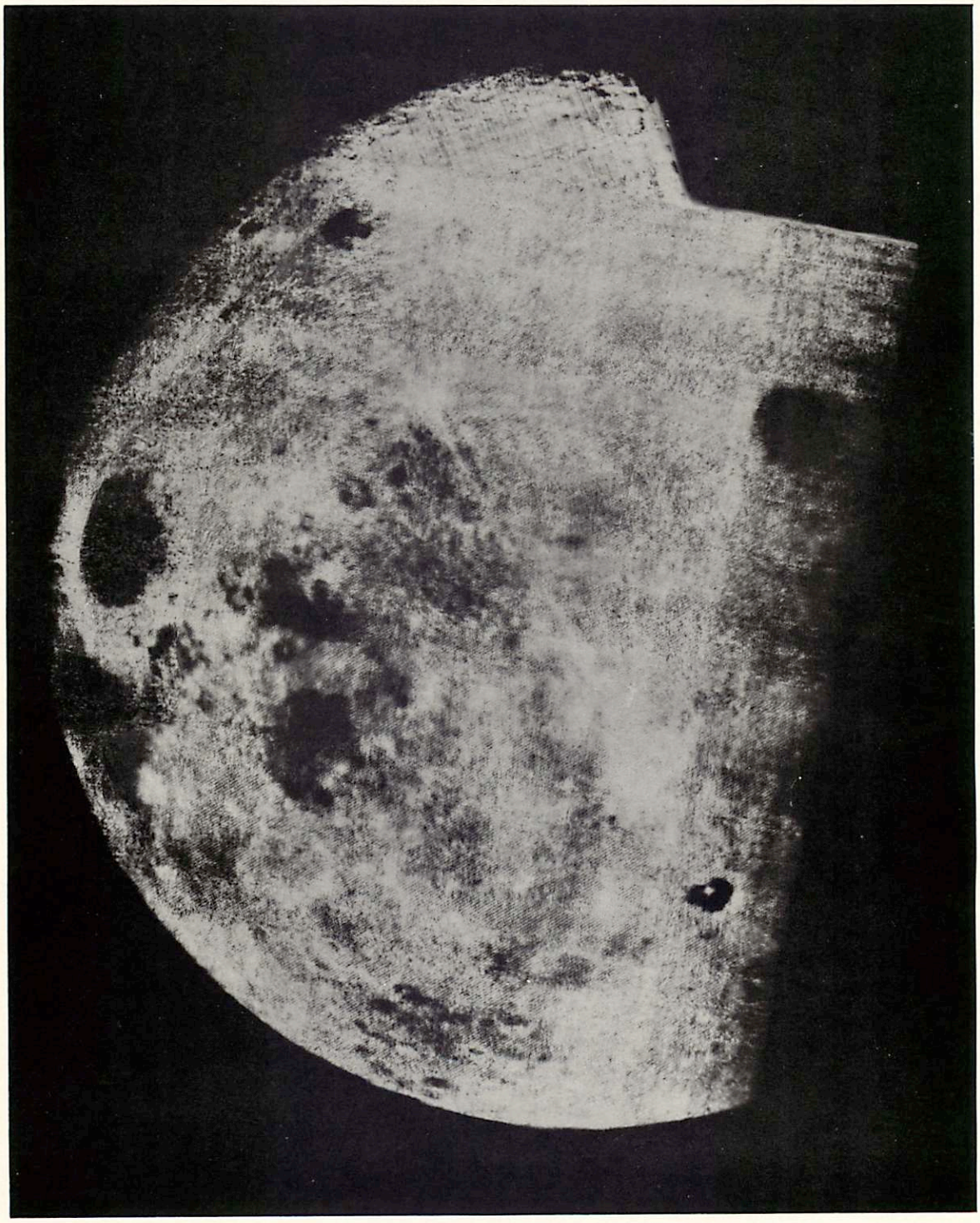

Plate 13.4. Montage prepared from plates 3, 6, 7, 23, 27, and 28.

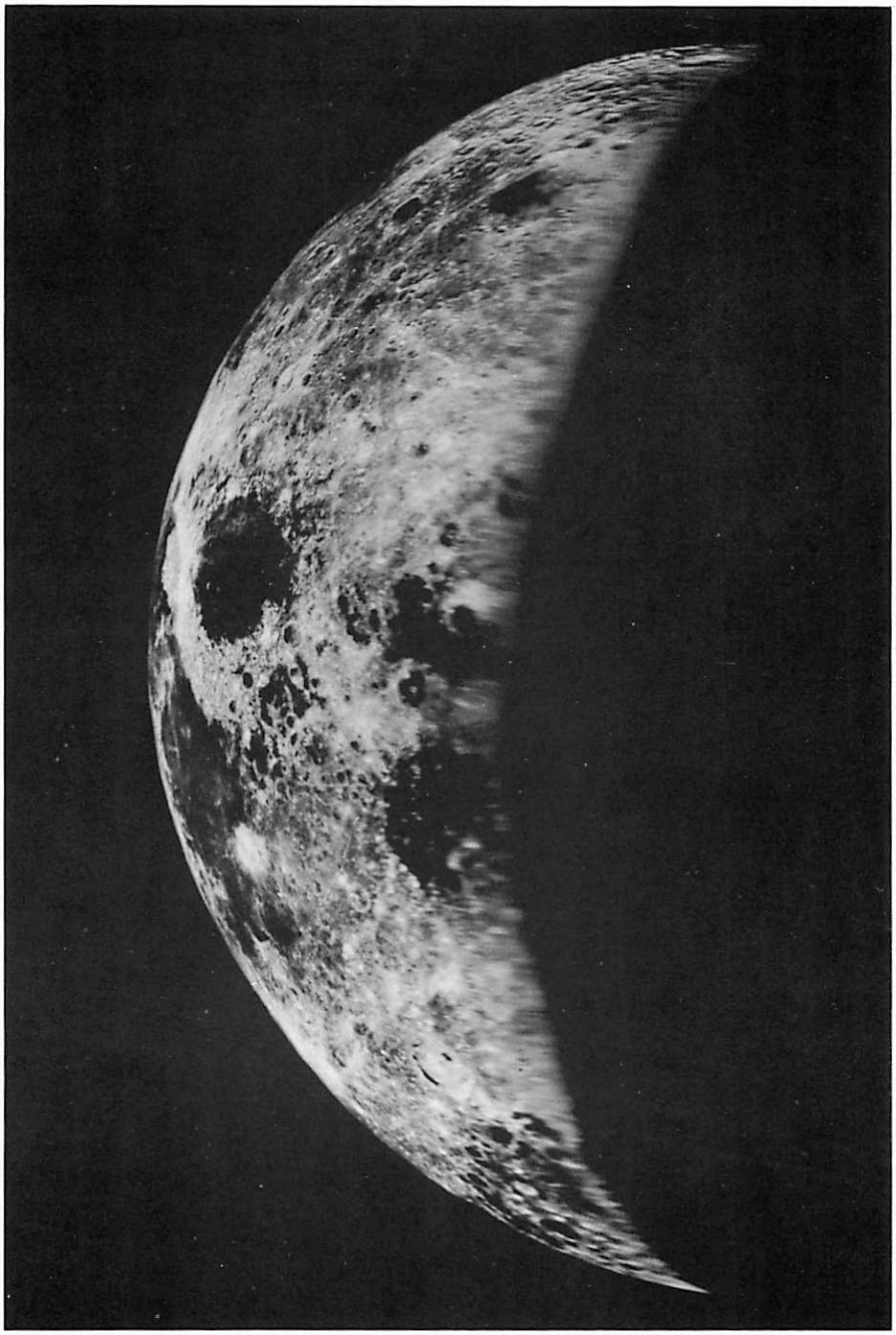

Plate 13.5. Re-centered photograph prepared from earth-based photographs.

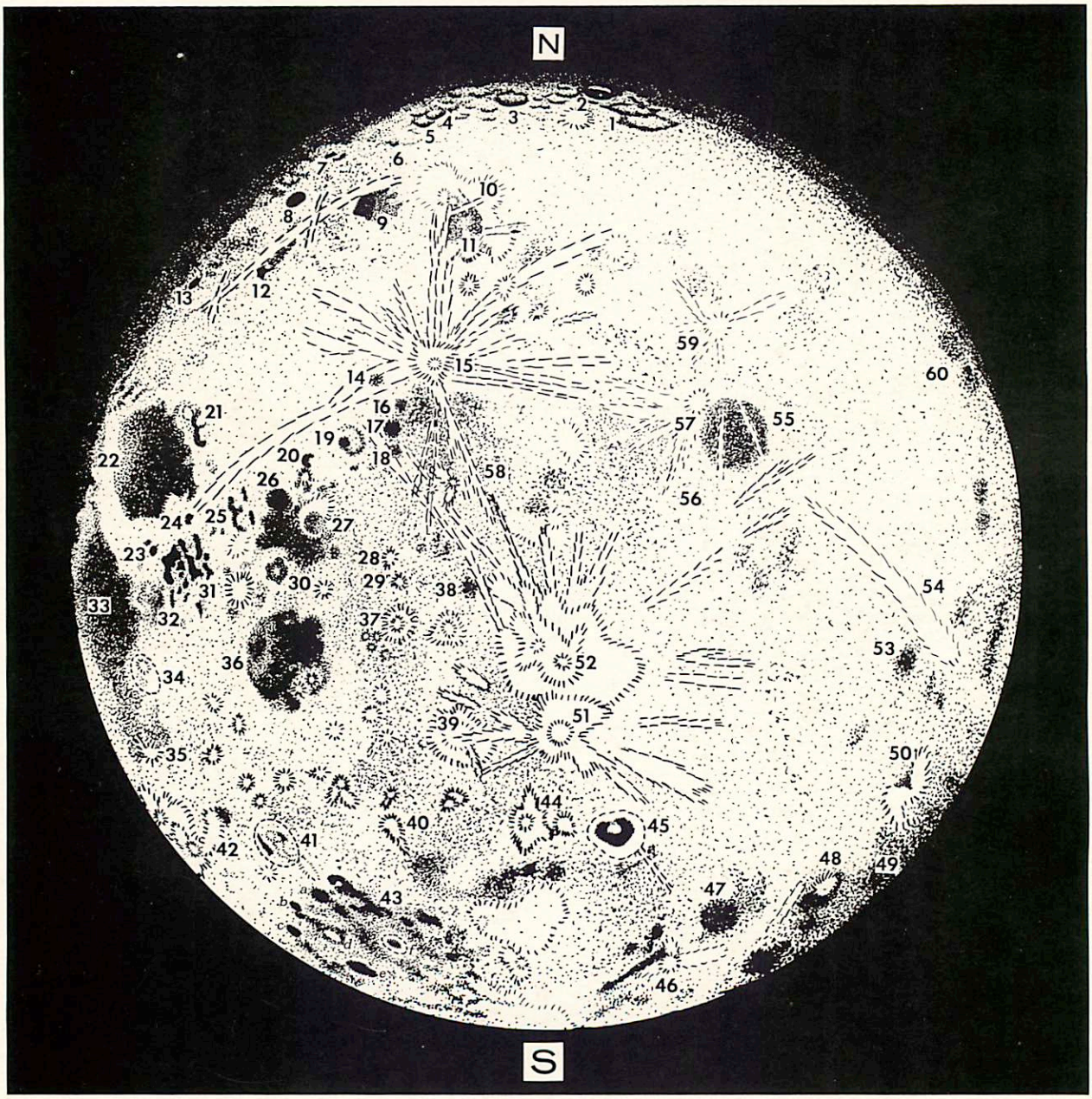

Plate 13.6. Schematic chart based on study of all material.