ISOTHERMS IN THE REGION OF PROCLUS AT A PHASE ANGLE OF 9.8 DEGREES

by

Andrew T. Young and Harold Boeschenstein, Jr.

Harvard College Observatory
Cambridge, Massachusetts (USA)

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ABSTRACT

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An isothermal map of the Proclus area of the Moon and a description of the method used for making the map are presented. Correlation between the isotherms and the visual features is also given. Author

This report presents an isothermal map of the Proclus area of the Moon and describes the method used for drawing it.

The data were obtained on the night of February 27-28, 1964, with the radiation pyrometer developed at Harvard College Observatory. The instrument was attached to the 61-inch Wyeth reflector at its Newtonian focus. This telescope is located in Harvard, Massachusetts at the George R. Agassiz Station of Harvard College Observatory. The pyrometer and the technique of its operation have been described in earlier reports.(1) For this work, we used a multilayer interference filter having a short wavelength cut-off at 8.0 microns and a long wavelength cut-off at 15.0 microns; the 50% transmission points were at 8.7 and 11.5 microns, respectively.

The position-identifying photographs* were taken on X·R film(2), and were processed by Edgerton, Germeshausen & Grier, Inc. The negatives were of very low contrast and all of the image was contained in the fastest layer of the emulsion. The image in this layer may be visually separated from those lying in the other two layers by viewing the negative through a blue filter, such as a Wratten No. 47B or No. 94.

Black and white prints were made from several of the negatives in which the intersections of the crosshairs were located along one of the central scans. In order to obtain adequate contrast, it was necessary to make the prints on high

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*For a description of the method employed in making photographic identifications of the areas under observation, see Scientific Report No. 6.

contrast printing paper. Kodabromide F·5 was used first, and then later, Agfa Brovira 111 No. 6. A mosaic was made from two of the prints in order to show in one picture the entire region scanned. The individual frames were then contact-printed by light filtered through a No. 94 Wratten filter. Each print was examined individually and the position of the intersections of the crosshairs in each frame was plotted on the mosaic.

Since the definition of the photographs was poor, and since the images of the intersections of the crosshairs frequently fell on the images of lunar areas with no distinguishable features, some difficulty was encountered in plotting the points. Several plotting techniques were tried; the most successful seemed to be one in which two strings were adjusted on top of the mosaic until they coincided with the same features as did the image of the crosshairs in the individual frames. A mark was then made under the intersections of the strings. This apparently primitive technique was time-consuming, but it worked quite well in practice. The plotted positions were reproducible to within less than the width of the detector (9").

A piece of plastic drafting film, which will be called the No. 1 film to distinguish it from the several films used later in the reduction, was then taped over the mosaic. Lines representing the individual scans were drawn through the points corresponding to the positions of the intersections of the crosshairs at the times of exposure.

The distances between the points representing the position of the intersection of the crosshairs at the times of the first and the last photographs of each scan were measured, as were the distances between the corresponding photograph event marks on the paper chart record. The ratios of the two distances were calculated for each scan; the positions of temperature measurements made at times in between those of the photographic exposures could then be plotted on the mosaic. The slope of each line was measured relative to the image of one of the crosshairs, and an average slope was computed. The individual scans were replotted onto a new (No. 2) piece of plastic drafting film. The average slope and the best visual fit through the points were used in making these plots. Since the motion of the Moon in declination provides the displacement between scans, a change in the rate of motion will cause a change in the slope of the scans relative to the crosshairs. But on the night the observations were made, the change in rate of motion in declination was only a few seconds of arc per hour. The increase in accuracy gained by using an average value of slope outweighed the decrease caused by the small change in the rate of motion.

The reduced data are given in brightness temperature (blackbody). To ease the task of plotting the isotherms, the measurements of the paper charts were made at fixed intervals of pen deflection. The deflections were proportional to the power received on the detector. Atmospheric transmittance, sky radiance, and instrumental drift were assumed to be constant during the total time required to make the scans (7.5 minutes). The lines of constant pen deflection were plotted as described later. Since the power intervals between lines are constant, the temperature intervals are not. The region mapped is sufficiently small that the over-all temperature differential is also small; thus the temperature interval between isopower lines does not vary greatly over the region mapped.

The distances were measured between the initial photograph mark of each scan on the paper chart and projections onto the time axis of the points determined by the intersections of the pen deflection lines and the lines of integral units of power. These distances were then multiplied by the appropriate ratio and plotted on a piece of plastic drafting film (No. 3), which had been placed over the No. 2 film and the mosaic. A number was written next to each point to correspond to the power level at that point.

The isopower lines were made by placing another piece of drafting film (No. 4) over the one called No. 3, and drawing in the lines connecting the points of equal power level.

An enlarged ink copy was made of the original. A photographic negative of this copy was made, and it was printed onto photographic paper. The paper was exposed a second time to produce the image of the Moon from the original X·R negatives. Registration marks were used throughout the enlarging and reproducing procedures, in order to accurately align the isopower lines on the lunar image. After the final mosaic print was made and mounted, the temperature differences between isopower lines were marked on it. The temperature differences were computed by assuming a value for the highest temperature recorded. Since the hottest point was near the subsolar point, a temperature of 390°K was assumed. Next, from a scan at reduced gain, the power signal from Proclus, $S(T_P)$, was measured in terms of the power signal, $S(T_S)$, from the subsolar point. By using the ratio of the two powers, $S(T_P)/S(T_S)$, and the tabular values of the equation

$$S(T_M) = K\int_0^{\infty} N_\lambda(T_M)\,\tau_o(\lambda)\,\tau_r(\lambda)\,d\lambda \quad \text{watt}$$

the approximate temperature for Proclus was found. In the above equation, T_M is the lunar temperature under consideration, $N_\lambda(T_M)$ is the spectral radiance, $\tau_o(\lambda)$ is the spectral transmittance of the instrument optics, $\tau_r(\lambda)$ is the spectral reflectance of the instrument optics, and K is an instrumental constant. Finally, the temperature differences between power levels were determined from double-entry graphs giving the family of curves $S(T_U)/S(T_P)$ versus $S(T_P)$ with ΔT as the parameter, where $S(T_U)$ is the power level of the isotherm of unknown temperature, and $S(T_P)$ is the power level from Proclus. The results are shown in Figure 1.

A mosaic photograph composed of prints was made from the identification negatives. The isotherms were then plotted on this mosaic. The data were obtained February 27-28, 1964. The air temperature was 24°F (-4.4°C), and the relative humidity was 20%. The Moon was 14.5 days old and the location of the resolution element in this particular case was within ± 6". Thirty-seven high-gain scans cover the area between parallels of latitude + 8° to + 20° and circles of longitude + 38° to + 60°. The isotherms were drawn for equal interval power level. Since absolute values of temperature could not be obtained, only increments in temperature (Kelvin) from an assumed value of "T" are indicated.

Figure 2 shows a photograph of the general area of the Moon for which the isotherms were plotted (Lick Observatory Photograph).

Owing to a gradual change in sky brightness, atmospheric attenuation, and instrumental base level, the contours must be somewhat distorted However, they probably suffice to point out local temperature anomalies. One readily notices that slopes tipped toward the Sun are warmer than those tipped away, and that the darker areas tend to be warmer than the brighter areas.

ACKNOWLEDGMENTS

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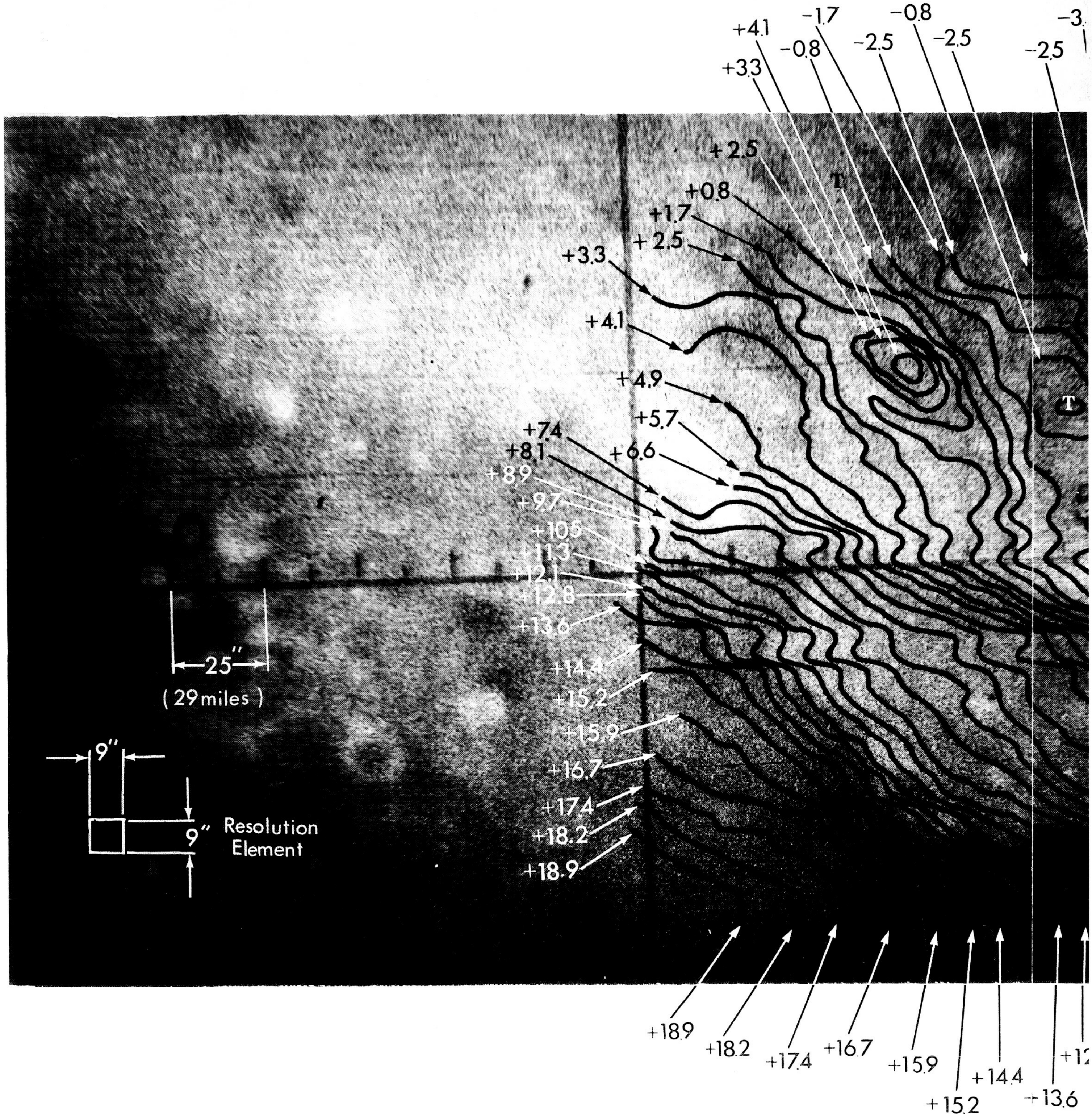
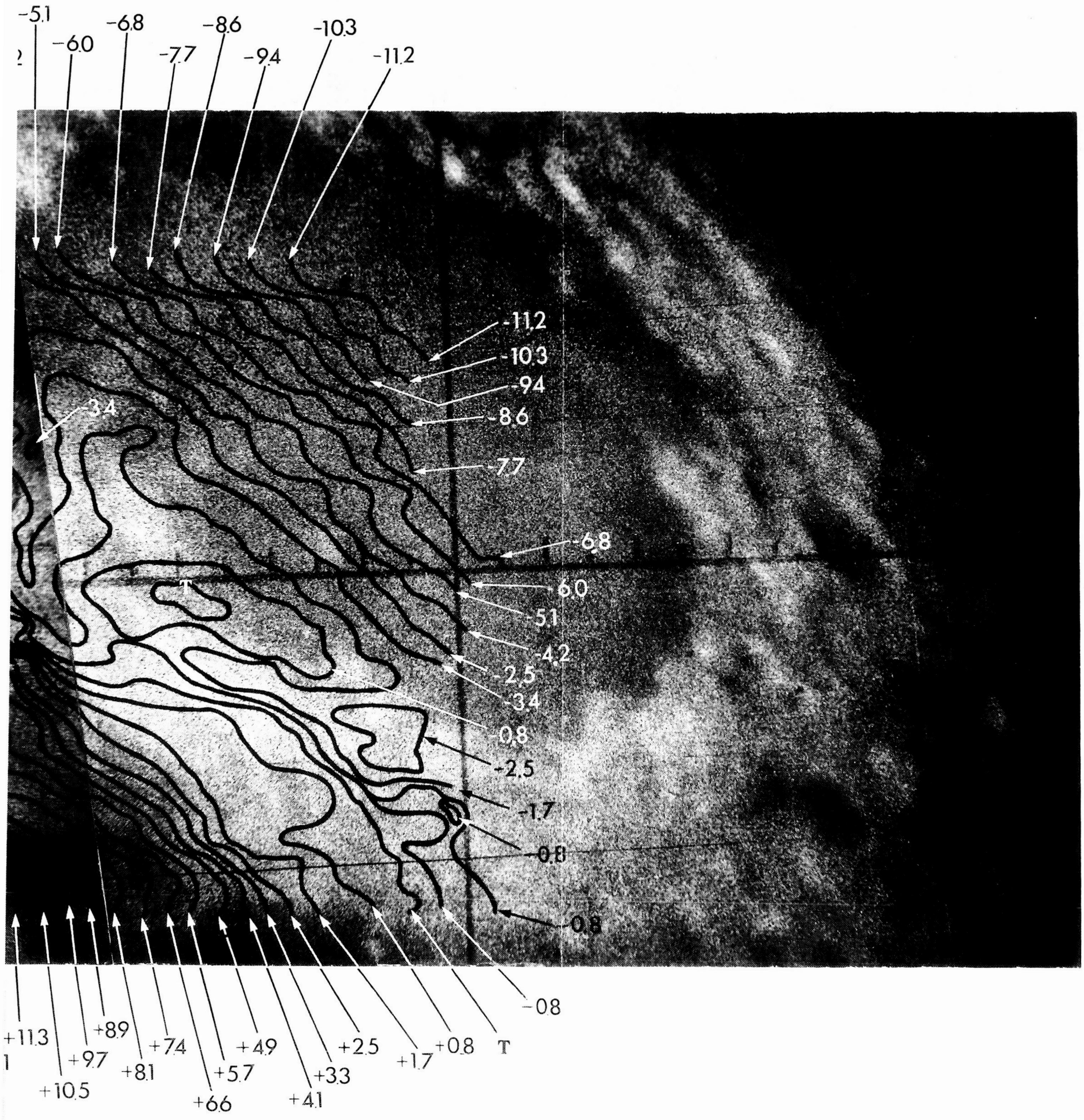


FIG. 1. A mosaic photograph composed of prints made from the identification negatives of the radiation pyrometer operating at the Newtonian focus of the 60-inch telescope at Agassiz Station (Harvard, Massachusetts). The isotherms were then plotted on this mosaic. The data were obtained February 27-28, 1964. The air temperature was 24°F (-4.4°C) and the relative humidity was 20%.



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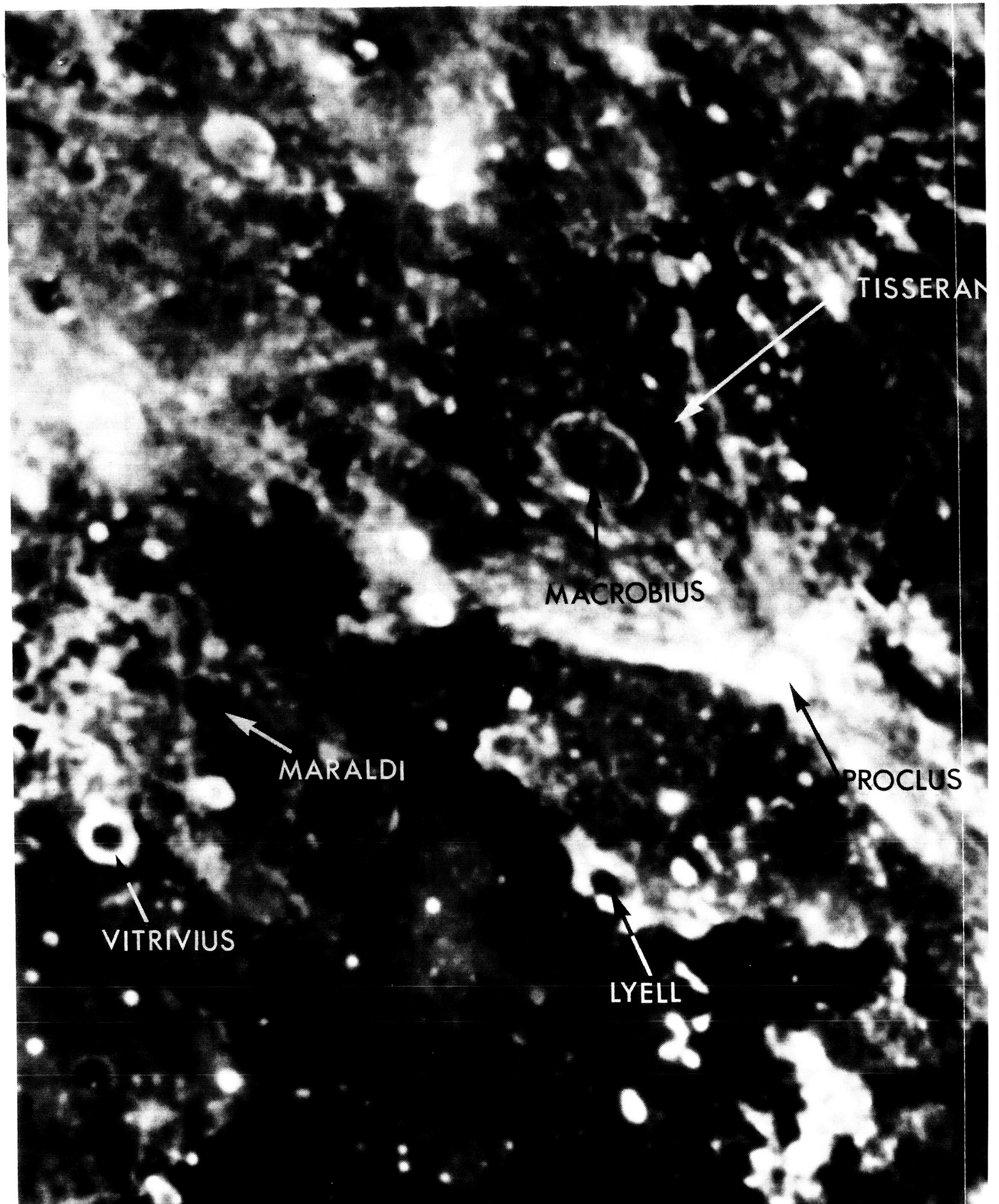

FIG. 2. Photograph showing the general
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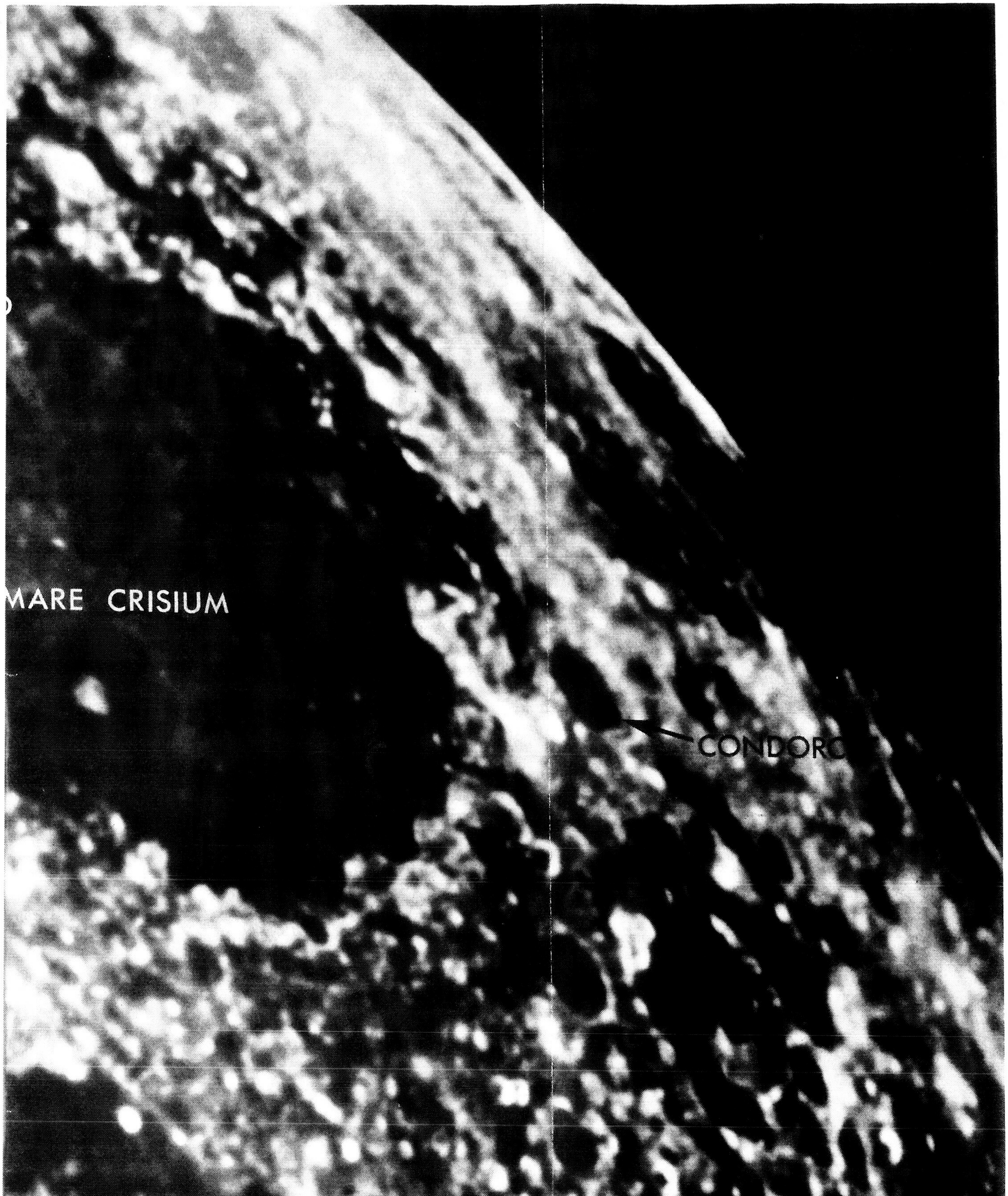

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Photograph)

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(2) Edgerton, Germeshausen & Grier, Inc.: Data Sheet, "X·R Extended Range Film"