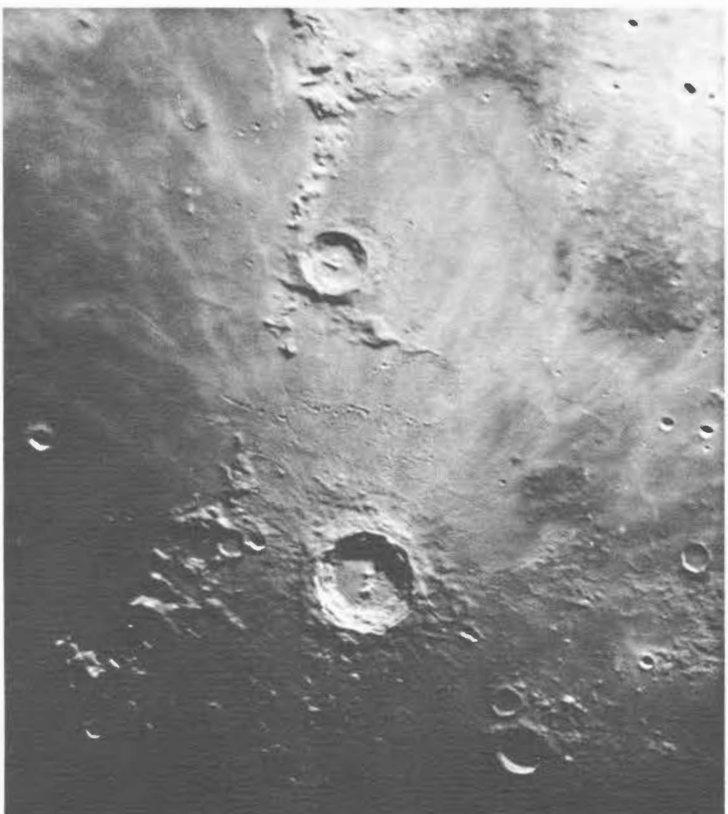
The Strolling Astronomer

The Journal Of
The Association Of Lunar
And Planetary Observers

Volume 23, Numbers 9-10

Published June, 1972



Photograph of Copernicus, Eratosthenes, and Sinus Aestuum on Moon. Taken by Richard J. Wessling with a 12.5-inch Newtonian reflector on July 24, 1969 at 2 hrs., 5 mins., Universal Time. No filter. Colongitude 26.8 degrees. Lunar east (IAU sense) at top, lunar north at left. This photograph (RW-2) is in the ALPO Lunar Photograph Library. Mr. Wessling has resolved the Corpernican secondary craters near the low ring Stadius (at center) down to a diameter of about 1200 meters.

THE STROLLING ASTRONOMER
Box 3AZ
University Park, New Mexico
88001

Residence telephone 524-2786 (Area Code 505)
in Las Cruces, New Mexico

Founded In 1947

IN THIS ISSUE

APPARITIONS OF TWO UNUSUAL MINOR PLANETS (#1685 TORO AND #433 EROS) IN AUGUST, 1972, by Richard G. Hodgson .... pg. 149

THE SHADOW OF THE MOON IN THE SKY AT A TOTAL SOLAR ECLIPSE, PART II, by William H. Glenn .... pg. 150

EVIDENCE FOR LUNAR VULCANISM FROM LUNAR PROBES, by Winifred Sawtell Cameron .... pg. 159

MERCURY IN 1966 AND 1967, by Richard G. Hodgson .... pg. 170

ALPO SELECTED AREAS PROGRAM REPORT: KEPLER, by Kenneth J. Delano .... pg. 174

LUNAR NOTES, by Winifred Sawtell Cameron, Kenneth J. Delano, Harry D. Jamieson, and Roy C. Parish .... pg. 179

THE PROGRAM FOR OBSERVATIONS OF LUNAR TRANSIENT PHENOMENA .... pg. 179

THE DARK-HALOED CRATERS PROGRAM .... pg. 181

PROGRESS REPORT ON A STUDY OF MESSIER AND PICKERING .... pg. 181

INDEX TO VOLUME 20 OF THE STROLLING ASTRONOMER, by J. Russell Smith .... pg. 182

BOOK REVIEWS .... pg. 186

ANNOUNCEMENTS .... pg. 188

ABC Print—Las Cruces

APPARITIONS OF TWO UNUSUAL MINOR PLANETS (#1685 Toro and #433 Eros) IN AUGUST, 1972

By: Richard G. Hodgson

In August, 1972 two minor planets with unusual orbits will make favorable approaches to the Earth, and will be bright enough to be seen with telescopes of 15 cms. (6 inches) or larger aperture.

The first of these planets, #1685 Toro, revolves around the Sun in 1.600 years in an orbit which is apparently gravitationally coupled with the Earth's, favorable approaches occurring regularly every eight years.[1] While Toro has a mean distance of 1.3677 A.U. (Astronomical Units) from the Sun, its orbit is of considerable eccentricity (e = 0.436), with the result that at perihelion the tiny planet is only 0.771 A.U. from the Sun — just 0.04 A.U. outside the orbit of Venus. At aphelion Toro moves out to 2.1387 A.U. Toro was discovered on 1948, July 17 by Carl A. Wirtanen at the Lick Observatory, and has been reobserved during the favorable approaches of 1956 and 1964. Its diameter is about 1½ kms. (1 mile); its period of rotation is not yet known.

Observers should attempt positional determinations (preferably by securing photographs), and should try to note its light variations with a view to determining its rotation period. Observations should be made in the early part of August: later in the month the Full Moon (August 24, 18^h U.T.) may cause trouble. To identify the planet, one should have access to a good star atlas reaching down to the 14th magnitude, such as Hans Vehrenberg's Atlas Stellarum.

Planet #433 Eros will be readily visible in 15-cm. or larger telescopes in late August and early September, 1972. This approach will not be so favorable as that coming in 1975, but observers may wish to locate this brick-shaped planet and to watch its considerable light variations. Discovered by G. Witt in 1898 at Berlin, Eros was used in measurements of the Astronomical Unit by Sir Harold Spencer Jones in 1930-31. Its period of rotation,[2] one of the best known in the Solar System, is $5^h16^m12\overset{s}{.}913$.

The following data are taken from Ephemerides of Minor Planets for 1972:

Planet #1685 Toro

Date (0^h E.T.)	R.A. 1950.0	Dec. 1950.0	Delta	r	mag.
1972					
July 2	$21^h26\overset{m}{.}0$	− 4°47'	0.358	1.301	15.3
7	21 30.8	− 1 01	0.312	1.267	....
12	21 35.6	+ 3 42	0.270	1.233	14.6
17	21 40.5	+ 9 46	0.231	1.198	....
22	21 46.1	+17 41	0.197	1.162	13.9
27	21 53.2	+28 04	0.168	1.127	....
29	21 56.8	+33 03	0.159	1.113	....
Aug. 1	22 03.7	+41 25	0.148	1.091	13.5
3	22 09.9	+47 32	0.142	1.077	....
5	22 18.2	+54 00	0.138	1.063	....
6	22 23.5	+57 18	0.137	1.056	....
7	22 29.9	+60 37	0.136	1.049	....
8	22 37.9	+63 57	0.136	1.042	....
9	22 47.9	+67 14	0.136	1.035	....
10	23 00.9	+70 27	0.136	1.028	....
11	23 18.6	+73 32	0.137	1.021	13.8
12	23 43.3	+76 27	0.139	1.014	....
13	0 19.4	+79 04	0.140	1.007	....
14	1 13.6	+81 13	0.143	1.000	....
16	4 04.6	+82 51	0.148	0.986	....
21	7 51.8	+74 31	0.168	0.952	14.7

Planet #433 Eros

Date (0^h E.T.)	R.A. 1950.0	Dec. 1950.0	Delta	r	mag.
Aug. 1	$22^h41\overset{m}{.}8$	+ 0°13'	0.814	1.748	13.5
11	22 28.7	+ 1 07	0.758	1.735	13.2
21	22 11.8	+ 1 37	0.722	1.720	13.0
31	21 53.5	+ 1 42	0.708	1.704	12.9

Planet #433 Eros (cont.)

Date (0^h E.T.)	R.A. 1950.0	Dec. 1950.0	Delta	r	mag.
Sept. 10	21^{h}36^m.4	+ 1°26'	0.717	1.685	13.1
20	21 22.9	+ 0 58	0.746	1.664	13.3
30	21 14.6	+ 0 30	0.790	1.642	13.5

In the above ephemerides, the column marked "Delta" gives the Earth - planet distance in A.U.; that marked "r" is the planet - Sun distance in A.U. The magnitudes quoted correspond to B in the UBV system; in visual light the planets may appear ½ to 1 magnitude brighter.

For most observers these data should be sufficient. Any readers who desire more extended ephemerides may secure them by sending $0.60 US in check, coin, or stamps to the writer to cover costs. His address is Dordt College, Sioux Center, Iowa, 51250.

References

1. See Modern Astronomy magazine, vol. 3, no. 4 (January-March 1972), p. 13 for more details.

2. T. Gehrels in Surfaces and Interiors of Planets and Satellites, edited by A. Dollfus (1970), p. 357.

Postscript by Editor. We heartily invite interested readers to join in the project described above. Equipped ALPO members not currently active on other programs may especially enjoy the observational work on Toro and Eros described above. Mr. Hodgson has kindly agreed to receive and to study all such observations made by our readers, which should accordingly be mailed to him promptly at the address given. Should enough data of good enough quality on Toro and Eros be submitted, Mr. Hodgson will report the results in a future issue.

THE SHADOW OF THE MOON IN THE SKY AT A TOTAL SOLAR ECLIPSE: PART II

By: William H. Glenn

The path of the total solar eclipse of July 20, 1963 first touched the Earth's surface at sunrise in Japan, crossed the North Pacific Ocean, Alaska, Canada, and Maine, and terminated at sunset in the North Atlantic Ocean. The appearance of the Moon's shadow in the sky as seen at sunrise from Japan has been described in Part I of this paper (Str. A., Vol. 23, Nos. 7-8, pp. 136-142). In North America, however, the Sun was well above the horizon during totality, and because of this greater altitude the Moon's elliptical shadow on the Earth's surface was far less eccentric than under the sunrise conditions in Japan. Because of this lesser eccentricity the V-shaped shadow cone seen in Japan was not observed in North America.

The effects seen during a "high sun" eclipse are not nearly so striking as those seen under sunrise conditions. Instead of the V projected upward from the horizon around the Sun, the entire sky over the observer becomes dark while sunset colors are seen completely around the horizon, the exact effect depending on the position of the observer within the shadow. The approaching shadow itself may sometimes be seen projected on clouds just before totality, and during totality the pattern of colors around the horizon will change from moment to moment. At third contact the shadow may sometimes be seen disappearing quickly in the direction of the shadow's motion.

Since observers are usually more concerned with the corona than with sky effects, few persons in 1963 had the opportunity to look continuously in all directions during totality and to record the moment to moment changes that they saw. Individual reports also differed considerably as to what was seen, undoubtedly in large part because of the brief periods of time available for observation. Rather than attempt to draw a generalized overall picture of what was seen from North America, therefore, the writer has simply summarized the reports, grouped together geographically; and these are presented below.

I: The Observations

Most of the observations received from Alaska came from Talkeetna, where totality occurred at 10:03 A.M. (A.S.T.) and the solar altitude was approximately 43°. The sky was perfectly clear at this location, except for some cumulus reported near the horizon in the southeast, east, northeast, and west. About one minute before totality, according to S. V. E. Waite and M. R. Fairfax, a dark but not clearly defined section of sky became noticeable in the southwest as the shadow approached. The color of the shadow was a deeper purple than the unshadowed sky around it; and the sky to the south-southwest, outside the shadow, appeared yellow. The shadow in the sky appeared to move toward the north and closer to the observers, darkening them as it came; but it could not be seen actually moving across the ground. At totality the sky was purple-black, with lighter areas being seen toward the horizon. Toward Mt. McKinley in the northwest and toward the south-southwest, the horizon remained yellowish, at least during the first part of totality. The mountains themselves were peach-colored; and as the end of totality approached, they became bright again sooner than did the observers' location. In the northeast the clouds were gray, becoming black at totality, while the other clouds remained white.

Gene J. Petrik also reported from Talkeetna that the Moon's shadow was first seen in the sky about 5-6 seconds before totality. At this time, the observer was made aware of its deepening presence when the shadow line, like a "great ominous roadway in the sky," descended upon him from the west. The shadow was described as being a very dusky and oppressive dark gray as it fell in upon the observer, and to the north and south the sky appeared steel-blue to light blue in comparison. Mt. McKinley, which lay to the north-northwest outside the shadow, was not darkened during totality, but rather "seemed to stand out." The far north sunlit horizon appeared to be quite bright and looked whitish-blue. This color changed gradually to dusky steel-blue in those parts of the sky closer to the observer until the definite dark or "black" full shadow was reached. At the end of totality the shadow appeared to "lift quite quickly to the east, and things brightened up immediately although it was still quite dark."

From Slana, Lee Coe reported that the shadow became visible in the west, had no definite boundaries, and appeared very deep blue, shading into the dark blue of the sky to the north and south. The horizon changed in color as the eclipse progressed. Sumner Adams, at Talkeetna, noted that the wide band of the dark shadow made the clouds and mountains in the east (the Talkeetna Mountains) almost black as the shadow passed over and receded.

Several additional descriptions of the horizon and sky were received. Wayne Dancer reported that several persons at Talkeetna noted that the sky near the horizon took on a pinkish hue just before second contact. This hue changed to yellow at totality. A pinkish glow shone on snow-clad Mt. McKinley during totality; and the sky behind the mountains, which was blue a half-hour before second contact, darkened continuously and became midnight-blue just before totality.

Both the southeastern and northern horizons were described by two other observers as being yellowish-white during totality. The horizon was also reported as being first pink, then light yellow, and then changing to dark yellow. The cumulus clouds near the horizon were reported by one observer as taking on pinkish or yellowish casts just before totality, and the clouds were described by another as white over the mountains and pink over the flat lands. The sky itself during totality was estimated as being dark blue to black, deep midnight blue, very dark inky blue, and dark blue respectively by four different observers.

Observers farther east had variable luck with the weather. At Fort Providence, N. W. T., James F. Wright, R. A. Nelson, E. M. Rogers, and James Prescott observed the eclipse successfully although about 30% of the sky was cloud covered. Low cumulus was fairly extensive all around the horizon, and high thin cirrus was scattered across the rest of the sky. The blue of the sky became paler as the partial phases advanced, the effect during the late partial phases being similar to viewing through sunglasses; and at second contact the sky darkened rapidly to a deep blue. A beautiful sunset effect was observed for 360° around the horizon during totality.

From Uranium City, Sask., William Cable and Gordon Thompson observed the eclipse under nearly perfect conditions. First contact occurred at 12:35 P.M., and totality at 1:49 P.M. (M.S.T.). Broken clouds cleared off 30 minutes before totality; and a clear blue sky was enjoyed until 30 minutes after totality, when a solid cloud deck moved in. During the partial phases the light drop was gradual until 1:20 P.M., when it more or less levelled off until 1:40 P.M., and then began to drop more rapidly. At 1:48, one minute before totality, the drop became very rapid, and became extremely fast a few moments before totality. By 1:20 the colors on the ground were becoming very sharp, noticeably green, and gave the feeling of a heavy thunderstorm coming in the evening, the deepening of colors being more noticeable on objects on the ground than in the sky. By 1:30 P.M. the light had become very dull, and clouds to the west had taken on a very light pink color while to the east they were normal. Totality moved in very rapidly with the feeling of rapid motion to the east. The observers were standing on the white sand shore of a lake, and during totality the light from the corona illuminated the area like a Full Moon on a fresh fall of snow. Objects were clearly visible but lacked color, and the gulls on the lake appeared snow white. After totality the light intensity rose more rapidly than it fell. The shadow was seen to rise and appeared projected against the sky for about 2 seconds after totality.

A graph of the changes in light level based on observations with a light meter pointed directly at the Sun is reproduced in Figure 1.

At Wivenhoe, Manitoba the sky was about 95% overcast, the clearing being in the northeast except for a vague clear area to the northwest, in line with the shadow path. The Sun was completely obscured by altostratus at about 8,000-10,000 ft., the large obscuring cloud being in the west and southwest. From the northeast to the south there was solid cumulonimbus with lightning. John N. R. Scatliff described the sky phenomena as follows: "About an hour before totality, a large thunder cloud (altostratus type) hovered between ourselves and the Sun, remaining there until well after the total phase. On the northwestern horizon were clouds, and above was a small patch of blue sky. There was some clearing to the east. At about 3:06 P.M. (C.S.T.) [totality] there was a noticeable sudden drop in illumination and the light on the horizon clouds was reduced just as if a great rheostat was being turned. The patch of blue sky became intensely blue (Prussian blue), of a very pure hue, and the clouds underneath on the horizon lit up in contrast with a vividly bright orange hue (these clouds presumably being well outside the shadow area). Then, the light on the clouds went up, somewhat jerkily, and all around became light again. The light around us was very much diffused by the enormous thunder cloud, and it never really got dark. It seems that part of the upper layers of the cloud extended beyond the 30 mile radius [of the shadow.]"

The horizon color was confirmed by B. F. Shinn, who described the horizon to the northwest as brilliant orange against a hazy blue sky at totality. The orange emerged during the rapid drop of light intensity at totality, and faded to the usual white-on-blue as the light intensity rose at the end of totality. The horizon color was described by another observer as reddish in the west and north, with detached red clouds low on the horizon. The illumination level was also described as similar to full moonlight. A third observer felt that the reflection of sunlight on clouds to the west made the interval of totality brighter than it would have been in a clear sky.

The degree of darkness prior to totality at Wivenhoe under overcast skies is shown well in a graph of zenith light intensity changes prepared by B. F. Shinn from observations made by J. N. R. Scatliff, and is reproduced in Figure 2.

Still farther east, at Moose River, Ont. the sky was 90% clear, with very heavy cumulus and altocumulus in the northeast and southwest. According to William A. Sherwood and George Mori, the shadow was first seen in the northwest on the distant horizon 25 seconds before totality, and appeared as a very thin ill-defined beam or ray, similar to a very faint and distant plume of black smoke (see Figure 3). Whether what was seen was actually the shadow is questionable, however. If the horizon were 20-30 miles distant, as seen from the high location from which the observations were made, the shadow on the ground would have been far larger than what was reported. Considering the scattered cloud cover in that direction, the observed shadow may have been the shadow of a cloud projected against the atmosphere and on the ground.

Sherwood and Mori also reported that the horizon in the west and north just before totality was a more vivid red than at sunset, decreasing in intensity to a dark blue sky 8° above the horizon, but that the sky during totality was "not dark." David D. Meisel and John E. Monahan reported, however, that the clouds near and far were colored about the same as the corona on their upper sides and that the lower cloud surfaces were about the color of the back side of the moon [dull blue-gray].

Meisel and Monahan also measured the sky illumination before, during, and after totality by setting up a diffuse white sphere and monitoring it with a photocell at an effective wavelength of 4300 Å. The values obtained, in foot candles (lumens/ft.^{2}), are shown in Figure 4. At totality, the value obtained was 0.04 ± 0.01 ft. candle.

From Quebec, several descriptions of the changes in sky color and of the appearance of the shadow in the sky were received. Craig L. Johnson reported that at Plessisville

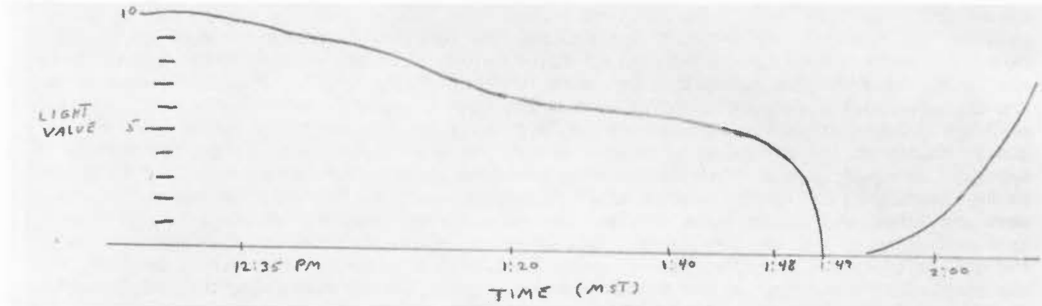


Figure 1. Graph of light meter readings made by W. Cable and G. Thompson at Uranium City, Sask. Light meter pointed directly at Sun. Light intensity units are undefined meter scale values. Totality at 1:49 P.M., M.S.T. See also text.

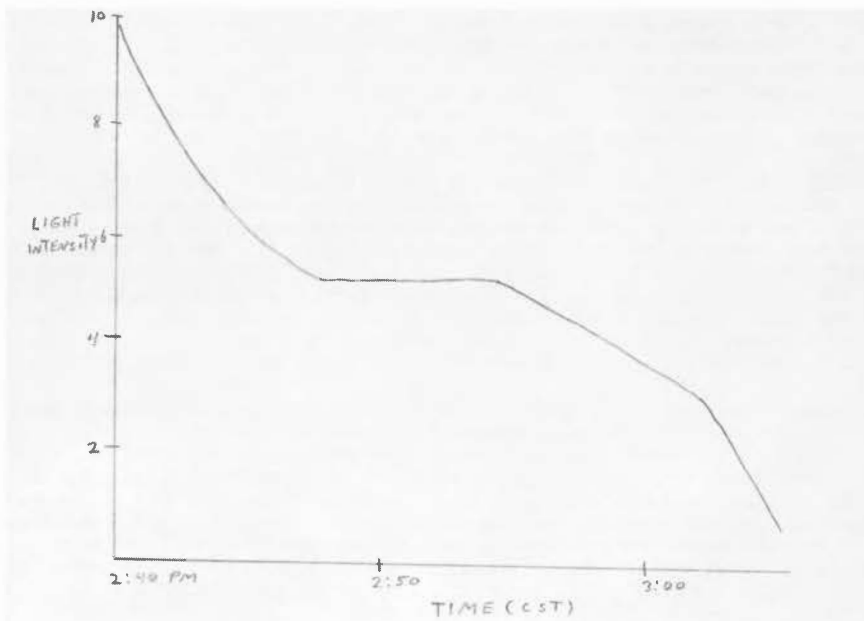


Figure 2. Graph of light intensity readings prepared by B. F. Shinn from readings made by J. N. R. Scatliff at Wivenhoe, Man. Light intensity units are undefined meter scale values. Totality at 3:06 P.M., C.S.T. Light meter directed at zenith.

Figure 3. Problematic possible appearance of Moon's shadow in sky and on ground near distant horizon as reported by G. Mori and W. A. Sherwood from Moose River, Ont. See also text.

****

totality occurred at about 5:40 P.M. (E.D.T.) with the Sun at an altitude of 23° in the western sky. Cloud cover was about 60%, mostly cumulus, extending from the west through the south to the east, with only some clouds in the north; and the Sun itself was slightly obscured during totality. Between first contact and 50% eclipse, no change in sky illumination was noticed. As totality approached, the landscape appeared to grow gradually darker until by 95% eclipse the level of illumination was that of very late evening at sea level, when the Sun is visible but casts no appreciable light. The Moon's shadow in the sky was first seen just north of northwest about 15 seconds before totality. It was noticeably darker than the sky background, but still fairly light, appearing like an ordinary shadow in early morning or late evening. Upon its appearance in the northwest, it appeared to swell in size without changing position much. Just before totality it looked to be indefinite; but a few seconds after totality began the boundary on the west-northwest was quite well defined, in contrast to the eastern boundary, which gradually faded into nothingness. In the northwest, just after the start of totality, the sky outside the shadow took on a very pronounced orange cast. This coloring soon faded, however, and was completely gone long before totality ended. There was no particular coloring in the south or east at any time. During totality, the illumination appeared to be somewhat brighter than with the Full Moon at midnight. The shadow disappeared almost instantly at third contact; and later it could not be seen, although the observer specifically looked for, and failed to see, the shadow racing away.

At Grand'mère, Quebec, where totality occurred at 5:39 P.M. (E.D.T.), the sky was 50% obscured with altocumulus and cumulus clouds. The clouds were heavy to the south and southeast and scattered to the northwest, and cumulonimbus were seen 15 miles to the north. The sky was completely clear around the Sun for at least 2° during totality. Lawrence Nadeau reported that shortly before totality the shadow was seen as a distinctly oval form passing over a cloud bank north of him. It was seen <u>only</u> on a cloud bank about 15 miles straight north. Its color was a deep brown black, and its edge was not so diffuse as expected, less than about half a degree across. The clouds remained yellow-brownish-orange up to its edge. When the shadow first hit the clouds it appeared very elliptical, and as it crossed the clouds it seemed to lose its ellipticity and became more straight along the one edge which was seen. It took five seconds to cross and engulf the clouds, eight or ten seconds then remaining before totality began (see Figure 5). The sky itself at totality was described as deep blue, similar to the evening sky near the end of nautical twilight. Observations made by the Camp Minnowbrook party, led by William Simon, confirm that the shadow appeared first in the northwest. The horizon during totality was described by different observers in this party as red, pink, orange-yellow, or slightly orange; and the rest of the sky was reported as being cloudy and dusky gray.

Also from Grand'mère, L. W. Smith reported that the shadow became visible about 20 seconds before totality. There was no appreciable change until shortly after 5:05 P.M. (E.D.T.), but from then on the light diminished "like an English twilight", and the storm clouds all around began to assume a dirty brown color and appeared more ominous. The surrounding sky was full of clouds ranging in color from dead white to dark gray and stormy brown. No comparison was possible, but the shadow looked deep gray. In the immediate vicinity of the Sun, where there were no clouds, the sky changed from sky blue to deep cobalt blue. At totality the sky was deep twilight and the clouds were light violet and orange.

At Coleraine, Quebec, where the sky was 1/3 obscured by small cumulus clouds in all directions, the sky overhead was reported as blue at totality; but the horizon was darker. At Senneterre, with 100% cloud cover, the period of greatest darkness was very short, with considerable light coming from the horizon. At totality no change of color was observed, the clouds overhead being dark gray to black. Yellowish clouds were seen on the northeastern horizon immediately after totality.

Near Grand Piles, with only a small part of the western sky clear, Michael G. Hunter saw the shadow in the northwestern sky 4 seconds before totality. Its motion was not so fast as expected. Peter Rothmaler, near the same location, failed to see the shadow, however, and reported that the sky at totality was "not very dark - similar to a half hour or hour after sunset."

At Pleasant Pond, Maine, the sky was 70% cloudy and the first 30 seconds of totality were obscured. According to Harold Solomon, the sky at totality was dark, similar to late evening, except that the sky was bright near the horizon at right angles to the direction of the solar azimuth. The near clouds and sky appeared dark and nearly colorless during totality, and red-orange immediately before and after totality. The far clouds and sky were not affected by the eclipse. Other observers reported that the shadow was not seen either before or after totality, because of the broken clouds.

At Athens, Maine, 80-85% of the sky was heavily overcast, and the corona was visible

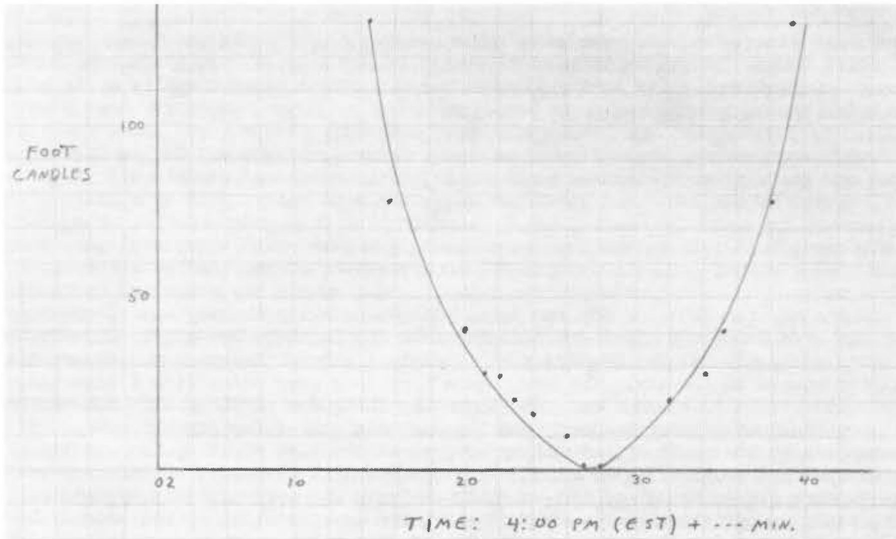


Figure 4. Graph of sky illumination in foot candles based on data obtained by D. Meisel and J. E. Monahan at Moose River, Ont. Effective wavelength 4300 Å. See also text.

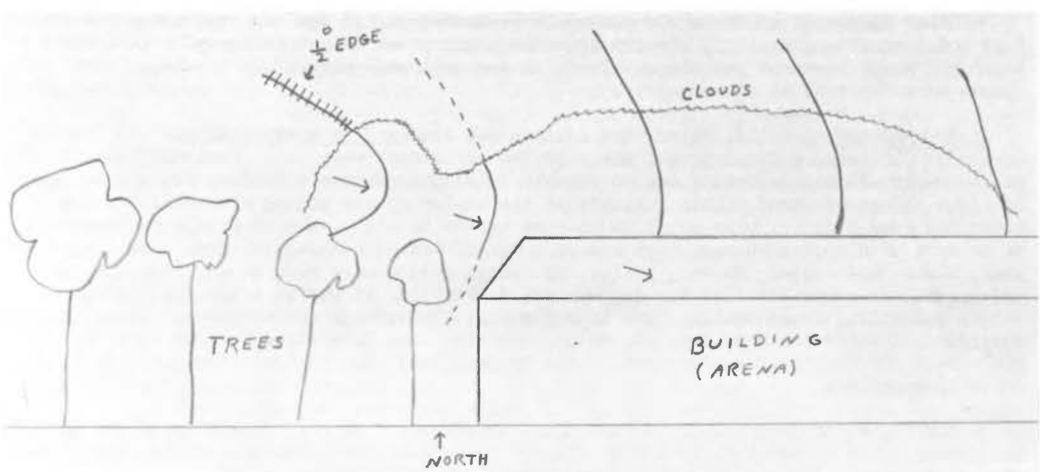


Figure 5. The shadow edge as seen on a cloud bank to the north by L. Nadeau from Grand'-mère, Quebec. See text.

****

through thin clouds. William H. Glenn and Florence Glenn reported that, at the onset of totality, the clouds in the northwest became dark steel-gray; but the edge of the shadow on the clouds was not sharp, and there was some doubt as to whether or not the shadow was actually seen at all. During totality there was considerable cloudiness in all directions, and the sky was dark steel-gray with deep orange horizons. At the end of totality the south-southeast appeared very dark gray for a few seconds, with orange to the southeast. An all-sky camera photograph by Charles Cuevas, taken immediately after the beginning of totality, showed the southern horizon much brighter than the northern. Members of the Manchester Astronomical Society also reported that no observer saw the shadow disappear, probably because of the cloud cover.

Color-temperature meter readings of the landscape taken by Charles Cuevas read 7000° K at first contact and dropped to 5000° K eight minutes before second contact, when the last readings were taken. His series of photographs of color patches showed only a very slight shift toward the yellow between first and second contact. From the same location, the change of landscape color to a yellowish hue was also noticed visually by 14 minutes before totality.

From Bangor, Maine, where it was overcast, Harry C. Stubbs and Carlos Rost reported that the sky was very dark overhead at totality, with orange-red visible all around the horizon, except in the south and southeast where the view was blocked by a hill.

At Orono, Maine, where the sky was completely covered with stratus clouds, John Pazmino recorded a rather complete account of the appearance of the shadow on the clouds, as seen from below. By four minutes before totality the overall sky color had become ruby-gray, and the sky far from the Sun was pink. During totality the sky and clouds surrounding the Sun were blue-gray and the clouds far from the Sun were red-gray. The sky along the horizon was gold. At the beginning of totality a wave of darkness was observed moving swiftly upward in the sky. The wave was a very deep gray color with a blue tinge and had comparatively sharp boundaries. The shape was that of a parabola with the vertex apparently on the northwestern horizon, and the easterly arm of the parabola swept out from the vertex toward the north. As totality progressed the wave moved upward and toward the east-southeast and southeast, the color changing from dark blue-gray to dark red-gray and finally to dark gray-red. About mid-totality the wave was approximately symmetrical about the Sun, standing upright with the arms of the parabola stretching up and around the north and south. Near the Sun the arms were inclined to the horizon at an angle of approximately 60°, and the color was dark red-gray. The wave rushed overhead and moved southeast. After mid-totality, in the south and southeast the storm clouds were almost black at their centers and gray-red to blood-red around their edges. The wave disappeared beyond the trees in the southeast just as totality ended, and the blue-gray of the sky faded into a definite reddish hue. In the north a sheet of gold color was seen.

Other observers at Orono did not see the shadow; but it was reported that, just before and just after totality, the sky near the horizon was bright salmon-pink in the north and south where it was clear. The east and west were completely covered. The clouds were reported as silvery-gray.

From Ellsworth Falls, Maine, the eclipse was observed in a sky that was 65% cloud covered. Clouds were found in all parts of the sky except overhead. Reverend Kenneth Delano reported that darkening was noticeable 20 minutes before totality, but a more rapid light change occurred within $\frac{1}{2}$ minute of the beginning and ending of totality. The clear sky grew a darker blue about 10 minutes before totality, and at totality appeared to be more of a violet color. Just before totality the clouds were various shades of gray, black, and white. No red, yellow, or orange colors were seen at any time. Reverend Delano was surprised that the sky was not darker than it was at totality, distant clouds reflecting considerable light into the sky. The shadow was not seen. Three other observers, located south of Castine, Maine, reported that in a cloudy sky at totality there were red clouds at every point of the compass; and immediately after totality this color disappeared.

The degree of darkness during totality was estimated by the visibility of the hour and second hands of watches, by the ability to read newsprint of various sizes, and by the ability to read camera dials. The combined data obtained from <u>all</u> observing locations are listed below.

Item Observed	No. of Observers reporting "Visible"	No. of Observers reporting "Not Visible"
Second hand of a watch	16	5
Hour hand of a watch	16	2
11-point standard type	20	2
10-point standard type	1	0
6-point standard type	1	0
$5\frac{1}{2}$-point boldface type	1	0
Camera dials	6	0

Another measure of the degree of darkness occurring at totality is the limiting magnitude of the stars and planets seen, and the length of time before and after totality that they are visible. From Alaska, where the skies were clear, seven observers reported seeing Mercury, nine reported Venus, five reported Jupiter, and one reported Castor and Pollux. One observer reported seeing a total of seven planets and stars, and another report indicated that "many observers reported seeing seven stars and planets. Second magnitude stars were visible." Little data were available concerning the length of time before and after totality that the various objects were visible. For Mercury, two observers indicated that the object appeared and disappeared at approximately second and third contacts. For Venus, one observer indicated that it appeared and disappeared at second and third contacts, but the average results of three other observers indicated that it appeared about 5 minutes before totality and disappeared about 6 minutes after totality.

Both groups of observers at Fort Providence, N.W.T., observed Venus and Mercury. Both objects appeared just before totality, but Venus was followed for 15 minutes afterwards. Mercury and Venus were also both observed during totality at Uranium City, Sask., Venus appearing 19 minutes before second contact and disappearing 20 minutes after third contact. Mercury and Venus were both visible during totality from Moose River, Ont., Mercury disappearing at the end of totality. Venus was first seen 1 3/4 minutes before totality and was followed for at least 15 minutes afterwards, through clouds.

From Quebec, where skies were partly cloudy, Venus was reported by 8 observers and Mercury by 3. One observer, who saw both Mercury and Venus, reported that he saw no stars, "although others did." Another observer reported that he first saw Mercury "a few minutes before totality" and kept it in view for 6 minutes after totality. This same observer followed Venus for at least 11 minutes after totality. Two other observers sighted Venus just before totality. Cloudiness interfered with observations of stars and planets from Maine also; but nevertheless three observers reported Venus, and one reported Mercury. One observer reported Arcturus and kept it in view for 1 ½ minutes after totality. Another observer reported that several objects were seen, and estimated that second magnitude stars must have been visible 90° from the Sun.

Because of the scattering of the light of the corona by the atmosphere and the presence of earthshine on the Moon, it was anticipated that the lunar disc would not be completely black during totality. Observations of the color of the lunar disc were made at all locations. The results appear very inconsistent but certainly indicate that something other than jet black was seen by most observers. The observations, arranged according to geographic location, are listed below.

	Color of Moon's Disc	No. of Observations
Alaska	Much darker than the sky	2
	Black	2
	Orange-brown	1
	Denser and blacker than the sky; maybe slightly reddish	1
Northwest Territories	Perhaps slightly darker than the sky	1
	No color noted	1
Ontario	Very dull blue-gray	1
	Moon and sky 1° away same color	1
Quebec	Light gray	1
	Gray	1
	Dark-gray	2
	Black-gray	1
	Black	4
	Black with tinge of blue	1
	Dark deep brown	1
	Green	1
	Bluish-orange	1
Maine	Black	2
	Dark purple	1
	Dark steel-wool gray	1
	Darker than the sky but of no particular color	1

Two rather extensive descriptions of the appearance of the Moon's disc were received in addition to the color estimates. Lawrence Nadeau, from Grand'mère, Quebec, reported that 24 minutes before totality he was able to make out a difference in contrast between the Moon near the middle of the Sun and the sky off the Sun's edge where the Moon most eclipsed the Sun. At totality, with a 3" reflector at 40X, he saw the Moon as deep black with a tinge of brown. The darkness of the disc was very pronounced; and earthshine was not so noticeable as on the crescent Moon, there being less detail and more black. No maria were seen; but a few black points, possibly mountains or craters, were seen near the left edge (in relation to the horizon). John L. Menke reported form Jackman, Maine, that with a 2.5" opera glass there was a very decided light variation across the lunar disc during totality. The Moon was a cool gray color. The light variation appeared radially symmetric, with the center being the bright region and the variation in intensity being very marked but quite gradual from center to edge. Perhaps the ratio of brightness from center to edge was about 2:1 or 3:1. The effect was similar to the shading used on textbook spheres to make them appear three-dimensional. The observer claims he verified that this effect was not an illusion.

II. Summary

The general impression obtained from the observations of the sky at totality is that the clear sky appeared dark blue with orange horizons in all directions, and that the color effects were modified by the amount of cloudiness present. Clouds within the shadow appeared dark gray; those outside appeared orange. In clear skies the approaching shadow manifested itself by appearing as a dark diffuse area in the sky in the direction of the shadow's approach, and the receding shadow was seen as a darkening of the sky in the opposite direction. In partly cloudy skies the shadow edge could be seen on the cloud banks, and observers beneath a complete overcast could detect the shadow projected on the cloud cover. The light level during totality was sufficiently high to allow 11-point standard type to be read; and although the faintest star identified was Arcturus (magnitude -0.06), several observers thought that second magnitude stars could have been seen. Photocell measurements of sky illumination gave readings of 0.04 ft. candles at totality. Estimates of the appearance of the lunar disc varied widely, and these were undoubtedly affected by meteorological factors as well as by the color sensitivity of the observers' eyes. The disc was apparently not jet black, however.

III: Suggestions for Future Work

Detailed visual reports of the appearance and disappearance of the shadow, and of the moment-to-moment changes in sky color and brightness throughout totality continue to be of interest. Observers whose schedules are not heavily occupied with other programs could carry out programs of this type, perhaps with the aid of a tape recorder to record on-the-spot commentary. The observations should be made regardless of the amount of cloud cover, even the results obtained under total overcast being of some interest.

The moment-to-moment variations in horizon illumination in all directions can be recorded photographically on 35-mm. color film by means of an all-sky camera or "fish-eye" 180° field-of-view lens. The camera should be directed toward the zenith with its long axis lined up in a known direction, either north-south or east-west. The use of a bubble level and compass makes this task very simple. It is then possible to mark the slides obtained with the correct directions. Exposures should be made at 15-second intervals from about 1½ minutes before totality to about 1½ minutes after totality. The writer found at the 1970 eclipse that using an F5.6 "fish-eye" with exposures of 1/8 second at ASA 200 produced slides that were several stops underexposed at totality, but which still showed the sky brightness around the horizon. A more realistic exposure would probably be at least 1 second, or even more. This program could also be carried out regardless of weather conditions.

The degree of darkness during totality can be estimated by the magnitudes of the faintest stars visible, and observers should therefore report all objects seen. A more quantitative approach, that can be carried out under clear or cloudy skies, is to make photocell readings of the zenith sky during totality. Most ordinary photographic light meters are incapable of measuring the low light levels during totality, and they are also generally calibrated in arbitrary scales which do not permit ready conversion to foot candles. The only photographic meter known to this writer that can reach the low light levels (less than 1 ft. candle) of the sky during totality is the Lunisix. Incident light readings made with this meter can be converted into approximate foot candle equivalents by means of a table printed on the meter.

Persons having access to more sophisticated equipment may be able to make continuous photocell readings of the zenith and of the horizon in each of the four cardinal directions throughout totality, as a means of monitoring the passage of the shadow over the observer's location.

A final suggestion is for observers to note the color and degree of darkness of the lunar disc during totality as compared to the surrounding sky, and to look for evidence of the lunar <u>maria</u> on the earthlit disc. This observation can be made at the same time that the observer is viewing the corona.

The writer would be interested in receiving reports from observers making these types of observations at the July 10, 1972 total solar eclipse. Please send reports to:

William H. Glenn
3235 Parkside Place
Bronx, New York 10467

In addition to those observers named in the text, the following persons submitted reports used in preparing this paper: Stuart J. Baldwin, D. Potter, C. G. Barnett, B. J. Engelke, Virginia Ekstrand, Alice Smith, Helen Winberger, Paul B. Grisso, Jr., Allen Feng, Bernard, Donald, Ervin, and Martha Jackson, Karl Glades, L. E. Olendorff, Sr., W. L. and Phyllis Hutchings, L. W. Alwin, University of Alberta, Calgary, expedition, M. Hastings-Trew, C. H. and D. C. Montrose, Mr. and Mrs. T. R. Dale and family, Walter C. and Margaret S. Espenlaub, Raymond N. Watts, George Lovi, Arthur Pearlmutter, D. C. J. Santhanem, M. R. Molnar, Antoinette J. Pridmore, Daniel J. Fernandes, Margaret Olmstead, Hugh Fray, H. J. Healer, Jr., Thomas B. Merritt, A. David Burdoin, and James D. Brownridge.

EVIDENCE FOR LUNAR VULCANISM FROM LUNAR PROBES

By: Winifred Sawtell Cameron,
Laboratory for Theoretical Studies, Goddard Space Flight Center

(An updated revision of a paper read at the Southwestern Astronomical Conference '68 at Las Cruces, New Mexico, August 21-24, 1968)

Selenological studies from Earth-based observations have resulted in divided opinions among selenologists on the origin of many features, especially the circular craters and <u>maria</u>. The interpretations have been divided into the exogenous (meteoritic impact) and endogenous (volcanic) processes. Results from the various U. S. probes of the Ranger, Surveyor, and Orbiter series and from the USSR lunar probes have convinced me that both processes have operated on the Moon in about equal importance. These results have supported and confirmed many of the Earth-based observations. Many selenologists have interpreted numerous features as having formed from, or been modified by, volcanic activity. There are some types which are almost universally agreed to show evidence of vulcanism and are the following: (1) surfaces of the <u>maria</u> and the dark, flat-floored craters; (2) the classical lunar domes; (3) crater chains; (4) sinuous rilles (not universally agreed upon, but regarded by many as due to internal activity); (5) wrinkle ridges. There are also ring dike-like features that many interpret as volcanic. Some of the Lunar Transient Phenomena (LTP) manifestations are thought to be from internal activity; in fact, their selenographic distribution implies that the majority are.

Dark, Flat Areas

The origin of the circular <u>mare</u> basins as formed by impact is now generally accepted. The black filling material of the basins, however, has been generally accepted as being volcanic. Until about fifteen years ago, the only terrestrial extensive flat volcanic plains known generally, even by geologists, were the flood basalt plateaus, such as our Columbia River Plateau or the Deccan Traps of South India. These are vast, level plains of about 100,000 sq. mis. in extent, with slopes of the order of a few degrees and lobate termini with substantial scarps. They resulted from great outpourings, mostly from fissures, of a very fluid, basic, dark type of lava, called basalt. Therefore, this was the kind of material selenologists thought had filled the <u>maria</u> and dark, flat-floored craters, e.g., Plato.

More recently, our studies of lunar features and volcanic phenomena have suggested similarities between the unusual phenomena of ash flows, which produce extensive plains of more than 10,000 sq. mis. of welded tuffs or ignimbrites, e.g., Yellowstone Park and its environs, and lunar plains. The characteristics (Ross and Smith, 1961) of these almost hydrostatically level plains are strikingly similar to those of the overall <u>mare</u> surfaces, e.g., slopes of about half a degree, feather edges, and sometimes preservation of the underlying topography in a much subdued form. Ash flows are a mixture of gas and dust (fluidized dust) that issue explosively from vents or fissures and flow at speeds of 100 mi./hr. to great distances, producing vast plains. The composition is acidic and results from differentiation. Differentiation is a process whereby lighter constituents of a magma (lava at depth) are separated from the denser constituents by gravity, the denser crystals sinking and the lighter ones rising. Rocks can be classified according to their silica content (SiO_2) as shown in Table I. The higher the silica content, the more acid and less dense the rocks become. The viscosity also rises with silica content so that the acidic lavas do not flow to as great distances as do the fluid basalts (except in the special case of ash flows). The gas content also rises with the silica content. When there is a great deal of gas, it pulverizes the lava into dust-sized particles which erupt as ash flows. Modern ash flows, erupting from volcanoes, are often called nuées ardentes. The characteristics of ignimbrites (the final deposit from an ash flow, which welds into rock after the escape of the gas and heat) led us (O'Keefe and Cameron, 1962) to suggest that the top surface of the maria was ignimbrite (welded tuffs) although probably underlain by basalt. Figure 6 shows: (a) characteristic flood basalt surface, (b) characteristic ash flow surface, (c) volcanic flow in Mare Imbrium, and (d) lunar surface around Surveyor I. The observable characteristics in these photographs invite comparisons as analogs between Fig. 6a and 6c and 6b with 6d.

The α-backscatter results from Surveyors V, VI, and VII most nearly match a basaltic composition (Turkevich et al., 1967). Intermediate type rocks, e.g., andesite (from the Andes Mts.), may not be entirely ruled out; but basalt is a closer match. Apollo results (Science, 1970) confirm this opinion. These results support the old hypothesis of flood basalts having filled the maria. Some silicic material, however, has been found; but the quantity and significance for the Moon's evolution are unknown. Gilvarry (1968), however, insists that mudstone is a closer match to the Surveyor results. Mudstone has not been found in the first Apollo samples, however. In fact, not even hydrated minerals have been found yet. It happens that, of the three first Apollo locations, two were on bluish areas of maria and one on the bluish halo of Tycho. Large portions of the dark areas are reddish, however, (Whitaker, 1966); and the difference in color may indicate a difference in composition. It is possible, therefore, that other dark areas may be ash flows. There is other supporting evidence for such interpretations. By analogy, however, since the characteristics of most flat areas are quite similar, one would expect the one interpretation to suit all similar appearances. The puzzling aspect about these results, though, is that the surfaces around the Surveyors do not look like lava surfaces. They look as if they were composed of particulate matter, i.e., dust. Surveyor experiments with the digging claw confirm that it is soil-like, not rock-like. Flood basalts have hitherto been regarded as lava rock. Recent investigations (Green, private communication) suggest that basalt plateaus are actually built up of alternating lava and ash deposits. If this is so, then the observations can be reconciled with the basaltic composition interpretation. Ash flows, being unconsolidated on top, would give the observed close-up characteristics around Surveyor sites as illustrated in Figures 6b and 6d.

Lunar Domes*

The classical lunar domes, such as those near Hortensius, Marius, and Arago, have various interpretations, all of them being of internal origins. The three major proposed possible origins are: (1) shield volcanoes (basaltic), (Pickering 1920, Spurr, 1945), (2) laccoliths (acidic) (Marshall, 1943, O'Keefe and Cameron, 1962), (3) pingos (ice or permafrost)(MacRae, 1965, Gold, 1966). Shield volcanoes, represented by the Hawaiian volcanoes Mauna Loa and Kilauea, for example, are built up from relatively gentle outpourings of fluid basaltic lava forming a lens-like or shield-like mass. At the summit there is usually, if not always, a crater or cladera. A caldera is a large crater, usually more than one mile in diameter, formed by collapse. Laccoliths are mushroom-shaped features caused by viscous (acidic) magma penetrating between layers of rock which solidifies in place because it cannot find a vent to the surface. The overlying layers of rock are thus arched up, and the surface expression is a gently-sloped mushroom-like or shield-like feature. Pingos are really temporary ice laccoliths. They are caused by ice or permafrost at some depth that arches up the ground above it into a dome-shaped feature of relatively short life (a few hundreds to a few thousands of years). Some objections to the interpretation of lunar features as pingos, other than their temporary nature, are: (1) their size, (2) their slope, and (3) the evidence that little water exists on the Moon (Ness et al., 1967) and now from Apollo samples (The Moon Issue of Science, 1970.) Pingos usually are just a few tens or hundreds of feet (up to one mile) in diameter, whereas lunar domes are often many miles (up to 40) in diameter.

Evidence that favors the shield volcano hypothesis is the appearance of summit depressions on more than 50% of the approximately 200 known domes. The recent Surveyor analyses also support this interpretation. Evidence that favors the laccolith hypothesis is the lack of color difference between the domes and their surroundings, their sizes (usually 5-10 miles in diameter), the roughness of surface of many domes, and the fact that

*Further background material on lunar domes may be found in these articles in Str. A., Vol. 23, Nos. 5-6, 1971: Kenneth J. Delano, "The Characteristics of Lunar Domes", pp. 85-90; John E. Westfall, "Statistical Analysis of Lunar Dome Characteristics", pp. 90-91; John E. Westfall, "Statistical Analysis of Lunar Dome Distribution", pp. 91-98.

(a)

Figure 6. (a). Aerial view of a flood basalt plain in Idaho, showing the general flatness of the terrain.

(b)

Figure 6. (b). Valley of Ten Thousand Smokes, Alaska, deposited by an ash flow in 1912, showing close-up characteristics of the surface (courtesy of W. H. Coulter, U.S. Geological Survey).

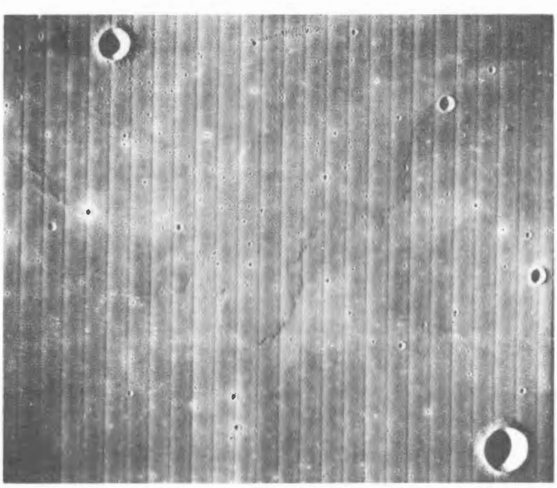


Figure 6. (c). Orbiter V photograph of a flow in Mare Imbrium near the crater Deslisle. Scarp is more than 50 ft. high.

TABLE I. VOLCANIC ROCK CLASSIFICATION.

Classification	Approximate Per Cent of Silica Content	Rock Type	Examples
Basic (fluid)	45-55	Basalt	Hawaiian volcano lava eruptions, Columbia River Plateau
Intermediate	55-65	Andesite, Dacite	Andes Mountains volcanoes lava
Acidic (viscous)	65-80	Granite, Rhyolite, Welded Tuff	Yellowstone Park environs, Valley of Ten Thousand Smokes, Crater Lake

****

many are found in the reddish parts of the dark areas. Terrestrial laccoliths are fissured, therefore rough in appearance; and these fissures meet radially at the summit, often producing a dimple depression. (See Figure 7c.) Sometimes a vent appears.

Orbiters II, IV, and V obtained remarkable photographs of the region of the Marius domes. Orbiter II made an oblique shot, and Orbiters IV and V made overhead shots (Figure 7a). Orbiter V obtained high resolution photographs, resolving features as small as about 2.5 meters (8 ft.). Earth-based observations have suggested that some domes are very rough, and these pictures verify the rugged nature of many. In this Marius Hills field especially, geologists think that two or three kinds of domes are found. Some U. S. Geological Survey people (MacCauley, 1968) think that the low, broad ones are shield volcanoes. Some are topped by steeper domes, akin to the more viscous tholoids like Mont Pelée, while still other domes may be laccoliths. Figure 7a, b, c, and d show, respectively, an Orbiter V shot of the Marius domes; Mauna Loa, a Hawaiian shield volcano; Green Mt., a laccolith in Utah; and a pingo.

Crater Chains

Some of the famous crater chains (Hyginus Rille, Stadius, etc.) are extremely difficult to explain except by an internal hypothesis. There are, however, three types of crater chains, two of which are almost certainly composed of volcanic craters, while the third kind is almost certainly composed of craters caused by secondary impacts. The Hyginus Rille (Figure 8a) contains an example of the first type of crater chain, namely those occurring in rilles. That the Hyginus craters are volcanic is generally agreed, but that the rille in which they occur is volcanic (tectonic) is not so generally accepted. A portion of the rille is radial to the center of Mare Imbrium, which many think is an impact basin, causing that portion of the Hyginus Rille. Since other subsequent volcanism occurred in and around the Imbrium basin, it is reasonable to suppose that this fissure was used by subterranean forces for the locus of several volcanic vents.

The crater chain in Davy Y indicates, I think, a second type. Here we have a long string of craters of almost certain volcanic origin. They lie, most likely, along a fault; but the fault or rille itself is not visible even in the Orbiter and Apollo pictures. In this case, I think that the rille or fault and the craters are solely volcanic and have no relation to impact.

The third kind of chain is exemplified in an Orbiter I photograph of Taruntius and its environs. The craters seen radiating away from Taruntius are certainly in straight lines. They generally are not contiguous or overlapping; but sometimes this arrangement does occur, e.g., around Aristoteles (Figure 8b). I think that the overlapping ones in the deep rille radiating from Aristotles are really volcanic, although the fissure is probably related to the impact; but the loop craters and others are ejecta secondaries. The Stadius crater chain may be a mixed bag of beans. It was an example previously almost universally agreed to be internal, but the Orbiter V view has cast some doubt on this. It appears to me that some of the craters are internal; probably the fissure is internal, but there also appear to be ejecta from Copernicus which added craters or modified the volcanic ones! Disentangling the two kinds may be very difficult to do.

Dark-Haloed Craters*

The comparatively rare dark-haloed craters, such as those in Alphonsus and those around Copernicus, have been considered to be maar-type volcanoes. A terrestrial maar is produced by an explosive, often single event which forms a crater with characteristics very similar to those of impact-craters. (See Figure 9b). The explosion gives a floor below, and a rim above the surrounding plain, ejecta, and sometimes central peaks. The lavas are usually basaltic, but explosive craters are formed in all kinds of volcanic suites. The lunar maars may be about the youngest features on the Moon, for their mantles sometimes overlie rays— e.g., around Copernicus. The lunar ones are comparable in dimensions to terrestrial ones.

****

Figure 6. (d). Surveyor I close-up photograph of the lunar surface around the spacecraft. Horizon is about 1 mi. away. Analogs seem to be 6(a) with 6(c) and 6(b) with 6(d). [All Ranger, Surveyor, and Orbiter photographs used in this paper are official NASA photographs].

Figure 7. (a). (above). Orbiter V medium resolution overhead view of the Marius Domes. Note ruggedness of some domes, different structures among them, and summit craters on some.

Figure 7. (c). (above). Green Mt., Utah, a laccolith. Note apparent crater at summit, caused by central meeting of radiating fissures. (<u>Principles of Geomorphology</u> by W. D. Thornbury, John Wiley & Sons, Inc., N. Y.).

****

*It is appropriate here to direct attention to Kenneth J. Delano's article "A Dark Haloed Craters Program", Str. A., Vol. 23, Nos. 3-4, pp. 51-54, 1971.

Figure 7. (b). Mauna Loa, with Kilauea in the background, Hawaii, examples of shield volcanoes (Geology Illustrated by John S. Shelton, H. H. Freeman & Co., 1966).

Figure 7. (d). (above). A pingo in Greenland about 30 ft. high and about 100 ft. in diameter. Note fairly steep slopes of walls. (Sky and Telescope, 29, pg. 143, 1965).

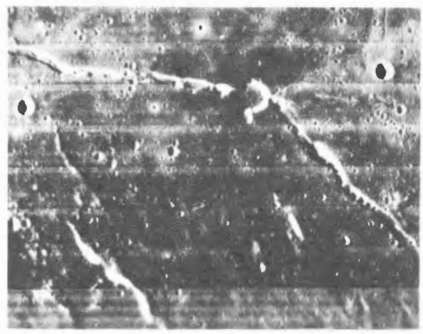


Figure 8. (a). (above). Orbiter IV high resolution photograph of Hyginus Rille. Note irregular shape of Hyginus, and presence of craters in only one branch of the rille.

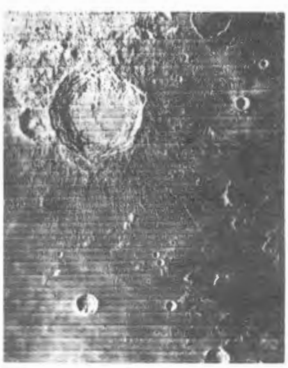


Figure 8. (b). (above). Orbiter IV high resolution photograph of Aristoteles. Note the deep fissure with a chain of probable volcanic craters in it (lower right), while other chains, e.g. in the loop (right edge), are from ejecta. (Use of a magnifying lens may be helpful).

******

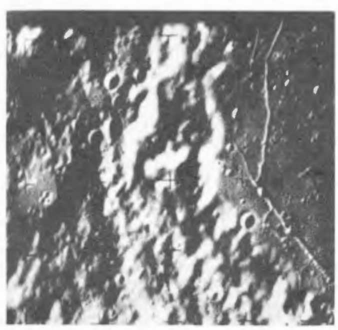


Figure 9. (a). (left). Ranger 9 photograph of part of eastern (IAU) floor and wall of Alphonsus, showing rilles and some of the famous dark-haloed craters. Note the filling in of the rille near these craters. Compare the form of these craters to nearby impact-craters. Note that there are fewer craters on the walls than on the floor.

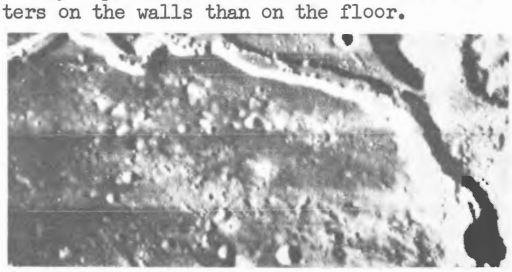


Figure 10. (a). (above). Orbiter IV high resolution photograph of the largest sinuous rille, Schröter's Valley, which first revealed the inner, even more sinuous rille that wanders across the floor of the large rille.

Ranger 9 gave us close-up views of some of the Alphonsus dark-haloed craters (Figure 9a), and we see in each case that the crater is associated with a rille. The maar ejecta often partially fill the rille around. The morphological (structural) characteristics are practically indistinguishable from those of nearby impact-craters.

The oblique view of Copernicus from the medium resolution camera on Orbiter II includes the dark-haloed crater, Copernicus H, which is the only sharp raised-rim crater in view! Orbiter V obtained a fine overhead photograph of it. The dune-like features surrounding it we interpret as due to a base surge. They are similar to, but have a much wider angle than, the ship-wake-like V-markings around lunar impact-craters. I think Copernicus H was a violent volcanic event which gave rise to a base surge (as do some terrestrial eruptions). The base surge was weaker than those from impacts. Copernicus H was evidently a higher energy event than those in Alphonsus.

Sinuous Rilles

The lunar sinuous rilles are also comparatively rare features (Cameron, 1964). Out of thousands of rilles (furrows) on the Moon, only a few dozen are winding. The most common allusion to them is "like a dried river bed" (Figure 10a). They have interested me for some time. In my studies of terrestrial volcanism, particularly ash flows, I found a description and discussion of a feature in Japan (Aramaki, 1956) whose characteristics were very similar to those of the lunar sinuous rilles. It is the Kambara Ditch (Figure 10c), which was produced by an ash flow from Asama in 1783. Most commonly, ash flows deposit material in large, level fields, as previously discussed. Sometimes, however, there may be less gas than usual; then the huge boulders that are ordinarily carried in suspension like corks are instead dragged along the ground, where they are capable of digging by abrasion. These boulders may reach dimensions of hundreds of feet! The Kambara Ditch is about 10 miles long, more than 1 mile wide at its widest, and over 120 feet deep at its deepest. It seems to have begun as a directed blast; it then followed, for some distance, a somewhat sinuous course. Other terrestrial features produced by ash flows are Diller Canyon on the flanks of Mt. Shasta, California, a long valley formed from the Santa Maria tholoid in Guatemala in 1929, and canyons eroded on the slopes of Arenal, Mayon, Merapi, Pelée, and others. These features are comparable in size to the lunar rilles and are similar in structure (Cameron, 1968).

Green (1963) suggested that the lunar sinuous rilles were produced by lava-eroded channels. The literature until very recently had no references to such features, and discussions with volcanologists elicited no experience with them. Green (1968), however, has compiled photographic evidence of lava channels, but dimensions have not yet become available. Figure 10b is from his collection. In this case the channel is about 4 miles long, about 50 feet wide, and about 5-10 feet deep. These dimensions (except the length) are orders of magnitude smaller than corresponding lunar ones. The lunar one shown in Figure 10a is the largest on the Moon; but all others are on the order of miles in length, thousands of feet wide, and 100 feet at least in depth. These and other objections apply also to the hypothesis of their being collapsed lava tubes. More recently, larger terrestrial lava channels and tubes have been discovered (Greeley, 1971). These are more the exception, though, whereas they are the rule for the Moon.

That sinuous rilles are caused by internal activity is almost inescapable. The rilles always originate in a crater which is at their wider, deeper, and higher end; they taper off in width and depth to merge eventually into the surrounding plain. Some students have argued against a volcanic origin because of the absence of a delta. This lack is indeed puzzling, but such is equally true of all of the other theories concerning their origin. None of the lava channels that Green showed had noticeable terminal deltas, and the Kambara Ditch becomes shallower and nearly merges into the surrounding plain. River deltas are formed when rivers carrying sediment are suddenly stopped by calm water, as in the Gulf of Mexico.

Menzel (1968), Firsoff (1959), and others favor the hypothesis that the sinuous rilles were produced by water. Some contend that the Moon had an atmosphere and a hydrosphere that existed for some extended period of time; others postulate that the Moon possesses a permafrost layer and that the sinuous rilles are river beds. It appears strange to me that the sinuous rilles always start in craters, often breached, which seldom have the characteristics of impact-craters. Also these rilles get narrower as they flow down instead of widening as terrestrial rivers do.

Firsoff (1959) advocates an explanation in terms of subsurface water in large quantities, with subterranean rivers over which subsidence occurred. There are other arguments against these aqueous hypotheses, the latest of which came from Explorer 35 (Ness et al., 1967). Ness found that the Moon has very little water (at least impure water, and pure water would be difficult to justify). One has to explain also how the Moon so quickly lost nearly all of its water (internal as well as external) in a very short geological time because the sinuous rilles appear to be very recent features. The results from Apollo lunar samples, indicating no water or even hydrous minerals, make the aqueous erosion hypotheses insupportable.

Wrinkle Ridges

Wrinkle ridges have generally been thought to result from volcanic activity. The term wrinkle ridge is unfortunate. The name implies that they are pressure ridges formed near the edges of volcanic flows. Terrestrial wrinkle ridges, however, are very much smaller in scale than lunar ones. (Scale has been a factor commonly ignored by many lunar students.) Terrestrial ridges measure in feet in length, while lunar ones measure in tens to hundreds of miles. They are thought now, more generally, to be intrusions or extrusions along faults. The latter hypothesis is more likely because some ridges have been traced into the highlands, a relation which would be impossible on the lava flow pressure ridge hypothesis. Orbiter I presents supporting evidence for volcanism, and differentiation. Figure 11 shows a mare ridge (term to be used henceforth) that is probably filled with a more fluid, therefore most likely basaltic lava, except at the place of the dome. This dome appears to be more viscous and is probably over a vent at which more differentiated lava was extruded.

Ring Dikes

There are many craters on the moon that contain concentric ridges or rilles or a mixture of both within the crater. Taruntius is an excellent example, and Posidonius is another. Taruntius, however, is an obvious impact-crater with subsequent volcanism, whereas Posidonius does not have such criteria.

Another type of feature should be included in this class. It is those craters with walls with inner and outer slopes about equal. Fielder (1967), O'Keefe et al., (1967), and others think that these are possible ring dike structures. Terrestrial ring dikes are lava-filled concentric, circular fractures. It is believed that the central part subsided; and lava was forced up through the circular faults, with a surface expression similar to what we see in the lunar features. Gambart has a wall with inward and outward slopes about equal. Most lunar craters, impact-craters, and most volcanic craters have steep inner walls (about 30°) and gentle outer walls (about 15°). The equal slopes of Gambart suggest that viscous lava erupted through a circular fracture and flowed in both directions. It too lacks impact criteria. The Flamsteed Ring (Figure 12a), in which Surveyor I landed, has the characteristics of ring dikes. The wall appears to be composed, in some cases, of coalescing flows of viscous lava from vents along a circular fissure and in other places of eruptions from the fissure itself. There is also an inner concentric mare ridge. Ash flows and tholoids (viscous domes) are a common occurrence in and around ring dikes. Our interpretation of Flamsteed Ring is that it was formed of comparatively new, viscous flows around a ring fracture and that it is not a buried (ghost) crater as previously thought. The floor (and perhaps the surrounding terrain) may be ash flow tuffs (ignimbrites). The wall slopes are not more than about 15° which is much less than the angle of repose (35°); therefore, we do not think that the real absence of craters on the walls is due to mass wasting (rock creep). We think that Alphonsus with its concentric rilles and low-cratered walls may also be a ring dike feature. Again, its walls look similar to Flamsteed Ring and have low slopes. The central peak is similar in form and size to the tholoid Mont Pelée, and the floor may be surfaced with ignimbrites. In Figure 12b there are several eroded terrestrial ring dikes. The central one looks somewhat similar to the lunar Flamsteed Ring.

Lunar Transient Phenomena

The Lunar Transient Phenomena (LTP) offer support for the hypothesis of lunar internal activity persisting even to the present time. I have been collecting and analyzing reports of these phenomena for many years and now have 800 or more. Temporary anomalies occur in several different manifestations that can be classified into several categories (Cameron, 1967, Cameron and Gilheany, 1967). I have broadly designated them as: (1) brightenings, (2) reddish, (3) bluish, (4) gaseous, and (5) darkenings. Some reports involve more than one category. I have been analyzing these data with respect to a number of hypotheses as to their origin (Cameron, 1971). Without discussing these analyses here, I shall say that I think the different categories are different kinds of phenomena and may be caused by different mechanisms. I think many are from internal processes, probably mostly

Figure 9. (b). The maar volcano Hole-in-the-Ground, Ore., which is of about the same dimensions as Meteor Crater, approximately 4000 ft. in diameter and 500 ft. deep. [Oregon State Dept. of Geology & Minerals Industry].

Figure 10. (b). Lava channels in Lanzarote Fire Mts., Azores, showing sinuousity of the channel. Compare its dimensions with the nearby road.

Figure 10. (c). (above). Kambara Ditch, Japan, dug by an ash flow in 1783, showing the upper 3.5 mi. of its 10 mi. length. [Courtesy of S. Aramaki.]

Figure 11. (above). Orbiter I medium resolution photograph of a <u>mare</u> ridge (wrinkle ridge) near Encke. Note lower elevation and flatness of the ridge, while the dome is higher and steeper.

degassing, although a few suggest actual volcanic eruptions. The visibility of some events may be due to external sources such as ultraviolet stimulation to fluorescence, or thermoluminescence. Some may be luminescence by surface materials; others may have been glimpses of ground color. Some are correlated with tidal effects, as was found by Burley and Middlehurst (1966); but I think that many are of internal origin and are not influenced by any external sources.

That many of the phenemona are the result of internal activity is supported by their surface distribution as shown in Figure 13 (Cameron, 1967). Middlehurst and Moore (1967) independently showed a similar LTP distribution, which is to be expected since the collection of reports used must be very similar. The LTP distribution alone indicates a correlation or relation to the maria, for which volcanic activity is strongly implied from other arguments. If, moreover, the distribution is compared to those of other features that are considered to indicate volcanism, the evidence for internal activity is strengthened. Figure 13 represents: (a) the plots of dark areas (other than the maria), (b) candidates for ring dikes from a study and search I have conducted, and (c) LTP's. The distributions are remarkably similar and display association with the borders of the maria. If the lunar domes and sinuous rilles were to be included, the evidence would be even more striking.

The large majority of LTP's are located around the mare edges, both in and outside. The others are in and around the very large craters, e.g., Schickard (130 miles in diameter). The mare edges are very probably areas of stress and movement. Evidence for this opinion is found especially in Mare Crisium and Mare Humorum. The latter shows unmistakable evidence of subsidence. Our conception (O'Keefe and Cameron, 1962) is that the centers of the maria basins are sinking and that the peripheral craters, like Doppelmayer, Lee, Gassendi, etc., are being dragged down so that they are tilted. Their "seaward" walls are lower than the "landward" ones and have probably sunk into the mare instead of the mare's having flooded the crater. This interpretation is supported by the recently published gravimetric measurements (Müller and Sjogren, 1968).

It was exciting and satisfying to me when Greenacre and Barr observed a LTP in Schröter's Valley and that region in 1963 because I had suggested (Cameron, 1964) that this area be monitored for such possibilities, and indeed they were seen before the paper was published. Greenacre says that he has noted morphological changes in the Valley since he has been observing and mapping this area.

These illustrations, then, provide evidence in support of the hypothesis that volcanic activity has played an important role in shaping and modifying the lunar surface.

References

Aramaki, S., 1956, Japan. J. Geol., Geog. Trans., 27, 216-233.

Burley, J. M. and B. M. Middlehurst, 1966, Proc. Nat. Acad. Sci., 55, 1007.

Cameron, W. S., 1964, J. Geophys. Res., 69, (12), 2423-2430.

Cameron, W. S., 1967, (Proc.) Working Group on Extraterrestrial Res., Fifth Ann. Meeting, March 1-3, 1967, Huntsville, Ala., 47-56.

Cameron, W. S., 1968, Lunar Probe Data Results-II Proc., Douglas Res. Lab., Huntington Beach, Cal., Jan. 17-18, 1968.

Cameron, W. S. and J. J. Gilheany, 1967, Strolling Astronomer, 20, (9-10), 145-155.

Cameron, W. S., 1971, Icarus.

Fielder, G., 1967, Nature, 213, (5074), 333-336, (Jan. 28).

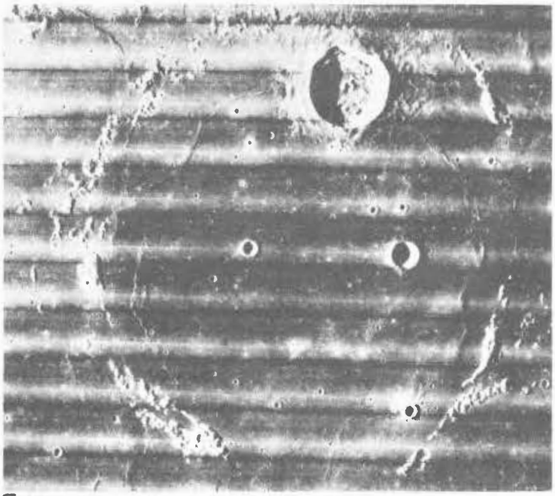
Firsoff, V. A., 1959, Strange World of the Moon, Basic Books, N. Y., p. 159.

Gilvarry, J. J., 1968, Space Research, 45-47, (July 6).

Gold, T., 1966, Nature of the Lunar Surface, W. N. Hess, D. H. Menzel, and J. A. O'Keefe, eds., Johns Hopkins Press, Baltimore, Md., p. 119.

Greeley, R., 1971, Science, 172, (3984), 722-25 (May 14).

Green, J., 1963, Lunar and Planet. Explor. Colloq. Proc., 3, (3), 83-84.



a

Figure 12. (a). Orbiter IV high resolution photograph of the Flamsteed Ring, within which Surveyor I landed (near bottom of picture). Note the coalescent domes nature of the wall in some places and its ridge nature in other places. Note also the inner concentric mare ridge.

b

Figure 12. (b). Terrestrial ring dikes in Arabia, photographed by Cooper and Conrad on the Gemini V manned orbital flight in August, 1965. Several dark circular or oval rings can be seen; these are eroded ring dikes. The one in the lower center is approximately 9 miles in diameter.

Figure 13. Mt. Wilson Observatory 100-inch photograph of the Full Moon, showing distributions of dark areas (dark blobs), ring dike candidates (dark ovals with unfilled interiors), and LTP sites (asterisks on white squares) superimposed on the photograph. Note the similarity in all three distributions, suggesting vulcanism and their relation to the maria. See also text on page 168.

Green, J., 1968, Lunar Probe Data Results-II Proc., Douglas Res. Lab., Huntington Beach, Cal., Jan. 17-18, 1968.

Hapke, B. M., 1962, Center for Radiophys. and Sp. Res., Rept. No. 127, Cornell Univ.

MacRae, D. A., 1965, Sky and Telescope, 29 (3), 143-144.

Marshall, R. K., 1943, Pop. Astron., 51, 415.

Menzel, D. H., 1968, Lunar Probe Data Results-II Proc., Douglas Res. Lab., Huntington Beach, Cal., Jan. 17-18, 1968.

Middlehurst, B. M. and P. A. Moore, 1967, Science, 155, 449.

Müller, P. M. and W. L. Sjogren, 1968, Science, 161, (3842), 680, (Aug. 16).

Ness, N. F., K. W. Behannon, G. S. Scearce, and S. C. Cantarano, 1967, J. Geophys. Res., 72, (23), 5769-79.

O'Keefe, J. A. and W. S. Cameron, 1962, Icarus, 1, (3), 271-284.

O'Keefe, J. A., P. D. Lowman, and W. S. Cameron, 1967, Science, 155, (3758), 77-79, (Jan. 6).

Pickering, W. H., 1920, Pub. A.S.P., 32, 116.

Ross, C. S. and R. L. Smith, 1961, U. S. Geol. Surv. Prof. Paper, 366.

Science, 1970, The Moon Issue, Science, 167, (3918), Jan. 30.

Spurr, J. E., 1945, Geology Applied to Selenology, V. 1, Science Press, Lancaster, Pa.

Turkevich, A. L., E. J. Franzgrote, and J. H. Patterson, 1967, NASA TR 32-1246, 119-151.

Wehner, G. K., 1962, General Mills Electronics Group Rept. No. 2308, Minneapolis, Minn.

Whitaker, E. A., 1966, Nature of the Lunar Surface, W. N. Hess, D. H. Menzel, and J. A. O'Keefe, eds., Johns Hopkins Press, Baltimore, Md., pp. 79-98.

MERCURY IN 1966 AND 1967

By: Richard G. Hodgson, A.L.P.O. Mercury Recorder

1. Introduction

The years 1966 and 1967 were something of a dark interlude in the history of surface observations so far as the planet Mercury is concerned. The news from the previous year that the planet rotates on its axis in approximately 59 days made all older surface observations suspect. This caused confusion in the ranks of observers. Only one observer -- Walter Haas -- made a serious attempt to learn something of the rotation rate from observation of surface markings. Many of those who had contributed drawings in the past failed to do so, perhaps out of discouragement. Due to the press of other work, the previous Mercury Recorder, Mr. Geoffrey Gaherty, Jr., had to resign in the autumn of 1966.

The confusion and pessimism began to abate when it was found that Mercury's axial rotation period is exactly two-thirds that of the planet's period of sidereal revolution, and that the older drawings could be reinterpreted to give meaningful data about Mercury's surface.[1] Photographic confirmation of the 58.6-day rotation period was secured at the New Mexico State University Observatory in 1968, ending the night of uncertainty.[2] An article entitled "Mercury's Rotation and Visual Observations" by Dale P. Cruikshank and Clark R. Chapman in the July, 1967 issue of Sky and Telescope was a landmark, explaining how the older visual observers had been led astray.[3] Chapman's map of Mercury, based in part on A.L.P.O. drawings, is quite valuable,[4] and should be compared with that of Henri Camichel and Audouin Dollfus based on observations at Pic du Midi.[5]

This writer regrets that this report has been so long in preparation. Part of the delay has been due to the need for a better ephemeris for physical observations. This lack was finally met in April, 1971, as will be noted below. The writer was also extremely busy during the summer of 1971 building an observatory to house his new 16-inch (41-cm.) Cave

Newtonian reflector. Hopefully the new instrument can contribute its share of Mercury observations in the months and years ahead. Reports for the years 1968 and 1969 and for 1970-1971 should be published in the near future.

2. Mercury's Elongations in 1966 and 1967

The dates of Mercury's conjunctions, elongations, and elongation angles from the Sun in 1966 were as follows:

Superior Conjunction	Greatest Elongation E.	Inferior Conjunction	Greatest Elongation W.
Feb. 6	Mar. 5 (18°)	Mar. 21	Apr. 18 (28°)
May 27	June 30 (26°)	July 28	Aug. 16 (19°)
Sept. 10	Oct. 26 (24°)	Nov. 17	Dec. 4 (21°)

Mercury was best seen in the Northern Hemisphere as an evening object in the first two weeks in March, and as a morning object in the third week in August. In the Southern Hemisphere the most favorable times were mid-April (morning) and the latter half of October (evening).

Corresponding data for the year 1967 were as follows:

Superior Conjunction	Greatest Elongation E.	Inferior Conjunction	Greatest Elongation W.
Jan. 18	Feb. 16 (18°)	Mar. 4	Mar. 31 (28°)
May 11	June 12 (24°)	July 9	July 30 (20°)
Aug. 24	Oct. 9 (25°)	Nov. 1	Nov. 17 (19°)
Dec. 28			

Mercury was best placed for Northern Hemisphere observers as an evening object in mid-February, and in mid-November as a morning object. For Southern Hemisphere observers the most favorable times were late March-early April (morning) and the first half of October (evening).

3. Observers and Observations in 1966 and 1967

The planet Mercury was not well observed in 1966 by A.L.P.O. members, and those participating were few in number. In 1967 very few observations were made. The following persons submitted observational reports:

Observer	Station	Instruments
Walter H. Haas	Las Cruces, New Mexico	32-cm. (12½-inch) Newtonian Refl.
Richard G. Hodgson	Colchester, Vermont	60-mm. (2.4-inch) Refractor
Karl Simmons	Jacksonville, Florida	15-cm. (6-inch) Newtonian and 20-cm. (8-inch) Newtonian Refl.
Douglas Smith	Vinton, Virginia	15-cm. (6-inch) Newtonian Refl.

In 1966 only two apparitions of the six which occurred were observed -- those of March 5 and June 30. All observations were made in evening twilight. In 1967 observations were limited to a few in February, also in evening twilight.

While all reporting observers attempted phase estimates together with written comment, most of the drawings of publishable quality were those made by A.L.P.O. Director Walter H. Haas. A total of 18 observations were received for 1966, distributed as follows in terms of disc drawings (first number), intensity estimates, and phase estimates respectively:

Apparition	1966, Mar. 5 (E)	1966, June 30 (E)	Totals
Period Observed	Feb. 15- Mar. 12	June 12-14	
Haas	7,7,7	3,3,3	10,10,10
Simmons	1,4,5,	.....	1, 4, 5
Smith	0,0,3	.....	0, 0, 3
Totals	8,11,15	3,3,3	11,14,18

In 1967 only 4 observations were reported, all during the February 16 (Eastern) apparition in twilight. Drawings, intensity estimates, and phase estimates respectively were as follows:

Apparition	1967, Feb. 16 (E)
Period Observed	Feb. 15-17
Hodgson	0, 0, 1
Simmons	3, 3, 3
Totals	3, 3, 4

All of this testifies that Mercury was (and still is) grossly underobserved by A.L.P.O. members.

In Mercury Section reports since 1963 the telescope aperture used for the average observation has been stated, partly with a view to encouraging the use of larger apertures. Perhaps with such a small number of observations (especially for the year 1967!) such an average is not very meaningful, but in the interests of continuity of statistics, the following data are presented:

1966 Apertures	No. of Observations
15-cm. (6-inch) reflectors	8
32-cm. (12½-inch) reflector	10
1967	
60-mm. (2.4-inch) refractor	1
20-cm. (8-inch) reflector	3

Thus the average aperture for 1966 was 24 cms. (9.6 inches), and 16.5 cms. (6.6 inches) for 1967, although the sample is too small to be really significant. The figure for 1963 was 6.6 inches; for 1964, 8.1 inches; for 1965, 9.3 inches. Except for 1967 -- which represents only a few observations -- the general trend has been to larger apertures.

4. The New IAU Hermographic Longitudes

With this report the longitudes of features on the surface of the planet Mercury (i.e., "hermographic longitudes") are no longer given in terms of the provisional ephemeris of Clark R. Chapman published in Sky and Telescope, Vol. 34, No. 1 (July, 1967), p. 26. In accordance with a resolution passed by the Fourteenth General Assembly of the International Astronomical Union (commonly called the "IAU") held in Brighton, England, in 1970, August, the hermographic coördinate system, based on a direct rotation with a period of 58.64617 days, or precisely two-thirds of Mercury's sidereal orbital period, and an obliquity equal to zero, is defined as follows: (a) The prime hermographic meridian is that containing the subsolar point at the first perihelion passage of A.D. 1950, i.e., Julian Day 2433292.63407, Ephemeris Time; (b) The hermographic longitude of the central meridian, as observed from a direction fixed with respect to an inertial coördinate system, increases with time, and the range of longitude extends from 0° to 360°.

The Mercury Section of the A.L.P.O. will use the IAU definitions of hermographic coördinates in future discussions of surface features. Students of the planet Mercury may wish to secure a copy of The Ephemeris for Physical Observations of Mercury for the Years 1965 through 1978, by Bradford A. Smith and Thomas C. Bruce. This ephemeris, which is in accordance with the IAU definitions, gives daily physical data for the period mentioned in its title, and can be used with fairly good accuracy for dates outside those years by means of fairly simple calculations which are explained in the introduction. Copies may be purchased for $1.50 (U.S.), prepaid, from the Department of Astronomy, New Mexico State University, Box 4500, Las Cruces, New Mexico 88001.

It should be noted that the hermographic longitudes used by Henri Camichel and Audouin Dollfus in their article previously mentioned[6] are defined in the same way as later adopted by the IAU.

In order to convert the Chapman longitudes quoted in previous reports (1963-1965) to the IAU longitudes as set forth in the New Mexico State University ephemeris, add 138.7 degrees. Since Chapman indicates for his provisional ephemeris an accuracy of ± 8 degrees, it might be better to round this value to 139 degrees; for there are doubtless large positional errors in the drawings. In the comparisons the writer has made, the

Fig. 14a. Mercury drawing by W.H. Haas, 1966 February 15, 0^h57^m-1^h13^m U.T., 32cm refl., 202X. Seeing 0-2, Transparency 4½. Longitude of C.M. 191°.6, Terminator, 262°.6. Apparent diameter of planet, 5".1 of arc.

Fig. 14b. Mercury drawing by W.H. Haas, 1966 February 17, 1^h03-16^m U.T., 32cm refl., 202X. Seeing 0-2, Transparency 4½. Longitude of C.M. 200°.2, Terminator 265°.1. Apparent diameter of planet, 5".2 of arc.

Fig. 15a. Mercury drawing by W.H. Haas, 1966 February 18, 0^h57^m-1^h14^m U.T., 32cm refl., 303X. Seeing 0-2, Transparency 4½. Longitude of C.M. 204°.5, Terminator 266°.3. Apparent diameter of planet, 5".2 of arc.

Fig. 15 b. Mercury drawing by W.H. Haas, 1966 March 8, 1^h16-28^m U.T., 32cm refl., 303X. Seeing 1-2, Transparency 4½. Longitude of C.M. 288°.5, Terminator 269°.6. Apparent diameter of planet, 7".9 of arc.

Fig. 16 a. Mercury drawing by W.H. Haas, 1966 June 14, 2^h09-27^m U.T. 32cm refl., 303X. Seeing 1-2, Transparency 5. Longitude of C.M. 73°.9, Terminator 99°.4. Apparent diameter of planet, 6".0 of arc.

Fig. 16b. Mercury drawing by K. Simmons, 1967 February 17, 23^h37^m U.T., 20cm refl., 76X. Seeing 2½, Transparency ? Longitude of C.M. 276°.3, Terminator 269°.8. Apparent diameter 7".4 of arc.

All drawings above have south at top, east at right.

error in the Chapman ephemeris is seldom more than 4 degrees.

With the arrival of the more precise NMSU ephemeris the longitude of the terminator as well as the central meridian (commonly called "C.M.") longitude is supplied with each published drawing, beginning with this report.

5. Disc Drawings

Six drawings (Figures 14-16) are published as part of this report, five of them the work of Walter Haas in 1966 (those of February 15, 17, 18, March 8, and June 14) and one by Karl Simmons in 1967 (February 17). There are, of course, some stylistic differences between observers. It would be well to remind A.L.P.O. members to draw only those surface features which are distinctly seen; a feature glimpsed for a brief moment should be clearly designated as such.

Note that as an apparition advances there are rather minimal changes in the longitude of the terminator. Thus on 1966, February 15 the terminator was 262°6 (NMSU); on February 18 it was 266°3; on February 21 it was 269°0. Thereafter the terminator longitude was almost stationary, reaching 269°6 on March 8. It is not surprising, therefore, that with such a slow rotation at the terminator, earlier observers were deceived in their estimates of rotation!

6. Conclusions and Recommendations

In the previous report (for 1965) there was a lengthy discussion of phase observations. Those interested in comparing observed phase with theoretical phase should consult that discussion.[7] On the basis of the limited work done in 1966 and 1967 there is little new to discuss unless one delights in repetitious exercises.

Observers are encouraged to attempt daylight observations, and, if possible, to experiment with filters, especially in the red end of the spectrum, which enhance surface detail. Intensity estimates should accompany all drawings inasmuch as they are often very valuable in interpreting the drawings.

References

1. See this writer's review article "Recent Studies of the Rotation of Mercury" in The Strolling Astronomer, Vol. 20, Nos. 5-6 (Published June, 1967), pp. 73-75.

2. See Smith, Bradford A., and Reese, E. J., "Mercury's Rotation: Photographic Confirmation" in Science, Vol. 162, pp. 1275-1277 (1968).

3. Vol 34, No. 1, pp. 24-26.

4. Ibid.

5. Cf. "La Rotation et la Cartographie de la Planète Mercure" in Icarus, Vol. 8, No. 2 (March, 1968), pp. 216-226.

6. See reference 5.

7. "Mercury in 1965" in The Strolling Astronomer, Vol. 21, Nos. 11-12 (Published October, 1969), p. 212.

ALPO SELECTED AREAS PROGRAM REPORT: KEPLER

By: Kenneth J. Delano, A.L.P.O. Lunar Recorder

Participants in the ALPO Selected Areas Program made 147 observations of Kepler between May 2, 1966 and March 20, 1970. Listed below are the names of those persons who submitted observations of Kepler. Included in the list are the telescopes and the number of observations made by each participant.

Inez N. Beck	Wadsworth, Ohio	6" Refl.	73	observations
Kenneth J. Delano	Taunton, Mass.	$12\frac{1}{2}$" Refl.	7	"
Carl F. Dillon, Jr.	Lowell, Mass.	6" Refl.	1	"
Chet B. Eppert	Philadelphia, Pa.	6" Refl.	1	"
H. W. Kelsey	Riverside, Calif.	8" Refl.	35	"
Richard Krezovich	Syracuse, N. Y.	3" Refr.	2	"
William H. Richrath	Westchester, Ill.	6" Refl.	1	"
Charles L. Ricker	Marquette, Mich.	10" Refl.	2	"
Martin Senour	Rochester, N. Y.	6" Refl.	2	"
Karl Simmons	Jacksonville, Fla.	8" Refl. & 4" Refr.	16	"

Douglas Smith	Vinton, Va.	6" Refl.	5 observations
Stephen Szizepanski	Harvey, Ill.	3" Refr.	1 "
Bruce Waddington	Long Beach, Calif.	8" Refl.	1 "

The amateur astronomer's preference for observing in the evening hours is indicated by the fact that 40% of all the observations received were made within the two-day period following sunrise at Kepler's location, whereas only 28 (i.e., 19%) of the observations were made during the 7-days-long afternoon period. Sunrise for Kepler occurs at colongitude 38°, or 4 days before Full Moon. Noon occurs at colungitude 128°, which means that the observer has to wait for the late-rising Moon in order to get views of Kepler under afternoon lighting. The following is a break-down of the 147 reports received, giving the number of observations made in each 24-hour period following sunrise at Kepler:

1st day - 30	8th day - 4
2nd day - 29	9th day - 9
3rd day - 18	10th day - 3
4th day - 16	11th day - 2
5th day - 5	12th day - 5
6th day - 14	13th day - 4
7th day - 7	14th day - 1

In the following discussion of distinct features and areas in and around Kepler, the reader should refer to the accompanying Figure 17, which identifies Marks A through N.

Marks A and B are Kepler's two brightest spots, being located on the SW and NE walls respectively (east and west by IAU resolution). Mark A was observed by everyone and was reported to be as bright at sunrise as under a high Sun. However, it showed a noticeable decline in brightness shortly (i.e., 1 day) after lunar noon. Beck recorded intensities of 8 to 10* for a Mark A until conlongitudes 151°, 153°, and 156°, when it appeared to be of intensity 7. Kelsey always put Mark A at intensity 8 or 9 until colongitudes 148° and 160°, when he recorded an intensity of 6.5 instead. No one reported seeing Mark A any later than colongitude 160°. Delano reported seeing Mark B as early as colongitude 42° at an intensity of only 6; but by the time of the next recorded observation, at colongitude 62° by Krezovich, Mark B was shining at an intensity of 10. Mark B was noted by six observers, usually at an intensity of 8 to 10. As late as 207°, Beck recorded Mark B at intensity 9.

Marks C, L, and N. Mark C is Kepler's most distinctive feature; it is usually apparent as a dark band running north-south across the floor and sometimes up the south wall and beyond, forming the dark ray marked L. In his 1964 drawing and report of Kepler,[1] Alika K. Herring stated that he "clearly observed a complex row of small hills and ridges in exactly the same position" as the dusky band seen when the Sun is higher over Kepler than it was at the time of his January 26th drawing -- colongitude 50°8. Perhaps it is because of the complexity of Mark C's sunlit and shadowed hills and of the overlying dark-band material that the observed intensities reported for Mark C by the participants in the Selected Areas Program show an inconsistent intensity range of 2.0 to 5.5. Only one hill of the north-south range depicted by Herring was seen as a distinct feature by the Selected Areas Observers. The central peak, Mark N, was variously reported as being of intensities between 6 and 9; and it was no longer apparent after Kepler's late morning, i.e., after 104°. Mark C was seen (between 48° and 122°) as a dusky band crossing the floor of Kepler and going up the crater's south wall, but no further, three times by Beck and 14 times by Kelsey. The dusky band was seen extending not only up the wall, but for 10 to 15 miles beyond the south rim, by Beck, Delano, Dillon, Krezovich, and Simmons upon a total of 10 occasions between colongitudes 55° and 136°. On 10 occasions (from 57° to 82°) Beck saw that the continuity of the end-to-end dusky band C - L was broken on the inner slope of Kepler's south wall.

Marks D, E, and H. The different sections of Kepler's floor did not vary in intensity in a uniform manner, as can be seen by referring to Figure 19, which gives the intensity values in increments of 0.2 on the left margin and the days since sunrise along the bottom. The striking difference between the east and west floor sections (Marks D and E) and the north and south sections (Mark H) is that Marks D and E brightened under a rising Sun, whereas Mark H then grew darker, at least in relation to the east and west floor sections, and began to brighten again under a setting Sun. (The great irregularities in the intensity curves of Marks D and E on the 5th day are inexplicable and are somewhat un-

*Lunar intensities are expressed on a scale of 0 (shadows) to 10 (most brilliant features).

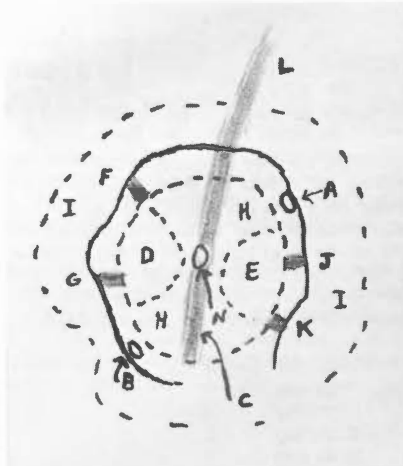


Figure 17. Key chart of lunar crater Kepler showing terminology used in Reverend Kenneth Delano's accompanying article. Constructed by Lunar Recorder Delano from 147 observations by ALPO Lunar Section members in 1966-70. Lunar south at top, lunar east in IAU sense at left.

****

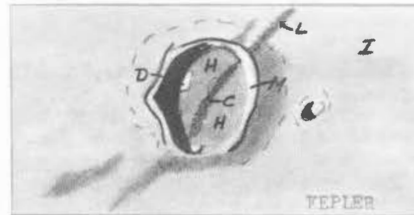


Figure 18. Drawing of lunar crater Kepler by Mrs. Inez N. Beck on August 6, 1968 at 4^h7^m - 4^h22^m, U.T. 6-inch reflector, 152X. Seeing 8 (scale of 0 to 10 with 10 best), transparency 5 (limiting stellar magnitude). Colongitude 57°1, about a day and one-half after sunrise on Kepler.

****

reliable due to the paucity of observations (3) made during the 5th day after sunrise on Kepler.) The boundaries of Marks D and E were ill-defined; and drawings show considerable shifting of positions and changes in size, unrelated to colongitude.

Marks F, G, J, and K. Commenting on his drawing of Kepler in Sky and Telescope, Herring stated that Kepler has "several faint, dusky bands on its inner walls."[2] He also mentioned seeing similar bands, produced by volcanic ash flows, on some cinder cones on the slopes of Hawaii's Mauna Kea. Three dusky bands appear on Kepler's south and southwest walls in Herring's drawing. The southernmost dusky band is situated on the Marks C and L dusky streak, although those two dark bands are not depicted in Herring's low-Sun drawing. The Selected Areas Program observers did not report seeing either one of the two radial bands on the inner SW slope of Kepler, but Kelsey reported four other dusky wall bands several times. Kelsey was the only person to see dusky radial bands within Kepler besides the one which is an extension of Mark C; and he commented upon one of his reports: "All the radial bands, except C, are difficult and may be subjective with me. They are not nearly as obvious as the Aristarchus bands." Mark F was seen 9 times (from colongitude 86° to 160°) at intensities 4 to 6.5; Mark G, 8 times (from 86° to 160°) at intensities 4 to 6.5; and Marks J and K, 8 times each (from 61° to 111°) at intensities of 4.5 to 6.8.

Mark I, the immediate surroundings of Kepler, was of intensity 5 up until colongitude 47°, and a rather constant 6 thereafter. Kepler is an outstanding bright-rayed crater; and these low intensity values refer only to an approximate 25-mile radius from Kepler's center, or in other words, to the close-in dark ring which Kepler, in common with Tycho and Copernicus, has at the center of its bright-ray system.

Mark M is a bright band that was seen 35 times by Beck (from colongitude 79° to 206°), usually at intensity 7. It was also observed twice by Smith but was not noted by anyone else.

There appears to be very little color within Kepler and its immediate environs. Selected Areas Observers found color in only 30 of the 108 observations in which color filters were employed; and of those 30 positive reports, Kelsey contributed 23. Beck used filters in 71 of her 73 observations and noted color only once. Dillon, Simmons, Szizepanski, and Waddington reported evidence of color on one occasion each; but Delano, Ricker, and Smith used filters without once detecting color. Kelsey's ability to detect color in 22 of the 23 observations in which he employed filters may be attributed to an above-average sensitivity to color. Since Kelsey was the only person to report color in Kepler an appreciable number of times and with some consistency, most of what follows is based on his observations. It should be noted that, unlike the color phenomena reported by Selected Areas Observers within Plato[3], no relationship could be found between the enhancement of any particular color in Kepler and the elevation of the Sun in the course of each lunar day.

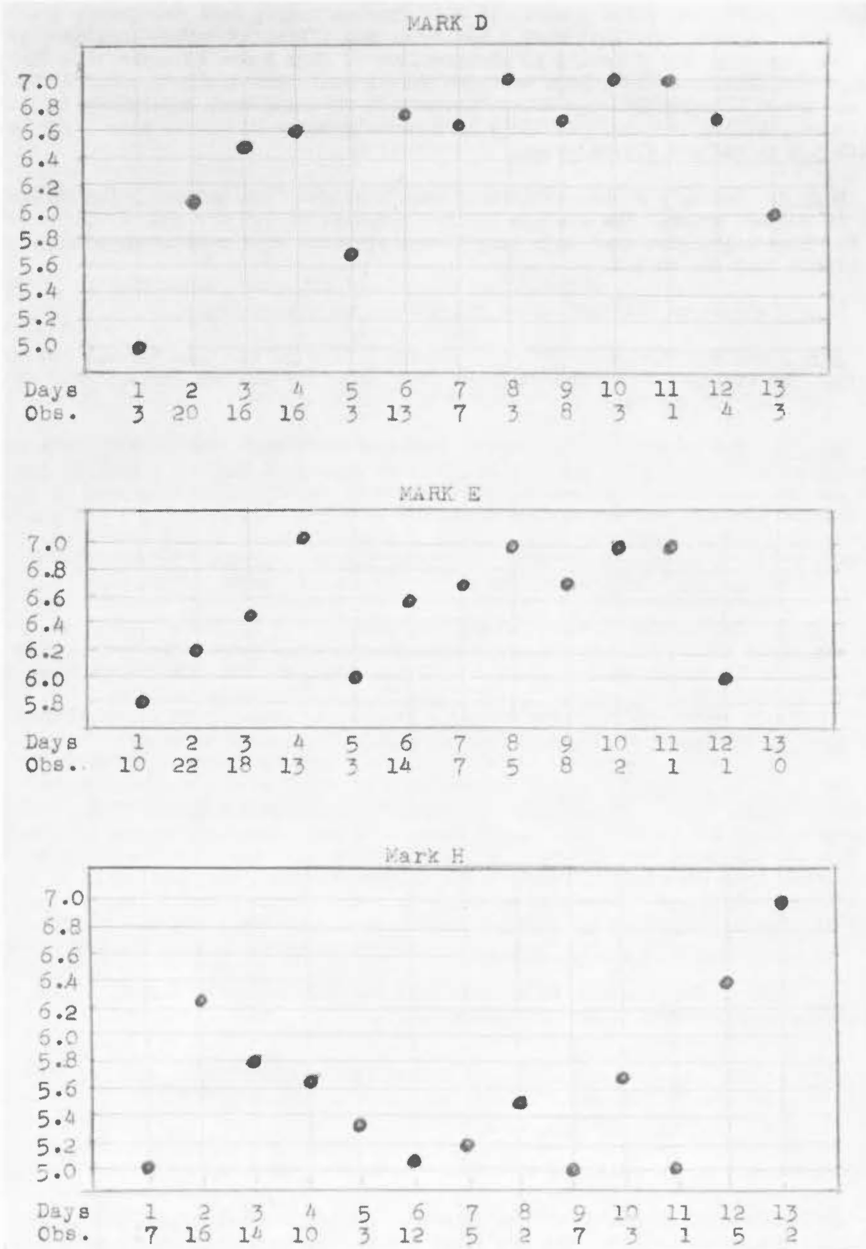


Figure 19. Intensity-variations of three features in Kepler (identified in key chart shown as Figure 17). The observed average intensity (scale of 0 to 10, with 10 brightest) of each feature is shown as a function of the number of days after lunar sunrise on Kepler. The number of observations averaged for each day for each feature is shown in the row marked "Obs." below each chart.

****

Mark A varied between 6.5 in white light to 10 in the red and green. The brightest it appeared in blue light was 9, just after sunrise (colongitude 41°). In 18 of Kelsey's 23 filter observations Mark A was reported to be fainter in blue than in red light, and in 16 observations it also appeared brighter in green than in blue light. Averaging the

23 intensity estimates gives a value of 8.15 for red light, 8.01 for green, and 7.13 for blue. These figures show that Mark A was often significantly darker in blue light. Nevertheless, in only one of Beck's 61 observations of Mark A are Kelsey's blue diminution findings confirmed: at 49°, Beck recorded Mark A at intensity 10 in red, but at 9 in both blue and green light. Although Kelsey never once recorded Mark A brighter in blue light than in red, Dillon recorded (at 136°) an intensity value of 9.2 in blue light, as compared with 8.8 in red and 9.5 in green.

Mark B. Kelsey's 8 observations of Mark B ranged from intensity 6.5 in blue light to 10 in red and green. The average intensity values of 9.0 for red, 8.75 for green, and 7.44 for blue light show that this bright spot appeared even more attenuated through a blue filter than did Mark A.

Mark C showed no distinct color enhancement or diminution.

Mark D was reported to be fainter through a blue filter than through red and green filters. The averages of 16 observations are: 6.10 for the red filter, 6.06 for the green, and 5.61 for the blue.

Mark E. The western floor, Mark E, appeared very much like Mark D, with an average intensity of 6.04 in red and green light, but of only 5.68 through a blue filter. Szizepanski was the only other observer besides Kelsey to detect any differences in color on the floor of Kepler: he recorded an intensity of 7 for Mark D, using a red filter at colongitude 56°, and an intensity of 6 through a green filter. At the same time, he noted that Mark E had an intensity of 5 in red light, and 6 in green. Kelsey, on the contrary, never reported seeing Mark E darker in red light than in green or blue.

Mark H. Unlike the eastern and western sections of Kepler's floor, the crater's north and south floor sections (Mark H) showed color only twice. At 61° the intensity of Mark H in blue light was 5.5, and at 67° it was 5.0. At both times Mark H was noted as being of intensity 6.0 in red and green light.

Mark I, the immediate surroundings of Kepler, evidenced no color.

Marks F, G, J, and K. Color observations of these radial bands of Kepler are few and inconclusive. The 6 observations of Marks F and G, made between 86° and 122°, revealed no color; but at 123° the radial bands were less apparent through a blue filter than through red and green filters. At colongitudes 148° and 160° the bands were indistinguishable from the west wall when a red filter was used, but they could be seen with blue and green filters. There was no color to radial bands J and K, except that a deficiency in blue is indicated by Kelsey's inability to see these two bands through a blue filter at 86° and 106° although they were simultaneously visible in red and green light.

In summary, the greatest color contrasts were evidenced by Marks B, A, E, and D, in that order, as presented in the following table:

	INTENSITY	
Mark	red	blue
B	9.00	7.44
A	8.15	7.13
E	6.04	5.68
D	6.10	5.61

An examination of Lunar Orbiter IV's high-resolution Frame 138, No. 2, reveals that the bright sector of Kepler's western floor (Mark E) is actually an extension of the crater's terraced walls, which nearly reach Kepler's central hills on the west. The bright east wall sector (Mark D) is not visible in Frame 138, for Kepler's east wall was then casting its shadow almost half-way to the crater's center. Although the west wall was sunlit, its upper terrace appears overexposed; and consequently the high radial dark bands "J" and "K" are not evident, nor is bright spot "A".

Frame 138 shows that the dark band (Mark H) traversing Kepler's floor in a north-south direction is the location of a line of low hills, appearing very much as drawn by Herring in 1964.[1] The Orbiter photo shows no sign of the Mark H dusky band, nor of its southern extension (Mark L) in Frame 138, No. 1; but it shows very clearly that the central-most hill has a well defined craterlet atop it, 0.7 kms. in diameter. With the exception of this particular craterlet and of a small, round, dark spot about 0.3 kms. across (which may be a shadow-filled craterlet a little to the SW of the 0.7 km. craterlet), there appear to be no other craterlets on the entire line of hills, thus offering little or no support to any suggestion that Kepler's long, dark floor band might have been caused by volcanic outpourings.

Mrs. Beck's drawing published here as Figure 18 is typical of many others and will illustrate the appearance of many of the features discussed in the text above.

References

1. The Strolling Astronomer, Vol. 17, Nos. 11-12, pp. 220-221.

2. Sky and Telescope, July, 1965, p. 50.

3. The Strolling Astronomer, Vol. 21, Nos. 9-10, pp. 161-166.

LUNAR NOTES

By: Winifred Sawtell Cameron, Kenneth J. Delano, and Harry D. Jamieson, ALPO Lunar Recorders, and Roy C. Parish

The Program for Observations of Lunar Transient Phenomena

(Winifred Sawtell Cameron, GSFC/NSSDC, Code 601.1, Greenbelt, Maryland 20771)

With the establishment of a Lunar Transient Phenomena (LTP) program in the Association of Lunar and Planetary Observers (ALPO) and as Lunar Recorder for this Section, I would like to promote a standardization to the procedures for observations.

Ideally, all the reported LTP sites should be monitored. There are about 100 sites (for which I have more than 1000 reports), of which about ½ dozen sites contribute 60%, and about 1 dozen contribute 80%, of all the observations. The newly-discovered Apollo missions seismic zones should also be covered although they are not sites of LTP reported thus far. In order to distribute all the sites for observational coverage, I would like to hear from everyone interested in participating in the program.

The procedures for standardization of observations are outlined in the following discussion.

Assigning of Lunar Features

Each observer is to be assigned a few features, not to exceed ½ dozen LTP features plus one seismic zone and one non-LTP feature as a comparison source. Observers' definite site preferences will be honored if possible. All directions used should be in the IAU convention (where east is in the direction of Mare Crisium).

Beginning of Observations

Record date, U.T. time, colongitude (either from the ephemeris or from observation of features through which the terminator passes), kind of telescope (refractor or reflector), aperture (in inches) and powers used, and seeing. Seeing should be tested by focussing on a star and estimating the star's image behavior either by estimating the amount of excursion in motion of the image and/or the pulsation (blowing up) of the image, giving the interval (in seconds) between successive blow-ups or steady periods, or between excursions in one direction, e.g., to the right, recording the type of motion and interval. On the basis of this star test, estimate the seeing (S) on a scale of 5 where 1 = P = poor, 2 = F = fair, 3 = G = good, 4 = VG = very good, and 5 = E = excellent and the transparency (T) (faintest star magnitude seen with the naked eye).

Observational Procedures

For each feature: (1) choose one spot at each cardinal point (N, E, S, and W) on the inner wall of craters (external sides of a mountain), one spot (summit) on the central peak, and two spots on the floor to monitor for albedo (always using same spots for every observation); (2) estimate for each spot in the feature the absolute albedo (from the accompanying albedo scale by Elger) and for a chosen spot (record selenographic coördinates of it) on the nearby plain (mare or terra), again always using the same spot. Elger's albedo scale features should be studied by the observer in his telescope so that he can become familiar with the appearance of each albedo step at each phase. Perhaps the observer can make his own albedo scale with the aid of pencil shadings; (3) observe each assigned feature for at least a few minutes and at least twice during an observing session. For at least two or three lunations (preferably all the time) observe every night that weather permits. Unfortunately, it will necessitate rising in the early morning hours for phases after Last Quarter. If such a schedule is too demanding, observe as frequently as possible, interspersing the observations through all phases.

Anomalies

In the event that an abnormality is noted, pay particular attention to the following: Is it a: (1) brightening, (2) darkening, (3) color, (4) shadow, or (5) obscuration or other anomaly? Does it appear to involve the surface material (ground) or something above the ground, e.g., gas and/or dust? Are there variations, e.g., expansion and contraction, dissipation, or motion? If there are motion variations of any kind, time the intervals of variations and compare with the seeing variations on a star's image (with same powers as used on the Moon). Estimate the Moon's altitude at this time. Estimate areal extent of phenomenon. Is there color? If so, are there color changes? Try to describe accurately the hue and tone of the color (use of a color chart would help). Note whether it is bright or dull, whether it scintillates (twinkles) or is steady, and how it behaves in different parts of the field of the telescope. Compare it with other features at the same distance from the terminator as it is, and to the nearby albedo standard feature as well as to the assigned non-LTP comparison feature. Use two different powers in these comparisons. If filters are used, compare the phenomenon in each filter, noting the behavior in each (whether duller or brighter than with no filter). Note any other details. It is suggested that the observer record every observing session in a record book, listing the above items in columns with each column headed by the name of the feature.

I would like to receive the reports of phenomena as soon as possible, on the standard forms that will be provided. In addition, perhaps on a monthly basis, I would like to receive a list of negative observations (observing sessions when no anomalies were noted), giving the date and UT times of observations, telescope and powers used, and features observed. Negative observations are almost as valuable as observations of positive phenomena. In positive reports, include normal parameters of the feature, e.g., the normal albedo you establish for that area.

Elger's Albedo Scale, with Examples.

Scale	Examples
0°	Black shadows.
1	Darkest parts of Grimaldi and Riccioli.
1.5	Interiors of Boscovich, Billy, and Zupus.
2	Floors of Endymion, LeMonnier, Julius Caesar, Crüger, and Fourier.
2.5	Interiors of Azout, Vitruvius, Pitatus, Hippalus, and Marius.
3	Interiors of Taruntius, Plinius, Theophilus, Parrot, Flamsteed, and Mercator.
3.5	Interiors of Hansen, Archimedes, and Mersenius.
4	Interiors of Manilius, Ptolemäus, and Guericke.
4.5	Surface around Aristillus and Sinus Medii.
5	Walls of Arago, Lansberg, and Bullialdus; surfaces surrounding Kepler and Aristarchus.
5.5	Walls of Picard and Timocharis, rays of Copernicus.
6	Walls of Macrobius, Kant, Bessel, Mösting, and Flamsteed.
6.5	Walls of Langrenus, Thaetetus, and LaHire.
7	Theon, Ariadaeus, Bode B, Wichmann, and Kepler.
7.5	Ukert, Hortensius, and Euclides.
8	Walls of Godin, Bode, and Copernicus.
8.5	Walls of Proclus, Bode A, and Hipparchus C.
9	Censorinus, Dionysius, Mösting A, and Mersenius B and C.
9.5	Interior of Aristarchus and LaPyrouse△.
10	Central peak of Aristarchus.

The Dark-Haloed Craters Program

(Kenneth J. Delano)

Since the introduction of the Dark-Haloed Craters Program last summer (The Strolling Astronomer, Vol. 23, Nos. 3-4, pp. 51-53) sixteen persons have written expressing an interest in the new program. Each inquirer was given the necessary instructions, lists of confirmed and unconfirmed Dark-Haloed Craters (DHC's), and a supply of reporting forms. The response has been rather disappointing so far since only four persons have submitted a total of 31 telescopic observations: Marvin Huddleston (5), Randy Lambert (5), Frank Des Lauriers (5), and Chris Vaucher (16). Kenneth Delano, the DHC Program Recorder, has observed all the confirmed DHC's and has looked for 50 of the unconfirmed DHC's.

The list of confirmed DHC's now stands at 65 — an increase of 32 over the original list of 33. A search of photographic lunar atlases carried out by Jamieson, Vaucher, and Delano and telescopic observations by the latter two have resulted in the doubling of the earlier list of confirmed DHC's.

There are 77 objects on the presently available list of Unconfirmed Dark-Haloed Craters. Their nature is not clearly determinable from photographs so that telescopic observations are a necessity to establish whether or not they are true DHC's. The emphasis at the present time is on trying to confirm the existence of the possible DHC's listed in the catalog of Unconfirmed Dark-Haloed Craters. More observers contributing larger numbers of reports are necessary if the DHC Program is to be a success.

Progress Report on a Study of Messier and Pickering

(Roy C. Parish and Harry D. Jamieson)

(Revision of a paper read at the A.L.P.O. Convention at Memphis, Tennessee, on August 18-22, 1971)

Purpose

Among the most interesting lunar formations are the craters Messier and W. H. Pickering, which have long been the subject of much controversy among lunar astronomers due to the changes in appearance they undergo with changing solar illumination. These changes are well documented. In 1847 the map of Beer and Mädler, which was based on their earlier work, was published in Der Mond; it showed the craters exactly alike[1,2]. Later micrometric measurements, of which Goodacre's are typical, show Messier to be the larger[3]. Wilkins and Moore[4] describe the apparent changes as follows:

> "Mädler thought Messier and Pickering alike, both in size and shape. Prof. W. H. Pickering, however, found that this similarity only exists at nine days after sunrise, Pickering being the larger near sunset and immediately after sunrise, but Messier appears to be the larger three days after sunrise. These changes are easily verified even in a small telescope."

That Pickering is usually seen to be larger is indicated by Jamieson's measurements of plates A5-a (morning) and A5-d (afternoon) in Kuiper's Orthographic Atlas of the Moon[5].

The craters were formerly included in the Lunar Section's Selected Areas Program, but were dropped in 1970.[6] Although very extensive files of observations exist, to the writer's knowledge a vertical profile of the area has not been derived, the previous observations not having been made for this specific purpose. The present study is being made for the purpose of obtaining a vertical profile of the region, and in order to shed some light on the apparent changes throughout the lunation.

Methods

The authors are currently making visual and photographic observations, Jamieson using a 10-inch reflector, and Parish using an 8-inch reflector. The present method is to estimate the fraction of each crater filled with shadow in terms of the crater's E-W diameter as the unit. Lengths of the shadows of the crater rims on the surrounding mare are also estimated in terms of the crater's diameter. H. Jamieson has supplemented visual observations with shadow measurements of drawings in ALPO files[6] as well as from non-ALPO sources. The authors also plan to make use of filar micrometer measurements, especially outside the craters where the shadow-fraction estimates are less accurate. After a sufficient number of estimates are accumulated, the data will be reduced and evaluated. At the present time it is thought that about 100 shadow-estimates will be sufficient, although that number will have to be modified if all colongitudes between 310° and 125° are not covered approximately equally well.

Observations will be corrected for effects of libration and foreshortening using equations devised for this purpose by John Westfall; the authors are grateful for his assistance.

Vertical heights of the crater rim or other shadow-casting feature above the mare surface or crater floor at the tip of the shadow will be calculated from the corrected data using the shadow-length method described in the ALPO Lunar Observer's Manual[7]. Using this relative scale of heights, we shall derive a vertical profile of the region.

Intensity estimates, drawings, and photographs are also being utilized in order to chart various low-profile features which may contribute to the changes in appearance through internal reflection, shadow-casting, or other mechanisms. Finally, visual and earth-based photographic observations will be supplemented by spacecraft photographs in the ALPO Lunar Photograph Library.

Interested observers who wish to contribute to this study are cordially invited to do so. All that is needed is the observer's name and address, telescope aperture, U.T. time and date of observations, seeing and transparency conditions, and the fraction of each crater which is filled with shadow as expressed in terms of the E-W diameter as the unit to the nearest 0.1. Additional data, such as verbal descriptions, intensity estimates, photographs, and drawings of unusual observations will also be helpful. All observations are welcome and will be greatly appreciated. Please send observations to:

Harry D. Jamieson
4030 S.E. Gladstone, Apt. 15
Portland, Oregon 97202

References

1. Pannekoek, A., A History of Astronomy, (New York: Interscience Publishers, Inc.), 1971.

2. Haas, Prof. Walter, personal communication, 1971.

3. Muriden, James, Amateur Astronomer's Handbook, (New York: Thomas Y. Crowell Co.), 1968.

4. Wilkins, H. Percy, and Moore, Patrick, The Moon, (London: Faber & Faber, Ltd.), 1961.

5. Kuiper, Gerard P., Editor, Arthur, D. W. G., and Whitaker, E. A., Orthographic Atlas of the Moon, (Tucson, Arizona, The University of Arizona Press), 1960.

6. Westfall, John E., Jamieson, Harry D., Ricker, Charles L., and Delano, Kenneth J., "Lunar Notes", The Strolling Astronomer, 22:109-112, (August, 1970).

7. Westfall, John E., "Lunar Mensuration", Lunar Observer's Manual, (Charles L. Ricker, Editor), pp. 8-10.

INDEX TO VOLUME 20 OF THE STROLLING ASTRONOMER

By: J. Russell Smith

(Published from January, 1967 to March, 1968)

Foreword by Editor. The usefulness of past issues of any publication is tremendously enhanced by an adequate index. Accordingly, talk of indexing this periodical began early in its history. Various colleagues have most helpfully indexed particular volumes from time to time, and these indices have been published in our journal. Mr. J. Russell Smith, our Book Review Editor, some months ago offered to bring this indexing up to date and to try to make it complete for all past volumes. We are extremely grateful for his help in this needed project. Volume 19 and several preceding volumes having been indexed already, we here begin with Mr. Smith's index of Volume 20.

Subject Index (references are to pages)

ALPO
The ALPO 1947-1967, twentieth anniversary 116-117
Index to Vol. 19 (1965) of The Strolling Astronomer 53-58
Library, Lunar Photograph, Catalogue of 212
Orbiter I photos added, list of 8-9
Orbiter I additional photos added, list of 46-47
A New Discipline: Lunar Libration Cloud Section 124-125
Observational Astronomy-Role of the ALPO 110-111
Observing Manual 105
A Personal Look at the ALPO - Some Suggestions 112-116
Research (Lunar and Planetary), the amateur role 111-112
Twenty years of the ALPO, an appreciation 109-110

Book Reviews (reviewer's name in parentheses)
"The American Ephemeris and Nautical Almanac for the Year 1967" (William O. Roberts) 28
An astronomical triology
"Names of the Plough" 58
"The Names of Orion and Its Stars" 59
"The Names of the Minor Planets and Their Meanings" 59
(James C. Bartlett, Jr.)
"Astronomy With Binoculars" (Rodger W. Gordon) 215
"Beyond the Observatory" (Samuel Gordon) 174
"1967 Celestial Calendar and Handbook" (J. Russell Smith) 28-29
"1968 Celestial Calendar and Handbook" (J. Russell Smith) 173
"Getting Acquainted with Comets" (W. Scott Obreza) 213-214
"Handbook of Physical Properties of the Planet Jupiter" (Rodger W. Gordon) 214-215
"Intelligent Life in the Universe" (Joel W. Goodman) 92-93
"Mariner IV to Mars" (Rodger W. Gordon) 59-60
"The Moon, A Fundamental Survey" (William O. Roberts) 60
"Neighbors of the Earth" (William O. Roberts) 93-94
"Solar Radio Astronomy" (Dale P. Cruikshank) 58
"Starlight Nights: The Adventures of a Star-Gazer" (H. Willard Kelsey) 130-132
"Der Sternenhimmel 1968" (William Shawcross) 213
"The Sun and the Amateur Astronomer" (Rodger W. Gordon) 133
"The Structure and Evolution of Galaxies" (Clark R. Chapman) 132
"The Telescope Handbook and Star Atlas" (H. Willard Kelsey) 129-130

Comets
Comet Observing 200-209
Ikeya-Seki, East 64-65
Ikeya-Seki 1967n 209-212
Magnitude, Comet Ikeya-Seki 1965f 165-173
Sketches 171-172
Mitchell-Jones-Gerber 128-129
Photo and sketch 129
Section News, fall 1967 161-164
Section Report: Comet Tuttle 1967a 193-194
Section Report: Ikeya-Everhart 1966d 194-195

Conventions
Astronomical League, National, 1967 68, 105-106
Mid-States Region, 1967 68, 137-141
Photos 141
ALPO Session at Astronomical League, 1967 158-161
Exhibit photos 159-161
ALPO, Long Beach, 1967 174-177
Photos 176-177
Southwestern Astronomical Conference, 1968 212

Instruments
Artificial-star photometer (use on earthlit moon) 87-89
Photo 89
Telescopes, small, uses for 118-119

Jupiter
Drawings, frontispiece, Nos. 7-8 and pages 103-104, 184-186

Jupiter (cont.)
Future prospects 43-44
Major S.E.B. Disturbance 120-122
Nature and origin of markings 181-188
Recent observations 103-104
Tables, Computing Longitudes 65-68
Why the Equatorial Zone darkens 188-192

Mars
Apparitions 1964-65, 1967 5-6, 12-18
Drawings 14-18, 137, 139
Observations 1961, 1963, and 1965 137

In Memoriam
Mr. Clive Chapman, Australia 142
Mr. Kazuyoshi Komoda, Japan 142
Mr. S. Walsom, Canada 105

Mercury
During total solar eclipse 1970, March 7 200
Research, small telescopes 7-8
Rotation, recent studies 73-75
Schiaparelli's influence (rotation) 75-76

Meteors
Leonid shower, 1966 29-32
Photos, frontispiece Nos. 1-2 and pages 31-32
Radiant from photos, Leonids 72

Moon
Aristarchus, violet glare 20-28
Color phenomena 135-137, 192-193
Contour Map 80-86
Craters
Mersenius 61-63
Overlapping 90-92
Photo 91
Plato, drawing 108
Domes 78-80
Gelogical map of moon, source of 178
Halo 6
Linné, drawing, frontispiece Nos. 5-6
Linné as a dome 99-101
Photos
Alpine Valley by Orbiter V, frontispiece Nos. 11-12
Messier and Messier A by Orbiter V, frontispiece Nos. 9-10
Orbiter I
Area near center of moon's averted hemisphere 11
Area at 0° Lat., 150° E., moon's averted hemisphere 50
Area at 10° S., 130° E., moon's averted hemisphere 49
Enlarged view from photo above- 10° S., 130° E. 51
Enlarged view from photo at 0° Lat., 150° E. 52
Mare Tranquillitatis showing a dome 48
Sinus Medii 10
Surveyor I, source of photos 34
Results of moon blink project 144-145
Simplified colongitude tables 161, 162-163
Steep places program 4-5
Steep places progress report 125-128
Steep places, working list 37-42
Total eclipse, Oct. 18, 1967 (with small photo) 180
Transient phenomena 94-99, 155-158, 177-178

Observing
Lunar and Planetary (and Cometary for March-May 1967)
Jan.-Feb., 1967 34-36
March-May, 1967 69-71
March-May, 1968 215-216
June-Aug., 1967 106-108
Oct.-Nov., 1967 143-144

Photography
  Lunar and Planetary 47-53

Planets
  Occultations and Appulses, 1967 9-11
  Surface of terrestrial 101-102

Saturn
  Composition of rings 19-20
  Drawing, showing condensation on east arm, 1966, and showing fainter western arm 36
  Drawing, frontispiece Nos. 3-4; notes on page 72
  Latitudes, comparing methods 133-135
  Occultation of BD -19° 5925 (with sketch) 76-78
  Rotation periods of spots near 60° N. latitude 122-124

Stars
  Star of Bethlehem 1-3

Uranus
  Observing in 1967 44-45
  Ellipticity 197-200

Venus
  Aims of Section, 1967 45-46
  Venus near inferior conjunction 119-120
  Water vapor on Venus 195-197

Author Index (references are to pages)

Ashbrook, Joseph	Comment on a Lunar Halo	6
----------------	A Working List of Steep Places on the Moon	37-42
Bartlett, James C.	Aristarchus: The Violet Glare	20-28
----------------	Twenty Years of the A.L.P.O., An Appreciation	109-110
Baum, Richard M.	Transient Lunar Phenomena: Some Obscure Nineteenth Century Accounts	155-157
Bortle, John E.	Ikeya-Seki, East	64-65
Brasch, Klaus R.	Report of the 1964-65 Apparition of Mars, Part 1	12-18
Cameron, W. S. and Gilheaney, J. J.	One and One-half Years of the Moon Blink Projects	145-155
Chapman, Clark R.	A Personal Look at the A.L.P.O. with Some Modest Suggestions	112-116
Chapman, Clark R., Cruikshank, Dale P., and Hartmann, Wm. K.	Visual Observations of an Occultation of BD -19° 5925 by Saturn	76-78
Cox, Robert E.	Seventeenth Annual Meeting of the Mid-States Region of the Astronomical League	137-141
Cross, Eugene W.	A Coloration Phenomenon in Theophilus	192-193
Cruikshank, Dale P.	Aims of the Venus Section in 1967	45-46
----------------	The Composition of Saturn's Rings	5-6
----------------	Surface Structures of the Terrestrial Planets	101-103
----------------	Water Vapor on Venus	195-197
Dart, Laren	Simplified Selenographic Colongitude Tables	161-163
Delano, Kenneth J.	Mersenius, A Major Crater of Plutonic Origin	61-63
----------------	The Observation of Lunar Domes	78-80
Goodman, Joel W.	Reflections on Amateur Lunar and Planetary Astronomy and the Role of the A.L.P.O.	110-111
Haas, Walter H.	The Association of Lunar and Planetary Observers, 1947-1967	116-117
----------------	Latitudes on Saturn: A Note on Comparing Methods	133-135
----------------	Lunar and Planetary Prospects, January-February, 1967	34-35
----------------	Lunar, Planetary, and Cometary Prospects, March-May, 1967	69-71
----------------	Lunar and Planetary Prospects, June-August, 1967	106-108
----------------	Lunar and Planetary Prospects, October- November, 1967	143-144
----------------	Lunar and Planetary Prospects, March-May, 1968	215-216
----------------	The Remarkable 1966 Leonid Meteor Shower	29-33
----------------	Some Recent Observations of Jupiter	103-104

Haas, Walter H.	Tables for Computing Jovian Longitudes	65-68
Hédervári, Péter	A Suggestion Concerning the Continuous Observation of Lunar Transient Phenomena	178-179
Hodgson, Richard G.	Mercury During the Total Solar Eclipse of 1970, March 7	200
------------------	Mercury: Research Projects for the Small Observatory	7-8
------------------	A Postscript on Schiaparelli's Influence	75-76
------------------	Recent Studies of the Rotation of Mercury	73-75
Krumm, Walter J.	A New Discipline for the A.L.P.O., The Lunar Libration Cloud Section	124-127
Mackal, P. K.	Future Jupiter Prospects	43-44
------------	Why Does Jupiter's Equatorial Zone Darken?	188-192
Milon, Dennis	A.L.P.O. Comets Section Report: Comet Ikeya-Everhart 1966d	194-195
-------------	A.L.P.O. Comets Section Report: Periodic Comet Tuttle 1967a	193-194
-------------	A.L.P.O. Comets Section News, Fall 1967	161-164
-------------	Comet Mitchell-Jones-Gerber 1967f	128-129
-------------	Comet Observing	200-209
Milon, Dennis, Solberg, Gordon, and Minton, R. B.	The Magnitude of Comet Ikeya-Seki 1965f	165-173
Milon, Dennis	New Comet Ikeya-Seki 1967n	209-211
Olivarez, José	Linné as a Lunar Dome	99-100
Podanoffsky, M. S.	Overlapping Lunar Craters	90-92
Richards, Carl Price	The Star of Bethlehem	1-3
Ricker, Charles L.	An Apparent Observation of Color in the Aristarchus-Herodotus Region	135-137
----------------	Lunar Section: The Steep Places Program	4-5
----------------	Lunar Transient Phenomena Selected Areas	94-99
----------------	Steep Places Program Report	125
Shartle, Stanley M.	The Ellipticity of Uranus	197-200
Sato, Takeshi	The Nature and Origin of the Markings on the Surface of Jupiter	181-188
Taylor, Gordon E.	Planetary Occultations and Appulses in 1967	9-11
Vitous, Joseph	Lunar and Planetary Photography-Some Random Thoughts	47-53
Wegner, Gary	Some Observations of Mars in 1961, 1963, and 1965	137
Wend, Richard E.	The Forthcoming 1967 Apparition of Mars	5-6
---------------	The Long Beach Convention of the A.L.P.O.	174-177
Westfall, John E.	Additions to the A.L.P.O. Lunar Photograph Library: Orbiter-I Photographs	8-9
----------------	Additions to the A.L.P.O. Lunar Photograph Library: Additional Orbiter-I Photographs	46-47
----------------	An Artificial-Star Photometer for Monitoring Brightness Variations on the Earthlit Moon	87-89
----------------	The A.L.P.O. Paper Session at the 1967 Astronomical League Convention: An Informal Report	158-161
----------------	A New Contour Map of the Moon	80-87

BOOK REVIEWS

The Harvard College Observatory, by Jones and Boyd. Harvard University Press, Cambridge, Mass., 1971. 495 pages. Price $15.00.

Reviewed by Carolyn Hurless

In reading this book, which is the history of the Harvard College Observatory during the first four directorships, 1839-1919, I found it not difficult to imagine another title. The Human Side of Astronomy. This book gives the most personal look at the astronomer of all books I have ever read.

Today, anyone venturing into astronomy sends a check, and soon he receives a handsome telescope resplendent with all kinds of gadgets. Little does he know of the agony of waiting and disappointment that prevailed in the early days of astronomy in the United States. Then, a lens was ordered; and months passed before the letter was acknowledged - more months passed before a letter came stating the lens "had been started".

The book reveals a look into the lives of the men and women behind each date, each problem, and each discovery mentioned. It indicates that there was a human being with all the good and bad qualities that make up all of us. For some reason, I never quite associated the astronomer with the same shortcomings, humor, and divine qualities with which we adorn others. He always seemed to be a quiet, logical, devoted seeker of heavenly discoveries.

All the well preserved personal papers and letters give an astonishing picture I had not realized. Great credit must go to the authors for the way in which they have so beautifully linked all the materials together to give the reader an emotional involvement. The book is hard to put down. After reading a few pages, the men and women become real, and you begin to feel as though you have suddenly slipped back into time -- that you are somehow a third party observer to all those interesting times and personalities.

What impressed me so much was the way in which letters were written. Yesteryears' eloquence in verbal expression has been literally "run over" by the haste to simplify in our 20th century. Even in his most heated moments of temper, an astronomer's letter to his colleague was beatifully written.

In addition to the book's ability to hold its reader through the intimate revelations of its personalities, it is an extremely exciting book. So much of what happened in the astronomical past we accept from the facts we read, but the thrilling moments surrounding the discoveries are yet another thing. For instance, on page 73 we find that Dr. John Draper achieves in March of 1840 the first "representation of the moon image". It was only one inch in diameter and the first to reveal any noticeable lunar detail. Contrast that to a quick snap of a Polaroid camera today.

The book is full of humor, and little known facts abound. For example, it is noted that when Solon I. Bailey cabled the New York Herald that Harvard had established the highest meteorological station in the world (p. 317), Pickering sent congratulations. It was based on El Misti in Arequipa (predominantly Catholic), and the Bishop requested permission to go along on the next trip to the summit to bless the station. Bailey wrote Pickering that he would go along with the Bishop, and he was sure the "Highest Mass" ever celebrated would soon occur.

The book's final chapters are "A Field for Women" and "Beyond the Observatory". The first is certainly a credit to the faithfulness of the gentler sex in the field of astronomy. As it is, any job should be done well -- be it man or woman. One can read of the fine work by such great women as Maria Mitchell, Miss Cannon, Mrs. Flemming, and Miss Maury, just to mention a few. I doubt that women's liberation can boast members with the caliber of these devoted women.

It is difficult to capture in a few hundred words, by way of a review, how truly inspiring the book was to me. Individuals taking up astronomy today have little or no idea of the wonderful heritage that these astronomers have left to them. It is for this reason that I believe The Harvard College Observatory should be read by everyone.

****

1972 Celestial Calendar and Handbook, by Chas. F. Johnson, Jr. Published by the author at 48 Roberts Street, Watertown, Conn. 06795. 38 pages, price $1.50, postpaid in the U.S.A., Canada, or Mexico.

Reviewed by J. Russell Smith

Here's an annual handbook, now in its eighth year of publication, which is chuckfull of basic information useful to the beginner as well as to the experienced observer. The book has a heavy paper cover with a plastic strip binding for flat opening which makes it easy to use.

The reviewer has used one of these handbooks on his desk for many years since it is quite helpful in planning observations and in making notes in the many date blocks which are left blank. One will find tables listing phenomena for Jupiter's satellites, eclipses, physical data for the Sun, Moon, and planets, occultations, variable stars, clusters, nebulae, galaxies, and meteor showers, as well as many other topics. There are finder-charts for Uranus and Neptune which one will find quite helpful in following those two faint outer planets. On pages 34 and 35 are useful hints on observing with binoculars and small telescopes. On the back cover is a key map of Jupiter's belts and zones which can be used at the telescope to aid in locating the constantly changing detail on the great planet.

ANNOUNCEMENTS

New Head of Selected Areas Program in Lunar Section. In August, 1971, Julius Benton had to resign as the Recorder of the Selected Areas Program in order to help manage the Jupiter Section. At that time Harry Jamieson kindly offered temporarily to head the S.A.P. until Christopher Vaucher (then the assistant for the program) found the time to take it on. Since then, the Selected Areas Program has been run jointly by Mr. Jamieson and Mr. Vaucher. Now that Mr. Vaucher has the time to direct the program, Mr. Jamieson is resigning as its head.

Harry Jamieson will continue to direct the Lunar Dome Survey as well as any advanced lunar training work, while Christopher Vaucher will now direct the Selected Areas Program. Any members who desire to participate in the S.A.P. are urged to write to Mr. Vaucher, and current participants are asked to begin sending their observations to him immediately.

Price of Apollo Data Users' Package. We have been informed that the Apollo Data Users' Packages are not free as indicated in the review on page 125 of *The Strolling Astronomer*, Volume 23, Nos. 7-8. If you are interested, we suggest that you write to the address on that page for actual prices.

The 1972 WAA-ALPO Convention. This joint meeting will be held on August 16, 17, 18, and 19, 1972 in Riverside, California. All ALPO papers should be sent to Walter Haas, Box 3AZ, University Park, New Mexico 88001. The deadline is July 15, 1972 if the paper is to be printed in the *Proceedings* of the Convention. Items for the ALPO Exhibit (drawings, photographs, charts, etc.) should be mailed to Harry D. Jamieson, 4030 S.E. Gladstone, Apt. 15, Portland, Oregon 97202. The specific location for this Convention is "Bannockburn", a student housing center in a European style near the campus of the University of California at Riverside. Persons and groups planning to attend should register as soon as possible in order to help the host society planning the meeting. All questions about the Convention should be directed to Clifford W. Holmes, 8642 Wells Ave., Riverside, California 92503.

Two attractive field trips are planned, one to the Goldstone Deep Space Communication Center and one to the Big Bear Solar Observatory. Visitors are strongly urged to plan to stay at "Bannockburn", and prices for room and meals there will be very moderate. Stores, restaurants, and other facilities are nearby. Many further details about the Convention are included in past mailings sent out by Mr. Holmes. These include full instructions for preparing papers for the *Proceedings*. See you at Riverside in August!

The Strolling Astronomer

SUBSCRIPTION RATES

Single Issue (in stock)	$ 1.50
1 Year	6.00
2 Years	10.00

SPECIAL MEMBERSHIPS

Sustaining Members	$10 per year
Sponsors	$25 per year

☆ ☆ ☆

ADVERTISING RATES

Full Page Display Ad	$40.00
Half Page Display Ad	22.50
Quarter Page Display Ad	15.00
Classsified or Listing (per col. in.)	4.00

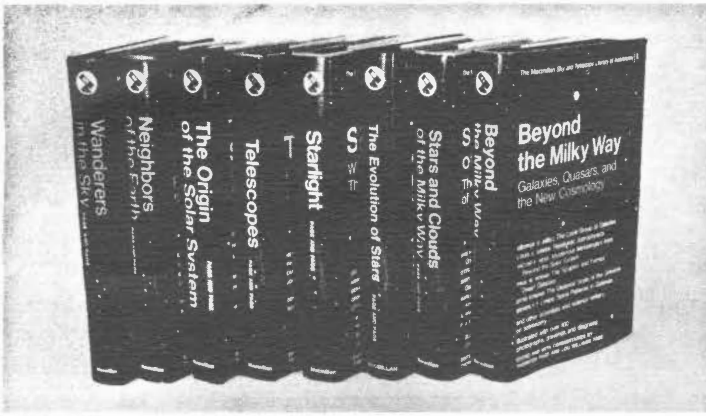
Discount of 10% on 3-time insertion.

☆ ☆ ☆

NOTICE: In order to facilitate the reproduction of drawings in future issues readers are requested to exagerate contrasts on drawings submitted. Extremely faint marks cannot be reproduced. Outlines of planetary discs should be made dark and distinct. It is not feasible to reproduce drawings made in colors. Following these precepts will permit better reproductions.

Persons requiring prompt acknowledgement of correspondence or contributed observations from staff members are requested to furnish stamped, self-addressed envelopes.

STAFF



Macmillan's *Sky and Telescope*

Library of Astronomy

Edited by Thornton Page and Lou Williams Page

No effort has been spared to make these eight large volumes cogent to today's interests. Dr. and Mrs. Page have fashioned books that are truly hard to put aside.

Now you can own the complete Library of Astronomy. Fill in your set from this listing and have the most comprehensive coverage of modern astronomy. If you haven't started, the entire series of eight volumes is available at a special price, if ordered at the same time and sent to one address.

Order B-M $57.50

BEYOND THE MILKY WAY: Galaxies, Quasars, and the New Cosmology.

More than 80 selections by 18 authors have been integrated into seven chapters that cover distances beyond the Milky Way; the structure and content of galaxies; evolution; peculiar galaxies; quasars; masses, luminosities, and models; cosmology. There are three appendixes, glossary, suggestions for further reading, and an index. 336 pages. 124 illustrations.

Order B-8 $7.95

STARS AND CLOUDS OF THE MILKY WAY.

Over 40 articles explore our Milky Way galaxy. After an introduction, seven sections cover: 1, Stellar Distances; 2, Star Clusters and the Galaxy's Nucleus; 3, Rotation of the Galaxy; 4, Between the Stars; 5, Gas Clouds; 6, The Radio Galaxy; 7, Size and Structure of the Milky Way Galaxy. A special epilogue presents the late Otto Struve's "A Historic Debate About the Universe." The articles have been updated and connected with editors' commentaries to produce a unified whole. Popular yet thorough, this book also includes appendixes to help the reader: a brief chronology of astronomy through the ages, notes on the contributors, a glossary, and suggestions for further reading. 361 pages. 137 illustrations.

Order B-7 $7.95

THE EVOLUTION OF STARS: How They Form, Age, and Die.

This popular volume in the Library of Astronomy contains articles by Bart J. Bok, Harlow Shapley, Otto Struve, G. P. Kuiper, Cecilia Payne-Gaposchkin, Donald H. Menzel, and 14 other authorities. In more than 80 articles (with about 100 illustrations) is told the life story of stars and how we have learned so much about them. A 27-page introduction sets the stage for eight sections: Inside the Sun and Stars; H-R and Color-Magnitude Diagrams; The Ages of Star Clusters; Star Formation; The History of Spinning Material; Stellar Explosions; Changes in Chemical Composition; Peculiarities in the Lives of the Stars. The editors' commentaries relate each entry to the overall picture of this important branch of astronomy. 334 pages.

Order B-6 $7.95

STARLIGHT: What It Tells About the Stars.

Over 75 articles by Leo Goldberg, Annie J. Cannon, Gerard P. Kuiper, George Ellery Hale, Otto Struve, and other equally famous authors. In nine chapters we read how light brings us information about the sun and stars, their luminosities and spectra. Also discussed are variable stars and novae, magnetic and flare stars, doubles, clusters, the distribution of stars, and the galaxy. The editors have given essential connective explanations, selected 142 illustrations, and supplied a glossary, appendixes, a reading list, and an index. 337 pages.

Order B-5 $7.95

TELESCOPES: How To Make Them and Use Them.

This 338-page volume answers the telescope maker's most important questions: What is the best telescope for me to build? How do I use it? What objects will it be most suited for? Covered in sequence are basic optical principles, early telescopes, making a reflector, mountings and drives, visual observations of the moon, planets, and stars, telescope accessories, and special-purpose instruments. The volume is rounded out with a tour of observatories and telescopes. 338 pages. 122 illustrations.

Order B-4 $7.95

THE ORIGIN OF THE SOLAR SYSTEM: The Genesis of the Earth and Planets, and Life on Other Worlds.

Over 75 selections by 39 authors, arranged as follows: 1, Questions of Origin; 2, The Sun, Source of Energy and Control; 3, The Outer Layers of the Sun; 4, Our Earth as a Planet; 5, The Earth's Atmosphere — Viewed from Below and Above; 6, Evidence of the Origin; 7, The Growth of Cosmogony; 8, Other Life on Other Worlds. The appendixes are similar to those in other volumes. 336 pages. 115 illustrations.

Order B-3 $7.95

NEIGHBORS OF THE EARTH: Planets, Comets, and the Debris of Space.

Some 100 selections by 38 contributors (including 10 by the late Otto Struve), arranged within the following chapters: 1, The Warmer Planets, Mercury and Venus; 2, Mars, Abode of Life?; 3, The Major Planets and Pluto; 4, Asteroids: Bits or Pieces?; 5, Comets, So Different from the Rest; 6, Meteors, Meteorites, and Meteoroids; 7, Atmospheres, Aurorae, and Exospheres; 8, The Debris of Interplanetary Space. There are over 130 illustrations in this timely volume. 336 pages.

Order B-2 $7.95

WANDERERS IN THE SKY: The Motions of Planets and Space Probes.

More than 100 selections are arranged within the following chapters: 1, The Dawn of Understanding; 2, Newton's Mechanical System; 3, Recent Probing of Space; 4, The Hazards of Interplanetary Space; 5, Our Moon, a Big Satellite. The appendixes include a brief chronology of astronomy through the ages, notes on the contributors (43 in this volume), a glossary of astronomical terms, suggestions for further reading, and an index. 338 pages. Over 100 illustrations.

Order B-1 $7.95

All items sent postpaid. Please enclose your check or money order. Send for the Blue Book, a 32-page catalog describing SKY PUBLICATIONS.

SKY PUBLISHING CORPORATION
49-50-51 Bay State Road Cambridge, Massachusetts 02138