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THE 1963 ARISTARCHUS EVENTS

James C. Greenacre

*U. S. Air Force Aeronautical Chart and Information Center
Lunar Observation Section
Lowell Observatory, Flagstaff, Ariz.*

The U. S. Air Force's Aeronautical Chart and Information Center, St. Louis, Mo., known to many as ACIC, has maintained a Lunar Observation Section at Lowell Observatory, Flagstaff, Ariz., since September 1961.

This section is responsible for making telescopic observations of the visible lunar disk for the purpose of compiling detailed topographic maps of the moon. It is well established that the human eye can resolve approximately twice as much detail through a telescope as a photographic emulsion; therefore, visual observations are used as a supplement to photography. Small details and characteristics of relief are annotated or recorded on photographs and later transferred to our lunar charts.

The observations discussed in this paper were made with the well-known Lowell 24-inch, f/16, Clark refractor. This doublet refractor is corrected between 5,000 and 6,200 Å in the visual region of the spectrum. During moments of very good seeing we have resolved small rilles or craters on the order of 200 meters in width or diameter.

Four ACIC observers are stationed at Lowell, each being responsible for one quadrant of the visible half of the lunar sphere. Each observer has specific charts assigned to him which are a part of an over-all schedule. The charts are being compiled at a scale of 1:1,000,000 or 16 miles to the inch and are designated as Lunar Astronautical Charts (LAC's) 1, 2, 3, etc.

In December 1962 I was assigned LAC 39 which contains the controversial crater Aristarchus and a portion of the Schröter's Valley. If it were possible to have cloudless skies every night, there would have been approximately 123 hours of first quarter observing and 43 hours of second quarter observing for the Aristarchus area. However, inclement weather and other duties reduced the observing time to about 80 hours of first quarter and 28 hours of last quarter. These observing hours are based on terminators that would be favorable for relief study.

For the most part the first 10 months of observations were of a routine nature. There were times of exceptional seeing when I was able to resolve a great deal of detail that could not be found on photographs. In addition, many feet of 35-mm. and 70-mm. motion picture film were taken. We have used this technique to capture those moments when the seeing was best, and in that we have been reasonably successful.

In July of 1963, Edward Barr became associated with our mapping efforts and shortly after was assigned as an observer. Since I had already started

observations on LAC 39, Mr. Barr was assigned LAC 38 which adjoins LAC 39 on the west. The major features cut by these two charts are Schröter's Valley and the crater Herodotus. Since we had common interests along the adjoining line of the two charts, we divided our observing time and kept both chart areas under observation, weather permitting.

Observations continued with the usual pattern until the night of 29 October 1963. I am sure everyone knows by this time that this was the night our observations for fine detail came to a standstill because of the astounding colors that appeared.

At 6:50 P.M. MST (1:50 U. T. on October 30) I first noted a reddish-orange color form over the dome-like structure on the southwest side of the Cobra Head. At the same time, I saw the same color appear on a small hill on the east side of Schröter's Valley. For the next two minutes these colors increased in intensity and had what I previously called a sparkle, particularly in the spot at the Cobra Head. Ed Barr was called and saw the color at the Cobra Head. He said he saw a dark orange color. I removed the Wratten 15 yellow filter and the colors appeared bright in hue. Without the filter we agreed that the color was reddish orange.

At 6:55 I observed an elongated streak, pinkish in hue, along the southwest interior rim of Aristarchus. No evidence of color could be seen anywhere else, on the inside or outside slopes of this crater. Barr confirmed this elongated streak and we observed it with and without a filter. There was a brighter pink cast without the filter.

By 7:00 the spots at the Cobra Head and the one to the east across Schröter's Valley had changed to a light ruby red, but they retained sufficient density to hide the surface underneath. Barr's opinion of the color at this time was that it was somewhat denser than I described and that it still contained some reddish orange.

Within the next five minutes the color began to fade. Using a proof copy of LAC 39, we outlined the areas they covered. The color near the Cobra Head and across the valley continued to fade so that by 7:10 they could no longer be seen; yet, the elongated streaks of pink on the rim of Aristarchus remained visible for another five minutes.

Shortly after these sightings were reported in *Sky and Telescope* we began to receive a considerable amount of correspondence. Some of the most frequent requests were for more information about the sparkle noted in the ruby red spots. It is possible the word was ill-chosen; therefore, I will attempt to redescribe this apparent activity.

The reddish-orange spot near the Cobra Head was the most vivid and easily observed, probably because of its size. When I first noticed this spot, there appeared to be small, bright, white spots that had a flowing motion. The direction of flow was from the top of the prominence downward toward the west or the terminator. It was impossible to tell whether these

Greenacre: 1963 Aristarchus Events

813

small light spots had their origin on the top of the structure or slightly down the west slope. As the color changed to ruby red the bright spots appeared somewhat more conspicuous.

The small red spot observed on the east side of Schröter's Valley also had these small white spots, and they, too, had a downward flow motion, but they appeared to flow downward from a central point in a radial pattern.

For sometime after these observations, I felt I had previously seen a very similar motion, and not long ago I discovered it was a large electric sign across the front of a supermarket in Flagstaff. The background of the sign is red and the blinking lights are white. The blinking is arranged in such a manner as to give a flowing motion so that the lights give the illusion of disappearing from the sign. The rate of flow appears to me about the same as we observed at the Cobra Head, and is about 10 per second.

No photographs were taken of these phenomena even though the 24-inch refractor is equipped with a 70-mm. camera. The camera had been left out of focus from the previous night, and we were reluctant to give up the visual work as several minutes are required to focus. We felt sure of one thing: that we had observed some kind of lunar activity. If the atmosphere had been responsible for these colors, we feel that there would have been other points, particularly bright points, that would have had these colors. But this was not the case, as no evidence of any color could be found on this upland area or the vast area surrounding it.

On the evening of 27 November 1963, Barr started observations at 5:00 P.M. Again the task was to observe the Aristarchus region. At 5:30 he observed a pinkish color streak beginning to appear on the southwest exterior rim of Aristarchus. Within a minute or two, he noticed the color growing in intensity to a brighter pink or light red.

Using the experience gained from our 29 October incident, Barr immediately started to scan bright areas north and south of Aristarchus. As in October, he was unable to detect any other colored spots or areas with or without a filter. Having satisfied himself that another phenomenon might be taking place, he immediately placed phone calls to other ACIC observers.

The first to arrive was Fred Dungan, one of our scientific illustrators. Mr. Dungan has had a good many hours of telescopic observing and is highly qualified in color determination. He is also very familiar with the Aristarchus plateau and its many features. He had no difficulty in seeing the color and agreed with Barr that it was pinkish red. At 5:45 they noticed a spot of color near the southern extremity of the pinkish red streak which was becoming more intense with a reddish-orange cast. This spot, some two or three miles in diameter, is a high point on the south rim of Aristarchus. The rest of the color remained a pinkish-red streak and extended some 12 miles northwest just along the upper exterior rim.

Soon after those first observations, I arrived and observed the pinkish streak and brighter reddish-orange spot. Barr and Dungan felt the intensity of the colors at this time was the same as they had observed a few minutes earlier. Immediately following these observations, I called John Hall, Director of Lowell Observatory. Hall's residence is only a short distance from the 24-inch dome, so he was able to be at the telescope in less than five minutes.

Hall had no trouble in seeing and verifying the colors, although he does little lunar observing. As a matter of personal satisfaction and a further check on his observing, Dr. Hall pinpointed the area on a photograph and on a copy of LAC 39. The rest of us agreed on the position.

Immediately following his observation Hall called Peter Boyce at the Perkins 69-inch reflector southeast of Flagstaff. Boyce was given a quick resume of the observations taking place at Lowell and was asked by Hall to observe the Aristarchus area. Fortunately "seeing" conditions were good at the Perkins Observatory and confirmation of the color phenomenon was made by Boyce within the next half hour.

The over-all length of the color streak was about 12 miles, while the one we observed in October was about 11 miles. The width was estimated to average 1.5 miles which was the same estimate for the October observation.

With the 70-mm. Hulcher camera we started taking black and white pictures on Panatomic X film. Two bursts at slow cine speeds of five frames per second were made intermixed with short time exposures of one-half and one second. Visual monitoring indicated that the color had not lost intensity while the first two bursts were being made.

The second burst was completed at 6:09, at which time visual observations were continued. Hall and Fred Dungan were the first to share the eyepiece. Shortly after 6:09 they detected a small reddish-orange spot on a hill on the east side of Schröter's Valley. Barr and I were unable to make positive identification of this small color spot; however, Dungan located the spot on LAC 39, and it proved to be very close to a small spot we had observed in October.

It was evident by 6:15 that the color was subsiding in intensity. Another burst of cine and time photography was taken at 6:23. Although we estimated the color intensity had dropped from 30 to 50 per cent, visual observations were continued until 6:39 when it became evident to all four observers that the color was rapidly fading.

The reddish-orange spot at the southern limit had changed to pink, and the remaining streak was much fainter. We took another burst of photography after which visual inspection indicated there was little or no color remaining. We continued sharing the eyepiece until 6:45 when all agreed there was no trace of color left. Additional cine and time photography was taken at this time and intermittently until 9:10.

Greenacre: 1963 Aristarchus Events

815

All of the film taken was developed on 28 November 1963. Time and temperatures were carefully controlled. Later prints were made using the same exposure and developing times for all frames printed. A careful study of the film and prints indicated that the phenomenon had not been recorded on film. Several sets of densitometer tracings were made, but they failed to produce conclusive evidence of what we had seen in the eyepiece of the 24-inch refractor.

On June 4 and 5, 1964, nearly identical lunar conditions will exist as existed on 29 October 1963. In particular the libration at this time will again be favorable to an observer for this portion of the disk.

Recently we have become interested in Jack Green's theory concerning the effect of earth tides on the lunar crust. In part, Green's theory states: "An analysis of the observed disturbances on the moon tends to indicate that they occur during periods of maximum changes in the moon's orbit. Earth tides may cause the lunar crust to flex to a greater degree at these times, promoting volcanic activity. During apogee, within this general time period of maximum orbital change, fractures would be more closely spaced, and fluids would theoretically be forced closer to the surface."*

We have noted with keen interest that perigee occurred on 2 November, and our observations were on 29 October. In November, perigee occurred on the 30th, and our observations were on the 27th.

Should events again occur similar to those of October and November 1963, we will be better prepared for visual observation. We now have in operation another telescope, a 20-inch, f/16, apochromatic triplet refractor. We have direct communication between our two telescopes and both are now capable of high resolution photography in color.

It is our belief that the observations we made in October and November of 1963 indicate some kind of activity on the lunar surface. Many authorities have communicated with us and expressed these sentiments.

It is possible that events of this nature will be difficult to observe with small aperture telescopes, since we were unable to see them with our 12-inch refractor. Amateurs, however, should not be discouraged in continuing their observations, as some of their fine instruments may have the required capabilities. The limited number of large telescopes available to lunar observers means that only areas most suspected of activity can be kept under surveillance. Thus, it may be that phenomena such as we witnessed in Flagstaff may go unnoticed should it occur in some area not under observation with large aperture telescopes.

*GREEN, J. 1963. Some lunar resources. *In* Proc. Lunar and Planetary Exploration Colloq. North American Aviation Space and Information Systems Div.

Discussion of the Paper

G. J. H. MCCALL (*University of West Australia, Nedlands, Australia*): A questioner suggested that the Aristarchus color changes have a distribution compatible with fracture line volcanism (from a ring feeder and dispersed foci) associated with a caldera such as Kuse of the Olso graben. He questioned whether such late minor renewals of volcanism do occur in terrestrial caldera complexes. The Kenya calderas (of the central Rift Valley) do show just such an effect — much renewal of activity from fracture line conduits long after the main phases of eruption preceding and associated with caldera formation. The discussion brought out the fact that the distribution suggests postcaldera volcanism on a minor scale, but that the idea of eruption of lava on any scale is unsatisfactory. Could not this be better likened to the glowing in a chimney when a fire is stirred up? Only gas is emitted in this case, and I suggest that the Aristarchus event reflects the emission of hot gas from a subjacent glowing mass, or else the hot gas itself has caused the rock in the conduit to glow red. Either could fit my own hypothesis presented in this monograph.

P. MOORE (*Sussex, England*): Relative to Mr. Greenacre's reference to a small cleft near the red spot in the Cobra Head area, not seen by him before the October 29 phenomenon. I am confident that this cleft is not new. It is very delicate, but in 1953 I recorded it, using the 33-inch refractor at Meudon Observatory, and I have also seen it since.

I would like to ask Mr. Greenacre what he considers to be the minimum telescopic aperture which would have shown the red patches. (Mr. Greenacre estimated 20 inches for a refractor, 16 inches for a reflector.)