Dating Ansel Adams's "Moon and Half Dome"

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Astronomical Computing

Edited by Roger W. Sinnott

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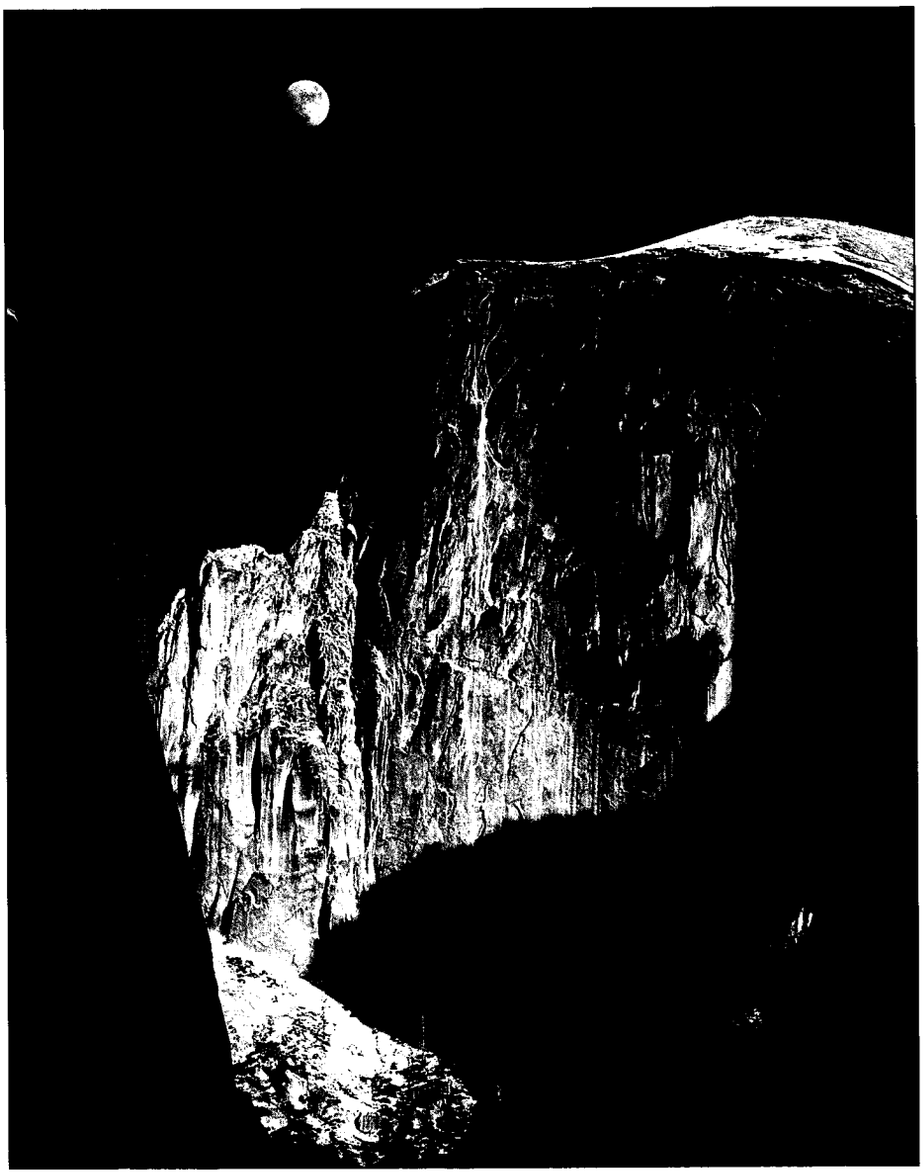
ON A COLD and clear winter afternoon some three decades ago, Ansel Adams set up his tripod in Yosemite Valley and focused a Hasselblad camera on the distinctive profile of the mountain known as Half Dome. He waited as the Sun sank closer to the horizon and the long afternoon shadows extended across the granite cliffs. Adams had photographed Half Dome hundreds of times over the years, but on this day he captured an especially remarkable image that included a waxing gibbous Moon rising just north of the monolith. He discussed this photograph in his *Autobiography*:

I have made many of my well-known photographs with the Hasselblad, but to single one out, a favorite is *Moon and Half Dome, Yosemite National Park, 1960.* I was driving a bit aimlessly around the valley one winter afternoon, when I clearly saw an image in my mind's eye of Half Dome as the moon rose over its right shoulder. . . . I used my 250 mm telephoto to compress the space relationship, making the moon appear somewhat larger in relation to Half Dome than it was in reality.

Other accounts by Adams give a better idea of the time of day:

I happened to be driving toward the Ahwahnee Hotel in Yosemite Valley one winter afternoon about 3:30 and saw the moon rising to the left of Half Dome. The sky was clear and the late afternoon shadows were advancing on the 2,000-foot cliff of the Dome. . . . As soon as I saw the moon coming up by Half Dome I had visualized the image. It was then a matter of walking several hundred feet to the point that best revealed the scene clear of nearby trees.

I waited until the moon rose to a favorable position for a balanced composition. I made several exposures, at intervals of about one minute, and the movement of the moon between exposures gives each a somewhat different aesthetic effect.



Moon and Half Dome **by Ansel Adams. The photographer was notorious for not recording when he took his photographs, so a Southwest Texas State University honors class used astronomical computing methods and a visit to Yosemite National Park to find out. Washington Column, left, frames the view, and a large overhanging ledge called the Diving Board casts the extensive shadow across the lower part of Half Dome. By permission of the Ansel Adams Publishing Rights Trust.**

UNCERTAIN CHRONOLOGY

Although Adams dated the image, he did not specify the beginning or end of 1960. And the year itself could be suspect, as Adams often acknowledged that his records did not include reliable dates for even his best-known photographs. In a typical remark he noted that because of "my unfortunate disregard for the dates of my negatives I have caused considerable dismay among photographic historians." For instance, Adams had variously labeled his most famous composition, *Moonrise, Hernandez, New Mexico,* as being from 1941, 1942, 1943, and 1944. But the waxing gibbous Moon in that image provided a key to establishing the correct date. As described in this department (*S&T:* November 1991, page 529), Dennis di Cicco used astronomical computing methods to prove that the Hernandez photograph must have been taken at 4:49:20 p.m., Mountain Standard Time, on November 1, 1941.

As part of a recent honors course titled "Astronomy in Art, History, and Literature," we read di Cicco's article and re-created his analysis using plane-

tarium programs. We had assembled a library of Adams's books to gain perspective on his long photographic career. From these we learned that *Moon and Half Dome* was one of his most famous and often reproduced images and currently graces the covers of Adams's *Camera* and *Classic Images*.

We had originally intended to study the Hernandez photograph only, but we decided to include astronomical dating of *Moon and Half Dome* as an exercise for the course. In our computer laboratory we were soon surrounded by Ansel Adams books and posters, topographic maps of Yosemite Valley, tourist brochures of the park, and our own slides from previous vacation trips to Yosemite.

SETTING THE SCENE

Our first step was to estimate the altitude and azimuth of the Moon, a task made more difficult by the lack of a horizon in *Moon and Half Dome*. The photograph shows the Moon standing about 1½° (three lunar diameters) above the summit of Half Dome, which rises more than 4,840 feet above the valley floor. But finding the camera position and the apparent altitude (in degrees) of the mountain required taking advantage of the dark cliff in the left foreground, used by Adams to frame the image.

From several tourist brochures we identified this rock formation as Washington Column, the corner of which stands about 1,800 feet above the valley floor. In the photograph, however, the column appears almost as tall as Half Dome. Using trigonometry and measurements from topographic maps, we found that Adams could have obtained this view only from the clearing known as Ahwahnee Meadow, about 2½ miles from Half Dome.

Although the Moon may appear to be just rising in the photograph, it was actually quite high in the sky. As seen from Ahwahnee Meadow, Half Dome towers over the east end of the valley, roughly 21° high, so the Moon had an altitude of about 22½° and was nearly due east (azimuth 90°).

POSSIBLE DATES

Several participants in the class searched for early published appearances of *Moon and Half Dome*. We found it reproduced in the catalog for an exhibition held at the de Young Museum in San Francisco during the fall of 1963. We also learned that Virginia and Ansel Adams used it as the frontispiece for their *Illustrated Guide to Yosemite* published in 1963. We decided to consider the years from 1955 to 1963, looking for dates when a waxing gibbous Moon rose into the sky just north of Half Dome.

This aerial view of Yosemite Valley shows Washington Column, Half Dome, the Diving Board, Glacier Point, Yosemite Falls, and Adams's location. The direction of this view is somewhat north of east. In Adams's photograph the Moon was nearly due east (azimuth 90°) as it rose past the summit of Half Dome.

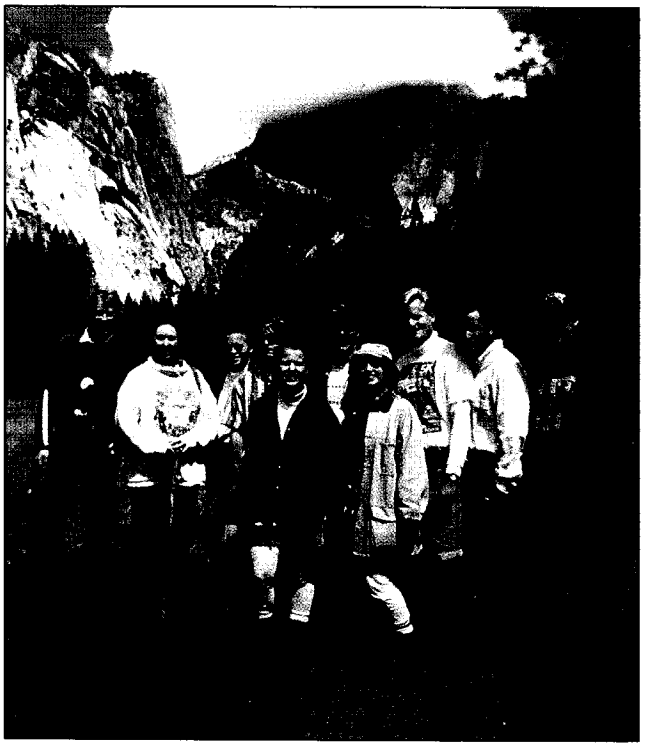
After a few hours of searching with planetarium programs, we realized that the Moon could appear in the correct phase and near the correct altitude and azimuth during only two periods of the year, one falling near the winter solstice and the other near the vernal equinox. The snow visible in the photograph seemed consistent with either time of year. However, as readers can verify with planetarium programs, a waxing gibbous Moon near the vernal equinox will rise with a tilt noticeably different from that seen in the photograph.

Our search produced nine possible dates near the winter solstice (one in late November, six in December, and two in early January) in various years. Our goal now was to find reasons to reject all but one of these and thereby identify the correct date for *Moon and Half Dome*. As our next step, we considered the position of the Sun. The photograph shows direct sunlight illuminating trees and granite outcroppings on a snowy slope below the face of Half Dome. We discovered that four of the dates could be rejected because when the Moon was in the correct position the Sun would have already dropped behind Glacier Point, putting the snowy slope in shadow.

LIBRATION OF THE MOON

Adams's tripod-mounted Hasselblad, Zeiss Sonnar 250-mm lens, and Kodak Panatomic-X 120 film combined to produce an extremely sharp 2¼-inch-square negative. When we studied our poster of *Moon and Half Dome,* we could identify features on the Moon's surface. By comparing these features to lunar libration, or the Moon's apparent oscillations (*S&T:* June 1992, page 670), we were able to rule out two more of the dates.

The photograph shows both Mare



Don Olson (far left) and his honors class from Southwest Texas State University in Yosemite's Ahwahnee Meadow. From left to right are Marillyn A. Douglas, Patricia D. Gardiner, Robert B. Fischer, Amanda K. Burke, Kevin L. Fields, Kellie E. McCarthy, Thomas W. Huntley, Mario E. Delgado, and Amber G. Messenger. Adams's camera position was at the east end of the meadow, near the tree line at the far left in this view. Photograph by Russell Doescher.

Crisium and Mare Undarum favorably placed for observation, relatively far from the lunar bright limb, and the north polar region tilted toward Earth. This suggests rather large positive librations in both longitude and latitude. Using the methods in Jean Meeus's *Astronomical Algorithms,* we calculated the lunar libration for each remaining date. On one of these the Moon had large negative librations in both longitude and latitude, definitely inconsistent with its appearance in the photograph. Also, near the lunar terminator in the Adams photograph we could see that both Sinus Iridum and the Jura Mountains were on the sunlit side of the Moon. On one of our tentative dates both of these were partially on the dark side of the terminator, which is likewise inconsistent with the photograph.

TRIP TO YOSEMITE

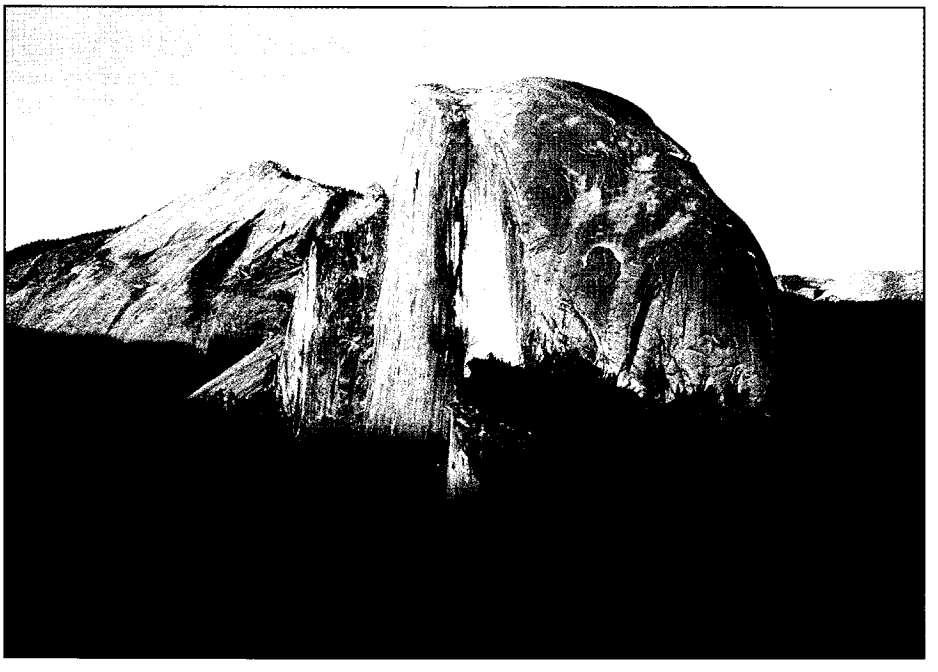
At this point we had narrowed the search to three dates on which *Moon and Half Dome* could have been taken. As the spring semester drew to a close, we planned a five-day trip to Yosemite for mid-May, hoping to photograph star fields from Ahwahnee Meadow and obtain more precise values for the relevant altitudes and azimuths. If our calculations so far were correct, the constellation Delphinus would rise between Washington Column and Half Dome shortly after midnight and would provide the necessary stars.

It was raining when we arrived in Yosemite Valley, but we were able to use binoculars and a small refractor to examine the detailed features on Washington Column and Half Dome and to see how they aligned. We clearly established that Adams took the photograph from the east end of Ahwahnee Meadow, at a point about 250 feet southeast of the stone gate marking the entrance road to the Ahwahnee Hotel.

We then looked forward to star-field photography. But for the next three days and nights temperatures hovered in the 30° range, and a cold rain fell almost without relief! Only Vega occasionally peeked through the clouds, so photography was impossible. As we kept glancing up at the overcast skies, we recalled that di Cicco had to make three trips to New Mexico before getting clear skies at Hernandez.

While waiting for the rain to stop, we ruled out another of the possible dates, fittingly, by considering rainfall. On December 21, 1958, the Moon had the correct phase and position to match the photograph. Although national weather maps for that date show a cold front pushing southward through California with a rain pattern behind, we knew that weather can be quite variable from place to place in the Sierra Nevada. At the Yosemite Research Library we found detailed observations from the valley weather station, located less than a mile from Ahwahnee Meadow. The records show that it was raining in Yosemite Valley between 3:00 p.m. and 5:15 p.m. on December 21, 1958, thus eliminating that date.

On our fourth night the skies suddenly cleared, and we rushed to set up our equipment in the meadow. Behind us was a bright Moon, just past first quarter, and ahead of us the stars of Delphinus rose between Washington Column and Half Dome as we had predicted! During the long exposures we had time to appreciate the scenery — Yosemite



This view shows the Diving Board silhouetted against Half Dome as seen from Glacier Point late on a summer afternoon. The authors walked south from Glacier Point in search of alignments and found that the sunlight must have been coming from an azimuth near 236° in order to cast the shadow of the Diving Board as seen in *Moon and Half Dome*. Photograph by Victor Michalk.

Falls was visible in the moonlight that lit up the cliffs surrounding the valley.

By the end of the night we had successfully obtained star trails, accurately timed by shortwave radio, on several kinds of film. But there was a complication. Since the trees on the edge of the meadow have grown over the years, a clear view is no longer possible from Adams's camera location, and we were forced to back up somewhat for our comparison photographs.

SUNLIGHT AND SHADOWS

Before leaving Yosemite, we planned to perform one more crucial experiment at Glacier Point, an overlook famed for its panoramas of the valley and High Sierra. From this vantage we would have excellent views of the Diving Board, a large overhanging ledge adjacent to Half Dome. Adams's photograph does not include the Diving Board, but its shadow can be seen extending across the lower part of the face of Half Dome.

We walked along the ridge south of Glacier Point until we could see the Diving Board aligned in azimuth with the correct features on the face of Half Dome. In order to cast the long shadow as seen in the Adams photograph, the sunlight must have been slanting in from near an azimuth of 236°. We now had enough information to reach a definite conclusion.

Ansel Adams must have recorded *Moon and Half Dome* at about 4:14 p.m. on December 28, 1960 — the only possible time with both the Moon and the Sun in the correct positions to match the photograph. Although the obstruction by trees meant that we could not photograph star trails from the correct spot, we allowed for this in our calculations, and we estimate that our result is accurate to about a minute. (For those who wish to check our calculations, Ahwahnee Meadow in Yosemite National Park lies near 37°45' N, 119°35' W.) The calculated lunar illumination for this time is 86 percent, in excellent agreement with the Moon's appearance in the photograph. This lunar phase corresponds to about four days before full Moon, which fell on January 1, 1961, 23^{h} UT.

On December 28, 1960, the nominal time of moonrise was 2:11 p.m., but this applies to the ideal horizon. We calculate that for an observer near Ahwahnee Meadow the waxing gibbous Moon would have first appeared in the gap between Washington Column and Half Dome at about 3:25 p.m., agreeing well

The stars of Delphinus rise into the sky just north of Half Dome, which is illuminated by moonlight in this photograph by Russell Doescher on Kodacolor Gold 1600 color-print film. Because of tree growth during the last three decades, the authors were forced to stand slightly behind Adams's actual camera position at the east end of Ahwahnee Meadow.

with Adams's account of spotting the rising Moon and then waiting for a favorable composition. The calculated lunar librations for this date are +5°.6 longitude and +6°.4 latitude, in perfect accord with the favorable views of Mare Crisium and Mare Frigoris in the photograph. The lunar terminator would have fallen near longitude 40°, placing Sinus Iridum and the Jura Mountains just on the sunlit side, again as seen in the photograph.

The weather records for December 28, 1960, indicate an afternoon temperature of 42° F, with high pressure and fair conditions. The Yosemite weather station records also indicate that precipitation occurred on five days in late November and early December of 1960, including a one-day snowstorm. We can even account for the snow seen in the picture!

THIRTY-FOUR YEARS LATER

The Moon on December 28, 1960, was waxing gibbous, 86 percent illuminated, and was recorded by Adams at about 4:14 p.m. The Moon on December 13, 1994, will be waxing gibbous, 86 percent illuminated, and will pass north of Half Dome's summit at 4:05 p.m. Since the 1994 date falls about a week before the winter solstice, while the 1960 moonrise took place a week after it, the Sun's declination is nearly the same for the two events. Even the direction of sunlight and the shadows on the cliffs will be similar. (The difference in times between the 1960 and the 1994 events is caused primarily by the difference in the equation of time.) Observers in Ahwahnee Meadow this year will see the waxing gibbous Moon appear between Washington Column and Half Dome and then rise up into the late afternoon sky, just as it did on that winter day in 1960 when Ansel Adams captured the remarkable image known as *Moon and Half Dome*.

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