

## A LUNAR LANDSCAPE.

CONTRIBUTIONS FROM THE LICK OBSERVATORY.

South.



A LUNAR LANDSCAPE.

Enlarged copy of a part of the negative reproduced on the next page, showing Mare Crisium, Mare Foecunditatis, the Crater Langrenus, etc.

WITH the coöperation of THE CENTURY, it is hoped to present from time to time some of the results of observations at the Lick Observatory — such as drawings and photographs of the Moon and planets, nebulae, star-clusters, etc. The original pictures accompanied by a word of explanation will put the reader almost in the position of an observer with the great telescope. He can at least see what an observer sees, and what he sees needs only to be correctly interpreted.

We may begin the series by showing (on this page) a typical lunar landscape. The negative from which this was copied represented the whole Moon (see next page), and was some five and a half inches in diameter. It was taken at 2:27 A. M. on the 31st of August, 1890. As the Moon is an excessively bright object the exposure-time has to be very short (something like two-tenths of a second) if the full aperture of thirty-three inches is employed.<sup>1</sup>

It is extremely difficult to give such short exposures accurately, and for this and other reasons the aperture of the telescope was reduced to a circle of eight inches in diameter, and an exposure-time of exactly three seconds was given. The negative was developed by one of the astronomers precisely as an ordinary landscape, only with unusual care, and the

<sup>1</sup> The visual object-glass is thirty-six inches in aperture, while the photographic is but thirty-three.

result was a representation of the whole of the nearly full Moon. The Moon is full when its age is about fourteen days and eighteen hours. The Moon of our picture was exactly two days older, so that the western limb or border was incomplete and in shadow. The sun was setting to the western regions of the Moon's surface. The original picture was very carefully enlarged in an ordinary camera about three times, so that the Moon's diameter would be nearly eighteen inches or 115 miles to one inch, approximately. The longest diameter of the crater near the top of the plate (page 436) is approximately 90 miles, therefore. The great walled plain at the bottom — *Mare Crisium* —

is about 281 miles from north to south and 355 miles from east to west. So much for the *scale* of the picture. The cardinal points are shown as they would be seen in an astronomical telescope. The top is south, the left-hand side west, the bottom north. The part of the original picture that is shown on a larger scale as a lunar landscape has representatives of all the marked lunar features. Let us begin with the *Mare Crisium* — the "Sea of Crises" — which is foreshortened in the picture, and whose western edge does not show. This spot is larger than Ohio and Indiana together (its area is some 78,000 square miles) and it is even visible to the naked eye. It was called by

South.



North.

PHOTOGRAPH OF THE MOON.

From a negative taken at the Lick Observatory August 31, 1890, at 14 hours, 27 minutes. Moon's age 16 days, 18 hours.

the ancients a "sea," but it is in fact a great walled plain, and attentive looking will show the rims of ruined craters on its surface, as well as systems of ridges and streaks across the floor. These have been called sand ridges, such as might be at the bottom of an ocean, but it is not certain that the surface is not that of a lava flow. On a grand scale it looks very much as parts of the Island of Hawaii would look if we could see them from above, and if we could clear away the luxuriant tropical forests and the great sugar plantations. A field of the lava which is called *pa-hoe-hoe* in Hawaii looks at least like a miniature of this sea bottom. We must always recollect that the volcanic energy of the earth is a mere trifle to that which has formed the surface of the Moon. The sea is surrounded by very steep mountains and high plateaux. The spur or finger which bounds it on the southwest is the *Promontorium Agarum*, which rises 11,000 feet above the plain. One of the mountains diametrically opposite is as high as Mt. Blanc. The two largest craters on the floor of *Mare Crisium* are *Picard* and *Peirce*. *Picard* is the larger and the further south, and we can fix the scale of the plate in our minds once more by recollecting its diameter, which is a trifle over twenty-one miles. Its walls rise some 3000 feet above the plain, and the cup is more than a mile deep. As a rule, the bottoms of such craters are lower than the general surface of the Moon. The sun is towards the east in our picture, and the eastern and outer wall of *Picard* is bright. This wall casts its shadow into the depths, and beyond the shadow is the bright inner and western wall. This again casts a shadow on the plain which is not well seen in the picture.

The highlands which border the *Mare* terminate in steep and broken cliffs and include great chasms and valleys. If the plate is examined with a common hand magnifier their structure is even better seen. Does this wilderness of mountains (many of them 10,000 to 12,000 feet high) and valleys show any signs of having been carved by water erosion? This is a very important question. I have examined this region many times with the telescope, and have always left it with the impression that the effect of erosion, as we see it on the earth, must have been exceedingly slight to have preserved such abruptness in the cliffs and such acuteness in the angles.

The two craters in the southern edge of the highlands are *Firmicus* and *Apollonius*, the one thirty-nine and the other thirty miles in diameter. From *Firmicus* (the furthest south) a bold ridge of mountains in high relief stretches southward and ends in the small crater *Webb* (fourteen miles in diameter). Southward again, there is a group of three craters, acolytes to

*Langrenus*. The upper two of these have their walls almost touching. Notice that just where they join, the walls must be low, for in the shadow which lies in the crater to the left hand there is a small break of sunlight which slips through the gap. These craters lie in the *Mare Facunditatis*. Notice again the similarity of the floors of the two seas, with their variations of color, their ruined crater forms, their sinuous ridges and the crater-pits scattered over them. Notice, too, that the crater-pits are very frequently situated on one of the ridges or streaks, and that where two ridges cross there is nearly always a crater. This is very like what we see on the earth in a region of volcanoes. Craters are usually found at the intersection of two faults. Finally, we come to the magnificent ring-crater *Langrenus*. It is just barely within the terminator. All the eastern half is in the shadow — the sun has set — hidden by walls which are some 9000 feet high. The twin peaks in the center cast their own shadows to the west all across the rugged floor of the crater and even up on the lower steps of the interior terraces. A measure of the length of these shadows has determined the height of the peaks which cast them to be some 3300 feet. Here again, the use of a hand magnifier will show some of the features a little more plainly. There are scores of interesting features which deserve attention but which must be left to the reader to select for himself. One only must not be neglected, as it relates to the vexed question of changes on the Moon's surface. It is absolutely certain that changes *must* take place there, but it is very difficult to be sure that any particular feature has actually changed. One of the chief objects of the lunar photographs which we are making at the Lick Observatory is to settle such points. We shall shortly have photographs of the Moon taken at intervals of a few hours throughout a whole lunation (twenty-nine days), so that each crater will be shown under every variety of illumination. These photographs will tell us exactly how the Moon is *now*. A comparison with similar photographs to be taken in the future will settle all questions of reported changes. We shall not be obliged to trust the verbal descriptions or the imperfect sketches of previous observers.

If the reader will draw an imaginary line two inches below the top of the landscape and parallel to it, and another line one inch from the right-hand border and parallel to this border, the two lines will intersect in two small crater pits which are known as *Messier* and *Messier A* (the latter is towards the right). Between the years 1829 and 1837 Maedler, who was then making his lunar map, examined these two craters more than 300 times, and he describes them as in

every way exactly alike, in diameter, form, height, depth, and color. The merest glance at the picture will show that the left-hand crater (*Messier*) is now oval, while its companion, *Messier A*, is round. There is a whole history connected with these craters and with the changes reported in them. The history is too long and too special to be given here, and it must suffice to say that some very competent authorities conclude that the craters have progressively changed in shape since 1829. Without going into particularities and without reflecting upon the skill of Maedler (who however used a comparatively small telescope), I must record my own conviction that the case is not yet conclusively proved. It was this case and others like it that inspired the plan which we are following at the Lick Observatory to-day, of securing a series of photographs so complete as to settle all such doubts in the future.

Veritable changes on the Moon's surface will be a most important discovery. It will be

equally important, though less interesting, to show that no great changes take place. Topographical alterations on the earth are largely due to the force of gravity aided by the destructive and leveling power of frost (alternate melting and freezing rather) and of running water. It is more than likely that the temperature of the Moon never rises above the freezing point, so that these agents are there bound in chains of ice. Gravity will act to pull down and level, but it lacks the aid of the forces which disintegrate and loosen.

We say that the Moon is a dead planet because it is certain that nothing like human life exists upon it; but it is doubly dead, for even topographical change must take place there far more slowly than it does upon the earth. It is almost impossible to conceive the immense step between the paroxysmal activity of the volcanoes which originally shaped its topography and the icy calm which now preserves its surface almost absolutely unchanged from century to century.

*Edward S. Holden.*



## THE DRUMMER.

AWAY back in those happy times  
 When we had little left to vex us,  
 On sea or land, save poets' rhymes  
 And talk about annexing Texas;  
 While yet with all our men and boys  
 "Forward, march!" was quite the fashion,  
 And the liveliest of our joys —  
 The old military passion —  
 Was not yet grown cold and numb;

While still full many a household niche  
 Enshrined the old-time regimentals,  
 And town and country were yet rich  
 With relics of the Continentals;  
 While still in splendid motley dressed,  
 Wonderful to all beholders,  
 Men were glad to march abreast  
 With their muskets on their shoulders,  
 To the sound of fife and drum —