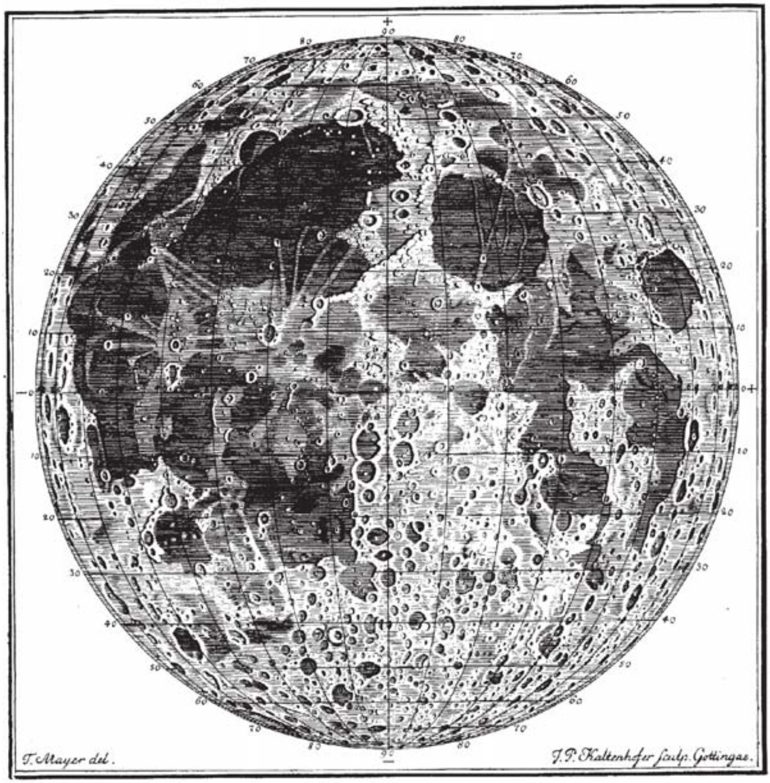
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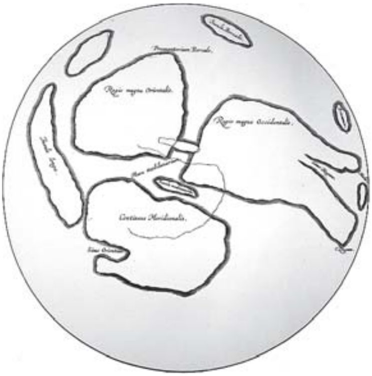
CHAPTER THREE

Charting the Moonscape

We have the ability to imagine places and spaces that don't even exist, but sometimes reality surpasses the imagination. The discovery of America not only was a complete surprise, it also opened up the world in geographical terms and brought about a complete change in perspective. In the case of the moon the starting point was different. Its existence had long been evident, but the first glimpse of the moon through a telescope—just over one hundred years after Columbus set foot on soil in the New World—triggered a dramatic conceptual shift. No longer a mythic figure, the moon became an object whose surface could be studied in detail. Although the physical distance between Earth and moon remained the same, the moon did not seem as out of reach anymore. Suddenly an extension of one of the human senses created an illusion of much greater proximity. This was a revolution. Humankind's progressive ability to explore the moon visually surely paved the way for exploration of the moon up close with the other senses.

Just a couple of years before the telescope came into use, around the year 1600, William Gilbert (1540–1603), physician to Queen Elizabeth I, produced a rather detailed pen-and-ink sketch

Tobias Mayer's lunar map



Moon map by William Gilbert

of the moon. This would not be noteworthy in itself, but Gilbert also introduced the first brief nomenclature for features of the moon. Gilbert, who assumed the dark spots to be land rather than seas, coined thirteen terms. What is called Mare Crisium today was “Brittannia” (Britain) for him, and his “Regio Magna Orientalis” (large eastern region) corresponds relatively well to the current Mare Imbrium. “Regio Magna Occidentalis” is a conglomerate of what are now Mares Serenitatis, Tranquillitatis, and Foecunditatis. “Continens Meridionalis” and “Insula Longa” are segments of the current Oceanus Procellarum. Gilbert’s names never came to be widely used, certainly in part because they weren’t published until 1651, by which time two other major schemes had been made public.

A Dutch spectacle maker, Hans Lippershey, introduced the earliest type of telescope, using two lenses, in 1608. Soon, unseen worlds appeared, but the new device first had to overcome considerable prejudice. As the art critic Martin Kemp reminds us, “strange things were becoming visible for which no ready frame of interpretative seeing existed,” and the telescope “was vulnerable to the charge that what was seen through it was in whole or in part produced by the instrument itself.”

Although Galileo is commonly believed to have been the first to examine the moon with the help of a telescope, the English scientist and mathematician Thomas Harriot (ca. 1560–ca. 1621) drew the first known sketch of the moon based on a telescope viewing. Harriot made his sketch on July 26, 1609, four months before Galileo's observations, and created a map about two years later. He used letters and numbers to help identify certain spots. His endeavors seem to have been known to some scholars in his field, but his renown was limited because he did not publish his lunar drawings.

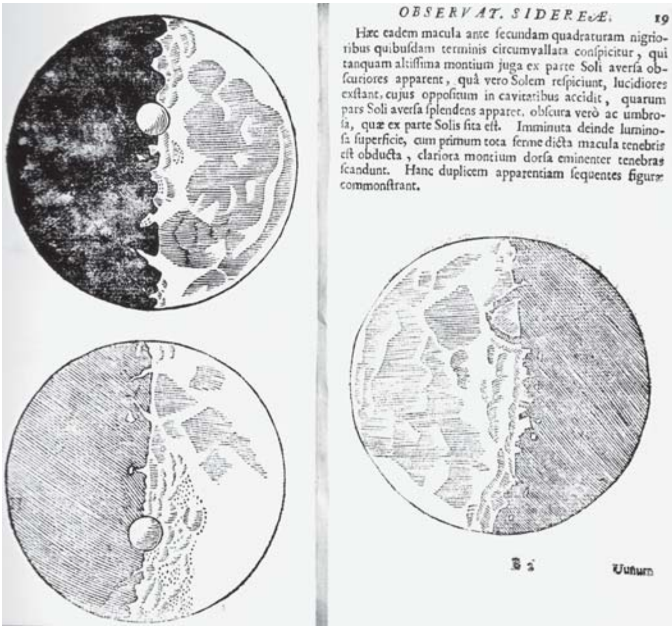
Thomas Harriot's map of the moon

Galileo Galilei (1564–1642) soon heard about the groundbreaking invention and set about improving upon it. Directing his telescope toward the Adriatic Sea, he was able to discern—as somewhat blurry images fringed with color—ships some hours earlier than with the naked eye. When he steered his device toward the moon on the clear night of November 30, 1609, he saw that its surface was not "uniformly smooth and perfectly spherical, as countless philosophers have claimed about it and other celestial bodies, but rather, uneven, rough, and full of sunken and raised areas like the valleys and mountains that cover the Earth." He wrote that the large dark spots "are not seen to be at all similarly broken, or full of depressions and prominences, but rather to be even

Galileo Galilei presents his telescope to the Doge Leonardo Donato and the Senate of Venice.

and uniform; for only here and there some spaces, rather brighter than the rest, crop up."

In his book *Sidereus Nuncius* (Starry messenger), published in March 1610, Galileo showed that characteristics of the Earth were not unique in the universe and that the celestial bodies didn't display the absolute perfection older traditions of thought ascribed to them. But despite the noted similarities between the two orbs, Galileo didn't share the view of his contemporaries that the moon was just another Earth composed of soil



Galileo's images from *Sidereus Nuncius*

and water. He conceded that other factors than land and water might account for the differences of brightness. Galileo's great accomplishment was to significantly narrow the gap between speculation and knowledge, to bring the moon almost within grasp. He was able to see what others had not seen, but the capacity of his telescope was limited. He saw neither mountains nor valleys but, as Scott L. Montgomery has remarked, "a jagged outer edge, evolving and irregular patterns of light and shadow." In his paintings, then, he has altered various aspects for effect: "The terminator is far more irregular than in reality, and the craters are enlarged to almost double their size."

Fantasies are often more attractive than reality, and close examination of a beloved object can reveal things we'd rather had remained hidden. The power of the telescope soon made it apparent that other satellites existed; the uniqueness of Earth was put into question. In fact, the Chinese astronomer Gan De, who lived in the fourth century B.C., had discerned Jupiter's satellites with the naked eye, but in the West Galileo is credited with this discovery in 1609. He called them *planetae.* In the following year he discovered the largest four satellites of Jupiter, namely Callisto, Io, Europa, and Ganymede, later called the Galilean moons.

Soon the development of increasingly powerful telescopes led to fierce competition to create the most accurate map of the moon—which led, ironically, to further inaccuracies. To begin with, drawing an image seen in the telescope was a challenge, requiring frequent repositioning to compensate for the movement of the moon. Competing mapmakers in different countries published their works at different stages of the production process, and on some copied maps the same feature on the surface might be perceived differently and given different names.

After Galileo, a line of scientists produced or commissioned engravings on the lunar theme. The Parisian mathematics professor Pierre Gassendi (1591–1655) provided names for some features revealed with the help of a telescope, such as *umbilicus lunaris* (the navel of the moon, now called the Tycho and ray system). Gassendi's beautiful map was executed by Claud Mellan and published in 1637.

Michael van Langren (1600–1675), also called Langrenus, came from a well-known Flemish globe and mapmaking family. His moon project was driven by the problem of determining longitude to orient ships on the oceans. He came up with the idea of timing sunrise and sunsets on "islands and the peaks of mountains most often isolated from the main continuum which in an instant appear on the face of the waxing Moon, and also those which suddenly vanish on the waning Moon, which first instant and duration is a help in finding longitude."

Mapping, of course, involves more than just creating an accurate visual representation. The identified bodies on a map need names that will resonate with those who use the map. Some artists and users were more able than others to enforce nomenclature. King Philip IV of Spain, for example, demanded that van Langren's map, which was published in 1645 with a moon measuring more than thirteen inches across, feature large formations named after the Catholic king and both living and deceased members of the royal family, such as the Oceanus Philippicus, now the Oceanus Procellarum. The royal hoped this act of naming would enhance his importance and even endow him with immortality. Scientific nomenclature played only a limited role in van Langren's map, and use of contemporaries' names for so many features partly explains why the map could not stand the test of time. Van Langren also used the names of thirteen saints, gave "water" features such names as Mare Venetum (Venetian Sea) or Portus Gallicus (French harbor), and dubbed the main highlands in honor of human virtues, resulting in features named Terra Pacis and Terra Dignitatis. Scott Montgomery recognizes the effort "to claim the Moon as Catholic territory." "The lunar surface, according to this scheme, did not belong to astronomy; astronomy, however, belonged entirely under royal power." None of the place names mentioned above survives today. On the other hand, vanity inspired van Langren to name a prominent crater Langrenus, and this name has stuck—a charming reminder of these early mapping efforts. Both Gassendi and van Langren used Caspian Sea—the name of a sea here on Earth—to designate the large dark oval spot now known as Mare Crisium. Ewen A. Whitaker assumes that this feature got its name "because it occupies roughly the same position with respect to the Moon's face that the Caspian Sea does with respect to a map of Europe, N. Africa, and the Middle East."

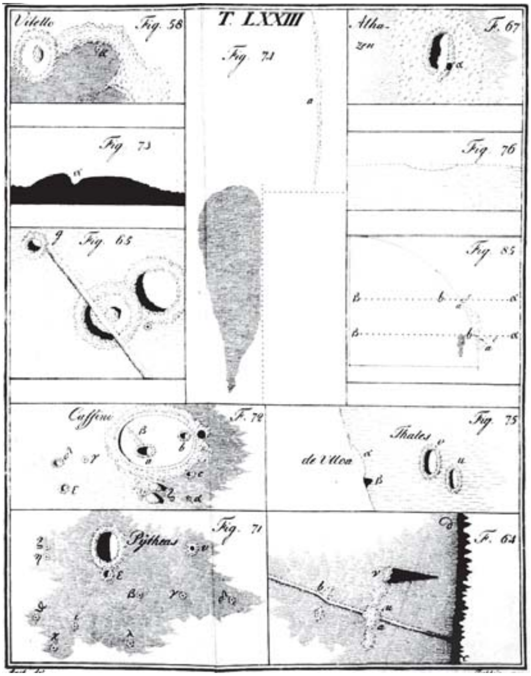
It is not clear whether the German-Polish politician and astronomer Johannes Hevelius (1611–1687) was familiar with van Langren's map. The hills, mountains, and crater rims in Hevelius's *Selenographia* (1647) resemble rows of termite hills, which was the usual geographic practice at this time for terrestrial maps. After considering the option of naming the lunar features for mathematicians credited with advances in astronomical science, Hevelius chose instead a profusion of geographical terms for newly discovered lunar features. As he put it: "I found to my perfect delight that a certain part of the terrestrial globe and the places indicated therein are very comparable with the visible face of the Moon and its regions, and therefore names could be transferred from here to there with no trouble and most conveniently; namely, think of the part of Europe, Asia, and Africa that surround the Mediterranean Sea, Black Sea, and Caspian Sea." His concept did not stand up. The names he chose were too awkward and sounded too archaic, and only ten have survived to modern times. Furthermore, his map created confusion because he accorded several groups of craters a single name and saw mountain features where none existed. Elsewhere, he mistook peaks for craters. Still, despite its shortcomings, Hevelius's map retained its primacy for almost one and a half centuries.


Drawing of the moon by Johannes Hevelius

The Italian Giovanni Battista Riccioli (1598–1671), who competed with Hevelius, used 63 of van Langren's names in his 1651 *Almagestum novum* (New almagest), but applied three of them to different lunar features and added 147 new names taken from persons connected to astronomy. Doing away with the catalogue of moral qualities, he chose names related to the weather on Earth, such as Terra Caloris (land of heat) and Terra Nivium (land of snows), none of which are used on maps of today. Riccioli was convinced that there were no humans and no water on the moon, and, as a Jesuit, he was obliged to reject the Copernican system—though it is revealing that he named three prominent craters after Copernicus, Kepler, and Aristarchus. The basic nomenclature devised by Riccioli—assigning the names of famous scientists to craters and classical Latin names characterizing weather or states of mind to maria (such as Mare Crisium and Mare Serenitatis)—has survived to the present day, though the names themselves have changed.

Beginning in 1748, the German astronomer Tobias Mayer (1723–1762) made more than forty detailed drawings of various lunar regions in an attempt to create a more accurate map. Although the moon globe he envisioned was never constructed, two lunar maps and some drawings eventually emerged. The engraver reversed one drawing by mistake, so the plate had to be accompanied by the following caption: "If you want to view the print correctly, you must hold it up to a mirror."

Johann Hieronymus Schröter (1745–1816) based his map on the measurements Mayer had performed. He surpassed his contemporaries in not only creating a vast number of drawings of many smaller areas of the moon at various states of illumination but also approximating both mountain heights and crater depths by measuring shadow lengths. Since there was now a consensus that water could not exist on the moon's surface, Schröter had to face the problem of outdated terms like *peninsula, river,* and *swamp* in



Some details from Schröter's map

older maps. As Latin no longer was the sole language of scholarship, he also introduced the German word *Rille* for "groove."

The most influential contribution to lunar topography in the nineteenth century—a highly detailed large-scale lithographic map that surpassed all predecessors in refining the system of feature names and positions based on micrometric measurements—was created in Berlin by Johann Heinrich von Mädler (1794–1874) and his friend Wilhelm Beer (1797–1850). Beer was a banker who provided the observatory and a four-inch refracting telescope and Mädler was the observer, artist, and scientist who drew the map.

A detail from the map by Mädler and Beer

Studying the moon for about six hundred nights, Mädler created a *Mappa Selenographica* more than three feet square that depicted the moon not in spatial lunar coordinates but as a disk with contortions on its fringes. He designated secondary craters by assigning each a letter associated with a nearby "parent" crater, and he assigned Greek letters to elevations, ridges, and rilles. Mädler concluded that the moon has no atmosphere or water and does not change: "The Moon is no copy of the Earth." Part of the publication was a bulky volume titled *Der Mond,* which was a resource of knowledge about the moon, "our satel-

Johann Heinrich von Mädler and a moon globe

lite which in front of the eyes of all inhabitants of the Earth repeats its eternal cycle."

In 1840 Mädler became the director of the Dorpat Observatory in Estonia. Based on the work with a larger refracting telescope available there, he published a revised version of his map in 1869. By this time, photography was starting to decrease the interest in lunar cartography, but illustration had the advantage of allowing emphasis of detail. The revised edition of Mädler's book seemed to answer conclusively the most important questions about the physical condition of the moon; the book had the effect of effectively paralyzing the study of the moon for decades.

As lunar maps evolved, their functions became more firmly fixed. Certainly they helped to serve the vanity of rulers who commissioned them, but otherwise they served no obvious political function, such as the territorial claims that terrestrial maps articulate. And unlike maps of Earth, visual representations of the moon didn't help travelers orient themselves in little-known terrain. Their function was largely symbolic—even though the moon was out of physical reach, mapping it had an imaginative value. More than at any previous era, the nineteenth century was obsessed with counting and measuring—an activity that engaged the many blank spaces and uncertainties related to the cosmos without quite solving them. Precise maps also had the effect of elevating science at the expense of ancient myth.

The degree of concentration required to chart a world so utterly out of reach was immense, and before the advent of photography it was a tedious task to observe the details and then transfer these impressions with a pencil. Mädler's obsession with his project was such that he is said to have met his wife in one of the rare moments when he was not looking through the telescope. The German astronomer Johann Friedrich Julius Schmidt (1824–1884) is credited with the most detailed lunar map of the nineteenth century, featuring no fewer than 32,856 craters. Such an obsession with ever-smaller features, as Paul D. Spudis has stressed, was inextricably linked with the idea common during this time "that the secrets of lunar history were in the details" rather than in the broader features.

The invention of photography had an impact on the depiction of the moon, just as it did on all forms of visual representation. In 1840 John William Draper (1811–1882), then a professor of medicine at New York University, created a few crude daguerreotypes of the moon. They were soon superseded in quality by the photographs by his son Henry (1837–1882), and those of William Cranch Bond (1789–1859), the first director of the Harvard College Observatory, who used a refracting telescope of fifteen inches, then the largest in the world. A particular challenge facing photographers was the need for long exposure times combined with the movement of the moon in the sky, which led to blurred images. But the complication could be resolved. A clockwork mechanism was attached to the camera to compensate for the rotation of the Earth and moon. Another pioneer of lunar photography was Lewis Morris Rutherford (1816–1892). A lawyer by education, he started to devote himself to astronomical photography in the 1850s and soon maintained a little observatory in Manhattan. Rutherford also designed a special telescope for this kind of photography. The quality of photographic emulsions steadily improved, but well into the twentieth century scientists continued to rely more on illustrations of the moon, which were richer in detail, than on photographs.

How did the progressive discovery of the moon fit into the larger development of astronomy? The observation and mapping of the moon in the centuries after Galileo continued to be-

Photograph taken by Henry Draper in 1863

come more precise, and astronomers grew ever more interested in the planets. Some of the scientists we have met in this chapter also began to study Mars and other planets. In 1830, for example, Wilhelm Beer published the first map of Mars. In 1869 Richard Proctor produced an even more detailed map. Cassini also devoted much of his attention to the Red Planet.

By the end of the nineteenth century, the telescope, now much improved and widely used, had rendered the moon rather mundane. Many researchers now devoted their energies to more promising fields of stellar enquiry. Some lamented that the profession had abandoned the moon to amateurs. What attention it did receive was mostly in the context of its surface and of larger issues of space exploration. But in the 1960s, some geologists looked up from Earth and began to take an interest in the surface and makeup of the moon. They began also to transform their methods to accommodate lunar exploration.

The scientist connected most with this major transition is the American geologist Eugene Shoemaker (1928–1997), who had devoted himself to the study of cosmic impacts, examining Barringer Meteor crater in Arizona and craters blasted by atomic bombs tested in Nevada. Realizing that geologists would eventually be needed to investigate the composition of the moon, Shoemaker founded the astrogeological branch of the U.S. Geological Survey in 1961, and the group began using telescopes and photographs to map lunar geological features. One result of this work, a few years before the moon could actually be scrutinized and mapped up close, was the *Photographic Lunar Atlas* (1960, 1967), published by the U.S. Air Force and the University of Arizona, which depicts the moon's near side under various light conditions. Originally a potential Apollo astronaut, Shoemaker had to abstain from a lunar trip for health reasons. But in another sense he still made it to the moon—his cremated remains were deposited there by the mission Lunar Prospector in the year after his death. So far, he is the first and only human interred on the moon.

Lunar features continued to be named and renamed throughout the twentieth century. Lunar nomenclature is a discipline both esoteric and complex, often resulting in confusion, if not chaos. Ewen A. Whitaker's *Mapping and Naming the Moon* (1999) deals with some of these "nomenclatural nightmares." When new features were discovered—for instance, after the photographs were made of the moon's far side—the lack of specific rules became apparent. Special committees were formed and international resolutions adopted. Thus it was determined that craters can be named only after deceased people and that specific types of lunar features, such as mountains, rilles, and valleys, must named in Latin: mons, rima, vallis.

Over time, improved resolution of images—as with the metric camera photography from Apollo missions 15, 16, and 17—brought new challenges in nomenclature: In how much detail should maps represent the surface now that even much smaller formations became discernible? And while few of the fanciful names given centuries ago to lunar features have survived, the dark patches continue to be called maria. Lunar nomenclature continues to reflect the advancement of scientific knowledge—with some erratic leftovers from older times.

Visual exploration of the moon only foreshadowed a much more complex scientific enterprise. Twenty-first-century study of the moon extends well beyond sight. Spectrometers allow for ever more precise analyses of the moon's mineralogy and composition. Measurement of gravitational fields, temperature, and radiation are becoming increasingly accurate. Navigation data of lunar spacecrafts revealed the existence of mascons: patches on the surface, mainly on the near side, with particularly high gravity. Efficient camera systems are able to detect the details of rock formations hardly three feet high. The Japanese lunar explorer Kaguya (Selene) has, since 2007, circled the surface at a distance of roughly sixty miles, using so-called laser altimeters that constantly send impulses to provide highly detailed three-dimensional information about the moon's topography.

These efforts to map the moon and name its features reveal that conquest no longer is the exclusive province of kings and gunships, but includes detailed scientific investigation. The moon is more than an object of study and contemplation; it is also a screen upon which our desires and aspirations can be projected. It is fascinating to note that the Italian philosopher and optician Giambattista della Porta (ca. 1535–1615) took this idea literally and proposed precisely such a project. In his book *Magia naturalis* (1589), he suggested that the moon could become a news medium. According to his proposal, a parabolic mirror with a wide focus would project letters onto the lunar surface that could then be read by people on Earth. Della Porta's idea was never put into practice, and the stories that shake the world today are to be found on computer screens, not on a lunar screen.