Observing the **Moon**

The modern astronomer's guide

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CHAPTER 2

The moon through the looking glass

Who first looked at the Moon through a telescope? The honest answer is that we do not know. We cannot even be sure as to when the telescope was invented, let alone who was first to look at the Moon through one.

Until a few years ago most historians had settled upon 1608 as the probable year of invention of the telescope and a Dutch spectacle maker, Hans Lippershey, as its probable inventor. Recently, however, evidence for an earlier invention has come to light. For instance, an Englishman, Thomas Digges, is thought to have produced a form of telescope sometime around 1555.

What we can be certain of is that Galileo heard of the Dutch telescope and, with few clues to help him, he did manage to design and build a small refracting telescope for himself in 1609. Shortly thereafter he built other slightly better and more powerful versions (though still extremely imperfect and lacking in magnification by modern standards) and we know that he used them to observe the celestial bodies, including the Moon.

Galileo made sketches of the lunar surface. An Englishman, Thomas Harriott, had managed to obtain a telescope from Europe and also used it to observe the Moon at about the same time as Galileo. Harriott even produced what was very probably the first complete map of the Moon's Earth-facing side to have been made using optical aid. Despite the imperfections of his telescope, Harriott's map does show features we can recognise today.

You might have expected the coarsest features of the Moon to have been charted before the invention of the telescope. Undoubtedly they were, though the earliest 'map' produced without optical aid that we know of is that by William Gilbert. This was published posthumously in 1651, though it is supposed that he made it in 1600, or at some time close to that date, approximately three years before his death.

Although the very beginnings of lunar study might be shrouded in the mists of time, all that occurred after Galileo's era is quite well documented. The Moon had become a subject for serious scientific study and astronomers set about mapping its surface features. As telescopes improved in their power and quality, so successive observers produced better and better maps.

An essential for any cartographic exercise is the standardisation of nomenclature. Naming systems were devised by Langrenus in 1645 and by Johannes Hevelius in 1647. As an aside, Hevelius's maps were notable because they were the first to take account of, and to represent, the regions of the Moon that were only shown as a result of libration. Despite this advance, Hevelius's system of nomenclature was quickly superseded. Our modern scheme of naming lunar surface features really stems from that devised by Giovanni Riccioli. Riccioli was an Italian Jesuit. A pupil of his, Francesco Grimaldi, had made a telescopic study of the Moon. Riccioli combined Grimaldi's observations into a map, which was published in 1651.

Before taking our story further, it will benefit us to pause to consider the appearance of the Moon through a telescope and to get a brief overview of the modern nomenclature of the main types of surface features revealed by one of these wonderful devices.

2.1 THE MOON IN FOCUS

Even a casual glance made without any form of optical aid reveals that the Moon is not a blank, shining disk. Aside from the phases, the Moon's silvery orb clearly shows patchy dark markings. These give rise to the "Man in the Moon" (and the variety of animals and maidens which feature in other folk lores) effect which is so obvious around the time of the full Moon. Figures 2.1–2.5 show the general appearance of the Moon at successive stages in its lunation, as it is seen through a normal astronomical telescope stationed in the Earth's northern hemisphere – in other words, with south uppermost. Since this book is intended for the amateur telescopist and since most of its readers are expected to reside in the northern hemisphere, all the telescopic views of the Moon in this book are orientated with south at least approximately uppermost.

The large dark areas are known as *maria*, Latin for 'seas'; the singular form is *mare*. Thanks to Riccioli, we have such charming names as Mare Imbrium (Sea of Showers), Mare Serenitatis (Sea of Serenity), and Mare Tranquillitatis (Sea of Tranquillity) to encounter on the Moon.

In Galileo's time it was widely believed that the patches on the Moon actually were seas. Admittedly, a few scholars considered the darker areas to be the land masses and the rest of the Moon's globe to be ocean-covered. Much later the true, arid, nature of the Moon was recognised and the difference in hue was taken to indicate a difference in chemical composition.

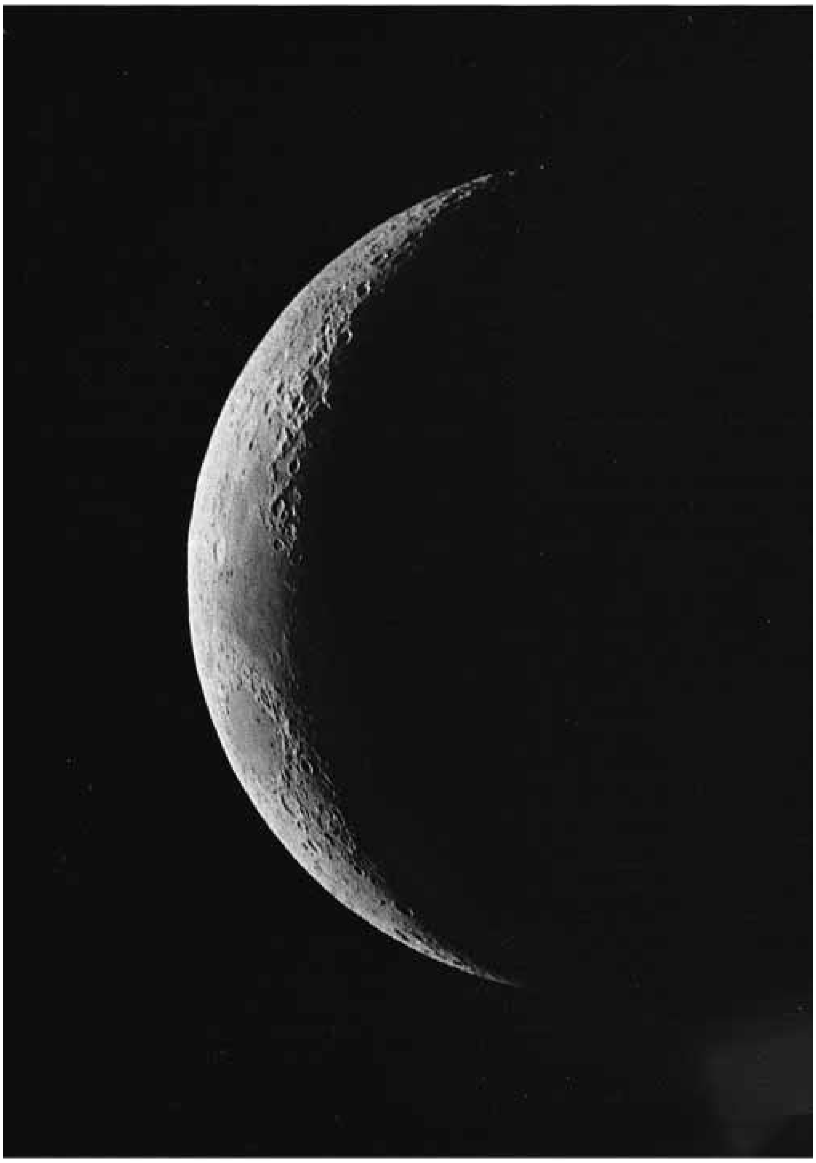


Figure 2.1 The 4-day-old Moon, photographed by Tony Pacey. He used his 10-inch (254 mm) Newtonian reflector at its f/5.5 Newtonian focus to directly image the Moon onto *Ilford* FP4 film, subsequently processed in Aculux developer. The 1/125 second exposure was made on 1991 January 19^{d}. The details of the precise time (from which I could work out the value of the Sun's selenographic colongitude) was not given. However, I estimate the Sun's selenographic colongitude as approximately 307° at the time of the exposure.

In pre-space-age times the dark plains were termed *lunarbase*, while the lighter-hued materials were termed *lunarite*.

As well as the 'seas', we have one 'ocean' (*oceanus*): Oceanus Procellarum (Ocean of Storms) and several 'bays' (*sinus* for the singular case), such as Sinus Iridum (Bay of Rainbows). These are the larger dark areas. In addition there are a number of 'marshes' (*paludes*), such as Palus Somnii (Marsh of Sleep) and 'lakes' (*lacus* for the singular case), for example Lacus Mortis

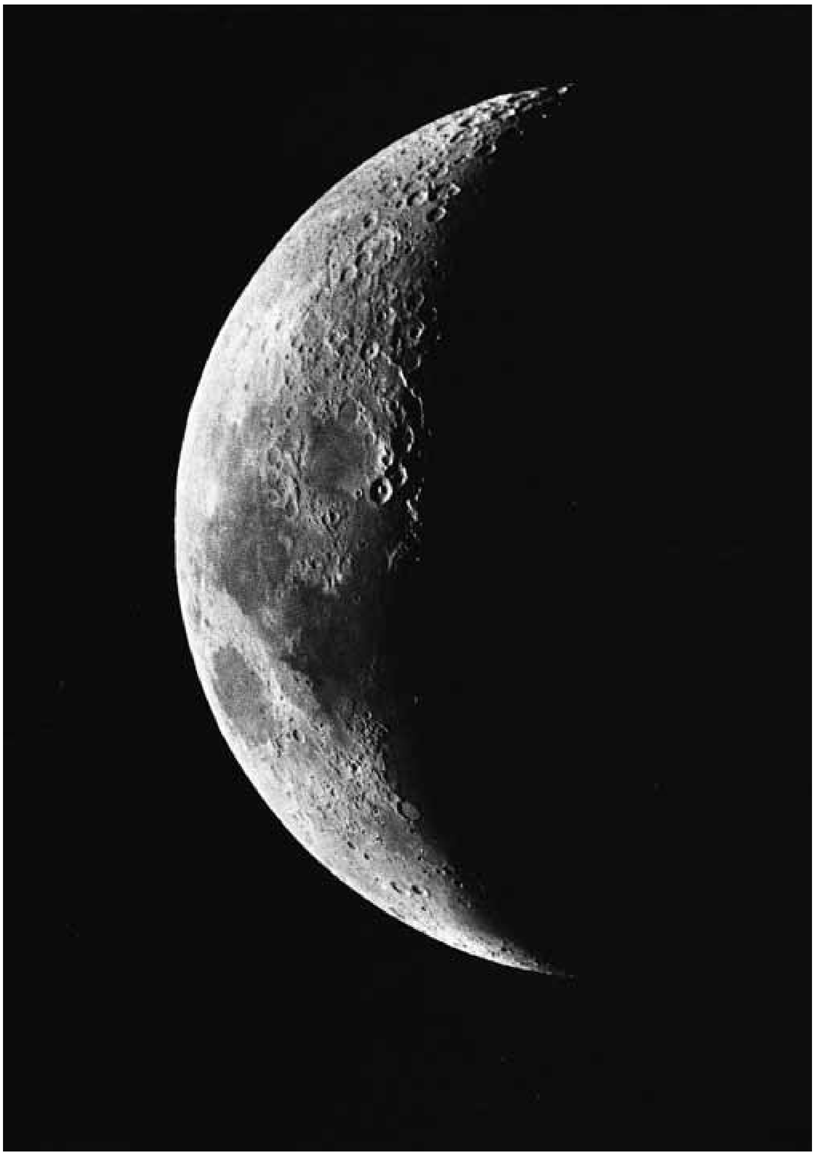


Figure 2.2 The 6-day-old Moon photographed by Tony Pacey. Same arrangement as for Figure 2.1 but he used a 1/60 second exposure on *Ilford* Pan F film, processed in ID11 developer. The photograph was taken on 1992 January 10^{d} 19^{h} 00^{m} UT, when the value of the Sun's selenographic colongitude was 327°.5.

(Lake of Death). These are the smaller mare-type dark plains. They are all easily visible to the user of a pair of binoculars. The lunar equivalent of the Earthly 'cape' is the *promontorium*. An example is the Promontorium Agarum (Cape Agarum) on the south-eastern (IAU co-ordinates) border of the Mare Crisium.

You will find a coarse map of some named lunar features presented in Chapter 7 (p. 152) of this book. In addition, many of the features named in

Figure 2.3 The 11-day-old Moon photographed by Tony Pacey. This time Tony used his 12-inch (305 mm) f/5.4 Newtonian reflector, though with the same technique as he used to obtain the photographs shown in Figures 2.1 and 2.2. The 1/250 second exposure was made on *Ilford* Pan F film on 1992 May $13^{d}\ 22^{h}\ 14^{m}$ UT, when the Sun's selenographic colongitude was 40°.0.

this chapter are discussed in detail in Chapter 8 and images/illustrations of them under differing lighting conditions are included there.

Of course, the view grows more detailed when a proper astronomical telescope is used. Even a small telescope reveals a mass of detail and the sight of the lunar surface in anything larger than a 3- or 4-inch (76 mm or 102 mm) telescope is impressive to say the least. I find that the appearance of the Moon's surface through such a telescope, and using a magnification of the order of $\times 100$, reminds me of plaster of Paris. The waterless 'seas' and other dark plains appear various shades of steely grey and the rougher, crater-strewn, 'highlands' that make up the rest of the surface seem greyish white.

Figure 2.4 The 14.7-day-old Moon photographed by Tony Pacey on 1990 December 31^{d} 20^{h} 15^{m} UT, when the Sun's selenographic colongitude was 78°.7. He used a 1/1000 second exposure. All other details as for Figure 2.1.

When the Moon is close to full (as shown in Figures 2.3, 2.4 and 2.5) its surface seems dazzlingly bright and covered in bright streaks and spots and blotches. At these times it is difficult to imagine that the Moon is made up of relatively dark rock. In fact the Moon's *albedo* is 0.07, meaning that it reflects, on average, 7 per cent of the light falling on it.

Surface features are difficult to make out near full Moon because the sunlight is pouring onto the lunar surface from almost the same direction as we are looking from. This means we cannot see the shadows, so we see very little in the way of the surface relief as a result.

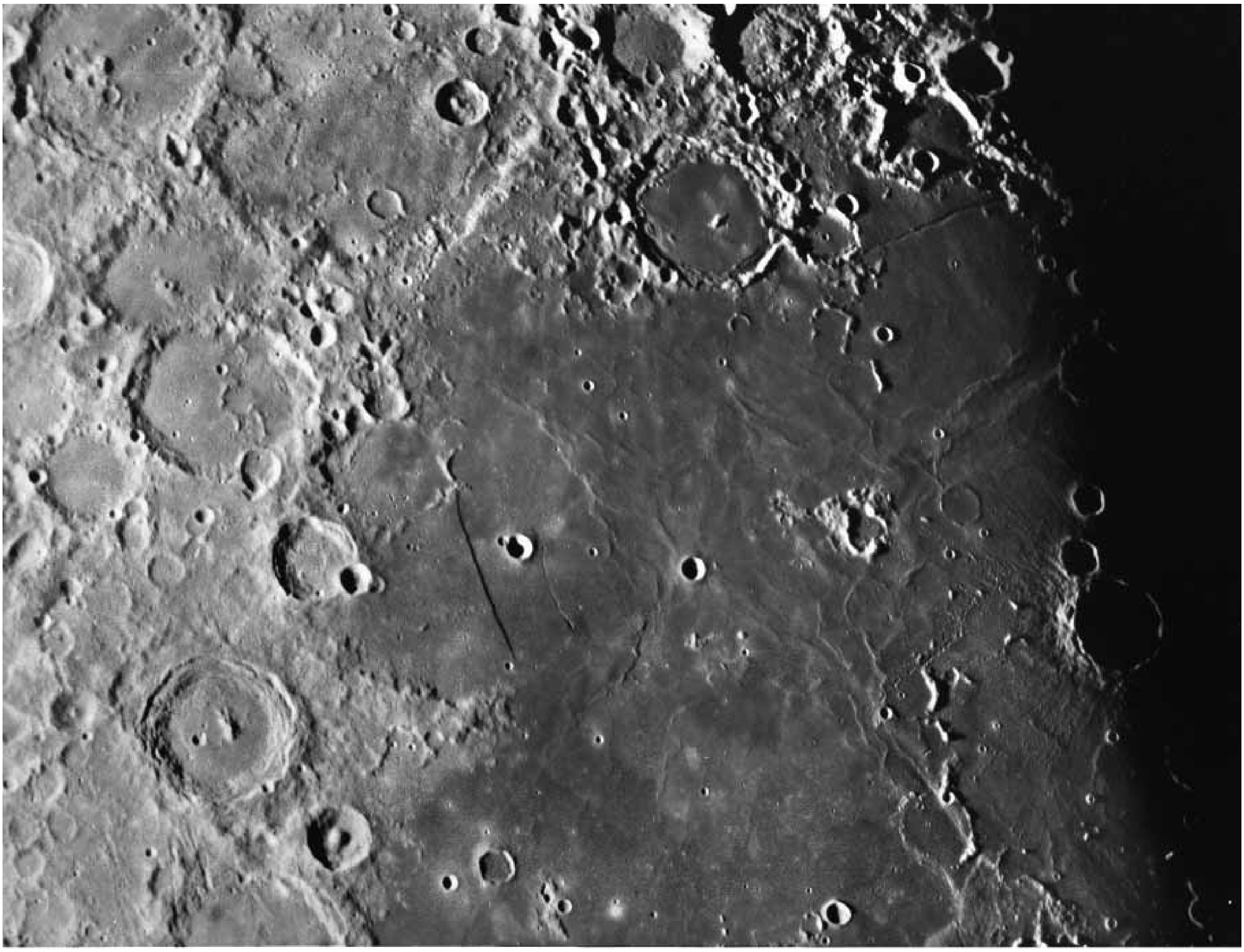
Away from the times when the Moon is full the effect is far less confusing. Shadowing then makes the lunar surface details stand out. This is especially so close to the terminator, where the sunlight is striking the Moon at a very shallow angle. This is evident even by comparing the wide-angle (and hence low-resolution) views shown in Figures 2.1 to 2.5. Notice how the surface relief along the terminator in Figures 2.1 and 2.2 is virtually invisible in the corresponding positions in Figures 2.3, 2.4 and 2.5.

Under low-angle lighting even the lunar maria are shown to be less than perfectly smooth. *Dorsum*, networks of ridges crossing the maria, then become obvious (see Figure 2.6). *Dorsa* are ridges occurring elsewhere than on the lunar maria. They are named after people, for example Dorsa Andrusov and Dorsum Arduino, but the average lunar observer will not have occasion to use these names.

Figure 2.5 The 16-day-old Moon photographed by Tony Pacey on 1992 November 11^{d} 21^{h} 45^{m} UT, when the Sun's selenographic colongitude was 100°.9. The exposure given was 1/500 second. Other details as for Figure 2.3.

If the lunar 'seas' are the easiest features to see with the minimum of optical aid, then the craters must count as the next-most-dominant surface feature on the Moon. These saucer-shaped depressions range in size from the smallest resolvable in telescopes (and smaller, down to just a few metres across, as revealed by the manned landings) to a few that are several hundred kilometres in diameter. The smaller craters vastly outnumber the larger ones.

Following the scheme originated by Riccioli, craters are given the names of famous personalities, most usually astronomers. If it strikes you that this is potentially a rather contentious system then you are correct! Over the years many selenographers had taken it upon themselves to modify the nomenclature assigned by the earlier workers, often putting their own names and the names of their friends onto their maps. The result was that a particular crater might have different names on different maps. Even more confusing, a particular name might refer to different craters on different maps! Fortunately, the system has been overhauled by the International Astronomical Union in modern times. Under the IAU-standardised scheme, craters are still named after famous personalities (with the proviso that the personality is deceased – the only exception to that being the *Apollo* astronauts) and most of the older assigned names have been retained. The IAU nomenclature is most



definitely the one to be adhered to and I would advise caution when using pre-1975 maps.

When seen close to the terminator, craters are largely filled with deep-black shadow and give the impression of being very deep holes. In reality they are rather shallow in comparison to their diameters and can often be quite difficult to identify when they are seen well away from the terminator. Craters saturate the highland areas of the Moon (see Figure 2.7) but there is an obvious paucity of larger craters on the maria. An observer using

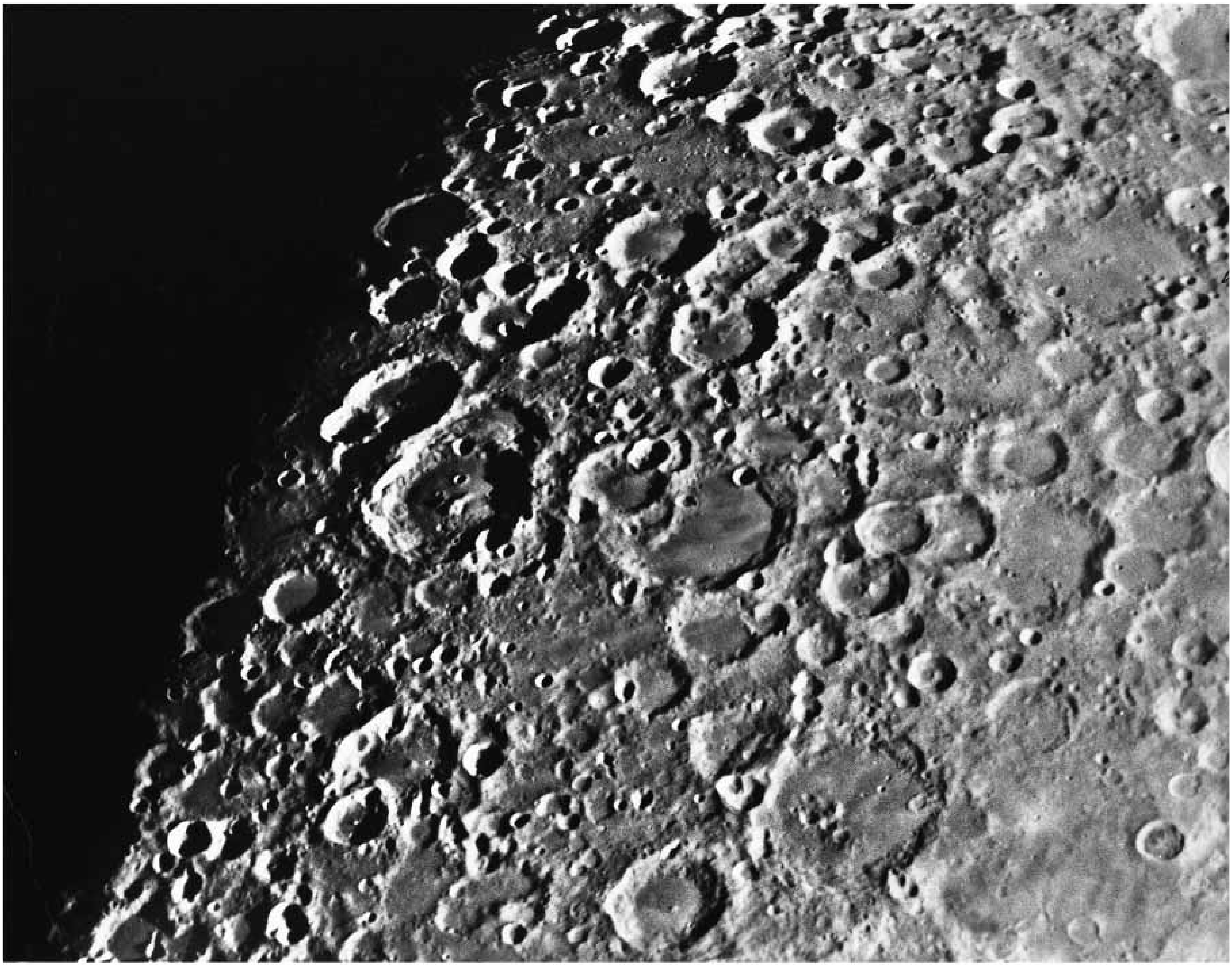
Figure 2.6 With sunlight illuminating the surface at a low angle even the lunar maria appear far from completely smooth. Patterns of ridges cross the part of the Mare Nubium that is shown in this Catalina Observatory photograph. The instrument used was the observatory's 1.5 m reflector and the photograph was taken on 1966 May 29^{d} 04^{h} 41^{m} UT, when the Sun's selenographic colongitude was 22°.6. (Courtesy Professor E. A. Whitaker and the Lunar and Planetary Laboratory, Arizona.)

a typical amateur-sized telescope (around 200 mm aperture) can resolve craters down to about 1–2 km in size and yet many areas of the maria appear craterless. Nonetheless, the photographs sent back by close-range orbiting probes show that even these areas are saturated with small and very small craters. Where there are recognised chains of small craters, these are termed *catena* and are named after the nearest most appropriate named feature. Catena Abulfeda is one example; a 210 km-long chain of small craters near the major crater Abulfeda.

Often the floors of large craters are cluttered with smaller craters and there are many examples of craters breaking into others. In almost all the cases it is the smaller crater which breaks into the larger. Clavius (see Section 8.12), Gassendi (Section 8.22), Posidonius (Section 8.35) and Cavalerius (Section 8.20) are examples of these.

Craters differ in more than their sizes. Some, such as Copernicus, have elaborately terraced walls. Copernicus (Section 8.13) is also an example of one of the many craters to have centrally positioned mountain masses. Other craters, such as Plato (Section 8.33), have their floors flooded with mare material. Some craters have their walls broken down and are almost totally immersed in mare material. Some craters have bright interiors, such as Tycho (see Section 8.46), which is also one of the best examples of craters which are the source of bright streaks of material, termed *rays*, which extend radially from the source crater. Tycho is very easy to see through a pair of binoculars any time close to full Moon, appearing as a bright spot in the Moon's southern highlands. The rays also seem to extend more than half-way around the Moon's globe. Figure 2.5 shows them particularly well. Other craters have relatively dark interiors and no associated *ray systems*. All this tells a story and I will have much more to say about crater morphologies and the evolution of the Moon and its various surface details later in this book. For now, we will continue our extremely brief survey of the main types of lunar surface feature and nomenclature.

After the maria and the craters, mountains (generic name *mons*) and mountain ranges and groups of peaks (*montes*) vie for the attention of the telescope-user. They have been named after their Earthly counterparts, so one can find the Apennine Mountains (Montes Apenninus – see Section 8.5) and Carpathian Mountains (Montes Carpatus – close to the crater Copernicus – see Section 8.13) on the Moon. The lunar highlands are very rough and hummocky, whereas the maria are much smoother. However, mountain ranges often border a mare. Isolated peaks also exist, sometimes actually on a mare. Examples of this type are Mons Piton and Mons Pico (close to the crater Plato – see Section 8.33), situated on the Mare Imbrium. Relatively small blister-like swellings on the lunar surface are termed *domes* but these are not given specific names and are, instead, identified by their



proximity to a known major location in the same way as for the crater chains. The easiest domes to locate are those near the crater Hortensius. These are described in Section 8.21.

The closest match to an Earthly cliff on the Moon's surface is an escarpment (a sudden rise in the ground which continues along an approximately linear, or slowly curved path). The generic name for these features are *rupes*, an example being the Altai Scarp (Rupes Altai – see Sections 8.30 and 8.44) on the Moon's south-eastern quadrant.

As well as the craters and the various raised formations, features sunk

Figure 2.7 The crater-saturated southern highlands of the Moon, photographed using the 1.5 m reflector of the Catalina Observatory, Arizona, on 1966 September $5^{d}\ 11^{h}\ 30^{m}$ UT, when the Sun's selenographic colongitude was 155°.5. (Courtesy Professor E. A. Whitaker and the Lunar and Planetary Laboratory, Arizona.)

below the Moon's surface abound. Gorge-like valleys, called *vallis*, such as the huge Rheita Valley (Vallis Rheita – see Section 8.25) are at one extreme of the size range. Much finer (though often longer) sinuous channels, known as *rilles* (obsolete spelling *rills*; in old books you will also find them often referred to as *clefts*, particularly so the larger examples), also cross the lunar terrain. Several are shown in Figure 2.8. As far as naming them goes, *rima* is used for single examples and *rimae* for networks or groups of rilles. Hence, Rima Hadley and Rimae Arzachel. Many examples are detailed in Chapter 8. All the rilles and most of the lunar escarpments and valleys are named after the closest appropriate major feature. The sole exceptions are: Rupes Altai, Rupes Recta, Vallis Bouvard and Vallis Schröteri.

Figure 2.8 Systems of rilles situated near the centre of the Earth-facing hemisphere of the Moon. Photograph taken using the 74-inch (1.9 m) reflector at Kottamia, Egypt, on 1965 August $4^{d}\ 20^{h}\ 43^{m}$ UT. (Courtesy Dr T. W. Rackham.)

All the foregoing described features can be seen through small telescopes. Even a humble 3-inch (76 mm) refractor is sufficient to show many rilles, despite their being hard to resolve due to their thinness, when they are seen under low-angle illumination from the Sun (and so largely filled with black shadow). They were first noted by Christian Huygens with the primitive telescopes of the seventeenth century.

As I indicated earlier, the Moon appears rather monochrome when seen with a small telescope (aside from the prismatic splitting of light through our atmosphere which causes images seen in a telescope often to be spoiled by colour fringing – discussed later in this book). However, if a sufficient aperture is used then some coloured tints can become visible to the observer. Or at least that is the case for many observers. Sensitivity to colours varies enormously from person to person. Some observers fail to see colour in anything they look at through the telescope. For a few lucky individuals the Universe is a very colourful place. Others can see some colours through the telescope eyepiece, perhaps just the strongest hues on Jupiter and the overall colours of Mars and Saturn.

I am fairly fortunate in that I can easily see colours in many objects through a telescope of sufficient size, though I must say that I have noticed some reduction in my colour-sensitivity as I have got older. I find that I can see subtle coloured tints on the Moon's surface when using a sufficiently low magnification on a reasonably large telescope; for example, ×144 on my 18¼-inch (0.46 m) Newtonian reflector. The overall colour of the rough highlands are still greyish, though perhaps a little 'creamier' in colour than through a smaller telescope, but the large plain of the maria seem tinted with faint blues and greens. In particular, the Mare Tranquillitatis seems especially blue when seen near full Moon. The interiors of some craters, such as Langrenus, appear with a faint brownish or even a golden-yellow tint at these times. Aristarchus appears slightly bluish-white while the raised plateau on which it stands seems particularly brownish to my eyes.

Of course, these colours are very far from accurate. Spectroscopic analysis reveals that the surface of the Moon is really various shades of brown. The human eye has a tendency to normalise the overall colour of the Moon as white. Hence the different shades of brown manifest as the apparent colours seen. A slightly 'redder' brown produces an apparent yellowish or brownish tint, while a 'cooler' shade of brown seems to the observer to be a greenish or bluish tint.

Figure 2.9 shows a specially prepared photograph on which all the usual grey-scale tones have been obliterated. Instead, the shades of grey represent colour differences. Redder tones show up as lighter, and bluer tones show up as darker. Note the relative blueness of the maria and the relative redness of the interiors of many craters. As far as I can ascertain

Figure 2.9 Colour-difference (610 nm – 370 nm). photograph of the Moon The normal grey-scale has been eliminated. Lighter regions are redder and darker regions are bluer.

only a minority of people can perceive these subtle tints through even a large telescope. To most users of small telescopes, the Moon is a world of black and white, and steely greys.

2.2 THE PIONEERING SELENOGRAPHERS

As the seventeenth century progressed so refracting telescope object glasses were made which were a little larger than the first, tiny, examples. However, these lenses were single pieces of glass and so suffered badly from chromatic aberration. The remedy for this aberration (and to an extent the other aberrations that arose mainly from the crudeness of the methods of lens manufacture) was to make the lens of larger focal ratio (and hence greater focal length). To reduce the aberrations to a tolerable level, the focal length had to increase out of proportion to the aperture. So, longer and longer refracting telescopes were made. In some cases the focal lengths reached hundreds of feet (several tens of metres). Even then, the sizes of the objective lenses were still less than 9 inches (23 cm)! Despite this handicap, *selenography*, the charting of the Moon's surface features, steadily improved.

Probably the best map of the Moon made in the seventeenth century was that published in 1680 by Cassini. His 54 cm map (54 cm representing the Moon's diameter), is of remarkable quality considering the cumbersome telescopes he had to work with. Not only is it artistically a fine piece of work but also the positional accuracy of the features it depicts is very good for the time (admittedly it is hardly up to modern standards in this respect!). It showed unprecedented fine details, such as the minute craters (which we now know as *secondary craters*) around Copernicus. It is also more comprehensive in its depiction of features than earlier works, for instance showing the ray systems that surround many bright craters (de Rheita was, arguably, the first to comprehensively chart the rays in 1645) and something of the variations of hue of the lunar maria.

The later years of the seventeenth century also saw the invention of the common forms of reflecting telescope (the Newtonian, the Cassegrain and the now obsolete Gregorian) which eventually led to more manageable and yet higher-quality instruments, and ever better lunar observations.

In Germany Tobias Mayer produced a small, though accurate, map, published posthumously in 1775. He was notable in that he was the first to introduce a system of co-ordinates for lunar surface features, having made his measurements with the aid of a primitive eyepiece micrometer.

As far as the 'leading lights' of selenography go, Germans dominated the period from Tobias Mayer's work through to the late nineteenth century. Perhaps the most famous of these was Johann Hieronymous Schröter. Schröter was a magistrate at Lilienthal (near Bremen, in Germany), where he had enough wealth and leisure time to set up his own observatory. He had various telescopes, including two by William Herschel. His largest (not by Herschel) was a 20-inch (0.51 m) Newtonian reflector of about 8 metres focal length. Completed in 1793, it was the largest telescope in Europe at the time and was surpassed only by William Herschel's 48-inch (1.2 m) of 40 feet (12 m) focal length, though it is thought that the optical quality of the 20-inch was not particularly good.

From 1778 to 1813, Schröter devoted considerable amounts of time and energy to observing the Moon and planets. He set himself the task of making the most detailed map of the Moon to date and he made hundreds of lunar drawings to that end. He used a crude eyepiece micrometer to aid his work, including making measurements of the heights of lunar mountains. He was the first to make a really detailed study of the crack-like rilles. In the end he did not complete his proposed lunar map but instead published the completed sections in a book, *Selenotopographische Fragmente*, in 1791 (a second part was completed and a bound two-volume edition published in 1802). Schröter's work attracted much attention and other selenographers undoubtedly were inspired by the (sometimes controversial) results issuing from Lilienthal.

On the downside, Schröter was not a particularly good draughtsman and he certainly made his fair share of mistakes. In particular he thought he had detected changes on the lunar surface over the years during which he carried out his observations and he was convinced that the Moon possessed a dense atmosphere. Of course, neither are true.

A cruel blow was to befall Schröter when, in April 1813, invading French soldiers looted and then burnt Lilienthal to the ground. His observatory was also looted and then destroyed. At that time Schröter was 67 years old and his health was already in decline. It was too late for him to rebuild his observatory and begin again. Undoubtedly the shock and sorrow he suffered hastened his death. He died three years later.

Wilhelm Lohrmann, of Dresden, also attempted to map the entire face of the Moon in great detail. The first sections of his map were published in 1824 but Lohrmann was eventually defeated by failing eyesight. However, he did manage a general map of the surface of 39 cm diameter. The quest was taken up by Wilhelm Beer and his collaborator Johann Mädler. Beer had a 3¾-inch (95 mm) refractor at Berlin and, together, they used this telescope to study the Moon in detail for over a decade. They eventually (1837) produced a highly detailed and very accurate map. On it, the whole Moon had a diameter of just over 0.9 m. It remained unsurpassed for decades to follow, a significant achievement given the diminutive size of the telescope they used. Beer and Mädler's map was supplemented with their book *Der Mond*. They portrayed the Moon as utterly dead and changeless, in complete contrast to the picture of it painted by Schröter.

Whereas the Moon of Schröter, with its supposed changes and active weather tended to excite the interest of others, that portrayed by Beer and Mädler tended to do the opposite. Given, also, the high quality of their map, the general feeling was that 'the last word' had been stated as regards lunar studies. Few others studied the Moon seriously for more than the next quarter-century.

However, one exception was Julius Schmidt. Schmidt had a lifelong interest in the Moon. After posts at various German observatories, he became Director of the Athens Observatory, in Greece, in 1858. He used the 7-inch (178 mm) refracting telescope there to continue his lunar studies. As well as revising the sections of the lunar maps of Lohrmann, and then going on to complete the mapping of the missing sections, Schmidt was eventually to complete one of his own by 1878.

Schmidt's map, 1.9 m to the Moon's diameter (the map was divided into 25 sections) was incredibly detailed as well as being reasonably accurate. It recorded and placed some 32 856 individual features. It took over the torch from Beer and Mädler as the best lunar map. It was to hold this premier position until 1910, when a 1.5 m map of greater positional accuracy was published by Walter Goodacre, the second Director of the Lunar Section of the *British Astronomical Association* (*BAA*).

This was not Schmidt's only contribution to selenography. Owing to an erroneous interpretation of his, and other people's, observations, he reinvigorated lunar research. The whole episode concerns a small crater, called Linné, in the Mare Serenitatis. Lohrmann, Beer and Mädler, and Schmidt himself had often recorded Linné as a deep crater. Then, in 1866, Schmidt announced that the crater had disappeared! In its place Schmidt could only find a small light patch. As one might expect, a statement like that was sure to get astronomers turning their telescopes back to the Moon. Many leading astronomers joined in and a vigorous debate ensued. In fact, many astronomers continued to cite Linné as a prime example of an area of the Moon that had changed significantly within the history of Man's observations of it, even to as late as the middle of the twentieth century!

We now know that Linné is really a small crater surrounded by a light area. Under certain angles of illumination it can, indeed, appear in the guise of a deep, apparently larger, crater. It seems certain that Schmidt was mistaken. There never was any change in this lunar feature within the period when astronomers were looking at it. However, this mistake was just what was needed at the time to counter the view of the Moon as a dead and uninteresting world that pervaded after Beer and Mädler's epic study of it.

As well as the maps, various other studies of the Moon's topography appeared in the form of books. For instance, there was *The Moon* jointly authored by James Nasmyth (a famous engineer and the inventor of the steam hammer) and James Carpenter. First published in 1874, the authors made serious efforts to understand the origins of the Moon and the evolution of its surface features (though their theories bear little relation to our modern ideas). Much of their researches were based on observations made with Nasmyth's home-made 20-inch (0.51 m) reflector of novel design. Incidentally, the optical arrangement Nasmyth originated is often used in today's largest telescopes and is known by his name. Nasmyth and Carpenter's book also contains beautiful drawings and photographs of sculpted models of regions of the lunar surface (at that time, photography had not technically advanced enough to enable good, detailed, photographs to be taken of the Moon's surface direct through the telescope) along with written descriptions.

Other notable books about the Moon included *The Moon* written by the Englishman Edmund Nevill and published two years after Nasmyth and Carpenter's book of the same name. Actually, Nevill wrote under the name Neison. His book contained a map based on that of Beer and Mädler, along with detailed descriptions of the named features.

If, as a result of the necessary brevity of these historical notes,* I have given the impression that selenography was only carried out by a few individuals then I must rectify that impression. For instance in England there was the *Selenographical Society*, formed in the early 1870s specifically for lunar studies. The *British Association for the Advancement of Science* appointed the Secretary of the Society, W. R. Birt, to head a committee to organise the construction of a new and more detailed map of the Moon. It was intended to be 200 inches (5.08 m) to the diameter of the Moon. Birt was an energetic selenographer and a start was made, though Birt's death and the eventual demise of the Selenographical Society in 1882 meant that the scheme did not bear fruit.

Also, many national and provincial astronomical societies had sections devoted to lunar study. One very active group of the period was the *Liverpool Astronomical Society*. It's director was T. G. Elger, who became the first director of the Lunar Section of the British Astronomical Association when it formed in 1890. In those early years many people spent a great many hours at the eyepieces of their telescopes studying the Moon.

The last really substantial Moon map to be made using the old-fashioned methods of eye and drawing board to record its finest details was the 300 inch (7.6 m to the Moon's full diameter) colossus of H. P. Wilkins. He published the first version of it in 1946 and made revisions in subsequent years. At the time he was Director of the Lunar Section of the British Astronomical Association. The only version of Wilkins' map I have seen is that reproduced in reduced scale in twenty-five sections in the book *The Moon* by Wilkins and Patrick Moore, published by Faber and Faber in 1955. I was lucky enough to find a copy of this work in a second-hand bookshop some years ago, though it is now very rare. The complexity of the hand-drawn details in the map is mind-boggling. Though it is now recognised that Wilkins' map contains many inaccuracies in its depictions of details (I have stumbled across several, myself, without making any effort to find them), the scale of his achievement still warrants admiration.

Photography, invented in the early nineteenth century, was sufficiently developed to come to the aid of Moon-mappers in the last decade of the nineteenth century and, particularly, those of the twentieth century – but that is a tale for later in this book. Now, after this 'potted' history of the earliest years of lunar study (admittedly leaving out much detail and not even mentioning many of the more minor participants), it is time to consider how the observer of today can get the best out of his/her telescope and enjoy and study the Moon's starkly beautiful vistas.

* Note added in proof: just published by Cambridge University Press is *Mapping and Naming the Moon* by E. A. Whitaker – a detailed and fascinating account of the history of selenography.