Introduction

The earliest idea for this book was a request made to a fellow committee member of The Astronomical Society of Singapore (TASOS) in 1992. He was given some rolls of slide film and given the task of photographing the Moon day by day for a complete lunar cycle. What we wanted was a set of daily Moon slides for society talks. Several years passed; that particular committee member became a celebrity as a successful radio DJ, but the set of lunar images was still not forthcoming. Many jokes were cracked about the project. Finally, in late 1997, a chance discussion between Albert and SM seriously mooted the idea of a Moon book. The concept of the book was discussed at length and eventually a preliminary working format was agreed to. What we wanted was a photographic guide to the Moon that would be complete day by day through an entire lunar cycle and that would be easy to use at the telescope. Although we knew of some excellent guidebooks to the Moon, none appeared to feature the Moon in colour or on a daily basis. Unfortunately, the colour concept had to be dropped because of cost issues. The final result is this book you are now holding.

The Moon is our nearest celestial neighbour, the second brightest celestial object in the sky and the Earth's only known natural satellite. As it appears so large and prominent, it must have attracted attention from the earliest humans and lunar stories and myths abound among ancient civilizations and cultures. It shows interesting phase changes that were cleverly used by the Chinese to construct the earliest known calendars. It is also the only celestial body that displays surface markings easily visible to the naked eye.

Since Galileo conducted the first telescopic observations of the Moon, many great selenographers have mapped the Moon to ever-increasing detail and accuracy. Men such as Michiel van Langren, Johannes Hevelius, Riccioli and Grimaldi, Tobias Mayer, Johann H. Schroter, Wilhelm G. Lohrmann, J. Madler and W. Beer, J.F. Julius Schmidt, Philipp Fauth, and J.N. Krieger have been responsible for defining and making modern Moon maps and nomenclature what they are today. Whilst it is true that their early techniques and equipment are crude by modern standards, their works stand out as monuments to motivate, inspire and spur us on to new heights and finally, to conquer the Moon.

Today, 12 human beings have walked the surface of the Moon and many robotic spacecraft have surveyed its surface at close range. These probes returned thousands of high-quality close-up pictures of the lunar surface and immediately rendered all previous Moon maps obsolete. Most of the lunar features visible in amateur telescopes have now been identified and named in accordance with internationally accepted nomenclature – a job that is supervised and administered by the International Astronomical Union's (IAU's) Lunar Task Group. There is no longer any scientific value in amateur Moon charts but Earthbound observers continue to be enchanted by the beauty, serenity and tranquillity of the stark lunar landscape. Simply observing the Moon and studying the regions once scrutinised by the late great selenographers is fun and educational and links us to their heritage.

Many earlier lunar atlases contained images obtained by the great observatories. With recent improvements in camera-film technology, however, we feel that it is now possible to obtain lunar images with a modest 40 cm telescope to comparable or better resolution than most of these early atlases. It was with this in mind that we embarked on this project to produce a new photographic lunar guide, a work that finally took 2 years to complete. Our basic photographic concept was to image an entire cycle of daily Moon phases in medium 6×7 format through a 40 cm telescope using high-resolution, low-speed film. This allowed excellent reproduction of essentially grainless lunar images to a scale of 25 cm in diameter, a size large enough to support the level of labelling necessary. Singapore is hardly a good astronomical site and so many images proved to be of only average quality. Eventually, more than 10,000 slides had to be examined to secure the best possible daily full phase Moon sequence. We regard our photographic lunar guide as complementary to, and certainly not as replacement to, the many other fine publications on the Moon in existence today.

In recent years, Charge Coupled Devices (CCDs) have become much cheaper and therefore, more popular with amateurs. In time, we believe that CCDs will replace film in most areas of astronomical imaging, except perhaps when extremely wide fields need to be imaged. We hope that our humble photographic lunar guide will remain a tribute to the closing days of good old film technology. Finally, because our work was completed at the close of the twentieth century, we hope that in some small way it will continue the legacy of the early selenographic giants.

Albert Lim, S.M. Chong and P.S. Ang

About this book

To begin with, the title proposed by the authors for this book was *The Realm of the Lunatic*. The Press, however, injected some Prozac and said that, with that title, it wouldn't sell. They're right, of course (would you, gentle reader, have even picked it up at the shops?) and so, regrettably we gave in to Mammon and agreed with the prosaic *Photographic Atlas of the Moon*. Because of the original title, however, there are assorted references to lunatics in the text. After all, to quote the OED (the Press allowed that, as there's no CED) a 'lunatic' is someone 'afflicted with the kind of insanity that was supposed to have recurring periods dependent on the changes of the Moon.' What a marvelously apt description for someone interested in the Moon!

Anyway, the sequence of photographs encompasses a complete lunar cycle from day 0 to day 29. For each day, there is a description of the features visible, together with a labelled black-and-white image of the Moon. This black-and-white image is reproduced from our colour image of that day. The first-day Moon is classified as that from 0.50 day to 1.49 day after New Moon, the second-day Moon is similarly from 1.50 day to 2.49 day, and so on. As the authors feel that the Moon is best viewed through a telescope, rather than with the naked eye or with binoculars, almost all full images are presented with a south-up, east-left orientation to match the view through an inverting telescope. All images have an approximate North indicator to assist orientation. A kilometre distance scale is also shown together with the labelled image. This scale shows distances from the Moon's centre to the different features. The age of the Moon to two decimal places is also given. A table of lunar features labelled and mentioned in the text is included in the lower box.

Depending on the day, one or more unlabelled full-phase Moon image or images are also presented. These images contain both lunar as well as photographic data. Under the column of 'lunar data', we have provided the time (local and Universal) and date when the image was acquired. The lunation number and the age and percentage illumination are also indicated. Lastly, the distance to the Moon in kilometres at the time the photograph was taken is mentioned.

In the 'photographic data' column, 'instrument' refers to the telescope used for photography. The technique is indicated, together with the type of film used and the exposure time. The altitude of the Moon, in degrees and minutes from the North or South horizon, at the time the photograph was taken is also indicated. We also provide the lunar diameter in arc minutes and seconds. Finally, an indication of the sky condition, according to an improvised scale, at the time the photograph was taken is included.

On some days, we have included a page containing enlarged photographs of selected regions of the Moon. These were included as an afterthought as we felt that they enhanced the text. Ironically, many of these projection photographs were originally fun shots taken when sky conditions were less than ideal for full phase photography! These images are all taken on 35 mm slides through a Nikon F3 at various projection focal lengths using a full range of Pentax XP projection eyepieces of 3.8 mm, 8 mm, 14 mm and 24 mm focal lengths.

The improvised sky condition scale employed by the authors is as follows:

Scale	*Descriptions*
1/10	Worst Sky, thick cloud covering 100% of sky – Moon totally invisible.
2/10	Very Bad Sky, thick cloud cover of 90% – Moon barely visible through cloud.
3/10	Bad Sky, cloud cover over 80% – Moon visible on and off but through cloud.
4/10	Average Sky, cloud cover 70% or less – Moon visible through clearings on and off.
5/10	Above Average Sky, about 50% cloud cover – Moon visible for extended periods.
6/10	Good Sky, about 40% cloud cover – Moon clearly visible with clouds at distance.
7/10	Very Good Sky, less than 30% cloud cover but Moon clearly visible in a dark sky.
8/10	Excellent Sky, less than 20% cloud cover and the Moon looks as good as it gets.
9/10	Near Perfect Sky, only traces of isolated thin clouds – average few days per year.
10/10	Perfect Sky, not a trace of clouds – we have yet to see this happen in Singapore!

How this atlas was done

From the beginning, it was decided that SM Chong, with whom cameras do not click, would write the daily text, while Albert Lim and PS Ang would focus on lunar photography. The first problem was to decide on the telescope required. Between us, we owned 14 good portable telescopes. Using any of them, however, would have entailed spending an inordinate amount of time on polar alignment before each session. Anyone who has tried polar alignment in the tropics knows that this is no easy task when neither pole star is visible. Unfortunately, time was the resource we never had enough of. In early 1998, we therefore approached Dr K.K. Cheong, divisional director of the Singapore Science Centre, and he generously gave permission for us to use the centre's 40 cm Cassegrain telescope. The optics of this superb instrument were ground to perfection by the famous Japanese comet discoverer, Mr Kaoru Ikeya. The telescope was mounted permanently and housed in a dome. The telescope was also compatible with the Pentax 6×7 medium format camera we planned to use. The focal length of the 40 cm at 5200 mm (f/13) turned out to be perfect to maximise the diameter of the Moon's image within our medium format 6×7 frame. On one occasion, the image of a Full Moon near apogee filled the 120 slide frame almost to the edge. The disadvantage was that our observing site would, like anywhere else in Singapore, be severely light polluted.

Choice of film was the next great debate. The authors have great admiration for the high-resolution photographic work of the famous French astrophotographer, Jean Dragesco and were haunted by a statement on page 49 of his book, *High Resolution Photography*, where he writes, 'I am hardly a supporter of colour photography when it comes to high resolution work: colour films (be they colour negatives or transparencies) have inadequate contrast and inferior resolving power.' Although the authors were painfully aware that Kodak's TP2415 is the film of choice for high-resolution lunar photography, we finally and with great reluctance chose another film. Essentially, we wanted colour images of the Moon that would match the naked-eye view as closely as possible. Also, the availability of TP2415 locally was a problem, as was the developing of TP2415, since none of the authors owned or had access to darkroom facilities. Our experience with a limited number of rolls of hypered and unhypered TP2415 suggested that the local commercial processing centres were unfamiliar with it and could not produce results that did justice to this magical film. Perhaps we should still have persevered and continued to employ TP2415 together with our main efforts with colour slides. We recognised very early, however, that there were simply not enough photographic windows at our suboptimal local site to allow us to capture the best possible lunar sequence in colour as well as in black and white. The prevailing cloudy conditions would have degraded photographic images far more than the difference in photographic latitude between TP2415 and our chosen colour film. The low ASA 120 colour slide films that we eventually chose had sufficient latitude to deliver the results we expected at the prime focus (Cassegrain focus) of our telescope.

The next problem, was the scheduling of observing sessions. Cloud and rain formed the major handicap – Singapore's situation within the tropics ensures that clear skies, like Pandas, are a very rare breed! Between 4th April 1998 and 25th April 1999, more than 100 attempts were made to photograph the Moon; on only 55 of these did we succeed in obtaining at least one photographic exposure. Thus, half of our observing nights were actually spent waiting for cloud to clear or rain to stop. Such nights were god-sent opportunities to catch up on lost sleep on the observatory floor, and sometimes these naps lasted until sunrise. For long periods also, we had to contend with haze from uncontrolled forest fires in Indonesia. On severe occasions, this haze limited line-of-sight visibility to a few hundred metres.

When conditions finally permitted, however, approximately 200 exposures were made on 120 films on average each night. Even so, many of the images presented here were either shot through some level of cloud cover or through small fortunate openings surrounded by thick cloud. In essence, most were shot through less than ideal conditions. We could not possibly have hoped for more. To acquire lunar images only under favourable conditions in Singapore would have extended the period of photography by many more years than we could afford. We did, however, attempt to replace less than satisfactory lunar images when opportunity allowed.

We attempted to photograph the Moon as near the zenith as possible to reduce image degradation by the Earth's atmosphere. Once again, weather conditions did not always allow this ideal. And of course, the first and last few days of any lunation, characterised by low-altitude Moons, were always problematic, with the first- and last-day Moon presenting significant challenges. Naked-eye sighting of these very early and very late crescents is difficult, photographing them even more so. The Moon is only a few degrees from the horizon, almost certainly obscured by cloud and the photographic window drops to a mere few minutes. The authors especially remember driving from home to the observatory on many early mornings to wait for that elusive last-day Moon.

On 4th April 1998, photography commenced with test exposures of the 7.5-day-old Moon. We exposed many different slide films – Kodak Ektachrome 25, 64, 200, 400, Kodak P1600 (processed at ASA400), Kodak TMax 400 (black and white), Fuji Velvia 50, Fuji Provia 400 and several others were all evaluated. Fuji Velvia 50 and Kodak Ektachrome 64 yielded the best results and both these slide films were subsequently used for prime focus (Cassegrain focus) photography.

During our initial photographic session, we employed the old photographer's 'hat trick' using a sheet of black cardboard approximately 0.7 by 1.0 metres in size. This proved impossible to sustain; handling a piece of cardboard this size while balancing on a tall ladder and trying to achieve shorter than quarter second exposures was virtually impossible. The whole act required extreme acrobatic skill!

We made test exposures using a cable release with the Pentax 6×7 camera's mirror locked up and were surprised to find no deterioration in image quality due to vibration. This we attributed to the instrument's weight, and in particular to its massive equatorial mount. The famous Japanese planetary astrophotographer Isao Miyazaki has also reported similar experiences. He too has very successfully employed the simple cable release and mirror lock up technique on his very massive telescope system without problem with vibration. All our subsequent lunar exposures relied solely on the cable release and mirror lock up technique. This provided an added advantage in that accurate exposures could be controlled and recorded for different phases of the Moon. These were then used as references to minimise bracketing thus resulting in a higher number of correct exposures consistently obtained throughout the sessions. Even with the lunar tracking rate, the photographic results at any phase were seldom good when exposure times lasted longer than 2 seconds. It would appear that the atmospheric turbulence at our site simply does not allow recording of fine details during exposures longer than 2 seconds. Fortunately, there were very few occasions when such long exposures were required.

By April 1999, the photography was almost complete. Some images turned out better than others because of better sky conditions. While we would have liked to have obtained consistently good images for all the days in the cycle, it was deemed impractical given our local circumstances. There is an old Chinese saying: 'Were I to await perfection, my book would never be finished.'

Taking 10,000 slides of the Moon was an enormous effort; keeping accurate records of each and every image became a nightmare. Several months were required to sort through all the slides to select the best images. Eventually, we narrowed our selection to about 50 slides. These were scanned with a Minolta Dimage Scan Multi film scanner, bought solely for this purpose. PS Ang, being the most computer-experienced, was tasked to process, format and label the selected images using Adobe Photoshop 5.0 and Illustrator 8.0 respectively. The data presented in our photographic images was largely obtained from 'The Sky' software from Software Bisque. This excellent astronomy program was found to be most useful in helping us prepare for all our photographic sessions. We also used it to determine the exact time of new Moon for each lunation. Everything was finally complete by the end of December 1999. We hope that this book will interest more people to observe the Moon and render day by day lunar observations easier at the telescope.

Before we begin . . .

Beginners often think that the best time to look at the Moon is when it is full because craters will then be easily visible. Unfortunately, they are often disappointed – features are only easily identified when close to the terminator – the dividing line between night and day – when oblique illumination provides contrast and shadow. At Full Moon, the terminator is barely visible at the limb (edge) of the Moon and the vertical illumination, without shadows, over most of the visible surface wipes out the features so that everything looks ghostly. The few craters that can be easily identified are severely distorted (foreshortened) because they lie at the limb of the Moon. Full Moon, however, is the best time to familiarise oneself with the main features because all unnecessary detail is wiped out.

So, tonight, if you are a beginner, concentrate on identifying the dark patches – the maria – and then look for the bright and dark rings formed by the larger craters as well as the other dark and bright spots between the maria. Note how some of the bright crater rings seem to have rays radiating from them.

Now, if you look at the Moon with south up and east to the left, the maria outline a figure resembling a crab. This is most pronounced in the left (east) half of the Moon where one crab pincer is very obvious. It is easy to remember that Mare Crisium, the Sea of Crises, is the teardrop in the east and Mare Frigoris, the Sea of Cold, the elongated streak near the North Pole. The main difficulty lies with the central maria. Now, starting at Mare Nectaris, the right (west) half of the crab's pincer, proceed in a counter clockwise spiral ending at the centre of the visible surface, and repeat, 'Nectaris, Fecunditatis, Tranquillitatis, Serenitatis, Imbrium, Roris, Procellarum, Humorum, Nubium, Medii, Vaporum'. This is pretty horrible – how about this mnemonic instead? '**N**ow **F**irst, **T**hen **S**econd **I**n **R**ace **P**lace, **H**e's **N**ext, **M**ove **V**ictor.' That leaves only the limb maria – on the eastern limb, from north to south, Humboldtianum, Marginis, Smythii, Australe – remember **HMS A**ustralia and that Australia is in the southern hemisphere. What about the western limb? Well, the only mare on the western limb is Mare Orientale, the Eastern Sea! Its incongruous name results from a decision in the late 1960s to reverse the identities of the then eastern and western limbs of the Moon.

Several smaller dark rings catch the eye against the bright background of the Full Moon. Starting in the northeast corner, first note foreshortened Endymion, east of Mare Frigoris. Moving west from Endymion, note Plato against the northern margin of Mare Imbrium. Grimaldi, in the west, stands out adjacent to the west margin of Oceanus Procellarum. Look also for Riccioli, a smaller dark spot west and somewhat north of Grimaldi. Then, from Grimaldi, follow an arc south parallel to the southwest limb of the Moon. Note first Schickard and then an unnamed mare-like region between Schickard and the South Pole. Finally, south of Mare Nubium, and resembling Plato, note the dark ring, Pitatus.

The southern highlands occupy a vast stretch around the South Pole and drive two wedges northwards. The smaller eastern wedge separates Mare Fecunditatis and Mare Nectaris. The huge western wedge stretches as far north as Mare Serenitatis. Dominating everything in this southern hemisphere is the bright ring of Tycho, whose far-flung rays blot out much of the highland region and extend as a double ray onto Mare Nubium west of Pitatus. A multitude of bright spots are found in both the highland and mare regions in this southern hemisphere. In the east, Stevinus A and Furnerius A, both bright ray craters like Tycho, are obvious. They point to Polybius A, which lies on one of the Tycho rays. Facing each other on the eastern and western shores respectively of Mare Tranquillitatis, note Censorinus and Dionysius. North of Tycho, forming an equilateral triangle with it are two bright objects – to the east, the unofficially named Cassini Bright Spot, lying on a ray that reaches Mare Serenitatis, and to the west, Cichus B, lying on the more prominent western component of the Tycho double ray. Midway between Grimaldi and Schickard, identify another little bright ray crater, Byrgius A. Grimaldi and Byrgius A form a right-angled triangle with the bright ring of Gassendi, which guards the northern tip of Mare Humorum.

The arc of mountains rimming Mare Imbrium is outstanding. Most prominent are the Apennines (Montes Apenninus), which form the southeast border of the mare. Their southern end continues westwards, north of the bright crater Copernicus, as the Carpathians (Montes Carpatus). The northern end continues northwards as Montes Caucasus, with Mons Hadley separating them. The Alps (Montes Alpes) then arc westwards to form the northern boundary of the mare. Recognise amongst them dark Plato and the bulge of Sinus Iridum. On Mare Imbrium, just south of Plato, are the isolated bright mountains, Pico and Piton. A western arc from Pico parallel to the mare margin leads first to the Teneriffe mountains and then to the Straight Range (Montes Recti). All of these stand out prominently against the dark floor of Mare Imbrium, as do the rings of Archimedes, Autolycus and Aristillus. These three craters, together with Montes Spitzbergen, form a kite-shaped figure.

Copernicus and Kepler, close to each other on Oceanus Procellarum in the western hemisphere, form an easily identified pair of bright rings. Aristarchus, brightest of all features on the Full Moon, forms a right-angled triangle with them, the right angle occuring at Kepler. Euler, Pytheas and Timocharis lie north of Copernicus. The Aristarchus–Kepler axis produced southwards leads to Euclides, on the edge of Montes Riphaeus. The Kepler–Copernicus axis produced eastwards leads the eye successively to bright **M**anilius, **M**enelaus, **P**linius and **P**roclus, the last-named lying on the edge of Mare Crisium. Note how the Proclus rays delineate pale Palus Somni, the Marsh of Sleep. Two bright rings, Godin and Agrippa, form a parallelogram with Dionysius, Menelaus and Manilius. The same Kepler–Copernicus axis produced westwards leads, first, to Reiner Gamma on Oceanus Procellarum and then to another bright ray crater, Olbers A. From here, move along the northern limb to identify three ray craters – Anaximander, west of the pole, Anaxagoras adjacent to the North Pole, and Thales, east of the Pole. Continuing south along the east limb, Langrenus, adjacent to Mare Fecunditatis, has a bright fuzz around it. Still further south is Petavius B. The Langrenus–Petavius B line produced the same distance further south leads us back to the close pair Furnerius A and Stevinus A.

Now return to the north polar region. Look between Mare Serenitatis and Mare Frigoris for the ghostly bright rings of Aristoteles and Eudoxus. Adjacent to Endymion are equally ghostly Hercules and Atlas. Endymion, Eudoxus and the ring of Posidonius form an equilateral triangle. The narrows between Mare Tranquillitatis and Mare Fecunditatis are guarded by Taruntius while the ring of Goclenius stands sentinel across Mare Fecunditatis from Langrenus.

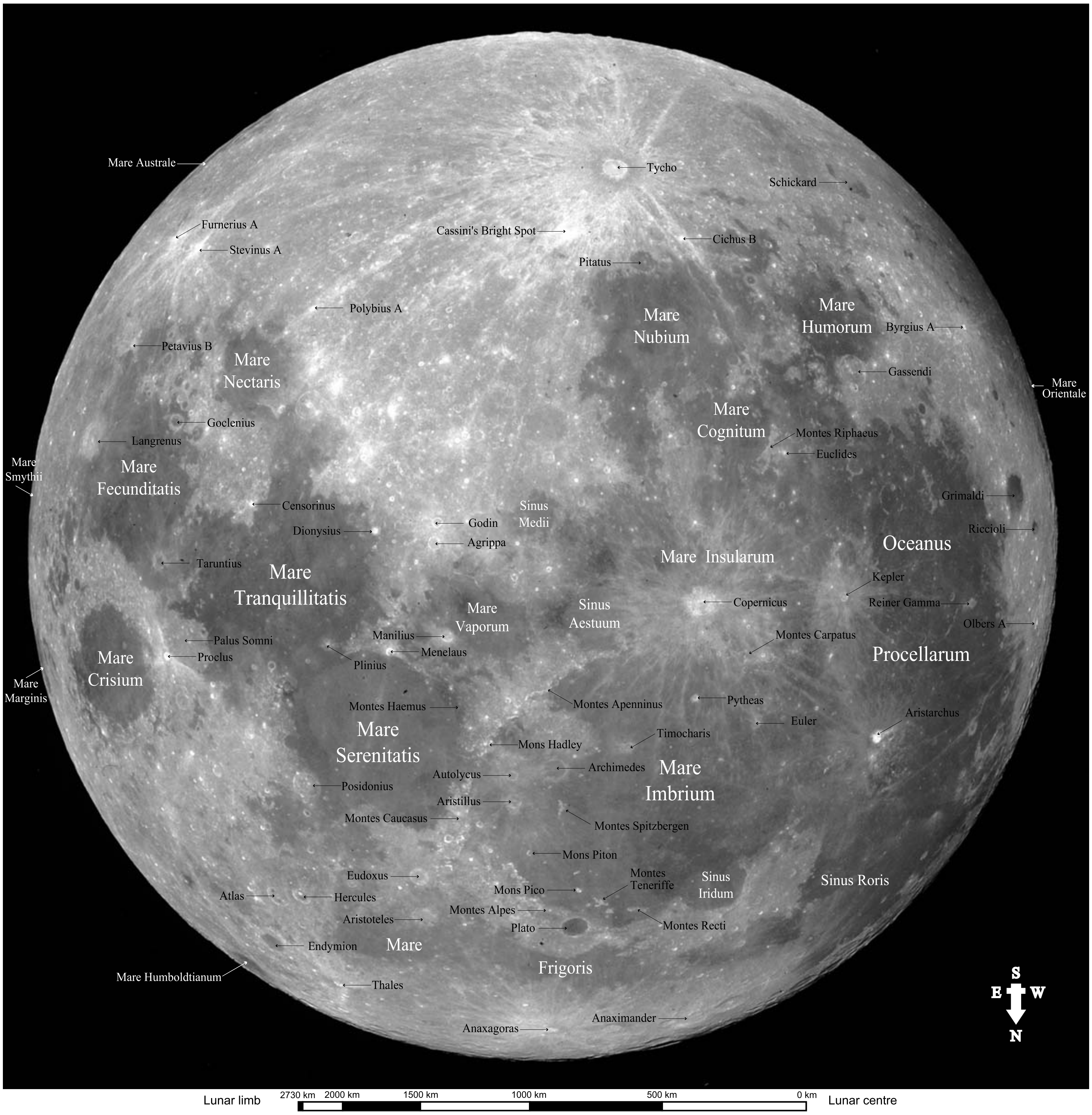
What does all this structure mean? What are we looking at when we look at the Moon? Let's ask the question another way – what do we see when we look at the Moon? Well, the age-old childhood answer is 'The Man in the Moon' and the adult answer is probably 'Craters'. Both answers are correct. The Man in the Moon refers to the resemblance of the dark portions of the Moon, the lowland maria (singular: mare, after the Latin word for 'sea'), to the figure of a man, perhaps sitting under a tree. The bright highland regions, now called terrae, form the bright background to The Man in the Moon. Look more closely at the maria – many of them have smooth dark floors and surrounding mountains. The mountain rim is easily recognised because it casts a discernible shadow. Now, look at a crater – it usually has a depressed floor surrounded by a raised rim. Some of the craters – those with smooth, dark floors – even look like miniature maria. They *are* little maria; or rather, the maria are just enormous craters, now distinguished as 'basins' because of their size. Both types of structure are impact-created; the only difference lies in size. Size of crater or mare basin is simply a function of size of impacting projectile, the bigger the impactor, the bigger the splash.

The entire Moon itself was probably impact-created some 4.6 billion years ago; the colliding objects being the young Earth and a Mars-sized planetesimal. The impact threw out a plume of terrestrial and impactor material that rapidly condensed to become the Moon. Over the years, more and more projectiles of various sizes have collided with the Moon, the larger ones creating the maria and the smaller ones the craters. And of course, there have been new impacts upon old impacts, so that one sees new craters lying on top of older ones. Knowing that maria and craters form a spectrum of impact-created structures, one can see how they merge one into another. The smallest craters (less than 20 km in diameter) are bowl-shaped. They are often young and may still be surrounded by a bright nimbus of ejecta flung out at the time of creation. Larger craters show slumping and terracing of the crater walls and often have a central peak. Several of these larger young craters also show traces of the ejecta from their origin. Because the splash was so large, this ejecta appears as bright rays that radiate for miles – sometimes halfway across the Moon's surface – from the crater of origin. Still larger craters start to show concentric rings in their floors. The largest objects, the maria, often show this multi-ringed structure and may resemble a target or a dart-board. Unfortunately, the best example of this – Mare Orientale – lies on the extreme west edge of the visible hemisphere of the Moon and is thus not easily seen as such.

After impact, lava sometimes wells up within the crater, eventually filling it and producing a smooth, dark floor, which will be younger than the surroundings. This is clearly what happened in the case of the maria. Compared to the highlands, the mare surfaces contain far fewer craters indicating that they are much younger than the highlands, which show the impact of many more cratering events. At times, the lava completely fills the crater to the brim, giving the appearance of a plateau rather than of a crater. And occasionally it spills over the rim and floods the surroundings. Other craters flooded by this overflow then appear just as ghost-craters with only portions of their rims visible. Sometimes the lava piles up and forms ridges. As the lava cools, it solidifies and cracks often start to appear, especially at the edge of the lava fields. These cracks now appear to us as arcuate rilles often located parallel to the mare boundaries. Underground lava tubes may also collapse and then give rise to another type of rille – a sinuous rille. Geological faulting is another event that occurs on lava beds. In that case, the result is a scarp or cliff – these are called rupes. Persistent volcanic activity through the ages has also resulted in little volcanic peaks – many of these appear as domes, often with a craterlet at their summit. Occasionally, these merge together to form dome complexes that appear as hills.

What we therefore see when we look at the Moon is a geological (selenological) record of impacts, and their aftermaths, since the creation of the Moon. Knowing this, let us now proceed to a more systematic tour of the Moon.

FULL MOON



Names of lunar formations							14.94-day-old Moon
Crater					**Mare – sea**	**Mons and montes**	**Palus – marsh**
Agrippa	Byrgius A	Furnerius A	Menelaus	Pytheas	Mare Australe	Mons Hadley	Palus Somni
Anaxagoras	Censorinus	Gassendi	Olbers A	Riccioli	Mare Crisium	Mons Pico	
Anaximander	Cichus B	Goclenius	Petavius B	Schickard	Mare Fecunditatis	Mons Piton	**Sinus – bay**
Archimedes	Copernicus	Godin	Pitatus	Stevinus A	Mare Frigoris	Montes Alpes	Sinus Iridum
Aristarchus	Dionysius	Grimaldi	Plato	Taruntius	Mare Humboldtianum	Montes Apenninus	Sinus Medii
Aristillus	Endymion	Hercules	Plinius	Thales	Mare Humorum	Montes Carpatus	Sinus Roris
Aristoteles	Euclides	Kepler	Polybius A	Timocharis	Mare Imbrium	Montes Caucasus	
Atlas	Eudoxus	Langrenus	Posidonius	Tycho	Mare Marginis	Montes Recti	
Autolycus	Euler	Manilius	Proclus		Mare Nectaris	Montes Riphaeus	**Others**
					Mare Nubium	Montes Spitzbergen	Cassini Bright Spot
					Mare Orientale	Montes Teneriffe	Reiner Gamma
					Mare Serenitatis		
					Mare Smythii	**Oceanus – ocean**	
					Mare Tranquillitatis	Oceanus Procellarum	
					Mare Vaporum		

The zero-day Moon

But you can't see the 0-day Moon; that's the New Moon when its unilluminated surface faces the Earth. Well, yes, that's true, but you certainly can see the New Moon. You may have to travel a bit and you certainly won't be able to see it every month, but it's probably much easier to see than the first-day Moon.

Now, the orbits of the Moon and the Earth aren't quite in the same plane – that of the Moon is tilted by about 5 degrees with respect to that of the Earth. This means that the New Moon usually passes north or south of the Sun – and then you certainly can't see it. Once in a while, however, at New Moon, the Moon will be at one of the two points in its orbit where the two orbital planes intersect. These points are called the ascending and descending nodes (see Figure 1). Then, the Moon will pass between the Earth and the Sun and we see an eclipse of the Sun (see Figure 2). And that's when you can see the New Moon.

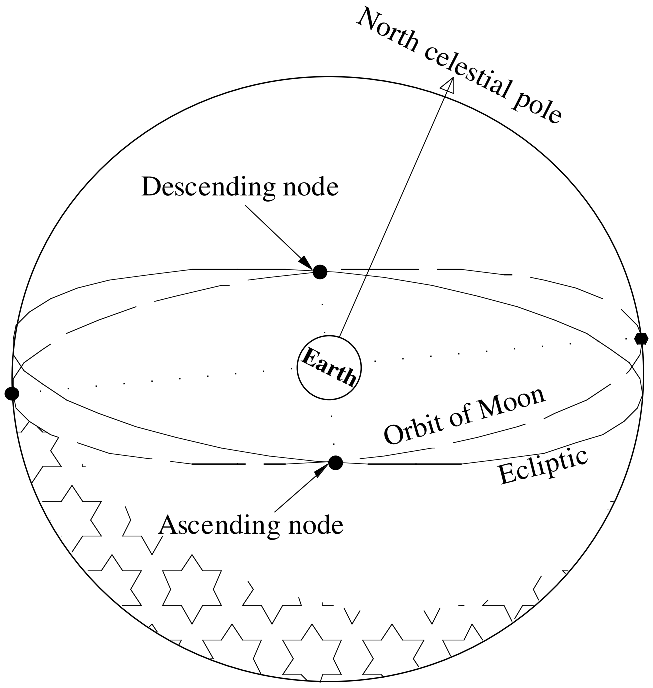


Figure 1 Orbit of the Moon

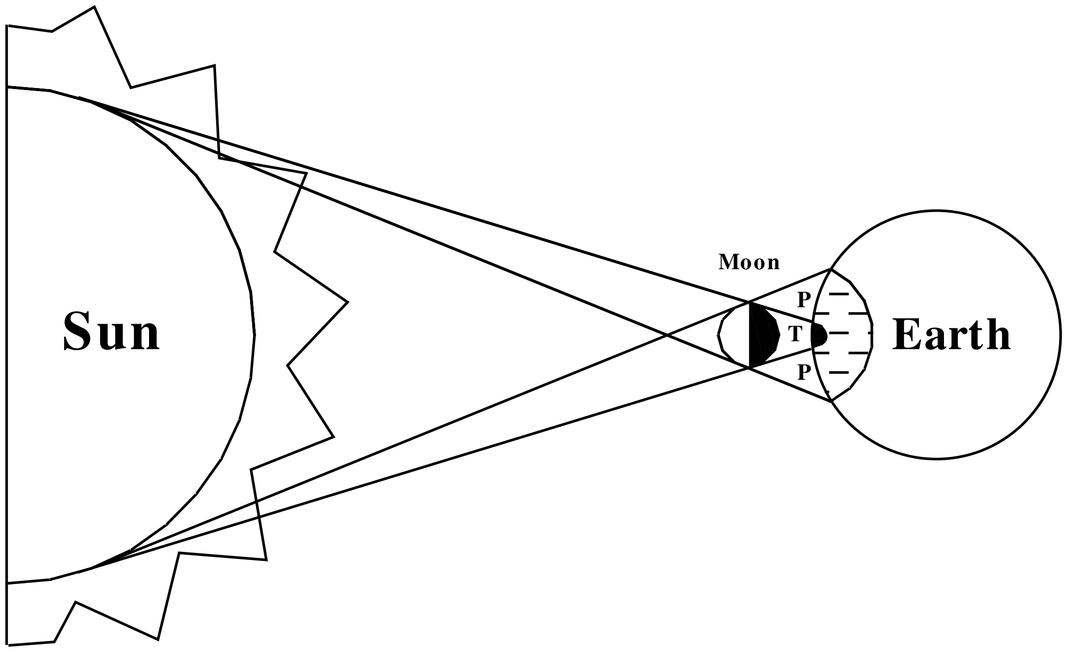
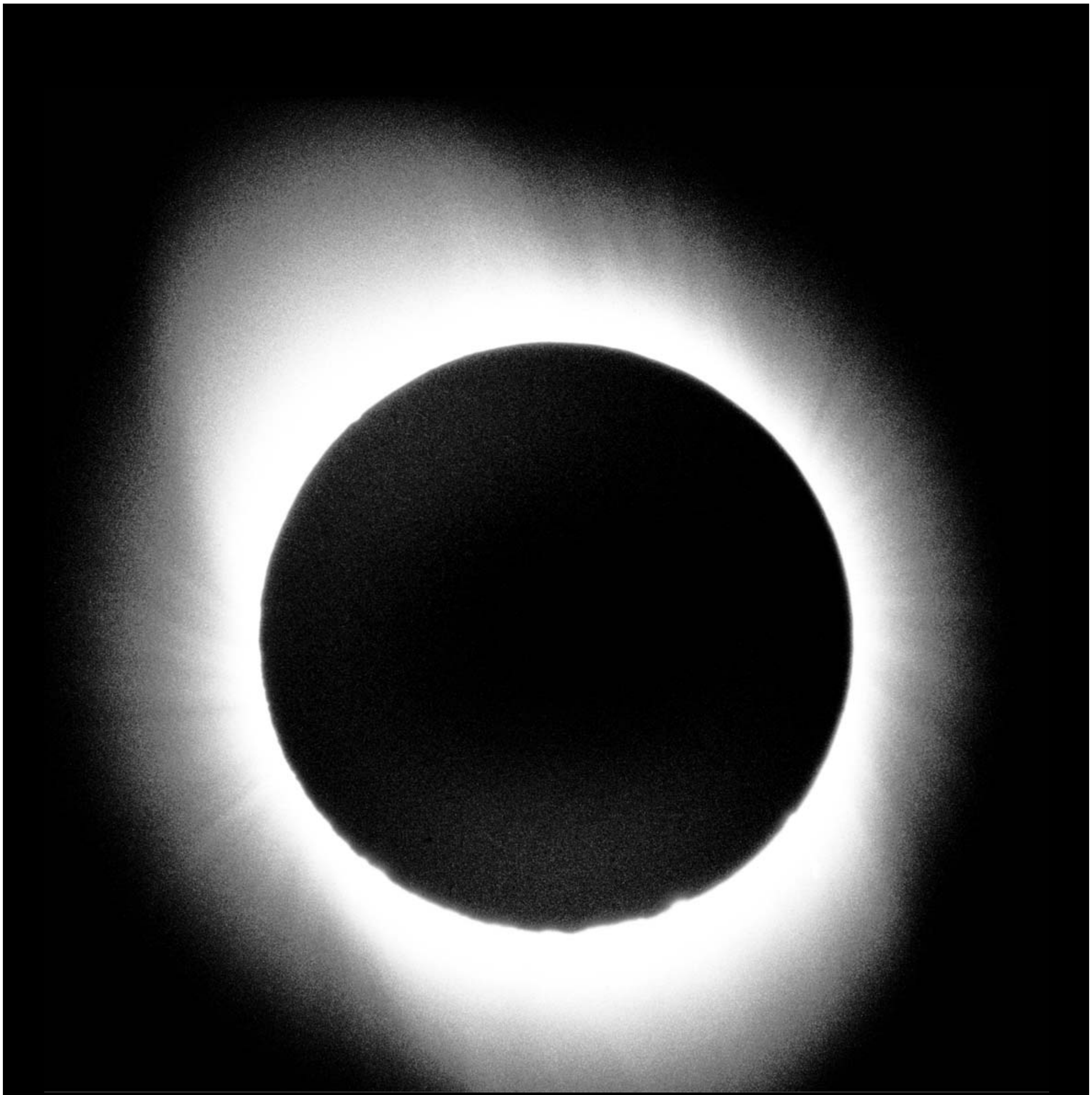


Figure 2 Total solar eclipse
A total eclipse is seen at T; while regions P will witness a partial eclipse.

DAY 0



Lunar data (total solar eclipse)

DTG (Local)	:	24 Oct. 95 (Tue.) 1051 hrs
DTG (UT)	:	24 Oct. 95 (Tue.) 0251 hrs
Lunation	:	No. 900
Age	:	0-day-old Moon
Illumination	:	0.0%
Diameter/dist.	:	32′48″/369,629 km
Location	:	Chai Badarn, Thailand

Photographic data

Instrument	:	3.5-inch f/16 Mak. Cassegrain
Technique	:	Prime focus (Cass. Focus)
Exposure time	:	1/2 s (Nikon F3 camera)
Slide film (135)	:	Kodak Ektachrome 200
Sky condition	:	9/10 (10/10 being perfect)
Moon altitude	:	58°19′ from N horizon

The 1st-day Moon

The first-day Moon is hard to find, really hard. From a religious point of view, it's important to Muslims because its sighting determines the beginning and the end of the fasting month of Ramadan. The youngest sighting, made in 1996, is of a crescent that is just over 12 hours old. To find this, you'll need to know exactly where to look just after sunset, in a still bright sky, for an extremely thin and incomplete crescent a few degrees above the horizon. Don't expect to see any significant detail on the illuminated portion; just finding this Moon is in itself a triumph. Savour it – you won't see it for more than a few minutes.

Notice that the Moon's cusps point toward the zenith and its convex eastern limb faces your western horizon. That's where the Sun is and obviously the illuminated portion is that which is closest to the Sun. Just think of how many artistic renderings you have seen where the artist had the horns of the crescent Moon pointing the wrong way.

Since there's so little to talk about the first-day Moon, let's discuss how much of the Moon one can actually see. Theoretically, because the Moon always keeps the same face toward the Earth, one should be able to see only that face. However, because of peculiarities in the Moon's motion, called librations, we can see a bit more than that – in total, therefore, 59% of the Moon's surface is visible, though, of course, at any one time, only 50% can be seen (see Figure 3).

There are three such librations – in longitude, in latitude, and diurnal. To get an idea of the first two, imagine a somewhat undecided person shaking his head from side to side while simultaneously nodding up and down. (You might want to try this yourself – it's a rather difficult movement to perform; until you recall those neck exercises recommended after long hours at the telescope eyepiece). Libration in longitude allows us to see more of the eastern (or western) margins of the visible lunar surface, up to as much as 8 degrees beyond the usual margins. Libration in latitude reveals more of the polar regions, tipping either pole towards us by 6 degrees every 2 weeks. Diurnal libration takes place between the rising and setting of the Moon each day, when the Earth's rotation carries the terrestrial observer from one side of the Earth–Moon line to the other. Using the same analogy, think of looking at the same person's cheeks from either side of his face. Occasionally, all these motions will coincide in such a way as to maximally reveal the appropriate limb regions.

Figure 3 Librations
Peculiarities of the Moon's motion around the Earth allow us to see its visible surface from a slightly different relative position every month. These periodic wobbles are called librations and are illustrated using a human face. The vertical sequence shows libration in latitude and the horizontal sequence shows libration in longitude. Diurnal libration would simply mean continuously shifting the camera position from one side of the model's face to the other on a daily basis.