THE ROYAL ASTRONOMICAL SOCIETY OF CANADA presents:

Explore the Moon

with a small telescope

photo by Ian Corbett, Liverpool, Nova Scotia

an RASC observing program with certificate and pin for beginning observers

Explore the Moon (telescope version)

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Preface

The idea behind *Explore the Moon* (EtM) surfaced in 2011–12 during casual conversations between RASC members Dave Chapman (Halifax Centre), Patrice Scattolin (Centre francophone de Montréal), and Kevin Dunphy (New Brunswick Centre). We were looking for a more elementary introduction to lunar observing than the more daunting *RASC Isabel Williamson Lunar Observing Program* (directed at intermediate-to-advanced observers. We also identified a general need for a beginner's observing program one step up from the novice-level *Explore the Universe*. Such a program would provide an opportunity for observers to gain experience operating their binoculars and small telescopes and hone their observing skills. We combined these goals and decided to base EtM on the list of lunar features and maps that have been available for some time in the *RASC Observer's Handbook* (most recently updated by Roy Bishop and Michael Gatto in 2014).

An innovation of EtM is the Q-Day method of locating and observing lunar features, which is explained in detail in the text. This method distinguishes the RASC program from other lunar observing programs available to the public. Time will tell if this will catch on, but several testers found it helpful.

We decided to offer two versions: a complete version of 94 features that require a small telescope to complete, and an abbreviated version of 40 features that can be identified in binoculars.

EtM has developed casually over the past few years and field-tested by eager observers. We thank Melody Hamilton, Jim Millar, Greg Dill, Michael Gatto, Paul Evans, and Bruce McCurdy. We now present *Explore the Moon* as an official RASC Observing Program with certificate—we hope you start observing soon!

Explore the Moon (telescope version)

Introduction: Why Observe the Moon?

This may seem like a funny question. Many amateur astronomers, however, shun the Moon. It is true that moonlight interferes with the enjoyment of observing and photographing the "faint fuzzies" which are deep-sky objects. A better option is to remain calm and observe the Moon on those nights when it dominates the sky. Here's a list of benefits of lunar observing, particularly for beginning observers:

- It's easy to find!;
- You can observe from home, even in the city—no need to travel to a dark-sky site;
- The Moon is bright, offering plenty of detail, even in small telescopes or binoculars;
- Observing the Moon is ideal for learning how to operate your telescope and binoculars;
- Finding the principal features is not hard, so you can learn *observing skills*;
- It's our nearest celestial neighbour!

Suggested Resources

For the most part, all you will need to complete this program is a telescope, this document, and a calendar showing the phases of the Moon (to be explained below). It is, however, always good to have a few extra resources at hand to assist or to provide additional details of the features. For a few small features (the craters Newcomb and Cook, for example) you may want to consult more detailed maps than are provided in this document. Here is a brief selection of the wide range of resources available:

- Bruce McCurdy's "Lunar Observing," *Observer's Handbook 2017*, pp. 158–161;
- Peter Grego, *Moon Observer's Guide* (Firefly Books, 2004);
- John A. Read, *50 Things to See on the Moon* (Formac Publishing, 2019);
- Sky & Telescope's *Field Map of the Moon* (illustrated by A. Rükl, 2007);
- Charles Wood and Maurice Collins' *21st Century Atlas of the Moon* (Lunar Publishing, 2012) available at Amazon and Chapters/Indigo;
- *Moon Atlas* (Horsham Online, Ltd. 2011, 2012), software application for Mac and iOS.

Planning and Observing

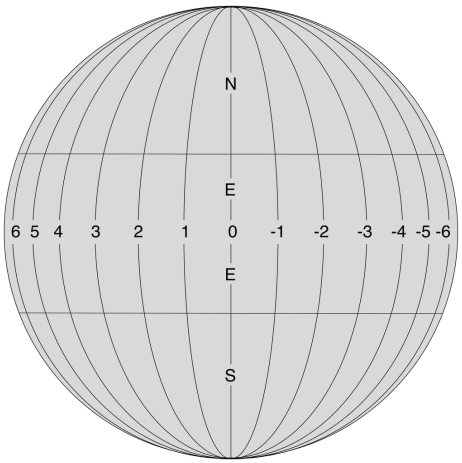
1. To prepare for observing at the telescope, you must choose and orient the correct map and feature chart from pages 6–9, for which you need to know whether your view at the eyepiece is (a) standard or (b) mirror-reversed, that is, left-right flipped. [Hint: *standard* view is for optics with an even number of reflections (0, 2, 4…) and *mirror-reversed* view is for optics with an odd number of reflections (1, 3, 5…).] For example, if you simply look at the Moon with the unaided eye or through binoculars, those are standard views; a classic Newtonian telescope has 2 mirrors, and also provides a standard view (although inverted); the same is true for a simple astronomical refractor with no star diagonal (0 mirrors). A refractor or Schmidt-Cassegrain Telescope with a typical star diagonal at the eyepiece end provides a mirror-reversed view. In either case, it will also be necessary to rotate the maps and charts to some

degree (as much as 180º) to match the orientation in your optics. Using the wrong map is probably the primary stumbling block for beginning lunar observers! Observing the Moon (or a terrestrial object) at low power in your telescope will help you choose the correct map and orient it to the eyepiece view.

2. The observing strategy we propose is to explore a strip of the Moon's illuminated surface next to the terminator (the boundary between light and dark). For the mathematically inclined, this would span around 20º of lunar longitude. Of course, you can observe any illuminated part of the Moon you like, but near the terminator the angle of the sunlight most clearly reveals the topography of craters, mountains, and valleys. The best "hunting" is to be had on the several nights surrounding First Quarter phase. One might expect that observing the Full Moon would be recommended, but in fact many of the features appear flat and washed-out by the near-overhead illumination. Observing next to the terminator also limits the number of target objects to a manageable goal for a single night of observing. Plan ahead!

3. You will most likely be observing in the mid-evening, during the 2 weeks between New Moon and Full Moon. Look on a calendar for the date of the nearest First Quarter phase. That is Q-Day 0 (We call them Q-Days to distinguish them from the Moon's age in days from New Moon). From your observing date, figure out how many days there are before First Quarter (negative Q-days) or after First Quarter (positive Q-days). That number will help you select your targets for the night from the table on pages 10–12. (If the number is greater than 7 days, see paragraph 8, below.)

4. The figure to the right shows a globe marked with the *approximate* location of the terminator, based on the number of days before or after the quarter phases. From New Moon to Full Moon, the *sunrise terminator* crosses the Moon's disk from east to west (right to left for northern-hemisphere observers viewing in binoculars), with shadow to the west and sunlight to the east. (Note that lunar east-west is opposite the east-west sky directions.) The north-south lines with **negative numbers** indicate **days before** the quarter phase; the lines with **positive numbers** indicate **days after** the quarter phase. It is important to know where the terminator will be!



5. For planning purposes, the table on pages 10–12 orders the features by the approximate day of appearance in the lunar cycle and from north to south along the terminator, and they are cross-referenced to numbers on the feature charts (see column **OH label**). To find or confirm a feature, the north-south lines are useful in roughly locating the listed lunar features on the maps and in your telescope, with the addition of the hints: N = north, E = equatorial, and S = south (see column **pos^{n}**). For example, the crater Copernicus (2 E) appears in the equatorial sector of the Moon, almost halfway from the centre to the western limb, and the sunrise terminator crosses this location about 2 days after First Quarter.

[From one month to the next, the apparent position of the terminator can vary by about half a Q-Day in either direction, relative to the lunar phase. In reality, lunar phase (percent illumination) is not a precise indicator of the visibility of lunar features, due to *longitudinal libration*, which is an apparent east-west rocking of the lunar globe caused by varying orbital speed of the Moon (owing to its elliptical orbit). A more precise means of determining the visibility of lunar features on any given date and time compares the longitude of the feature with the longitude of the terminator. For more information, read the articles "The Sky Month by Month" and "Lunar Observing" in the *RASC Observer's Handbook*.]

6. Most nights, the strip of lunar terrain just to the east of the sunrise terminator is your main hunting ground. For example, let's say you are observing on April 29, 2017. First Quarter occurs on May 2 (Q-Day 0), so April 29 would be Q-Day –3. Accordingly, try to look for features in the Q-Day range –3 to –4: the Sea of Fertility (–4 E); the Rheita Valley (–4 S), the Taurus Mountains (–3 N), and the Pyrenees Mountains (–3 S); and the craters Newcomb (–4 N), Macrobius (–4 N), Taruntius (–4 E), Atlas (–3 N), Hercules (–3 N), Cook (–4 E), Fractasorius (–3 S), and Piccolomini (–3 S). Note that some features may lie right on the terminator or even in shadow to the west, in which case you will want to observe these the following night. You could also look for: Endymion (–5 N), Cleomedes (–5 N), the Sea of Crises (–5 E), Langrenus (–5 E), Vendelinus (–5), Furnerius (–5 S), and Petavius (–5 S), although the view of these objects might have been better a day earlier.

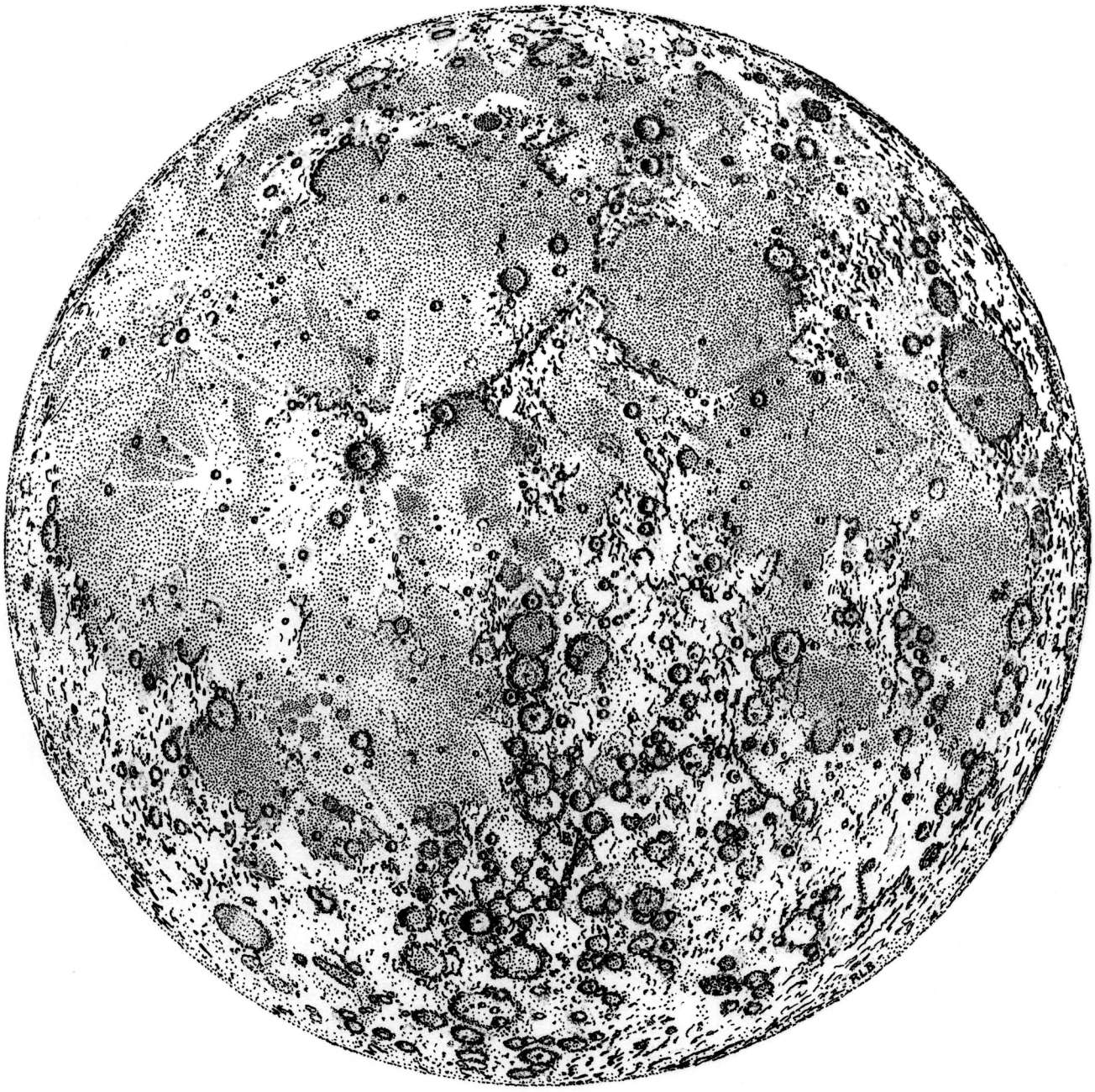
7. You can use the same method, with slight adjustment, to plan observing during the two weeks *following* Full Moon, when the *sunset* terminator crosses the Moon. In this case, the Q-Days refer to days before and after the *Last Quarter*, and you will be looking to the *west* of the sunset terminator. You might want to try observing a day earlier than the indicated day number. You will be out very late at night or early in the morning!

Recording Observations and Applying for your Certificate

There is no set recording or reporting format, but if you want to apply for the EtM certificate, you must keep a record of the date and time of observations, the sky conditions, the telescope characteristics, the magnification, and any observing remarks or details noticed. You are encouraged to include drawings or photographs, but it is not at all mandatory. You could use the table itself as a checklist of completed observations. Consider setting up a separate logbook for EtM, for ease of validation. The application form and directions are online at www.rasc.ca/observing/explore-the-moon-observing-certificate

Explore the Moon (telescope version)

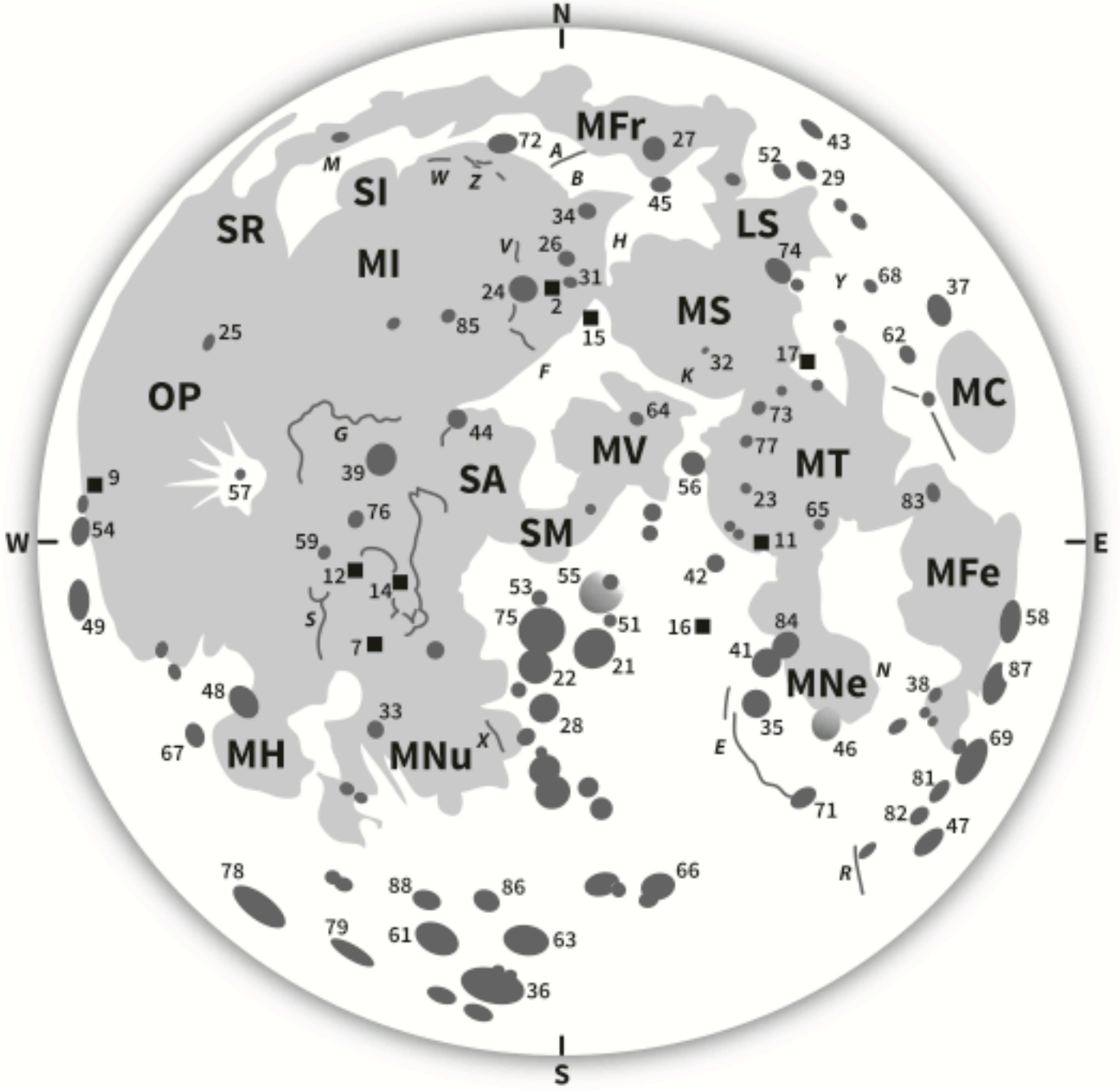
The Moon: Standard View*



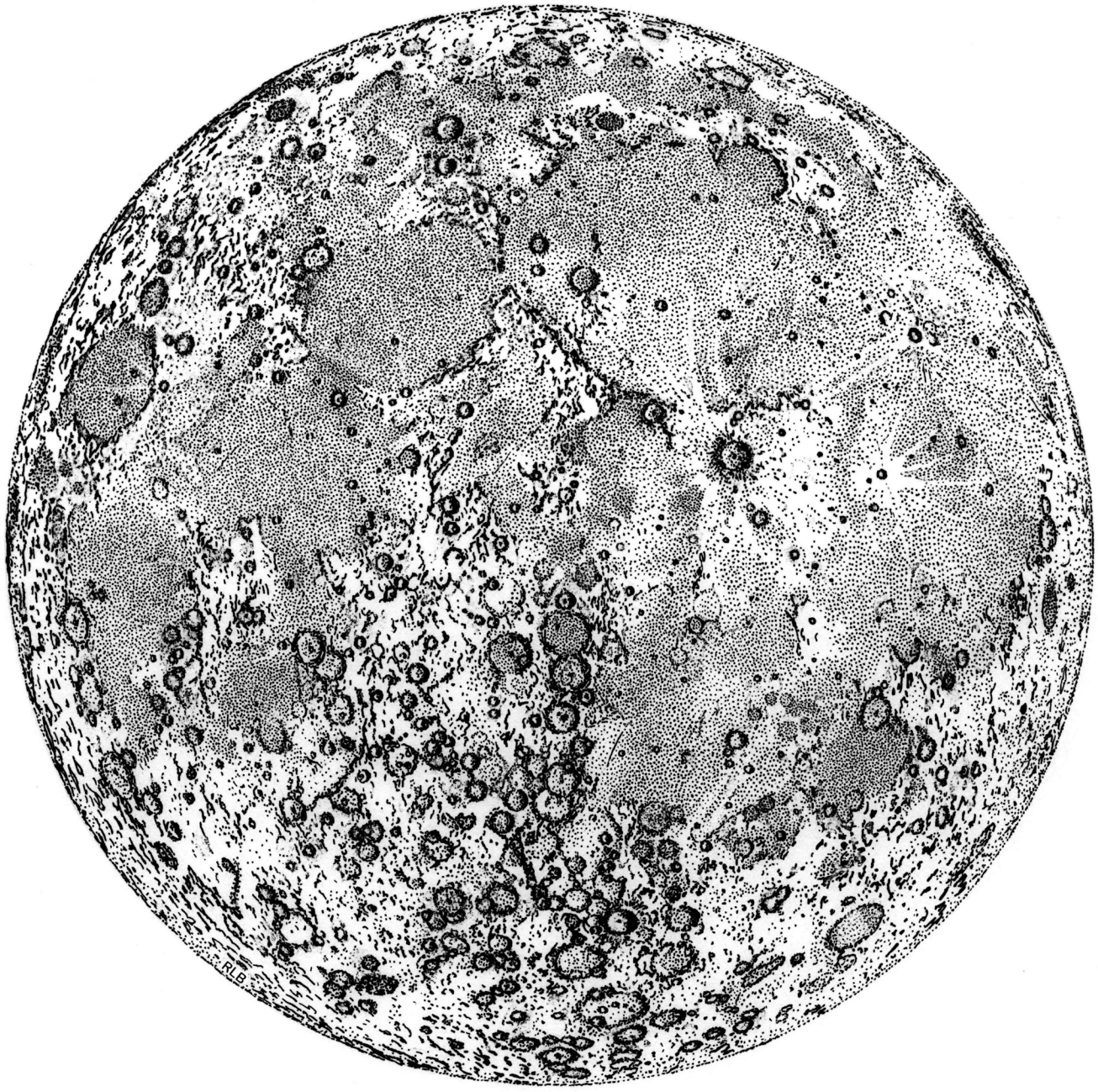
* "Standard" view is for optics with an even number (0, 2, 4, …) of reflections (e.g. binoculars and Newtonian reflectors) and "mirror-reversed" view is for optics with an odd number (1, 3, …) of reflections (e.g. most telescopes that use star diagonals). It will be necessary to rotate the maps and charts (as much as 180º) to match the orientation in your optics.

Moon Feature Chart: Standard View

(See pages 10–12 for feature index.)

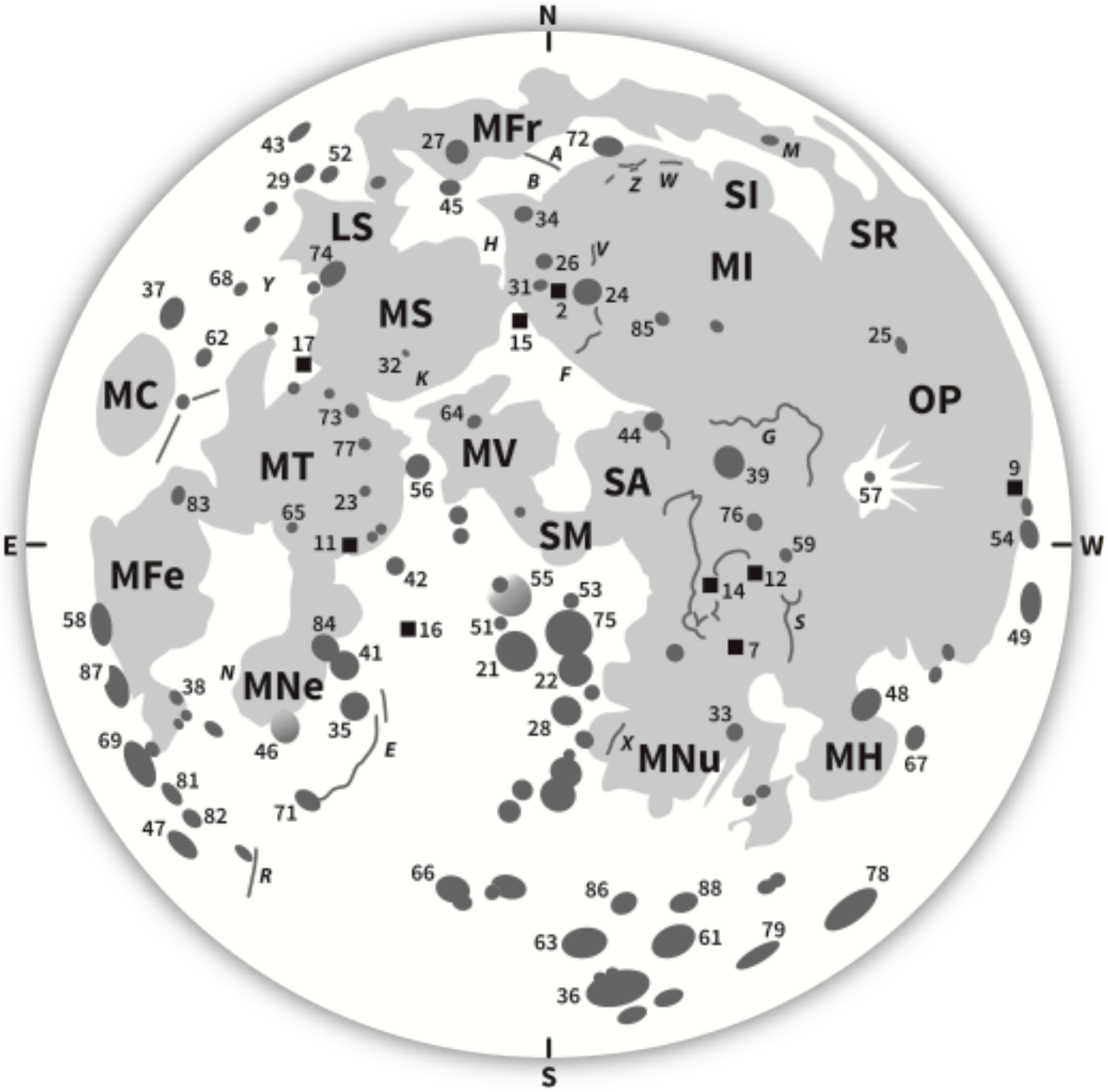


The Moon: Mirror-Reversed View



Moon Feature Chart: Mirror-Reversed View

(See pages 10–12 for feature index.)



Explore the Moon (telescope version)

OH label	name	pos[n]		description
43	Endymion	–5	N	Large dark–floored crater to the E of Mare Frigoris
37	Cleomedes	–5	N	Prominent eroded crater to the N of Mare Crisium.
M C	Mare Crisium (Sea of Crises)	–5	E	Spectacular lava–filled basin features, impressive wall structures. It covers 20 degrees of the lunar surface, and may require various terminator angles for optimum views of all its features
58	Langrenus (Gang of Four)	–5	E	Crater with twin peaks, finely terraced walls and pronounced ejecta field
87	Vendelinus (Gang of Four)	–5	E	Large, heavily eroded crater
69	Petavius (Gang of Four)	–5	S	Crater with a massive, complex central peak and floor uplift as indicated by rifts
47	Furnerius (Gang of Four)	–5	S	Old eroded crater with ejecta on its floor
81	Snellius	–5	S	Old eroded crater SW of Petavius
82	Stevinus	–5	S	Prominent circular crater with deep–terraced walls
68	Newcomb	–4	N	Midsize crater, part of a complex of 5 craters NE of Taurus Mountains
62	Macrobius	–4	N	Well–defined crater with central feature NW of Mare Crisium
83	Taruntius	–4	E	Midsized crater at the N edge of Mare Fecunditatis
M Fe	Mare Fecunditatis (Sea of Fertility)	–4	E	A mare consisting of two contiguous, nearly round areas of dark basaltic lavas
38	Cook	–4	E	Midsized lava–filled crater on the SW edge of Mare Fecunditatis
R	Rheita Valley	–4	S	Spectacular lunar valley that is the longest visible from Earth, W of Furnerius
29	Atlas	–3	N	Prominent crater, to E of Hercules (below)
52	Hercules	–3	N	Prominent crater on E edge of Mare Frigoris
Y	Taurus Mountains	–3	N	Mountain range E of Mare Serenitatis
N	Pyrenees Mountains	–3	S	Mountain range forming an inner ring E of Mare Nectaris
46	Fracastorius	–3	S	Lava–filled crater at the S tip of Mare Nectaris
71	Piccolomini	–3	S	Midsized crater S of Fracastorius and at the S tip of the Altai Scarp
L S	Lacus Somniorum (Lake of Dreams)	–2	N	Large lava field connected with the NE of Mare Serenitatis
74	Posidonius	–2	N	Flooded crater with very irregular terrain
17	Apollo 17 landing site	–2	E	(optional)
M T	Mare Tranquillitatis (Sea of Tranquility)	–2	E	Large sea on the E side. First lunar landing site
73	Plinius	–2	E	Complex crater with multiple central mountains, appearance changes considerably under different lighting conditions
77	Ross	–2	E	Crater within Mare Tranquillitatis on its W side
23	Arago	–2	E	Crater within Mare Tranquillitatis on its W side
65	Maskelyne	–2	E	Crater within Mare Tranquillitatis on its S side
11	Apollo 11 landing site	–2	E	(optional)
84	Theophilus	–2	E	Bordering the edge of Mare Nectaris. Part of trio formed with Cyrillus and Catharina
41	Cyrillus	–2	E	Older than Theophilus, which overlaps its eastern wall, and is more eroded
35	Catharina	–2	E	Eroded crater at the N edge of the Altai Scarp

Explore the Moon (telescope version)

OH label	name	posn		description
M Ne	Mare Nectaris (Sea of Nectar)	–2	S	Smallest of the major circular maria, 350 km across
E	Altai Scarp	–2	S	Incredible Rupa Altai is the continuous SW outer rim of the Nectaris basin. Spectacular at low Sun
27	Aristoteles	–1	N	Crater located at the S edge of Mare Frigoris
45	Eudoxus	–1	N	Neighbor of Aristoteles
M S	Mare Serenitatis (Sea of Serenity)	–1	N	Impact basin predating Mare Imbrium, filled with Imbrium Era mare material
32	Bessel	–1	N	Sharp crater near the center of Mare Serenitatis
K	Haemus Mountains	–1	E	Raised edge forming the SW shore of Mare Serenitatis
64	Manilius	–1	E	Fairly large crater, located in a relatively crater–free area directly E of Mare Vaporum
56	Julius Caesar	–1	E	Lava filled eroded crater W of Mare Tranquillitatis
42	Delambre	–1	E	Sharp crater with terraced rim to the SW of Mare Tranquillitatis
16	Apollo 16 landing site	–1	E	(optional)
66	Maurolycus	–1	S	Large crater with terraced walls
M Fr	Mare Frigoris (Sea of Cold)	0	N	Large linear sea at the N limb of the Moon
A	Alpine Valley	0	N	Runs perpendicular to the prominent Alps Mts.
B	Alps Mountains	0	N	Spectacular boundary of the Mare Imbrium basin
34	Cassini	0	N	Mid-sized crater on the NE edge of Mare Imbrium containing two smaller craters
H	Caucasus Mountains	0	N	Mountain chain forming the NW shore of Mare Serenitatis
26	Aristillus	0	N	Crater in Mare Imbrium featuring a notable ejecta blanket
31	Autolycus	0	N	Crater directly S of Aristillus
2	Luna 2 landing site	0	N	(optional)
15	Apollo 15 landing site	0	N	(optional)
F	Apennine Mountains	0	E	Spectacular mountain range NW of Mare Vaporum
M V	Mare Vaporum (Sea of Vapours)	0	E	Smaller mare between the larger Mare Imbrium and Mare Serenitatis
S M	Sinus Medii (Central Bay)	0	E	Lighter–coloured lava feature S of Mare Vaporum
55	Hipparchus	0	E	Old eroded square–ish crater below Sinus Medii
51	Halley	0	E	Small crater touching the S of Hipparchus
21	Albategnius	0	E	Large crater with off–centre peak
53	Herschel	0	E	Smaller crater N of Ptolemaeus
75	Ptolemaeus	0	E	Younger neighbor of Alphonsus
22	Alphonsus	0	E	Prominent crater with central peak, E of Mare Nubium
28	Arzachel	0	E	Crater with sharply–defined, deep–terraced walls
72	Plato	1	N	Dark–floored crater on the margin of Mare Imbrium south of Mare Frigoris
Z	Teneriffe Mountains	1	N	Small mountain range in the N part of Mare Imbrium
V	Spitzbergen Mountains	1	N	Small range in the E quadrant of Mare Imbrium
24	Archimedes	1	N	Sharp crater with terraced walls to the E of Mare Imbrium to the west and Palus Putredinis
85	Timocharis	1	N	Prominent crater located near the middle of Mare Imbrium
44	Eratosthenes	1	E	Large crater at the S tip of Montes Apenninus

Explore the Moon (telescope version)

OH label	name	posn		description
S A	Sinus Aestuum (Seething Bay)	1	E	Bay S of Mare Imbrium
M Nu	Mare Nubium (Sea of Clouds)	1	S	Southernmost sea directly W of Alphonsus
X	Straight Wall	1	S	Rupes Recta, a cliff on the E side of Mare Nubium
86	Tycho	1	S	Recent crater best seen at the Full Moon when its rays can be traced over much of the lunar surface
63	Maginus	1	S	Large old and eroded crater above Clavius
36	Clavius	1	S	Large crater at the S end of the Moon
W	Straight Range	2	N	Montes Recti, a small mountain range in N Mare Imbrium
M I	Mare Imbrium (Sea of Rains)	2	N	Large S of Mare Frigori
G	Carpathian Mountains	2	E	Large mountain chain forming the S edge of Mare Imbrium
39	Copernicus	2	E	Features spectacular central peaks and is surrounded by both a prominent ejecta blanket and numerous secondary craters. Most prominent feature in the otherwise mostly flat Mare Insularum
76	Reinhold	2	E	Terraced wall crater with ejecta blanket, N of Mare Cognitum
59	Lansberg	2	E	Deep terraced wall crater SW of Reinhold
12	Apollo 12 landing site	2	E	(optional)
14	Apollo 14 landing site	2	E	(optional)
S	Riphaeus Mountains	2	E	Mountain range in the S part of Oceanus Procellarum separating it from Mare Cognitum
7	Ranger 7 landing site	2	E	(optional)
33	Bullialdus	2	S	Exceptional crater with ejecta blanket in W Mare Nubium
88	Wilhelm	2	S	Large crater located to the W of Tycho
61	Longomontanus	2	S	Very large prominent crater in heavily impacted region
M	Jura Mountains	3	N	High mountain range almost completely encircling Sinus Iridum
S I	Sinus Iridum (Bay of Rainbows)	3	N	Dark–flooded crater on the edge of Mare Imbrium
57	Kepler	3	E	Recent impact crater with its uneven floor and bright ray system
48	Gassendi	3	E	Eroded crater with extensive system of rilles on its floor
79	Schiller	3	S	Large and elongated crater in the SW quadrant
25	Aristarchus	4	N	Bright, complex crater located near the edge of Oceanus Procellarum.
O P	Oceanus Procellarum (Ocean of Storms)	4	E	Large lava covered area W of Mare Imbrium
M H	Mare Humorum (Sea of Moisture)	4	S	Small sea S of Oceanus Procellarum
67	Mersenius	4	S	Large eroded crater W of Mare Humorum
S R	Sinus Roris (Bay of Dew)	5	N	NW bay linking O. Procellarum and Mare Frigoris
9	Luna 9 landing site	5	E	(optional)
78	Schickard	5	S	Very large crater containing bright spots on the SW quadrant
54	Hevelius	6	E	Low–rimmed and eroded crater N of Grimaldi and W of Oceanus Procellarum
49	Grimaldi	6	E	Large round basin with dark floor on the W edge of the Moon, just S of the equator, visible in binoculars