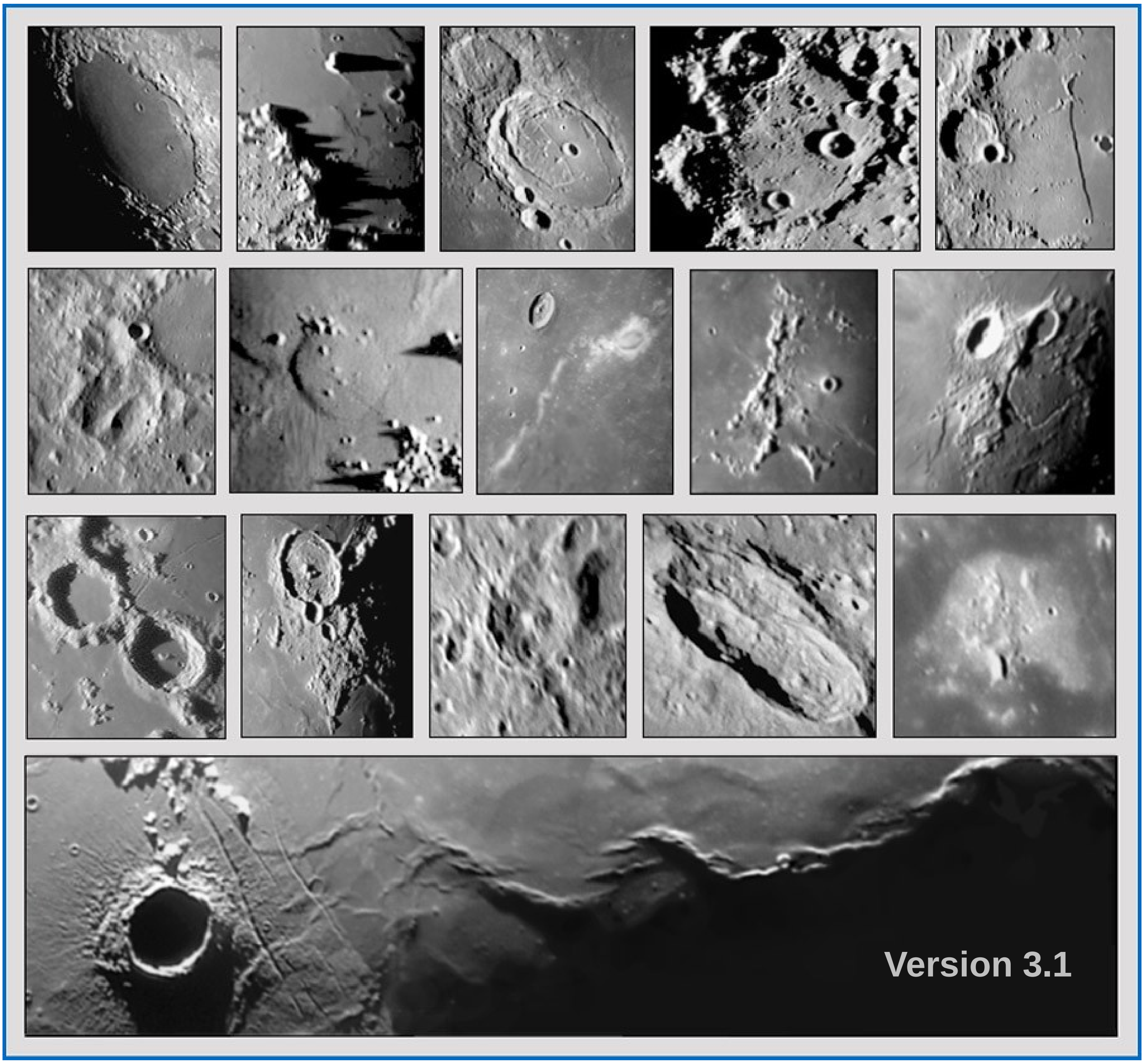
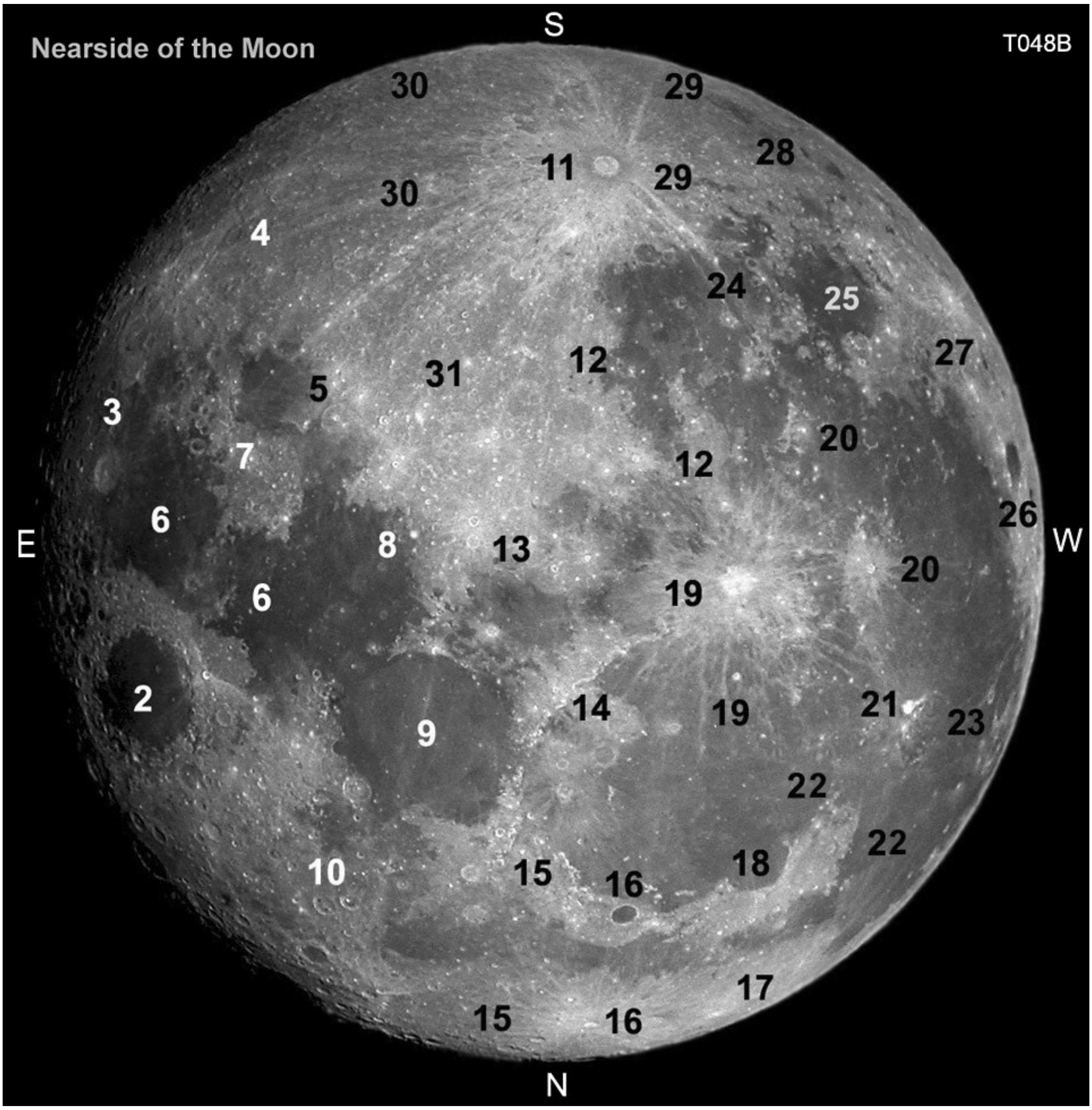
Photographic Moon Book

Alan Chu





Lunar Features by Map No.

1. *Maria, Montes and Moon Rocks*
2. Mare Crisium, Proclus, Cleomedes, Messala
3. Langrenus, Vendelinus, Petavius, Furnerius
4. Janssen, Fabricius, Vallis Rheita, Mare Australe
5. Theophilus, Cyrillus, Catharina, Rupes Altai, Fracastorius
6. Messier, Censorinus, Taruntius, Cauchy
7. Capella, Isidorus, Torricelli, Bohnenberger, Gutenberg
8. Sabine, Ritter, Hypatia, Delambre, Arago, Lamont
9. Serpentine Ridge, Plinius, Posidonius, Manilius, Menelaus
10. Atlas, Hercules, Bürg, Endymion, Mare Humboldtianum
11. Tycho, Clavius, Maginus, Deslandres, Pitatus, Hesiodus
12. Ptolemaeus, Alphonsus, Rupes Recta, Purbach, Fra Mauro
13. Rima Ariadaeus, Rima Hyginus, Rimae Triesnecker
14. Montes Apenninus, Rima Hadley, Archimedes, Aristillus
15. Vallis Alpes, Cassini, Aristoteles, Eudoxus, Meton
16. Plato, Mons Pico, Anaxagoras, Goldschmidt
17. J. Herschel, Anaximander, Philolaus, Pythagoras
18. Sinus Iridum, Montes Recti, Bianchini, Sharp, Maupertuis
19. Copernicus, Eratosthenes, Stadius, Euler, Lambert
20. Kepler, Marius, Flamsteed, Reiner Gamma
21. Aristarchus, Herodotus, Vallis Schröteri, Prinz
22. Mons Gruithuisen Gamma, Mons Rümker
23. Eddington, Struve, Russell, Seleucus, Olbers
24. Capuanus, Ramsden, Marth, Bullialdus, Kies
25. Gassendi, Rimae Hippalus, Vitello, Mersenius
26. Grimaldi, Hevelius, Cavalerius, Riccioli, Hedin
27. Darwin, Byrgius, Rimae Sirsalis, Crüger, Billy
28. Schiller, Schickard, Wargentin, Phocylides
29. Bailly, Longomontanus, Wilhelm, Mee, Hainzel
30. Maurolycus, Faraday, Stöfler, Boussingault
31. Catena Abulfeda, Catena Davy, Hipparchus
32. *Domes*
33. *Lunar Rays*

Event 1. *Libration*
Event 2. *Terminator*
Event 3. *Crescent*
Event 4. *Eclipse and Occultation*

Contents

About This Book

The current version is intended for advanced lunar observations. It is also a complement to the wide-field "Hatfield" Photographic Lunar Atlas and the cartographic "Rükl" Atlas of the Moon.

The book collects about 270 photographs including the mosaics. Most of them were taken with the author's 10-inch (254 mm) telescope since December 2002. It meets the following criteria:

- All lunar images are selenographic south up unless otherwise noted. They resemble the eyepiece view in a Newtonian reflector.
- The date, time, Moon age and equipment used during an exposure are given together with a brief description of the lunar features.
- An Overview to refresh the Moon basics.
- A section on the Methods of Imaging.
- In general, images of the lunar nearside are sequenced in regio MAPs from east to west, e.g. Mare Crisium and Petavius come first, finally Grimaldi and Schickard. Lunar events such as eclipses are described in the EVENT pages. A cross-reference with Hatfield's and Rükl's maps is also indicated in the page corner whenever applicable.
- The English-Chinese index at the back of the book facilitates the search of 1,000 named features. The glossary explains lunar terms in simple language.

A CD copy of the current version is available by post. It is best viewed in 19-inch or bigger PC screen.

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1. Overview

Our natural satellite, the Moon, is a fascinating object. It is a little more than a quarter of the Earth diameter, about 1.3 light-seconds away. Virtually it has no atmosphere, no surface water and no active volcanism. Lots of surface features can be observed through telescopes as small as 6-cm (2.4-inch) aperture, and they change in view under different angles of sunlight.

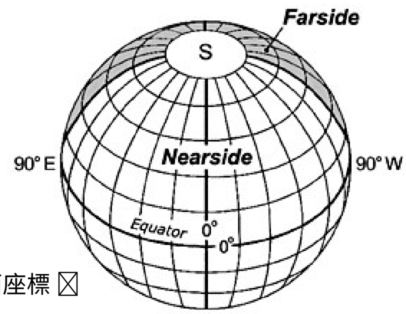
Lunar features are traditionally classified in Latin as

Mare	(sea, plural: *maria*)	海
Oceanus	(ocean)	洋
Sinus	(bay)	灣
Lacus	(lake)	湖
Palus	(marsh)	沼
Mons	(mountain)	山
Montes	(mountain ranges)	山脈
Vallis	(valley / trough)	谷 / 槽
Promontorium	(promontory / cape)	岬 / 海角
Rima	(rille / cleft, plural: *rimae*)	溪 / 溝紋
Rupes	(scarp / cliff / fault)	懸崖 / 峭壁 / 斷層
Dorsum	(wrinkle ridge, plural: *dorsa*)	皺脊
Catena	(crater chain, plural: *catenae*)	環形山串

while craters (環形山) are named after mythic legends or individuals who contributed in science, technology, philosophy, mathematics or expedition. Crater is a generic term for circular depression, typically a ring mountain or a walled plain. A ring mountain looks smaller in diameter but relatively deeper than a walled plain. There are 33,000 craters greater than one-km diameter on the visible side of the Moon, about 870 of them bear names and 5,400 are identified by letters added to the name of a nearby prominent crater, e.g. *Gassendi A*. The largest crater visible from Earth is *Bailly* near the south limb. It is a walled plain, outer diameter 300 km. Dozens of craters are also centers of bright rays (輻射紋). On the maria, wrinkle ridges and small low hills called domes (拱丘) are visible under very oblique sunlight.

Lunar features are best seen when they are near the terminator, the border line between light and shadow. Their positions are defined by the selenographic coordinates in which the 0^0 longitude and 0^0 latitude are within a small mare named *Sinus Medii* (Central Bay). This sinus is visible in binoculars, see next page. The lunar hemisphere permanently facing Earth is termed the nearside; it ranges from 90^0 E to 90^0 W through the 0^0 longitude. When the Moon's south pole is positioned at top, the east limb of the nearside is at the left-hand side, the west limb is at the right-hand side.

Surface features of the nearside are depicted under Map 1 to Map 33 with the selenographic south at top. Lunar phenomena about libration, terminator, crescent, eclipse and occultation are illustrated under Event 1 to Event 4. A map of the Farside that opposes the nearside is also



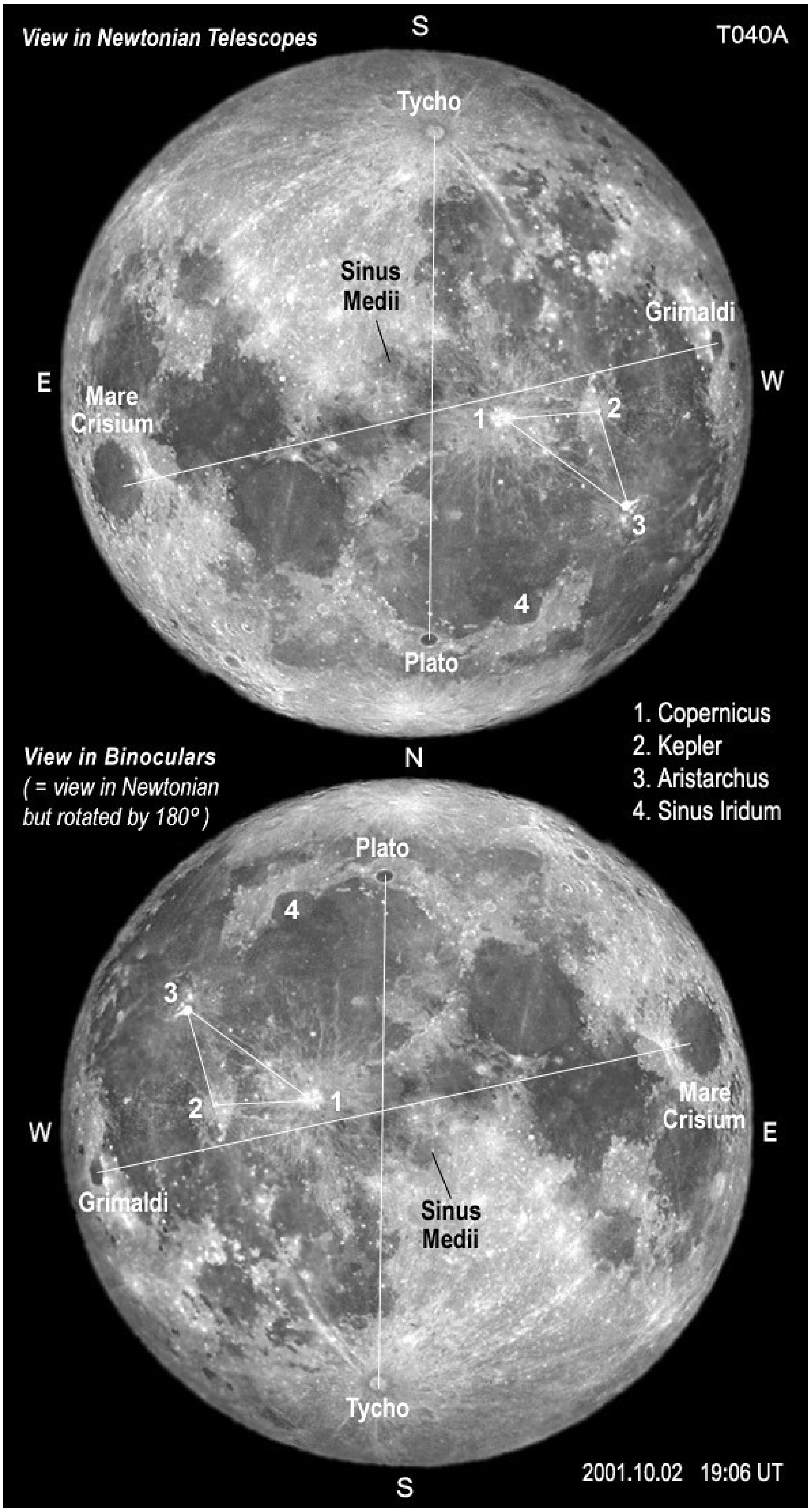
Selenographic Coordinates 月面座標 ☒

given.

Landmarks on the Moon

Mare Crisium, Grimaldi, Tycho and Plato form a cross; Copernicus, Kepler and Aristarchus form a triangle. Sinus Medii is almost at the center of the disc. The thumbnail is the mirror-reverse image through a star diagonal fitted on refractor or Cassegrain-type telescope. N, S, E and W are selenographic directions as seen by an astronaut on the Moon; they are similar to the geographic directions on Earth.

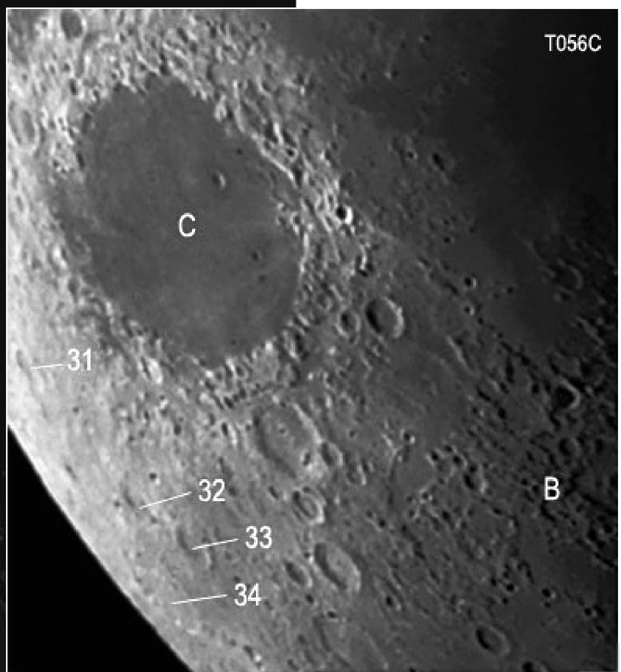
In telescopes, the eastern half of a Moon disc (S-E-N) looks slightly brighter than the western half (S-W-N).



In telescope with star diagonal

The Moon in small telescopes

This Moon crescent was photographed with a digital camera one hour after sunset through a 3-inch (8 cm) refractor. South is up. It represents a typical view of the Moon from a small telescope at low magnification. Although the telescope is small, it shows plenty of lunar features such as craters, mountains and dark plains. Small telescopes are easy to carry and less sensitive to atmospheric turbulences. Even owners of big instruments enjoy the use of smaller telescopes in field work and poor-seeing nights. The original parts of this image are cropped and shown in the inlets.



1. Janssen
2. Fabricius
3. Metius
4. Brenner
5. Vallis Rheita
6. Vallis Snellius
7. Snellius
8. Stevinus
9. Wrottesley
10. Furnerius
11. Petavius
12. Vendelinus
13. Langrenus
14. Lamé
15. Santbech
16. Colombo
17. Gutenberg
18. Fracastorius
19. Capella
20. Taruntius
21. Proclus
22. Cleomedes
23. Geminus
24. Messala
25. Macrobius
26. Römer
27. Atlas
28. Hercules
29. Endymion
30. Hubble
31. Plutarch
32. Hahn
33. Berosus
34. Gauss
35. Condorcet
36. Vlacq
37. Boussingault

A. Montes Pyrenaeus
B. Montes Taurus
C. Mare Crisium

The Moon and its Terminator

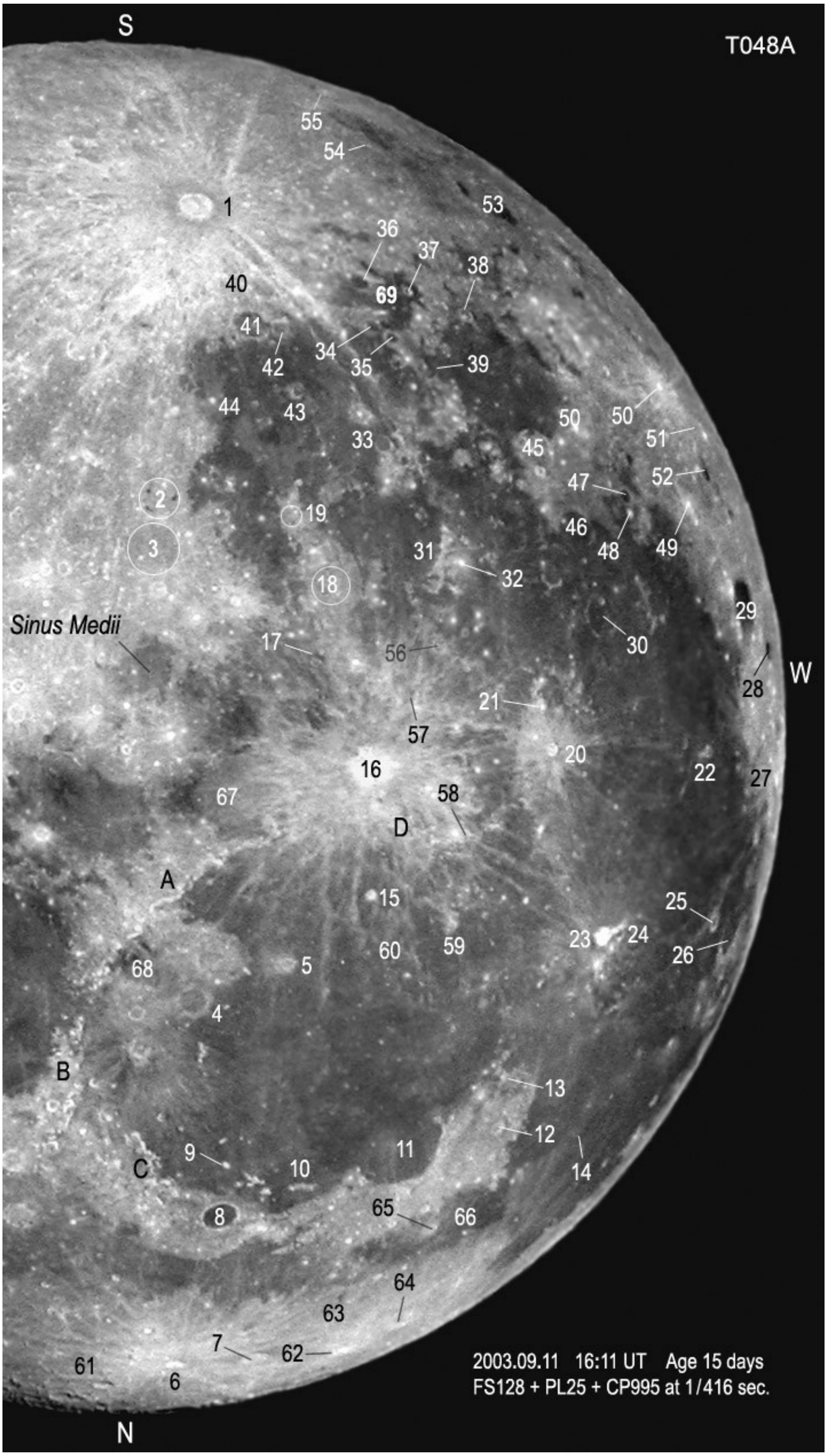
The terminator is the border line between light and shadow. It looks irregular because of different height and albedo (reflectivity) of surface features. Features away from the terminator are often too bright (e.g. No. 62) or hidden in darkness (e.g. No. 15), yet they become distinctive when the bright margin of the terminator passes over them.

1. Tycho
2. Maginus
3. Clavius
4. Deslandres
5. Walter (Walther)
6. Purbach
7. Arzachel
8. Alphonsus
9. Ptolemaeus
10. Davy
11. Albategnius
12. Hipparchus
13. Hind
14. Guericke
15. Fra Mauro
16. Birt, Straight Wall
17. Eratosthenes
18. Archimedes
19. Autolycus
20. Aristillus
21. Conon
22. Timocharis
23. Eudoxus
24. Aristoteles
25. Cassini
26. Plato
27. Anaxagoras
28. Godin
29. Triesnecker
30. Rima Hyginus
31. Dionysius
32. Julius Caesar
33. Vallis Alpes
34. Manilius
35. Menelaus
36. Bessel
37. Plinius
38. le Monnier
39. Posidonius
40. Bürg
41. Atlas
42. Hercules
43. Endymion
44. Thales
45. Abulfeda
46. Janssen
47. Vallis Rheita
48. Piccolomini
49. Rupes Altai
50. Fracastorius
51. Theophilus
52. Cyrillus
53. Catharina
54. Capella
55. Isidorus
56. Messier
57. Sabine
58. Snellius
59. Furnerius
60. Petavius
61. Vendelinus
62. Langrenus
63. Taruntius
64. Proclus
65. Cleomedes
66. Pallas
67. Murchison
68. Regiomontanus
69. Maurolycus
70. Faraday
71. Stöfler
72. Moretus

A. Montes Apenninus
B. Montes Caucasus
C. Montes Alpes

The Moon at full brightness

This photograph shows the western half of a full moon. The terminator has gone completely. Crater Tycho, Copernicus, Kepler and Aristarchus (No. 1, 16, 20 & 23) radiate extensive bright rays that overwhelm large areas of the surface. Other landscapes lose their contrast too, though recognizable. The full moon is not a favorable time to spot lunar details.

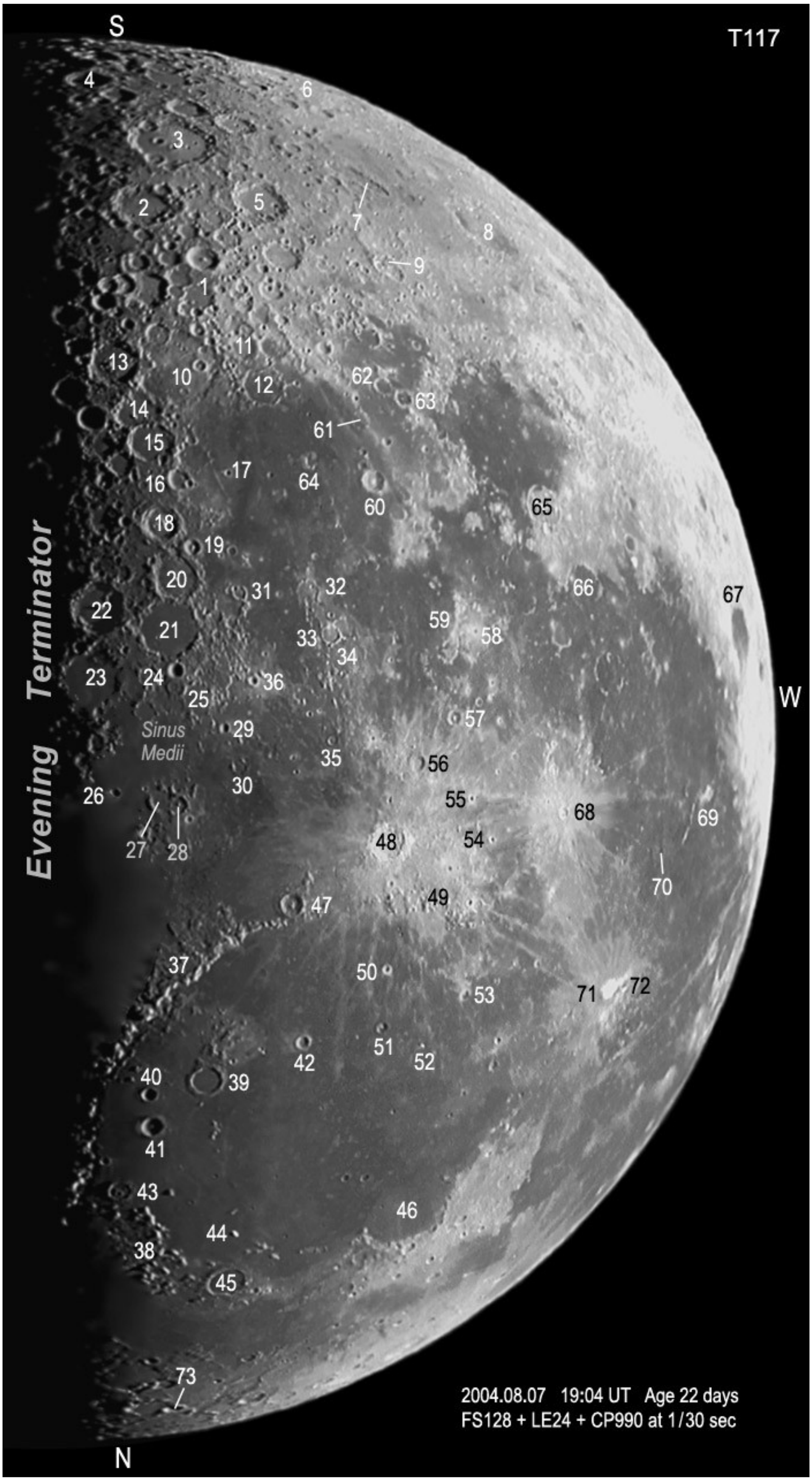


1. Tycho
2. Alphonsus
3. Ptolemaeus
4. Archimedes
5. Timocharis
6. Anaxagoras
7. Philolaus
8. Plato
9. Mons Pico
10. Montes Recti
11. Sinus Iridum
12. Mairan
13. Mons Gruithuisen Gamma
14. Mons Rümker
15. Pytheas
16. Copernicus
17. Gambart
18. Fra Mauro
19. Guericke
20. Kepler
21. Encke
22. Reiner Gamma
23. Aristarchus
24. Herodotus
25. Seleucus
26. Eddington
27. Olbers A
28. Riccioli
29. Grimaldi
30. Flamsteed P
31. Montes Riphaeus
32. Euclides
33. Bullialdus
34. Mercator
35. Campanus
36. Capuanus
37. Ramsden
38. Vitello
39. Hippalus
40. Wurzelbauer
41. Pitatus
42. Hesiodus
43. Wolf
44. Birt
45. Gassendi
46. Letronne
47. Billy
48. Mons Hansteen
49. Sirsalis
50. Byrgius A
51. Darwin
52. Crüger
53. Schickard
54. Schiller
55. Zucchius
56. Lansberg
57. Reinhold
58. T. Mayer
59. Euler
60. Lambert
61. Meton
62. Carpenter
63. J. Herschel
64. Pythagoras
65. Harpalus
66. Sinus Roris
67. Sinus Aestuum
68. Palus Putredinis
69. Palus Epidemiarum

A. Montes Apenninus
B. Montes Caucasus
C. Montes Alpes
D. Montes Carpatus

The Moon and its "Evening" Terminator

The terminator is designated "evening" because the places under it are experiencing sunset. If a moon man stands now on the floor of crater No.23, he will see the setting Sun and anticipate nighttime as the terminator crosses the crater from east to west (from left to right of the frame). Compare this photograph with T078 in previous page which was taken 6 days before the full moon. T078 shows the "morning" terminator implying the Sun is rising over that part of the Moon. In T117, note also the highland region, around 2~3 o'clock position of the west limb. It is even brighter than the full moon because the Sun is illuminating it at high angles (hence appears white and featureless).



1. Tycho
2. Maginus
3. Clavis
4. Moretus
5. Longomontanus
6. Bailly
7. Schiller
8. Schickard
9. Hainzel
10. Deslandres
11. Gauricus
12. Pitatus
13. Walter (Walther)
14. Regiomontanus
15. Purbach
16. Thebit
17. Birt
18. Arzachel
19. Alpetragius
20. Alphonsus
21. Ptolemaeus
22. Albategnius
23. Hipparchus
24. Herschel
25. Flammarion
26. Triesnecker
27. Murchison
28. Pallas
29. Mösting
30. Schröter
31. Davy
32. Guericke
33. Parry
34. Fra Mauro
35. Gambart
36. Lalande
37. Montes Apenninus
38. Montes Alpes
39. Archimedes
40. Autolycus
41. Aristillus
42. Timocharis
43. Cassini
44. Mons Pico
45. Plato
46. Sinus Iridum
47. Eratosthenes
48. Copernicus
49. Montes Carpatus
50. Pytheas
51. Lambert
52. Mons La Hire
53. Euler
54. Milichius
55. Hortensius
56. Reinhold
57. Lansberg
58. Euclides
59. Montes Riphaeus
60. Bullialdus
61. Kies
62. Mercator
63. Campanus
64. Wolf
65. Gassendi
66. Letronne
67. Grimaldi
68. Kepler
69. Reiner Gamma
70. Marius
71. Aristarchus
72. Herodotus
73. Anaxagoras

Impact Craters and Lunar Rays

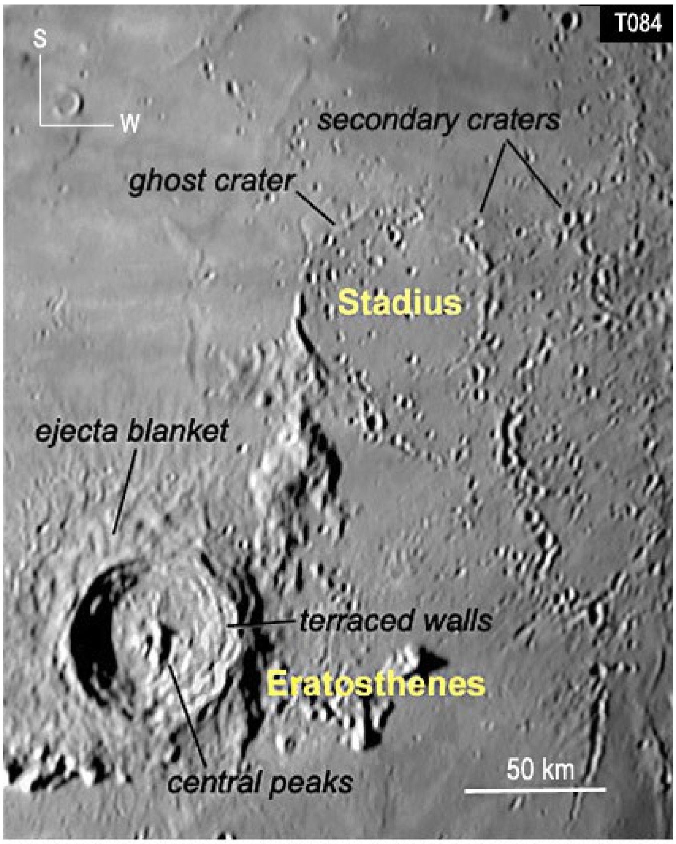
*Over 99% of the existing lunar craters are impact originated. Their diameters range from about 300 km to 1 km and below. Diameters larger than 300 km are generally referred to **Impact Basins**.*

*A mid-sized impact crater is illustrated by Eratosthenes in Image T084. It is located near the central part of the Moon disc and is easily visible in small telescopes 5 to 6 days before the full moon. It is characterized by **central peaks** and **terraced walls**. The highest peak rises 3600 m above the crater floor, and the rim of the terraced walls measures 58 km across. Both the peaks and terraced walls are natural formations from a massive impact process, in which the impactor was an asteroid-like body of few kilometers only (much less than the diameter of Eratosthenes), hitting the Moon surface at 20 km per second or so. The tremendous impact energy vaporized a portion of the impactor and melted the rocky materials of the impact site to a much larger circular cavity. The downward pressure of the impact induced a concentrated rebound that uplifted subsurface rocks into central peaks. Other impact melt splashed out in all directions as **ejecta**. Most of the ejecta deposited around the cavity as **ejecta blanket**, the rest might take the advantage of low surface gravity (1/6 that of Earth) to fly far away before raining down to hit the surface again as **secondary craters**. All secondary craters are too small to have central peaks. The right part of T084 shows a mix of secondary craters produced by various sources including the Eratosthenes impact.*

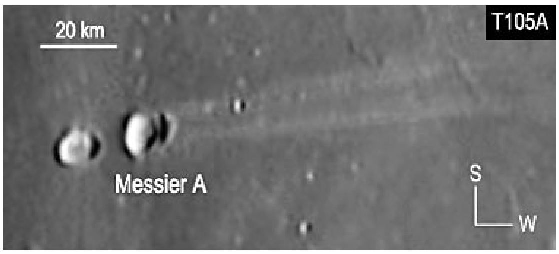
The terraced walls of Eratosthenes formed at later stage, when the steeper inner walls could not sustain their own masses and stresses but collapsed by linear segments along the slopes. Normally, lunar craters with diameters under about 25 km are lack of terraced walls, and craters with diameters under about 15 km are lack of central peaks.

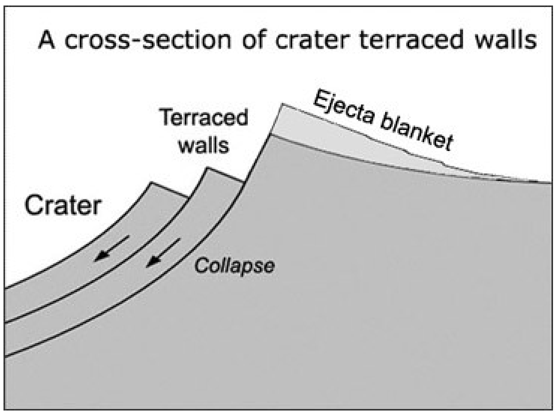
*A unique feature, known as **ghost crater**, is also shown in T084. It is a crater almost buried beneath the surface of the Moon or destroyed through aging, leaving only a bare hint of recognition.*

*In general, impact craters remain circular unless modified by post-volcanism and aging, or the initial impact angle is very low (less than about 5^o measured from ground level). A typical crater caused by low-angled impact is Messier A as shown below. It appears elongated, and its ejecta in the pattern of dual **rays** implies a grazing impact from east to west direction.*



2005.04.18 11:29 UT Age 10 days. 10-in f/6 Newtonian + 2.5X + ToUcam

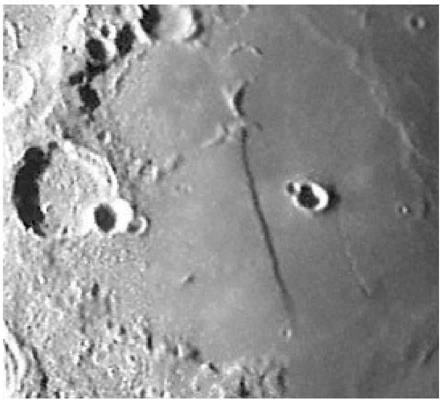




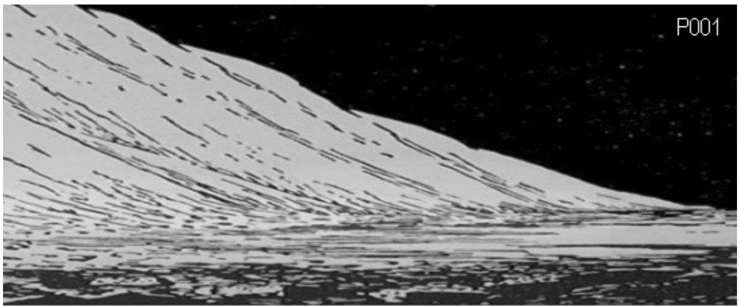
See also the terraced walls of ***Copernicus*** Map 19 and ***Boussingault*** Map 30.

It must be aware that lunar nomenclature is not always exact. For instance, today's selenographic coordinates make Mare Orientale (Eastern Sea, Farside Map) confusingly on the western longitude. Vallis Rheita in Map 4 is not a true valley but a chain of overlapping craters. Grimaldi in Map 26 appears like a lava-filled basin more than a crater. Rupes Recta (the Straight Wall) in Map 12 is not a narrow wall but a fault where its western side slopes down by 300 m. Many lunar views in Earth-based telescopes are dramatically different from the scenes on the Moon's surface and from the images taken in space. Below are some comparisons.

The Straight Wall 直壁



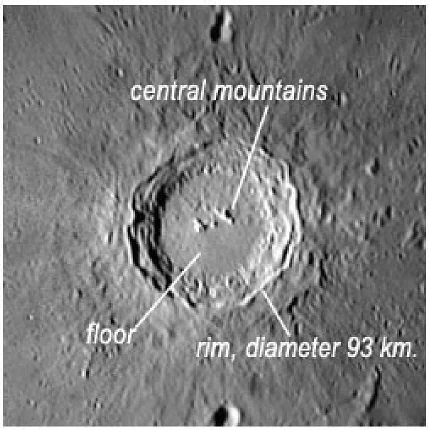
View in telescope, Map12



Standing at the foot of the 300-m high Straight Wall --- In telescope, the Straight Wall with shadow appears like a steep cliff. Actually its slope is rather gradual, no more than 20^0.

(Modified from a sketch in Perelman's Astronomy For Entertainment, Moscow, 1958.)

Crater Copernicus 哥白尼環形山



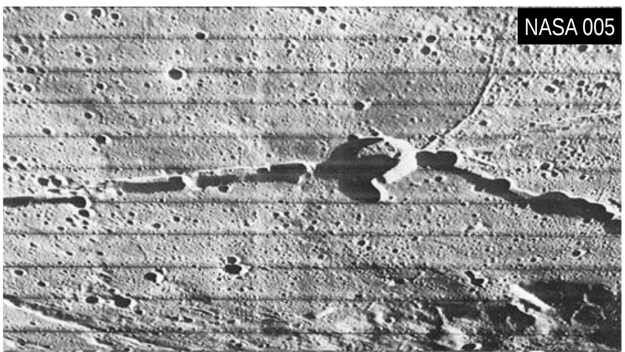
View in telescope, Map19

For an astronaut standing on the central floor of Copernicus, his horizon distance is 2.5 km only. He cannot see the crater rim unless he climbs the central mountains to a height over 600 m. This picture simulates the astronaut's view at 800 m above the crater floor.

(Sketch from Perelman's Astronomy For Entertainment, Moscow, 1958.)

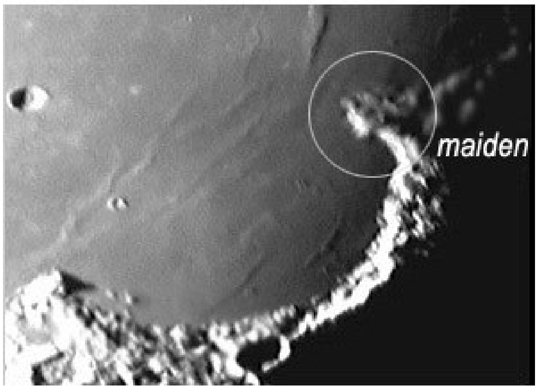
Rima Hyginus 海金努斯月溪

View in telescope, Map 13

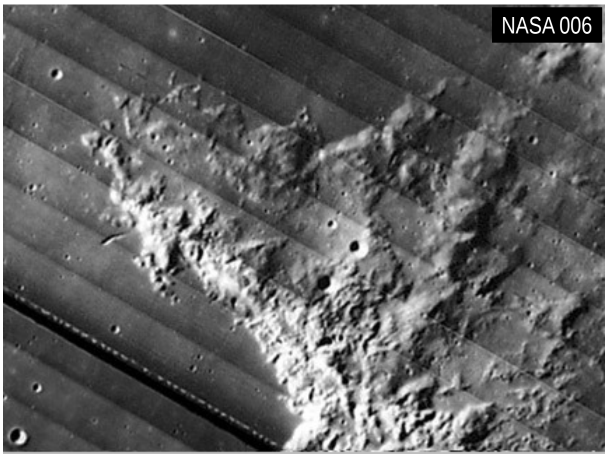


Rima Hyginus from Lunar Orbiter 3 probe that orbited around the Moon's equator in 1967. This closeup shows numerous craterlets on the lunar surface not resolvable by any observatory telescopes.

Prom. Heraclides 赫拉克莱特海角



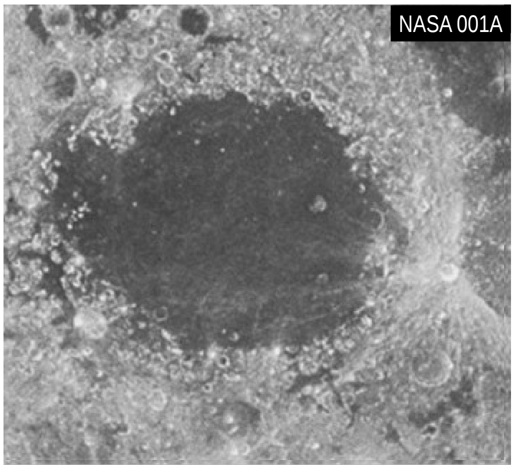
View in telescope, Map 18. Poor seeing creates illusion which makes Promontorium Heraclides to resemble a maiden's face with waving hair.



Closeup image of Promontorium Heraclides from the Lunar Orbiter mapping. Here it is rotated with south up.

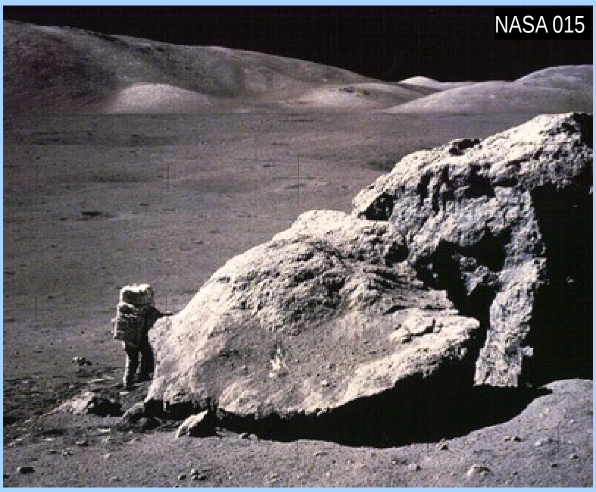
Mare Criusium 危海

*Two views of Mare Crisium in telescope, Map 2. They differ slightly in aspect ratio (east-west **:** north-south diameter) due to libration* 天平動 ***.*** *Libration is the apparent vertical or horizontal rocking motion of the Moon as it orbits around the Earth. It distorts the surface features seen near the Moon's limb, or even makes them temporarily out of sight. Libration is detailed in Event 1 pages.*



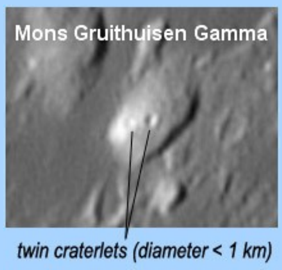
This image from Apollo 11 spacecraft shows the non-oblique view of Mare Crisium. Its east-west diameter is longer than the north-south by 33%.

Resolving Power of Telescopes



Left: *The isolated boulder on the Moon is probably a dropping of ejecta from crater impact. Although it looks big to the Apollo-17 astronaut, it is not detectable by any observatory optics. Even the Hubble Space Telescope, with its 2.4-m mirror, is unable to spot moon rocks smaller than about 80 m. At best night, a 25-cm (10-inch) telescope resolves to 0.45 arcseconds, or lunar craters of about 800 m in diameter.*

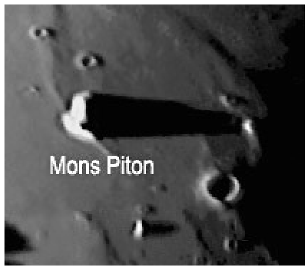
Right: *A 25-cm (10-inch) telescope can be tested by resolving the twin craterlets in Mons Gruithuisen Gamma, Map 22 .*

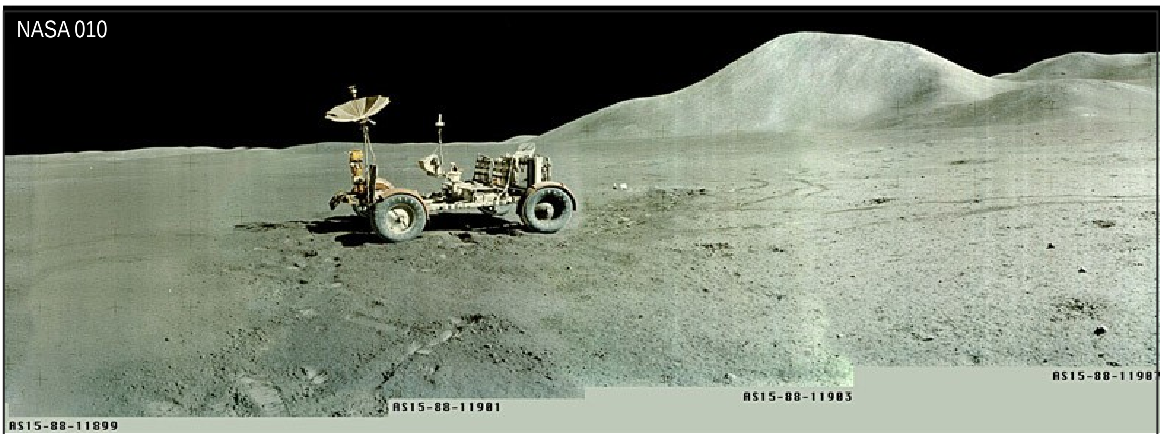


In telescopes, a crater close to the lunar terminator looks like deep hollow because the shadow on it exaggerates the impression of depth. Actually the floor of a lunar crater is not deep against its diameter. For example, Tycho (figure below) is about 100 km in diameter, 5 km deep at most. The depth-diameter ratio is 1 : 20, rather shallow by terrestrial norm. During the full moon, the exaggerated depth of Tycho will vanish, and the crater looks almost flat with a dark halo.

3/4 Tycho in shadow 1/2 Tycho in shadow No shadow (at full moon)

The shadow effect, together with the global curvature of the Moon, also play trick to the appearance of lunar mountains. In the right figure which shows the telescopic view of Mons Piton, an isolated mountain in Map 15, it has the appearance of a steep cliff, exaggerated by the long triangular shadow under low illumination. However, an astronaut on the Moon would find its slope quite gradual, roughly 20^0. This is because the global curvature of the Moon is greater than that of the Earth; the short horizon distance of the astronaut (2.5 km) makes him or her to perceive Mons Piton not as steep as the shadowed view in telescopes.





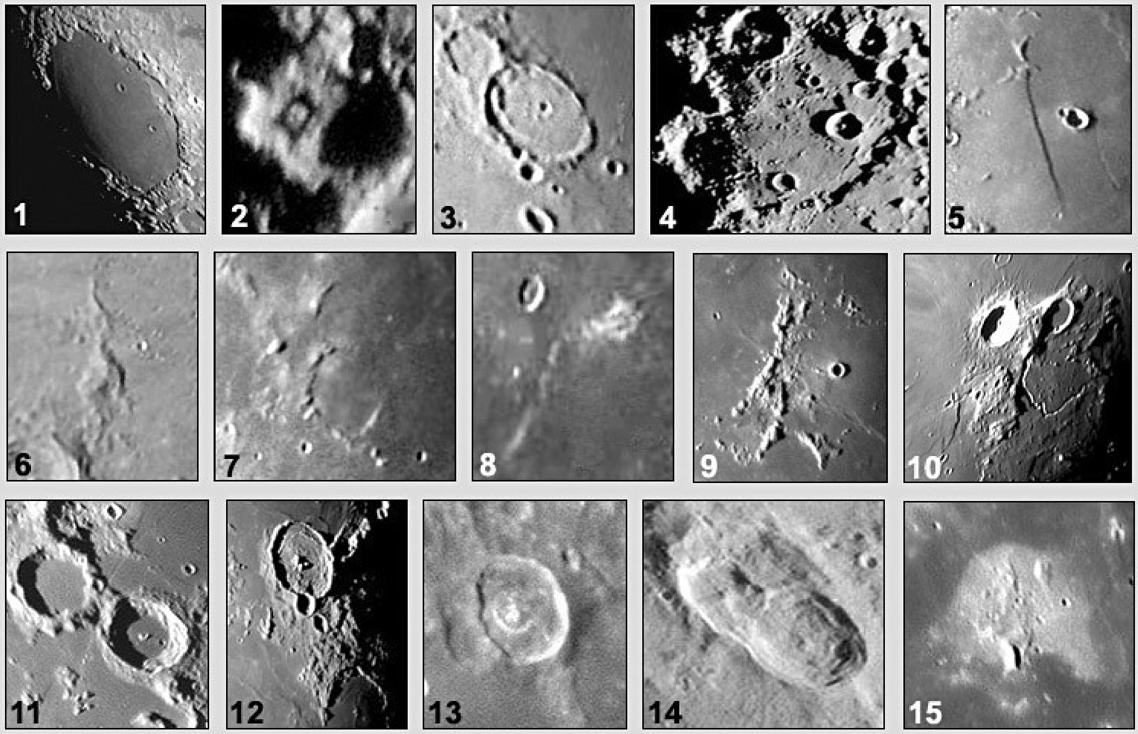
The above mosaic shows the landing site of Apollo 15 (1971 July). The mountain is Hadley Delta at the foothills of Montes Apenninus Map 14. Astronauts called it a “featureless mountain” (quite true in this picture). They found lunar scenery almost white or black. They also reported that distances on the Moon were hard to estimate, partly because the Moon’s surface curves more sharply than that of the Earth and hence the horizon is closer, partly because there is no atmosphere and hence no softening of shadows. Note that on the airless Moon, the sky is dark even at daytime. (*NASA Image*)

Here is the shadow effects experienced by the Apollo astronauts on the Moon:
http://science.nasa.gov/headlines/y2006/03jan_moonshadows.htm?list137588

Although the Moon is physically a barren world compared to our vivid Earth, yet there are lots of surface features visible in telescopes. See these funny highlights:

Funny Features on the Moon

Under certain illuminating conditions, the lunar features may look conspicuous and funny in telescopes. Below are the glimpses of them. Their details are traceable from the **MAP** *pages.*

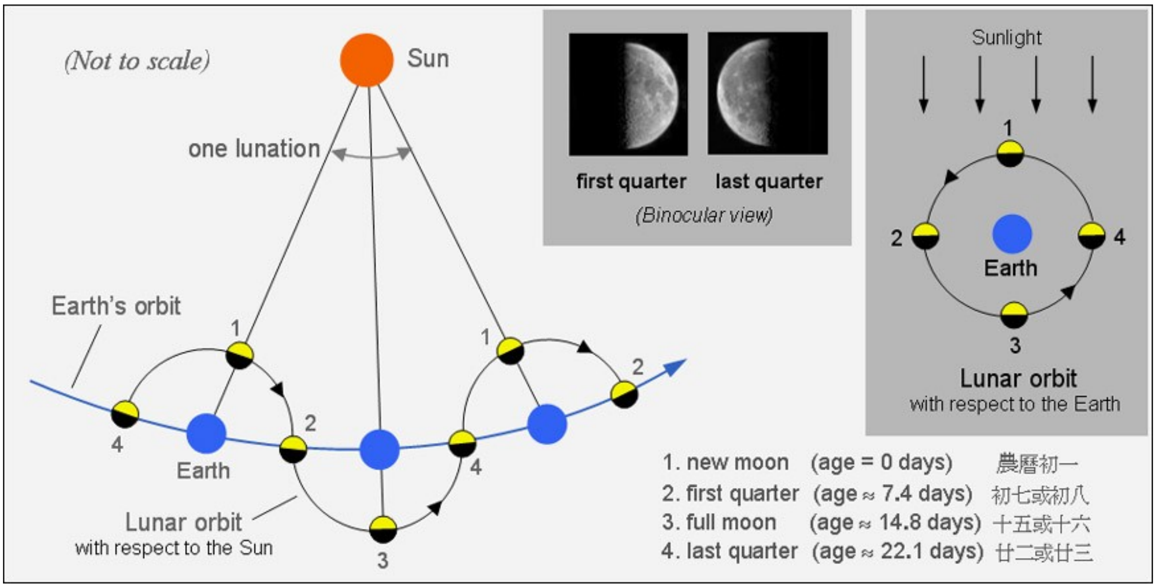


Funny Features on the Moon 1. Crab shell 2. Tortoise 3. Pan cake 4. Tropical fish 5. Sword 6. Elephant with swirling nose 7. ET face 8. White-head snake 9. Man walking with torch 10. Cat face 11. Spectacles 12. Lobster 13. Rope-jumping rabbit 14. Peanut shell 15. Helmet (*South is up.*)

Age of the Moon

The ***age*** *is the number of days that has elapsed since the last new moon***.** *In average***,** *the new moon repeats every 29.53 days***;** *this period is called* ***synodic month*** *or one* ***lunation****. Because the Moon's orbital speed is not constant, the first quarter, the full moon and the last quarter may occur slightly earlier or later than the indicated age. It is also possible to have two full moons in a calendar month, e.g. 2001 December and then 2004 August (once every 33 months). "****Blue Moon****" is a misaligned term for the second full moon in the same calendar month. Rarely the Moon is tinted blue unless there is a large amount of smoke or dust particles in the atmosphere, such as the 1883 eruption of Krakatoa volcano in Indonesia.*

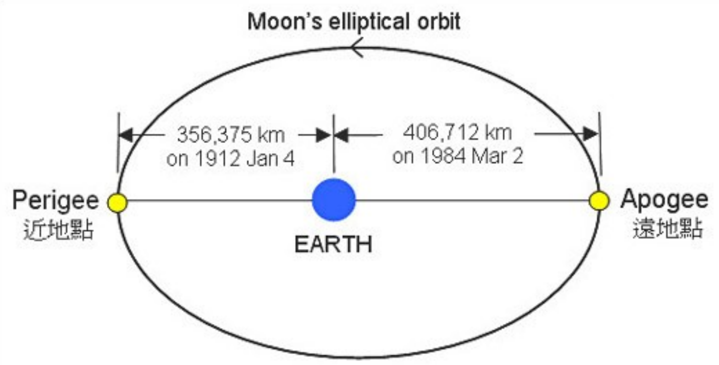
In the drawing below, note also the Moon must orbit about the Earth more than 360^0 from new moon to next new moon.



Perigee and Apogee

The angular diameter of the Moon is about 0.5^{0}, equivalent to viewing a pencil thickness at an arm's length. It is not constant but changes according to the instantaneous Moon-observer distance. Thus the Moon appears about 1.5 % bigger at zenith (overhead) than at horizon, though this change is quite small. To an observer on the Earth's equator, the Moon's angular diameter can vary up to 34.1 arcminutes at ***perigee*** *(closet to Earth) and down to 29.8 arcminutes at* ***apogee*** *(farthest from Earth), a total change of almost 14 %. The average is 31.6 arcminutes, when the Moon is 378,000 km (30 times Earth's diameter) from the observer. A lunar crater of 2 km diameter and facing Earth gives a visual angle of about 1 arcsecond.*

Greatest high tide, also called ***perigean spring tide***, *will occur when the Moon is at perigee and when the Sun, the Earth and the Moon (whether new moon or full moon) are aligned to reinforce gravitational interactions. Such high tides are not uncommon and can be observed at some coastal spots in Hong Kong, e.g. on 2005 January 10 the new moon was at perigee; the river in Shatin area overflowed the bank during the high tide.*



(The Moon's elliptical orbit is exaggerated to show its perigee and apogee.)

River overflowed a bank during perigean spring tide. This picture was taken shortly after tidewater retreat.

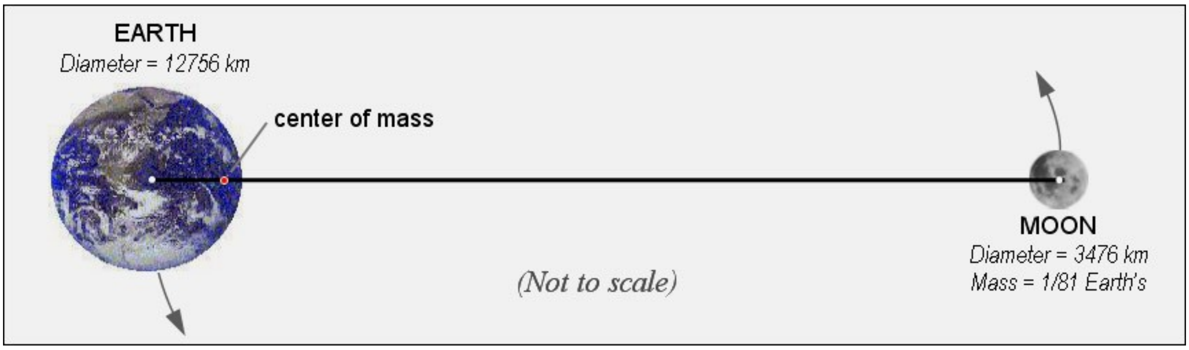
The Earth-Moon System

Actually the Earth and the Moon move in slightly elliptical orbits about the ***center of mass*** *of the system which acts as if all the mass were concentrated there. The Earth and the Moon are always in opposite sides of the center of mass. They go around this center once every* ***sidereal month*** *(27.322 days).*

The center of mass is about 1900 km below the Earth's surface when the Moon is at perigee, and 1400 km below the Earth's surface when the Moon is at apogee.

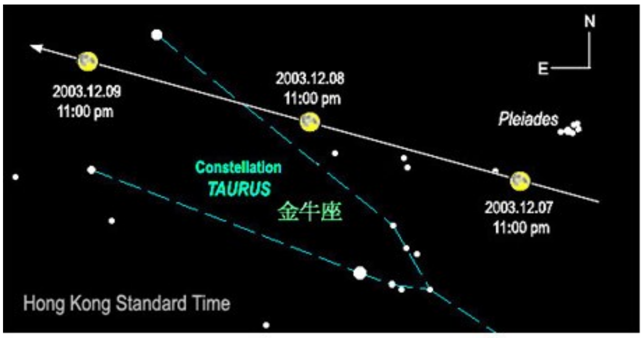
The center of mass is not stationary. It follows the Moon's orbital motion to sweep an elliptical loop inside the Earth globe.

Over time, the friction of tidewater slows down the Earth's axial spin by 0.0016 second per century. This loss of spin is absorbed by the Moon's orbital momentum, which causes the Moon to spiral away from the Earth at average of 3.8 cm per year. However, the Moon remains with the same face (nearside) locked towards Earth. The Moon's distance shall not increase forever. It will stabilize billion years later, probably at 560,000 km. By that time, the length of one day on Earth and one lunation will both be equal to 1200 hours; or perhaps the Sun might have expanded to a red giant swallowing up the Earth and the Moon !

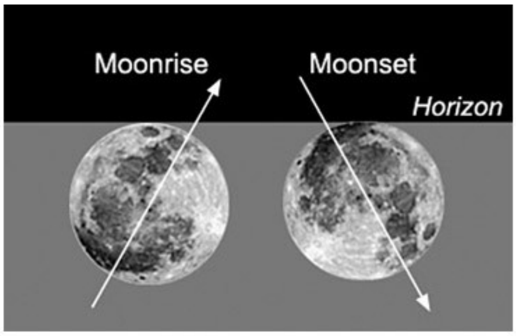


Moonrise and Harvest Moon

Between apogee and perigee, the Moon moves 12 ~ 15 degrees per day eastward among the star background. As a result, moonrise repeats every 24.3 ~ 25.2 hours, and so it must be delayed in successive days. There is always one day with no moonrise (e.g. 2003 December 16 in Hong Kong) and one day with no moonset (2003 December 30) in each lunar month.



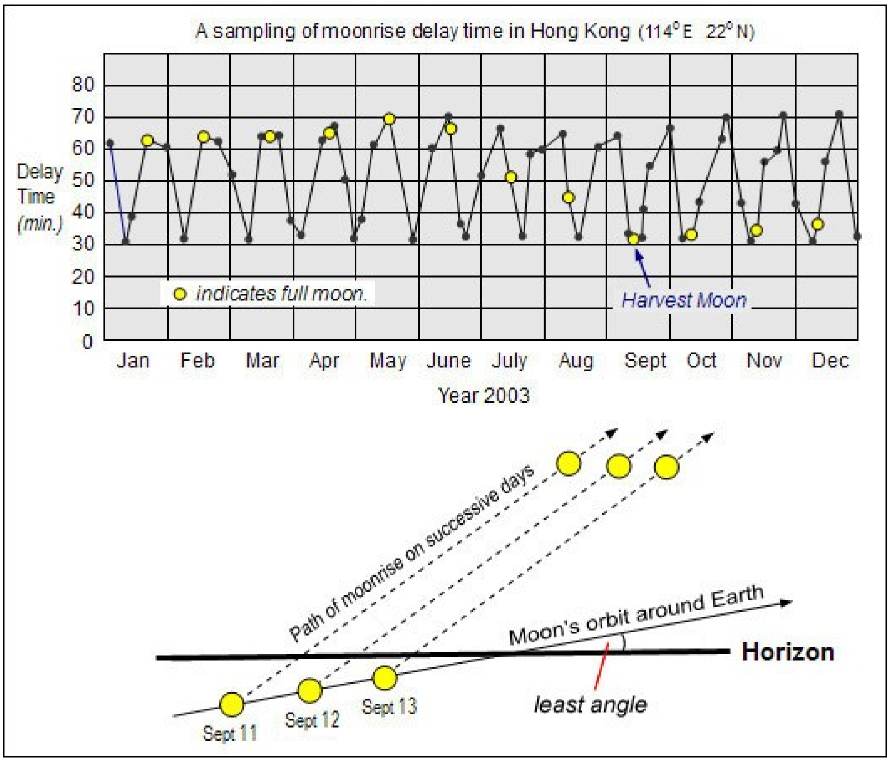
The Moon's retrograde motion in the sky: It takes the Moon two full days to cross Taurus from west to east.



Exact moonrise or moonset is defined by the time when the upper limb of the Moon contacts with the horizon.

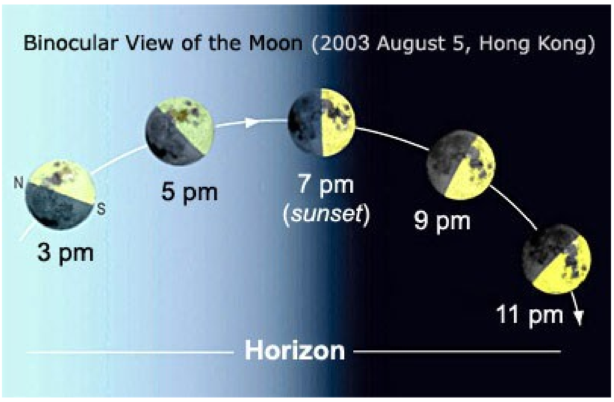
The graph below illustrates the delay of moonrise *during 2003 in Hong Kong. For example, the Moon rose about 62 minutes later per day by the last week of January; but in the first week of February, the Moon appeared to speed up and rose just 32 minutes later per day. This indicates a very large variation of moonrise time within two weeks. The general saying that the Moon rises about 50 minutes later per day is not applicable most of the time.*

Harvest Moon (穫月) *refers to the full moon that rises at minimum delay time during a year. It happens in few successive nights close to autumnal equinox (September 23) in the northern hemisphere. At these nights, the full moon rises around the time of sunset, and it appears only 30 minutes later than the Moon did the day before. This is because at days close to autumnal equinox, the ecliptic, and hence the Moon's orbit, is at its least angle to the horizon at the time of moonrise in the northern latitudes. In higher latitudes (e.g. 50⁰ N), the daily delay time of the Harvest Moon is even shortened to 20 minutes or less. Harvest Moon happens in March in the southern hemisphere. It is so named because the moonlight helps farmers to work at harvest time.*



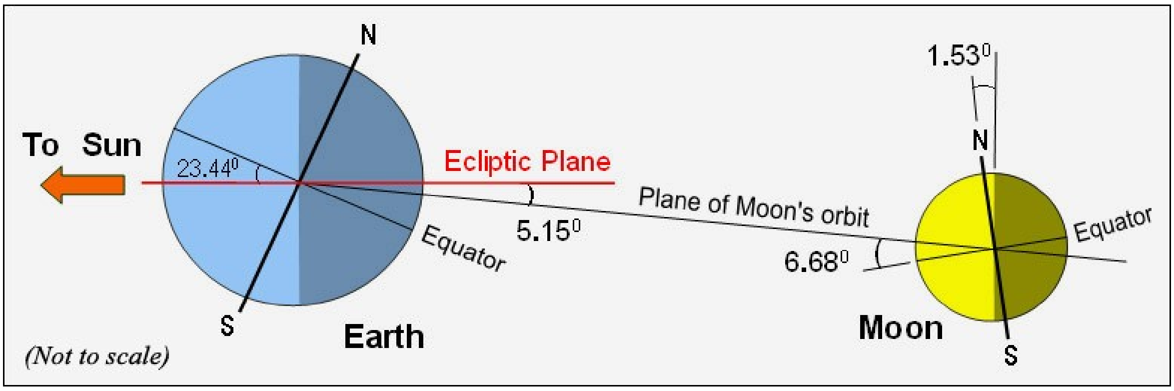
Tilting of the Moon's terminator, as seen from Earth

Between moonrise and moonset, the Moon in the sky seems to tilt differently from the vertical. This is because our eyes see the sky as its projection on the celestial sphere, and the Moon appears to move in a curved path above the horizon. Such perception is illustrated by a binocular watch on 2003 August 5 Hong Kong. At 3 pm, the first-quarter Moon was visible in daylight at an altitude of 30°. It was rising in south-east with the upper end of the terminator tilting to the observer's left hand side. At transit when the Moon was highest above horizon, the terminator looked almost vertical. Thereafter the Moon was sinking westward, and the terminator tilted to the right.



Tilting of the Moon's rotation axis, as seen from space

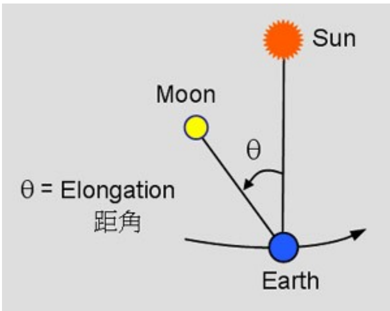
The Moon's rotation axis is tilted 1.53° from the vertical of the ecliptic (plane of the Earth's orbit). Hence the Sun always appears very low above the horizon at the poles of the Moon. Some craters at the poles are so deep that sunlight probably never reaches their bottoms. Based on the spectroscopic surveys by spacecraft, scientists speculate upon the existence of water-ice on the Moon (e.g. from impacts of water-bearing comets), especially an area of about 100 km diameter around the south pole which contains permanently shadowed depressions and where the temperature does not exceed -180° C. So far traces of water-ice on the Moon are not affirmative. (http://science.nasa.gov/newhome/headlines/ast03sep99_1.htm)



Brightness of the Moon

Due to the elongation of the Moon from the Sun, the brightness of the Moon changes against its age in a lunation. Maximum brightness is at the full moon, equivalent to visual magnitude of about -12.7. Minimum brightness is at the crescents, see the following table. A moon-filter is sometimes needed to suppress the lunar brightness in visual observations.

Note that the eastern half of a Moon disc is slightly brighter than the western half, and that at ages approaching full illumination, the Moon rises in the afternoon and is naked-eye visible in daylight.



Moon Age (days)	3	5	7	First Qtr.	9	11	13	Full Moon	17	19	21	Last Qtr.	24	26	28
Elongation	37°	61°	85°	90°	110°	134°	158°	180°	207°	232°	256°	270°	293°	317°	341°
Relative Brightness	0.7	3	6	8	16	30	58	100 (full illumination)	49	26	13	8	4	1	0.2

Notes on lunar observation

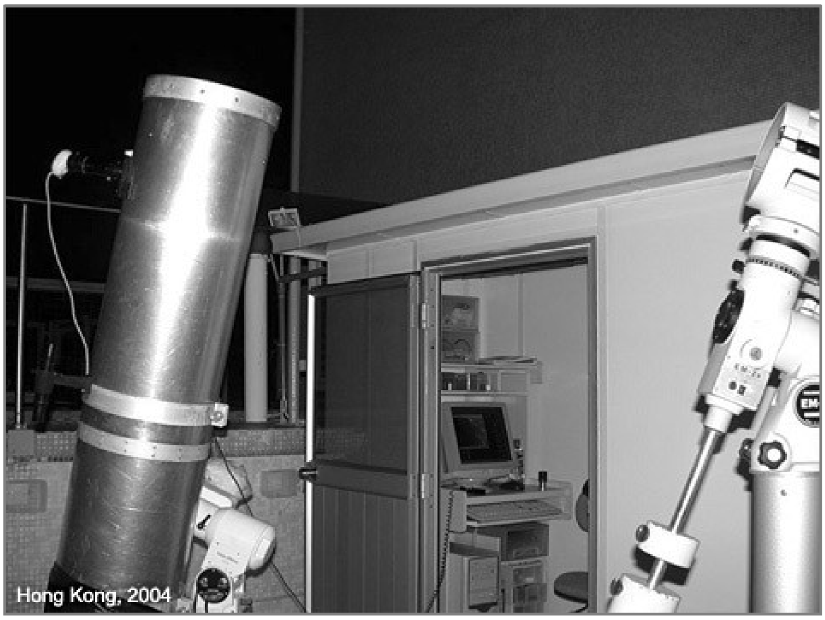
This book presents lunar images taken with small and medium-sized telescopes. They indicate that the requirements of a Moon telescope are not critical except personal preference. The author's preference tends to have three:

- A 4-inch (102 mm) f/8 refractor for portability, the front objective is fluorite for supreme sharpness in visual enjoyment.
- A 5-inch (128 mm) f/8 refractor for imaging at wide field (happened to be fluorite too).
- A 10-inch (254 mm) f/6 Newtonian for imaging lunar details. It is most frequently used by the author.

The 5- and 10-inch are not supposed portable. Newtonian bigger or longer than 10-inch f/6 is seldom used because the observer needs to "stand high on stool" by the eyepiece (sounds to cause falling accident), and the seeing is not always supportive. The C9 (Celestron 9.25-inch Schmidt-Cassegrain) is sometimes used when the 10-inch Newtonian is unavailable, e.g. recoating of mirror. In the author's experience, a collimated C9 gives best optics among all Celestron Schmidt-Cassegrain, but it never outperforms a quality, equal-aperture Newtonian. The Celestron kit of vibration suppression pads is highly recommended. It kills vibration residue of the telescope almost instantly, and has been tested equally well for loading as heavy as 150 lbs (68 kg).

Try to observe the Moon even when the seeing is mediocre, because the peculiar view of a landscape lasts for few hours only (e.g. the "golden handle" and wrinkle ridges of Sinus Iridum MAP 18). If this session is missed, the observer must wait at least 4 weeks to meet similar view.

Moon after the last quarter rises late at night or even at dawn. Be relaxed before observation. It is advantageous to plan an observing session in advance, such as where the lunar terminator and libration are expected, and how high is the Moon in the sky. Always check the collimation of the optics and allow them to reach thermal equilibrium; these are essential for high magnification works.



The author's current site for lunar (and planetary) observation.

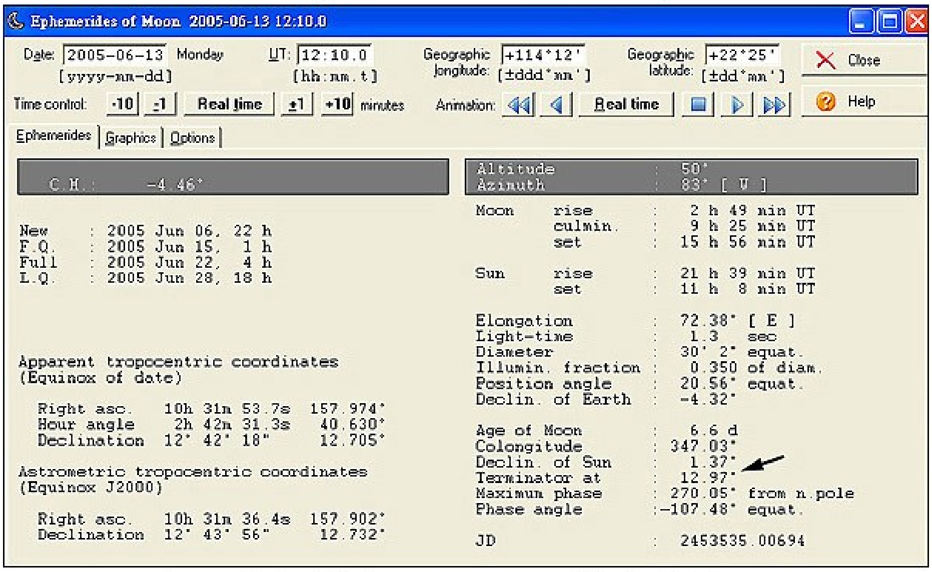
Left is a 10-in (254 mm) f/6 Newtonian; right is a moveable mount for 4- to 5-in refractors. The site is at open roof of a 32-storey building in the urban area of Hong Kong. A high wall behind the site chamber blocks the east.

Here is an example to plan observing the features in Map 8 where Apollo 11 landed on their vicinity. They include crater Sabine, Ritter, Lamont, Armstrong, and the nearby domes, rilles and wrinkle ridges.

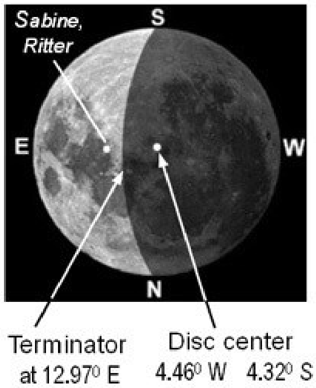
****** EXAMPLE ******

Reference No. 13 suggests a freeware *WinJupos* for moon ephemeris, a table giving the predicted positions of the Moon (and planets). Download this freeware from Internet. After setup, select the object “Moon” in the dialogue window. Input the date, time and geographic location similar to below.

Moon Ephemeris from WinJupos



The predicted Moon
2005.06.13 12:10 UT



+ means East or North. - means West or South.

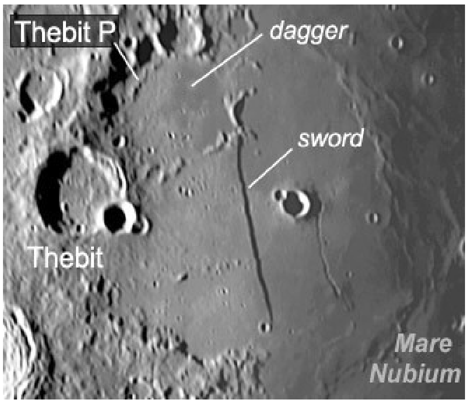
WinJupos then predicts that at the given Universal Time and geographic location, the Moon is 50^0 above horizon and is sinking. Its C. M. (***Central Meridian***) is -4.46^0. The negative C. M. means the Moon disc is centered at longitude 4.46^0 W, causing 4.46^0 extra zone of libration** along the west limb. However the 6.6-day Moon age makes the west side too dark to be seen. Similarly, ***Declination of Earth*** -4.32^0 implies that the Moon disc is centered at latitude 4.32^0 S, causing 4.32^0 extra zone of libration near the south pole. WinJupos also predicts ***Terminator at*** 12.97^o E, so the Sun is illuminating Sabine (20^0 E) and Ritter (19^0 E, Map 8) at favorable observing angle. The angle is also low enough to reveal the wrinkle ridges around Lamont. On the other hand, crater Armstrong is known small (diameter 5 km or 2.5 arcseconds angular). It is easier to spot Armstrong with bigger telescopes, as well as the domes and rilles in the map.

In the above table, ***Terminator at*** 12.97^0 is just an alternative quote of ***Colongitude*** 347.03^0, because both angles always sum to 360^0, 180^0 or 0^0. The colongitude** tells the Sun’s illuminating angle from which one can estimate a feature height from the length of its shadow. Examples to estimate a feature height on the Moon are given in http://paganastronomy.net/lunarcrater.html.

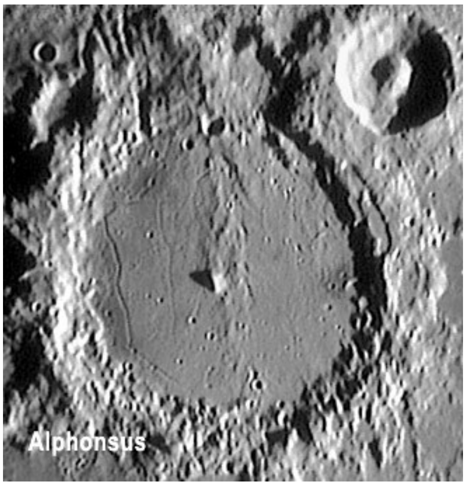
WinJupos is not the only program available. There are other sources of moon ephemerides.

** *Libration and Colongitude are elaborated in the* Event 1 *and* Event 2 *pages respectively.*

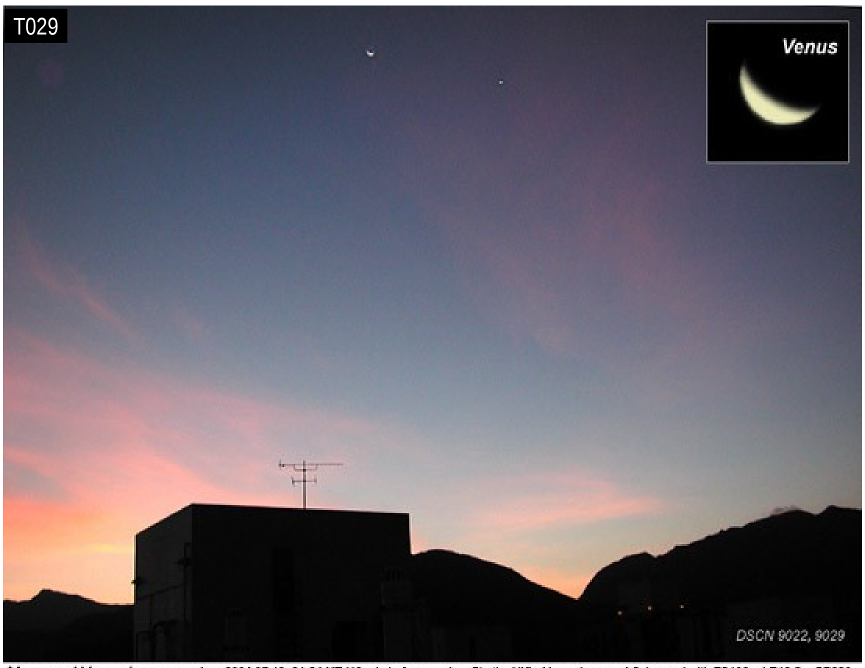
IMAGINATION helps tremendously in lunar observation. Give a name or token to your feature favorite. It will not appear in standard Moon atlas but is a good marker of memory. For instance, the Straight Wall (***Rupes Recta***) can be thought as a sword with a handle at the southern end. This handle is also the wall portion of the "ghost crater" ***Thebit P***, see figure at right or Map 12. The floor of Thebit P is shaded by a pattern of darker lava which resembles a dagger. The combination is then a sword and a dagger side by side on the edge of Mare Nubium.



The imagination may be extended to crater ***Alphonsus,*** see figure at right or Map 12. A close look at its floor shows three small, dark lava patches along the inner rim, and there are clefts and craterlets on the patches. Such appearance suggests that it might be a remnant of volcanism, probably very young by geologic age. If the Moon's interior is not totally inert, someday volcanic outgases may leak through the craterlets. They would be ionized by sunlight, becoming luminously noticeable as some kind of LTP (Lunar Transient Phenomena). LTP are short durations of brightness, color or shape changes on the lunar surface. They have been reported for decades even during the Apollo Missions, although a lot of them remain controversial. More informations of LTP are available from Reference No. 29 and 30.



In Map 1, there is a page on three families of Moon rocks. The mare basalt looks dark. The anorthosite, which exists in highlands or beneath the mare basalts, is light-colored. The breccia is a cemented type caused by the heat and pressure of a meteorite impact. This rock scenario may inspire speculation about the peculiarities of some surface features. Reference No. 16 -18, 31 and 32 help to understand the geology of the Moon. A simple but good introduction of lunar geology is given in http://volcano.und.edu/vwdocs/planet_volcano/lunar/Overview.html.

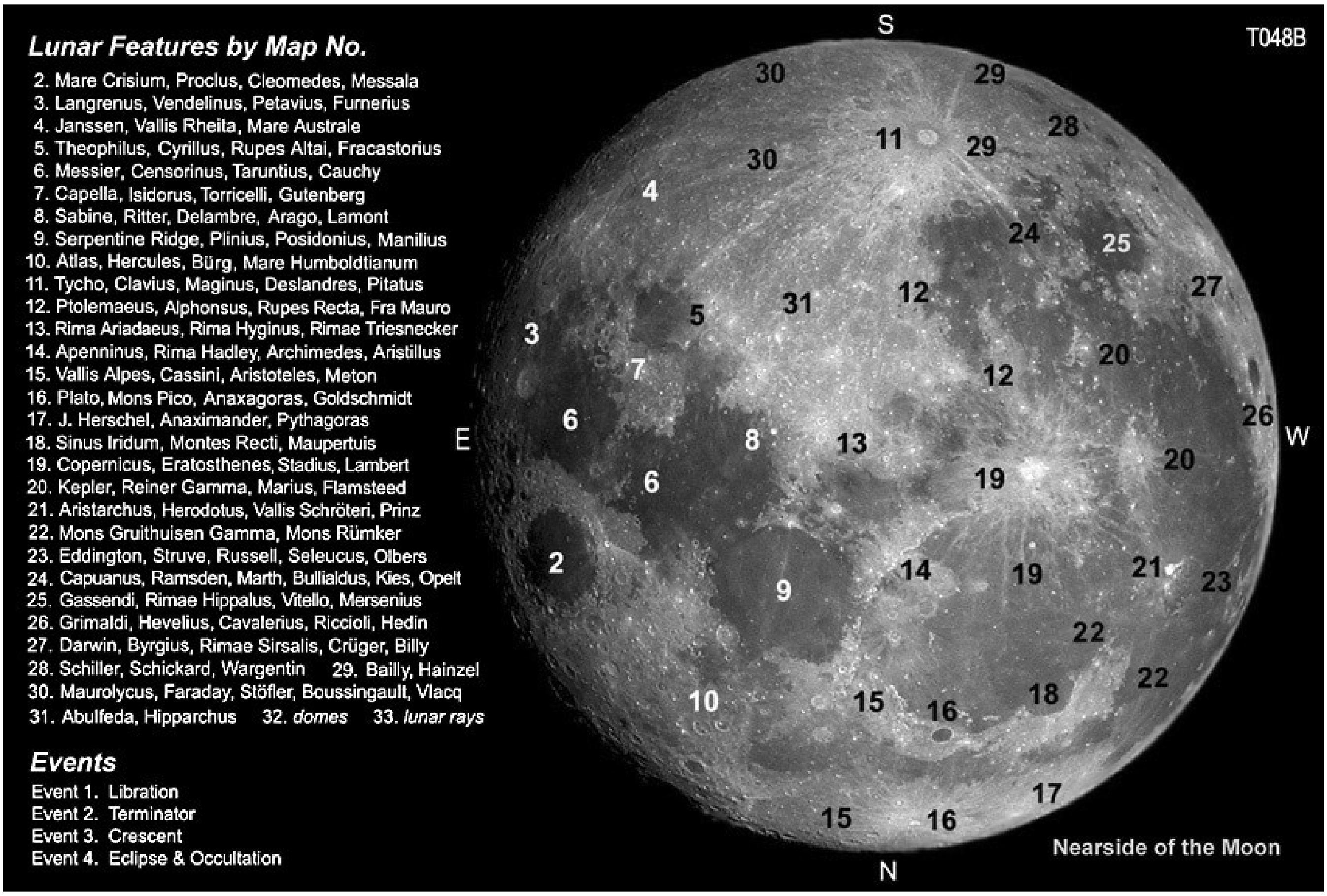


Moon and Venus in crescents 2004.07.13 21:34 UT (13 min before sunrise, Shatin, HK). Venus is mag -4.5, imaged with FS102 + LE12.5 + CP990.

The Moon & Venus in Crescents

Taken at the author's home roof in dawn of 2004.07.13, after a night of observing the 26-day old Moon. Venus appears as a bright morning star about 7 degrees from the Moon crescent, however telescope shows Venus is a crescent too.

2. Lunar Features and Events



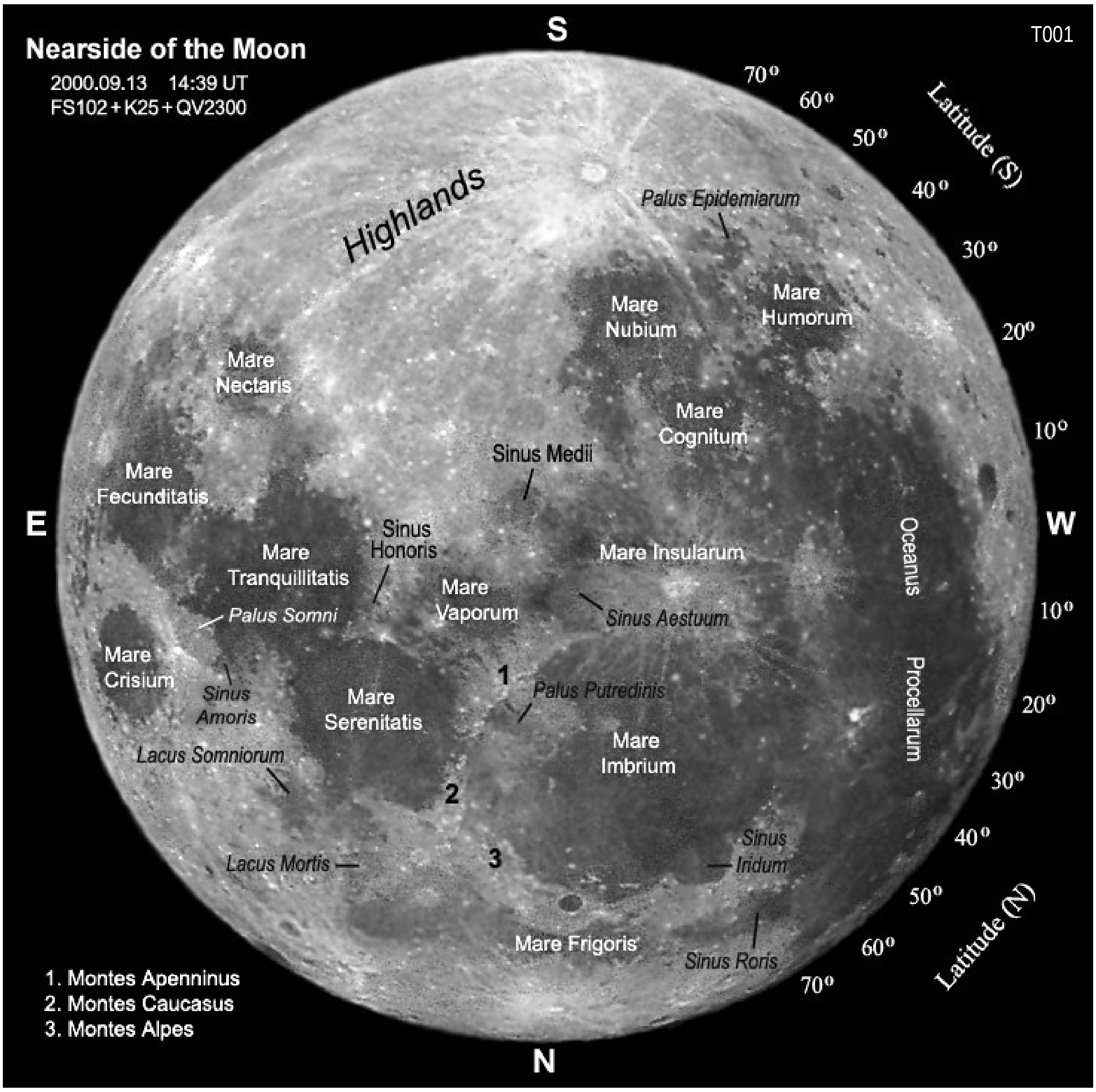
- All lunar photographs in **MAP** and **EVENT** pages are south up unless otherwise noted.
- Moon ages when the lunar features were photographed**:**

Map No.	Lunar Features	Moon Age *(days)*																		
		~4	5	6	7	**8**	9	10	11	12	13	14	**15**	16	17	18	19	20	21	**22**
2	Mare Crisium, Proclus, Cleomedes, Messala				o						o		o	o		o				
3	Langrenus, Vendelinus, Petavius, Furnerius												o	o	o					
4	Janssen, Vallis Rheita, Mare Australe		o					o					o		o					
5	Theophilus, Cyrillus, Rupes Altai, Fracastorius			o											o	o	o			
6	Messier, Censorinus, Taruntius, Cauchy		o		o	o								o		o				
7	Capella, Isidorus, Torricelli, Gutenberg		o	o												o				
8	Sabine, Ritter, Delambre, Arago, Lamont			o												o	o	o		
9	Serpentine Ridge, Plinius, Posidonius, Manilius		o		o		o						o		o	o	o	o		
10	Atlas, Hercules, Bürg, Mare Humboldtianum	o	o	o									o	o	o	o				
11	Tycho, Clavius, Maginus, Deslandres, Pitatus						o	o	o			o	o						o	o
12	Ptolemaeus, Alphonsus, Rupes Recta, Fra Mauro					o	o	o											o	o
13	Rima Ariadaeus, Rima Hyginus, Rimae Triesnecker			o	o		o	o								o			o	o
14	Apenninus, Rima Hadley, Archimedes, Aristillus				o		o	o											o	
15	Vallis Alpes, Cassini, Aristoteles, Meton				o	o	o										o		o	
16	Plato, Mons Pico, Anaxagoras, Goldschmidt						o	o		o		o							o	o
17	J. Herschel, Anaximander, Pythagoras								o	o										
18	Sinus Iridum, Montes Recti, Maupertuis							o	o	o										
19	Copernicus, Eratosthenes, Stadius, Lambert						o	o	o	o										
20	Kepler, Reiner Gamma, Marius, Flamsteed								o	o		o								
21	Aristarchus, Herodotus, Vallis Schröeteri, Prinz								o	o	o		o							
22	Mons Gruithuisen Gamma, Mons Rümker									o	o									
23	Eddington, Struve, Russell, Seleucus, Olbers											o	o							
24	Capuanus, Ramsden, Marth, Bullialdus, Kies, Opelt						o	o	o											
25	Gassendi, Rimae Hippalus, Vitello, Mersenius							o	o	o										
26	Grimaldi, Hevelius, Cavalerius, Riccioli, Hedin										o	o	o							
27	Darwin, Byrgius, Rimae Sirsalis, Crüger, Billy									o	o	o								
28	Schiller, Schickard, Wargentin, Phocylides									o	o	o	o							
29	Bailly, Longomontanus, Wilhelm, Mee, Hainzel							o	o	o		o								
30	Maurolycus, Faraday, Stöfler, Boussingault, Vlacq		o		o		o	o									o	o		
31	Abulfeda, Hipparchus, *crater chains*				o	o	o												o	

Maria, Montes and Moon Rocks

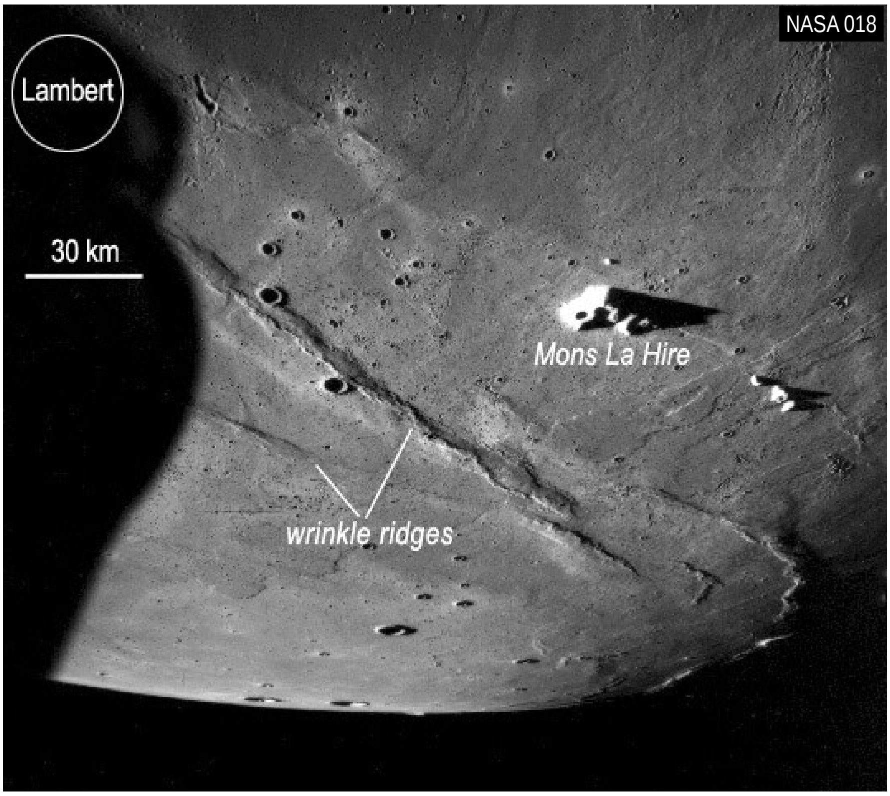
The Moon keeps the same face towards the Earth. The large dark area of this face (the nearside) is termed *Mare*, the Latin for "Sea". The term was originally used in the 17th century, when the dark plains of the Moon were thought to be water. Maria are physically smooth lowlands of solidified lava, typically 500~2000 m thick over the lunar crust. They erupted 3~4 billion years ago and are younger than the surrounding highlands.

Plains of relatively small areas are Latinized as *Sinus* (Bay), *Lacus* (Lake) or *Palus* (Marsh). *Montes* are "mountain ranges". Three huge montes run along the eastern edge of Mare Imbrium − Montes Apennius, Montes Caucasus & Montes Alpes as shown in T001. They are part of the rising rim of the impact basin that holds the lava floor of Mare Imbrium. The map projection is orthographic, with 0^0 longitude at S-N and latitudes marked approximately along the west limb.



Mare Cognitum	Known Sea 知海	***Mare Nubium***	Sea of Clouds 雲海	***Palus Putredinis***	Marsh of Decay 凋沼 (腐沼)
Mare Crisium	Sea of Crises 危海	***Mare Serenitatis***	Sea of Serenity 澄海	***Palus Somni***	Marsh of Sleep 夢沼
Mare Fecunditatis	Sea of Fertility 豐富海	***Mare Tranquillitatis***	Sea of Tranquillity 靜海	***Sinus Aestuum***	Bay of Billows 暑灣 (浪灣)
Mare Frigoris	Sea of Cold 冷海	***Mare Vaporum***	Sea of Vapors 汽海	***Sinus Amoris***	Bay of Love 愛灣
Mare Humorum	Sea of Moisture 濕海	***Oceanus Procellarum***	Ocean of Storms 風暴洋	***Sinus Honoris***	Bay of Honor 榮譽灣
Mare Imbrium	Sea of Rains 雨海	***Lacus Mortis***	Lake of Death 死湖	***Sinus Iridum***	Bay of Rainbows 虹灣
Mare Insularum	Sea of Isles 島海	***Lacus Somniorum***	Lake of Dreams 夢湖	***Sinus Medii***	Central Bay 中央灣
Mare Nectaris	Sea of Nectar 酒海	***Palus Epidemiarum***	Marsh of Epidemics 疫沼	***Sinus Roris***	Bay of Dew 露灣

Maria on the east limb are given in Event 1 pages.

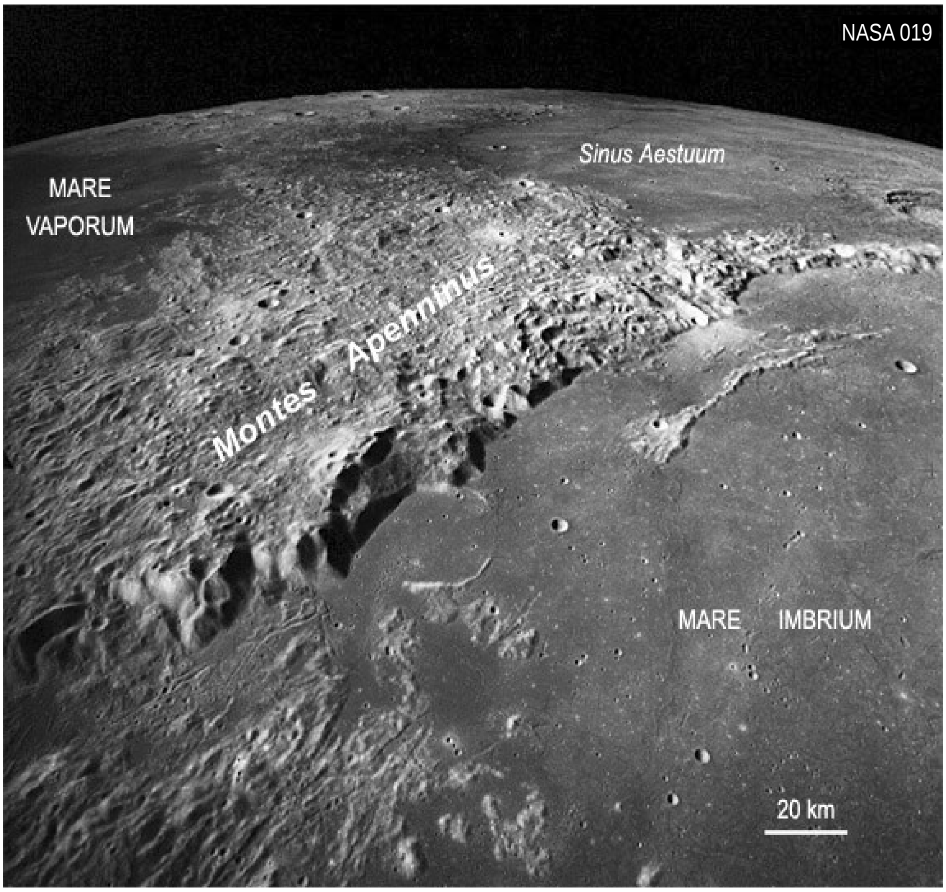


Close-up view of Mare Imbrium and its wrinkle ridges

An oblique view taken by the crew of Apollo 15 in July 1971 when they flew over the southern region of Mare Imbrium. South is up. Ancient lava flow (now solidified) on the mare floor is evident. Prominent wrinkle ridges are also seen in the middle of the picture. Wrinkle ridges are common in lunar maria, height up to about 200 m. Quite often, they tend to group like concentric ripple rings along the inner edge of a mare. Wrinkle ridges may have resulted from surface shrinkage following the cease of volcanism, or buckling of the lunar crust due to the weight of accumulating lava in the mare.

The isolated massif *is Mons La Hire, which is about 1500 m high, base 10 x 20 km. The crater Lambert happens behind an obstacle in front of the camera. A similar telescope view is given in* Map18*.*

(NASA image AS15-1555.)



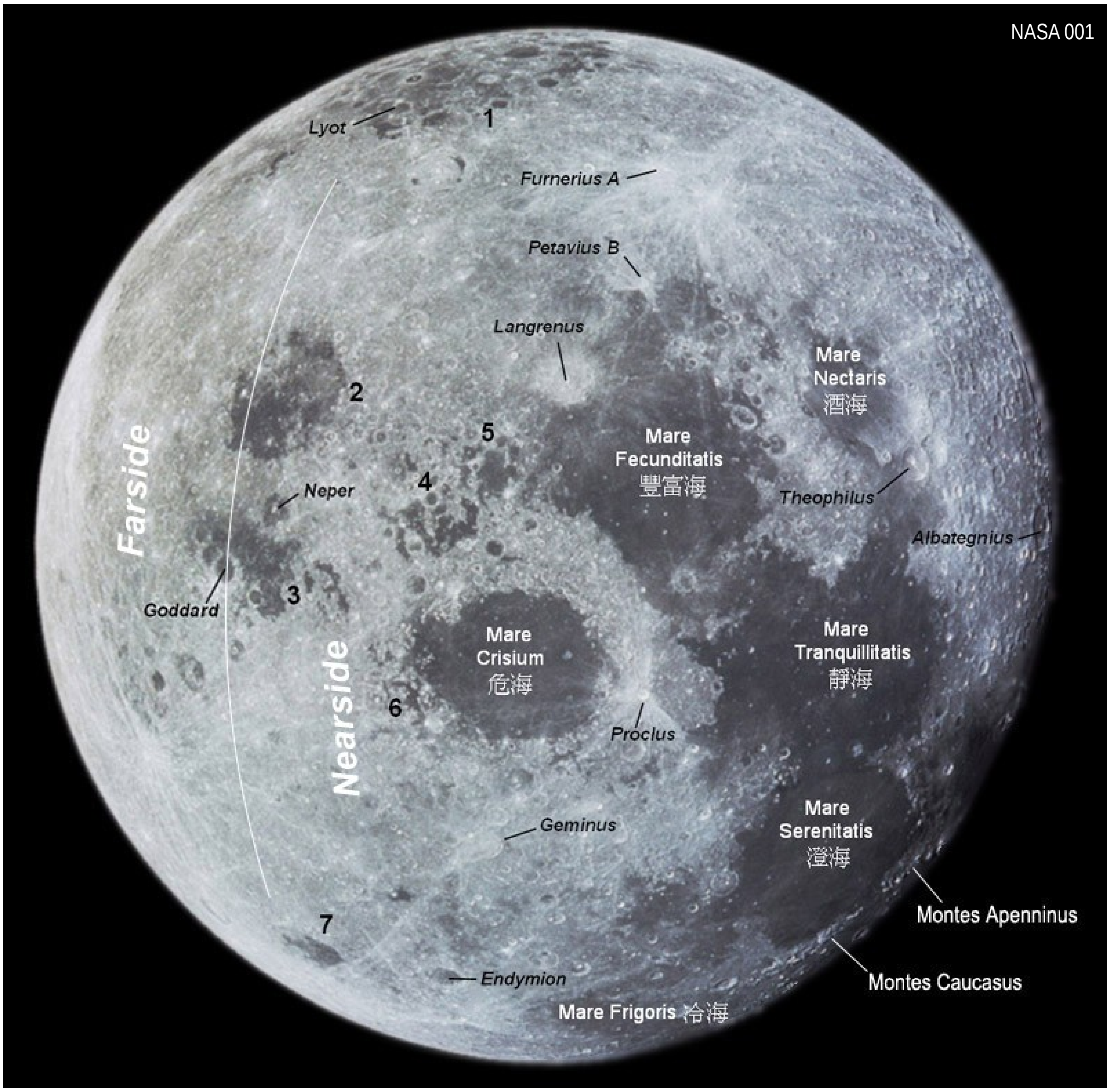
Close-up view of Montes Apenninus

A picture by Apollo 17 crew in December 1972. Montes Apenninus, which forms part of the main rim of Mare Imbrium, is the largest mountain ranges on the nearside of the Moon. The peaks of Montes Apennimus are 5000 m higher than Mare Imbrium. Compare this image with the Apenninus in Map 14*.*

(NASA image AS17-2432)

The Moon seen by Apollo 11 crew on return trip, 1969 July (NASA AS11-44-6667)

This view is not visible from Earth-based telescopes. Mare Crisium and Mare Fecunditatis now appear close to the center of the disc, and Maria Nos. 1 to 7 (seen obliquely along the east limb of the Moon from Earth) are positioned in better perspective. The curve passing through Goddard is approximately at longitude 90⁰ E which separates the Moon's nearside from its farside.



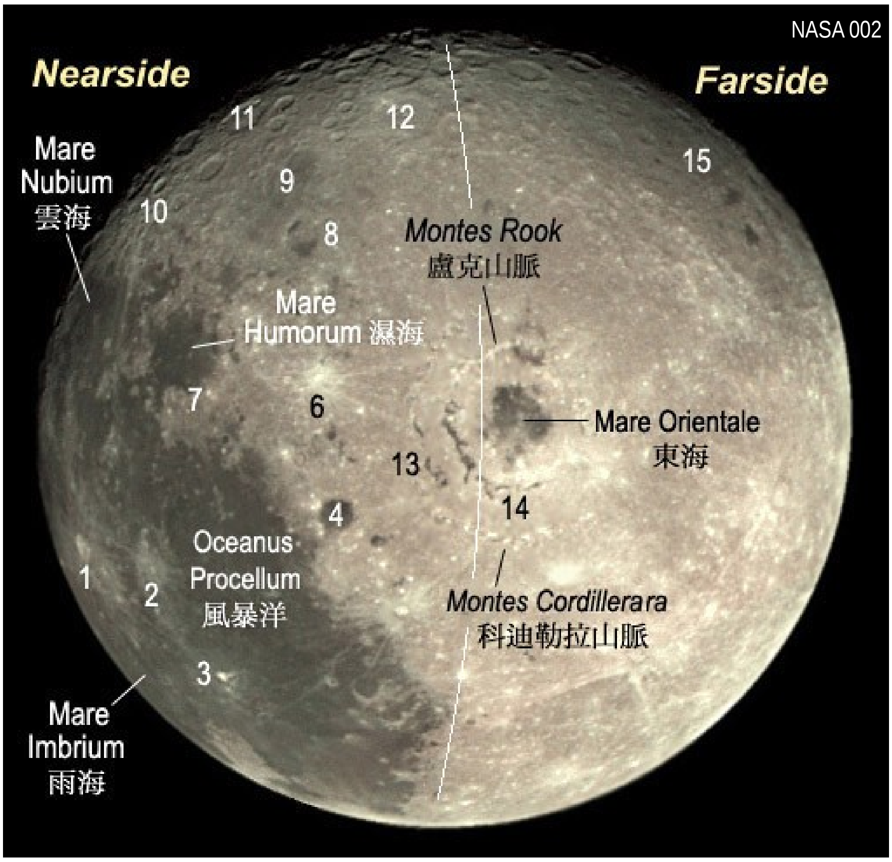
1. Mare Australe (Southern Sea) 南海
2. Mare Smythii (Smyth's Sea) 史密斯海
3. Mare Marginis (Border Sea) 界海
4. Mare Undarum (Sea of Waves) 浪海
5. Mare Spumans (Foaming Sea) 泡海
6. Mare Anguis (Serpent Sea) 蛇海
7. Mare Humboldtianum (Humboldt's Sea) 洪堡海

Note the shape of Mare Crisium in above image. It is more circular compared to the oblique view in Image T001.

MAP 1

View from Galileo spacecraft as it flew past the Moon on 1990 Dec 9

Mare Orientale (Eastern Sea) is near the center of the picture, but on Earth it is hidden behind the west limb of the Moon and is partially visible only at very favorable librations. Mare Orientale is the lava-flooded part of an impact basin, about 300 km in diameter. Its outer vicinity is encircled by two concentric mountain ranges (Montes Rook and Montes Cordillera). The whole mare is located on the farside, at 93^0 W 19^0 S.



Impact Craters
1. Copernicus 哥白尼
2. Kepler 開普勒
3. Aristarchus 亞利斯塔克
4. Grimaldi 格里馬第
5. Sirsalis 希薩利斯
6. Byrgius 伯朱斯
7. Gassendi 加桑迪
8. Schickard 西卡爾德
9. Schiller 席勒
10. Tycho 第谷
11. Clavius 克拉維
12. Bailly 貝利

13. Lacus Autumni (Autumn Lake) 秋湖
14. Lacus Veris (Spring Lake) 春湖
15. South Pole - Aitken (impact basin) 南極艾肯隕擊盆地

The curve passing through the edge of Mare Orientale is approximately at longitude 90^{0}W which separates the Moon's farside from its nearside.

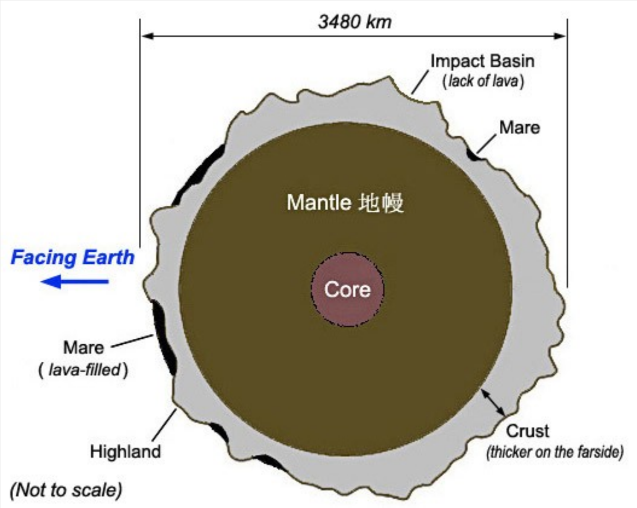
By comparing the nearside of the Moon (T001) with the two spacecraft images (NASA 001 & 002), it can be seen that the dark maria are concentrated on the nearside but the farside is mostly brighter highlands with very few maria. It also shows, in general, maria tend to be circular in shape. This suggests that, like craters, the maria were firstly created by colossal impactors which struck the Moon some billion years ago, thus forming basins. The basins subsequently flooded with lava that flowed out from the Moon's interior through cracks in the crust, forming the maria that appear in image T001. An illustration of maria formation and Moon rocks are given in following pages, also a table of the Moon's geologic time scale in Appendix – Moon Data.

A question is why maria on the nearside are much more than the farside. One belief is that the nearside crust is thinner. It is easier to eject magma (non-solidified lava beneath the crust) through cracks of this side after colossal impacts. Magma is a relatively dense material; its flooding on the lunar surface makes the nearside hemisphere slightly more massive than the farside. Over time, the Earth's gravity must have dragged the Moon until its more massive nearside pointed towards the Earth.

In the above image, No.15 marks the South-Pole Aitken of the lunar farside. It is the largest impact basin in the solar system, diameter 2300 km and depth 12 km. A research suggested that the shock waves from this impact traversed the Moon's interior to the opposite face, producing part of the cracks in the nearside crust. The South-Pole Aitken is supposed responsible for part of the maria formation. *(http://researchnews.osu.edu/archive/moonboom.htm)*

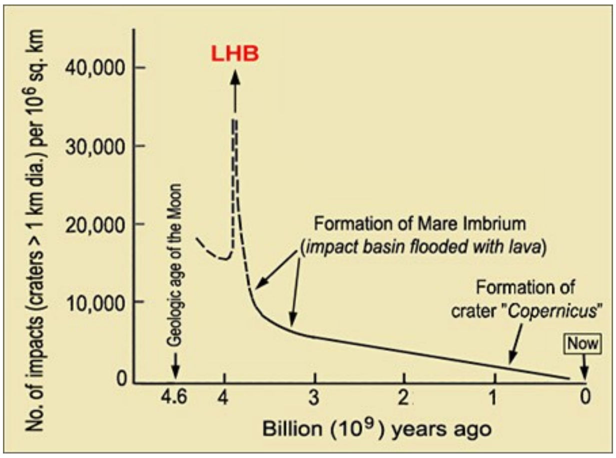
Cross-section of the Moon's interior

The Moon's nearside crust has an average thickness of 60 km, and the farside crust is roughly 50 % thicker. It is easier to eject magma (non-solidified lava) through cracks of the nearside crust after colossal impacts, hence creating vast areas of dark plains or maria we see from the Earth. The farside has very few maria due to thicker crust. The lack of global magnetic field on the Moon's surface suggests that the present Moon may or may not have a metallic-iron core. If it has, the core is small, probably less than 700 km in diameter. The mantle is the zone lying below the crust. It is believed plastic now but was quite fluid 3 ~ 4 billion years ago.



Moonquakes: *The lunar crust is about 2 times thicker than the Earth's continental crust. Therefore it is not surprising that moonquakes on the surface are less intensive than earthquakes. Indeed, almost all moonquakes are very minor, less than magnitude 2 in the Ritcher Scale. The lack of plate tectonics on the Moon crust also suggests that moonquakes are less frequent. Roughly 3000 moonquakes are detected per year, whereas hundreds of thousands of earthquakes are recorded per year with similar equipment on the Earth. Because of the tidal force of the Earth acting on the Moon, the occurrence of moonquakes is maximum during perigee. (Mysterious Moonquakes: http://science.nasa.gov/headlines/y2006/15mar_moonquakes.htm?list137588)*

Lunar Impact History

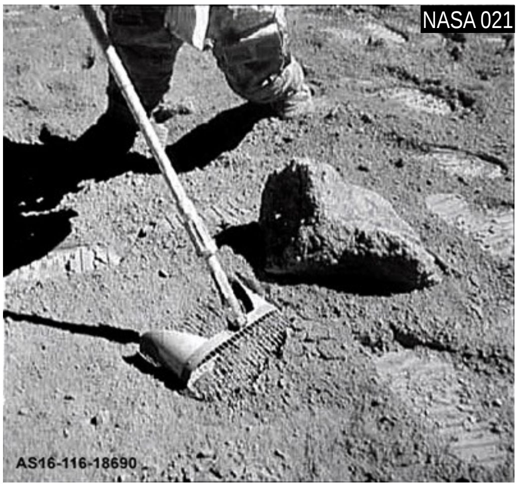


Left: *The impact rate on the Moon can be deduced from crater counts. Generally it is much higher during the first 0.8 billion years of lunar history. The high initial impact rate is probably due to early stages of planetary accretion, or fragmentation of nearby asteroids. The exact cause of early bombardment is uncertain but it is likely that the impact rate increased abruptly at about 3.9 billion years ago, a transient stage known as Late Heavy Bombardment (LHB, http://www.swri.org/9what/releases/2005/Spots.htm). Following the LHB is an exponential drop of impact rate between 3.9 and 3.2 billion years ago. In this period, many impact basins of the nearside flooded with lava forming the maria. Since then the lunar impact rate has been quite slow. The maria and mountains we see today remain nearly same status as 3.0 billion years ago.*

Lunar Regolith

Although the impact rate to produce craters is slow today, the airless Moon is still under continuous bombardment by countless micrometeoroids, cosmic rays and charged particles of the solar wind. As a result, a layer of loose and broken rock and dust, termed regolith 浮土 *, has accumulated 3 to some tens of meters thick over the lunar crust. The right picture from Apollo 16 Mission shows the astronaut's bootprints on the lunar regolith. He is dragging a rake through the regolith to collect rock fragments. Despite the "light" weight of the astronaut under low surface gravity (1/6 that of the Earth or about 25 kg on the Moon), his bootprints appear quite deep suggesting that the regolith is loose indeed. It is this loose layer that scatters sunlight making the full moon very bright.*

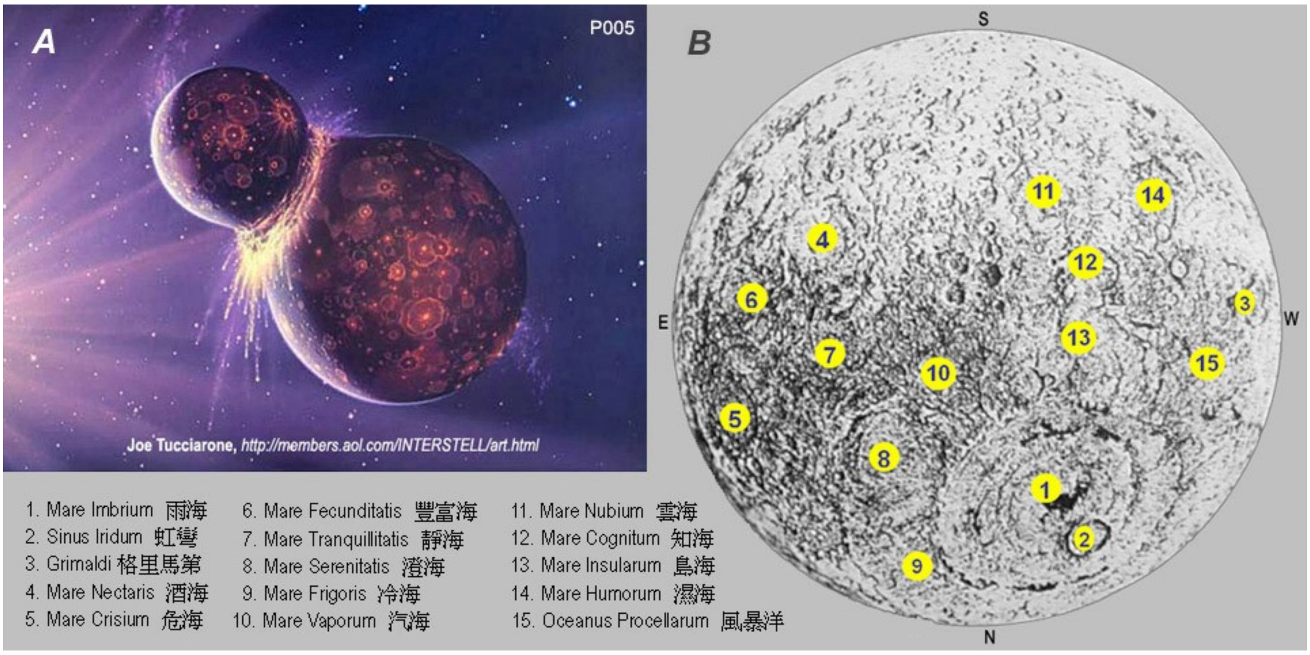
The dusty particles in lunar regolith are known as "moondust". They are electrostatically sticky, as noted by the Apollo astronauts in their missions (Ref. No. 35). Lunar regolith also contains traces of small black glass beads, size 1 mm in average. These beads were produced by melting due to the heat and pressure of micro bombardment.



Maria Formation

A: *4.6 billion years ago, the proto-Earth rotated rapidly at few hours per day only. Another proto-planet about the size of Mars stuck the proto-Earth. The debris so created cast into space, then gradually accreted to form the Moon orbiting around the Earth. The giant impact* caused high degrees of melting, resulting *the Moon covered by a global layer of hot magma possibly 100 km thick (the so called* ***magma ocean****).*

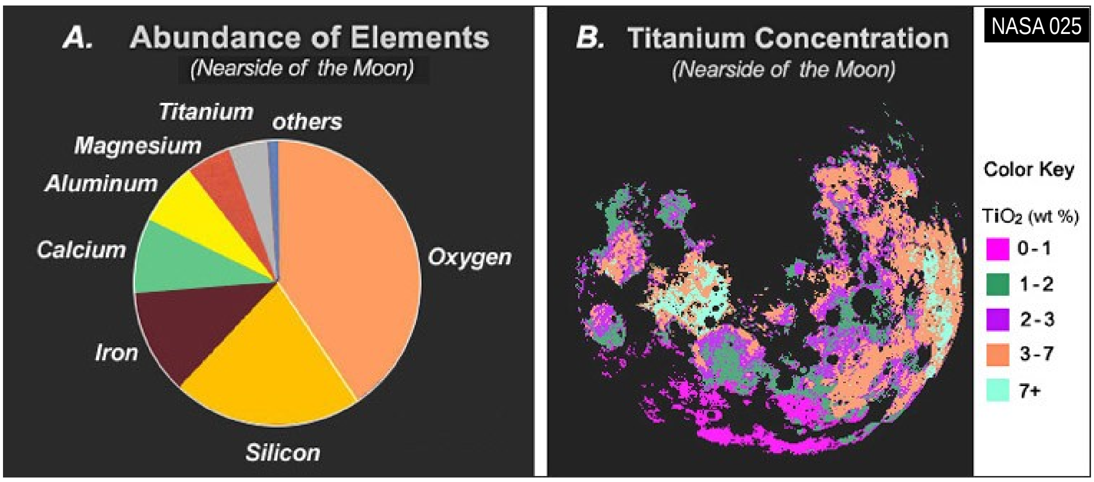
B: *About 0.7 billion years after the giant impact, the Moon appeared as shown. Its surface had somewhat solidified while bombardment by colossal impactors continued.* ***Impact basins*** *several hundred km or larger in diameter formed at the impact sites. A number of them subsequently flooded with lava, forming the dark* ***maria*** *we see today. The number label corresponds to the name of the overlaying mare, oceanus or sinus.*



Abundance of Elements

A: *The abundance of elements on nearside surface of the Moon is shown by a statistical pie chart. These elements do not stand alone but are bonded to oxygen as oxides, so iron may exist as FeO and titanium as TiO_2.*

B: *Like Earth, the abundance of elements on the Moon actually varies from place to place. Map B, derived from NASA lunar exploration (Reference No. 32), shows the titanium / TiO_2 concentration in the maria on the nearside of the Moon. Highland areas have been masked out in black. Generally lunar maria contain titanium at different weight percentages. They can be grouped as high-titanium (more than 7 % TiO_2), low-titanium (2-7 % TiO_2) and very-low-titanium (less than about 2 % TiO_2).*



Moon Rocks

Moon rocks are much similar to terrestrial but completely free of water molecules. This is a strong support to the giant impact theory (previous illustration) that the Moon had been molten in its infant stage.

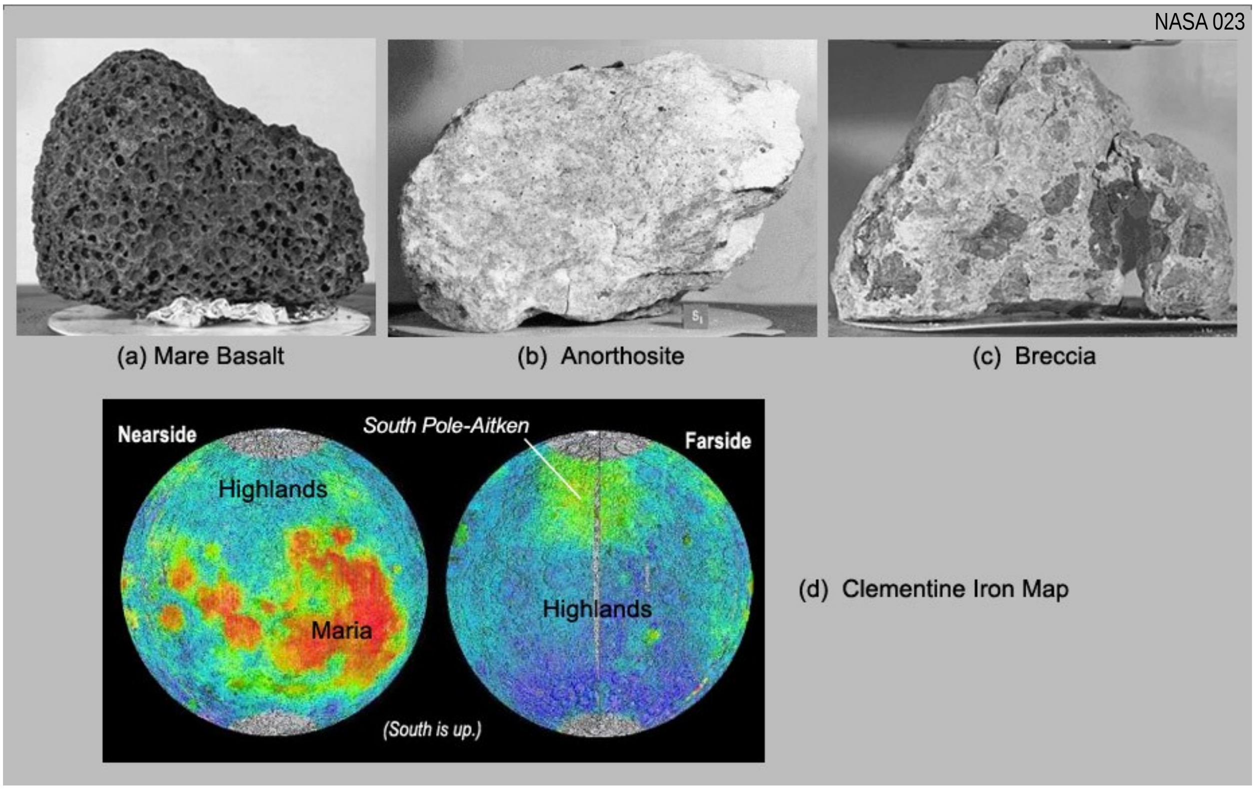
Among the moon rocks sampled from the Apollo Missions, there are two distinct families: ***mare basalt*** 玄武岩 *in the lava plains and* ***anorthosite*** 斜長岩 *in the mountainous highlands. The mare basalt is mostly 3.2 ~ 4.0 billion years old whereas the anorthosite is older, in range of 4.0 ~ 4.6 billions years. Mare basalt and anorthosite are just broad terms in geology; they can be subdivided into various rock types depending on their mineral concentrations.*

Figure (a) shows a sample of dark, vesicular mare basalt. It is these basaltic rocks and overlaying material of similar composition that make the maria look dark in telescopes. The rock is vesicular because of many holes in its body. It indicates that gas must have dissolved under pressure in the lava from which this rock solidified. When the lava reached the airless Moon's surface, bubbles formed as the gas pressure dropped. The dark color is a characteristic of mare basalt. It implies enriched contents of heavier elements like iron and titanium. Compare Figure (a) with (b) which shows another sample collected from the lunar highlands. The rock, so called anorthosite, is rich in silicon, calcium and aluminum. Hence it is light-colored and less dense than iron-rich materials. During the period when the Moon's surface was molten, the less dense anorthosite rose to the top, forming the highlands. The anorthosite is believed to be the most ancient type of moon rocks; it is the material of the original lunar crust. On the other hand, the mare basalt formed from lava flooded on the lunar crust; hence it must be a relatively shallow layer over the anorthosite.

Figure (c) shows another common rock ***breccia*** 角礫岩 *which is not as light-colored as the anorthosite. It is made up of different types of rock fragments cemented mechanically by the heat and pressure of a meteorite impact. The lunar* ***regolith*** 浮土 *(Image NASA 021 in previous page) acts as the cementing agent.*

A unique type of rock ***KREEP*** 克里普岩*, was also sampled in the highlands near the rims of maria. It is rich in potassium (symbol K), rare-earth elements (REE), phosphorus (P) as well as the radioactive thorium and uranium. It is these radioactive elements that had given the heat energy to support the viscous magma in the Moon's interior. KREEP is incompatible to common rock-forming process and hence it floated to the upper lunar crust in the last chemical separation of the magma ocean. The presence of KREEP enables scientists to trace the volcanic history of the Moon.*

By imaging the surface brightness of the Moon at multiple discrete wavelengths, it is possible to map the abundance of elements on the lunar crust. For instance, iron absorbs light mostly around 950 nm whereas titanium absorbs more light near 415 nm. Using such multispectral technique, Clementine spacecraft derived an Iron (FeO) map of the Moon in 1996, Figure (d). The red are the areas of highest iron concentrations; they coincide closely with the maria where molten, iron-rich materials flowed from cracks of the lunar crust in the ancient past. The lowest concentrations of iron are found in blue, which correspond to the highlands. The intermediate iron concentrations are in green. The broadest green region lies on the South Pole - Aitken, a gigantic impact basin in the farside. (



(a) Mare Basalt (b) Anorthosite (c) Breccia

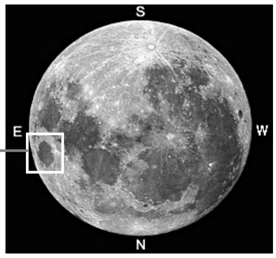
(d) Clementine Iron Map

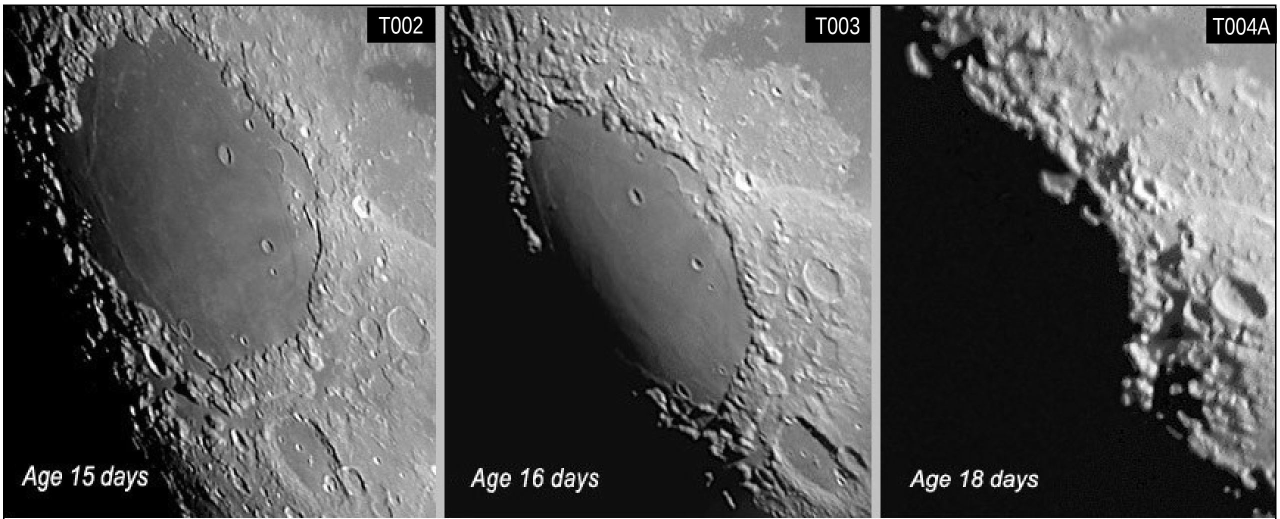
MAP 2

Mare Crisium, Proclus, Palus Somni, Cleomedes, Messala

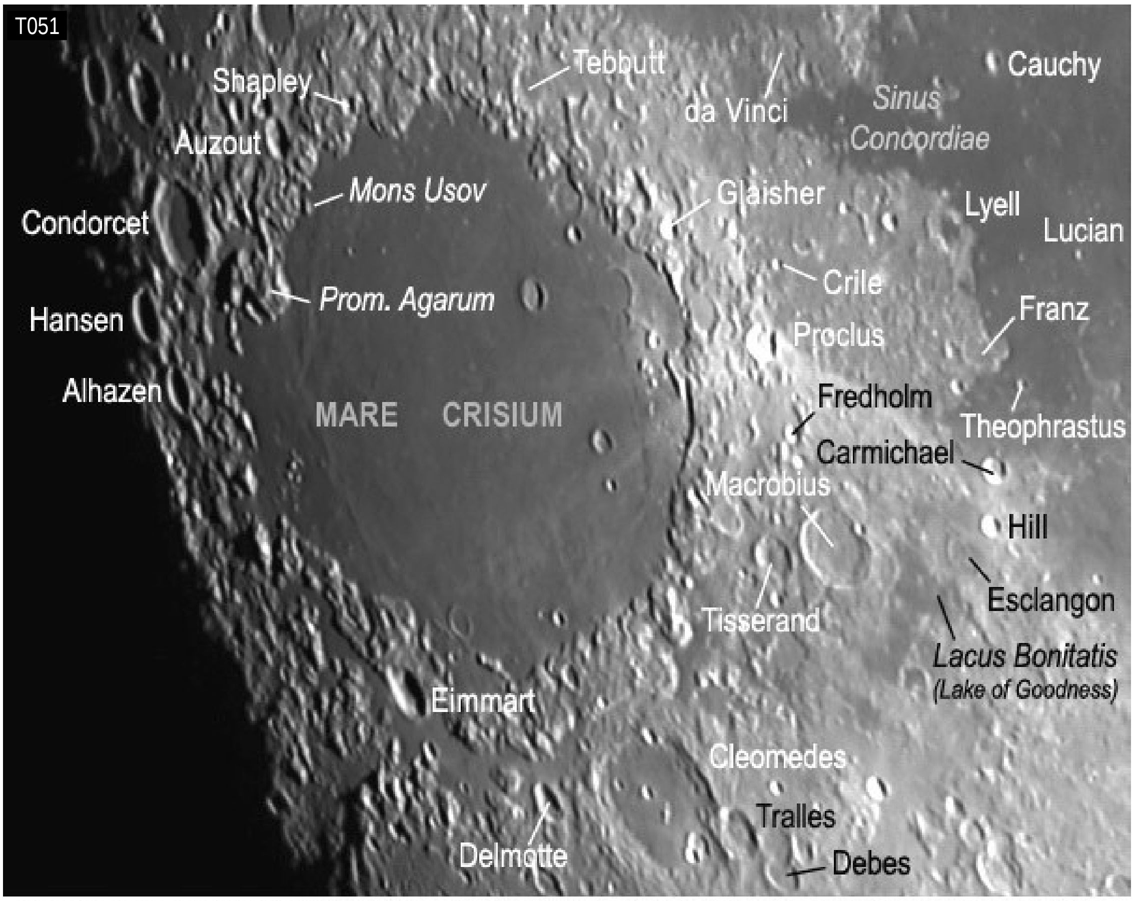
Hatfield 3, 4
Rükl 26, 27, 37, 38, 16

Mare Crisium
59°E 17°N





3 views of Mare Crisium *Left:* 2000.04.20 17:52 UT FS102 *Middle:* 2000.09.15 12:25 UT MK67 *Right:* 2006.11.08 20:06 UT ETX90

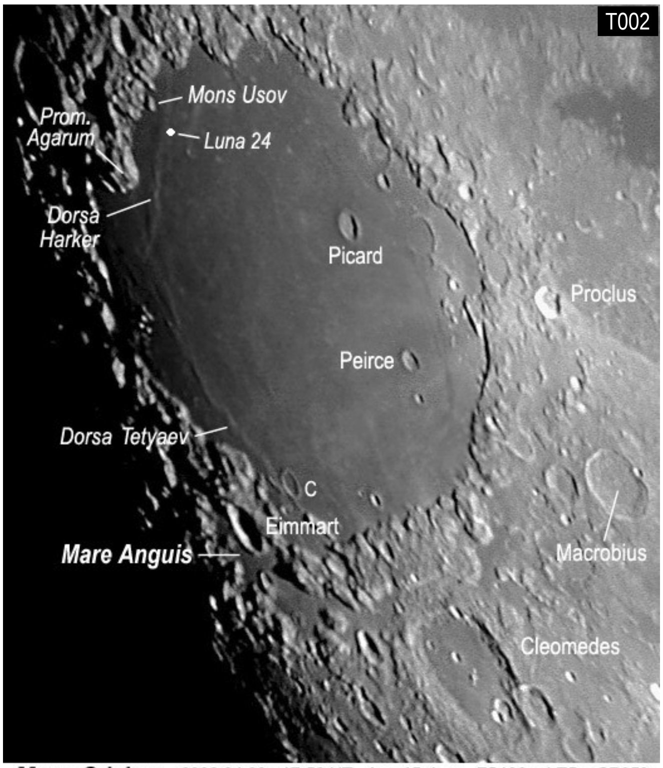


MARE CRISIUM 2004.08.31 19:07 UT Age 15 days. Longitudinal libration 6°. 10-in f/6 + ToUcam at prime focus

Mare Crisium (Sea of Crises) is a dominating feature near the east limb of the Moon. It is a dark, lava-filled oval basin surrounded by mountain walls. The mountains average to 3000 m high. The mare measures 570 km east-west and 430 km north-south, but to Earth the north-south diameter always appears longer due to foreshortening. Mare Crisium is the site of a gravitational anomaly known as a "mascon," or mass concentration that probably represents thick accumulation of dense lava, or the fragments of an impactor that created the basin buried beneath the mare surface. Mascons exist in other mare regions and few flat-floored craters as well, e.g. Ptolemaeus Map 12 and Grimaldi Map 26. Their high-gravity causes lunar satellites orbiting at low altitudes to either impact the Moon or to be flung out into interplanetary space after a few years. (http://science.nasa.gov/headlines/y2006/06nov_loworbit.htm?list137588)

Under oblique illumination, concentric wrinkle ridges are visible along the inner circumference of Mare Crisium. The most apparent wrinkle ridges are ***Dorsa Harker*** and ***Dorsa Tetyaev*** on the eastern edge (Image T002); they measure 180 ~ 200 km in length. Crater ***Eimmart C*** happens to locate on the northern tip of Dorsa Tetyaev, and the combined formation resembles a string looped at one end. The neighbor of ***Eimmart*** is an irregular patch of lava named ***Mare Anguis*** (Serpent Sea); it seems to be a leak piece from Mare Crisium. The cape on the southern edge is ***Promontorium Agarum***; it rises about 5000 m above the mare and looks almost disconnected from the rest of the highlands. In 1976, the former USSR probe, Luna 24, returned soil samples from the vicinity of Promontorium Agarum.

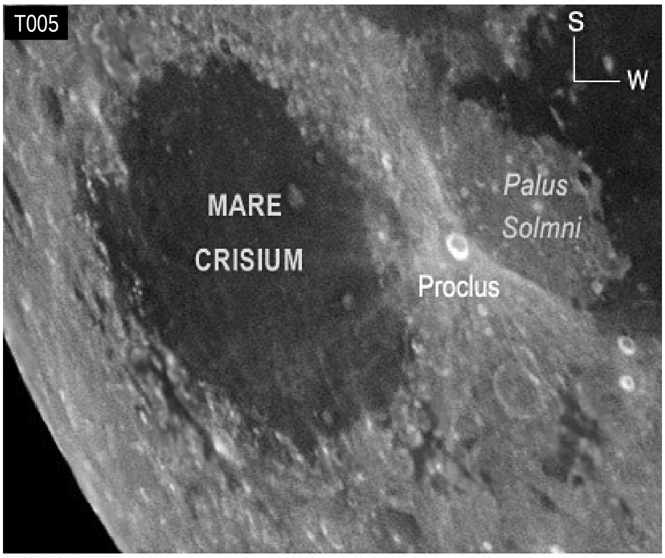
The end pages of this map give the closer views of Crisium region.



Mare Crisium 2000.04.20 17:52 UT Age 15 days. FS102 + LE5 + CP950

Proclus 46.8^0 E 16.1^0 N
Palus Somni 44^0 E 15^0 N

Proclus is a prominent impact crater on the western highlands of Mare Crisium. It has sharp rim and rough floor, 28 km in diameter, 2400 m deep. Its ejecta begins to shine as asymmetrical pattern of rays around Moon age of 5 ~ 6 days, gradually glowing up to be one of the brightest features on the entire Moon. The longest rays slide through the dark floor of Mare Crisium. The asymmetrical ray pattern is an evidence of a grazing impact, in which the space impactor intruded from southwest (top right corner of Image T005) and hit the Moon surface at very low angle, likely less than 5^0 measured from ground. A low-angled impact is



The bright reflection around the inner rim of Proclus makes this crater resembling a bull's eye. (2000.06.15 16:28UT Age 13 days) characterized by ejecta in confined directions. The lower the impact angle, the more unidirectional the ejecta is. This explains ***Palus Somni*** (Marsh of Sleep), a diamond-shaped area at immediate west of Proclus, is lack of Proclus' ejecta rays. Palus Somni measures 200 km north-south and looks neither a complete highland nor dark mare. Its northern floor is rough but the southern floor is relatively flat. The peculiar gray tone of Palus Somni has been a study subject by astrogeologists.

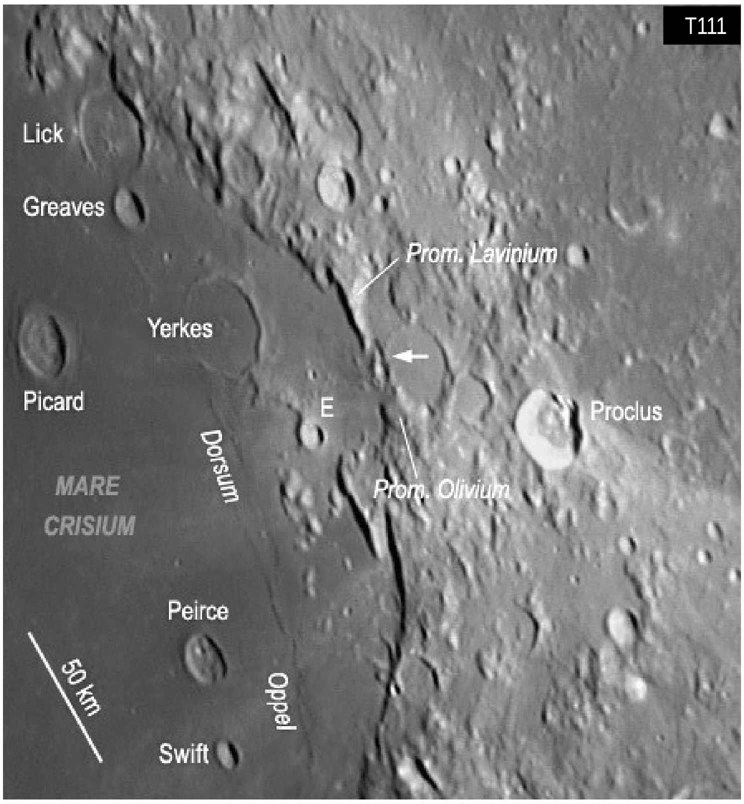
Proclus & Palus Somnii 2004.12.19 ~12:13 UT Moon age 7 days. 10-in f/6+2.5X+ToUcam (*mosaic*)

Macrobius 46.0^{0}E 21.3^{0}N
An impact crater with terraced walls and central peaks, 64 km in diameter. Its rim is interrupted by a small crater. The adjacent Tisserand (36 km) looks like a small version of Macrobius. A small irregular patch of mare named Lacus Bonitatis (Lake of Goodness) spreads in the vicinity; its full view is given in T051, starting page.

Sinus Concordiae 43^{0}E 11^{0}N
Bay of Concord, an inconspicuous bay-like mare adjoining the southern edge of Palus Somni, east-west length about 150 km.

(Image T111)

O'Neill's Bridge 49.2^0 E 15.2^0 N
This nicknamed feature, firstly noted by amateur John O'Neill in 1953, is elusive. It is noticeable shortly after the full Moon when the terminator approaches the west edge of Mare Crisium. During unfavorable seeing, it resembles a bridge connecting two spiky capes: ***Promontorium Lavinium*** and ***Promontorium Olivium*** (both are unofficial names). When seeing is good, it resolves into two adjoined, small eroded craters.



O'Neill's Bridge (arrow) is a nicknamed feature composed of two adjoined, small eroded crater. 2004.08.31 16:53 UT Age 15 days. 10-in f/6 + 2.5X + ToUcam

Picard 54.7^0 E 14.6^0 N
Peirce 53.5^0 E 18.3^0 N
Picard (diameter 22 km) and Peirce (18 km) are the most noticeable craters on the floor of Mare Crisium.

Lick 52.7^0 E 12.4^0 N
Yerkes 51.7^0 E 14.6^0 N
This is a pair of similar shaped flooded craters. Lick is 31 km in diameter. Yerkes is 36 km and connects to a satellite crater (***Yerkes E***, 10 km) through a ridge.

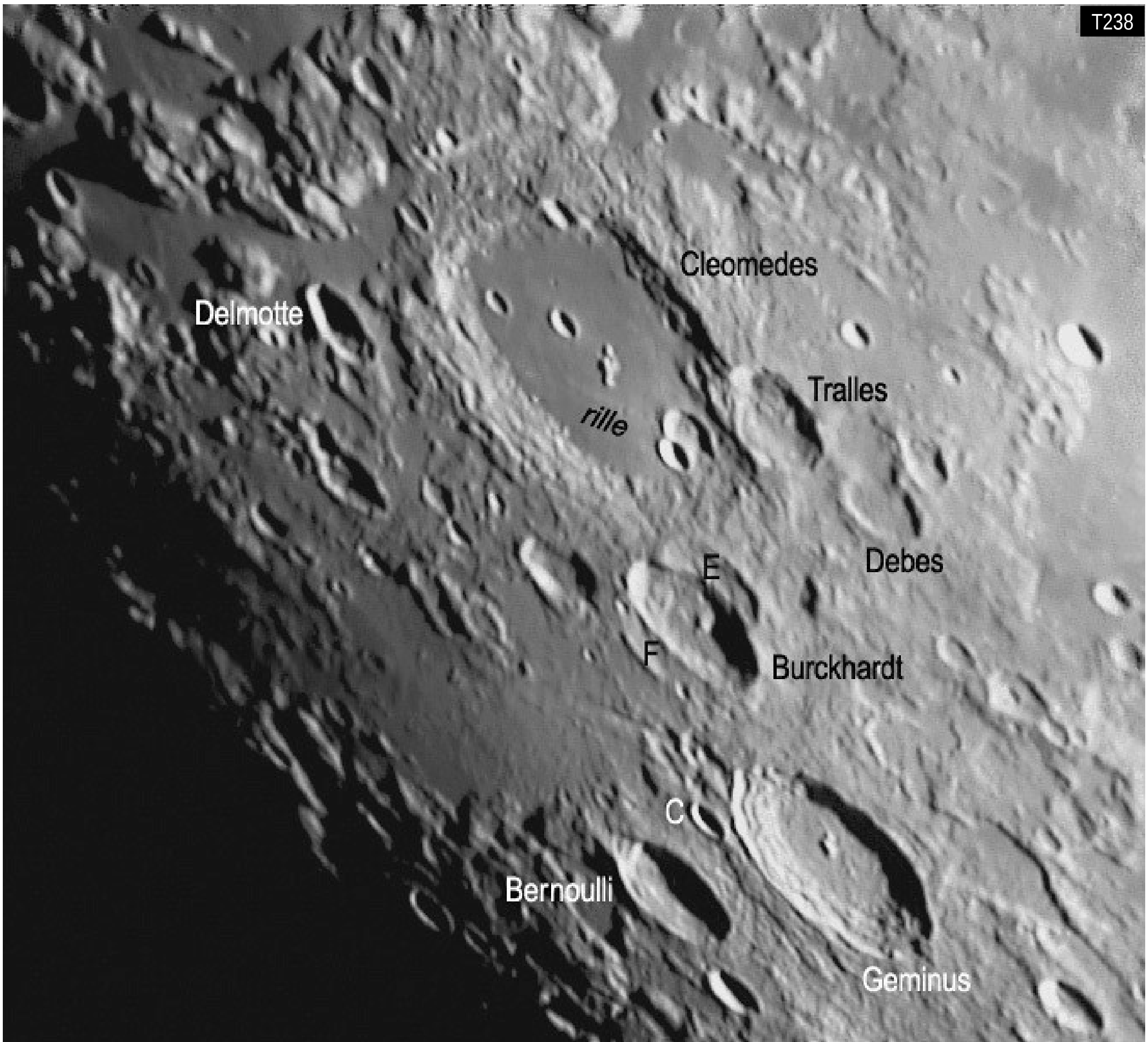
Dorsum Oppel 52^0 E 19^0 N
The most noticeable wrinkle ridges on the western edge of Mare Crisium, 300 km long. This dorsum, together with ***Dorsa Harker*** and ***Dorsa Tetyaev*** on the eastern edge (Image T002), form a concentric ring of mare ridges. All sizeable lava-flooded impact basins on the Moon, including Mare Crisium, are characterized by concentric mare ridges.

(Images in next page)

Cleomedes 56.0^0 E 27.7^0 N
Geminus 56.7^0 E 34.5^0 N
Messala 60.5^0 E 39.2^0 N
Cleomedes is a prominent crater in the north of Mare Crisium. It is 125 km in diameter, with small craters, central peaks and an elusive rille (***Rima Cleomedes***) on the floor. Its northern wall is intruded by a smaller crater ***Tralles*** (43 km). On the contrary, ***Burckhardt*** (56 km) is a bigger crater that overlaps a close pair of small craters (***Burckhardt E*** and ***Burckhardt F***). This is an exception of the trend that small craters superposed on larger ones.

Further north of Cleomedes are two small craters ***Geminus C*** and ***Messala B***. They appear no special near the terminator but become centers of bright rays during the full moon. ***Geminus*** itself is 85 km across, with a central peak and a wide cleft cutting on the southern rim. ***Messala*** is a fairly large walled plain, 125 km in diameter.

Lacus Spie (Lake of Hope) 65^0 E 43^0 N
A small lava plain, about 80 km across.

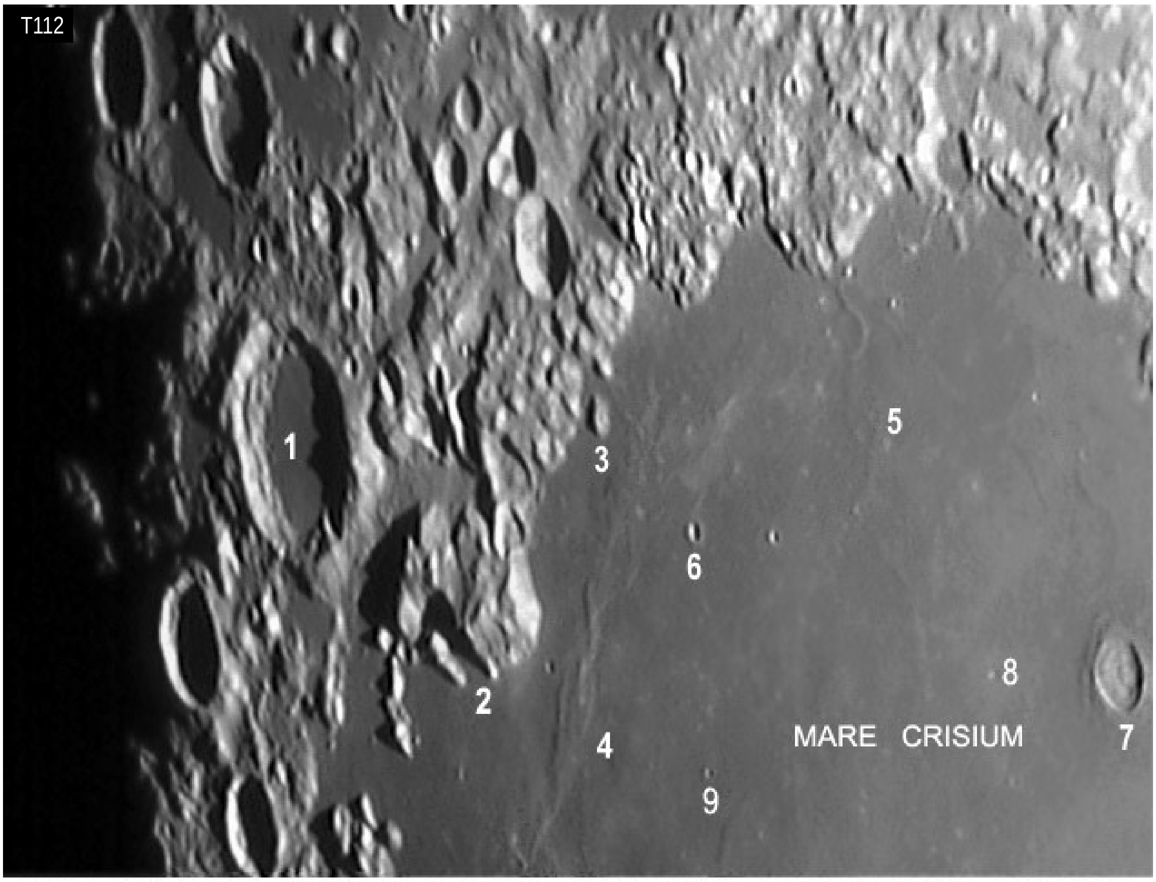


↑ *Cleomedes, Geminus & Messala*

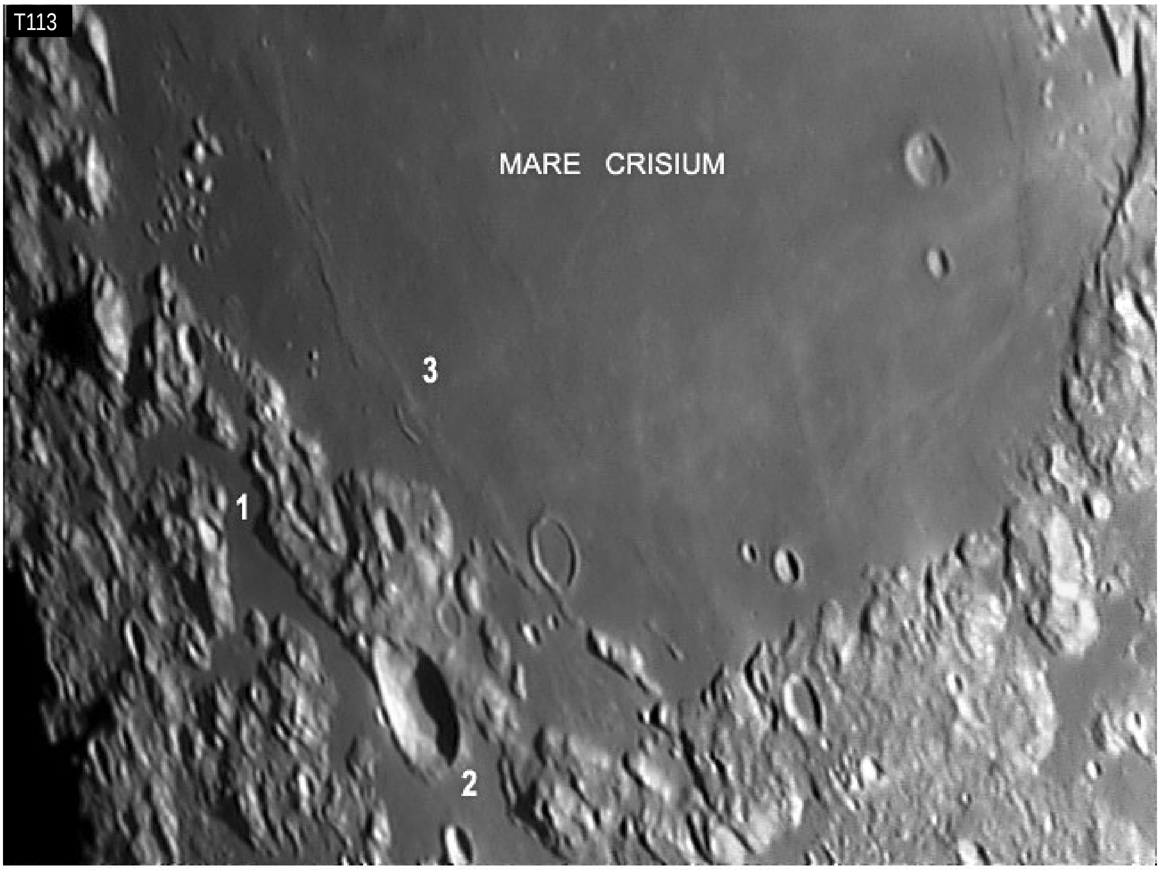
2005.10.19 ~16:27 UT Moon age 16 days.
10-in f/6 Newtonian + 2.5X + ToUcam (mosaic)

1. Messala 2. Messala B 3. Schumacher 4. Mercurius 5. Zeno 6. Lacus Spei (*Lake of Hope*)
2004.08.31 17:38 UT Moon age 15 days. 10-in f/6 Newtonian + 2.5X + ToUcam at 1/100 sec.

Features along the edges of Mare Crisium

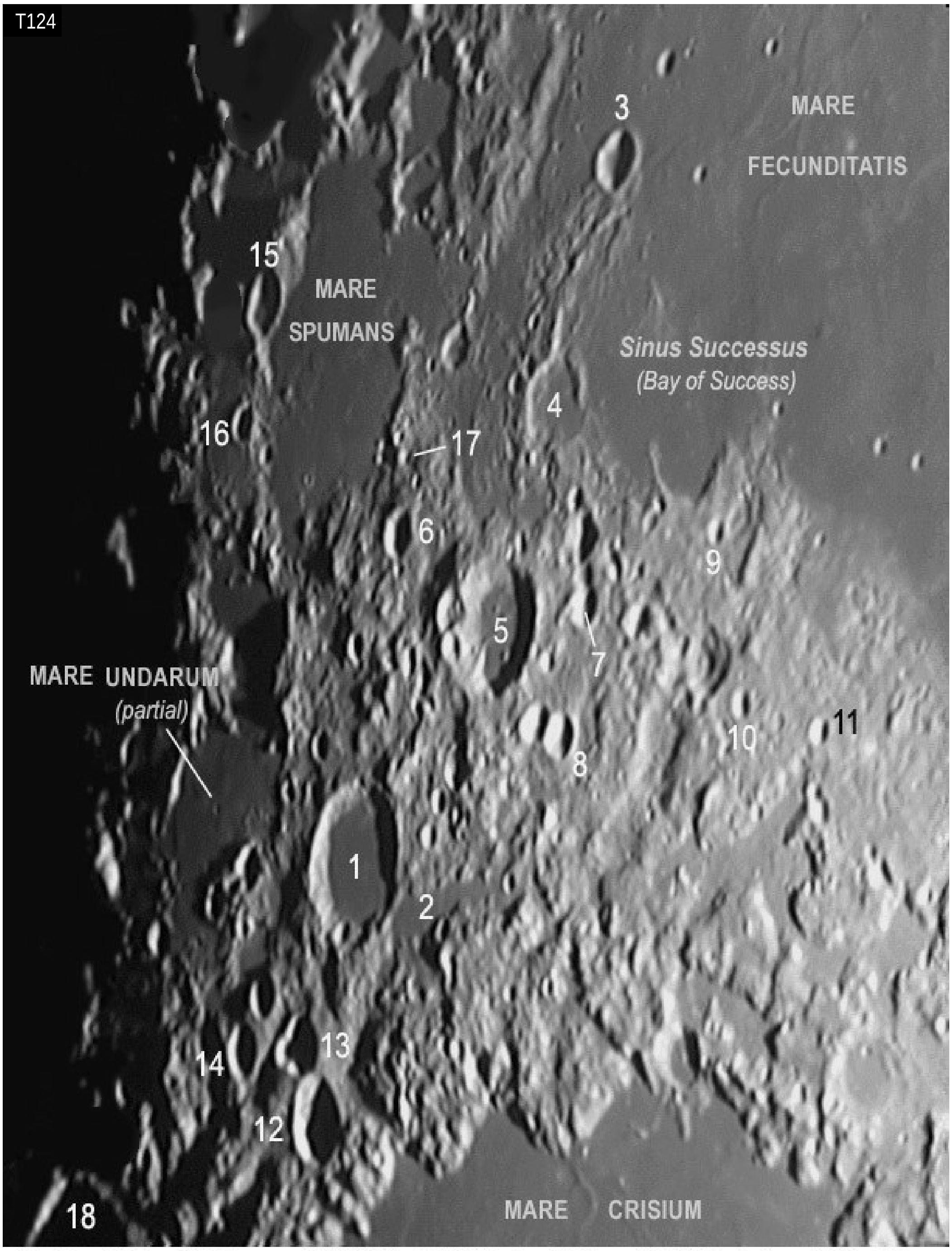


1. Condorcet 2. Prom. Agarum 3. Mons Usov 4. Dorsa Harker 5. Dorsum Termier 6. Fahrenheit 7. Picard 8. Curtis 9. Eckert 2004.08.31 18:38 UT Age 15 days. 10-in f/6 Newtonian + 2.5X + ToUcam



1. Mare Anguis (*Serpent Sea*) 2. Eimmart 3. Dorsa Tetyaev 2004.08.31 18:54UT Age 15 days. 10-in f/6 + 2.5X + ToUcam

MAP 2



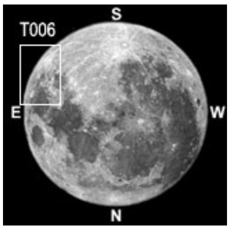
South of Mare Crisium 2004.08.02 ~17:53 UT Age 16 days. 10-in f/6 Newtonian + 2.5X + ToUcam

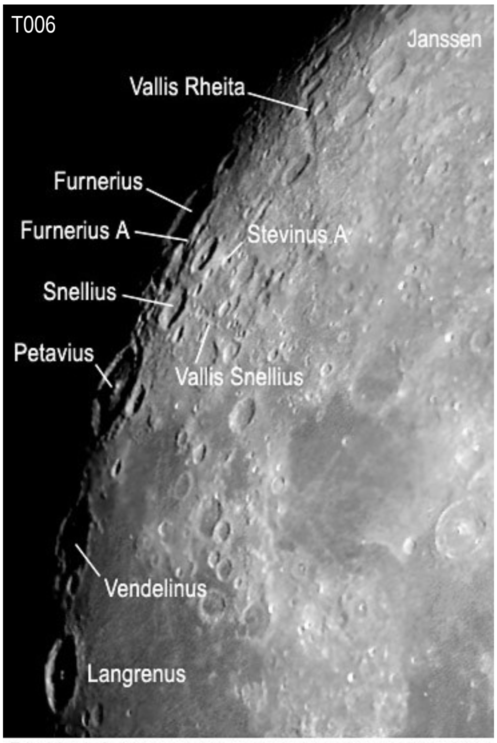
1. **Firmicus** (63.4^{0}E 7.3^{0}N, diameter 56 km)
2. **Lacus Perseverantiae** *(Lake of Persistence, a small wedge-shaped lava plain extruded from Firmicus.)*
3. **Webb** (60.0^{0}E 0.9^{0}S, diameter 21 km)
4. **Condon** (60.4^{0}E 1.9^{0}N, diameter 34 km)
5. **Apollonius** (61.1^{0}E 4.5^{0}N, diameter 53 km)
6. **Townley** (63.3^{0}E 3.4^{0}N, diameter 18 km)
7. **Cartan** (59.3^{0}E 4.2^{0}N, diameter 15 km)
8. **Daly** (59.6^{0}E 5.7^{0}N, diameter 17 km)
9. **Ameghino** (57.0^{0}E 3.3^{0}N, diameter 9 km)
10. **Bombelli** (56.2^{0}E 5.3^{0}N, diameter 10 km)
11. **Abbot** (54.8^{0}E 5.6^{0}N, diameter 10 km)
12. **Auzout** (64.1^{0}E 10.3^{0}N, diameter 32 km)
13. **van Albada** (64.3^{0}E 9.4^{0}N, diameter 21 km)
14. **Krogh** (65.7^{0}E 9.4^{0}N, diameter 19 km)
15. **Pomortsev** (66.9^{0}E 0.7^{0}N, diameter 23 km)
16. **Stewart** (67.0^{0}E 2.2^{0}N, diameter 13 km)
17. **Petit** (63.5^{0}E 2.3^{0}N, diameter 5 km)
18. **Condorcet** (69.6^{0}E 12.1^{0}N, diameter 74 km)

MAP 3

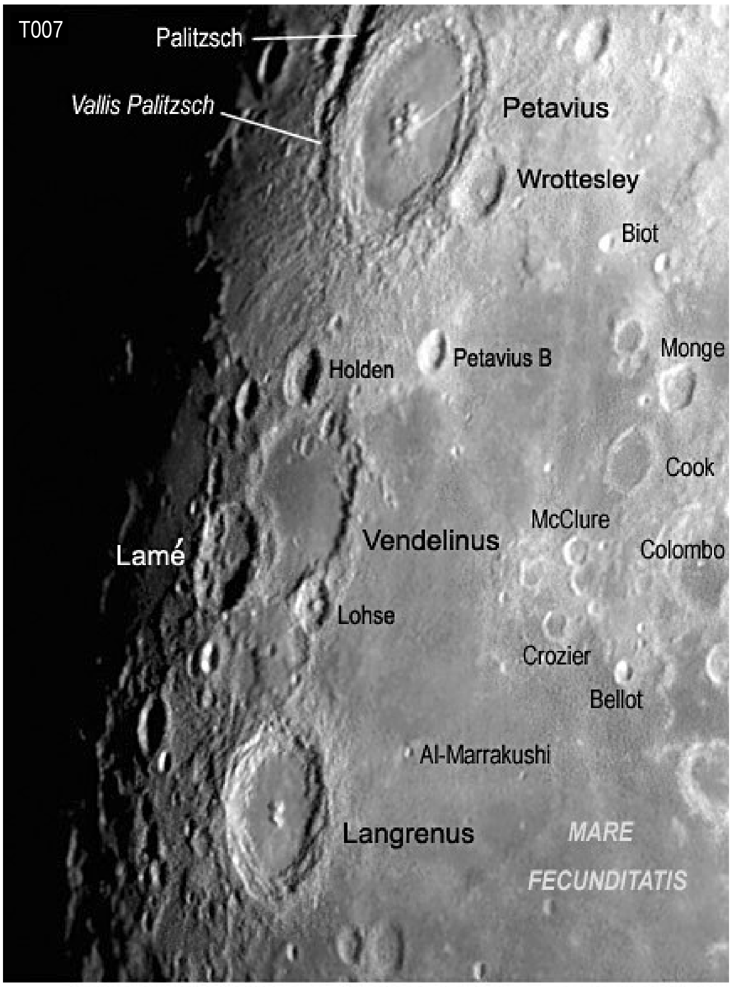
Hatfield 15, 16
Rükl 49, 59, 60, 69

Langrenus, Vendelinus, Petavius, Furnerius





Furnerius to Langrenus 2000.09.15 15:52 UT Age 17days. MK67+CP950



Petavius to Langrenus 2000.04.20 17:58 UT Age 15 days. FS102+CP950 1/4 sec DSCN1591

The magnificent chain of craters in Image T006 – The Great Eastern Chain – lines up on the terminator when the Moon age is 15 ~ 17 days.

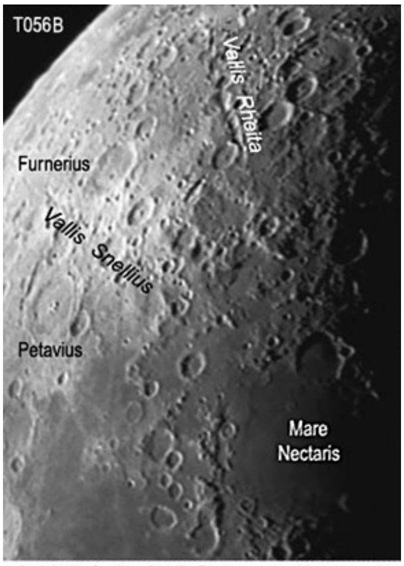
Langrenus 61.1^0 E 8.9^0 S
A prominent crater with terraced walls, central twin peaks and hilly floor, 127 km in diameter. The walls rise to nearly 3000 m high. At high illuminations, the floor takes on a distinctly yellowish-brown tint, compared to its surroundings. At full moon, Langrenus emits bright rays.

Vendelinus 61.6^0 E 16.4^0 S
A walled plain, diameter 131 km. Its rim is interrupted by ***Lamé*** (84 km) and few smaller craters.

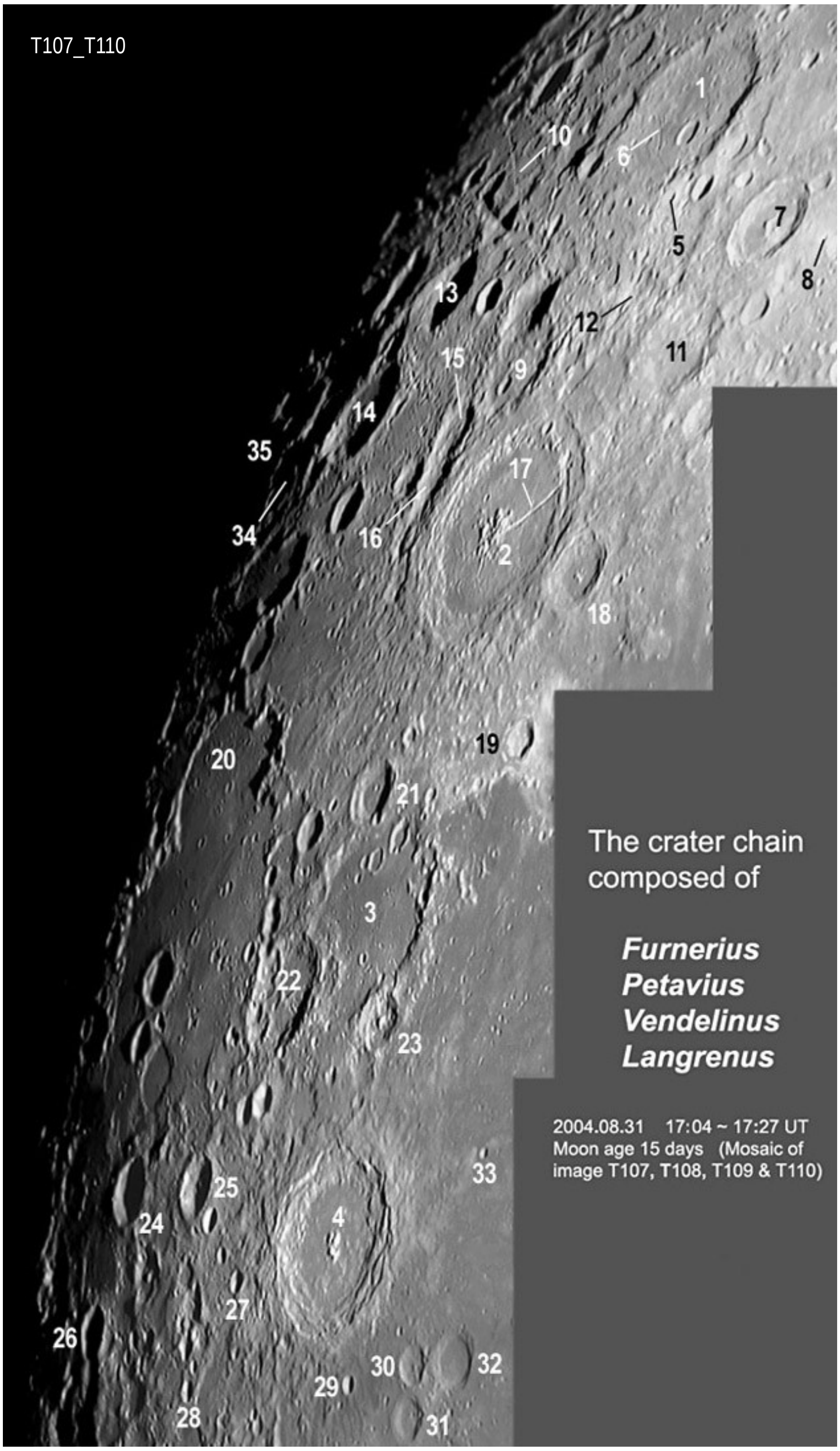
Petavius 60.4^0 E 25.2^0 S
A large ring mountain with central peaks, clefts and dark patches on its floor, 188 km in diameter, 3300 m deep. Part of the ring mountain splits into a double wall. The cleft running from central peaks to the south-western wall (main part of ***Rimae Petavius***) is very distinct. Minor clefts also run on the northern floor. In fact the whole floor of Petavius is fractured, likely caused by post-volcanism that took place inside the crater. The western wall of Petavius is flanked by ***Wrottesley*** (57 km) and the eastern wall is flanked by a crater-valley pair, ***Palitzsch*** (41 km) and ***Vallis Palitzsch*** (110 x 20 km). Petavius is very bright during the full moon.

Furnerius 60.6^0 E 36.0^0 S
Furnerius is a walled plain, 135 km in diameter. Its floor contains ***Rima Furnerius*** (50 km long) and a prominent off-center crater. Immediately outside the wall is ***Vallis Snellius***, a 590 km-long valley pointing towards the impact basin that holds ***Mare Nectaris***, see Image T056B. The valley floor appears as a chain of many overlapping craters. Like ***Vallis Rheita*** in Map 4, Vallis Snellius was created by secondary impacts during the formation of Nectaris basin.

Snellius, Petavius B, Furnerius A, Stevinus A
These craters are centers of bright rays. See Map 33.



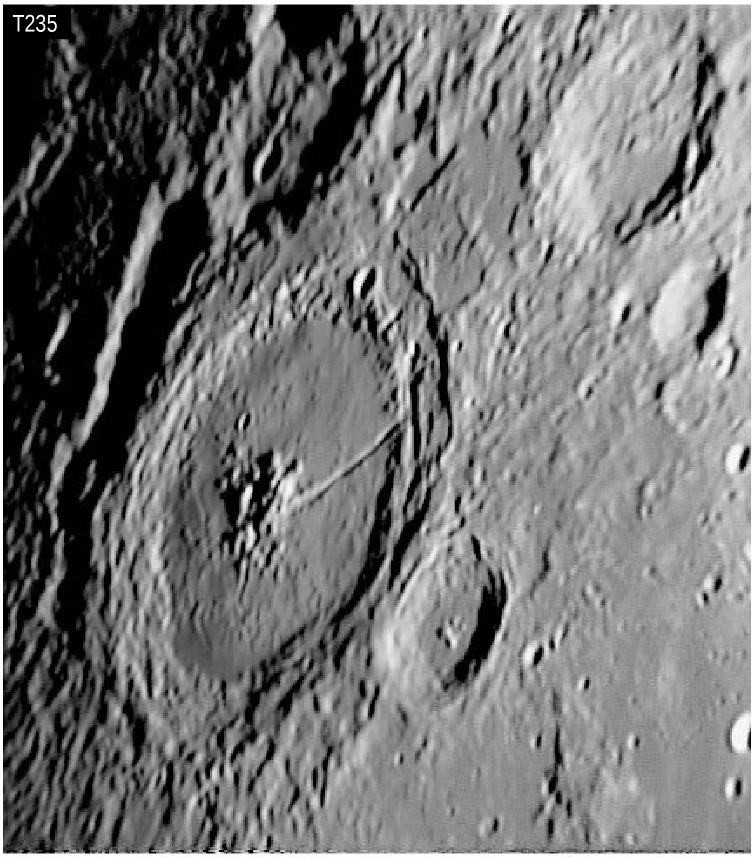
Both Vallis Snellius & Vallis Rheita point to Mare Nectaris.



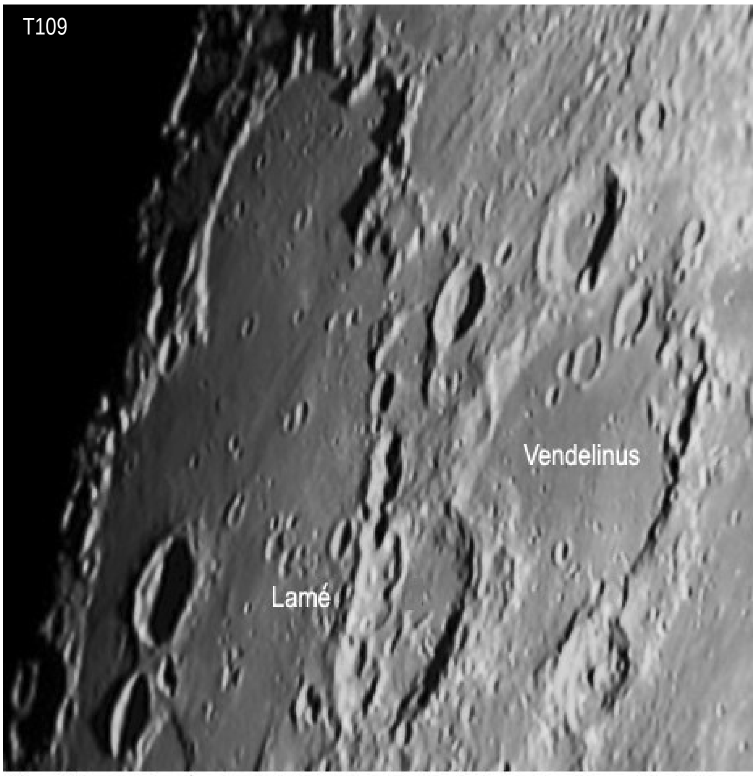
1. Furnerius *(Dia. 135 km)*
2. Petavius *(188 km)*
3. Vendelinus *(131 km)*
4. Langrenus *(127 km)*
5. Furnerius A
6. Rima Furnerius
7. Stevinus *(74 km)*
8. Stevinus A
9. Hase *(83 km)*
10. Rima Hase (*IAU-dropped name*)
11. Snellius *(83 km)*
12. Vallis Snellius
13. Adams *(66 km)*
14. Legendre *(78 km)*
15. Palitzsch *(41 km)*
16. Vallis Palitzsch
17. Rimae Petavius
18. Wrottesley *(57 km)*
19. Petavius B
20. Balmer *(138 km)*
21. Holden *(47 km)*
22. Lamé *(84 km)*
23. Lohse *(41 km)*
24. Kapteyn *(49 km)*
25. Barkla *(42 km)*
26. von Behring *(38 km)*
27. Somerville *(15 km)*
28. Born *(14 km)*
29. Acosta *(13 km)*
30. Atwood *(29 km)*
31. Naonobu *(34 km)*
32. Bilharz *(43 km)*
33. Al-Marrakushi *(8 km)*
34. Phillips *(122 km)*
35. Humboldt *(189 km, hidden)*

1. **Furnerius** 2. **Furnerius A** *(bright)* 3. **Stevinus** 4. **Stevinus A** *(bright)* 5. **Rima Hase** *(IAU-dropped name)*
6. **Snellius** 7-7. **Vallis Snellius** *(end to end)* 8. **Adams** 2004.08.31 17:14UT Age 15 days. 10-in f/6+2.5X+ToUcam

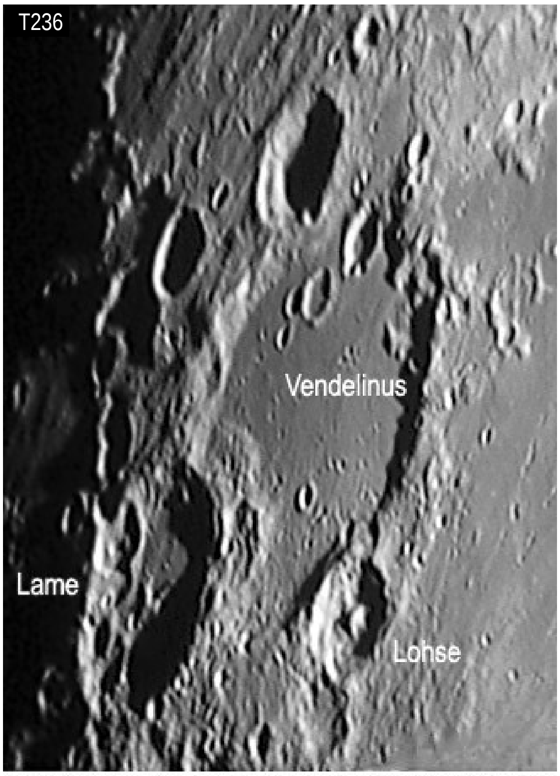
Petavius 2004.08.31 17:04 UT Age 15 days. 10-in f/6 scope



Petavius 2005.10.19 16:08 UT Age 16 days. 10-in f/6 Newtonian + 2.5X + ToUcam

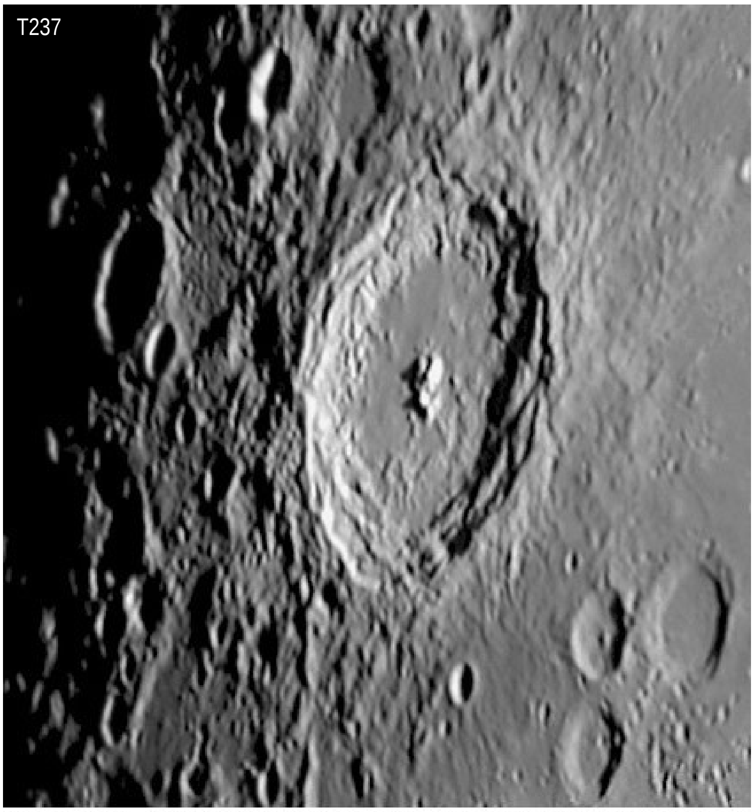


Vendelinus & Lamé 2004.08.31 17:27 UT Age 15 days. 10-in f/6 + 2.5X + ToUcam



2004.08.02 18:15 UT Age16 days. 10-in f/6 + 2.5X + ToUcam

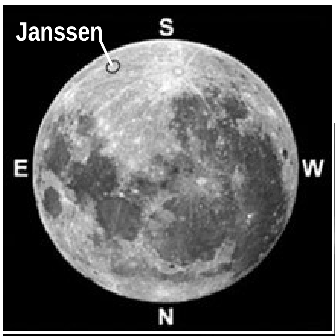
Langrenus 2004.08.31 17:16UT Age 15 days. 10-in f/6+2.5X+ToUcam

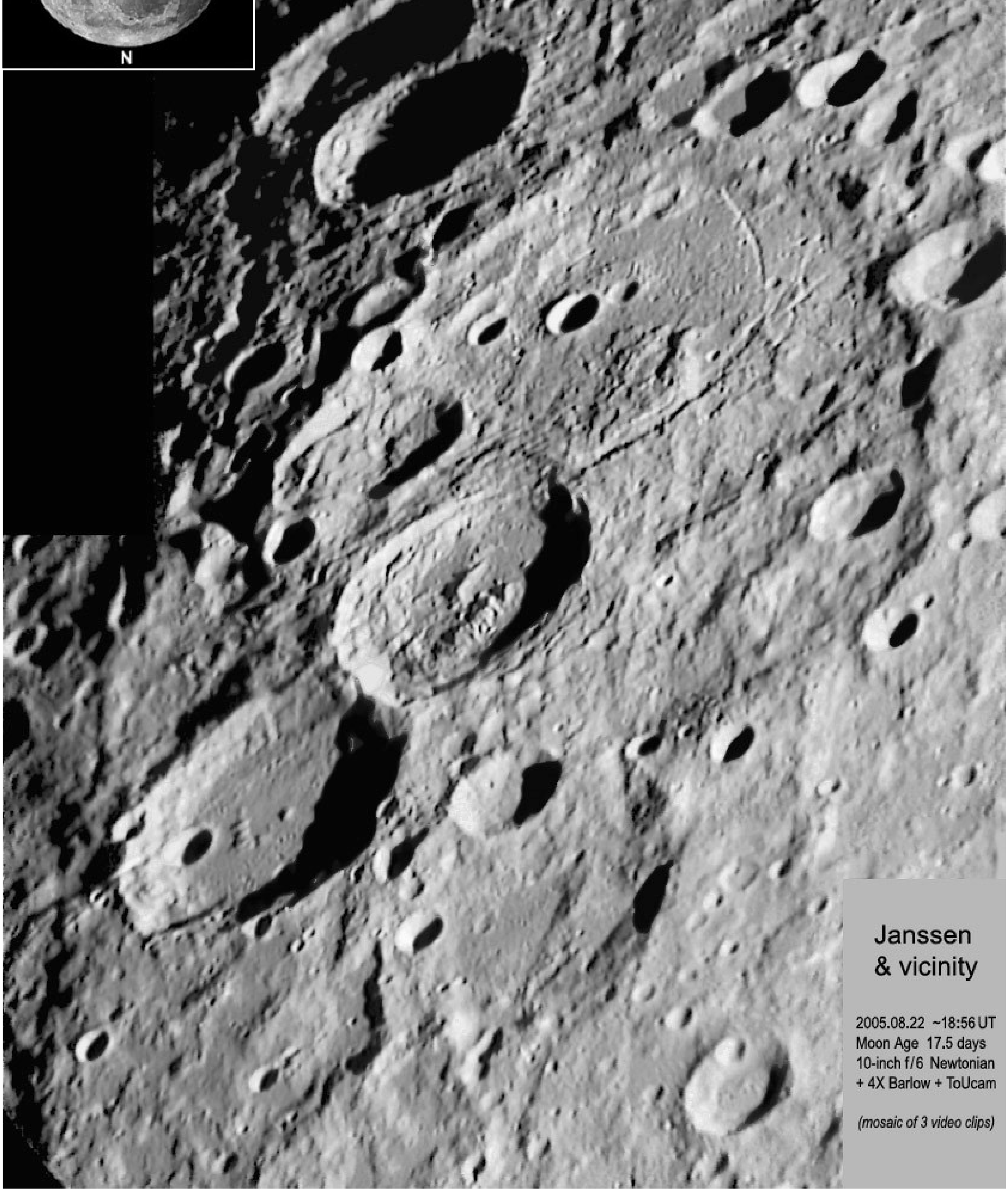


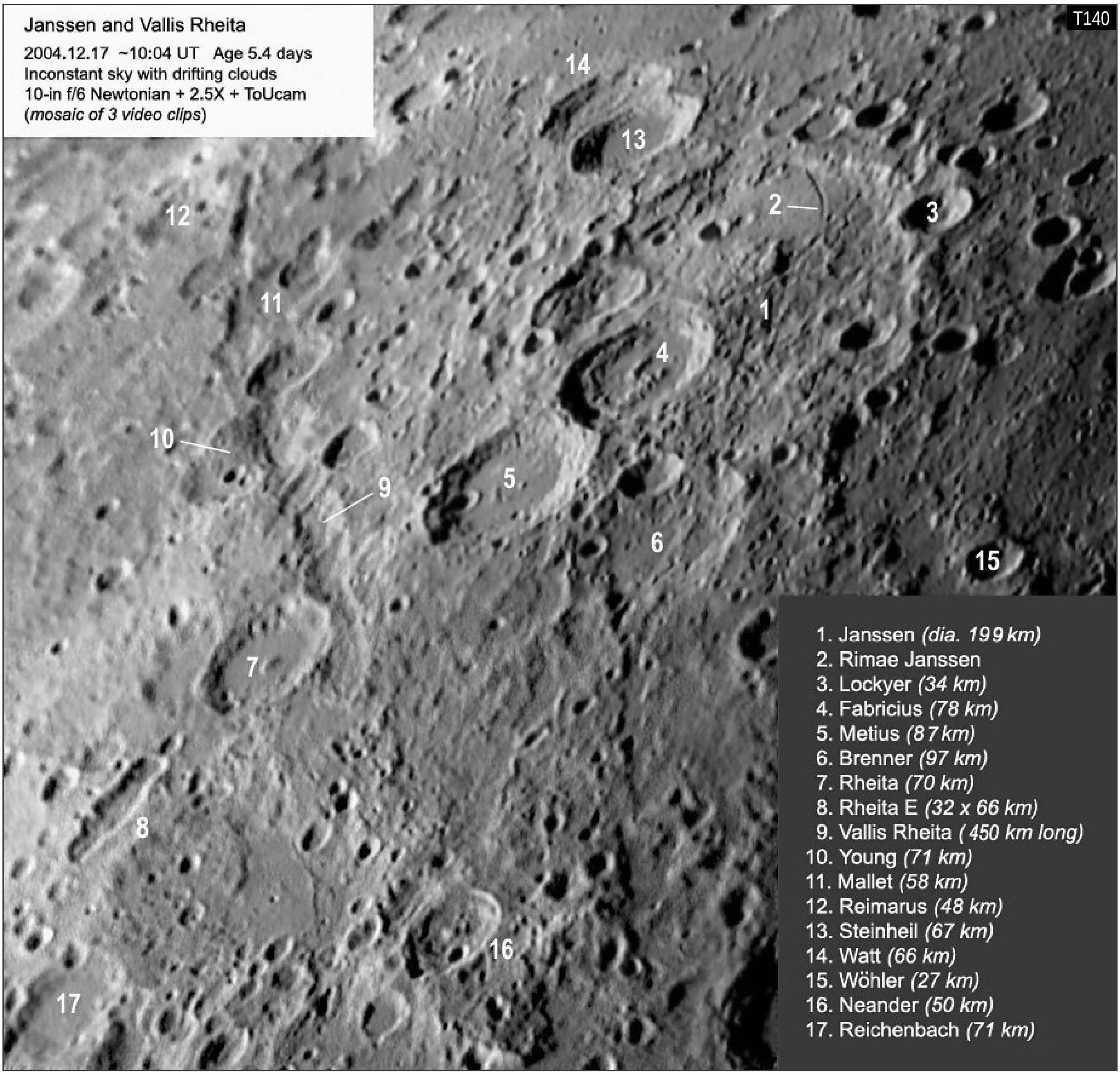
Langrenus 2004.08.02 18:10 UT Age 16 days. 10-in f/6 Newtonian + 2.5X + ToUcam

Hatfield 16
Rükl 67, 68, 69, 76

Janssen, Fabricius, Vallis Rheita, Mare Australe





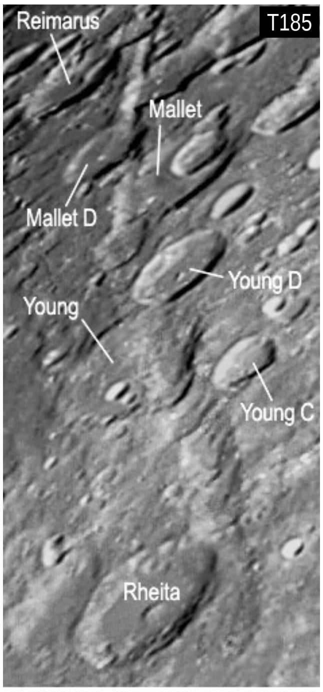


Janssen 40.3^0 E 45.4^0 S
A large walled plain with craters, rilles and mountain massifs on its floor, 199 km in diameter. It is highly eroded by impacting debris. The system of curved rilles that crosses the southern floor is ***Rimae Janssen***, length 140 km. So far no one knows how these curved rilles formed. The northwest wall of Janssen is broken by the fairly large crater ***Brenner*** (97 km).

Fabricius 42.0^0 E 42.9^0 S
This crater hits on Janssen. It is 78 km in diameter, with a central peak. At one observation with small telescope, the wall appeared double, making it look as though one crater is almost perfectly centered in another. However, this is only apparent under certain angle of illumination, and photographs do not confirm this.

Metius 43.3^0 E 40.3^0 S
A crater joining the walls of Janssen and Fabricius, 87 km in diameter.

Vallis Rheita 51^0E 42^0S
Vallis Rheita is a long valley near Janssen, 450 km in length. It begins from the outer rim of ***Rheita*** (70 km), passes through ***Young*** (71 km) and ***Mallet*** (58 km), then ends beyond ***Reimarus*** (48 km). The floor of Vallis Rheita appears as a chain of overlapping craters more than a true valley. The chain also points to Mare Nectaris (Image T056B, Map 3), suggesting it was created by secondary impacts during the formation of Nectaris basin. ***Rheita E*** is an elongated crater-valley feature, 32 x 66 km, probably created by the fusion of 3 or more pre-existing craters.

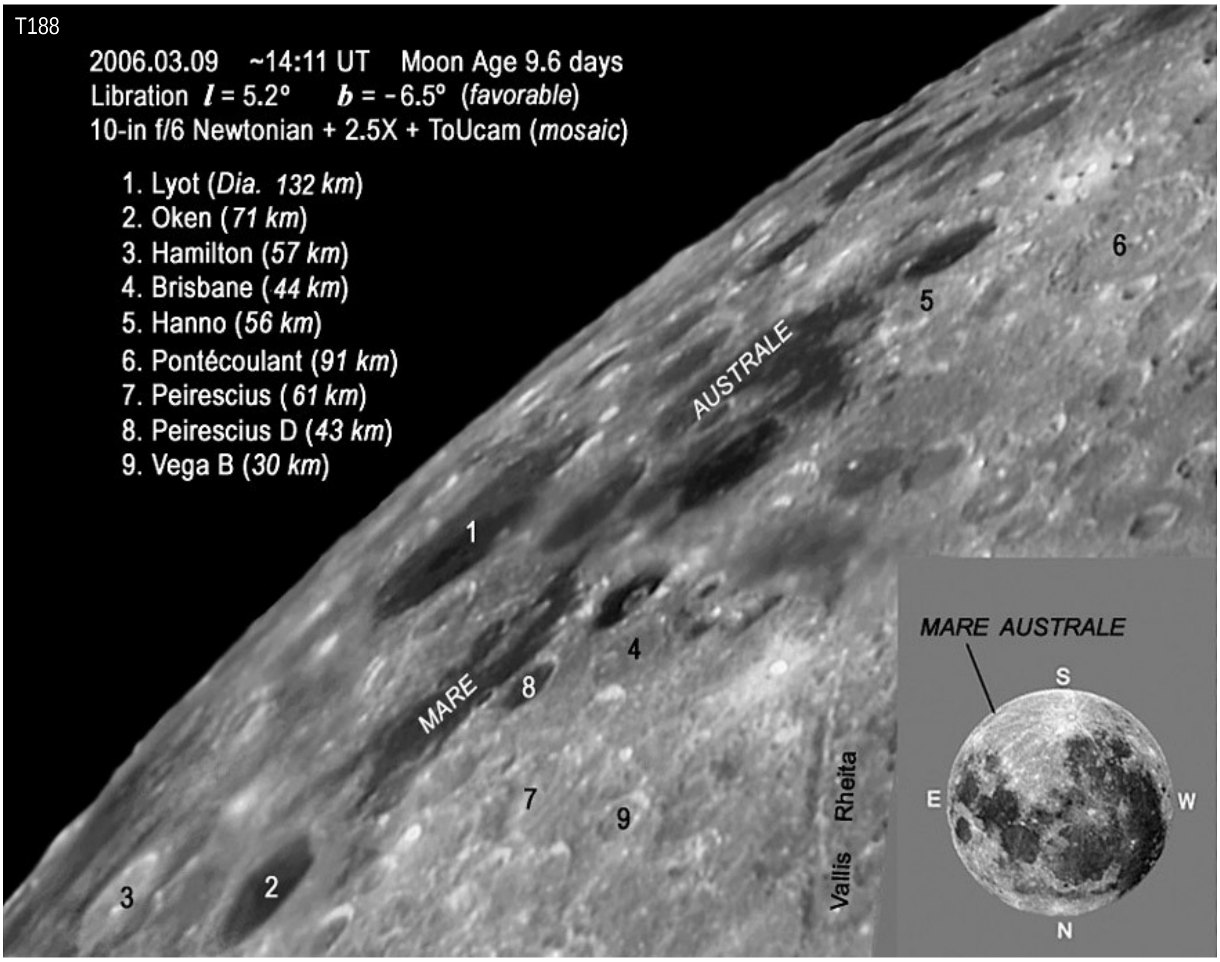


Vallis Rheita 2004.08.31 19:59UT Age 15 days

Young 50.9^0E 41.5^0S
A shallow crater superimposed on Vallis Rheita, 71 km in diameter.

Steinheil 46.5^0E 48.6^0S **Watt** 48.6^0E 49.5^0S
A pair of overlapped craters, each about 67 km in diameter. The east inner wall of Steinheil houses a group of small but noticeable craters (T228).

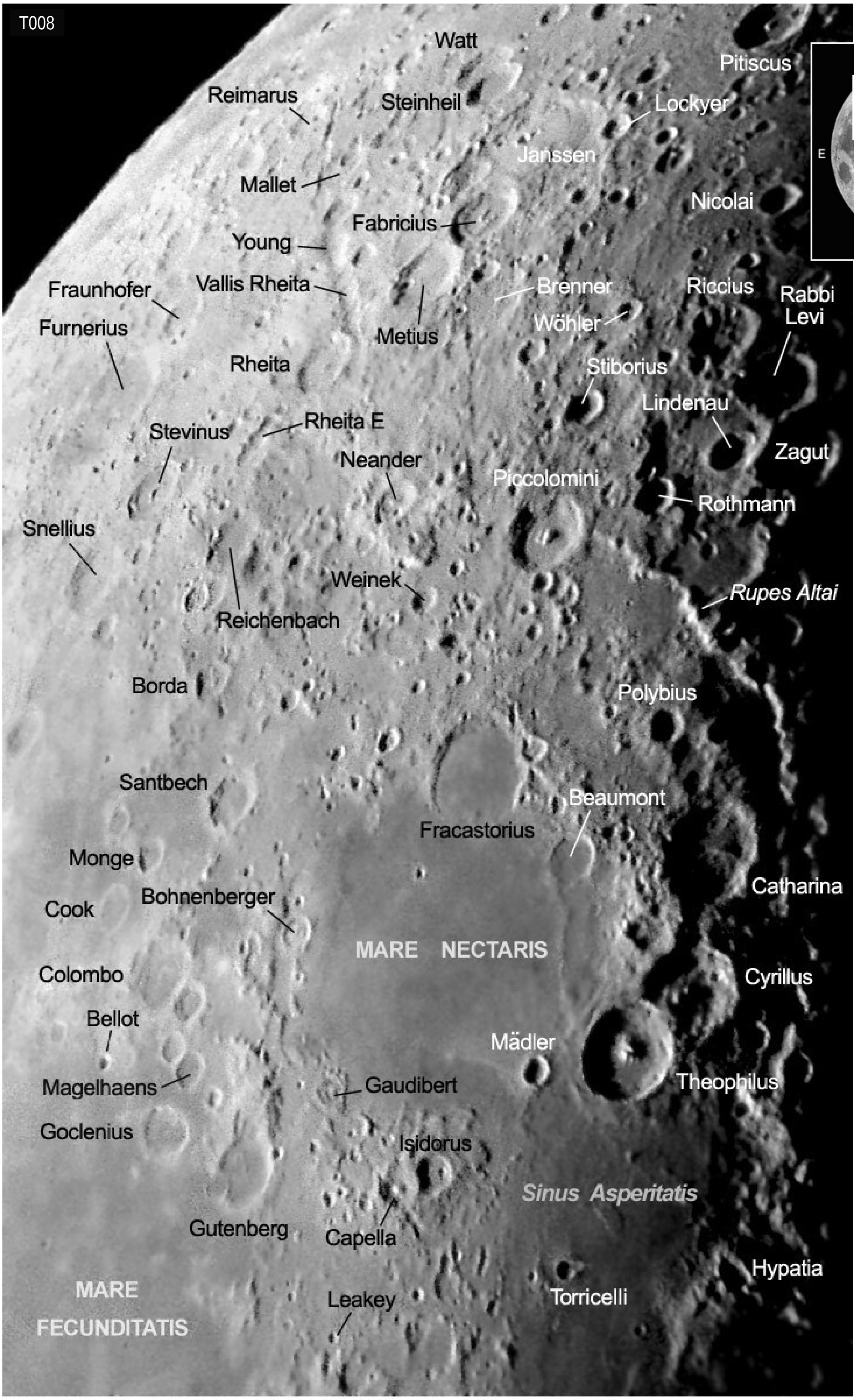
Mare Australe 93^0E 39^0S *(Image T188)*
Mare Australe (Southern Sea) is on the south-east limb, overlapping the nearside and farside of the Moon. It is a difficult object due to foreshortening. Its dark irregular shape stretches 35^0 x 35^0, covering a span of about 600 km. In Lunar Orbiter mapping, nearly 200 craters of different sizes are scattered in this mare, hence scientists thought Australe could be the most ancient mare among all. ***Lyot*** (84.5^0E 49.8^0S) is a large flooded walled plain lying within Mare Australe, 132 km in diameter. More details in Farside map.

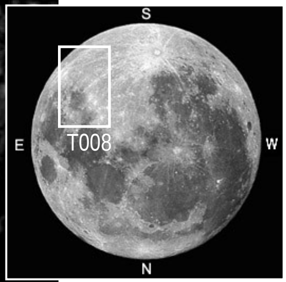


MAP 5

Mare Nectaris, Theophilus, Cyrillus, Catharina, Piccolomini, Rupes Altai, Fracastorius

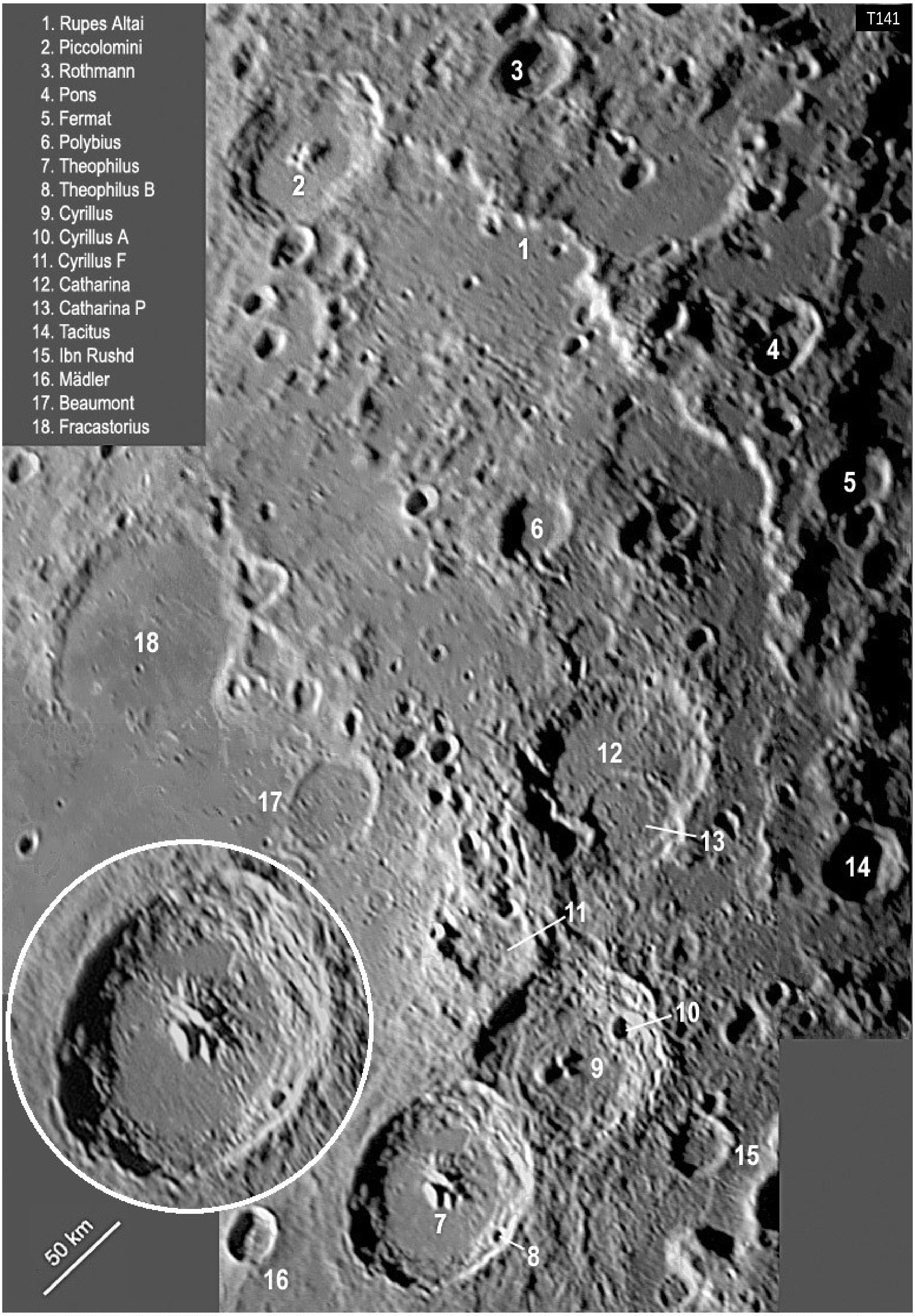
Hatfield 15, 13,14
Rükl 46, 57, 58, 67





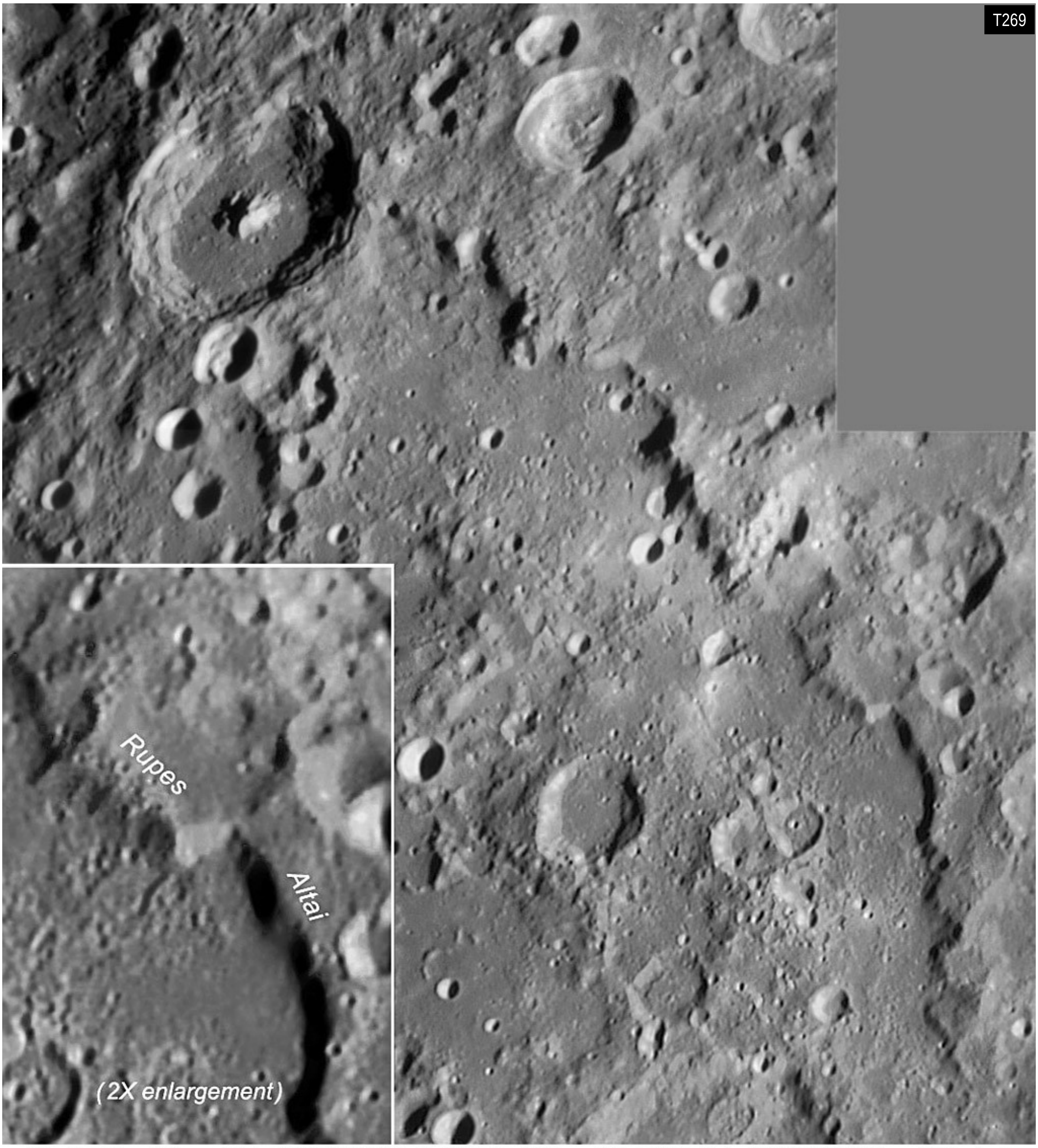
Janssen to Torricelli 2000.11.02 12:14 UT Age 6 days. FS128 + LE12.5 + QV2300 at 1/6 sec.

From Piccolomini to Theophilus



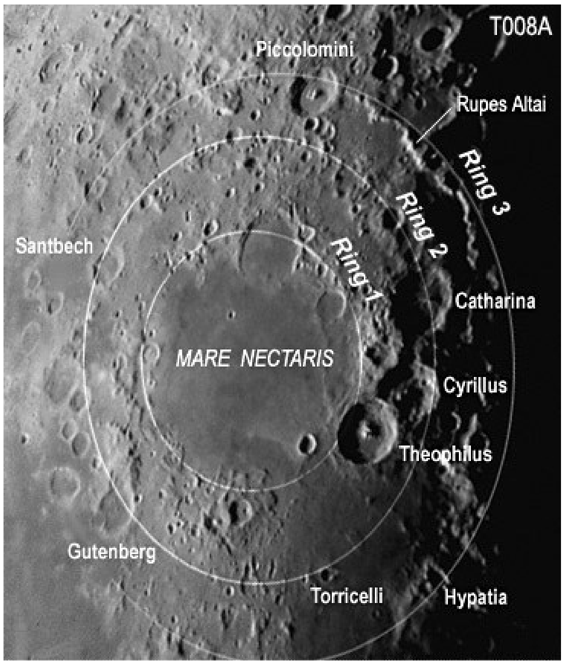
Piccolomini to Theophilus 2004.09.20 ~12:00 UT Age 6 days. 10-in f/6 Newtonian + 2.5X + ToUcam (Thumbnail is from 4X Barlow)

Piccolomini and Rupes Altai at Moon Age of 18 days

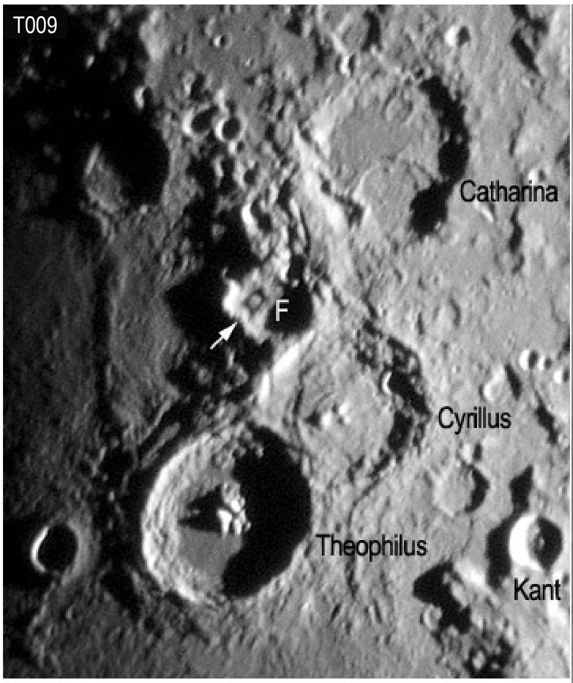


Piccolomini and Rupes Altai 2006.08.12 21:30 ~ 21:41 UT Age 18.5 days. 10-inch f/6 Newtonian + 2.5X + 1.6X + ToUcam, 95 % resized.
The 2X-enlargement shows the details of slope along a section of Rupes Altai, visible only when sunlight illuminates from the west. *(mosaic)*

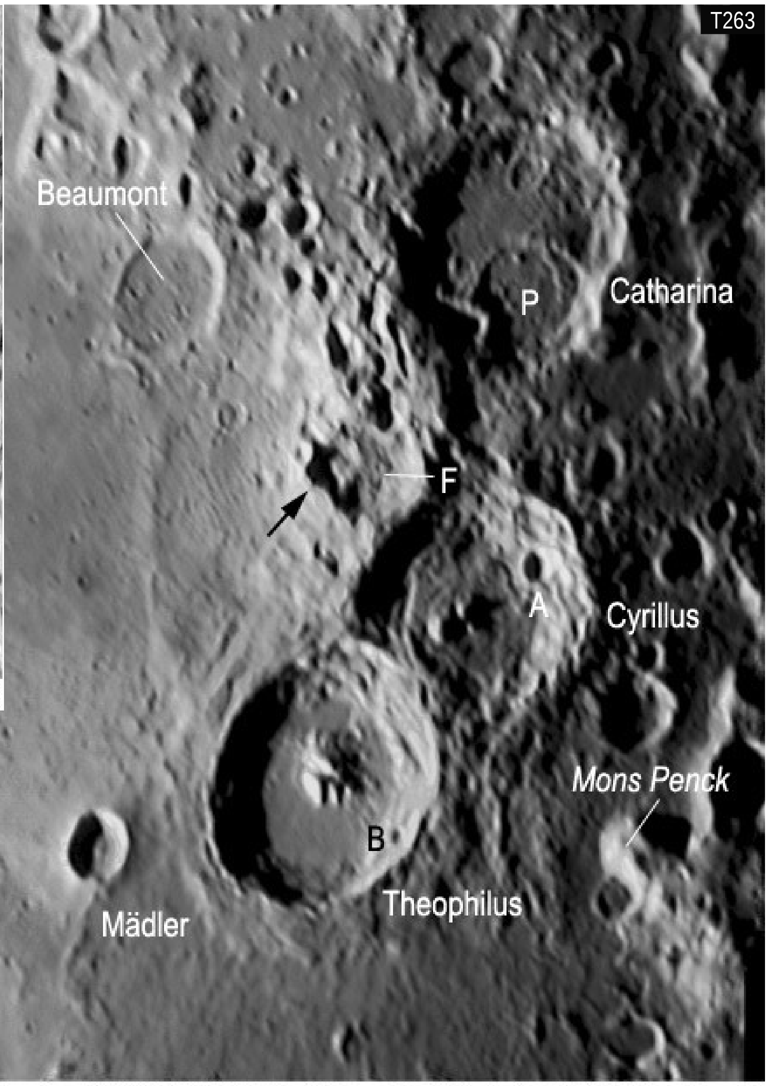
Mare Nectaris (Sea of Nectar) 35^0 E 15^0 S
This is a small mare inside an impact basin, diameter about 330 km. The impact basin is traceable by a pattern of three concentric rings, as suggested in Image T008A. Rupes Altai lies on the outmost ring of the basin. Theophilus, Cyrillus and Catharina form a prominent crater trio between Ring 1 and Ring 2.



Theophilus 26.4^0 E 11.4^0 S
A ring mountain, 110 km in diameter. Its massive terraced walls rise 4400 m above the interior. These huge walls appear as two to three concentric ring mountain ranges, each successively lower to the next until the floor is reached. At lower powers Theophilus appears to be circular while higher powers show the walls to be composed of linear segments. On the north-western wall is a small crater ***Theophilus B***. Theophilus also contains magnificent multiple central mountains with one of the peaks rising 1400 m above the floor. Theophilus is a rayed center under high illumination.

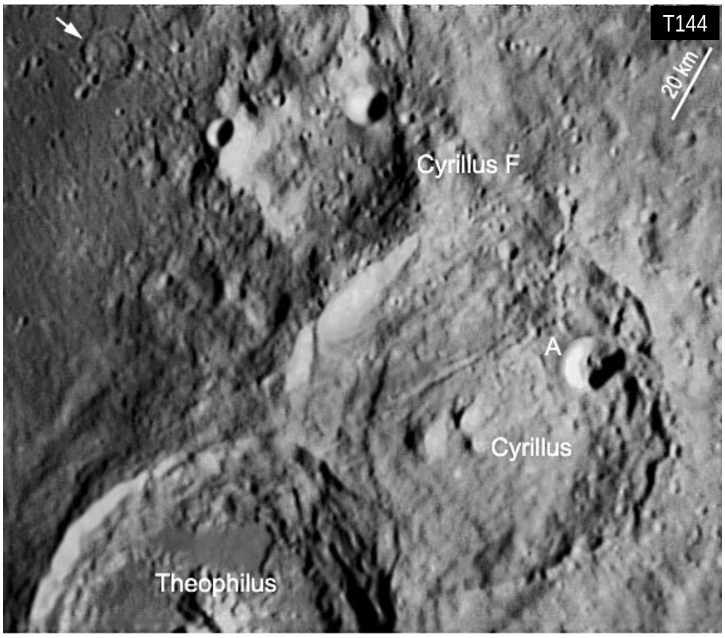


2001.05.12 18:20 UT Age 19 days. C9 + LE12.5 + Nikon CP990



Theophilus, Cyrillus & Catharina 2006.07.31 12:18 UT Age 6.3 days. 10-in f/6 Newtonian + 2.5X + ToUcam (*mosaic*)

Cyrillus 24.0^0 E 13.2^0 S
A ring mountain with disintegrated wall and three central peaks, 98 km in diameter. It is obvious that the Theophilus impact destroyed a section of Cyrillus's walls. Cyrillus is therefore older than Theophilus. The southwest wall contains a small crater, ***Cyrillus A***. The floor of Cyrillus does not appear smooth like the floor of Theophilus, but rough with depressions. The floor of ***Cyrillus F*** (diameter 44 km) also contains a shallow depression with central uplift. It casts a tortoise-shaped dark shadow during Moon age of 18~19 days. (Image T009 & T144).



Cyrillus & Cyrillus F 2006.08.12 21:43 UT Age 18 days 10-in f/6 Newtonian + 4X + ToUcam
The arrow points to an interesting crater trio (Beaumont A + 2 craterlets) that resembles a magnifying glass.

In the vicinity of Cyrillus F is an interesting trio of craters (***Beaumont A*** + 2 craterlets) that resembles a magnifying glass.

Catharina 23.4^0 E 18.1^0 S
A ring mountain with disintegrated wall, 104 km in diameter. Catharina is connected to Cyrillus by a broad valley, and is believed the oldest of the trio. It has been nearly obliterated by several impacts. There are big and small craters on its floor (the most prominent being ***Catharina P***), but no sign of central peaks. The central peaks must have existed years ago but finally overwhelmed by Catharina P.

Mädler 29.8^0 E 11.0^0 S
A 27-km crater. Its ejecta blanket is fan-like and relatively whitish. See also Map 7.

Piccolomini 32.2^0 E 29.7^0 S
A prominent crater with terraced walls and central peaks, 87 km in diameter.

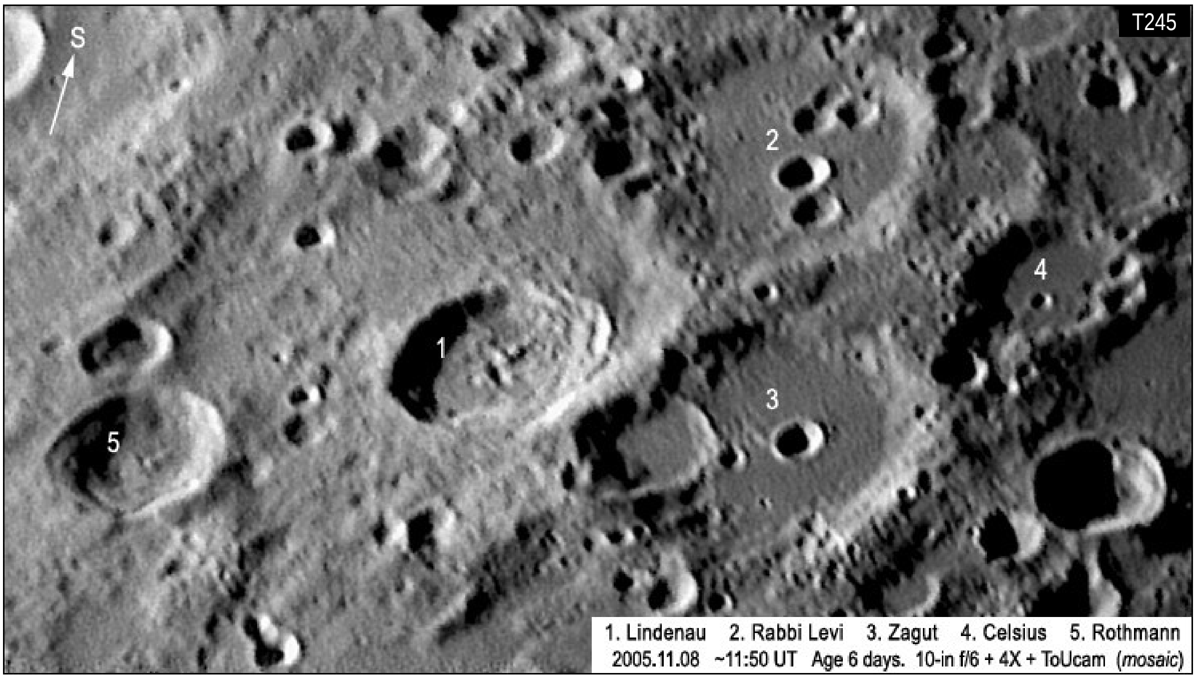
Rupes Altai 23^0 E 24^0 S
A sinuous mountain fault running between Piccolomini and Catharina, length 430 km. It is the remains of the rising rim of an impact basin in which the central part is Mare Nectaris. See also Image T008A. The slope of this fault toward Mare Nectaris drops 1000 m in average.

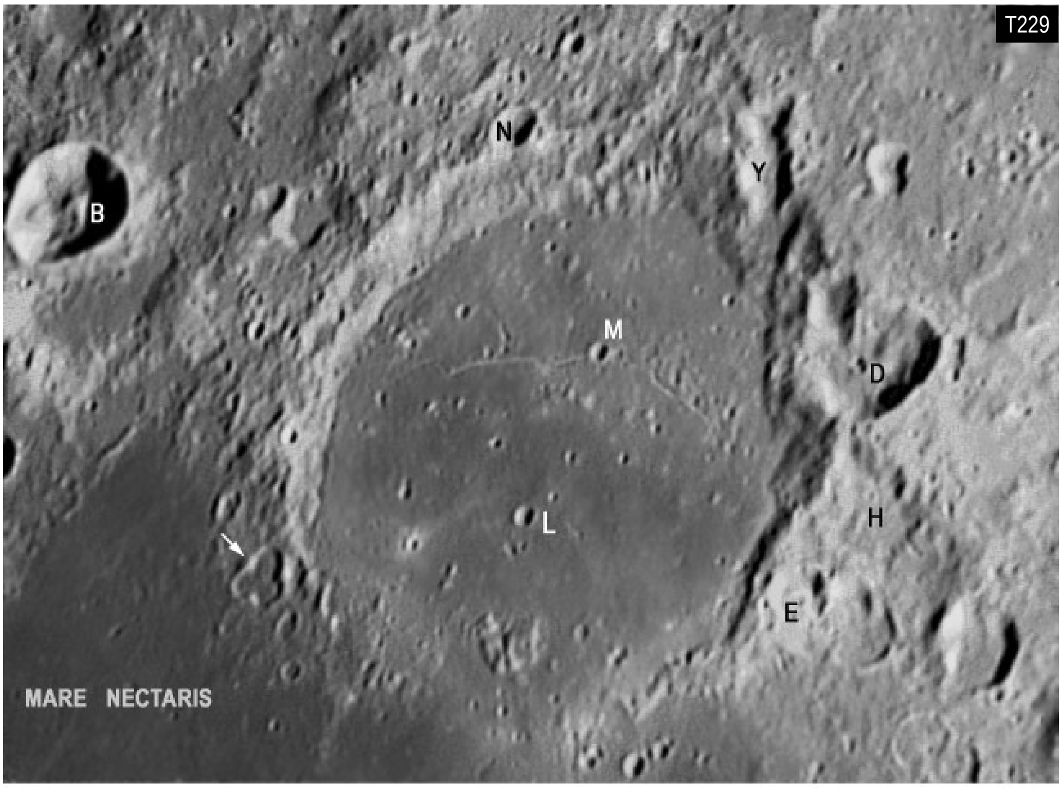
(Image T245, next page)

Lindenau 24.9^0 E 32.3^0 S
A prominent crater with terraced walls and multiple central peaks, 53 km in diameter.

Rabbi Levi 23.6^0 E 34.7^0 S
An 81-km crater with 5 smaller but prominent ones on the floor. Its eastern wall is heavily ruined by a cluster of impact craters.

Zagut 22.1^0 E 32.0^0 S
A crater adjoining Rabbi Levi, 84 km in diameter. Its floor contains a small central crater. Its eastern wall is hit by a fairly large crater (***Zagut E***, diameter 35 km).



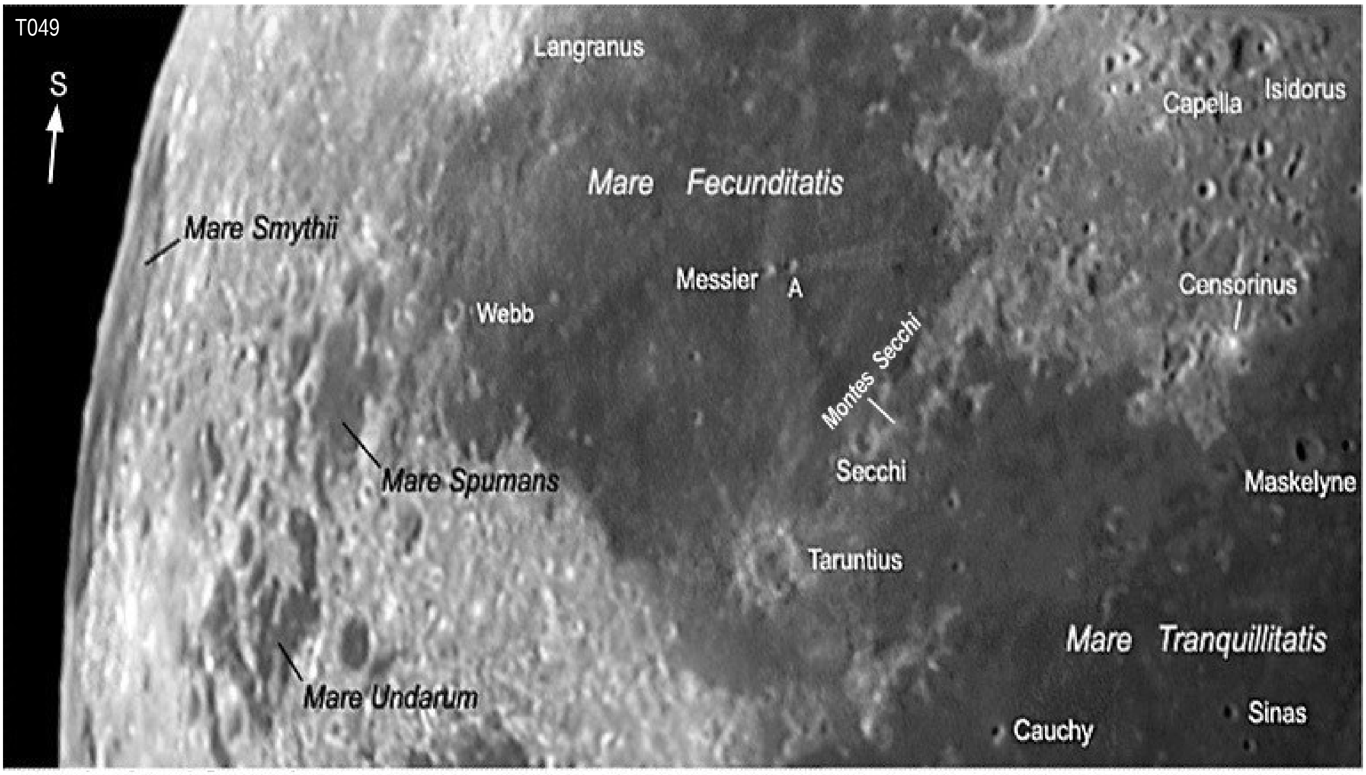


Fracastorius 2005.08.22 19:07 UT Age 17.5 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam, 93 frames stacked.

Fracastorius 33.2^0 E 21.5^0 S *(Image T229)*

An incomplete walled plain, 112 km in diameter. Its bay-like floor opens to Mare Nectaris and contains a long narrow, unnamed rille that intersects ***Fracastorius M***. This rille is rather elusive to spot unless the illumination angle is appropriate. The floor also contains a tiny rayed crater and dome-like hills. The western wall of Fracastorius is partially ruined by irregular craters ***Fracastorius Y, D*** and ***H***. Note the interesting crater-trio formation (arrow in T229).

Messier, Censorinus, Taruntius, Cauchy



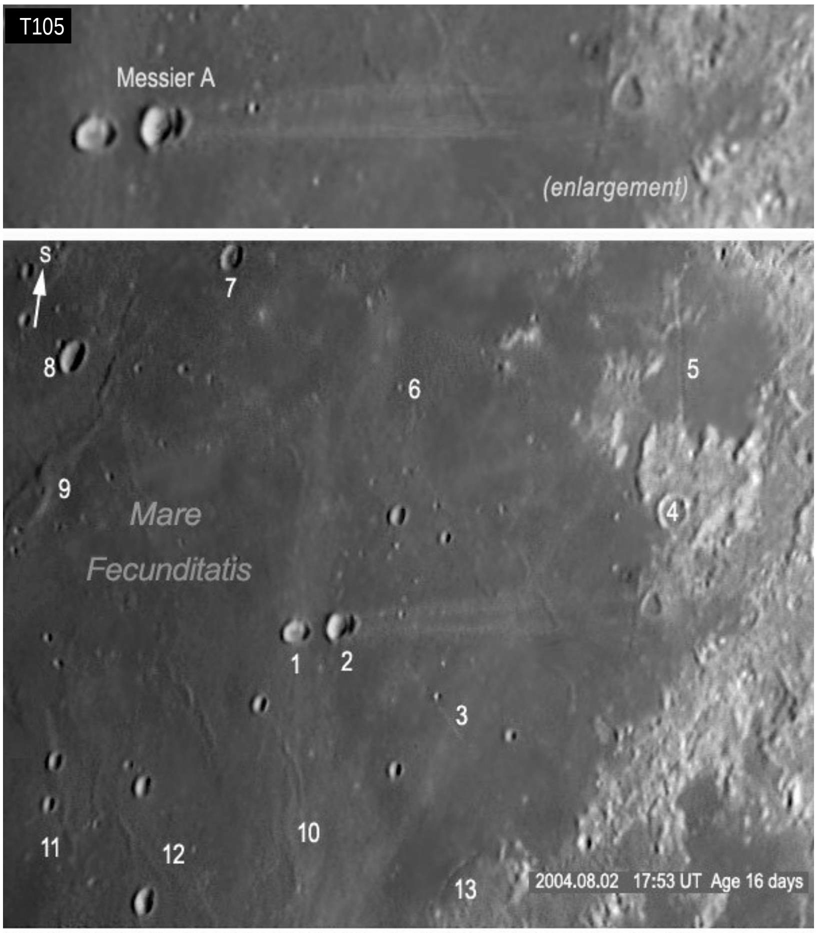
Messier A and Censorinus 2004.10.21 ~14:26 UT Age 8 days. Libration l = 3.3° b = 6.8°. 10-in f/6 + ToUcam at prime focus (*mosaic*)

(Image T105)

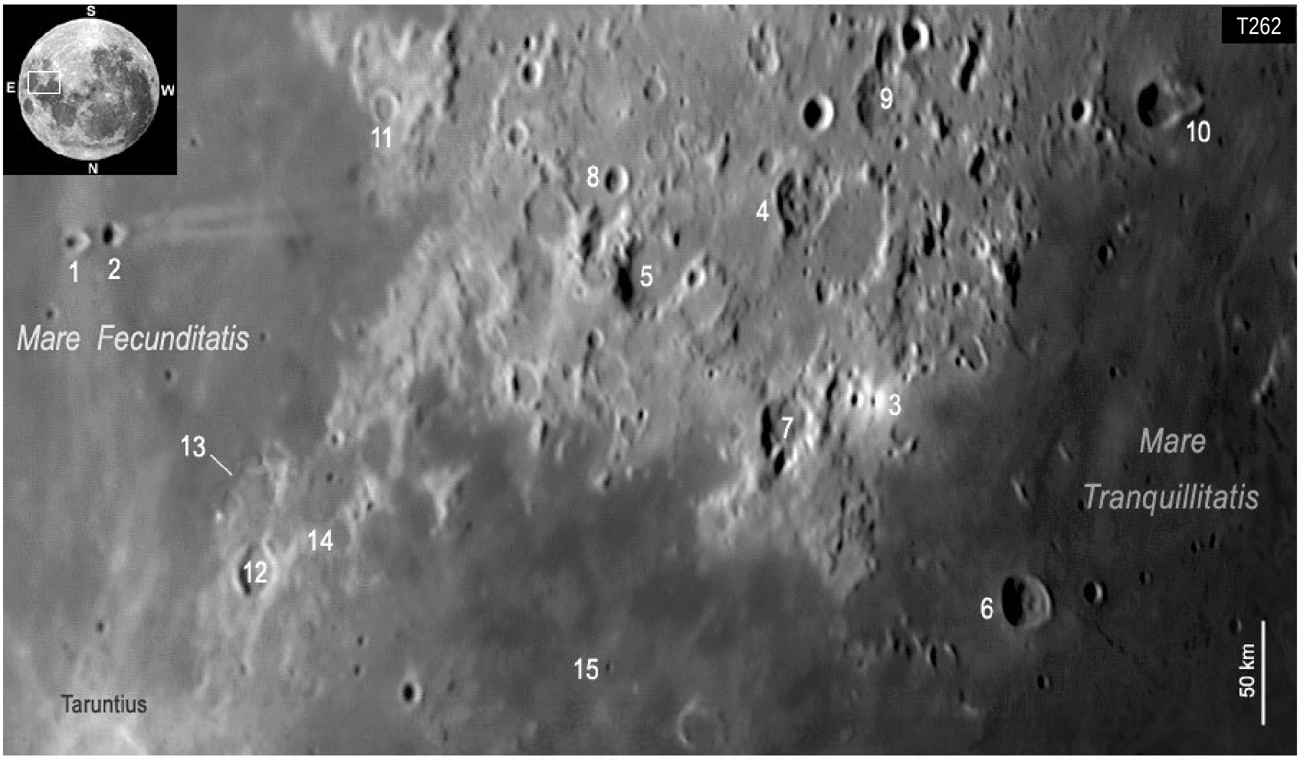
Messier 47.6^{0}E 1.9^{0}S
Messier A 47.0^{0}E 2.0^{0}S
A pair of small impact craters in Mare Fecunditatis (Sea of Fertility), diameter 11 ~ 13 km. Messier looks oval in shape that is definitely not caused by foreshortening. Messier A is a double crater and hence looks somewhat elongated. Its ejecta splashes out as two long bright rays like a comet; each ray is over 100 km long towards the west. This crater pair probably formed simultaneously by a grazing binary or broken impactor.

Rima Messier 45^{0}E 1^{0}S
An inconspicuous rille, length about 100 km.

Rimae Secchi 44^{0}E 1^{0}N
An inconspicuous rille, length 35 km. It is in the south of ***Secchi*** (Label 13, T262 in next page).



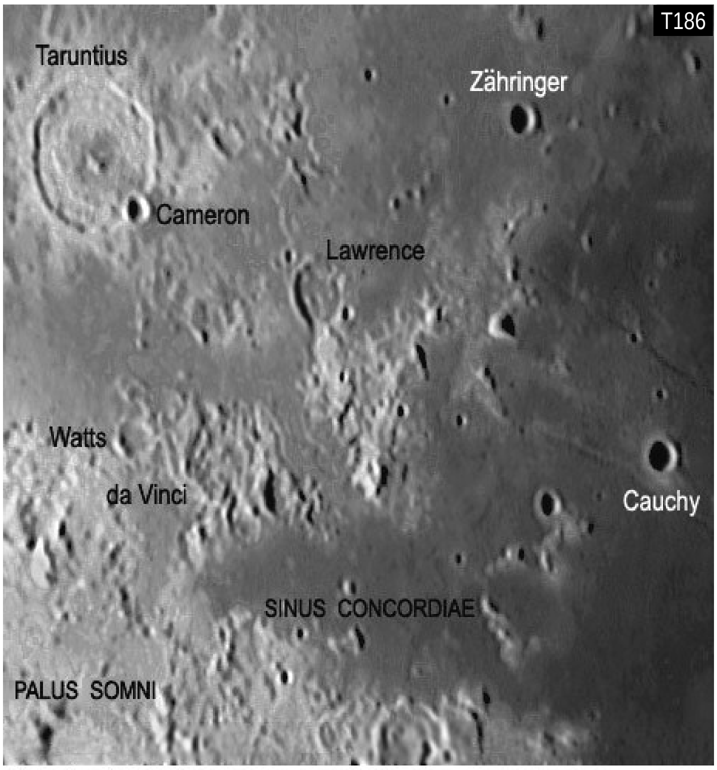
1. Messier 2. Messier A 3. Rima Messier 4. Lubbock 5. Rimae Goclenius 6. Amontons 7. Ibn Battuta 8. Lindbergh 9. Dorsa Mawson 10. Dorsa Cato 11. Dorsum Cayeux 12. Dorsum Cushman 13. Rimae Secchi (10-in f/6 Newtonian)



1. Messier 2. Messier A 3. Censorinus 4. Censorinus C 5. Censorinus N 6. Maskelyne 7. Maskelyne A 8. Leakey 9. Isidorus B
10. Torricelli 11. Lubbock 12. Secchi 13. Rimae Secchi 14. Montes Secchi 15. Menzel 2006.07.02 12:40UT Age 7 days. 10-in f/6 Newtonian + 2.5X + ToUcam

(Image 262)

Censorinus 32.7^0 E 0.4^0 S
A crater on the southern edge of Mare Tranquillitatis, 3 km in diameter. It is surrounded by a white halo and is exceptionally bright under high illumination.



Taruntius & Cauchy 2004.12.17 10:54 ~ 11:01 UT Age 5.4 days. 10-in f/6 + 2.5X + ToUcam

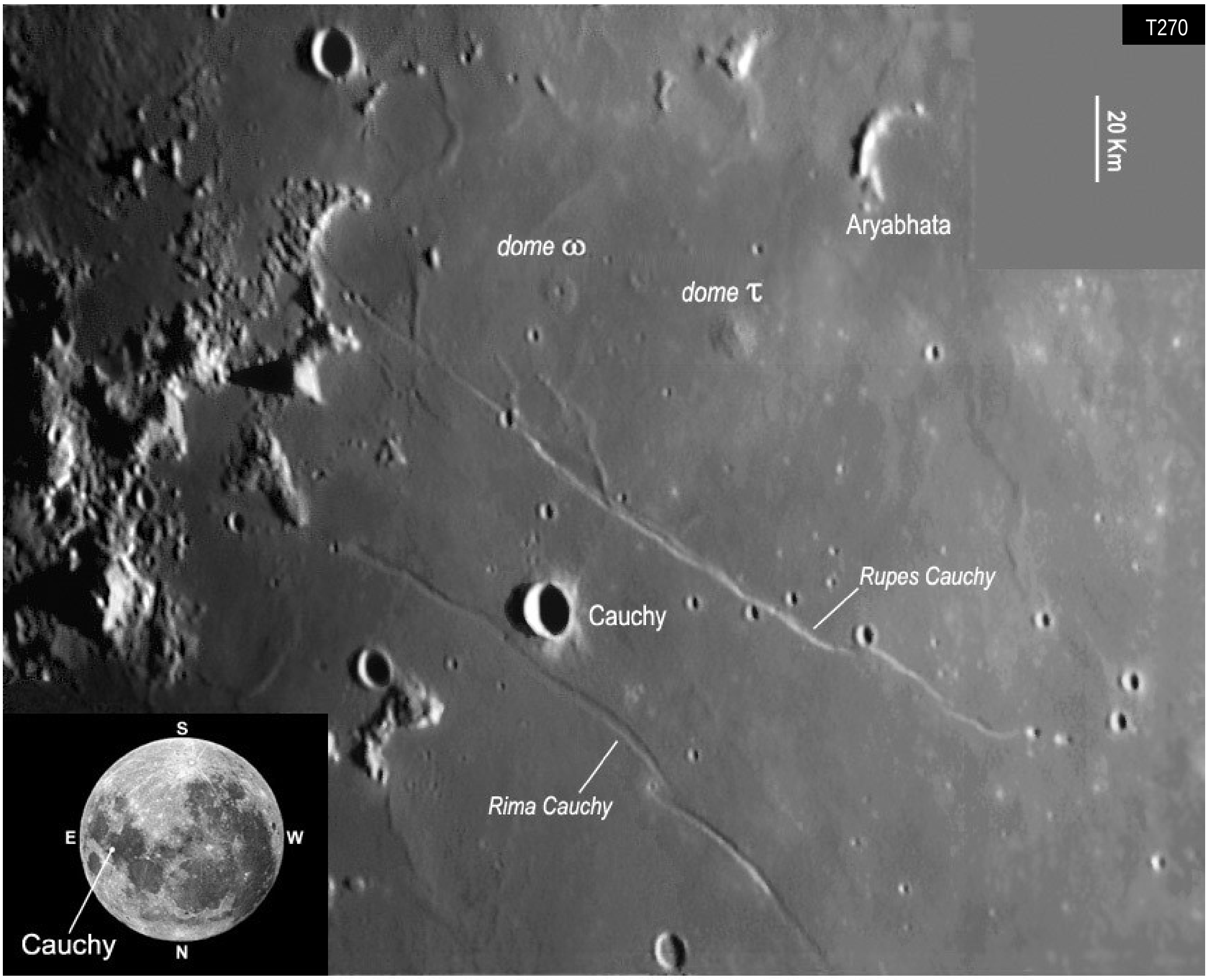
Maskelyne 30.1^0 E 2.2^0 N
A crater with terraced walls and central peak, 23 km in diameter. Its rim is somewhat polygonal.

Secchi 43.5^0 E 2.4^0 N
A crater with broken wall, 22 km in diameter. Its western rim adjoins a narrow mountain range (***Montes Secchi***, length about 50 km).

(Image T186)

Taruntius 46.5^0 E 5.6^0 N
A rayed crater at the "neck" between Mare Fecunditatis and Mare Tranquillitatis. It is 56 km in diameter, with concentric walls and a central peak on the partially darkened floor.

da Vinci 45.0^0 E 9.1^0 N
A disintegrated crater, 37 km in diameter. Its floor is rather rough.

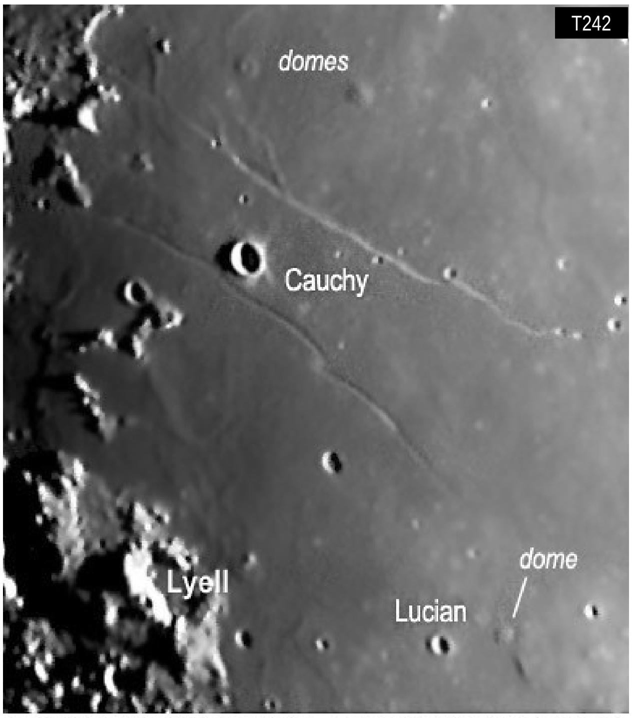


Cauchy, its adjacent rille, scarp and 2 domes 2006.08.12 ~21:11UT Age 18 days. 10-in f/6 Newtonian + 4X + ToUcam (*mosaic*)

Cauchy 38.6^0 E 9.6^0 N
A crater, 12 km in diameter. It is bright during the full moon but in the above images its floor is heavily shadowed and only the ejecta blanket is brightened. Bounding this crater are two parallel features: ***Rupes Cauchy*** (120 km long) and ***Rima Cauchy*** (140 km long). Rupes Cauchy is a fault and Rima Cauchy is a rille; they bear similarity to Rupes Recta and Rima Birt in Map 12. To the south of Cauchy are two domes designated ***Cauchy ω*** and ***Cauchy τ*** which are visible only at low Sun angles. Cauchy ω has a summit craterlet.

Aryabhata 35.1^0 E 6.2^0 N
A heavily flooded crater, 22 km in diameter. Its western wall is overwhelmed in lava.

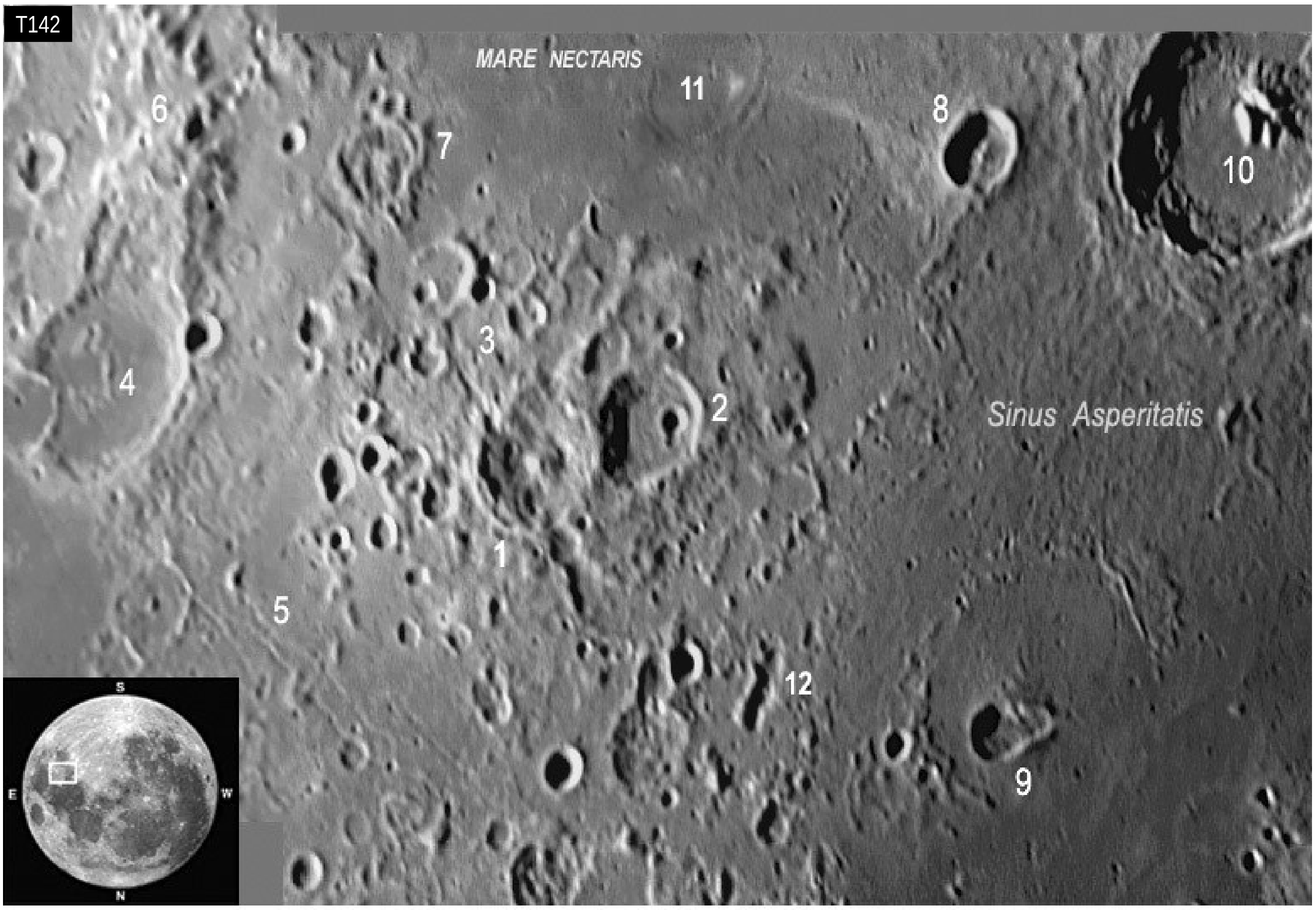
Lucian 36.7^0 E 14.3^0 N
A 7 km-crater. It has a nearby dome.



Lucian dome 2005.10.21 15:37UT Age 18 days. 10-in f/6 + 2.5X + ToUcam

Capella, Isidorus, Torricelli, Bohnenberger, Gutenberg

Hatfield 15
Rükl 47, 48, 58

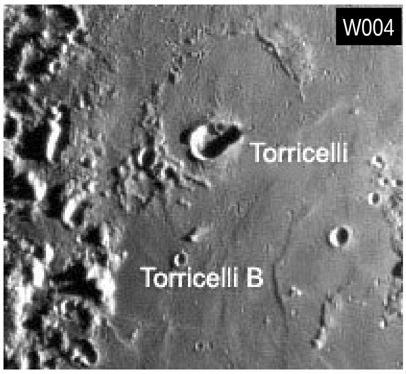


1. Capella 2. Isidorus 3. Vallis Capella 4. Gutenberg 5. Rimae Gutenberg 6. Montes Pyrenaeus 7. Gaudibert 8. Mädler 9. Torricelli 10. Theophilus 11. Daguerre 12. *a crater-valley* 2004.09.20 ~11:17UT Age 6 days. 10-in f/6 Newtonian + 2.5X + ToUcam.

Capella 35.0^0 E 7.5^0 S
A crater in the north of Mare Nectaris, 49 km in diameter. It has an oversized central peak with a summit pit. A valley (***Vallis Capella***, *fill* length 110 km) cuts through Capella and the adjacent smaller craters. This valley was formed by a chain of broken craters. If Image T142 is turned clockwise, Capella resembles a monkey face.

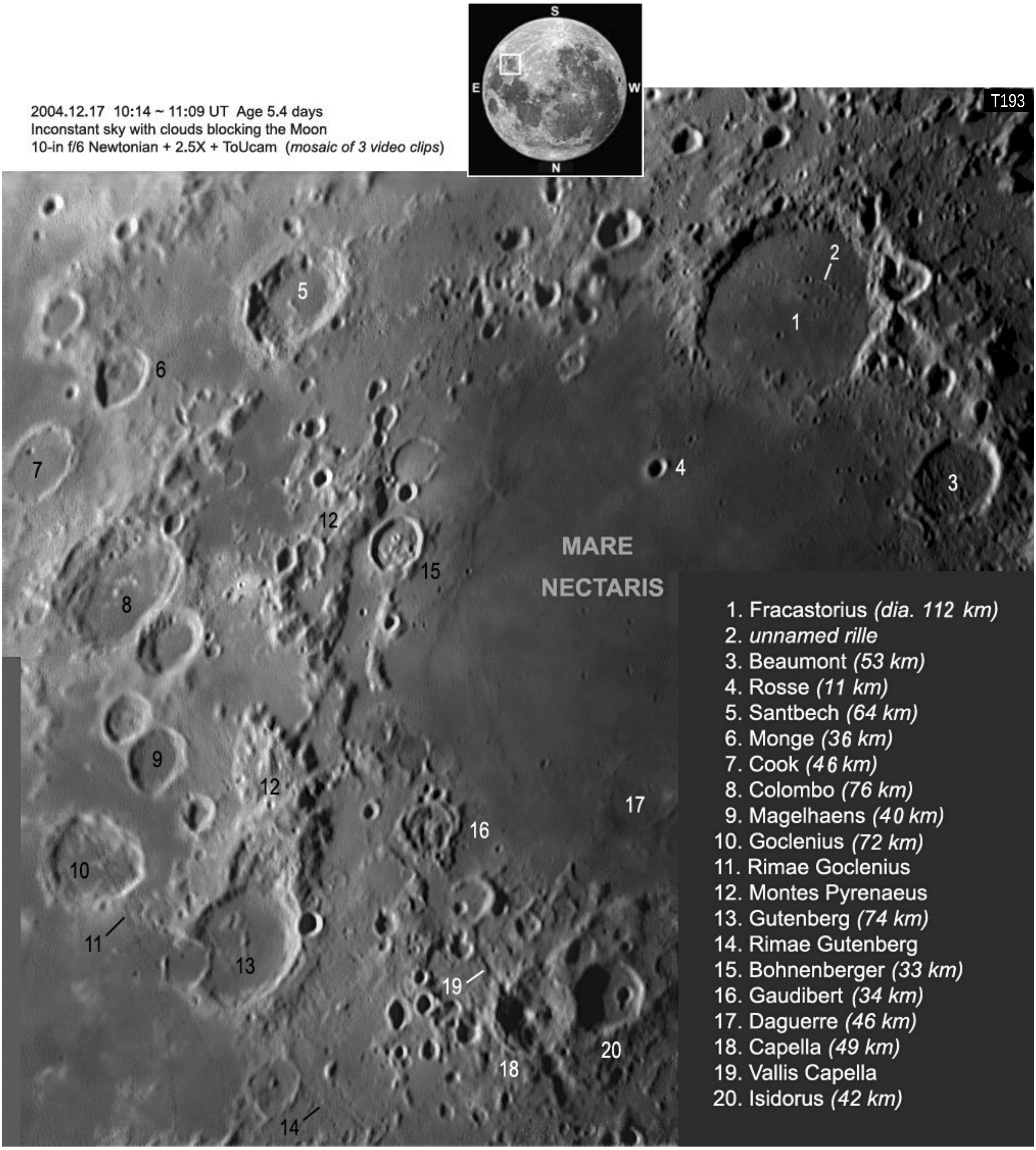
Isidorus 33.5^0 E 8.0^0 S
A crater with relatively flat floor, 42 km in diameter. Its wall is interrupted by Capella. It has no central peak. A prominent crater (***Isidorus A***, 10 km) is located on the floor near the western rim. A nameless crater-valley feature, formed by overlapping craters, exists in the north of Isidorus.

Mädler 29.8^0 E 11.0^0 S
A 27-km crater with prominent ejecta blanket. See also Map 5.



Torricelli 28.5^0 E 4.6^0 S
Torricelli is a strange-looking crater, 22 km in diameter. It is inside a ghost crater located in an uneven mare called ***Sinus Asperitatis*** (Bay of Roughness). The western wall of Torricelli is open and linked with a smaller crater, so that the whole formation appears pear-shaped.

2004.12.17 10:14 ~ 11:09 UT Age 5.4 days
Inconstant sky with clouds blocking the Moon
10-in f/6 Newtonian + 2.5X + ToUcam (*mosaic of 3 video clips*)



Fracastorius Details in Map 5.

Gaudibert 37.8^0 E 10.9^0 S *(Image T193, Label 16)*
A crater with internal massifs and ridges, 34 km in diameter. Its southern wall adjoins a trio of small craters while the rest of the walls are surrounded partially by mountain ranges.

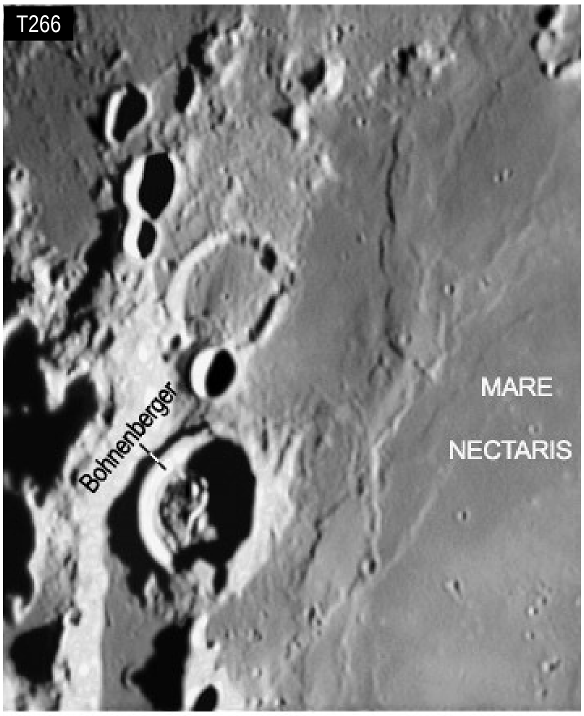
Daguerre 33.6^0 E 11.9^0 S *(T193, Label 17 and T142, Label 11)*
A ghost crater in Mare Nectaris, 46 km in diameter. A rayed craterlet is in the inner western floor.

Santbeth 44.0⁰ E 20.9⁰ S
Colombo 45.8⁰ E 15.1⁰ S
These are typical craters with terraced walls and central peaks. Santbech is 64 km in diameter, Colombo is 76 km.

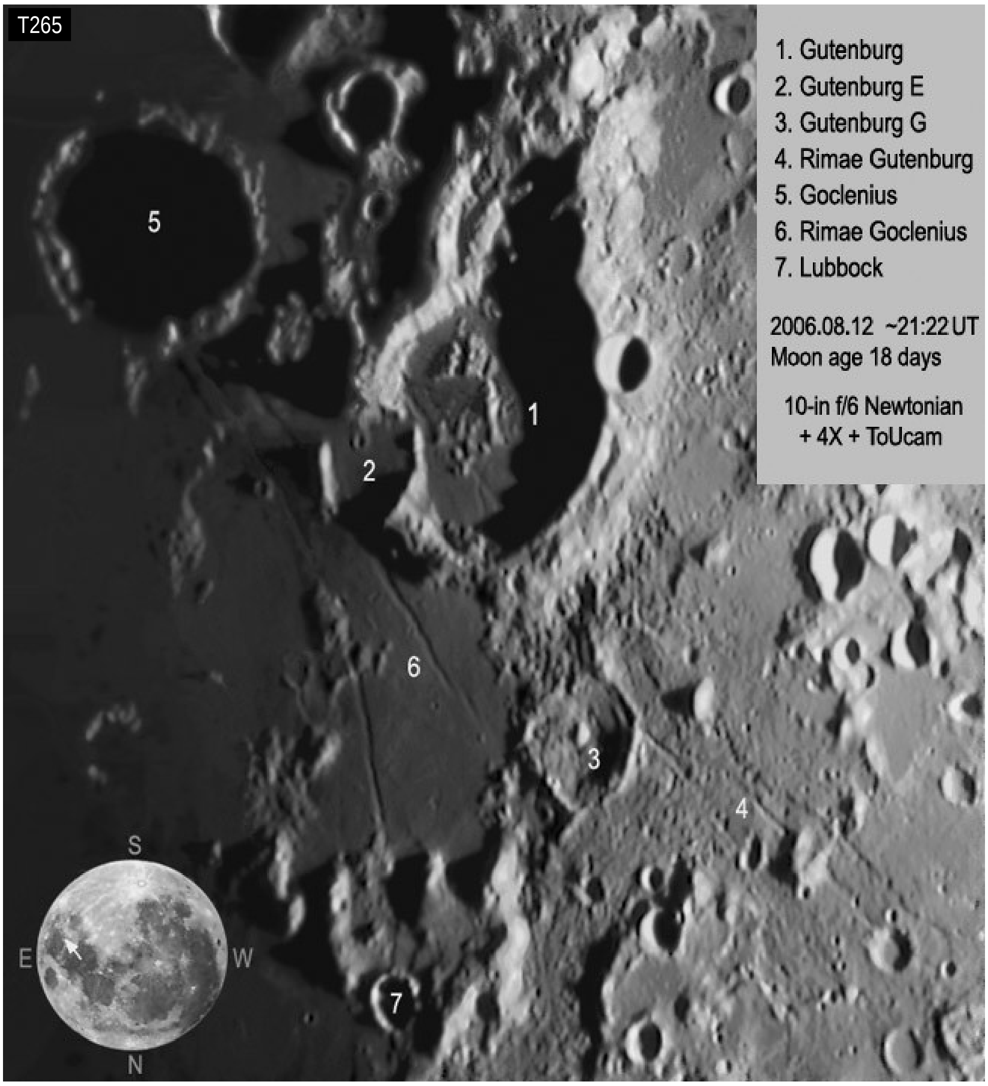
Bohnenberger 40.0⁰ E 16.2⁰ S
A crater with internal low hills, 33 km in diameter. It rests on the eastern edge of Mare Nectaris where wrinkle ridges are prominent at Moon age of 18 days.

Gutenberg 41.2⁰ E 8.6⁰ S
A flooded crater, 74 km in diameter. Its eastern wall is broken by a smaller flooded crater. Two wide systems of rilles, ***Rimae Gutenberg*** (length 330 km) and ***Rimae Goclenius*** (length 240 km) run in the vicinity.

Montes Pyrenaeus 41⁰ E 14⁰ S
Mountain range covering the area between Gutenberg and Bohnenberger, length about 170 km. It appears as part of the rising rim of the Nectaris impact basin.



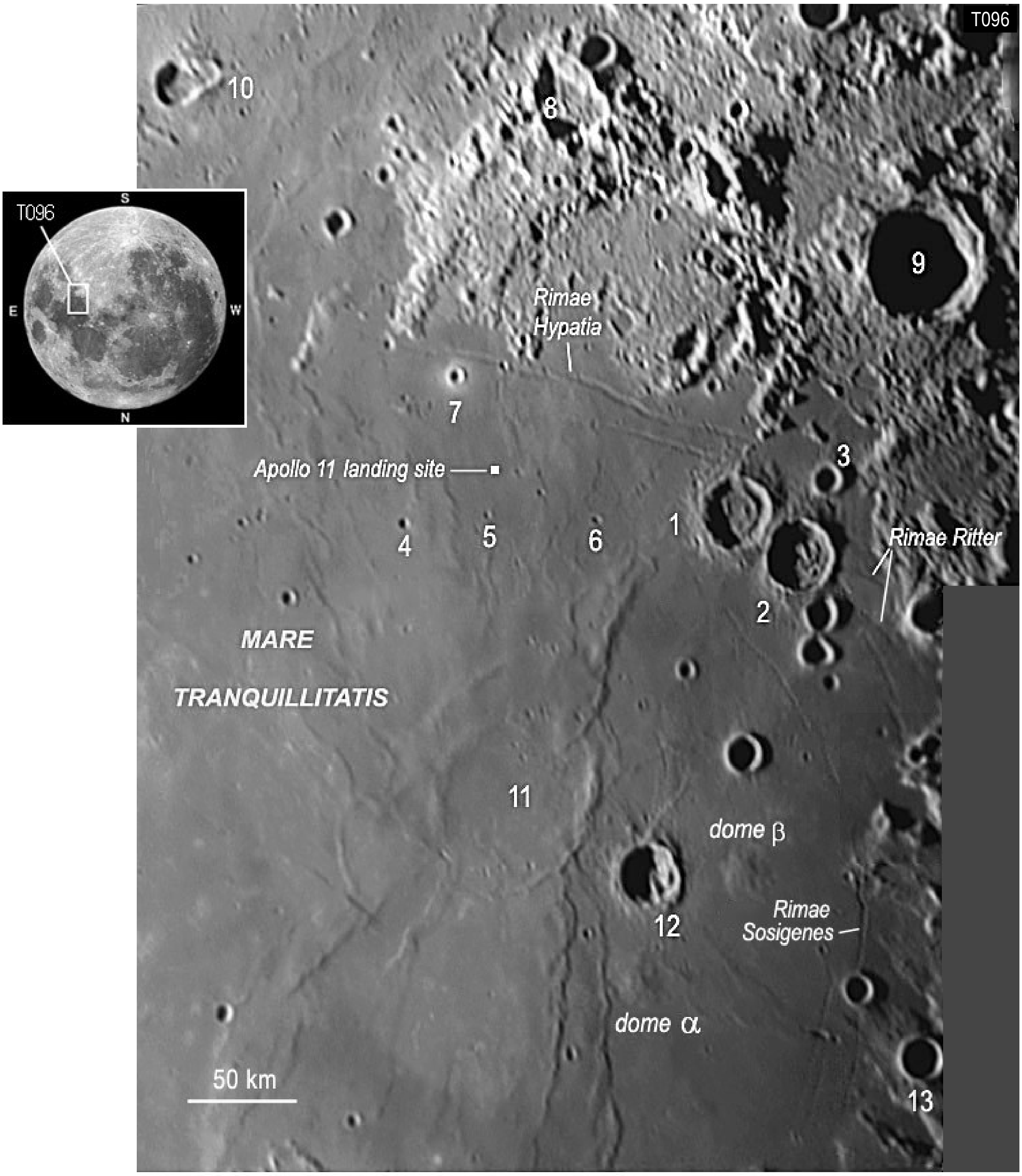
2006.08.12 21:23 UT Age 18 days. 10-in f/6 Newtonian + 4X + ToUcam



MAP 8

Hatfield 1,13
Rükl 35, 46

Sabine, Ritter, Hypatia, Delambre, Arago, Lamont



1. Sabine 2. Ritter 3. Schmidt 4. Armstrong 5. Collins 6. Aldrin 7. Moltke 8. Hypatia 9. Delambre 10. Torricelli 11. Lamont 12. Arago 13.Sosigenes 2004.09.20 11:13UT Age 6 days. 10-in f/6+2.5X+ToUcam

Sabine 20.1^{0} E 1.4^{0} N **Ritter** 19.2^{0} E 2.0^{0} N

Two adjoining craters near the equator, each about 30 km in diameter and with rough floors. A prominent ridge intersects the southern rim of Sabine. On 1969 July 20, the Apollo 11 Lunar Module landed on the west of Sabine. The landing site is a flat area called ***Statio Tranquillitatis*** (Tranquillity Base). It is truly flat and was chosen by the Apollo mission planners to prevent any obstacle or hazard during final descent. To honor this pioneer expedition, three nearby craters are named after ***Armstrong*** (4.6 km), ***Collins*** (2.4 km) and ***Aldrin*** (3.4 km). Armstrong is the Apollo 11 astronaut who first set his foot on the Moon; Collins and Aldrin are other crew members.

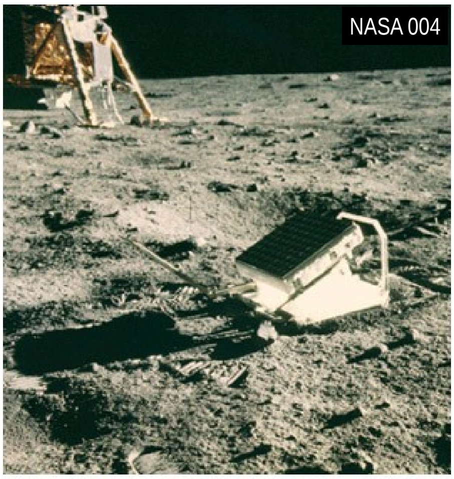
Two systems of parellel rilles, ***Rimae Hypatia*** (length 200 km) and ***Rimae Ritter*** (length 100 km) are in the close vicinity of Sabine and Ritter.

Moltke 24.2⁰ E 0.6⁰ S
A small crater with a bright halo, 6 km in diameter. The bright halo makes easier to recognize where crater Armstrong should be.

Hypatia 22.6⁰ E 4.3⁰ S
A curiously shaped crater. It measures 28 x 40 km and appears to sit on its own plateau.

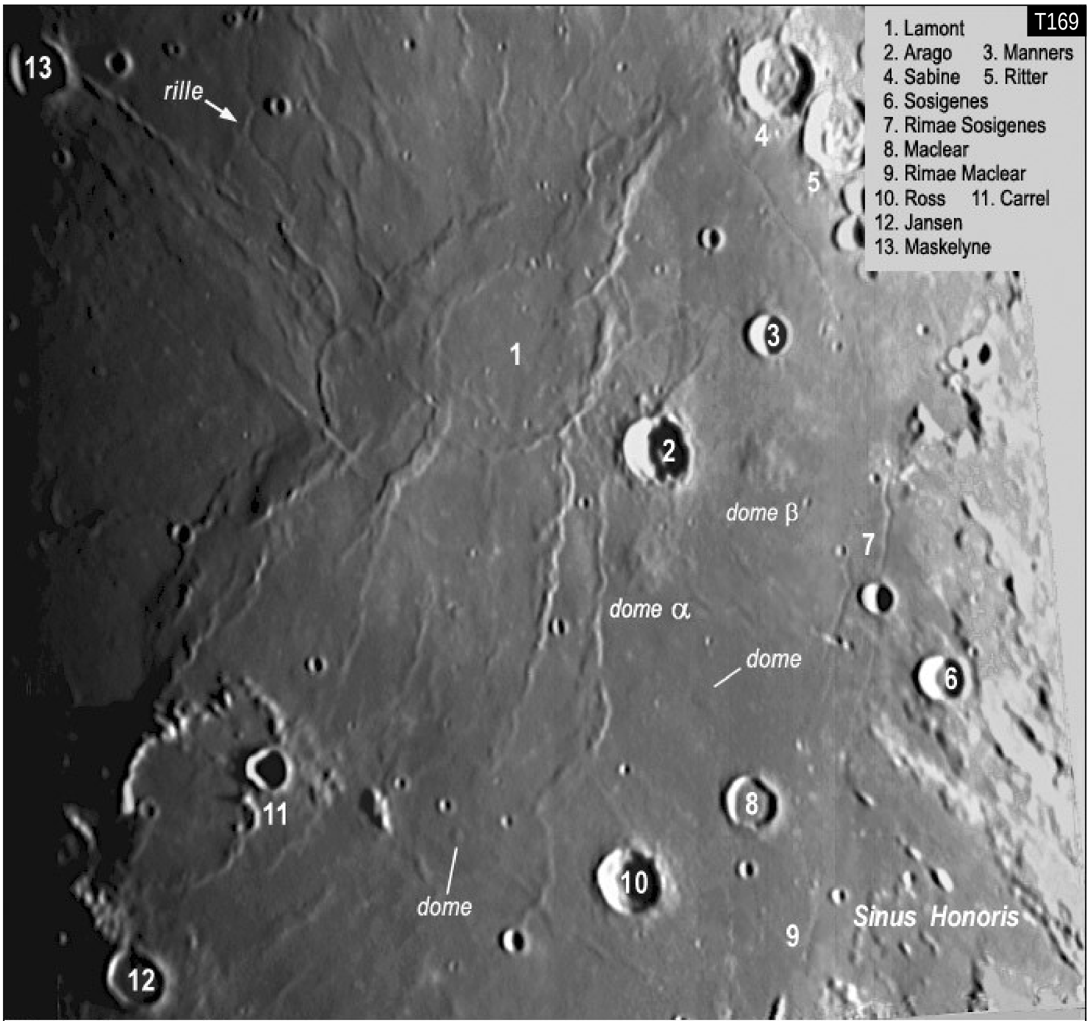
Delambre 17.5⁰ E 1.9⁰ S
A terraced crater, 51 km in diameter, about 3000 m deep.

Arago 21.4⁰ E 6.2⁰ N
A crater with sharp rim and ridged floor, 26 km in diameter. Two domes (α, β) and few smaller domes are in the vicinity.

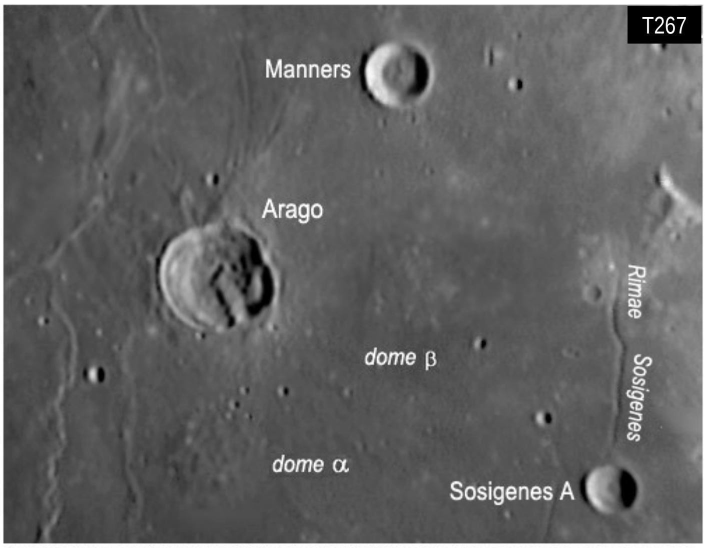


Apollo 11 Landing Module (picture corner) and the Laser Ranging Retro-reflector Array. The reflector was left by Apollo 11 crew on the landing site, and is still used today by the McDonald Observatory to monitor the precise Earth-Moon distance. (*http://www.csr.utexas.edu/mlrs/*)

Lamont 23.7⁰ E 4.4⁰ N
A ghost crater outlined by concentric wrinkle ridges, 100 km in diameter. It contains a macon.



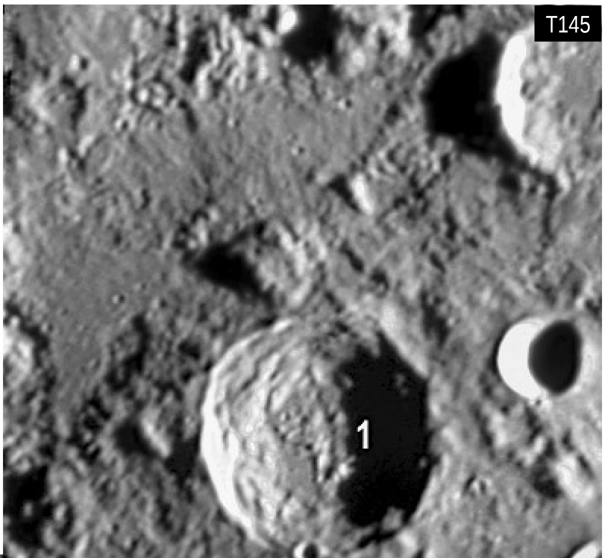
Wrinkle ridges around Lamont 2004.10.03 21:40UT Age 19 days. 10-in f/6+2.5X+ToUcam. Arrow points to *Diamondback Rille* (nickname).

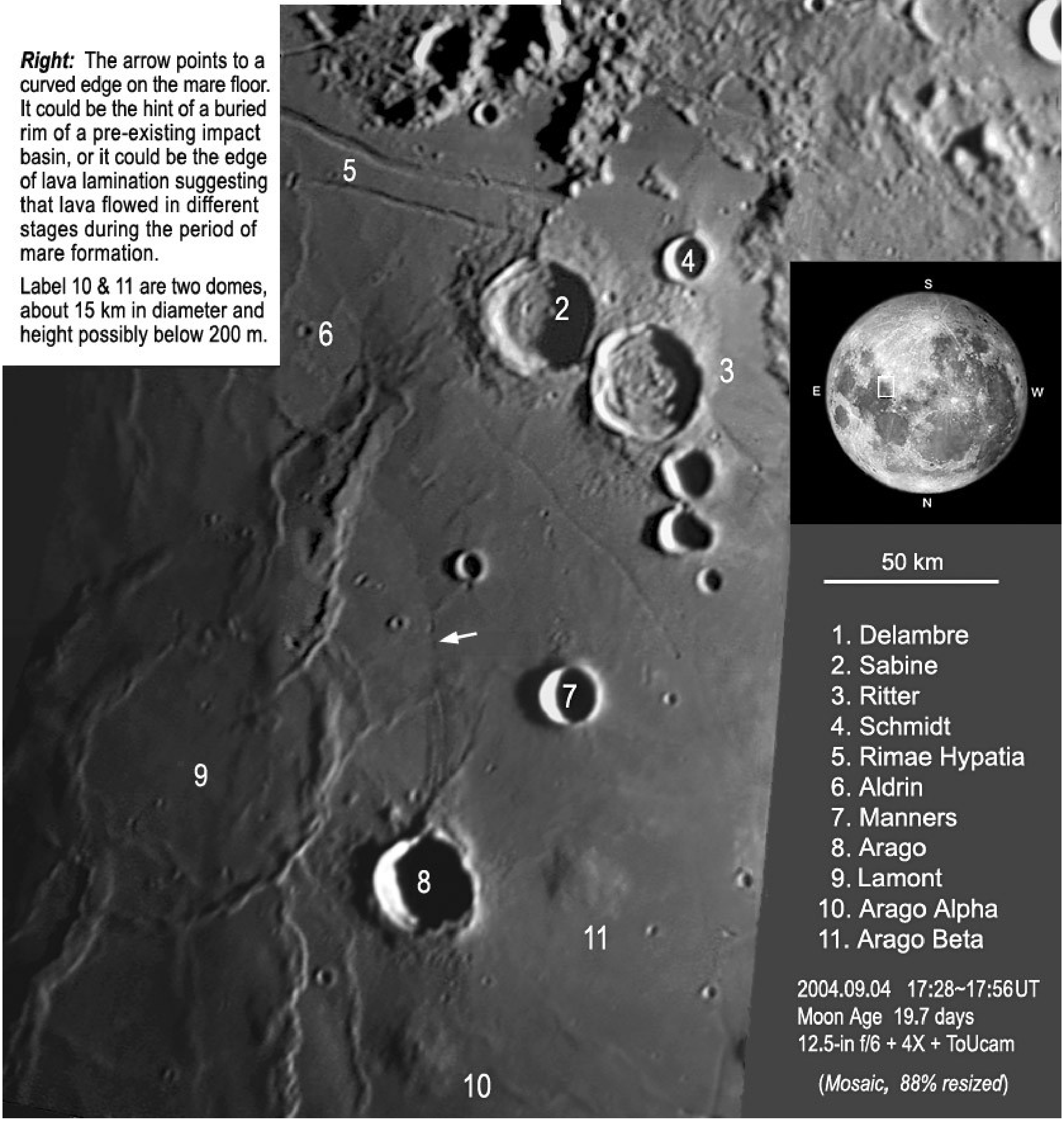


2006.08.12 20:42 UT Age 18 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam

Right: The arrow points to a curved edge on the mare floor. It could be the hint of a buried rim of a pre-existing impact basin, or it could be the edge of lava lamination suggesting that lava flowed in different stages during the period of mare formation.

Label 10 & 11 are two domes, about 15 km in diameter and height possibly below 200 m.



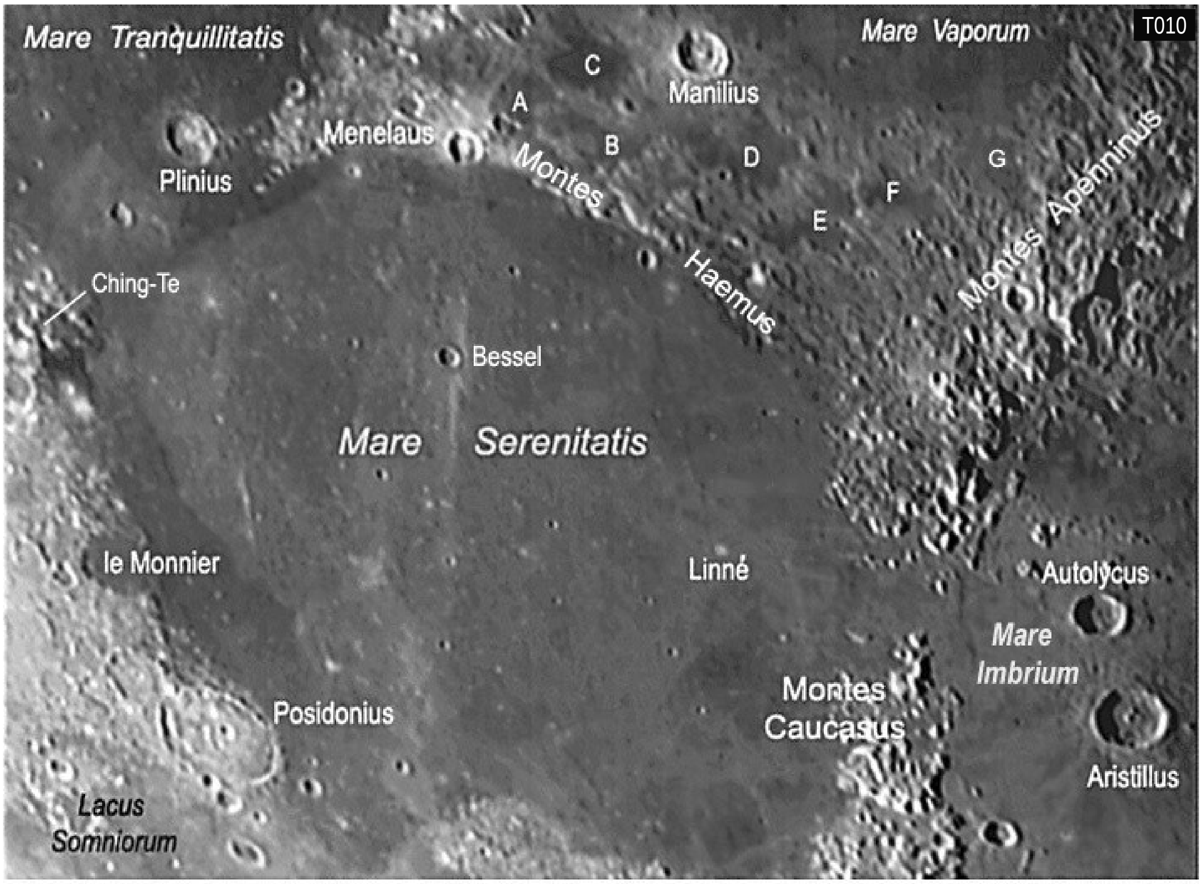


2004.09.04 17:28~17:56UT
Moon Age 19.7 days
12.5-in f/6 + 4X + ToUcam

(*Mosaic, 88% resized*)

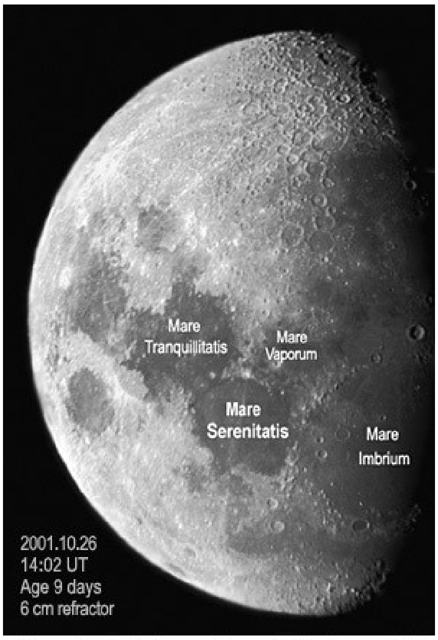
Hatfield 1, 3
Rükl 23, 24, 25, 14

Mare Serenitatis, Serpentine Ridge, Plinius, Posidonius



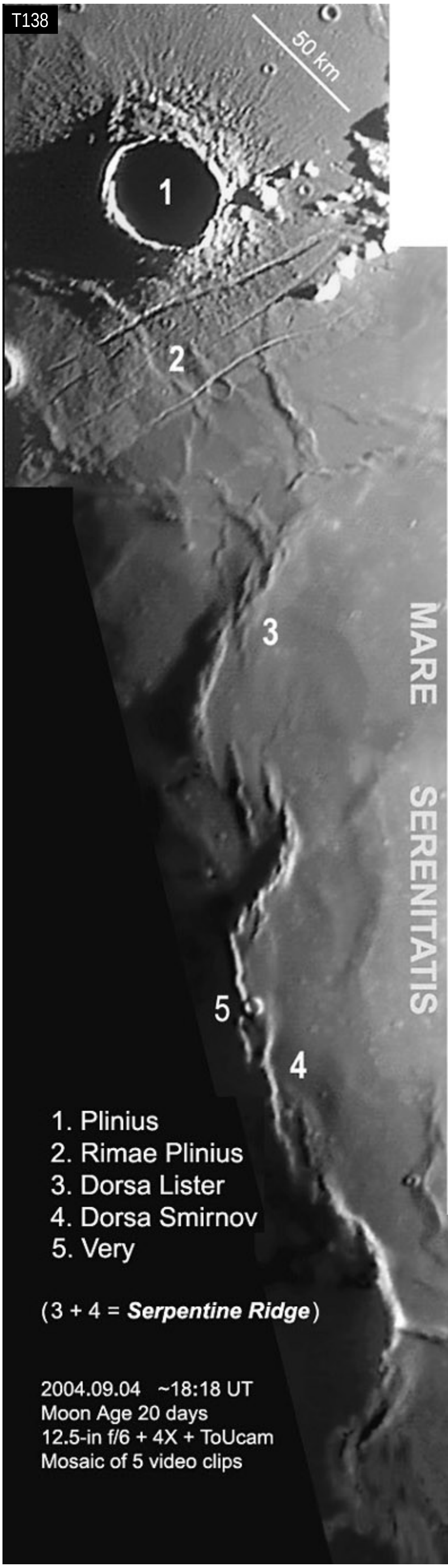
Mare Serenitatis 2004.06.26 14:54 UT Age 9 days. 10-in f/6 Newtonian + ToUcam at prime focus, 1/100s, 38 frames stacked.
A. Lacus Hiemalis (Winter Lake) B. Lacus Gaudii *(Lake of Joy)* C. Lacus Lenitatis *(Lake of Tenderness)* D. Lacus Doloris (Lake of Sorrow) E. Lacus Odii *(Lake of Hate)* F. Lacus Felicitatis *(Lake of Happiness)* G. Sinus Fidei *(Bay of Faith)*

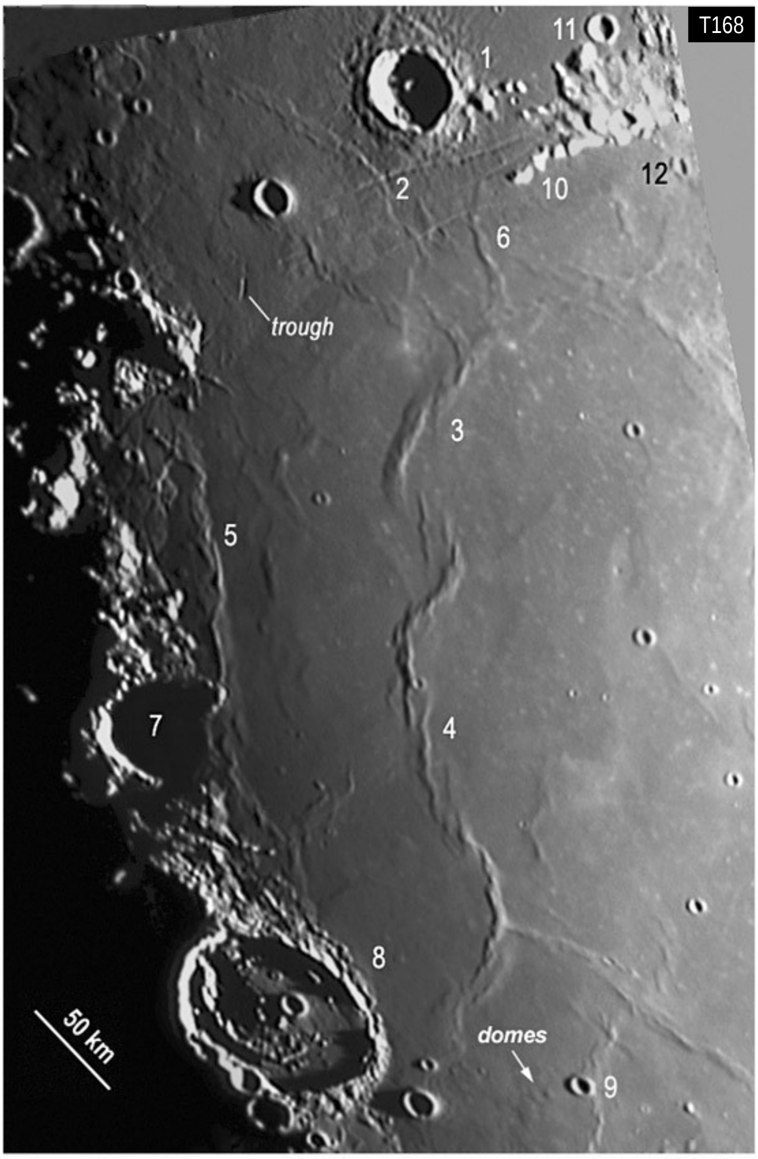
Mare Serenitatis (Sea of Serenity) is a vast, near-circular lava plain, size about 500 x 700 km. The inner collar of the mare looks somewhat darker, suggesting richer in metallic composition than the rest of the floor. The eastern floor is crossed by two snaky wrinkle ridges named ***Dorsa Lister*** and ***Dorsa Smirnov*** (also collectively called ***Serpentine Ridge***, see next page). Each of them is about 10 km wide and meanders quite a long distance. They may have resulted from surface shrinkage following the cease of volcanism, or buckling of the lunar crust due to the weight of accumulating lava in the Serenitatis impact basin. Wrinkle ridges are fairly low in height (200 m or less), so they are distinctive only under very oblique sunlight.



Mare Serenitatis and its neighboring maria

The southwest edge of Mare Serenitatis is the 400-km long ***Montes Haemus***; it is part of the rising rim of the Serenitatis impact basin. In the vicinity are six irregular lava "lakes", labeled A to F in Image T010. ***Menelaus, Plinius, le Monnier*** and ***Posidonius*** are the most conspicuous craters in this region. A lava channel between Montes Apenninus and Montes Caucasus connects Mare Serenitatis with Mare Imbrium.

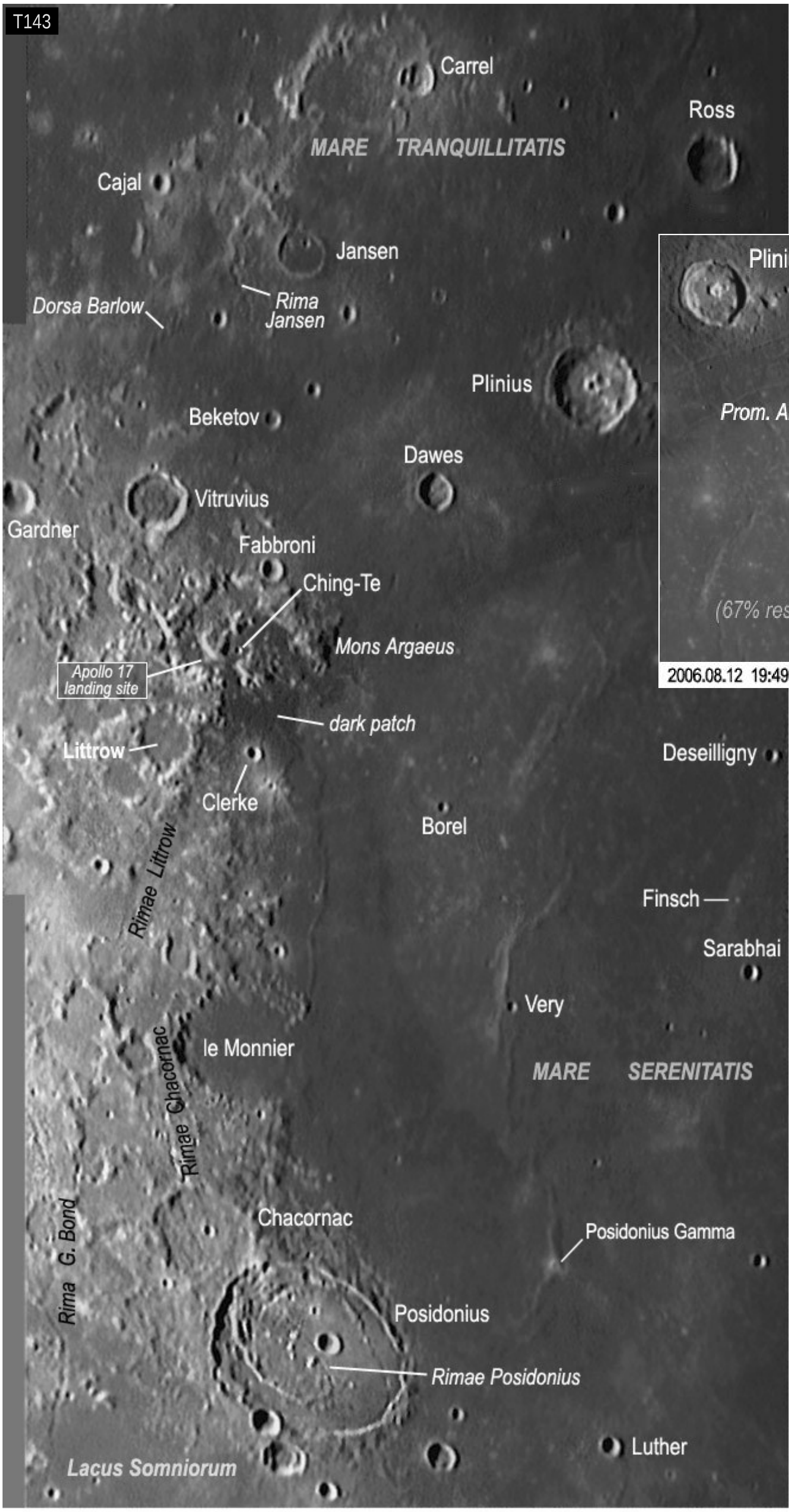




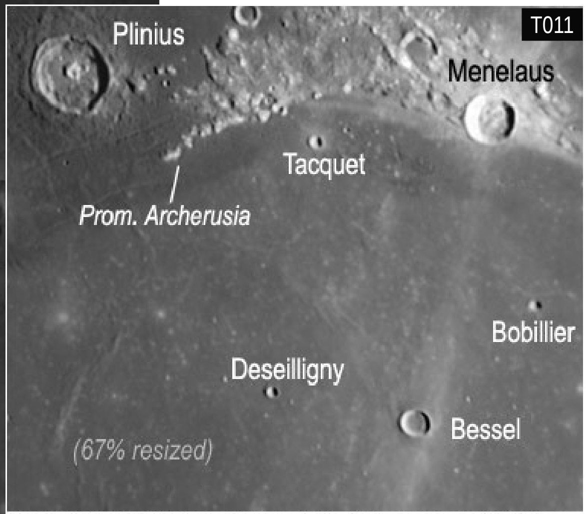
1. Plinius 2. Rimae Plinius 3. Dorsa Lister 4. Dorsa Smirnov 5. Dorsa Aldrovandi 6. Dorsum Nicol 7. le Monnier 8. Posidonius 9. Luther 10. Promontorium Archerusia 11. Al-Bakri 12. Tacquet
2004.10.03 21:28~21:36 UT Moon Age 19 days. 10-inch f/6 Newtonian + 2.5X + ToUcam (mosaic)

Serpentine Ridge 蛇脊

*Serpentine Ridge (a former name) consists of Dorsa Lister & Dorsa Smirnov, length about 400 km. It is prominent only when it is close to the bright side of the terminator. In the middle of this ridge is crater **Very** (diameter 5 km). Near the southern end is an unnamed, 12 km-long trough (T168). Near the northern end are **Luther** and a small group of indistinctive domes.*



Plinius to Posidonius 2004.12.19 12:18~12:26 UT Age 7.4 days. 10-in f/6 + 2.5X + ToUcam (*mosaic*)



2006.08.12 19:49 UT Age 18 days. 10-in f/6 Newtonian + 4X + ToUcam

Menelaus with rays

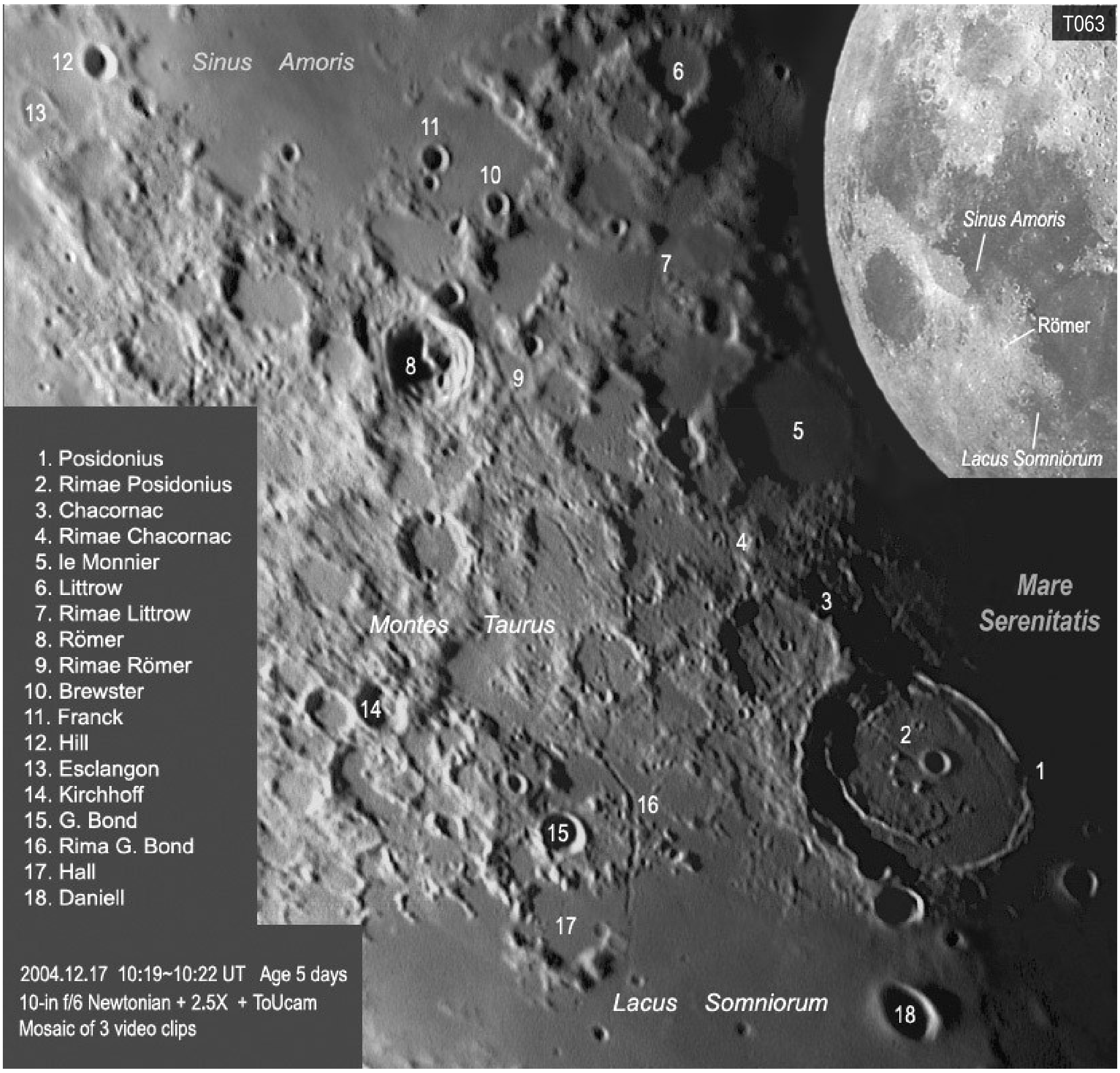
Left: *A remarkably dark patch appears near crater Littrow. The inner edge of Mare Serenitatis is also darker than the rest of the floor. Posidonius Gamma is a former name referring to the peak on wrinkle ridge (Dorsa Smirnov). It has a summit craterlet with a diameter of about 2 km. This craterlet is surrounded by a halo of bright material.*

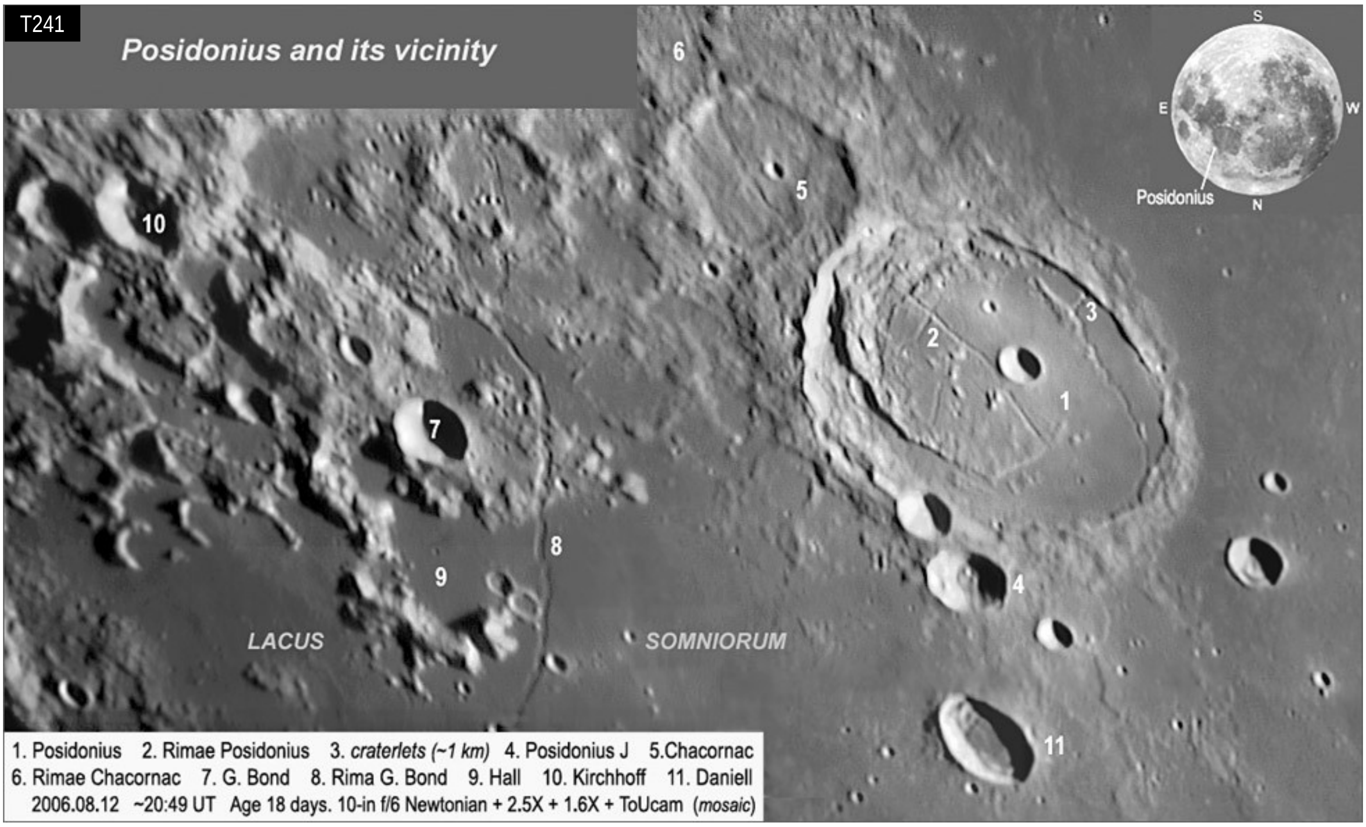
Plinius 23.7^0 E 15.4^0 N *(Image T138 & T143)*
A sharp rimmed crater between Mare Serenitatis and Mare Tranquillitatis, 43 km in diameter. It is visible even in the full moon. A system of parallel rilles (***Rimae Plinius***, length 120 km) lies on its immediate north and cuts through the wrinkle ridges on the mare. Plinius is a Roman general and naturist, also the author of the encyclopedia "Historia Naturalis". He died in the witness of the massive eruption of Mount Vesuvius, a volcano in Italy that destroyed the City of Pompeii in AD79.

Montes Taurus 36^0 E 26^0 N *(Image T063)*
Montes Taurus (Bull Mountains) is in the east of Mare Serenitatis. It rises to 3000 m peak, spanning 250 km north-south between Sinus Amoris (Bay of Love) and Lacus Somniorum (Lake of Dreams). It holds the fairly prominent crater ***Römer*** and several longitudinal rilles named ***Rimae Römer***, ***Rimae Littrow***, ***Rimae Chacornac*** and ***Rima G. Bond***. Like wrinkle ridges, these rilles rely on low angles of sunlight to be distinctive.

Römer 36.4^0 E 25.4^0 N
A sharp rimmed crater with terraced walls and a central peak, 39 km in diameter.

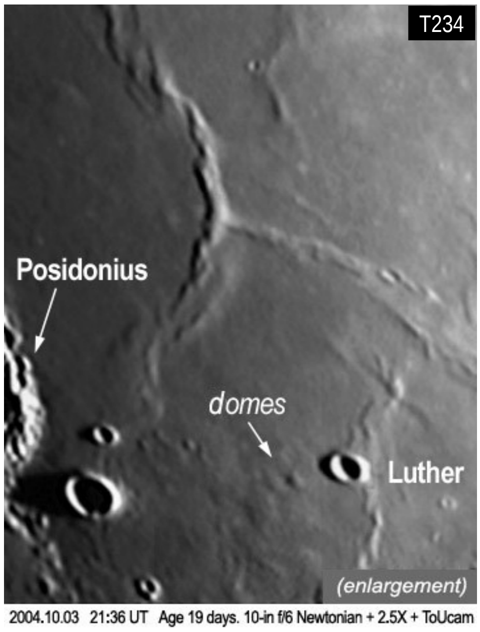
le Monnier 30.6^0 E 26.6^0 N
A bay-like flooded crater with a dark floor, 60 km in diameter.





Posidonius 29.9^0 E 31.8^0 N *(Image T241)*
A walled plain between Mare Serenitatis and Lacus Somniorum, 95 km in diameter. Its floor contains low hills (probably volcanic domes), prominent ridges and rilles (***Rimae Posidonius***). Near first quarter, Posidonius appears like "a thin pancake on the dark mare" because of its raised floor. Label 3 in T241 is a short chain of tiny craters, barely resolvable in 10-inch telescopes.

In T234, three small domes are distinguishable between Posidonius and ***Luther*** **(**diameter 9 km).



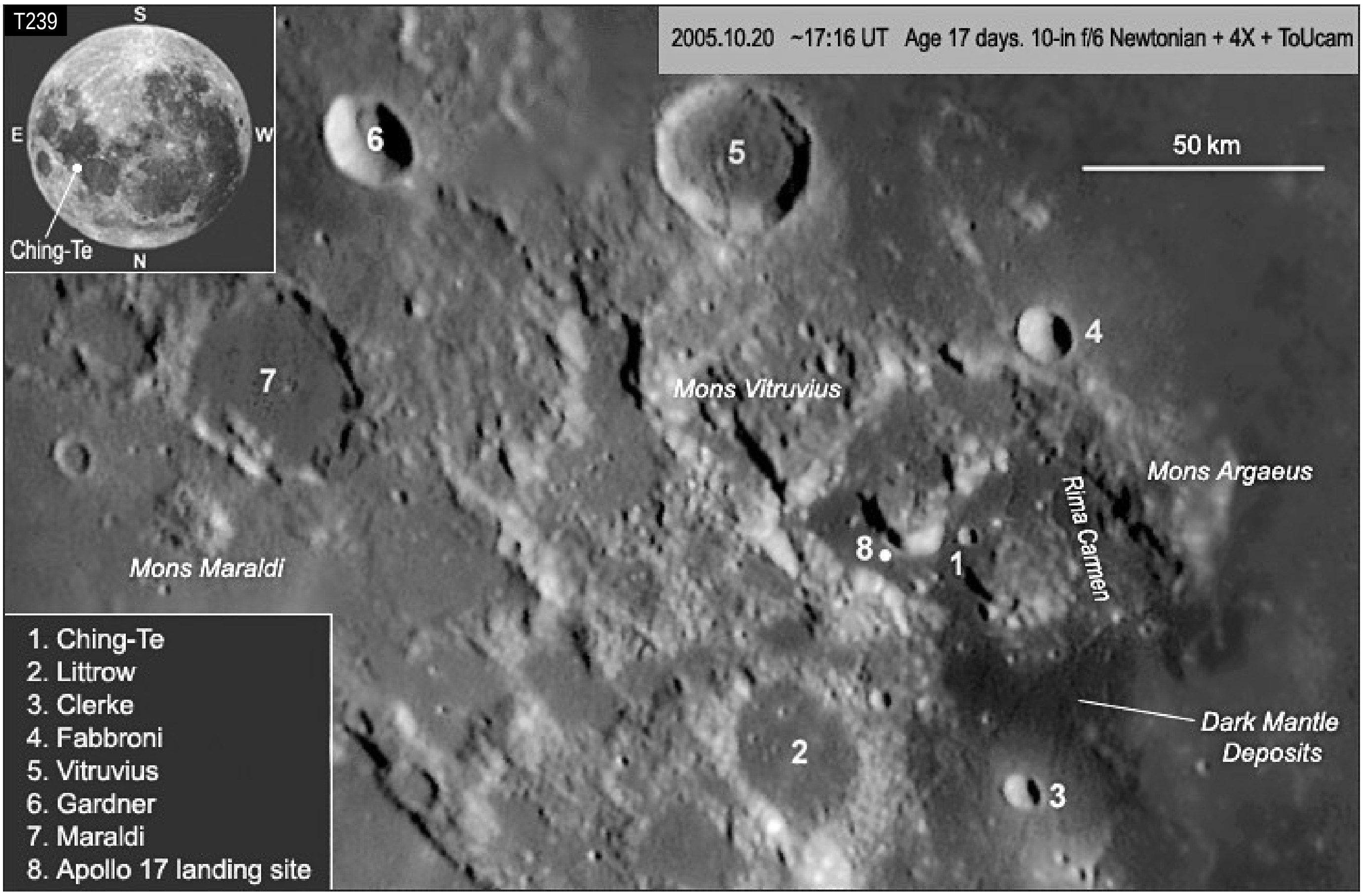
Three domes near Luther

Chacornac 31.7^0 E 29.8^0 N
A disintegrated crater adjoining Posidonius. It is 51 km in diameter, with hexagonal walls and a small off-center crater. Few rilles (***Rimae Chacornac***) on the floor are visible under high magnifications. Chacornac appears as the little brother of Posidonius.

Daniell 31.1^0 E 35.3^0 N
A sharp-rimmed oval crater, size 23 x 29 km. See also Map 10.

Rima G. Bond 35^0 E 33^0 N
A prominent rille extending into Lacus Somniorum, length 160 km, width up to 4 km.

Hall 37.0^0 E 33.7^0 N
A disintegrated flooded crater, 35 km in diameter.

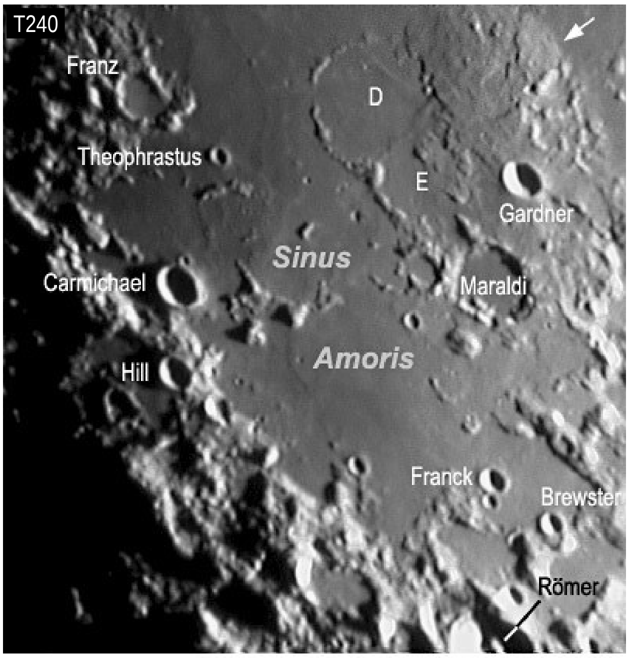


Ching-Te 30.0° E 20.0° N
Ching-Te (Chinese male name) is a small crater close to ***Mons Argaeus***, 4 km in diameter. It is an obscure object for small telescopes and is likely hidden when the Sun angle is not appropriate. The surroundings of Ching-Te are massifs. Apollo 17 landed on the other side of the massifs on 1972 December 11, about 20 km east of Ching-Te. (http://antwrp.gsfc.nasa.gov/apod/ap040412.html)

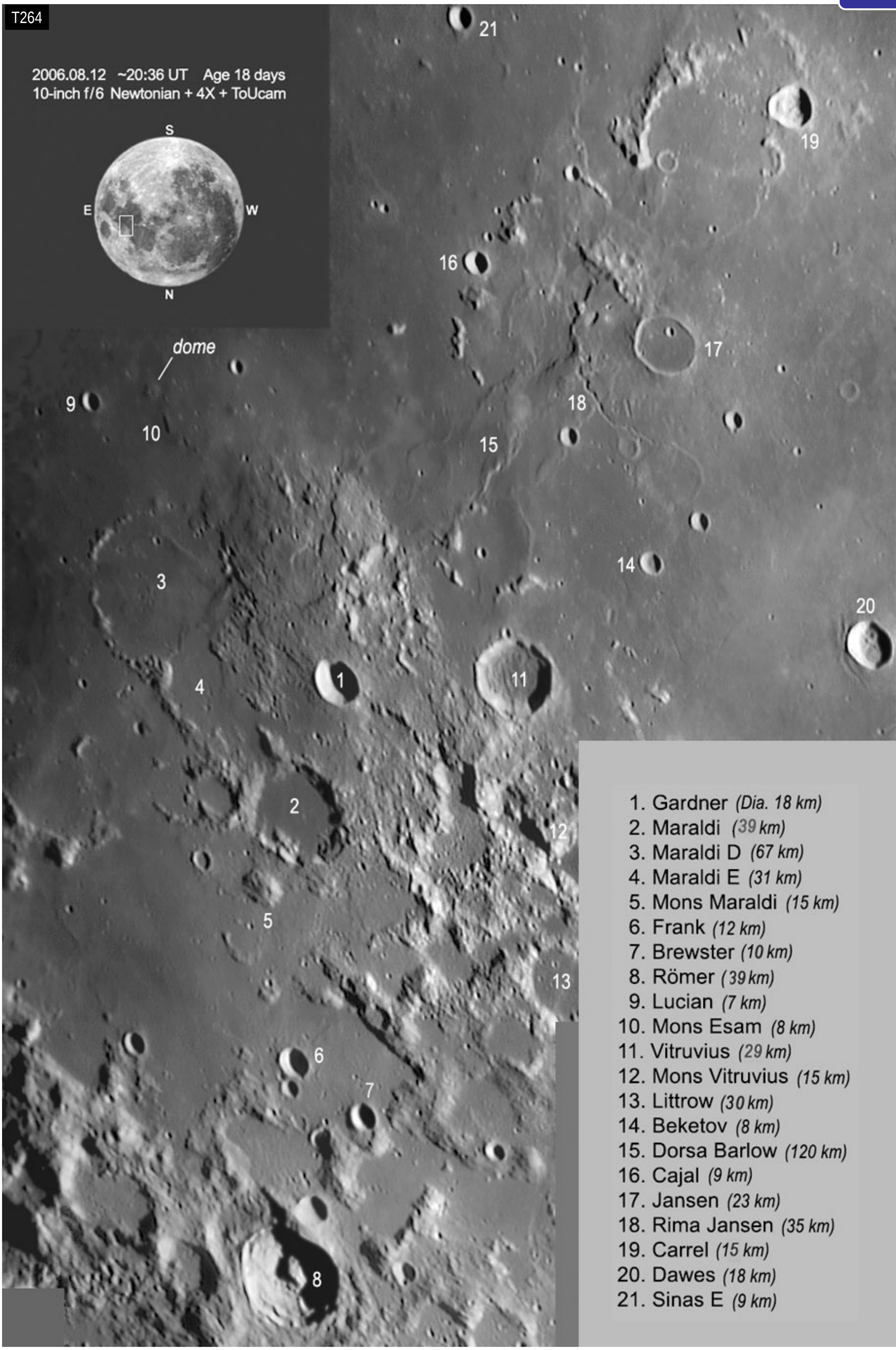
The northern vicinity of Ching-Te is a remarkably dark patch, so called DMD (dark mantle deposits). It is easily recognized as a tiny sesame during the full-moon. It contains a mixture of small black and dark orange glass debris which formed from quickly cooled droplets of a nearby volcanic fountain. (http://www.psrd.hawaii.edu/Feb97/MoonVolcanics.html)

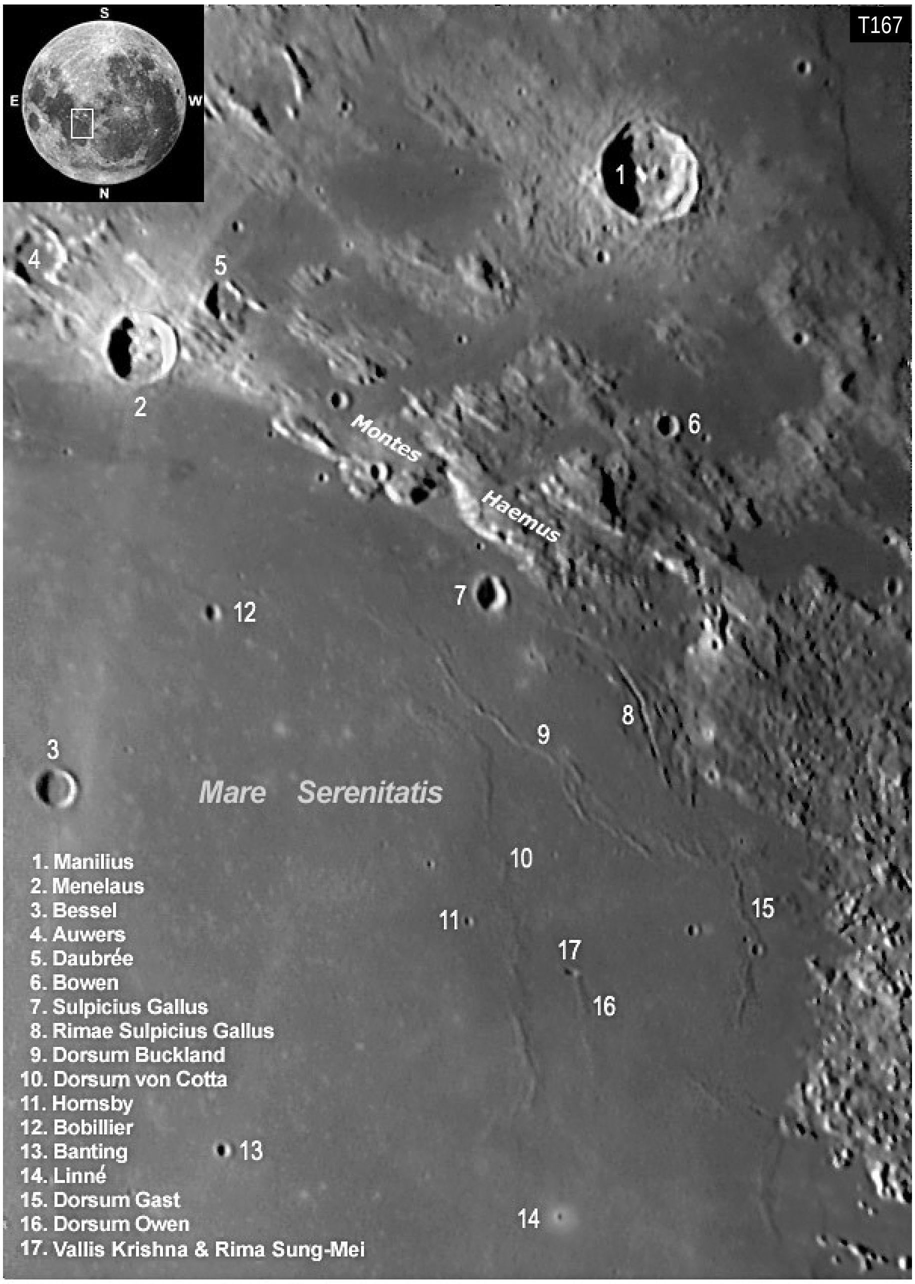
Littrow 31.4° E 21.5° N
A flooded crater, 30 km in diameter. It has a nearby complex system of rilles (***Rimae Littrow***, length 110 km, shown in Image T143).

Maraldi 34.9° E 19.4° N
A fairly dark flooded crater facing ***Sinus Amoris*** (Bay of Love), diameter 39 km. ***Maraldi D*** (67 km) is a ghost crater. The arrow in T240 indicates a dome-like plateau (megadome). See also T264 in next page and Map 32.

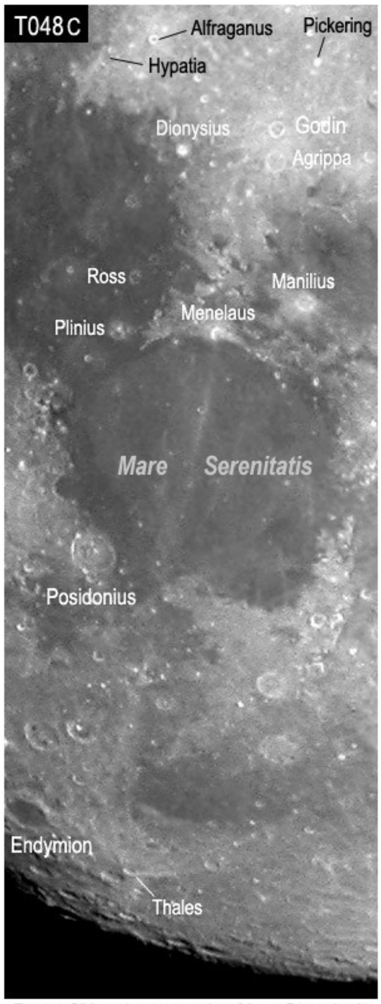


Sinus Amoris 2005.10.20 15:59 UT Age 17 days. 10-in f/6 + 2.5X + ToUcam


T264
2006.08.12 ~20:36 UT Age 18 days
10-inch f/6 Newtonian + 4X + ToUcam
S
E
W
N
dome
1. Gardner (Dia. 18 km)
2. Maraldi (39 km)
3. Maraldi D (67 km)
4. Maraldi E (31 km)
5. Mons Maraldi (15 km)
6. Frank (12 km)
7. Brewster (10 km)
8. Römer (39 km)
9. Lucian (7 km)
10. Mons Esam (8 km)
11. Vitruvius (29 km)
12. Mons Vitruvius (15 km)
13. Littrow (30 km)
14. Beketov (8 km)
15. Dorsa Barlow (120 km)
16. Cajal (9 km)
17. Jansen (23 km)
18. Rima Jansen (35 km)
19. Carrel (15 km)
20. Dawes (18 km)
21. Sinas E (9 km)



Manilius, Menelaus & Bessel 2005.11.09 11:45 UT Age 7 days. 10-in f/6 Newtonian + 2.5X + ToUcam (*mosaic*)



Rays of Menelaus crossing Mare Serenitatis
2003.09.11 16:11 UT Age 15 days. FS128 + PL15 + CP995

Montes Haemus 13^{0}E 17^{0}N
A 400 km-long mountain range forming the south-western edge of Mare Serenitatis. Just beyond it are several irregular dark lava patches: ***Lacus Hiemalis*** (Winter Lake), ***Lacus Gaudii*** (Lake of Joy), ***Lacus Lenitatis*** (Lake of Tenderness), ***Lacus Doloris*** (Lake of Sorrow), ***Lacus Odii*** (Lake of Hate) and ***Lacus Felicitatis*** (Lake of Happiness). See also T010, front page of this map.

Manilius 9.1^{0}E 14.5^{0}N
A bright rayed crater with sharp rim, terraced walls and central peaks, 38 km in diameter. See also T257 in Map 33.

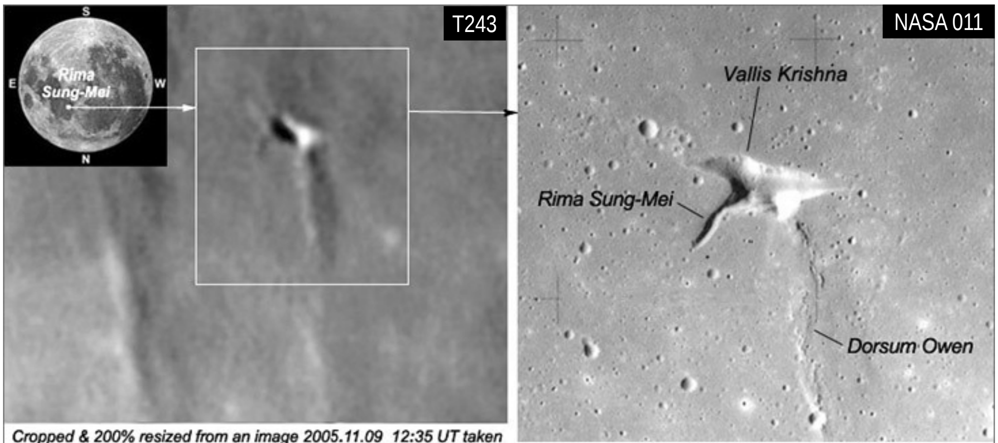
Menelaus 16.0^{0}E 16.3^{0}N
A remarkably bright rayed crater with sharp rim and central peaks, 26 km in diameter. One of its rays is over 1000 km long, stretching across Mare Serenitatis and beyond. Other rays are traceable from the outer rim of Menelaus, between ***Auwers*** and ***Daubrée*** (T167).

Bessel 17.9^0 E 21.8^0 N
A crater with prominent bright rays, 15 km in diameter.

Sulpicius Gallus 11.6^0 E 19.6^0 N
A sharp rimmed crater, 12 km in diameter and fairly deep (2100 m). Its vicinity is ***Rimae Sulpicius Gallus***, a system of prominent rilles, 90 km long.

Linné 11.8^0 E 27.7^0 N
A small, relatively young crater surrounded by bright ejecta material. Linné is only 2.4 km in diameter or one arcsecond angular, yet it is easily recognized through telescopes as a bright spot under high illumination. Since the second half of the 19th century, numerous mysterious changes and disappearances of Linné have been reported. Some observers suggested there could be outgoing gases from the crater and referred it to LTP (Lunar Transit Phenomena). Even today, the Linné controversy goes on. (See Reference No. 21.)

Rima Sung-Mei 11.3^0 E 24.6^0 N
A 4-km long, narrow rille adjoining ***Vallis Krishna*** and close to ***Dorsum Owen*** in Mare Serenitatis. It is a difficult object, hardly noticeable unless seeing is good. Vallis Krishna was previously named as crater ***Krishna***. Sung-Mei is originated from the name of a Chinese female.



Cropped & 200% resized from an image 2005.11.09 12:35 UT taken with 10-in f/6 Newtonian + 4X + ToUcam under bad seeing of ~2/10.

Cropped from Apollo-15 image AS15-M-0407

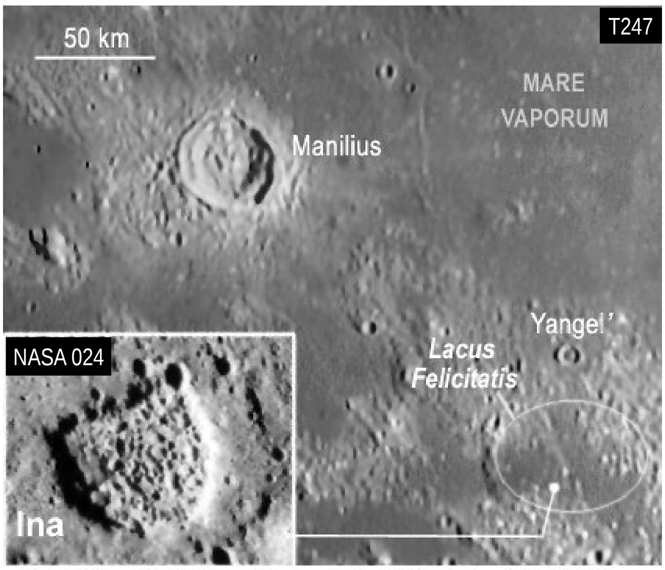
Rima Sung-Mei

Left: *Image in telescope*

Right: Closeup from *Apollo 15*

Lacus Felicitatis 5^0 E 19^0 N
(Lake of Happiness)

An irregular lava plain where scientists found evidence for volcanic "outgassing" that may have happened within the past ten million years --- and may still be happening today. The evidence was spotted in 2006, inside a young crater named ***Ina*** at the rim of Lacus Felicitatis. Ina (5.3^0 E 18.6^0 N) is a semi-circular depression, about 3 km in diameter and less than 100 m deep. This shallow depression is difficult to observe from the Earth. See NASA close-up image at right. (Reference: *http://science.nasa.gov/headlines/y2006/09nov_moonalive.htm?list137588*)

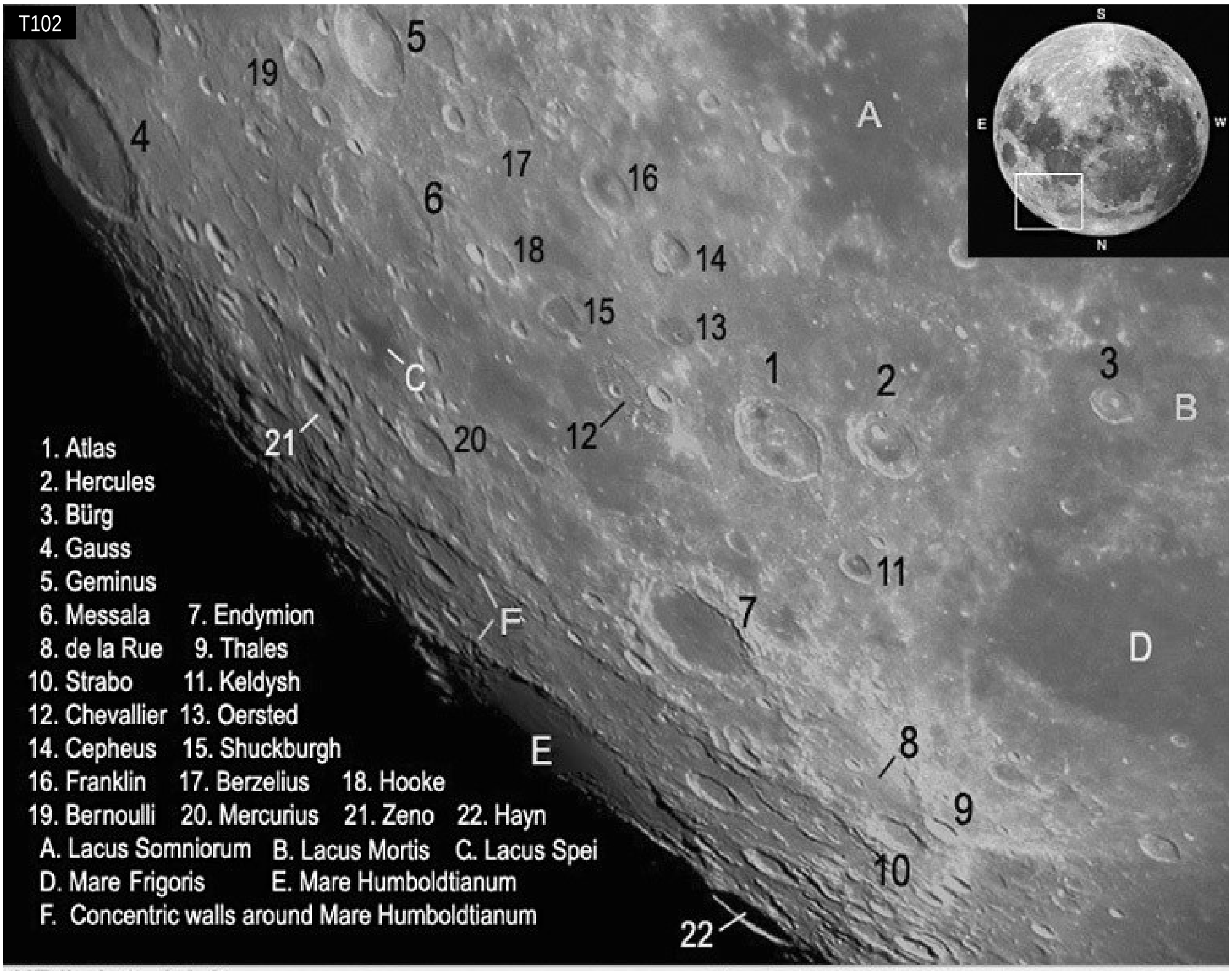


2004.10.03 21:00 UT Age 19 days. 10-in f/6 Newtonian + 2.5X + ToUcam

MAP 10

Hatfield 4
Rükl 14, 15, 16, 7, 6

Atlas, Hercules, Bürg, Endymion, Mare Humboldtianum

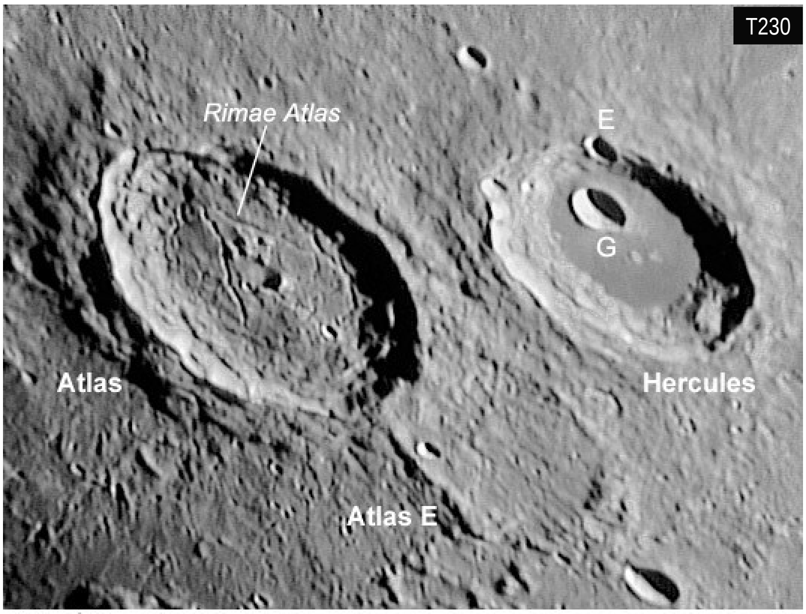


NE limb & vicinity 2004.08.01 14:22 UT Age 15 days. Libration 4.5° (long.) 6.4° (lat.) FS128 + LE12.5 + CP990 at 1/38 sec.

Atlas 44.4^0 E 46.7^0 N
Hercules 39.1^0 E 46.7^0 N

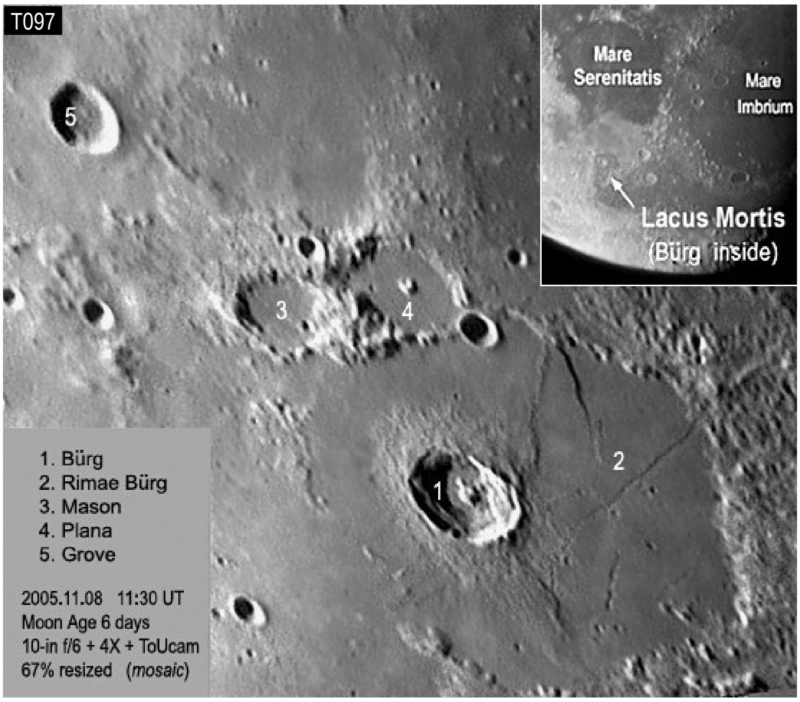
Atlas and Hercules are prominent pair of craters near the north-east limb. Their walls look similar but their interiors are very different.

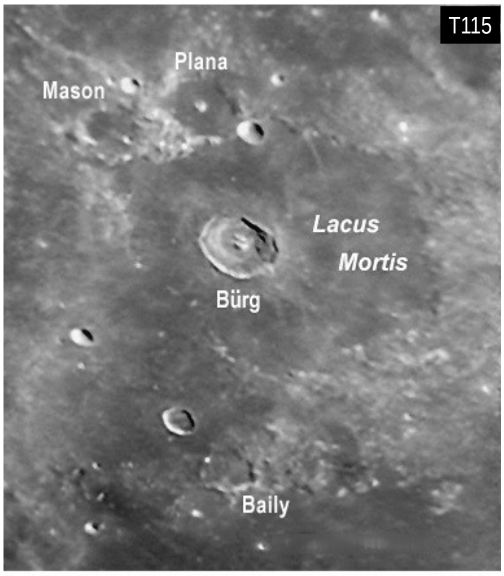
Atlas is 87 km in diameter, with a small central peak and terraced walls rising to about 3000 m. Its rough floor contains two fairly dark patches and a complex system of rilles (***Rimae Atlas***) which are believed of volcanic origin.



Atlas & Hercules 2005.08.22 19:34 UT Age 17.5 days. 10-in f/6 Newtonian + 4X + ToUcam

Hercules is a terraced crater with relatively flat floor, 69 km in diameter. It has no central peak but contains the bowl-shaped ***Hercules G***, easily seen in small telescopes. A small crater, ***Hercules E***, is on the southern wall.





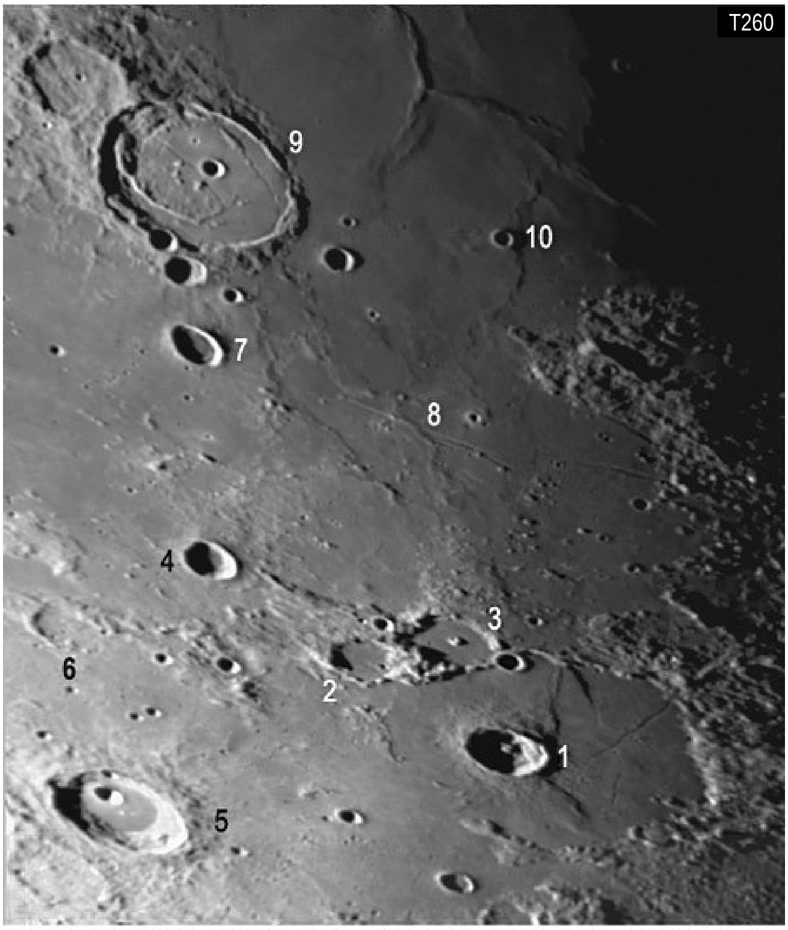
2004.08.02 17:28 UT Age 16 days. Misty sky. 10-in f/6 + 2.5X + ToUcam, 9 frames.

Bürg 28.2^{0} E 45.0^{0} N
Bürg is a prominent sharp-rimmed crater in ***Lacus Mortis*** (Lake of Death), 39 km in diameter. Its high terraced walls contain deep clefts. Bürg's ejecta blanket can be seen thrown out into two main swaths heading north and south from the impact zone. Between these swaths of material are two rilles (***Rimae Bürg***) that intersect roughly at right angles. The two rilles add up to 140 km in length.

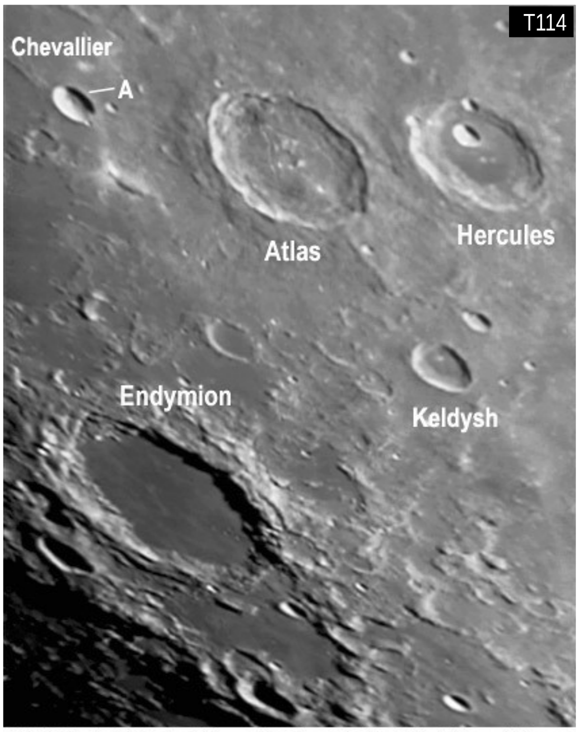
Mason 30.5^{0} E 42.6^{0} N
Plana 28.2^{0} E 42.2^{0} N
Manson and Plana are overlapped flooded craters. Mason is 33 x 43 km. Plana is 44 km in diameter with a central peak.

Grove 32.9^{0} E 40.3^{0} N
A crater, 28 km in diameter. Its ejecta blanket resembles that of Bürg.

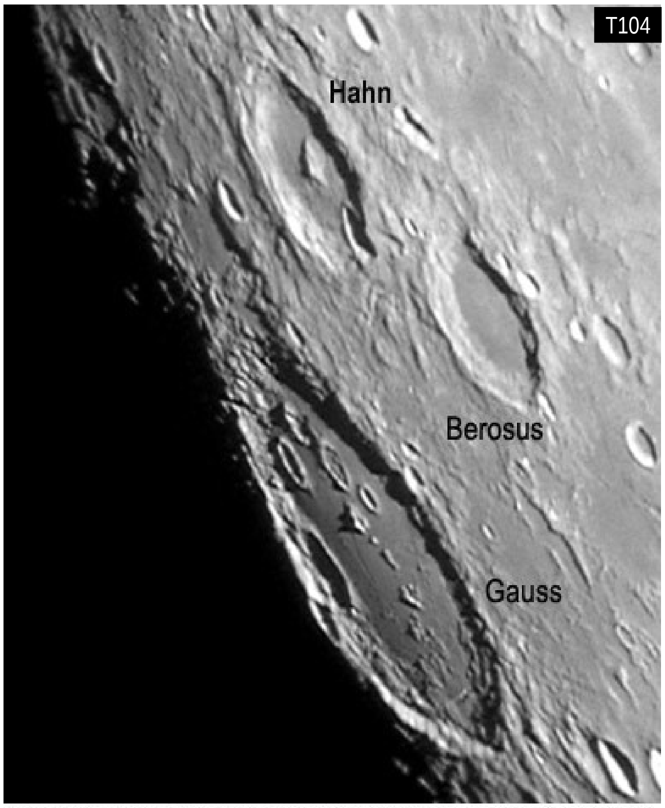
Daniell 31.1^{0} E 35.3^{0} N
An oval crater, size 23 x 29 km. In its west is ***Rimae Daniell***, a system of straight rilles up to 200 km long.



1. Bürg 2. Mason 3. Plana 4. Grove 5. Hercules 6. Williams 7. Daniell 8. Rimae Daniell 9. Posidonius 10. Luther 2006.04.04 11:46 UT Age 6 days. 10-in f/6 + 2.5X + ToUcam (mosaic)



2004.08.02 17:24 UT Age 16 days. Misty sky. 10-in f/6 + 2.5X + ToUcam, 12 frames.



2004.08.01 17:12 UT Age 15 days. 10-in f/6 + 2.5X + ToUcam, 4 frames stacked.

Image T114:

Endymion 57.0^0 E 53.9^0 N
A prominent crater with flat and fairly dark floor, no central peaks, 123 km in diameter.

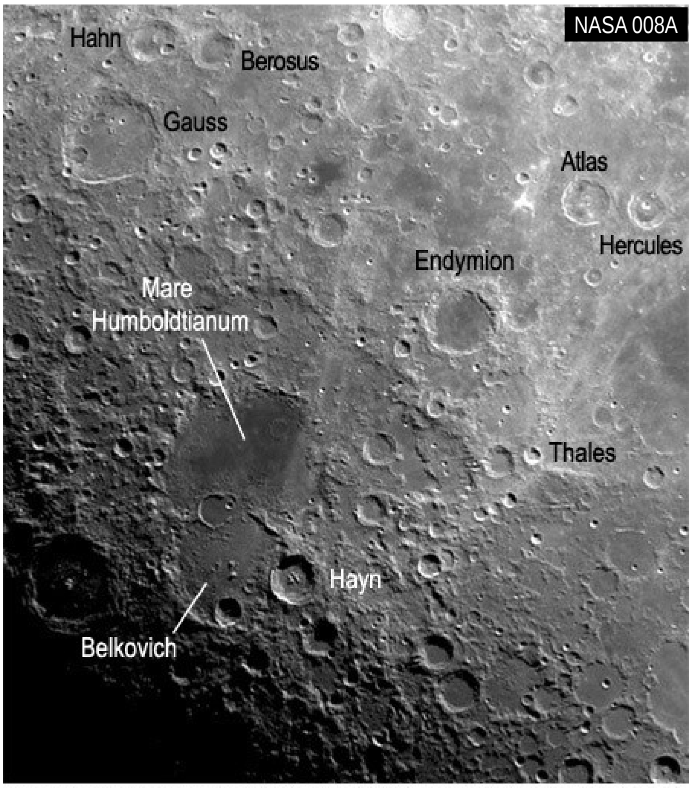
Chevallier 51.2^0 E 44.9^0 N
A heavily flooded walled plain, 52 km in diameter. Chevallier is interrupted by the smaller but deeper crater ***Chevallier A***.

Keldysh 43.6^0 E 51.2^0 N
A crater, 33 km in diameter.

Image T104:

Gauss 79.0^0 E 35.7^0 N
A vast walled plain, 177 km in diameter. Its floor contains small hills and craters which become distinctive under favorable illumination.

Hahn 73.6^0 E 31.3^0 N
A mid-sized crater with terraced walls and central peaks, 84 km in diameter.

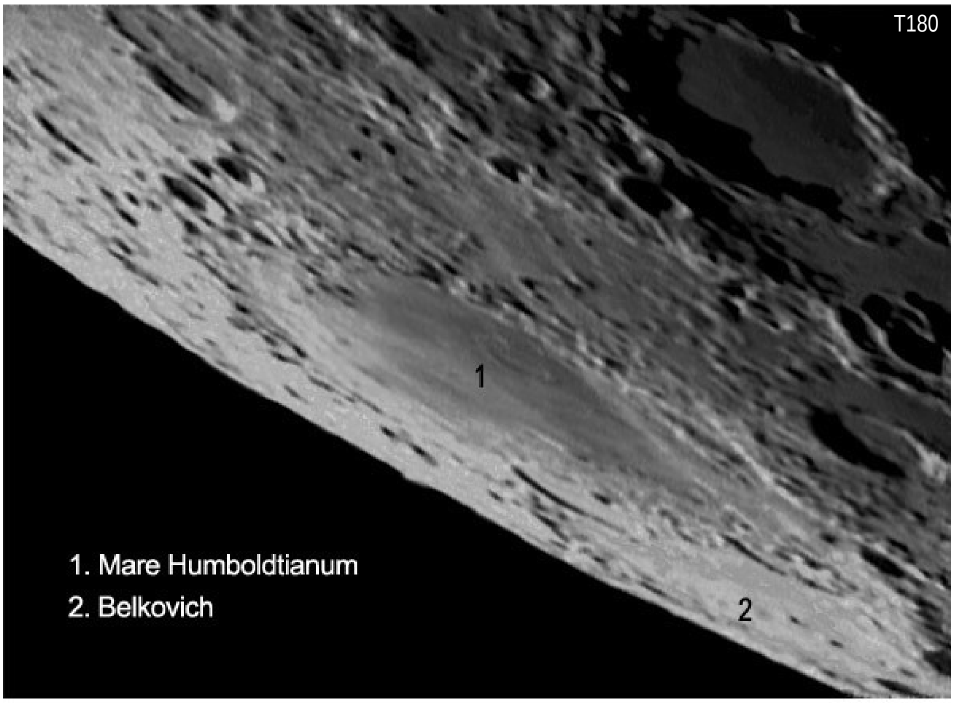


Gauss, Endymion & Mare Humboldtianum seen by Galileo spacecraft, 1992

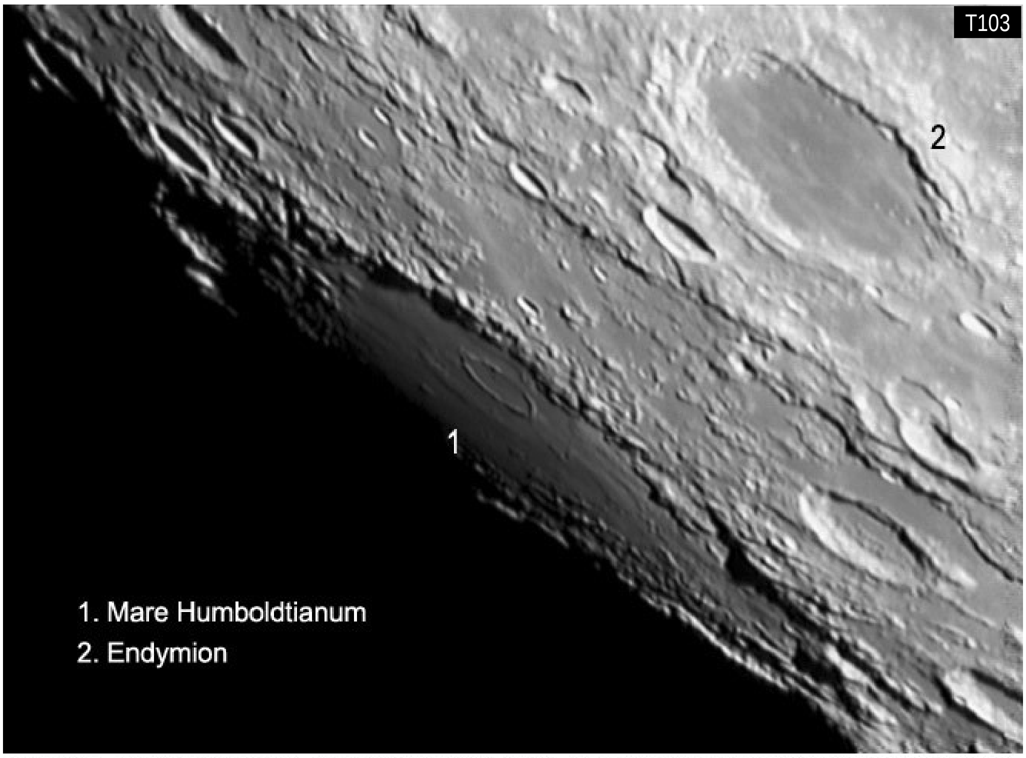
Berosus 69.9^0 E 33.5^0 N
A flooded crater, 74 km in diameter. Its flat floor contains no central peak.

Mare Humboldtianum 80^0 E 57^0 N

Mare Humboldtianum (Humboldt's Sea) is a difficult visual object because its rim extends to 91^0 E on the Moon's farside. A better terrestial view is given in T180 and T103, when the libration was favorable. Mare Humboldtianum is physically the central lava-flooded portion of a large impact basin. The lava floor is about 200 km in diameter, but the whole basin including the outer concentric walls is 600 km across. See also the non-oblique view of Mare Humboldtianum in the NASA image (previous page). Occasionally Mare Humboldtianum makes the northeast limb of a Moon disc appeared dark and broken, like T040A in the Overview Section.



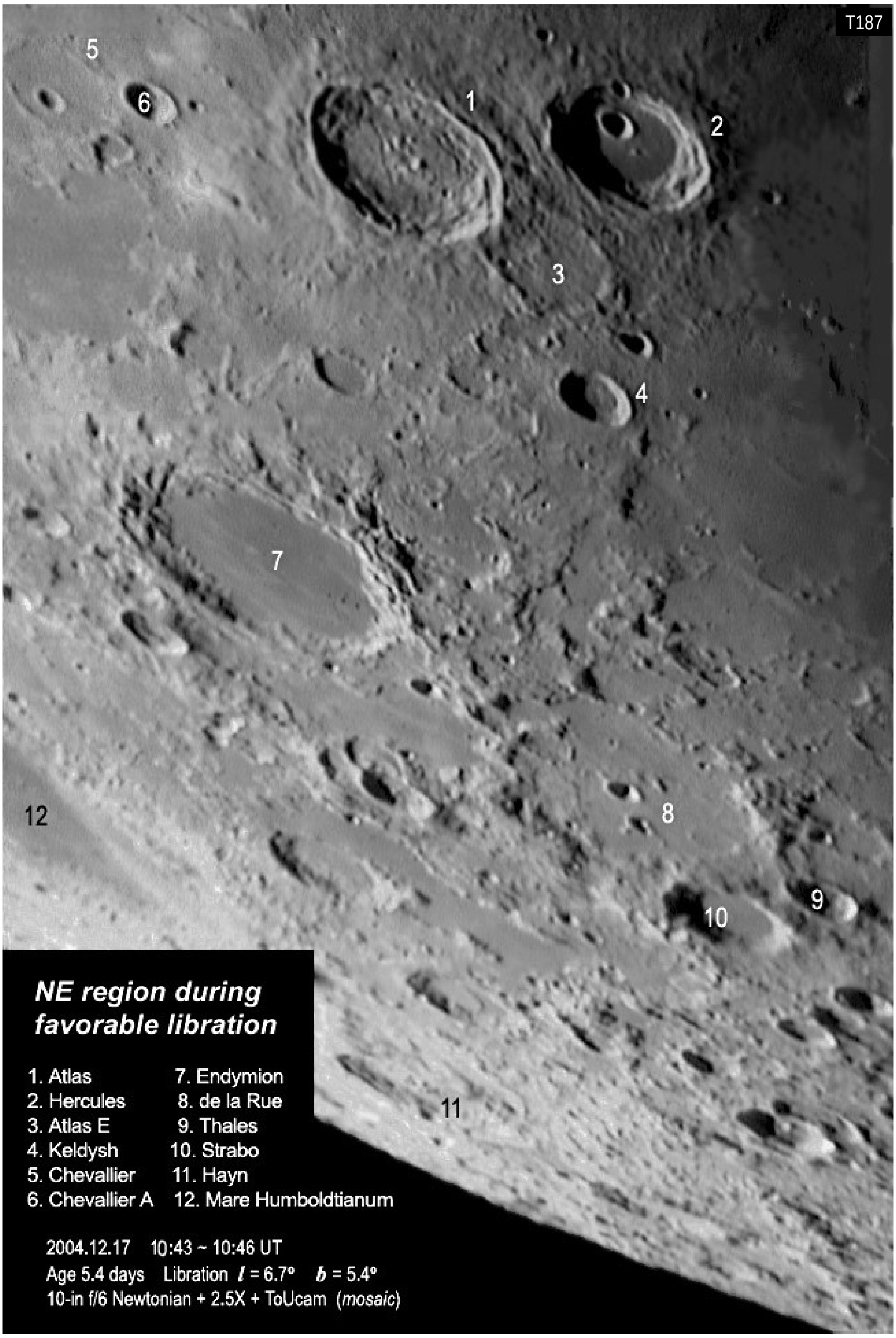
Mare Humboldtianum 2004.12.15 19:13 UT Age 3.4 days. Libration l = 4.6° b = 6.5°. 10-in f/6 + 2.5X + ToUcam



2004.08.01 16:50 UT Age 15 days. Libration 4.5° (long.) 6.5° (lat.) 10-in f/6 + 2.5X + ToUcam at 1/100s, 9 frames stacked.

de la Rue 52.3^{0}E 59.1^{0}N
A disintegrated walled plain, 134 km in diameter. It is named after the British amateur astronomer Warren de la Rue (1815-89) who first succeeded in producing a copper plate for printing from a photographic negative of the Moon.

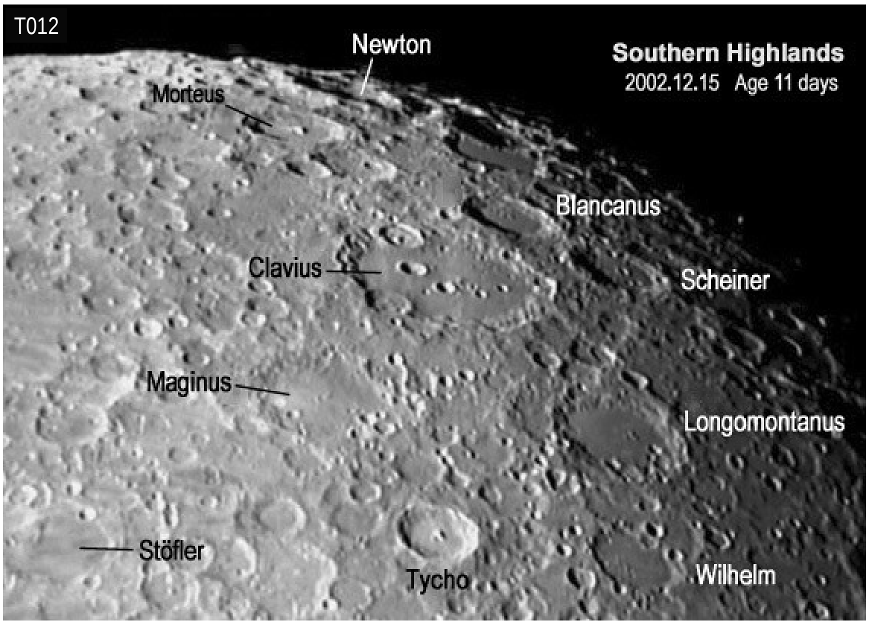
Thales 50.3^{0}E 61.8^{0}N **Strabo** 54.3^{0}E 61.9^{0}N
Thales is a rayed crater, 31 km in diameter. The neighboring Strabo (55 km) is non-rayed.

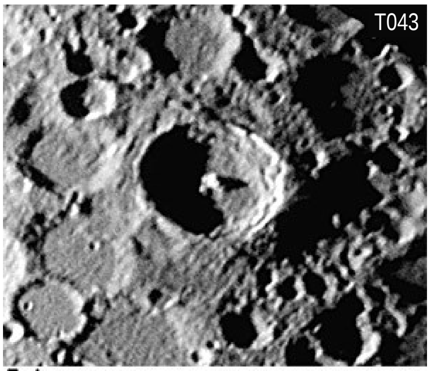


MAP 11

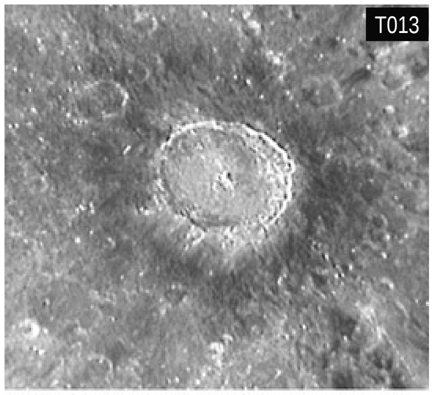
Hatfield 10
Rükl 64, 65, 72, 73, 54

Tycho, Clavius, Maginus, Deslandres, Pitatus



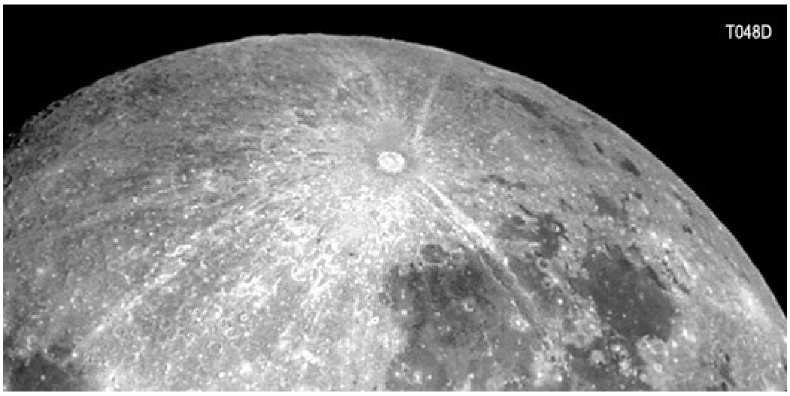


Tycho 2001.04.03 10:08 UT Age 9 days. FS128+CP990 DSCN8764



Tycho 2003.03.17 16:49UT Age 14 days. 10-in+2.5X+ToUcam

The dark halo around Tycho is impact melt materials.

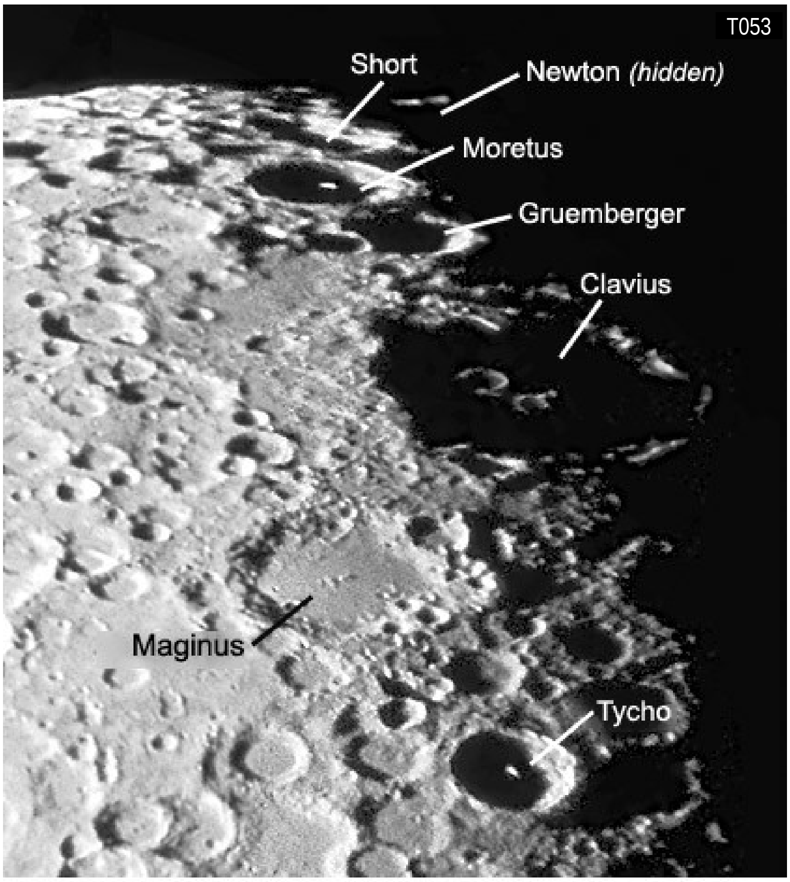


Tycho and its system of rays
2003.09.11 16:11 UT Age 15 days.
The rays are lines of deposits of highland rocks and debris ejected from the Tycho impact 110 million years ago.

Tycho 11.1^0W 43.4^0S
Tycho is a prominent crater in the "Southern Highlands" region. Its diameter is 102 km. During the full moon, Tycho stands out as the brightest beacon, and its system of rays extends far across the lunar surface. It is this ray system that strongly supports the impact theory of Tycho's origin, and the origin of other craters as well. The bright rays also prove Tycho is very young, about 110 million years old. Near quarter moon (T053, next page), Tycho appears as an abyss 4800 m deep surrounded by thick walls. A central peak, 2300 m high, also stands out prominently.

Clavius 14.1^0W 58.8^0S
Clavius is a spectacular, vast walled plain in the Southern Highlands, diameter 245 km. Its walls are broken by crater ***Rutherfurd*** (48 km) and ***Porter*** (51 km), and there are ridges running between them, see T080 & T085. Note also the L-shaped relief near Porter. An arc-array of craters extends across the floor, which also contains many craterlets and small hills. Clavius is best seen shortly after first quarter or before last quarter but hardly visible during the full moon.

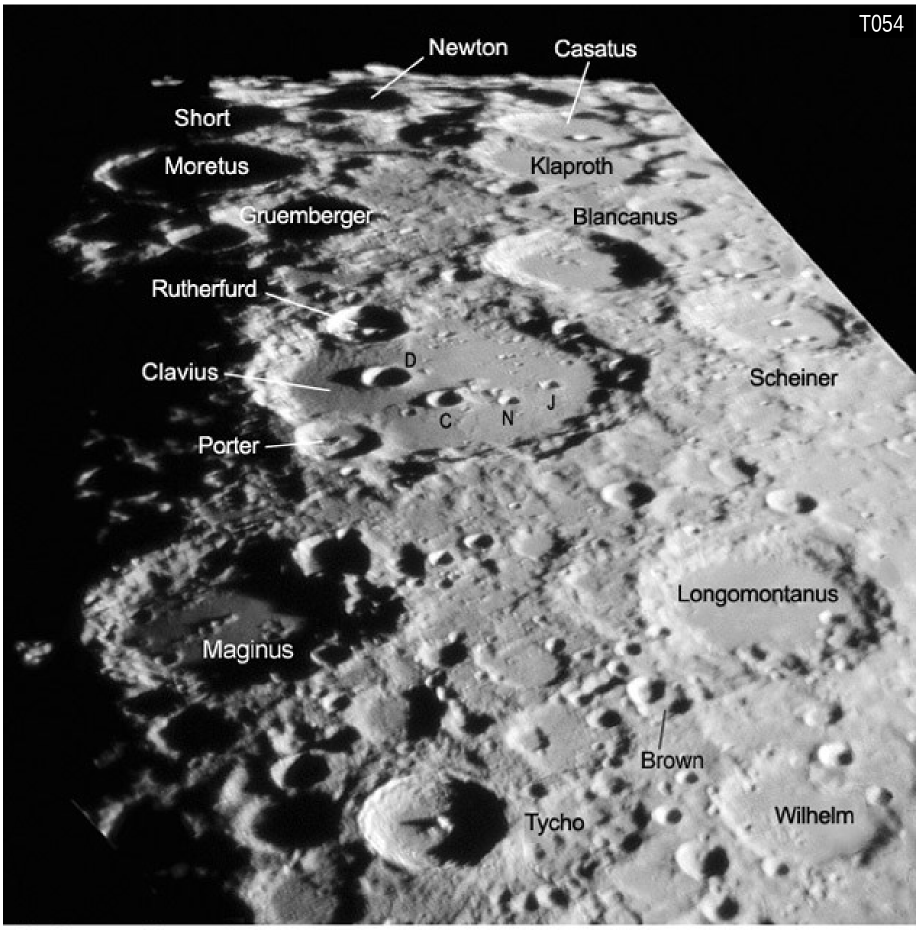
Newton 16.9^0W 76.7^0S
A crater on the south limb, 78 km in diameter. It is difficult to be seen well. Its depth is not ascertained, probably 6000 ~ 8000 m. See also Image T197, Event 1 pages.



Clavius on terminator 2000.11.05 13:50 UT Age 9 days. FS128+QV2300

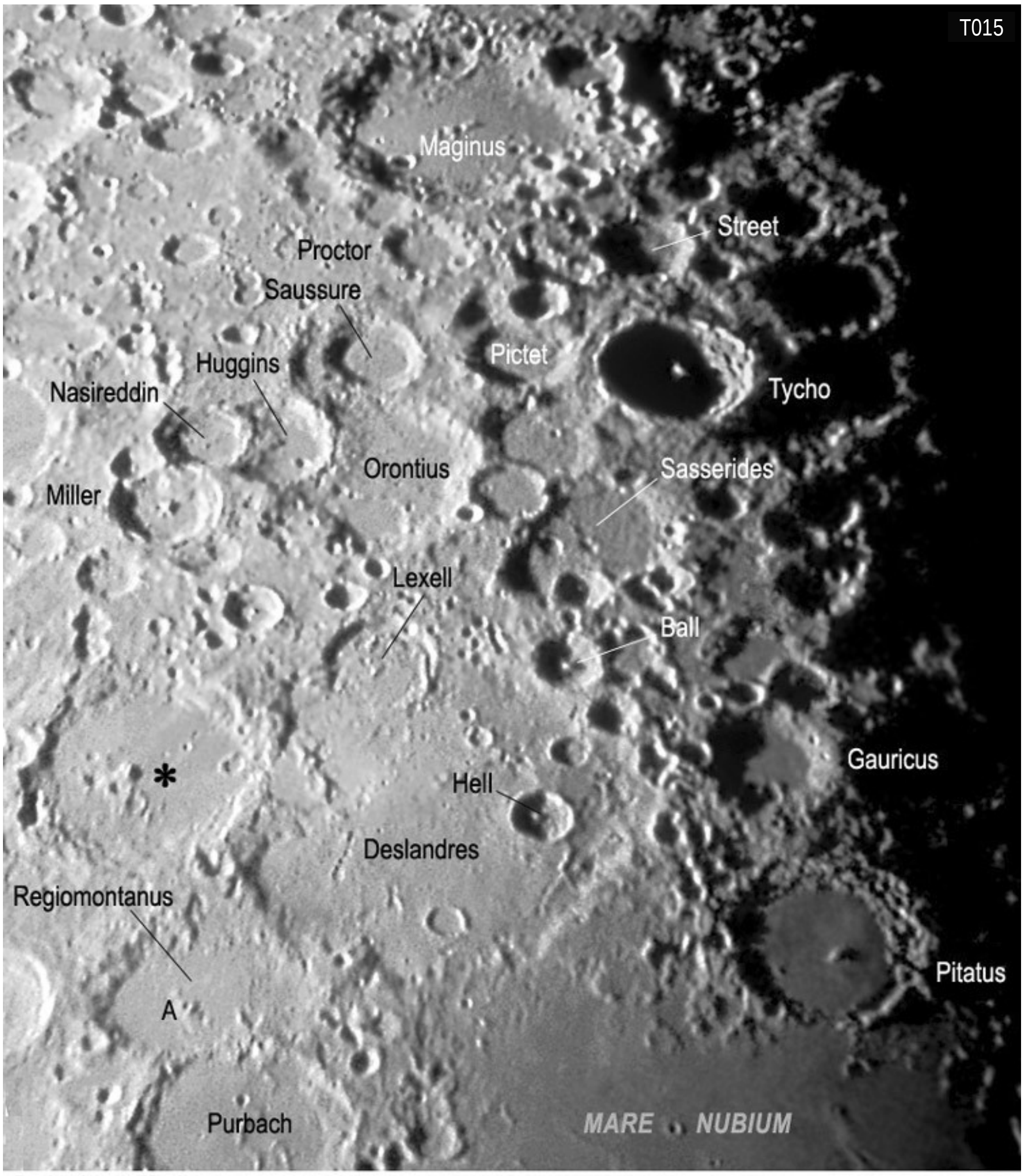
Clavius right on the terminator

It looks like an abyss. The inside craters are Clavius D (larger) and Clavius C.



Clavius outside terminator 2001.08.11 20:21 UT Age 22 days. C9 + LE12.5 + CP990 DSCN9622

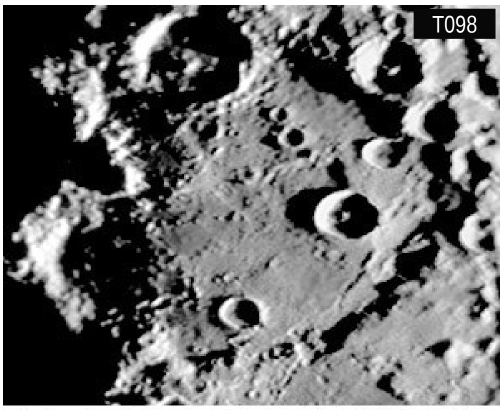
Clavius just outside the terminator.



Deslandres to Maginus The * was crater Walter but now renamed as Walther. 2000.11.05 13:35 UT Age 9 days. FS128+LE12.5+QV2300

Maginus 6.3^0 W 50.5^0 S
A large walled plain, 194 km in diameter. It is much older than Tycho, as suggested by the absence of rays and its interior peppered with many impact craters.

Deslandres 4.8^0 W 33.1^0 S
A vast ruined walled plain, 256 km in diameter. Its floor contains crater ***Hell*** (33 km) and few short chains of craterlets created by secondary impacts.

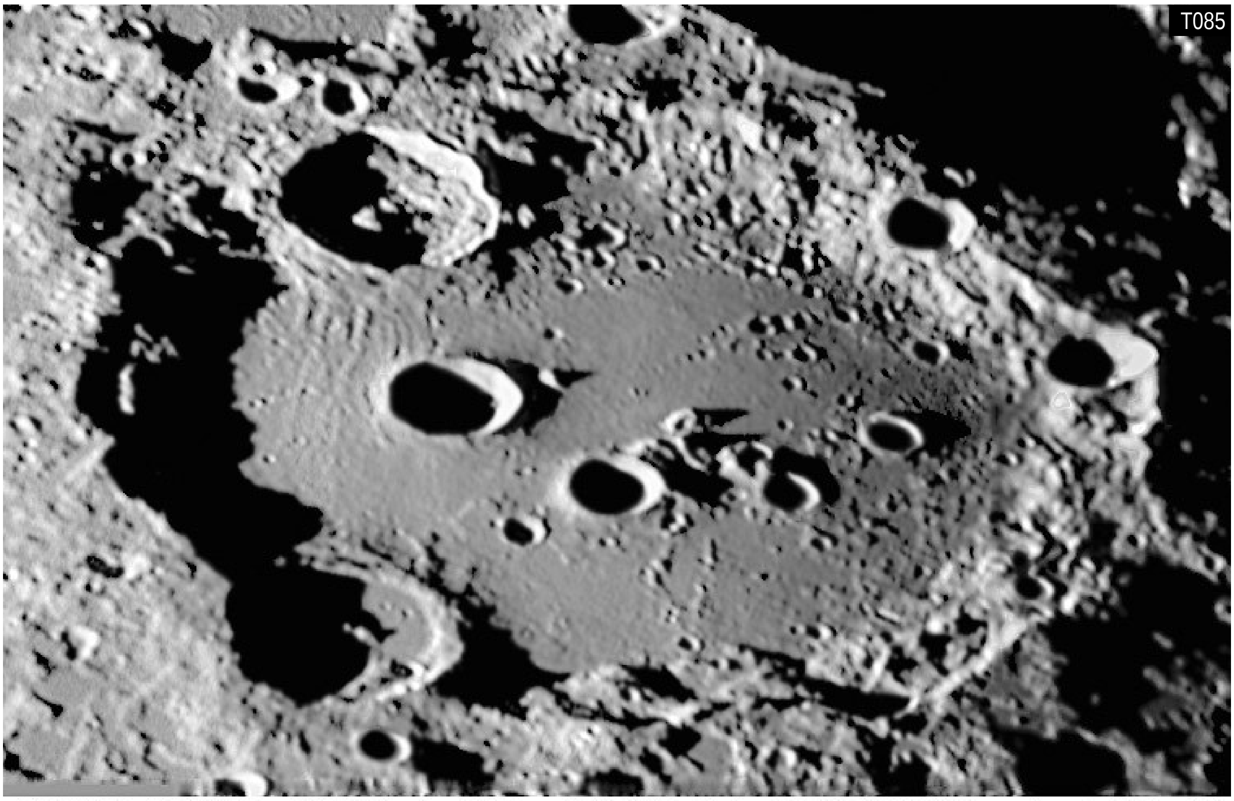


Deslandres in shadow 2001.08.11 21:01UT Age 22 days

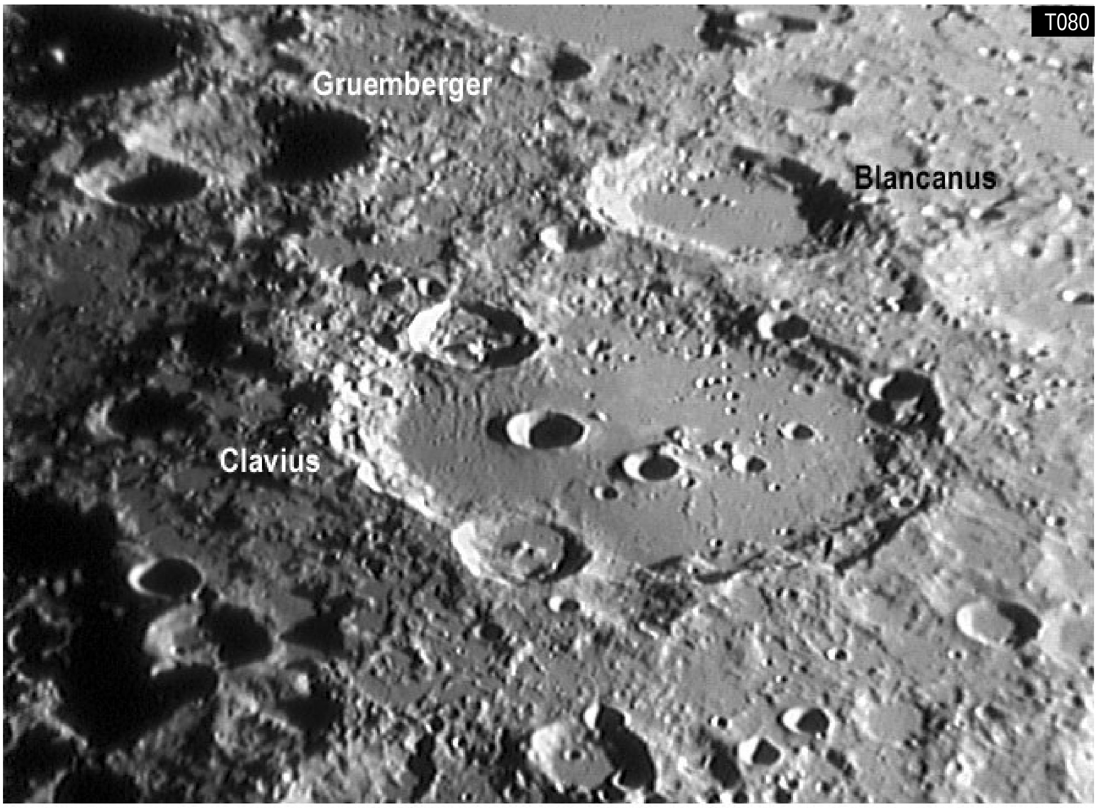
Walter 1.0^0 E 33.1^0 S
A walled plain with mountain massif on its eastern floor, 128 km in diameter. *(Remark: This crater is now renamed as **Walther**. The original "**Walter**" is confusingly allocated to a 1-km crater at 33.8⁰W 28.0⁰N near Diophantus. See Map 22.)*

Regiomontanus 1.0^0 W 28.3^0 S
A walled plain, 126x108 km. It has a summit crater ***Rigiomontanus A*** (5 km) on the central peak.

Clavius at age of 10 and 22 days

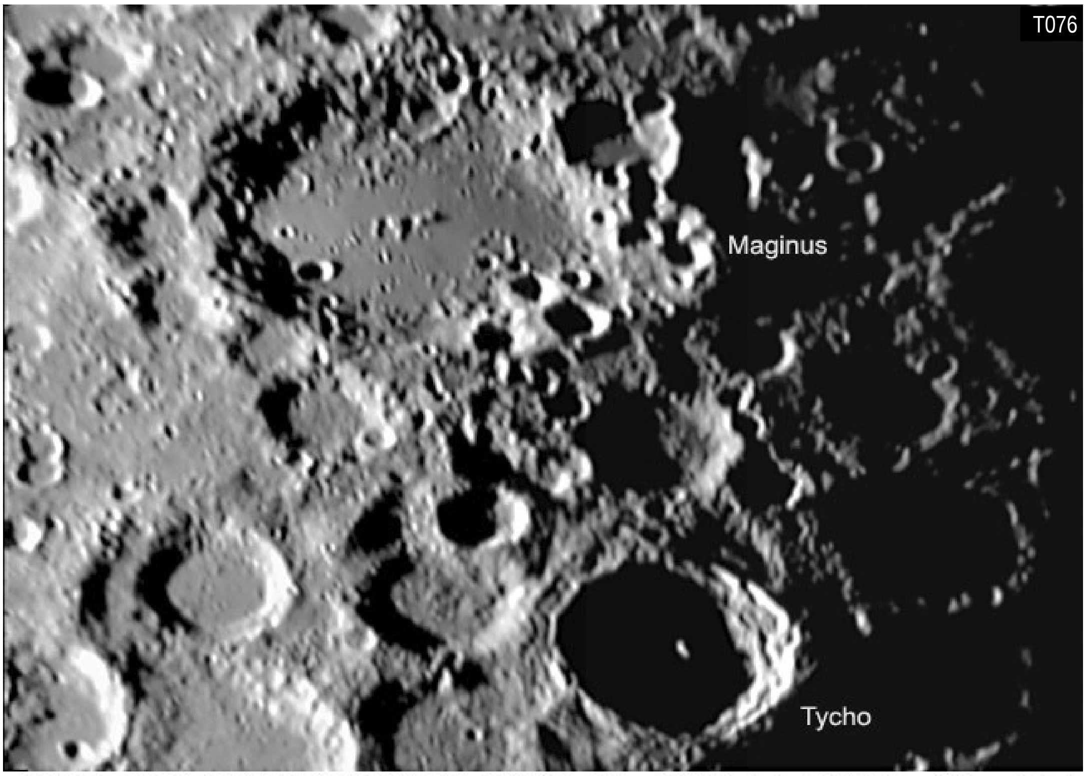


Clavius 2005.04.18 ~14:53 UT Age 9.8 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam *(mosaic of 2 video clips)*

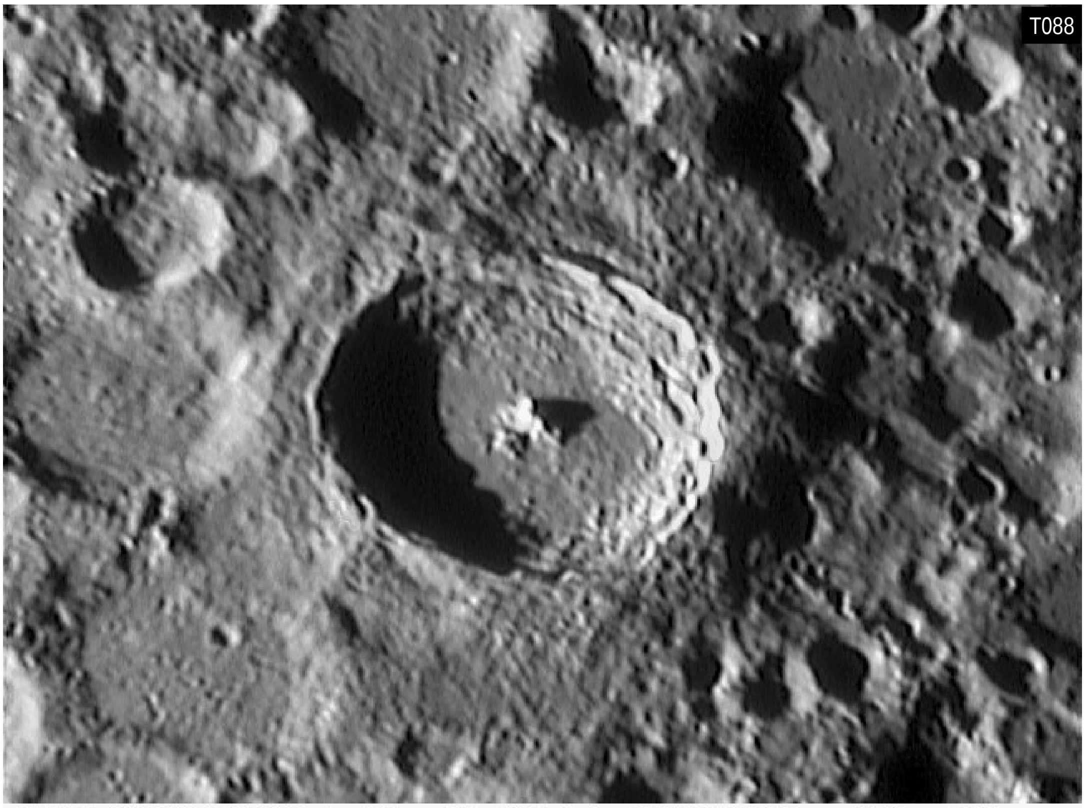


Clavius & Blancanus 2004.08.07 19:48 UT Age 22 days. 10-in f/6 Newtonian + 2.5X + ToUcam at 1/33 sec

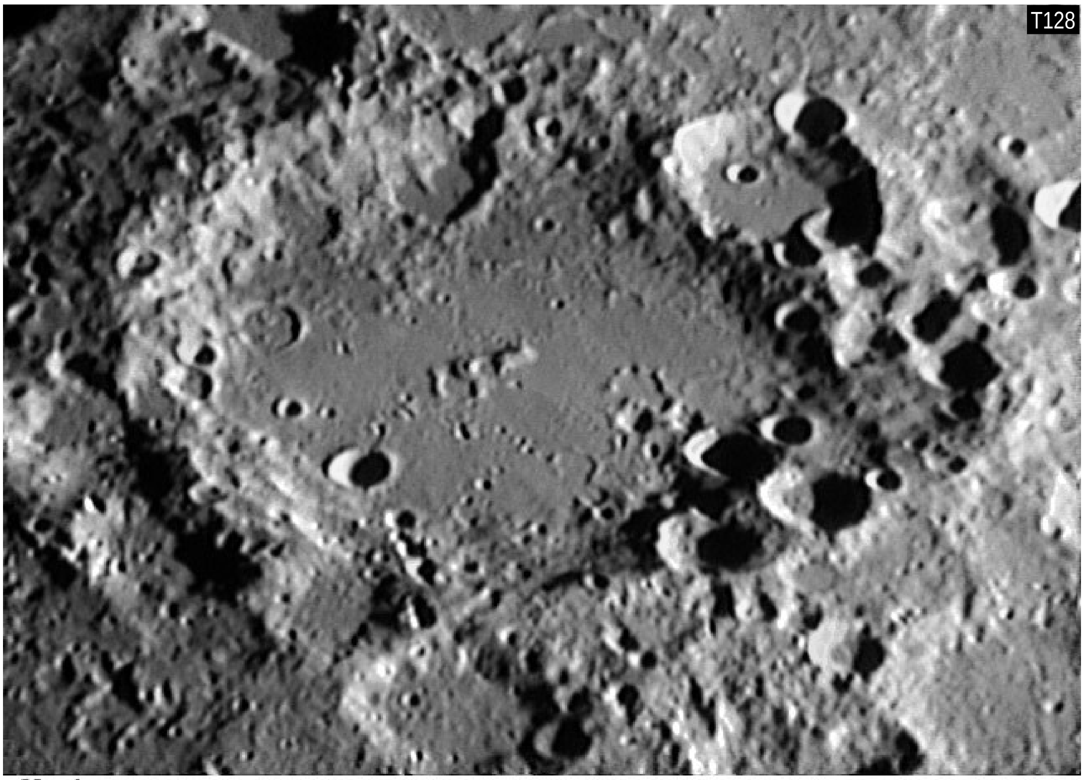
Tycho at age of 9 and 10 days (1 day difference).



Maginus and Tycho (in shadow) 2004.06.26 13:53 UT Age 9 days. 10-in f/6 Newtonian + 2.5X + ToUcam, 12 frames stacked.

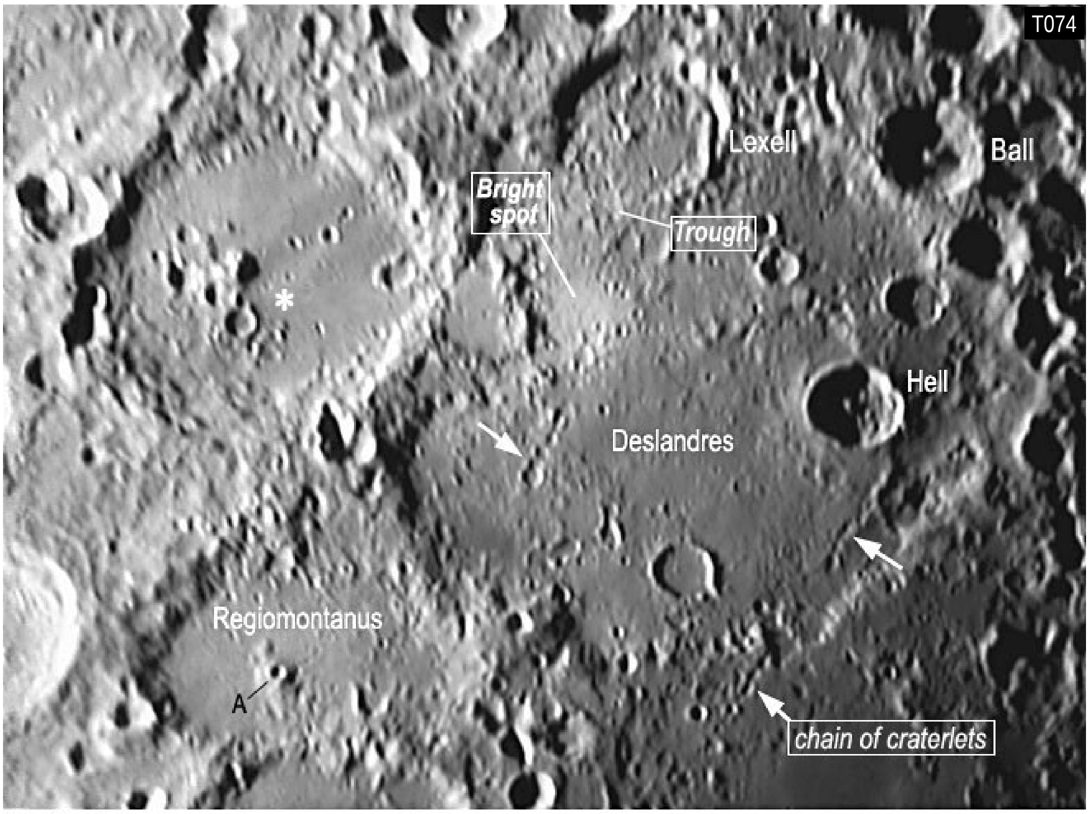


Tycho 2005.04.18 14:56UT Age 10 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam at 1/33 sec, 52 frames.

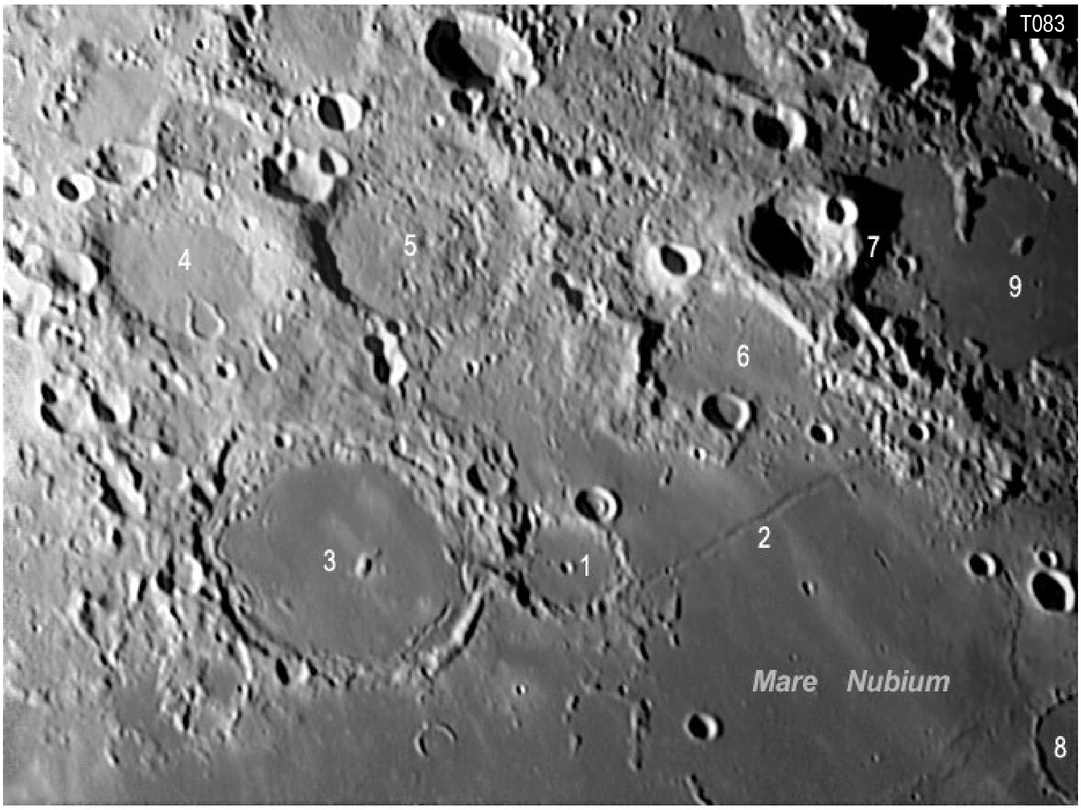


Maginus 2004.09.05 21:18 UT Age 21 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam at 1/25 sec. 47 frames.

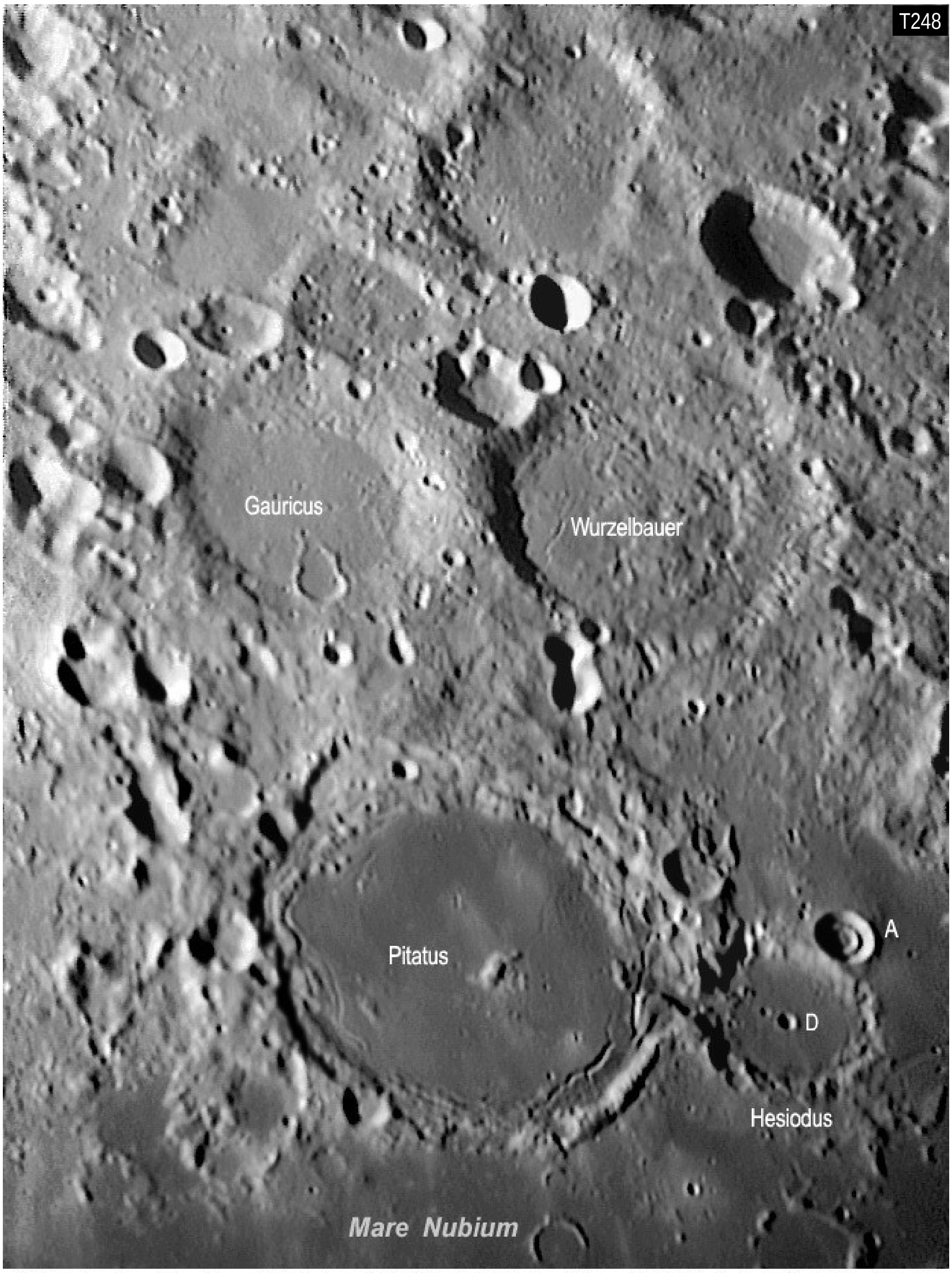
1. Moretus 2. Newton 3. Gruemberger 2004.09.05 21:16 UT Age 21 days. 10-in f/6 + 2.5X + 1.6X + ToUcam



Deslandres. The ✱ was crater **Walter** but now renamed as **Walther**. 2004.06.26 13:47UT Age 9 days. 10-in f/6+ToUcam. Note the chains of craterlets and bright spot on the floor of Deslandres, also the trough crossing the northern rim of Lexell.



1. Hesiodus 2. Rima Hesiodus 3. Pitatus 4. Gauricus 5. Wurzelbauer 6. Weiss 7. Cichus 8. Kies 9. Palus Epidemiarum 2005.11.11 12:06 UT Age 9.5 days. 10-inch f/6 Newtonian + 2.5X + ToUcam, 97 frames stacked.



Pitatus, Gauricus, Wurzelbauer & Hesiodus 2005.11.11 12:19 UT Age 9.5 days. 10-in f/6 Newtonian + 4X + ToUcam (*mosaic*)

Pitatus 13.5^0 W 29.9^0 S
A flooded walled plain with small central peak, 106 km in diameter. A system of sinuous rilles (***Rimae Pitatus***, length about 100 km) runs along the inner rim. The white patches on the floor are remnant of deposited materials thrown out from the Tycho impact.

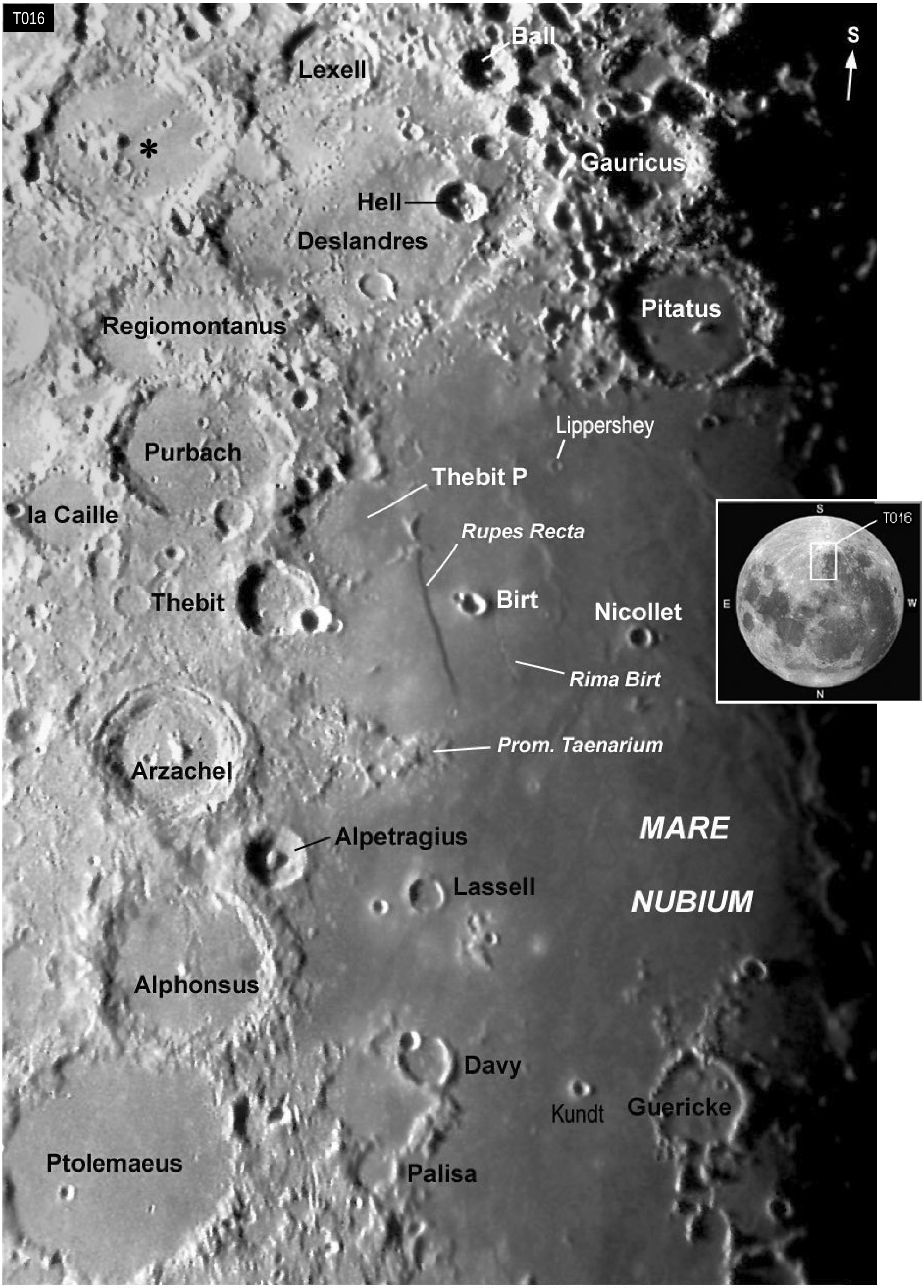
Gauricus 12.6^0 W 33.8^0 S
An eroded crater, 79 km in diameter. Its wall is encircled by a ring of small craters.

Hesiodus 16.3^0 W 29.4^0 S *(Image T083 & T248)*
A 42-km flooded crater. The center of its floor is hit by another smaller crater ***Hesiodus D***. The adjoined crater ***Hesiodus A*** (15 km) has double concentric walls. ***Rima Hesiodus*** is a linear rille running from Hesiodus into ***Palus Epidemiarum***, 3 km wide, 250 km long. See also Map 24.

MAP 12

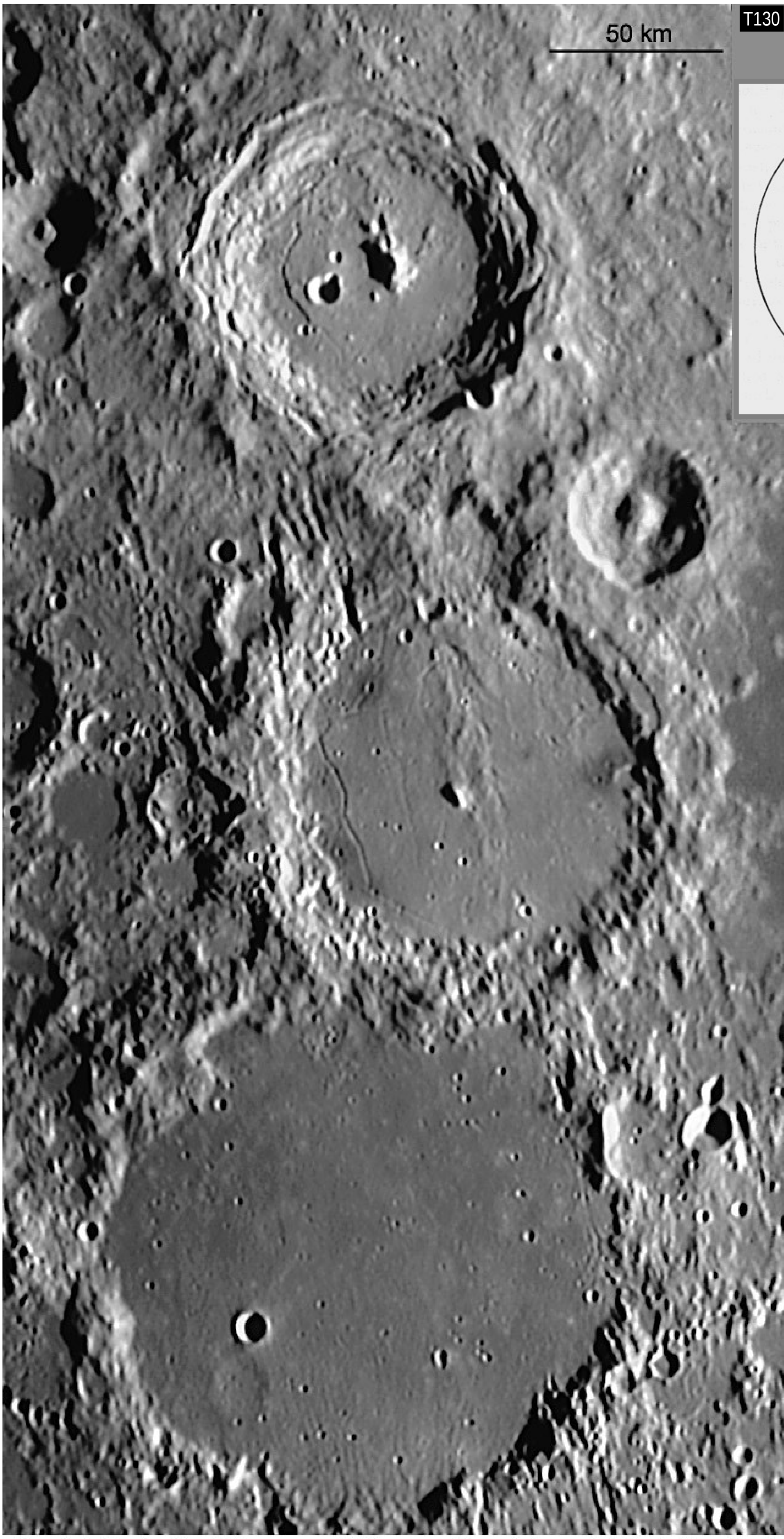
Hatfield 13, 9
Rükl 54, 55, 42, 43, 44

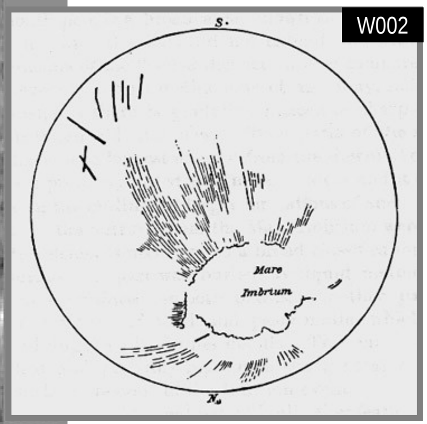
Ptolemaeus, Alphonsus, Rupes Recta, Fra Mauro



Ptolemaeus to Deslandres The ✱ was crater Walter but now renamed as Walther. 2000.11.05 13:38UT Age 9 days. FS128+LE12.5+QV2300

The prominent crater trio: *Arzachel, Alphonsus and Ptolemaeus*

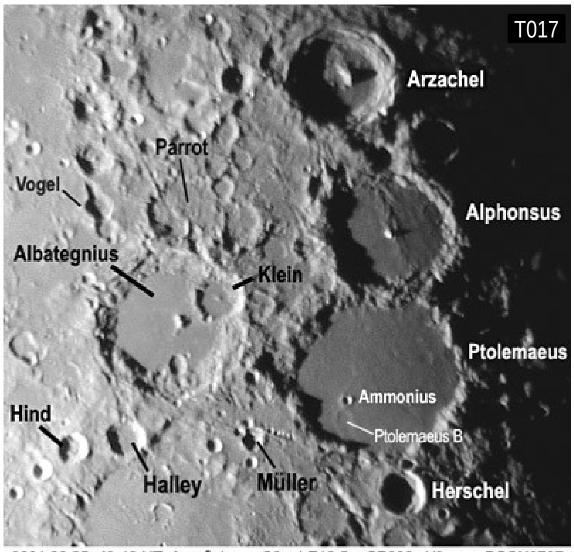




↑ *A sketch of **Imbrium Sculpture** in a paper by the American geologist Grove Karl Gilbert (1843-1918). It is a terrain of grooves and ridges radial to Mare Imbrium, and affects a large area of the lunar surface. Part of this sculpture is easily seen on the walls of Alphonsus at the middle of T130. Other parts are traceable in T101 and T179 of following pages, also in Map 31.*

Arzachel, Alpetragius, Alphonsus and Ptolemaeus (mosaic from a batch of video clips)
2004.09.05 20:53 ~ 21:11 UT Age 21 days. Very misty sky. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam at 1/25 sec.

Ptolemaeus 1.9^{0}W 9.3^0 S
Ptolemaeus is a prominent walled plain, 164 km in diameter. Its floor contains a mascon and appears flat, but numerous craterlets and pits are detectable at high powers. ***Ammonius*** (8 km) is a distinctive crater on the floor; it adjoins a saucer-shaped depression (***Ptolemaeis B***, 17 km). The floor of Ptolemaeus also changes dramatically during a lunation. It is very bright during the full moon but appears quite dark at days close to the first and last quarters.



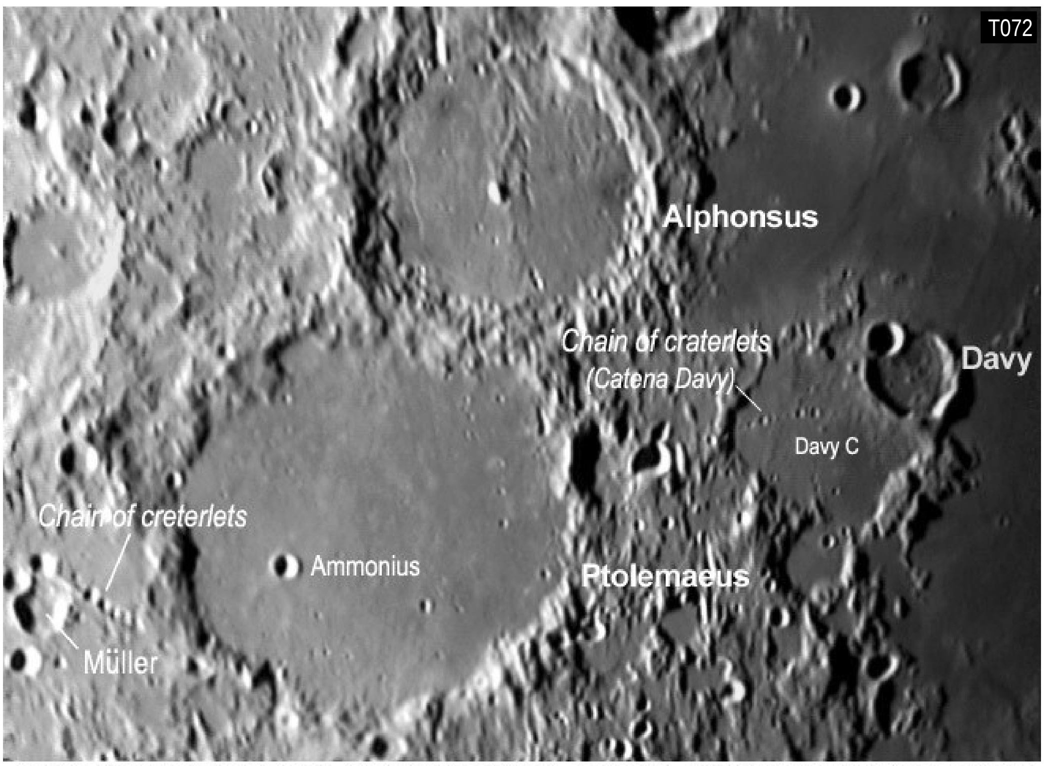
2001.09.25 !2:49 UT Age 8 days. C9 + LE12.5 + CP990 1/2 sec DSCN9797

Ptolemaeus, Alphonsus (108 km) & ***Azachel*** (96 km) form an interesting trio. The floor of Arzachel contains a system of sharp rilles (***Rimae Arzachel***, length 50 km). Alphonsus is characterized by ridged floor with dark halo craters and rilles (***Rimae Alphonsus***) along its inner rim, more details in next page. The NASA Ranger 9 probe made a hard impact on Alphonsus in March 1965. Alphonsus is also an object of LTP (Lunar Transient Phenomena, briefed at the end of Overview Section).

Note that in T130, the crater trio and their surroundings are modified by a radial pattern of grooves and ridges known as ***Imbrium Sculpture***, formed from a hurricane of ejecta at low angles during the giant Imbrium impact. (*http://www.lpi.usra.edu/meetings/lpsc2001/pdf/1900.pdf*)

Alpetragius 4.5^{0}W 16.0^{0}S
A bowl-shape crater with oversized central mountain, 39 km in diameter, 3900 m deep.

Davy 8.1^{0}W 11.8^{0}S *(Image T072)*
A crater, 34 km in diameter. The nearby chain of craterlets is ***Catena Davy***, details in Map 31.



Ptolemaeus, Alphonsus, Davy 2004.06.26 13:32 UT Age 9 days. 10-in f/6 Newtonian + 2.5X + ToUcam

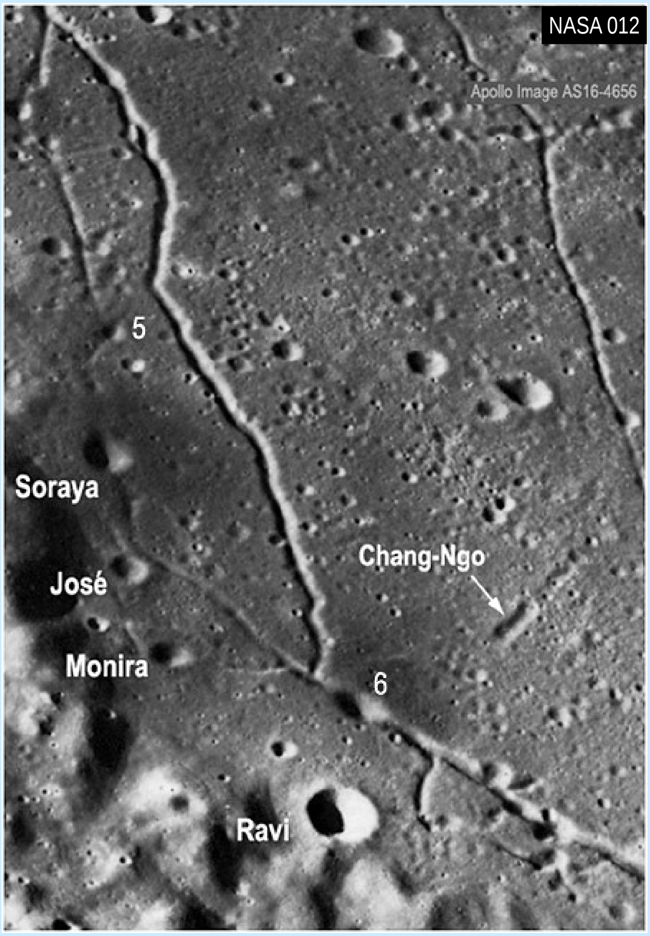
The craters inside Alphonsus

At least 10 *dark halo craters* are inside Alphonsus. Some of them along the eastern inner edge of Alphonsus are highlighted in the right image:

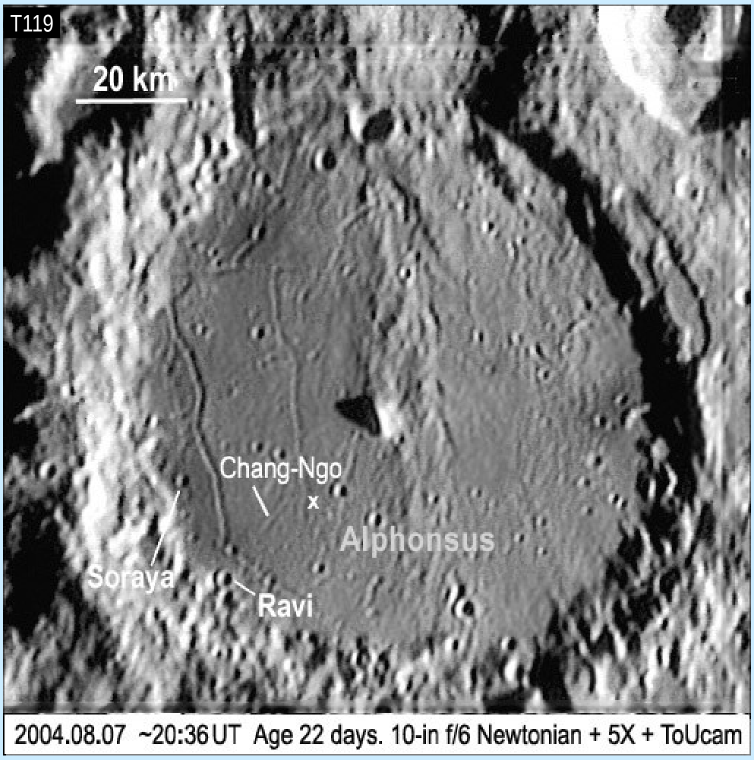
Ravi 1.9°W 12.5°S diameter 2.5 km
Monira 1.7°W 12.6°S diameter 2 km
José 1.6°W 12.7°S diameter 2 km
Soraya 1.6°W 12.9°S diameter 2 km
No. 5 and 6 bear no formal names.

These craters are volcanic according to a study report http://www.lpi.usra.edu/meetings/lpsc2005/pdf/2344.pdf. The dark halos around them are deposits of volcanic eruption, and the adjacent connecting rilles are lava tubes.

The arrow points to the elongated crater ***Chang-Ngo*** 嫦娥 at 2.1°W 12.7°S, linear size 3 km. It is of impact origin, probably created by a grazing impactor, which could be an orbiting debris spiraling into the Moon and hitting the Moon at very low angle. The floor of Chang-Ngo appears scalloped, possibly due to the "rubble-pile" nature of the impactor which disrupted into fragments on its way towards the Moon. Several of the fragments hit to form Chang-Ngo, other fragments hit to form the chain of craterlets next to Chang-Ngo.



Above: The craters and rilles inside Alphonsus. South is up. (*Apollo image AS16-4656*)



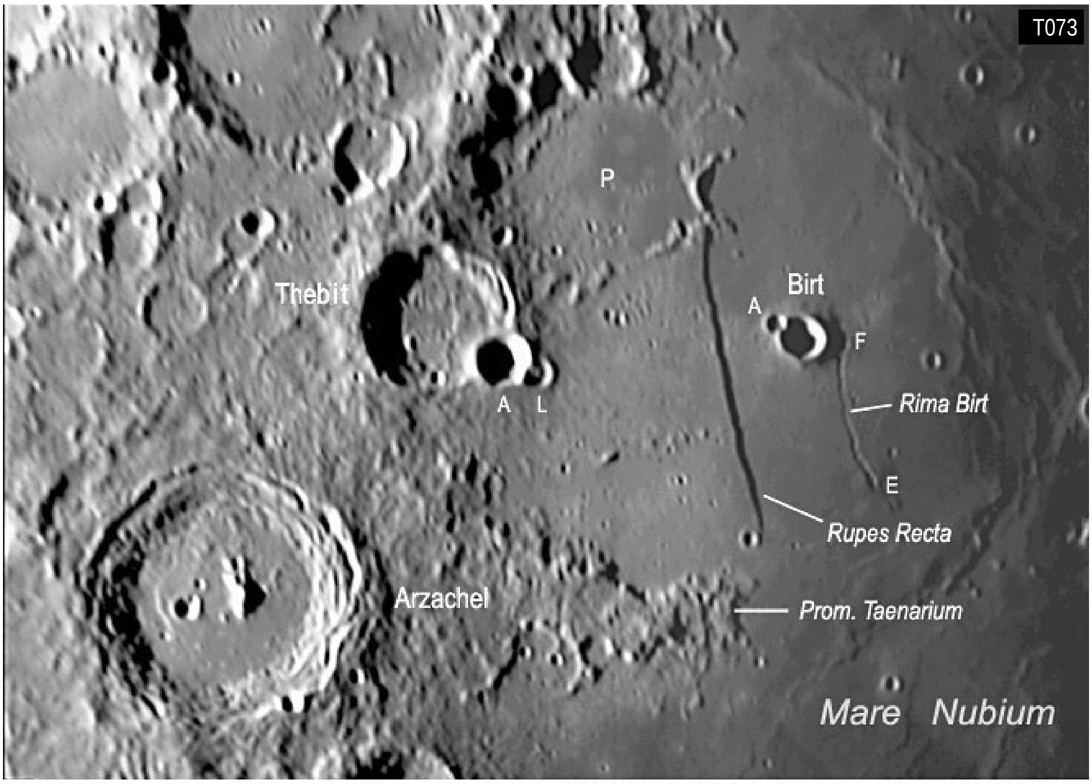
Left: Crater Chang-Ngo (嫦娥) seen from a 10-inch telescope. It is named after a lady in a Chinese myth. The **X** Indicates the impact site of Ranger 9 probe.

Rupes Recta 7^0 W 22^0 S

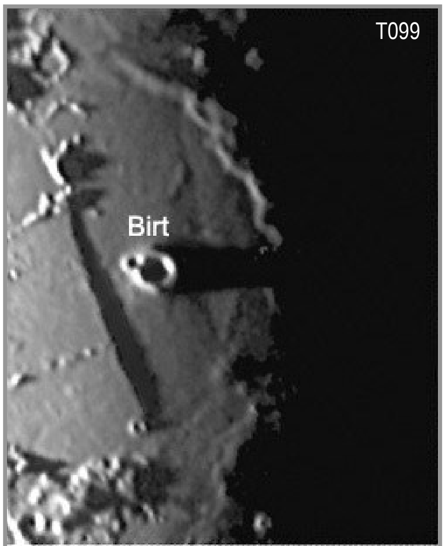
Also called the ***Straight Wall***. It casts striking shadow at days near the first quarter. Physically Rupes Recta is a fault 120 km long, 2 km in apparent width. The western side of this fault slopes down by about 300 m.

Rima Birt 9^0 W 21^0 S

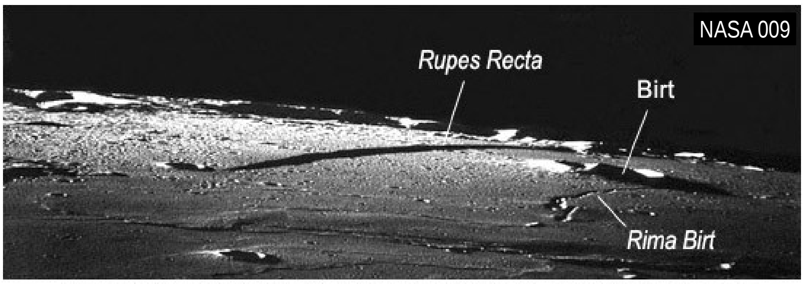
A 50-km rille near crater ***Birt*** (diameter 16 km) and running in parallel with Rupes Recta. Its north end connects the small crater ***Birt E***. Its south end connects ***Birt F***. See also image T131.



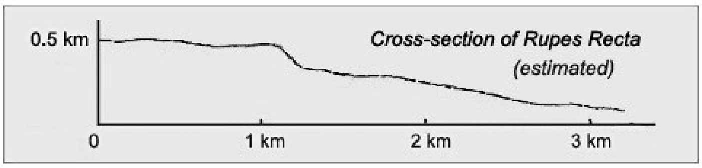
Rupes Recta, Rima Birt, Thebit, Arzachel 2004.06.26 13:59 UT Age 9 days. 10-in f/6 Newtonian + 2.5X + ToUcam



Very long shadow casted by Birt
2004.07.25 12:16 UT Moon age 8 days



Oblique View from Apollo-16 Mission *(Ap16-120-19224)*

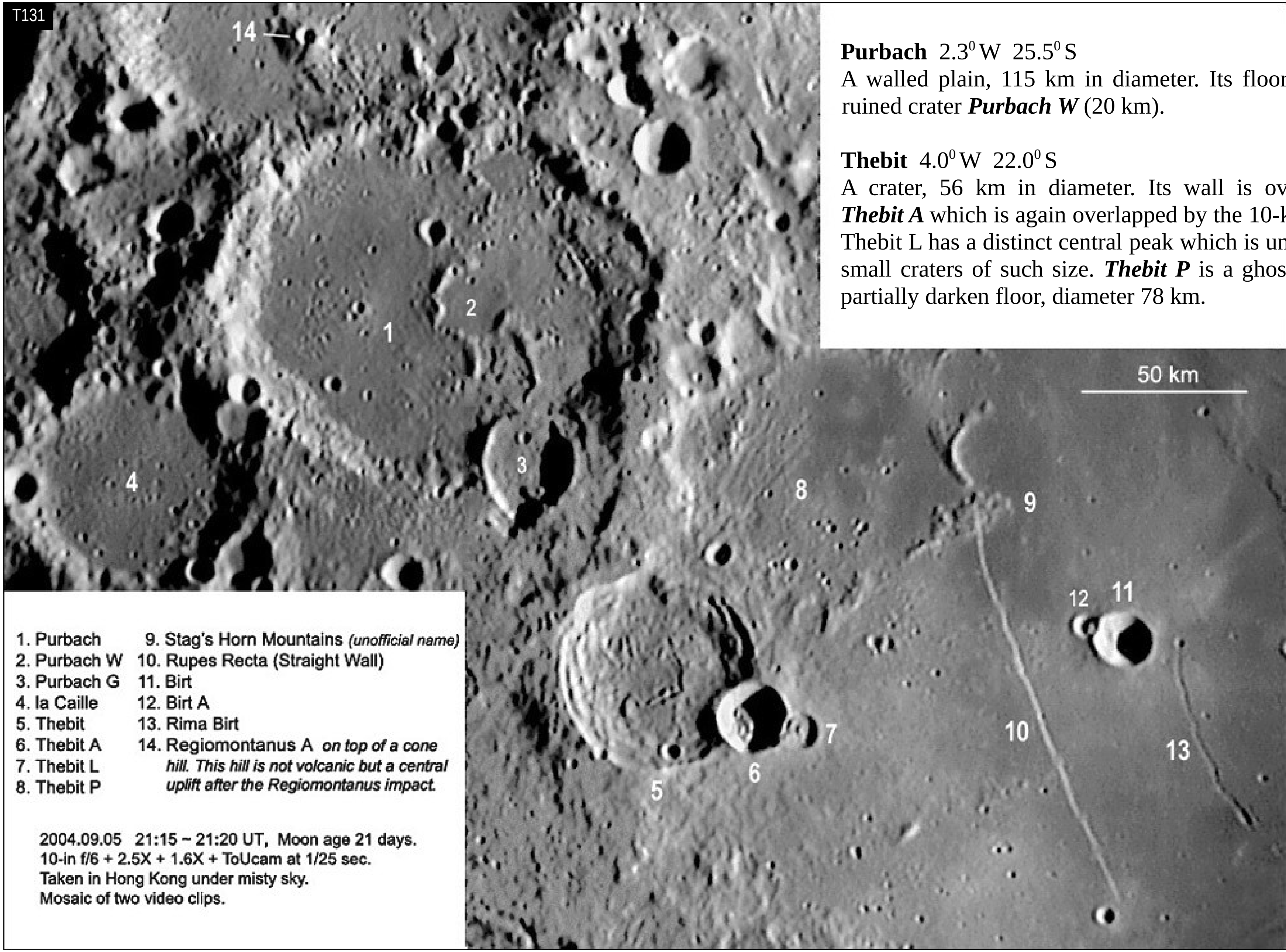


Purbach 2.3^0 W 25.5^0 S

A walled plain, 115 km in diameter. Its floors contains a ruined crater ***Purbach W*** (20 km).

Thebit 4.0^0 W 22.0^0 S

A crater, 56 km in diameter. Its wall is overlapped by ***Thebit A*** which is again overlapped by the 10-km ***Thebit L***. Thebit L has a distinct central peak which is uncommon for small craters of such size. ***Thebit P*** is a ghost crater with partially darken floor, diameter 78 km.



MAP 12

Burnham 7.3^{0}E 13.9^{0}S
A 24-km crater with broken wall.

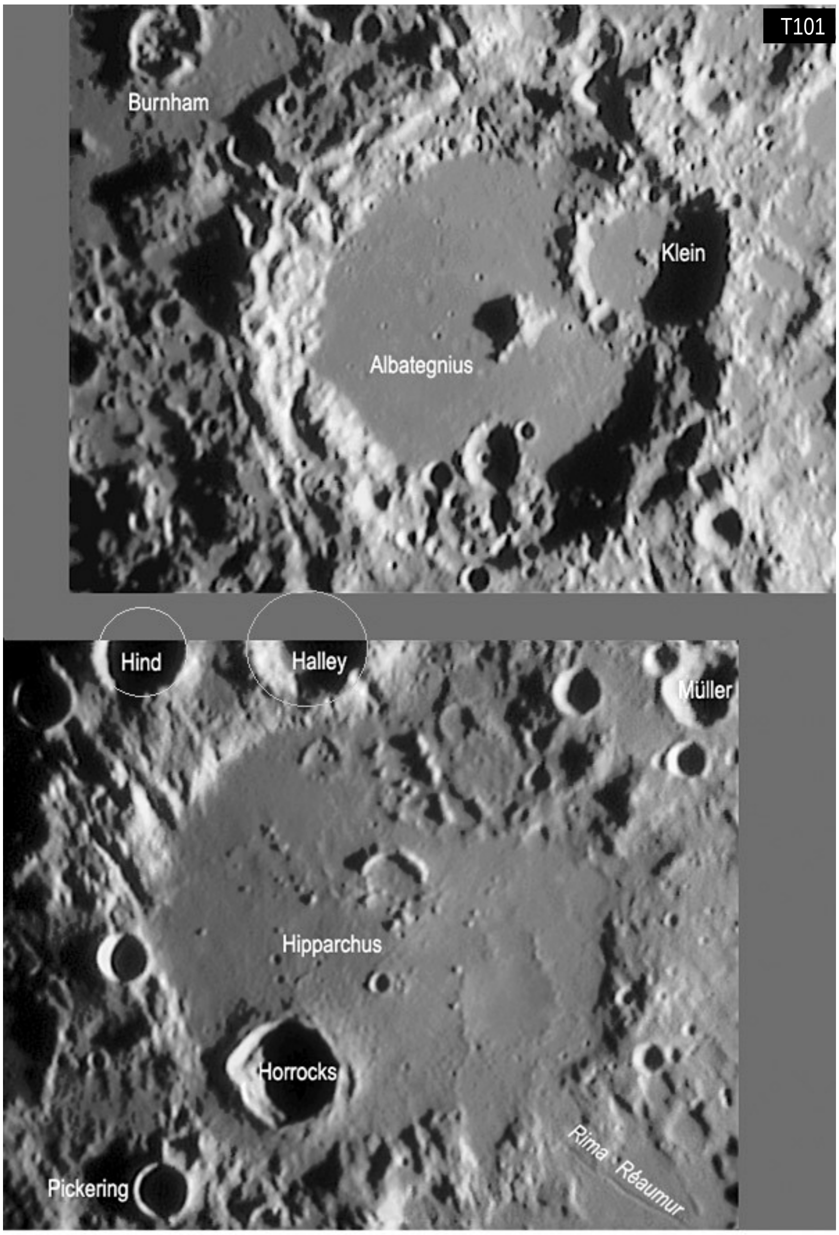
Albategnius 4.3^{0}E 11.7^{0}S
A prominent ring mountain with small central peak, 114 km in diameter. Its inner wall is heavily eroded with landslides, valleys and impact craters including ***Klein*** (44 km). The immediate north of Albategnius is Hipparchus.

Hipparchus 5.2^{0}E 5.1^{0}S
A vast walled plain, 138 km in diameter. The eastern wall is cut by a pair of deep clefts, which is part of the ***Imbrium Sculture***. The western wall is fairly disintegrated, with a gap opened to ***Rima Réaumur*** (length 30 km). The floor of Hipparchus contains small hills, ghost craters and ***Horrocks***. See also Image T071 in Map 31.

Image T179, next page:

Herschel 2.1^{0}W 5.7^{0}S
A crater with terraced walls and rough floor, 40 km in diameter.

Lalande 8.6^{0}W 4.4^{0}S
A 24-km rayed crater under high illumination. See also Map 19.



Albategnius & Hipparchus 2004.09.05 ~21:49 UT Age 21 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam

Mösting 5.9^{0}W 0.7^{0}S
A crater with terraced walls and rough floor, 24 km in diameter.

Sömmering 7.5^{0}W 0.1^{0}N
A disintegrated crater, 28 km in diameter.

Flammarion 3.7^{0}W 3.4^{0}S
A walled plain, 74 km in diameter. Its northern wall is lava flooded and crossed by ***Rima Flammarion*** (length 80 km). Its western wall is stuck by a 13-km crater ***Mösting A*** whose selenographic position (5^{0} 12’ 39.6”W 3^{0} 12’ 43.2” S) is a reference standard.

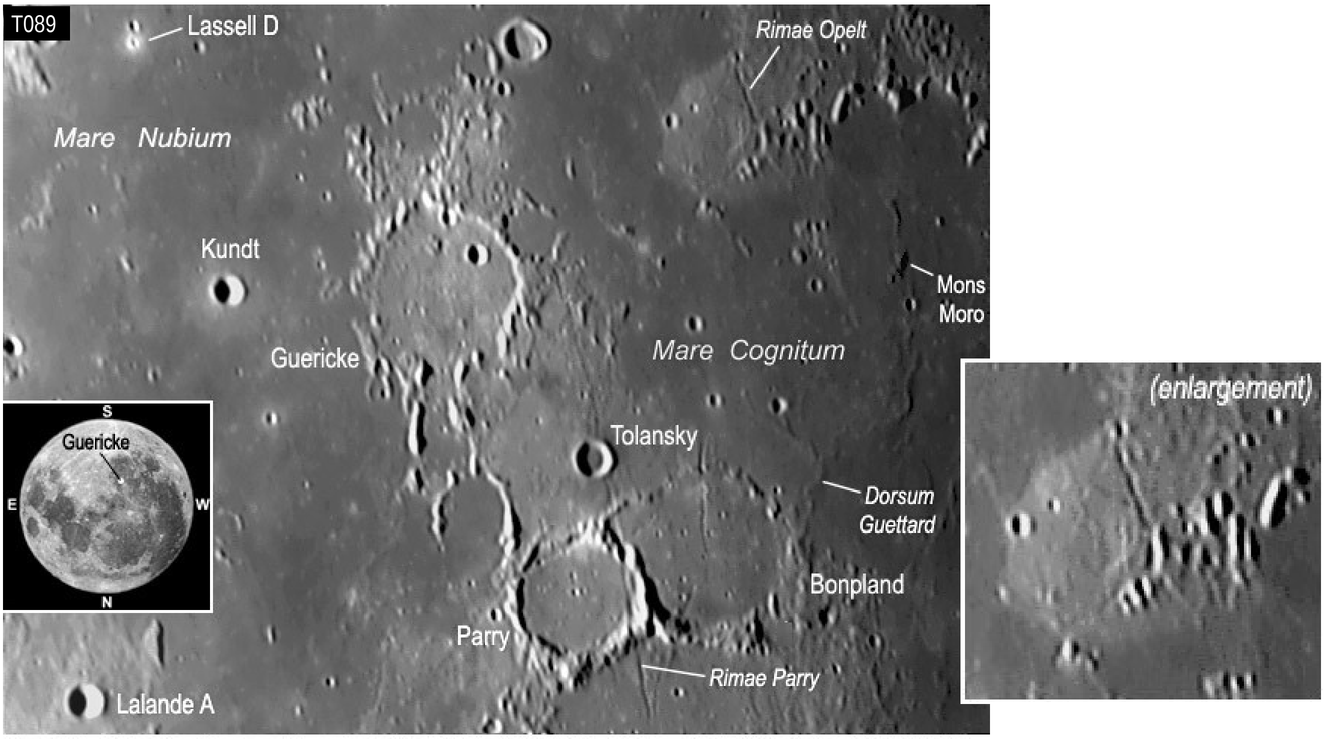
Rima Schröter 6^{0}W 1^{0}N
A rille near crater ***Schröter*** (diameter 35 km), 40 km long.

Gyldén 0.3^0 E 5.3^0 S
A disintegrated crater, 47 km in diameter. Its southwestern wall is interrupted by a valley which is part of the Imbrium Sculpture.

Réaumur 0.7^0 E 2.4^0 S
Remains of a crater, 52 km in diameter. See also Image T133, Map 13.

Oppolzer 0.5^0 W 1.5^0 S
Remains of a crater adjoining Réaumur, 40 km in diameter. Its southern wall is intersected by ***Rima Oppolzer*** (shown more prominently in Image T133, Map 13).

Ptolemaeus & northern vicinity 2005.04.18 ~13:49 UT Age 9.8 days. 10-in f/6 + 2.5X + ToUcam (*mosaic*)



Guericke, Tolansky, Parry and Bonpland 2004.06.27 13:30 UT Age 10 days. 10-in f/6 Newtonian + 2.5X + ToUcam

Lassell D 10.5^0 W 14.5^0 S *(Image T089)*
A bright halo crater, 2 km in diameter.

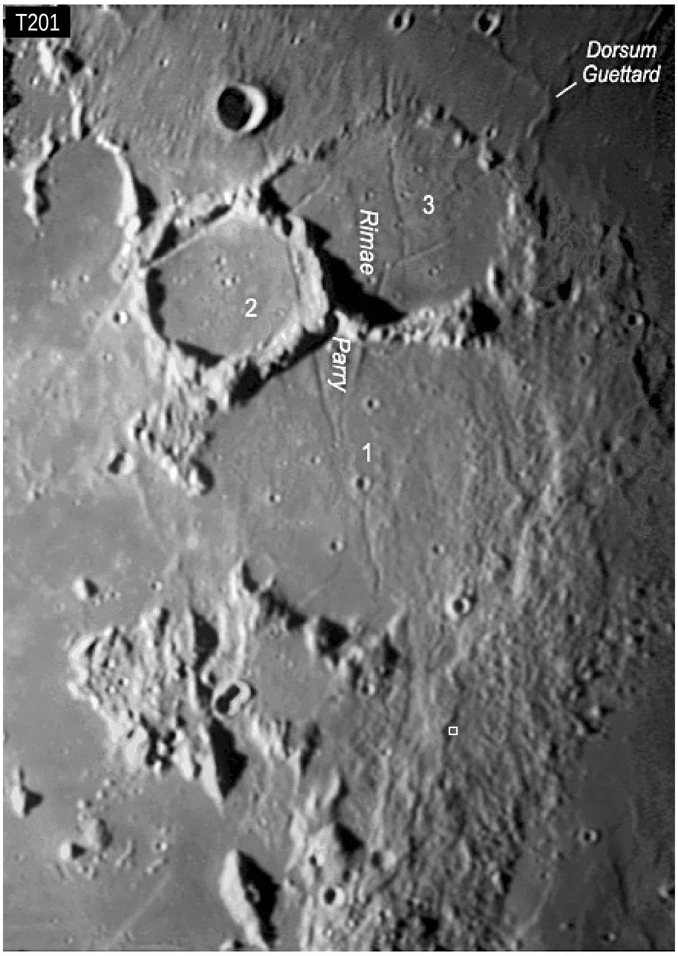
Rimae Opelt 18^0 W 13^0 S
A system of rilles, length 70 km. It is located on a dome-shaped plateau above the mare floor. See also T258 in Map 24.

Mons Moro 20^0 W 12^0 S
A low hill on a wrinkle ridge, base size 10 km.

Guericke 14.1^0 W 11.5^0 S
Parry 15.8^0 W 7.9^0 S
Guericke is the remains of a walled plain, 63 km in diameter. Together with another walled plain Parry (47 km), they form a *g*-shaped pair lying between Mare Nubium and Mare Cognitum. A wide system of rilles spanning 150 km north-south (***Rimae Parry***) intersects the southern and western rim of Parry.

Bonpland 17.4^0 W 8.3^0 S
A shallow walled plain, 60 km in diameter. Its floor is also crossed by Rimae Parry.

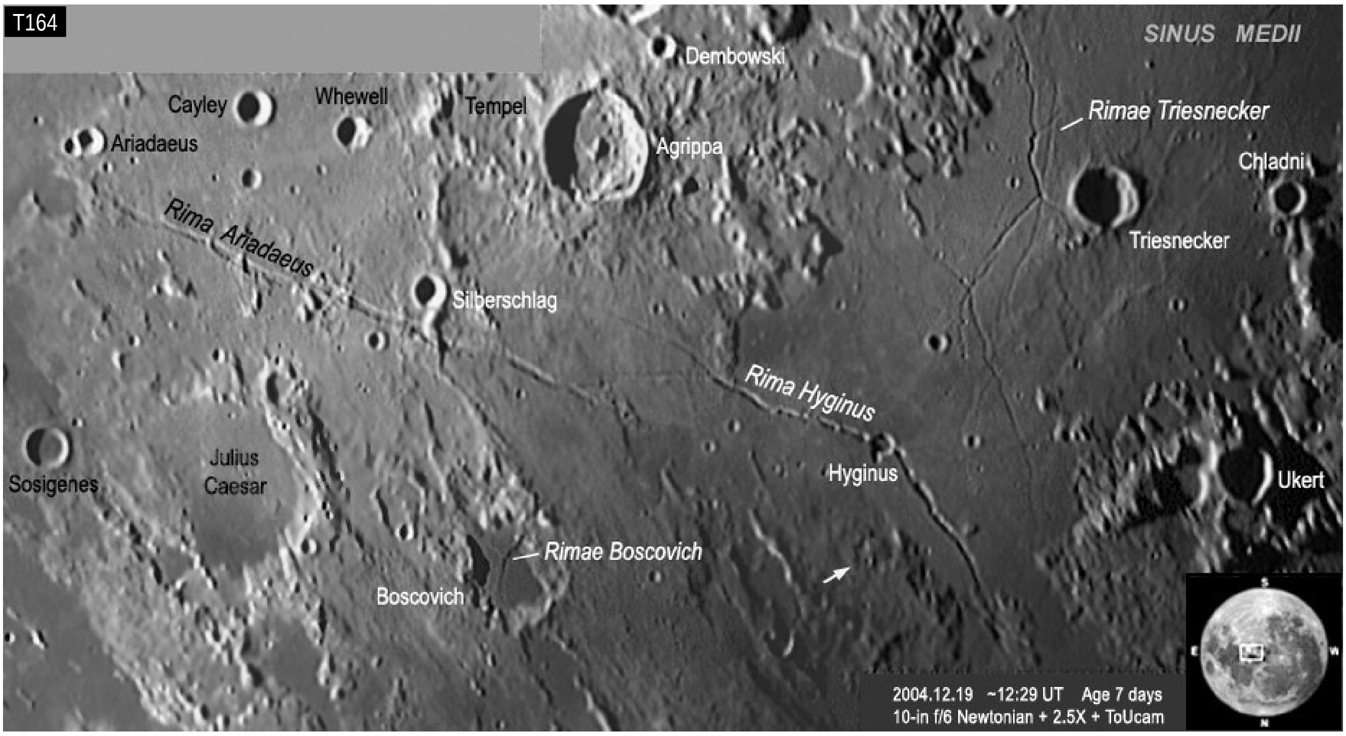
Fra Mauro 17.0^0 W 6.1^0 S
Remains of a walled plain, 101 km in diameter. Its floor is bisected by Rimae Parry. Apollo 14 landed on its northern vicinity on 1971.02.05.



1. Fra Mauro 2. Parry 3. Bonpland ◻ indicates *Apollo 14* landing site.
2005.04.18 ~11:58 UT Age 9.8 days. 10-in f/6 + 4X + ToUcam, 85% resized.

Rima Ariadaeus, Rima Hyginus, Rimae Triesnecker, Agrippa

Hatfield 1, 13
Rükl 33, 34, 44



A rima is a rille, an open or slumped channel on the Moon's surface. Rilles are classified according to their appearance. *Sinuous rilles* are thought to have been formed by running lava, typically 1 ~ 2 km wide and are found mostly in maria (flooded lava plains); fine examples are ***Rima Hadley*** in Map 14 and ***Rima Marius*** in Map 20. *Linear rilles* are straighter and wider, typically 3 ~ 10 km in width. They can cross mare and highland boundaries, and might be either collapsed lava tubes, or more likely, surface fractures where the ground to either side has been pulled slightly apart. An example of surface fractures is ***Rimae Hippalus*** in Map25.

There are three prominent rille systems in this map, all visible in small telewscopes:

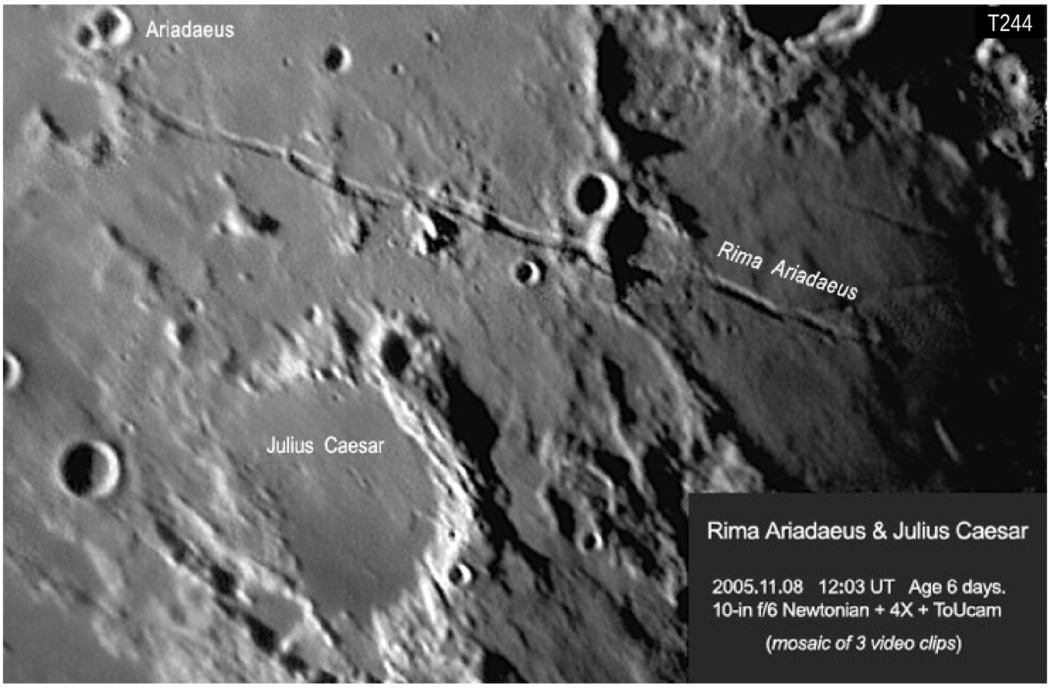
Rima Ariadaeus 13^{0}E 7^{0}N
A linear rille, 250 km long, with a nearly uniform width of about 5 km. A section of it is interrupted by a ridge extending from ***Silberschlag*** (diameter 13 km).

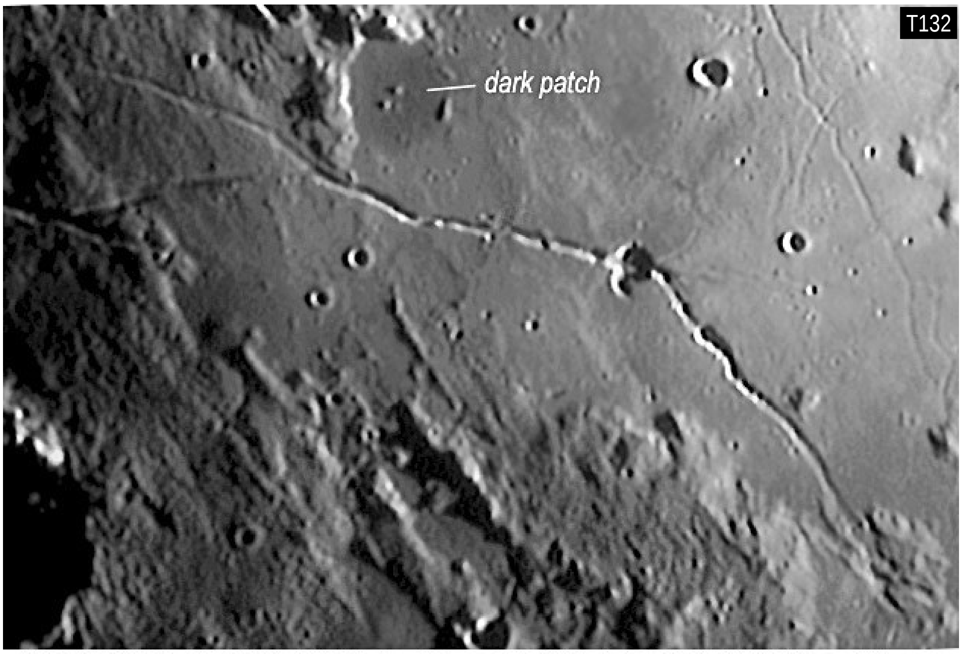
MAP 12

Rima Hyginus 6^{0}E 8^{0}N
It is composed of two linear segments jointed at ***Hyginus*** (diameter 9 km), total length 220 km, 3 ~ 5 km wide, 400 m deep. Presumably the rimless Hyginus is volcanic originated, the rille segments could be lava tubes and the chain of craterlets inside the rille floor could be exploded lava bubbles formed by rapid escape of gases.

Rimae Triesnecker 5^{0}E 5^{0}N
A group of rilles spreading like the branches of a tree. It measures 200 km north-south. ***Triesnecker*** (diameter 26 km) happens to stick in vicinity.

In the north of Hyginus is a small spiral mountain resembling a rotated letter "e", as marked by the arrow in T164. Observers call it ***Mount Schneckenberg***. In the east of this mountain is the disintergrated crater ***Boscovich*** (46 km) and ***Rimae Boscovich*** composed of short rilles. ***Julius Caesar*** (90 km) is a flooded crater with partially darkened floor.





Rima Hyginus 2004.09.05 21:23 UT Age 21 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam, 47 frames.

(Images in next page)

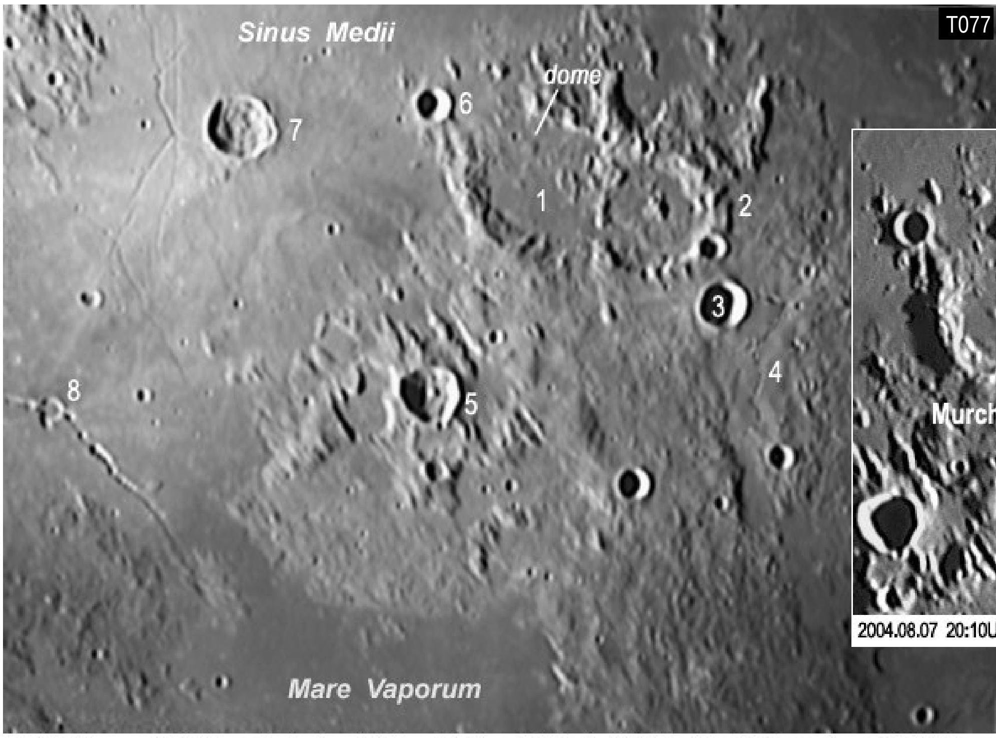
Pallas 1.6⁰ W 5.5⁰ N **Murchison** 0.1⁰ W 5.1⁰ N
A pair of joined craters near Sinus Medii. They appear like the Greek alphabet Φ. Both have disintegrated walls. Pallas is 46 km in diameter and Murchison is 57 km with an internal dome.

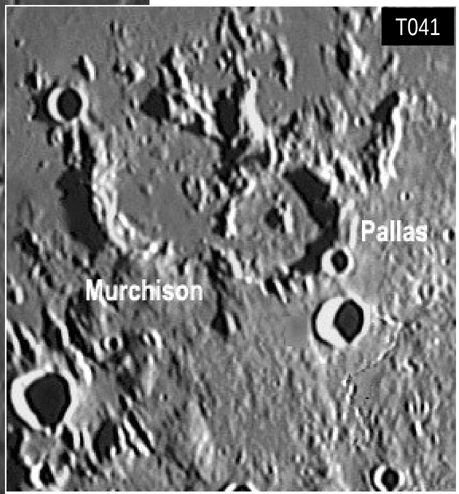
Bode 2.4⁰ W 6.7⁰ N
A crater, 18 km in diameter. ***Rimae Bode*** (70 km long) runs northwards from this crater.

Rhaeticus 4.9⁰ E 0.0⁰ N
A crater with ruined wall, 43 x 49 km in diameter.

Bruce 0.4⁰ E 1.1⁰ N
A named crater in Sinus Medii nearest to the zero-point coordinates, 6 km in diameter.

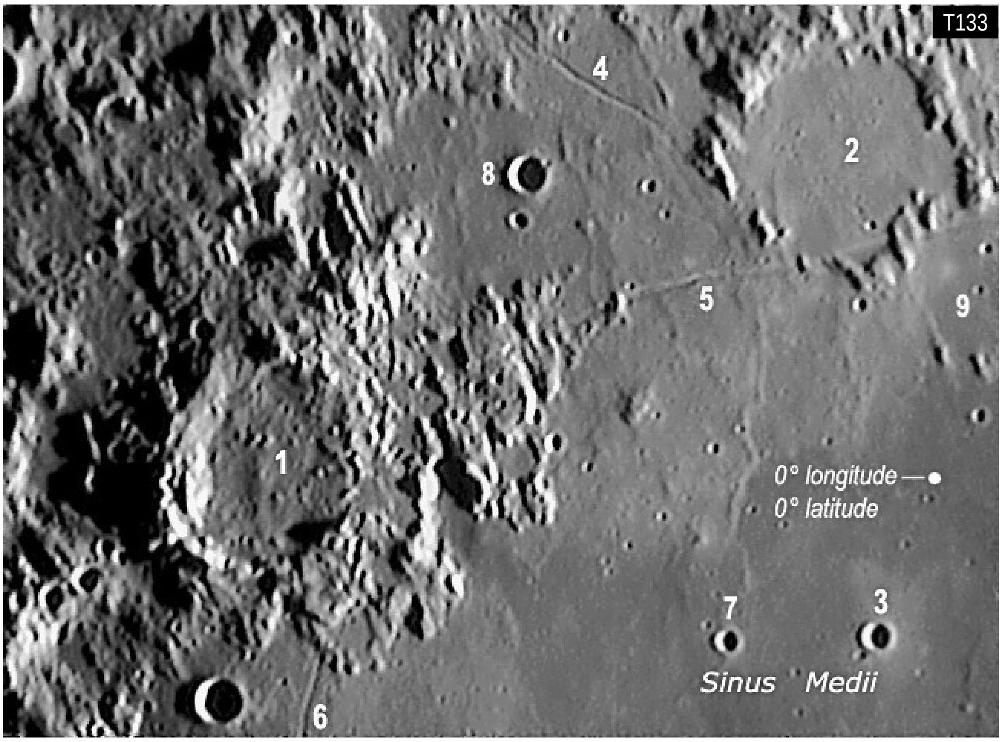
Réaumur 0.7⁰ E 2.4⁰ S
Remains of a crater, 53 km in diameter. Its rim is intersected by ***Rima Réaumur*** (length 30 km) and ***Rima Oppolzer*** (length 100 km).

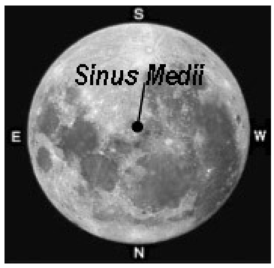




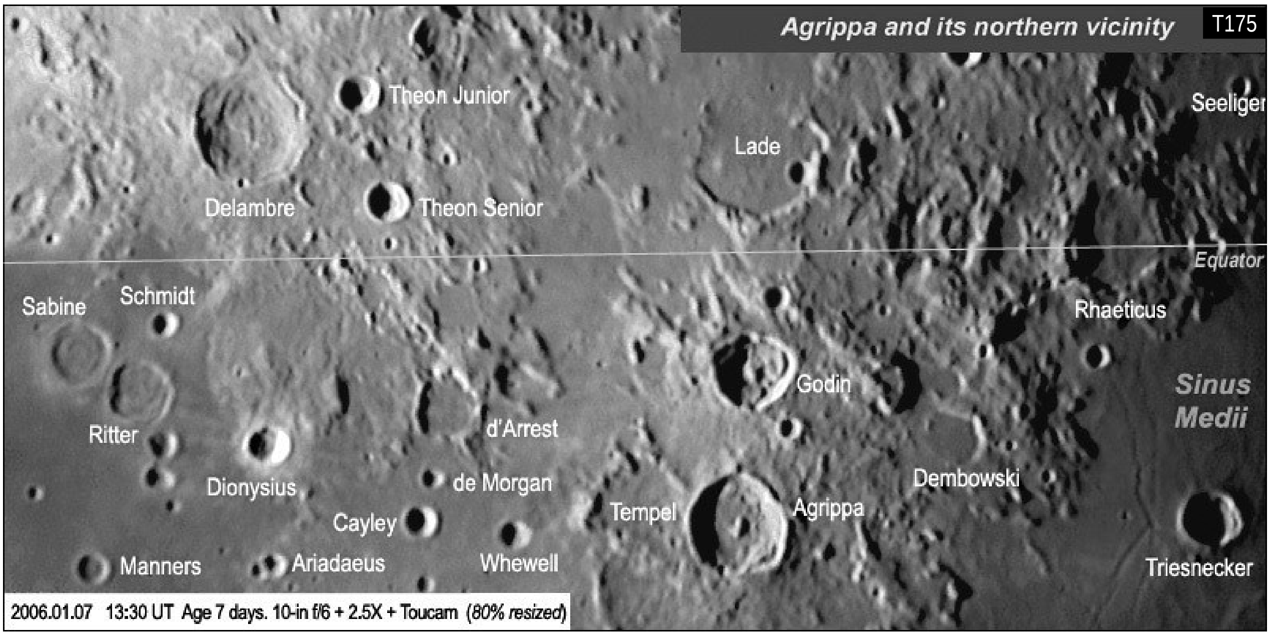
2004.08.07 20:10UT Age 22 days. 10-in f/6 + 2.5X + ToUcam

1. Murchison 2. Pallas 3. Bode 4. Rimae Bode 5. Ukert 6. Chladni 7. Triesnecker 8. Hyginus
2005.05.17 11:43 UT Age 9 days. 10-in f/6 Newtonian + 2.5X + ToUcam, 85 frames stacked, 90% resized.





1. Rhaeticus 2. Réaumur 3. Bruce 4. Rima Réaumur 5. Rima Oppolzer 6. Rimae Triesnecker *(partial)*
7. Blagg 8. Seeliger 9. Oppolzer *(partial)* 2004.09.05 21:46UT Age 21 days. 10-in f/6 + 2.5X + 1.6X + ToUcam



2006.01.07 13:30 UT Age 7 days. 10-in f/6 + 2.5X + Toucam (*80% resized*)

Godin 10.2^{0}E 1.8^{0}N
A rayed crater under high illumination, fairly irregular and with rough floor, 34 km in diameter.

Agrippa 10.5^{0}E 4.1^{0}N
A crater with central peak, 44 km in dia.

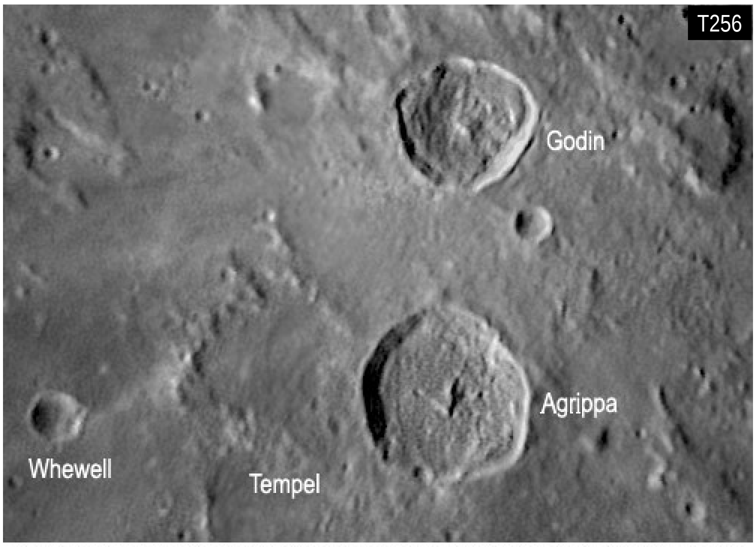
Tempel 11.9^{0}E 3.9^{0}N
An irregular, disintegrated crater adjoining Agrippa, 45 km in diameter.

Lade 10.1^{0}E 1.3^{0}S
A pentagonal flooded crater, 55 km in diameter. Its southern wall is nearly overwhelmed in lava. The Moon's equator is between Lade and Godin.

Dembowski 7.2^{0}E 2.9^{0}N
A flooded crater, 26 km in diameter.

Dionysius 17.3^{0}E 2.8^{0}N
A crater with a white halo, very bright during the full moon. It is 18 km in diameter. Close inspection reveals that an additional pattern of dark rays is beneath the white halo. One arm of the dark rays extends across Ritter to the outer rim of Sabine. See also Map 33.

Delambre, Sabine, Ritter
See Map 8.



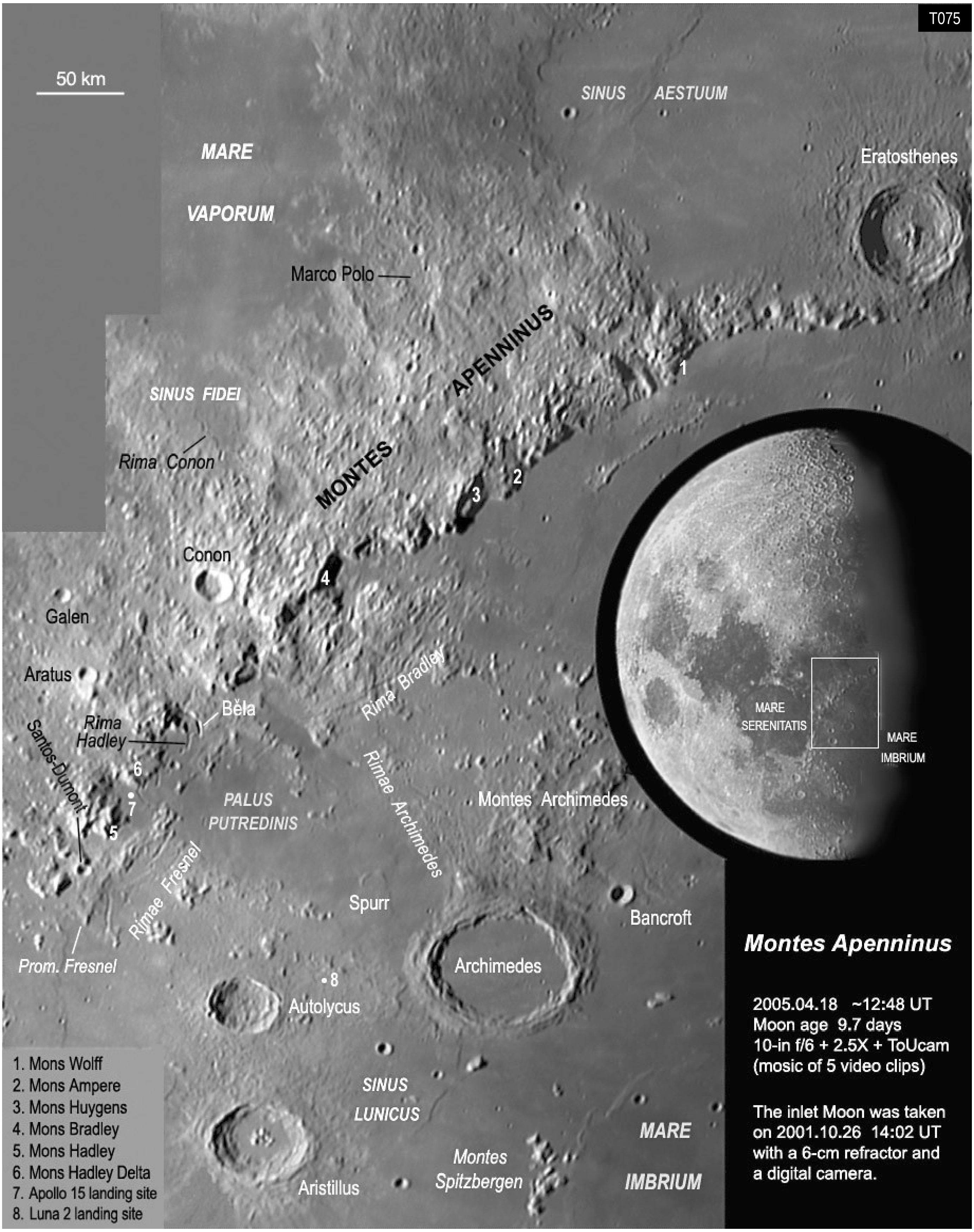
Godin & Agrippa 2006.03.09 13:56 UT Age 9.6 days. 10-in f/6 Newtonian + 4X + ToUcam

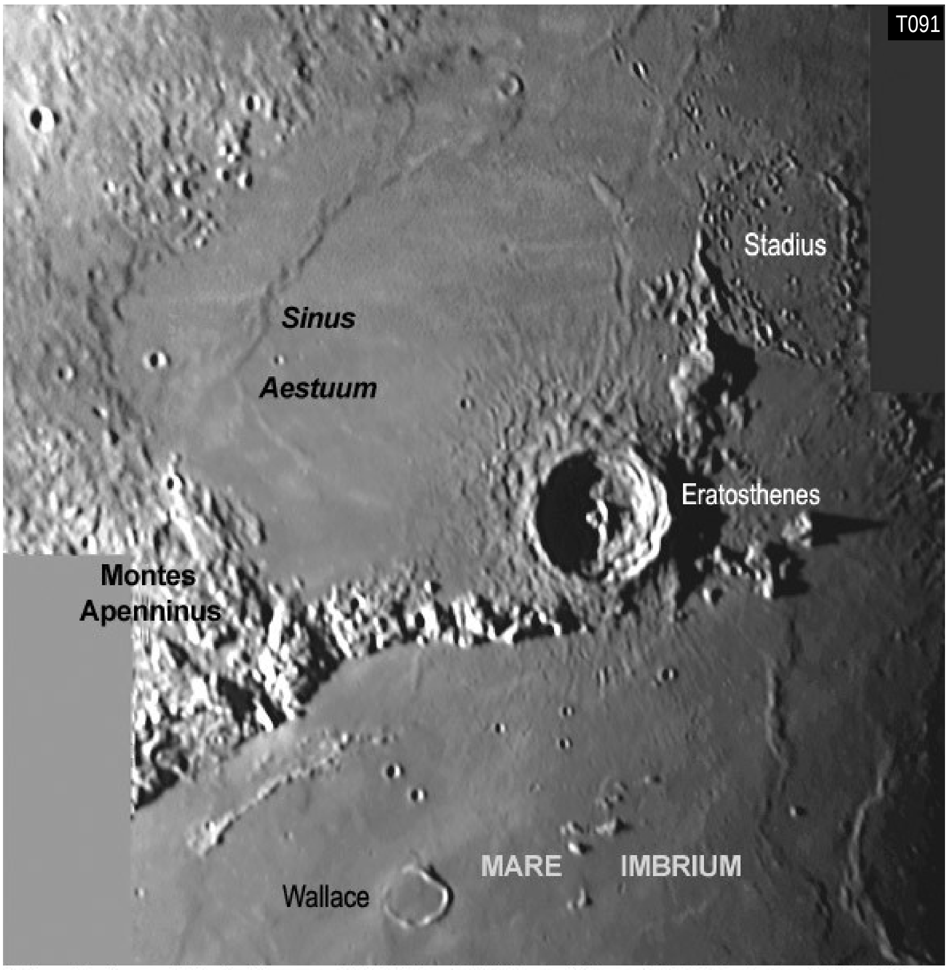
Dionysius with bright halo and dark rays 2006.08.12 20:27 UT Age 18 days. 10-in f/6 Newtonian + 4X + ToUcam

MAP 14

Hatfield 1, 5
Rükl 22, 21 12

Montes Apenninus, Rima Hadley, Archimedes, Aristillus





Sinus Aestuum & Eratosthenes 2005.05.17 ~12:30 UT Age 9 days. 10-in f/6 Newtonian + 2.5X + ToUcam

Montes Apenninus 3^0 W 20^0 N
The largest mountain range on the nearside of the Moon, named by the Polish astronomer and selenographer Hevelius (1611-1687). It is on the south-eastern edge of Mare Imbrium (Sea of Rains), and is part of the rising rim of the impact basin that holds the mare. Apenninus measures about 600 km end-to-end, 5000 m peak. The mountain slopes towards Mare Imbrium are rather steep (roughly 30^o) but the back slopes towards south are gradual. The back slopes are believed massive deposits of the ejecta produced by the Imbrium impact. Montes Apenninus is very bright at days close to the full moon.

Remark: *Take a close look on other mountain ranges along the edge of Mare Imbrium (Montes Caucasus & Montes Alpes* Map 15*, Montes Jura* Map 18*, and Montes Carpatus* Map 19*), their slopes towards Mare Imbrium are steeper than the back slopes. These are also evidences of the Imbrium impact.*

Sinus Aestuum 8^0 W 12^0 N
Sinus Aestuum (Bay of Billows) is a mare-like lowland where its eastern edge is the slopes of Montes Apenninus, 290 km in diameter. Its floor contains concentric wrinkle ridges.

Eratosthenes See Map 19.

Conon 2.0^0 E 21.6^0 N
A prominent crater on Apenninus, 21 km in diameter. It could be a secondary crater produced by the gigantic Imbrium impact (*Ref. 18*). The sinuous ***Rima Conon*** (length 30 km) is in the vicinity.

Macro Polo 2.0^0 W 15.4^0 N
An irregular shallow crater on the southern slope of Montes Apenninus, 21 x 28 km.

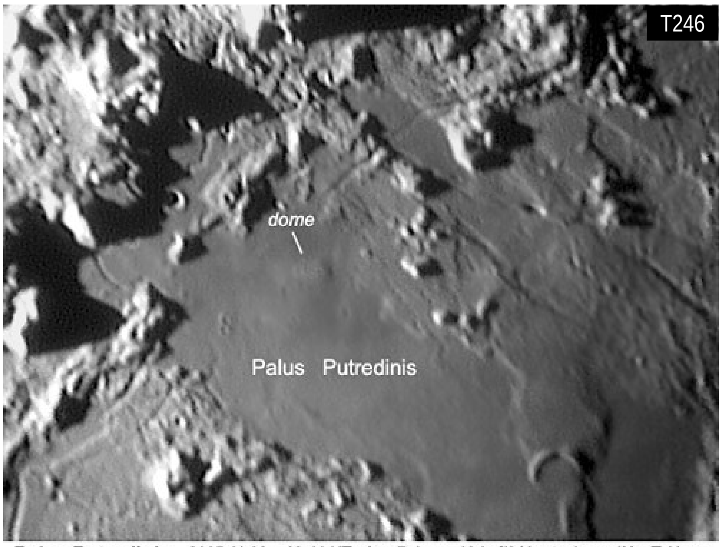
Rima Bradley 2° W 23° N
A prominent straight rille running parallel with Montes Apenninus, length 160 km.

Rima Hadley 3° E 25° N
A sinuous rille which begins at the elongated crater ***Běla*** (2 x 11 km), 80 km long, 1~2 km wide, 300 m deep. It is a typical lava channel. On 1971 July 30, Apollo 15 landed on the eastern side of this rille, near ***Mons Hadley Delta***. See Image T137.

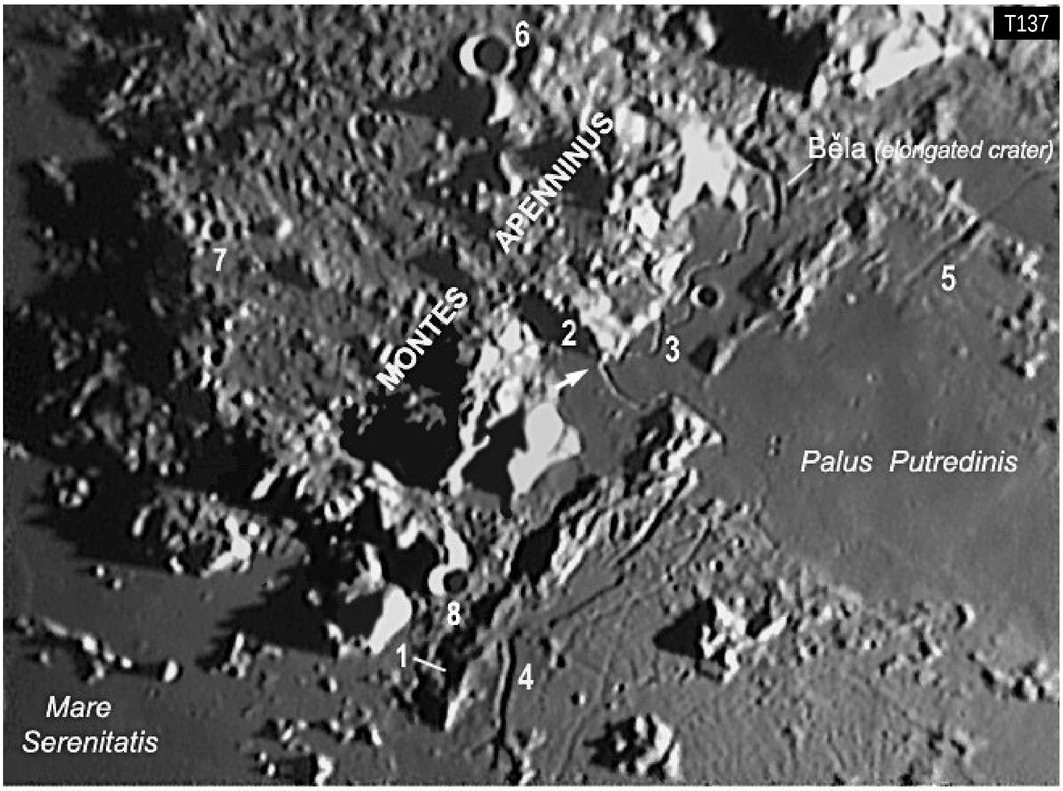
Rimae Fresnel 4° E 28° N
A system of rilles, length 90 km. A closer view is shown in T137. The main rille appears to be a continuation of Rima Hadley. It ends near the spiky cape ***Promontorium Fresnel***.

Montes Spitzbergen 5° W 35° N
A group of adjoined mountains with peak height up to 1400 m, length 60 km.

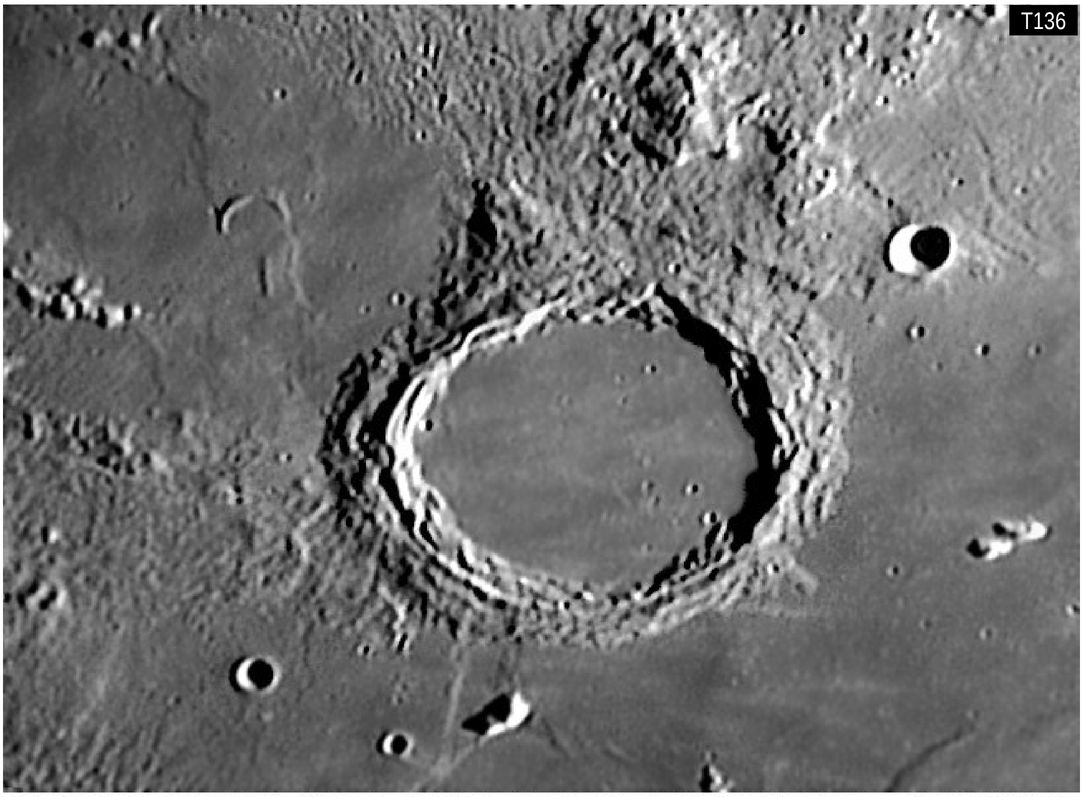
Palus Putredinis 0° 27° N
Palus Putredinis (Marsh of Decay) is a small mare facing Montes Apenninus, east-west length 160 km. It contains a dome, noticeable only under low sun angle.



Palus Putredinis 2005.11.09 12:41 UT Age 7 days. 10-in f/6 Newtonian + 4X + ToUcam



1. Promontorium Fresnel 2. Mons Hadley Delta 3. Rima Hadley 4. Rimae Fresnel 5. Rima Bradley (partial) 6. Aratus 7. Joy 8. Santos-Dumont 2004.09.05 21:26 UT Age 21 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam
(The arrow points to the landing site of Apollo 15.)

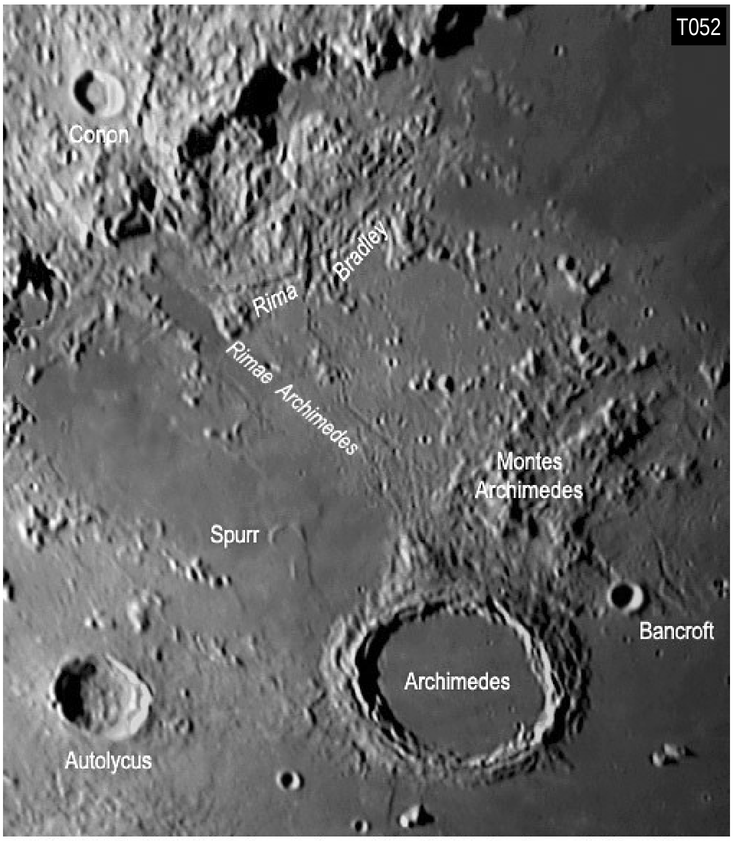


Archimedes 2004.09.05 21:40 UT Age 21 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam, 69 frames stacked.

Archimedes 4.0^0 W 29.7^0 N
A flooded crater with terraced walls, 82 km in diameter, 2100 m deep. Its size suggests central peaks once existed, but the peaks were buried by post-flooding of lava. The rim of Archimedes looks bulgy. The triangular cape-like feature towards Apenninus makes this crater a distinctive landmark.

Montes Archimedes 5^0 W 26^0 N
A mountain range adjoining the south rim of Archimedes, length 160 km. It might be part of Montes Apenninus four billion years ago, before Mare Imbrium was filled with lava.

Rimae Archimedes 4^0 W 27^0 N
A broad system of rilles running between the south-east of Archimedes and Montes Apenninus, length 170 km. At least two rilles of the system are recognizable in small telescopes.

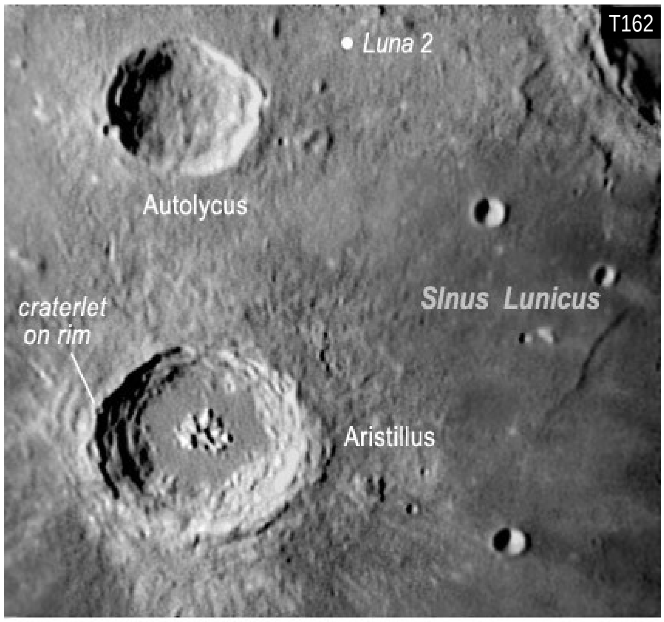


2004.06.26 14:09 UT Age 9 days. 10-in f/6 Newtonian + 2.5X + ToUcam

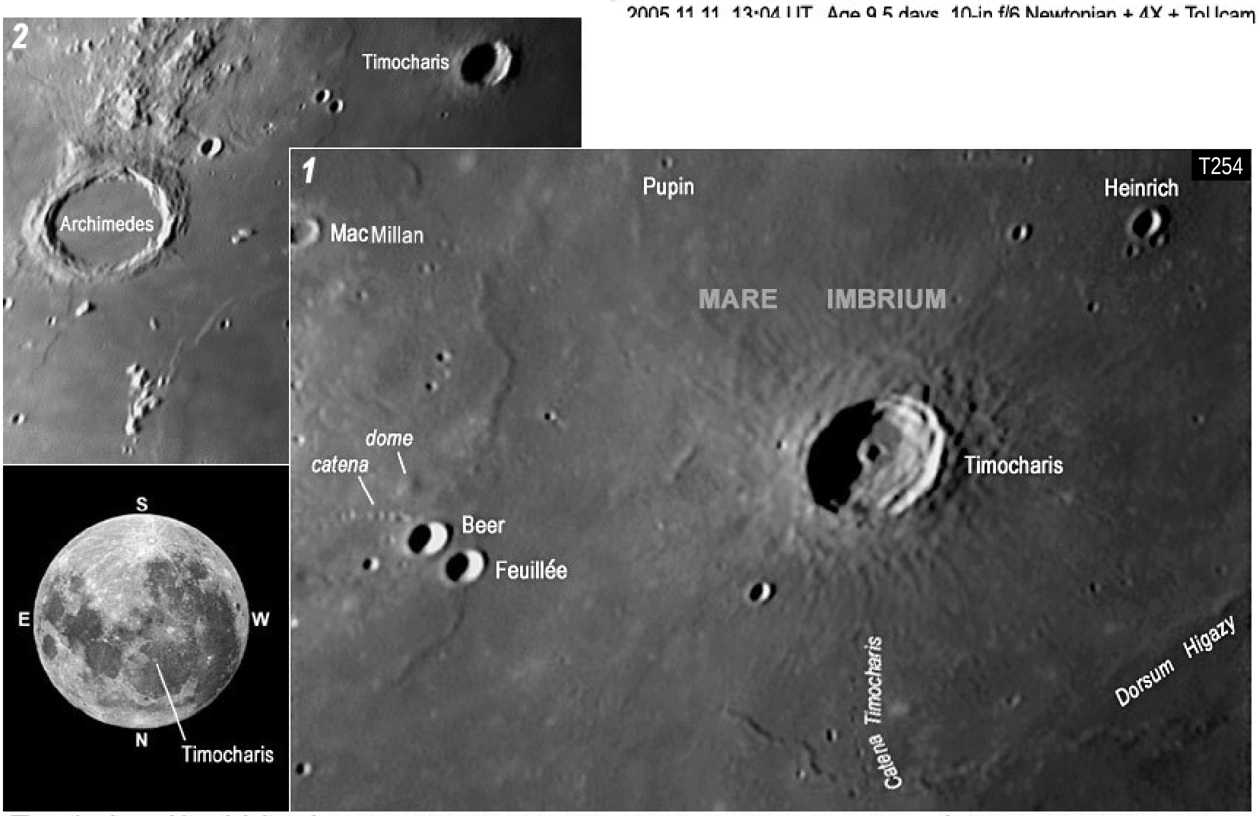
Spurr 1.2^0 W 27.9^0 N
Remains of a flooded crater, 13 km in diameter.

Autolycus 1.5^0 E 30.7^0 N
Aristillus 1.2^0 E 33.9^0 N
These are prominent crater pair in the Apenninus region. Autolycus has a rough floor with disintegrated central peaks, 39 km in diameter. Aristillus has terraced walls and multiple central peaks, 55 km in diameter. A ghost crater is also beneath the ejecta blanket of Aristillus (shown in Image T120, Map 15.) Both craters are centers of bright rays under high illumination.

In 1959, the Russian Luna 2 probe hit the Moon near Autolycus between Palus Putredinis and ***Sinus Lunicus*** (Bay of Luna). Luna 2 is the first probe on the Moon surface.



2005 11 11 13:04 UT Age 9.5 days 10-in f/6 Newtonian + 4X + ToUcam



Timocharis and its vicinity **1.** 2006.03.09 13:26 UT Age 9.6 days. 10-in f/6 + Newtonian + 4X + ToUcam **2.** 2006.02.07 12:36 UT Age 8.9 days.

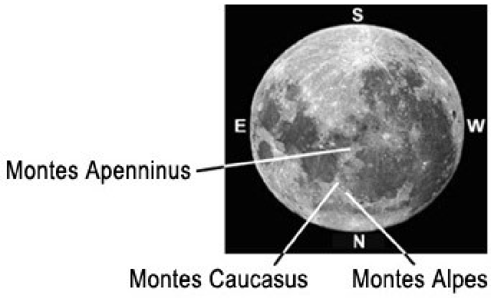
Timocharis 13.1^0 W 26.7^0 N
A sharp rim crater with a small central crater, 33 km in diameter. It is also a rayed center under high illumination.

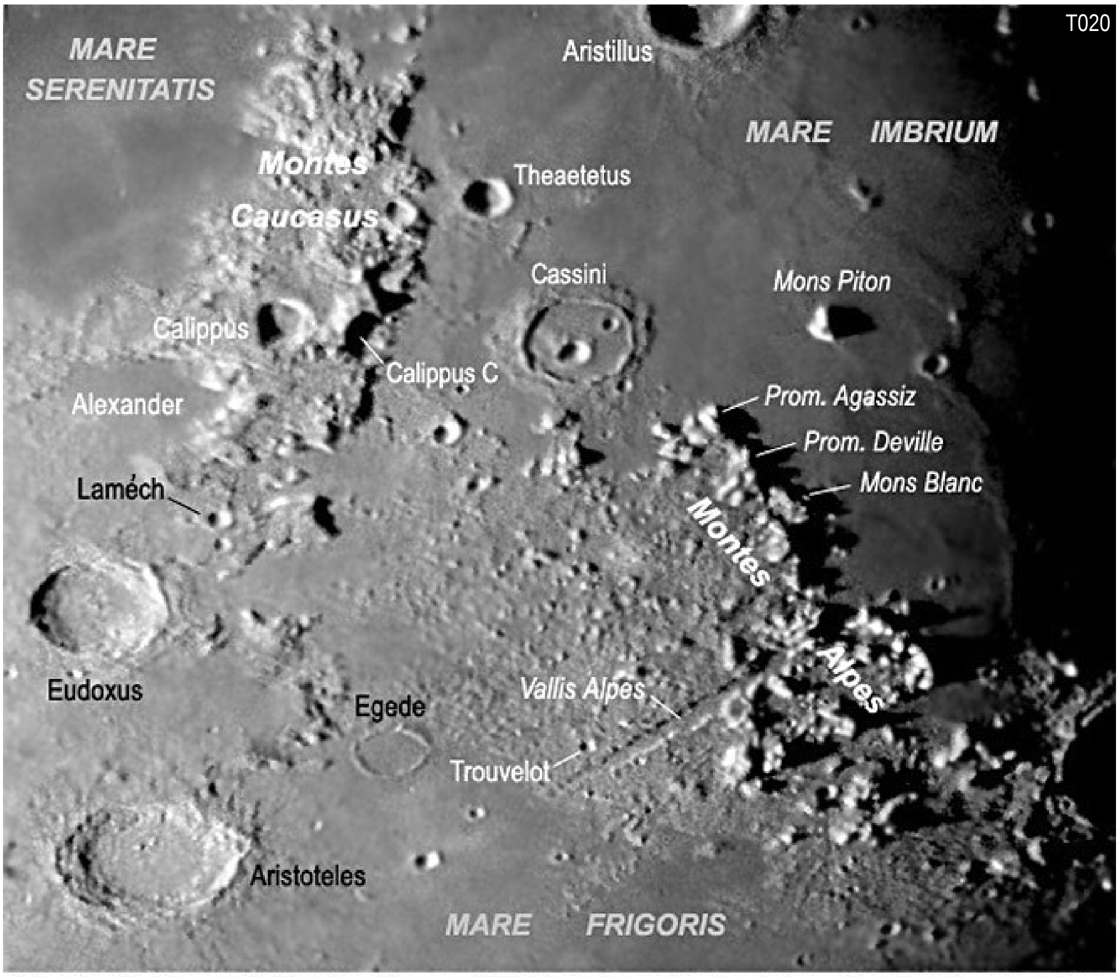
Catena Timocharis 13^0 W 29^0 N
A chain of craterlets, about 50 km long. It is barely distinguishable in Image T254.

Beer 9.1^0 W 27.1^0 N **Feuillée** 9.4^0 W 27.4^0 N
A close pair of craters, each about 9 km in diameter. Note the nearby dome and catena which are noticeable only under low illuminatrion.

Hatfield 2
Rükl 13,12, 5, 4

Montes Caucasus, Montes Alpes, Mons Piton, Vallis Alpes, Cassini, Aristoteles, Eudoxus, Meton

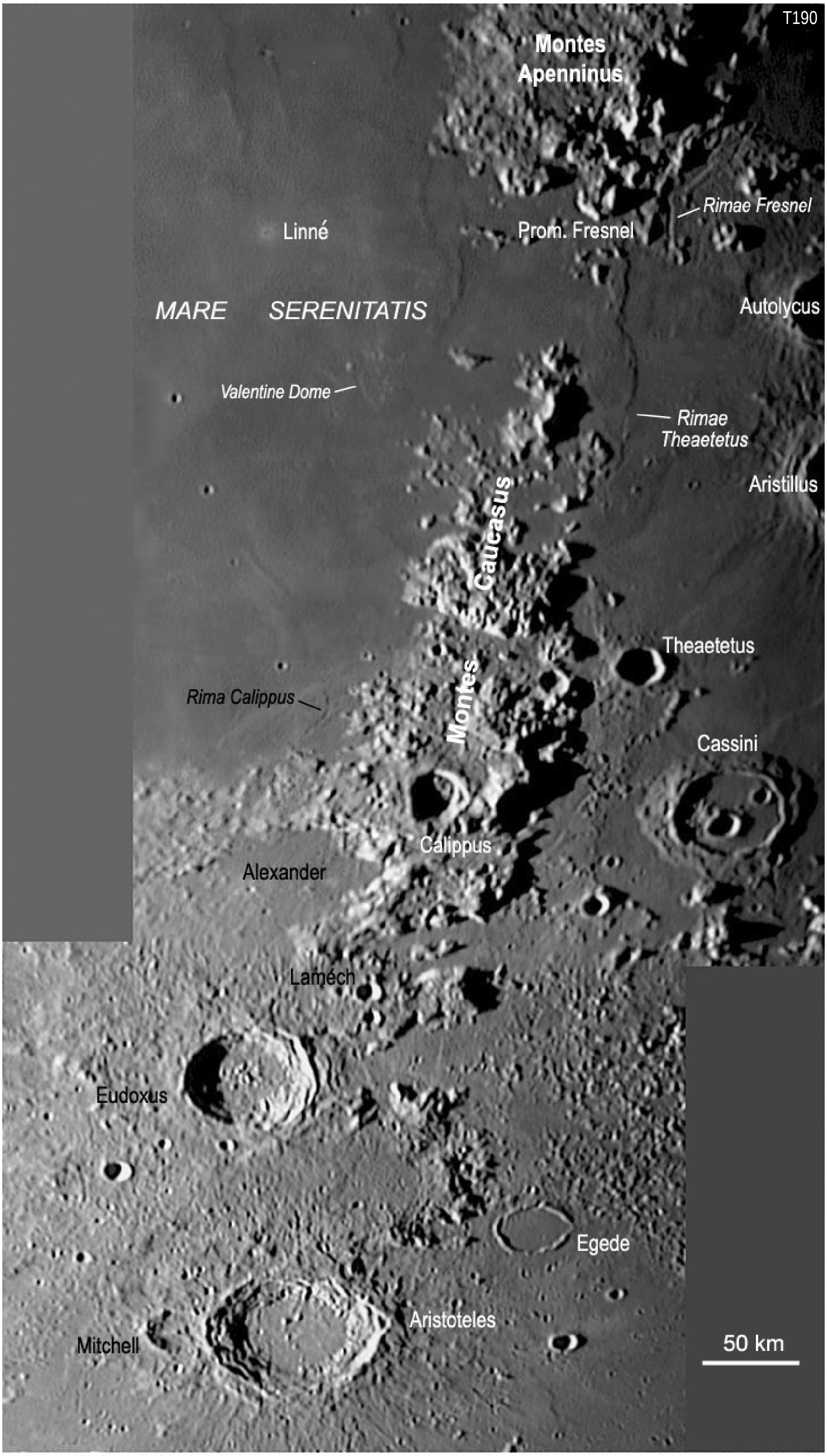




Montes Caucasus & Montes Alpes 2001.09.25 12:57 UT Age 8 days. C9 + CP990 (*DSCN9804*)

Montes Caucasus 9^0 E 39^0 N
A mountain range between Mare Serenitatis in the east and Mare Imbrium in the west. It measures 450 km north-south, with height up to 6000 m. It is the highest montes on the nearside of the Moon. Standing on the highest peak, an observer could see a hozizon 140 km away,* including almost the full view of Cassini. Montes Caucasus appears once united with Montes Apenninus but subsequently a channel of mare lava separated them, see Image T190 in next page.

** Horizon range ≈ square root of (altitude of observer* x *diameter of the Moon)*



Montes Caucasus, Cassini, Eudoxus & Aristoteles 2004.12.19 ~13:09 UT Age 7 days. 10-in f/6 + 2.5X + ToUcam (*mosaic*)

Calippus 10.7^0 E 38.9^0 N
A crater sitting on the highlands of Montes Caucasus, 32 km in diameter. Its eastern wall looks linear more than curved. ***Calippus C*** is a flooded crater resembling a bay in Mare Imbrium.

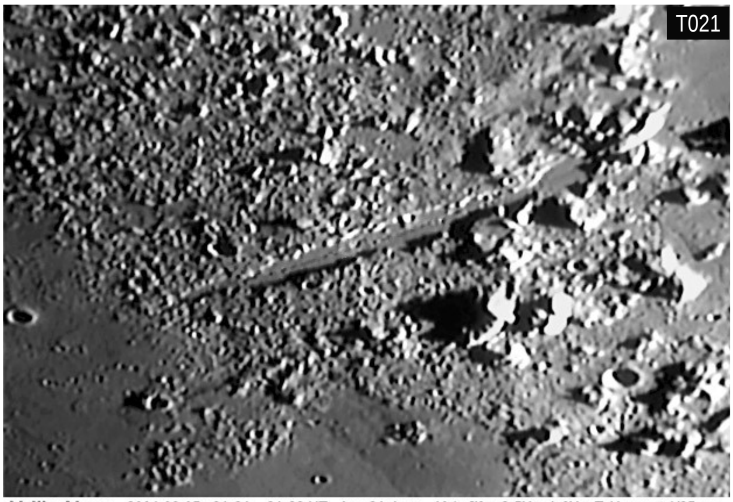
Alexander 13.5^0 E 40.3^0 N
A heavily eroded walled plain, 81 km in diameter.

Montes Alpes 1^0 W 46^0 N
A mountain range named by the Polish astronomer Hevelius (1611-1687) on the northeast edge of Mare Imbrium, length 280 km and average height 2400 m. Under low Sun angles, the mountain peaks cast strikingly long triangular shadows. The southern end of Montes Alpes has two named capes: ***Promontorium Agassiz*** and ***Promontorum Deville***.

Mons Blanc (Mont Blanc) 1^0 E 45^0 N
A mountain adjoining Montes Alpes, 3600 m high, base width 25 km.

Mons Piton 1^0 W 41^0 N
An isolated mountain, 2250m high, base 25 km wide. It casts long shadow under low Sun angles.

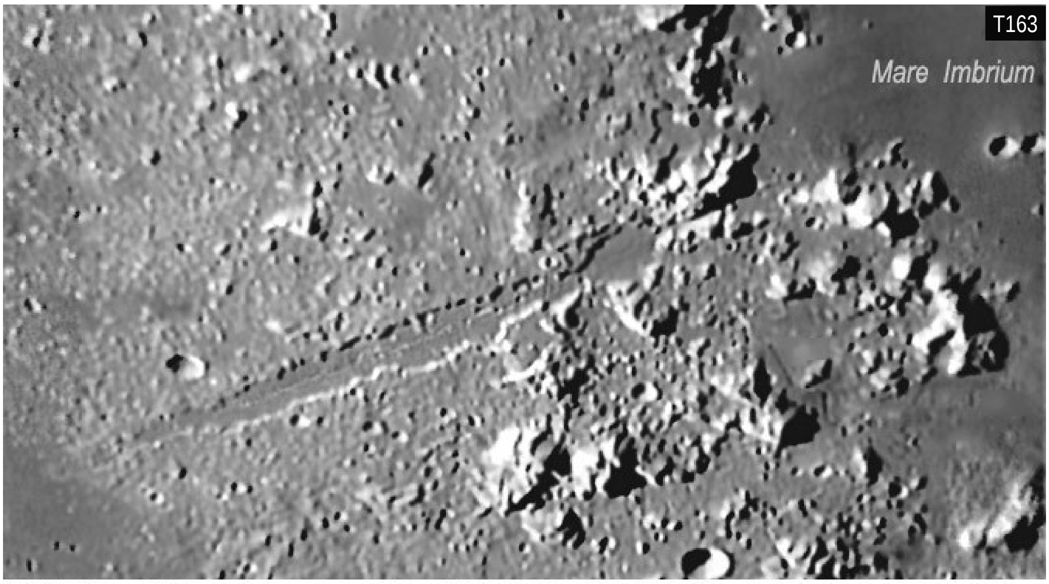
Vallis Alpes (Alpine Valley) 3^0 E 49^0 N



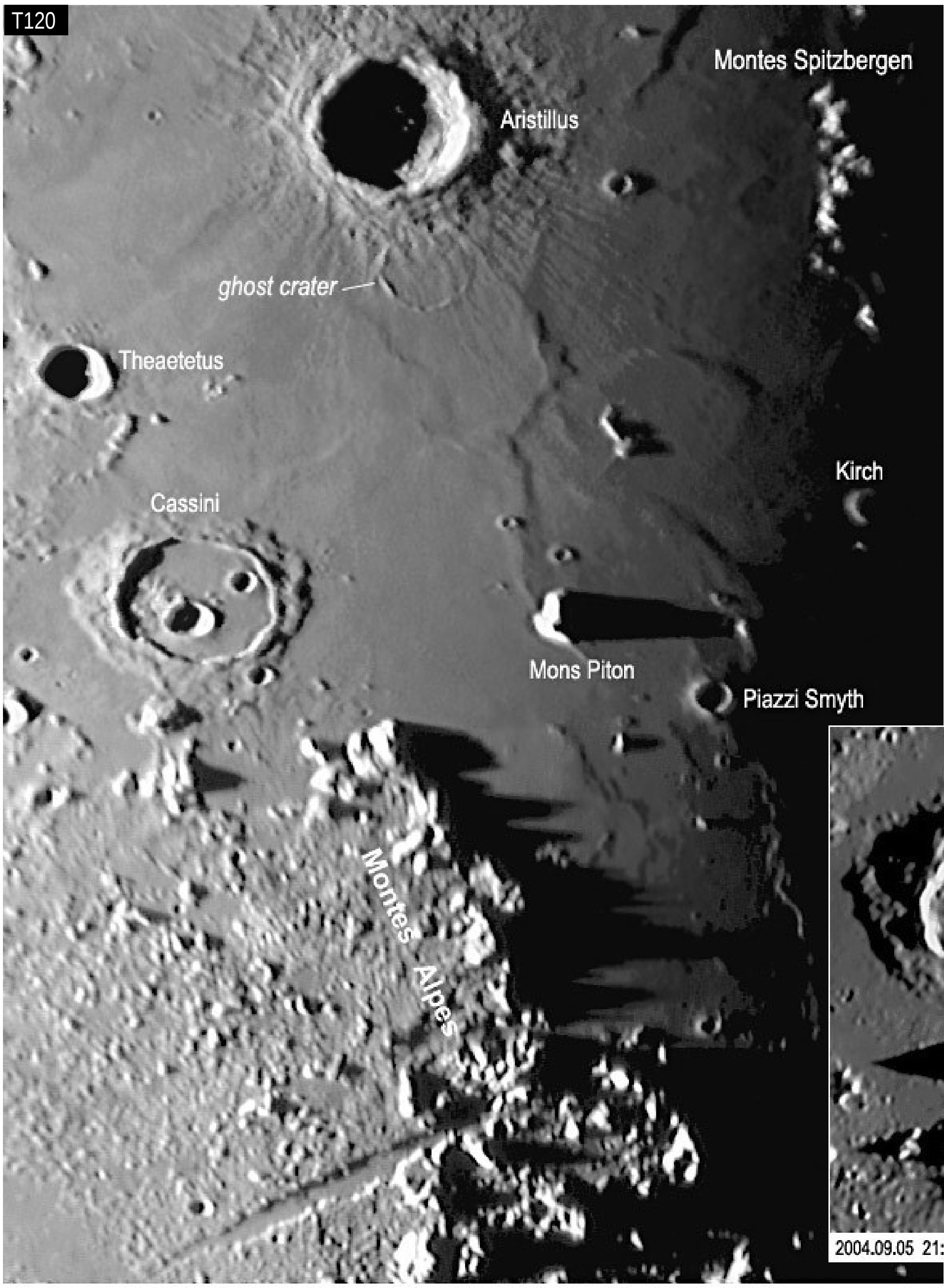
Vallis Alpes 2004.09.05 21:31 ~ 21:33 UT Age 21 days. 10-in f/6 + 2.5X + 1.6X + ToUcam at 1/25 sec.

Vallis Alpes is a prominent landmark, length 170 km, width up to 11 km. It looks radial to the Imbrium impact basin and bisecting Montes Alpes. Under good seeing and appropiate illumination, a very narrow central cleft (less than 500 m wide) can be detected with an 8-inch telescope. Vallis Alpes is a graben (sunken area between faults), likely resulted from horizontal stresses pulling apart the local crust; subsequently the valley floor is flooded by lava leaked out from the central cleft.

Vallis Alpes at Moon age of 21 days (above) and 9 days (right)



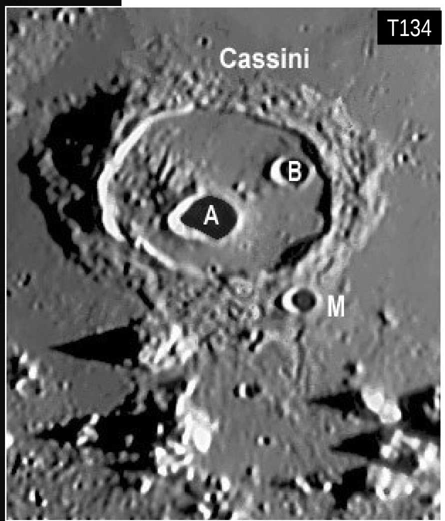
Vallis Alpes & its central narrow cleft. 2005.11.11 13:22 UT Age 9.5 days. 10-in f/6 Newtonian + 4X + ToUcam



Shadows of Montes Alpes and Mons Piton 2005.11.09 12:00UT Age 7.4 days. 10-in f/6 + 2.5X + ToUcam

Left: *Montes Alpes and Mons Piton cast long spiky shadows during the first quarter. Note also the ghost crater beneath the ejecta blanket of Aristillus.*

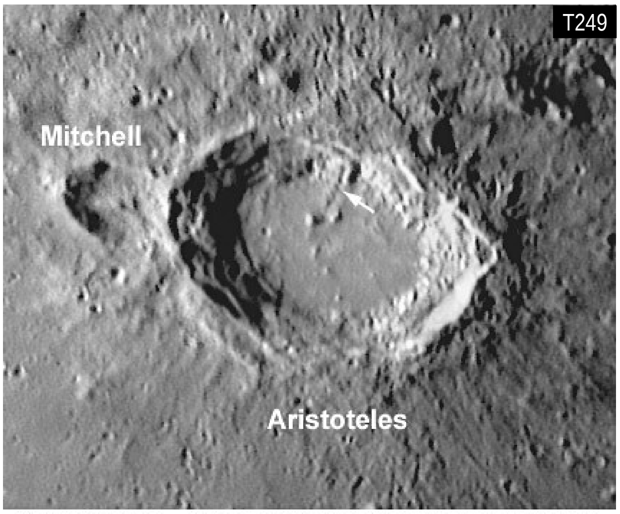
Below: *A trough-like feature (length about 20 km) extends northward from the rim of Cassini M.*



2004.09.05 21:30 UT Age 21 days. 10-in f/6 + 4X + ToUcam

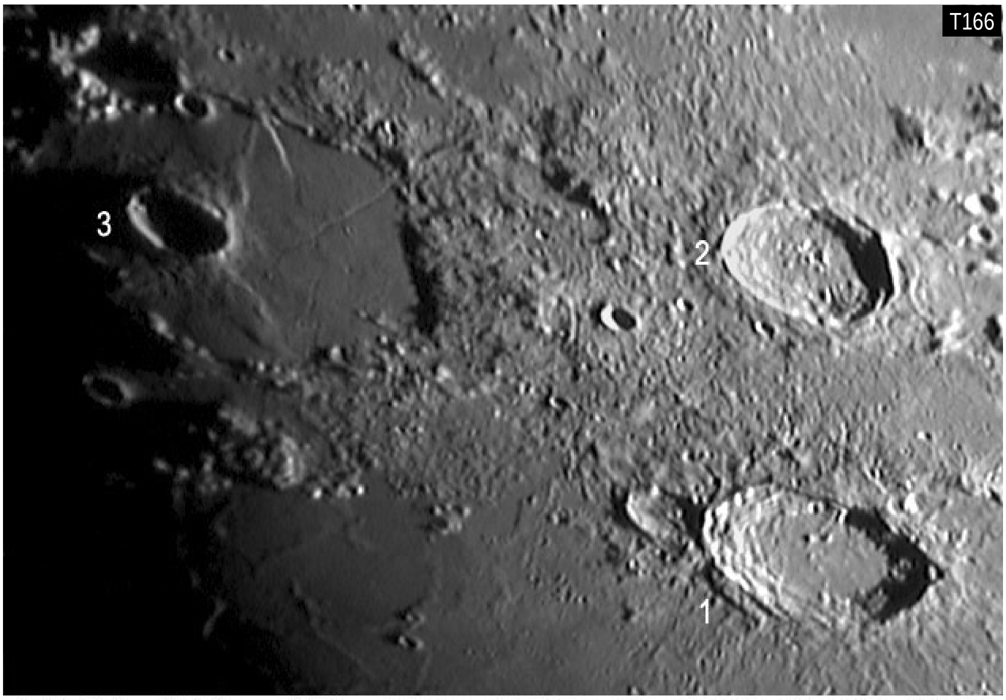
Cassini 4.6^{0}E 40.2^{0}N
A flooded crater with raised floor and bulging outer slopes, diameter 56 km. Two distinct craters are on its floor, ***Cassini A*** & ***B.*** A third crater ***Cassini M*** is close to the rim. A rille is located between Cassini and Calippus (Image T190).

Aristoteles 17.4^{0}E 50.2^{0}N
A crater with terraced walls, 87 km in diameter. Its eastern wall adjoins crater ***Mitchell*** (30 km). A triangular landslide is on the western wall. The southern wall is crossed by a chain of craterlets which appears only under appropriate illumination.



Aristoteles The arrow points to a chain of craterlets.
2005.11.09 11:04 UT Age 7.4 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam

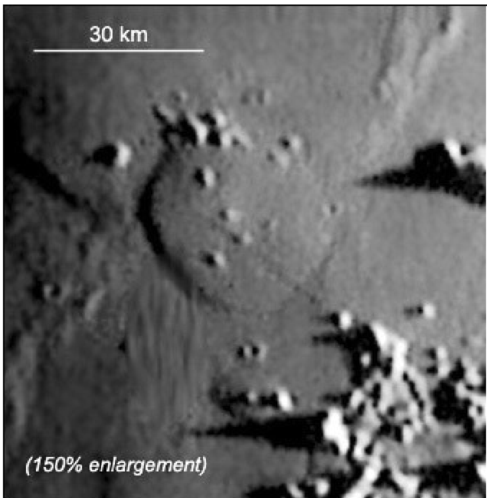
Eudoxus 16.3^{0}E 44.3^{0}N
A crater with terraced walls, 67 km in diameter. It is often described with Aristoteles as a twin.



1. Aristoteles 2. Eudoxus 3. Bürg 2004.10.03 21:15 UT Age 19 days. 10-in f/6 + 2.5X + ToUcam, 10 frames.

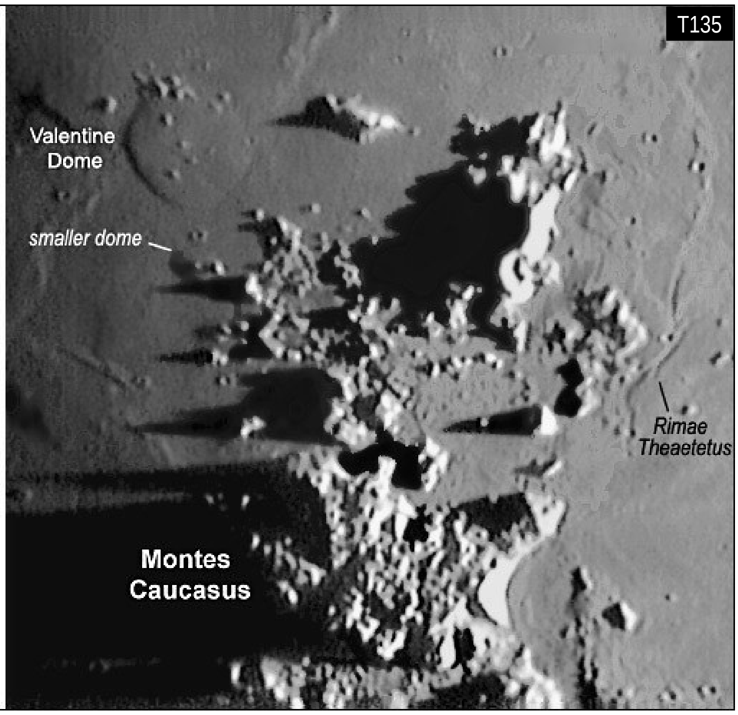
Rimae Theaetetus 6^{0}E 33^{0}N
Inconspicuous rilles, length about 50 km.

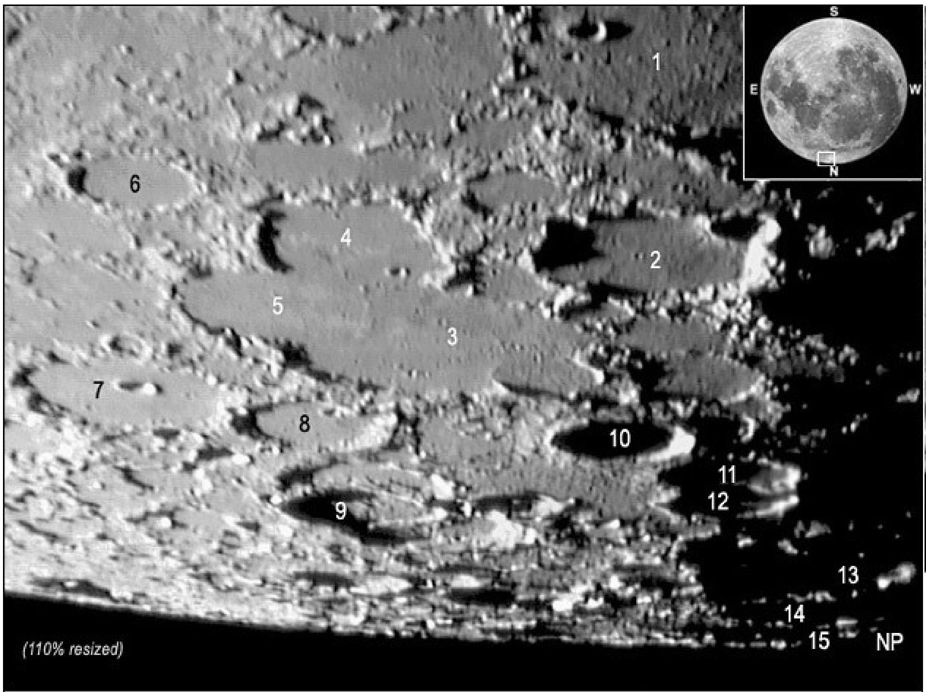
Valentine Dome (nickname) 10.2^{0}E 30.5^{0}N
A raised, circular plateau near the southern end of Montes Caucasus. Together with the nearby smaller dome, they are noticeable only at very low Sun angles. Compare Image T135 with T190.



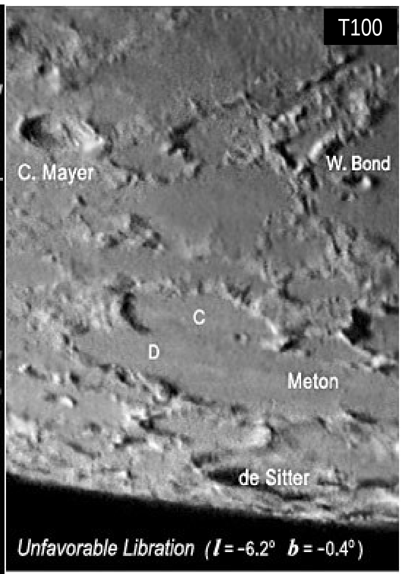
Valentine Dome with protrusions (at least 5 are prominent) and one rille on its surface. The dome is located at about 10° E 31° N, 30 km in diameter.

2004.09.05 20:46 UT Moon age 21 days.
10-in f/6 Newtonian + 5X + ToUcam at 1/25 sec.
Taken in Shatin, Hong Kong under misty sky.



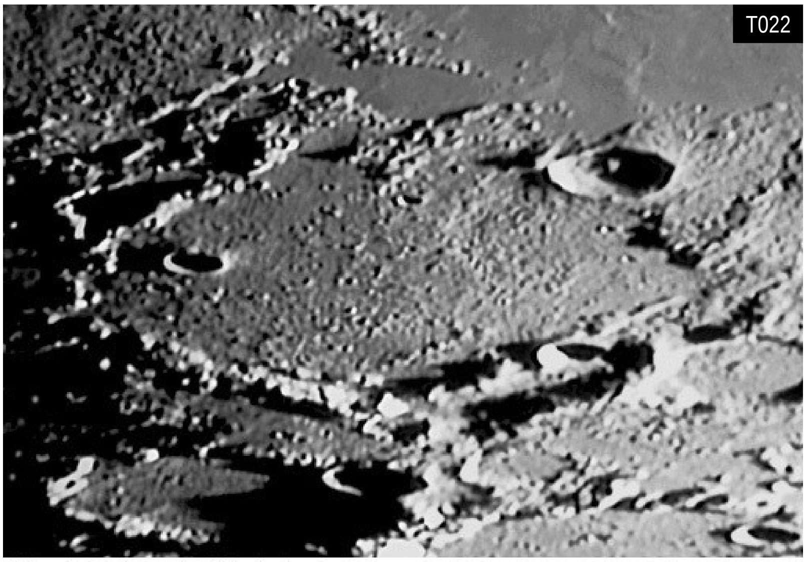


1. W. Bond 2. Barrow 3. Meton 4. Meton C 5. Meton D 6. Neison 7. Baillaud 8. Euctemon 9. de Sitter 10. Scoresby 11. Challis 12. Main 13. Gioja 14. Byrd 15. Peary 2005.11.09 12:06UT Age 7 days. Lat. Libration = 5°. 10-in f/6 + 2.5X + ToUcam



2004.07.25 13:06UT Age 8 days.
10-in f/6 Newtonian + 2.5X + ToUcam

Image T100 & T022:



W. Bond under low angle of illumination 2004.09.05 21:37UT Age 21 days. 10-in f/6 + 2.5X + 1.6X + ToUcam

W. Bond 4.5^0 E 65.4^0 N
A vast walled plain with rough floor, 156 km in diameter.

C. Mayer 17.3^0 E 63.2^0 N
A crater with ridged floor, 38 km in diameter.

Barrow 7.7^0 E 71.3^0 N
A crater, 92 km in diameter.

Meton 18.8^0 E 73.6^0 N
Remains of a vast walled plain, 130 km in diameter. It overlaps with two flooded craters, ***Meton C*** (77 km) and ***Meton D*** (78 km).

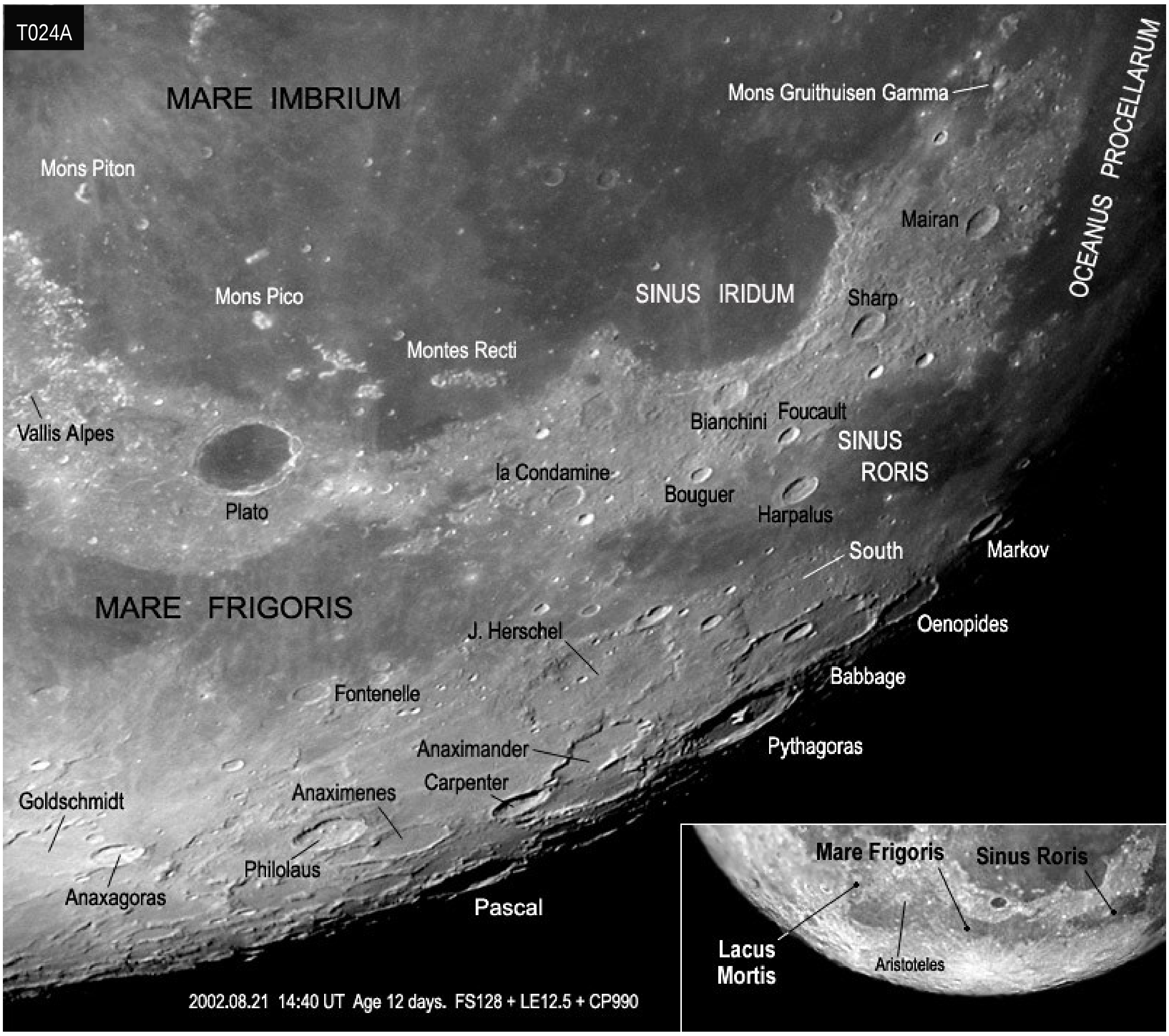
Baillaud 37.5^0 E 74.6^0 N
A crater, 89 km in diameter. Its floor contains a small off-centered crater.

Gioja 2.0^0 E 83.3^0 N 41 km
Byrd 9.8^0 E 85.3^0 N 93 km
Peary 33.0^0 E 88.6^0 N 73 km
These craters are too close to the northern limb, hardly recognized except in very favorable libration.

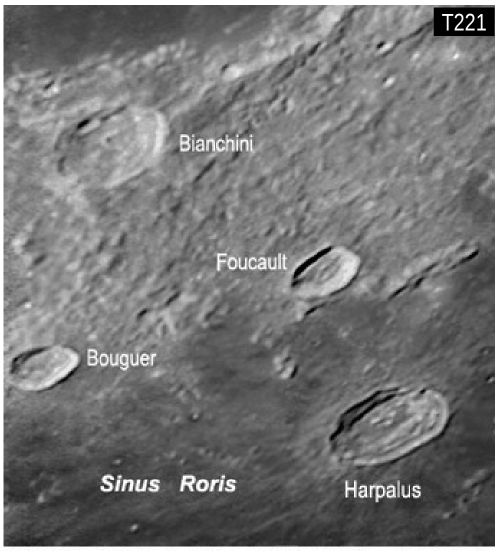
MAP 16

Mare Frigoris, Plato, Mons Pico, Anaxagoras, Goldschmidt

Hatfield 6
Rükl 4, 3, 2, 11



Mare Frigoris (Sea of Cold) 5° E 55° N
While lunar maria generally tend to be circular in shape, Mare Frigoris is not. It extends roughly 300 km north-south and 1,500 km east-west between Lacus Mortis and Sinus Roris, see Image T001 in Map 1. The formation of Mare Frigoris is not ascertained. Some geologists suggested that it could be part of the lava-filled depression that belongs to the outmost circumference of the gigantic Imbrium Impact; the other parts of depression including Mare Vaporum, Sinus Aestuum and perhaps, the eastern portion of Oceanus Procellarum. There is no conscpicuous features within Mare Frigoris except the on-edge crater Aristoteles.

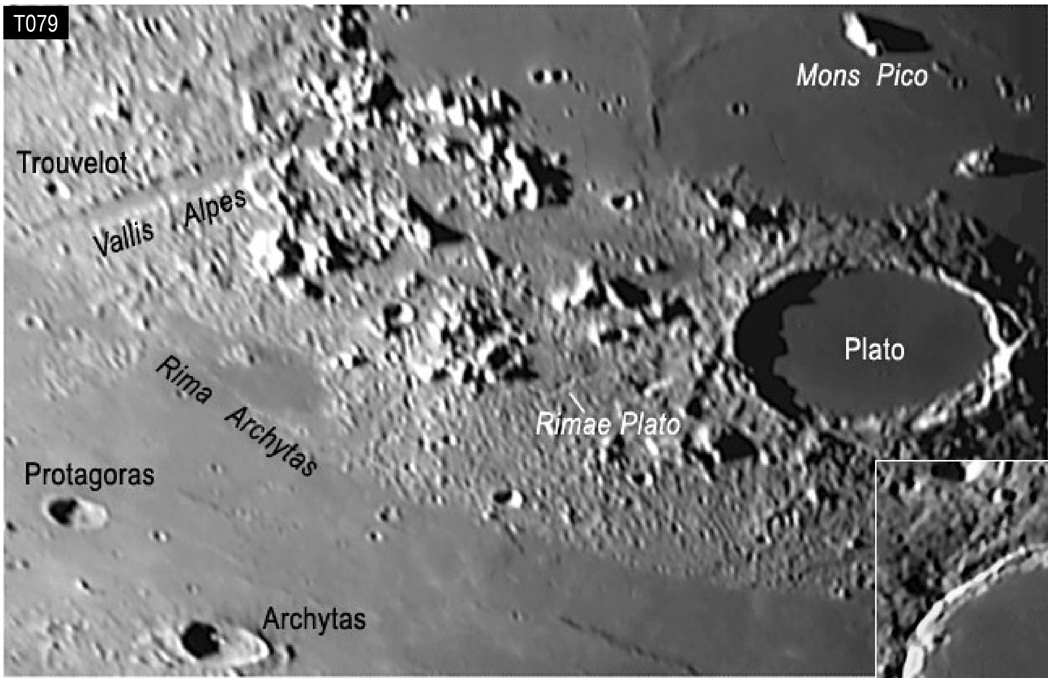


2005.05.22 15:02UT Age 14 days. 10-in f/8+5X+ToUcam (70% *resized*)

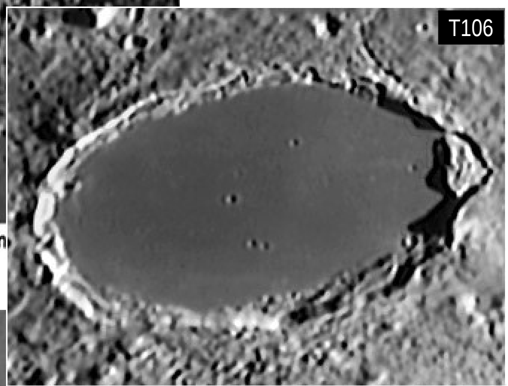
Sinus Roris (Bay of Dew) 50° W 51° N
A mare area linking Mare Frigoris and Oceanus Procellarum, length up to 350 km. ***Harpalus*** (diameter 39 km) is the only prominent crater within this sinus.

Plato 9.4^0 W 51.6^0 N

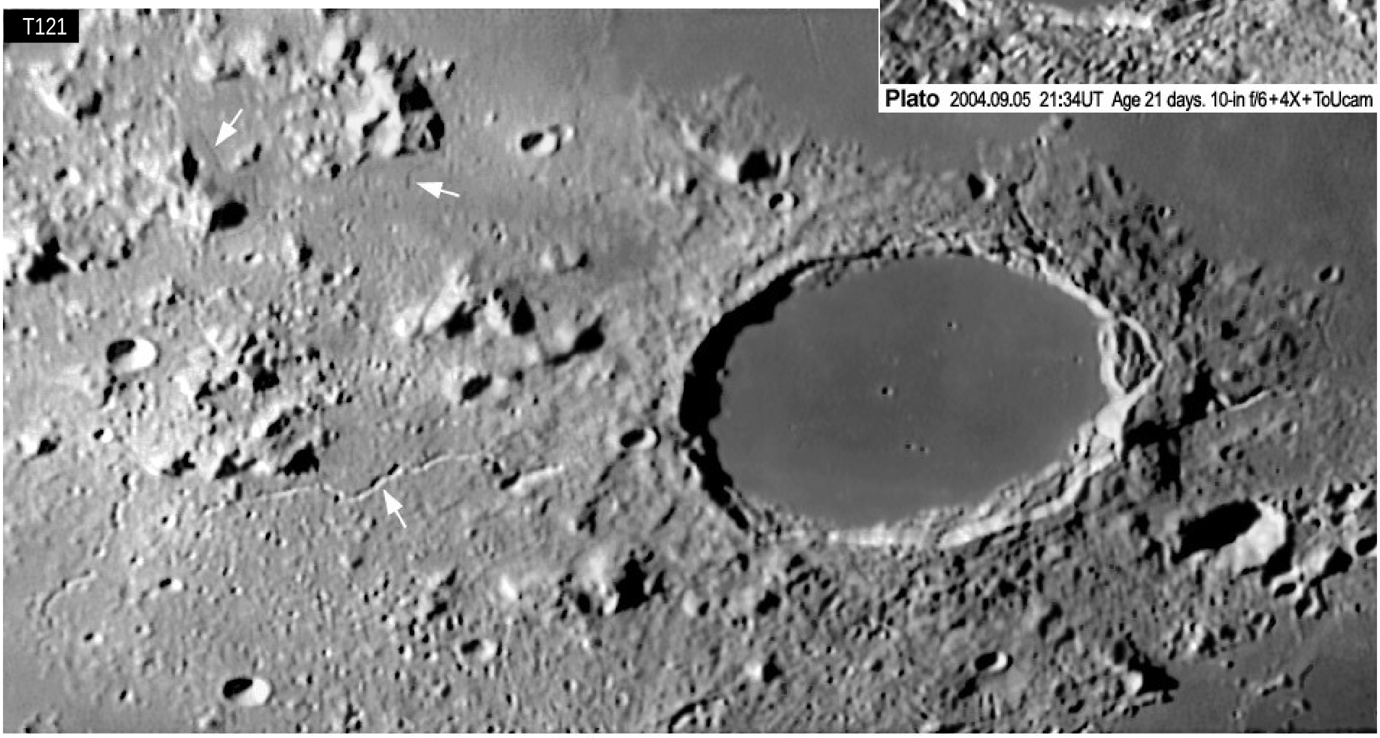
Plato is a walled plain, 109 km in diameter. The 17^{th} century Polish astronomer Hevelius called it "The Great Black Lake". It is one of the darkest surface features, even in the full moon. Its floor looks flat and blank, but tens of tiny craterlets are detectable using big telescopes under good seeing. At Moon age of about 9 days, the eastern walls of Plato cast spiky shadows on the floor. The western walls also cast similar shadows at Moon age of about 21 days. In T079, note the two triangular landslides on Plato's rim; similar landslides also exist in Aristoteles Map15 and Gassendi MAP 25. Note the oval ghost ring "***Ancient Newton***" just south of Plato. It was named by Schröter in 18th century while "***Newton***" refers to a crater towards the lunar south pole.



Plato and Vallis Alpes 2004.06.26 14:15 UT Age 9 days. 10-in f/6 Newtonian + 2.5X + ToUcam



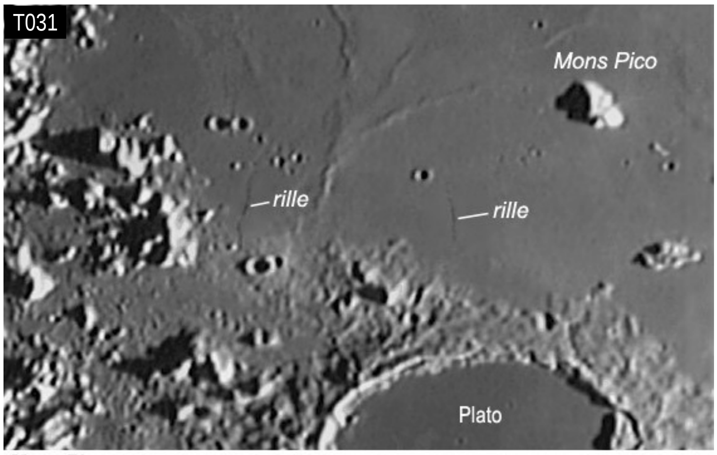
Plato 2004.09.05 21:34UT Age 21 days. 10-in f/6+4X+ToUcam



Plato and Rimae Plato (*arrows*) 2005.11.11 13:08~13:10 UT Moon Age 9.5 days. 10-inch f/6 Newtonian + 2.5X + 1.6X + ToUcam (*mosaic*)

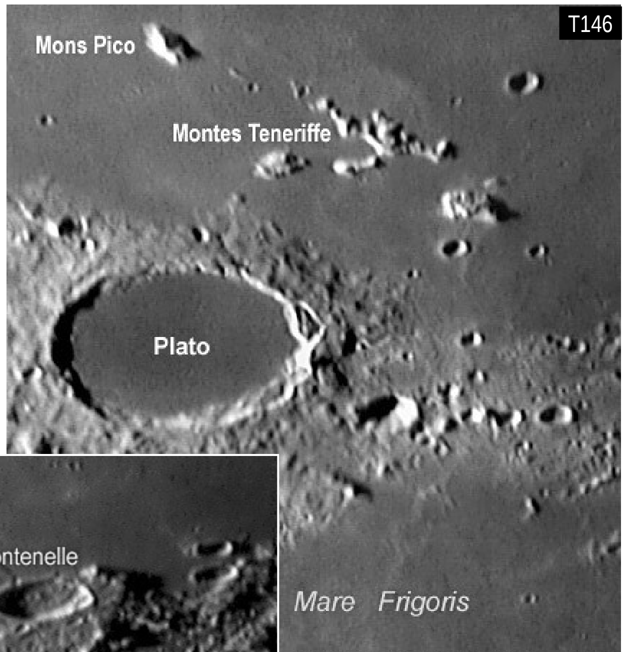
Rimae Plato 2^{0}W 51^{0}N *(Image T121)*
A system of rilles east of Plato. It contains three isolated sections as indicated by arrows in T121. The main section, which is nearest to Plato, is about 80 km long.

Mons Pico 9^{0}W 46^{0}N *(Image T031)*
An isolated mountain on the circumference of a ghost ring (once called *Ancient Newton* just south of Plato). The mountain measures 15 x 25 km, 2400 m high. It casts a long shadow under low-angle illumination. Note also the two short rilles marked in the image.



Mons Pico 2004.08.07 20:27 UT Age 22 days. 10-in f/6 Newtonian + 2.5X + ToUcam (150% resized)

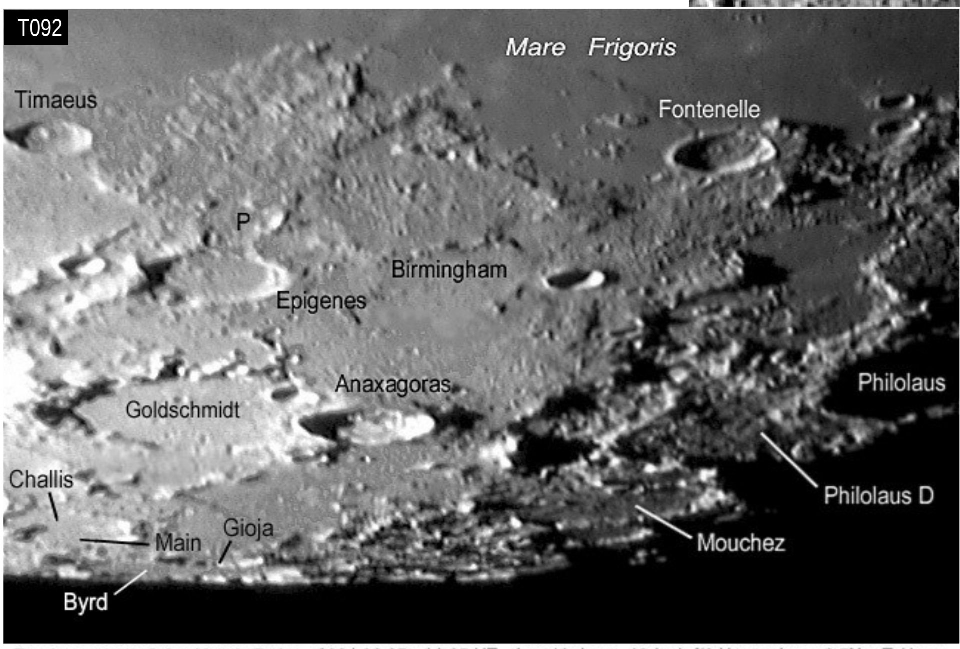
Montes Teneriffe 13^{0}W 48^{0}N *(Image T146)*
A group of isolated mountains close to Plato, with peaks up to 2400 m high. The whole group spreads about 110 km east-west.



2004.06.27 14:23 UT Age 10 days. (10-in)

(Image T092)

Birmingham 10.5^{0}W 65.1^{0}N
A heavily ruined crater, 92 km in diameter.



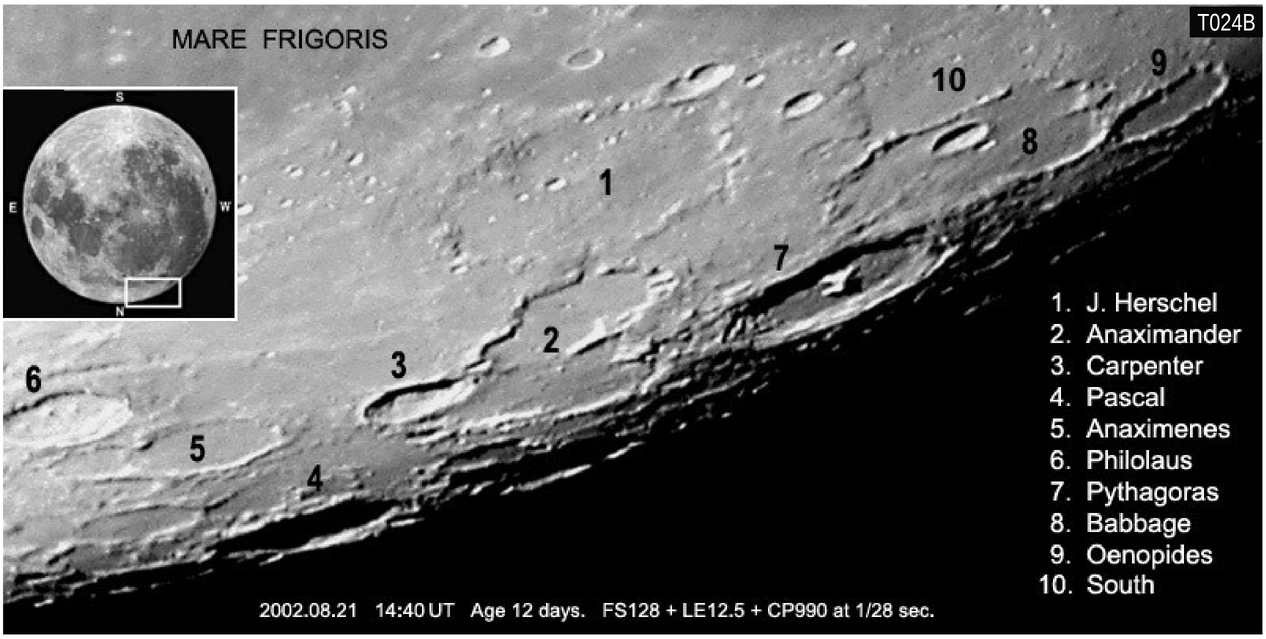
Region west of the North Pole 2004.06.27 14:25 UT Age 10 days. 10-inch f/6 Newtonian + 2.5X + ToUcam

Anaxagoras 10.1^{0}W 73.4^{0}N
A crater near the north limb, 50 km in diameter. It emits bright rays during the full moon.

Goldschmidt 3.8^{0}W 73.2^{0}N
A walled plain, 113 km in diameter. Its western wall is interrupted by Anaxagoras.

J. Herschel, Anaximander, Philolaus, Pythagoras

Hatfield 6
Rükl 3, 2, 1



J. Herschel 42.0^0 W 62.0^0 N
A disintegrated walled plain, 165 km in diameter.

Anaximander 51.3^0 W 66.9^0 N
A crater with broken wall, 67 km in diameter.
It joins almost with another crater ***Carpenter*** (59 km in diameter). Details in Image T157.

Pascal 70.3^0 W 74.6^0 N
A crater close to the limb, 115 km in diameter.

Anaximenes 44.5^0 W 72.5^0 N
A walled plain, 80 km in diameter.

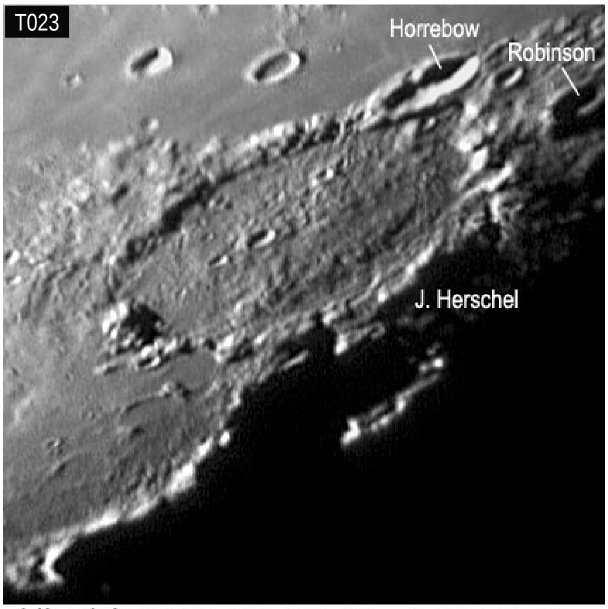
Philolaus 32.4^0 W 72.1^0 N
A crater with double central peaks, 70 km in diameter.

Pythagoras 63.0^0 W 63.5^0 N
A crater with central peaks, 142 km in diameter.

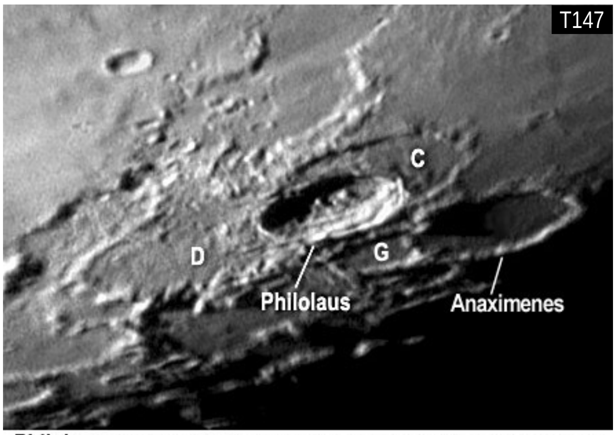
Babbage 57.1^0 W 59.7^0 N
A walled plain, 143 km in diameter. Its floor contains another crater, ***Babbage A*** (32 km).

Oenopides 64.1^0 W 58.0^0 N
A walled plain, 67 km in diameter.

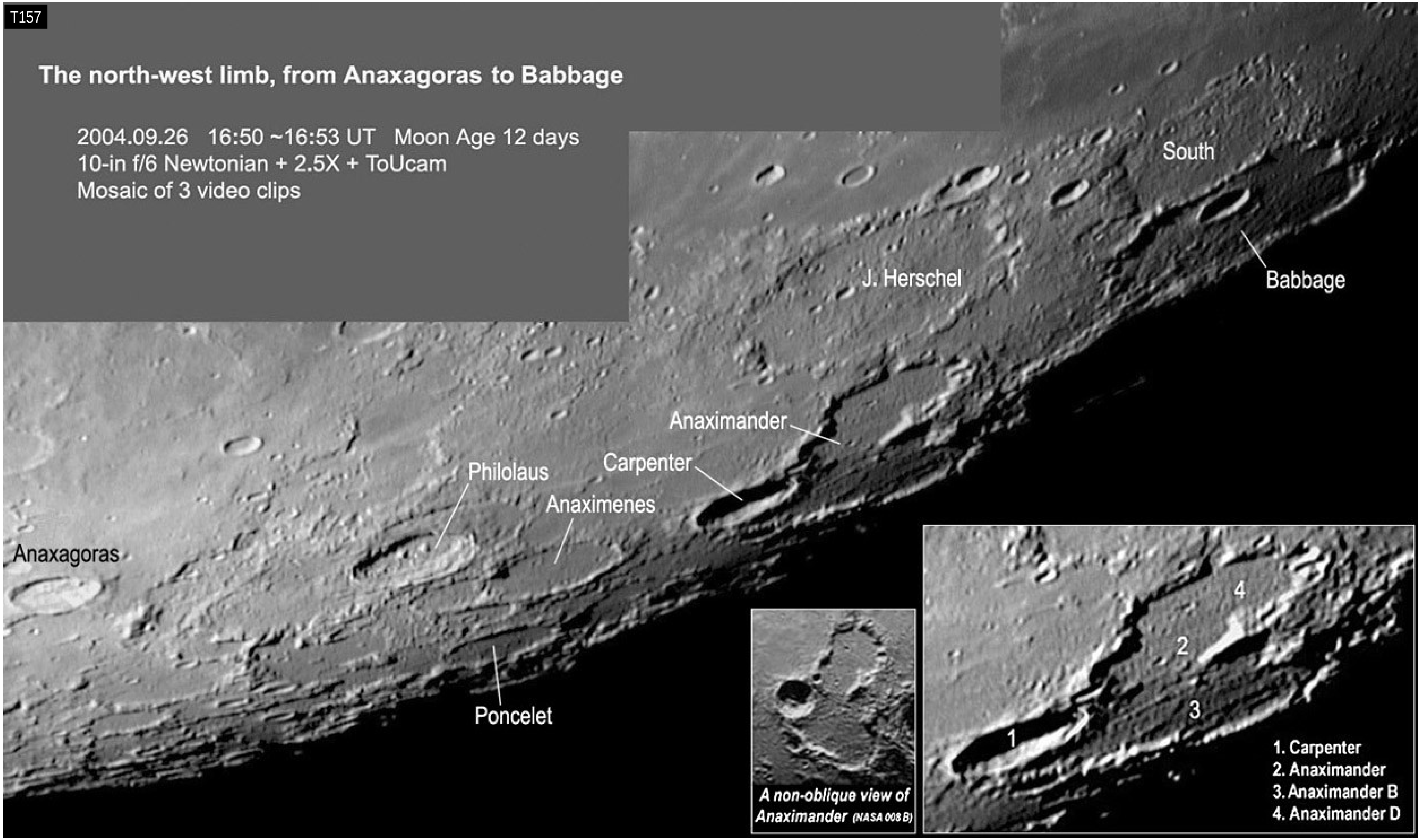
South 50.8^0 W 57.7^0 N
A disintegrated walled plain, 104 km in diameter.



J. Herschel 2004.09.25 14:10 UT Age 11 days. 10-in f/6 + 2.5X + ToUcam



Philolaus 2004.09.25 14:12 UT Age 11 days. 10-in f/6 + 2.5X + ToUcam

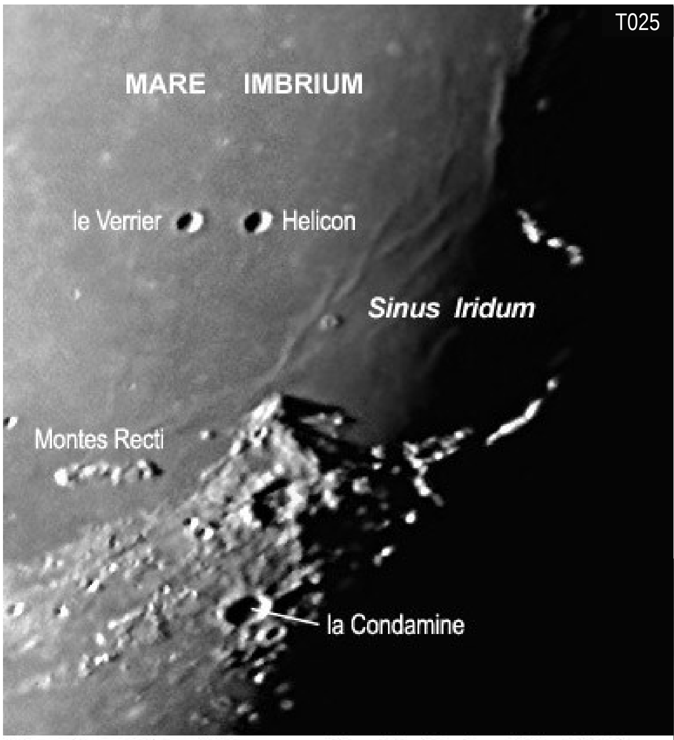

T157
The north-west limb, from Anaxagoras to Babbage
2004.09.26 16:50 ~16:53 UT Moon Age 12 days
10-in f/6 Newtonian + 2.5X + ToUcam
Mosaic of 3 video clips
South
J. Herschel
Babbage
Anaximander
Carpenter
Philolaus
Anaximenes
Anaxagoras
Poncelet
A non-oblique view of Anaximander (NASA 008 B)
1
2
3
4
1. Carpenter
2. Anaximander
3. Anaximander B
4. Anaximander D

MAP 17

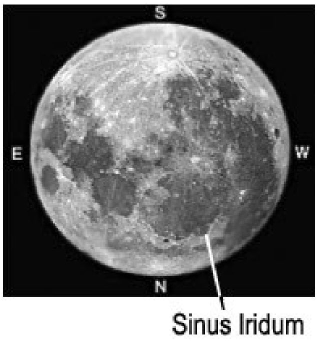
MAP 18

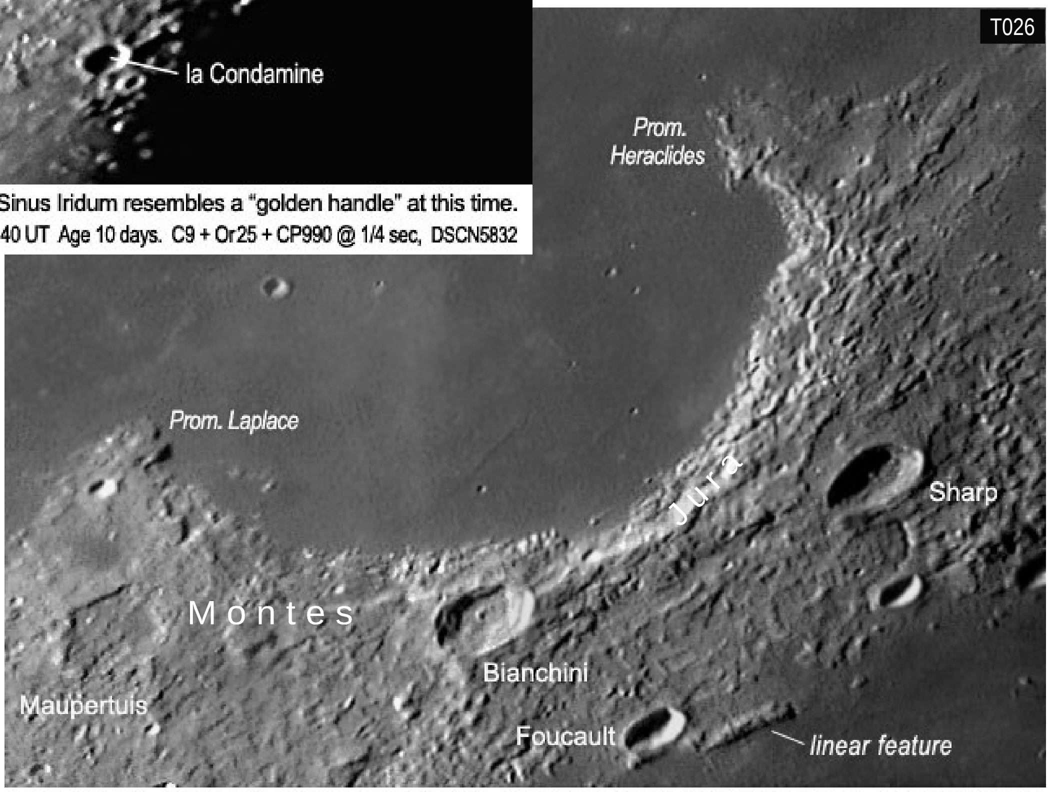
Sinus Iridum, Montes Recti, Bianchini, Sharp, Maupertuis

Hatfield 6
Rükl 10, 11, 20



The edge of Sinus Iridum resembles a "golden handle" at this time.
2002.12.14 16:40 UT Age 10 days. C9 + Or25 + CP990 @ 1/4 sec, DSCN5832

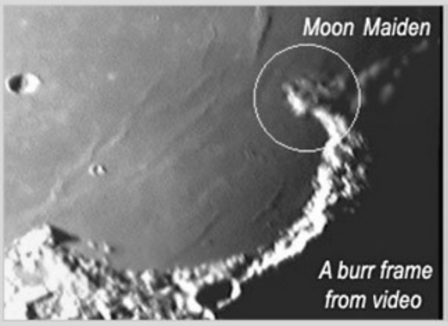


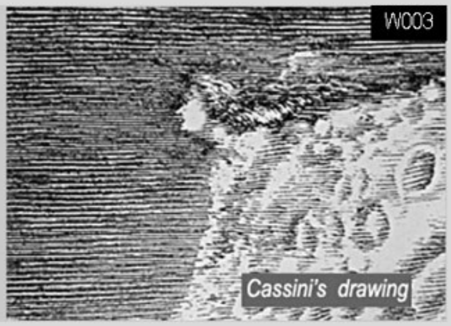


Sinus Iridum 2002.12.16 14:02UT Age 12 days. 10-in f/6 Royce mirror + 2.5X + ToUcam, 2 frames stacked.

Sinus Iridum (Bay of Rainbows) 32^0W 45^0N
Sinus Iridum is a distinct landmark on the north-western edge of Mare Imbrium (Sea of Rains). It measures 220 km between two capes named ***Promontorium Laplace*** and ***Promontorium Heraclides***. Its origin is believed a crater but large part of the walls is overwhelmed by Mare Imbrium. Under low Sun angle, the floor of Sinus Iridum is crossed by wrinkle ridges, and ***Montes Jura*** (the semicircular mountain range along the shore) resembles a "golden handle" of a teapot. In the 17^{th} century, the western cape of Sinus Iridum was nicknamed "The Moon Maiden" by the French astronomer Cassini.

The Moon Maiden When the Italian-born French astronomer Cassini observed Sinus Iridum in the 17th century, he depicted Promontorium Heraclides (circled) as the "Moon Maiden", complete with face and waving hair. Cassini's "Moon Maiden" is in fact an illusion and may not show up all the time. The trick to knowing it is to view it on a night when seeing is not that good; this exaggerates the illusion !

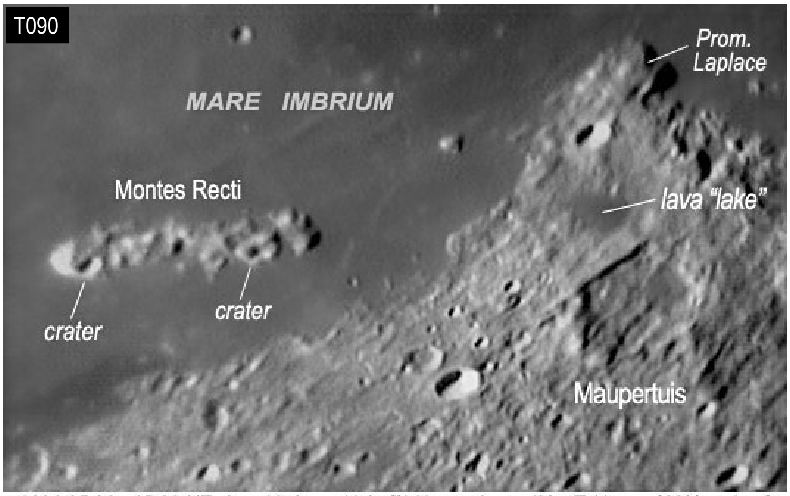




Bianchini 34.3^{0} W 48.7^{0} N **Sharp** 40.2^{0} W 45.7^{0} N
Crater Bianchini (38 km) and Sharp (39 km) resemble a pair of "eyes" guarding Sinus Iridum.

Maupertuis 27.3^{0} W 49.6^{0} N
A pentagon-shaped disintegrated crater close to Promontorium Laplace, 45 km across. A small lava "lake" is just in the south.

Montes Recti 20^{0} W 48^{0} N
A straight range of mountains close to Sinus Iridum, 20 x 90 km and up to 1800 m high. A small crater lies near the eastern and western end of this range respectively.



2006.05.09 15:03 UT Age 12 days. 10-in f/6 Newtonian + 4X + ToUcam (*80% resized*)

Image T065, next page:

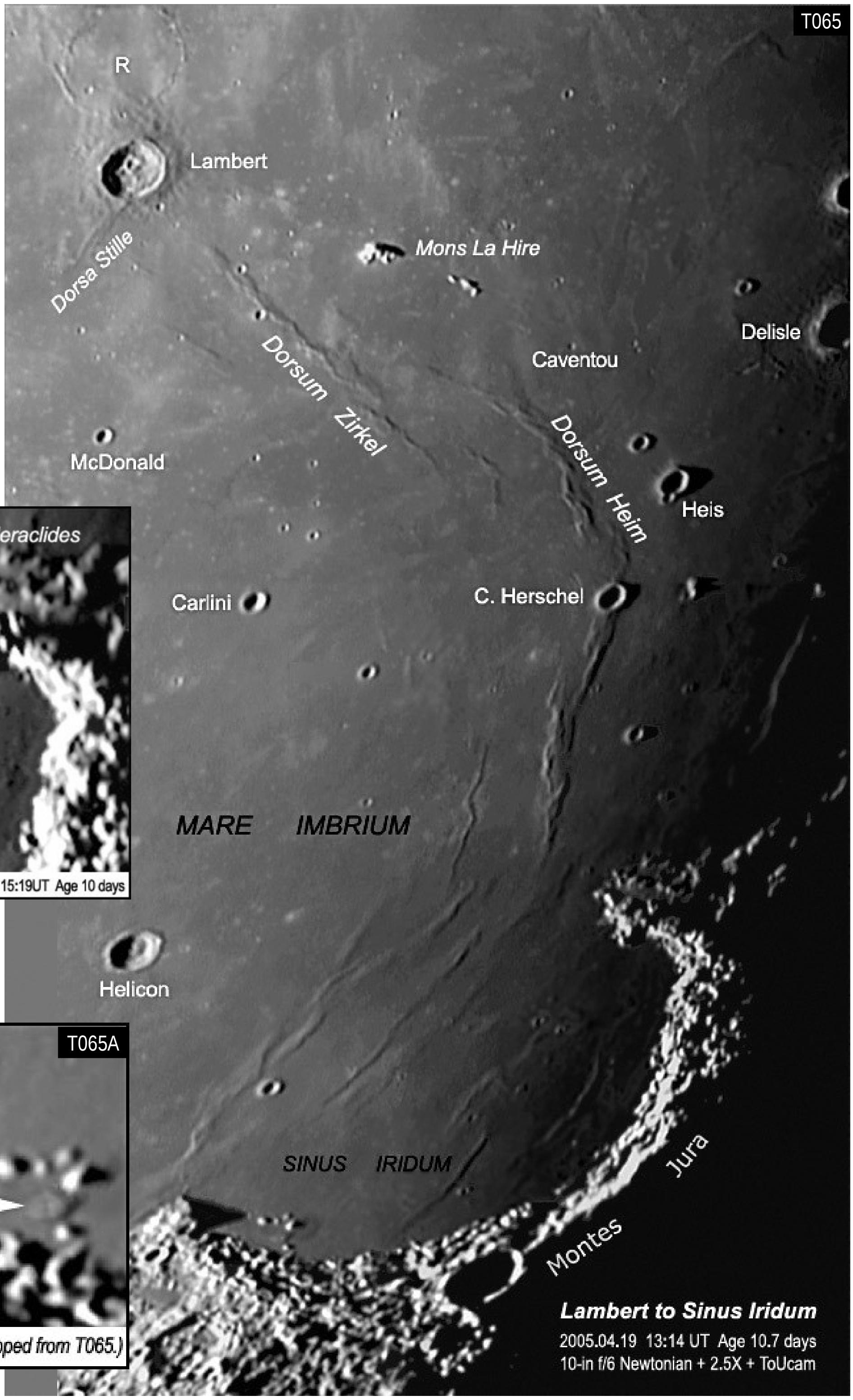
Lambert 21.0^{0} W 25.8^{0} N
A crater with terraced walls, 30 km in diameter. Its immediate south is the ghost crater ***Lambert R*** (55 km). See also Image T177 in Map 19.

C. Herschel 31.2^{0} W 34.5^{0} N
A 13-km crater named after Caroline Herschel, the sister of the German-born English astronomer William Herschel who discovered Uranus in 1781. She assisted her brother lifetime and was the first woman to discover a comet.

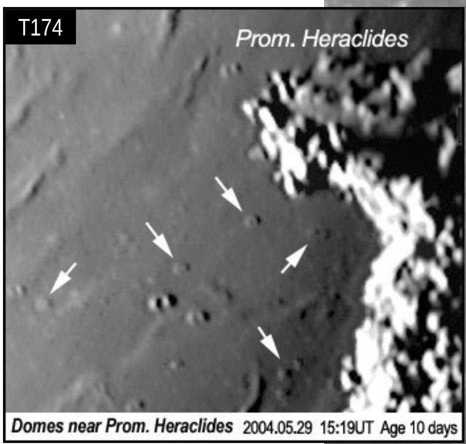
Mons La Hire 25^{0} W 28^{0} N
An isolated mountain, base 10 x 20 km, peak height 1500 m. Its view from the Apollo mission is given in Map 1.

Dorsum Zirkel 24^{0} W 29^{0} N **Dorsum Heim** 29^{0} W 31^{0} N
They are wrinkle ridges on the western side of Mare Imbrium. Dorsum Zirkel is 200 km long. Dorsum Heim is 140 km, followed by few more unnamed wrinkle ridges that extend northwards into Sinus Iridum.

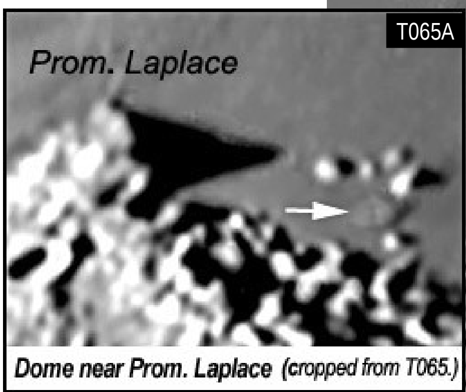
Sunrise over Sinus Iridum



Lambert to Sinus Iridum
2005.04.19 13:14 UT Age 10.7 days
10-in f/6 Newtonian + 2.5X + ToUcam



Domes near Prom. Heraclides 2004.05.29 15:19UT Age 10 days



Dome near Prom. Laplace (cropped from T065.)

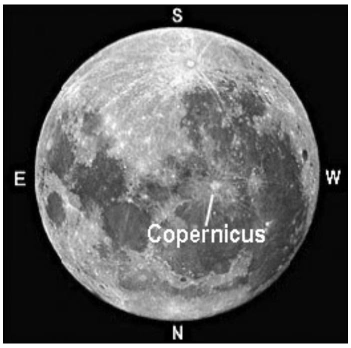
The wrinkle ridges on the floor of Sinus Iridum are particularly prominent when the terminator passes over them. To emphasize the profile of these ridges, Montes Jura (the mountain range under illumination) is inevitably over-exposed in Image T065. Sunlight comes from the east, suggesting that an observer on the shore of Sinus Iridum would experience sunrise at this time.

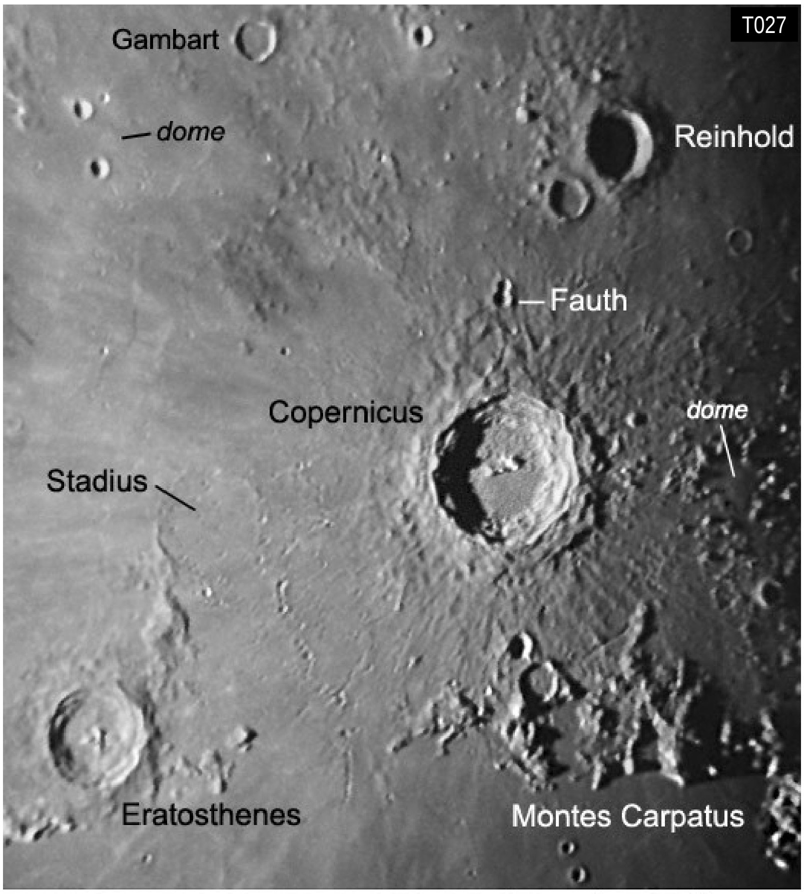
Helicon is a crater resembling a bowl, 24 km in diameter and 1900 m deep. The cape-like feature that casts triangular shadow is Promontorium Laplace. It rises 2600 m high and has an indistinctive dome in the west (T065A). Other domes exist near Promontorium Heraclides (T174), but they are noticeable only under very low illumination angles.

MAP 19

Hatfield 5
Rükl 32, 31, 30, 20, 19

Copernicus, Eratosthenes, Stadius, Montes Carpatus, Euler, Lambert, Hortensius, Milichius





2002.11.14 14:58UT Age 9 days. C9+LE12.5+CP990 1/7 sec DSCN5818

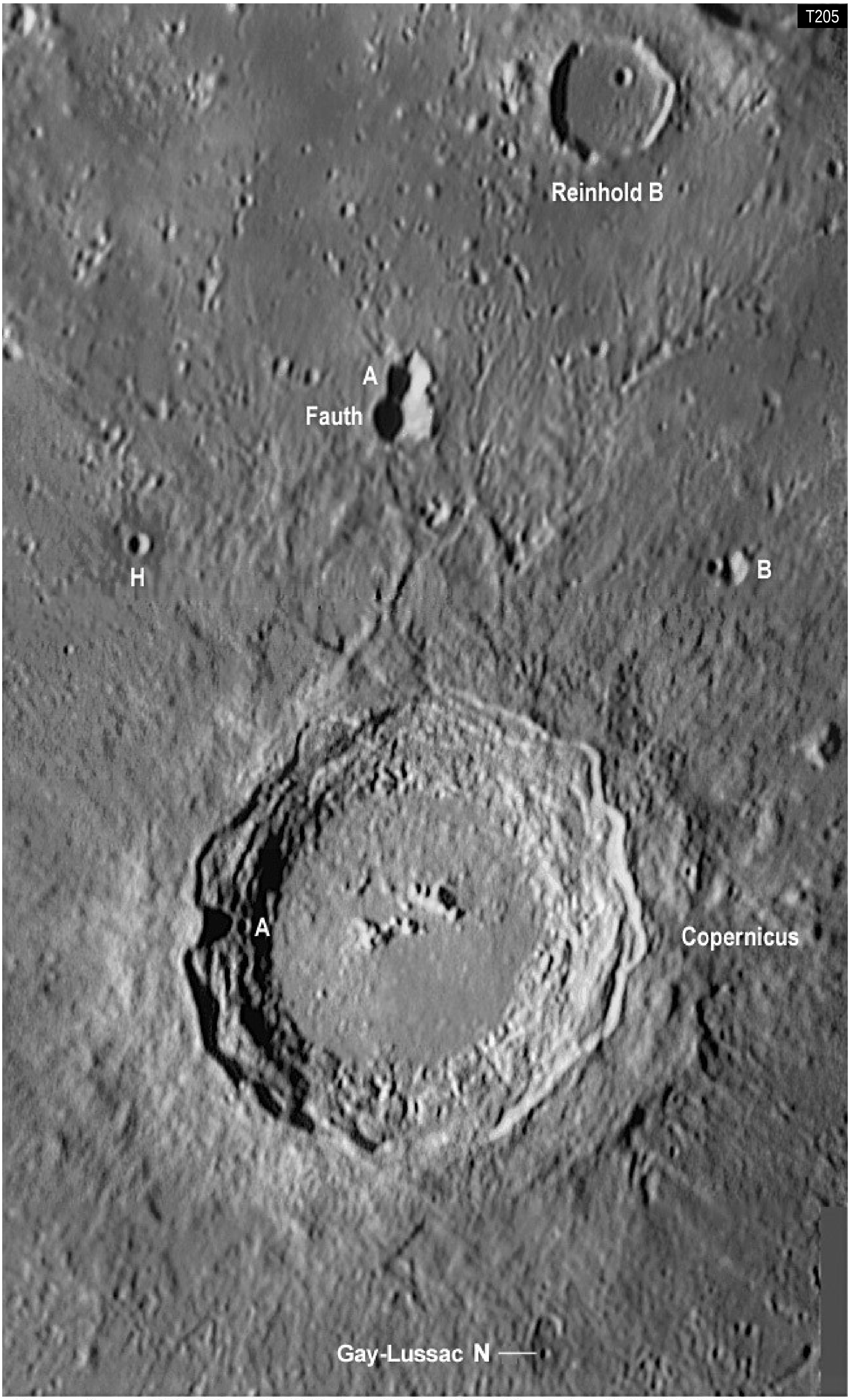
(Image T027)

Copernicus 20.1^{0}W 9.7^{0}N
Copernicus is a fine example of a young ring mountain, formed about 0.8 billion years ago. It is in Mare Insularum (Sea of Isles), 93 km in diameter, with a group of central peaks and terraced walls 3700 m above the floor. The depth-diameter ratio of Copernicus is 1:25; this makes the crater to resemble a pie pan rather than a bowl. Copernicus is rich in obersevation details. At Moon age of 9 ~10 days when Copernicus is not fully illuminated, a dome is barely visible about one diameter west of the crater. Numerous secondary craterlets and pits also spread like raisin holes in the north-east vicinity. Extensive bright rays emit from the crater at days close to the full moon.

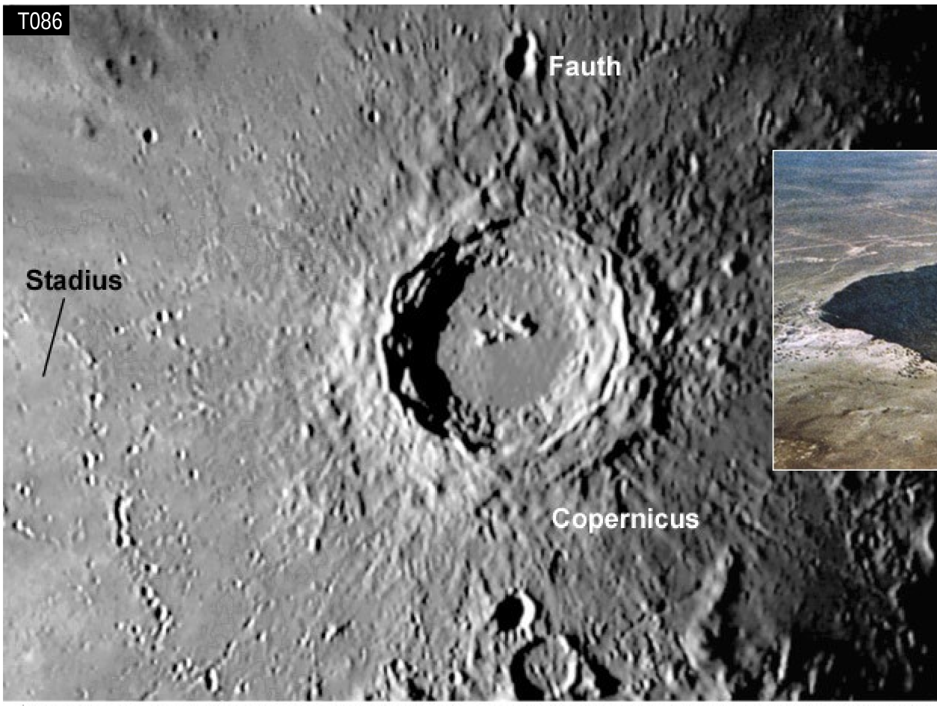
The number of central peaks in Copernicus is a challenge to observation. Three peaks of height up to 1200 m are obvious in small telescopes. Large telescopes may spot additional small “bumps”. Images from spacecraft, however, reveal even more peaks. The terraced walls look somewhat hexagonal. The radial scars around the outer walls are the ejecta blanket resulted from an asteroid-like impact. The two small overlapping craters in the south of Copernicus are ***Fauth*** (12 km) and ***Fauth A*** (10 km); they are good indicators to align an image’s north-south orientation.

(Image T205, next page)

Outside the rim of Copernicus are two small craters surrounded by dark halo --- ***Copernicus H***, diameter 5 km and ***Gay-Lussac N***, diameter 2 km. Presumably these craters formed from secondary impact, the dark halo could be the deposits of mare basalt excavated from the impact site. The impact is supposed not too energetic, so only the top-most layer of dark basalt was excavated but the deeper underground of light-colored anorthosite remained unhurt.

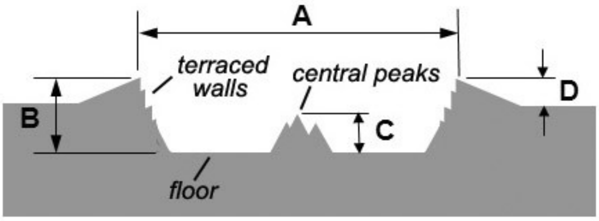


Copernicus 2005.04.19 ~12:39 UT Age 10.7 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam (*mosaic*)



↑ *Compare Copernicus with this "baby-sized" impact crater in Arizona, USA. The latter is 1.2 km in diameter, 170 m in depth. It formed from a ~ 50 m meteor impact 50,000 years ago.*

Copernicus 2004.06.27 13:16 UT Age 10 days. 10-in f/6 Newtonian + 2.5X + ToUcam, Frame No. 50.



Cross-section of Copernicus

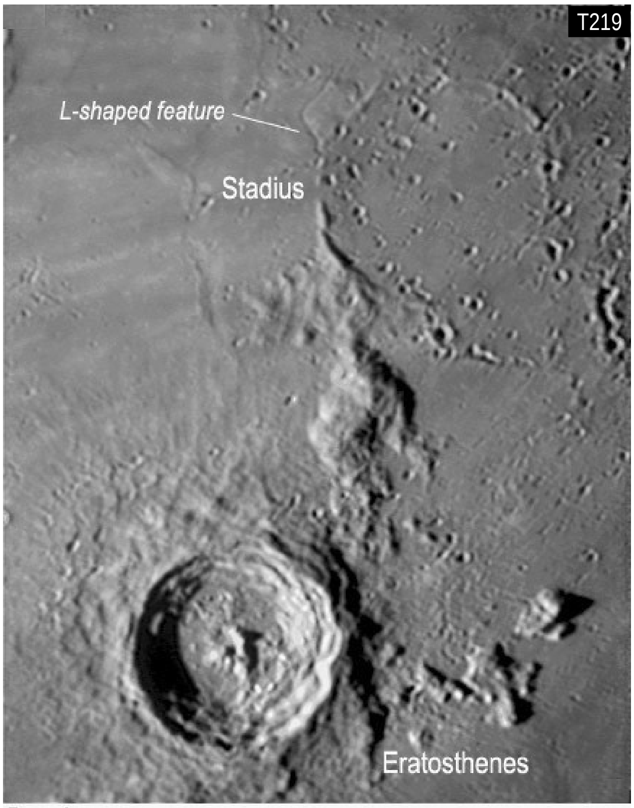
Diameter **A** *= 93 km* *Depth of floor* **B** *= 3700 m*
Height of central peaks **C** *= 1200 m*
Wall height **D** *= 1400 m*

Small impact craters (less than about 15 km in diameter) do not have central peaks. They tend to have simple bowl-shaped forms whereas in larger craters, slumping of material off the inner walls helps to flatten the crater floor.

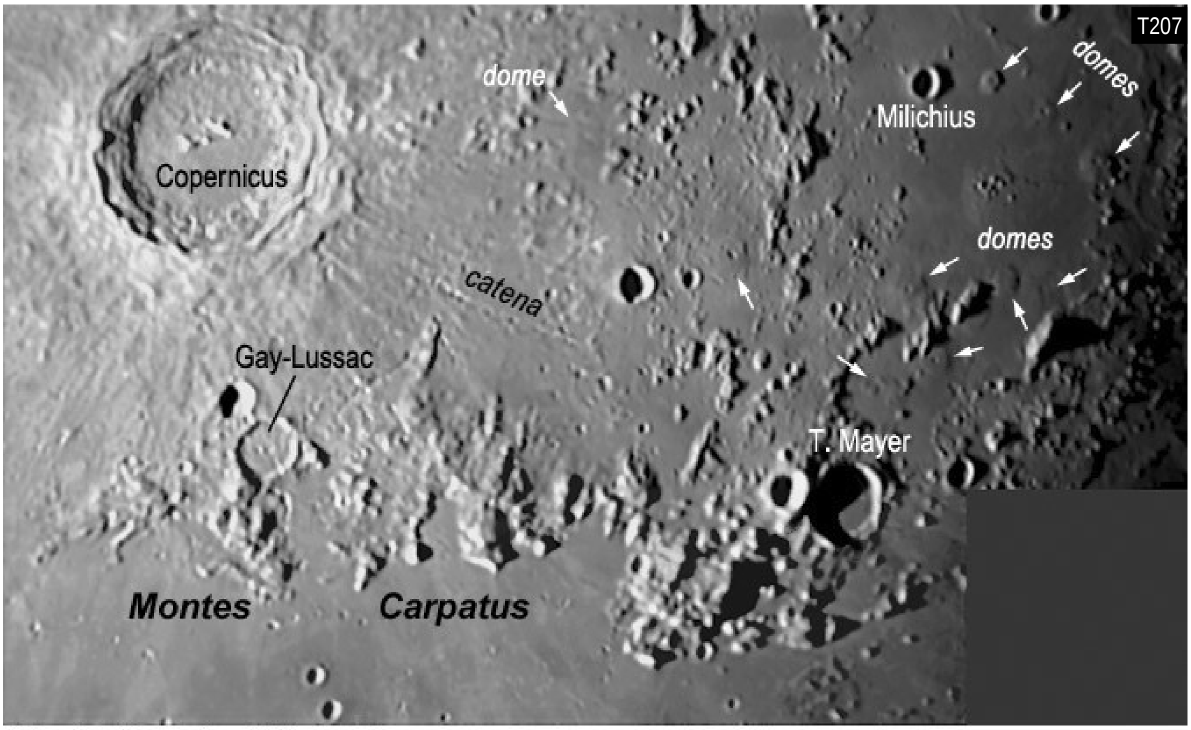
Image T219:

Eratosthenes 11.3° W 14.5° N
A prominent crater between the south end of Montes Apenninus and the east of Copernicus, 58 km in diameter and 3600 m deep. It has a sharp rim, terraced walls and three central peaks. Eratosthenes changes in appearance during a lunation. At full moon it almost disappears. The lack of bright rays around this crater suggests that the rays were washed out by aging, so Eratosthenes must be older than Copernicus. The adjacent land relief is interesting; it resembles an elephant with an upward swirling nose.

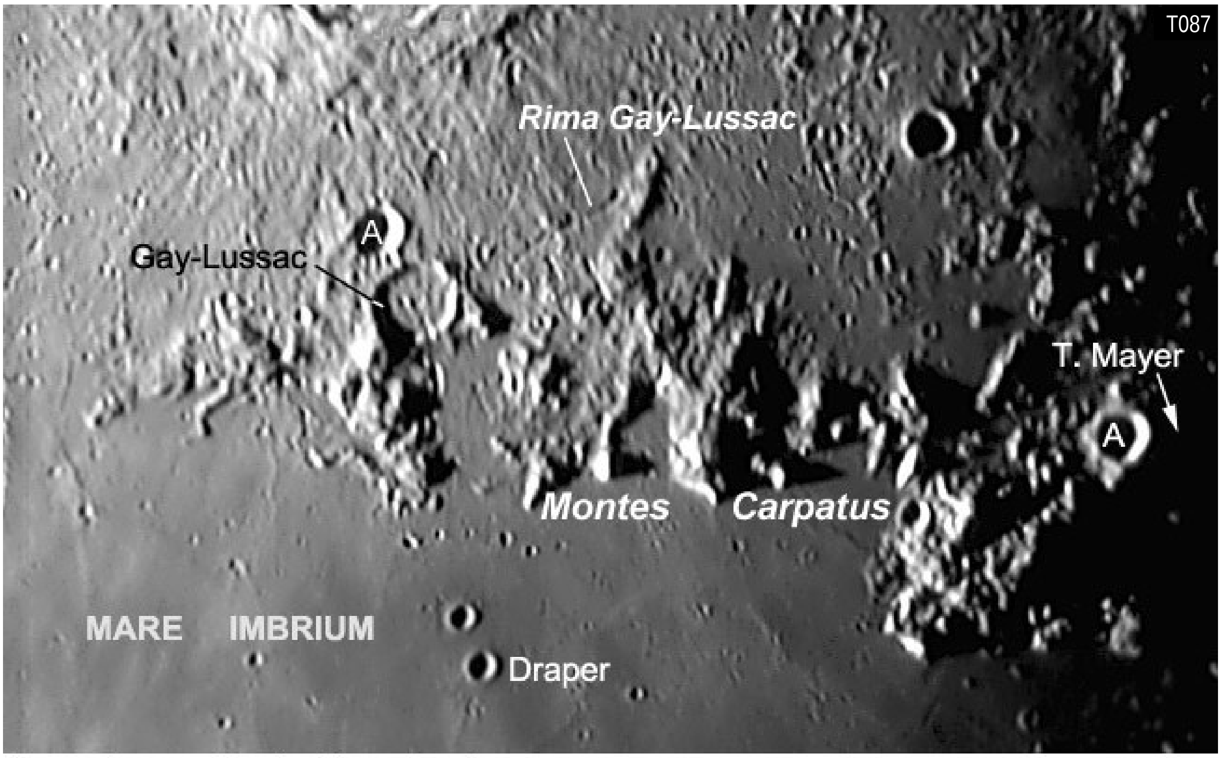
Stadius 13.7° W 10.5° N
A ghost depression with incomplete low walls, 69 km in diameter. It is peppered with many secondary craterlets and pits, A L-shaped feature (catena?) extends from the southeast rim. The height of the northeast wall is 650 m.



Eratosthenes 2005.04.18 11:53UT Age 9.8 days. 10-in f/6 + 4X + ToUcam, 85% resized.

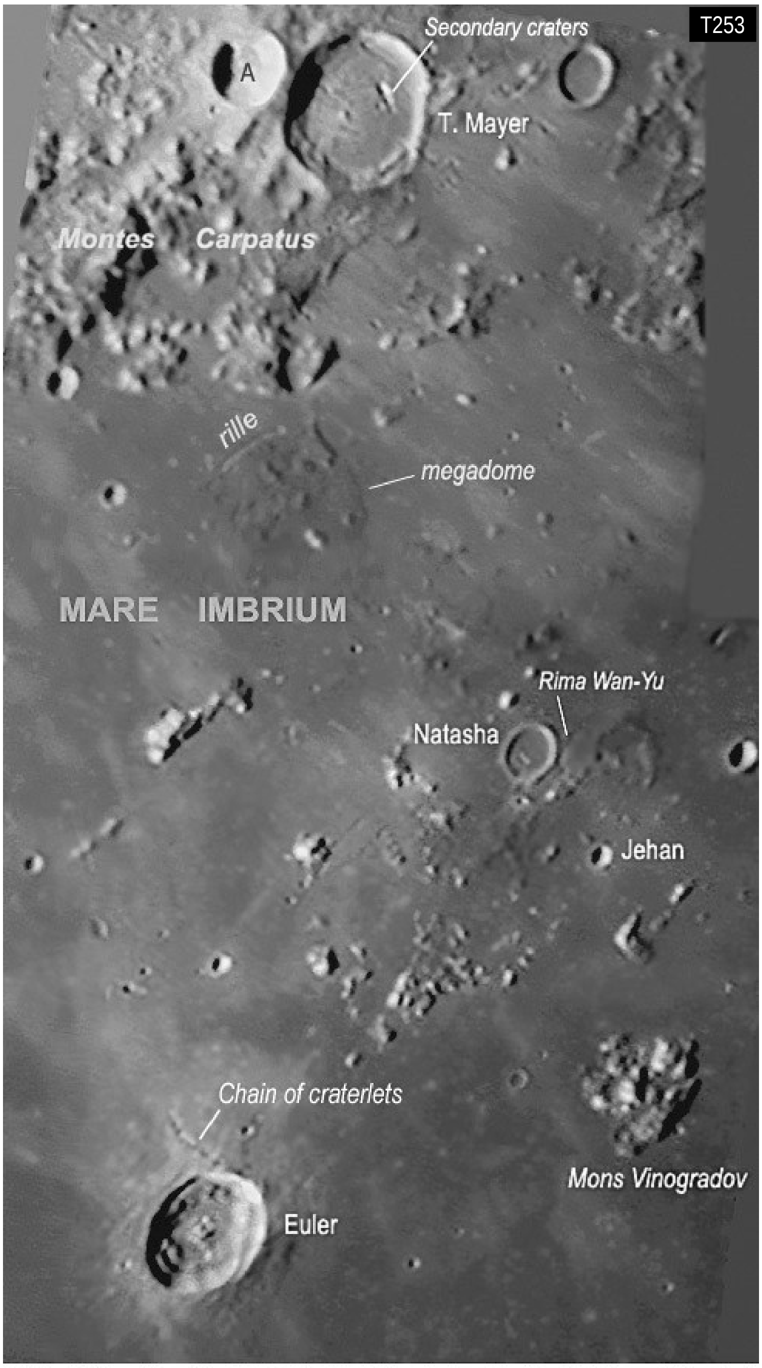


Montes Carpatus & Copernicus 2005.04.19 13:40 UT Age 10.7 days. 10-in f/6 Newtonian + 2.5X + ToUcam

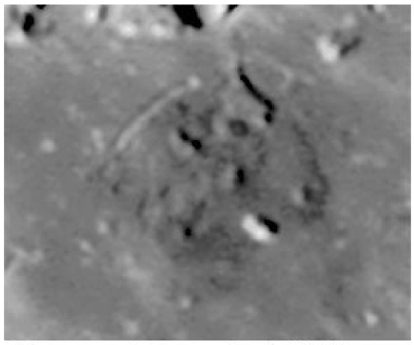


Montes Carpatus (north of Copernicus) 2004.06.27 13:47 UT Age 10 days. 10-in f/6 Newtonian + 2.5X + ToUcam, 11 frames.

Montes Carpatus 25^0 W 15^0 N
A mountain range, length 400 km, height 2300 m. It is one of the montes that form the rising rim of Mare Imbrium. It holds crater ***T. Mayer*** (diameter 33 km), ***Gay-Lussac*** (26 km), and one rille (***Rima Gay-Lussac***, length 40 km) that runs across the ejecta blanket of Copernicus. Short chains of craterlets and a megadome (low elevated plateau) can be spotted in the northern vicinity, see also T253 in next page.

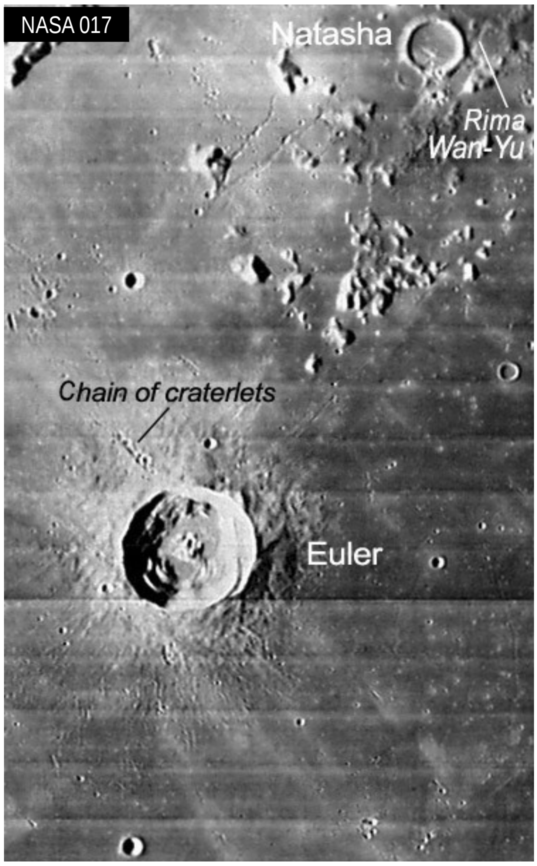


Euler & Rima Wan-Yu 2006.05.09 13:37 UT Age 12 days. 10-in f/6 + 5X + ToUcam (88% resized)



The ***megadome*** north of of T. Mayer

(*Enlargement from T253*)



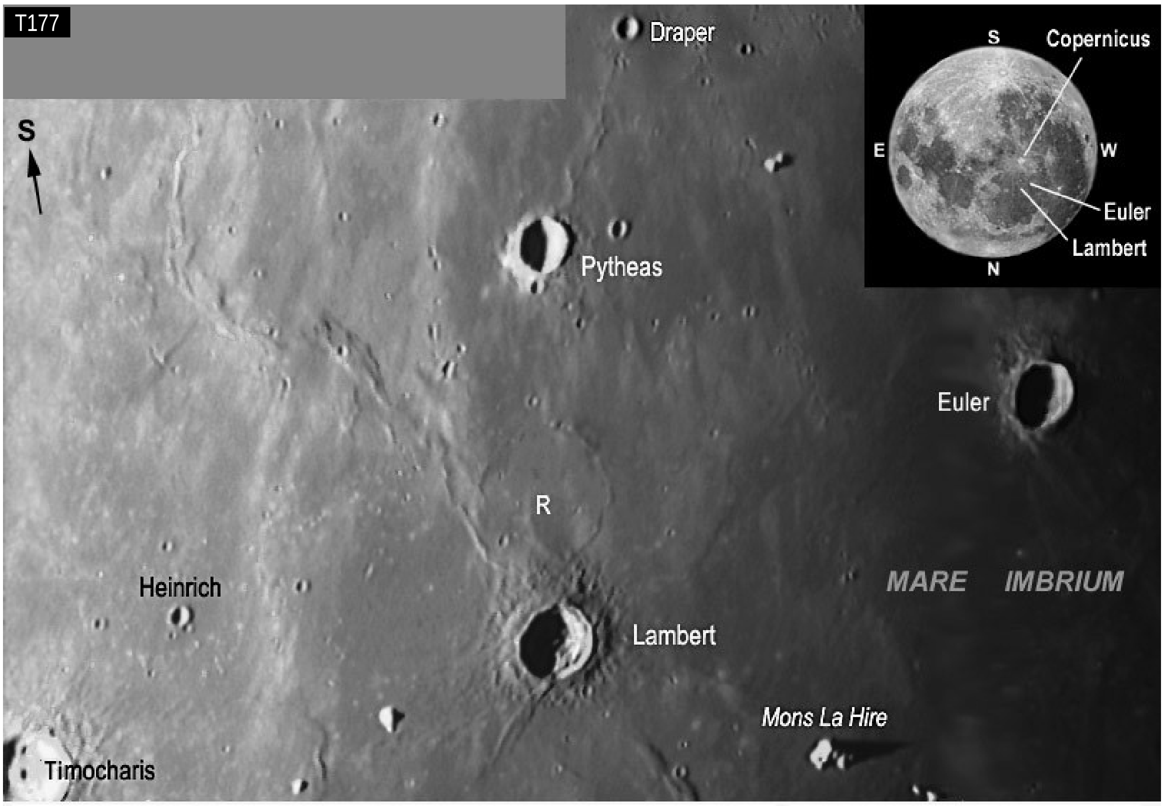
(Lunar Orbiter image)

Image T253:

Euler 29.2^{0} W 23.3^{0} N
A crater with central peak, 27 km in diameter. A short catena (chain of craterlets) is in the immediate south.

Mons Vinogradov 43.4^{0} W 22.4^{0} N
An irregular mountain, base width 25 km.

Natasha 31.3^{0} W 20.0^{0} N
A crater, 12 km in diameter. ***Rima Wan-Yu*** (31.5^{0} W 20.0^{0} N, length 12 km) is an elusive rille very close to the west rim of Natasha.



Lambert and wrinkle ridges 2005.11.11 ~11:49 UT Moon Age 9.5 days. 10-inch f/6 Newtonian + 2.5X + ToUcam

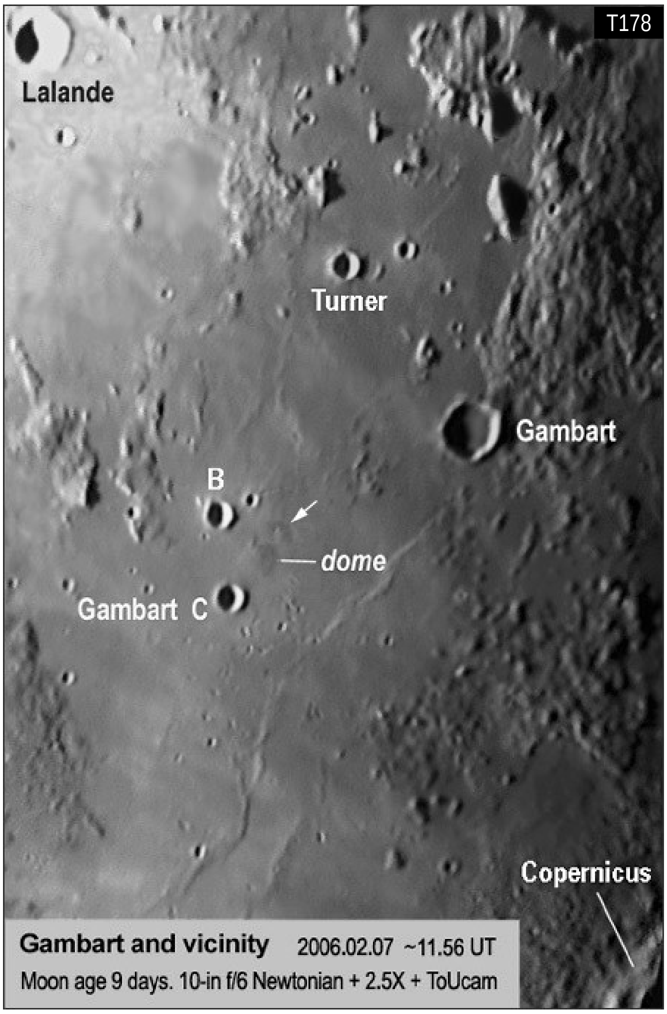
Lambert 21.0^0 W 25.8^0 N *(Image T177)*
A terraced crater, 30 km in diameter. It adjoins the ghost crater ***Lambert R*** (55 km) which is almost buried beneath the mare floor. In the southeast of Lambert is a nameless network of wrinkle ridges. See also Map 18.

Pytheas 20.6^0 W 20.5^0 N
A crater with sharp rim, 20 km in diameter.

Gambart 15.2^0 W 1.0^0 N (*Image T178)*
A ring-shaped flooded crater, 25 km in diameter. In the south of Gambart are two opposing spiky mountains that cast triangular shadows. A dome (~10 km) is located close to ***Gambart C***. The arrow points to another skeptical dome.

Turner 13.2^0 W 1.4^0 N
A crater, 11 km in diameter, 2600 m deep.

Lalande 8.6^0 W 4.4^0 S
A bright rayed crater under high illumination, 24 km in diameter. See also Map 12.



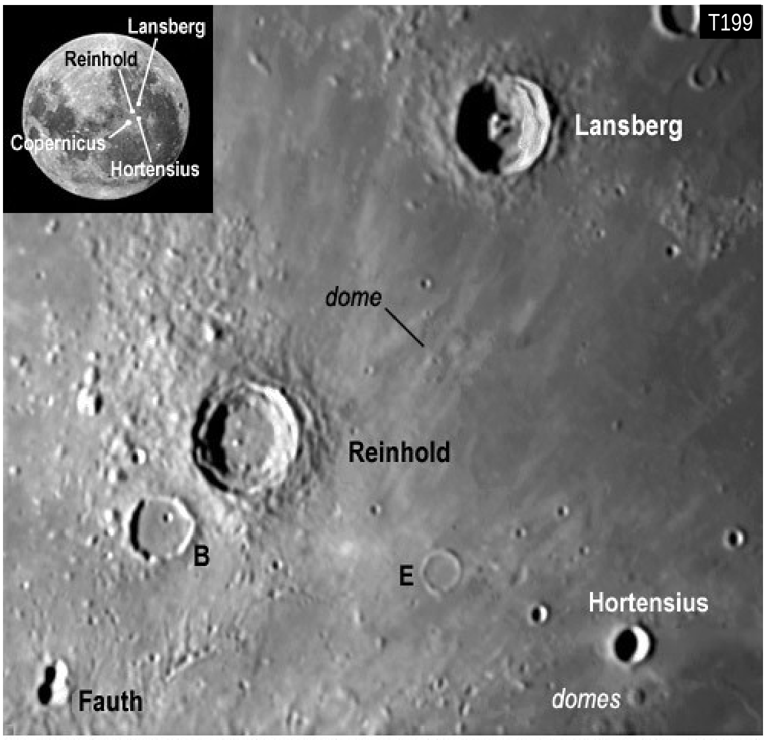
Gambart and vicinity 2006.02.07 ~11.56 UT
Moon age 9 days. 10-in f/6 Newtonian + 2.5X + ToUcam

Image T199:

Lansberg 26.6⁰ W 0.3⁰ S
A crater with terraced walls and multiple central peaks, 38 km in diameter.

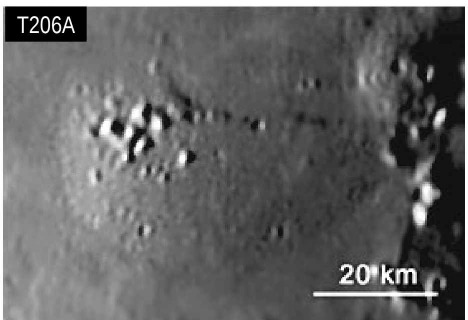
Reinhold 22.8⁰ W 3.3⁰ N
A terraced crater with a small central peak, 42 km in diameter. Between this crater and Lansberg is a volcanic dome which has a summit pit.

Reinhold B 21.7⁰ W 4.3⁰ N
A flood crater with a conspicuous craterlet on the floor, 26 km in diameter. Although it is close to Reinhold, its interior is completely different from Reinhold. See also T205, previous page.

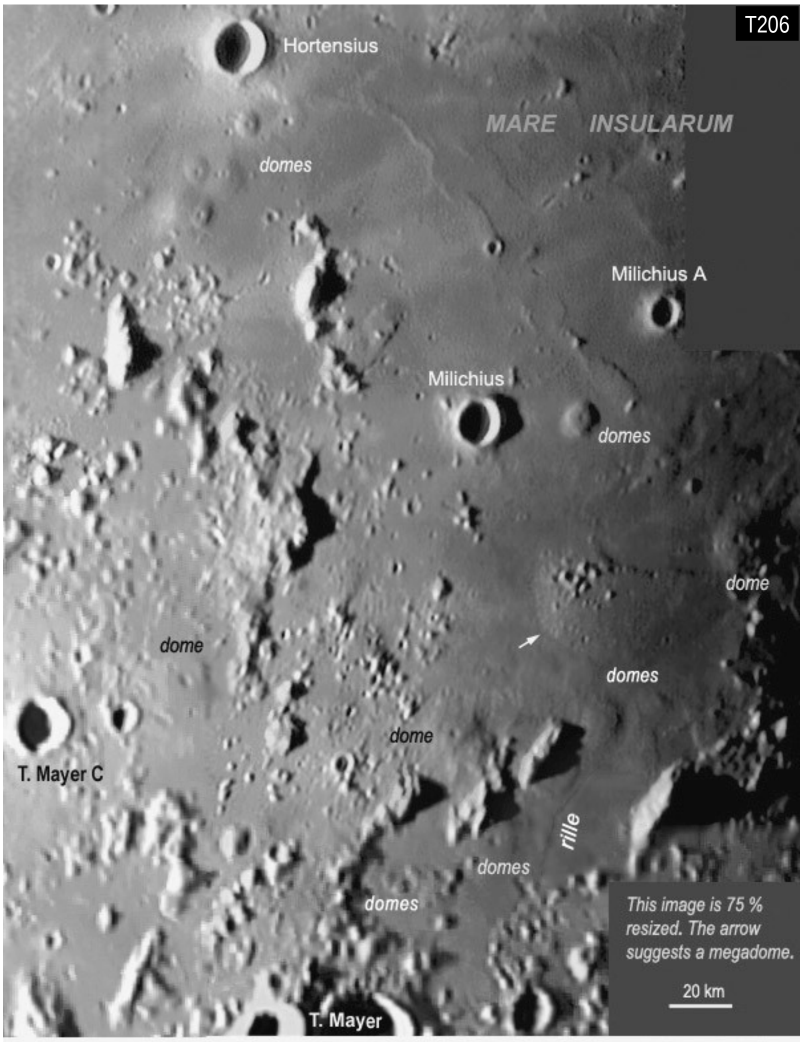


Reinhold & Lansberg 2005.04.19 13:36 UT Age 11 days. 10-in f/6 Newtonian + 2.5X + ToUcam

Hortensius 28.0⁰ W 6.5⁰ N
Milichius 30.2⁰ W 10.0⁰ N
In T206, Copernicus is beyond the left edge of the frame. Hortensius (dia. 14 km) and Milichius (12 km) are well-known for the clusters of volcanic domes in their vicinity. These domes range from about 5 to 15 km in diameter and are few hundred meters high. They are visible only under very low Sun angles. The summits of some domes have single or even double pits. Six domes are clustered at the immediate north of Hortensius, and at least 10 domes spread in the region between Milichius and T. Mayer. Note also the nameless rille and the "megadome" marked in T206.



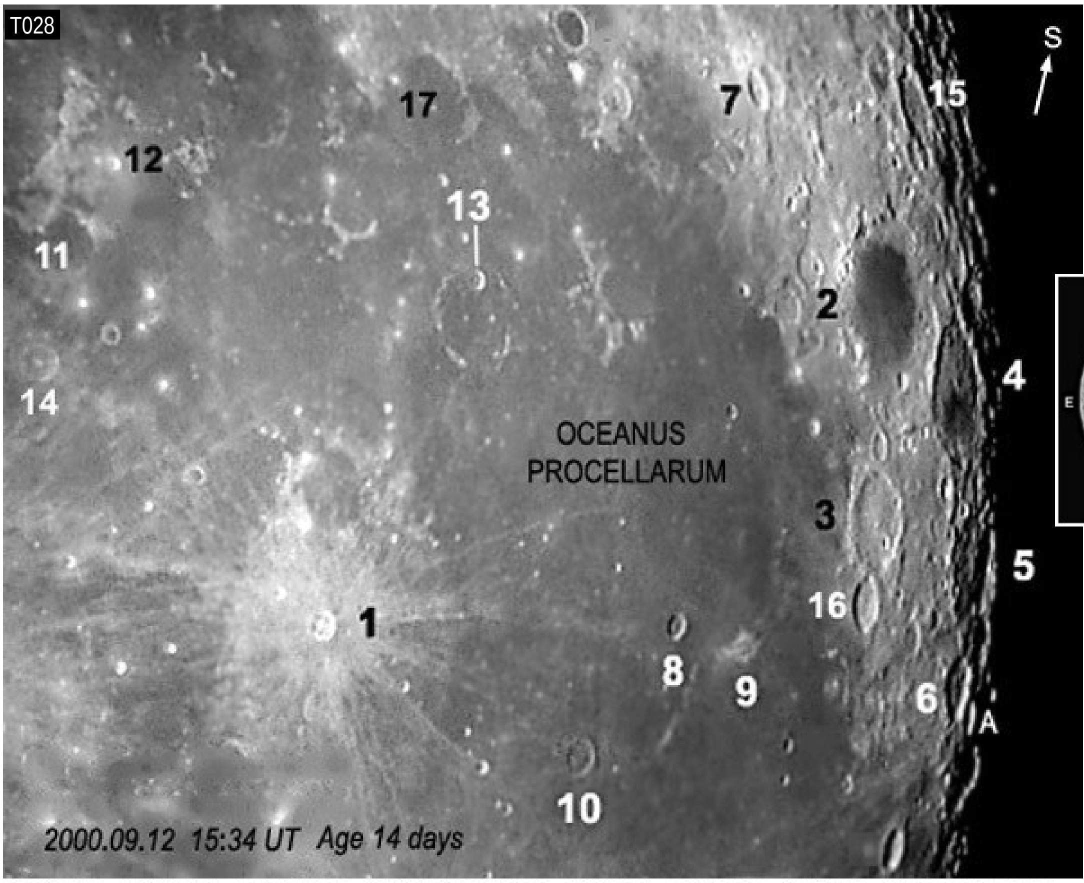
The "megadome" (dome-shaped plateau)

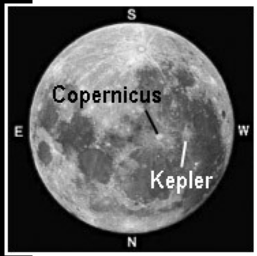


Domes near Hortensius & Milichius 2005.04.19 ~12:35 UT Age 10.7 days. 10-in f/6 + 5X + ToUcam (*mosaic*).

Oceanus Procellarum (Kepler, Marius, Montes Riphaeus, Flamsteed, Letronne, Reiner Gamma)

Hatfield 7, 11
Rükl 30, 29, 28, 40, 41, 42



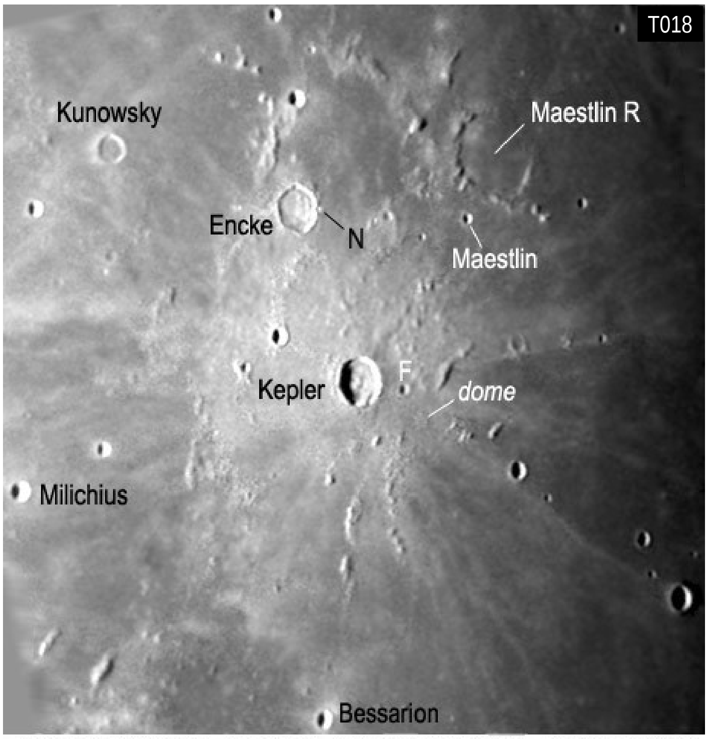


1. Kepler 2. Grimaldi 3. Hevelius 4. Riccioli 5. Hedin 6. Olbers 7. Sirsalis 8. Reiner 9. Reiner Gamma
10. Marius 11. Montes Riphaeus 12. Euclides 13. Flamsteed 14. Lansberg 15. Rocca 16. Cavalerius 17. Letronne

Kepler 38.0° W 8.1° N
A crater with uneven floor, 31 km in diameter. It is also a center of prominent bright rays. An inconspicuous dome is in the northwest of Kepler.

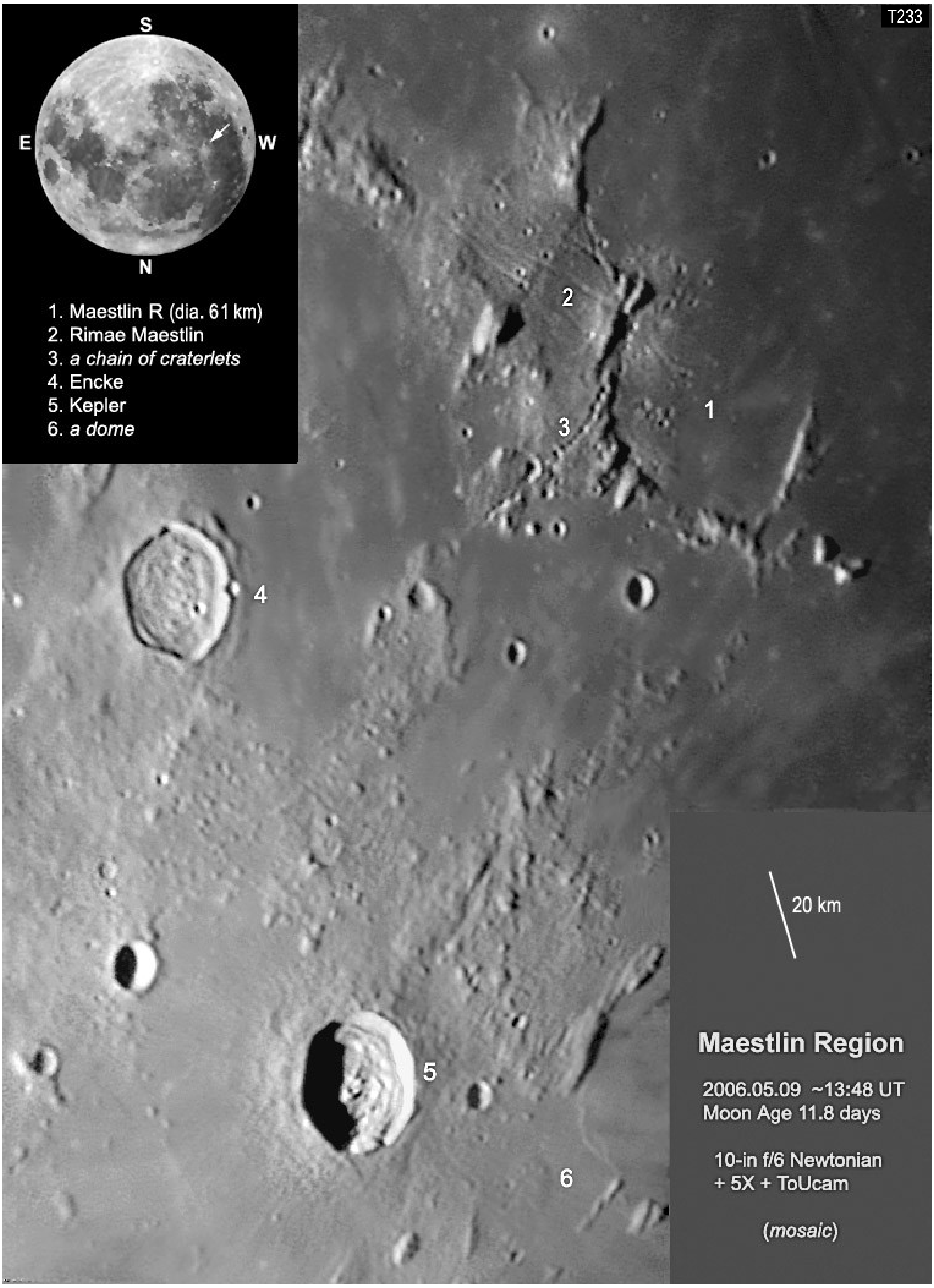
Encke 36.6° W 4.6° N
A crater with uneven floor, 28 km in diameter. Its rim is interrupted by craterlet ***Encke N***. During the full moon, Encke is overwhelmed by the bright rays from Kepler.

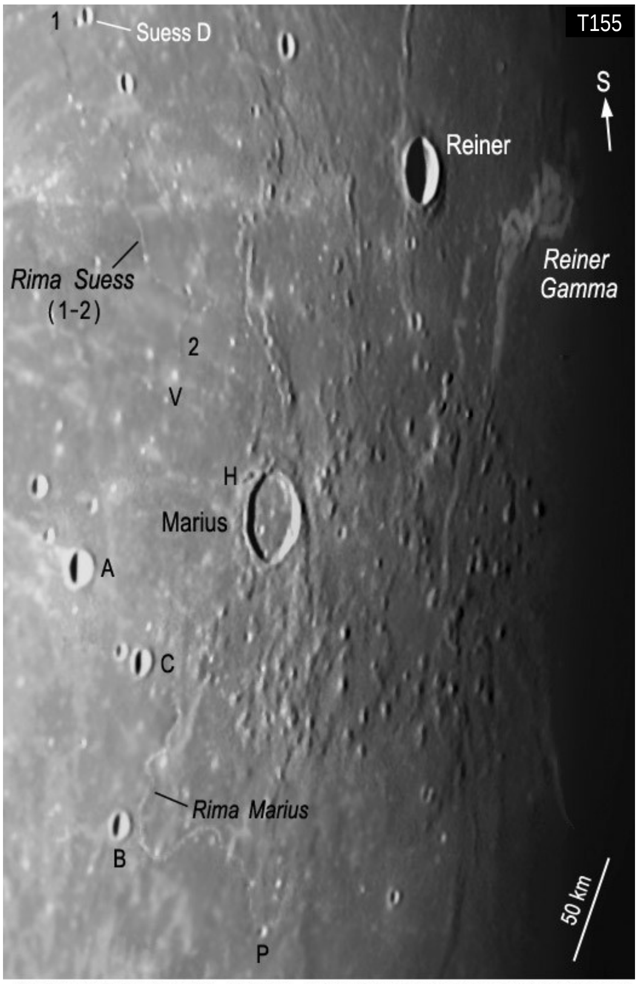
Image T233:
Maestlin R 41.5° W 3.5° N
A disintegrated walled plain, 61 km in diameter. A chain of craterlets extends outward from the east wall of Maestlin R. A system of rilles (***Rimae Maestlin***, length 80 km) passes through the southeast wall.



Kepler with rays 2001.01.06 15:17 UT Age 11 days. FS102 + QV2300

The Maestlin Region appears as a low elevated plateau (megadome) that holds Maestlin R, Rimae Maestlin and a nameless chain of craterlets. It is located on the eastern edge of Oceanus Procellarum near Kepler, size about 100 km north-south.





Marius Region 2004.09.26 ~15:36 UT Age 12 days. 10-in f/6 Newtonian + 4X + ToUcam

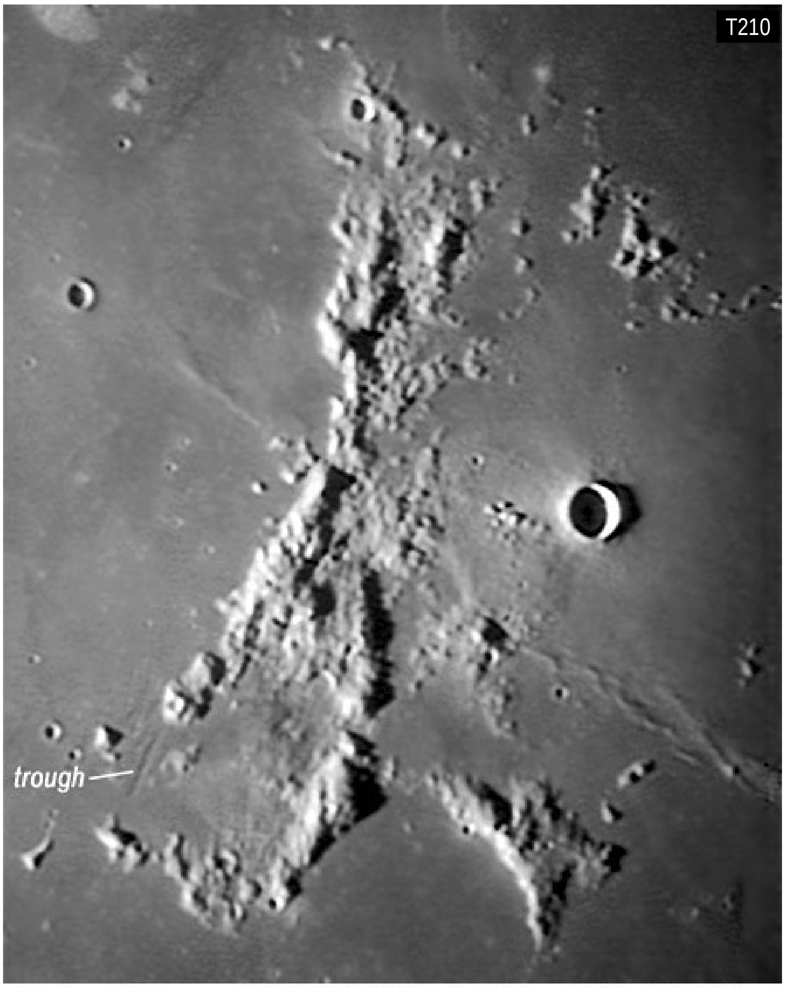
2005.04.21 14:17UT Age 12.5 days. 10-in f/6+4X+ToUcam

Marius 50.8^{0} W 11.9^{0} N
A crater in the middle of Oceanus Procellarum. It has a flat floor, 41 km in diameter. Its rim is stuck by a small elongated crater ***Marius H***. The vicinity of Marius is rich in wrinkle ridges and dome-like hills, best seen at Moon age of about 12 days. About 300 hills of few hundred meters high were estimated in this area. They are believed to form from concentrated rise of magma within the lunar crust, when volcanism was active 3~4 billion years ago. The bright streaks at the left edge of T155 are rays radiated from ***Kepler***.

Rima Marius 49^{0} W 17^{0} N
A sinuous rille in the north of Marius. It is shown more clearly in T057. Rima Marius begins near crater ***Marius C***, where its width is about 2 km. At ***Marius B***, the rille turns west and ends about 40 km west of ***Marius P***, where it is less than 1 km wide. The full length of this rille is about 200 km. Rima Marius is a lava channel. It runs long distance because lunar lava is less viscous and the Moon's surface gravity is weaker than that of the Earth. Compare Rima Marius with the terrestrial equivalent in the right image.

A lava channel on Kilauea Volcano, Hawaii, in 1986. It is about 4 meters wide, much smaller than a lunar volcanic rille. The cone in the distance is Pu'u O'o, the source of the lava. (University of Hawaii)

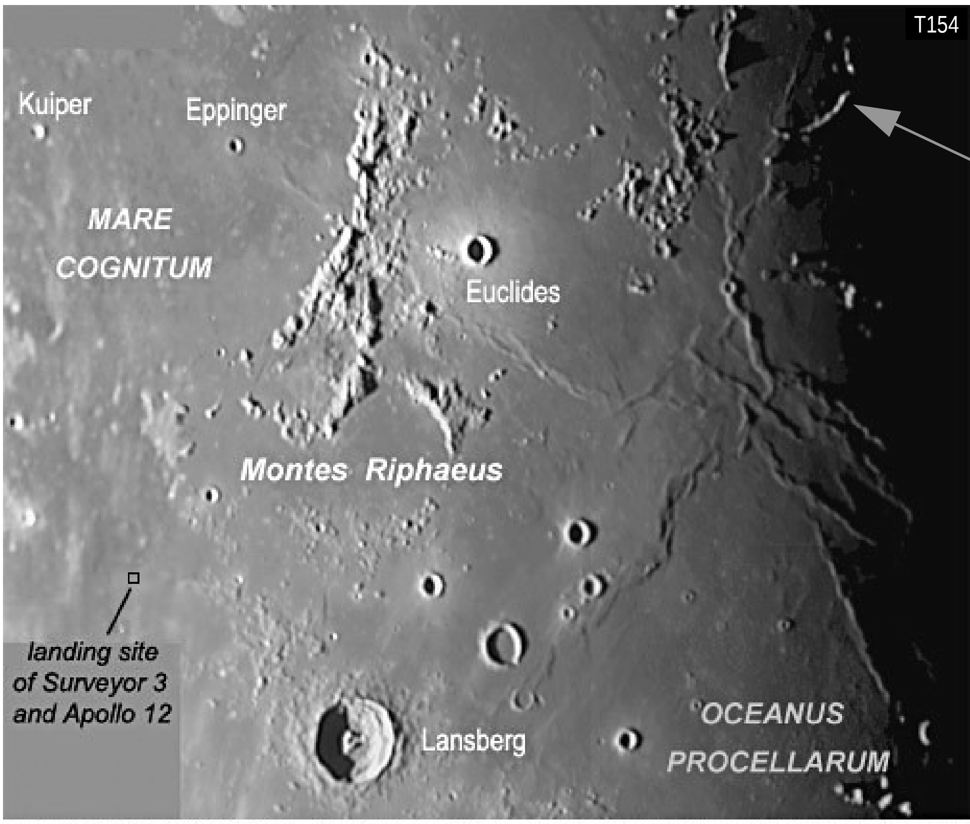
Rima Suess 47^{0} W 6^{0} N
A narrow sinuous rille (label 1 to 2 in T155) meandering between ***Suess D*** and ***Marius V***, length about 170 km. It is barely observable even in steady seeing with 10-inch telescope.



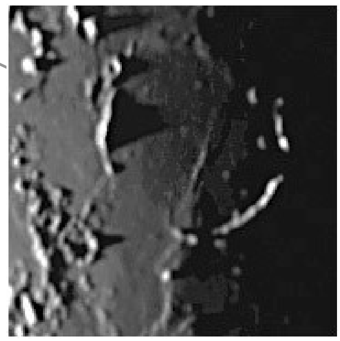
Montes Riphaeus 2005.04.19 12:58 UT Age 11 days. 10-in f/6 + 5X + ToUcam

Montes Riphaeus 28⁰W 7⁰S
A mountain range between Oceanus Procellarum (Ocean of Storms) and Mare Cognitum (Known Sea), length 180 km, peak height about 1000 m. It includes several long narrow mountains, giving the scene that resembles a hunter armed with a spear (wrinkle ridge) and a torch when viewed with south up. The "torch" is the bright rayed crater ***Euclides***, 11 km in diameter. An inconspicuous trough (length 30 km) is located on the north-east end of Montes Riphaeus.

Image T154 shows the landing site of the American unmanned probe *Surveyor 3* (April 1967). The manned *Apollo 12* visited the same site in November 1969, about 400 m away from Surveyor 3. The network of wrinkle-ridges in the west of Montes Riphaeus looks like an alien creature fighting with the "hunter".

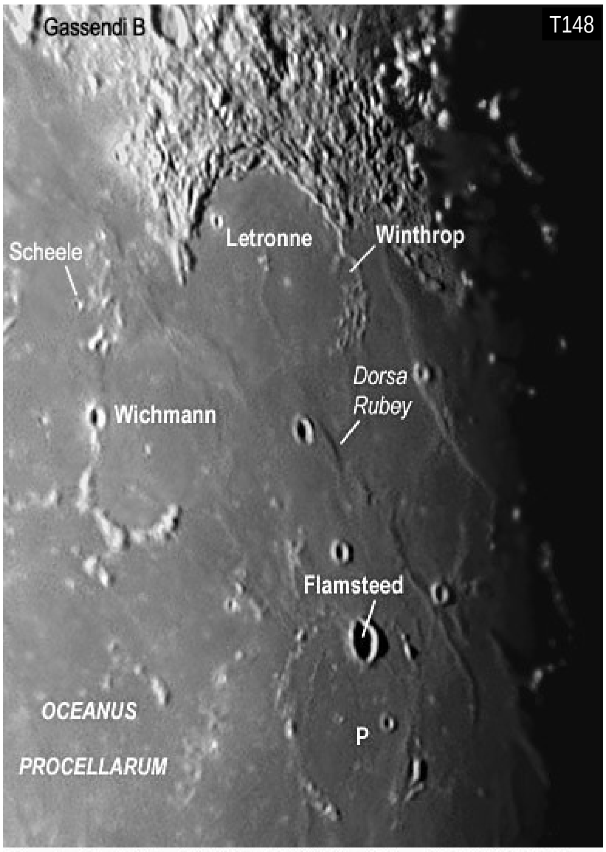


Montes Riphaeus & vicinity 2005.04.19 13:33UT Age 11 days. 10-in f/6+2.5X+ToUcam (*mosaic*)



🡐 *The wrinkle ridges in Oceanus Procellarum become prominent near the terminator. Note also the ghost ring formation at the picture corner.*

Flamsteed 44.3^{0}W 4.5^{0}S



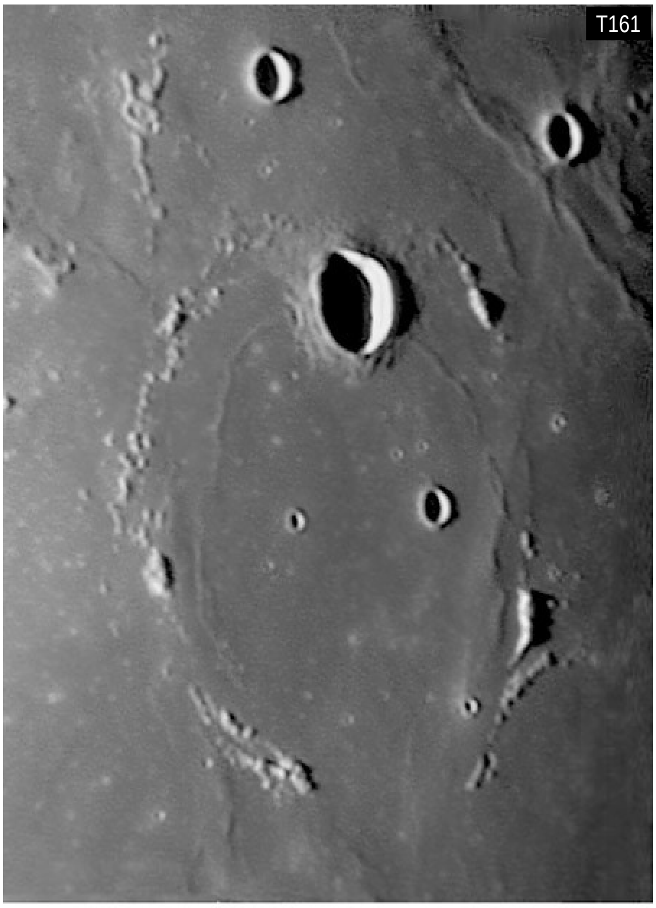
Flamsteed & vicinity 2004.09.25 ~14:44UT Age 11 days. 10-in f/6 + 2.5X + ToUcam

A crater, 20 km in diameter. It is inside the ghost ring formation ***Flamsteed P***. This ring has incomplete wall of diameter 112 km, and is believed an ancient impact crater flooded by lava during the formation of Oceanus Procellarum.

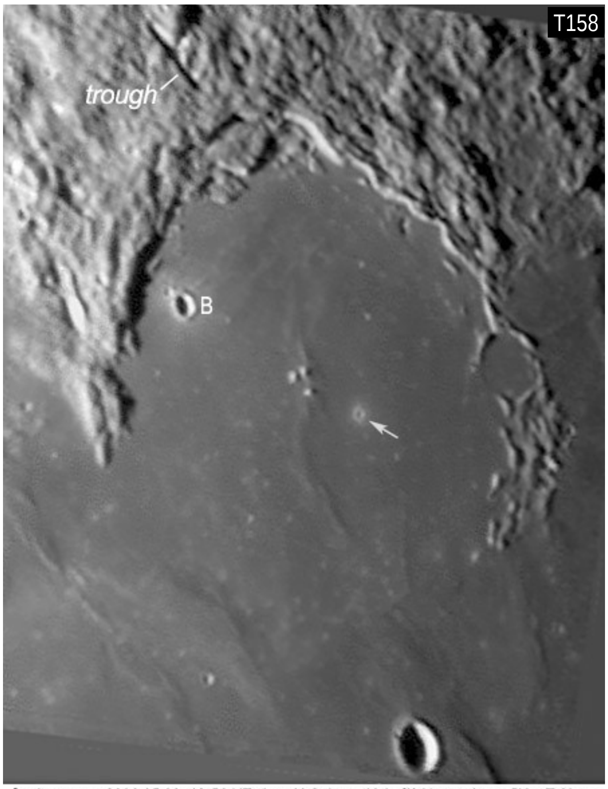
Letronne 42.5^{0}W 10.8^{0}S
Remains of a flooded walled plain. It appears like a bay which opens to Oceanus Procellarum, 116 km in diameter. Part of Letronne's central peaks, and a white halo cratelet close to the peaks, are distinguishable in T158. Letronne B (5 km) is also a white halo crater. A trough feature is in the immediate south of Letronne.

Winthrop 44.4^{0}W 10.7^{0}S
Remains of a flooded crater lying on the rim of Letronne, 17 km in diameter.

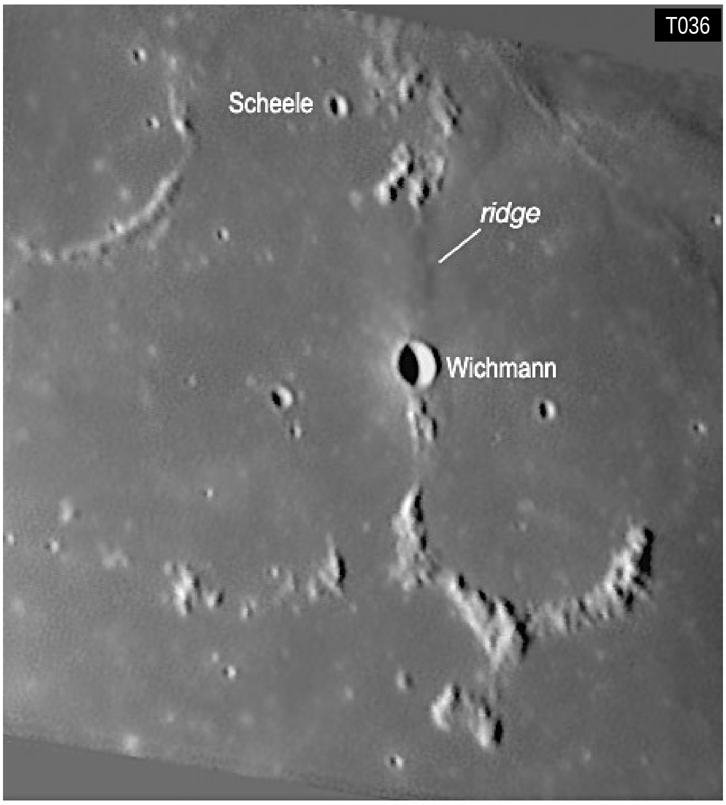
Dorsa Rubey 42^{0}W 9^{0}S
A system of wrinkle ridges extending outward from Letronne, length 100 km.



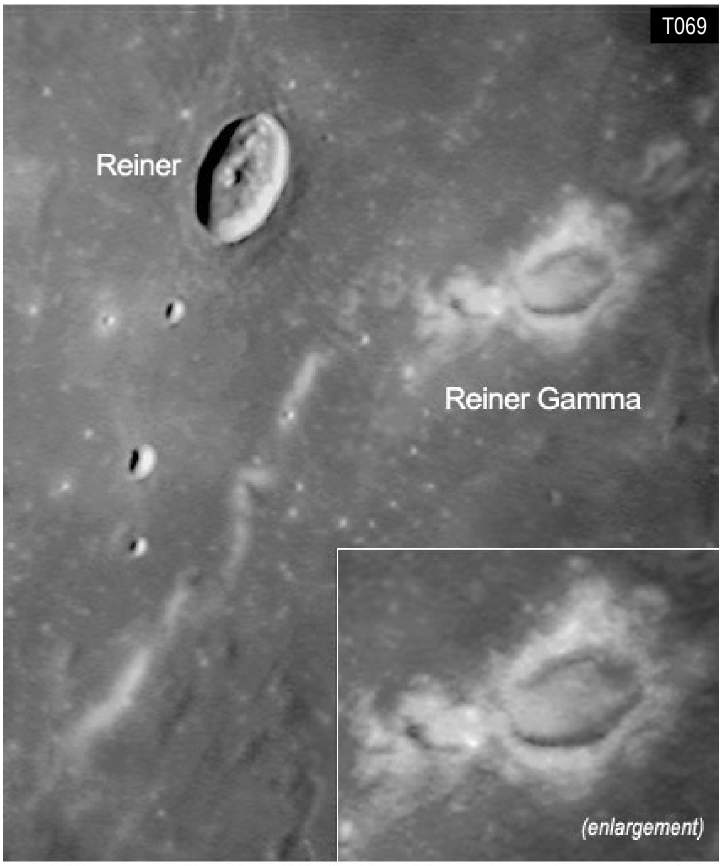
Flamsteed 2006.05.09 13:50 UT Age 11.8 days. 10-in f/6 Newtonian + 5X + ToUcam



Letronne 2006.05.09 13:56 UT Age 11.8 days. 10-in f/6 Newtonian + 5X + ToUcam
The arrow points to a white halo craterlet close to three central peaks.
Letronne B is also a white halo crater, diameter 5 km. Its rim adjoins a craterlet.



Wichmann 2006.05.09 14:40 UT Age 12 days. 10-in f/6 Newtonian + 4X + ToUcam



Reiner Gamma 2005.04.22 16:00 UT Age 13.8 days. 10-in f/6 + 4X + Toucam

Image T036:

Wichmann 38.1^0 W 7.5^0 S
A fairly bright crater, 10 km in diameter. Its northern wall connects to an arc-shaped mountain. Its southern wall is linked to an irregular mountain through a ridge.

Scheele 37.8^0 W 9.4^0 S
A crater, 4 km in diameter.

Image T069:

Reiner 54.9^0 W 7.0^0 N
A crater with fairly rough floor and a central peak, 29 km in diameter. It is circular in shape but appears oval due to foreshortening.

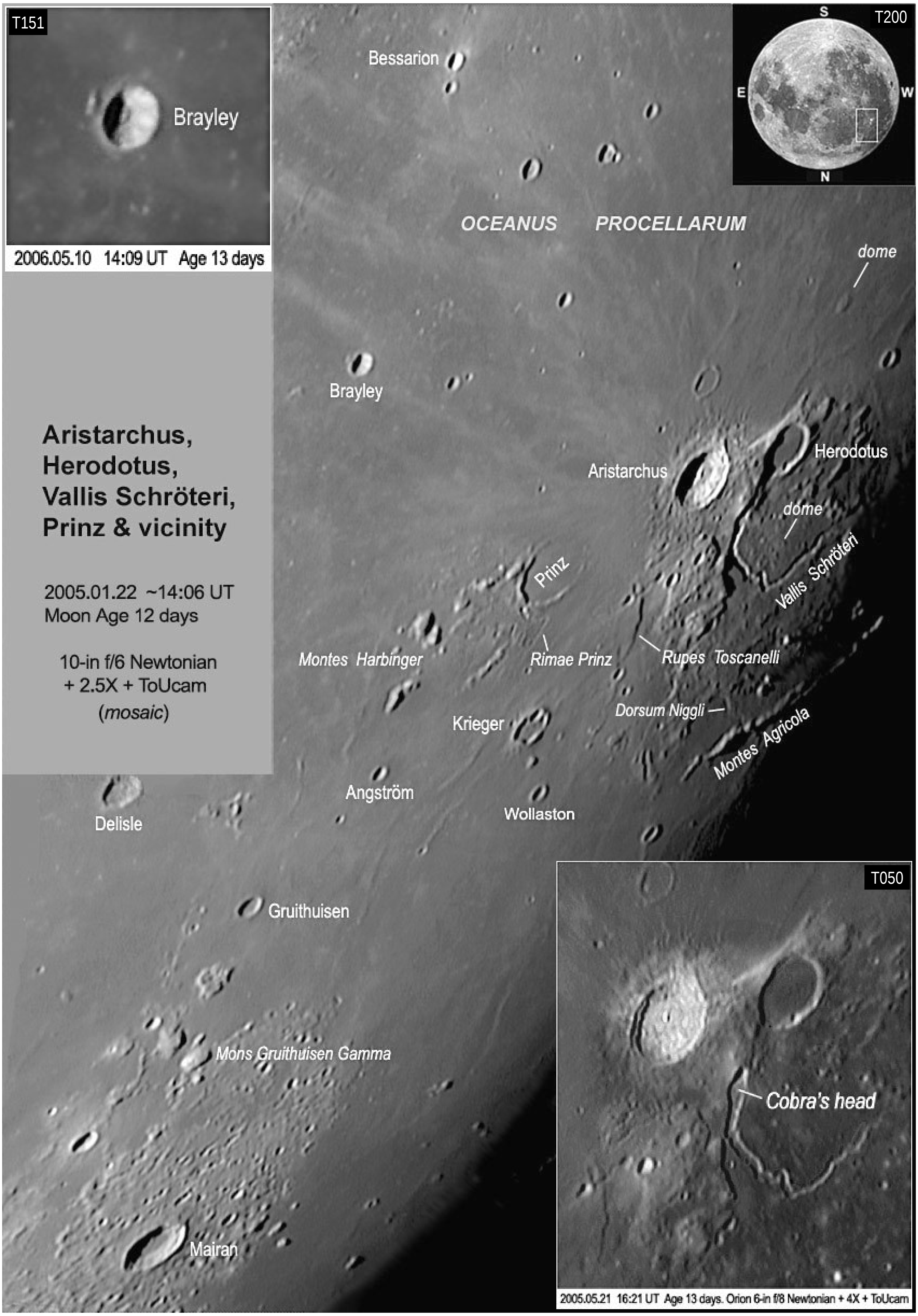
Reiner Gamma 59^0 W 8^0 N
A swirling deposit of bright material. Its main part appears like an oval dome, width about 30 km. Combined with the nearby bright tail formation, Reiner Gamma resembles the head of a white snake. Visually the snake has two tails, but only one tail prominent at a time. The "east tail" is shown in T069 (Moon age 14 days); the "west tail" is shown in T155, previous page (Moon age 12 days).

Current research suggests that Reiner Gamma is a locally magnetized area probably related to asteroid impact.

(More details:
http://science.nasa.gov/headlines/y2006/26jun_lunarswirls.htm?list137588
http://www.geocities.com/kc5lei/SWIRL2001.htm)

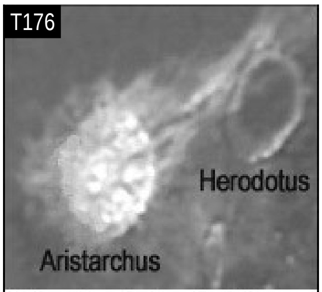
Hatfield 8
Rükl 18, 19

Aristarchus, Herodotus, Vallis Schröteri, Prinz



Aristarchus, Herodotus and Vallis Schröteri form an interesting feature group on the floor of Oceanus Procellarum (Ocean of Storms). Near the terminator shortly before the full Moon, the feature resembles the face of a cat (or an owl) when viewed with south up.

Aristarchus 47.4^0 W 23.7^0 N
A rayed crater with terraced walls and small central peak, diameter 40 km. Its depth is 3000 m, deep enough to expose the bright anorthosite materials of the lunar crust. Indeed its brightness is even detectable in the earthshine portion of a Moon crescent, Event 3. Aristarchus is very young, formed about 0.5 billion years ago. The Aristarchus region is a site of LTP (Lunar Transient Phenomena) glows. Some researchers speculated that the glows could be related to gases released from decay of radioactive elements. The inner walls of Aristarchus are shaded with radial dark bands near the full Moon (Image T176).



Aristarchus during the full moon on 2005.04.23. Radial dark bands extend up the inner terraced walls of the crater.

Herodotus 49.7^0 W 23.2^0 N
A flooded crater with flat floor, 34 km in diameter. A dome is in the south of Herodotus (T200).

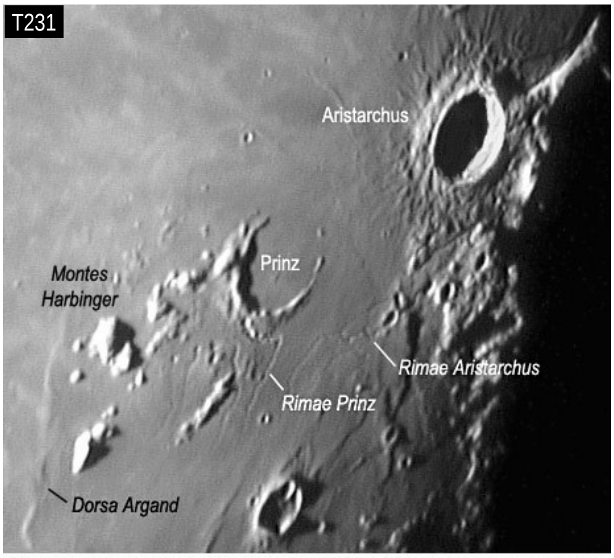
Vallis Schröteri (Schröter's Valley) 51^0 W 26^0 N
This is the largest sinuous valley on the Moon. It starts about 30 km north of Herodotus on a diamond-shaped plateau, then bends through nearly 180^0 to the west before opening out onto Oceanus Procellarum. The starting end actually joins with a 6-km diameter crater; observers call this end the ***Cobra's head***. Vallis Schröteri is about 160 km long, up to 11 km wide and 1000 m deep. Current theory suggests that the entire valley, including the head, is a collapsed lava tube. Note the dome with summit craterlet in the west of Vallis Schröteri, T159.

Rupes Toscanelli 47^0 W 27^0 N
A fault, length 70 km.

Montes Agricola 54^0 W 29^0 N
A straight narrow mountain range, 160 km long.

Dorsum Niggli 52^0 W 29^0 N
A short wrinkle ridge connecting Montes Agricola and the plateau that holds Vallis Schröteri, 50 km long.

Prinz 44.1^0 W 25.5^0 N *(Image T231)*
The remains of a flooded crater, about 46 km in diameter. A wide system of rilles (***Rimae Prinz***) emerges northward from the crater wall.

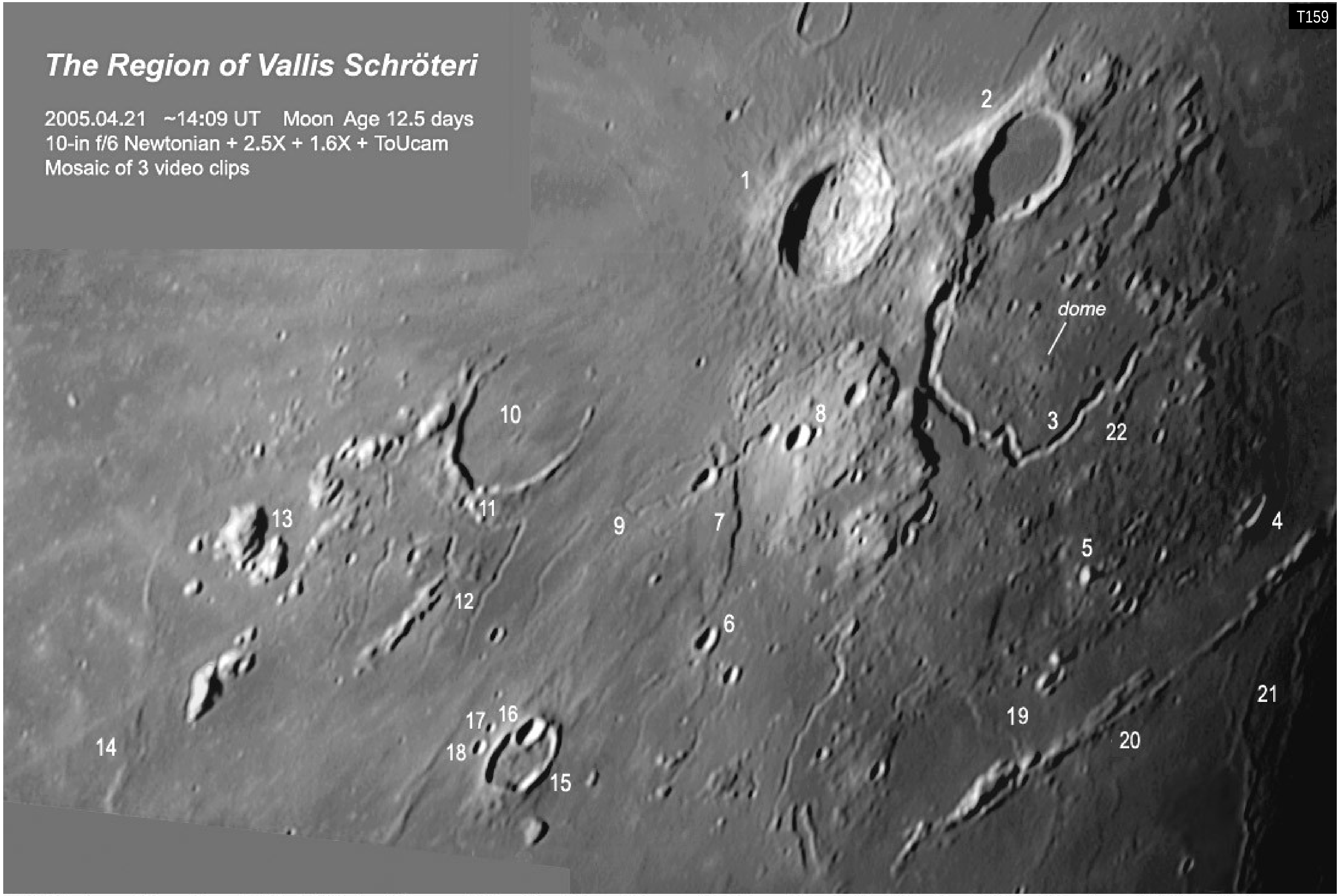


Aristarchus (in shadow) 2005.10.14 14:14UT Age 11 days. 10-in f/6 + 2.5X + ToUcam

Montes Harbinger 41^0 W 27^0 N
A group of isolated mountains spanning 90 km north-south, peak height 2500 m.

Rimae Aristarchus 47^0 W 28^0 N
A wide system of rilles near Aristarchus, length 120 km. The longest rille runs beyond Prinz.

Brayley 36.9^0 W 20.9^0 N *(Image T151, previous page.)*
A bowl-shaped crater, diameter 14 km. Its depth is as great as 1/5 of the diameter. Like Aristarchus under high illumination, the inner walls of Brayley are shaded by radial dark bands.

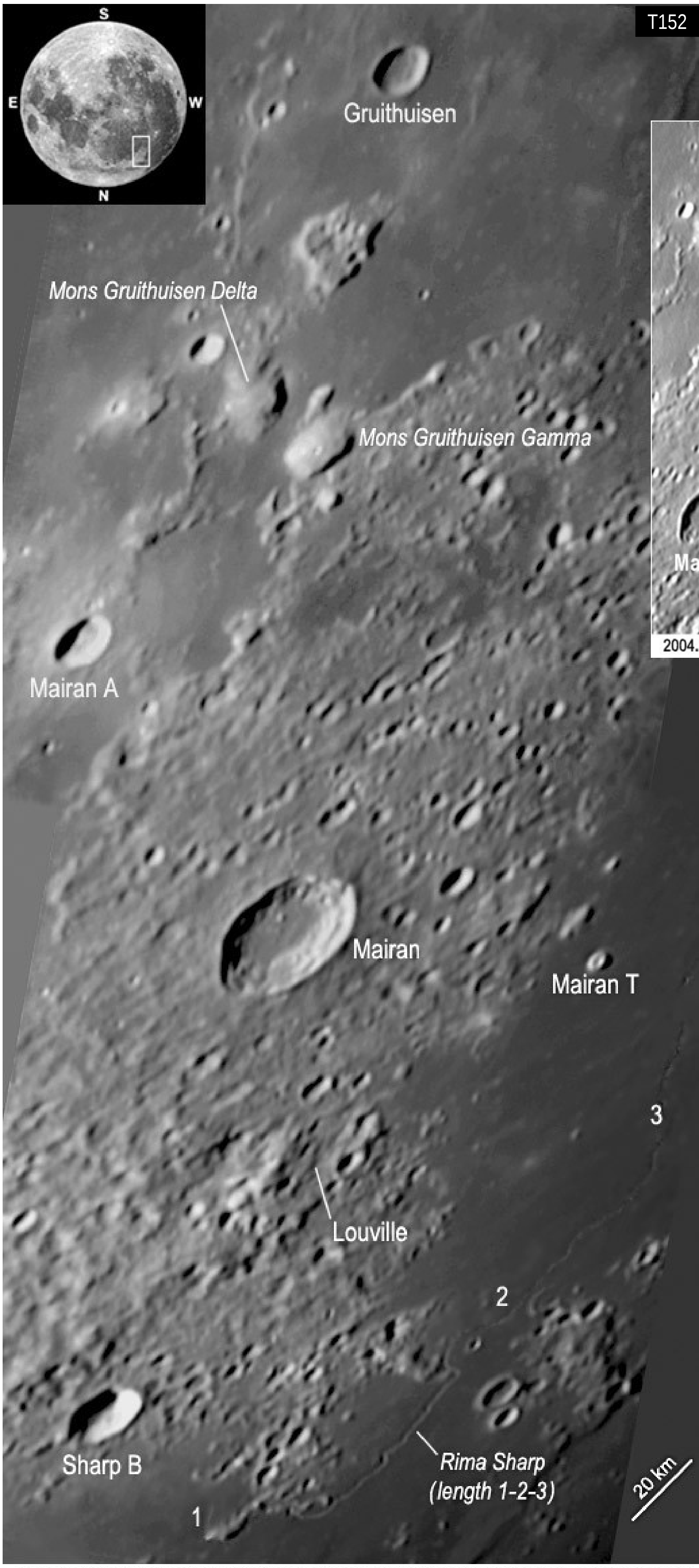


1. Aristarchus 2. Herodotus 3. Vallis Schröteri 4. Raman 5. Mons Herodotus 6. Toscanelli 7. Rupes Toscanelli 8. Väisälä 9. Rimae Aristarchus 10. Prinz 11. Vera 12. Rimae Prinz 13. Montes Harbinger 14. Dorsa Argand 15. Krieger 16. Van Biesbroeck 17. Ruth 18. Rocco 19. Dorsum Niggli 20. Montes Agricola 21. Dorsa Burnet 22. Freud

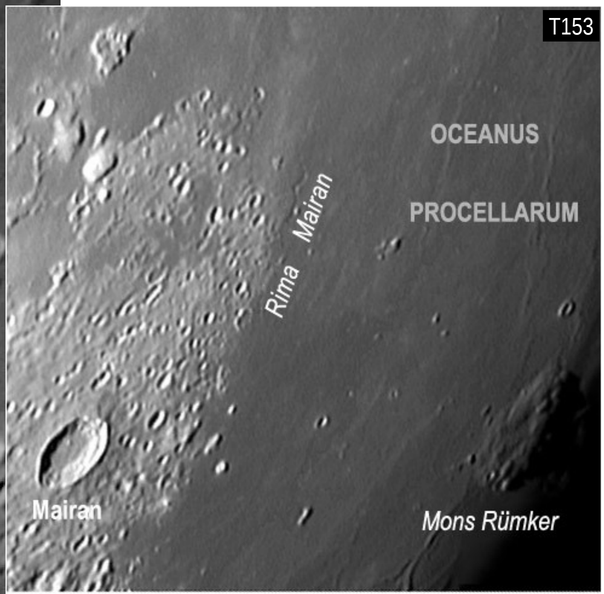
MAP 22

Mons Gruithuisen Gamma, Mons Rümker, Mons Delisle

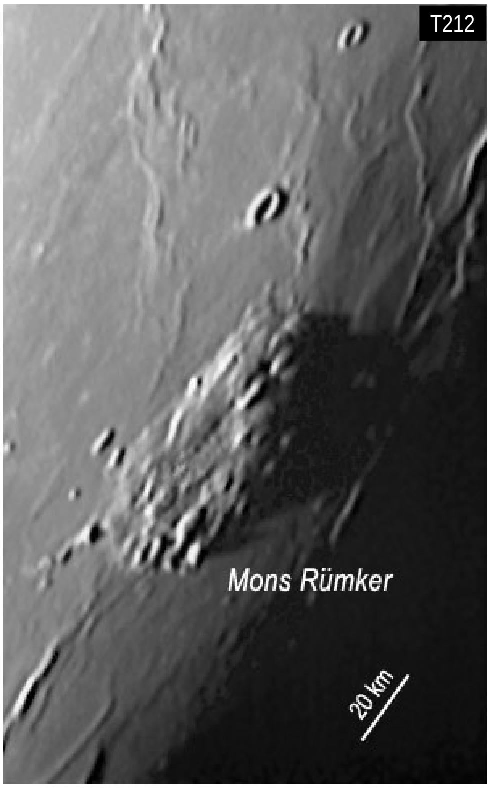
Hatfield 8
Rükl 9, 8, 19



Mairan Region 2006.05.10 15:06 UT Age 12.8 days. 10-in f/6 Newtonian + 4X + ToUcam



2004.09.26 14:22 UT Age 12 days. 10-inch f/6 Newtonian + 2.5X + ToUcam



2005.04.21 14:29 UT Age 12.5 days. *(10-in f/6 scope)*

Mairan 43.4^{0}W 41.6^{0}N
A crater with sharp rim, 40 km in diameter. ***Mairan T*** (3 km) is a small dome with a summit craterlet. In small telescopes, Mairan T appears as a bright spot only.

Rima Mairan 47^{0}W 38^{0}N
An inconspicuous rille, about 80 km in length.

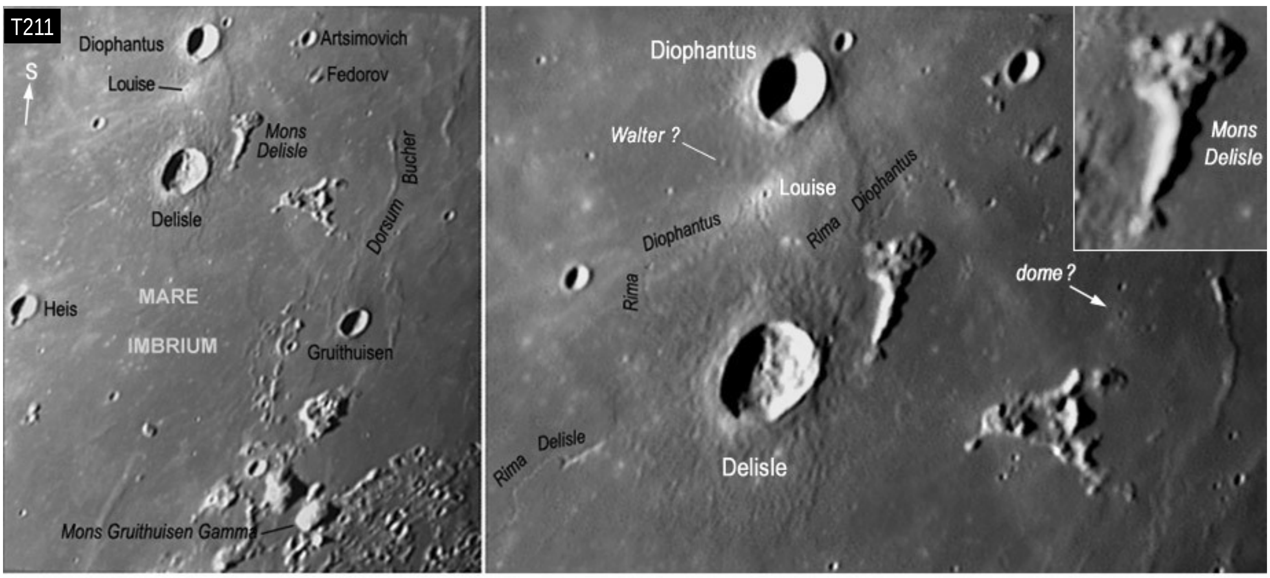
Rima Sharp 50^{0}W 45^{0}N
An inconspicuous sinuous rille, about 110 km in length.

Novarupta volcanic dome in Alaska, Earth (base ~2 km, height ~840 m)

Mons Gruithuisen Gamma 40.5^{0}W 36.6^{0}N
A dome mountain in the south of Mairan, base 20 km, height about 1 km. Its summit has two craterlets; the larger one is 900 m in diameter, the other is very shallow and less distinctive. Both craterlets are good tests for ~10-in telescopes. Compare this lunar mountain with Novarupta dome on Earth (USGS 003). See also http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=39713.

Mons Gruithuisen Delta 39.5^{0}W 36.0^{0}N
A mountain which appears similar to Mons Gruithuisen Gamma in nature but irregular in shape.

Mons Rümker 58^{0}W 41^{0}N
A volcanic complex of dome mountains on Oceanus Procellarum, base 70 km, height 500 m. It contains a shallow depression sculptured by clefts and craterlets. At low Sun angles, wrinkle ridges are seen in the vicinity.



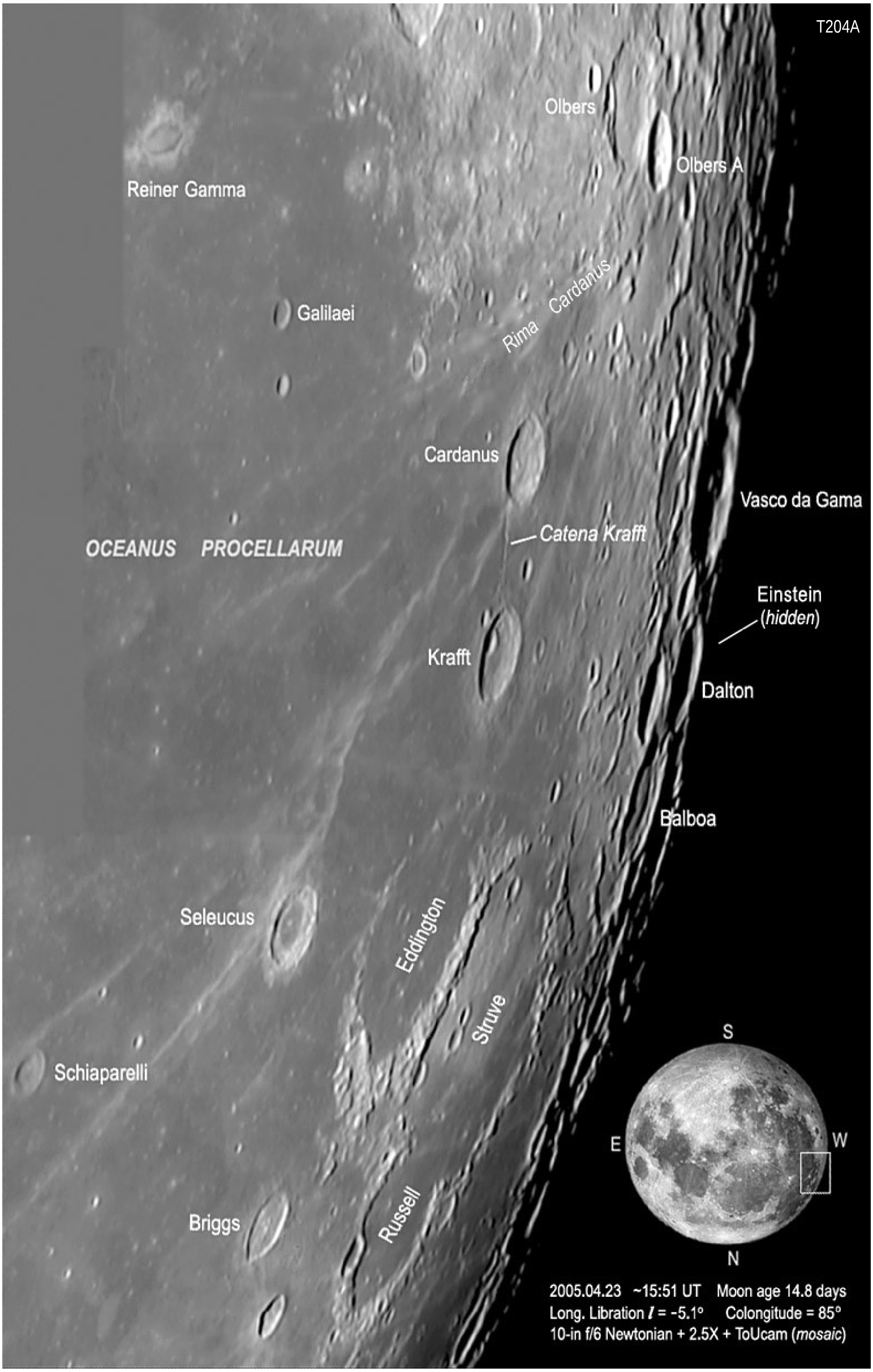
Right: 2006.05.09 13:31 UT Age 12 days. 10-in f/6 Newtonian+5X+ToUcam. Louise is a rayed craterlet, dia. 1 km. Mons Delisle looks like a baby crawling to Diophantus.

Delisle 34.6^{0}W 29.9^{0}N **Diophantus** 34.3^{0}W 27.6^{0}N *(Image T211)*
A pair of craters, diameter 25 and 17 km respectively. Delisle has uneven floor with a central broken craterlet. ***Mons Delisle*** is an interesting isolated mountain which measures 30 km south-north. It has a bulgy southern head but narrows down to a "tail" at the other end. ***Louise*** is a tiny rayed crater, about 1 km in diameter. Two inconspicuous rilles ***Rima Diophantus*** (length 150 km) and ***Rima Delisle*** (length 60 km) are in the close vicinity. Both rilles are rather difficult to observe. ***Walter*** is an obscure craterlet near Diophantus; it is named by IAU but this gives confusion mentioned in Map 11. The arrow in the picture points to a skeptical dome.

MAP 23

Hatfield 7
Rükl 17, 28

Eddington, Struve, Russell, Seleucus, Olbers, Einstein



Eddington 72.2^0 W 21.3^0 N, **Struve** 77.1^0 W 22.4^0 N, **Russell** 75.4^0 W 26.5^0 N
These are fine examples of remains of flooded walled plains, named to honor three astrophysicists in the early 20th Century. They are located near the north-west limb, visible as long as lunar libration is favorable. Their diameters are 118 km, 164 km and 103 km respectively. The longitude of 80^0 W passes through Struve's western wall.

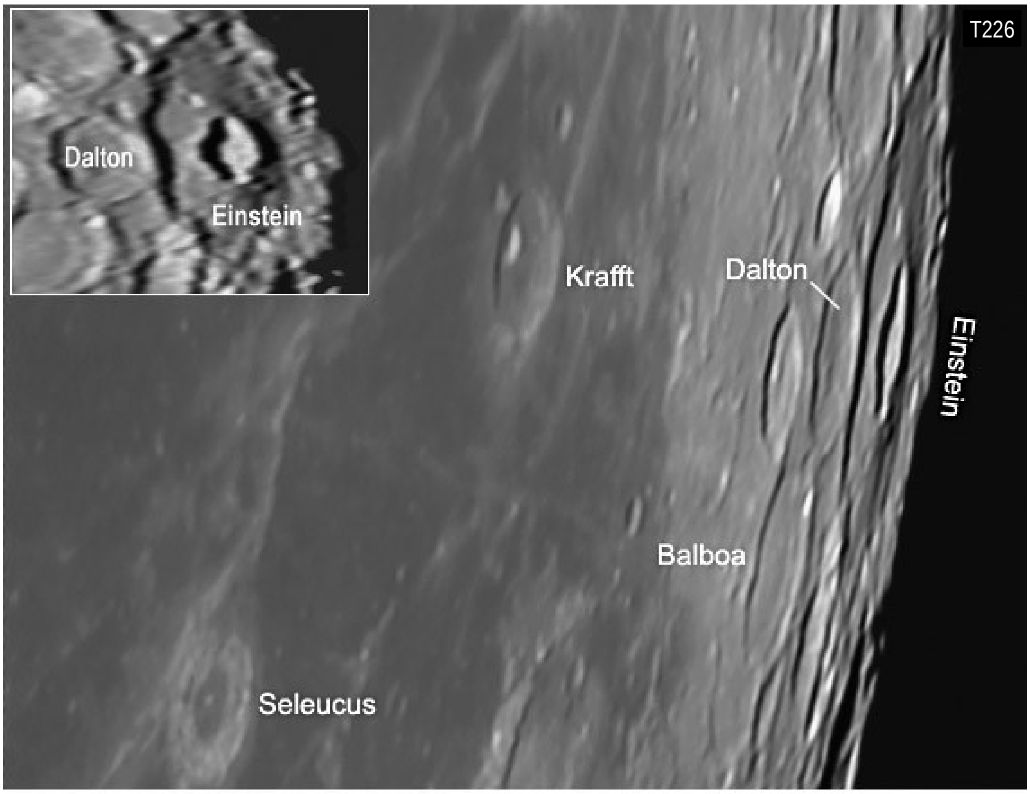
Seleucus 66.6^0 W 21.0^0 N
A prominent crater with terraced walls, 43 km in diameter. Note the bright rays passing the rim of Seleucus. The bright rays are the ejecta deposits originated from Olbers A.

Schiaparelli 58.8^0 W 23.4^0 N
A crater, 24 km in diameter, named after the 19th century Italian astronomer whose description of "canali" (channels) on Mars was misinterpreted as "canals" by other astronomers of his times.

Briggs 69.1^0 W 26.5^0 N
A crater with small central peaks, 37 km in diameter.

Olbers 75.9^0 W 7.4^0 N
A crater, 74 km in diameter. Its wall is interrupted by ***Olbers A.*** Both Olbers and Olbers A are rayed centers under high illumination. The long rays of Olbers A extend far beyond Schiaparelli.

Dalton 84.3^0 W 17.1^0 N **Einstein** 88.7^0 W 16.3^0 N
Dalton is 60 km in diameter. Its western wall adjoins the walled plain Einstein which is visible only at very favorable libration. Einsten is truly circular in shape, diameter 198 km and has a smaller central crater as shown in Image T226. Spacecraft mapping indicates the crater inside Einstein also has a small central peak, but the peak does not appear in T226 due to inappropriate illumination.



Einstein 2005.05.23 14:52 UT Age 15 days. 10-in f/6+2.5X+ToUcam. Insert is a rescaled projection.
This image was taken at fairly favorable libration of l = -4.7° b = 4.1°.

Vasco da Gama 83.9°W 13.6°N *(Image T204A)*
A crater with central peaks, 83 km in diameter.

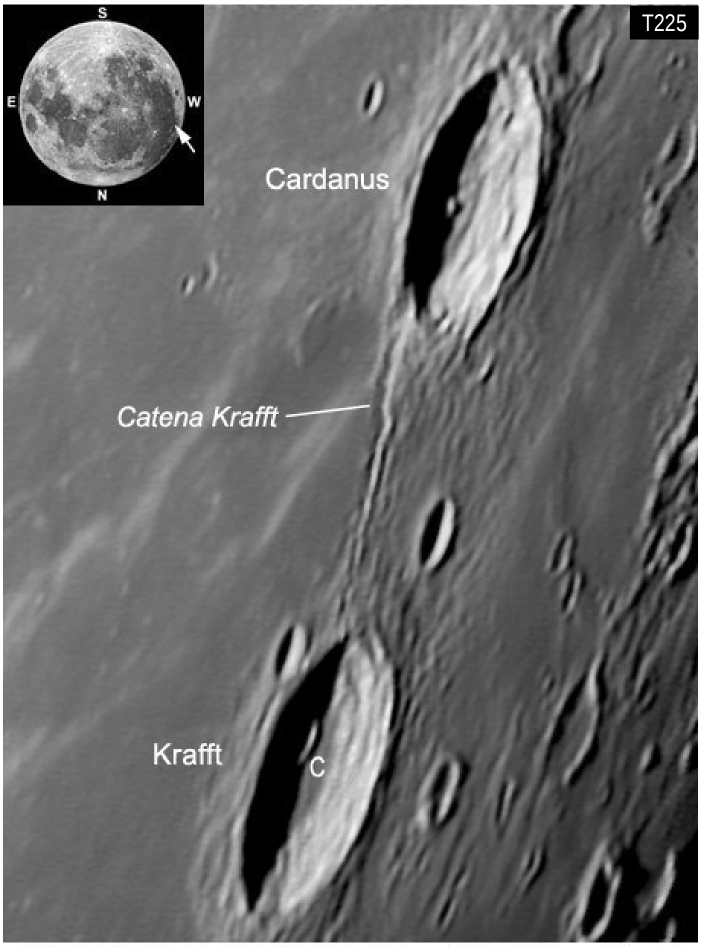
Rima Cardanus 71°W 11°N *(Image T204A)*
A linear rille, length about 170 km. It is indistinctive when the bright rays of Olbers A happen to sweep over it.

(Image T225)

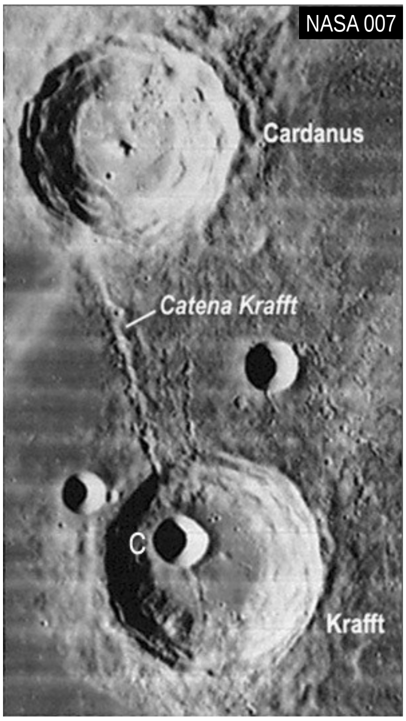
Cardanus 72.5°W 13.2°N
A terraced crater with a small central peak, 49 km in diameter. A skeptical ghost crater lies outside the northeast rim of Cardanus.

Krafft 72.6°W 16.6°N
A crater with flooded floor, 51 km in diameter. The floor contains a small crater ***Krafft C*** (diameter 13 km). Under shadows, Krafft and Cardanus look like a twin.

Catena Krafft 72°W 15°N
A chain of tiny, eroded overlapping craters which connects Cardanus and Krafft. In Image T225, foreshortening of the Moon's limb makes the chain not as distinctive as the overhead view of Lunar Orbiter (NASA 007). Actually, the catena crosses into Krafft's floor and bisects Krafft C, total length 60 km.



Catena Krafft 2005.05.22 15:11 UT Age 14.3 days. 10-in f/6+5X+ToUcam, 95% resized.



MAP 24

Hatfield 9
Rükl 53, 52, 63

Capuanus, Ramsden, Marth, Bullialdus, Kies, Opelt

This map covers the western part of ***Mare Nubium*** (Sea of Clouds). The impact basin that holds Mare Nubium does not shape clearly, so it is a very ancient one, likely formed 4 billion years ago.

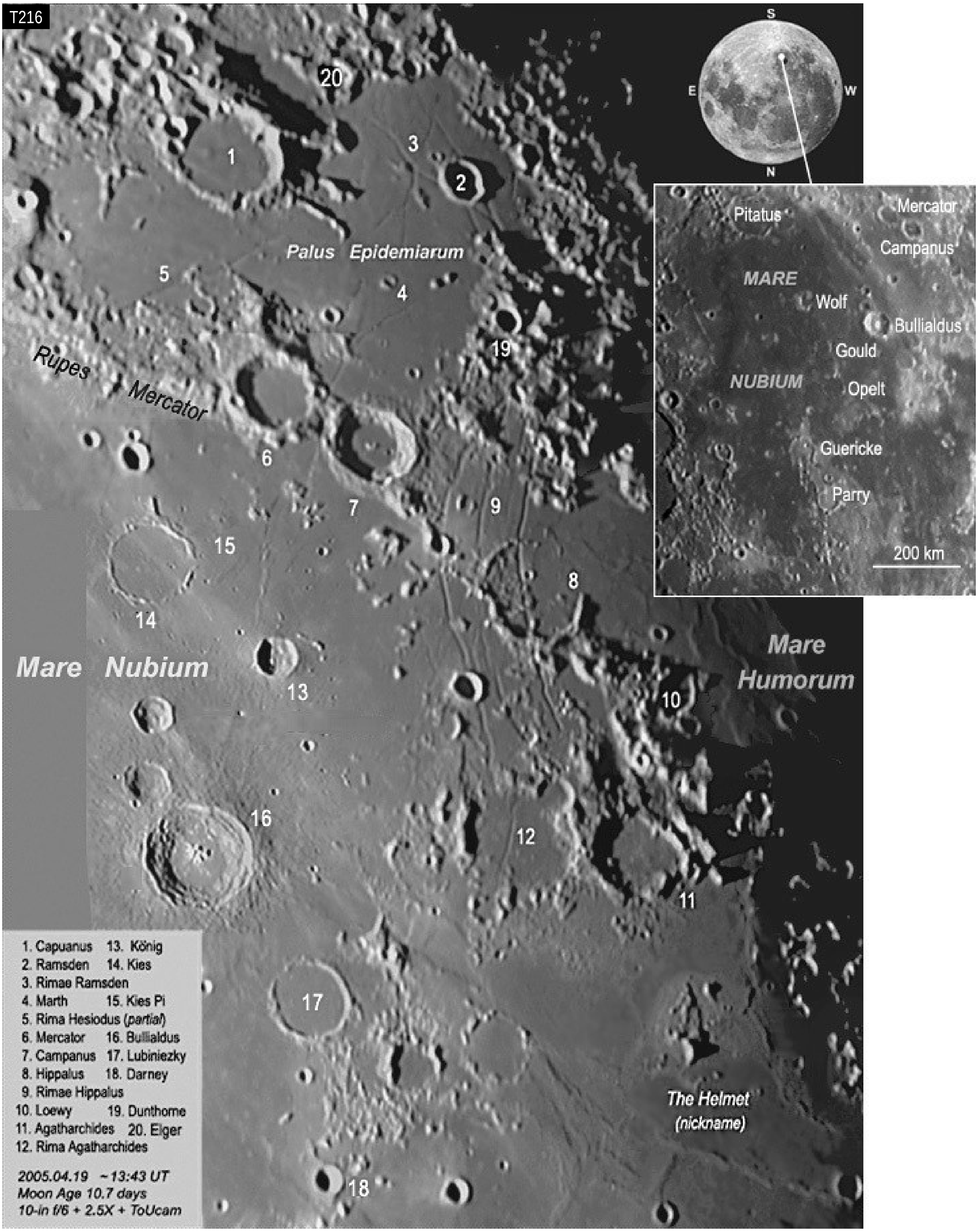


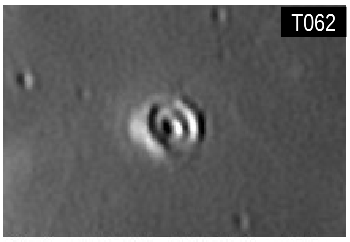
Image T216, previous page:

Capuanus 26.7^0 W 34.1^0 S
A flooded crater, 59 km in diameter. Its floor contains low ridges and dome-like features.

Mercator 26.1^0 W 29.3^0 S **Campanus** 27.8^0 W 28.0^0 S
Adjoining craters of almost same size (46~48 km). The twin resembles a pair of spectacles. Campanus has a small, arc-shaped central peak. Two segments of inconspicuous rilles extend north-south from the junction wall between Mercator and Campanus.

Ramsden 31.8^0 W 32.9^0 S
A crater in ***Palus Epidemiarum*** (Marsh of Epidemics), 24 km in diameter. It sits on a wide system of rilles (***Rimae Ramsden***, 110 km).

Marth 29.3^0 W 31.1^0 S
A double-walled crater in Palus Epidemiarum, 6 km in diameter.



Marth 2004.04.30 14:05UT Age 11 days

Rimae Hippalus 29^0 W 25^0 S
A spectacular system of wide rilles at the boundary between Mare Nubium and Mare Humorum. It cuts through the ruined crater ***Hippalus***. See also T068, Map 25.

Rima Hesiodus 21^0 W 30^0 S
A linear rille, 250 km long. Part of it enters into Palus Epidemiarum. See also T083 in Map 11.

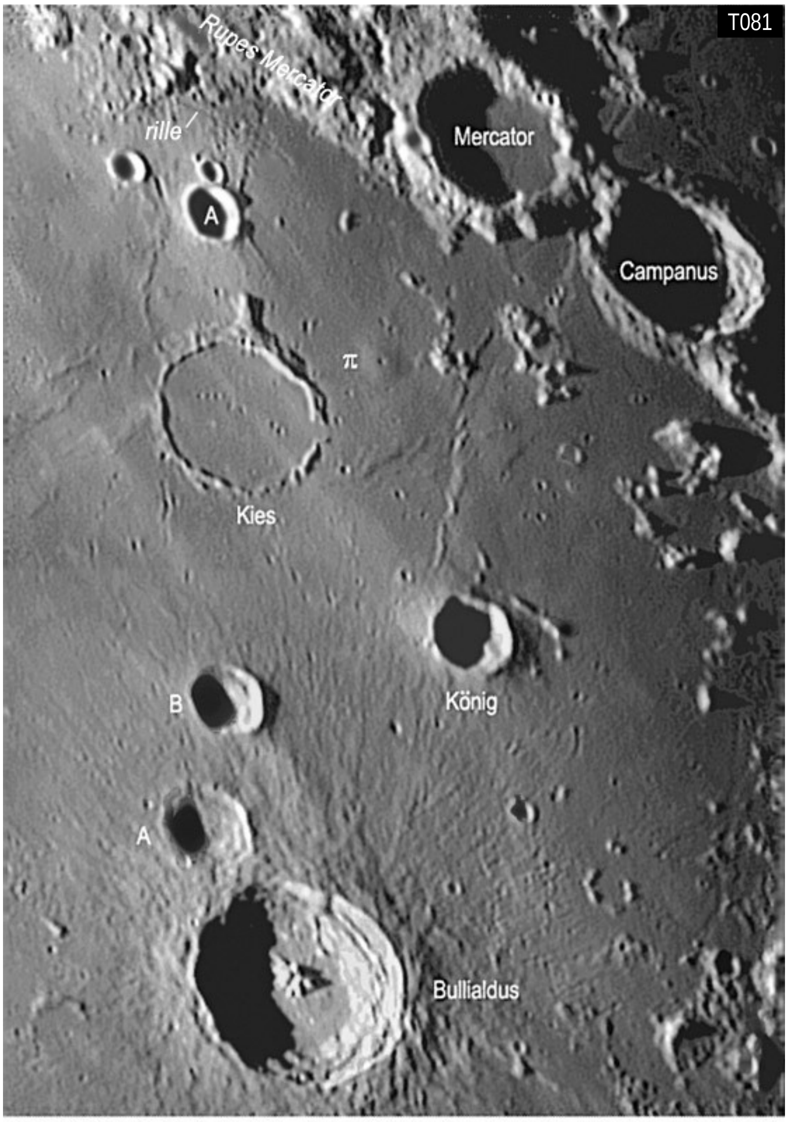
Rupes Mercator 23^0 W 30^0 S
A fault on the southern edge of Mare Nubium, length about 100 km.

Image T081:

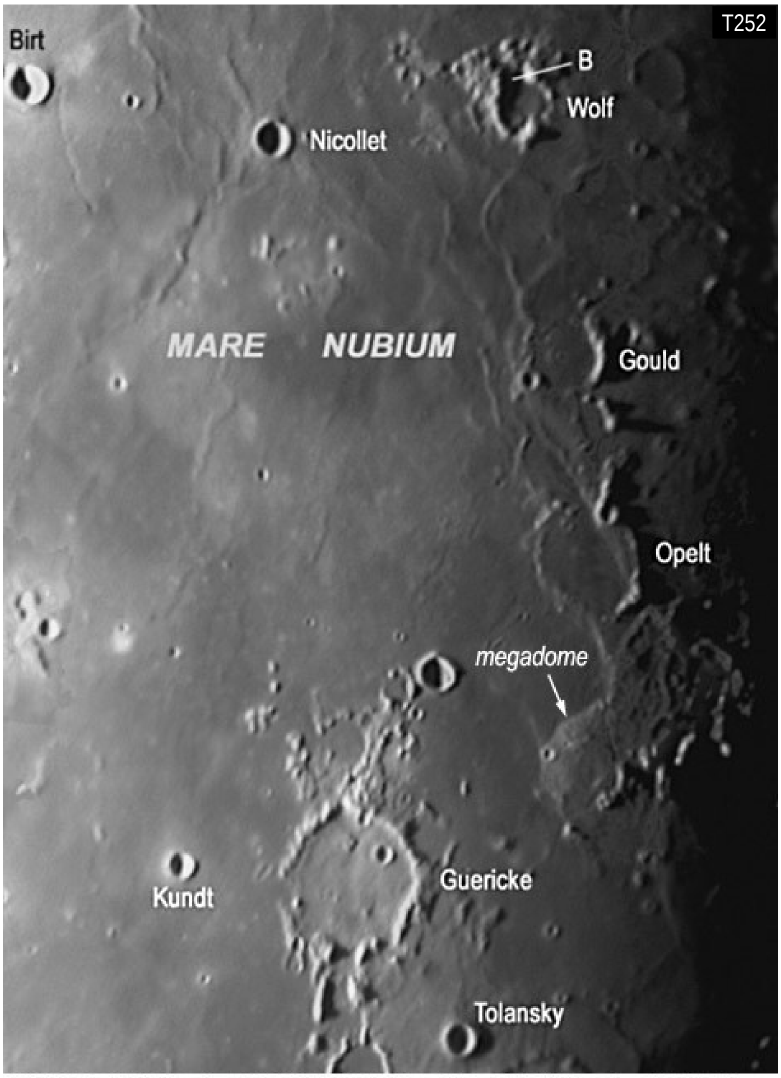
Bullialdus 22.2^0 W 20.7^0 S
A crater with central peaks, terraced walls, and radial ejecta blanket outside the rim, 60 km in diameter, 3500 m deep. It looks like a "small version" of Copernicus, Map 19.

Kies 22.5^0 W 26.3^0 S
A flooded crater with a spiky cape, 45 km in diameter. A dome with summit craterlet, designated ***Kies Pi*** (π), is in the immediate west of Kies. An unnamed linear rille is in the south of ***Kies A***.

König 24.6^0 W 24.1^0 S
A crater, 23 km in diameter, fairly deep (2400 m).



2005.11.11 12:43 UT Age 9.5 days. 10-in f/6 Newtonian + 4X + ToUcam, 85% resized (*mosaic*)



Wolf, Gould & Opelt 2006.02.07 ~12:00 UT Age 9 days. 10-in f/6 Newtonian + 2.5X + ToUcam

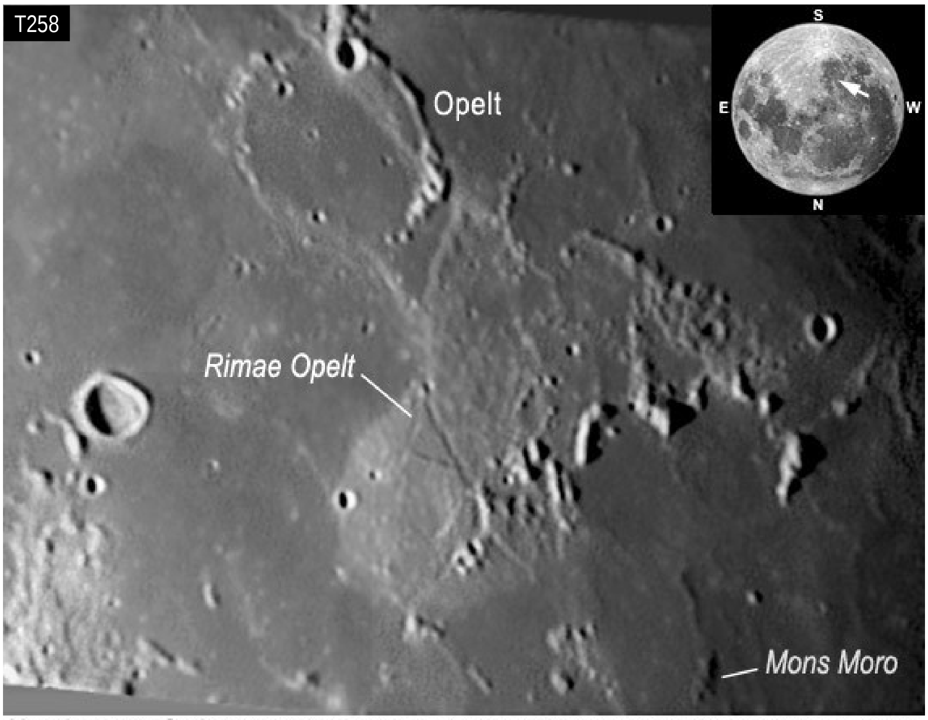
Other features in Mare Nubium:

Wolf 16.6^{0}W 22.7^{0}S
Remains of a flooded crater, 25 km in diameter. Its wall is opened to ***Wolf B***.

Gould 17.2^{0}W 19.2^{0}S
Remains of a flooded crater, 34 km in diameter.

Opelt 17.5^{0}W 16.3^{0}S
Remains of a flooded crater, 48 km in diameter.

The arrow in T252 points to a dome-shaped plateau, diameter about 60 km and height possibly few hundred meters. Its top is sculptured by a system of rilles (***Rimae* Opelt**, see also T258). This plateau, together with Opelt, Gould and Wolf, form an interesting quartet on the terminator.

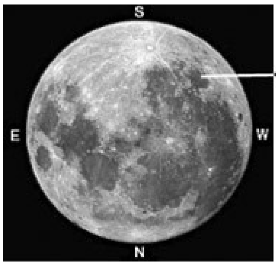


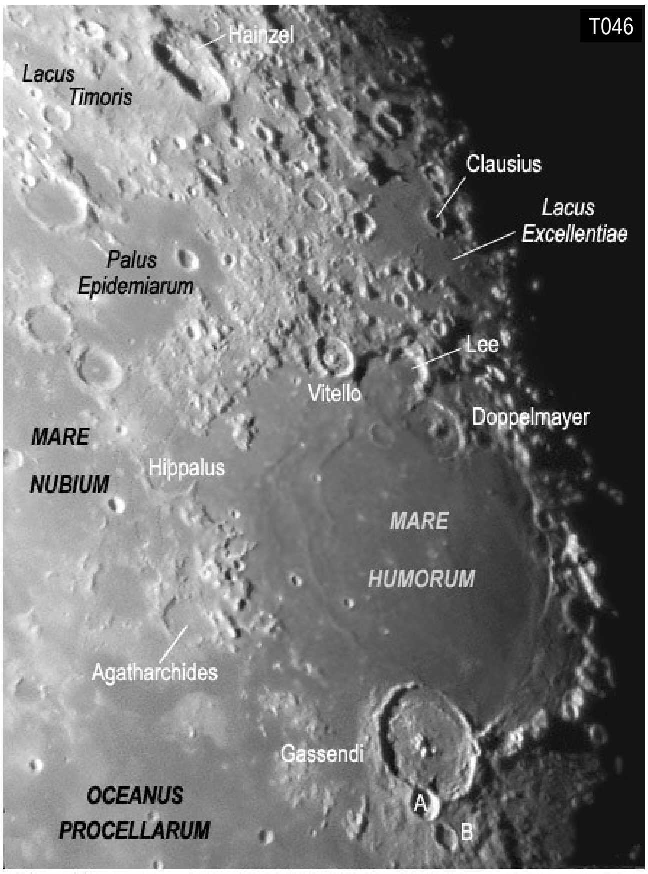
Megadome near Opelt 2006.03.09 ~15:30 UT Age 9.6 days. 10-in f/6 + 2.5X + 1.6X + ToUcam (*stack of 3 videos*)

MAP 25

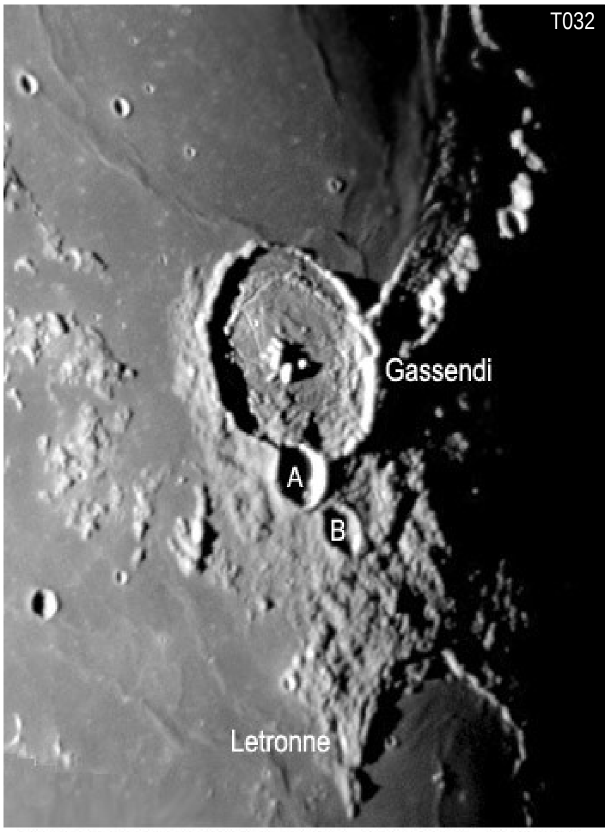
Hatfield 11
Rükl 52, 51, 62

Mare Humorum, Gassendi, Lacus Excellentiae, Rimae Hippalus, Vitello, Mersenius





Mare Humorum 2000.12.07 14:16UT Age 11 days. QV2300-20001207-0002



Gassendi 2002.06.21 13:30UT Age 10 days. C9+CP990

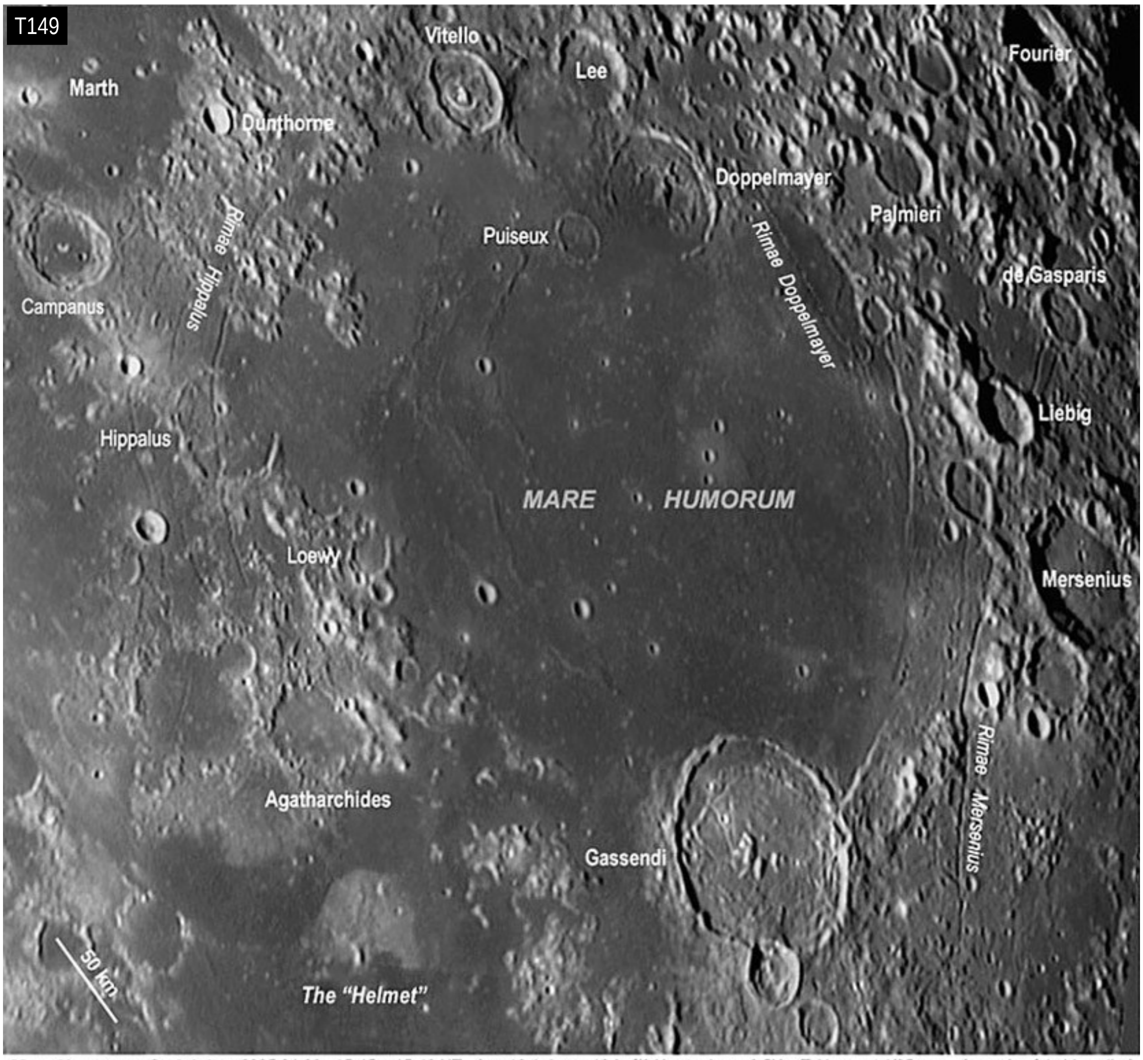
Mare Humorum 39^{0}W 24^{0}S
Mare Humorum (Sea of Moisture) is a lava plain inside a fairly small impact basin, about 400 km in diameter. Concentric wrinkle ridges and small craters are located on the mare floor. ***Palus Epidemiarum*** (Marsh of Epidemics), ***Lacus Excellentiae*** (Lake of Excellence) and ***Lacus Timoris*** (Lake of Fear) are in the south of Mare Humorum.

Gassendi 40.1^{0}W 17.6^{0}S
Gassendi is a prominent walled plain on the edge of Mare Humorum, 101 km in diameter. Its floor contains hilly elevations and a wide system of rilles (***Rimae Gassendi***, T261). Gassendi is truly circular in shape, but it looks oval due to its proximity to the lunar limb. Gassendi formed from an impact object which struck almost perpendicular to the lunar surface.

A jumble of three prominent peaks lies on the center of Gassendi. The northern wall has been broken by a smaller crater, ***Gassendi A.*** This crater is 33 km in diameter, 3600 m deep while the depth of Gassendi is just 1800 m. Note the triangular landslide on Gassendi's western wall.

Letronne 42.5^{0}W 10.8^{0}S
A semi-circular relief just north of Gassendi. It is the remains of a flooded walled plain, 116 km in diameter. Letronne together with Gassendi resemble a "lobster". See also Map 20.

Full view of Mare Humorum



Mare Humorum & vicinity 2005.01.22 15:45 ~ 15:49 UT Age 12.1 days. 10-in f/6 Newtonian + 2.5X + ToUcam at 1/25 sec. (*mosaic of 4 video clips*)

Gassendi 2006.05.09 14:02 UT Age 11.8 days. 10-inch f/6 Newtonian + 5X + Toucam

Gassendi – The most prominent feature in the Humorum region.

Lacus Excellentiae (Lake of Excellence) 43^0 W 36^0 S
An irregular strip of mare among the rugged terrain of the Southern Highlands, maximum length 180 km. ***Clausius*** (diameter 24 km) is a fairly prominent crater in this region. On 2006 September 03, the European Smart-1 lunar orbiter ended its mission with a controlled clash on the northern end of Lacus Excellentiae. (*http://www.cfht.hawaii.edu/News/Smart1/*)

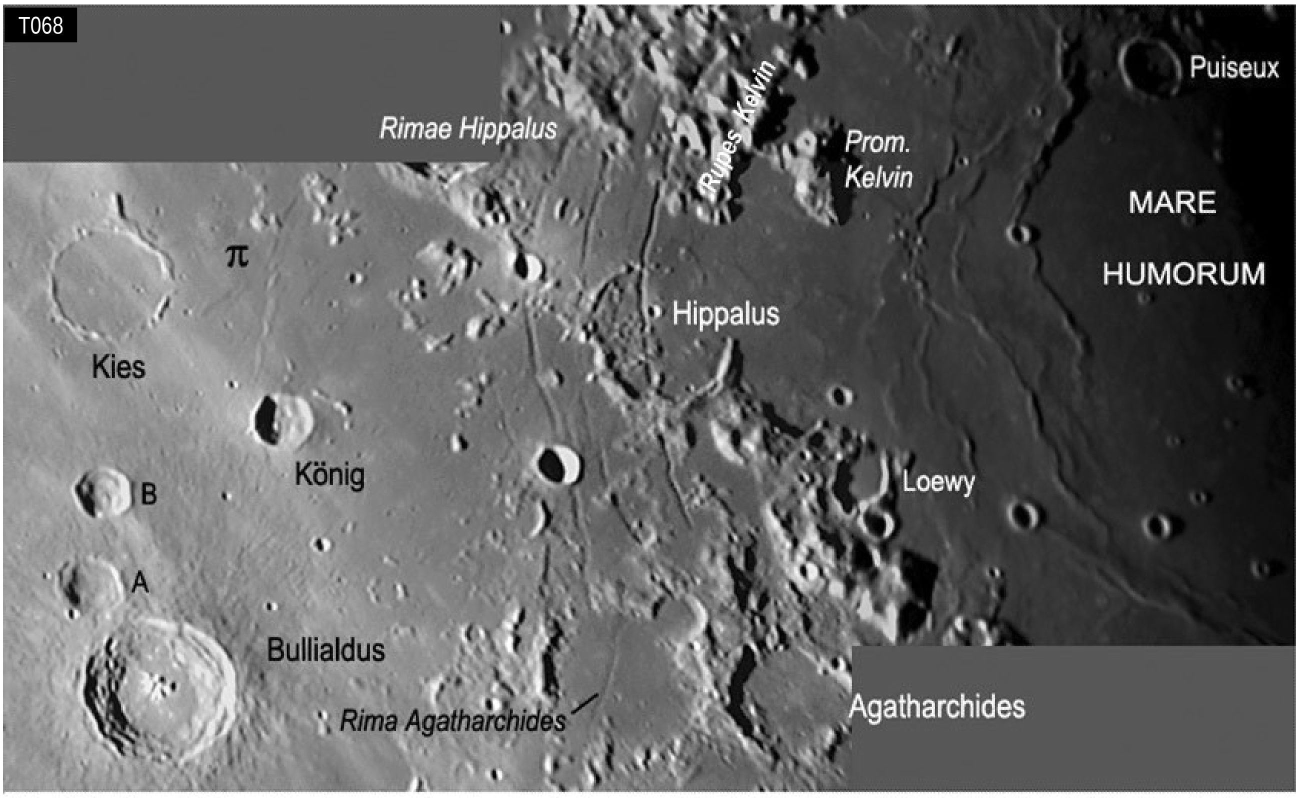
(Image T068, next page):

Rimae Hippalus 29^0 W 25^0 S
A spectacular system of wide rilles crossing the ruined crater ***Hippalus***, length about 200 km. At least 3 rilles of the system are visible in small telescopes. These rilles appear as concentric fractures along the circumference of Mare Humorum, caused by the subside of immense lava masses in the Humorum Basin. See also T216, Map 24.

Agatharchides 30.9^0 W 19.8^0 S
A ruined-wall flooded crater, 48 km in diameter. ***Rima Agatharchides*** (50 km long) is in the east.

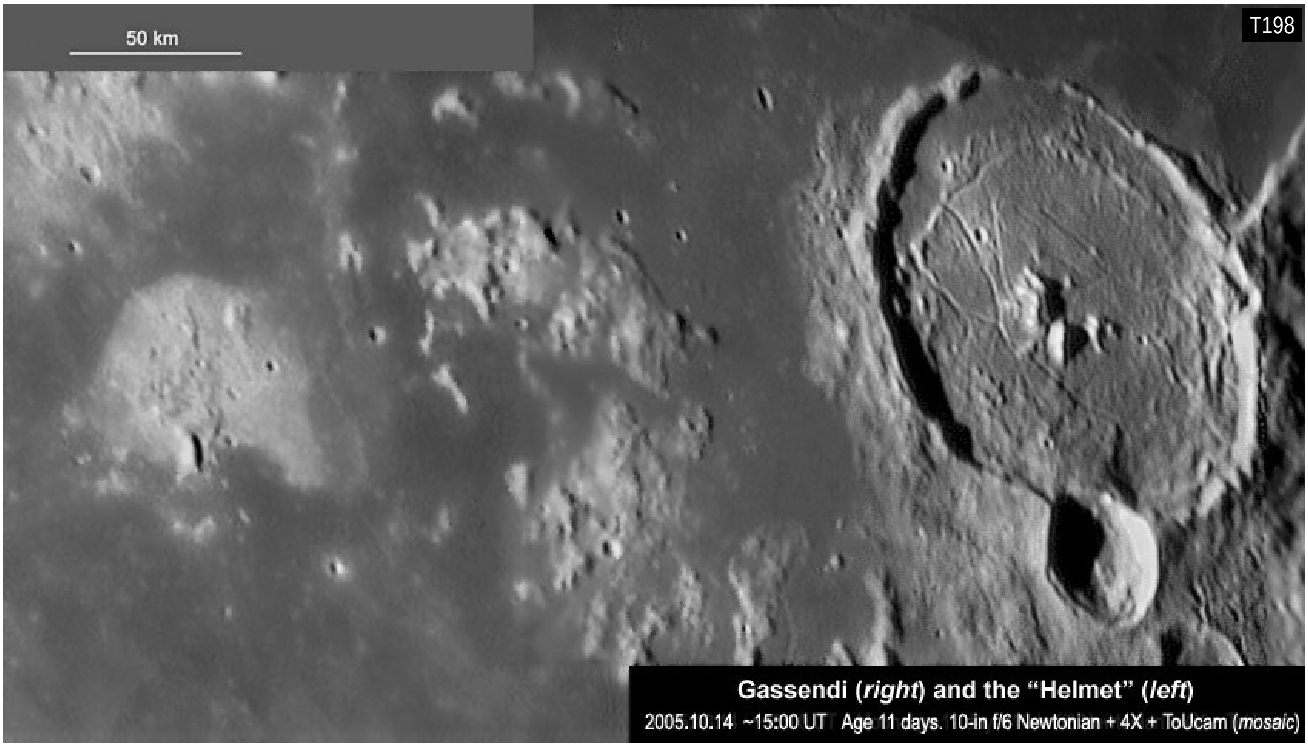
Loewy 32.8^0 W 22.7^0 S **Puiseux** 39.0^0 W 27.8^0 S
Loewy (22 x 26 km) and Puiseux (24 km) are named after the co-authors of the *Atlas Photographique de la Lune*, first published by Paris Observatory in 1896-1910.

East Region of Mare Humorum *(Wrinkle ridges and rilles become prominent at this Moon age.)*



East Region of Mare Humorum 2004.04.30 13:06~13:27 UT Age 11 days. 10-in f/6 Newtonian + 2.5X + ToUcam (*mosaic*)

Gassendi and the "Helmet"

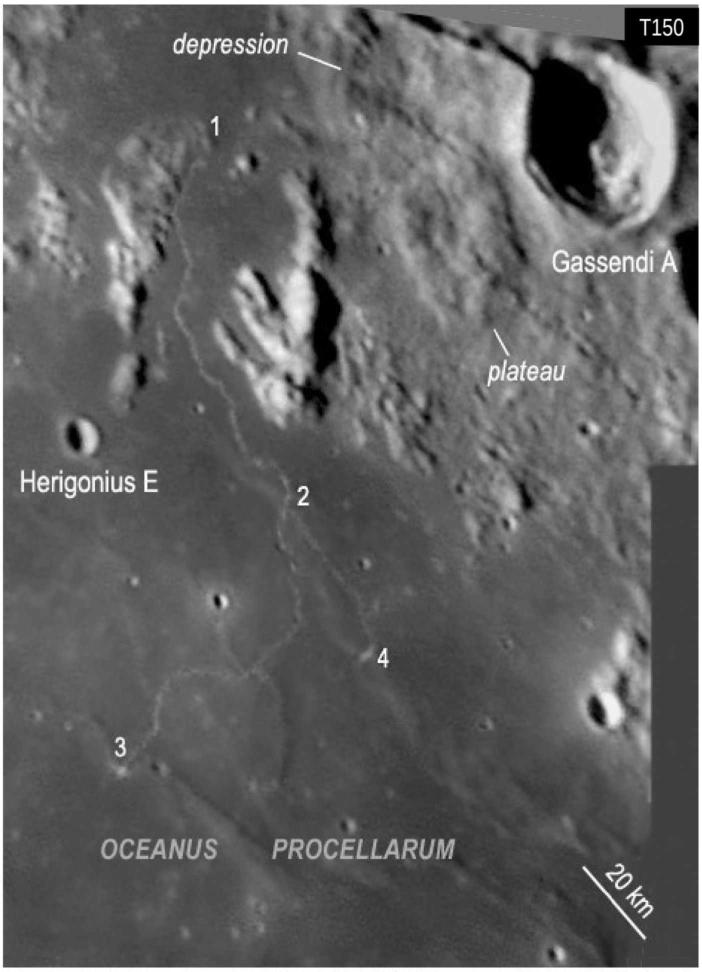


Gassendi (*right*) and the "Helmet" (*left*)
2005.10.14 ~15:00 UT Age 11 days. 10-in f/6 Newtonian + 4X + ToUcam (*mosaic*)

The Helmet 31° W 17° S *(Image T198)*
A bright dome-shaped plateau (megadome) nicknamed by the Apollo-16 crew, size about 60 km.

Image T150:

Rimae Herigonius 37^0 W 13^0 S
A system of sinuous rilles meandering on the southern edge of Oceanus Procellarum, 100 km long. Note the rectangular depression and plateau feature between Rimae Herigonius and Gassendi A. The plateau top appears somewhat depressed and crossed by a chain of broken craterlets.



Rimae Herigonius, composed of section 1-2-3 & 2-4, length 100 km. **Gassendi A** (dia. 33 km) is at top corner. 2006.05.09 14:14UT Age 12 days. 10-in f/6+5X+ToUcam

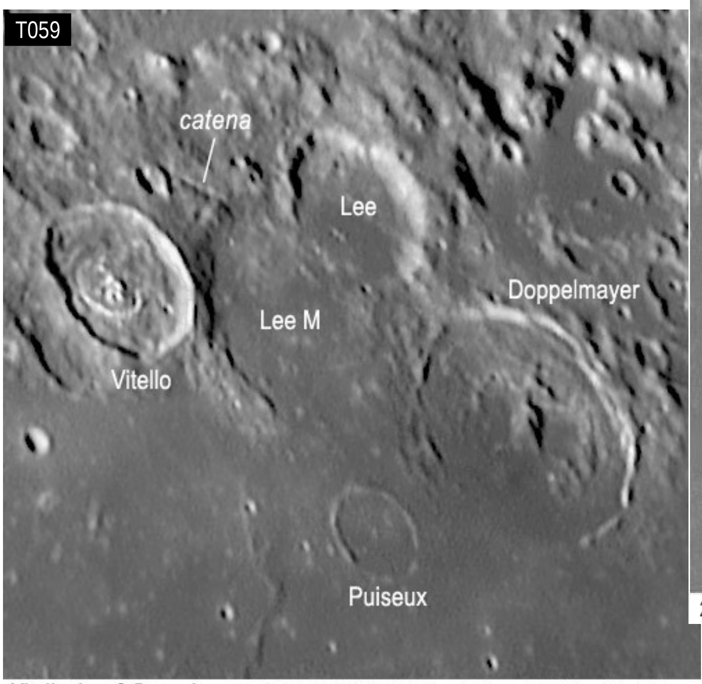
Image T059 & T123:

Vitello 37.5^0 W 30.4^0 S
A crater on the southern edge of Mare Humorum, 42 km in diameter. Its central peak is encompassed by a C-shaped cleft, giving the impression of a rope-jumping rabbit in a Chinese myth. A short chain of caterlets (catena) is in close vicinity.

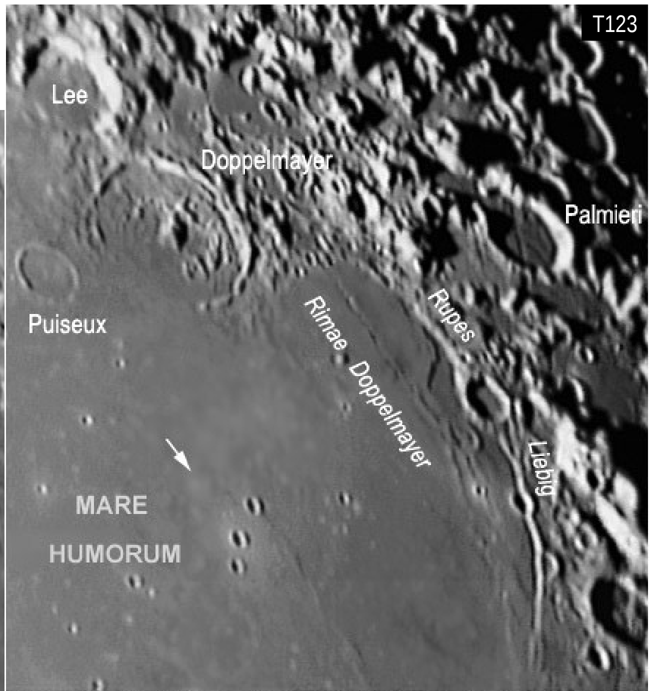
Lee 40.7^0 W 30.7^0 S,
Remains of a flooded crater, diameter 41 km. Its wall shares with ***Lee M*** (77 km).

Doppelmayer 41.4^0 W 28.5^0 S
A ruined crater with fairly large central peak, diameter 63 km. An inconspicuous system of rilles (***Rimae Doppelmayer***, length 160 km) runs in the vicinity. The arrow in T123 points to a skeptical dome.

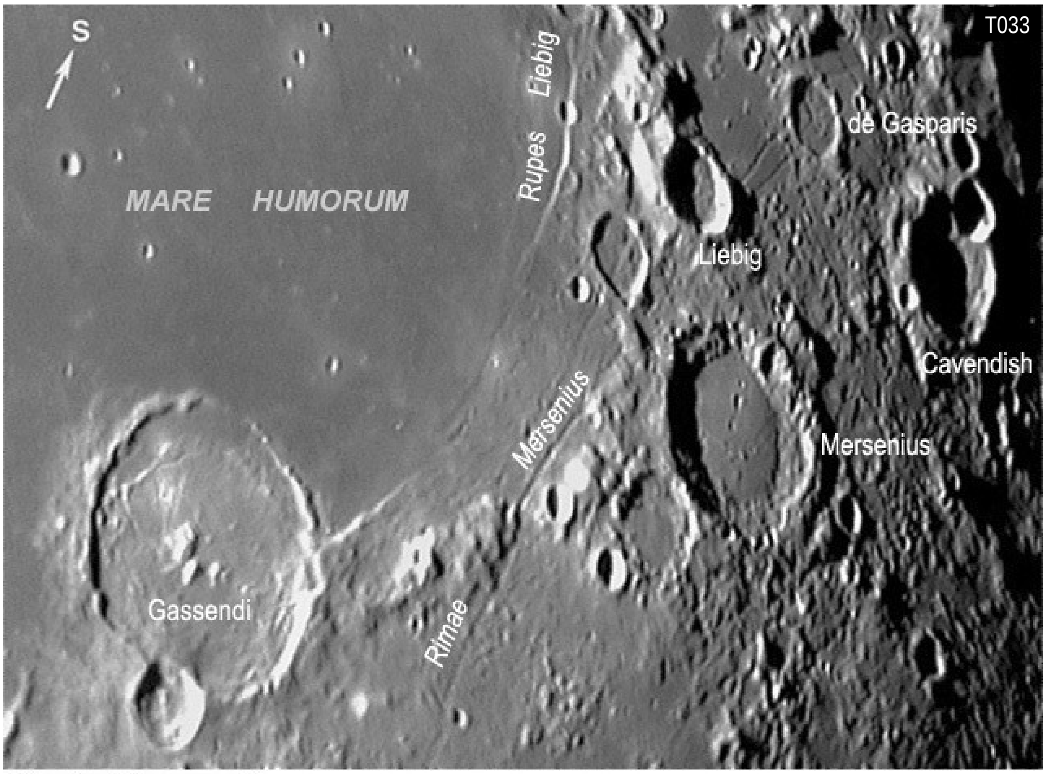
Palmieri See Map 28.



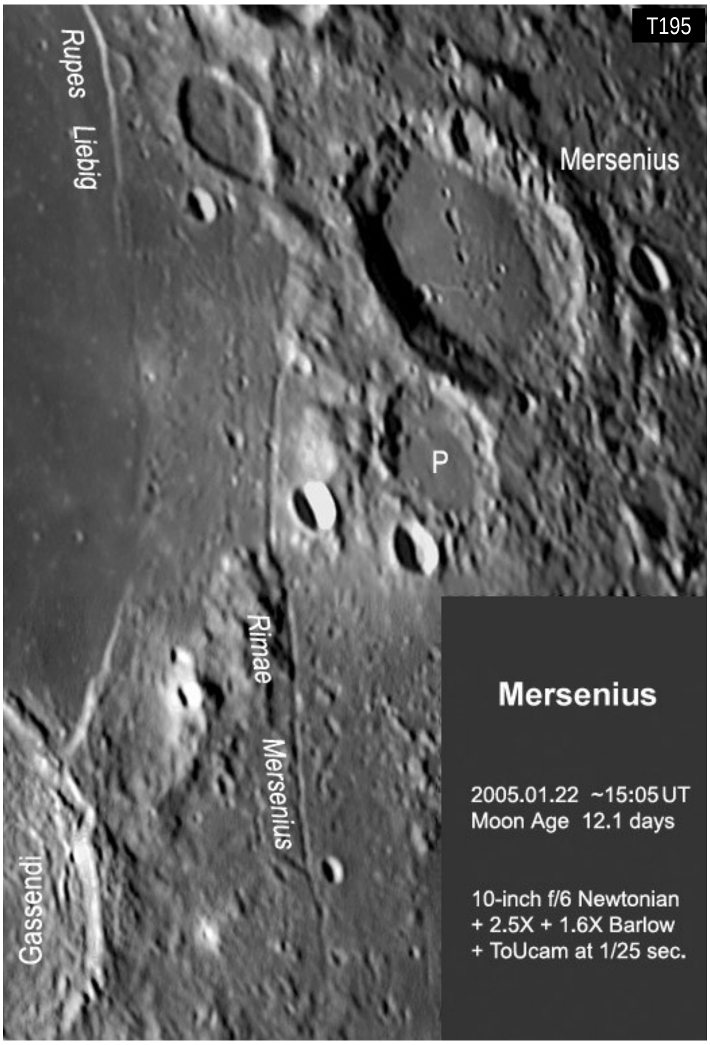
Vitello. Lee & Doppelmayer 2005.01.22 15:10 UT Age 12 days. 10-in f/6 + 4X + ToUcam



2006.09.04 14:18 UT Age 12 days. 10-in f/6 Newtonian + 2.5X + ToUcam



West of Gassendi 2002.12.16 15:12 UT Age 12 days. 10-in f/6 Royce mirror + 2.5X + ToUcam, 7 frames stacked.



Mersenius

2005.01.22 ~15:05 UT
Moon Age 12.1 days

10-inch f/6 Newtonian
+ 2.5X + 1.6X Barlow
+ ToUcam at 1/25 sec.

Images T033 & T195:

Cavendish 53.7^0 W 24.5^0 S
A crater, 56 km in diameter. Its wall is interrupted by two craters: ***Cavendish A*** and ***Cavendish E*** (the larger one).

de Gasparis 50.7^0 W 25.9^0 S
A flooded crater, 30 km in diameter. Its floor is crossed by ***Rimae de Gasparis*** (length 100 km).

Mersenius 49.2^0 W 21.5^0 S
A flooded crater, 84 km in diameter. It is somewhat convex and contains a group of inconspicuous rilles. Its wall adjoins the smaller flooded crater ***Mersenius P***.

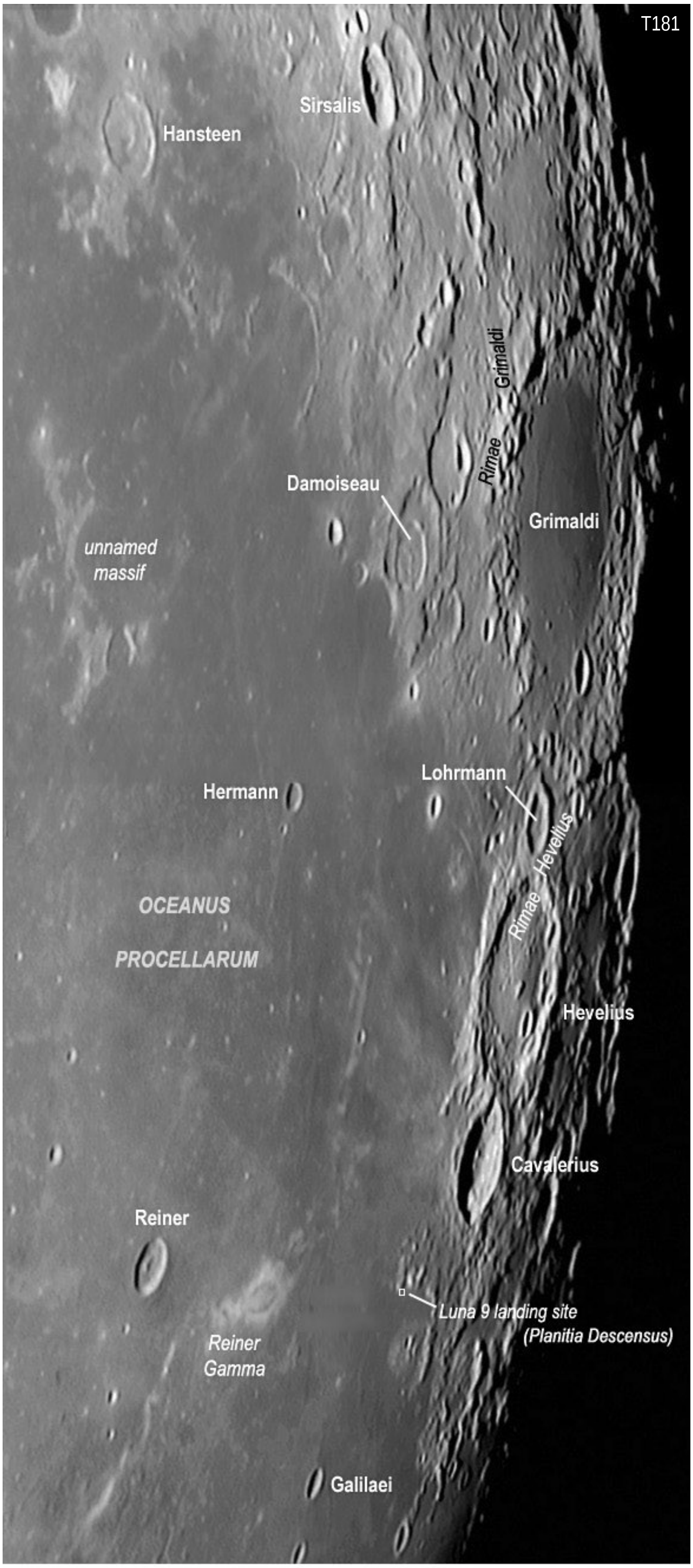
Rimae Mersenius 45^0 W 20^0 S
A prominent system of straight rilles, length 300 km.

Rupes Liebig 46^0 W 25^0 S
A scarp where the floor of Mare Humorum ends, length 180 km.

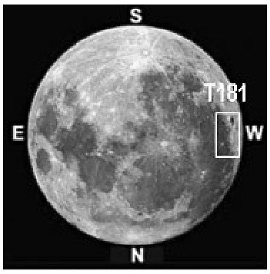
MAP 26

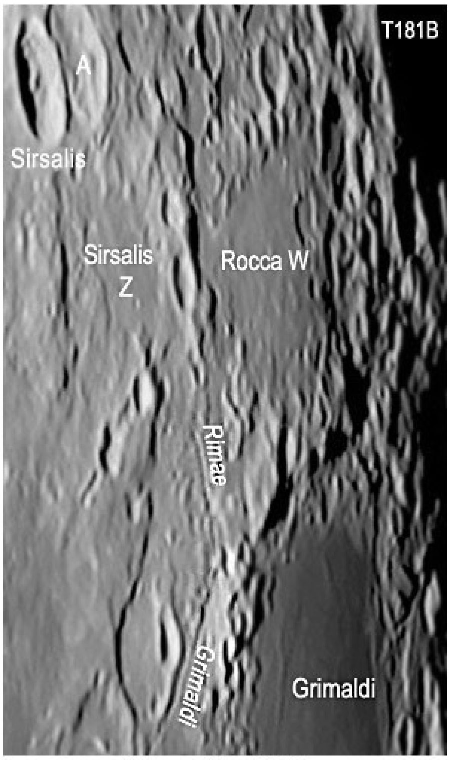
Hatfield 7
Rükl 39, 28

Grimaldi, Hevelius, Cavalerius, Riccioli, Hedin

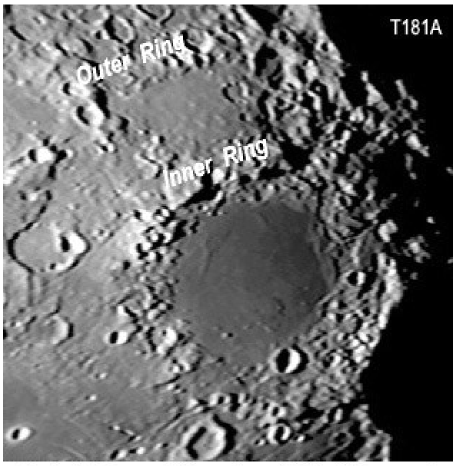


Grimaldi to Reiner Gamma 2004.11.25 16:42–16:45 UT Age 13 days. 10-in f/6 Newtonian + 2.5X + ToUcam

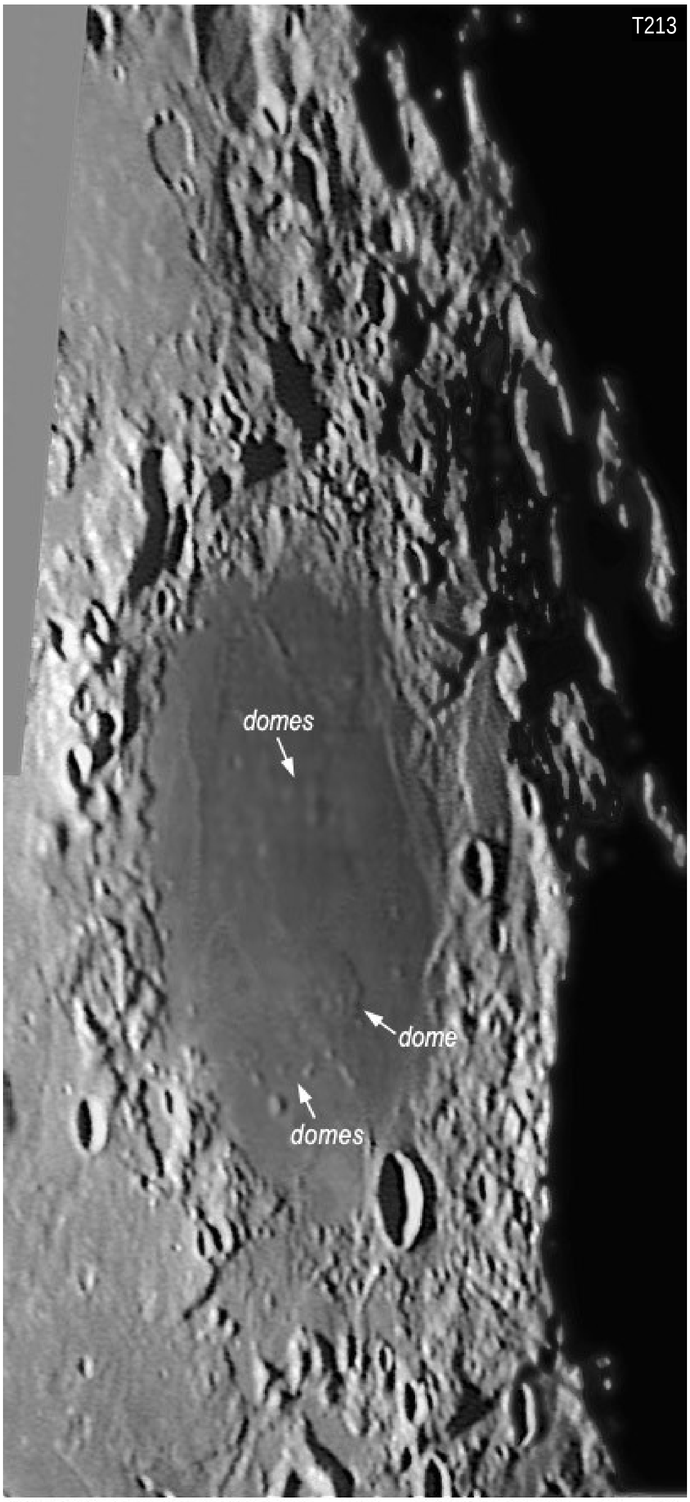




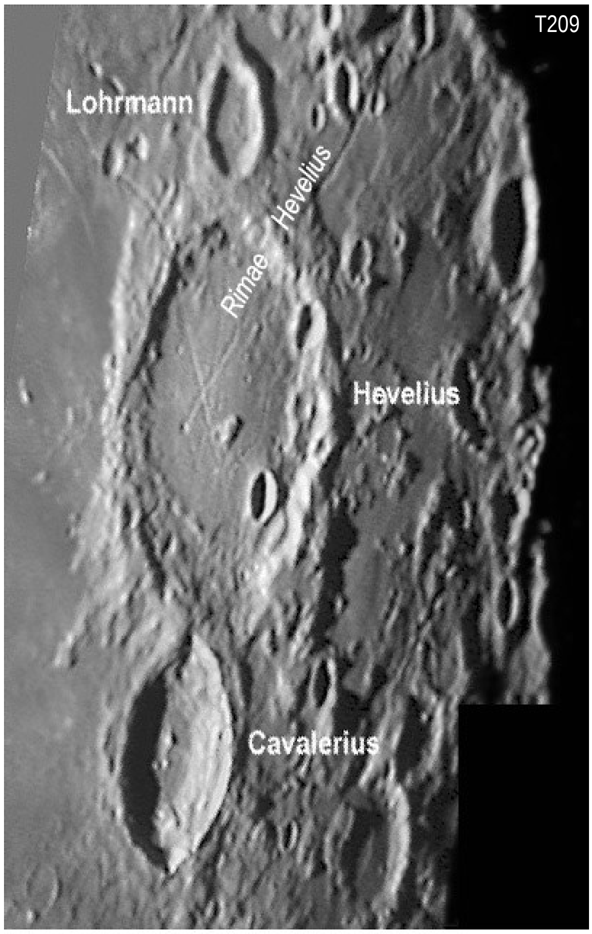
(Cropped from T181)



A simulated non-oblique view of Grimaldi, cropped from T181 and rescaled horizontally. Note the concentric ring mountains around the lava floor.



Grimaldi 2005.04.22 16:32UT Age 14 days. 10-in f/6+4X+ToUcam (*mosaic*)



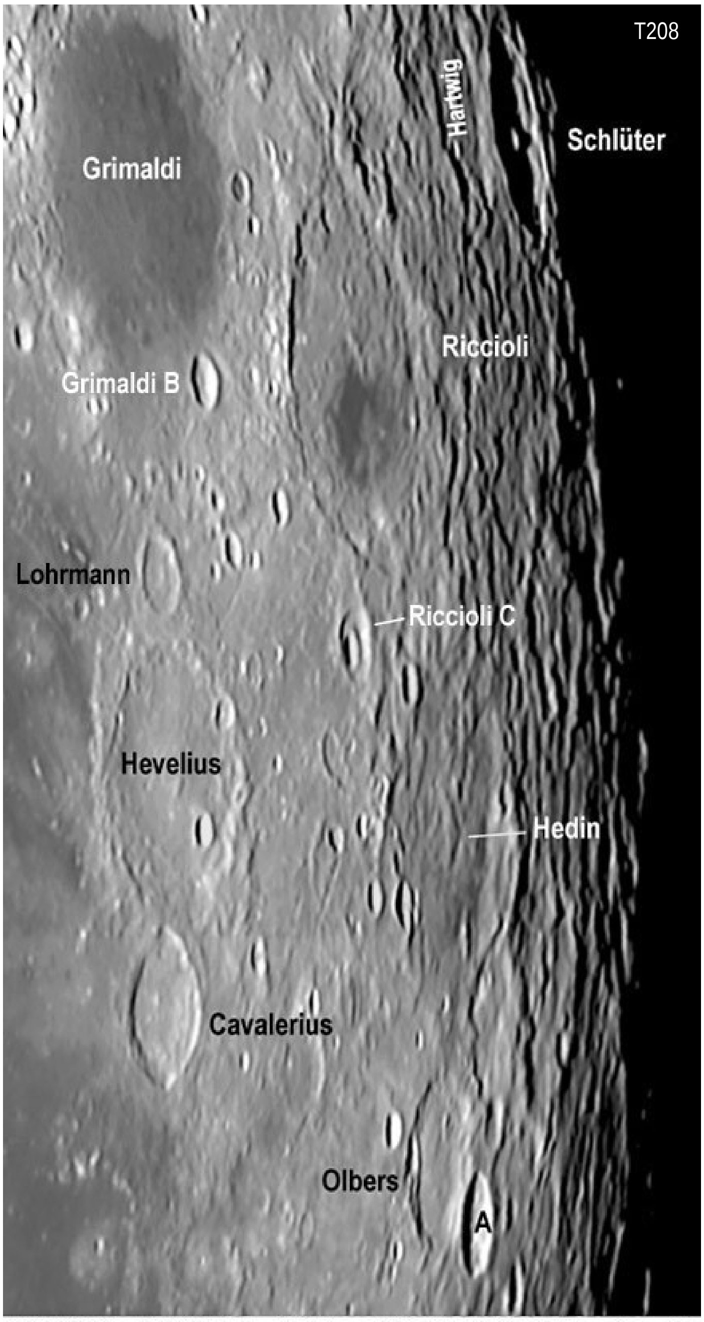
2005.04.22 ~16:25 UT Age 13.8 days. 10-in f/6 + 4X + ToUcam (mosaic)

Hevelius 67.6^{0} W 2.2^{0} N
A walled plain with small central peak, 115 km in diameter. Its southern floor is crossed by an X-pattern of rilles (***Rimae Hevelius***, length 180 km). The northern floor is less even and has a straight ridge.

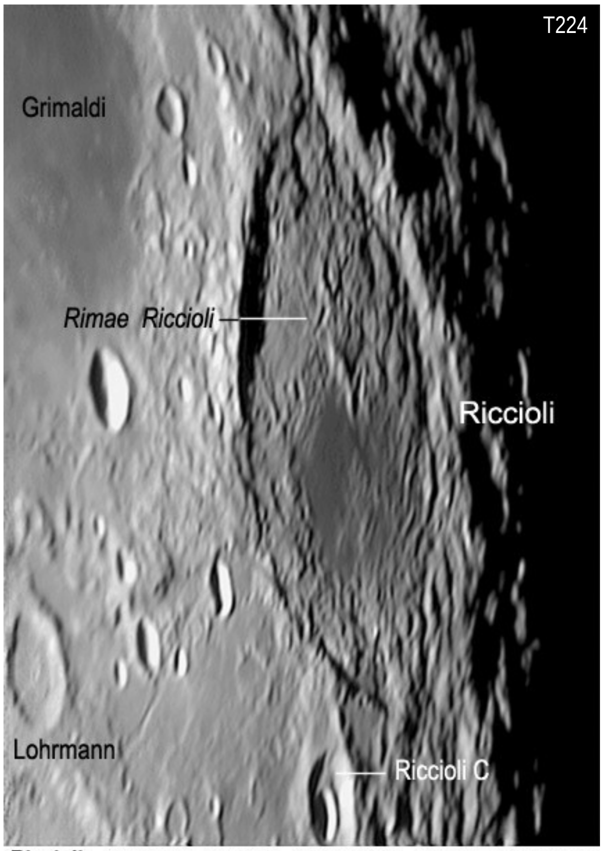
Cavalerius 66.8^{0} W 5.1^{0} N
A crater adjoining Hevelius, 57 km in diameter, 3000 m in depth (deeper than Hevelius in Image T209).

Lohrmann 67.2^{0} W 0.5^{0} S
A crater with fairly even floor, 30 km in diameter.

Grimaldi 68.3^{0} W 5.5^{0} S
By geology, Grimaldi is an impact basin flooded with lava more than a crater. It is characterized by two concentric mountain rings, see Image T181A. The outer ring, which is partially ruined, is about 400 km in diameter. The inner ring is about 200 km and the lava floor is 150 km. A dome with summit pits is located on the northern part of the floor; few smaller domes are also found under good seeing. In T181, an inconspicuous system of rilles (***Rimae Grimaldi***, length 230 km) adjoins the south-east wall. A blade of dark shadow appears to cut along the northern rim of Grimaldi. Like Mare Crisium in Map 2, Grimaldi contains a mascon.



2005.04.23 ~15:38 UT Age 14.8 days. 10-in f/6 + 2.5X + ToUcam (mosaic)



Riccioli 2005.05.22 ~14:31 UT Age 14.3 days. 10-in f/6 + 5X + ToUcam

Riccioli 74.6^0 W 3.3^0 S
A walled plain near the limb, 139 km in diameter. The Moon's equator crosses its northern outer wall. The southern floor of Riccioli is crossed by a system of rilles (***Rimae Riccioli***, 400 km) and the northern floor is lava-flooded. ***Riccioli C*** is a crater in which the floor is stuck by another crater.

Hedin 76.5^0 W 2.0^0 N
A disintegrated walled plain, 150 km in diameter. A large part of its floor is crossed by linear rilles.

Schlüter 83.3^0 W 5.9^0 S
A crater with terraced walls and central peaks, 89 km in diameter.

Olbers & **Olbers A** A pair of rayed craters, see Map 23.

(Image T181, previous page)

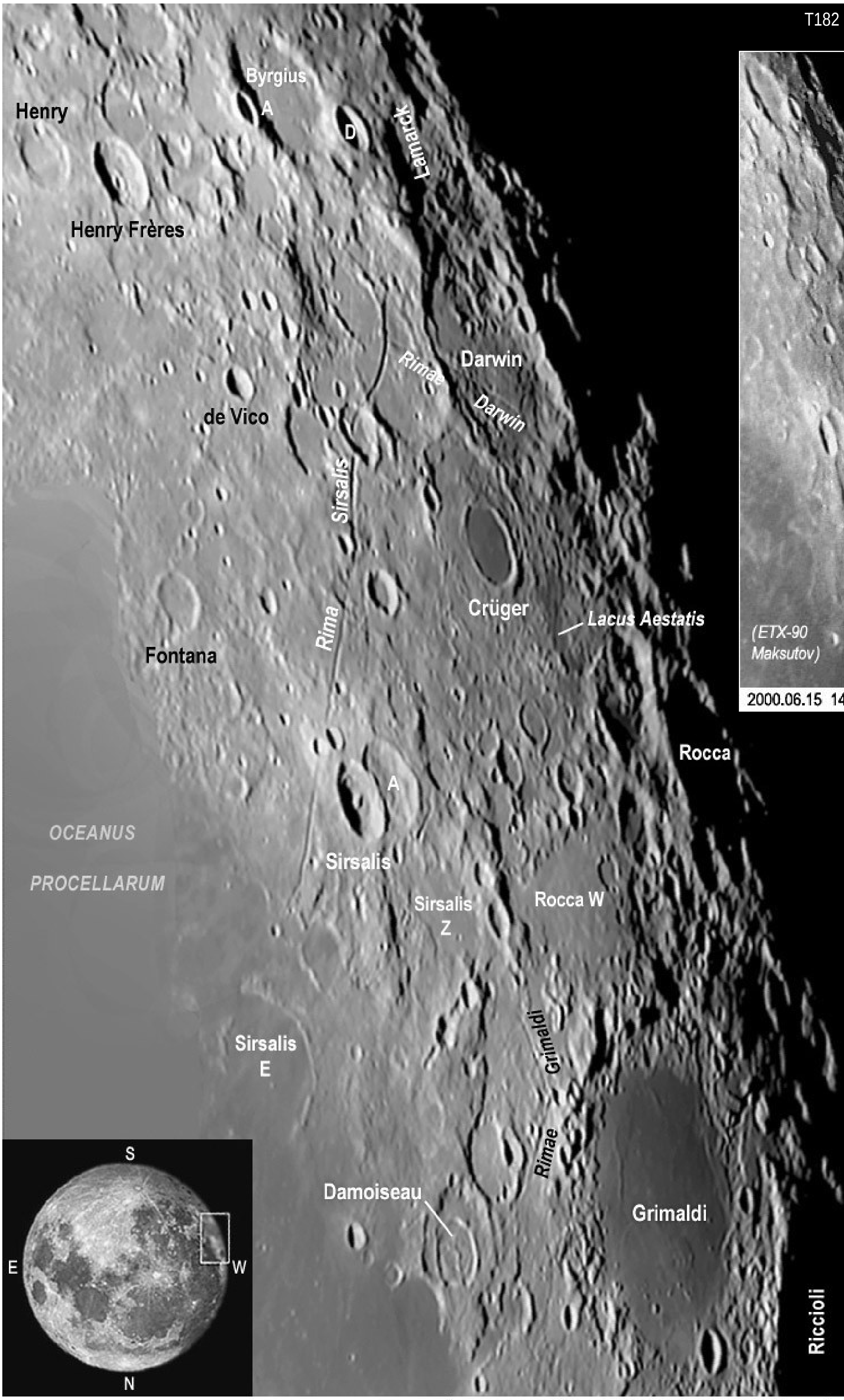
Planitia Descensus (Plain of Desert) 64^0 W 7^0 N
Originally named for the site of the first soft landing by the Soviet Luna 9 probe in 1966. The American Lunar Orbiter probe, however, maps Planitia Descensus including the adjacent mare.

Damoiseau 61.1^0 W 4.8^0 S
A crater with shallow floor, 36 km in diameter. See also Map 27.

MAP 27

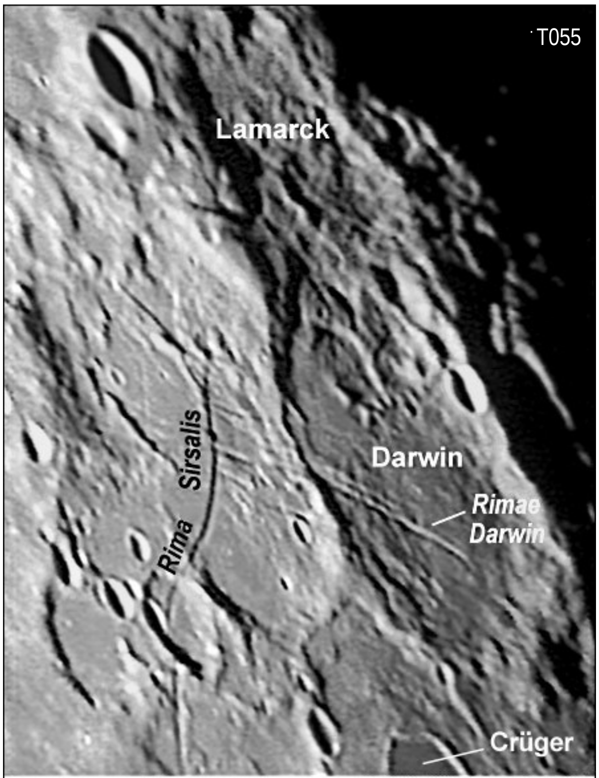
Hatfield 11
Rükl 50, 39, 40

Darwin, Byrgius, Rimae Sirsalis, Crüger, Billy, Hansteen



2005.04.22 ~16:09 UT Age 13.8 days. Longitudinal libration *l* = -5.3°. 10-in f/6 Newtonian + 2.5X + ToUcam (*mosaic*)

2000.06.15 14:36 UT Age 13 days.



Darwin & Rimae Darwin 2005.04.22 16:34UT Age 13.8 days. 10-in f/6 + 4X + ToUcam

Darwin 69.5^0 W 20.2^0 S
Darwin is a complex disintegrated walled plain, 120 km in diameter. A cluster of smaller craters is located on its southern floor. Its northern floor is crossed by ***Rimae Darwin*** (length 150 km) and contains a weird dome hill which is visible only under appropriate illumination. See Image T034. When Darwin is near the terminator, it resembles one wing of a butterfly while the other wing is an unnamed feature.

Lamarck 69.8^0 W 22.9^0 S
A disintegrated crater sharing the walls with Darwin, 100 km in diameter.

Byrgius 65.3^0 W 24.7^0 S
Byrgius is a crater with fairly flat floor, 87 km in diameter. ***Byrgius A*** (19 km) is a bright rayed crater under high illumination.

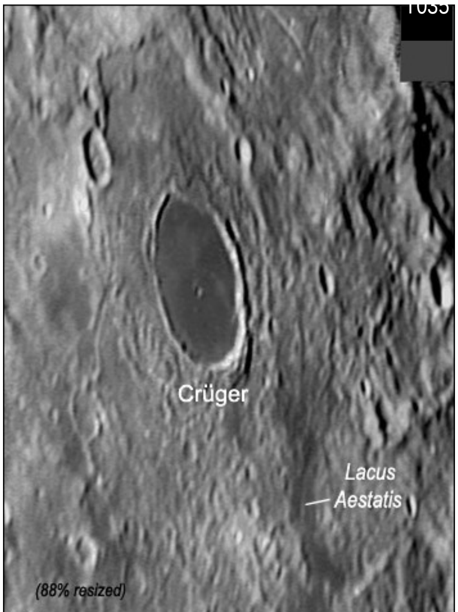
Sirsalis 60.4^0 W 12.5^0 S
A crater with small central peak, 42 km in diameter. It is also a rayed center under high illumination. Sirsalis intersects the rim of ***Sirsalis A*** (once known as ***Bertaud***, 49 km in diameter). A trough is just outside Sirsalis A.

2005.05.22 15:42 UT Age 14 days. 10-in f/6 Newtonian + 5X + ToUcam

In T156+T196 of next page, Sirsalis is shadowed by the terminator and hence appears like a black hole. Note also the narrow strip of wall extending from the northern rim of Sirsalis. This wall belongs to the irregular crater ***Sirsalis Z*** (~ 90 km); it casts a weird triangular shadow around Moon age of 12 days.

Rimae Sirsalis 62^0 W 17^0 S
A sizeable system of rilles. The most prominent rille in this system is ***Rima Sirsalis***, about 400 km long, visible even in small telescopes. Its northern end begins near crater Sirsalis and its southern end extends almost to Byrgius.

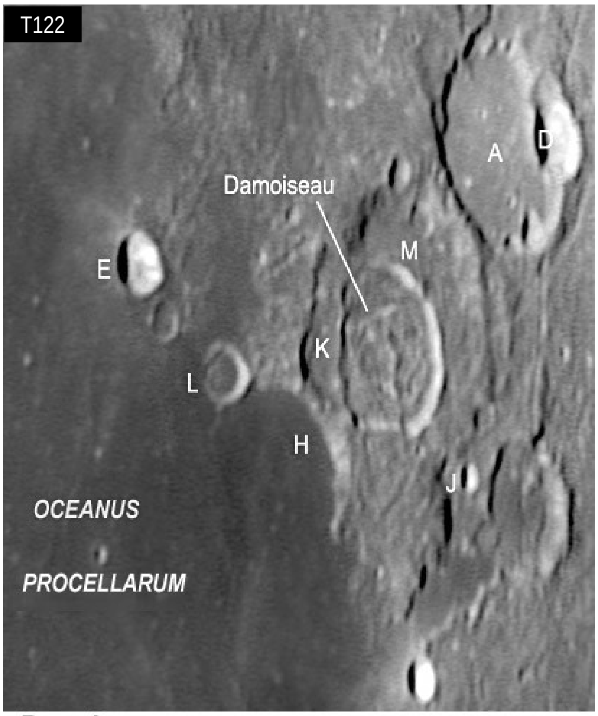
Image T035:



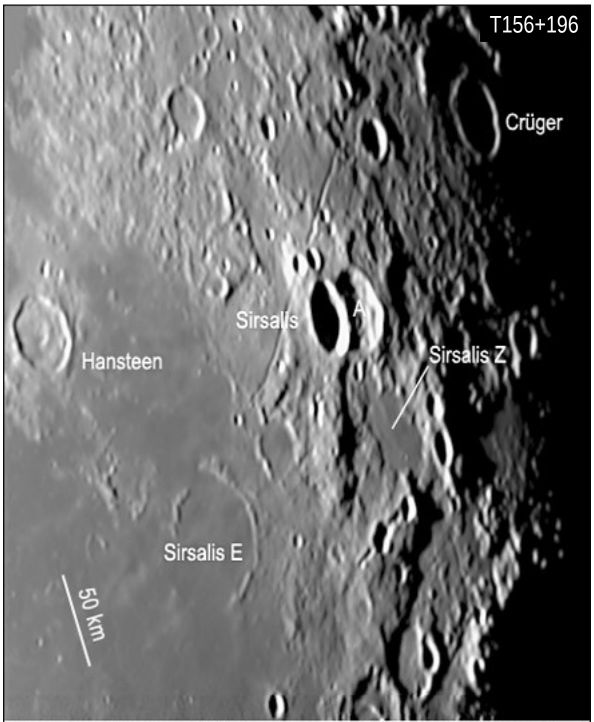
Crüger 2005.05.22 15:26UT Age 14 days. 10-in f/6 + 5X + ToUcam

Crüger 66.8^0 W 16.7^0 S
A flooded crater with a central craterlet on the dark-flat floor, 45 km in diameter.

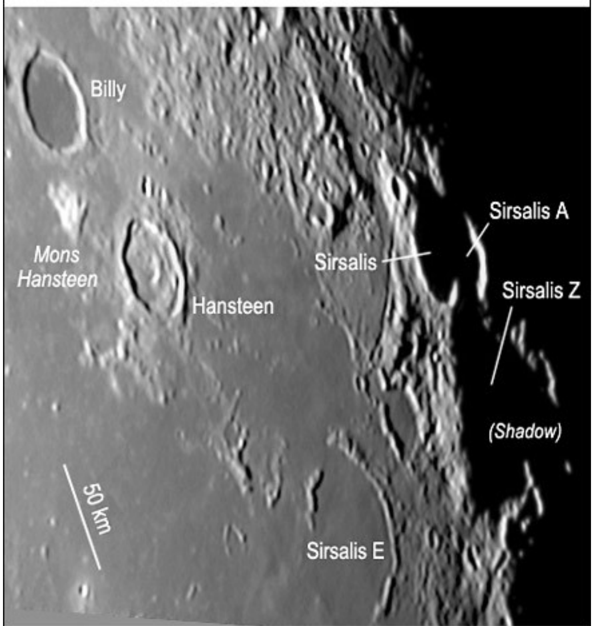
Lacus Aestatis (Summer Lake) 69^0 W 15^0 S
A curved strip of dark lava, about 90 km long, total area 1000 square km.



Damoiseau 2005.05.22 15:44UT Age 14 days. 10-in f/6+5X+ToUcam



Sirsalis 2005.05.21 15:16 UT Age 13 days. Orion 6-in f/8 Newtonian + 2.5X + ToUcam



Shadow of Sirsalis Z 2004.09.26 16:35UT Age 12 days. 10in f/6+2.5X+ToUcam

Damoiseau 61.1^0 W 4.8^0 S (*Image T122*)
A shallow crater with rough ridged floor, 36 km in diameter. It is encompassed by crater ***Damoiseau K*** and ***Damoiseau M***.

Image T037, next page:

Billy 50.1^0 W 13.8^0 S
A dark-floor crater almost identical to Crüger, 45 km in diameter; but Billy does not have a central craterlet. ***Rima Billy*** (length 70 km) is in the south-east.

Hansteen 52.0^0 W 11.5^0 S
A crater with fractured floor and internal hills, diameter 44 km. A short rille (***Rima Hansteen***, length 25 km) is in the close vicinity.

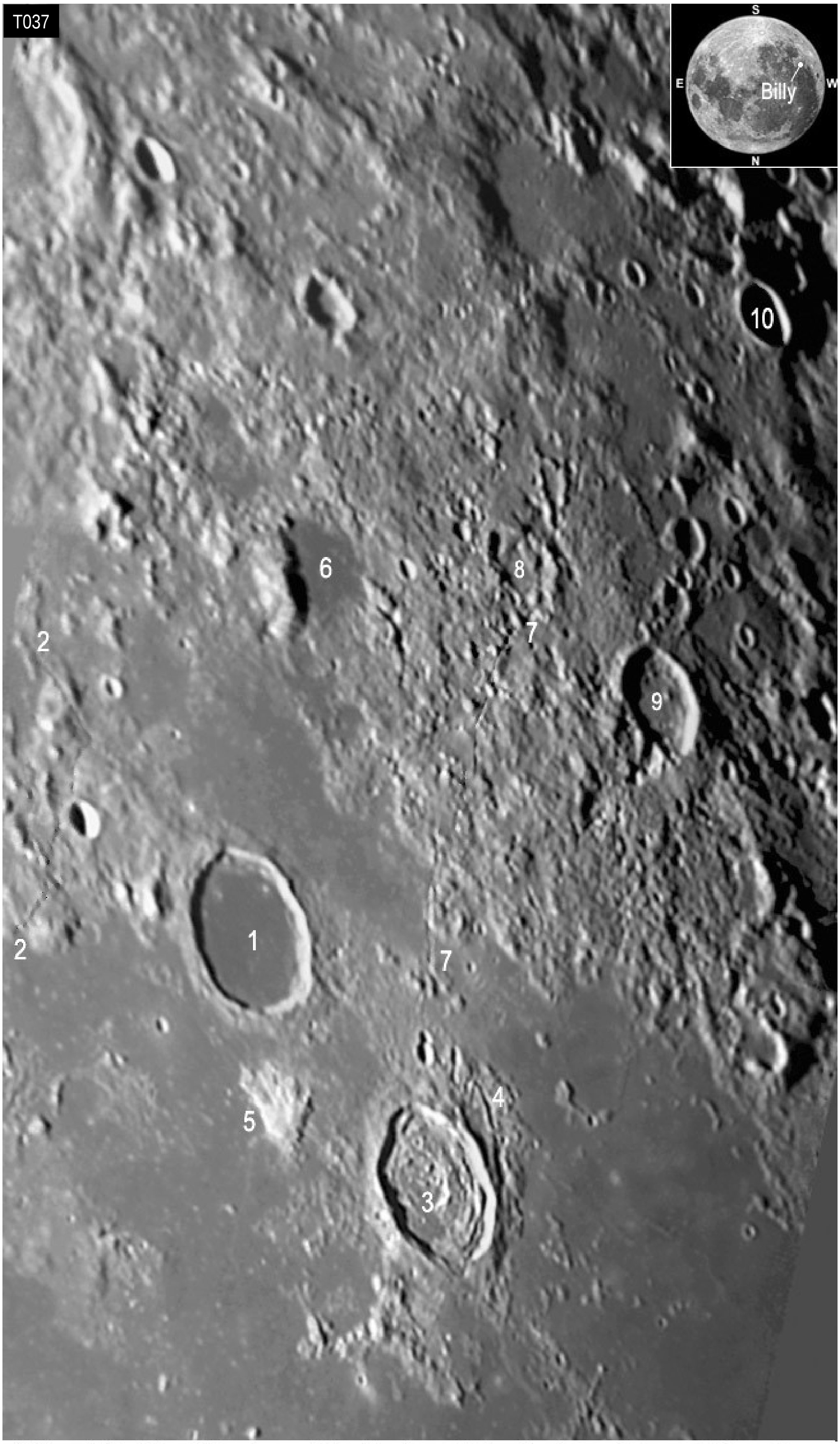
Mons Hansteen 50^0 W 12^0 S
A triangular hand-shaped mountain, base 30 km. Very bright.

Zupus 52.3^0 W 17.2^0 S
Remains of a lava-flooded craters, 38 km in diameter. Its floor is darkened. Its eastern rim looks straight and is considerably higher than the western surroundings.

Rimae Zupus 53^0 W 15^0 S
A system of rilles, 120 km in length. It is difficult to observe.

Fontana 56.6^0 W 16.1^0 S
A crater with off-centered peak, 31 km in diameter.

Billy, Hansteen and southern vicinity

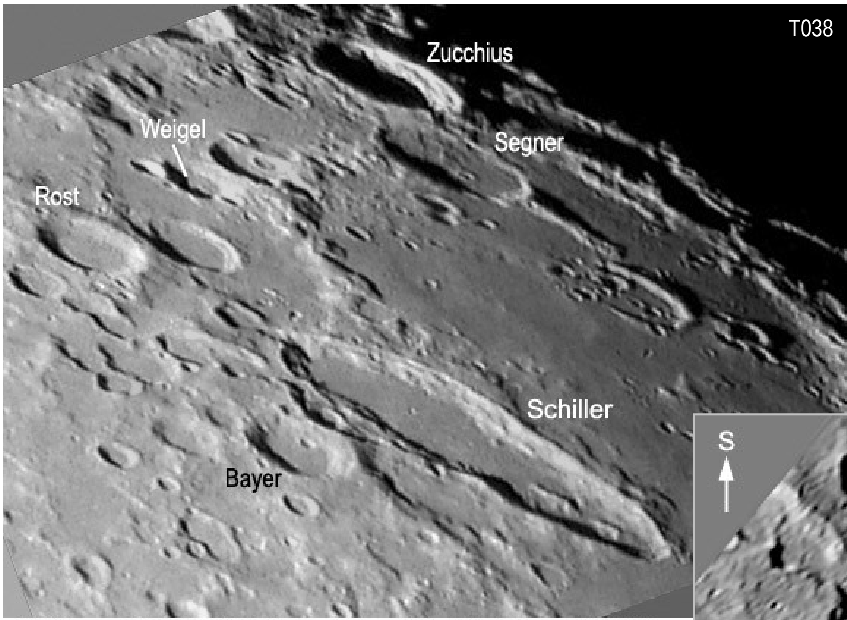


1. Billy 2. Rima Billy 3. Hansteen 4. Rima Hansteen 5. Mons Hansteen 6. Zupus 7. Rimae Zupus 8. Zupus C 9. Fontana 10. de Vico 2006.05.10 14:52 UT Age 13 days. 10-in f/6 Newtonian + 4X + ToUcam

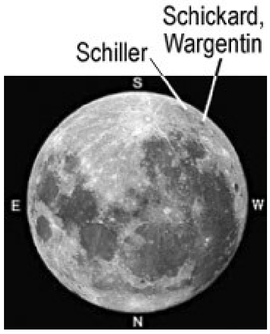
MAP 28

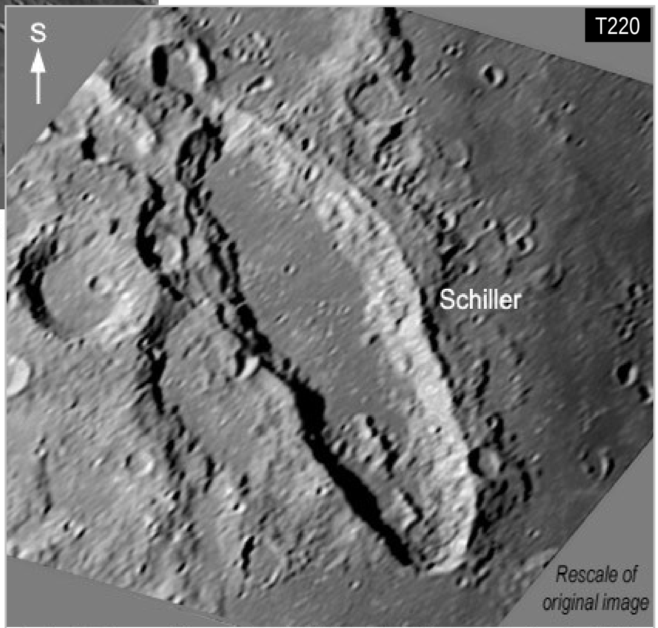
Hatfield 10, 12
Rükl 71, 70, 62, 61

Schiller, Schickard, Wargentin and southwest limb



Schiller 2002.12.16 !5:17UT Age 12 days. 10-in f/6 Newtonian + 2.5X + ToUcam,





A simulated non-oblique view of Schiller. The picture center line is 40° W.
2005.04.21 13:56UT Age 12.5 days. 10-in f/6+4X+ToUcam, 65 frames stacked.

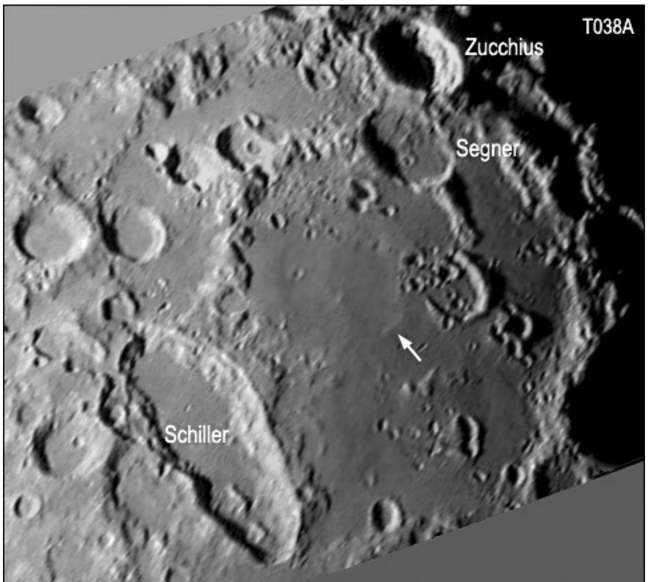
Schiller 39.0° W 51.9° S
A truly elongated crater, 178 x 71 km. The southern half of the floor is fairly flat but the northern half contains two mountain peaks. It seems Schiller is the fusion of two adjoined near-sized craters which formed at the same time. An alternative proposal based on NASA laboratory experiment is that Schiller was created by a grazing impactor, which could be an orbiting debris spiraling into the Moon and hitting the Moon at very low angle (few degress measured from ground).

(Other examples of elongated craters in Map 3, 4, 6, 12, 14 & 20 .)

Segner 48.3° W 58.9° S
A shallow crater with rough floor, 67 km in dia.

Zucchius 50.3° W 61.4° S
A crater with terraced wall, 64 km in diameter.

Schiller-Zucchius Impact Basin
The territory between Schiller and Zucchius is an impact basin characterized by two concentric mountain rings. The inner ring (dia. 200 km) intersects Segner; the outer ring (dia. 330 km) intersects Zucchius. There is also the hint of a third ring almost buried beneath the mare floor, as marked by arrow in Image T038A. This basin contains a mascon.

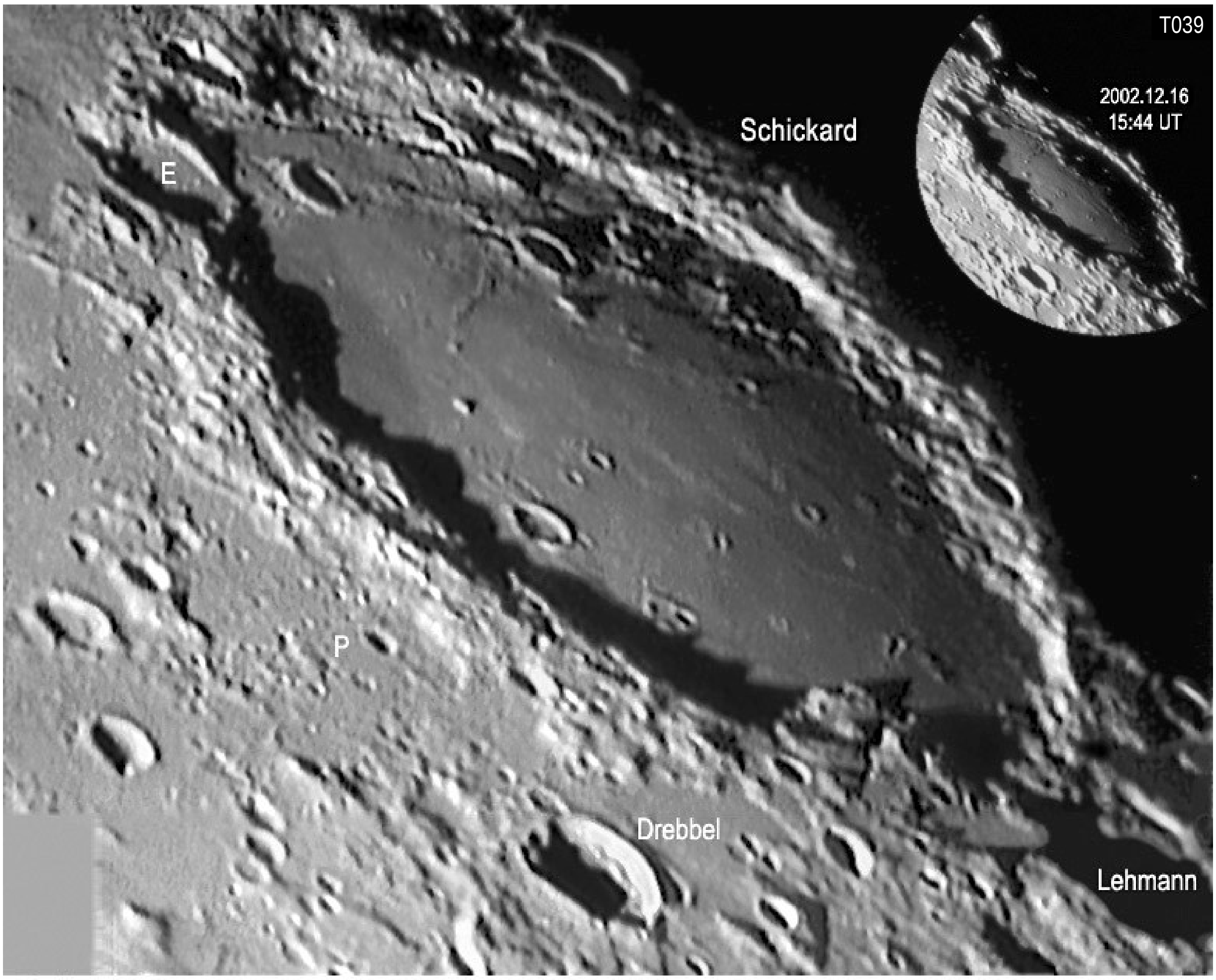


Same image as T038 but rescaled to simulate a non-oblique view of the Schiller-Zucchius Basin.

Image T039:

Schickard 55.3^0 W 44.3^0 S
A prominent vast walled plain, 206 km in diameter. A large part of the floor is flooded with dark lava. It casts spiky shadows on the floor under low Sun angles. Schickard adjoins ***Schickard P*** (ghost crater, diameter 92 km) and ***Lehmann*** (53 km). Quite often, the floor of Schickard looks convex (T039 top corner).

Drebbel 49.0^0 W 40.9^0 S
A sharp-rimmed crater, 30 km in diameter.



Schickard 2005.01.22 15:17~15:20 UT Age 12.1 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam at 1/25 sec (*mosaic*)

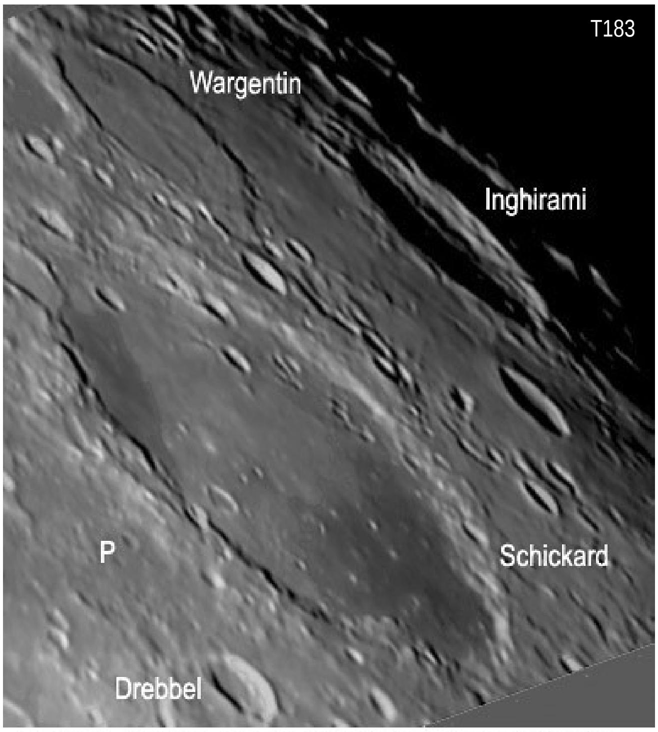
Images in next page:

Inghirami 68.8^0 W 47.5^0 S
A crater with rough floor, 91 km in diameter.

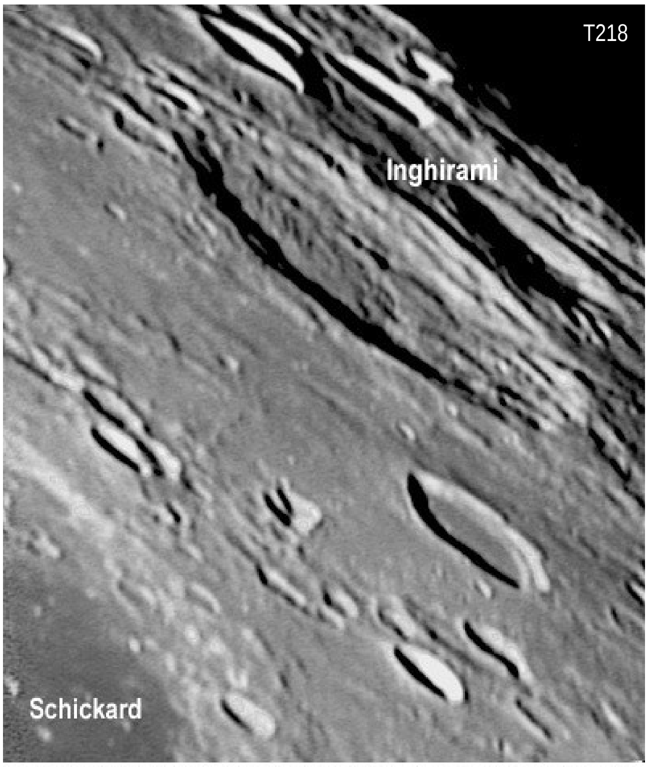
Lacus Excellentiae (Lake of Excellence) 43^0 W 36^0 S
A 180 km-long irregular mare where the Smart-1 lunar probe clashed deliberately. See Map 25.

Nöggerath 45.7^0 W 48.8^0 S
A crater with smooth floor, 30 km in diameter.

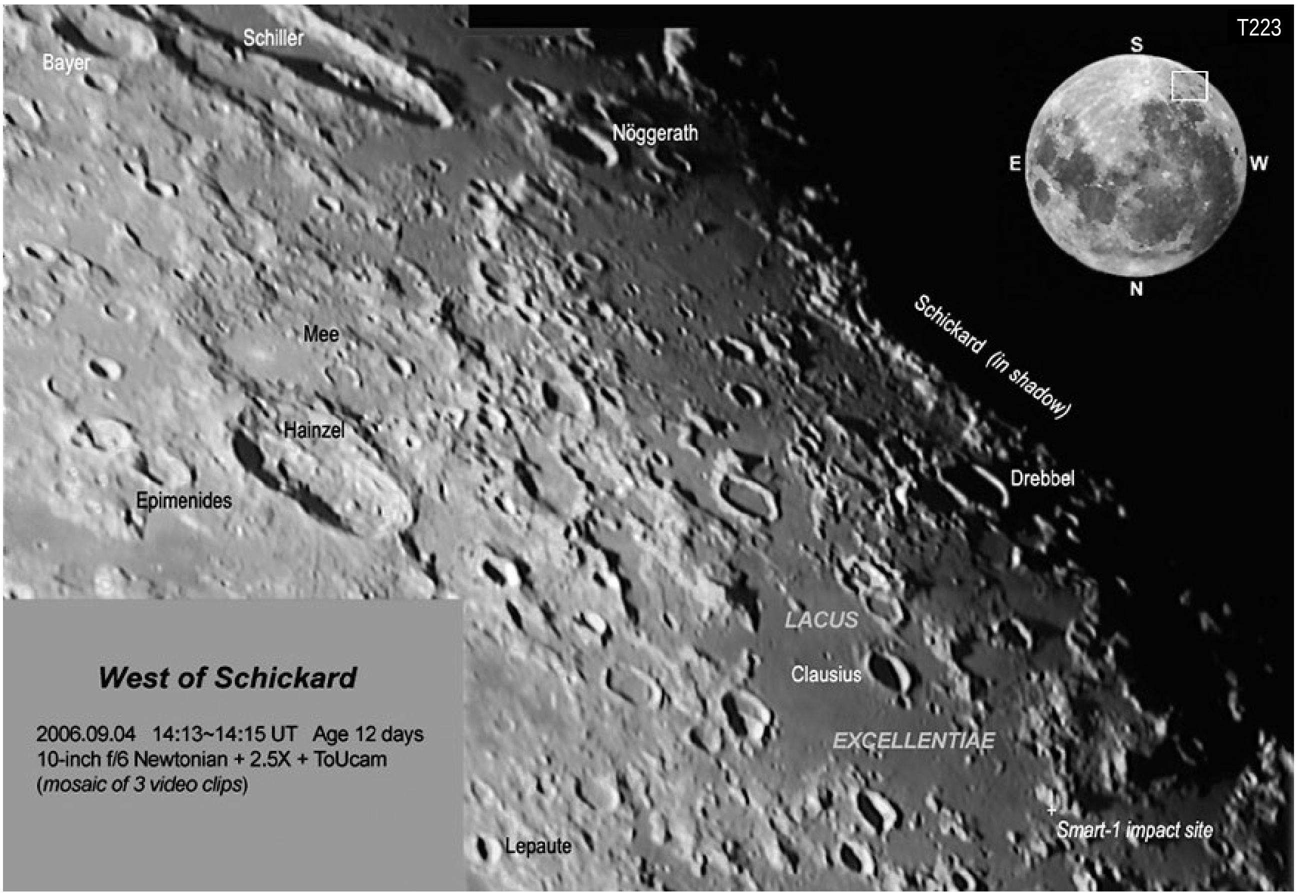
Mee, Hainzel A crater pair. Details in Map 29.



2004.11.25 14:52 UT Age 13 days. 10-in f/6 Newtonian + 2.5X + ToUcam

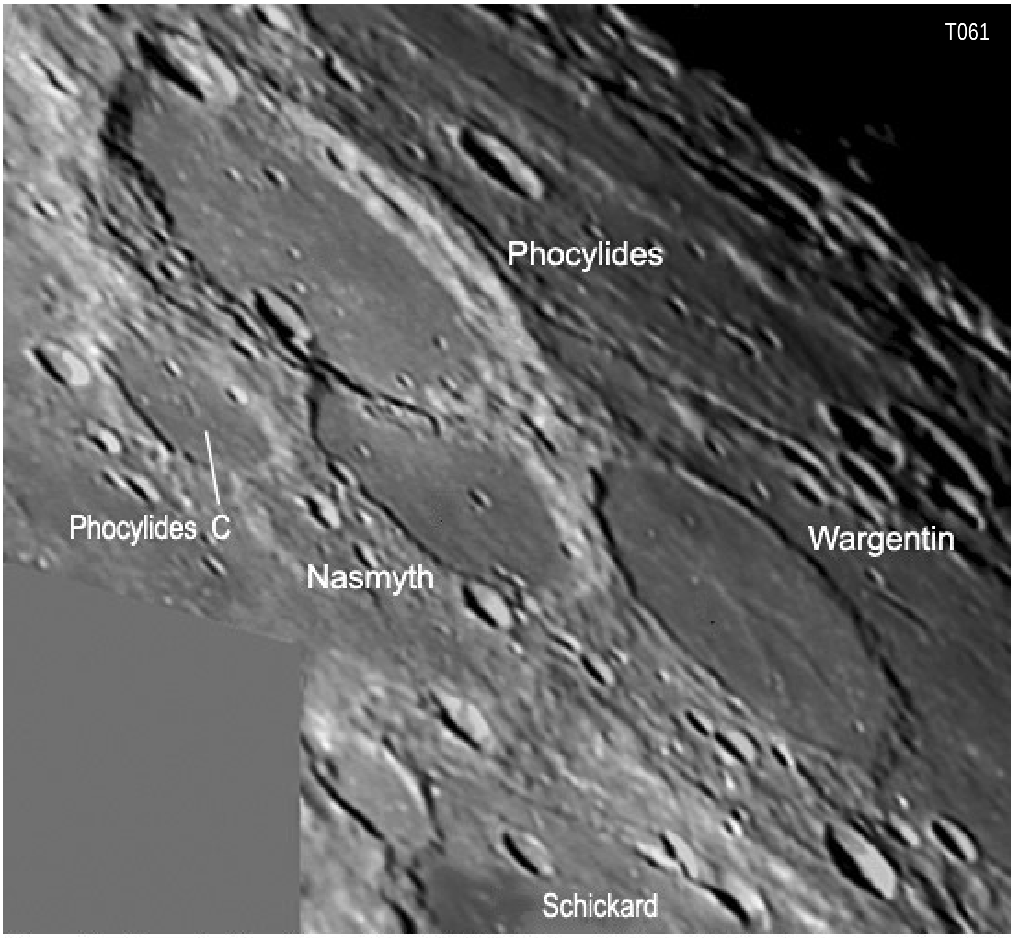


Inghirami 2005.05.22 15:42UT Age 14 days. 10-in f/6 + 5X + ToUcam (80% resized)



West of Schickard

2006.09.04 14:13~14:15 UT Age 12 days
10-inch f/6 Newtonian + 2.5X + ToUcam
(*mosaic of 3 video clips*)



Wargentin, Nasmyth, Phocylides 2005.04.22 16:41 UT Age 13.8 days. 10-in f/6 + 4X + Toucam, 85% resized.

Image T061:

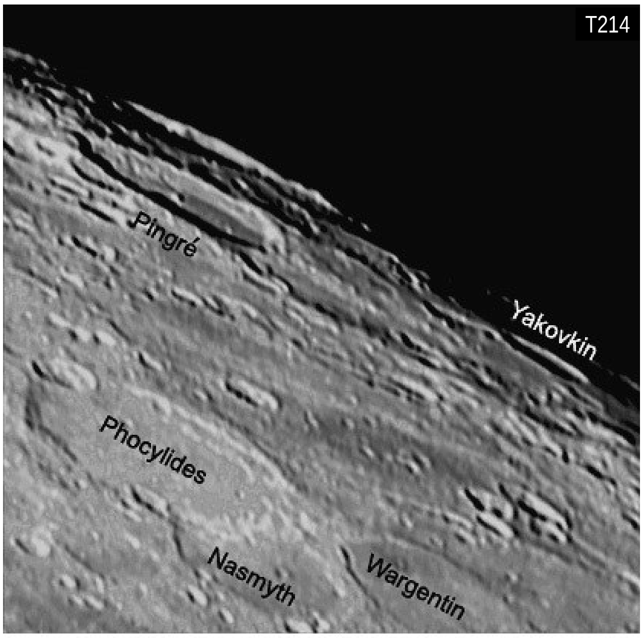
Wargentin 60.2^0 W 49.6^0 S
A rare type of "plateau crater", 84 km in diameter. It is filled up with solidified dark lava almost to the top of the rim. The floor is raised 400 m above the surrounding, and is crossed by a complex of wrinkle ridges. A craterlet with dark halo is found on the southern floor.

Phocylides 57.0^0 W 52.7^0 S
A flooded crater, 121 km in diameter. Its eastern wall is eroded and adjoins ***Phocylides C*** (46 km).

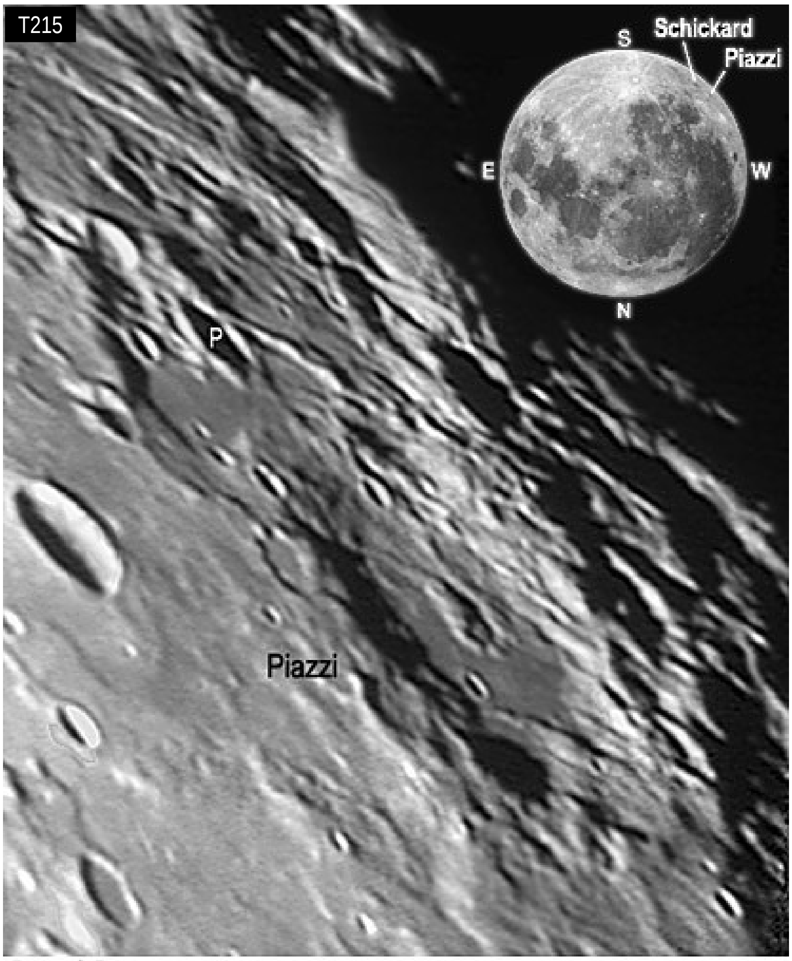
Nasmyth 56.2^0 W 50.5^0 S
A flooded crater sharing the walls with Wargentin and Phocylides , 76 km in diameter.

Image T214:

Pingré 73.7^0 W 58.7^0 S
Yakovkin 78.8^0 W 54.5^0 S
Both craters are quite close to the limb and hence best seen in favorable libration. Pingré is 89 km in diameter, Yakovkin is 37 km.



2005.04.23 16:08 UT Age 14.8 days (99% full Moon). 10-in f/6 + 2.5X + ToUcam



Piazzi & Piazzi P 2005.05.22 17:17UT Age 14 days. 10-in f/6 Newtonian + 4X + ToUcam

Image T215 & T184:
Craters in the north of Schickard

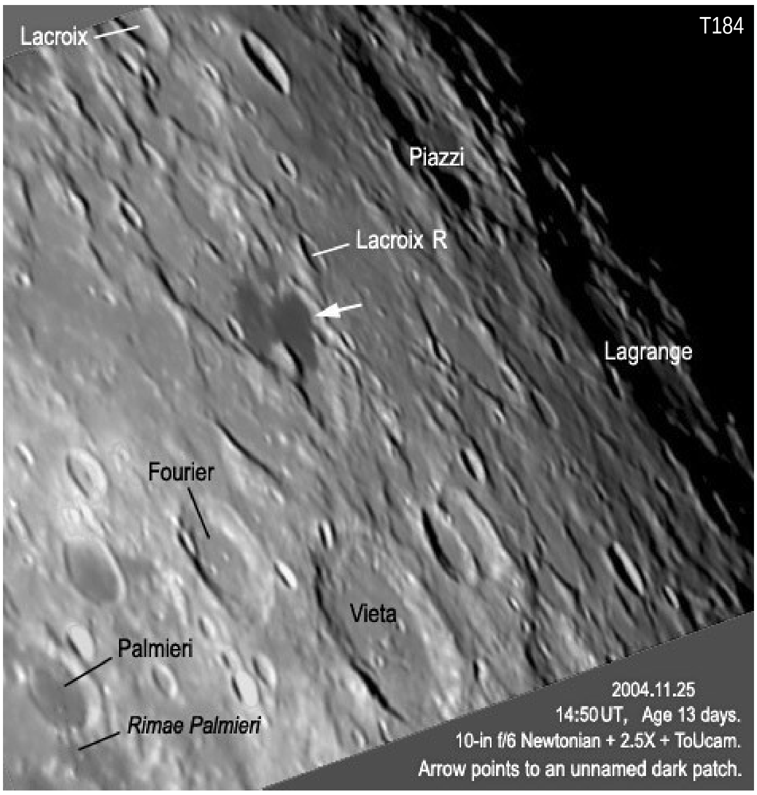
Piazzi 67.9^{0} W 36.6^{0} S
An eroded walled plain, 134 km in diameter.

Lagrange 72.8^{0} W 32.3^{0} S
A walled plain, 225 km in diameter.

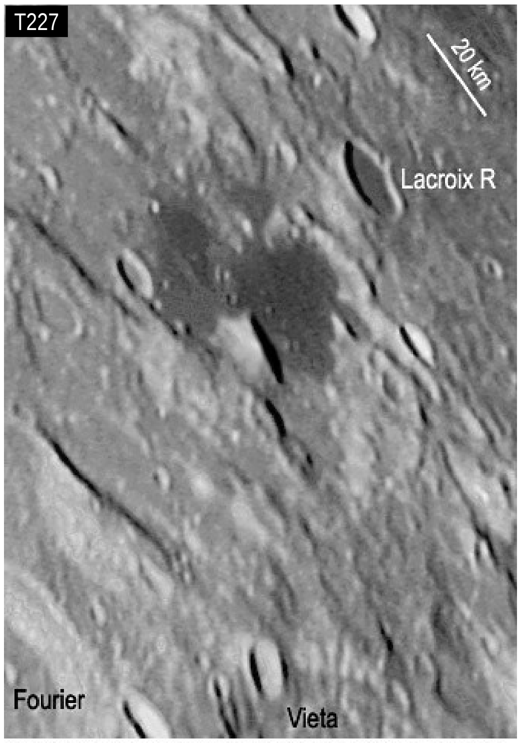
Vieta 56.3^{0} W 29.2^{0} S
A crater, 87 km in diameter. In its south is an unnamed, isolated dark patch, roughly 40 km across. The irregularity of the patch suggests this might be magma leaked out through the local crust fractures. The darkened floor of ***Lacroix R*** might be similar magma leak but trapped by the crater walls. See also T227.

Fourier 53.0^{0} W 30.3^{0} S
A crater, 51 km in diameter.

Palmieri 47.7^{0} W 28.6^{0} S
A flooded crater, 40 km in diameter. Its floor is crossed by a system of narrow rilles (***Rimae Palmieri***, length 150 km). See also T123 in Map 25.



2004.11.25
14:50UT, Age 13 days.
10-in f/6 Newtonian + 2.5X + ToUcam.
Arrow points to an unnamed dark patch.

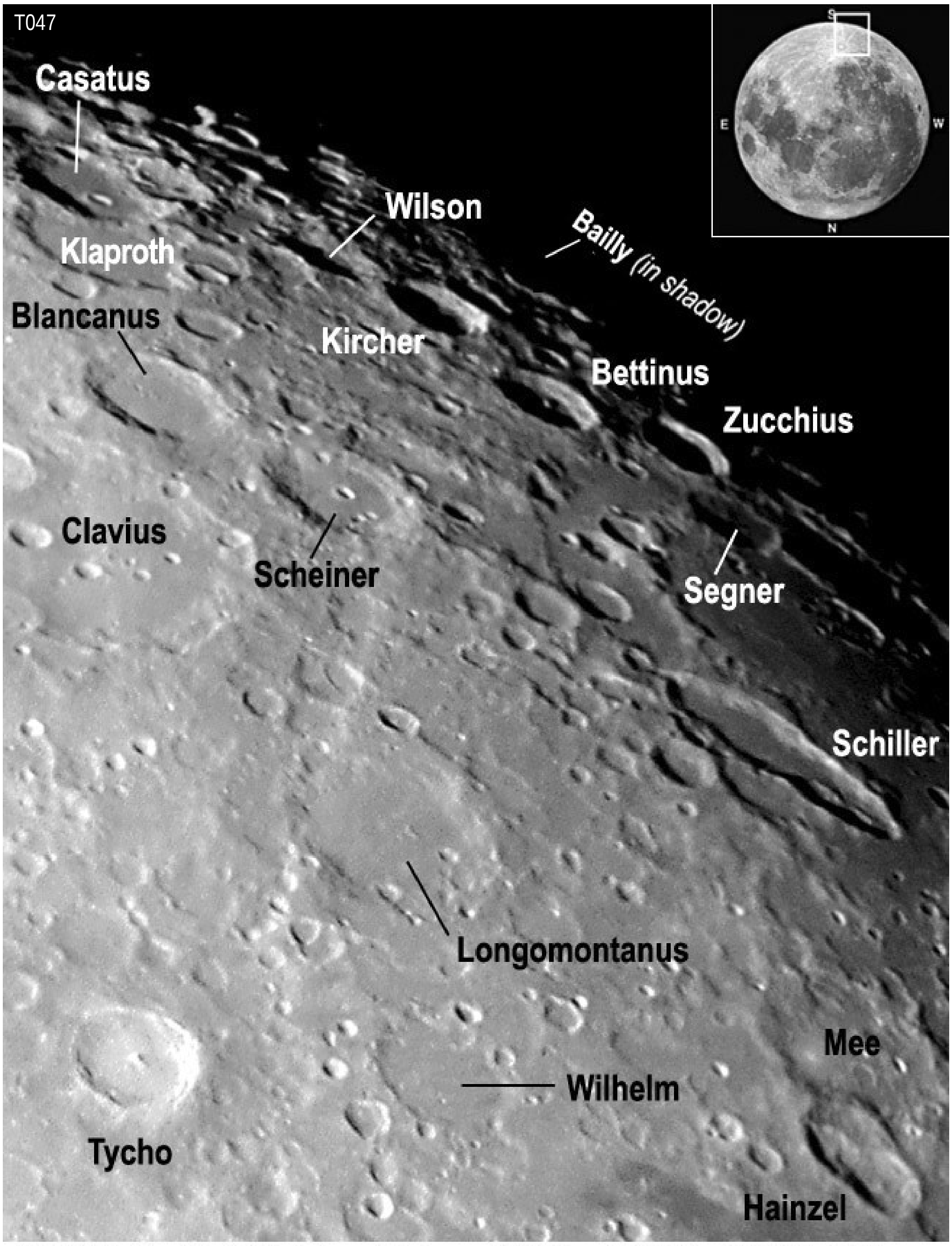


Dark patch south of Vieta 2005.05.22 15:38UT Age 14 days
10-in f/6 Newtonian + 5X + ToUcam, 88 frames stacked, 85% resized.

MAP 29

Hatfield 12
Rükl 71, 72, 63, 64

Bailly, Longomontanus, Wilhelm, Mee, Hainzel

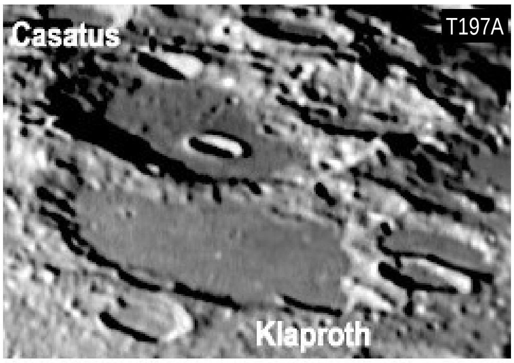


2000.05.15 14:15 UT Age 11 days. FS102 + LE12.5 + CP950 1/40 sec.

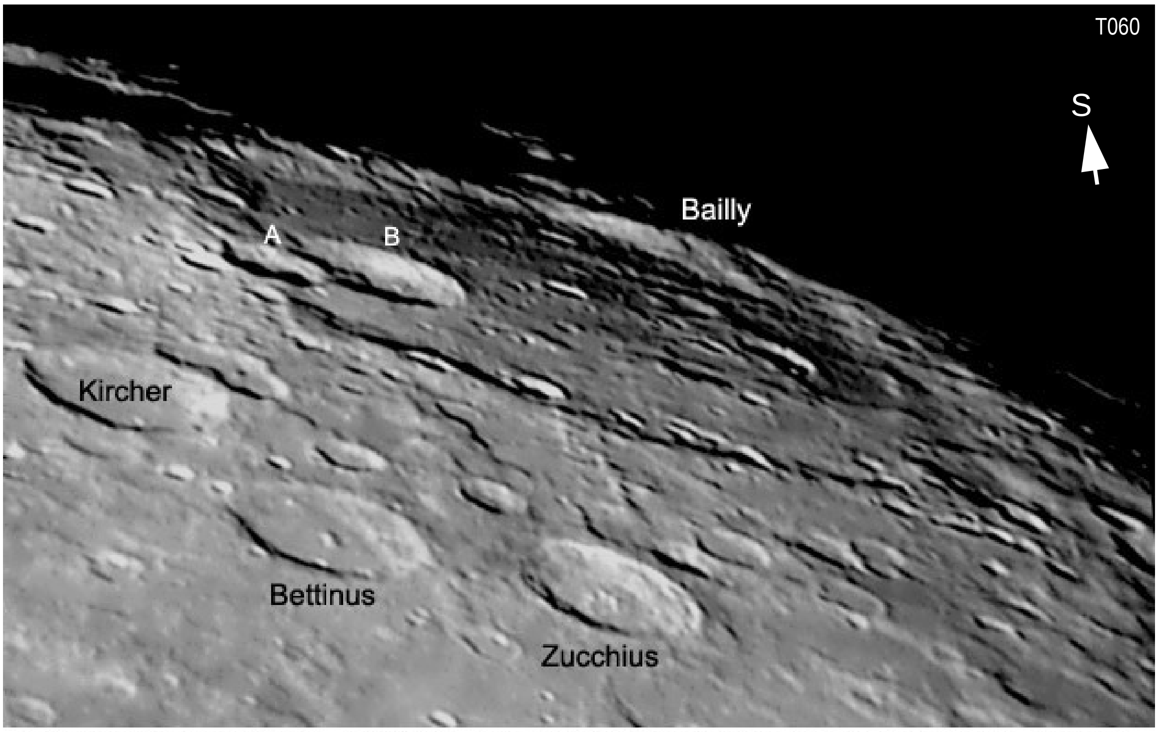
Casatus 29.5⁰ W 72.8⁰ S
A flooded crater, 108 km in diameter. Its western rim rises higher than the rest.

Klaproth 26.0⁰ W 69.8⁰ S
A flooded walled plain sharing the wall with Casatus, 119 km in diameter.

Blancanus 21.4⁰ W 63.8⁰ S
A crater with fairly flat floor, 117 km in diameter.



2005.01.22 15:34 UT Age 12 days. (*10-in scope*)



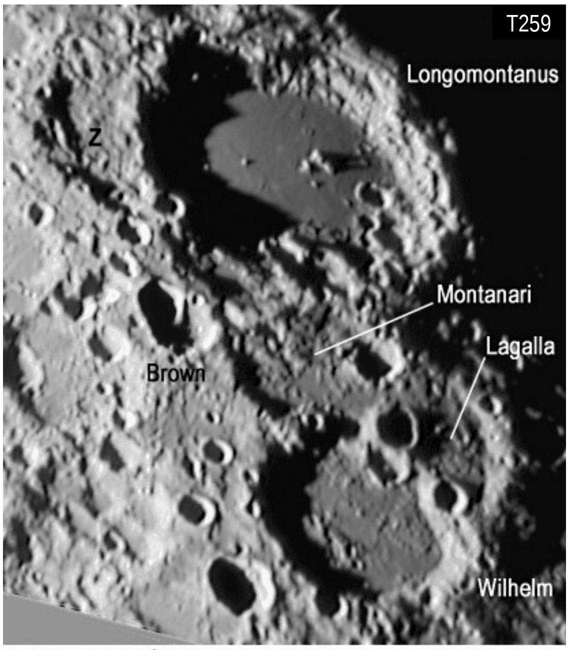
Bailly 2004.01.06 15:03 UT Age 14 days. Libration *l* = -2.5° *b* = -4.7° 10-in f/6 + 2.5X + ToUcam, 48 frames.

Bailly 69.1⁰W 66.5⁰S
The largest crater (walled plain) on the nearside of the Moon, 287 km in diameter. The floor is scattered with craters, the largest being ***Bailly A*** (38 km) and ***Bailly B*** (65 km). Bailly is best seen during favorable libration, as in above image when the latitudinal libration is -4.7⁰.

Kircher 45.3⁰W 67.1⁰S Diameter 72 km
Bettinus 44.8⁰W 63.4⁰S Diameter 71 km
Zucchius 50.3⁰W 61.4⁰S Diameter 64 km
These craters have roughly same size. They form a prominent trio outside the rim of Bailly, especially when Bailly is hidden in shadow (Image T047).

Longomontanus 21.8⁰W 49.6⁰S
A walled plain with off-centered peaks, 157 km in dia. and interrupting the smaller ***Longomontanus Z***.

Wilhelm 20.4⁰W 43.4⁰S
A walled plain with fairly rough floor, 106 km in diameter. It intrudes on two smaller craters ***Lagalla*** (85 km) and ***Montanari*** (76 km).



Longomontanus & Wilhelm 2006.03.09 14:08 UT Age 9.6 days. 10-in f/6

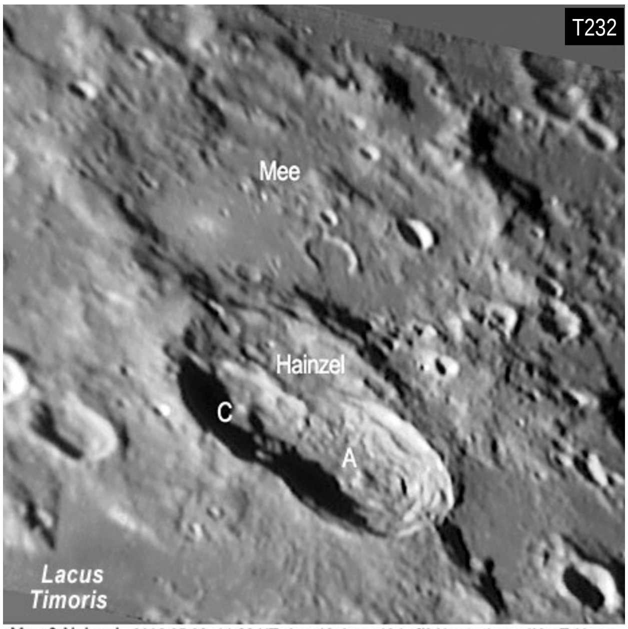
2005.01.22 15:34 UT Age 12 days.

Scheiner 27.5⁰W 60.5⁰S
A crater, 110 km in diameter. Its floor contains a prominent central crater but no mountain peak. In T197B, the southern wall of Scheiner is intersected by two straight ridges. In T047 of previous page, one arm of Tycho's rays hits on the western wall of Scheiner.

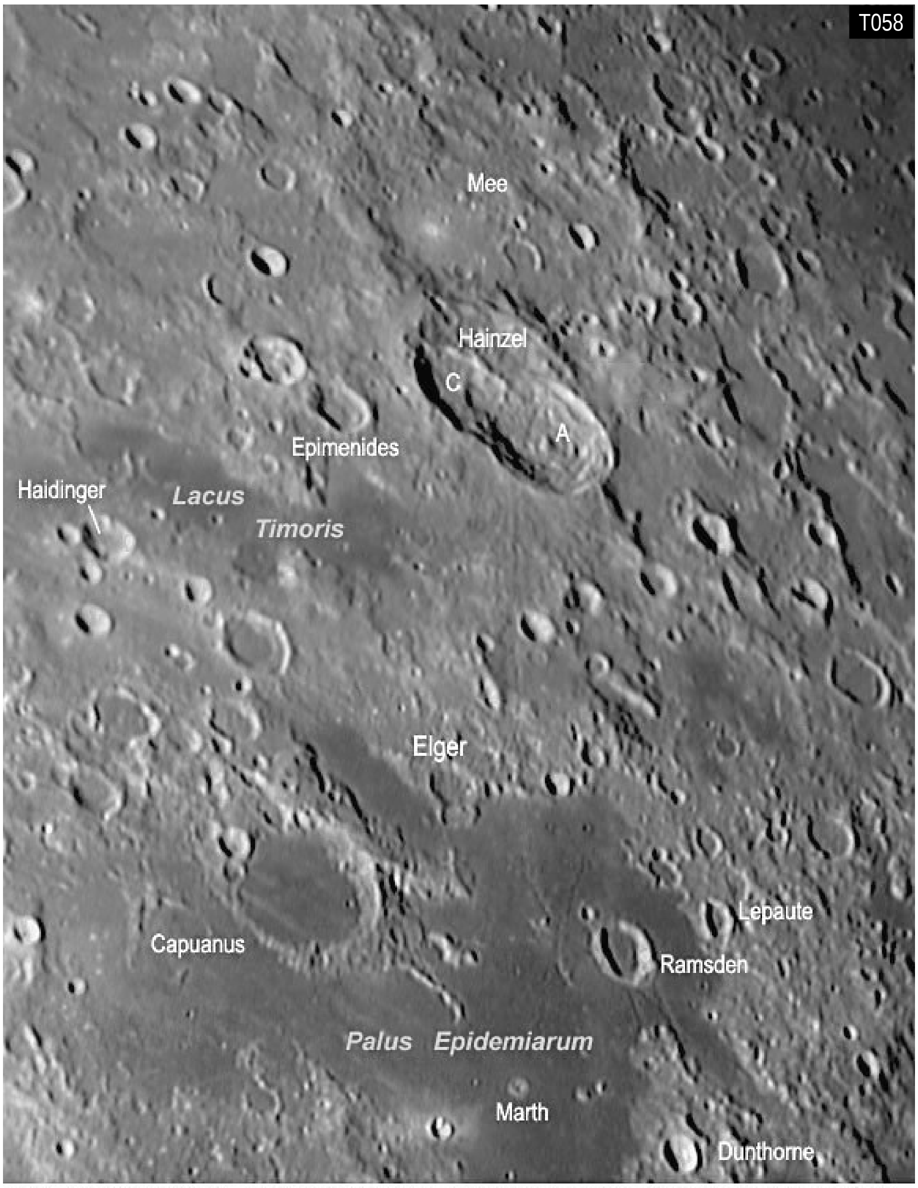
Mee 35.3⁰ W 43.7⁰ S
An eroded crater, 126 km in diameter. Its floor contains a white spot that brightens up under illumination.

Hainzel 33.5⁰ W 41.3⁰ S
A crater adjoining Mee, 70 km in diameter. It is overlapped by ***Hainzel A*** and ***Hainzel C***. The trio formation resembles the shape of a peanut shell. ***Lacus Timoris*** (Lake of Fear, length 120 km) is in the vicinity.

Palus Epidemiarum
(Marsh of Epidemics) 27⁰ W 32⁰ S
A lava plain that holds crater ***Capuanus***, ***Marth*** and ***Ramsden***, about 280 km across. See also Map 24.



Mee & Hainzel 2006.05.09 14:28 UT Age 12 days. 10-in f/6 Newtonian + 4X + ToUcam

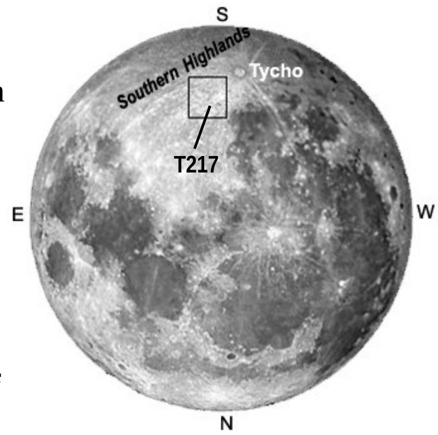


Mee, Hainzel & vicinity 2005.01.22 15:38~15:39 UT Age 12 days. 10-in f/6 + 2.5X + ToUcam (*mosaic*)

MAP 30

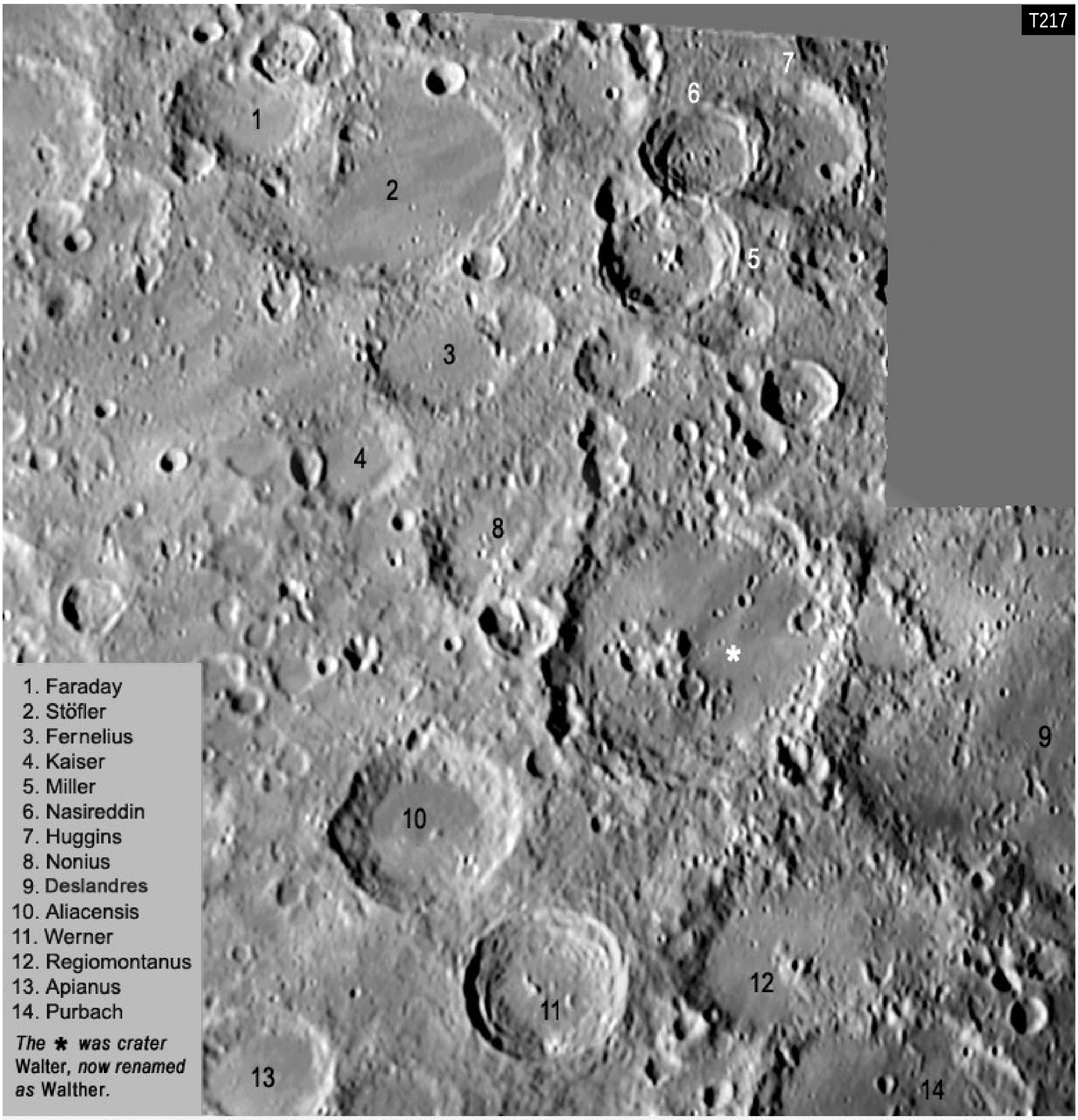
Hatfield 14, 16
Rükl 66, 65, 74, 75

Southern Highlands (Maurolycus, Stöfler, Boussingault)

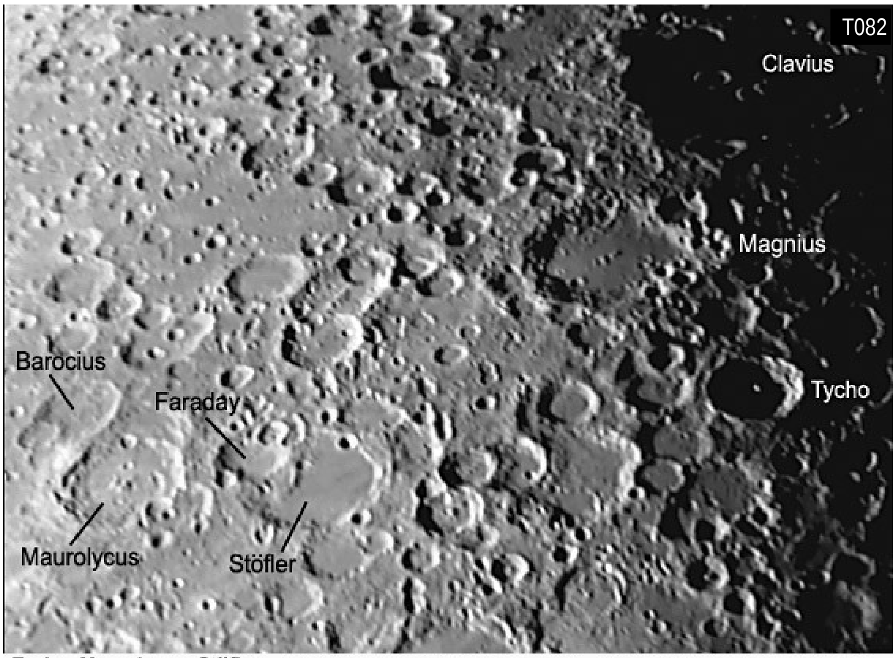


The Southern Highlands is a vast, heavily cratered region where no mare exists. It includes Tycho and its vicinity, the south polar zone, and the broad bright territories in the southeast quadrant. This region is high because it rises few kilometers above the maria level. It is bright because the lands are dominated by light-colored anorthosite, the most ancient type of Moon rocks briefed in Map 1.

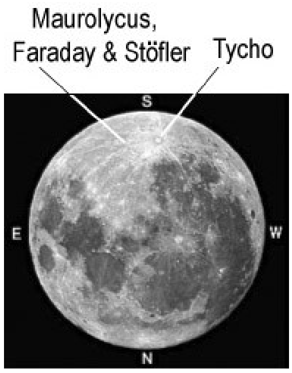
T217 shows a portion of the Southern Highlands. Note that some crater floors are splashed by the deposits of light-colored ejecta, which are traceable to the Tycho impact occured 110 million years ago. Tycho is an impact crater located beyond the top right corner of this frame.



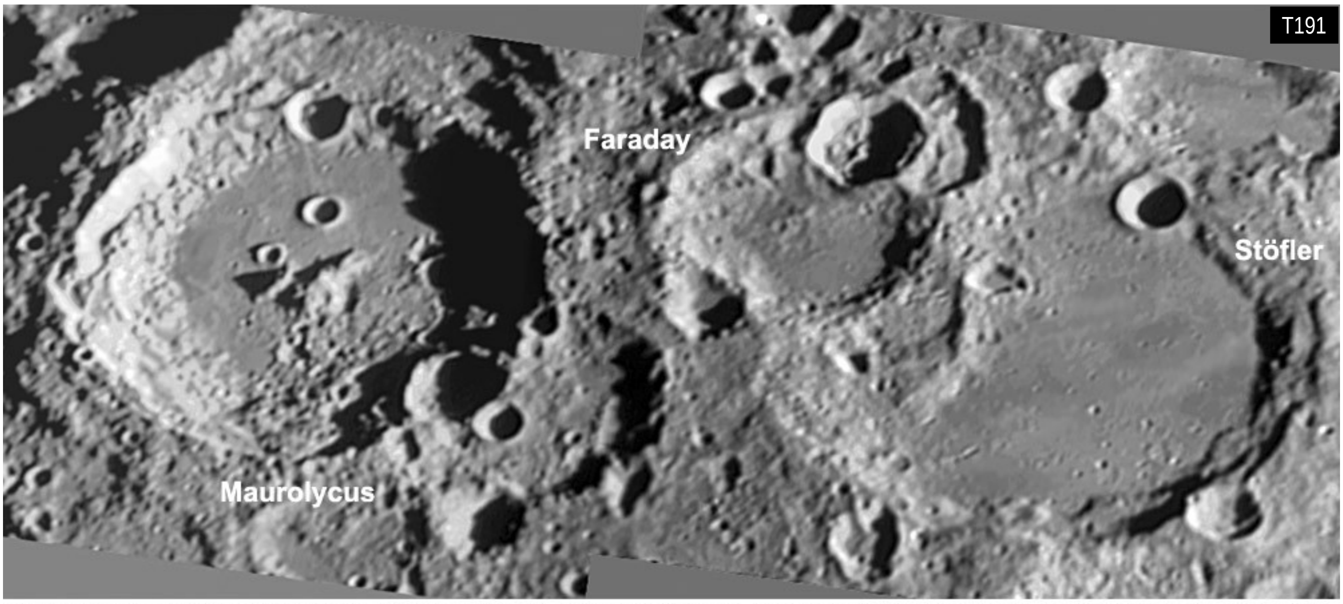
A portion of the Southern Highlands (Stöfler to Regiomontanus) 2005.04.18 ~13:35 UT Age 9.8 days. 10-in f/6 Newtonian + 2.5X + ToUcam



Tycho, Maurolycus, Stöfler 2004.06.26 15:03 UT Age 9 days. 10-in f/6 Newtonian + ToUcam



Left: A chaos of *craters in the Southern Highlands*

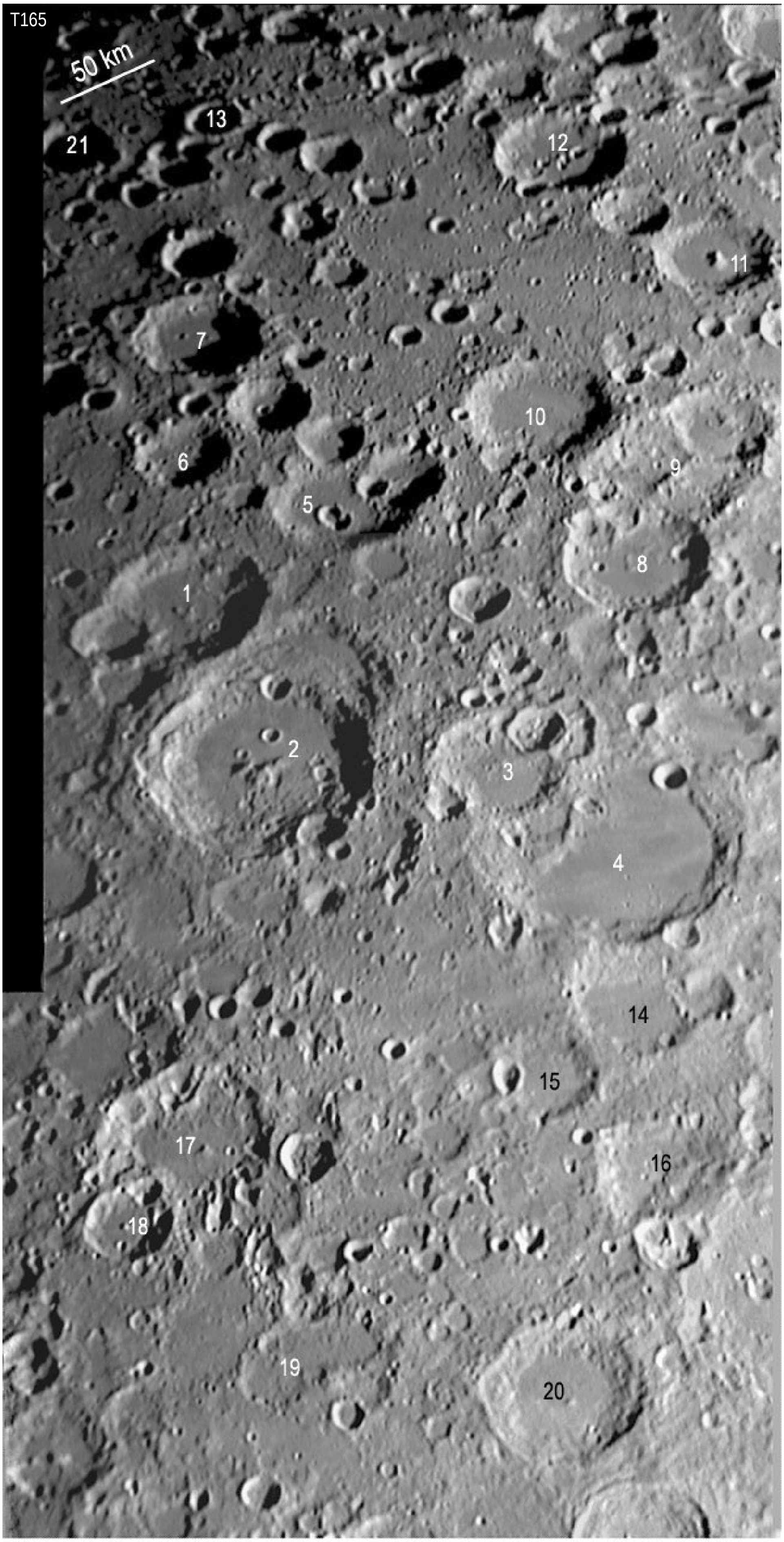


Crater Trio : Maurolycus, Faraday & Stöfler 2004.09.04 ~19:08 UT Age 20 days. 12.5-in f/6 Newtonian + 4X + ToUcam. (*mosaic of 2 video clips, 88% resized.*)

Maurolycus 14.0^0 E 42.0^0 S **Faraday** 8.7^0 E 42.4^0 S **Stöfler** 6.0^0 E 41.1^0 S

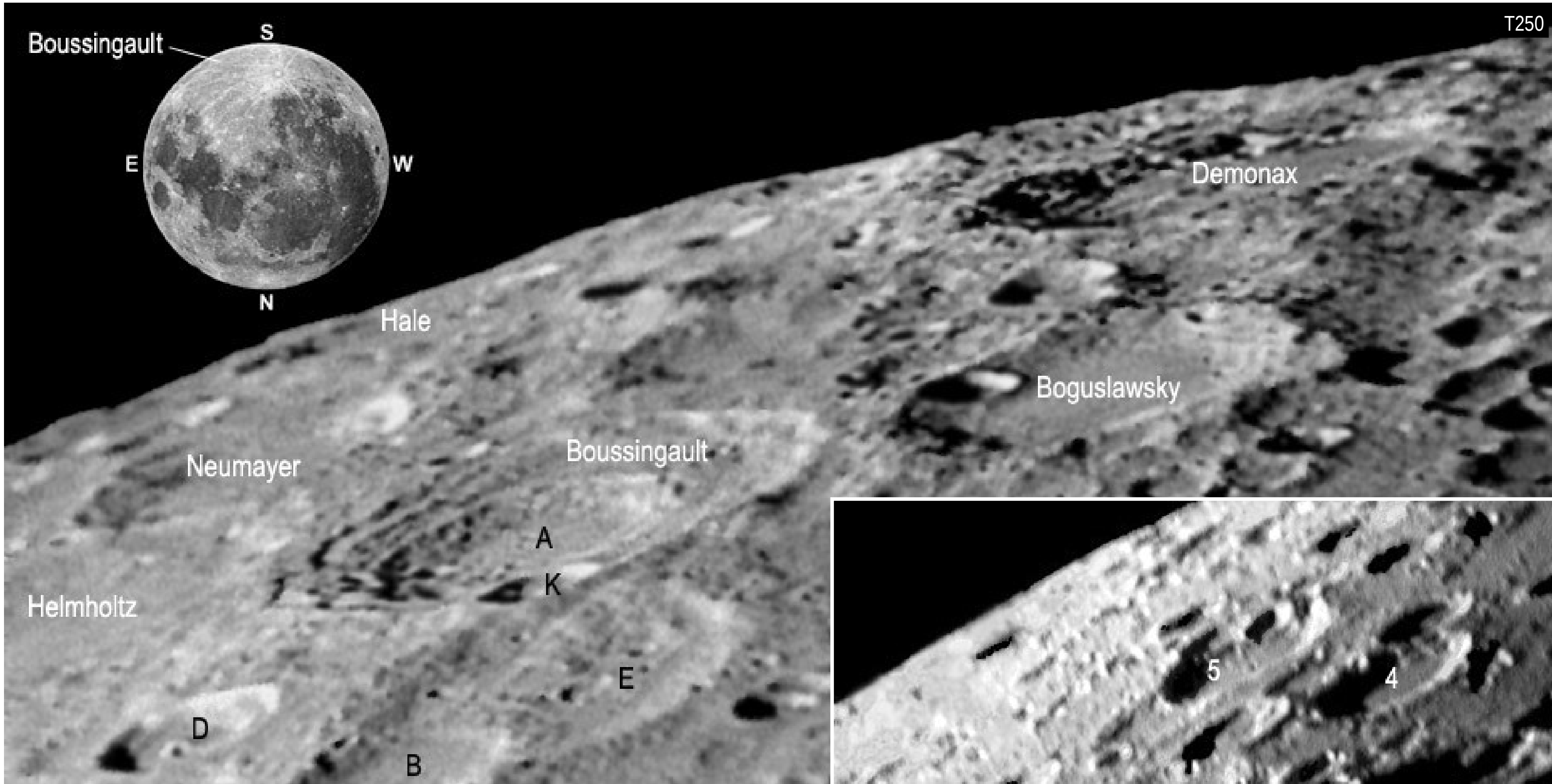
These are often depicted as a trio feature in the Southern Highlands. Maurolycus is a typical crater with central mountains and terraced walls, 114 km in diameter, 4700 m deep. The shadow in Image T191 tells that Maurolycus must be the deepest of the trio. Its walls and floor are interrupted by smaller craters. Faraday lies in the middle of the trio, 69 km in diameter, 4000 m deep. Its walls are also interrupted by three conspicuous craters. Stöfler is a vast walled plain peppered with secondary craterlets, 126 km in diameter and 2700 m deep. A large portion of Stöfler's floor is flat, but the eastern portion is mountainous suggesting it could be the remains of a crater which was ruined by the Faraday impact. The light-colored strips on Stöfler's floor are the ejecta deposits from the Tycho impact.

This trio is a fine example to demonstrate a chaos of craters battering at other pre-existing craters.



Maurolycus & vicinity 2004.10.03 ~21:49 UT Age 19 days. 10-in f/6 + 2.5X + ToUcam

1. Barocius *(Dia. 82 km)*
2. Maurolycus *(114 km)*
3. Faraday *(69 km)*
4. Stöfler *(126 km)*
5. Clairaut *(75 km)*
6. Breislak *(49 km)*
7. Baco *(69 km)*
8. Licetus *(74 km)*
9. Heraclitus *(90 km)*
10. Cuvier *(75 km)*
11. Lilius (61 km)
12. Jacobi *(68 km)*
13. Tannerus *(28 km)*
14. Fernelius *(65 km)*
15. Kaiser *(52 km)*
16. Nonius *(69 km)*
17. Gemma Frisius *(87 km)*
18. Goodacre *(46 km)*
19. Poisson *(42 km)*
20. Aliacensis *(79 km)*
21. Asclepi *(42 km)*

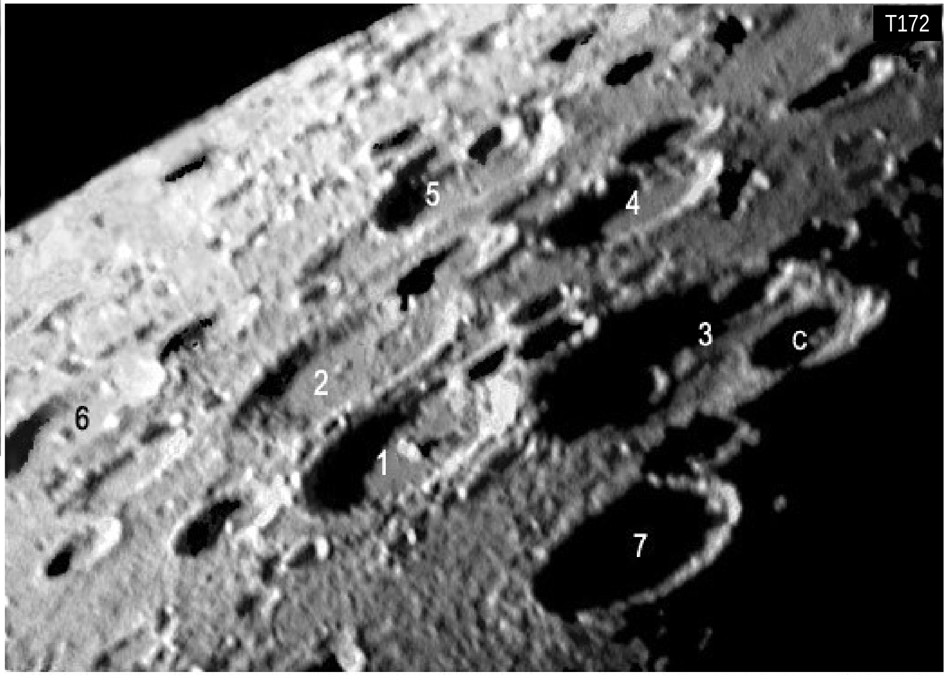


2006.01.07 ~13:08 UT Age 7.4 days. 10-in f/6 Newtonian + 4X + ToUcam (*mosaic*)

Boussingault 54.6° E 70.2° S
A terraced crater, diameter 142 km. Its floor contains another large crater ***Boussingault A.*** The whole formation resembles a triple-walled crater.

Boguslawsky 43.2° E 72.9° S Diameter 97 km.

Vlacq 38.8° E 53.3° S Diameter 89 km.



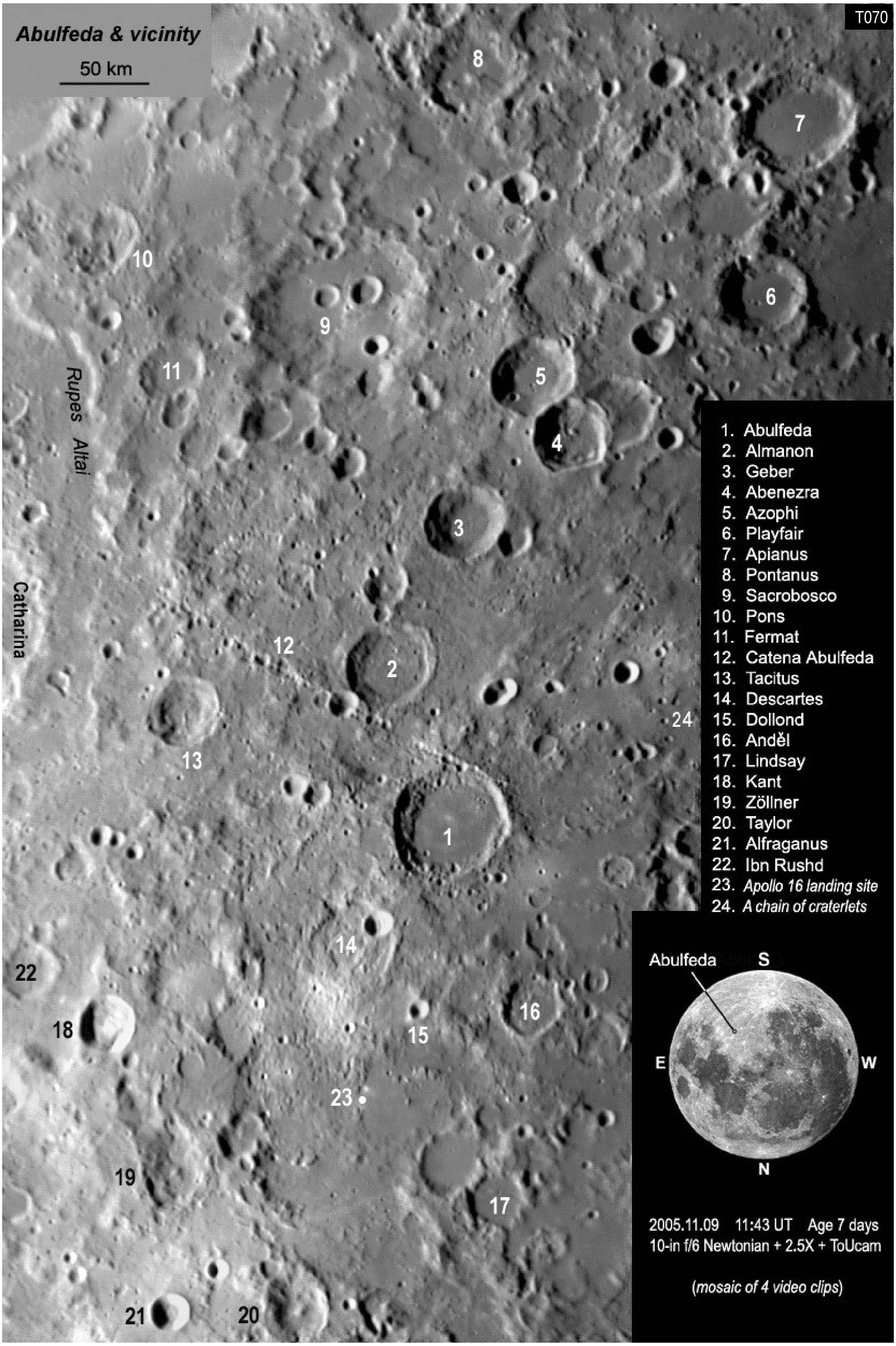
1. Vlacq 2. Rosenberger 3. Hommel 4. Nearch 5. Hagecius 6. Biela 7. Pitiscus
2004.09.19 11:00 UT Age 5 days. 10-in f/6 Newtonian + 2.5X + ToUcam at 1/33 sec (*Seeing 2/10*)

MAP 30

MAP 31

Catena Abulfeda, Catena Davy, Hipparchus, Delaunay

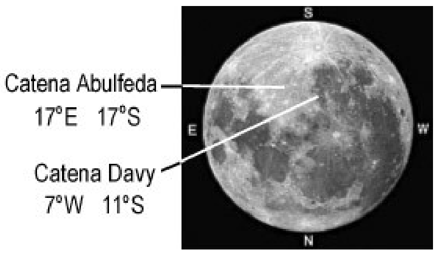
Hatfield 13
Rükl 56, 55, 45, 44, 43

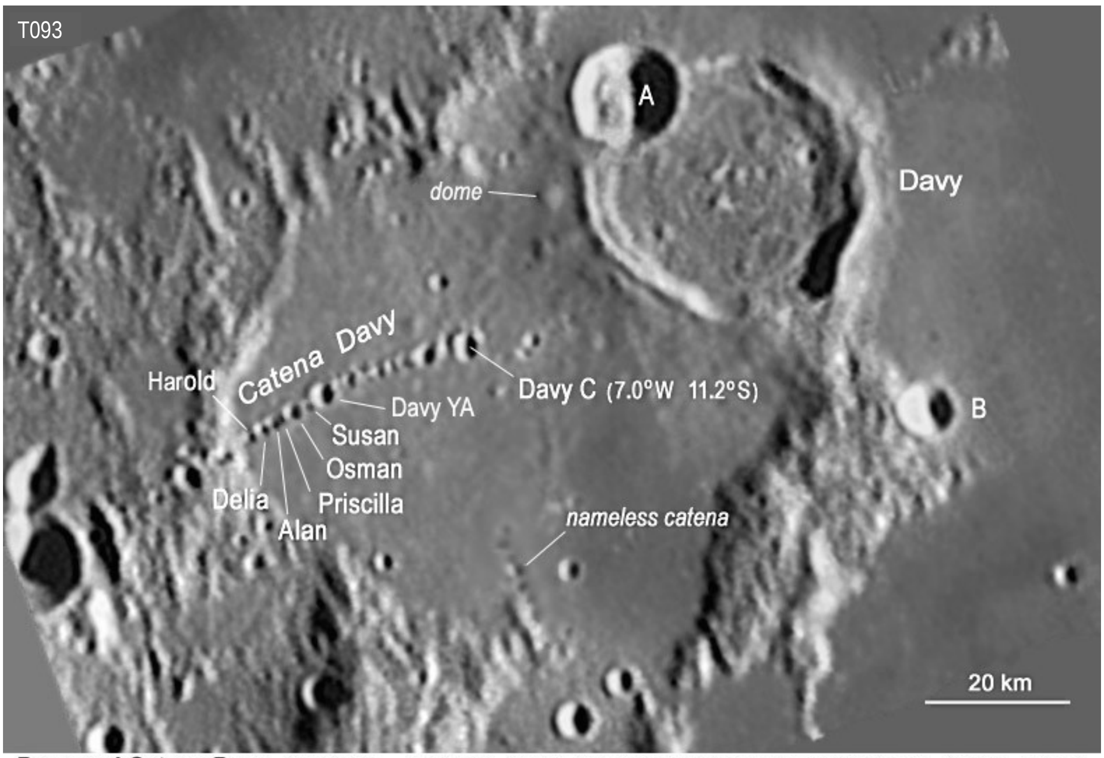


Catena is a chain of small craters, generally resulted from secondary impacts, or from fragmental impacts of a tidally disrupted meteorite / asteroid. An exception is the chain of tiny craters in Rima Hyginus Map 13, which appears to be volcanic rather than impact-originated.

The most known crater chain is ***Catena Abulfeda*** shown in the middle of Image T070, length 210 km. At low power, it resembles a thin, bright line running from the rim of ***Abulfeda*** (diameter 65 km) to the northern end of Rupes Altai. At high power, it resolves into over 20 craterlets in a chain. A short, loose chain of craterlets is also shown by *Label 24* in T070. Note also the interesting arc array of craters from ***Abulfeda*** to ***Apianus*** *(Label 1 to 7)*, the irregular crater ***Sacrobosco*** (*dia. 98 km*, *Label 9*) and the bright patch just north of ***Descartes*** *(Label 14)*.

Another crater chain, ***Catena Davy***, is shown in T093. It requires high power to spot. This chain consists of 23 craters from 1 to 3 km in diameter, 50 km long. It is likely caused by fragmental impacts of a tidally disrupted "rubble pile" meteorite / asteroid, because most craters in the chain do not overlap. To the north of ***Davy C*** (diameter 3.4 km) is another catena but it is nameless.





Davy and Catena Davy 2004.09.05 ~20:12 UT Age 21 days. 10-in f/6 Newtonian + 5X + ToUcam (*150% resized*)

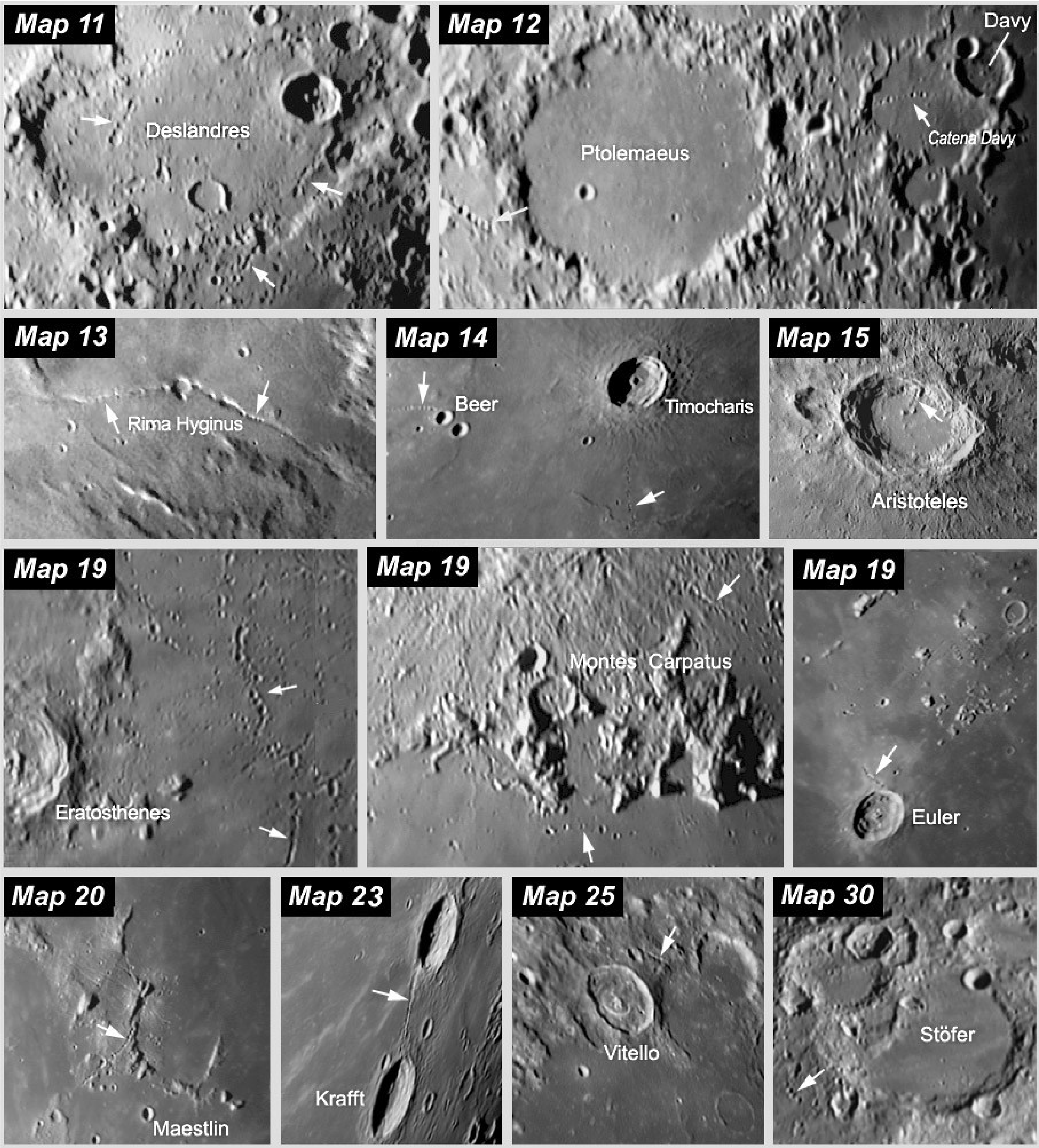
Remark In 1976, IAU named 6 craters along Catena Davy but no related map was available :

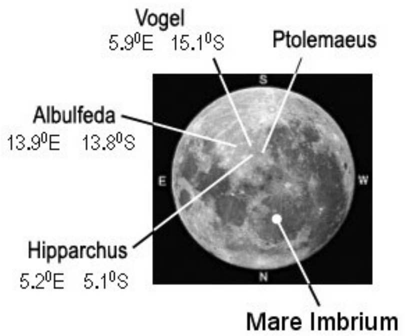
Harold *(6.0^0W 10.9^0S 2 km)* **Alan** *(6.1^0W 10.9^0S 2 km)* **Osman** *(6.2^0W 11.0^0S 2 km)*
Delia *(6.1^0W 10.9^0S 2 km)* **Priscilla** *(6.2^0W 10.9^0S 1.8 km)* **Susan** *(6.3^0W 11.0^0S 1 km).*

An attempt was made to map above craters in T093, which is subject to the author's further review. Note also the dome hill *in the picture.*

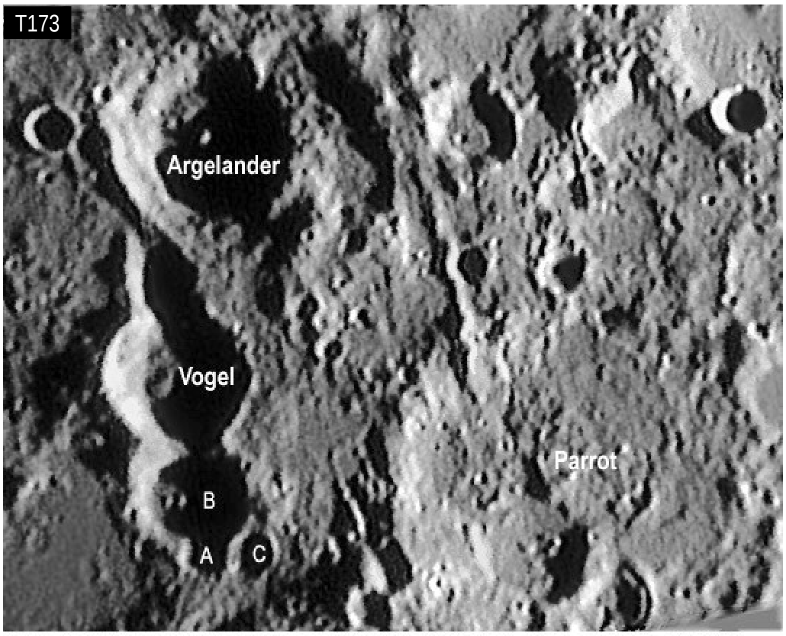
Other chains of craterlets are found close to Deslandres, Ptolemaeus, Rima Hyginus, Timocharis, Aristoteles, Eratosthenes, Montes Carpatus, Euler, Maestlin, Krafft, Vitello and Stöfler. They are marked by arrows in the guide maps below. Most of them are nameless.

Chain of Craterlets *(Refer to the Map No. for full picture.)*



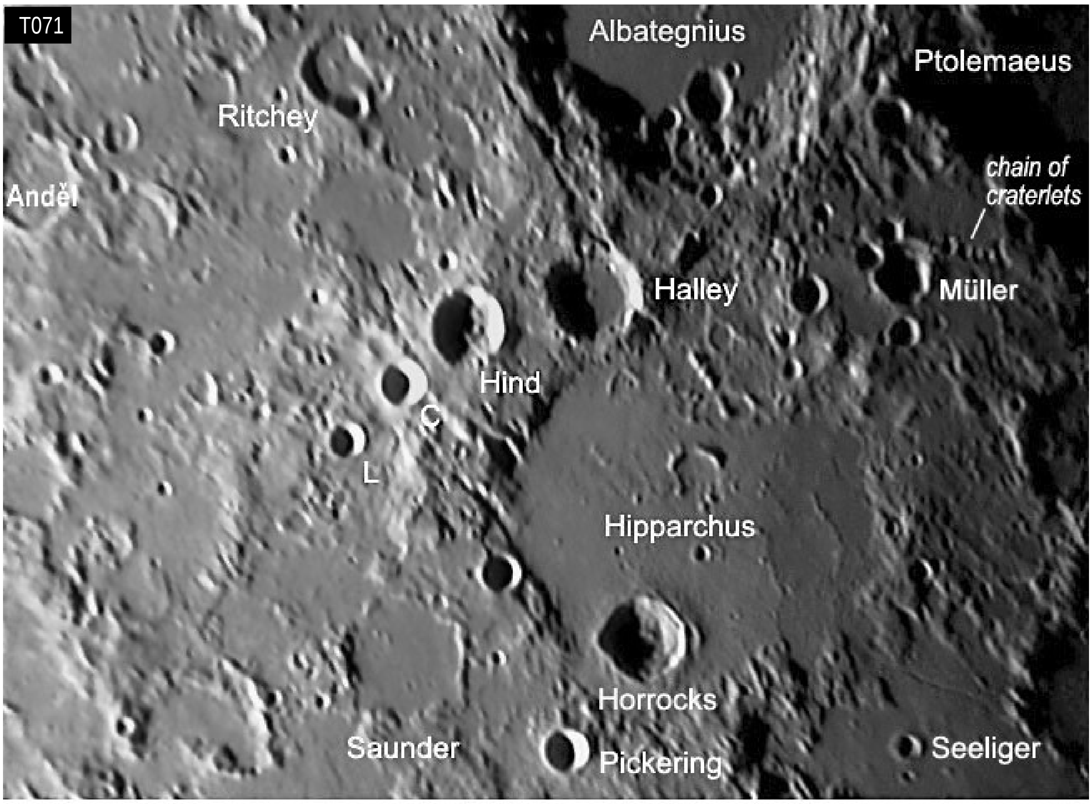


T173 shows a gourd-like (葫蘆狀) crater array composed of ***Vogel***, its satellite craters A, B and C. Vogel can be spotted with the larger map in next page. It is 26 km in diameter.

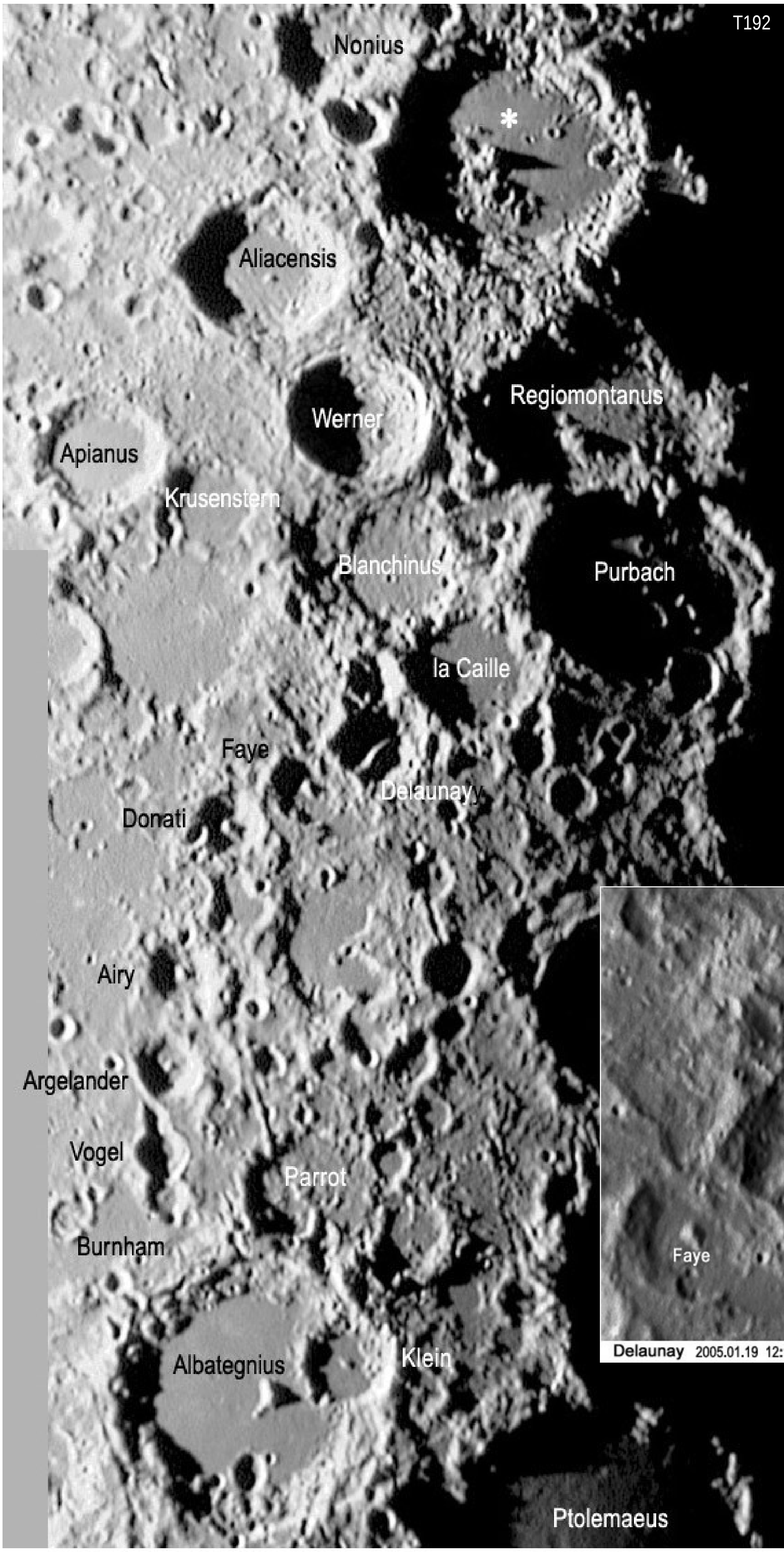


Vogel and its satellite craters 2004.09.05 20:27 UT Age 21 days. 10-in f/6 + 5X + ToUcam

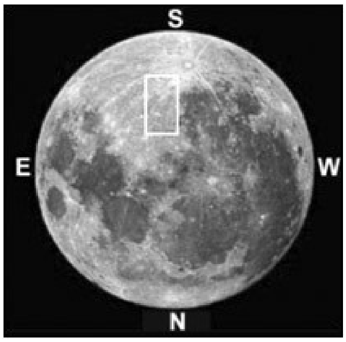
T071 shows a row of diminishing craters, composed of ***Halley, Hind, Hipparchus C*** and ***Hipparchus L***. Hipparchus is a vast walled plain, 138 km in diameter, Map 12. Its wall is modified by a pattern of grooves and ridges known as "***Imbrium Sculpture***". This pattern is radial to Mare Imbrium, which affects the lunar surface for more than 1000 km from Imbrium. The same pattern can be seen in the middle of T173. ***Horrocks*** (30 km) is a younger crater within Hipparchus. ***Pickering*** (15 km) is named after E. C. Pickering, the former director of Harvard College Observatory. [*Remark:* ***Messier A*** *of Map 6 was once named as Pickering (after W. H. Pickering, the smaller brother of E. C. Pickering), but this W. H. Pickering was removed from crater nomenclature since 1964.*]



Hipparchus & vicinity 2004.06.25 12:47 UT Age 8 days. 10-in f/6 Newtonian + 2.5X + ToUcam, 6 frames stacked.



2004.12.19 12:41UT Age 7 days. 10-in f/6+2.5X+ToUcam. The * was crater Walter, now renamed as Walther.



← *An array of diminishing small craters, composed of*

la Caille *(67 km)*
Delaunay *(46 km)*
Faye *(36 km)*
Donati *(36 km)*
Airy *(36 km)*
Argelander *(34 km)*
Vogel *(26 km).*

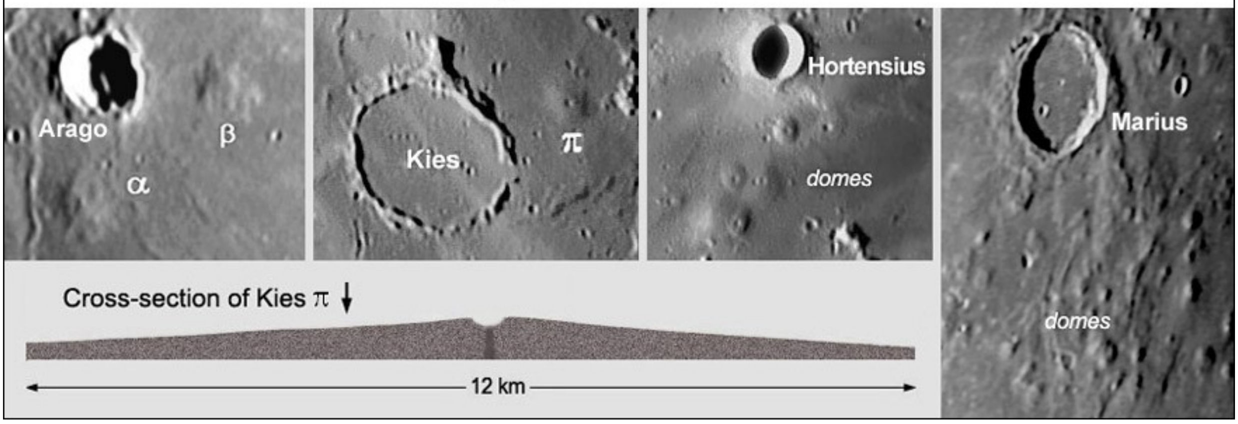
Delaunay 2005.01.19 12:18 UT Age 9 days. 10-in f/6 + 5X + ToUcam at 1/25 sec

↑ **Delaunay, Delaunay E** *and* **Delaunay M** *form a bell-shaped crater array. Delaunay is 46 km in diameter. Its floor is divided by a sharp central ridge.*

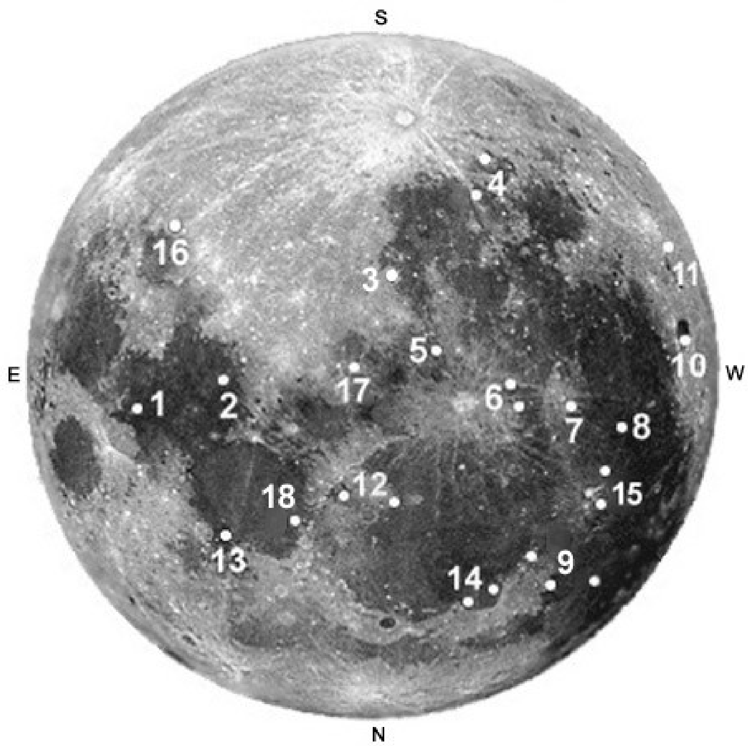
Domes

Domes refer to small, rounded low elevation found mostly on mare floor, some of them with summit pits. They swell up from ground level to slope $1^0 \sim 5^0$ and are believed to form during the later stages of lunar volcanism, when the rate of lava extrusion had decreased. Lunar domes are similar to the shield volcanoes on Earth. *(Shield volcano is a gently sloping cone constructed of solidified lava flows.)* The ***megadomes***, however, are wider in size (30 km or above) and are more complex in nature. Lunar domes and megadomes located near a known feature are highlighted in the following maps; they require very oblique sunlight to be distinctive.

Examples of volcanic domes



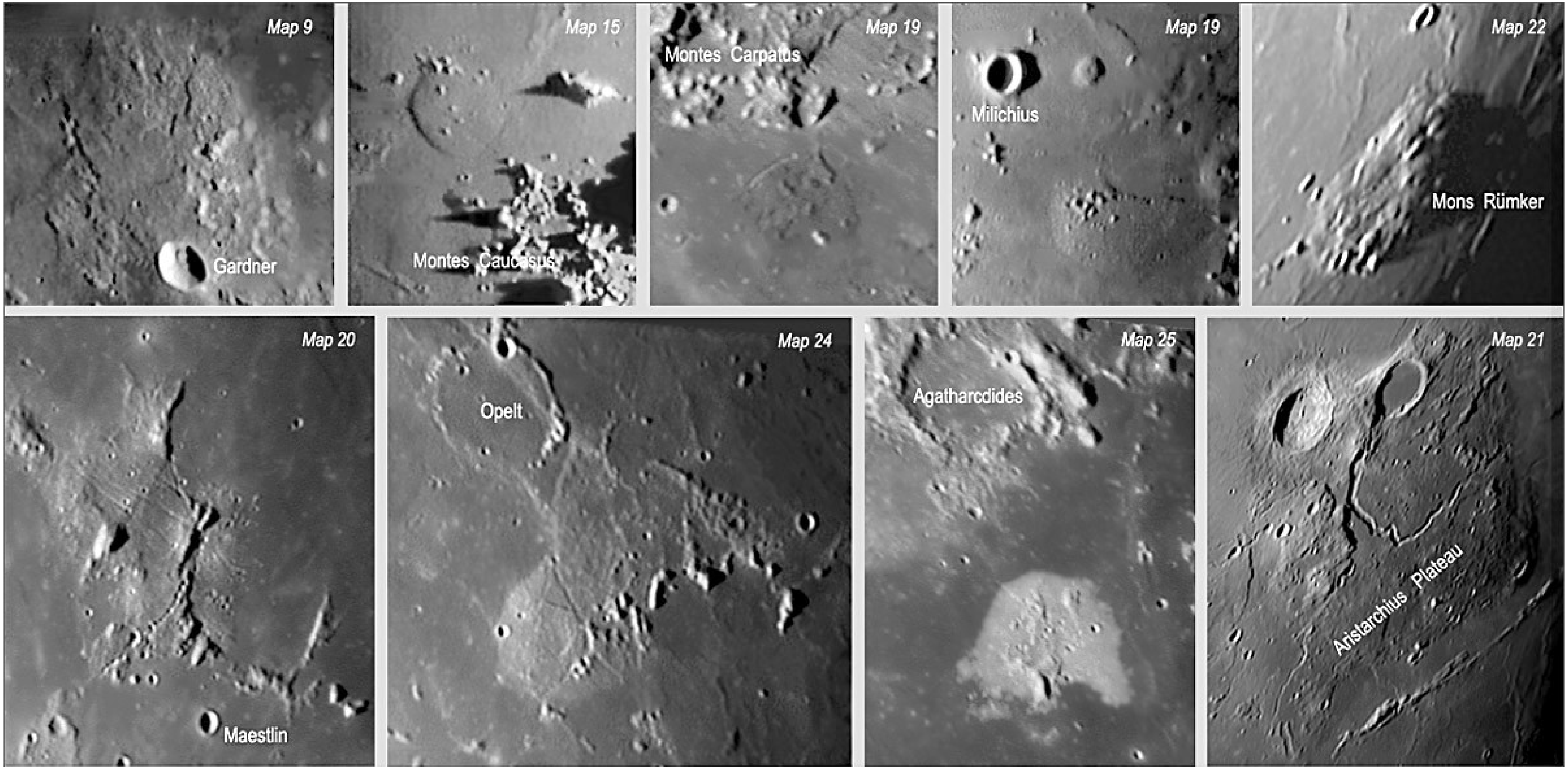
Map of Lunar Domes (nearside)



1. Cauchy & Lucian, Map 6.
2. Arago, Maclear & Ross Map 8.
3. Davy, Map 31.
4. Kies & Capuanus, Map 24.
5. Gambart & Reinhold, Map 19.
6. Copernicus, Hortensius & Milichius, Map19.
7. Kepler, Map 20.
8. Marius, Map 20.
9. Gruithuisen domes, Mairan T & Mons Rümker, Map 22.
10. Grimaldi, Map 26.
11. Darwin, Map 27.
12. Palus Putredinis & Beer, Map 14.
13. Luther, Map 9.
14. Sinus Iridum, Map18.
15. Aristarchus & Herodotus, Map 21.
16. Fracastorius, Map 5.
17. Murchison, Map 13.
18. Valentine Dome (megadome), Map15.
    Other megadomes are shown in next page.

More details: *http://www.glrgroup.org/news/28.htm*
http://digilander.libero.it/glrgroup/

Megadome is a circular or irregular plateau which has diameter more than 30 km and considerably low height (few hundred meters). The plateau surface is textured (containing protrusions, depressions, ridges, rilles, craterlets etc.). The large diameter means it is within the reach of small telescopes. But the trick is that all megadomes are truly low in height and poor in contrast, so they are noticeable only under very oblique sunlight. The nature of megadomes is complicated and not fully understood, though hints suggest that they are volcanic.



Megadomes on the nearside of the Moon (low elevated plateaus, size greater than 30 km) *Aristarchius Plateau is 60% resized. Refer to the Map No. for full picture.*

MAP 32

Lunar Rays

When the Sun illumination angle is high enough (e.g. 30^0 or more), bright rays begin to emit from certain craters. The table below lists those craters known to have bright rays. They are particularly prominent during a full moon.

Craters with bright rays

Anaxagoras	(Map 16)	Copernicus	(Map 19)	Lalande	(Map 19)	Olbers A	(Map 23)	Stevinus A	(Map 3)
Aristarchus	(Map 21)	Euclides	(Map 20)	Langrenus	(Map 3)	Petavius B	(Map 3)	Taruntius	(Map 6)
Aristillus	(Map 14)	Furnerius A	(Map 3)	Manilius	(Map 9)	Proclus	(Map 2)	Thales	(Map 10)
Autolycus	(Map 14)	Geminus C	(Map 2)	Menelaus	(Map 9)	Reiner Gamma *	(Map 20)	Theophilus	(Map 5)
Bessel	(Map 9)	Godin	(Map 13)	Messala B	(Map 2)	Sirsalis	(Map 27)	Timocharis	(Map 19)
Birt	(Map 12)	Hind	(Map 12)	Messier A	(Map 6)	Snellius	(Map 3)	Tycho	(Map 11)
Byrgius A	(Map 27)	Kepler	(Map 20)	Olbers	(Map 23)				

* *bright feature*

Lunar rays are bright due to two separate causes, or a mix of both.

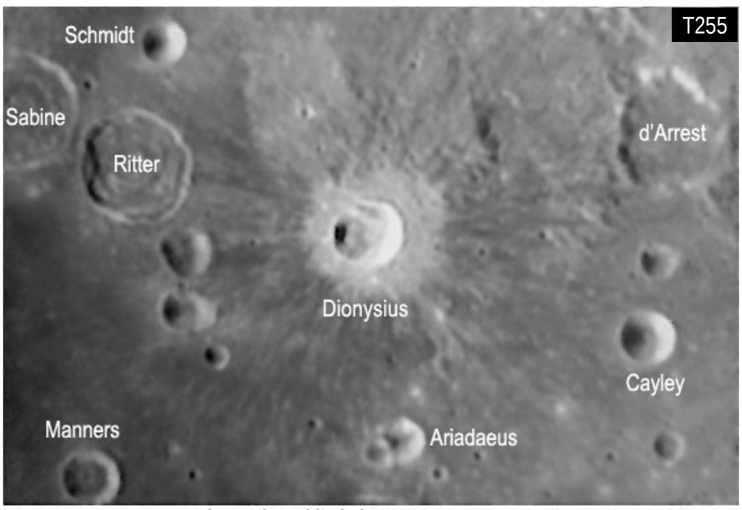
- Some rays are composed of materials ejected from an impact site on the highlands. The highlands are predominately light-color anorthosite (illustrated in Map 1). These rays become bright simply because anorthosite is deposited on the darker maria.
- The ray may also contain fine pulverized rock powder created by the energy of the impact. This powder reflects sunlight effectively making the ray (ejecta) bright under illumination. However, the brightness of such powdery ray is weathered away by micrometeoroids, cosmic rays, and solar winds more rapidly than the ejecta that is rich in anorthosite.

In theory all fresh impact craters have rays. As time goes by, both the anorthositic and powdery rays will vanish. This suggests that rayed craters are generally younger than non-rayed craters.

Lunar rays are unique in the following characteristics:

- They do not have fixed direction and pattern. For example in next page, A large part of the rays from Manilius bisects Mare Vaporum towards Montes Apenninus. The rays from Tycho are long in multi directions but those from Copernicus and Kepler are wispy.
- The rays may not point exactly back to the crater from which they supposedly originated.
- The rays may shift slightly in position during a lunation.

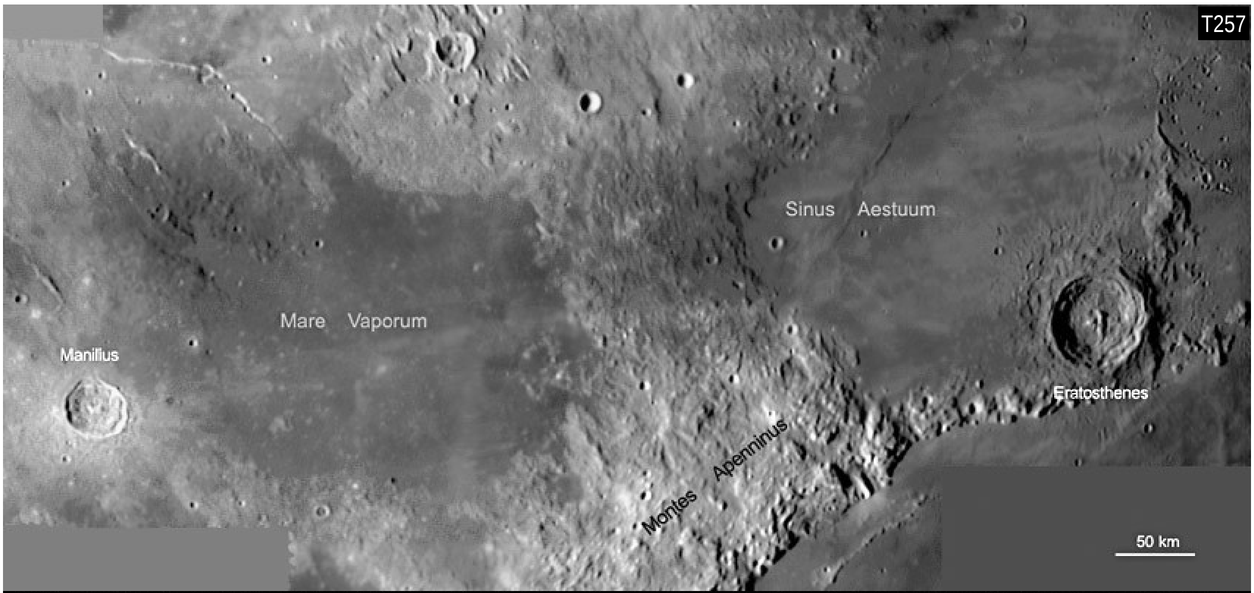
While bright rays are common, there is a rare type of dark rays. In T255, Dionysius (diameter 18 km, Map 13) seems to appear with a bright halo only. Close inspection, however, shows an additional pattern of dark rays beneath the bright halo. The dark rays were first noted by Clementine spacecraft in 1994. They are actually ejecta composed of dark material excavated from the mare basalt. The bright halo is deposits of anorthosite excavated from deeper layer of the impact site.



Dionysius with dark rays beneath a white halo 2006.03.09 13:48UT Age 10 days. 10-in f/6+5X+ToUcam

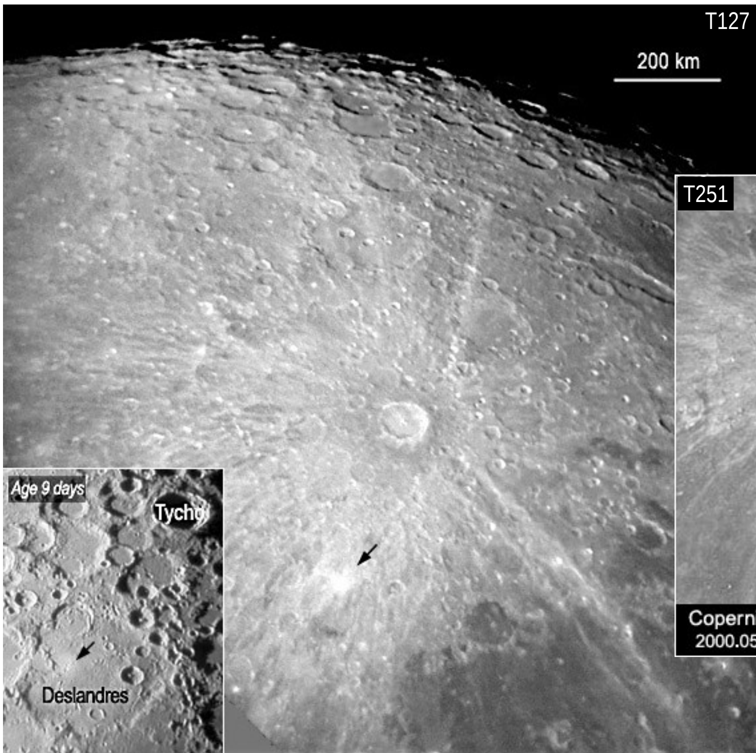
Rayed Craters

MAP 33



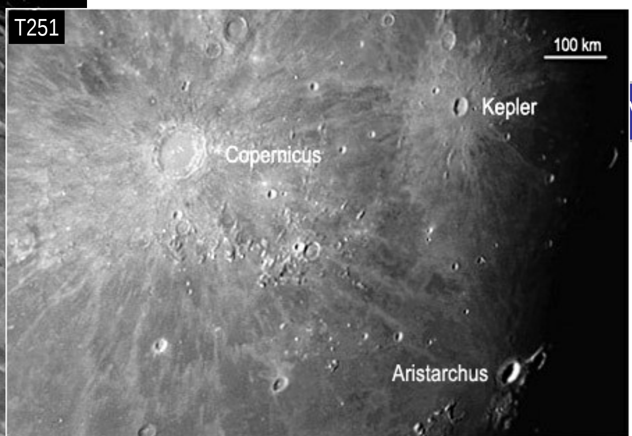
Back slope of Montes Apenninus and Manilius with bright rays 2006.03.09 ~14:53 UT Age 9.6 days. 10-inch f/6 Newtonian + 2.5X + ToUcam

T257 shows one arm of Manilius rays stretching across Mare Vaporum and the back slope of Montes Apenninus. The ray is as long as 450 km, almost penetrating into Sinus Aestuum. Such lengthy ray is feasible because (1) the impact energy to create Manilius is truly huge; (2) the Moon's surface gravity is only 1/6 that of Earth and (3) the Moon has no air to retard the ejected materials during the crater-forming impact. In the more massive Tycho impact, the bright rays stretch even longer, up to 1800 km !



Deslandres overwhelmed by Tycho's bright rays 2000.05.16 18:25 UT Age 12 days (FS102)

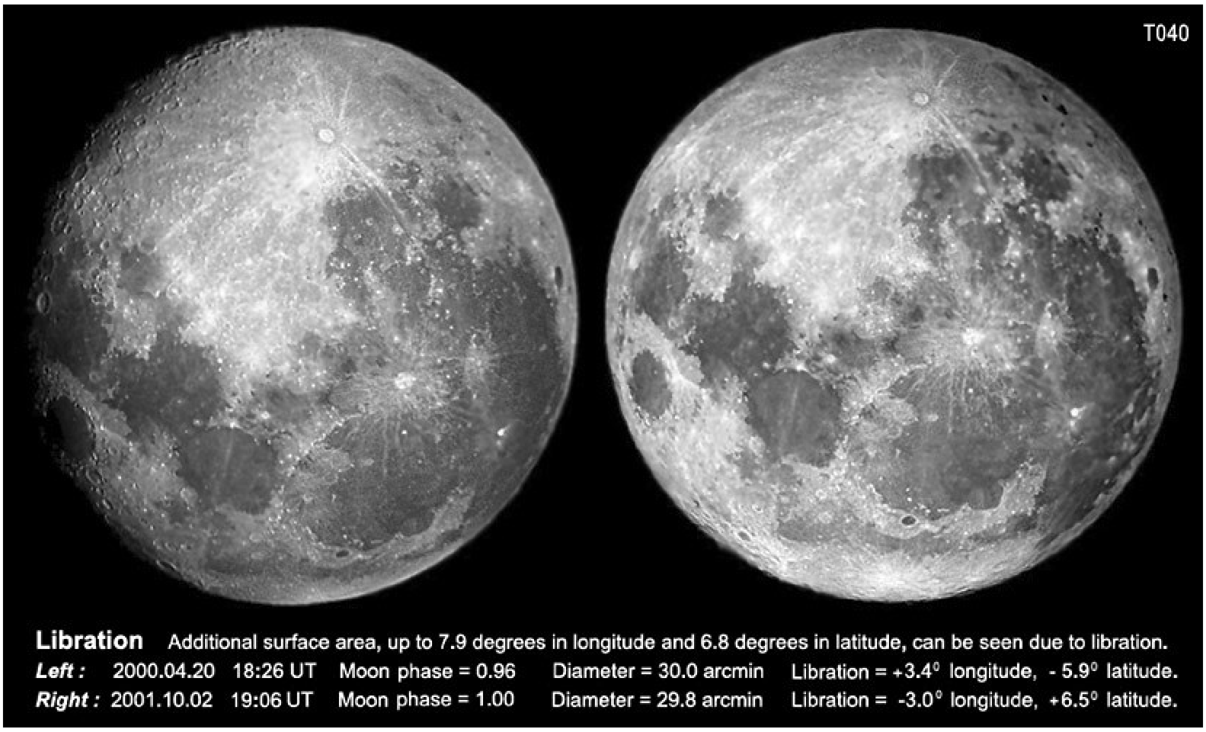
The arrow points to a bright patch on the floor of Deslandres. This patch was first noted by the 17th century astronomer Cassini, hence nicknamed "*Cassini's Bright Spot*".



Copernicus & Kepler with rays. Aristarchus is just on the terminator.
2000.05.15 14:02 UT Age 11 days. FS102 + LE7.5 + CP950 at 1/13 sec

MAP 33

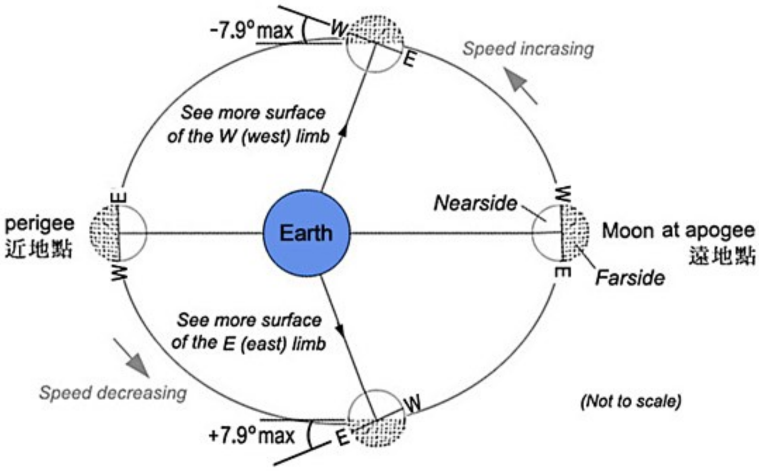
Libration



Libration (天平動) allows the nearside of the Moon to be seen from slightly different angles at different time, producing an overall view of the lunar surface that adds up, over time, to 59% of the total. It was first noted by the Polish astronomer Johannes Hevelius (1611-1687).

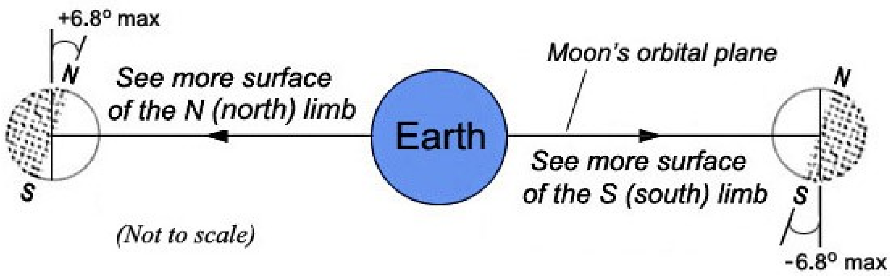
There are three major types of librations.**

- ***Libration In Longitude*** (經天平動) is due to the fact that the Moon moves faster when it is near perigee and slower when near apogee, but its rotation remains constant. This means that the Moon's rotation is not yet in perfect synchronization with its orbital motion. As a result, the Moon appears to wobble back and forth around its rotation axis. The additional longitudinal surface that can be seen with this libration is ±7.9 degrees.

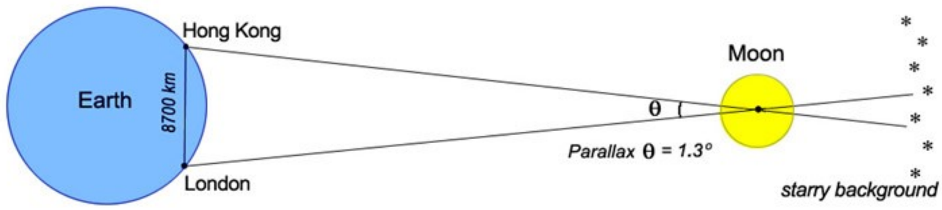


** *Due to irregularities of gravitational pull by the Earth and the Sun, the Moon librates very slightly by itself; this is known as physical libration. See Appendix –* Moon Data.

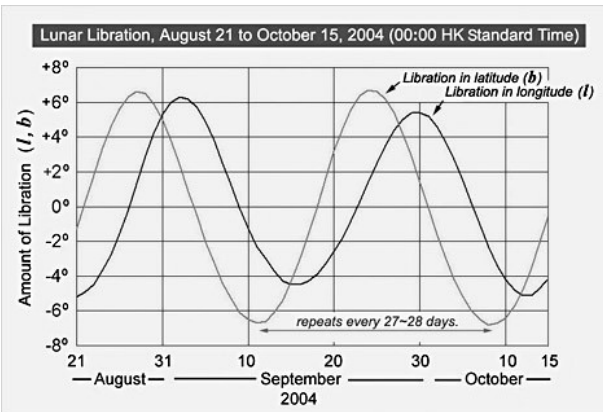
- ***Libration In Latitude*** (緯天平動) is due to the tilt angle of the Moon's equator (or rotation axis) from its orbital plane. As a result, the Moon appears to nod its polar regions towards and away from the Earth as it goes around its orbit. The additional latitudinal surface that can be seen with this libration is ± 6.8 degrees.

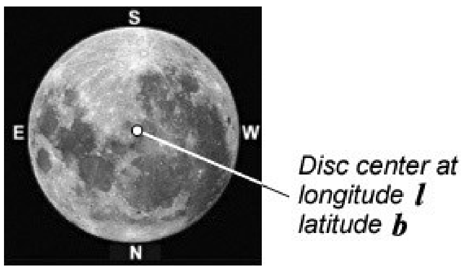


- ***Diurnal Libration*** (周日天平動) gives an extra 1 degree of visible surface round the east or west limb of the Moon, because the Earth's rotation brings a terrestrial observer at slightly different view angles between moonrise and moonset. Simultaneous observations of the Moon disc from two cities on Earth also produces a parallax, such as θ shown below.

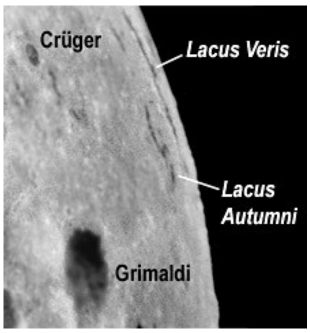


Libration in longitude and libration in latitude occur concurrently and repeat every 27 ~ 28 days (approximately one sidereal month). They are quantified by parameters ***l*** and ***b***, i.e. the shift of zero coordinates (0^0 longitude and 0^0 latitude) from the Moon disc's exact center at that moment. They also mean that the disc center is now at longitude ***l*** and latitude ***b***. A positive value of ***l*** or ***b*** gives more surface of the east or north limb exposed to Earth. A negative value of ***l*** or ***b*** gives more exposed surface of the west or south limb.

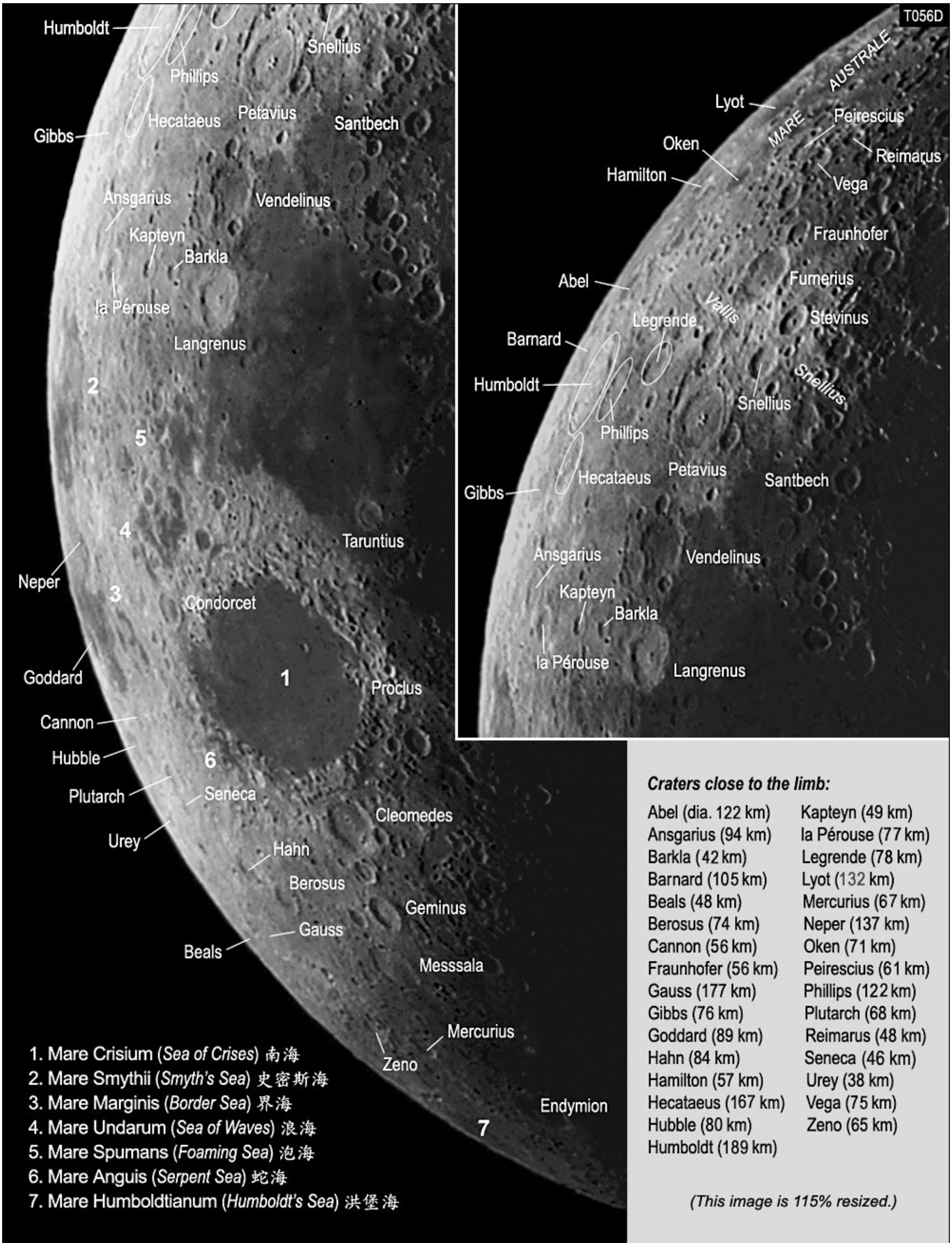




Lunar libration causes surface features near the limb distort noticeably in angular dimensions, and features very close to the limb may be temporarily out of sight. For instance, Lacus Autumni (Autumn Lake), Lacus Veris (Spring Lake) and Mare Orientale (Eastern Sea) appear on the west limb only at very favorable libration. The visibility of the maria on the east limb (T056D, next page) are also libration dependent.



The east limb during favorable libration

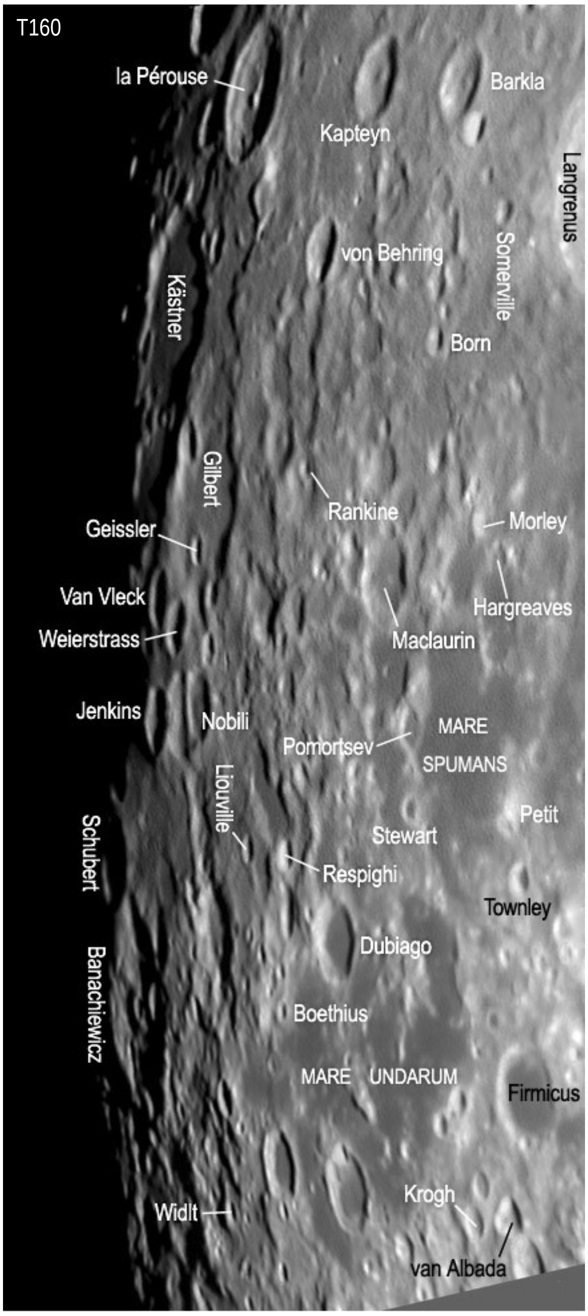


East Limb of the Moon 2001.09.22 11:27 UT Age 5 days. Kenko ED refractor 8cm f/8 + Or18 + Nikon CP990 at 1/6 sec.
This day is almost autumnal equinox. It also happened that lunar libration was maximum in longitude (l = +7.8°). *DSCN9724*

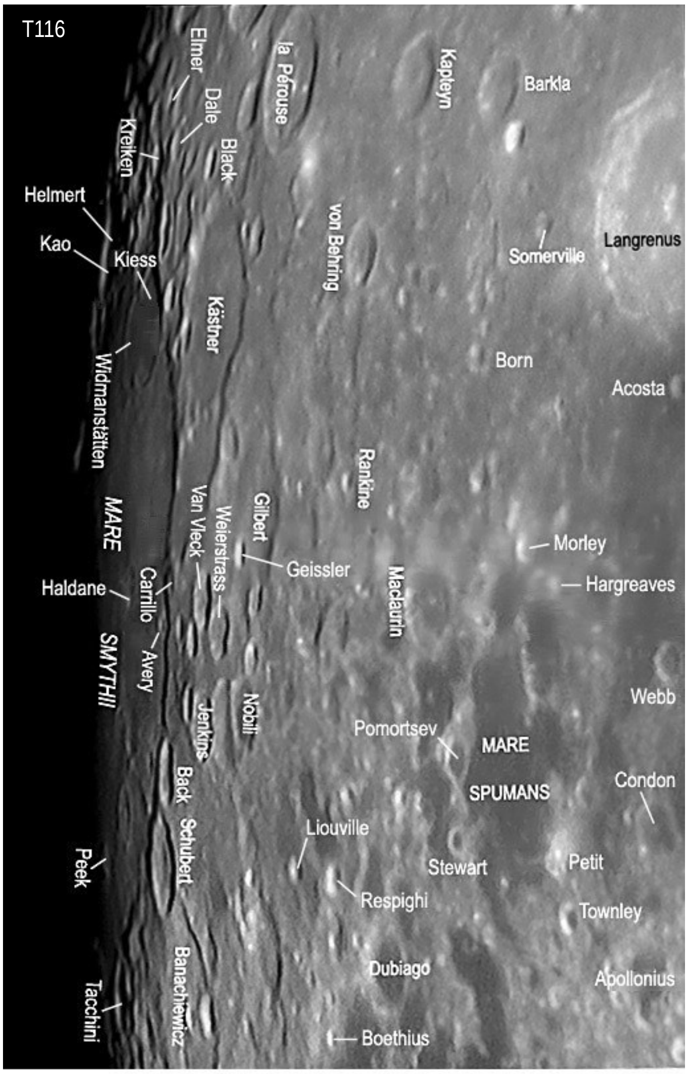
Hatfield 3, 15 Rükl 38, 49

EVENT 1

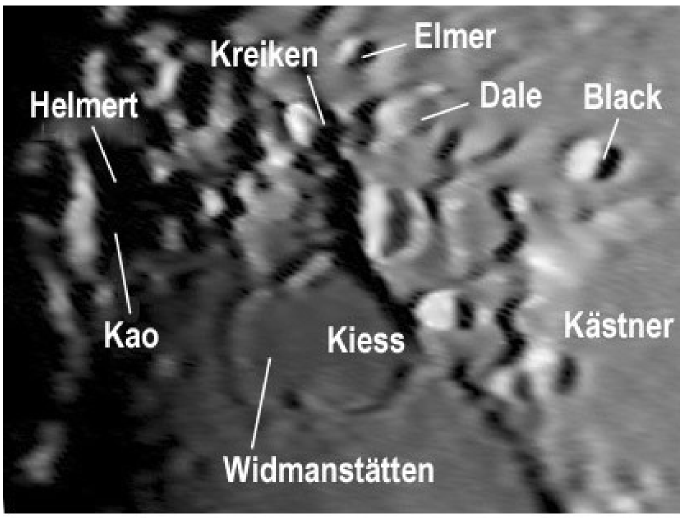
The east limb near equator during favorable libration



Mare Spumans & Mare Undarum 2004.09.29 ~15:32UT Age 15 days
Libration l = 5.4° b = 1.4° Terminator at 82° E



Mare Smythii & Mare Spumans at fairly favorable libration (l = 4.5° b = -1.0°)
2004.10.28 ~14:09 UT Age 15 days. Terminator at 89° E. 10-in f/6 Newtonian + 2.5X +ToUcam

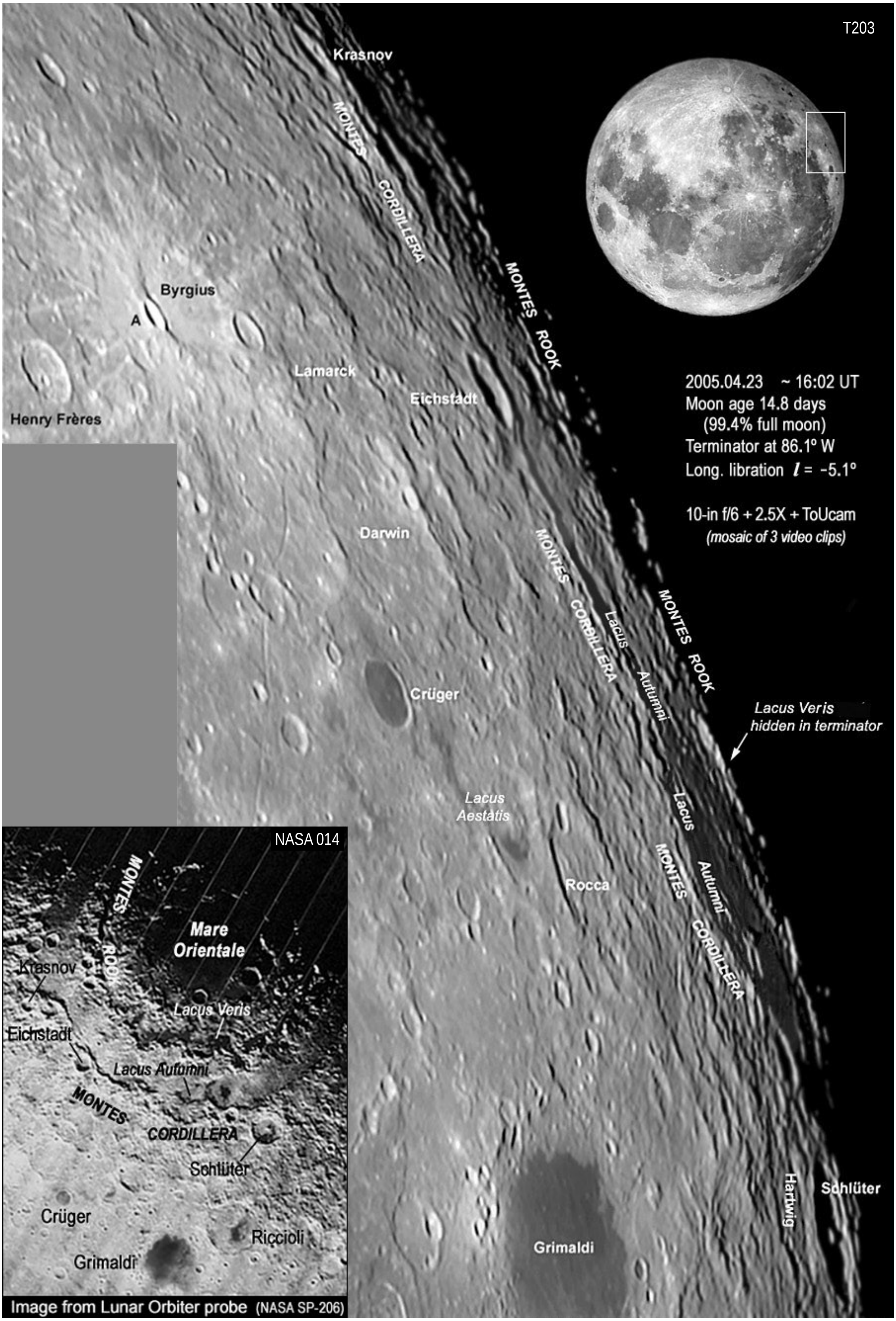


Simulated non-oblique view of **Kiess** & **Widmanstätten**
(Cropped from T116 and rescaled.)

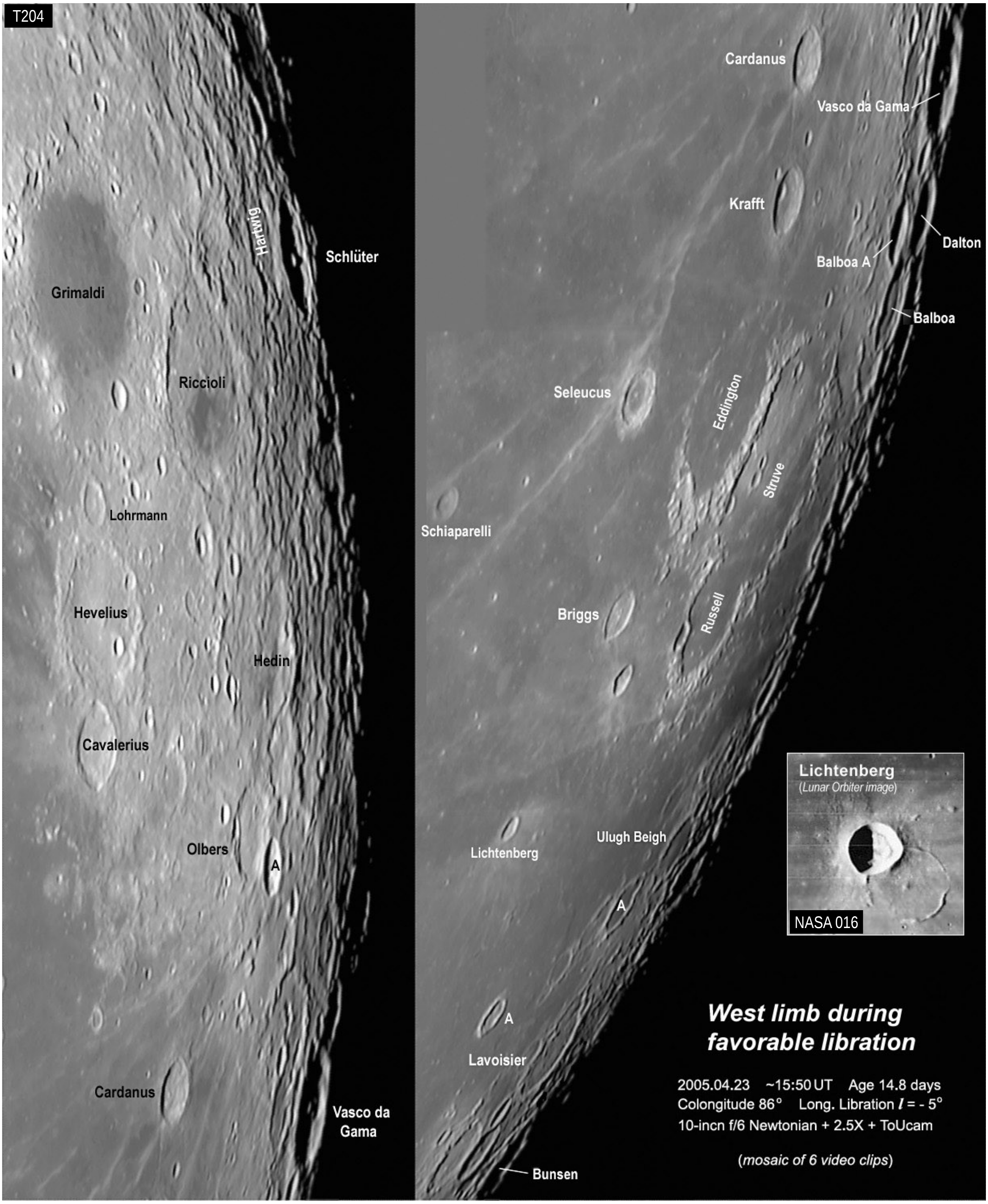
Crater Diameters:

Back *(35 km)*
Banachiewicz *(92 km)*
Barkla *(42 km)*
Born *(14 km)*
Condon *(34 km)*
Dubiago *(51 km)*
Firmicus *(56 km)*
Gilbert *(112 km)*
Jenkins *(38 km)*
Kao (34 km)
Kapteyn *(49 km)*
Kästner *(108 km)*
Kiess *(63 km)*
Krogh (19 *km)*
la Pérouse *(77 km)*
Liouville *(16 km)*
Maclaurin *(50 km)*
Nobili *(42 km)*
Pomortsev *(23 km)*
Rankine *(8 km)*
Respighi *(18 km)*
Schubert *(54 km)*
Somerville *(15 km)*
Stewart *(13 km)*
Townley *(18 km)*
van Albada (*21 km*)
Van Vleck (31 km)
von Behring *(38 km)*
Weierstrass *(33 km)*
Widmanstätten *(46 km)*

The west limb during favorable libration (from 31° S to 4° S)

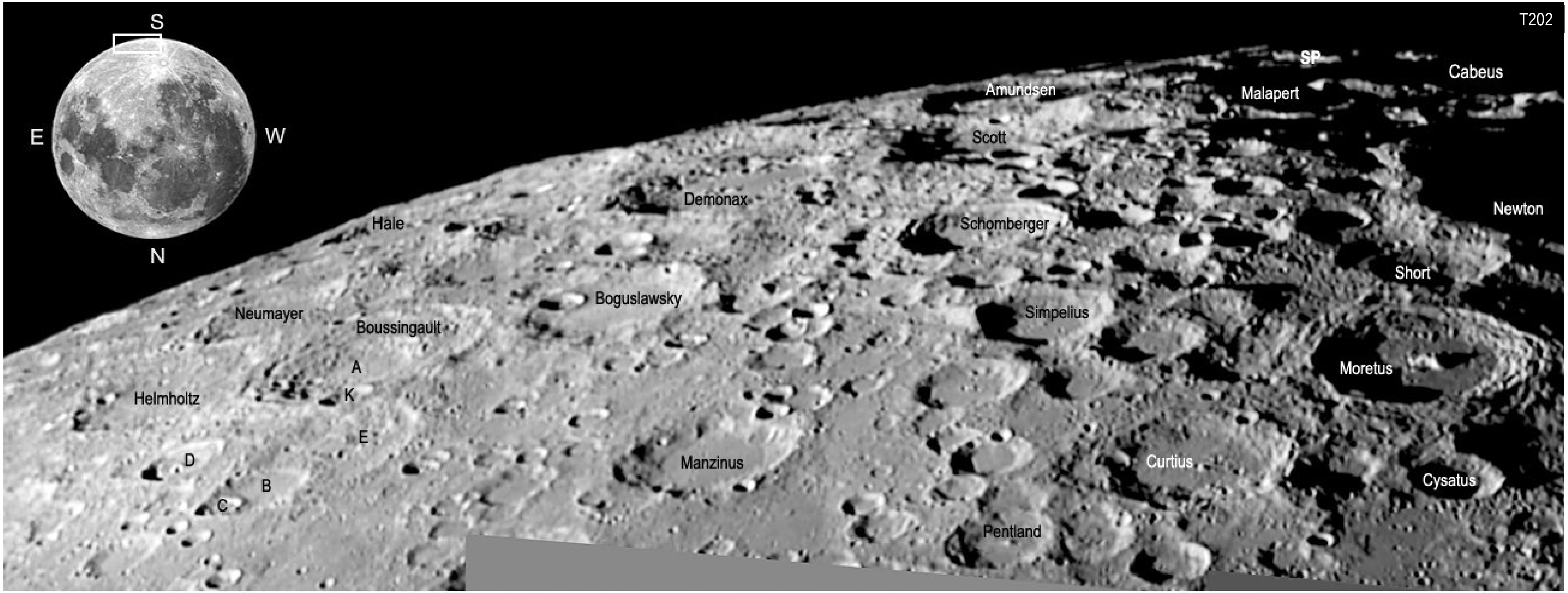


The west limb during favorable libration (from 12° S to 42° N)



South pole and its eastern region during favorable libration

The south pole is marked SP*. Crater Cabeus (diameter 98 km) and Newton (78 km) are hidden in the dark side of the terminator. Malapert (69 km) is also heavily shadowed. Amundsen (85.6⁰E 84.3⁰S, 101 km) is not visible usually but it is recognizable in this image. See also the* Farside *map for non-oblique views of these craters.*



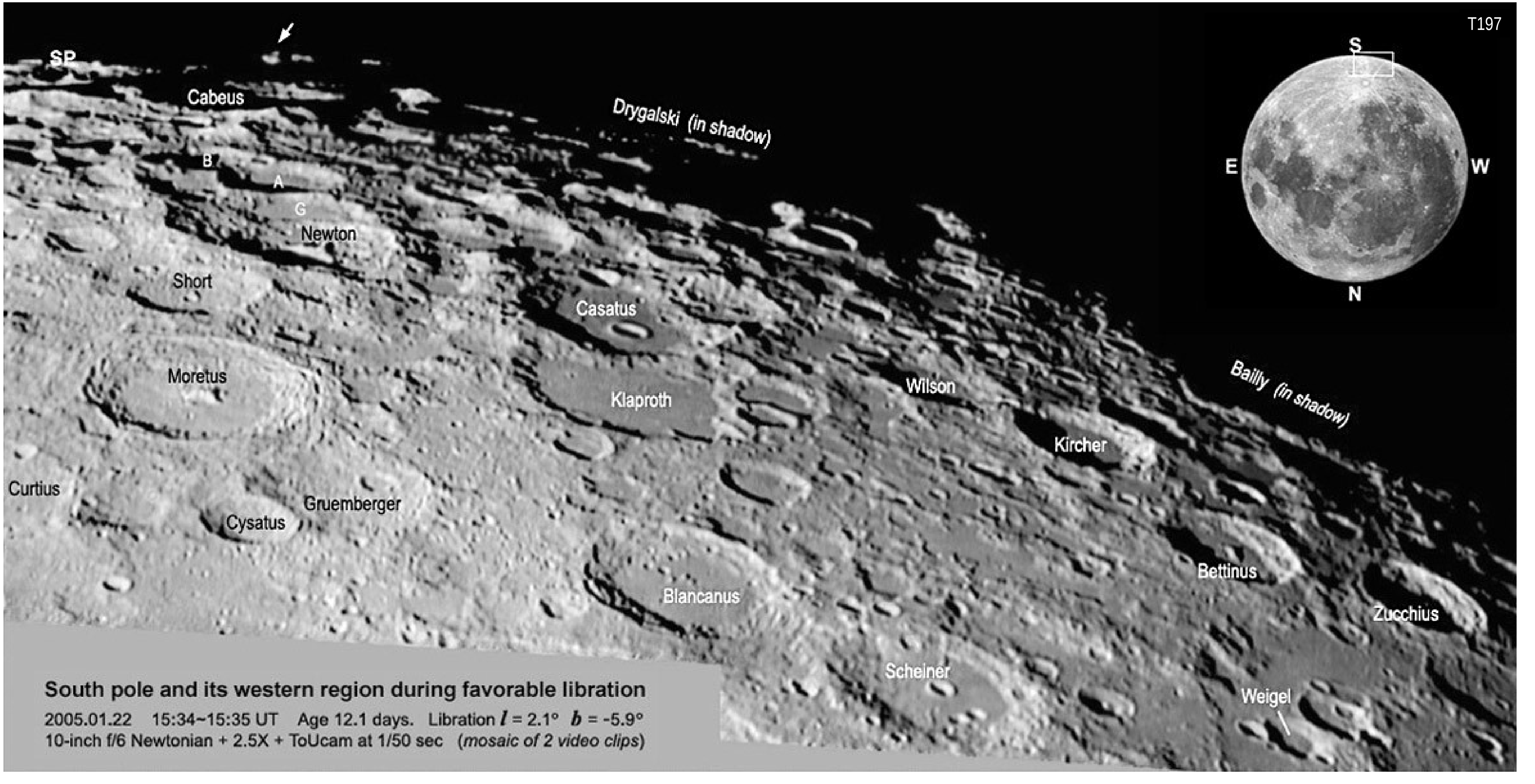
South pole and its eastern region during favorable libration 2005.04.18 14:44 ~ 14:47 UT Age 10 days. Libration l = - 2.3° b = - 6.0°. 10-in f/6 Newtonian + 2.5X + ToUcam

Hatfield 14, 16 Rükl 73, 74, 75

EVENT 1

South pole and its western region during favorable libration

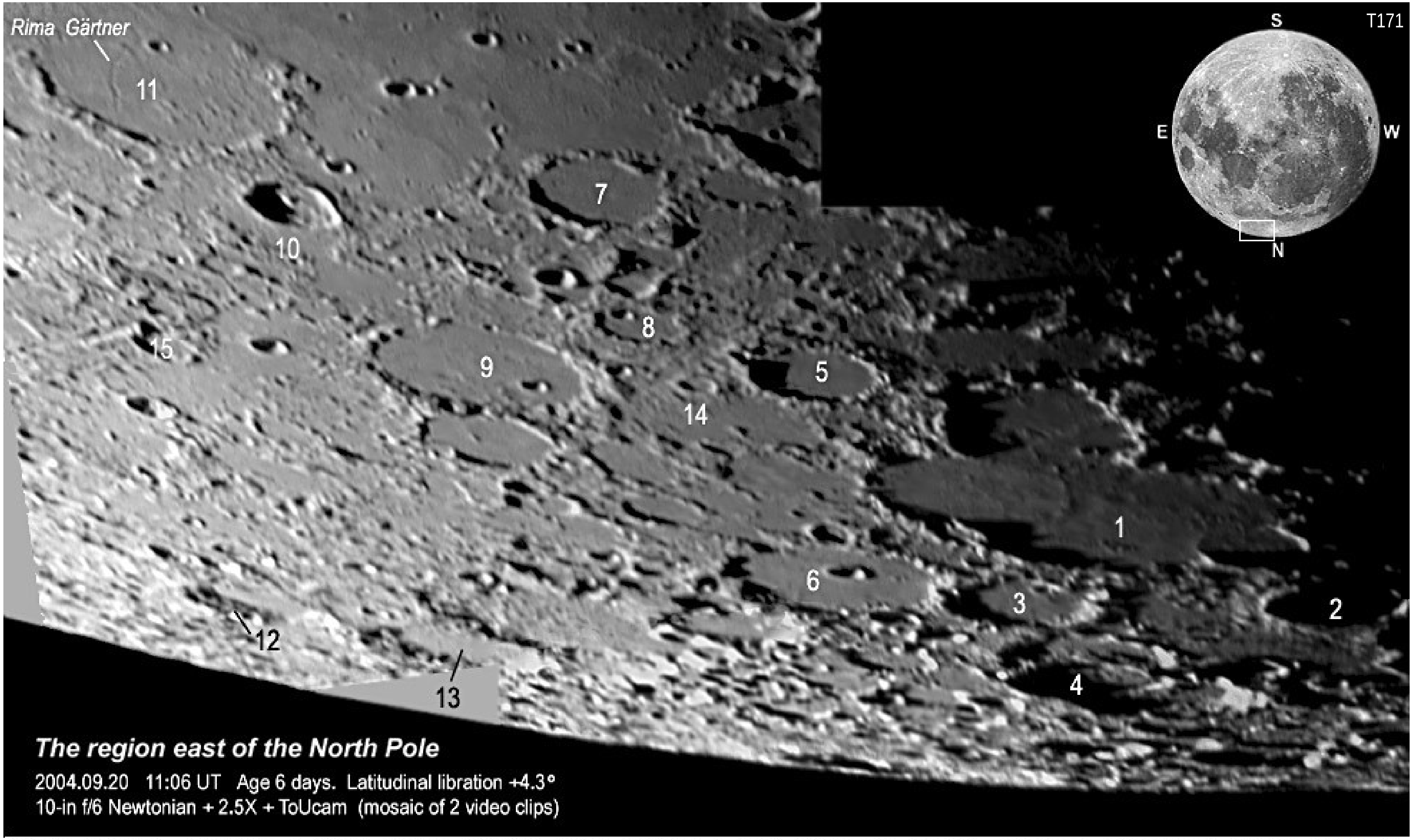
*The south pole is marked SP. Large crater Drygalski and Bailly are hidden in the dark side of the terminator. Newton (diameter 78 km) is shown together with satellite craters A, B and G. The arrow points to the high peaks of **Leibnitz Mountains** which rise up to 10,000 m above mean level. Leibnitz Mountains (an informal name) is the highest surface feature on the entire Moon.*



Hatfield 10 Rükl 73, 72, 71

EVENT 1

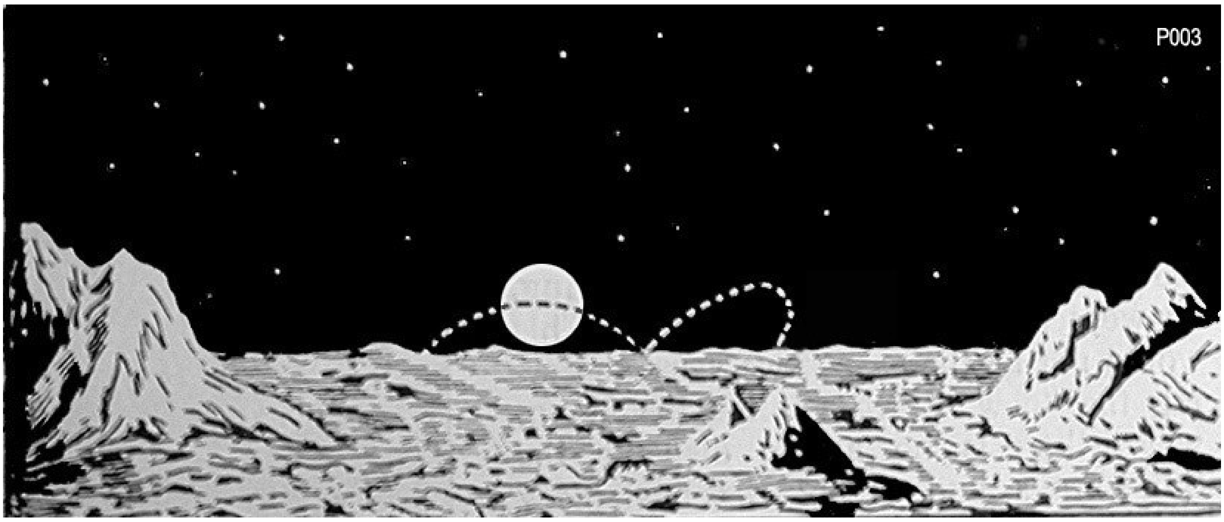
The region east of the North Pole during favorable libration



1. Meton 2. Scoresby 3. Euctemon 4. de Sitter 5. Neison 6. Baillaud 7. Kane 8. Moigno 9. Arnold 10. Democritus 11. Gärtner 12. Cusanus 13. Petermann 14. Peters 15. Schwabe

Artist's impression of libration

To an observer at a given place on the nearside of the Moon, the Earth would seem to be almost fixed in the sky. Lunar libration, however, produces an additional peculiar motion of the Earth. Whenever on the Moon the Earth is seen above horizon, it will seem to set and then rise again, as indicated by the broken curves. This peculiar rising or setting of the Earth at the horizon follows the period of libration, which repeats approximately every 27~28 days. (Sketch from Perelman's Astronomy For Entertainment, Moscow, 1958.)

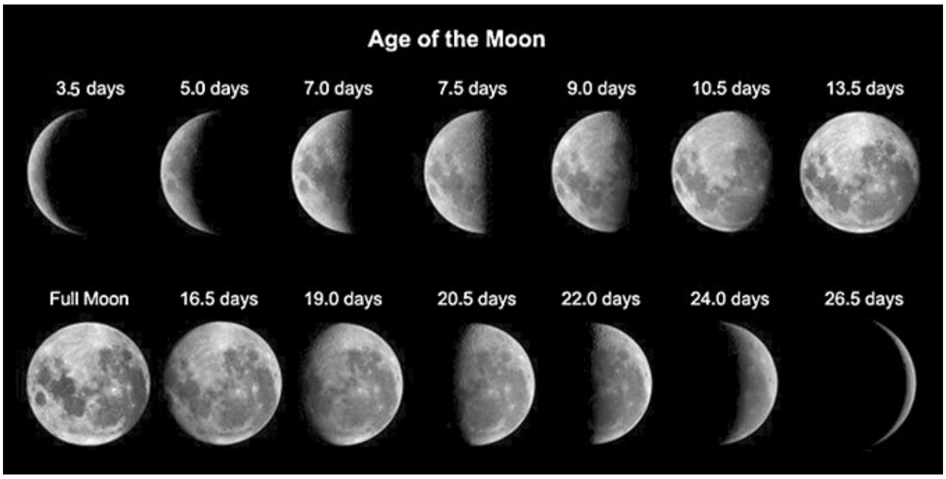


A partially illuminated Earth rises above the lunar horizon

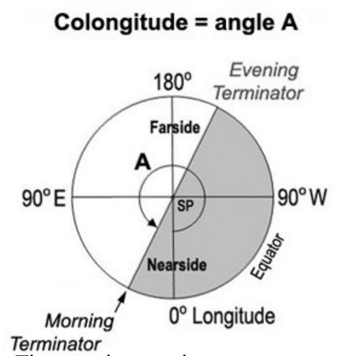
Taken by Apollo 11 crew flying over Mare Smythii, 1969 July 20 (NASA Image AS11-44-6550). Mare Smythii Is on the east limb of the Moon's nearside. If the crew landed on Smythii and stayed there long, they would find the Earth wandering very slowly above the horizon, similar to the above sketch.

Terminator

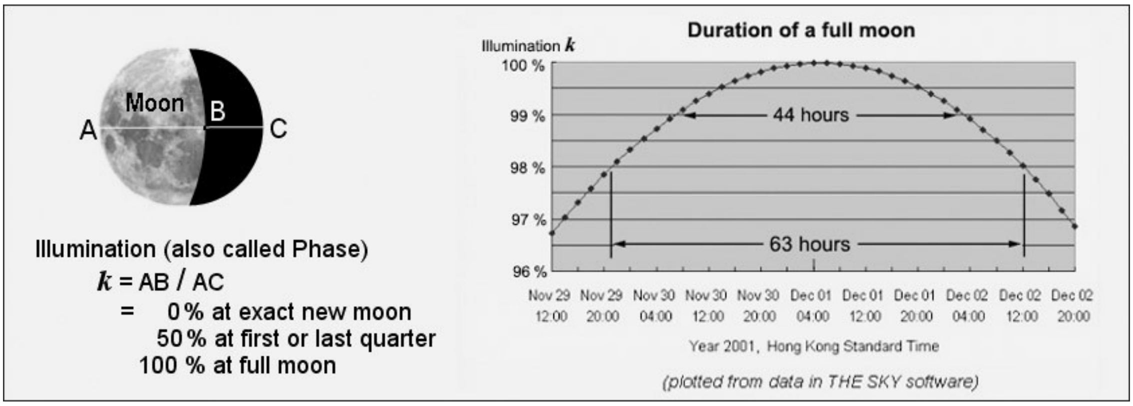
The terminator (明暗界線) is the border line between the illuminated and dark portions of the Moon. It is the line of sunrise or sunset. At the morning terminator, the Sun is rising over that part of the Moon; at the evening terminator, the Sun is setting. Precisely the terminator position is specified by the Sun's *colongitude*, which is same as the selenographic longitude of the morning terminator, measured westwards from the 0^0 longitude of the Moon globe. Thus the terminator position is approximately colongitude 0^0 at first quarter, 90^0 at full moon, 180^0 at last quarter and 270^0 (= 90^0 E) at new moon. In some lunar ephemerides, it is often measured in relation to the mean center of the lunar disc not accounting for any effect of libration. This may cause the observer to notice a deviation between the actual terminator position and the position quoted by the ephemeris. To avoid such ambiguity, this book marks the terminator position simply in terms of the "Age of the Moon" or the fractional "Illumination ***k***" although both parameters are not exact indication of the sunlight angle. See the following illustrations.



Mosaic from various images, south is up and west is right. The top row (before full moon) gives the morning terminator; the bottom row (after full moon) gives the evening terminator. Note that Moon age less than 2 days or greater than 27 days is very difficult to trace due to close proximity to the Sun. Practically the Moon crescent is not visible if it is less than 7^0 from the Sun. (Reference No. 23)



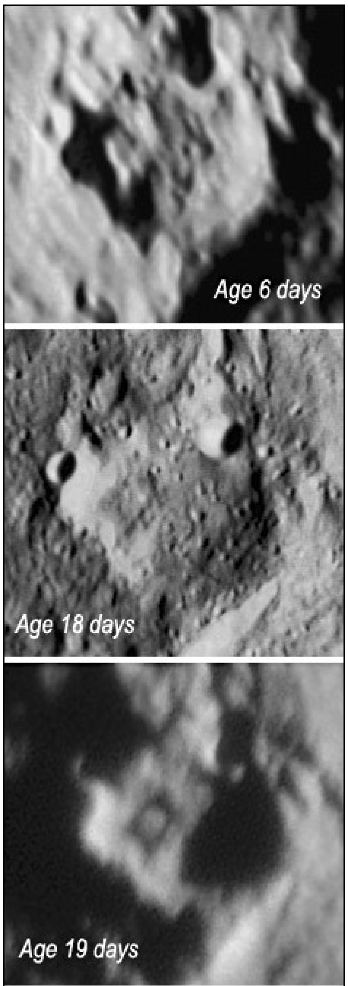
The terminator always moves westwards on the nearside of the Moon, hence it rotates anticlockwise if viewed from top of the lunar south pole. However the terminator rotation is not uniform. It may vary from about 29.3 to 29.8 calendar days for one revolution. The average is 29.53059 days, generally known as the Synodic Month 朔望月 .



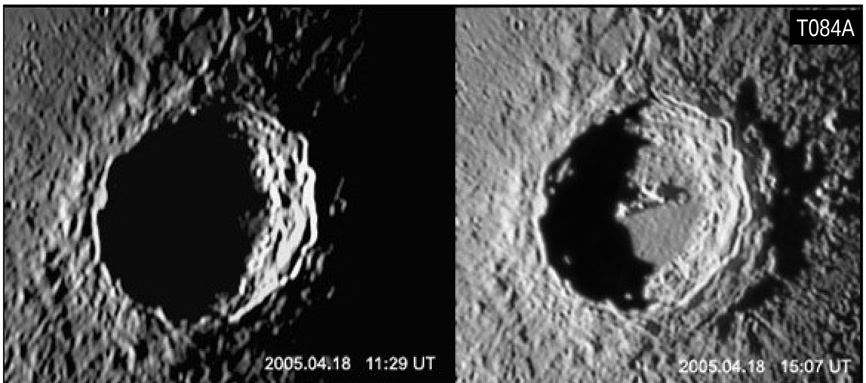
The terminator moves quite slow at days close to full moon. This can be simulated by astronomy software in the above diagram, which shows no terminator at exact full moon (***k*** = 100 %), and that the Moon remains "pretty full" (***k*** > 98 %) in 63 hours.

Although the terminator moves slowly, it is possible to detect this movement with telescopes. One observation through a 4-inch refractor at low power indicates that the movement is barely distinguishable in interval as short as 10 minutes (Image T040B). When the terminator is crossing Copernicus, its movement can even be detected in a couple of minutes under high power (T084A).

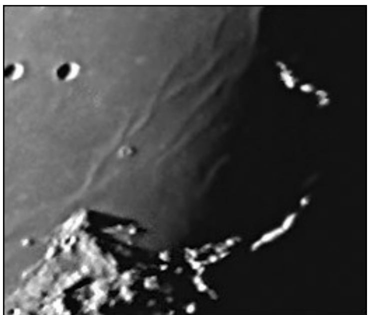
The lunar terminator has moved very slightly in duration as short as 10 min. FS102+K25+CP990.



Three views of shadow in Cyrillus F (*reprocessed from T009, T144 & T263.)*



Two views of Copernicus on the lunar terminator, separated by 3.5 hours (11:29 to 15:07 UT)


The edge of Sinus Iridum resembles a golden handle. 2002.12.14 16:40UT Age 10 days. Cropped from T025.

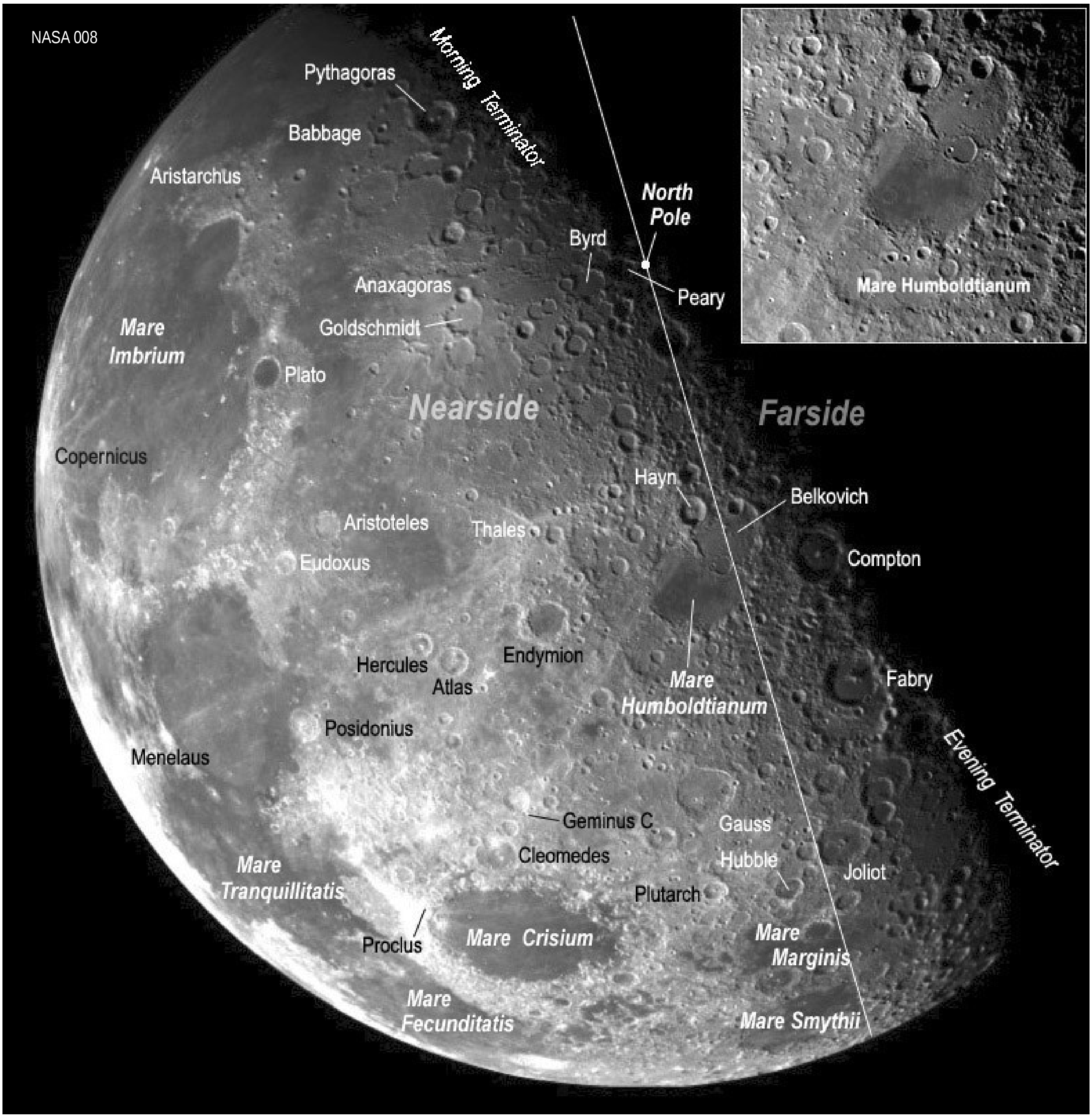
The lunar terminator produces many intriguing but momentary views. In the above images, Cyrillus F (Map 5) appears with a tortoise-shaped shadow on depressed floor around Moon age of 18 ~ 19 days. The edge of Sinus Iridum (Map 18) appears like a “golden handle” of a teapot.

Other views relying on the terminator are − the Serpentine Ridge & Rimae Plinius in Map 9, the Valentine dome in Map 15, and the triangular shadow cast by Sirsalis Z in Map 27.

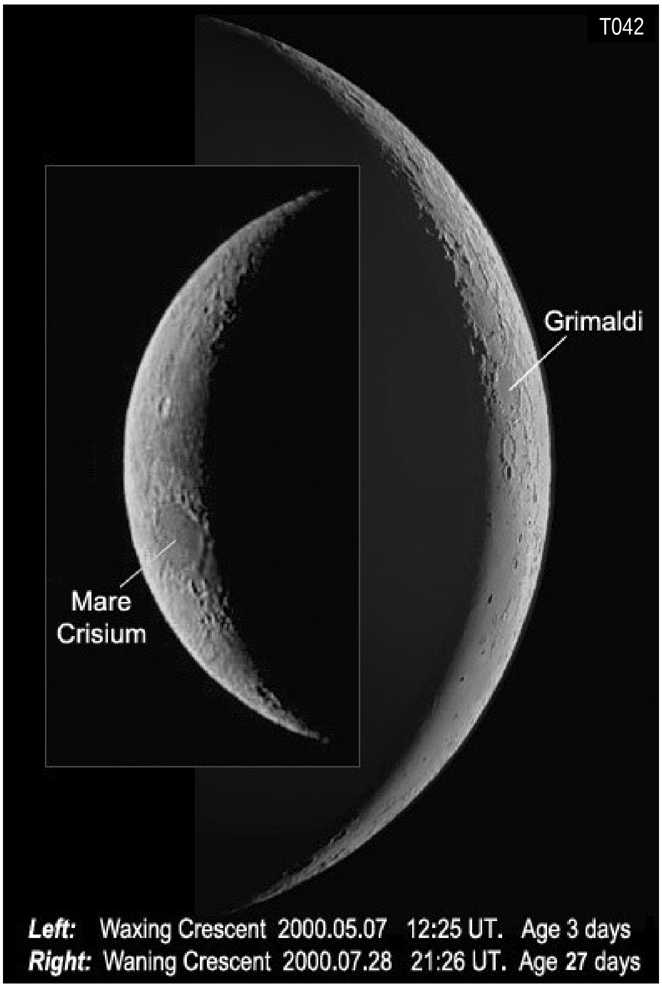
Terminator seen by Galileo spacecraft as it flew by the Moon

*Below is a mosaic of 18 images from the spacecraft's camera through a green filter on 1992 December 7, when the Moon was 94 % full and with the illuminated portion approximately facing the Earth. The lunar north pole is on the outer rim of crater **Peary**. This crater is 73 km in diameter and lies just inside the shadow zone next to **Byrd**. To a terrestrial observer, **Mare Humboldtianum** is a difficult object on the northeast limb of the Moon but here it is seen clearly with two concentric mountain rings. Note the bright ray from **Geminus C** striking on the edge of Mare Humboldtianum. The shapes of Mare Tranquillitatis, Mare Fecunditatis and Mare Crisium also change significantly from their usual impressions.*

The straight line separates the nearside from the farside of the Moon. The morning terminator indicates the Sun is rising over that part of the region. At the evening terminator, the Sun is setting. Because the Moon has no atmosphere, there is no Earth-like twilight. The day and night transition over a lunar place occurs quite instantly. During daytime (which lasts approximately 2 weeks by Earth calendar), the surface temperature can reach 130^{0}C maximum. During nighttime (which also lasts approximately 2 weeks), it falls to -180^{0}C or even lower at the polar regions. The temperature at depth of 1 m under surface, however, is relatively constant, around -35^{0}C. This suggests that lunar "soil" (regolith) is a good thermal insulator. (Reprocessed from NASA image JPL-PIA00130)



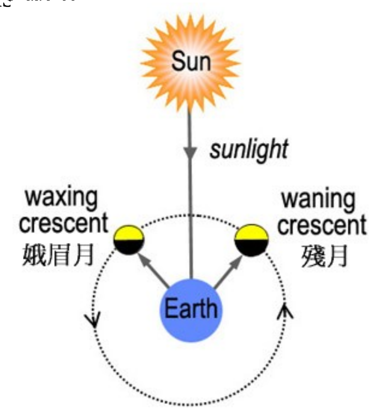
Crescent

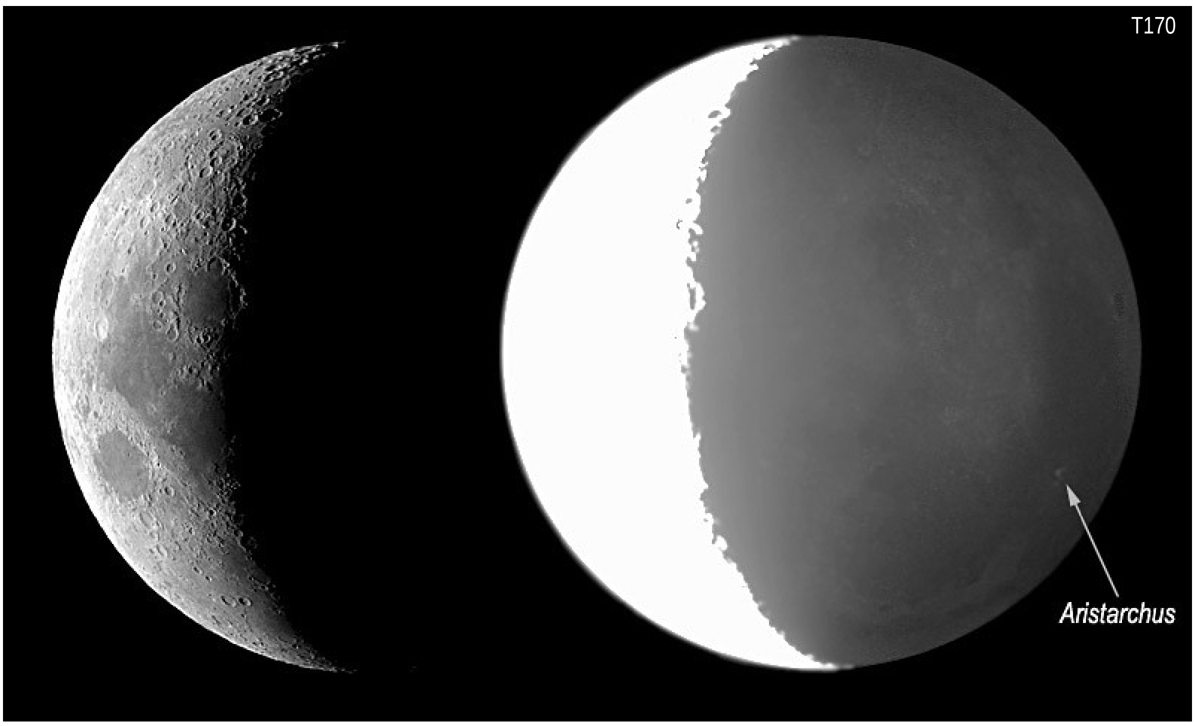


Left: Waxing Crescent 2000.05.07 12:25 UT. Age 3 days
Right: Waning Crescent 2000.07.28 21:26 UT. Age 27 days

When the Moon is a crescent, its sky position is not far away from the Sun. The ***Waxing Crescent*** (*T042 left*) indicates the Moon phase (its illuminated surface) is increasing. The ***Waning Crescent*** (*T042 right*) indicates the Moon phase is decreasing.

Thin crescents often appear with ***Earthshine*** 地照, as shown in T170 and T095. Earthshine refers to a faint illumination of the dark portion of the crescent, caused by sunlight reflected from the Earth. Surface features in a photograph of thin crescent are likely lack of contrast, because the reflection of Earth shines on the crescent as well



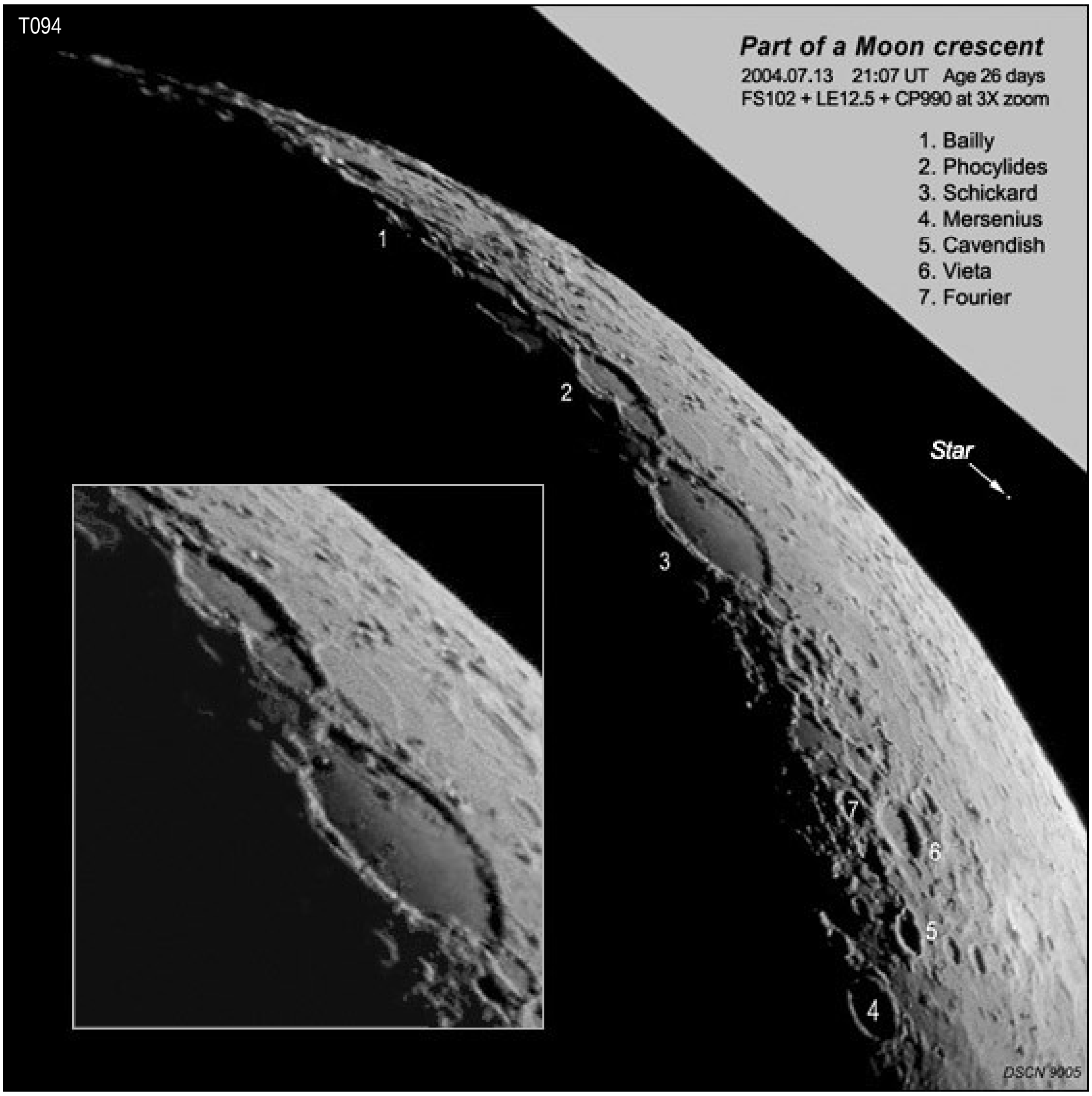


Moon crescent with earthshine 2002.08.13 ~12:00 UT Age 4 days. FS102 + Or 25 + CP990. The right image is deliberately overexposed to show the earthshine. Note that Aristarchus, a truly bright crater near the west limb, is visible even in earthshine.

A 26-day old Moon ***Right:*** Crescent portion ***Left:*** Earthshine portion 2004.07.13 20:42~20:57 UT. FS102 + PL25 + CP990 (2 images)

Crescent & Earthshine

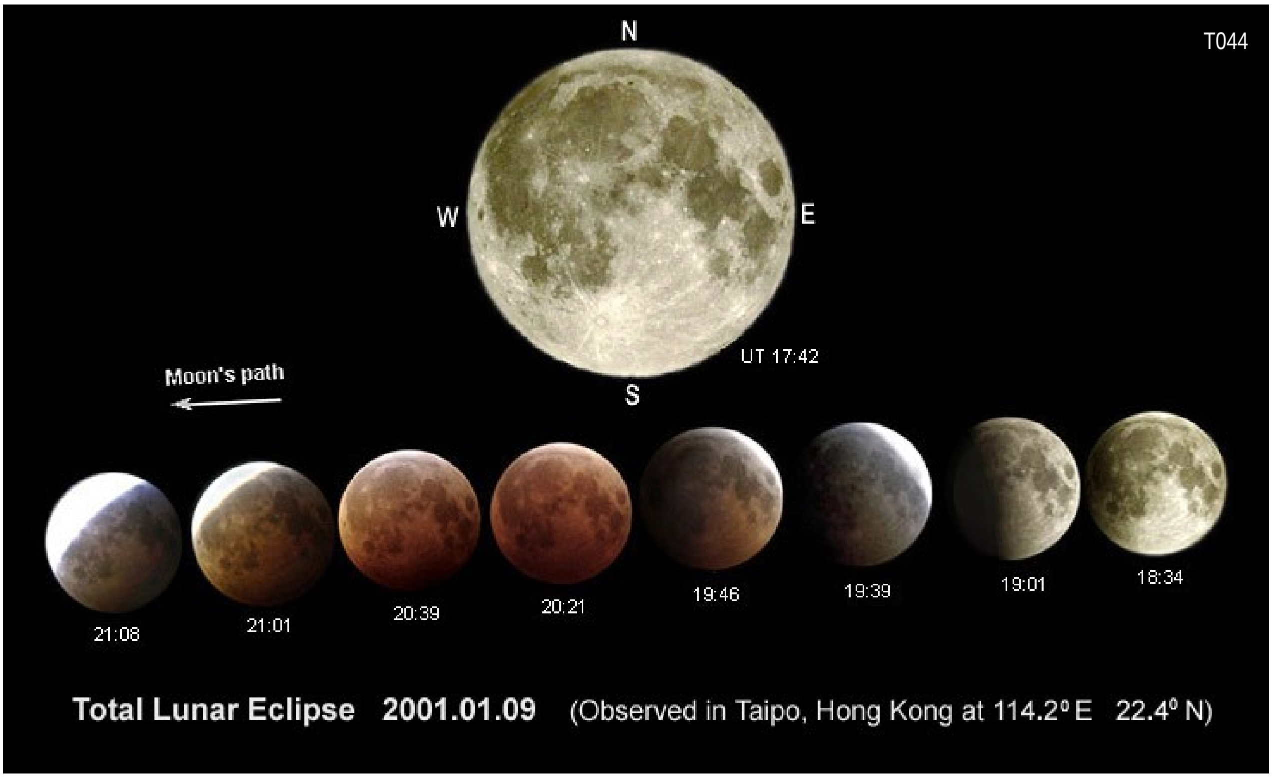
All images in this page were captured from the 26-day old Moon on 2004.07.13 when its altitude was only 27 degrees.



EVENT 4

Eclipse and Occultation

A mosaic of the 2001 January 9 total lunar eclipse (月全食) is given in T044 where north is up to simulate the view in binoculars. The color and brightness of the Moon did not change much in the Earth's penumbra (18:34 UT). As the Moon entered the Earth's umbra, its color changed gradually and became dull red at eclipse maximum (20:21 UT). The brightness drop during total eclipse was about 1: 10000, as shown by the graph in next page. It also happened that the Moon almost occulted Delta Geminorum (a 3.5-magnitude star) in this event, see T045.

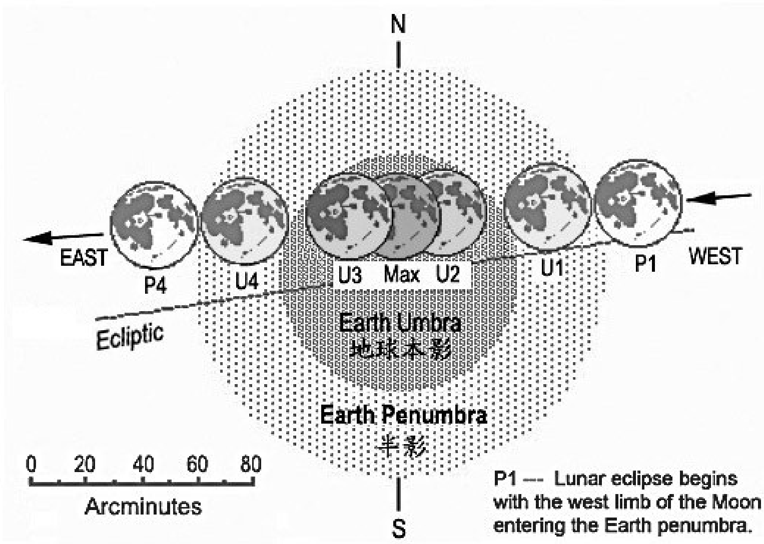


Total Lunar Eclipse 2001.01.09 (Observed in Taipo, Hong Kong at 114.2° E 22.4° N)

Path of the Moon through the Earth's shadows 2001 January 9

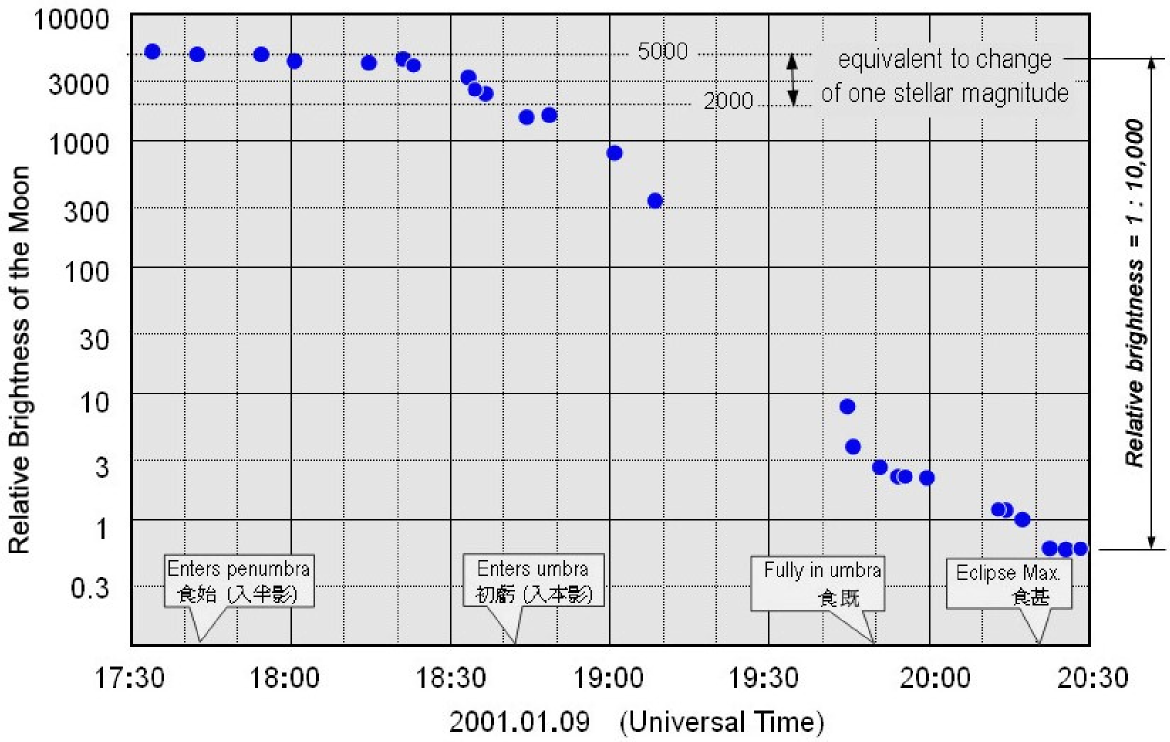
Stage of Lunar Eclipse		2001.01.09 (UT)	Moon's Altitude
P1	食始	17:43	71°
U1	初虧	18:42	58°
U2	食既	19:50	43°
Max	食甚	20:21	36°
U3	生光	20:52	29°
U4	復圓	21:59	15°
P4	食終	22:58	3°

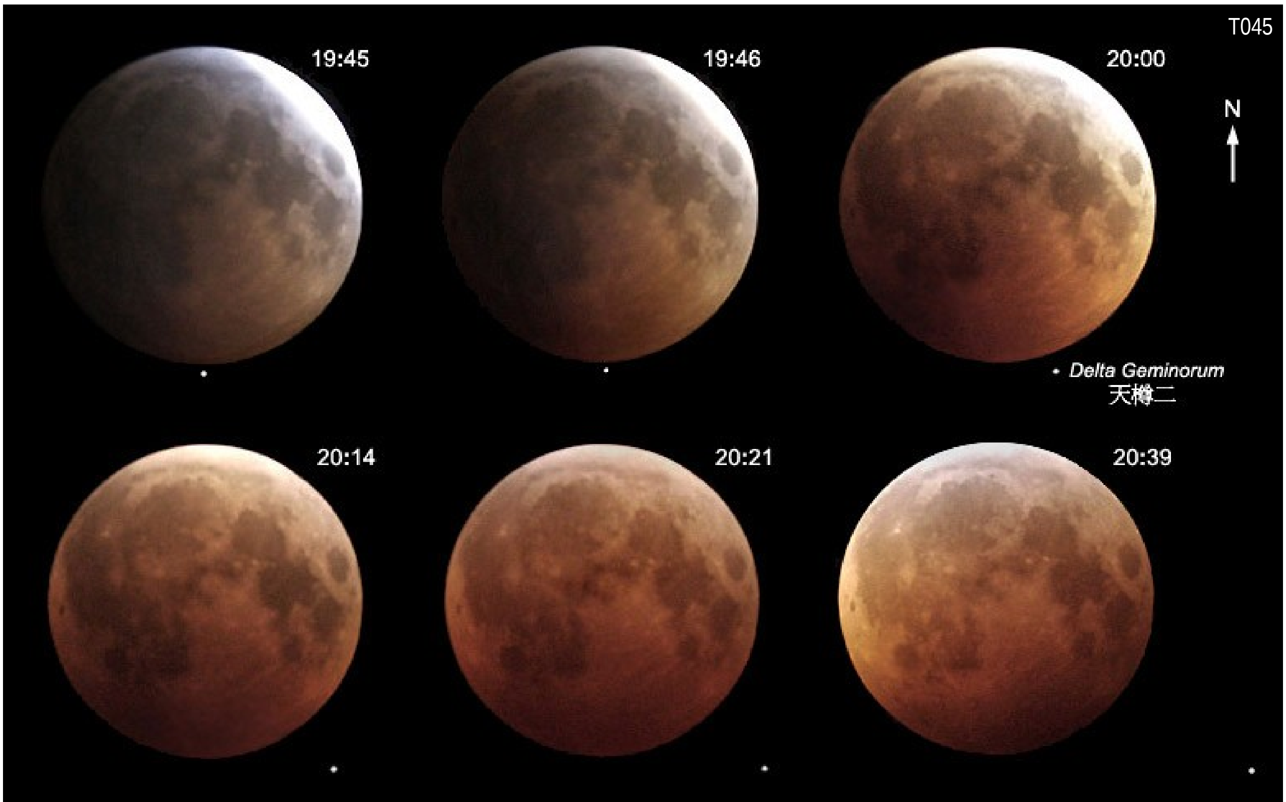
Duration of Moon in Earth umbra = 62 min.



Brightness of the eclipsed Moon, 2001 January 9

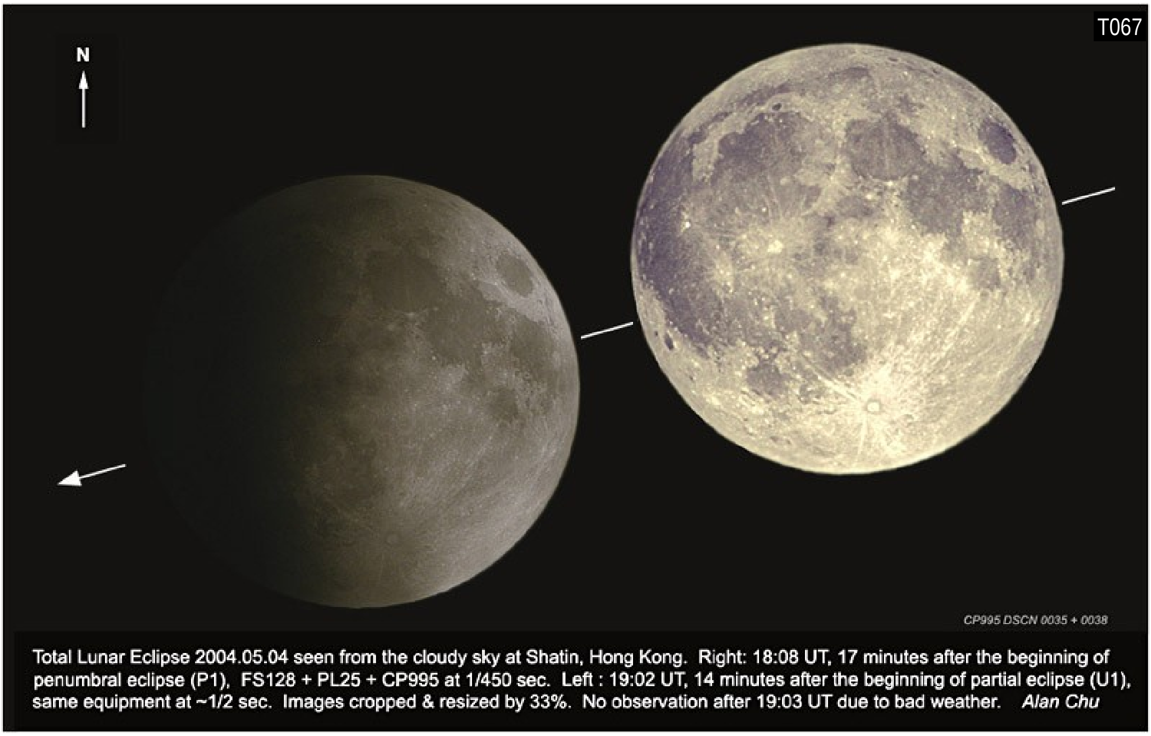
The relative brightness is deduced by comparing the exposure readings of different images captured by Casio QV2300 digital camera during the eclipse.





The eclipsed Moon and Delta Geminorum (3.5-magnitude star) in near-occultation on 2001.01.09 19:45 UT. The closest separation is 0.9 arcmin between the star and the Moon's south limb. Observed in Hong Kong.

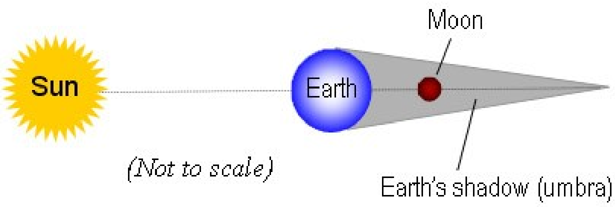
T067 was taken is another Total Lunar Eclipse, occurred on 2004 May 4 and observed in Hong Kong. When the eclipse began, the sky was overcast for rain. Only this picture is available in the full course of the event.



Total Lunar Eclipse 2004.05.04 seen from the cloudy sky at Shatin, Hong Kong. Right: 18:08 UT, 17 minutes after the beginning of penumbral eclipse (P1), FS128 + PL25 + CP995 at 1/450 sec. Left : 19:02 UT, 14 minutes after the beginning of partial eclipse (U1), same equipment at ~1/2 sec. Images cropped & resized by 33%. No observation after 19:03 UT due to bad weather. *Alan Chu*

Lunar and solar eclipses at the same time

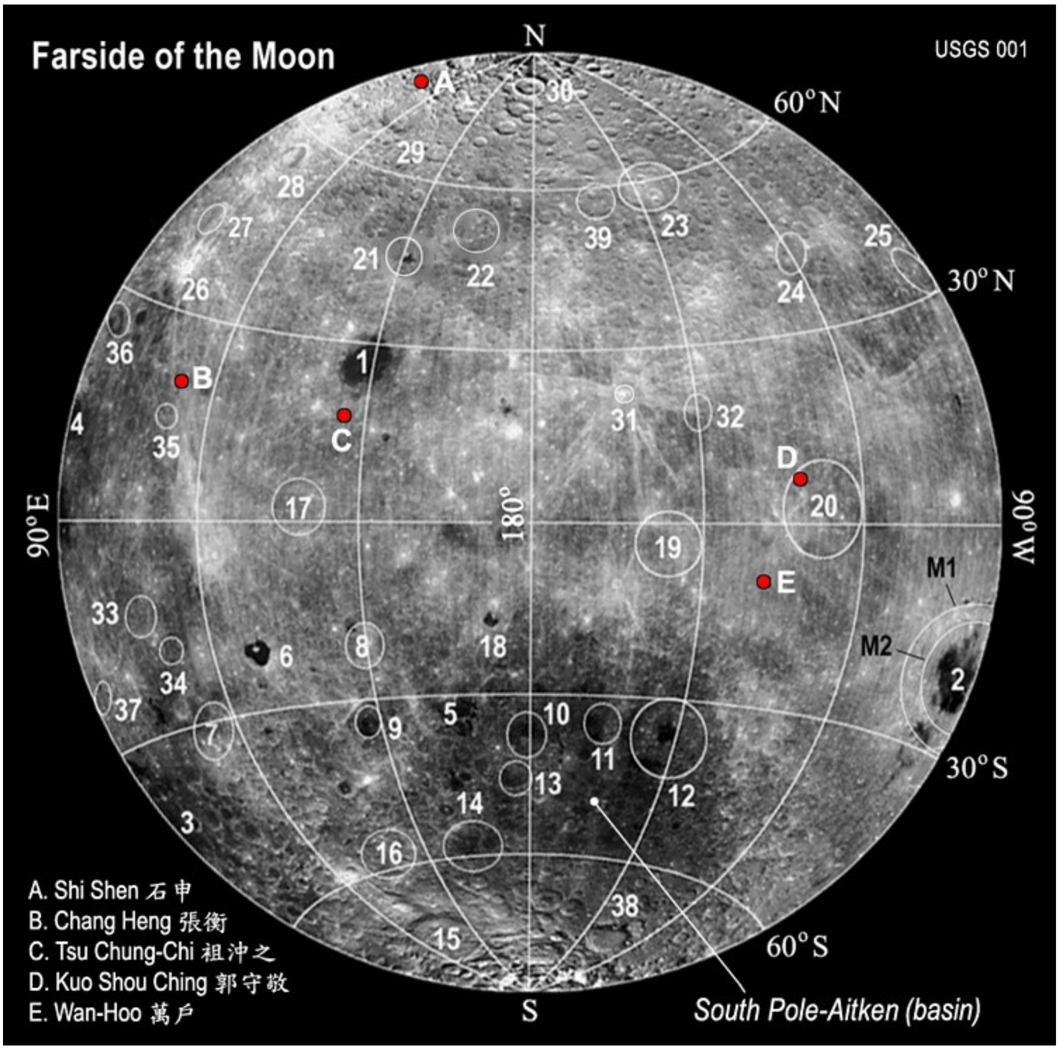
While watchers on Earth see a lunar eclipse, watchers on the Moon could experience a solar eclipse as well. If the Moon passes through the umbra (darkest portion) of the Earth's shadow, the total solar eclipse seen from the Moon can last up to 1.7 hours, much longer than the duration of any solar eclipse seen from the Earth.



The right is a space painting which depicts an eclipse of the Sun by Earth as seen from the Moon. From here the Earth looks four times larger than the solar disc; hence the corona (extremely hot ionized gas surrounding the Sun) would not be seen. The Earth's atmosphere forms a "ring of fire" as sunlight is refracted by it, giving a typical coppery tint. The red glow is caused by the "sunset" effect. The Moon also turns red by the illumination of the Earth's atmosphere.
(This explains why the eclipsed Moon in T045 looks red.)

Credit: **David A. Hardly** *http://www.astroart.org*

3. Farside of the Moon



	Feature Name	Long. (deg.)	Lat. (deg.)	Dia. (km)
Mare				
1	Mare Moscoviense (*Moscow Sea*) 莫斯科海	148 E	27 N	~280
2	Mare Orientale (*Eastern Sea*) 東海	93 W	19 S	~300
3	Mare Australe (Southern Sea) 南海	93 E	40 S	~600
4	Mare Marginis (Border Sea) 界海	86 E	13 N	~400
5	Mare Ingenii (*Sea of Ingenuity*) 智海	163 E	34 S	~300
Crater				
6	Tsiolkovsky 齊奧爾科夫斯基	129 E	21 S	185
7	Milne 米爾恩	112 E	31 S	272
8	Gagarin 加加林	149 E	20 S	265
9	Jules Verne 朱爾斯・維恩	147 E	35 S	143
10	Leibnitz 萊布尼茲	179 E	38 S	245
11	Oppenheimer 奧本海默	166 W	35 S	208
12	Apollo 阿波羅	152 W	36 S	537
13	Von Kármán 卡曼	176 E	45 S	180
14	Poincaré 龐加萊	164 E	57 S	319
15	Schrödinger 施羅丁格爾	132 E	75 S	312
16	Planck 普朗克	137 E	58 S	314
17	Mendeleev 門捷列夫	141 E	6 N	313
18	Aitken 艾肯	173 E	17 S	135
19	Korolev 科羅列夫	157 W	4 S	437
Crater				
21	Campbell 坎貝爾	151 E	45 N	219
22	D' Alembert 阿蘭伯特	164 E	51 N	248
23	Birkhoff 伯克霍夫	146 W	59 N	345
24	Landau 蘭道	118 W	42 N	214
25	Lorentz 勞蘭斯 (勞倫斯)	95 W	33 N	312
26	Giordano Bruno 左丹奴布魯諾	103 E	36 N	22 #
27	Fabry 法布里	101 E	43 N	184
28	Compton 康普頓	104 E	55 N	162
29	Schwarzschild 史瓦西	121 E	70 N	212
30	Plaskett 普拉斯基特	174 E	82 N	109
31	Jackson 杰克遜	163 W	22 N	71 #
32	Mach 馬赫	149 W	18 N	180
33	Pasteur 巴士德	105 E	12 S	224
34	Hilbert 希爾伯特	108 E	18 S	151
35	Fleming 費萊明	110 E	15 N	106
36	Joliot 約里奧	93 E	26 N	164
37	Curie 居里	91 E	23 S	151
38	Zeeman 塞曼	134 W	75 S	190
39	Rowland 勞蘭德	162W	57 N	171
Montes				
M1	Montes Cordillera 科迪勒拉山脈	81 W	18 S	570 *

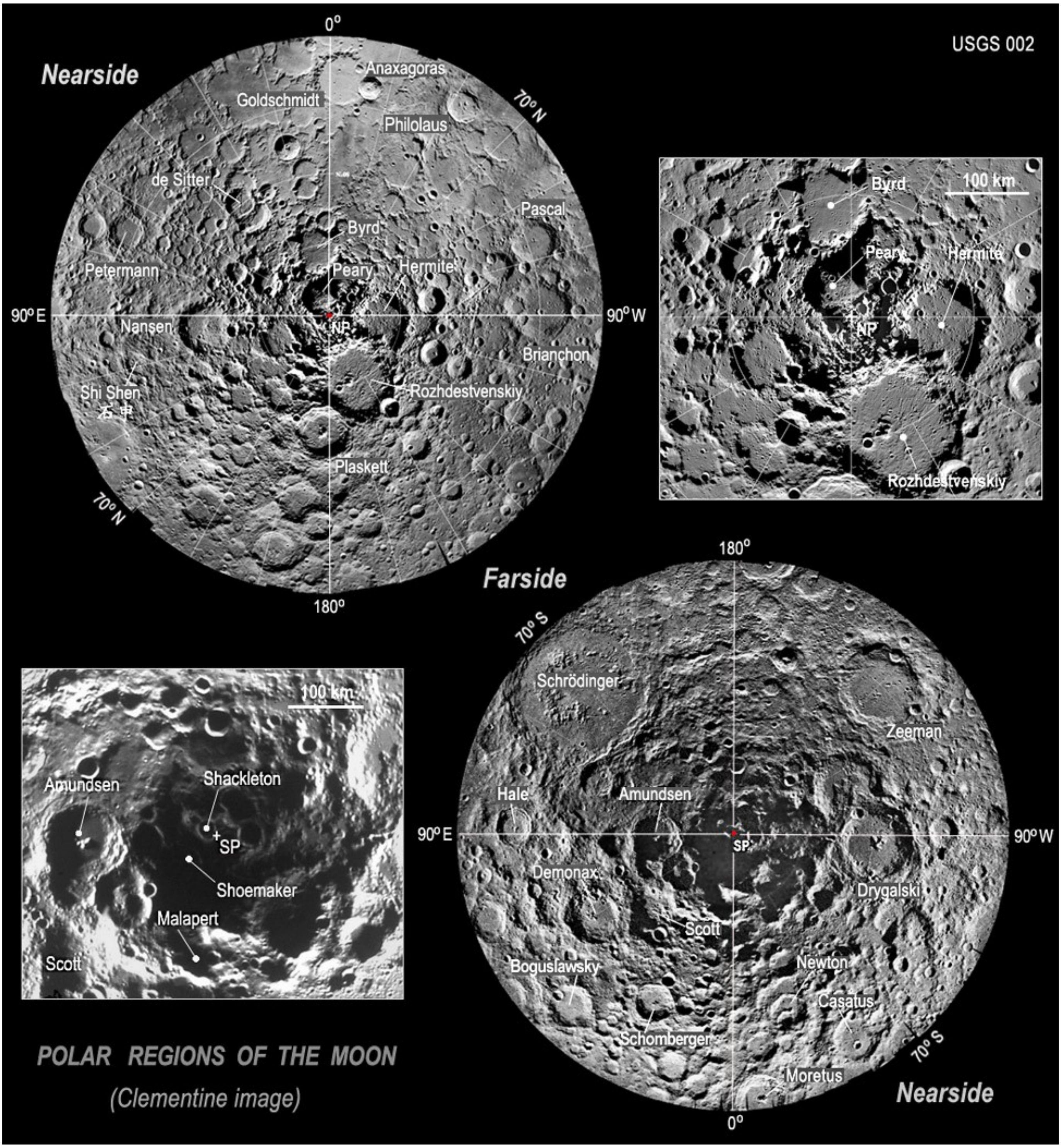
20	Hertzsprung 赫茨普隆	129 W	3 N	591 ◆	M2	Montes Rook 盧克山脈	83 W	20 S	

◆ Largest crater on the entire Moon # Crater with bright rays * Length **Detail maps:** http://planetarynames.wr.usgs.gov/luna_ccsr.html

The farside ranges from 90°E to 90°W with the mean center of the disc at 180° longitude, 0° latitude. Compared to the nearside, the farside is more heavily cratered, contains only few small maria and mascons (mass concentrations).

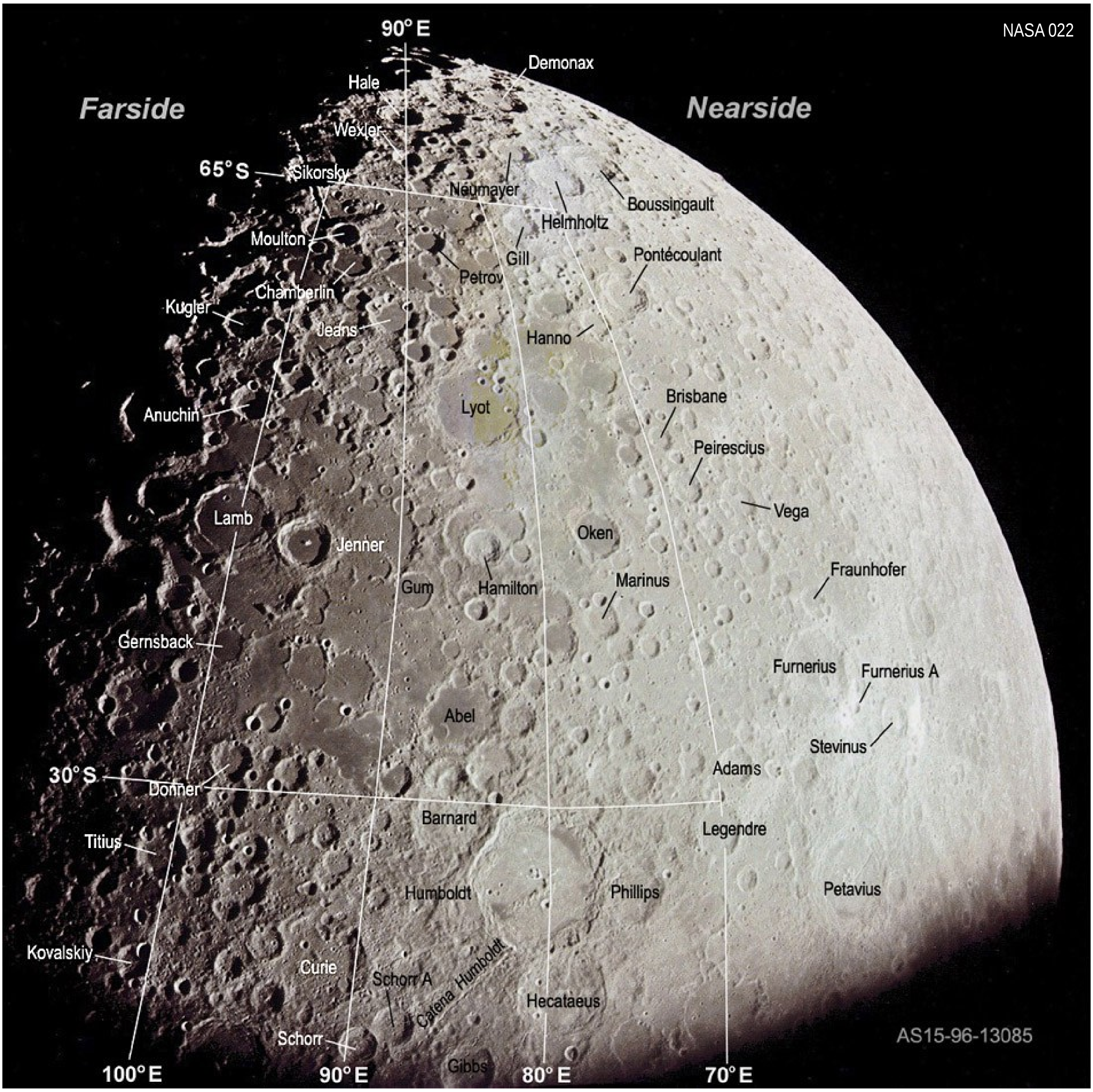
*The north pole lies on the outer rim of crater **Peary** 皮爾里. The south pole is on a depression, which is roughly 100 km across and is so deep that sunlight probably never reaches there. The south pole is therefore a speculative cold area where water ice could exist. On 1999 July 31, the American probe **Lunar Prospector** ended its mission with a controlled clash in a permanently shadowed crater near the lunar south pole.This crater is **Shoemaker** 蘇梅克 (44.9°E 88.1°S, diameter 51 km), named after the American astrogeologist Eugene M. Shoemaker (1928-1997). Shoemaker, his wife Carolyn and his amateur colleague David H. Levy discovered the fragmented comet SL-9 which subsequently collided on Jupiter during 1994 July 16 - 22. Shoemaker is also one of the pioneers in crater counting technique.*

*The **South Pole - Aitken** 南極艾肯盆地 is an impact basin about 2300 km in diameter and 12 km deep. It is the largest and oldest known impact basin in the solar system.*



Mare Australe as seen by Apollo-15 in orbit

The lunar south pole is at frame top. Mare Australe (Southern Sea) is the dark area ranging from longitude 70^0 ~ 110^0 E and latitude 30^0 ~ 65^0 S, size about 600 km. The mare floor is stuck with many craters of various sizes, ***Lyot*** *(diameter 132 km) being the largest and visible in telescope under favorable libration.* ***Jenner*** *and* ***Lamb*** *are prominent crater pair, but they are on the farside and hence invisible from Earth. A long narrow valley cuts through the farside crater* ***Sikorsky****.* ***Humboldt*** *is a large walled plain on the nearside close to Mare Australe, diameter 189 km.* ***Catena Humbodlt*** *is a chain of craterlets running between Humboldt and* ***Schorr A****, length 160 km. See also T188 in* Map 4. (*NASA image AS15-96-13085*)

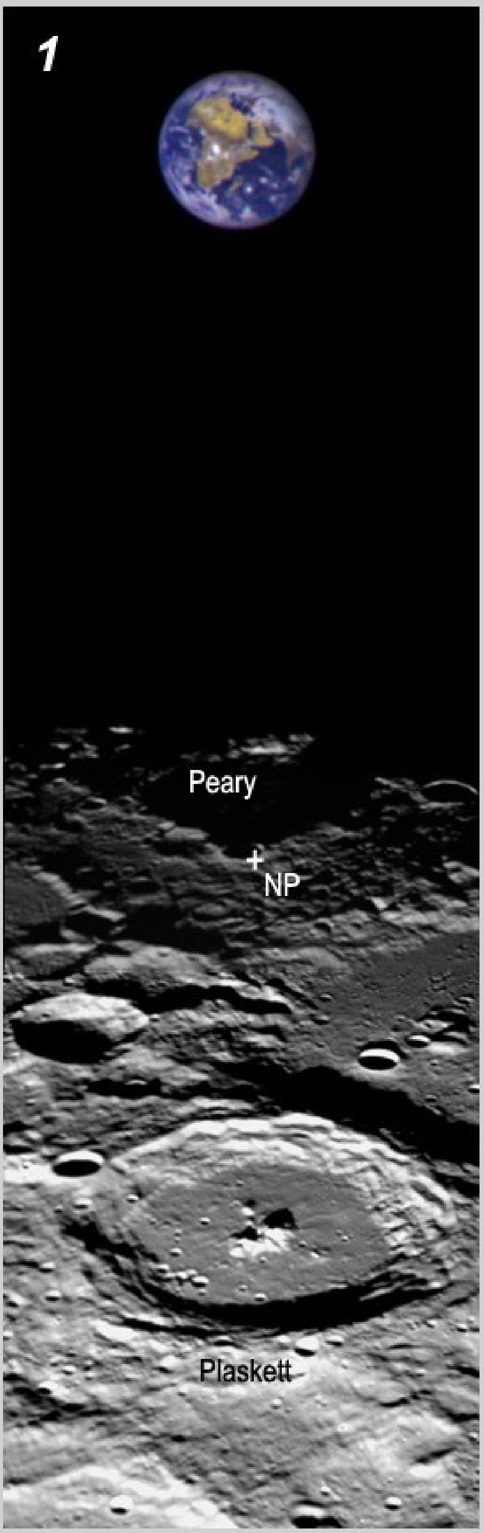


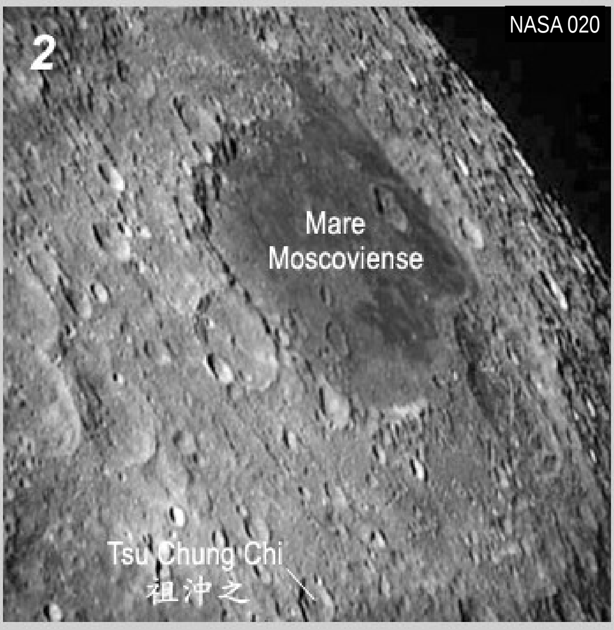
Barnard	85.6^0 E	29.5^0 S	dia. 105 km
Curie	91.0^0 E	22.9^0 S	dia. 151 km
Humboldt	80.9^0 E	27.0^0 S	dia. 189 km
Jeans	91.4^0 E	55.8^0 S	dia. 79 km

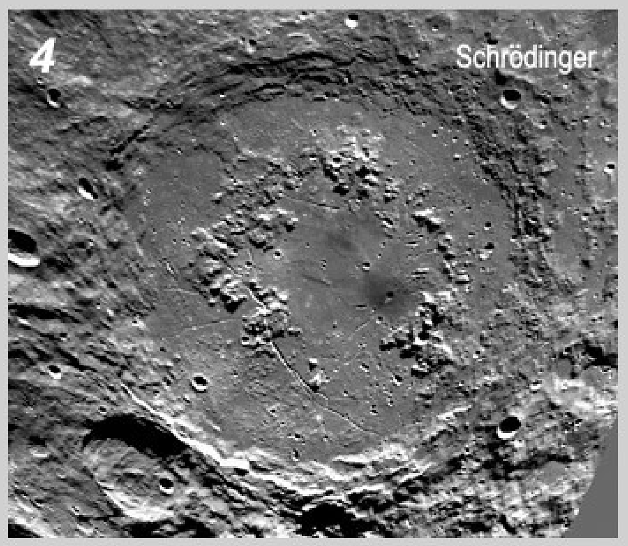
Jenner	95.9^0 E	42.1^0 S	dia. 71 km
Lamb	100.1^0 E	42.9^0 S	dia. 106 km
Lyot	84.5^0 E	49.8^0 S	dia. 132 km
Sikorsky	103.2^0 E	66.1^0 S	dia. 98 km

Features on the Farside of the Moon

1. Earthrise over the north pole: *The Earth actually appeared about twice as far above the lunar horizon as shown. Africa is clearly visible (Clementine image).* ***2. Mare Moscoviense:*** *This mare (Moscow Sea) is the most prominent feature on the farside, about 280 km in diameter. Tsu Chung-Chi* 祖沖之 *is a crater named after a Chinese mathematician in the 5th century, 28 km in diameter (Apollo 13 image).* ***3. Tsiolkovsky:*** *A feature that appears partially crater and partially mare, size 185 km. The crater itself is fairly circular, but its dark mare-like floor is distinctly not circular. The central peaks, terraced walls and slump blocks on the inner rim of the crater are typical of many large impact craters (Apollo 15 image).* ***4. Schrödinger:*** *A large impact crater (basin) with fractured floor, 312 km in diameter. The internal crater with dark halo is believed volcanic-originated (Clementine image).*







Farside

Lunar Features named after Chinese

There are 10 lunar features named after Chinese, 5 on the nearside and 5 on the farside. See the full list below.

Feature Name	Year Adopted	Long. (deg.)	Lat. (deg.)	Dia.* (km)	Origin	Where
Crater						
Chang Heng 張衡	1970	112.2 E	19.0 N	43	Astronomer, 78 - 139	Label B, Farside map.
Chang-Ngo 嫦娥	1976	2.1 W	12.7 S	3	Female in Chinese myth	Inside Crater Alphonsus, Map 12.
Ching-Te #	1976	30.0 E	20.0 N	4	Male name	Southwest of Crater Littrow, Map 9.
Kao (Ping-Tse) 高平子	1982	87.6 E	6.7 S	34	Astronomer, 1888 - 1970	On the southern edge of Mare Smythii, Event 1.
Kuo Shou Ching 郭守敬	1970	133.7 W	8.4 N	34	Astronomer, 1231 - 1316	Label D, Farside map.
Shi Shen 石申	1970	104.1 E	76.0 N	43	Astronomer, ~ 300 B.C.	Label A, Farside map.
Tsu Chung-Chi 祖沖之	1970	145.1 E	17.3 N	28	Mathematician, 429 - 500	Label C, South of Mare Moscoviense, Farside map.
Wan-Hoo 萬戶	1970	138.8 W	9.8 S	52	Inventor, ~ 1500	Label E, Farside map.
Rima						
Rima Sung-Mei #	1985	11.3 E	24.6 N	4	Female name	Near western edge of Mare Serenitatis, Map 9.
Rima Wan-Yu #	1976	31.5 W	20.0 N	12	Female name	Almost at the west rim of crater Natasha, Map 19.

*Names in native language are not yet ascertained.   * *Diameter or longest dimension*

Shi Shen 石申 ~ 300 B.C.

石申（石申夫）是戰國時代魏國人。他和楚國人甘德各自編過一本星表。兩者都是世界上最早的星表，後人將石申編的資料歸納成《石氏星經》，此書已失，但唐朝《開元占經》輯錄了大量片斷內容。《石氏星經》主要記錄了二十八宿距星和 121 顆恒星的赤道座標位置，可以說是中國古代天體測量工作的基礎。

Chang Heng 張衡 78 - 139

東漢西鄂人（今河南省南陽市北），字平子。少年時代醉心於文學，曾花十年時間，寫成《二京賦》，藉以諷諫當時的奢侈。三十歲後開始從事天文科學技術的研究工作。三十八歲由郎中遷任太史令，晚年任尚書。他利用滴漏原理設計的「渾天儀」（公元 117 年），是世界上第一台用水力推動的大型星象演示儀器；他的「候風地動儀」（公元 132 年），是世界上第一架測定地震及方位的儀器。他還制造出巧妙的指南車、自動記里鼓車和飛行數里的木鳥。主要學術著作有《靈憲》、《渾天儀注》、《算罔論》等。張衡亦是東漢六大畫家之一。

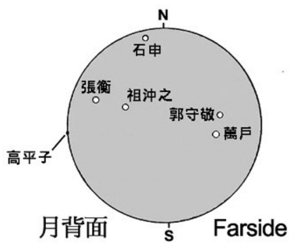
Wan-Hoo 萬戶 ~1500

據傳原是木匠，後在明朝軍營擔任兵器技藝的開發。他的姓名不詳，萬戶可能是一軍階的名謂。他曾把47 枚火箭捆綁在自己的座椅上，並且手持風箏試圖飛天（見下圖），可惜點火後火箭爆炸喪命。外國稱他是「最早乘搭火箭的人」。

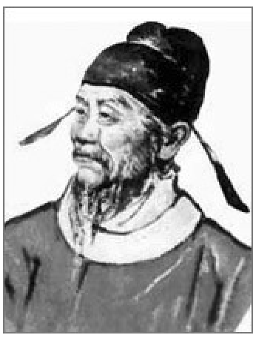
Wan-Hoo's attempt to fly on chair powered by 47 rockets.

Tsu Chung-Chi 祖沖之 429-500

南北朝时代南朝人。他把圓周率精確地推算到數值在 3.1415926 和 3.1415927 之間，比歐洲人的演算早一千一百多年。他的數學專著《綴術》到唐朝時被定為學校的課本。他根據自己長期觀測天象的结果，于 33 歲時創制了《大明曆》，採用的一個回歸年的天數，跟現代值只多出 54 秒；採用的一個交點月的天數，跟現代值相差不到 1 秒。在《大明曆》中，祖沖之首次引入了歲差，每隔 391 年設 144 個閏月。這些做法，都是對前代曆法的重大改革。在制曆過程中，他發明了用圭表測量冬至前後正午時日影長度以定冬至時刻的方法，這個方法為後世長期採用。



Kuo Shou Ching 郭守敬 1231 - 1316



元代河北邢台人，字若思，他在全國各地設立 27 個觀測站進行大規模的天文和地理測量，最北遠至西伯利亞，最南的在西沙群島，並且首次運用海拔概念，比歐洲的同樣概念早五百年；他的「招差術」，比牛頓的內插法早四百年；他主持編成的《授時曆》，一年的周期 (365.2425 天）與現在的公曆相同。另外，他還創造和改進了十餘種天文儀器，包括著名的「簡儀」、「量天尺」(巨型圭表）、景符」及「窺幾」等。同時，他又建造「元觀星台」。他主持治水工程，集防洪、灌溉、航運為一體。天文數學著作有十四種共 105 卷。

Kao (Ping-Tse) 高平子 1888 - 1970

原叫高均，江蘇人，對張衡十分敬仰，故又名平子。他沒有接受正規的天文教育，震旦學院畢業後入徐家匯天文台及佘山天文台，隨法國神父從事太陽黑子、小行星及雙星的觀測，工餘自修天文。1924 年他代表中國接管由日本人佔用的青島觀象台， 1926 年參加國際經緯度的測定工作，他也曾主持編算天文年曆及協建南京紫金山天文台。抗日時期避居上海租界研究中國古天文，1948 年遷居台灣。其後發起創立台灣「中國天文學會」，連任幾屆理事長，著作有《史日長編》、《圭表測影論》等。1987 年台灣的中央研究院數學研究所出版了《高平子天文曆學論著選》。

Shi-Shen 石申 ~300 B.C.

Shi-Shen was an astronomer and astrologist. He catalogued the equatorial positions of 121 stars in 28 *Su* (ancient Chinese constellations). His catalogue, together with similar works of another Chinese observer Gan-Te, are supposed to be the earliest star catalogue in the world. The original star catalogue by Shi-Shen was lost, but much of his works were frequently quoted and preserved in *Kaiyuan Zhanjing* (Treatise on Astrology of the Kaiyuan Reign Period) compiled in the 8th century.

Chang Heng 張衡 78-139

Chang was interested in literature at youth and produced several works that brought him recognition as a writer. In his early 30s, he decided to turn to astronomy. He was soon recognized as a scientist and entered government service at the age of 38. Eventually he became chief astronomer and minister under the emperor. In year 123 Chang introduced a calendar reform, which aligned the months again with the seasons. Chang's best known invention is a seismograph, or more accurately a “seismoscope”, since it did not produce a graph of the earthquake but indicated in which direction it occurred. He also invented a chariot that knew direction automatically and a wooden bird that could fly few thousand feet. He had several papers in science, philosophy and literature. Chang also excelled in picture painting.

Tsu Chung-Chi 祖沖之 429-500

A mathematician and an astronomer. He determined Pi (π) between 3.1415926 and 3.1415927, a thousand years ahead of the European precision. At age 33, he proposed an improved calendar with one tropical year only 54 seconds longer than today’s value, and a nodical month accurate to within 1 second. He also introduced the concept of “precession of the equinoxes” in his calendar and suggested 144 extra-months (leap months) per 391 years for the season alignment scheme. During calendar development, Tsu invented a method to time the accurate moment of winter solstice by measuring the Sun’s shadow at noon on days near the solstice. This method remains to be a standard reference for many later years. However, his calendar was not accepted by court until 10 years after his death.

Kuo Shou Ching 郭守敬 1231-1316

An astronomer and a senior government officer. He once conducted a large-scale land survey, north up to Siberia and south up to the islands in southern China. His survey conveyed the concept of “the elevation above sea level” and the mathematical method of “interpolation”, both being 400~500 years earlier than the European did. He developed a calendar with one tropical year = 365.2425 days, almost as precise as today’s value. He invented or improved over 10 astronomical instruments including a torquetum (see photo in http://www.perceptions.couk.com/kuo.html), sight tubes and a huge gnomon for measuring the sun’s shadow with a device to read the shadow position effectively. He also built an observatory and held credits in national projects of flood prevention, agriculture and navigation. He authored a variety of scientific books in 105 volumes.

Wan-Hoo 萬戶 ~1500

Wan-Hoo is supposed a carpenter who later joined the army of the Ming Dynasty as a weapon builder and inventor. Wan-Hoo may not be his real name but probably a term in the military rank. He attempted to fly by binding himself on a 47-rocket powered chair together with large kites. Unfortunately the rockets, being gun-powder fueled, exploded during ignition. Wan-Hoo died in his attempt. He is credited to be “the first man to fly in rockets”.

Kao (Kao Ping-Tse) 高平子 1888-1970

Kao is one of the pioneer astronomers in the 20th century China. He did not have a formal education in astronomy. He picked up everything by himself. In his earlier career, Kao worked under two French observatories in Shanghai, major in the observations of sunspots, asteroids and binary stars. In 1924, he represented the Chinese government to resume the supervision of Qingdau Observatory (青島觀象台) from the Japanese. In 1926, He participated in the international project of longitude-latitude survey. He had been an editor of astronomical almanac and also one of the planners to establish the Purple Mountain Observatory in Nanjing of China. During World War II where no observations were feasible, he resided in Shanghai to study the history of Chinese astronomy. In 1948 he moved to Taiwan. There he founded the Taiwan-China Astronomical Society and was its president for some years. His papers in astronomical measurements and calendar studies were published collectively in Taiwan in 1987.
(http://www.chinataiwan.org/web/webportal/W2001315/A2015706.html)

Moon Sketch by Jie Xuan 揭暄 (1610-1702)

Moon Watch in China

The first Chinese who saw the Moon in telescope was probably court minister **Xu Guang Qi** (徐光啟) in the late Ming dynasty, when the Jesuit **Schall von Bell** (湯若望 1592-1666) brought the Galilean telescopes to China. The most early documented watch of the Moon by Chinese is a sketch by **Jie Xuan** (揭暄) through his telescope. The sketch was presented in his *New Words About Celestial Bodies* 《寫天新語》, 後稱《璇璣遺述》, published around

1675 during the Ching dynasty.

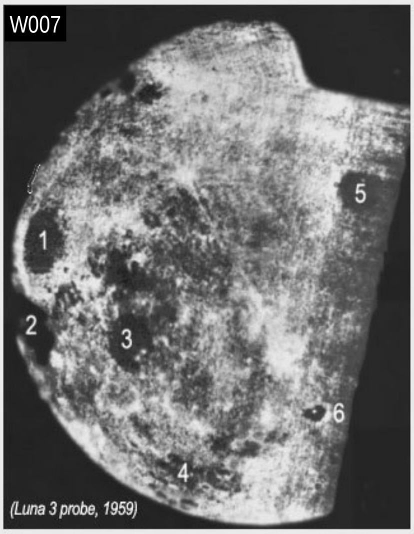
4. Lunar Spacecraft

From 1959 to 2006, over 30 unmanned spacecraft were launched successfully to the Moon. They returned volumes of information about the Moon surface.

List of the major unmanned spacecraft

Unmanned Spacecraft	Date of Launch	Missions / Results
Luna 2, 3, 9 to 14, 16, 17, 19 to 24 (former USSR) 「月球號」	1959 September ~ 1976 August	● Clashed or soft-landed on the Moon surface, or entered lunar orbits. ● First succeeded to photograph Moon's farside (Luna 3, 1959). ● Returned a total of 300g soil samples to Earth. http://www.lpi.usra.edu/expmoon/luna/luna.html
Ranger 7, 8, 9 (USA) 「徘徊者」	1964 July ~ 1965 March	● Returned closeup images before the spacecraft clashed on the moon. http://www.lpi.usra.edu/expmoon/ranger/ranger.html
Surveyor 1, 3, 5, 6, 7 (USA) 「探測者」	1966 June ~ 1968 January	● Tested or analyzed lunar soils directly on landing sites. ● Transmitted to Earth about 86,000 lunar photographs. http://www.lpi.usra.edu/expmoon/surveyor/surveyor.html
Lunar Orbiter 1, 2, 3, 4, 5 (USA) 「月球軌道飛行器」	1966 August ~ 1967 August	● Photographed the entire moon surface from orbit. ● Discovered the existence of mascons (the abbreviation of "mass concentrations"; they are areas of denser rock within the Moon which exhibit an increased gravitational pull on the orbiting spacecraft). http://www.lpi.usra.edu/resources/lunar_orbiter/
Clementine (USA) 「克萊門泰」	1994.01.25	● Mapped the entire Moon at various wavelengths from which scientists deduced the abundance of elements on the lunar surface without coming into direct contact with it (the so-called remote sensing technique). http://www.cmf.nrl.navy.mil/clementine/
Lunar Prospector (USA) 「月球勘探者」	1998.01.06 (Ended its mission with a controlled clash on the Moon on 1999.07.31.)	● Went into polar orbit around the Moon to survey the composition of lunar crust; searched water-ice at the poles. ● Monitored volcanic emission. ● Mapped the Moon's gravity and magnetic fields. http://lunar.arc.nasa.gov/
Smart-1 (Europe) 「智能一號」	2003.09.27 (Ended its mission with a controlled clash on the Moon on 2006.09.03.)	● Testing and proving of an ion drive engine and miniaturized instruments, along with investigations of lunar geochemistry and a search for water-ice at the lunar south pole. http://sci.esa.int/science-e/www/area/index.cfm?fareaid=10

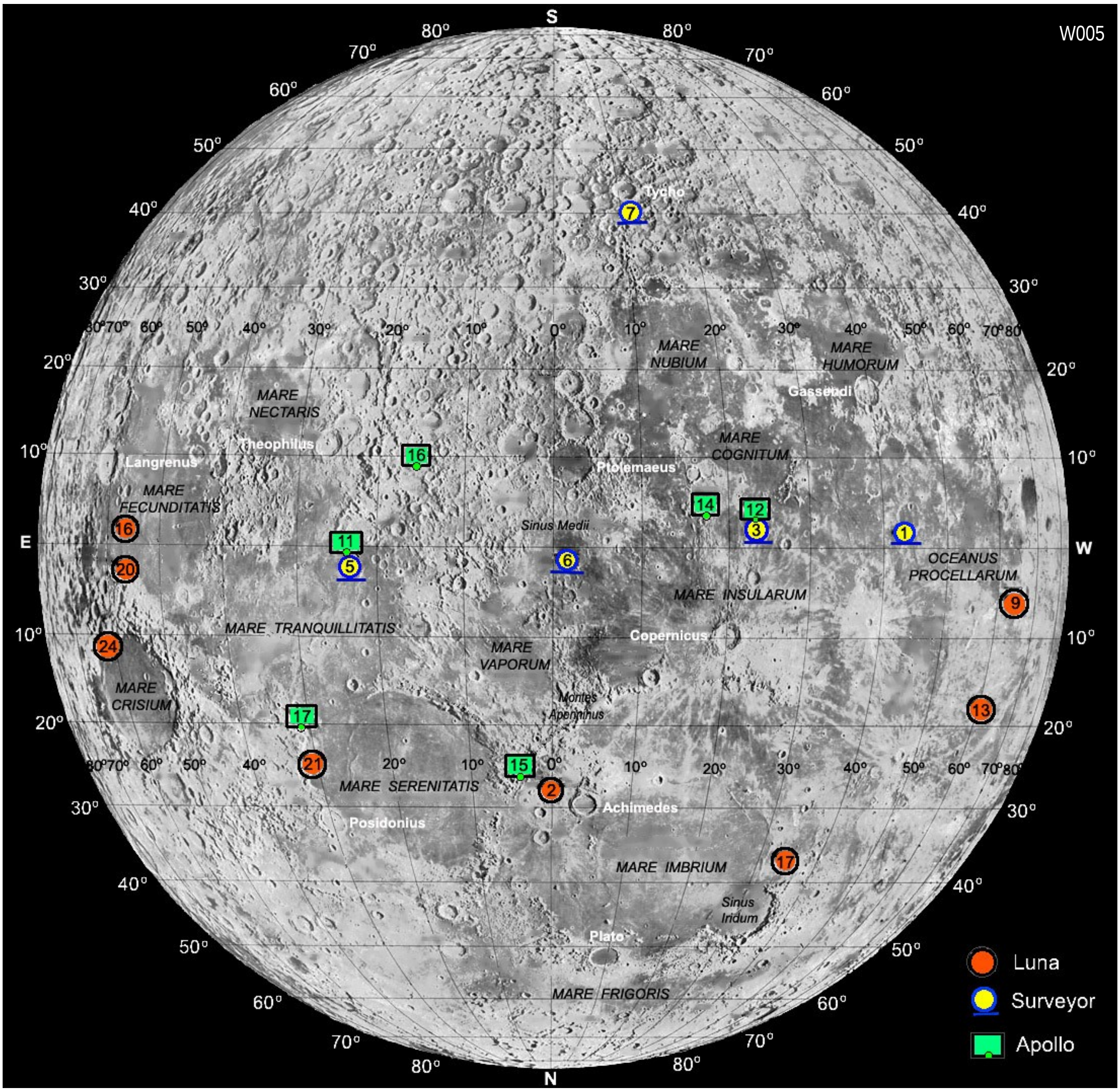
First photograph showing the Moon's farside



1. Mare Crisium *(nearside)* 2. Mare Fecunditatis *(nearside)*
3. Mare Smythii *(nearside)* 4. Mare Australe *(nearside)*
5. Mare Moscoviense *(farside)* 6. Tsiolkosky *(farside)*

The first manned landing began with the Apollo 11 mission when two American astronauts Neil Armstrong and Edwin Aldrin set foot on the Moon in Mare Tranquillitatis (Sea of Tranquility) on 1969 July 20. Meanwhile Michael Collins orbited in the command module. Apollo is a program to land humans on the Moon. A total of six Apollo spacecraft succeeded in landing, see Landing Map in next page. Since then no human landed on the Moon but surveys by unmanned spacecraft (Clementine, Lunar Prospector and Smart-1) continued. The best rewards from the Apollo are 380 kg of Moon rocks collected by the astronauts, the on-site experiments about solar-wind, lunar atmosphere, cosmic-ray, heat-flow, magnetic field, seismometry and laser ranging, along with the live experience on the low-gravity lunar surface. The Moon rocks played the key role to reveal the lunar evolution. By analyzing the rocks with the technique of radiometric dating, scientists determined the Moon was created 4.6 billions years ago, almost same age as the Earth. *(Reference: http://www.lpi.usra.edu/expmoon/science/lunar10.html)*

Moon Landing Map



Spacecraft	Date of Landing	Results
Luna Probes (former USSR)		
Luna 2	1959.09.13	Hit moon in Palus Putredinis.
Luna 9	1966.02.03	Soft-landed in Oceanus Procellarum.
Luna 13	1966.12.24	Soft-landed in Oceanus Procellarum.
Luna 16	1970.09.20	Returned 100g soil from M. Fecunditatis.
Luna 17	1970.11.17	Landed one rover in Mare Imbrium.
Luna 20	1972.02.21	Returned 30g soil from Crisium highlands.
Luna 21	1973.01.15	Landed one rover in Mare Serenitatis.
Luna 24	1776.08.18	Returned 170g soil from Mare Crisium.
Surveyor Probes (USA)		
Surveyor 1	1966.06.02	Soft -landed in Oc. Procellarum. *(11,000)*
Surveyor 3	1967.04.20	Tested soil in Mare Insularum, later visited by Apollo 12 astronauts. (6,300)
Surveyor 5	1967.09.11	Tested soil in Mare Tranquillitatis. *(18,000)*
Surveyor 6	1967.11.10	Tested soil in Sinus Medii. *(30,000)*
Surveyor 7	1968.01.10	Tested soil near crater Tycho. *(21,000)*

Spacecraft	Date of Landing	Results
Apollo Missions (USA)		
Apollo 11	1969.07.20	First manned landing on 23.5° E 0.7° N, Map 8. Collected 21 kg rock/soil samples.
Apollo 12	1969.11.19	Landed on 23.4° W 3.0° S, Map 20. Collected 34 kg rock/soil samples.
Apollo 14	1971.02.05	Landed on 17.5° W 3.6° S, Map12. Collected 42 kg rock/soil samples.
Apollo 15	1971.07.30	Landed on 3.6° E 26.1° N, Map 14. Collected 76 kg rock/soil samples.
Apollo 16	1972.04.21	Landed on 15.5° E 9.0° S, Map 31. Collected 94 kg rock/soil samples.
Apollo 17	1972.12.11	Landed on 30.8° E 20.2° N, Map 9. Collected 110 kg rock/soil samples.

Figures in brackets indicate the approximate number of photographs transmitted to Earth.

5. Methods of Imaging

The author of this book applied two methods to image the Moon – the "afocal" method and the "video" method.

5.1 Afocal Method

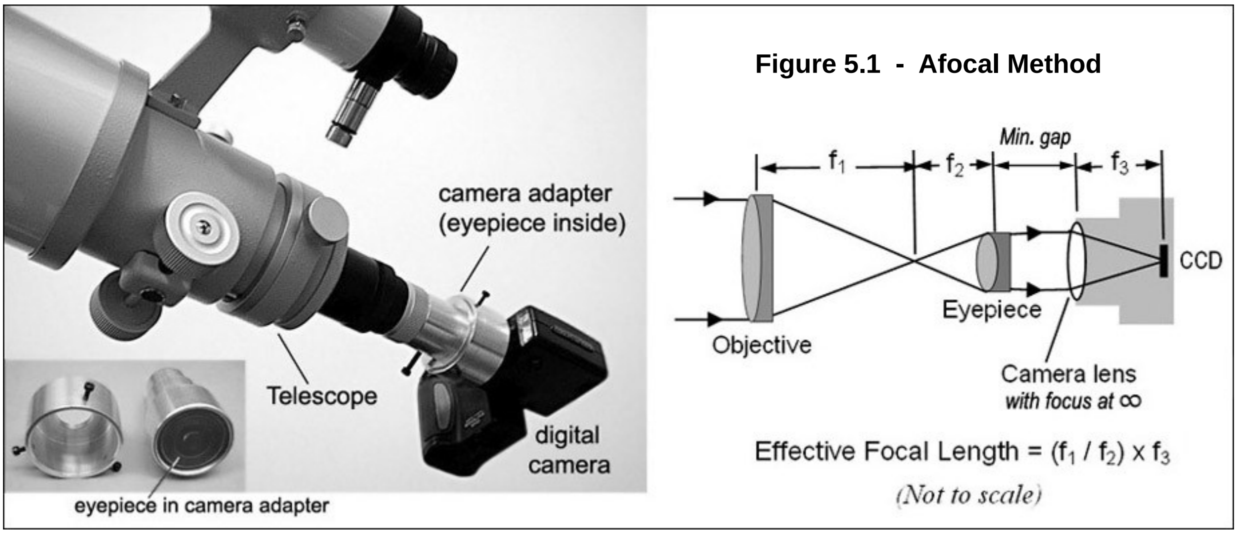


Figure 5.1 - Afocal Method

This is implemented by coupling a digital camera to the telescope's eyepiece, Figure 5.1. The camera's focus mechanism is fixed at infinity (hence the term "afocal"). Actual focusing is adjusted on the telescope while watching the camera LCD screen.

The effective focal length of an afocal system is equal to the telescope magnification times the focal length of the camera's front lens.

<u>Example</u>

Telescope focal length, f_1 = 1040 mm
Eyepiece focal length, f_2 = 12.5 mm
Telescope magnification = f_1 / f_2 = 1040 / 12.5 = 83
Camera lens focal length, f_3 = 24 mm
Effective focal length for afocal imaging = $(f_1 / f_2) \times f_3 = 83 \times 24 \approx 2000$ mm

The frame FOV (field of view) is equal to the FOV of the camera lens divided by telescope magnification. If the FOV of the camera lens is 17 x 13 degrees (which can be estimated from its specifications), then following the above example, the frame FOV will be 12 x 9 arcmin. This covers about 1/3 ~ 1/4 diameter of the Moon disc.

The afocal method is very flexible while image quality is quite promising. Changing the eyepiece, zooming the camera lens, rotating the camera body, and/or using telescopes of different sizes virtually satisfy all needs of wide-field and close-up images of the Moon. However, there is a limit of telescope magnification. Under average seeing, the author controls the telescope magnification not to exceed 25X per inch aperture. 40X per inch is used only during very good seeing. The author also avoids using eyepieces longer than 30mm focal length, because they produce excessive darkening (vignette) of the frame corners.

The telescopes used depend on instant availability, as shown in Figure 5.3. The digital cameras are 3X optical zoom type, including Casio QV2300 (2M pixels), Nikon Coolpix-950 (2M pixels) and Coolpix-99x (3M pixels); these cameras incorporate CCD of pixel size = 3.45 μm square. Knowing the pixel size is more affirmative to determine the resolution of a CCD imaging system.

Typically a raw image from any digital camera looks flat. The author enhances it with the editing software "Photoshop" (http://www.adobe.com/products/photoshop/).

Figure 5.2 - FS102 Refractor on EM2 Mount

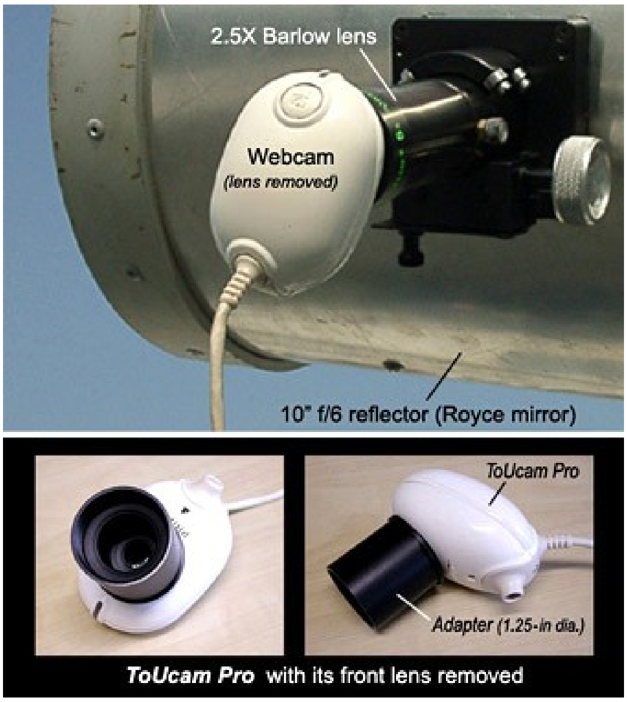
The early works of the author used this portable setup.

Figure 5.3 - Telescopes Used for Afocal Imaging

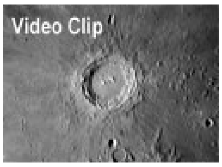
5.2 Video Method

The default setup of this method is illustrated in Figure 5.4. It includes a 10-inch (254 mm) f/6 Newtonian reflector in which the prime mirror was produced by the specialist Robert F. Royce (http://www.rfroyce.com/), a 2.5X Barlow lens, a webcam with its original lens removed and a computer that controls the webcam exposure. The webcam is Philips ***ToUcam Pro*** (PCVC740K). It incorporates a Sony CCD chip ICX098BQ (3.58 x 2.69 mm, 640 x 480 pixels, each pixel = 5.6 μm square), allowing video frames to be captured at shutter speed 1/25 ~ 1/1000 sec and beyond. The whole setup is quite powerful for high magnification works, for the webcam can be set at highest possible speed to compensate the jittering of images, and the overall resolution can reach 3.3 pixels per arcsecond of the imaged object. Each frame

Figure 5.4 - Video Method



covers a FOV of 3.2 x 2.4 arcmin or roughly 1/10 of a lunar diameter at 2.5X Barlow. In theory this 10-inch telescope resolves round objects to 0.45 arcsecond or lunar craters as small as 800 m in diameter. Linear objects like clefts can be detected to 400 m or less in width, subject to their contrast and the atmospheric seeing.



CD-version only

← Click here to play a half-minute ToUcam video clip. It produces Image T064 in Figure 5.7.

ToUcam Settings: Video Format = I-420, Frame Size = 640x480 pixels, Frame Rate = 10 frames/sec, Color = off (B&W only), Audio = off, Gamma = 1/5 full scale, Gain = 1/3 full scale, Shutter = 1/50 sec. All other settings at default values.

After video capturing, the sharper raw frames are extracted and stacked with the freeware "RegiStax" (*http://registax.astronomy.net/*). Stacking is a technique to reduce image noise inherent in CCD. RegiStax can sort out the sharper frames automatically while the user determines by preference the number of frames stacked. No more than 250 frames are stacked, for over-stacking leads to loss of image details. In general, good seeing allows less stacking (e.g. 50 frames) and bad seeing requires more stacking (e.g. 200 frames). RegiStax also provides a sharpening tool, so called the *wavelet layers* where image sharpness is adjustable on individual layers. However, the author prefers to enhance the image by "Photoshop" whereas the wavelets serve only as ancillary tool. Note that this method, though superior, may take several minutes to convert a video clip to final image. A high-speed PC is preferred to run RegiStax.

Figure 5.5 - The 10-inch f/6 Newtonian

Figure 5.5 shows the full view of the 10-inch f/6 Newtonian, equipped with a Barlow lens and a motorized Crayford-type focuser designed by JMI (*http://www.jimsmobile.com/*). When seeing is good, a 4X or even a 5X Barlow lens is used instead of the 2.5X. The 4X is supposed an optimal choice according to Nyquist sampling theory. At 4X, the effective focal length of the 10-inch Newtonian is 6100 mm. A lunar feature of angular size equals to the telescope's resolution (i.e. 0.45 arcsecond) thus projects an image length = 6100 *sin* (0.45 / 3600) = 13 μm at the focal plane. This covers approximately two pixels on each side of the CCD chip in ToUcam --- a fitted Nyquist sampling. However the 4X is not always useable due to unfavorable seeing.

The choice of afocal or video method is a matter of FOV and seeing consideration. For instance in Figure 5.6, a wide field like T019 is obtained with the afocal method. High magnification like T118 in Figure 5.7 is obtained with the video method. The image is rotated south up like an eyepiece view in Newtonian / Dobsonian telescope. It also helps to develop a "space" impression in which lunar scenery is likely tilted.

This Moon book adopts magnified images more than wide-fields. Therefore much of the imaging works were done with the video method (10-inch f/6 Newtonian + Barlow lens + ToUcam). Sometimes, frames from different video clips were combined to make a mosaic.

Figure 5.6 - Moon imaging by afocal method

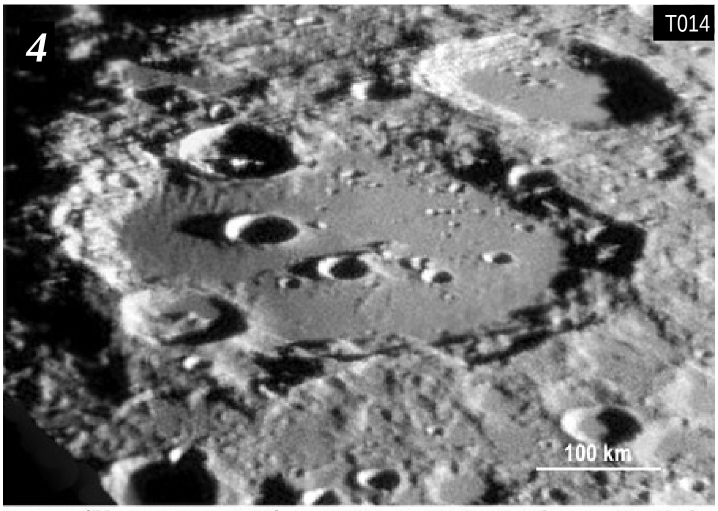
Vixen 7x50 finderscope + CP995 at 4X zoom, 1/85 sec.

Digital camera coupled to:

1. *7x50 mm finderscope with cross-hair removed.*
2. *4-inch (102 mm) f/8 refractor + 25 mm eyepiece.*
3. *5-inch (128 mm) f/8 refractor + 12.5 mm eyepiece.*
4. *9.25-inch (235 mm) f/10 Schmidt-Cassegrain + 7.5 mm eyepiece.*

8+LE12.5+QV2300

Total Lunar Eclipse 2001.01.09 FS104 + Or25 + QV2300



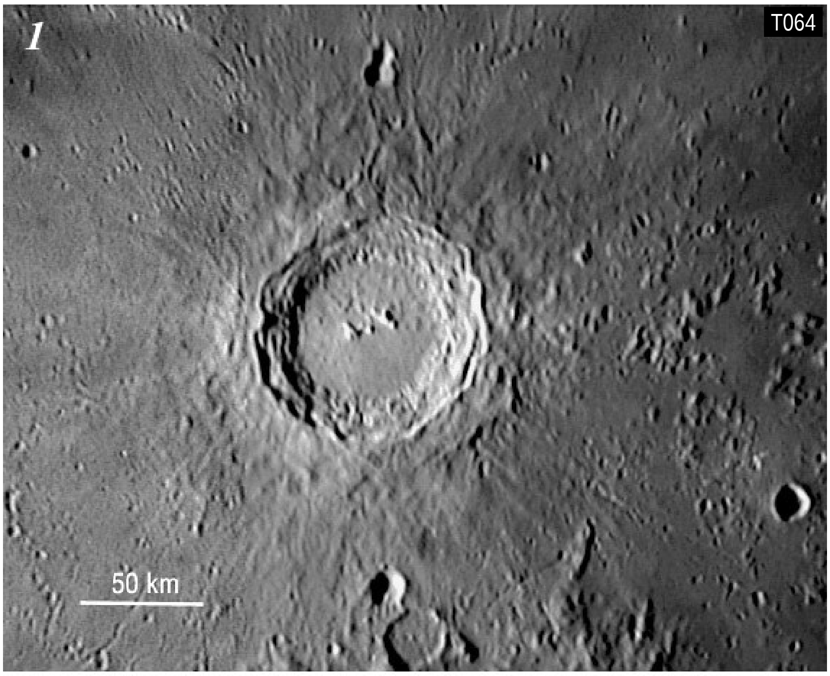
Clavius (Blancanus at corner) 2001.08.11 20:42 UT Age 22 days. C9+CP990

Figure 5.7 - Moon imaging by video method

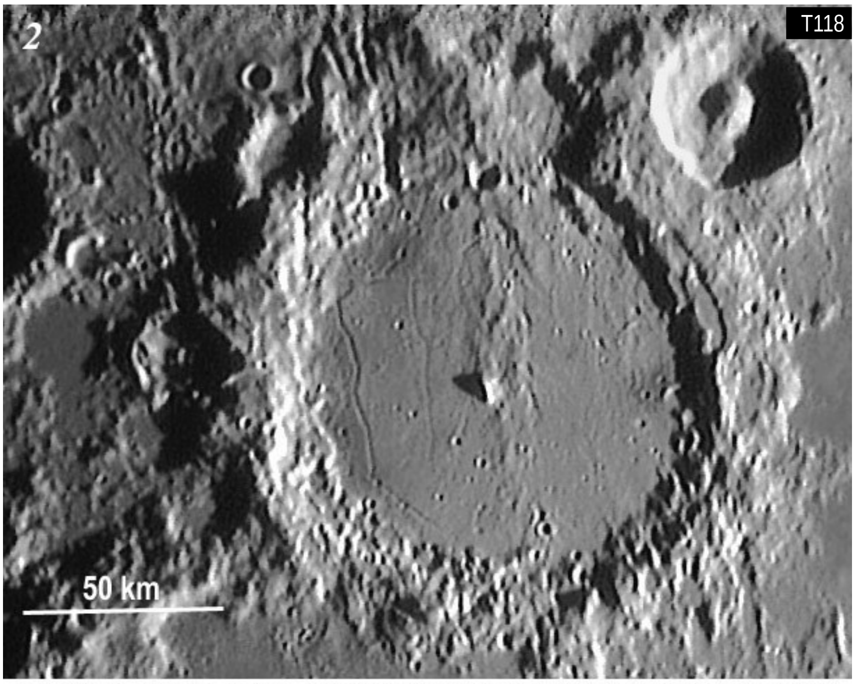
Webcam coupled to:

1: *Royce 10-inch (254 mm) f / 6 Newtonian + 2.5X Barlow lens, effective f / 15.*
2: *Royce 10-inch (254 mm) f / 6 Newtonian + 2.5X + 1.6X Barlow lenses in cascade, effective f / 24.*
3: *Orion 6-inch (150 mm) f /8 Newtonian + 2.5X Barlow lens, effective f / 20.*
4: *Orion 6-inch (150 mm) f /8 Newtonian + 2.5X + 1.6X Barlow lenses in cascade, effective f / 32.*

(All images are south up.)

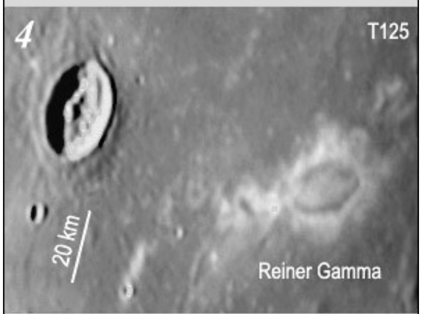


Copernicus 2004.05.29 15:20 UT Age 10 days. 10-in f/6 Newtonian + 2.5X + ToUcam

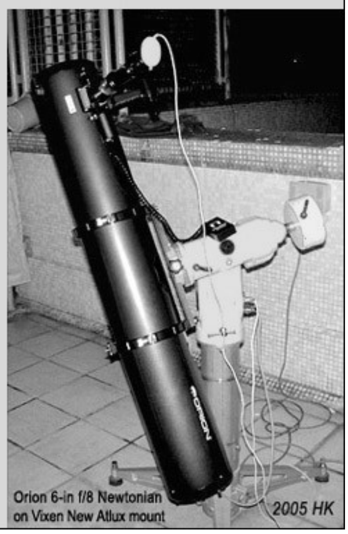


Alphonsus 2004.08.07 21:31 UT Age 22 days. 10-in f/6 Newtonian + 2.5X + 1.6X + ToUcam, 14 frames stacked.

2005.05.21 15:16 UT Age 13 days (Orion 6-in f/8)



2005.05.21 16:09 UT Age 13 days (Orion 6-in f/8)



5.3 Other Considerations

It should be noted that the brightness of the Moon changes significantly with its age in a lunation. This implies that when shooting the Moon, a wide range of camera shutter speed is required. Typically the shutter speed is a fraction of a second at crescent to about 1/500 second for a full moon. If the frame includes both very bright and very dark features, the exposure is compromised by trials. Today's technology makes exposure rather easy, because the trials can be judged from the digital camera or PC screen any time.

A second consideration is precise focusing. In close-up images taken by the video method (the setup in Figure 5.5), a motorized focuser has been found extremely useful. It also avoids telescope vibration as focusing is made.

Object tracking is important to create image mosaic from a multiple of video clips, otherwise the post-work of stacking and mosaicking are complicated by any excessive drift of the object in field. The author tracks the Moon's R.A. and Declination with the ***Vixen New Atlux*** mount (http://www.vixen-global.com/TELESCOPE/NewAtlux_mount/NewAtlux_mount.html); it virtually "locks" the object in field during the entire video session.

For high magnification works, it is essential to ensure proper collimation of the optics and allow them to reach thermal equilibrium.

5.4 Environment and Image Archives

All lunar images in this book and taken by the author are traceable from the Image Data in next pages. The images were taken mostly in City One Shatin of Hong Kong where the author's observing site is located. The night sky above the site is heavily light-polluted, and there are hundreds of air conditioners in the windows of the neighbor buildings. The site is also blocked in the east direction, hence much of the imaging were done in phases before the last quarter.

In the list of Image Data, the **Moon Age** is expressed in rounded number, e.g. *15* means the age is about *15 days*. The **Equipment Used** are abbreviated, e.g. *FS102 + K25 + QV2300* = Takahashi FS102 refractor with Kellner 25mm eyepiece and Casio QV2300 digital camera. All digital cameras are set to ~ISO100 and full resolution for maximum available pixels. When the ToUcam was used, not all video clips were archived; only the stack of raw frames were saved.

Figure 5.8 - The Night Sky

A light-polluted sky like this is disappointing to explore deep sky objects but still manageable for lunar (and planetary) observations.

Data of Lunar Images

The following data apply to lunar images taken by the author in Hong Kong; each image is identified by a T code *at the frame corner.*

Image Code	Date / Time (UT)	Moon Age	Equipment Used	Exposure (sec)	Raw Image
T001	2000.09.13 14:39	15 days	FS102 + K25 + QV2300	1/265	QV2300-20000913-0072
T002	2000.04.20 17:52	15	FS102 + LE5 + CP950	1/3	CP950-DSCN 1589
T003	2000.09.15 15:25	16	MK67 (6-in f/12) + PL16 + CP950	1/11	CP950-DSCN 4013
T004	2006.11.08 20:06	18	ETX90 Maksutov + LE24 + CP990	1/20	CP990-DSCN 9738 (2)
T005	2000.06.15 16:28	13	FS102 + LE7.5 + CP950	1/21	CP950-DSCN 2989
T006	2000.09.15 15:52	17	MK67 (6-in f/12) + K25 + CP950	1/42	CP950-DSCN 3997
T007	2000.04.20 17:58	15	FS102 + LE5 + CP950	1/4	CP950-DSCN 1591
T008, A	2000.11.02 12:14	6	FS128 + LE12.5 + QV2300	1/6	QV2300-20001102-0044
T009	2001.05.12 18:20	19	C9 + LE12.5 + CP990	?	CP990-DSCN 9080
T010	2004.06.26 14:54	9	10-in f/6 + ToUcam at prime focus	1/100	38 frames stacked
T011	2006.08.12 19:49	18	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	180 frames stacked
T012	2002.12.15 ? 11				ToUcam single frame ?
T013	2003.03.17 16:49	14	10-in f/6 Royce + 2.5X + ToUcam	1/500	60 frames stacked
T014	2001.08.11 20:42	22	C9 + LE7.5 + CP990	?	CP990-DSCN 9642
T015	2000.11.05 13:35	9	FS128 + LE12.5 + QV2300	1/10	QV2300-20001105-0018
T016	2000.11.05 13:38	9	FS128 + LE12.5 + QV2300	1/8	QV2300-20001105-0020
T017	2001.09.25 12:49	8	C9 + LE12.5 + CP990	1/2	CP990-DSCN 9797
T018	2001.01.06 15:17	11	FS102 + LE7.5 + QV2300	1/8	QV2300-20010106-0041
T019	2000.11.05 13:58	9	FS128 + LE12.5 + QV2300	1/8	QV2300-20001105-0029
T020	2001.09.25 12:57	8	C9 + LE12.5 + CP990	1/4	CP990-DSCN 9804
T021	2004.09.05 ~21:31	21	10-in f/6 +2.5X + 1.6X + ToUcam	1/25	Stacked from 2 video clips
T022	2004.09.05 21:37	21	10-in f/6 +2.5X + 1.6X + ToUcam	1/25	88 frames stacked
T023	2004.09.25 14:10	11	10 in f/6 Royce + 2.5X + ToUcam	1/50	16 frames stacked
T024, A, B	2002.08.21 14:40	12	FS128 + LE12.5 + CP990	1/28	CP990-DSCN 5490
T025	2002.12.14 16:40	10	C9 + Or25 + CP990	1/4	CP990-DSCN 5832
T026	2002.12.16 14:02	12	10-in f/6 Royce + 2.5X + ToUcam		2 frames stacked
T027	2002.11.14 14:58	9	C9 + LE12.5 + CP990	1/7	CP990-DSCN 5818
T028	2000.09.12 15:34	14	MK67 (6-in f/12) + PL16 + QV2300	1/10	?
T029	2004.07.13 21:34	26	FS102 + LE12.5 + CP990 (Venus)		CP990-DSCN 9022 + 9029
T030	2006.09.04 ~14:30	12	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T031	2004.08.07 20:27	22	10-in f/6 Royce + 2.5X + ToUcam	1/25	27 frames stacked
T032	2002.06.21 13:30	10	C9 + LE12.5 + CP990	1/3	CP990-DSCN 4483 (lost)
T033	2002.12.16 15:12	12	10-in f/6 Royce + 2.5X + ToUcam	1/33	7 frames stacked
T034	2000.06.15 14:36	13	ETX90 Maksutov + PL16 + CP950	1/15	CP950-DSCN 2964
T035	2005.05.22 15:26	14	10-in f/6 Royce + 5X + ToUcam	1/25	82 frames stacked
T036	2006.05.09 14:40	12	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	120 frames stacked
T037	2006.05.10 ~14:52	13	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 3 video clips
T038, A	2002.12.16 15:17	12	10-in f/6 Royce + 2.5X + ToUcam		2 frames stacked
T039	2005.01.22 ~15:17	12	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T040, A, B	2000.04.20 18:26	15	FS102 + K25 + CP950	1/322	CP950-DSCN 1596
	2001.10.02 19:06	15	Kenko 8cm f/8 + Or18 + CP990	1/140	CP990-DSCN 9823
T041	2004.08.07 20:10	22	10-in f/6 Royce + 2.5X + ToUcam	1/33	11 frames stacked
T042	2000.05.07 12:25	3	7x50 finderscope + CP950 at 3X	1/4	CP950-DSCN 1958
	2000.07.28 21:26	27	FS102 + K25 + CP950	1/7	CP950-DSCN 3399
T043	2001.04.03 10:08	9	FS128 + LE12.5 + CP990	?	CP990-DSCN 8764
T044	2001.01.09 Total lunar eclipse		FS102 + Or25 + QV2300		Mosaic from a batch of images
T045	2001.01.09 Total lunar eclipse		FS102 + Or25 + QV2300		Mosaic from a batch of images
T046	2000.12.07 14:16	11	?	1/8	QV2300-20001207-0002
T047	2000.05.15 14:15	11	FS102 + LE12.5 + CP950	1/40	CP950-DSCN 2350
T048, A – D	2003.09.11 16:11	15	FS128 + PL25 + CP995	1/416	CP995-DSCN 9883
T049	2004.10.21 ~14:26	8	10-in f/6 + ToUcam at prime focus	1/100	Mosaic of 2 video clips
T050	2005.05.21 16:21	13	Orion 6-in f/8 + 4X + ToUcam	1/25	68 frames stacked
T051	2004.08.31 19:07	15	10-in f/6 + ToUcam + IR Blocker	1/500	12 frames stacked
T052	2004.06.26 14:09	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	11 frames stacked
T053	2000.11.05 13:50	9	FS128 + LE12.5 + QV2300	1/8	QV2300-20001105-0024
T054	2001.08.11 20:21	22	C9 + LE12.5 + CP990	?	CP990-DSCN 9622
T055	2005.04.22 16:34	14	10-in f/6 + 2.5X + 1.6X + ToUcam	1/33	69 frames stacked
T056, A – D	2001.09.22 11:27	5	Kenko 8cm f/8 + Or18 + CP990	1/8	CP990-DSCN 9724
T057	2005.04.21 14:17	13	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	64 frames stacked
T058	2005.01.22 ~15:38	12	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T059	2005.01.22 15:10	12	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	68 frames stacked
T060	2004.01.06 15:03	14	10-in f/6 Royce + 2.5X + ToUcam	1/50	48 frames stacked
T061	2005.04.22 ~16:41	14	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T062	2004.04.30 14:05	11	10-in f/6 Royce + 2.5X + ToUcam	1/33	19 frames, cropped, 2X resized.
T063	2004.12.17 ~10:19	5	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T064	2004.05.29 15:20	10	10-in f/6 Royce + 2.5X + ToUcam	1/50	2 frames stacked
T065, A	2005.04.19 ~13:14	11	10-in f/6 Royce + 2.5X + ToUcam	1/33	Mosaic of 3 video clips
T066	2004.05.31 12:37	12	7x50 finderscope + CP995 at 4X	1/85	CP995-DSCN 0120
T067	2004.05.04 Total lunar eclipse		FS128 + PL25 + CP995		CP995-DSCN 0035 + 0038
T068	2004.04.30 13:06	11	10-in f/6 Royce + 2.5X + ToUcam	1/33	55 frames stacked
T069	2005.04.22 16:00	14	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	88 frames stacked
T070	2005.11.09 ~11:43	7	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 4 video clips

Data of Lunar Images

Image Code	Date / Time (UT)	Moon Age	Equipment Used	Exposure (sec)	Raw Image
T071	2004.06.25 12:47	8 days	10-in f/6 Royce + 2.5X + ToUcam	1/50	6 frames stacked
T072	2004.06.26 13:32	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	10 frames stacked
T073	2004.06.26 13:59	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	14 frames stacked
T074	2004.06.26 13:47	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	5 frames stacked
T075	2005.04.18 ~12:48	10	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 5 video clips
T076	2004.06.26 13:53	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	12 frames stacked
T077	2005.05.17 11:43	9	10-in f/6 Royce + 2.5X + ToUcam	1/25	85 frames stacked
T078	2000.11.05 13:22	9	FS128 + Or25 + QV2300	1/74	QV2300-20001105-0016
T079	2004.06.26 14:15	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	35 frames stacked
T080	2004.08.07 19:48	22	10-in f/6 Royce + 2.5X + ToUcam	1/33	9 frames stacked
T081	2005.11.11 ~12:43	9	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T082	2004.06.26 15:03	9	10-in f/6 + ToUcam at prime focus	1/100	16 frames stacked
T083	2005.11.11 12:06	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	97 frames stacked
T084, A	2005.04.18 11:29	10	10-in f/6 Royce + 2.5X + ToUcam	1/33	33 frames stacked
T085	2005.04.18 ~14:53	10	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T086	2004.06.27 13:16	10	10-in f/6 Royce + 2.5X + ToUcam	1/33	Single frames (No. 50)
T087	2004.06.27 13:47	10	10-in f/6 Royce + 2.5X + ToUcam	1/33	11 frames stacked
T088	2005.04.18 14:56	10	10-in f/6 + 2.5X + 1.6X + ToUcam	1/33	52 frames stacked
T089	2004.06.27 13:30	10	10-in f/6 Royce + 2.5X + ToUcam	1/50	18 frames stacked
T090	2006.05.09 15:03	12	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	130 frames stacked
T091	2005.05.17 ~12:30	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T092	2004.06.27 14:25	10	10-in f/6 + 2.5X + 1.6X + ToUcam	1/50	3 frames stacked
T093	2004.09.05 ~20:12	21	10-in f/6 Royce + 5X + ToUcam	1/25	Stacked from 3 video clips
T094	2004.07.13 21:07	26	FS102 + LE12.5 + CP990, 3X zoom	1/8	CP990-DSCN 9005 (2)
T095	2004.07.13 ~20:42	26	FS102 + PL25 + CP990, 2X zoom	1 sec	CP990-DSCN 8992+9000(2)
T096	2004.09.20 ~11:13	6	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T097	2005.11.08 ~11:30	6	10 in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T098	2001.08.11 21:01	22	C9 + LE7.5 + CP990	?	CP990-DSCN 9648
T099	2004.07.25 12:16	8	10-in f/6 Royce + 2.5X + ToUcam	1/50	9 frames stacked
T100	2005.11.09 12:06	7	10-in f/6 Royce + 2.5X + ToUcam	1/50	98 frames stacked
	2004.07.25 13:06	8	10-in f/6 Royce + 2.5X + ToUcam	1/50	4 frames stacked
T101	2004.09.05 ~21:49	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Two adjacent images
T102	2004.08.01 14:22	15	FS128 + LE12.5 + CP990	1/38	CP990-DSCN 9081(2)
T103	2004.08.01 16:50	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	9 frames stacked
T104	2004.08.01 17:12	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	4 frames stacked
T105, A	2004.08.02 17:53	16	10-in f/6 Royce + 2.5X + ToUcam	1/50	16 frames stacked
T106	2004.09.05 21:34	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	88 frames stacked
T107	2004.08.31 17:14	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	16 frames stacked
T108	2004.08.31 17:04	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	16 frames stacked
T109	2004.08.31 17:27	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	16 frames stacked
T110	2004.08.31 17:16	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	16 frames stacked
T111	2004.08.31 16:53	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	16 frames stacked
T112	2004.08.31 18:38	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	9 frames stacked
T113	2004.08.31 18:54	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	25 frames stacked
T114	2004.08.02 17:24	16	10-in f/6 Royce + 2.5X + ToUcam	1/100	12 frames stacked
T115	2004.08.02 17:28	16	10-in f/6 Royce + 2.5X + ToUcam	1/50	9 frames stacked
T116, A	2004.10.28 ~14:09	15	10 in f/6 Royce + 2.5X + ToUcam	1/100	Mosaic of 2 video clips
T117	2004.08.07 19:04	22	FS128 + LE24 + CP990	1/30	CP990-DSCN 9131 (2)
T118	2004.08.07 21:31	22	10-in f/6 + 2.5X + 1.6X + ToUcam	1/33	14 frames stacked
T119	2004.08.07 ~20:36	22	10-in f/6 Royce + 5X + ToUcam	1/25	50 frames (from 5 video clips)
T120	2005.11.09 ~12:00	7	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T121	2005.11.11 ~13:08	9	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T122	2005.05.22 15:44	14	10-in f/6 Royce + 5X + ToUcam	1/25	81 frames stacked
T123	2006.09.04 14:18	12	10-in f/6 Royce + 2.5X + ToUcam	1/33	130 frames stacked
T124	2004.08.02 ~17:53	16	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T125	2005.05.21 ~16:09	13	Orion 6-in f/8 + 4X + ToUcam	1/25	Mosaic of 2 frames
T126	2004.08.31 17:38	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	16 frames stacked
T127	2000.05.16 18:25	12	FS102 + LE12.5 + CP950	1/41	CP950-DSCN 2465
T128	2004.09.05 21:18	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	47 frames stacked
T129	2004.09.05 21:16	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	64 frames stacked
T130	004.09.05 ~20:53	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 6 video clips
T131	2004.09.05 ~21:15	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T132	2004.09.05 21:23	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	47 frames stacked
T133	2004.09.05 21:46	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	41 frames stacked
T134	2004.09.05 21:30	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	68 frames stacked
T135	2004.09.05 20:46	21	0-in f/6 + 5X + ToUcam	1/25	90 frames stacked
T136	2004.09.05 21:40	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	69 frames stacked
T137	2004.09.05 21:26	21	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	87 frames stacked
T138	2004.09.04 ~18:18	20	12.5-in f/6 Royce + 4X + ToUcam	1/25	Mosaic of 5 video clips
T139	2001.01.09 20:39	15	FS102 + Or25 + QV2300	4 sec	QV2300-20010110-0021
T140	2004.12.17 ~10:04	5	10 in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips

Data of Lunar Images

Image Code	Date / Time (UT)	Moon Age	Equipment Used	Exposure (sec)	Raw Image
T141	2004.09.20 ~12:00	6 days	10 in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 4 video clips
T142	2004.09.20 ~11:17	6	10 in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T143	2004.12.19 ~12:18	7	10 in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 4 video clips
T144	2006.08.12 21:43	18	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	180 frames stacked
T145	2004.09.04 ~17:28	20	12.5 in f/6 +2.5X + 1.6X + ToUcam	1/25	Mosaic of 4 video clips
T146	2004.06.27 14:23	10	10-in f/6 Royce + 2.5X + ToUcam	1/33	2 frames stacked
T147	2004.09.25 14:12	11	10-in f/6 Royce + 2.5X + ToUcam	1/50	22 frames stacked
T148	2004.09.25 ~14:44	11	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T149	2005.01.22 ~15:45	12	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 4 video clips
T150	2006.05.09 14:14	12	10-in f/6 Royce + 5X + ToUcam	1/25	190 frames stacked
T151	2006.05.10 14:09	13	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	200 frames stacked
T152	2006.05.10 ~15:06	13	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 3 video clips
T153	2004.09.26 14:22	12	10-in f/6 Royce + 2.5X + ToUcam	1/50	34 frames stacked
T154	2005.04.19 13:33	11	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T155	2004.09.26 ~15:36	12	10-in f/6 + 2.5X + 1.6X + ToUcam	1/33	Mosaic of 2 video clips
T156	2005.05.21 15:16	13	Orion 6-in f/8 + 2.5X + ToUcam	1/33	68 frames stacked
T157	2004.09.26 ~16:50	12	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T158	2006.05.09 13:56	12	10-in f/6 Royce + 5X + ToUcam	1/25	176 frames stacked
T159	2005.04.21 ~14:09	13	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 3 video clips
T160	2004.09.29 ~15:32	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	Mosaic of 3 video clips
T161	2006.05.09 13:50	12	10-in f/6 Royce + 5X + ToUcam	1/25	108 frames stacked
T162	2005.11.11 13:04	9	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	98 frames stacked
T163	2005.11.11 13:12	9	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	99 frames stacked
T164	2004.12.19 ~12:29	7	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T165	2004.10.03 ~21:49	19	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T166	2004.10.03 21:15	19	10-in f/6 Royce + 2.5X + ToUcam	1/50	10 frames stacked
T167	2005.11.09 ~11:45	7	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T168	2004.10.03 ~21:28	19	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T169	2004.10.03 21:40	19	10-in f/6 Royce + 2.5X + ToUcam	1/50	48 frames stacked
T170	2002.08.13 ~12:00	4	FS102 + Or25 + CP990		CP990-DSCN 4967 + 5021
T171	2004.09.20 ~11:06	6	10-in f/6 Royce + 2.5X + ToUcam	1/33	Mosaic of 2 video clips
T172	2004.09.19 11:00	5	10-in f/6 Royce + 2.5X + ToUcam	1/33	60 frames stacked
T173	2004.09.05 20:27	2	10-in f/6 Royce + 5X + ToUcam	1/25	67 frames stacked
T174	2004.05.29 15:19	10	10-in f/6 Royce + 2.5X + ToUcam	1/33	18 frames stacked
T175	2006.01.07 ~13:30	7	10-in f/6 Royce + 2.5X + ToUcam	1/33	Mosaic of 2 video clips
T176	2005.04.23 16:15	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	68 frames stacked
T177	2005.11.11 11:49	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	68 frames stacked
T178	2006.02.07 ~11:56	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T179	2005.04.18 ~13:49	10	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T180	2004.12.15 19:13	3	10-in f/6 Royce + 2.5X + ToUcam	1/50	68 frames stacked
T181, A	2004.11.25 ~16:42	13	10-in f/6 Royce + 2.5X + ToUcam	1/100	Mosaic of 3 video clips
T182	2005.04.22 ~16:09	14	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T183	2004.11.25 14:52	13	10-in f/6 Royce + 2.5X + ToUcam	1/100	67 frames stacked
T184	2004.11.25 14:50	13	10-in f/6 Royce + 2.5X + ToUcam	1/100	64 frames stacked
T185	2004.08.31 19:59	15	10-in f/6 Royce + 2.5X + ToUcam	1/50	25 frames stacked
T186	2004.12.17 ~10:54	5	10-in f/6 Royce + 2.5X + ToUcam	1/50	Stack of 4 video clips
T187	2004.12.17 ~10:43	5	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T188	2006.03.09 ~14:11	10	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T189	2004.12.19 ~12:13	7	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T190	2004.12.19 ~13:09	7	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 4 video clips
T191	2004.09.04 ~19:08	20	12.5-in f/6 Royce + 4X + ToUcam	1/25	Mosaic of 2 video clips
T192	2004.12.19 ~12:41	7	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T193	2004.12.17 ~10:14	5	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T194	2005.01.19 12:18	9	10-in f/6 Royce + 5X + ToUcam	1/25	88 frames stacked
T195	2005.01.22 ~15:05	12	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of a batch of video clips
T196	2004.09.26 16:35	12	10-in f/6 Royce + 2.5X + ToUcam	1/50	50 frames stacked
T197, A, B	2005.01.22 ~15:34	12	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T198	2005.10.14 ~15:00	11	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T199	2005.04.19 13:36	11	10-in f/6 Royce + 2.5X + ToUcam	1/50	78 frames stacked
T200	2005.01.22 ~14:06	12	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T201	2005.04.18 ~11:58	10	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T202	2005.04.18 ~14:44	10	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T203	2005.04.23 ~16:02	15	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 4 video clips
T204, A	2005.04.23 ~15:50	15	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 6 video clips
T205	2005.04.19 ~12:39	11	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 3 video clips
T206, A	2005.04.19 ~12:35	11	10-in f/6 Royce + 5X + ToUcam	1/25	Mosaic of 3 video clips
T207	2005.04.19 13:40	11	10-in f/6 Royce + 2.5X + ToUcam	1/33	78 frames stacked
T208	2005.04.23 ~15:38	15	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T209	2005.04.22 ~16:25	14	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T210	2005.04.19 12:58	11	10-in f/6 Royce + 5X + ToUcam	1/25	54 frames stacked

Data of Lunar Images

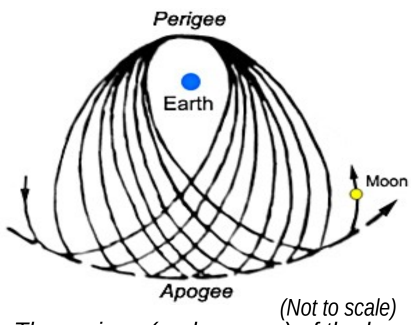
Image Code	Date / Time (UT)	Moon Age	Equipment Used	Exposure (sec)	Raw Image
T211	2006.05.09 13:31	12 days	10-in f/6 Royce + 5X + ToUcam	1/25	198 frames stacked
T212	2005.04.21 14:29	13	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	88 frames stacked
T213	2005.04.22 ~16:32	14	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T214	2005.04.23 16:08	15	10-in f/6 Royce + 2.5X + ToUcam	1/50	57 frames stacked
T215	2005.05.22 17:17	14	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	88 frames stacked
T216	2005.04.19 ~13:43	11	10-in f/6 Royce + 2.5X + ToUcam	1/33	Mosaic of 3 video clips
T217	2005.04.18 ~13:35	10	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T218	2005.05.22 15:42	14	10-in f/6 Royce + 5X + ToUcam	1/25	75 frames stacked
T219	2005.04.18 11:53	10	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	67 frames stacked
T220	2005.04.21 13:56	13	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	65 frames stacked
T221	2005.05.22 15:02	14	10-in f/6 Royce + 5X + ToUcam	1/33	68 frames stacked
T222	2005.05.22 15:42	14	10-in f/6 Royce + 5X + ToUcam	1/33	75 frames stacked
T223	2006.09.04 ~14:13	12	10-in f/6 Royce + 2.5X + ToUcam	1/33	Mosaic of 3 video clips
T224	2005.05.22 ~14:31	14	10-in f/6 Royce + 5X + ToUcam	1/25	Mosaic of 2 video clips
T225	2005.05.22 15:11	14	10-in f/6 Royce + 5X + ToUcam	1/25	85 frames stacked
T226	2005.05.23 14:52	15	10-in f/6 Royce + 2.5X + ToUcam	1/100	68 frames stacked
T227	2005.05.22 15:38	14	10-in f/6 Royce + 5X + ToUcam	1/25	88 frames stacked
T228	2005.08.22 ~18:56	17	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 3 video clips
T229	2005.08.22 19:07	17	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	93 frames stacked
T230	2005.08.22 19:34	17	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	88 frames stacked
T231	2005.10.14 14:14	11	10-in f/6 Royce + 2.5X + ToUcam	1/33	97 frames stacked
T232	2006.05.09 14:28	12	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	180 frames stacked
T233	2006.05.09 ~13:48	12	10-in f/6 Royce + 5X + ToUcam	1/25	Mosaic of 3 video clips
T234	2004.10.03 21:36	19	10-in f/6 Royce + 2.5X + ToUcam	1/50	68 frames stacked
T235	2005.10.19 16:08	16	10 in f/6 Royce + 2.5X + ToUcam	1/50	92 frames stacked
T236	2004.08.02 18:15	16	10 in f/6 Royce + 2.5X + ToUcam	1/50	10 frames stacked
T237	2004.08.02 18:10	16	10 in f/6 Royce + 2.5X + ToUcam	1/50	11 frames stacked
T238	2005.10.19 ~16:27	16	10 in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T239	2005.10.20 ~17.16	17	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T240	2005.10.20 15:59	17	10 in f/6 Royce + 2.5X + ToUcam	1/50	92 frames stacked
T241	2006.08.12 ~20:49	18	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T242	2005.10.21 15:37	18	10-in f/6 Royce + 2.5X + ToUcam	1/50	92 frames stacked
T243	2005.11.09 12:35	7	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	400 frames stacked (testing)
T244	2005.11.08 ~12:03	6	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 3 video clips
T245	2005.11.08 ~11:50	6	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T246	2005.11.09 12:41	7	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	150 frames stacked
T247	2004.10.03 21:00	19	10-in f/6 Royce + 2.5X + ToUcam	1/50	48 frames stacked
T248	2005.11.11 ~12:19	9	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T249	2005.11.09 11:04	7	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	72 frames stacked
T250	2006.01.07 ~13:08	7	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T251	2000.05.15 14:02	11	FS102 + LE7.5 + CP950	1/13	CP950-DSCN 2354
T252	2006.02.07 ~12:00	9	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 4 video clips
T253	2006.05.09 ~13:37	12	10-in f/6 Royce + 5X + ToUcam	1/25	Mosaic of 2 video clips
T254	2006.03.09 13:26	10	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	100 frames stacked
T255	2006.03.09 13:48	10	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Stack of 2 video clips
T256	2006.03.09 13:56	10	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	190 frames stacked
T257	2006.03.09 ~14:53	10	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 3 video clips
T258	2006.03.09 ~15:30	10	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Stack of 3 video clips
T259	2006.03.09 14:08	10	10-in f/6 Royce + 2.5X + ToUcam	1/50	200 frames stacked
T260	2006.04.04 ~11:46	6	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T261	2006.05.09 14:02	12	10-in f/6 Royce + 5X + ToUcam	1/25	169 frames stacked
T262	2006.07.02 ~12:40	7	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T263	2006.07.31 ~12:18	6	10-in f/6 Royce + 2.5X + ToUcam	1/50	Mosaic of 2 video clips
T264	2006.08.12 ~20:36	18	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 6 video clips
T265	2006.08.12 ~21:22	18	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips
T266	2006.08.12 21:23	18	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	200 frames stacked
T267	2006.08.12 20:42	18	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	170 frames stacked
T268	2006.08.12 20:27	18	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	200 frames stacked
T269	2006.08.12 ~21:30	18	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 4 video clips
T270	2006.08.12 ~21:11	18	10-in f/6 + 2.5X + 1.6X + ToUcam	1/25	Mosaic of 2 video clips

Data of the Moon

Equatorial diameter 赤道直徑	3476 km (0.272 of Earth's diameter)
Polar diameter 極直徑	3472 km
Mean angular diameter 平均角直徑	31' 05" (geocentric 從地心計), 31' 37" (topocentric 從地面計)
Variation of angular diameter 角直徑的變化	29' 23" to 33' 31" (geocentric)
Axial rotation period 自轉周期	27.32166 days (= sidereal month)
Mass 質量	7.35 x 10^{22} kg (1/81 of Earth's mass)
Mean density 平均密度	3.34 g / cm^3 (0.6 of Earth's density)
Surface gravity 表面引力	1.62 m / sec^2 (1/6 of Earth's gravity)
Escape velocity 脫離速度	2.38 km / sec
Surface temperature 表面溫度	approx. 130^0 C at day to -180^0 C at night
Albedo 反照率	0.12
Mean visual magnitude 平均目視星等	12.7 (full moon)
Average thickness of crust 平均地殼厚度	approx. 60 km (nearside), 90 km (farside)
Surface magnetic field 表面磁場	almost undetectable
No. of named surface features 已被命名的月面特徵 (Ref. 5)	about 8800 (incl. lettered craters & non-crater features on nearside & farside.)
Mean distance from Earth 月地平均距離	384 401 km (30 times Earth's diameter)
Increase of mean distance from Earth 月地平均距離增加率	3.8 cm per year
Distance of Moon at apogee (farthest from Earth) 遠地點距離	406 712 km (on 1984 March 2)
Distance of Moon at perigee (closest to Earth) 近地點距離	356 375 km (on 1912 January 4)
Period of revolution of perigee 近地點移行周期	3232 days (8.849 years)
Orbital eccentricity 軌道偏心率	0.055 (variable 0.026 ~ 0.077), ***Note 1.***
Inclination of lunar equator to orbit 月球赤道與白道交角	6.68^0 (oscillating between 6.48^0 ~ 6.85^0)
Inclination of orbit to ecliptic 白道與黃道交角	5.15^0 (oscillating between 4.98^0 ~ 5.30^0 every 173 days), ***Note 2.***
Inclination of lunar equator to ecliptic 月球赤道與黃道交角	1.53^0
Mean orbital velocity 平均軌道速度	1.023 km / sec
Mean sidereal motion 平均月移行	13.18^0 per day (moving eastward, variable 12^0 ~ 15^0 per day)
Mean value of lunar month:	
Sidereal month (orbital period) 恒星月	27.32166 days
Synodic month (new moon to new moon) 朔望月	29.53059 days (variable 29.27 ~ 29.83 days), ***Note 3.***
Anomalistic month (perigee to perigee) 近點月	27.55455 days
Tropical month (equinox to equinox) 分至月	27.32158 days
Draconic month (node to node) 交點月	27.21222 days
Regression of nodes 交點退行	19.34^0 per year (period = 18.61 years), ***Note 4.***
Earth-Moon Lagrangian points 拉格朗日點(地月系統	***Note 5.***

Libration of the Moon 月球天平動 (Reference No. 27)

	Longitudinal 經天平動	Latitudinal 緯天平動
Optical libration 光學天平動		
Displacement (selenocentric) 從月心位移	± 7.88^0	± 6.85^0
Period	approximately one sidereal month	
Physical libration 物理天平動		
Displacement (selenocentric) 從月心位移	± 66"	± 105"
Period	1 year	6 years
Surface area of Moon visible from Earth	59 % maximum	



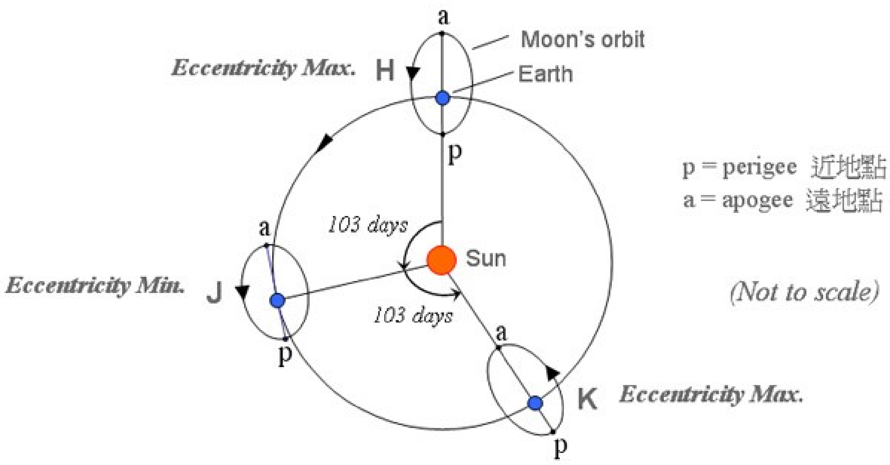
The perigee (and apogee) of the lunar orbit revolves in a period of 8.849 years.

Lunar Geologic Time Scale 月球地質紀年 (Reference No. 32)

Time (10^9 years ago)	Name of Period	Marking events
4.55 - 4.5		accretion & melting, magma ocean
4.5 - 3.9	Pre-Nectarian 前酒海紀	cooling & differentiation, crust formation
3.9 - 3.85	Nectarian 酒海紀	intense bombardment, impact basins, highlands
3.85 - 3.2	Imbrian 雨海紀	volcanism, mare basalt formation
3.2 – 1.1	Eratosthenian 愛拉托遜紀	continuing but less intense bombardment
1.1 - present	Copernican 哥白尼紀	crater & regolith formation

Note 1:

According to Jean Meeus (Reference No. 26), the instantaneous eccentricity of the Moon's orbit can vary between the extremes 0.026 and 0.077. Eccentricity maximum occurs at position **H** of the following diagram, where the apogee and perigee line up towards the Sun. Eccentricity minimum occurs 103 days later at position **J**, where the apogee and perigee are perpendicular to the Sun-Earth line. A new eccentricity maximum is reached again after 103 days at position **K**. Overall the apogee and perigee lines up towards the Sun every 206 days or 7 synodic months.



Note 2:

Because the ecliptic inclines at 23.44^0 to the celestial equator, the Moon's declination (赤緯) shall vary up to $23.44^0 + 5.30^0 = 28.74^0$ north or south of the celestial equator.

Note 3:

The relationship between synodic month and sidereal month is theoretically given by

1 / synodic month = 1 / sidereal month - 1 / sidereal year, i.e.

1 / 29.53059 days = 1 / 27.32166 days - 1 / 365.25636 days

Note 4:

The regression (eastward movement) of the Moon's nodes, together with the Sun's gravity on the Earth's equatorial bulge, cause a periodic oscillation of the Earth's pole about its mean position and hence a similar variation in the celestial positions of stars. The main oscillation has an amplitude of about 9 arcseconds and a period equal to the regression of the Moon's nodes (18.61 years). This periodic oscillation of the Earth's pole is termed *Nutation* 章動.

Note 5:

The Lagrangian points refer to 5 points L_1 ... System. L_1 L_2 and L_3 are points of quasi-equilibriu... in these points to drift away. The L_4 and L_5 are point...

Let **E** = Center of the Earth

M = Center of the Moon

O = Center of mass

d = Earth-Moon distance

(i.e. **EM** ≈ 384,000 km)

Then **EO** ≈ 0.012 d ≈ 4,600 km

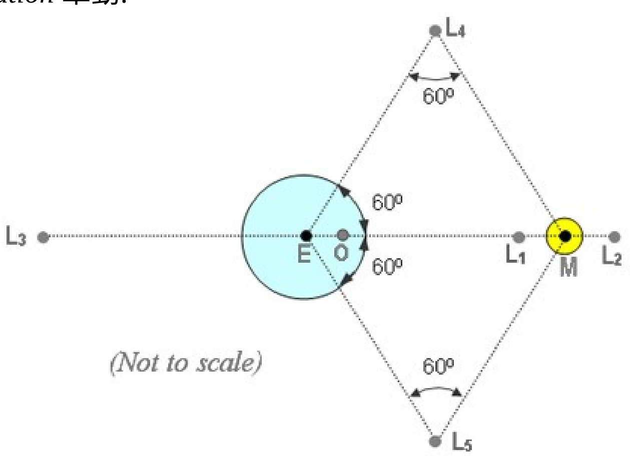
$ML_1 \approx 0.16\, d \approx 62{,}000$ km

$ML_2 \approx 0.16\, d \approx 62{,}000$ km

$EL_3 \approx d \approx 384{,}000$ km

$EL_4 = ML_4 = d \approx 384{,}000$ km

$EL_5 = ML_5 = d \approx 384{,}000$ km



Glossary

Abundance of Elements 元素豐度 The relative amount of each element in a given object such as a star, planet or satellite.

Accretion 吸積 The increase of mass of a body by the accumulation of smaller objects that collide and stick to it.

Age of the Moon 月齡 The period that has elapsed since the last new moon. It starts at "zero" day (exact new moon).

Albedo 反照率 A measure of the reflectivity of a surface. The albedo of lunar mare is 6 % typical while highland is 17 %.

Anorthosite 斜長岩 Light-colored rock from lunar highlands or beneath mare basalts, rich in silicon, calcium and aluminum.

Apogee 遠地點 The farthest point on the Moon's orbit from the Earth.

Apollo Missions 阿波羅登月任務 The American NASA (National Aeronautics and Space Administration) program to land humans on the Moon. The first manned landing is Apollo 11 (1969 July 20), and the last is Apollo 17 (1972 December 11). Apollo 13 (1970 April) aborted in the 3rd day of the mission.

Basalt 玄武岩 Igneous rock formed from solidified lava.

Breccia 角礫岩 Rock consists of two or more types cemented together. On the Moon, it is produced by heat and pressure of meteorite impacts.

Catena 環形山串 Latin for chain of relatively small craters (plural: catenae).

Center of Mass 質心 The point in a system of bodies (e.g. Earth-Moon) which acts as if all the mass were concentrated there.

Colongitude 餘經度 A measure of the Sun's relative position. On the Moon, it is same as the selenographic longitude of the morning terminator, measured westwards from the prime or central meridian. Thus its value is 0^0 at first quarter, 90^0 at full moon, 180^0 at last quarter & 270^0 at new moon. (Remark: At the morning terminator, the Sun is rising over that part of the Moon; at the evening terminator, it is setting.)

Crater 環形山 A generic term for circular depression on surface, such as ring mountain and walled plain. A ring mountain looks smaller in diameter but deeper than a walled plain. Craters are of either impact or volcanic origin.

Crescent 娥眉月 The phase of the Moon when it is less than half illuminated as seen from the Earth.

Crust 地殼 The outermost solid layer of a planet or satellite.

Dark Mantle Deposits 黑地幔澱積物 Remarkably dark deposits on the Moon's surface. They contain a mixture of small black and dark orange glass debris which formed from quickly cooled droplets of a nearby volcanic fountain.

Diurnal 周日的 Happening daily.

Dome 拱丘 Low rounded elevation of height a few hundred meters only. It appears to have been formed by volcanic activities.

Dorsum 皺脊 (plural: dorsa) Latin for wrinkle ridge. Long narrow rising feature on the mare floor, possibly resulted from surface shrinkage following the cease of volcanism, or buckling of the lunar crust due to the weight of accumulated lava in the impact site.

Earthshine 地照 / 地球照 The faint illumination on the dark side of a crescent, caused by sunlight reflected from the Earth.

Eccentricity 偏心率 A measure of how far an orbit diverges from a circle. A perfect circle gives eccentricity = zero.

Ejecta 噴出物 Material thrown out from an explosive event, such as a crater-forming impact or volcanic eruption.

Ejecta Blanket 噴出覆蓋物 The area immediately outside the rim of an impact crater where the ejecta has completely covered the underlying terrain.

Farside of the Moon 月背面 The side of the Moon facing away from the Earth.

Fault 斷層 A fracture of surface along which there has been slippage, either vertical or horizontal.

First Quarter 上弦 The phase of the Moon that occurs midway between new and full moon, when half of the Moon is illuminated. At first quarter, the Moon has moved 1/4 of its orbit around the Earth and lies 90^0 east of the Sun.

Full Moon 滿月 / 望 The phase of the Moon when it is fully illuminated and 180^0 away from the Sun, as seen from the Earth.

Ghost Crater 假環形山 The bare hint of a crater formation that has been destroyed or heavily modified by some later action.

Giant Impact Theory 大碰撞論 A theory for the origin of the Moon from impact debris when a Mars-sized proto-planet collided with the proto-Earth in about 4.6 billion years ago, developed after the Apollo Missions.

Graben 地塹 A sunken area between faults.

Harvest Moon 穫月 The full moon closest to the autumnal equinox when it rises at minimum delay time in successive days.

Highlands 高地 Raised areas on the Moon, light-colored, heavily cratered and chemically distinct from the maria.

IAU 國際天文聯合會 International Astronomical Union, an assembly to govern the world of astronomy, founded in 1919.

Illumination 照度 A measure of moon phase, equal to the ratio of illuminated area to the total area of the Moon disc. New moon gives Illumination = 0 %, full moon gives 100 %.

Impact Basin 隕擊盆地 A vast depressed surface (size larger than about 300 km) caused by colossal impactors. A smaller impact basin is often termed **impact crater** while lava-filled area within the basin is termed **mare**.

Igneous 火成的 Referring to processes that involve the formation and solidification of hot, molten magma or lava.

KREEP 克里普岩 An elusive rock type sampled in lunar highlands near the rim of maria, rich in potassium (chemical symbol K), rare-earth elements (REE), phosphorus (P) as well as other radioactive elements such as thorium and uranium.

Lacus 湖 Latin for lake. A "small version" of lunar mare.

Laser Ranging 激光測距 Establishment of precise Earth-Moon distances by aiming and reflecting laser beams between them.

Last Quarter 下弦 The phase of the Moon that occurs midway between full and new moon, when half of the Mo[illegible] illuminated. At last quarter, the Moon has moved 3/4 of its orbit around the Earth and lies 90^0 west of the [illegible]

Libration 天平動 The apparent vertical or horizontal rocking motions of the Moon as it orbits around the Earth. [illegible] libration is measured by the shift of longitude and latitude at the center of the Moon disc.

LTP 月面瞬變現象 Abbreviation for "Lunar Transient Phenomena" or "Transit Lunar Phenomena". A controversial observed phenomena of weird happenings or changes on the Moon's surface.

Lunar Eclipse 月蝕 The eclipse seen on Earth as the full Moon passes through the Earth's shadow.

Lunation (**Synodic Month**) 朔望月 The period of time taken for the Moon to go through a complete cycle of phases.

Magma 岩漿 Subterranean molten rock. When it reaches the surface during a volcanic eruption, it is called **lava** 溶岩.

Mantle 地幔 The thicker layer in the interior of a planet or satellite, underneath the crust but overlying the core, and differing in composition from both.

Mare 海 **/** 月海 Latin for sea (plural: maria). The broad dark plain formed from ancient lava outflow from the Moon's interior.

Mare Basalt 月海玄武岩 Dark rock on lunar maria, enriched by heavy metals like iron and titanium. Few samples of mare basalt from the Apollo are vesicular.

Mascon 質量瘤 **/** 重力異常區 Abbreviated from the term "mass concentration". An area on the Moon either composed of, or underlain by denser material, as evidenced by an increased gravitational pull on orbiting spacecraft.

Meteorite 隕石 **/** 隕星 Object from space that hits the Moon or other planets. Large meteorites are believed to have created most of the craters on the Moon. The distinction between a large meteorite and a small asteroid is blurred.

Micrometeoroid 微流星體 Micro object from space that hits the Moon or other planets, sometimes just called **meteoroid**.

Mineral 礦物 Inorganic solid with a definite composition and crystal structure. Minerals are basic components to form rocks.

Mons 山 Latin for mountain.

Montes 山脈 Latin for mountain ranges or a group of isolated mountains.

Moonquake 月震 Sudden trembling of the Moon caused by the abrupt release of internal energy or landslides inside craters.

Nearside of the Moon 月正面 The side of the Moon facing the Earth.

New Moon 新月 / 朔 The phase of the Moon when it is directly between the Earth and the Sun.

Occultation 掩 The movement of one celestial object (e.g. a star) behind another (e.g. the Moon).

Oceanus 洋 Latin for ocean. The "large version" of lunar mare. Oceanus Procellarum is the only feature so named.

Palus 沼 Latin for marsh or swamp. A "small version" of lunar mare.

Penumbra 半影 The less dark outer region of the shadow of the Earth.

Perigee 近地點 The nearest point on the Moon's orbit from the Earth.

Phase 月相 The amount of the illuminated Moon disc. There are four specific phases － new moon, first quarter, full moon and last quarter － and also non-specific phase names such as waxing moon, waning moon, gibbous moon and crescent.

Promontorium 岬 **/** 海角 Latin for promontory or cape.

Radiometric Dating 放射性同位素計年 Age-determination of rocks by comparing the decay of radioactive elements such as the isotopes of potassium (^{40}K), rubidium (^{87}Rb) and uranium (^{235}U) embedded in the samples.

Rays, Lunar 月面輻射紋 Streaks (normally bright) radiating from certain impact craters of the Moon.

Regolith 浮土 From the Greek for "blanket of stone". A layer of loose and broken rock and dust on the crust of a planet or satellite. The lunar regolith contains a small amount of tiny, black glass beads produced by micrometeoroid impacts.

Rima 溪 **/** 月溪 **/** 溝紋 Latin for rille (plural: rimae). A narrow and relatively long cleft, slumped channel or valley on the surface of the Moon, caused by ancient running lava or slight pulling of ground to either side.

Ritcher Scale 黎克特地震等級 A logarithmic scale to determine the magnitude of earthquake (and moonquake). Each whole number increase in scale magnitude represents a tenfold increase in measured amplitude of the strongest quake waves, or 31.6 times more energy release than the preceding magnitude. Thus magnitude 8.0 releases energy 1000 times more energy than magnitude 6.0. Magnitudes below about 2.0 are generally not felt by people.

Rupes 懸崖 / 峭壁 / 斷層 Latin for scarp, cliff or fault.

Secondary Craters 次級環形山 **/** 次級隕擊坑 Impact craters produced by the ejecta of a large impact-crater.

Seeing 視寧度 A measure of the steadiness of air through which a celestial object is observed.

Seismometry 地震測量 Measurement of seismic waves, such as those produced by earthquakes or moonquakes.

Selenographic 月面的 Belonging or relating to the surface of the Moon. "Selene" is the Greek goddess of the Moon.

Shield Volcano 盾形火山 Volcano that appears in gently sloping cone, constructed of solidified lava flows.

Sinus 灣 Latin for bay. A "small version" of lunar mare, usually in the appearance of a bay but can be irregular in shape.

Southern Highlands 南面高地 The heavily cratered region in the southern part of the Moon's nearside where no mare exists.

Tectonics 地殼構造作用 Large-scale movements of the crust of a planet or satellite, such as land rising to form a mountain.

Terminator 明暗界線 The boundary on the Moon between day and night, or between light and shadow.

Terraced Wall 台地牆 The inner wall (of a lunar crater) that appears in terrace structure.

Terrain 地體 / 地勢 A generic term referring to any surface area with a distinctive geological character.

Tidal Force 起潮力 The difference of gravitational pulls by a celestial body on another body's surface and center. It is inversely proportional to the cube of distance between the two bodies. The lunar tidal force acting on Earth is 2.2 times greater than the Sun's tidal force.

Umbra 本影 The darker core of the shadow of the Earth, typically cone shaped, and surrounded by a lighter penumbra shadow. Within the umbra, the Moon is completely obscured from direct sunlight; a **total lunar eclipse** will be seen on Earth.

UT 世界時 Abbreviation for "Universal Time". For time conversion, UT = Hong Kong Standard Time - 8 hours.

Vallis 谷 / 月谷 / 槽 Latin for lunar valley that appears as a broad trough of volcanic origin or a chain of overlapping craters.

Volcanism 火山作用 Any process to transfer molten material and gases in the interior of a planet or satellite to its surface.

Wrinkle Ridge 皺脊 Sometimes called mare ridges because they are found usually in mare floors. See also *Dorsum*.

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Crater List

(As at 2007 January)

Nearside

Crater, Long., Lat., Dia. (+Longitude = East, −Longitude = West, +Latitude = North, −Latitude = South, Diameter in km)

Crater	Long.	Lat.	Dia.
Abbot	54.8	5.6	10
Abel	87.3	-34.5	122
Abenezra	11.9	-21.0	42
Abetti	27.8	20.1	1.5
Abulfeda	13.9	-13.8	65
Acosta	60.1	-5.6	13
Adams	68.2	-31.9	66
Agatharchides	-30.9	-19.8	48
Agrippa	10.5	4.1	44
Airy	5.7	-18.1	36
Akis	-31.8	20.0	2
Alan	-6.1	-10.9	2
Al-Bakri	20.2	14.3	12
Albategnius	4.3	-11.7	114
Aldrin	22.1	1.4	3
Alexander	13.5	40.3	81
Alfraganus	19.0	-5.4	20
Alhazen	71.8	15.9	32
Aliacensis	5.2	-30.6	79
Almanon	15.2	-16.8	49
Al-Marrakushi	55.8	-10.4	8
Aloha	-53.9	29.8	3
Alpetragius	-4.5	-16.0	39
Alphonsus	-3.2	-13.7	108
Ameghino	57.0	3.3	9
Ammonius	-0.8	-8.5	8
Amontons	46.8	-5.3	2
Amundsen	85.6	-84.3	101
Anaxagoras	-10.1	73.4	50
Anaximander	-51.3	66.9	67
Anaximenes	-44.5	72.5	80
Anděl	12.4	-10.4	35
Ango	-32.3	20.5	1
Angström	-41.6	29.9	9
Ann	-0.1	25.1	3
Annegrit	-25.6	29.4	1
Ansgarius	79.7	-12.7	94
Anville	49.5	1.9	10
Apianus	7.9	-26.9	63
Apollonius	61.1	4.5	53
Arago	21.4	6.2	26
Aratus	4.5	23.6	10
Archimedes	-4.0	29.7	82
Archytas	5.0	58.7	31
Argelander	5.8	-16.5	34
Ariadaeus	17.3	4.6	11
Aristarchus	-47.4	23.7	40
Aristillus	1.2	33.9	55
Aristoteles	17.4	50.2	87
Armstrong	25.0	1.4	4
Arnold	35.9	66.8	94
Artemis	-25.4	25.0	2
Artsimovich	-36.6	27.6	8
Aryabhata	35.1	6.2	22
Arzachel	-1.9	-18.2	96
Asada	49.9	7.3	12
Asclepi	25.4	-55.1	42
Aston	-87.7	32.9	43
Atlas	44.4	46.7	87
Atwood	57.7	-5.8	29
Autolycus	1.5	30.7	39
Auwers	17.2	15.1	20
Auzout	64.1	10.3	32
Avery	81.4	-1.4	9
Azophi	12.7	-22.1	47
Baade	-81.8	-44.8	55
Babbage	-57.1	59.7	143
Back	80.7	1.1	35
Baco	19.1	-51.0	69
Baillaud	37.5	74.6	89
Bailly	-69.1	-66.5	287
Baily	30.4	49.7	26
Balboa	-83.2	19.1	69
Ball	-8.4	-35.9	41
Balmer	69.8	-20.3	138
Banachiewicz	80.1	5.2	92
Bancroft	-6.4	28.0	13
Banting	16.4	26.6	5
Barkla	67.2	-10.7	42
Barnard	85.6	-29.5	105
Barocius	16.8	-44.9	82
Barrow	7.7	71.3	92
Bartels	-89.8	24.5	55
Bayer	-35.0	-51.6	47
Beals	86.5	37.3	48
Beaumont	28.8	-18.0	53
Beer	-9.1	27.1	9
Behaim	79.4	-16.5	55
Beketov	29.2	16.3	8
Béla	2.3	24.7	11
Bel'kovich	90.2	61.1	214
Bellot	48.2	-12.4	17
Bernoulli	60.7	35.0	47
Berosus	69.9	33.5	74
Berzelius	50.9	36.6	50
Bessarion	-37.3	14.9	10
Bessel	17.9	21.8	15
Bettinus	-44.8	-63.4	71
Bianchini	-34.3	48.7	38
Biela	51.3	-54.9	76
Bilharz	56.3	-5.8	43
Billy	-50.1	-13.8	45
Biot	51.1	-22.6	12
Birmingham	-10.5	65.1	92
Birt	-8.5	-22.4	16
Black	80.4	-9.2	18
Blagg	1.5	1.3	5
Blancanus	-21.4	-63.8	117
Blanchinus	2.5	-25.4	61
Bliss	-13.5	53.0	20
Bobillier	15.5	19.6	6
Bode	-2.4	6.7	18
Boethius	72.3	5.6	10
Boguslawsky	43.2	-72.9	97
Bohnenberger	40.0	-16.2	33
Bohr	-86.6	12.4	71
Boltzmann	-90.7	-74.9	76
Bombelli	56.2	5.3	10
Bonpland	-17.4	-8.3	60
Boole	-87.4	63.7	63
Borda	46.6	-25.1	44
Borel	26.4	22.3	4
Boris	-33.5	30.6	1
Born	66.8	-6.0	14
Boscovich	11.1	9.8	46
Boss	89.2	45.8	47
Bouguer	-35.8	52.3	22
Boussingault	54.6	-70.2	142
Bowen	9.1	17.6	8
Brackett	23.6	17.9	8
Brayley	-36.9	20.9	14
Breislak	18.3	-48.2	49
Brenner	39.3	-39.0	97
Brewster	34.7	23.3	10
Brianchon	-86.2	75.0	134
Briggs	-69.1	26.5	37
Brisbane	68.5	-49.1	44
Brown	-17.9	-46.4	34
Bruce	0.4	1.1	6
Brunner	90.9	-9.9	53
Buch	17.7	-38.8	53
Bullialdus	-22.2	-20.7	60
Bunsen	-85.3	41.4	52
Burckhardt	56.5	31.1	56
Bürg	28.2	45.0	39
Burnham	7.3	-13.9	24
Büsching	20.0	-38.0	52
Byrd	9.8	85.3	93
Byrgius	-65.3	-24.7	87
C. Herschel	-31.2	34.5	13
C. Mayer	17.3	63.2	38
Cabeus	-35.5	-84.9	98
Cajal	31.1	12.6	9
Calippus	10.7	38.9	32
Cameron	45.9	6.2	10
Campanus	-27.8	-28.0	48
Cannon	81.4	19.9	56
Capella	35.0	-7.5	49
Capuanus	-26.7	-34.1	59
Cardanus	-72.5	13.2	49
Carlini	-24.1	33.7	10
Carlos	2.3	24.9	4
Carmichael	40.4	19.6	20
Carpenter	-50.9	69.4	59
Carrel	26.7	10.7	15
Carrillo	80.9	-2.2	16
Carrington	62.1	44.0	30
Cartan	59.3	4.2	15
Casatus	-29.5	-72.8	108
Cassini	4.6	40.2	56
Catalán	-87.3	-45.7	25
Catharina	23.4	-18.1	104
Cauchy	38.6	9.6	12
Cavalerius	-66.8	5.1	57
Cavendish	-53.7	-24.5	56
Caventou	-29.4	29.8	3
Cayley	15.1	4.0	14
Celsius	20.1	-34.1	36
Censorinus	32.7	-0.4	3
Cepheus	45.8	40.8	39
Chacornac	31.7	29.8	51
Challis	9.2	79.5	55
Chang-Ngo	-2.1	-12.7	3
Charles	-26.4	29.9	1
Chevallier	51.2	44.9	52
Ching-Te	30.0	20.0	4
Chladni	1.1	4.0	13
Cichus	-21.1	-33.3	40
Clairaut	13.9	-47.7	75
Clausius	-43.8	-36.9	24
Clavius	-14.1	-58.8	245
Cleomedes	56.0	27.7	125
Cleostratus	-77.0	60.4	62
Clerke	29.8	21.7	6
Collins	23.7	1.3	2
Colombo	45.8	-15.1	76
Condon	60.4	1.9	34
Condorcet	69.6	12.1	74
Conon	2.0	21.6	21
Cook	48.9	-17.5	46
Copernicus	-20.1	9.7	93
Courtney	-30.8	25.1	1
Cremona	-90.6	67.5	85
Crile	46.0	14.2	9
Crozier	50.8	-13.5	22
Crüger	-66.8	-16.7	45
Curie	91.0	-22.9	151
Curtis	56.6	14.6	2
Curtius	4.4	-67.2	95
Cusanus	70.8	72.0	63
Cuvier	9.9	-50.3	75
Cyrillus	24.0	-13.2	98
Cysatus	-6.1	-66.2	48
da Vinci	45.0	9.1	37
Dag	5.3	18.7	0.5
Daguerre	33.6	-11.9	46
Dale	82.9	-9.6	22
Dalton	-84.3	17.1	60
Daly	59.6	5.7	17
Damoiseau	-61.1	-4.8	36
Daniell	31.1	35.3	29
Darney	-23.5	-14.5	15
d'Arrest	14.7	2.3	30
Darwin	-69.5	-20.2	120
Daubrée	14.7	15.7	14
Davy	-8.1	-11.8	34
Dawes	26.4	17.2	18
de Gasparis	-50.7	-25.9	30
de Gerlache	-87.1	-88.5	32
de La Rue	52.3	59.1	134
de Morgan	14.9	3.3	10
de Sitter	39.6	80.1	64
de Vico	-60.2	-19.7	20
Debes	51.7	29.5	30
Dechen	-68.2	46.1	12
Delambre	17.5	-1.9	51
Delaunay	2.5	-22.2	46
Delia	-6.1	-10.9	2
Delisle	-34.6	29.9	25
Delmotte	60.2	27.1	32
Deluc	-2.8	-55.0	46
Dembowski	7.2	2.9	26
Democritus	35.0	62.3	39
Demonax	60.8	-77.9	128
Desargues	-73.3	70.2	85
Descartes	15.7	-11.7	48
Deseilligny	20.6	21.1	6
Deslandres	-4.8	-33.1	256
Diana	35.7	14.3	2
Dionysius	17.3	2.8	18
Diophantus	-34.3	27.6	17
Dollond	14.4	-10.4	11
Donati	5.2	-20.7	36
Donna	38.3	7.2	2
Doppelmayer	-41.4	-28.5	63
Dove	31.5	-46.7	30
Draper	-21.7	17.6	8
Drebbel	-49.0	-40.9	30
Drygalski	-84.9	-79.3	149
Dubyago	70.0	4.4	51
Dunthorne	-31.6	-30.1	15
Eckert	58.3	17.3	2
Eddington	-72.2	21.3	118
Egede	10.6	48.7	37
Eichstadt	-78.3	-22.6	49
Eimmart	64.8	24.0	46
Einstein	-88.7	16.3	198
Elger	-29.8	-35.3	21
Elmer	84.1	-10.1	16
Encke	-36.6	4.6	28
Endymion	57.0	53.9	123
Epigenes	-4.6	67.5	55
Epimenides	-30.2	-40.9	27
Eratosthenes	-11.3	14.5	58
Esclangon	42.1	21.5	15
Euclides	-29.5	-7.4	11
Euctemon	31.3	76.4	62
Eudoxus	16.3	44.3	67
Euler	-29.2	23.3	27
Fabbroni	29.2	18.7	10
Fabricius	42.0	-42.9	78
Fahrenheit	61.7	13.1	6
Faraday	8.7	-42.4	69
Faustini	77.0	-87.3	39
Fauth	-20.1	6.3	12
Faye	3.9	-21.4	36
Fedorov	-37.0	28.2	6
Felix	-25.4	25.1	1
Fermat	19.8	-22.6	38
Fernelius	4.9	-38.1	65
Feuillée	-9.4	27.4	9
Finsch	21.3	23.6	4
Firmicus	63.4	7.3	56
Flammarion	-3.7	-3.4	74
Flamsteed	-44.3	-4.5	20
Fontana	-56.6	-16.1	31
Fontenelle	-18.9	63.4	38
Foucault	-39.7	50.4	23
Fourier	-53.0	-30.3	51
Fra Mauro	-17.0	-6.1	101
Fracastorius	33.2	-21.5	112
Franck	35.5	22.6	12
Franklin	47.7	38.8	56
Franz	40.2	16.6	25
Fraunhofer	59.1	-39.5	56
Fredholm	46.5	18.4	14
Freud	-52.3	25.8	2
Furnerius	60.6	-36.0	135
G. Bond	36.2	32.4	20
Galen	5.0	21.9	10
Galilaei	-62.7	10.5	15
Galle	22.3	55.9	21
Galvani	-84.6	49.6	80
Gambart	-15.2	1.0	25
Gardner	33.8	17.7	18
Gärtner	34.6	59.1	115
Gassendi	-40.1	-17.6	101
Gaston	-34.0	30.9	2
Gaudibert	37.8	-10.9	34
Gauricus	-12.6	-33.8	79
Gauss	79.0	35.7	177
Gay-Lussac	-20.8	13.9	26
Geber	13.9	-19.4	44
Geissler	76.5	-2.6	16
Geminus	56.7	34.5	85
Gemma Frisius	13.3	-34.2	87
Gerard	-80.0	44.5	90
Gibbs	84.3	-18.4	76
Gilbert	76.0	-3.2	112
Gill	75.9	-63.9	66
Gioja	2.0	83.3	41
Glaisher	49.5	13.2	15
Glushko	-77.6	8.4	43
Goclenius	45.0	-10.0	72
Goddard	89.0	14.8	89
Godin	10.2	1.8	34
Goldschmidt	-3.8	73.2	113
Golgi	-60.0	27.8	5
Goodacre	14.1	-32.7	46
Gould	-17.2	-19.2	34
Grace	35.9	14.2	1
Graff	-88.6	-42.4	36
Greaves	52.7	13.2	13
Grimaldi	-68.3	-5.5	172
Grove	32.9	40.3	28
Gruemberger	-10.0	-66.9	93
Gruithuisen	-39.7	32.9	15
Guericke	-14.1	-11.5	63
Gum	88.6	-40.4	54
Gutenberg	41.2	-8.6	74
Gyldén	0.3	-5.3	47
Hagecius	46.6	-59.8	76
Hahn	73.6	31.3	84
Haidinger	-25.0	-39.2	22
Hainzel	-33.5	-41.3	70
Haldane	84.1	-1.7	37
Hale	90.8	-74.2	83
Hall	37.0	33.7	35
Halley	5.7	-8.0	36
Hamilton	84.7	-42.8	57
Hanno	71.2	-56.3	56
Hansen	72.5	14.0	39
Hansteen	-52.0	-11.5	44
Harding	-71.7	43.5	22
Hargreaves	64.0	-2.2	16
Harlan	79.5	-38.5	65
Harold	-6.0	-10.9	2
Harpalus	-43.4	52.6	39
Hartwig	-80.5	-6.1	79
Hase	62.5	-29.4	83
Hausen	-88.1	-65.0	167
Hayn	85.2	64.7	87
Hecataeus	79.4	-21.8	167
Hédervári	84.0	-81.8	69
Hedin	-76.5	2.0	150
Heinrich	-15.3	24.8	6
Heinsius	-17.7	-39.5	64
Heis	-31.9	32.4	14
Helicon	-23.1	40.4	24
Hell	-7.8	-32.4	33
Helmert	87.6	-7.6	26
Helmholtz	64.1	-68.1	94
Henry	-56.8	-24.0	41
Henry Frères	-58.9	-23.5	42
Heraclitus	6.2	-49.2	90
Hercules	39.1	46.7	69
Herigonius	-33.9	-13.3	15
Hermann	-57.0	-0.9	15
Hermite	-89.9	86.0	104
Herodotus	-49.7	23.2	34
Herschel	-2.1	-5.7	40
Hesiodus	-16.3	-29.4	42
Hevelius	-67.6	2.2	115
Hill	40.8	20.9	16
Hind	7.4	-7.9	29
Hippalus	-30.2	-24.8	57
Hipparchus	5.2	-5.1	138
Holden	62.5	-19.1	47
Hommel	33.8	-54.7	126
Hooke	54.9	41.2	36
Hornsby	12.5	23.8	3
Horrebow	-40.8	58.7	24
Horrocks	5.9	-4.0	30
Hortensius	-28.0	6.5	14
Houtermans	87.2	-9.4	29
Hubble	86.9	22.1	80
Huggins	-1.4	-41.1	65
Humason	-56.6	30.7	4
Humboldt	80.9	-27.0	189
Hume	90.4	-4.7	23
Huxley	-4.5	20.2	4
Hyginus	6.3	7.8	9
Hypatia	22.6	-4.3	40
Ian	-0.4	25.7	1
Ibn Battuta	50.4	-6.9	11
Ibn-Rushd	21.7	-11.7	32
Ideler	22.3	-49.2	38
Ina	5.3	18.6	3
Inghirami	-68.8	-47.5	91
Isabel	-34.1	28.2	1
Isidorus	33.5	-8.0	42
Isis	27.5	18.9	1
Ivan	-43.3	26.9	4
J. Herschel	-42.0	62.0	165
Jacobi	11.4	-56.7	68
Jansen	28.7	13.5	23
Jansky	89.5	8.5	72
Janssen	40.3	-45.4	199
Jehan	-31.9	20.7	5
Jenkins	78.1	0.3	38
Jerik	27.6	18.5	1
Jomo	2.4	24.4	7
José	-1.6	-12.7	2
Joy	6.6	25.0	5
Julienne	3.2	26.0	2
Julius Caesar	15.4	9.0	90
Kaiser	6.5	-36.5	52
Kane	26.1	63.1	54
Kant	20.1	-10.6	33
Kao	87.6	-6.7	34

Crater List

(As at 2007 January)

Nearside

Crater Long. Lat. Dia. (+Longitude = East −Longitude = West +Latitude = North −Latitude = South Diameter in km)

Crater	Long.	Lat.	Dia.
Kapteyn	70.6	-10.8	49
Kästner	78.5	-6.8	108
Kathleen	-0.7	25.4	5
Keldysh	43.6	51.2	33
Kepler	-38.0	8.1	31
Kies	-22.5	-26.3	45
Kiess	84.0	-6.4	63
Kinau	15.1	-60.8	41
Kirch	-5.6	39.2	11
Kircher	-45.3	-67.1	72
Kirchhoff	38.8	30.3	24
Klaproth	-26.0	-69.8	119
Klein	2.6	-12.0	44
Knox-Shaw	80.2	5.3	12
König	-24.6	-24.1	23
Kopff	-89.6	-17.4	41
Krafft	-72.6	16.6	51
Krasnov	-79.6	-29.9	40
Kreiken	84.6	-9.0	23
Krieger	-45.6	29.0	22
Krogh	65.7	9.4	19
Krusenstern	5.9	-26.2	47
Kuiper	-22.7	-9.8	6
Kundt	-11.5	-11.5	10
Kunowsky	-32.5	3.2	18
la Caille	1.1	-23.8	67
la Condamine	-28.2	53.4	37
la Pérouse	76.3	-10.7	77
Lacroix	-59.0	-37.9	37
Lade	10.1	-1.3	55
Lagalla	-22.5	-44.6	85
Lagrange	-72.8	-32.3	225
Lalande	-8.6	-4.4	24
Lallemand	-84.1	-14.3	18
Lamarck	-69.8	-22.9	100
Lambert	-21.0	25.8	30
Lamé	64.5	-14.7	84
Lamèch	13.1	42.7	13
Lamont	23.7	4.4	106
Landsteiner	-14.8	31.3	6
Langley	-86.3	51.1	59
Langrenus	61.1	-8.9	127
Lansberg	-26.6	-0.3	38
Lassell	-7.9	-15.5	23
Lavoisier	-81.2	38.2	70
Lawrence	43.2	7.4	24
Le Gentil	-75.7	-74.6	128
Le Monnier	30.6	26.6	60
Le Verrier	-20.6	40.3	20
Leakey	37.4	-3.2	12
Lebesgue	89.0	-5.1	11
Lee	-40.7	-30.7	41
Legendre	70.2	-28.9	78
Lehmann	-56.0	-40.0	53
Lepaute	-33.6	-33.3	16
Letronne	-42.5	-10.8	116
Lexell	-4.2	-35.8	62
Licetus	6.7	-47.1	74
Lichtenberg	-67.7	31.8	20
Lick	52.7	12.4	31
Liebig	-48.2	-24.3	37
Lilius	6.2	-54.5	61
Linda	-33.4	30.7	1
Lindbergh	52.9	-5.4	12
Lindenau	24.9	-32.3	53
Lindsay	13.0	-7.0	32
Linné	11.8	27.7	2
Liouville	73.5	2.6	16
Lippershey	-10.3	-25.9	6
Littrow	31.4	21.5	30
Lockyer	36.7	-46.2	34
Loewy	-32.8	-22.7	24
Lohrmann	-67.2	-0.5	30
Lohse	60.2	-13.7	41
Longomontanus	-21.8	-49.6	157
Louise	-34.2	28.5	0.8
Louville	-46.0	44.0	36
Lubbock	41.8	-3.9	13
Lubiniezky	-23.8	-17.8	43
Lucian	36.7	14.3	7
Luther	24.1	33.2	9
Lyapunov	89.3	26.3	66
Lyell	40.6	13.6	32
Lyot	84.5	-49.8	132
Maclaurin	68.0	-1.9	50
Maclear	20.1	10.5	20
MacMillan	-7.8	24.2	7
Macrobius	46.0	21.3	64

Crater	Long.	Lat.	Dia.
Mädler	29.8	-11.0	27
Maestlin	-40.6	4.9	7
Magelhaens	44.1	-11.9	40
Maginus	-6.3	-50.5	194
Main	10.1	80.8	46
Mairan	-43.4	41.6	40
Malapert	12.9	-84.9	69
Mallet	54.2	-45.4	58
Manilius	9.1	14.5	38
Manners	20.0	4.6	15
Manuel	11.3	24.5	0.5
Manzinus	26.8	-67.7	98
Maraldi	34.9	19.4	39
Marco Polo	-2.0	15.4	28
Marinus	76.5	-39.4	58
Marius	-50.8	11.9	41
Markov	-62.7	53.4	40
Marth	-29.3	-31.1	6
Mary	27.4	18.9	1
Maskelyne	30.1	2.2	23
Mason	30.5	42.6	33
Maupertuis	-27.3	49.6	45
Maurolycus	14.0	-42.0	114
Maury	39.6	37.1	17
Mavis	-26.4	29.8	1
McClure	50.3	-15.3	23
McDonald	-20.9	30.4	7
Mee	-35.3	-43.7	126
Menelaus	16.0	16.3	26
Menzel	36.9	3.4	3
Mercator	-26.1	-29.3	46
Mercurius	66.2	46.6	67
Mersenius	-49.2	-21.5	84
Messala	60.5	39.2	125
Messier	47.6	-1.9	11
Metius	43.3	-40.3	87
Meton	18.8	73.6	130
Michael	0.2	25.1	4
Milichius	-30.2	10.0	12
Miller	0.8	-39.3	61
Mitchell	20.2	49.7	30
Moigno	28.9	66.4	36
Moltke	24.2	-0.6	6
Monge	47.6	-19.2	36
Monira	-1.7	-12.6	2
Montanari	-20.6	-45.8	76
Moretus	-5.8	-70.6	111
Morley	64.6	-2.8	14
Moseley	-90.1	20.9	90
Mösting	-5.9	-0.7	24
Mouchez	-26.6	78.3	81
Müller	2.1	-7.6	22
Murchison	-0.1	5.1	57
Mutus	30.1	-63.6	77
Naonobu	57.8	-4.6	34
Nasireddin	0.2	-41.0	52
Nasmyth	-56.2	-50.5	76
Natasha	-31.3	20.0	12
Naumann	-62.0	35.4	9
Neander	39.9	-31.3	50
Nearch	39.1	-58.5	75
Neison	25.1	68.3	53
Neper	84.6	8.5	137
Neumayer	70.7	-71.1	76
Newcomb	43.8	29.9	41
Newton	-16.9	-76.7	78
Nicholson	-85.1	-26.2	38
Nicolai	25.9	-42.4	42
Nicollet	-12.5	-21.9	15
Nielsen	-51.8	31.8	9
Nobile	53.5	-85.2	73
Nobili	75.9	0.2	42
Nöggerath	-45.7	-48.8	30
Nonius	3.8	-34.8	69
Norman	-30.4	-11.8	10
Oenopides	-64.1	57.0	67
Oersted	47.2	43.1	42
Oken	75.9	-43.7	71
Olbers	-75.9	7.4	74
Opelt	-17.5	-16.3	48
Oppolzer	-0.5	-1.5	40
Orontius	-4.6	-40.6	105
Osama	5.2	18.6	0.5
Osiris	27.6	18.6	1
Osman	-6.2	-11.0	2
Palisa	-7.2	-9.4	33
Palitzsch	64.5	-28.0	41
Pallas	-1.6	5.5	46

Crater	Long.	Lat.	Dia.
Palmieri	-47.7	-28.6	40
Parrot	3.3	-14.5	70
Parry	-15.8	-7.9	47
Pascal	-70.3	74.6	115
Patricia	0.3	25.0	5
Peary	33.0	88.6	73
Peek	86.9	2.6	12
Peirce	53.5	18.3	18
Peirescius	67.6	-46.5	61
Pentland	11.5	-64.6	56
Petavius	60.4	-25.1	188
Petermann	66.3	74.2	73
Peters	29.5	68.1	15
Petit	63.5	2.3	5
Petrov	88.0	-61.4	49
Pettit	-86.6	-27.5	35
Phillips	75.3	-26.6	122
Philolaus	-32.4	72.1	70
Phocylides	-57.0	-52.7	121
Piazzi	-67.9	-36.6	134
Piazzi Smyth	-3.2	41.9	13
Picard	54.7	14.6	22
Piccolomini	32.2	-29.7	87
Pickering	7.0	-2.9	15
Pictet	-7.4	-43.6	62
Pilâtre	-86.9	-60.2	50
Pingré	-73.7	-58.7	88
Pitatus	-13.5	-29.9	106
Pitiscus	30.9	-50.4	82
Plana	28.2	42.2	44
Plato	-9.4	51.6	109
Playfair	8.4	-23.5	47
Plinius	23.7	15.4	43
Plutarch	79.0	24.1	68
Poisson	10.6	-30.4	42
Polybius	25.6	-22.4	41
Pomortsev	66.9	0.7	23
Poncelet	-54.1	75.8	69
Pons	21.5	-25.3	41
Pontanus	14.4	-28.4	57
Pontécoulant	66.0	-58.7	91
Porter	-10.1	-56.1	51
Posidonius	29.9	31.8	95
Prinz	-44.1	25.5	46
Priscilla	-6.2	-10.9	1.8
Proclus	46.8	16.1	28
Proctor	-5.1	-46.4	52
Protagoras	7.3	56.0	21
Ptolemaeus	-1.9	-9.3	164
Puiseux	-39.0	-27.8	24
Pupin	-11.0	23.8	2
Purbach	-2.3	-25.5	115
Pythagoras	-63.0	63.5	142
Pytheas	-20.6	20.5	20
Rabbi Levi	23.6	-34.7	81
Raman	-55.1	27.0	10
Ramsden	-31.8	-32.9	24
Rankine	71.5	-3.9	8
Ravi	-1.9	-12.5	2.5
Rayleigh	89.6	29.3	114
Réaumur	0.7	-2.4	52
Regiomontanus	-1.0	-28.3	108
Regnault	-88.0	54.1	46
Reichenbach	48.0	-30.3	71
Reimarus	60.3	-47.7	48
Reiner	-54.9	7.0	29
Reinhold	-22.8	3.3	42
Repsold	-78.6	51.3	109
Respighi	71.9	2.8	18
Rhaeticus	4.9	0.0	45
Rheita	47.2	-37.1	70
Riccioli	-74.6	-3.3	139
Riccius	26.5	-36.9	71
Riemann	86.8	38.9	163
Ritchey	8.5	-11.1	24
Ritter	19.2	2.0	29
Robert	27.4	19.0	1
Robinson	-45.9	59.0	24
Rocca	-72.8	-12.7	89
Rocco	-45.0	28.9	4
Römer	36.4	25.4	39
Rosa	-32.3	20.3	1
Rosenberger	43.1	-55.4	95
Ross	21.7	11.7	24
Rosse	35.0	-17.9	11
Rost	-33.7	-56.4	48
Rothmann	27.7	-30.8	42
Runge	86.7	-2.5	38

Crater	Long.	Lat.	Dia.
Russell	-75.4	26.5	103
Ruth	-45.1	28.7	3
Rutherfurd	-12.1	-60.9	48
Sabatier	79.0	13.2	10
Sabine	20.1	1.4	30
Sacrobosco	16.7	-23.7	98
Samir	-34.3	28.5	2
Sampson	-16.5	29.7	1
Santbech	44.0	-20.9	64
Santos-Dumont	4.8	27.7	8
Sarabhai	21.0	24.7	7
Sasserides	-9.3	-39.1	90
Saunder	8.8	-4.2	44
Saussure	-3.8	-43.4	54
Scheele	-37.8	-9.4	4
Scheiner	-27.5	-60.5	110
Schiaparelli	-58.8	23.4	24
Schickard	-55.3	-44.3	206
Schiller	-39.0	-51.9	180
Schlüter	-83.3	-5.9	89
Schmidt	18.8	1.0	11
Schomberger	24.9	-76.7	85
Schorr	89.7	-19.5	53
Schröter	-7.0	2.6	35
Schubert	81.0	2.8	54
Schumacher	60.7	42.4	60
Schwabe	45.6	65.1	25
Scoresby	14.1	77.7	55
Scott	48.5	-82.1	103
Secchi	43.5	2.4	22
Seeliger	3.0	-2.2	8
Segner	-48.3	-58.9	67
Seleucus	-66.6	21.0	43
Seneca	80.2	26.6	46
Shackleton	0.0	-89.9	19
Shaler	-85.2	-32.9	48
Shapley	56.9	9.4	23
Sharp	-40.2	45.7	39
Sheepshanks	16.9	59.2	25
Shoemaker	44.9	-88.1	51
Short	-7.3	-74.6	70
Shuckburgh	52.8	42.6	38
Silberschlag	12.5	6.2	13
Simpelius	15.2	-73.0	70
Sinas	31.6	8.8	11
Sirsalis	-60.4	-12.5	42
Slocum	89.0	-3.0	13
Smithson	53.6	2.4	5
Snellius	55.7	-29.3	82
Somerville	64.9	-8.3	15
Sömmering	-7.5	0.1	28
Soraya	-1.6	-12.9	2
Sosigenes	17.6	8.7	17
South	-50.8	58.0	104
Spallanzani	24.7	-46.3	32
Spörer	-1.8	-4.3	27
Spurr	-1.2	27.9	13
Stadius	-13.7	10.5	69
Steinheil	46.5	-48.6	67
Stella	29.8	19.9	1
Stevinus	54.2	-32.5	74
Stewart	67.0	2.2	13
Stiborius	32.0	-34.4	43
Stöfler	6.0	-41.1	126
Stokes	-88.1	52.5	51
Strabo	54.3	61.9	55
Street	-10.5	-46.5	57
Struve	-77.1	22.4	164
Suess	-47.6	4.4	8
Sulpicius Gallus	11.6	19.6	12
Susan	-6.3	-11.0	1
Swasey	89.7	-5.5	23
Swift	53.4	19.3	10
Sylvester	-79.6	82.7	58
T. Mayer	-29.1	15.6	33
Tacchini	85.8	4.9	40
Tacitus	19.0	-16.2	39
Tacquet	19.2	16.6	7
Taizo	2.2	24.7	6
Talbot	85.3	-2.5	11
Tannerus	22.0	-56.4	28
Taruntius	46.5	5.6	56
Taylor	16.7	-5.3	42
Tebbutt	53.6	9.6	31
Tempel	11.9	3.9	45
Thales	50.3	61.8	31
Theaetetus	6.0	37.0	24
Thebit	-4.0	-22.0	56

Crater	Long.	Lat.	Dia.
Theiler	83.3	13.4	7
Theon Junior	15.8	-2.3	17
Theon Senior	15.4	-0.8	18
Theophilus	26.4	-11.4	110
Theophrastus	39.0	17.5	9
Timaeus	-0.5	62.8	32
Timocharis	-13.1	26.7	33
Tisserand	48.2	21.4	36
Tolansky	-16.0	-9.5	13
Torricelli	28.5	-4.6	22
Toscanelli	-47.5	27.4	7
Townley	63.3	3.4	18
Tralles	52.8	28.4	43
Triesnecker	3.6	4.2	26
Trouvelot	5.8	49.3	9
Tucker	88.2	-5.6	7
Turner	-13.2	-1.4	11
Tycho	-11.1	-43.4	102
Ukert	1.4	7.8	23
Ulugh Beigh	-81.9	32.7	54
Urey	87.4	27.9	38
Väisälä	-47.8	25.9	8
van Albada	64.3	9.4	21
Van Biesbroeck	-45.6	28.7	9
Van Vleck	78.3	-1.9	31
Vasco da Gama	-83.9	13.6	83
Vega	63.4	-45.4	75
Vendelinus	61.6	-16.4	131
Vera	-43.7	26.3	2
Verne	-25.3	24.9	2
Very	25.3	25.6	5
Vieta	-56.3	-29.2	87
Virchow	83.7	9.8	16
Vitello	-37.5	-30.4	42
Vitruvius	31.3	17.6	29
Vlacq	38.8	-53.3	89
Vogel	5.9	-15.1	26
Volta	-84.4	53.9	123
von Behring	71.8	-7.8	38
von Braun	-78.0	41.1	60
Voskresenskiy	-88.1	28.0	49
W. Bond	4.5	65.4	156
Wallace	-8.7	20.3	26
Wallach	32.3	4.9	6
Walter	-33.8	28.0	1
Walther	1.0	-33.1	128
Wargentin	-60.2	-49.6	84
Warner	87.3	-4.0	35
Watt	48.6	-49.5	66
Watts	46.3	8.9	15
Webb	60.0	-0.9	21
Weierstrass	77.2	-1.3	33
Weigel	-38.8	-58.2	35
Weinek	37.0	-27.5	32
Weiss	-19.5	-31.8	66
Werner	3.3	-28.0	70
Wexler	90.2	-69.1	51
Whewell	13.7	4.2	13
Wichmann	-38.1	-7.5	10
Widmannstätten	85.5	-6.1	46
Wildt	75.8	9.0	11
Wilhelm	-20.4	-43.4	106
Wilkins	19.6	-29.4	57
Williams	37.2	42.0	36
Wilson	-42.4	-69.2	69
Winthrop	-44.4	-10.7	17
Wöhler	31.4	-38.2	27
Wolf	-16.6	-22.7	25
Wollaston	-46.9	30.6	10
Wright	-86.6	-31.6	39
Wrottesley	56.8	-23.9	57
Wurzelbauer	-15.9	-33.9	88
Xenophanes	-82.0	57.5	125
Yakovkin	-78.8	-54.5	37
Yangel'	4.7	17.0	8
Yerkes	51.7	14.6	36
Yoshi	11.0	24.6	1
Young	50.9	-41.5	71
Zach	5.3	-60.9	70
Zagut	22.1	-32.0	84
Zähringer	40.2	5.6	11
Zeno	72.9	45.2	65
Zinner	-58.8	26.6	4
Zöllner	18.9	-8.0	47
Zucchius	-50.3	-61.4	64
Zupus	-52.3	-17.2	38

(See Reference 5 for lettered craters.)

(As at 2007 January)

(+ Longitude = East - Longitude = West + Latitude = North - Latitude = South Diameter in km)

Crater Name	Long.	Lat.	Dia.	Crater Name	Long.	Lat.	Dia.	Crater Name	Long.	Lat.	Dia.	Crater Name	Long.	Lat.	Dia.
Abbe	175.2	-57.3	66	Champollion	175.2	37.4	58	Fairouz	102.9	-26.1	3	Icarus	-173.2	-5.3	96
Abul Wáfa	116.6	1.0	55	Chandler	171.5	43.8	85	Fechner	124.9	-59.0	63	Idel'son	110.9	-81.5	60
Aitken	173.4	-16.8	135	Chang Heng	112.2	19.0	43	Fényi	-105.1	-44.9	38	Il'in	-97.5	-17.8	13
Al-Biruni	92.5	17.9	77	Chant	-109.2	-40.0	33	Feoktistov	140.7	30.9	23	Ingalls	-153.1	26.4	37
Alden	110.8	-23.6	104	Chaplygin	150.3	-6.2	137	Fermi	122.6	-19.3	183	Innes	119.2	27.8	42
Alder	-177.4	-48.6	77	Chapman	-100.7	50.4	71	Fersman	-126.0	18.7	151	Ioffe	-129.2	-14.4	86
Alekhin	-131.3	-68.2	70	Chappe	-91.5	-61.2	59	Fesenkov	135.1	-23.2	35	Isaev	147.5	-17.5	90
Al-Khwarizmi	106.4	7.1	65	Chappell	-177.0	54.7	80	Finsen	-177.9	-42.0	72	Izsak	117.1	-23.3	30
Alter	-107.5	18.7	64	Charlier	-131.5	36.6	99	Firsov	112.2	4.5	51	Jackson	-163.1	22.4	71
Amici	-172.1	-9.9	54	Chaucer	-140.0	3.7	45	Fischer	142.4	8.0	30	Jarvis	-148.9	-34.9	38
Anders	-142.9	-41.3	40	Chauvenet	137.0	-11.5	81	Fitzgerald	-171.7	27.5	110	Jeans	91.4	-55.8	79
Anderson	171.1	15.8	109	Chawla	-147.5	-42.8	15	Fizeau	-133.9	-58.6	111	Jenner	95.9	-42.1	71
Andersson	-95.3	-49.7	13	Chebyshev	-133.1	-33.7	178	Fleming	109.6	15.0	106	Joliot	93.1	25.8	164
Andronov	146.1	-22.7	16	Chernyshev	174.2	47.3	58	Florensky	131.5	25.3	71	Joule	-144.2	27.3	96
Antoniadi	-172.0	-69.7	143	Chrétien	162.9	-45.9	88	Focas	-93.8	-33.7	22	Jules Verne	147.0	-35.0	143
Anuchin	101.3	-49.0	57	Clark	118.9	-38.4	49	Foster	-141.5	23.7	33	Kamerlingh Onnes	-115.8	15.0	66
Apollo	-151.8	-36.1	537	Coblentz	126.1	-37.9	33	Fowler	-145.0	42.3	146	Karima	103.0	-25.9	3
Appleton	158.3	37.2	63	Cockcroft	-162.6	31.3	93	Fox	98.2	0.5	24	Karpinskiy	166.3	73.3	92
Armiński	154.2	-16.4	26	Compton	103.8	55.3	162	Freundlich	171.0	25.0	85	Karrer	-141.8	-52.1	51
Arrhenius	-91.3	-55.6	40	Comrie	-112.7	23.3	59	Fridman (Friedmann)	-126.0	-12.6	102	Kasper	122.1	8.3	12
Artamonov	103.5	25.5	60	Comstock	-121.5	21.8	72	Froelich	-109.7	80.3	58	Katchalsky	116.1	5.9	32
Artem'ev	-144.4	10.8	67	Congreve	-167.3	-0.2	57	Frost	-118.4	37.7	75	Kearons	-112.6	-11.4	23
Ashbrook	-112.5	-81.4	156	Cooper	175.6	52.9	36	Fryxell	-101.4	-21.3	18	Keeler	161.9	-10.2	160
Avicenna	-97.2	39.7	74	Cori	-151.9	-50.6	65	Gadomski	-147.3	36.4	65	Kekulé	-138.1	16.4	94
Avogadro	164.9	63.1	139	Coriolis	171.8	0.1	78	Gagarin	149.2	-20.2	265	Kepínski	126.6	28.8	31
Babakin	123.3	-20.8	20	Couder	-92.4	-4.8	21	Galois	-151.9	-14.2	222	Khvol'son	111.4	-13.8	54
Babcock	93.9	4.2	99	Coulomb	-114.6	54.7	89	Gamow	145.3	65.3	129	Kibal'chich	-146.5	3.0	92
Backlund	103.0	-16.0	75	Cremona	-90.6	67.5	85	Ganskiy (Hansky)	97.0	-9.7	43	Kidinnu	122.9	35.9	56
Balandin	152.6	-18.9	12	Crocco	150.2	-47.5	75	Ganswindt	110.3	-79.6	74	Kimura	118.4	-57.1	28
Baldet	-151.1	-53.3	55	Crommelin	-146.9	-68.1	94	Garavito	156.7	-47.5	74	King	120.5	5.0	76
Barbier	157.9	-23.8	66	Crookes	-164.5	-10.3	49	Gavrilov	130.9	17.4	60	Kira	132.8	-17.6	3
Barringer	-149.7	-28.0	68	Ctesibius	118.7	0.8	36	Geiger	158.5	-14.6	34	Kirkwood	-156.1	68.8	67
Bawa	102.6	-25.3	1	Curie	91.0	-22.9	151	Gerasimovich	-122.6	-22.9	86	Kleymenov	-140.2	-32.4	55
Becquerel	129.7	40.7	65	Cyrano	157.7	-20.5	80	Gernsback	99.7	-36.5	48	Klute	-141.3	37.2	75
Bečvář	125.2	-1.9	67	D. Brown	-147.2	-42.0	15	Ginzel	97.4	14.3	55	Koch	150.1	-42.8	95
Beijerinck	151.8	-13.5	70	Daedalus	179.4	-5.9	93	Giordano Bruno	102.8	35.9	22	Kohlschütter	154.0	14.4	53
Bel'kovich	90.2	61.1	214	D'Alembert	163.9	50.8	248	Glauber	142.6	11.5	15	Kolhörster	-114.6	11.2	97
Bell	-96.4	21.8	86	Danjon	124.0	-11.4	71	Glazenap	137.6	-1.6	43	Komarov	152.5	24.7	78
Bellinsgauzen	-164.6	-60.6	63	Dante	180.0	25.5	54	Golitsyn	-105.0	-25.1	36	Kondratyuk	115.5	-14.9	108
Belopol'skiy	-128.1	-17.2	59	d'Arsonval	124.6	-10.3	28	Golovin	161.1	39.9	37	Konoplev	-125.5	-28.5	25
Belyaev	143.5	23.3	54	Das	-136.8	-26.6	38	Grachev	-108.2	-3.7	35	Konstantinov	158.4	19.8	66
Benedict	141.5	4.4	14	Davisson	-174.6	-37.5	87	Grave	150.3	-17.1	40	Korolev	-157.4	-4.0	437
Bergman	137.5	7.0	21	Dawson	-134.7	-67.4	45	Green	132.9	4.1	65	Kosberg	149.6	-20.2	15
Bergstrand	176.3	-18.8	43	de Forest	-162.1	-77.3	57	Gregory	127.2	2.2	67	Kostinskiy	118.8	14.7	75
Berkner	-105.2	25.2	86	de Moraes	143.2	49.5	53	Grigg	-129.4	12.9	36	Kovalevskaya	-129.6	30.8	115
Berlage	-162.8	-63.2	92	de Roy	-99.1	-55.3	43	Grissom	-147.4	-47.0	58	Koval'skiy	101.0	-21.9	49
Bhabha	-164.5	-55.1	64	de Vries	-176.7	-19.9	59	Grotrian	128.3	-66.5	37	Kozyrev	129.3	-46.8	65
Bingham	115.1	8.1	33	Debus	99.6	-10.5	20	Guillaume	-173.4	45.4	57	Kramarov	-98.8	-2.3	20
Birkeland	173.9	-30.2	82	Debye	-176.2	49.6	142	Gullstrand	-129.3	45.2	43	Kramers	-127.6	53.6	61
Birkhoff	-146.1	58.7	345	Dellinger	140.6	-6.8	81	Guthnick	-93.9	-47.7	36	Krasovskiy	-175.5	3.9	59
Bjerknes	113.0	-38.4	48	Delporte	121.6	-16.0	45	Guyot	117.5	11.4	92	Krylov	-165.8	35.6	49
Blackett	-116.1	-37.5	141	Denning	142.6	-16.4	44	H. G. Wells	122.8	40.7	114	Kugler	103.7	-53.8	65
Blanchard	-94.4	-58.5	40	Deutsch	110.5	24.1	66	Hagen	135.1	-48.3	55	Kulik	-154.5	42.4	58
Blazhko	-148.0	31.6	54	Dewar	165.5	-2.7	50	Hale	90.8	-74.2	83	Kuo Shou Ching	-133.7	8.4	34
Bobone	-131.8	26.9	31	Diderot	121.5	-20.4	20	Harden	143.5	5.5	15	Kurchatov	142.1	38.3	106
Bok	-171.6	-20.2	45	Dirichlet	-151.4	11.1	47	Haret	-176.5	-59.0	29	L. Clark	-147.7	-43.7	16
Boltzmann	-90.7	-74.9	76	Dobrovol'skiy	129.7	-12.8	38	Harkhebi	98.3	39.6	237	Lacchini	-107.5	41.7	58
Bolyai	125.9	-33.6	135	Doerfel	-107.9	-69.1	68	Harriot	114.3	33.1	56	Lamb	100.1	-42.9	106
Bondarenko	136.3	-17.8	30	Donner	98.0	-31.4	58	Hartmann	135.3	3.2	61	Lampland	131.0	-31.0	65
Borman	-147.7	-38.8	50	Doppler	-159.6	-12.6	110	Harvey	-146.5	19.5	60	Landau	-118.1	41.6	214
Bose	-170.0	-53.5	91	Douglass	-122.4	35.9	49	Hatanaka	-121.5	29.7	26	Lander	131.8	-15.3	40
Bowditch	103.1	-25.0	40	Dreyer	96.9	10.0	61	Hayford	-176.4	12.7	27	Lane	132.0	-9.5	55
Boyle	178.1	-53.1	57	Drude	-91.8	-38.5	24	Healy	-110.5	32.8	38	Langemak	118.7	-10.3	97
Bragg	-102.9	42.5	84	Dryden	-155.2	-33.0	51	Heaviside	167.1	-10.4	165	Langevin	162.7	44.3	58
Brashear	-170.7	-73.8	55	Dufay	169.5	5.5	39	Helberg	-102.2	22.5	62	Langmuir	-128.4	-35.7	91
Bredikhin	-158.2	17.3	59	Dugan	103.3	64.2	50	Henderson	152.1	4.8	47	Larmor	-179.7	32.1	97
Bridgman	137.1	43.5	80	Dunér	179.5	44.8	62	Hendrix	-159.2	-46.6	18	Laue	-96.7	28.0	87
Bronk	-134.5	26.1	64	Dyson	-121.2	61.3	63	Henyey	-151.6	13.5	63	Lauritsen	96.1	-27.6	52
Brouwer	-126.0	-36.2	158	Dziewulski	98.9	21.2	63	Heron (Hero)	119.8	0.7	24	Leavitt	-139.3	-44.8	66
Brunner	90.9	-9.9	53	Edison	99.1	25.0	62	Hertz	104.5	13.4	90	Lebedev	107.8	-47.3	102
Buffon	-133.4	-40.4	106	Edith	102.3	-25.8	8	Hertzsprung	-129.2	2.6	591	Lebedinskiy	-164.3	8.3	62
Buisson	112.5	-1.4	56	Ehrlich	-172.4	40.9	30	Hess	174.6	-54.3	88	Leeuwenhoek	-178.7	-29.3	125
Butlerov	-108.7	12.5	40	Eijkman	-141.5	-63.1	54	Heymans	-144.1	75.3	50	Leibnitz	179.2	-38.3	245
Buys-Ballot	174.5	20.8	55	Einthoven	109.6	-4.9	69	Heyrovsky	-95.3	-39.6	16	Lemaître	-149.6	-61.2	91
Cabannes	-169.6	-60.9	80	Ellerman	-120.1	-25.3	47	Hilbert	108.2	-17.9	151	Lents (Lenz)	-102.1	2.8	21
Cailleux	153.3	-60.8	50	Ellison	-107.5	55.1	36	Hippocrates	-145.9	70.7	60	Leonov	148.2	19.0	33
Cajori	168.8	-47.4	70	Elvey	-100.5	8.8	74	Hirayama	93.5	-6.1	132	Leucippus	-116.0	29.1	56
Campbell	151.4	45.3	219	Emden	-177.3	63.3	111	Hoffmeister	136.9	15.2	45	Leuschner	-108.8	1.8	49
Cannizzaro	-99.6	55.6	56	Engel'gardt	-159.0	5.7	43	Hogg	121.9	33.6	38	Levi-Civita	143.4	-23.7	121
Cantor	118.6	38.2	81	Eötvös	133.8	-35.5	99	Hohmann	-94.1	-17.9	16	Lewis	-113.8	-18.5	42
Carnot	-143.5	52.3	126	Erro	98.5	5.7	61	Holetschek	150.9	-27.6	38	Ley	154.9	42.2	79
Carol	122.3	8.5	8	Esnault-Pelterie	-141.4	47.7	79	Hopmann	160.3	-50.8	88	Lindblad	-98.8	70.4	66
Carver	126.9	-43.0	59	Espin	109.1	28.1	75	Houzeau	-123.5	-17.1	71	Lippmann	-114.9	-56.0	160
Cassegrain	113.5	-52.4	55	Evans	-133.5	-9.5	67	Hume	90.4	-4.7	23	Lipskiy	-179.5	-2.2	80
Chadwick	-101.3	-52.7	30	Evdokimov	-153.0	34.8	50	Husband	-147.9	-40.8	29	Litke (Lütke)	123.1	-16.8	39
Chaffee	-153.9	-38.8	49	Evershed	-159.5	35.7	66	Hutton	168.7	37.3	50	Lobachevskiy	112.6	9.9	84
Chalonge	-117.3	-21.2	30	Ewen	121.4	7.7	3	Ibn Firnas	122.3	6.8	89	Lodygin	-146.8	-17.7	62
Chamberlin	95.7	-58.9	58	Fabry	100.7	42.9	184	Ibn Yunus	91.1	14.1	58	Lomonosov	98.0	27.3	92

(As at 2007 January)

Farside

(+ Longitude = East - Longitude = West + Latitude = North - Latitude = South Diameter in km)

Crater Name	Long.	Lat.	Dia.												
Lorentz	-95.3	32.6	312	Paraskevopoulos	-149.9	50.4	94	Shatalov	141.5	24.3	21	von der Pahlen	-132.7	-24.8	56
Love	129.0	-6.3	84	Parenago	-108.5	25.9	93	Shayn	172.5	32.6	93	von Kármán	175.9	-44.8	180
Lovelace	-106.4	82.3	54	Parkhurst	103.6	-33.4	96	Sherrington	118.0	-11.1	18	von Neumann	153.2	40.4	78
Lovell	-141.9	-36.8	34	Parsons	-171.2	37.3	40	Shi Shen	104.1	76.0	43	von Zeipel	-141.6	42.6	83
Lowell	-103.1	-12.9	66	Paschen	-139.8	-13.5	124	Shirakatsi	128.6	-12.1	51	Walker	-162.2	-26.0	32
Lucretius	-120.8	-8.2	63	Pasteur	104.6	-11.9	224	Shternberg (Sternberg)	-116.3	19.5	70	Wan-Hoo	-138.8	-9.8	52
Ludwig	97.4	-7.7	23	Patsaev	133.4	-16.7	55	Shuleykin	-92.5	-27.1	15	Waterman	128.0	-25.9	76
Lundmark	152.5	-39.7	106	Pauli	137.5	-44.5	84	Siedentopf	135.5	22.0	61	Watson	-124.5	-62.6	62
Lyman	163.6	-64.8	84	Pavlov	142.5	-28.8	148	Sierpinski	154.5	-27.2	69	Weber	-123.4	50.4	42
M. Anderson	-149.0	-41.6	17	Pawsey	145.0	44.5	60	Sikorsky	103.2	-66.1	98	Wegener	-113.3	45.2	88
Mach	-149.3	18.5	180	Pease	-106.1	12.5	38	Sisakyan	109.0	41.2	34	Wexler	90.2	-69.1	51
Maksutov	-168.7	-40.5	83	Perel'man	106.0	-24.0	46	Sita	120.8	4.6	2	Weyl	-120.2	17.5	108
Malyy	105.3	21.9	41	Perepelkin	129.0	-10.0	97	Sklodowska	95.5	-18.2	127	White	-158.3	-44.6	39
Mandel'shtam	162.4	5.4	197	Perkin	-175.9	47.2	62	Slipher	160.1	49.5	69	Wiechert	165.0	-84.5	41
Marci	-167.0	22.6	25	Perrine	-127.8	42.5	86	Smith	-150.2	-31.6	34	Wiener	146.6	40.8	120
Marconi	145.1	-9.6	73	Petrie	108.4	45.3	33	Smoluchowski	-96.8	60.3	83	Wilsing	-155.2	-21.5	73
Mariotte	-139.1	-28.5	65	Petropavlovskiy	-114.8	37.2	63	Sniadecki	-168.9	-22.5	43	Winkler	-179.0	42.2	22
Maunder	-93.8	-14.6	55	Petzval	-110.4	-62.7	90	Soddy	121.8	0.4	42	Winlock	-105.6	35.6	64
Maxwell	98.9	30.2	107	Pikel'ner	123.3	-47.9	47	Sommerfeld	-162.4	65.2	169	Woltjer	-159.6	45.2	46
McAdie	92.1	2.1	45	Pirquet	139.6	-20.3	65	Spencer Jones	165.6	13.3	85	Wood	-120.8	43.0	78
McAuliffe	-148.9	-33.0	19	Pizzetti	118.8	-34.9	44	St. John	150.2	10.2	68	Wróblewski	152.8	-24.0	21
McCool	-146.3	-41.7	21	Planck	136.8	-57.9	314	Stark	134.6	-25.5	49	Wyld	98.1	-1.4	93
McKellar	-170.8	-15.7	51	Planté	163.3	-10.2	37	Stearns	162.6	34.8	36	Xenophon	122.1	-22.8	25
McLaughlin	-92.9	47.1	79	Plaskett	174.3	82.1	109	Stebbins	-141.8	64.8	131	Yablochkov	128.3	60.9	99
McMath	-165.6	17.3	86	Plummer	-155.0	-25.0	73	Stefan	-108.3	46.0	125	Yamamoto	160.9	58.1	76
McNair	-147.3	-35.7	29	Poczobutt	-98.8	57.1	195	Stein	179.0	7.2	33	Zanstra	124.7	2.9	42
McNally	-127.2	22.6	47	Pogson	110.5	-42.2	50	Steklov	-104.9	-36.7	36	Zasyadko	94.2	3.9	11
Mechnikov	-149.0	-11.0	60	Poincaré	163.6	-56.7	319	Steno	161.8	32.8	31	Zeeman	-133.6	-75.2	190
Mees	-96.1	13.6	50	Poinsot	-145.7	79.5	68	Sternfeld	-141.2	-19.6	100	Zelinskiy	166.8	-28.9	53
Meggers	123.0	24.3	52	Polzunov	114.6	25.3	67	Stetson	-118.3	-39.6	64	Zernike	168.2	18.4	48
Meitner	112.7	-10.5	87	Popov	99.7	17.2	65	Stoletov	-155.2	45.1	42	Zhiritskiy	120.3	-24.8	35
Melissa	121.8	8.1	18	Poynting	-133.4	18.1	128	Stoney	-156.1	-55.3	45	Zhukovskiy	-167.0	7.8	81
Mendel	-109.4	-48.8	138	Prager	130.5	-3.9	60	Störmer	146.3	57.3	69	Zsigmondy	-104.7	59.7	65
Mendeleev	140.9	5.7	313	Prandtl	141.8	-60.1	91	Stratton	164.6	-5.8	70	Zwicky	168.1	-15.4	150
Merrill	-116.3	75.2	57	Priestley	108.4	-57.3	52	Strömgren	-132.4	-21.7	61				
Meshcherskiy	125.5	12.2	65	Purkyně	94.9	-1.6	48	Subbotin	135.3	-29.2	67				
Mezentsev	-128.7	72.1	89	Quételet	-134.9	43.1	55	Sumner	108.7	37.5	50				
Michelson	-120.7	7.2	123	Racah	-179.8	-13.8	63	Sundman	-91.6	10.8	40				
Milankovič	168.8	77.2	101	Raimond	-159.3	14.6	70	Sverdrup	-152.0	-88.5	35				
Millikan	121.5	46.8	98	Ramon	-148.1	-41.6	17	Swann	112.7	52.0	42				
Mills	156.0	8.6	32	Ramsay	144.5	-40.2	81	Szilard	105.7	34.0	122				
Milne	112.2	-31.4	272	Raspletin	151.8	-22.5	48	Tamm	146.4	-4.4	38				
Mineur	-161.3	25.0	73	Rayet	114.5	44.7	27	Teisserenc	-135.9	32.2	62				
Minkowski	-146.0	-56.5	113	Razumov	-114.3	39.1	70	Ten Bruggencate	134.4	-9.5	59				
Minnaert	179.6	-67.8	125	Recht	124.0	9.8	20	Tereshkova	144.3	28.4	31				
Mitra	-154.7	18.0	92	Resnik	-150.1	-33.8	20	Tesla	124.7	38.5	43				
Möbius	101.2	15.8	50	Ricco	176.3	75.6	65	Thiel	-134.5	40.7	32				
Mohorovičić	-165.0	-19.0	51	Richards	140.1	7.7	16	Thiessen	-169.0	75.4	66				
Moiseev	103.3	9.5	59	Richardson	100.5	31.1	141	Thomson	166.2	-32.7	117				
Moissan	137.4	4.8	21	Riedel	-139.6	-48.9	47	Tikhomirov	162.0	25.2	65				
Montgolfier	-159.8	47.3	88	Rittenhouse	106.5	-74.5	26	Tikhov	171.7	62.3	83				
Moore	-177.5	37.4	54	Ritz	92.2	-15.1	51	Tiling	-132.6	-53.1	38				
Morozov	127.4	5.0	42	Roberts	-174.5	71.1	89	Timiryazev	-147.0	-5.5	53				
Morse	-175.1	22.1	77	Robertson	-105.2	21.8	88	Tiselius	176.5	7.0	53				
Moseley	-90.1	20.9	90	Roche	136.5	-42.3	160	Titius	100.7	-26.8	73				
Moulton	97.2	-61.1	49	Romeo	122.6	7.5	8	Titov	150.5	28.6	31				
Murakami	-140.5	-23.3	45	Röntgen	-91.4	33.0	126	Trumpler	167.1	29.3	77				
Nagaoka	154.0	19.4	46	Rosseland	131.0	-41.0	75	Tsander (Zander)	-149.3	6.2	181				
Nansen	95.3	80.9	104	Rowland	-162.5	57.4	171	Tseraskiy (Ceraski)	141.6	-49.0	56				
Nassau	177.4	-24.9	76	Rozhdestvenskiy	-155.4	85.2	177	Tsinger (Zinger)	175.6	56.7	44				
Necho	123.1	-5.0	30	Rumford	-169.8	-28.8	61	Tsiolkovskiy	128.9	-21.2	185				
Nernst	-94.8	35.3	116	Rutherford	137.0	10.7	13	Tsu Chung-Chi	145.1	17.3	28				
Neujmin	125.0	-27.0	101	Rydberg	-96.3	-46.5	49	Tyndall	117.0	-34.9	18				
Niepce	-119.1	72.7	57	Ryder	143.2	-44.5	17	Valier	174.5	6.8	67				
Nijland	134.1	33.0	35	Rynin	-103.5	47.0	75	Van de Graaff	172.2	-27.4	233				
Nikolaev	151.3	35.2	41	Saenger	102.4	4.3	75	Van den Bergh	-159.1	31.3	42				
Nishina	-170.4	-44.6	65	Šafařík	176.9	10.6	27	van den Bos	146.0	-5.3	22				
Nobel	-101.3	15.0	48	Saha	102.7	-1.6	99	Van der Waals	119.9	-43.9	104				
Nöther	-113.5	66.6	67	Sanford	-138.9	32.6	55	Van Gent	160.4	15.4	43				
Nu?1	167.6	32.3	61	Sarton	-121.1	49.3	69	Van Maanen	128.0	35.7	60				
Numerov	-160.7	-70.7	113	Scaliger	108.9	-27.1	84	van Rhijn	146.4	52.6	46				
Nunn	91.1	4.6	19	Schaeberle	117.2	-26.2	62	Van Wijk	118.8	-62.8	32				
Oberth	155.4	62.4	60	Schjellerup	157.1	69.7	62	van't Hoff	-131.8	62.1	92				
Obruchev	162.1	-38.9	71	Schlesinger	-138.6	47.4	97	Vashakidze	93.3	43.6	44				
O'Day	157.5	-30.6	71	Schliemann	155.2	-2.1	80	Vavilov	-137.9	-0.8	98				
Ohm	-113.5	18.4	64	Schneller	-163.6	41.8	54	Vening Meinesz	162.6	-0.3	87				
Olcott	117.8	20.6	81	Schönfeld	-98.1	44.8	25	Ventris	158.0	-4.9	95				
Olivier	138.5	59.1	69	Schrödinger	132.4	-75.0	312	Vernadskiy	130.5	23.2	91				
Omar Khayyam	-102.1	58.0	70	Schuster	146.5	4.2	108	Vertregt	171.1	-19.8	187				
Onizuka	-148.9	-36.2	29	Schwarzschild	121.2	70.1	212	Vesalius	114.5	-3.1	61				
Oppenheimer	-166.3	-35.2	208	Scobee	-148.9	-31.1	40	Vestine	93.9	33.9	96				
Oresme	169.2	-42.4	76	Seares	145.8	73.5	110	Vetchinkin	131.3	10.2	98				
Orlov	-175.0	-25.7	81	Sechenov	-142.6	-7.1	62	Vil'ev	144.4	-6.1	45				
Ostwald	121.9	10.4	104	Segers	127.7	47.1	17	Virtanen	176.7	15.5	44				
Paneth	-94.8	63.0	65	Seidel	152.2	-32.8	62	Viviani	117.1	5.2	26				
Pannekoek	140.5	-4.2	71	Seyfert	114.6	29.1	110	Volkov	131.7	-13.6	40				
Papaleksi	164.0	10.2	97	Shahinaz	122.4	7.5	15	Volterra	132.2	56.8	52				
Paracelsus	163.1	-23.0	83	Sharonov	173.3	12.4	74	von Békésy	126.8	51.9	96				

(See Reference 5 for lettered craters.)

Index

*(Lunar features are by **Map No.**)*

Index

*(Lunar features are by **Map No.**)*

Index

*(Lunar features are by **Map No.**)*

Index

*(Lunar features are by **Map No.**)*

Index

*(Lunar features are by **Map No.**)*

Index

*(Lunar features are by **Map No.**)*

Index

*(Lunar features are by **Map No.**)*

Index

*(Lunar features are by **Map No.**)*

Index

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Version History

Version	Date	Major Changes
1.1	2003.10.28	- First release with 90 photos and illustrations, 62 pages.
1.6	2004.02.09	- 150 photos and illustrations, 95 pages. - Expanded *Overview*, *Maria*, *Event* & *Method of Imaging* pages. - Added *Lunar Rays*, *Farside of the Moon* & *Moon Landing* maps. - Rechecked *Moon Age*.
1.7	2004.02.12	- More Lacus & Crater names. - Released to web for free access.
1.9	2004.08.01	- P001 reprocessed to show true slope of the Straight Wall. - Added *Map 30* to cover southeastern region. - Canceled *Romantic Moon*.
2.1	2005.01.28	- Extensive refinement, over 200 images, 184 pages, additions including 30 mosaic images & illustrations on lunar geology.
3.0	2006.02.15	- *Map 22* & *Map 23* interchanged. - Over 250 original Moon images including mosaics. - Over 900 named surface features, 209 pages.
3.1	2007.01.15	- Renewed crater diameters & coordinates as IAU/USGS publications. - Marked *Krishna*, *Sung-Mei* & *Rima Hase* as IAU-dropped names. - Rechecked *Data of Lunar Images* & *Index*. - Added *Lunar Spacecraft* & *Crater List (Nearside + Farside)*. - Added/renewed 40 images, 225 pages.

The latest version is free for download in http://www.alanchuhk.com.