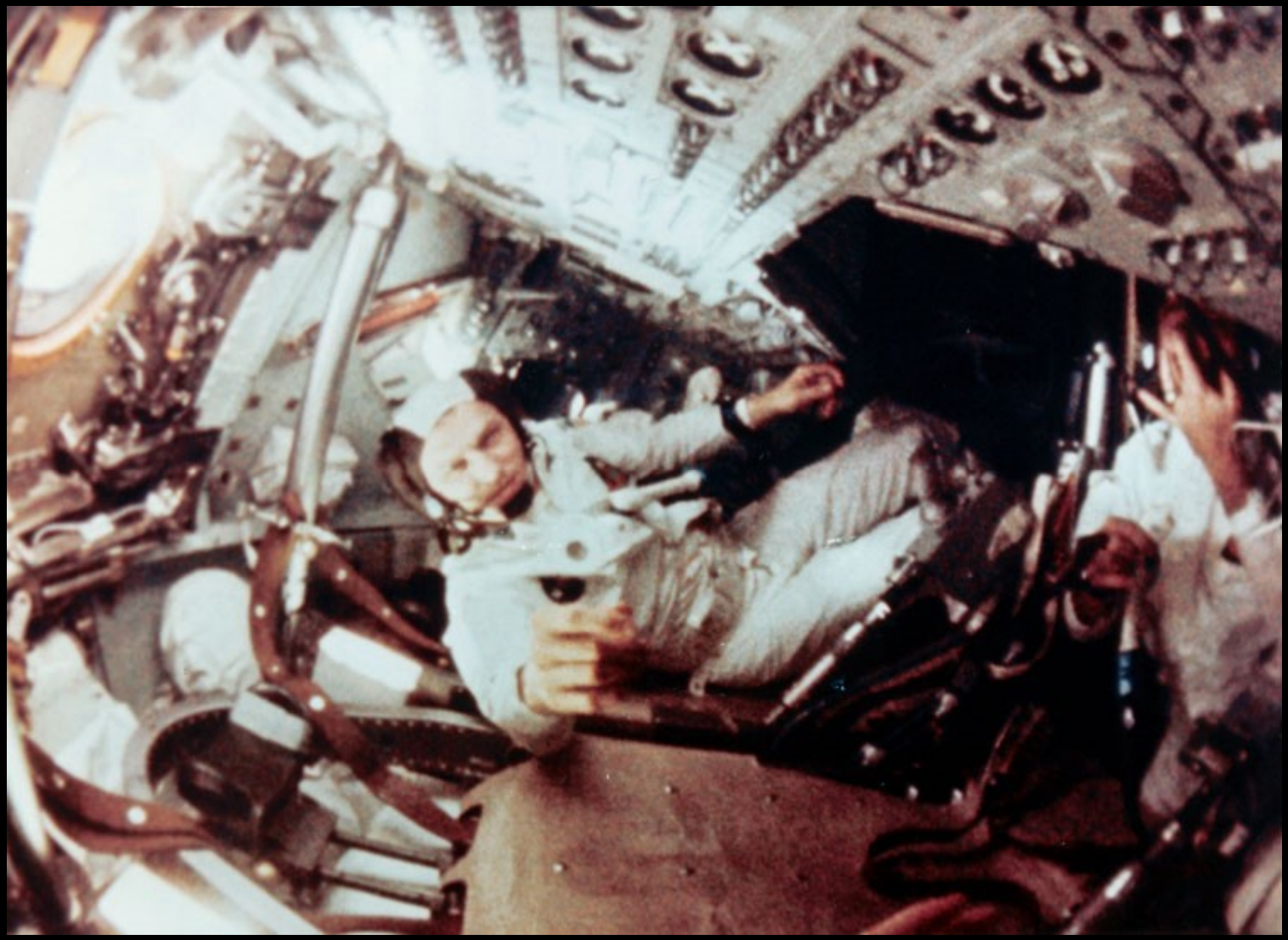
Paul Comision (1929-2018)

Lunar Nights:
An Amateur Astronomer's 50-year Journey to the Moon

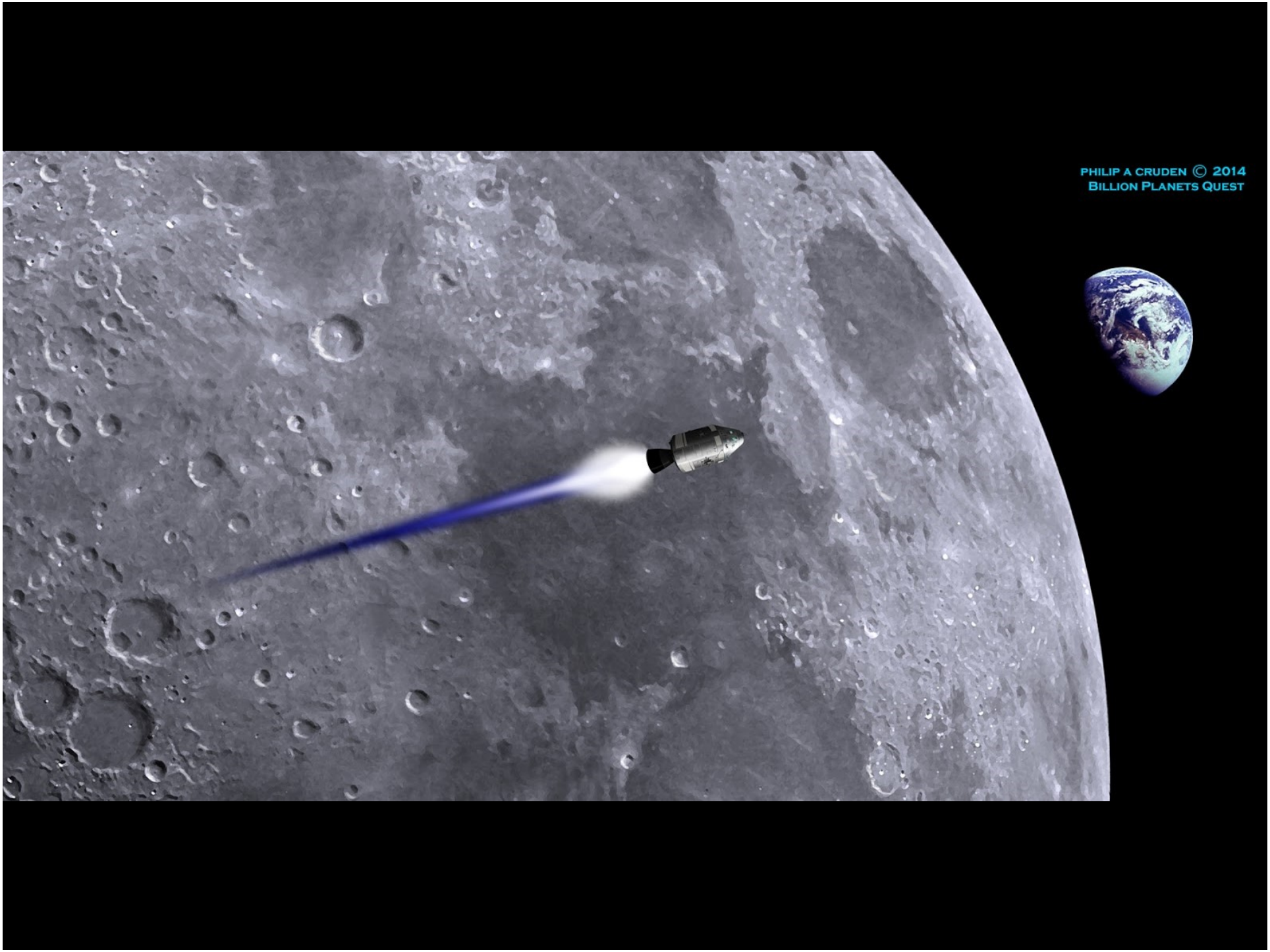
Presented by
Brian McCullough

Ottawa Centre
Royal Astronomical Society of Canada

NBC News



NASA

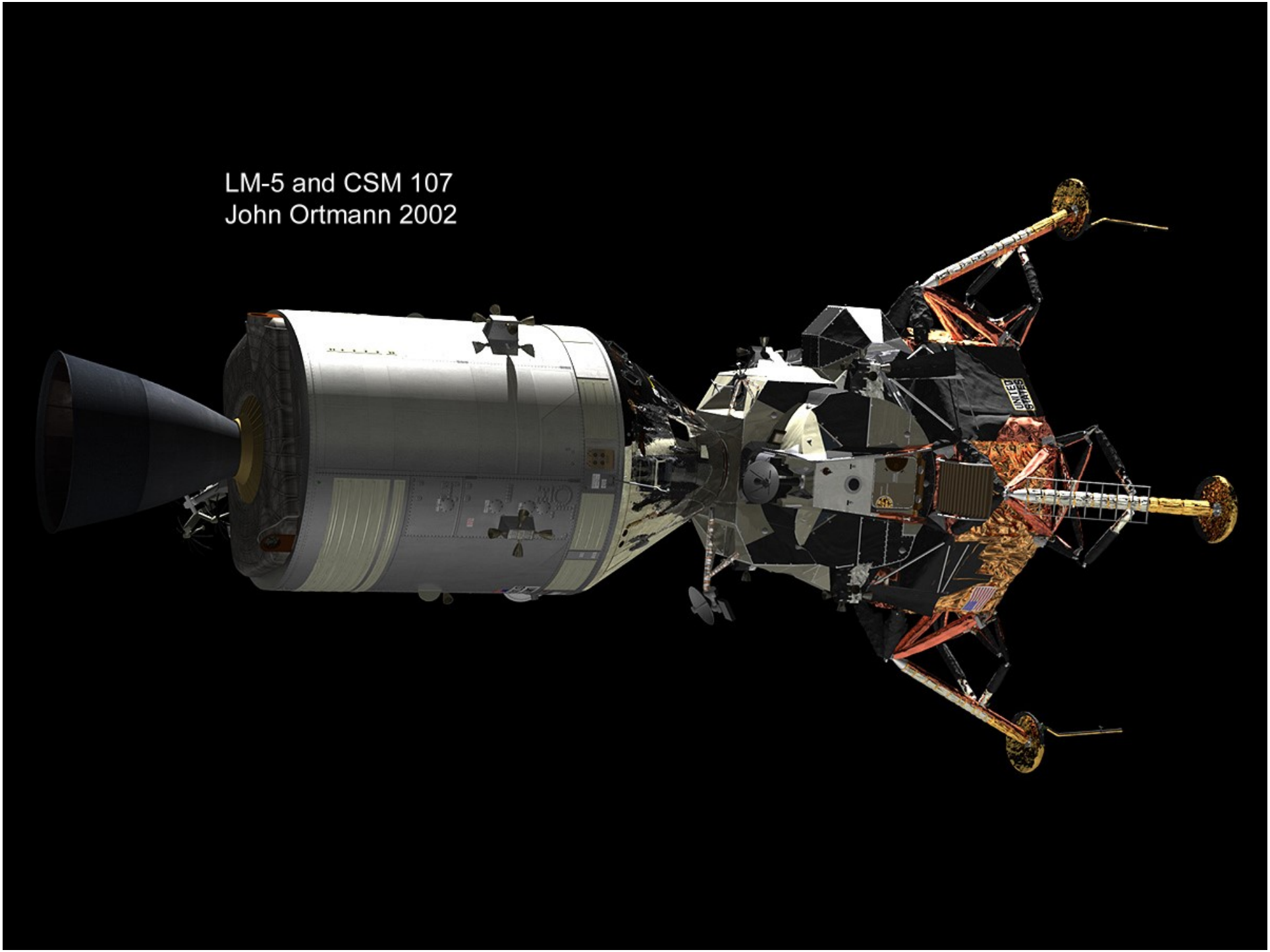

PHILIP A CRUDEN © 2014
BILLION PLANETS QUEST

Apollo 8

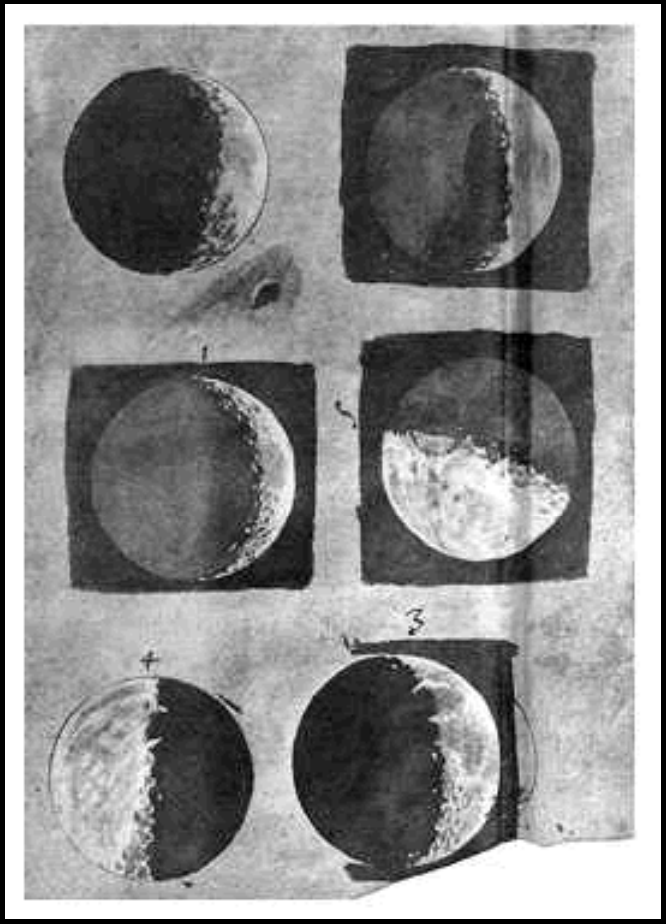
December 1968

NASA

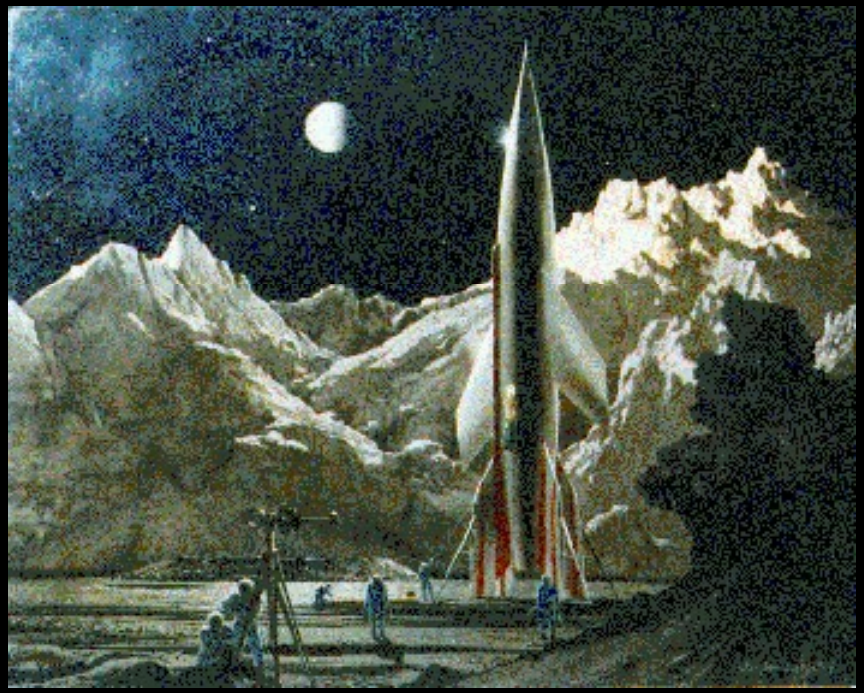

NASA, Apollo 8


LM-5 and CSM 107
John Ortmann 2002

“Early” Views of the Moon

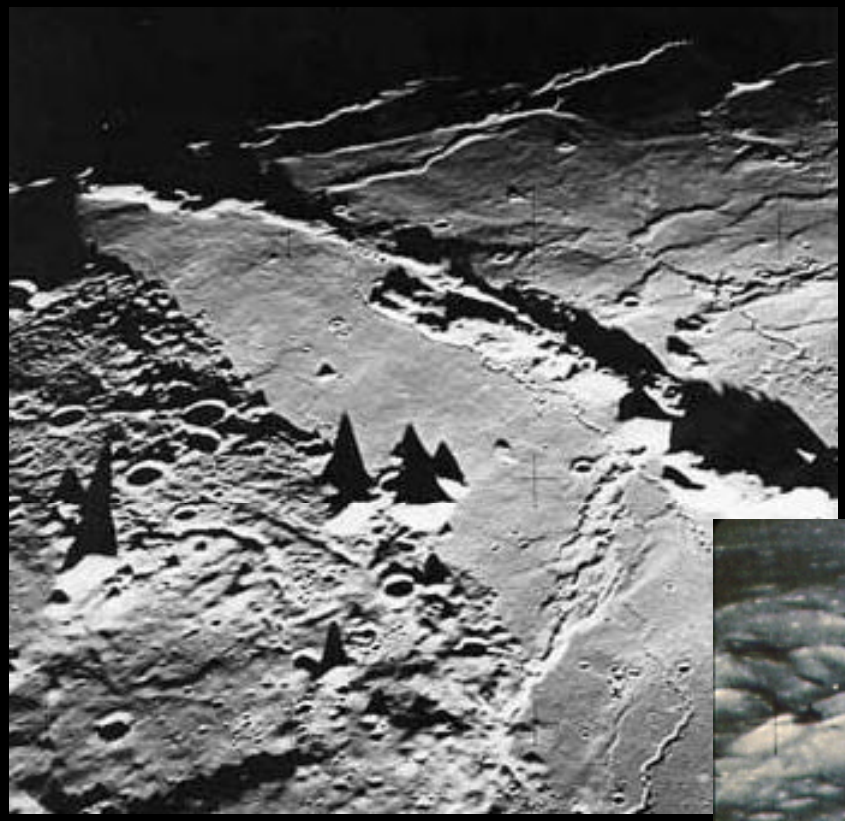


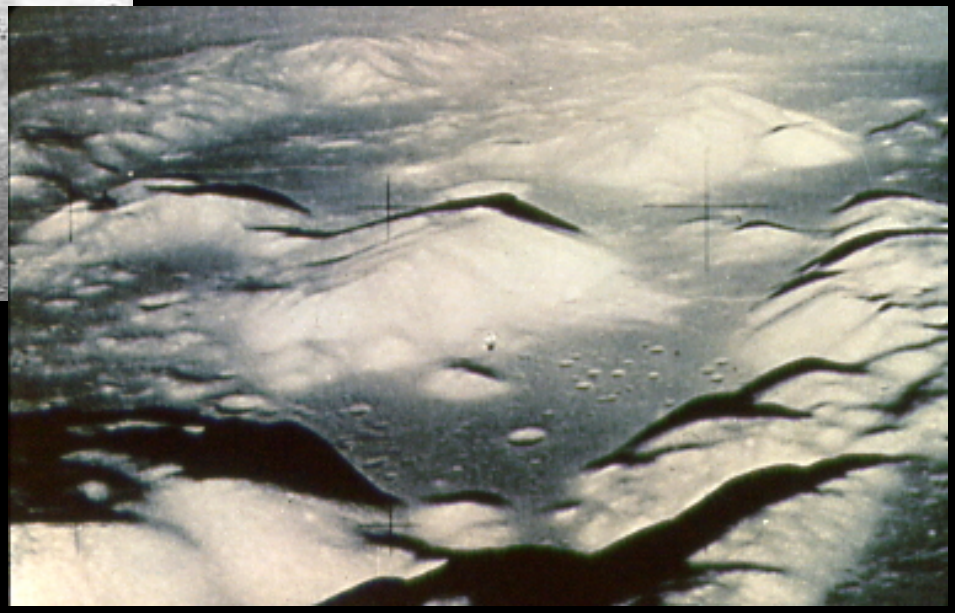
Galileo Galilei —
The first space artist!



Chesley Bonestell

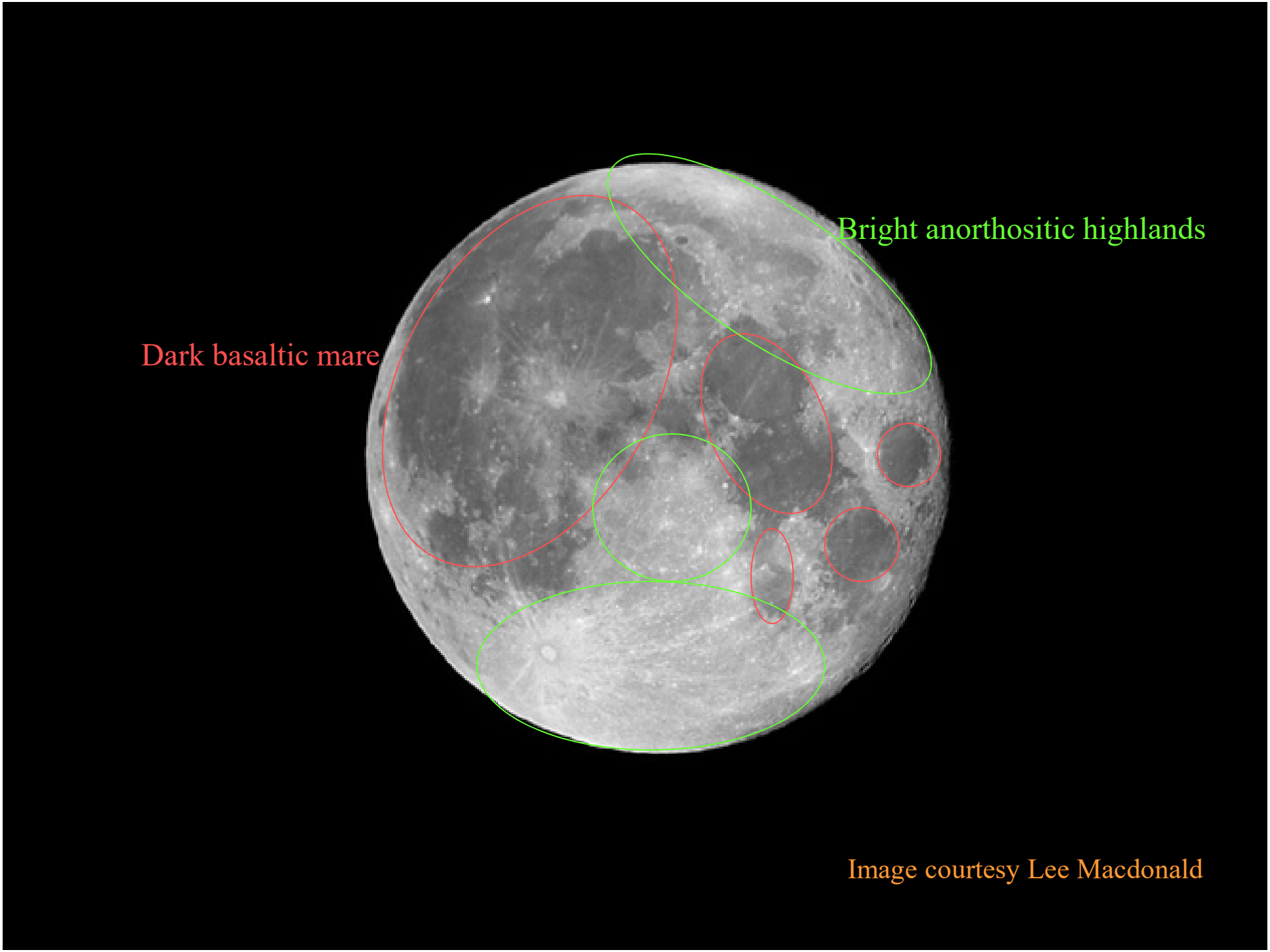
Pointy shadows, but no jagged mountain peaks

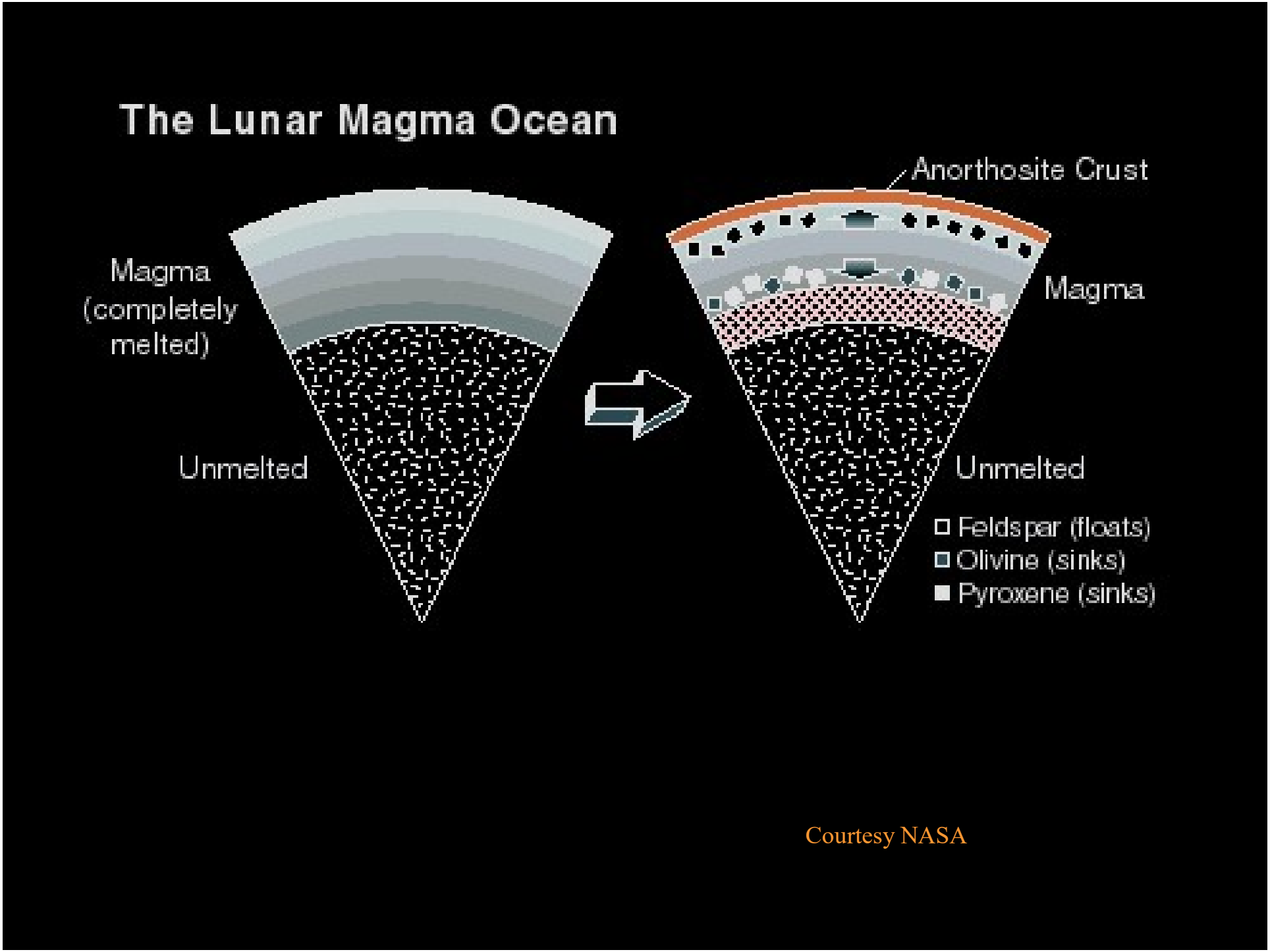




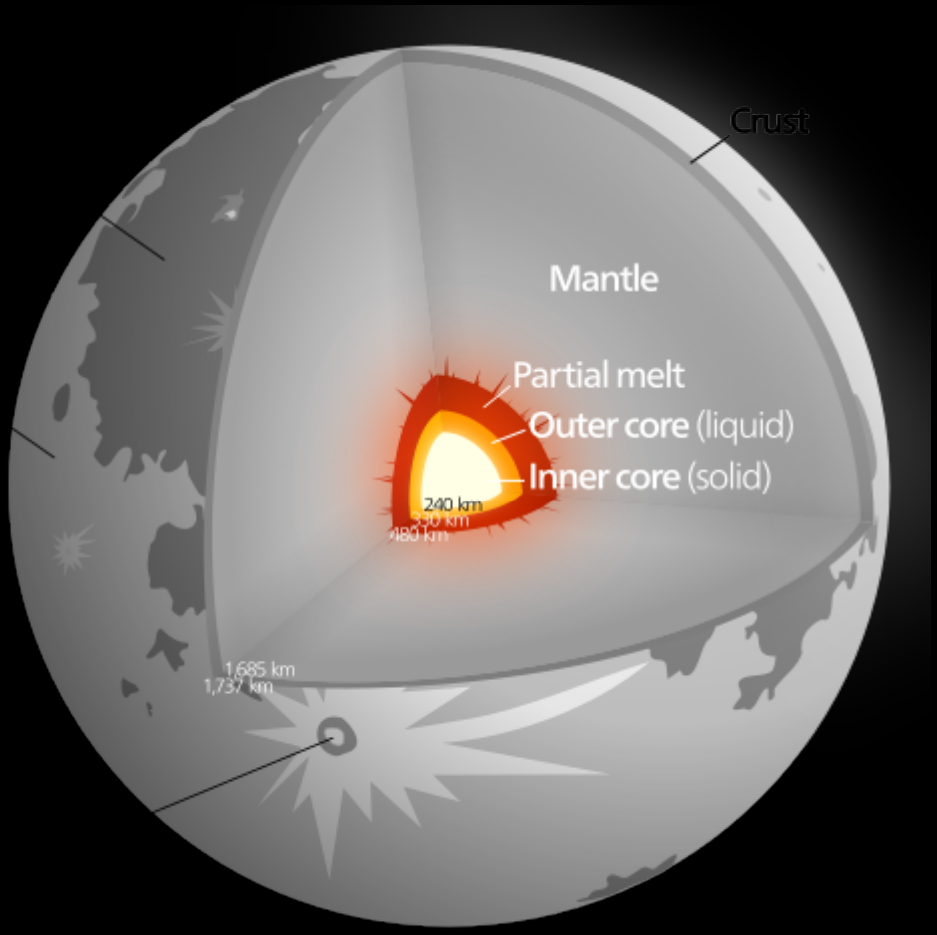
NASA photos above and right

How the Moon was created
4.5 billion years ago


Bright anorthositic highlands
Dark basaltic mare
Image courtesy Lee Macdonald



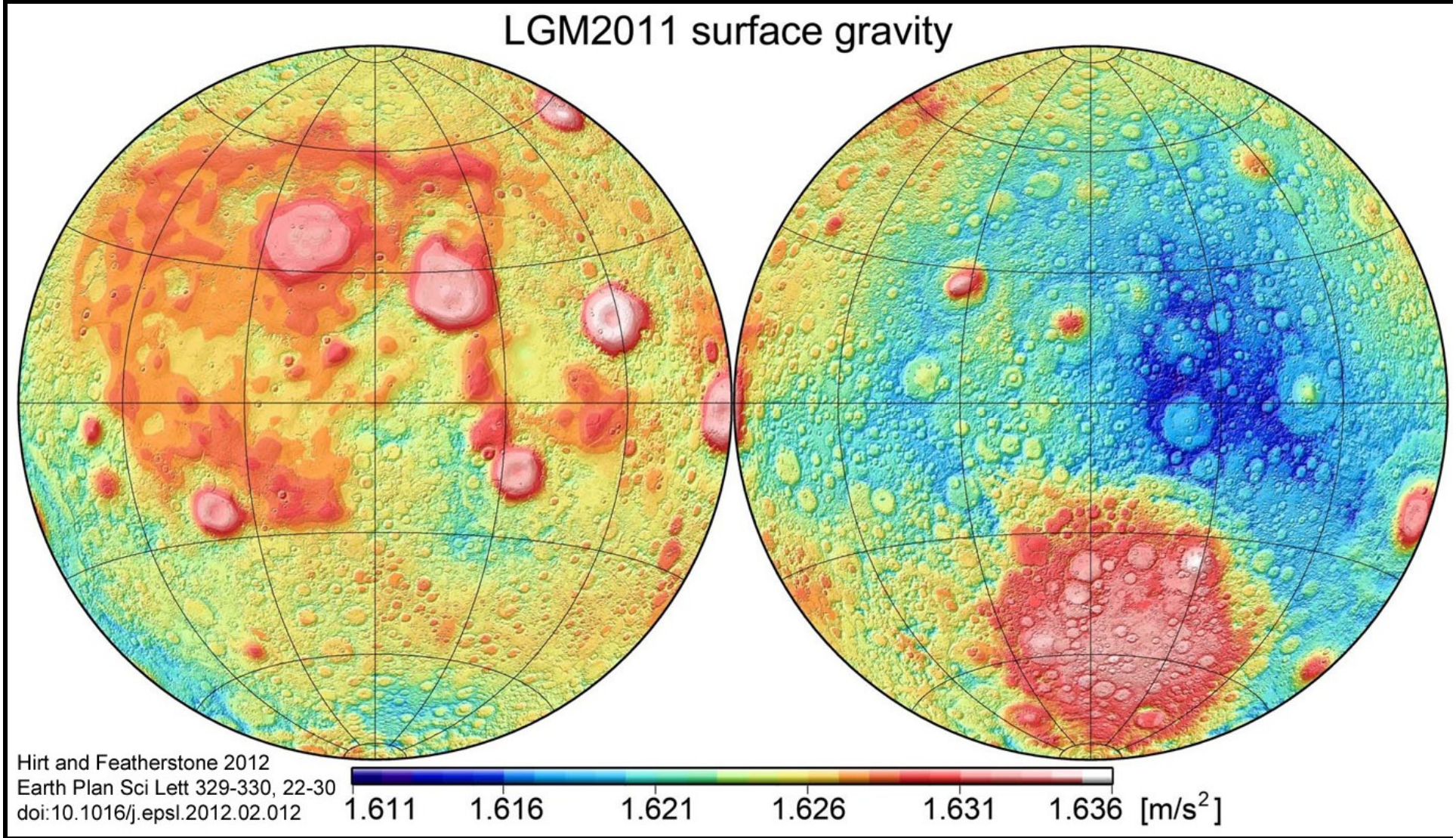
Courtesy NASA

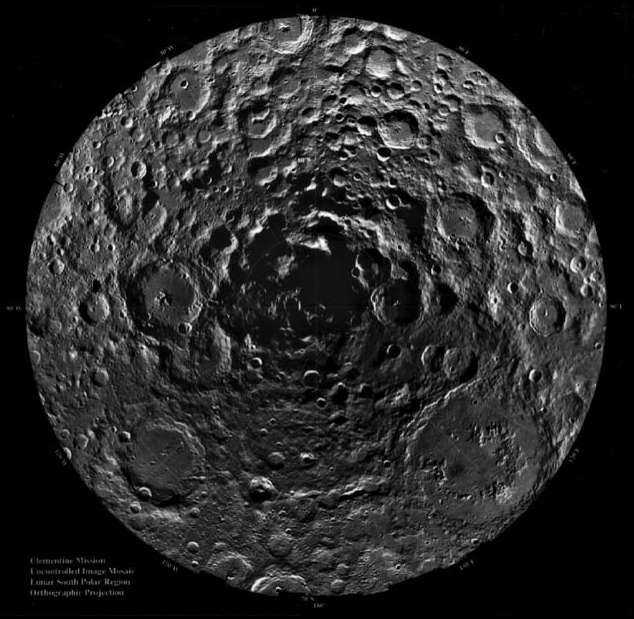


https://en.wikipedia.org/wiki/Internal_structure_of_the_Moon

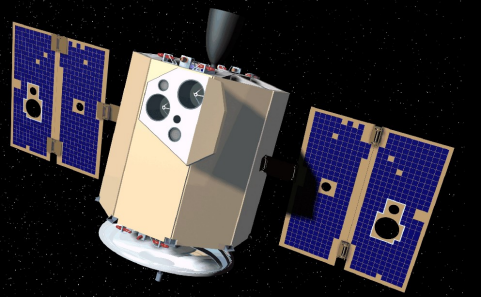
NASA

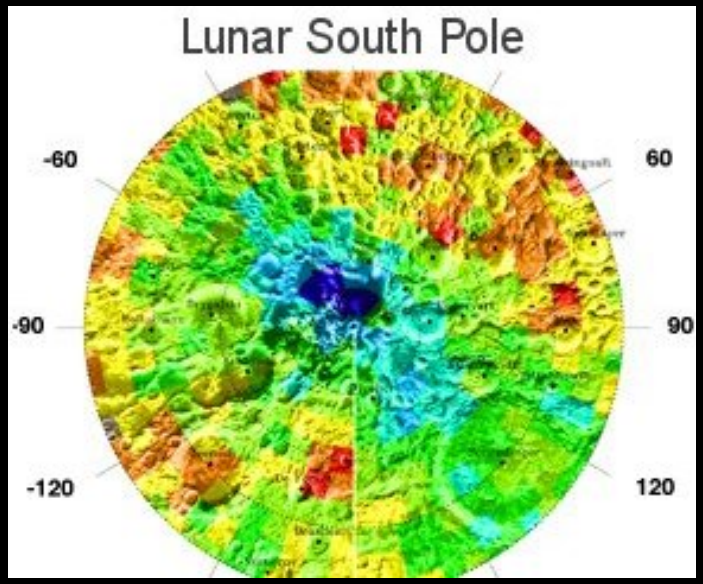
NASA

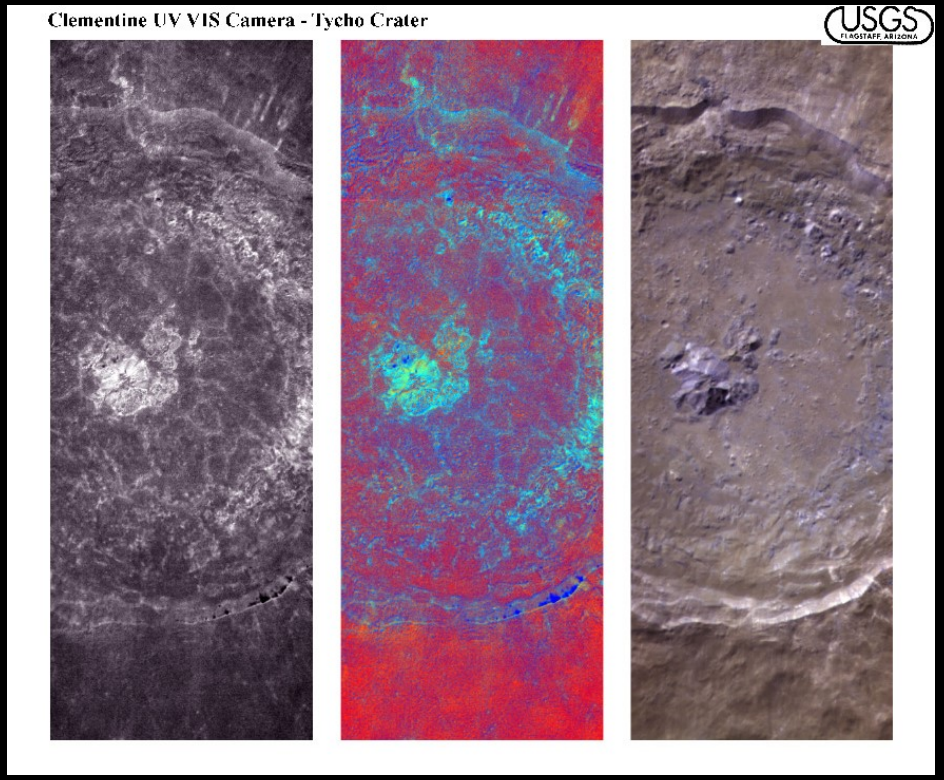

LGM2011 surface gravity
Hirt and Featherstone 2012
Earth Plan Sci Lett 329-330, 22-30
doi:10.1016/j.epsl.2012.02.012
1.611
1.616
1.621
1.626
1.631
1.636
[m/s^2]



Clementine Mission
1994







Basic Moon Specs

One-quarter the size of the Earth
(diameter = 3,475 km)

One-sixth the mass of the Earth
(3.3 t/m^3 vs. 5.52 t/m^3)

Albedo – reflectivity
(12% vs. Earth's 37%)

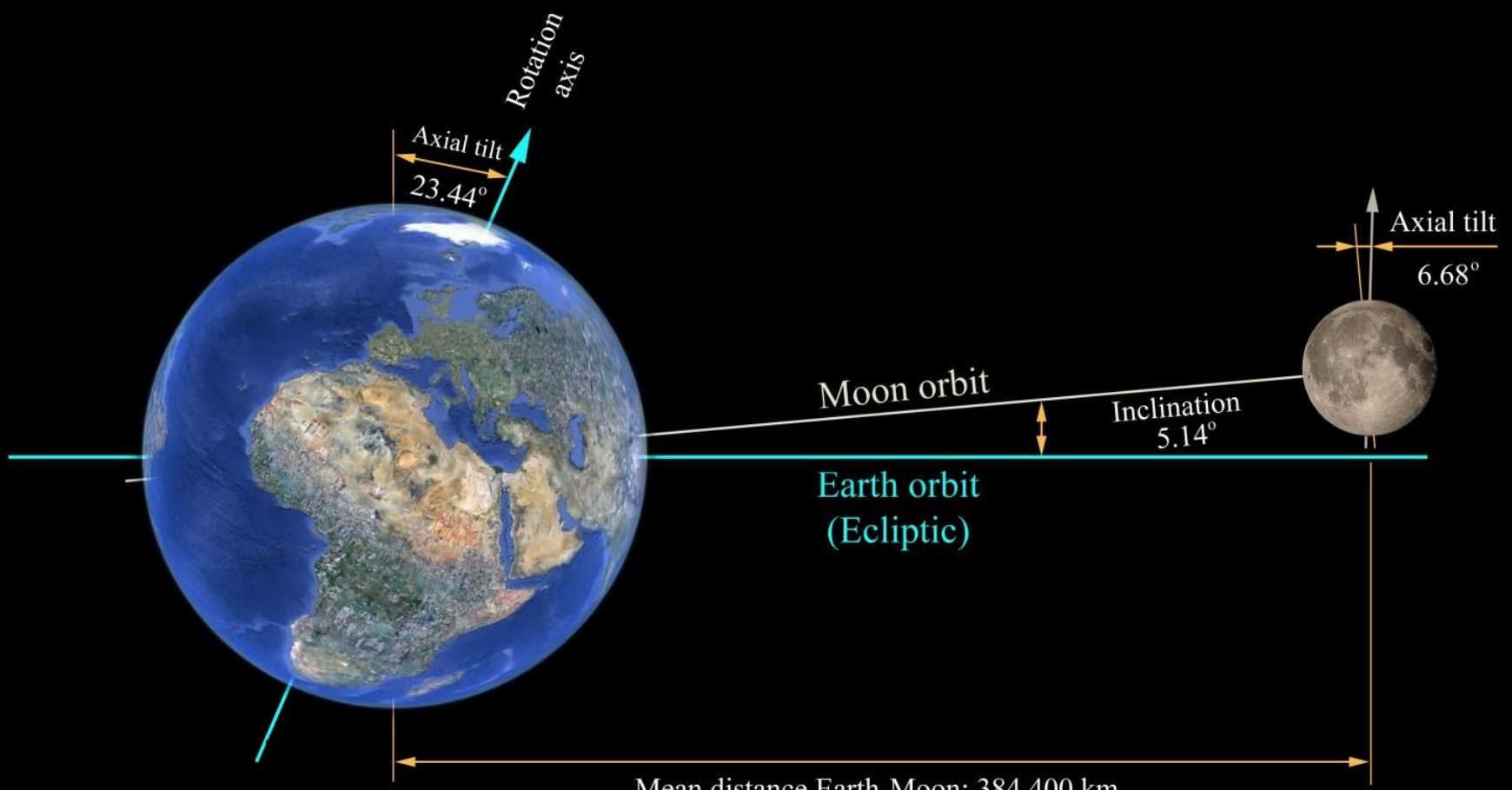
Orbital period of 29.5 days
(phase to phase)

Chart courtesy John Walker / Photo courtesy NASA

Image by Sr. Fins Eirexas

Courtesy Brian Stokoe, RASC Ottawa

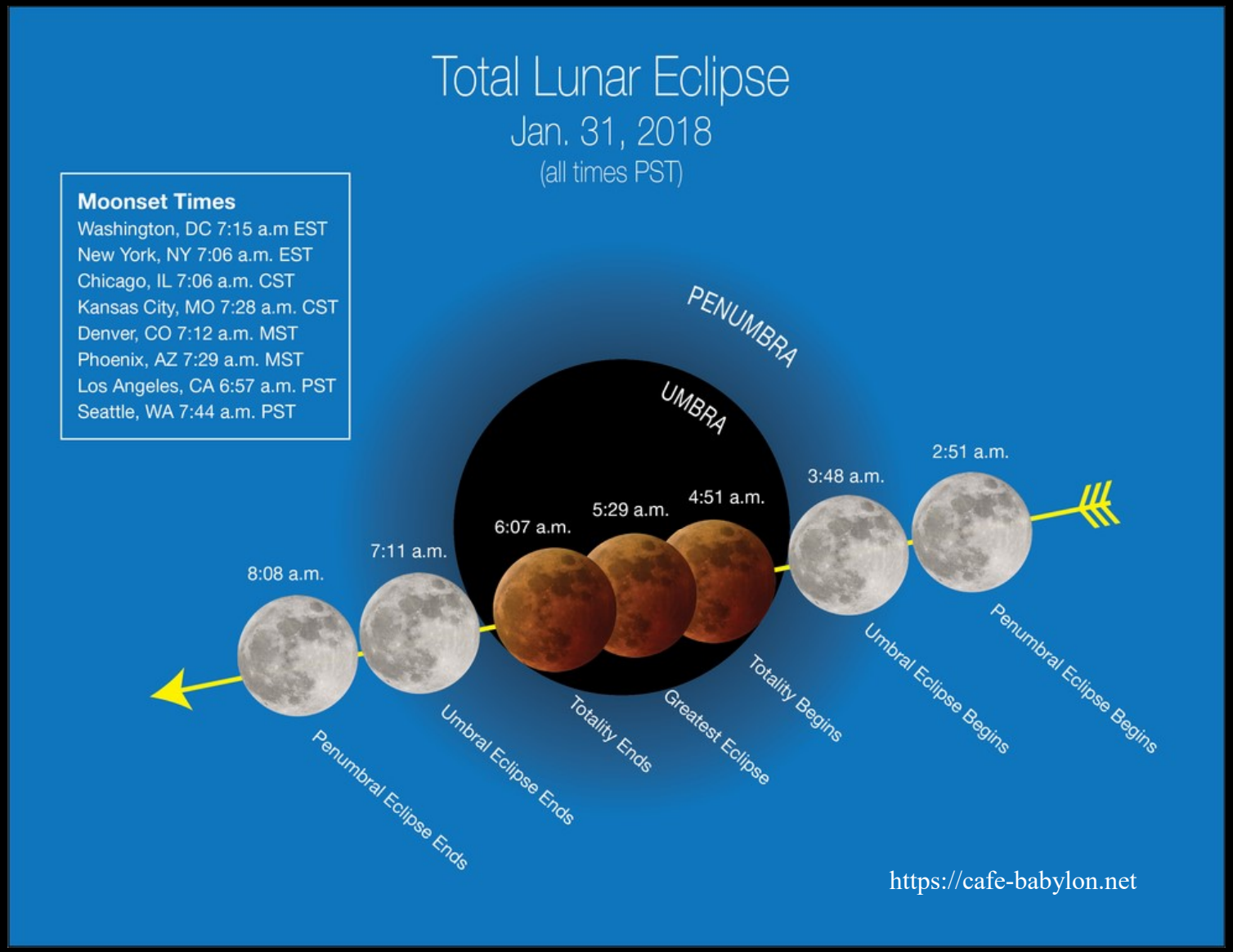
Earth-Moon system



Equatorial radius: 6378.1 km
Polar radius: 6356.8 km
Mean radius: 6371.0 km

Equatorial radius: 1738.14 km
Polar radius: 1735.97 km
Mean radius: 1737.1 km

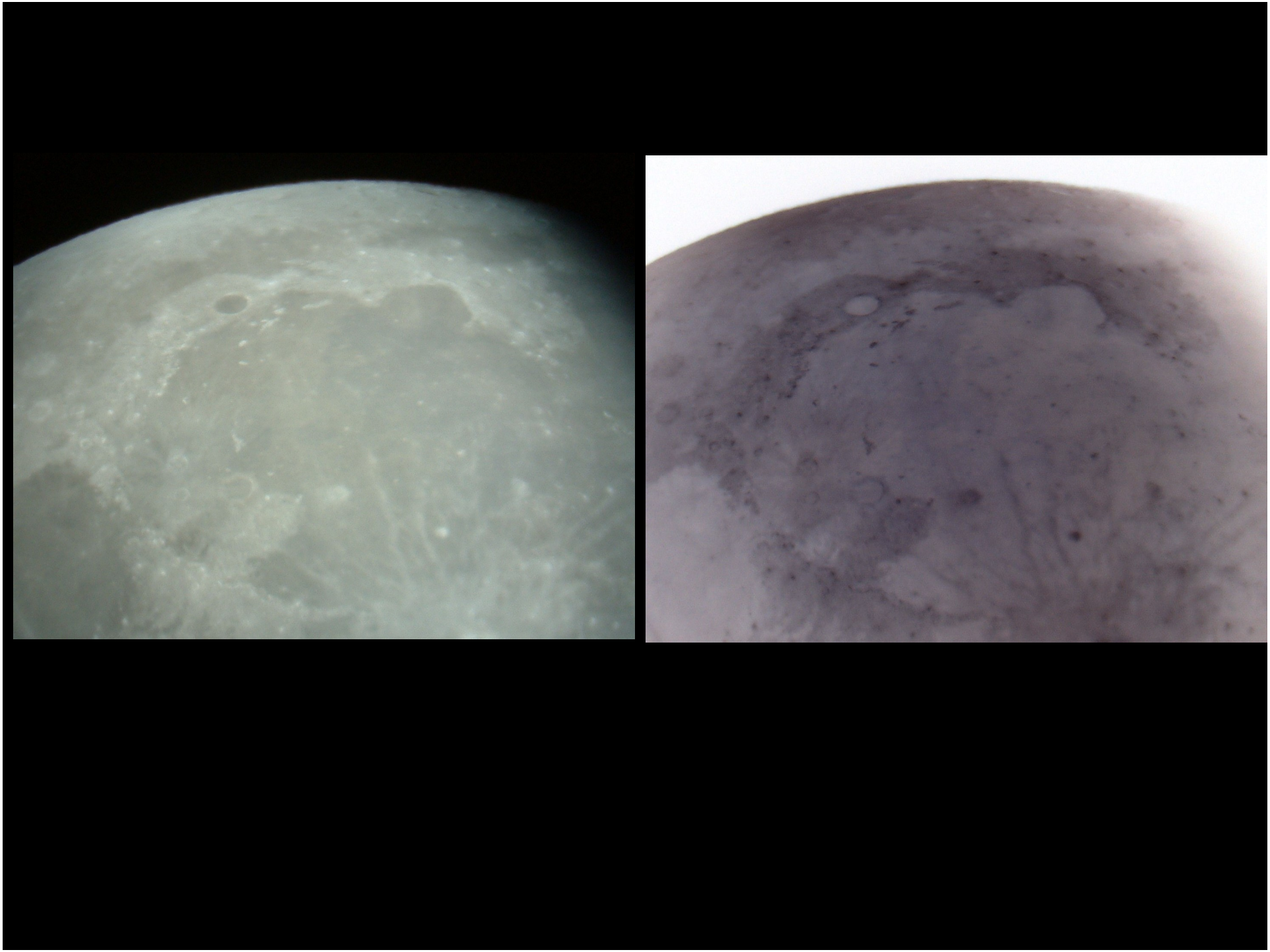
http://sob.nao-rozhen.org/content/super-moon-march-19-2011

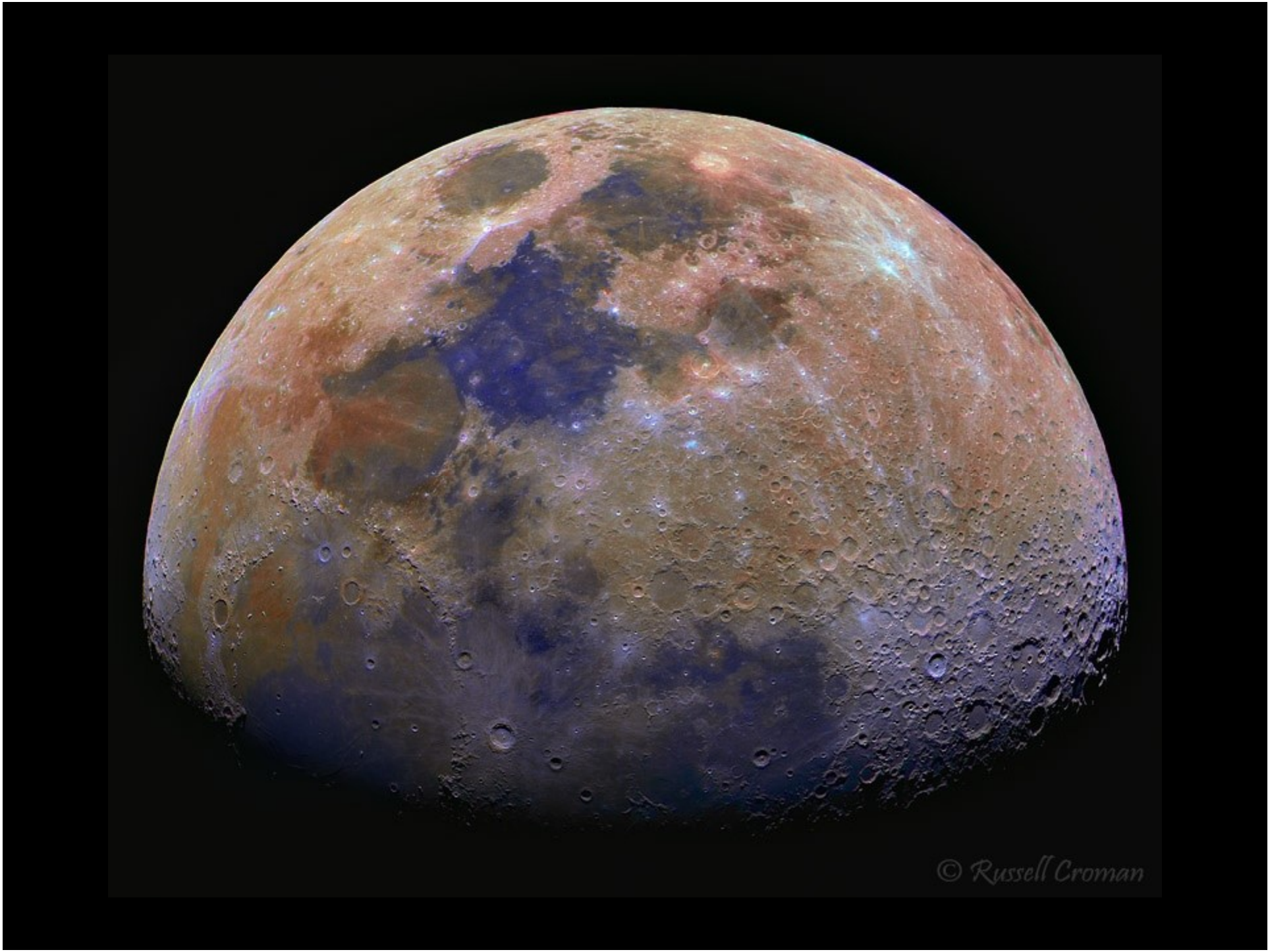

Total Lunar Eclipse
Jan. 31, 2018
(all times PST)
Moonset Times
Washington, DC 7:15 a.m EST
New York, NY 7:06 a.m. EST
Chicago, IL 7:06 a.m. CST
Kansas City, MO 7:28 a.m. CST
Denver, CO 7:12 a.m. MST
Phoenix, AZ 7:29 a.m. MST
Los Angeles, CA 6:57 a.m. PST
Seattle, WA 7:44 a.m. PST
PENUMBRA
UMBRA
8:08 a.m.
7:11 a.m.
6:07 a.m.
5:29 a.m.
4:51 a.m.
3:48 a.m.
2:51 a.m.
Penumbral Eclipse Ends
Umbral Eclipse Ends
Totality Ends
Greatest Eclipse
Totality Begins
Umbral Eclipse Begins
Penumbral Eclipse Begins
https://cafe-babylon.net

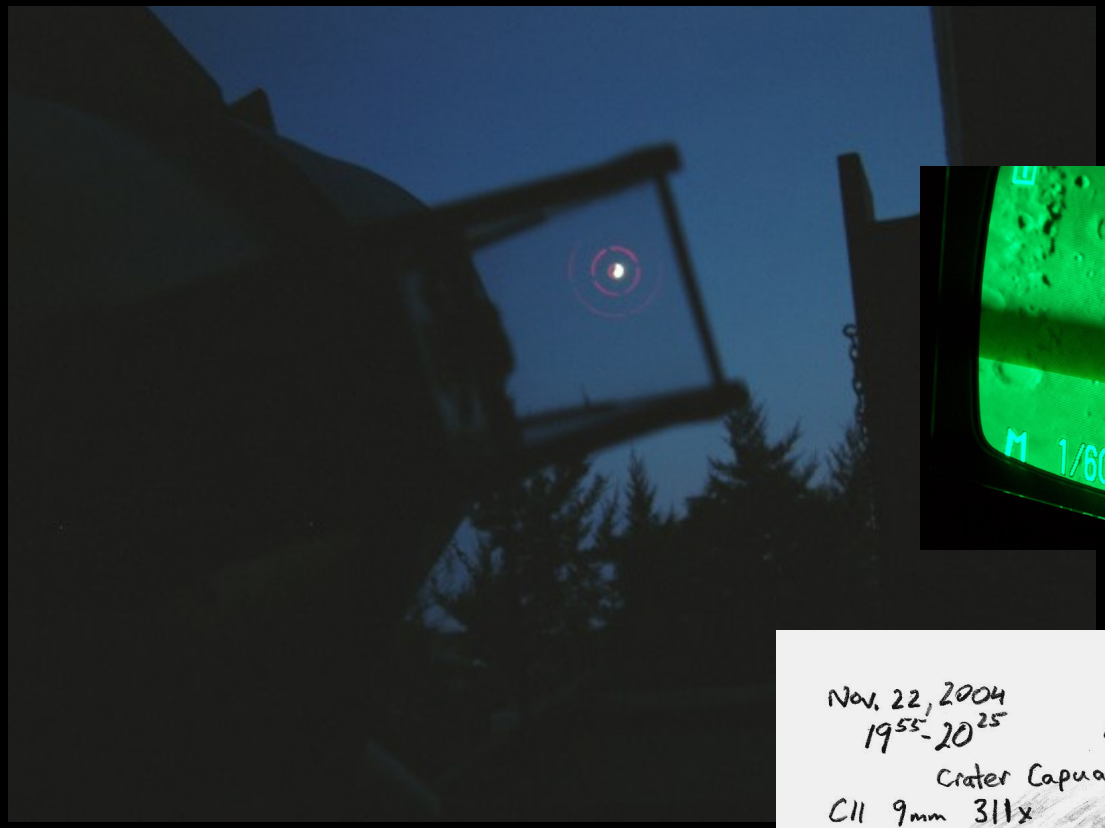

Earth's shadow in space
Lunar eclipse images by Lee Macdonald

Phases of the Moon

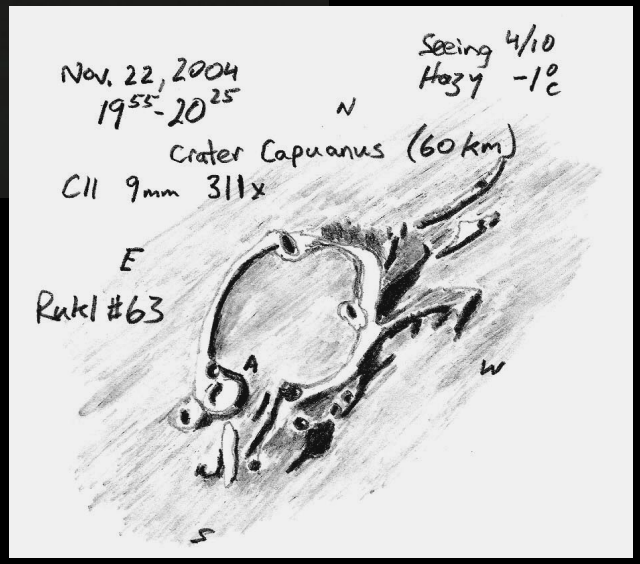
Image by Paul Klauninger



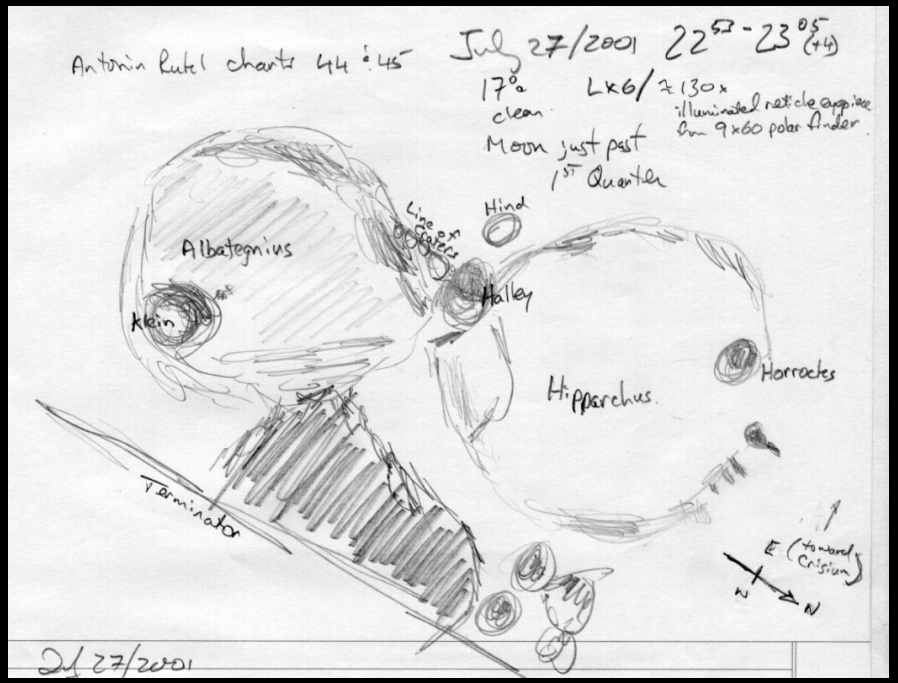

© Russell Croman

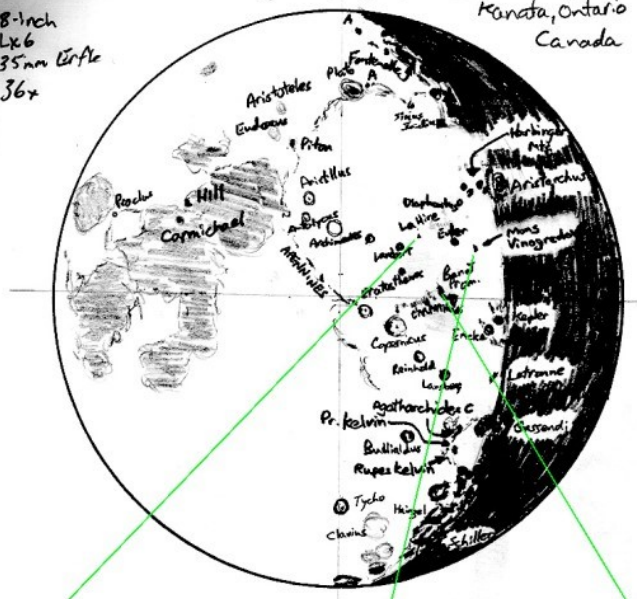



100
1600
FINE
M 1/60 F4.3
91


Nov. 22, 2004
19^55 - 20^25
Seeing 4/10
Hazy -1°c
N
Crater Capuanus (60 km)
C11 9mm 311x
E
Rukl #63
W
S


B. McCullough
2009





① Mons LaHire (28°N, 25°W) ② Mons Vinogradov (22°N, 33°W) ③ Prom. Barat (17°N, 26°W)

Distance from ℄: D = 16mm = 479.36km | D = 27mm = 808.92 km | D = 21mm = 629.16 km

$\theta = \arcsin \frac{D}{L} \;//\; \theta = \arcsin \frac{479.36\text{ km}}{1{,}738}$ | $\theta = \arcsin \frac{808.92\text{ km}}{1{,}738}$ | $\theta = \arcsin \frac{629.16\text{ km}}{1{,}738}$

$\theta = \arcsin .2758$ | $\theta = \arcsin .4654$ | $\theta = \arcsin .3620$

$\therefore \theta = 16°$ from ℄ | $\therefore \theta = 27.7°$ | $\therefore \theta = 21.2°$

$\alpha = 57.5°$ [Earth-Moon-Sun angle from ephemerides] | $\alpha = 57.5°$ | $\alpha = 57.5°$

$\phi = 73.5°$ [angle of illumination] | $\phi = 85.2°$ | $\phi = 78.7°$

S (shadow length) = .75mm = 22.47 km | S = 1mm = 29.96 km | S = .8mm = 23.97 km

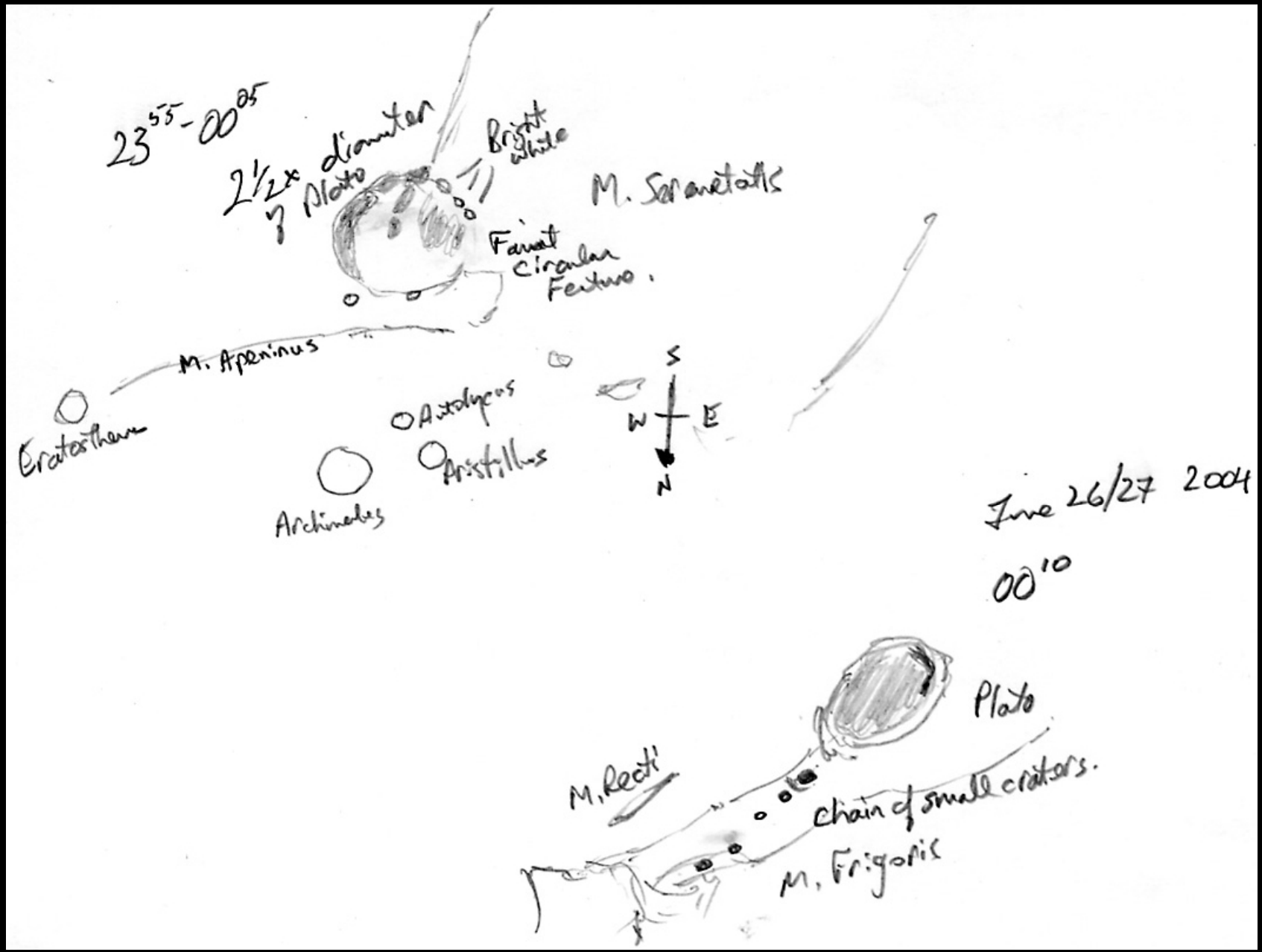
$h = \frac{S}{(\tan \phi)(\cos \theta)}$

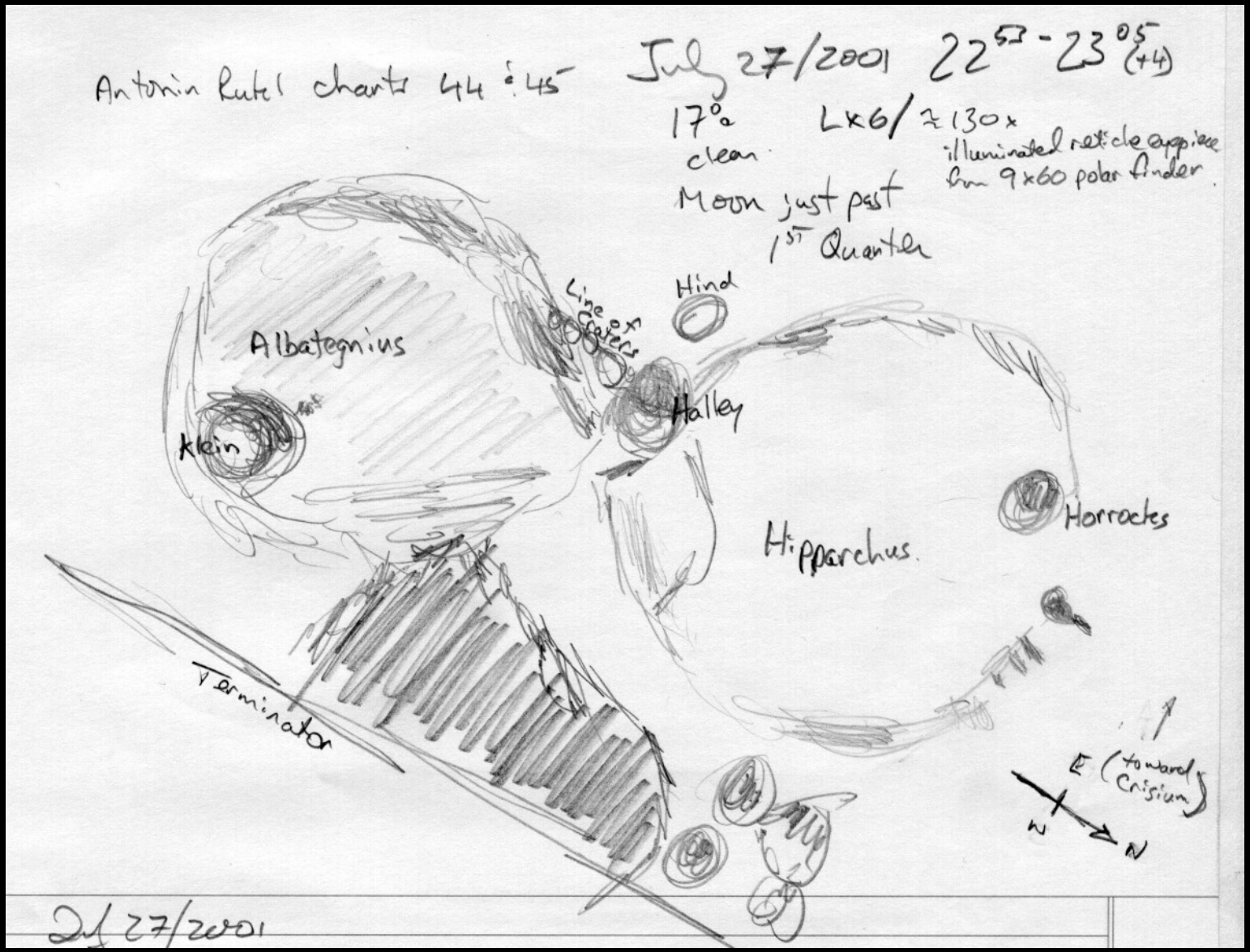
$h = \frac{22.47\text{ km}}{(\tan 73.5)(\cos 16)}$ | $h = \frac{29.96\text{ km}}{(\tan 85.2)(\cos 27.7)}$ | $h = \frac{23.97\text{ km}}{(\tan 78.7)(\cos 21.2)}$

$h = \frac{22.47}{(3.3759)(.9612)}$ | $h = \frac{29.96}{(11.90)(.8853)}$ | $h = \frac{23.97}{(5.0045)(.9323)}$

$h = \frac{22.47}{3.2449}$ | $h = \frac{29.96}{10.5350}$ | $h = \frac{23.97}{4.6656}$

$\therefore h = 6.92$ km [6,920 metres] | $\therefore h = 2.8438$ km [2,844 m] | $\therefore h = 5.1376$ km [5,138 metres]


23^55 - 00^05
2 1/2 x diameter of Plato
Bright white
M. Saranctatis
Faint Circular Feature.
M. Apeninus
Eratosthenes
Autolycus
Aristillus
Archimedes
S
W
E
N
June 26/27 2004
00^10
Plato
M. Recti
chain of small craters.
M. Frigoris


Antonin Rukl charts 44 & 45
July 27/2001 22^53 - 23^05 (+4)
17° clear
L x 6/ ≈ 130 x
illuminated reticle eyepiece from 9 x 60 polar finder.
Moon just past 1ST Quarter
Hind
Line of craters
Albategnius
Halley
Klein
Horrocks
Hipparchus
Terminator
E (toward Crisium)
N
N
July 27/2001


01:36 am.
31 July 2010
Face
Zigut
Altai
Cyrillus
Cathi
Polybius
Theophilus
Riccius

Mare Humorum
Crater Gassendi

Aug. 8/2003

$22^{25} - 22^{43}$ EDT (clouded over suddenly)
$23^{50} - 00^{30}$

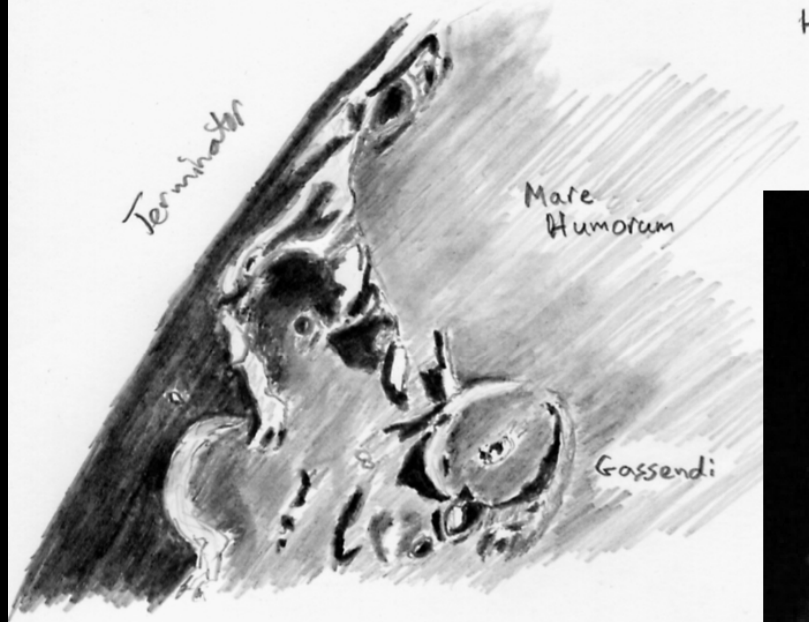
C11 140× (20 mm)

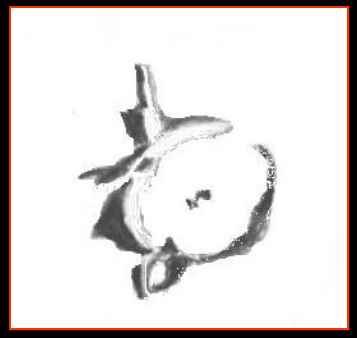
23°c

HAM #52

Images

DCP_1331
1332 *
22^{15} EDT





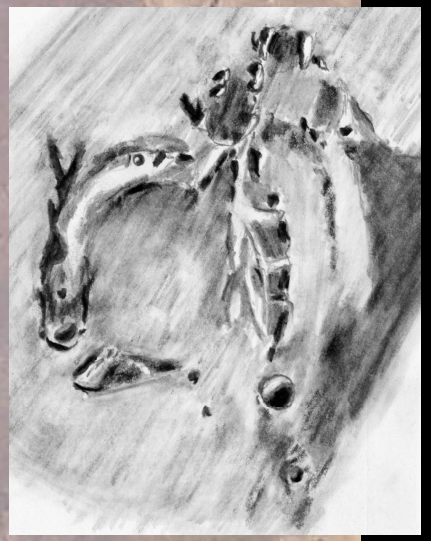
CASSINI & ALPINE VALLEY MIKE WIRTHS


FACES OF THE MOON


The Moon
by
RASC Ottawa
May 11, 2012
TLAS OF THE MOON

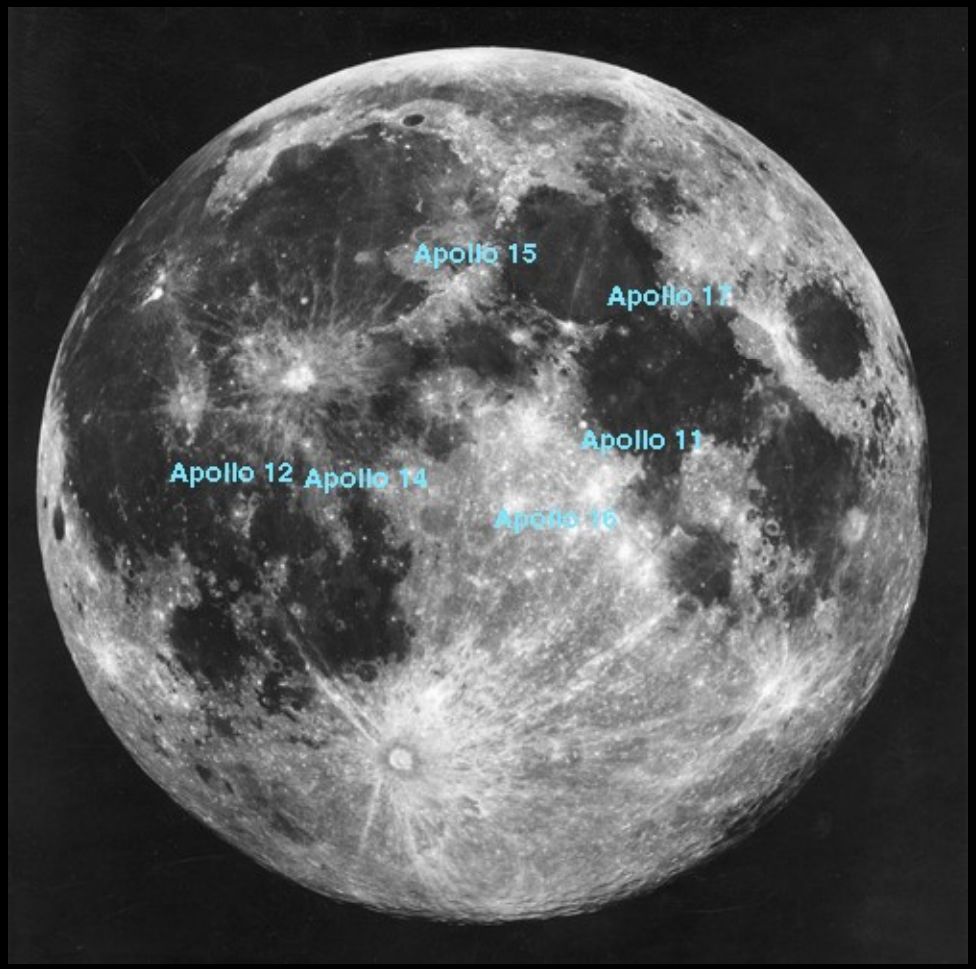

Mini Marshmallows
Mini guimauves
250 g
Mini Marshmallows
Mini guimauves
250 g
FULL-MOON OBSERVING HIGHLIGHTS

When in Rome….

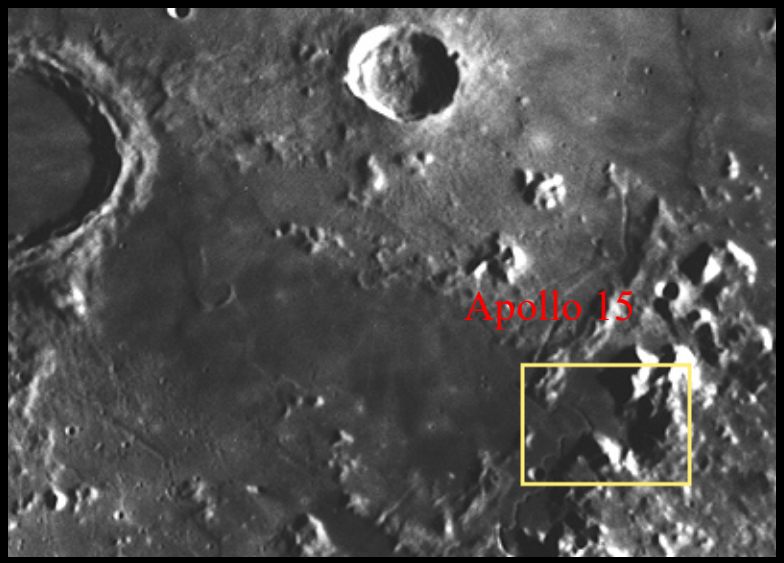


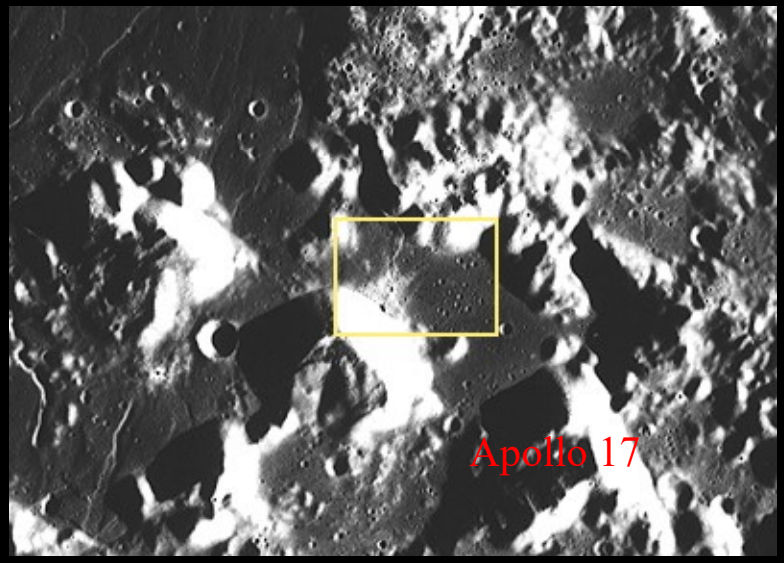

Lee Macdonald

Exploring the Apollo Landing Sites

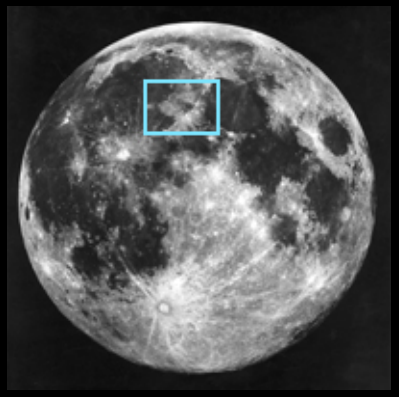


http://www.boulder.swri.edu/~durda/Apollo/landing_sites.html

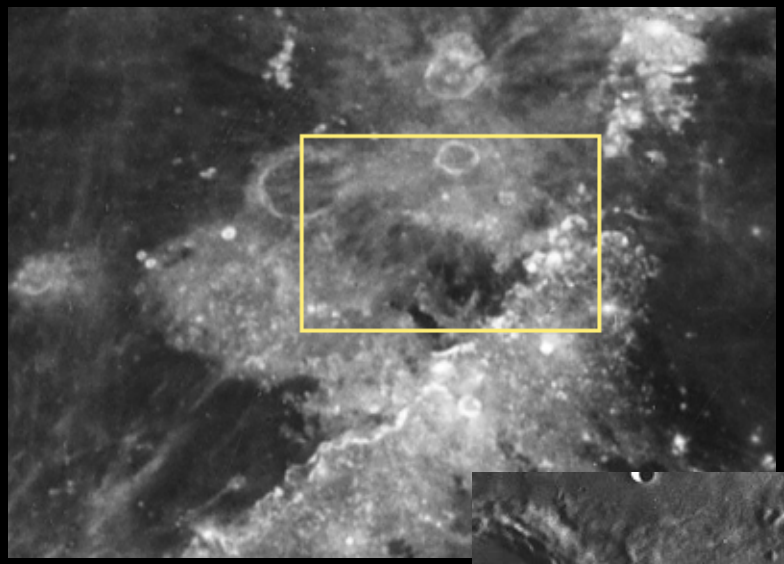




NASA

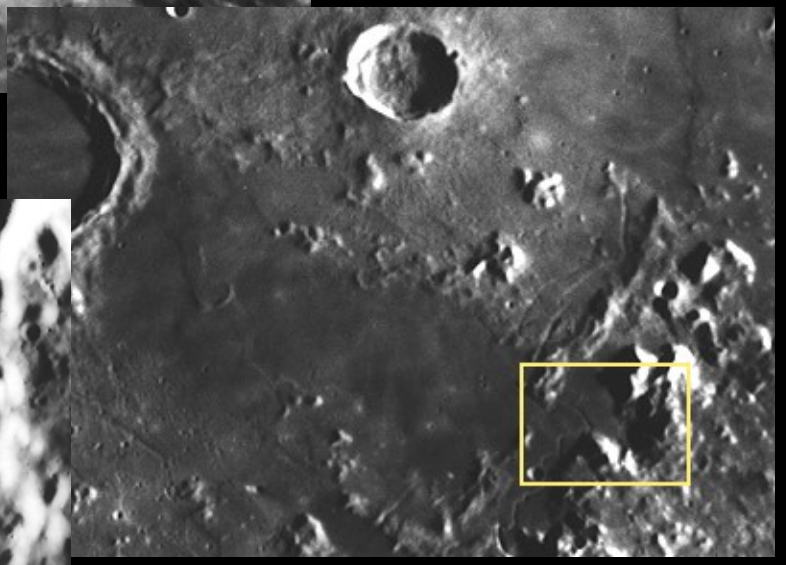


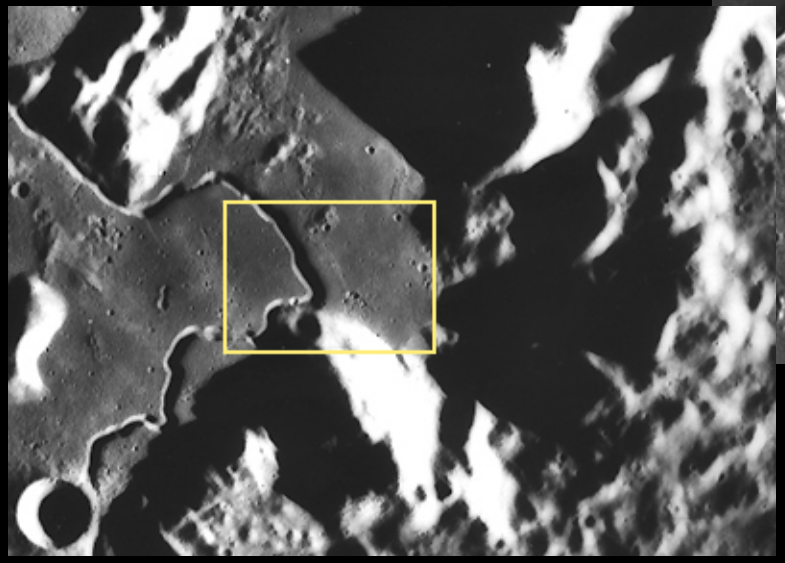
Earth-based Images



Apollo 15

Hadley Rille



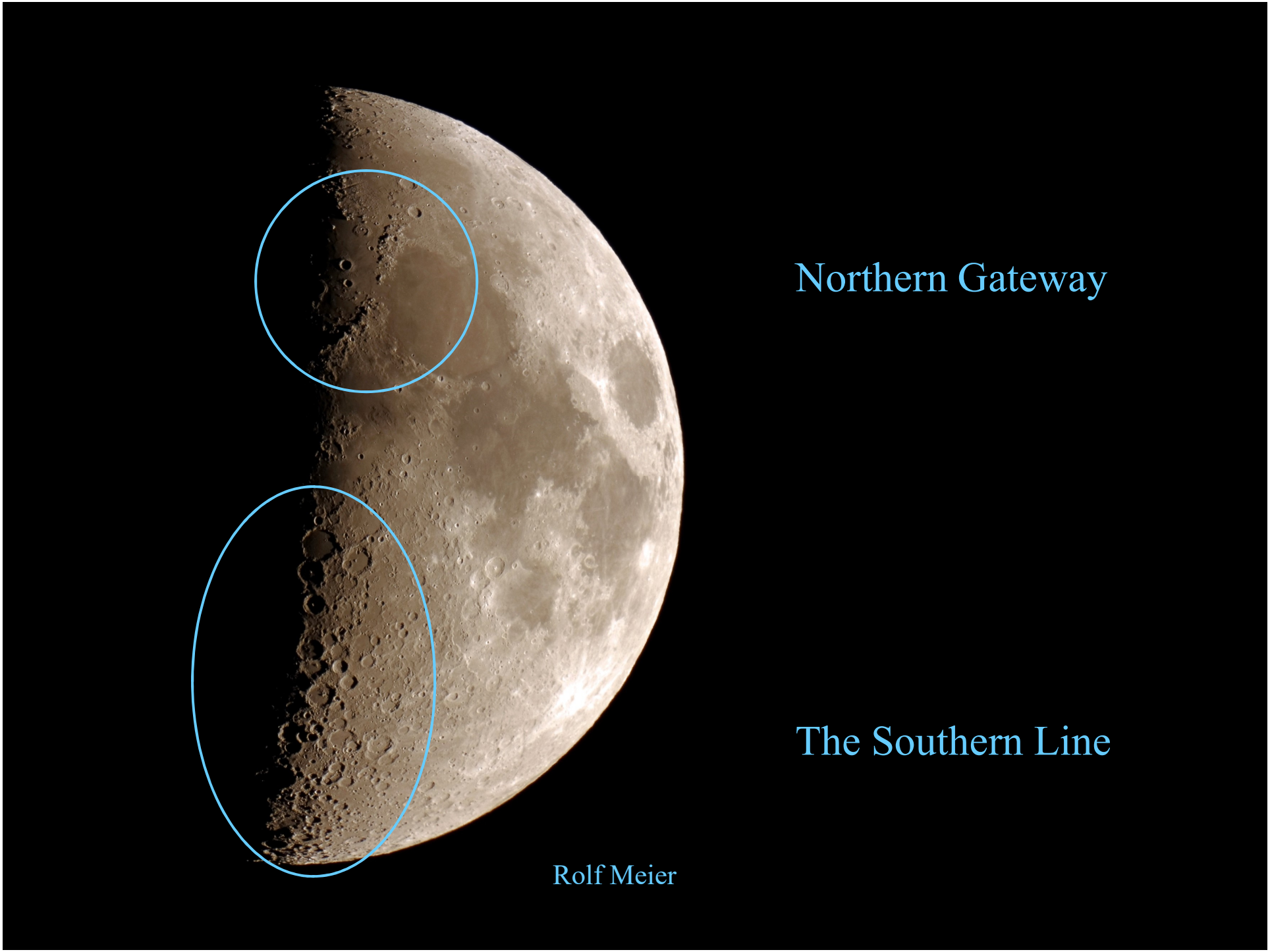


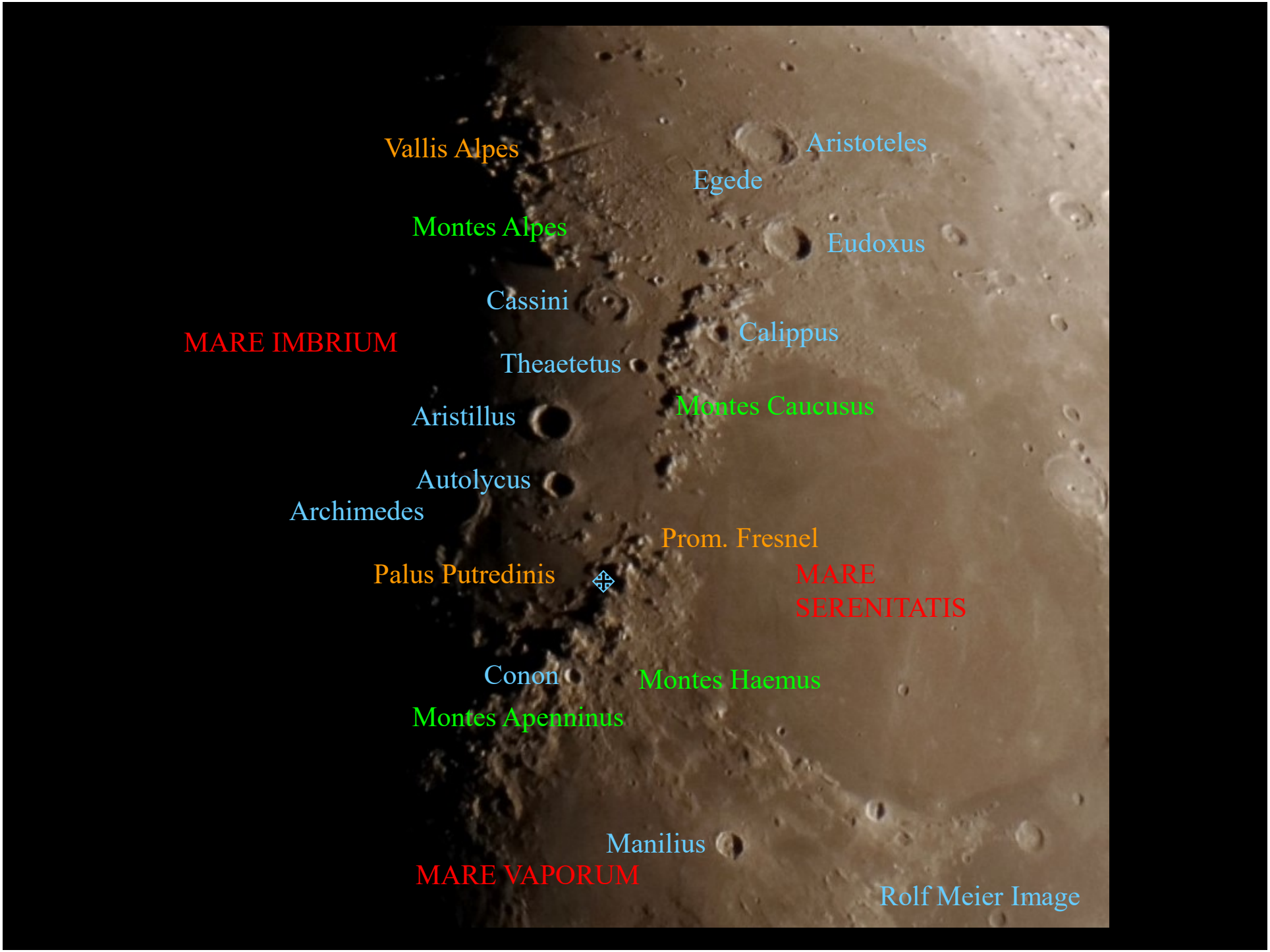
Lunar Orbiter Images

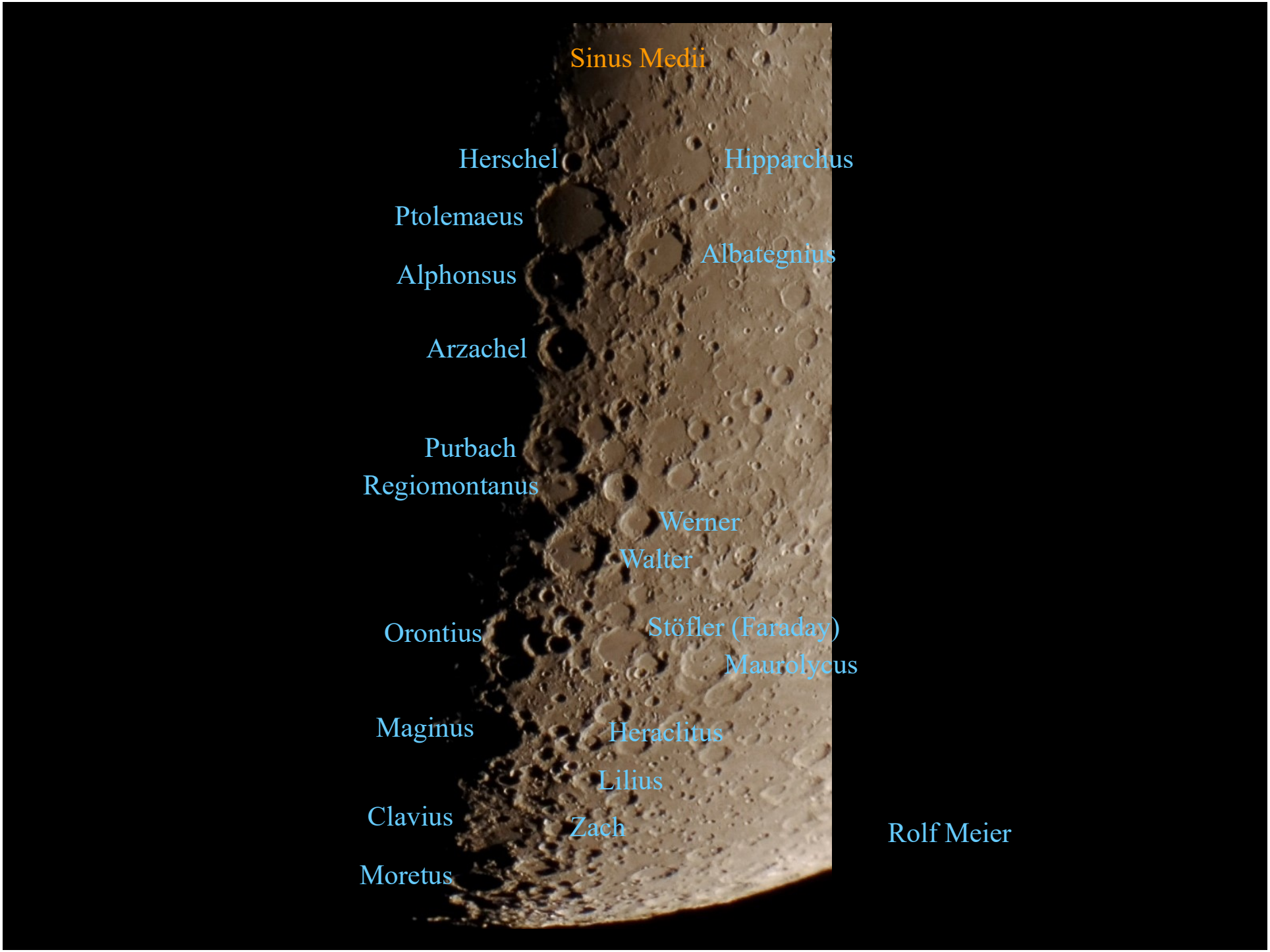
NASA /as17-145-22224

Lunar Challenge(s)

Rolf Meier


Northern Gateway
The Southern Line
Rolf Meier


Vallis Alpes
Aristoteles
Egede
Montes Alpes
Eudoxus
Cassini
Calippus
MARE IMBRIUM
Theaetetus
Montes Caucusus
Aristillus
Autolycus
Archimedes
Prom. Fresnel
Palus Putredinis
MARE
SERENITATIS
Conon
Montes Haemus
Montes Apenninus
Manilius
MARE VAPORUM
Rolf Meier Image


Sinus Medii
Herschel
Hipparchus
Ptolemaeus
Albategnius
Alphonsus
Arzachel
Purbach
Regiomontanus
Werner
Walter
Orontius
Stöfler (Faraday)
Maurolycus
Maginus
Heraclitus
Lilius
Clavius
Zach
Moretus
Rolf Meier

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Explore the Moon

ETM Recipients

Start Year (2016...)

2016

And

2099

Surname

Centre:

- Any -

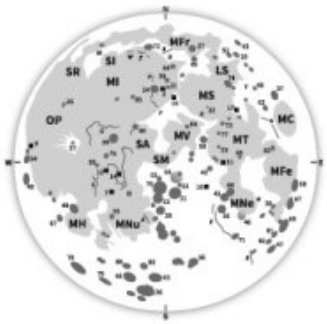
Subtype:

- Any -

Apply

Explore the Moon—a beginner's lunar observing program

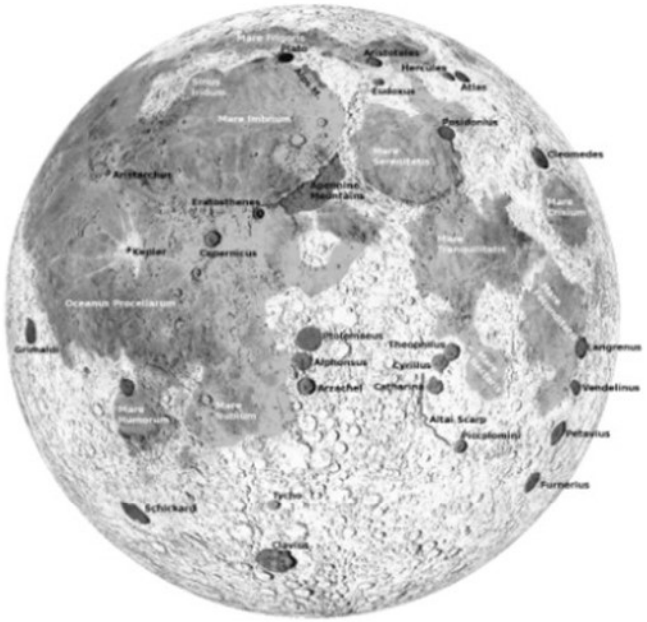
This observing program bridges the gap between the introductory ***Explore the Universe Observing Program*** and the more challenging ***Isabel Williamson Lunar Observing Program***. It is ideal for beginning observers who are just learning about telescopes and binoculars, by providing a hands-on observing experience on an easy object—the Moon. The telescope program is based on the 94 lunar features listed and charted in the RASC *Observer's Handbook*, originally selected by Roy Bishop. There is also a binocular program consisting of a reduced set of 40 features. We welcome feedback from observers!



Why Observe the Moon?

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

Explore the Moon (binocular version)

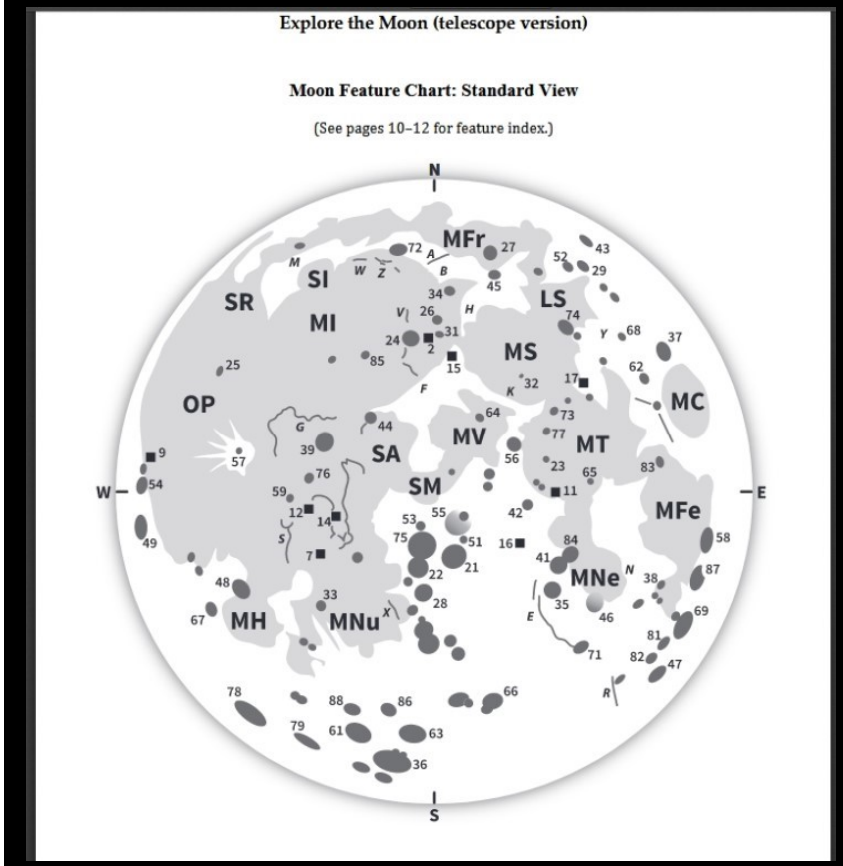


(map by Clara Scattolin, 2014, based on the Virtual Moon Atlas ap-i.net/avl/en/start

***Maria* or "Seas"**

Mare Crisium = Sea of Crises
Mare Fecunditatis = Sea of Fertility
Mare Frigoris = Sea of Cold
Mare of Humorum = Sea of Moisture
Mare Imbrium = Sea of Showers
Sinus Iridum = Bay of Rainbows
Mare Nectaris = Sea of Nectar
Mare Nubium = Sea of Clouds
Oceanus Procellarum = Ocean of Storms
Mare Serenitatis = Sea of Serenity
Mare Tranquilitatis = Sea of Tranquility

The "Gang of Four" Craters
(north to south)
Langrenus
Vendelinus
Petavius
Furnerius



Explore the Moon (telescope version)

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

Isabel Williamson Lunar Observing Program

IWLOP Recipients

Start Year (2006...)

2006

And

2099

Surname

Centre:

- Any -

Apply

About the Isabel Williamson Lunar Observing Program

The Moon is by far the most detailed astronomical object to observe through a telescope and the comprehensive Isabel Williamson Lunar Observing Program (IWLOP) will guide you through a complete tour of our near neighbour's incredible surface. The tour includes many outstanding craters, mountains, valleys, scarps, ridges, and more, not only showing you how they appear, but also describing the history of their formation over four billion years. The RASC Observing Committee created the IWLOP in 2006 as a certificate program for intermediate-to-advanced observers; since then, more than a dozen RASC members have earned their IWLOP certificates and many have provided constructive comments, leading to several minor revisions and corrections in 2013, plus one important revision in 2015 regarding the craters Jansen and Janssen.

IWLOP guide (Revised 3nd Edition, 2015)

The IWLOP is an educational experience, including a detailed guide with key information about the lunar surface and how to observe it. The guide begins with an overview that outlines the required objectives for

28 – Capella and Vallis Capella – 7.6 S 34.9 E — Check □

Origin: Multiple linear impacts **Size:** Crater 49 km, Vallis 110 km **Rukl:** 47 **Type:** CC &Valley

Interesting crater with a valley running through it on the northern edge of Mare Nectaris.

® Note the valley running through Capella and the large central peak of the crater.
® Observe the crater Isidorus just to the west, and note how Capella is superimposed upon it.
© Try to count eight or more craters along Vallis Capella.
© Observe the bright, haloed crater Censorinus located further north at the edge of Mare Tranquillitatis. Re-observe it at several lunar phases and note its changing appearance

29 – Fracastorius – 21.2 S 33.0 E — Che

Origin: Impact **Size:** 124 km **Rukl:** 58 **Type:** CC

Since this crater transects the Nectarian Basin wall, it formed after the Nectarian Basin impact but before the area was flooded with lava.

® Observe Fracastorius and note the degraded northern wall flooded by Nectarian lava.
© Observe the small craters L and M, and the rille running east to west across the crater.

30 – Hommel – 54.6 S 33.0 E — Che

Origin: Impact **Size:** 125 km **Rukl:** 75 **Type:** CC

Extremely complex crater with several overlapping structures.

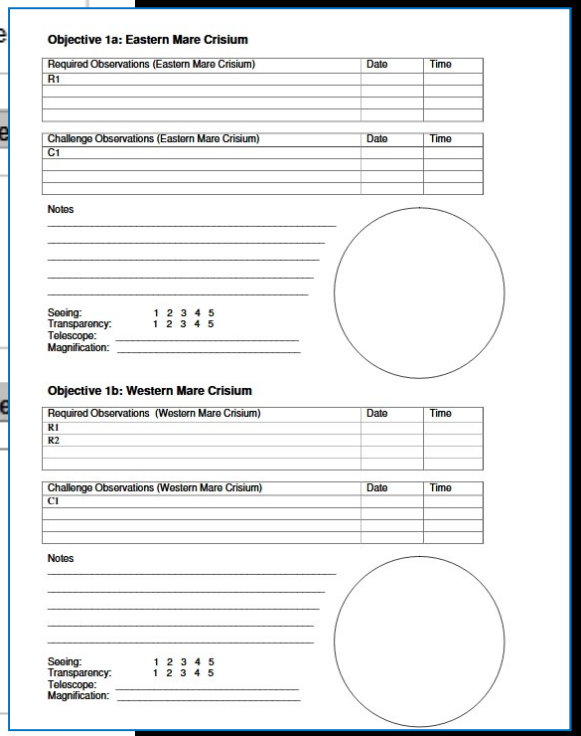
® Look for a large crater significantly covered by the overlapping secondary craters Hommel A,B,C,D,H, and P.
® To the north of Hommel, note the crater Pitiscus and identify the prominent duo Vlacq and Rosenberger to the east.
© Farther east look for Biela, and to the southeast look for Nearch and Hagecius. Identify the smaller secondary craters next to Hommel designated Hommel Q,S, and J.

31 – Piccolomini – 29.7 S 32.2 E — Check □

Origin: Impact **Size:** 88 km **Rukl:** 58, 68 **Type:** CC

Piccolomini is thought to be an Upper Imbrian Era crater superposed on Rupes Altai and on secondary craters related to the Imbrium Basin (most of the smaller, older craters nearby).

® Observe Piccolomini and note its terraced walls and massive central peak.
© Note the slumped area on the southern wall of Piccolomini.



Objective 1a: Eastern Mare Crisium

Required Observations (Eastern Mare Crisium)	Date	Time
R1		

Challenge Observations (Eastern Mare Crisium)	Date	Time
C1		

Notes

Seeing: 1 2 3 4 5
Transparency: 1 2 3 4 5
Telescope: _____
Magnification: _____

Objective 1b: Western Mare Crisium

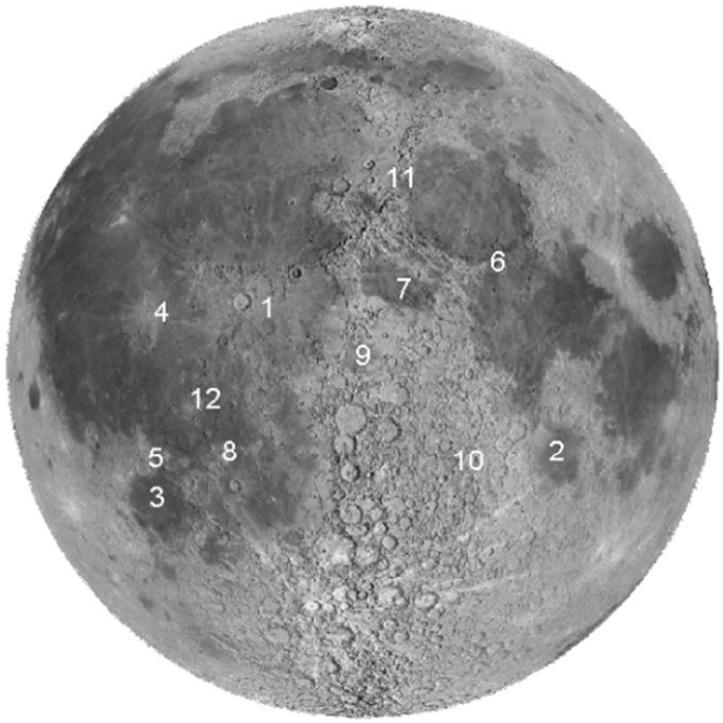
Required Observations (Western Mare Crisium)	Date	Time
R1		
R2		

Challenge Observations (Western Mare Crisium)	Date	Time
C1		

Notes

Seeing: 1 2 3 4 5
Transparency: 1 2 3 4 5
Telescope: _____
Magnification: _____

W.H. Pickering Unaided Eye Scale



This challenge activity will test the sharpness of your vision and help you gain a better understanding of pre-telescopic observations of the Moon. The following list, originally proposed by W.H. Pickering, presents, in order of probable difficulty, twelve lunar features you may be able to observe **without** any optical aid.

1. Bright surroundings of crater Copernicus
2. Mare Nectaris
3. Mare Humorum
4. Bright surroundings of crater Kepler
5. Region of crater Gassendi
6. Region of crater Plinius
7. Mare Vaporum
8. Crater Lubiniezky Region
9. Sinus Medii
10. Faint shading near crater Sacrobosco
11. Dark spot at foot of the Montes Apennines
12. Montes Riphaeus

Rukl Chart No. 18

Isabel Williamson
No. 122

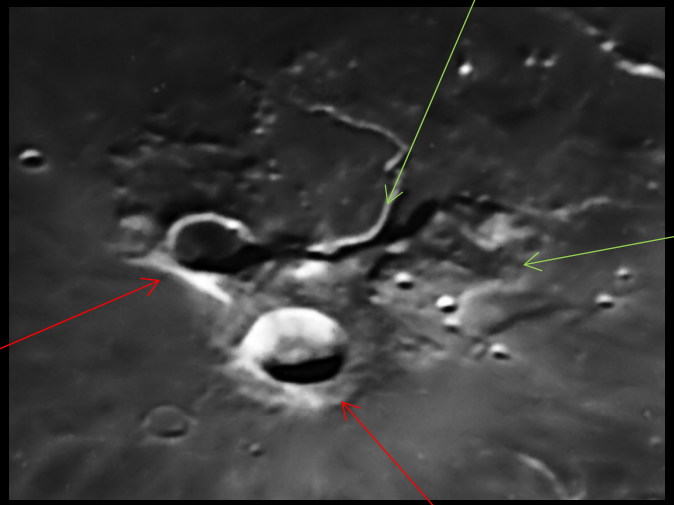


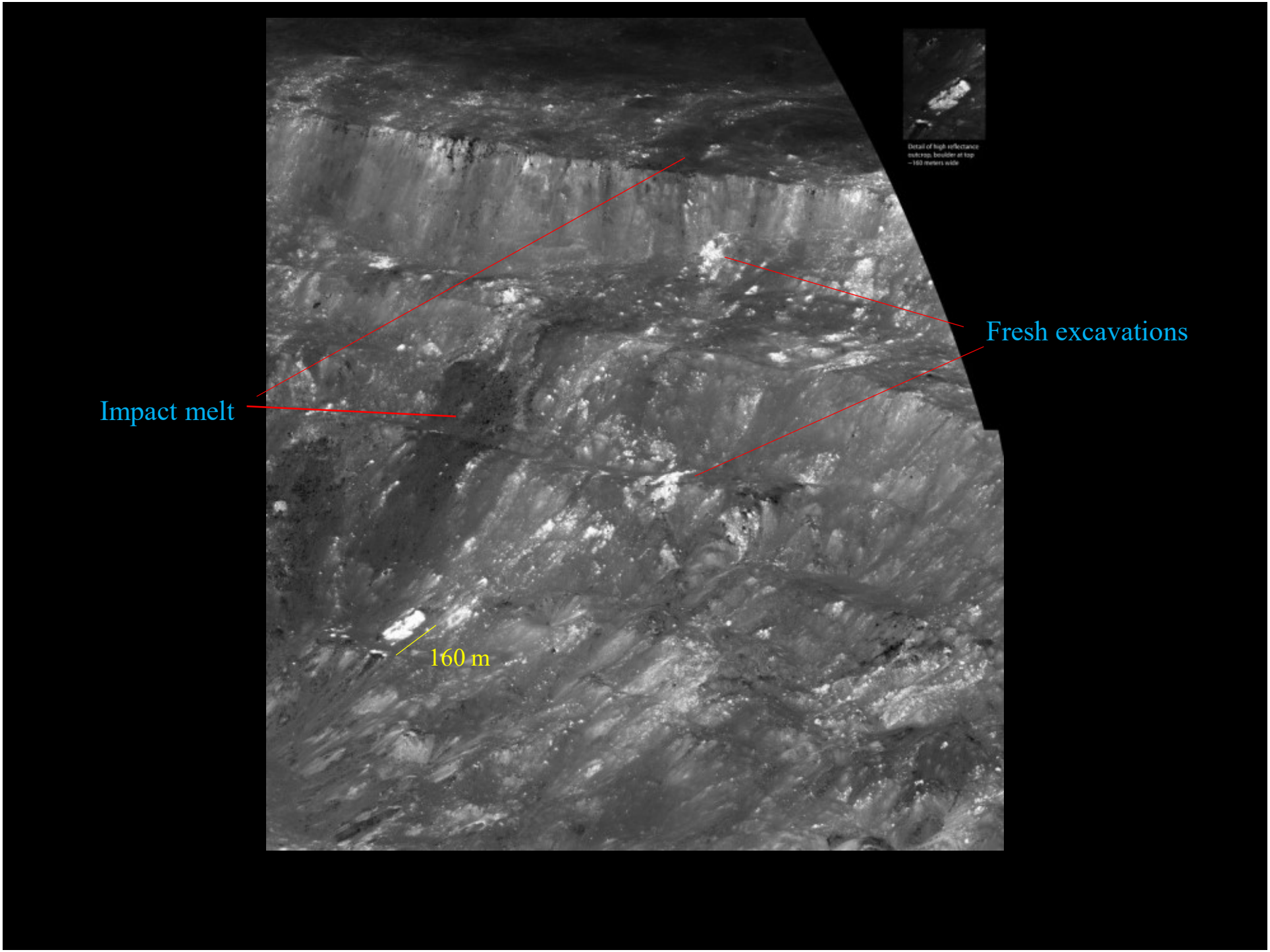
Image by Paul Klauninger

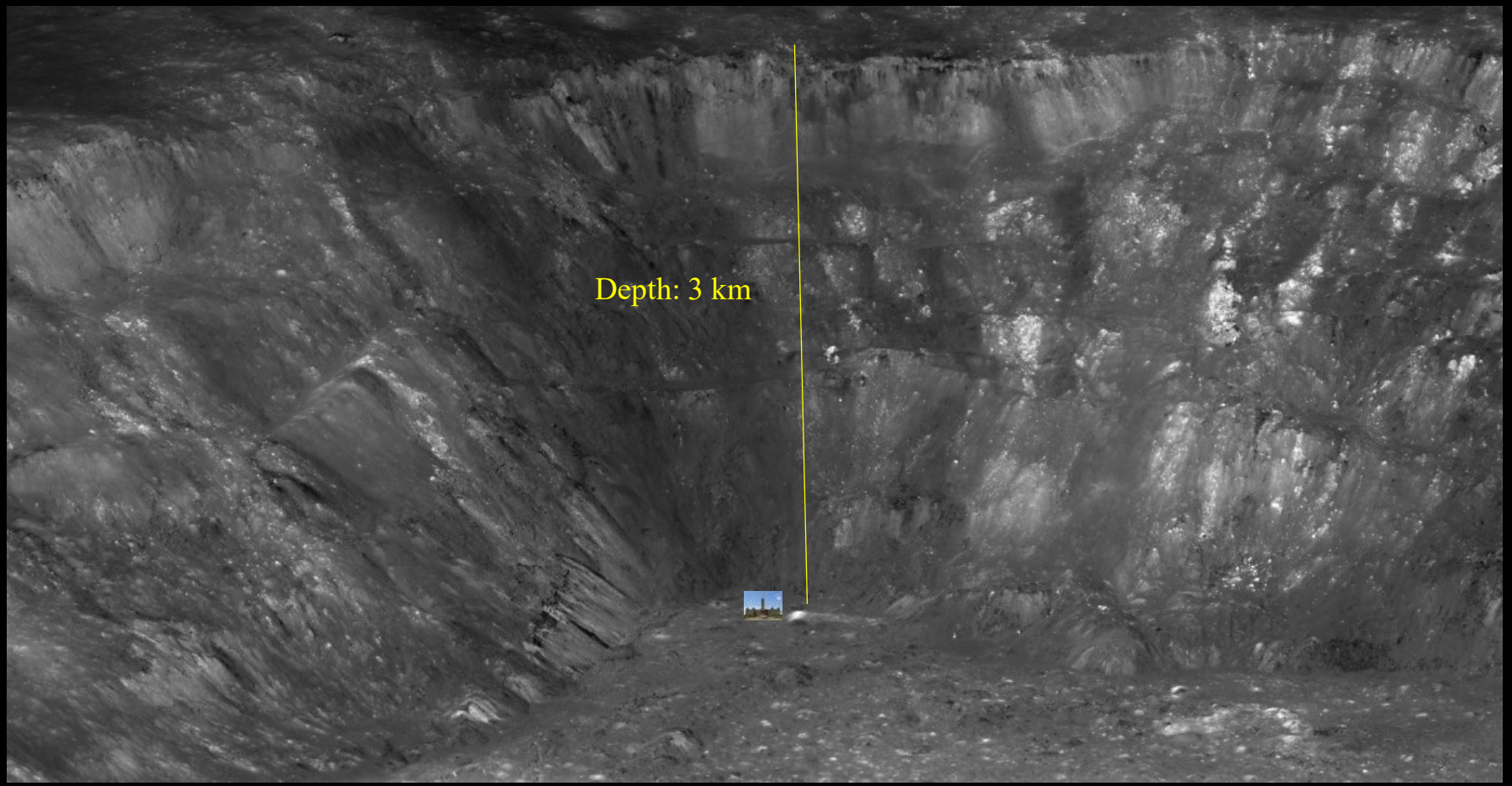
Aristarchus West Wall
(Lunar Reconnaissance Orbiter Camera)

Astronomy Picture of the Day — Feb. 17, 2012

25 km

Orbiter 70 km east of Aristarchus; Altitude 25 km


Detail of high reflectance outcrop, boulder at top ~160 meters wide
Impact melt
Fresh excavations
160 m


Depth: 3 km


Where I want my house to go!

Apollo 17 – Harrison Schmitt

NASA

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A Dream Come True —
Examining “Thin Slices” of Apollo Lunar Samples
with Annemarie Pickersgill, Western University

http://kpfu.ru/eng/news-eng/moon-rotation-research.html