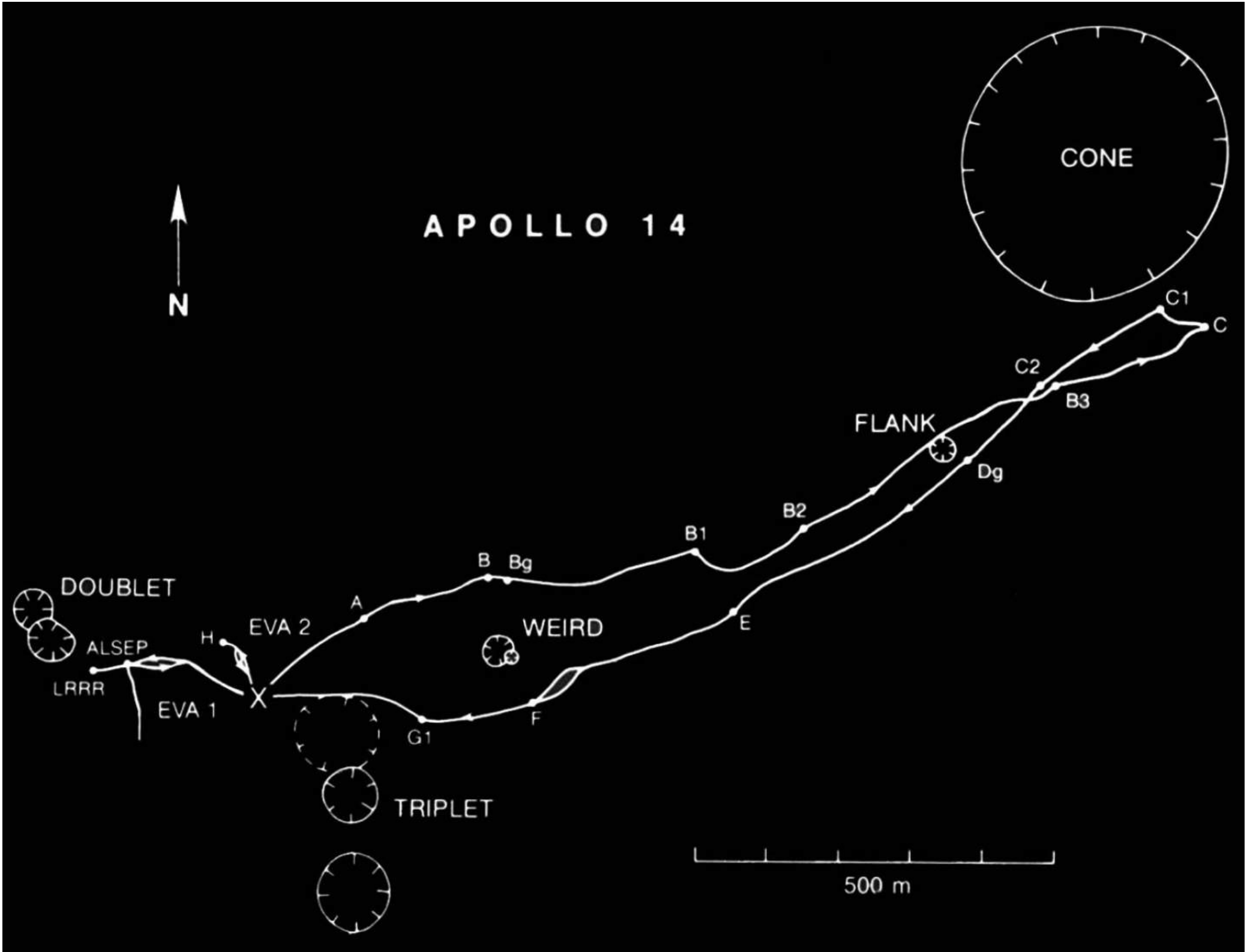
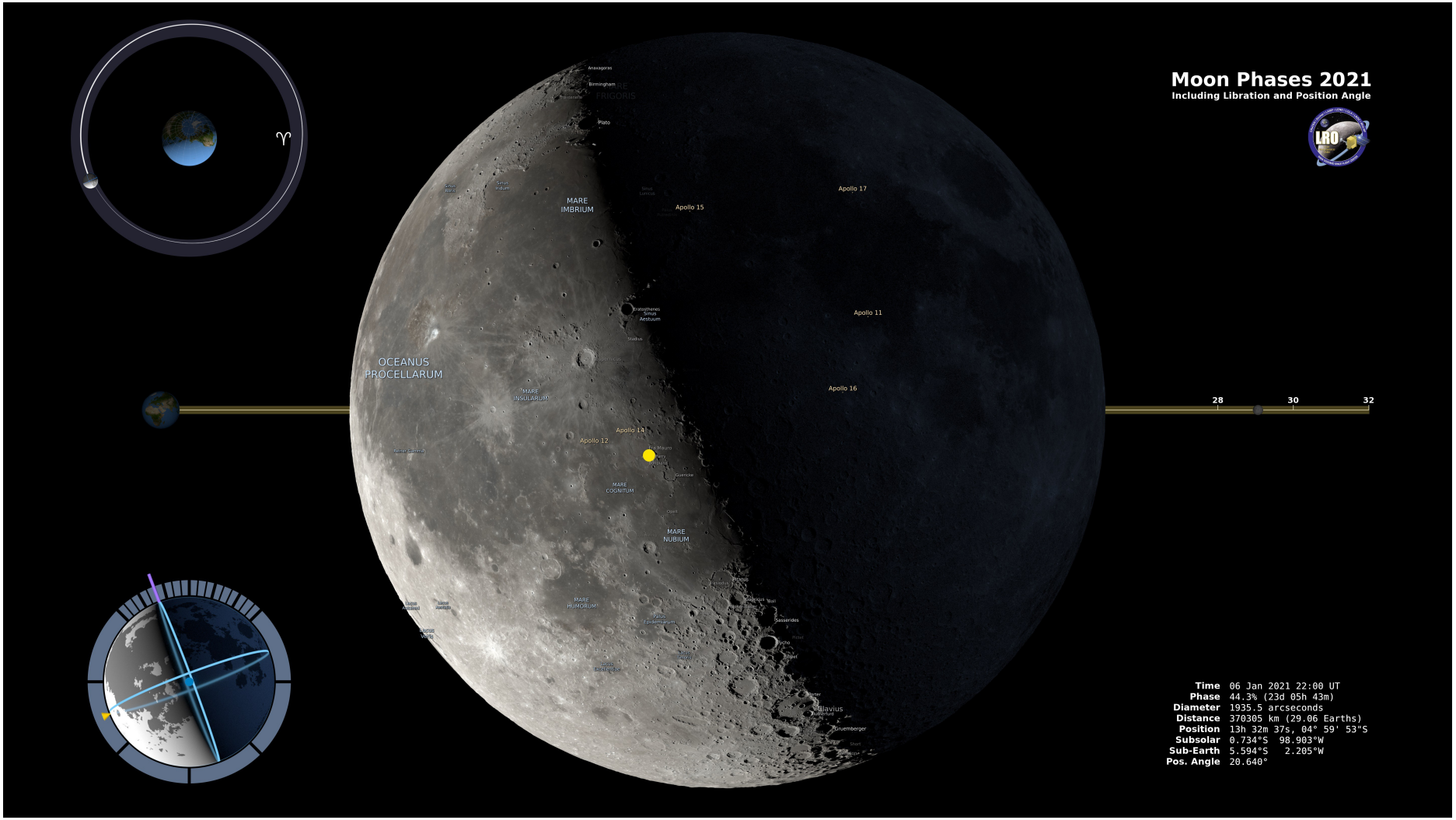

APOLLO 14
N
CONE
C1
C
C2
B3
FLANK
Dg
B2
B1
B
Bg
A
DOUBLET
ALSEP
LRRR
H
EVA 2
EVA 1
WEIRD
E
F
G1
TRIPLET
500 m

FRA MAURO Jan 6, 2021

CONTEXT

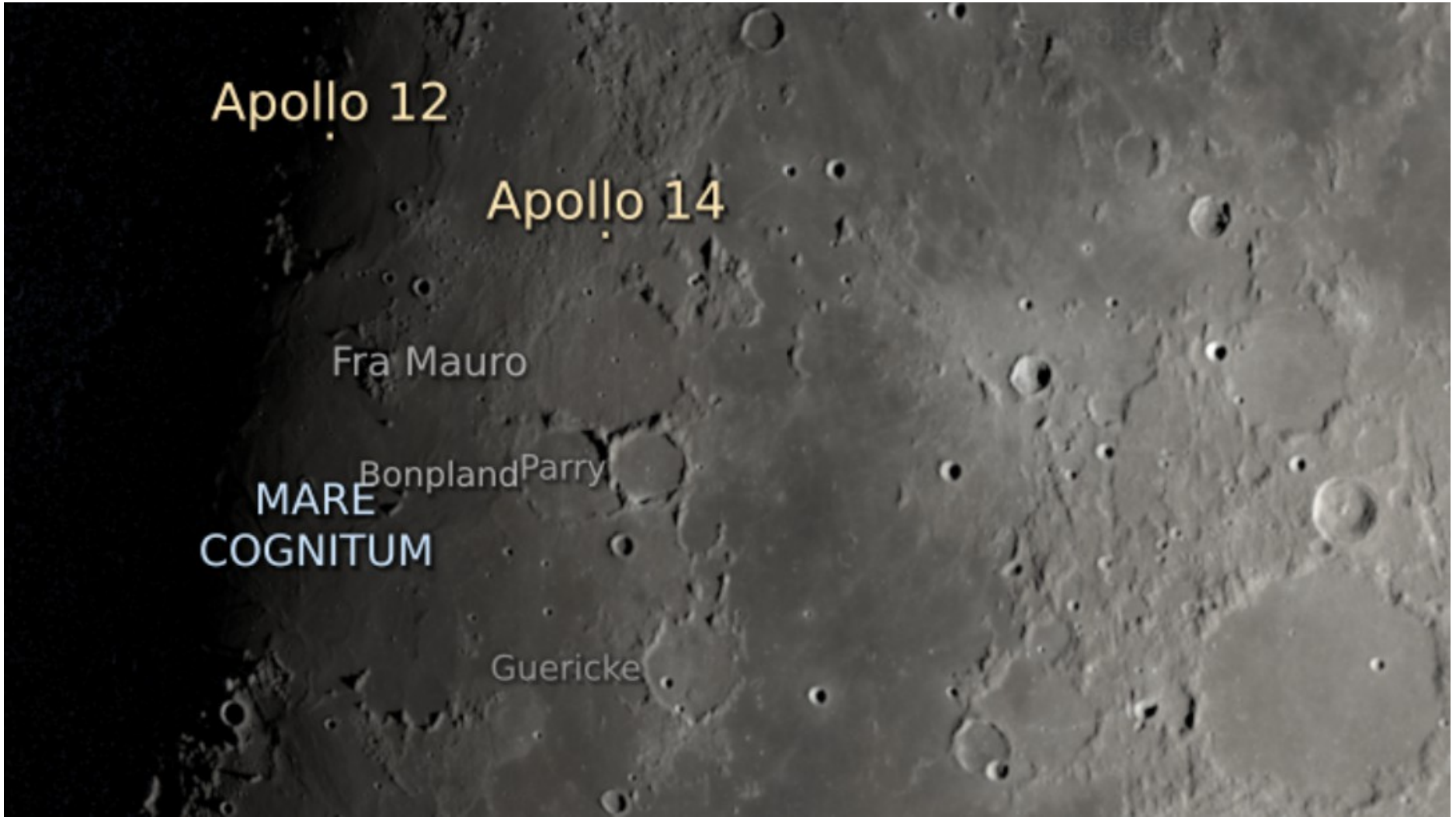

Moon Phases 2021
Including Libration and Position Angle
LRO
MARE IMBRIUM
OCEANUS PROCELLARUM
MARE INSULARUM
MARE COGNITUM
MARE NUBIUM
MARE HUMORUM
FRIGORIS
Plato
Apollo 17
Apollo 15
Apollo 11
Apollo 16
Apollo 14
Apollo 12
28
30
32
Time 06 Jan 2021 22:00 UT
Phase 44.3% (23d 05h 43m)
Diameter 1935.5 arcseconds
Distance 370305 km (29.06 Earths)
Position 13h 32m 37s, 04° 59' 53"S
Subsolar 0.734°S 98.903°W
Sub-Earth 5.594°S 2.205°W
Pos. Angle 20.640°

- Fra Mauro is both the name of a crater and a lunar formation – Imbrium ejecta
- Crater is a subdued feature not seen under high illumination, 6 deg S, 17 deg W
- Best seen near terminator at 9 or 23 days
- Forms a recognizable group with Bonpland, Parry and Guericke
- Formation consists of low ridges and hills with valleys between, radial to Imbrium basin 500 km away

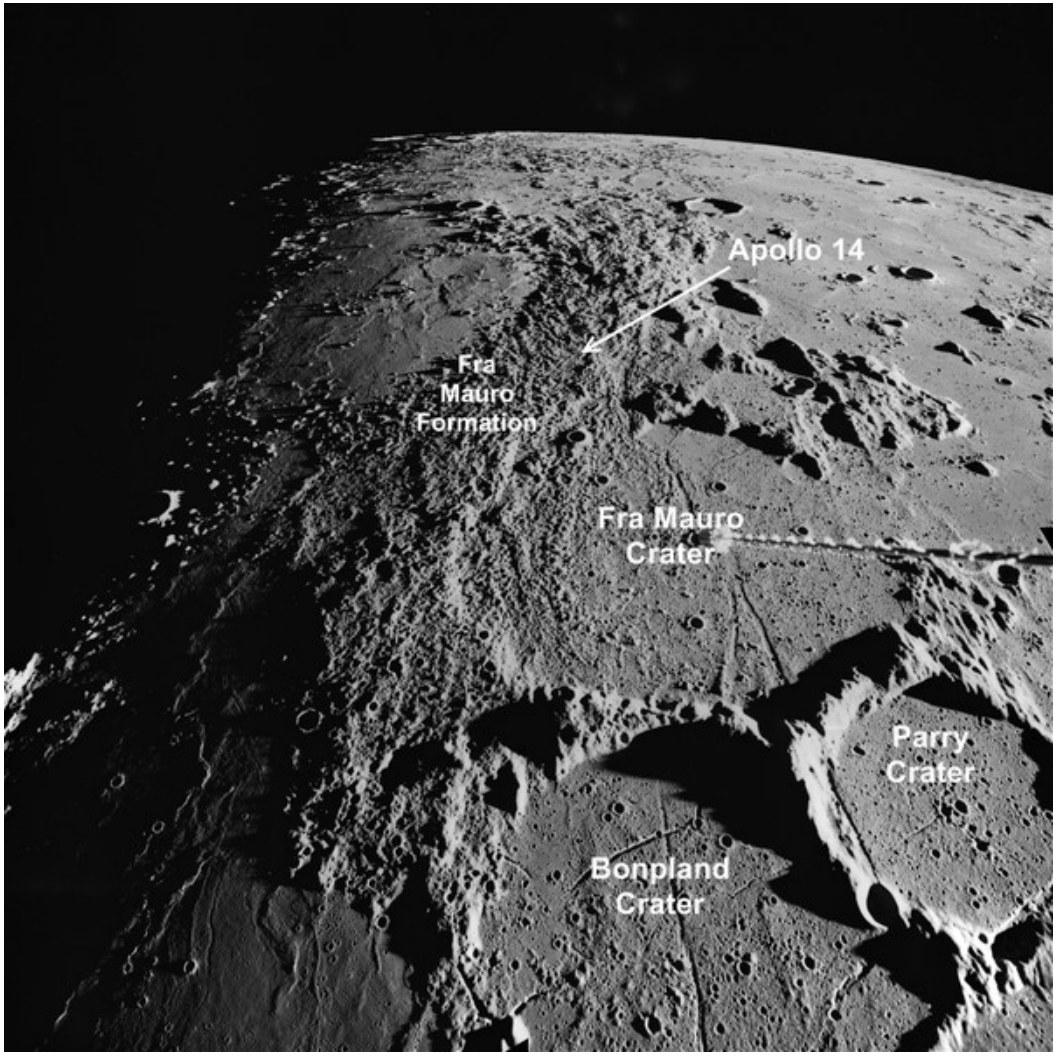
Waning Gibbous Dec 31, 2020

- RASC Observe the Moon – Telescope #14 optional
- RASC Isabel Williamson Lunar Observing Program # 93
- Lunar 100 #67

Jan 22, 2021 5 pm EST 9 days



Apollo 16 Metric Mapping Camera Frame

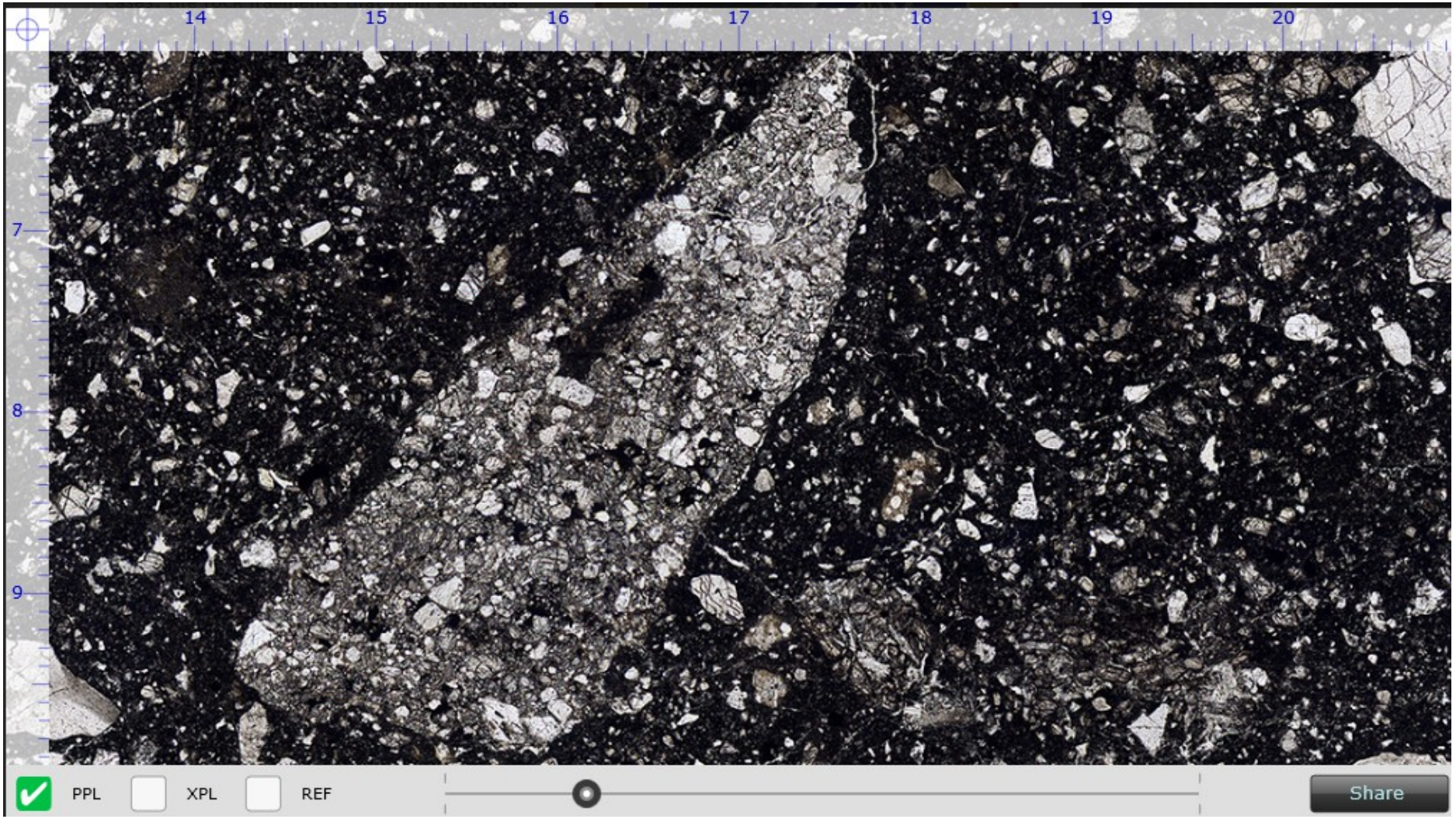


- Fra Mauro 96 km dia, age Pre-Nectarian
- Bonpland, 60 km dia, Pre-Nectarian
- Parry, 48 km dia, depth 560 m, Pre-Imbrian
- Guericke, 58 km Imbrian (3.85 -3.2 Ga)
- Interesting floor fractures
- Very battered appearance
- Fra Mauro western wall swamped by ejecta

Apollo 14 Mission

- Primary objective to sample and date ejecta from Imbrium event
- Originally intended as Apollo 13 mission
- 24 Mya Cone crater penetrated regolith and exposed ejected material from Imbrium event
- Major rock types sampled were breccias, composed of fragments/clasts cemented together by heat and pressure from later impacts
- Some clasts are themselves breccias

Virtualmicroscope.org sample 14321(240)
breccia within breccia



- Breccia within breccia indicates history of multiple impact events, fragmentation and sintering
- Clasts are older than the event that created the breccia
- Age of Imbrium must be younger than the youngest clast

- Initial dating of Imbrium event was 3.85 Ga
- Later refined to 3.938 Ga +/- 4 ma by Merle et al, 2014 - U-Pb dating of Ca-phosphates in Apollo 14 breccias
- O'Brien, Robinson & Kring 2019 L&PSC suggest apatites in A14 samples could be used to test hypothesis that there was an earlier phase of enhanced magmatism around 4.3 to 4.36 Ga, which may coincide with the SPA basin forming event and to characterize the water content of the magma reservoir.

- Apatite grains found in samples permit analysis of OH in highland rocks
- Barnes J.J et al 2014 measured OH concentrations in sample 14303 between 178 and 2290 ppm. Conclusion is that average H isotope composition of water in lunar samples is similar to terrestrial and chondritic water. Propose a common origin for Earth and lunar water.

“Terrestrial like Zircon grains in a clast from Apollo 14 breccias”

- Bellucci et al 2019, report possible evidence of terrestrial meteorite clast in sample 14321, “Big Bertha”. Conditions of formation for the two grains resemble those on Earth, more than the Moon. Crystals formed in an oxygen rich and possibly water rich environment, more common on Earth. Also pressure require for crystallization makes more sense for a shallower formation on Earth.

Apollo Seismology Results

- Understanding that the Moon has a crust, mantle and core. The core of the Moon is smaller relative to its size, 25%, than the Earth's core is to the Earth, 54%.
- Different seismic sources, meteoroid impacts and moonquakes. Moonquakes occur at depths of 800 to 1000 km and occur at monthly intervals. Measure less than 2 on Richter scale.
- Seismic attenuation on the Moon is different than on Earth. First 20 km of crust are heavily

- Fractured due to impact which causes scattering of seismic waves.
- Below this there is less attenuation as the Moon is cooler and contains less water than Earth.
- Below 1000 km attenuation increases again possibly due to a layer of molten rock.

From Latham, Ewing, Dorman & Lammlein, Science Reports Nov 12, 1971

- “Although the average rate of seismic energy release within the moon appears to be far below that of the earth, over 100 events believed to be moonquakes have been recorded by the two seismic stations installed on the lunar surface during Apollo missions 12 & 14. With few exceptions, the moonquakes are believed to occur at not less than 10 different locations. However, a single focal zone accounts for 80% of the total seismic energy detected. This active zone appears to be 600 km south-southwest of the Apollo 12 and 14 sites deep within the moon. Each focal zone must be small (less than 10 km in linear dimensions) and fixed in location over a 14-month period. Cumulative strain at each location is inferred.”

- “Thus, the moonquakes apear to be releasing internal strain of unknown origin, the release being triggered by tidal stresses.”
- Moonquake activity peaks at monthly intervals from 4 days before to 3 days after perigee. 85% of seismic energy from moonquakes occurs during this time.
- Longer term variations in the moonquake activity - “these variations are similar to the long-term gravity variations...The period of these variations is about 213 days which is in very good agreement with the theoretical 7-month gravity cycle.”

- Review of lunar perigee distances (Geocentric Ephemeris for the Moon) from 2020 to early 2023 seems to show a 7 or 6 month cycle of close lunar perigees.
- Closest lunar perigees occur at or near full or new Moon.
- Announcement in 2019 of ongoing lunar tectonic activity (Watters et al) are related to shallow moonquakes and lunar apogee. The shallow quakes are stronger and less frequent.

THANK YOU
HAPPY NEW YEAR
CLEAR SKIES AND GOOD HEALTH