The Moon

1

“A few interesting things about the Moon”

Things which stood out for me when I read about it.
I was asked, “Is the Moon made of Green Cheese?”
So here we go…
And we’ll start with what I remember from my childhood…

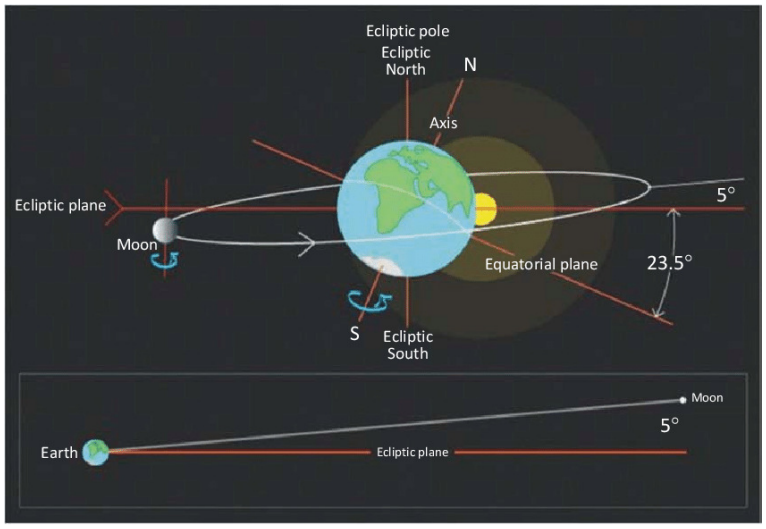
The man in the moon

The man in the moon,
Came down too soon,
And asked his way to Norwich;
He went by the south,
And burned his mouth
By eating cold plum porridge.

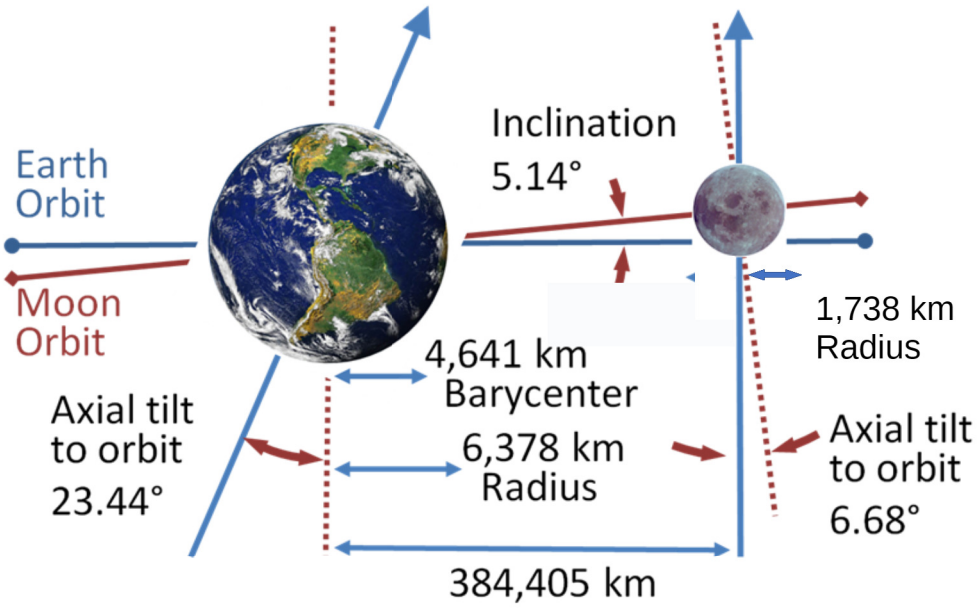
This is how I was brought up to think about the Moon…
But seriously let’s go on...

Moon · Luna · Selene

- 385,000 km away
- Axial tilt 6.7°
- Orbit 27.32 E days
- Temp Max 120°C
- Temp Min -247°C



- So here we have a diagram which shows the Moon and the Earth and their respective orbits and relationships.
- The Moon is called “Luna” in Latin and “Selene” in Greek.
- The word Moon means “month” or “moon” from Old German.
- The Moon moves around the Earth in an elliptical orbit.
- The shape of the Moon is a slightly squashed sphere, similar to the Earth



- And this diagram shows the same information in a slightly different way.
- Note that the Moon and the Earth are shown to scale, but the distance between them is not
- The Barycentre is the centre of mass of the Earth and the Moon combined, and it is the centre of the gravity of the two bodies (combined). They both orbit around this centre which is 4,700 km from the centre of the Earth (that's 73% of the radius).

dimensions

27% Diameter 3,474 km

2% Volume 21.9 x 10^9 km^3

7.4% Surface 37.9 x 10^6 km^2

1.2% Mass 7.35 x 10^{22} kg

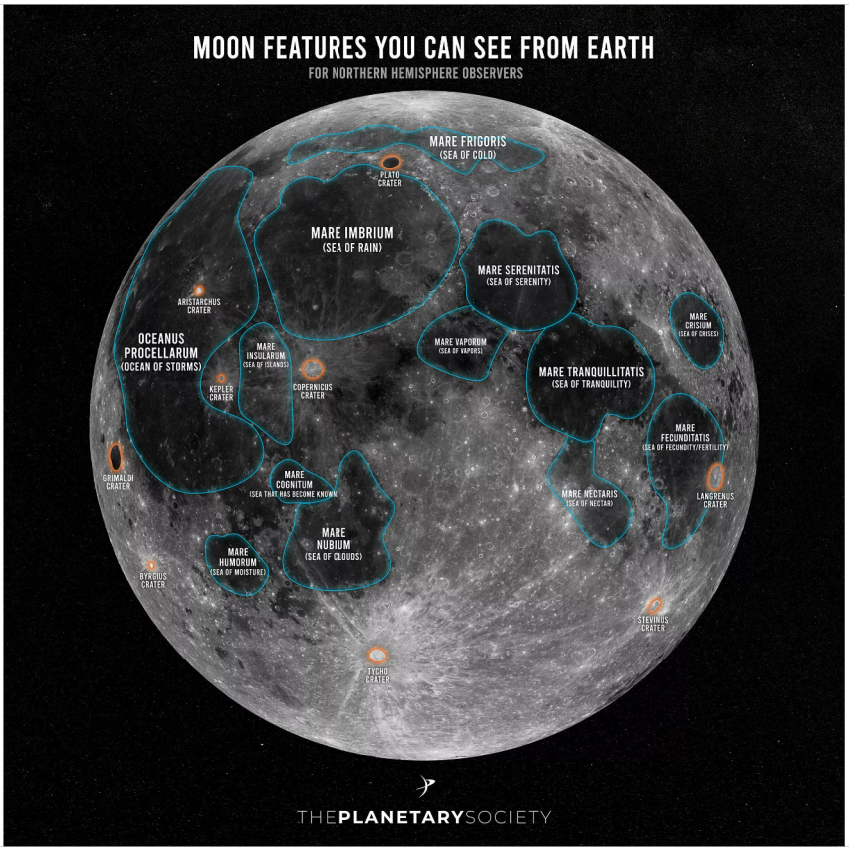
60% Density 3,344 kg/m^3

17% Gravity 1.6 m/s^2

This slide gives the dimensions of the Moon and compares them to the Earth.

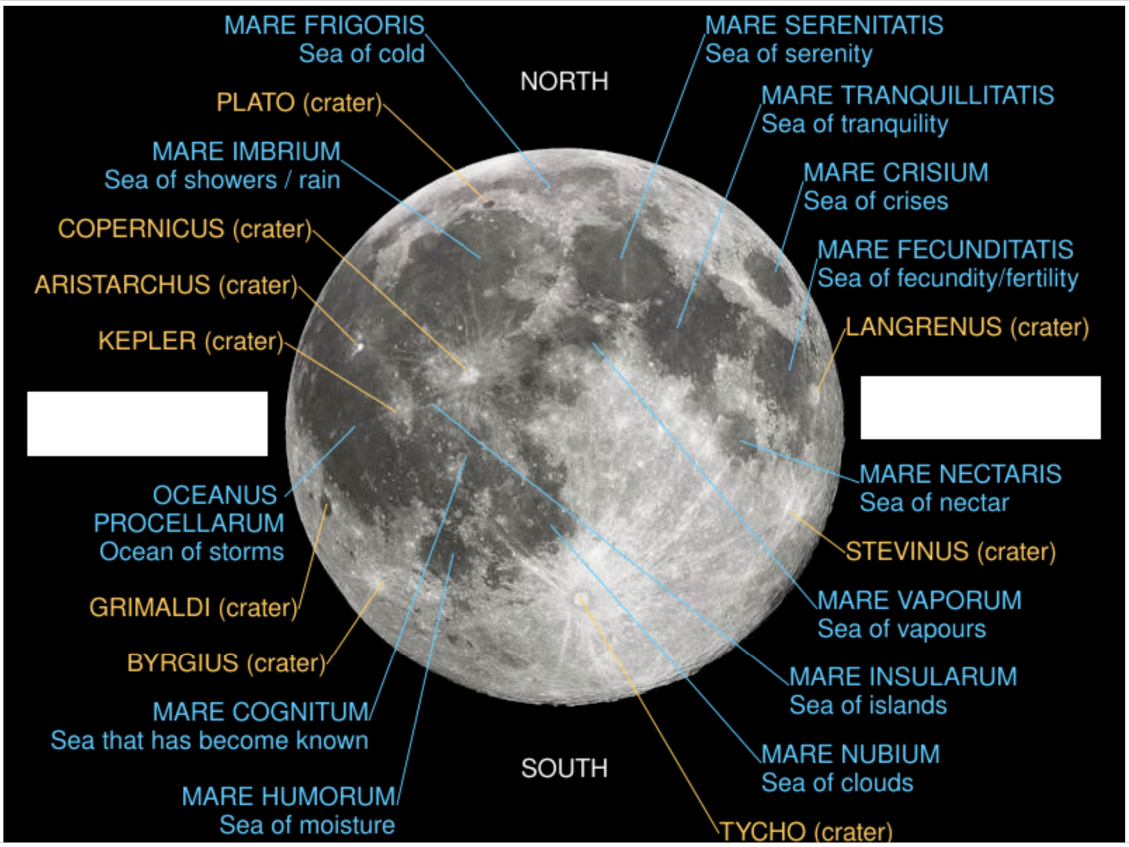
No other Moon in the solar system is bigger in comparison to the size of the planet it orbits.

[Dimensions detail]



The next two slides show some of the features of the Moon that we can see from the earth.

Later I will go on to describe the geographic features.



This shows the features with a little more details as to their names.

The seas called “maria” are shown with blue names

And the craters are shown with yellow names.

The next slide shows that we can actually see 59% of the moon’s surface (not just 50% as you might expect). This is called Libration. And there are three reasons for this:

- The Moon’s orbit is elliptical (not circular)
- The Moon’s axis is not aligned with the Earth’s axis
- There is a variation between the Moon’s orbital speed and it’s rotational rate (due to elliptical path – faster when closest to earth, slower when further away).

Lunar Libration - Animation

Link to animation:

https://commons.wikimedia.org/wiki/File:Lunar_libration_with_phase_Oct_2007_HD.gif

So there you have it.

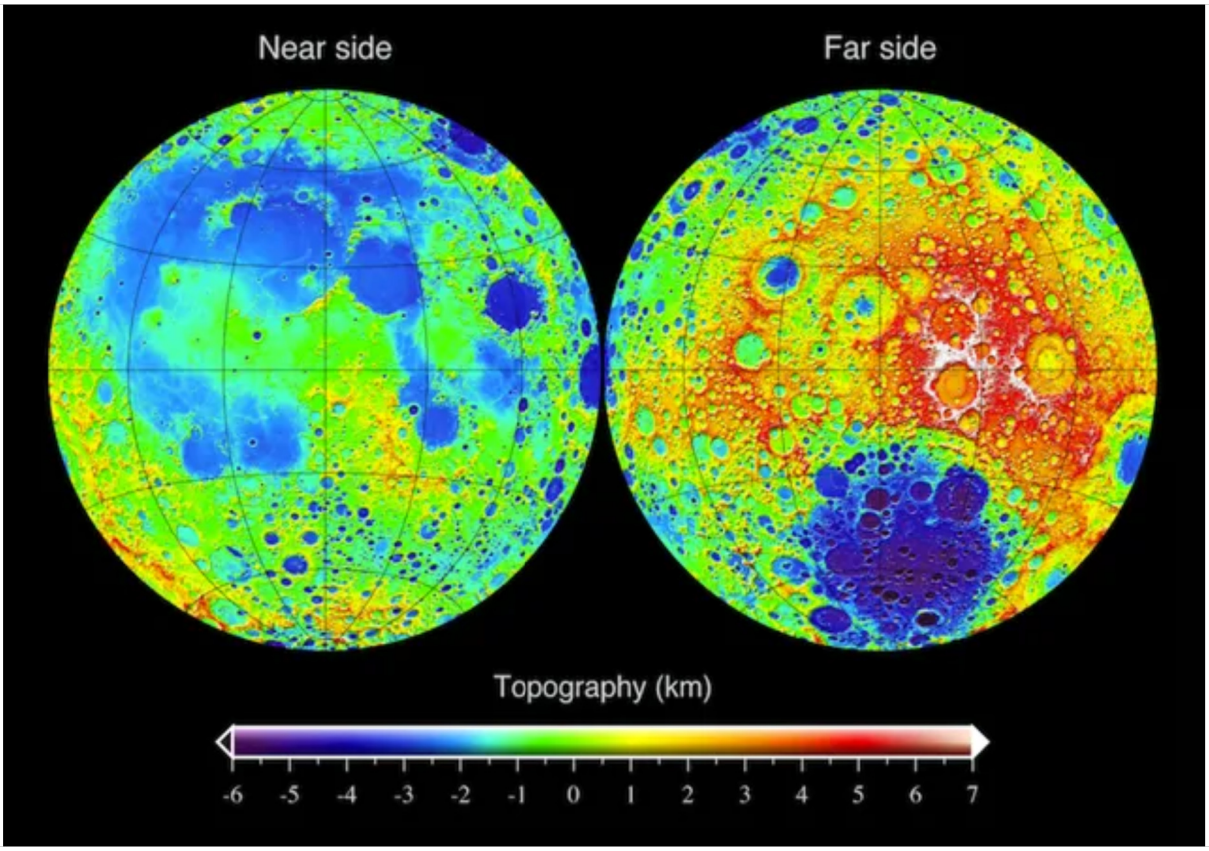
Link to animation:

https://commons.wikimedia.org/wiki/File:Lunar_libration_with_phase_Oct_2007_HD.gif

Landscape

- Mountains
- Ridges
- Craters
- Maria
- Terra
- Rilles
- Domes
- Wrinkle ridges
- Troughs

- Mountains rise up to 8km from the lunar surface
- Craters go down up to 9km from the surface, caused by surface impacts
- The deepest crater is the Aitken basin which is 12km deep from rim to bottom.
- The atmosphere is thin and so there is very little erosion – and the craters remain forever.

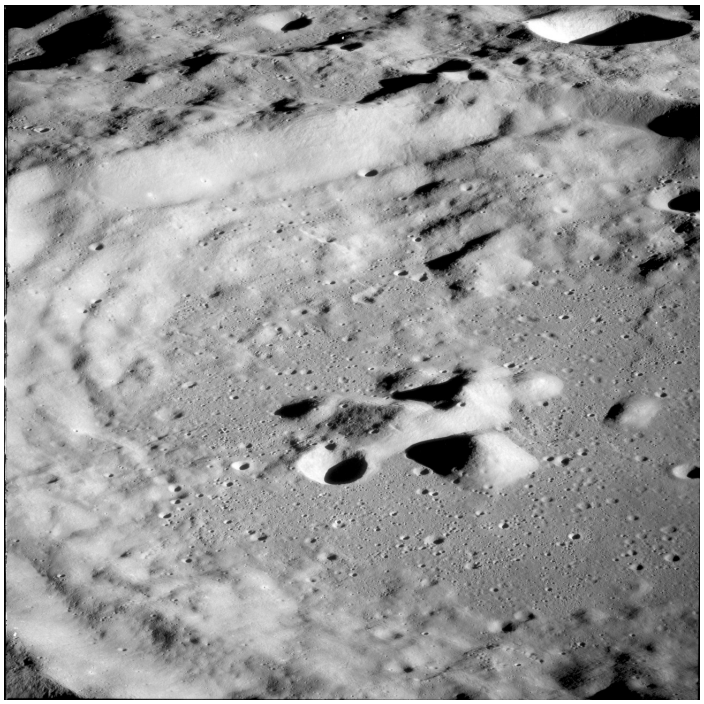


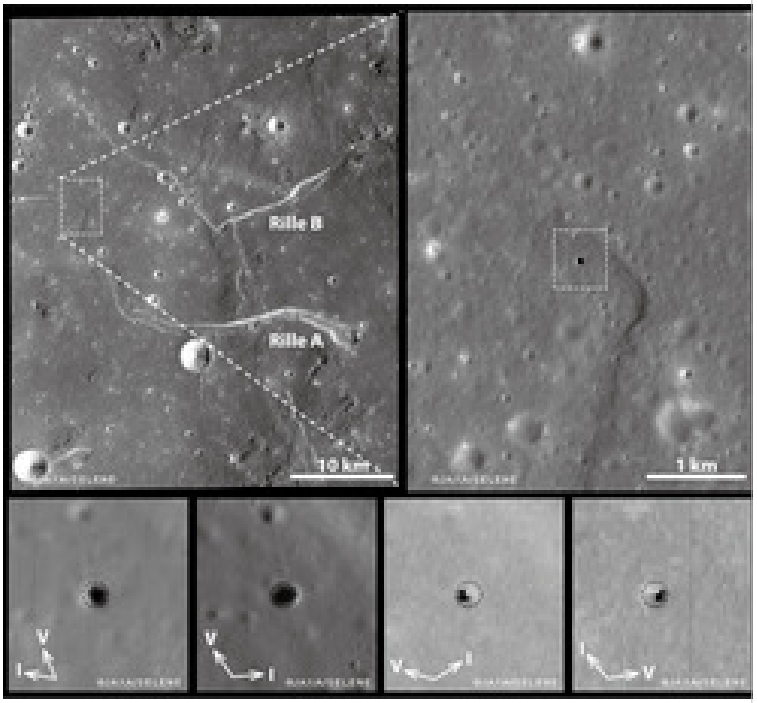
This shows the topography that I have spoken about

As we have already seen the the landscape is visible as two areas – dark areas are maria – seas; light areas are terrae – highlands

The highlands are the parts of the crust that remain (and are highly cratered)

The Maria (originally thought to be full of water), are plains of basalt lava (50% SiO_2) erupted from the core of the Moon, cover 15% of surface



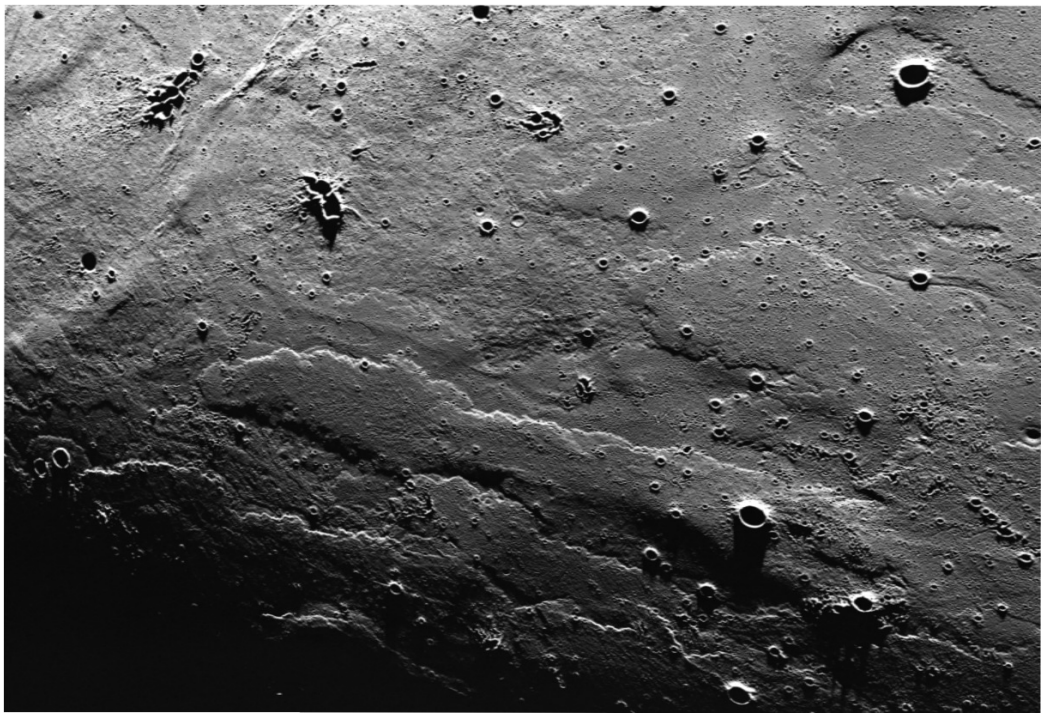


The next two slides some pictures of the fine landscape detail:

- Rilles are grooves or furrows, cracks caused by earlier volcanic activity
- Domes are solidified lava (volcanic) 10-20km diam
- Wrinkle ridges are a result of tectonic activity within lava flows and cooling
- Grabens are troughs – two parallel cracks are stretched by tectonic activity to form a trough

Left Image: A view of a larger crater, the three-kilometre-deep Daedalus on the Moon's far side

Right Image: Sinuous rilles features and lunar tube cave Marius Hills pit as observed under different solar illumination conditions.



Old hardened lava flows of Mare Imbrium forming wrinkle ridges

Environment

- Temp -247 to +120°C
- Gravity 17% of Earth
- Magnetic field
- Thin atmosphere
- Moon day = E month

Temp at poles -50 to – 247°C

Temp elsewhere +120 to -150°C

There are cold traps at the poles

(∴ volatile chemicals may be there)

Gravitational Field

17% of earth's and very lumpy due to concentrations of mass below surface (mascons) due to asteroid impact.

Mag Field: very small, residual magnetism found in rocks on surface

Atmosphere: contains Helium, Argon, Sodium, Potassium

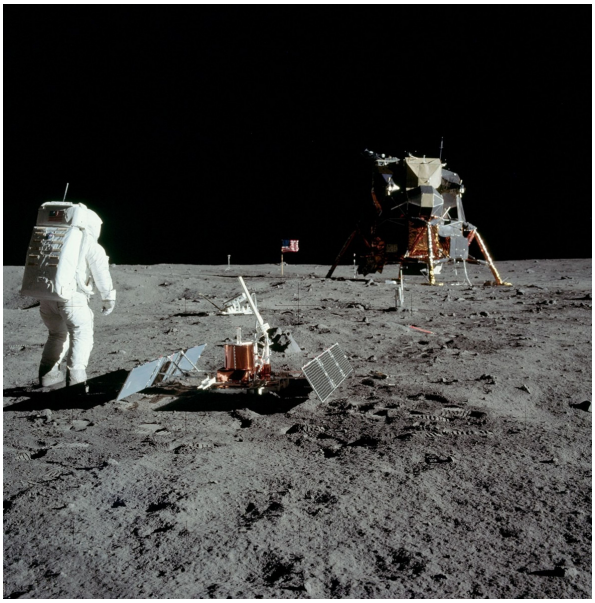
Moon takes 27.3 E days to orbit the Earth & also rotate on its axis

Solar day on Moon is 29.5 Edays (time between sunrises) so Moon has 2 weeks of day, followed by 2 weeks of night.

No seasons (small axial tilt 1.5° relating to the elliptic compared with 23.4° on Earth)

Moonquakes

- Deep quakes
- Meteor impacts
- Thermal quakes
- Shallow quakes



The Moon is seismically active

•Deep quakes (700 km deep) caused by the gravitational bond with the earth

•Meteoric impact vibrations

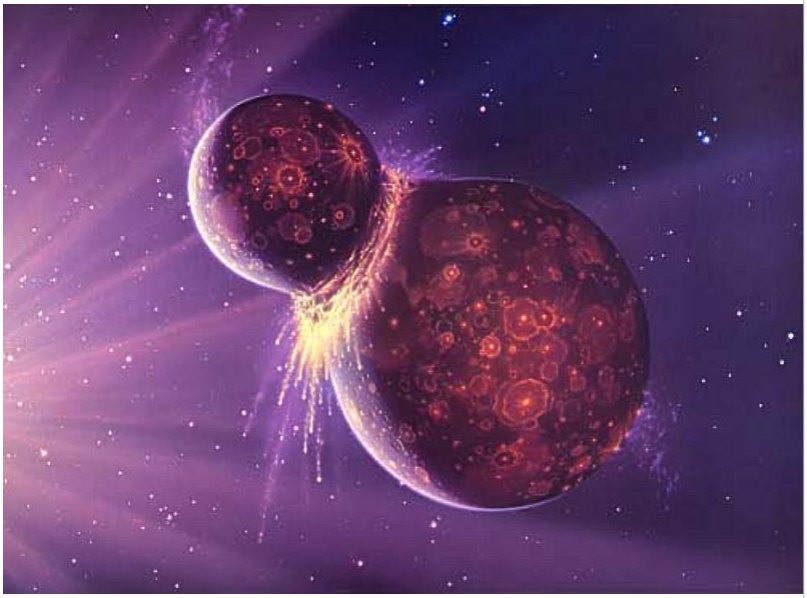
•Thermal quakes – sudden changes in temperature e.g. after the two week lunar night.

•Shallow quakes (50-220km below the surface, last for up to 10 mins)

The first three types are mild, but the shallow ones can register 5.5 on the body wave magnitude scale, occurrence is about 5 times a year.

Formation theories – pre Apollo

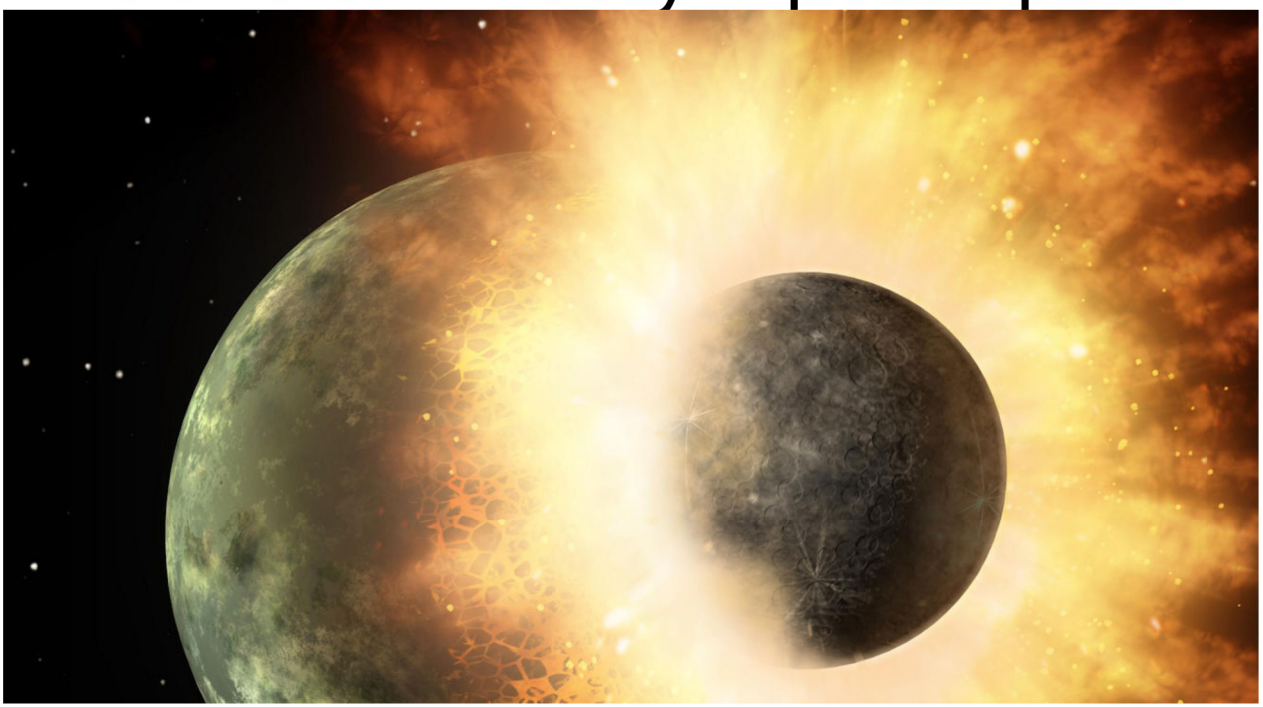
- Moon capture
- Co-Formation
- Seeded from Earth



Early theories (pre Apollo):

- Moon Capture – a passing large asteroid captured by the Earth's gravitational field.
- Co-Formation – formed at same time as Earth in one event. Formed out of an "accretion disk" – a spinning disk of materials containing gas plasma and particles orbiting a central body, e.g. the Sun. Over time it separates into bands and clumps together to form two bodies, Earth and Moon. The Moon is then captured by the Earth's gravitational field causing it to orbit round the Earth. This theory is one which explains why the Earth and the Moon have similar compositions.
- Seeded from Earth – the early Earth spins so fast that a lump spins off and forms the Moon.

Collision Theory – post Apollo



Collision Theory – a small planet collides with the Earth in a glancing blow. This sends molten material away from the Earth which coalesces to form the Moon.

I’m now going to show you a computer simulation of this theory.

How did the Moon form?
The Collision Theory

https://www.youtube.com/watch?v=kRlhlCWplqk&t

Please ensure SUB-TITLES are OFF, and SOUND is OFF

[Animation]

https://www.youtube.com/watch?v=kRlhlCWplqk&t

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[University of Durham – Super Computer Simulation]

History of the Moon

- 4½ billion years old
- 4 billion years ago period of meteor and asteroid activity causing craters etc.

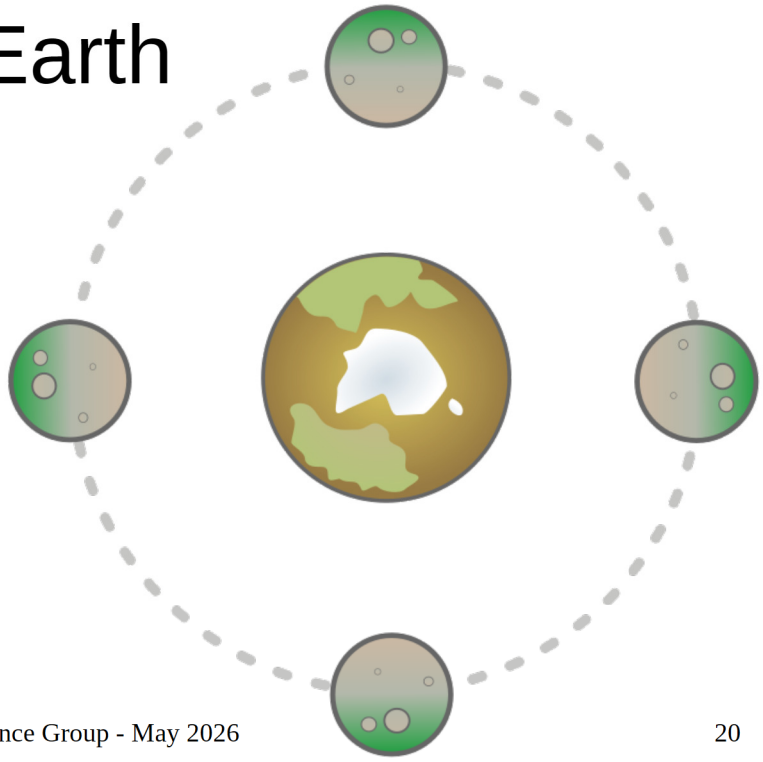
The moon is thought to have been created about 4½ billion years ago. {Age of the earth 4.54 billion years} So the Moon was created about 40 million years after the Earth.

And then, ½ a billion years (500 million years) later there was an extended period of meteor and asteroid activity which caused the craters and other moon geographic features.

The next section is about how the Moon affects the Earth

Moon affects Earth

- Tidal locking
- Tides
- Life creation
- Spin speed control

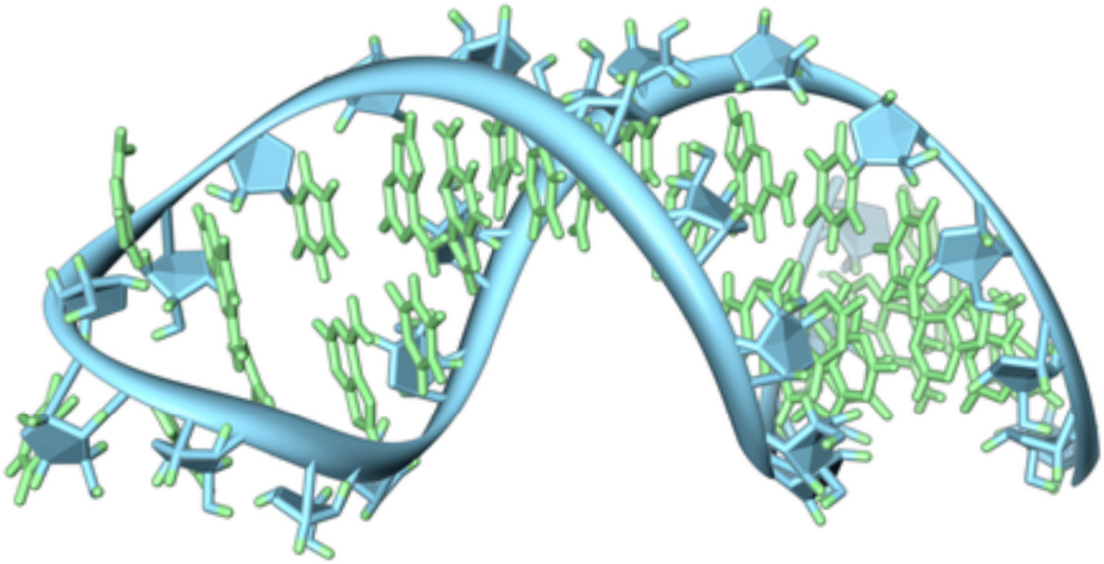


- Tidal Locking – this means that the Moon is locked to the Earth in the sense that the Moon always presents the same face to the Earth and as such it is locked to it.

This happened during the early life of the Moon, as each part of the Moon was in close proximity to the Earth it was deformed by the gravitational pull, creating bulges which acted as gravitational handles. Pulling on these caused the Moon's rotation to slow down until the bulges were always in the same place and at that point the Moon was tidally locked to the Earth.

- Tides – are the bulge of water on Earth, but why are there two high tides each day? There are two factors: the gravitational pull of the Moon, & the centrifugal force created by the Earth, which pulls away from the centre of rotation. The Sun's gravity also affects the tides but to a much smaller extent. At the new Moon and the full Moon, the Moon and the Sun are both pulling in the same direction, causing the highest monthly tides (called "spring" tides – opposite are the smallest or "neap" tides).

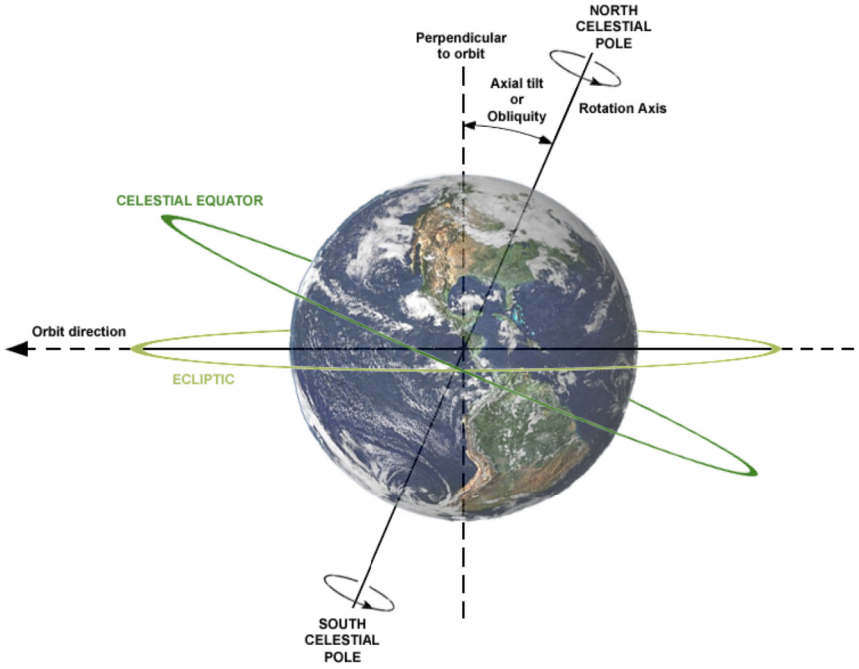
Moon Creates Life on Earth



Take 3 gases – H_2, H_2S, CH_4
Mix and heat up to high temperature
Add electrical discharge (lightning)
►amino acids (basis of proteins)
[this is the Miller-Urey experiment]

Let's go back to 500 million years after the formation of the Moon. The Moon is much closer to the Earth (than it is now) there are enormous tides, land is covered by water which recedes twice a day. Minerals are deposited in pools, the Sun evaporates the pools and the chemicals become concentrated, process repeats daily. If you take primordial chemicals and heat them up and evaporate and repeat and add UV light (from Sun) you can create RNA.

Moon Controls Earth's Spin Speed



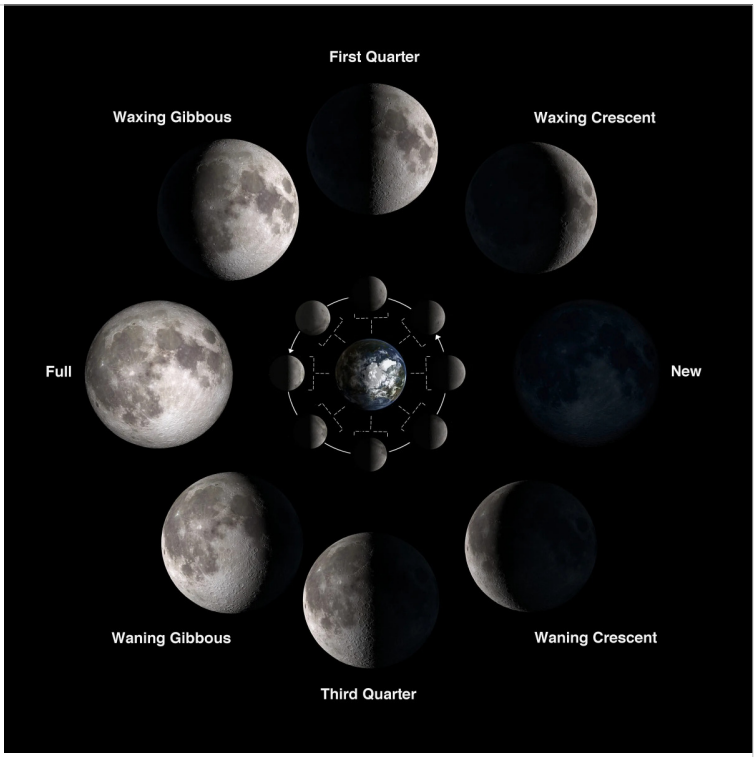
The Moon is drifting away from the Earth by about 3.78cm/year. This is because the Moon is speeding up and as a result the Earth is slowing down. Gravity causes bulges on the Earth & Moon, on the Moon the effect is to pull the core off-centre, on Earth it mainly affects the tides. On the Earth the tides lag behind the Earth's rotation and this slows down the Earth.

On the Earth – the Earth is rotating and pulls at the tidal bulge taking it out of alignment with the Moon, and cause it to sit ahead of the Moon. As this water has a significant mass, it exerts a small gravitational pull on the Moon – effectively causing the Moon to speed up. So the tidal bulge effectively slows the Earth and speeds up the Moon. This process is known as the conservation of angular momentum. [For a linked system e.g. Earth & Moon, angular momentum cannot be created or destroyed.] So if one body slows down, the other speeds up.

If we look back 400 Million years (to the Devonian period) an Earth day was 21 hours 54 minutes. So the Earth has slowed since then.

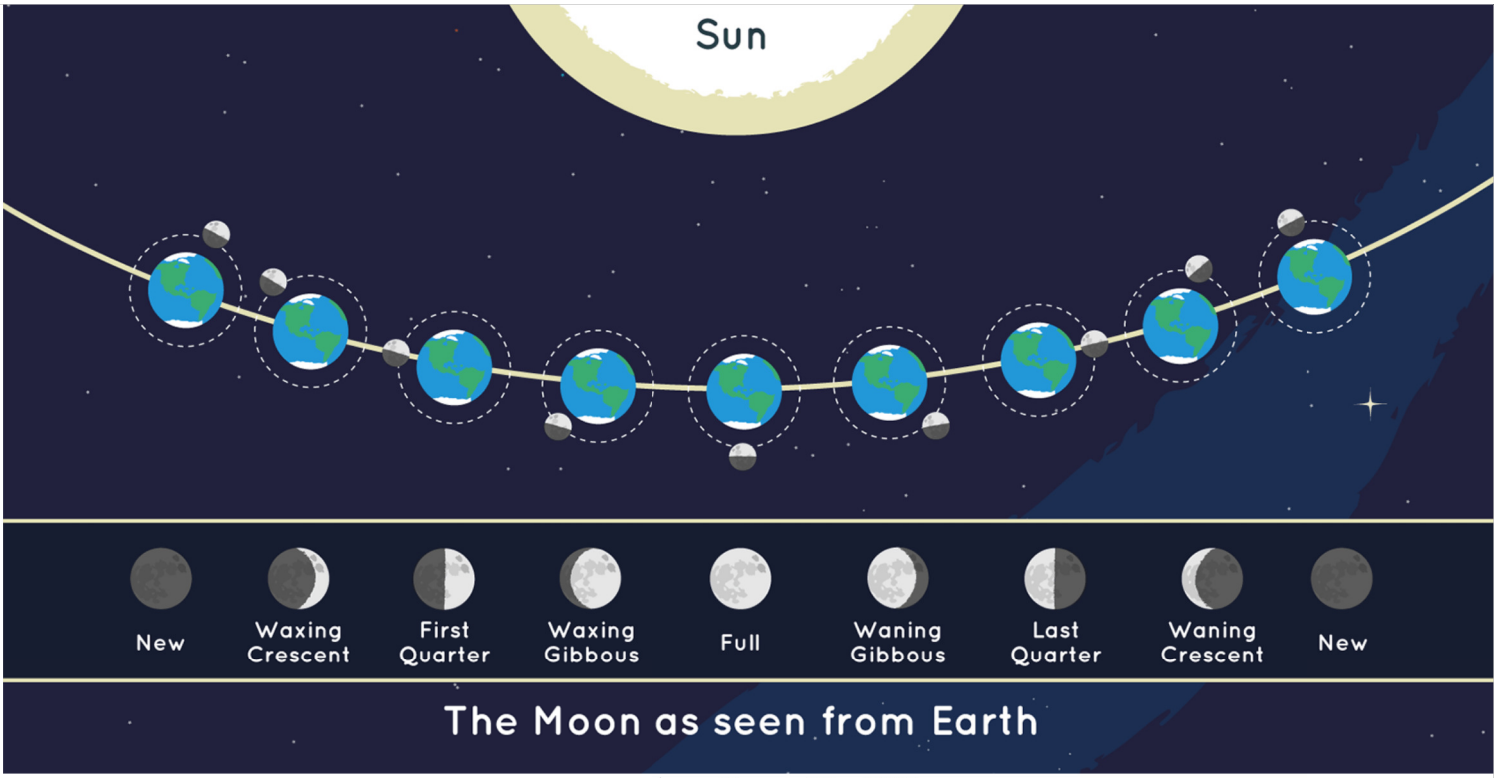
In a billion years the Moon will no longer exert enough gravitational pull on the Earth to keep the Earth in a stable position – at this point the Earth may flip and the poles may move significantly.

Phases of the Moon



The Moon is locked to the Earth so we always see the same face. As the Moon travels around the Earth each month we see a sequence of partial amounts of the moon as it passes through its different phases:

New Moon, waxing crescent, first quarter
Waxing gibbous, Full Moon
Waning Gibbous, third quarter, waning crescent
New Moon



Another diagram showing the phases

And an animation

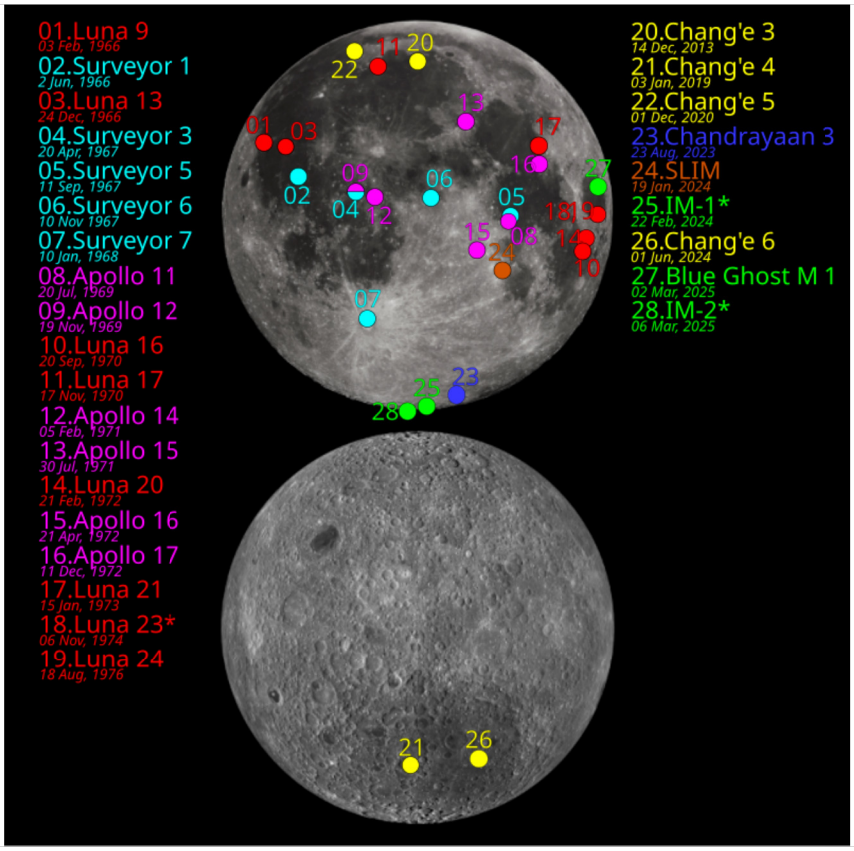
Phases of the Moon - Animation

https://www.youtube.com/watch?v=LHD4Pk0D8_g

[Animation]

https://www.youtube.com/watch?v=LHD4Pk0D8_g

Missions And Landing Sites

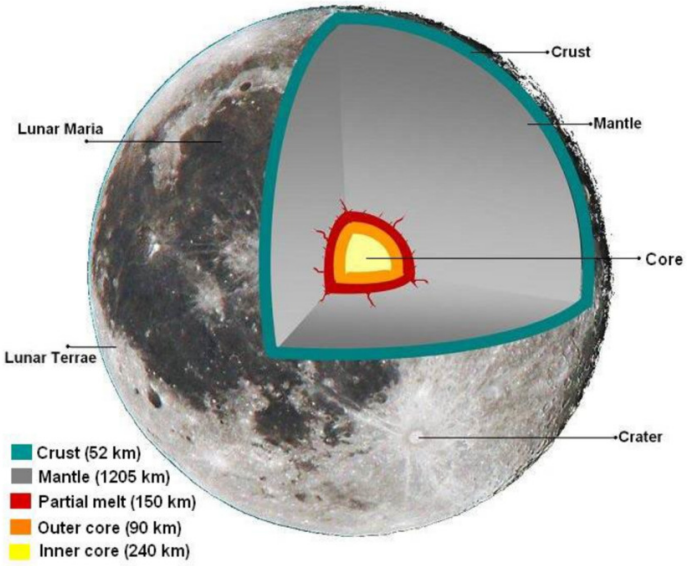


This shows the various landing sites of the moon missions.

Recent ones are looking at the South Pole as a possible Moon Base where water vapour and/or ice may be present.

Internal Structure

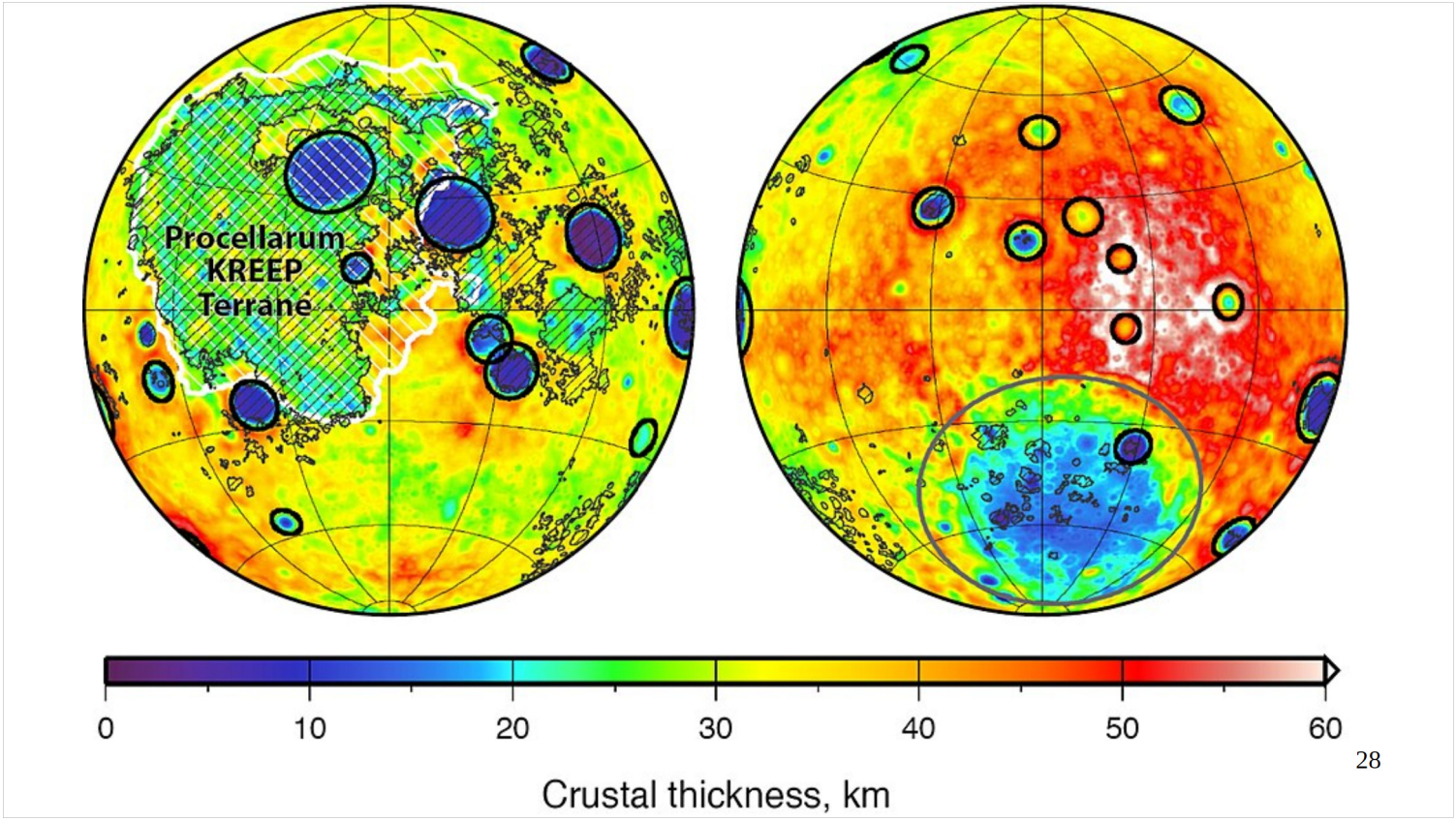
- Core (90 + 240 km)
- Partial Melt (150 km)
- Mantle (1205 km)
- Crust (52 km)
- Regolith (“soil”)



- Core is yellow and orange at the centre
- Partial melt is red
- Mantle is the huge grey area
- Crust is the dark edge

- Core is mostly Iron
- Mantle is a mixture of Basalt, Olivine and Pyroxene
- Regolith is the “soil” fragments of rock caused by impacts. Boulders to tiny fragments.

O_2, Si, Fe, Ca, Al, Mg (Ti, Th, Mn)



This slide shows the thickness of the crust

Map of the Moon coloured by the thickness of the crust, with main regions marked.

Potassium, rare earths, and phosphorus are lumped together in the term KREEP

The KREEP rich magma terrane (hatched), with its most prominent part labelled on the near side (left), the Mare Procellarum KREEP Terrane (PKT).

The South Pole–Aitken Terrane (SPAT) is marked on the far side (right, largest circle).

The 24 crater basins with crustal thinning greater than 200 km (120 mi) are marked (black circles) across both hemispheres.

The rest is the high-thickness Felspathic Highlands Terrane (FHT; red and white).

The Mantle

- Basalt
- Olivine $(Mg,Fe)_2SiO_4$
- Pyroxene

Basalt is a fine grained extrusive igneous rock formed from the rapid cooling of lava and is rich in magnesium and iron. Image is of Columnar basalt formation in Boyabat, Sinop Province, Turkey.

The mineral Olivine is a magnesium iron silicate with the chemical formula $(Mg,Fe)_2SiO_4$. [Mg and Fe can substitute for each other in any ratio. It is a type of nesosilicate or orthosilicate. The primary component of the Earth's upper mantle, it is a common mineral in Earth's subsurface, but weathers quickly on the surface. Olivine has many uses, such as industrial applications like metalworking processes.

Pyroxene consists of silicon, aluminium, oxygen, calcium, iron/(or)/sodium, (titanium sometimes)

Chemical composition of Moon Rocks

	maria	**highlands**
Al_2O_3	15%	24%
CaO	12%	16%
Fe_2O_3	14%	6%
MgO	9%	7½%
TiO_2	4%	½%
Na_2O	½%	½%

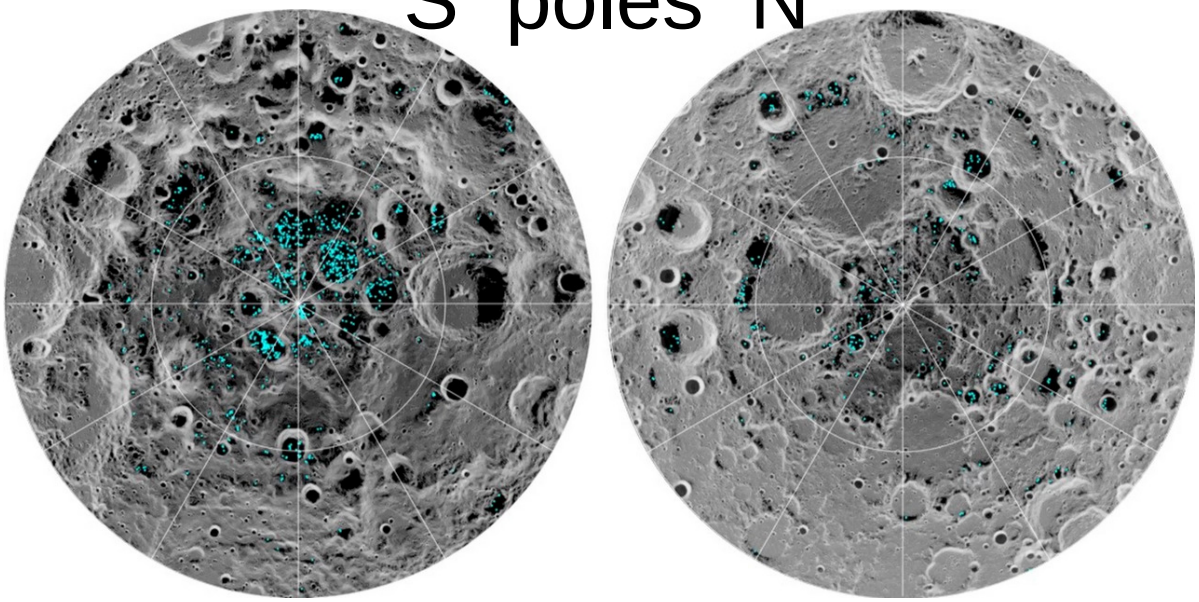
This slide shows the make up of the rocky material on the Moon, possibly suitable for exploitation.
[run through list]
The calcium is in the form of lime
And the Ferric Oxide is in the form of rust and hemaetite (iron ore)

Helium 3 is also thought to be present on the Moon in large quantities in the Regolith. It is produced by fusion processes on the Sun and is distributed by solar wind. It is expected to be a good source of fuel for fusion reactors to create energy. It is not radio-active. However, you would need to mine over 150 tonnes of regolith to obtain one gram of helium-3 .

There is also a concentration of rare earth metals on the surface.

Ice on the Moon

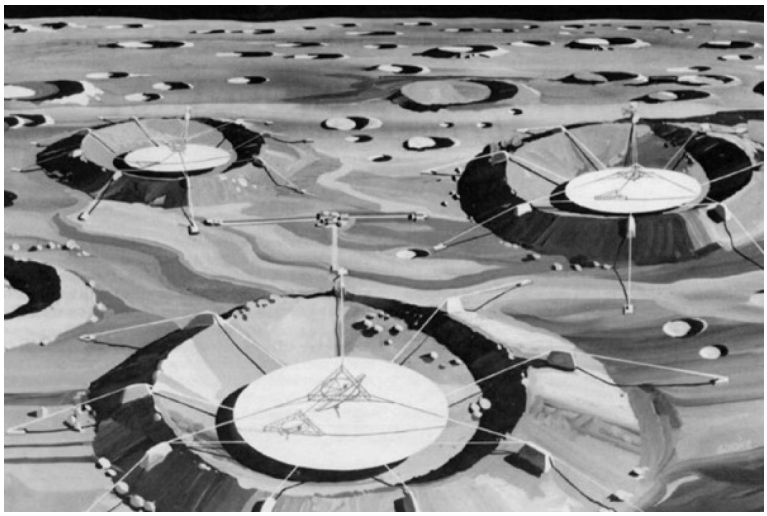
S poles N



This photo shows where Ice is thought to be present.

Future projects

- Optical telescope
- Radio telescope
- Solar farm
- Looking for water/ice
- Moon base



Future projects include:

An optical telescope – avoids Earth's atmosphere – avoids light pollution – maybe hide it in a crater.

A radio telescope – avoids problem of radio activity on Earth – also avoids problems of the Earth's ionosphere (this has the effect of reflecting low frequency signals (less than 5MHz) back into space). Also we want to look at signals from space – on Earth signals greater than 30GHz are affected by water vapour and CO_2 in our atmosphere.

A solar farm – creating power for Moon base – could beam energy back to Earth via microwaves. Good location, lots of sun, no atmosphere.

Looking for water and ice (needed for Moon Base)

Sources and Acknowledgements

- Main sources:
- Sky at Night Book of the Moon – Maggie Aderin-Peacock
- The Moon – a History for the Future – Oliver Morton
- For details of images and sources, see separate document

For details of images and animations used in the slides please see separate document.

The End

Thank you for listening.
I will attempt to answer any questions.
I will be putting copies of the slides, notes and image sources on the U3A web-site.

U3A Moon Presentation – May 2026 – Image sources and credits

Slide #	Slide Title	Wikipedia page	Image Title/File Name	Author Name	License Name/Source	Access Date	Notes
1	The Moon	The Moon	Full Moon Photograph	Gregory H Revera	Wikimedia Commons	25MAY2026	
2	The Man in the Moon	The Man in the Moon	The Man in the Moon	Anonymous	Public Domain	01JUN2026	amended
3	Moon-Luna-Selene		Illustration of the Moon's orbital plane around the Earth and rotational axes of Earth & Moon		"Fair Use", Researchgate.net	25MAY2026	
4	Barycentre	Orbit of the Moon	Earth-Moon.PNG	NASA	Public Domain	25MAY2026	edited
5	Dimensions		Earth & Moon		"Fair Use", Britannica	25MAY2026	
6	Visible Features 1		Moon Features Seen From Earth	NASA	Public Domain, Planetary Society	25MAY2026	
7	Visible Features 2	Near Side of the Moon	Moon names.svg	Peter Freiman	Creative Commons	25MAY2026	edited
8	Libration	Link to animation: https://commons.wikimedia.org/wiki/File:Lunar_libration_with_phase_Oct_2007_HD.gif				25MAY2026	amended
9	Landscape		No Image				
10	Topography	Seleno-graphy	Moontopolola.png	Mark A. Wieczorek	Creative Commons	25MAY2026	
11	Near & Far Sides		The Moon's nearside and farside	NASA	Public Domain, Planetary Society	25MAY2026	
12a	Topography Detail 1	The Moon	Daedalus crater AS11-41-6151.jpg	NASA	Public Domain	25MAY2026	
12b		The Moon	LROC202 - KaguyaTerrainCamera 039.png	NASA	Public Domain	25MAY2026	

	Slide Title	Wikipedia page	Image Title/File Name	Author Name	License Name/Source	Access Date	Notes
13	Topography Detail 2	The Moon	AS15-M-1558).png	NASA	Public Domain	25MAY2026	
14	Environment	The Moon	AS11-40-5903.jpg	NASA	Public Domain	25MAY2026	Buzz Aldrin
15	Moonquakes	The Moon	GPN-2000-001102.jpg	NASA	Public Domain	25MAY2026	Aldrin looks back at Tranquility Base
16	Formation Theories		The Giant Impactor Theory	Joe Tucciarone / NASA	Public Domain	25MAY2026	
17	Collision Theory	Giant-impact hypothesis	172555.jpg	NASA	Public Domain	25MAY2026	
18	Collision Theory	Link to animation: n.b. turn sub-titles OFF, sound OFF https://www.youtube.com/watch?v=kRlhlCWplqk&t			Public Domain	25MAY2026	NASA Animation
19	History	The Moon	*Voyage dans la lune*	Georges Méliès (1861–1938)	Public Domain	25MAY2026	
20	Moon Affects Earth	Tidal Locking	Synchronous rotation.svg	Smurrayinchester	Creative Commons	25MAY2026	
21	Moon Creates Life on Earth	RNA	Pre-mRNA-1ysv-tubes.png	Vossman	Creative Commons	25MAY2026	
22	Moon Controls Earth's Spin Speed		Earth's Axis of Rotation	CK - 12	"Fair Use", CK-12	25MAY2026	
23	Phases of the Moon 1		Phases of the Moon	NASA/Bill Dunford	Public Domain	25MAY2026	

	Slide Title	Wikipedia page	Image Title/File Name	Author Name	License Name/Source	Access Date	Notes
24	Phases of the Moon 2		Moon as seen from Earth	NASA	Public Domain	25MAY2026	
25	Phases of the Moon	Link to animation: https://www.youtube.com/watch?v=LHD4Pk0D8_g		Phil Hart	“Fair Use”	25MAY2026	Animation
26	Missions & Landing Sites	The Moon	Moon Soft Landings.svg	EnzoTC	Creative Commons	25MAY2026	
27	Internal Structure		Internal_Structure_of_the_Moon.JPG	IqbalMahmud	Creative Commons Researchgate.net	25MAY2026	
28	Crustal Thickness		Moon – crustal thickness	NASA (GRAIL) S. Miljkovic	Public Domain	25MAY2026	
29	The Mantle	Basalt Rocks	Boyabat.jpg	Lagrima	Creative Commons	01JUN2026	amended
30	Moon Rocks Composition		No Image				
31	Ice on the Moon	The Moon	Surface Ice Distribution	NASA - Moon Mineralogy Mapper	Public Domain	25MAY2026	
32	Future Projects		Radio telescopes	NASA	Public Domain Astronomy.com	25MAY2026	
33	Sources & Acknow-ledgements		No Image				
34	The End	The Moon	Eclipse of the Moon	NASA	Public Domain	25MAY2026	