

Moon Formation / Processes



By the Lunar and Planetary Institute

For use in teacher workshops

How are they different?

Earth



7930 miles (12,756.3 km)
diameter

23 degree axis tilt (seasons!)

Surface temps -73 to 48 C (-100 to 120 F)

Thick atmosphere, mild
greenhouse effect

Liquid water – lots! - at
surface

Moon



2160 miles (3476 km)
diameter

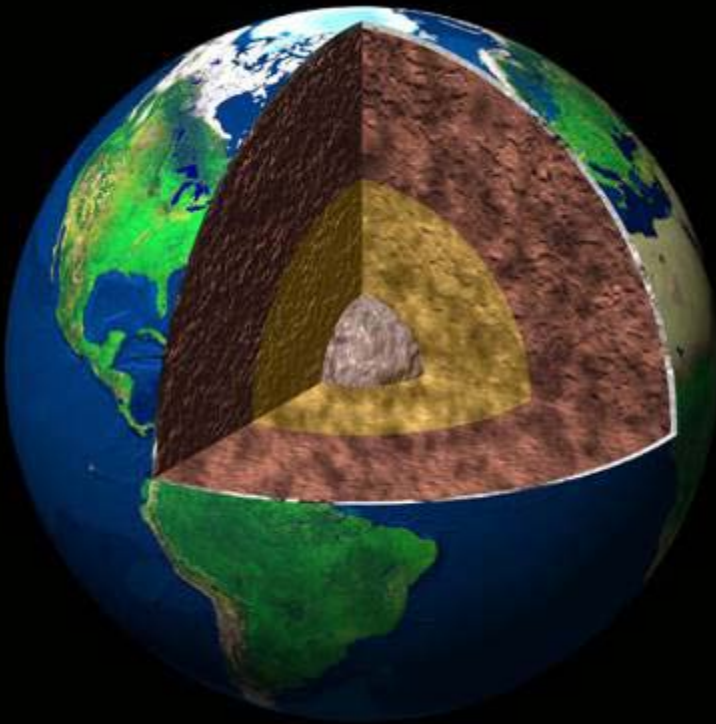
7 degree tilt (\sim no seasons)

Surface temps - 107 C to -153 C (224 F to -243 F)

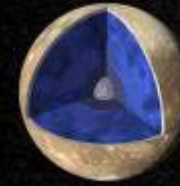
No atmosphere

No liquid water ... Ice at
poles in shadows?

Earth



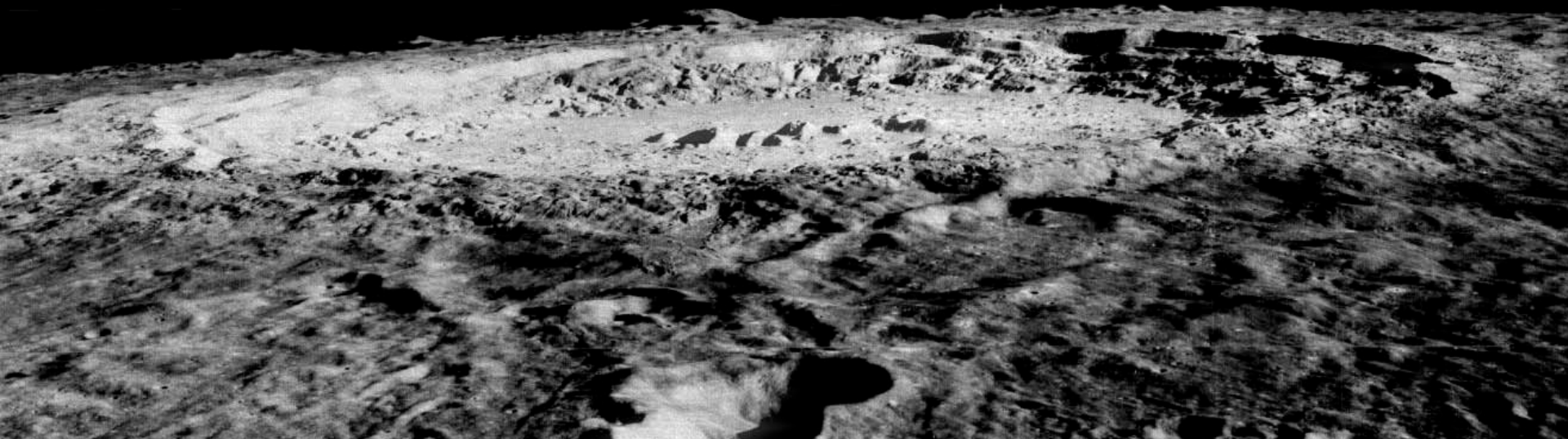
Moon



No Magnetic Field
Small Moon Quakes
Small, Offset Core

Earth's Moon

- How did our Moon form?
- What's been happening since?



A few data to ponder

Lower density – “lighter” -
relative to planets

Less iron than whole Earth,
more aluminum and
titanium

Moon's chemical signature ~
Earth's mantle



A few more data to ponder

Does not orbit in equatorial
plane of Earth, or ecliptic

Earth/Moon - high angular
momentum



How Did the Moon Form?

Lunar Formation Models

The moon is a sister world that formed in orbit around Earth as the Earth formed.

The moon formed somewhere else in the solar system then was captured into orbit around Earth.

Early Earth spun so fast that it spun off the moon.

Impact by *Mars-sized* proto-planet

4.5 billion years ago

Explains:

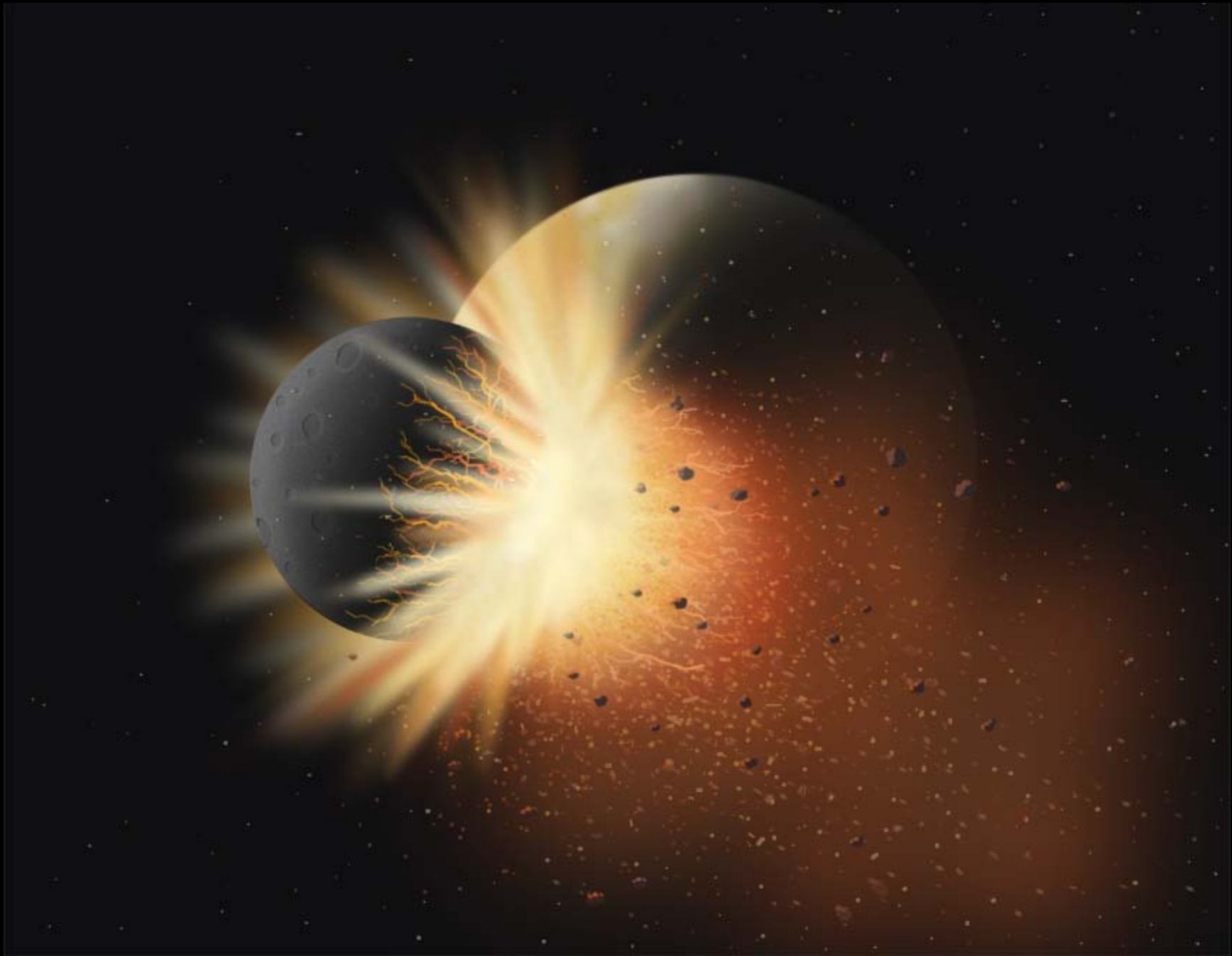
- Chemistry
- Orbit
- High angular momentum

NATURAL
HISTORY

S2



4/81







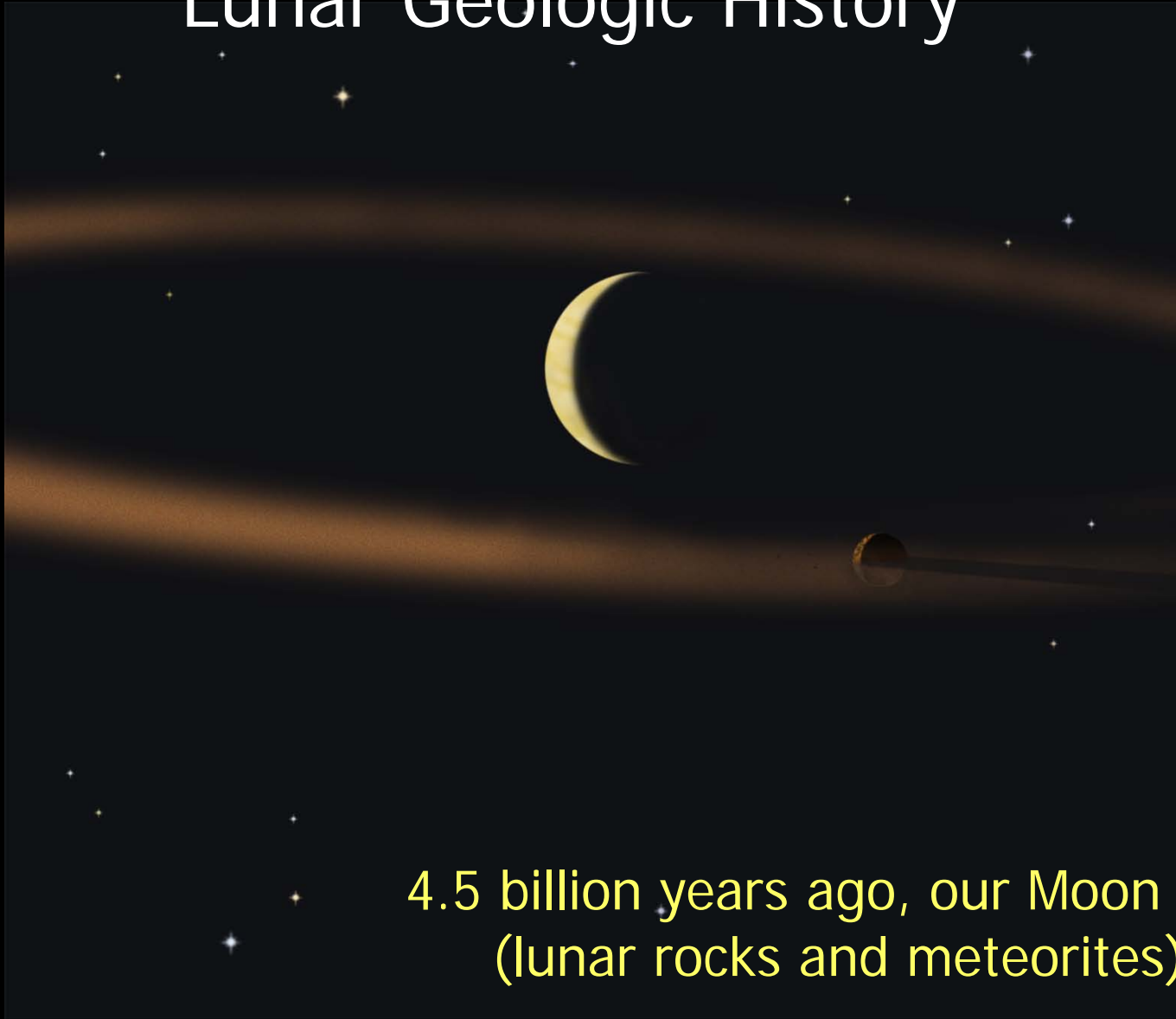




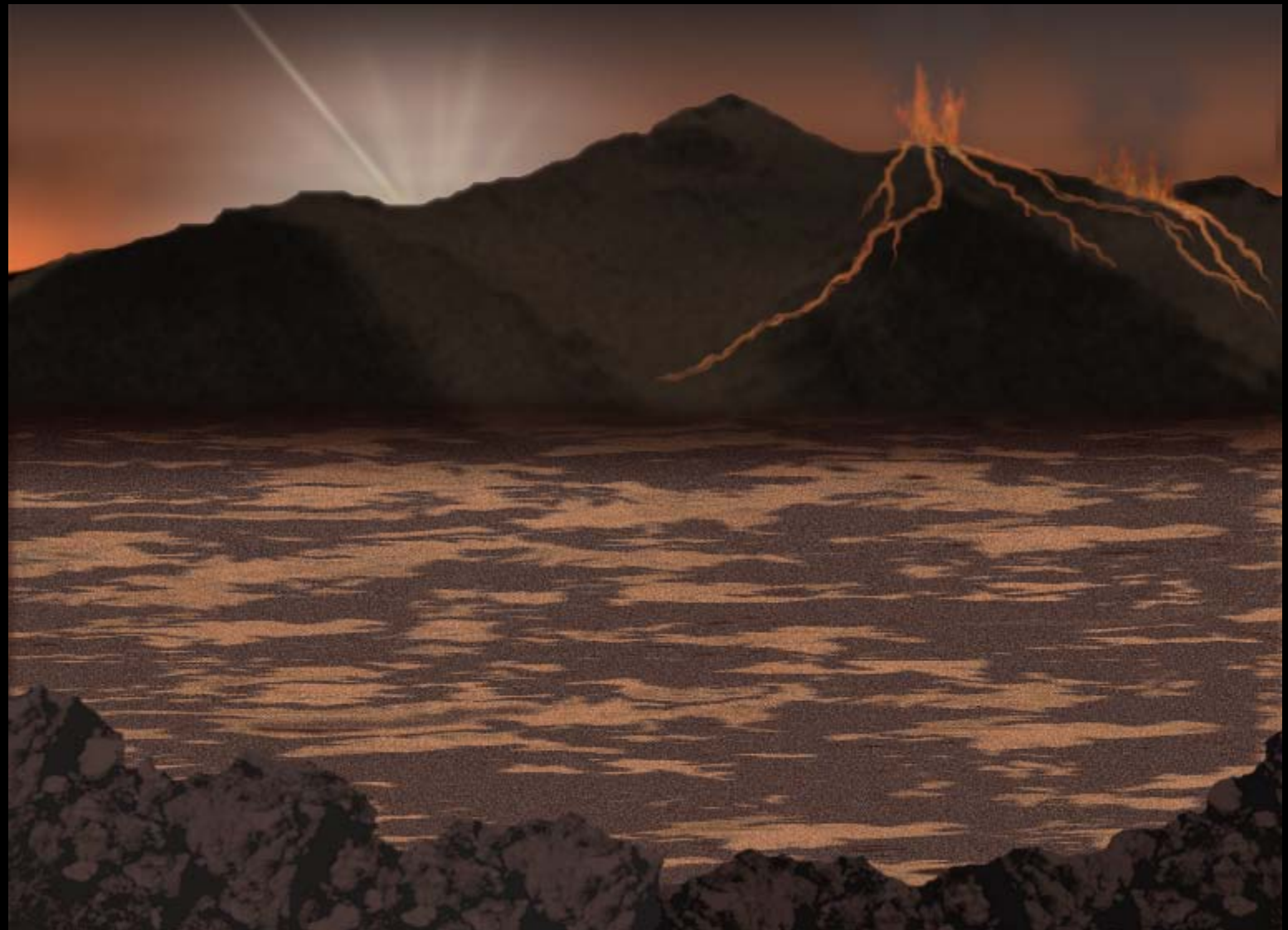
Lunar Geologic History



Lunar Geologic History



4.5 billion years ago, our Moon forms
(lunar rocks and meteorites)



Magma Ocean Rocks



76535
Troctolite
4.2-4.3 Ga

Apollo 17 troctolite 76535

60025
Anorthosite
4.44-4.51 Ga
95% Plag Feld (anorthite)
Magma Ocean!
No Water!



1 cm

NASA/Johnson Space Center photograph

Lunar Geologic History

Highlands - light, rough
(Terrae)

Mostly anorthosite

(plagioclase feldspars -
lots of calcium and
aluminum)

“In place” rocks are 4.5
to 4.3 billion years old

BIG Dark areas?



Lunar Impact *Basins*



Imbrium Rim

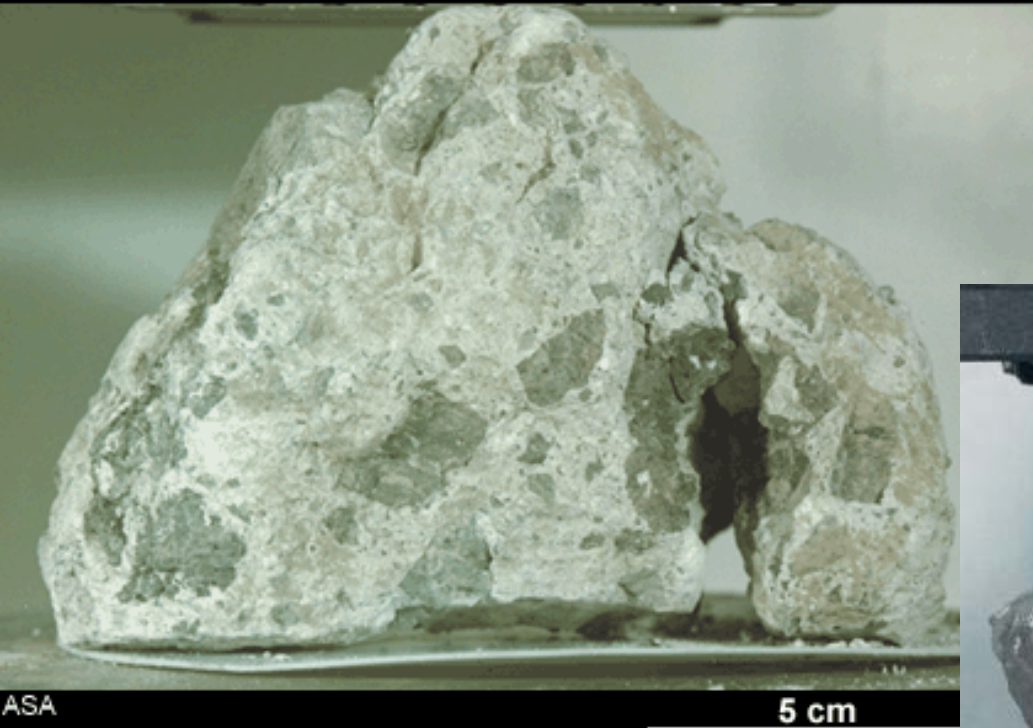


Orientale Basin

Big, frequent impacts until 3.8 billion years ago
Impact events continue on all moons and planets today

Breccias and Impact Melts

Apollo16 breccia 67016



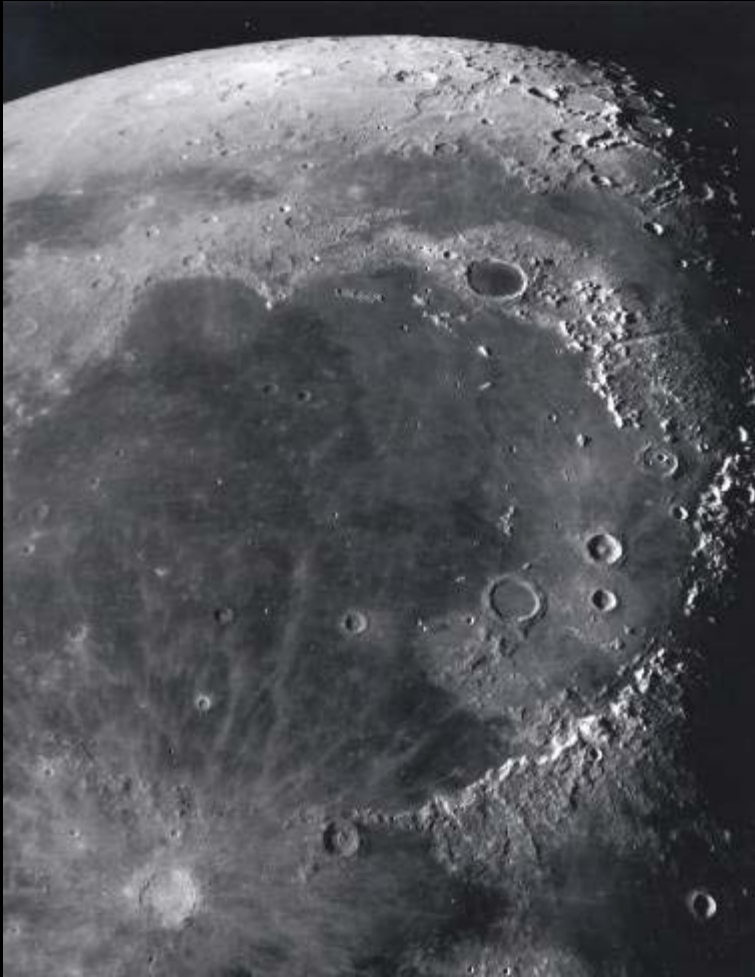
67016
Polymict Breccia

15445
Impact melt + clasts



Lunar Geologic History

Mare Volcanism



Mare Imbrium



SW Mare Imbrium

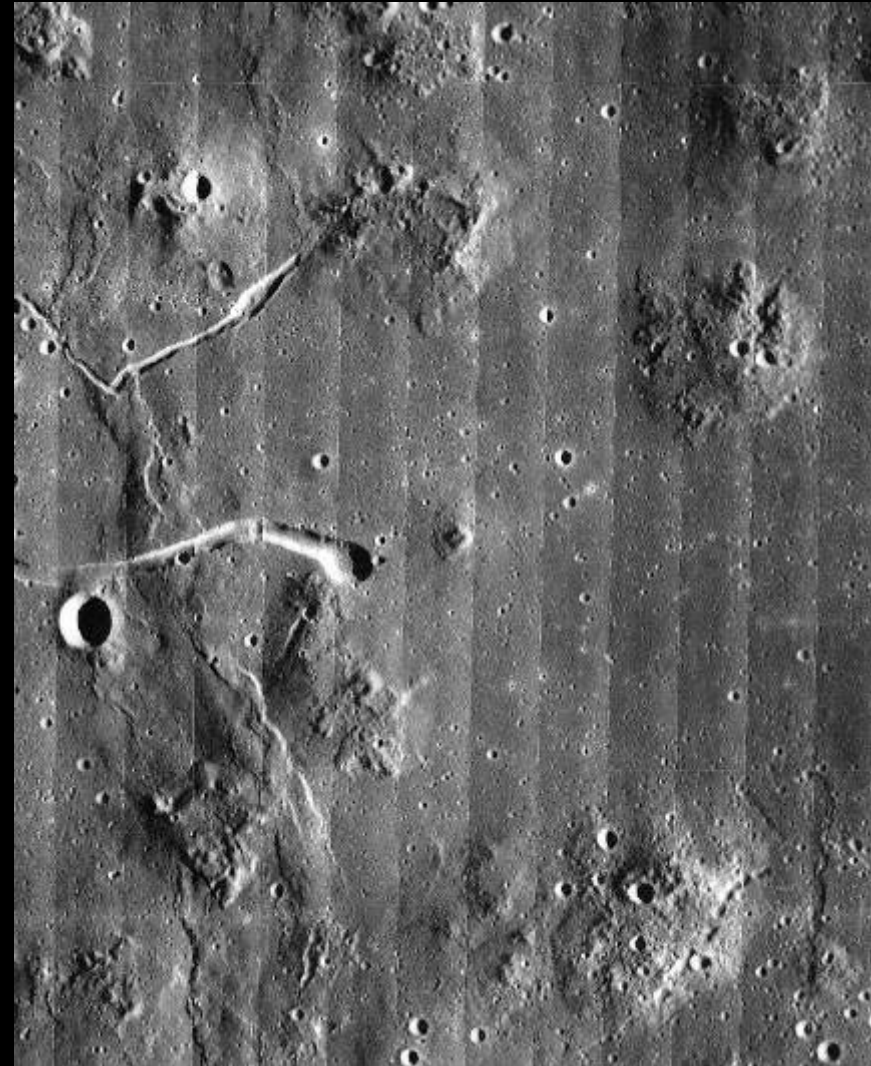
Volcanism *after* impacts – most before 3 Ga (to 1 Ga)



Lunar Volcanism



Aristarchus
Plateau



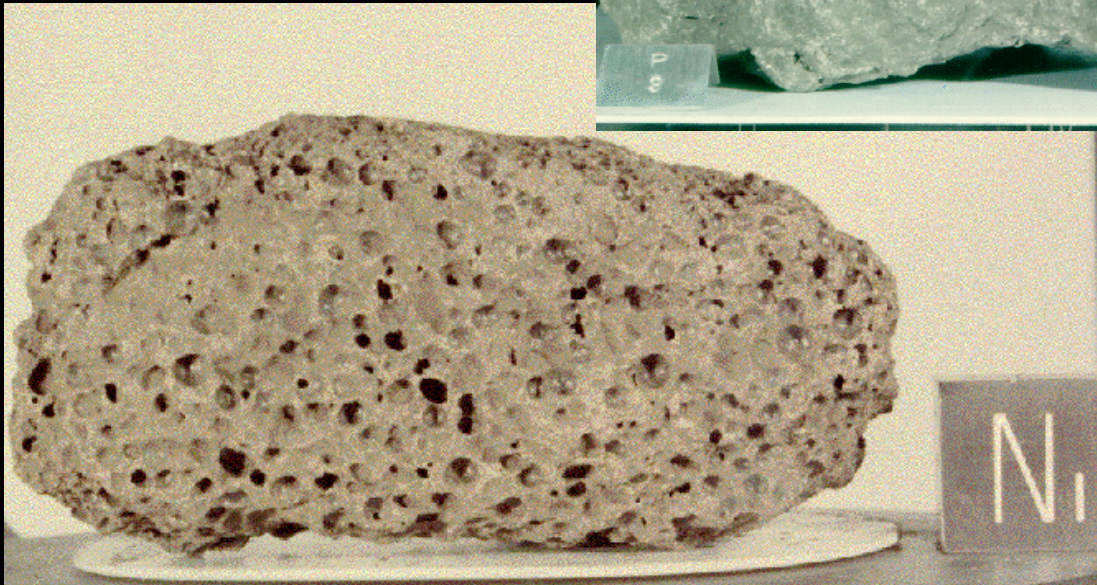
Marius Hills

Lava Tubes



Lunar Basalts

15555



3.3 Ga

15016

Lunar Geologic History



Lowlands – dark, smooth
Maria (16%)

Basalt – fine grained dark
igneous rock rich in iron
and magnesium (stuff
that sank in magma
ocean)

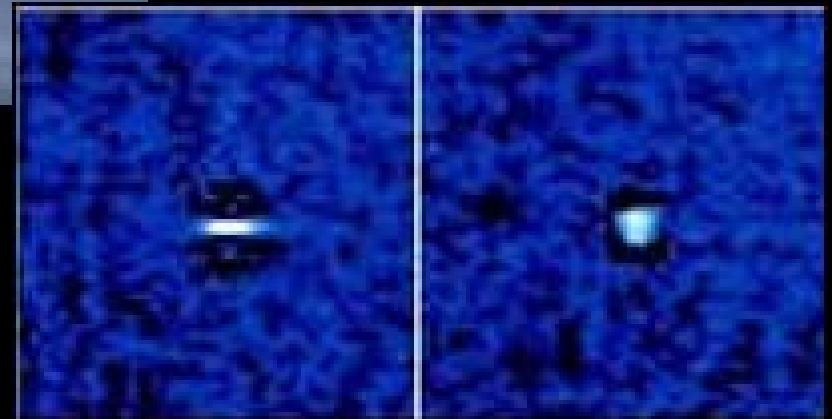
Few hundred meters thick

Rocks are 4.3 to 3.1 billion
years old ... volcanic
flows as recently as 1
billion years ago!!

And then

All was quiet.

- Except for impacts...



7 November; ~30 lb TNT
3 m-wide crater (estimate)

- No Wind
- No Flowing Water
- No Erosion



- Except for impacts...





How are they different in terms of
geologic processes?
And WHY?

Earth



Active wind/water erosion

Impacts

Active volcanoes

Earthquakes

Active magnetic field

Few craters

Geologically Active!

Moon



NO Active wind/water erosion

Impacts

NO active volcanoes

Small moonquakes

NO active magnetic field

Buckets of craters

Geologically Inactive!

Earth

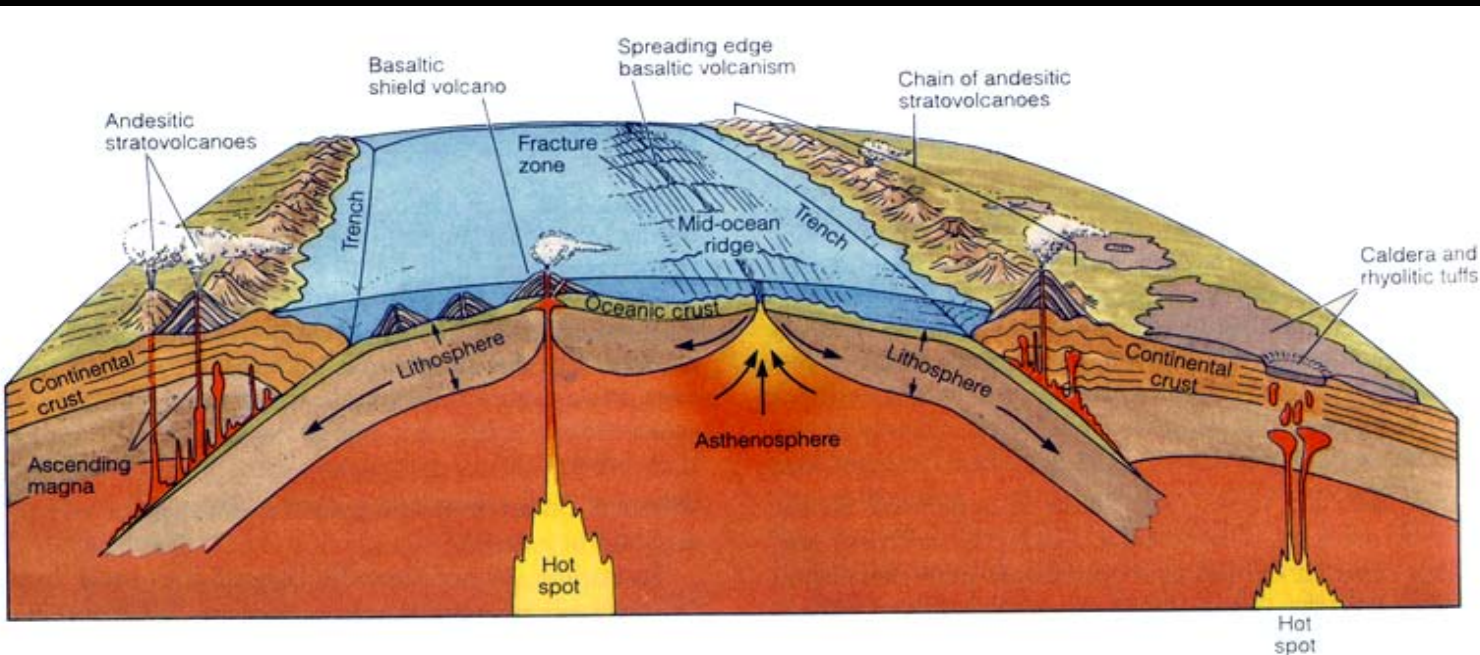


Plate tectonics!
Recycles!

Moon



NO plate tectonics



Earth



HOT!

Moon



Not so hot!

Why so different?

What's Our Plan for Space?

- Fly the shuttle as safely as possible until 2010
- Complete the ISS – 6-person crew by 2009
- Align science, exploration, and aeronautics to support human space flight
- Bring the new Crew Exploration Vehicle – CEV - on line
- Establish a lunar program that informs future missions to Mars and other destinations

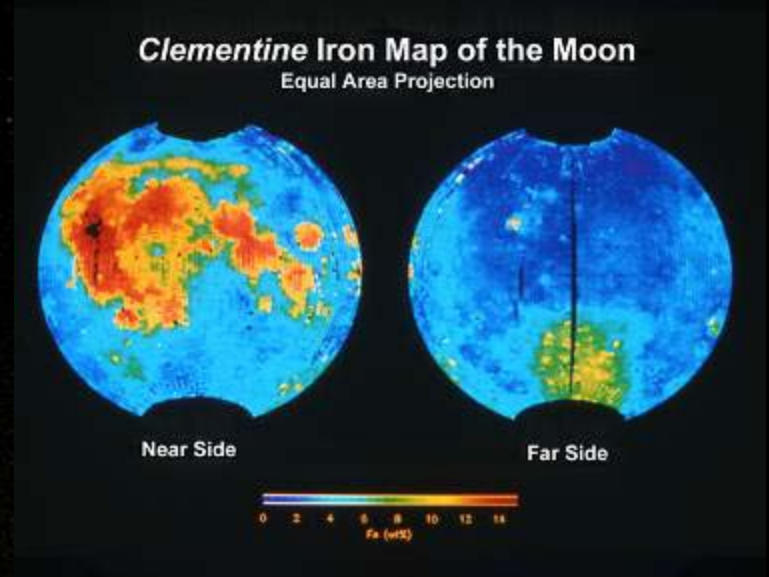


Why?

- Set up, for the first time, a full-fledged habitat on another world.
- Test advanced spacesuits and rovers.
- Try out methods for protecting explorers from deadly radiation.
- Learn to operate crucial life support and power needed on Mars.
- Gauge the effects of the absence of normal gravity on the body.
- New technology.

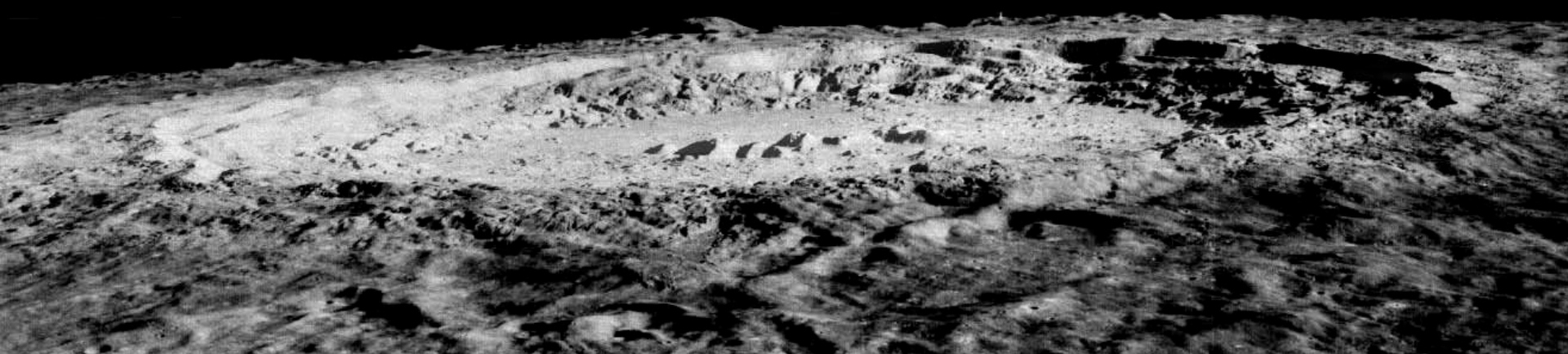
Return to the Moon Chandryaan – 2007! LRO – 2008 !

Identify Resources
Map the Surface



Return to the Moon!

- 2012 – Develop and test technologies for resource utilization, communications, power
- 2014 – CEV, Ares launch vehicle



- 2018 – Humans for week-long stays
- Next: 45-day stays at outposts

