Welcome to Astro-1 Honors 2020

Dr. Jatila van der Veen
Project Scientist, Physics Department, UCSB
Adjunct Professor of Astronomy, SBCC

Let’s introduce ourselves…

Name – major – why you are taking this class – one item of interest about you

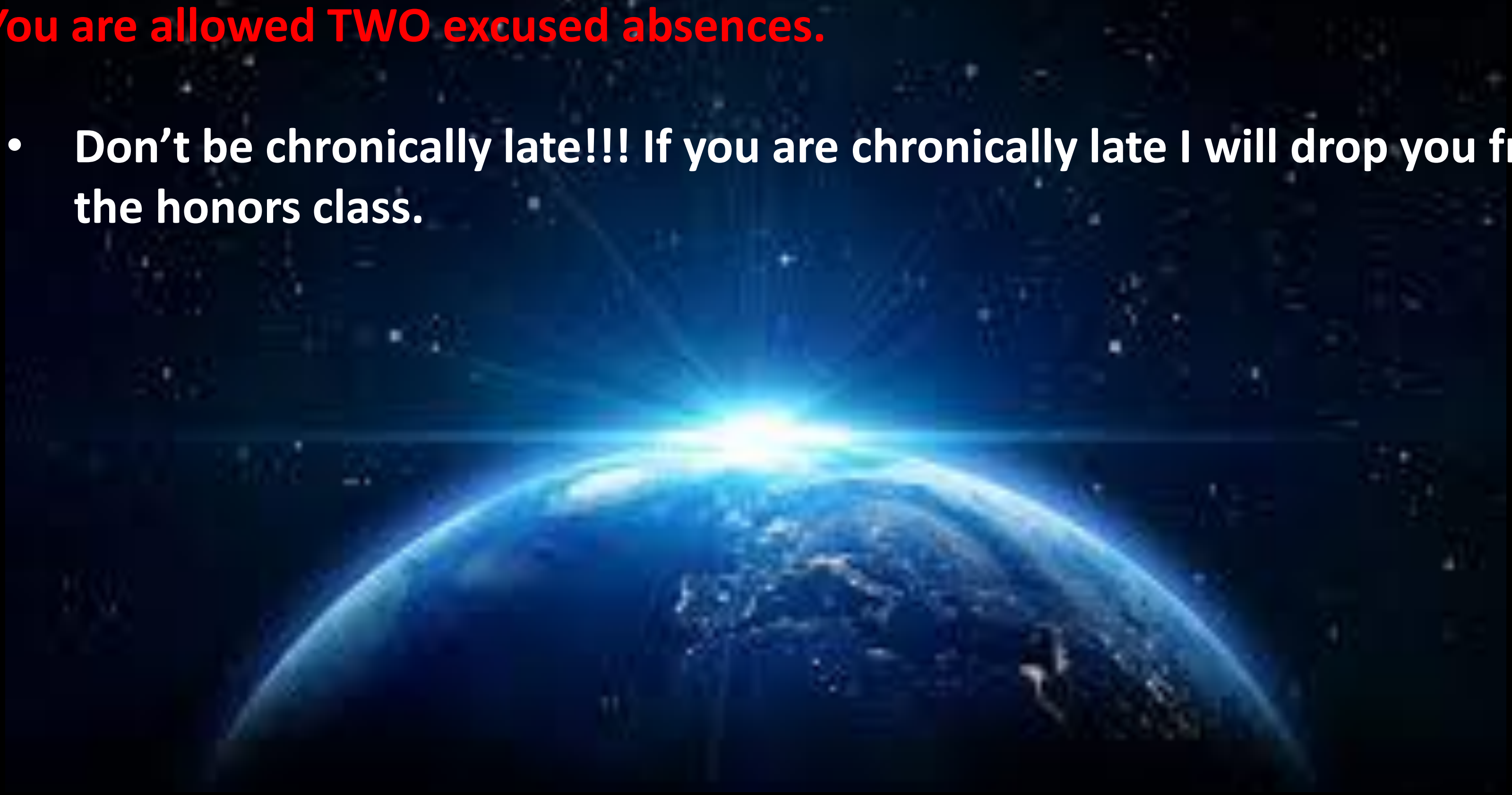
Expectations for this seminar:

- **This is a research seminar. No tests; there will be a final group presentation.**
- **Meets every Wednesday, 08:15 – 09:20. <u>YOU ARE EXPECTED TO BE ON TIME.</u>**

Expectations for this seminar:

- **Attendance and participation are part of your grade. If you are sick, please email me before class. If I don't get it until later, that's ok; the date/time will be recorded so I'll know you at least tried to reach me.**
- **You are allowed TWO excused absences.**

  - **Don't be chronically late!!! If you are chronically late I will drop you from the honors class.**



Expectations for this seminar:

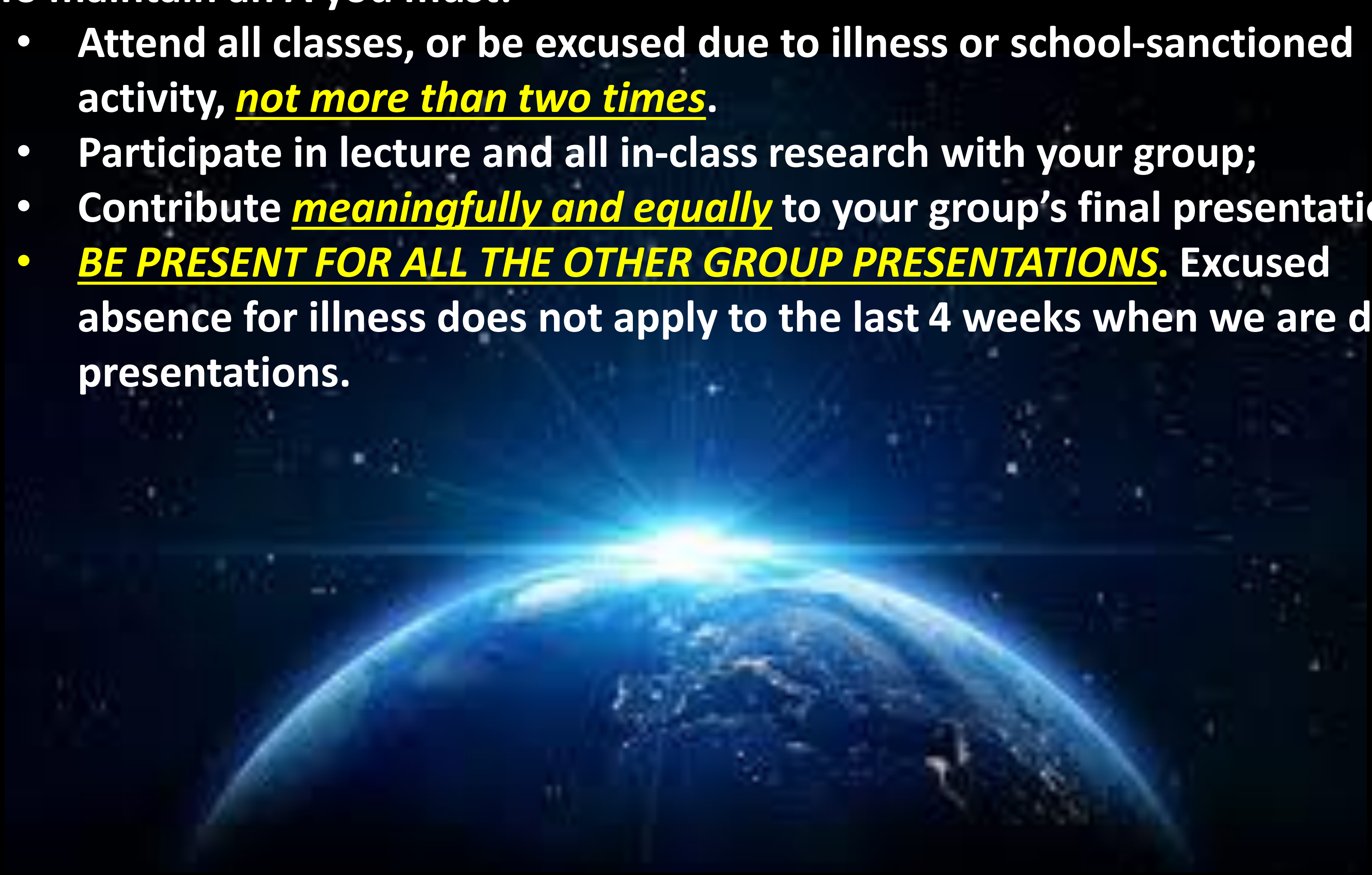
- To be in this class, you must:
  - ... be in a regular Astro-1 class;
  - ... be enrolled in the Honors program;
  - ... maintain your honors status.

Expectations for this seminar:

- **Your grade in Honors is ¼ of your grade in regular astronomy.**

Expectations for this seminar:

- To maintain an A you must:
  - Attend all classes, or be excused due to illness or school-sanctioned activity, ***not more than two times***.
  - Participate in lecture and all in-class research with your group;
  - Contribute ***meaningfully and equally*** to your group's final presentation;
  - ***BE PRESENT FOR ALL THE OTHER GROUP PRESENTATIONS***. Excused absence for illness does not apply to the last 4 weeks when we are doing presentations.



This year’s honors topic is…

Colonizing the Moon

“ President Donald Trump has asked NASA to accelerate our plans to return to the Moon and to land humans on the surface again by 2024. We will go with innovative new technologies and systems to explore more locations across the surface than was ever thought possible. This time, when we go to the Moon, we will stay. And then we will use what we learn on the Moon to take the next giant leap - sending astronauts to Mars. ”

—NASA Administrator Jim Bridenstine

Dec. 11, 2017

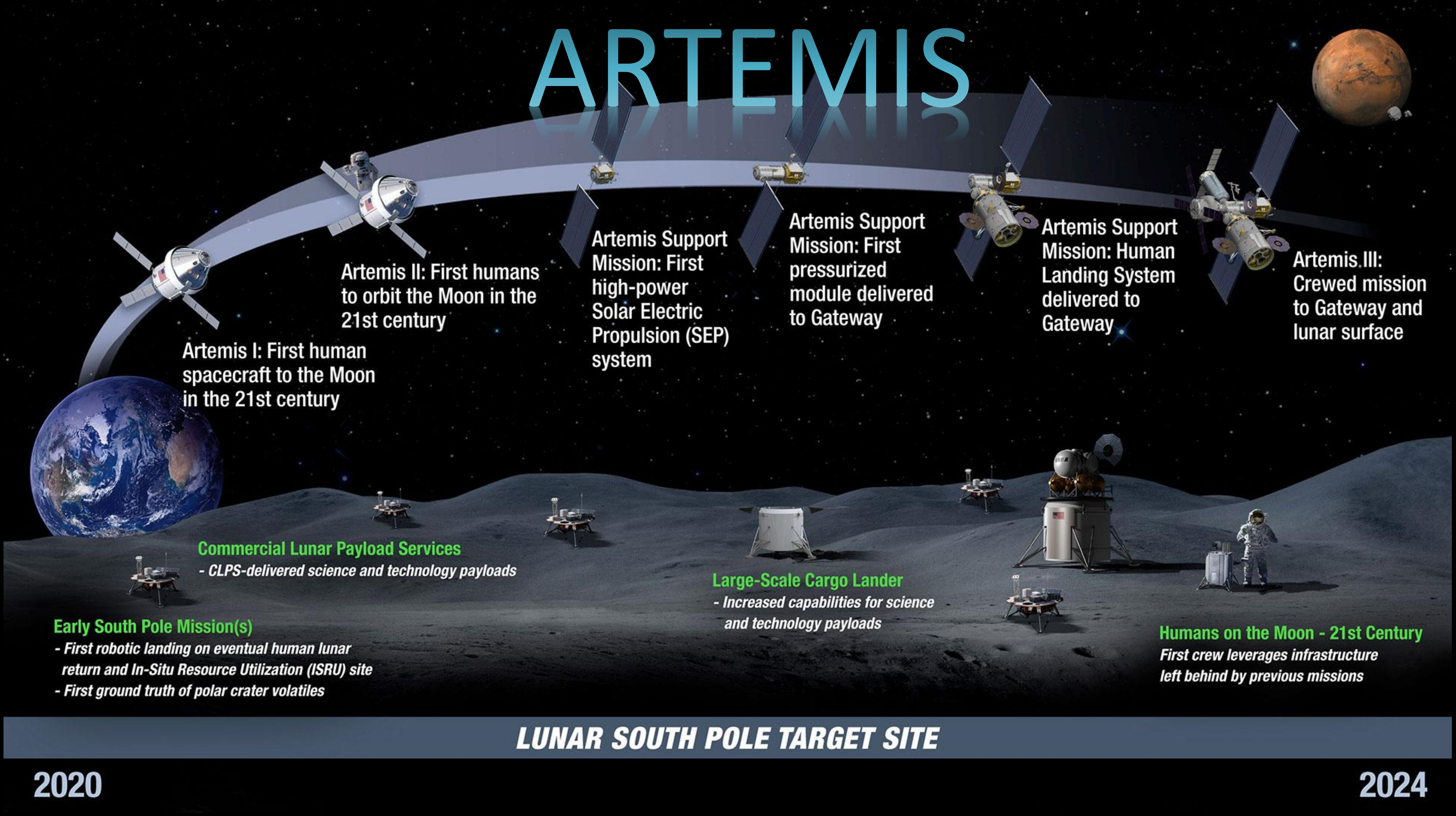
RELEASE 17-097

New Space Policy Directive Calls for Human Expansion Across Solar System

"The president Monday signed at the White House Space Policy Directive 1, a change in national space policy that provides for a U.S.-led, integrated program with private sector partners for a human return to the Moon, followed by missions to Mars and beyond."

https://www.nasa.gov/press-release/new-space-policy-directive-calls-for-human-expansion-across-solar-system

NASA plans to send the first woman and next man to the Moon in 2024.



There is a lot of preparation and exploration that must happen before people return to the Moon.

Commercial Lunar Payload Services (CLPS) landers

Each commercial lander will carry NASA-provided payloads that will conduct science investigations and demonstrate advanced technologies on the lunar surface, paving the way for NASA astronauts to land on the lunar surface by 2024.

https://www.nasa.gov/press-release/nasa-selects-first-commercial-moon-landing-services-for-artemis-program

Why is the Moon important?

The origin of the Moon gives clues to the early days of the Solar System and to the origin of life on Earth.

The presence of water on the Moon is important for the future of robotic exploration of the Moon, and future human colonization of the Moon.

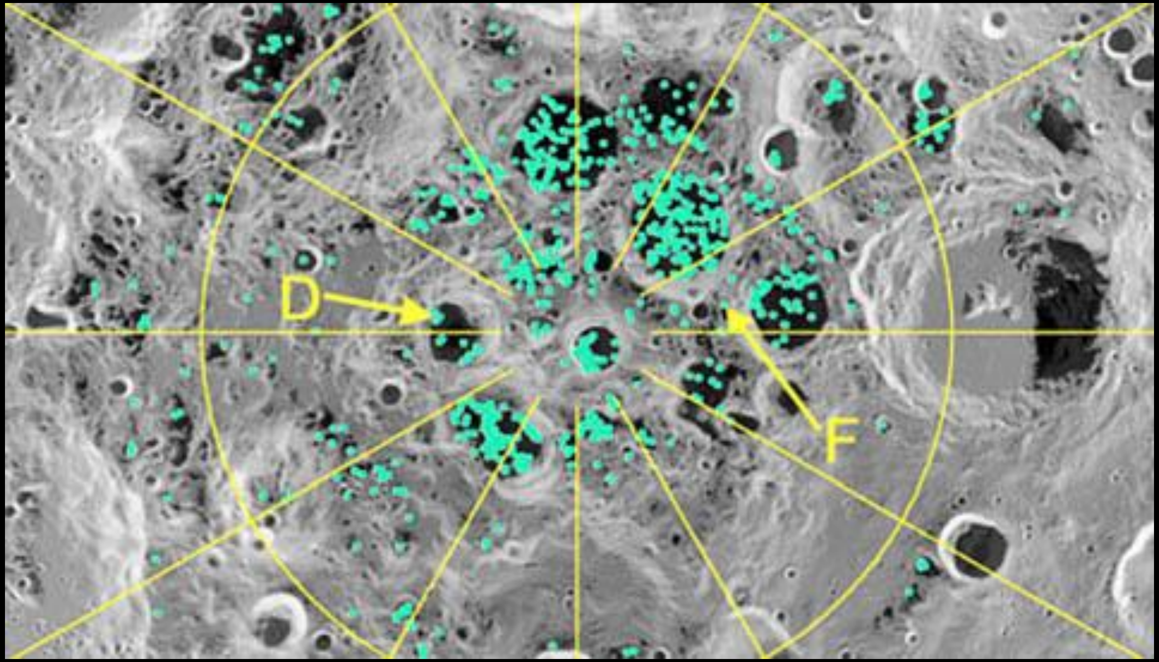
Overview of the Moon from the Lunar Reconnaissance Orbiter:
https://www.youtube.com/watch?v=nr5Pj6GQL2o

Homework due next week: Watch video and answer questions on Canvas
https://www.youtube.com/watch?v=WGTBJHFNywI

Why is the Moon important?

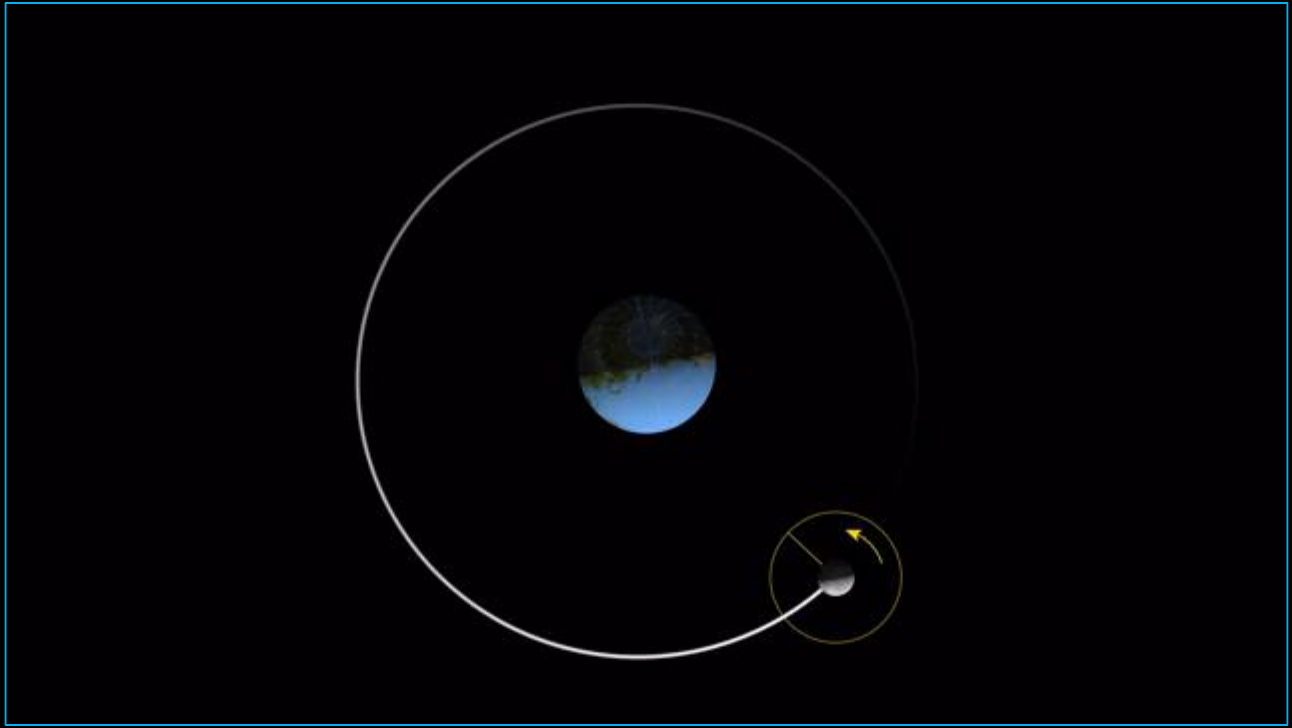
Facts about the Moon:

- Length of day/night,
- Temperature variations,
- Geology,
- Polar regions and Permanently Shadowed Regions

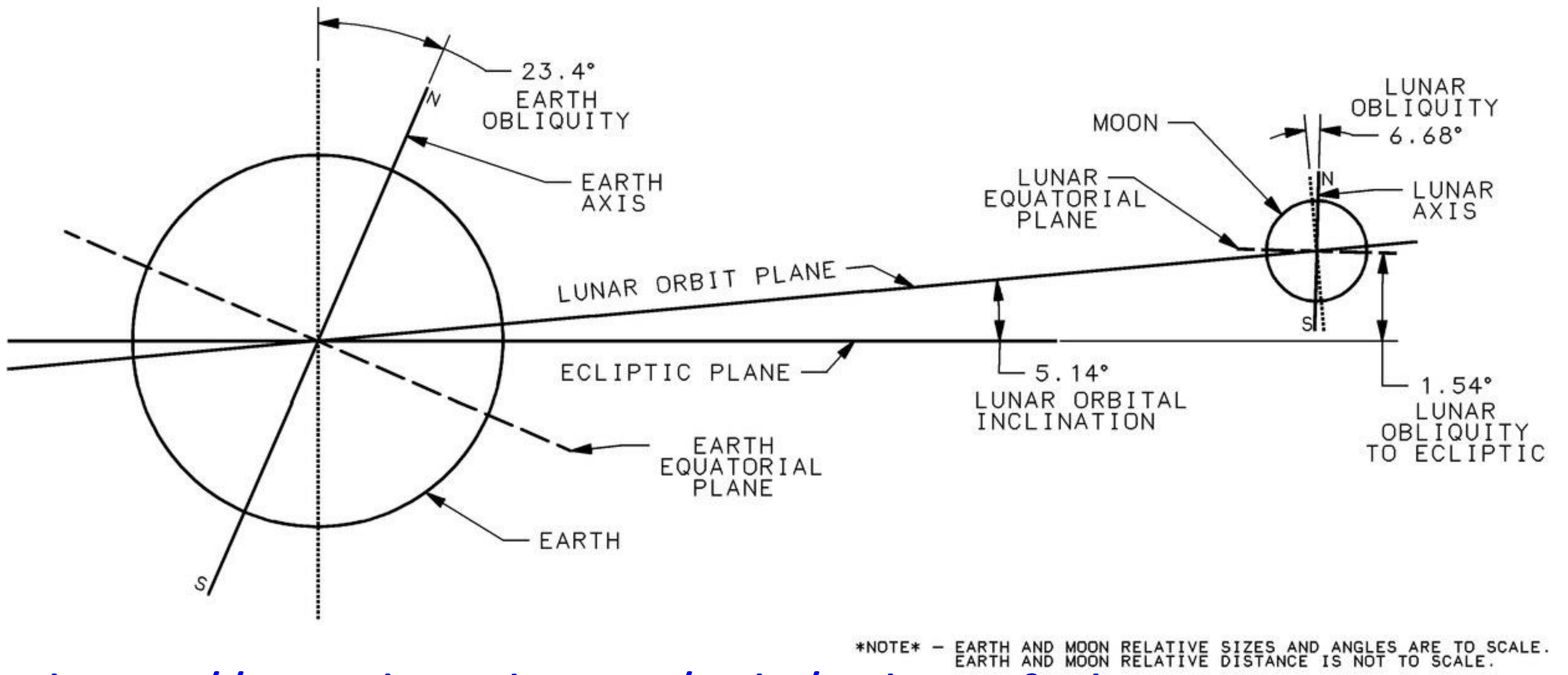


Length of day and night on the Moon:

Lunar day is around 28 Earth days because the Moon spins once on its axis of rotation for every orbit it makes around the Earth.



Unlike the Earth, whose axis of rotation is tilted at 23.5^0 to the plane of its orbit around the Sun (the ecliptic), the Moon's axis of rotation is tilted at only around 1.5^0 to the plane of the ecliptic.



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

Consequences:

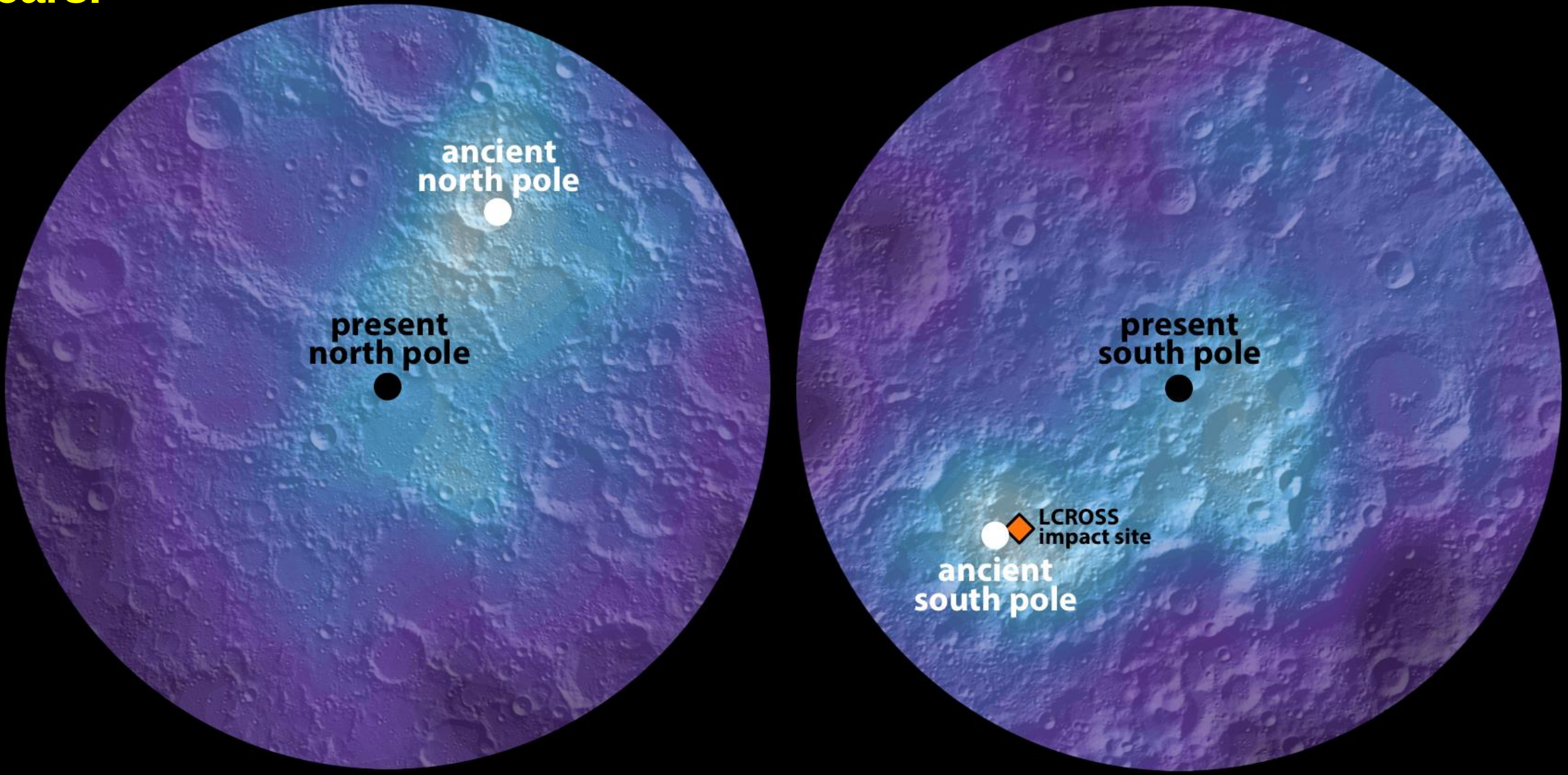
At the lunar equator there are 14 Earth days of sunlight and 14 Earth days of complete darkness.

There are no seasons.

At the poles there are ~ 314 days of sunlight and 51 days of complete darkness.

Craters at the poles are in permanent shadow, and have not seen sunlight for billions of years!

But there is evidence that the polar axis has shifted over billions of years.

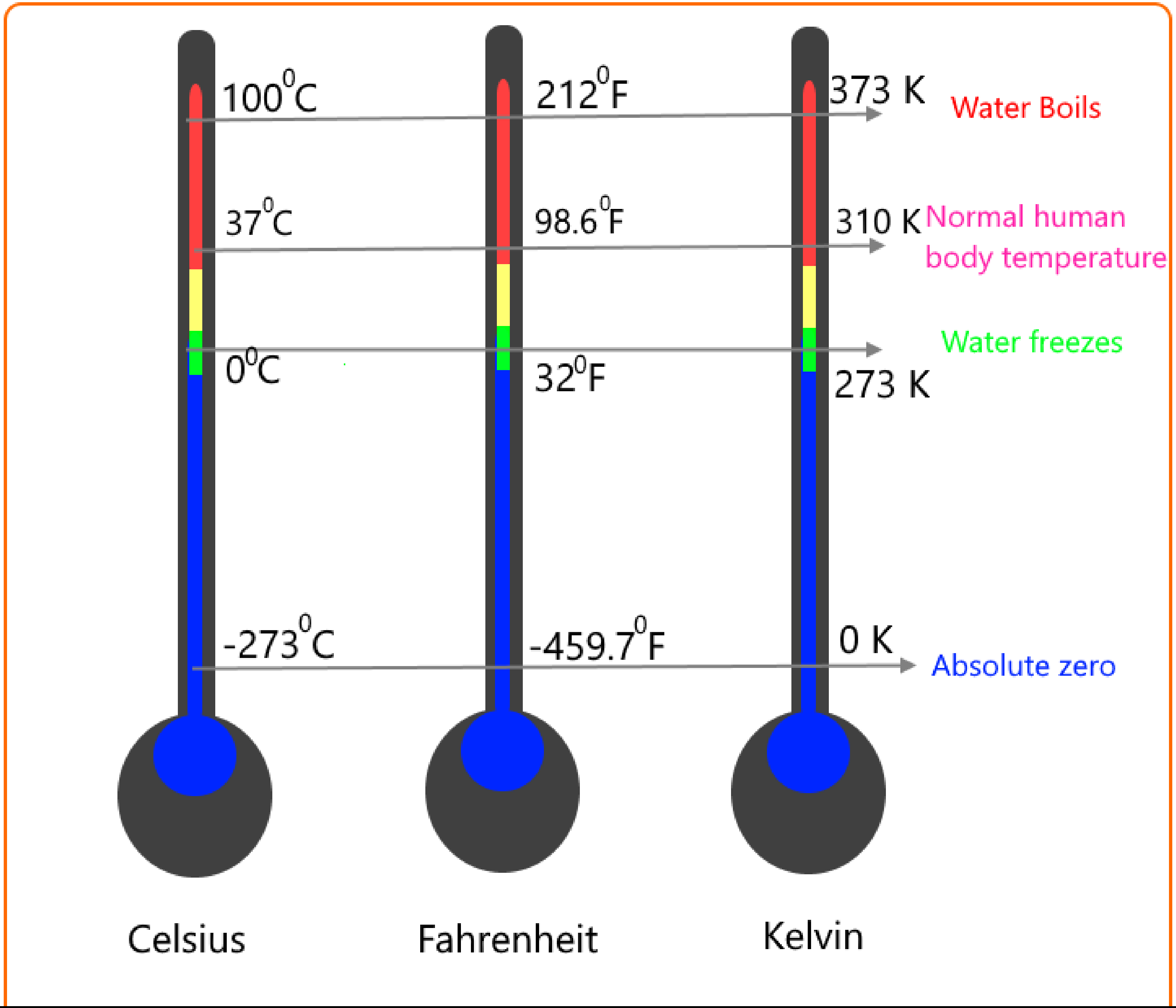


Temperature extremes on the Moon:

Daytime temperatures near the lunar equator reach a boiling 250 degrees Fahrenheit (120° C, 400 K), while nighttime temperatures get to a chilly -208 degrees Fahrenheit (-130° C, 140 K).

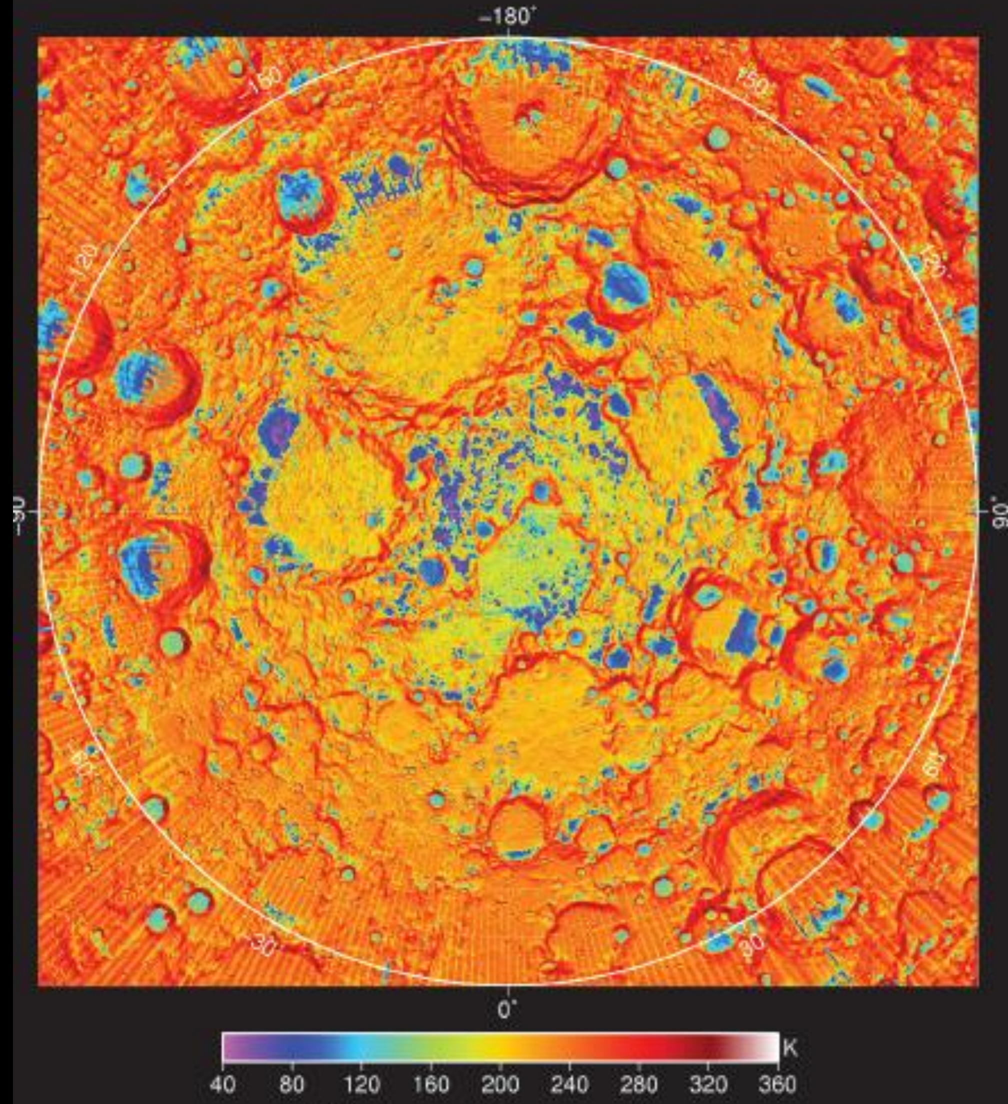
The Moon’s poles are even colder. Diviner even found a place in the floor of the Moon’s Hermite Crater that was detected to be -410 degrees Fahrenheit (-250° C, 25 K), making it the coldest temperature measured anywhere in the solar system!

Extremely cold regions similar to the one in Hermite Crater were found at the bottoms of several permanently shadowed craters at the lunar south pole and were measured in the depths of winter night.

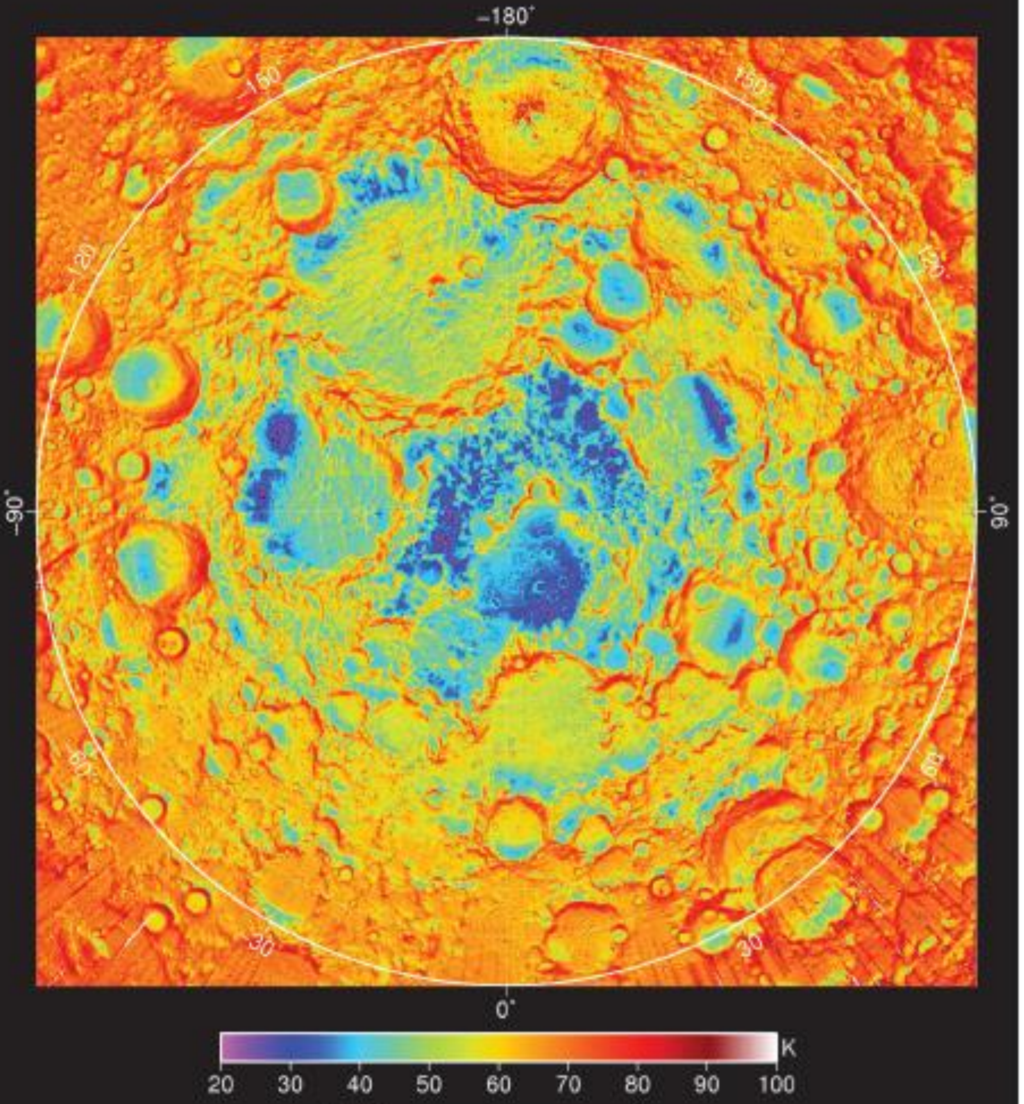


100⁰C
37⁰C
0⁰C
-273⁰C
212⁰F
98.6⁰F
32⁰F
-459.7⁰F
373 K
310 K
273 K
0 K
Water Boils
Normal human body temperature
Water freezes
Absolute zero
Celsius
Fahrenheit
Kelvin

North Pole



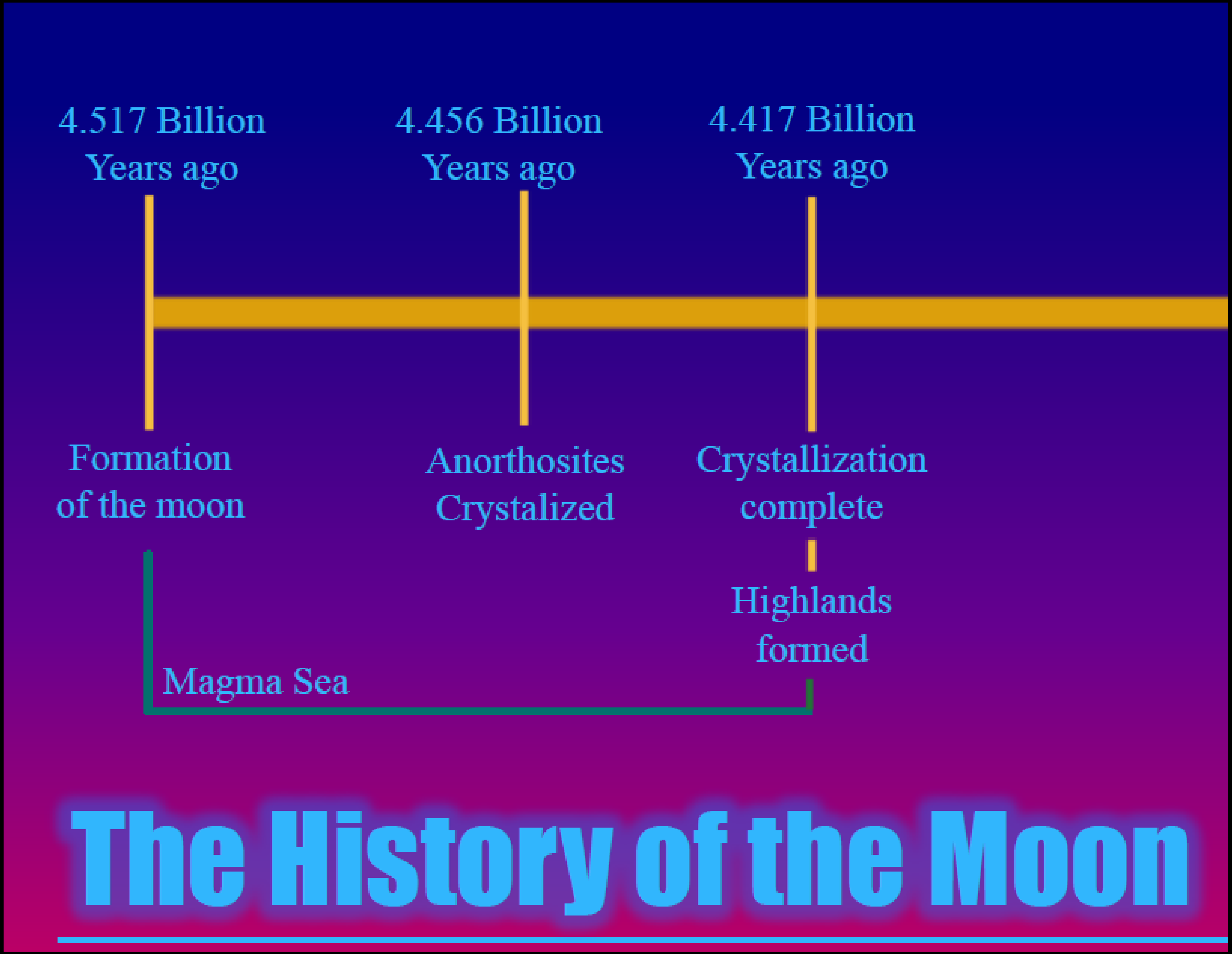
Maximum Temperature



Minimum Temperature

LUNAR RECONNAISSANCE ORBITER: Temperature Variation on the Moon

What we know of the geology of the Moon:



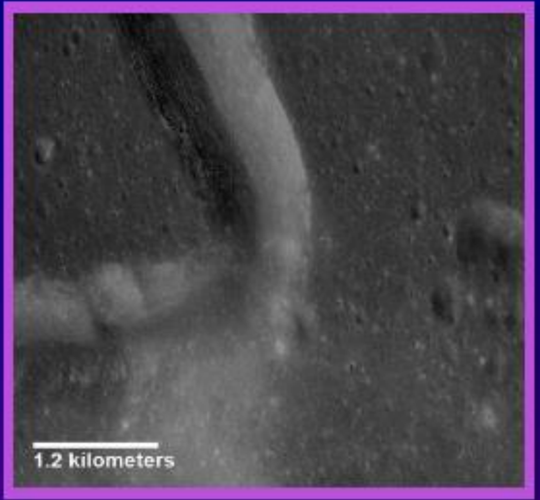
Light areas: Highlands
Dark areas: Maria
only on the Earth-facing side
Everywhere:
Impact craters

The Giant Impact Hypothesis

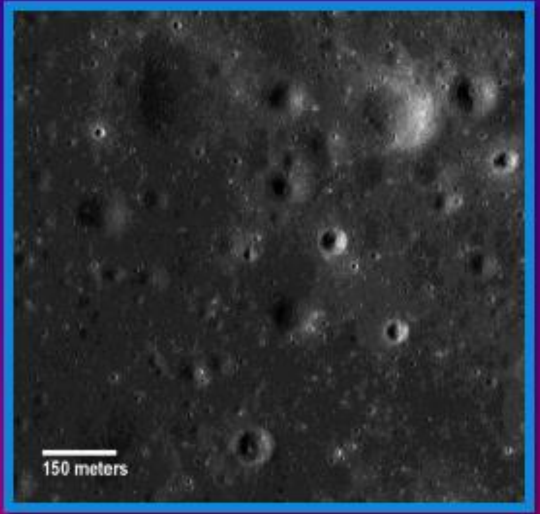
- **Formed from the debris of a large-scale impact**
- **Explains:**
  - **The ratio of volatiles to nonvolatile**
  - **The identical oxygen isotopic composition**
  - **The angular momentum and angle of the Earth’s rotation**
- ***Natural part of planetary formation***

The Lunar Highlands

- Formed from magma sea 4.4 b.y.a
- Predate the Maria by 800 m.y
- The elevated and more rugged regions
- Cover 80% of the visible surface
- Heavily cratered
- Feldspar rich and contain low density rocks
- High albedo

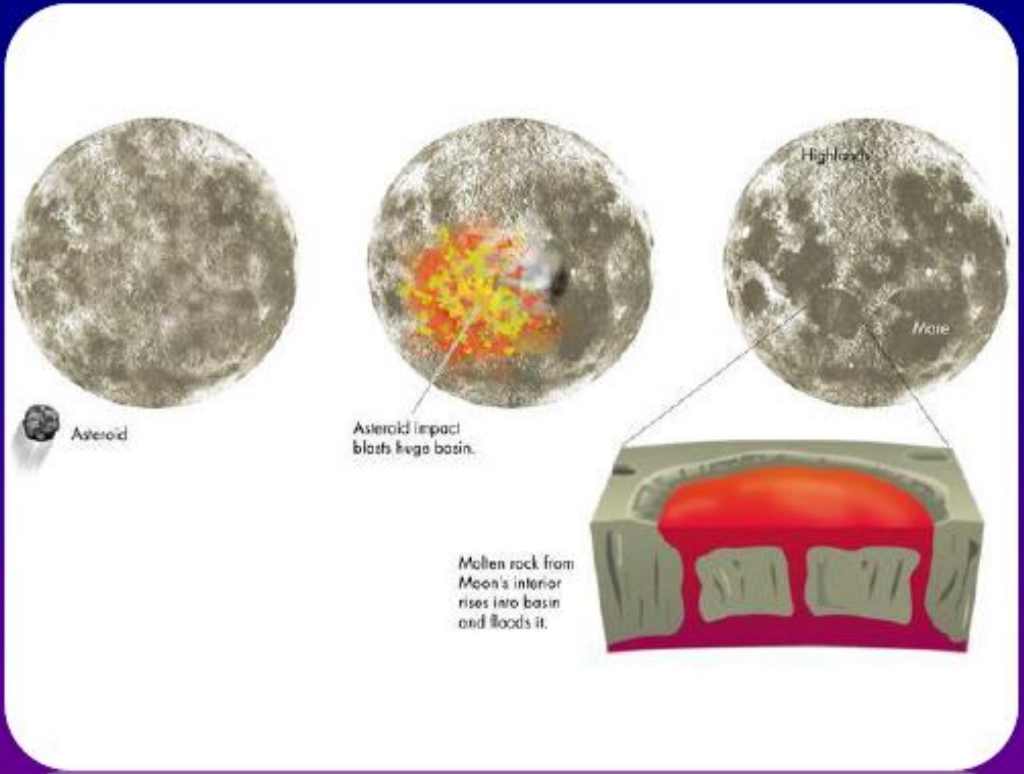


- Smooth, dark flood-plains
- Cover 16% of the moon's surface
- Less impact cratering than the highlands
- Basaltic composition
- Bear resemblance to Earth's volcanic terrains
- Home numerous morphologies



The Lunar Maria

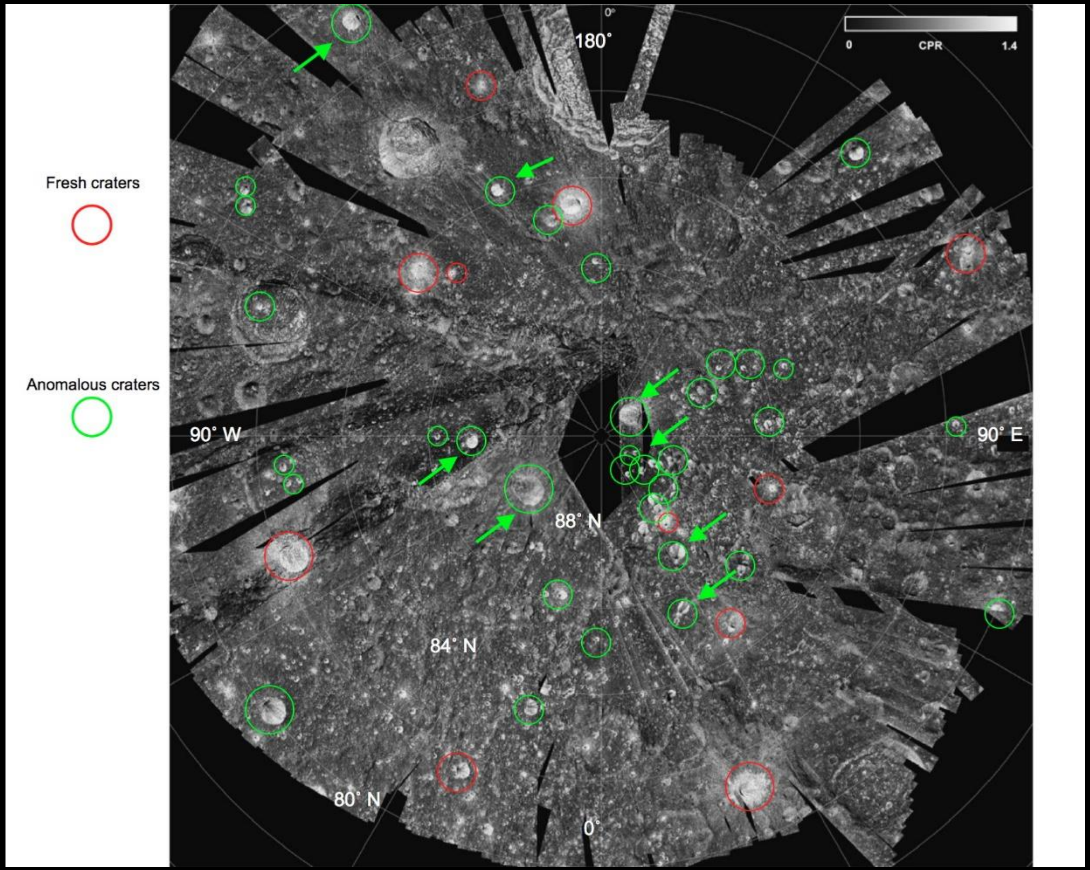
- **Created by volcanic eruptions 3.5 b.y.a**
- **Partial melting of the crust formed magma**
- **Heat produced by radioactive materials**
- **Occurred 60 to 500 meters below the surface**
- **Magma pooled in basins**

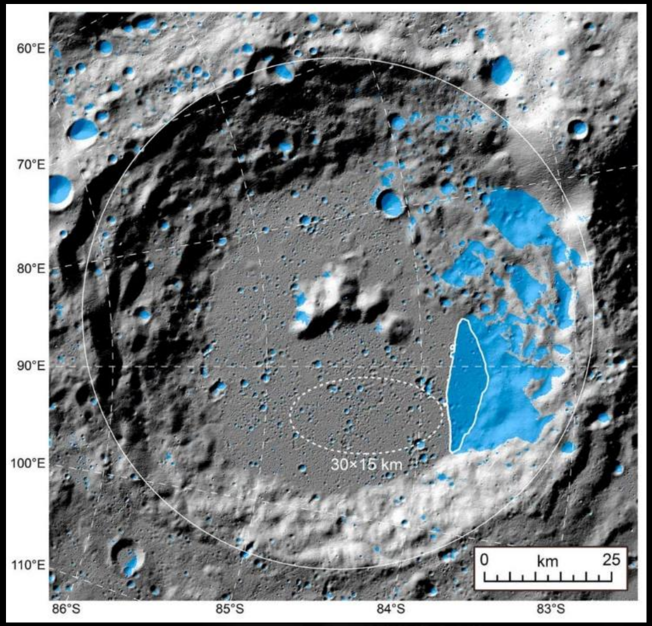


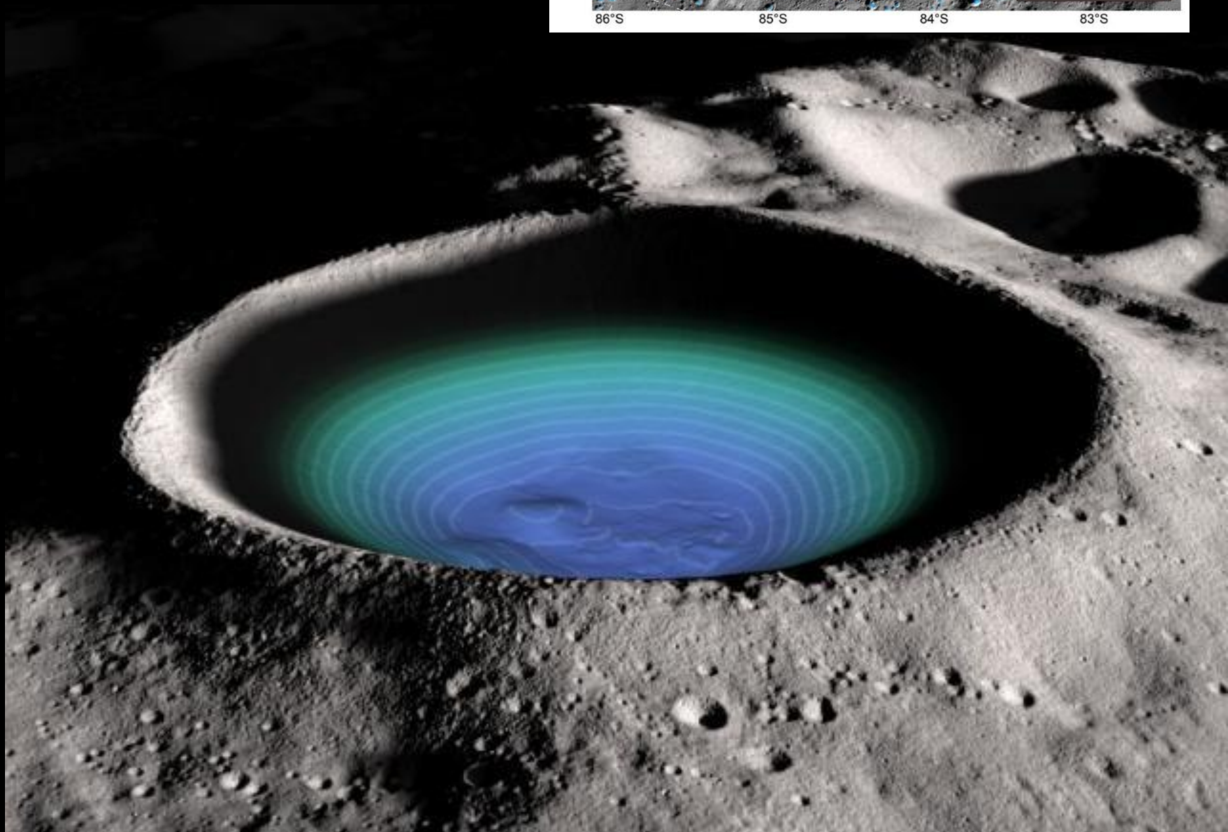
https://www.lpi.usra.edu/exploration/education/hsResearch/presentations/2012_2013/LanghamCreek1.pdf

Formation of the Lunar Maria

Permanently Shadowed Regions (PSRs) at the lunar poles contain deposits of water ice and hydroxide molecules.







https://svs.gsfc.nasa.gov/11218

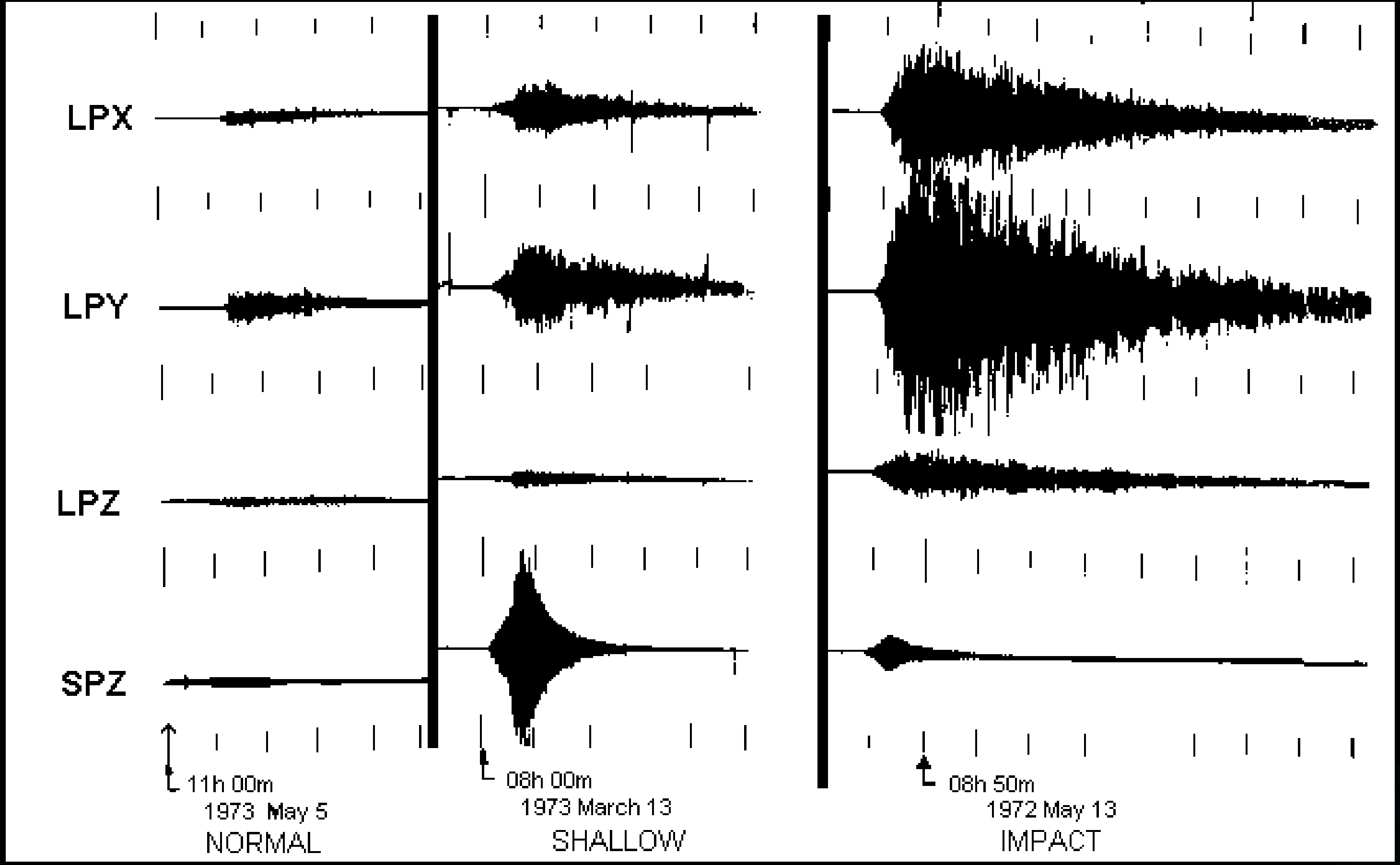
Other findings we have learned from the various orbiting and lander missions:

* There are moonquakes.

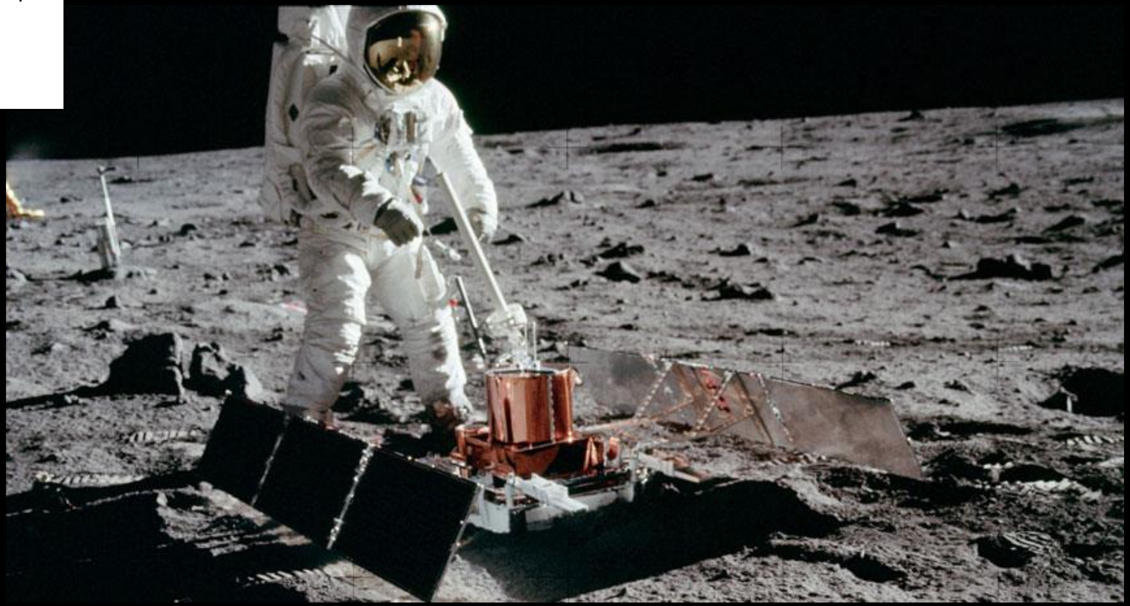
* The Moon has a very small core.

* The Moon has no magnetic field, or an extremely weak one.

* The surface of the Moon is covered with fine powder called regolith.

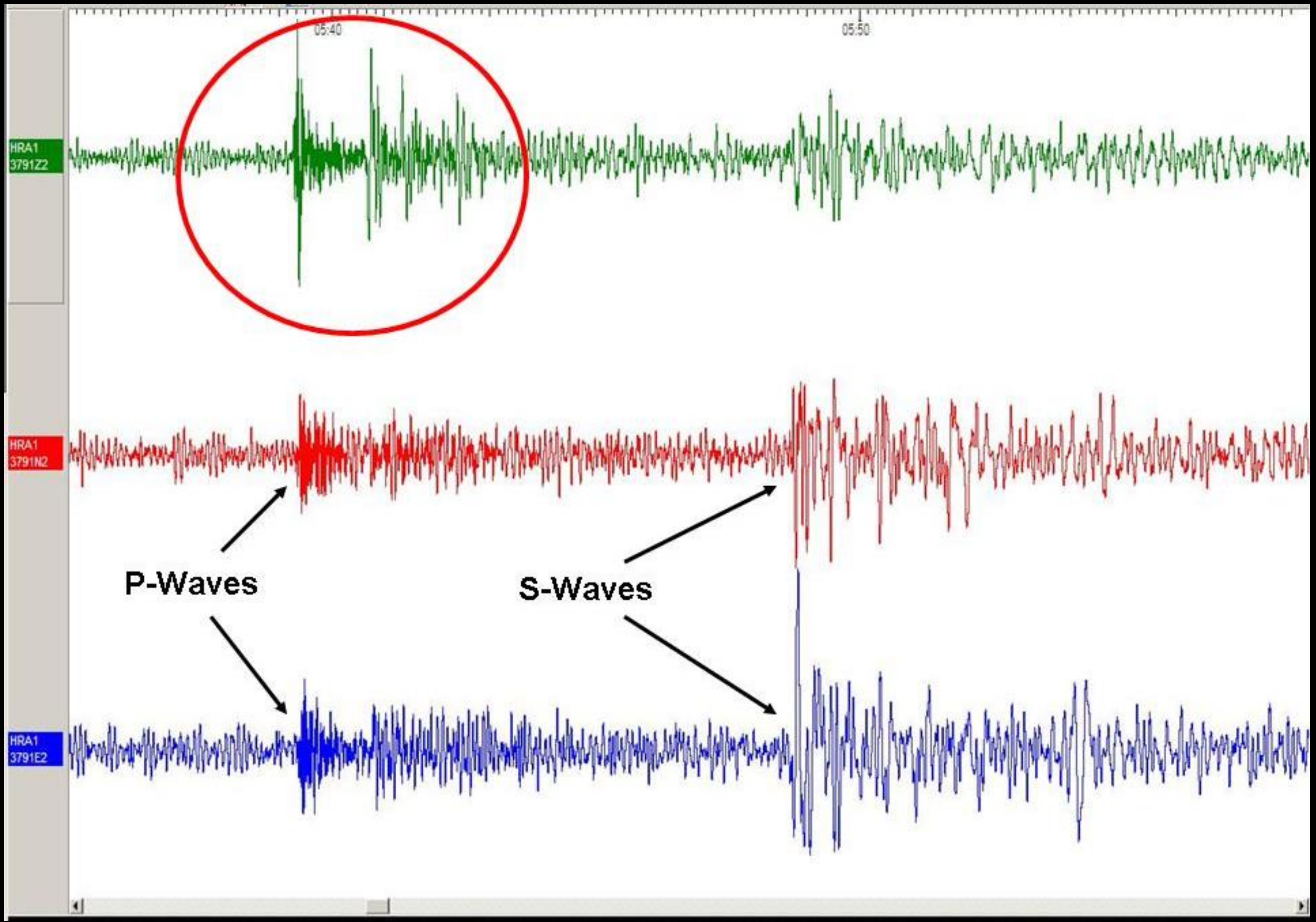


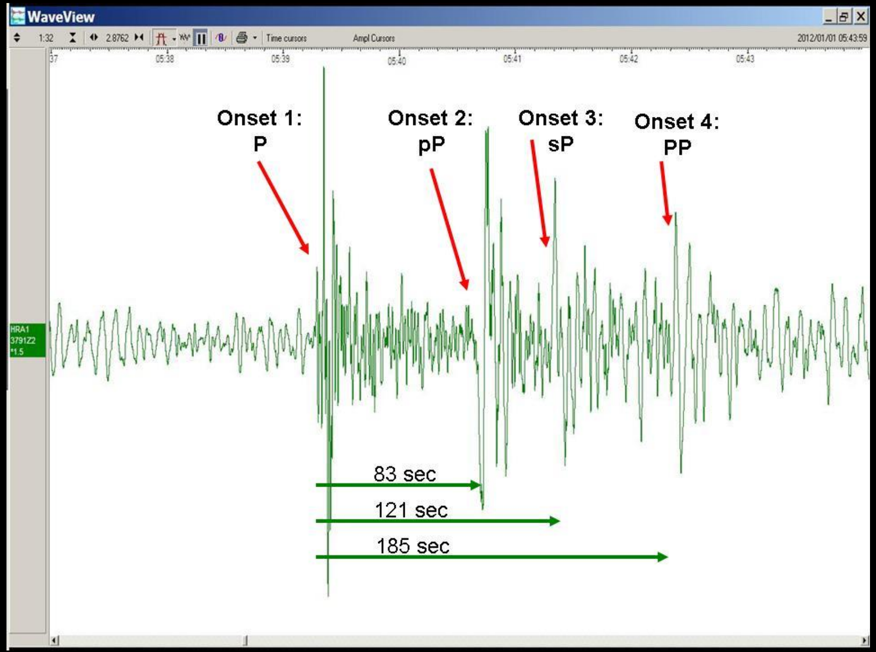
Apollo astronauts planted seismometers on the Moon.

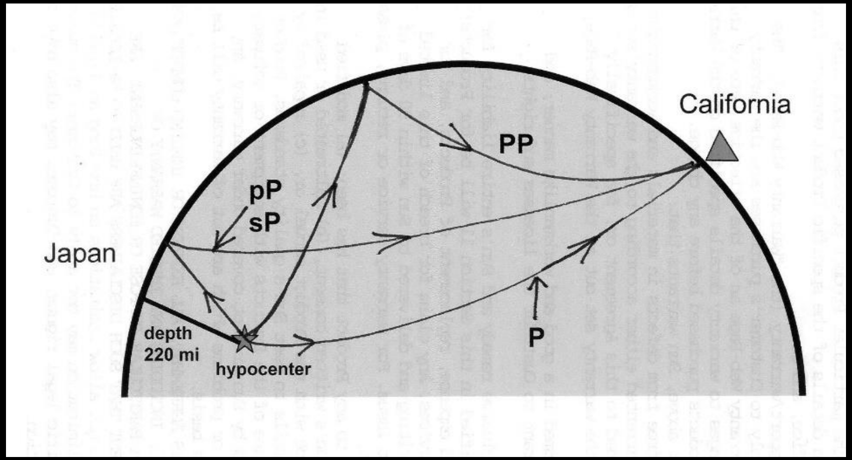


Seismic recordings of moonquakes from the Apollo seismometers.

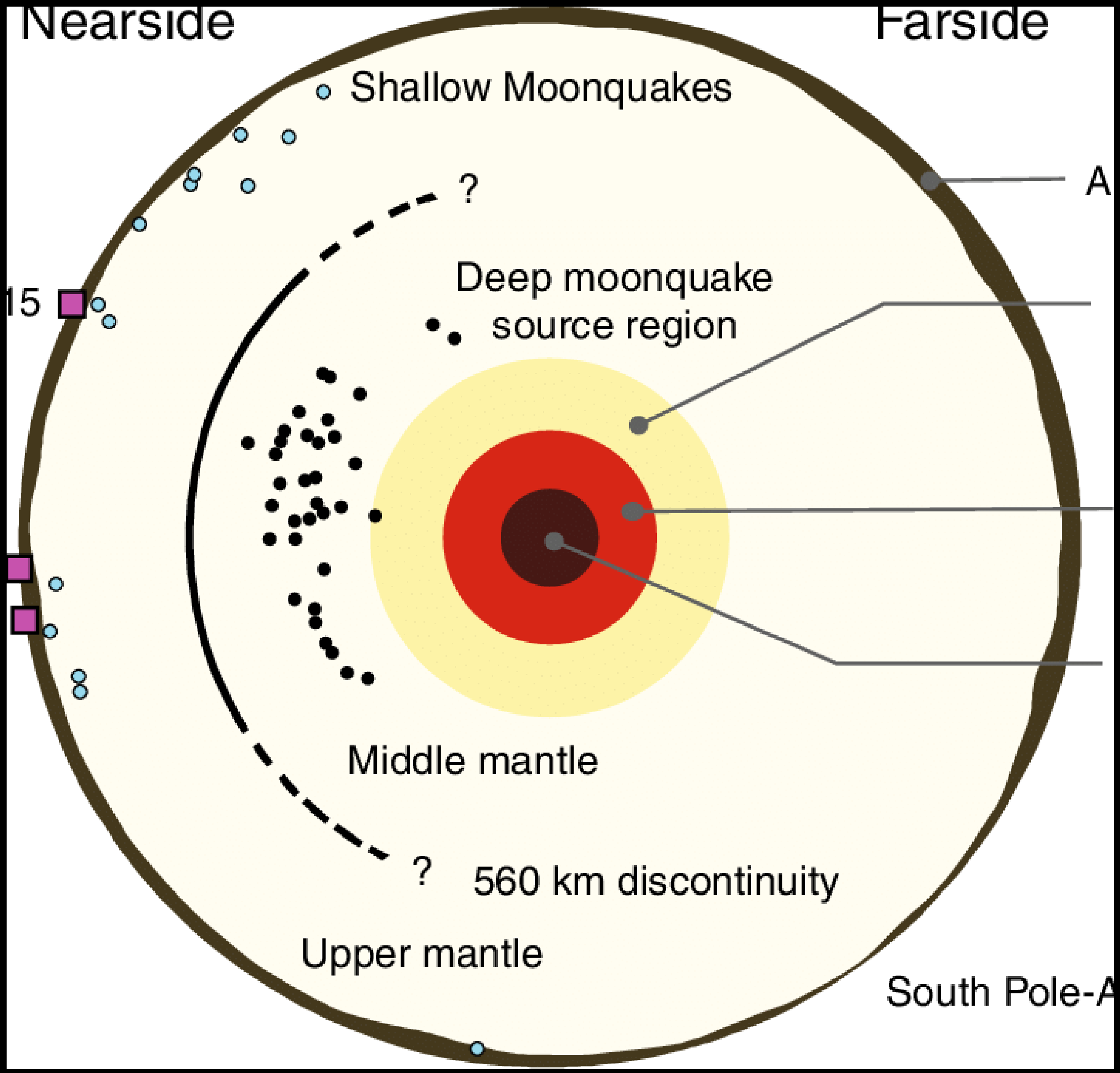
Compared to Earthquake seismic recordings on Earth, the Moon “rings like a bell.”







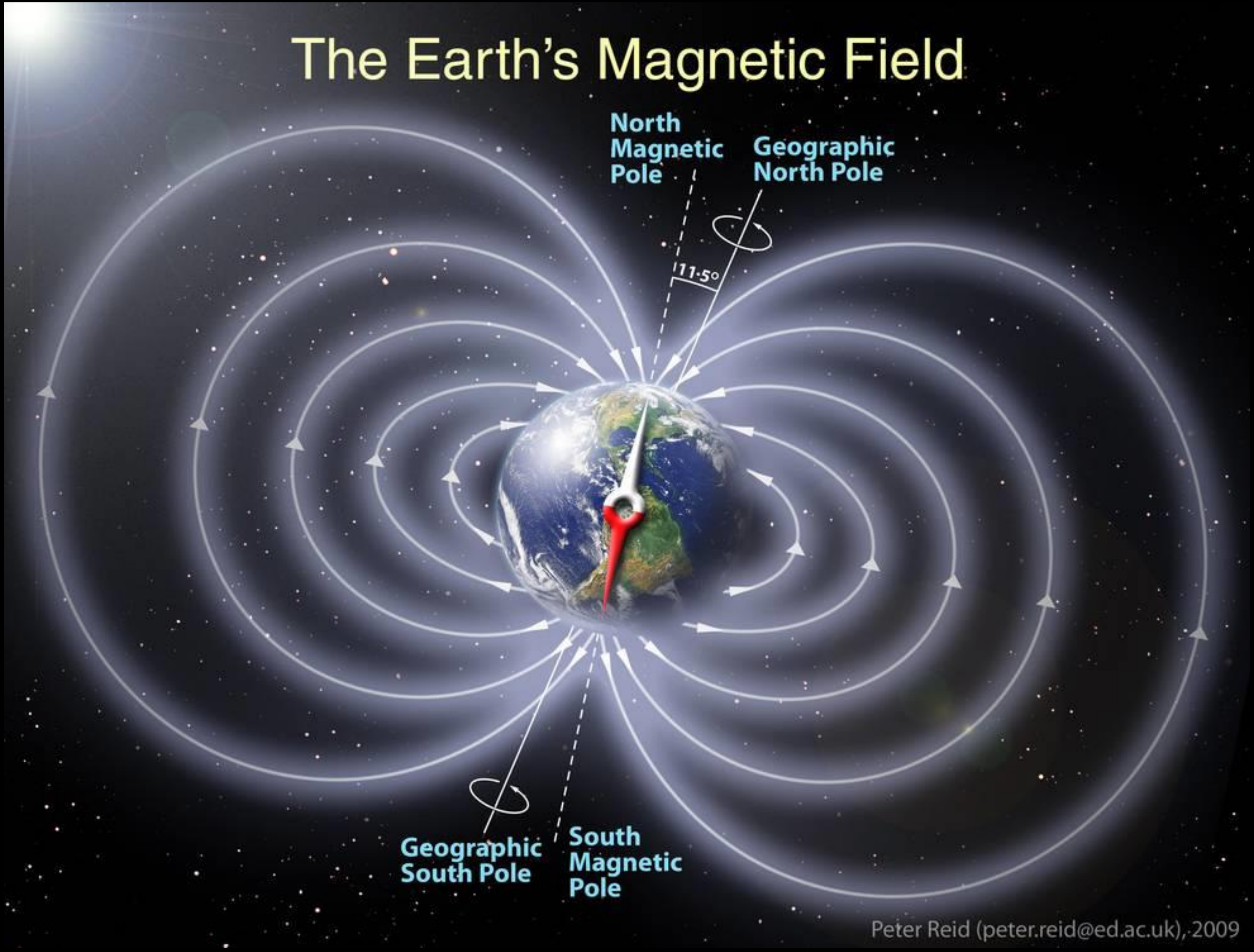
Recording of an earthquake in Japan by the Berkeley Seismic Network.

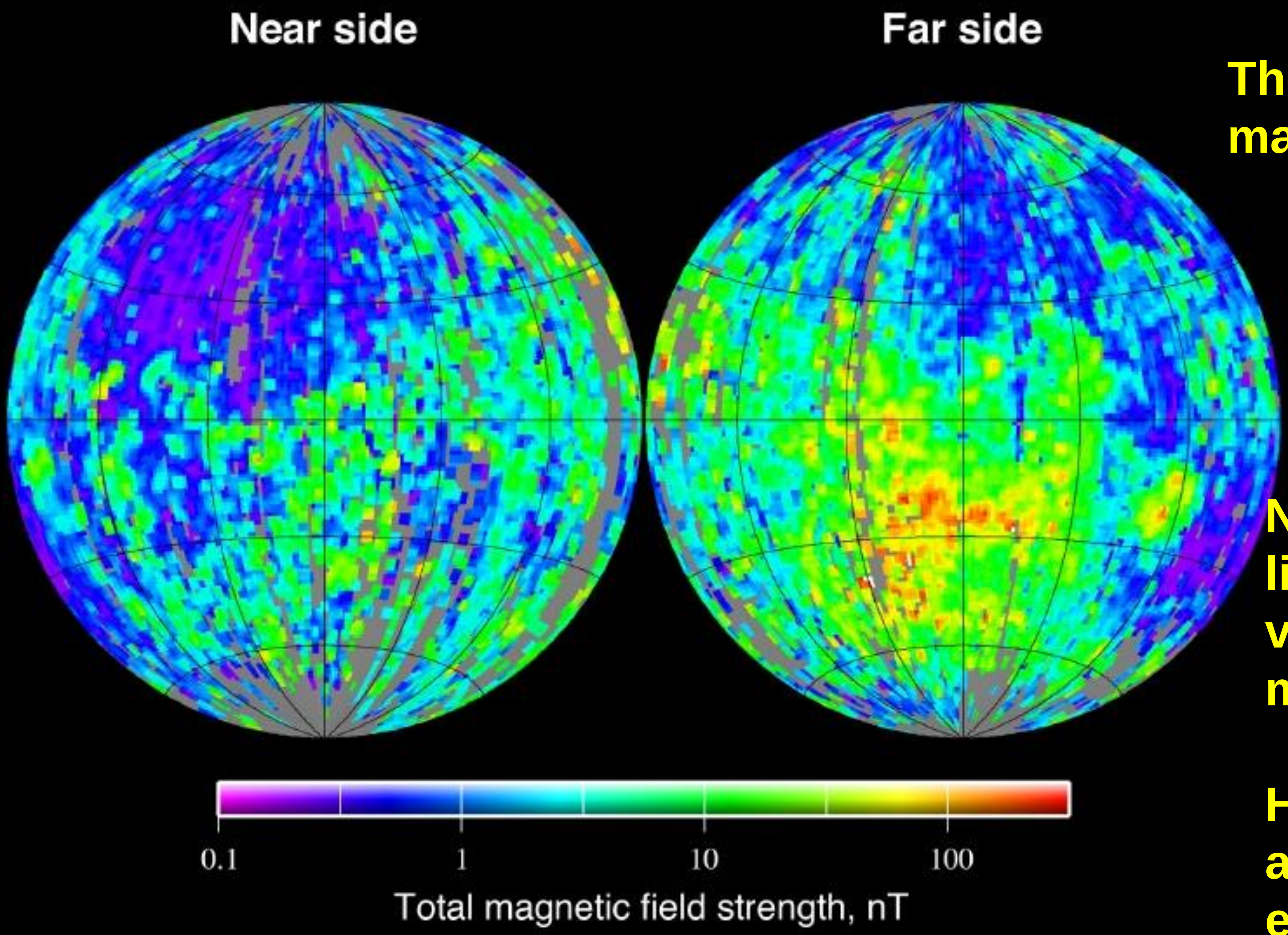


Schematic diagram (to scale) of the Moon's interior structure.

Shown are the Apollo seismic stations (squares), all shallow moonquakes (blue circles), the deep moonquake source regions that are periodically activated by Earth-raised tides (black circles), inferred variations in crustal thickness, and a possible discontinuity ~500 km below the surface.

The structure below the deep moonquake source region is constrained only by indirect means, and little is known about the far side hemisphere.


The Earth's Magnetic Field
North Magnetic Pole
Geographic North Pole
11·5°
Geographic South Pole
South Magnetic Pole
Peter Reid (peter.reid@ed.ac.uk), 2009



The Moon has no global magnetic field.

No dipole magnetic field, like the Earth. Only local variations in local surface magnetism.

However, there does appear to be an electrostatic field at the surface.

Lunar regolith: fine dust covering the surface – hazard to people and equipment

https://www.youtube.com/watch?time_continue=11&v=7o3Oi9JWsyM&feature=emb_logohttps://www.youtube.com/watch?time_continue=11&v=7o3Oi9JWsyM&feature=emb_logo

An entertaining summary of what we know of the Moon:

https://www.youtube.com/watch?time_continue=143&v=-dKPT4qSIww&feature=emb_logo

Class # /date	topics
1/ Jan 15	Introduction – Why is the Moon important scientifically? Facts about the Moon: length of day/night, Temperature variations, geology, PSRs
2/Jan 22	Why go to the Moon? History of lunar exploration Lunar orbiters; what Apollo astronauts brought back; What we have learned since Apollo 17 from orbiters
3/Jan 29	Finding and extracting water ice and other volatiles; finding resources for building and 3D printing of things
4/Feb 5	Getting to the Moon and surviving; hazards of radiation, dust, temperature extremes; living in 1/6 g
5/Feb 12	Providing power for lunar operations; solar, directed energy, fusion, batteries
6/Feb 19	What would a lunar colony look like? Politics of developing a human settlement on the Moon
7/Feb 26	Ethics of developing a human settlement on the Moon
8/Mar 4	Summary and selection of 8 groups by topic of interest for Presentations; begin group collaborations
9/Mar 11	First in-class collaboration day – bring laptops

Class #/date	Topics
10/Mar 18	Second in-class collaboration day – bring laptops
Mar 25	**spring break – no class**
11/Apr 1	Third and final in-class collaboration day – bring laptops
12/Apr 8	First & second presentations
13/Apr 15	Third & fourth presentations
14/Apr 22	Fifth & sixth presentations
15/Apr 29	Seventh & eighth presentations

HW for next week: See
https://canvas.sbcc.edu/courses/30653/assignments