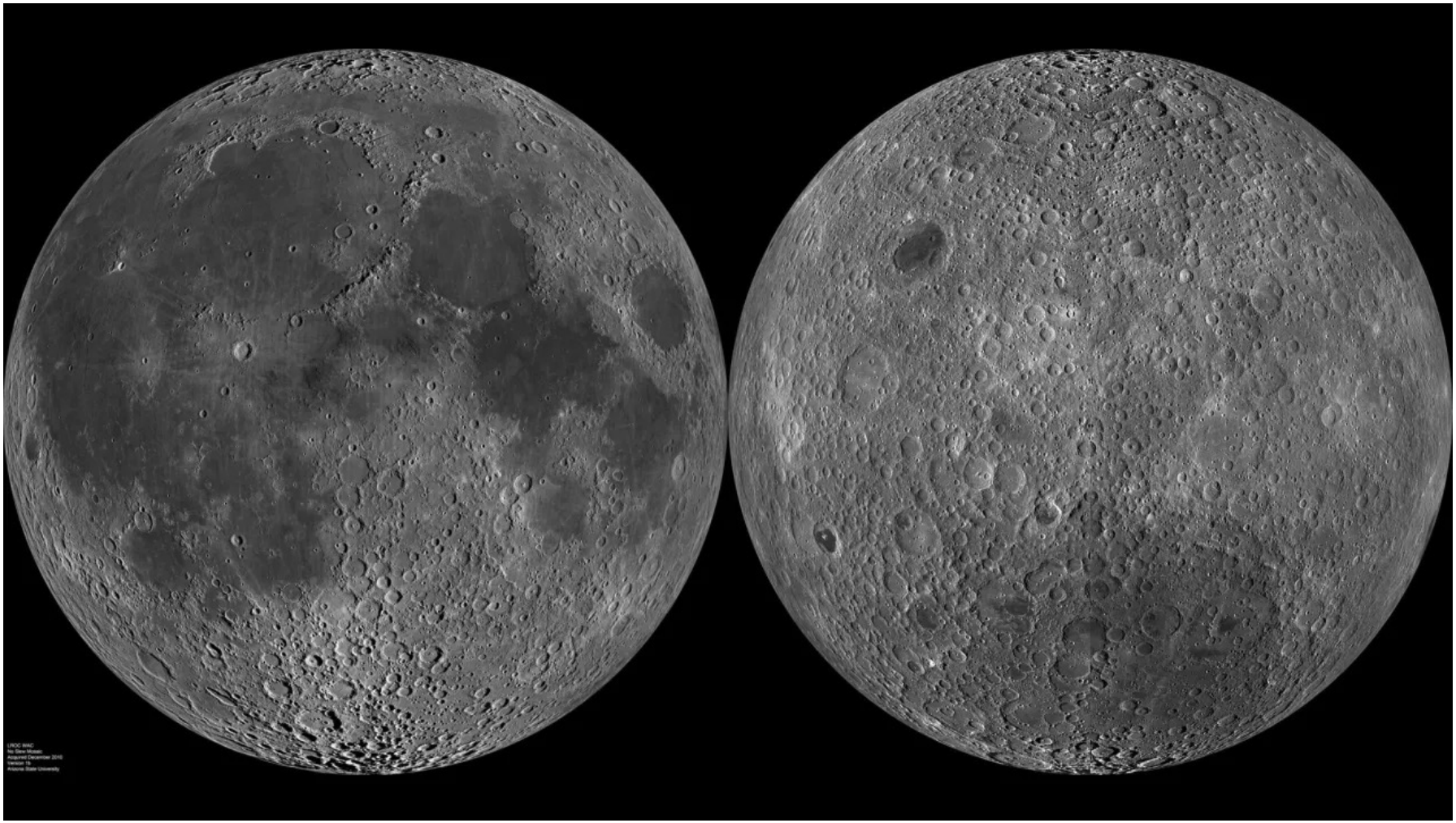
TWO SIDES OF THE MOON – BOTH DIFFERENT

MOON'S TWO FACES


LROC WAC
No Slew Mosaic
Acquired December 2010
Version 1b
Arizona State University

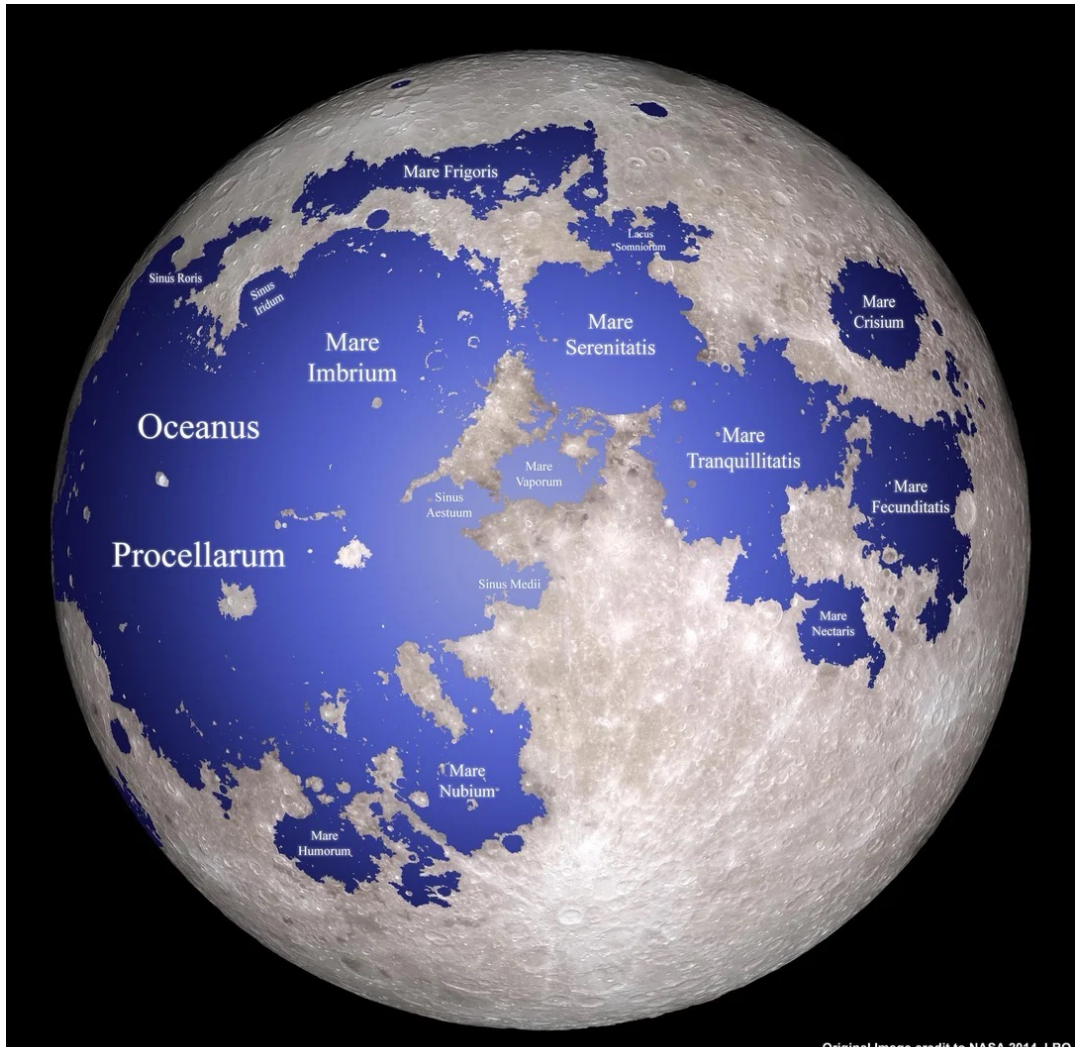
TAKE AWAYS FROM THIS TALK

- The Moon formed following an impact with the proto-Earth by a smaller planet (referred to as Theia) approx. 4.5 billion years ago (*according to the Giant Impact Hypothesis*)
- The Moon is tidally locked with the Earth, and this occurred earlier than conventionally thought
- The far side is radically different from the near side
- Reasons?
- **early tidal locking**, along with **extreme heat gradient** and **differential crust formation** on the two sides (*based on the Earthshine hypothesis)*

Both Sides Seem Different

- Maria dominates the geography of the Near Side – volcanic plain covers 31% of the surface
  - composed of basalt from internal lava
- The far side is dominated by craters and highlands
- The crust is thicker (40 – 60km vs 30 – 40km)
- Very few maria – less than 2% of the surface
- KREEP* congregated in concentration on the Near Side but not on the Far Side *(think Procellarum KREEP terrane (PKT) region – Oceanus Procellarum and Imbrium Basin)*

*** potassium, rare earth elements and phosporus**


Mare Frigoris
Lacus Somniorum
Sinus Roris
Sinus Iridum
Mare Crisium
Mare Imbrium
Mare Serenitatis
Oceanus
Mare Tranquillitatis
Mare Vaporum
Mare Fecunditatis
Sinus Aestuum
Procellarum
Sinus Medii
Mare Nectaris
Mare Nubium
Mare Humorum

Both Sides Seem Different

What is Tidal Locking?

The Moon's rotation speed matches its orbit speed around the Earth – 27.3 days

The conventional view has tidal locking occurring 10 to hundreds of millions of years after the Moon's formation

Moon’s Origins

The Giant Impact Hypothesis

When?

Roughly 4.5 billion years ago

Explaining the Differences

- The study published in *the Astrophysical Journal Letters* in June 2014,
- Study's title "*Earthshine on a Young Moon: Explaining the Lunar Farside Highlands*"
- Studies authors: Arpita Roy, Jason Wright, and Steinn Sigurdsson from Penn State.

Explaining the Differences

Here are the key findings of their study:

Early Tidal Locking: The researchers determined that the Moon quickly became tidally locked when it was 10 to 20 times closer to Earth than today

”Almost immediately” in geological terms (thousands to tens of thousands of years)

When the Moon formed so close to Earth, it would have lost rotational energy extremely rapidly - essentially forming in a tidally locked state from the beginning.

Explaining the Differences

Here are the key findings of their study:

Extreme Heat Gradient: The still-hot Earth, at temperatures exceeding 2,500 degrees Celsius, continuously radiated heat toward the Moon's near side

While the far side cooled much more quickly to around 250 K. This created a dramatic temperature difference between the two hemispheres.

Explaining the Differences

Here are the key findings of their study:

Extreme Heat Gradient: The still-hot Earth, at temperatures exceeding 2,500 degrees Celsius, continuously radiated heat toward the Moon's near side

Temperature difference may have **driven global circulation in the magma ocean,** transporting floating crystals to the far side while leaving the denser **KREEP** on the near side.

KREEP generates internal heat through radioactive decay, keeping the near side warmer for billions of years, facilitating volcanic activity that creates the maria we see from Earth

Explaining the Differences

Here are the key findings of their study:

Differential Crustal Formation: The key mechanism they proposed involves how the Moon's crust formed under these asymmetric conditions.

As rock vapour cooled, aluminum and calcium - the first elements to condense - preferentially accumulated on the cooler far side because the near side remained too hot.

These elements eventually combined with silicates to form plagioclase feldspars, resulting in a significantly thicker crust on the far side.

Explaining the Differences

To be confirmed upon further analysis:

Temperature (internal) Differences: Lunar rock samples from Chang'e-6 spacecraft suggest a colder internal temperature on the Moon's far side.

Possible Reasons?

- Less potassium, thorium, and uranium on the far side (KREEP elements) that release heat when they undergo radioactive decay
- Earthshine on the near side heated the near side while the far side radiated its heat into space

QUESTIONS?