

Earth and Space Science

Unit 2 Lecture 3: Formation of the Moon

Lunar Facts

- ◆ The moon ended its formation period approximately 4 billion years ago.
- ◆ After the period of formation, the surface of the moon continued to be heavily bombarded by the remains of planetary materials. This period is common to all planets and is referred to as the period of Late, Heavy Bombardment. During this period, the moon warmed, separated into a core and mantle, and experienced volcanism. Toward the end of this period the moon is thought to have experienced a series of significant collisions which formed the lunar Maria.
- ◆ Due to its small size, the moon should have cooled very rapidly compared to earth. All surface activity in the form of plate tectonics would have ceased once the moon had cooled. Even today, the interior of the moon appears to have cooled to a point of complete inactivity.

Factors to be taken into account when hypothesizing about formation of the Moon

- ◆ the moon's low density of 3.3 g/cc proves that the moon does not have a significant iron core like the earth does,
- ◆ the moon's rocks contain very few volatile substances which implies it was heated more than the earth
- ◆ the earth and the moon have identical values for the relative abundance of oxygen isotopes, which implies that the Earth and the Moon formed at the same distance from the sun.



The Five Major Theories of Formation of the Earth's Moon

Evidence supporting the Co-accretion Theory

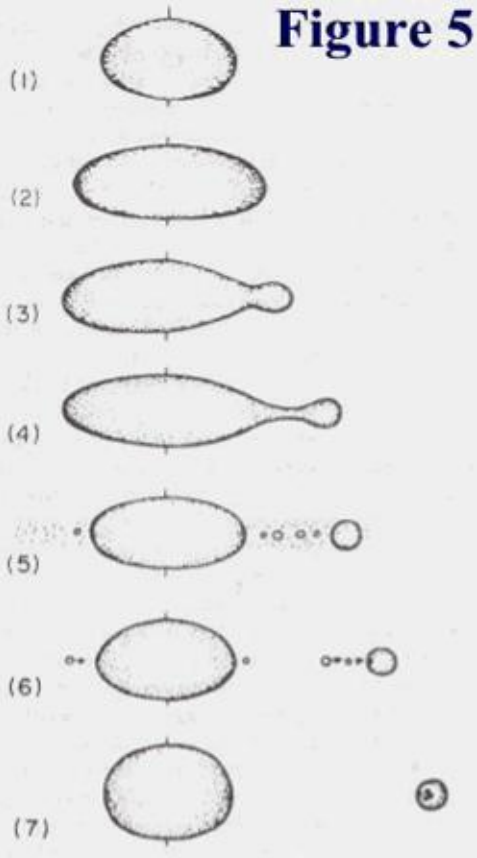
- ◆ States that the earth and the moon accreted at the same time out of the same nebular material
- ◆ In this theory, the proto-moon drew material out of the same nebular cloud as the earth in the same relative location as result, the two should be very similar in composition
- ◆ Why it doesn't work: The co-formation theory explains why the moon is located in its current location, but cannot explain the evidence that the earth and moon are composed of different materials.

Co-accretion Image



Did the moon form by Fission?

Figure 5



- Theory proposed by Darwin
- Based on fast-spinning primordial earth
- Earth spun and flattened so quickly that it ejected a large piece of material, which eventually became the moon
- Strengths: Isotopic ratio and Iron content similarities between Earth and Moon are explained
- Flaws: Energy needed to cause loss of the material not supported by present day spinning of the earth

The Capture Theory

- ◆ Ring of dust around the earth slows the moon, which has already formed, allowing it to be captured into the earth's gravitational field.

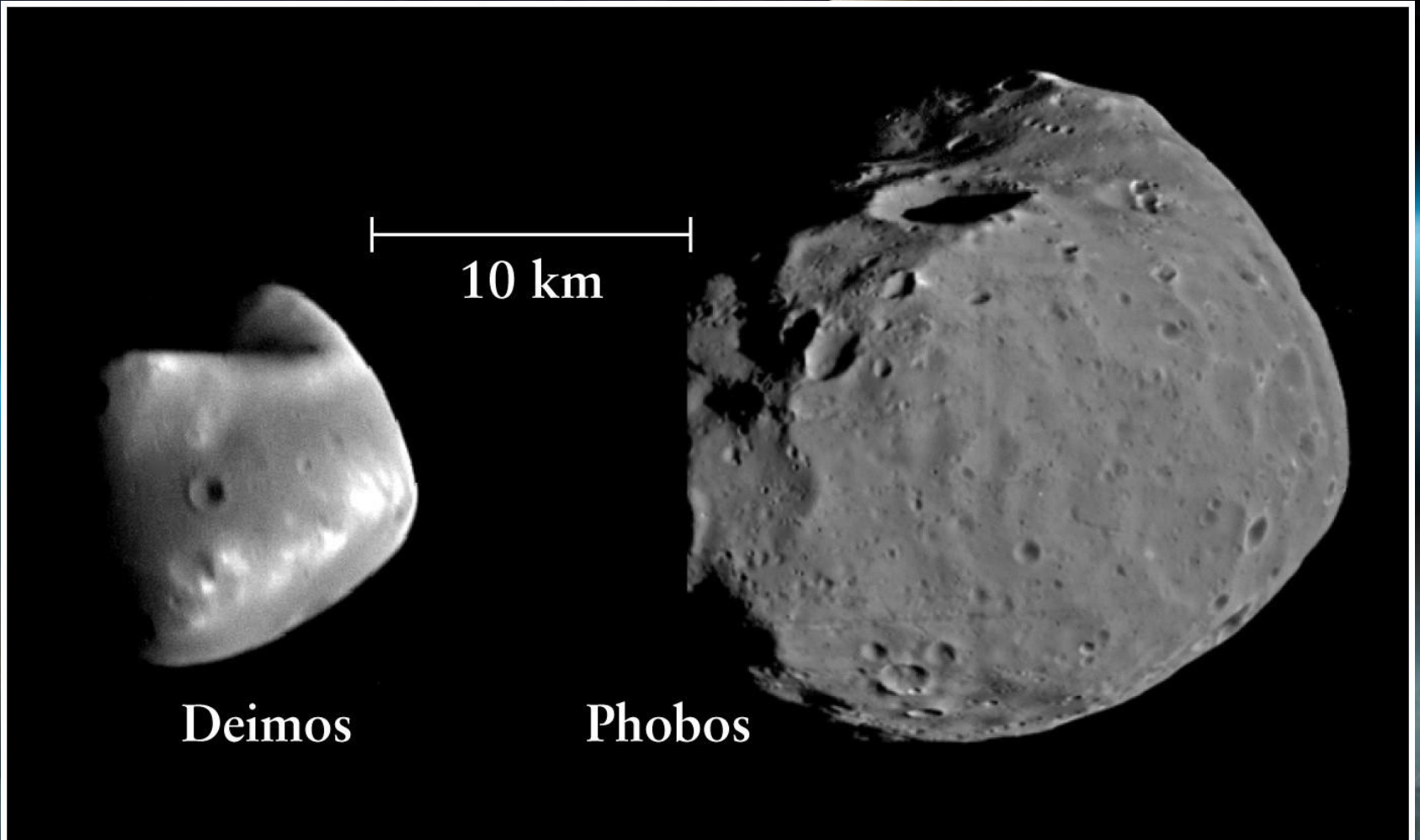


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Capture Theory Continued...

- ◆ **The Capture theory** postulates that the moon was formed at another place and time in the solar system and while passing by the earth, it was pulled into the earth's gravitational field.
- ◆ Reasonable hypothesis because many moons surrounding other planets are actually captured asteroids and not objects that formed in place with the mother planet. A moon that is captured would most likely have a non-spherical shape. Ex. Phobos and Deimos, the moons of Mars

The Moons of Mars (captured satellites)



Why the Capture theory does not work

- ◇ indicator that a moon has been captured would be if it orbited in a direction that differed from that of the mother planet, but our moon is rounded in shape and orbits the earth, the capture theory does not hold up.
- ◇ The only piece of evidence supported by the capture theory is the difference in composition between the earth and the moon.

The Colliding Planetesimals Theory

- ◆ Hypothesizes that the moon condensed from the debris of planetesimally sized objects that collided during the formation of the solar system
- ◆ Limited evidence to support this theory



The Collision-Ejection Theory

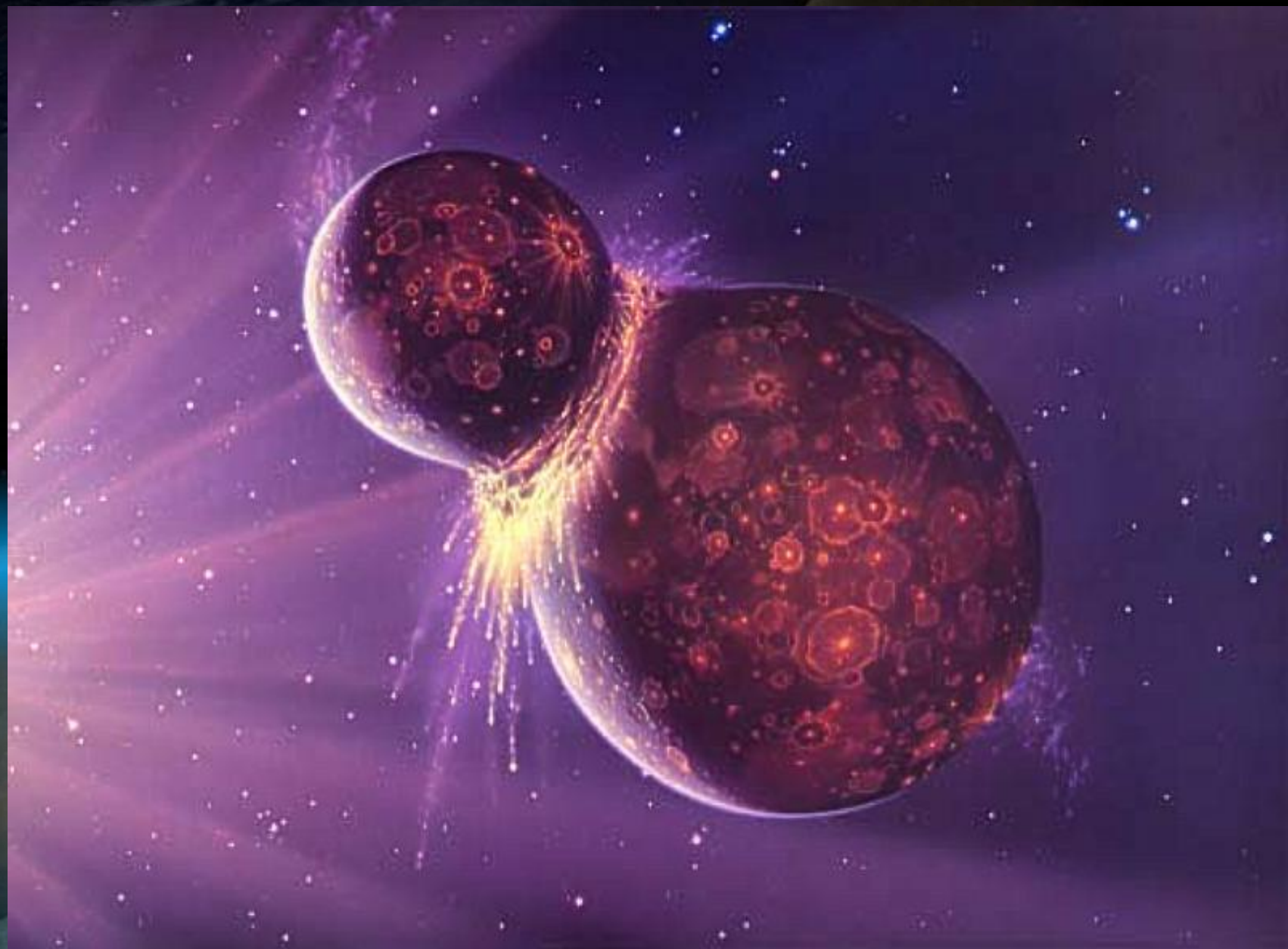
aka: The Giant Impactor Theory

What this theory is all about

- ◆ hypothesizes that the moon was formed when a planetesimal the size of mars struck the earth, thereby ejected large volumes of matter from the earth.
- ◆ disk of orbiting material ejected from the collision eventually condensed to form our moon in its orbit around the Earth.

Origin of the Theory

- ◆ The theory was proposed in the mid-1970's, but was rejected by many scientists until 1984 when a conference evaluating the validity of theories of the moon left no doubt that the collision theory was the most likely possibility
- ◆ New models of planet formation had suggested that giant impacts were not at all uncommon during the late stages of terrestrial planet formation.







Why this theory works

Explains the Lack of volatiles on the Moon's surface

- ◆ In order to explain the lack of volatiles on the moon, we would need an event which created a heat so high that all would have been vaporized. If an object the size of Mars were to collide with the forming Earth, the heat produced by this collision would provide a reasonable explanation as to why the moon's surface characteristics imply that it has been 'baked' more than the earth.

The Iron Core of the Moon explained

- ◇ moon is also thought to contain a small iron core
- ◇ The collision theory states that the moon would be able to retain the iron core even through the collision.
- ◇ The earth's Iron core had already undergone gravitational differentiation at the time of the impact, therefore, the debris ejected from the earth consisted of material from the iron depleted rocky mantle.

Supports similarities in Oxygen isotopic ratios

- ◆ The earth and the moon have exactly the same oxygen isotope composition while rocks and meteorites from different areas of the solar system have differing ratios.
- ◆ The similarity in isotopic ratios supports the belief that the moon formed from material in the earth's vicinity.