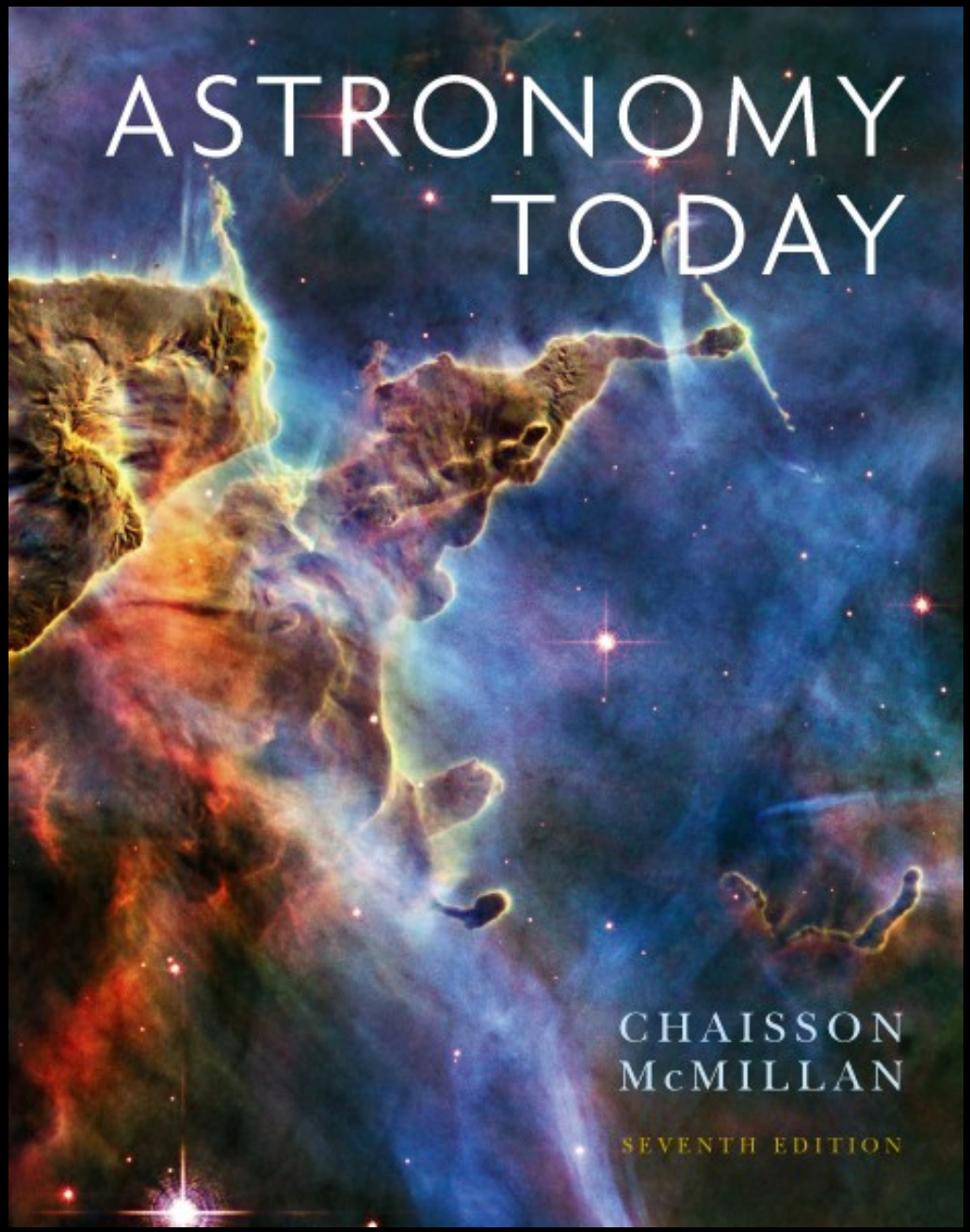


Lecture Outlines

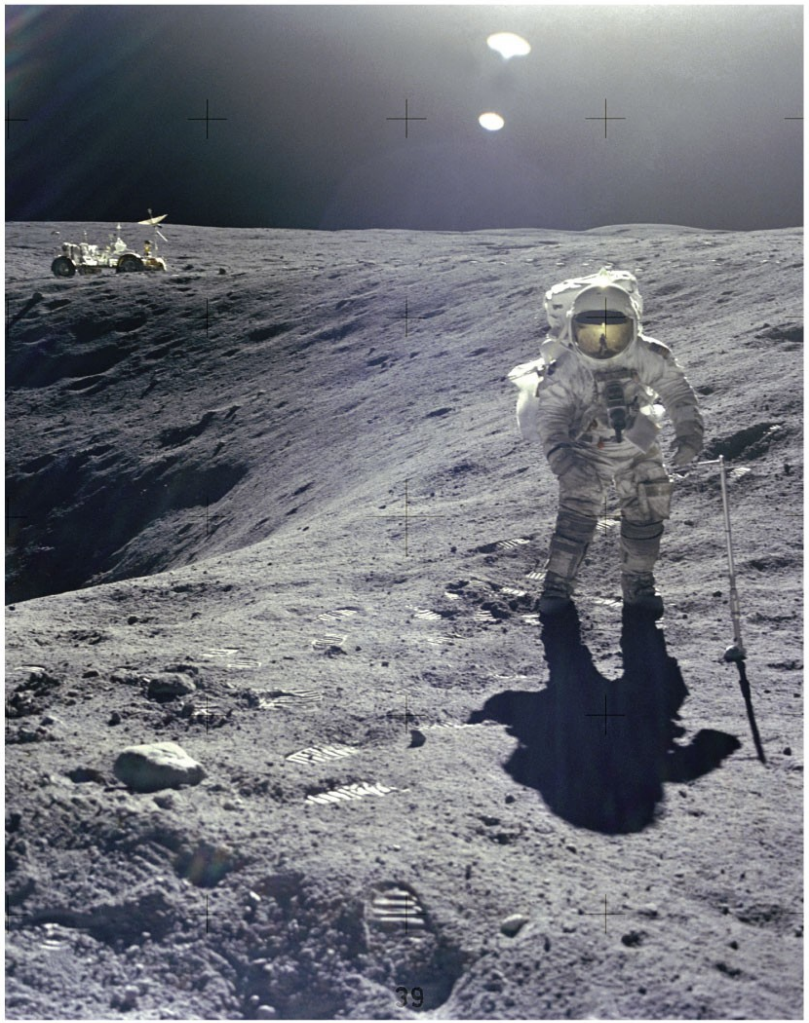
Chapter 8

Astronomy Today

7th Edition

Chaisson/McMillan

Chapter 8
The Moon and Mercury



Units of Chapter 8

Units of Chapter 8 (cont.)

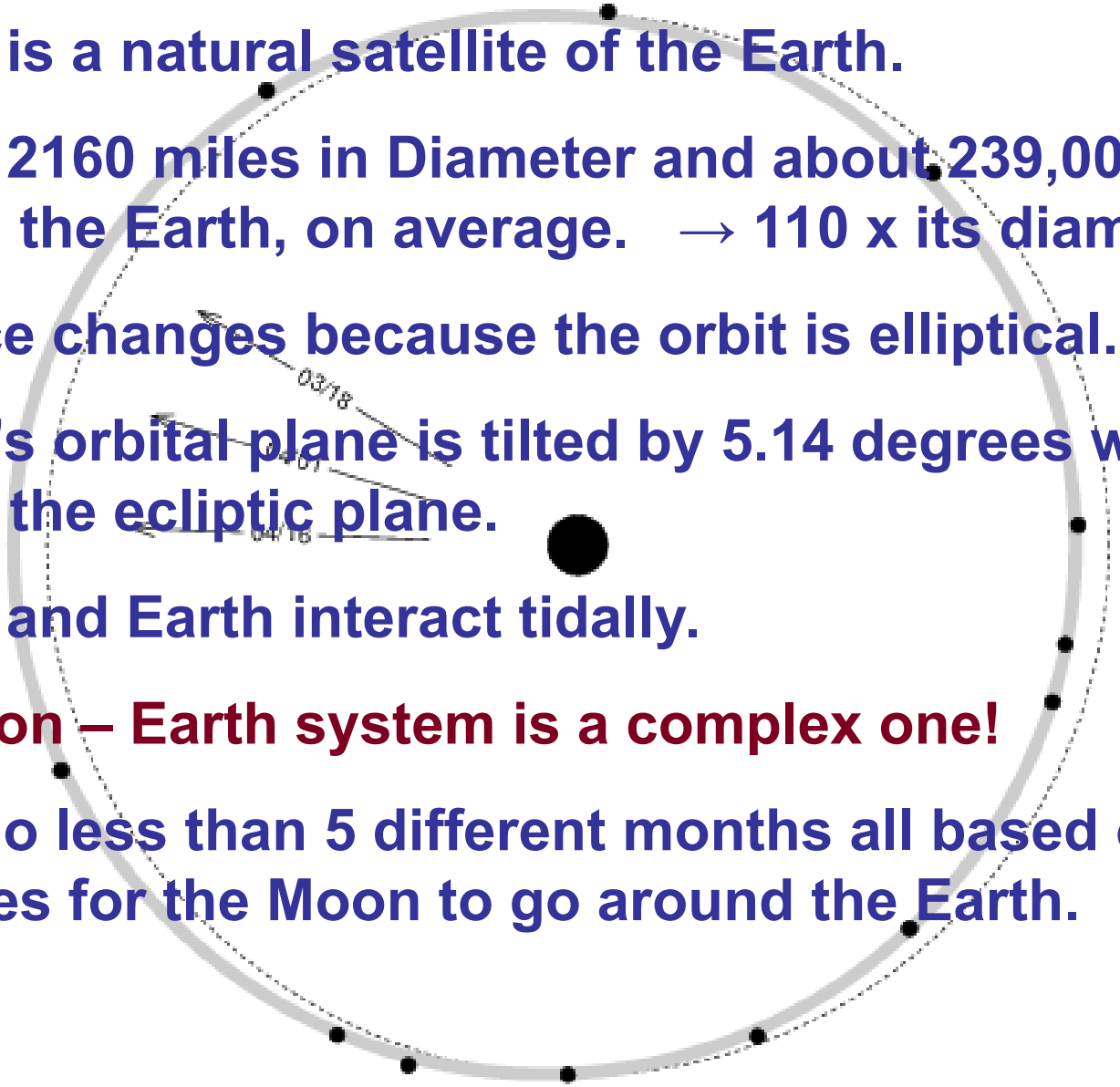
8.6 The Surface of Mercury

8.7 Interiors

8.8 The Origin of the Moon

8.9 Evolutionary History of the Moon and Mercury

Orbital properties (from week3)



The Moon is a natural satellite of the Earth.

It is about 2160 miles in Diameter and about 239,000 miles away from the Earth, on average. → 110 x its diam away

Its distance changes because the orbit is elliptical. (e=.055)

The Moon's orbital plane is tilted by 5.14 degrees with respect to the ecliptic plane.

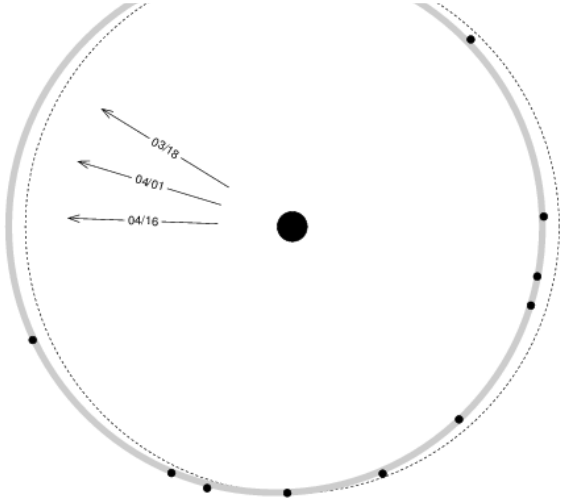
The Moon and Earth interact tidally.

→ The Moon – Earth system is a complex one!

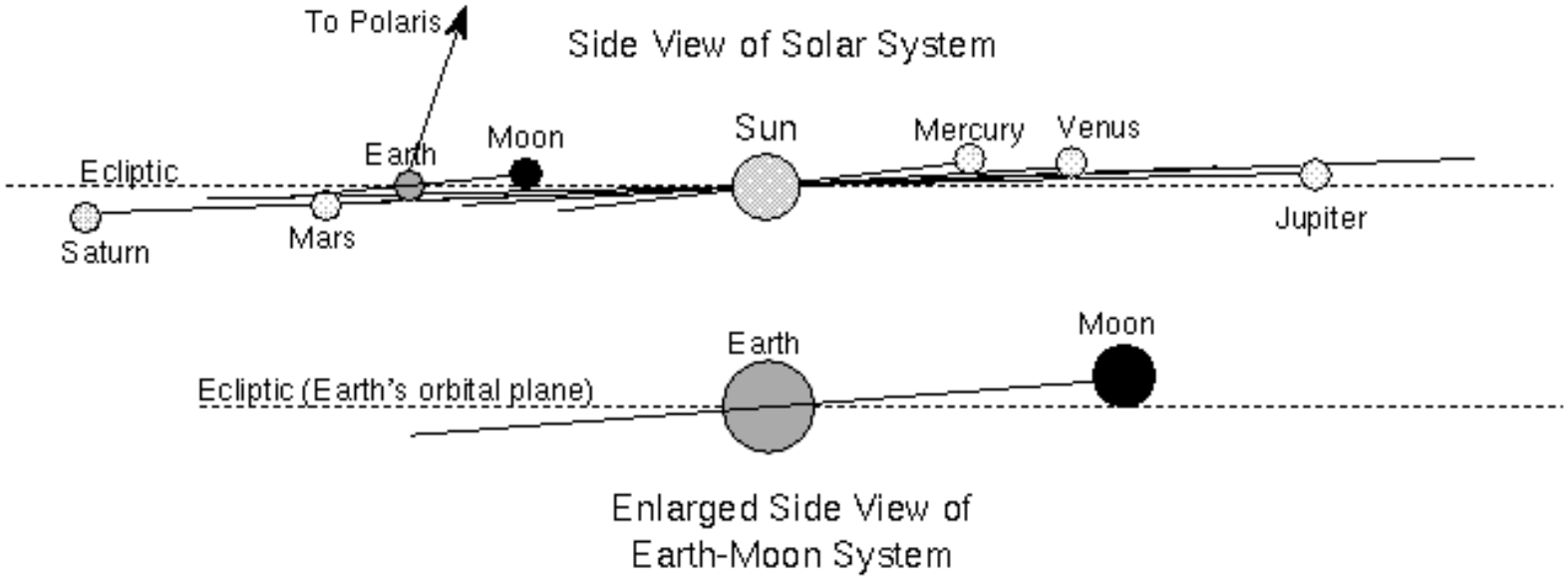
We have no less than 5 different months all based on the time it takes for the Moon to go around the Earth.

Orbital properties (from week 3)

Top View:

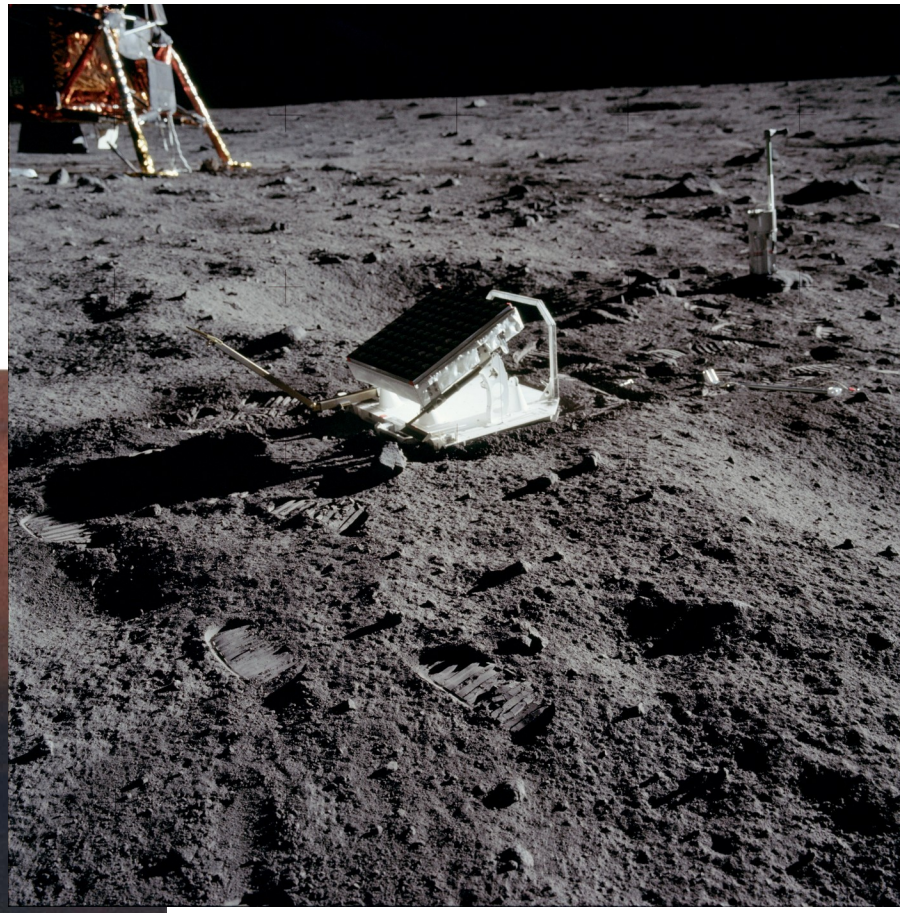


Side View:



8.1 Orbital Properties – Moon

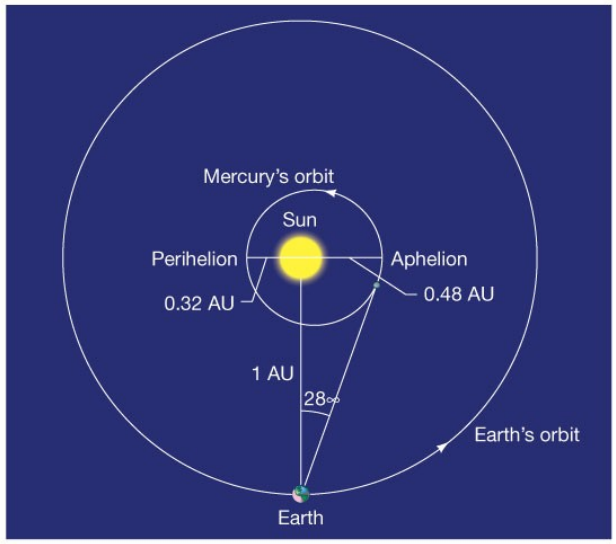
Distance between Earth and Moon can be measured to centimeter precision using laser ranging.



8.1 Orbital Properties

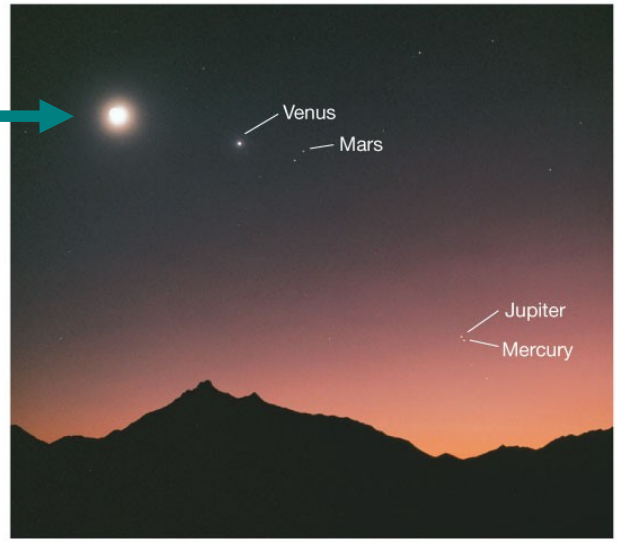
Viewed from Earth, Mercury is never over 28 degrees from the Sun.

It has an eccentric orbit, so it can have maximum elongation's range from 18 to 28°.



(a)

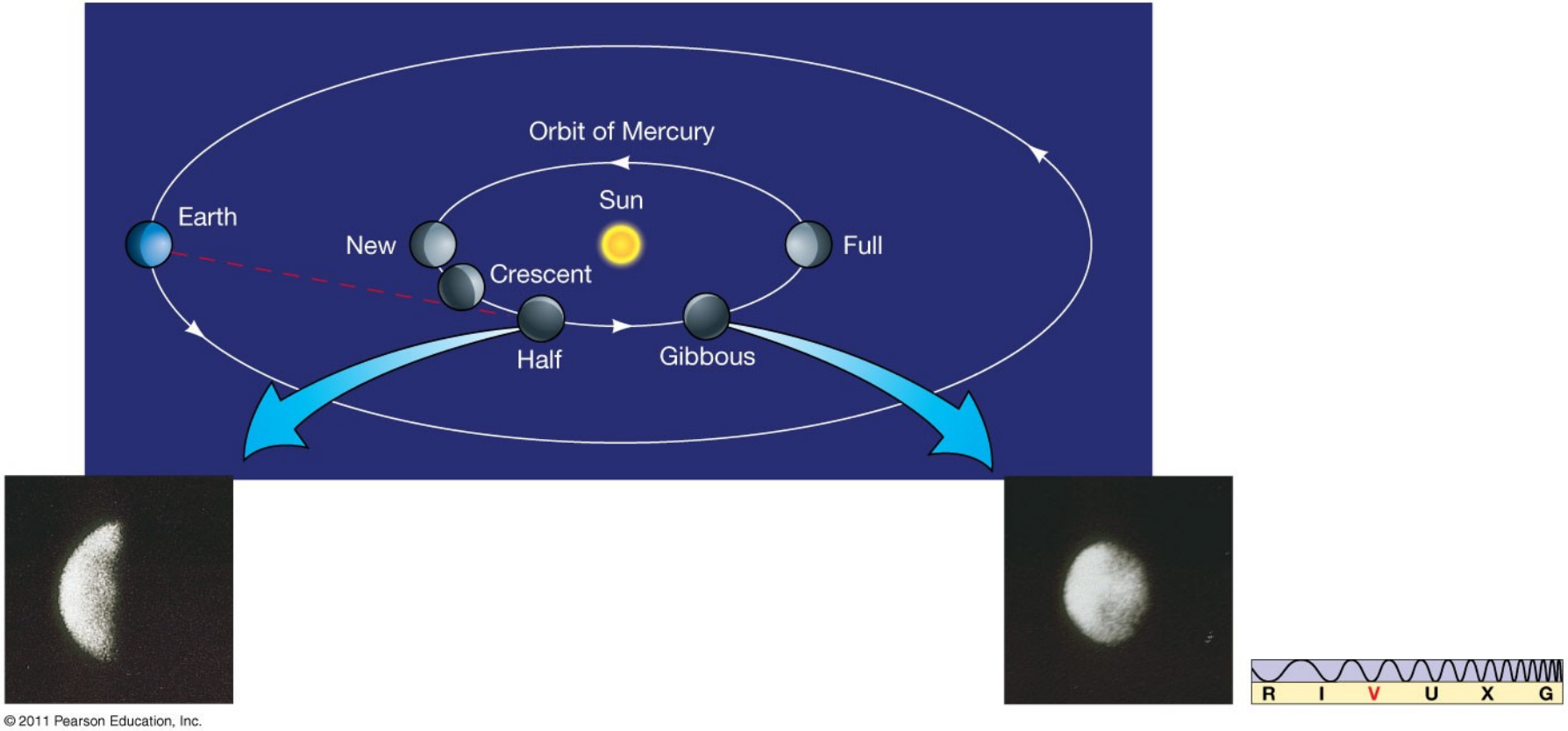
(Moon)



(b)

8.1 Orbital Properties

Half-lit (quarter) Phases of Mercury are seen when Mercury is near its maximum elongations



8.1 Orbital Properties

The Moon's orbit

Orbit Period (relative to stars) = 27.3 d

Rotation Period (rel. to stars) = 27.3 d

Radius of orbit = 385,000 km (avg)
Perihelion/Aphelion 363,000 / 405,000 km

Eccentricity = 0.054

Inclination = 5.2 deg

8.1 Orbital Properties

Mercury's Orbit:

Orbit Period (relative to stars) = 88 d

Rotation Period (rel. to stars) = 59 d

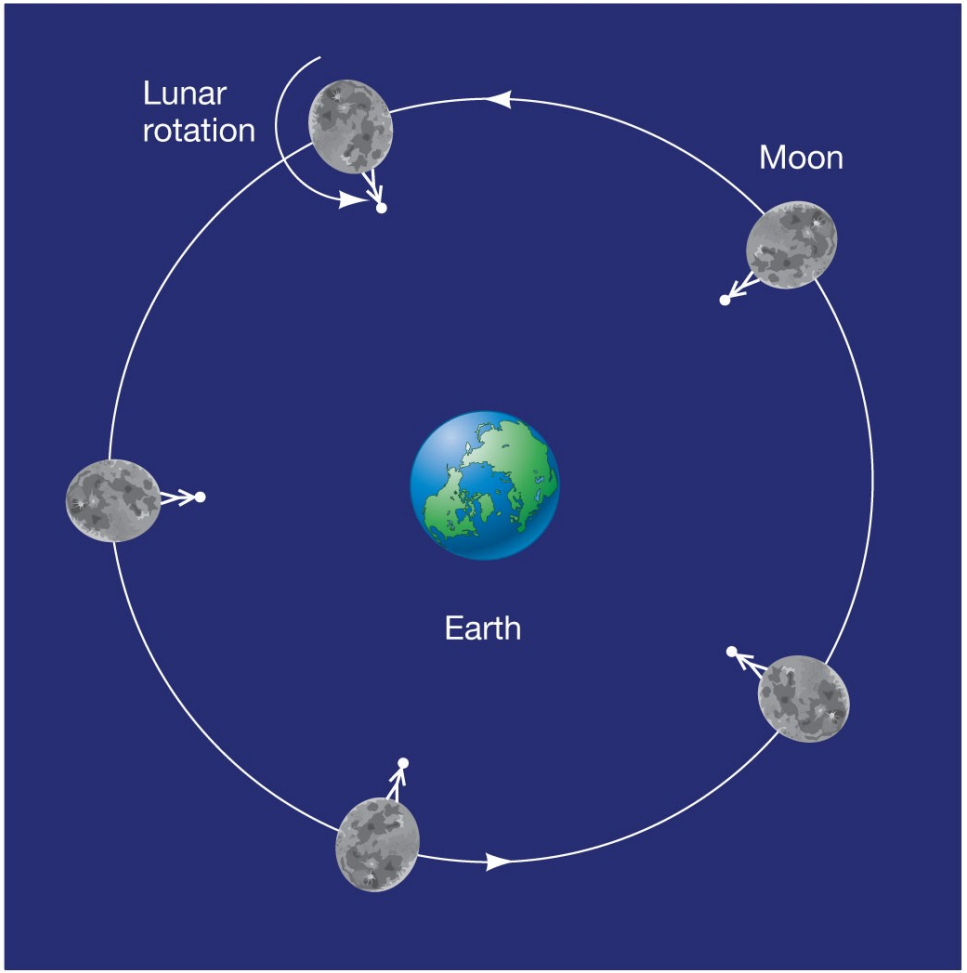
Radius of orbit = 0.39 AU (avg)
Perihelion/Aphelion 0.31 / 0.47 AU

Eccentricity = 0.206

Inclination (to ecliptic) = 7 degrees

8.4 Rotation Rates

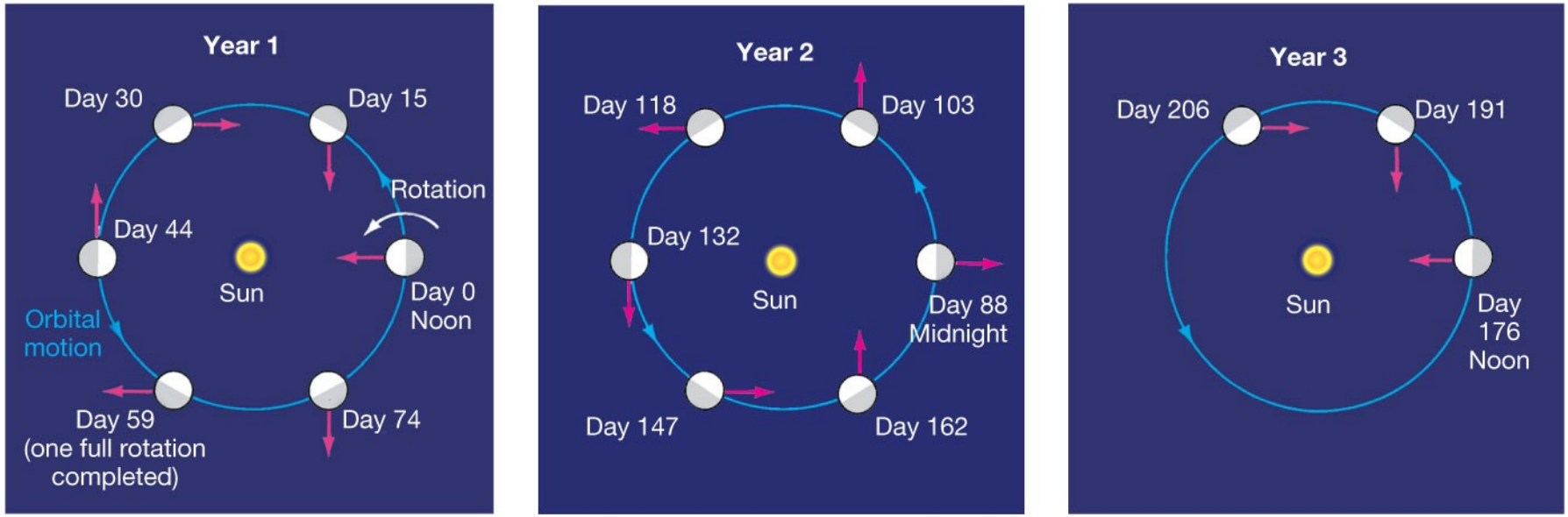
Moon is tidally locked to Earth—its rotation rate is the same as the time it takes to make one revolution, so the same side of the Moon always faces Earth



8.4 Rotation Rates

Mercury was long thought to be tidally locked to the Sun; measurements in 1965 showed this to be false.

Rather, Mercury's day and year are in a 3:2 resonance; Mercury rotates three times (rel to stars) while going around the Sun twice.



8.2 Physical Properties

	Moon	Mercury	Earth
Radius	**1738 km**	**2440 km**	**6380 km**
Mass	**7.3×10^{22} kg**	**3.3×10^{23} kg**	**6.0×10^{24} kg**
Density	**3300 kg/m^3**	**5400 kg/m^3**	**5500 kg/m^3**
Escape speed	**2.4 km/s**	**4.2 km/s**	**11.2 km/s**

Why Air Sticks Around

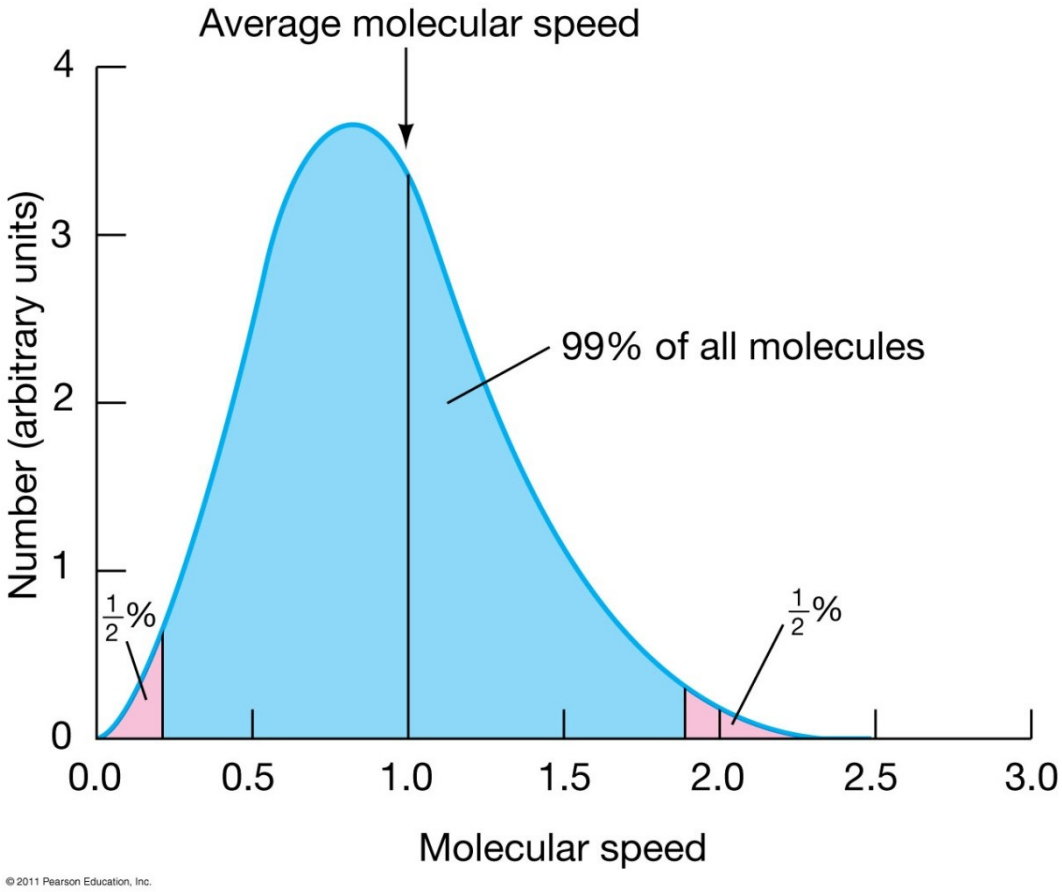
Air molecules have high speeds due to thermal motion. If the average molecular speed is well below the escape velocity, few molecules will escape.

Escape becomes more probable:

- For lighter molecules (higher speed for same kinetic energy)
- At higher temperatures
- For planets with low escape velocity (or low surface gravity) – low Mass, large R.

Why Air Sticks Around

Molecules in a gas have a range of speeds; the fastest might escape (if they don't incur another collision, and they are moving upward)



8.2 Physical Properties

Surface Temperatures

Planet	Minimum °F (°C)	K	Maximum (°F) (°C)	K
Mercury	- 275 °F (- 170°C)	103	+ 840 °F (+ 449°C)	722
Venus	+ 870 °F (+ 465°C)	738	+ 870 °F (+ 465°C)	738
Earth	- 129 °F (- 89°C)	184	+ 136 °F (+ 58°C)	331
Moon	- 280 °F (- 173°C)	100	+ 260 °F (+ 127°C)	400
Mars	- 195 °F (- 125°C)	148	+ 70 °F (+ 20°C)	293

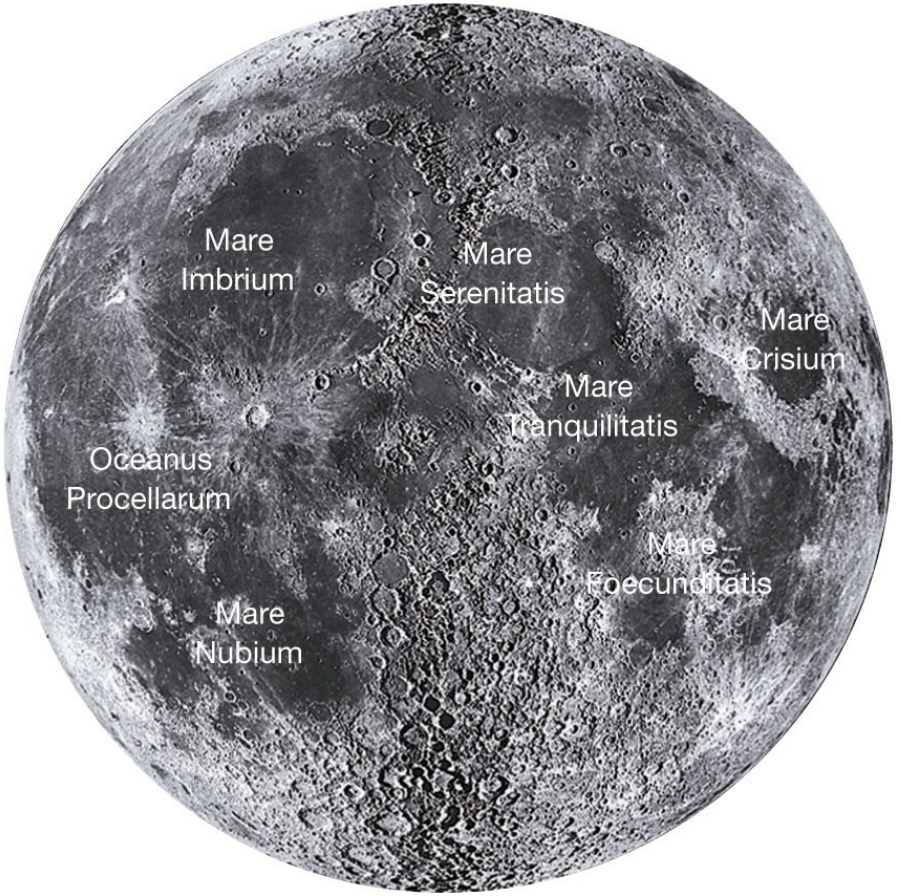
Source: Worldbook at NASA.

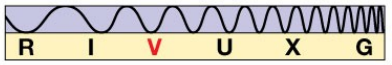
8.3 Surface Features on the Moon and Mercury

Moon has large dark flat areas called maria. (They look like oceans)

These are some of the biggest, oldest craters.

They flooded with lava.





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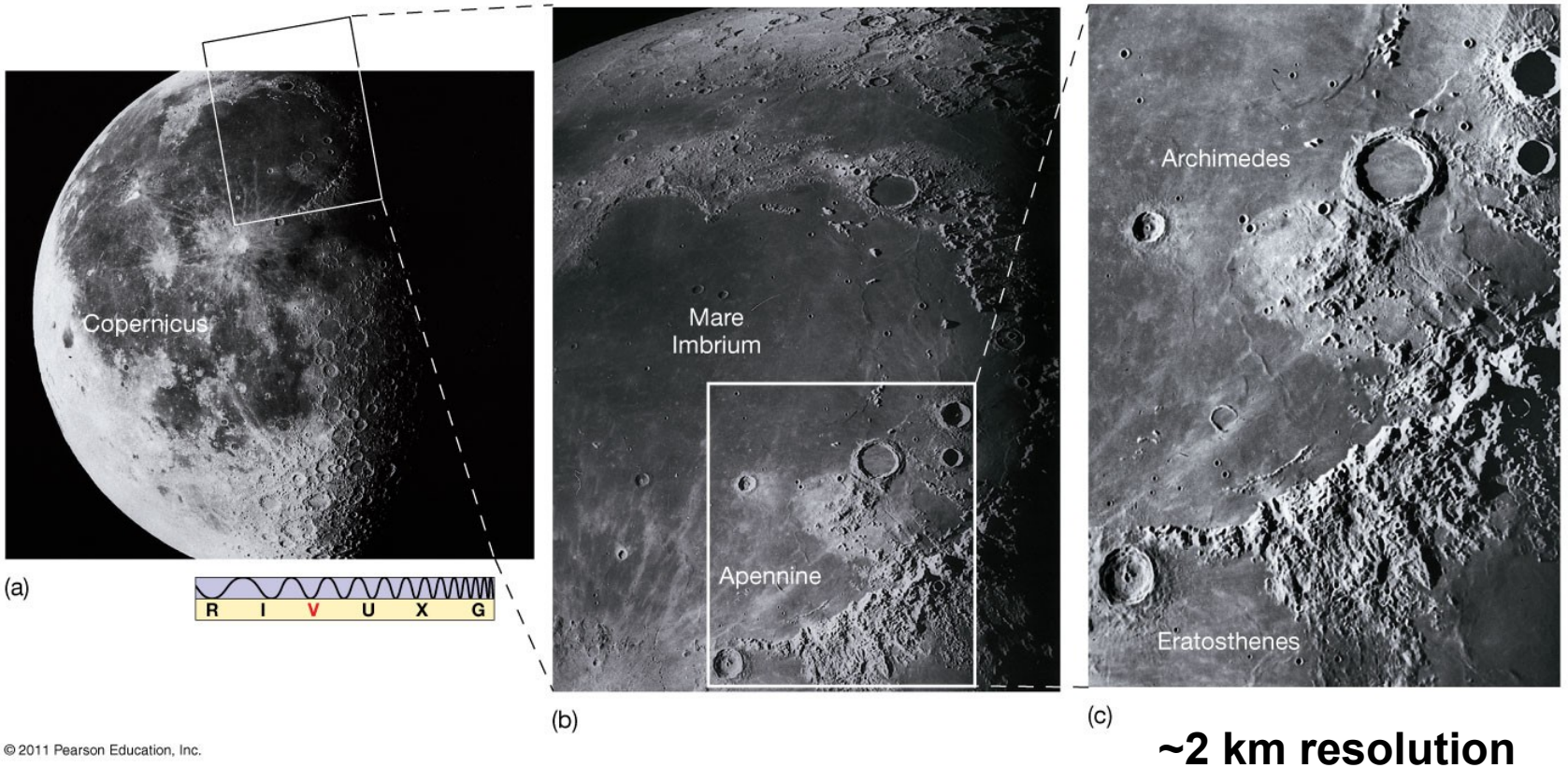
8.3 Surface Features on the Moon and Mercury

The best place to study craters and mountains is near the terminator.

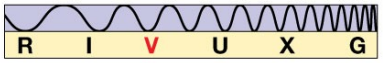


~2 km resolution

8.3 Surface Features on the Moon and Mercury

Far side of Moon has many craters but no maria.

(Compare with lunar globe.)



Clues to age/order of impact:
Overlapping, crispness, ejecta or rays.
In general, older surfaces have MORE craters!

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8.3 Surface Features on the Moon and Mercury

Mercury is slightly darker than the Moon.

Albedo: the fraction of light incident on a surface that is reflected.

Avg. Albedos:

- **Mercury: 0.106**
- **Moon: 0.12**
- **Earth: 0.36**

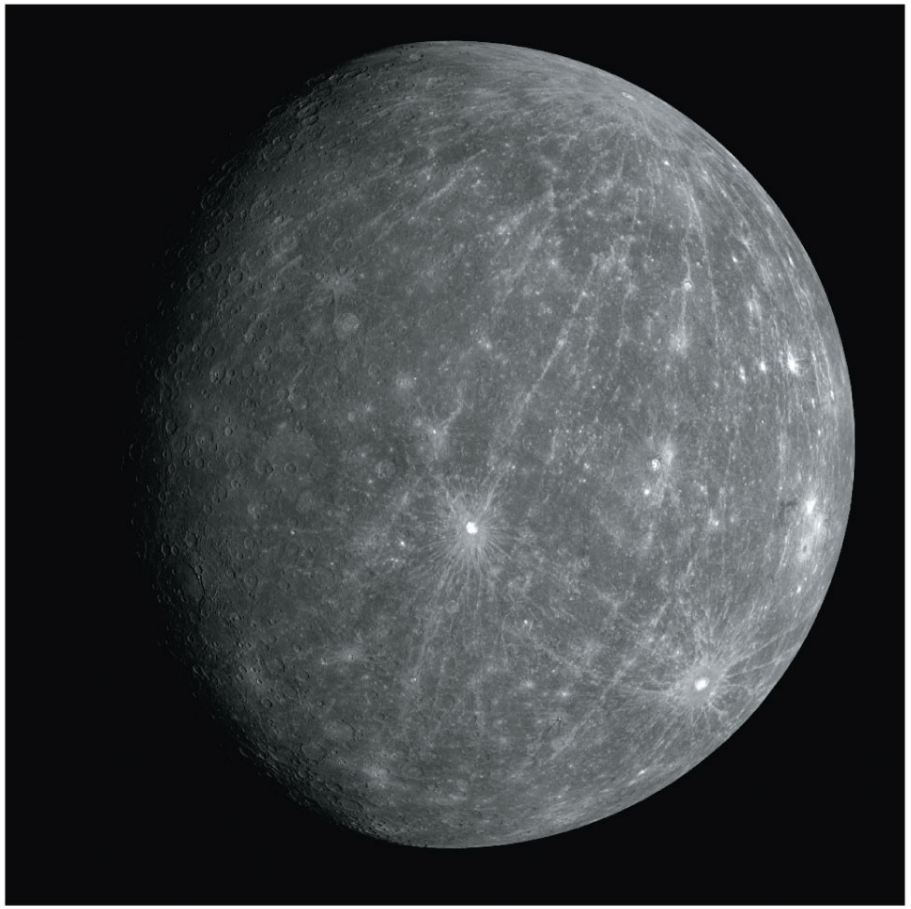
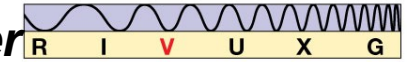


Image from *Messenger*



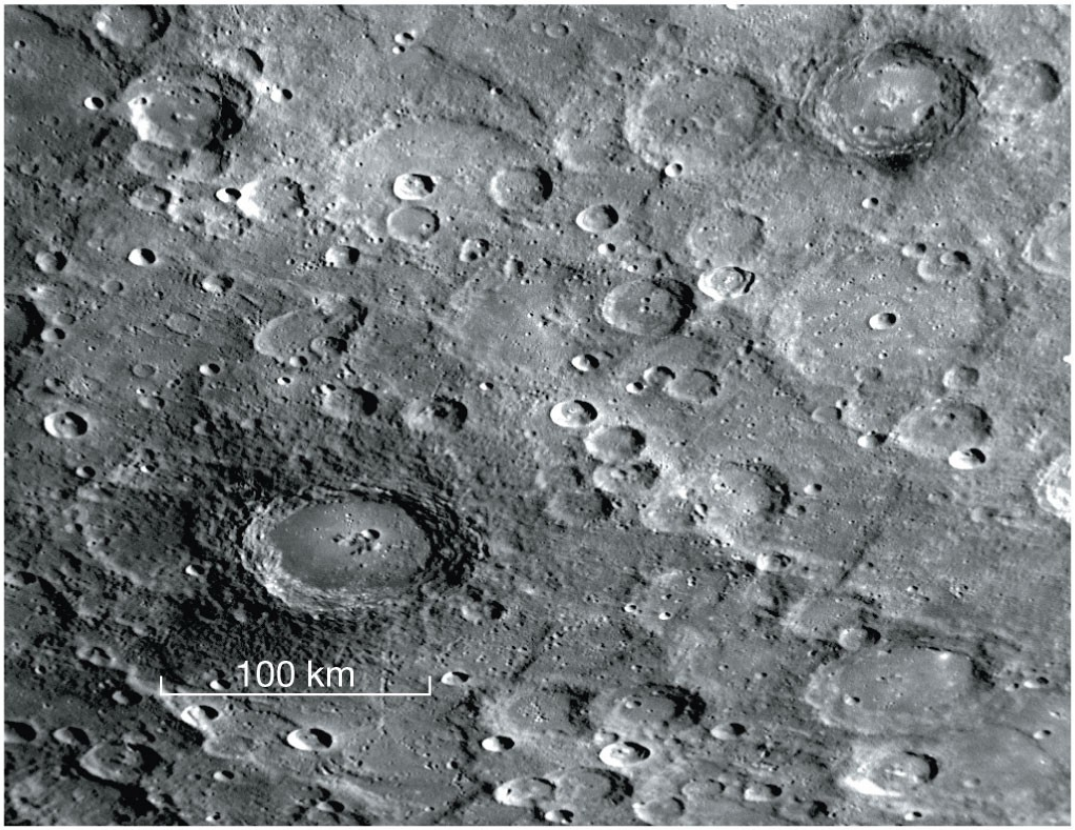
8.3 Surface Features on the Moon and Mercury

Cratering occurred on Mercury like on the Moon, but they are more widely spaced.

Peculiar to Mercury:

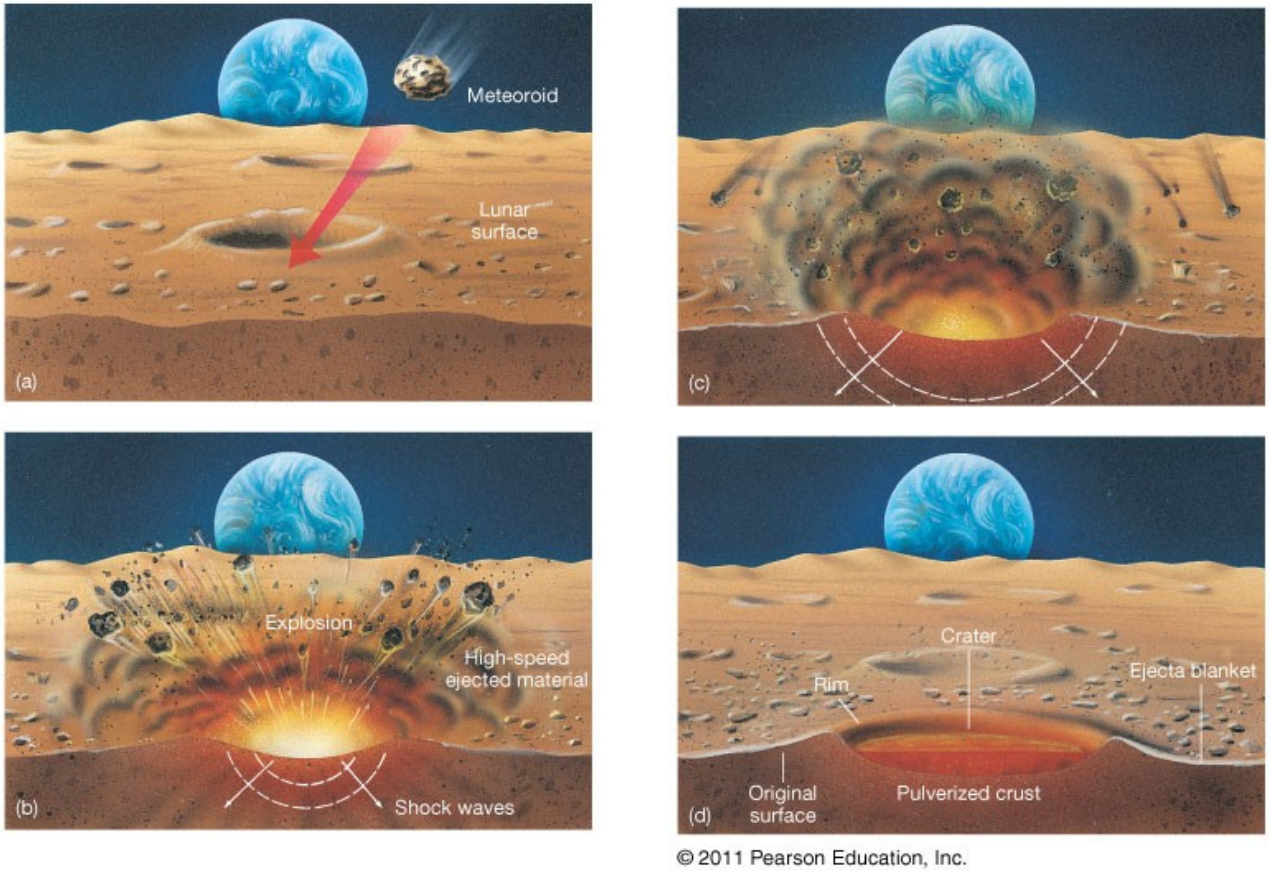
Scarps: linear features interpreted as wrinkles from contraction

Hollows: small, bright depressions within some craters.



8.5 Lunar Cratering and Surface

Meteoroid strikes Moon, ejecting material; explosion ejects more material, leaving crater



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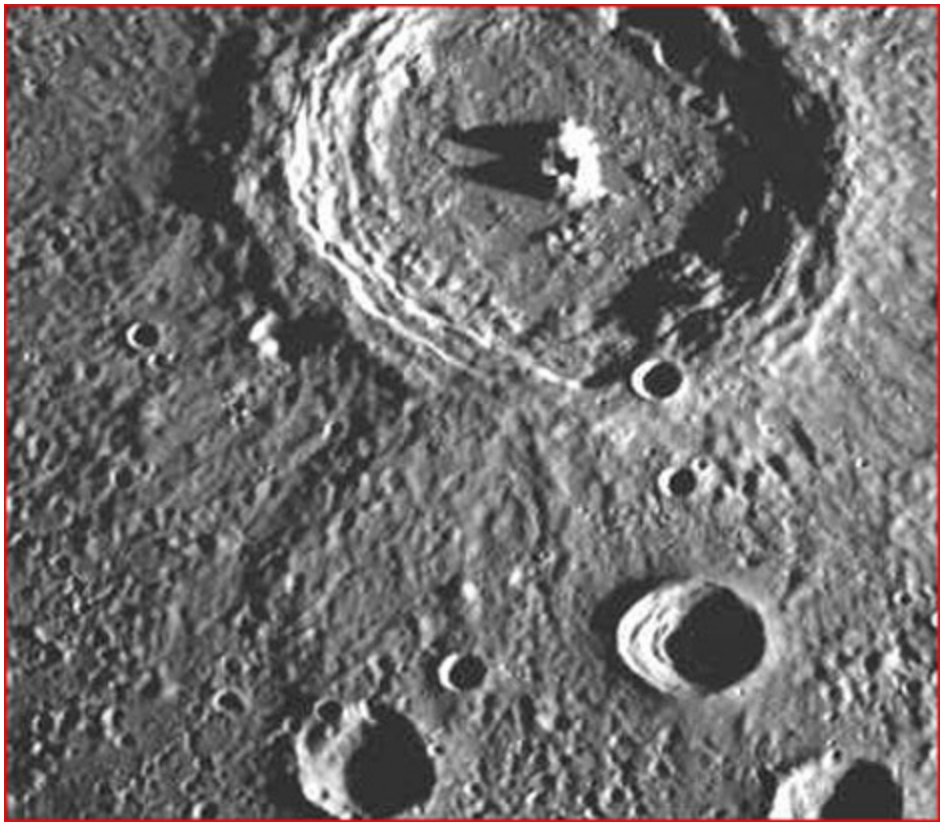
8.5 Cratering

Craters

Rim and Basin
Terraced walls
Central uplifts
Ejecta blankets
Rays
Walled Plains
Crater Chains
Other features:
- **Secondary craters**
- **Rilles: collapsed lava tubes**

<See videos of LPI flyovers>



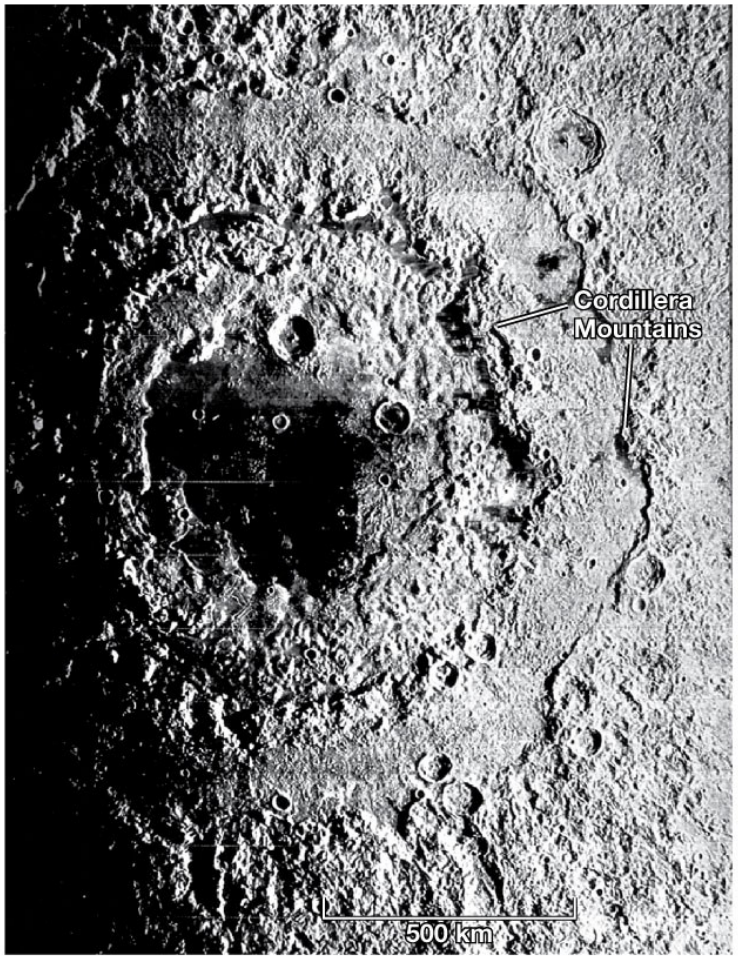
Brahms crater on Mercury

8.5 Cratering

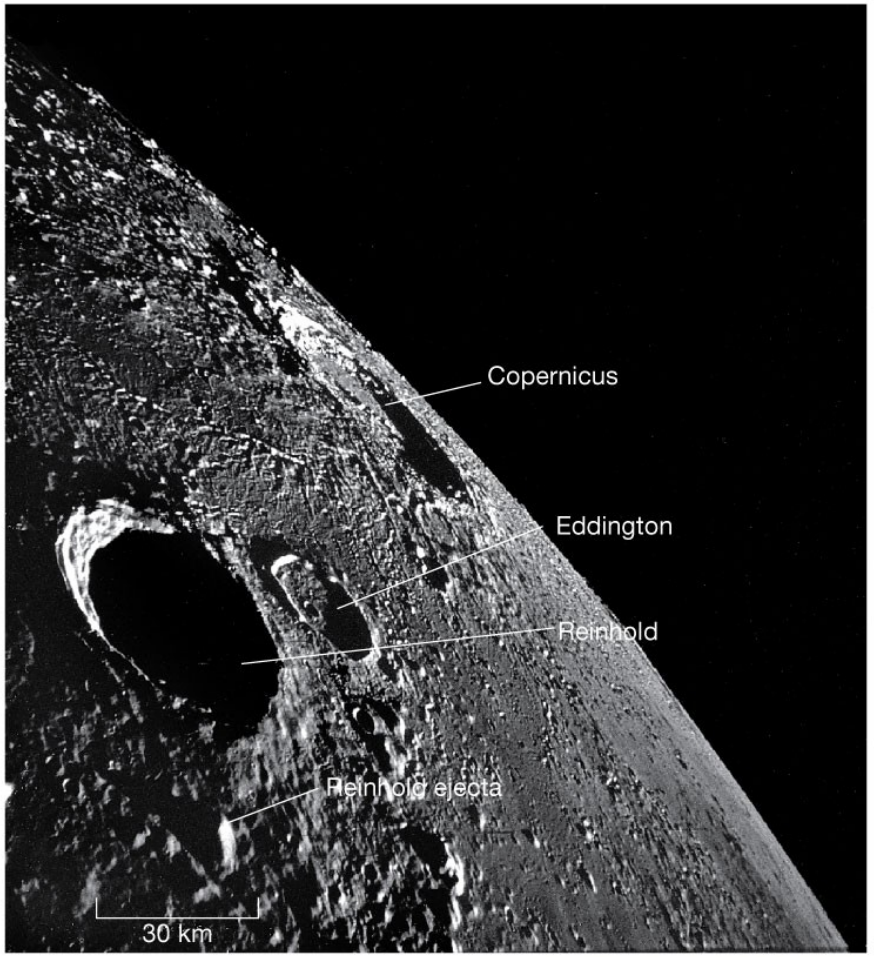
- **Craters** are typically about 10 times as wide as the meteoroid creating them, with a depth about 1/5 of the width
- Rock is **pulverized** to a much greater depth
- Most lunar craters date to at least 3.9 billion years ago; much less **bombardment** since then.

8.5 Lunar Cratering

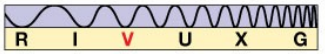
Big Craters: Orientale Basin(1000km); Rheinhold (40km)



(a)

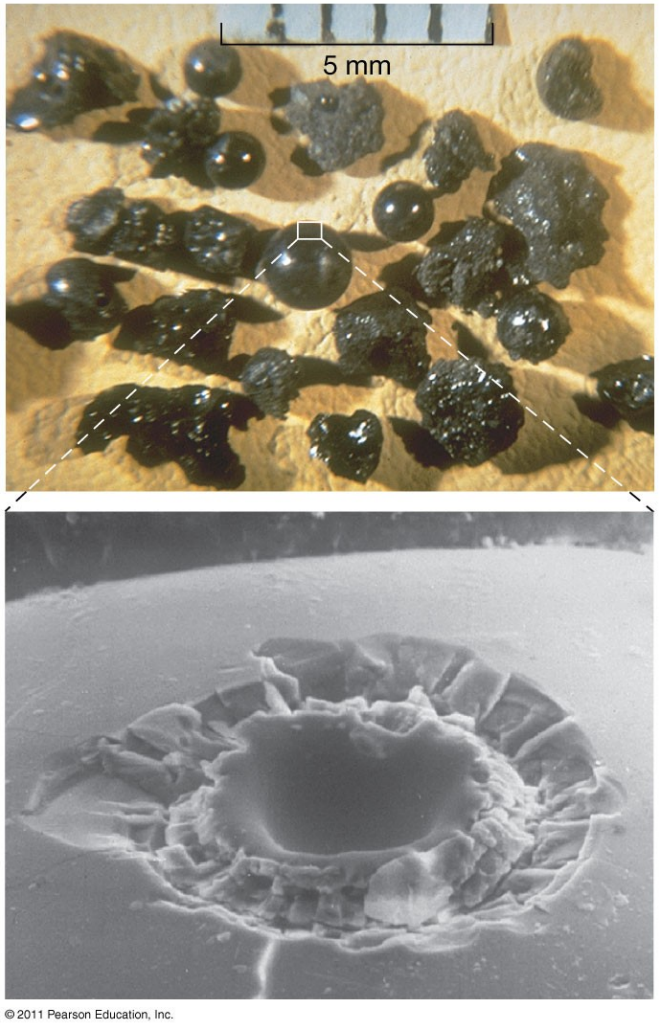


(b)



8.5 Lunar Cratering and Surface Composition

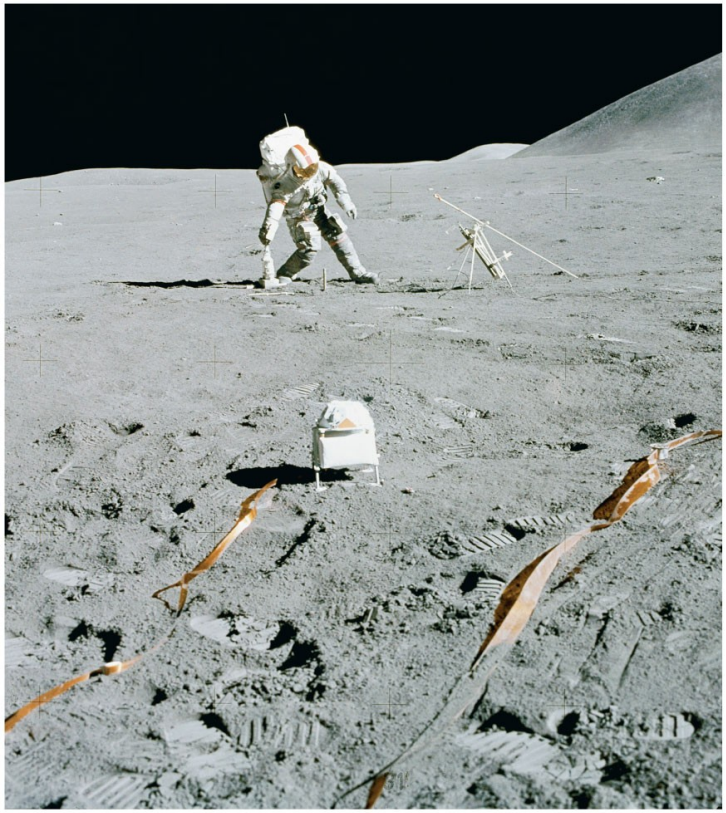
Small craters...
<u>Micrometeorites</u> on glassy beads found in the lunar regolith.

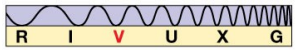


8.5 Lunar Cratering and Surface Composition

Regolith: Thick layer of dust left by meteorite impacts (average depth = 20 m)

Moon is still being bombarded, especially by very small micrometeoroids; softens features





8.5 Lunar Cratering

The rate of small impacts was difficult to guess until LRO.

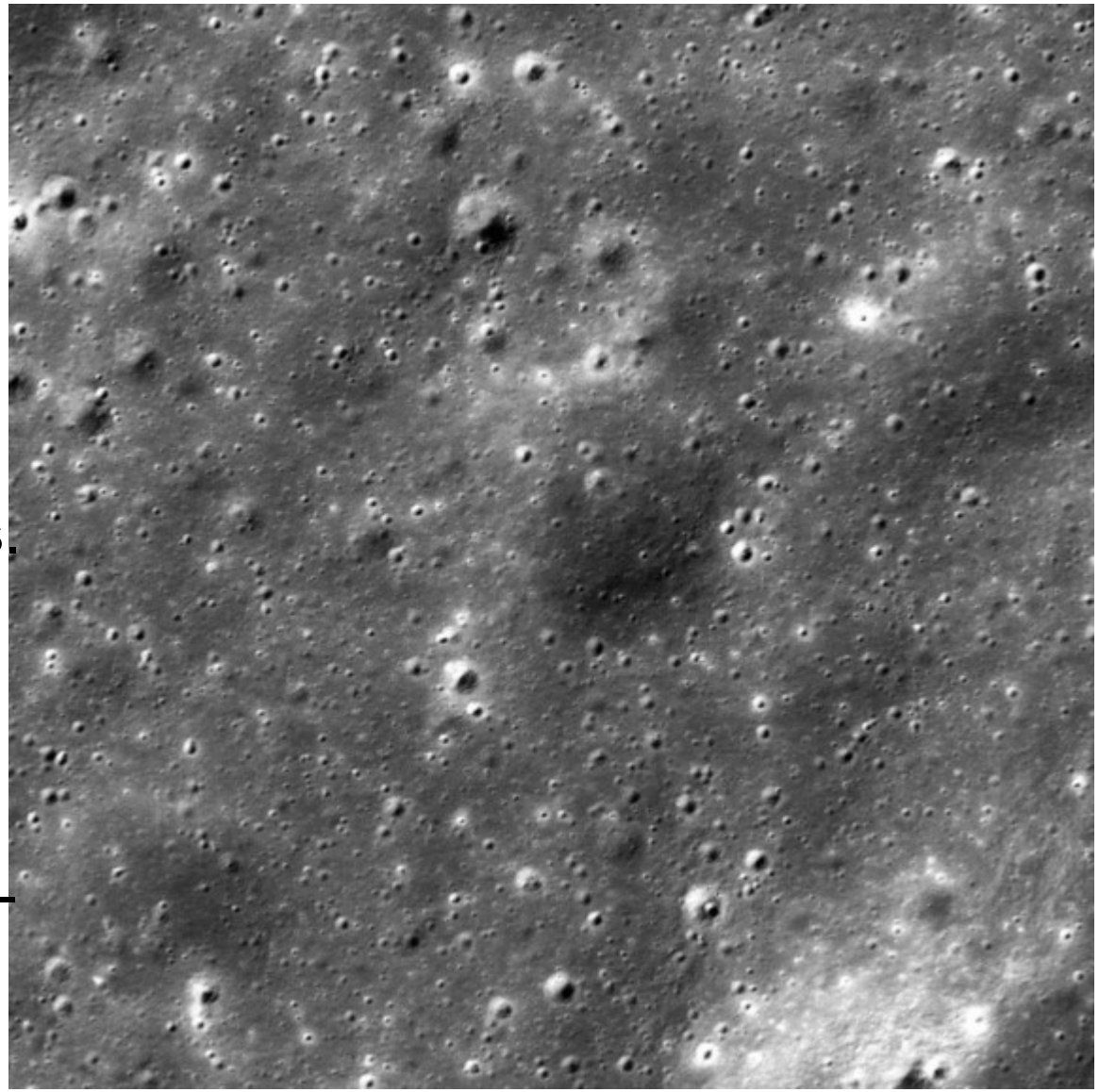
222 new craters!

Pictures 0.5-3.4 yrs apart.

Relatively tiny:
10-43 meters across.

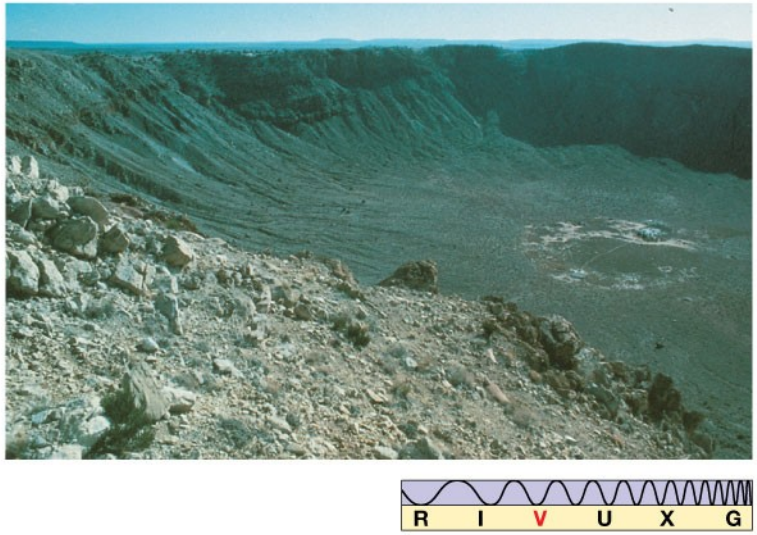
Two flashes seen from Earth!

Regolith altered frequently.



8.5 Lunar Cratering and Surface Composition

Meteorites also hit Earth; this Barringer crater is in Arizona. 50,000 yrs old. ~1km diam.

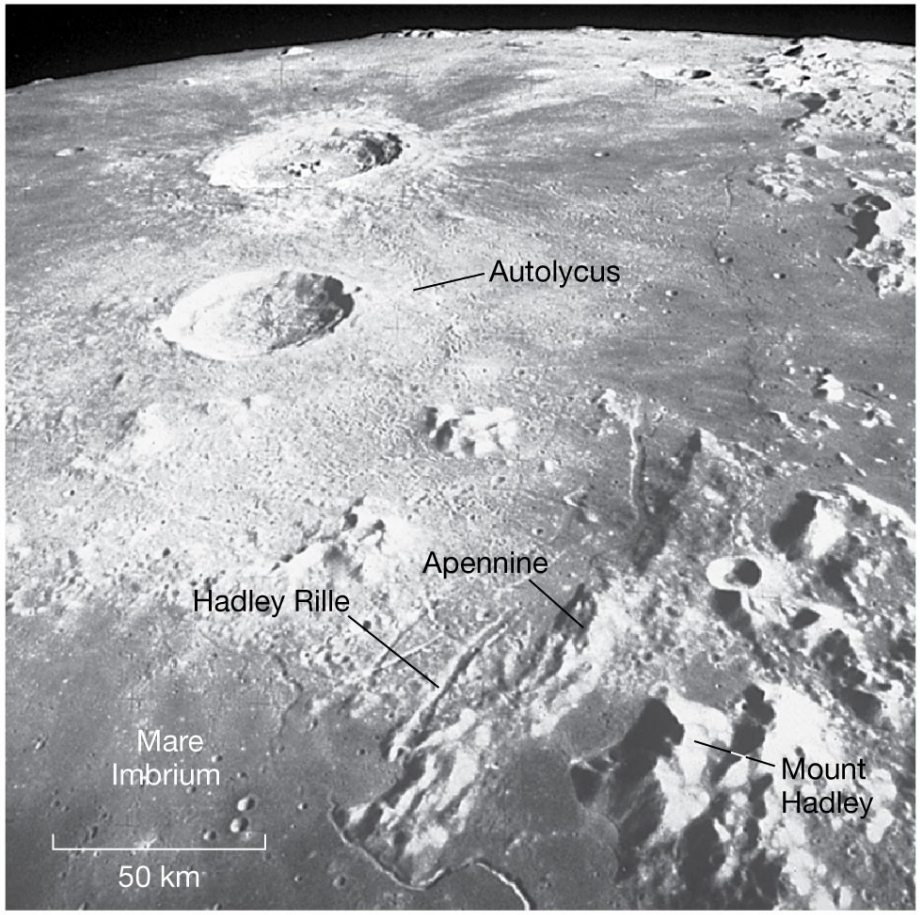


Also see:
excavation of 30 ton meteorite,
Chelyabinsk meteor

8.5 Lunar Surface

More than 3 billion years ago, the moon was volcanically active; the rilles shown here are thought to trace old lava tubes.

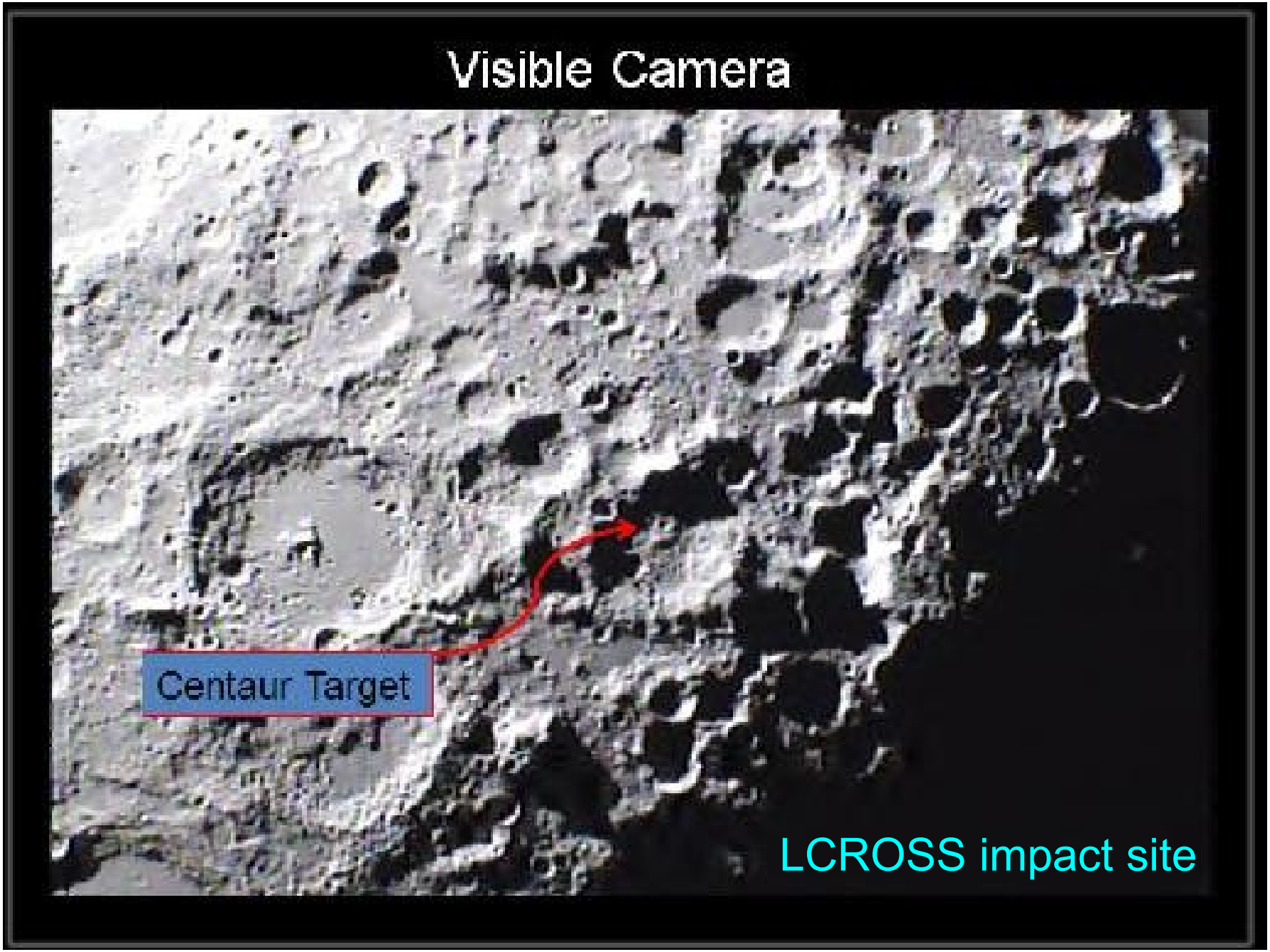
Straight rilles probably trace faults.



Lunar Surface – water on Moon?

- **Presence of water ice long suspected in polar craters. Deposited by impacts, then sublimated/evaporated.**
- **Protons detected above polar craters.**
- **LCROSS – Lunar Crater and Observation Sensing Satellite. Oct 2009 impact reveals trace amounts of water.**
- **Human colonization.**

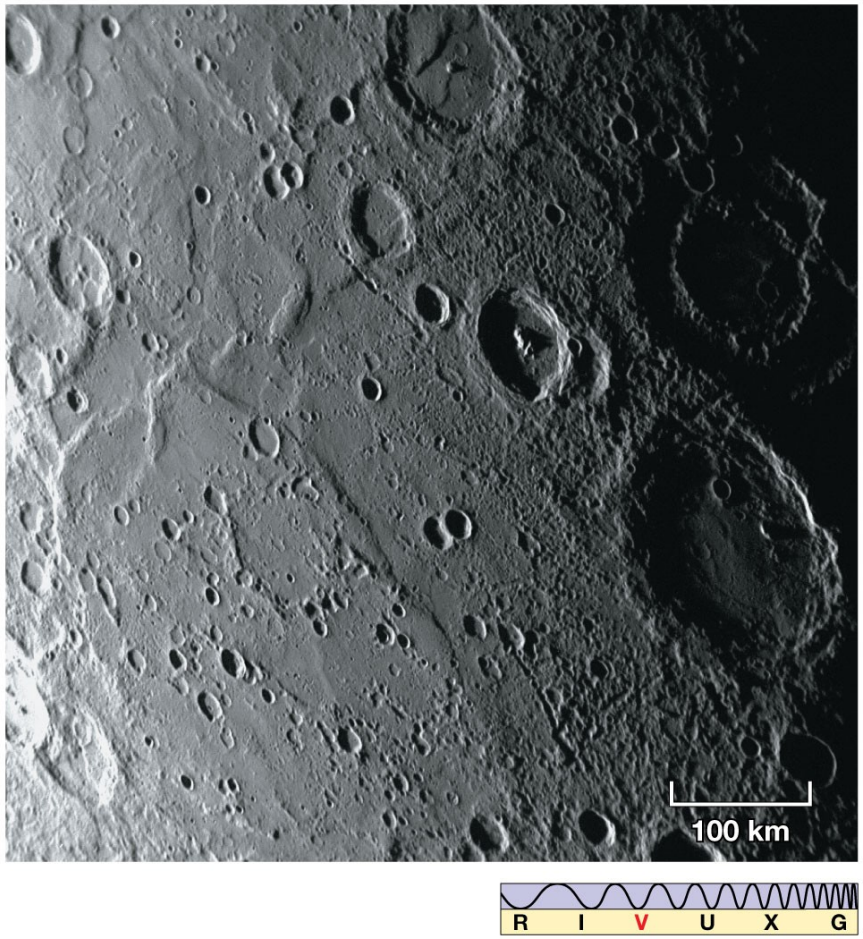
Lunar Surface – water on Moon?



8.6 The Surface of Mercury

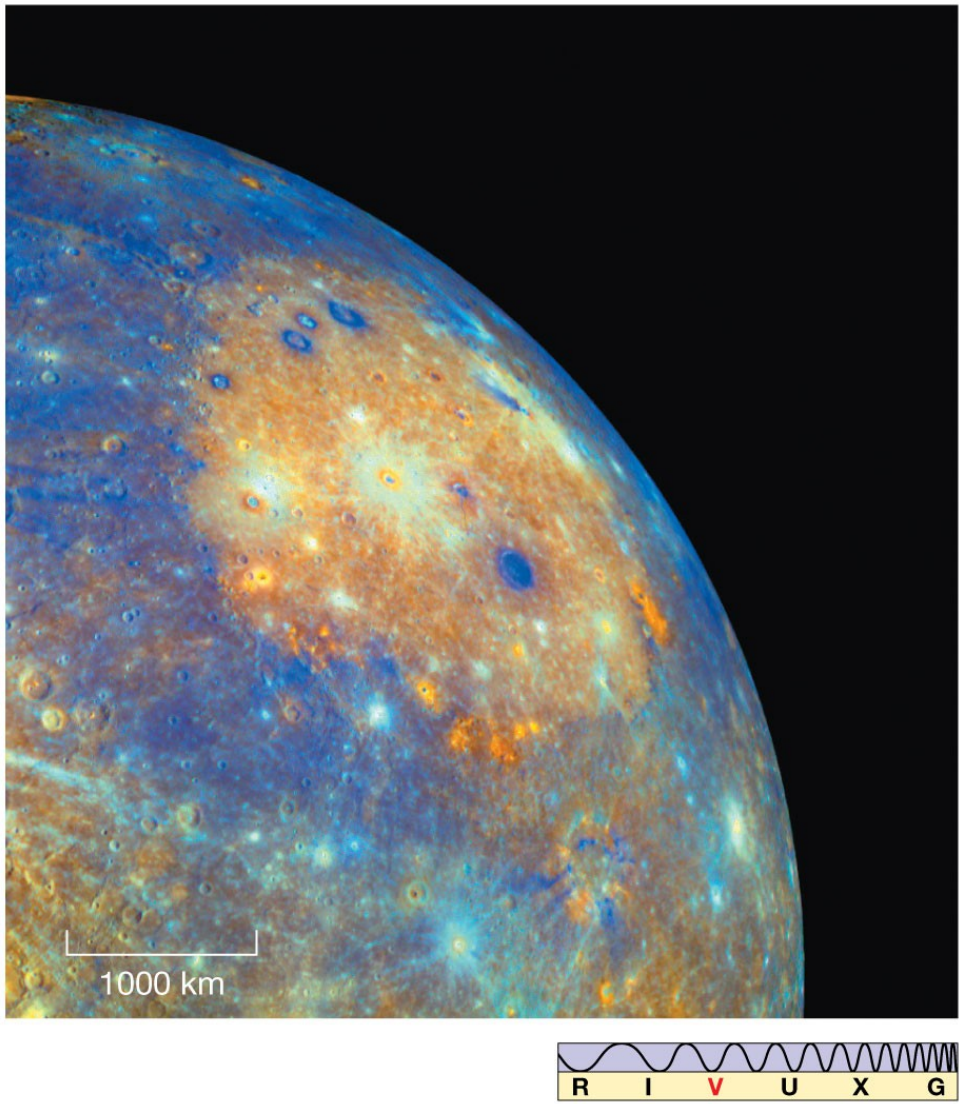
Mercury is less heavily cratered than the Moon

Some distinctive features:
Scarp (cliff), several hundred kilometers long and up to 3 km high



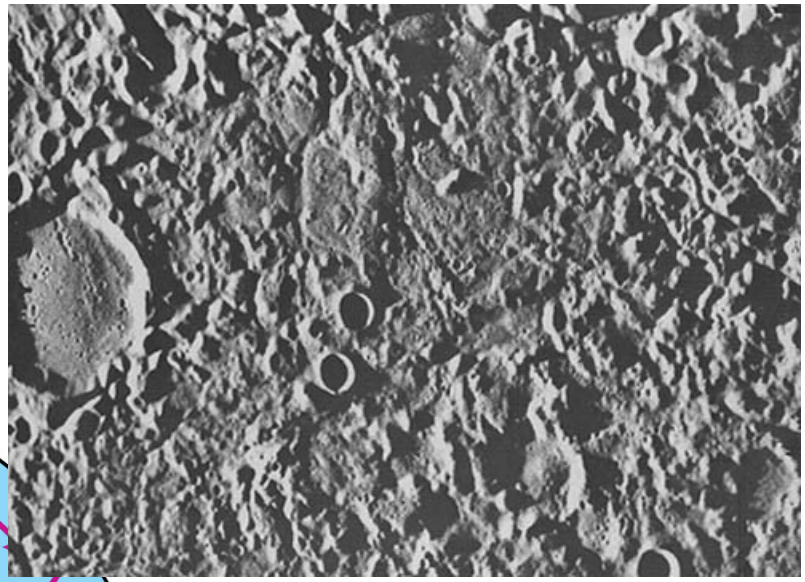
8.6 The Surface of Mercury

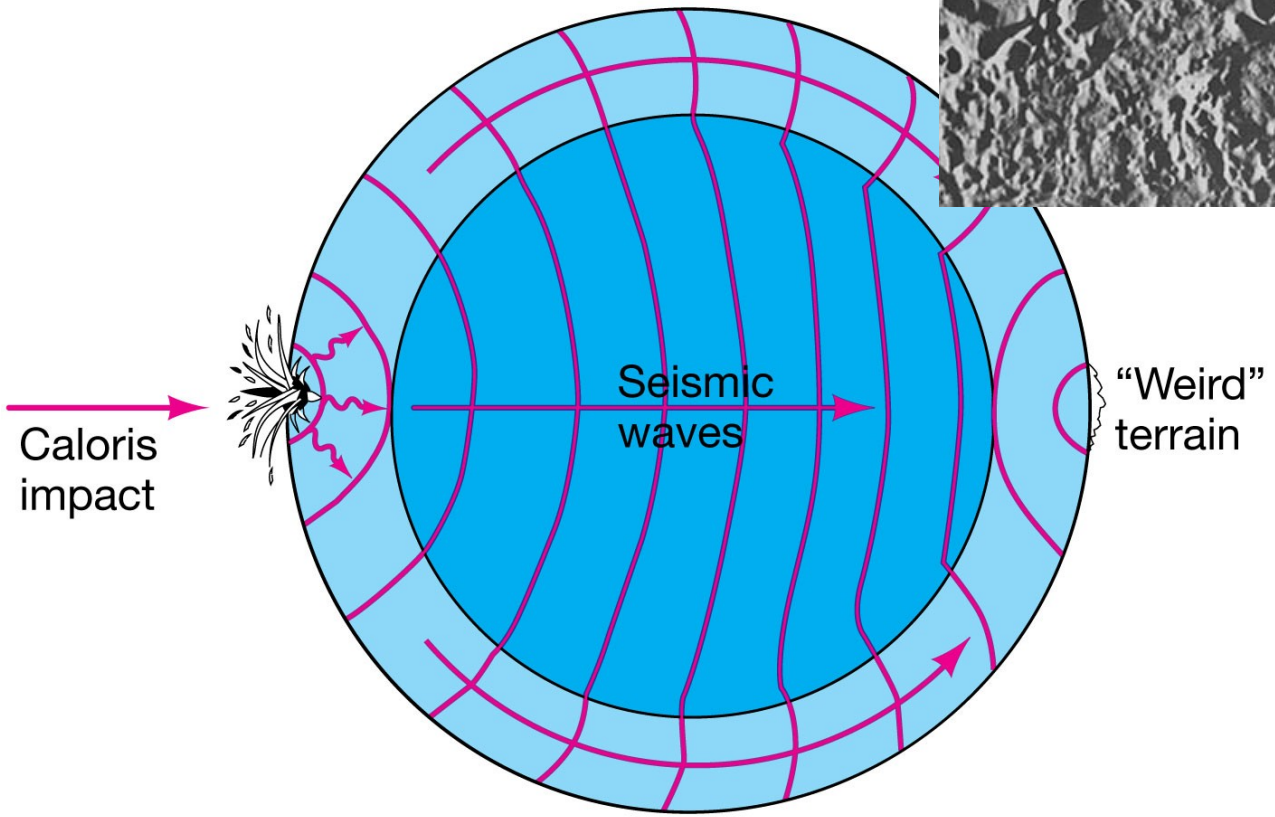
Caloris Basin:
A very large impact feature located on opposite side of weird, jumbled terrain



8.6 The Surface of Mercury

"Weird terrain" is thought to result from focusing of seismic waves





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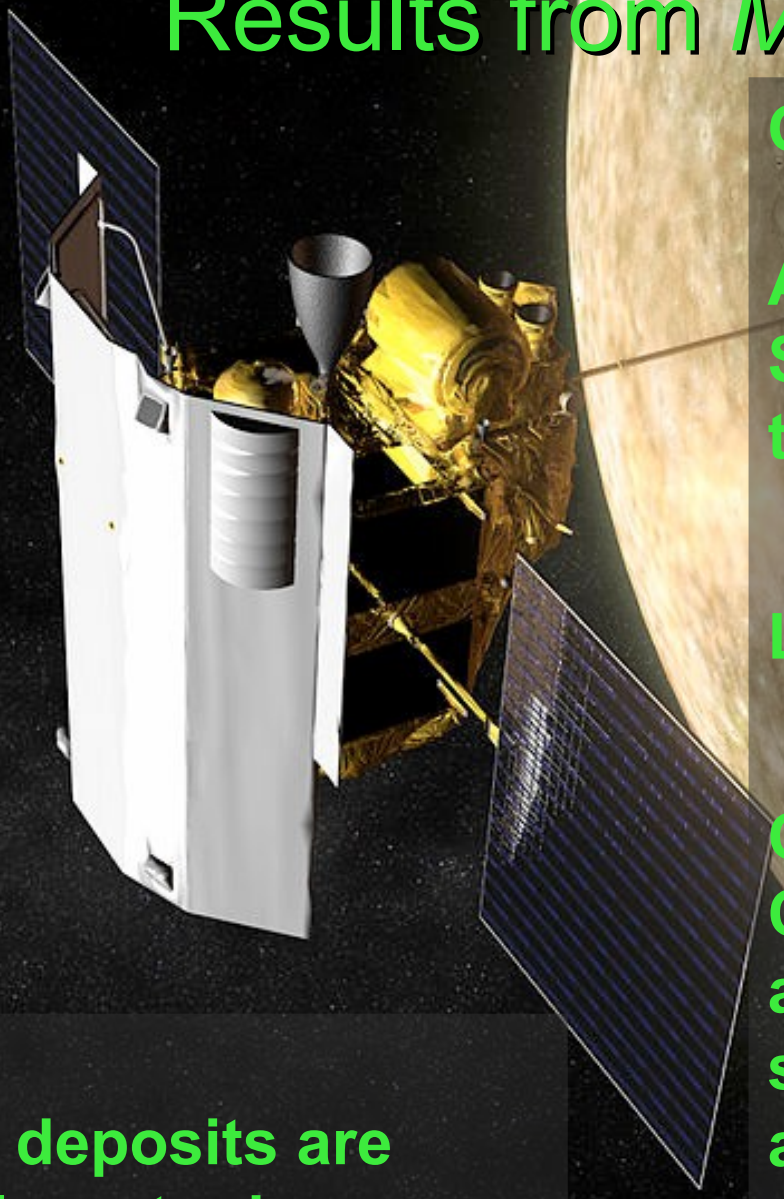
Results from *Messenger*



Orbitted 2011-2015

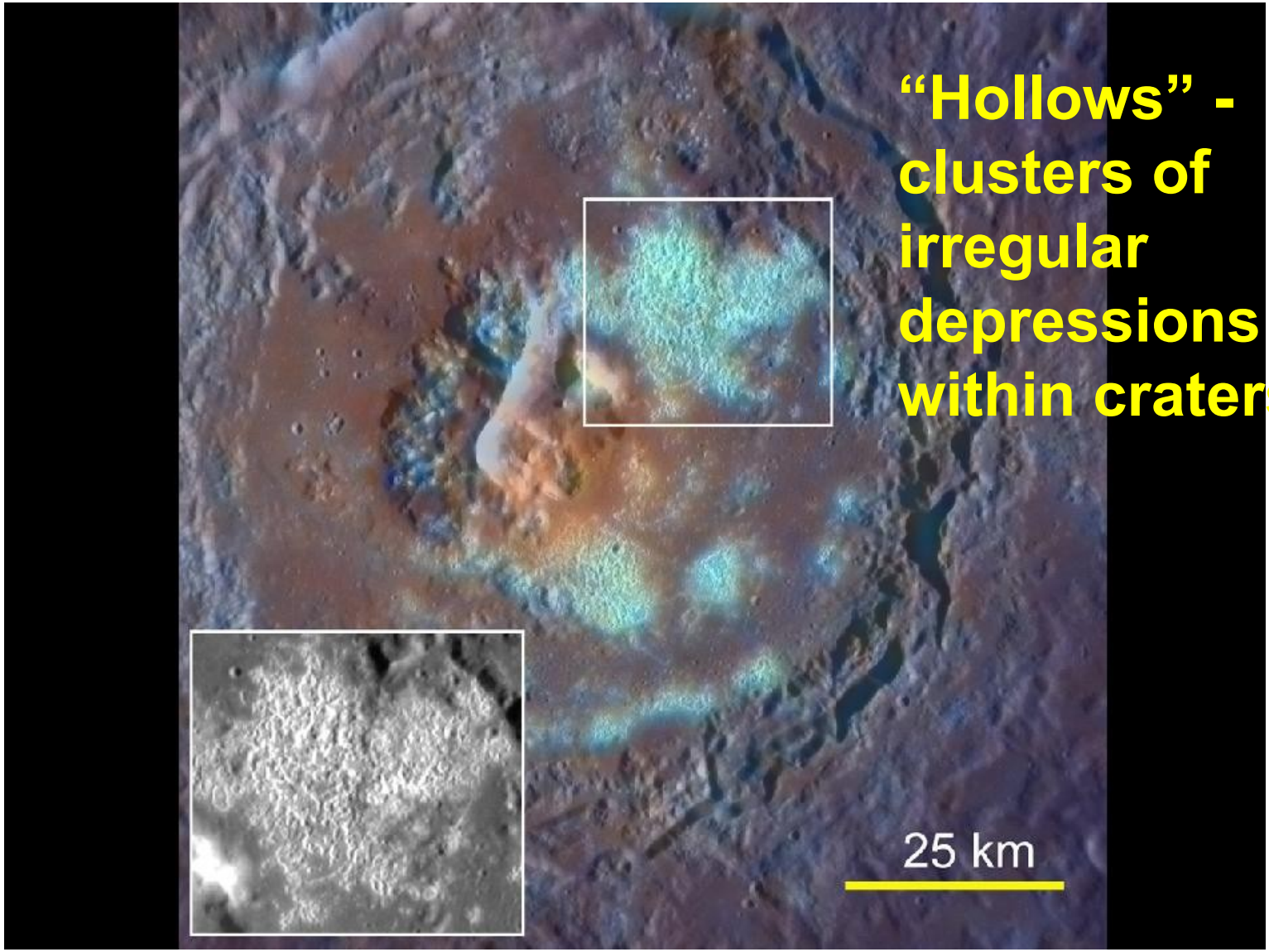
Asym. Mag field makes S pole more exposed to charged particles.

Liquid outer core.

Concentrations of Na, Ca, Mg in exosphere and surface vary with seasons (more abundant during night.)

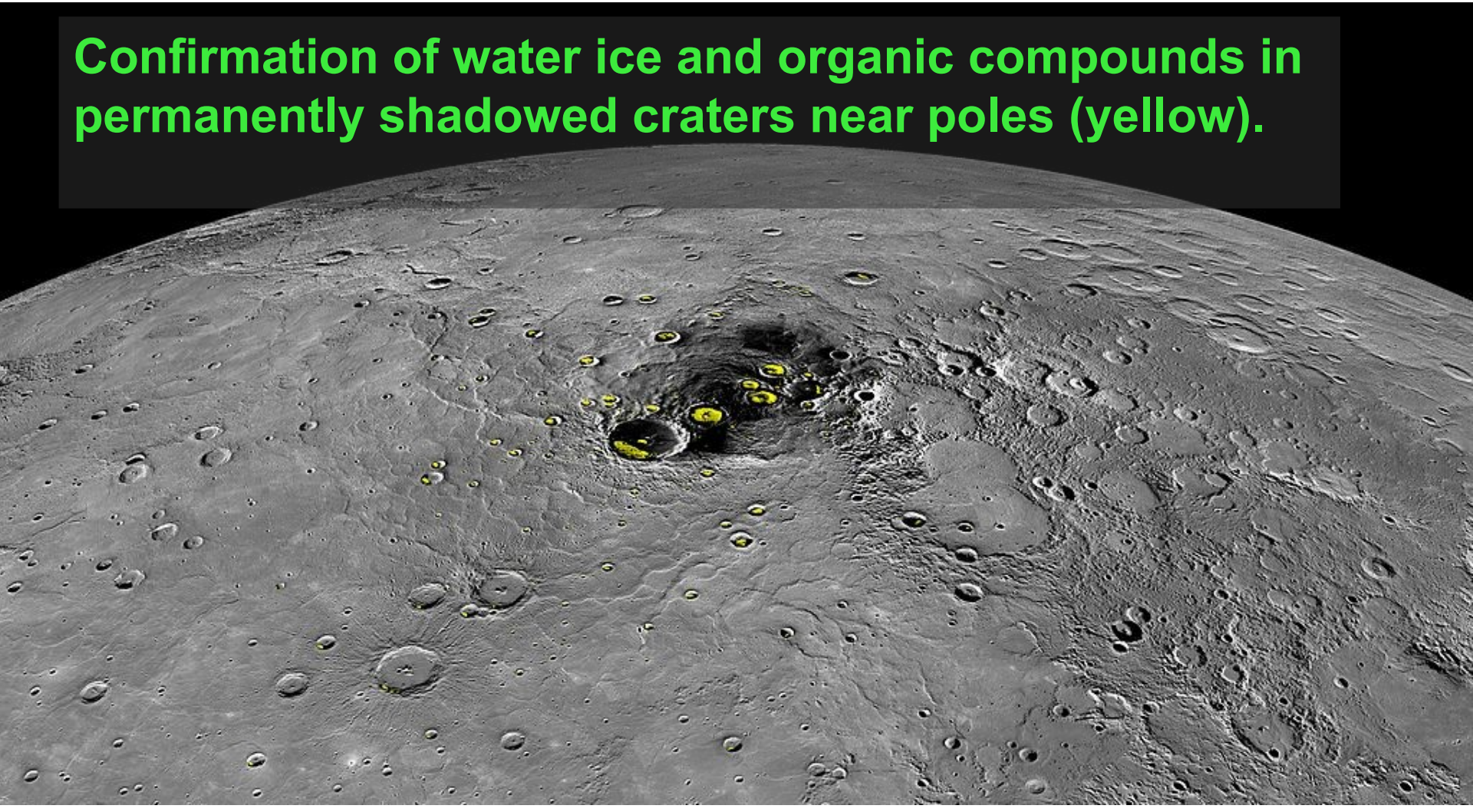
Polar deposits are mostly water ice.

Results from *Messenger*



Results from *Messenger*

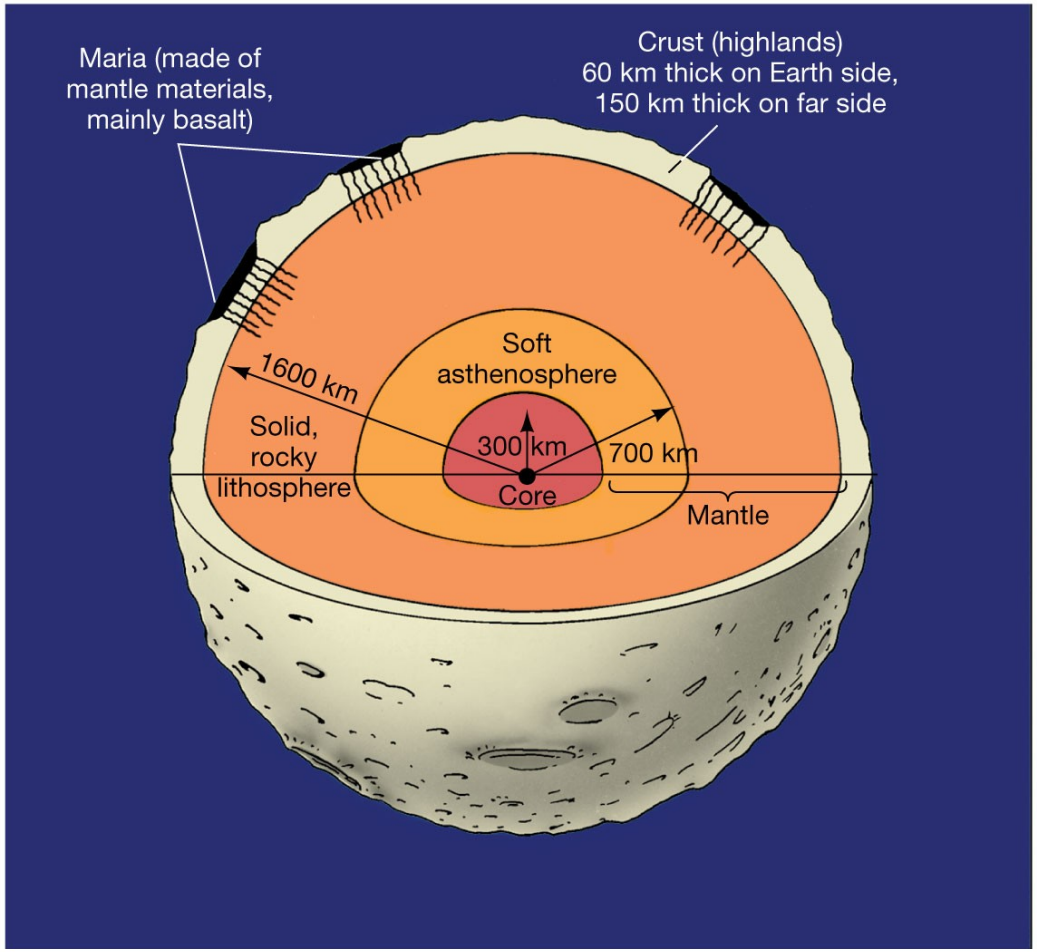
Confirmation of water ice and organic compounds in permanently shadowed craters near poles (yellow).



8.7 Interiors

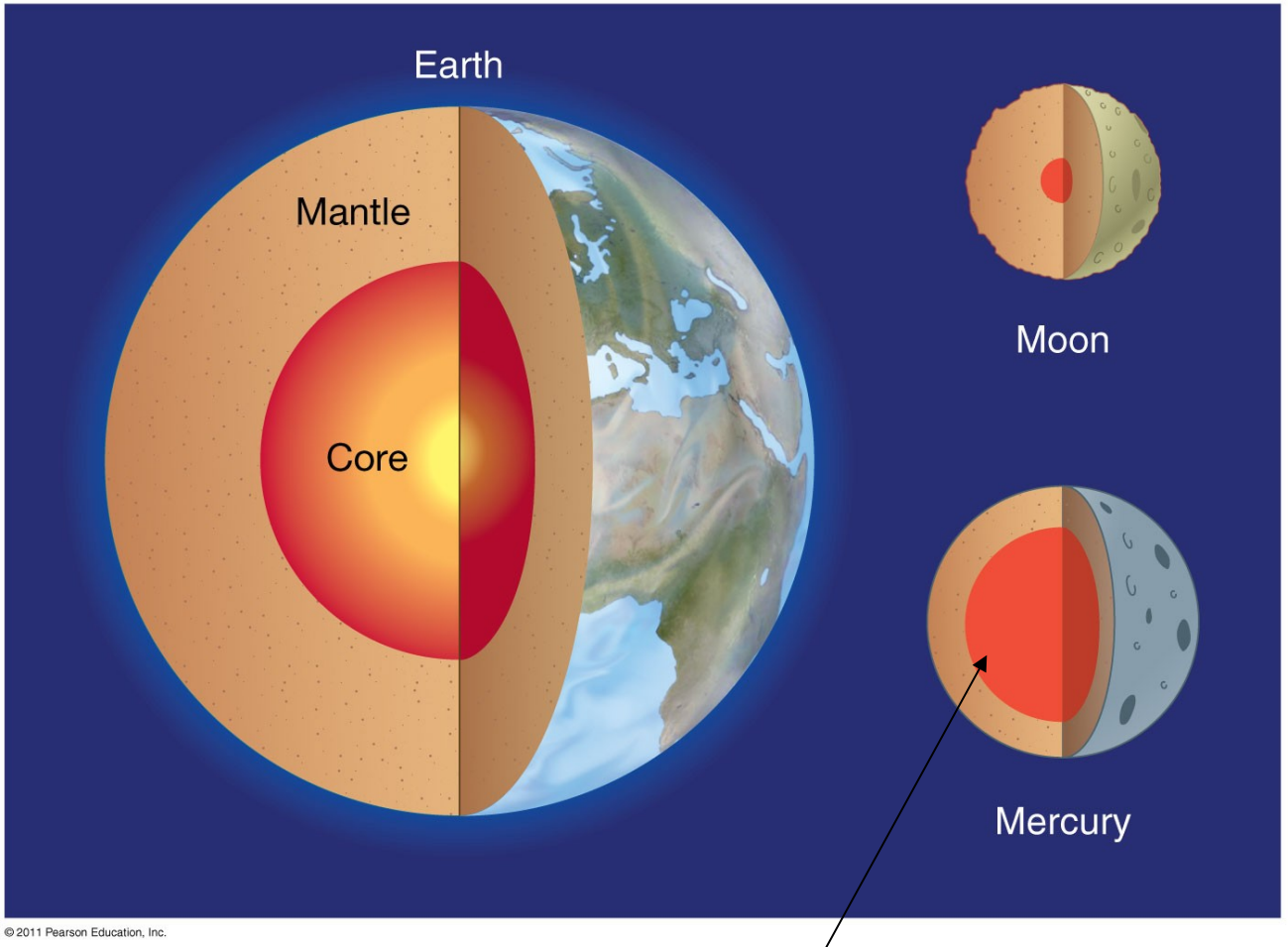
Moon's density is relatively low, and it has no magnetic field— no dynamo effect.

Crust is much thicker than Earth's



8.7 Interiors

Mercury is much denser than the Moon and has a weak magnetic field—not well understood!

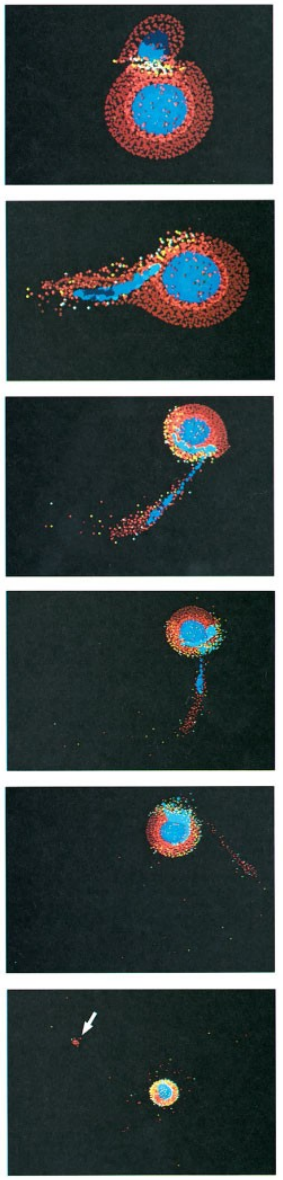


Now has liquid outer core!

8.8 The Origin of the Moon

Current theory of Moon's origin: Glancing impact of Mars-sized body on the still-liquid Earth caused enough material, mostly from the mantle, to be ejected to form the Moon

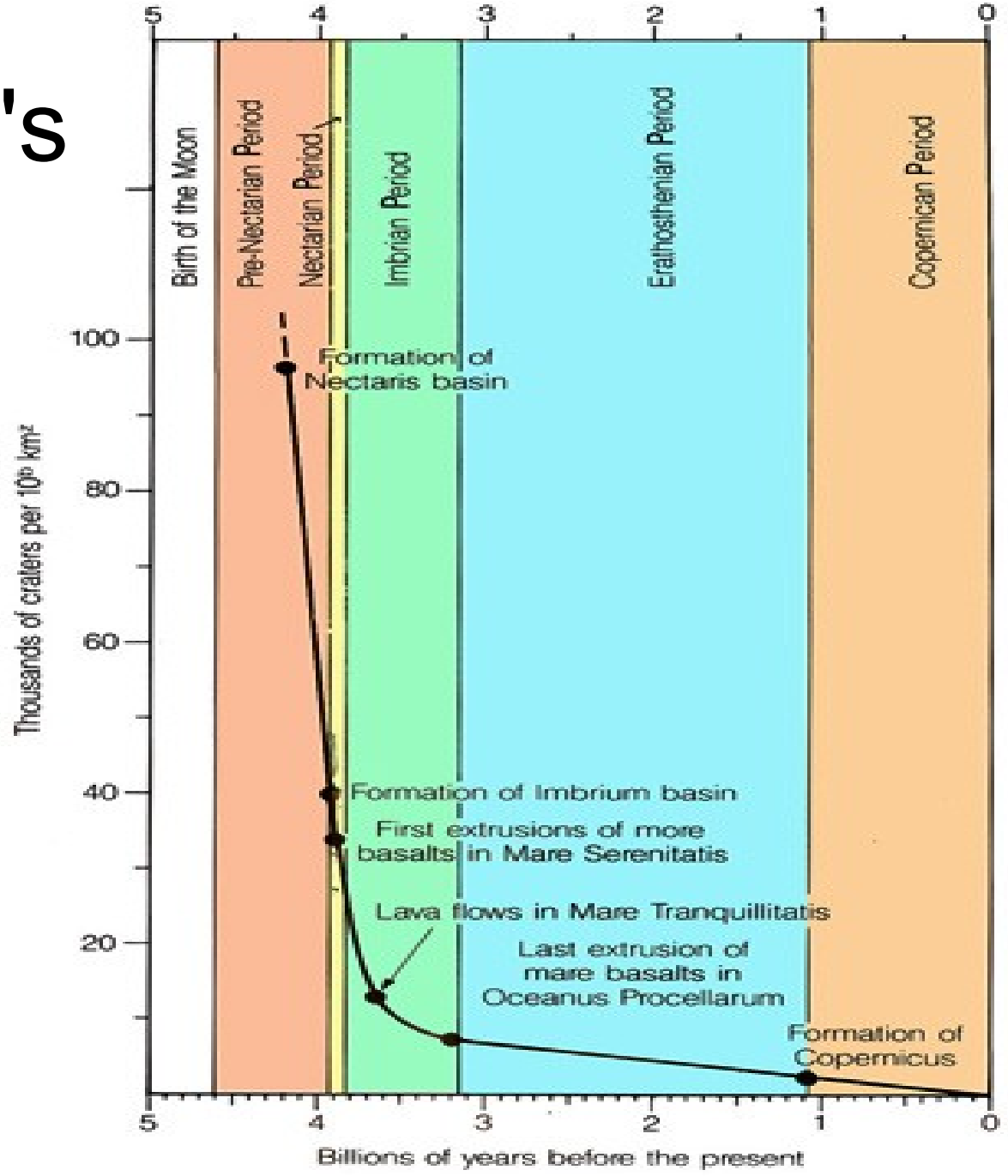
Computer simulation shows how dense material from both bodies ends up in Earth's core.



8.9 Evolutionary History of the Moon

Time before present	Event
4.6 billion yr	Formation of Moon; heavy bombardment liquefies surface
3.9 billion yr	Bombardment much less intense; lunar volcanism fills maria
3.2 billion yr	Volcanic activity ceases

8.9 Moon's history



From "Exploring the Planets" 2007

8.9 Evolutionary History of the Moon and Mercury

Mercury much less well understood

- **Formed about 4.6 billion years ago**
- **Melted due to bombardment, cooled slowly**
- **Shrank, crumpling crust**
- **No later flooding like Moon**

Summary of Chapter 8

- **Main surface features on Moon: maria, highlands**
- **Both heavily cratered**
- **Both have no atmosphere, and large day–night temperature excursions**
- **Tidal interactions responsible for synchronicity of Moon's orbit, and resonance of Mercury's**

Summary of Chapter 8 (cont.)

- **Moon's surface has both rocky and dusty material**
- **Evidence for volcanic activity**
- **Mercury has no maria but does have extensive intercrater plains and scarps**