

Natural Disasters

Lecture 24

Ch 17 – Impacts with Space Objects

Text Source Today:

Chapter 17 (p. 451-462)

Part III (this Ch. 17 material is **not** on Exam #2)

17.1: Ch. 17 – Impacts with Space Objects

● **Impact Scars:** the moon is riddled with millions of impact scars, but the **maria (“seas”)**, created by flood basalt eruptions 3.8 to 3.2 billion years ago, show few impacts. This tells us that the **intense bombardment was over before** 3.8 billion years ago, since there have not been any **lunar plate tectonics** since.



(Fig. 17.3)

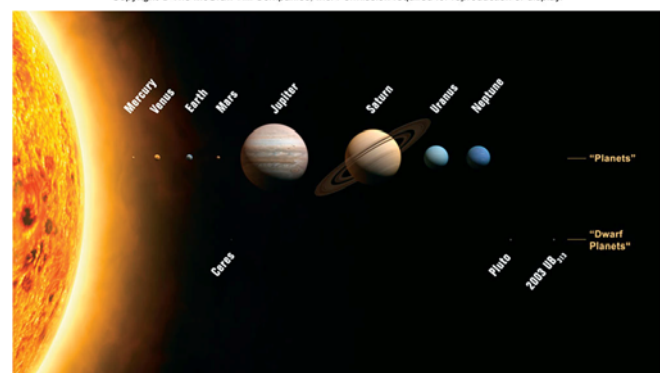
◆◆ Earth is **dynamic** and the impact scars are **“erased”** through **plate tectonics** (consumed at subduction zones; crumpled in continent-continent collisions) and by **agents of erosion**.

◆ **Sources of Extraterrestrial Debris:** pieces of **asteroids and comets** that orbit the sun are called **meteoroids**. When **meteoroids** blaze through Earth’s atmosphere, they are referred to as **meteors (“shooting stars”)**. The ones that reach Earth’s surface are called **meteorites**.

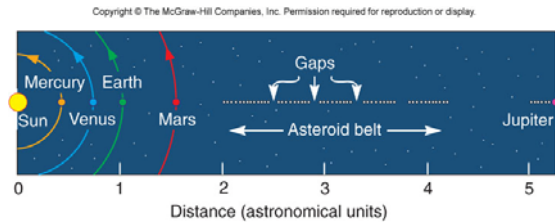
(Fig. 17.5)

● The four **inner planets** (Mercury, Venus, Earth, Mars) are **small**, close together, and **rocky**.

● Whereas the four **outer planets** (Jupiter, Saturn, Uranus, Neptune) are **larger**, spaced farther apart and composed mainly of **hydrogen and helium gas**, surrounding a rocky core. They are commonly orbited by **icy moons and rings**.



♦ **Asteroids:** lie between the inner and outer planets (more specifically, between the orbits of **Mars and Jupiter**) and are a swarm of **rocky, metallic and icy masses**.

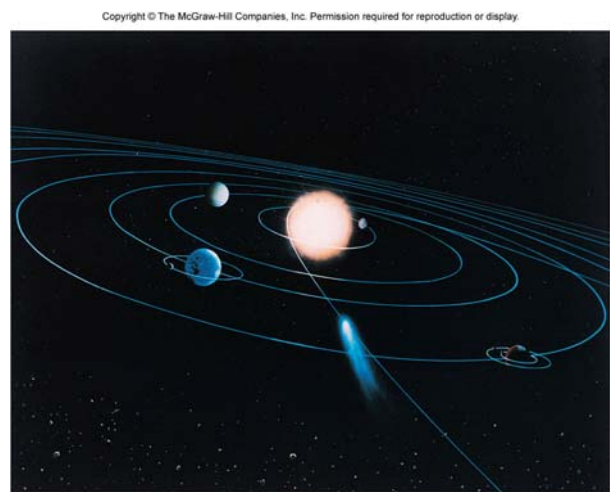


(Fig. 17.6)

- Some of the asteroids are made up of **two or more bodies** held together by gravity, and others just be a loose collection of **rocky debris (a “rubble pile”)** held together by gravity.
- Apparently the strong gravitational pull of **Jupiter** prevented a **9th planet** from forming, but does occasionally create **collisions** between the **asteroids** themselves, which may send one out of the **asteroid belt** to someday collide with a planet.
- **Asteroid clusters**, such as the **Apollos**, have orbits that intersect Earth's.
- The three largest **asteroids, Ceres, Pallas and Vesta**, make up the half the combined mass of all the **asteroids**.

♦ **Comets:** are composed of **ice and rocky debris (“dirty snowballs”)** and orbit the Sun.

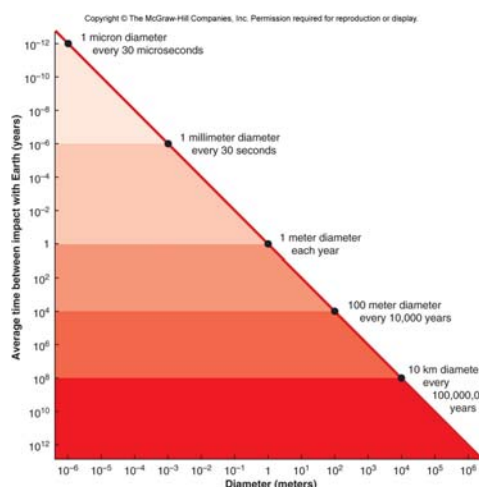
♦ As a **comet** makes its closest approach to the Sun, the sunlight and solar wind sublimates the outer portion of the **“dirty snowball,”** creating a luminous **“tail.”** The **“tail”** always points away from the Sun.



(Fig. 17.10)

- **Short-period comets** make a complete orbit in fewer than 200 years and some are found in the **Kuiper belt** (a flattened disk of comets with orbits ranging from near Neptune, out to 50 **Astronomical Units**, where, 1 AU = 93 million miles [or the distance between **Earth and Sun**]). Most of these comets were captured by the gravitational pulls within the Solar System, and the remaining 800 or so will meet their fate by either **erosional destruction** or by **colliding** with a planet or the Sun itself.
- **Long-period comets** have orbits lasting longer than 200 years and there are **trillions** of these icy objects, whose orbits take them far beyond the outermost planets into a vast and diffuse envelope of encircling comets, known as the **Oort cloud**.
- The planets, the asteroid belt and *Kuiper belt* orbit the Sun in **planes**, but the **Oort cloud** has a **spherical** distribution.
- **Halley's Comet** is the most famous of the comets and orbits the Sun every 74 to 79 years, last passing Earth in **1986**. Back in 1910, Earth passed through the **"tail" of Halley's Comet**.
- ◆ The **ices of comets** contain **carbon compounds**, some of which are important **building blocks of life** on Earth. (Comets may carry bacteria known as **extremophiles**.)!

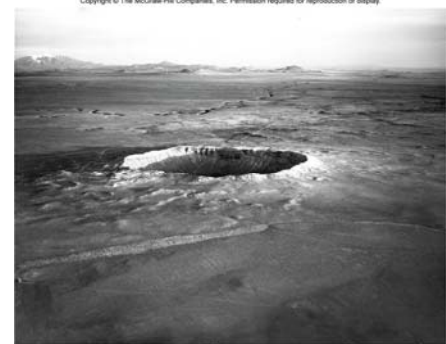
(Fig. 17.13)



◆ **Rates of Meteoroid Influx:** an estimated **100,000 million or more** meteoroids enter Earth's atmosphere every **24 hours**!

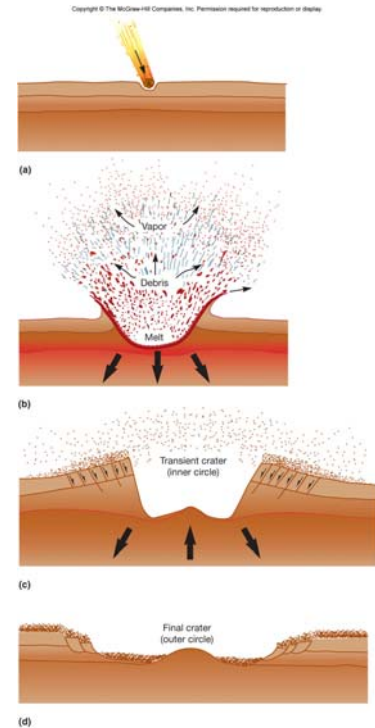
- The smaller the meteoroids, the greater their abundance.

- A typical **meteor** is seen about **100 km (60 miles)** above the ground, where the atmosphere is dense enough to cause the meteoroid to glow, and is usually vaporized before reaching **60 km (35 miles)** above the ground. At high impact speeds (anywhere from 25,000 to 70,000 mph), the atmosphere behaves more like **a solid** and the meteoroid may even **be deflected into space** if it impacts the atmosphere at an **oblique angle**.
 - The tiniest meteoroids (diameter ~ 0.001 mm) pass through the atmosphere unchanged and eventually reach the surface as **cosmic dust**.
 - **“Shooting stars”** are meteoroids the size of **sand grains** (diameters up to 1 mm) and typically “flame out” as they melt. The tiny droplets fall to Earth’s as little **glassy rock spheres**.
 - Meteoroids weighing 1 gram (~ 0.04 ounce) or more will pass through the atmosphere and reach the surface. The melted surface materials are stripped away upon descent, leaving a **meteorite**, with a **glazed and blackened outer crust**.
- ♦ **The Crater-Forming Process:** The **energy** released by an asteroid or comet depends on its **speed and mass**. Asteroids may impact at **14 km/sec (> 30,000 mph)** and a **long-period comet** at **70 km/sec (> 150,000 mph)**! (Fig. 17.17)
- ♦ The impact of **small** meteorites creates **simple craters**, with **raised** rims and concave bottoms, **lacking central uplifts** (such as *Meteor Crater* near Winslow, AZ.)



♦ The impact of **larger bodies** form **complex craters**, with **central uplifts** and **collapsed** outer rims. Large impacts generate so much heat and pressures that much of the asteroid and crater rock is **melted and vaporized**. (Fig. 17.18)

- In an **instant**, temperatures reach **thousands of degrees Celsius** and pressures may exceed **100 gigapascals** (more than the weight of a **million** atmospheres)!
- The **shock wave** pushes rocks at the impact site **downward and outward**. The rocks in the crater are broken, melted and vaporized; new minerals, such as **hexagonal nano-diamonds** are created; and, a common mineral such as **quartz** can be transformed into its high-density form as the mineral **stishovite (shocked quartz)**. (Fig. 17.19)



- Within the **initial second**, a **release or dilatation wave** follows into the Earth and catches up with the accelerating rocks, causing a deflection of material **upward and outward**, forming a **central uplift** on the crater floor.



- As the crater is emptied of vaporized and pulverized asteroid and rock, the **fractured walls** of the transient crater **fail and slide in** toward the center of the crater.