

Natural Disasters

Lecture 25

Ch 17 – Impacts with Space Objects

Text Source Today:

Chapter 17 (p.462-472)

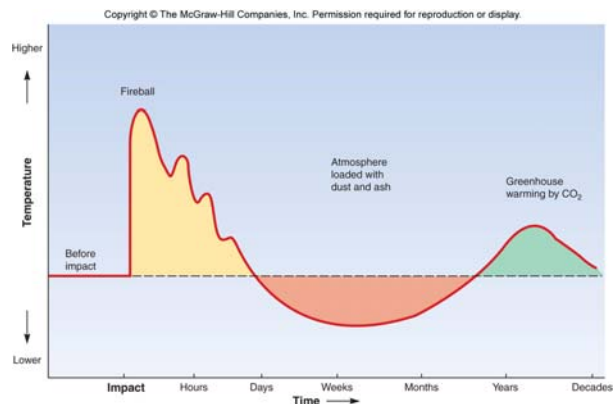
17.2: Ch. 17 – Impacts with Space Objects

- **Crater-Forming Impacts:** **Meteoroids** with weights greater than 350 tons are not slowed down much by the atmosphere and impact the ground at nearly their **original speed**, explode and excavate large craters.
- Craters are **“erased” by erosion**, consumed by **subduction**, mangled by **continent collisions**, and **buried beneath** younger sediments. Thus far, there are **164** known **impact craters**, including **56** in the U.S. and Canada.

(Fig. 17.26)

● Problems for Life from Impacts:

- ◆ **A massive asteroid land impact would:** (1) create huge **EQs ($M_w > 11$)**, with numerous gigantic **aftershocks**; (2) create **wildfires** which would rage regionally, perhaps even globally; (3) put huge amounts of **nitrogen oxides** in the atmosphere which would fall as **acid rain**; (4) put **dust and soot** in the atmosphere, which blocks sunlight and **turns “day into night”**, making **photosynthesis** difficult for weeks to several months; (5) once the dust settles, eventually lead to **global warming** for years due to the excess **water vapor and CO₂** left in the atmosphere.
- ◆ **A massive asteroid ocean impact would:** (1) create huge **tsunami** up to 300 m (1000 ft) tall; (2) create a **bubble of steam** up to 500 km³ (120 mi³) volume that blows into the upper atmosphere, carrying Earth rock and asteroid debris; and, (if the



impact is in shallow, tropical marine waters underlain by **limestone [CaCO_3]**, (3) vaporize enormous quantities of **limestone**, thereby increasing atmospheric CO_2 by an order of magnitude! (This would force any remaining life on Earth to endure an “**extra cold winter**” followed by an “**overly hot and long summer.**”)

♦ **Near-Earth Objects (NEOs):** There are over **2000** known NEOs and **25 to 50%** of them will eventually impact Earth. About **90%** of the NEOs are **asteroids or short-period comets**. The average time interval between impacts exceeds **100,000 years**. The “**Torino Scale**” was developed to assess the threat of a single comet or asteroid impact.

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TABLE 17.4	
The Torino Scale	
Assessing Comet and Asteroid Impact Hazards	
<i>Events with no likely consequences (White zone)</i>	
0	No collision hazard, or object is small.
<i>Events meriting careful monitoring (Green zone)</i>	
1	Collision is extremely unlikely.
<i>Events of concern (Yellow zone)</i>	
2	Collision is very unlikely.
3	Close encounter with >1% chance of local destruction.
4	Close encounter with >1% chance of regional devastation.
<i>Threatening events (Orange zone)</i>	
5	Significant threat of regional devastation.
6	Significant threat of global catastrophe.
7	Extremely significant threat of global catastrophe.
<i>Certain collisions (Red zone)</i>	
8	Collision will cause localized destruction (one event each 50 to 1,000 years).
9	Collision will cause regional devastation (one event each 1,000 to 100,000 years).
10	Collision will cause global catastrophe (one event each 100,000 years).

♦ **Mitigation?** Suggestions if we discover a large NEO on a **collision path** with Earth include: (1) blowing it apart with a **nuclear explosion**; (2) attaching a **rocket engine** that could drive it away; (3) using a **big mirror** to focus sunlight that would vaporize rock; (4) scooping **rock (mass)** and tossing it away; and, (5) launch a **heavy “space tractor”** to hover near the NEO and use **gravitational attraction** to pull the NEO into an Earth-avoiding path. **There are no formal plans at this time!**

♦ **Asteroid 99942 “Apophis”:** This asteroid will make a close pass to Earth in **2012**, but on Friday, **13 April 2029**, it will pass only **18,000 miles** above the mid-Atlantic Ocean. After that near-miss, **if** Earth’s gravity gives it a good pull, it could return and **impact** Earth on **Easter Sunday, 13 April 2036!**

♦ **Biggest Event of the 20th Century -**

Tunguska, Siberia, 1908: just after 7 AM on 30 June, a **massive fireball** streaked in from the east, exploding about 8 km (5 mi) **above ground** in a monstrous blast heard 1000 km (> 600 mi) away!



● **No impact crater was found**, but the 80 million downed trees and little globules of once-melted metal and silicon-rich rock, indicated that the impact was by either an **icy comet** about 50 m (165 ft) in diameter or a **stony meteorite** about 30 m (100 ft) in diameter, traveling about 15 km/sec (33,000 mph) when it **disintegrated** in a spectacular midair explosion!

(Similar to Fig. 17.17)

♦ **Meteor Crater, Arizona:**

also known as the **Barringer Crater** west of Winslow, AZ. The evidence suggests that about **50,000 years ago**, a nickel-iron metallic meteorite, with a diameter of about **40 m (130 ft)**, slammed into the

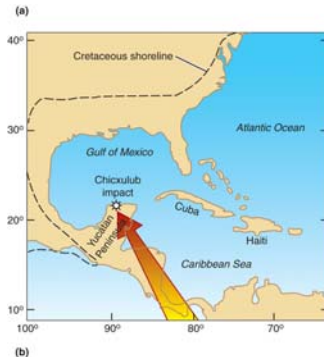
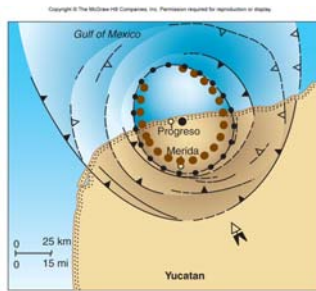


ground at about 12 km/sec (27,000 mph). The result was a huge crater **nearly a mile wide**, over **500 feet below** the surrounding plateau, with a rock rim rising nearly **200 feet above** the plateau.

● The impact likely **liquefied 80%** of the meteorite and the enveloping ground in **less than a second**. An estimated **100 million tons** of rock were pulverized (about **double** the energy released by the 1980 Mount St. Helens eruption). The resulting shock wave **leveled all the trees** in the region, **wildfires** broke out and **dust** darkened the sky.

● **The Most Famous Asteroid Impact – The K/T Impact, ~65 million years ago:** As previously discussed, the **End Cretaceous Mass Extinction** (including the **dinosaurs**)

was likely finalized by this impact, which occurred at the Cretaceous (**K**) / Tertiary (**T**) boundary. What evidence supported this theory?



(Fig. 17.25)

◆ The **K/T impact theory** was proposed by the late Luis Alvarez, a Nobel Prize-winning physicist and his geologist son, Walter. They found an abnormally **high percentage of the element iridium in a clay layer** near Gubbio, Italy, dating back to the K/T boundary time period. Most of Earth's **iridium** lies deep in the iron-rich core and is uncommon at the surface. However, **meteorites are enriched in iridium**.

● Where is the crater?

● Geologists searched for **impact scars worldwide**, but some were too small, while others were too old or too young.

◆ **Sedimentary deposits**, dating back to ~65 million years ago, in the northeast Gulf of Mexico, Cuba and Haiti, contained evidence of an impact. The Mexican national petroleum company (**PEMEX**) was drilling for oil in the **Yucatan Peninsula** and encountered a 90 m (300 ft) thick zone of shattered rock containing **shocked quartz** and **glassy blobs of once-melted rock**. Geological surveys revealed the **Chicxulub** crater, caused by an estimated **10 km (> 6 mi)** wide asteroid.