

GLG 110 – Chapter 11 – Impact of Extraterrestrial Objects

- **Asteroid** - metallic or rocky body from 10 m to 1000 km in diameter
- **Comet** – icy/dusty body from a few meters to a few hundred kms in diameter
 - o “ice” may be water ice, carbon dioxide, carbon monoxide, methane, ammonia
 - o “dust” is silicate minerals, metallic iron and nickel specks, and carbon compounds
 - o Earth’s water is thought to have come mostly from comets
- **Meteoroid** - >dust to 10 m-sized metallic, rocky, icy, or carbonaceous fragment *in space*
- **Meteor** - >dust to 10 m-sized metallic, rocky, icy, or carbonaceous fragment *in atmosphere*
- **Meteorite** - >dust to 10 m-sized metallic, rocky, or carbonaceous fragment *on surface*

- **Impact cratering** is one of the four basic types of geologic processes that occur on planets
(erosion/gradation, volcanism, and tectonism are the other 3)
 - o Extremely energetic and rapid explosion
 - o Meteor is almost instantly vaporized upon impact, as are some rocks (others melt)
 - o Intense pressures produce “shocked” minerals, distinctive to impact events (and nuclear blasts) and highly fractured/brecciated rock layers beneath crater
 - o Material in ground is compressed, then bounces back and flies out of growing crater
 - o Material thrown out of crater is called **ejecta**
 - o **Ejecta blanket** is layer of fragments produced by falling to Earth of ejecta around crater
 - ♣ thickest at rim and thins rapidly away from crater
 - ♣ produces “inverted layering” with top layers thrown out and landing first, deeper layers excavated and landing later

- **Tunguska “event”** – Siberia, 1908 – **aerial blast** - explosion of meteor in Earth’s atmosphere, several kms above the surface, blasted down 2000 km² of forest, but left no impact crater
 - o Largest “impact” event in **recorded** human history
 - o http://en.wikipedia.org/wiki/Tunguska_event

- Impacts of materials from outer space onto/into the Earth have been happening since the Earth formed
 - o It is by accretion, or “sweeping up” of space debris, via impacts, that Earth is thought to have grown from the nebula in the first place
 - o If an impact hits the surface at “hypervelocity” (i.e., it is still moving kms/sec), it will produce an explosion crater, known as an **impact crater**
 - o Meteoroids/comets enter Earth’s atmosphere with velocities of 12 to 72 km/sec!

- The Moon has many obvious impact craters because its surface has experienced so little other activity, so they are retained for billions of years
 - o any significant gradation requires an atmosphere, which the Moon lacks
 - o significant volcanism ended over 3 billion years ago,
 - o tectonism/faulting appears to have been a very minor process on the Moon
 - o impact cratering was initially intense, but has dropped to a much lower frequency over the past 3.8 billion years or so

- Earth has few obvious impact craters (Meteor Crater in Arizona is the most famous)
 - o Erosion, combined with tectonic activity and volcanism have “erased” almost all of

the

craters that formed on Earth during its 4.5 billion year history
o Careful study has revealed the presence of over 150 impact structures, most of

which

have been heavily eroded

o <http://www.unb.ca/passc/ImpactDatabase/index.html>

• Some (but not all) mass extinction events correspond in time with dated impact structures

o Most famous is the “K-T” boundary impact that coincided with a mass extinction
that

included the dinosaurs (among MANY other species)

o Best evidence (short of actual crater) was enhanced *iridium* in clay layer at

boundary

o **Chicxulub crater** subsequently found in Yucatan of Mexico – ~180 km diameter

♣ <http://antwtrp.gsfc.nasa.gov/apod/ap000226.html>

♣ **10 km asteroid**

♣ **100 million megaton blast** (10,000x entire world’s nuclear arsenal)

♣ Dust in atmosphere

♣ Acid rains

♣ Forest fires

♣ Mega-tsunami (3000 ft high!)

♣ Food chain collapsed

♣ ~40 to 100 million year recurrence interval for event of this size

• Impact risks for humanity:

o Tunguska-like event every 1,000 years or so

o With current city distribution, massive impact catastrophe should hit a city, on
average,

every few tens of thousands of years

o Such an event could kill *millions* almost instantaneously – averages out to hundreds
of

deaths/year, similar to storms and floods in U.S. (our number one threat!)

o Chicxulub-type event would likely wipe out humanity entirely

• Surveys being done of Near-Earth Objects (NEOs), including asteroids (and also space
junk, like spent Apollo rocket stages, etc.)

o Extrapolations from sky surveys suggest there are about 1,500 objects of 1 km or
more

in diameter are in Earth-crossing orbits

• Comets have orbits that take them very far from the Sun, and may cross Earth’s path

o Such objects are far harder to predict/see and would give far less lead time to
prepare

and potentially nudge out of Earth’s path