

Lecture 21 - Impacts and Extinction

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Astronomy 141 – Autumn 2012

This lecture examines the role of asteroidal impacts on the history of life on Earth.



Major impacts ended 3.8 Gya at the end of the Hadean Eon, but impacts generally tapered off to a steady rate.



Near Earth Asteroids (NEOs) are asteroids that orbit near the Earth, with 1000-2000 ~1 km in size.



An asteroidal impact caused the extinction of the dinosaurs 65Mya, and perhaps other mass die offs.



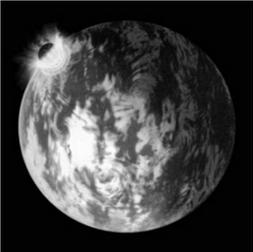
5 major mass extinctions in the past 500 Myr important for driving diversity and evolution.

Impacts by 300-500 km asteroids during the Hadean would have sterilized the early Earth.

Impact energy would have vaporized the oceans and melted much of the crust.

"Steam atmospheres and magma seas."

Any early life would have been wiped out.



The last such sterilizing impacts occurred during the Hadean Eon 4.3 – 3.8 Gya

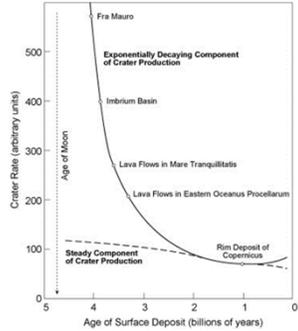
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Asteroidal impacts of the Earth, however, did not end with the Hadean Eon...

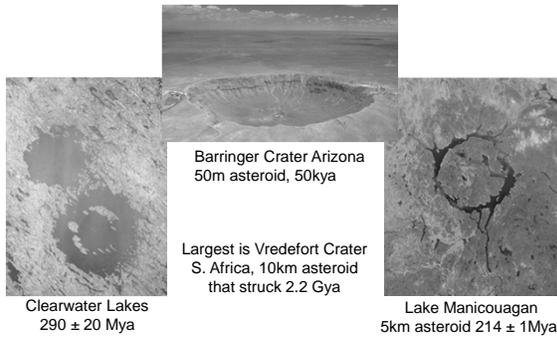
The impact rate started out high and then declined exponentially.

Massive sterilizing impacts ended by the start of the Archean Eon.

Impact rate tapered off until it became roughly constant for the past 1 – 2 Gyr.



Craters from past impacts are found on all continents, with 50 craters larger than 20km across.

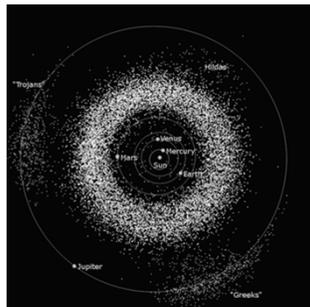


The sources of asteroids today are the asteroid belt and outer solar system.

Asteroids are leftover rocky/icy material from the formation of the Solar System

Disturbed by Jupiter's gravity into the inner solar system.

~1.2 million asteroids larger than 1km across, but only 100 more than 140 km across.



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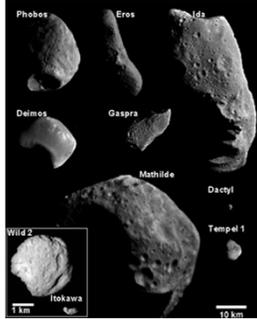
Near-Earth Objects (NEOs) are asteroids and comets that have orbits that bring them near Earth.

6300 known, most a few meters across.

Probably 1000-2000 NEOs larger than 1 km across.

On unstable orbits, but are constantly supplied from the outer asteroid belt.

Numerous groups are actively searching for NEOs. (Spaceguard)



A hit by the small asteroid 2008 TC3 was predicted and occurred in the Sudan in October 2008.

First prediction of a small asteroid strike – but only 20^{hr} before impact.

Asteroid was 3-5m in size.

Burned up in the atmosphere, but 4 kg of fragments were collected.

Energy release was 1-2 kilotons.

Rocks of this size hit the Earth 2 or 3 times per year.



A bigger direct hit occurred in Siberia in 1908 near the Tunguska River

Seismic activity recorded 1000 km away.

Airburst ~10-15 km altitude with an estimated energy release of 10-15 megatons.

Probably an asteroid or comet 40 meters in diameter.

Such strikes should happen once per century.



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The K-T Boundary is a layer of sediments that divides the Cretaceous and Tertiary Periods

Boundary occurs 65 Myr ago.

Layer of clay sediment unusually rich in Iridium and soot.

The Iridium content is 100x the natural abundance in the crust, but comparable to what is found in asteroids and chondrites.

At the time of the K-T boundary 65 Mya, 75% of land and marine species, including all non-avian dinosaurs, went extinct.



The favored explanation is that the K-T boundary is the after effects of a massive asteroidal impact.

10 km diameter asteroid making a direct hit.

Energy release 2 million times that of the most powerful nuclear bombs.

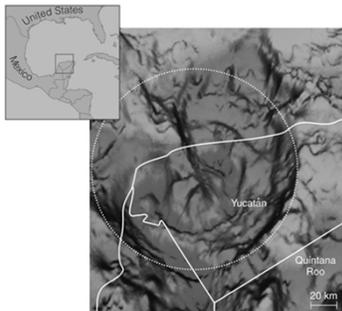
Global firestorms

Mega tsunamis

Dust in the air causing 10-20% less sunlight.



Physical evidence of the impact is Chicxulub Crater in the Yucatan.



180 km in diameter.

Shocked quartz

Impact glasses (tektites)

Gravitational anomaly

Radiometric dating gives 65 Mya

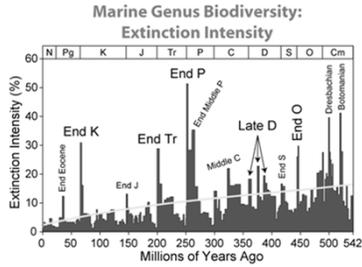
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Mass extinctions have occurred a number of times during the history of the Earth.

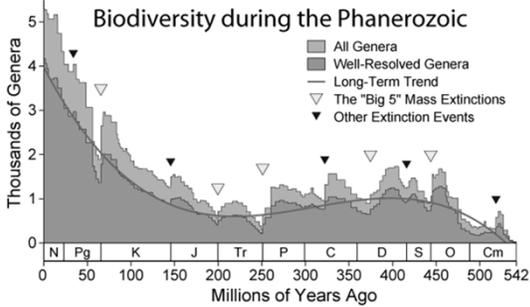
Sharp decrease in the number of species.

5 major events during the past 500 Myr

Largest was the "Great Dying" at the Permian-Triassic boundary 251 Mya killed 98% of marine species and 77% of land species



Extinctions have the effect of opening up ecological niches and accelerating evolution.



It's only a matter of time...

