

# Lecture 19: Extinction



*Edmontosaurus* ([source](#))

# Key Taxon: *Tyrannosaurus*

## *Tyrannosaurus*

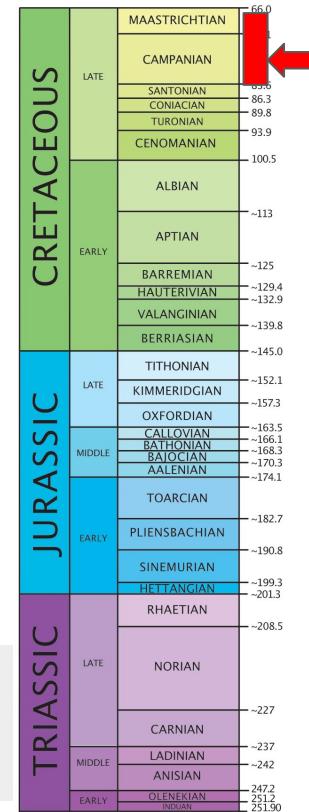
Greek: “tyrannos” = tyrant; “saurus” = lizard



Tyrannosaurus by Mark Whitton (source)

- Wide range across N. America (with close relative in Asia)
- ~40 feet long, ~9 tons

Fowler et al. (2012) How to eat a *Triceratops*: large sample of toothmarks provides new insight into the feeding behavior of *Tyrannosaurus*. Journal of Vertebrate Paleontology 32(5, abstracts vol): 96



# *Eoraptor* versus *Tyrannosaurus*

## Morphology terms:

Anterior (head) /  
posterior (tail)

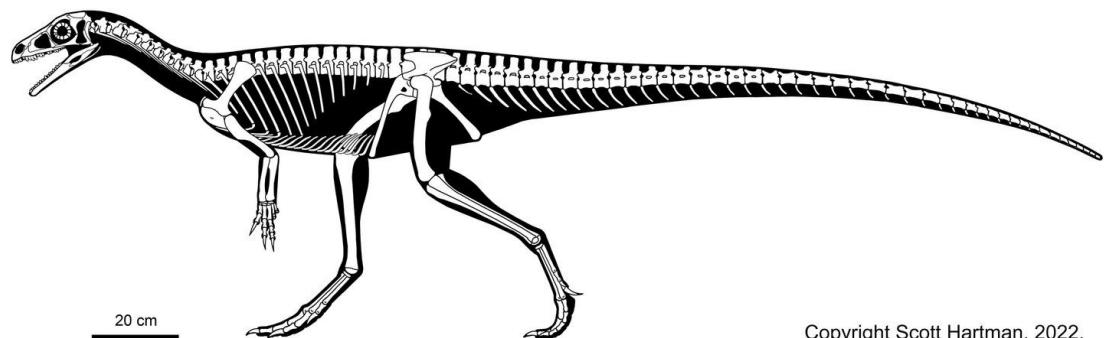
Dorsal ↑ \ Ventral ↓

Humerus : tibia ratio

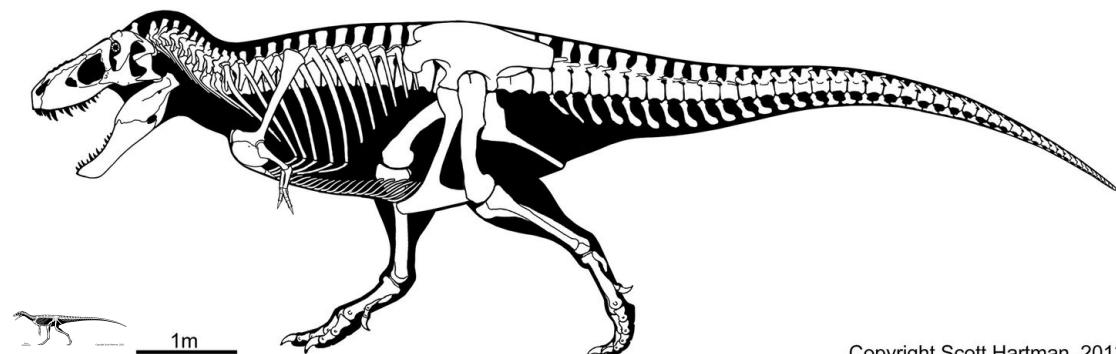
Pelvis: pubis / ischium

Neural spines

Ossified tendons



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# *Allosaurus* vs. *Tyrannosaurus*



*Allosaurus* skull ([source](#))



*Allosaurus* skull ([source](#))

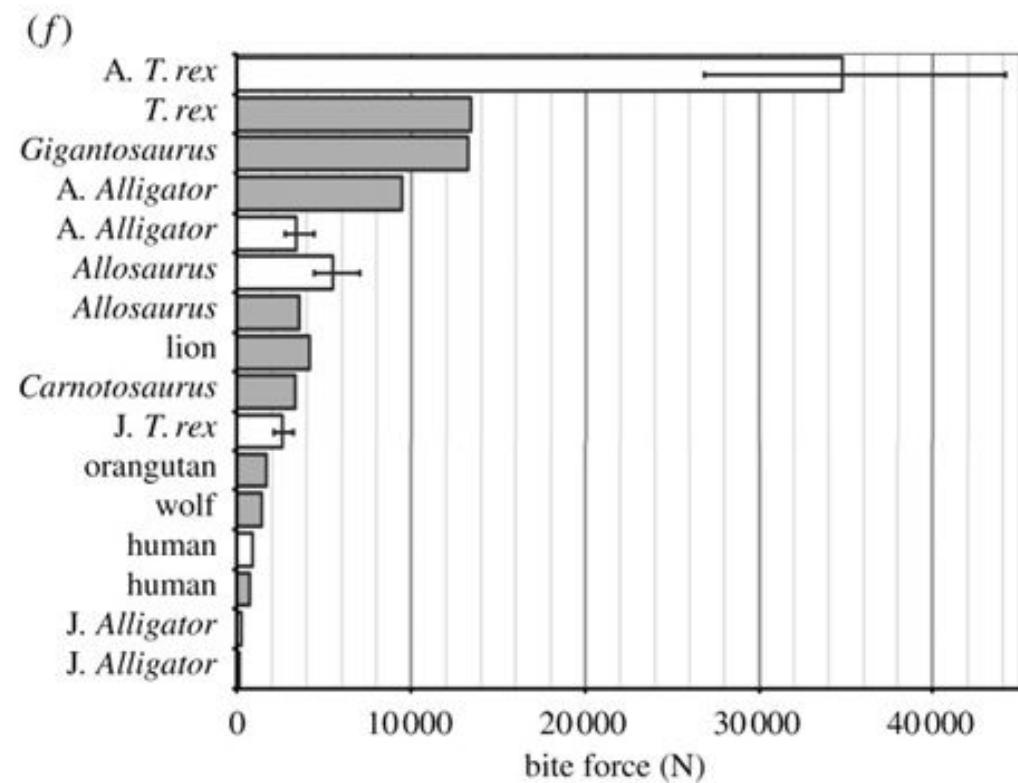
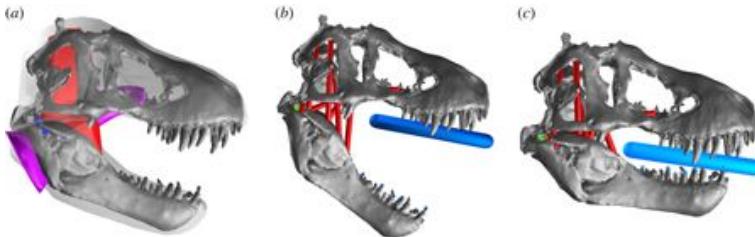


*Tyrannosaurus* skull ([source](#))



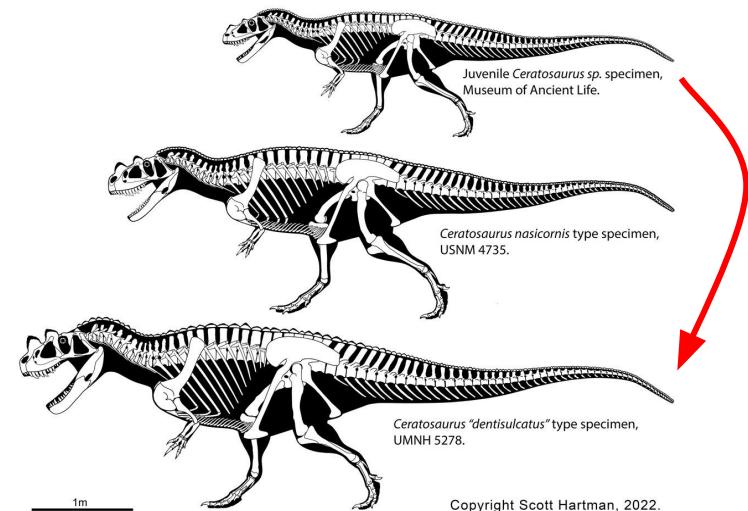
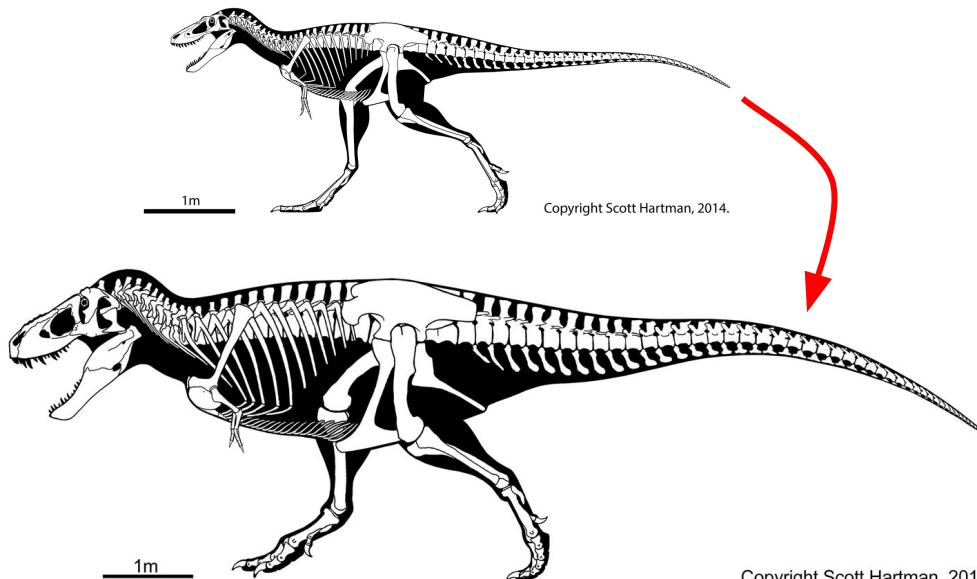
*Tyrannosaurus* skull ([source](#))

# *Tyrannosaurus* bite force



Bates, Karl T., and Peter L. Falkingham. "Estimating maximum bite performance in *Tyrannosaurus rex* using multi-body dynamics." *Biology Letters* 8.4 (2012): 660-664.

# *Tyrannosaurus* growth vs. *Ceratosaurus*



# *Tyrannosaurus* growth



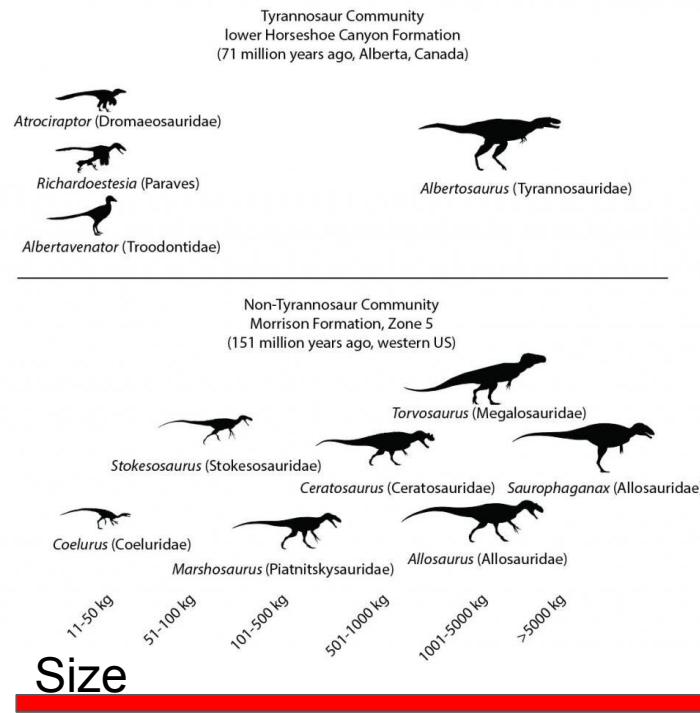
- **Developmental niche partitioning:** juvenile and adult members of the same species have different ecological roles

# *Tyrannosaurus* growth

- Because of developmental niche partitioning, tyrannosaurs were effective at outcompeting other medium to large predators
- Opposite of pattern seen in herbivores

Cretaceous

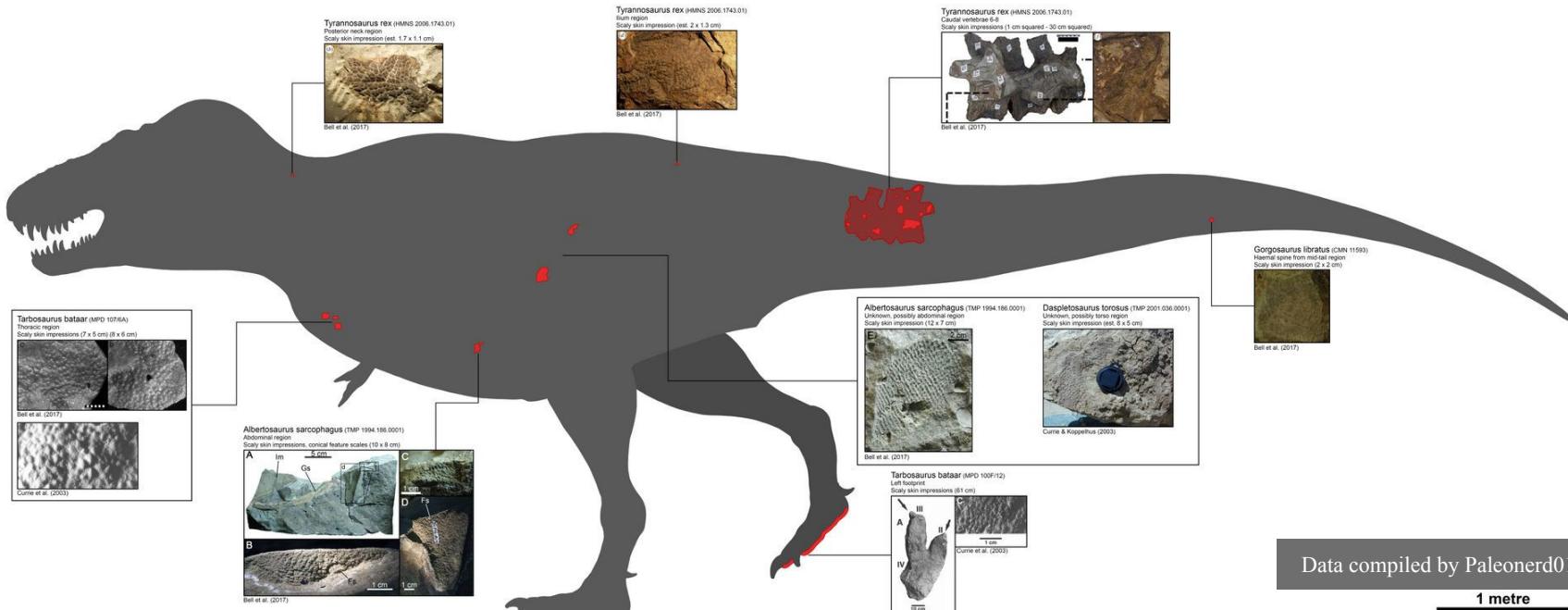
Jurassic



Thomas R. Holtz. Theropod guild structure and the tyrannosaurid niche assimilation hypothesis: implications for predatory dinosaur macroecology and ontogeny in later Late Cretaceous Asiaamerica. Canadian Journal of Earth Sciences, 2021

Silhouettes from PhyloPic.org. Originals by Tasman Dixon, Craig Dylke, FunkMonk, Scott Hartman, T. Michael Keesey, Matt Martyniuk, Dean Schnabel

# Feathers?



Data compiled by Paleonerd01 ([source](#))

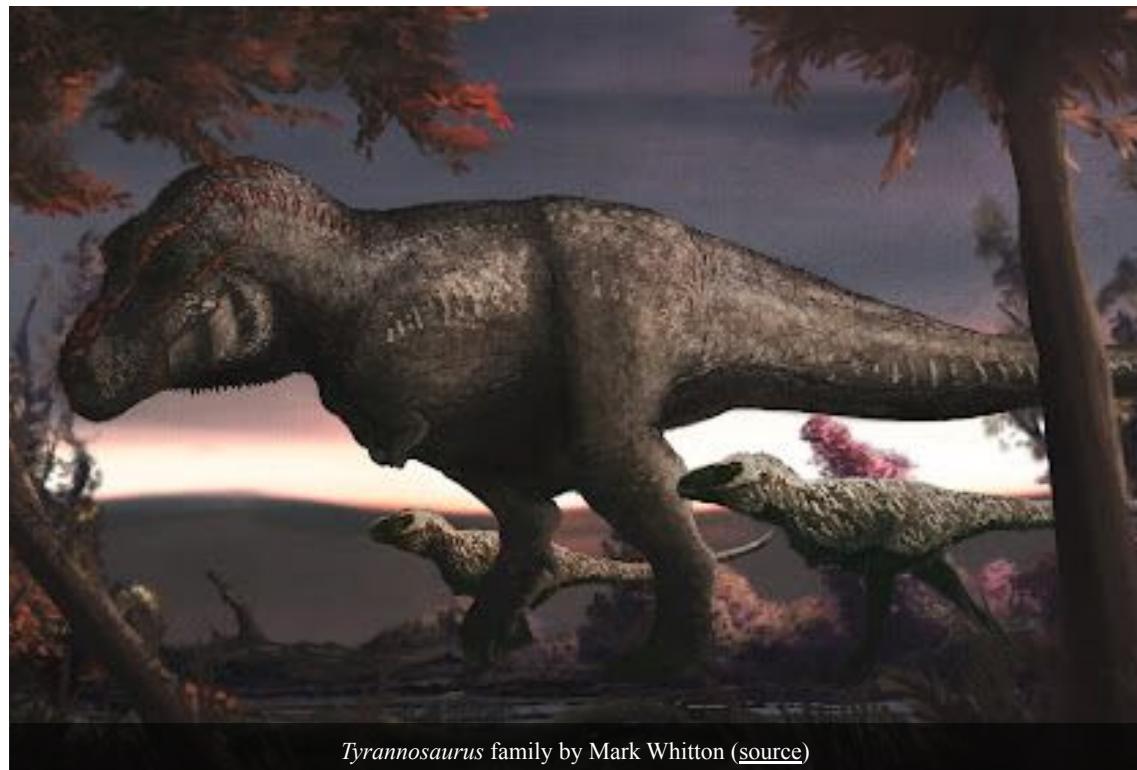
1 metre

## References

- Bell, P., Campione, N., Persons, W., Currie, P., Larson, P., Tanke, D., Bakker, R. (2017). "Tyrannosauroid integument reveals conflicting patterns of gigantism and feather evolution." *Biology Letters*, 13(6), 20170092.
- Currie, P., Badamgarav, D., Koppelhus, E. (2003). "The First Late Cretaceous Footprints from the Nemegt Locality in the Gobi of Mongolia." *Ichnos*, 10(1): 1-13.
- Currie, P. J., Koppelhus, E. B. (2015). "The Significance of the Theropod Collections of the Royal Tyrrell Museum of Palaeontology to Our Understanding of Late Cretaceous Theropod Diversity." *Canadian journal of earth sciences*, 52(8): 620-629.

# Summary: *Tyrannosaurus*

- One of the last **theropods**
- Adults adapted for crushing bites; juveniles take the role of medium-sized predators
- One of the toughest dinos ever!



*Tyrannosaurus* family by Mark Whitton ([source](#))

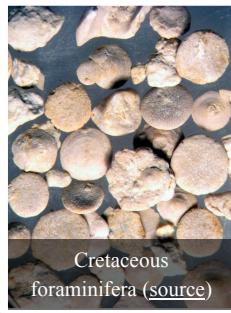
# Extinction



*Tyrannosaurus* by Raúl Martin (source)

- **Cretaceous–Paleogene (K–Pg) extinction** marks the end of the Mesozoic
- Second worst mass extinction event (after **Permian-Triassic**)
- ~75% of species go extinct, including non-avian dinosaurs

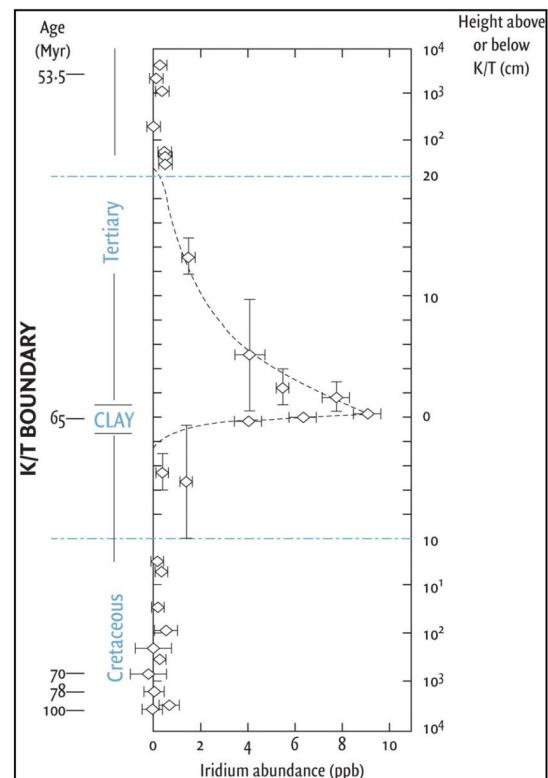
# Development of the impact hypothesis



- Father/son team Luis and Walter Alvarez were studying foraminifera in Gubbio, Italy
- Found a paucity of fossils at the K-T boundary.
- Just above this boundary, there was a thick clay layer that had no fossils at all, pointing to an almost complete extinction of microscopic sea life

# Development of the impact hypothesis

- Luis Alvarez suggested that the level of iridium, might determine how quickly the clay layer was deposited.
- Iridium is an element deposited from cosmic dust at a fixed rate.
- The amount of iridium was found to be 9 parts per billion, 90 time higher than anticipated over natural production.

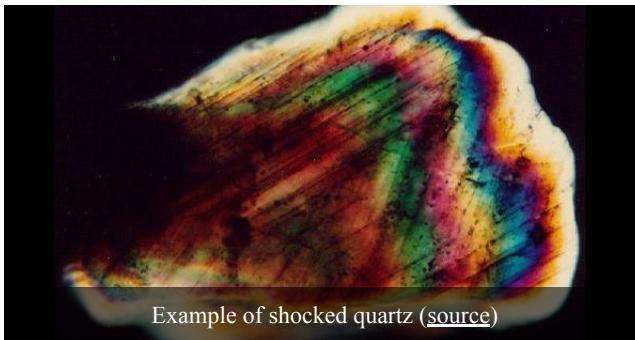


# What could add so much Iridium to the Earth so quickly?

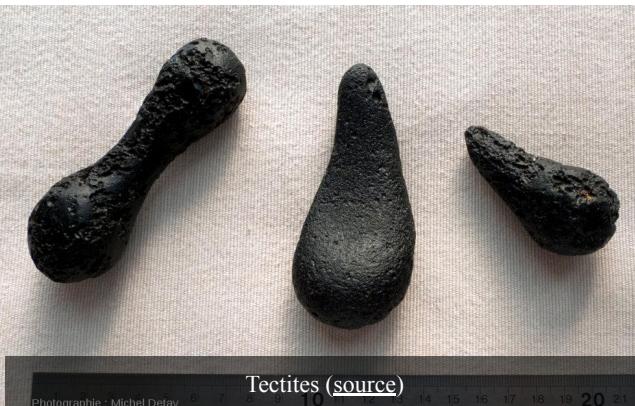


Artist's interpretation of an asteroid impact ([source](#))

# Development of the impact hypothesis

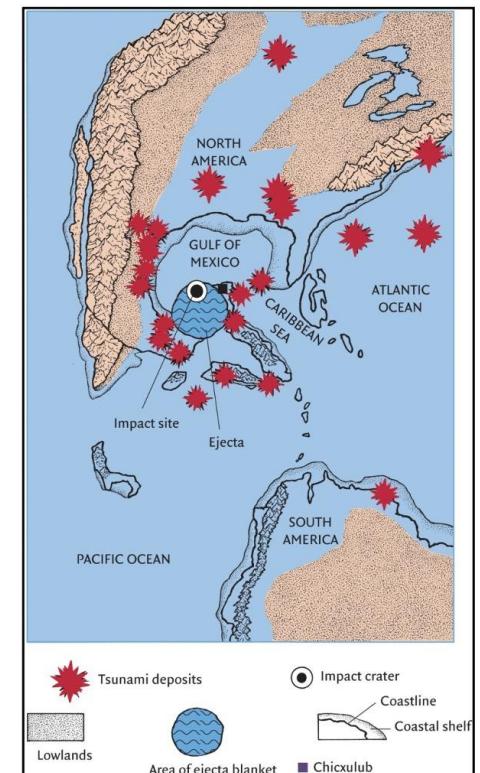


- The iridium spike in ~65 My-old soil layer has been found many places around the world.
- The same soil contains grains of shocked quartz that were deformed by high pressures, as would occur in a giant explosion.
- Also evidence of tektites around the globe at this time.

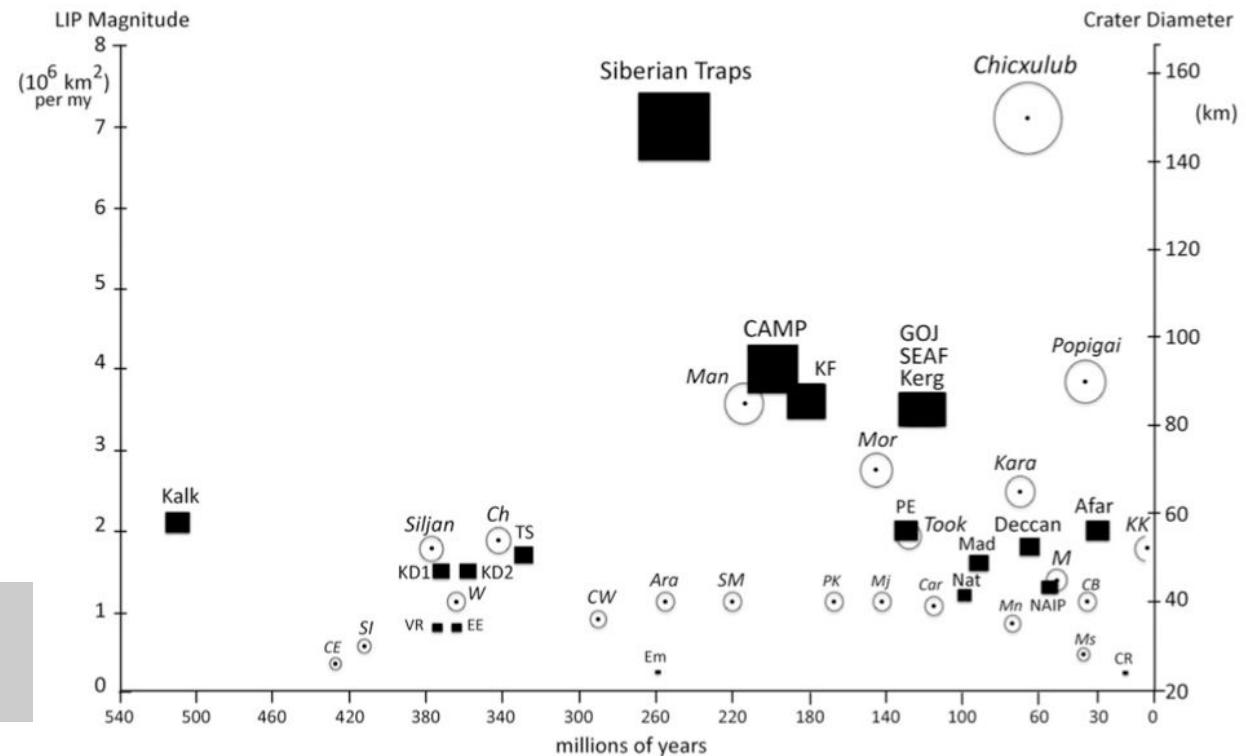


# Development of the impact hypothesis

- Evidence of tsunamis pointed to a Gulf of Mexico origin
- Chicxulub crater identified: ~110 miles in diameter and ~12 mi deep
- In the 1990s, the impact was dated to ~66 Million years



# Cretaceous–Paleogene (K–Pg) extinction



Scotese, Christopher R., et al. "Phanerozoic paleotemperatures: The earth's changing climate during the last 540 million years." *Earth-Science Reviews* 215 (2021): 103503.

# Size of the asteroid



# Size of the asteroid



# Impact of the impact



- Computer models suggest a fiery plume from the impact reached halfway to the moon.
- Infrared radiation pulse from kinetic energy triggers global fires 1500 miles from impact

# Impact of the impact



- Vaporized limestone releases a trillion tons of carbon dioxide, 10 Gt of methane, and 1Gt of carbon monoxide.
  - For comparison, humans produced ~31.5 Gt of carbon dioxide in 2018
- Vaporized anhydrite rock releases ~10 Gt of sulfur compounds into the atmosphere, which combine with water to make acid rain

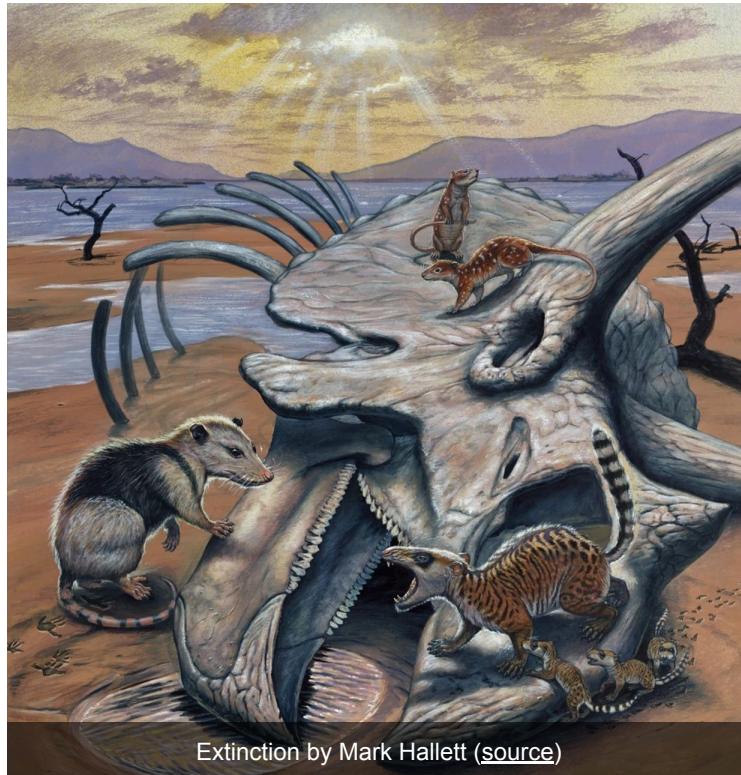
# Fossil Deposit: Tanis



- A fossil deposit made within hours of the impact
- Generated a wave that threw the continents of a river
- Tektites rained down on washed up fish (otoliths demonstrate the asteroid hit in spring)

DePalma, Robert A., et al. "A seismically induced onshore surge deposit at the KPg boundary, North Dakota." *Proceedings of the National Academy of Sciences* 116.17 (2019): 8190-8199.

# Last class: Conclusion



Extinction by Mark Hallett ([source](#))