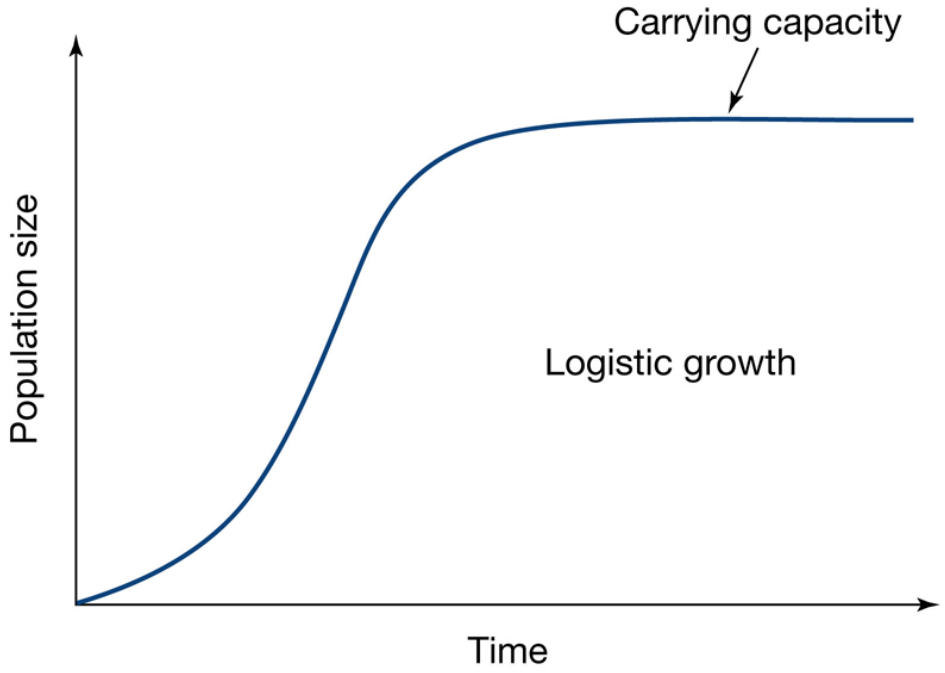
Biodiversity Through Earth History

What does the fossil record tell us about past climates and past events?

Useful terminology:

- Evolution
- Natural Selection
- Adaptation
- Extinction
- Taxonomy
- Logistic Growth



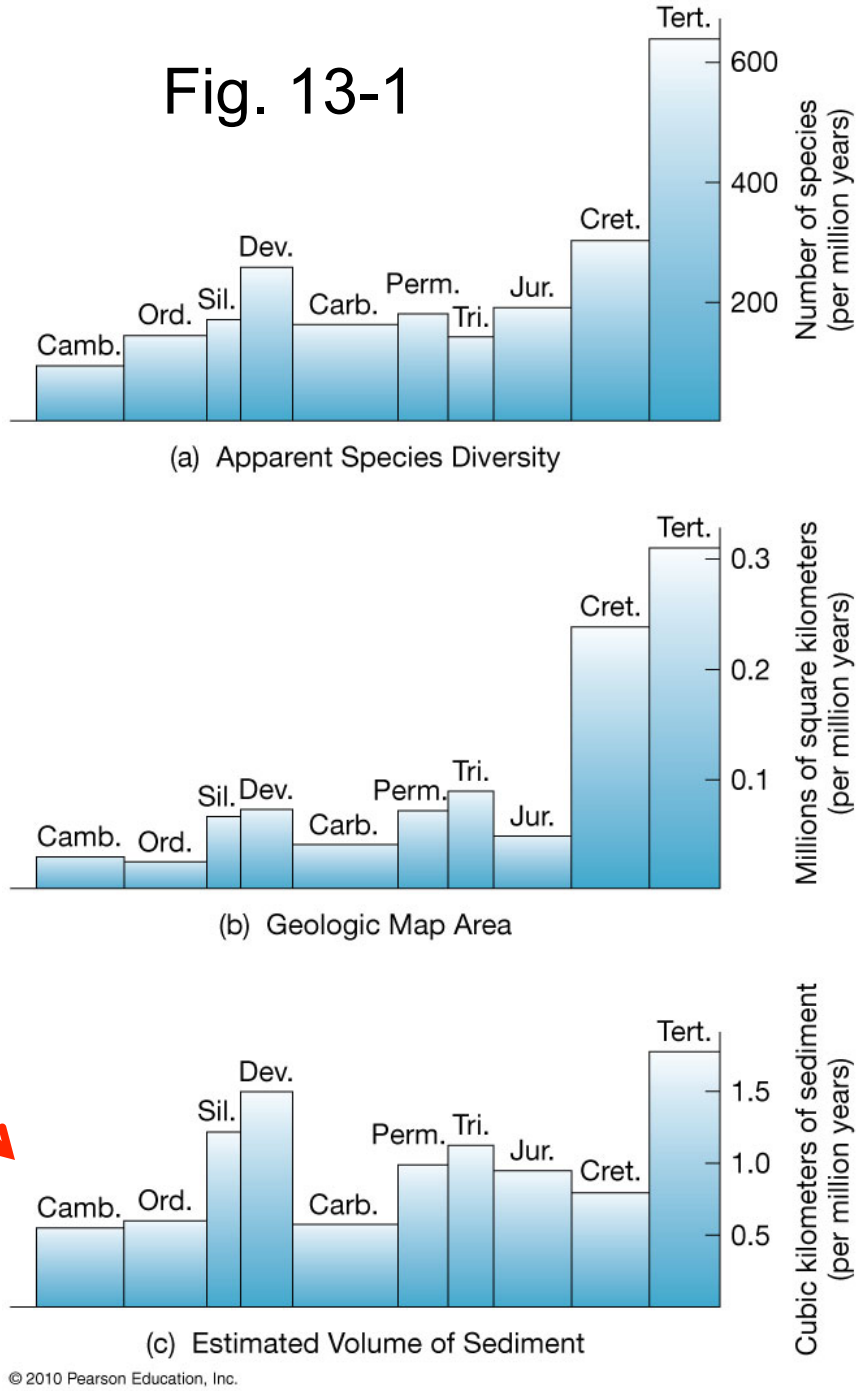
What corresponds to each definition?

- Characteristics that enhance an organism's survival
- "The unequal survival and reproduction of organisms, owing to environmental pressures that result in the preservation of favorable characteristics."
- "Descent, with modification (genetic mutation) of pre-existing life forms"
- Systematic organization of living or fossil organisms into a hierarchy
- The loss of all individuals within a species

Worrisome…

- Apparent species diversity (a) is similar to…
- Area of exposed rocks of different ages…
- Volume of rock from each time period
- **Bias?**

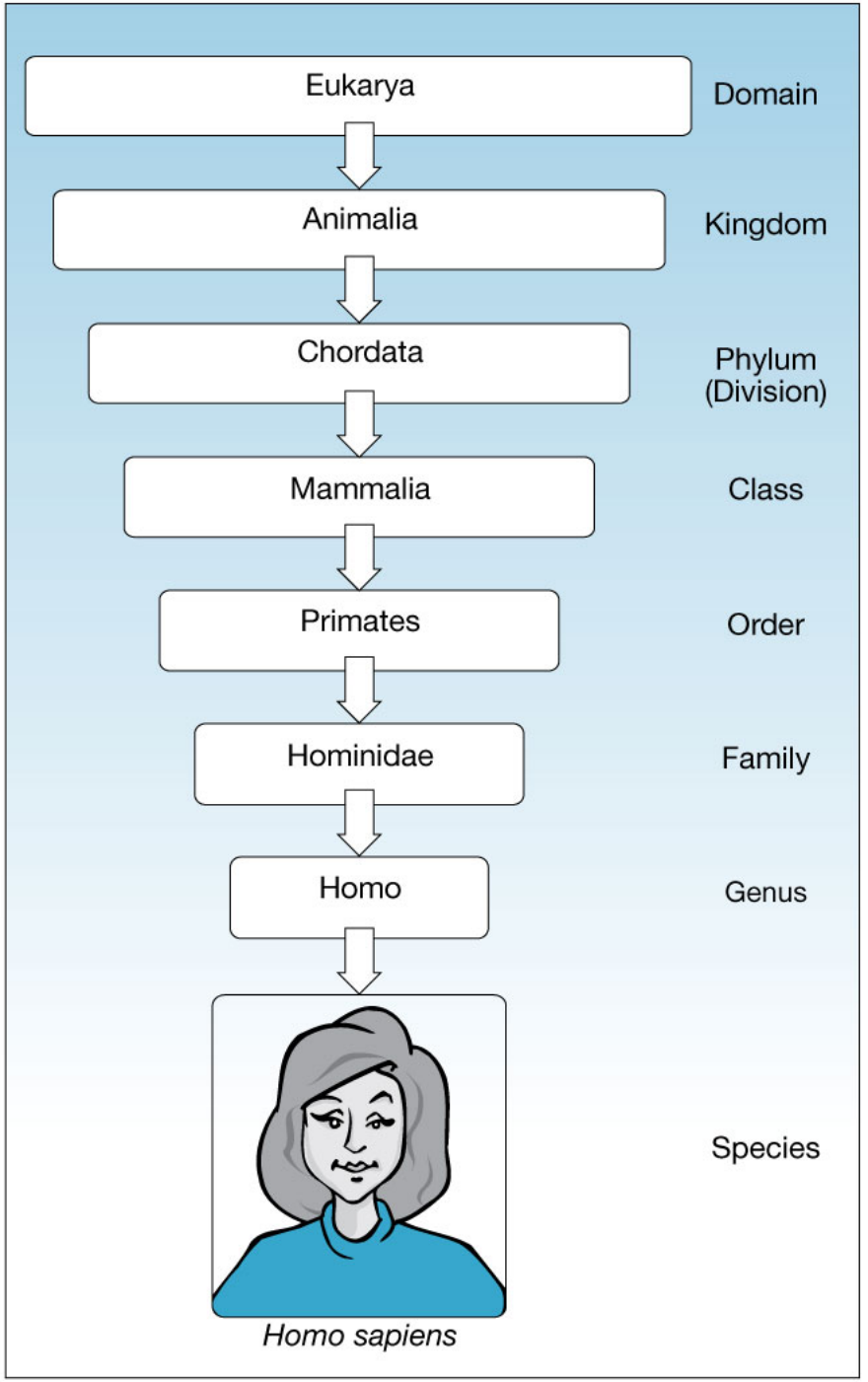
Fig. 13-1



Linnaeus

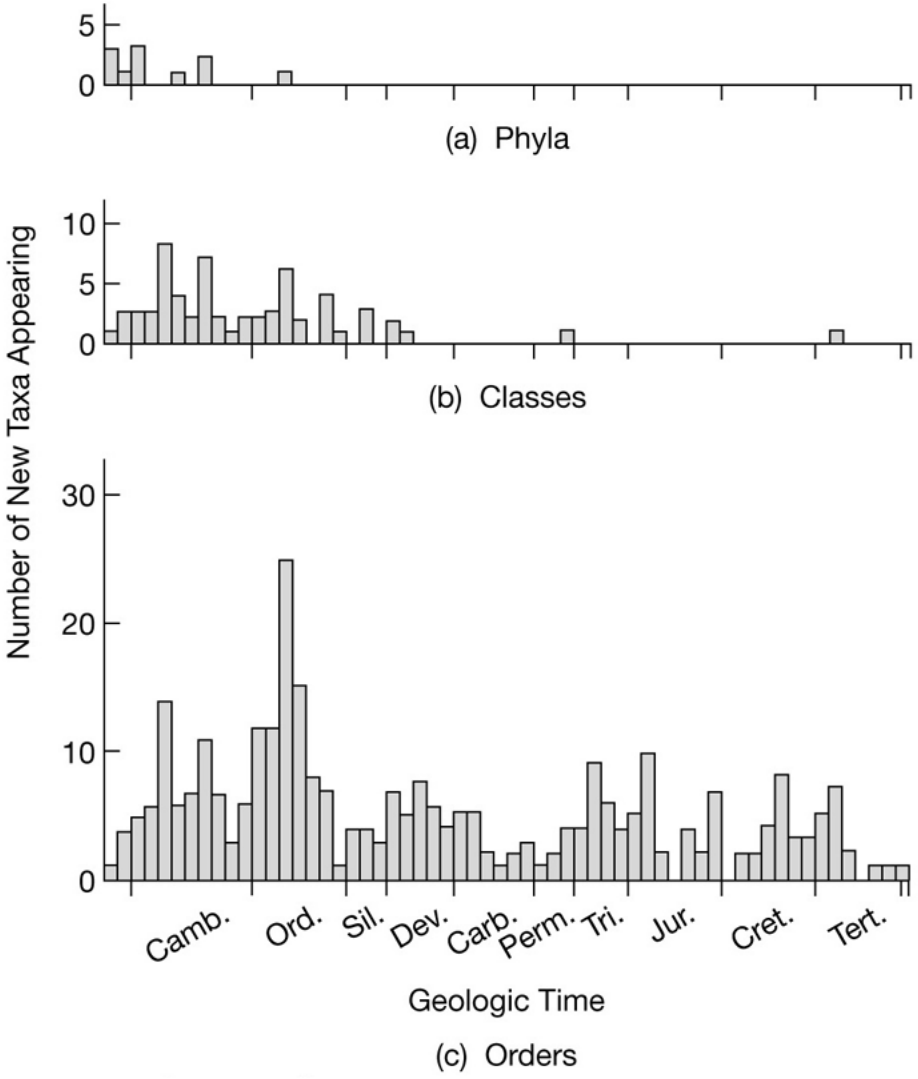
- The fossil record at the level of family and above is much more reliable than simple species diversity

Fig. 13-2



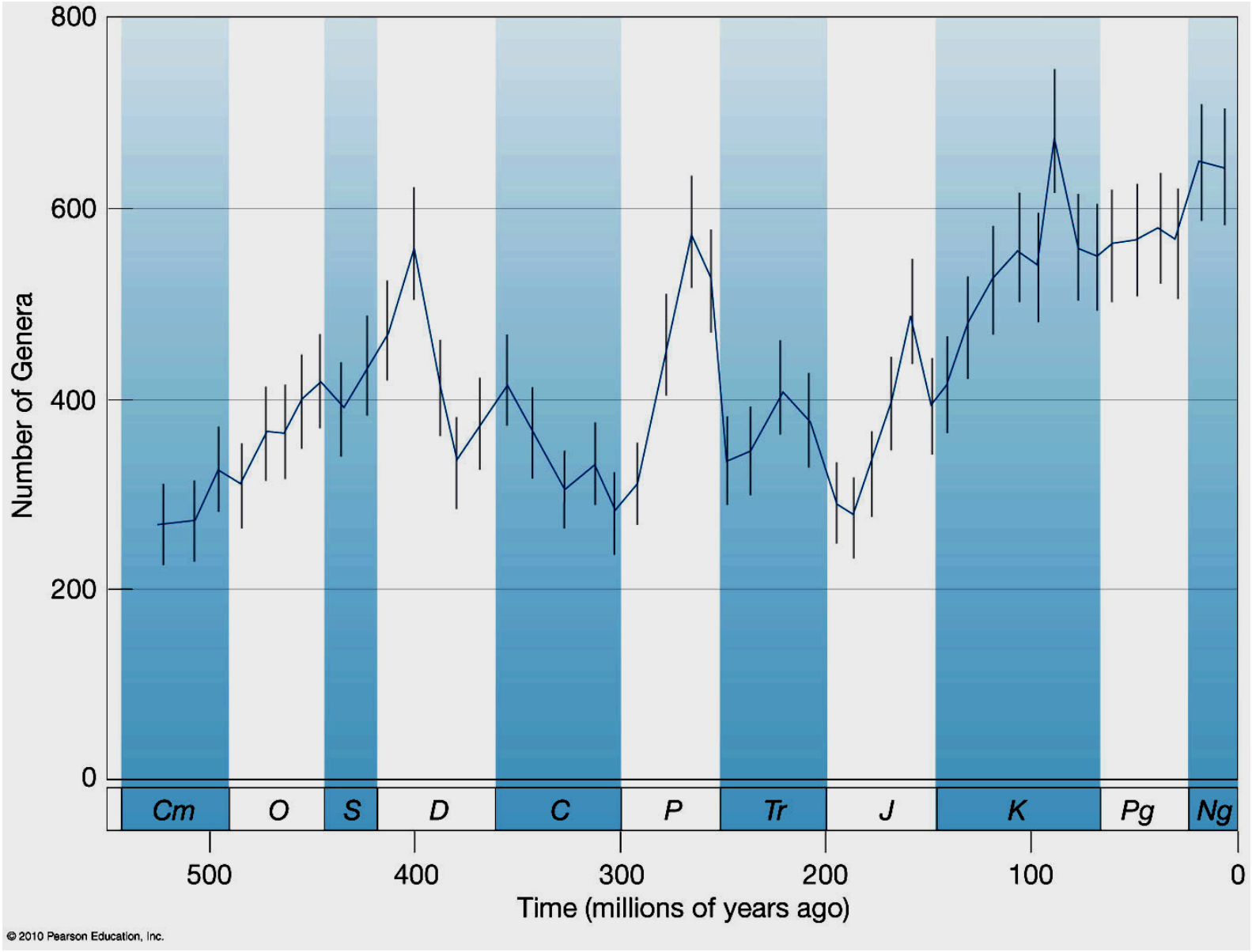
Origins of body plans…

- No new Phyla since the Ordovician!
- Only two new Classes since the Devonian
- Even at the Order level, less evolutionary innovation lately



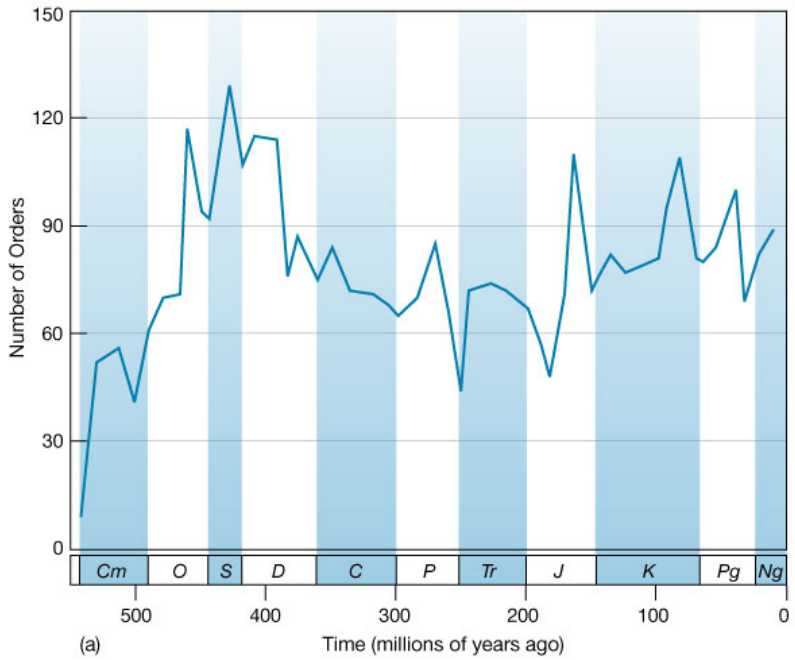
“Niches…”

- Major evolutionary “experimentation” with different ways of adapting to environments took place soon after the advent of “hard parts” in the Cambrian
- There are far fewer new ways to make a living now than there were back then!
- In other words, by now evolution has probably tried it already…

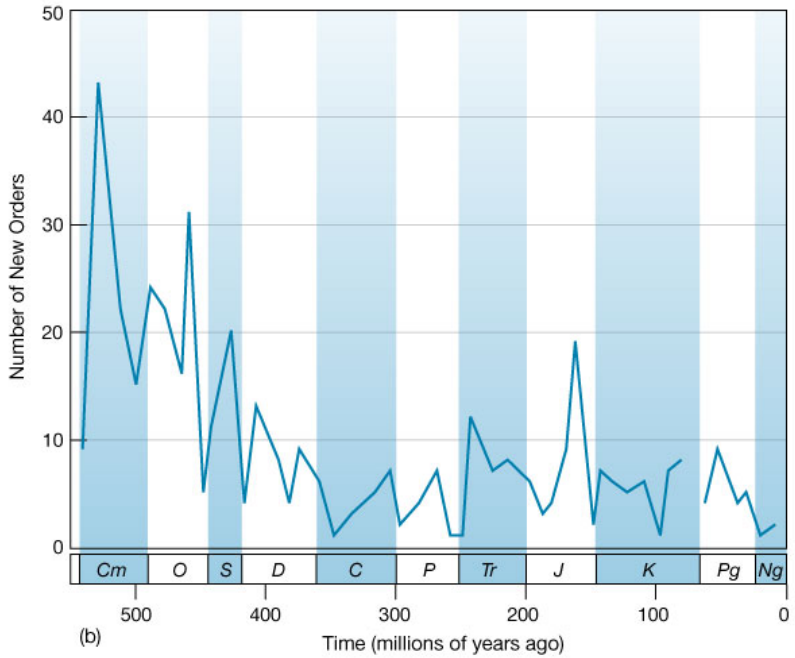


Number of Orders

After rapid development of new Orders and Families etc., the number of Orders has been fairly stable

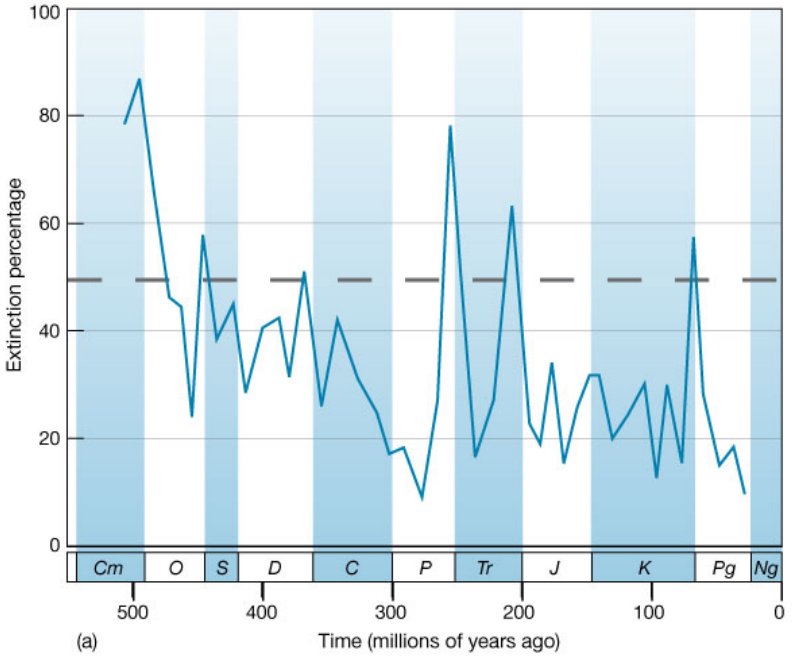


Number of NEW Orders



Extinctions

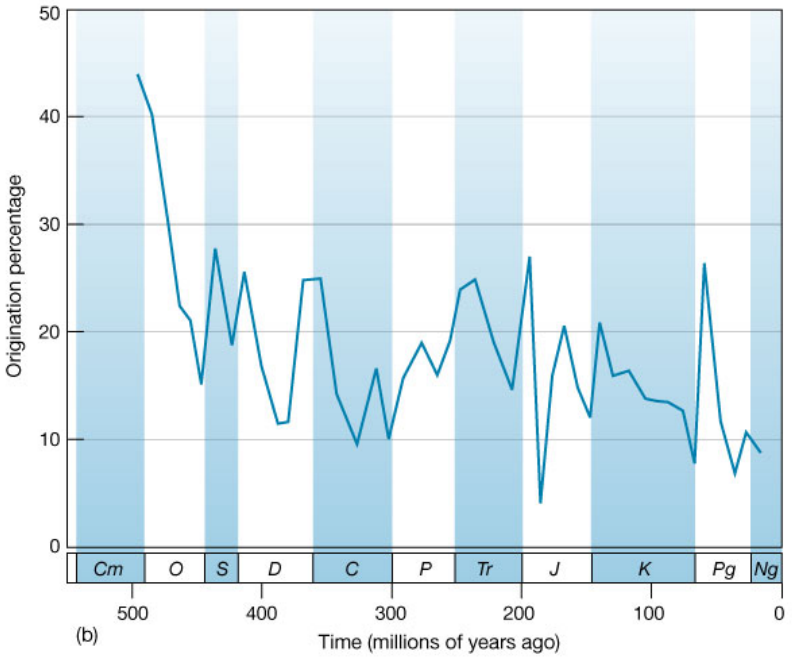
% genera in one 11 my period that are absent from the next 11 my period (or "bin")



At the Genera level, however, the extinctions are apparent

5 major episodes where ~ 50% of Genera lost

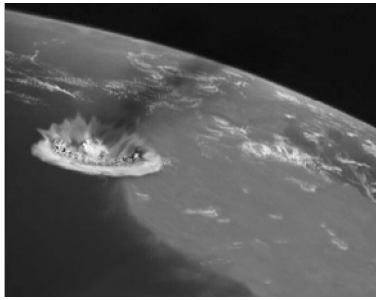
% genera in one 11 my period that were absent from the previous 11 my period.

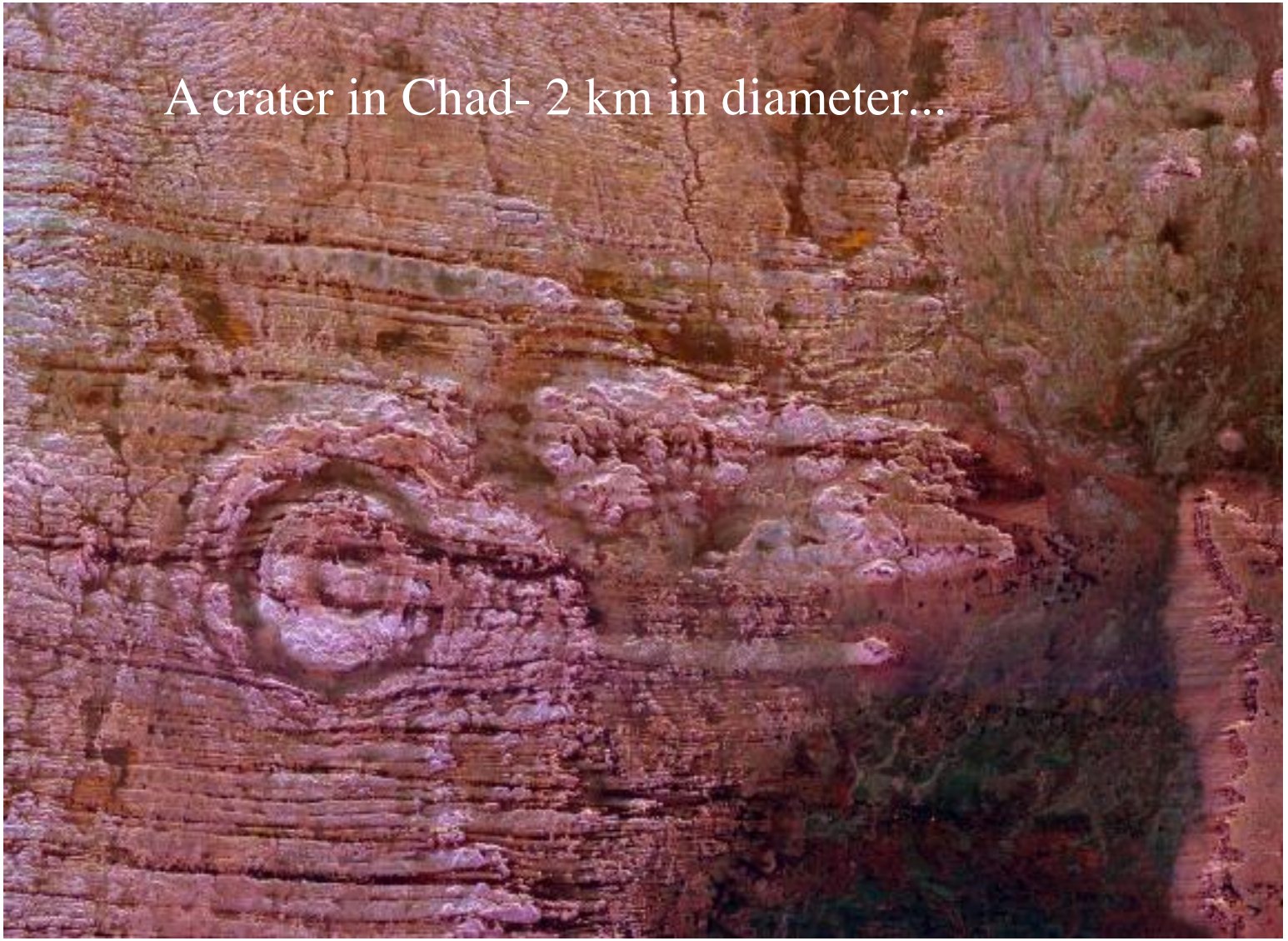


K-T Extinction

- ~75% of all species went extinct at 65 my
- Both marine and land (dinosaurs, except birds)
- There were a number of competing ideas about why this happened, from sudden changes in sea level to volcanic eruptive events

- K-T Impact - evidence



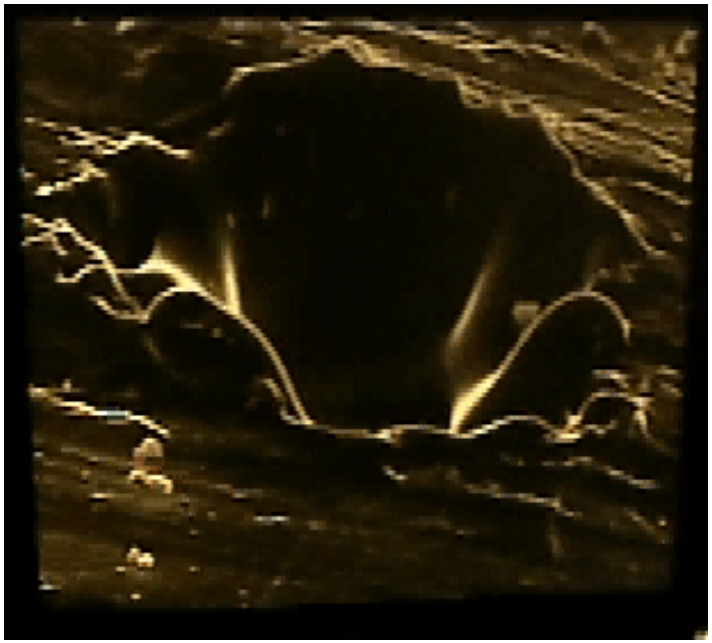

A crater in Chad- 2 km in diameter...

Wolf crater, Australia- 300,000 years old, 165 ft deep, 0.875 Km in diameter.

Tress blown down in Tunguska, Siberia

- From 1908 blast (no crater)

- Impacts occur at a predictable average rate



"Zap Pit"; 1/1000 in.

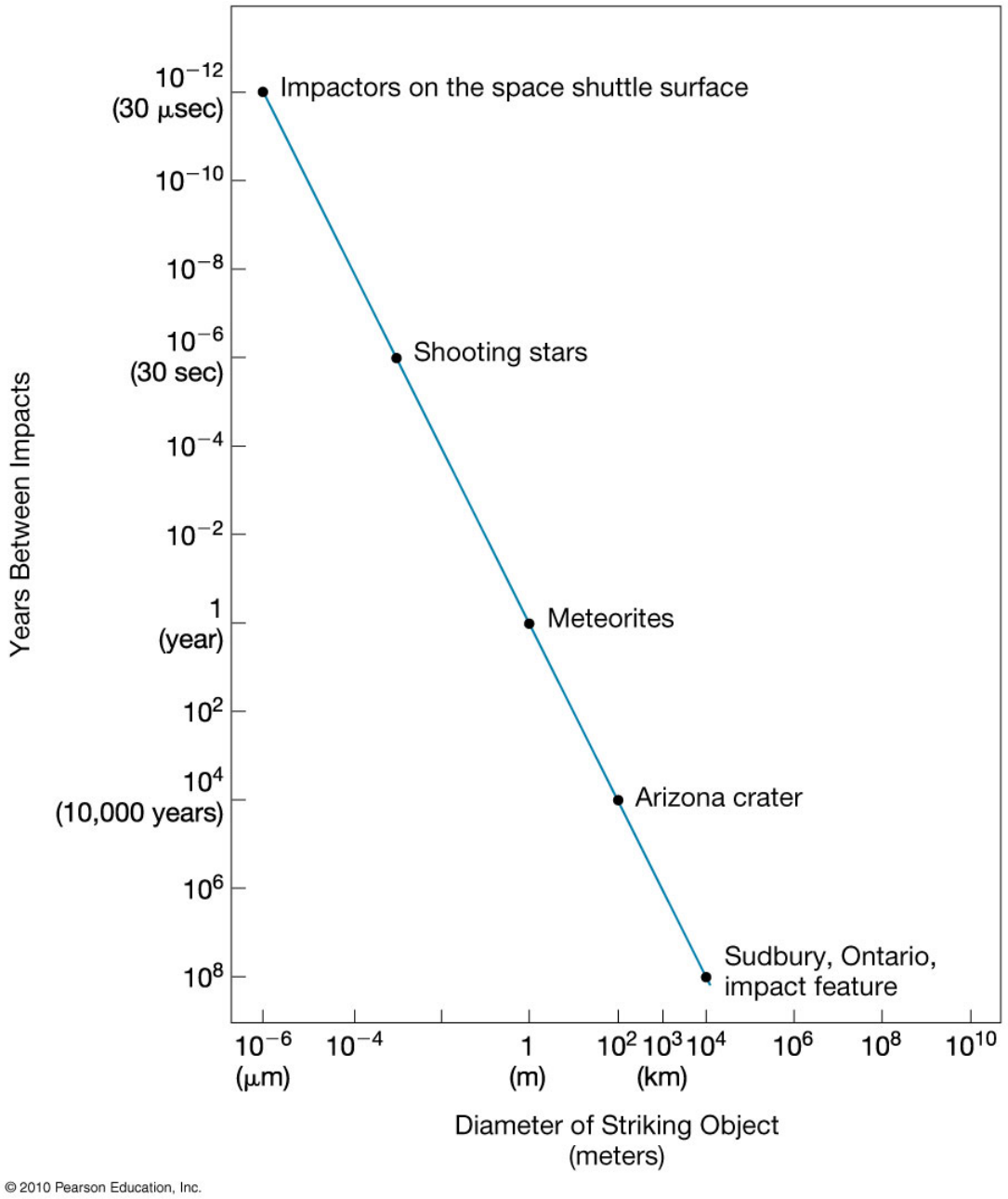
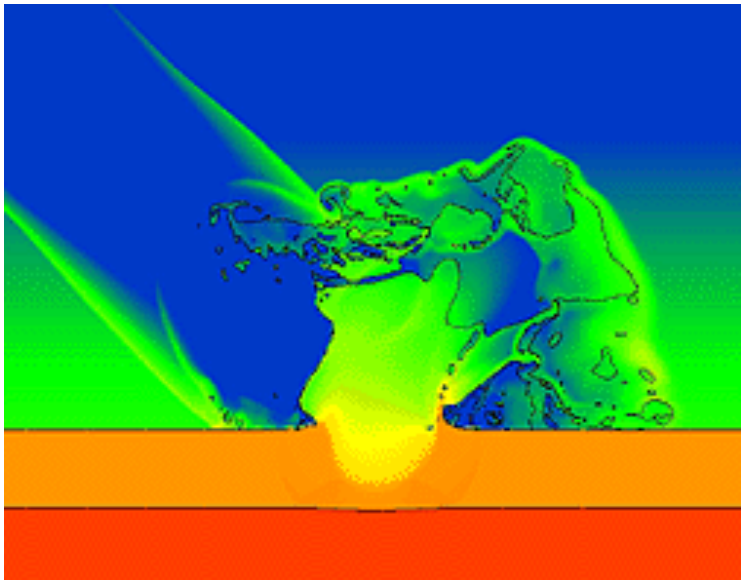


Fig. 13-5

Severe impact is no joke...

- This image comes from Sandia National Lab calculations, answering the question: What if the Comet Shoemake-Levy 9 impacted Earth instead of Jupiter?
- Green is atmosphere
- Orange is Earth's crust
- The high velocity asteroid punches a hole in the atmosphere, brings vacuum of space right down to the surface momentarily!

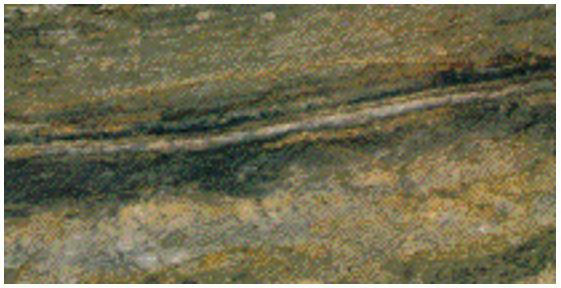


Meteorite Impact?

- Iridium normally would be found only in the core - or on meteorite, which would spread a thin Ir-rich layer worldwide
- An object about 10 km in diameter would be needed to account for the Iridium
- Evidence that large impacts can be frequent enough on long time scales, but not on short time scales
- Extinction widespread, both plants and animals
- Impact layer should be similar globally
- Different from sediment above and below
- Extraterrestrial component in boundary layer
- Evidence of high temperatures in boundary layer
- Evidence of impact “shock” (sudden high pressure)
- Evidence of global wildfires
- No dinosaur fossils above layer!
- No preferential survival for Cretaceous adaption

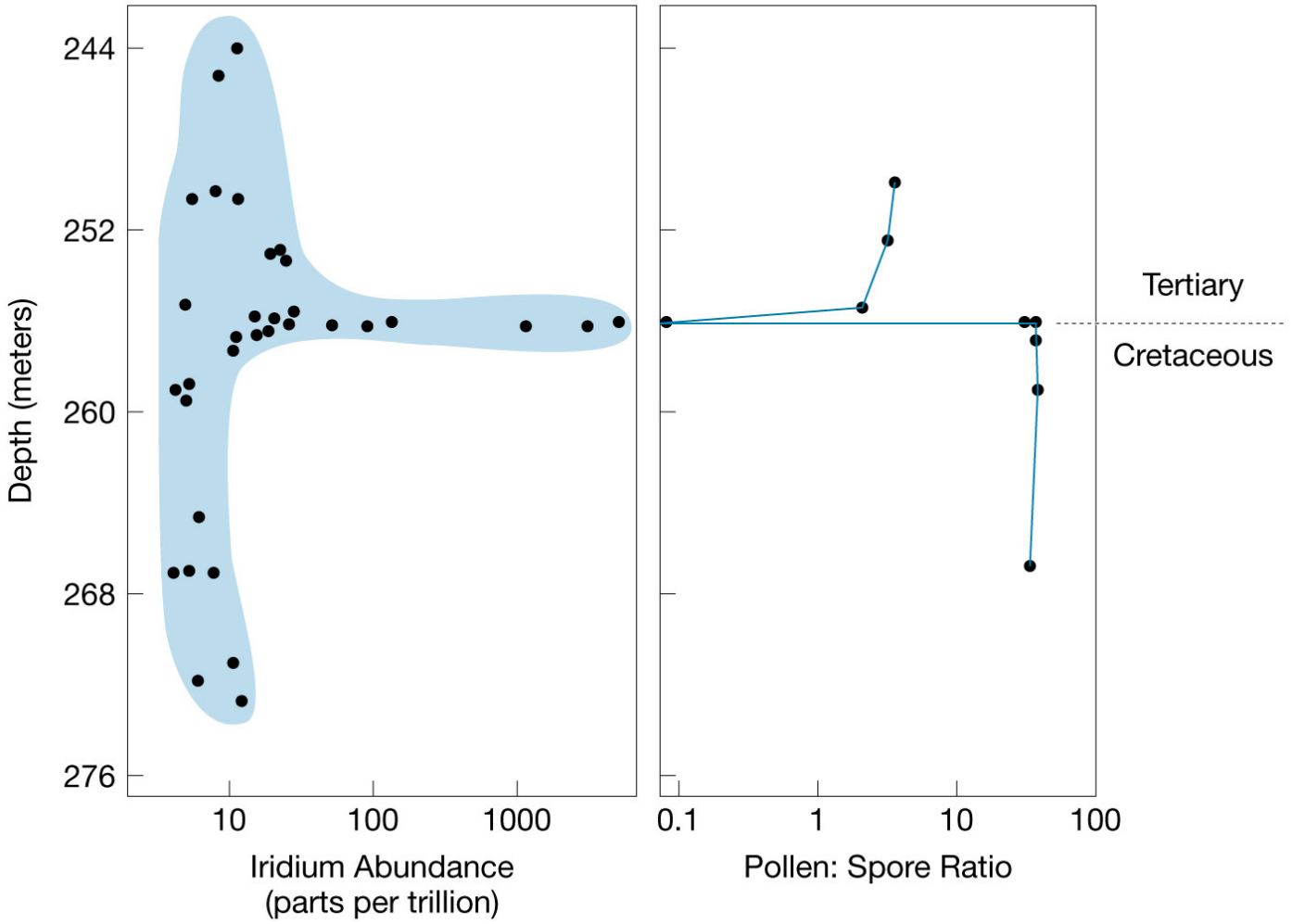
Smithsonian, Wash. DC:

- Clay layer



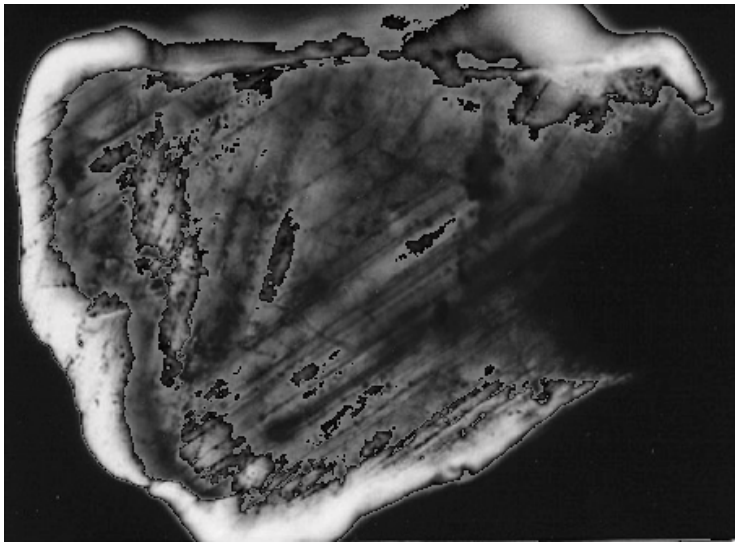
Iridium, Pollen/Spore

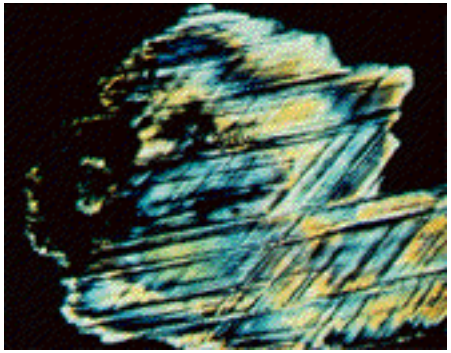
But…major volcanic eruptions, such as the Deccan Traps flood basalts in India that occurred at about the same time, could possibly have a similar effect

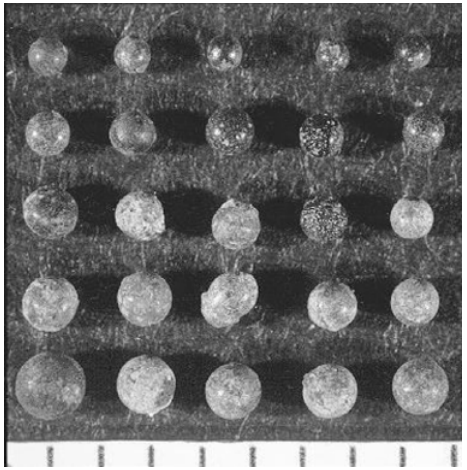


Forms of evidence:

- “Shocked” quartz, such as that found around nuclear blasts and known impact craters
- Tsunami deposits, Mexico and Texas
- Soot from global fires, tektites





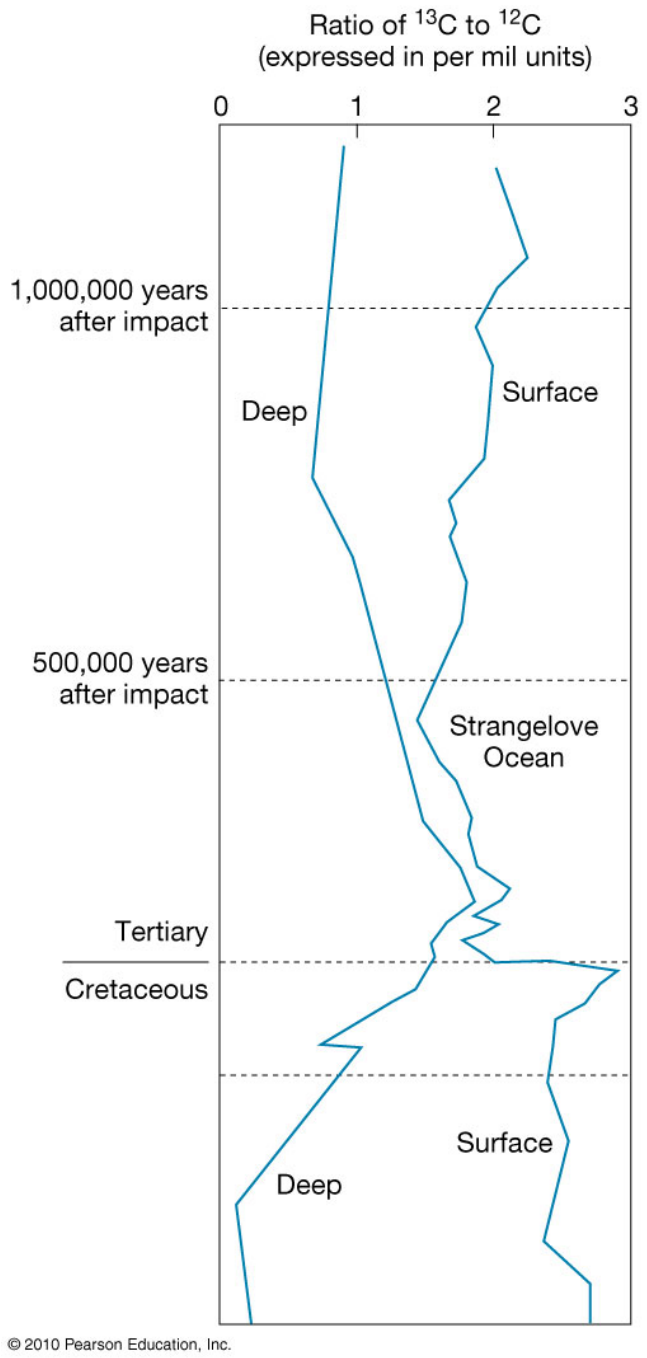


Osmium Isotopes

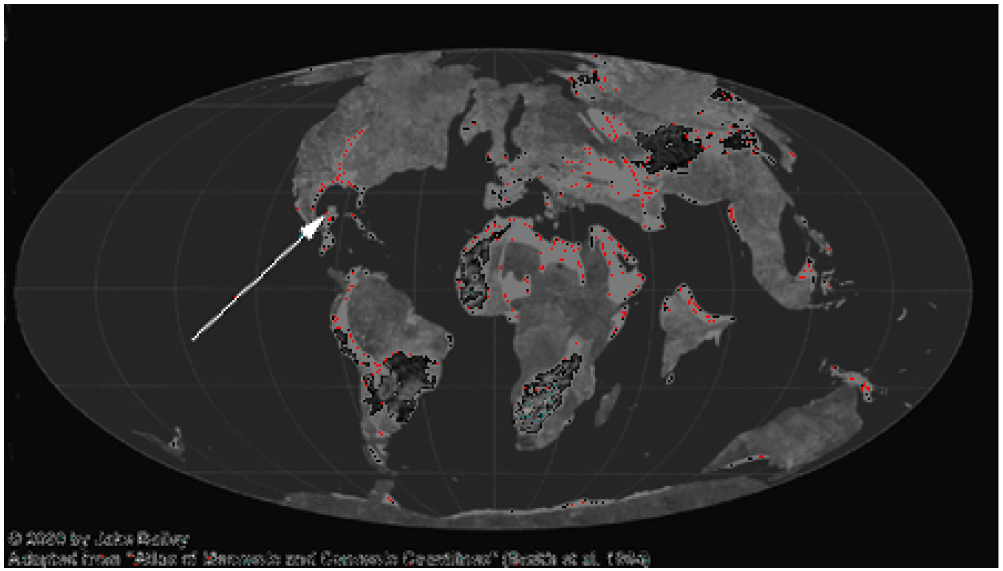
- An isotope of osmium, ^{187}Os, is created by the radioactive decay of ^{187}Re (rhenium). In contrast, other isotopes or osmium are rare in the crust because osmium is another of the "siderophile" (iron-loving) elements that tend to segregate to the core. The $^{187}Os/^{186}Os$ ratio of recent ocean sediments is about 7.5, and of meteorites is about 1.0. The $^{187}Os/^{186}Os$ ratio of the K-T boundary layer has been measured at 1.3 to 1.6. This suggests that the material there more closely resembles meteorite material than it does modern crustal material

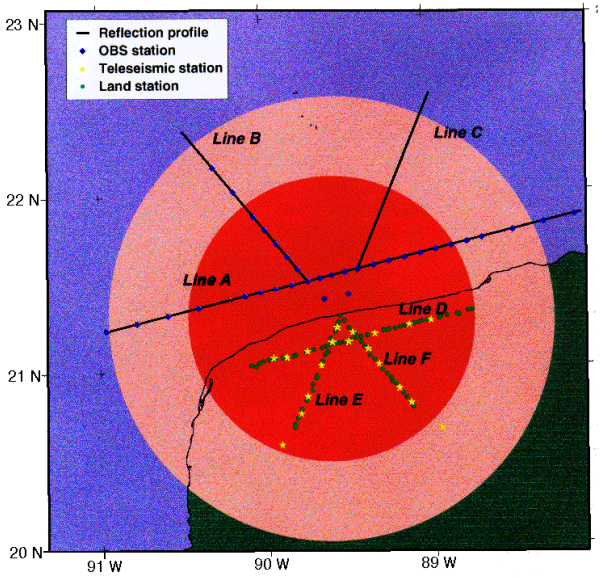
Strangelove Ocean?

- Normally, ocean biological "pump" enriches deep water in ^{12}C and surface water in ^{13}C, so $^{13}C/^{12}C$ ratio differs between foraminifera of surface waters compared to deep water
- Lack of difference at K-T boundary shows "shutdown" of biological pump
- Amazingly, this shutdown lasts hundreds of thousands of years! Oceans subject to toxic metal contamination after impact?

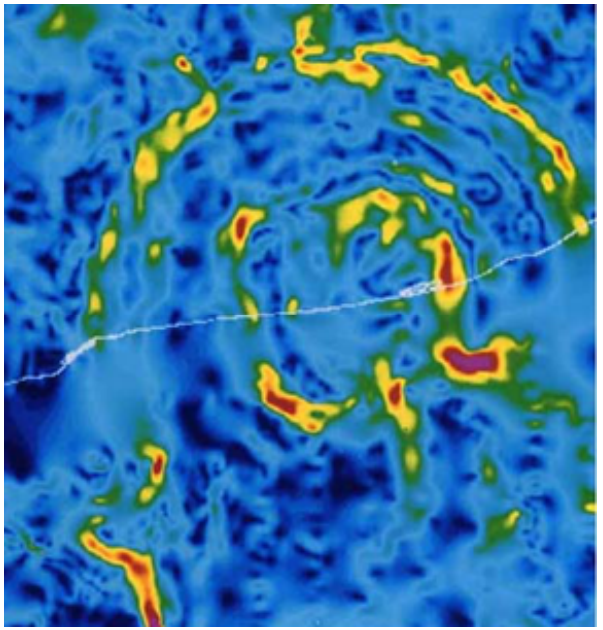


“Smoking Gun”: Chicxulub





- Discovered in 1950s by Pemex (using seismology)
- Shocked quartz, microspherules, Ir enrichment
- 200 km diameter - one of the biggest craters in the Solar System!



Seismic Evidence