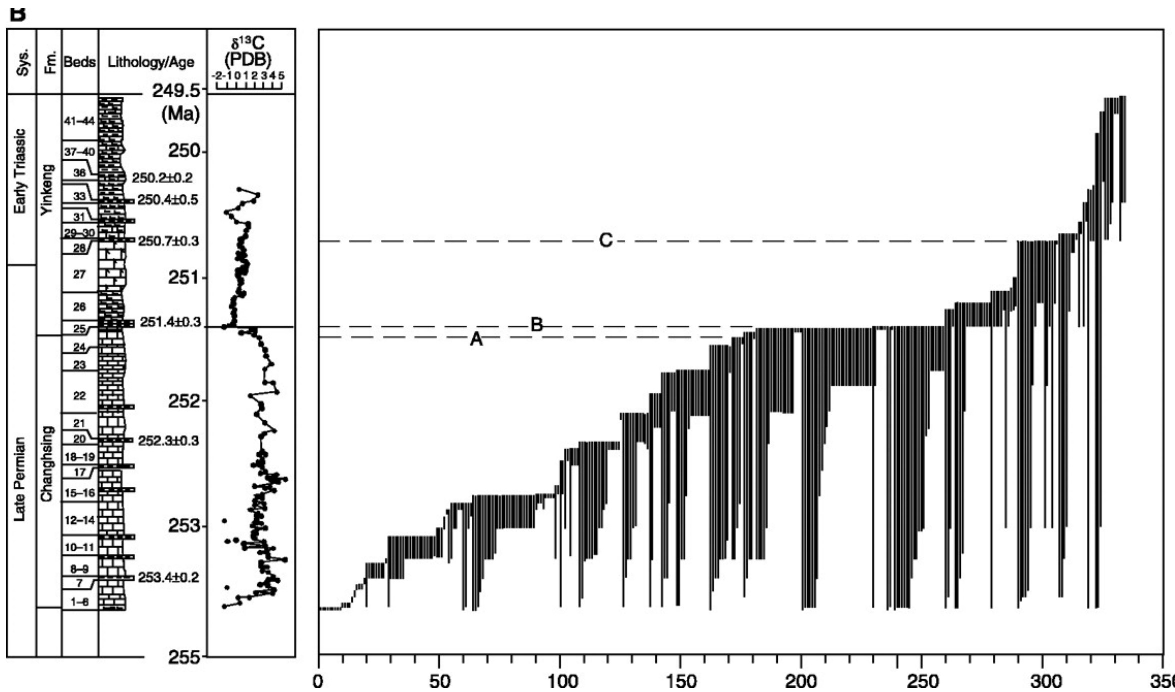
Mass Extinction Practical

---

1. Rates of extinction during the end-Permian mass extinction

The end-Permian mass extinction was the largest of all time. The record of the extinction is well documented in the Meishan section in south China, where the history of over 300 species has been tracked before and during the crisis (Jin *et al*. 2000).



The diagrams below are typical stratigraphic range charts showing the distribution of species of planktonic foraminifera before and after the K-T boundary. Information from two sites is given. The purpose of the exercise is to calculate extinction rates to determine whether there was a single sudden event, or a more prolonged one, and to compare the evidence from both sites.

The total extinction rate is calculated for the entire sample of species at each site, for fixed units of time. Extinction rate, ∂E, may be defined as, $\partial E = E/\partial t$, where E is the total number of species dying out within a specified time unit, and ∂t is the duration of that time unit.

The time scale is marked in millions of years, from 255 to 249.5 million years ago on the left hand side. The other information to the left includes names of geological formations, the bed numbers, and a sketch sedimentary log.

(a) Calculate origination and extinction rates through the 5.5 myr. Divide the time span into units of 500,000 years (∂t), record O and E for each, and calculate ∂O and ∂E, in rates per myr. Plot both origination and extinction rate curves against the time axis, from 249.5 to 254.5 myr.

(b) Interpret your results. Can you identify a ‘background’ extinction rate? What happens at the levels marked A, B, and C in the original diagram? How does the highest extinction rate measure up to calculated global rates for species loss of 80-96%?

(c) What are the kinds of sources of error and practical problems of data collection that might affect the results? Are we sure these are all genuine species? What about sampling and neighboring areas also?

2. Professor Alvarez’s equation

Luis Alvarez and colleagues (1980) presented a model for the KT mass extinction 65 million years ago that calculated the minimum size of the asteroid that might have hit the Earth and blanketed the surface in iridium. If the aseteroid was too small, the effects would not have been worldwide. Their formula was,

$$M = \frac{sA}{0.22f}$$

where *M* is the mass of the asteroid, *s* is the surface density of iridium just after the time of the impact, *A* is the surface area of the Earth, *f* is the fractional abundance of iridium in meteorites, and 0.22 is the proportion of material from Krakatoa, the huge volcano in Indonesia that erupted in 1883, that entered the stratosphere. The surface density of iridium at the KT boundary was estimated as 8×10^{-9} grams per square centimeter, based on the local values at Gubbio, Italy and Stevns Klint, Denmark, their two sampling localities. Measurements of modern meteorites gave a value for *f* of 0.5×10^{-6}.

(a) Use these values to work out *M*, the mass of the asteroid. You will have to convert all units to standards, and we suggest grams (g) for masses and cm (centimeters) for lengths and areas. Remember that there are 100 cm in 1 m, 10^5 cm in 1 km, 10^{10} cm^2 in 1 km^2, 1000 (10^3) g in 1 kg, and 10^6 g in 1 metric tonne.

(b) Work out the diameter of the asteroid, assuming that the density of planets and asteroids is 2.2 gcm^{-3}, and recalling that the volume of a sphere, V, is $V = 4/3\pi r^3$ and that diameter = 2r.

References

Alvarez, L.W., Alvarez, W., Asaro F. and Michel, H.V. (1980) ‘Extraterrestrial cause for the Cretaceous-Tertiary extinction’, *Science*, **208**: 1095–1108.

Jin, Y.G., Wang, Y., Wang, W., Shang, Q.H., Cao, C.Q. and Erwin, D.H. (2000) ‘Pattern of marine mass extinction near the Permian-Triassic boundary in South China’, *Science*, **289**: 432–6.