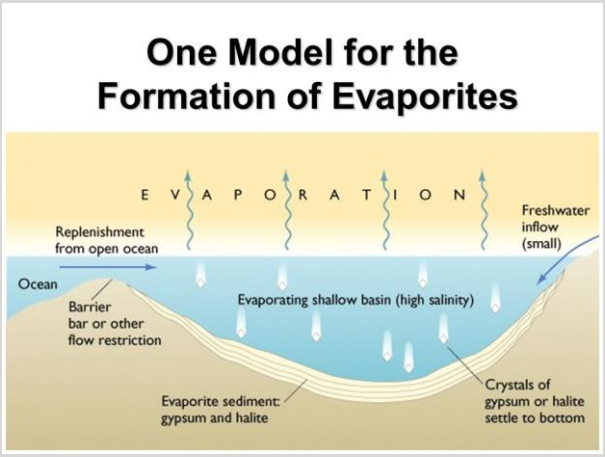
THE GEOLOGICAL COLUMN

- **Geothermal gradient:** the rate of increase of temperature with depth. In continental crust it averages 25^0C per km, but it is higher in areas of igneous activity.
- **Uniformitarianism:** is the principle that states geology is the result of processes that have been operating over a very long period of time and can still be seen today.
- **Era:** a major unit of time that contains several periods/systems.
- **Period:** a unit of time, a division of an era (e.g. the Carboniferous period)
- **System:** all the rocks laid down in a named time period (e.g. the Carboniferous system).
- **Geological column:** A table containing all the eras and systems in the correct time sequence.

THE AGE OF THE EARTH BY SALT CONTENT OF OCEANS

One Irish geologist, Joly, assumed that the oceans were once made of fresh water and that rivers added salt slowly overtime. To find the age of the oceans, the salt content is divided by the amount of salt that is added each year.



This method though does have many limitations. For a start, finding the salt contents of all rivers and their annual discharges would be very difficult. Joly estimated that there were 160 million tonnes of sodium added to the oceans each year. The salt content of oceans remained remarkably constant, at 0.35%, so after a quick estimate of the oceans' volumes, he arrived at an age of 90 Ma.

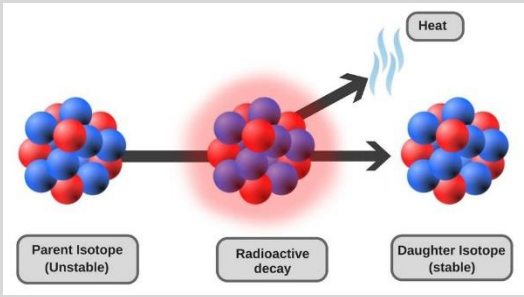
This is far too small, as the real age of the oceans is closer to 2500 Ma. If Joly had taken into account, the salts taken out of the seas as evaporates and the changes in the amount of salt carried from the land over geological time, his estimate would not have been so low.

THE AGE OF THE EARTH BY RATES OF COOLING

Lord Kelvin, 1862, obtained the geothermal gradient from measurements of the increase in temperature with depth in mines (25^0C – 30^0C per km). The amount of heat flowing out of the Earth is dependent on its conductivity. Conductivity is measured using rock sample sin the laboratory. Kelvin assumed correctly that the Earth began as a molten body.

This gives the temperatures and rate of temperature decrease and so how long the Earth has taken to cool.

Kelvin's result came out as 30-40 Ma which did not satisfy many geologists who had seen field evidence that rocks had formed over much longer time spans. What Kelvin did not know was that the Earth was being continually heated by radioactive decay – it appeared to have been cooling over a short period of time.



THE AGE OF THE EARTH BY RATES OF SEDIMENTATION

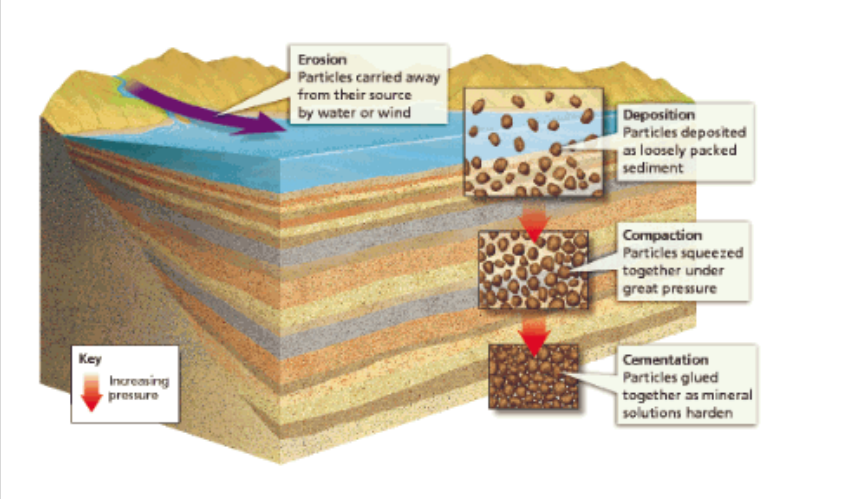
By knowing the time it takes to form a certain thickness of sediment (the deposition rate of a bed) and the thickness of sediment that have been deposited all together, then a lower limit to the age of the Earth can be calculated.

However, there are lots of variables in geology that mean this method is not so accurate. Coarse sediment in the delta or alluvial fan accumulate rapidly, and a single flash flood in a wadi may even deposit a metre or more of poorly sorted material. At the other end of the scale, fine sediments may settle over a very slow rate in a low energy environment.

This means deposition rates are differential and it can be hard to put an exact time to the formation of a bed. Another obvious difficulty is that the thickness of sedimentary rocks to be found in different parts of the world vary greatly, depending on both geography and geology.

The principle of uniformitarianism tells us just that. At extremes, there are parts of the world experiencing erosion rather than deposition, these are regions that will form the unconformities of the future.

Sediment also requires compaction to lithify to a rock. A thick wet rock will reduce in size by a great extent when pressure is applied. At great depths, (>10km), sedimentary rocks will become metamorphic due to great pressures and temperatures. This makes it hard to tell what the original sedimentary rock thickness was.



THE GEOLOGICAL COLUMN

The Phanerozoic eon is subdivided into three eras:

Cenozoic	Age of mammals, 65.5 Mya
Mesozoic	Age of reptiles, 251 Mya
Palaeozoic	Ancient life, 542 Mya
Precambrian	Oldest known life/rocks, age of earth, 4500 Mya

The eon before the Phanerozoic is divided into two eras: the Proterozoic & the Archean

These mark drastic changes in the fossil content of rocks as the mass extinctions of the **Permian-Triassic** and **Cretaceous-Tertiary** boundaries took their effects. Up **to 95% of species were wiped out** and a **sudden evolutionary radiation** of new species occurred to **occupy the vacant environment niches**.

Each era is divided into a number of periods on the basis of important **changes in fossil species** that are recognised worldwide.

The appearance and **extinction of graptoloids** occurred principally between the **beginning of the Ordovician** and the **end of the Silurian**. Fossil evidence has been used to **further subdivide** the periods **into epochs** and then even smaller divisions.

The useful **zone fossil ammonites** and **graptolites changed so rapidly** that some divisions are as **short as 80,000 years.**

The **actual length of the periods** could not be known **until radiometric dates** were added to **palaeontological knowledge.**

Sediments may be covered by a layer of **lava or ash** containing radioactive minerals which allow for an **absolute age LIMIT** of the rocks beneath.

Dates from igneous rocks all across the world and using cross-cutting relationships allows the geological timescale to be built up, with boundaries of the divisions in the geological column.

Subdivisions of Geologic Time and Symbols

ERA	PERIOD AND SUBPERIOD	EPOCH	AGE (Ma)
CENOZOIC	QUATERNARY	Holocene	2.6
		Pleistocene	
	TERTIARY — NEOGENE SUBPERIOD	Pliocene	5.3
		Miocene	23.0
	TERTIARY — PALEOGENE SUBPERIOD	Oligocene	33.9
		Eocene	55.8
		Paleocene	
MESOZOIC	CRETACEOUS	Late	65
		Early	145
	JURASSIC	Late	
		Middle	
		Early	200
	TRIASSIC	Late	
		Middle	
		Early	251
PALEOZOIC	PERMIAN	Late	
		Middle	
	PENNYSLVANIAN	Late	
		Middle	
		Early	320
	MISSISSIPPIAN	Late	
		Early	359
	DEVONIAN	Late	
		Middle	
		Early	416
	SILURIAN	Late	
		Middle	
		Early	444
	ORDOVICIAN	Late	
		Middle	
		Early	488
	CAMBRIAN	Late	
		Middle	
		Early	542
PROTEROZOIC			2500
ARCHEAN			3800

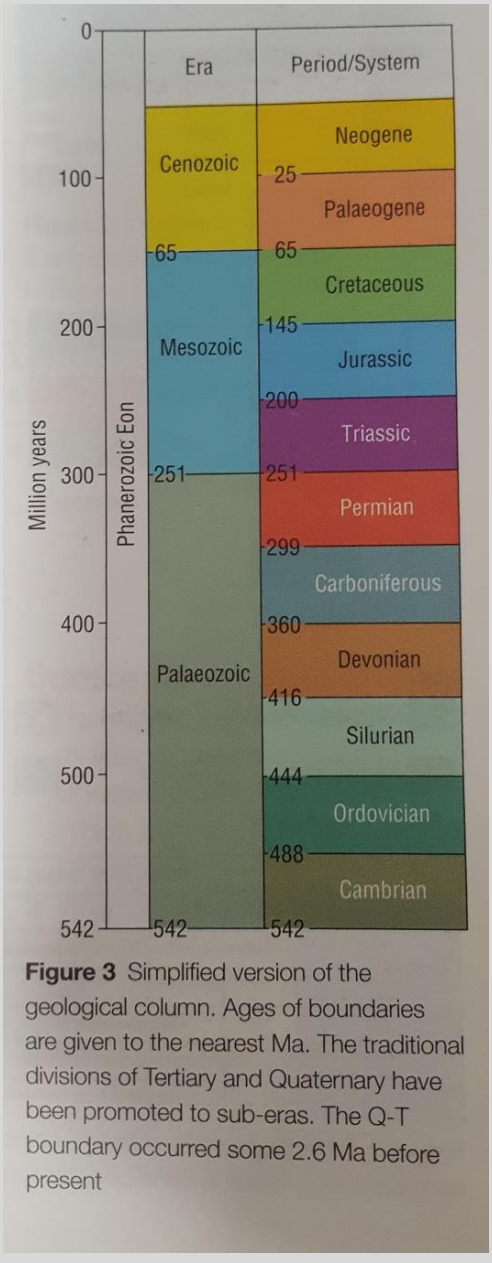


Figure 3 Simplified version of the geological column. Ages of boundaries are given to the nearest Ma. The traditional divisions of Tertiary and Quaternary have been promoted to sub-eras. The Q-T boundary occurred some 2.6 Ma before present

The dates of the Eras (65/251/542) should be learnt. The order of the eras in the geological column and its systems should be learnt too.

https://www.memrise.com/course/1306608/geological-timescale-as/