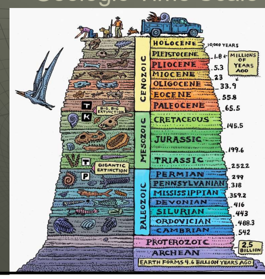
Radiodating

Geologic Time Scale



Radiodating

- A method of determining the age of materials.
- Radio-dating works by looking for some radioactive isotope present in a certain material.
- All radioactive elements decay at a known rate, the half life.
- If we can make an accurate assumption about how much radioactive isotope was present at some past date, we can determine how long it took for the isotope to decay to present levels.

Carbon dating

- One method is carbon-14 dating or C-14 dating.
- This method <u>only</u> can be used on things that were once alive.
- Also this method is only used relatively recent materials on a geologic time scale. It can't be accurately used on anything more than 60,000 years old.
- It is good for the span of human existence, not for dinosaurs.

C-14

- C-14 is an isotope of carbon.
- Until it decays it will act exactly like Carbon-12 (nonradioactive carbon), it will make all the same compounds, for all the same bonds.
- Except, over time Carbon-14 will decay becoming Nitrogen-14

How carbon dating works

- Radiation on this planet causes radioactive isotopes to form.
- A known percentage of the carbon dioxide in the air contains the radioactive C-14 isotope.
- This carbon dioxide is used to "build" all living things (plants use it for food, animals eat the plants etc.)

Finding an age

- The amount of C-14 in an object can be measured.
- This amount is compared to the amount assumed to be there when it died.
- You count the half lives to determine its age.

Radiodating

- Radiodating always require you to determine the amount of radioactive isotopes present in the past and compare it to what is present today.
- C-14 works because the amount of C-14 in living things hasn't changed over time.
- Other types today compare the amount of **daughter isotope** present to the amount of **radioactive isotope** to determine how old it is.

Fossils

- Most older things being dated are fossils.
- REMEMBER FOSSILS ARE NOT BONES!!
- An item, like a bone, is left is soft sediment. That sediment hardens into a rock. The bone itself decays away turning back into carbon dioxide.
- Leaving an imprint in the rock. Another rock forms in the "mold" left and now you have a **rock** in the shape of that bone.
- It doesn't have to be a bone, it can be a footprint, shell, really anything that could leave an imprint.

Potassium-40 dating

- Fossils, and any other rock can also be dated if they have other certain isotopes.
- K-40 decays into Ar-40.
- When a rock is formed we can assume all gases would escape, so all argon in a rock should be the product of K-40 decay.
- measure the K-40 and compare it to the Ar-40 and you can determine its age.

Uranium-238 dating

- U-238 decays into Pb-206 which is extremely rare.
- If you have a rock with U-238 and Pb-206 present, you can assume the Pb-206 came from the decay of U-238.
- Scientists have come up with the **4.6 billion year age of the planet** using these methods.

Other methods

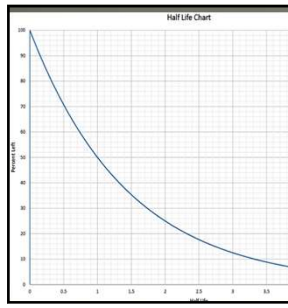
- There is a whole list of other isotopes that can be used.
- Samarium-neodymium
- Rubidium-strontium
- Uranium-thorium
- Chlorine-36

Calculations

- If you measure 15 g of C-14 and you assume you started with 60 g, then the object is…
- 11,430 years old
- 60g→30g→15g (2 half lives)
- 5715 years x 2 = 11,430 years

Math

- Percentage left is current mass/initial mass x100 $\% = m_f/m_i \times 100$
- Multiply the number of half lives by the value of one half life to get an age.
- The equation is difficult to use, so instead we will read it off a **graph**.
- Here is equation $m_f/m_i = 1/2^{hl}$
- *hl is the number of half lives passed.
- $\ln(m_f) - \ln(m_i) = -\ln(2)\, t / t_{1/2}$
- $\ln(m_f / m_i) = -\ln(2)\, t / t_{1/2}$
- $t_{1/2}$ is the accepted value of 1 half life



Isotope	Half Life
In-115	4.41×10^{14} yrs
K-40	1.28×10^{9} yrs
U-238	4.468×10^{9} yrs
U-235	7.038×10^{8} yrs
Pu-241	14.35 yrs
Pu-239	24,400 yrs
C-14	5715 yrs
Am-241	432 yrs
Sr-90	29.1 yrs
Pb-210	22.3 yrs
H-3	12.3 yrs
Fm-257	100.5 days
Tc-96	4.28 days
Ra-223	11 days
Rn-222	3.8 days
Th-231	26 hrs
Es-252	472 days
Po-210	138 days
No-259	58 min
Ra-227	42.2 min
Kr-89	3.16 min
Fr-223	21.8 min
Po-214	1.64×10^{-4} s
At-219	56 s

Problems

- If you have 32% of a material left, how many half lives have passed?
- If you have 17% of Ra-223 left, how old is it?

Problems

- If you have 32% of a material left, how many half lives have passed?
- 1.64 half lives
- If you have 17% of Ra-223 left, how old is it?
- 2.55 half lives x 11 days =
- 28 days

Problems

- If original sample had 78 g of Pu-241, and you now have 49 g left; how old is the sample?
- A sample of Radon-222 is 9.4 days old. There are .27 g present, how much was originally present?

Problems

- If original sample had 78 g of Pu-241, and you now have 49 g left; how old is the sample?
- 62.8% left
- 0.67 half lives x 14.35 yrs
- 9.6 years
- A sample of Radon-222 is 9.4 days old. There are .27 g present, how much was originally present?
- 9.4/3.8 day/hl = 2.47 half lives
- 18% $.18 = .27/m_i$
- 1.5 g

Problems

- If you have 67 g of Tc-96, and you assume you started with 188 g, how old is the object?
- If you have an 160 minute old sample of No-259 and there are 2.5 g present, how much was there to start?

Problems

- If you have 67 g of Tc-96, and you assume you started with 188 g, how old is the object?
- 35.6% left
- 1.5 half lives x 4.28 days
- 6.4 days
- If you have an 160 minute old sample of No-259 and there are 2.5 g present, how much was there to start?
- 160/58 hl/min = 2.75 hl= 15%
- 17 g