

Introductory Astronomy

Week 3: Solar System(s)

Clip 2: It's Old

It's Old

- Oldest rocks on **Earth** are **4.4 billion years (Gy)** old.
- Oldest **Moon** Rocks are **4.4-4.5 Gy** old
- Oldest **meteorite** is **4.54 Gy**
- Best estimate: Solar system age **4.55-4.58 Gy**
- How do we know? **Radioactive dating**

Inside the Nucleus

- Atomic nucleus of atomic number Z and atomic mass A contains Z positive protons (Hydrogen nuclei, Rutherford 1917) and $A - Z$ neutral neutrons (Chadwick 1932)
- Nuclei with same Z but different A form chemically indistinguishable isotopes

Nuclear Decay

- Most combinations are **unstable** and decay via
 - α decay: emission of **Helium** nucleus $(Z, A) = (2, 4)$
 - β decay: emission of **electron** with conversion $n \rightarrow p$ or **positron** with conversion $p \rightarrow n$
 - **Fission**: breakup into two smaller nuclei
 - Accompanied in general by γ rays
- **Alchemy** achieved – but lead often **product**

Uses of Radioactivity

- Helium does not stick around. At temperatures in upper atmosphere
 $\langle \frac{mv^2}{2} \rangle = \frac{3}{2}kT$ means $v \sim v_{\text{escape}}$
Helium on Earth today is the product of α -decay
- Radioactive decay is a source of internal heat

Radiometric Dating

- Radioactive decay is random statistical process. Time in which **half** a sample decays is property of isotope – **half-life**

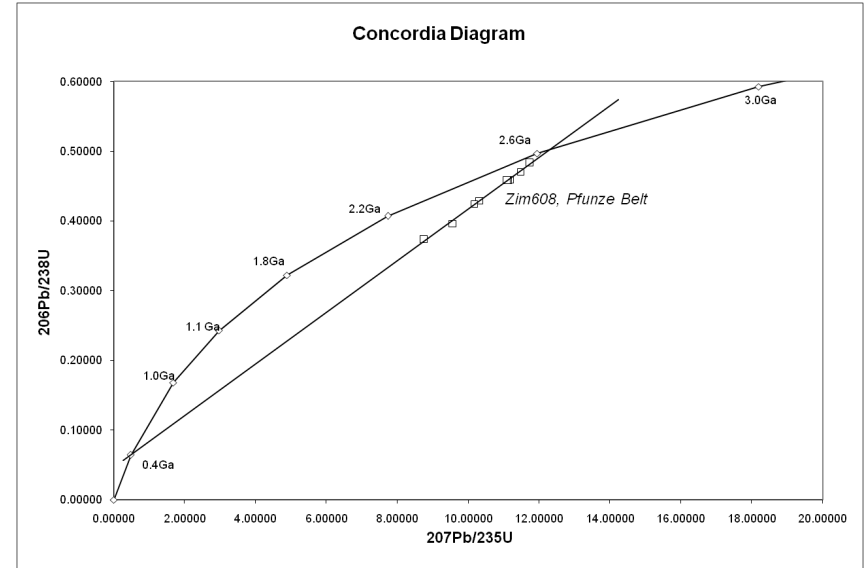
$$N(t) = 2^{-t/t_{1/2}} N(0)$$

- With time, **daughter** concentration increases while **parent** concentration decreases
- If we find a case where **daughter** escapes liquid magma but is **trapped** in solid rock, then

$$N_D/N_P(t) = 2^{t/t_{1/2}} - 1$$

Using the Method

- Zircon binds Uranium but not Lead
- Two isotopes of Uranium produce two isotopes of lead providing cross-check



Credits

- Concordia diagram, as used in U-Pb dating, with data from the Pfunze Belt, Zimbabwe. Diagram own work using data points from: Vinyu, M.L., Hanson, R.E., Martin, M.W., Bowring, S.A., Jelsma, H.A. and Dirks, P.H.G.M. 2001. U-Pb zircon ages from a craton-margin Archaean orogenic belt in northern Zimbabwe. Journal of African Earth Sciences, 32, 103-114.
[http://en.wikipedia.org/wiki/
File:Pfunze belt concordia.png](http://en.wikipedia.org/wiki/File:Pfunze_belt_concordia.png)