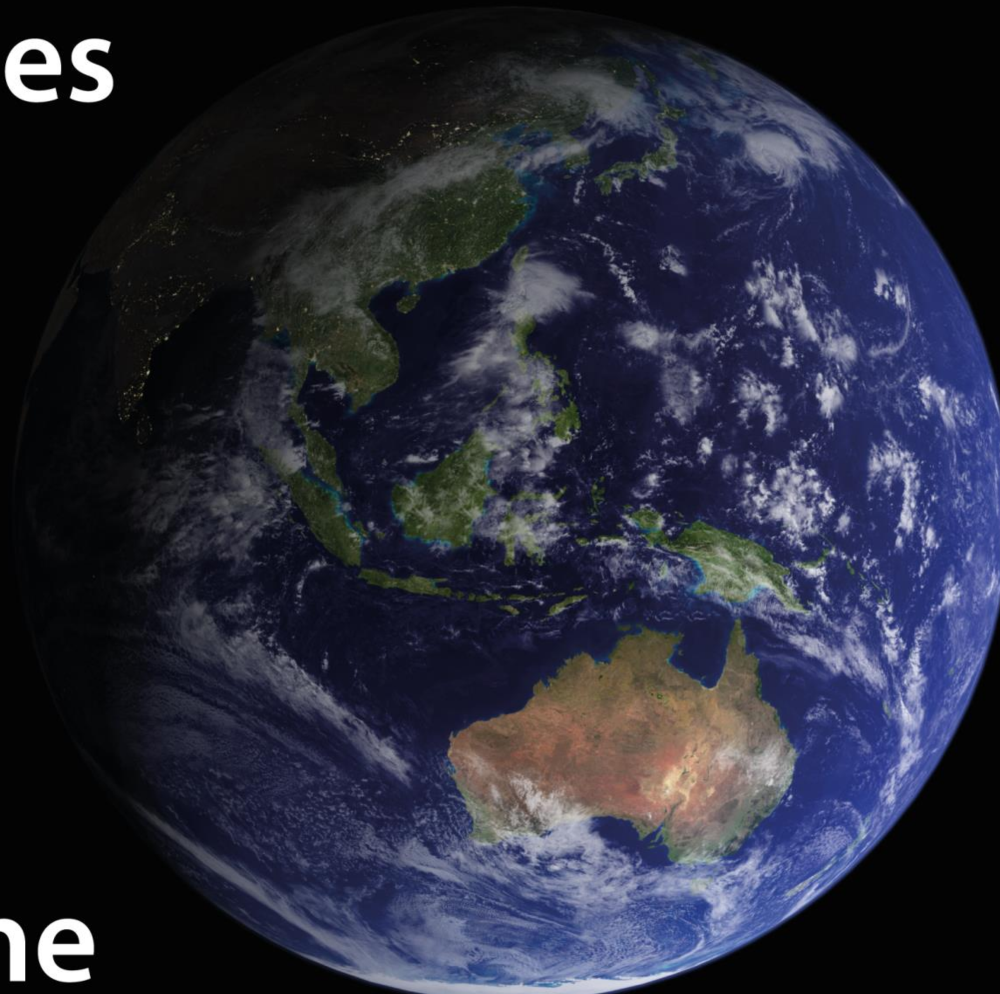
Geochronology: Understanding the uncertainties



Justin Payne

My opinion is for two viable options

1. The Earth is ca. 4.5 billion years old

2. The Earth is ca. 6000 years old and it was created in such a manner that the geological record provides evidence for the Earth being ca. 4.5 billion years old

Not a Flood "Geology" Scenario

Take-Home Message

A quick survey of criticisms

a) Different techniques don't always yield the same answer

b) Old techniques don't yield the same answers as new techniques

c) The 3 "assumptions"

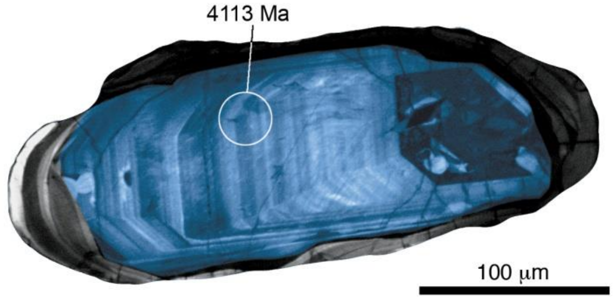
The first two are true, the 3 assumptions are largely mis-interpreted

Horses for courses

Different isotopic systems and different minerals will provide information on different processes and events, or even different temperatures within a single event

Part of geochron is choosing the right technique!

U-Pb Geochronology – Useful minerals

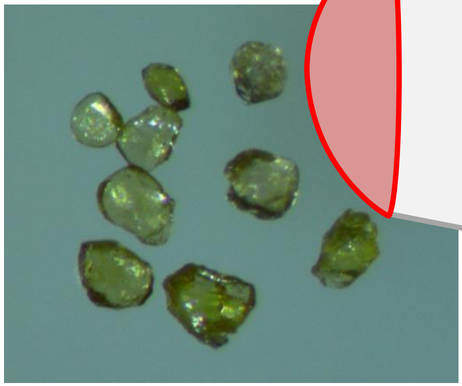


Zircon

Serc.carlton.edu

Rutile

S datlas.org



Monazite

+ Titanite, apatite, baddelyite

A quick survey of criticisms

a) Different techniques don’t always yield the same answer

b) Old techniques don’t yield the same answers as new techniques

c) The 3 “assumptions”

The first two are true, the 3 assumptions are largely mis-interpreted

Iterations and uncertainties

Geochronology, like almost all science and engineering pursuits, is an iterative process.

One of the key things the process focuses on is better understanding the uncertainties of a method and trying to improve them.

Sometimes the uncertainties are too large and we move on to a different technique altogether.

Uncertainty

The time of someone's birth

Iterative processes to improve uncertainty

The length of a piece of wood

A quick survey of criticisms

a) Different techniques don’t always yield the same answer

b) Old techniques don’t yield the same answers as new techniques

c) The 3 “assumptions”

The first two are true, the 3 assumptions are largely mis-interpreted

Flood Geology YECs are forced to assume that geochronology is incorrect

Geochronologists assume that it will be difficult to obtain the age of a geological event and fight against the limitations of equipment, techniques, geological systems and sample availability to try and give an accurate (within uncertainty) estimate of the true age of geological events

FG YEC list of "Assumptions" in geochron

1. That the decay rate has been constant throughout time.

2. That the isotope abundances in the specimen dated have not been altered during its history by addition or removal of either parent or daughter.

3. That when the rock formed it contained a known amount of daughter material.

Estimates based on the apparent cooling of the Earth from an initially molten state were formally of superior quality, but, as they necessarily failed to allow for the thermal effects of radioactive disintegration, then still undiscovered, they are now of little more than historical interest. The discovery of radioactivity led at once to the abandonment of these estimates, and after the pioneer work of Strutt (Lord Rayleigh) they

2. The total change since the formation of a suitable radioactive mineral or series of minerals of known geological age can be found from chemical analysis accompanied by atomic weight determinations on the separated mixture of lead isotopes. Here "suitability" means

(a) that the minerals have remained uncontaminated by external influences since the time of their crystallization, so that it can be assumed safely that no lead, uranium, or thorium or other lead-generating elements have been either removed from or introduced into the minerals; and

(b) that the minerals were either initially free from lead; or that if such lead were originally present, its proportion can be estimated from atomic weight determinations and so allowed for.

ences since the time of their crystallization, so that it can be assumed safely that no lead, uranium, or thorium or other lead-generating elements have been either removed from or introduced into the minerals; and

(b) that the minerals were either initially free from lead; or that if such lead were originally present, its proportion can be estimated from atomic weight determinations and so allowed for.

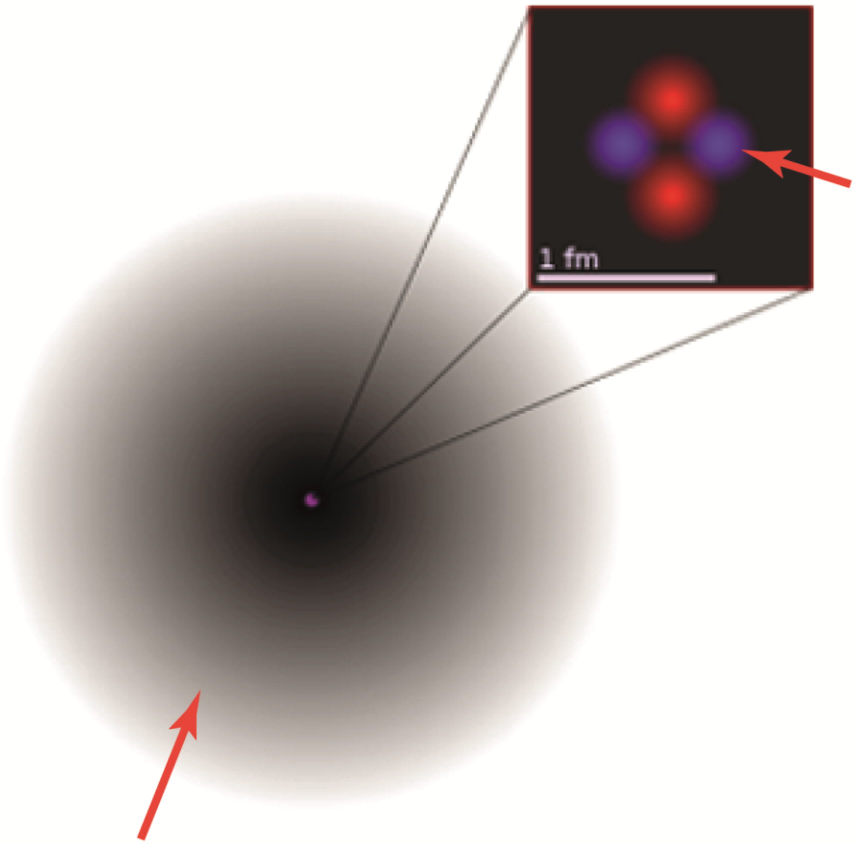
Holmes, A. (1931). Radioactivity and Geological Time, in Physics of the Earth IV – Age of the Earth (NRC)

The accumulation of helium in minerals is a process in which this second condition is never adequately fulfilled, since no mineral * is capable of retaining the whole supply of the helium that has been generated within it, more especially when it has been prepared for analysis. For this reason helium analysis in general gives only a minimum estimate of the age of a mineral.

3. The variation of the rate of radioactive generation of lead isotopes in the Earth during geological time is believed with ever-increasing confidence to be completely in accordance with the disintegration theory of Rutherford and Soddy, and to vary in no other way whatsoever. In the course of this chapter the nature of the evidence has been summarized which leads to the conclusion that there is nothing known in the terrestrial environment—including changes in space or time, temperature or pressure changes, chemical reactions, and bombardment by cosmic or radioactive radiations—that disturbs the normal rates of disintegration within the limits of experimental error (i. e., within about 1 per cent). The modern theory of the atom adequately accounts for this remarkable immunity.

Holmes, A. (1931). Radioactivity and Geological Time, in Physics of the Earth IV – Age of the Earth (NRC)

Basics of Radiometric Dating/Geochronology



Electron Cloud

public domain image

Atoms are:

Nucleus

Protons and Neutrons

Helium =

2 Protons + 2 Neutrons

Atomic Number: 2

Atomic Weight: 4

Basics of Radiometric Dating/Geochronology

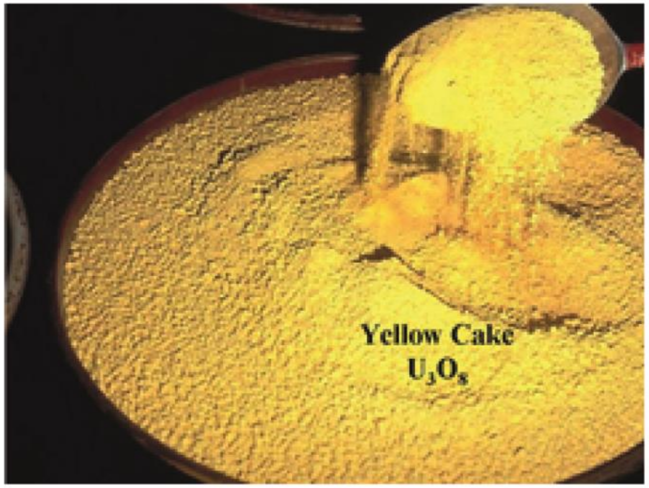
Atomic Number (z) defines the element

Atomic Weight defines the isotope

Uranium z=92

^{238}U has 146 neutrons

^{235}U has 143 neutrons



http://www.uraniumproducersamerica.com/

Basics of Radiometric Dating/Geochronology

Some elements and/or some isotopes are unstable and undergo radioactive decay

(Highly useful process - provides power, medical imaging and treatment and means the Earth is still alive!)

This decay occurs at a constant, predictable rate - represented by the half life.

Decay

Alpha (α) Decay - Helium nuclei

Speed on order of 15,000 km/s

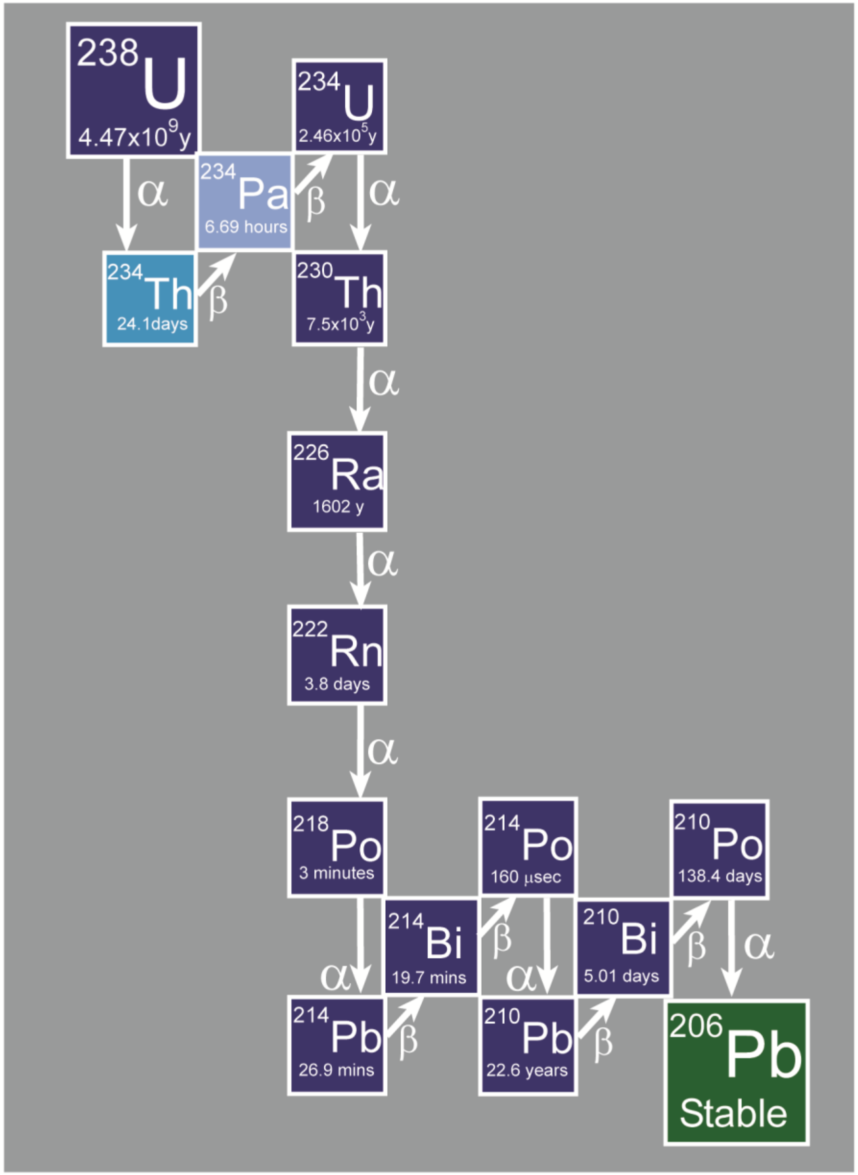
(stopped by paper, or few cm in air)

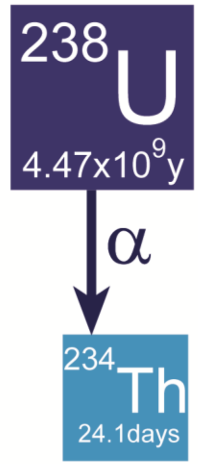
Beta (β) Decay - High speed electrons

(stopped by few mm of aluminium, or cm of flesh)

Plus gamma (γ) rays

The ^{238}U --> ^{206}Pb Decay scheme (with isotope half-lives)





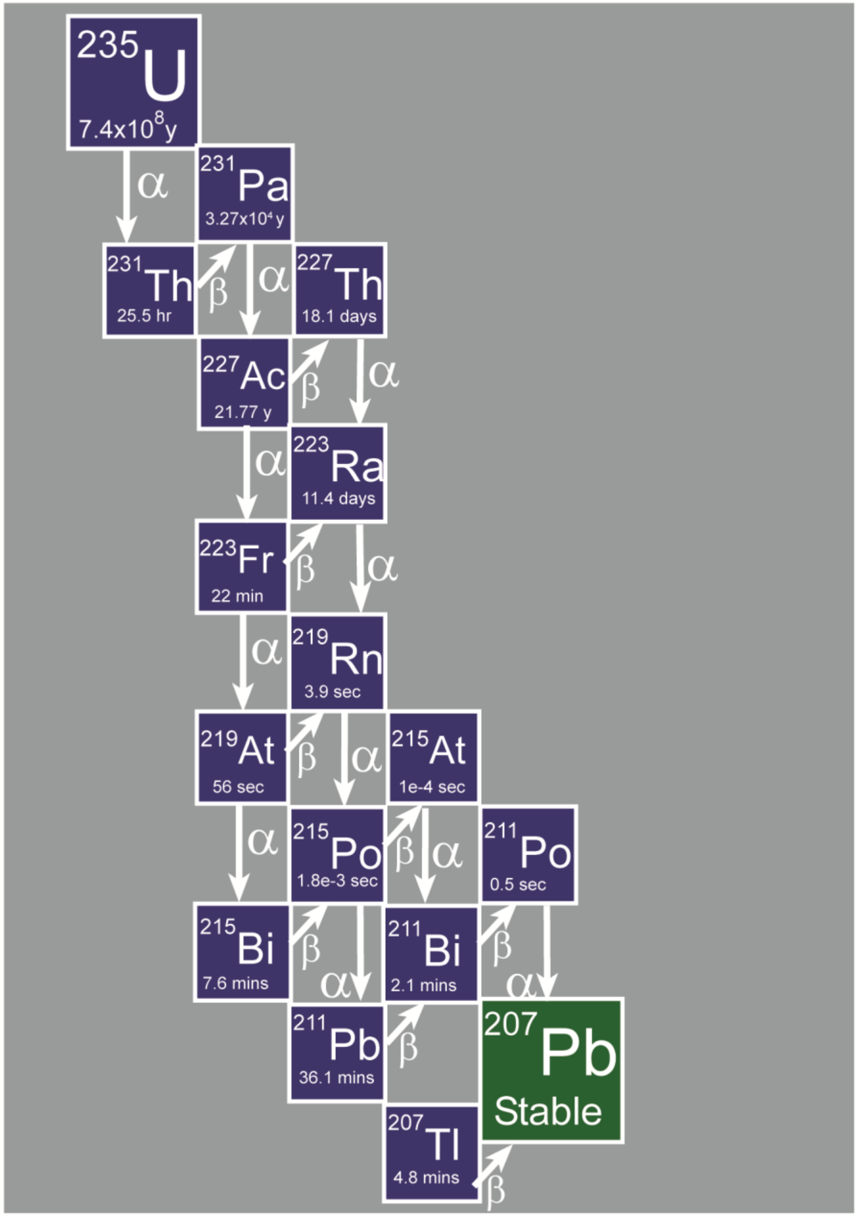
^{238}U decays to ^{234}Th by α-decay

$z = 92$

$\downarrow \alpha$

$z = 90$

weight drops 4



The ^{235}U --> ^{207}Pb Decay scheme (with isotope half-lives)

Two U isotopes going to two Pb isotopes

Half lives

^{235}U -> ^{207}Pb = 4.47 Byrs

^{235}U -> ^{207}Pb = 0.70 Byrs

U decay Schemes

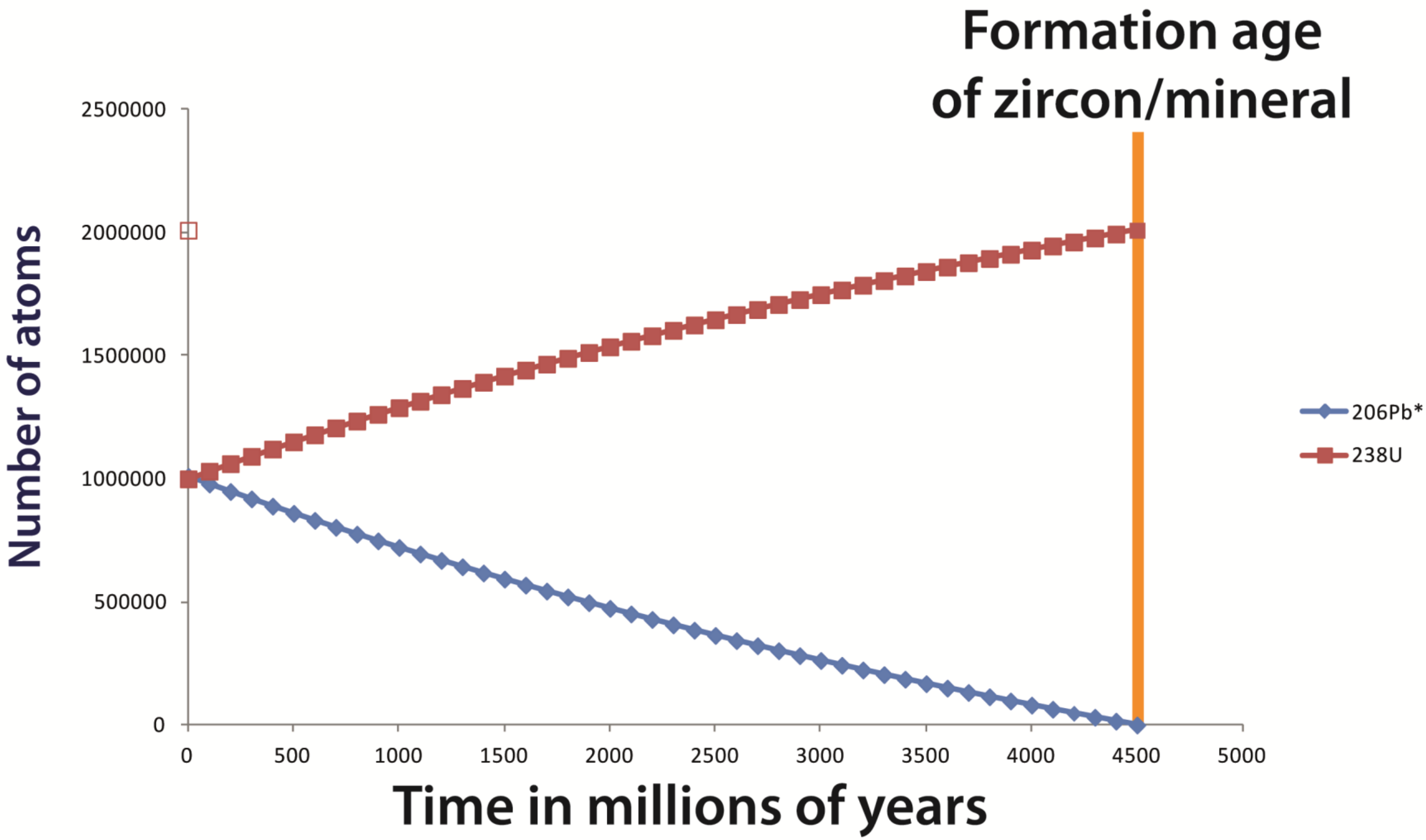
Exponential Decay Equation

The decay constant (e.g. $\lambda 238$) provides a measure of the rate of decay of the isotope (Inverse of the mean life of a U atom)

$\lambda 238 = 1.55125 \times 10^{-10}$

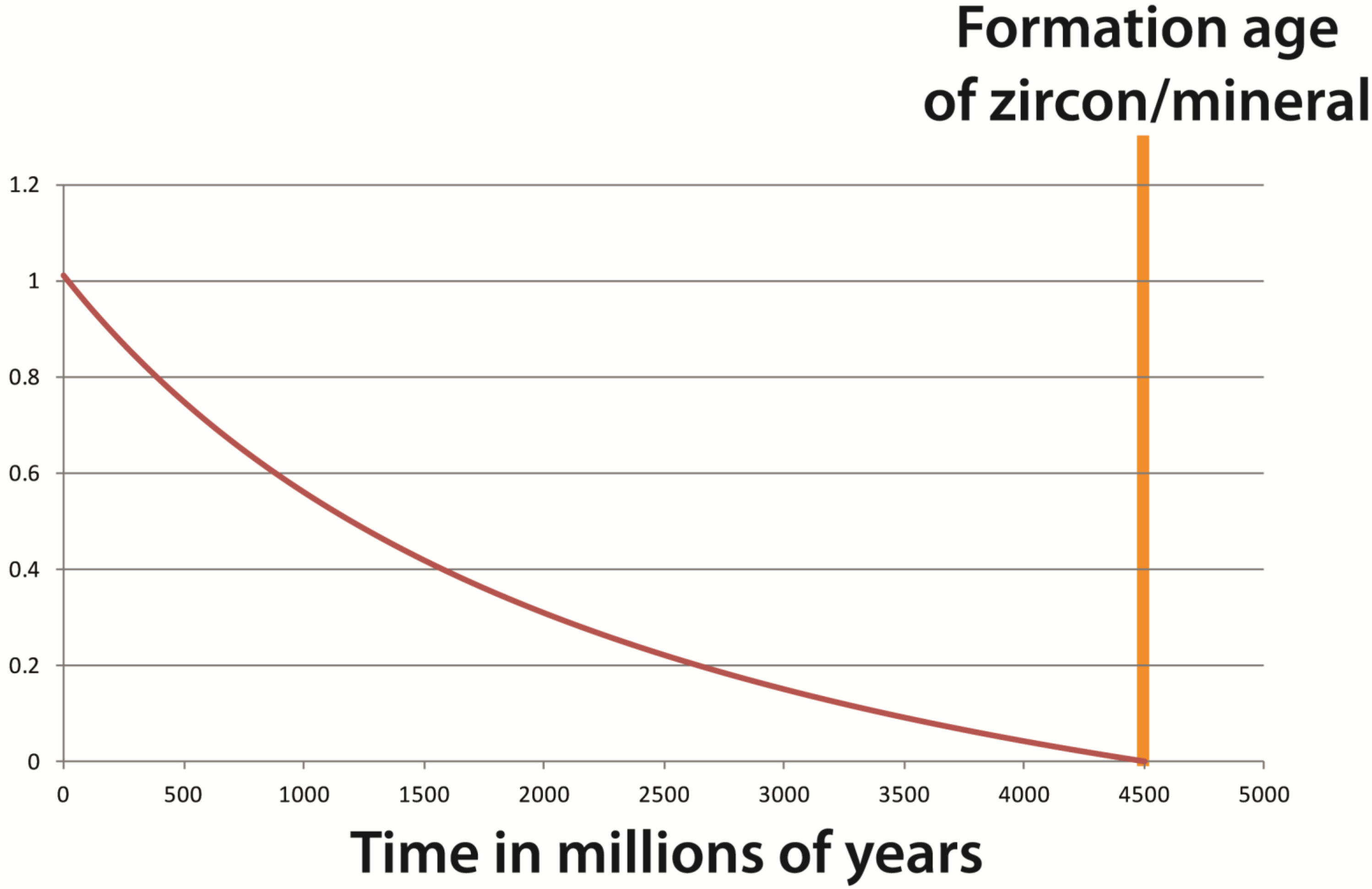
$$^{206}Pb^* = {}^{206}Pb_{initial} + {}^{238}U.(e^{\lambda 238 t}-1)$$

^{206}Pb produced from ^{238}U decay



Decay of Uranium

$^{206}Pb/^{238}U$ ratio over time



Measured ratios and their ages

Today, a measured $^{206}Pb/^{238}U$ ratio of:

0.001 is equal to an age of 6.44 million years (Ma)

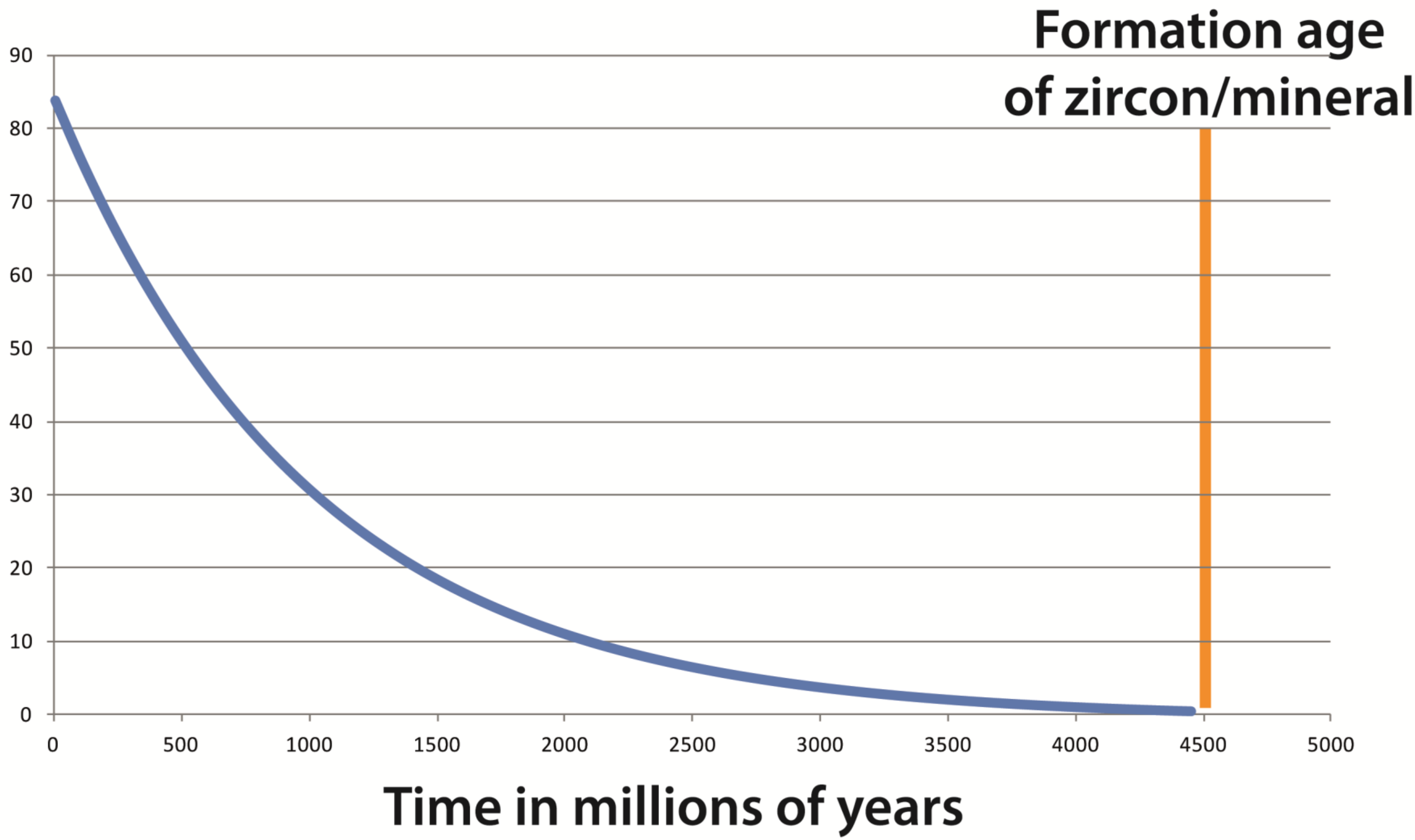
0.05 is equal to an age of 314.5 Ma

0.1 is equal to an age of 614.4 Ma

0.5 is equal to an age of 2613.8 Ma

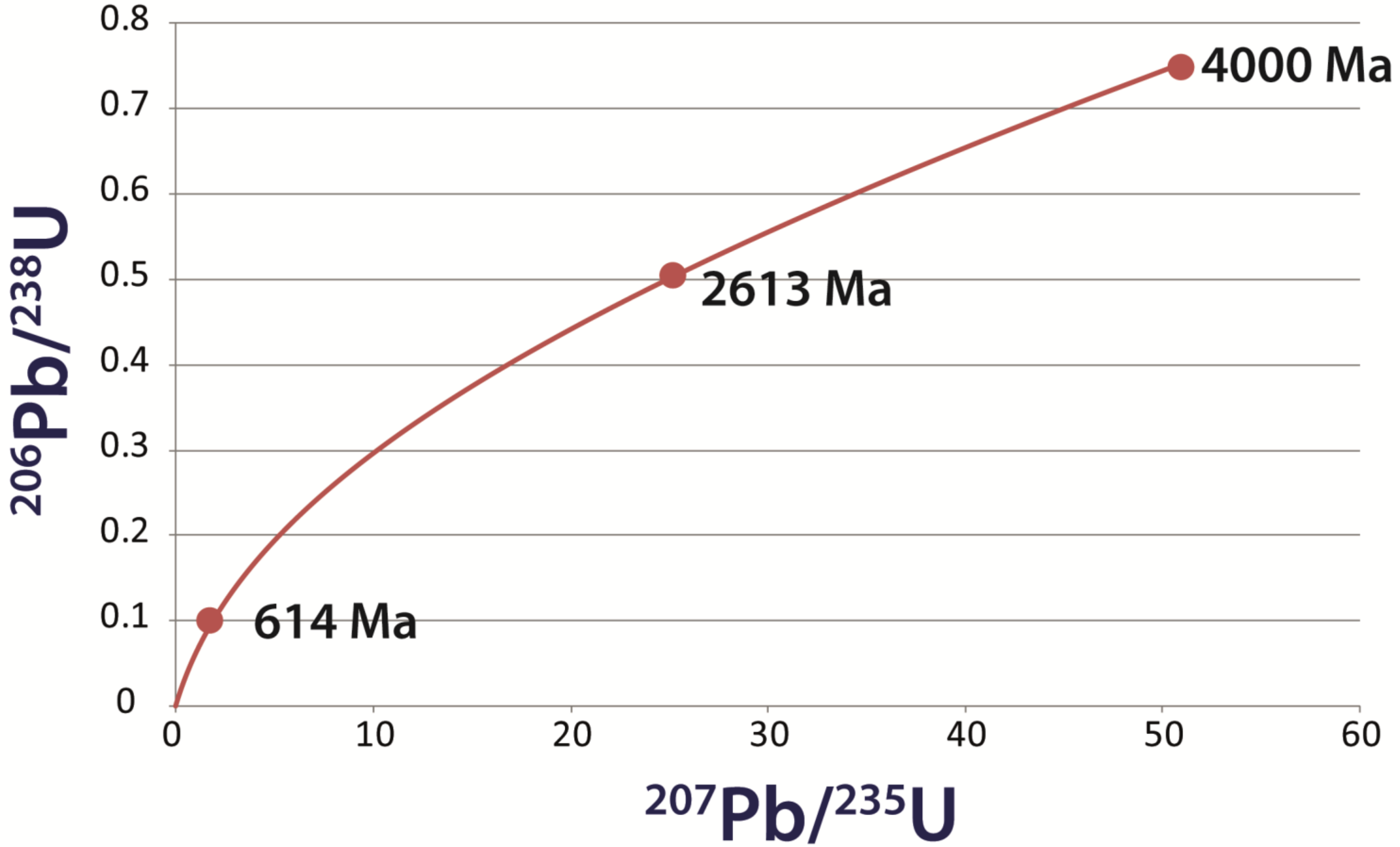
1 is equal to an age of 4468.3 Ma

$^{207}Pb/^{235}U$ ratio over time



Pb/U Isotope ratios

Concordant isotope ratios - equivalent



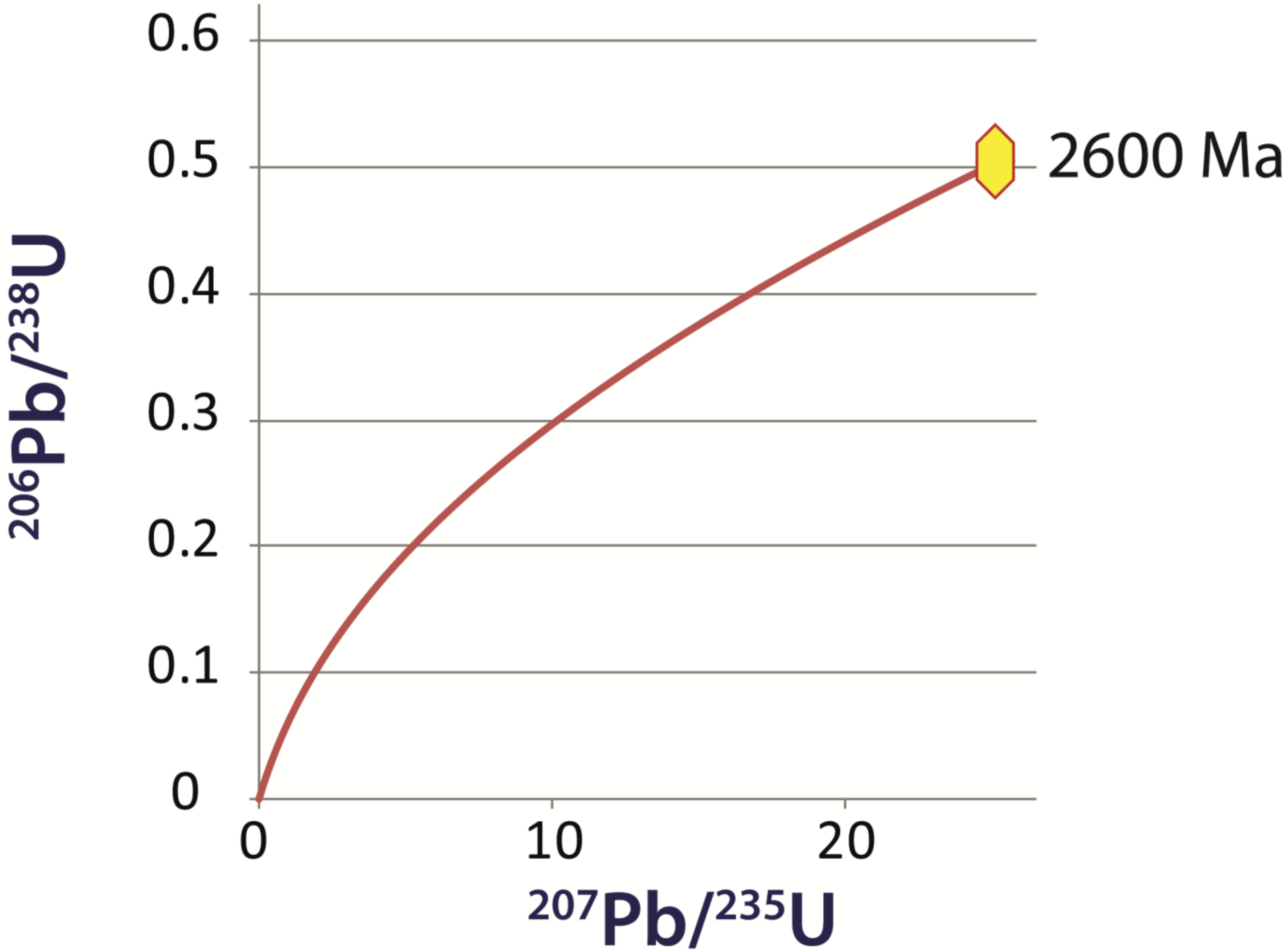
FG YEC list of “Assumptions” in geochron

1. That the decay rate has been constant throughout time.

2. That the isotope abundances in the specimen dated have not been altered during its history by addition or removal of either parent or daughter.

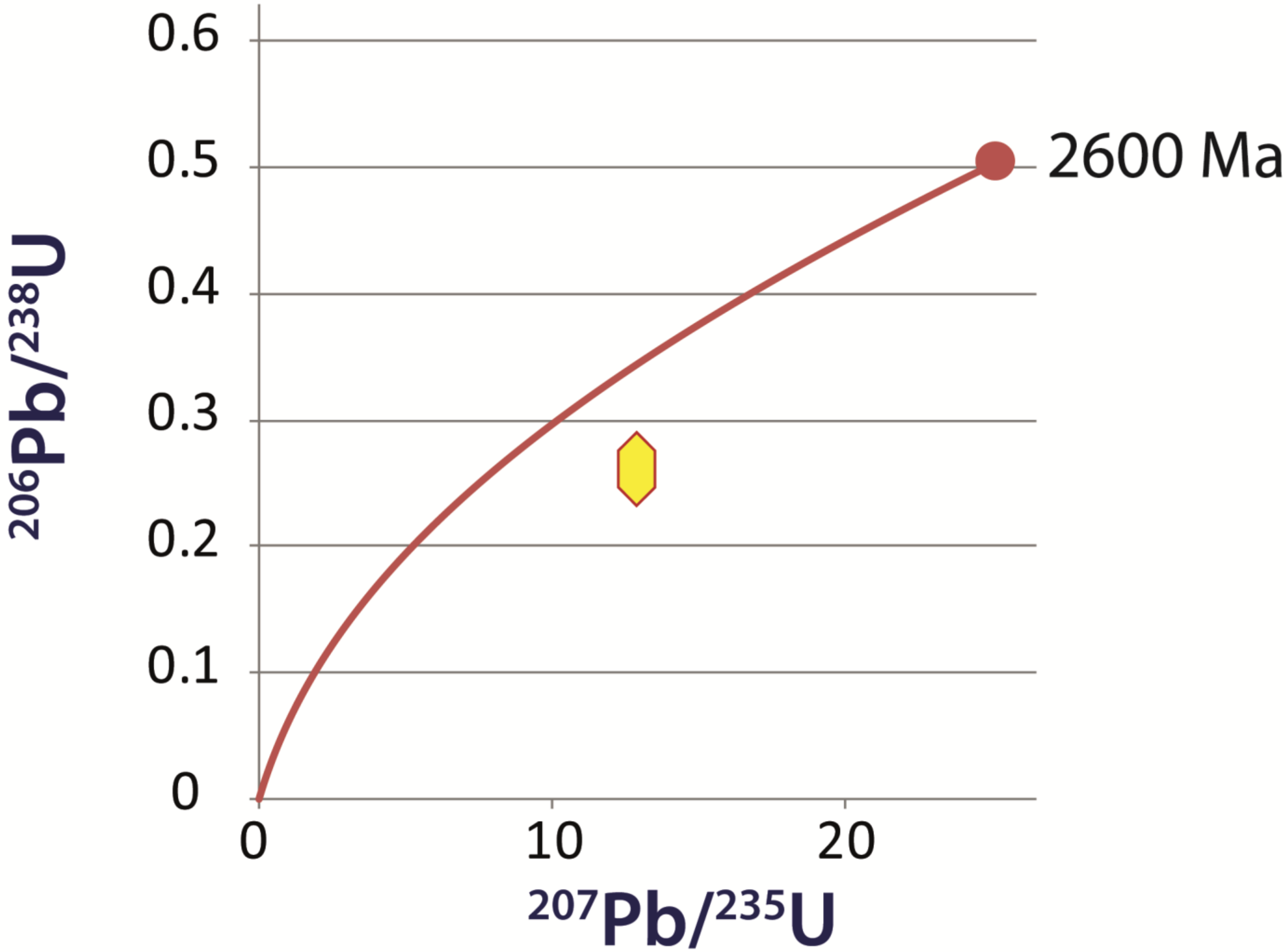
3. That when the rock formed it contained a known amount of daughter material.

Pb-loss - Discordant ages

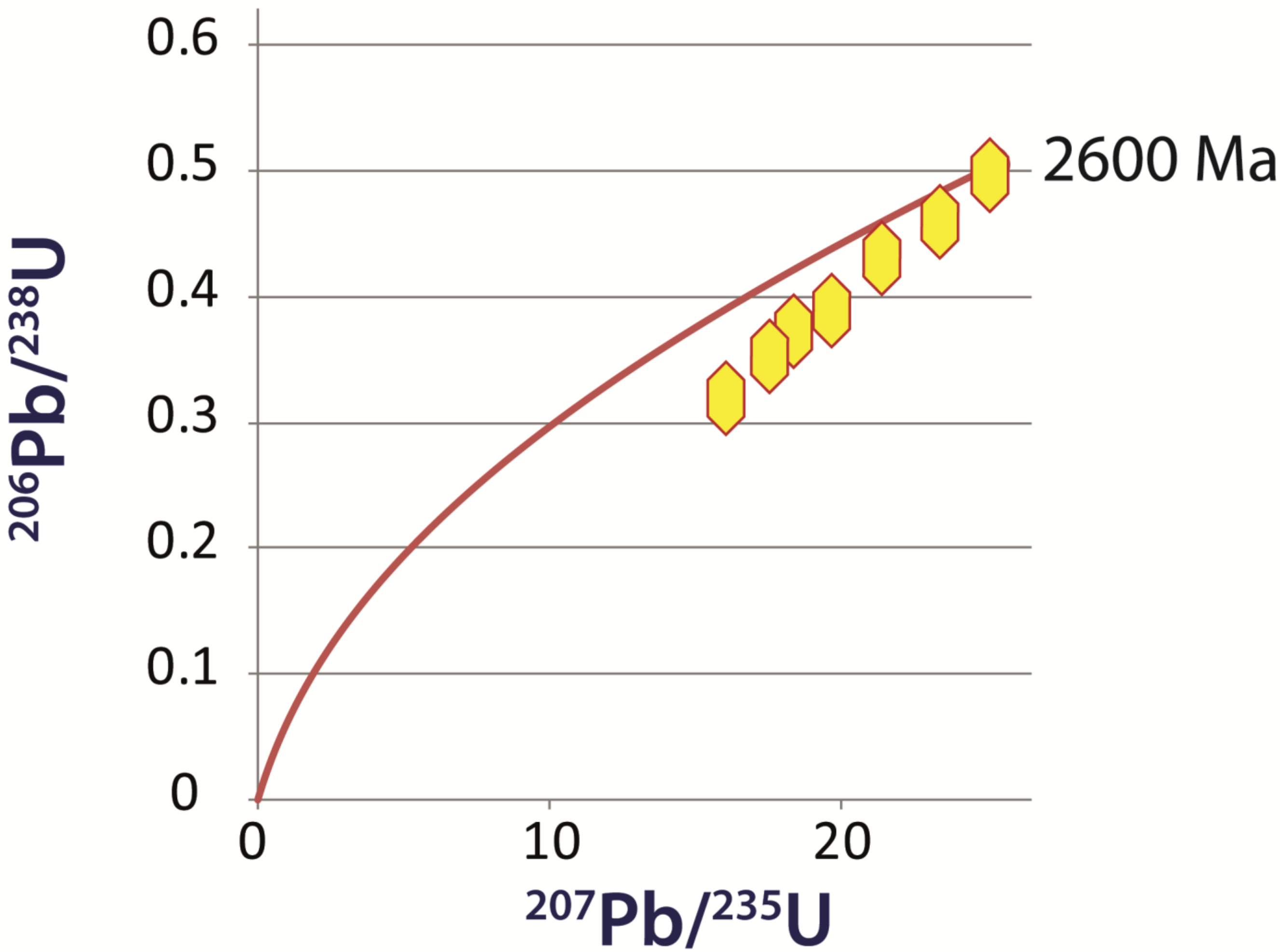


Pb/U Isotope ratios

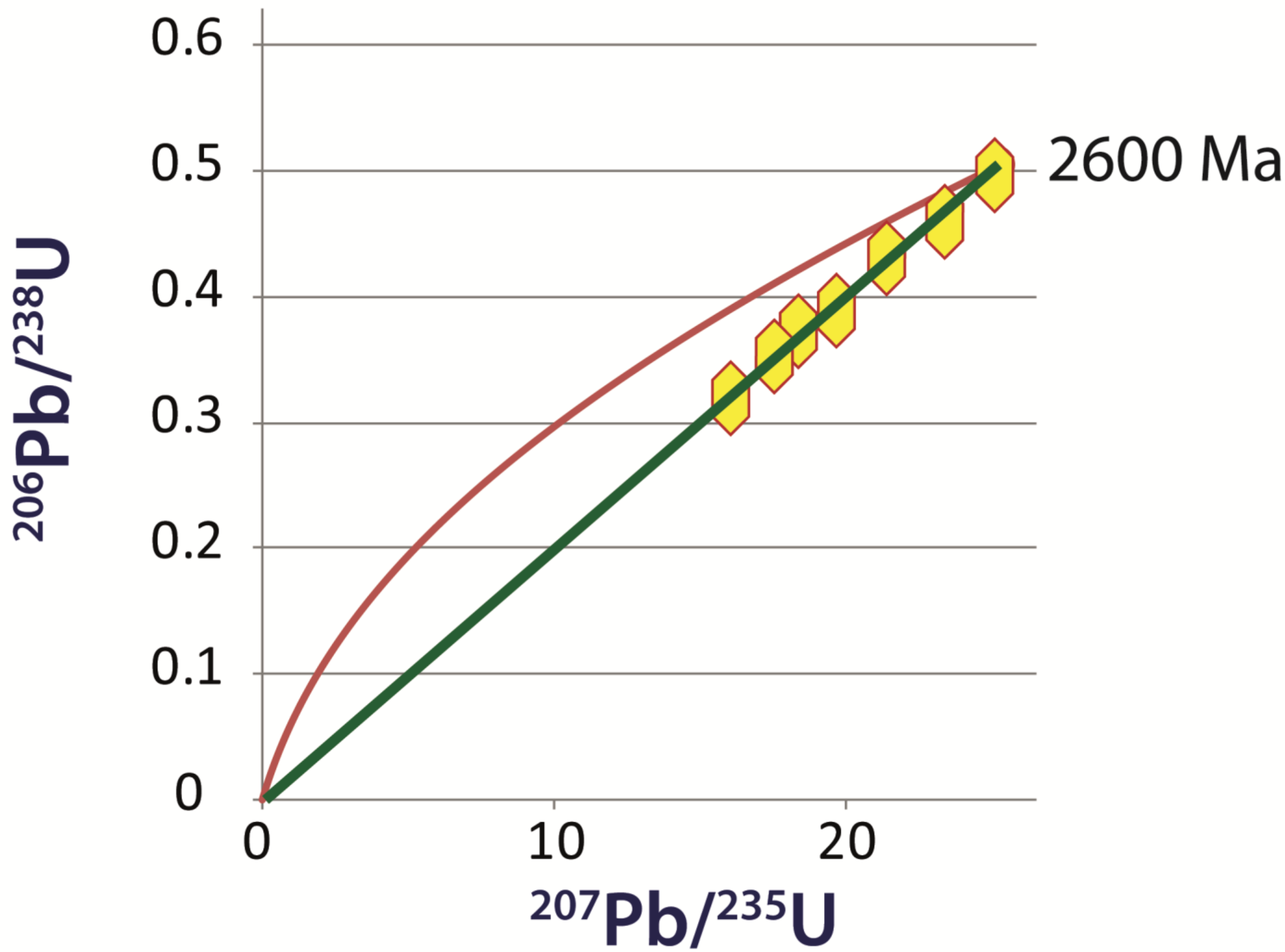
Pb-loss - Discordant ages



Pb-loss - Discordant ages

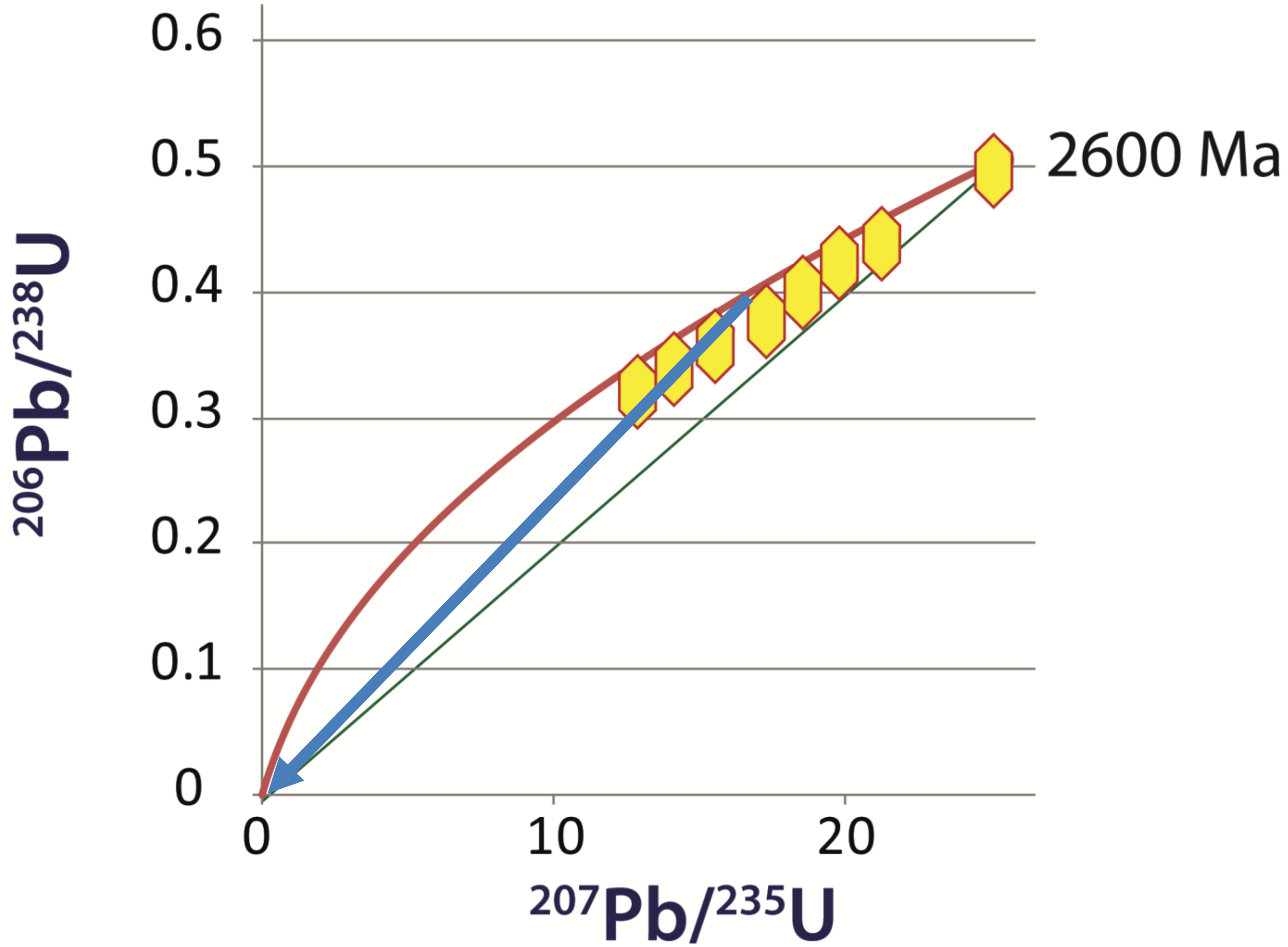


Pb-loss - Discordant ages

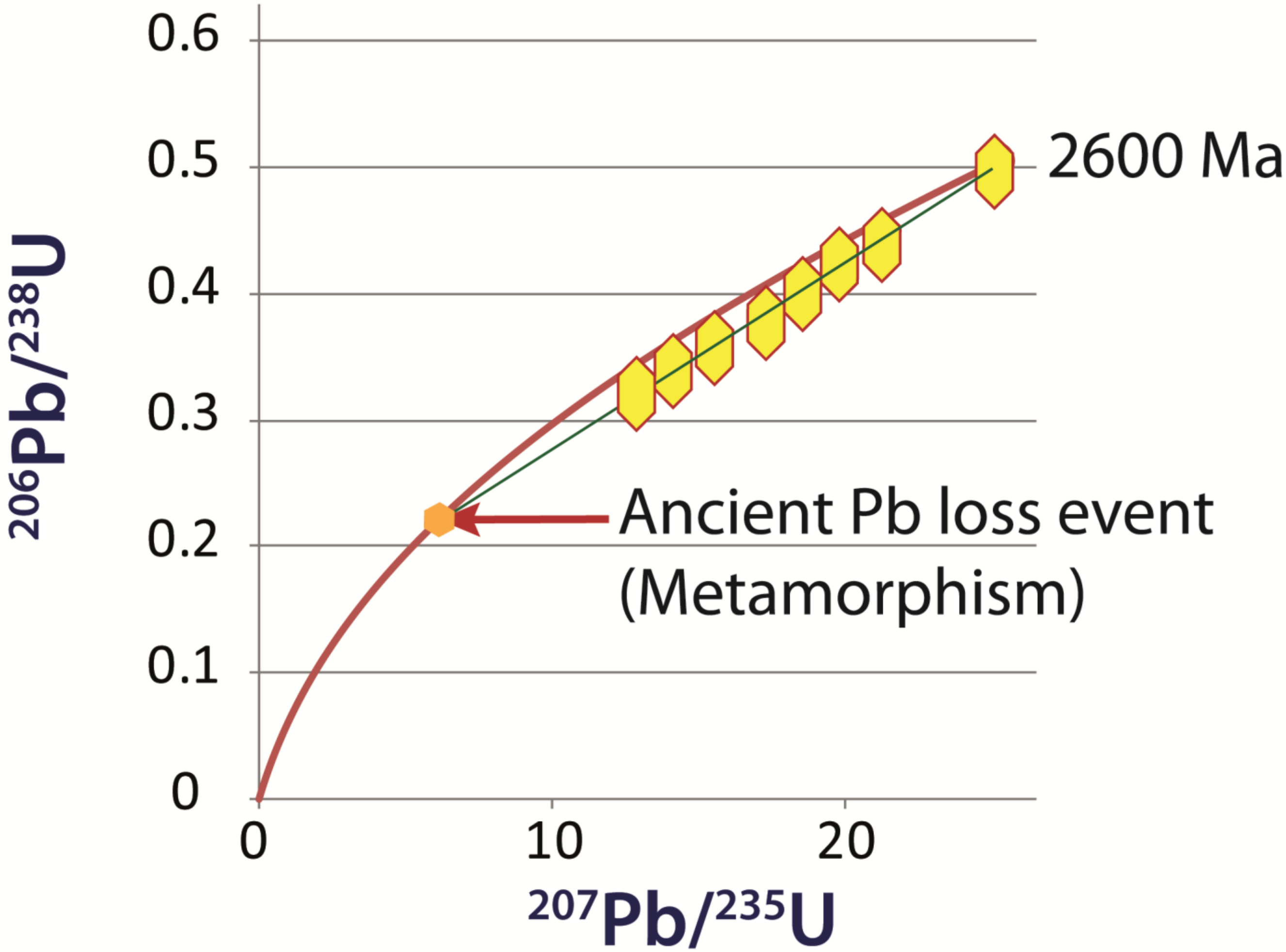


Pb/U Isotope ratios

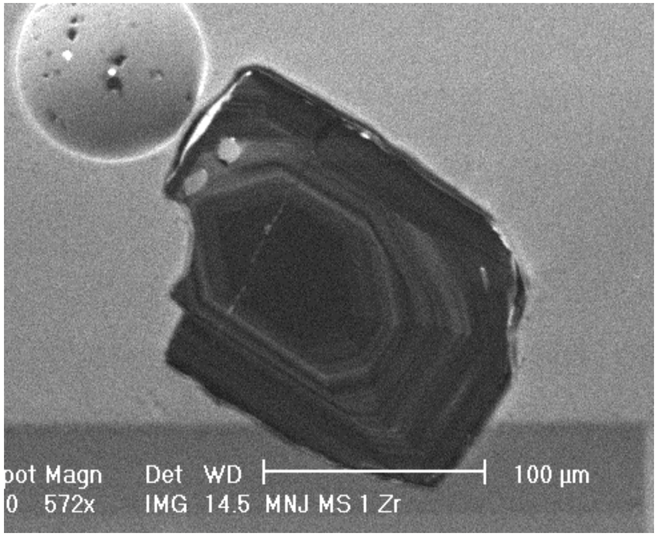
Pb-loss - Discordant ages

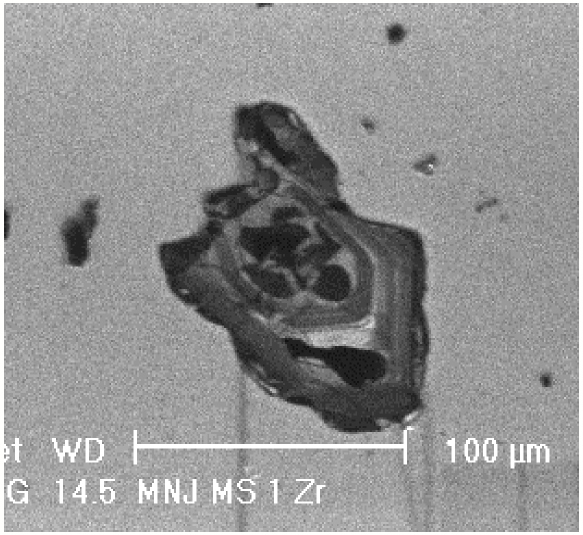


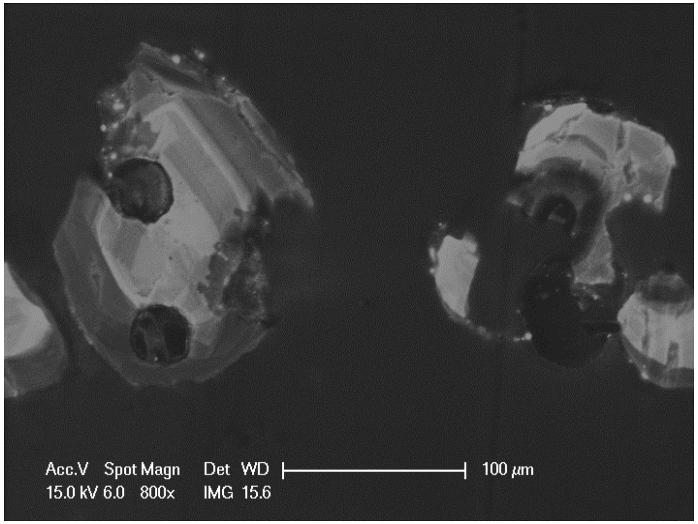
Pb-loss - Discordant ages



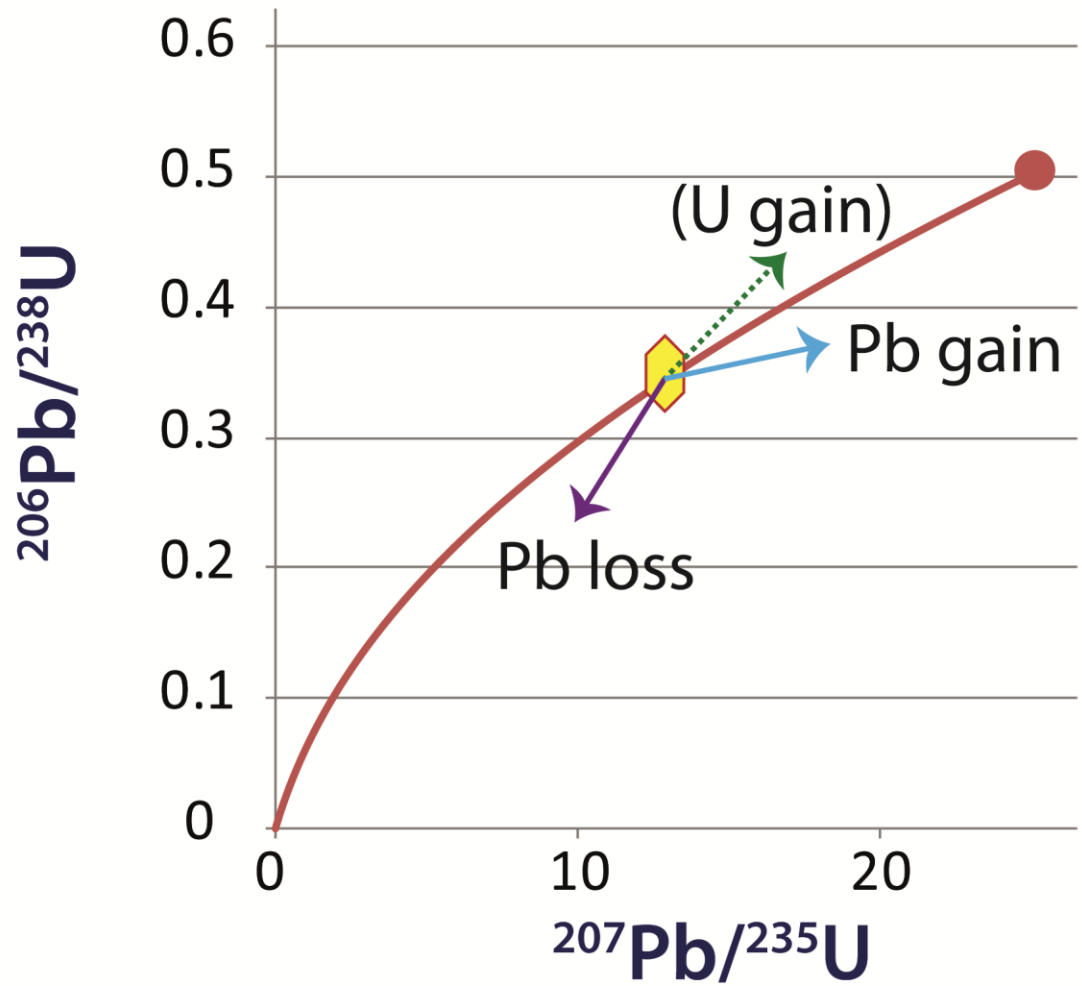
Pb/U Isotope ratios


pot Magn
0 572x
Det WD
IMG 14.5 MNJ MS 1 Zr
100 µm


et WD
G 14.5 MNJ MS 1 Zr
100 µm


Acc.V Spot Magn
15.0 kV 6.0 800x
Det WD
IMG 15.6
100 µm

Pb-loss - Discordant ages



Pb/U Isotope ratios

FG YEC list of "Assumptions" in geochron

1. That the decay rate has been constant throughout time.

2. That the isotope abundances in the specimen dated have not been altered during its history by addition or removal of either parent or daughter.

3. That when the rock formed it contained a known amount of daughter material.

Assumptions

Common Lead (Pb)

Pb has four isotopes

^{204}Pb

^{206}Pb and ^{207}Pb - Produced from U

^{208}Pb - Produced from Thorium (Th)

The composition of common Pb is changing

Known amount of daughter material

Common Lead (Pb)

The composition of common Pb is changing

TABLE 8

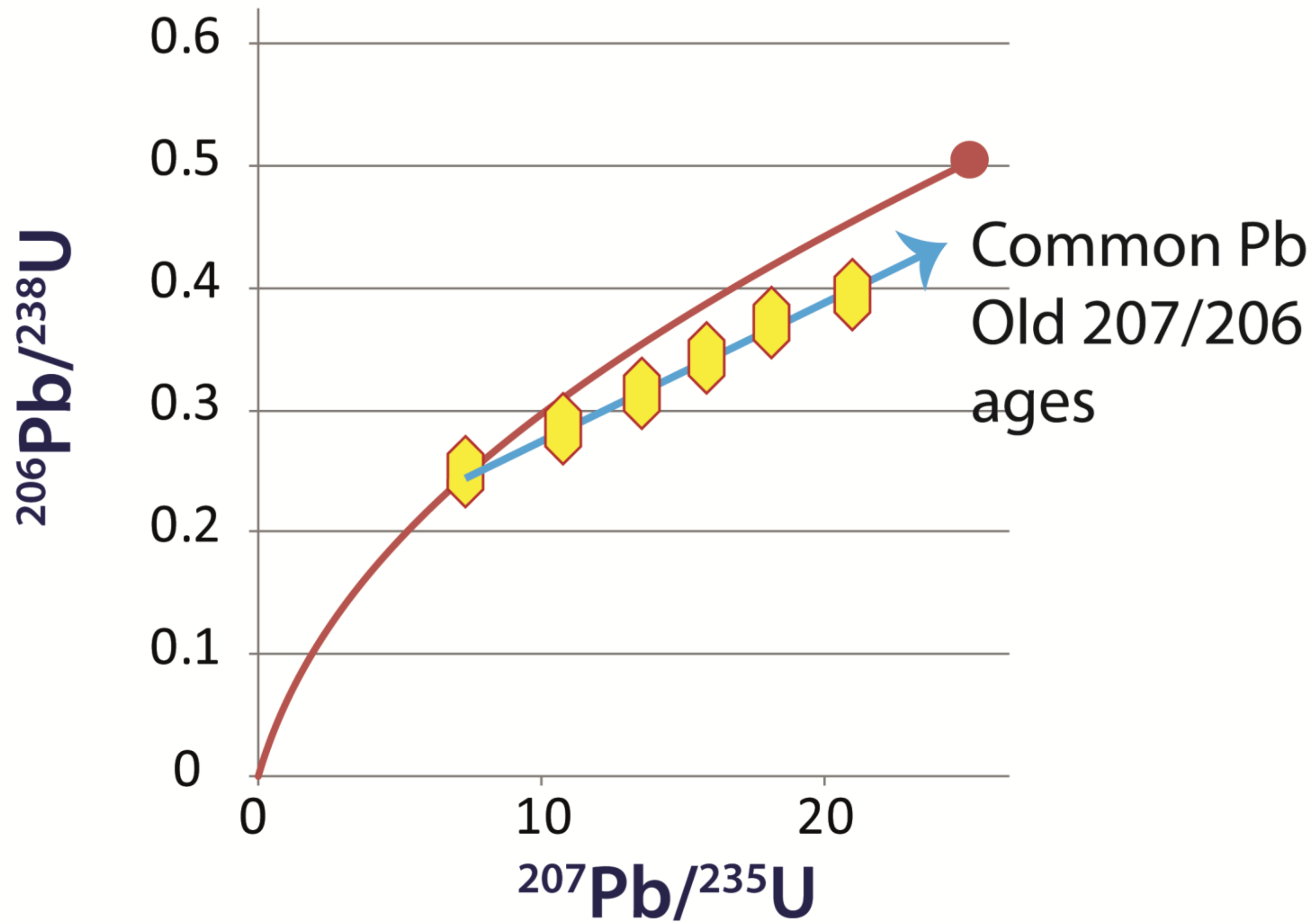
Two-stage model parameters for average active terrestrial lead

	Time (b.y.)	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	U/Pb	Th/Pb	Th/U
Start 1st stage	4.57	9.307	10.294	29.487	7.19	33.21	4.62
Start 2nd stage	3.70	11.152	12.998	31.23	9.74	36.84	3.78
Present day	0	18.700	15.628	38.63	9.74	36.84	3.78

Stacey and Kramers (1975)

Known amount of daughter material

Common Pb



0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
$^{206}Pb/^{238}U$
$^{207}Pb/^{235}U$
Common Pb
Old 207/206
ages

Common Lead (Pb)

We can tell that the cause of discordance in a suite of zircon analysis is incorporation of common Pb by the simple fact of measuring ^{204}Pb when we are measuring the other Pb and U isotopes

We can even correct for common Pb if it is there because we can determine the amount that was there and estimate it's composition (pretty accurately)

Known amount of daughter material

FG YEC list of “Assumptions” in geochron

1. That the decay rate has been constant throughout time.

2. ~~That the isotope abundances in the specimen dated have not been altered during its history by addition or removal of either parent or daughter.~~

3. ~~That when the rock formed it contained a known amount of daughter material.~~

Assumptions

Excerpt from Snelling - Fission Tracks in Zircons: Evidence for Abundant Nuclear Decay, Chapter 4 – RATE2 report

“11. Conclusions

The observed fission track densities measured in zircons from
samples of Cambrian, Jurassic, and Miocene tuffs in the Grand Canyon-Colorado Plateau region were found to exactly equate to the quantities of nuclear decay measured by radioisotope age determinations of these same rocks. . . .”

“Given the evidence in that strata sequence of catastrophic deposition and independent evidence that most of this strata sequence was deposited during the year-long global catastrophic Biblical Flood only 4500 years ago, then 500 million or more years worth (at today’s rates) of nuclear and radioisotope decay had to have occurred during the Flood year only 4500 or so years ago. Thus, this nuclear and radioisotope decay had to have occurred at accelerated rates, and the fission tracks in the zircons in the tuffs within that strata sequence are physical evidence of that accelerated nuclear decay.”

The Age of Mt Ararat – in the bible Noah landed on the mountains of Ararat

A quick internet search –
Mt Ararat is a stratovolcano – basalt flows are 1.5 Ma
Mountains in the region are on the order of < 20 Ma

Assuming accelerated decay – 500 Ma in 1 year

Mt Ararat is 1.09 days old to 14.6 days

This still can’t account for rocks that are 3000 Ma or older

My opinion is for two viable options

1. The Earth is ca. 4.5 billion years old

2. The Earth is ca. 6000 years old and it was created in such a manner that the geological record provides evidence for the Earth being ca. 4.5 billion years old

Not a Flood "Geology" Scenario

Take-Home Message