How Old Is the Earth? and how do we know?

Methods for the identification of strata (stratigraphy) came from religiously orthodox individuals such as Niels Stensen (“Steno”).

There is no assumption of evolution in either stratigraphy or methods for aging strata.

- These require merely the application of known physical and chemical processes

Remember

Dating methods prior to 1900

- Biblical
- Cooling of the Earth (Thermodynamic)
- Orbital dynamics (George Darwin)
- Ocean chemistry
- Erosion and sedimentation
Biblical Estimates of Age

- Theophilus – 7,519
- Eusebius – 7,167
- St. Basil – 5,994
- St Augustine – 6,321
- Alphonso X – 8,952
- Lightfoot – 5918

Ussher’s 1650 estimate of 4004BCE

Edward Halley
1656–1742

- Proposed that the age of the Earth could be estimated from the salt content of the ocean (1715).
- The experiment “is chiefly intended to refute the ancient notion, some have of late entertained, of the eternity of all things; though perhaps by it the world may be found much older than many have hitherto imagined.”

John Joly
1857 – 1933

“The quantity of sodium now in the sea, and the annual rate of its supply by the rivers, lead, it will be seen, to the deduction that the age of the Earth is 99 million years.” (1899)

By 1909 he had revised his estimate to 150 million years.
### Modern Oceanic “Clock” Results

<table>
<thead>
<tr>
<th>Element</th>
<th>Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>68,000,000</td>
</tr>
<tr>
<td>Mg</td>
<td>45,000,000</td>
</tr>
<tr>
<td>Li</td>
<td>20,000,000</td>
</tr>
<tr>
<td>Sr</td>
<td>18,000,000</td>
</tr>
<tr>
<td>K</td>
<td>11,000,000</td>
</tr>
<tr>
<td>Ag</td>
<td>2,100,000</td>
</tr>
<tr>
<td>Au</td>
<td>560,000</td>
</tr>
<tr>
<td>Mo</td>
<td>500,000</td>
</tr>
<tr>
<td>Sb</td>
<td>350,000</td>
</tr>
<tr>
<td>Rb</td>
<td>270,000</td>
</tr>
<tr>
<td>Zn</td>
<td>180,000</td>
</tr>
<tr>
<td>Sn</td>
<td>100,000</td>
</tr>
<tr>
<td>Ba</td>
<td>84,000</td>
</tr>
</tbody>
</table>

### Problems with the salt clock

1. Assumption of constant rate of influx across geologic time known to be wrong.

2. Poorly estimated parameters: rates of erosion and solution, rainfall, runoff, continental area, average exposed rock composition over time.

3. Ignores movement of elements out of oceans, movement which occurs at approximately the same rate as influx. Therefore confuses residence time with accumulation time.

### Georges–Louis Leclerc

**Compte de Buffon, (1707 – 1788)**

- Examined cooling of metal spheres of various diameters
- Estimated 96,670 years for Earth to cool to current temperature.
- Privately believed 3 billion years.

### William Thomson

**Lord Kelvin, 1824 – 1907**

- Kelvin scale (1848)
- Second Law of Thermodynamics (1851)
- Thermodynamic argument that the age of the Earth was 24 million years.
Assumption: The earth is a warm, chemically inert planet that is cooling.

Assumption: It can be modeled as an infinite plane of infinite thickness.

Assumption: Heat loss is through conduction from the center.

T.C. Chamberlain, 1899

“The fascinating impressiveness of rigorous mathematical analyses, within its atmosphere of precision and elegance, should not blind us to the defects of the premises that condition the whole process. There is perhaps no beguilement more insidious and dangerous than an elaborate and elegant mathematical process built upon unfortified premises.”

So, by 1900 ...

- **Theologians** had rejected a literal reading of the Bible and the implied young age of the earth.

- **Physicists** seemed to be limiting the age of the Earth to *circa* 25 million years.

- For **biologists**, this wasn’t a problem as they generally didn’t subscribe to an evolutionary process that required long periods of time and instead allowed for directed evolution.

- This was, however, a problem for the **geologists** who felt that long periods of time were needed for formation of the Earth as we see it today.

Problems with Kelvin’s method

1. **Parameters** are poorly known (conductivity of rocks; thermal gradient; initial temperature of the Earth; heat released upon crystallization; exact composition and structure of the Earth).

2. Considers conduction but not **convection**, when the latter is a more important source of heat loss.

3. Ignores other **sources** of heat:

   a. Heat left over from the formation of the Earth, e.g. gravitational energy from compaction, mechanical energy from meteor impacts, chemical energy from the formation of the Fe-Ni core.
   
   b. Energy from contraction due to cooling
   
   c. Energy from ongoing core expansion
   
   d. Radioactivity
T.C. Chamberlain, 1899

“What the internal constitution of the atoms may be is yet an open question. It is not improbable that they are complex organizations and the seats of enormous energies.”

Radiometric dating
How the geologists used physics to show the physicists that they were wrong.
The helium observed in the radioactive minerals is almost certainly due to its production from the radium and other radioactive substances contained therein. If the rate of production of helium from known weights of the different radioelements were experimentally known, it should thus be possible to determine the interval required for the production of the amount of helium observed in radioactive minerals, or, in other words, to determine the age of the mineral.

**Basic Radiometric Age Equation**

\[ t = -\frac{1}{\lambda} \ln \left(1 + \frac{D}{P}\right) \]

where \( t \) is the age of the rock or mineral specimen, 
\( D \) is the number of atoms of a daughter product today, 
\( P \) is the number of atoms of the parent isotope today, 
\( \ln \) is the natural logarithm (logarithm to base e), and 
\( \lambda \) is the appropriate decay constant.

(The decay constant for each parent isotope is related to its half-life, 
\( t_{1/2} \) by the following expression: 
\( t_{1/2} = \frac{\ln 2}{\lambda} \))

**Ernest Rutherford, 1906**

"The helium observed in the radioactive minerals is almost certainly due to its production from the radium and other radioactive substances contained therein. If the rate of production of helium from known weights of the different radioelements were experimentally known, it should thus be possible to determine the interval required for the production of the amount of helium observed in radioactive minerals, or, in other words, to determine the age of the mineral."
The association of lead with uranium in rock-minerals and its application to the measurement of geological time." *Transactions of the Royal Society* (1911)

“One of the greatest pieces of geological literature ever published.” (Peter Wyse Jackson, 2007)

Assuming a closed system

(c) That no appreciable amount of lead was present when the mineral was formed.

(d) That no lead has originated by any other radioactive process than that suggested.

(e) That no lead nor uranium has subsequently been added or removed by external agencies.

Scott Huse (1997)

“Dates obtained from these techniques are merely circumstantial and are necessarily based on numerous assumptions, which may or may not be true ... none of these assumptions are found to be valid!” [p 65]
Type of Rock and Dating

- **Metamorphic** – Unsuitable as rocks of this type form with incomplete melting (usually)
- **Sedimentary** – Unsuitable as these are composed to debris of older rocks.
- **Igneous** – Useable if they haven’t been significantly heated since formation. Can test for this using various methods.

Choose your isotope(s)

<table>
<thead>
<tr>
<th>Isotope Techniques</th>
<th>Year age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radioisotope dating</td>
<td>100 to 1,000,000,000,000 years</td>
</tr>
<tr>
<td>Potassium-argon dating</td>
<td>100,000 to 100,000,000,000 years</td>
</tr>
<tr>
<td>U-Th series dating</td>
<td>100,000 to 1,000,000,000,000 years</td>
</tr>
<tr>
<td>Other Techniques</td>
<td>10,000 to 1,000,000,000,000 years</td>
</tr>
</tbody>
</table>

Types of decay
An age–diagnostic diagram

- Isochrons
  - Rb–Sr, K–Ar
- Argon Spectrum
  - $^{40}$Ar–$^{39}$Ar
- Concordia and Discordia
  - U–Pb

Collectively these allow:

- Estimate of the amount of daughter initially present
- Examination of whether the system was closed
- Determination of whether dating is even possible
The \(^{40}\text{Ar}/^{39}\text{Ar}\) Spectrum

Initial \(^{40}\text{Ar} = 1.76 \pm 0.27 \times 10^8\) mole / gram

Equation of isochron: \(^{40}\text{Ar} = 0.0347 \times ^{40}\text{K} + 1.76 \times 10^9\)
Holmes’ Closed System

- Daughter leakage would yield younger ages than the correct one.
- Parent leakage – which would give older ages – does not occur in the types of rock used.
- Known (and detectable) effects of weathering and thermal stress.

The RATE Project

Radioisotopes and the Age of The Earth

Institute for Creation Research
Creation Research Society
Answers in Genesis
Andrew Snelling

- Ph.D. in Geology (1982); Worked as mining geologist until 1983 and as consultant thereafter.
- Lecturer with Answers in Genesis (Editor of Creation Ex Nihilo)
- Associate Professor of Geology at the Institute for Creation Research
- Developed much of their approach to radiometric dating

Snelling’s Scientific Publications 1982 – 1987


Andrew Snelling

“Creationist geologists need to completely abandon the evolutionist's geological column and associated terminology. It is necessary to start again, using the presence of fossils or organic matter as a classification criterion in the task of rebuilding our understanding of geological history within the Biblical framework.” (1983)

Snelling’s Impact(s) since 1999

2. The rapid ascent of basalt magmas (2007)
7. Polonium Radiohalos: The Model for Their Formation Tested and Verified (2005)
Assumption #1
The amount of parent and daughter isotopes have not been altered by anything except radioactive decay.

Assumption #2
When the rock was formed, it contained a known amount of the daughter isotopes, in many cases, believed to be zero.

Assumption #3
The decay rate has been constant throughout history.

Nuclear decay appears to have been accelerated at different periods during earth's history.
The radioactive decay rates of nuclides used in radiometric dating have not been observed to vary since their rates were directly measurable, at least within limits of accuracy. This is despite experiments that attempt to change decay rates. Only a single variation in decay rate has been reproduced (that of $^7\text{Be}$) and that was a variation of only 0.18%, not enough to alter any clock (if there was one using $^7\text{Be}$). There is insufficient energy in geological processes to affect the decay rate. The half-lives of radioisotopes can be predicted from first principles through quantum mechanics. Any variation would have to come from changes to fundamental constants.

Decay rates are experimentally observed and are constant. Not all rocks can be dated but those that can provide "brackets." We can check for enrichment, leakage and thermal stress.
**Oldest Rock Outcappings**

- **Greenland / Canada**
  - 3.85 billion years
  - Gneisses (metamorphic)

**How Old Is The Earth?**

- Oldest rocks
  - 3.85 billion years
- Oldest mineral
  - Zirconium silicate $\text{ZrSiO}_4$
  - Contains Thorium & Uranium and thus can estimate *age of crystallization*
  - 4.40 billion years
- Oldest meteorite
  - 4.55 billion years

**Meteorites (extraterrestrial)**
Is there a positive case for a young Earth?
Henry Morris (1974)

68 methods presented

5 give age of zero (~7%)
5 give age under 500 years (~7%)
9 give age under 5,000 years (~13%)
7 give age between 8 and 15,000 years (~10%)
Rest give older (~63%) with median of 1,000,000

Note: “... based on standard assumptions of (1) zero initial ‘daughter’ component; (2) closed systems; (3) uniform rate”

Some YECs claim ...

- Magnetic field is decreasing over time
- Would have a enormous value approximately 10,000 years ago
- Therefore, this is the maximum age of the Earth
“If we went back about 10 thousand years, the Earth’s magnetic field would have been as strong as the field in a magnetic star. A magnetic star is like our sun; it has a nuclear power source. Surely our Earth never had a nuclear source like the Sun. Surely, the Earth never had a magnetic field stronger than that of a star. That would limit the age of the Earth to ten thousand years.”

*The Earth, A Young Planet?* (1983)
"The earth’s magnetic field is decaying at a certain rate right now, it would take about 1400 years to decay down to half its present strength, and we know from archaeomagnetic data that it has been decaying at that rate for about 1000 years. … Historically it has been measured for the past 150 years, actually 170 years. Its followed that nice decay path, K curve, right on down. But before that it did complicated things, and we think the complicated things are the result of reversals of the earth’s magnetic field that happened during the Genesis flood. … In other words, one week, during the Genesis flood, the magnetic field was pointing north and the next week the magnetic field was pointing south."
"[My theory] is straightforward, based on sound physics, and explains many features of the field: its creation, rapid reversals during the Genesis Flood, intensity fluctuations (up and down) until about the time of Christ, and a steady decay since then. This theory matches paleomagnetic, historic, and present data."

D. Russell Humphreys

*Creation Ex Nihilo*, 1991
Variation in dipole

Variation around mean

Variation during pole reversal

Problem of the Speed of Light

Andromeda Galaxy (M31): 2,520,000 light years

Barry Setterfield
Change in Speed of Light

Fitted Curve $c = aT^2 + b$

Extrapolate to 6000 BCE

What about Mass/Energy equivalency?
Extrapolate to 6000 BCE

Time before 1981

0 1000 2000 3000 4000 5000 6000 7000 8000

Predicted Speed

2.0e+5
4.0e+5
6.0e+5
8.0e+5
1.0e+6
1.2e+6
1.4e+6
1.6e+6

Electron charge
Planck's Constant
Permittivity of Free Space
Fine-structure constant
Electromagnetic radiation

Professor, Geophysics Department, Institute for Creation Research Graduate School (1987 – '94)

"At the present time, it appears that general support by the creationist community of the decay of the speed of light hypothesis is not warranted by the data upon which the hypothesis resets" (Impact #179, 1988)

What do other YECs say?

"Because its historical research and statistical analyses have no depth, [the work] fails to prove that the speed of light has decreased over the past three centuries. Its theoretical interpretations are flawed, and in some parts do not make sense." (CSRQ, 1988)
Gerald E. Aardsma

- Professor, Geophysics Department, Institute for Creation Research Graduate School (1987 – ’94)
- Rejects arguments from:
  - decrease in speed of light,
  - magnetic decay,
  - changing decay constants
- Uses C-14 dating on research in Israel.

Paul Nelson & John Mark Reynolds

"Recent creationists should humbly agree that their view is, at the moment, implausible on purely scientific grounds."

Why maintain YEC position?

"There are, however, two very good reasons to maintain a young earth position during the struggle [against theistic and secular naturalism]. First, recent creationism is intellectually interesting ... Second, a coherent recent creationism would be a great boon to religious belief."
Would this lead you to accept evolution?

“There are, however, two very good reasons to maintain an evolutionary position during the struggle [against religious belief]. First, evolution is intellectually interesting ... Second, a coherent evolutionism would be a great boon to atheism.”

Nelson & Reynolds

“[W]e can admit that as recent creationists we are defending a very natural biblical account, at the cost of abandoning a very plausible scientific picture of an 'old' cosmos. But over the long term, this is not a tenable position. In our opinion, old earth creationism combines a less natural textual reading with a much more plausible scientific vision. There are fewer 'problems of science'. At the moment, this would seem the more rational position to adopt.”

Three reasons for taking Young Earth Creationism seriously

- Young earth creationism has grown and developed intellectually over time
- Young earth creationism has been the overwhelming view of the traditional church
- Young earth creationism is intellectually exciting

We believe these reasons alone are sufficient to allow a reasonable person to call himself provisionally 'young earth'

Phillip E. Johnson (2004)

“I have consistently said that I take no position on the age of the earth, and that I regard the issue as not ripe for debate yet. I have also rejected all suggestions that I should denounce the YECs and instead have said that I regard high-quality YECs like Andrew Snelling as respected allies.”
“[W]e're the ones that stand for good science, objective reasoning, assumptions on the table, a high level of education, and freedom of conscience to think as we are capable of thinking.”

Reclaiming America for Christ, 1999

“I'm on the religious side myself as a believer in divine creation but on the other hand many errors come out of our camp as well as out of the other one. And it's good that they should be challenged.

The Monkey Trial, PBS, 2005