Counting Annual Layers

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The question

- The diversity of life is enormous.
- Yet evolution is slow.
- Evolution is plausible only if the earth is old.
- Has there been enough time?

The young-earth view

Claims that the earth is only 6000 years old.

Too little time for evolution.

Is the earth really this young?

Measuring geological time

- Radiometric dating
- Salt in sea water
- Total thickness of sedimentary strata
- Counting annual layers

Using annual layers as a clock

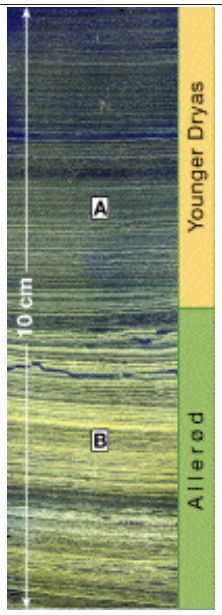
- Nature makes several kinds of annual layer
- It is easy to date such materials: you just count the layers.
- What can we say about the age of the earth, just by counting layers?

Tree rings

Varves

- Annual layers, in some lakes and ocean basins
- Every spring, the lake fills with tiny creatures (diatoms).
- These die and settle to the bottom as a light layer.
- Each year, one light layer and one dark layer are deposited.

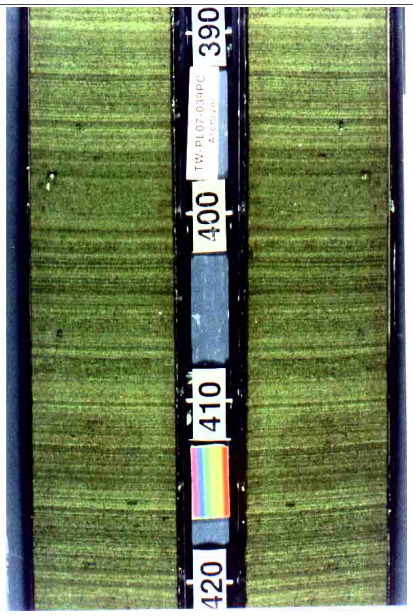
Lake Gosciaz, Poland



Lake Gosciaz varves

- Figure shows a small fraction of the total sequence
- Light layers are wide in bottom half, narrow in the top.
- Dark portion was deposited during a cold, dry period: the Younger Dryas.

Varves from Lake Suigetsu, Japan



Varves from Cariaco Basin, Venezuela

Sources of error

- Missing layers
- Long sequences of layers are constructed by overlapping shorter
- The overlaps may not be correctly aligned.

Experts say these errors are small. How can we be sure?

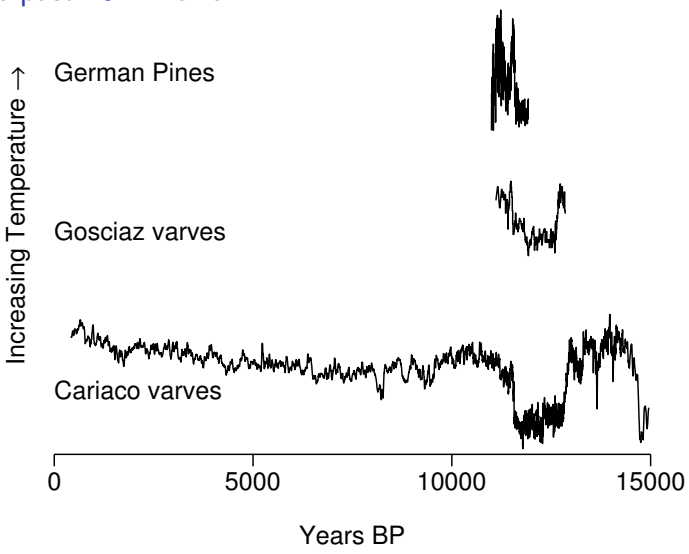
Cross-validation

- Date the same event using several different sequences of annual layers.
- If the dates are accurate, they should agree.
- This is easy for recent events, but we need something really old.
- What about a drastic change in climate?

Annual layers are sensitive to climate

- Trees lay down thick growth rings in good years.
- With varves, good years make lots of diatoms, which make the bright layers thicker and brighter.
- The ratio of ^{18}O to ^{16}O in rainwater measures temperature.

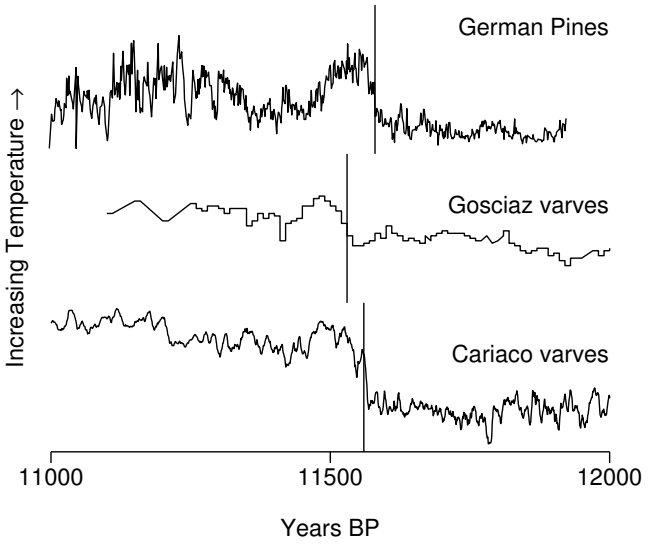
The past 15 millenia



The Younger Dryas

- Last great cold snap of last ice age.
- Very cold from about 12.5 to 11.5 thousand years ago.
- End was abrupt: within a couple of decades.
- Do different series of annual layers give the same date?

Twelfth millenium BP



End of Younger Dryas

- 11,560 according to Cariabo Basin varves
- 11,540 according to Lake Gosciaz varves
- 11,570 according to German pines
- Many other series of annual layers give similar dates

- Annual layers give accurate dates
- What do they tell us about the age of the earth?

How many years can we count?

Tree rings back to 11,855 BP (German pines)
Varves back to 37,930 BP (Lake Suigetsu, Japan)
The earth is at least that old.

Green River deposit

Green River deposit

- Varved shale deposit in Utah, Colorado, and Wyoming
- 5 million varves
- The deposit took 5 million years to form.
- The earth is at least this old.

Summary of counts

Tree rings back to 11,855 BP (German pines)
Modern varves back to 37,930 BP (Lake Suigetsu, Japan)
Ancient varves 5,000,000 y (Green River Deposit, Utah)

Summary

- By counting annual layers, we can show that it is at least 5 million years old.
- This is over 800 $\times$ the "young earth" figure of 6000 years.
- No support for the "young earth" hypothesis.

How old is the earth?

- Best dating methods are "radiometric."
- Some atoms are unstable: decay into other atoms, releasing energy when they do.
- This happens at a constant clock-like rate.
- Allows us to date events in the distant past.
- For details, see Ch 7 of *The Evidence for Evolution*.
- Bottom line: the earth is about 4.5 billion years old.