

THIRTEEN WAYS TO TELL TIME BACKWARDS

From an early 1970s article in *The Saturday Evening Post*

Fossils of human ancestors, remains of lost civilizations, granite vestiges of the birth of the planet - the ages of nearly all of these mysterious discoveries can be told, thanks to a variety of techniques that tell time backwards, enabling archeologists to assign dates to relics of the past.

Of the 13 methods described below and in the chart attached, the most useful are the so-called atomic clocks (solid lines on the chart), whose "ticks" are precisely measurable transformations within atoms because they give fairly accurate data for a wide range of materials, no matter where they are unearthed.

(Addendum: Since this article was published, the sensitivity of many of the following methods has been improved, increasing the accuracy and/or the time spans of those methods. In addition, other methods have also been developed. For example, Geomagnetic Reversal Patterns can help in the dating process.)

ATOMIC DATING TECHNIQUES

RADIOACTIVE DECAY CLOCKS:

Carbon 14 is the best-known example of an atomic clock based upon radioactive decay. The element carbon 14 changes its atomic structure by the processes of radioactivity at a fixed, known rate, it "decays" into nitrogen 14. Carbon 14 exists in a stable level in our atmosphere (as CO₂). This level is maintained in the living plants which take in CO₂ or the animals which consume those plants, until they die. This sets the clock. From death, the carbon 14 decays into nitrogen 14, slowly and steadily reducing the amount of carbon 14 below the level expected in a living organism. When the organic sample is tested for carbon 14, the amount provides a direct indication of how long ago the organism died.

Other atomic clocks based upon radioactivity make use of the decay of **potassium into argon, uranium into lead, or rubidium into strontium**. In these cases, the clock is set when a mineral with the radioactive element (e.g. potassium 40) in it solidifies from a molten state (e.g. molten lava). The product of decay (e.g. argon 40) accumulates in the mineral. Measuring the amount of both elements (e.g. potassium 40 and argon 40) provides a ratio which is proportional to how long ago the mineral solidified from a molten state. When layers of lava flows (or volcanic ash) alternate between layers of fossil-bearing sedimentary rock, the age of the fossils can be very closely determined.

The rate at which each of these elements decays is specified in terms of its "half life". In the case of carbon 14, half of a given amount decays in 5,730 years, half of the remainder decays in the next 5,730 years, and so on; its half life is thus 5,730 years. The other clock elements decay at much slower rates, so they can be used to date much older materials. Potassium 40 has half life of 1.25 billion years. Rubidium 87, a recently developed clock with a half life of 48.8 billion years, has already been credited with dating the oldest existing rocks in the world: some granite from West Greenland that proved to be four billion years old.

FISSION TRACK:

Fission track dating depends upon spontaneous splitting of atoms of the element uranium 238 (a process similar to the one operating atomic power plants) within certain natural glasses and minerals, such as quartz and zircon. The transformation leaves tiny scars in the material. By measuring the profusion of these scars, scientists are able to date the object accurately.

THERMOLUMINESCENCE:

Thermoluminescence provides a clock that is dependent upon a transformation within certain atoms of the minerals that form clay. As clay is fired in the potter's kiln, the heat causes an unstable subatomic arrangement to settle into a more stable one. This process produces light; hence the name thermoluminescence. When the finished ceramic is removed from the kiln its atoms begin once again to slowly return to the unstable form. This second process is the clock mechanism; when the archeologist finds the ancient ceramic and puts it into the fire again, the amount of light that is released indicates how long the instability has been accumulating and thus how old the ceramic is.

NON-ATOMIC DATING TECHNIQUES

TREE RINGS:

One of the most widely observed of non-atomic clock dating phenomena is the addition of a new ring in a tree trunk with each year's growth. This regular annual process permits scientists to correlate the inner rings of young trees with the outer rings of old - or dead - trees. Thus, the tree rings of the bristlecone pine can be used not only for dating but for checking the accuracy of carbon 14 dates.

VARVES:

A phenomenon strikingly similar to the growth of tree rings is the laying down, year by year, of varves. The word is Swedish and refers to the layers of sediment and silt in riverbeds and lake floors. The annual stacking of varves produces a sandwich effect which resembles, in cross section, a tree-ring sequence. The sediment of a varve itself - and anything that may have become embedded in it - can be dated simply by counting the number of varves above it (relative to the time the lake or river last dried up).

STRATIGRAPHY:

Yet another layering phenomenon that has long been used as a dating technique is the sequence of sedimentary rocks. Tiers of geological strata in rock formations can be identified to give a rough idea of age; certainly a sequence is shown, with lower layers being older than upper layers. But since geological stratification does not occur at a fixed rate, this technique - known as stratigraphy - is not precise or absolute.

FOSSILS:

Rocks can often be dated if they contain embedded within them fossils of once-living organisms. When such remains are found, and the period during which the organism flourished is known (from other studies in other localities), the approximate age of the rock can be inferred. Certain fossils ("Key Fossils"), once very abundant, and very specific in form during a particular point in time, are especially useful in this process.

POLLEN:

In rocks, sediment or peat without fossil traces, grains of pollen are sometimes found. Botanists can associate various pollen types with the timespan in which their plants flourished, and thus the objects in which they are embedded can be dated, again approximately.

OBSIDIAN:

A more accurate dating technique, but one limited to objects and artifacts made of volcanic glass (obsidian), is the measurement of water absorption (hydration). Since the rate of hydration in a given type of glass is fixed, the depth at which moisture can be detected in an obsidian arrowhead, for example, tells its age.

RACEMIZATION:

Racemization is the newest dating technique, and a very precise one. It was announced in July 1972 at the University of California's Oceanographic Institute. Racemization depends on the peculiar behavior of amino acids - the building blocks of all living things - when they are subjected to light that is polarized, i.e., made to vibrate in one rather than all directions. If living amino acids are crystallized, they affect the polarization of an incoming beam of light by rotating it to the left. (For this reason, the molecules are called "left-handed"). But when an organism dies, amino acid crystals begin to realign, and as they do, incoming polarized light tends to be rotated to the right. This slow transformation into geometric mirror-image "right-handed" molecules is called racemization. Since the California scientists discovered that this journey through the looking glass takes about 60 million years before half of the left-handed molecules turn into right-handed ones, it serves as a new clock by which to tell when nearly any once-living thing died.