SOLAR FLARES, RADIOACTIVE DECAY, AND THE AGE OF THE EARTH - (Print)

How old is the planet Earth? The majority of geologists today tell us that radiometric dating has narrowed the age of Earth to about 4.5 billion years, give or take 330 million. How accurate are the dating methods, though, and how much do we truly understand about radiometric dating? Researchers at Purdue and Stanford have found evidence that radio decay rates are not as constant as geochronologists have thought. Dating the earth through radiometric methods may therefore be even less simple than previously believed.

Dec 13, 2006, a magnificent solar flare flung radiation and solar particles toward Earth. Purdue nuclear engineer Jere Jenkins had been measuring the decay rate of manganese-54, and he noticed that a day and a half before the flare, the decay rate of Mn-54 started to drop a little. That was interesting.

Ephraim Fischbach, a physics professor at Purdue, had already found a variety of disagreements on decay rates in the literature. Fischbach had been looking for a good way to generate truly random numbers and had turned to radioactive isotopes. Chunks of radioactive elements might decay at steady rates, but the individual atoms within them decay unpredictably. Fischbach could therefore use the randomly timed ticks of a Geiger counter to generate lists of numbers.

As he did more research, though, Fischbach found variations in the published decay rates of certain isotopes. He also found that the decay rates of silicon-32 and radium-226 showed seasonal variation, according to data collected at Brookhaven National Laboratory on Long Island and the Federal Physical and Technical Institute in Germany. So when when the decay rate of Jenkins' Mn-54 dropped during the solar flare, Jenkins and Fischbach stood up straighter and paid attention.

"Everyone thought it must be due to experimental mistakes, because we're all brought up to believe that decay rates are constant," Peter Sturrock, Stanford professor emeritus of applied physics, commented on the issue.

There was more to the issue than instrumental error. Jenkins, Fischbach and their colleagues proceeded to publish papers on the variations in radiometric decay rates in journals like *Astroparticle Physics*, *Nuclear Instruments* and *Methods in Physics Research*. They argued that positions like Sturrock's were incorrect; the variations were not caused by weaknesses in their detection systems, but were actual variations in the decay rates themselves.

Radiometric Dating 101:
While radiometric dating sounds like a jazzy way to find a mate, it's actually about unruly isotopes.

The world around us is made up of atoms, each with a specific number of positively charged protons, negatively charged electrons, and neutral proton-sized neutrons in their nuclei. Neutrons and electrons are important, but it is the proton number that defines an element. All carbon atoms have six protons, iron atoms have 26, and platinum atoms have 78. If a sodium atom loses an electron, it's still sodium, it's just a positively-charged sodium ion, ready to ionically bond with a negatively charged chlorine ion to make table salt for mashed potatoes. If iron loses electrons, it starts to rust, but it's still iron.

If carbon gains an extra neutron, it still behaves like carbon. Carbon generally has six neutrons with its six protons, and so has an atomic weight of 12. Adding one neutron makes carbon-13, a stable isotope that makes up about 1.1% of the carbon on Earth.

Not all isotopes, though, are stable. In a crowd of one trillion carbon atoms, one can always find a single unstable carbon-14 isotope sipping on the punch. Over the course of about 5730 years, half of a sample of C-14 will decay into nitrogen-14. A scientist can take a carbon sample, measure the amount of C-14 among its trillions of carbons-12 atoms, measure the N-14 in the mix, and get a ratio of the two isotopes. C-14 has a half-life of 5730 years – the amount of time it takes half a sample to decay. *Theoretically*, if the scientist measures a sample and finds an equal amount of C-14, the parent material, and N-14, the daughter material, then 5730 years should have passed since that hunk of carbon formed. *Theoretically.* This is the idea behind radioisotope dating.

Chemists have been able to measure the half-lives of most isotopes and, for the most part, have found their decay rates consistent. The accuracy of the dating methods hangs on a few assumptions, though. First, we have to assume that no extra daughter material contaminated the sample from an outside source. We have to assume that only parent material and no daughter material was in there at the start. We have to assume than no parent material leached out of the sample during its lifetime. Ultimately, we have to assume that the decay rates for various isotopes are the same now as they always have been, without variation. To deal with these obvious problems, geochronologists work to correlate dates through the use of several different dating methods.

Meteors:
In Brent G. Dalrymple's book *The Age Of The Earth* (1991), he includes lists of meteorites that have been dated between 4.23-4.88 billion years old. These lists are often cited as evidence for the age of the earth, because meteorites are believed (by most parties) to be from material that formed at the same time as Earth. Earth has a dynamic crust that is constantly changing; it wears away and gets torn up in earthquakes; it gets covered with volcanic ash and ocean sediments; it gets pressure cooked and torn up and ripped apart. Earth's surface has taken a lot of abuse through the years. On the other hand, meteorites have been floating around in space untouched, and the trace elements in them are fairly evenly mixed. They are therefore considered good subjects to determine Earth's age.

Dalrymple includes the specific radiometric dating methods that were used to date the meteorites. Argon-argon dating was used most frequently in dating the meteorites, but rubidium-strontium and samarium-neodymium dating methods were also used. Dalrymple makes the case that three different dating methods, measuring three different mother-daughter pairs, all gave basically the same age dates. This has been seen as solid well-correlated evidence that the given chondrite age-dates are reliable.

Dalrymple's lists do raise some issues, however. It is worth noting that all three of the methods used to date those meteorites involved parent isotopes with massively large half lives. The half life for rubidium-87 is approximately 50 billion years. The alpha-decay of Sm-147 to Nd-143 has a half life of 1.06×10^{11} years. That's 100 billion years! The argon-argon method depends on the 1.25 billion year half life of potassium-40 decaying to argon-40, which is still high. Geochronologists using these dating methods have to detect trace amounts of elements that would hardly have had time to decay, even with billions of years at their disposal. The dates of these specific meteorites may correlate, but it is difficult to determine whether there was just so little of each element in the first place that there was not much room for variation. It is also difficult to know whether the chondrites did not have relatively homogenous amounts of parent and daughter materials from the start.

The question to ask is, were there outliers that Dalrymple didn't list? Were there other meteorites that gave significantly higher or lower ages? Did Dalrymple only include the meteorites that fit his position, or did all the meteorites truly date between 4.29 +/- .06 and 4.55 +/- .33 billion years? Also, should we consider the age-date span of 650 million years – more than half a billion years - as significant?

Discordant Dating:
There is reason for skepticism. Age dating methods do not always produce correlating results. (See links below.) Wood buried in igneous rock in Queensland Australia has been dated to 40,000 years, while the basalt around it dated to 45 million years. Both dating subjects should have given the same date, since the igneous rock was formed at the same time the wood was buried (and the wood still had plenty of carbon-14 in it). Dalrymple himself reported "excess argon-36" in three out of 26 lava flows in his article, "40Ar/36Ar Analyses Of Historic Lava Flows". The excess argon gives negative age-dates because of too much daughter product. Since it is impossible to date a rock that hasn't formed yet, there was a good indication that the Ar-36 wasn't coming from just the parent material. Geologist Steve Austin describes discordant age dates in his article "Excessively Old 'Ages' For Grand Canyon Lava Flows." He tested different layers of the Grand Canyon and got age dates for older layers that tested younger than the layers above them. The science of geochronology is occasionally exact, but it has a lot of room for error.

Ultimately, the researchers who age-dated the meteorites on Dalrymple's lists assumed the rocks were billions of years old, they used methods that fit their presuppositions, and they got results that fit their presuppositions.

It is always dangerous to come to science with assumptions, regardless of one's position. Scientists have long assumed that radioisotope decay rates are constants, but the evidence now indicates that decay rates vary over time. If, as Jenkins and Fischbach have argued, solar neutrinos zipped through space, effecting Mn-54's decay rates in a Purdue laboratory, then those tiny energetic particles certainly have had the capacity to affect the decay rates of trace nuclides in chunks of rock floating out in space.

Are the observations of Jenkins and Fischbach minor fluctuations, or have decay rates actually slowed down over time? Has the very speed of light slowed through the years, and how might that have affected decay rates? Are there truly any physical constants in the universe?

These are the questions that astrophysicists and geochronologists can have a fun time trying to answer. In the meanwhile, we'll keep on watch for further developments. The variability of decay rates has massive implications - for medicine, for technology, and for mankind's longing to produce a birth certificate for the Earth.

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